Originally Processed With FOIA(s):
2005-0336-F

FOIA Number:
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Series:	Bromley, D. Allan, Files
Subseries:	Global Climate Change Files

OA/ID Number:	62051
Folder ID Number:	62051-008

Folder Title:
President's 1990 International Environmental Initiative [1989]

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THE WHITE HOUSE

WASHINGTON

November 29, 1989

MEMORANDUM FOR THE PRESIDENT

FROM: DAVID Q. BATES
D. ALLAN BROMLEY

SUBJECT: Recommendations of the DPC Working Group on Global Change for President's 1990 Environmental Program

ISSUE

The Cabinet-level DPC Working Group on Global Change was first convened in October to formulate and coordinate United States policy on global warming and other selected environmental issues. The Working Group was recently assigned the task of developing options to fulfill the President's campaign pledge to host an international conference on the environment and to seize the initiative on the international environmental agenda. The group has developed a consensus recommendation for a series of three events to be held during 1990.

BACKGROUND

A. Campaign Pledge -- during the campaign you pledged to hold during your first year in office an international conference on the environment:

> "In my first year in office, I will convene a global conference on the environment at the White House. It will include the Soviets, the Chinese, the developing world as well as the developed. All nations will be welcome -- and indeed, all nations will be needed..."
>
> "The agenda will be clear. We will talk about global warming. We will talk about acid rain. We will talk about saving our oceans, and preventing the loss of tropical forests. And we will act."

B. IPCC Activity -- the U.S. participates in the U.N. Intergovernmental Panel on Climate Change (IPCC) as the principal international forum to address the issue of global warming:

> -- Key working groups are chaired by Great Britain on science, the Soviet Union on effects and the United States on response strategies.

-- U.S. will host the third plenary session of the IPCC in February, 1990, in Washington. The IPCC will meet in plenary session a final time in August, 1990, at which the completed reports of the working groups will be presented, leading up to the Second World Climate Conference in November, 1990.

-- You have stated that you expect the IPCC deliberations to lead, upon completion of the IPCC reports, to the negotiation of a framework convention on climate change.

RECOMMENDATIONS

The following series of events recommended by the Working Group on Global Change was developed within the context of the U.S. commitment to the IPCC and the accomplishments of the Administration on global warming (set forth in greater detail at Appendix A).

It should be noted that you will announce your budget in the State of the Union on January 30, 1990, which will include a number of environmental initiatives related to global warming. It is strongly suggested that the package described below be announced either in the State of the Union or in a major address directly before or after the State of the Union, whichever is appropriate.

I. The President's 1990 Environmental Initiative

The three events recommended below are packaged as a 1990 Presidential environmental initiative culminating in the President's International Conference on the Conservation of Nature.

A. **Address to the February, 1990 IPCC plenary session in Washington**

-- speech would explain U.S. policy on global climate change and promote the enormous investment the United States has made both in understanding the scientific elements of global climate change and in beginning to take mitigating action.

-- opportunity to assert the U.S. leadership role on global climate change and reinforce the U.S. commitment to the IPCC as the principal forum for addressing the problem.

B. **White House meeting on international environmental research**

-- attended by international delegations composed of the chief science official, chief economics official and chief environmental official from each nation.

-- focus of the meeting would not be on any particular environmental issues but on advancing the quality and understanding of the analytical tools for confronting environmental problems. Result would be a common integrated approach for use in future negotiations on environmental problems.

-- all or any parts of the deliberations could be attended by the President.

C. **President's International Conference on the Conservation of Nature**

-- President to host an international conference, in the tradition of Teddy Roosevelt, focused on the twin goals of the conservation of nature and sustainable development.

-- emphasis on energy conservation, biological diversity, reforestation, wetlands and oceans, highlighting as models successful domestic programs, international ventures (e.g., the pending U.S.-Brazil agreement for assistance in the management of Brazilian national forests, banning of ivory imports, and debt-for nature swaps), and future initiatives (e.g., the reforestation initiative to be announced in the State of the Union and the America the Beautiful initiative to be included in the 1991 budget).

-- significant "thousand points of light" voluntary component to be included.

-- approach separates the volatile issues of atmosphere and global warming from the event with which you will be most closely identified.

II. Timing (see attached calendar)

A. IPCC Plenary Session: date fixed, February, 1990.

B. White House Meeting on Environmental Research: Spring, 1990, date to be determined.

C. <u>President's Conference on the Conservation of Nature:</u> Spring - Summer - Fall, 1990, date to be determined.

III. Additional Initiative

The Working Group also discussed the issue of hosting the first negotiating session of the international framework convention on climate change. The United States has agreed to participate in the negotiations, yet has made no decision to serve as host. The United States, in our capacity as chair of the Response Strategies Working Group under the IPCC, hosted a "workshop" to begin discussions of the likely elements of a framework convention. It is suggested that the United States may wish to host the negotiations for the framework convention, which are not scheduled to begin until after the Second World Climate Conference in November, 1990 (which for practical purposes means not until 1991), and announce that decision at an appropriate time.

PROS

- decision to host the framework convention and, by extension, an early announcement of the decision, could give the U.S. leverage and an element of control in the negotiation process, allowing the U.S. to promote concepts such as market mechanisms, emissions trading and offset policies.

- hosting the "Washington Convention" would put the U.S. in a leadership role on international environmental issues.

- concern that any delay on a decision within the U.S. government will result in the U.S. being bypassed by another nation acting faster.

CONS

- no international consensus on the legal instrument to be employed for the framework convention. The legal instrument could range anywhere from model employed to negotiate the Law of the Sea Convention to a model less intrusive on national sovereignty.
Unwise to host a negotiating session for a framework convention before the U.S. knows what the convention will be.

- consensus that the framework convention will be extraordinarily difficult to negotiate and could easily result in a document that the U.S. could not sign.

- would place enormous pressure on the United States to commit to economically injurious reductions, arrived at politically, of emissions for which there are no known substitutes at this time.

- unique mix of Congressional, interest group, and media interplay that would surround a "Washington Convention" would make any discipline or control over U.S. negotiating positions all but impossible.

In the discussion of this issue within the Working Group, a majority of your advisors expressed the opinion that in the very near future, namely after the February IPCC plenary session, the United States will be in a better position to gauge the direction of the IPCC and the legal instrument to be employed in negotiating the framework convention, and that it would better serve U.S. interests to postpone a decision on hosting the convention until that time.

<u>**1990 ENVIRONMENTAL CALENDAR**</u>
(Dates and Events in Bold are Fixed)

January	**State of the Union**
February 5-8	**IPCC Plenary Session (Presidential Address)**
March-April	*White House Meeting on Environmental Research
April 22	**Earth Day** *President's International Conference on Conservation of Nature
May 8-16	**Conference on "Action for our Future" - Bergen**
May	*White House Meeting on Environmental Research
July 9-11	**G-7 Economic Summit**
July	*White House Meeting on Environmental Research or President's International Conference on Conservation of Nature
August	**Final Plenary Session of IPCC - Stockholm**
September-October	*President's International Conference on Conservation of Nature
November 12-13	**Second World Climate Conference - Geneva**

* Represents Alternative Dates for Events

U.S. ACTIONS ALREADY UNDERWAY TO CUT GREENHOUSE GASES

In the first 11 months of the Administration, the U.S. has already taken several actions unilaterally which, in addition to being meritorious in their own right, will reduce CO_2 emissions and address the global warming problem.

- o The Administration's proposed Clean Air Act, by significantly reducing pollution from coal-fired power plants and placing a permanent cap on emissions, creates a powerful incentive for conservation. This alone could reduce CO_2 emission by several percent a year. No other nation has adopted such an ambitious clean air strategy.

- o The Administration's action to increase required corporate average fuel efficiency (cafe) standards to 27.5 miles per gallon will cut CO_2 emissions from automobiles.

- o The Administration has not only called for a worldwide phase out of CFC's by the year 2000, but the Administration's February 9th budget included a unilateral fee on CFC emissions, which will sharply reduce U.S. production and emissions of CFC's. The CFC fee has been adopted by the Congress. Scientists believe that CFC's are responsible for 20% of the greenhouse problem. In addition, the Administration has proposed expanding the Montreal Protocol to cover additional greenhouse gases which deplete the ozone layer.

- o The Administration has sharply increased funding for global climate change research. The fiscal year 1990 budget contains almost $1/2 billion for this effort, a 21% increase over 1989 levels. We expect another increase in the FY 1991 budget, with the amount to be determined. No other nation is spending nearly this much on research.

- o The Administration is now developing a national energy strategy, to be released in April. One of the clear goals in developing the strategy is to increase energy conservation.

- o Clean coal technologies proposed by the President in his Clean Air proposal and federally funded will reduce the production of greenhouse gases which are a by product of current, older technologies. Current technologies can add approximately 3% to greenhouse gas production per plant.

- o The President's proposed alternative fuels program for automobiles has the potential to reduce CO_2 emissions from automobiles.

o The Administration is preparing a major reforestation initiative for possible inclusion in the State of the Union address. The initiative will include funding of approximately $175 million annually under a program called "America the Beautiful." This program will encompass a national partnership for tree planting. We hope to work hand in hand with state and local governments, foundations, corporations, and private citizens to reforest urban and rural areas, on public and private lands.

December 20, 1989

ISSUE

Review and approval of the elements of the President's 1990 International Environmental Initiative is needed.

BACKGROUND

The Cabinet-level DPC Working Group on Global Change was first convened in October to formulate and coordinate United States policy on global change and other selected environmental issues. As part of its charge, the Working Group was assigned the task of developing options to fulfill the President's campaign pledge to host an international conference on the environment and to seize the initiative on the international environmental agenda. The Working Group developed a consensus recommendation for a series of three events to be held during 1990, which was presented to the President prior to his departure for Malta. After his discussions with Chairman Gorbachev, the President chose to announce two of the initiatives identified by the Working Group - an international meeting at the White House next spring of government science, economics and environmental officials and an offer for the U.S. to host the first negotiating session for an international convention on climate change, to be held after the Second World Climate Conference. In subsequent meetings, the Working Group identified one additional possible event for consideration. Four consensus proposals (including the science/economics conference previously announced by the President, which has been refined by a representative task force convened by Dr. Bromley) are presented below for review and approval.

RECOMMENDATIONS

The President's 1990 International Environmental Initiative (the Initiative) has been developed within the context of the U.S. commitment to the Intergovernmental Panel on Climate Change (IPCC) as the principal international forum to address the issue of global change and the Administration accomplishments to date on global change. The Initiative represents a coherent omnibus process by which the President can address the full range of international environmental issues.

I. Major Environmental Speech in January.

To set the tone for 1990 as a year in which the environment will be a major focus of Administration activity and to introduce some or all of the components of the Initiative, the President should make a major speech on the environment in early to mid-January (prior to the State of the Union).

In the speech the President should note the accomplishments of the Administration on environmental issues, which have often been overlooked, as a means of establishing the leadership of the Administration in this area in the minds of the media and the public. He could also announce several of the environmental initiatives that will be part of the 1991 budget. To heighten the impact of the speech, an appropriate venue with some strong link to the outdoors and the environment could be found.

II. Address to the February 1990 IPCC Plenary Session in Washington.

The President should address the opening plenary session of the IPCC in February 1990. His speech should explain U.S. policy on global change and promote the enormous investment the U.S. has made both in understanding the scientific elements of global change and in beginning to take mitigating actions. The speech represents a clear opportunity for the U.S. to assert its leadership role on global change and reinforce its commitment to the IPCC as the principal forum for addressing this problem.

III. White House Conference on Science and Economics Research on the Environment

The general purpose of the conference, which will be co-chaired by Drs. Bromley and Boskin, will be to advance the quality and understanding of the analytical tools and data necessary to confront international environmental problems, primarily global change. Analytical techniques and research will be shared in an effort to develop a common integrated approach that takes a balanced account of scientific, economic and environmental factors. National delegations attending the conference will be comprised of the senior scientist, the senior economist and the senior environmentalist in the governments of the participants.

A. Timing of Conference

In his announcement of the conference, the President simply specified that the meeting would be held next spring. To avoid conflicts with the various events already on the international and domestic environmental calendar (Appendix A), and to take advantage of the worldwide attention on environmental issues that will accompany the 20th anniversary of Earth Day (April 22), the conference should be held near Earth Day.

B. Participants at Conference

The conference was announced by the President as international in nature, without any elaboration as to invitees. It bears emphasis from the outset that it will be a scientific and economic conference focusing on problems of the environment. To that end, it will be important to bring together nations and organizations that have internationally recognized expertise and have developed data relevant to the required analysis of the available tools for confronting the scientific and economic aspects of the global change issue. It will also be critical to include nations or representatives of nations that, because of their land masses, large populations or heavy future energy needs, will be compelled to deal with environmental problems having a global magnitude and impact. Finally, in order to avoid duplicating the work of the IPCC, a smaller number of participants is more appropriate.

Based on these criteria, the following nations and organizations will be invited: the G-7 nations, China, Brazil, India, the Soviet Union, Australia, Nigeria (or another African nation), Mexico, the European Community and the Organization for Economic Cooperation and Development (OECD).

C. Objectives of Conference

The objectives of the conference are both general and specific.

General Objectives

o To identify gaps and uncertainties in the science and economics relating to environmental matters, particularly the scientific gaps that impact economic analysis and vice versa, and establish priorities for compiling specific data and information to resolve these uncertainties.

o To ensure that the conference supports the work of the IPCC and that it does not conflict with the efforts currently underway in the IPCC working groups.

o To review actual products and deliverables, including real data and models, in both science and economics.

o To raise the level of attention given by the major scientific, economic and environmental policy makers to the problems posed by global change and to foster a more inclusive dialogue leading up to negotiations of a framework convention.

o To seek agreement on common assumptions (e.g., CO2 equivalencies) that can be used when making decisions regarding responses to global change.

o To provide background and guidance for the Second World Climate Conference, to be held in Geneva in November, and other international meetings.

o To increase general awareness of the scientific and economic parameters that impact national and international environmental policy-making.

Specific Objectives

Science. The scientists will focus on the largest gaps and uncertainties in the current understanding of global warming and greenhouse phenomena and on such topics as:

o The range of predicted temperature changes under the current major world climate models, the uncertainties in these predictions and the primary sources of these uncertainties. This will yield greater awareness of these uncertainties among the participant economists and environmentalists.

o The relative sensitivity of the climate models to their input parameters and the most critical new experimental measurements required to address existing gaps and uncertainties.

o The expected global impacts from different global warming scenarios in such areas as agricultural and oceanic productivity, sea level change, vegetation patterns and migration, changes in storm patterns and severity and occurrence of droughts.

o The availability and inter-comparability of national data bases pertinent to environmental research.

o Improvement of current climate and weather models to begin to address regional changes on a larger time horizon than is currently possible.

o The possibility of developing an integrated, coherent international plan of research to build upon the expertise, experience and relevant data available in the participant countries. This plan could form a structure within which the contributions of all interested nations could be used with greatest effectiveness and form the basis for coordinated resource allocation and implementation.

o The development of greater awareness on the part of participating scientists of the economic aspects of global change and the relative economic value of improved understanding and predictive capability in different areas.

Economics. The participation of economists should enhance four useful information flows:

o Best-practice methods of estimating the costs of action, including adaptation and mitigation costs, and the methods and costs of transferring or aiding in the development of technology. Discussions of this topic should serve to advance the state of the art, to lead to a greater standardization of methods and to enhance awareness of robust results.

o Greater familiarity on the part of economists with the actual state of scientific knowledge, increasing their ability to render it more faithfully in their modeling.

o Greater awareness on the part of environmentalists of the benefits to both the economy and the environment of adopting flexible, market-based response strategies.

o Greater interaction among economists with scientists working in areas where resolution of scientific uncertainties will have the greatest impact on economic modelling and costs.

Environment. With a great deal of work on environmental effects, particularly in the area of global change, already underway, the primary objective with respect to the environmental officials at the conference will be to engage them in a dialogue on scientific and economic issues, thus providing them with greater familiarity with and sensitivity to those factors as they consider environmental policies and response options.

D. Structure

Pre-Conference Actions

o To give greater visibility to the conference, the invitations to government officials will come directly from the President.

o To refine the scope of the conference, a questionnaire requesting specific information (e.g., major uncertainties in the areas, major gaps in existing information, new developments, activities in both science and technology relating to the environment in the recipient country, and identification of the proposed national delegation members) will be sent to all participants.

o Assignments for the preparation of a limited number of short papers will be made, with the authors presenting these papers at the conference.

o To finalize the presentations and preparations for the conference, a pre-meeting of a limited number of scientists and economists will be held.

Conference Activities

o To ensure full discussion of the issues, the conference will extend over three days.

o The conference, which should be open to the media, will begin with an opening plenary session, a key portion of which will be keynote addresses pulling together the current state of the science and economics on global change and highlighting the uncertainties and gaps in current knowledge. The responses to the questionnaires circulated prior to the conference will serve as the basis for these keynote addresses and the initial discussions. The participants will then break into mixed groups of science, economic and environmental officials, ensuring that representatives of each of the disciplines is sufficiently exposed to the others. At the end of each day's proceedings, all participants will reconvene in plenary session for summary discussions.

o Presidential involvement will be a key factor in heightening the visibility of the conference. The President should address the opening plenary session, participate in the concluding session, and host the conference reception and banquet at the State Department.

IV. President's International Conference on the Conservation of Nature

In the fall of 1990 (probably October), the President should host an international conference, in the tradition of Teddy Roosevelt, focused on the twin goals of the conservation of nature and sustainable development. The announcement of this conference should be a major event, made in the environmental address prior to the State of the Union or as one of the highlights of the State of the Union. The announcement should declare that the U.S. is leading the world in its commitment of resources and expertise to increasing the understanding of, and the response to, atmospheric pollution and global change through its Clean

Air and Acid Rain legislation, its participation in the IPCC, the above-mentioned science/economics conference and its offer to host the initial global change framework convention negotiating session; what remains for international consideration among the major environmental issues is conservation and the preservation of nature, natural resources and biodiversity. The President could at the same time announce that the U.S. will also host negotiations for an international convention on biological diversity, planned to begin in 1991, which the United Nations Environment Programme (UNEP) has offered to the U.S.

The emphasis of the conservation of nature conference would be on energy conservation, biological diversity, reforestation, wetlands and oceans, highlighting, as models, successful domestic programs, international ventures (e.g., the pending U.S.-Brazil agreement for assistance in the management of Brazilian national forests, banning of ivory imports and debt-for nature swaps), and future initiatives (e.g., the reforestation initiative to be announced in the State of the Union and the America the Beautiful initiative to be included in the 1991 budget). Attendance would include local as well as national officials and representatives from non-governmental environmental groups. It would focus attention on issues the general public traditionally thinks of when discussing the environment and could include a significant "thousand points of light" volunteer component. The conference would also provide developing nations and environmental groups, which have special expertise and have achieved notable successes in these areas, an opportunity for more active participation. It would be open to participation by all nations, consistent with the President's commitment to such a conference.

This approach of this conference, coupled with the other proposed events, is consistent with a coherent overall approach to international environmental issues. It supports established forums for issues relating to the atmosphere, such as the IPCC and the ongoing Montreal Protocol negotiations, separating these volatile issues from the event with which the President will be most closely identified.

In preparation for the conference, the White House could host a series of open meetings with "constituents" of the conference -- conservationists, environmentalists, business, economists, scientists and international organizations -- to build support, consensus and media attention. These meetings, or selected parts of the meetings, which would be open, could be attended by the President to show his commitment and desire to lead the public with his agenda.

To ensure that both this conference and the science/economics conference are successful, a full-time White House coordinator will be designated through detail or otherwise; another professional to coordinate the logistics of the conferences is also required, either through detail or contract.

1990 ENVIRONMENTAL CALENDAR
Major International and Domestic Events

[Events, dates and locations in brackets are tentative]

January [25]	State of the Union
February 5-8	Plenary Session of Intergovernmental Panel on Climate Change (IPCC) - Washington
[February 6]	[Presidential Address to IPCC]
[April]	White House Conference on Science and Economics Research on the Environment - [Washington]
April 22	Earth Day 1990 (20th anniversary; events are scheduled throughout country several days before and after April 22)
April 29-May 2	Interparliamentary Conference on the Global Environment - Washington (sponsored by U.S. Senate)
May 8-16	Conference on Action for our Future - Bergen (ministerial-level meeting; follow-up to conference on sustainable development previously held under auspices of Prime Minister Bruntland)
[June 18-30]	Summit Meeting between Bush and Gorbachev
June 20-29	Second Meeting of Parties to Montreal Protocol - London (negotiating session to expand Montreal Protocol under Vienna Convention to ozone-depleting substances other than CFCs)
July 9-11	G-7 Economic Summit - Houston
August	Final IPCC Plenary Session - Stockholm
[September-October]	[President's International Conference on Conservation of Nature]
November 12-13	Second World Climate Conference - Geneva
[December 1990-January 1991]	First Negotiating Session for Framework Convention on Global Change

December 20, 1989

Dear CESers,

We (Jarvis Moyers and I) attach the **last draft** of the CES January 1990 document. Please look at it carefully. It is even shorter than the previous document, now 29 pages (including figures, tables and budget text).

Please provide me with any final comments marked on this draft by 9am at the latest on Friday, December 22, at Bob Watson's office at NASA HQ--DOI and DOE need to read their Budget sections--see Fellows memo of 12/20/89.

The budget tables and figures are place holders - the numbers are artificial. The need is still to get these data to Paul Dressler as soon as possible.

The document has not been spell-checked- I will do this Thursday, 12/21/89 after the CEs Pricipals meeting.

Bob

Bob

OUR CHANGING PLANET:

THE FY 1991

U.S. GLOBAL CHANGE RESEARCH PROGRAM

A REPORT BY THE COMMITTEE ON EARTH SCIENCES

TO ACCOMPANY

THE U.S. PRESIDENT'S FISCAL YEAR 1991 BUDGET

Draft: 20 December 1989

CONTENTS

EXECUTIVE SUMMARY

- Although the Earth has been changing for millions of years, dramatic changes that have occurred in recent times, e.g., Antarctic ozone depletion, demonstrate that human activities are affecting the Earth system.

- Recognizing the profound economic and social implications of responding to global environmental changes, particularly climate change, world leaders are making the environment an issue central to both national and international affairs.

- An improved predictive model of the integrated Earth system and a better understanding of the human interactions will provide direct benefits by anticipating and planning for impacts on commerce, agriculture, energy, resources utilization, and human safety.

- However, there are substantial uncertainties associated with the current understanding of many of the vital Earth processes and changes, including global warming.

- The U.S. Global Change Research Program is designed to reduce key scientific uncertainties, thus accelerating the development of more reliable scientific predictions upon which policy strategies and responses will be based.

- This report summarizes the key features and budget of the U.S. Global Change Research Program for FY 1991. A more detailed FY 1991 research plan will be released in the spring of 1990.

- The U.S. Global Change Research Program was developed by the Committee on Earth Sciences of the Federal Coordinating Council for Science, Engineering and Technology, in association with the National Academy of Sciences, the International Council of Scientific Unions' International Geosphere-Biosphere Programme and the World Meterological Organizations' World Climate Research Programme.

- The President's proposed FY 1991 budget for the focused U.S. Global Change Research Program of $1034 million is an increase of $371 million over that for FY 1990. This budget will allow for a significant expansion in research activities with both near- and long-term scientific and public-policy benefits

- This proposed budget would initiate multi-agency ground-based research thrusts in several critical areas, including cloud-climate feedback mechanisms; fluxes of greenhouse gases and energy throughout the Earth system; responses to global change; past changes in the Earth system; and the role of human actions in global change.

- The proposed budget would also initiate the development of the NASA Earth Observing System, a key element in "Mission to Planet Earth", which will provide the centerpiece of an integrated international satellite program for monitoring global change variables, coupled with a comprehensive data and information system.

- The proposed balance of ground- and space-based research embodied in the U.S. Global Change Research Program is essential, given the temporal and spatial variability of the systems being studied and the need to scale local processes to the regional and global levels.

INTRODUCTION

World leaders are taking an unprecedented interest in the economic and social implications of global environmental changes, both natural and human-induced. The 1988 U.S. midwestern drought underscored the vulnerability of even a modern industrial society to a warm, dry summer, just as the climate in recent decades in the Sahel starkly reveals the human tragedy that can occur in marginal-subsistence zones of a changing planet. Furthermore, the very recent linking of the Antarctic ozone "hole" to man-made chlorofluorocarbons and the prominence of the current debate over man's role in the "greenhouse" effect have placed the environment high on the national and international agenda.

In virtually each of these issues, the salient feature is the uncertainty of current scientific understanding of the future behavior of the Earth system. The formidable costs associated with addressing environmental change require that policy decisions be based on adequate scientific knowledge. The U.S. Global Change Research Program has been created to provide this knowledge.

The present document is the second in a series of overviews that accompanies the President's annual budget to the Congress and that highlights the Program's FY 1991 research activities and budget developed by the Committee on Earth Sciences (CES) of the Federal Coordinating Council for Science, Engineering, and Technology.

The CES activities of the past year began with the publication in January 1989 of *Our Changing Planet: A U. S. Research Strategy for Global Change Research.* Following this strategic plan, the CES then prepared *Our Changing Planet: The FY 1990 Research Plan* (July 1989), which reviewed the Earth system changes that have occurred in the past; the forces that are at work today; and the strengths and weaknesses in current understanding. It also described the highest-priority interdisciplinary research needs, agency roles, and new FY 1990 research initiatives.

The *FY 1990 Research Plan* was reviewed by the National Academy of Sciences, American Geophysical Union, and others, all of which strongly endorsed the holistic approach to understanding the Earth system. The *Plan* is also consistent with the concepts outlined by the International Geosphere-Biosphere Programme and the World Climate Research Programme.

While recognizing that a broad predictive capability is both a necessary and longer-term goal, the FY 1991 Program also focusses on the policy questions of today and coming years: Should the Montreal Protocol on Substances that Deplete the Ozone Layer be strengthened quickly? Has a global warming signal been detected, and what are the relative contributions from natural processes and human activities? What will the climate of the coming century be like, and how will it impact agriculture, forestry, habitation, and water and energy supply and use?

Furthermore, the present document shows how this integrated interdisciplinary Program has begun to address such cross-cutting activities as understanding the carbon cycle, data management, education, and emerging disciplines.

A comprehensive FY 1991 research plan will be provided in the spring of 1990, updating the *FY 1990 Plan*.

PLANNING THE FY 1991 PROGRAM

In *The FY 1990 Research Plan*, the CES established the following goal and objectives for the U.S. Global Change Research Program:

Goal: *To establish the scientific basis for national and international policymaking relating to natural and human-induced changes in the global Earth system.*

Objectives: *Establish an integrated, comprehensive long-term program of documenting the Earth system on a global scale.*

Conduct a program of focused studies to improve our understanding of the physical, geological, chemical, biological, and social processes that influence Earth system processes and trends on global and regional scales.

Develop integrated conceptual and predictive Earth system models.

Over the past year, the CES has formulated the FY 1991 extension of the research program that is needed to continue to address these objectives. That formulation process is summarized briefly here. The CES agencies submitted individual U.S. Global Change Research Program initiatives to the Committee on Earth Sciences in mid-July, 1989. At a series of meetings over the ensuing months, agency representatives developed a final CES- and agency-endorsed recommendation on the content and resource requirements for the FY 1991 Program. Subsequently, during the fall of 1989, there were extensive program reviews and discussions that led ultimately to the FY 1991 program and budget summarized herein.

Planning Framework

The CES has forged stronger partnerships among the Federal agencies and with the scientific community. A new paradigm for cooperative planning is emerging (see the box on page XX for details).

Priority Framework

In the preparation of *The FY 1990 Research Plan*, the CES has created and implemented a multi-level priority-setting framework that was used to focus and integrate the program development and budget proposals for FY 1991. This framework contains three levels of priorities for the U.S. Global Change Research Program, which are diagramed in Figure 1. These strategic, integrating, and science priorities focus on those research questions that will produce significant early improvements in understanding and modeling the interactive Earth system. For example, there is little disagreement that a major shortcoming of existing general circulation models is their inability to simulate the role of clouds and convective processes accurately; hence, that research is top priority in the Climate and Hydrologic Systems element. However, concurrent progress in high-priority activities in all science elements is necessary for the Program to achieve its overall goal, although not all will receive equal support.

Evaluation Framework

Within each science element, the CES evaluated proposed FY 1991 research itaking into account the priorities and several evaluation criteria (see box on page XX). These

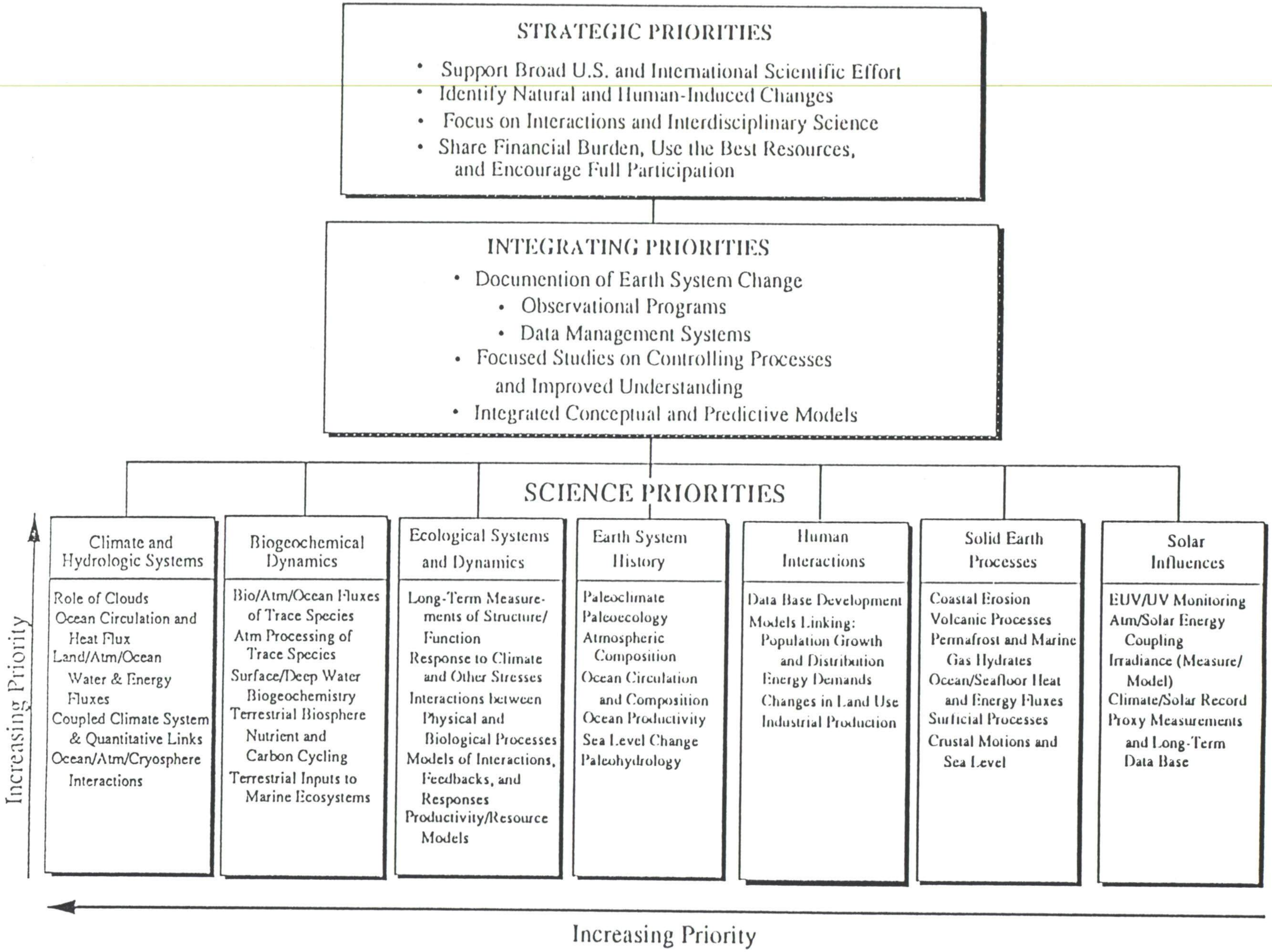


Figure 1. U.S. Global Change Research Program Priority Framework

criteria provided a framework for designing the specific project-by-project structure that constitutes the Program.

Agency and Organizational Roles

At the outset of the Program, the CES developed a set of role statements that specifically define each agency's respective role in the Program (see Appendix A, *The FY 1990 Research Plan*). In developing the FY 1991 Program, that process of role definition has been extended. The current status of the participation in the Program by CES agencies and other Federal organizations has three categories:

(1) *Agencies whose budget initiatives are in the "focused" category and hence are detailed in this document.* These include the Department of Commerce (DOC/NOAA), Department of Energy (DOE), Department of Interior (DOI), Environmental Protection Agency (EPA), National Aeronautics and Space Administration (NASA), National Science Foundation (NSF), and the United States Department of Agriculture (USDA).

(2) *Agencies whose programs fall into the "contributing" category.* Their budgets are noted in Table 2. These agencies programs support many of the science elements, but were initiated for reasons other than the focussed Program goal. They include the Department of Defense (DOD) and the research agencies of the services (including the Office of Naval Research, the Oceanographer of the Navy, and the U.S. Army Corp of Engineers, etc.).

(3) *Agencies and offices of the Executive Branch that contribute policy and coordination counsel and guidance to the Program.* These agencies and offices contribute to the architecture of the Program and are key vehicles for coordinating and linking the Program with overall national and international policy on global change. These include the Council on Environmental Quality (CEQ), Departments of State (DOS) and Transportation (DOT), Office of Management and Budget (OMB), Office of Science and Technology Policy (OSTP), and the White House Policy Office.

[Boxed] The CES Process: Basic Tenets

o <u>Integrate Science Into the Policy Process.</u> The need for effective relationships between the policy processes of governments and the underlying science of environmental issues has always been recognized and central to the U.S. Global Change Research Program. A process for policy development has evolved within the Executive Branch that directly involves the CES, including (i) its being the focal point for the development and coordination of U.S. scientific programs for global change, both domestically and internationally and (ii) ensuring that the results of these scientific efforts provide the foundation for rational policy debate and effective action.

o <u>Maintain a Partnership Among all Participants.</u> A partnership has evolved among the CES members and between CES and the non-Federal research community through the relevant Committees and Boards of the National Academy of Sciences (NAS), notably the Committee on Global Change (CGC). Within CES, there has been a conscious effort not to designate "lead" agencies. Leadership is distributed among the agencies, with each contributing their strengths to the planning, documentation, review, and implementation process. This partnership concept is fundamental to the workings of the CES. The same philosophy is operative in the parallel-planning relationship with the NAS, including joint meetings, substantial "cross" review and coordination, and exchange of ideas for developing implementation strategies. In addition, the CES has interacted with (i) the international scientific community and agencies of other governments, (ii) several intergovernmental bodies with global change concerns, (iii) the environmental community, and (iv) the private sector.

o *Focus on Interdisciplinary Science, Interactions, and Interfaces.* The CES science program is founded on the premise that the essential scientific questions can only be addressed through interdisciplinary research that reflects the interfaces among the interacting components of the Earth system. This is also the scientific strategy of the CGC and its international counterpart, the International Geosphere-Biosphere Programme (IGBP), thereby further strengthening the interactions of the CES and CGC.

[Boxed] The CES Evaluation Criteria

o Relevance/Contribution. The research must address the overall goal and one or more of the three key scientific objectives of the Program.

o Scientific Merit. The proposed work must be scientifically sound and of high priority, and be the product of a documented scientific planning and review process.

o Readiness. The level of planning must be high, the capabilities of high quality and in place, and the research likely to produce vital and needed advances.

o Linkages. The CES looks for established interagency, other national, and international connections.

o Costs. The CES considers whether the identified resources are adequate; if they represent an appropriate share of total available resources (e.g., a balance between space- and ground-based program elements); prospects for joint funding; and the degree to which long-term resource implications have been evaluated.

o Enhancements to Existing Program Research. The highest priority existing programs will receive adequate support before new initiatives are funded.

o Agency Approval. The proposed program or activity must have policy-level approval by the submitting agency.

BENEFITS

As noted, the U.S. Global Change Research Program is founded on the premise that effective strategies to address environmental issues can be built only on sound scientific information. Therefore, a hallmark of the Program strategy is linking the U.S. scientific program for global change to the policy process. This is done by identifying and addressing scientific priorities that are central to the policy process (see the box on page XX for examples).

These areas of emphasis include such *general* short-term (i.e., next few years) and long-term (i.e., the decades ahead) scientific needs and policy benefits as:

o predicting the magnitude and timing of impacts environmental variations, thereby providing the means to plan or avoid their impact.

o separating the "natural" changes from human-induced changes, thereby balancing regulatory needs with economic and social development and providing the ability to focus on those parts of the problem that are tractable to human intervention.

In addition, the Program has established several *specific* "benefit" goals designed to address public needs for predicting and dealing with environmental change through:

(i) Providing Timely Information - making available the results of scientific research through special briefings and other information "products" for the Congress, the Executive Branch, and others, immediately after new insights are obtained;

(ii) Evaluations of the State of the Science - providing periodic assessments of the "state of science" in the critical areas of global change (as has been done regarding the stratospheric ozone layer), employing both domestic and international mechanisms, such as the Committees of the NAS and the Intergovernmental Panel on Climate Change (IPCC);

(iii) Regular Prediction/Forecasting Products - providing a "line" of information products that address three time scales, seasonal, interannual, and interdecadal.

- o Seasonal Projections - It is anticipated that research already underway (including developments from the sciences associated with weather forecasting) will lead to seasonal forecasts (i.e., 30- to 60-day projections) within three to five years. These products will likely be derived from the existing weather forecasting systems operating throughout the countries of the world. Ocean forecasting is in an earlier state of development and will require increased effort to achieve this goal.

- o Interannual Projections - The advent of a greatly improved understanding of how the tropical ocean induces changes in heating patterns within the atmosphere (El Nino and the Southern Oscillation) is leading toward one of the next realizable lines of predictive products. It is anticipated that within about 10 years regular assessments and forecasts will be produced quarterly, each providing three- to six-month forecasts, a one-year prognosis, and a two-year outlook of interannual climate variability for selected climatic processes.

- o Interdecadal Projections - It is anticipated that prediction of selected climatic processes on interdecadal (ten to twenty years out) time scales will emerge during the coming decade. The products will consist of interpretive reports and model predictions. The process is beginning with the science assessment of the IPCC and the Second World Climate Conference in late 1990.

Lastly, the *overall* benefits of the Program are substantial: (i) providing critical data to minimize economic or other adverse impacts by supporting prudent near-term actions where justified, while accelerating the development of more reliable scientific understanding on which to base long-term policies; (ii) contributing to the Nation's environmental leadership and credibility, both domestically and internationally; and (iii) serving as a catalyst for similar scientific commitments from other nations.

[Boxed] Benefits of the U. S. Global Change Research Program: Examples

- o <u>Greenhouse Gases.</u> A better understanding of the processes, both natural and human-influenced, that govern the sources and fates of "greenhouse" gases will provide a basis for analyzing integrated control strategies and cost-benefit analyses.

- o <u>Ozone Depletion.</u> An improved knowledge of the mechanisms controlling the stability of the stratospheric ozone layer will aid the formulation of appropriate amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer.

- o <u>Energy.</u> Establishing links between carbon dioxide emissions and atmospheric abundances with energy policy scenarios will facilitate assessment of the consequences of globally distributed mixes and development of different energy technologies.

- o <u>Agriculture/Forestry.</u> Better knowledge of the linkages of crops, forests and other ecosystems to environmental conditions will enhance the ability to make sound decisions regarding food security, forest products, and conservation of natural resources, including crop selection, reforestation, and deforestation practices.

- o <u>Water policy.</u> A more complete knowledge of the interaction of the climate and hydrological cycles will assist reconciliation of issues involving water supply and demand and will allow better planning for the allocation of water resources during extreme events.

- o <u>Sea Level.</u> Elucidation of the processes that control sea level will provide the predictive capability to guide policies regarding coastal human settlements and wetlands.

RESEARCH PROGRAM AND BUDGETS

The following sections summarize the FY 1991 activities of the U.S. Global Change Research Program in the seven interdisciplinary science elements and data management. Short descriptions of the FY 1991 research programs are given, and the agencies involved are identified. The benefits of this commitment are outlined in terms of the policy issues for which a better predictive understanding is required.

Budget Overview

Table 1 shows the U.S. Global Change Research Program budget proposal by science element, by agency, and by science objective. In FY 1990 funding for the U.S. Global Change Research Program was $668 million. The President's FY 1991 budget

Table 1

FY 1990-1991 U.S. Global Change Focussed Research Program Budget

(Dollars in Millions)

Focused Program	Total Budget		Climate and Hydrologic Systems		Biogeochemical Dynamics		Ecological Systems and Dynamics		Earth System History		Human Interactions		Solid Earth Processes		Solar Influences	
	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991
Agency Totals	663	1034														
DOC/NOAA	18	87														
DOE	50	66														
DOI	11	44														
EPA	17	26														
NASA	489	661														
NSF	51	103														
USDA	33	47														
Program Objectives																
Observations																
Understanding																
Prediction																
Data Management																

Table 2

FY 1990 - 1991 Budget of Contributory Programs to U.S. Global Change Research

(Dollars in Millions)

Contributing Program	Total Budget		Climate and Hydrologic Systems		Biogeochemical Dynamics		Ecological Systems and Dynamics		Earth System History		Human Interactions		Solid Earth Processes		Solar Influences	
	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991
Agency Totals																
DOC/NOAA																
DOE																
DOI																
EPA																
NASA																
NSF																
USDA																
DOD																
DOT																

= NONE OF THESE #'s ARE REAL
= FIGURES REPRESENT TYPES TO BE USED WHEN # ARE KNOWN.

Figure 2
U.S. Global Change Research Program
by Science Element

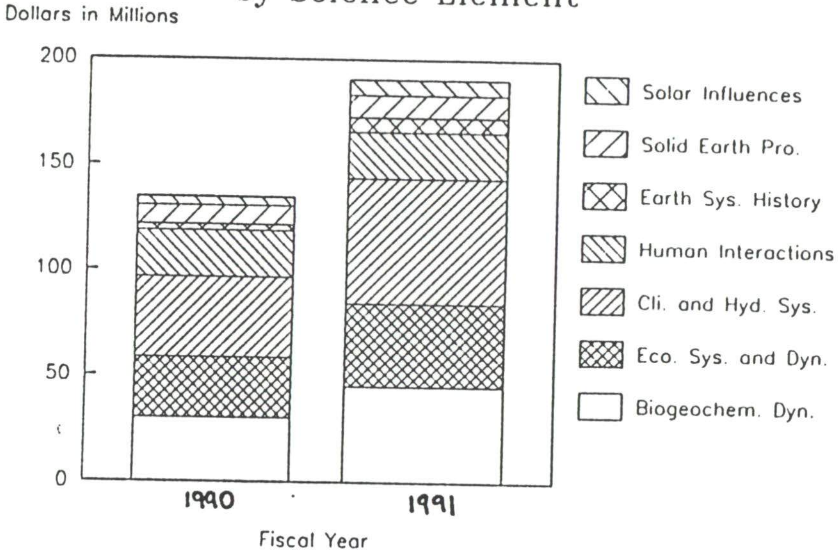


Figure 3
U.S. Global Change Research Program
by Objective

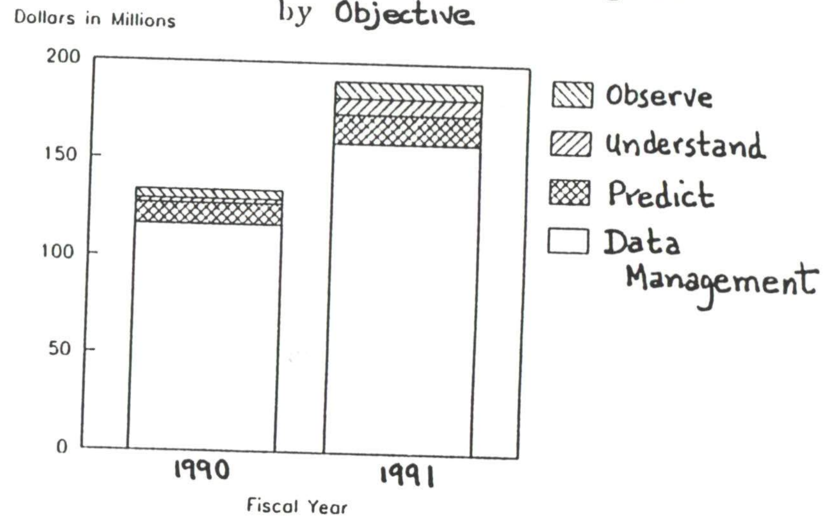


Figure 4
U.S. Global Change Research Program by Agency

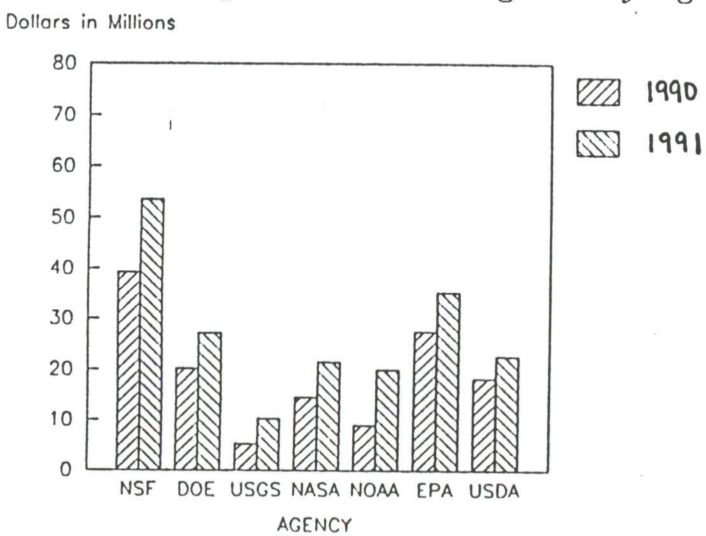
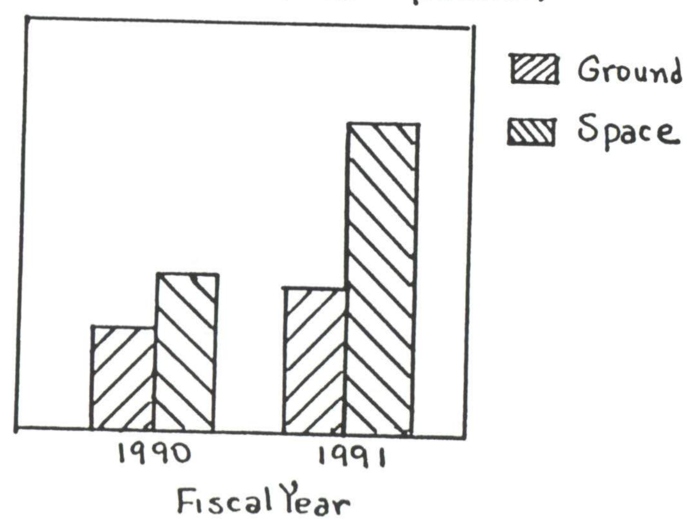


Figure 5
U.S. Global Change Research Program: Space-Vis-a-Vis Ground-Based Research



proposes a funding level of $1034 million, a $366 million (55 percent) increase over the FY 1990 level. The FY 1990 budget differs from that presented in *Our Changing Planet: A U. S. Research Strategy for Global Change Research,* and*The FY 1990 Research Plan* (July 1989) because CES has redefined which of the agency programs are "focussed" and which are "contributing". Table 2 shows the budgets for programs that contribute to Global Change research and provide important support to the Program objectives. Because of the complex nature of the Program, examples of important research, data collection and modeling activities will be described along with how they address the research priorities and related policy questions.

Budget by Science Element

This section summarizes the FY 1991 activities in the seven interdisciplinary science elements and data management. Figure 2 shows the proposed FY 1990 and FY 1991budgets for the U.S. Global Change Research Program by science element. At this time the U.S. Global Change Research Program focuses primarily on the three highest priority science elements: Climate and Hydrological Systems, Biogeochemical Dynamics, and Ecological Systems and Dynamics. However,the Program maintains an appropriate level of effort in all seven science elements consistent with the science priorities and with the current state of scientific program development. The relatively high level of funding for Solid Earth Processes and Solar Influences reflects investment in space-based measurements.

Climate and Hydrologic Systems

Table 1 shows the requested FY 1991 budget for this science element by agency. The FY 1991 request for this element is a $x million (y percent) increase over the FY 1990 level.

The increasing abundances of greenhouse gases in the Earth's atmosphere are altering the radiative balance of the planet. However, the impact on climate is uncertain. The response of the Earth's climate is strongly tied to the natural variability of the climate and hydrologic systems, including the atmospheric, oceanic , cryogenic, and land surface processes that govern the distribution of temperature, moisture, clouds and rainfall. Effective policy formulation requires quantification of the natural variability in the climate and hydrological systems, and reliable predictions of the magnitude and timing of regional and global changes in response to the increasing abundances of greenhouse gases.

These research efforts reflect the Program's research priorities (see Figure 1) and involve the following relevant policy questions:

(1) What is the role of clouds in the Earth's radiation and heat budgets?

Clouds and water vapor play a pivitol role in the Earth's radiation and heat budgets. They control the amount of solar energy absorbed by the climate system as well as the infrared radiation emitted to space, and they strongly influence the redistribution of heat throughout the climate system. A change of a few percent in global mean cloud cover or type could either dramatically enhance or counteract the radiative effects of anthropogenic greenhouse gas emissions.

To understand the role of clouds in controlling the Earth's radiative and heat budgets require knowledge of their distribution, radiative properties, and cloud-radiation feedback mechanisms. For example, ongoing and new research programs that are focused on this area include: NASA's Earth Radiation Budget satellite; the NASA, NOAA, and

NSF International Satellite Cloud Climatology Project (ISCCP) and associated field campaigns; and a broad range of proposed studies and measurements (NASA's Earth Observing System and DOE's Atmospheric Radiation Measurements (ARM) program).

(2) *How do the oceans interact with the atmosphere in the storage, transport and uptake of heat?*

The oceans and atmosphere play a vital role in the transport of energy from the equator to the polar regions. The rate at which the oceans exchange heat with the atmosphere controls the magnitude and timing of the predicted global warming due to greenhouse gases.

The prediction of climate change will require ocean observation systems analogous to the existing atmospheric systems used to predict the weather. Understanding the role of the oceans in exchanging energy with the atmosphere requires knowledge of ocean circulation and air-sea energy fluxes.

Numerous ongoing and new research programs contribute to these areas. In situ (NOAA, NSF, and DOI) and remote (NASA scatterometer (Earth Probes) and altimeter (TOPEX)) ocean observation systems will contribute to studies of ocean circulation and the coupling of the ocean and the atmosphere. Interannual climate change (Tropical Ocean-Global Atmosphere: NOAA, NSF, and NASA), and the general circulation of the oceans (World Ocean Circulation Experiment: NSF, NOAA, and NASA) are critical investigations. Other key research includes the NOAA Atlantic Climate Change Project; and the proposed new generation of space-based measurements of ocean altimetry, temperature, and wind stress (NASA Eos).

(3) *How will changes in climate affect temperature, precipitation and soil moisture patterns, and the general distribution of water and ice on the land surface?*

Changes in seasonal temperatures, precipitation and soil moisture patterns could have significant ramifications for water resources, agricultural productivity, natural ecosystems, and the exchange of water between oceans and glaciers.

Understanding the distribution of precipitation and the impacts on the distribution of water and ice on land surfaces requires knowledge of the fluxes of energy and water within the Earth system, water resources on the land, and changes in the area and volume of glaciers.

Ongoing and new research programs that will contribute to these areas include: the Global Energy and Water Cycle Experiment (NOAA, NSF, DOI, and NASA); the proposed new generation of space-based measurements of precipitation, winds, water vapor, clouds, and ice extent (NASA Earth Probes and Eos); long-term observational networks of water resources (DOI, NOAA, and DOE); field and modeling studies of the climate sensitivity of watersheds (DOI and USDA), continental scale hydrologic processes (NSF and DOE), water budgets in managed and manipulated ecosystems (USDA) and in temperate and arctic regions (DOE); and compilation of glacier extent, including Antarctica, using ground-based and satellite data (NSF, DOI and NASA).

(4) *How can the reliability of global and regional scale climate predictions be improved?*

Accurate predictions of climate change, natural and human-induced, are vital for evaluating environmental and socio-economic impacts. The current generation of climate prediction models are inadequate to confidently predict the magnitude and timing of climate change. This is particularly true at the regional scale.

Improving the reliability of model predictions will require the development of climate diagnostics; model assimilation of climatic data; modeling shorter space and time scales; and an improved parameterization of key Earth system processes.

Ongoing and new research programs that will contribute to these areas include: enhanced climate modeling and diagnostics efforts (NOAA, NASA, NSF, and DOE); mechanistic studies of climatic change through analysis of observations (NOAA and NSF); development of climate modeling data assimilation techniques (NOAA and NSF); a critical review of data needs both for detection of climate change and for climate modeling (DOE); development of regional climate and hydrology models linked to global climate models (EPA and USDA); and the development of the capability to forecast seasonal conditions through coupled ocean-atmosphere modeling and extension of conventional weather prediction techniques (NOAA). Results from a number of process-oriented studies will be utilized to parameterize key interactions in models, including cloud-radiation interactions (NASA, NOAA, and NSF ISCCP and DOE ARM), and land-cryosphere-atmosphere, land surface hydrology, and ocean-atmosphere interactions (NSF, NOAA, DOI, and NASA).

Biogeochemical Dynamics

Table 1 shows the requested FY 1991 budget for this science element by agency. The FY 1991 request for this element is a $x million (y percent) increase over the FY 1990 level.

There is compelling scientific evidence that the atmospheric concentrations of several key radiatively and chemically active gases are increasing, primarily due to human activities. The rates of increase of these gases depend not only on their emissions, but also on the fate of these gases, which involves the cycling of carbon and other key nutrients between the ocean, atmosphere and terrestrial biosphere. Currently, there are significant uncertainties in understanding these processes, thus limiting the ability to quantitatively predict future increases in atmospheric trace gas concentrations. This restricts the formulation of effective policies regarding trace gas emissions.

These research efforts reflect the Program's research priorities (see Figure 1) and involve the following relevant policy questions:

(1) *What is the relative importance of the oceans and terrestrial biosphere as a sink for fossil fuel carbon dioxide, and how do they change with time?*

Increasing atmospheric concentrations of carbon dioxide are predicted to contribute to global warming. Presently about half of the emissions from the combustion of fossil fuels and deforestation stay in the atmosphere, with the remainder being taken up by the oceans and the terrestrial biosphere, but the proportions and responsible processes are not well understood. For a given anthropogenic emission scenario, the prediction of atmospheric growth rates of carbon dioxide depend upon an understanding of this sequestering of emitted carbon dioxide.

To understand the relative importance of the oceans and terrestrial biosphere as a sink for fossil fuel carbon dioxide requires knowledge of the fluxes of carbon dioxide between the atmosphere and land and ocean surfaces; the biogeochemical and physical processes responsible for the exchange of carbon and nutrients between the surface, deep ocean waters, and sediments; and the cycling and transformation of carbon and nutrients within the terrestrial biosphere.

Numerous ongoing and new research programs contribute to these areas. In-situ studies of the processes responsible for controlling the distribution and cycling of oceanic carbon and the concentrations of carbon dioxide in surface waters (NSF, NOAA, and DOE), complemented by remote sensing measurements of ocean productivity, sea surface temperatures and winds (NASA) contribute towards the Joint Global Ocean Flux Study. In-situ studies of the sequestering of carbon dioxide and the storage and cycling of carbon and other key nutrients within natural and disturbed terrestrial ecosystems (DOI, NSF, EPA, DOE, and USDA) will be complemented by estimates of standing biomass and the biological productivity of terrestrial ecosystems using satellite imagery (NASA Eos).

(2) *What are the major sources responsible for the current increases in atmospheric nitrous oxide and methane?*

The well-documented increases in the atmospheric concentrations of methane and nitrous oxide are predicted to contribute to global warming, affect stratospheric ozone, and, in the case of methane, to increase tropospheric ozone. The natural and anthropogenic sources of these gases have been qualitatively explained, but not adequately quantified. Hence, effective emission control strategies cannot be formulated.

Understanding current and future trends in the atmospheric concentrations of methane and nitrous oxide requires knowledge of their fluxes from industrial and ecological sources; the processes that control their fluxes between the atmosphere, biosphere and land and ocean surfaces; the impact of changing environmental conditions upon their fluxes; and their atmospheric distribution and transformations.

Many ongoing and new research programs will contribute to these areas including: studies of the fluxes of methane and / or nitrous oxide, the processes controlling them, and their response to environmental changes, from one or more of the key sources, including natural ecosystems, agricultural systems, managed forests, cattle, biomass burning, gas hydrates, and coal mining (NASA, NOAA, NSF, EPA, DOI, DOE, and USDA); quantification of the areal extent and environmental and ecological conditions conducive to methane and nitrous oxide emissions from terrestrial ecosystems (NASA Eos); atmospheric distributions and trends of methane and nitrous oxide (NASA and NOAA); and the atmospheric distribution and transformations of species (such as tropospheric ozone, hydroxyl radicals, oxides of nitrogen, carbon monoxide, and non-methane hydrocarbons) that control the distribution and lifetime of methane (NSF, NASA, NOAA, DOE, and EPA).

(3) *What are the implications for stratospheric ozone, globally and in polar regions, of increased concentrations of chlorine and bromine?*

Current scientific understanding indicates that the Antarctic ozone hole will seasonally reoccur until the stratospheric chlorine levels decrease by 30% from today's level. However, it is not yet possible to quantify, under conditions of enhanced chlorine and bromine concentrations, the impact of the Antarctic ozone hole on ozone levels at mid-latitudes in the southern hemisphere or the probability of significant ozone depletion over the Arctic. An improved quantitative understanding of the processes controlling stratospheric ozone, particularly in the polar regions, would allow improved environmental impact assessments to be conducted and improve policy formulation concerning chlorine and bromine containing chemicals, including the proposed substitutes.

To understand the response of stratospheric ozone to changes in chlorine and bromine requires knowledge of their fluxes into the stratosphere; the chemical composition and physical structure of the stratosphere; and the coupling between chemical, dynamical and radiative processes in the stratosphere.

Ongoing and new research programs that will contribute to these areas include: monitoring the atmospheric distribution of the source gases (NOAA and NASA); monitoring the chemical composition and dynamical structure of the stratosphere using a ground-based network of remote sensing, aircraft and balloons, and satellite observations (NASA, NOAA, and NSF) and studies of the atmospheric cycling and transformations of compounds that influence the chemistry of the stratosphere (NASA, NOAA, NSF, and EPA).

Ecological Systems and Dynamics

Table 1 shows the requested FY 1991 budget for this science element by agency. The FY 1991 request for this element is a $x million (y percent) increase over the FY 1990 level.

Ecological systems are important in global change research for two principal reasons. First, changes in climate, atmospheric composition, and radiation can affect the productivity, diversity, and habitat associated with both natural and managed ecosystems. Indeed, much of the policy concern over global change is explicitly linked to such possible ecosystem impacts. Second, photosynthesis, deforestation, and other biospheric characteristics can affect the chemical composition of the atmosphere, hence contributing to global change. Human-influences on ecosystem changes are increasingly a part of current policy debates.

Thus, ecological systems are intrinsically linked to global change through interwoven roles in biogeochemical dynamics, physical climate and the hydrologic cycle, and the actions of humans. However, the scientific uncertainties associated with the composition, distribution, and processes of ecosystems (see Figure 1) currently slow the formulation of sound, science-based policy options.

The current key questions in these research areas, their relevance to the evolution of public policy of global change, and the associated research of the FY 1991 U.S. Global Change Research Program are the following:

(1) What ecological systems are most sensitive to global change, and how can "natural" change in ecological systems be distinguished from change caused by other factors?

The diverse climates of the Earth support an equally diverse array of species and ecosystems. Separating the intrinsic natural dynamic changes of ecosystems from those changes induced by human activities is a challenge that has plagued the ecological sciences and public policy for some time.

The highest priority for determining the sensitivity, types, and causes of possible changes in ecosystems is the documentation of past, current, and future variation in ecosystem properties. Several ongoing monitoring programs and proposed research initiatives will address this need with regard to sensitive ecosystems (e.g., boreal forests, grasslands, and arid and high-elevation areas): DOE's research parks, USDA's forests and experiment stations, DOI's parks, widernesses,
and other public lands, and NSF's Long-Term Ecological Research Sites. NASA's Eos satellite-based instruments will extend global observations of ecosystem type, state, and spatial extent. Furthermore, EPA, USDA, NSF, DOI, NOAA, and DOE will examine the

ecosystem responses (e.g., alpine treeline change in the Western U.S., shrub encroachment into rangeland, ecological succession, small-animal ranges and habitats, and marine ecosystems) to carbon dioxide increases, climatic stresses, and disturbances.

(2) *What are the likely rates of change in ecological systems due to global change, and will natural and managed systems be able to adapt?*

Ecosystem change is controlled by the physiological processes of the individual species, as well as by the environments in which they exist. The photosynthetic response of plants to increased carbon dioxide concentrations is relatively fast and often accompanied by higher biological productivity and drought and salinity resistance. However, the full responses of complex ecosystems, such as forests and rangelands, to changes in the climate system and in the chemical composition of the atmosphere may take decades or longer.

Understanding the ecological response to rates of change and how well ecological systems can adapt to change is clearly linked to quantifying impacts for the formulation on policy options. This will require (i) knowledge of ecological responses to specific forcing agents (e.g., temperature stress, soil moisture, chemical exposure, ocean circulation, and ultraviolet radiation), (ii) research on the interactions between biotic and abiotic processes, and (iii) modeling of interactions, feedbacks, and ecological responses.

The proposed and ongoing research of several agencies will contribute to these knowledge gaps. EPA and DOI will develop correlations and models to investigate rates of change in forested and semi-arid ecosystems. USDA, DOE, NSF, and DOI will acquire data on physiological and ecosystem responses in seedling productivity; variation of plant growth due to carbon dioxide, temperature, and ultraviolet exposure; ecosystem changes in high-desert rangeland and Arctic coastal and other seas; successional change of vegetation across climate gradients; and response of managed forests to drought stress. Furthermore, DOE, DOI, USDA, NOAA, and NSF will investigate the responses of particularly sensitive species (e.g., arctic marine mammals, reef corals, commercial fish stock, grasses, grains, and endangered or limited-habitat species) to climatic and other stresses.

(3) *How do ecological systems themselves contribute to processes of global change?*

The biogeochemical and physical feedbacks from living systems strongly influence the fluxes and amounts of methane, nitrous oxide, carbon dioxide, and the reactive trace gases in the atmosphere, as well as albedo and water fluxes. Decisions regarding land-use policies require that these causative interactions be understood and that their feedbacks be represented correctly in global-system models.

DOE, EPA, USDA, NSF, and DOI ongoing and new programs will address these needs: determining the influence of soil biology, total biomass, land-cover type, and transpiration on biogenic gas fluxes and evapotranspiration in different vegetation types, and characterizing the interactions between climate, vegetation, and soils in diverse ecosystems.

Earth System History

Table 1 shows the requested FY 1991 budget for this science element by agency. The FY 1991 request for this element is a $x million (y percent) increase over the FY 1990 level.

Geological and historical records document the natural variability of the physical environment, climate, and ecosystems on all time scales from interannual to millennia. These data reveal periods that were significantly colder and warmer than today, as well as past abrupt climate changes and subsequent environmental responses. Understanding this past behavior of the natural system is essential for detecting predicted human-caused perturbations against the background of normal variability and for providing data sets to test climate models.

Confidence in the predictions of climate models is already a key factor in policy debates, as is whether a greenhouse "signal" can be found in the data record of recent decades. In addition, past evidence of the impact of climate changes on ecosystems are graphic demonstrations of the vulnerability or resilience of these systems to change.

These research efforts reflect the Program's research priorities (see Figure 1) and involve the following relevant policy questions:

(1) *What are the natural ranges and rates of change in the climate and environmental systems?*

The paleoclimatic record shows the covariation of several variables, thereby providing particular insight into cause and effect. The history of atmospheric carbon dioxide and methane along with records of past climates can be reconstructed from ice core samples. Similarly, the temporal covariations in the terrestrial biosphere, the carbon cycle, and climate need to be reconstructed from fossils, ocean sediments, and the geological record.

To address these opportunities and needs, DOI and NSF will focus on developing new paleoclimate methods, will reconstruct past abrupt climate transitions, and past warm intervals on Earth, and will emphasize studies in the sensitive arid (DOI) and polar (NSF and DOI) regions.

(2) *How rapidly have ecosystems adapted to past abrupt transitions in climate?*

The long-term geologic record contains evidence for a number of minor- to large-scale, rapid changes that have had profound effects on Earth systems and hence offers the opportunity to observe the environmental effects (e.g., extinction and replacement of biota) of a large sudden perturbation.

While the general characteristics and timing of major abrupt changes throughout the geological record are known, the existing studies are generally incomplete and limited in scale and scope. Better understanding of their effects on earth systems will require the integrating of records on regional to global scales for selected events.

The programs of USDA, DOI, and NSF will contribute studies that emphasize the effects on the biosphere. The ongoing paleoclimate programs of USDA will include a strengthened emphasis on the impacts of fire severity and frequency on the life histories and distributions of biota. New initiatives will be begun to study the effects of climate change on arid regions (DOI), and the impact of abrupt climate changes on ecosystems (NSF).

(3) *Do past warm intervals in Earth history provide appropriate scenarios to test model predictions of future global warming?*

The assessment of the regional predictions of general circulation models will benefit from a comparison to data showing how representative regions responded during past warm periods. Intervals of past warm climates are known, but most of the environmental reconstructions of those times are qualitative and the scope of the variables is not comprehensive, which is a limitation in assessing the reliability of the models.

The Program will focus on determining if regional responses to global warming are similar for all warm intervals regardless of boundary conditions or causes of the warming. This goal will be addressed by ongoing NSF and DOI paleoclimatic research, as well as augmenting existing interdisciplinary programs such as the Climate of the Holocene Mapping Project (COHMAP) (NSF and DOE) and the Pliocene Project (DOI). NOAA will augment its study of integrated paleoclimate investigations and global model assessment for these warm-Earth scenarios.

Human Interactions

Table 1 shows the requested FY 1991 budget for this science element by agency. The FY 1991 request for this element is a $x million (y percent) increase over the FY 1990 level.

A comprehensive picture of global change must include the relationship between biological, atmospheric, hydrologic, and terrestrial changes and the human activities that stimulate or mediate them. These relationships include both the cumulative effects of individual or group actions over long periods of time and the less-concentrated, but equally influential, effects of the actions of social and economic institutions. For example, greenhouse gas emissions are due to several social and economic factors, including growth of human population, energy consumption, agricultural and industrial practices, and regulations.

Without an understanding of human behavior and its consequences on the environment, models of physical and biological of change will be inadequate to explain, or to develop policies to deal with, global change phenomena. The following research efforts reflect the Program's research priorities (see Figure 1) and involve the following relevant policy questions:

(1) *What kinds of empirical data are needed to measure and understand human interactions in global change?*

The study of human interactions is dependent on having time-series data on a wide variety of human activities and related phenomena, ranging from energy demands to food consumption patterns. Such data must be cross-national to reflect the differing technological, economic, and cultural forces in various societies. The necessary first step is to establish baseline data on environmentally significant human activities in many regions.

NSF is supporting the collection of baseline data in environmentally critical areas and will establish Long Term Regional Research Sites. These will support research on methodological problems in creating cross-national data bases which span the range of human activities in the region and will encompass historical as well as baseline data collection. DOI's research addresses the human factors that influence supply and demand of water and land resources. USDA will study the role of human behavior in natural and managed ecosystems, and in the extent and severity of fires. DOE will continue its data collection on fossil fuel utilization and carbon dioxide emissions.

(2) *How and why do human beings and human systems influence physical and biological systems?*

The development of accurate predictive understanding of the human factor in global change (and hence appropriate public policy responses) is dependent not only upon the availability of data bases that span time and space, but also on characterizing the fundamental processes of change in human systems and the interactions with the physical and biological systems. Therefore, a critical early step in understanding human interactions in global change is the support of process studies.

NSF will expand its Human Dimensions of Global Environmental Change Program to put additional emphasis on social processes such as the economic influences in deforestation and the effectiveness of legal and regulatory controls over water resources. The Long-Term Regional Research Sites will be the focus of research on long-term patterns and processes of social, economic, and ecological change. DOI will support the development of methods to estimate: (i) tradeoffs among competing social, environmental, and economic goals and (ii) the role of human choices on water supplies and in coastal erosion and inundation. USDA's research program will include the effect of fires on rural population distributions.

Solid Earth Processes

Table 1 shows the requested FY 1991 budget for this science element by agency. The FY 1991 request for this element is a $x million (y percent) increase over the FY 1990 level.

Many solid earth processes are directly involved in the life-sustaining elements of the regional and global environment. Melting of glaciers, especially polar ice sheets, would cause sea level to rise; large volcanic eruptions can cause climatic cooling for short periods of time; and methane released from permafrost and gas hydrates in response to climatic warming can change atmospheric composition. An improved understanding of solid earth processes will allow for more effective long-term planning in those coastal regions most vunerable to rising sea level and in protecting human populations most apt to be endangered by volcanic eruptions and other catastrophic solid earth processes.

These research efforts reflect the Program's research priorities (see Figure 1) and involve the following relevant policy questions:

(1) *How do different coastal regions respond geologically and ecologically to higher sea level, and how can the contributions from changes in climate (e.g. glacier melting and ocean warming) be differentiated from those due to tectonic processes?*

Sea level is predicted to rise as a consequence of global warming, but the absolute magnitude, rate, and timing of the sea level rise are uncertain. Elevated sea level could have serious consequences for coastal environments and human populations and an improved predictive capability for sea level rise is required for the effective formulation of adaptation or mitigation stategies.

To understand sea level changes, and their consequences, requires measurements of the absolute magnitude and rate of sea level rise; differentiation between the contributions arising through climatic change from those due to movements of the Earth's crust; and prediction of the geological and ecological response of different coastal environments.

Ongoing and new research programs that contribute to these areas include: studies of glaciation and deglaciation during periods of climatic change (NSF); in-situ global sea level network (NOAA); satellite ocean altimetry (TOPEX-NASA); the NOAA, NSF, and NASA programs to use space-based Global Positioning System (GPS), Satellite Laser Ranging (SLR), and Very Long Baseline Interferometry (VLBI) to measure sea level changes; coastal erosion and inundation on the East coast of the USA (DOI and NASA); coastal wetlands change dynamics program (DOI); and the application of new isotopic methods for dating of landforms, soil, and sediments (NSF).

(2) *What are the magnitude, geographic location, and frequency of occurrence of volcanic eruptions?*

Large volcanic eruptions emit gases, ash, and aerosols into the atmosphere that can cause significant short-term perturbations to the Earth's climate by changing the radiative budget. It is essential to quantify climate change induced both by volcanic eruptions and by increased abundances of greenhouse gases.

Understanding the impact of volcanic eruptions on the Earth's climate requires an improved understanding of the magnitude, frequency, and geographic location of subaerial and submarine volcanic events and the nature and amount of emitted material. Hydrothermal venting from the ocean floor is a major source of heat from the Earth's interior, and influences the global carbon cycle.

Several ongoing and new programs contribute to this research effort including: studies of gas and ash emissions and degassing processes from U.S. volcanoes (DOI); satellite measurements of atmospheric volcanic aerosols and sulfur gases (Total Ozone Mapping Spectrometer, Earth Probes, and Eos (NASA)); and studies of the fluxes of energy, gases, fluids, and particulates from submarine eruptions on the mid-ocean ridges (Ridge Interdisciplinary Global Experiment (RIDGE)-NSF, NOAA and DOI).

(3) *How do permafrost regions of the northern hemisphere respond to climate warming?*

An accelerated release of methane trapped in Arctic permafrost and gas hydrates due to a climatic warming would alter the chemical composition of the atmosphere and further enhance the greenhouse effect. Ongoing and new research will contribute to this area through projects that study the dynamics of permafrost change (NSF) and by assessing whether there is a current climatic warming on a local, regional or hemispheric scale by monitoring sub-surface temperatures in Arctic permafrost (DOI).

Solar Influences

Table 1 shows the requested FY 1991 budget for this science element by agency. The FY 1991 request for this element is a $x million (z percent) increase over the FY 1990 level.

The sun influences two of the most important current policy-related phenomena: the depletion of ozone by chlorofluorocarbons and climate warming due to greenhouse gases. In both areas, the main scientific problem is one of separating the effects that are due to human influences from changes induced by natural forcing agents, such as the sun.

These research efforts reflect the Program's research priorities (see Figure 1) and involve the following relevant policy questions:

(1) *What aspects of solar variability are influencing the stratospheric ozone layer?*

Since ozone is generated by the breakup of oxygen by solar UV radiation, observed ozone changes will depend, in part, on solar activity. Thus, the detection of human-caused ozone depletions requires that the solar component of ozone change be properly accounted for. This understanding requires long-term UV observations of adequate precision (±1%) over the solar cycle. The required observations will be provided by instruments on NASA's Upper Atmosphere Research Satellite and Eos.

(2) *What impact do other inputs, e.g., particles, have on the upper atmosphere and how are they coupled to other atmospheric regions?*

The physical properties of the upper atmosphere (e.g., temperature, composition, and density) are sensitive to human-influenced gases, such as carbon dioxide and methane, and to solar particles. Such changes could be quite substantial and hence could affect satellite orbits and provide insight into potential sun - atmosphere couplings. NSF's Coupled Energetics and Dynamics of Atmospheric Region (CEDAR) and Geospace Environment Modelling (GEM) programs will begin the establishment of data bases on solar inputs relevant to the global circulation and couplings.

(3) *How does the sun's output vary and what is the impact on terrestrial climate?*

A key factor in establishing the Earth's radiation budget is the total solar radiation reaching the planet. This requires continuous measurements of the total solar radiation with very high long-term stability (0.1%). These observations will be provided by Active Cavity Radiometer Irradiance Monitors (ACRIM) on NASA's UARS and Eos.

Data Management

Table 1 shows the data management budgets by agency. The FY 1991 request for data management is a $x million (y percent) increase over the FY 1990 level.

Data and information management will provide a bridge between global-change observations and scientific understanding, and will be a key factor in the success of programs carried out within all seven interdisciplinary science elements. The traditional concepts and present practices of data management are inadequate for global change studies, since the interdisciplinary, interagency, and international aspects of these studies, coupled with a long-term view, pose unprecedented challenges to the data management and research communities alike. Consequently, cooperation in seeking new approaches to archiving and mangement of data is essential.

Data management includes the means and mechanisms to describe, gather, transmit, validate, process, archive, and disseminate data. The initial thrust will be on data base development in the highest priority science elements and strengthening the infrastructure required to process, manage and improve access to the great variety of ground- and space-based observations.

The key data management questions with policy implications include:

(1) *How can the data handling and access capabilities be best organized and strengthened?*

Data management systems for global change must be able to accept and archive dissimilar types of data collected from different data collection systems by different organizations in different formats and on different media, i.e., both ground- and space-based data.

Interactions among CES agencies through the Interagency Working Group on Data Management for Global Change and with the science community have been enacted to facilitate improved data handling capabilities. Studies have been initiated to develop archives with improved quality control, documentation, and ease of access to satellite data, including formation of the Eos Data and Information System (NASA, NOAA and DOI) and procedures are being developed for better distribution of CD-ROM data bases. Acess to and assimilation of the DOD environmental data base is being addressed. Bilateral agreements have been signed between NASA and NOAA and between NASA and DOI for the development of data systems to manage satellite data and the exchange of satellite information between NASA, NOAA, ESA, Canada, and Japan has been instituted. NASA and NOAA are gathering relevant foreign data to combine with U.S. data.

A major problem facing scientists attempting to use global-change data sets is that it is extremely difficult to find who has what data and how good the data are. Using existing facilities, NASA, NOAA, NSF, DOE, and DOI will continue to develop and expand a Master Directory for Global Change by linking with a common architecture directories, catalogs, and inventories of data in all global change science elements. Hundreds of global change data sets already have been documented and entered.

(2) *How can the agencies build the data sets needed to facilitate early results from the Program?*

Long-term global measurements must routinely result in analyzed fields of well-defined accuracy, supported by documentation regarding instrument calibrations, coverage, sampling, data editing, data reduction algorithms, including ancillary data, algorithm validation, assimilation or analysis procedures, and correlative measurements.

Many ongoing and new research programs contribute to the task of developing integrated global-scale satellite and in situ data sets that will support model development including: the development of data bases in support of biological responses to climate, abrupt climate change, anthropogenic forces in global change, long-term ecological research, studies of ecosystem stress, land-surface data, fire severity and occurrence, sea surface temperature fields, and regional ecosystem variables that are sensitive to global change (All CES agencies are involved in one or more of these activities). DOE will support a critical review of data for climate modelling, and NSF will support a geosystem data base activity that includes the development and quality control of model-generated data sets. On a priority basis, data sets are being extended into the past, both to document global change, and to test and validate diagnostic and predictive models. NOAA and NSF data management elements provide resources for the digitization of historical data bases and the organization of paleo data bases. DOE and DOI have similarly focused programs.

Budget by Scientific Objective

Figure 3 shows the FY 1990 and FY 1991 proposed budgets for the U.S. Global Change Research Program by scientific objective: observations, understanding, prediction, and data management. The proposed budget reflects a balance between each of the scientific objectives, with a strong committment to data management.

Budget by Agency

Figure 4 shows the FY 1990 and FY 1991 proposed budgets for the U.S. Global Change Research Program by agency. The individual agency efforts build upon their respective scientific and technical strengths.

National Oceanic and Atmospheric Administration (NOAA). In FY 1991, NOAA has proposed an $87 million Climate and Global Change Program in support of the U.S. Global Change Research Program. This represents a $69 million or 383% increase over FY 1990. The FY 1991 NOAA contribution involves enhancements to ongoing efforts in: operational IN SITU and satellite observation programs with an emphasis on oceanic and atmospheric dynamics (including sea level), circulation, and chemistry; focused research on ocean-atmosphere interactions, the global hydrological cycle, the role of oceanic circulation and biogeochemical dynamics in climate change, atmospheric trace gas/climate interactions, and the response of marine resources to climate change and related stresses; and programs to improve climate modelling, prediction and information management capabilities.

Department of Energy (DOE). In FY 1991 DOE has proposed a $66 million budget for global change research, a $16 million dollar or 32% increase above FY 1990 levels. The DOE maintains a research program directed at the impact of energy production and use on the global Earth system by focussing primarily on climate, atmospheric, ocean, and ecosystem responses. DOE proposes augmentations to research efforts for climate modeling and studies of carbon dioxide sources and fates in the atmosphere, oceans, and land; impact of climatic processes on vegetation and ecosystems. New initiatives include efforts to identify critical data needs for global change research and the climatic variables that may serve as indicators of global change; research efforts to quantitatively describe the radiative balance and the cloud-climate feedback in the atmosphere; funding to provide education and training to the next generation of scientists.

Department of the Interior (DOI). In FY 1991 DOI has proposed a $44 million budget for global change research, a $33 million dollar or 300% increase above FY 1990 levels. DOI programs focus on monitoring, understanding and predicting global change and its interactions with managed and natural ecosystems and resources in diverse climatic and physical settings, and hydrological and carbon cycles using recent geological information.

Environmental Protection Agency (EPA). In FY 1991, EPA has proposed $22.1 million for global change research, an increase of $8.9 million or 67% over the FY 1990 level. EPA's research efforts are focused on evaluating the processes and quantifying the relative contributions of anthropogenic and biological sources of trace gases, quantifying and modeling the consequences of climate change on ecosystems and their subsequent feedback to the atmosphere, and the interaction of trace gases in the atmosphere. Special emphasis will be given to climate sensitive regions, e.g. tundra, wetlands and forests. EPA's research will help provide the process-level understanding and modeling capabilities to predict global change.

National Aeronautics and Space Administration (NASA). In FY 1991, NASA has proposed $661 million for global change research, an increase of $172 million or 35 percent above the FY 1990 level. NASA research efforts are primarily focused on space-based studies of the Earth as an integrated system. These activities include ongoing research and satellite programs (e.g., the Upper Atmosphere Research Satellite, Ocean

Topography Experiment, etc.) that are important precursors to the FY 1991 initiatives: Earth Probes (a series of satellite measurements prior to Eos to monitor atmospheric ozone, ocean color, precipitation in the tropics, and ocean surface winds) and the Earth Observing System (Eos). Eos will provide an integrated, comprehensive monitoring and data management program of simultaneous measurements of key global change variables.

National Science Foundation (NSF). In FY 1991, NSF has proposed $103 million for global change research, an increase of $52 million dollar or 102 percent above the FY 1990 level. NSF proposes to augment and initiate programs coordinated internationally to observe, understand, and model atmospheric, oceanic, terrestrial, and social processes and their coupled interactions. Studies include ocean circulation, ocean-atmosphere interactions, cloud-radiation, global atmospheric chemistry, biogeochemical processes, land-sea interactions, past climate change, crustal and related processes impacting global change, ecosystems, solar processes, human dimensions of global change, data bases, and a multi-agency education initiative for global change.

United States Department of Agriculture (USDA). In FY 1991 USDA has proposed $47.4 million for global change research, an increase of $27.3 or 136% above the FY 1990 level. USDA research efforts are focussed on ground-based research programs studying agricultural, forest and range ecosystems as influenced by factors such as water balance, atmospheric deposition, plant responses to changes in atmospheric constituents, UV-B radiation and other global change variables. Some representative studies that will focus on agricultural effects on environmental variables will include; mechanisms of methane generation and nitrous oxide release, soil properties including moisture, erosion, organic matter dynamics, nutrient fluxes, and microbes; relationship of global change to forest and range fires, insects, and plant pathogens; and, agricultural management systems.

Budget by Federal Budget Function

Scientific, environmental, energy, and agricultural resources are vital to the health of our nation. Table 3 shows the FY 1990 and FY 1991 proposed budgets for the U.S. Global Change Research Program by Federal budget function. In FY 1991, significant increases above FY 1990 levels are proposed for each budget function. The U.S. Global Change Research Program must be viewed as a single integrated research effort where its success is dependent upon cooperation and contributions from each of the individual agency programs.

Table 3
1990 - 1991 U.S. Global Change Research Program Budget
by Budget Function
(Dollars in Millions)

Budget Function	Budget Function Number	1990	1991
TOTAL		663	1034
General Science, Space and Technology	250	540	764
NASA		489	661
NSF		51	103

Energy (DOE)	270	50	66
Natural Resources and Environment	300	46	157
DOI / DOI		11	44
EPA		17	26
DOC / NOAA		18	87
Agriculture (USDA)	350	33	47

Budget by Ground- and Space-Based Research

Figure 5 shows the FY 1990 and FY 1991 proposed budgets for the U.S. Global Change Research Program by space- and ground-based research activities. Maintaining an appropriate balance between ground- and space-based research programs is essential for a successful U.S. Global Change Research Program. In-situ and theoretical studies of physical, chemical, biological and geological processes must be complemented by a comprehensive space-based program to provide the global observations of key environmental variables. The combination of ground- and space-based measurements is required given the temporal and spatial variability of the systems being studied, and the need to scale the processes occurring at the local level to the regional and global levels. The ground-based program is essential to interpret some of the global satellite observations (e.g., long-term trends), as well as obtain scientific information not attainable from space (e.g., trace gas fluxes). Both types of program need to be strongly supported, and the FY 1991 budget reflects a reasonable balance.

Ground-based: The budgets of DOE, DOI, EPA, NOAA, NSF, and USDA include support for a broad range of ground-based and modeling research activities. The activities range from small individual principal investigator research programs to participation in complex international scientific projects. The budgets would initiate multi-agency research thrusts in several critical areas including: the role of the oceans and terrestrial biosphere in trace gas fluxes; the exchange of energy between the oceans and atmosphere; the cycling of water throughout the entire Earth system; and the expanded monitoring of responses to global change, such as sea level.

Space-based: The NASA budget includes continued support for TOPEX and UARS, as well as the Earth Probes and Eos initiatives. The TOPEX, UARS, and Earth Probes missions will provide key global measurements, prior to the Eos era that starts in 1998, of stratospheric composition, including ozone, and dynamics; surface topography of the global oceans and sea surface wind velocity in order to advance the understanding of ocean circulation; rainfall in the tropics in order to determine the role of tropical precipitation in climate; and ocean color to improve the understanding of ocean productivity. The Eos will provide an integrated, comprehensive monitoring program of simultaneous measurements of key global change variables, coupled with a comprehensive data and information system.

THE CARBON CYCLE: AN EXAMPLE OF INTERDISCIPLINARY RESEARCH

Modification of the global carbon cycle by human activities spans both science and policy concerns. This section of the report presents a case study of how important comprehensive multidisciplinary research is to the U.S. Global Change Research Program.

Emission of carbon dioxide from the combustion of fossil fuels and changes in land-use practices, and of methane from cattle, rice paddies, coal mining, and natural gas production are partly responsible for perturbation of the carbon cycle. Changes in the carbon cycle may affect regional and global climate, the chemistry of the atmosphere, the hydrologic cycle, and the productivity and functioning of ecosystems. Consequently, prudent environmental policy formulation will require a defensible scientific understanding of how the carbon cycle varies naturally, how human activities change it, and how it might respond to future changes in environmental conditions.

Scientific Background

Atmospheric carbon dioxide is a radiatively active trace gas whose concentrations are now 25% greater than those in the pre-industrial era (prior to 1850) and are increasing at about 0.4% annually because of human activities. Annual anthropogenic emissions of carbon dioxide are currently about 5.5 billion metric tons from fossil fuel combustion, plus an additional 0.8 to 3.0 billion metric tons from tropical deforestation. Over the past century, fossil fuel use and cement manufacturing released about 200 billion metric tons of carbon into the atmosphere. In the same time period, land-use changes (primarily deforestation) may have released as much as an additional 115 billion metric tons of carbon. However, only 130 billion metric tons of these combined releases remain in the atmosphere. A critical question concerning the global carbon balance is "What has happened to the remaining carbon dioxide and what will happen to it in the future"?

The natural fluxes of carbon dioxide into and out of the atmosphere from the oceans and terrestrial biosphere are an order of magnitude greater than the anthropogenic fluxes. The oceans, which contain about 50 times more carbon than does the atmosphere, are known to be an important long-term sink for carbon from the atmosphere. In addition, while terrestrial vegetation has always assimilated atmospheric carbon dioxide by photosynthesis, it has recently been suggested that vegetation and soils at northern midlatitudes may be becoming more effective in sequestering carbon from the atmosphere because of either changes in land management (e.g., reforestation) or because the increasing atmospheric carbon dioxide concentrations may be stimulating plant productivity. These oceanic, terrestrial, biogeochemical, and ecological processes ultimately determine the fate of carbon dioxide from human activities. However, uncertainties in the knowledge of the magnitude of the oceanic and terrestrial sinks limit the accuracy of forecasts of the future fraction of "anthropogenic" carbon dioxide that will remain in the atmosphere.

Atmospheric methane is a radiatively and chemically active trace gas whose concentrations are now a factor of two greater than those in the pre-industrial era and are increasing at about 1% annually, presumably because of human activities. The atmospheric abundance of methane is controlled by emissions from oxygen-deficient sources such as natural wetlands, permafrost and gas hydrates, rice cultivation, biomass burning, cattle, coal mining, natural gas venting, and removal by atmospheric chemical reactions.

Uncertainties in the knowledge of the magnitude of the individual sources and sinks of carbon dioxide and methane severely limit the accuracy of forecasts of their future atmospheric concentrations.

Required Understanding

Biological and physical processes control the uptake and release of carbon by the oceans, and ecosystem dynamics are equally important on land. Economic and human factors dictate the magnitude of fossil fuel emission and the intensity of land disturbance. The task of predicting future abundances of atmospheric carbon dioxide, methane, and other carbon-containing gases requires scientific information, spanning numerous scientific disciplines, including: the exchange of carbon dioxide between the oceans and the atmosphere; the exchange of carbon dioxide and total carbon between the shelves and open oceans, and between the surface waters, deep ocean and sediments; the exchange of gases between terrestrial ecosystems and the atmosphere; the storage and cycling of carbon within terrestrial ecosystems; the extent and ecological state of terrestrial and aquatic ecosystems; atmospheric distributions and transformations of gases; paleocarbon budgets; and the influence of human choices on the carbon cycle.

U. S. Global Change Research Program: The Carbon Cycle

The proposed U.S. Global Change Research Program of observations, process studies, and predictive modeling will provide significant scientific advances in the short- and the long-term that will assist in policy formulation. In-situ and theoretical studies will be complemented by space-borne measurements to address the spatial and temporal variability of the sytems being studied, and to provide a framework for scaling processes operating at the local level to the regional and global level.

Table 4 gives examples of specific research activities related to the carbon cycle. Synthesis and integration of results obtained by investigators working within their numerous disciplines is a critical challenge guiding the U.S. Global Change Research Program. This diversity of activities is typical of global change research.

Table 4. Examples of carbon-cycle research activities in the FY 1991 U.S. Global Change Research Program.

Climate and Hydrologic Systems

- o Global Climate Models. Conduct carbon dioxide scenario experiments in GCMs using coupled atmosphere-ocean models. (DOE, NASA, NSF, and NOAA)

Biogeochemical Dynamics

- o Earth Probes Satellite Ocean Color Imager and Scatterometer. Determine ocean productivity and the wind stress at the ocean surface, which will help characterize the carbon dioxide flux across the air/sea interface. (NASA)
- o Ocean Carbon Studies. Initiate a program of high-precision measurements of carbon dioxide and total carbon, investigate the cycling of carbon in the world's oceans, and determine the air-sea flux of carbon dioxide. (NSF, NOAA, and DOE)
- o Global Carbon Dioxide and Methane Trends. Monitor the changing abundance of the radiatively active trace species at globally distributed sites. (NOAA, NSF, NASA, and DOE)
- o Terrestrial/Atmospheric Carbon Cycling. Determine the fluxes of methane and non-methane hydrocarbons from terrestrial ecosystems and the atmospheric processes that establish their lifetime. (NASA, NSF, NOAA, DOE, EPA, and DOI)

Ecological Systems and Dynamics

- o Carbon Cycling in Ecosystems. Study carbon cycling in terrestrial ecosystems and the processes controlling carbon dioxide fluxes from photosynthesis, respiration, and land-use changes. (DOE, EPA, DOE, USDA, and NSF)

- o Land Surface Characterization. Develop data bases for improved vegetation characterization, such as vegetation / land cover maps, vegetation greenness indices. (DOI, NOAA, and NASA)

Earth System History

- o Paleo-Atmospheric Carbon Dioxide Abundances. Carry out ice core studies of carbon dioxide concentrations and other associated variables. (DOE and NSF)

- o Geological History of the Carbon Cycle. Reconstruct changes in the distribution of carbon isotopes in the Earth's systems. (NSF and DOI)

- o Modeling the Past Carbon Cycle. Develop models of the long-term partitioning of carbon between the atmosphere, ocean, and terrestrial reservoirs. (DOI)

Human Interactions

- o Carbon Dioxide Emissions. Development of second-generation carbon dioxide emission models. (DOE)

- o Carbon Dioxide and Standard of Living. Examine the national differences in fossil fuel consumption and its relation to the standard of living. (NSF)

Solid Earth Processes

- o Volcanic Carbon Dioxide. Assess long term volcanic contributions of carbon dioxide to the oceans and atmosphere. (DOI, NSF, and NOAA)

- o Methane Emissions from Permafrost and Methane Hydrates. Assess the volume and potential release of methane from permafrost and methane hydrates. (DOI and NSF)

SPECIAL ISSUES

The CES has addressed several issues that, while they are not research *per se*, are important to the success of the U.S. Global Change Research Program. The sections below describe those issues and the approach that CES has taken.

Education

The science of global change is complex and inherently multidisciplinary. While unraveling answers to scientific questions undoubtedly will require new approaches and technology, another important concern is the development of the human resources and scientific talent to conduct multidisciplinary global change research.

To address this need NSF and DOE will initiate human-resources programs in FY 1991 that will annually support several hundred postdoctoral appointments, graduate students, and undergraduate students as research participants, as well as several summer institutes on interdisciplinary global change research problems. The NSF program will be managed by representatives from each of the CES agencies, and training opportunities, both in the U.S. and abroad, will include: (i) support at the individual project level; (ii) training centered at major research centers or technology centers; and (iii) opportunities for students to pursue training at institutions of their choice. The DOE program will encourage basic training at universities offering interdisciplinary programs and operational experience in team research at national laboratories and other science and technology centers.

Emerging Disciplines

The U.S. Global Change Research Program presented here should not be viewed as a full exposition of the details of the program in the outyears. The program will evolve as new projects are developed in response to scientific developments and policy needs. Each of the U.S. scientific agencies has programs at various stages of planning, and furthermore, there are major scientific planning activities related to global change within the U.S. (Global Change Committee of the National Academy of Sciences) and international (e.g., the International Geosphere-Biosphere Programme of ICSU, and the World Climate Research Program of WMO) scientific communities that have not reached the point of submission to agencies for any formal consideration. Examples include work on paleontology, hydrology, experimental ecology, and human interactions.

International Dimension

The U.S. Global Change Research Program is founded on the premise that international cooperation and coordination is fundamental to the scientific planning and the implementation of the entire Program. Research programs, like the WCRP and the IGBP are truly international in scope and in design. The complex scientific agenda and the infrastructure needed to address the programs outlined here require a careful assessment and integration of its components with programs of other governments; intergovernmental bodies [e.g., U.N. bodies such as the IPCC]; and international non-governmental science coordinating and facilitating mechanisms [e.g., ICSU]. A major CES coordinating effort has been initiated with ICSU and the international scientific community, the intergovernmental organizations, and with CES-like bodies in other countries. During 1990, it is expected that an integrating infrastructure will begin to evolve; will be endorsed by the various participating agencies, organizations, and institutions; and will involve to some extent the private and industrial sector.

One critical activity now in its early stages of development and cooperative planning is an internationally coordinated data and information management system. The scientific data generated by the U.S. Program and similar programs in other countries will ultimately be essential to the enhancement of worldwide scientific understanding of the Earth system and is crucial to improved input to the policy process, both domestic and international.

An important and growing international issue, one with both policy and scientific dimensions, concerns the special needs of developing countries and the linkage between the environment and sustainable development. The CES and its member agencies are attempting to address some of the scientific aspects of this issue by promoting cooperative environmental research with a number of developing countries (e.g., China, Brazil, Mexico, Hungary, Poland, and India).

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of: EEU 20 December 1989

to: Nancy Maynard, OSTP ✓

cc: Lennard Fisk, HQ/E
Shelby Tilford, HQ/EE
Barbara Cherry, HQ/XC

from: Michael Prather and Robert Watson, HQ/EEU mp.

subject: Space Shuttle Impact on Stratospheric Chlorine and Ozone

We enclose a draft of the report being prepared for the Upper Atmosphere Program as part of the 1990 report to the Congress and the EPA. These calculations have received some interest lately. The basic results have been discussed along with a press release from the USSR which comments (unfavorably) on the adverse atmospheric impacts from Shuttle launches (Times of London, article not available). As you can see, the current draft of the article is incomplete; however, the results of the model assessments are final. We will forward a final version as soon as it is available.

Global change
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frequently

DRAFT

December 19, 1989, 4:10pm

Stratospheric Chlorine from the Space Shuttle and Titan IV

Michael J. Prather and Maria M. Garcia, 212-678-5625 -5552 (fax)
NASA, Goddard Institute for Space Studies, New York, NY
Anne R. Douglass and Charles H. Jackman,
NASA, Goddard Space Flight Center, Greenbelt, MD
Malcolm K. W. Ko and Nien Dak Sze,
Atmospheric and Environmental Research Inc, Cambridge, MA

ref Peter Evanoff, Morton-Thiokol 703-892-6308 (fax-8962)

1. Introduction

The launch of NASA's Space Shuttle and similar rockets injects chlorine compounds directly into the stratosphere, adding to the current burden of stratospheric chlorine and increasing the chlorine-catalyzed destruction of ozone (ref: WMO, 1985; UNEP/WMO, 1989). The Solid Rocket Motors (SRM) on the Space Shuttle and Titan IV launch vehicles use a solid fuel composed of ammonium perchlorate and aluminum which releases most of the chlorine as gaseous HCl when burned. The last assessment of the Shuttle in terms of stratospheric ozone was more than a decade ago (ref: Hudson et al., 1978?); and our understanding of stratospheric chemistry and modelling has evolved much since then.

DRAFT

We present here current estimates for the amount of stratospheric chlorine injected with each launch of the Shuttle or Titan IV (ref: Peter Evanoff, Morton-Thiokol, private communication, 1989). A scenario consisting of 9 Shuttle launches and 6 Titan launches per year is examined with three independent stratospheric models: two-dimensional models with complete chemistry (AER: Ko et al., 1985, 1989; GSFC: Douglass et al., 1989, Jackman et al., 1989) and a three-dimensional model for chemical tracers (GISS: Prather et al., 1989). The increases in total inorganic chlorine (Cl_y) associated with the expected scenario of launches would take several years to build up in the stratosphere.

On average Cl_y will increase due to these rocket launches by about 10 ppt in the middle stratosphere of the northern hemisphere, an increase over current levels of less than 0.5%. The corresponding ozone depletions are predicted to be less than 0.2% locally, with smaller perturbations to the ozone column. Two days after a Shuttle launch in January, Cl_y enhancements in the middle stratosphere are predicted to range from 10 to 50 ppt (about 0.5 to 3%) above background for a region about 20 latitude by 30 longitude. One month later the Shuttle plume has dispersed, and increases in Cl_y are less than 4 ppt throughout the stratosphere.

The profiles and amounts of chlorine injected from the solid rockets are summarized in section 2. Model predictions of the steady-state accumulation of Cl_y are described in section 3, and the transient response to a single launch is shown in section 4. The overall impact on stratospheric chlorine and ozone is discussed in section 5.

2. Source of chlorine from rocket exhaust

Estimates of the amount and distribution of chlorine released from the launch of the NASA Space Shuttle and the Titan IV expendable launch vehicle are available from Morton-Thiokol (Peter D. Evanoff, private communication, 1989). In Table 1 we report the kg of chlorine (as Cl) released in 5 km vertical intervals for Shuttle launches from Cape Canaveral, Florida (9 per yr) and for Titan IV launches from both Cape Canaveral (4 per yr) and Vandenberg Air Force Base, California (2 per yr). The chlorine is released as HCl which we treat as Cl_y in the models.

The total amount of chlorine released into the stratosphere (above 15 km) by the solid rocket motors is 725 metric tons (1000 kg) per year, and can be compared with that associated with industrial halocarbons. The chemical industry's production of halocarbons exceeds one million metric tons of chlorine per yr (see UNEP/WMO, 1989). The release of chlorine during photochemical destruction of the chlorofluorocarbons (CFCs) occurs predominantly in the stratosphere, but happens slowly, on time scales of order 100 yr, over the lifetime of the gas. The estimated annual source of stratospheric chlorine from the industrial halocarbons is only about 0.3 million metric tons of chlorine per yr (AER model). Thus, the launch schedule in Table 1 would add only about 0.25% to the current stratospheric source of Cl_y, which is dominated in the present atmosphere by photochemical oxidation of industrial halocarbons.

The release of chlorine from the 15 launches summarized in Table 1 was averaged over the year and put into the models as a continuous source of Cl_y every time step. The vertical distribution specified in Table 1 was used by the models. The latitudinal location of the two launch sites was included in all three models; but the longitudinal location could only be specified in the 3-D simulation. In a separate calculation the 3-D model was used to follow the dispersion of the chlorine from a single Shuttle launch at Cape Canaveral by using, as an instantaneous source, the annual rate in Table 1 divided by nine.

3. Steady-state accumulation of stratospheric chlorine

The three models used the continuous source of stratospheric chlorine from the rocket launches as described in section 2. The ultimate removal for the injected stratospheric Cl_y is transport into the lower atmosphere (troposphere) where most inorganic chlorine species are soluble and therefore removed rapidly by rainfall and other processes. In these models this sink was applied (?help others) by imposing either rapid loss for Cl_y or a negligibly small concentration of Cl_y in the lower troposphere. Small differences in the application of this lower boundary condition do not affect the calculated stratospheric Cl_y

distribution because almost all of the chlorine transported into the troposphere is removed and cannnot be recirculated back into the stratosphere.

These calculations were initiated and then continued for several model years until a steady-state distribution was reached. In steady state, stratospheric Cl_y levels have built up until the amount of chlorine injected into the stratosphere equals that transported into the lower troposphere.

The computed addition to Cl_y (ppt) in steady state that is associated with the Shuttle/Titan launches is shown as monthly, zonal averages in Figures 1-3 for the GSFC, AER and GISS models, respectively. The magnitudes of the Cl_y increase is largest in northern midlatitudes (30-50 N) near the source, and peaks in the upper stratosphere (30-45 km altitude) where the rocket emissions are largest on a molecule per molecule of air basis. Concentrations of Cl_y in the northern upper stratosphere range from 6 to 14 ppt in the GSFC model (Figure 1), 4 to 9 ppt in the AER model (Figure 2) and 6 to 12 ppt in the GISS model (Figure 3). The GSFC and GISS models predict a similar buildup of Cl_y; the AER model appears to have a more rapid stratospheric circulation (see Jackman et al., 1989b) that flushes out the chlorine more rapidly. In the lower stratosphere (15-25 km altitude) Cl_y concentrations are less enhanced: about 2 ppt at 15 km increasing to about 6 ppt at 25 km. Several years are required to transport substantial concentrations of the rocket source of Cl_y into the southern hemisphere stratosphere. Concentrations in the southern stratosphere range from less than 1 to as much as 6 ppt, and are generally a factor of 2 or greater below the corresponding enhancements in the northern stratosphere.

During northern winter, all models show rapid northward mixing between 30 N and the pole, with isolines that slant poleward and downward. This basic pattern shown in Figures 1a-3a is typical of other long-lived stratospheric tracers, both from model calculations (see Jackman et al., 1989b) and observations (see WMO, 1985). The pattern of Cl_y during northern summer, however, shows dramatically the impact of a localized stratospheric source in a season without substantial latitudinal mixing. The concentrations of Cl_y in July (Figures 1b-3b) peak strongly at 30 N between 30 and 50 km altitude in all three models, with monthly and zonally averaged maxima of more than 12 ppt in the GSFC and GISS models, and 9 ppt in the AER model.

In order to determine the relative perturbation to Cl_y from the rocket launches, the 2-D models compared the calculated Cl_y enhancements (Figures 1-2) with the Cl_y calculated from all other sources: the CFCs, CCl_4, CHF_2Cl, CH_3CCl_3, CH_3Cl. Air enters the stratosphere containing a mix of these halocarbons representing the bulk tropospheric mixing ratios of these species and with negligible concentrations of the more soluble inorganic chlorine (Cl_y). In the lower stratosphere Cl_y concentrations are small because only a fraction of the CFCs have been photochemically destroyed, thereby releasing chlorine atoms. In the upper stratosphere where the halocarbon and CFC concentrations are greatly reduced, Cl_y concentrations approach their upper limit, about 3 ppb today. The scenario for rocket launches in Table 1 leads to only modest perturbations in stratospheric Cl_y, as shown in Figures 4 (GSFC) and 5 (AER). The GSFC results predict increases ranging from 0.3 to 0.6% over the northern midlatitudes; while the AER model gives smaller perturbations, +0.2 to +0.3%. In the southern hemisphere, Cl_y increases are less than 0.2% for the GSFC model and 0.1% for the AER model.

Ozone perturbations associated with the source of Cl_y from rocket launches are shown in Figure 6 for the GSFC model. The largest depletions in ozone concentration, between 0.10% and 0.15%, occur in the upper stratosphere (30-45 km altitude) in the northern midlatitudes. Losses elsewhere are much smaller with the exception of the corresponding locations in the southern hemisphere. The impact on the total column abundance of ozone is likewise small, less than 0.05%(???Anne/Charley???). The photochemical model used here includes only gas-phase, homogeneous chemical reactions; it does not account for the heterogeneous reactions occurring on polar stratospheric clouds that have been shown to be responsible for the chlorine-catalyzed destruction of ozone in the lower stratosphere during polar winter (the Antarctic ozone hole). Nevertheless, we can place limits on the impact of rocket launches on further polar ozone loss since the relative perturbations to Cl_y in the lower stratosphere are less than 0.1% over Antarctica and 0.5% over the Arctic.

4. Transient response to a Shuttle launch

One launch of the Space Shuttle injects a single, very large pulse of 68 tons of chlorine into the stratosphere. On a globally averaged scale this amount of chlorine in inconsequential as noted above, but the greatly enhanced levels of Cl_y in the vicinity of the exhaust plume may lead to large ozone depletions over a spatially limited region. We examined the transient response of stratospheric Cl_y to a single Shuttle launch using the 3-D GISS model. The chlorine is released over Cape Canaveral (29 N, 80 W) by using one-ninth of the annual source given in Table 1 as an instantaneous source.

Two simulations were initiated on January 1 and July 1, and continued for one month. Figures 7 and 8 summarizes the instantaneous change in Cl_y concentrations at 3.4 mbar (about ?? km altitude) as a function of latitude and longitude for days 1 to 8 following both the January and July initializations. Other levels in the upper stratosphere show similar effects, but lower altitudes in stratosphere have smaller absolute enhancements of Cl_y (see Figures 1-3).

After one day (Figures 7a & 8a) the added chlorine burdens of 75 ppt (January) and 105 ppt (July) are still localized near the launch site (36 N, 70 W) with peak levels barely resolved by the model grid (8 latitude by 10 longitude). After four days (Figures 7c & 8c) the peak levels have decreased by at least a factor of two, have moved away from the launch site in accord with the prevailing winds, and have dispersed to horizontal scales that are resolved by the model. For the January launch most of the added chlorine (concentrations greater than 1 ppt) resides in the region bounded by 20 -50 N and 40 W-100 W. The summer stratosphere is less dispersive, and for the July launch most of the Cl_y is contained between 20 -36 N and 150 E-140 W. Eight days after the January 1 launch (Figure 7d) the area with concentrations of Cl_y more than 10 ppt (about 0.4%) above background levels is about 20 latitude by 20 longitude. [check #s for day 8] Eight days after the July launch (Figure 8d) the added Cl_y remains more concentrated: greater than 30 ppt (about 1%) above background over a smaller area.

The transient pulse of Cl_y from a single Shuttle launch can be compared with the steady-state buildup from a regular schedule of launches as described in Section 3. One week after a shuttle launch, chlorine enhancements in the upper stratosphere are less than or comparable the steady-state accumulation (about 10 ppt) over more than 99% of the globe. In the remaining fraction of the globe (about 0.5%) Cl_y levels average about 2 to 3 times greater than the steady-state cumulative perturbation. The globally averaged depletion of ozone associated with a single launch should be less than that caused by the steady-state buildup of chlorine. Local destruction of ozone in the immediate vicinity of the rocket plume could be significantly larger and is not explicitly resolved in these global models. However, ozone loss should not exceed 10% (corresponding to Cl_y enhancements of more than 100 ppt) when averaged over a 10 x10 area.

5. Conclusions and Potential for Ozone Depletion

The calculated differences in Cl_y concentrations at the poles is of particular interest due to role that chlorine has in the catalytic cycles that deplete ozone under polar winter, but small effect.

Note that in the future, if Cly drops to ≤2 ppb (Montreal Protocol) then the Cly from solid rocket motors ~~is/isnot~~ is still not important.

~~??Also~~ Note that large increases in the launch schedule (>10*) would be necessary to have a 5-10% effect in Cly.

~~We believe that the~~ Shuttle and Titan IV comprise the largest sources of stratospheric chlorine expected from rocket launches. Other major launch vehicles (e.g., ESA, USSR, China) are much smaller or do not use SRMs with chlorine-based fuels. The strategic nuclear arsenal uses solid fuel with chlorine, but most of the chlorine would be released below 15 km.

INCOMPLETE CONCLUSIONS

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Ko, M.K.W., N.D. Sze and D.K. Weisenstein, The roles of dynamics and chemical processes in determining the stratospheric concentration of ozone in 1-D and 2-D models, JGR 94, 9889-, 1989.

Prather, M.J., 1989.

Table 1. Stratospheric Chlorine Released by Shuttle/Titan Launches

lat	29 N	29 N	34 N	
long	80 W	80 W	121 W	
altitude	shutt:9	titan:4	titan:2	
	ton Cl /yr			ton(Cl)
15-20 km	176.8	16.8	8.4	202.0
20-25 km	136.1	14.7	7.3	158.1
25-30 km	109.6	12.6	6.3	128.5
30-35 km	87.4	10.6	5.3	103.3
35-40 km	69.3	8.9	4.5	82.7
40-45 km	25.9	7.3	3.7	37.0
45-50 km	4.5	6.0	3.0	13.5
sum	609.6	76.9	38.4	724.9

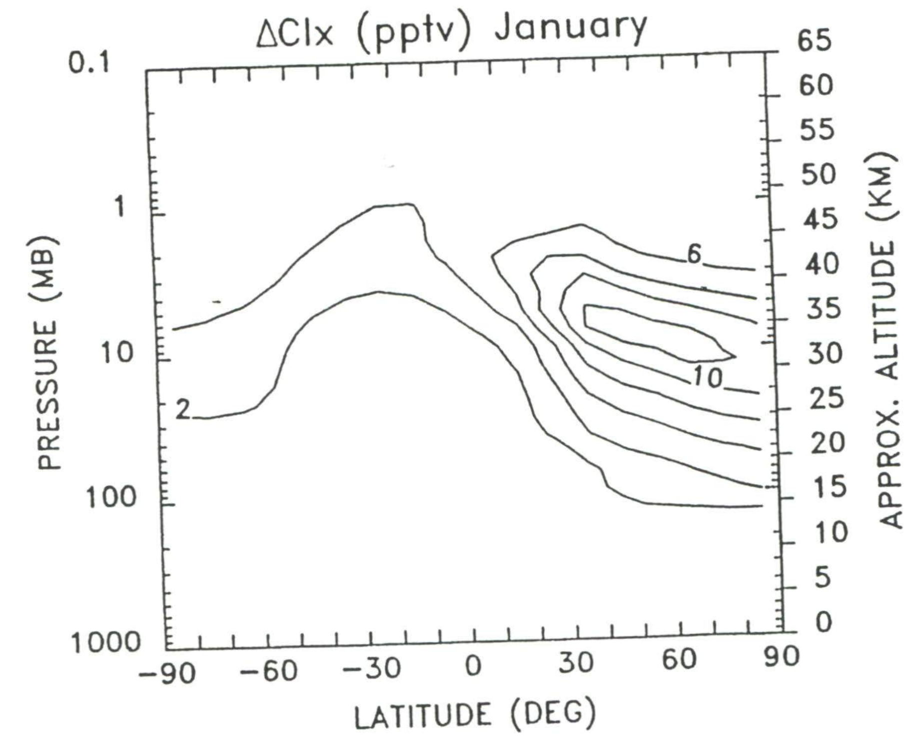


Fig 1a

ΔCly (ppt)

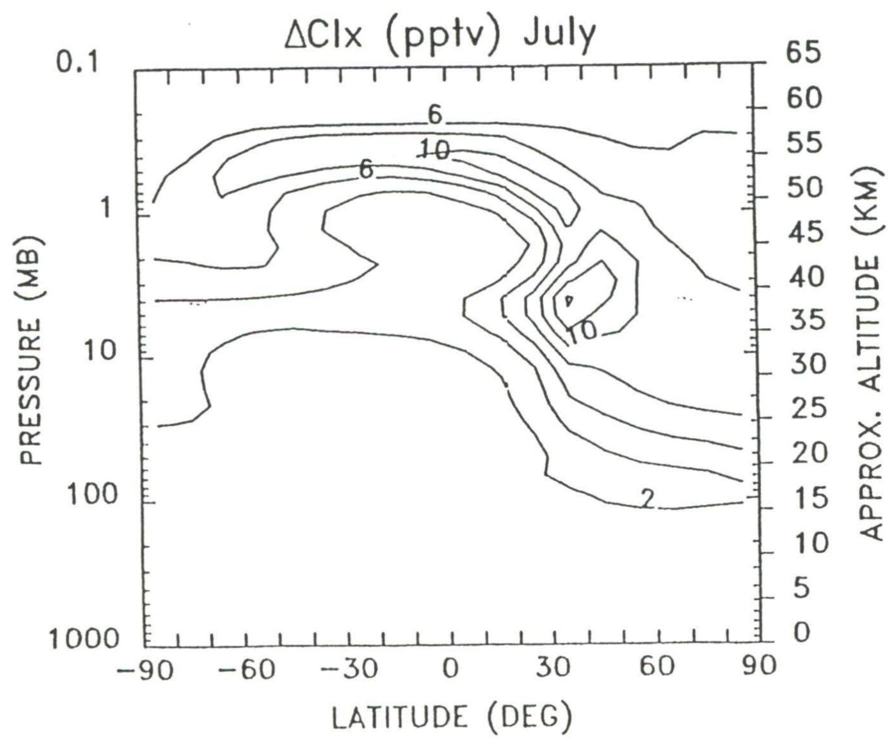


Fig 1b

ΔCl_Y in (ppt)

CLX DIFFERENCE (ppt) WITH SHUTTLE/TITAN (13.14)

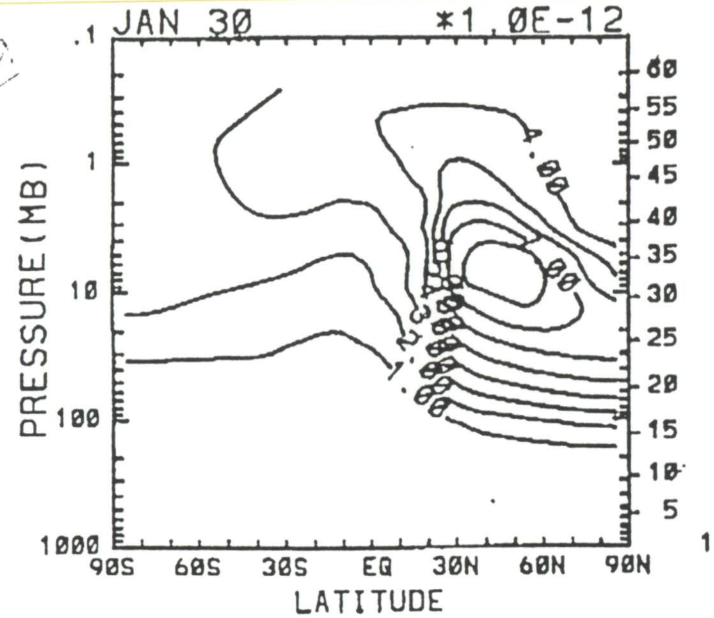


Fig 2a

ΔCl_y (ppt)

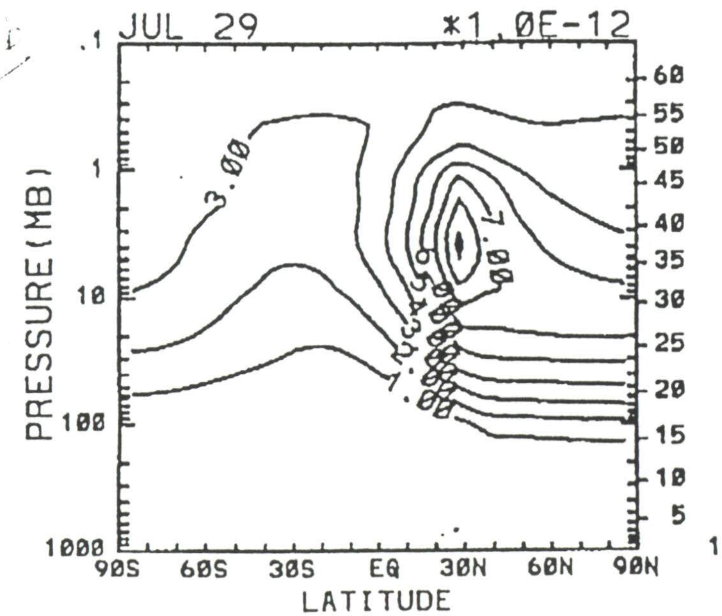


Fig 2b

CLX JAN

GISS 3-D

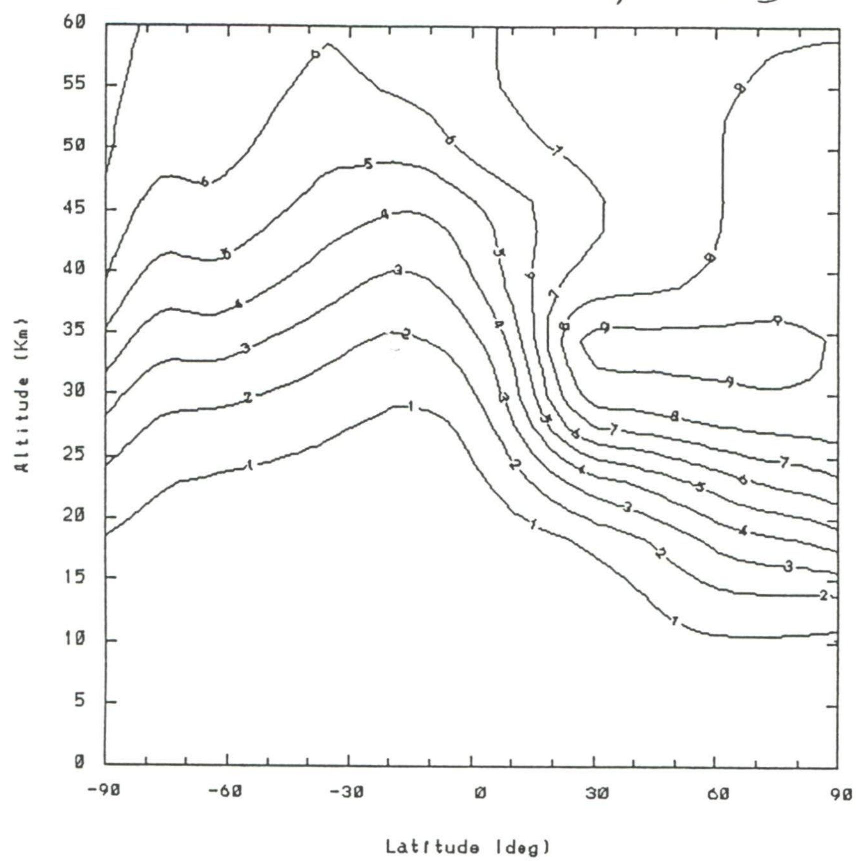


Fig 3a

ΔCly (ppt)

CLX JUL

GISS 3-D

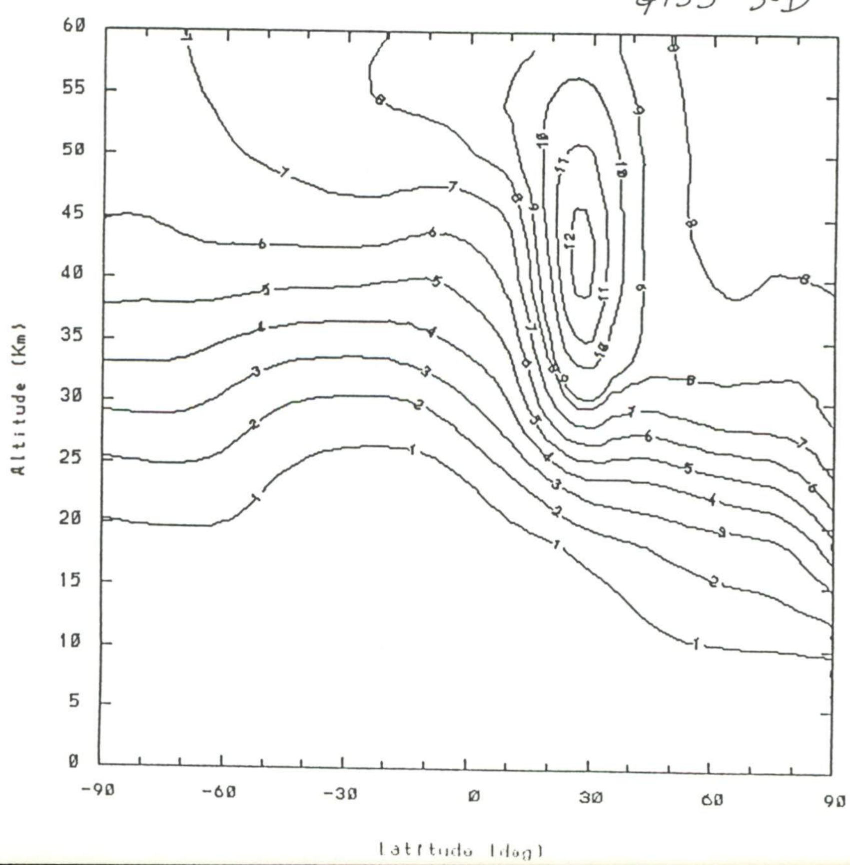


Fig 3b

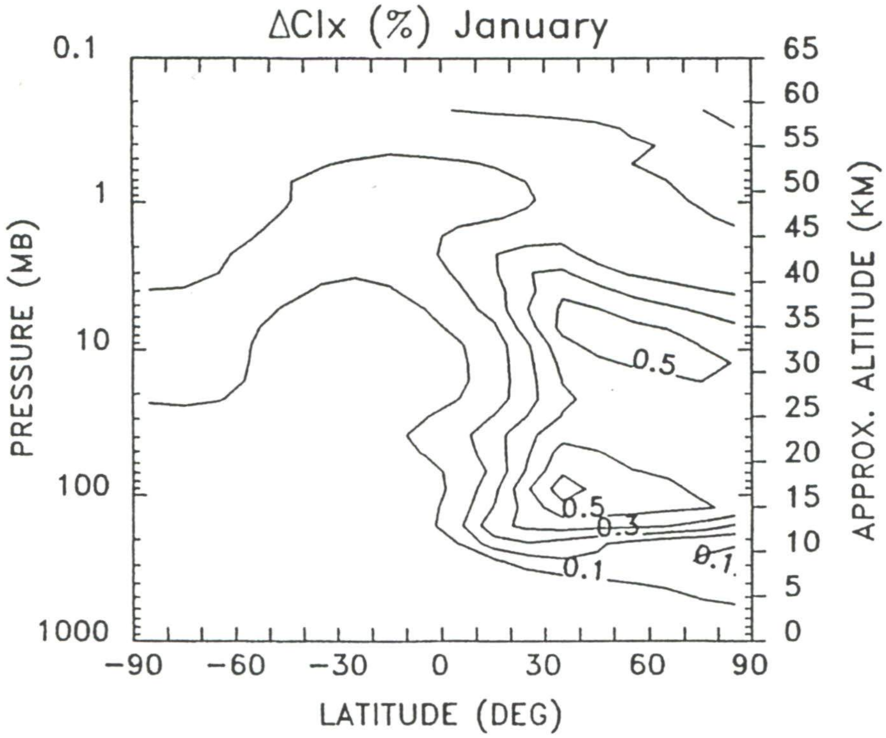


Fig 4a

ΔCly (%)

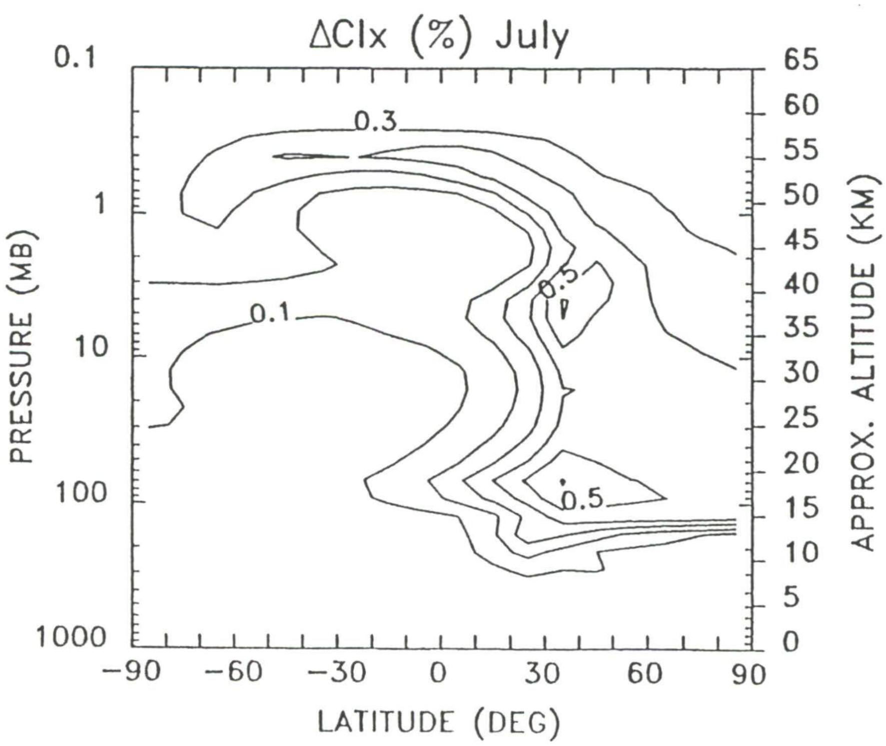


Fig 4b

(Malcolm KO)

emission at lats 13, 14   % difference

CLX DIFFERENCE WITH SHUTTLE/TITAN (%)

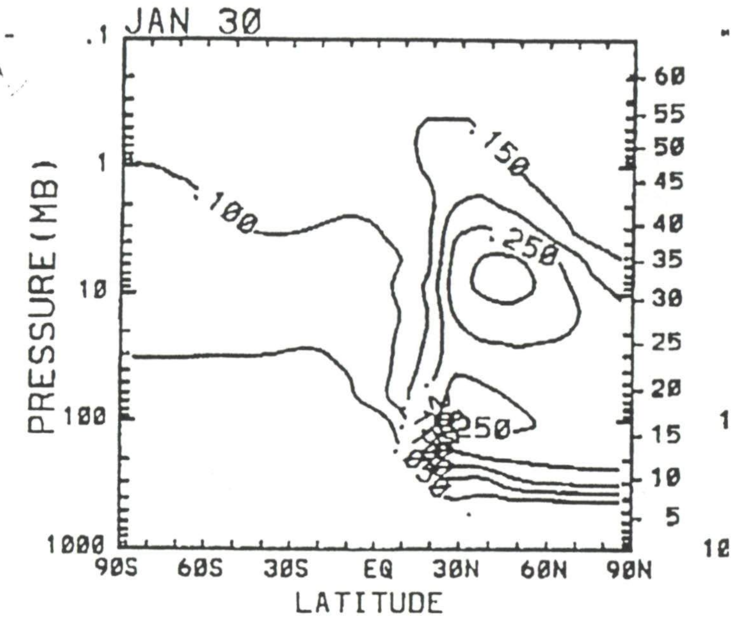


Fig 5a

ΔCly (%)

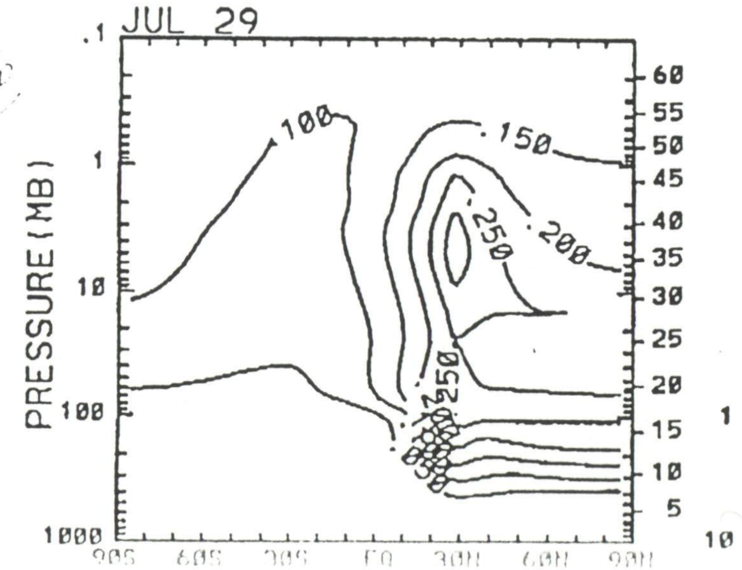


Fig 5b

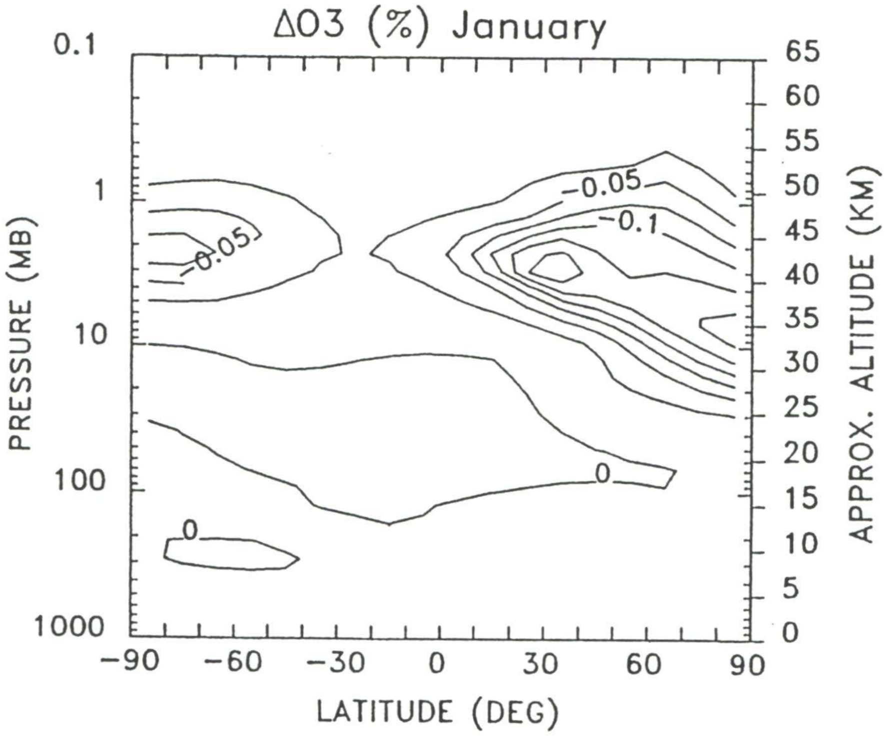


Fig. 6a

ΔO_3 (%)

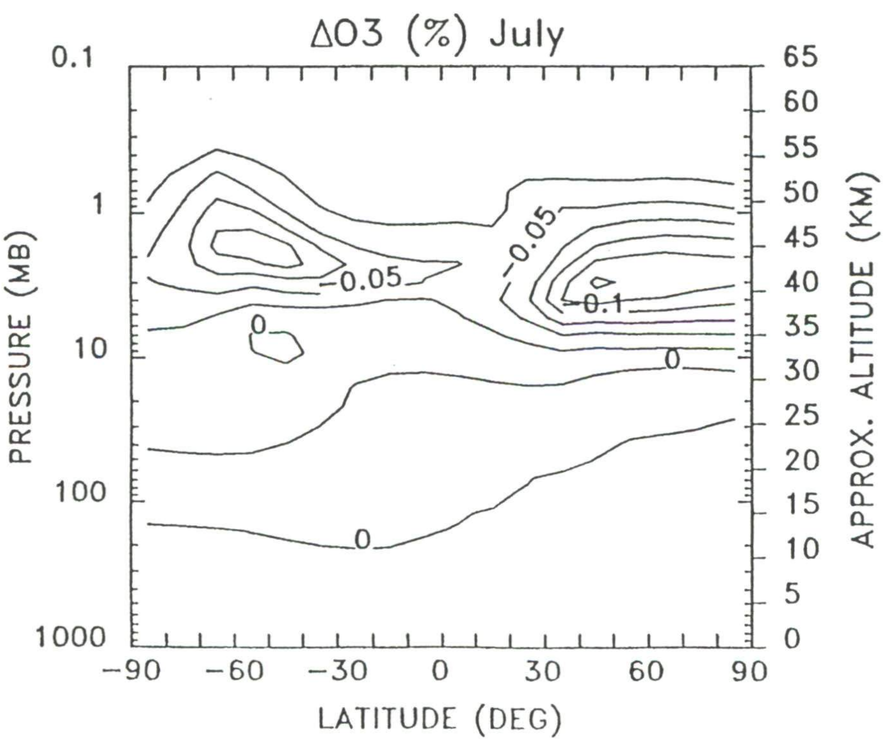


Fig. 6b

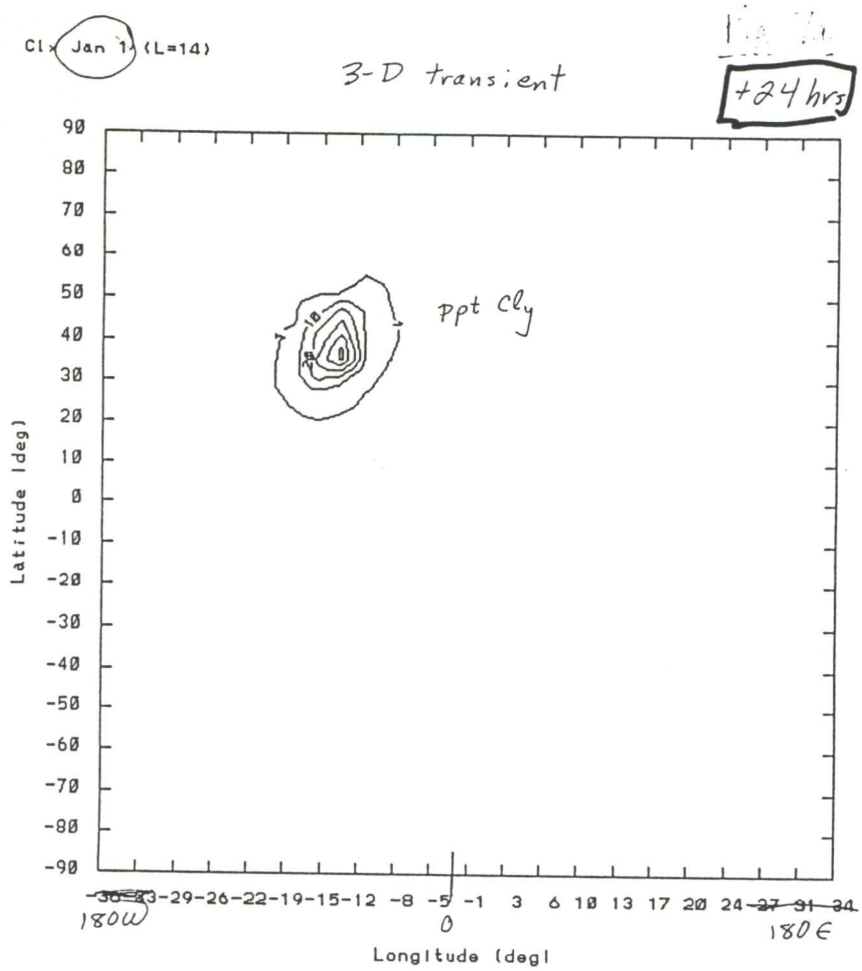
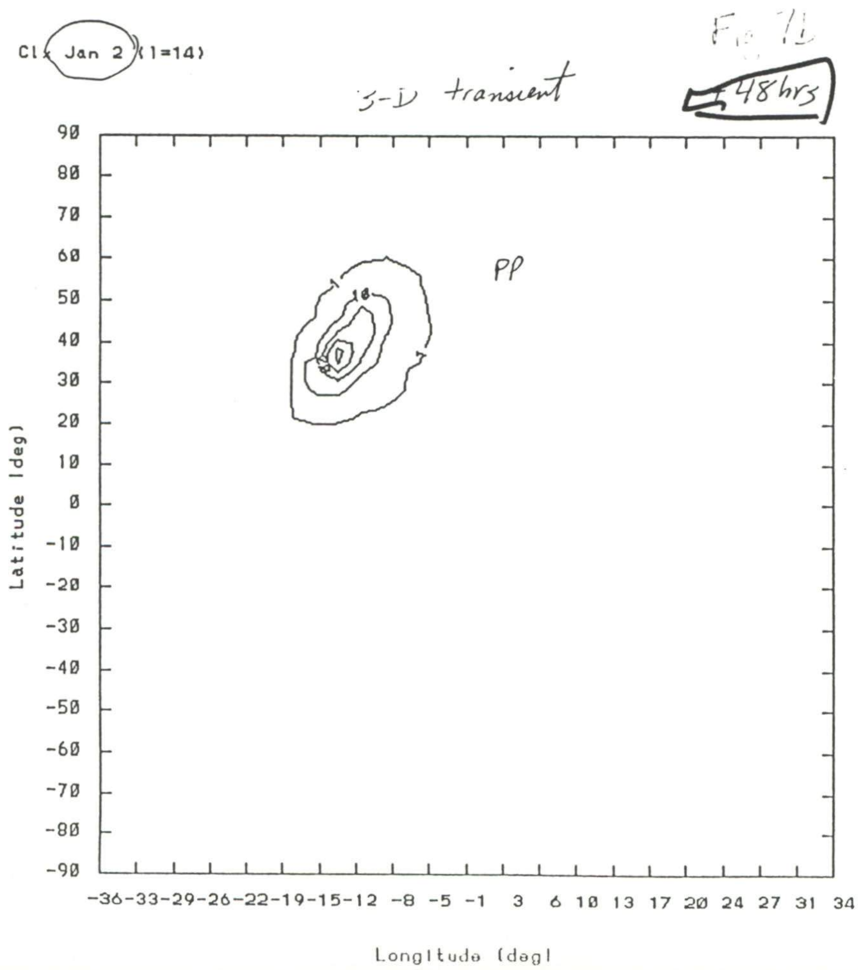


Fig 7a

ΔCly (ppt)



7b

thanks. CES — Dick Johnson (special thanks)
— announce Bob Corell as V.C. —

12/20

NH

DPC Briefing

President's 1990 International Environmental Initiative

Background

1. At the President's request, a new Working Group on Global Change was set up under the DPC

With the specific objective:

- to insure the development and coordination of an agressive and intelligent US policy on global change

- one which would be based upon sound scientific principles and strong economic growth.

2. The WG immediately called for a series of studies to compile the best and most up-to-date info avail for policy-making
   - DOI/DOE - Private Sector Issues/concerns (report complete)
   - DOS/DOJ - Legal mechanisms (1st draft complete)
   - CEA - Economic impacts (the most difficult subject -MB and subgroup making great progress - due Jan.)

3. WG was also assigned the task of developing options:

   - to fulfill the President's campaign pledge to host an international conference on the env't
   - to seize the environmental initiative in the international arena

a. WG has developed a concensus recomendation for a series of events to be held during 1990 as part of a package which will become the part of the President's International Environmental Initiative for the 1990's

[The events were carefully developed within the context ofthe ongoing IPCC process, which the US continues to support strongly]

b. The WG recommended the following events as part of that package

* 1. A major Presidential speech -in January (pre-SOU)

   - to set the tone for 1990 as a year in which the envt will be a major focus of the Adm's activity

   - to introduce some or all of the components of the Initiative

   - to help establish the leadership of the Administration in this area in minds of media and public

   - to list the many ongoing global change activities already underway

     e.g.,

       - US Global Change Research Program
       - Clean Air
       - Acid Rain
       - etc

2. State of the Union Address - strong environmental component (Jan 25)

3. Presidential Address to IPCC Plenary in Washington, D.C. (Feb 5-8)

4. White House Meeting of international scientific/economic/environmental chiefs - Earth Day (April 22 timeframe)

5. June (18-30): Bush-Gorbachev Summit

6. July 9-11: G-7 Economic Summit

7. The President's International Conference on the Conservation of Nature (twin goals: conservation of nature and sustainable devt) (Sept/Oct?)

8. 2nd World Climate Conference (Nov 12 - 13)

9. President to host first negotiating session for Framework Convention on Global Change (early '91)

* one of main reasons to have this in Jan before SOU = leaks and so can announce entire package as showcase initiative