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ALTERNATIVE DRAFT
MINISTERIAL DECLARATION
FOR THE
SECOND WORLD CLIMATE CONFERENCE

PREAMBLE

WE, MINISTERS FROM ___ COUNTRIES, ASSEMBLED IN GENEVA, SWITZERLAND, FROM 6 TO 7 NOVEMBER 1990 AT THE SECOND WORLD CLIMATE CONFERENCE.

CONSCIOUS OF OUR RESPONSIBILITY TO PRESENT AND FUTURE GENERATIONS TO PRESERVE AND PROTECT OUR FRAGILE PLANET;

DEEPLY CONCERNED BY RECENT EVIDENCE THAT OUR ACTIONS MAY BE ALTERING THE ATMOSPHERE WHICH NURTURES LIFE AND SETS EARTH APART FROM ALL OTHER PLANETS;

RECOGNIZING THE NATIONAL AND INTERNATIONAL EFFORTS OF THE PAST DECADE BY THE WORLD CLIMATE PROGRAM, WMO, ICSU, AND UNEP TO IDENTIFY AND RESOLVE SCIENTIFIC AND SOCIOECONOMIC ISSUES RELATED TO CLIMATE CHANGE;

WELCOMING THE TIMELY COMPLETION OF THE FIRST ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE WHICH PROVIDES THE FIRST COMPREHENSIVE ASSESSMENT OF THE SCIENCE, IMPACTS AND POSSIBLE RESPONSES TO CLIMATE CHANGE;

UNCERTAIN STILL OF WHAT MAY FOLLOW, AND AT WHAT COST, BUT CONCERNED THAT DELAY COULD CONSTRAIN OUR ABILITY TO ACT;

WE EMBARK NOW WITH COMMON RESOLVE ON AN EFFORT WHICH WILL REQUIRE PERSEVERANCE, RESOLUTION AND STEADFAST PURPOSE, AN EFFORT WHICH WILL TEST EVERY VIRTUE OF OUR PEOPLES, BUT WITHOUT WHICH WE CAN HAVE NO HOPE OF SUCCESS.

RISKS AND UNCERTAINTIES

1. SCIENCE TELLS US THAT GREENHOUSE GASES ARE ACCUMULATING IN THE ATMOSPHERE BECAUSE OF HUMAN ACTIVITIES. MOST OF THESE GASES ARE PRODUCED NATURALLY AND ARE ESSENTIAL TO THE HABITABILITY OF OUR PLANET; STILL, THE HUMAN CONTRIBUTION, PARTICULARLY SINCE THE DAWN OF THE INDUSTRIAL AGE, HAS DISTURBED THEIR BALANCE IN THE ATMOSPHERE.

2. SCIENCE ALSO WARNS US THAT UNRELENTING ACCUMULATION OF GREENHOUSE GASES PRODUCED BY HUMAN ACTIVITIES WILL LEAD INEVITABLY TO A GLOBAL WARMING, PERHAPS AT RATES FASTER THAN ANY MANKIND HAS EXPERIENCED. SCIENCE PREDICTS THAT THE WARMING WILL NOT BE EVEN, THAT IT IS LIKELY TO VARY BY LATITUDE AND SEASON, AND THAT THE LONG ATMOSPHERIC LIFETIMES OF SOME GREENHOUSE GASES MAY MAKE CONTROL DIFFICULT.

3. THE STATE OF OUR KNOWLEDGE IS IMPERFECT -- MANY IMPORTANT UNCERTAINTIES REMAIN. STILL WE ARE AWARE THAT SIGNIFICANT CLIMATE CHANGES MAY HAVE HARMFUL CONSEQUENCES FOR OUR PLANET AND OUR PEOPLES. SEAS MAY RISE, STORMS MAY INCREASE AND INTENSIFY AND MANY SPECIES OF LIFE MAY NOT BE ABLE TO ADAPT.

4. FACING THESE RISKS, BUT ACKNOWLEDGING GREAT UNCERTAINTIES, WE MUST DETERMINE HOW EXTENSIVELY WE MUST ACT, WHAT THE COSTS OF ACTION AND INACTION MAY BE, AND WHAT MEASURE OF SUCCESS WILL LIKELY GRACE OUR EFFORTS.

5. AT THIS SECOND WORLD CLIMATE CONFERENCE WE REAFFIRM OUR SUPPORT FOR THE WORLD CLIMATE PROGRAMME AND FOR OTHER COOPERATIVE SCIENTIFIC INITIATIVES TO RESOLVE THE QUESTIONS BEFORE US.

PAST AND PROLOGUE

6. THIS ENDEAVOR IS NOT WITHOUT PRECEDENT. OUR NATIONS HAVE ALREADY DEVELOPED A COMMON STRATEGY TO ADDRESS A RELATED GLOBAL CRISIS -- STRATOSPHERIC OZONE DEPLETION. FROM A MODEST BEGINNING IN 1985, WE HAVE QUICKLY NARROWED SCIENTIFIC UNCERTAINTIES AND SUMMONED THE RESOLVE TO TAKE MORE STRINGENT BUT NECESSARY ACTION. THAT ACTION IS ALSO THE MOST SIGNIFICANT FIRST STEP TO REDUCE THE ACCUMULATION IN THE ATMOSPHERE OF GREENHOUSE GASES FROM HUMAN ACTIVITIES.

7. WE HAVE UNDERTAKEN AN UNPRECEDENTED INTERNATIONAL EFFORT TO ANALYZE THE SCIENCE, IMPACTS, AND RESPONSE OPTIONS FOR FURTHER DEALING WITH CLIMATE CHANGE. THIS EFFORT, INITIATED UNDER THE JOINT AUSPICES OF THE WORLD METEOROLOGICAL ORGANIZATION AND THE UNITED NATIONS ENVIRONMENT PROGRAMME, HAS PRODUCED THE FIRST ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. THE REPORT HAS HEIGHTENED OUR AWARENESS AND ENLISTED AN INCREASING NUMBER OF NATIONS IN THE SEARCH FOR SOLUTIONS.

8. WE HAVE THUS SET THE STAGE FOR NEGOTIATIONS ON A FRAMEWORK CONVENTION ON CLIMATE CHANGE. WE NOTE WITH SATISFACTION THAT THESE NEGOTIATIONS WILL BEGIN IN FEBRUARY 1991 AND THAT ALL PARTIES HAVE RESOLVED TO COMPLETE THE CONVENTION, TOGETHER WITH ANY RELATED LEGAL INSTRUMENTS AS MAY THEN BE AGREED, BY THE TIME OF THE UNITED NATIONS CONFERENCE ON ENVIRONMENT AND DEVELOPMENT IN JUNE 1992.

9. WE FURTHER NOTE THAT THE UNITED NATIONS GENERAL ASSEMBLY WILL SHORTLY CONSIDER WAYS, MEANS AND MODALITIES FOR FURTHER PURSUING THESE NEGOTIATIONS ON THE BASIS OF RECOMMENDATIONS PRODUCED A MONTH AGO BY GOVERNMENT REPRESENTATIVES.

CALL FOR A GLOBAL STRATEGY

10. WHILE UNCERTAINTY COMPLICATES OUR TASK, IT WILL NEITHER DELAY NOR DETER US. WE MUST DEVELOP A GLOBAL STRATEGY TO PROTECT OUR ATMOSPHERE. THE STRATEGY MUST BE:

-- UNIVERSAL, INVOLVING ALL NATIONS OF THE WORLD, FOR ONLY TOGETHER CAN WE HOPE TO PREVAIL.

-- COMPREHENSIVE, ADDRESSING ALL SOURCES AND SINKS OF THE GASES WE PRODUCE, WHICH MUST BE CONSIDERED TOGETHER IF OUR EFFORTS ARE TO SUCCEED.

-- EQUITABLE, TAKING INTO ACCOUNT OUR DIFFERING OPPORTUNITIES TO ACT AND OUR DIFFERING CONTRIBUTIONS TO PRESENT AND PREDICTED FUTURE ACCUMULATIONS OF GREENHOUSE GASES.

-- PRAGMATIC, RECOGNIZING THE COMMON DESIRE TO GROW AND PROVIDE FOR OUR PEOPLES, WITHOUT WHICH PROSPECT HOPE FOR HUMAN PROSPERITY AND DIGNITY WILL WHITHER; AND

-- FARSIGHTED, RECOGNIZING THAT INNOVATION WILL OPEN POSSIBILITIES AS YET UNKNOWN, IF WE BUT DIRECT OUR COLLECTIVE INGENUITY TO SHAPE THAT FUTURE.

THE EFFORT REQUIRED

11. THE CHALLENGE BEFORE US IS GREAT. WE ARE AWARE THAT THE COLLECTIVE EFFORT REQUIRED WILL BE AMONG THE MOST COMPLEX AND DIFFICULT EVER UNDERTAKEN. OUR SUCCESS OR FAILURE WILL INFLUENCE LIFE ON OUR PLANET. WE MUST FIND WAYS TO ACCOMMODATE A WIDE RANGE OF LEGITIMATE CONCERNS WHILE ENSURING THAT WE DEVELOP A SPECIFIC PROGRAM OF ACTION.

12. FOREMOST AMONG THESE CONCERNS IS THAT SHARED BY ALL COUNTRIES -- THAT THE ACTIONS WE AGREE TO TAKE NOT UNDULY CURTAIL ECONOMIC GROWTH. THIS CONCERN IS PARTICULARLY ACUTE AMONG DEVELOPING COUNTRIES WHO HAVE NOT YET ATTAINED THE LEVEL OF PROSPERITY THAT PREVAILS AMONG COUNTRIES OF THE INDUSTRIALIZED WORLD. STILL, THE NEED FOR GROWTH IS NOT UNIQUE TO THEM, FOR DISPARITIES EXIST AS WELL WITHIN THE INDUSTRIALIZED WORLD.

13. WE MUST ALSO FIND WAYS TO ACCOMMODATE:

--THE CONCERNS OF COUNTRIES NOW DETERMINED TO LIMIT AND REDUCE GROWING EMISSIONS OF GREENHOUSE GASES AS WELL AS THE CONCERNS OF COUNTRIES WHOSE GROWTH DEPENDS ON FOSSIL FUEL;

--THE CONCERNS OF COUNTRIES, WHOSE FORESTS ARE INTEGRALLY TIED TO THEIR ECONOMIC DEVELOPMENT YET WHOSE FORESTS PROVIDE A CRITICAL ELEMENT OF THE WORLD'S DEFENSE AGAINST GLOBAL WARMING;

--THE CONCERNS OF COUNTRIES WHICH BEAR A PROPORTIONATELY LARGE DEGREE OF RISK FROM THE IMPACTS OF CLIMATE CHANGE, PARTICULARLY COUNTRIES IN ARID AND SEMI-ARID REGIONS AND SMALL, LOW-LYING COASTAL AND ISLAND COUNTRIES; AND

--THE CONCERNS OF ALL WHO UNDERSTAND THAT THE BURGEONING GROWTH IN OUR PLANET'S POPULATION MUST BE TAKEN INTO ACCOUNT IN OUR EFFORTS TO DEAL WITH GLOBAL CLIMATE CHANGE.

14. WE ACKNOWLEDGE THAT WE MUST ALSO DEAL ANEW WITH ISSUES WE HAVE ENCOUNTERED IN OTHER FORA, ISSUES WHOSE RESOLUTION OFTEN STILL ELUDES US. IN PARTICULAR, NEGOTIATORS MUST DEVELOP:

--WAYS TO ASSURE THAT ADEQUATE FINANCIAL RESOURCES ARE MADE AVAILABLE TO COUNTRIES THAT WOULD OTHERWISE BE UNABLE TO JOIN FULLY IN THIS COMMON EFFORT;

--WAYS TO ASSURE THAT KNOW-HOW AND TECHNOLOGICAL INNOVATION CONTINUE TO ADVANCE AND ARE MADE WIDELY AVAILABLE TO SOLVE THIS COMMON PROBLEM;

--WAYS TO ASSURE THAT KNOWLEDGE AND INFORMATION ARE FULLY AND OPENLY SHARED; AND

--WAYS TO ASSURE THAT THE EDUCATIONAL AND SCIENTIFIC INFRASTRUCTURE IN ALL COUNTRIES, PARTICULARLY IN THE DEVELOPING COUNTRIES, IS EXTENDED AND ENHANCED TO ENABLE EACH OF US FULLY TO APPRECIATE THE SCIENTIFIC BASIS FOR CLIMATE CHANGE, THE POTENTIAL IMPACTS OF SUCH CHANGE AND EVALUATIONS OF PRACTICAL RESPONSE STRATEGIES.

OUR COMMON FUTURE

15. GENERATIONS PAST ONCE RELIED ON FAITH IN MOVING TOWARD THE FUTURE. LATER GENERATIONS PLACED THEIR FAITH IN REASON. AS WE MOVE NOW TOWARD THE SECOND MILLENNIUM WE MUST SEEK TO MARRY FAITH AND REASON. WE MUST URGENTLY RESOLVE THE UNCERTAINTIES THAT CONFRONT US. WE MUST ALSO ACCEPT THAT FULL KNOWLEDGE MAY ELUDE US FOR SOME TIME. WE MUST BEGIN NOW TO TAKE SUSTAINED, PRAGMATIC ACTION TO SECURE OUR COMMON FUTURE. WE DEDICATE OURSELVES HENCEFORTH TO DEVELOP A PHASED, FLEXIBLE RESPONSE THAT WILL ENABLE US TO TAKE ACTION NOW EVEN AS WE SEEK TO RESOLVE REMAINING UNCERTAINTIES AND DEVELOP A COMPREHENSIVE ACTION PLAN FOR THE FUTURE.

3 pm 19/X/90

Opening Statement of Dr. John Knauss
Second World Climate Conference
November 6-7, 1990

A great American statesman, philosopher, and sometime scientist, Benjamin Franklin once observed that science is an essential element of public service and public policy making. The Second World Climate Conference and this Ministerial are testament to the fact that science and environmental policy are but two sides of the same coin.

The science which has resulted from the World Climate Program, initiated from the First World Climate Conference in 1979, is now an essential element in public policy making. Based on concerns then which included the effects of greenhouse gases; depletion of stratospheric ozone; widespread, persistent

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drought and the possibility of global cooling, the First World Climate Conference began a process to study the key issues that are now the center of our current policy discussions. The World Climate Program has served as a focus for international scientific cooperation and provided much of the information available today. Many contributed to this effort. Naturally, I am proud of the U.S. role and the role of U.S. scientists made to this successful Program.

We must now reaffirm our commitment to the World Climate Program and to associated programs dealing with research on climate and climate change. The U.S. pledges to continue its support of international climate and climate change research. We also pledge our continued support for the infrastructure that supports these programs, such as the World Weather Watch, the International Global Ocean Observing System, the Global Atmosphere Watch and the Climate Studies Fund.

I have studied the Conference Statement from the scientific proceedings carefully. This Statement identifies the key issues that must be address if the science in this area is to contribute to the public policy debate.

Several themes from this past week's conference have

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emerged. We must ensure that all of our often disparate activities are fully coordinated. We must engender broad participation in these global efforts, particularly from developing countries.

Data and information are the foundation of understanding. It is essential that there is full, open and efficient access to and exchange of information and data. Without this full and open exchange, our efforts are for naught. Closely linked to this is our ability of our institutions to use the information and data to translate scientific understanding into policy decisions.

If these themes are put into practice, they will make a good scientific program better. In many respects, the work of the World Climate Program is the foundation of the Report of the Intergovernmental Panel on Climate Change (IPCC). The IPCC Report provides the first complete assessment of the science, impacts and possible responses to climate change. It summarizes our present state of knowledge. It brings to light the gaps and uncertainties and it suggests actions to address them. The World Climate Program can, and I believe, will respond to the challenge this presents.

Yes, there are gaps, there are unanswered questions, and

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the models are based on assumptions which are not certainties. But that doesn't mean we should not act. More knowledge, more information, better models will always be required. The United States is not waiting; we are already taking action.

We are taking actions now that, although they may affect the climate, have other benefits. We estimate that current U.S. environmental initiatives, when implemented, will reduce net emissions of greenhouse gases.

These initiatives include:

- phasing out the production of CFCs, halons, and other ozone depleting substance by the year 2000 ((under the Montreal Protocol))
- reducing transportation emissions of reactive gases ((Clean Air Act amendments, just signed into law by President Bush))((to be resubmitted to the U.S. Congress when it reconvenes in 1991))
- improving energy efficiency ((DoE initiative, proposed regulations, Clean Air Act Amendments))
- controlling emissions of methane from landfills ((EPA initiative, no proposed regulations))
- increasing the forested areas in the U.S. through an

-5-

aggressive tree planting program ((Presidential initiative, America the Beautiful))

This is a comprehensive approach to a technically, economically and politically complex issue.

There is a desire among the global community to leave for our grandchildren an atmosphere not significantly different than the one we now enjoy. From a scientific perspective and based on our current scientific understanding, this means our objective should be to focus on the concentrations of greenhouse gases in the atmosphere. To do this, we must consider all sources and sinks and understand, as best we can, the dynamic processes involved. How we set specific objectives can only be decided in the context of international negotiations, with the widest possible participation. The U.S. is eager for such negotiations to get underway in the appropriate forum.

Science and environmental policy are but two sides of the same coin. This Conference is the bridge between science and policy decisions. Our role here is not to determine a framework convention on climate change. That is a task assigned to our negotiators beginning in February 1991 in

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Washington, D.C. We should not attempt to predetermining the results of those negotiations any more than scientists should predetermine the results of scientific research. Let us use our time to reflect on how best to meld science with policy. Let us use our time here to build a strong, yet flexible bridge to make science an essential component of public policy making.

Japan Presents Plan on Global Warming Issue

By 2000, 'Greenhouse Gases' To Be Held to Current Levels

By T. R. Reid
Washington Post Foreign Service

TOKYO, Oct. 23—Japan's government established a multifaceted program to combat global warming today, setting targets to stabilize emissions of so-called "greenhouse gases" at current levels by 2000.

The Japanese program, announced just in time for the second World Climate Conference, which convenes next week in Geneva, leaves the United States as one of the few developed countries that has not set targets to control the gases that may cause global warming.

"They pushed this out in time for the conference, which means we'll be all by ourselves in Geneva," said a U.S. Embassy official. "But our position is that the scientific community has still not made up its mind about global warming, and we are not setting targets in an unsettled situation."

The Japanese plan expresses no doubt about the concept of global warming—the theory that the burning of fossil fuels has changed the earth's atmosphere and is gradually raising average temperatures.

"Global warming is a grave concern which is likely to pose a serious threat to the very foundation of human life," the report says, citing the risk of environmental changes and possible social consequences. It stresses the prediction—rather fearsome to an island nation with many big cities on the coast—that global warming could melt polar ice packs and raise the level of the oceans, submerging low-lying areas.

Japanese emissions of carbon dioxide, the most important of the greenhouse gases, already are low compared to other industrialized countries. According to the Organization for Economic Cooperation and Development, Japan's emissions in 1988 came to about 2.5 tons per person, lower than most other wealthy countries. The U.S. rate was more than twice as high, at 6.14 tons.

Under the program announced today, carbon dioxide emissions will be capped in 2000 at 1990 levels, increased only to match population growth. Officials here estimated that Japan's economic growth would increase carbon dioxide emissions by 5 to 10 percent over the next decade, if no corrective steps were taken. There would be no assurance that the current level will be maintained through the 1990s, however.

The Japanese program calls for various steps to reduce the use of fossil fuels, which release carbon dioxide when burned. In particular, the plan calls for cutting

See JAPAN, A14, Col. 1

Japan Presents Plan to Rein In Global Warming

JAPAN, From A12

oil's share of total energy consumption from the 1989 figure of 58 percent to 51 percent by 2000 and 45.3 percent by 2010.

To achieve those reductions, the government said Japan should increase construction of nuclear-powered generating plants, which do not emit significant greenhouse gases. The plan also calls for increased use of hydrogen fuels, although it is not clear that the technology exists to do so within the next decade.

Also mandated is more use of mass transportation, which may be an ambitious goal in a country where trains and subways are already the main form of daily trans-

port for a large majority of the population.

The government is to use "administrative guidance"—a sort of official nudging that is often highly effective—to make auto manufacturers produce lighter cars that use less gasoline. In 1988, according to Japan's Environmental Agency, cars here averaged 27.2 miles per gallon, about 30 percent higher than the American average. The plan says this figure should increase by 10 percent before 2000 and 15 percent by 2010.

The program also calls for Japan to switch to daylight saving time, known here as *samma tymuh* or "summer time." That would save energy now used for air condition-

ing in the morning and lighting of-
fices in the evening.

Japan's global-warming targets represent a compromise between proposals by the Environmental Agency and the concerns of the Ministry of International Trade and Industry, which protects business interests. The two agencies squabbled for months over the plan, according to reports here, and finally settled their differences so that Japan could present formal targets at the Geneva conference.

"Europe has already settled on targets, and now Japan has decided," said Taku Omura, a planning official in the Environmental Agency. "The U.S. has been behind the others in this area."

Yale

US COMMENTS ON SWCC DRAFT DECLARATION

General Comments

- References should be to a framework convention on climate change, rather than the Climate Change Convention;
- There should be no mention of concurrent negotiation of the framework convention and any implementing protocol(s);
- References to limitation measures should include mention of all GHGs and their sources and sinks, not just CO2;
- References to funding should not call for additional resources.
- There should be no specific commitments to quantitative reductions in greenhouse gas emissions.
- Text similar to that of the IPCC Policymakers Summaries and other previously adopted documents should be as consistent as possible with the texts of those sources.
- References should be to "industrialized" and "developing" countries, rather than "developed" and "less developed"
- The subtitles in parentheses should be eliminated.
- All paragraphs relating to the IPCC should be gathered together in one section.
- All paragraphs relating to the framework convention on climate change should be gathered together in one section.
- The small number of paragraphs dealing with science is disproportionate to the large number dealing with policy issues.

Key:

- "Original Version" is the 13 July 1990 Draft prepared by the SWCC organizers.
- "Comments" are the August 24 US Comments provided via STATE 291963, with the amendments agreed to in Sundsvall.
- "New Version" is the version distributed to other governments during the 4th IPCC Plenary.

DRAFT

PRIORITY CONCERNS ON SWCC

<u>Concern</u>	<u>Para</u>
✓ We need to correctly convey scientific context and uncertainties.	4 8
✓ We should take no-regrets actions.	9 17 20 22
✓ All countries must share obligations.	20 24
✓ We should take a comprehensive approach.	20 21 40
✓ We will negotiate a framework convention only.	23 40
✓ No new funding will be available	25 26 27

1

(4)

Original:

PREAMBLE

1. We, the Ministers from countries representing the world community met in Geneva, Switzerland, from 6 to 7 November 1990 at the Second World Climate Conference.

Comments:

Specific Changes

Delete title "Preamble"

Para 1, line 1: delete "the" before "Ministers".

Para 1, line 1: delete "representing the world community"

New Version:

1. We, Ministers from [] states, met in Geneva, Switzerland, from 6 to 7 November following the Second World Climate Conference.
- 1 ?

Original:

2. Our Meeting following the IPCC Report is a demonstration of our intention to take active and constructive step in the global response to the global climate change issue. It is also the expression of our will to fully contribute to the preparation for the 1992 UN Conference on Environment and Development.

scientific understanding

Comments:

Para 2, line 2: replace "IPCC" with "adoption by the Intergovernmental Panel on Climate Change of its First Assessment"

Para 2, line 2-3: replace "step in the global response to the global climate issue" with "steps in response to concerns regarding human-induced global climate change"

Para 2, line 4: delete last sentence

New Version:

2. Our Meeting, following the adoption by the Intergovernmental Panel on Climate Change of its First Assessment Report, is a demonstration of our intention to take active and constructive steps in response to concerns regarding human-induced global climate change.

Original:

3. Ever since the dawn of history, man's life on earth has been largely dependent on the environmental processes which we call weather and climate. The world climate system consists of a delicately balanced combination of many interactive components which include the atmosphere and the biosphere, as well as the land, sea and ice surfaces.

Comments:

Para 3, line 1: delete "largely"

Para 3, line 3: delete "delicately balanced"

Para 3, line 4-5: add a comma after "atmosphere" and change the rest of the sentence to read: "the oceans, the biosphere, as well as land and ice surfaces."

New Version:

3. Since before the dawn of history, life on Earth has depended on the natural processes we call weather and climate. The world climate system has many interactive components which include the atmosphere, the oceans, the biosphere, as well as land and ice surfaces.

4

⑦
①

Original:

4. Climate has varied in the past. But the temperature increase which is predicted to occur in the decades to come due to the increasing accumulation of the greenhouse gases in the atmosphere has not been encountered in the last 100,000 years at least; nor has the past rapidity of change been as fast as that predicted. The greenhouse gases result from a host of human activities such as the burning of fossil fuel, deforestation, mining operations and waste management.

USE IPCC OVERVIEW LANGUAGE

Comments:

Para 4, replace with:

Climate has varied significantly in the past; however, the potential change in global mean temperatures over the next century associated with human activities is predicted to be larger and more rapid than those seen in the last 10,000 years. The magnitude, timing, rate, and regional distributions of these predicted climate changes are uncertain because of limitations in our present scientific understanding of climate processes and in our ability to model the behavior of climate systems and components. The human caused emissions of greenhouse gases are much smaller than the exchange between the atmosphere and natural systems. Stabilization of atmospheric concentrations of long-lived gases at today's levels, for example, would require a 60-80% reduction in anthropogenic emissions compared to a 2-3% increase in absorption by natural systems.

New Version:

4. Climate has varied significantly in the past; however, the potential change in global mean temperatures over the next century associated with human activities is predicted to be larger and more rapid than those seen in the last 10,000 years. The magnitude, timing, rate and regional distribution of these predicted climate changes are uncertain because of limitations in our present scientific understanding of climate processes and in our ability to model the behavior of climate system and components. The human-caused emissions of greenhouse gases, while significant, are much smaller than the exchange between the atmosphere and natural systems. Stabilization of atmospheric concentrations of long-lived gases at today's levels, for example, would require either a 60 to 80 percent decrease in anthropogenic emission or a 2 to 3 percent increase in absorption by natural systems.

Original:

5. Recognising that climate change is a common concern of mankind United Nations General Assembly's Resolution 43/53 urged the intergovernmental and non-governmental organisations and scientific institutions, to treat climate change as a priority issue, and to co-operate in research and action-oriented programmes so as to increase the understanding of the causes and effects of climate change.

Comments:

Para 5: add to the end of the paragraph:

Industrialized countries and developing countries have a common responsibility in dealing with problems arising from climate change.

(AND VARIED)?

New Version:

5. Recognizing that climate change is a common concern of mankind, the United Nations General Assembly urged intergovernmental and non-governmental organizations and scientific institutions to treat climate change as a priority issue and to cooperate in research and action-oriented programmes so as to increase the understanding of the causes and effects of climate change. Industrialized countries and developing countries have a common responsibility in dealing with problems arising from climate change.

Original:

6. The World Climate Programme undertaken jointly by the World Meteorological Organisation, the International Council of Scientific Unions with the co-operation of its Scientific Committee on Oceanic Research, and UNESCO and its International Oceanographic Commission and UNEP have endeavoured during the last decade to promote a quantitative understanding of climate, and predictions of global and regional climate changes on all time scales and on their potential impacts. Through its three major projects the study of Tropical Ocean and Global Atmosphere, the Global Energy and Water Cycle Experiment, and the World Ocean Circulation Experiment, the World Climate Research Programme has succeeded in providing valuable information on the causes, processes and some of the effects of climate change.

Comments:

Para 6, lines 1-5: list all sponsors on an equal basis: WMO, UNEP, ICSU including SCOR, UNESCO and its Intergovernmental Oceanographic Commission

Para 6, line 5: replace "a quantitative understanding.... impacts." with

an improved quantitative understanding of climate, advances in predictions of global and regional changes on all time scales and estimates of the potential impacts of these changes.

Para 6, line 7-10: delete "Through its three.... Circulation Experiment,"

Para 6, lines 11-12: replace both lines with:

...improved our understanding of climate change processes, thus providing valuable information on the causes and possible manifestations of such change. However many uncertainties remain and must continue to be addressed by these and national scientific programs.

New Version:

6. The World Climate Programme, undertaken jointly by the World Meteorological Organization (WMO), the United Nations Environment Program (UNEP), the International Council of Scientific Unions (ICSU), with the cooperation of the Scientific Committee on Oceanic Research (SCOR), and the United Nations Educational, Scientific and Cultural Organization (UNESCO) and its Intergovernmental Oceanographic (IOC), has endeavored during the last decade to promote improved quantitative understanding of climate, advances in predictions of global and regional climate changes on all time scales, and estimates of the potential impact of these changes. The World Climate Research Programme has improved our understanding of climate processes, providing valuable information on the causes and possible manifestations of climate change. However, many uncertainties remain and must continue to be addressed by international and national scientific programs.

Original:

7. The Intergovernmental Panel on Climate Change (IPCC) established by U.N.E.P. and W.M.O. has undertaken to study the problem of climate change including global warming. Through the work of its various working groups and their sub-groups the I.P.C.C. has produced a comprehensive report on the causes and effects of climate change. It has also proposed strategies to delay, limit or mitigate the impact of climate change, and at the request of United Nations General Assembly has proposed the elements for inclusion in a convention on climate.

identified

also identified possible

Comments:

Para 7: place in a new section entitled "The Intergovernmental Panel on Climate Change" after rewriting as follows:

The Intergovernmental Panel on Climate Change (IPCC) was established by WMO and UNEP to assess the current level of scientific knowledge on climate change including its possible impacts and options for limiting or adapting to adverse impacts. Based on the work of its various working groups and their subgroups the IPCC has produced its First Assessment of global climate change. It has also identified options to limit and to adapt to climate change, and has identified elements to be considered for inclusion in a framework convention on climate change and in possible subsequent protocols.

New Version:

The Intergovernmental Panel on Climate Change

11. The Intergovernmental Panel on Climate Change (IPCC) was established by WMO and UNEP to assess the current level of scientific knowledge on climate change including its possible impacts and options for limiting or adapting to adverse impacts. Based on the work of its various working group and their subgroups, the IPCC has produced its First Assessment Report on global climate change. Its Report identifies options to limit and adapt to climate change and elements to be considered for including in a framework convention on climate change and in possible subsequent protocols.

Original:

8. Global warming poses environmental threat of a magnitude the world has never known before. Human activities which have led to the emission of greenhouse gases into the atmosphere have so far committed the Global Commons to an irreversible warming so far. In order to stem unprecedented global warming likely to lead to serious environmental consequences such as a rise in sea level of about 20 cm by the year 2100 and 65 cm by the end of the next century urgent action should be taken now. Carbon dioxide has been responsible for over half the enhanced greenhouse effect in the past and is likely to remain so in the future. It is therefore important that emissions of greenhouse gases especially CO₂ and other long lived greenhouse gases be reduced as soon as possible. This is urgent because changes in emission rates of these gases lead to a slow rate of change in their concentration in the atmosphere. If action is delayed, it will take much longer and much greater reductions at greater economic sacrifice to stabilize concentrations at today's levels. The long lived gases (CO₂ and N₂O) would require at least 60% reductions in emissions, and methane 15-20% reduction in emissions in order to stabilise their concentrations in the atmosphere at today's levels. The other gases of concern, namely the CFC are addressed under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Comments:

Para 8: delete the title "Definition of Problem and Risks"

Para 8: Replace with the following paragraph from RSWG Policymakers Summary, page 12:

The consideration of climate change response strategies present formidable difficulties for policymakers because of: (a) remaining scientific uncertainties regarding climate change; (b) uncertainty with respect to how effective specific response options or groups of options would be in actually limiting or averting potential climate change; and (c) uncertainty with respect to the costs, effects on economic growth, and other economic and social implications of specific response options or groups of options.

New Version:

7. The consideration of global climate change response strategies presents formidable difficulties for policymakers because of: (a) remaining scientific uncertainties regarding climate change; (b) uncertainty in the effectiveness of response options in actually limiting or adapting to potential climate change; and (c) uncertainty in estimates of costs, effects on economic growth, and other economic and social implications of specific response options or groups of options.

4.

①

Original: GLOBAL STRATEGY

9. We consider therefore that a global response must be decided and implemented without further delay based on the best available knowledge such as those resulting from the IPCC assessment. Recognizing that the principle of equity should be the basis of any global response to the climate change phenomena industrialized countries, which are responsible for most of the observed increase in the greenhouse gases' concentration in the atmosphere must take the lead, commit themselves to immediate action and provide resources and assistance to developing countries to help them in addressing climate change in a way compatible with their development needs. [To this end the industrialized countries will support developing countries with additional and specific contributions.] [To this end there is a need to negotiate the necessary support needed by developing countries] [To this end there is a need to provide the necessary support, including additional and specific financial assistance to the developing countries]

Comments:

Para 9: delete the title "Global Strategy"

Para 9: replace with the following:

The potentially serious consequences of human-induced climate change, however, give sufficient reasons to begin adopting response strategies that are fully justified for other reasons even in the face of significant uncertainties. These strategies could include improved energy efficiency; use of cleaner, more efficient and lower greenhouse gas-emitting energy sources; improved forest management; development of comprehensive coastal management plans; use of practices to recycle and reuse CFC gases and their substitutes; and improved agricultural practices.

CHECK IPCC
OVERVIEW
+ PMS

New Version:

8. The potentially serious consequences of human-induced climate change, however, give sufficient reasons to begin adopting response strategies that are fully justified for other reasons, even in the face of significant uncertainties. These strategies could include: improved energy efficiency, use of lower greenhouse gas-emission sources; improved forest management; development of comprehensive coastal management plans; use of practices to recycle and reuse cfc gases and their substitutes; and improved agricultural practices.

Original:ACKNOWLEDGMENT OF THE CONCLUSIONS OF LONDON CONFERENCE ON THE MONTREAL PROTOCOL

10. [Short text to be included after the conclusions of the London Meeting]

Comments:

significant

Para 10, replace text in parenthesis with:

We acknowledge the agreement of the Parties to the Montreal Protocol in June in London to phase out substances that deplete the ozone layer. This action, when implemented, will have a beneficial influence on global climate change by reducing human emissions of greenhouse gases, ~~by~~ We urge all states to participate in the Protocol and implement the London agreements.

ratify

amendments

join

New Version:

The Montreal Protocol

10. We acknowledge the agreement of the Parties to the Montreal Protocol in June in London to phase out substances that deplete the ozone layer. This action, when implemented, will have a beneficial influence on global climate change by reducing human emissions of greenhouse gases by [percent]. We urge all states to participate in the Protocol and implement the London agreements.

WASCH FINAN. MECH. "PRECEDENT"

Original:

HEDGE

ENDORSEMENT OF THE CONCLUSION OF THE SCIENTIFIC PART OF SWCC

11. ^{acknowledge} We are highly appreciative of the work done by IPCC.

^{take note of} We ~~accept~~ and are highly appreciative of the conclusions and recommendations of the scientific part of the Second World Climate Conference as presented in the annex 1 of this Declaration. Their implementation should be strongly supported by governments.

Comments:

Para 11, lines 1-4: replace with:

We acknowledge the conference statement of the scientific and technical part of the Second World Climate Conference. We urge all nations and relevant international organizations to respond to the conference statement and incorporate relevant actions into their scientific and technical programs.

Para 11, lines 2-3: rewrite first part of sentence to read:

We are also appreciative of the conference statement of the scientific part of the Second World Climate Conference

New Version:

The SWCC Conference Statement

14. We acknowledge the conference statement of the scientific and technical part of the second world climate conference. We urge all nations and relevant international organizations to respond to the conference statement and incorporate relevant actions into their scientific and technical programs.

SFR
SECTION

Original:THEREFORE:I. ROLE OF SCIENCE IN IMPROVING OUR UNDERSTANDING, CAPACITY OF PREDICTION AND OUR RESPONSE TO CLIMATE CHANGE

12. We reaffirm that, in order to reduce uncertainties, to increase our ability to predict (including early identification of as yet unknown climate-related problems) and to design scientifically sound response strategies, there is a need to strengthen both national and international activities in research, monitoring, and data and information exchange related to climate change.

Comments:

Para 12: delete the title "Therefore"

Para 12: title should read "Role of Science"

Para 12, lines 2-3: replace "(including early identification of as yet unknown climate related problems) and to design scientifically sound response strategies" with

climate and climate change on a global and regional basis and to design response strategies that are scientifically and economically sound

Para 12, line 5: scientific research, monitoring, analysis.

Para 12, line 6: add additional paragraph:

To this end, we pledge our full support to the needs of the World Climate Program including contributions to the WMO Special Fund for Climate and Atmospheric Environment Studies.

New Version:

Role of Science

15. We reaffirm that in order to reduce scientific uncertainties, to increase our ability to predict climate and climate change on a global and regional basis, and to design response strategies that are scientifically and economically sound, there is need to strengthen both national and international activities in scientific research, monitoring, analysis, and data and information exchange related to climate change.

To this end, we pledge our full support to the needs of the world climate program including contributions to the wmo special fund for climate and atmospheric environmental studies.

OTHER

Original:

13. Recognizing that climate changes are of a complex interdisciplinary character, we urge the full participation of scientists dealing with atmosphere, the oceans and land, as well as with the physical, chemical and biological processes needed for a deeper understanding of climate issues. Given the intrinsically global nature of climate and climate research, we stress the need to strengthen international cooperation. The magnitude of the problem being addressed is such that no nation can undertake it alone. It is imperative therefore, that, to the extent feasible, national research programmes on climate be planned in such way that they form integral parts of international research programme. We urge that special resources to sustain such programmes are made available to less developed countries in order to insure their full participation in the international research effort and the response strategies based upon the results.

Comments:

Para 13, line 1: climate change | and its impacts |

Para 13, line 10: replace "from integral parts of" with "are consistent with and support"

Para 13, line 12: replace "less developed" with "developing"

Para 13, lines 13-14: delete "and the response strategies based upon the results"

EDITOR.

New Version:

16. Recognizing that climate change and its impacts are of a complex interdisciplinary character, we urge the full participation of all scientists who are expert in dealing with the atmosphere, the oceans, and land as well as with the physical, chemical and biological processes needed for deeper understanding of climate issues. Given the intrinsically global nature of climate and climate research, we stress the need to strengthen international cooperation. The magnitude of the problem being addressed is such that no nation can undertake it alone. It is imperative therefore, that, to the extent feasible, national research programmes on climate be planned in such a way that they are consistent with and support international research programmes. We urge that special resources to sustain such programmes be made available to developing countries in order to insure a full partnership in the international research effort.

Original:

14. We stress that special efforts be directed to key areas of uncertainty, including:

the role of clouds, ocean and greenhouse gases; ecosystem responses to global change; effects of land-use changes in the hydrological cycle; climate changes on a regional scale and the socio-economic and cultural dimensions and impacts of climate change.

Comments:

Para 14, line 3-7: replace with

the roles of clouds, oceans, and greenhouse gases;
ecosystem interactions with climate; net emissions of
greenhouse gases; types and levels of atmospheric aerosols;
effects of land-use changes in climate change; regional
climate change; and the regional socio-economic and
ecological implications of impacts of climate change.

New Version:

17. We stress that special efforts be directed to key areas of uncertainty, including: the roles of clouds, oceans and greenhouse gases; ecosystems interactions with climate; net emissions of greenhouse gases; types and levels of atmospheric aerosols; effects of land-use changes on climate change; regional climate; and regional socioeconomic and ecological implications of climate change.

Original:

15. We consider that research programmes must be accompanied by long-term monitoring programmes so designed as to provide continuous and comprehensive coverage of climate-influencing variables as well as those useful in detecting climate change. We agree that long term governmental commitments are necessary to sustain these monitoring programmes. We ask further-more that obstacles to the free flow of relevant data and information be removed.

Comments:

LDC SOVEREIGNTY
ISSUE

1 ?

Para 15: replace last two sentences with:

We recommend that governments make the long term commitments necessary to the development and operations of these monitoring and data management programs. We fully support the Climate Change Detection Project of WMO with its goal of regularly providing assessments of the state of the global climate to all governments.

Para 15, line 7: add a new paragraph:

We support the ^{Full} free and open exchange of relevant data between nations, recognizing its important use in monitoring, detecting and predicting and understanding climate and climate change. It is critically important to move ahead as quickly as possible with the development of integrated, comprehensive (satellite and in situ) ocean and terrestrial monitoring systems and with the improvement of the existing atmospheric system. We agree to strengthen and improve the utilization of our current data resources by improving the quantity, quality and accessibility of these data. We recommend that governments make the long-term commitments necessary to the development and operation of these monitoring and data management programs. We stress that full and open access to relevant data and information by global change researchers from all countries must be a fundamental principle of international climate data policy, and we urge countries to establish national policies and administrative practices consistent with this principle.

"Free" vs
"full"
1

New Version:

18. We consider that research programmes must be accompanied by long-term monitoring programmes so designed as to provide continuous and comprehensive coverage of climate-influencing variables as well as those useful in detecting climate change. We recommend that governments make the long-term commitments necessary to the development and operation of these monitoring and data management programs. We fully support the Climate Change Detection Project of WMO with its goal of regularly providing assessments of the state of the global climate to all governments.

New Version:

19. We support the free and open exchange of relevant data between nations, recognizing its important use in monitoring, detecting, predicting and understanding climate and climate change. It is critically important to move ahead as quickly as possible with the development of integrated, comprehensive (satellite and in situ) ocean and terrestrial monitoring systems and with the improvement of the existing atmospheric system. We agree to strengthen and improve the utilization of our current data resource by improving the quantity, quality, and accessibility of these data. We recommend that governments make the long-term commitments necessary to the development and operation of these monitoring and data management programs. We stress that the free and open access to relevant data and information by climate and global change researchers from all countries must be a fundamental principle of international climate data policy, and we urge countries to establish national policies and administrative practices consistent with this principle.

Original:

16. We reaffirm that there is no need to establish new international coordination mechanisms, but rather urge all countries and relevant organizations to contribute through their national efforts and to increase financial support and assistance in kind on a sustained basis to important existing programmes such as the World Climate Programme including the WMO/ICSU World Climate Research Programme, the ICSU International Geosphere-Biosphere Programme, and the climate-related components of programmes of WMO, UNEP, Unesco and its IOC and FAO. We further urge that these programmes be better supported in order to continue to strengthen their interdisciplinary approach, to include the participation of all nations, and to increase coordination in order to achieve still greater efficiency.

Comments:

Para 16: line 1: add "scientific" after "international"

Para 16: line 3: delete "through their national efforts"

Para 16: lines 9-12: redraft final sentence as follows:

We further urge that these programs continue to strengthen their interdisciplinary approach, broaden national participation, and strive for more effective coordination.

2-3

New Version:

20. We reaffirm that there is no need to establish new international scientific coordination mechanisms, but rather urge all countries and relevant organizations to contribute and increase financial support and assistance in kind on a sustained basis to important existing programmes such as the World Climate Programme, including the WMO/ICSU World Climate Research Programme; and the climate-related components of programmes of WMO, UNEP, UNESCO and its IOC, and FAO. We further urge that these programs continue to strengthen their interdisciplinary approach, broaden national participation, and strive for more effective coordination.

WATCH

Original:

II. POLICY TARGET FOR URGENT POLICY ACTION

(Precautionary measures)

17. In order to achieve sustainable development, we must base ourselves on the precautionary principle. Environmental measures must anticipate, prevent and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

BERGEN
QUOTEComments:Para 17: title should read: "Policy Considerations"Para 17: add at the end of the paragraph "which are justified in their own right"New Version:

9. In order to achieve sustainable development, we must base ourselves on the precautionary principle. Environmental measures must anticipate, prevent and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation which are justified in their own right.

Bergen as fallback

18.

4

Original:

18. We note that a mechanism is being set up by WMO and UNEP to undertake the necessary intergovernmental negotiations on global warming.

ADD TO IPCC
FOLLOW-UP
H

Comments:

Para 18: move to end of Declaration to new section entitled "Framework Convention on Climate Change" after rewriting to read:

We note that a mechanism has been created by WMO and UNEP for intergovernmental negotiations on a framework convention on climate change.

Not in new version

Original:

(Stabilization and reduction of greenhouse gases)

19. We recognise the fundamental need [to conserve the global climate,] and protect it from anthropogenic interference. Taking into account that the increase of greenhouse gas concentrations in the atmosphere threaten the natural variability of climate, we agree that the ultimate global objective should be to stabilize and reduce those concentrations.

REWRITE

EMISSIONS VS CONCENTRATIONS

Comments:

Para 19: delete entirely to improve balance between science paragraphs and policy paragraphs

BAD LANG.; MEANINGFUL
PARTS ELSEWHERE?

LOOK FOR BERGEN/NOORDWIJK VHR.

Original:

20. We stress, as a first step, the need to stabilize, while ensuring stable development of the world economy, emissions of greenhouse gases not controlled by the Montreal Protocol. We note with appreciation the unilateral commitments of some industrialized countries to stabilize emissions at present level or reduce them by the year 2000.

Comments:

(OVERVIEW)

ADD PMS II, p. 13

(1)

Para 20: rewrite as follows:

We recognize that the most effective response strategies, especially in the short-term, are those which are:

- Justified for reasons other than climate change and also provide beneficial impacts on potential climate change;
- Economically efficient and cost effective;
- Able to serve multiple social, economic, and environmental purposes;
- Easily modified to respond to increased scientific and economic understanding of climate change;
- Compatible with the concept of sustainable economic growth and development;
- Compatible with the concept of a comprehensive approach that deals with all sources and sinks of greenhouse gases;
- Administratively practical and effective in terms of application, monitoring, and enforcement; and
- Inclusive of obligations by both industrialized and developing countries in addressing this issue.

New Version:

Policy Considerations

21. We recognize that the most effective response strategies, especially in the short-term, are those which are:

- Justified for reason other than climate change and also provide beneficial influence on potential climate change;
- Economically efficient and cost effective;
- Able to serve multiple social, economic, and environmental purposes;
- Easily modified to respond to increased scientific and economic understanding of climate change;
- Compatible with the concept of a comprehensive approach addressing all sources and sinks of greenhouse gases;
- Compatible with the concept of sustainable economic growth and development;
- Administratively practical and effective in terms of application, monitoring, and enforcement;
- Inclusive of obligations by both industrialized and developing countries.

BEEN
& NOORD.
IPCC
PMS
P.13

Original:

21. We agree that stabilization of greenhouse gas emissions should be achieved by industrialized countries by the year (2000) and should be set at [present] emission levels.

INDUST. / ASAP
 - (BERGEN / NOORD.)

Comments:

Para 21: rewrite as follows:

We recommend that limitation and adaptation strategies be considered as an integrated package that complement each other to minimize net costs. These strategies should include measures which limit emissions from greenhouse gas sources as well as those which increase the ability of natural systems to utilize greenhouse gases. A comprehensive approach is needed which considers the costs of reducing emissions of different greenhouse gases and the effects of those reductions on potential climate change.

ADD TO #20

New Version:

21. We recommend that limitation and adaptation strategies be considered as an integrated package that complement each other to minimize net costs. These strategies should include measures which limit emissions from greenhouse gas sources as well as those which increase the ability of natural system to utilize greenhouse gases. A comprehensive approach is need to which considers the costs of options for reducing emissions of different greenhouse gases and the effects of those reductions on potential climate change.

Original:

22. We urge industrialized countries to establish greenhouse gases reduction programmes aiming at achieving at least 20% reduction of their current contribution to global warming potential, possibly by the year 2005 and in any case not later than the year 2010;

Comments:

Para 22: delete entirely to improve balance between science paragraphs and policy paragraphs

Original:

23. We recommend that the specifications of the obligation to stabilize and reduce greenhouse gases emissions be realized in the form of separate Protocols to the Climate Convention. Some of these protocols could be negotiated concurrently with the framework convention.

MOVE TO SEP. SECTION

Comments:

Para 23: delete entirely; point addressed in para 37-8.

Original:(Economic situation of certain countries)

24. We recognize that developing countries with, as yet, relatively low energy requirements, which can reasonably be expected to grow in step with their development, may have targets that accommodate that development. We also recognize that additional financial resources [will] [may] have to be made available to developing countries to enable them to limit their net emissions of greenhouse gases while ensuring a steady development of their economies;

Comments:

Para 24: replace with page ii of RSWG Policymakers Summary:

We note that all countries have a common responsibility for dealing with problems arising from climate change. Industrialized countries should adopt domestic measures to limit climate change by adapting their own economies in line with future agreements to limit emissions. Industrialized countries should also cooperate with developing countries in international action, without standing in the way of the latter's development. Developing countries should, within limits feasible, take measures to suitably adapt their economies. Because a large, projected increase in world population is a major factor in causing the projected increase in global greenhouse gases, it is essential that global climate change strategies include strategies and measures to deal with the rate of growth of the world population.

MEX:

New Version:

23. We note that all countries have a common responsibility for dealing with problems arising from climate change. Industrialized countries should adopt domestic measures to limit greenhouse gas emissions by adapting their own economies in line with future agreements to limit such emissions. Industrialized countries should also cooperate with developing countries in international action addressing climate change, without standing in the way of the latter's development. Developing countries should, within limits feasible, take measures to suitably adapt their economies. Because a large, projected increase in world population is a major factor in causing the projected increase in global greenhouse gases, it is essential that global climate change strategies include strategies and measures to deal with the rate of growth of the world population.

Original:(Fund (Climate Fund))

25. We recommend that existing institutions for development and financial assistance including the World Bank and other Multilateral Development Banks, Bilateral Assistance Programmes, the relevant United Nations organisations and specialized agencies, and scientific and technological organisations should give greater attention to climate change issues within their environmental and other relevant programmes by providing expanded funding including concessional funding. In addition, regional and subregional co-operation should be reinforced and funded so as to address and implement the required action at that level.

①

Comments:CHECK
IPCC RPT.

Para 25: delete "by providing expanded funding including concessional funding"

New Version:

24. We recommend that existing institutions for development and financial assistance including the world bank and other multilateral development bank, bilateral assistance programmes, the relevant United Nations organizations and specialized agencies, and scientific and technological organizations give greater attention to climate change issues within their environmental and other relevant programmes. In addition, regional and sub-regional cooperation should be reinforced and funded so as to address and implement the required action at that level.

Original:

26. We ^{te}commend that consideration should be given to the need for funding facilities including a clearinghouse mechanism and a possible new international fund and their relationship to existing funding mechanisms, both multilateral and bilateral. Such funding should be related to the implementation of the climate convention and associated protocols. In the meantime the donor community is urged to provide assistance to developing countries to support immediate actions addressing climate change without waiting for the Convention.

Comments:

Para 26: replace with:

We recommend that financial resources channelled to developing countries to limit and/or adapt to climate change be focused on those activities which contribute both to limiting greenhouse gas emissions and promoting economic development.

New Version:

25. We recommend that financial resources channelled to developing countries to limit and/or adapt to climate change be focused on those activities which contribute both to limiting greenhouse gas emissions and promoting economic development. We recommend further that the scope of resource needs for these activities be assessed for developing countries. Such assessments should include, inter alia, country studies and the capabilities of existing institutions and mechanisms to meet the financing needs identified.

Whether there is a

Any

HOLD LINE

27,

(1)

Original:

27. We recommend that additional resources should progressively, be mobilized to help developing countries take the necessary measures to address climate change consistent with their development needs.

Comments:

Para 27: delete in its entirety.

Original:

28. We recommend further that the scope of resources needed be assessed. Such assessments should include *inter alia* country studies and the capabilities of existing institutions and mechanisms to meet the financing needs identified, ~~similar to the approaches developed under the Montreal Protocol.~~

EDIT.

as has been done under

LEAVE AS IS

Comments:

Para 28, line 1: after "assessed" add "for developing countries".

Para 28, lines 4-5: delete "similar to the approaches developed under the Montreal Protocol."

combined into para 25 of new version

New Version:

25. We recommend that financial resources channelled to developing countries to limit and/or adapt to climate change be focused on those activities which contribute both to limiting greenhouse gas emissions and promoting economic development. We recommend further that the scope of resource needs for these activities be assessed for developing countries. Such assessments should include, *inter alia*, country studies and the capabilities of existing institutions and mechanisms to meet the financing needs identified.

Original: 29. We recommend that, initially, international funding be directed to:

- (i) conducting research and monitoring;
- (ii) promoting public awareness, education and institutional and manpower development.
- (iii) promoting efficient use of energy, including appropriate end use technologies, increasing the use of non-fossil fuels and switching to energy sources with lower greenhouse gas emissions and the use of renewable energy sources; ^{such as}
- (iv) increased financial support for forest protection and forest management improvement, [for example through the Tropical Forest Action Plan (TFAP), the Plan of Action to Combat Desertification, the International Tropical Timber Organization (ITTO) and other relevant international organizations;]
- (v) arranging for technology transfer to and technology development in developing countries;
- (vi) assisting developing countries in planning how to address problems posed by climate change;
- (vii) supporting developing countries to enable their full participation in international meetings on the subject of climate change.

(The use of financial resources could subsequently be extended inter alia to major energy sources with little or no environmentally damaging characteristics and for steps to reduce other global man-made emissions of greenhouse gases due to human activities.)

Comments:

Para 29, line 1, subpara (iii): break into two subparas by starting new subpara with "increasing the use of...."

Para 29, line 1, subpara (iv): delete "financial"

Para 29, para 1, subpara (iv): following "for example through" add "a global forestry agreement".

Para 29, para 1, subpara (v): replace with:

(v) fostering technology development and transfer of technology that is usable and applicable to economic development opportunities that would be beneficial to developing countries.

Para 29, para 1, subpara (vii): replace "their full" with "greater"

Para 29, para 1, subpara (vii): replace "meetings" with "activities"

Para 29, para 1, add new subpara (viii):

(viii) improving climate data management related to global and regional data sets with special emphasis on developing country requirements.

Para 29, second paragraph: delete entirely

KEEP
IS

KILL (OR
KEEP INTER
ALL)

New Version:

26. We recommend that initially international funding be directed towards:

- (i) conducting research and monitoring;
- (ii) promoting public awareness, education and institutional and manpower development;
- (iii) promoting efficient use of energy, including appropriate end use technology;
- (iv) increasing the use of non-fossil fuels and switching to energy sources with lower greenhouse gas emissions and the use of renewable energy sources;
- (v) increasing support for forest protection and improving forest management, for example through a global forestry agreement, the Tropical Forestry Action Plan (TFAP), the Plan of Action to Combat Desertification, the International Tropical Timber Organization (ITTO) and other relevant international organizations;
- (vi) arranging for technology transfer to and technology development in developing countries;
- (vii) assisting developing countries in planning how to address problems posed by climate change;
- (viii) supporting greater participation of developing countries in international climate change activities; and
- (ix) improving climate data management related to global and regional data sets with special emphasis on developing country requirements.

Original:(Economic instruments)

30. We recognise that an environmentally sound development must include policies which will achieve a sustainable energy system and take the environmental costs and benefits of energy fully into account. We are convinced that promoting energy efficiency is the most cost effective immediate measure for reducing energy-related emissions of atmospheric pollutants, in particular CO₂.

Comments:

Para 30, replace with:

We recognize that environmentally sound development must include policies which consider the costs and benefits of energy use. We are convinced that, in many states, increasing energy efficiency is one of the most cost effective measures for reducing energy-related emissions of greenhouse gases.

Para 30, line 6: add new sentence at end as follows:

However, considerable research is necessary for each nation to establish what degree of energy efficiency is also economically efficient taking into account environmental externalities.

New Version:

27. We recognize that environmentally sound development must include policies which consider the costs and benefits of energy use. We are convinced that, in many states, increasing energy efficiency is one of the most cost effective measures for reducing energy-related emissions of greenhouse gases. However, considerable research is necessary for each nation to establish what degree of energy efficiency is also economically efficient taking into account environmental externalities.

Original:

31. We recommend that [new] policies at national level be established making extensive use of economic instruments in order to increase energy efficiency and reduce energy consumption. (2)

Such instruments could include:

- (i) taxes on environmentally damaging activities and energy inefficient product
- (ii) emission trading (tradeable permits/allowances)
- (iii) reduction or, wherever possible, elimination of subsidies to (energy intensive and other) activities that induce climate change
- (iv) other measures such as emission charges and fees deposit refund systems and fiscal incentive

Such action ^{C/W} should in particular affect energy prices with the aim to reflect environmental costs and benefits and provide incentives to reduce energy consumption. They ^{C/W} should also modify production and consumption pattern and encourage production and use of energy efficient technologies.

Comments:

Para 31, para 1, line 1: replace "new policies at the national level be established making" with "policies at the national level make"

Para 31, line 3: replace "reduce energy consumption" with "conservation"

Para 31, subpara (iii): delete "energy intensive and"

Para 31, subpara (iv): replace "change" with "charge"

Para 31, subpara (iv): move "fiscal incentives" to before "measures" and delete the word "and" at the end.

Para 31, para 2 (on p. 7): delete this paragraph.

New Version:

28. We recommend that policies at the national level increase energy efficiency and conservation, making use of economic instruments including:

- (i) taxes on environmentally damaging activities and energy inefficient products;
- (ii) emission trading (tradeable PERMITS/allowances);
- (iii) reduction or, wherever possible, elimination of subsidies to activities that induce climate change; and
- (iv) other fiscal incentive measures such as emission charges and fee-deposit-refund systems.

Original:**(Technology development)**

32. We agree that technological breakthrough in a wide range of fields covering energy, industry and other sectors related to the emission and absorption of CO₂ and other greenhouse gases is the key element of any long-term strategy that deals with climate change in a way that meets the goal of sustainable development. To this end, we urge all countries, the industrialized countries in particular, to intensify their individual efforts and international cooperation in technology development concerning, inter alia, low-energy and low-GHG production processes and products (e.g. chlorofluorocarbon substitutes with little or no global warming potential), and CO₂ fixation and reutilization.

Comments:

Para 32, line 3: delete "CO₂ and other"

Para 32, line 4-5: delete "in a way.....sustainable development"

Para 32, line 6: delete "the industrialized countries in particular,"

Para 32, lines 7-10: replace "in technology developing..." with
on technologies and practices which reduce emissions or
 increase absorption of greenhouse gases.

New Version:

29. We agree that technological breakthrough in a wide range of fields covering energy, industry and other sectors related to the emission and absorption of greenhouse gases is the key element of any long-term strategy that deals with climate change. To this end, we urge all countries to intensify their individual efforts and international cooperation on technologies and practices that reduce emissions or increase absorption of greenhouse gases.

Original: (Transfer of technology)

[Alternative 1]

33. We urge that relevant technology be utilized by all sectors in all countries to the full extent possible. We recognize that there are great disparities in energy efficiency, even among the industrialized countries, and further urge all countries, industrialized and developing, to identify and take effective measures to remove barrier to the dissemination of the best available technology. This requires in the case of developing countries, effective measures to aid their efforts in meeting the specific needs arising, to a great extent, from their lack of human and financial resources and other elements necessary for the continuous development and dissemination of the most appropriate technology. The East European countries, which are currently suffering the consequences of inefficient use of energy and other resources, also require special attention. To this end, we also urge all industrialized countries and relevant international institution to step up their contributions to the effective transfer and dissemination of relevant technology in ways that fully address the constraints that all these countries face.

[Alternative 2]

33. We consider important that this expansion of development employ appropriate and environmentally sound technology in order that the problem of global warming and climate change not be exacerbated. Consequently, the transfer and development of such technologies must assume a high priority. It will be important for the industrial nations to respond to this priority and assign sufficient resources to assure technological development and establishment of mechanisms for successful transfer.

Comments:

Para 33, We prefer Alternative 2.

Para 33, Alternative 2: replace "this expansion of" with "economic" on line 1

Para 33, Alternative 2: delete "and environmentally sound" on line 2

Para 33, Alternative 2: replace "technology in order... exacerbated" with "technologies and practices" on line 2

Para 33, Alternative 2: revise second sentence as follows:

Consequently, consideration of effective mechanisms to develop and transfer such technologies must be accorded a high priority.

Para 33, Alternative 2, lines 5-8: Rewrite last sentence to:

It is important for both industrialized and developing nations to respond to this priority, by creating conditions that would be conducive to the development and transfer of such technologies and practices.

New Version:

30. We consider important that economic development employ appropriate technologies and practices. Consequently, consideration of effective mechanisms to develop and transfer such technologies must be accorded a high priority. It is important for both industrialized and developing nations to respond to this priority by creating conditions that would be conducive to the development and transfer of such technologies

(Forestry)

34. We recognize that the conservation of the world's forests is of crucial importance for global climatic stability, particularly having regard to the important contribution of forest destruction to global warming through the emission of carbon-dioxide, methane and other trace gases.

We stress the need to reduce the rate of deforestation and to enhance the potential of the world's forests as a sink for greenhouse gases, through vigorous programmes of reforestation and afforestation.

① Urge the earliest completion of the feasibility assessment of
We endorse the target included in the Noordwijk Declaration of achieving net global forest growth of 12 million hectares per year, through conservation of existing forests and through aggressive programmes of reforestation and afforestation.

We call on all countries to:

- EDIT.
REWRITE
- (i) Adopt clear objectives for the conservation, reforestation and sustainable management of forests in national development plans.
 - (ii) Amend national policies to minimize forest loss and their human disturbance associated with public and private development projects (e.g. roads, dams, resettlement projects, mining, logging).
 - (iii) Integrate forest management solutions with policies on environment, agriculture, transportation, energy, poverty and landlessness.
 - (iv) Strengthen, support and extend the Tropical Forestry Action Plan (TFAP) process to all countries with tropical forests, and expand support for immediate implementation of completed plans.
 - (v) Strengthen the role of the International Tropical Timber Organization (ITTO) in supporting the sustainable utilization of forest resources.
 - (vi) Strengthen the role of development banks, IMF, FAO, UNEP, and other multilateral and bilateral organizations in helping developing countries achieve conservation and sustainable development of forests by:
 - a) Requiring analyses of climate change implications, potential greenhouse gas emissions, and response programmes in their review of project proposals involving forests;
 - b) Expanding greatly aid and investment flows to the forest sector as well as for the production of energy from biomass.
 - c) Expanding debt relief via renegotiation of debt, and debt for conservation exchanges; and
 - d) Linking structural adjustment measures to alleviation of climatic impacts and reduction of gas emissions.
- FIX IF KEPT

Comments:

Para 34, line 2: after "importance" add "to the stability of the global climate"

Para 34, lines 2-4: delete "for global climatic stability,.... and other trace gases."

Para 34, lines 2-4: delete "for global climatic stability,.... and other trace gases."

Para 34, para 3: delete in its entirety because it goes beyond the Noordwijk Declaration

Para 34, para 4, delete subpara (vi)(b-d)

New Version:

31. We recognize that the conservation of the world's forests is of crucial importance to the stability of the global climate. In particular we note the significance of forest destruction to global climate change both in contributing to the increase in emissions of carbon-dioxide, methane and other trace gases, and in reduction of natural absorption of carbon dioxide.

We stress the need to reduce the rate of deforestation and to enhance the potential of the world's forests as a sink for greenhouse gases, through vigorous programs of reforestation and afforestation.

We call on all countries to:

- (i) adopt clear objectives for the conservation, reforestation and sustainable management of forests in national development plans;
- (ii) amend national policies to minimize forest loss and disturbance by public and private development projects (e.g. roads, dams, resettlement projects, mining, logging);
- (iii) integrate forest management solutions with policies on environment, agriculture, transportation, energy, poverty and landlessness;
- (iv) strengthen, support and extend the tropical forestry action plan (tfap) process to all countries with tropical forests, and expand support for immediate implementation of completed plans;
- (v) strengthen the role of the international tropical timber organization (ITTO) in supporting the sustainable utilization of forest resources;
- (vi) strengthen the role of development banks, IMF, FAO, UNEP, and multilateral and bilateral organizations in helping developing countries achieve conservation and sustainable development of forests by requiring analyses of climate change implications, potential greenhouse gas emissions, and response programmes in their review of project proposals involving forests.

Original:

35. We call finally for the development of a World Forest Conservation ~~Protocol or Convention~~, covering temperate, boreal and tropical forests, in the context of or in association with a Climate Convention which also addresses energy supply and use. The specific elements of such a protocol or convention are a matter for international negotiations which should begin at an early date. These elements may include: fundamental research, tropical forest planning, measures to use, protect and reforest, international trade, financial assistance and possible national and international targets for conservation, reforestation and afforestation.

Comments:

Para 35, line 7: before "tropical" add "temperate and"

Para 35: replace first four lines with:

We call finally for the development of a global forest convention or agreement. The specific elements of such a convention or agreement....

New Version:

32. We call finally for the development of a global forest convention or agreement. The specific elements of such a convention or agreement are a matter for international negotiations which should begin at an early date. These elements may include: fundamental research, temperate and tropical forest planning, measures to use, protect and reforest, international trade, financial assistance and possible national and international targets for conservation, reforestation and afforestation.

Original: 36. We recommend that regional and/or sub-regional studies on these subjects be undertaken to cover the impacts of climate change in the following fields:

- (i) Drought;
- (ii) Desertification;
- (iii) Water resources and their evolution;
- (iv) Agriculture (positive and negative impacts);
- (v) Energy;
- (vi) Forests.

Comments:

These studies should lead to the development of scenarios and short, medium- and long-term measures for mitigation of drought and stopping and reversing desertification for the attention of economic and political decision makers.

Para 36: expand list of items to include coastal resources, human health, infrastructure, human settlements, fisheries and biodiversity.

Para 36, para 1, line 2: positive and negative impacts

Para 36, para 1, line 3: replace "fields" with "areas"

Para 36, subpara (iii): delete "and their evolution"

Para 36, subpara (iv): delete "(positive and negative impacts)"

Para 36, subpara (v): replace with: "Energy supply and use:"

Para 36, para 2: replace with:

We recommend that all nations assess the potential impacts of climate change on their resources and plan for adaptation. Appropriate regional institutions should work with member countries to assess and plan for regional impacts of climate change. Industrialized countries should provide technical assistance to developing countries to conduct such assessments. These activities might be facilitated by the establishment, within an existing institution, of an international clearinghouse on climate change impacts and assessments.

3

New Version:

33. We recommend that regional and/or sub-regional studies be undertaken to evaluate the positive and negative impacts of climate change in the following areas:

- (i) drought;
- (ii) desertification;
- (iii) water resources;
- (iv) agricultural;
- (v) energy supply and use;
- (vi) forests;
- (vii) coastal resources;
- (viii) human health;
- (ix) national infrastructure;
- (x) human settlements;
- (xi) fisheries; and
- (xii) biodiversity.

We recommend that all nations assess the potential impacts of climate change on their resources and plan for adaptation. Appropriate regional institutions should work with member countries to assess and plan for regional impacts of climate change. Industrialized countries should provide technical assistance to developing countries to conduct such assessments. These activities might be facilitated by the establishment, within an existing institution, of an international clearinghouse on climate change impacts and assessments.

Original:

III. GLOBAL CONVENTION

37. We welcome the resolutions of the Executive Council of the WMO and Special Governing Council of UNEP authorising their Secretary General and Executive Director to begin negotiations for a Climate Convention, and associated Protocols. We call for such negotiations to begin without delay. We endorse the WMO and UNEP Governing Bodies Decisions in this respect. We urge all countries to join in these negotiations, with the aim of completing negotiations to ensure adoption of a Climate Convention by the time of the UN Conference on Environment and Development in 1992;

on a Framework
convention on
climate
change

MEX ADDITION 01C

Comments:

Para 37, title should read "Framework Convention on Climate Change"

Para 37, line 3: replace "begin negotiations for a" with

establish an ad hoc group of government representatives to prepare for negotiations for a Framework

Para 37, line 4: delete "and associated protocols"

Para 37, line 5: replace "without delay" with "no later than February 1991"

4
+ TRACK
WMO
RESOL.

New Version:

Framework Convention on Climate Change

34. We welcome the resolutions of the Executive Council of the WMO and special session of the governing council of UNEP ~~authorizing their Secretary General and Executive Director to establish an ad hoc group of government representatives to prepare for negotiations on a framework convention on climate change.~~ We call for such negotiations to begin not later than February 1991. We urge all countries to join in these negotiations, with the aim of completing negotiations to ensure adoption of a framework convention by the time of the UN conference on environment and development in 1992.

with respect to

1-2

Original:

38. We recommend that such negotiations take account of the possible elements compiled by the IPCC, and that the Climate Convention be framed in such a way as to gain the support of the largest possible number of countries.

KEEP AS IS

Comments:

Para 38: change "the Climate" to read "the Framework Climate"

Para 38, line 1: replace "take account of" with "consider"

New Version:

35. We recommend that such negotiations consider the possible elements compiled by the IPCC, and that the framework convention be framed in such a way as to gain the support of the largest possible number of states. We recommend that the framework convention contain, at a minimum, general principles and obligations, and that it advocate a comprehensive approach that includes sources and sinks of all greenhouse gases.

③
COR (1) IF
COMPREH. DOESN'T
GET IN ELSEWHERE

Original:

39. We welcome the offer of the Government of the United States to host the first negotiating ~~meeting of a Working Group~~ on the elaboration of a Climate Convention. We also welcome the possible invitation of Italy to host the first meeting of the Working Group for the elaboration of an Energy Protocol. We urge that these two meetings be convened at the beginning of 1991.

Comments:

- ① HASN'T HAPPENED
- ② NO SIMULTAN. PROTOCOLS
- ③ UNCONNECTED

Para 39, lines 2-3: revise first sentence to read:

We welcome the offer of the Government of the United States to host the first negotiating session on the Framework Convention in February 1991.

Para 39, lines 3-6: delete the last two sentences.

New Version:

36. We welcome the offer of the government of the United States to host the first negotiating session on the framework convention in February 1991.

Original:

40. We recommend further that the Climate Convention [and associated Protocols] contain specific obligations and address in particular:

- ①
ITEMS
FOR
NEGOT.
- (i) the enhancement of research and systematic observation of climate
 - (ii) the control of greenhouse gas emissions
 - (iii) the adaptation to the adverse effects of climate change in coastal areas
 - (iv) The needs of developing countries for financial assistance in their development efforts and transfer of technology
 - (v) appropriate institutional and decision-making procedures.

Comments:

COVERED BY 438

Para 40: replace with language from RSWG Policymakers Summary:

We recommend that the framework convention contain, at a minimum, general principles and obligations, and that it take a comprehensive approach addressing all sources and sinks of greenhouse gases.

Combined with para 35 in new version.

New Version:

35. We recommend that such negotiations consider the possible elements compiled by the IPCC, and that the framework convention be framed in such a way as to gain the support of the largest possible number of states. We recommend that the framework convention contain, at a minimum, general principles and obligations, and that it advocate a comprehensive approach that includes sources and sinks of all greenhouse gases.

PUT
SOMEWHERE
ELSE

Original:

IV. INFORMATION AND PUBLIC AWARENESS

41. We believe that a well informed public is essential for addressing and coping with as complex an issue as climate change and urge countries
- (i) encourage wide participation of all sectors of the population in addressing climate change issues and developing appropriate responses
 - (ii) provide guidance for positive practices to limit/or adapt to climate change
 - (iii) incorporate in the curricula of their educational systems environmental education
 - (iv) establish national committees or clearing houses to collect, develop and disseminate accurate information on climate change issues.

Comments:

None

New Version:

Information and Public Awareness

37. We believe that well informed public is essential for addressing and coping with as complex an issue as climate change and urge countries to:

- (i) encourage wide participation of all sectors of the population in addressing climate change issues and developing appropriate responses
- (ii) provide guidance for positive practices to limit/or adapt to climate change
- (iii) incorporate in the curricula of their educational systems environmental education
- (iv) establish national committee or clearing houses to collect, develop and disseminate accurate information on climate change issues.

Original:

V. INSTITUTIONAL MATTERS

42. We congratulate the IPCC for the outstanding achievement of producing a very short time its first report on the state of the science of climate change, the socio-economic impact and policy options. We recognize that the IPCC structure can provide an invaluable mechanism for periodic assessments, perhaps every five years, of the evolving knowledge from research and impact studies. We urge that the IPCC continue its analysis of risks of action and inaction, policy options and economic aspects of alternative measures for limiting greenhouse gas emissions, mitigating or adapting to climate change. We also urge that ~~a further report~~ ^{studies} on these issues should be produced during 1991 to support the then ongoing negotiations of a Climate Convention on Climate Change.

Comments:

Para 42 and 43, place paragraphs in new section on IPCC.

Para 42, line 3: policy options to limit or adapt to climate change

Para 42, line 4: delete "structure"

Para 42, line 5: delete "perhaps every five years"

Para 42, lines 7-8: delete "risks of action and inaction"

Para 42, lines 8-9: replace "and economic aspects.... adapting to climate change." with "especially the economic aspects of alternative measures for limiting greenhouse gas emissions of adapting to climate change."

Para 42, line 10: delete "during 1991"

Para 42, lines 11: delete "then"

Para 42, last sentence: framework convention

New Version:

12. We congratulate the IPCC for the outstanding achievement of producing its First Assessment Report on the state of the science of climate change, the socio-economic impacts and policy options to limit or adapt to climate change. We recognize that the IPCC can provide an invaluable mechanism for periodic assessments of the evolving knowledge from research and impact studies. We urge that the IPCC can provide an invaluable mechanisms for periodic assessments of the evolving knowledge from research and impact studies. We urge that the IPCC continue its analysis of policy options, especially the economic aspects of alternative measures for limiting greenhouse gas emissions or adapting to climate change. We also urge that further reports on these issues be produced to support the ongoing negotiations of a Framework Climate Convention on Climate Change.

43

Original:

- ✓ 43. We further express our appreciation to WMO and UNEP for initiating the IPCC and providing an efficient Secretariat. We urge that this arrangement be continued and that countries continue to provide resources to support the Secretariat and participation of developing countries in the work of IPCC.

Comments:

Para 43, line 2: after "efficient" add "and effective"

Para 43, line 3: replace "that countries continue..... in the work of the IPCC." with "expanded to provide secretariat support for negotiations on a framework convention on climate change"

New Version:

13. We further express our appreciation to WMO and UNEP for initiating the IPCC and providing for an efficient and effective Secretariat. We urge that this arrangement be continued and expanded to provide secretariat support for the negotiations on a framework convention on climate change.

DRAFT

DRAFT

October 26, 1990

MEMORANDUM FOR THE PRESIDENT

FROM: *The first part of* D. Allan Bromley
~~Edo Holiday~~

SUBJECT: *Swcc will be a* ~~The~~ Second World Climate Conference

insure a This will provide additional information on the Second World Climate Conference (SWCC).

Swcc The Second World Climate Conference is controversial

ing The SWCC is one of many international conferences held to address global climate change issues. These conferences are used to heighten the visibility of the issues, to encourage scientific and economic inquiry into climate phenomena, and for political positioning. *ing*

to the scientific discussions This meeting will review scientific information, including materials compiled through the U.N. sponsored, Intergovernmental Panel on Climate Change (IPCC), which has been endorsed by the U.S. government as the appropriate channel to consider climate change science. In addition, the conference is intended to provide a forum for discussions that connect scientific understanding with the continuing policy debate. *It will provide* The U.S. will participate in the scientific discussions, for which there are no official "delegations." The U.S. plans to spend about \$1 billion dollars on climate change research in FY 1991. *of*

U.S. A ministerial meeting will occur the week after the conference, increasing the political tone of this event. As a result, there will be pressure to begin negotiations on greenhouse gas emissions reductions. The U.S. does not recognize SWCC as the forum to begin substantive climate change negotiations. Thus Dr. John Knauss, Administrator of the National Oceanic and Atmospheric Administration, will head the Ministerial delegation. *John* Dr. Knauss headed the U.S. delegation to the Bergen meeting and was a member of the Noordwijk delegation. European heads of state are interested because the meeting is in Europe. Asian, African and Latin-American heads of state will not attend, but will send their environmental ministers. *who was chosen to*

is that The U.S. position on this meeting is to discuss the scientific issues and preserve any negotiations for the February meeting in Washington. The delegation will also try to gather support for the "comprehensive approach" to emissions reductions, which takes into account characteristics of all greenhouse gases and their effect on the environment. Some countries will seek to push agreement on elements to be included in a framework convention, but the U.S. delegation plans to hold firm in deferring such issues to the negotiations and we are likely to get a compromise declaration acceptable to the U.S. that does not venture into these topics. *should*

This thought needs explanation before it is introduced. *to emphasize on view of the meeting as science-focused, will make this point.* *we*

Ag

actions should be within the context of

There are five major issues in the controversial draft Ministerial Declaration

The draft declaration is highly controversial. Major issues for the U.S., along with the U.S. positions, are:

- (1) Targets and Timetables. We should not commit to specific targets and timetables for reducing greenhouse gases. Instead, we should take actions that are justified for other reasons; ~~and the comprehensive approach to greenhouse gas limits (considering all gases) should be taken.~~
- (2) Content of a Convention. The Ministerial ^{VC} declaration should not prejudice the negotiations which are to begin in Washington in February.
- (3) Financial Assistance. The U.S. will not commit to providing new, additional international assistance which increases the overall budget. Existing resources and mechanisms must be fully utilized before new monies can be considered.
- (4) Climate Change Science. The declaration must be accurate in describing the scientific context and uncertainties associated with potential climate change.
- (5) Precautionary Principle. ~~Lack~~ of full scientific certainty is no excuse to postpone actions which are justified in their own right.

insist B

The U.S. may be isolated on a number of issues

The U.S. does not agree with many countries ~~on a broad interpretation of the precautionary principle, targets and timetables, and financial assistance.~~ Other countries interpret the precautionary principle as urging immediate action for the prevention of environmental degradation, regardless of the extent of scientific uncertainty. The Soviet Union and Saudi Arabia may be our allies on this issue.

Or their calls for

As noted above, D

Press interest in the conference may be intense for a period of time because of pressure from a growing number of countries to set targets and timetables ~~for greenhouse gas emissions.~~ Japan will highlight ~~their~~ recently announced strategy for stabilizing CO₂, ~~a major greenhouse gas,~~ at current levels by the year 2000. Australia will also announce ~~their~~ strategy to stabilize. The U.S. could be portrayed as stalling on greenhouse gas emissions reductions. In fact, actions that the U.S. is taking or planning to take are estimated to stabilize our net greenhouse gas emissions at 1987 levels by the year 2000.

its

An alternative declaration will be proposed by the U.S. delegation

To decrease the possibility of isolation, the U.S. has prepared an alternative draft Ministerial Declaration, which is shorter, less technical and more ministerial in tone. It will probably not be readily accepted in its entirety by SWCC participants. However, it will influence the discussions and could encourage support for the U.S. position by a number of countries uncomfortable with the current draft Ministerial Declaration.

litescan C

should

Given that Ede will be out after 2:00 or so, and that the primary purpose for this memo is to remind the President and others of Allan's leadership on this issue within the White House, I think the memo should come from him alone -- it has been revised accordingly. Because of that, please feel free to ignore any or all of my comments -- if you have trouble reading any of them, just call me.

INSERT A

, supplementing Roger Porter's memo to you of October 23.

Preparations for SWCC

The U.S. positions for SWCC have been developed through a working level group headed by the State Department, which has reported to the DPC Global Change Strategy Task Force that I chair. The task force has developed our positions on the five major issues in the draft Ministerial Declaration, reviewed and approved the alternative draft declaration discussed below, and reviewed the opening statement of NOAA Administrator Dr. John Knauss, who will head the U.S. delegation to the Ministerial portion of the meeting. Throughout this process I have kept Governor Sununu fully apprised of developments.

INSERT B

Many nations rely on the precautionary principle as the rationale for acting where a threat exists, regardless of the state of scientific knowledge. The U.S. will assert, as was spelled out in the Houston Economic Summit declaration, that lack

*Precautionary Principle
language originated in German
law → this is not concise.*

INSERT C

, a significant reduction over anticipated levels (estimated to be from 15 to 20 percent).

approximately 20%

nty with Struchs

Document Originally
Attached to
Following Page

Second World Climate Conference

Negotiations on a Framework Convention on Climate Change

Proposed actions:

Products:

1. Development of appropriate definitions [**Task Force on Climate Approaches**]
2. Preliminary assessments of best available information on effectiveness and Economic consequences of various response strategies before negotiations begin. [**DOE, EPA, CEA**]
3. Develop detailed analyses of the feasibility of meeting certain proposed targets in order to demonstrate the impracticability of these proposals. [**DOE, EPA, CEA**]
4. Calculate the impact on radiative forcing of emissions targets implemented by only a subset of countries (e.g., OECD members) [**DOE, EPA AND CEA**]
5. Set out in detail how the approach will work and the advantages of a comprehensive approach prior to negotiations.
6. Evaluate the feasibility and economic consequences of emissions targets for the U.S. and other key countries. (Part of the effort will be to identify potential allies) [**EPA, CEA, OMB AND DOE**]
7. Determine what could be listed under a "no regrets" heading. [**STATE IN COOPERATION WITH OTHER AGENCIES**]
8. Develop options regarding to what extent (i.e., how much detail) the framework convention should "tilt" the protocol in the direction of a comprehensive approach. [**STATE WORKING WITH THE TASK FORCE ON CLIMATE APPROACHES**]
9. Options paper on how to handle the possibility of differentiated treatment in the framework convention. [**STATE**]
10. Catalogue existing U.S. financial assistance related to climate change. [**STATE**]
11. Assessment of existing institutions and mechanisms related to financial assistance for climate change. [**STATE**]
12. Develop positions regarding technology development issues. [**STATE, DOE, USDA, EPA'S INTERNATIONAL ENVIRONMENTAL**]

**TECHNOLOGY TRANSFER ADVISORY BOARD, DOC, USTR, AND
OTHER RELEVANT AGENCIES]**

13. Consider surveillance/verification/compliance functions that might accompany comprehensive/economic mechanisms to be included in the framework convention. **[STATE AND THE TASK FORCE ON CLIMATE APPROACHES]**

14. Review and analysis of existing institutions, identifying gaps. **[STATE, TASK FORCE ON CLIMATE APPROACHES AND OTHER AGENCIES AS APPROPRIATE]**

15. Develop proposals it considers the U.S. should make with respect to research and monitoring. **[INTERAGENCY WORKING GROUP ON DATA MANAGEMENT FOR GLOBAL CHANGE]**

16. Develop an updated list of research areas to include in the convention, perhaps in an annex. The list should include areas in which further research is needed to determine an appropriate response strategy toward greenhouse gases. **[TASK GROUP ON CLIMATE APPROACHES]**

17. Determine the kinds of scientific and economic information should be exchanged and under what conditions. **[STATE WITH APPROPRIATE AGENCIES]**

18. Identify whether there is a need for the elaboration of a comprehensive international research program in order to facilitate cooperation in the exchange of scientific, economic and other information on climate change. **[INTERAGENCY WORKING GROUP ON DATA MANAGEMENT FOR GLOBAL CHANGE]**

19. Options paper discussing whether we should support stronger dispute settlement provisions. **[STATE]**

20. Analyses to demonstrate the advantages of economic approaches and options for references in the convention to economic mechanisms. **[TASK FORCE ON CLIMATE APPROACHES]**

Task Force on Comprehensive and Incentives Approaches to Climate
October 12, 1990
Work products to prepare for framework convention negotiations.

[List is based on Task Force Interim Report]

1. Drafting a U.S. version of a possible framework convention. [STATE AND DOJ]
2. Develop an improved radiative forcing index. [CEES, EPA (ALBRITTON AND TIRPAK, ET. AL.)]
 - Develop a plan for resolving areas of uncertainty.
 - Sketch of the design of a global change index
3. Design an international GHG monitoring system. [EPA, CES, DATA MANAGEMENT WORKGROUP, EPA, MARS]
4. Development of talking points including quantitative demonstrations that piecemeal proposals would have little environmental benefit, or actually be counterproductive. [DOJ]
5. Conduct quantitative analysis of the comprehensive and economic incentives approaches, and its variations by gas, strategy, sector, nation. [NORM HARTNESS, DOE]
6. List of the net index-weighted emissions change wrought by relevant U.S. actions, including "no regrets" measures. Prepare a similar list for other countries. [EPA]
7. Develop language for the framework convention to address the vision of decisionmaking under uncertainty. [CEES AD HOC ECONOMICS TASK FORCE]
8. Assess other's proposals. [EPA, DOE, CEA]

We definitely need to
revise this listing to
include ~~CEA~~ in
appropriate fashion. DAB

October 29	SWCC Science Meeting
November 5	SWCC Ministerial Portion of Meeting
November 14	Global Change Strategy Task Force Meeting

November 16 PCC WGCC (DOS) meeting - Progress report on preparations for a framework convention by all subgroups.

Agenda items: (1) Progress Report on Preparations for framework convention by PCC subgroups; (2) briefing on comprehensive approach EPA/DOJ

Agenda items: (1) Discussion of framework convention preparation of options package for presentation at DPC GCWG meeting; (2) selection of a negotiator and head of delegation.

December 5 DPC GCWG to review U.S. preparations and approaches to negotiating framework convention, and discussion of PCC WGCC Workgroup reports which will be distributed to them the preceeding Friday.

Agenda items: (1) package options (based on DPC GCWG comments) for consideration by DPC GCWG.

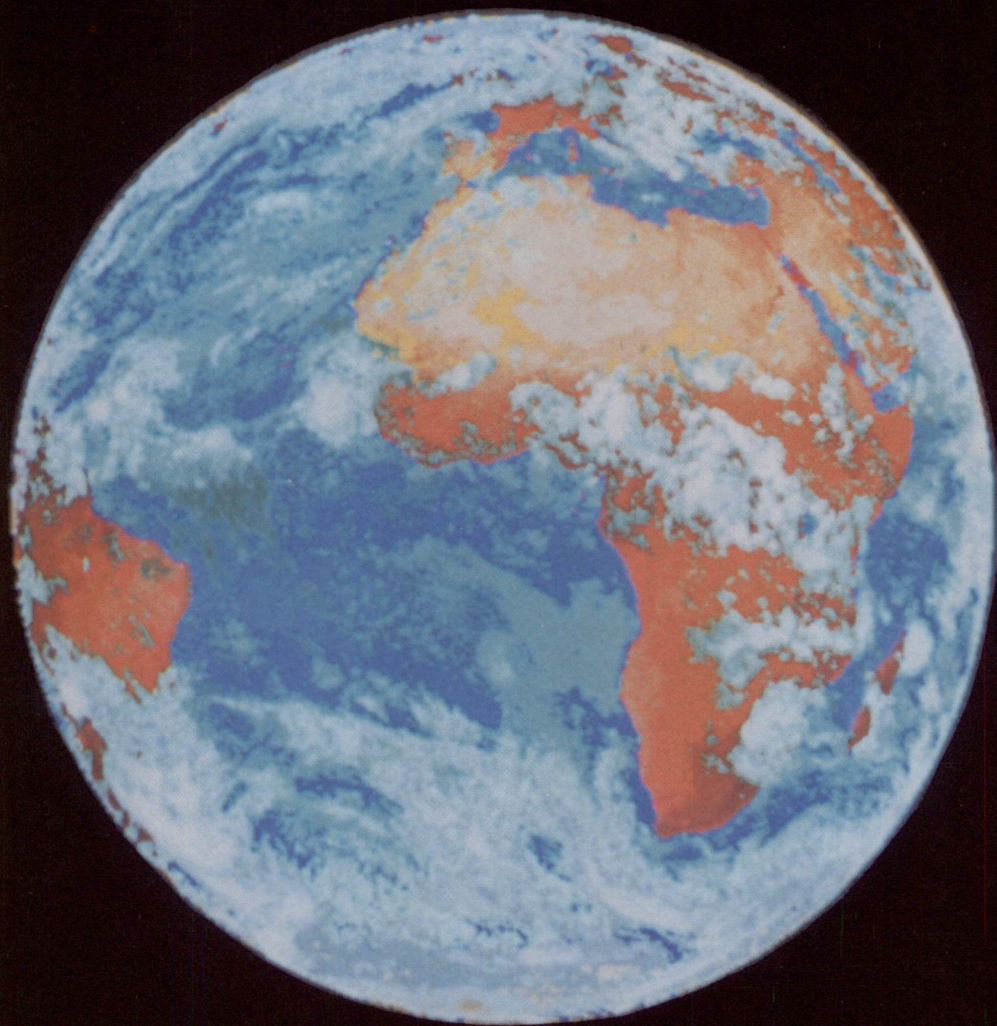
December 19 **Strategy Task force meeting**

Agenda items: (1) Review Options Package to be presented to full DPC.

January 7 Options package distributed to DPC members in preparation for meeting.

January 15 Full DPC meeting to consider Options package.

GLOBAL CLIMATE CHANGE



**WORLD
METEOROLOGICAL
ORGANIZATION**

**INTERNATIONAL
COUNCIL OF
SCIENTIFIC UNIONS**



**WORLD
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GLOBAL CLIMATE CHANGE

**A SCIENTIFIC REVIEW
PRESENTED BY
THE WORLD CLIMATE RESEARCH PROGRAMME
January 1990**

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FOREWORD

The world's climate system is a sensitive combination of many interactive components: the atmosphere; oceans; biosphere; land and sea ice; and the land surface itself. Climate has large natural variability on all time and space scales. In prehistoric times, glaciers covered large portions of the land and, at other times, tropical rain forests existed at high latitudes. Now, each year, farmers around the world wait to see whether the seasonal rains will come at the right time. In Asia, society has developed around the occurrence of the monsoon. We now realize that the influence of the El Niño phenomenon or Southern Oscillation extends beyond the tropical Pacific and that it has global consequences. In some areas of the world, the social and economic structures are such that society can survive several years of abnormal climate; in other locations, droughts or excessive rainfall have immediate and catastrophic impacts. Climate is made of extreme events as well as periods of more normal conditions. Extreme events are the critical and frequently destructive part. To a large extent, human societies have become attuned to current climate; crops flourish within an expected range of climatic variations, our dams and dykes are built on assumptions based upon the climatological record of the last 30 to 50 years. Yet, the earth's climate has never been static and, for the first time in history, human activities have now reached the stage where they affect climate on regional and global scales.

In recognition of the variability of climate and the immense importance of its impacts, the International Council of Scientific Unions and the World Meteorological Organization have jointly undertaken, since 1979, the World Climate Research Programme. Co-operation has been established with many international organizations and bodies to plan the activities of the Programme in various scientific disciplines, first of all the Scientific Committee on Oceanic Research of ICSU and the Intergovernmental Oceanographic Commission of Unesco.

Climate research is aimed at understanding those fundamental processes of the earth's atmosphere, ocean and ice that cause the climate to behave as it does. From observation and models will come the ability to predict the future evolution of climate. Consider the value of being able to predict whether the next growing season will be wetter and colder than normal, or hotter and dryer. Consider the usefulness to society of precise information on the long-term trends in mean sea level, changes in precipitation and river flow, or the occurrence of the next El Niño disturbance. Consider how different our policy for the use of fossil fuels might be if we knew, with

confidence, how far such use will cause the climate to warm and precipitation to change, not only globally, but for each region of the world.

Confident prediction of climate will only come when we have comprehensive models of the full climate system that have been thoroughly tested against observation. Obviously, we cannot wait for climate change over the next fifty or hundred years to see whether our models are correct. We must build up the reliability of model predictions by testing forecasts against the observed evolution of climate from season to season and year to year, and also verify that our models accurately reproduce the present climate. Through this process, we can improve our prediction skill and develop confidence in model results.

Climate research is expected to provide a service to society. To deliver this service effectively, we need to determine the rate and timing of future climate warming and the impact on the global hydrological cycle; we need to predict not only global mean changes, but also regional variations and changes in the frequency and severity of extreme weather events. In consideration of the quantity of carbon dioxide and other greenhouse gases already added to the atmosphere, we can assert that some climate warming is inevitable. Climate scientists work to provide the information that society can use for adaptation to and amelioration of the consequences of this warming. **The World Climate Research Programme is the international scientific programme which has been established to provide a quantitative understanding of climate and predictions of global and regional climate changes on all time scales.**

In the following, a review of our knowledge of global climate change is presented. Although the World Climate Research Programme is concerned with all kinds of climatic variations, the emphasis of this review is climate change expected to occur during the next century due to the accumulation of greenhouse gases in the atmosphere.

G.A. McBean

A.D. McEwan

Chairman

Chairman

Joint Scientific Committee for

Committee on Climate

World Climate Research Programme

Changes and the Oceans

OVERVIEW

The climate of the world is a dynamic regime subject to natural variations on all time scales and to possible alteration by human activities. Climate is known to have varied between glacial and interglacial conditions over the past million years, due to only small changes in the amount of solar radiation absorbed by the earth. The problem of predicting future climate change, induced by man's activities, cannot be separated from that of understanding and predicting natural variations. The World Climate Research Programme (WCRP) has been established by the International Council of Scientific Unions and the World Meteorological Organization to address both problems.

Greenhouse gases reduce the amount of earth's radiation that escapes to space, with consequent warming of the lower atmosphere and the earth's surface. The concentration of the most important greenhouse gas, carbon dioxide, has already increased by 25 per cent since the beginning of industrialization. This increase results from deforestation, causing an imbalance between the absorption and release of carbon dioxide by vegetation, and from the combustion of fossil fuels extracted by man from the earth's interior. Other greenhouse gases, also found in the atmosphere in

increasing amounts, are methane, nitrogen oxides and, especially, chlorofluorocarbons. Uncertainties on emissions of greenhouse gases entail corresponding uncertainty on future atmospheric concentrations and attendant greenhouse warming. Anthropogenic emissions are but small increments on the large exchanges which occur naturally between the atmosphere and the oceans or the land, and thus relatively minor adjustments in these natural fluxes could significantly affect the future concentration of greenhouse gases. The International Geosphere-Biosphere Programme, the Joint Global Ocean Flux Study and the World Climate Research Programme are working on this problem.

Currently, the accumulation of greenhouse gases in the atmosphere is proceeding at a rate such that their combined effect will reach a level equivalent to doubling the pre-industrial concentration of carbon dioxide by the middle of the next century. Nevertheless, the change in the earth's climate over the last hundred years has been substantially less than could be inferred directly from the change in the radiation budget at the surface. One reason for this is that the climate system is constituted by a "fast component" and a "slow component". The fast component is controlled by

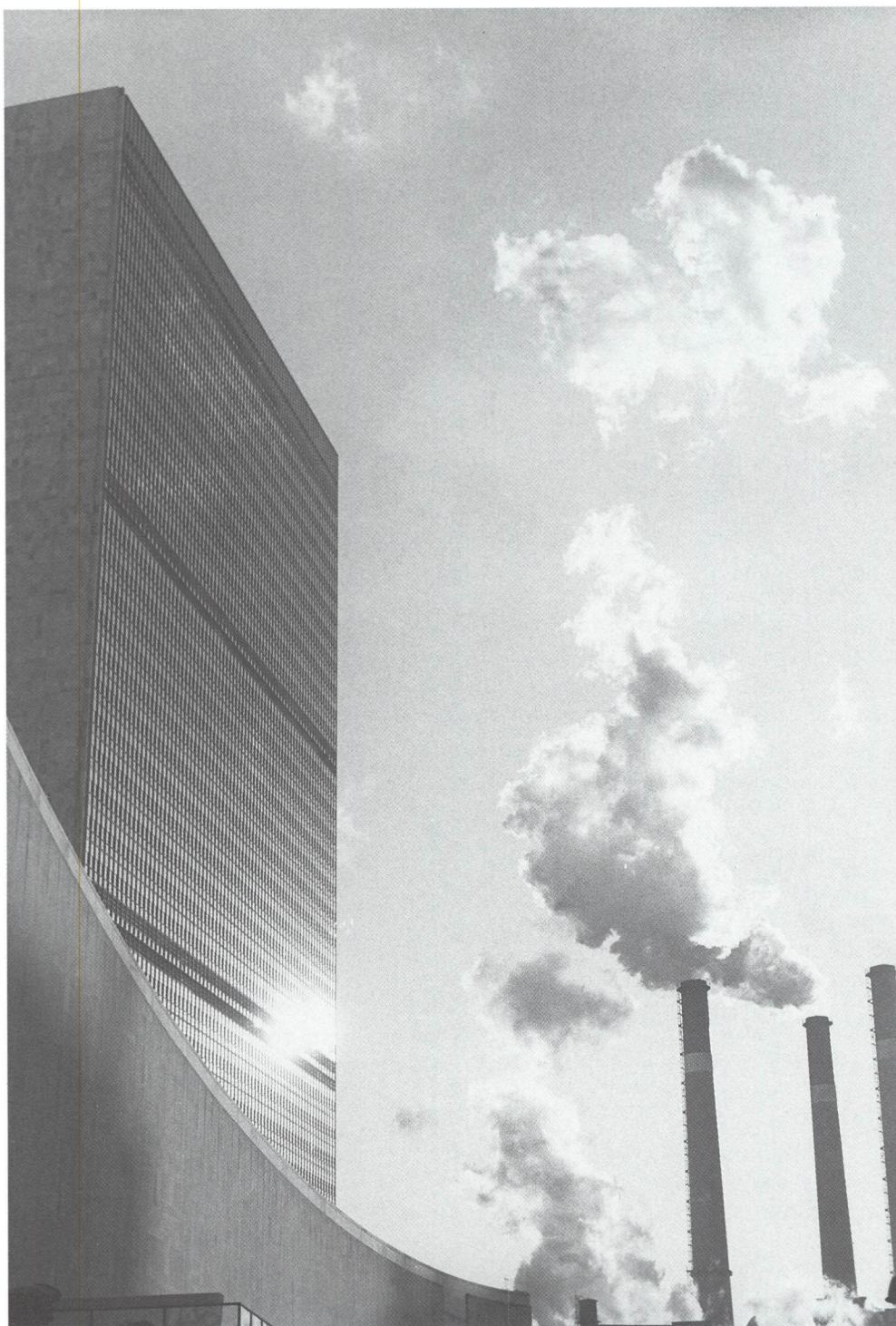
the atmospheric and upper-ocean heat engine which drives the whole earth environment and determines the ultimate amplitude and geographical patterns of climate change. The slow component is controlled by the global ocean which sets the pace for climatic change and may introduce delays of 50 years or more in the transient response of the earth's climate to greenhouse forcing.

Adjustments in the fast climate system are very complicated and involve feedback processes which amplify or reduce the primary greenhouse effect. Present climate models of the atmosphere coupled to a shallow ocean indicate a global mean warming of 3 to 5°C for the modified steady-state climate which would obtain with a doubled concentration of carbon dioxide. A major unresolved problem is that of predicting accurately the effect of clouds on the earth radiation budget. Another outstanding problem is that of predicting the global and regional changes in the precipitation and water resources. Altogether, these unsolved problems are the root of considerable uncertainty in the sensitivity of climate to a specified change of atmospheric composition. The WCRP Global Energy and Water Cycle Experiment is designed to study these processes and to incorporate them into a consistent representation of the earth's fast climate system.

If the fast system alone was involved in climate change, the computed earth's climate change would now be a global warming of 1 to 2°C. Observational evidence shows that this is not the case. The

probable reason is that the ocean, which has its own complex dynamics and feedback processes, has delayed climate change. By the same token, warming will continue toward a new quasi-steady climate long after the composition of the atmosphere is stabilized. Regardless of ongoing efforts to control emissions of greenhouse gases, the global warming to which we are already committed will be realized in the next fifty to hundred years. Global environmental change is inevitable.

The evolution of the earth climate over the next fifty years will result from ongoing natural variations combined with a warming trend forced by anthropogenic modifications of the atmospheric concentrations of greenhouse gases. At present, the trend cannot be distinguished unambiguously from natural transient climate changes. However, it must be expected that the warming trend will accelerate in the future, possibly up to 0.3 or 0.4°C per decade. This would be a faster change than any sustained temperature trend known to have occurred in the past. A central objective of climate research is to assess the delay introduced by ocean processes in the response of the earth climate, and to determine the timing of future change induced by greenhouse gases. The WCRP World Ocean Circulation Experiment is designed to acquire the basic information needed to understand quantitatively these oceanic processes and to predict the response of the whole climate system, including the global ocean.



*Photo:
United
Nations/
A. Travis/
Ara.*

A large fraction of year-to-year climate variability can be traced to the interaction between the atmosphere and oceans in the tropics. The WCRP has launched and is pursuing the Tropical Ocean and Global Atmosphere (TOGA) research programme to study and predict transient variations associated with

the El Niño phenomenon and other features of tropical climate.

Ultimately, characterizing the spatial structure and time signature of natural variations will be the key to an early detection of change in the earth climate, induced by man's activities.

THE WORLD CLIMATE RESEARCH PROGRAMME

Although climatic variations and their economic impacts are seen from year to year and from region to region around the earth, the problem of both natural and man-induced climate change is global and its study is beyond the resources of any one country. It follows that scientific initiatives bearing on this problem must effectively be planned as contributions to internationally co-ordinated programmes such as the World Climate Research Programme and the International Geosphere-Biosphere Programme.

The World Climate Research Programme (WCRP) was established in 1979 as a joint undertaking of the International Council of Scientific Unions (ICSU) and the World Meteorological Organization (WMO), to determine to what extent climate can be predicted and the extent of man's influence on climate. For carrying out this task, the WCRP receives the help of many national and international organizations besides WMO and ICSU. In particular, the Unesco Intergovernmental Oceanographic Commission (IOC), ICSU's Scientific Committee on Oceanic Research (SCOR) and their joint Committee on Climatic Change and the Ocean play the major role in the organization of oceanographic projects in the WCRP.

Achieving the objectives of the WCRP requires quantitative understanding of the physical climate system, constituted by four major components:

- The **global atmosphere** which is the most rapidly varying component and also the most energetically active since it is the heat engine that drives the whole climate system and, in particular, the global water cycle.
- The **world ocean** which interacts with the overlying atmosphere on periods of months to years within its superficial layers, while the deeper ocean responds over periods of decades to centuries.
- The **cryosphere** which comprises the continental ice sheets and ice caps, mountain glaciers and sea-ice.
- The **land surface** of the continents with its surface and groundwater flow systems that control evaporation from land and water storage in the ground.

The WCRP incorporates all internationally co-ordinated research activities that are being pursued to study the physical climate system of our planet.

In particular, the WCRP has instituted three major projects to investigate climate change mechanisms which can be studied within a subset of the overall climate system. These projects are:

- The study of **Tropical Ocean and Global Atmosphere** (TOGA) interactions, which are at the root of the principal mode of climatic variation from year to year, namely the Southern Oscillation and the associated El Niño phenomenon.
- The **Global Energy and Water Cycle Experiment** (GEWEX) to study, model and predict the transport and exchanges of radiation, heat and water within the atmosphere and at the earth surface, as well as the impact of climate change on global and regional rainfall regimes.
- The **World Ocean Circulation Experiment** (WOCE) to provide, for the first time, almost simultaneous observations of all oceans, as a basis for the development of realistic mathematical models of the global ocean circulation and heat transport, similar in principle to those which exist for the atmosphere.

Further developments planned by the WCRP also include long-term monitoring of the ocean volume (sea-level) and circulation, systematic measurements of the sun energy output and the earth radiation budget, and the surveillance of polar sea-ice and ice-caps. Scientific work is constantly pursued to refine the formulation of **numerical models** of the earth climate system, which provide the most effective tool for integrating the observations from diverse sources into a consistent global picture and for exploring the range of possible future climatic variations.

The WCRP co-operates with the International Geosphere-Biosphere Programme (IGBP) of ICSU to introduce the chemical, biological and ecological dimensions into model and field studies of the earth system. The IGBP was initiated by ICSU in 1986 to describe and understand the interactive physical, chemical and biological processes that regulate the total earth system, the unique environment that it provides for life, the changes that are occurring in this system and the manner in which they are influenced by human activities. A central objective of the IGBP is to establish the scientific basis for quantitative assessments of changes in the earth's **geo-biochemical cycles**, which control the concentration of carbon dioxide and other molecules in the atmosphere. While the emphasis in the IGBP is on bio- and geo-chemical aspects and in the WCRP on physical aspects, both promote activities to further advance our knowledge of the total earth system. Together these two programmes constitute the international framework of the quest for a scientific understanding of global change.

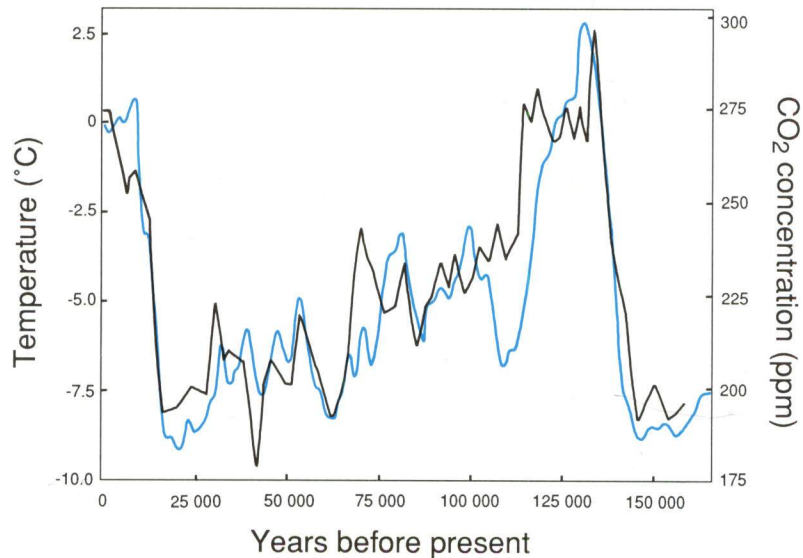
OUR CHANGING CLIMATE

Few scientific issues in recent years have attracted greater public interest and political attention than the increase in the atmospheric burden of carbon dioxide and other gases, and possible consequences for the earth's climate. In order to consider this phenomenon in the proper perspective, one must first recognize a fact long known by climatologists, namely that climate is not a static feature of the earth environment.

Climate is a dynamic regime subject to **natural variations** on all time-scales, from years to millenia, as well as possible alteration by human activities.

Many scientific clues can be found which indicate that past climates have been quite different from the present. The best information we have about paleoclimates is that which describes the most recent glacial cycle, the last of a series of

*Figure 1.
Paleoclimatological
record of
temperature
change with
respect to modern
climate (coloured
line) and
atmospheric CO₂
concentration
(black line) over
Antarctica during
the last glacial cycle (adapted
from Barnola et
al., 1987).*



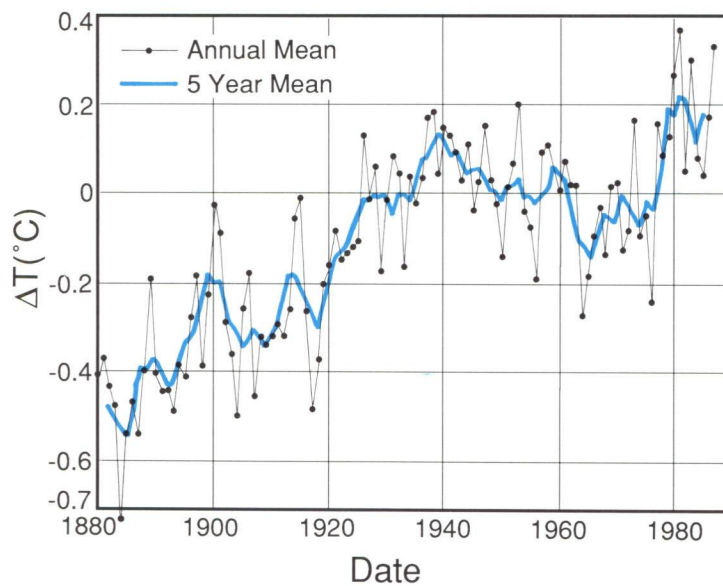


Figure 2. Record of global-mean air temperature change at the surface of the earth (adapted from Hansen and Lebedeff, 1987).

quasi-periodic variations which have occurred at about 100,000 year intervals over the past two or three million years. These variations are related to changes in the orbital parameters of the earth, according to the theory first proposed by Milankovitch (Berger, 1984).

One of these astronomical phenomena is the recurrent variation of the eccentricity of the earth's elliptical orbit around the sun, with a period of about 100,000 years. This phenomenon causes a 0.2% variation in the amount of solar radiation intercepted by the earth, equivalent to a 0.7 Watt/m^2 change in the primary solar energy input which drives the earth

atmosphere and oceans, compared to a mean annual value of 342 Watt/m^2 averaged over the globe. Such a small change in the solar radiation flux must be considerably amplified by the earth climate system in order to induce such profound changes in climatic conditions as occurred in the transition to an ice age.

The ice sheets of Antarctica and Greenland preserve the climatological history of the last ice age. The isotopic composition of the ice from a 2000 metre deep ice core, drilled at the Soviet Vostok Antarctic station, allowed Barnola et al. (1987) to estimate the air temperature at this location over the past 150,000 years. This is shown as the coloured line in Figure 1. Small air bubbles

THE TROPICAL OCEAN AND GLOBAL ATMOSPHERE STUDY

The Tropical Ocean and Global Atmosphere (TOGA) study is a ten-year programme, led by the WMO/ICSU Joint Scientific Committee for WCRP in co-operation with ICSU's Scientific Committee on Oceanic Research, the Unesco Intergovernmental Oceanographic Commission and their joint Committee on Climatic Changes and the Ocean.

The objectives of TOGA are to achieve a description of large-scale transient variations of tropical ocean basins and the global atmosphere, to determine the extent to which this system is predictable on time-spans of months to several years, to understand the mechanisms underlying this predictability and to develop the means, both field observations and coupled atmospheric-oceanic models, to achieve effective predictions. The main scientific targets of the TOGA programme are the **El Niño/Southern Oscillation** phenomenon and the variations in the **monsoon** regime from month-to-month and year-to-year.

TOGA has initiated a range of specific projects to establish or complement oceanic and atmospheric observing systems in the tropical zone and the southern hemisphere. These projects include launching temperature probes from merchant vessels to provide systematic bathythermographic sections every month or every second month along selected shipping routes across the three tropical ocean basins, surface pressure and temperature measurements from automatic drifting buoys in the southern hemisphere, real-time acquisition and transmission of tide-gauge data, and upper-air wind observations at several island stations along the equator, working toward the implementation of an operational observing system in the framework of the World Weather Watch and the Integrated Global Ocean Services System. Data from TOGA systems and existing operational networks already serve as a basis for experimental predictions of El Niño or similar events in the tropical Pacific, using coupled atmosphere-ocean models. Other global modelling studies are being pursued to investigate, in particular, the sensitivity of the global atmosphere to localized anomalies in sea-surface temperature and the variability of monsoonal regimes.

Furthermore, TOGA is fostering renewed interest in the physics of meso-scale air-sea interactions in the tropics, and is planning a major field study of these complex processes in the sensitive west tropical Pacific region where the warmest ocean waters on earth can be found and where total annual rainfall currently reaches 6000 millimetres.

To learn more about TOGA, see: Scientific Plan for the Tropical Ocean and Global Atmosphere Programme (WCRP Publications Series No. 3, WMO Geneva, 1985) together with its addendum, Science Plan for the TOGA Coupled Ocean-Atmosphere Response Experiment.

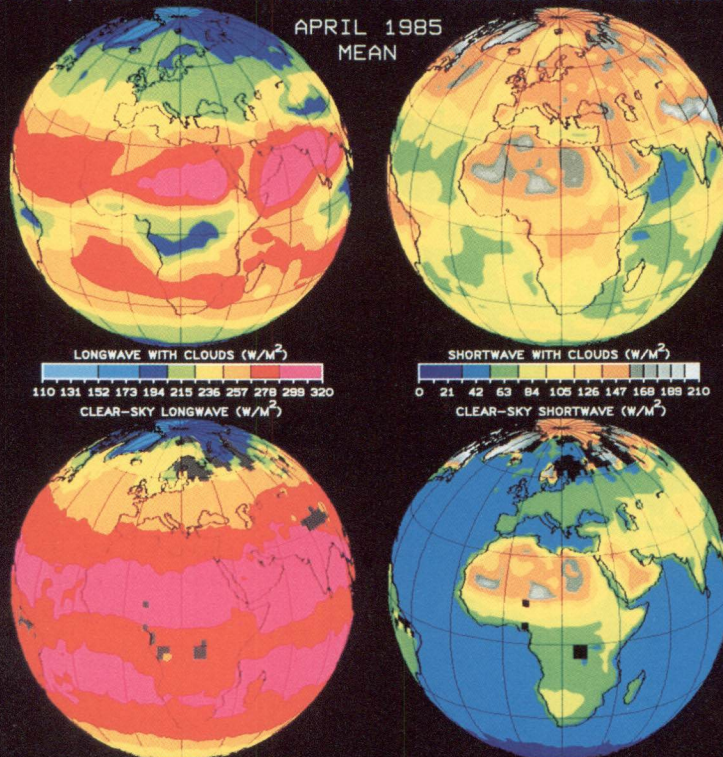
are trapped in the ice sheet as it is formed from accumulated snow and the concentration of carbon dioxide (CO₂) in these bubbles can be analysed as shown by the black line in the same figure. The Antarctic air temperature and the CO₂ concentration rise and fall together.

At the end of the last ice age, the air temperature was some 10 degrees colder and the CO₂ concentration nearly 100 ppm less than modern values before the beginning of

industrialization. The rises of CO₂ and temperature 15,000 and 140,000 years ago are remarkable. We do not know the processes by which the terrestrial biosphere or the ocean have caused this change in CO₂ concentration but we know that worldwide cold glacial climates could not have existed without the weakening of the greenhouse effect caused by the reduction in the amount of atmospheric CO₂.

WCRP/NASA EARTH RADIATION BUDGET EXPERIMENT

APRIL 1985
MEAN



DATA BY NASA LANGLEY RESEARCH CENTER
GRAPHICS BY NASA GODDARD INSTITUTE FOR SPACE STUDIES

The climate system also shows significant variations on time-scales of years to centuries. Figure 2 (on page 11) shows an estimate of global mean surface air temperatures during the past century, compiled from observations over both land and oceans by Hansen and Lebedeff (1988). This record indicates not only a noticeable warming of the earth's surface during the last hundred years but also ongoing climatic fluctuations of comparable amplitude, which do not constitute a long-term trend and must be ascribed to the natural variability of the atmosphere-ocean-ice system. The problem of predicting future climate change induced by man's activities cannot be separated from that of understanding such natural variations.

Climate research has already made significant progress towards developing the capability for actual predictions of fast (interannual) transient climate variations, from observed initial conditions. Predicting the El Niño/Southern Oscillation phenomenon, caused by dynamic and thermodynamic interactions between the atmosphere and tropical oceans, is the central objective of the Tropical Ocean and Global Atmosphere (TOGA) programme of the WCRP. Achieving even this relatively modest objective is by no means a simple task as many complex atmospheric and oceanic processes are involved, from individual clouds and storms to basin-wide oceanic waves.

THE GREENHOUSE EFFECT

Many human activities, both agricultural and industrial, are causing the emission of increasing quantities of polyatomic molecules into the atmosphere.

As a result, the concentration of these chemical substances in the air has already risen substantially and continues to rise. In particular, the atmospheric concentration of carbon dioxide has increased by 25% over the period 1740 to 1980 (Figure 3). Polyatomic molecules generally absorb infrared radiation and thus contribute to the greenhouse effect of the atmosphere by reducing the amount of far-infrared radiation emitted by the earth surface which escapes to outer space. For this reason these substances are called **greenhouse gases**. We know that the greenhouse effect causes a general warming of the lower atmosphere and earth surface, and a compensating cooling of the upper atmosphere.

The greenhouse gases, primarily water vapour and carbon dioxide, play a crucial role in **regulating the temperature of the earth** and the earth's atmosphere. In the absence of these gases, the average surface temperature would be 33 degree Celsius colder, -18°C instead of the present value of $+15^{\circ}\text{C}$, and the earth would be a frozen lifeless planet. The natural greenhouse effect of the atmosphere is an essential

component of the regulating mechanism which has maintained the earth's climate within a range suitable for the development of life in the course of four billion years. However, there is now concern that tropospheric temperatures will rise further due to steadily **increasing concentrations** of the various greenhouse gases.

Well-established methods exist to compute the increase in the primary greenhouse effect, i.e., the net energy gained by the earth, for various specified contributions of greenhouse gases, in the absence of clouds and before the earth's climate can adjust to the new conditions. These computations show that the excess carbon dioxide already accumulated since the beginning of the nineteenth century has enhanced the radiative heating of the planet by 1.3 Watt/m^2 , on the average over the whole earth surface. This value rises to 2.2 Watt/m^2 when the other absorbing gases are also taken into account. Doubling the concentration of carbon dioxide (from 300 to 600 ppm) would yield a net radiative heating of about 4 Watt/m^2 (Ramanathan, 1988).

While carbon dioxide is generally regarded as the main cause of the increased radiative heating of the planet, any gas which absorbs

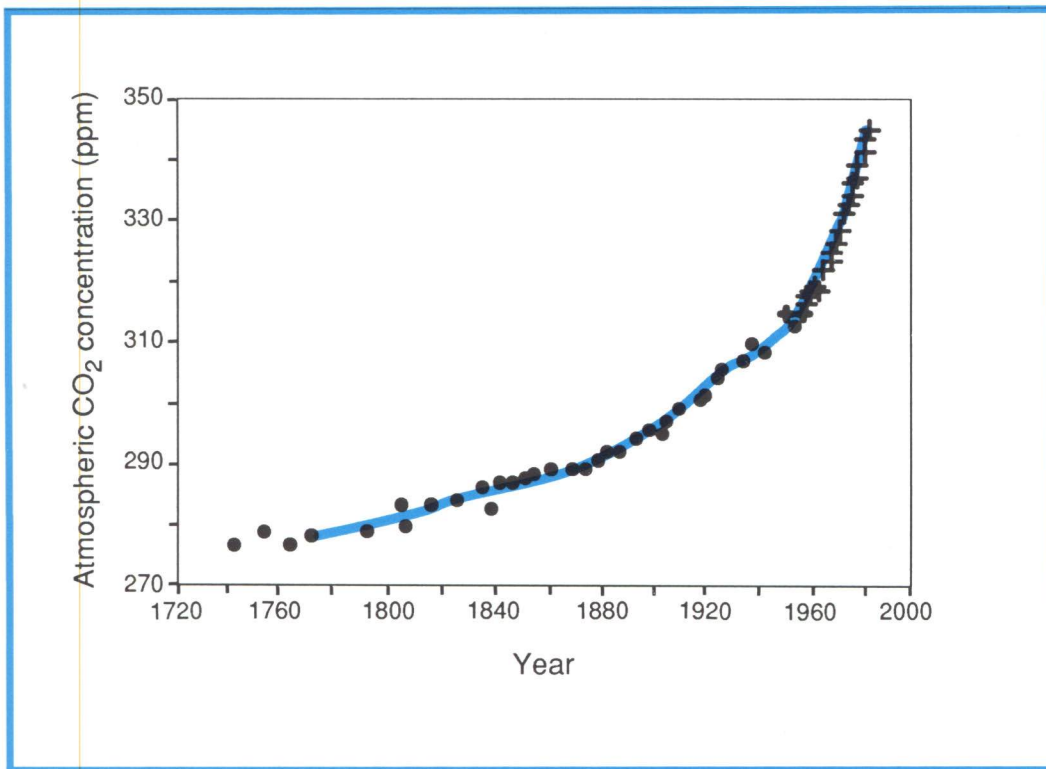
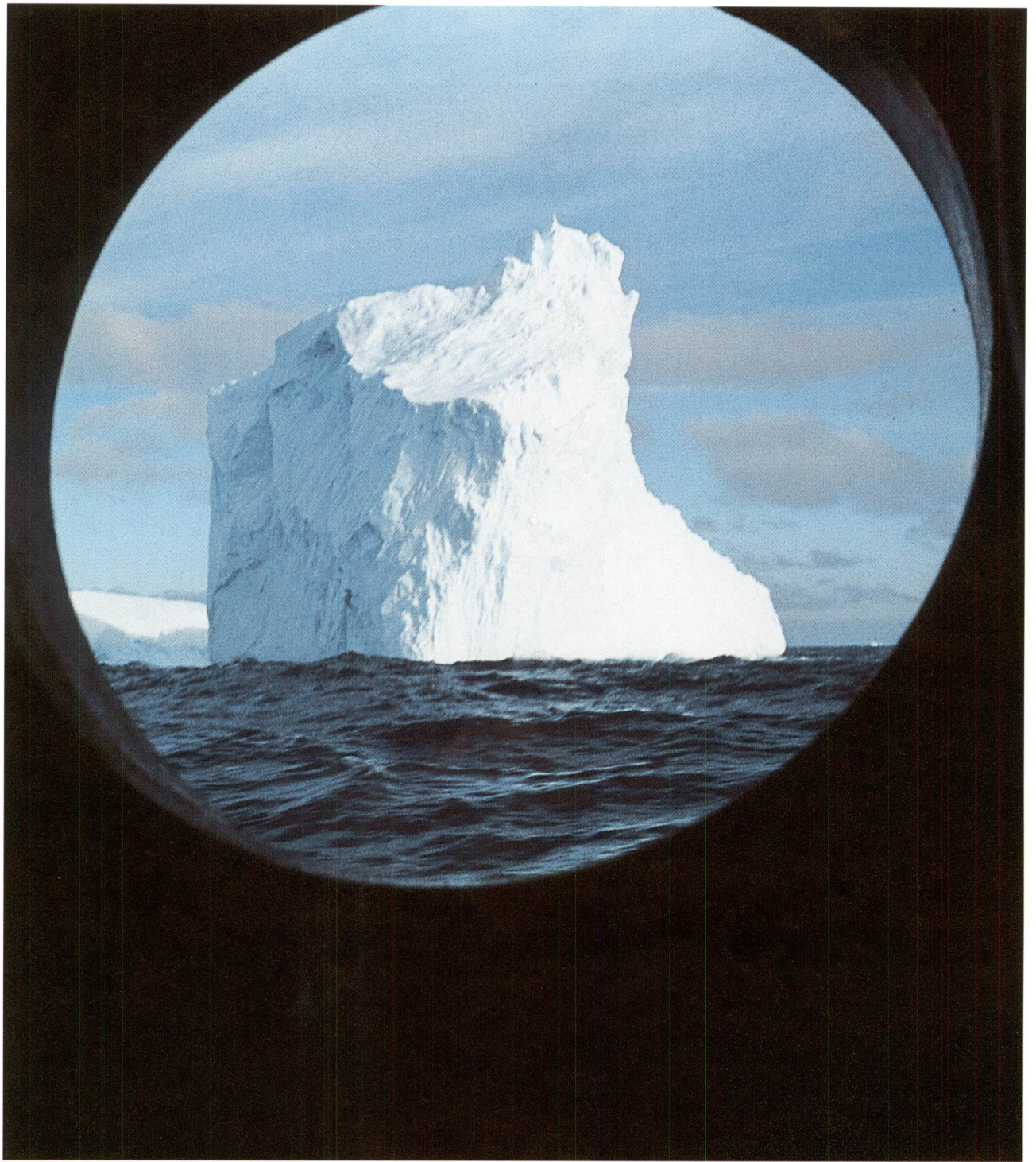


Figure 3. Record of the atmospheric concentration of carbon dioxide (adapted from Siegenthaler and Oeschger, 1987). Circles refer to the composition of air bubbles trapped in Antarctic ice. Crosses are annual values measured at the Mauna Loa Observatory.

infrared radiation contributes to the greenhouse effect. Because the existing amount of carbon dioxide in the atmosphere already absorbs most of the radiation in its particular wavelength range, absorption by other gases at different wavelengths has a disproportionate importance in the overall greenhouse effect. For this reason, an increase in the methane content has 25 times the effect of adding the same number of CO₂ molecules, and freons have an effect 10,000 times greater than CO₂ (Ramanathan et al., 1985). Figure 4 shows the contributions by various

gases to the increase in radiative heating of the earth during each successive ten-year period since 1830 (adapted from Hansen et al., 1988). Altogether, it is estimated that the excess greenhouse heating due to all absorbing gases is now increasing more or less linearly with time, although the concentration of carbon dioxide may be rising exponentially (Figure 3). Unless yet unknown mechanisms can counteract this increase, humanity will eventually face a significant warming of the earth's climate.



FUTURE TRENDS

FUTURE TRENDS IN GREENHOUSE GAS CONCENTRATION

Future trends in the concentration of carbon dioxide (CO_2) and other greenhouse gases can only be surmised on the basis of assumed rates of continued release into the atmosphere. Excess carbon dioxide originates primarily from the combustion of fossil fuels for energy production. Proven reserves of fossil fuels are sufficient to allow extraction at the present rate for at least 30 years in the case of oil and more than 200 years for coal, so that

consumption in the near future will not be limited by the available supply. Furthermore, the exploitation of fossil carbon deposits is an essential component of the world economy: in 1988, 88% of all commercial energy production was based on the combustion of fossil fuels, the rest being provided by hydroelectric plants (7%) and nuclear reactors (5%). No convincing technological scheme has yet been proposed to reduce the atmo-

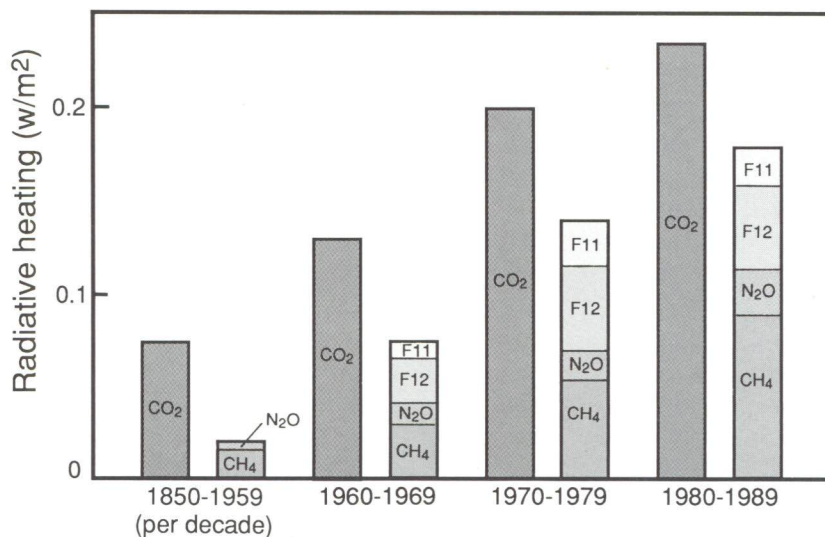


Figure 4. Computed decadal increments of the heating due to increases in the concentration of various greenhouse gases in each successive ten-year period (adapted from Hansen et al., 1988). F 11 and F 12 are the two most common chlorofluorocarbons.

spheric CO₂ burden and it may well be that any effort to scrub CO₂ from the air would consume more energy than was obtained from the combustion of fossil carbon in the first place. The most ambitious actions proposed so far are only aiming at limiting the rate of emission, thus allowing a steady increase of the concentration of carbon dioxide in the earth atmosphere.

Methane is produced by anaerobic decomposition of vegetal materials in wetlands, rice paddies and also in the stomach of cattle, so that emissions are related to the development of agriculture and animal husbandry. Accordingly, methane concentration has been rising steadily for several centuries, keeping pace with the increase in the world population and expansion of the world economy. On the other hand, chlorofluorocarbons (CFCs) do not occur naturally: they are synthetic products used in various industrial processes and also as propellant gas for sprays. The uses of CFCs, now still increasing, can be regulated and their future abundance depends on the implementation of international agreements to limit production.

The atmospheric concentration of carbon dioxide, measured with great precision at stations such as the Mauna Loa Observatory, is now increasing at the rate of 1.4 ppm per year. This annual increase corresponds to the addition of 3.3

gigatons (billion tons) to the total mass of carbon contained in the atmosphere in the form of carbon dioxide. This is to be compared to the current **annual emission of 5.5 gigatons of carbon** in carbon dioxide molecules produced by the combustion of fossil fuels, plus an amount of the order of 1 gigaton resulting from the combustion or oxidation of wood and other biomass. Thus, only about 50% of the anthropogenic carbon dioxide emission remains in the atmosphere.

This additional emission is a small percentage of the large fluxes of CO₂ between the atmosphere, the ocean and the terrestrial biosphere during a seasonal cycle, and an even smaller fraction of existing reservoirs of carbon in ocean waters and sediments. Relatively minor adjustments in the world ocean circulation and chemistry, or in the life cycle of terrestrial vegetation, could affect significantly the amount of CO₂ in the atmosphere, even when emissions are stabilized. In particular, ocean warming is likely to decrease the absorption of carbon dioxide by sea water. Conversely, positive changes in the primary biomass production of the ocean could increase the oceanic CO₂ uptake and ameliorate the greenhouse effect significantly.

Current knowledge of oceanic and terrestrial biochemical processes is not yet sufficient to account quantitatively for exchanges between the atmosphere, ocean and land

THE JOINT GLOBAL OCEAN FLUX STUDY

The Joint Global Ocean Flux Study (JGOFS) is an internationally co-ordinated programme, organized by ICSU's Scientific Committee on Oceanic Research, to be carried out during the period 1990-2000. The objective of JGOFS is to understand the global bio- and geo-chemical cycling of carbon and other biologically important chemical elements, which play a major role in the global environment. An essential component of JGOFS is a suite of basic physical and chemical measurements, to be carried out along representative oceanic sections, in co-operation with the WCRP World Ocean Circulation Experiment. Also essential will be satellite remote sensing of ocean colour, to characterize the marine primary biomass production and the fixation of CO₂ by the ocean.

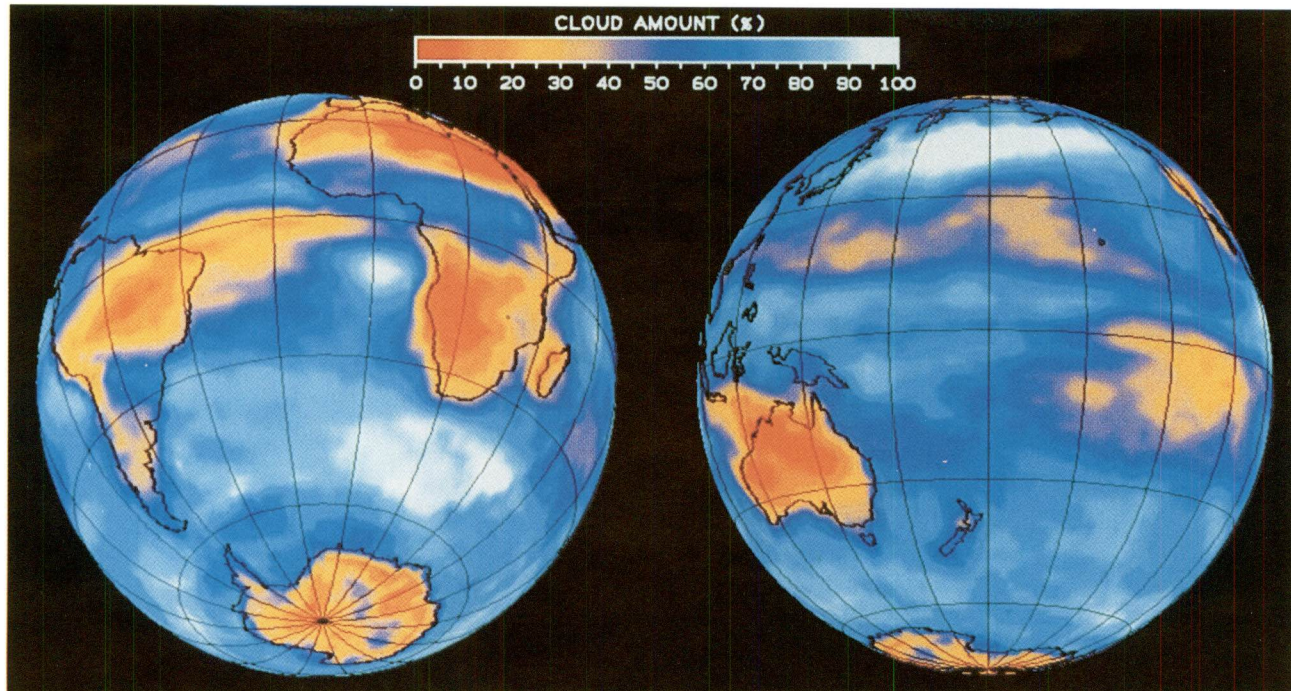
To learn more about JGOFS, see: Report of the International Scientific Planning Meeting for Global Ocean Flux Studies, ICSU, Paris (1987).

vegetation: the discrepancy may be as large as 1 gigaton of carbon per year. Scientists have undertaken the international Joint Global Ocean Flux Study (JGOFS) to investigate the oceanic geochemical and biochemical processes that determine the cycle of carbon in the ocean and to assess the capacity of the ocean for absorbing CO₂. The new scientific knowledge sought by JGOFS may be the key to future successful intentional human interventions to control the global carbon cycle and regulate atmospheric carbon dioxide.

In summary, the global budget of atmospheric CO₂ of anthropogenic origin is not well understood quantitatively. Until this problem is resolved, predictions of the proportion of future CO₂ emissions which will remain in the atmosphere will be subject to considerable

uncertainty. An even larger uncertainty lies in the future worldwide use of fossil fuels, for which estimates range from an annual increase of 1.5% to at least double this figure.

Under any circumstance, it is expected that considerable increase in the atmospheric concentration of most, if not all, greenhouse gases will occur in the next century. The working assumption adopted by the WMO/UNEP Intergovernmental Panel on Climate Change consists of three possible scenarios concerning the rate of increase of the total atmospheric burden. The high rate scenario is **equivalent to doubling the early 20th century concentration of carbon dioxide** (from 300 to 600 ppm) by the year 2030, the medium scenario by the year 2060 and the low rate scenario by the year 2090.



THE INTERNATIONAL SATELLITE CLOUD CLIMATOLOGY PROJECT

The International Satellite Cloud Climatology Project (ISCCP), is one of several systematic data collection and analysis efforts organized by the WCRP to derive essential climatological information. The objectives of the ISCCP, initiated on 1 July 1983, is to produce a continuous record of monthly mean cloud amounts and optical properties over the whole earth.

The properties of the cloud fields are described by more than eighty different parameters computed every month for each 2.5° latitude by 2.5° longitude box. To produce this information with appropriate time and space sampling, the project collects visible and infrared image data, produced **every three hours** by a multiple satellite array including one or two polar orbiting satellites and four geostationary meteorological satellites distributed around the equator. The vast task of assembling and processing these data from four different satellite systems, and extracting meaningful cloud parameters, is carried out by the NASA Goddard Institute for Space Studies in the USA.

To learn more about ISCCP, see Schiffer and Rossow, 1985.

THE CLIMATE RESPONSE

The earth climate has changed only minimally during the last fifty years, certainly much less than could be inferred directly from the imbalance of the radiative energy budget. The reason is that **the climate regime is determined by a fast system and a slow system.**

The fast system is controlled by the atmospheric “heat engine” which drives the whole earth environment and determines the ultimate amplitude and geographical patterns of climate change. The slow system is regulated by the global ocean which sets the pace for climatic change and may introduce a delay of 50 years or more in the transient response of the earth’s climate to greenhouse forcing.

It would be a serious mistake to imagine that the response of climate to the increasing greenhouse effect will be anything but complex. One may consider that the atmosphere and the upper-ocean layer (subject to an annual cycle of vertical stirring and mixing under the action of wind) constitute the fast component of the climate system. The fast component encompasses also transient processes at the air-land and air-sea interfaces, like the formation of snow and sea-ice. It is the active mechanism, the thermodynamic engine, which drives the whole climate system by transforming heat derived from the sun into kinetic

energy. The slow component, on the other hand, is constituted by the deep ocean and perennial sea- and land-ice: its response sets the pace of long-term climate trends and climate change.

Interactions between the fast and the slow components are relatively weak over most of the globe because mixing between the warm upper ocean and the colder and denser deep water is limited by the stable stratification of the ocean. The slow response is associated with the transfer of heat by upwelling and downwelling motion of ocean water and, at high latitudes, by the sinking of cold, dense water from the surface. The slow pace of downwelling and subsequent upwelling sets a timetable, decades to centuries, for the adjustment of the deeper ocean to changes of the fast system.

The Response of the Fast Climate System

By the simple device of including only a shallow layer of upper ocean water, numerical models of the fast component can be made to adjust quickly to any specified change of externally imposed conditions and nevertheless simulate realistic meteorological processes on all time scales from a few hours to several weeks, and seasonal variations. Numerical experiments have been carried out recently on this basis,

Modelling Experiment

Computed Annual Mean Surface Warming

Manabe and Wetherald (1987)	4.0°C
Hansen et al. (1984)	4.2°C
Washington and Meehl (1984)	3.5°C
Wilson and Mitchell (1987)	5.2°C

Table 1: Computed global mean warming of the earth's surface for a doubled concentration of CO₂, when the atmosphere has reached equilibrium with the ocean.

with a 50 or 60 metres thick upper-ocean layer (Washington and Mehl, 1984; Wilson and Mitchell, 1987; Manabe and Wetherald, 1987; Hansen et al., 1984). These experiments show that the fast component comes to a state of **climatic equilibrium** after some 5 years of simulated time, with stable mean properties and no systematic climate drift. Such experiments are therefore suitable for describing the complex re-adjustments which would occur in the atmosphere and at the surface of the earth as a result of artificially switching-on new environmental conditions such as doubling the concentration of carbon dioxide.

Adjustments in the fast climate system are very complicated and involve **feedback processes** which amplify or reduce the primary greenhouse effect. The combined result of these feedback processes is a considerable augmentation of the computed climatic response. The most significant re-adjustment is the increase in the amount of

atmospheric water vapour, which is itself a greenhouse gas. The next most significant feedback process is the change in the amount and distribution of clouds.

The response of the fast climate system affects all aspects of climate, in particular, the temperature of the lower atmosphere and earth surface. The **surface warming** varies with geographical location and season, but can be summarized by the global and annual average over the whole earth (Table 1).

The geographical patterns of temperature change appear broadly similar in all four simulations, with larger warming at high latitudes (up to twice the global average in the winter hemisphere) and lesser warming of the ocean compared to land. However, the predicted regional changes in temperature, and even more so precipitation, are very unevenly distributed and differ widely from one model to another. It is generally accepted that current models cannot provide reliable

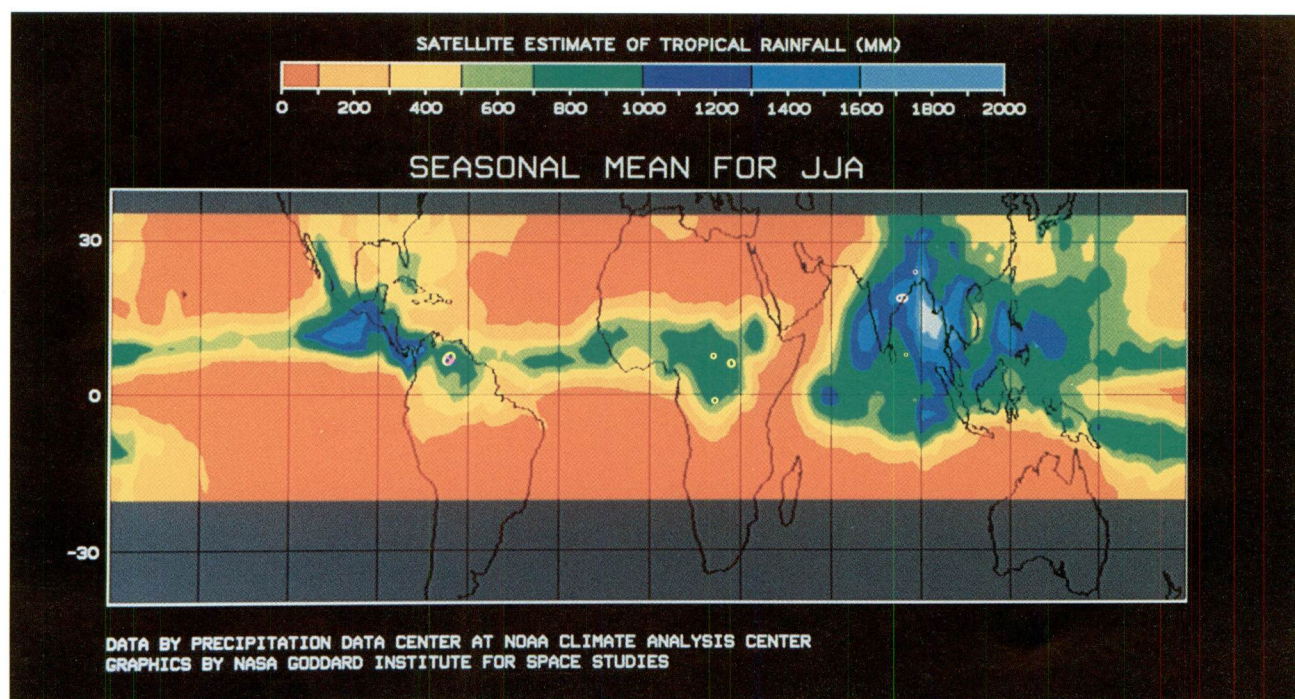
estimates of climate change on the regional scale.

The basic physical relationship between temperature and the saturation pressure of water vapour is such that a warmer climate entails a wetter atmosphere and thus a general **increase in precipitation**. On the other hand, a warmer climate results in **increased evaporation** and dryness, especially in the already arid sub-tropical belts. Some model simulations suggest that the increasing greenhouse effect will exacerbate soil aridity and the depletion of ground water in dry mid-continental temperate regions. One should recall, however, that ground water storage is a small difference between rainfall and evaporation, the latter being much dependent upon soil and vegetation properties, in models as well as in nature. A small and altogether plausible modification of assumed soil characteristics can make the difference between wet or dry soil predictions with a doubled CO₂ concentration (Mitchell and Warrilow, 1987).

The sensitivity of land hydrological processes to many poorly determined factors is, at present, an impediment to reliable computation of climate warming impacts on water resources. On the other hand, this very sensitivity is an indication that undesirable climatic impacts may be amenable to amelioration, at least in some regions, by appropriate treatment of soil and adaptation of vegetation. A central component of WCRP, the

Global Energy and Water Cycle Experiment, is aimed at elucidating these problems.

Finally, it should be emphasized that even the general agreement obtained for global mean warming in recent model studies may be more an indication of the evolving state-of-the-art than a real proof of accuracy. A major unsolved problem is that of predicting reliably **the effect of clouds on the earth climate**. Low-level clouds reduce the absorption of sunlight and tend to cool the earth, while high clouds are essentially transparent to sunlight but trap infrared radiation from the earth, thus contributing positively to the greenhouse warming of the surface. Not only is the cloud amount important to climate, but also cloud altitude and cloud optical properties. To illustrate this point, we note that a recent change made at the UK Meteorological Office, to introduce a more detailed formulation of physical and optical properties of ice and water clouds in their climate model, has yielded a drastically reduced estimate of global warming associated with a doubled CO₂ concentration, i.e. 1.9°C instead of 5.2°C as shown in Table 1 (Mitchell et al., 1989). The matter is made more difficult by the lack of reliable global statistics of observed cloudiness, cloud properties or precipitation, which could serve to calibrate existing climate models. The WCRP has undertaken the International Satellite Cloud Climatology Project to produce the required global cloud statistics.



The Response of the Slow Climate System

The model studies tell us that, if the fast system alone was involved in climate change, the earth climate would almost immediately follow the computed increase in greenhouse heating. Computations made with such simplified climate models indicate that the rise in greenhouse gases concentration already caused by human activities since the eighteenth century corresponds to a global surface warming in excess of 1.5°C . Such a highly visible climatological change has not occurred yet, as demonstrated by Figure 5, showing a 125-year time series of global mean sea-surface temperature compiled by Folland et al., (1984). As a matter of fact, it can be seen from this work that the mean ocean surface temperature during the period 1860-1880 was essentially the same as now, although a noticeable cooling and

subsequent warming occurred in the intervening period. The record of the global mean near-surface air temperature, combining measurements over ocean and land (Figure 2), indicates a definite warming trend, about $+0.6^{\circ}\text{C}$ over the last hundred years. However, most of the temperature rise was observed during the first fifty years from 1880 to 1930, although less than one third of the total greenhouse gas increase occurred during that period. Global warming for the period 1940-1990 has only been about 0.2°C . In short, it is clear that the real climate is behaving quite differently from the fast response of a planet with only a very shallow ocean, and **does not follow directly the trend in radiative heating** induced by the increasing greenhouse effect.

In simple terms, the response of the slow climatic system is

THE GLOBAL ENERGY AND WATER CYCLE EXPERIMENT

The Global Energy and Water Cycle Experiment (GEWEX) is a programme launched by the WCRP to observe, understand and model the hydrological cycle and energy fluxes in the fast component of the climate system. The goal of the programme is to reproduce and predict, by means of suitable models, the variations of the global hydrological regime and its impact on atmospheric and oceanic dynamics, as well as variations in regional hydrological processes and water resources, and their response to change in the environment such as the increase of greenhouse gases. The GEWEX programme incorporates a major atmospheric modelling and analysis component requiring a substantial increase in computer capabilities, especially because high spatial resolution is needed in climate models to achieve realistic simulations of regional effects.

The GEWEX programme has begun with an ensemble of modelling studies focused on both atmospheric and hydrological processes, such as reproducing the hydrology of a continent-size river basin driven by daily precipitation and evaporation estimates and field studies on the scale of a small region (10 to 100 km). The GEWEX programme has also undertaken assembling available rain gauge measurements and meteorological data with satellite observations of rain clouds, using either infrared images or microwave radiation, to produce the first climatological record of monthly-mean rainfall totals over the whole earth including, of course, the oceans.

It is clear that achieving the objective of GEWEX will require a major step forward in the development of global observing techniques using new, more massive and power-demanding satellite sensors, such as lidars and radars, which will be placed on the next generation of heavy earth observation spacecraft in polar orbit and/or the International Manned Space Station in the late 1990s. For this reason, the support of the major space agencies, particularly in the USA, Europe and Japan, is essential to the success of GEWEX. In addition, GEWEX also requires strong support from meteorological and hydrological agencies and institutions to upgrade the collection and interpretation of essential ground-based measurements of radiation, rain, riverflow, etc.

GEWEX has been formally endorsed by WMO and ICSU as a major component of the international climate research strategy, including the participation of the International Association of Hydrological Sciences. GEWEX and the IGBP programme on the biospheric aspects of the hydrological cycle are jointly planning interdisciplinary field studies.

To learn more about GEWEX, see: Concept of the Global Energy and Water Cycle Experiment, WCRP-5 (WMO Technical Document TD-215, Geneva, Switzerland).

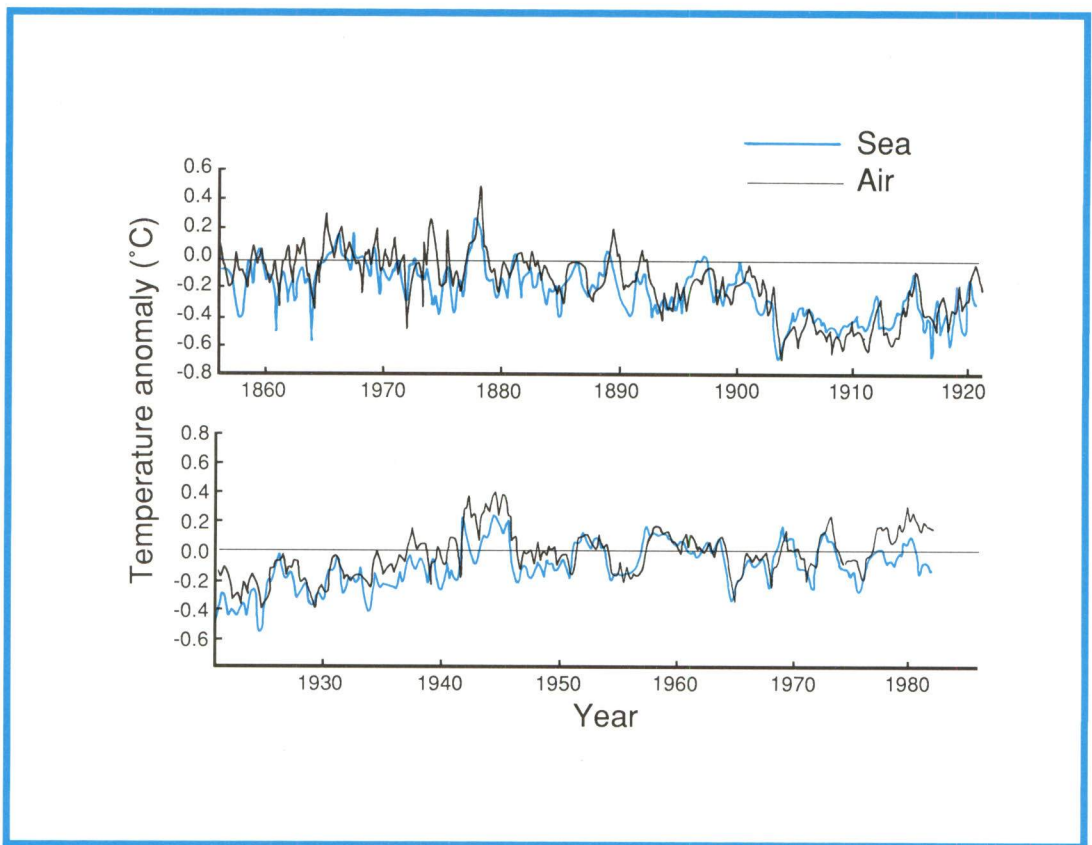


Figure 5. Record of the sea-surface and night-time air temperature anomalies (relative to the period 1951-1960) averaged over all oceans (adapted from Folland and Parker, 1984). The global mean sea-surface temperature during the last fifty years has not been markedly different from that prevailing around 1860.

controlled by two basic parameters: first, the change in the net energy flux at the surface of the ocean produced by the increase in the concentration of greenhouse gases and subsequent readjustments of the atmosphere and land surface, and second, the heat capacity of that part of the ocean which will be effectively subject to warming over a period of several decades. The first quantity can be estimated from suitably designed numerical

experiments with models of the atmosphere and upper-ocean layer only. The effective heat capacity of the ocean is determined by the **penetration of heat in deep water**. This penetration into the upper kilometre of the ocean cannot be represented by a simple diffusion process because it results, for the main part, from the sinking of water at mid-latitudes and subsequent equatorward and downward circulation in the ocean, itself

controlled by surface winds and surface cooling. The rate of renewal of water below the near-surface mixed layer can be inferred from the penetration of ^{14}C isotopes released into the atmosphere by the mid-1950s series of thermonuclear explosions (Figure 6). Such observations, combined with knowledge of the subsurface temperature/salinity structure and ocean circulation, allow the estimation of the residence time of water at different density levels.

Information about net surface heat fluxes and the world ocean circulation can be combined to estimate the characteristic response-time for realizing a given fraction (e.g. 70%) of the computed equilibrium surface warming after a constant double CO_2 concentration is introduced.

This “e-folding time” indicates the **delay of the response** of the whole climatic system, compared to that of the fast component alone. A wide range of values has been proposed

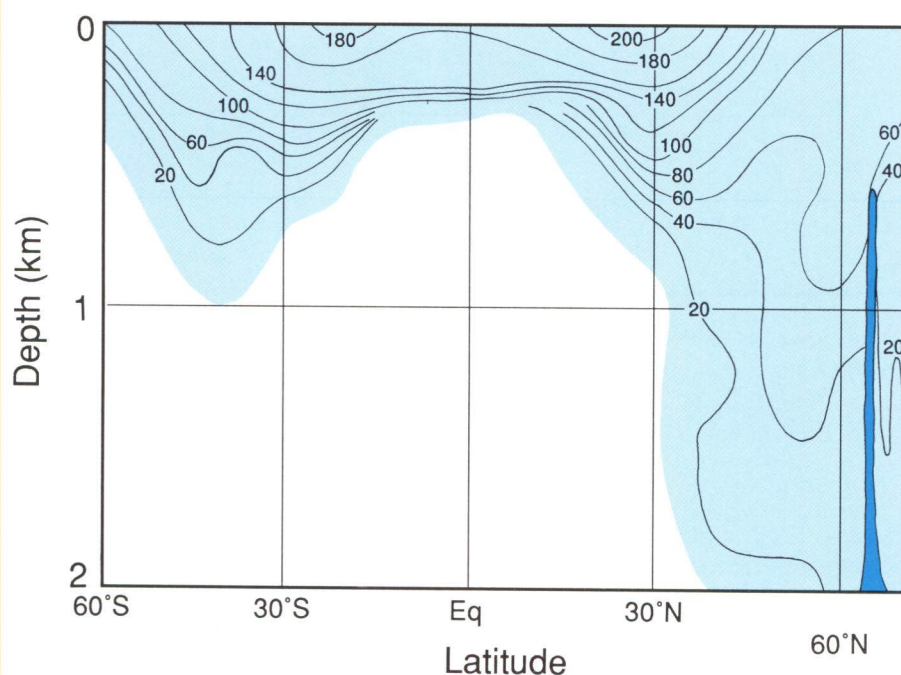


Figure 6. Penetration of the radioactive isotope ^{14}C from the time of the first thermo-nuclear bomb tests in the mid-1950s until the 1973 GEOSECS survey in the Atlantic ocean (arbitrary radioactivity units). Mixing has occurred down to a depth of about 300 m in the course of twenty years, except at high northern latitudes where deep sinking occurs.

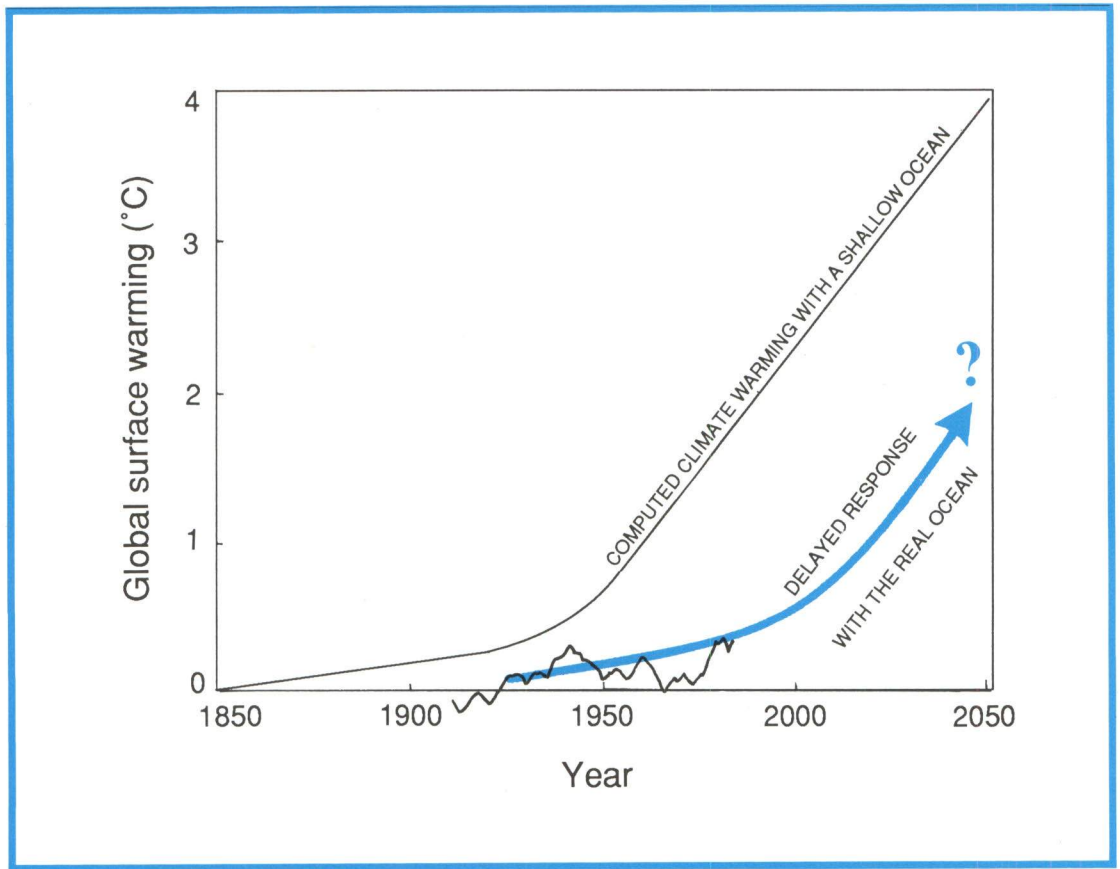


Figure 7. A possible climate warming scenario for the global atmosphere only (black line) and the complete earth climate system (coloured line). The observed global temperature record is shown on the same scale (Morel, personal communication).

for this e-folding time, from 10 to 100 years. Values derived from global ocean circulation models developed so far are in the upper part of this range: 75 -100 years for the Oregon State University model (Schlesinger et al., 1985) and about 50 years for the Geophysical Fluid Dynamics Laboratory model (Bryan et al., 1988).

Figure 7 compares the plausible response of the coupled atmosphere and ocean, with the computed change in earth surface temperature

for the atmosphere alone, given a linear increase of greenhouse heating equivalent to doubling the pre-industrial concentration of CO_2 by year 2050 (Morel, personal communication).

Deep water formation, renewing the water in the lower two kilometres of the ocean, occurs at high latitudes through surface cooling, formation of sea-ice and subsequent deep convective mixing. However, it is possible that surface warming (and permanent melting of sea-ice) would

THE WORLD OCEAN CIRCULATION EXPERIMENT

The World Ocean Circulation Experiment (WOCE) is a worldwide oceanographic programme, led by ICSU's Scientific Committee on Oceanic Sciences (SCOR) and the Unesco Intergovernmental Oceanographic Commission, and organized as a component of the WCRP, to determine the oceanic circulation at all depths and on the global domain, within a five-year period (1990-1995).

The primary goal of WOCE is to develop global ocean models that are useful in the prediction of climate change and to develop the data sets necessary to test those models. Over the five years of the programme, there will be an intensification of the effort to determine air-sea fluxes globally by combining marine meteorological and satellite data, an upper-ocean measurement programme to determine the annual and interannual oceanic response to atmospheric forcing, and a programme of high quality hydrographic and chemical tracer observations, surface and under-water drifters, current meter arrays, tide gauges and satellite altimetry to determine the zero order deep-ocean circulation. WOCE will also make intensive use of historical oceanographic data to assess the longer-term variability of ocean circulation.

All major oceanographic agencies and institutions are joining forces to deploy the research vessel fleet needed to implement the WOCE hydrographic and geochemical surveys at sea, which call for 25 years of ship operation time. In addition, three new satellite missions are in the final stages of preparation or are being planned to support WOCE:

- The US-French TOPEX/POSEIDON precision altimetry mission, to measure the ocean surface topography with unprecedented accuracy (1991);
- The European Space Agency ERS-1 mission to measure wave-height and ocean surface topography, wind stress and temperature (1991);
- The US-Japanese ADEOS mission to provide, in particular, more complete observations of the wind stress over the global ocean (1995).

In addition to observing activities at sea and in space, WOCE is planning a major oceanic modelling and data analysis activity, requiring a substantial increase in computer capabilities. Larger and faster computers are necessary to develop and run global eddy-resolving ocean models with sufficient vertical resolution, to adequately simulate the process of convection in the upper layers, the flow of deep water over sills and through passages and the eddy exchanges of momentum, heat and salt in the strong boundary currents of the principal ocean gyres.

To learn more about WOCE, see: J.D. Woods, 1985; also: World Ocean Circulation Experiment, Implementation Plan, Vols. I and II, WCRP-11 and 12 (WMO Technical Documents TD-242 and 243, Geneva, 1988).

suppress this sinking and essentially insulate the deep ocean water from the upper-ocean and atmosphere. The consequences of such an event would be catastrophic for marine life and would drastically reduce the buffering of further change by the ocean.

The World Ocean Circulation Experiment is a major worldwide oceanographic programme, undertaken under the WCRP, to achieve a global description of the ocean circulation and to establish on a firm scientific basis, the estimation of the transient response of the ocean to atmospheric influences.

PREDICTING SEA-LEVEL RISE

In past historical times, variations of the mean sea-level at a particular shore have been caused mainly by tectonic effects which force the **land to sink or rise** locally with respect to the global reference geoid, without much change in the mean ocean surface. The rapid increase in greenhouse gases and consequent climate warming is expected to cause, in the 21st century and thereafter, a global rise in mean sea-level resulting from an actual increase in the **volume of the world ocean** due both to the addition of meltwater from glaciers and polar ice caps and to the thermal expansion of sea water. An upper limit of 60 centimetres can be estimated for the rise in global sea-level expected by the end of the next century, but this estimate is fraught with large uncertainties.

Few coastal stations exist where long time-series of consistent sea-level measurements are available and these stations are not distributed evenly around the globe. For this reason, estimates of variation in the global mean sea-level can only be obtained for the last century. The latest and most rigorous analysis of tide-gauge data (Barnett, 1984) indicates a global rising trend of 14 cm per century with a tendency to accelerate in the last fifty years. There is no way to

relate this observed rise to possible causes with any degree of certainty.

If all mountain glaciers and small inland ice caps were to disappear entirely and add their meltwater to the ocean, they would cause the global sea-level to rise by only 33 cm. It is clear that the continuing retreat of mountain glaciers, begun two centuries ago, could not add much to the volume of the ocean, possibly a further 20 cm rise by the end of the 21st century. On the other hand, the interplay between snow accumulation on large ice caps and melting or iceberg calving, when ice discharge takes place into the sea, could in principle cause much more substantial excursions in global sea-level.

Ice budget estimates for the Greenland and Antarctic ice caps under the warmer climate conditions expected in the 21st century have been given in the review published by ICSU's Scientific Committee on Problems of the Environment (SCOPE, 1986).

Increased ablation is expected to dominate the ice budget of the Greenland ice cap, yielding a general decrease of the inland ice mass and a 13 to 26 cm rise in mean sea-level due to the release of meltwater during the next century. On the other hand, temperatures are and will remain well below freezing in

Antarctica, so that melting can be altogether neglected there.

The ice budget of the Antarctic ice sheet will therefore be balanced by snow accumulation and iceberg discharge into the ocean. Because the horizontal extent of the ice sheet is limited by the size of the Antarctic continent, barring a "fast" surge of the west Antarctic ice sheet, now solidly anchored offshore by submarine obstructions, the budget of the Antarctic ice cap under warmer climate conditions will be dominated by more abundant snowfall and increased accumulation, yielding a thicker ice cover and a consequent **lowering of mean sea level**, between -20 and -90 cm by the year 2100. For lack of more precise knowledge, glaciologists tend to the view that melting of the Greenland ice sheet and snow accumulation on the Antarctic ice sheet will counter-balance over the next century. This would leave a net contribution to sea-level rise of about 20 cm, coming mainly from the melting of mountain glaciers.

The global ocean, on the other hand, has been storing energy for several decades and may continue to do so at an even faster rate during the next century as the greenhouse effect increases. Since the variations of the thermal expansion coefficient are relatively moderate in the upper layer of the ocean, where most of the warming will take place, the linear

expansion of a water column is, to first order, independent of its depth and directly proportional to the total amount of heat stored in the column.

The problem of ocean thermal expansion is thus reduced to that of estimating the integrated heat intake of the world ocean over a particular period in the future, given a specific scenario for the increase of the greenhouse heating. Based on a full three-dimensional computation of the initial response of a coupled ocean-atmosphere model to doubling the concentration of CO_2 , Bryan and co-workers estimated a net heating rate of 2.5 Watts/m^2 (Bryan et al., 1988). This value has been obtained after adjustment of model properties in the troposphere and on the land surface (fast component of the climate system) but before significant adjustment of the ocean temperature (slow component). Since the ocean surface must warm up eventually, it is plausible that the imbalance, measured by the net energy flux at the ocean-atmosphere interface, should not exceed 2.5 Watts/m^2 during the next century. This line of reasoning places an upper limit of about 40 cm on the global sea-level rise which can be expected from thermal expansion of the oceans by the year 2100.

Critical elements in these estimations are the changes in the rate of snowfall over Antarctica and net energy flux at the ocean-

atmosphere interface under changing climate conditions. Both quantities are strongly dependent upon climate model assumptions and the accuracy of computed energy and water fluxes in the atmosphere. A major scientific objective being pursued by the WCRP is to determine these fluxes correctly. The planned Global

Energy and Water Cycle Experiment is the centrepiece of the scientific strategy to achieve this goal. In addition, detailed investigations will be required in the future to understand heat and water exchanges around the Antarctic continent and the mass budgets of the Greenland and Antarctic ice sheets and shelves.

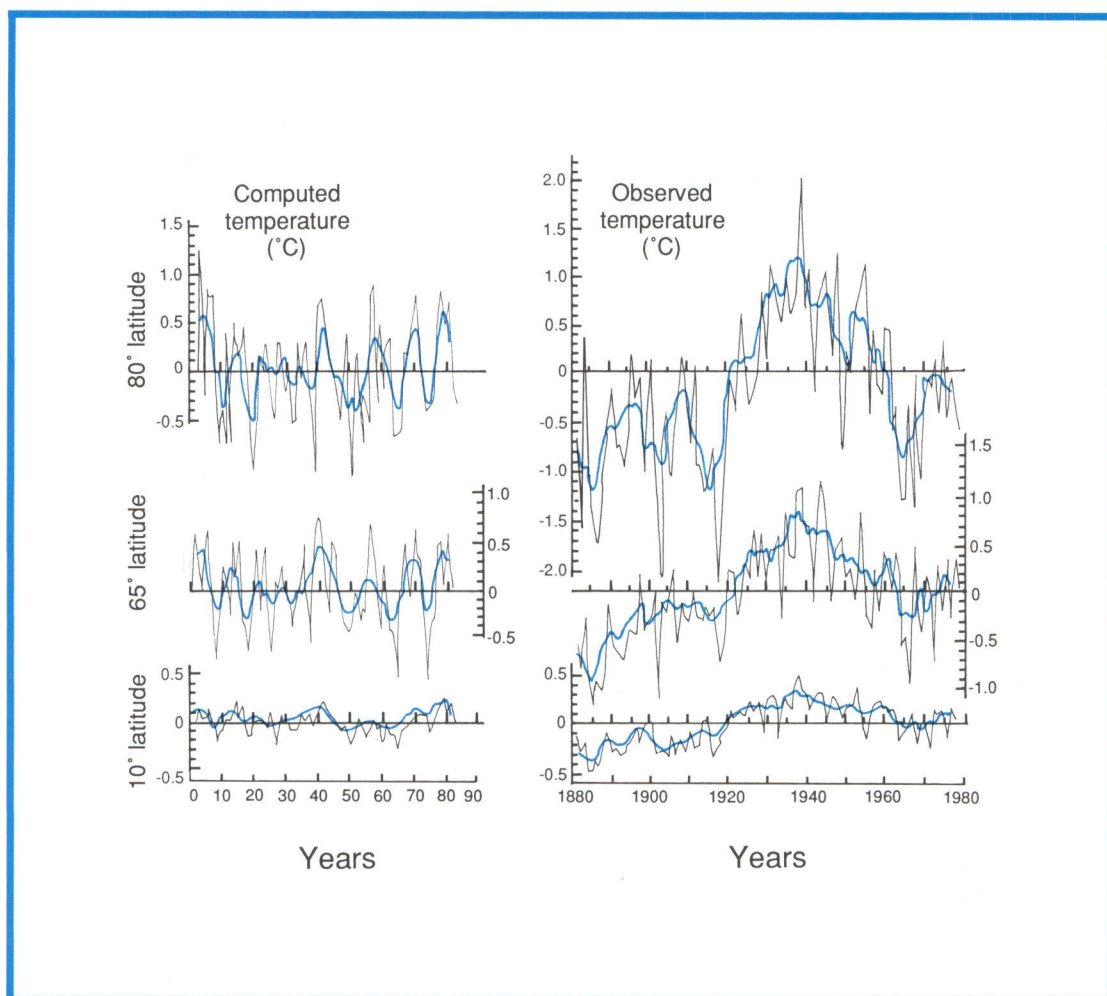


Figure 8. Zonal-mean temperature in the northern hemisphere, as computed by a global atmosphere-ocean model on the left hand panel and as observed on the right-hand panel, according to Mahlman (personal communication) and Vinnikov et al. (1980). The model simulation gives a reasonable facsimile of shorter-term climate variations but does not predict climate change resulting from (still unknown) processes of the deep-ocean circulation.

PREDICTING FUTURE CLIMATE CHANGE

The evolution of the earth climate in the next fifty years will result from ongoing natural variations combined with a warming trend forced by man-made modifications of the atmospheric concentration of greenhouse gases. Natural variations on relatively short time-periods of decades to a century will be caused by the internal dynamics of the earth's climate system. The warming trend, on the other hand, will be induced by the steady increase of the greenhouse effect in the atmosphere. Actual warming is being delayed by the thermal inertia of the world ocean, but it will also continue long after the composition of the atmosphere is stabilized. No matter how drastic the actions taken to control the emission of greenhouse gases into the atmosphere, the global warming to which we are already committed will be realized in the next fifty to hundred years; global environmental change is inevitable.

The warming realized so far is still well within the range of transient natural variations and cannot be separated from these with our present knowledge. It is possible, however, that the limits of natural variability could be exceeded in the next ten to twenty years.

The left-hand panel of Figure 8 represents the mean zonal surface temperature of the earth in various

latitude bands for the last period of a 200-year simulation of the earth's climate carried out at the Geophysical Fluid Dynamics Laboratory, Princeton, New Jersey (USA) with coupled models of the global oceanic and atmospheric circulations.

The computation reproduces fairly the observed climate variability on short time-periods (i.e. year-to-year or decade-to-decade) and also the latitude dependence of this variability which increases from the equator to the Arctic, as can be seen by comparing with climatological statistics compiled by Vinnikov et al. (1980), on the right-hand panel. The simulation, however, does not reproduce the substantial longer-term climate variations which have occurred during the last hundred years. This discrepancy was expected because, unlike the real climate, the simulated system was, by the very nature of the experiment, forced into an artificial state of climate equilibrium.

The experiment illustrates the fact that the real climatological history of the earth includes transient variations which involve, in an essential way, the behaviour of the deep ocean and substantial departures from equilibrium between the fast and the slow components of the earth climate system. Any attempt to predict the future

evolution of climate must include a forecast of the evolution of this slow component, starting from **observed initial conditions**. We are unable at present to carry out such a forecast for lack of suitably accurate ocean circulation models (not yet perfected) and even more so, for lack of an adequate synoptic (instantaneous) description of the global ocean circulation. The WCRP World Ocean Circulation Experiment (1990-1995) will be the first attempt to collect the observations needed to produce this kind of global description, which will be essential to discriminate the warming trend caused by the increase in the man-made greenhouse effect from transient natural variations.

For the purpose of estimating long-range climatic trends such as mean global warming, however, the climate system may be approximated by a simple conceptual model, consisting of a heat reservoir receiving cumulative annual net energy inputs. A property of this simple model is its long latency period during which the climate response to greenhouse forcing remains small, as observed now. However, after a delay of the order of the e-folding time, the pace of global warming

accelerates markedly and approaches that of the response to greenhouse heating of the atmosphere alone.

The **global warming rate**, consistent with an assumed equivalent doubling of the concentration of carbon dioxide by the year 2050 and an estimated 4°C equilibrium warming for this doubled concentration, is about 0.3°C per decade (Figure 7). A transient climate warming simulation experiment, reported by the Goddard Institute for Space Studies (Hansen et al., 1988), actually indicates a warming rate of 0.35°C per decade for a similar greenhouse gases scenario. This rate of global warming exceeds the fastest global temperature trend observed during any ten-year period since 1880 (Figure 2) and would soon cause a major departure from the prevailing climatic regime.

Detailed investigation into the dynamics and thermodynamics of natural transient climate variations, and quantitative computations of the response to the steady increase in greenhouse heating, is the approach WCRP is pursuing for detection of incipient warming and prediction of the future course of global and regional climates.

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