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TESTIMONY
OF
DR. J. MICHAEL HALL
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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

BEFORE THE

COMMITTEE ON COMMERCE, SCIENCE AND TRANSPORTATION
UNITED STATES SENATE

OCTOBER 7, 1991

RE: THE ROLE OF CLOUDS IN GLOBAL CLIMATE CHANGE

INTRODUCTION

I would like to express my appreciation to the Committee for the opportunity to discuss a topic that is undeniably recognized within the scientific community as the most critical area forestalling progress in our understanding of the global climate system. Climate changes may arise from natural forces within the earth system, or as a consequence pressures on our natural resources by an increasing world population, and by an increasing capacity to exploit those same resources to achieve technological progress.

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The current urgency felt by the scientific community to produce accurate predictions of change under a regime of significantly enhanced atmospheric carbon dioxide and other "greenhouse" gases, has pushed computerized models of the climate system beyond a satisfactory level of credibility. Different general circulation models of the climate system, forced in identical ways, produce new "climates" that are similar in their gross characteristics, but differ significantly in detail. At a regional level, for example over parts of the continental U.S.A., the differences can be so large that conflicting guidance would be given to those planning strategies to adapt to changing climatic regimes.

Detailed studies of the root causes of these differences reveal that they are typically caused by subtle variations in the way different models attempt to mimic physical processes operating in the total global system, and by the number of such processes different models attempt to incorporate. Processes which operate at scales smaller than the spatial and temporal resolutions of the simulation models are represented by physically based but approximate mathematical schemes (parameterizations). These schemes include attempts to distribute incoming and outgoing radiant heat energy, develop the many cloud forms, allow for the presence of atmospheric aerosols, cause clouds to precipitate, and partition the precipitation into the surface components of the hydrological cycle, eg. surface runoff, infiltration etc.

THE SCIENTIFIC ISSUES

Clouds and water vapor together are the dominant control on the amount of solar energy reaching the earth's surface and the infrared emission to space. The "greenhouse" effect as we all know is critical for life on earth. Direct anthropogenic enhancement of other radiatively active trace gases in the atmosphere (CO2, methane, chloroflurocarbons etc) that has the potential for causing major climatic change may be amplified or diminished by feedbacks within the global energy and water cycle, especially those that affect the development and distribution of clouds. NOAA is engaged in major monitoring and research programs to improve our understanding of atmospheric trace gases that influence the Earth's chemical and radiative balance. NOAA is also committed to a climate model development program to increase skill in representing the many complex feedbacks in the global climate system.

Atmospheric aerosols are increasingly seen as an important factor in the atmospheric component of the global energy and water cycle. As a direct modulator of the greenhouse effect, atmospheric aerosols can interact with radiant energy through scattering and absorption processes. In a more indirect way, atmospheric aerosols also modulate the greenhouse effect since they are critical as nuclei for the formation of clouds and cloud properties, such as brightness enhance the ability of clouds to reflect incoming solar radiation back to space. Atmospheric aerosols are therefore a pervasive and necessary component of the climate system yet their roles are poorly represented, if at all, in the current generation of climate models. Furthermore, just as human activity is changing the background levels of some radiatively active gases, so too it is changing the levels of atmospheric aerosols. Unlike the principal radiatively active anthropogenic gases which generally become well-mixed throughout the atmosphere, anthropogenic aerosol loadings tend to have maximum concentrations downwind of major centers of population and industry. The impacts of anthropogenic aerosols on the climate system, therefore, are likely to be manifested in ways quite unlike the impacts of the enhanced greenhouse gases. NOAA scientists are engaged in research projects to monitor the sources and sinks of both natural and anthropogenic aerosols in order to assess the relative changes in concentrations. We are also working closely with other agencies on the need for a comprehensive research plan to address this complex issue.

Charlston wld agree
not a global phenom

THE INTERNATIONAL RESPONSE

Small-scale processes in climate models such as evaporation and the formation of clouds have been collectively described as the "fast component" of the climate system. The World Meteorological Organization (WMO) and the International Council of Scientific Unions (ICSU) have developed the Global Energy and Water Cycle Experiment (GEWEX) as a focus for this component of their jointly sponsored World Climate Research Programme (WCRP). The Tropical Oceans and Global Atmosphere (TOGA) Project and the World Ocean Circulation Experiment (WOCE) of the WCRP are concerned with longer time-scale processes of the climate system.

The nature of GEWEX is such that its objectives underpin progress on all time scales. Similarly, TOGA is primarily concerned with prediction on seasonal and inter-annual time scales, but understanding and modeling latent and sensible heat fluxes as well as radiative fluxes at the air-sea interface, are critical for getting the right distribution of clouds and cloud types in the coupled global climate models that will be used in various configurations to predict on seasonal, inter-annual and decadal time scales. The Coupled Ocean Atmosphere Response Experiment (COARE), a major field program in TOGA is planned for the Western Pacific region from November 1992 through February 1993. It will address many of the key problems in understanding why this region of the globe is such a critical area for large-scale, seasonal and inter-annual fluctuations in the climate system. However, COARE will also provide opportunities to gather data on unique features of tropical cloud systems. TOGA COARE, therefore is one of the most important initiatives in this decade directed at improving our understanding of the climate system. NOAA, NSF, NASA, ONR, and the U.S. academic community along with the scientific communities of many other nations are devoting considerable resources towards ensuring its success.

The earth's biosphere also plays a substantial, interactive role in partitioning energy and water in the climate system, and the potential exists for major impacts on the current make-up and distribution of ecosystems as a consequence of climate change. To study and understand better the sensitive balance between the physical and living components of the earth and its climate system, International Council of Scientific Unions (ICSU) has instituted the International Geosphere Biosphere Programme (IGBP). In view of the strong interaction between climate and the biosphere, the WCRP and IGBP are developing common planning processes in several key areas including the hydrological cycle. However, just as with TOGA COARE, the international agencies sponsoring these programs look to individual, national funding agencies to respond in a coordinated way to the variety of scientific initiatives being proposed to tackle the many global change research issues. NOAA plans to continue its support for many of these initiatives which include the very successful International Satellite Cloud Climatology Project, the developing Global Precipitation Climatology Project and the emerging GEWEX Continental-scale International Project (GCIP).

GCIP warrants special mention since it will enable the U.S. to offer a significant portion of its land mass - the Mississippi Basin - for an intensive large-scale climate data gathering and modeling study. In turn, the U.S. will reap the benefits of an international scientific effort to understand and model the complex hydrological cycle of this region. Skills learned in this data rich region, will help us to improve our models in those regions of the globe with poorer climatic records. Much of the data for GCIP will come from existing NOAA data bases and observing systems, and from planned upgrades to those systems. A successful GCIP will also speed the benefits of the next era of space-based remote sensing satellites.

THE NATIONAL RESPONSE

At the national level the Committee on Earth and Environmental Sciences (CEES) has strongly endorsed the international initiatives for developing better techniques to model and ultimately predict moisture, radiative and sensible heat fluxes throughout the climate system. Climate and Hydrologic Systems continues to be rated as the area of highest priority within the U.S. Global Change Research Program (USGCRP). The role of clouds in the Earth's radiation and heat budget, and processes driving energy and water fluxes within the climate system are among the Program's highest rated topics for research. Each agency participating in the CEES process has developed a program of research and activities that reflects its own capabilities to address the issues.

Within the USGCRP the broadly stated, long-term goal of NOAA's Climate and Global Change Program is: **to establish a new national information service based on the achievement of reliable assessments and quantitative predictions of a changing global climate.** Considerations of the NOAA-wide, and even National infrastructure ultimately needed to achieve this goal have been substantial factors in developing the program. NOAA has made many contributions already to the understanding of the issue of the role of clouds in climate and is continuing to foster research within its own institutions and the academic community through a grants program. NOAA scientists are also participants in several joint research initiatives with other agencies. Integration and synthesis of climate information on a National and International scale has been a touchstone of the NOAA Climate and Global Change Program from the outset. The strong research character of the program at present is emphasized in the somewhat more narrowly conceived program objective: **to (learn how) to provide reliable predictions of global climate change and associated regional implications on time-scales ranging from seasons to a century or more.** As we have emphasized throughout this testimony/address, establishing system predictability on any time or space-scale will ultimately be underpinned by our ability to understand, model and predict those basic physical processes including particularly the role of cloud processes which drive the system. Developing a nationally supported, integrated modeling, prediction and assessment capability will be an important step to achieving this goal.