ATMOSPHERIC COMPOSITION AND CLIMATE

The Atmospheric Composition and Climate Program (ACCP) pursues two overall research objectives: (i) to improve the predictive understanding of the radiative forcing of the climate system by aerosols and by chemically active greenhouse gases, such as tropospheric ozone and methane, and (ii) to better characterize the recovery of the stratospheric ozone layer, including its role in climate change. The integrated research activities that address these objectives involve instrument development, regional to global observations, laboratory studies, and theoretical modeling by NOAA and extramural partners. A hallmark of the Program is that its objectives are cooperatively framed with both national and international collaborators.

NOAA has several key partners in its climate research; for example, NASA, NSF, DOE, and NOAA co-plan and execute collaborative/coordinated field studies. Further, frameworks exist to facilitate this cooperation: (i) from an organizational perspective, e.g., the CCSP/USGCRP Atmospheric Composition interagency subgroup, which NOAA and NASA co-chair; and (ii) via international coordination, e.g., International Global Atmospheric Chemistry (IGAC) and Stratospheric Processes and their Role in Climate (SPARC) programs.

FY 2005 Focus

In FY 2005, the ACCP will give attention to proposed research contributing to a better understanding of the interaction of aerosols and tropospheric ozone with the global climate system. Aerosols and tropospheric ozone play key and unique roles in the Earth's climate system. However, many aspects of these roles remain poorly quantified. Several characteristics of aerosols and ozone make quantification of their impact on climate challenging:

- Both ozone and aerosols are short-lived and, hence, variable on temporal and spatial scales where long-lived greenhouse gases are relatively homogeneous.
- Ozone also affects other climate-related variables; for example, ozone controls the abundance of greenhouse gases (such as methane) and the formation of certain aerosols (such as sulfate) via its central role in the production of the OH radical.
- Aerosols of different composition and origin (e.g. natural versus anthropogenic) force the climate to different extent and, indeed, in very differing ways.
- Aerosols could greatly affect the properties of clouds, cloud cover, and convection.
- Vertical profiles of aerosol chemical, physical and optical properties would provide important information that can be used to delineate their impact.

An essential reason for addressing aerosols and tropospheric ozone together is that many research projects can focus on these short-lived species in concert. Two overarching needs associated with a better understanding of the climatic roles of aerosols and tropospheric ozone are (i) an observationally-based, regional climatology of aerosols and tropospheric ozone ("what's out there and how is it changing?"), and (ii) an observationally- and theoretically-built/evaluated predictive understanding of the processes linking emission sources to resulting spatial and temporal distributions, chemical composition, and radiative properties of anthropogenic and natural aerosols and ozone ("why is it changing?"). Such regional observations and source/radiative characteristics are essential for improved radiative and climate models and assessment of their uncertainties, which, in turn, are the only tools that can yield estimated simulations of societal-needed "If …, then …" decision-support scenarios. Further, such observations are essential for evaluating/improving the needed global observations from, for example, the Aerosol Polarization Spectrometer (APS) on the NPOESS platform.

In FY2005, the ACCP will concentrate on three activities.
(1) Influence of aerosols on the radiative balance of the atmosphere. The uncertainty in influence of aerosols on climate including their roles in changing clouds and cloud properties is noted to be the largest single contributor to the uncertainty in radiative forcing by anthropogenic activities since the year 1750 [IPCC, 2001; CCSP, 2002]. Therefore, a better characterization of the effects of natural and anthropogenic aerosols on the radiative balance of the atmosphere is crucial for a more accurate prediction of the impact of human activities on climate [CCSP, 2002]. Hence, the principle research objective for the ACCP in 2005 is focused on gaining a better predictive understanding of aerosols on the radiative balance of the atmosphere with particular emphasis on the indirect effect of aerosols on climate, i.e., in their roles in changing clouds and cloud properties.

To reach this objective, the focus of the activity is four-fold.

- Development and application of new techniques and approaches for understanding aerosol-climate interactions.
- Development and application of new techniques and approaches to improve the understanding of cloud processing on the chemical composition and distribution of radiatively important aerosols in the atmosphere.
- Carrying out atmospheric measurements needed to elucidate the processes governing these interactions.
- Development, evaluation, and application of theoretical models that can simulate these chemical/radiative effects and their influence on the radiative balance in the earth's atmosphere.

It will also have an eye to NOAA-initiated field programs required to determine the influence that aerosols have of the radiative balance of the atmosphere and the application of enhanced measurement and modeling capabilities to support those programs.

In terms of atmospheric measurements needed to elucidate the processes governing aerosol-climate interactions, NOAA will help lead a major interagency field program in 2006, the Gulf of Mexico Atmospheric Composition and Climate Study (GoMACCS), to study the influence of aerosols on the radiative balance of the atmosphere over the Gulf of Mexico and Western Tropical North Atlantic. In the study, NOAA will investigate how North American emissions influence the chemistry and the radiative forcing of climate across the Gulf of Mexico. In addition to the clear-sky radiative effects, GoMACCS will focus on how continental aerosols influence the radiative properties of clouds. The 2006 field study objective is to better characterize marine/continental chemical and meteorological processes in order to improve the simulation of the radiative forcing of climate change by lower-atmosphere ozone and aerosol particles. This will be the first major experiment of NOAA's new climate program initiative on the aerosol indirect effect.

In addition to support for the GoMACCS field study, the ACCP research activity in 2005 also will undertake to initiate measurement programs that can provide the essential observational data and diagnostic studies needed to evaluate and improve model estimates of the outflow of chemicals from major continental sources (e.g., Asia) into the more remote marine atmosphere (e.g., the western Pacific) and to evaluate the impact of these compounds on the radiative balance and chemistry of the atmosphere in the receptor region (e.g., the eastern Pacific and western North America). Theories and models of chemical aerosol production and loss in background and polluted air masses will be tested and the role of aerosols in heterogeneous chemical processes and partitioning of key trace gases investigated. The plans for future studies will be developed in coordination with multiple governmental agencies and institutions in the United States, abroad.

(2) Regular vertical profiling of aerosols. As a specific extension of the research outlined in the first activity, this activity provides additional systematic monitoring of aerosols and their effects on the radiation balance of the atmosphere. NOAA is expanding its effort at carrying out regular measurements of aerosols and their properties at selected sites using small aircraft. Data from regular monitoring flights will be used to test chemical transport models and satellite retrieval algorithms, evaluate the extent to which surface measurements represent column averages, and enable an observationally-based calculation of the aerosol radiative forcing. The light aircraft sampling program will be complementary to intensive field programs, such as the ITCT 2004 study, by emphasizing frequent flights (several times weekly) over an extended time period (several years). The monitoring nature of the light aircraft program requires instrumentation that is optimized for small size and weight, low power, and automated operation.

(3) Analysis, interpretation, and theoretical modeling using data from ITCT 2004. The Intercontinental Transport and Chemical Transformation (ITCT) program will undertake an intensive field study during the summer of 2004 to investigate the tropospheric chemistry and transport of ozone, aerosols, and other chemically active greenhouse compounds. The plans for the NOAA ITCT study in 2004 were developed in coordination with multiple governmental agencies and institutions in the United States, Canada, and Europe. The principal research activity of ITCT in 2004 is aimed at providing observational data needed to evaluate and improve model estimates of the outflow of chemicals from North America across the Atlantic Ocean and to evaluate the impact of these compounds on the radiative balance and chemistry of the atmosphere over the Eastern United States and North Atlantic. Diagnostic studies and theoretical models of ozone and aerosol production and loss in background and polluted air masses will be used to analyze and interpret the observational data in order to obtain a better understanding of the chemical processes and partitioning of key trace species. This study has exceptional merit in this regard due to the extensive, high-quality data sets that will be collected during the study and the well developed anthropogenic and biogenic emission inventories for the known ozone and aerosol precursors that are available for North America. (For a copy of the NOAA Science Plan and a detailed list of measurements and observations that will be made by NOAA see http://www.al.noaa.gov/2004/)

References

The following references may be useful to those seeking more information on atmospheric composition and climate:

CCSP, October 2002. Strategic Plan for the Climate Change Science Program, Climate Change Research Initiative and U.S. Global Change Research Program. Chapter 1 places the climatic effect of aerosols as one of the top-three priorities of the CCRI (aerosols, North American carbon flux, and feedback processes). Chapter 3 underscores that the importance and complexities associated with aerosols require a longer-term plan. The CCRI/USGCRP Workshop on 3-5 December 2002 provided input to the near- and longer term planning.

IGAC, International Global Atmospheric Chemistry Newsletter, Issue No. 12, March 1998; No. 24, August 2001; and No. 29, December 2003 (c.f., Dr. Timothy Bates; IGAC Core Project Office; NOAA/Pacific Marine Environmental Laboratory, 7600 Sand Point Way NE, Seattle, WA, 98115, USA; Tel: (+1-206) 526-6248; Fax: (+1-206) 526-6744, e-mail: IGAC.CPO@unh.edu; internet: http://www.igac.unh.edu/).

IPCC, 2001. Climate Change 2001: The Scientific Basis. Intergovernmental Panel on Climate Change. See Chapters 5 and 6, and see Section C, Technical Summary.

NOAA, 16 December 2002. NOAA Strategic Plan. FY 2003 – FY 2008 and Beyond. NOAA Mission Goal 2. "Understand climate variability and change in order to enhance society's ability to respond." Among the five Research Strategies is "Understand and describe how natural systems work together through investigation and interpretation of information."

Announcements

- FY 2005 Program Announcement
- FY 2005 Proposal Solicitation of the Atmospheric Composition Project of the NOAA Climate and Global Change Program: Background Information
- Previous Program Announcements

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