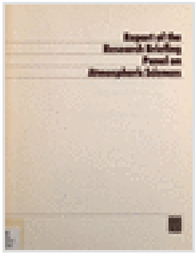
This PDF is available from The National Academies Press at http://www.nap.edu/catalog.php?record_id=19527

FROM THE ARCHIVES



Report of the Research Briefing Panel on Atmospheric Sciences (1983)

Pages
21

Size
8.5 x 10

ISBN
0309327415

Research Briefing Panel on Atmospheric Sciences; Committee on Science, Engineering, and Public Policy; National Academy of Sciences; National Academy of Engineering; Institute of Medicine

Find Similar Titles

More Information

Visit the National Academies Press online and register for...

- Instant access to free PDF downloads of titles from the
  - NATIONAL ACADEMY OF SCIENCES
  - NATIONAL ACADEMY OF ENGINEERING
  - INSTITUTE OF MEDICINE
  - NATIONAL RESEARCH COUNCIL
- 10% off print titles
- Custom notification of new releases in your field of interest
- Special offers and discounts

Distribution, posting, or copying of this PDF is strictly prohibited without written permission of the National Academies Press. Unless otherwise indicated, all materials in this PDF are copyrighted by the National Academy of Sciences.

To request permission to reprint or otherwise distribute portions of this publication contact our Customer Service Department at 800-624-6242.

Copyright © National Academy of Sciences. All rights reserved.

NATIONAL ACADEMY OF SCIENCES
1863–2013
Celebrating 150 Years of Service to the Nation

Report of the Research Briefing Panel on Atmospheric Sciences

Committee on Science, Engineering, and Public Policy
National Academy of Sciences
National Academy of Engineering
Institute of Medicine

RECEIVED
JUN 26 2008
THE GEORGE E. BROWN, JR. LIBRARY

NATIONAL ACADEMY PRESS
Washington, D.C. 1983

NOTICE: The National Academy of Sciences was established in 1863 by Act of Congress as a private, nonprofit, self-governing membership corporation for the furtherance of science and technology for the general welfare. The terms of its charter require the National Academy of Sciences to advise the federal government upon request within its fields of competence. Under this corporate charter, the National Academy of Engineering and the Institute of Medicine were established in 1964 and 1970, respectively.

The Committee on Science, Engineering, and Public Policy is a joint committee of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. It includes members of the councils of all three bodies.

This work was supported by the National Science Foundation under Contract PLN-8218330.

QC981 .S355 1983 c.1
Report of the Research
Briefing Panel on
Atmospheric Sciences

Available from

Committee on Science, Engineering, and Public Policy
National Academy of Sciences
2101 Constitution Avenue, NW
Washington, DC 20418

Printed in the United States of America

Research Briefing Panel on Atmospheric Sciences

Charles L. Hosler, Jr. (Chairman), Pennsylvania State University
Richard A. Anthes, National Center for Atmospheric Research
Louis J. Battan, University of Arizona
Ralph J. Cicerone, National Center for Atmospheric Research
Peter V. Hobbs, University of Washington
John E. Kutzbach, University of Wisconsin, Madison
C. Gordon Little, NOAA Wave Propagation Laboratory
Michael B. McElroy, Harvard University
Norman A. Phillips, National Meteorological Center (NOAA)
Joseph Smagorinsky, Princeton University
Verner E. Suomi, University of Wisconsin, Madison

Staff

John S. Perry, Executive Secretary, Board on Atmospheric Sciences and Climate
Allan R. Hoffman, Executive Director, Committee on Science, Engineering, and Public Policy

Copyright © National Academy of Sciences. All rights reserved.

PREFACE

This is one of seven research briefings prepared in response to a request from Dr. George A. Keyworth, Science Advisor to the President and Director of the White House Office of Science and Technology Policy (OSTP). The effort was directed by the Committee on Science, Engineering, and Public Policy (COSEPUP), a joint committee of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

Topics for the seven research briefings were selected by OSTP. For each topic a balanced panel of 11-13 experts was organized to develop the briefing. The specific charge to each panel was to critically assess its field and to identify those research areas within the field that were likely to return the highest scientific dividends as a result of incremental federal investments in FY 1984. It was also emphasized that these briefings were not to be construed as substitutes for the much more detailed surveys occasionally undertaken in major scientific fields (e.g., the recent report of the National Research Council's Astronomy Survey Committee entitled Astronomy and Astrophysics for the 1980's, Volume 1).

Through discussions with OSTP, the seven topics were defined as follows:

1. MATHEMATICS: Research covering the following fields of investigation: statistics, pure and applied mathematics, mathematical systems theory, numerical analysis, operations research, computational mathematics, and scientific computing.

2. ATMOSPHERIC SCIENCES: The study of the physical, chemical, and dynamic properties of the atmosphere and its interactions with the Earth, the oceans, and the planetary environment with a view to understanding and predicting the atmosphere's changes and behavior as manifested in weather, climate, air quality, and other characteristics relevant to human society, both as a result of natural processes and as influenced by human activities.

3. ASTRONOMY AND ASTROPHYSICS: Research with the objective to obtain information about astronomical bodies by remote sensing from the surface of the Earth, from the Earth's atmosphere, and from Earth orbit.

4. AGRICULTURAL RESEARCH: Research of greatest promise for increasing the productivity and efficiency of American agriculture, including:

- plant sciences targeted on developing more productive, resistant, tolerant, and energy-efficient crop plants;
- an objective assessment of the realistic expectations of genetic engineering for developing more productive, resistant, tolerant, and energy-efficient crop plants; and
- research on crops and cropping practices that are more resource conservative.

5. <u>NEUROSCIENCE</u>: Research directed toward understanding the molecular, cellular, and intercellular processes in the central nervous system (CNS) and the way in which those processes are integrated in CNS functional control systems, with emphasis on research relating CNS functions with behavior.

6. <u>HUMAN HEALTH EFFECTS OF HAZARDOUS CHEMICAL EXPOSURES</u>: Research on the responses of organisms to hazardous chemical exposures, including:

- the nature of the steps leading to damage to the organisms;
- the mechanisms and kinetics of metabolism of hazardous substances;
- the nature of protective responses and repair mechanisms; and
- the in vitro, animal bioassay, and epidemiological methods used to characterize hazardous exposures.

7. <u>MATERIALS SCIENCE</u>: Research concerned with reaching a clearer understanding of the complex relationships that exist among the atomistic structure, composition, and defects of materials and their behavior in an engineering environment. Specific areas of investigation include those concerned with surface characterizations, defect structure, electronic structure, catalysis, the theory of crystalline solids, and the properties of solids (e.g., electrical, magnetic, optical, thermal, and mechanical).

Each panel met once, for 2 or 3 days, to carry out its charge. Knowledgeable representatives of government and the private sector were invited to provide input to the panels. Rapporteurs, knowledgeable in the field, were present to summarize the discussions and prepare initial drafts of briefing papers. These papers were reviewed and revised by the panel members and served as the bases for the oral briefings presented to federal officials.

The seven one-hour briefings, presented by panel chairmen and, in some cases, 1 or 2 other panel members, were reviewed by COSEPUP in mid-October and presented to Dr. Keyworth and members of his staff between October 26 and November 18, 1982. The same briefings were subsequently presented to Dr. Edward Knapp, Director of the National Science Foundation, and other Foundation officials on three days in December. Briefings for other interested departments and agencies were held separately on the same dates.

None of this would have been possible without the financial support of the National Science Foundation and the cooperation, under difficult time constraints, of the panel members and staffs. We are indebted to both groups.

If judged useful to federal decision makers, the seven initial research briefings developed as an experiment in 1982 could serve as the basis for research briefings on other major fields of science in future years. Such briefings could supplement other inputs and become important new channels for communication between the federal government and the scientific community.

George M. Low, Chairman
Committee on Science, Engineering, and
Public Policy

REPORT OF THE RESEARCH BRIEFING PANEL ON ATMOSPHERIC SCIENCES

SUMMARY

Advancing scientific understanding and technology have put us on the threshold of dramatic improvements in our ability to predict the future state of the atmosphere. At this time, special opportunities for scientific advances, which also involve important social concerns, are presented by three areas of the atmospheric sciences: small-scale severe weather systems, atmospheric chemistry, and climate.

This brief report recommends specific actions that should expand our knowledge and predictive capability in each of these areas. The recommendations are based upon the scientific merits of the various actions and do not consider details of execution and cost. Advances in these three areas will improve human productivity and efficiency, protect life and property, and enhance the quality of life. (See Table 1.)

INTRODUCTION

The global atmosphere forms an indivisible, unified object of study: space-borne observation/communications platforms to view the earth as a whole and cooperative programs among all the world's nations are fundamental and indispensable prerequisites for meaningful research. Thus, while the atmospheric sciences, like other branches of the scientific enterprise, continually present challenging problems and opportunities, their progress depends to an unusual extent upon multi-disciplinary investigations, a global supporting infrastructure of space- and ground-based observing/monitoring programs (largely justified by operational requirements), and multinational activities of many kinds.

Man's influences on certain atmospheric processes are now comparable in some respects to nature's. By release of carbon dioxide, industrial effluents, and entirely new substances such as the chlorofluorocarbons, we may be changing the radiative and chemical nature of the atmosphere and thus affecting its ability to maintain a stable climate and a habitable world for humans.

TABLE 1 High-Leverage Investments in the Atmospheric Sciences

Problem Area	Recommended Action	Probable Benefits
1. Small-scale Severe Weather Systems	Use near-term technological enhancements (Doppler radar and wind profiling, data management and and display) as a basis for planning long-term mesoscale research	Immediate improvements in forecasts/warnings; improved aviation safety; basic understanding; accelerated progress in research; improved prediction techniques
2. Atmospheric Chemistry:		
a. Acid Rain	Conduct field studies on dry deposition, in-cloud processes, and remote-region sources	Cost-effective and environmentally sound control strategies
b. Tropospheric Chemistry	Support a comprehensive research program, including data base	Air quality protection and climate prediction
c. Stratospheric Ozone	Support the Upper-Atmosphere Research Satellite (and associated research)	Ozone layer protection
3. Climate Variability and Change		
a. Long-term Climate Change	Study the circulation of the World Ocean and its interaction with the atmosphere and climate	Predictive models for long-term climate change
	Measure and model trace gas concentrations	Assessment of effects on radiation balance and climate
b. Short-term Climate Variations	Support El Nino/Southern Oscillation studies	Seasonal/interannual predictions
	Conduct prediction studies with general circulation models	Monthly/seasonal predictions

Through daily weather, through the slow march of climate, through effects and control of pollution, the atmosphere influences myriad daily activities and decisions throughout our complex society, all of which contribute to our nation's efficiency and productivity. The atmosphere's constituency thus includes not only pilots, farmers, commodity dealers, and builders, but every citizen. To ensure our continued welfare in a variable and vulnerable atmosphere, we must acquire better fundamental understanding of the atmosphere and an enhanced capability to predict its changes arising from both natural processes and human interventions.

SMALL-SCALE SEVERE WEATHER SYSTEMS

During the past decade there has been a growing consensus within the meteorological community that significant improvements can be made in the short-range forecasting (0-12 hours) of mesoscale--or stormscale--weather systems. In terms of size and duration, these lie between individual clouds and the larger storms depicted on the conventional weather map. Although they tend to elude the conventional observing/forecasting system, they produce much of our weather and most of our severe weather: tornadoes, flash floods, hailstorms, snowstorms, and strong winds. Optimism about our ability to forecast these systems is based on recent advances in both technology and understanding. Technological improvements include satellite systems (which provide information on cloud cover and temperature and humidity soundings), various types of radars (which can provide continuous and quantitative information on winds, precipitation, and--through pattern recognition--various weather phenomena), and electronic means for the rapid assimilation of this large quantity of information and its communication to the public in the form of timely forecasts. Scientific advances have been made in the understanding of such phenomena as frontal circulations and precipitation, severe mountain winds, and severe thunderstorms which produce hail, wind shear, and sometimes tornadoes.

Currently, much of this technology is not available to the public or private weather forecaster, although it has been well tested in the research community. Transfer of the technology to the forecasting sector should enable weather services, public and private, to make more timely and accurate predictions of stormscale weather phenomena. Such improvements would aid in protecting life and property, serve the national economy, and help meet defense requirements. Widespread employment of this technology would also provide a badly needed research data base and accelerate the progress of research in this area.

Long-Term Mesoscale Research

Two areas should be emphasized in long-term mesoscale research. First, we must improve our understanding of the physical processes that determine the growth, maintenance, and decay of mesoscale weather systems. This improved understanding can be achieved through appropriate special observational programs and theoretical research. Such knowledge is essential for the development and improvement of the conceptual and numerical models necessary to improve the forecasts and warnings of significant mesoscale weather.

The second major research objective is to develop methods of analyzing the massive data sets that would be available from the new measuring facilities. The development of analysis schemes and the communication systems required to process, transmit, and display the data are necessary both for short-range forecasts and warnings and for numerical weather prediction models. The recommendations outlined below will lead the way to more effective research in these areas, and will also begin to realize the improvements in short-range severe weather forecasting made possible by new technology.

Near-Term Technological Enhancements

Rapid exploitation of several technological advances could quickly accelerate our research progress and improve our forecasting capabilities. Doppler radar operating in the near-horizontal can detect the special motion patterns within thunderstorms that precede the formation of tornadoes. Also, the formation of weather-producing stormscale circulations, such as squall lines or heavy snow bands, can be detected from small changes in wind patterns before they have formed. Tests have demonstrated that Doppler radar observations can lead to earlier issuance of tornado warnings and an appreciable reduction in false alarms, thus enhancing public confidence in and response to warnings. Such radars can also warn of thunderstorm-generated severe downdrafts and wind shears that pose hazards to aircraft in landing and takeoff. Federal recognition of this potential already exists in the interagency NEXRAD program, involving the Department of Defense, the Federal Aviation Administration, and the National Weather Service. Funding for this program should be accelerated in order to keep all essential elements of the program moving on schedule. Full financial support of this system presents the most effective contribution to improved forecasting of severe weather that the federal government can now bring about. The routine use of Doppler radar will also increase scientific understanding of these destructive and erratic wind storms and the small-scale circulations hazardous to aviation.

- In the near term, the technological advances offered by Doppler radar should be exploited by accelerating funding of the interagency NEXRAD program.

Radar wind profiling systems using longer wavelengths can measure upper-air winds to considerable heights from naturally occurring refractive index variations. Radiometric temperature sounding systems can similarly obtain temperature and pressure data. The systems operate unattended and produce accurate and continuous observations in all weather conditions. The latter characteristics are completely new and highly valuable from both scientific and operational viewpoints.

Continuous observations permit accurate tracking of significant characteristics of the flow of weather, such as fronts and wind shear lines. The continuous availability of enroute winds for aircraft would also make possible significant fuel savings. In addition, dual-polarization Doppler radars can provide valuable information on cloud and precipitation processes for research purposes.

- An array of Doppler radar upper wind sounding systems should be deployed promptly in parts of the country most subject to violent weather to permit evaluation of their impact on weather forecasting and to aid research on mesoscale weather systems.

Both research and applications on the storm scale are currently limited by the coarse horizontal and temporal resolution of our present upper air data network and data handling systems. Radar can provide additional information, and sounding instruments on geostationary satellites are beginning to provide immense improvements in horizontal and temporal resolution. In addition, frequent images in the visible, the infrared and water vapor bands are becoming available from satellites. Interpreting this enormous flood of data has been likened to trying to drink from a fire hydrant without drowning. Over the last several years, however, demonstrations have shown that it is possible to digest this data flood in real time and to convert it into highly useful information for forecasting and research. To do this, the user must be provided with computer-based video displays and graphics capabilities. When this is done, the improvement in forecasting performance has been dramatic. Unfortunately, our existing system for communicating and displaying this information to the user falls far short of what is possible. The communications industry continues to develop an impressive number of new communications systems, including direct broadcast from satellites, that could serve to collect and disseminate weather information and support services to a wide range of users including researchers, forecasters, and the general public. This is an unusual opportunity to provide large improvements at reasonable cost.

These capabilities can be and should be made available in the near future for use by the weather services and the research community. Their widespread availability would provide immediate economic advantages and reductions in losses of lives and property. Moreover, they would provide the basic framework needed for a longer-term program of research on small-scale weather systems. In addition, the availability of state-of-the-art data management and display capabilities to the research community would significantly accelerate progress in other important areas such as climate.

- Federal agencies should promptly initiate actions to make advanced communications, data management, and display capabilities available both to the research community and to operational forecasters.

The above near-term technological enhancements would provide the basis for development of a long-term research program to improve our scientific understanding and operational capabilities in small-scale severe weather systems.

ATMOSPHERIC CHEMISTRY

The past decade has seen a revolution in the field of atmospheric chemistry. In the 1970s, chemists were primarily engaged in identifying problems and reacting to crises; in the 1980s they are seeking a new level of maturity for this area of science. They have learned that crisis assessment, in the absence of a deep understanding of the chemistry and physics of the natural atmosphere, is a hazardous exercise.

In a larger context, the earth is a planet characterized by change. Moreover, the human race has now achieved the ability to alter its environment on a global scale, with implications for food production, the quality of air and water, and the integrity of the global chemical cycles essential to life. In the past, human needs could be met by the expansion of frontiers, by land clearance, by the application of chemical fertilizers and pesticides, by irrigation, and through the exploitation of energy resources harvested from the sun by the biosphere millions of years ago. An understanding of the overall system is essential if the human race is to live successfully with global change.

Several current issues relating to atmospheric chemistry are singled out below for special near-term emphasis.

Acid Rain

Many of the general problems facing atmospheric chemistry are illustrated by the acid rain problem. Unlike Europe, no routine monitoring of the chemical properties and acidity of precipitation has been conducted in North America until very recently, and the effects of increased industrialization on the acidity of precipitation have been largely undocumented. Similarly, little is known about the chemical composition and acidity of "natural" (i.e., "clean" background) rainfall in remote regions of the world, which sometimes exhibit unexpected acidity. Since the cost of controlling industrial emissions is large, and the economic consequences could be great, the effects of control strategies on acid rain should be carefully assessed scientifically.

The principal contributors to acid rain are compounds of sulfate and nitrate, both of which are released by human activities. These compounds may appear in precipitation through two mechanisms: "scavenging" of sulfate and nitrate compounds already present in the atmosphere and/or "*in situ*" production through incorporation of trace gases into cloud and precipitation droplets followed by chemical reactions within the droplets to form sulfates and nitrates. Acidic material also reaches the ground through dry deposition. Establishment of the dominant mechanism ("scavenging," "*in situ*" production, or dry deposition) will dictate, in part, appropriate control strategies; it might even indicate that currently available control techniques would have relatively little effect on the occurrence of acid rain.

- Three essential investigations should be undertaken in an attack on the problem of acid rain: Field measurements of dry deposition for acidic gases, e.g., SO_2 and HNO_3; field studies of in-cloud chemistry and cloud physics from aircraft or at mountain laboratories; and assessment of natural sources of acidity in remote regions.

Tropospheric Chemistry

An understanding of the acid rain problem will require a broad assessment of tropospheric chemistry, not simply on a local but also on a global scale. For example, a major gap has developed in the measurement and understanding of tropospheric ozone. Available data and theory indicate that commercial aircraft operations can increase tropospheric ozone. Photochemical pathways to ozone production in the troposphere should be simpler than those in urban smog, and measurements of the relevant variables should be easier. Coordinated measurements are needed, techniques need to be developed, and global measurements from space will eventually be required to provide a data base for global tropospheric models.

More generally, tropospheric chemistry has a major impact on the quality of life for the planet as a whole, e.g., air quality and climate stability. The natural state of the tropospheric system, including its interaction with the global scale biosphere, must be defined to provide a basis for assessment of such issues as acid rain. A long-term integrated program of observations and research is now being defined by a study group of the National Research Council.

- Acquisition of a data base and a level of understanding sufficient to define the natural state of the troposphere should be a major goal for an integrated program of tropospheric research. To this end a program of research should be mounted to develop data on the distribution of important gases such as ozone, and a strategy should be implemented to improve our understanding of chemical cycles, with definition of important biospheric sources and sinks for key species.

Stratospheric Ozone

Scientific interest is now aimed at improving basic understanding of the stratospheric photochemical system. It is possible that the redistribution of stratospheric ozone caused by man's activities will be as important environmentally as the change in the total amount of ozone. Fuller quantitative understanding of man's impact on the ozone layer is needed to provide a sound basis for future decisions by industry and government.

Observations are needed to test available models of stratospheric chemical and dynamic processes and to guide the development of future models. Strategies for an orderly study of the stratosphere have been developed involving all segments of the concerned scientific communities--atmospheric chemists, laboratory chemists, meteorologists, and modelers. The research is interdisciplinary and international in scale, and it demands the collaboration of government, academia, and the industrial sector.

• The Upper Atmospheric Research Satellite (UARS) is a central element of this nation's stratospheric research program, and a commitment to this satellite program should be made at the earliest possible time.

CLIMATE

In the past dozen years, the attention of atmospheric and oceanic scientists has increasingly turned to problems of climate. Quantitative study of past climates has revealed the long-term variability of climate, while the Sahel drought and the grain trade dislocations of the early 1970s showed our vulnerability to changing climate. Numerical models and field observations (e.g., the measurement of increasing atmospheric concentrations of carbon dioxide and some other radiatively active trace gases) raised concern that our own actions might be producing damaging and irreversible changes in climate. However, it was realized that both prediction of natural climate variations and assessment of man-made changes require as an indispensable prerequisite a basic understanding of the workings of the global climate system comprising the oceans, the land surface, the ice and snow masses, and the atmosphere, and the ability to construct quantitative models based upon this understanding. These concerns prompted a worldwide surge of research on the global climate system and the organization of coordinated national and international programs. They also focused interdisciplinary research effort on critical problems such as the increase in atmospheric carbon dioxide. These endeavors are well under way and should proceed unabated. However, they have already revealed several opportunities that merit exploitation.

World Ocean Circulation

The World Ocean, covering 70% of the planet's surface, is an integral component of the climate system and provides its long-term memory. The dynamics of the oceans, however, are only poorly understood in comparison to those of the atmosphere, impeding our ability to model the coupled combined systems. Hence, we are unable to determine adequately the important thermal and chemical interactions between the ocean and the atmosphere. As a result, we cannot predict climate beyond a season or elucidate completely the sensitivity of climate to a CO_2 increase.

A fundamental necessity is to establish observationally the three-dimensional structure of the circulation of the World Ocean, its seasonal variation, its interannual variability, and its interactions with the atmosphere. Only then can we establish definitively the relative role of the ocean in storing and transporting heat in the climate system, stimulate modeling improvements, and supply a validation base for climate simulation studies. Such advances would be of equal benefit to the discipline of oceanography.

New technology for ocean measurements makes it possible to conceive of an observational experiment to determine the circulation of the World

Ocean. Satellite-borne radar altimeters can determine the sea-surface topography, while scatterometers coupled with other observations provide measures of wind stress. Acoustic tomography promises ocean-scale density measurements, and measurements of man-made tracers directly reveal long-term circulations. These and other observations will supplement the ongoing global observing system.

• Investments should be begun now to ensure the availability of long lead-time satellite-borne observing and communications capabilities (typified by the TOPEX program) to permit initiation of a world ocean circulation experiment by the end of this decade.

Trace Gases

Much attention has been focused on projected global warming due to increased atmospheric CO_2. However, the corresponding effects of other radiatively active trace gases are additive to those of CO_2 and can be significant. Concentrations of nitrous oxide, the chlorofluorocarbons, methyl chloroform, and methane have increased worldwide, and there is circumstantial evidence that tropospheric ozone is also increasing. These and other gases absorb infrared energy in otherwise transparent regions of the infrared spectrum and thus block heat from leaving the earth.

Monitoring the concentrations of these gases (except for ozone) is economical and feasible. Vertical profiles with good latitudinal coverage are needed for nitrogen oxides, ozone, some hydrocarbons, water vapor, and carbon monoxide, among others, as a basis for theoretical and modeling improvements.

• Field and laboratory measurements should be taken to provide a firmer basis for our understanding and prediction of the behavior of the trace gases that influence climate.

El Nino, the Southern Oscillation, and Interannual Predictability

A large and growing body of evidence suggests that the tropical oceans influence the global circulation of the atmosphere on time scales from a season to about two years, and provides encouraging possibilities for prediction of seasonal and interannual climate fluctuations.

The Southern Oscillation encompasses a large variety of phenomena throughout the global atmosphere and ocean that are known to be correlated with the large-scale oscillations of south Pacific surface pressure to which the term was first applied. These phenomena include large increases in water temperature off the Peruvian coast (El Nino), equatorial sea-surface temperature anomalies, variations in the Indian Monsoon, and seasonal climate irregularities over North America. A full cycle of the Southern Oscillation endures over about a two-year period, and is initiated aperiodically at intervals of two to ten years. It is the largest coherent signal in short-term climate variability.

Much of what has been learned recently about the interannual variability of the tropical ocean and the global atmosphere has come from existing observational sources and climate models, and the implications of these findings for climate predictability should be exploited promptly. Already, simple empirical methods based on these phenomena are being applied to produce crude seasonal forecasts over North America.

Further progress will require a better understanding of atmospheric and, especially, oceanic mechanisms. A more complete description of the chain of events is needed. What are the energetics of the cycle? What triggers it? Is there a beginning to the sequence? What determines the length of the cycle? Why is the frequency of occurrence so irregular?

A strong base for productive research exists in a group of Pacific-oriented oceanographic programs completed, in progress, or already planned. Study of this problem is now under way, and a national plan for a comprehensive research program in both the atmosphere and the ocean will be completed before the end of 1982. International interest and participation is already evident.

- A concentrated program of observation and research should be mounted in the early to mid-1980s in strong and continuing support of El Nino/Southern Oscillation studies.

Monthly and Seasonal Prediction

Recent research with global atmospheric general circulation models designed for prediction in the 5- to 15-day range indicate that in some instances atmospheric events may be predictable in the 30-day range. In particular, blocking episodes* and their attendant dramatic regional temperature and rainfall anomalies and shifts in storm tracks have been successfully predicted. There is some evidence that this enhanced predictability could be extended to the seasonal range. The investigation of atmospheric predictability was a prime objective of the Global Atmospheric Research Program, in particular of the 1979 Global Weather Experiment. This highly successful international endeavor yielded a unique body of detailed data on the time-dependent behavior of the atmosphere. Success in this research will require the sustained availability of substantial research funds.

- Comprehensive observational and theoretical studies should be conducted to discover the physical reasons for persistent circulation states and to determine whether there are any other circulation characteristics that may also be predictable in the monthly/seasonal time range.

---

*The term "blocking" refers to the development of strong and almost stationary circulation patterns that persist over large regions for extended periods, i.e., a few days to several weeks.

Report of the Research Briefing Panel on Atmospheric Sciences
http://www.nap.edu/catalog.php?record_id=19527

Copyright © National Academy of Sciences. All rights reserved.

Copyright © National Academy of Sciences. All rights reserved.