



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>

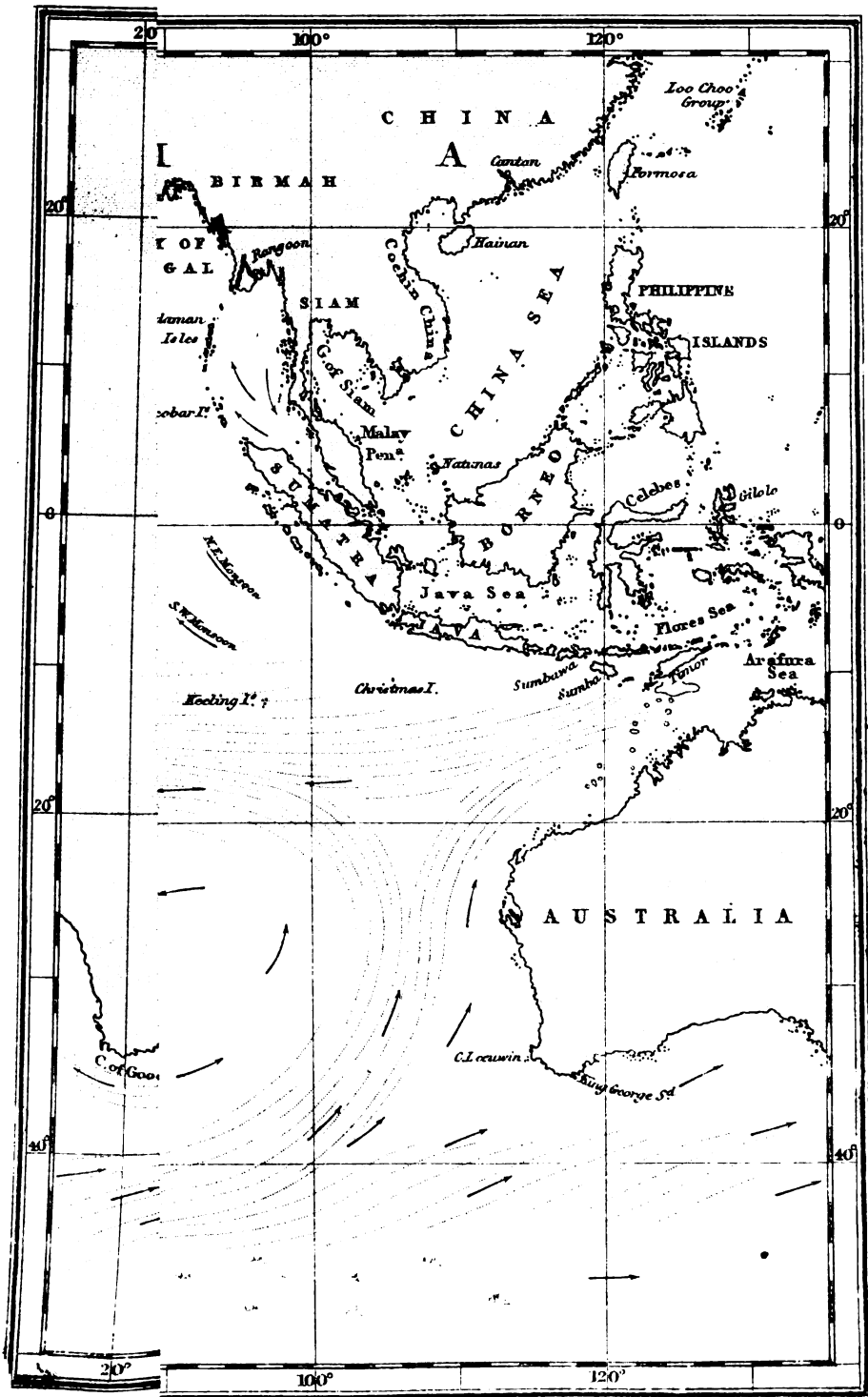




THE LIBRARY
OF
THE UNIVERSITY
OF CALIFORNIA

PRESENTED BY
PROF. CHARLES A. KOFOID AND
MRS. PRUDENCE W. KOFOID

CEAN



INDIAN OCEAN DIRECTORY.

THE
SEAMAN'S GUIDE
TO THE
NAVIGATION
OF THE
INDIAN OCEAN
AND
CHINA SEA;

INCLUDING

A DESCRIPTION OF THE WINDS, STORMS, TIDES, CURRENTS, &c.; SAILING DIRECTIONS; A FULL ACCOUNT OF ALL THE ISLANDS; WITH NOTES ON MAKING PASSAGES DURING THE DIFFERENT SEASONS.

WITH NUMEROUS ILLUSTRATIONS, CHARTS AND PLANS.

By W. H. ROSSER, AND J. F. IMRAY, F.R.G.S.



LONDON E.:
JAMES IMRAY AND SON,
CHART PUBLISHERS AND NAUTICAL BOOKSELLERS,
MINORIES AND TOWER HILL.
1867.

**** UNLESS OTHERWISE EXPRESSED THE BEARINGS ARE ALL MAGNETIC;
AND THE DISTANCES ARE IN NAUTICAL MILES.**

VK 885
R6

CONTENTS.

PART I.

NOTES ON THE PHYSICAL GEOGRAPHY OF THE INDIAN OCEAN IN ITS APPLICATION TO NAVIGATION.

CHAPTER I.

INTRODUCTORY.

The Indian Ocean described, 1-2.

CHAPTER II.

GENERAL REMARKS ON THE WINDS AND SEASONS.

Winds representing the various Regions of the Globe, 3; Theory of the Winds, 3; Maury's Theory, 5; Dove's Theory, 5; Trade region in the Atlantic, 12; Trade-winds in the Pacific, 17; Winds of the Indian Ocean, General Remarks, 19; Monsoons, 19; Summary of Winds in the Monsoon Region, 21; the Seasons of the Monsoon Region, 22; Winds and Calms in the Indian Ocean, 22.

CHAPTER III.

WINDS IN THE INDIAN OCEAN.

The Wind Regions, Indian Ocean, classified, 23; Explanation of the Chart Diagrams of the Winds, 24; Region of the N.W. Passage Winds, 24; S.E. Trade-wind, 25; Winds off the Cape and the Eastern Coast of South Africa, 25; Winds of the Southern Spring in the Western Indian Ocean, 29; the Southern Summer Winds, W. Indian Ocean, 32; the Southern Autumn Winds, W. Indian Ocean, 35; the Southern Winter Winds in the W. Indian Ocean, 38; Winds of Central and Eastern Indian Ocean, in Spring, 43, in Summer, 45, in Autumn, 47, in Winter, 49; Maury on the Monsoons, 50; Meldrum's Meteorological Journal of the Indian Ocean (for March, 1853), 53.

M363288

CHAPTER IV.

WINDS ALONG THE COAST OF THE INDIAN OCEAN.

South Africa, 69; Table Bay, 69; False and Simon's Bay, 69; Mossel Bay, 70; Algoa Bay, 70; Port Natal, 70; Delagoa Bay, 71; Mozambique Channel, and from C. Corrientes to the Equator, 71; Zanzibar, 71; Equator to Guardafui, 72; East Coast, Madagascar, 72; Reunion, 73; Mauritius, 74; Rodrigues, 74; Gulf of Aden, 75; Red Sea, 76; S.E. Coast of Arabia, 80; Gulf of 'Omman, 83; Persian Gulf, 83; Bombay and coast to westward, 86; West Coast, Hindostan, 86; Laccadivh Islands, 87; Maldivh Islands, 87; Ceylon, 87; Gulf of Manaar, 88; Bay of Palk, 88; Bay of Bengal, 88; Weather on the Coromandel coast, 89; Head of Bay of Bengal, 92; Gales in the Bay, 93; Martaban and Tenasserim, Andaman and Nicobar, 94; Straits of Malacca, 94; Sumatra, W. Coast, 95; Sunda St., 96; Sunda Strait to Timor Island, 96; S. Coast of Java, Sumbawa, &c., 96; N.W. side Timor Island, 97; between the Indian Archipelago and Australia, 97; Java Sea, 97; Banka, Gaspar, and Carimata Straits, 100; Borneo, 100; Celebes, 101; Macassar Straits and Molucca Passage, 101; Seas of Celebes and Sulu, 102; New Guinea, W. Coast, 102; Molucca Islands, &c., 102; Arafura Sea, 102; General Remarks on the Malay Archipelago, 103; Winds in the China Sea, 104; Malacca, 106; between Pulo-Timoan and Pulo-Condore, 106; Gulf of Siam, 106; Cambodia, 106; Coast from Siam to Cape Padaran, 107; Tong-Quin, 107; Hainan and South Coast of China, 107; Canton River to the Chusan Islands, 107; Formosa Channel, 108; Philippines, 108; Palawan, 108; Japan, 109; Tsugar Strait, 110; Ladrone, or Mariana Islands, 110.

AUSTRALIA AND TASMANIA.

West and South Coasts of Australia, 111; Bass Strait, 112; Tasmania, 112; Australia, East Coast, 112; Torres Straits and Coral Sea, 113; Sydney, 113; Winds of New Zealand, 115.

CHAPTER V.

ON THE USE AND APPLICATION OF METEOROLOGICAL INSTRUMENTS.

Barometer, Thermometer, and Hygrometer—their Connexion with the law of Gyration, 123; Mean Movements of Meteorological Instruments, 124; Oscillations of Barometer, Thermometer, &c., 126; Position of the Barometer in a Ship, 126; Mean Height of the Barometer in the Northern and Southern Hemispheres, 127, 129; Clouds and their Variations, 129; Beaufort's Notation of Wind and Weather, 134; Table showing the Force and Velocity of the Wind, 135; Moon's Influence on the Weather, 136.

CHAPTER VI.

HURRICANES OR CYCLONES, AND THE LAW OF STORMS.

Revolving Storms, 143 ; Veering of the Wind-vane, 144 ; the Bearing of the Storm's Centre, 144 ; Rotatory and Progressive Motions of Hurricanes, 146 ; on the Use of a Barometer in a Hurricane or Cyclone, 147 ; Meteorological Signs preceding a Hurricane, 148 ; the Storm Wave, 150 ; Rules for Trimming a Ship in a Hurricane, 150 ; Hurricanes and Weather in the Indian Ocean, 152 ; Hurricane Seasons in the different Oceans, 187 ; Cyclones in the Hoogly, 189.

CHAPTER VII.

TIDES OF THE INDIAN OCEAN, CHINA SEA, AND WESTERN PACIFIC.

To find the Time of High Water, 192 ; Tide-table, 193.

CHAPTER VIII.

CURRENTS IN THE INDIAN OCEAN, CHINA SEA, AND WESTERN PACIFIC.

Sketch of Oceanic Currents, 206 ; Currents of the Indian Ocean, 210 ; Equatorial Current, 210 ; Mozambique Current, 211 ; Counter-currents round Madagascar, 211 ; Agulhas Current, 212 ; Counter-current of the South Indian Ocean, 213 ; Australian Current, 217 ; Arabian Sea, 217 ; Gulf of Aden, 218 ; Red Sea, 219 ; Persian Gulf, 222 ; West Coast, Hindostan, 223 ; Laccadivhs and Maldivhs, 223 ; Gulf of Manaar, 224 ; Currents round Ceylon, 224 ; Bay of Bengal, 226 ; Malacca Strait, 226 ; West Coast Sumatra, 226 ; Sunda Strait, 226 ; Currents of the Bay of Bengal during the S.W. Monsoon, 227 ; Indian Archipelago, S. of the Equator, 231 ; Java Sea, 231 ; Gaspar, Carimata, and Macassar Straits, 231 ; Celebes, Sulu, and Arafura Sea, 231 ; Banda Sea and Molucca Channels, 231 ; Australia, N.W. Coast, 232 ; Currents in the China Sea during the N.E. and S.W. Monsoons, 232 ; Palawan Passage, 233 ; Gulf of Siam, 233 ; China Coast, 234 ; Pescadores, 234 ; Currents of W. Pacific, 234 ; Equatorial Currents, 234 ; Kuro-Siwo, or Japan Stream, 235 ; Notes on the Current Charts, 241.

CHAPTER IX.

Ice and Icebergs in the Southern Indian Ocean, 241-254.

CHAPTER X.

On the Specific Gravity and Temperature of the Water of the Indian Ocean, 254 ; Specific Gravity and Temperature of each Square of Ten Degrees in the Indian Ocean, 256 ; Summary, 259 ; Specific Gravity and Temperature of each Square of Ten Degrees in the China Sea, 260 ; Saltness of the Ocean, 261.

CHAPTER XI.

Deep-sea Soundings in the Indian Ocean, 261-263.

CHAPTER XII.

Whaling Grounds in the Pacific, Atlantic, and Indian Oceans, 26-263.

CHAPTER XIII.

On the Magnetism of Iron Ships, &c., 268-271; Table of the Variation of the Compass in the Indian Ocean and China Sea, 272.

PART II.

Sailing Directions for the S. and E. Coasts of Africa; the S.E. Coast of Arabia and Gulf of Aden; the W. Coast of India; the Bay of Bengal; the Islands in the Indian Ocean; the W., N.W., and S. Coast of Australia and Tasmania, 273-715.
—See Special Index of Places, 755-763.

Catalogue of reported Rocks and Shoals, Doubtful Dangers, Vigias, &c., 716-731.

Notes on making Passages, 731-753.

For List of Illustrations, Charts, &c., see end of Book, p. 764.

ERRATUM.

p. 456, line 2 from top, *for* 80° 20' *read* 82° 20'.

INDIAN OCEAN DIRECTORY.

[*ADDENDA to MARCH 81st, 1869.*]

ROBBEN ISLAND.—The lighthouse has been coloured red and white in bands. Page 274.

MOUVILLE POINT.—The lighthouse has been coloured black and white in bands. Page 277.

CAPE OF GOOD HOPE.—Heavy breakers, during bad weather, having been reported by the keepers of the Cape of Good Hope lighthouse in a north-westerly direction, the following is the result of an examination made by the direction of the Commodore at Simons bay.

The breakers are on a rocky ledge, about a mile in extent, and from $1\frac{1}{2}$ to 2 miles from the shore, having $10\frac{1}{2}$ fathoms on its shoalest part (near a depth of 11 fathoms already marked on the chart), with soundings gradually increasing to 20 fathoms on its outer edge, and with 18 fathoms between the ledge and the coast.

From it the following bearings were observed :—Cape of Good Hope lighthouse, S.E. $\frac{1}{4}$ S., $6\frac{1}{2}$ miles; Polesberg, E. by S.; and Slangkop point, N. by E. $\frac{1}{4}$ E., 10 miles.

This rocky bank lies somewhat in the fairway for vessels passing round the coast to and from Table bay, and as in heavy southerly gales, a continuous line of breakers has been observed to extend between this ledge and the shore, vessels are accordingly cautioned not to approach this part of the coast in bad weather. (1868). Page 285.

In reference to the following reported bank of soundings, it should be stated that the neighbourhood of the bank was closely examined by H.M.S. *Petrel* in 1868, and bottom touched at 200 fathoms on the assigned spot, and soundings of not less than 130 fathoms obtained within a radius of 5 miles of it; hence the bank, if it exists, must be in a different position than that assigned to it.

“The Spanish merchant vessel *Justa*, on her voyage from Macao to Havana, is said to have discovered a patch of shoal ground at about 5 leagues south-westward from the Cape of Good Hope.

The shoal bank, on which several casts of the lead were taken during a calm, had from $15\frac{1}{2}$ to 13 fathoms, rocky bottom; from the latter depth the water suddenly deepened and no bottom could be found.

At the time of the first sounding in $15\frac{1}{2}$ fathoms, the Cape of Good Hope lighthouse bore E. by N. (N. 49° E. true), and the assumed distance from the cape

*

was 16 miles. This bearing and distance would place the bank in lat. $34^{\circ} 31\frac{1}{2}'$ S., long. $18^{\circ} 15\frac{1}{2}'$ E." (1867). Page 286.

CAPE RECIFE.—The lighthouse on the cape now shows a ray of red light over Roman or Dispatch rock, in the arc from it of N. 39° E. to N. 12° E. (27°). Vessels bound to Port Elizabeth, after passing cape Recife, should not enter this red ray until the Harbour light on the hill (which when first seen is red) is seen bearing N.W., but as the southern limit of the Harbour light passes only 2 cables northward of Roman rock, it is recommended that a course for the anchorage should not be shaped until the red ray from the Harbour light is passed and the white light seen bearing N.W. by W. Pages 309-310.

ALGOA BAY.—The Harbour Master at Algoa bay has given notice of the existence of a rocky shoal lying to the southward of the anchorage in Algoa bay, .3 cables from the shore.

The shoal, named *Strutts reef*, is about 50 square yards in extent, and has 15 feet water on it at low water springs. The shoal lies with the Water pipe and reservoir house in a line with the two southernmost houses of the town bearing W. $\frac{1}{2}$ N.; Scotch church spire in a line with the square tower of St. Mary's church N.W.; Bird rock S.S.E.; Harbour lighthouse N.W. $\frac{1}{2}$ W.

Clearing Marks.—The tower of the Mosque (which is red) open of the north end of the breakwater, and the tower of the Grey institute open to the northward of the harbour lighthouse, clears the shoal in 25 feet water. Page 310.

NATAL.—A white conical tower 81 feet high has been erected on the bluff at the east side of the entrance to the harbour. It shows a light revolving every minute at 292 feet above the sea, visible 24 miles. The arc illuminated is 230° (from North eastward and southward to S. 59° W).

As this light is not visible from Aliwal shoal, which is 25 miles S. 53° W. from the lighthouse, vessels approaching the harbour from southward and westward should not approach the shore nearer than 4 miles, nor get into a less depth than 40 fathoms. The lead should be hove freely until the light is well made out from the deck, when they may stand in until it bears N. 59° E.; this bearing will keep them outside all known dangers until abreast of Umlazi river which is about $9\frac{1}{2}$ miles southward from the lighthouse. As the land then trends more to eastward, the light must be kept more to northward, and the shore must have a berth of at least a mile; when the light bears about W.N.W., they can haul in northward for the anchorage. The anchorage is in from $8\frac{1}{2}$ to 10 fathoms at about a mile N.E. to N.E. $\frac{1}{2}$ N. from the lighthouse. Pages 335-337.

DARRA SALAAM.—The following description of the harbour of Darra Salaam, on the East Coast of Africa, is by Commander Richard Bradshaw, commanding H.M.S. *Star*, 1867.

The harbour of Darra Salaam is situated on the main land South, distant 41 miles from Zanzibar, and is approximately in lat. $6^{\circ} 49'$ S., long. $39^{\circ} 22'$ E.; it lies in the bight of a bay formed by Motumoko point, 12 miles N.W. by W. $\frac{1}{2}$ W. from the latter.

On approaching the harbour from Zanzibar, and after passing Choomby

island, the course is S. by E. $\frac{1}{2}$ E. to avoid the Tom shoal, which latter will be seen breaking about 2 miles distant. The same course should be preserved until Sindo island is clearly made out, bearing about S. by W. $\frac{1}{2}$ W., then steer to keep Sindo island on the port side, passing it about $\frac{1}{4}$ of a mile distant, the Goonjo islands being kept on the starboard side. By this time the coast, which is low, will be clearly seen, and between two red cliffs, each about 80 feet high, is the harbour of Darra Salaam, the entrance being nearly opposite the east cliff.

Outside the entrance there is good anchorage under Sindo island. If proceeding into the harbour, two buoys will be seen nearly $\frac{1}{2}$ a mile distant from the East cliff; they are placed on the edge of the reefs extending from the West and East cliffs, in $3\frac{1}{2}$ fathoms at low water, $1\frac{1}{2}$ cables apart, and bearing W. by S. $\frac{1}{4}$ S. and E. by N. $\frac{1}{4}$ N. from each other. In approaching the buoys, a vessel should not get less than 5 fathoms; it deepens between them to 9 and 10 fathoms; immediately after passing the buoys, alter course quickly to S.W. by W. $\frac{1}{2}$ W., keeping the inner point (a point forming the left extreme of a long sandy beach) a little on the starboard bow; not less than 5 fathoms should be struck in this channel. On rounding the inner point a large sheet of water opens to the view, in any part of which a vessel may anchor in 5 or 6 fathoms.

The entrance channel is about a mile long; it is narrow but strait, with coral reefs on either side; all dangers may be seen from half-way up the lower rigging. The harbour is capable of holding a great number of ships of moderate tonnage; the Sultan of Zanzibar with his fleet was at anchor during the visit of H.M.S. *Star*.

TIDES.—It is high water, full and change, at 4h. 0m.; springs rise 12 feet.

Caution.—A dangerous bank of coral lies 5 miles N.N.E. from the buoys, and which was passed over in 3 fathoms, about an hour after low water.

It was observed that a new palace was nearly completed, and a town laid out, the allotments of which were nearly all taken. The jungle was being rapidly cleared, and the soil is said to be excellent. It is thought that this port will supersede Quiloa as the domestic slave depôt of the Sultan, the caravans from the interior altering their route for it on account of its proximity to Zanzibar, Quiloa being 160 miles distant, the difference being a great consideration to the Dhows conveying slaves. Page 340.

COMORO ISLANDS.—The French ship *Persévérance* is reported to have touched the bottom on a bank westward of the island of Comoro. The bearings taken were, the north-west point of the island N. 40° E. and the south point of the island S. 58° E.—the depth was about 17 feet. The bank was apparently of considerable extent. (1867). Pages 353-355.

ADEN.—A lighthouse of dark blue stone and 60 feet high, has been erected on Ras Marshig the eastern extremity of the peninsula known as cape Aden. It shows a fixed light at 244 feet above the sea, visible 20 miles. Its geographical position is lat. 12° 45' 23" N., long. 45° 4' E. It is of service chiefly to vessels approaching Aden from eastward; those westward of the port, can see it only when it is open southward of Ras Tye. Page 388.

* *

KARACHI.—The following instructions for approaching *Karachi Harbour* were issued by Mr. E. GILES, Master-Attendant at the Port, July 1st, 1866 :—

The lighthouse on *Manora Point* is in lat. $24^{\circ} 47' 21''$ N., long. $66^{\circ} 58' 15''$ E. The light is *fixed*, at 119 feet above the sea level, and visible from a distance of about 17 miles in clear weather, but only 7 to 9 miles in the hazy weather prevalent during the South-west Monsoon.

It is high water on the days of full and change of the moon, at 10h. 30m.; the rise and fall on ordinary spring tides is 9 feet 6 inches.

Depth on the Bar.—The depth of water on the bar during the South-west Monsoon season (May to September) is at springs 22 to 23 feet 6 inches, at neaps 19 to 18 feet;—during the fine season (October to April) it is at springs 20 to 21 feet 6 inches, at neaps 19 to 18 feet.

Ships may load from September 15th to April 15th (the bar being generally smooth)—spring tides 20 feet, neap tides 18 feet.

From April 15th to the end of May; from September 15th to the 30th; periods before and after the South-west Monsoon—spring tides 18 feet 6 inches, neap tides 17 feet 6 inches.

From June 1st to the middle of September, with the average weather in the South-west Monsoon—spring tides 17 feet, neap tides, 15 feet.

There are days during this Monsoon when the sea on the bar is so heavy that ships at the above draft cannot with safety cross, and it is advisable not to send out vessels of above 600 tons burthen during the bad weather season.

Approaching the Port.—At all seasons, if coming from southward, the coast of Sind, from the parallel of $23^{\circ} 30'$ N., should not be approached under 14 fathoms. This line of soundings will carry a ship from 7 to 8 miles off the dangerous banks which extend from the Hujamree, Kedewarry, and Kokowarry mouths of the Indus river to a distance of 7 miles, showing in several places 10 fathoms on their extreme edge. The set of the tides and currents being very uncertain, the coast low throughout, and barely visible from the outer edge of the banks in clear weather, too much attention cannot be paid to the lead in passing these banks.*

Ras Muari (or cape Monze), distant 18 miles W. $\frac{1}{4}$ N. from the western entrance to Karachi, is high and bold of approach. Ships during the South-west Monsoon season should make this headland, running eastward for Manora point, keeping it (Manora point) on any bearing to the north of East.

Manora point forming the west side of Karachi harbour, is 100 feet in height, and can be approached to within $\frac{1}{4}$ a mile on any bearing from North to East, with 5 fathoms water; on this point stands the lighthouse and signal station. As at certain times of tide pilots cannot get off, attention should be given to all directions signalled from the shore.

* Note.—Since the beginning of 1857, the *Admiral Bozer* has been totally lost on the Indus banks. The *Thomas Campbell* and *Augusta*, with the steamer *Pioneer*, have grounded on them, but were eventually floated off. Two large Troop Steamers have also, in the same period, touched on them.

Masters of ships should not, under any circumstances, attempt to enter the port without a pilot.

Anchorage in the Roads.—*June to the middle of September.* Ships should not on any account anchor, but stand off and on, keeping the lighthouse bearing from N. by E. to N.E., 1 to 2 miles distant, until boarded by a pilot, or directed by signal.

September 15th till the end of March. The anchorage is with the lighthouse bearing N. by E. to N.N.E. distant 1 mile, in 7 fathoms.

April and May. The anchorage is with the lighthouse bearing N.N.E. to N.E. distant $1\frac{1}{2}$ miles, in 8 fathoms. Pages 398-407.

GULF OF CAMBAY.—The *fixed* light on Perim island is from a white stone building 78 feet high; it is 128 feet above the sea, and visible 17 miles. Its geographical position is lat. $21^{\circ} 35' 54''$ N., long. $72^{\circ} 23' 38''$ E.

The *fixed* light at Tapti is on a column 91 feet high, and painted in red and white bands, erected on the north side of the river, in lat. $21^{\circ} 5' N.$, long. $72^{\circ} 38' E.$ It is at 100 feet above the sea, and visible from an offing of about 15 miles. Page 407.

BOMBAY.—A lighthouse consisting of an octagonal tower on the centre of a flat roof house has been erected on Khundari island, south of Bombay harbour. It shows a *fixed* light at 161 feet above the sea, visible from all parts of the sea horizon at the distance of 20 miles. Its geographical position is lat. $18^{\circ} 42' 20'' N.$, long. $72^{\circ} 48' 50'' E.$ Page 408.

The Outer lightvessel now shows a *red* light, *revolving* in 20 seconds. Page 410.

The fairway buoy has been removed. Page 410.

RATNA GHIRI, at about 115 miles southward from Bombay. A *red fixed* light is shown here from the south-west bastion of an old fort; it is 300 feet above the sea and *said* to be visible from the distance of 18 miles. Its geographical position is lat. $16^{\circ} 59' 30'' N.$, long. $73^{\circ} 15' 47'' E.$

At Ratna Ghiri there are three anchoring grounds:—The outer anchorage for sailing vessels; the outer anchorage for steamers; and the inner anchorage for steamers during the fair season only.

Vessels anchoring at the outer roadstead should do so in 8 fathoms, at a little more than a mile from the lighthouse, with the lighthouse bearing N. $59^{\circ} 4' E.$ or N.E. by E. $\frac{1}{4} E.$; Adawlut building, (a very large house on the hill bordering the creek to the North), N. $81^{\circ} 33' E.$ or E. $\frac{1}{4} N.$; and the white tomb, (near the beach southward of the creek), S. $75^{\circ} 56' E.$ or E. by S. $\frac{1}{4} S.$

Steamers making the port at the beginning or close of the South-west Monsoon should anchor in $6\frac{1}{2}$ fathoms with the lighthouse bearing North and the Adawlut building E.N.E.

The inner anchorage is only available for steamers during the fair season. Vessels should anchor in not less than 4 fathoms with the lighthouse bearing N.W. $\frac{1}{4} N.$ and the Adawlut building E. by N. $\frac{1}{4} N.$;—that position will place them at about 1200 yards from the landing place and 700 yards from the edge of a ridge of rocks running out from the beach in front of the custom-house.

The port of Ratna Ghiri does not afford the least shelter to vessels during the South-west Monsoon, but a vessel in distress would, in a measure, be sheltered by anchoring in 5 fathoms after rounding the north point of Meria Donghur, a hill 3 miles northward from the lighthouse.

The bay between Meria Donghur and the lighthouse hill does not afford any shelter, but, on the contrary, is open to the full force of the Monsoon. Page 413.

SEDASHIGUR BAY.—The *fixed* light on the summit of the outer Oyster rock is at 205 feet above the sea, and visible from the distance of 25 miles. Page 414.

CANNANORE.—We believe that this light is now coloured *red*. Page 416.

CALICUT.—A black buoy has been moored off this port in 4 fathoms, to mark the inner edge of the best anchorage; it lies with the lighthouse bearing E. $\frac{1}{2}$ S., and Conolly hill N.E. by N. To avoid dangers when passing to or from southward and in the vicinity of Cooty reef, great care should be taken not to bring the buoy westward of North, as there are several shoal patches of rocky ground close inside of that bearing (1869). Page 416.

COCHIN.—The new lighthouse is of white stone and 89 feet high; it shows a *fixed* light at 95 feet above the sea, visible 14 miles. Its geographical position is lat. $9^{\circ} 57' 50''$ N., long. $76^{\circ} 14' 40''$ E. *The light referred to in the text has been discontinued.* The best anchorage in the roadstead is in $5\frac{1}{2}$ to $6\frac{1}{2}$ fathoms, soft ground, at from 2 to $2\frac{1}{4}$ miles from the shore, in the direction of W. $\frac{1}{2}$ S. to W. by N. from the lighthouse. (1868).

Limits of the Port.—The limits of the Port are as follows: *To the North.*—The boundary pillar, 1 mile north of the Northern point of the entrance to the harbour or back water.

To the South.—The boundary pillar, 3 miles south of the Southern point of the entrance to the back water.

The sea shores between them to within 50 yards of high water mark, spring tides.

To the East.—The harbour and back water with all creeks and channels leading thereto, that may be within the Indian Government territories, and so much of the shores thereof, whether of the main land, or the islands, as are within 50 yards of high water mark, spring tides.

To the West.—The space enclosed by two lines, running due West from the boundary pillars, to 9 fathoms water.

Anchorage.—The best anchorage in the roads is with the following bearings; flag-staff E. $\frac{1}{2}$ N. to E.N.E. in $5\frac{1}{2}$ to $6\frac{1}{2}$ fathoms, soft ground, about 2 to $2\frac{1}{4}$ miles off shore.

All post office packets and letters are to be delivered to the post office peon who is sent for them.

Commanders are required to report themselves in person on landing at the master attendant's office, and to bring with them the ship's register, with two lists of the officers, ship's company, and passengers; and no vessel will be admitted to entry at the custom house, without producing a certificate from the master attendant that the provisions of this article have been complied with.

Commanders are also required, previous to clearing out, to deliver to the master attendant two lists of the officers, crew and passengers proceeding by the vessel, together with notification of all casualties which may have occurred during her stay in port, whether by death, discharge, or desertion. No vessel will be granted port clearance until the production of a certificate from the master attendant that the port rules have been complied with.

Commanders requiring a pilot to enter the inner harbour are to hoist the union jack at the fore royal mast-head. Applications for pilots inwards and outwards are to be made to the master attendant in writing.

No cargo is to be landed in ship's boats under a penalty of 50 rupees and confiscation of the boat.

No ballast is to be thrown overboard in less than 9 fathoms; nor is any to be discharged on the beach or elsewhere from which it would be liable to be washed into the port. The penalty for infringing this rule is 200 rupees.

Commanders of vessels having more than 50lbs. of gunpowder or other combustibles on board are, under a penalty of 200 rupees for default, to report the same to the conservator who will arrange, if necessary, for landing and storing the excess.

When the surf is so high as to render communication with the shore dangerous, a red and white chequered flag will be hoisted at the master attendant's flag-staff. When the surf is impassable the first distinguishing pennant will be displayed under that flag.

Should a boat be urgently required during the night, three lights should be hoisted horizontally; and in case of danger from fire or other causes, blue lights should be burnt, and guns fired.

No boats are to be detained alongside after 6h. p.m.—The detention of a boat during the day for more than three hours will entail double hire. Commanders and officers are particularly requested to abstain from illusing boatmen or other natives. All complaints will be promptly inquired into.

No vessel of 200 tons and upwards is to be moved in the inner harbour without having a pilot or the conservator on board; and no vessel exceeding 100 tons and less than 200 tons is to be moved without a pilot except under the authority of the conservator, under penalty in each case of 100 rupees.

All vessels in the inner harbour shall have their jib and driver booms rigged in, and their yards and top-masts struck, unless otherwise permitted by the conservator. All projections from the ship's sides must be removed.

All vessels moored in the stream shall keep a clear hawse.

No vessels anchored between the buoys and the inner harbour shall have lights exhibited aloft or above the deck.

No warps are to be made fast to the fairway buoys.

A free passage of half a cable's length or 120 yards shall be kept between the wharves, jetties, landing-places, and dockyards, and the position of the vessels moored in the inner harbour.

Schedules of the boat hire, pilot and other charges of the port are hereto annexed.

SCHEDULE A.—*Maximum rate of boat hire.*

QUILON BOATS.

	RS.	A.	P.
Ordinary trip to the Roads	1	4	0
Beyond 7 fathoms	1	12	0
Return trip from the Roads either with cargo or ballast.....	0	12	0
Transshipment in the Roads	0	12	0
Ordinary trip at night	2	8	0
Foul weather trip	2	8	0

CARGO DHONIES.

Ordinary trip to the Roads	2	8	0
Beyond 7 fathoms	3	4	0
Return trip from the Roads either with cargo or ballast.....	1	4	0
Transshipment in the Roads	1	4	0
Ordinary trip at night	5	0	0
Foul weather trip	4	0	0

SCHEDULE B.

Pilotage for vessels from 600 to 800 tons and upwards (inward or outward)	50	0	0
Do. do. " 400 to 600 " "	40	0	0
Do. do. " 200 to 400 " "	30	0	0
Do. do. " 100 to 200 " "	25	0	0
Do. do. " 50 to 100 " "	15	0	0
Do. do. " 50 " "	10	0	0

SCHEDULE C.

For the use of the anchor boat from 8h. a.m. to sunset, per diem.....	20	0	0
For the use of a hawser (besides making good any injury it may sustain per diem	5	0	0
Transporting a vessel from one position to another after she has been moored: of 300 tons and upwards	7	0	0

SCHEDULE D.—*Scale of fees for measuring vessels.*

Under 50 tons	Rs,	7
50 tons and under 100 tons.....	"	11
100 tons and under 150 tons.....	"	15
150 tons and under 200 tons.....	"	19
200 tons and under 250 tons.....	"	23
250 tons and under 300 tons.....	"	27
300 tons and upwards.....	"	30

NARRAKEL.—A first class buoy, painted *red*, is moored in 18 feet water, soft bottom, with the Narrakel flagstaff bearing E. by S. $\frac{1}{4}$ S.

The best anchorage in the South-west Monsoon is with the buoy bearing E. to E.S.E., in from $3\frac{1}{4}$ to $4\frac{1}{4}$ fathoms. Vessels of small draft, from 12 to 15 feet, can anchor close to the buoy.

The buoy will remain in position throughout the South-west Monsoon, and is seen from a distance of about 3 miles.

The Master Attendant's office, which has been recently erected a little to the northward of the flagstaff, will be clearly seen from the offing as a white object, and form a good guide to ships running in for the roads. (May 7th, 1867). Pages 417-419.

CAPE COMORIN.—A lighthouse is being erected on this cape. Pages 422 and 442.

ADAMPATAM is in lat. $10^{\circ} 20' N.$, not $12^{\circ} 20' N.$ as in the text. Page 447.

POINT CALIMERE.—The land at this point has suffered so much from the sea, that the beacon upon it is now surrounded by water. At about a mile inshore is a flagstaff. The two pagodas in lat. $10^{\circ} 22\frac{1}{2}' N.$ bear West, when in line. Page 448.

NEGAPATAM SHOAL is a small patch of about a mile in extent, and with only 3 fathoms upon it; it is in lat. $10^{\circ} 36' N.$, long. $79^{\circ} 55' E.$, and consequently $3\frac{1}{2}$ miles from the beach. From it a narrow 4-fathom tongue extends $4\frac{1}{2}$ miles due North, in a direction parallel to the coast; and also extends southward from it until at last it joins the flats off point Calimere. At a mile eastward from it the depth is 7 fathoms, and immediately westward of it 5 fathoms. As the channel between this shoal and the shore is shallow for a distance of two miles from the land, vessels approaching Negapatam from southward should keep eastward of it, in a depth of not less than 8 fathoms. Page 448.

COLEROON SHOAL, in lat. $11^{\circ} 27' N.$, consists of a sandy flat at the mouth of the Coleroon river. It projects from the shore about $1\frac{1}{2}$ miles, and at a mile eastward from it is a depth of 7 to 9 fathoms. Page 448.

TRIPALLOOR REEF, in lat. $12^{\circ} 37' N.$, extends one mile from the land, and is immediately succeeded by a depth of 5 and 6 fathoms, deepening to 11 and 12 fathoms at $2\frac{1}{2}$ miles from the beach. This reef runs off the coast at the seven Moolivaram pagodas. Page 449.

The bank in lat. $12^{\circ} 26' N.$, 10 miles from the shore, reported to have been sounded upon by Captain Barclay, does not exist. The depth in that latitude and at that distance from the shore is 23 to 25 fathoms. Page 449.

COCANADA.—We have been informed that the small *fixed* light mentioned as being shown at Cocanada to guide vessels to the anchorage, is not yet exhibited. Pages 456 and 460.

CHITTAGONG RIVER.—Two *fixed* lights are now shown on Norman point, a short distance southward of the entrance to this river, at the respective heights of 39 and 30 feet above the sea, visible about 8 miles. During day, the point may be recognised by a barrel-shaped beacon on a tripod 65 feet high.

Vessels making the port should sight the lights on the bearing of about N.E. They should approach them on the bearing of N.E. to E.N.E. and when distant about 3 miles from them, should anchor or wait for a pilot. Page 472.

AKYAB.—The harbour-master at the port of Akyab has notified that there is no light on the western Borongo island, as indicated on recent charts, the light on the table-land (exhibited experimentally for 12 months) having been removed.

This table-land was formed by the tops of trees, a portion of which were cut away to erect the lighthouse; the *table* is consequently destroyed, and should now be called the highest part of the western Borongo island.

A flagstaff carrying a ball at the mast-head stands on Oyster island. It is 82 feet above the sea-level and bears from the lighthouse on Savage island N. 69° W., distant 21 miles.

The *fixed* light on Savage island is the only light in the vicinity of the port at present exhibited. (June 30th, 1865). Page 473.

KRISHNA SHOAL.—A screw pile lighthouse has been erected on the south edge of this shoal, in *about* latitude 15° 36½' N., and longitude 95° 35' E. It will exhibit a *fixed* light at 55 feet above the sea, visible 13 miles. The purpose of its establishment is to keep vessels off the shoal and clear of the Baragu flats.* Page 481.

CHINA BUCKEER RIVER.—A screw pile lighthouse (the lower part of which is white) has been erected near the high-water mark, at about 2 miles north-eastward from the mouth of the river. It will exhibit a *revolving* light (attaining its greatest brilliancy every minute) at an altitude sufficient to make it visible at the distance of 18 miles. Its approximate geographical position is lat. 16° 17' N., long. 96° 13' E.* Page 482.

RANGOON RIVER.—A screw pile lighthouse erected near Eastern Grove, on the east side of the entrance to the river, is intended to show a *fixed* light in the arc from it of South to S.W. by W. ¼ W. (62°). It will show a more intense light over an arc of 5° on each side of the present position of the lightvessel outside the river, the centre of this arc being S.S.W. ¾ W. The approximate position of the lighthouse is lat. 16° 29' N., long. 96° 27½' E.*

Vessels from south-westward bound to Rangoon have hitherto been advised to make the coast about China Buckeer river to prevent being driven, by the strong spring tides, on the sands *eastward* of the mouth of Rangoon river; but it is now particularly recommended that all vessels from southward should strike the coast in lat. 15° 50' N., long. 96° E., where the soundings at low water springs will be 6 fathoms, mud. Thence by making a due N.E. by N. course (calculating for the tides) they cannot miss the entrance.

Particular care must be taken not to shoal under 5 fathoms, low water, and never to go from mud to sand—the latter being only found *eastward* of the Rangoon river.

A vessel to the north of lat. 15° 50' N. striking soundings on sand should immediately haul to the westward till she gets into 6 fathoms, mud.

By strictly attending to these directions and with the proper use of the lead, no vessel can get into danger on this coast. Page 483.

MAULMAIN.—The light on Amherst point is discontinued. Page 485.

* It is expected that the arrangements will be sufficiently completed to permit the exhibition of these lights on May 31st, 1869. When exhibited, the lightvessel now moored outside the entrance to Rangoon river will be removed.

DOUBLE ISLAND.—The lighthouse on this island shows a *fixed* light, visible at the distance of 19 miles. Its approximate geographical position is lat. $15^{\circ} 52' 30''$ N., long. $97^{\circ} 36' 30''$ E., and from it Amherst point bears N. $\frac{1}{4}$ W.; the Patch buoy N. by W. $\frac{1}{4}$ W.; and the west point of Kalegouk island S. by E. The arc illuminated is 164° (from N.N.W. westward to S. $\frac{1}{4}$ E.); the bearing of N.N.W. passes $1\frac{1}{2}$ miles westward of the Patch buoy, off Amherst; that of S. $\frac{1}{4}$ E. $1\frac{1}{2}$ miles westward of Kalegouk island.

A strip of light is shown from the Patch buoy eastward as far as Amherst point.

Vessels making the light should endeavour to keep it between the bearings of S.E. and N.E., paying particular attention to the tides, as at springs they run about 5 knots an hour, parallel with the coast. If the land be too closely approached the light will be lost to view, but so long as the light is in sight, they will be in no danger until they are 10 miles northward of it, when they will be in the neighbourhood of the Goodwin sands, where the tides set very strong. The anchoring ground in the vicinity of Double island is good, but, on account of the strength of the tides, vessels should avoid as much as possible the risk of anchoring in such deep water. Page 486.

FORT LOUIS (Mauritius).—The *red* light at Great River bay, and the *green* light at fort George, Tonnelier island, have both been discontinued.

A lightvessel bearing a *flashing white* light, visible 9 miles, has been moored at the Bell-buoy anchorage. It is in 15 fathoms at a little to the north-westward of the present well-known bell buoy, and from it the extreme of the land to the northward bears N.E. by N.; the extreme of the land to the westward W.S.W.; and the flagstaff on fort George S.E. $\frac{1}{4}$ S. As the mooring chain of the vessel runs about 150 fathoms in a N.N.W. direction, care must be taken when anchoring to avoid hooking it.

Vessels from northward, after rounding Canonnier point, must be careful not to bring the lighthouse on that point westward of Flat island lighthouse till this lightvessel is seen. They may then steer for the latter on a S.S.W. $\frac{1}{4}$ W. bearing, and anchor on that bearing at from half a mile to a mile from the light.

Vessels from westward may steer for the lightvessel on an E. by N. $\frac{1}{4}$ N. bearing, and anchor either at half a mile from it on that bearing or further to the northward as may be convenient. The depth at the anchorage is from 12 to 20 fathoms. Pages 528-530.

MARIE EUGENIE BANK (Madagascar).—This bank situated 6 miles off the east coast of Madagascar, N. 38° E. from Nossy Alana or Plum island, and S. 28° E. from the Mamelles de Natte, has recently been examined by the French steamer *Prégent*; the reported sounding of $3\frac{1}{2}$ fathoms has not been found, but there are several coral patches with not more than 5 fathoms water,—thus verifying the existence of the bank. (1866). Page 550.

PARQUEAR ISLANDS.—These islands were visited in 1867 by M. Lieutard of the French marine. The hill at the north-west end of the largest and northernmost island, according to his observations is in lat. $10^{\circ} 7' S.$, long. $51^{\circ} 13' 14'' E.$; the latter is dependent upon the position assigned to St. Paul, Réunion.*

* Unfortunately M. Lieutard does not state the longitude of St. Paul, nor his meridian distance. He had two chronometers, which were timed four days previously at St. Paul.

The north point of the island (near which is the only anchorage possible during south-easterly winds, the prevalent winds in these parts) is terminated by a reef. Upon this point there is a hill, which is conspicuous from a moderate distance by a white spot in its centre; this hill resembles an islet when first seen, at the distance of about 8 miles, but a nearer approach shows it to be attached to the north point of the island, and at the same time land more extensive than it will be seen behind the southern reefs.

The anchorage is in $8\frac{1}{2}$ fathoms at about a mile from the land, in the direction of N.N.W. from the hill. In this position the south part of the hill will appear in one with the north part of the most northern hill of the south island.

When seeking the anchorage either from northward or southward it is for the hill at the north end of the island that a shipmaster should steer. When it bears S. by E., a course may be shaped for it, until distant about a mile from the land, when the best anchorage in the vicinity of the islands will have been attained.

Approaching the anchorage from westward, the hill will be seen in the form of an islet, with a white spot on its north face. Great care is required to give a good berth to the southern reefs and also to keep a good look out for other dangers, because according to Captain Berloim, who has a thorough knowledge of the islands, a bank of 16 to 18 feet exists at about $4\frac{1}{2}$ miles W.S.W. from the south-west point of the south reef.

The bottom near the Farquahar islands consists generally of sand. A prudent shipmaster would not run for the anchorage at night.

The channel into the lagoon formed by the islands and reefs is fronted by a bar, upon which at low tide the depth is only 7 to 10 feet. When running in, it is necessary to get as close to the land as possible to avoid the heads of rocks about the edge of the reef. At high water, the ebb tide in this channel has a strength of about 5 knots.

Tides, &c.—The tides in front of the bar have been observed to rise from 3 to 7 feet. The flood flows to the N.E., the ebb to the W.N.W. with a maximum strength of one mile an hour, the wind being south-easterly.

The current, which, after passing cape Amber (Madagascar) bifurcates to the West and S.W., attains in the vicinity of these islands a strength of 2 to 4 miles an hour, flowing in a westerly direction. Page 565.

SEYCHELLES.—The following observations are from one of the Consular Reports presented to Parliament, April 1868.—They are furnished by the Civil Commissioner of the Seychelles islands, Mr. Swinburne Ward:—

Land in and near port Victoria has greatly increased in value. A plot about six miles distant was sold last year for £17 per acre, and I have been offered £200 for a portion of land reclaimed from the sea in front of the town to the north of the river St. Louis. Several more acres of very valuable land might be easily reclaimed at no great outlay a little further to the north; and should the Victoria pier be extended to the edge of the reef opposite the Ilot Hodoul, the whole of the space between it and the pier now in ordinary use would soon be filled up by the silt of the sand, and become a most valuable property. The town is fast becoming too small for its annually increasing population, and house rent is more than double what it was four years ago, so that as a speculation the extension of the Victoria pier would answer very well. All vessels trading to this port could

lay alongside it at all tides to discharge their cargoes; the owners would gladly pay for such an advantage, and the sale of the land reclaimed from the sea would ultimately recover the whole of the amount expended on the extension of the pier.

In all new buildings, masonry work in coral is wholly superseding wood, now becoming very scarce and dear, hardly obtainable, in fact, except upon Felicite and Silhouette islands. Coral is so easy of manipulation that the trade of a mason is very easily acquired here. All ordinary carpenters' tools can be employed when working it, and there is no difficulty about turning it to any pattern required.

I take the opportunity while on this subject of drawing attention to the very important fact that the harbour is filling up in many places, and that the coral all round the Seychelles group is growing with an extraordinary rapidity. Taking the original survey of Captain Owen, executed in 1825, the difference between some of his soundings and the existing ones is very large; more than might have been expected even after so many years. In one spot on the anchorage near St. Ann's island, on the opposite side of the harbour, only 7 fathoms are now found where 14 are marked on the chart. In the inner basin, the triangulation of which was made three years ago by the master of the *Orestes*, almost on the spot marked as the best and most secure anchorage for vessels of war, and soundings given as 7 fathoms, the coral is now within 2 and 2½ fathoms of the surface, not water enough for the larger vessels of the East African squadron, such as the *Highflyer*.

Another instance, or rather a series of instances, will be found on the whole bank extending from Frigate island to Eagle island, the whole of which has much increased, but most markedly when passing half way between Mahé and Silhouette, the ordinary course for ships. In many places, 6, 7, 8, 9, and 10 fathoms only are now found where 39 and 40 are marked on the chart. According to the men who now constantly resort to this shallow portion of the bank to fish, this difference has taken place within the past 4 years, but it probably has only been noticed by them since that date. It is at a distance of 6 miles from Mahé, in the middle of the usual passage for vessels of all classes. Of its actual depth at present I have made certain by personal observation and soundings, but for want of proper instruments I was unable to fix their exact positions on the chart.

The same increased growth of coral I am informed by the captains of the different trading vessels and of the whalers cruising in these waters is found on all the banks between this and Mauritius. "Coetivy" is in reality very much larger than what it is marked on the chart, and the soundings very much less, 7 fathoms only having been obtained for a distance of 20 miles. At this depth in anything like heavy weather, the sea would necessarily break. The "Fortune bank" has greatly expanded. "Saya de Malha" is becoming dangerous, and is likely to appear above the surface before many years elapse.

It is very important in the interests of navigation that these waters, especially such portions as are frequently crossed, should be re-surveyed. The French charts contain some valuable additions to the English ones, but they are all based upon Captain Owen's. Of the growth of coral nothing absolutely positive is known beyond the fact that it requires a substantial basis. The bank between

Frigate and Eagle islands is part of the Seychelles geological range, and probably, therefore, composed of granite, upon which the coralline insect has commenced its work. This work can be advanced to within six feet of the surface, but the progress of its advance is very uncertain. Still, the well ascertained growth of more than 20 fathoms, as is the case in the channel between Mahé and Silhouette, supposing the coral to have been growing since the date of Captain Owen's survey, sufficiently denotes the great necessity that exists for fresh soundings being taken. Pages 576-582.

ANDAMAN ISLANDS.—The lighthouse on Table island (one of two islands, Table and Skipper) at the north end of Great Coco island, consists of an iron building 72 feet high; the light (*fixed*) is 200 feet above the sea and visible in clear weather from the distance of about 20 miles. Its approximate geographical position is lat. $14^{\circ} 10' 52''$ N., long. $93^{\circ} 20' 45''$ E.

This light, at the southern limit of the Preparis south channel, forms for vessels passing between the gulf of Martaban and the Madras coast, and between Calcutta and the Malacca straits or China, a good point of fresh departure in the South-west Monsoon, while the Alguada reef *revolving* light, placed at the northern limit of the Preparis north channel, is a good point of fresh departure in the North-east Monsoon. By shaping a course to make either of these lights, the dangers about Preparis island are avoided.

Vessels using Preparis channels in the South-west Monsoon, should endeavour to make Cocos light, and in the North-east Monsoon, Alguada light; powerful steamers between Calcutta and the ports of Pegu, use the latter in both monsoons.

Table and Skipper islands are steep-to, with no dangers to seaward; there is a passage between them and great Coco island, but its navigation is not safe without a pilot. Page 625.

The following Notice relative to the geographical position of the Andaman islands, was issued in March 1866, by Lieut. Col. J. T. Walker, R.E., Superintendent of the Great Trigonometrical Survey of India;—

Doubts having been expressed as to the accuracy of the longitudes assigned to the Andaman islands on existing charts, notice is hereby given that the longitude of Chatham island, port Blair, has been recently determined to be $92^{\circ} 43'$ E. of Greenwich; whereas in the chart of the Andaman islands, which is compiled from the surveys of Lieutenant Blair, and Captain Morrison in 1789—90, revised by Lieut. Heathcote in 1853, it is assumed to be $92^{\circ} 56'$. The whole group of islands is probably 13 miles west of the position that has hitherto been accepted.

The recent determination of the position of Chatham island is deduced from 202 observations of lunar zenith distances, and 29 culminations observed by Mr. Nicholson, of the Survey Department, with an alt-azimuth instrument, having a vertical circle 36 inches in diameter. They were reduced in the office of the Great Trigonometrical Survey of India. Page 634.

AUSTRALIA (West Coast of).—A bank with 20 fathoms water on it has been discovered some 50 miles to the west of Rottneest island, and breakers were said to have been seen in 1864 from the *Beaver*, merchant vessel, W. by S. 52 miles from cape Vlaming, the west extreme of Rottneest island. Pages 652-669.

The following information on the current in the neighbourhood of cape Leeuwin

and Swan river, on the west coast of Australia, during the summer months January and February), is extracted from the remark book of CAPT. CHARLES W. HOPE, of H.M.S. *Brisk*, 1868 :—

After rounding cape Leeuwin a strong set to the E.N.E. was experienced. At 8h. p.m., abreast of cape Naturaliste, 15 miles distant, a course was steered to pass 8 miles to the westward of Rottnest island; but at daylight Garden island was observed on the starboard bow and Rottnest island on the port bow, the ship having been set 20 miles to the E.N.E. during the night. Had the weather been thick, so that the land or Rottnest light could not be distinguished, the ship would have been in a very dangerous position, as the course steered would have led directly on to the reefs north of Garden island. Pages 232, 652-663.

KING GEORGE SOUND.—The *fixed* light on Breaksea island is visible by a vessel approaching from south-eastward between Bald head and cape Vancouver (S.W. $\frac{1}{4}$ S. southward and eastward to E. by N. from the light); approaching from south-westward, it is first seen for a brief interval over the sinking of Bald Head ridge (S.W. $\frac{1}{4}$ W from the light). Within the sound it is shown over the horizon (360°), but is masked by Michaelmas island to a small vessel passing through the north channel. This light must not be steered for till it bears N.N.E. $\frac{3}{4}$ E. from the vessel, to clear Maude and Vancouver reefs. Page 671.

SPENCER GULF.—The lightvessel moored in 15 feet off the south-west part of Tipara reef, now shows two *fixed* lights.

A red pyramidal-shaped buoy has been placed in $5\frac{1}{2}$ fathoms at low water, off the outer end of the reef which extends nearly a mile, in a N.W. by W. direction from cape Elizabeth, Spencer gulf. The buoy is moored 4 cables length to the westward of the shoalest part of the reef, and in clear weather, from an elevation of 10 feet above the sea level, should be seen from a distance of 4 miles.

The bearings from the buoy are given as follows, viz. :—cape Elizabeth E.N.E., and Tipara lightvessel N.N.W. $\frac{1}{4}$ W. Page 673.

CAPE BORDA (Kangaroo Island).—The following instructions were issued by Capt. Douglas, President of the Marine Board, Adelaide, in 1866.

Captain LEOG, of the ship *The Murray*, reports that, on his passage from London to Australia, at 4h. 30m. a.m., on the 21st of October 1864, running in for cape Borda on an E.N.E. course, with strong S.S.W. winds and thick rainy weather, he saw the land between capes Bedout and Borda, before sighting the light, although, from the course and position (subsequently verified by cross-bearings) he should have seen the light at 2h. a.m., allowing for the state of the weather.

At 5h. a.m., after tacking off the land, cape Borda bore N.E. $10\frac{1}{2}$ miles, cape Couëdie S.E. by E.; thus putting the ship quite within the range of the light (it being visible from N.E. by N. to S.W. by W. round by west); it was not seen until some clouds cleared off the summit of the cape and adjoining land.

The light is placed 510 feet above the sea level, and in clear weather is visible at a distance of 30 miles.

By Captain LEOG's report, it appears that, during thick or hazy weather, the light is occasionally partially obscured; in such weather, commanders of ships should exercise great caution in approaching the land, even when quite confident

of their position. No safer guide exists in the vicinity of Kangaroo island than the lead, as by keeping in a depth of not less than 70 fathoms, a ship will be well outside all the dangers off this part of the coast, including the Neptune island group. In fact, in that depth, a ship will be clear of all danger on any part of the coast of South Australia, as included between the Great Australian bight, and cape Northumberland.

During strong S.E. winds, the prevailing easterly current on this part of the coast is checked and diverted to the northward into Spencer gulf, and north-westward along the coast-line; whilst after S.E. winds, and the wind changing to the northward and westward, the current exhibits an unusual force and sets strongly to the S.E., sometimes at the rate of $1\frac{1}{4}$ knots per hour.

Commanders of ships, after a prevalence of S.E. winds, should, on the wind changing to the N.W., be on their guard, as they are liable to be set to the S.E. on approaching the western end of Kangaroo island. Pages 672-682.

ADELAIDE.—*The lightvessel has been removed*, and instead of it an iron tower has been erected on piles near the end of South sand, in 7 feet water. It is 65 feet high, and shows a *fixed* light at 50 feet above the sea, visible 10 to 12 miles. The navigable channel for large vessels is 70 yards northward of the lighthouse; the depth in it at present (1868), is 13 feet at low tides, ordinary springs—the rise is 8 feet.

Approaching Adelaide from south-westward in a heavy ship, endeavour to make the lighthouse on a bearing from N.N.E. to N.E., and carefully avoid bringing it northward of N. by E. to avoid the Wonga shoal, southward of the jetty. The most convenient anchorage (in 5 fathoms, sand) will be found with the lighthouse bearing N. by E. to N.N.E.; and the red light on the jetty from E. by S. to E.S.E. Page 685.

The Wonga, a sandy shoal, extends in a north-westerly direction from the sand-hills southward of the Semaphore. A bell buoy painted *red* (shaped like a boat, with a staff and ball) has been placed in 17 feet at low water, on its northern extremity, off the end of the jetty; it may be seen during day at a distance of $2\frac{1}{4}$ miles. From the buoy the water shoals gradually in a south-easterly direction to the shore.

The buoy should be left to the southward and eastward, but small vessels may cross the shoal southward of the buoy in 12 feet water, by bringing the Semaphore jetty light to bear E. by S. $\frac{1}{4}$ S., and anchor according to draft of water off the end of the jetty. Large vessels should avoid crossing the shoal southward of the buoy.

The best anchorage for large vessels is anywhere northward of the bell buoy, in 4 or 5 fathoms at low water. Vessels waiting for orders will find it convenient to anchor tolerably close to the buoy; whilst those only waiting for tide to pass the bar, should anchor with the jetty light bearing S.E. Small vessels may anchor inside the bell buoy with the jetty light from E. by S. to E.S.E.

It is high water at full and change, at the Outer bar of port Adelaide, at 4h. 30m.; and the rise is about 8 feet. Tidal signals are shown from the Semaphore flagstaff on the hill, but as strangers are required to take a pilot, it is unnecessary to describe them here. The signal for a steam-tug is the ensign at

the fore. A signalman is stationed on the hill above the inner end of the jetty, to attend to vessels' signals. (1866). Page 685.

PORT WAKEFIELD (Gulf of St. Vincent).—The following instructions for making this port were issued at Adelaide, in September 1866.

From port Adelaide outer bar, steer N.W. by W. $\frac{1}{2}$ W., making allowance for tide and leeway. The tides N.W.-ward of the lighthouse are strong; the flood sets over the long spit N.W., and the ebb S.E., attaining at springs a velocity of 2 knots.

Keep the above course (N.W. by W. $\frac{1}{2}$ W.) for 25 miles, to sight a large red buoy with a pyramidal top, surmounted by a triangular head; this buoy marks the western extremity of the long spit, extending 20 miles to the westward, from the low sandy shore to the northward, and in the vicinity of the Gawler river. The buoy is placed at the south-west and western extremity of the shoal in 19 feet at low water, ordinary springs, in lat. $34^{\circ} 33' 40''$ S., long. $138^{\circ} 7' 40''$ E., with the western summit of the Hummock range of hills at the head of the gulf, bearing N. 8° W., and mount Lofty, S. $56^{\circ} 30'$ E.

The coast line on the east side of the Gulf, in the vicinity of the long spit, is very low, and cannot be seen from the deck of a small vessel when outside the buoy, unless there be much refraction. The coast on the west side, to the westward of the long spit, is bold, and in places cliffy.

At about $1\frac{1}{2}$ miles northward of the buoy there is a swathway or channel, in which there are from 6 to 8 fathoms.

It is probable the patch on which the buoy is placed is detached from the main shoal; but until this portion of St. Vincent gulf has been accurately surveyed, this cannot be determined.

To the eastward and N.E. of the buoy the water appears to shoal gradually towards the land, the before-mentioned channel, or swathway probably intervening.

Caution.—In thick weather, or in the middle of a summer's day, when the sun is ahead, and objects much affected by refraction, the lead should be carefully attended to; by maintaining a depth of 5 fathoms, reduced to low water, the edge of the long spit may be avoided, and the buoy sighted.

Sailing Directions.—Having brought the buoy to bear N.E., distant 2 miles, steer N.W. by N. $\frac{1}{2}$ N. for 5 miles, until the western summit of the Hummocks is seen bearing North, when alter the course to North for 15 miles, until the land at the head of the gulf is distinguished, and a bold hill on the east side (inside Sandy point) observed; then alter the course to N.N.E., not going into less than $4\frac{1}{2}$ fathoms, until a large nun buoy is seen; steer then to keep the buoy to the eastward, at a distance of 2 cables; then alter the course to North.

The buoy is placed in 17 feet on the outer extremity of the shoal spit, stretching out to the westward of Sandy point, on the Bald hill spit. Before nearing the buoy, sail should be reduced, and the ship got ready for anchoring.

The soundings southward of the buoy are shoal; this portion of the gulf being only navigable by barges and small craft of little draught of water.

Thistle Rock.—This rock has been removed by blasting, the debris of the rock being only 3 feet above the surface of the bottom. Its position was lat.

34° 19' 2" S., long. 138° 11' 30" E.; from it mount Lofty bore S. 40° E.; and the west summit of the Hummocks range. N. 20° W.

It will be seen by the above that the rock was apparently close in shore. This is owing to the imperfect charts of this portion of the gulf, as the rock was fully 2 miles from the low coast line. It was, however, quite out of the track of large vessels, and could be always avoided by not coming under 8 fathoms at low water.*

Anchorage.—Having brought the largest store in the township of port Wakefield to bear N.N.E. $\frac{1}{4}$ E., or the buoy S. $\frac{3}{4}$ E., and the mangrove bushes on the Sandy point to between E.S.E. and S.E. by E. $\frac{1}{4}$ E., anchor in 4 fathoms at low water.

There will be room to swing in this berth, but not space to beat out of it without going into 18 feet at low water.

Beating up the Gulf.—In making a passage from the lighthouse to port Wakefield against head winds, make the first board to the westward, and stand on that tack—say West,—for about 16 miles, taking care not to come under 8 fathoms, so as to avoid the shoal water on Orontes bank; then, going about, endeavour to work between the two shoals,—viz., Orontes bank and the long spit,—but, in drawing to the northward, do not fail to sight the buoy on the latter danger, as it forms an excellent guide for enabling a commander of a ship to know when he is to the northward of Orontes bank.

Being off the buoy, and consequently northward of Orontes bank, the western coast may be safely approached, making long boards from 5 fathoms outside the long spit, on the east side, to within a mile of the western shore.

On nearing Sandy point, the red buoy on the Bald Hill spit should be passed as previously directed, when short tacks must be made, taking care not to bring the buoy to bear to the southward of S. $\frac{1}{4}$ E., and not standing to the westward into less than 3 $\frac{1}{2}$ fathoms, anchoring in the space before indicated.

Anchorage for small vessels.—Small vessels may stand towards the creek, observing that the water shoals very rapidly, from 3 fathoms in some places; but even should a vessel touch the ground no injury will arise, as the bottom is generally composed of sand and mud, and there is no sea.

Care, however, must be taken to keep a ship in such a position as to be clear of her anchor.

Land Wind.—When leaving port Wakefield, it is advisable not to start until morning, when the wind generally being easterly, an offing may be easily obtained without beating out.

Winds.—The winds during fine weather, in the summer, are generally as follows:—From sunrise to about 8h. a.m. from E. to E.S.E.; in hot weather, the wind in the morning may be from N.E., gradually falling calm towards 8h. a.m.

The sea breeze generally sets in after an interval of a couple of hours light winds, or calm at about 11, and freshens towards 5 o'clock, gradually moderating till sunset, when it comes round to the S.E., and dies away towards night. The barometer falls rapidly with northerly winds both in the summer and winter seasons, and generally precedes a change of weather from the westward.

* The coasters report other small rocks in the vicinity of the site of the Thistle rock; but until the gulf is re-surveyed, no further information can be given.

In summer the change often occurs suddenly from the southward, when it blows hard.

In the winter the strongest winds are from the westward.

Tides.—The tides at the head of the gulf are very irregular, and much affected by prevailing winds.

With strong westerly winds the rise of tide is much augmented, whilst the fall is much diminished. It often occurs during westerly winds, at neaps, that a higher tide will be experienced than at the springs, with fine weather, and south or south-east winds.

With the latter the tides are at the lowest, and the rise at springs is much reduced.

In fine weather, with the ordinary land and sea breezes, the time of high water at F. and C. is 5 hours, and the rise about 9 feet.

At neaps, in fine weather, the rise and fall is almost imperceptible, the time of apparent high water being very irregular.

Remarks.—Produce is now sent from port Wakefield to the shipping in the roadstead by barges. The river entrance is very shallow, and has a flat of upwards of a mile in extent, uncovered at low water springs. At a rise of 6 or 7 feet above the low water spring level, the loaded barges can cross the bar. The question of either deepening the entrance of the river, or building a jetty across the flat, is now under the consideration of the Government.

The supply of fresh water at port Wakefield is limited, and difficult to procure. It is, therefore, recommended that a sufficient stock should be procured at port Adelaide, if the ships call there on their way up the gulf; or water can be obtained by arranging for the barges used at port Wakefield, but which generally belong to persons at port Adelaide, bringing up a supply. Page 687.

Beacons.—The following notice was issued in 1868. "Two triangular beacons have been placed on Bald hill, the termination of the low wooded range rising above the mangrove swamp southward of the town of port Wakefield, as anchoring marks for large vessels.

Bald Hill Beacons.—The upper triangular beacon, about 50 feet above high water mark is painted red, 16 feet high, and distant 322 yards E. $\frac{1}{4}$ S. from the lower triangular beacon, which is painted white, and 20 feet in height.

Channel Beacons.—The channel leading to the anchorage has been recently deepened, and beacons have been placed on its edges; the western side of the entrance is marked by a black beacon with a round top, and the eastern side by a red beacon having a lozenge-shaped head: a similar black beacon and a red beacon are placed inside.

Anchorage.—Large vessels approaching this anchorage should shorten sail off the Spit buoy, and anchor in 4 fathoms low water, with Bald hill beacons in line; Sandy point, the end of the low mangrove swamp under Bald hill, S.E. by E. $\frac{3}{4}$ E.; and the Spit buoy S. $\frac{3}{4}$ E. Page 685.

PORT WILLUNGA (Gulf of St. Vincent).—A large red buoy has been placed outside the edge of the reef, extending to the westward of Snapper point, the southern horn of the bay in which lies port Willunga.

The buoy is of pyramidal shape, with a round top, and may be seen at a

distance of 4 miles in clear weather. It is moored in 10½ fathoms at low water, immediately beyond the edge of the reef, and affords an excellent guide for clearing the rocky and uneven ground lying to the S.S.W. of the reef.

In the event of any accident happening to the buoy, the reef may be cleared by keeping the inn close to the beach (to the northward of the jetty) twice its own breadth open to the northward of the end of the jetty. The buoy is placed inside this mark.

The moorings which were laid down in 1855 have been removed; ships will, therefore, have to depend on their own anchors. The holding ground is good anywhere outside the 4-fathom line off the jetty.

Anchorage.—The anchorage is exposed to all winds from N.W. to S.W. round by west. At times a heavy sea rolls in, rendering ships at anchor very uneasy, and, unless well found in ground tackle, in an unsafe position; it is, therefore, recommended, on the approach of a S.W. gale—which is indicated by a falling barometer, and the wind freshening from northward, with a cloudy sky—that shelter should be sought in Eastern cove, Kangaroo island, where a ship may anchor in perfect safety, according to draft of water, and remain until the wind shifts to the southward, when she will have a fair wind to return to port Willunga to complete her loading. (1866). Page 689.

PORT VICTOR (Encounter Bay).—Commanders of vessels bound to port Victor, port Elliot, or the mouth of the river Murray, are hereby informed that a very heavy break has been seen about ¼ a mile south-east of the Seal rock.

The break was observed from the Government schooner *Flinders*, when lying at port Victor during an unusually heavy swell after a hard south-west gale. The sea did not break oftener than every half hour; but with such violence and volume as would imperil any small or deeply-laden vessel.

Immediately on the south-west swell slightly subsiding, the break was no longer seen. Soundings were taken in the *Flinders* during a favourable opportunity, when from 15 to 17 fathoms were found on a sandy bottom in the vicinity of where the breakers were seen; it is moreover probable that less water may exist on a small patch; but it is evident, from the sea being only seen to break on very rare occasions after violent south-west gales, no shoal water exists, as the ocean swell, if at all heavy, generally breaks on the uneven bottom to the southward of the passage between Granite island and Seal rock, on which there are 5 fathoms.

Commanders of vessels bound for port Victor, in rounding Seal rock during south-west gales, or during the heavy swell that often succeeds a gale in the offing, should either keep close to the rock (outside), or give it a berth of at least a mile, until it bears W.N.W., when a course may be shaped for the anchorage.

At night, when Seal rock can easily be distinguished, it is advisable to keep off the land until daybreak, with the remarkable conical peak of Rosetta head bearing North—thus avoiding the sight of the bay between that headland and the Murray mouth and the rocky patches between Rosetta harbour and Seal rock.

The soundings off Seal rock do not afford any guide within a reasonable distance of the land. (1867). Page 690.

GUICHEN BAY.—Captain Douglas (Adelaide) has published the following instructions for this bay;—

Guichen bay is formed by cape Lannes,* in lat. $37^{\circ} 9' 45''$ S., long. $139^{\circ} 44' 15''$ E., on its southern extreme, and Baudin's rocks and reefs N. by W. $4\frac{1}{2}$ miles from thence, at its northern extreme. From cape Lannes, a reef of rocks runs N.N.W. $1\frac{1}{2}$ miles: from Baudin's rocks, another reef stretches $1\frac{1}{2}$ miles in a S.E. direction. Cape Lannes may be known by an obelisk on its extremity, 40 feet in height, painted red and white in horizontal stripes, which being about 100 feet above the sea level, is visible 12 miles from the deck of a moderate-sized vessel in clear weather; the coast to the southward is composed of sandy hillocks lightly timbered. Breakers extend fully 2 miles off this part of the coast, and, from their treacherous nature, and the heavy ocean swell settling directly on them, should be most carefully avoided. Baudin's rocks form a group of islets, situated from cape Lannes, N. by W., $4\frac{1}{2}$ miles; they are visible about 7 miles.

The bay inside the reefs, off cape Lannes and the Baudin's rocks, is 3 miles deep, and lined by a clean sandy beach, the bottom quite clear, and of excellent holding ground, with gradual soundings from 5 fathoms in the stream of the reefs to the shore, with the exception of a few rocky points, near the township, which terminates a few fathoms from the beach.

A convenient jetty, with a tramway from the road to the end, is now completed, having, at its extremity, 6 feet at low water; boats can load here in any weather, by having a line fast to a grapnell outside, to steady them and haul off by.

Vessels bound into this anchorage, from the southward, should bring the obelisk on cape Lannes, to bear S.E. $2\frac{1}{2}$ miles, when the point of the reef will bear E.S.E.; having a leading wind, run in East until the obelisk bears S.S.W., and from thence steer South for the anchorage. Small vessels will find excellent anchorage inside the buoys, with the pier-head S.W. by S. $\frac{1}{2}$ S., and the obelisk W. $\frac{1}{2}$ N., in 3 fathoms, veering away a good scope of chain at once; and, in the event of bad weather, having a second anchor ready to let go.

Vessels coming from the northward should carefully avoid the reef off cape Jaffa, in lat. $36^{\circ} 55' 30''$ S., long. $139^{\circ} 35' 30''$ E., by keeping at least 10 miles off the point; for, though the outer rock is not more than 5 miles from the beach, the bottom is so uneven that the sea often breaks in deep water, in bad weather, with such violence as would jeopardize a small deep-loaded vessel.

Having sighted the obelisk, and brought it to bear S.E. 6 miles, and the Baudin's rocks E. $2\frac{1}{2}$ miles, steer in S.E. by E., keeping the reef off Baudin's rocks on the port hand or to the eastward, until the obelisk bears S.W. by S. $\frac{1}{2}$ S. when shorten sail and stand in to the anchorage.

Small vessels in the winter season should carefully avoid anchoring too close to a rocky point at the eastern end of the town; as, in the event of their wanting to veer away cable, such a position might be inconvenient.

Vessels working into the bay with head winds will find the channel between Baudin's and cape Lannes reefs fully $2\frac{1}{2}$ miles broad; by not borrowing within the already prescribed distances, and keeping the lead going, they may work in

* Cape Lannes, or Dombey, of Admiralty Charts.

in safety, taking care not to approach the shelf which lies inside cape Lannes too closely.

The barometer in this bay, as is generally found on all parts of the coast, is an invaluable guide. The mercury falling with an N.E. wind and sultry close weather in the winter season, is a sure precursor of bad weather, for which preparation should be made. Page 691.

MACDONNELL BAY.—Vessels bound into port MacDonnell by day should give cape Northumberland a good offing, taking care not to bring the cape to bear to the westward of N.W. by N., until mount Schanck bears N. by W., when a course may be shaped for the anchorage, which will then bear N.W.; stand boldly on, carefully observing the breakers on the reef. On this course, the water will shoal rapidly from 10 to 6 fathoms, and as the beach is approached to 3 fathoms on a rocky bottom, generally, in the latter depth, the soundings will be very regular, as, although the ground is rocky, the patches appear to be composed of limestone flats covered slightly with seaweed.

Before thus closely approaching the coast, strangers should hoist the signal for a pilot, who will, if the weather be not too bad, come off.

Should the pilot not be able to board, it is recommended to obtain an offing until the weather moderates.

At night, except under the charge of the pilot, it is not prudent to enter the bay; and masters of vessels should keep the light bearing from N.N.W. to N.N.E., taking care not to come under 25 fathoms water, which will place a ship about 5 or 6 miles from the cape. Masters of vessels acquainted with this port will find no difficulty in entering it by observing the following directions:—

On approaching from seaward keep point Douglas, a headland to the W.N.W. of cape Northumberland, well open of the latter, and mount Gambier more than the length of mount Schanck open to the eastward of the latter before standing in, after which steer for mount Schanck until the mooring-buoys are made out. By keeping the eastern set, bearing between N.W. $\frac{1}{4}$ W. and W.N.W., they may be safely approached, when the Harbour-Master will, if possible, come off and moor the ship.

Masters of vessels are requested to carefully observe if any of the signals hereinafter mentioned are made from the flagstaff near the jetty.

In the event of the moorings being occupied, vessels entering the bay must anchor; and should be kept in such a condition, as to ballast and trim, as will enable them to seek an offing in the event of bad weather coming on.

Although the moorings now laid down at this port are of the heaviest description, and fully competent to hold any vessel that can enter port MacDonnell, it must be remembered that, during heavy south-west gales, the sea rolls in over the outlying reefs, and breaks in the bay very heavily. On these occasions vessels will ride very uneasily, and be cut off from communication with the shore.

A life-boat and an efficient boat's crew, together with Dennett's rocket apparatus for saving life, has been established at this port.

The following signals are established at this port. The flagstaff at which the signals will be displayed is situated near the base of the jetty.

From Shipping to Signal Station on Shore.

Signals.	Where shown.	By day.	By night,
Harbour Master.....	At Peak	Union Jack.	{ One flash or blue light; red above green light.
Pilot	At Fore.	"	Two flash or blue lights.
Police	At Peak.	{ Wheft, or No. 1 Pennant.	{ In harbour.—Two lights horizontal at peak. In the Roads.—Two lights horizontal.—one flash light
Shipping Master.....	At Fore.	No. 1 Pennant.	—
Water tank	At Main.	No. 6.	—
Custom House Officer	"	Ensign.	—
Health Officer.....	"	No. 9.	{ Two blue or flash lights; two vertical lights.
Medical assistance required..	At Peak.	No. 1.	{ Two lights horizontal; two flash or blue lights.
Provisions	At Main.	No. 7.	—
Ship's agent.....	At Peak.	No. 8.	—
Distress	—	{ Ensign Union down.	{ Guns; blue or flash light, or rockets alternately, until reply is made.
Ship calling for orders	At Main.	Telegraph flag.	—

By day will be answered from shore by Numeral Pennant by night by flash light.

From Signal Station on shore to Shipping.

Signals.	Where shown.	By day.	By night.
Gale approaching from north	Below Ensign or Jack.	No. 1.	Two horizontal lights.
Ditto, north-west	"	No. 8.	{ Two horizontal lights; one flash light.
Ditto, west	"	No. 5.	Two vertical lights.
Ditto, south-west	"	No. 6.	{ Two vertical lights; one flash or blue light.
Ditto south	"	No. 7.	One rocket.
Ditto, south-east	"	{ 1st. disting. Pennant.	{ Two horizontal lights; one rocket.
Send down top-gal. masts and yards and let go second anchor	Above Ensign.	No. 6.	One flash or blue light; one rocket.
Proceed to sea. Not safe to remain at anchorage	—	{ Blue and white flag.	Two rockets or two guns.
Anchorage unsafe	—	Blue flag.	{ One gun; one flash light (repeated if necessary).

(1867). Page 692.

KING ISLAND (Bass Strait).—A rocky ledge, which appears to be several miles in length in a north and south direction, has lately been found to exist 6 miles seaward of Sea Elephant bay, King island: the general depths on this ledge are $4\frac{1}{2}$ and 5 fathoms, but a patch with only 22 feet was found near the northern extreme, from which Sea Elephant rock bore E. $\frac{1}{4}$ S., distant $4\frac{1}{2}$ miles.

As a dangerous sea will be found on this ledge during bad weather, ships should approach Sea Elephant bay with caution. Page 696.

PORT PHILLIP.—The lighthouse on point Lonsdale is coloured in red and white bands; it exhibits a *fixed* light, visible about 10 miles. The light is *green*, from about S. by E. eastward to S.E. $\frac{1}{4}$ E. (394°); *red* from S.E. $\frac{1}{4}$ E. eastward to

E. by N. ($50\frac{1}{2}^\circ$); bearings from the lighthouse. Lonsdale point is a mortar and rocket station. Tidal signals, denoting the quarter of the tide with reference to the stream, are made at the flagstaff on the point.

The Lonsdale rock lies nearly $\frac{1}{2}$ mile, and the Lightning rock $1\frac{1}{2}$ miles from the lighthouse, both on a S.E. $\frac{1}{2}$ E. bearing. While the *green* light is in sight, vessels are outside these rocks; while the *red* light, inside:—the blending of the lights is on a line with the dangers, hence the greatest caution is required when the colours are about to blend. Pages 697 and 700.

Shortland Bluff.—The Low lighthouse shows a *fixed* light at 90 feet above the sea, visible 10 to 14 miles. The light is *white* from S.W. by W. southward to S.W. ($11\frac{1}{4}^\circ$); *red* from S.W. southward to S.S.W. ($22\frac{1}{4}^\circ$); *white* from S.S.W. eastward to E. by S. ($101\frac{1}{4}^\circ$);—bearings from the lighthouse.

The High lighthouse, a stone tower on the bluff at 352 yards N.E. by N. from the Low light, shows a *fixed* light at 130 feet above the sea, visible 17 miles. Its geographical position is lat. $38^\circ 16' 27''$ S., long. $144^\circ 39' 46''$ E. The light is shown seaward from about W. by S. to South ($78\frac{1}{2}^\circ$). By an observer close in with the Lonsdale land it will be seen only between the bearings from it of S.W. by W. southward to South ($56\frac{1}{2}^\circ$). Within the harbour it is shown over an arc of 180° (from S.W. by W. southward and eastward to N.E. by E.). Shortland bluff is a Life-boat station.

The two lights in one, N.E. by N., lead in. The *red* light (in the Low lighthouse) must be kept in sight until within the Heads; the change of colour from red to white indicates the immediate vicinity of the reefs extending from points Lonsdale and Nepean, hence the line of the lights in one should be strictly followed. At the extremity of the reef extending from point Nepean (east side of the entrance) is the Corsair, a rock 8 feet under water, having a depth of 8 to 5 fathoms close to it; Lonsdale reef is also very steep. Pages 697 and 701.

JAMES IMRAY & SON,

89, MINORIES, & TOWER HILL, LONDON.

[To be inserted behind the Title of the Indian Ocean Directory.]

PART I.

NOTES

ON THE

PHYSICAL GEOGRAPHY

OF THE

INDIAN OCEAN

IN ITS APPLICATION TO NAVIGATION.

CHAPTER I.

INTRODUCTORY.

1. **THE INDIAN OCEAN**, like the Atlantic and Pacific, has its boundaries partly natural and partly artificial: it is limited westward by the African and Arabian coasts; and northward by Persia and India—the latter (by its peninsular-form) breaking it into two deep and nearly symmetrical indentations; its eastern boundaries are Birmah, the Malayan peninsula, the west coast of Sumatra, the southern coasts of Java, Baly, Lombok, Sumbawa, Floris and Timor, and the west coast of Australia from Melville Island on the north thence round to the southern point of Tasmania; these constitute its natural lines of demarcation: southward it communicates freely with the Great Southern Ocean, but its artificial boundaries in this direction are the meridian of Cape Agulhas on the west, and that of the south point of Tasmania on the east, each prolonged to the Antarctic Circle, which forms its southern limit,*—and hence the track of vessels bound for the colonies of Australia and New Zealand lies in the Southern Indian Ocean.

Within the boundaries just indicated the Indian Ocean cannot be said to be rich in islands: in mid-ocean, rocks, shoals, and vigias—some real and some imaginary, such as have been and still are so frequently reported as existing in the Atlantic and Pacific—are comparatively few, although such dangers are numerous enough in the

* These are the geographical boundaries of the Indian Ocean as settled by the Council of the Royal Geographical Society in 1847.

vicinity of some parts of the coast. The *continental* islands are represented by Madagascar and Ceylon; the *oceanic* islands—sometimes volcanic, sometimes of coral formation, sometimes partaking of both characters—dispersed singly or in groups, have representatives in Mauritius, Réunion, the Seychelles, Kerguelen, &c. &c., and in that long chain which, commencing with the northernmost of the Laccadives, is continued through the Maldives to the Chagos; but by far the most remarkable mass of islands—one which has nowhere else a parallel—is the Indian Archipelago, which, while sketching out the connexion between the Asiatic and Australian continents, forms, by the numerous channels and straits between the islands, the only equatorial communication of the Indian with the Pacific Ocean,—the channels, however, being everywhere encumbered with a wilderness of shoals and rocks, islets, and small islands, rendering the navigation of that region the most hazardous on the globe.

The chief branches of the Indian Ocean are the Bay of BENGAL, the ARABIAN Sea, the RED Sea, the PERSIAN Gulf, the MOZAMBIQUE Channel, and the Straits of MALACCA.

The fame of the isles which stud the Ocean as its waters roll by their shores from the Pacific to the Indian had, in early ages, filled the minds of western adventurers with luxurious dreams of gold, pearls, gums, spices, rubies, sapphires, emeralds, velvets, damasks, silks, and the “purple light of perfumed lamps.” From such visions, created by the romancing of earlier voyagers, men awoke to soberer views of the barbaric grandeur of the people and of the neglected treasures of those distant groups—for there was wealth enough and to spare. Extending through thirty degrees of latitude and forty-five degrees of longitude, the Archipelago is the centre of those ocean highways which connect the Asiatic nations with the ports of Europe and Western America. It lies along both sides of the equator, and is approached from the west through the Straits of Sunda and Malacca,—with openings from the southward too numerous to indicate here. The islands are abundantly volcanic, and the islets, rocks, and shoals are of coral: their appearance to the navigator of the narrow seas that separate them is singularly pleasing—while the dangers for incautious mariners are strewn about by myriads; but it is in this very region that commercial enterprise has yet to show its power in the development of unbounded wealth at present neglected.

It is the whole of the oceanic area here briefly indicated—the coast-line surrounding it, and the groups of islands scattered over its surface—the bays, gulfs, and straits—the principal ports, harbours, and roadsteads—the character of the seasons, and of the prevalent winds—the tides and currents—together with other information useful to the Navigator, which will be found abundantly discussed and examined in the following pages, and in such a form that the work may be a complete

“SAILING DIRECTORY FOR THE INDIAN OCEAN.”

CHAPTER II.

GENERAL REMARKS ON THE WINDS AND SEASONS.

2. The WINDS representative OF THE DIFFERENT REGIONS OF THE GLOBE.—In parts of the world widely separated there is a distribution of the winds peculiar to the region, and these differences serve to characterize the climate of each. In and near the tropics, in the Atlantic and Pacific Oceans, the winds blow, almost all the year, from the same points of the horizon—the *eastern*—the deviation being near the equatorial regions, where the “belt of calms” separates the “N.E.-ly perennial Trade-wind” of the Northern Hemisphere from the “S.E.-ly Trade-wind” of the Southern Hemisphere. In the Indian Ocean (and in the seas connected with it) the same persistency of the winds during the whole year is not observable between the tropics; here they are periodical, blowing for five months from one quarter of the horizon, and for another five months from an opposite quarter; these are the “Monsoons;” and the interval between the termination of one characteristic wind and the setting-in of another is known as the “change” of the Monsoon. In middle and higher latitudes all the winds are variable, but with a general prevalence from the *west*, being S.W.-ly in the Northern Hemisphere, and N.W.-ly in the Southern Hemisphere. On the sea-coast—more or less in all climates, but especially between the tropics—a regular period of change is observed every day; at nearly the same hour in the evening the wind blows from the land, in the morning it comes from the sea; these are the “land-and-sea breezes.”

In this brief sketch is indicated the general distribution of the different currents of air over the surface of the globe, while the alternating land-and-sea breezes give us an insight into their origin.

3. THEORY OF THE WINDS.—The main cause of the disturbance of the equilibrium of the atmosphere and of the propagation of currents of air (*winds*) over the surface of the globe is the *unequal heating* of portions of that surface more or less widely separated; for, under the influence of heat, the air expands and becomes lighter, and even acquires an ascensional (or upward) tendency when pressed upon by the cooler (and heavier) particles surrounding it. We see the simplest instance of this in the land-and-sea breezes prevalent on nearly all seaboards at certain seasons, and especially characteristic of all large tropical islands. The respective surfaces of land and water absorb and radiate the sun's heat unequally, and the variation in the atmospheric temperature corresponds thereto: in proportion as the sun rises above the horizon, the land becomes warmer than the neighbouring ocean, hence the cooler *sea-breeze* sets in towards the land to restore the equilibrium. During the night, the process is reversed, the land loses heat by radiation and cools more quickly than the ocean, hence the stream of air flows from the land towards the sea as a *land-breeze*, which ceases as soon as the density of the two atmospheres has again become the same.

Similar causes on a large scale set the whole atmosphere in motion—producing winds characteristic of the tropical regions on the one hand, and of the temperate and polar regions on the other,—the direction and intensity of each system of air-currents being, however, greatly modified (1) by the earth's rotatory motion, and

(2) by the relative position of the continents and the oceans. Such was the theory first announced by Halley,* and afterwards enlarged and modified by Hadley,†—the latter insisting especially on the necessity for the S.W. and N.W. *compensating* currents beyond the tropics.

The effect of the diurnal motion of the earth in altering the direction of a current of air moving from North to South, or *vice versâ*, will be readily understood; for, since all circles parallel with the equator decrease in circumference as they approach the poles, it follows that, in one diurnal revolution, a spot on the equator must describe a greater circle than any spot in middle and polar latitudes, and must consequently move with greater velocity: the earth in turning on its axis from west to east carries the atmosphere with it and imparts its own motion to it; a *polar current* of air, therefore, on passing towards the equator takes with it only the velocity which it had acquired from that part of the earth whence it came, and must, in its progression, be moving more slowly than the region towards which it is travelling; in being thus left behind, the apparent motion will be in the contrary direction, and, accordingly, the North wind in the *Northern Hemisphere* and the South wind in the *Southern Hemisphere*—the tendency of both being ever towards the equator—will have a westerly direction impressed upon them by virtue of the movement of the earth on its axis, *i.e.* the North wind will become successively a N.E. and East wind,—and the South wind, a S.E. and East wind, for their respective hemispheres; and these are the *TRADE-WINDS*—*perennial* (or constant) breezes—the expression at once of the difference of temperature between the tropics and the polar regions, and of the *permanent inequality* of the distribution of the solar heat: but the *MONSOONS*—so characteristic of the tropical area of the Indian ocean—being *periodical* winds, are expressive of the difference of temperature between the extreme seasons of the countries where they are prevalent, as will be presently shown in detail.

Where the trade-winds approach towards each other, and from the excessive heat of the equatorial regions take the form of an ascending current, is the Region of Equatorial Calms, or Doldrums—an irregular belt varying in breadth and form, as well as oscillating with the sun's position in the ecliptic. Notwithstanding, however, that the predominating condition of the air within this belt is one of intense (oppressive) heat and general stillness, the equilibrium is but imperfect, and consequently easily disturbed;—storms occur occasionally, and are frequent in the vicinity of the land,—while deluges of rain at intervals of a few hours are accompanied by deafening thunder and the most vivid of forked and sheet lightning; here also originate the *hurricane* and *cyclone*.

The *upper* or *return Trade-winds* ("COUNTER-TRADE" of MAURY, and ANTI-TRADE" of HERSCHEL) are the natural consequences of the ascending current of air at the equator *overflowing* and passing off towards the temperate and polar regions; in the Northern Hemisphere the heated air is determined towards the north,—in the Southern Hemisphere, towards the south, and hence these *equatorial air-currents* must behave in a manner exactly the reverse of the polar: they come from regions moving with the greatest speed round the earth's axis—a speed which they share themselves—and as they advance into higher latitudes where the rate of

* An Historical Account of the Trade-Winds and Monsoons observable in the Seas between and near the Tropics, with an attempt to assign the Physical Cause of the said Winds. PHIL. TRANS. 1686.

† The Cause of the General Trade-Wind. PHIL. TRANS. 1735.

motion is slower, they must, the further they get from the place of their origin, appear to move to the east at a rate proportionate to the difference between their own velocity and that of the earth in the latitude at which they arrive;—thus the wind is from the westerly points of the horizon, which combined with the initial movement (from N. or S.) gives a S.W. wind for the temperate zone (or middle latitudes) of the Northern Hemisphere, and a N.W. wind for the middle latitudes of the Southern Hemisphere.

Where the equatorial upper currents first approach the earth's surface (in about lat. 30°) is another *Calm-belt*—in each hemisphere—chiefly remarkable however for light baffling airs, intermingled with frequent squalls; that of the Northern Hemisphere is known (after MAURY) as the *Calm-belt of Cancer* or the *Horse-latitudes*—that of the Southern, as the *Calm-belt of Capricorn*; here the winds from S.W., N.W., N.E., and S.E. blow (approximately) the same number of days in the year, for within these belts a constant conflict is sustained between the upper (descending) and the surface currents of air—a portion only of the former current pursuing its course polar-wise, since a large part necessarily returns to the equatorial regions to feed the Trade-winds.

1. MAURY'S Theory of the circulation of the wind, in which the air is supposed to travel *from pole to pole* and then return to the place whence it originally started—making the Trade-wind of one hemisphere pass into the other hemisphere as an upper current within the tropics, and so also placing the source of the rainfall of one hemisphere in its opposite—is known to all navigators who have read either his "*SAILING DIRECTIONS*," or his "*PHYSICAL GEOGRAPHY OF THE SEA*,"—works which discuss the theory at great length; it is sufficient here to say that such a system of atmospheric circulation does not find acceptance with the best meteorologists—British and Foreign.

2. DOVE'S Theory—THE LAW OF GYRATION:—The general tendency of the wind to "*veer with the sun*" is an old observation,* but now confirmed; in fact, meteorological data, accumulated with assiduous care during the last 30 years, show that the wind often makes a complete circuit in that direction—passing (in northern latitudes) from south through west, north and east, to south, in succession—or sometimes making more than one circuit in succession, occupying several days or weeks in such veering; and that it rarely veers in a contrary direction—"against the sun"—and rarer still makes a complete circuit in such a direction. The credit of having reduced these data into a system is due to Dove, of Berlin, one of the first meteorologists in Europe—who, by comparing observations gathered from all parts of the world, infers that the influence of the earth's rotation is not alone felt in the great system of

* Lord BACON, in his "*Historia Naturalis et Experimentalis de Ventis*," speaking of the order of succession of the winds, says,—“When the wind shifts in the direction of the sun's course—that is, from morn till noon, and from noon till evening, &c., it seldom retrogrades; or when it does so, it is only for a short time. When, however, it shifts in the opposite direction—that is to say, from morning till midnight, from midnight till evening, &c.—it always returns to its initial point; at all events it does so before it has gone quite round the compass. When the south wind has blown for two or three days, the north will suddenly blow towards it; but when the north wind has blown just as many days in succession, it is not succeeded by the south wind until an easterly one has blown for some time.” Still earlier observations to the same effect were made by ARISTOTLE and PLINY. The latest observers are MARIOTTE, in France; STURM, ROMME, KAEMTZ, and DOVE, in Germany; and TOALDO, in Italy.

circulation which affects the whole atmosphere, but that even *local* aerial movements are modified by it; this is the basis of what he terms the **LAW OF GYRATION*** (or **ROTATION**) of the Wind—a law not peculiar to any particular region, but, in fact, the general law (with few exceptions) throughout the world—and he has shown, that the Trade winds, and the entangled relations of the winds of the temperate zone, are but the necessary and simple results of the same physical conditions.

Suppose an observer stationed at a spot, in the **NORTHERN HEMISPHERE**, where the excitement of the wind begins—where, for instance, currents of warm air are mounting upwards from the heated soil, and if by this agency a current sets in from the North, he will see the wind-vane settle itself at first in a direction due North and South; if the cause of this motion of the air continues to act, the air of higher latitudes must share more and more in the effects, and coming to the place of observation from a continually higher and higher latitude, it arrives with continually less and less rotatory velocity; hence, in its passage over the station, it will take a direction more and more *towards the westward*, and thus the wind-vane must gradually pass from a North direction through N.E. to East.

If the North wind has passed by degrees into an East wind, the air will assume the rotatory velocity of the place over which it is situated, and it will thus remain suspended over it in a state of relative rest. If the tendency of the air to rush towards the equator still continues, precisely the same phenomena as before indicated will be repeated.

If, however, a South wind spring up and impinge on the polar current, which has become more or less easterly, it will evidently be deflected towards the North, and the wind pass through S.E. to South. As the northward movement continues, the South wind will shift gradually round through S.W. to West, for the fresh arrivals of air (coming from the equator towards the poles) move from places which possess a *greater* rotatory velocity towards those which move *less* swiftly eastward.

A West wind will have a neutralizing effect on equatorial currents, and reduce them to rest. If the tendency *towards* the pole continues, the phenomena will always be repeated, until fresh polar currents change the West wind (through N.W.) into North, finally coming round again to N.E.

Similarly, in the **SOUTHERN HEMISPHERE**, winds which at their outset are South will gradually pass through S.E. towards East. An equatorial current (from the North) impinging on the polar current, which has become more or less easterly, will cause it to veer from East, through N.E. into North; and the movement continuing, the northerly wind in its progress will shift more and more through N.W. to West.

The West wind, as is the case in the Northern Hemisphere, will tend to check equatorial currents, and reduce them to relative rest; but if the polar-ward tendency continue, the phenomenon will always be repeated until fresh polar currents change the West wind (through S.W.) into South.

6. If, therefore (A), polar and equatorial currents are alternating with each other in the *northern hemisphere*, the regular shifting of the wind round the compass will be through

→ S., S.W., W., N.W., N., N.E., E., S.E., S. →

* "DAS GESETZ DER DREHUNG."—This law is amply illustrated in the recent work of this meteorologist, "DAS GESETZ DER STURME in seiner Beziehung zu den allgemeinen Bewegungen der Atmosphäre." (The Law of Storms considered in relation to the ordinary movements of the Atmosphere.) 2nd. ed. 1861.

and the changes will take place oftener between South and West, and between North and East, than between West and North, or East and South;—for the first changes show a continuance of the exciting cause, while the latter point to a change of it—and being transition winds, they cannot blow for any length of time.

By a like course of reasoning (B), when, in the *southern hemisphere*, polar currents alternate with equatorial, the regular shifting of the wind round the compass will be successively through

↗ S., S.E., E., N.E., N., N.W., W., S.W., S. ↘

and the changes ensue oftener between North and West, and between South and East than between West and South, or East and North.

7. This is the **LAW OF GYRATION**,—or the *Law of the Rotation of the Wind*—and we see that the *veering* of the vane may merely indicate the existence of a steady current of air. It is a misapprehension of this fact that causes the existing confusion with reference to questions bearing on the theory of the winds. The essential difference between the veering of the vane as produced by a steady breeze and that resulting from a centripetal current, or a whirling motion with an advancing centre, is, however, that in the first instance (*i.e.* with a steady breeze) the rotation is constantly in the same direction, but in the case of the second it veers on both sides of the track and in opposite directions. If, therefore, as regards the Northern Hemisphere, the partial rotation through S., W., N., E. be called “with the sun” or *direct*, and the partial rotation through S., E., N., W. be called “against the sun,” or *retrograde*, as is customary: and similarly, in the Southern Hemisphere, the partial rotation through S., E., N., W. be called “with the sun,”* and the partial rotation through S., W., N., E. be called “against the sun,”* it follows that—

Steady winds turn the vane only in a *direct* sense, or *with the sun*;

Whirlwinds, or centripetal gales, when they advance, turn the vane either with or against the sun, according to the side on which the vortex passes by the place of observation.

When steady winds from different directions approach each other, rotations commence in either way;—direct when, on the west side of the compass, a wind is more northerly than that which preceded it, and retrograde when it is more southerly. On the east side, on the contrary, the gyration is direct when a wind is more southerly than its predecessor, and retrograde when it is more northerly. Winds blowing from directly opposite points may, by arresting each other's course, produce a calm, and therefore give rise to the same phenomenon which is visible in the vortex of a centripetal current (or in the centre of a whirlwind), that is to say, a calm intervening between opposite winds.

* Neither of these expressions accords with the seaman's view: he is accustomed to regard a movement *from left to right* as being “with the sun,” for the term originated in the *northern hemisphere*, beyond the tropic, where the sun culminates in the South, and hence, looking in that direction, the sun rises on the left and sets on the right hand—*i.e.* *left to right*, “with the sun;” this idea he carries over every part of the globe. But, in truth, left to right, “with the sun,” is erroneous in the southern hemisphere, for, to an observer there, the sun culminates in the North, and when he looks in that direction he sees the sun rise on the right hand and set on the left, hence for the *southern hemisphere right to left* is “with the sun.” The *northern term*—*left to right* “with the sun”—is therefore scientifically inaccurate when used in the southern hemisphere; the expression in the text is consequently correct, but not in the seaman's sense.

And we thus see that the same phenomena may occur under totally different conditions.

3. Such is a brief sketch of DOVE's *law of the rotation of the winds*; and a general summary of the result of his investigations may be given in (nearly) his own words, as follow :—*

- (1.) All steady winds are modified by the rotation of the earth in such a manner that equatorial currents receive a westerly deflection, and polar currents an easterly deflection.

The N.E. and the S.E. Trade winds are steady polar currents.

The Monsoons are alternations of a polar and an equatorial current twice during the year,—therefore, they are N.E. and S.W. in the northern hemisphere,—and S.E. and N.W. in the southern hemisphere.

- (2.) Bodies of air set in motion from a state of rest turn the wind-vane in the direction of the meridian, as follows :—

- (a) The polar current in the northern hemisphere, from N. to E.
- (b) The polar current in the southern hemisphere, from S. to E.
- (c) The equatorial current in the northern hemisphere, from S. to W.
- (d) The equatorial current in the southern hemisphere, from N. to W.

Hence, of the winds in the northern hemisphere—

- (a) Those from N. to E. are the polar current.
- (b) Those from E. to S. mark the transition of a polar to an equatorial current.
- (c) Those from S. to W. are the equatorial current.
- (d) Those from W. to N. mark the transition of an equatorial to a polar current.

Similarly, in the southern hemisphere, the winds—

- (a) From S. to E. are the polar current.
- (b) From E. to N. mark the transition of a polar to an equatorial current.
- (c) From N. to W. are the equatorial current.
- (d) From W. to S. mark the transition of the equatorial to the polar current.

A complete rotation in the *northern* hemisphere is therefore—

→ S., W., N., E., S. → with the sun.

And in the *southern* hemisphere—

→ S., E., N., W., S. → also with the sun.

- (3.) The course of a steady wind may be obstructed by the deflection originating in the rotation of the earth :—

(a) By a wind blowing constantly in a direction perpendicular to its primitive one: such are the West India hurricanes, which, for this reason, go first from S.E. to N.W.; and those of the southern hemisphere, from N.E. to S.W.

(b) By an aerial current with less deflection; such are the typhoons during the S.W. monsoon, which is circumscribed farther to the eastward by the South monsoon. Of the typhoons, however, many probably

* "Das Gesetz der Stürme," p. 187—192.

have a progressive motion from W. to E., caused by the heavy air of the trade-wind region—situated to the eastward—rushing directly towards the rarefied air of the region of the S.W. monsoon, and thereby producing a whirlwind.

(c) By a mechanical impediment; as in the instance of a storm (described by PIDDINGTON) which occurred in the Bay of Bengal, June, 1839.

In these cases, when the storm is an equatorial one, whirlwinds are produced in the *northern* hemisphere in a *direction contrary to that in which the hands of a watch move*: and in the *southern* hemisphere in the *same direction as the hands of a watch move*. Hence in the *northern* hemisphere the following shiftings of the wind-vane occur:—

(a) If the vortex (or centre) of the storm passes to the westward of the place of observation—

The rotation will be $\Rightarrow$ S., W., N., E., S. $\Rightarrow$ with the sun;

(b) If the vortex of the storm passes to the eastward—

The rotation will be $\Rightarrow$ S., E., N., W., S. $\Rightarrow$ against the sun.

But, in the *southern* hemisphere, when the storm is also an equatorial one:—

(a) If the vortex of the storm passes to the west of the place of observation—

The rotation will be $\Rightarrow$ S., E., N., W., S. $\Rightarrow$ with the sun;

(b) If it passes to the eastward—

The rotation will be $\Rightarrow$ S., W., N., E., S. $\Rightarrow$ against the sun.

Thus, in both hemispheres, the passage of an EQUATORIAL whirlwind-storm on the west side of the place of observation produces *normal* revolutions, *i.e.* revolutions in accordance with the law of gyration; but its passage on the east side produces *anomalous* revolutions, *i.e.* contrary to the law of gyration. POLAR whirlwind-storms move precisely in an opposite direction:—the revolution is normal when the vortex passes to the eastward, and anomalous (or abnormal) when it passes to the westward of the place of observation.

The old rule that “anomalous shiftings of the vane occur in stormy weather” is in this manner justified. It cannot, however, be ascertained from those shiftings whether an equatorial whirlwind passes on one side, or a polar one on the other;—this depends on the initial point of the shifting, and, as a consequence of the whirlwind, can never amount to more than half a circle.

(4.) The vane may shift from one direction to that immediately opposite to it—

(a) When steady winds oppose each other, or fight with each other, as the seaman says;

(b) When the vortex of a whirlwind-storm passes over the place of observation.

(5.) A whirlwind-storm may be passing even when the wind-vane does not shift at the place of observation. This happens when the place is but touched by the whirlwind. On one side the storm then appears to retrograde,—and on the other to advance:—for instance, a whirlwind (revolving in a direction contrary to that in which the hands of a watch move) is advancing from S.W. to N.E.; on the north-west side of such a storm, a N.E. wind appears

in the south-westerly regions *earlier* than in the north-easterly, whilst on the south-east side of the storm a S.W. wind actually appears to advance, *i.e.* it enters the north-easterly regions at a later period. The first, is the well-known case observed by Franklin during an eclipse of the moon. Those who, founding their theory on this and analogous instances, divide the winds into positive and negative,—into winds *par inspiration*, and *par impulsion*,—call one side of such a storm positive and the other negative.

- (6.) In the temperate zones storms are caused, also, by two currents of air in juxtaposition,—one pressing laterally on the other,—and during the transition, the shifting of the vane may be either with or against the sun, but ever according to the direction of the currents impinging on each other.
- (7.) Local phenomena (as land and sea breezes, winds blowing through valleys, deflections of the trade-winds along the coast, trombs, &c.) affect the wind vane according to local conditions, and they may be such as either to produce a veering of the vane in accordance with that consequent on general air-currents, or one in an opposite direction. In open regions they are more prominent during the day, when the general air-currents are less prevalent;—so also in the region of the “variables” between the trades, at the time the monsoons change, and particularly in summer, when the ascending current (*courant ascendant*) weakens the power of the horizontal currents. Indeed, it is not impossible that, setting aside local influences, one cause of a periodical shifting of the vane is to be found in the daily course of the sun;—thus, if the spot where the daily maximum of temperature occurred formed *a point of attraction* for bodies of air lying near it, the direction of the wind during the *morning* would necessarily be *westerly*, and during the *afternoon easterly*,—and thus the vane would turn in a direction contrary to the movement of the magnetic needle.

As whirlwinds are not confined to a definite locality, the probability that any given place is situated on its east side is just as great as that it should be on the west side; the same remarks also apply where whirlwinds owe their origin to local causes—and thus display a great degree of similitude as regards their course. The predominance of the gyration of the wind in a certain direction (with the sun) is consequently a phenomenon which is not connected with the whirling motion of the storm-winds, but only with the influence of the earth's rotation on progressive steady winds.

Now three things are possible:—

1. Either all revolutions of the vane through great arcs are caused by whirlwinds; and in this case,—
 - (a) If these whirlwinds occur first at one spot and then at another, indifferently, then there is no predominating direction in the shifting of the vane;
 - (b) Or, if the origin of these whirlwinds is local, and if in their progress they advance more or less along the same path, then there are, at certain places in each hemisphere, predominant shiftings of the wind-vane in the direction S., E., N., W., and in others, in the direction S., W., N., E.

2. Or, all shiftings of the wind-vane commence with the alternation of steady meridional air-currents, in accordance with the principles of Hadley's theory of the trade winds, and in consequence of opposing currents pushing through each other: then the vane traverses in the direction S., E., N., W. in the northern hemisphere,—and S., W., N., E. in the southern: *i.e.* in both cases the wind veers with the sun. The backing of the wind cannot under these conditions exceed the quadrant of a circle.
3. Or, lastly, the shiftings of the wind-vane arise, in both ways, (1) from the alternation and displacement of meridional air-currents, and (2) from a progressive whirlwind; consequently, in each hemisphere, both descriptions of rotation must occur, but that "with the sun" will predominate. The first cause—alternations of meridional currents—produces (in both hemispheres) only gyrations with the sun; and the second—*i.e.* the whirlwind—just as many with the sun as against it. Hence, however frequent whirlwinds may be, there must always be more gyrations that are direct than retrograde.

It is well known that whirlwind-storms, hurricanes, or cyclones, originate at certain places, and spread in certain directions; for instance,—

- (a) The West India hurricanes (*Aracan* or *Huiran-vucan* of the coast of Mexico, *Vuthan* of Patagonia) commence on the inner edge of the N.E. trade, and even within the trade itself, especially in the latter part of summer and in autumn, the whirling motion of which is caused originally by the wind blowing from the S.E. encountering the N.E. trade, or by portions of the upper trade descending from above. They progress from S.E. to N.W. in the torrid zone, then recurving at right angles at the outer edge of the trade-winds, they move from S.W. to N.E.; during the progression the whirlwind, which revolves in a direction opposite to that in which the hands of a watch move, expands very considerably. In the region of the S.E. trade-wind of the Atlantic, whirlwind-storms occur with less frequency.
- (b) The typhoons in the northern Indian Ocean and China Sea occur most frequently in autumn, but are also violent at the commencement of the S.W. monsoon. The direction in which they advance is rather more from E. to W. than from N.E. to S.W., especially on the south coast of China. In the southern half of the Indian Ocean they are likewise very violent, going there from N.E. to S.W., and recurving at right angles at the outer edge of the trade, whence they advance from N.W. to S.E.

The rotation of the air in the whirlwind-storms of the northern hemisphere is in the opposite direction to that in which the hands of a watch move; and in the direction with watchhands in the southern. The causes which produce these effects lie in the lateral juxtaposition of the regions of the monsoons and trade winds, as well as in the displacement of one monsoon by the other.

Under certain local conditions, a whirlwind-storm may be so modified as to assume at particular spots the form of a steady wind; although, when its course is observed over a large circuit, it shows itself to be a real whirlwind. This is the case, for instance, according to REDFIELD, with the hurricanes (*northers*) of the

northern part of the Gulf of Mexico, which, especially from September to March, at Vera Cruz, reach their greatest height four hours after they commence, and then rage for 48 hours with undiminished fury. The explanation given by REDFIELD of this long duration of the storm without changing its direction is, that the whirlwind advancing from the eastward comes in contact with and is arrested by the high land, by which means it becomes, as it were, flattened, and its circular form is partially changed to a rectilinear one. The N.E. and N.N.E. storms in the Pacific Ocean, on the coasts of Nicaragua and Guatemala, known by the names *Papagallo* and *Tehuantepec*, are, according to REDFIELD, the fine-weather side of a whirlwind-storm,—while the S.W. gales in August and September, which are called *Tapayaguas*, represent the other side.

The indications of approaching weather will be most simple in the zone of the trade-winds, because the rotation of the earth, owing to the simple circumstance of the initial and terminal points of the aerial current remaining nearly the same, does not produce a regular shifting of the vane, but its constant deflection, viz., a steady wind—that of the trade; and the storms have only one form—a rotatory one. In the region of the monsoons they will be somewhat more complicated, because *there* two aerial currents, alternating once with each other in the year, produce one annual shifting of the vane, being periodical winds; and the storms, the form of which is likewise rotatory, have consequently a less constant direction, and in fact it must differ in a certain degree from the prevalent one in order to produce a whirlwind. They must, lastly, be most complicated in the temperate zone, where the law of gyration is universally prevalent, but where storms also occur in all forms hitherto known. The temperate zone has, however, this advantage over the torrid zone, that whirlwinds produce but modified effects as compared with the fearful violence of storms of this description in the tropics, and where they are so destructive.

The relation of the winds to the temperature and pressure of the air will be discussed in a future chapter.

9. The Trade-Wind Region in the Atlantic Ocean:*—Although this work is principally designed to place before the Shipmaster such information as may be useful in the navigation of the Indian Ocean and the China Seas—where the number of regular traders, plying exclusively from port to port in those waters, has enormously increased of late years—still, the traffic between Atlantic ports and the East is so large and of such importance, that a general but brief notice of the distribution of the Trade Winds in the Atlantic Ocean is absolutely necessary, for the speedy crossing of this region may make all the difference between a long and a short voyage.

10. The *average breadth* of the ATLANTIC TRADE-WIND REGION—estimating it to extend from the mean polar boundary of the N.E. to the mean polar boundary of the S.E. Trade-wind—is about $53\frac{1}{2}$ degrees—3195 geographical miles—*i. e.* from Lat. $27\frac{1}{2}^{\circ}$ N. to Lat. 26° S.

11. No fact is better known to the navigator than that the position—and even the direction—of the Trade-winds greatly depends on the position of the sun in the

* This is introduced, as all shipmasters may not have an "Atlantic Directory:"—such a work is published by Messrs. LAMAY and SON:—in it the physical phenomena of the Atlantic are fully described, and "sailing directions" given for all the principal ports.

Ecliptic—oscillating north and south, according as the sun has N. or S. declination. The polar boundary of the N.E. Trade has a mean oscillation of five degrees, i. e. from Lat. 30° N. in August to Lat. 25° N. in January, but the position in which it may generally be found at any of the four quarters of the year, and in any longitude between 15° and 75° W., is shown in the following table:—

TABLE I.—*Giving the Mean Polar Boundary of the N.E. Trade Wind in the Atlantic Ocean.**

Long. W.	WINTER Jan., Feb., March.	SPRING. April, May, June.	SUMMER. July, Aug., Sept.	AUTUMN. Oct., Nov., Dec.
	Lat. N.	Lat. N.	Lat. N.	Lat. N.
°	°	°	°	°
75	27½	29	29½	28½
70	26	29½	29	27½
65	24½	25½	28½	26½
60	22	23	25½	25
55	21	25½	27½	23
50	24	27	31	26
45	27	30½	30½	30
40	26	28	29½	26
35	25	28½	28½	24½
30	24½	25½	31½	22½
25	22½	27½	29½	25
20	27½	31	33½	28
15	29½	33	34½	29½
Mean	25½	28	29½	26½

12. The steady winds of the torrid zone (i.e. the N.E. Trade in the northern portion, and the S.E. Trade in the southern) is divided into two parts by the intervening *Zone of Calms*: in the Atlantic ocean, not only is the oscillation of this zone very considerable—but its breadth during the northern summer is great; thus, the mean range of the equatorial boundary of the N. E. Trade varies between Lat. 10° or 12° N. (in August, September, and October) and Lat. 1° or 3° N. (in March and April), but it has been reported as far north as Lat. 17° N. and as far south as Lat. 3° S. The equatorial boundary of the S.E. Trade is more frequently found north of the equator than south of it, its mean position being in Lat. 3° or 4° N. on the western side of the Atlantic, and in Lat. 1° or 2° N. on the eastern side—and its range is small as compared with that of the N.E. Trade. The axis of the Belt of Equatorial Calms lies near the parallel of 5° N., which coincides with the greatest number of Calms as reported by MAURY; and the mean breadth of this belt, for the whole year, is about 3½ degrees (or 220 geographical miles), being the mean distance between the equatorial margins of the two Trade-winds. A convergence of the two winds (N.E. and S.E.) takes place on the westerly meridians, and hence the Calm-belt is narrower on the western side of the Atlantic than on the eastern. These remarks are illustrated in the following table:—

* This is a table of double entry, but the headings explain themselves,—thus, during Autumn, in long. 20° W., the northern (or polar) boundary of the N.E. Trade Wind is in lat. 28° N.,—during Summer, in lat. 33½° N.

TABLE II.—Showing the Mean Position of the Equatorial Boundary of the N.E. and S.E. Trade-Winds in the Atlantic Ocean for the Four Quarters of the Year,—and giving the approximate Breadth of the intervening Zone or "Calm-belt."^{*}

		BETWEEN LONGITUDE										Mean Position.
		55° W. and 50° W.	50° W. and 45° W.	45° W. and 40° W.	40° W. and 35° W.	35° W. and 30° W.	30° W. and 25° W.	25° W. and 20° W.	20° W. and 15° W.			
WINTER.	Of N. E. Trade	3½° N.	2¾° N.	2½° N.	1° N.	1½° N.	2½° N.	3¾° N.	5° N.	2¾° N.	2¾° N.	
	Of S. E. Trade			2½° N.	0	0½° N.	0½° N.	0	0	0½° N.	0½° N.	
	Breadth of Zone—C. . . .			0½	1	1½	2½	3¾	5		2½	
SPRING.	Of N. E. Trade	6° N.	4½° N.	4° N.	2¾° N.	3¾° N.	4° N.	5½° N.	5° N.	4½° N.	4½° N.	
	Of S. E. Trade			3½° N.	1° N.	1° N.	1½° N.	1½° N.	0½° N.	1½° N.	1½° N.	
	Breadth of Zone—C. & S. W.			0½	1½	2½	2¾	4½	4½		3	
SUMMER.	Of N. E. Trade	10½° N.	10½° N.	10½° N.	10½° N.	10¾° N.	11¾° N.	11½° N.	1° N.	10¾° N.	10¾° N.	
	Of S. E. Trade			5½° N.	4½° N.	5° N.	2° N.	2° N.		3½° N.	3½° N.	
	Breadth of Zone—C. & S. W.			4¾	5¾	5¾	9¾	9¾		7½	7½	
AUTUMN.	Of N. E. Trade	6½° N.	6° N.	6½° N.	6½° N.	6½° N.	6¾° N.	7° N.	5¾° N.	6½° N.	6½° N.	
	Of S. E. Trade			5½° N.	4½° N.	3¾° N.	2½° N.	2½° N.	1½° N.	3½° N.	3½° N.	
	Breadth of Zone—C. & S. W.			1½	2	2¾	4½	4¾	4½		3½	

* In this table the seasons are those of the Northern Hemisphere as in Table I.; and the information contained in this table is read thus,—during winter, between Long. 30° and 25° W., the equatorial (or inner) boundary of the N.E. Trade is in Lat. 2½° N., the equatorial boundary of the S.E. Trade is in Lat. 0½° N., and the average breadth of the Calm-belt is consequently 2½ degrees: this sufficiently explains the rest.

This differs but slightly from HORSBURGH's Table, derived from 100 voyages made within the range of the track of vessels outward and homeward bound between England and India :—

TABLE DERIVED FROM HORSBURGH.		Southern boundary of the N.E. Trade-wind.	Northern boundary of the S.E. Trade-wind.	Breadth of the intervening Zone.
Period of the Year.				
		° /	° /	° /
1. January, February, March . .		5 35 N.	1 45 N.	3 50
2. April, May, June		7 15 N.	2 20 N.	4 55
3. July, August, September . . .		12 15 N.	3 15 N.	9 0
4. October, November, December .		7 50 N.	3 20 N.	4 30
Annual Mean		8 14 N.	2 40 N.	5 34

In Table II. it will be noticed that the "breadth of zone" is sometimes marked C. and sometimes C. and S.W.; although this is the region of Equatorial Calms, yet a portion of this zone is, from May to November, occupied by the S.W. Monsoon, and during July, August, and September it may be found as far as the parallel of 8° to 10° N.; it is wedge-shaped, with its base resting on the African coast, and its apex stretching to the meridian of 30° or 35° W.

13. The S.E. Trade-wind blows with great regularity, and is generally more persistent than the N.E.; its polar boundary is given below:—

TABLE III.—*Showing the Polar Boundary of the S.E. Trade Wind in the Atlantic Ocean.*

Long.	SUMMER.	AUTUMN.	WINTER.	SPRING.
	Jan., Feb., March.	April, May, June.	July, Aug., Sept.	Oct., Nov., Dec.
	Lat. S.	Lat. S.	Lat. S.	Lat. S.
°	°	°	°	°
45 W.	23½	23½	25½	26½
40	23½	23	26	26½
35	22	21½	23	24
30	25½	23	25	22
25	26½	25½	26½	24½
20	27½	26½	27½	27½
15	28	28½	29	28½
10	28	27½	28½	28½
5 W.	28½	29	28½	28½
0	26½	25	24	26
5 E.	24½	23	23½	24½
10	26	25	24½	26
15	29	29	28½	29
Mean	26	25½	26	26

14. The *mean direction* of the N.E. Trade-wind, in the Atlantic, between Lat. 5° N. and 30° N. is $N. 52\frac{1}{2}^{\circ}$ E.; that of the S.E. Trade-wind, between Lat. 5° N. and 30° S. is $S. 48^{\circ}$ E.; and it must be remembered that between Lat. 5° N. and the Equator the N.E. Trade-wind does not blow for more than 85 days in the year.

15. These Tables (p. 13 to 15) may be aptly closed with MAURY'S SUMMARY ON THE N. ATLANTIC TRADE-WIND REGION, in which, referring to the marked difference in the prevailing direction of the wind, according to the season of the year, in the different parts of the ocean, he says that—

“As a general rule it will be observed by the navigator—

1. That the nearer to the coast of Africa and to the Equator, the more the so-called N.E. Trade-wind hauls to the South.

2. That to the *west* of Long. 45° , between Lats. 20° and 30° N., the N.E. Trades blow much more steadily in May, June, July, August, and September than they do the rest of the year; and that during the other months, but particularly in March, they blow, between these parallels, nearly alike from all points of the compass.

3. That between Lats. 15° and 20° N. they are most variable *west* of Long. 35° in the months of September, October, and November; while between the same parallels, *east* of Long. 30° , they are most variable in February, March, April, and October.

4. That between Lats. 10° and 15° N., to the *west* of Long. 35° they are steadily between E.N.E. and S.E., except in July, August, September, October, and November, when they are more variable, but especially so in the three months first named. To the *east* of Long. 35° , between these parallels, they may be said to lose their character as Trades during July, August, September, and October,—particularly in August and September—when they blow nearly alike from the four quarters. Calms, too, are more frequent here in these months.

5. That between the Equator and 10° N., to the *east* of Long. 35° , the winds assume a new feature. It may be said, almost literally, that in this part of the ocean they uniformly blow (when they blow at all), during July, August, and September, from some point between S.E. and W.; they blow most between South and W.S.W., and vary rarely from any point between North and E.S.E. To the *west* of the meridian of 35° , during the same months, they blow most between S.E. and N.E., inclining more and more to the North as you go west; and these are the months in which the winds vary most in this part of the ocean.”

The S.E. Trade-wind is generally more persistent, and blows with greater strength than the N.E. Trade-wind—hence it is of rarer occurrence for a captain to record in his journal “no S.E. Trade” than “no N.E. Trade;” the “heart” of the S.E. Trade has been shown* to lie on each side of a line drawn from the Cape of Good Hope to the meridian of 36° W. on the Equator,—this is the track of all homeward-bound vessels that come from the Indian Ocean and China Seas, and they seldom have to record, “no S.E. Trade;” it is generally outward-bound vessels, and those coming from Australia and the Pacific, that are doomed to this experience, for, by having to shape *their* course on the S.W. flank of that “vein” of wind, they only fall in with it near the Equator; all, however, are in the same category as regards the N.E. Trade.

* See the reports of all homeward-bound East India and China traders; and the notice of the same by JANSSEN, in MAURY'S “Physical Geography of the Sea.”

It is scarcely necessary to make any remarks here on the CALM BELTS OF CANCER AND CAPRICORN; but, under all circumstances, endeavour to cross either the one or the other as direct as possible, never sailing *along the line* of one of these bands, nor even *diagonally*, if the wind will permit of a more meridional course.

16. *The Trade-Winds in the Pacific Ocean*.—A brief notice of the Trade-winds in the Pacific will complete our remarks on this subject. Table IV. is derived from the voyages of 92 vessels as determined by KERHALLET; Table V. is derived from MAURY's "Nautical Monographs," No. 1.

TABLE IV.—*Showing the Distribution of the N.E. and S.E. Trades, and Equatorial Calm Belts in the Pacific Ocean.*

Months.	Polar Limit of N. E. Trade-Wind	Equatorial of N. E. Trade-Wind	Boundary of S. E. Trade-Wind	Breadth of the Equatorial Calm Belt.	Polar Limit of S. E. Trade-Wind
	Lat. N.	Lat. N.	Lat. N.		Lat. S.
January	21 0	6 30	3 0	3 30	33 25
February	28 28	4 1	2 0	2 1	28 51
March	29 0	8 15	5 50	2 25	31 10
April	30 0	4 45	2 0	2 45	27 25
May	29 5	7 52	3 36	4 16	28 24
June	27 41	9 58	2 30	7 28	25 0
July	31 43	12 5	5 4	7 1	25 28
August	29 30	15 0	2 30	12 30	24 18
September	24 20	13 56	8 11	5 45	24 51
October	26 6	12 20	3 32	8 48	23 27
November	25 9	—	—	—	28 39
December	24 0	5 12	1 56	3 16	20 30
1st Quarter of Year*	26 9	6 15	3 37	2 38	31 9
2nd " "	28 55	7 32	2 42	4 50	26 56
3rd " "	28 31	13 40	5 15	8 25	24 52
4th " "	25 5	8 46	2 44	6 2	24 51
Yearly Mean . .	27 10	9 5	3 39	5 26	26 57

TABLE V.—*Showing the Distribution of the N.E. and S.E. Trades in the Pacific (in days, and as regards direction) between Lat. 10° N. and the Equator.*

Bands in Latitude.	Mean Direction of the Wind.				No. of Days Calm.	No. of Obs.
	N. 54° E.	S. 44° E.	S. 33° W.	N. 46° W.		
Lat. 10° to 5° N. No. of days . . .	143	134	54	20	14	14,064
Lat. 5° N. to Eq. No. of days . . .	49	206	89	12	9	46,162

* The seasons cannot be given here, for the table appertains to both hemispheres, consequently the seasons differ.

These Tables show that though the annual oscillation of the Trade-winds in the Pacific is not quite so great as it is in the Atlantic, still it is much more considerable than is generally allowed; and further, that, between Lat. 10° and 5° N., the N.E. Trade can, on the average, be expected for only 9 days (the difference between 143 and 134 days) longer than the S.E. Trade, while between Lat. 5° N. and the Equator the S.E. Trade blows for nearly two-thirds of the year.

According to COMMANDER MAURY, the S.W. Monsoon is better developed in the Pacific than in the Atlantic; and the N.E. Trade-wind of the Pacific is better developed than the S.E. Trade-wind of that ocean, or indeed than the N.E. Trade-wind of either the Atlantic or Indian Ocean.

17. The fact of the inner (or equatorial) boundary of the S.E. Trade-wind crossing the Equator and advancing into the Northern Hemisphere has been noticed by navigators from an early date,—by SELLAR in 1675, by DAMPIER, by d'APRÈS &c.; now, it is well known to meteorologists that, owing to the preponderance of land in the Northern Hemisphere and the peculiar distribution of the Oceanic Currents, the EQUATOR OF GREATEST HEAT is in that hemisphere, but far from being a regular line, parallel with the terrestrial equator. According to DOVE* the mean temperature of the northern part of the torrid zone is as follows:—

MONTHS.	LATITUDE.			
	0	10°	20°	30°
	Therm.	Therm.	Therm.	Therm.
January . .	79.5° F.	77.2° F.	70.0°	58.6° F.
February . .	80.2	78.6	72.7	59.9
March . .	80.6	79.7	75.2	63.7
April . . .	81.3	81.1	79.0	68.2
May . . .	80.2	81.3	80.6	73.6
June . . .	79.9	81.1	81.1	77.2
July . . .	78.6	80.8	81.7	78.4
August . .	78.8	80.8	81.7	80.6
September .	79.0	80.8	80.6	77.5
October . .	79.0	80.2	79.0	72.9
November .	79.7	79.7	76.3	66.0
December .	79.3	78.4	73.0	59.7
Winter Mean	80.1	78.8	72.6	60.7
Spring „	80.5	81.2	80.2	73.0
Summer „	78.8	80.8	81.3	78.8
Autumn „	79.3	79.4	76.1	66.2
Annual Mean	79.7	80.0	77.5	69.7

This Table shows the position of the place of greatest rarefaction for the different months and quarters of the year. Thus, during the northern winter it is near the

* "Die Verbreitung der Wärme auf der Oberfläche der Erde." (The Distribution of Heat on the Surface of the Earth.) Berlin. 1852.

Equator,—during the spring it has advanced to Lat. 5° and 10° N., reaching Lat. 10° to 20° N in summer (July and August),—after this its recession (southward) commences, being found in Lat. 10° N. during the autumn, as in spring,—and finally, again attaining the Equator in winter. This is precisely the march of the Equatorial Belt of Calms and of the inner boundary of the N.E. Trade-wind.

Since then the inner boundary of the S.E. Trade-wind crosses the Equator and, from thermometrical causes passes into the Northern Hemisphere, it must advance more and more north (according to the season) following the place of greatest rarefaction; and as it advances, its direction must change to South and S.W. because it is constantly approaching parallels on the earth's surface where the velocity of rotation is diminishing as compared with the velocity of rotation at the Equator. Hence the origin of the S.W. Monsoon—alike in the Atlantic, Pacific and Indian Oceans—but best developed in the latter. Similarly, a N.W. Monsoon originates from the N.E. Trade-wind passing into the Southern Hemisphere.

18. WINDS OF THE INDIAN OCEAN.—GENERAL REMARKS:—Southward of the 30° parallel the N.W. Counter-Trades or "Passage Winds" are more or less prevalent throughout the year: between them and the S.E. Trade lies the Calm-belt of Capricorn. The S.E. Trade, as in the Atlantic and Pacific Oceans, occupies the region from the Calms of Capricorn to within a few degrees of the equator—but undergoing in the Indian Ocean a slight modification on its northern border, according to the season of the year. The area northward of the S.E. Trade is occupied by the Monsoon Region.

19. Monsoons are prevalent, between the tropics, in every ocean; in the Atlantic and Pacific they occupy the place of the Trade-winds only at a certain distance from the land (100 to 300 miles)* and during certain seasons; but in the northern Indian Ocean they are the characteristic winds, to which the Trades are subordinate.

The distribution of land in the Indian Ocean differs widely from that in the other oceans.—As regards the Atlantic and Pacific, the continents run north and south. In the Indian Ocean, on the north there is the great central Asiatic plateau fronted by the loftiest mountains in the world,—then the two slightly elevated table-lands of Persia and Arabia, void of rivers, and comparatively destitute of vegetation,—southward of these and advancing into the ocean is the Indian peninsula, of which the Malabar (or western) coast rises abruptly from the sea, whilst the slope on the Coromandel (or eastern) side is gradual;—on the N.E. is Birmah, the Malayan peninsula and China,—the China sea is bounded by mountains on the north and by the Philippine archipelago on the east;—then come innumerable islands, many of which are lofty and mountainous;—finally, on the east of the Indian Ocean is the Australian continent, on the west the African continent:—it is this configuration of the land that has caused the Indian ocean to be regarded as only *half an ocean*, and it is this preponderance of the terrestrial over the oceanic element that disturbs the regularity of the Trade-winds and produces opposite seasons (wet or dry) to places even on the same parallel.

Thus, it is the preponderance of the land and the difference of temperature constantly existing between it and the neighbouring ocean which produce the season-breezes—known as Monsoons.† No other winds than these, and land and sea breezes,

* Monsoons are prevalent, in a modified form, alike on the west coast of Africa and the west coast of America, during the summer of the region.

† Arabic, *mausim*, season.

are recognised in the China sea and Indian archipelago; but in the Indian ocean, the Monsoon region is limited to its northern part—extending from Lat. 13° or 10° S. to the Asiatic continent.

Speaking in general terms, it may be said that, north of the equator, a north-easterly wind prevails when the sun has southern declination, and a south-westerly wind when the sun's declination is north,—the former is the N.E., and the latter the S.W. Monsoon of the region; but between the equator and Lat. 12° S. a N.W. Monsoon is prevalent when the sun has south declination, and a S.E. Monsoon when his declination is north: thus in each hemisphere there are two season-winds—of variable duration, according to the position of the place and the surrounding physical features:—in no case does one Monsoon terminate abruptly and the other commence forthwith, but there is a period of *change* known as the *breaking up* of the Monsoon; when one season-wind is about to cease it decreases in force and is occasionally replaced by calm; the atmosphere at sea and on the land shows evidence of disturbance; the sky is overcast and the air becomes sultry, oppressive, and foggy; the clouds of the upper region move in the direction of the succeeding Monsoon; and as the change progresses the wind becomes more and more variable. The following description of this phenomenon, “the breaking up of the Monsoon,” is aptly depicted by SIR J. E. TENNENT, in his work on “Ceylon.”*

“Meanwhile the air becomes loaded to saturation with aqueous vapour drawn up by the augmented force of evaporation acting vigorously over land and sea: the sky, instead of its brilliant blue, assumes the sullen tint of lead, and not a breath disturbs the motionless rest of the clouds that hang on the lower range of hills. At length, generally about the middle of the month, but frequently earlier, the sultry suspense is broken by the arrival of the wished-for change. The sun has by this time nearly attained his greatest northern declination, and created a torrid heat throughout the lands of Southern Asia and the peninsula of India. The air, lightened by its high temperature and such watery vapour as it may contain, rises into loftier regions and is replaced by indraughts from the neighbouring sea, and thus a tendency is gradually given to the formation of a current bringing up from the south the warm, humid air of the Equator. The wind, therefore, which reaches Ceylon comes laden with moisture, taken up in its passage across the great Indian Ocean. As the monsoon draws near, the days become more overcast and hot, banks of clouds rise over the ocean to the west, and in the peculiar twilight the eye is attracted by the unusual whiteness of the sea-birds that sweep along the strand to seize the objects flung on shore by the rising surf.

“At last the sudden lightnings flash among the hills and sheet through the clouds that overhang the sea, and with a crash of thunder the monsoon bursts over the thirsty land, not in showers or partial torrents, but in a wide deluge, that in the course of a few hours overtops the river banks and spreads in inundations over every level plain.

“All the phenomena of this explosion are stupendous; thunder, as we are accustomed to be awed by it in Europe, affords but the faintest idea of its overpowering grandeur in Ceylon, and its sublimity is infinitely increased as it is faintly heard from the shore, resounding through night and darkness over the gloomy sea. The light-

* “CEYLON: An account of the Island—Physical, Historical, and Topographical, &c.” By Sir James Emerson Tennent, K.C.S. L.L.D. (1859.)

ing, when it touches the earth where it is covered with the descending torrent, flashes into it and disappears instantaneously; but when it strikes a drier surface, in seeking better conductors, it often opens a hollow like that formed by the bursting of a shell, and frequently leaves behind it traces of vitrification. In Ceylon, however, occurrences of this kind are rare, and accidents are seldom recorded from lightning, probably owing to the profusion of trees, and especially of cocoa-nut palms, which, when drenched with rain, intercept the discharge, and conduct the electric matter to the earth. The rain at these periods excites the astonishment of a European; it descends in almost continuous streams, so close and so dense that the level ground, unable to absorb it sufficiently fast, is covered with one uniform sheet of water, and down the sides of acclivities it rushes in a volume that wears channels in the surface. For hours together, the noise of the torrent as it beats upon the trees and bursts upon the roofs, flowing thence in rivulets along the ground, occasions an uproar that drowns the ordinary voice and renders sleep impossible."

20. Before proceeding to give a detailed account of the winds in the different regions of the Indian Ocean, it may be useful to draw up a **Summary of the Winds in the Monsoon Region**; they are as follow:—

During the **SUMMER MONTHS** of the Northern Hemisphere the S.E. Trade-wind is prevalent in the southern part of the torrid zone,*—and the S.W. Monsoon blows in full force in its northern part.

During the **WINTER MONTHS** of the Northern Hemisphere the N.W. Monsoon prevails in the southern part of the torrid zone,—and the N.E. Trade-wind is in full strength in its northern part.

The N.E. Trade-wind, however, is, in these regions, called the N.E. Monsoon,—and the S.E. Trade-wind, the S.E. Monsoon. As shown in sec. 19, p. 19, the N.E. Monsoon gradually and by degrees glides into the N.W. Monsoon,—and the S.E. Monsoon into the S.W. Monsoon. And thus the Monsoons of the Indian Ocean are not separated by any such distinctly-defined *belt of calms* as is interposed between the Trade-winds of the Atlantic and Pacific Oceans. A Belt of Calm is to be found in the middle of the Indian Ocean, but it exists under different circumstances from that in either of the two other oceans,—and its range is more varied,—as might be expected where the winds are *seasonal* and not perennial.

In the **SPRING** and **AUTUMN** of the Northern Hemisphere—in the months when the Monsoons change—calms and variable winds prevail in the open ocean; and daily land-and-sea breezes along the coasts, from which, however, they extend but a few leagues; as soon as the Monsoon becomes regular and blows in its strength the distinctive land-and-sea breezes may be said to cease. In this ocean the land-breeze usually commences about midnight and terminates at sunrise,—the sea-breeze blowing from about mid-day until near sunset; both are moderate, but the sea-breeze is much fresher than that from the land.

The season of change from one Monsoon to the other varies in different parts of the Indian Ocean. This can be readily conceived from the physical characters (see sec. 19, p. 19) to which we have already adverted; being much more exposed than the other oceans to the disturbing influences consequent upon proximity to land,

* The torrid zone extends from Lat. $23\frac{1}{2}^{\circ}$ N. to Lat. $23\frac{1}{2}^{\circ}$ S., and may be considered as divided into two parts—a northern and a southern—by the equator.

the winds are consequently affected in a proportionate degree by *local* conditions. Thus the S.W. Monsoon stretches into the Northern Hemisphere much further to the North (as far as Lat. 30°) than the N.W. Monsoon into the Southern Hemisphere. Along the Arabian and East African coasts, and also along the N.W. coast of Australia the Monsoons assume in each case a direction which is dependent on the contour of the land and the peculiar physical features of the interior of the continents. In the Red sea the Monsoons blow alternately up and down, following the direction of the long, trough-like valley, within which the currents of air are confined. In no case is it correct to say that any one of these Monsoons blows for six months; they may prevail each for five months, but in many places not for more than four months—the intervening period being characterized by variable winds, with alternating calms, or squalls, and occasional cyclones.

The Monsoons of the CHINA SEA—(i.e. N. of the Equator)—are not entirely similar to those of the Indian Ocean; they may be divided into three periods—

1. The N.E. Monsoon, in October, November, December, and January,—changing in February.
2. The East Monsoon, in March and April,—changing in May.
3. The S.W. Monsoon, in June, July and August,—changing in September.

In the JAVA SEA and among the islands of the INDIAN ARCHIPELAGO (i.e. S. of the Equator) S.-Easterly winds prevail while the sun is in the Northern Hemisphere, and these are replaced by N.-Westerly during the stay of that luminary in the Southern Hemisphere; the former are known as the East Monsoon and the latter as the West Monsoon—and are characteristic of all that region by which the South Pacific communicates with the Indian Ocean. Comparing together the seasons of the two tropics, the West Monsoon (S. of the Equator) corresponds with the N.E. Monsoon of the Indian Ocean and China Sea,—the East Monsoon is the representative of the S.W. Monsoon.

21. The Seasons (wet and dry) within the Monsoon region are, in a great measure, determined by the direction of the wind (i.e. whether the direction of the air-current has come over the land or over the ocean); or perhaps it would be more strictly accurate to say that they are concurrently dependent on the Monsoons and the lay of the land. The west coast of India (Malabar coast) has its rainy season during the prevalence of the S.W. Monsoon; no portion of the rain at this season passes the Ghauts or central table land of India. Along the east, or Coromandel coast of this peninsula it is the N.E. Monsoon that brings rain, which waters the country to the summit of the eastern flank of the Ghauts. Thus the two coasts of the peninsula have their seasons reversed; one has the dry season when the other has the rainy season, and reciprocally: similar facts appertain to all countries within the Monsoon region of the Indian Ocean,—and even in a diminished degree to the islands—especially such as Ceylon, Borneo, and those of the largest class.

22. We may appropriately close this chapter with the following Table of the WINDS AND CALMS IN THE INDIAN OCEAN, from MAURY'S "Nautical Monographs," No. 1;—it gives the *total number of observations in each band of latitude, the mean direction of the wind from each quarter, and the average annual duration of each wind in days*. It is a table to which we shall have occasionally to refer.

Bands in Latitude.	Mean direction of the Wind.				No. of days of Calm.	No. of Obs.
Lat. 25° to 20° N.	N. 41° E.	S. 42° E.	S. 43° W.	N. 40° W.		
No. of days . . .	84	54	148	66	13	1874
Lat. 20° to 15° N.	N. 42° E.	S. 47° E.	S. 46° W.	N. 44° W.		
No. of days . . .	116	36	145	57	11	6800
Lat. 15° to 10° N.	N. 46° E.	S. 46° E.	S. 47° W.	N. 45° W.		
No. of days . . .	127	52	123	51	12	7488
Lat. 10° to 5° N.	N. 44° E.	S. 47° E.	S. 50° W.	N. 52° W.		
No. of days . . .	111	42	140	60	12	8841
Lat. 5° N. to Eq.	N. 41° E.	S. 41° E.	S. 46° W.	N. 51° W.		
No. of days . . .	82	60	138	67	18	9869
Lat. Eq. to 5° S.	N. 46° E.	S. 42° E.	S. 44° W.	N. 51° W.		
No. of days . . .	49	124	96	71	25	14,264
Lat. 5° S. to 10° S.	N. 53° E.	S. 48° E.	S. 38° W.	N. 51° W.		
No. of days . . .	51	178	63	54	19	16,018
Lat. 10° S. to 15° S.	N. 60° E.	S. 45° E.	S. 41° W.	N. 50° W.		
No. of days . . .	37	241	47	27	13	18,028
Lat. 15° S. to 20° S.	N. 67° E.	S. 50° E.	S. 34° W.	N. 46° W.		
No. of days . . .	43	272	34	10	6	17,340
Lat. 20° to 25° S.	N. 62° E.	S. 49° E.	S. 29° W.	N. 42° W.		
No. of days . . .	83	215	40	18	9	31,965
Lat. 25° to 30° S.	N. 54° E.	S. 48° E.	S. 36° W.	N. 40° W.		
No. of days . . .	108	146	62	39	10	33,160
Lat. 30° to 35° S.	N. 45° E.	S. 43° E.	S. 44° W.	N. 48° W.		
No. of days . . .	75	84	113	83	10	26,249
Lat. 35° to 40° S.	N. 39° E.	S. 44° E.	S. 41° W.	N. 51° W.		
No. of days . . .	49	52	128	129	7	56,336
Lat. 40° to 45° S.	N. 32° E.	S. 39° E.	S. 54° W.	N. 48° W.		
No. of days . . .	47	20	126	167	5	18,628
Lat. 45° to 50° S.	N. 38° E.	S. 49° E.	S. 53° W.	N. 51° W.		
No. of days . . .	62	39	97	161	6	6333

CHAPTER III.

WINDS IN THE INDIAN OCEAN.

23. The WIND REGIONS of the Indian Ocean may be classed under four well-marked heads, which, commencing from the south, are—

1. The Region of the N.W. PASSAGE-WINDS, usually found to the southward of the 32nd parallel;
2. The Region of S.E. TRADE-WIND, between 32° or 30° S., and 12° to 10° S.;
3. The Region of the S.E. and N.W. MONSOON, between 12° or 10° S. and the Equator or 3° N.;
4. The Region of the N.E. and S.W. MONSOON between the Equator and the Asiatic Continent;—

Each of these *wind-regions* will be treated separately, after which a general description of the *winds along the coast* will be given in detail.

It may be as well, at this point, to draw attention to and explain the CHART

DIAGRAMS OF THE WINDS which have been prepared for this work : they are drawn for each of the four quarters of the year,—

CHART DIAGRAM No. I.	embracing	October, November, and December.
„ No. II.	„	January, February, and March.
„ No. III.	„	April, May, and June.
„ No. IV.	„	July, August, and September.

By this arrangement, Nos. I. and II. give the period of the N.E. Monsoon, and Nos. III. and IV. the period of the S.W. Monsoon. *The direction of the arrows shows the point towards which the stream of air is moving.* These diagrams are chiefly compiled from the BOARD OF TRADE and MAURY'S Wind-Charts, modified by the observations contained in the Log-books in the possession of the Author, which contain about 300,000 eight-hourly observations. The area of the ocean is generally divided into squares of ten degrees of latitude and ten degrees of longitude, except where well-marked differences in the direction of the air-currents require a subdivision into squares of five degrees of latitude and longitude; the numbering of the ten degree squares of the Board of Trade Wind Charts, has also been retained in the letter-press, for the purpose of reference.

24. REGION OF THE N.W. PASSAGE-WINDS—SOUTHWARD OF LAT. 32° S.

In the most southerly portion of this region, *i.e.* in latitudes higher than 55° S. (the Polar region), winds from the N. and S. are equally prevalent with a greater tendency to blow from the *eastward* during the *summer* (December to March), but from the *westward* during the *winter* (March to December).

Between lat. 40° and 50° S. the winds are generally from the westward—between W.N.W. and W.S.W., the former predominating (see Table, p. 23); easterly winds are frequent during the summer, but calms and light baffling airs are rare; the storms of this region are at times very heavy and may be expected at any season. This part of the ocean is represented on the CHART DIAGRAMS by *areas* Nos. 56 to 65, both inclusive.

Between Lat. 30° and 40° S. the winds are still, as a rule, westerly, but the influence of the African and Australian continents is very perceptible—as indeed is the effect of the warm current from the Indian Ocean—producing a diversion of the main stream of air towards the region of greatest rarefaction. This is well seen in the CHART DIAGRAMS, I., II., III., and IV. (*areas* Nos. 46 to 55, both inclusive) where, in mid-ocean, the prevalent winds may be said to be between N.W. and S.W.; but on the African side of the ocean, westward of long. 70° E., easterly winds (E.N.E. to S.S.E.) are very common from November to March; during April, May, and June, these easterly winds scarcely extend beyond the 45th meridian, and during July, August, and September, they are very rarely experienced. Similarly, the areas in the vicinity of the Australian continent are characterized by winds between W.N.W. and S.S.W.—drawing towards and along the land. Easterly winds may, however, be expected more or less along the whole of this band (lat. 30° to 40° S.) during the Southern summer—December to February.

Between the parallels of 25° and 35° S. is situated the polar boundary of the S.E. Trade-wind, oscillating with the march of the sun in declination; between these parallels is also the place of the CALM BAND OF CAPRICORN—its mean position and average breadth being shown on the CHART DIAGRAMS, as well as its tendency to

expand, where it nears the African coast: by reference to Table, p. 23, it will be seen that in this band there are 10 calm days in the year, on an average. Between Lat. 35° and 40° S. the N.W. and S.W. winds blow an equal number of days (129 each),—the S.W. predominating over the N.W. between Lat. 35° and 30° S. in the ratio of 113 to 83. Considerable unsteadiness in the S.E. Trade is shown on its polar limit between 30° and 25° S., by not being prevalent more than 146 days, while winds between N. and E. are experienced for 108 days.

25. THE REGION OF THE S.E. TRADE-WIND.

The region of the S.E. Trade-wind in the Indian ocean is comprised between the Calm Belt of Capricorn and lat. 12° to 10° S. (See CHART DIAGRAMS I., II., III., IV., *areas* 30 to 36, and 38 to 44); the area of the ocean between 50° E. and the African coast is only partially affected by this wind,—the disturbing cause being the high land of Madagascar in close proximity to the African continent; but the greatest modification of the Trade-wind occurs in the Mozambique Channel, as will be shown presently. The S.E. Trade-wind does not touch the west coast of Australia—the general winds on that side of the Southern Indian Ocean, and for fully 400 miles from the land, being from N.N.W. to S.S.W. according to the season.

26. OFF THE CAPE OF GOOD HOPE AND THE EASTERN COAST OF SOUTH AFRICA. LAT. 50° S. TO THE EQUATOR, LONG. 15° TO 60° E.

A glance at the four CHART DIAGRAMS will convince the reader that there are at least three systems of winds prevalent, more or less, over the oceanic area bounded by the Equator and Lat. 50° S., and by the meridians of 10° and 60° E. One of a very peculiar character sweeps from the neighbourhood of Cape Agulhas to the northern part of Mozambique, and this, with but slight interruptions, is maintained *all the year round*; it appears closely to follow the coast-line,—or more properly speaking, the line of table-land, which runs nearly parallel with the coast, and at a distance from it of about 100 or 150 miles. This air-current terminates in the summer (Southern Hemisphere) near the centre of the Mozambique Channel: in the winter it is continued to the Equator.

The northern part of the area, skirting the African coast, is characterized during the southern summer, from October to March, by N.E. winds, but winds from E.N.E. are found as high as 30° S. lat. during the six months: during the succeeding six months these winds are replaced by the S.E. trade.

It will be seen on CHART DIAGRAMS Nos. I. and II. that during the six months of summer, in the northern part of the Mozambique Channel, there is a point of convergence of the winds which sweep along the eastern coast of Africa,—in fact, that in this immediate locality there is a rarefying surface producing, in all probability, an ascending and upward current; notwithstanding that a N.E. wind penetrates to the parallel of Cape Corrientes, during the months of October to December, the directions of the arrows on *areas* Nos. 38 and 31 indicate that the wind along the eastern coast of Africa really converges to the north of the Mozambique, and that *there* N.E. and S.W. currents meet and ascend—and, as a consequence, frequent calms ensue in that part.

In the MOZAMBIQUE CHANNEL it is difficult to say what Monsoons are prevalent; but that which goes under the name of the N.E. is variable between N.E. and N.W.—

it commences in November and ends in March: variable winds are more frequent in the southern part of the channel during this season than in the northern, for to the north of Mozambique the winds are generally from N.E. to N., accompanied with rain and squalls. At the southern entrance to the channel the variable N.E. to N.W. winds not unfrequently encounter the fresh S. and S.E. winds blowing on the south coast of Madagascar; under these circumstances severe gales of the rotatory type may be experienced, and the navigator should be prepared for them. This is the rainy season in the Mozambique Channel.

The so-called S.W. Monsoon commences in the Mozambique Channel in April and terminates towards November; this is the fine season. At the southern entrance to the channel the winds are S. and S.S.W., becoming more westerly towards the northern entrance, and finally uniting with the S.W. Monsoon, which is at this season prevalent over the northern part of the Indian Ocean: but at times these winds are variable, as, for instance, from S.W. to S.E. and E.S.E.—those from the last direction being squally and strong off the south end of Madagascar. Near the coast of Africa this is the period of land-and-sea breezes. In mid-channel both Monsoons are more regular than along the coast.

South of the parallel of 30° S. is the general region of the N.W. "passage-winds;" these also require a separate quarterly notice; they are of great importance to all commanders sailing to Australia, as the track to that important colony lies through the heart of these winds, and the voyage to India and China is also accelerated by pursuing this track. We have already alluded to E.N.E. winds being found as high as 30° S. lat. (see CHART DIAGRAM No. I., areas 38, 39). On the same CHART DIAGRAM, areas 47, 48, 49 are characterized by W.S.W. winds—*exactly the opposite*; here to all intents and purposes there is an *ascending current*, and it would appear that the surface of the ocean in the neighbourhood of the parallel of 30° S. and between long. 30° and 50° E. becomes during the three months, October to December, sufficiently heated, as compared with localities north and south of it, to produce an indraught of cooler air from E.N.E. and W.S.W. This does not occur in the more open spaces of the Indian Ocean to the eastward. It is in the neighbourhood of the parallels 30° to 35° S. that COM. MAURY places the Calms of Capricorn, and it is well known that he explains these, as well as the Calms of Cancer, by a *descending current* or rather by two *descending currents* resulting from the meeting of two opposite currents in the upper regions of the atmosphere, which come out on the surface, as two opposite winds *blowing away from each other*, thus $\leftarrow \text{---} \rightarrow$

The second meteorological axiom announced by CAPT. CHARLES WILKES, U.S.N., in his "Theory of the Wind," is as follows: "that if the atmosphere is disturbed by any change of temperature, the *denser and colder* portions seek the warmer, from *every direction*, to restore the equilibrium in the most direct lines it can follow."

It is not intended on this occasion to enter into any examination of the controversy between COM. MAURY and CAPT. WILKES; our object is of a more practical nature—to show the navigator the principal winds he may meet with, in various localities, as he prosecutes his voyages, and the connexion that exists between these winds and certain other physical phenomena, by which he may the more readily take advantage of such winds as may be suitable for his purpose.

In immediate connexion with the locality under consideration, HORSBURN has this remark: "The late CAPT. J. WILSON, of the Company's ship *Hythe*, a very scientific officer, has ascertained by careful observation that the temperature of the *central*

part of the stream of westerly current which prevails upon the verge of Cape Agulhas bank, is about 8° or 9° higher than that of the sea beyond the stream of current, and as the maximum of temperature is in the middle of the stream of current, a ship may be kept in it by attending to changes of temperature in the surface water, and hereby be enabled to accelerate her progress to the westward during adverse winds."

MAURY, in his "Physical Geography of the Sea," edition 1864, page 195, sections 393-4, speaking of a current of warm water in the Indian Ocean, says, "There is sometimes, if not always, another exit of warm water from the Indian Ocean. It seems to be an overflow of the great intertropical caldron of India,—seeking to escape thence, it works its way polarward, more as a drift than as a current: this Indian overflow is very large . . . and finds its way south, midway between Africa and Australia, and appears to lose itself in a sort of Sargossa Sea, thinly strewed with patches of weed. Nor need we be surprised at such a vast flow of warm water as these *three* currents indicate from the Indian Ocean, when we recollect that this ocean is land-locked on the north, and that the temperature of its waters is frequently as high as 90° Fahr. There must therefore be immense volumes of water flowing into the Indian Ocean to supply the waste created by these warm currents.

"On either side of this warm current that escapes from the intertropical parts of the Indian Ocean, but especially on the Australian side, an ice-bearing current is found wending its way from the Antarctic regions with supplies of cold water to modify climates and restore the aqueous equilibrium in that part of the world."

On turning to the chart of *sea drift* (Currents of Indian Ocean), we find indicated a stream of warm water flowing from the eastward between Australia and Borneo; this is divided into *three* branches;—one goes north to the Arabian Sea and Bay of Bengal, at least during a part of the year; another goes south, to the Sargossa Sea before spoken of; and a third moves west,—a prolongation of this forms the Agulhas current before mentioned: and as the temperature of the *central* part of this current is 8° or 9° higher than that of the water on either side, so it is to be inferred, and most probably such inference is not far from the truth, that the Indian Ocean is parcelled out by these currents into portions of warm and cold, or at least *cool* water. We have now only to apply WILKES' axiom before quoted, and we see at once, that according to this axiom, the wind must blow from the cooler *towards* the warmer areas; such a warm area most probably exists in the neighbourhood of 30° S. between the *areas* Nos. 38, 39, and 40 on the north, and *areas* 47, 48, and 49 on the south; in fact, this supposed warm area is in the line of the *warm water current*.

Whatever evidence may exist in support of MAURY's idea, that the Calms of Capricorn and Cancer are produced by opposite winds meeting in the *higher regions of the atmosphere* and seeking the surface by a *downward* current,—*here*, in the region of the southern calms, there is evidence of at least one movement of an opposite character,—for the *meeting* of the E.N.E. and W.S.W. winds could not result in any way from a descending current, nor is it easy to see how *two parallel but oppositely directed* currents could be produced by such means; the current exhibited on the CHART DIAGRAM being of this character, as will be shown further on. To proceed with the analysis of winds:—

During the next three months, *i.e.* from January to March, the same opposition of the E.N.E. and W.S.W. winds obtain, although somewhat considerably modified by

the position of the sun,—see CHART DIAGRAM No. II. Between Lat. 20° and 40° S. (in *areas* Nos. 40, 49, and 48) the prevalent winds are from E.N.E. or N.N.E., while in *area* No. 39 and also in 49 we have it from E.S.E. It is in the parallels between 40° and 50° S., that the opposing wind from W.S.W. occurs, and this would indicate that the partial belt, or zone of warm water, above mentioned, had *receded from the Equator with the sun.*

During the winter season in the southern hemisphere, this peculiar arrangement of the winds, arising from the presence of warm and cold water, disappears. Between April and June the S.E. Trade is fully established over the northern part of CHART DIAGRAM No. III.,—and the breadth of the sweep of winds along the African coast is greatly augmented; it may be seen stretching as far as *areas* 49 and 39, and the arrow in 40 clearly shows the tendency of the stream of air to the great rarefying surface of the central part of South Africa.

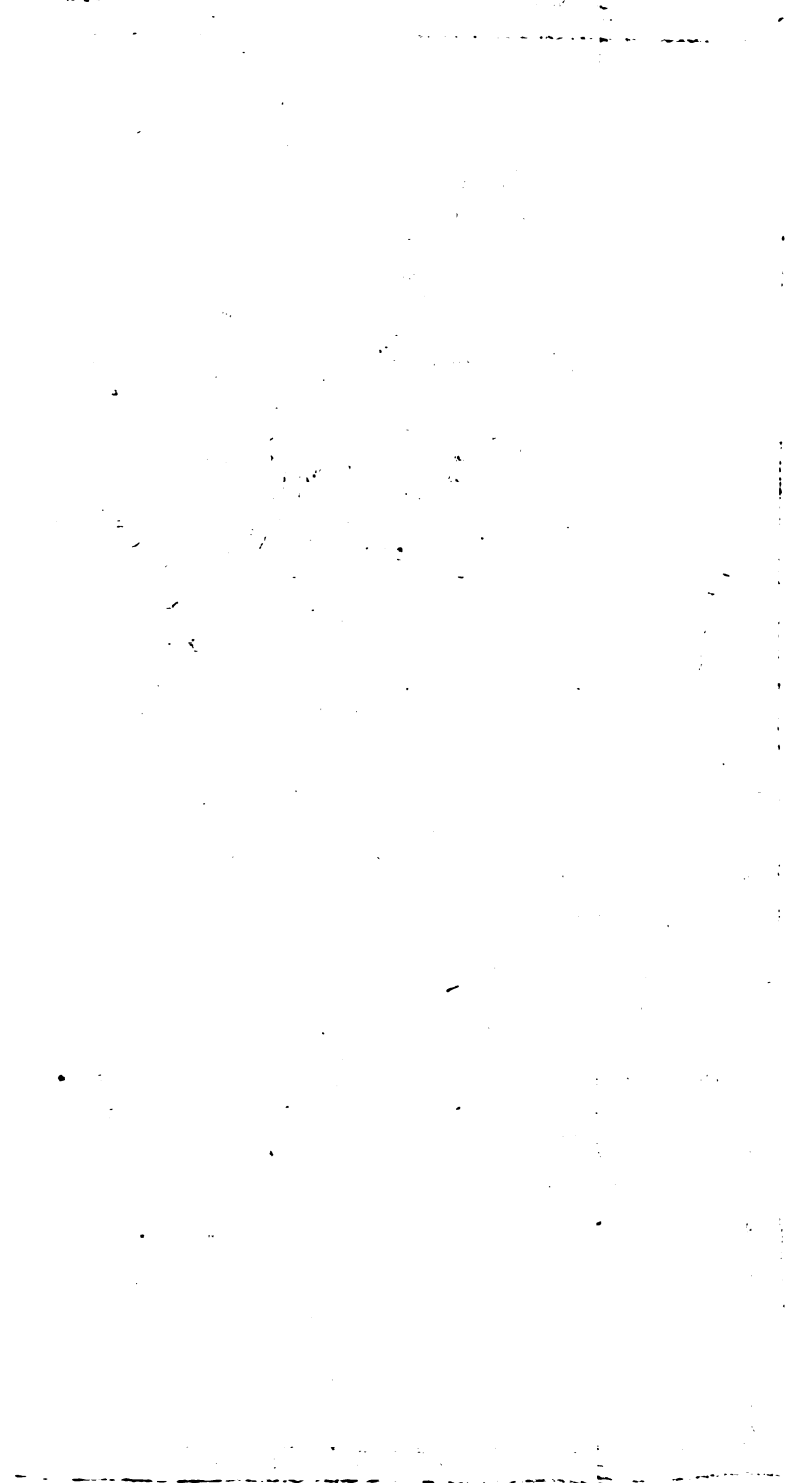
During the months of July, August and September,—the Southern winter—a very remarkable arrangement of the wind occurs, as seen in CHART DIAGRAM IV. Taking the space between lat. 20° and 30° S. as a sort of central area, we have the winds blowing towards the north on the north of it, and towards the south on the south of it;—those blowing towards the north are clearly the S.E. Trade, which at this season reaches the Equator as the S.E. Monsoon. It would appear that some powerful force exists at this period of the year, *considerably to the south of Africa*, and that this force draws the air from the north of 30° S. (*area* 40) in a curved sweep touching the southern extremity of Madagascar (*area* 39) and merging into a general N.N.E. current, as seen in *areas* 48, 58, and 39; how far this northerly current extends, or in what it results, we have at present no evidence to show, except that it probably has its explanation in the warm water current, which flows almost due south on the meridian of the Cape at this period of the year.

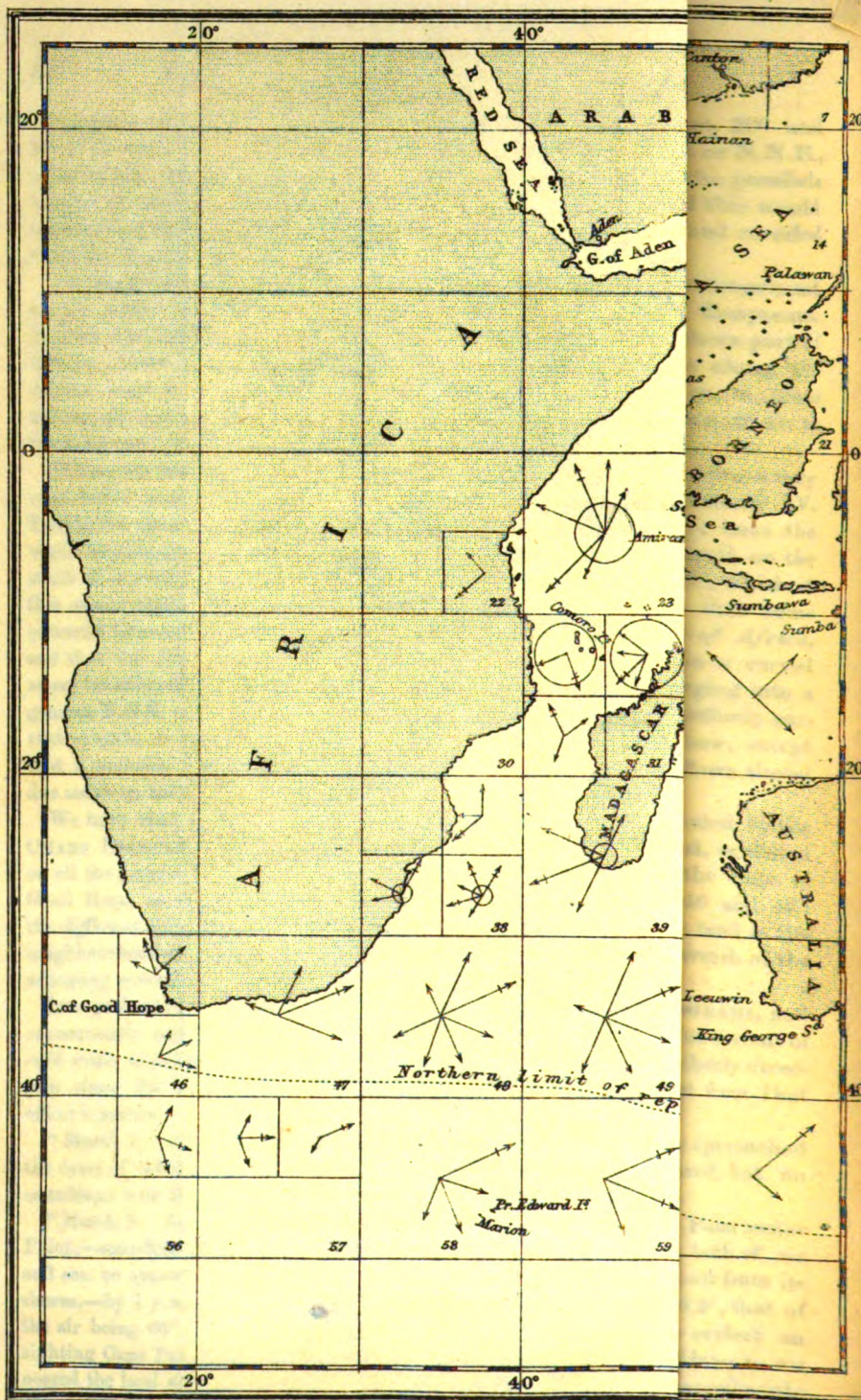
We have thus noticed the three principal systems of winds, as indicated by the CHART DIAGRAMS; there is, however, another feature of no little interest, exhibited on all the diagrams; it is a kind of *out-blow* in the neighbourhood of the Cape of Good Hope, as shown by the arrows in the upper corners of *areas* 46 and 47; the *different* directions of the arrows clearly indicate the *coldness* of the land in the neighbourhood of the Cape and of South Africa, as compared with the warmth of the adjoining waters.

It is probable that this out-blow, which is seen on the four CHART DIAGRAMS, and consequently exists all the year round, is occasioned in some degree by the current of *cold water* which CAPT. SIR JAMES CLARKE ROSS found running in a northerly direction along the west coast of Africa. We give the following abstract from that officer's journal.

"March 7. A gradual diminution of temperature of air and sea as we approached the coast of Africa.—At midnight, entered a cold mist,—water discoloured, but no soundings with 130 fathoms of line."

"March 8. Latitude $32^{\circ} 21'$ S., Longitude $17^{\circ} 6'$ E.—45 miles from Paternoster Point,—soundings 127 fathoms.—Expected an *elevation* of temperature, both of air and sea, on approaching the African coast, by reason of the radiation of heat from its shores,—by 1 P.M. the temperature of the sea had fallen from 70° to 56.5° , that of the air being 65° .—The cause of the depression of temperature became evident on sighting Cape Paternoster, for a current increasing in strength and coldness as we neared the land was found to exist. The following is a summary of the experiments





on it: The current barely reaches 40 miles from shore—where the sea is more than 300 fathoms deep—but spreads over double that distance in shallower parts;—45 miles from land, at a depth of 120 fathoms, the temperature of the water was 40° , that of the surface being 56° ; and 60 miles off land, at 200 fathoms, it was 43.5° , the surface being 61° ;—thus a northerly current of very limited extent, but of considerable force, exists from the Cape of Good Hope along the west coast of Africa, which in general terms may be represented by a volume of water 60 miles wide and 200 fathoms deep, averaging a velocity of a mile an hour . . . running between the shores of Africa and the waters of the adjacent sea. The mist which hangs over the stream of cold water is occasioned by the condensation of the vapour of the superincumbent atmosphere whose temperature is generally so many degrees higher than that of the sea."

The temperature of the atmosphere first quoted is 65° , that of the surface being 85° lower; at 45 miles from land we find the surface temperature also 56° , but at 60 miles, *i.e.* 15 miles further, it is as high as 61° ; it is probable the temperature increased still further out at sea, so that the natural effect of the heated sea-water (adjacent to the cold current) would be to draw the air from the coast, *i.e.* to produce the western part of the out-blow noticed, the eastern part being due to the general westerly current.

Having sketched out the general distribution of the winds in the western part of the southern Indian Ocean, the next consideration is to specify the phenomena of each area of ten degrees square, and in so doing first to pass in review the stream of air sweeping along the eastern coast of Africa,—next, the opposing winds in the neighbourhood of the 30th parallel,—and lastly the S.E. Trade.

CHART DIAGRAM No. I., October, November, December. (The Southern Spring.)

Winds along the Eastern Coast of Africa :—

* 46b. Area included between Lat. 30° and 35° S., Long. 15° and 20° E.

Prevailing wind, S.S.E.

Frequent winds, E.S.E.—S.E.—S.S.E. (442.) The wind in this *area* blows mostly towards and along the land.

46d. Area included between Lat. 35° and 40° S., Long. 15° and 20° E.

Prevailing wind, W.N.W.

Frequent winds, S.S.E.—S.S.W.—W.S.W. (442.) The prevailing wind in this *area* is a portion of the general stream from westward between the parallels of 30° and 40° S.

47. Area included between Lat. 30° and 40° S., Long. 20° and 30° E.

Prevailing wind, W.S.W.

Frequent winds, S.S.W.—W.N.W.—E.S.E. (441.) Here there is an indication of the stream of air sweeping round the southern part of Africa, as well as a tendency to the *area* of heated water mentioned on p. 27; the E.S.E. wind is in the direction of the same wind that blows outward from the land in *area* No. 46.

38d. Area included between Lat. 25° and 30° S., Long. 35° and 40° E.

Prevailing winds, S.S.W.—S.S.E.—E.N.E.

* The numbers before the word "*area*" refer to the numbers on the CHART DIAGRAMS which accompany this work; the numbers in brackets are those on the Board of Trade Wind Charts.

Frequent winds, N.N.E.—E.S.E. (404.) In this *area* the winds generally set towards the African coast, although one of the prevailing winds is along shore, this is very similar to the winds in the adjoining *area*, and is in decided contrast with those in *area* No. 48, where the set is outward, from the land.

38c. Area included between Lat. 25° and 30° S., Long. 30° and 35° E.

Prevailing wind, S.S.W.

Frequent winds, E.S.E.—E.N.E. (404.)

38b. Area included between Lat. 20° and 25° S., Long. 35° and 40° E.

Prevailing wind, N.E.

Frequent winds, S.—S.S.E. and E. (404.) The winds from the *eastward* seem to indicate a point of convergence or rarefaction on this part of the African continent.

31c. Area included between Lat. 15° and 20° S., Long. 40° and 45° E.

Prevailing wind, S.S.E.

Frequent winds, S.—S.S.W.—S.W.—N.N.E. (367.)

31a. Area included between Lat. 10° and 15° S., Long. 40° and 45° E.

Prevailing wind, N.N.W.

Frequent wind, E.N.E. (367.)

31b. Area included between Lat. 10° and 15° S., Long. 45° and 50° E.

Prevailing wind, N.E.

Frequent winds, S.E.—E.S.E.—E.—N.N.E. (367.)

In the three latter *areas* we see the play of the winds in the northern part of the Mozambique Channel. In *area* 31a the prevailing wind is *outward* from the land, but in the other two *towards* it. *Areas* 31a and 31b are subject to *frequent calms*.

The so-called N.E. Monsoon :—

22d. Area included between Lat. 5° and 10° S., Long. 35° and 40° E.

Prevailing wind, N.E.

Frequent winds, S.E.—E.—E.S.E. (332.) Stream of air from eastward.

23. Area included between Lat. 0° and 10° S., Long. 40° and 50° E.

Prevailing wind, N.E. and S.S.E.

Frequent winds, N.N.E.—E.N.E.—E.—E.S.E.—S.E.—S. (331.) In this *area* the set of the wind *towards the land* is unmistakable. Calms are very frequent during the three months. Similar remarks appertain to *areas* 31a and 31b, to which the N.E. Monsoon probably extends.

Opposing currents of air in the neighbourhood of 30° S :—

39. Area included between Lat. 20° and 30° S., Long. 40° and 50° E.

Prevailing wind, E.N.E.

Frequent winds, S.S.E.—S.E.—E.S.E.—E.—N.E.—N.N.E. (403.)

40. Area included between Lat. 20° and 30° S., Long. 50° and 60° E.

Prevailing wind, E.N.E.

Frequent winds, E.S.E.—E.—N.E.—N.N.E. (402.) It will be observed that in *area* No. 39 there is a greater spread of wind than in *area* 40; in both, however, the general stream is from *eastward*; and probably as it approaches the land it is more divided, being subject to more numerous influences.

48. Area included between Lat. 30° and 40° S., Long. 30° and 40° E.
 Prevailing wind, W.S.W.
 Frequent winds, S.S.W.—S.W.—W.N.W.—N.N.W.—N.N.E.—E.N.E.
 (440.)

49. Area included between Lat. 30° and 40° S., Long. 40° and 50° E.
 Prevailing wind, W.S.W.
 Frequent winds, S.S.W.—W.N.W.—N.N.W.—N.N.E. (439.)

50. Area included between Lat. 30° and 40° S., Long. 50° and 60° E.
 Prevailing wind, N.N.W.
 Frequent winds, S.S.E.—S.S.W.—W.S.W.—W.N.W. (438.)

The direction of the arrows in the three last *areas* indicate a general movement of the air from the *westward*, and consequently in a nearly opposite direction to the movement of the air in *areas* 39 and 40. The movement of the air in *area* 38 is precisely of the same character as in *areas* 39 and 40, viz., from the *eastward*, while that in *area* 47 is of the same character as the movements in 48, 49, and 50; it is clear, therefore, that to the south of Lat. 30° S. we have generally an opposite stream of air to that immediately north of the same parallel.

The wind in *area* No. 48 blows during the three months almost directly along and *outwards* from the land, and the same directions are preserved (nearly) in *area* No. 49. In *area* No. 50 it is altered, the general winds being from N.N.W. to W.S.W., although the prevailing wind is towards N.N.W.

The winds in *areas* 58, 59, and 60 are very similar in their character to those in *areas* 48, 49, and 50, as will be seen below.

58. Area included between Lat. 40° and 50° S., Long. 30° and 40° E.
 Prevailing wind, W.S.W.

Frequent winds, N.N.W.—W.N.W.—N.N.E. (476.)

59. Area included between Lat. 40° and 50° S., Long. 40° and 50° E.
 Prevailing wind, W.S.W. and W.N.W.

Frequent winds, N.N.W. (475.)

60. Area included between Lat. 40° and 50° S., Long. 50° and 60° E.
 Prevailing wind, W.N.W.

Frequent winds, W.S.W.—N.N.W. (474.)—The wind in *areas* 56*b*, 57*a*, 57*b*, is part of the same N.W.-ly stream of air.

- 56*b*. Area included between Lat. 40° and 45° S., Long. 15° and 20° E.
 Prevailing wind, N.N.W.

Frequent winds, S.W.—W.S.W.—W.—W.N.W. (478.)

- 57*a*. Area included between Lat. 40° and 45° S., Long. 20° and 25° E.
 Prevailing wind, W.

Frequent winds, S.S.W.—W.N.W.—N.N.W. (447.)

- 57*b*. Area included between Lat. 40° and 45° S., Long. 25° and 30° E.
 Prevailing wind, W.S.W.

Frequent winds, W.N.W., N.N.E., and N.N.W. (477.) The last two are, however, far less common than the prevalent W.S.W. to W.N.W. winds.

The South East Trade.

The only instances of the S.E. Trade during the three months occur in *areas* 24 and 32. In the first (or northern) of these *areas* the prevalent wind is S.; in the southern it is S.E.

24. Area included between Lat. 0° and 10° S., Long. 50° and 60° E.

Prevailing wind, S.

Frequent winds, S.E.—S.W.—W.—N.E. (330.)

32b. Area included between Lat. 10° and 15° S., Long. 55° and 60° E.

Prevailing wind, S.E. (366.)

32d. Area included between Lat. 15° and 20° S., Long. 55° and 60° E.

Prevailing wind, S.E.

Frequent wind, E. (366.)

In area 23 the S.E. Trade shows itself, but is overpowered by other streams of air.

CHART DIAGRAM No. II., January, February, March. (The Southern Summer.)

The stream of air sweeping the coast of Africa:—

46b. Area included between Lat. 30° and 35° S., Long. 15° and 20° E.

Prevailing winds, S.S.E. and S.S.W.

Frequent winds, E.S.E.—S.E.—S. (442.) The general direction of the wind in this area is scarcely altered during these three months as compared with its direction during October, November, and December, (see same area on p. 29,) it is now perhaps more parallel with the coast than blowing towards the land. The same kind of *out-blow* mentioned on p. 28 is however apparent.

46d. Area included between Lat. 35° and 40° S., Long. 15° and 20° E.

Prevailing wind, E.S.E.

Frequent winds, S.S.E.—S.E.—S.S.W.—W.S.W.—W.N.W. (442.) As regards this area, it is not a little remarkable that while the *prevailing* wind during January, February, and March is exactly the *opposite* of that during October, November, and December, *the frequent winds should be nearly the same*; the legitimate conclusion is that the *same* winds prevail between Lat. 35° and 40° S. and Long. 15° and 20° E. *during the summer six months of the southern hemisphere*. The area is one that is sailed over by many ships proceeding to Australia, and by nearly all bound to India and China; it will be seen that the wind mostly blows towards the African continent.

47. Area included between Lat. 30° and 40° S., Long. 20° and 30° E.

Prevailing wind, W.S.W.

Frequent winds, E.N.E.—E.S.E.—S.S.E.—S.S.W.—W.N.W.—N.N.E. (441.) Of these winds the E.N.E., S.S.E., and W.N.W., are more frequent than the other three, so that the *wind-star* in the chart of the Board of Trade presents a very *flattened* appearance, being drawn out in its greatest length towards E.N.E. and W.S.W. But there is evidence that at this season of the year, there is a considerable tendency towards *Easterly* winds.

38d. Area included between Lat. 25° and 30° S., Long. 35° and 40° E.

Prevailing wind, S.S.E.

Frequent winds, S.—E.S.E.—E.N.E. (404.) The character of a system of *on-shore* winds is maintained in this area during the southern summer.

38c. Area included between Lat. 25° and 30° S., Long. 30° and 35° E.

Prevailing wind, S.S.W.

Frequent winds, S.—S.S.E.—E.S.E.—E.N.E.—N.N.E. (404.) In this area, during the summer, winds along-shore are prevalent.





36b. Area included between Lat. 20° and 25° S., Long. 35° and 40° E.

Prevailing wind, S.

Frequent winds, S.E.—S.S.E. (404.) The tendency of the winds in this *area* during the summer is towards the rarefying surface northward of the Mozambique Channel.

The so-called North-East Monsoon :—

31. Area included between Lat. 10° and 20° S., Long. 40° and 50° E.

Prevailing wind, N.N.W.

Frequent winds, N.W.—W.N.W.—S.S.W.—S.S.E.—E.S.E.—E.N.E.—N.N.E. (367.)

As in the spring months, so in the summer months of the Southern Hemisphere, the winds in the northern part of the Mozambique Channel are subject to very considerable variations. The frequent winds indicate that *three* systems alternate here : (1) that of the wind sweeping along the coast ; (2) that of the N.E. monsoon ; and (3) that of the wind towards the interior of Madagascar—of which the prevailing wind of the *area* is a component part. In addition, it must be borne in mind that calms are *very* frequent at this period.

23. Area included between Lat. 0° and 10° S., Long. 40° and 50° E.

Prevailing wind, N.N.E.

Frequent winds, E.S.E.—E.N.E.—N.E.—N.—N.W. (331.)

22d. Area included between Lat. 5° and 10° S., Long. 35° and 40° E.

Prevailing wind, N.E. (332.)

The winds of the above *areas* (31, 23, and 22d) are those of the Monsoon, many of them being evidently part of the N.W. Monsoon winds prevalent at this season south of the Equator ; but whether any characteristic wind marks the Mozambique Channel during the summer is very doubtful.

Easterly Winds North of Lat. 40° S. :—

32b. Area included between Lat. 10° and 15° S., Long. 55° and 60° E.

Prevailing wind, E.

Frequent winds, N.E.—N. (366.)

32d. Area included between Lat. 15° and 20° S., Long. 55° and 60° E.

Prevailing wind, E.

Frequent winds, E.S.E.—E.N.E.—N.E. (366.)

40. Area included between Lat. 20° and 30° S., Long. 50° and 60° E.

Prevailing wind, E.N.E.

Frequent winds, E.S.E.—E.—S.E.—S.S.E. (402.)

39. Area included between Lat. 20° and 30° S., Long. 40° and 50° E.

Prevailing wind, E.S.E.

Frequent winds, S.S.E.—E.—E.N.E.—N.E.—N.N.E. (403.)

Similar remarks to those made on the spring wind (October, November, December) will apply to January, February, and March, for *areas* 40 and 39.

43. Area included between Lat. 30° and 40° S., Long. 30° and 40° E.

Prevailing wind, E.N.E.

Frequent winds, N.N.E.—E.S.E.—S.S.E.—S.S.W.—W.S.W. (440.)

During the summer months (January, February, March) the general blow of the winds in this *area* is nearly the opposite to that which is recorded for

October, November, and December. On page 31 it is noticed that in *area* No. 48 the winds blow *outwards* from the land during the spring months. In the summer they blow *inwards*, towards and along the coast of Africa; in fact there are two distinct systems traceable—that along the African coast, and a general stream from the eastward, gradually becoming north-easterly.

49. Area included between Lat. 30° and 40° S., Long. 40° and 50° E.

Prevailing winds, N.N.E. and S.S.W.

Frequent winds, E.S.E.—E.N.E.—S.S.E.—W.S.W.—N.N.W.—W.N.W.

(439.) The numerous arrows inscribed on this *area* are sufficient to show that the locality is subject to great variations in the direction of the wind during the three summer months. There is, however, a preponderance towards the African coast, and this combined with one of the prevalent winds coming from N.N.E., will enable us to include it in the stream of air shortly to be noticed blowing in a somewhat contrary direction to that sweeping along the coast. On the whole, the winds in this *area* during the southern summer are very variable, and of all the *areas* between Lat. 0° and 50° S., Long. 10° and 60° E., this is the most likely one in which vessels either outward or homeward bound may fall in with *head winds* during the three months:—If proceeding towards the Mauritius, a head wind may be experienced from E.N.E. or thereabouts; if coming eastward round the Cape, the head wind may be W.S.W.; the chances are, that the wind may spring up from almost any of the other six points recorded above as frequent winds, but with no degree of certainty from either N.N.E. or S.S.W. It may be regarded, therefore, as a tedious *area* to sail across, owing possibly to this fact, that when the sun takes up his position over the southern tropic, the heated water (alluded to on page 27) advances towards the south, giving an almost entirely new direction to the winds of *areas* Nos. 49 and 48, and creating streams of air the tendency of which is to oppose one another. It would, however, be better to trim the ship to sail on the best course compatible with the general sweep of wind, which we now proceed to notice.

Westerly Winds South of Lat. 40° S. :—

- 56b. Area included between Lat. 40° and 45° S., Long. 15° and 20° E.

Prevailing wind, W.S.W.

Frequent winds, W.N.W.—N.N.W. (478.)

57. Area included between Lat. 40° and 50° S., Long. 20° and 30° E.

Prevailing wind, W.N.W.

Frequent winds, S.S.W.—W.S.W.—N.N.W.—N.—N.N.E.—E.N.E. (477.)

58. Area included between Lat. 40° and 50° S., Long. 30° and 40° E.

Prevailing wind, W.S.W.

Frequent winds, S.S.W.—W.N.W.—N.N.W.—N.N.E. (476.)

59. Area included between Lat. 40° and 50° S., Long. 40° and 50° E.

Prevailing wind, W.S.W.

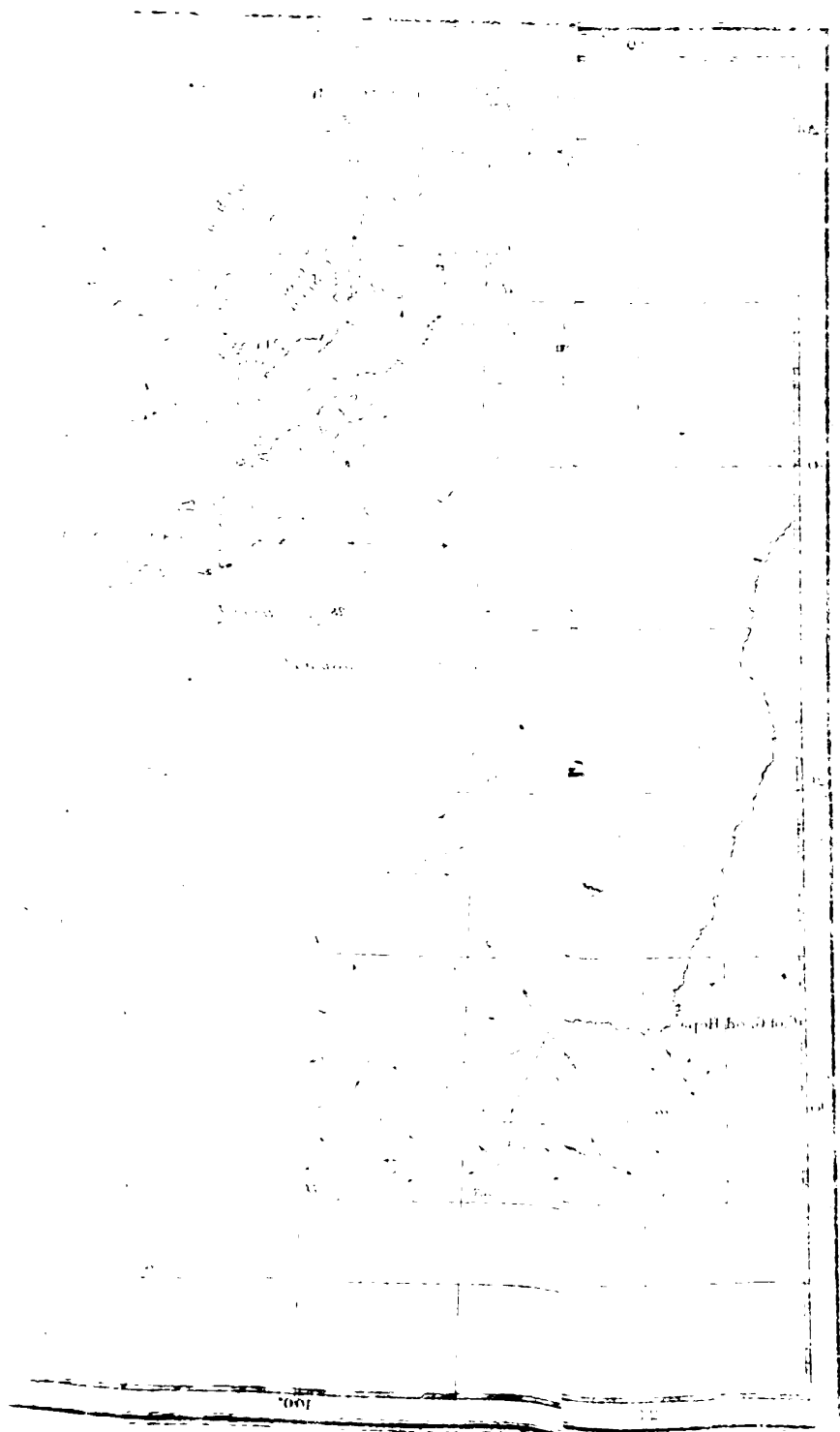
Frequent winds, W.N.W.—N.N.W.

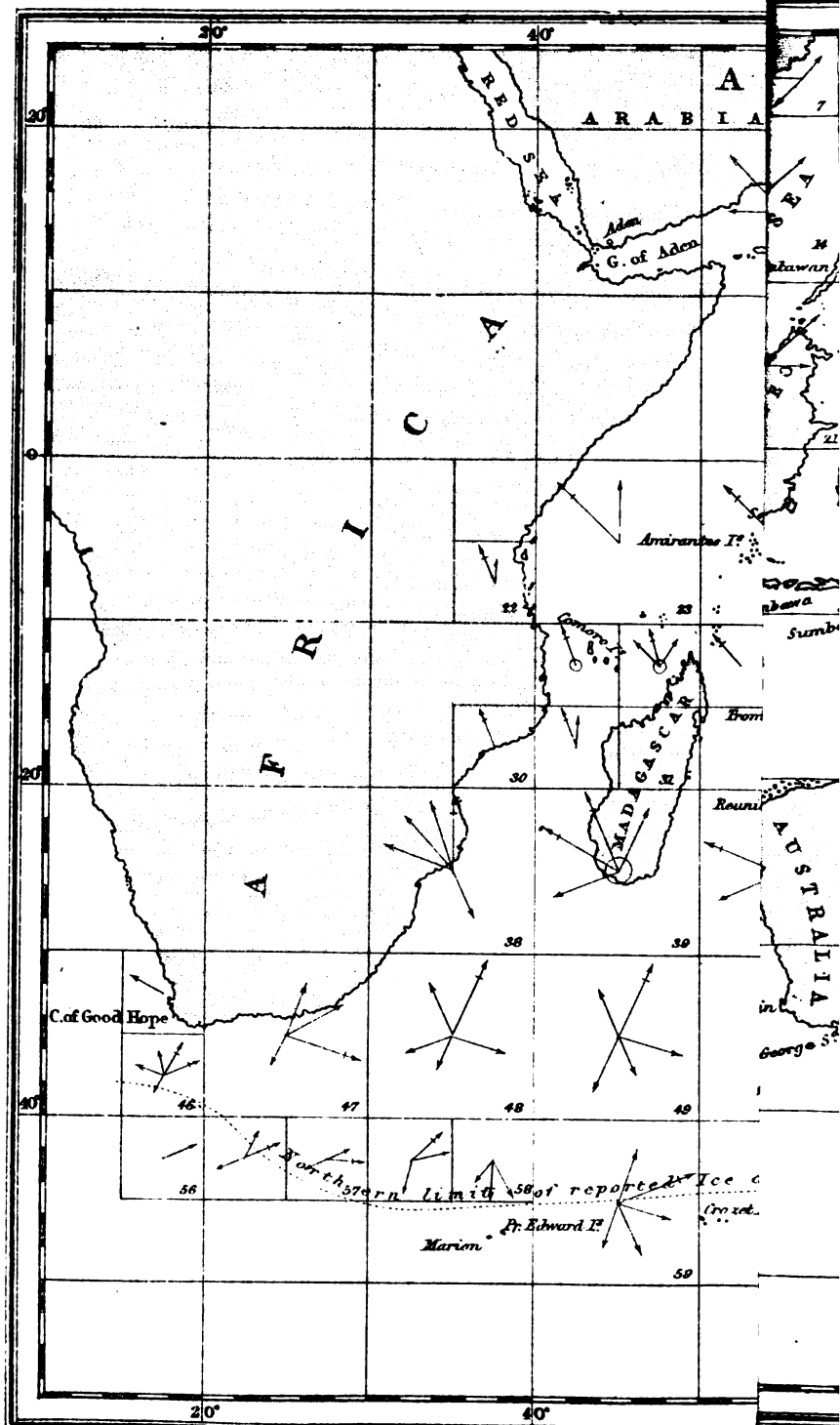
Occasionally, N.N.E. (475.)

60. Area included between Lat. 40° and 50° S., Long. 50° and 60° E.

Prevailing wind, N.N.W.

Frequent winds, W.S.W.—W.N.W. (474.)





The *general* direction of the wind in the above five *areas* is from W.N.W. to W.S.W., in comparison with which scarcely any winds are experienced from the eastern horizon. The only well-marked instance of a series of winds opposite to those from W.N.W.—viz. E.S.E.—is found in *area* 48; the phenomena are, however, incompatible with the notion of a *descending* current, resulting from opposite streams of air.

In *area* 50 there is a somewhat similar play of winds to that in *area* 49, and the well-marked distinction between an easterly and westerly movement at this season probably commences in the former *area*, or perhaps it would be better to regard *areas* 50 and 49 as of an intermediate character, separating the easterly current to the north, and the westerly current to the south. The winds are as under.

50. Area included between Lat. 30° and 40° S., Long. 50° and 60° E.

Prevailing wind, N.N.W.

Frequent winds, partaking of the westerly movement, W.N.W.—W.S.W.—S.S.W.

Frequent winds, partaking of the easterly movement, S.S.E.—E.S.E.—E.N.E.—N.N.E. (438.)

It will be observed that the prevalent winds of *areas* 50 and 60 are identical,—they would indicate that, in addition to the two streams above alluded to, a stream of air towards S.S.E. existed in these *areas* during the three months: indeed, referring to CHART DIAGRAM No. I., *area* 50, it appears that, more or less, during the *southern summer*, the wind has a tendency to blow in this direction.

The *N.W. Monsoon*:—There is only one more *area* to notice,—24, Lat. 0° to 10° S., Long. 50° to 60° E., the prevalent wind of which is N.W.,—the remaining winds bear but a small proportion to this, which is the characteristic wind of the region.

Allusion is made to the *change in the direction of the wind* that is effected over the *area* embraced by that part of the CHART DIAGRAMS during the winter season of the southern hemisphere, as compared with the summer, more especially as regards the establishment of the S.E. Trade, embracing the western portion of the Southern Indian Ocean to the Equator,—and also the remarkable influence which is exerted on the so-called N.W. passage winds to the south-eastward of the Cape of Good Hope, particularly during the months of July, August, and September.

CHART DIAGRAM No. III., April, May, June. (The *Southern Autumn*.)

Winds along the Southern and Eastern Coasts of Africa:—

The augmentation of the number of *areas* in which this *coasting wind* is found, during the months of April, May, and June, shows most distinctly that not only is its prevalence *increased*, but it extends much farther from the shore than at other seasons. It is during the southern autumn, therefore, that the mariner may expect to find this particular wind not only sweeping over a greater extent of surface, but most probably blowing with greater strength.

466. Area included between Lat. 30° and 35° S., Long. 15° and 20° E.

Prevailing wind, E.S.E. (442.)

Other winds, chiefly between S.S.E. and W.N.W., may be expected, but are insignificant as compared with the E.S.E. wind, which blows *outward* from the land.

46*d*. Area included between Lat. 35° and 40° S., Long. 15° and 20° E.

Prevailing winds, S.S.W. and W.S.W.

Frequent winds, N.N.E.—E.S.E.—S.E.—S.S.E.—S.—S.S.W.—S.W.—W.S.W.—W.—W.N.W. (442.) Although the winds in this *area* are so numerous, yet the prevailing direction is towards the Cape: from the great spread of the wind in this *area* it is not at all unlikely that a stream sets from the southward towards the Cape, and that, as it approaches the land, it is divided into two branches, one passing *outwards* toward the N.W., the other *outwards* toward the N.E.; this kind of movement is shown on the CHART DIAGRAM, and it is more or less established from January to June inclusive (*i.e.* during the summer and autumn months), while the sun is receding from the southern tropic.

In anticipation of any remarks to be offered on this *area*, when treating of CHART DIAGRAM No. IV., it may be here observed, that during the months of July, August, and September, the direction of the wind in *area* 46*d* is so altered, as to blow rather *along* than *towards* the land. This fact is worthy of notice, because it may be seen by reference to the four CHART DIAGRAMS that during nine months of the year—between Lat. 35° and 40° S., Long. 15° and 20° E.—the wind blows almost directly towards the southern extremity of the African continent; but before it arrives there, it diverges into two well-marked streams—one towards W.N.W. or N.W., the other towards E.S.E., while there is also, from October to June, a general tendency of the wind *towards* the land.

57*a*. Area included between Lat. 40° and 45° S., Long. 20° and 25° E.

Prevailing wind, W.S.W.

Frequent winds, S.S.W.—E.N.E. (477.)

57*b*. Area included between Lat. 40° and 45° S., Long. 25° and 30° E.

Prevailing wind, W.

Frequent winds, W.S.W.—E.N.E.—N.N.E.—W.N.W.

58*a*. Area included between Lat. 40° and 45° S., Long. 30° and 35° E.

Prevailing wind, S.W.

Frequent winds, W.S.W.—W.—N.N.E. (476.)

47. Area included between Lat. 30° and 40° S., Long. 20° and 30° E.

Prevailing wind, W.N.W.

Frequent winds, W.S.W.—W.—S.S.W.—N.N.E. (441.) The direction of the prevailing wind is that of the general sweep of the so-called N.W. passage winds, while the directions of the frequent winds are more or less in accordance with the sweep round the African coast. The N.N.E. stream is also observable;—there are more calms met with in this than in the neighbouring *areas*.

The sun is now north of the Equator, and the general stream of air is from the *westward*, although easterly winds are sufficiently conspicuous to be embarrassing to vessels running down their easting.

48. Area included between Lat. 30° and 40° S., Long. 30° and 40° E.

Prevailing wind, S.S.W.

Frequent winds, S.—S.W.—W.N.W.—N.N.W.—N.—N.N.E.—N.E.—E.N.E.—E.S.E.—S.S.E. (440.) The direction of the wind in this *area* is very variable, more especially from January to June. It has already been remarked that the general direction is reversed in January, February and March, as compared with October, November and December—being

from the land during the latter period, and to it during the former. In April, May and June, the wind can hardly be said to blow either to or from the land, being somewhat similar in form to that of *area* No. 47. The prevailing wind is from S.S.W., the next in length of duration is exactly opposite, viz., from N.N.E., and the third, from E.N.E. It is clear, therefore, that at least two streams of air prevail here at this season,—that from S.S.W. being part of the African *along-shore* wind, while that from N.N.E. and E.N.E. (tending towards the south) is more strikingly developed in July, August and September, although indications of it exist all the year round. The general westerly current is perceptible in the wind from W.N.W.

49. Area included between Lat. 30° and 40° S., Long. 40° and 50° E.

Prevailing wind, S.S.W.

Frequent winds, N.N.E. — W.N.W. — S.S.E. — S.W. — W.S.W. — W. — N.W. — N.N.W. — N. — N.E. — S. (439.) This *area* during the three months partakes of precisely the same character as *area* 48. The winds are subject to considerable variations, but generally prevalent between S.S.W. and N.N.E., round by west.

39. Area included between Lat. 20° and 30° S., Long. 40° and 50° E.

Prevailing winds, S.S.E. — E.S.E.

Frequent winds, S.S.W. — S. — S.E. — E. — E.N.E. (403.)

38. Area included between Lat. 20° and 30° S., Long. 30° and 40° E.

Prevailing wind, S.

Frequent winds, S.S.W. — S.S.E. — S.E. — E.S.E. — E. — E.N.E. — N.N.W. (404.) The merging of the African *along-shore* wind into the S.E. Trade is so apparent in *areas* 39, 38, that no further remarks are required, and the remaining *areas* will be described in connexion with that Trade-wind.

The South-East Trade-Wind :—

During the three months of April, May and June, the S.E. Trade sweeps over the whole of the northern part of the Southern Indian Ocean, *i.e.* from the parallel of 28° S. to the Equator. In the region under discussion (*viz.*, the westernmost portion of the Indian Ocean) the S.E. Trade has this peculiar modification,—it blows from S.E. to S., with a tendency near the Equator to merge into the *S.W. Monsoon*.

In all the *areas* bounded by the Equator and Lat. 20° S., Long. 35° and 60° E., the prevailing wind is either S.E. or S.S.E.

40. Area included between Lat. 20° and 30° S., Long. 50° and 60° E.

Prevailing wind, E.S.E.

Frequent wind, E.N.E. — E. (402.)

- 32d. Area included between Lat. 15° and 20° S., Long. 55° and 60° E.

Prevailing wind, E.

Frequent winds, E.S.E. — S.E. — S.S.E. — S.W. — S. (366.)

- 32b. Area included between Lat. 10° and 15° S., Long. 55° and 60° E.

Prevailing wind, S.E.

Frequent winds, E. — E.S.E. (366.)

- 32a. Area included between Lat. 10° and 15° S., Long. 50° and 55° E.

Prevailing wind, S.E.

Frequent wind, S.S.E.

31*b*. Area included between Lat. 10° and 15° S., Long. 45° and 50° E.

Prevailing wind, S.E.

Frequent winds, S.S.E.—S.—S.S.W. (367.)

30*d*, 31*c*, 31*a*, 22*d*. Areas included between Lat. 5° and 20° S., Long. 35° and 45° E.

Prevailing wind, S.S.E.

Frequent winds, S. and S.E.

24. Area included between Lat. 0° and 10° S., Long. 50° and 60° E.

Prevailing wind, S.E.

Frequent winds, S.—S.S.E. (330.)

23. Area included between Lat. 0° and 10° S., Long. 40° and 50° E.

Prevailing wind, S.E.

Frequent winds, S.—S.S.E.—E.S.E. (331.)

The easterly winds between Lat. 20° and 40° S., which were so conspicuous during January, February, and March, are only to be recognised as mere frequent or occasional winds in April, May, and June, and by no means as prevalent ones.

The westerly winds south of Lat. 30° S. are only predominant in areas 50, 59, and 60.

50. Area included between Lat. 30° and 40° S., Long. 50° and 60° E.

Prevailing wind, W.N.W.

Frequent winds, N.N.E.—N.—N.N.W.—N.W.—E.S.E.—S.S.E.—S.—S.S.W.—W.S.W. (438.)

59. Area included between Lat. 40° and 50° S., Long. 40° and 50° E.

Prevailing wind, W.S.W.

Frequent winds, S.S.W.—W.N.W.—N.N.W.—N.N.E. (475.)

60. Area included between Lat. 40° and 50° S., Long. 50° and 60° E.

Prevailing wind, W.S.W.

Frequent winds, S.S.W.—W.—W.N.W.—N.W.—N.N.W. (474.)

CHART DIAGRAM No. IV., July, August, September. (The *Southern Winter*.)

The winds at this season admit of the same four-fold arrangement as in CHART DIAGRAM No. II., viz., the winds along the African shore,—the S.E. Trade, the easterly stream,—and the westerly winds forming the so-called N.W. passage winds. Of these, the first three are most strikingly developed, but the last is not so prominent in this part of the Indian Ocean as might be expected.

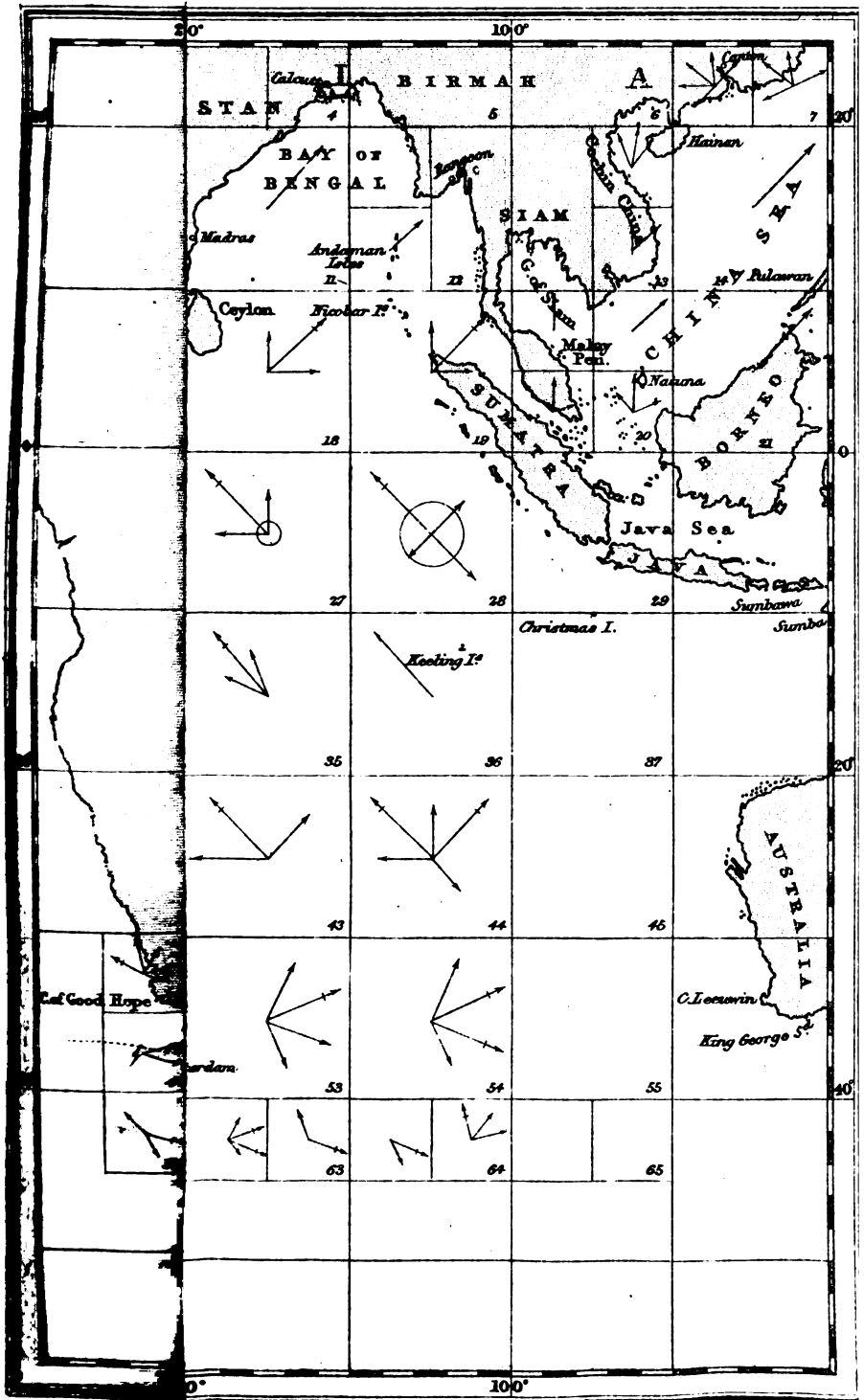
Winds along the Southern and Eastern Coasts of Africa :—

46*b*. Area included between Lat. 30° and 35° S., Long. 15° and 20° E.

Prevailing wind, E.S.E.

Frequent winds, S.E.—S.S.E.—S.S.W.—W.S.W.—W.N.W. (442.)

Upon comparing these frequent winds with others in the same *area* at the various seasons, we find that during the three months, July, August and September, the wind blows more *towards* the land, or from the S. and W., than at the other periods of the year. The following table will place this in a clear light, and show at a glance the winds that may be expected at any season in making the Cape.





Seasons	Spring.	Summer.	Autumn.	Winter.
Prevailing winds ...	S.S.E.	S.S.E. S.S.W.	E.S.E.	E.S.E.
Frequent winds ...	E.S.E. S.E. S.S.W.	E.S.E. S.E.	Unimportant.	 S.E. S.S.E. S.S.W. W.S.W. W.N.W.

46d. Area included between Lat. 35° and 40° S., Long. 15° and 20° E.

Prevailing wind, W.N.W.

Frequent wind, W.S.W. (442.)

The arrangement of the wind in the two *areas* Nos. 46b, 46d, for July, August, and September, is somewhat similar to that for October, November, and December, see CHART DIAGRAM No. I. and p. 29; thus it would appear that during the six months from July to December, inclusive, the same meteorological forces are in operation in the neighbourhood of the Cape. The collected results are as under:—

Seasons	Spring.	Summer.	Autumn.	Winter.
Prevailing winds ...	W.N.W.	E.S.E.	S.S.W. W.S.W.	W.N.W.
Frequent winds.....	S.S.E. S.S.W. W.S.W.	S.S.E. S.S.W. W.S.W. W.N.W.	S.S.E. S.S.W. W.S.W. W.N.W.	 W.S.W.

The prevailing wind of winter and spring appears only as a subordinate wind in the summer and autumn. The similarity between the winds of winter and spring is very apparent, also the difference that exists between these seasons and summer.

56b. Area included between Lat. 40° and 45° S., Long. 15° and 20° E.

Prevailing wind, W.N.W.

Frequent winds, S.E.—S.W.—W.S.W.—W.—N.N.W. (478.)

This *area* has been considered previously under the head of "Westerly winds." In consequence however of the great northerly stream of air, shortly to be noticed, it must now be considered as a part of the wind sweeping along the African Coast. The following Table shows the changes the wind undergoes here at different seasons:—

Seasons	Spring.	Summer.	Autumn.	Winter.
Prevailing winds ...	N.N.W.	W.S.W.	W.S.W.	W.N.W.
Frequent winds.....	 S.W. W.S.W. W. W.N.W.	 W.N.W. N.N.W.	 W.N.W.	S.E. S.W. W.S.W. W. N.N.W.

WINDS OF THE SOUTH INDIAN OCEAN.

47. Area included between Lat. 30° and 40° S., Long. 20° and 30° E.

Prevailing winds, W.S.W.—W.N.W.

Frequent winds, S.S.W.—S.W.—W.—N.N.W.—N.N.E. (441.)

The *wind-stars* of this *area*, in the Board of Trade Charts, from April to December, inclusive, present a somewhat similar appearance to each other, which is greatly in contrast with the flattened *wind-star* of January, February, and March. The *area* is an important one, as both our outward and homeward-bound vessels generally pass through it. The following Table exhibits the variations of wind (at different seasons) that take place within its boundaries:—

Seasons	Winter.	Spring.	Summer.	Autumn.
Prevailing winds ...	W.S.W. W.N.W.	W.S.W.	W.S.W.	W.N.W.
Frequent winds.....	S.S.W. N.N.E. N.N.W. W. S.W.	S.S.W. E.S.E. W.N.W.	S.S.W. S.S.E. E.S.E. E.N.E. W.N.W.	S.S.W. W. W.S.W.

38. Area included between Lat. 20° and 30° S., Long. 30° and 40° E.

Prevailing wind, S.

Frequent winds, S.S.W.—S.S.E.—S.E.—E.S.E.—E.—E.N.E.—N.E.—N.N.E.—N.N.W. (404.)

It will be seen on consulting the CHART DIAGRAM, that the along-shore winds merge into the S.E. Trade as is the case during April, May, and June (see p. 37).

The South-East Trade:—

The *areas* on our diagrams over which the S.E. Trade sweeps during the winter of the southern hemisphere, are nearly the same as those over which it sweeps during the autumn, viz. Nos. 22, 23, 24, 31, 32, and 40. In these *areas*, with the exception of Nos. 31 and 40, the prevailing wind is S.E., in 31 it is S.S.E., and in 40 E.S.E.; the commander may therefore fully reckon upon S.E. breezes (as is well known) during July, August and September, between the Equator and Lat. 20° S., Long. 35° and 60° E., also between Lat. 20° and 30° S., Long. 50° and 60° E.; this, however, forms but a small part of the S.E. Trade that sweeps over the Indian Ocean. No further remarks are necessary on the *areas* above mentioned.

Easterly Winds between Lat. 20° and 30° S.:—

These winds scarcely show during the winter season of the southern hemisphere. The easterly stream of air so well marked between 20° and 30° S. Lat. in the Indian Ocean during April, May, and June, and to which we shall direct further attention, now only occurs as a very subordinate wind. The E.N.E. wind of *area* 39 is the only well-marked remnant of this easterly wind, and an inspection of the CHART DIAGRAM will show that it forms a portion of the stream to the southward, which

was somewhat obscurely indicated during the autumn, and is now strongly developed and most decidedly well marked.

39. Area included between Lat. 20° and 30° S., Long. 40° and 50° E.

Prevailing wind, E.N.E.

Frequent winds, N.N.E.—N.E.—E.—E.S.E.—S.S.E.—S.S.W. (403.)

During the months of April, May, and June, the winds in this *area* (39) certainly form a portion of the great S.E. stream of the Trades; now (July, August, and September) they appear to form a part of the great N.N.E. stream, that sweeps over the southern part of the ocean towards the *south*. The change the direction of the wind undergoes in the winter, as compared with the autumn, will be seen in the following arrangements:—

Autumn.....S.S.W.—S—S.S.E.—S.E.—E.S.E.—E.—E.N.E.

Winter..... S.S.W.— * —S.S.E.— * —E.S.E.—E.—E.N.E.—N.E.—N.N.E.

which shows that the S.E. winds are less numerous, while the northerly winds become more so. The asterisks indicate that the S. and S.E. winds have not been met with in winter to the same extent as in autumn.

The great Southerly Sweep of Winds, South of Africa:—

An inspection of CHART DIAGRAM No. IV., *areas* Nos. 39, 48, 57a, 57b, 58a, 58b, 59a, 59b, and 60a, shows that over these portions of the Indian Ocean, the wind is drawn by some powerful force *towards the south*. While the general body of the S.E. Trade tends towards the N.W., the general body of the air south of Madagascar and the Cape tends towards S.S.W. It is difficult in the present state of our geographical knowledge to point out the locality of such a force. It is not a little remarkable that this stream of air is moving *southerly* in the *winter*, and may perhaps receive its explanation in the large condensation that takes place in the Antarctic Regions at this season. Professor Dove has shown that the condensation of aqueous vapour raises the temperature, and Mr. Hopkins* insists that this raising of the temperature produces the most powerful winds. While, however, this is a very interesting subject for investigation, the great object we have to deal with now is the practical application of it to the wants of the seaman. We shall therefore simply analyse the facts as they stand before us.

Area No. 39, see above.—It will be remarked that a very decided change of wind has taken place in this *area* since the autumnal months of April, May and June; then the prevalent winds formed a portion of the S.E. Trade; now, the *southern* force acts, and it is likely this *area* is situated in the most northern part of the great southerly stream.

48. Area included between Lat. 30° and 40° S., Long. 30° and 40° E.

Prevailing wind, N.N.E.

Frequent winds, N.N.W.—W.N.W.—W.S.W.—S.S.W. (440.) The prevailing wind above is exactly opposite to the prevailing wind of this *area* in April, May and June;—and the wind blows much more from the land than at that season.

57a. Area included between Lat. 30° and 40° S., Long. 20° and 25° E.

Prevailing wind, N.N.E.

Frequent winds, E.—W.S.W.—W.N.W. (477.)

57b. Area included between Lat. 40° and 45° S., Long. 25° and 30° E.

* Hopkins, "On Winds and Rain."

- Prevailing wind, N.N.E.
 Frequent winds, E.S.E.—W.N.W.—S.S.W. (477.)
- 58*a*. Area included between Lat. 40° and 45° S., Long. 30° and 35° E.
 Prevailing wind, N.N.E.
 Frequent winds, E.N.E.—N.E.—N.—S.—W.S.W. (476.)
- 58*b*. Area included between Lat. 40° and 45° S., Long. 35° and 40° E.
 Prevailing wind, N.N.E.
 Frequent winds, N.—W.N.W. (476.)
- 59*a*. Area included between Lat. 40° and 45° S., Long. 40° and 45° E.
 Prevailing winds, N.N.E.—N.N.W.
 Frequent winds, W.N.W.—W.S.W. (475.)
- 59*b*. Area included between Lat. 40° and 45° S., Long. 45° and 50° E.
 Prevailing wind, N.N.E.
 Frequent winds, N.N.W.—E.N.E.—W.S.W. (475.)
- 60*a*. Area included between Lat. 40° and 45° S., Long. 50° and 55° E.
 Prevailing wind, N.N.E.
 Frequent winds, S.S.W.—W.N.W.—N. (474.)

The Westerly Winds South of Lat. 30° S. :—

In consequence of the great southerly sweep just indicated, the *areas* over which the westerly winds blow are greatly reduced in number; it will be sufficient here to notice the prevalent and frequent winds of these *areas*.

49. Area included between Lat. 30° and 40° S., Long. 40° and 50° E.
 Prevailing wind, N.N.W.
 Frequent winds, N.N.E.—W.N.W.—W.S.W.—S.S.W. (439.)
50. Area included between Lat. 30° and 40° S., Long. 50° and 60° E.
 Prevailing wind, W.N.W.
 Frequent winds, N.N.W.—W.S.W.—S.S.W. (438.)
- 60*b*. Area included between Lat. 40° and 45° S., Long. 55° and 60° E.
 Prevailing wind, W.N.W.
 Frequent winds, N.N.W.—N.W.—W.S.W. (474.)

¶ 27. It remains now to discuss, briefly, that part of the central and northern Indian Ocean over which the MONSOONS are prevalent—Lat. 10° S. to 30° N., Long. 50° to 100° E.

CHART DIAGRAM No. I., October, November, December.

The *S.E. Trade* is now the general wind between Lat. 30° S. and 5° S.

A brief remark may here be made on a very interesting phenomenon that takes place in connexion with the streams of air, situated more or less in the neighbourhood of the Calms of Capricorn. It is the divergence of the S.E. and E. streams between 20° and 30° S. into two well-defined branches,—the S.E. into the branch flowing northward, past Madagascar, and along the African Coast to 10° N., where it becomes a S.W. wind—and the E. into the branch flowing southward, past the southern extremity of Madagascar as an E.N.E. wind, off the extremity of Africa as a N.N.E. wind, and finally becoming N.N.W. in *areas* 58 and 59. It would appear that it is the African Coast that *turns the two streams aside*, but under what circumstances and to what region of rarefaction is not quite clear.

The intimate connexion that subsists between the winds in the region bounded by the parallels of 10° S. and 10° N., Long. 40° to 100° E., necessitates a separation of that part of the ocean from the more northerly *areas*.

Regions of Westerly and South-Westerly Winds :—

In *areas* 15, 16, 17, 18, 19, 23, 24, 25, 26, 27, and 28, there are several distinct systems of wind—the most marked being a Westerly stream directed towards the Indian Archipelago (see *areas* 17, 18, 19, 25, 26, 27, and 28). A N.Wly. stream of air is also directed towards the Equator, and approaches, at times, very close to the S.E. Trade, and occurs likewise in *areas* 15, 16, 17, 18, and 19. A S.W. wind is not unfrequent in *areas* 15, 16, 17, 18, 19, 25, 26, 27, and 28; and a N.E. wind in *areas* 15, 16, 18, 19, 23, and 24. This is clearly the N.E. Monsoon, which penetrates as far as the parallel of Cape Corrientes during the southern spring.

15. Area included between Lat. 10° and 0° N., Long. 50° and 60° E.

Prevailing wind, N.E.

Frequent winds, S.W.—W.—N.W.—N. (31.) The frequent S.W. wind is evidently the closing portion of the S.W. Monsoon, and may be looked for mostly in October.

16. Area included between Lat. 10° and 0° N., Long. 60° and 70° E.

Prevailing wind, N.E.

Frequent winds, S.W.—N.W.—N. (30.) The N.W. wind is much more prevalent in this *area* than in No. 15.

17. Area included between Lat. 10° and 0° N., Long. 70° and 80° E.

Prevailing wind, N.W.

Frequent winds, S.W.—W.—N.N.W.—N. (29.) It is in this *area* that the Westerly wind is first perceptible, north of the Equator. The N.E. Monsoon is scarcely experienced here; the S.W. is also much subdued,—the prevailing wind being N.W., which blows more or less during the three months along the Malabar coast.

18. Area included between Lat. 10° and 0° N., Long. 80° and 90° E.

Prevailing wind, W.

Frequent winds, S.W.—N.W.—N.—N.E.—E. (28.) Approaching the Indian Archipelago there is a much greater play of the winds.

19. Area included between Lat. 10° and 0° N., Long. 90° and 100° E.

Prevailing wind, W.

Frequent winds, S.W.—N.W.—N.—N.E.—E.—S.E. (27.)

25. Area included between Lat. 0° and 10° S., Long. 60° and 70° E.

Prevailing wind, W.

Frequent winds, S.E.—S.W.—N.W.—E.S.E. (329.) Calms are frequent. It is in this *area*, south of the Equator, proceeding from west to east, that there is the earliest indications of the westerly stream towards the Indian Archipelago.

26. Area included between Lat. 0° and 10° S., Long. 70° and 80° E.

Prevailing wind, S.W.

Frequent winds, W.—W.N.W.—S.E. (328.) Of these frequent winds that from the west is nearly as prevalent as the S.W. Calms are less frequent.

27. Area included between Lat. 0° and 10° S., Long. 80° and 90° E.

Prevailing winds, W.—S.E.

Frequent winds, S.W.—N.W.—E. (327.) In this *area* the S.E. Trade is quite as prevalent as the westerly wind, but it is characterized by the greatest number of calms that are met with between the Equator and 10° S. Lat.

28. Area included between Lat. 0° and 10° S., Long. 90° and 100° E.

Prevailing wind, S.E.

Frequent winds, S.S.E.—S.—S.W.—W.—N.W.—E. (326.)

The S.E. Trade is by far the most prevalent, then the streams from S.S.E. and S.W.; with the exception of the easterly and westerly streams of air, the wind blows mostly from the *South*. Calms are very prevalent.

The North-East Monsoon:—

It will be seen that the N.E. Monsoon blows, at least during a portion of the three months (October, November, December), a N.E. wind from the northern parts of the Bay of Bengal and the Arabian Sea, towards the Equator. The Peninsula of Hindostan separates the Northern Indian Ocean into two parts;—in the eastern portion the Monsoon *blows as far as the Equator*. Between the Equator and 10° S. lies the region of calms—and here it is that a very remarkable arrangement of the winds obtains. The N.E. Monsoon north, and the S.E. Trade south of the Equator, are similarly disposed to the N.E. and S.E. Trades of the Atlantic, which meet under the “Cloud-ring.” While, however, we have the N.E. Monsoon thus blowing towards the Calm Belt, there is also a *north-west* wind meeting the S.E. Trade in the same region. It is in the western portion of the Indian Ocean that the N.E. Monsoon crosses the Equator;—it appears to blow steadily from the head of the Arabian Sea, not only in the open ocean, but along the coasts of Arabia and Africa, penetrating the Mozambique Channel as far as Cape Corrientes. It is only on the western shores of Hindostan that the N.E. Monsoon is interrupted by the N.W. wind.

- 1d. Area included between Lat. 25° and 20° N., Long. 55° and 60° E.

Prevailing wind, E.

Frequent winds, N.E.—S.—S.W. (103.)

- 2d. Area included between Lat. 25° and 20° N., Long. 65° and 70° E.

Prevailing wind, N.E. (102.)

8. Area included between Lat. 20° and 10° N., Long. 50° and 60° E.

Prevailing wind, N.E.

Frequent winds, E.—S.W.—W. (67.)

9. Area included between Lat. 20° and 10° N., Long. 60° and 70° E.

Prevailing wind, N.E.

Frequent wind, N.N.E. (66.)

- 10a. Area included between Lat. 20° and 15° N., Long. 70° and 75° E.

Prevailing wind, N.E.

Frequent wind, N.W. (65.) The N.W. wind is well marked.

11. Area included between Lat. 20° and 10° N., Long. 80° and 90° E.

Prevailing wind, N.E.

Frequent wind, N.N.E. (64.)

12. Area included between Lat. 20° and 10° N., Long. 90° and 100° E.

Prevailing wind, N.E.

Frequent winds, E.—N. (63.)

In this *area* the wind blows from the land.

The N.W. Stream on the West of Hindostan :—

10a. See above.

10. Area included between Lat. 15° and 10° N., Long. 70° and 75° E.

Prevailing wind, N.W.

Frequent wind, N. (65.)

10d. Area included between Lat. 15° and 10° N., Long. 75° and 80° E.

Prevailing wind, N.W.

Frequent wind, S. (65.)

Winds at the Head of the Arabian Sea :—

1b. Area included between Lat. 30° and 25° N., Long. 55° and 60° E.

Prevailing winds, N.W.—E.—W.—S.

Frequent winds, S.S.E.—S.W. (103.)

In this *sub-area*, during the three months, not only is there a very great play of winds, but frequent calms; it is generally in similar localities that we find such great diversities. It would appear to be very difficult to reduce these winds to any well-recognised rule, such as the Trades and Monsoons.

1a. Area included between Lat. 30° and 25° N., Long. 50° and 55° E.

Prevailing wind, W.

Frequent wind, N.W. (103.)

In this *sub-area* there is a N.W. wind nearly as prevalent as the W. wind; it does not, however, appear to form part of the stream sweeping the west coast of Hindostan, being separated from it by the N.E. Monsoon.

2c. Area included between Lat. 25° and 20° N., Long. 60° and 65° E.

Prevailing wind, N.

Frequent winds, N.E.—W. (102.)

The wind in this *sub-area* appears to be a part of the N.E. Monsoon.

Winds at the Head of the Bay of Bengal :—

4d. Area included between Lat. 25° and 20° N., Long. 85° and 90° E.

Prevailing wind, N.

Frequent wind, N.E. (100.)

5c. Area included between Lat. 25° and 20° N., Long. 90° and 95° E.

Prevailing wind, N.

Frequent winds, N.N.W.—N.W. (99.)

The prevalent wind in *areas* 4d and 5c is North, which merges into the Monsoon, while the frequent winds blow along-shore.

CHART DIAGRAM No. II., January, February, March.

The South-East Trade :—

During this quarter of the year the S.E. Trade attains its maximum polar development, but it scarcely reaches 10° S. except on the eastern side of the Indian Ocean, hence we may say it is fully developed over twenty degrees of latitude—viz., from 31° to 11° S. It is found to the northward of 10° S., in *areas* 26, 27, and 28, but

owing to the more general prevalence of a westerly current of air between the Equator and 10° S., it ranks only as a frequent wind.

Region of the N.W. Monsoon :—

Between the Equator and 10° or 11° S. the N.W. Monsoon is in full operation during Jan., Feb., and March;—in *areas* 24 and 25 blowing from the N.W., but in *areas* 26, 27, and 28 having a more westerly direction.

25. Area included between Lat. 0° and 10° S., Long. 60° and 70° E.

Prevailing wind, N.W.

Frequent winds, N.—N.N.W.

Occasional wind, W. (329.)

26. Area included between Lat. 0° and 10° S., Long. 70° and 80° E.

Prevailing wind, W.

Frequent winds, N.—N.N.W.—S.E.—S.W.—N.N.E.—N.W.—W.N.W.—N.E.—W.S.W. (328.)

27. Area included between Lat. 0° and 10° S., Long. 80° and 90° E.

Prevailing wind, W.

Frequent winds, N.W.—S.W.—W.S.W.—S.E.—W.N.W.—E. (327.)

28. Area included between Lat. 0° and 10° S., Long. 90° and 100° E.

Prevailing wind, W.

Frequent winds, N.W.—S.W.—S.E.—W.N.W.—E.—W.S.W. (326.)

Calms are of very frequent occurrence in *areas* 27 and 28.

Region of the N.E. Monsoon :—

The N.E. Monsoon, during January, February, and March, is prevalent over all the northern part of the Indian Ocean.

15. Area included between Lat. 0° and 10° N., Long. 50° and 60° E.

Prevailing wind, N.E.

Frequent winds, N.N.E.—N. (31.)

16. Area included between Lat. 0° and 10° N., Long. 60° and 70° E.

Prevailing wind, N.E.

Frequent winds, N.N.E.—N.—Occasional wind, N.W. (30.)

17. Area included between Lat. 0° and 10° N., Long. 70° and 80° E.

Prevailing wind, N.

Frequent winds, N.E.—N.N.E.—Occasional winds, N.W.—S.W. (29.)

18. Area included between Lat. 0° and 10° N., Long. 80° and 90° E.

Prevailing wind, N.E.

Frequent winds, N.—E.—N.N.E.—E.N.E. (28.)

19. Area included between Lat. 0° and 10° N., Long. 90° and 100° E.

Prevailing wind, N.E.

Frequent winds, N.W.—E.—N.—S.W.—S.E.—W.—E.N.E.—N.N.E.—S. (27.) Calms are very common in this *area*: from the relative size of the lines in the wind-star of the Board of Trade Wind Chart, the wind during the quarter is, more or less, all round the compass.

8. Area included between Lat. 10° and 20° N., Long. 50° and 60° E.

Prevailing wind, N.E.

Frequent winds, E.—E.N.E.—N.N.E.—Occasional wind, S.E. (67.)

9d. Area included between Lat. 10° and 15° N., Long. 65° and 70° E.

- Prevailing wind, N.
 Frequent winds, N.E.—N.W. (66.)
11. Area included between Lat. 10° and 20° N., Long. 80° and 90° E.
 Prevailing wind, N.E.
 Frequent winds, E.—N.—E.N.E.—N.N.E.
 Occasional wind, S.W. (64.)
- 12a. Area included between Lat. 15° and 20° N., Long. 90° and 95° E.
 Prevailing wind, W.S.W.
 Frequent winds, N.—W.—S.W.—N.W.
 Occasional wind, N.E. (63.)
- 12c. Area included between Lat. 10° and 15° N., Long. 90° and 95° E.
 Prevailing wind, N.
 Frequent winds, N.E.—N.N.E. (63.)
- 4d. Area included between Lat. 20° and 25° N., Long. 85° and 90° E.
 Prevailing wind, N.E.
 Frequent winds, N.—N.N.E.—W.—S.W.—N.N.W.—S. (100.)

The N. and N.W. Streams of Air on the West of Hindostan :—

- 10a. Area included between Lat. 15° and 20° N., Long. 70° and 75° E.
 Prevailing wind, N.
 Frequent winds, N.W.—N.N.W. (65.)
- 10c. Area included between Lat. 10° and 15° N., Long. 70° and 75° E.
 Prevailing winds, W.—N.N.W.
 Frequent winds, N.E.—N.—N.W. (65.) Occasionally a S.E. wind is experienced.
- 10d. Area included between Lat. 10° and 15° N., Long. 75° and 80° E.
 Prevailing wind, N.W.
 Frequent winds, N.N.W.—N. (65.)

Winds at the Head of the Arabian Sea :—

- 2c. Area included between Lat. 20° and 25° N., Long. 60° and 65° E.
 Prevailing wind, S.W.
 Frequent winds, W.—W.S.W.—S.S.W.—S.E.
 Occasional wind, N.W. (102.) Calms frequent.
- 2d. Area included between Lat. 20° and 25° N., Long. 65° and 70° E.
 Prevailing winds, N.W.—W.N.W.
 Frequent winds, W.—S.W.—S. (102.)

During the six months, April to September, the *S.E. Trade-wind* reaches the Equator, being known as the *S.E. Monsoon* in its more northern portion, and thence gradually merging into the *S.W. Monsoon*. Calms are less frequent during this period than during the other six months, viz. from September to April.

CHART DIAGRAM No. III., April, May, June.

The South-West Monsoon :—

- 1d. Area included between Lat. 25° and 20° N., Long. 55° and 60° E.
 Prevailing wind, S. (103.)

- 2a. Area included between Lat. 25° and 20° N., Long. 60° and 65° E.
Prevailing wind, S.W. (102.)
- 4d. Area included between Lat. 25° and 20° N., Long. 85° and 90° E.
Prevailing wind, S.W.
Frequent wind, S. (100.)
8. Area included between Lat. 20° and 10° N., Long. 50° and 60° E.
Prevailing wind, S.W.
Frequent winds, S.E.—S.—E. (67.) Calms frequent.
11. Area included between Lat. 20° and 10° S., Long. 80° and 90° E.
Prevailing wind, S.W.
Frequent winds, S.—S.S.W. (64.)
- 12a. Area included between Lat. 20° and 15° N., Long. 90° and 95° E.
Prevailing wind, S.W. (63.)
- 12c. Area included between Lat. 15° and 10° N., Long. 90° and 95° E.
Prevailing wind, S.W. (63.)
15. Area included between Lat. 10° N. and Equator, Long. 50° and 60° E.
Prevailing wind, S.W.
Occasional winds from N.E. to N.W. (30.)
16. Area included between Lat. 10° N. and Equator, Long. 60° and 70° E.
Prevailing wind, W.
Frequent winds, W.N.W.—S.W. (30.) Calms frequent.
17. Area included between Lat. 10° N. and Equator, Long. 70° and 80° E.
Prevailing wind, W.
Frequent winds between N.W. and S.W. (29.) The winds in the two areas 16 and 17 seem to be connected with the north-westerly stream of air on the west side of the Indian peninsula.
18. Area included between Lat. 10° N. and Equator, Long. 80° and 90° E.
Prevailing wind, S.W.
Frequent winds between W. and S.
Occasional winds between S.E. and N.E. (28.)
19. Area included between Lat. 10° N. and Equator, Long. 90° and 100° E.
Prevailing wind, S.W.
Frequent winds between W. and S.
Occasional wind, S.E. (27.)

The N.W. and W. Winds on the West Side of Hindostan:—

9. Area included between Lat. 20° and 10° N., Long. 60° and 70° E.
Prevailing wind, N.W.
Frequent winds, S.—W.S.W.—S.; occasionally N.E. (66.)
- 10a. Area included between Lat. 20° and 15° N., Long. 70° and 75° E.
Prevailing wind, N.N.W.
Frequent winds, S.W.—N.W. (65.)
- 10c. Area included between Lat. 15° and 10° N., Long. 70° and 75° E.
Prevailing wind, W.
Frequent winds between S.W. and N. (65.)
- 10d. Area included between Lat. 15° and 10° N., Long. 75° and 80° E.
Prevailing wind, N.W.
Frequent winds between S.W. and N. (65.)

CHART DIAGRAM No. IV., July, August, September.

The S.W. Monsoon :—

- 1d. Area included between Lat. 25° and 20° N., Long. 55° and 60° E.
Prevailing wind, N.
Frequent winds, S.E.—S.W. (103.)
- 2c. Area included between Lat. 25° and 20° N., Long. 60° and 65° E.
Prevailing wind, S.W.
Frequent wind, W.S.W. (102.)
- 2d. Area included between Lat. 25° and 20° N., Long. 65° and 70° E.
Prevailing wind, W. (102.)
- 4d. Area included between Lat. 25° and 20° N., Long. 85° and 90° E.
Prevailing wind, S.W. (100.)
- 8b. Area included between Lat. 20° and 15° N., Long. 55° and 60° E.
Prevailing wind, S.W. (87.)
- 8c. Area included between Lat. 15° and 10° N., Long. 50° and 55° E.
Prevailing wind, S.
Frequent winds, between S.W. and S.S.E.
Occasional wind, N.E. (67.)
- 8d. Area included between Lat. 15° and 10° N., Long. 55° and 60° E.
Prevailing wind, S.W. (67.)
9. Area included between Lat. 20° and 10° N., Long. 60° and 70° E.
Prevailing wind, W.
Frequent winds, S.W.—W.N.W. (66.)
- 10a. Area included between Lat. 20° and 15° N., Long. 70° and 75° E.
Prevailing wind, W.
Frequent winds, W.N.W.—W.S.W. (65.)
- 10c. Area included between Lat. 15° and 10° N., Long. 70° and 75° E.
Prevailing wind, N.W.
Frequent winds, W.N.W.—W. (65.)
- 10d. Area included between Lat. 15° and 10° N., Long. 75° and 80° E.
Prevailing wind, N.W.
Frequent winds, S.E.—W.—S. (65.)
11. Area included between Lat. 20° and 10° N., Long. 80° and 90° E.
Prevailing wind, S.W. (64.)
- 12a & c. Area included between Lat. 20° and 10° N., Long. 90° and 95° E.
Prevailing wind, S.W. (63.) In the northern part of this area the wind is more westerly; in the southern part more southerly.
15. Area included between Lat. 10° N. and Equat., Long. 50° and 60° E.
Prevailing wind, S.W. (31.)
16. Area included between Lat. 10° N. and Equat., Long. 60° and 70° E.
Prevailing wind, W.
Frequent winds, S.W.—S. (30.)
17. Area included between Lat. 10° N. and Equat., Long. 70° and 80° E.
Prevailing wind, N.W.
Frequent winds, W.N.W.—W.—S.W. (29.)
18. Area included between Lat. 10° N. and Equat., Long. 80° and 90° E.

Prevailing wind, S.W.

Frequent winds, between W. and S. (28.)

19. Area included between Lat. 10° N. and Equat., Long. 90° and 100° E.

Prevailing wind, S.W.

Frequent winds, between W. and S. (27.)

The N.W. stream of air on the West Coast of Hindostan is still present (see area 10); but now (July to September) it is not the prevailing wind to the same extent as in the previous quarter.

These remarks (pp. 25-50) sufficiently explain CHART DIAGRAMS Nos. I., II., III., and IV., of the winds of the Indian Ocean.

28. MAURY on the Monsoons.—With the view of investigating certain monsoon-phenomena—when and where each wind (N.E. or S.W.) begins and terminates, as well as the duration of each—Maury examined his abstract logs, and from 11,697 observations made at sea, between the meridians of 80° and 85° E., and from Calcutta to the Equator, constructed the following table, illustrative of what he aptly terms the *march of the Monsoons* :—

MONTHS.	BANDS OF LATITUDE.										MONTHLY MEAN.	
	22° to 20° N.		20° to 15° N.		15° to 10° N.		10° to 5° N.		5° N. to Eq.			
	N.E.	S.W.	N.E.	S.W.	N.E.	S.W.	N.E.	S.W.	N.E.	S.W.	N.E.	S.W.
	Days.	Days.	Days.	Days.	Days.	Days.	Days.	Days.	Days.	Days.	Days.	Days.
October	9	6	12	6	8	10	6	16	4	14	8	10
November	11	6	25	2	21	2	10	6	5	14	14	6
December	27	0	26	1	24	1	15	3	12	11	21	3
January	17	6	21	2	23	1	20	1	19	3	20	3
February	11	11	13	6	19	3	22	1	16	2	16	5
March	4	18	7	15	18	5	13	0	15	2	11	8
April	2	24	2	22	6	21	6	11	4	14	4	17
May	1	26	1	24	3	29	1	23	0	19	1	23
June	0	28	1	27	0	12	1	25	0	24	0	27
July	2	24	1	27	0	30	0	28	0	24	1	27
August	0	28	1	24	0	24	1	22	0	18	0	23
September	6	14	1	18	0	23	0	26	1	18	2	20
Mean Days*	81	173	104	157	119	149	92	151	62	156	90	155

And, taking into consideration the causes of these winds, MAURY says that† “the S.W. Monsoons commence at the north, and *back down*, or work their way towards the south. Thus they set in earlier at Calcutta than they do at Ceylon, and earlier at Ceylon than they do at the Equator. The average rate of travel, or *backing down* to the south, as seamen express it, is from 15 to 20 miles a day. It takes the S.W.

* These means for the duration of each wind are obtained as follows: for N.E. = $9+11+27+17+11+6=81$ days; for S.W. = $11+18+24+26+28+24+28+14=173$ days.

† “Physical Geography of the Sea,” 11th edition, revised, chap. vi. §§ 684-689.

Monsoon six or eight weeks to *back down* from the tropic of Cancer to the Equator." And again—"As the vernal equinox approaches, the heat of the sun begins to play upon the steppes and deserts of Asia with power enough to rarefy the air, and cause an uprising sufficient to produce an indraught thitherward from the surrounding regions. The air that is now about to set off to the south as the N.E. Monsoon, is thus arrested, turned back, and drawn into the place of low-barometer as the S.W. Monsoon. These plains become daily more and more heated, the sun more and more powerful, and the ascending columns more and more active; the area of inrushing air, like a circle on the water, is widened, and thus the S.W. Monsoons, *backing down* towards the Equator, drive the N.E. Monsoons from the land, replace them, and gradually extend themselves out to sea."

29. The Table on p. 50 establishes what has already been observed, the greater persistency of the S.W. Monsoon over the N.E., but it is to be regretted that MAURY should have selected the western side of the Bay of Bengal as an illustration of his theory of the *backing down* of the wind, inasmuch as the Monsoons undergo a greater modification from the *lay of the land* on that side than in any other part of the N. Indian Ocean; and again, during the change of the Monsoon the breezes there by night are from S.W. to W., by day from S. to E.; and these have evidently been confounded with the season of the S.W. Monsoon.* That these winds do penetrate far into the land is certain, but that their direction is very considerably modified thereby is also evident from the following observation made at Dum-dum, near Calcutta:—

Months.	Approximate Direction of Wind in the Order of Frequency.	Mean Direction.
October	N.W.; S.W.; N.E.; N.; W.; S.E.; S.; E.	N. 46° W.
November	N.W.; N.; N.E.; W.	N. 19° W.
December	N.W.; N.; N.E.; W.	N. 25° W.
January	N.W.; N.; N.E.; W.; S.W.; E.; S.E.	N. 23° W.
February	N.W.; W.; E.; N.E.; S.W.; N.; S.E.; S.	N. 37° W.
March	S.W.; S.; S.E.; W.; E.; N.E.; N.W.	S. 10° W.
April	S.; S.W.; S.E.; W.	S. 17° W.
May	S.; S.E.; S.W.; E.	S. 12° E.
June	S.W.; E.; S.; S.E.	S. 11° E.
July	S.E.; S.W.; S.; E.; W.	S. 12° E.
August	S.W.; E.; S.E.; S.; W.; N.E.	S. 25° E.
September	S.E.; S.W.; E.; N.E.; S.; W.	S. 31° E.

In the winter months there appears to be a marked predominance of N.W. winds; so that in December the mean direction is N.N.W.: this predominance gradually diminishes, and in March the winds blow more frequently from the south than from the north,—the west winds still retaining their superiority over those from the east: this relation ceases, in its turn, in proportion as the meridian altitude of the sun increases; and at the summer solstice the wind blows from the S.S.E., a direction dia-

* That uncertainty as to the season does prevail is evident from the following remarks, extracted from HORSBURGH:—

(Madras). "During the S.W. Monsoon, particularly in the early part of it, after the 1st of February," &c.

(Hoogly). "When the southerly winds begin to have strength, during the latter part of March, or early in April," &c. &c. "North-westers are liable to happen near the entrance and in the river Hoogly about the changes of the Monsoon, particularly in April and May," &c. &c.

metrically opposite to that of the winter. The winds turn to the west when the declination of the sun is more southerly; and in winter they settle, without variation, in the west. It will not fail to be observed that, generally, the winds are far too variable at the head of the Bay of Bengal to indicate when either Monsoon commences,—though the two seasons, in the main, are sufficiently well marked.

The influence of the declination of the sun upon the Monsoons has long been recognised on the west coast of Hindostan; as the sun arrives later at the zenith of places situated more northerly, so the S.W. wind also blows later at these places: at Anjenga, in Lat. $8\frac{1}{2}^{\circ}$ N., it commences as early as the middle of April; at Bombay, in Lat. 19° N., not until the middle of May.* On the coast of Aracan it is not recognised to commence earlier than May. Such being the case, it is difficult to see how this Monsoon can *back* down on the east coast of Hindostan, and yet more difficult to understand the influence of the “steppes and deserts” at the back of the Himalaya range (see p. 51), for these, together with the desert region behind the Hindoo Koosh, should, on MAURY’s supposition, be more potential for Bombay than for Calcutta. Nor, if MAURY is correct, could the S.W. Monsoon be any longer regarded as the prolongation of the S.E. wind of the S. tropic into the N. tropic, as the N.W. wind is the prolongation of the N.E. from the N. to the S. tropic. The heated land unquestionably has an influence, but the sun must heat the tropical land bounding the Northern Indian Ocean before its effect can be felt on steppes and deserts in extra-tropical regions. There appears then no reason to alter the opinion already formed (pp. 18, 19) on the production of the Monsoons.

30. As showing the predominance of the S.W. Monsoon over the N.E., as well as the great variableness of the latter, the following Table, deduced from MAURY’s charts, and the direction of the wind determined on the formulæ of LAMBERT, will be both useful and interesting to the navigator:—

MONTHS.	NORTH LATITUDE.					S. LATITUDE.	
	25° to 20°	20° to 15°	15° to 10°	10° to 5°	5° to 0°	0° to 5°	5° to 10°
October . . .	E.S.E.	N.E.	S.S.E.	S.W.	W.S.W.	S.	E.S.E.
November . .	N.N.W.	N.N.E.	N.E.	N.E.	W.S.W.	W.S.W.	N.N.E.
December . .	N.N.E.	N.N.E.	N.E.	E.N.E.	N.N.W.	W.	W.
January . . .	N.E.	N.E.	N.E.	N.E.	N.N.E.	W.	S.
February . .	W.N.W.	W.S.W.	N.E.	N.E.	N.N.E.	W.N.W.	S.W.
March	W.S.W.	N.N.E.	N.E.	N.E.	N.E.	W.N.W.	S.W.
April	S.S.W.	S.S.W.	S.	S.S.E.	S.W.	W.N.W.	S.W.
May	S.S.W.	S.S.W.	S.S.W.	S.W.	S.W.	S.W.	S.E.
June	S.S.W.	S.W.	S.W.	S.W.	S.W.	S.S.E.	S.E.
July	S.S.W.	S.W.	W.S.W.	S.W.	S.S.W.	S.S.W.	S.E.
August	S.S.W.	S.W.	S.W.	S.W.	S.W.	S.	S.E.
September . .	S.S.W.	S.S.W.	S.W.	S.W.	S.W.	S.E.	E.S.E.

* CAPPER, “On Winds and Monsoons.” See also HORSBURGH: “The S.W. Monsoon (on the western side of Hindostan) sets in earlier on the southern part of the coast than at Bombay, the difference in time being frequently fifteen or twenty days between Cape Comorin and that island.”
 * * * “Between Cape Comorin and Anjenga the S.W. Monsoon or stormy weather from the S.W. may be expected to commence between the 20th and 28th of May, between Mount Dilly and Goa early in June, and at Bombay from the 6th to the 15th of June.”



BY C. MELDRUM ESQ.^R



31. This general review of the winds of the Indian Ocean may be aptly closed with an extensive abstract from MR. MELDREUM'S* excellent paper—**A Meteorological Journal of the Indian Ocean, FOR MARCH, 1853, WITH A SUMMARY OF THE RESULTS OF THE OBSERVATIONS.** It is based on observations made at Mauritius, and from information derived from the Logbooks of 30 vessels, whose tracks were across the Indian Ocean during that month.

The space over which these vessels were scattered extended, generally, from 20° N. and 39° S. to 90° E. and 15° E., in a belt from 20° to 30° in longitude, stretching obliquely across the ocean, from the southward of the Cape of Good Hope to the Bay of Bengal.

Very few of the observations were made to the westward of 60° and northward of 15° S., or to the eastward of 75° and southward of 15° S.

With so few and imperfect data it is useless to expect to obtain precise and accurate results respecting almost any of the meteorological phenomena that presented themselves in the space within which the observations were taken; while with regard to other parts of the ocean, the Journal affords no data whatever.

But information far short of absolute correctness may be of no small practical utility, as well as of scientific interest. Observations which are not sufficiently numerous or precise for the complete investigation of a phenomenon may, nevertheless, place its existence beyond all doubt, and afford a rough view of the laws which it obeys. A general knowledge of this sort serves to point out the direction to be given to future observations, each fresh accumulation becoming the basis for another step in advance, till truth is at length fully attained.

The Limits of the S.E. Trade-Wind :—

During the first five or six days of the month the S.E. Trade-wind extended much nearer to the Equator on the eastern than on the western side of the ocean.

If the positions of the vessels, and the direction of the winds, on each of those days be projected on a chart, the equatorial limits will be found to have stretched obliquely across the ocean, from the vicinity of Mauritius to 7° or 8° S. and 85° E.

During the next seven days the equatorial limits gradually receded still further to the southward, on both sides of the ocean, but with nearly the same relative distances from the Equator, till the Trade almost entirely disappeared.

On the 13th, 14th, and 15th, calms prevailed over several hundred miles around Mauritius, the Trade setting in far to the southward and westward of that tract, and appearing also to the northward and eastward of it.

From the 14th to the end of the month the Trade seems to have approached as near to the Equator on the western as on the eastern side of the ocean, but to have blown more strongly and steadily on the latter.

The mean equatorial and polar limits for the month were 11° S. and 29° S. respectively, giving a mean breadth, in latitude, of eighteen degrees.

From the 1st to the 13th the western equatorial limits were, on an average, 19° 20' S., or about eight degrees more to the south than the mean limits for the month. The mean western polar limits were 29° 17' S.

The mean eastern equatorial limits for the same time were 11° 24' S., leaving a

* CHARLES MELDREUM, Esq., M.A., Secretary of the Mauritius Meteorological Society. This work was originally published in the colony, and has since been reprinted by the Board of Trade. Both issues are now scarce.

difference, between them and the western limits, of also eight degrees: the mean eastern polar limits, so far as they can be ascertained, were about 25° S.

From the 12th to the 16th, inclusive, the Trade-wind appeared, on the western side, as far south as 38° ; that is, nine degrees beyond the mean polar limits.

After the 16th it gradually receded, till, by the 25th, the polar limits were in the vicinity of Mauritius.

But on the 30th it is again found as far south as Lat. $33^{\circ} 4'$ S.

We thus perceive several distinct vibrations of the Trade-wind in the course of the month on its equatorial and polar borders. The western equatorial limits gradually receded from about 16° S. on the 1st and 2nd, to 26° S. on the 12th, and there seems, upon the whole, to have been, at the same time, a similar contraction of the polar limits, till at length the Trade almost entirely disappeared. It is then found to have suddenly extended both north and south over 18° in the one direction and 18° in the other. After the 16th, again, the polar limits began gradually to recede, till they at length reached the vicinity of Mauritius. And then, on the 30th, they are once more found far to the southward, as if about to undergo a similar contraction.

It would seem that the northern limits approached nearest to the Equator between the meridians of 65° and 75° .

Deflection of the S.E. Trade-Wind to North and N.E. on its Equatorial Borders :—

As a general rule the S.E. Trade, on approaching the Equator, is deflected to N. and N.E., forming a S. and then S.W. wind, which lasts from a few hours to several days, according to the longitude. This is observed on almost every day of the month.

From a comparison of the observations, it appears that this deflection of the S.E. Trade to N. and N.E. takes place to the eastward of 58° E. only, and that the space over which the S.W. wind blows is greater on the eastern than on the western side of the ocean, gradually narrowing from about 86° E. to 60° and 58° E.

The extreme eastern limit for the month is $86^{\circ} 39'$ E., and the extreme western $58^{\circ} 35'$ E., the limits in latitude being $6^{\circ} 1'$ N. and $15^{\circ} 43'$ S.

The mean southern limits are $8^{\circ} 32'$ S., and the mean northern limits $2^{\circ} 4'$ S.

The average breadth in latitude is $5^{\circ} 16'$, and in longitude $16^{\circ} 4'$.

Between the meridians of 75° and 85° the average breadth in latitude is about 10° , but it diminishes towards the meridian of Mauritius.

The prevailing direction is W.S.W., and the mean direction about S.W. by W.

The mean daily force is 2.5.

The wind was lightest from the 1st to the 10th, and strongest from the 21st to the 29th, when it again became light.

Seventy-five observations contributed to the above data.

Deflection of the S.E. Trade to S. and S.W. on its Southern Borders :—

One of the most remarkable features presented by the charts is the constant prevalence of a N.E. wind on the south-western limits of the Trade-wind.

There is hardly a day on which this N.E. wind is not found somewhere between the meridians of 14° and 70° E., blowing in strong gales over an extensive tract.

On the 1st of March we find four vessels, situated between Lat. $34^{\circ} 46'$ S., Long. $44^{\circ} 50'$ E., and Lat. $31^{\circ} 38'$ S., Long. $57^{\circ} 48'$ E., experiencing N.E. and E.N.E. winds in moderate and fresh breezes during the whole day, and no other

wind is observed in that space; while to the northward of it, as far as Lat. $16^{\circ} 49'$ S., Long. $56^{\circ} 21'$ E., the S.E. Trade is blowing strongly and steadily, as shown by observations taken at five different places variously remote from one another.

On the 2nd of March this N.E. wind is still seen in the same locality, blowing in fresh breezes; but it now extends as far north as Lat. $24^{\circ} 35'$ S., Long. $49^{\circ} 27'$ E. Between that point and Lat. $35^{\circ} 1'$ S., Long. 49° E., there were six vessels which had it constantly, and no other wind was observed within the same limits. The S.E. Trade was at the same time blowing a little farther to the north.

These N.E. winds are found on every succeeding day down to the 14th, when they disappear. They gradually advanced towards the east and north, to about Lat. 17° S., Long. 70° E. On the 5th, for example, they stretched from Lat. $22^{\circ} 37'$ S., Long. $57^{\circ} 9'$ E., to Lat. $33^{\circ} 40'$ S., Long. $52^{\circ} 10'$ E., as shown by seven vessels; and on the 6th they extended to Lat. $18^{\circ} 31'$ S., Long. $62^{\circ} 26'$ E. From want of observations, their northern limits on some of the following days are not easily ascertained.

On the 14th they are not seen; the space which was occupied by them is now occupied by the S.E. Trade. But on the 15th one vessel, in Lat. $39^{\circ} 13'$ S., Long. $27^{\circ} 7'$ E., is found with a N.E. wind; and on examining the observations for the following days, this second N.E. wind, like the former, gradually progressed to the eastward, till, by the 29th, it reached at least the 67th meridian. On the last two days of the month it is again encountered far to the westward by seven or eight vessels.

Thus, a N.E. wind on three different occasions is found gradually advancing from the south-western extremity of the ocean to the eastward.

Of these three successive winds or currents from the same quarter, the *first* advanced from Lat. $34^{\circ} 46'$ S., Long. $44^{\circ} 50'$ E., on the 1st, to Lat. $24^{\circ} 24'$ S., Long. $74^{\circ} 9'$ E., on the 10th, giving a range in longitude of $29^{\circ} 19'$;—the *second* from Lat. $39^{\circ} 13'$ S., Long. $27^{\circ} 7'$ E., on the 15th, to Lat. $36^{\circ} 17'$ S., Long. $67^{\circ} 7'$ E., on the 29th, giving a range in longitude of 40° ;—and the *third*, which extended from Lat. $38^{\circ} 50'$ S., Long. $21^{\circ} 50'$ E., to Lat. $28^{\circ} 4'$ S., Long. $33^{\circ} 41'$ E., on the 30th, extended from Lat. $28^{\circ} 55'$ S., Long. $33^{\circ} 37'$ E., to Lat. $38^{\circ} 54'$ S., Long. $40^{\circ} 20'$ E., on the 31st, which gives an advance to the eastward of about 7° .

The mean eastern limit of the *first* is $63^{\circ} 24'$ E., and the mean western limit 52° E., so that its mean extent in longitude is $11^{\circ} 24'$. Its mean northern limit is $23^{\circ} 17'$ S., and its mean southern limit $32^{\circ} 45'$ S., giving a mean extent in latitude of $9^{\circ} 28'$.

The mean eastern limit of the *second* is $56^{\circ} 5'$ E.; its mean western limit 42° E.; and its mean longitudinal extent $14^{\circ} 5'$ E. Its mean northern and southern limits are $30^{\circ} 23'$ S. and $38^{\circ} 40'$ S. respectively, and its mean extent in latitude $8^{\circ} 17'$.

The mean limits of the *third* for the two days on which it was observed are $38^{\circ} 52'$ S. to $28^{\circ} 29'$ S., and $23^{\circ} 47'$ E. to $42^{\circ} 58'$ E., showing a mean of $10^{\circ} 23'$ in latitude, and $19^{\circ} 11'$ in longitude.

So far, therefore, as can be judged from these observations (136 in number), the mean extent of this N.E. wind, for the month, is $9^{\circ} 22'$ in latitude, and $14^{\circ} 13'$ in longitude, and the wind which is confined to this average space has a mean range in longitude of at least 35° , it being found to advance from the west towards the east.

Its extreme northern and southern limits are about 18° S. and 39° S., and consequently its range from north to south about 21° .

The prevailing direction of the wind is E.N.E. and N.E., and its mean direction between N.E. and N.E. by E.

Its mean daily force is 5·2.

Connexion between the S.E. Trade and the N.E. Wind, on its Polar Limits :—

On comparing the polar limits of the Trade-wind and the northern limits of the N.E. winds to the southward of them, we find that as the former recede towards the eastward and northward, the latter advance in the same direction. From the 1st to the 11th of the month the polar limits of the Trade became more and more northerly, till they reached Mauritius, or were found even beyond it; and during those days the N.E. wind advanced from 34° or 35° S. to 18° or 19° S. in the same meridians. When, again, the S.E. wind appeared far to the southward and westward, after the 12th, the N.E. wind made its appearance still farther to the westward; and as the Trade receded towards the Equator, till it reached Mauritius a second time, on the 25th, the N.E. wind seems to have followed it. And the commencement of another repetition of the same thing probably occurs on the 30th and 31st, for the S.E. Trade is found at 33° 4' S. and 53° 21' E., and the N.E. wind to the westward of it.

The two winds are, on the first seven days of the month, seen so near to each other that the immediate impression is that the one is a continuation of the other; and on examining the logs of the vessels, from day to day, the S.E. Trade is in some cases actually found to have veered to E. and N.E.

I have therefore considered the N.E. wind to be merely a deflection and continuation of the S.E. Trade. It is not quite clear, however, that it is so, for many of the vessels, on losing the S.E. Trade, had calms and variables for at least a few hours previously to their getting the N.E. wind, no gradual veering from S.E. to E. and N.E. having been experienced.

It may be, and there are some indications that seem to favour the supposition, that these N.E. winds are the N.W. Monsoon, which, *having overleaped the intervening S.E. Trade*, makes its reappearance on the surface, and is deflected towards the S.W. by the heated land which lies in that direction.

On the S.W. Wind found to the Southward of the S.E. Trade-Wind :—

The N.E. winds beyond the polar limits of the Trade-wind are invariably accompanied by a current of air moving from the opposite direction, which always makes its appearance to the westward of the N.E. current.

This S.W. wind presents itself on every day of the month, except from the 14th to the 21st, and on the 31st, when (the N.E. wind being far to the westward) the journal does not show whether the S.W. wind appeared still farther to the west or not, as no observations taken to the westward of the 13th meridian were extracted from the log-books. But on every other day, when the N.E. wind extended considerably far to the E., a S.W. wind was constantly found to blow beyond its western limits, and to follow the progression of the N.E. wind to the eastward; and it is probable that, if the observations had a greater extent in longitude, the S.W. wind would be seen on the other days also.

The extreme eastern limit observed is 58° 53' E., on the 11th, and the extreme western 14° E., on the 8th; so that the range in longitude was at least 44°.

The extreme northern limit observed is 19° 43' S. on the 8th, and the extreme southern 39° 27' S., on the 26th; which gives a range in latitude of 19° 44'.

The mean eastern and western limits are 42° 15' E. and 27° 7' E. respectively giving a mean extent in longitude of 15° 8'.

The mean northern and southern limits are $28^{\circ} 48'$ S. and $35^{\circ} 30'$ S.; and hence the mean extent in latitude is $6^{\circ} 42'$.

From an average of nearly four daily observations, the mean daily force of the wind appears to have been about 4·8.

The prevailing direction of the wind was S.S.W. and S.W., and the mean direction nearly S.W. Comparing the mean force of the S.W. wind with that of the N.E. wind to the east of it, the latter (5·2) appears to be somewhat greater than the former, but the difference may be owing to the fewness or inaccuracy of the observations.

The mean directions of the two winds seem to have been nearly diametrically opposite.

These S.W. winds, like the N.E. winds to the eastward of them, extend obliquely across the part of the ocean where they prevail, namely, from the southern extremities of Africa towards Cape St. Mary and Mauritius, and sometimes blow over an extensive tract. On the 8th, for example, they extended from the Cape of Good Hope up to Mauritius. To the southward of the 30th parallel they seldom appear farther to the east than the meridian of 48° , their eastern limits being found at their northern extremity, about the meridian of 59° . There is, therefore, a strong presumption that they are caused by the high temperature which prevails at that season of the year in the Islands of Mauritius and Bourbon, and in Madagascar and Southern Africa.

It will be seen, on comparing the limits of the S.E. Trade-wind and that of the N.E. and S.W. winds which prevail to the southward of it, that the changes of position which they undergo are closely related. When the S.E. Trade sets in far to the westward, as on the 14th and 15th, it occupies the whole ocean to the eastward and northward of 30° E., the N.E. and S.W. winds not appearing at all. In a short time, however, the N.E. wind, as on the 16th, makes its appearance to the southward of the 30th parallel, near the meridian of 30° , and the Trade is pushed to the eastward and northward. The N.E. wind then continues to advance, and, by and bye, as on the 21st, the S.W. wind sets in to the westward of it, and the northern and eastern limits of the two daily increase, in proportion as the southern and western limits of the Trade decrease.

Ninety-one observations contributed to the above data.

Direction and Force of the S.E. Trade:—

In order to ascertain, approximately, the mean direction and force of the S.E. Trade, the number of hours during which it blew on each day, from E., E.S.E., S.E., S.S.E., and S., respectively, has been determined; and as each of these winds blew in different parts of the ocean, the point which gives the greatest number of hours is regarded as the point of maximum direction.

It is scarcely necessary to observe that in determining the direction of the S.E. Trade, as well as of the other systems of winds, no allowance is made for magnetic variation.

The prevailing direction of the Trade in March 1853 was S.E.

The mean direction was $S. 51^{\circ} E.$

The mean daily force was 3·4.

The point from which the wind blew in greatest force was the east, and in least force the south.

With regard to the Trade, the stormiest days of the month were from the 1st to the 9th, inclusive, and the calmest days the 10th and 23rd.

The easterly winds prevailed to the westward of 60° E.

The Trade blew with greatest steadiness to the eastward of 66° E. and southward of 15° S.

Limits, &c., of the N.W. Monsoon :—

The southern limits of the N.W. Monsoon, during the first fourteen days of the month, stretched obliquely across the ocean from about 17° S. and 46° E. to the Equator, in about 80° E., and thence towards the north of Sumatra.

After the 14th, the mean southern limits were $5^{\circ} 22'$ S.; but they still extended farther to the south on the western than on the eastern side of the ocean.

The northern limits appear to have been to the north of the Equator during the whole month, at least on the eastern side, and to have extended, from the 1st to the 16th, obliquely up to 14° N. and 90° E. In fact, a N.W. wind is found, on almost every day, blowing over the southern part of the Bay of Bengal, from Ceylon to the Straits of Malacca; and I suppose it to be the Monsoon—the vessels situated to the southward and westward of that space having the wind from the same quarter.

On this supposition, the mean northern limits on the east side are $9^{\circ} 27'$ N. and $88^{\circ} 7'$ E.

The mean southern limits on the west are $10^{\circ} 52'$ S. and $58^{\circ} 33'$ E.

The mean extent in latitude appears to be about 12° .

The N.W. Monsoon, on approaching the S.E. Trade, is sometimes deflected to S. and S.W., becoming a N. and N.E. wind.

One hundred and eight observations contributed to these data.

The N.E. Trade-Wind :—

The N.E. Trade seldom appears to the eastward of 66° E., south of 10° N.

On some days, as on the 17th and 18th, it seems to take the place of the N.W. Monsoon, to the eastward of Ceylon. On the 17th, four vessels, from Lat. $7^{\circ} 51'$ N., Long. $89^{\circ} 27'$ E., to Lat. $2^{\circ} 17'$ N., Long. $78^{\circ} 55'$ E., had N. and N.E. winds during the whole day; and this is observed also on the 18th. But, with the exception of these and one or two other days, there are few signs of the N.E. Trade in the Bay of Bengal, or to the eastward of the 66th meridian.

The winds in the northern part of the Bay were generally from N.W. and S.W.

From the 25th to the end of the month a strong S.E. wind prevailed from about 6° N. and 84° E. to 14° N. and 87° E., blowing towards the east coast of India.

To the westward of 66° E. the N.E. Trade was generally found on every day on which vessels made their appearance there, prevailing during the month from $1^{\circ} 40'$ N. to at least 18° N.; but that to the eastward of the meridian of 66° E. the prevailing wind on the north side of the Equator was N.W.

The logs seem to indicate that in the line between the N.E. and N.W. winds, and coinciding more or less with the meridian of 66° , the wind was due north.

With regard to the mean force and direction of the N.E. Trade, the observations are too few to enable one to obtain an approximate value. The former, however, appears to have been 3, and the latter to have been N.E., between 55° and 65° E.

Belts of Calms :—

Although the observations show, upon the whole, the existence of a belt of calms to the north of the equatorial borders of the S.E. Trade, and another to the south of its polar borders, yet they are not sufficiently numerous for determining the exact limits of these belts.

Between the N.E. and S.E. Trades lies the region of the N.W. Monsoon, and also, on the eastern side, the region of the S.W. wind or Monsoon, the limits of which have been given at p. 56.

Now, between the S.E. Trade and N.W. Monsoon, to the westward of 60° E., where the S.W. wind is rarely found, most of the vessels met with calms and light variable airs, which lasted from a few hours to a few days.

Also, to the northward of the Monsoon, and between it and the N.E. Trade, similar calms and variables were found; but it often happened that the Trade gradually veered to N. and N.W., without any calms, the N.W. Monsoon appearing to be merely a continuation of the Trade.

Again, between the S.E. Trade and S.W. Monsoon, on the east side of the ocean, calms were sometimes experienced. Generally, however, the Trade seems to have veered to S. and S.W., without any interruption; but to the northward of the S.W. wind, between it and the N.W. Monsoon, calms and variables were much more frequent.

Calms and variables were also experienced on the polar limits of the S.E. Trade, but it more frequently happened that, though the wind became variable, or shifted, it blew in strong breezes and gales.

Hurricanes and Gales :—

The relative mean forces of the different systems of winds above described were apparently as follows :—

N.E. Trade	3
N.W. Monsoon	3·7
S.W. wind towards the Indian Archipelago	2·5
S.E. Trade	3·4
N.E. wind to the southward of the S.E. Trade	5·2
S.W. wind	4·8

It seems, therefore, that the two latter winds are the strongest; that the N.W. Monsoon is stronger than the S.E. Trade, and that the S.W. wind, which blows towards Sumatra, &c., is the weakest.

Again, if the N.W. Monsoon be regarded as a continuation of the N.E. Trade, caused by the combined influence due to the sun's elevation and the heated land of the Indian Archipelago, Australia, &c., it may be said to extend over a greater space than the S.E. Trade, and to put a greater mass of air in motion.

Hence, the Monsoon pushes the S.E. Trade back towards the Tropic. The two opposing winds are in conflict, and the weaker gives way to the stronger; it is therefore in the belt of calms and variables which separates them, that storms and hurricanes are most likely to occur.

Now, the position of this belt is constantly changing. It follows the sun. When the land in the southern hemisphere begins to be heated up by the sun's rays, the N.W. Monsoon begins to set in, and it advances more and more to the southward, in proportion as the heat increases, till, in the month of March, it attains its highest limit, after which it gradually recedes, and at length disappears, the S.E. Trade taking

its place. But although the Monsoon from October to March is, upon the whole, advancing towards the south, and the Trade receding, the two winds fluctuate backward and forward within certain limits, according to temporary fluctuations of temperature, both alternately occupying the same space.

If, then, the hurricanes of the Indian Ocean, as here maintained, occur in one space between the N.W. Monsoon and the S.E. Trade, the localities of these hurricanes should vary according to the season—according to the sun's declination—and observation shows that such is the case. The Monsoon begins to blow in the latter part of October, or in the beginning of November; the hurricane season of the South Indian Ocean begins at the same time; and, in the early part of that season, the hurricanes occur far to the eastward and northward of Mauritius, in the vicinity of the Equator. But as the sun's southern declination increases, they gradually attain higher latitudes, and make their appearance in localities farther to the westward, till at length they come down as far as Mauritius, or even beyond it. In November 1851, for example, a very severe hurricane occurred in 6° to 16° S. and 80° to 90° E., and in March of the same year an equally severe one took place in about 25° S. and 60° E. Now, these storms were the two extremes of a series of gales which took place in intermediate localities, and at intermediate times in the course of the season; and a similar series of storms or gales is, in general, observed annually, the first storm occurring in the early part of the season in the neighbourhood of the Equator, and the last, towards the end of the season, in the neighbourhood of the Tropic; while at a still later period storms occur again, nearer to the Equator, as the sun advances to the north.

In the hurricanes of the South Indian Ocean the wind moves in a circular direction, from west to east by the north, and from east to west by the south, or with the hands of a watch. This is termed their law of rotation. They have at the same time a progressive motion in a course of from about E.N.E. to W.S.W., which is termed their law of progression. Now, the explanation of these laws, about which writers on storms have so widely differed, will, I think, be afforded by an examination of the connexion between the ordinary prevailing winds, as influenced and determined by the action of heat.

The N.W. Monsoon, on approaching the belt of equatorial calms, appears to have, as already remarked, a tendency to veer to N. and N.E., becoming first a N. and then a N.E. wind; and the S.E. Trade, to the eastward of 60° E., veers to S. and S.W., forming a wind, first from south, and then from S.W. These veerings, then, would evidently give rise to a wind rotating according to the law which obtains in the southern hemisphere.

This is the explanation which was given of the law of rotation by Dr. Thom, on hypothetical grounds; and the observations given in the journal show that the two opposing winds, especially the Trade-wind, do actually veer in the manner which he supposed.

I am not aware, however, that any satisfactory explanation has been given of the law of progression. Why is it that the hurricanes of the South Indian Ocean generally travel from E.N.E. to W.S.W.?

This question will, I think, be answered in the course of these researches.

It has already been observed that the N.W. Monsoon extended farther to the south on the western than on the eastern side of the ocean. Its southern limits, during the first half of the month, stretched obliquely from about 17° S. and 46° E. up to

the Equator in 80° E. or 85° E.; and the northern limits of the S.E. Trade extended at the same time from 20° S. and 50° E. to 11° S. and 80° or 85° E., where it was deflected towards the N.E., forming a S.W. wind.

Between the two opposite systems of winds is the belt of calms and variables.

Now, if the hurricanes of the South Indian Ocean take place on the borders of the Monsoon and of the S.E. Trade—and it appears certain that they generally do so—it is manifest that a storm originating near the Equator in about 85° E. would, if it progressed at all, move along the belt of calms which separates the two winds. But the position of the belt of calms is determined by the limits of the Trade and Monsoon, which extended during a considerable part of the month from the vicinity of the Equator, in 85° E., down towards Mauritius; and that is exactly the course which hurricanes generally take at that season of the year.

The position of the belt of calms is indicated in CHART DIAGRAM V. On the one side of it is represented the region of the S.E. Trade, and on the other that of the N.W. Monsoon. The Trade on nearing the Equator is deflected towards Sumatra, &c., forming a S.W. Monsoon. Now, it often happens that the N.W. Monsoon, in veering to N. and N.E., penetrates into this S.W. wind, while, somewhat farther to the westward, the S.W. wind still pursues its course; and it is easily conceived how a rotatory wind may thus be generated. I have therefore represented the supposed formation of a circular gale in this manner, where the belt of calms crosses the Equator, and it is more than probable that, if such a gale had actually been formed there, it would, if it did not remain stationary, move along the belt of calms.

The journal shows distinctly that the Monsoon and Trade, and consequently the belt of calms between them, had, during a considerable portion of the month, the relative positions assigned to them in the chart, and it is these relative positions that determine the usual tracks of hurricanes.*

Some writers often speak of the hurricanes of the South Indian Ocean as passing down across the Trade, and have recourse to extraordinary causes to account for the supposed phenomenon. But it does not follow, that because hurricanes may originate about 8° or 9° S. and 80° or 85° E., and come down towards Mauritius, they travel through or across the Trade. They do not pass through the Trade, but along its equatorial edge, which, in the hurricane season, often extends considerably further to the southward on the western than on the eastern side of the ocean, as shown by the journal, and represented in CHART DIAGRAM V.

If the usual tracks of hurricanes coincide with the equatorial limits of the Monsoon and Trade, it is plain that the cause or agent which determines the one will also determine the other; that is, that whatever causes the N.W. Monsoon to extend to Mauritius, or beyond it, also determines the hurricane tracks.

What is it, then, that gives rise to the N.W. Monsoon? and why does it extend so far to the southward in the meridians of 50° and 60° ?

The answers to these questions are furnished by considering the distribution of the land and the influence of solar heat. The Monsoon is caused by the increase of temperature which takes place in the summer months of the southern hemisphere in Australia, Madagascar, and Southern Africa; its equatorial limits being deter-

* The edges of the calm belt, and of the Trades and Monsoons, are sharper in CHART DIAGRAM V. than they are in nature—where they are irregular, jagged, or waving and indented. The chart gives merely the average limits.

mined by the positions of localities in which the temperature attains its highest elevation in different parts of the ocean, from eastward to westward. In other words, the belt of calms, or of maximum temperature, in the Indian Ocean is drawn to the southward by the influence of the heated land, as well as by the direct action of the sun. If there were no land at all, the maximum isotherm would extend due east and west, in a parallel corresponding to the sun's declination; but the heated land on either side of the ocean causes the zone of maximum temperature to extend farther to the southward, along its whole extent, than it would have done in the absence of that land, and to attain a still higher latitude towards the coast of Africa, where the heat is greatest; and hence the oblique position of the equatorial edges of the Monsoon and Trade, and of the belt of calms, or tracks usually followed by hurricanes.

If it be asked why these hurricanes travel from E.N.E. to W.S.W., and not in the contrary direction, it may be answered, that they travel towards the westward because the temperature is more elevated on the African side of the ocean, and because the N.W. Monsoon, which is, upon the whole, stronger than the S.E. Trade, impinges upon the N.E. quadrant of the storm with a force greater than that with which the Trade impinges upon the S.W. quadrant.

With regard to the continued action of the storm for several days in succession, it may be inferred that, if it is originally set in motion by the Trade and Monsoon, the same forces may keep it in motion; for, in progressing towards the westward, the Trade and Monsoon still continue to act as at first. It is not necessary to suppose that the Monsoon moves down, sideways, from 10° S. and 85° E. to Mauritius, in proportion as the storm advances. The equatorial edge of the Monsoon may have had a slanting direction across the ocean before the storm commenced, and also during the whole time it lasted; the motive power, instead of requiring to be renewed, at each successive step, residing in the Monsoon itself, along the whole extent of its southern limits. But even if it were necessary to suppose that the Monsoon did advance sideways to the southward and westward, according as the hurricane moved in the same direction, this would only show that an elevation of temperature had taken place in the direction of Mauritius and Madagascar, which caused the Monsoon to extend to the southward and westward, pushing the Trade back towards the Tropic, and thus producing a storm or hurricane.

The object of these remarks is simply to direct attention to what the journal indicates, viz., that the localities of the hurricanes of the South Indian Ocean, and their laws of rotation and progression depend upon the observed relative strength, positions, and veerings of the Trade and Monsoon, and upon the known effects of heat. Whether or not they observe in other respects that precision and regularity which have been ascribed to them by writers on the subject is a question the consideration of which must be deferred to another occasion. It is not impossible that further investigation will show that they are not quite so regular in their movements as some suppose, and that several of the views entertained respecting them have been put forward rather prematurely.

Besides the position of the belt of calms, and the regions of the N.W. Monsoon and S.E. Trade, CHART DIAGRAM V. represents the deflection of the Trade towards Sumatra, forming the S.W. Monsoon referred to at p. 56. It also shows the N.E. and S.W. winds which prevailed to the southward of Mauritius and Madagascar, with the supposed formation of a circular gale between them; and, on

the north side of the Equator, the N.E. Trade is seen to the westward of 65° E., while to the eastward of that meridian the prevailing winds, north of the 10th parallel, are N.W. and S.W.

The various systems of winds represented in the chart are explained by the effects of heat. The S.W. wind towards Sumatra is caused by the heat which prevails there at that season of the year; and a similar cause will account for the S.W. Monsoon, which blows up towards the southern coasts of Africa, Madagascar, and Mauritius. This influence of heated adjacent land seems to be exemplified in the case of the N.E. Trade. So far as the observations which were made in that part of the ocean go, it would appear that, while the wind blows from the N.E. towards Africa, it blows towards the coast of India chiefly from N.W., its direction in about 65° E., being north or intermediate.

The chart and journal seem to indicate that the N.W. Monsoon is a continuation of the N.E. Trade, and the S.W. Monsoon, toward Sumatra, a continuation of the S.E. Trade. Is not the S.W. Monsoon of the northern hemisphere, from April to October, also a continuation of the S.E. Trade? If the N.W. Monsoon is not caused by a deflection and prolongation of the N.E. Trade, and the S.W. Monsoon by a similar deflection and prolongation of the S.E. Trade, whence comes the air that feeds them? When the N.W. Monsoon of the southern hemisphere prevails, the N.E. Trade is found blowing to the vicinity of the Equator, and a little beyond it are the northern limits of the Monsoon. Whence, then, is the air which sustains the Monsoon derived, unless from the N.E. Trade which prevails in its immediate vicinity, and has, like itself, a southerly course? Similarly, when the S.W. Monsoon prevails in the northern hemisphere, the S.E. Trade blows down to the Equator, or beyond it, and the southern limits of the Monsoon are in the immediate neighbourhood of the northern limits of the Trade, both winds moving in a northerly direction. The S.W. Monsoon sets in at Ceylon and on the southern shores of India in the early part of April, and it gradually advances to the northward, reaching Bombay about the 15th of May, and places farther to the north at later dates, it being caused by the rarefaction which takes place over the extensive plains and deserts of Asia as the sun's meridian altitude increases. Now, whence does this great rush of air proceed unless from the S.E. Trade? The Trade blows in greater force in the winter of the southern hemisphere, in consequence of the elevated temperature which prevails to the north of the Equator, and after passing over into the northern hemisphere it is deflected to the N.E., and blows like the S.W. Monsoon near Sumatra, towards the localities of maximum heat.

As the Monsoon progresses to the northward the N.E. Trade recedes before it, or rather, the Trade on reaching the line of maximum temperature is rarefied and ascends. Thus, between the two opposite winds there is a zone of calms and variables, analogous to that between the S.E. Trade and N.W. Monsoon in the southern hemisphere; and theory would lead us to infer that this zone, also, is the scene of storms and hurricanes, which in the Bay of Bengal, and in the China Seas, revolve in a direction contrary to that of the hurricanes of the southern hemisphere, and have a progressive motion from E.S.E. to W.N.W.; for the heated land of Asia lying to the west of those seas, the belt of calms and variables in them would extend toward the land in the direction indicated; and the Monsoon being stronger than the Trade, and impinging on the S.E. quadrant of the storm, the latter would be impelled towards

the W.N.W., whither the elevated temperature in that direction would also have a tendency to draw it. In short, the great agent in the production both of the ordinary winds and of their stormy gyrations seems to be *Heat*.

It does not appear that any hurricane was experienced on the south side of the Equator during this month (March 1853), but gales were of frequent occurrence between the Cape of Good Hope and the parallel of Mauritius, as far as 65° or 70° E. These gales generally took place between the S.W. and N.E. currents of air which prevailed in that part of the ocean. On some days, also, the N.W. Monsoon in coming down towards the 20th parallel seems to have veered to N. and N.E.; and the S.E. Trade blowing at the same time to the southward of Mauritius, and the S.W. Monsoon of the Cape blowing towards Madagascar, a circular wind of great extent was occasionally formed.

These two systems of winds which we have been considering are, apparently, caused by the action of heat on the atmosphere of Southern Africa, Madagascar, and the Islands of Bourbon and Mauritius. If, for example, we suppose the zone of maximum temperature to be in or near the southern parts of Madagascar, we should infer that currents of air would flow thither from all sides, viz., a S.W. current from the southward of the Cape of Good Hope, a S.E. current from the Indian Ocean, east of 45° E., a N.E. current from Mauritius, and a N.W. current from the Mozambique Channel. Now, such currents are actually found in those parts, but the zone of maximum heat is constantly varying: it may on one day be several degrees farther to the east or the north, and on another as many degrees farther to the west or south, and hence the confines of the aerial currents flowing towards it are subject to fluctuation.*

At the commencement of the month we find a S.E. wind (the Trade) flowing towards the south end of Madagascar; but a little to the southward of this S.E. wind is found a N.E. wind; and in the same parallels with this N.E. wind, but considerably far to the westward, a S.W. wind prevails. The S.E. wind, however, gradually disappears, being replaced by the N.E. wind, which ultimately extends as far north as Mauritius and as far east as 70° or even 75° , the S.W. wind still appearing in the same parallels to the westward. On the 8th, for example, the N.E. wind is observed extending from $21^{\circ} 10'$ S. and $65^{\circ} 55'$ E. to $33^{\circ} 21'$ S. and $52^{\circ} 46'$ E., a distance of 700 miles, over which it is blowing in strong breezes and gales; and it is probable that it extended still farther south. The S.W. wind, at the same time, extends from $35^{\circ} 3'$ S. and $20^{\circ} 4'$ E. to $19^{\circ} 43'$ S. and $58^{\circ} 9'$ E., a distance of nearly 900 miles.

These two winds (the N.E. and S.W.) seem to have attained their maximum force on the 7th, when a heavy gale was blowing from $19^{\circ} 44'$ S. to $36^{\circ} 2'$ S., and from $44^{\circ} 3'$ E. to $68^{\circ} 48'$ E. And it is remarkable that on that day there was scarcely a breath of air in motion at Mauritius, though a strong gale was raging in its immediate vicinity. Yet, calm though the weather was, there were unmistakable signs of what was occurring in the neighbourhood. The barometer, at $3\frac{1}{2}$ p.m. of the 6th, stood at 29.615 (the minimum pressure for the year), to which it gradually fell from 29.848 on the 3rd, on which day the gale was felt most at $34^{\circ} 51'$ S. and $48^{\circ} 45'$ E. On the 8th the barometer at the same hour stood at 29.621; the sky during the day was overcast and lowering, the sea sending in breakers on the reefs, and at 2 p.m.

* The N.E. wind, however, appears upon the whole to proceed from warmer to colder latitudes, which may be owing to a disturbance of the atmospheric equilibrium caused on the south-east coasts of Africa by the air being removed thence by the S.W. wind.

there was thunder at north. About 120 miles to the east of the island a gale was blowing from E.S.E., the ship's barometer standing at 29.66; and about 56 miles to the S.W. of it the same gale was blowing from E.N.E.; while in the island itself the atmosphere was perfectly tranquil. On the 6th, however, the wind was E.S.E., in moderate breezes, with a falling barometer.

We here find that though the wind was E.S.E. at Mauritius (on the 6th), and the barometer low and falling, yet there was no hurricane, nor any sign of one, to the northward of the island. The bad weather was in the very opposite direction, to the southward. Yet, how often has it not been announced, with confidence, that because the barometer was falling at Port Louis, with a S.E. or E.S.E. wind, a hurricane was bearing down upon the island from E.N.E.?

As the northern limits of the N.E. wind go on extending, the S.E. Trade seems to run into it. This is exemplified on the 8th, when, in the case above cited, the wind was E.S.E. at 19° 44' S. and 59° 14' E., and E.N.E. at 20° 58' S. and 56° 48' E., and various other instances might be adduced; I shall, however, give only one other.

When, on the 7th, the wind was E.S.E., with a falling barometer, and other indications of bad weather, Captain Harold, of the *Fanny Fisher*, in 25° S. and 78° E., trusting to what is called the Law of Storms, evidently thought that he was in the "dangerous quadrant" of a hurricane or gale, the centre of which bore N.N.E. of the vessel's position.

Now, there is no evidence of there having been bad weather in that direction, but we have, on the other hand, positive proof that a strong gale was prevailing to the westward.

It is recommended by cyclonologists that when a vessel has the wind at any point between E. and S.S.E., with a low barometer and other "premonitory signs," her commander should, if possible, pass in front of the storm which is considered to be bearing down upon him from the north-eastward; that is, that he should steer to the W. or W.N.W. But in the present case it seems certain, that by steering W. the vessel would have run into the very heart of the gale.

On the 9th the wind, after having been at E.S.E. and S.E. for four days, "gradually veered to E.N.E.," the barometer rising from 29.35 at 2 A.M. to 29.60 at 8 A.M.

Here, according to the Law of Storms, we should infer that the centre of the gale or hurricane had passed to the northward of the vessel's position, and that it now bore N.N.W. of her. But of this, also, we have no evidence; while it is certain that a strong gale still prevailed to the westward; and, moreover, the veering of the wind from S.E. and E.S.E. to E.N.E. is precisely what had occurred on the preceding days to vessels situated to the west of the vessel in question.

We have no proof whatever, but the very contrary, that the gale was bearing down upon the *Fanny Fisher* from the north-eastward, and yet her intelligent commander was perfectly justified in supposing that it was; for, with the wind and weather which he had, and a falling barometer, a cyclonologist would have assured him that he was in the "dangerous quadrant" of a revolving storm.

These remarks are not made with the view of casting doubt upon the general theory of storms, which I think is, in the main, unassailable, but of pointing out the danger of laying down dogmatic rules for the guidance of vessels in the circumstances in which the *Fanny Fisher* was placed. Commanders who have acted

according to such rules have, in some cases, proclaimed the Law of Storms to be without any foundation, because the very reverse of what was expected has turned out.

The great practical importance of a knowledge of these N.E. and S.W. winds which have now been briefly passed in review, and of the revolving gales which seem to be formed on their borders, is so palpable as to require no notice here. The advantages which the former wind offers to vessels sailing from India, Ceylon, Mauritius, and the East generally, towards the Cape of Good Hope, and the similar advantages afforded by the S.W. wind to vessels steering on an opposite course, are manifest to every one.

Pressure and Temperature of the Air :—

The number of observations made with the barometer in the course of the month is 343, and with the thermometer 267, which gives a daily average of 11 of the former and of 8 to 9 of the latter.

The greatest altitude of the barometer was observed on the days and at the localities subjoined :—

30·20, on the 14th, in 38° 46' S. & 26° 0' E.
 30·24, on the 19th, in 23° 27' S. & 54° 25' E.
 30·24, on the 20th, in 25° 56' S. & 52° 40' E.
 30·25, on the 30th, in 37° 0' S. & 28° 5' E.
 30·25, on the 31st, in 38° 4' S. & 53° 31' E.

It stood lowest at the following localities :—

29·615, at 3½ P.M. of the 6th, at Port Louis.
 29·66, on the 7th, in 19° 44' S. and 59° 14' E.
 29·66, at 9½ A.M. of 7th, at Port Louis.
 29·65, at 3½ P.M. of 8th, at Port Louis.
 29·60, at 4 P.M. of 8th, in 24° 52' S. & 77° 17' E.
 29·35, at 2 A.M. of 9th, in 24° 59' S. & 76° 59' E.
 29·55, on the 9th, in 35° 10' S. & 21° 4' E.
 29·60, on the 21st, in 33° 57' S. & 25° 39' E.
 29·64, on the 25th, in 36° 30' S. & 46° 6' E.
 29·60, on the 29th, in 37° 7' S. & 48° 12' E.
 29·55, on the 29th, in 39° 3' S. & 32° 55' E.
 29·60, on the 30th, in 38° 50' S. & 21° 50' E.
 29·50, on the 31st, in 38° 30' S. & 25° 45' E.

The highest temperature was observed on the 1st, in 12° 20' S. and 75° 5' E., and on the 15th, in 15° 9' S. and 88° 56' E., the thermometer on both occasions standing at 91°.

The lowest temperature was observed on the 26th, in 36° 37' S. and 10° 52' E., where the thermometer was at 59°.

In consequence of the fewness of the observations, and of the instruments not having been verified by common standards of comparison, no definite results, with regard to the pressure and temperature of the atmosphere in different parts of the ocean can be obtained. I have, however, after rejecting the observations made with instruments which were evidently too high or too low set, taken the means of the

remaining observations for each square of 10 degrees, and exhibited the results on CHART DIAGRAM V.

It will be seen that, upon the whole, the zone of maximum temperature extends from the Equator in about 90° E. to the north end of Madagascar, and that the barometer stands highest in the vicinity of the Tropic and in the region of the N.E. Trade, and lowest from Mauritius to the north of Madagascar.

That the pressure was so great in the district of the N.E. Trade as is represented may, however, be doubted, for the observations were made by only one vessel, and her barometer, though a subtractive correction of .045 was made, may have still been too high. The general results, also, are doubtless somewhat different from what they would have been even with the same instruments if the observations had been made in the different squares on the same days, instead of at different periods of the month.

The difference between the temperature of the air south of Cape Colony and in the neighbourhood of Mauritius accounts for the S.W. Monsoon, which blows from the former to the latter locality; but the counter N.E. current of air does not admit of a similar explanation, for it flows from warmer to colder latitudes. The probability is, therefore, that it moves southward, to preserve the equilibrium which would otherwise be disturbed by the constant withdrawal of air from those parts by the S.W. wind. On this supposition the two currents are owing to the influence of heat, the S.W. directly, and the N.E. indirectly.

Most of the observations made south of the 30th parallel show that the barometer is subject there to great fluctuation. But, with regard to this and many other subjects of inquiry, a far greater number of barometric and thermometric observations made with instruments compared with common standards and with one another are required.

The observations show that the swell and heavy sea depend upon the strength and direction of the winds. The sea appears to have been agitated most on the 7th, 11th, 29th, and 30th, and also on the 5th, 6th, 8th, 9th, 21st, 24th, 25th, 26th, 27th, and 28th, when the wind blew in strong gales; and to have been least agitated from the 13th to the 20th, when the African S.W. Monsoon did not appear, and no rotatory gales occurred in that part of the ocean.

The direction of the swell and heavy sea seem to be determined by the direction of the wind, though the directions of the wind and swell are frequently different at the same locality, the swell in that case being caused by a stronger wind in another quarter. This is exemplified in the case of vessels approaching the equatorial limits of the S.E. Trade, where a swell from S.E. is generally experienced, though the wind may be coming from a different direction. Most of the instances of a S.E. swell were owing to this cause, and the other directions of the swell were owing to similar causes. On the 11th, for example, a vessel in 8° 28' S. and 65° 58' E. had a swell from S.S.W., the wind being from N.W.; but on that and previous days a S.W. wind extended from the southern coasts of Africa to at least Mauritius; and it is probable that it was the swell caused by this wind which the vessel in question experienced. In circular gales, also, the directions of the wind and swell are often different. On the 23rd, for instance, a vessel in 38° 11' S. and 27° 54' E. had a heavy sea from N., while the wind was strong from S.S.W.; but a N.E. gale had recently passed over or near that locality. On the 28th, in 36° 6' S. and 46° 8' E., a heavy swell set in from N.W. at midnight, the wind being strong from N.E.

Rain:—

The rainiest days were from the 1st to the 9th inclusive, especially the 1st, 2nd, and 3rd, and also from the 23rd to the end of the month; and these were the days on which gales were prevalent. Very little rain fell from the 10th to the 18th, when the wind was generally light, and calms frequent.

There were, generally speaking, two regions of aqueous precipitation, viz., the equatorial borders of the S.E. Trade, and the region of the N.E. wind to the southward of Mauritius.

The district of the N.W. Monsoon was almost rainless, condensation taking place only on its limits.

The S.W. Monsoon, which blows towards Madagascar and Mauritius, also appears to be a dry wind. In the circular gales which took place between it and the N.E. wind rain fell abundantly on the east side of the gale, where the wind was N.W., N., and N.E., but on the west side, where the S.W. wind prevailed, the weather was generally fine.

It is apparently to the vibration of the northern limits of the S.E. Trade, and of the belt of calms, that the Indian Ocean owes its rainy season, which at Mauritius usually commences in the latter end of December, when the Trade arrives there loaded with moisture. The rainy season of Sumatra, it may be presumed, sets in when its S.W. Monsoon, which is but a continuation of the S.E. Trade, reaches it, depositing moisture on meeting the high lands, as the S.W. Monsoon of India on arriving at the Western Ghats.

Thunder and Lightning:—

In the course of the month thunder was heard, or lightning seen, on 41 different occasions.

The distribution of these 41 observations, as regards the regions of the different systems of winds, was as follows:—

Region of the N.W. Monsoon	No. of Obs.	14
" " N.E. wind to the southward of Mauritius	" "	12
" " S.W. Monsoon towards Sumatra	" "	3
" " S.E. Trade	" "	3
Calms and variables	" "	5

The remaining 4 observations were made south of 30° S., the wind being from the N.W. quadrant.

No lightning was observed in the region of the S.W. wind to the southward of Mauritius, or in that of the N.E. Trade.

Frequent electrical discharges occurred in the vicinity of the Equator, about 80° E., from the 3rd to the 8th inclusive, when, as has been seen above, heavy gales prevailed to the southward; and much lightning was observed also on the 20th, 21st, and 22nd, when a second series of gales was commencing near the southern promontory of Africa.

It is very desirable that MR. MELDRUM should, in the interest of navigation, discuss the meteorological phenomena of the Indian Ocean for every month in the year in a manner similar to the foregoing very able paper (pp. 53-68).

CHAPTER IV.

WINDS ALONG THE COAST OF THE INDIAN OCEAN.

32. South Coast of Africa.—Speaking in general terms, S.E. winds prevail from September to May; should these rise to a gale they follow the trend of the coast, blowing S.E. by E. to the eastward of Cape Agulhas, and S.S.E. in False Bay. Such a gale may last for three or four days, after which it is succeeded by calms and light westerly winds, but as regards strength these S.E. gales are only local, for while ships have been driven from their anchors in one port, at another the wind from the same direction has been only moderate.

From May to September the prevalent winds are from the westward, which very frequently rise to gales, especially in June, July, and August, when they are very strong; beginning at W. they veer to N.W. and N., then going back to W. may eventually blow up fine at S.W. Should the wind, when veering, shift to N.E. or N.W., with lightning, hard squalls and general bad weather may be expected. Hard gales frequently commence very suddenly in these regions, and it must always be borne in mind that in the southern hemisphere the barometer stands lower with northerly than with southerly winds.

Westerly winds and gales may occur at any season of the year, but are most prevalent in the months stated above, although they are also *occasionally* experienced with some severity in September, October, and April.

33. Table Bay.—From October to April (summer) the prevalent winds are from S. and E., generally S. by E. to S.S.E.; these frequently rise to a very severe gale, known as the *south-easter*, and may generally be expected in January, February, and March, though one of them may occur in any month of the year, and its sure precursor is the white cloud (table-cloth or cap) on Table Mountain; when there is no cloud on the mountain the south-easter is more moderate.

The *black south-easter*, generally from S.S.W., differs from the preceding by the *simbus*, or rain tint, of a canopy of cloud on the mountain, and is usually accompanied with light rain.

From May to September (winter) winds from N. to W. are prevalent. With the regular N. and N.N.W. gales of this period, which are very strong and not unfrequently disastrous, a mountainous sea rolls into the bay, requiring the very best ground-tackle; the first indication of a *north-wester* is the appearance of a mass of condensed vapour rolling over the Lion Hill, and enveloping the signal station; there is also a damp chilliness in the air. These N.W. gales may spring up in any month of the year, but seldom blow home from November to May; their duration fluctuates between two days and a week. Strong W. and S.W. winds, with fog, hail, and general cloudy weather, are also frequent during this season. Winds from the N.E. quarter are only occasionally experienced, and rarely last.*

34. False Bay and Simon's Bay.—S.E. winds prevail here from October to April; when they rise to a gale they blow at about S.S.E. $\frac{1}{2}$ E. and fre-

* Sir T. MACLEAR. Also, for fuller particulars respecting Table Bay, see W. H. ROSSEN'S "South Atlantic," pp. 43-47, published by Messrs. LIMEY and SON.

quently last from three days to a week; when they moderate they are followed by light variable airs from the land. Muysenberg *capped* with white cloud indicates the approach of these south-easters, which will probably be very violent if the Hottentot Holland range (east of False Bay) is also capped; when the barometer stands at 30·2 to 30·3, and falls suddenly to 30 or 29·95 inches, in nine cases out of ten a strong S.S.E. gale will blow.

From May to September strong N.W. winds are very frequent, but gales from this quarter may occur at any season, although not with such likelihood during the period of the south-easters. Winds from the N.E. are rare. The *kloof*, or S.W. wind, is cold and rainy.

35. Mossel Bay.—The heaviest gales during the year are from the W.N.W.—i.e., off the shore, hence vessels ride in security. Winter gales, May to August, commence from the N.N.W. with heavy gusts, unsteady both in direction and force, then veering to W.N.W. or W. they blow very hard and continuously, with a low barometer (29·6 inches), finally shifting rather suddenly to the S.W., when they subside with steady breezes and occasional showers. At this latter period a swell sometimes sets round the bay, but nothing to cause apprehension for the safety of vessels, nor to interfere with landing.

In the summer months, September to April, strong breezes from the S.E. recur at intervals, bringing into the bay a heavy break of sea; these, however, seldom continue thirty hours, and vessels with good ground-tackle have nothing to fear. Moderate S.W. winds at this season of the year are also very common.

36. Algoa Bay.—The wind and weather here is the same as appertains to the South African coast in general; the S.E. and easterly gales, common to the summer, are the only winds to be apprehended in this bay, and of them due notice is generally given by the aspect of the sky and by the barometer.

37. Port Natal.—Winds between S. and E. are more or less prevalent throughout the year; more rain falls from October to February than at any other time of the year; when the weather is very fine N.E. winds are not uncommon; W., S.S.W., and N.W. winds are also prevalent during the dry weather.

At a short distance inland (at EKUKANYENI and MARITZBURG) the following observations have been made on the winds in 1858 and 1859:—

April to September, at 9 A.M.:—N. 17½ days; N.E. 14; E. 26½; S.E. 20; S. 20; S.W. 25; W. 25½; N.W. 29; calm 5½ days.

At 3 P.M.:—N. 10 days; N.E. 11½; E. 70½; S.E. 59½; S. 10; S.W. 3½; W. 4; N.W. 13½; calm ½ day.

September to April, at 9 A.M.:—N. 16 days; N.E. 17; E. 40; S.E. 29½; S. 26; S.W. 15; W. 12; N.W. 25½; calm 1 day.

At 3 P.M.:—N. 6 days; N.E. 9½; E. 63; S.E. 70½; S. 12½; S.W. 4½; W. 2; N.W. 14 days; calm 0.

Dr. Mann also makes the following observations on the same subject:—

“During the ninety days of the summer season the wind was blowing from the E. or from the S.E. forty times at nine in the morning, sixty-seven times at three in the afternoon, and forty-nine times at nine in the evening. The sky very fre-

quently bears the precise aspect of the Trade-wind sky during this season. During the summer the S.E. Trade-wind, in all probability, affects in a measure the South African region, becoming at the same time partially a Monsoon, on account of the N.E. and S.W. trending of the coast of the vast continent, and being also frequently broken for short intervals by disturbing influences dependent on the irregular heating of the land. The capricious and wet season which accompanies the advent of the summer bears very much the appearance of holding some connexion with the calm-belt of Capricorn, which serves as an outskirt to the region of the Trades, and which sweeps backwards and forwards over the earth's surface, with this region, as it follows the southing or northing of the sun. There is no doubt that the calm-belt of Capricorn extends further south than the parallel of Natal, in both the Atlantic and Indian Oceans, during the summer of the southern hemisphere, and that it is encountered to the north of that parallel in the winter of the same hemisphere."

38. Delagoa Bay.—The rainy season lasts from September to March, but it is quite as often fine as wet; after a strong E.N.E. sea breeze, alternating with light land winds at night, the rain sets in with S. and S.W. winds. At this season a gale of thirty or forty hours' duration is not uncommon, which ceases with fine weather, and the wind at S.E.

Winds from W. to S. always bring bad weather, which clears up as soon as it hauls to eastward.

39. African Coast from Cape Corrientes to the Equator, with the Mozambique Channel.—The seasons here are very uncertain: the so-called N.E. Monsoon, variable between N.E. and N.W., is the ordinary wind from November to April; this is the rainy season. From May to October, during the fine season, the prevailing winds are from S.S.E. to S.S.W. The regular land and sea breezes are very persistent. In the vicinity of the Comoro islands the N.E. winds (as determined by numerous observations) set in about the middle or end of December, a fortnight later than at Zanzibar. The southerly Monsoon blows at S.S.E. between Europa island and Mozambique. In the area comprised between Mozambique, Cape Delgado and the Comoro islands, this Monsoon is variable between S.S.E. and S.W., but blows more from the S. as it approaches ZANZIBAR.

At the southern entrance to the Mozambique Channel southerly winds from beyond the Tropics often produce a strong wind and heavy sea; and when this amounts to a gale it will very commonly penetrate far to the northward into the region of the northerly Monsoon, which it displaces for a time.

The Mozambique Channel is subjected at times to very hard gales and severe weather, though it generally escapes the hurricanes of the Southern Indian Ocean. (See also pp. 25, 26.)

40. Zanzibar.—From the middle of December to the middle of March the wind blows from the north-eastward, and for the first two months with considerable force—varying, however, from E.N.E. to E.S.E. towards the end of the season. When the Monsoon changes, towards the end of March, heavy squalls from S.W. and W. are very frequent, with a copious rainfall; during the remainder of the year (eight months) the prevalent winds are from S. and E. The heaviest rains fall in March, April, and May; the second rainy season is in September and

October. The temperature does not vary much, but it is rarely oppressive, owing to the general prevalence of fresh breezes from seaward. January, February, and March are the hottest months; July, August, and September, the coolest. The climate is not so unhealthy as has been often reported; but under all circumstances avoid sleeping in the open air, and near the jungle.

41. Equator to Cape Guardafui (Eas Asir).—The S.W. Monsoon—variable between W.N.W. and S.W.—from March to October. The N.E. Monsoon from October to March, but it is rarely strong near the coast.

From October to January the winds are very variable, not unfrequently veering all round the compass; the prevailing N. wind brings rain, at times in great quantities. From January to May the wind is commonly fresh from N.E. to N.N.E., with fine weather; but after March it varies to S.W., bringing bad weather in the vicinity of Cape Guardafui.

From May to October southerly winds are prevalent; occasional calms are, however, to be expected near the coast during July, August, and September, although it may be blowing strong at sea.

In the immediate vicinity of Cape Guardafui, owing to its peculiar prominent position, general bad weather and heavy squalls are of common occurrence during July, August, and September, although at the distance of thirty leagues there may be fine weather and a smooth sea.

Land and sea breezes are prevalent and fresh along this part of Africa during February and March, and again in October; these months separate the Monsoon seasons.

42. East Coast of Madagascar.—Respecting Madagascar, a memoir was read to the Royal Geographical Society in 1849, from J. A. LLOYD, Esq., F.R.S., F.R.G.S., Surveyor-General of Mauritius. From this report it appears that "there are two distinct seasons on the eastern coast of the island: the first, called by Europeans the *fine* season, begins in May, and terminates towards the middle of October. The heat is moderate; strong breezes from the S. and S.E. blow during the day, and from the S. to S.W. after sunset, which renew the air and dissipate the effluvia of the stagnant waters. The appearance of the country during this period of the year is delightful to an extreme, and the provinces of the interior especially are most healthy and salubrious.

"The second, or *bad* season, begins towards the end of October, and continues until April. The hottest and most unhealthy weather happens in January, February, and March. Storms of thunder and floods of rain inundate the country during this period. The wind is calm, or blows lightly from the N.E. during the day, and from the N. to N.W. during the night. It is in this season that the influence of the intense heat upon the animal and vegetable substances washed down by the floods breeds infectious and deadly vapours.

"On the N.W. coast the N.E. Trade-wind blows without intermission from October to April. During the remaining part of the year it varies from S. to W. from noon to night; it then shifts by S. to E., and remains in the latter quarter the next forenoon.

"The temperature of the interior is much cooler than that of the sea-shore, the

thermometer in summer (October to May) rising to 85° Fahr., and in winter falling as low as 40° Fahr.*

Respecting that part of the east coast of Madagascar south of Lat. 18° S., it has been observed,† that the N.E. Monsoon, variable to N.N.E., prevails from November to April; the S.E. Monsoon, variable to S. and S.S.W., and which brings the fine or dry season, occupies the remainder of the year. But north of the parallel of 18° S.—comprising Fong Island, Tamatave, Foul Point, Mahambo, Fenerive, St. Mary Island, and Tintingue—S. and S.S.W. winds, generally fresh, are prevalent from March to the beginning of September. During September the winds haul to N.E. and N., alternating at times with southerly breezes; when the former succeed the latter they frequently blow strong for two or three days, after which they subside and gradually veer again to S. This succession of winds continues until the N.E. Monsoon is fully established. Land and sea breezes begin in September; the land breeze, always very light, sets in at 10 or 11 P.M., lasting till 9 or 10 A.M.; after a calm of an hour or two the sea breeze begins and lasts the remainder of the day; the land breeze does not extend seaward to a greater distance than 9 or 10 miles.

From the middle of April to the middle of June the E. and E.S.E. winds seldom or never bring rain; in November, and while the winds are veering to the northward, stormy weather may be expected,—sometimes, however, not beginning before December; then, towards 3 P.M., the sky is generally overcast, and an evening seldom passes without rain; this lasts till April—it is also the hottest period of the year. A second rainy season occurs from the middle of June to the middle of July or August. The winds are generally fresh during the rainy season, and produce at times a heavy sea. The cyclones of the Indian Ocean occasionally reach the coast of Madagascar.

The insalubrity of the coast has been somewhat exaggerated according to recent French accounts. *Malaria* fevers may be expected during the rainy season, and excess of every description must be avoided here as much as on the African coast.

23. Reunion.—This island is entirely within the limits of the S.E. Trade-wind, which, however, undergoes some modification, arising from the altitude of the interior, and its proximity to the region of the N.W. Monsoon.

All the roadsteads of the island on the windward side, between St. Pierre and St. Denis, feel the full effects of the S.E. Trade, which is generally strong, but during the day its inclination is more *from seaward*, according to the position of the place; towards evening the strength of the wind gradually diminishes, and during the night its direction is more *along the land*. These slight modifications are all that constitute the difference between the land and sea breezes on that part of the island;—for example, at St. Denis the wind is generally fresh from S.E. to S.E. by E. by day, but during the night it changes to S.S.E., and is usually not so strong.

On the leeward side of the island the influence of the land is well established.

* "Jour. R. Geog. Soc.," 1850, p. 54, "Memoir on Madagascar."

† "Annales Hydrographiques," 1864, tome xxv. p. 318.

From 6 P.M. to 6 A.M. the S.E. Trade-wind pursues its course directly across the high land, but towards morning its force diminishes, and a calm may possibly follow; after which, towards mid-day, the sea breeze sets in from S.W. by W. or S.W., veering gradually as the day advances, and dying out as it gets to W.N.W.

During the fine season, from April to December, the wind blows continually from the S.E., varying to S.S.E. and E.S.E. The breeze generally freshens at 9 A.M., and decreases at 4 P.M. The nights are generally calm, and if otherwise, you may be almost sure that it will blow strongly the following day. If during the day the breeze is moderate, and fails early, there will be a light land breeze during the night.

The winds are generally fresh during June, July, and August. The usual S.E. winds continue during winter, or from December to April (a period improperly called the N.W. Monsoon), but they are generally more moderate, and interrupted by calms and winds from W. and N.W. It is in this season that heavy gusts, and even hurricanes, occur. After these gusts there is often a profound calm, or a W. wind, which is always of short duration, and is soon followed by winds, generally from S.E. Hurricanes are most dreaded by the regular traders about the days of full and change of the moon, but for this there is no sufficient reason.

The distribution of the winds, as above indicated, is further modified between the months of November and April. At that season of the year the N.W. Monsoon is well established to the southward of the Equator, on the African side of the Indian Ocean, and its influence is felt at Réunion in the variable (chiefly westerly) winds prevalent there during that period. This Monsoon rarely blows either with great strength or regularity, but during its prevalence the weather is fitful and squally.

44. Mauritius.—Most of the remarks on the winds given above (*see* RÉUNION) apply with equal force to Mauritius; and there is a marked difference in the climate of the island in different situations: the windward (or S.E.) side enjoying a lower temperature by several degrees than the leeward (or N.W.), owing to the cooling and refreshing influence of the S.E. Trade which prevails during the greater part of the year.

The principal rainy season is from the end of December to the beginning of April, but showers occur in all months.

The prevailing direction of the wind at St. Louis is as follows:—*January, February, and March*, E.S.E. to N.E. and N.W.; *April*, E.S.E. to E.N.E.; *May*, S.E. to E.S.E.; *June*, S.S.E. to S.E.; *July and August*, S.E. to S.; *September*, S.E. to E.S.E.; *October*, S.E. to E.; *November*, S.E. to E.N.E.; *December*, S.E. to E. and N.W.; Mean of the year, E.S.E. to E.

See also the Chapter on "HURRICANES and CYCLONES."

45. Rodrigues.—The Trade-wind blows here more persistently than at Mauritius and Réunion, prevailing between E. and S.E. nearly all the year round: occasionally the influence of the N.W. Monsoon of the northern part of the Southern Indian Ocean extends as far as this island, when a hurricane may be the consequence, after which there will be a succession of calms and light airs. Rodrigues is of too small an extent to feel the influence of land and sea breezes, but the steady Trade for eight or nine months in the year keeps the temperature cool and equable.

26. The Gulf of Aden.—The N.E. Monsoon commences early in November, increasing in strength at full and change of the moon. During November and December the weather is unsettled and cloudy, frequently blowing a moderate gale, with heavy rain. In January, February, and March, the wind varies from E. to E.N.E., increasing in strength towards the Strait of Bab-el-Mandeb; the weather is now fine and the sky generally clear, the temperature ranging from 68° to 80° Fahr.

During April and May the wind is often light and variable, between E.N.E. and S.E., near the coast; and though the weather is generally fine, the sky is frequently cloudy and the horizon obscured by fog: close in-shore land and sea breezes are now prevalent, the land breeze lasting from 4 A.M. to 8 A.M. During April it rains occasionally, and at night a heavy dew falls.

The weather is generally unsettled and dull during June; with a calm or light air in the morning, a fresh breeze from the S. will set in, freshening towards noon, and producing a long swell on the Arabian coast. Towards the middle of the month, and during July and August, between Burnt Island and the Strait of Bab-el-Mandeb, strong westerly winds are prevalent, which facilitate the passage from the Red Sea to the Indian Ocean. These winds will probably fail before a vessel reaches Râs Rehmat, but afterwards she will get the Monsoon from the southward, from which direction it blows with great strength through the channel separating Socotra from the main land of Africa. The weather is generally dull, with a thick fog at times. A southerly wind—very fresh by day and light at night—may always be expected on the Arabian coast at this time of the year; not unfrequently, however, severe land-squalls come off at night, which, by raising a cloud of dust, give ample warning to the seaman.

In September the westerly winds cease, and the land and sea breezes are tolerably regular. The nights are often calm, and always more or less sultry.

At Aden the temperature during May is generally intolerably hot, ranging from 84° to 95° Fahr.; so also in September, owing to the cessation of westerly winds. In November and December the range is between 76° and 84° Fahr., the weather being cooler as the N.E. Monsoon increases; the same average temperature may be expected in January and February: during March and April it becomes warmer, ranging from 80° to 86° during the latter month.

On the African coast the heat is intense (sometimes 110° Fahr.) during the prevalence of the S.W. Monsoon; as a consequence, the natives sometimes leave the coast for the uplands, and trade ceases.

What is termed the S.W. Monsoon in the Indian Ocean generally blows out of the Red Sea in a southerly direction, varying with the line of mountains on the Arabian coast: outside the Straits of Bab-el-Mandeb it takes a westerly direction, but seldom extends far beyond Aden. At Cape Guardafui it blows with great violence along the coast from N.N.E., and thence across the Gulf of Aden to Râs Rehmat; and on this line, after experiencing variable, light airs or a calm for a few hours, a vessel proceeding eastward generally enters the Monsoon.

That part of the Arabian Sea included between a line drawn from Cape Guardafui (Africa) to Râs Rehmat (Arabia) on the one hand, and Râs Kossair (Arabia) on the other, is a region of calms and light, variable winds during the period of the S.W. Monsoon; and it serves to separate the wind region of the Gulf of Aden from that of the Arabian Sea.

47. Red Sea.—COMMANDER T. ELWON, I.N., gives the following general notes on the winds and weather of the Red Sea :—

“The N.E. Monsoon entering the Red Sea, becomes a S.E. wind, and, being repelled by the high land of Africa into a narrow strait, blows with considerable force, and rather inclining towards the Arabian coast; for it is probable that they are stronger there than on the Abyssinian side, even in the lowest part of the sea. These winds generally begin to decrease in force after passing the Harnish and Zoogur islands in Lat. 14°; and as they approach the wider part of the sea, they are gradually lost in light winds along the outer reefs on the Arabian side, or turn to the westward amongst the banks and islands on the African side, and gradually unite with the prevailing northerly winds in that part.

“The southerly winds commence in October, and subside in the latter part of May, or beginning of June. They blow with most force from October to the end of January, and in some months extend as far as Suez, but most commonly do not reach Jiddah; they are frequently succeeded by light, variable, or northerly winds in the 18th degree of latitude. From February to the end of May they do not always blow so strong as in the preceding months, and are frequently succeeded by northerly winds for several days, particularly in the month of February, at which time the native boatmen avail themselves of the opportunity to quit, and reach the southern parts of the sea.

“From October to January, in the lower part of the sea, the weather is generally thick and hazy, obscuring objects until pretty near; and along the outer reefs squalls and rain are frequently experienced in November and December. From February to May the weather is unsettled—in April and May particularly. Below the 15th degree of latitude we experienced fresh squalls from the eastward, with heavy clouds of sand, and sometimes rain.

“In the beginning of June the southerly Monsoon is succeeded by north-westerly winds, which, in the lower part of the sea, seldom blow with great force. They continue pretty regular during June and July, and in August and September are frequently light and variable; in the latter month there are sometimes light southerly winds or calms. During this time the weather is frequently very thick and hazy, particularly on the Arabian side; and the Abyssinian shore is consequently much the most pleasant, and is considered the most healthy.

“In October the pilot drew our attention to the Pleiades, which the Arabs call ‘Tryer,’ and which were then seen low down in the East; he informed us that, on their first being seen in that quarter in the evening, it indicated the commencement of the southerly winds. The latter part of April, in the evening, the Pleiades set, when he said there would be light, variable winds for forty days, after which they will be again seen in the East in the morning, when the N.W. winds commence, and continue until they again set in the morning in the beginning of September, when there will be light, variable winds for forty days, after which the southerly winds commence again, when they are seen in October early in the evening.

“In the *inner channel* on the Abyssinian side of the Red Sea, northerly winds, inclining to land and sea breezes, seem the most prevalent of all the year round, but most probably are, as in all other parts to the south, light and variable in August and September, when there are also frequent calms, and southerly winds are by no means common. From the month of August to October is generally fine weather,

but from November to the end of March appears to be the rainy Monsoon upon that coast. In April the weather was cloudy, and fine in May, June, and July; but between 19° and 20° of lat. in these months we experienced several hot winds and fresh land squalls; and by Mr. Salt's journal, it appears that the *Panther* was driven from her anchorage, in Lat. $15^{\circ} 30' N.$, at Massowah, June 20th, 1805, by a partial *Simoon*, or land squall.

"There are similar winds and weather on the Arabian side; and though we had land and sea winds more frequently in March and April, the land squalls in the lower part of the sea occurred in April and May. From May to July, when we experienced them on the Nubian coast, there was at that time thick, hazy weather; and heavy dews on the Arabian side opposite."

COMMANDER T. E. ROGERS, I.N., from observations made over a lengthened period, also furnishes the following memorandum on the winds of the Red Sea throughout the whole year:—

"From the beginning of October to the end of April, which may be called the winter months, from the Straits of Bab-el-Mandeb to Jibbel Teer, in Lat. $15^{\circ} 31\frac{1}{2}' N.$, the wind may be said to blow constantly from the southward, with the exception of an occasional day or two of northerly winds on the full and change of the moon; but two months frequently pass without any change. The current generally takes the direction of the wind 15 or 20 miles per day, particularly that from the northward, from the southerly winds having, as it were, heaped the waters in the upper part of the sea; from this cause also I imagine it is, that a set is at times found against the southerly winds, on the decreasing of a strong breeze from that quarter.

"The effect of the southerly wind in raising the water, and the northerly wind in decreasing it, very plainly appears in Jiddah roads; with the former a small boat can go straight from the anchorage to the shore, whereas with the latter, in the same direction, a succession of dry banks appears, having only a circuitous and shallow channel.

"From Jibbel Teer to Lat. 19° or 20° the winds at the same season are variable, blowing nearly as much from the N. as the S., that particular wind predominating as you approach the north or the south of the above limits. The currents here, in general, set with the wind, but at times are found to run across the sea as much as 20 miles in twenty-four hours; occasionally, but not often, a set to windward is experienced of 12 or 15 miles in the same time. The winds here do not, in general, blow so strong as the prevailing ones above and below these limits.

"From Lat. 21° to 27° at the same season, the northerly is the prevailing wind, but half a moon seldom passes without having the wind one or two days from the southward, more particularly from the end of November to the beginning of March. The currents here are much the same as between Jibbel Teer and Jiddah; the southerly wind is less frequent as you approach the north extreme of these limits; strong northerly winds, of two or three days' continuance, are often experienced here in these months.

"From Lat. 27° to Suez the wind is almost constantly from the northward, and, unless during the months of December, January, and February, seldom interrupted by that from the southward. The currents run with the wind, but are not so strong as those experienced more to the southward. The north-western seldom blows with violence here for more than twelve or fifteen hours at a time, and, from what I have

experienced, I should say it does not blow so strong in the summer as in the winter.

"In June, July, August, and September, the northerly winds prevail, with more or less strength, throughout the sea from Suez to Bab-el-Mandeb, with little interruption; occasional slants from the land are met with, particularly in August and September; and a vessel that sails fairly will average 35 miles a day in working from Mocha to Suez in these months.

"Leaving Mocha in the end of July, the *Euphrates* worked to Suez in thirty-six days; leaving Mocha in the end of August, she completed the same voyage in thirty-two days. On both these occasions, from leaving Mocha until she passed the Straits of Jubal, she never had a second reef in the topsails. The water was in general smooth; the current generally against, sometimes with her, the difference giving an average of $3\frac{1}{2}$ and 4 miles daily against her during the voyage.

"In opposition to HORSBURGH,* who says the wind in the Sea of Suez generally blows strongest during the day, I have found in working up on three occasions, once in June, another in July, and again in August, the contrary to be the case, never, on any occasion, having found a second reef in the topsails necessary during the day, whereas at night I have been generally obliged to double-reef the topsails, and at times take in the mainsail.

"Throughout the Sea of Suez a hazy horizon is generally a sign of a breeze; but it is not always its precursor. The same remark applies to a light, fleecy cloud hanging above the tops of the Tor or Sinai mountains, as seen from the southern entrance of the Straits of Jubal.

"During the winter months, throughout the sea, the northerly wind is generally accompanied by a dry atmosphere, and the southerly wind by one that is damp. A change of wind is thus often indicated some hours before it takes place, or before any other sign is visible.

"During the summer months the atmosphere is generally damp throughout the sea; but the sky overhead is so clear that a planet can often be seen at noonday.

"In working up the sea to the Straits of Jubal, I think the Arabian coast is the best to keep on; and in this opinion I am strengthened by the practice of Turkish ships, which, in their way from Jiddah to Cosire, sight the island of Tirahn before they venture to cross over, so much do they dread making the Egyptian coast below Cosire. This is 60 miles further to the northward than I think a fair sailing ship need go, and the practice is sometimes attended with provoking consequences, as I have known one Turk reach Cosire before another who left Jiddah thirteen days earlier, in consequence of the former getting a southerly wind below Cosire, which to the other was a foul wind, from his being so far to the northward.

"The wind in the Red Sea seldom blows in squalls, but its gradual rise is often very rapid in the northern part.

"In the months of December, January, and February, a ship sometimes will carry a fair wind from Mocha to Cosire, and make the passage in six or seven days. I never heard of this being done from Cosire to Mocha unless in the summer months."

CAPTAIN MORESBY says:—"The winds from Suez to Jiddah, during the whole of the year, are mostly northerly, blowing with great violence at times, but generally moderate with the changes of the moon. During the winter months, from December

* Observations by CAPTAIN KYDD, E.I.C. service.

in April, southerly winds at times prevail for a few days, occasionally blowing fresh; more especially in the Sea of Suez, where they freshen at times to a moderate gale. In these months, in the Sea of Suez, westerly gales are not unfrequent; they are called by the natives the Egyptian winds, and from their violence are much dreaded. On the Arabian coast, near Jiddah, both to the southward and northward of it, northerly, north-east, and easterly winds at times blow with great violence during the winter months, bringing off clouds of dust from the land."

Some navigators, d'Après de Mannevillette, Malham, &c., say that southerly winds prevail in the southern part of the Red Sea during two-thirds of the year, from October to May or June, after which, northerly winds take their place for the remaining four months.

The following remarks on the same region are by LIEUT. R. WELLSTED, I.N. :—

"During the warm season, from May to October, in the northern part of the sea, the reefs are observed to have about two feet less water on them than in the remaining months of the year. This effect is produced by the influence of northerly winds at this season, which, prevailing throughout the whole extent of the sea, cause a continued current to set through the Straits into the Gulf of Aden. When the southerly winds, which at the lower part of the sea prevail from October to May, set in, these currents are observed to change their direction, and to flow back with rapidity; the whole body of water having no means of escape, then collects towards the northern part of the sea, and becomes considerably elevated. The partial influence of a southerly breeze during the former months was observed to produce for a short time a similar effect, the water subsiding to its former level on the return of the northerly breezes."

Climate.—Though the sea-coast of Hejás is pronounced unhealthy, yet, afloat, we do not find it so. The temperature, compared with that of the Persian Gulf, is moderate; near the sea-coast, where the winds are light with intervals of calm, it is usually much warmer than in the middle of the sea, where there is rarely any intermission of the prevailing breezes.

The north-westerly winds are cool and refreshing; but the southerly winds are damp, sultry, and unwholesome. During the period at which the latter prevail, in September and October, the dampness of the air is very great in the warmest days; and the heavy dews at night, when all are obliged to sleep in the open air, renders them particularly disagreeable. The sudden and grateful change which a return of the north-westerly breezes produces in the atmosphere renders them particularly desirable at this season.

In the cold weather the sky is, for the most part, clear and cloudless; generally speaking, there is no want of rain, which falls in heavy showers during the months of November, December, and January. In this respect the climate of this coast differs widely from that of Egypt, where (though the distance between the two countries is only about 160 miles, the width of the Red Sea), it is well known, rain is of rare occurrence. A season of drought, it is calculated, occurs here about once in four years; the floods during the rainy season pour down from the hills with great violence. Almost every part of the coast bears traces of torrents formed during this season. Fogs are not uncommon at Jiddah and in its neighbourhood, but rarely prevail to the northward of that port.

* "Jour. Roy. Geog. Soc.," 1886. "Observations on the Coast of Arabia between Rás Mohammed and Jiddah."

48. The S.E. Coast of Arabia, from the Gulf of Aden to Ras-al-Hed.—On this part of the coast the N.E. Monsoon sets in about the middle of November, and lasts until the middle of March—the direction of the wind being greatly modified by the trend of the coast-line; at some distance off shore the direction varies between N.E. and E. by S. The weather is generally fine and the sky clear, with neither squalls nor rain, except between Rás Seger and the island of Masírah, and the vicinity of the bay of KURIYÁN MURIYÁN, where the winds and weather are more boisterous and variable than on any other part of the coast.

The following remarks respecting the extensive bay of Kuriyán Muriyán are by CAPT. S. B. HAINES, I.N.:—

"The sudden changes of the winds, and the great violence with which they blew, frequently rendered the position of the surveying-vessel which I commanded dangerous; nor could she have been extricated but for the activity of the officers and crew, and her good supply of ground-tackle. It is also necessary to observe that these changes give no warning, owing to which I was compelled, for the safety of the vessel, to secure her 30 miles from the islands, while I surveyed them in my boats; and it was not an uncommon occurrence for boats to be manned and ready when, from a clear, serene sky, a light arched cloud would appear over the table cliffs surrounding the bay, and in five minutes (just time enough to run the boats up) we could not see ten yards from us, and it blew a perfect gale from the northward. These winds, termed by the Arabs *Beldt*, are much dreaded; but what surprised me more than these land winds were the frequent and heavy gales from S.S.W. during February and March, blowing for six days together. In one of these, after the close of the survey of the islands, I was overtaken when surveying round the bay on a dead lee-shore, having parted two bowers. A *Beldt* lasted for twenty-one days on a recent occasion, during the time the Red Sea and Indian Telegraph Company occupied Hulláníyáh, the largest of the Kuriyán Muriyán group.

"These northerly gales do not extend far southwards, but appear to be confined to the limits above mentioned; when clear of Kuriyán Muriyán Bay, and past Rás Nús, they blow along the line of coast, being influenced by the high range of the Subhán mountains towards Morbát, in which anchorage the water is smooth from the wind's blowing off shore; but through the deep valley of Dhofár it again blows off shore with great violence.

"The southerly breezes appear also confined to that part of the Arabian coast, as to the southward they are seldom felt, and the S.W. Monsoon does not reach Socótra before the 1st or 10th of May. For three years successively it reached Socótra the 4th of May, with heavy rain on the 6th and 9th; so that navigators coming from the Gulf towards the Red Sea must not take the S.S.W. winds they may fall in with in February or March for the S.W. Monsoon, as has been the case; and in consequence of such a mistake a fast-sailing vessel, to my knowledge, bore up for Bombay. From the 15th of March till April the winds are light and variable along the whole line of coast, and the weather warm; land and sea breezes then enable the crowd of boats from Súr and Masírah to run back with their cargoes of shark-fins, the produce of some months' toil, to the southward. The sky is then generally cloudless, and the atmosphere light and pure, with heavy night-dews.

"May is a doubtful month, for if the Monsoon is early it may blow hard from the S.W. At times, however, moderate weather is experienced.

"During June, July, and August, the S.W. Monsoon is in its full strength, and at times blows very hard along the whole line of coast, particularly in July. In the early part of June large boats run from the Red Sea to the Persian Gulf; and this voyage, which is accomplished after the first blast of the Monsoon, is termed the '*tadhbir*.'* They also set sail at the latter end of August, and run up during the '*dekmáni*,† or after the strength of the Monsoon is over.

"During the month of September the winds are moderate from the W. and S., and the weather is warm.

"In October light uncertain breezes and calms are common; land and sometimes sea breezes when in-shore; and at night cloudy, with passing showers of rain.

"The experience of several years along the coast has taught me not to place implicit confidence on the regularity of the seasons, as I have frequently during the same month, in different years, experienced exactly opposite winds. In March, 1835, I was twenty days in passing from the Kuriyán Muriyán Islands to Makallah, with southerly and westerly winds, and adverse currents; and in March, 1836, I was only three days working the same passage, having the N.E. Monsoon with me. Further, I have observed that at all seasons, and on all parts of the coasts of Arabia, particularly when the land is low, the wind is influenced more or less by the sun's position and the changes in the state of the atmosphere towards the sea; and even in strong breezes the same influence prevails to a certain degree."

The following is a SYNOPTICAL TABLE of the weather experienced off the Kuriyán Muriyán Islands in 1835 and 1836:—

Date.	Winds.	Date.	Winds.
Dec.		Feb.	
14	Light E.N.E. to E.S.E.	1	E. and moderate.
15	Light S.E.	2	E.N.E. and light.
16	Light S.E. and S.	3-5	Fresh gale, N. to N.W.
17, 18	Hard gale from N. to N.W.	6	Moderate E.N.E. breezes.
19	Fresh W.N.W. <i>Reliance</i> whaler wrecked.	7	N.E. to E.S.E. moderate.
20	Fresh gale, N.W. to N.	8, 9	Fresh gale, N. to N.W.
21, 22	Moderate A.M., light P.M., N.	10	Moderate N.N.E. to E.N.E.
23, 24	Light E.N.E.	11	Fresh southerly gale to S.E. by S.
25-27	Light airs and calms.	12-14	S. to S.W. by S.; fresh gale.
28	A.M. N., P.M. S.E.	15	Calm light airs, clear sky.
29, 30	Light E.N.E. and S.E.	16-18	Hard gale, N. to N.W.
31	Calm.	19, 20	S.S.E. to S.W. fresh.
Jan.		21	Moderate gale at S.S.W.
1-5	Hard gale, N. to N.W.	22, 23	N.; moderate gale.
6	Fresh A.M., P.M. light airs.	24	Gale at S.S.W.; squalls and rain.
7-11	Light land and sea breezes.	25, 26	Hard gale, S.S.W. Vessel parted two bowers.
12-17	Moderate from N.E. to E.S.E.	27	Moderate S.S.W.
18-23	A furious <i>belát</i> from N. to W.N.W.	28	S. by E. to S.S.W. moderating.
24	Moderate gale, P.M. light airs.	29	Moderate.
25-27	Blowing a gale from N. to W.N.W.	March.	
28	Moderate N.E.	1	S.E. by E. to S.; moderate.
29	N.E. to N. moderate.	2	E.S.E. to S.S.E.
30	N.N.E. light.	3	Fresh S.
31	N.E. moderate.	4	Light airs from N.N.E. to E.

* *Tadhbir* signifies a certificate; it is here probably used technically for the first indication of the Monsoon.

† Probably *dekmáni*, "the season of mischief;" if so, *ba'd ad dekmáni* would be, after the violence of the Monsoon is past.

The observations of COMMANDER J. P. SAUNDERS on this coast are to the following effect:—

"I was much hindered on my first arrival (December) on the coast by the strong *Beldt* winds which prevail on it, one breeze succeeding another at intervals of eight or ten days, always blowing very strong, sometimes a perfect gale, and constantly varying in gusts from N.N.E. to N.N.W., rendering it quite unsafe to send a boat away from the vessel. These *Beldts* never last less than three, but sometimes seven, or even ten days.

"The *Beldt* is also dangerous to ships near the shore. Occasionally at night the breeze would die away to a perfect calm, and remain so for an hour or two; heavy gusts would then blow down from the mountains at intervals of a few minutes (without any warning except the noise on the water) sufficiently strong to split the sails or carry away the masts of any ship under sail not prepared for it: these gusts would succeed each other for five or six hours.

"The Arabs consider that the N.E. Monsoon lasts only three months to the N.E. of Rás Farták—viz., part of November, December, January, and part of February. The S.W. Monsoon is considered over at the middle or end of August, and they begin to trade at the beginning of September. Between the 1st of September and the setting in of the N.E. Monsoon is about six weeks, and is a season of light, variable winds called *Damauro*.

"In March the southerly winds to the E.N.E. of Rás Farták blow sometimes very fresh, particularly in Kuriyán Muriyán Bay. April and May is considered another season, which is called *Bayn el Autem* by the Arab navigators. The winds are variable, though generally inclining to the south. Vessels pass up and down, and, as the current sets up to the east, they make rapid passages to Muskat and the Persian Gulf. Nearly all the trading-boats which pass down in the commencement of the N.E. Monsoon return again in these months, bringing back rafters, grain, and slaves, from the different ports to which they have been.

"The winds to the south-westward of Farták towards the end of March generally blow to the S. of E., sometimes S.E., and even S.S.E. and S.; occasionally the current also changes and sets to E.N.E. along the shore. The wind generally dies away at night, rendering progress to the west very difficult. The trading-boats from the Persian Gulf and Muskat begin to return in this month for Zanzibar and the Red Sea, and continue to do so until near the end of May. An occasional turn in the current to the westward may take place, and a shift of wind from the N.E., even as late as the 25th of May, but it does not often occur.

"To the E.N.E. of Cape Bogashua, after the beginning of May, a high long swell gradually sets in from the southward, rising much higher in the day and falling towards sunset. A long swell rolls on to the coast during the whole of the Monsoon; but the fishermen, when they have a small nook to shelter their boats in launching, go out to fish in it at times.

"In the *Palinurus* I experienced this swell during the whole month of May, which, when the wind died away, caused her to roll very heavily. It would affect a steamer, of course, in the same way in passing, as generally it would be four or five points on her bow.

* "Jour. R. Geog. Soc.," 1846, p. 169. "Memoir of the Proceedings of the Hon. Co.'s Surveying-brig *Palinurus*, between Rás Morbat and Rás Seger, and between Rás Farták and the Ruins of Misenát."

From the best information I could procure from many of the natives on the part of the coast I was surveying, fishermen and others, it would appear that the S.W. Monsoon, to the south-westward of Morbat, close to the shore, blows fresh only occasionally—a breeze lasting from three to four days, and is then succeeded by light breezes and calms from three to ten days; the swell, however, remains. The sea is not so great as that experienced on approaching India. A large steamer passing down from Morbat would be obliged to keep near the shore, where she would experience lighter winds; and it would of course be necessary to keep a good look-out, and the lead constantly going; though, in some parts, even that would be no guide for the distance off shore. She might, if necessary, pass along at one mile's distance in the day, and a few miles off it at night; occasionally she might probably set her try-sails; but a strong current, from a half to a mile and a half per hour, would be constantly experienced running against her to E.N.E.-ward.

From Morbat to Rás Isolette the coast bends a good deal to the westward, forming two bays, with the Kuriyán Muriyán Islands projecting from it at a distance of upwards of thirty miles. Along these bays, and nearly as far as Masirah Island, the natives that I have spoken to all agree that the Monsoon blows stronger and the swell is much higher than on any other part of the coast; this part is much dreaded by them. They also stated that the Monsoon sets in there with a gale of wind, dark gloomy weather, thunder, lightning, and rain. Many boats that have been caught in it have been lost; after the first burst the weather is the same as in the open ocean."

19. Gulf of 'Omman.—During the N.E. Monsoon winds known as *nashis* and *shemál* prevail; during the summer, calms and light winds from S.E. are common, rendering the navigation tedious. The S.W. Monsoon is not felt inside Rás-al-Hed. But neither here nor in the Persian Gulf are the winds regular or of long continuance; those from N.W. and S.E. are the most prevalent; the former being more or less persistent throughout the year, the latter appertaining more especially to November, December, and January; but there is great diversity of opinion respecting the winds in these regions.

20. Persian Gulf.—Here the navigation of a ship requires great attention; the winds, as in most inland seas, are very uncertain, and blow occasionally with great force down the gulf; and in winter, also in the opposite direction: they set in without much warning.

The following remarks are chiefly by CAPT. C. G. CONSTABLE and LIEUT. A. W. STIFFE, of the Indian Navy:—

The prevailing wind in the gulf is undoubtedly the north-wester, called by the natives *Shemál*; this wind blows down the gulf, changing its direction with the trend of the coast. Thus, on the Arab coast, from Koweit to Bahrein its average direction is N. by W. to N.N.W.; on the Gutr coast N. to N.N.W.; and on the west coast of 'Omman W.N.W.

On the Persian coast it blows N.W. by N. down as far as the angle at Jabel Dreng, veering to N.W. and W.N.W. between that and Sheikh Sho'aib. Off Kais the direction is about W. by N.; and from Bostáneh, eastward, it blows from W. to S.W. by W. at the entrance of the gulf.

In the Gulf of 'Omman its general direction is N.W. The *Shemál* blows about

nine months in the year in the northern half of the Persian Gulf; it blows almost incessantly during June and part of July (called the *Great Shemdl*), seldom exceeding a moderate gale in force, and at times quite light; its general duration is three days, but it may last seven days; the worst *Shemds* often only last one day.

During a *Shemdl*, if after rain, the air may be clear and sky cloudless, but generally the air is so loaded with dust from the Mesopotamian deserts that a dense mist is the result. This makes the navigation very dangerous, as the land cannot be seen; the white surf on the beach is often first seen, while the land is still hidden. In the *Shat-al-'Aráb* this is sometimes so much the case that neither bank of the river can be seen. Out of sight of land a vessel's decks and rigging get covered with fine dust. The air during the *Shemdl* is generally very dry and sky cloudless, but in the winter they are sometimes attended at the commencement by rain squalls (often with thunder and lightning), which generally clear off during the breeze; it veers during the twenty-four hours a few points, blowing more off the Persian coast, or from the northward, at night; and off the sea, or more from the westward, in the day, which a vessel should take advantage of when working against one: it sets in at any hour of the day or night, and generally suddenly.

The barometer cannot be said, as a rule, to give any warning of the approach of a *Shemdl*; if it was low before, it will begin to rise as soon as the *Shemdl* sets in, but generally not before, and continue high during the whole duration of the gale. It sometimes falls before a bad winter *Shemdl*, but rises again after the first burst of the gale; the barometer in the surveying-ship was not at all affected by one of the heaviest *Shemds*, either before, during, or after it. This breeze is sometimes preceded by the drying up of the dew by night, or the dampness of the air ceasing, which is a pretty sure sign.

A heavy swell from the N.W., especially in the southern part of the gulf, is often the precursor of a *Shemdl*, although such a swell sometimes occurs without any wind following it.

Some of the heaviest winter *Shemds* set in in fine weather, with no warning except a heavy bank to the N.W. an hour or two previously, which rolls down and gradually obscures all objects, and yet this occurs sometimes without any wind following. Such a warning should, however, never be disregarded.

Ships should be prepared in winter, during a S.E. gale, for a sudden shift to the N.W., especially at night, as the *Shemdl* often blows then very strong.*

The worst of the *Shemdl* is always at the beginning: frequently it does not extend over the whole gulf, and often lulls for a short time about daylight. In the summer *Shemds* the wind rarely exceeds the force of a moderate gale, but in the winter they are often fresh gales, or at times hard gales; it is generally advisable to seek shelter, if possible, during the strength of a *Shemdl*, as little or no way will be made against it. The Persian coast and islands offer many suitable places of shelter.

During the winter months south-easters, called by the natives *Skurgi* or *Koss*, alternate with the north-westers, and, like the *Shemds*, follow to a certain extent the

* On 17th March, 1820, E.I.C. brig of war *Ariel*, from the river, bound to Bú-shehr, beating against a south-easter, under double-reefed topsails. At 1 A.M., 18th, sail was further reduced, as a squall was expected from the N.W. This was scarcely accomplished when the squall burst upon them, and taking her right aft, she ran through the opposing head-sea, buried herself in it, and sank about twenty miles W. by N. of Kháreg Island. There were about ninety souls on board; of these only the surgeon, boatswain, and three of the crew were saved, on a canoe which floated off the booms.

direction of the coast; they only blow strong from December to April. The *Koss* is generally accompanied by thick, gloomy weather, with hard squalls, and often much rain, sometimes thunder and lightning. The atmosphere is moist, and the barometer generally low. With a falling barometer and cloudy, threatening weather, a *Koss* may be expected in the above months, but timely warning is not always to be expected, although the barometer always falls during the gale, if not before. It seldom blows more than three days; its strength is generally a moderate gale, but at times it blows a fresh gale; the strongest only last one day. When the wind begins to veer to the southward the *Koss* is over, and is often succeeded by a *Shemál* almost immediately; or it may blow hard for a short time at S. or S.W. and so die away, no *Shemál* occurring for several days. The wind sometimes, however, after blowing hard at S.W., chops round suddenly to N.W., when a strong *Shemál* will follow; the notion that a *Koss* is always followed by a *Shemál* is not correct.

If a vessel has anchored for the *Koss* in an anchorage open to the *Shemál*, she should weigh immediately the *Koss* is found to be over, as she may otherwise have to ride out a N.W. gale on a lee-shore; easterly winds are of most frequent occurrence in the southern part of the gulf.

In the winter, particularly in the southern part of the gulf, strong breezes are experienced from N.E., called *Nashí*; they are attended by dark, cloudy weather, and generally rain; the natives make a distinction between these breezes and the *Koss*. The barometer is not affected by this breeze, being generally high, and if so, it will fall a little when the *Nashí* is over; there is sometimes a dense haze before a *Nashí*, caused by the dust blown off the land. This breeze often blows three or five days, but frequently only one day; after the first day the air becomes clearer, possibly owing to rain on the land. The *Nashí* blows in gusts with frequent lulls, and if a three days' gale is strongest on the third day; it blows very strong in the Gulf of 'Omman, and is much dreaded by native craft, as the Bátneh coast is a lee-shore, and there is no shelter.

The south-wester, called by the natives *Sahcili*, is much feared by them, as it blows into nearly all the sheltered anchorages on the Persian coast; it lasts generally only a few hours, and often follows the *Koss*, but sometimes occurs after fine weather; it is accompanied by rain, and is preceded by masses of clouds rising from the S., with lightning; it is not of frequent occurrence, and only happens in the winter months; it blows all over the gulf, and also in the Gulf of 'Omman, especially off Rás al Kúh.

The land and sea breezes are uncertain, but in fine weather land winds are experienced near the coast. On the Arabian coast strong land winds—often in hot gusts—are not uncommon in the morning. At KOWEIT sea breezes are regular during fine weather. At BU-SHEHR sea breezes are regular in summer when there is no *Shemál*; they set in about 9 A.M.; there is scarcely any land wind. At BANDUR the sea breezes are regular, and the land winds are strong, lasting till 10 A.M.

When the season changes—between Oct. 15th and Nov. 5th—very severe squalls (called *Lehey.nak*) may be expected; their direction is uncertain. During this period an unusual amount of electrical action is present, and St. Elmo's fire has been observed on board ship; the air is also wonderfully clear. No native vessels put to sea at this time. Should no such squalls occur before the 5th of November it is generally supposed that the season will be free from them until the bad weather of winter sets in.

In Basfidh roadstead very violent squalls have been experienced from the N. in May; the E.I.C. schooner *Tigris* drove with two anchors ahead until she struck off the hospital. Heavy squalls from the S.E., with lightning and rain, are occasionally experienced in July. In the winter tremendous gusts blow out of the valley in the mountains (Devil's Gap) below Muskat.

At the north end of the gulf very heavy squalls blow at times from the northward.

A succession of squalls from opposite quarters, each lasting only a few minutes and alternating several times, is no uncommon occurrence in any part of the gulf and at any season. During winter, also, the winds are very local—a *shemál* blowing at one end of the gulf, while in the centre or at the other end it may be calm, or perhaps a wind from the opposite direction, and moderate.

At Bú-shehr gales of wind with rain occur in January and February; the wind is often from an opposite quarter to that at Shat-al-'Arab.

The hottest weather occurs in the Persian Gulf during June, July, August, and September, when, on board ship, the thermometer may range from 90° to 98° Fahr. at 4 P.M.; on shore the thermometer has risen to 124° in the shade, and 150° in the sun. With a southerly wind the heat is almost insupportable, from the increase of moisture in the air. December is fine and cool, while January and February are cold and often boisterous; thermometer from 67° to 72° Fahr. The heavy dew in the summer months will wet the sails so that they appear as if a shower of rain had fallen; dense fogs also occur at times near the coast in the morning, wetting everything as with rain. Calms, lasting for days together, are common in the Persian Gulf and Gulf of 'Omman; a continuous steady breeze is rare: water-spouts, and sand-spouts on shore, are frequently observed. Rain is variable, less probably on the Arabian than on the Persian coast, and it generally falls in winter; the barometer is not reckoned a safe guide against bad weather in the gulf.

51. Bombay and the Coast to the Westward.—During November and December the winds are fresh from N.E. and N.—stronger at sea than near the coast,—but the weather is fine. In January and February the winds are more moderate, but sudden squalls from the southward and westward are occasionally experienced. During March and April the N.E. Monsoon is dying out, and fresh N.W. winds alternating with calms are frequent. Off Bombay and Kurrachi, and thence seaward, during March, April, and May, the winds are variable between N.W. and S.W., after which the S.W. Monsoon sets in.

52. West Coast of Hindoostan.—During October and the beginning of November the navigation of this coast presents many difficulties, arising from the inconstancy and variability of the winds; subsequently, from November to March, the N.E. Monsoon is well established, and brings with it remarkably fine weather. This is also the *season of land and sea breezes*, which to the south of Calicut extend some distance seaward; but the land breeze is tolerably fresh in December and January along the whole coast. The sea breeze commences about 11 A.M., or near mid-day, varying between W.S.W. and N.W., and is moderately strong; at some period between 6 P.M. and 9 P.M. a calm ensues, after which the land breeze sets in from N.E. to E.S.E. These alternating winds are prevalent between Cape Comorin and Surat, and cease in March, after being rather uncertain in February.

In April the winds are variable, between W.N.W. and N.N.W., and sometimes N.E., indicating the termination of the N.E. and approach of the S.W. Monsoon; at this time a calm is not unfrequent during the morning, after which light airs from N.E. to N. are not uncommon.

During May the weather is very uncertain, being squally, with rain, and the wind from S. to S.W., passing to N.W., after which it is fine. If near the land in May and June very strong squalls may be anticipated during the night.

The S.W. Monsoon sets in with dark, cloudy weather, and generally a strong gale from S.E. to S.W., lasting several days. The Monsoon is in its strength during June and July, with the mean direction of the wind W.S.W., and W. by S. in August; no vessels should at this season unnecessarily approach too near the coast. In August the squalls are frequently from W.N.W. and N.W.; in September the weather is finer, but the prevalent winds are still from W. and W.N.W., with heavy squalls occasionally between S.W. and W.N.W., and when these occur there are brief intervals of calm between the gusts.

In the middle of the SOUTHERN PART OF THE ARABIAN SEA, westward of the Laccadivh Islands, in a rude oval area included between Lat. 5° and 12° N., Long. 56° and 71° E., the sky is generally cloudless, the wind light, the water smooth, and squalls seldom happen, notwithstanding that the S.W. Monsoon may be blowing in full force on the Arabian and Indian coasts. This region, as well as the band of strongest Monsoon and apparent course of the rain-clouds from Africa, is shown on CHART DIAGRAMS III. and IV.

Towards the middle of October the force of the S.W. Monsoon has decreased, and shows signs of terminating; at this period land and sea breezes commence near the coast.

53. Laccadivh Islands.—Hereabouts, and thence to Cape Comorin, the S.W. Monsoon is very fresh, and varies from W.S.W. to S.S.W., rarely passing to S. From the end of September to the beginning of November the weather is often squally, with rain. To the westward of these islands and in their vicinity, from November to the end of February, the N.E. Monsoon is regular between N. and N.E., hauling to E. during night. In March and April the wind varies between N. and N.N.W. In May westerly winds may be expected, and as soon as the S.W. Monsoon sets in there is generally a long rolling swell near the Laccadivh and Maldivh Islands; but the weather is never so bad as that near the coast of India; the squalls are not as strong, nor is the rain so copious. In September the S.W. Monsoon is dying out; calms are common; and the wind is generally from the N.W.-ward.

54. Maldivh Islands.—Among and in the vicinity of the Maldivh Islands the winds vary from N.W. to W.N.W. during February, March, and April, after which the rainy season sets in with the S.W. Monsoon. The dry (or fine) season extends from October to April, although it rains occasionally during the former month. This is the period of the N.E. Monsoon; the prevalent winds are, however, easterly—but inconstant both as regards direction and strength.

55. Ceylon.—The position of this island is such that the weather and seasons of its N.E. side approximate to the meteorological character of the Coromandel coast,

while its S.W. side has more affinity with the Malabar coast. The N.E. Monsoon prevails from November to February, and the S.W. Monsoon from April to September, the intervening months being periods of variable winds and calms. The N.E. Monsoon is the fine season of the west coast of the island, and the S.W. Monsoon the wet and stormy season.

POINT DE GALLE.—During the N.E. Monsoon, from December to March (inclusive), the harbour of Galle is always accessible, for a sea breeze, varying from S.S.E. to W., generally prevails during a part of each day, and early in the morning the wind is from the northward, off the land. During the S.W. Monsoon, from April to November (inclusive), a heavy swell rolls into the mouth of the harbour from the southward, even though the wind frequently veers to the northward of W. The annual range of the thermometer is from 70° to 87° Fahr.

COLOMBO.—A gale of wind may occur about the changes of the Monsoon, in the months of May, June, November, and even as late as December; though a gale in the latter month is very rare, and several years sometimes pass away without any beyond a stiff Monsoon breeze. These gales are seldom violent, and communication between the shore and shipping is seldom interrupted, although there are occasional spells of squally weather and a high sea during the S.W. Monsoon, making the passage over the bar difficult. The annual range of the thermometer is from 76° to 87° Fahr.

In the **GULF OF MANAAR** the N.E. Monsoon often blows with great strength even as far south as Cape Comorin, bringing with it the bad weather common at that season on the Coromandel coast.

On the **SOUTH COAST OF THE ISLAND**, AND AS FAR AS THE **BASSES**, westerly winds are prevalent, more or less, throughout the year; for even during the period of the N.E. Monsoon, when the land and sea breezes are tolerably regular, the E. and N.E. winds of the morning change to W. and S.W. after mid-day.

On the **EAST COAST OF THE ISLAND** the N.E. Monsoon is prevalent at the same period as on the Coromandel coast. In November the wind is from N.N.E. to E.N.E., and the weather generally squally and rainy. Heavy rain falls on the north part of the island during October, November, and December. Towards the middle of December to the end of January, although the Monsoon is occasionally strong, yet it is generally moderate from N. to N.N.E., and during the remainder of the season it is at times very hazy. Gales may, however, be expected any time during November, December, and January, rendering it dangerous to approach the east coast, for they blow for the most part dead on shore. At Trincomalee the annual range of the thermometer is from 74° to 91° Fahr.

In the **BAY OF PALK** the S.S.W. winds are often very fresh and squally during May, June, and July.

At the change of the Monsoon land and sea breezes are prevalent.

In general, the eastern part of Ceylon, which is open to the N.E. Monsoon, partakes of the hot and dry climate of the coast of Coromandel. The western division, which is open to the S.W. Monsoon, has a climate like that of the Malabar coast, which is temperate and humid. The N.E. winds, although accompanied with rain, are drier than those from the S.W., and the country over which they blow has an arid appearance as contrasted with the luxuriant verdure of the southern and western districts, which continues during the greater part of the year. The driest seasons

as those which occur between the range of the two Monsoons, partaking slightly of the influence of both.

The climate and seasons of the northern and southern districts may be thus strikingly contrasted. On one side of the island, and even on one side of a mountain, the rain may fall in torrents, while on the other the earth is parched and the herbage withered. The inhabitants in one place may be securing themselves from inundations, while in another they are carefully distributing the little water of former seasons, which is retained in their wells and tanks.

56. Bay of Bengal.—In the middle of the Bay of Bengal, during the N.E. Monsoon, the winds vary from N.N.E. to E.N.E.; during the S.W. Monsoon their direction is generally from the southward, and more persistent at sea than near the coast.

In March variable winds from S.W. to S., veering even to E. and N.E., are prevalent; frequently when the wind is from S. near the coast, it may vary from N.E. to S.E. at sea.

In April and May S.S.W. and S.W. winds are prevalent, varying to W.S.W. in May; when the breeze is light and variable, in April, it is occasionally interrupted by calms; and should it veer to N.E. and E., it may blow fresh, if not strong.

In June, July, and August, the S.W. Monsoon is at its height, variable between S.W. and W.; towards the end of July, and during August, it may veer to W.N.W. or N.W.

In September and October the prevalent winds are W. and S.S.W.; these, from the middle of August to the commencement of October, are accompanied by heavy rain; after the middle of September the Monsoon begins to die away, and winds, variable between N.E. and N.N.W., are not uncommon.

In November variable winds from N.N.E. to E.N.E. are prevalent, and in December and January the N.E. Monsoon is fully established in the bay. In October and November the weather is squally, and a gale or two may be expected; at such times there is a copious rainfall. From the middle of December to the end of January the weather is more moderate.

February is generally a fine month, and the wind fresh from N.N.E. to N.E.; towards the end of the month the Monsoon is gradually disappearing, when southerly winds are as frequent as those from the N.

In January, February, and March, the alternations of the wind are from N.E. to S.E., rarely to S.W.

BETWEEN THE EQUATOR AND LAT. 8° OR 10° N., in October and November, the winds are often very fresh or strong from the westward, and continue so for several days in succession; near the Equator they will blow from N.W. to N.N.W. On the parallel of Ceylon and Acheen Head (especially in the vicinity of the Nicobars) they vary from W.S.W. to W.N.W., while more to the north they may be from S.W. and S.S.W.

57. Weather on the Coromandel Coast.—The following statement of the weather during each month of the year is from an extensive series of meteorological observations made at the Madras Observatory:—

During January the wind blows uniformly and steadily from the N.E., with occa-

sionally an inclination towards the E. about the middle of the day, in the shape of sea breeze. In the mornings, for the most part, heavy dew is deposited, and occasionally fog, which reaches only to two or three feet above the surface of the ground. The weather is mostly very serene, presenting about twenty days of uninterrupted clearness, and five of mist, the remaining days being clouded, with perhaps a single shower of rain; lightning is almost unknown in this month. The hottest time of the day is about 1 P.M., the coldest at 4.20 A.M.

In February the N.E. Monsoon continues, with occasional exceptions, till the middle of the month, after which calms and S.E. winds as frequently prevail. In the early part of the forenoon it is usually calm until 11 A.M., when the sea breeze sets in, and blows till 10 or 12 P.M. During the whole of this month the weather is, without exception, always beautifully clear and placid, and it is generally considered to be the most healthy period of the year. There are no more than one day of haze, and one of clouds. Rain or lightning does not occur once in seven years. The hottest time of the day is at 0.40 P.M., the coldest at 5 A.M.

Throughout March the S. (or alongshore) wind prevails with very unequal force. It is accompanied with a profuse dampness and sultriness, which render its effects highly prejudicial to health and comfort. On this account the sea breeze, which sets in at noon and blows till 10 P.M., is less courted than at other seasons. The sky is, however, beautifully clear for about twenty-seven days, the remaining four being cloudy. Dew less frequently occurs and is less in quantity than last month; rain and lightning are little known. The hottest time of the day is at 0.20 P.M., the coldest at 5 A.M.

The remarks of last month relative to the winds are equally applicable to April. The S. wind, varying from S.E. to S.W., still continues, at times blowing very fresh, but occasionally calms ensue, which are exceedingly oppressive. The weather is clear for about twenty-four days, with four days of flying clouds, or haze, and two of clouds, on one of which rain falls; lightning occurs for two days. Dew is very little in quantity, and of unfrequent occurrence. The hottest time of the day is about noon, the coldest at 4.50 A.M.

The S. wind, which is mentioned as peculiar to the two last months, continues till the middle of May, relieved sometimes by a land wind from the W. or S.W. In this interval gales of wind of extreme violence have occasionally been experienced, commencing generally at the N.W., and veering to every point of the compass. About the 16th the regular land or hot winds set in, which are moderated in their effect towards the end of the month by occasional showers. The sea breeze sets in about noon, and blows till 9 or 10 P.M. There are about nineteen days of clear weather, eight of flying clouds and haze, and four cloudy days, on two or three of which there is rain.* The dew is almost imperceptible; and lightning, with thunder, occurs about four times. The hottest time of the day is 11.20 A.M., the coldest at 4.20 A.M.

The land wind has arrived at its maximum of effect about the beginning of June, being afterwards much moderated by clouds and rain. The sea breeze, which is extremely uncertain, sets in about 1 P.M., and blows till about 9 or 10 P.M., but sometimes altogether fails. The weather is clear for about eight days, there being eleven

* In this statement the rain which fell during three gales of wind has been omitted; on the 2nd May, 1811, during the gale which then blew, there fell 5.5 inches; on the 8th, 9th, and 10th May, 1820, 16.54 inches; and on the 7th, 8th, and 9th May, 1827, 23.30 inches.

days of flying clouds and haze, and the same number of cloudy days. Of these there are six days in which rain occurs, and three or four of lightning and thunder. Dew is almost imperceptible. The hottest time of the day is about 2 P.M., the coldest at 1.30 A.M.

With July, the rains of the S.W. Monsoon being generally in heavy but partial showers, the weather may be reckoned among the most cloudy of the year, there being only six clear days; the remaining days consist of thirteen cloudy and twelve of flying clouds and haze. Of these there are eight days on which rain falls, and about three of thunder and lightning. The sea breeze is very uncertain as to the time it commences or ceases, and not unfrequently fails for several days together. The hottest time of the day is at 2.20 P.M., the coldest at 4 A.M.

The regular westerly winds, which terminate about the middle of August, are succeeded by winds of a light and variable nature, mostly from the W. and S. Calms, haze, and rain, occur in about the same proportions as last month, leaving about eight days of clear weather. Lightning, unattended by thunder, is very frequent, but thus accompanied it occurs only once or twice. The sea breeze assumes much the same character as that experienced last month, commencing at 2 or 3 P.M., and continuing till 8 or 10 P.M. Dew is sometimes discovered, but more frequently fails. The hottest time of the day is at 2 P.M., the coldest at 3 A.M.

Throughout September light and variable winds, with occasional calms, continue; and with the exception that the weather is not quite so much clouded, the remarks of last month apply with equal propriety to this. Lightning occurs almost every evening, but accompanied by thunder three times only. The sea breeze sets in about 2 or 3 P.M., and blows till 8 or 10 A.M., but occasionally fails for two or three days together. Dew is common, but small in quantity. The hottest time of the day is at 2 P.M., the coldest at 4.20 A.M.

In October the clouds begin to assume a more dense appearance than heretofore. Calms, lightning, and rain, are very frequent, till the 9th, when the N.E. Monsoon, or rainy season, sets in. From this time till the end of the month the atmosphere assumes a very disturbed appearance. Extremely heavy rain, with storms of wind, thunder, and lightning, invariably occur, and gales of wind, of a similar nature to those which occur in the earlier part of the year (*see* May), are sometimes experienced. On these occasions a depression of the barometer of four or five-tenths of an inch is observed. The sea breeze, or rather a slight modification of the N.E. wind, is perceived towards the middle of the day. The hottest time of the day is at 1 P.M., the coldest at 4.50 A.M.

In November the N.E. Monsoon continues with unabated force, and the state of the weather generally is much the same as that experienced towards the end of October, save that an increased dampness of the air, and the less frequent occurrence of lightning, render a distinction necessary. The number of clear and cloudy days in this, as well as last month, is liable to great uncertainty. The remarks relative to the sea breeze of last month apply equally to this. The hottest time of the day is at 0.20 P.M., the coldest at 5.40 A.M.

The heavy rains and violent gusts of wind are much moderated at the beginning of December, and arrive at their close about the 15th. From this time the sky assumes an appearance of tranquillity and clearness, which forms a strong contrast

with the disturbed state of the preceding month. The N.E. wind, however, continues throughout the month without interruption; there are about thirteen clear days, eleven cloudy, and seven days of flying clouds and haze. Of these there are six days on which rain falls. The mornings exhibit a copious deposition of dew, and sometimes a ground fog, which does not reach more than two or three feet above the surface. The sea breeze sets in at 10 A.M., and blows till 4 P.M. The hottest time of the day is at 0.50 P.M., the coldest at 2.50 A.M.

58. At the head of the Bay of Bengal the Monsoons are very irregular, and the direction of the wind far from persistent; similar remarks apply to the period of change. To the northward of the parallel of 17° N. the N.E. Monsoon rarely blows with any strength, and is variable between N.N.E. and N.N.W. During this season calms, alternating with light airs, are very frequent.

Between MASULIPATAM AND THE MOUTH OF THE HOOGLY, in October and November, the N.E. Monsoon is variable; during November and December the weather is very uncertain, and heavy squalls, if not gales, may be expected. Towards January the N.E. Monsoon decreases in strength, and the rainy season terminates, after which land breezes from W.N.W. to S.W., and sea breezes from E.N.E. set in; these continue throughout February and March, although the Monsoon may at times blow strong for a few hours. In March the winds are frequently from S.E. to E.S.E. during the day, and from S.S.W. to S.W. during the night. In the vicinity of Balasore and the Sunderbunds the wind, during March and the beginning of April, is frequently from N.W., in gusts.

In April southerly and south-easterly winds prevail—at times strong—bringing cloudy weather and fog. In Balasore roads, during May, the wind varies from S.S.E. to S.W. and W.S.W. These south-westerly winds are often very strong, especially so in May, when the weather is overcast and heavy squalls and gusts may be expected, if not a gale or two; this continues till June and July; the squalls are always accompanied by rain. The S.W. Monsoon is in its strength on this coast during June, July, and August.

The Monsoon in Balasore roads blows from W.N.W. to W.S.W., generally strong; in August the weather is very uncertain and squally, and the wind variable—from S.S.E. to S.S.W. and W.N.W. Heavy rain may also be expected at this time; in the same roadstead, during April and May, the wind usually blows from S. to S.E.; but should it pass from S.S.E. to S.W., it comes in strong gusts, with heavy rain, while it may be fine along the coast to the southward. During the change of either Monsoon, Balasore should be avoided.

At the mouth of the HOOGLY the weather is always very changeable between the Monsoons; and when N.W. winds occur at that time, they usually come in squalls and gusts,—with thick, cloudy weather, and lightning.

The rainy season terminates in October on the coast of ARACAN. Southerly winds are prevalent, yet strong N.E. and E. winds are not unusual. Thus it may be said, they are variable between N.E. and S.W. February is the finest month of the year; the wind is from N. and E., while on the opposite side of the Bay of Bengal fresh W.N.W. and S.W. winds are prevalent. Land and sea breezes occur at this period.

19. Gales in the Bay of Bengal.*—In that part of the Bay of Bengal BETWEEN THE COROMANDEL COAST AND THE ANDAMAN ISLANDS the October and November storms come from W.S.W., varying to W.N.W. and N.W., and blow with great force. Sometimes they come from S.E., and more frequently still from N.E. When a N.E. gale occurs in January its strength is generally not so great as in the previous months.

Storms, during April to June, generally begin from N.N.W. to N.N.E., veering to N.E. and E., but moderating and dying out when they change to the southward of E.; they blow hardest from N.E. to E.; but should they continue in any strength from the southward and eastward, which is rarely the case, they will not moderate until they have blown hard from S.W., after which they cease. The approach of these gales towards the coast is indicated by a heavy swell, eight to twelve hours before their arrival.

On the COROMANDEL COAST the storms of April and May begin at N.W., changing in succession to N., N.E., E., or E. by S., after which they abate, having blown hardest at N.E. and E.; when the wind veers to S.E. or S., and thence to S.W., their force is very great, and they send a heavy swell towards the coast. An ugly, threatening appearance of the sky is the precursor of these storms, but the same aspect at this period may merely betoken heavy rain, with little wind. From the beginning of October to that of December is also a stormy season; when the wind blows hard from N.E., and after a lull veers to S.E., S., and S.W., it always blows hard. The coast should be avoided at the latter end of October and during November, unless bound to a port there, because general bad and squally weather begins, attended by heavy rain, thunder, and lightning. The squalls and gales, when they shift to the south of E., generally die out; a strong breeze in September off the land seldom lasts long.

At the HEAD OF THE BAY OF BENGAL, since the Monsoons are uncertain and irregular, storms are equally so; in April, May, and June, they are indicated by a partial lull in the S.W. Monsoon and a smooth sea, when the wind becomes variable—all round the compass—with calms; the horizon is clearer than usual, there is a hollow moaning through the rigging, and light gossamer threads are wafted through the air. In the storm which succeeds these signs the wind is strong from W.S.W., but passing quickly through W. to W.N.W. and N.W., it blows very hard and steadily from that quarter for some time—the gale generally lasting from ten to twelve hours, and with greater force on the western than on the eastern side of the bay. Off Cape Palmyras, though ordinary gales veer as above, yet they sometimes change from N.W. to N. and N.N.E., or N.E., when, after a brief calm, they blow from S.W. with equal fury for an hour or so; then follows a breeze from E.S.E. to N.E., when it may again change to S.W. Heavy rain is a constant concomitant of these gales.

The gales of October and November are heavier than those of any other season. After a slight shower, with a moderate wind from E.S.E., the breeze freshens at E., veering to E.N.E., N.E. and N., where it gradually lulls. Sometimes the changes proceed to N.N.W. and N.W., with heavy rain throughout. These Easterly and Northerly gales may last a day or two, and when a brief calm ensues, the

* KIRHALLET:—" *Considérations Générales sur l'Océan Indien*," 3me ed. p. 29, et seq.

wind is very likely to change rapidly to S.S.W., lasting with great fury for half an hour or more.

The hurricanes of the Northern Indian Ocean are described in Chap. VI.

60. Coasts of Martaban and Tenasserim: ISLANDS OF ANDAMAN AND NICOBAR.—Along the coast the S.W. Monsoon commences towards the end of May, its direction being W. and W.S.W. until the middle of July; it attains its greatest strength in August and September, after which it becomes variable, alternating with calms and light airs. During October, when the S.W. Monsoon is about to close, land and sea breezes set in, but they are neither so strong nor so persistent as the similar breezes at the end of the N.E. Monsoon. In October and November the weather is squally, and the wind, commencing at E.S.E., will frequently pass through E. and E.N.E. to N.N.E. and N., accompanied with heavy rain.

The N.E. Monsoon is regular during December and January, decreasing in strength towards the middle of February, when the Monsoon alternates with land and sea breezes; this continues until April, the alternation being frequently from E. to N.W., though more commonly from the southward than from the northward. Calms of short duration may be expected occasionally during February, March, and April, after which the change to the S.W. Monsoon becomes sensible.

Among the islands forming the **MERGUT ARCHIPELAGO**, and thence both north and south, the wind is generally light during July and August—variable between N. and W. The strong winds so common in the Bay of Bengal at that period of the year lose much of their strength before reaching the archipelago. The foregoing remarks apply equally to the coast east of Cape **NEGRAIS** and to the Gulf of **MARTABAN**.

While the N.E. Monsoon, variable between N.E. by E. and E.N.E., is prevalent off the Tenasserim coast, northerly winds are frequently experienced off the islands of **Andaman** and **Nicobar**. Similarly with regard to the S.W. Monsoon, it is very irregular in the narrow sea between those islands and the coast; the winds, though generally variable between W. and N., are sometimes from S.E. or S.W., and in respect to strength are equally uncertain, heavy squalls and rain alternating with light airs or calms, while the sky is generally cloudy. The change of each Monsoon is always characterized by heavy squalls and cyclonic gales of short duration. The N.E. Monsoon (more northerly than easterly) commences among the Nicobars in November, and is the fine season; land and sea breezes are prevalent during that period, for the Monsoon wind is rarely strong, except in December and January; towards the end of April sudden squalls from the W. may occur. The S.W. Monsoon begins in May, and in the vicinity of the Andaman and Nicobars generally blows fresh or strong from the S.

61. Straits of Malacca.—The Monsoons are very irregular in the Straits of Malacca, and the winds variable; that of the N.E. (the fine season) lasts from November to April, the S.W. from May to October. During the S.W. Monsoon the sky is cloudy, and the weather squally, with rain.

In October and November the winds are from N.W. to W.; however, the N.E. Monsoon—from N.E. to E.N.E.—has generally set in towards the middle of November, and it blows with force in December and January, moderating in March: N. and N.W. winds are not uncommon during the season; and westerly winds at

times last for a day or two. The Monsoon may be expected to draw to the N. any time between the latter end of February and beginning of April, in which case it becomes light and variable; at this time fresh land and sea breezes prevail, with calms towards mid-day. These calms are more frequent along the Sumatra coast than along that of the peninsula of Malacca.

The S.W. Monsoon is at its height in June and July; and for four months, between May and September, it is variable, from S.W. to S., but never very strong, except at the northern entrance to the strait. Calms are now more prevalent along the Malacca than the Sumatra shore, but they are of short duration, generally occurring near mid-day; but the breeze is tolerably fresh during the night and at sunrise. The rainy season is from the end of August to the beginning of December, when in some parts, as at the N.W. entrance of the strait, the fall is very great, with the wind from N.W. and W., and squally weather.

During the S.W. Monsoon the winds on the N.E. COAST OF SUMATRA frequently hang to S.S.E. and S.E.; but during the night, when in the vicinity of the high land between Cape Pedir and the Carimon Isles, during June, July, and August, heavy and dangerous gusts from S.W. to S.—called *Sumatras*—are often experienced between midnight and 2 or 3 A.M. In some places they commence at 6 P.M. and last till 8 P.M., alternately squally and calm, strong and moderate. In the roadstead of Malacca they commence at 7 P.M. and last till midnight, and are dangerous if no precautions are taken against their approach.

Heavy squalls from the N.W. may also be expected at times off the north coast of Sumatra, as well as in the vicinity of the Carimon Isles and the Straits of Singapore; their approach is indicated by the rapid rising of a black and arched cloud, scarcely leaving time to take in sail; the first gust is the strongest, and, as is the case with the *Sumatras*, they are attended with rain, thunder, and lightning.

The Monsoons are more regular near Singapore.

62. West Coast of Sumatra.—This island, owing to its intersection by the Equator, is very difficult to deal with, as regards wind and weather; for there appears to be a strange blending and modification of the different Monsoons, at least along the central part of the coast, if not towards the north and south parts, where the seasons are better contrasted.

At Acheen and its vicinity the S.W. Monsoon is prevalent from April to November; this is the hot season, as well as that of rain, which falls in April, and again in August. Near the coast the winds are S. and S.S.W.; at sea, W.S.W. to S.W. Along the equatorial part of the island S. winds prevail, varied at times by those from N.W. and S.E., the former very strong. During the same months, or perhaps beginning in May and terminating in October, the S.E. Monsoon (or dry season), with the wind from S.S.E. to S.S.W., occurs, and is at its height in June, July, and August, when there are no land breezes; at the beginning and end of the season S. and S.W. winds (sea breezes) are prevalent during the day, and land breezes from N. and N.W. during the night. Strong *north-westers* are not uncommon at this season, though more prevalent north than south of the Equator.

The N.E. Monsoon, on the northern part of the island, is comparatively weak, and land and sea breezes prevail as far south as Bencoolen during December and January; this is the fine season. The N.W. Monsoon, south of the Equator, com-

mences at the end of November and terminates in March, bringing with it rain and bad weather. The general winds are now from N.W. to W.N.W., occasionally interrupted by a breeze from S. and S.S.E.; strong squalls, especially during the night, may always be expected at this season, and they are invariably accompanied by rain; the sea breeze often veers to W.S.W. in March and April.

As is usual in most parts of the Indian Ocean, the land and sea breezes are most conspicuous when the Monsoons become light and are dying out; and it must be remembered that the fine season at the south extreme of the island takes place during the wet season of the northern part, and *vice versa*; so also with regard to general bad weather off the coast.

Off the coast, on the Equator, calms are very frequent, and squalls and bad weather comparatively rare; but sudden gusts of short duration come off the mountains during the night, as near Priamen. At Padang the regular Monsoon is marked by the land and sea breezes, which blow with great constancy every day at right-angles to the coast; hence the land breeze is from E.N.E., and the sea breeze from W.S.W. The great quantity of rain and the frequency of thunderstorms in the months of March and April, and again from October to December, alone serve to mark the change of the Monsoon.

63. Sunda Strait.—From April to October the Easterly Monsoon is prevalent—variable between S.S.E. and E.S.E. The Westerly Monsoon, variable between W.N.W. and N.W., prevails from November to May, and is generally accompanied with bad weather.

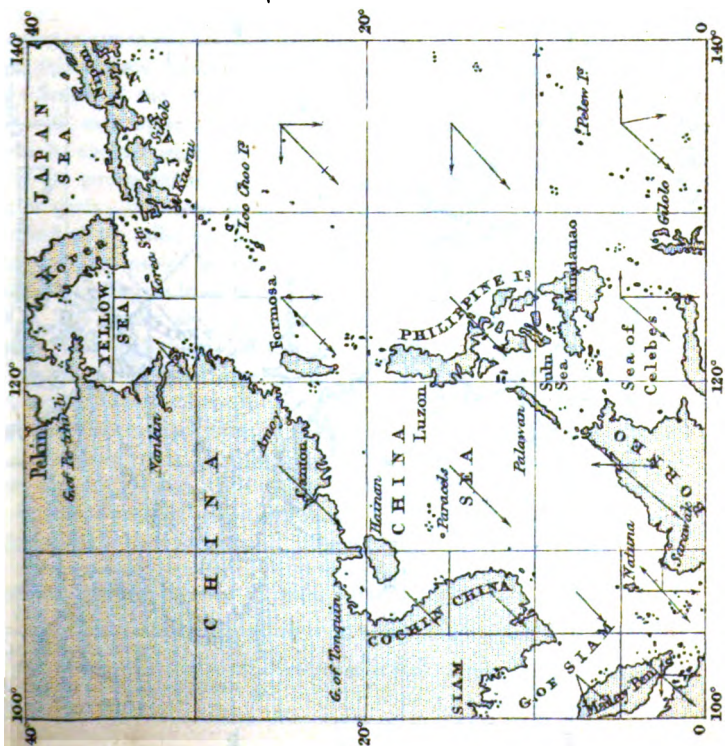
64. From the Strait of Sunda to Timor Island the Easterly Monsoon, variable between E. and S.S.E., commences in May, and is at its height in June and July. The Westerly Monsoon commences in November, and is at its height in January; bad and squally weather sets in with this Monsoon, and gales are not uncommon from November to the middle of February; this is also the rainy season, especially December and January. In March the Monsoon is dying out; April is tolerably fine, and the wind variable. The ordinary strength of the E. Monsoon is fresher than that from the W.

65. South Coast of Java—Sumbawa, &c.—In April the winds are variable, after which (in May) the E. Monsoon begins, bringing with it fine weather, and being at its height from June to August. In October this Monsoon is about to terminate, and after variable winds the N.W. Monsoon commences, lasting till the middle of February.

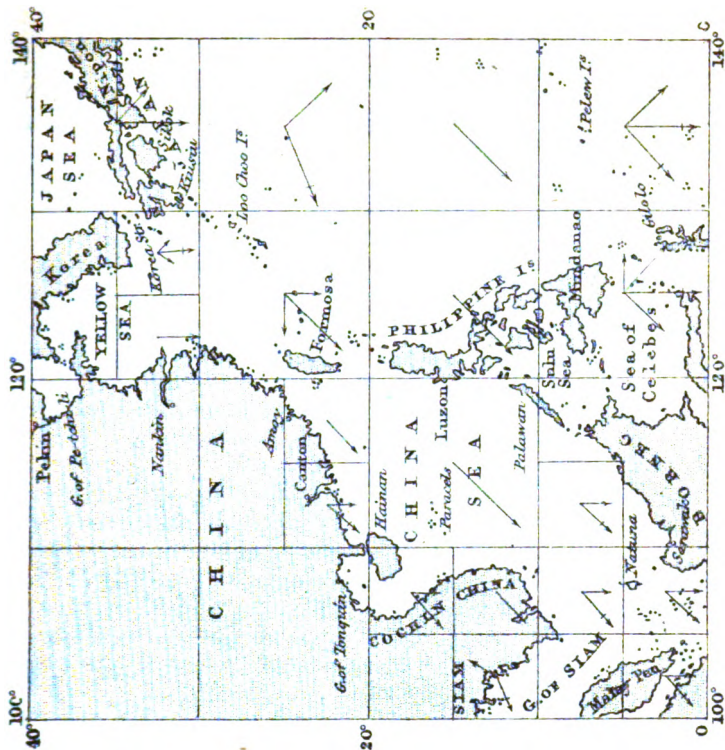
During February and March, and also in October—months when the Monsoons change—land and sea breezes are prevalent, stronger in October than at the former period. In February, March, and even in April, the land breeze often sets in with a strong gust, or in a squall, speedily moderating. The weather is also apt to be squally and puffy with the sea breeze in April and May, but only when it first springs up. During May and November the rain is very abundant on this coast.

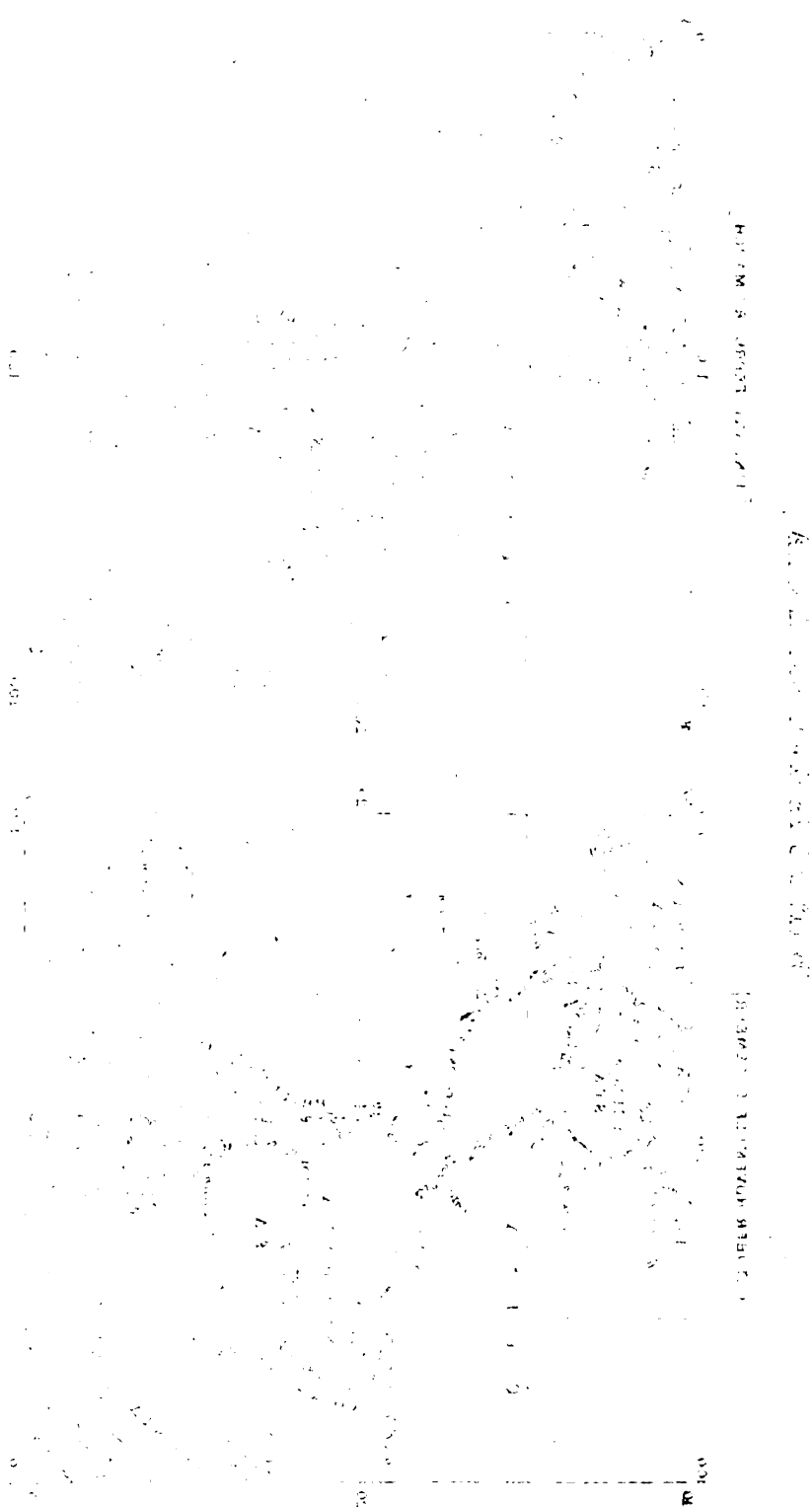
In the STRAITS OF BALY the wind often blows with great strength from the N. In the other straits to the east of Java a breeze from the S. very often blows during the morning and forenoon, when, after a calm, towards 2 P.M., it changes to N.

[OCTOBER, NOVEMBER, DECEMBER]



[JANUARY, FEBRUARY, MARCH]





19 JAN 1952 TULSA OK

7/12/2010 at 20:22:40

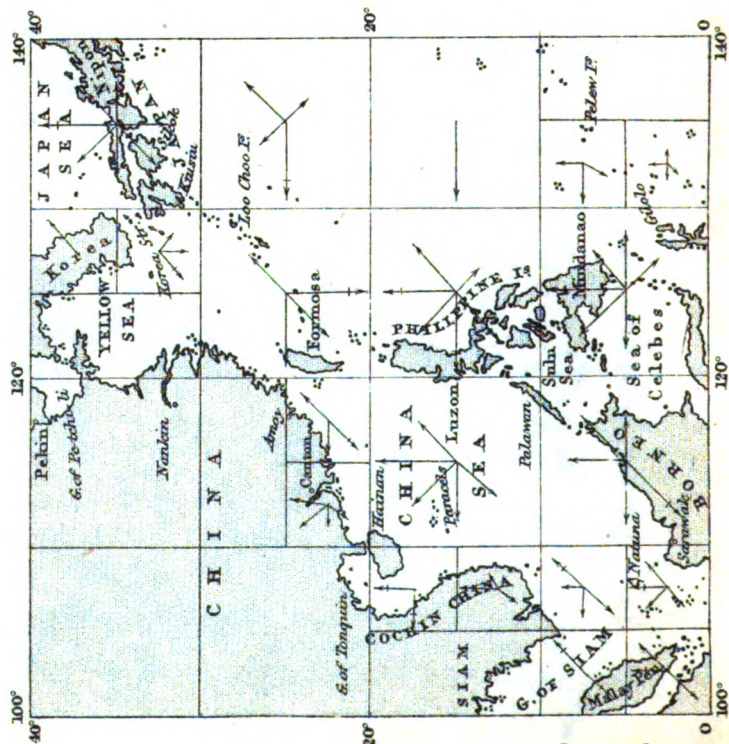
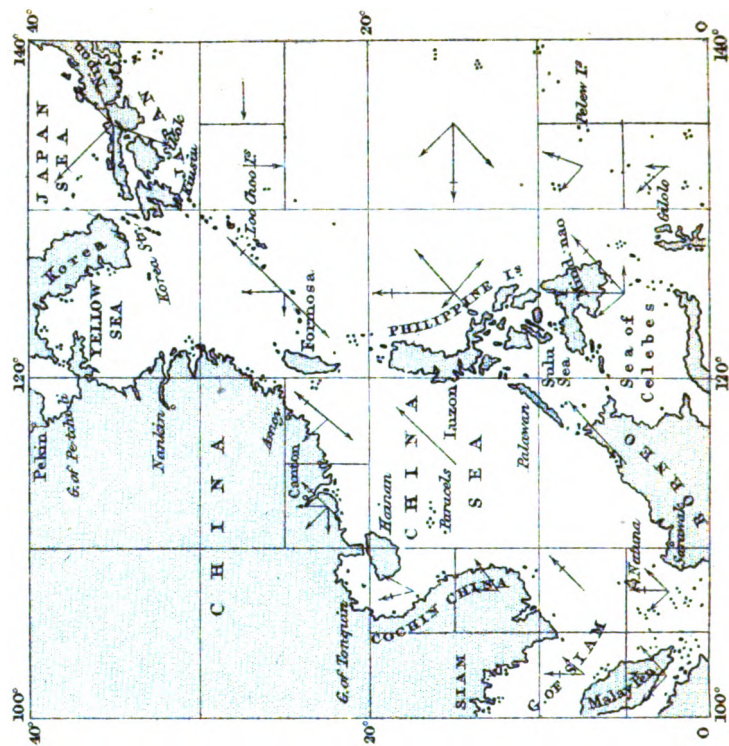
[2406.YAH.J187A]



WINDS in the CHINA SEA

[APRIL, MAY, JUNE]

[JULY, AUGUST, SEPTEMBER]



On the N.W. side of the island of **Timor**, from October to February, the N.W. Monsoon, variable between N. and W., is fully established, but is at its height only in December and January, when the rains fall, which, however, last till February; this is a season of overcast, squally weather, and the wind is often very strong, from W. to N.N.E. Towards the end of April the easterly Monsoon, variable between E. and S.S.E., brings fine weather, and is stronger than on the south side of the island. On both coasts land and sea breezes set in with the fine season, the land breeze on the south coast being from N.E. to N., the sea breeze from S.S.E. to S.S.W.

Gales may be expected on the south coast in October, on the north coast not before December.

66. In that part of the Ocean between the Indian Archipelago and the North Coast of Australia calms are very frequent at all seasons of the year, and Monsoon-like weather is always more or less prevalent. The westerly Monsoon, variable between S.W. and N.W., begins in October and ends in April, blowing with considerable strength and in squalls during December, January, and February. The E. and S.E. Monsoon, from May to September, is the fine season. These remarks apply also to the Ocean as far west as the meridian of Christmas Island.

67. The Java Sea.—The following observations are by CAPTAIN JANSEN, of the Dutch Royal Navy:—"In the Java Sea, during the month of February, the W. Monsoon blows strong almost continually; in March it blows intermittingly, and with hard squalls; but in April the squalls become less frequent and less severe. Now the changing commences; all at once gusts begin to spring up from the E.; they are often followed by calms. The clouds which crowd themselves on the clear sky give warning of the combat in the upper air which the currents there are about to wage with each other. The electricity, driven thereby out of its natural channels, in which, unobserved, it has been performing silently, but with the full consciousness of its power, the mysterious task appointed to it, now displays itself with dazzling majesty; its sheen and its voice fill with astonishment and deep reverence the mind of the sailor—so susceptible, in the presence of storm and darkness, to impressions that inspire feelings both of dread and anxiety, which by pretended occupations he strives in vain to conceal.† Day and night we now have thunderstorms. The clouds are in continual movement, and the darkened air, laden with vapour, flies in all directions through the skies. The combat which the clouds seem to court and to dread appears to make them more thirsty than ever. They resort to extraordinary means to refresh themselves; in tunnel form, when time and opportunity fail to allow them to quench their thirst from the surrounding atmosphere in the usual manner, they descend near the surface of the sea, and appear to lap the water directly up with their black mouths. Water-spouts thus created are often seen in the changing season, especially among small groups of islands, which appear to facilitate their formation.‡ The water-spouts are not always accom-

* Bijdrage Natuurkundige Beschrijving der zeën, vertaald door M. II. JANSEN, Luitenant ter zee.

† No phenomena in nature make a deeper impression upon the sailor than a dark thunderstorm in a calm at sea.—JANSEN.

‡ I never saw more water-spouts than in the Archipelago of Bloua Singen during the changing. Almost daily we saw one or more.—JANSEN.

panied by strong winds; frequently more than one is seen at a time, whereupon the clouds whence they proceed disperse in various directions, and the ends of the water-spouts bending over, finally cause them to break in the middle, although the water which is now seen forming around their base has suffered little or no movement laterally."

Water-spouts.—"Yet often the wind prevents the formation of water-spouts. In their stead the wind-spout shoots up like an arrow, and the sea seems to try in vain to keep it back. The sea, lashed into fury, marks with foam the path along which the conflict rages, and roars with the noise of its water-spouts; and woe to the rash mariner who ventures therein!* The height of the spouts is usually somewhat less than 600 feet, and their diameter not more than 20 feet, yet they are often taller and thicker; when the opportunity of correctly measuring them has been favourable, however, as it generally was when they passed between the islands, so that the distance of their bases could be accurately determined, I have never found them higher than 2100 feet, nor thicker than 150 feet. In October, in the Archipelago of Rio, they travel from N.W. to S.E. They seldom last longer than five minutes; generally they are dissipated in less time. As they are going away, the bulbous tube, which is as palpable as that of a thermometer, becomes broader at the base, and little clouds, like steam from the pipe of a locomotive, are continually thrown off from the circumference of the spout, and gradually the water is released, and the cloud whence the spout came again closes its mouth."

The East Monsoon in the Java Sea.—"During the changing of the Monsoons it is mostly calm or cool, with gentle breezes, varied with rain-storms and light gales from all points of the compass. They are harassing to the crew, who, with burning faces under the clouded skies,† impatiently trim the sails to the changing winds. However, the atmosphere generally becomes clear, and, contrary to expectation, the N.E. wind comes from a clear sky; about the coming of the Monsoon it is northerly. Now the clouds are again packed together; the wind dies away, but it will soon be waked up to come again from another point. Finally, the regular land and sea breezes gradually replace rain, and tempests, calms, and gentle gales. The rain holds up during the day, and in the Java Sea we have the E. Monsoon. It is then May. Farther to the south than the Java Sea the E. Monsoon commences in April.‡ This Monsoon prevails till September or October, when it turns to become the W. Monsoon. It has seemed to me that the E. Monsoon does not blow the same in every month, that its direction becomes more southerly, and its power greater after it has prevailed for some time.§

* The air-spouts near the Equator always appear to me to be more dangerous than the water-spouts. I have once had one of the latter to pass a ship's length ahead of me, but I perceived little else than a waterfall in which I thought to come, yet no wind. Yet the water-spouts there also are not to be trusted. I have seen such spouts go up out of the water upon the shore, where they overthrew strong isolated frame-houses. I have, however, never been in a situation to observe in what direction they revolved.—JANSEN.

† At sea the face and hands burn (change the skin) much quicker under a clouded than under a clear sky.—JANSEN.

‡ In the north-east part of the Archipelago, the E. Monsoon is the rainy Monsoon. The phenomena in the north-east part are thus wholly different from those in the Java Sea.—JANSEN.

§ As is well known, the Strait of Sourabaya forms an elbow whose easterly outlet opens to the E., while the westerly outlet opens to the N. In the beginning of the E. Monsoon the sea wind (E. Monsoon) blows through the westerly entrance as far as Mt. Gievie (in the elbow); in the latter part of this Monsoon the sea wind blows, on the contrary, through the easterly entrance as far as Sambilangan (the narrow passage where the westerly outlet opens into the sea).—JANSEN.

"As the sea makes the coming of the southern summer known to the inhabitants of the Java coast,* the turning of the E. Monsoon into the W. Monsoon commences. After the sun has finished his yearly task in the northern hemisphere, and brings his powerful influence to operate in the southern hemisphere, a change is at once perceived in the constant fine weather of the E. Monsoon of the Java Sea. As soon as he is at his height upon the Java Sea (Lat. 6° S.), then the true turning of the Monsoon begins, and is accomplished much more rapidly than the spring turning. The calms then are not so continuous. The combat in the upper atmosphere appears to be less violent; the S.E. Trade, which has blown as the E. Monsoon, does not seem to have sufficient strength to resist the aggressors, which with wild storms from the N.W. and W., make their superiority known. Upon and in the neighbourhood of the land thunderstorms occur, but at sea they are less frequent.

"The atmosphere, alternately clear and cloudy, moves more definitely over from the N.W., so that it appears as if no combat was there waged, and the S.E. gives place without a contest. The land breezes become less frequent, and the phenomena by day and night become, in a certain sense, more accordant with each other. Storms of wind and rain beneath a clouded sky alternate with severe gales and steady winds. In the last of November the W. Monsoon is permanent.

"Such are the shiftings. But what have they to do with the general system of the circulation of the atmosphere? Whenever we read attentively the beautiful meditations of the founder of the Meteorology of the Sea, and follow him in the development of his hypothesis, which lays open to view the wheels whereby the atmosphere performs its varied and comprehensive task with order and regularity, then it will not be necessary to furnish proof that these turnings are nothing else than the passing of a belt of calms which separates the Monsoons from each other, and which, as we know, goes annually with the sun from the S. to the N., and back over the torrid zone to and fro.

"So also the calms, which precede the land and sea winds, are turned back. If, at the coming of the land wind in the hills, we go with it to the coast, to the sea, we shall perceive that it shoves away the calms which preceded it from the hills to the coast, and so far upon the sea as the land wind extends. Here, upon the limits of the permanent Monsoon, the place for the calms remain for the night, to be turned back to the land and to the hills the following day by the sea wind. In every place where these calms go the land and sea winds turn back. If various observers placed between the hills and the sea, and between the coast and the farthest limit of the land wind, noted the moment when they perceived the calms, and that when they perceived the land wind, then by this means they would learn how broad the belt of calms has been, and with what rapidity they are pushed over the sea and over the land. And even if the results of one day should be found not to agree very well with those of another, they would at least obtain an average thereof which would be of value. So, on a larger scale, the belt of calms which separates the Monsoons from each other presses in the spring from the S. to the N., and in the fall from the N. to the S., and changes the Monsoons in every place where it presses."

* In the Archipelago we have generally high water but once a day, and with the Equinoxes the tides also turn. The places which have high water by day in one Monsoon get it at night in the other.—JANSEN.

68. Banka—Gaspar and Carimata Straits.—Observations made at PALEM-BANG (Lat. $6^{\circ} 52' S.$, Long. $105^{\circ} 16' E.$), on the east side of Sumatra, during 1850–1856, show that from November to March the prevailing winds blow from W. and N.W.; this is also the rainy season—usually attendant on the W. Monsoon. In April the Monsoon changes, and, during the month, storms accompanied with thunder are very frequent. From May to September the prevalent winds are from E. to S.E., and the change occurs in September and October; during the year the veering of the wind is regular through $\Rightarrow S., W., N., E.,$ to $S. \Rightarrow$.

In STANTON Channel the wind in the N.W. Monsoon blows off the Banka coast, and throughout the year land breezes generally occur during the night. A strong land breeze from the N.E. has been experienced in Stanton Channel during the S.E. Monsoon, when the wind was blowing directly through the Lucipara from the S.W.

In RHIO Straits the southerly Monsoon is generally strong in September, with rain and heavy squalls at the Equinox. In October calms alternate with light southerly airs, during which the atmosphere is damp and close; Sumatra squalls, or south-westerners, also occur at night, with thunder and lightning. In November the northerly Monsoon sets in with heavy gusts.

In SINGAPORE Strait the winds during the S.W. Monsoon prevail from W. to S.E. In December, January, and February, the N.E. Monsoon is in full force, and generally very strong.

In GASPAR Strait and the CARIMATA Passage N.W. winds are generally prevalent when N.E. and N. winds are found north of the Equator.

69. Borneo, cut by the Equator, and extending through $11\frac{1}{2}^{\circ}$ of lat.—from $7^{\circ} N.$ to $4\frac{1}{2}^{\circ} S.$ —exhibits a great diversity of seasons and of climate; in fact, the northern part of the island is characterized by the N.E. and S.W. Monsoons of the Indian Ocean and China Sea, while the southern part experiences the S.E. and N.W., or E. and W. Monsoons of the Java Sea. From May to October the S.W. Monsoon is prevalent on the N.W. coast, while the S.E. Monsoon extends over the west and south parts of the island. Similarly, from October to May, the N.E. Monsoon blows on the N.W. coast, while the N.W. Monsoon is the prevalent wind on the west and south coasts.

"The climate is damp and sultry, the thermometer at the level of the sea seldom falling below 80° , or rising above 90° The whole island is one huge primeval forest; but it has not been charged with peculiar insalubrity, although to the European constitution it must be both uncomfortable and debilitating.

"The coast of Borneo would be a dangerous one to navigation from the absence of the shelter of harbours, of which it can hardly be said to have any, if it did not lie in the latitudes exempt from the storms and typhoons which prevail in the northern part of the China Sea, and which, although they extend to the Philippine group, never reach it. Heavy squalls are experienced at the changes of the Monsoons, and this is all."*

Respecting the SOUTHERN PART OF BORNEO, the remarks already made on the Java Sea appertain to this coast and the neighbouring waters. From October to April, with the W. Monsoon, it rains continuously, and often brings heavy and stormy

* "Jour. Roy. Geog. Soc.," vol. xxiii. p. 71. "A Sketch of the Geography of Borneo, by JOHN CRAUFORD, Esq., F.R.S."

weather. During the E. Monsoon the weather is still very damp and misty, though there is less rain. In Borneo it probably rains during ten months of the year.

KRECKE* observes that at BANJERMASSIG, ON THE SOUTH COAST OF BORNEO, a S.W. Monsoon blows from December to March, and a S.E. Monsoon from April to October. The remaining months are periods of change. The rainfall is most copious from July to October, while storms, with thunder, are most frequent in November, December, and May, though in this respect there is considerable difference, for while eighteen such storms occurred in 1851, no less than eighty-three took place in 1857. The following is the prevalent direction of the wind for the different months:—In December, S.W. to W.S.W.; in January, W.S.W. to W.; in March, variable; in April the wind changes to S.E., and augments in strength till August and September; in October it hauls more to the S.; in November, during the morning it is southerly, but changes to S.S.W. and S.W. in the afternoon; when in December, the S.W. wind is again fully established.

The N.W. COAST from Lat. 2° N., Long. 109° E., to Lat. 7° N., Long. 117° E., a distance of 600 miles, was visited by CAPTAIN C. D. BETHUNE, R.N.,† who says:—“The N.E. Monsoon prevails on the coast from November to April, and the S.W. Monsoon for the other six months. The months of November, December, and January, may perhaps be called the rainy season, but considerable quantities of rain usually occur about the change of each Monsoon; the finest weather is during the S.W. Monsoon. I am, however, inclined to think there is no decidedly dry season. Land and sea breezes alternate near the shore; the nights are always cool. The temperature assimilates to that of Singapore, which for India is considered a temperate climate; a shower of rain often makes a difference of 10° at each place.”

70. Celebes.—The position of the Island of Celebes approximates to that of Sumatra and Borneo in being cut by the Equator; but with respect to Celebes, the larger part of the island is to the *southward* of that line, and to this we shall refer at present. The S.E. Monsoon is the fine season, and lasts from May to September. The N.W. Monsoon, from October to April, is often very strong, with heavy rain at all times. In March, and again in September, when the sun is near the Equator, the winds are northerly, with rain.

71. Straits of Macassar and Molucca Passage.—In the northern part of Macassar Strait, from May to October, the easterly Monsoon is prevalent on the east coast of Borneo: the same Monsoon occurs also in the Molucca Passage. From November to April is the period of the westerly Monsoon.

In the middle and southern part of Macassar Strait the wind is N.E. during April, May, and June, after which it becomes more variable and light from E.N.E. to E.S.E. Fresh breezes from W.S.W. to W.N.W. prevail in October, November, and December, sometimes during January also.

As regards the wind near the land, it would appear that from May to October the wind is tolerably steady from the southward on the east side of Borneo, while at the same time there are regular land and sea breezes off the west side of Celebes.

* “*Meteorologische Waarnemingen in Nederland en zijne Besittingen.*”

† “*Jour. Roy. Geog. Soc.*,” vol. xvi. p. 302.

Off the west coast of Celebes the fresh S.W. Monsoon generally veers to W.N.W. and N.W. on approaching the opposite shore of Borneo.

During the S.E. Monsoon there is no strong land breeze on the low shores of Borneo, while on the coast of Celebes, owing to the interior being more elevated, a very fresh breeze comes from the land during the night, followed by the regular sea breeze: these winds are very beneficial in December. During August and September the wind is always light, with calms, at times alternating with a squall or two, which may rise to a storm.

72. Seas of Celebes and Sulu, or Mindoro.—The easterly Monsoon begins in October, but is not fully established before November, and terminates in April: this is the fine season. The westerly Monsoon, beginning in May, is in full strength in June, and ends in September; the weather is now gloomy and overcast, with rain; it is also very squally during this season, and in some of the heavy showers the wind veers round to E., especially in July and August; heavy gales are not uncommon, and occasionally a hurricane; between the islands of Celebes and Mindanao very strong squalls, in gusts, from the N.W. are prevalent. On the coast of Mindanao a heavy mist is not uncommon in September, and westerly winds have been known to last till November.

The N.E. or E. wind in the fine season, and especially in the Sulu Sea, is rarely fresh—more generally variable with calms; such, at least, is the case in December and January.

Similar seasons and winds prevail as far north as Manilla.

73. On the WEST COAST of New Guinea the S.E. Monsoon lasts from April to October, and the rainy season is from June to September, when dark, gloomy weather may be expected, with frequent fogs. The N.W. Monsoon begins early in November (sometimes in October), and terminates in April, which is the fine season; during January the winds are variable between N.N.W. and N.E.; in March, April, and May, heavy squalls occur at times, with an occasional gale.

74. The Molucca Islands AND NEIGHBOURING SEAS.—Northward of the islands of Boero and Ceram the S.E. Monsoon from April to October varies from S.S.E. to S.S.W., at Amboina from E. to S.E. The N.W. Monsoon, from November to March, is variable between W.S.W. and N.W., and occasionally a heavy storm occurs near the islands just mentioned. Generally, in the vicinity of the Moluccas, the easterly Monsoon brings bad weather and heavy rain, with hard gales at times; but it cannot be said that either Monsoon is very regular, and for two months at least, between the establishment of each, the wind and weather are more variable and uncertain than at any other time of the year.

75. Arafura Sea.*—In the Arafura and Timor seas the E. or S.E. Monsoon blows with the greatest regularity; at its height, from May to August, it is fresh from E.S.E. to S.E.; earlier and later it hangs more to E., and often veers to E.N.E.; at full and change of the moon calms and variable squally weather may be expected, as is also the case on the east coast of Australia.

* CAPTAIN M'KENZIE, "Naut. Mag.," 1847, pp. 114, 115.

In TORRES Strait E. winds are most prevalent. The W. Monsoon is never very steady, but is often checked by easterly winds, when light and variable airs continue for several days, until it comes up again with fresh strength. In that portion of the sea between New Guinea and Australia, during January and the commencement of the W. Monsoon, winds from N.E. and N. are greatly prevalent, backing to W. at times. In the inner passage, winds from N.E. to W.N.W. may be expected as far as Lat. 14° S., beyond which they haul to E. and S.E.

Between the Monsoons there are often long calms, and the sea at that time abounds with water-snakes: the period when the S.E. changes to the N.W. Monsoon is most liable to these calms. At the approach of the Monsoon, W. winds often blow for five or six days, and then dying away are succeeded for a week or so by light, variable airs: at full or change the true Monsoon sets in, with thick, rainy, and squally weather; this lasts a few days, after which it clears up and the breeze is moderate, bringing finer weather than the E. Monsoon, and certainly the land is more distinctly visible. At the limit of this Monsoon, in 16° S., I have always found rainy and squally weather. The mean direction of the wind is from W.N.W. to W.S.W., hauling to N.W. and S.W.

76. General Remarks on the Malay Archipelago.—The following additional remarks on the Archipelago, from a paper recently read at the Royal Geographical Society, are at once interesting and instructive, and convey an excellent general summary of the seasons of this region :—

"The contrasts of vegetation and of climate in the Archipelago may be best considered together, the one being to some extent dependent on the other.

"Placed immediately upon the Equator, and surrounded by extensive oceans, it is not surprising that the various islands of the Archipelago should be almost always clothed with a forest vegetation from the level of the sea to the summits of the loftiest mountains. This is the general rule. Sumatra, New Guinea, Borneo, the Philippines, and the Moluccas, and the uncultivated parts of Java and Celebes, are all forest countries, except a few small and unimportant tracts, due perhaps, in some cases, to ancient cultivation or accidental fires. To this, however, there is one important exception in the Island of Timor and all the smaller islands opposite, in which there is absolutely no forest such as exists in the other islands, and this character extends in a lesser degree to Flores, Sumbawa, Lombok, and Bali.

"In Timor the most common trees are *Eucalypti* of several species, so characteristic of Australia, with sandalwood, acacia, and other sorts in less abundance. These are scattered over the country more or less thickly, but never so as to deserve the name of a forest. Coarse and scanty grasses grow beneath them on the more barren hills, and a luxuriant herbage in the moister localities. In the islands between Timor and Java there is often a more thickly-wooded country, but thorny and prickly trees abound. They seldom reach any great height, and during the force of the dry season they almost completely lose their leaves, allowing the ground to be parched beneath them, and contrasting strongly with the damp, gloomy, ever-verdant forests of the other islands. This peculiar character, which extends in a less degree to the southern peninsula of Celebes and the east end of Java, is most pro-

* "Jour. Roy. Geog. Soc.," vol. xxxiii., p. 224. "WALLACE on the Physical Geography of the Malay Archipelago."

bably owing to the proximity of Australia. The S.E. Monsoon, which lasts for about two-thirds of the year (from March to November), blowing over the northern parts of that country, produces a degree of heat and dryness which assimilates the vegetation and physical aspect of the adjacent islands to its own. A little further eastward in Timorlaut and the Ke islands a moister climate prevails, the S.E. winds blowing from the Pacific through Torres Straits, and, as a consequence, every rocky islet is clothed with verdure to its very summit. Further west again, as the same winds blow over a wider and wider extent of ocean, they have time to absorb fresh moisture, and we accordingly find the Island of Java possessing a less and less arid climate in the dry season, till, in the extreme west, near Batavia, rain occurs more or less all the year round, and the mountains are everywhere clothed with forests of unexampled luxuriance.

"The changes of the Monsoons and of the wet and dry seasons in some parts of the Archipelago are very puzzling; and an accurate series of observations in numerous localities is required to elucidate them.

"Speaking generally," says MR. WALLACE, "the whole south-western part of the Archipelago, including the whole range of islands from Sumatra to Timor, with the larger half of Borneo and the southern peninsula of Celebes, has a dry season from April to November, with the S.E. Monsoon. This same wind, however, bends round Borneo, becoming the S.W. Monsoon in the China Sea, and bringing the rainy season to northern Borneo and the Philippines.

"In the Moluccas and New Guinea the seasons are most uncertain. In the S.E. Monsoon, from April to November, it is often stormy at sea, while on the islands it is very fine weather. There is generally not more than two or three months of dry, hot weather, about August and September. This is the case in the northern extremity of Celebes and in Boero, whereas in Amboina July and August are the worst months in the year. In Ternate, where I resided at intervals for three years, I never could find out which was the wet and which the dry season. The same is the case at Banda, and a similar uncertainty prevails in Menado, showing probably that the proximity of active volcanoes has a great disturbing meteorological influence. In New Guinea a great amount of rain falls, more or less, all the year round. On the whole, the only general statement we can make seems to be that the countries within about 3° on each side of the Equator have much rain and not very strongly contrasted seasons; while those with more south or north latitudes, have daily rains during about four months in the year, while for five or six months there is almost always a cloudless sky and a continual drought."

77. Winds in the China Sea.—In the China Sea the Monsoon periods have not the same regularity as in the Indian Ocean; they have already been sketched at p. 22, and are indicated graphically on CHART DIAGRAMS VI., VII., VIII., and IX., where, as before, *the direction of the arrows shows the point of the horizon towards which the stream of air is moving.*

The greater persistency of the N.E. over the S.W. Monsoon is clearly shown by these Diagrams, as well as the variability of the latter.

The following Table is from MAURY'S "Nautical Monographs, No. I.;" it gives *the average winds and calms in the CHINA Sea, the total number of observations in each band of latitude, the mean direction of the wind from each quarter, and the average annual duration of each wind in days:—*

Bands in Latitude.	Mean Direction of the Winds.				No. of Days of Calm.	No. of Obs.
Lat. 30° to 25° N.	N. 28° E.	S. 44° E.	S. 34° W.	N. 36° W.		
No. of days . . .	189	43	72	60	1	318
Lat. 25° to 20° N.	N. 47° E.	S. 47° E.	S. 39° W.	N. 32° W.		
No. of days . . .	199	80	56	26	4	2564
Lat. 20° to 15° N.	N. 47° E.	S. 47° E.	S. 32° W.	S. 33° W.		
No. of days . . .	175	84	73	29	4	4298
Lat. 15° to 10° N.	N. 46° E.	S. 45° E.	S. 51° W.	S. 49° W.		
No. of days . . .	135	68	116	42	4	5358
Lat. 10° to 5° N.	N. 43° E.	S. 42° E.	S. 42° W.	S. 51° W.		
No. of days . . .	125	54	134	45	7	4672
Lat. 5° N. to Eq.	N. 38° E.	S. 37° E.	S. 34° W.	S. 46° W.		
No. of days . . .	106	85	113	48	13	3834

In the NORTH-WESTERN PART OF THE CHINA SEA the N.E. Monsoon commences about the middle of October; in the SOUTHERN part it rarely appears before November. It generally sets in with a sudden storm, in which the wind increases in force very rapidly, and produces a great swell; consequently, exposed anchorages should be avoided. This outburst lasts a week or more; occasionally, however, the Monsoon sets in without any storm. It is at its height in December and January. The whole period is one of dark, cloudy weather, and heavy rain; and usually a high, turbulent sea is experienced when the wind has been strong for a few days, especially near PULO-SAPATA, and thence to the STRAITS OF SINGAPORE. Off the COAST OF LUZON, although the winds are generally from N. and N.E. during the N.E. Monsoon, still they often veer to N.W. and W., blowing strong, with cloudy weather and a copious rainfall. During February the wind in the China Sea moderates and blows steadily, bringing fine weather. On the LUZON coast, land and sea breezes are not uncommon during this month, and during March and April become more or less prevalent over the whole China Sea. (CHART DIAGRAMS VI. and VII.)

Towards the end of April the S.W. Monsoon sets in; but notwithstanding this, the winds are still light and variable at sea during May, with land and sea breezes near the coast. The Monsoon is at its height during June, July, and August, when the weather is cloudy and rainy; but the wind, though generally fresh, is rarely stormy, except near the entrance to the Gulf of Siam, whence hard squalls sometimes descend very suddenly. In September, winds from N. and E. are occasionally encountered in any part of the China Sea, but they are especially to be expected near Formosa in July, August, and September, though the prevailing wind is S.W. Wind and weather are very unsettled in October; from S.W. and W. to N.W. the wind shifts to N. and E.N.E., puffy and strong, after which the Monsoon sets in. (CHART DIAGRAMS VIII. and IX.)

During the period of the S.W. Monsoon the winds are never as strong, nor the weather so gloomy as during the prevalence of the N.E. Monsoon; it is difficult to beat against the latter, but it is very common to make good progress against the former, especially by taking advantage of the breezes near the coast.

SEVERE GALES, commencing at N.N.W. or N.W., and accompanied by gloomy weather and a deluge of rain, occur in some seasons during May, June, July, and

August; veering to W. and S.W., they still blow with great violence, and finally abate at S. During the same time strong S.W. or S. gales prevail in the middle of the China Sea.

Strong N.E. gales have occurred in the China Sea during the S.W. Monsoon; but this is rare.

On the south coast of China steady gales from N.E. or E.N.E., lasting several days, may be expected in September or October; at the same time, on the west coast of Luzon, they commence at N. or N.W., veering by W. to S.W. and S., with heavy rain and a heavy cross sea.

78. Malacca.—On the east coast of Malacca heavy, continuous rain falls during the N.E. Monsoon. During the change to the S.W. Monsoon strong gales may be expected, after which the wind is moderate or light for some time.

With the S.W. Monsoon, from April to October, the weather is fine on the east coast, but squally and generally bad on the west coast of the peninsula.

On the east coast in June the wind is from S.E. during the day, veering to westward towards evening, whence it blows until 10 or 11 A.M.

79. Between Pulo-Timoan and Pulo-Condore the N.E. Monsoon has set in towards the middle or end of October; at Pulo-Timoan the winds are exceedingly variable from September, and the change of the Monsoon brings at times very bad weather.

The N.E. Monsoon is the fine season, and is generally established by November; nevertheless, during this month, storms with rain do occur, and perhaps a hurricane. The S.W. Monsoon brings the rainy season, and frequently lasts seven months; at Pulo-Condore it rains for a month after the N.E. Monsoon has set in.

80. Gulf of Siam.—From the position of the Gulf of Siam the Monsoon winds are irregular, and the seasons vary.

At sea the S.W. Monsoon begins in April with rain, which lasts during May and June. From June to September the winds are more westerly, but still with rain.

On the coast southerly winds prevail from March to May, but from June to September they are from S.W.—generally very strong near Pulo-Oby. During September they are variable.

In October the Monsoon changes, and the weather is squally; in November, December, and January, the wind is N. and the weather fine. During February variable winds between S. and E. are prevalent; and now, as well as in March, land and sea breezes are tolerably regular.

On the west coast of the Gulf of Siam, during May, and thence to July, when the S.W. Monsoon is at its height, a land wind sometimes prevails, lasting from three to ten days.

81. Cambodia.—On the coast of Cambodia the Monsoons are irregular, and land and sea breezes are more or less constant, those during the N.E. Monsoon being generally much fresher than at the period of the S.W. Monsoon, and lasting longer. In June, July, and August, heavy rain falls, and the wind is strong from the S.W.

82. On that part of the Coast between the Gulf of Siam and Cape Padaran the N.E. Monsoon begins with October, and ends during April. When the S.W. Monsoon sets in it blows parallel with the coast; ships approaching the land at night frequently experience a light land breeze, which dying away terminates in a brief calm, after which the Monsoon is fresh during the day.

83. Cochin-China.—Near the coast the Monsoons are never strong, and the winds are more or less variable throughout the year. Heavy rain falls in September, October, and November, with the N.E. Monsoon; and from December to February there is a kind of winter, with northerly winds and occasional rain.

During the N.E. Monsoon the wind is often easterly between the coast and the Paracels, and thence to Cape Værela; calms are often prevalent in the vicinity of the Paracels, while to seaward the Monsoon is fresh.

During the S.W. Monsoon land and sea breezes are prevalent along the coast; the land breeze is irregular in the time of setting in, although it is sure to come at some hour during the night: after a calm or gentle, light air till mid-day, a fresh S.E. wind springs up.

84. Gulf of Tong-Quin.—With the S.W. Monsoon comes the rainy and hot season, which, beginning in April, lasts till August; in September and October the weather is moderately fine. In November, when the N.E. Monsoon sets in, fresh northerly winds may be expected, veering to E. and E.S.E. towards the end of the month; in December N.N.E. to E. winds bring foggy weather; in January and February fresh N.E. and N.N.E. breezes are prevalent, with cold weather. In March the Monsoon has died out, and warmer weather is approaching. Typhoons occasionally enter the gulf.

85. Hainan and the South Coast of China.—The N.E. Monsoon from E.N.E. very generally blows along the land; at times, however, it hauls to S.E.

During the S.W. Monsoon S. and S.E. winds are very prevalent; in June, July, and August, heavy rain falls, and the weather is usually overcast and gloomy.

86. From the entrance of the Canton River to the Chusan Islands* the N.E. Monsoon usually blows from the beginning of October to the end of April. It sets in strongest in the months of November, December, and January, its medium force being a double-reefed-topsail breeze for a frigate when close-hauled; but frequently, owing to the heavy sea running, a press of sail cannot be carried, and it is therefore necessary at all times to keep as close in-shore as possible, where, owing to the conformation of the land, the rapidity of the tide, and other local circumstances, smoother water will always be found.

During the period of this Monsoon severe gales, lasting for two or three consecutive days, occur at times; it is then supposed that a Typhoon is blowing not far distant, and when the gale breaks the wind usually becomes light and to the southward of E. for a few days. It will again freshen up for a week or ten days together to a steady breeze, for treble-reefed topsails and reefed courses, with a high, short, cross sea, particularly at the entrance of the Formosa Channel.

* CAPT. G. R. MUNDY, R.N., in "Naut. Mag.," 1846, p. 621.

In October, November, and December, the atmosphere is moderately clear, rain and thick weather seldom lasting without a break for twenty-four hours. In January, February, and March, hazy weather with thick mist is not unfrequent. In April the Monsoon begins to slacken, light southerly winds for a day or two occasionally blow, and foggy, dirty weather, with returning heavy squalls and rain from N.E. will again set in and continue till the middle of May.

These remarks only apply to that part of the China Sea to the northward of the Canton River.

The S.W. Monsoon, variable between S.S.W. and S., begins in June and ends in October: this is the season when squally weather prevails, and when Typhoons occur.

87. In the **Formosa Channel** bad weather may be experienced at any season of the year. During the S.W. Monsoon heavy squalls with rain are common.

88. Off the **Bashees** the N.E. Monsoon, from N.E. to E.N.E., blows strong and raises a high sea.

89. Among the **Filippines** the N.E. Monsoon commences in October; fine weather may then be expected until April, with winds variable between N. and N.E.; if they veer to N.W. they generally blow hard.

The S.W. Monsoon may be expected at the end of May, but is not regularly established until June. During this season the weather is dark and gloomy, exceedingly wet and foggy. In September the rain abates, but fogs still prevail, lasting till mid-day. The worst Typhoons occur in July and August.

90. Palawan.—On the coast of Palawan the winds are variable during October, November, and December, offering no obstruction to vessels proceeding either to the N.E. or S.W.; but the weather is often cloudy and rainy. Near the southern part of the island, however, strong S.W. winds, with overcast sky, may be expected in September and during the early part of October.

The Monsoons are, however, so subject to interruption from local causes that it is difficult to say at what period either fairly sets in. The following is the experience of the late **COMMANDER W. T. BATE, R.N.**, when employed surveying the coast in the *Royalist*:—

“In November and December the weather is variable; N.E. and easterly winds, changing at times to S.E., more frequently prevail. In the former month a south-westerly blow, with dark, cloudy weather and rain, is not unusual, and one of the heaviest gales experienced shifted to N.W. just before the change of moon, and lasted till the end of the quarter.

“In January, when the N.E. Monsoon is blowing steadily, and sometimes with great violence, in the China Sea, moderate N.E. and easterly winds prevail on the coast of Palawan, and on the coast of Luzon land and sea breezes have been experienced with considerable regularity.

“In April, when light N.E. and frequently S.E. winds prevail in the China Sea, N.E. and easterly winds usually blow steadily on the coast of Palawan, freshening considerably after daylight, and dying away towards sunset.

“May and the early part of June, appear to be the finest period of the year on

the coast of Palawan, when land and sea breezes prevail with tolerable regularity, the former coming fresh from the S. and S.E. in the morning, and the latter from the N. and N.W. in the afternoon.

"Towards the end of June, and throughout July, unsettled weather, generally commencing about the change of moon, may be expected. A slight depression of the mercury, after a succession of fine weather, frequently indicates the approach of strong W.S.W.-ly squalls, which are usually accompanied by dark, cloudy weather and much rain, lasting for a week or ten days. These are generally succeeded by a period of fine weather, with N.W. and S.W. winds, which draw to the southward and eastward in the mornings. If June or July has been unsettled, it may be expected that August generally will be fine, with moderate S.W., but more frequently westerly winds, particularly in the afternoon.

"If, on the contrary, June or July has been tolerably fine, very unsettled weather may be expected in August. In either of these months, when strong S.W. squalls have succeeded a period of fine weather, vessels will not unfrequently, in the S.W. part of the passage, experience a weatherly set of the current.

"In September and October the wind generally blows strong from the W.S.W., with dark, cloudy weather; and off the S.W. end of Palawan, squalls, which veer to W.N.W. and N.W., sometimes blowing with great violence, succeed each other rapidly, and are accompanied by rain. Between the squalls the wind very often shifts to S.E.

"The barometer is of little use in prognosticating the changes; the difference in the column of mercury for the whole year, except in cases where the condition of the atmosphere has been disturbed by some physical cause, such as the approach of one of those violent cyclones known in the China Sea by the name of Typhoon, seldom exceeding $\frac{1}{10}$ ths of an inch. In general the mercury rises to N.E. and easterly winds, and falls to S.W. and westerly; but in some instances we have known the reverse of this to occur, doubtless from some such disturbing cause as above-mentioned, when the barometer by falling or rising indicates as usual the approach and recession of the vortex."

92. During the expedition of the American squadron to Japan the following observations were gathered:—

"The S.W. Monsoon sweeps over the Loo-CHOO group, and reaches the southern shores of Japan and the Bonin Islands.

"At NAPIA, Loo-CHOO, we found it prevailing steadily in May and June, and veering to the southward and eastward in July. In August the wind was very changeable, and blew at times quite strong, with squally, rainy weather.

"The N.E. Monsoon set in about the 1st of September, and continued until the departure of the squadron on the 7th of February, being, however, interrupted during the winter months by fresh gales from the northward and westward, which were generally accompanied by heavy rain.

"The climate of Loo-CHOO is as free from the severity of winter's cold or summer's heat as any in the world; and the island is nearly, if not quite, as healthy as any on the bosom of the sea. 'Droughts' are spoken of in an official Loo-CHOO document, and we know that the country is in the direct range of Typhoons or hurricanes. These drawbacks are not frequent.

"At the **BONIN** Islands, in April, the wind was variable; in June it was from the southward and westward, and in October from the northward and eastward. The passage from Loo-Choo, in October, was found to be exceedingly boisterous by the United States ship *Plymouth*.

"On the **COAST OF JAPAN** northerly winds were most prevalent in February, March, and April; and during this period we had occasionally strong gales, which most frequently commenced at S.W., hauling to the northward and westward, and were accompanied with heavy rain. In May and July we had south-westerly winds, and in June they were variable.

"During our stay in **JAPAN**, from February to June, the weather was generally pleasant. In the Bay of Yedo the mean temperature for February was 44° Fahr., and the apricot and camelia japonica were in full bloom.

"**Typhoons**.—The whole region from Formosa to the Bonins is within the track of these storms, though we believe they seldom reach the coast of Japan. The season during which they may be expected is from May to November, inclusive; but in the neighbourhood of the Bonins they seem to occur more frequently in October.

"**Fogs**.—We had but few fogs on the coast of Japan. They commenced at Hakodadi about the 1st of June, but did not extend as far south as Simoda."

92. The winds that generally prevail on the **east coast of Japan** are:—January to May, W. and N.W.; May, variable; June to August, E. to E.N.E., and sometimes S.E.; September to December, W. and N.W. October is a bad month for navigation, and from the middle of August to the middle of October is the worst season for cyclones, which blow with great fury, and give but little warning. From December to June the climate is delightful—clear, cool, and bracing. The mean range of the barometer throughout the year is from 29·70 to 30·06 inches. The range of the thermometer, mean 26° to 70°, extreme 14° to 74°.

93. In the months of August and September, 1858—the period *H.M.S. Furious* remained in **Yedo Bay**—heavy gales from the E.N.E., shifting round to the S.W., and increasing in force, were frequent. Winds from W., round northerly to E.N.E., generally brought fine weather, and rain when between S.E. and S.W.

During *H.M.S. Saracen's* survey of the **Strait of Tsugar**—May, June, July, and August, 1855—the prevailing winds were from the S., with much fine, clear weather. The wind was less frequent from the N.W. than any other quarter. Dense fogs prevailed in May and June; after that period they were comparatively rare. The wind, in shifting, usually followed the course of the sun. After a few days of light southerly wind and fine weather it freshened, and veered to the westward, accompanied by fine, clear, and cold weather. At N.W. it usually died away, or flew round suddenly to the eastward; in the latter case it was always followed by a dense fog or a gale, the weather getting fine again as the wind veered to the southward.

94. The Ladrones, or Mariana Islands.—The N.E. and S.W. Monsoons of the China Sea extend to these islands, notwithstanding their distance from the Asiatic continent. The strongest winds blow in August, September, October, and November, from N.W. to S.W., sometimes from S. to S.E.; in December, January, and February, wind and weather are variable; during March, April, May, and June, when the wind is from N.E. and E., the season is extremely fine. Storms, with rain

and thunder, as well as general bad weather, may be expected from July to November. Typhoons are not unknown, but they occur at intervals of a few years.

AUSTRALIA AND TASMANIA.

95. West Coast of Australia.—The prevalent winds are from S.S.W. and S.S.E., especially from October to April, the summer season; from April to October, the winter, the regularity of the southerly winds is interrupted by strong breezes from the north-westward, accompanied by cloudy weather, and rain or mist. Land and sea breezes are experienced near the coast; the former, from S.E. and E., gradually die out towards noon, and after a calm the sea breeze from W. to S.S.W. gradually draws round to S. towards sunset. The westerly Monsoon of the N.W. coast, generally prevalent from N.W. to S.W., blows from W. and W.N.W. in November and December, but it is scarcely more than a sea breeze. N.W. gales are not frequent, but hurricane squalls from E.S.E. to N.E., lasting about two hours during the night, are very terrific; they give ample warning by a bank of clouds and much lightning in the quarter whence they come.

The prevailing winds at *Swan River* are as follows:—In December, January, and February, S. and S.S.W. winds during the day, and S.S.E. to S.E. winds at night; these are occasionally interrupted by strong and oppressive gusts from the E. In March and April the sea breeze is moderate, and the land breeze more perceptible; calms are frequent, as well as light airs from the northward; when the sea breeze is strong the land breeze is light, and *vice versé*. May brings winter and rain; the wind beginning at N.N.E., veers to the westward with increasing strength; but the rain is not continuous, for there are intervals of fine weather, when the climate is beautiful, and when the land and sea breezes are as regular as during the summer. The N.W. gales of winter are very violent, and the weather is then gloomy and rainy; the west coast is then a lee-shore, for commencing at N.N.E., and shifting to the westward, it blows hardest between W.N.W. and W.S.W. Sudden squalls of a hurricane character, shifting round the compass, may be occasionally expected, but they are of short duration. The barometer generally foretells all these gales a day or so before they commence.

96. South Coast of Australia.—In the vicinity of Cape Leeuwin the winds are generally from the westward throughout the year: frequently during the summer from N.W. in the night, and from S.W. in the latter part of the day, but with no regularity.

Between the Archipelago of the Recherche and Cape Northumberland the prevalent winds from the middle of January to the middle of April are between S.E. and E.N.E., moderate, and generally fine; they partake of the nature of land and sea breezes: W. and S.W. gales, should they occur at this season, seldom blow home on the coast.

Along the whole southern coast of Australia, and as far as Bass Strait, the strongest and most durable winds are from the south-westward, frequently rising to heavy gales varying between S. by W. and N. by E.; they produce at all times a long, rolling swell, which, however, is almost incessant from April to November. CAPTAIN FLINDERS remarks,* "that the progress of the gales is usually this: the barometer falls

* "A Voyage to Terra Australis," by MATTHEW FLINDERS, Commander of the *Investigator*, 1814. Vol. I. p. 241, et seq.

to 29½ inches, or lower, and the wind rises from the north-westward, with thick weather, commonly with rain; it then veers gradually to the westward, increasing in strength, and generally clearing up as soon as it obtains any southing. At S.W. the gale blows hardest, and the barometer rises; and by the time it reaches S. or S.S.E., it becomes moderate, with fine weather, and the barometer above 30 inches. Sometimes the wind may back round to W. or something to the northward, with a fall in the mercury, and with diminishing strength, or perhaps die away; but the gale is not over, although a cessation of a day or two may take place. In some cases the wind flies round suddenly from N.W. to S.W.; and the rainy, thick weather then continues a longer time.

"Such is the usual course of the gales along the south coast and in Bass Strait; but on the east side of the strait the winds partake of the nature of those on the east coast, where the gale often blows hardest between S. and S.E., and is accompanied with thick weather, and frequently with heavy rain."

These observations are further corroborated by **COMMANDER HENRY L. CON, R.N.**, from an experience of four years on the coast of Victoria; and he adds, that "gales sometimes commence from N.E., thence round by N. to N.W., and continue as above described; they are experienced at all seasons of the year, and their usual duration is from three to four days, causing a furious sea on the coast. July, August, and September, are usually the wettest months; but this is uncertain, the largest floods recorded being in December."

97. Bass Strait.—The prevailing winds are S.W. for nine months in the year. During January, February, and March, N.E. winds, with clear weather, are not unfrequent, but they do not last for many days in succession.

Squalls from S.W. and S.E. may be expected on the east side of the strait, as well as on the coast of **TASMANIA**; the latter are very strong, and when blowing from the coast between Cape Howe and Wilson Promontory should be avoided.

98. Tasmania.—From April to October W.N.W. and N.W. winds prevail; these are interrupted at times by S.E. winds from October to March. Moderate breezes from N.E. are not uncommon on the east coast. Approaching Tasmania from the southward and westward, carefully avoid falling in with its rocky and dangerous coast at night, for you may be out in your reckoning, or may be caught in a S.W. gale. During February, March, and the beginning of April, winds from S.E. to S. are very common off the South Cape.

99. East Coast of Australia.—Northward of the Tropic the S.E. Trade-wind is regular from the end of April until September; this is the fine season. From October to April N.W. winds are prevalent, with rain and general bad weather.

In the vicinity of the Tropic, and thence to Sydney, there is considerable variation; here the S.E. Trade only blows home during summer, but may be interrupted by N.W. breezes at any time; gales from the S.E. may be expected in December, January, February, and March, especially during the two latter months. From May to September, the winter, westerly winds bring fine weather; gales at this period come from N.E. and S., always bringing rain.

At **SANDY CAPE** the S.E. Trade prevails at least nine months in the year.

South and south-easterly breezes are generally prevalent at **PORT STEPHENS** during the summer, as well as land and sea breezes; the sea breeze sets in at S.E., and veers to N.E. as the day advances; during the winter strong westerly winds are very common.

On the N.E. coast the hot N.W. wind of summer is almost always followed by sudden squalls varying from S.E. to S.S.W.

Northward of Sandy Cape, at the entrance to **Torres Straits**, and in the **Coral Sea**, the winds, though generally from N.W., are not persistent during the period of the N.W. Monsoon—from November to March—and are interrupted by calms and rain, as well as by occasional heavy gales—with rain, thunder, and lightning. These Westerly winds are steadier and stronger 200 to 400 miles to seaward than nearer the coast, but beyond that they become light, and finally give place to the S.E. Trade.

From April to September the S.E. Trade is the prevalent wind along the N.E. coast, with land and sea breezes near the shore; the weather is generally fine, though squalls and gales may be expected at the commencement of the season—during March and May. **CAPTAIN DENHAM**, while surveying the **CORAL SEA**, found the S.E. Trade frequently interrupted by variable wind and calms, and by occasional heavy gales.

100. Sydney.—Land and sea breezes are regular at Sydney from October to April, the former lasting only from midnight to 8 A.M.; these are occasionally interrupted by hot winds from N.W., which last from twelve hours to three days, and are always followed by heavy breezes from the southward, which come on without much warning. From April to October winds from N.W. to S.W. rule, with fine weather; occasionally there may be gales from the N. or S., with gloomy weather and rain. At the spring equinox the wind generally freshens to a gale from S.E. to E., with rain and a high barometer; as the wind veers to S. and S.W. the strength of the gale declines; they last from one to three days.

The following is a general synoptical table of the wind and weather, and of the range of meteorological instruments, for the different months:—

January—Light Easterly winds and calms; stormy if the wind shifts to S.W.

February—Winds between N.E. to S.E. prevail; at times from N.W. to S.W. by the W., and then bringing heavy rain.

March—S.E. and S. winds; the latter bring rain.

April and May—Winds between N.W. and S.W. are predominant, and they often blow strong.

June, July, and August—Westerly winds prevail, variable between N.N.W. and S.S.W.; in general moderate, and with fine weather. Winds from S. and E. in August are accompanied with cloudy weather and rain.

September—The prevalent winds are from W.N.W. to W.S.W, but occasionally from the eastward.

October—Easterly winds, variable between N.E. and S.E.

November—The prevailing winds are S.S.E., veering to S. and S.S.W. occasionally.

December—E.N.E. to S.S.E. are the usual winds, which, however, at times veer to S. and S.S.W.

MONTHS.	BAROMETER 62 FEET ABOVE THE SEA.			THERMOMETER.			WINDS.	WEATHER.			
								Days Fine.	Days Rain.	Stormy.	Cloudy.
January . .	30-300	29-430	29-865	91	60	75½	S.S.E.	15	4	12	—
February . .	30-300	29-680	29-990	90	58	74	E.S.E.	20	4	5	—
March . . .	30-490	29-580	30-035	83	60	71½	E.	19	10	2	—
April	30-458	27-772	29-115	83	57	70	W.	21	6	—	3
May	30-442	29-602	30-022	73	50	61½	W.	23	3	—	5
June	30-350	29-290	29-820	62	42	52	S.W.	20	1	—	9
July	30-315	29-840	30-077	60	48	54	S.W.	17	8	5	1
August . . .	30-248	29-488	29-868	66	44	55	S.W.	14	9	7	1
September .	30-380	29-520	29-950	67	42	49½	N.E.	20	—	8	2
October . . .	30-200	29-300	29-750	82	57	69½	N.E.	21	3	5	2
November .	30-220	29-860	30-040	91	57	74	E. & W.	31	—	—	—
December .	30-110	29-530	29-820	87	63	75	N.E.	20	—	10	1

NEW ZEALAND.

101. The following paper, by CAPTAIN BYRON DRURY, R.N., is the result of observations continued over four years, and made on board H.M.S. *Pandora*, combined with valuable contemporaneous observations on shore :—

"It is a matter of interest to trace the extent of the almost rotatory storm, the N.E. wind, which commences at E., and frequently, after suddenly changing from N.E. to N.W. and S.W., ends within a few points of where it commenced. This is more ob-

service at sea than in the vicinity of the land; where it is an expanded rotary gale, and therefore has not the dire effects of a hurricane. Its prognostics are so certain, and commence so gradually, that the anticipated changes can be made subservient to effecting a passage.

"This N.E. gale appears to be common to the southern regions from Bass Strait eastward to Tierra del Fuego. Descriptions of it at the latter place do not materially differ from what is observed here, except that here they are more decided in the spring and summer than in the winter.

"Before discussing the local winds of these islands, we may describe the ordinary winds off the coast, extending to Australia and Tasmania, beyond those latitudes where periodical Monsoons exist.

"The barometer is a certain indicator of changes in these latitudes; no vessel should be without it; but it requires study, for the greater height presages N.E. gales, and its changes require special notice in reference to the weather. In the latitude of Auckland we have known it to range from 30.66 to 28.80 during the revolution of a gale, which began at N.E.

"The ordinary wind of these seas is Westerly nearly the whole year round.

"It may be generally assumed that the barometer falls to N. and N.W. winds; that these are the rainy quarters; and that although the wind becomes stronger at first as it draws to S.W., the weather will clear up.

"The steadiest wind is about W.S.W. The changes are almost invariably with the sun, or contrary to the movements of the hands of a watch.* South winds bring cold clear weather, and raise the barometer high. S.E. winds are uncommon, but when they do set in, usually in April, May, and June, they last several days; with cold, raw weather, and the barometer about 30 inches. The N.E. wind occurs about once a month in spring and summer, but less regularly in winter; it is preceded by cloudless serenity and calms; the barometer from 30.30 to 30.60. A light breeze from the eastward, drawing to N.E., is gradually accompanied by a dull sky; the barometer begins to fall and the breeze freshens briskly. The sky becomes overcast, and usually in twelve hours it begins to rain. From that time to thirty-six or forty-eight hours the wind continually increases: in a heavy squall it will suddenly shift to the N.W., from which quarter it blows still stronger for from six to eighteen hours, latterly accompanied by heavy rain or hail: lightning is frequently seen in the S.E. quarter. The barometer is at its lowest a little before there is another (sometimes) sudden change to the S.W., from which quarter it begins to clear, while the glass rises rapidly, although the squalls are at first very violent. The wind sometimes remains in this quarter, sometimes veers round as far as S.S.E.; but if it should remain at W.S.W., fresh steady breezes and fine weather will last for several days. We have traced the diameter of one of these rotary gales to 960 miles.† They seldom last more than three days, before the weather becomes fine.

"We now come to the subject more specifically connected with New Zealand, having thus stated a few generalities, and we find it necessary to divide the group into eight portions to distinguish all the local winds.

"The formation of these islands, their comparative breadth at the parallel of the

* Contrary to those of the northern hemisphere, though still with the sun, which here culminates in the N.

† The N.E. gale is a progressive cyclone, not a merely local wind.

East Cape, with the narrow strip of land to the northward; the Strait, the high snow-capped mountains, and extensive plains and forest tracts, must produce varieties of currents of air; and we find frequent changes, though of short duration. But placed as these islands are, apart from any deserts or icy regions, the ordinary Westerly current, unless blowing with unusual force, becomes neutralized by the varied configurations of the country's surface; and for this reason we purpose to divide the islands into eight atmospheric districts, namely—

"1st.—From the North Cape to Mercury Bay on the east coast, and to Kawhia on the west.

"2nd.—From Mercury Bay to the East Cape.

"3rd.—From the East Cape to Cook Strait.

"4th.—From Kawhia to Cape Farewell.

"5th.—Cook Strait.

"6th.—From Cape Campbell to Cape Saunders.

"7th.—From Cape Saunders to Foveaux Strait.

"8th.—The West Coast of the Middle Island.

"It has been frequently stated that New Zealand is a moist climate as compared to England, but if meteorological data during a number of years be taken as the basis of comparison, it will be found such is not the case. Persons residing in New Zealand during 1851-52 might conclude there was an excess of moisture; but had a person lived in the country in 1853-54 alone he would come to an opposite conclusion, for the drought then was a source of considerable uneasiness.

"Farmers do not complain there of excessive moisture. Indeed, at Auckland no more falls than is required to produce its prolific vegetation, although perhaps too frequent to bring grapes and some other fruits to perfection which thrive in other parts of the colony.

"We believe that more rain falls in the West of England and on the west coast of Scotland and Ireland than in any part of New Zealand.

"The comparative absence of great intensity of electricity may modify the falls of rain. It is seldom such floods are heard of as accompany the thunderstorms of other regions. The greatest quantity of rain known to fall in twenty-four hours at Auckland within the three last years was less than at Sydney Heads. We have not been able to trace any accident occurring from lightning.

"Fogs are rare, except in the extreme South. In the Bay of Islands and Hokianga there is a morning fog occasionally in September, October, and November, which generally clears up at 10 A.M., and is followed by a fine day. In the Bay of Plenty we experienced a fog of three days' duration in the month of October, but it was considered quite extraordinary, and they have been experienced in the months of June and July in Hauraki Gulf, but seldom throughout the day.

"FROM THE NORTH COAST OF NEW ZEALAND TO MERCURY BAY ON THE EAST COAST, AND KAHIA (OR KAWHIA) ON THE WEST.—In this division the ordinary wind throughout the year is from N.W. to S.W. on the west coast, and from W.S.W. it lasts longest. In summer the N.W. and S.W. are both fine. In winter the N.W. wind is prevalent, accompanied by rain. When the wind veers S. of W.S.W., it blows from the westward off the shore on the east coast, otherwise the wind takes a direction down the coast. There is a sea breeze into Auckland and other harbours on the east coast in summer weather.

"N.N.W. winds are accompanied by rain. The N.E. wind, already described, generally ends in a severe gale. S.E. wind is rare, but when it comes lasts several days, with cold, raw weather, sometimes showery.* In winter there are sometimes very sudden changes on the east coast after short intervals of calm. Cloudless serenity in winter is usually followed by a wet day; and a lunar halo is a sure prognostic of rain. The narrow interval between the seas on the west and east coasts and the extensive forests of Manukau conduce to moisture prevailing in Auckland to a greater extent than at the Bay of Islands. It is also for this reason Auckland is milder in winter, frost being uncommon; whereas at the Bay, though a lower latitude, ice may be found an inch thick occasionally.

"In the harbours on the west coast the ordinary breezes are from S.W., with land winds in summer, which, however, are very light and partial. In Manukan the W. winds are peculiarly fresh, the contour of the coast here forming the apex of an obtuse angle. The harbours on the east coast draw the sea breeze into their various channels in summer. In winter the weather is very variable.

"During our experience the maximum temperature in the shade at Auckland in summer was 79°; minimum in winter, 40°; mean in summer, 67°; mean in winter, 52°. And the mean annual fall of rain was 43 inches.

"**MERCURY BAY TO EAST CAPE.**—Between Mercury Bay and the East Cape the summer breezes are from the westward, dying away at night in and near the shore, but not in the bay. A N.E. gale may be expected once a month, prevailing from March to July. S.E. winds are common near the East Cape, sometimes lasting for several days, and often very strong, but seldom blowing beyond the Mercury Islands. There is also a very strong S.W. gale, which is dangerous in the roadsteads between Cape Runaway and the East Cape; it is preceded by rollers and unsteady flaws of wind.

"The people in sight of White Island can foretell weather by the appearance of the steam from Whakeri: with W. winds the smoke is low, and more of it is seen. The S.E. wind, they say, smotheres the steam. No doubt the density of the atmosphere tells on that vast body of vapour.

"The climate of Mercury Bay may be considered fine, generally.

"**FROM EAST CAPE TO COOK STRAIT.**—Going from East Cape to Cook Strait a very marked phenomenon frequently takes place on rounding the East Cape. The strong Westerly wind that drives across the bay carries its line a few miles eastward of the cape, but southward of this the breeze is N.E. Sometimes a vessel may be becalmed for hours between two strong breezes from W. and N.E. The configuration of the coast at once accounts for this:—The W. wind meets with little obstacle in crossing the narrow and comparatively low land north of the ranges forming the southern boundaries of the Bay of Plenty; at the East Cape it meets the lofty Ikonargi, and the breadth of the country now being considerable, the rarefied air over it induces regular sea breezes from the N.E., succeeded in the evenings by the

* We found on an average of three years that there were only twenty days with the wind between S. and E. They were preceded by S.W. winds, and ended in calm. They occurred in April, May, June, and July. Although S.E. gales are common—from a degree S. of Auckland to the southward—we found only one blow home in the Hauraki Gulf (in June, 1852). It lasted forty-eight hours.

land wind for a short distance from the shore. An exception is the N.E. gale, known on this part of the coast as the black north-easter, to distinguish it from the ordinary sea breeze from the same quarter. In winter the sea breeze cannot be depended upon, and S.E. and S. gales set in very suddenly, and even in summer the S.E. winds sometimes last for some days.

"In Hawke Bay in spring there are fierce Westerly winds for days, with a low barometer and variable weather, ending in a cold S. wind, blowing hard for a short time, when the ordinary weather returns.

"This part of New Zealand has a fine climate.

"The barometer rises for N.E., S.E., and S. winds, and falls for N., N.W., and W. winds.

"**WEST COAST, FROM KAWHIA TO CAPE FAREWELL.**—Along the coast of Taranaki the sea breeze sets in from W.S.W. to S.W., drawing round to S.E. during the day and dying away at sunset.

"A N.E. gale produces a northerly swell at Taranaki, greater than when at N.W.

"N.W. winds blow very hard for about twelve hours, and then change to W.S.W., afterwards to S.W.

"From November to April the weather is fine. In June and July S.E. winds prevail. Gales at any season seldom last more than forty-eight hours. Sometimes a N.W. swell sets in without the wind blowing home. The barometer rises for S. and E. winds, and falls for northerly, and north-westerly, which is the rainy quarter.

"The proportion of N.W. to S.E. winds is about seven to four, which may be assumed as also the proportion of S.W. winds to all others on the West coast.

"**COOK STRAIT.**—In Cook Strait, that is, between Cape Campbell and Stephen Island, it may be said there are only two winds, N.W. and S.E. It is easy to account for the wind coming only from these two points, N.W. or S.E., by the configuration of the strait, a channel of that direction, bounded by lofty hills on either side; but it is not so easy to establish the causes of the sudden changes with regard to the winds which are blowing outside the strait. It may, however, be partially accounted for, if we suppose the ordinary ocean wind (W.S.W.) to be represented by the N.W. wind in the strait until overcome by either of the winds prevalent on the near part of the east coast—namely, the black north-easters, the south-easters, or the S. winds; either of these produce a south-easter in the strait, and when the W. wind is very light on the west coast the N.E. sea breeze of the east coast draws through the strait, forming the fine S.E. wind. The varied height of the mountains, the snow-capped Kaikoras, the extensive and heated plains, must concur to produce great effects on the currents of air. The N.W. wind prevails with fine weather, the S.E. with bad weather: both often blow very violently, and succeed each other suddenly. The appearance of the sky indicates the approach of the south-easter by banking up in that quarter, and by the neighbouring mountains becoming capped with clouds. There is also a fine S.E. wind. The finest months are April, August, November, and December. The most windy and rainy are May, June, and July.

"Thunder and lightning are unusual."

The following information was obtained from STAFF-SURGEON PRENDERGAST, who

kept a register at Wellington :—" Average fall of rain in 1852, 40 in. ; 1853, 67 in. 1854, 39 in. : mean, 52 in. Maximum amount of rain in one day, 2 in. During the same period the barometer (at the sea level) maximum, 30·67 ; minimum, 28·81 range, 1·86 in.

" The following table of the winds was made from observations at Wellington :— In 1852, N.W. wind 225 days, S. 141 days, gales 20 ; in 1854, N.W. winds 221 days, S. 144 days, gales 15.

" There were fifteen shocks of earthquake in 1852, and twelve in 1854."

The Meteorology of Nelson was observed during eleven years by the late SAMUEL STEPHENS, Esq., to whom CAPTAIN DEURY was indebted for the following information on that subject.

" The prevailing winds are—

" January.—N.N.E. to N.N.W. S.E. to N.E.

" February.—N.N.E. to N.N.W. S.W. and S.E. to N.E.

" March.—N.N.E. to N.N.W. Variable and calms.

" April.—N.N.E. to N.N.W. S.E. to N.E.

" May.—S.W. Calms and variable.

" June.—S.E. to N.E. Calms.

" July.—S.E. to N.E. Calms.

" August.—N.N.E. to N.N.W. S.E. to N.E.

" September.—S.E. to N.E. and S.W.

" October.—N.N.E. to N.N.W. S.E. to N.E.

" November.—N.N.E. to N.N.W. S.W.

" December.—N.N.E. to N.N.W.

" It appears that the N.W. winds of the strait are represented by those from N.N.E. to N.N.W., and the S.E. winds by those from S.E. to N.E., and that Blind Bay is only partially affected by the gales in Cook Strait.

" For the years 1852-53 we have this proportion :—

Year.	N.N.E. to N.N.W.	N.W. to West.	S.W.	S.E. to N.E.	Calm or Variable.	Gales.
1852 . .	110	35	62	99	60	28
1853 . .	107	34	45	96	88	21

" The N.E. is the rainy quarter (southward of the strait). It is the N.E. gale of these seas, and is but of short duration, veering to N.W. and S. W.

" The common S.E. wind of the strait seldom blows home to Nelson.

" The ordinary sea breeze begins from the westward, working round to N.W., and drawing to N.E. at sunset. At Nelson the strongest gales are from S.W.

" Rainy weather is generally indicated by vapoury clouds hanging on the hills. When strong gales occur without rain, they are often preceded by a red, wild, and lurid sky. These come mostly from the westward.

" The maximum amount of rain was in May 16th, 1853, when 3½ inches fell in eight hours, the barometer falling to 29·08 ; on common rainy days about three-quarters of an inch falls in twenty-four hours.

" The average fall of rain in 1852-53-54, for each month, was as follows :—

"January, 2·69; February, 2·78; March, 2·53; April, 2·45; May, 3·41; June, 3·37; July, 2·53; August, 3·24; September, 3·87; October, 3·51; November, 2·56; December, 3·44. September, October, and December, being the most rainy months. Snow rarely falls on the low lands about Nelson, but the mountain ranges are covered for months. The barometer falls considerably previous to snow storms, which occur in the end of May and June.

"Thunder clouds proceed from S.E. to N.W. Thunder occurred on forty-two days during three years, chiefly in January, September, and December. Fogs and misty weather are rare. Dews occur at all seasons. The temperature at Nelson was as low as 26° during three days in August, 1854; the wind being S.S.E. The highest range was 87° in February.

"The greatest amount of pressure was 30·50 in April; wind S.E. to S.W. The lowest 28·74, on May 17th, 1853, with much thunder and lightning.

"The following Table is from observations in 1852-53-54:—

Year.	N.N.E. to N.N.W.	N.W. to West.	S.W.	S.E. to N.E.	Calms.	Gales.
1852 . .	110	35	62	99	60	28
1853 . .	107	34	45	96	83	21

"N.B.—These observations were made in the town of Nelson, 120 feet above the sea level."

"CAPE CAMPBELL TO CAPE SAUNDERS.—About Lyttelton, nearly central in this district, we find the summer sea breezes blow from the N.E. with hazy weather, occasionally changing to N.W. for two or three days. The summer sea breeze dies away at sunset, and is succeeded by a light S.W., springing up about midnight, which lasts until 9 A.M.

"In winter the prevailing winds are S.E. at sea, but at Lyttelton and Canterbury the wind is S.W., while at sea it is S.E. In spring and autumn the winds are variable from N.E. for two or three days, with very fine weather; then light winds for a day, shifting to N.W., blowing a gale from twelve to forty-eight hours; then a sudden shift to S.W., strong wind and rain for three days, when it comes round again to N.E. along shore.

"Fortunately it seldom blows strong from E., but even light winds from that quarter produce a heavy swell in Port Cooper. This wind is accompanied by fog and misty rain.

"The violent S.W. wind in this harbour off the land is accompanied with more danger to shipping than any wind that has blown in. In December we experienced a south-easter between Canterbury and Otago. It fell calm for an hour, when the S.S.E. wind came up suddenly, and with little warning; it veered to S.S.W. This S.W. wind corresponds to the south-eastern of Cook Strait.

"It is very necessary to be aware of the prognostics of the sudden changes along this coast, especially the north-wester, which comes on at once to blow furiously. The most unmistakable sign is a remarkable transparency of the atmosphere, which is very clear indeed.

"The N.W. wind of this district resembles the sirocco of the Mediterranean; it comes on suddenly, and changes the temperature in a few minutes from 12 to 20 degrees. This change in the temperature perhaps arises from the rapid melting of snow in crossing the Southern Alps, or from crossing heated plains.

"The S.W. wind is preceded by heavy, hard-edged, dark cumuli in that quarter. At sea this is probably S.S.E.*"

"Again, the mountains are clouded in a south-easter, and partially in a south-wester, while all distant objects, including the Kaikoras, are distinct, with a fine blue tint, on the approach of the N.W. wind. The finest months are December, January, February, and March. Rains and gales are chiefly in June, July, and August. The rainy quarter is N.W. to S.W. The hot north-wester in summer frequently terminates in wet. There is also a wet and a dry south-wester. In autumn or winter the barometer rises very high, with light E. winds, producing fogs and much rain, lasting ten or fourteen days.

"The barometer is very variable on this coast; its fluctuations amount almost to a puzzle on shore. It is supposed the lofty mountains must have some share in producing local pressure, as the mercury is frequently moving, though no apparent atmospheric disturbance takes place.* The following remarks are specially applicable at sea. In winter the mercury falls previously to a S.S.E. or S.W. gale, but immediately before commencing it rises, and when at its greatest height the gale blows strongest. In winter such a gale brings continuous rain for three days; but in spring and autumn severe squalls, with rain, hail, and sleet, the glass remaining high, and it is succeeded by N.E. wind and fine weather. The mercury falls before a N.W. gale, especially if followed by a wet S.W. wind; the change is often immediate. It is very low when snow falls, although without wind.

"At Lyttelton the barometer has been very low for many days without any change: it has been at its highest with very bad weather, and soon after at its lowest with very fine weather. It appears that the cyclone north-easter does not occur above four times a year, then the rain from this quarter is heavy. The greatest fall of rain yet known in twenty-four hours was 2.14 inches in April, 1853.

"The uncertainty of the weather is shown to be remarkable by the following example:—The rain that fell in April, 1852, 3.09 in.; April, 1853, 9.40 in.; April, 1854, 1.08 in.

"April is considered a fine dry month, but in 1853 more rain fell than in any other month. Snow rarely falls on the plains, but it has fallen in May, July, August, and September. In August, 1851, there was a heavy fall of two inches deep, that lay all day. Thunder and lightning are rare. Their clouds proceed from N.W. or S.W., with dense cumulo-stratus. This occurs in spring and autumn.

"The temperature at Christchurch has been as low as 27° (June 10th, 1852); the highest was 91° in the shade on February 1st, 1854, at 3 P.M. The greatest amount of pressure was 30.64, August 14th, 1854; the least pressure, 28.85, May 17th, 1853.

"The following Table is from observations in 1852-53-54 at Christchurch:—

* Similar effects have been noticed near Tierra del Fuego.

Year.	N.N.E. to N.N.W.	N.W. to West.	S.W.	S.E. to N.E.	Calm or Variable.	Gales.
1852 . .	4	20	112	119	110	...
1853 . .	6	21	115	120	103	...
1854 . .	5	27	99	151	83	...

"On only two or three days in each of the years 1852, 1853, and 1854, was any thunder heard.

"It has been a matter of surprise and speculation that the hot N.W. winds proceeding directly from the snow should produce considerable heat, instead of (as would appear natural) an opposite sensation; nor can it be accounted for by the air traversing the plains, as the heat is found fully as sensible and perhaps more so at the foot of the snowy range.

"We may, perhaps, account for it thus:—We find this hot N.W. wind is preceded by cloudless serenity; therefore a great deal of radiation is taking place. The melting surface of the snow covering the heights releases latent heat, causing the atmosphere to become highly rarefied, which consequently rises, but, meeting an upper current, becomes cool and condensed, and rushes towards the coast, carrying at first a portion of the lower strata of caloric, the immediate sensible precursor of the gale. In a few hours the equilibrium is restored, and condensed moisture falls in rain, which is frequently the termination of the gale.*

"At Akaroa this gale is seldom felt, being sheltered by the Peninsula mountains. In this place the sea breeze follows the bends of the harbour. S.W.† gales follow N.W. winds, and blow very hard. The land wind has more than ordinary strength in passing Akaroa Heads in the morning.

"At Otago no register appears to have been kept previous to 1854.

"Our information [regarding the weather there is gathered from an intelligent pilot, who resided sixteen years near the Heads.

"North winds are rare. The ordinary sea breeze is N.E. It seldom blows from E.

"S.E. winds are accompanied by thick, hazy weather, but seldom blow home.

"South winds do not blow strongly, unless they veer to S.S.W. and S.W.

"The winds off the land are the strongest, and W.N.W. winds blow the hardest, the latter being at times a hot wind. The squalls from this quarter are heavy.

"The heaviest gales are in November, often with large hailstones.

"The dirtiest weather is in June and July. January is the hottest, and July the coldest month. Snow falls and lies on the ground for two or three days in June, July, and August. S. to S.E. is the rainy quarter.

"The pilot considered that there are about thirty days in the year when it would not be prudent to cross the bar because of the swell, which is worse in attempting to leave. He states that 1853 was a peculiarly dry season. It is curious that in that year there should have fallen at Canterbury nearly double the annual average amount of rain, and that in all other parts of New Zealand it was remarkably dry.

* Perhaps this hot wind is a tail of an Australian "brinkfelder." Compare relative positions on the map, and consider the direction from which this remarkable wind blows. It is not felt far N. or S. of this particular section of New Zealand.—ADMIRAL FITZROY.

† S.E. outside and in Cook Strait.

"The effects on the barometer may be generally assumed as similar to those of Canterbury, allowing for $2\frac{1}{2}^{\circ}$ higher latitude. At Otago there is much more fog.

"CAPE SAUNDERS TO FOVEAUX STRAIT AND TO THE WEST COAST OF MIDDLE ISLAND.—There is less information of the weather in this district. In the summer season the N.E. winds and Otago weather extend to the Traps; but after passing the meridian of Stewart Island, a very different climate may be met with. We found on two occasions that on approaching the west coast, N.N.W. gales blew down the west coast, with thick, foggy weather.

"It is said that in summer Easterly winds blow occasionally for six weeks at a time. It is, therefore, as well for vessels bound eastward at that season to pass considerably south of this latitude, unless it is wished to make a landfall.

"We may allow the district between Hawke Bay and the East Cape the superiority of climate; although that of Nelson is more bracing.

"The Bay of Islands claims an exemption from the ordinary humidity of the northern district.

"Auckland is subject to more moisture, although no more rain falls than is necessary for the prolific vegetation, which its excellent soil and delightful temperature produce.

"The summer during two years, 1853 and 1854, was even too dry, threatening a drought.

"Having concluded this statement of the Meteorology of New Zealand, as far as we have been able to collect facts from imperfect observations, and our own knowledge of the coast, we may remark that the climate is in general peculiarly adapted for colonists of our race. That the navigator will experience frequent changes, but is well warned by certain prognostics with the assistance of his barometer. That all gales are of short duration. And that the temperature throughout the year is so equable, especially in the northern portion, that it is difficult to define the limits of summer and winter."

CHAPTER V.

ON THE USE AND APPLICATION OF METEOROLOGICAL INSTRUMENTS.

102. Three instruments—the **BAROMETER**, the **THERMOMETER**, and the **HYGROMETER**—used together, constitute a perfect **WEATHER GLASS**. The Barometer indicates the changes in the pressure of the atmosphere,—the mercury falling as the air becomes lighter, rising as it becomes heavier, and remaining stationary so long as there is no change in the air; the Thermometer shows changes in the temperature of the air; and the Hygrometer, the changes in the moisture of the air.

103. DOVE comes to the following conclusions as regards the movements of meteorological instruments in connexion with the Law of Gyration:—Calculating the mean of all the readings of the barometer, thermometer, and hygrometer, observed during all the different changes of the wind, taken individually, after the elimination of the periodical changes,—if we define the mean distribution of pressure, temperature, and moisture round the compass, or if, in other words, we construct a *barometrical, thermal, and atmospherical wind-rose*,—it becomes evident that *this wind-rose has two poles of pressure and heat*;—in fact, that there are two points in it situated

opposite to each other, at one of which the weather is coldest, and the reading of the barometer is highest,—and at the other the weather is hottest, and the reading of the barometer is lowest. From the maximum of pressure to its minimum, as well as from the maximum of heat to its minimum, the mean barometrical and thermal influence of the wind decreases in an uninterrupted ratio. The former point happens to be nearly at N.E., and the other nearly at S.W. But from S.W. through W. to the N.E. the mean height of the thermometer decreases, whilst the mean readings of the barometer increase; from N.E. through E. to S.W. the mean height of the thermometer increases, whilst the mean readings of the barometer decrease. What is perceptible in the mean thermal and barometrical influence (in the mean thermal and barometrical movements) of the winds must also occur at the time of their transition into each other,—and just as much on the supposition of a varying as on that of a uniform rotatory velocity. Now, however, as the elasticity of vapour, so far as regards its distribution around the compass, is in close connexion with the thermal wind-rose, but the pressure of the dry air is closely connected with the barometrical one, it follows that the fluctuations in the pressure of the dry air and of the barometer are precisely in an inverse ratio to the changes in the temperature of the air and in the elasticity of the vapour suspended in it. Assuming then that the N.W. point has the same part in the southern hemisphere as the S.W. point in the northern, the S.E. point in the former corresponds to the N.E. point in the latter; consequently we have as the

MEAN MOVEMENTS OF METEOROLOGICAL INSTRUMENTS:—

In the Northern Hemisphere.

1. The Barometer sinks with E., S.E., and S. winds, is arrested in its downward progress by a S.W. wind, rises with W., N.W., and N. winds, and ceases to rise with one from N.E.

2. The Thermometer rises with E., S.E., and S. winds, and ceases to rise with a S.W. wind; it falls with W., N.W., and N. winds, and ceases to fall with one from N.E.

3. The Elasticity of *vapour* increases with E., S.E., and S. winds; its increase changes to a decrease with one from S.W.; it decreases with W., N.W., and N. winds; and its decrease changes to an increase with a N.E. wind.

4. The Pressure of the *dry air* decreases with E., S.E., and S. winds; its decrease changes to an increase with a S.W. wind; it increases with W., N.W., and N. winds; and its increase changes to a decrease with one from N.E.

In the Southern Hemisphere.

1. The Barometer sinks with E., N.E., and N. winds, is arrested in its downward progress by a N.W. wind, rises with W., S.W., and S. winds, and ceases to rise with one from S.E.

2. The Thermometer rises with E., N.E., and N. winds, and ceases to rise with a N.W. wind; it falls with W., S.W., and S. winds, and ceases to fall with one from S.E.

3. The Elasticity of *vapour* increases with E., N.E., and N. winds; its increase changes to a decrease with one from N.W.; it decreases with W., S.W., and S. winds; and its increase changes to a decrease with a S.E. wind.

4. The Pressure of the *dry air* decreases with E., N.E., and N. winds; its decrease changes to an increase with a N.W. wind; it increases with W., S.W., and S. winds; and its increase changes to a decrease with one from S.E.

Thus, the movements of meteorological instruments are the *same* with *east* winds in the NORTHERN HEMISPHERE as they are with *east* winds in the SOUTHERN : the same is the case with *west* winds. The *difference* between the two hemispheres is only quantitative with N.W., N.E., S.W., and S.E. winds ; and on the other hand, it is qualitative with N. and S. winds—*i.e.*, the mean fluctuations of the meteorological instruments are greatest in the Northern Hemisphere with N.W. and S.E. winds, and of the least importance (owing to the compensation of the opposite movements) with N.E. and S.W. winds ; in the Southern Hemisphere (owing to the compensation of opposite movements) they are of least importance with N.W. and S.E. winds, and, on the contrary, they are greatest with N.E. and S.W. winds. The changes with N. winds in the Northern Hemisphere are, however, different from the changes which occur with N. winds in the Southern Hemisphere ; under like climatic conditions, however, they are the same in both, according to their amount,—if, for instance, there be a rise in an instrument with a N. wind in the Northern Hemisphere, it sinks with a N. wind in the Southern, and *vice versa*. The same occurs with S. winds.

102. It is in reference to these observations, in so far as they appertain to the North Temperate Zone, that DOVE shows that the weather indices (words) on the barometer are of very subordinate importance, because the difference in the temperature and, as a consequence of it, in the pressure of the two currents (polar and equatorial) is generally far greater in winter than in summer. As thus the fluctuations of the barometer are generally far more considerable in winter than in summer, the relative proportions, according to which the scale has been constructed, should be at least double in winter what they are in summer ; as they are constructed at present, however, we are easily led astray by them. Properly speaking, the upper part of the index should represent the N.E. wind or a tranquil polar current ; the middle part, the E. and W. winds, or, more correctly, the transition of the two aerial currents ; and the lower part, the S.W. wind, or, better still, the equatorial current. Now, as the air of the polar current flows from colder to warmer regions, its capacity for creating vapour increases, and the effect of this increase stands on the index thus : “very dry, or fine.” If owing to the transition of the currents into each other from E. and W., and their mingling together, precipitation follows, but clearer weather sets in afterwards, this is set down on the index as “changeable.” If, as the current from the S. moves onwards into higher latitudes it gradually loses its vapour over the ground, which becomes colder as it advances, this effect is set down as “rainy.” If, however, it rushes rapidly into higher latitudes, and its pressure, although diminished, is contrasted when it is strongest, owing to the rarefaction of its air by heat and the loss of its accompanying vapour, with its mean amount, it is set down under the head of “stormy.”

103. On these and similar researches ADMIRAL FITZROY has recommended that the old and comparatively useless BAROMETER-SCALES, on which are marked “fair,” “change,” “rain,” “stormy,” &c., be abolished, and that the following be substituted, as better adapted to the improved state of meteorological science, and therefore conveying more information to ordinary observers :—

On Barometer-scales the following contractions are for NORTH LATITUDE :—

RISE	FALL
FOR	FOR
N.E.-ly	S.W.-ly
N.W.—N.—E.	S.E.—S.—W.
Dry or Less	Wet or more
Wind.	Wind.
<hr/>	
Except Wet	Except Wet
from	from
N.E.-ward.	N.E.-ward.

In SOUTH LATITUDE substitute South or Southward for North, &c.

And the following summary may be useful *generally* throughout the world :—

RISE	FALL
FOR	FOR
Cold, Dry,	Warm, Wet,
or	or
Less	More
Wind.	Wind.
<hr/>	
Except Wet	Except Wet
from	from
Cold Side.	Cold Side.

Thus, 1. The BAROMETER rises for Northerly Wind (including from N.W., by the North to the Eastward); for Dry or *less* Wet Weather; for *less* Wind; or for more than one of these changes :—

Except on a few occasions when Rain (or Snow) comes from the Northward with *strong* Wind.

The THERMOMETER falls for *change* of Wind towards *any* of the above directions.

Also, 2. The BAROMETER falls for Southerly Wind (including from S.E., by the South to the Westward); for Wet Weather; for *stronger* Wind; or for more than one of these changes :—

Except on a few occasions when *moderate* Wind with Rain (or Snow) comes from the Northward.

The THERMOMETER rises for *change* of Wind towards the Southerly directions *only*.

MOISTURE or Dampness in the air (shown by a HYGROMETER) increases *before* or *with* Rain, Fog, or Dew.

106. Position of the Barometer in a Ship:—It is essentially requisite that the Barometer be suspended in a good light, but out of the reach of sunshine or the heat of a fire or lamp; nearly amidships, and exposed as little as possible to sudden changes of temperature; also in such a position that it may swing freely in the gimbals, and yet be in no danger of a sudden side blow from the rolling of the ship.

The tube of the marine Barometer being contracted to prevent "pumping" or undue oscillation, this instrument is generally considered by mariners to be slow in its indications, hence many now prefer the **ANEROID**, or the **Sympiesometer**.

The Aneroid Barometer is a good instrument, inasmuch as it is quick in showing the variation of atmospheric pressure, is easily read, and may be placed out of harm's way better than the ordinary mercurial barometer; but it requires to be occasionally compared with a good barometer.

The Sympiesometer must be set with the thermometer before reading its indications; it is a very delicate instrument, and requires even more care than the marine Barometer; it must never be turned upside down, nor exposed carelessly to casual heat.

107. Well-discussed barometrical observations are still wanted for the Indian Ocean; lacking which, we turn to MAURY's Monograph, No. 2, "The Barometer at Sea," giving the approximate **MEAN HEIGHT OF THE BAROMETER IN THE NORTHERN AND SOUTHERN HEMISPHERES**, derived from the observations of American and Dutch vessels:—

Lat. 78° 37' N.	29·759 inches.	DR. KANE.
59° 51'	29·88 "	St. Petersburg.
55° to 50° N.	29·95 "	England.
50° to 45°	30·060 "	from 8282 observations.
45° to 40°	30·077 "	" 5899 "
40° to 35°	30·124 "	" 5103 "
35° to 30°	30·210 "	" 4989 "
30° to 25°	30·149 "	" 4392 "
25° to 20°	30·081 "	" 3816 "
20° to 15°	30·018 "	" 3592 "
15° to 10°	29·964 "	" 4496 "
10° to 5° N.	29·922 "	" 5343 "
5° to Equator	29·915 "	" 5114 "
Equat. to 5° S.	29·940 "	" 3692 "
5° to 10°	29·981 "	" 3924 "
10° to 15°	30·028 "	" 4156 "
15° to 20°	30·060 "	" 4248 "
20° to 25°	30·102 "	" 4536 "
25° to 30°	30·095 "	" 4780 "
30° to 36°	30·052 "	" 6970 "
40° to 43°	29·88 "	" 1703 "
43° to 45°	29·78 "	" 1130 "
45° to 48°	29·63 "	" 1174 "
48° to 50°	29·62 "	" 672 "
50° to 53°	29·48 "	" 665 "
53° to 55°	29·36 "	" 475 "
56½ S.	29·29 "	" 1126 "

And the following Table, published by the Meteorological Department of the Board of Trade, gives, from verified instruments, the *mean* normal pressure (and range) in the Indian Ocean—between Lat. 0° and 10° N., Long. 50° to 110° E. :—

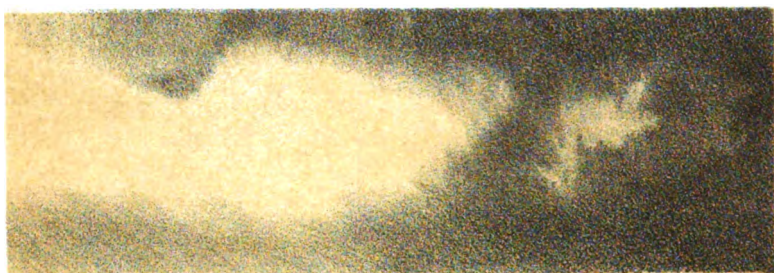
	January.	Feb.	March.	June.	July.	August.	Sept.	October.	Nov.	Dec.
Lat. 10° N.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Means	30.036	—	29.946	29.890	29.825	29.824	29.926	29.935	29.961	29.890
Range	0.16	—	0.08	—	0.13	0.22	0.14	0.32	0.30	0.02
No. of Observations	16	—	5	1	6	5	11	13	15	2
Lat. 5° N.	30.016	29.980	29.883	29.882	29.907	29.950	29.962	29.973	29.888	29.820
Means	0.25	0.10	0.02	0.09	0.10	0.04	0.31	0.30	0.23	0.04
Range	20	3	3	6	7	2	14	24	7	2
No. of Observations										
Equator.										

The navigator must always bear in mind that the range of the barometer between the Tropics is very small (a few tenths), and that any deviation from this announces the approach of a tropical gale, or perhaps of a hurricane.

1. Cirrus.



3. Stratus.



7. Nimbus.



2. Cumulus.

108. MAURY gives the following as the *mean height of the Barometer* in high southern latitudes :—

Bands of Latitude.	As observed between the Meridians of			
	20° W. and 140° E.		140° E. and 80° W.	
	No. of Observations.	Height of Barometer.	No. of Observations.	Height of Barometer.
		Inches.		Inches.
Lat. 40° S. to 43° S.	1115	29·90	210	29·84
„ 43° S. „ 45° S.	738	29·80	155	29·73
„ 45° S. „ 48° S.	611	29·58	226	29·71
„ 48° S. „ 50° S.	175	29·53	247	29·56
„ 50° S. „ 53° S.	108	29·35	198	29·45
„ 53° S. „ 55° S.	6	29·17	92	29·35
S. of 55°	7	29·27	64	29·42

109. It only remains to give the *mean height of the Barometer as observed in 1429 gales of wind south of the parallel of 40° S.* :—

Bands of Latitude.	No. of Observations.	Height of Barom. with wind between N. & E.	No. of Observations.	Height of Barom. with wind between S. & E.	No. of Observations.	Height of Barom. with wind between S. & W.	No. of Observations.	Height of Barom. with wind between N. & W.
Lat. 40° to 43° S.	36	29·86	17	29·59	88	29·65	116	29·50
„ 43° „ 45° S.	30	29·58	11	29·59	72	29·49	88	29·50
„ 45° „ 48° S.	38	29·42	24	29·51	98	29·48	169	29·38
„ 48° „ 50° S.	25	29·35	10	29·46	63	29·33	83	29·27
„ 50° „ 53° S.	29	29·46	11	29·34	59	29·34	70	29·18
„ 53° „ 55° S.	15	29·31	5	29·07	60	29·23	39	29·19
„ S. of 55° . .	22	29·24	6	29·45	62	29·17	78	29·14

And from this Table it appears that on the polar side of 40° S. *eighty per cent.* of the gales have westing in them, and that they are distributed in the following proportion: from the northward and eastward 14 per cent.; from the southward and eastward 6 per cent.; from the southward and westward 25 per cent.; and from the northward and westward 45 per cent.; consequently, the last is the stormy quarter of the Great Southern Ocean.

110. Clouds and their Variations.*—HOWARD distinguished, according to their forms, three sorts of clouds—the *cirrus*, the *cumulus*, and the *stratus*, to which four forms of transition were attached—viz., *cirro-cumulus*, *cirro-stratus*, *cumulo-stratus*, and *nimbus*.

The *cirrus*—the cat's tail of sailors [*see* Plate X., fig. 1], is composed of thin filaments, the association of which sometimes resembles a brush, at other times woolly hair, and at times slender network.

* KÆMTZ' "Meteorology."

The *cumulus*, or summer-cloud (*ball of cotton* of sailors), frequently presents itself in the form of a hemisphere, resting on an horizontal base. Sometimes these hemispheres are built one upon the other, and form those great clouds which accumulate on the horizon, and resemble at a distance mountains covered with snow. [See Plate X., fig. 2.]

The *stratus* is an horizontal band, which forms at sun-set, and disappears at sunrise. [See Plate X., fig. 3.]

Under the name of *cirro-cumulus*, HOWARD designates those little rounded clouds which are often called woolly clouds; when the sky is covered with them it is said to be *fleecy*. [See Plate X., fig. 4.]

The *cirro-stratus* is composed of little bands of filaments more compacted than those of the *cirrus*; for the sun has sometimes a difficulty in piercing them with his rays. The clouds form horizontal strata, which, at the zenith, seem composed of a great number of thin clouds; whilst at the horizon, when we see the vertical projection, a long and very narrow band is visible. [See Plate XI., fig. 5.]

When the *cumulus* clouds are heaped together, and become more dense, this species of clouds passes into the condition of *cumulo-stratus* [see Plate XI., fig. 6], which often assumes at the horizon a black or a bluish tint, and passes into the state of *nimbus*, or rain-cloud. [See Plate XI., fig. 7.] The latter is distinguished by its uniform grey tint and its fringed edges; the clouds of which it is composed are so compounded that it is impossible to distinguish them.

Though it be easy to distinguish these clouds when their forms are well characterized, it is often a very difficult matter to designate accurately certain forms of transition; and one observer, for example, will call *cirro-stratus* what another observer would designate under the head of *cumulo-stratus*.

After a continued period of fair weather, and when the barometer slowly begins to fall, well-characterized *cirri* often appear under the form of slender filaments, whose whiteness contrasts with the azure of the sky. At other times they are arranged in parallel bands, scarcely visible, and which are directed from the S. to the N., or from S.W. to the N.E.* Sometimes they separate, and resemble the floating tail of a horse. In Germany these clouds are known under the name of wind-trees (*Windsbäume*.) These filaments are also seen to cross each other in various ways.

* The tendency which the *cirri* have to arrange themselves in bands parallel to each other is remarkable; and it proves that the cause which directs their filaments to one azimuth rather than another, instead of being merely local and accidental, extends to great distances.

By a well-known law of perspective, parallel bands ought to appear diverging from one point of the horizon, and converging at the point of the horizon diametrically opposite. The observance of these points of convergence greatly facilitates the knowledge of the direction. The observations that I made with M. BRAVAIS, on the Faulhorn, prove, agreeably to M. KAEMTZ' observations, that the predominant direction is that of the S.W. to N.E. The meteorological registers of the members of the Commission of the North, who wintered in Lapland, give a slightly different direction merely: from W. by S. to E. by N. Moreover, the phenomenon occurs more frequently there than in the temperate zones. At the Equator, HUMBOLDT found that the parallel bands were generally directed from N. to S.

The cause, which thus arranges the great axes of these clouds, according to parallel lines, is still unknown. FORSTER was the first who made the very just remark that these clouds almost always travel along a parallel to their great axis, which greatly contributes to render them apparently motionless. M. BRAVAIS, without being aware of FORSTER's observations, arrived at the same conclusion. Many meteorologists (HOWARD, FORSTER, PELTIER) seem to believe that the *cirri* serve as conductors between two distant foci of electricity of opposite names, the fluids of which tend to combine, and that the flexibility of the conducting clouds terminates in the rectilinear form, which is necessitated by the condition of the shortest path from one focus to the other.—MARTIN.



4. *Cirro-cumulus.*



5. *Cirro-stratus.*



6. *Cumulo-stratus.*



Cumulonimbus.

These clouds frequently resemble carded cotton, and pass into the state of *cirro-cumulus* and *cirro-stratus*. The white colour by which they are characterized does not always permit their structure to be recognised, or their transformations to be followed; but by means of the mirrors of blackened glass, which landscape painters use, this may be managed with the greatest facility. The eye is not dazzled, and the cloud reflected in the glass may be studied at leisure.

The *cirri* are the most elevated clouds; it is difficult to determine their height. Measures made at Halle have often led me to assign to them a height of four miles. Travellers who have passed over high mountains are unanimous in asserting that, from the highest summits their appearance is the same. During a stay of eleven weeks within sight of Finsteraarhorn, the elevation of which is 13,800 feet, I never observed any *cirri* below the summit of that mountain. It is among the *cirri* that halos and parhelia are formed; and on studying these clouds by means of the blackened mirror, it is a rare case not to find in them traces of halos. These phenomena being due to the refraction of light in frozen particles, we may conclude that the *cirri* are themselves composed of flakes of snow floating at a great height in the atmosphere. Observations continued for ten years have convinced me of the truth of this assertion; and I know of no observation tending to prove that these clouds are composed of vesicles of water. We may feel astonished, no doubt, that in summer, when the temperature frequently attains 77° Fahr., the clouds which float above our heads are composed of ice; but the doubt will disappear when we reflect on the decrease of temperature with height. During one of those hot days, when rain falls on the plains, this rain is snow on the summits of the Alps.

The appearance of *cirri* often precedes a change of weather. In summer they announce rain; in winter frost or thaw. Even when the vanes are turned towards the N. these clouds are often carried along by S. or by S.W. winds; and the latter are soon felt also at the surface of the earth. We can admit that these clouds are brought by the S. winds, which determine the fall of the barometer, and the vapours of which are precipitated in the form of rain. Such at least is DOVE's theory: it justifies the denomination under which the Swiss peasants have designated this class of clouds.

When the S.W. wind prevails, and extends to the lower regions of the atmosphere, the *cirri* also become more and more dense, because the air is moister. They then pass into the condition of *cirro-strati*, which first appear under the form of a mass like carded cotton, the filaments of which are closely interlaced, and they gradually take a greyish tint; at the same time, the cloud seems to get lower, and vesicular vapour is formed, which fails not to be precipitated in the form of rain.

The same meteorological circumstances sometimes determine the formation of light *cirro-cumuli*, which are entirely composed of vesicular vapour. They do not weaken the light of the sun, for it passes through them; and HUMBOLDT has often been able to see through these clouds stars of the fourth magnitude, and even to recognise the spots on the moon. When they pass before the sun or the moon, these bodies are surrounded with an admirable corona. The *cirro-cumuli* foretell heat: it seems that the hot S. winds, which prevail in the lower regions, do not convey a sufficient quantity of vapours to cover the sky entirely with clouds, and that they only act by their elevated temperature.

While the clouds of which I have spoken are the produce of the S. wind, the

cumuli owe their existence to ascending currents: their height varies greatly, but it is always less than that of the *cirri*. The *cumuli* are most characteristic in the fine days of summer. When the sun rises in a clear sky, a few small clouds may be seen appearing about eight o'clock in the morning, which seem to increase from within outward. They become thicker, and accumulate to form masses clearly circumscribed and limited by curved lines, which cut each other in different directions. Their number and size increase till the hour of greatest heat in the day; they then diminish, and at sunset the sky is again perfectly serene; in the morning they are very low, but they continue ascending until mid-day, when they again re-descend in the evening. I convinced myself of this by direct measurement, and observations made in the mountains. How often have I seen the *cumuli* under my feet in the morning! They then rise: toward mid-day I was surrounded by clouds for about an hour, and the rest of the day I saw above my head clouds, which in the evening re-descended to the plain.*

Cumuli are formed when ascending currents draw the vapours into the higher regions of the atmosphere, where the air, being very cold, is rapidly saturated. If the current increases in force, the vapours and clouds become more elevated; but there they increase in greater ratio, on account of the reduction of temperature. Hence it happens that the sky, though fine in the morning, is entirely clouded at mid-day. When the ascending current relaxes towards evening, the clouds descend: as, on arriving into strata of air which are less heated, they again pass into the state of invisible vapour. According to SAUSSURE, the rounded form of clouds is due to this mode of formation. Indeed, when one liquid traverses another in virtue of the resistance of the ambient medium, and the mutual resistance of its parts, the former takes a cylindrical form with a circular section, or one composed of arcs of a circle. We may convince ourselves of this by letting a drop of milk or of ink fall into a glass of water. Thus the masses of ascending air are great columns, the shape of which is defined by the clouds. Add to this the little whirlwinds on the borders of the clouds, which are frequently observed in mountains, by means of the blackened mirror, and which also contribute to give to the whole rounded forms analogous to those of whirls of smoke escaping from a chimney.

The *cumuli* do not always disappear toward evening; on the contrary, they often become more numerous, their borders are less brilliant, their tint deeper, and they pass to the state of *cumulo-stratus*, especially if a stratum of *cirrus* exists below them. We may then expect rains or storms, for in the higher and the mean regions the air is near the point of saturation. The S. wind and the ascending currents give rise to changes of temperature which determine the precipitation of aqueous vapour in the form of rain.

* There exists a great number of measurements of the heights of clouds. KAEMTZ ("Lehrbuch der Meteorologie," t. I., p. 385) relates several which are due to RICCIOLI, BOUGUER, HUM-BOLDT, LAMBERT, CROTHWAITE, and to himself. The extremes are 440 and 7000 yards. During the cruise of the *Venus*, 1000 and 1500 yards were found on the Atlantic and the South Sea as the extreme terms.

M. L'ÉTYER, staff-officer, communicated to the Institut, January 2nd, 1837, forty-eight measures of the height of clouds, made in 1826, during the triangulation that he executed in the Pyrenees with M. HOSSARD. The extremes for the lower plane of clouds were 500 and 2700 yards; for the upper plane, 1000 and 3300. They obtained these different determinations by aid of the heights previously measured, of the peaks to which the clouds were tangents by their superior or inferior surfaces. On September 29th the two observers were so placed as to see at the same moment the two opposite surfaces of a cloud. Its thickness was 500 yards. Next day it was 900.—MARTINS.

The *cumuli* that are heaped up on the horizon in the fine days of summer are those which are most fertile for plays of the imagination. Who has not fancied that he recognises in the changing forms of these clouds men, animals, trees, and mountains? They furnish comparisons to the poets; and OSSIAN has borrowed from them his most beautiful images. The popular traditions of mountainous countries are full of strange events, in which these clouds play a prominent part. As they are often of the same height, an appearance results which I should mention. When I was living at the Faulhorn, the sky was frequently clear above my head; but a little above the horizon, a belt of clouds, the width of which did not exceed double or treble that of the moon, extended like a pearl necklace along the West Alps, from France to the Tyrol. My station, at 8800 feet above the sea, was a little more elevated than the clouds, and their projection on the sky formed a narrow belt, although they were spread over a vast extent of the sky. From this projection, it follows that it is often very difficult to distinguish the *cumulus* from the *cumulo-stratus*. How frequently do we see *cumuli* spread over the sky! The horizon appears charged with clouds; it seems that the heavens will in a short time be entirely covered with them; and yet the sun continues to shine without intermission. A very simple reasoning proves that the eye has been deceived by a projection. Imagine a series of globular clouds of the same size, equi-distant from each other: if the observer draws two lines from the station he occupies to the limits of the clouds, the interval between those which are at the zenith will be very great, but it will be contracted in proportion as they approach the horizon, when it becomes entirely null.

While the true *cumuli* are formed, and disappear during the night, another variety of these clouds is seen under very different circumstances. It is common to observe in the afternoon dense cloudy masses, rounded or extended, with borders badly defined, the number of which increases towards evening, until, during the night, the sky is completely overcast. The next day it is still overcast, but, some hours after sunrise, all disappears; the true *cumuli* then occupy the sky, where they float at a more considerable height. I have determined this by direct measurements. At evening, clouds of the former class again replace the true *cumuli*. These clouds are composed of very dense vesicular vapour, like the *cumulus* and the *cumulo-stratus*. They differ in their dependence on the hours of the day; they have also an analogy with the *stratus*, on account of their extent, and are distinguished from them by their greater height. However, they approach nearer to them than to the *cumulus*, and I propose designating them under the name of *strato-cumulus*. During winter this kind of cloud frequently covers the whole sky for weeks together; their presence is probably due to the decrease of temperature, reckoning from the ground, being more rapid than usual. But as the sun rises, its rays dissolve the clouds, the vapours ascend, and *cumuli* are formed.

This influence of the sun on the clouds gives rise to atmospheric variations, which are well known to husbandmen. In the morning the sky is clouded, and it rains abundantly; but towards nine o'clock the clouds separate, the sun shines through, and the weather is fine for the rest of the day. At other times, during the morning, the sky is clear, but the air moist. The clouds soon appear; toward mid-day the sky is covered, the rain falls, but it ceases towards evening. In the former case, they were *strato-cumulus*; in the latter, *cumulo-stratus*. The former are dissipated by the rays of the sun, the latter are formed under their influence. If the temperature

and hygrometric conditions of the air at two or three thousand yards above the earth were as well known as at its surface, these apparent anomalies which astonish us might be more easily explained.

111. Beaufort's Notation of Wind and Weather.—The following method, first devised by the late Hydrographer to the Admiralty, SIR FRANCIS BEAUFORT, is generally used by seamen to indicate the State of Weather, and the Force of Wind at Sea; also in lighthouses, and at many stations on land :—

b	Blue Sky	also 1	0	Calm.
c	Clouds (detached)	2	1	Steerage way.
d	Drizzling rain.		2	Clean full—from 1 to 2 knots.
f	Foggy	3	3	Ditto 3 to 4 knots.
g	Gloomy.		4	Ditto 5 to 6 knots.
h	Hail	4	5	With royals.
l	Lightning.		6	Topgallant sails over single reefs.
m	Misty (hazy)	5	7	Two reefs in topsails.
o	Overcast (dull) (<i>also g</i>)	6	8	Three reefs in topsails.
p	Passing showers.		9	Close-reefed maintopsail and courses.
q	Squally.		10	Close-reefed topsails and reefed fore-sail.
r	Rain	7	11	Storm staysails.
s	Snow	8	12	Hurricane.
t	Thunder. Lightning	9	From 2 to 10 being supposed "close-hauled."	
u	Ugly (threatening) appearance of weather.			
v	Visibility. Objects at a distance unusually visible.		The above method is very general, and in practice it answers well—not only for seamen, but even for popular use on land, by <i>estimating</i> the force of wind, proportionally, between the extremes of its slightest motion and its utmost violence.	
w	Wet dew.			

Note.—A letter repeated augments its signification :—thus *ff* very foggy, *rr* heavy rain, *rrr* heavy and continuing rain. Sometimes a bar (—) or dot (.) is used for this purpose, as *r* heavy rain.

Mr. Glaisher, of the Royal Observatory, Greenwich, considers the following notation (0 to 6) of the wind preferable to the above, at least for land purposes, where there can be no definite reference to the power of the sails :—

SCALE OF WIND :— (Beaufort . . . 1—12 corresponding to Land 1—6)		1—3	Light . . .	1
		3—5	Moderate . . .	2
		5—7	Fresh . . .	3
		7—8	Strong . . .	4
		8—10	Heavy . . .	5
		10—12	Violent . . .	6

TABLE SHOWING THE FORCE AND VELOCITY OF THE WIND FROM LIGHT AIRS TO HEAVY GALES AND TEMPESTS.

Pressure in lbs. on Square Foot.	Velocity.		Popular Descriptions.
	Feet per Second.	Miles per Hour.	
0.002	1	0.68	Gentle airs (unappreciable by gauge).
0.004	1.47	1	
0.005	1.56	1.06	
0.019	3	2	Light airs (just appreciable by gauge); would fill the lightest sail of a yacht.
0.028	3.67	2.5	
0.032	3.9	2.66	
0.043	4.5	3	Light breezes; such as would fill the lightest sails of a large ship.
0.052	4.9	3.3	
0.065	5.58	3.8	
0.071	5.87	4	
0.090	6.6	4.5	
0.100	6.98	4.75	
0.112	7.34	5	
0.130	7.89	5.38	
0.136	8.1	5.5	
0.162	8.8	6	
0.228	10.4	7	Moderate breezes, in which ships can carry all sail.
0.260	11	7.6	
0.291	11.8	8	
0.364	13.2	9	
0.390	13.6	9.27	
0.452	14.7	10	Fresh breezes,—topgallant- sails and royals.
0.521	15.8	10.77	
0.551	16.2	11	
0.650	17.66	12	
0.780	19.3	13	
0.830	20	13.6	Fresh winds; reefs.
0.884	20.6	14	
0.910	20.9	14.25	
1.042	22	15	
1.170	23.6	16	
1.250	24.2	16.5	Strong winds; treble-reefed topsails.
1.302	25	17	
1.430	26.2	17.8	
1.470	26.5	18	
1.563	27.39	18.67	
1.630	28	19	Gales; close-reefed topsails and reefed courses.
1.790	29.35	20	
1.820	29.55	20.14	
2.084	31.15	21.47	
2.600	35.32	24	
3.126	38.73	26.40	Strong gales; close-reefed topsails and staysails.
3.647	41.83	28.52	
4.168	44.83	30.56	
4.689	47.44	32.34	
5.200	50	34	
7.800	61.18	41	Heavy gales and storms.
10.400	70.72	48.2	
13.000	79.07	53.91	
15.600	86.61	59	
20.800	100	68.18	
26.000	111.74	76.18	Very heavy gales; great storms; tempests.
31.200	122.62	83.6	
36.400	132.18	90.12	
41.600	141.30	90.34	
52.000	157.98	107.7	
62.400	173.06	120	Tornadoes; cyclones; hur- ricanes.

112. The Moon's Influence on the Weather.—Sailing directions, as well as popular belief, very commonly attribute *changes of weather to the moon's influence*. As the subject has been critically tested it may not be amiss to place the results before the seaman.

TOALDO made a series of observations, continued for forty-five years, at Padua, in which changes of weather were recorded in juxta-position with lunar phases: without detailing the particulars, it will be sufficient to state at once the results. He found that for every seven *new* moons the weather changed at six, and was settled only at one; for every six *full* moons, the weather changed at five, and was settled only at one; for every three epochs of the *quarters*, there were two changes of weather.

He also examined the state of the weather in reference to the moon's distance from the earth, which is subject to some variation. The position of the moon when most distant from the earth is called *apogee*, and her position when nearest is called *perigee*. He found that of every six passages of the moon through *perigee* there were five changes of weather; and of every five through *apogee* there were four changes of weather. If these results would bear the test of rigid examination, they would be decisive in favour of the popular notion of the lunar influence. But let us see in what manner TOALDO conducts his inquiry.

He was himself an avowed believer in the lunar influence, not merely upon the atmosphere, but even on the state of organized matter. In his memoir on the subject he has not stated what atmospherical changes he has taken as *changes of weather*; and it is not unfair to presume that the bias of his mind would lead him to class the slightest vicissitudes under this head. But further, TOALDO, in recording the changes of weather coinciding with the epochs of the phases, did not confine himself to changes which took place upon the particular day of the phase. On the pretext that time must be allowed for the physical cause to produce its effect, he took the results of several days. At the new and full moon he included in his enumeration all changes which took place two or three days before or two or three days after the day of new or full moon; while for the quarters he only included the day preceding and the day following the phases; and for epochs not coincident with the lunar phases, he only counted the changes of weather which took place on the particular day in question.

It appears, then, that for the changes coinciding with a new and full moon, as recorded by TOALDO, may be taken any changes occurring within the space of from four to six days; also, for the changes recorded at the quarters are to be understood those which occurred within the space of three days; and for those not coinciding with the phases may be taken the changes which occurred on a single day. It will not require much sagacity to perceive that the results of such an inquiry must have been just what TOALDO found them to be; and that, if instead of taking the epochs of the lunar phases, he had taken any other periods whatsoever, and tried them by the same test, he would have arrived at the same results. Five days at the new and full moon would include a third of the entire lunar month; and thus a third of all the changes of weather which occurred in that period were ascribed by TOALDO to the lunar influence.

PROFESSOR PILGRIM has also examined a series of observations on the *lunar phases as connected with the changes of weather*, made at Vienna, and continued from 1763 to 1787—a period of twenty-five years—and he has found that, of every hundred

cases of the phases, the proportion of the occurrence of changes to that of the settled state of the weather was as follows :—

	Changes.	Settled Weather.
New moon	58	42
Full moon	63	37
Quarter	63	37
Perigee	72	28
Apogee	64	36
New moon at perigee	80	20
New moon at apogee	64	36
Full moon at perigee	81	19
Full moon at apogee	68	32

Admitting these results, it would follow, contrary to popular belief and to the observations of TOALDO, that the new moon is the least active of the phases; and that the full moon and quarters are equally active; also that the influence of *perigee*, or the nearest position of the moon, is greater than that of any of the phases; while the influence of *apogee*, or its greatest distance, is equal to that of the quarters and full moon, and greater than that of the new moon.

But PILGRIM's calculations are liable to objections similar to those which vitiate the observations of TOALDO; for he included in his enumerations of changes corresponding to the phases, changes which occurred the days preceding and following the phases: this being the case, the only wonder is that the proportion which he found especially for the new moon, is not more favourable to his hypothesis. But independently of this, PILGRIM's results are not entitled to any confidence: they not only bear internal evidence of inaccuracy, but the observations were not continued for a sufficient length of time to give a safe and certain conclusion.

In the years 1774 and 1775 DR. HOBSLEY directed his attention to the question, and published two papers in the *Philosophical Transactions*, with a view to dispel the popular prejudice on the subject of lunar influences. HOBSLEY's observations, however, were confined to so short a period of time (two years), that they could not be expected to afford any satisfactory results. He found that in the year 1774 there were only two changes of weather which corresponded with the new moon, and none with the full moon; and that in the year 1775 there were only four changes which corresponded with the new moon, and three with the full moon.

Examining the question of lunar influences in a more general point of view, to see whether observation has supplied any ground for the supposition of any relation whatever of periodicity between the moon and the weather, it appears that M. SCHUEBLER made a series of observations, with considerable care, and published the following results, which, shortly after, were re-examined by M. ARAGO.

SCHUEBLER's calculations were founded on meteorological observations made at Munich, Stutgard, and Augsburg, for 28 years.* His object was to ascertain whether any correspondence existed between the lunar phases and the quantity of rain which fell in different parts of the month. He defined a rainy day to be one in which a fall of rain or snow was recorded in the meteorological journals, provided it affected the rain-gauge to an extent exceeding the six-hundredth part of an inch.

* At Munich, from 1781 to 1788 inclusive; at Stutgard, from 1809 to 1812 inclusive; and at Augsburg, from 1813 to 1828 inclusive.

So far as his observations may be relied upon, it would follow, that in the places where they were made, out of 10,000 rainy days the following are the number of those days which would happen at the different lunar phases :—

New moon	306
First octant	306
First quarter	325
Second octant	341
Full moon	337
Third octant	313
Last quarter	284
Fourth octant	290

Now, as there are about $29\frac{1}{2}$ days in the lunar month, if we suppose the fall of rain to be distributed equally through every part of the month, the total number of these 10,000 days which should happen on the eight days of the phases, would be found by simple proportion, since it would bear to 10,000 the same proportion that 8 bears to $29\frac{1}{2}$:—the number would therefore be 27·12. Whereas, it appears from the above Table, that the actual number which fell upon these days was 52·02; and thus less than the proportional amount occurred upon them.

PILGRIM had already, in 1788, attempted to ascertain the influence of the lunar phases on the fall of rain; and he found that in every hundred cases there were 29 of rain on the full moon, 26 at the new moon, and 25 at the quarters.

The preceding observations refer only to the number of wet days. SCHUEBLER, however, also directed his inquiries to the influence of the lunar phases on the *quantity* of rain and on the clearness of the atmosphere. From observations continued for sixteen years at Augsburg, including 199 lunations, he obtained the following results :—

Epochs.	Number of clear days in 16 years.	Number of overcast days in 16 years.	Quantity of rain in 16 years, in inches.
New Moon . . .	31	61	26·551
First quarter . . .	38	57	24·597
Second octant . . .	25	65	26·728
Full Moon . . .	26	61	24·686
Last quarter . . .	41	53	19·536

In this Table, by a clear day, is meant such days as exhibit a cloudless sky at seven in the morning, and at two and nine o'clock in the afternoon; those that were not clear at these hours were counted as cloudy days. These results are in accordance with the former. It appears that the number of clear days is more frequent in the last quarter, which is an epoch at which, by the former method of inquiry, the number of rainy days was least; also the number of cloudy days is greatest at the second octant, which is a period at which the number of rainy days is found to be greatest; the depth of rain also agrees with this, being the greatest about the second octant, and least at the last quarter. SCHUEBLER extended his inquiries to the influence of the moon's distance on rain; and he found that, on examining 371 passages of the moon through the positions of her extreme limits of distance,—during

the seven days nearest to *perigee* it rained 1169 times; and during the seven days nearest *apogee* it rained 1096 times. Thus, *ceteris paribus*, the nearer the moon to the earth, the greater would be the chances for rain.

The latest theory relating to the influence of the moon on the quantity of rain is that of M. MATHIEU, as announced in his work "*De la Prédiction du Temps*."

M. MATHIEU, though disbelieving in lunar influence, entertained the idea that all the aqueous meteors with which our atmosphere is visited or affected obey laws as fixed and immutable as those which regulate the movements of the planets. With the view, therefore, of ascertaining these laws, he commenced an investigation which resulted in the admission that what he had previously considered mere popular prejudice is perfectly philosophical. He became convinced that whilst the sun plays the principal part in raising vapours, it is the moon that determines their precipitation and distribution; and further, that this is effected by the agency of atmospheric tides and the changes of the wind consequent thereon.

Avoiding the methods usually adopted, which he considers necessarily produce negative results, M. MATHIEU was led to examine the relation which exists between the moon's phases and the four cardinal positions of the sun, viz., whether the changes occur whilst that luminary is on the upper or lower meridian, and whether near the rising or setting. He then, it appears, extracted, from the meteorological register kept by SAUSSURE at Geneva (from 1796 to 1856), the observations of rain for the several days of the lunation, and arranged them in categories according to the time of the day and season of the year when the change occurred. The difference in the quantity of rainfall thus elicited is very considerable; and though the number of observations is not large, it should be remembered that they are spread over an extended series of years; and the results, according to M. MATHIEU, appear to be remarkably uniform.

For example, in the case of the new moon in the months of September, October, November, and December, if that phase occurred between the hours of 8 A.M. and 9.30 A.M., the amount of rain greatly exceeded the quantity registered when the new moon arrived between 7 A.M. and 8 A.M. During sixty years there were seventeen instances of its occurrence between 8 and 9.30 A.M.; and fifteen instances between 7 and 8 A.M.

The 17 instances gave 532 millimetres rain.

The 15 instances gave 266 mm. rain.

M. MATHIEU, after giving other examples at new moon, passes on to the first quarter, which he finds of the four phases is the one "which gives or transmits the most rain."

Two Tables are given of the amount of rain which was registered, in June, July, and August, in the 60 years, at first quarter.

From these Tables it appears that the first quarters which arrived between 11.30 A.M. and 3 P.M. brought more rain than those which occurred between 10 P.M. and 1 A.M. There were twenty instances of the former, and twenty-three instances of the latter time of the change.

The 20 instances gave 509 mm. rain.

The 23 instances gave 336 mm. rain.

In the case of the twenty-three instances which occurred between 10 P.M. and

1 A.M., nearly the whole rain-fall was registered in quarters where the phase arrived between *ten and eleven o'clock P.M.*

Again, the first quarters which occurred in the months of July and August between 4 A.M. and 5.30 A.M. were found to bring more rain than those which arrived between 6 A.M. and 8 A.M. There were nine instances of the first hour of the change, and fifteen instances of the second.

The 9 instances gave 301 mm. rain.

The 15 instances gave 108 mm. rain.

Encouraged by these results, and tempted by the numerous coincidences and indications of system which have led many, from TOALDO downwards, to believe it possible to foretell the weather by the aid of our satellite, M. MATHIEU enters into a full analysis, from which new combinations of hours and phases are obtained, by means of which he believes *rainy periods* may be predicted.

It is well to notice that M. MATHIEU's theory deals strictly with *aqueous metcors*, and not with the weather of any particular day.

M. MATHIEU having appealed to the French Emperor on behalf of his theory, M. LEVERRIER was directed to examine and report on its merits; the following is the result of M. LEVERRIER's investigation of his theory of the lunar influence:—

Following M. MATHIEU over his own ground, that of figures, I shall perhaps not arrive at the same conclusions as he has done. However, he will have no reason to complain that he has been condemned without a sufficiently serious examination.

M. MATHIEU bases his researches on the quantity of rain upon the meteorological observations commenced at Geneva on Jan. 1, 1796, by M. DE SAUSSURE, and continued without interruption from that time. He takes account of the quantity of water fallen and collected each day; he groups the results according to the phases of the moon, and the hour at which it entered into this phase; and discussing what he calls *the horary influence of the moon upon a phase taken isolately*, he finishes by setting forth this first rule:—

“SEPTEMBER, OCTOBER, NOVEMBER, DECEMBER.—The new moon that occurs between 8 and 9 A.M. presents more water than that which occurs between 7 and 8 A.M.

“The first case occurred	17 times.
The second ” 	15 ”
The seventeen former cases presented	532 ^{mm} of water.
The fifteen latter ” 	266 ”
Mean of the former cases	31·5 ”
” ” latter ” 	17·11 ”

Let us dwell upon this first rule. Doubtless the author will have placed at the head of his precepts the one that he would consider as the best established; and it is right that we should begin where he has himself begun.

M. MATHIEU does not give the different quantities of rain, of which he offers only the sum. This could not satisfy us. We conceive that the author had desired to be brief; but he should at least have given a complete illustration of his mode of discussion. In statistical researches, illusion is easy; it requires a great amount of skill to avoid the errors that too frequently arise from an artificial grouping of the figures.

In order to fill up this blank, I have had recourse to the publications of the Observatory of Geneva, and have extracted the figures upon which M. MATHIEU has laid his foundation.

Following the plan laid down by the author, I have had regard to the day on which the new moon occurred, and neglected that on which the first quarter occurred. I am not aware whether he took a precaution that I have taken. I reduced all the quantities of rain to a like duration of seven days. When the duration of the phase was only six days, I have added a sixth to the quantity of water measured; when the phase was of eight days, I have abstracted from it an eighth. However, this correction has no influence over the general results.

On tabulating the figures on which M. MATHIEU based his theory, M. LEVERRIER comes to the conclusion that when the new moon occurs from 6 to 7 A.M., or from 9.30 to 11.30 A.M., the rain is at a mean of from 21 to 22 millimetres.

From 21 to 22 millims. are also collected when the moon occurs between 7 and 8 A.M.

Finally, when the new moon occurs from 8 to 9.30 A.M., the mean quantity is still the same.

We may therefore conclude that the assumed rule, given by M. MATHIEU for Geneva, has no foundation.

The fact which caused M. MATHIEU's illusion is palpable. It is the great quantity of rain (107 millims.), which fell at Geneva in 1840, during the first phase of the moon, which commenced on October 25th at 9.7 A.M. Suppress that year (1840), and nothing of the law remains. At this point, which for the fifteen other years, in which the moon occurred from 8.11 to 9.26 A.M., which is according to M. MATHIEU the great period of rain, the mean amount, on the contrary, is not more than 18½ millims., which is the smallest of all.

This answer, extracted from the figures, may yet assume another form, under which it will strike every one. The mean quantity of rain in the lunar conditions under consideration, is 22 millims. Very well: in the seventeen years for which the new moon occurs between 8 and 9.30 A.M., and which according to M. MATHIEU should be very rainy, *there are eleven* in which the rain is below the mean, and only six in which it is superior to this mean. Where then, we ask, is the law which is false more than half the time? I even think that, had M. MATHIEU first considered the question under this point of view, he would have deduced a result diametrically contrary to the rule that he has given.

Besides, it is perfectly well known that, when we desire to establish physical laws, we must carefully guard ourselves against every combination of figures in which the result is exceptionally influenced by a solitary fact, as takes place in the case before us.

The connexion of barometric oscillations with atmospheric disturbances is so obvious, that the inquiry as to a correspondence between the lunar phases and the variations of the barometer would necessarily claim the attention of meteorologists, if any value were to be attached to lunar influence on the weather. M. FLAUGERGUES accordingly made a series of observations at Viviers (in the department of Ardèche), in France, which was continued from 1808 to 1828, a period of twenty years, on the heights of the barometer in relation to the lunar phases: that the influence of the sun might be always the same, the observations were made at noon, and the heights