Title: Aerosols, Chemistry, and Radiative Forcing: A 3-D Model Analysis of Satellite and ACE-Asia data (ACMAP)

PI: Mian Chin
Georgia Institute of Technology and NASA Goddard Space Flight Center
Code 916, NASA Goddard Space Flight Center
Greenbelt, MD 20771
Phone: 301-614-6007
Fax: 301-614-5903
Email: chin@rondo.gsfc.nasa.gov
URL: http://code916.gsfc.nasa.gov/People/Chin/

Co-I: Paul Ginoux
GEST, UMBC
Code 916, NASA Goddard Space Flight Center
Greenbelt, MD 20771
ginoux@rondo.gsfc.nasa.gov

Co-I: Omar Torres
JCET, UMBC
Code 916, NASA Goddard Space Flight Center
Greenbelt, MD 20771
torres@tparty.gsfc.nasa.gov

Co-I: Xuepeng Zhao
NOAA NESDIS
ORA, 5200 Auth Rd.
Camp Springs, MD 20746

Abstract

We propose a research project to incorporate a global 3-D model and satellite data into the multi-national Aerosol Characterization Experiment-Asia (ACE-Asia) mission. Our objectives are (1) to understand the physical, chemical, and optical properties of aerosols and the processes that control those properties over the Asian-Pacific region, (2) to investigate the interaction between aerosols and tropospheric chemistry, and (3) to determine the aerosol radiative forcing over the Asia-Pacific region. We will use the Georgia Tech/Goddard Global Ozone Chemistry Aerosol Radiation and Transport (GOCART) model to link satellite observations and the ACE-Asia measurements. First, we will use the GOCART model to simulate aerosols and related species, and evaluate the model with satellite and in-situ observations. Second, the model generated aerosol vertical profiles and compositions will be used to validate the satellite products; and the satellite data will be used for during- and post-mission analysis. Third, we will use the model to analyze and interpret both satellite and ACE-Asia field campaign data and investigate the aerosol-chemistry interactions. Finally, we will calculate aerosol radiative forcing over the Asian-Pacific region, and assess the influence of Asian pollution in the global atmosphere.

Summary

With support from NASA's ACMAP and Radiation Program, we have developed aerosol simulation capability with the Georgia Tech/Goddard Global Ozone Chemistry Aerosol Radiation and Transport (GOCART) model. The GOCART model is a global model driven by assimilated meteorological fields from the Goddard Earth Observing System Data Assimilation System (GEOS DAS), which are model-assimilated global analyses constrained by meteorological observations, with extensive diagnostics archived for chemistry transport model applications. Major troposphere aerosol species, including sulfate, black carbon, organic carbon, dust, and sea-salt, are simulated in the model [Chin et al., 2000a,b; Ginoux et al., 2001; Chin et al., 2002a]. Our results, which have been frequently used by other groups, have a wide range of applications, from imposing initial conditions for regional models, providing dust source functions for other global models, to supplying aerosol fields for chemistry models; from helping data group interpret their measurements, selecting monitoring sites for ground observation network, to assisting satellite retrievals. The GOCART model has also contributed to the international assessment reports by the IPCC (2001) and WMO (2002). More information and publications of GOCART model can be found at http://code916.gsfc.nasa.gov/People/Chin/.

In Spring 2001, the Aerosol Characterization Experiment-Asia (ACE-Asia) took place over the Asian-Pacific region to investigate the aerosol properties and their radiative forcing in the anthropogenically modified atmosphere of eastern Asia and northwestern Pacific. During the intensive field study period (March 30 – May 4, 2001), we used the GOCART model to provide a 24- to 96-hour forecast of aerosols everyday, and worked with the mission scientists and measurement teams on daily flight planning at the field operation center. During spring 2001, large amounts of pollution and dust aerosols originating in Asia were frequently transported to the Yellow Sea and the Sea of Japan. Several large dust outbreak episodes that allowed dust plumes to make their way across the Pacific to reach North America were all predicted by the model. Both the model forecast and the measurements showed that most pollution aerosols over the ACE-Asia measurement area were concentrated below 2 km, with sulfate as the dominant aerosol type. However, above 2 km, dust controlled the total aerosol optical thickness. The aerosol model forecast provides direct information on aerosol optical thickness and concentrations that were measured in the experiment, making flight planning more effective; while quick feedback from measurements helps improve the model processes, ensuring meaningful data analysis [Chin et al., 2002b].

In the past year, our work has been concentrated on analyzing ACE-Asia field data. We have been working closely with several groups involved in ACE-Asia experiments on model comparisons and evaluation. To understand the origin of the pollution and dust aerosols over the Pacific and to assess the regional to global scale impact of these aerosols, we have used the GOCART model to analyze the origin of the aerosols. The relative contributions of sulfate (as pollution aerosol) and dust from different major source regions have been labeled in order to track their evolution. Major anthropogenic source regions are in Asia, Europe, and North America, while major dust source regions are in China/Mongolia (Taklimaken and Gobi deserts), Africa, and Middle East. We have found that Asian pollution sources account for 30 to 50% of sulfate loading over the entire open ocean of the North Pacific and the western North America in April 2001, and dust emitted from Taklimaken and Gobi encompasses 50 to 70% of the dust loading over the same region. While Asian continent is the major export of pollutions and dust in spring, it also receives a large amount of pollution from Europe and dust from Africa in the same season. Our model results show that 40 to 60% of sulfate over northern Asia originates

from Europe, and 50 to 70% of dust over the western Asia is imported from Africa. The European pollutants and African dust can even make a significant contribution to the aerosol loading over the west coast of North America (20-30% of sulfate, 20-40% of dust) as a result of intercontinental transport.

We have also been working on analyze the satellite data from TOMS, AVHRR, and ground-based sun-photometer network AERONET [Chin et al., 2002]. Since last year, we have been working with the MODIS team to analyze the MODIS aerosol products including optical thickness, fine/coarse model aerosol fractions, and anthropogenic radiative forcing.

Related Publications

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