

Ship Logbooks Help Analyze Pre-instrumental Climate

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The Climatological Database for the World's Oceans: 1750–1854 (CLIWOC) project, which concluded in 2004, abstracted more than 280,000 daily weather observations from ships' logbooks from British, Dutch, French, and Spanish naval vessels engaged in imperial business in the eighteenth and nineteenth centuries.

These data, now compiled into a database, provide valuable information for the reconstruction of oceanic wind field patterns for this key period that precedes the time in which anthropogenic influences on climate became evident. These reconstructions, in turn, provide evidence for such phenomena as the El Niño–Southern Oscillation and the North Atlantic Oscillation. Of equal importance is the finding that the CLIWOC database—the first coordinated attempt to harness the scientific potential of this resource [García-Herrera *et al.*, 2005]—represents less than 10 percent of the volume of data currently known to reside in this important but hitherto neglected source.

Data Abstraction and Processing

The CLIWOC team abstracted and processed data for over 280,000 days using log books from national archives across Europe. The abstraction and transcription process alone was demanding and required care as the abstraction team was working with original, hand-written documents of variable quality.

The data were gathered from more than 3000 logbooks encompassing 5000 voyages through the Indian and the North and South Atlantic oceans. The geographic distribution of the data points is shown in Figure 1, in which the paucity of observations for the Pacific Ocean is a regrettable consequence of the relative infrequency with which those waters were navigated.

Ships' senior officers prepared these logbooks for purposes that were manifold but largely pragmatic: Though they were the official account of the ship's management, they were also navigational documents, and, in the age of sail, close attention to wind and weather was needed to assess the degree to which they influenced the vessel's course and speed. All officers, irrespective of their country of origin, were assiduous in their recording of wind force and wind direction. Entries were scattered throughout each day as conditions changed but were always noted at noon, which was in those distant times the start of the nautical day and 12 hours ahead of the civil day, which begins at midnight.

This was, however, a pre-instrumental age as far as marine observations were concerned; only toward the close of the study period do records of barometric pressure and temperature appear with any useful frequency, and most observations were made by judgement. Wind data, on the other hand, are available throughout the period. Directions were gauged by reference to the ship's compass and from the behavior of the sails and flags and the movement of the waves. Because such directions were noted with respect to magnetic north, corrections had to be applied by the CLIWOC team to express them in terms of true north.

Wind force records offered more intractable problems in the preparation of the database. Mariners estimated it, as many do today, by reference to the state of the sea and the effect that wind has on the ship's superstructure. The terms in which the mariners chose to describe their judgements used a specialized, in part archaic, vocabulary that required translation by the team into the more familiar terms of the Beaufort Scale before they could be of any scientific value. Access to a large volume of data permitted identification of the range and variety of the nautical vocabulary employed in the logbooks. It was soon apparent to the team that although more than 100 terms were used by each language group, there were signs of a consistency of usage that suggested a common understanding, and the dozen or so most popular terms (in all languages) served to meet the needs of the officers in nearly 90 percent of cases. By applying methods of content analysis to these data and using contemporary nautical manuals and 'word books,' a multilingual dictionary was prepared that included modern-day Beaufort force equivalents of nearly 99 percent of the wind force terms across

the four languages [Royal Netherlands Meteorological Institute, 2003].

By these means, each observation could be brought to a present-day standard and fixed by time—the date and time of entry being known—and by location, as each midday entry includes also the ship's estimated position by latitude and longitude. Navigational methods were, however, imprecise for much of the study period, and care was taken to ensure that longitude, in particular, was correctly interpreted. Greenwich was not adopted as the universal meridian until 1884, and the CLIWOC team uncovered 600 local meridians used by officers in different parts of their voyages, each requiring correction of the stated longitude to confirm to the Greenwich standard. This issue is discussed more fully by Können and Koek [2005]. The problem posed by not adopting such corrections is illustrated in Figure 2. Finally, modifications had to be applied to dates and times to take into account the nature of the nautical day and the fact the English logbooks were based on the Julian calendar until 1752.

These corrected data possess a further, and important, property in that they are not 'proxy' in character and are instead the consequence of direct experiences of the weather. Moreover, it has been established that such observations were made only by seasoned and experienced officers, tutored in their craft and unlikely to make mistakes. Objective assessments of consistency of the record have been undertaken within CLIWOC [Wheeler, 2005].

The CLIWOC Database

The CLIWOC database became publicly available in 2003 and includes the instrumental temperature and pressure readings that became common toward the end of the study period. In addition to these routine observations, the database provides records of events such as hurricanes, iceberg sightings, precipitation in its various forms, and cloud cover. Metadata provide background material on the ships, officers, and voyages.

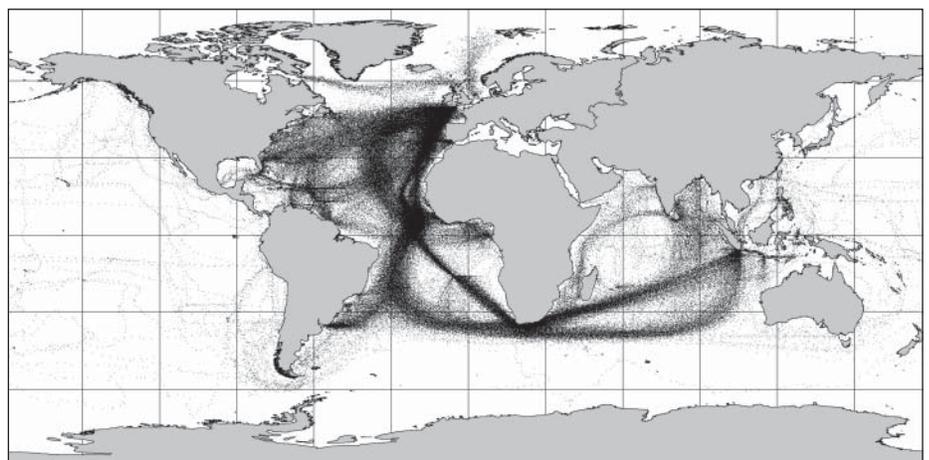


Fig. 1. Spatial coverage of all CLIWOC data (1750–1854) from Release 1.5. Every dot represents a ship report.

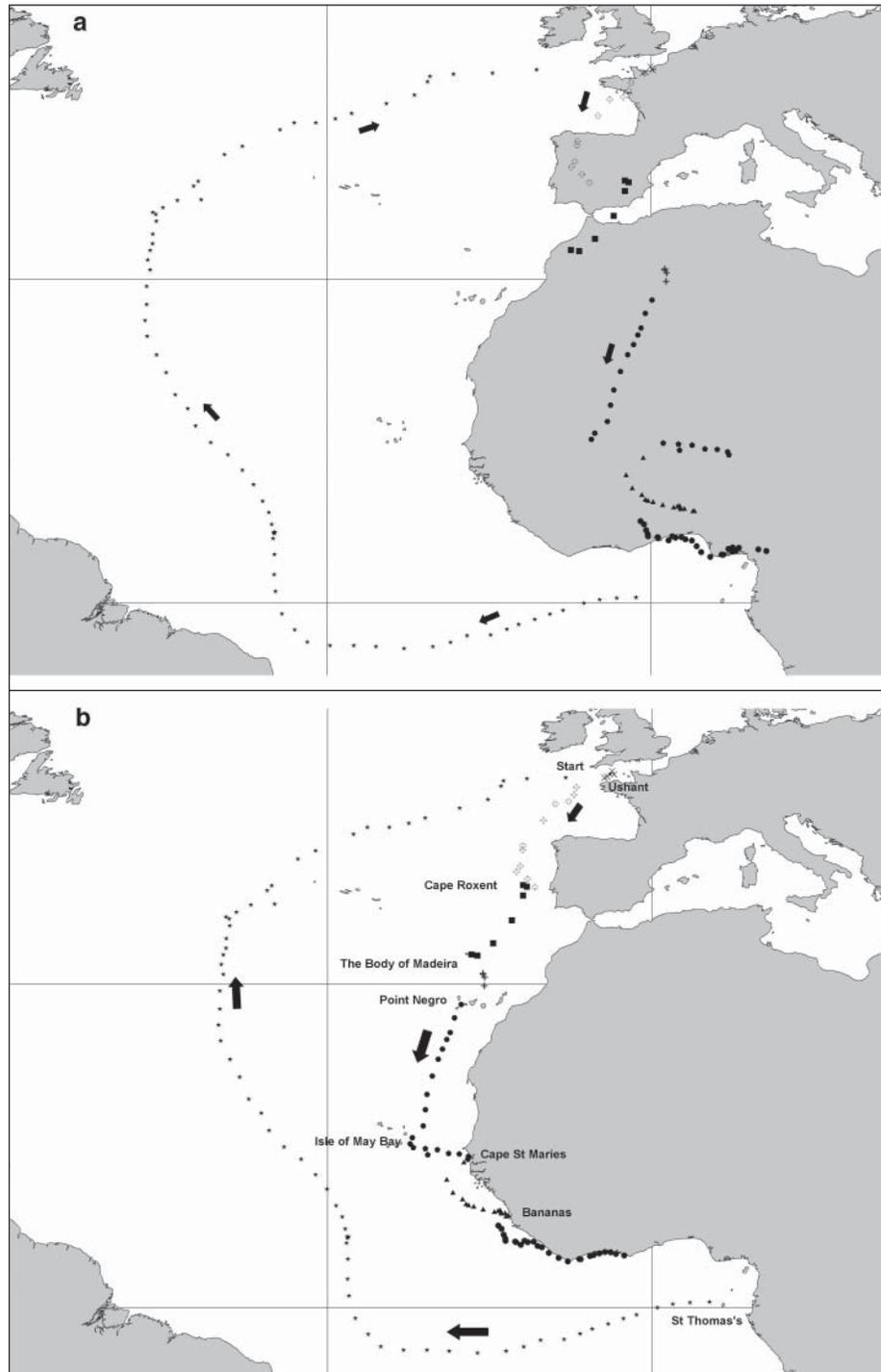


Fig. 2. (a) Triangles represent logbook positions of the British HMS Surprise (1750–1751) on a round trip from England to the Gulf of Guinea without correcting the longitude to the standard of Greenwich. During the return voyage, there were no intermediate sightings of land and, as a result, no change in the prime meridian. (b) Corrected positions of the HMS Surprise after converting the longitudes to the Greenwich meridian. Note how without corrections, the HMS Surprise appears to be going over land.

Such large-scale provision of data for the two principal meteorological elements of wind force and wind direction can serve many purposes. As the wind speed and direction over the oceans relate closely to atmospheric circulation patterns, and are less disrupted by boundary layer influences than are land-based observations, the data offer the potential to reconstruct past occurrences of major regional phenomena such as the El Niño–Southern Oscillation and the North Atlantic Oscillation. Jones and Salmon [2005] have made the first attempts at filtering these signals from the CLIWOC data, while Gallego *et al.* [2005] have explored the possibilities of using the data to reconstruct sea level pressure, resolving those reconstructions at the seasonal scale.

The CLIWOC data are unique in their provision of pre-1850 observations of large-scale atmospheric circulation patterns over the world's oceans. The coverage over the seas and oceans is extensive and comparable with that derived from modern networks. In addition, spatial interpolation of the atmospheric fields allows for reconstructions of the atmospheric circulation over continental land surfaces. A good example of the latter is eighteenth-century Africa, which is surrounded by oceans that are well represented by observations from ships, while the land surface remains largely devoid of data.

The CLIWOC project has demonstrated its scientific value for climatic studies of meteorological observations, most notably wind, recorded in ships' logbooks from before the middle of the nineteenth century. The database therefore represents a valuable back-

ward extension of world climatological oceanic databases such as the International Comprehensive Ocean Atmosphere Data Set [see Worley *et al.*, 2005] by a full century.

However, it by no means realizes the full potential of the pre-1854 ship logbook information, and further studies have suggested that over 130,000 logbooks with daily records of the prevailing weather and winds may have survived from this period. Exploration of the remaining logbooks, drawing upon the foundations provided by the CLIWOC project, would allow for an extension yet farther backward in time until at least 1690. A significant increase in data density in the 1750–1854 period could be made by calling upon the estimated six million days of data yet to be reclaimed. Much has been accomplished, but much more can yet be achieved with this remarkable source.

The CLIWOC database is freely available from the project Web site (<http://www.ucm.es/info/cliwoc>) or at <http://www.knmi.nl/cliwoc>, or on CD-ROM by request. The new release, 2.0, containing 5000 new data entries, will be issued in July 2006.

Acknowledgments

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NEWS

New Products From the Shuttle Radar Topography Mission

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New data products with broad applicability to the Earth sciences are now available from the Shuttle Radar Topography Mission (SRTM). SRTM, a joint project of the National Geospatial-Intelligence Agency (NGA) and NASA, flew aboard the Space Shuttle Endeavour on an 11-day mission in February 2000 with the goal of collecting a near-global data set of high-resolution elevation data [Farr and Kobrick, 2000]. Data from the mission have been available to researchers for several years, but newly available products offer enhanced usability and applicability.

Final products include elevation data resulting from a substantial editing effort by the NGA in which water bodies and coastlines were well defined and data artifacts known as spikes and wells (single pixel errors) were removed. This second version of the SRTM data set, also referred to as 'finished' data, represents a significant improvement over earlier

versions that had nonflat water bodies, poorly defined coastlines, and numerous noise artifacts. The edited data are available at a one-arc-second resolution (approximately 30 meters) for the United States and its territories, and at a three-arc-second resolution (approximately 90 meters) for non-U.S. areas.

The data can be freely downloaded in 1° by 1° tiles in a simple binary raster format (see <ftp://e0srp01u.ecs.nasa.gov/srtm/version2/>). The data may also be acquired by purchasing a DVD in several different formats for a nominal cost (see <http://eros.usgs.gov/products/elevation.html>), or by downloading user-defined areas from the U.S. Geological Survey's (USGS) seamless data distribution system (see <http://seamless.usgs.gov/>).

In addition to the edited elevation data, the vector format water body and coastline mask derived by NGA during the editing process is also available. The SRTM Water Body Data (SWBD) is a 30-meter resolution near-global map of oceans and inland water

bodies derived from radar data and Landsat data [Slater *et al.*, 2006]. The SWBD is available for download and on DVD at the same sources as the SRTM elevation data.

SRTM30, a near-global elevation model at a resolution of 30 arc-seconds (approximately one kilometer), is another SRTM data product that has been recently upgraded. SRTM30 has been enhanced by incorporating the edited version of SRTM elevation data in combination with the widely used USGS GTOPO30 global elevation model [Gesch *et al.*, 1999]. As with the other new SRTM data products, SRTM30 can be freely downloaded (see <ftp://e0srp01u.ecs.nasa.gov/srtm/version2/SRTM30/>).

In addition to the updated SRTM data products, new documentation and recent research results are also available, serving as helpful resources for the SRTM data user community. The Jet Propulsion Laboratory (Pasadena, Calif.) has released a detailed report [Rodriguez *et al.*, 2005] on the accuracy and quality of SRTM data (see http://www2.jpl.nasa.gov/srtm/SRTM_D31639.pdf).

Results from many recent investigations using SRTM data were presented at an SRTM data validation and applications workshop held in Reston, Va., in June 2005. Most of the 60 oral and poster presentations given at the workshop are available for viewing and/or