Coastal Aerosol Distribution by Data Assimilation

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LONG-TERM GOALS

The long-term goal of this research is to develop an initialization scheme for a multi-dimensional, predictive aerosol model in coastal regions. The initialization scheme will have global coverage and include data gathering, quality control and data assimilation of the available aerosol observations, including satellite aerosol retrievals, ground-based remote sensing, point measurements, and the previous aerosol forecast.

OBJECTIVES

The objectives of this program are to (1) investigate and evaluate the existing and proposed aerosol retrievals from satellites for applicability to aerosol model initialization and (2) develop and test aerosol analysis and data assimilation techniques using satellite and other aerosol measurements.

APPROACH

The approach to the problem of aerosol and Electro-Optical (EO) extinction prediction follows that used in numerical weather prediction, namely real-time assessment and first-principle modeling. A predictive model requires the initial spatial distribution of the aerosol field including composition, concentration, and size distribution. Sensors and retrieval techniques exist for obtaining the aerosol optical depth (AOD) and some information about particle size. The remotely sensed aerosol properties typically are vertical integrals and are generated at horizontal resolutions ranging from one kilometer to one degree. An objective analysis method is being devised to merge these 2-D distributions with point measurements and model constraints to produce a three-dimensional description of aerosols.

WORK COMPLETED

A global predictive model of tropospheric aerosols has been developed over the past several years. Improvements have been made this year to the source functions, validation techniques, and product distribution. With its global, continuous coverage, the Navy Aerosol Analysis and Prediction System (NAAPS) is invaluable in filling the gaps in observations of aerosols and visibility and in satellite observations and extends our understanding of aerosols and their impact on Navy operations. NAAPS simulations have revealed that inter-continental transport of aerosols is common and occurs nearly every day somewhere in the world. These improvements will make the model's forecasts even more accurate.

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14. ABSTRACT
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NAAPS was utilized during the Intercontinental Transport of Chemical Transformation (ITCT-2K2. Several years of NAAPS simulations for the Pacific Ocean have been analyzed for use in planning the Asian Dust Above Monterey (ADAM) experiment, scheduled for April 2003, and intended to study the properties and distribution of the Asian dust and aerosols that cross the Pacific every spring.

A program to retrieve aerosol optical depth from AVHRR and GOES satellite data has been evaluated for the tropical Atlantic using data collected during the ONR-sponsored Puerto Rico Dust Experiment (PRIDE) in 2000. The algorithm was improved in a number of ways and is now used daily over selected areas.

The Wildfire-ABBA (Automated Biomass Burning Algorithm) product for fire detection in the western hemisphere from GOES data is now received every half hour at NRL/MRY from University of Wisconsin. This product is used to specify western hemisphere smoke sources in NAAPS. The NASA/GSFC MODIS fire product is now received daily. This product is used to specify global smoke sources, except for the western hemisphere.

Region-specific web pages have been developed for the Mediterranean, Persian Gulf, and Caribbean regions and are being transitioned to SIPRNET so local Navy personnel can be involved in the development and content of these pages. These contain only the products relevant to a particular region on the single page. This approach facilitates the analyses of aerosol events for a particular region. These would be templates for METOC and warfighter specific pages that would be distributed on SIPRNET.

RESULTS

Dust and pollution events were simulated during ITCT-2K2 in April of 2001 to forecast aerosol events five days in advance The NAAPS forecasts were used to choose aircraft flight days and stand-down days. Until recently, such long-range transport was not considered possible in the troposphere, but NAAPS along with several recent satellites, have demonstrated that these event are occurring numerous times each year. Explaining the long tropospheric lifetime of these aerosols is the focus of a 6.1 program.

The combined GOES-ABBA/MODIS product allows, for the first time, simulations of realistic fire smoke plumes in Siberia, Africa, Southeast Asia, and Indonesia. In particular, NAAPS accurately modeled the large Russian fires of August and September 2002 (Figure 1). Previously, NAAPS used a historical dataset (1993) for fires, based on AVHRRR data, from ESA, to specify smoke sources in Africa, Australia and Indonesia.

IMPACT/APPLICATIONS

Presently, NAAPS runs in a predictive mode and can help to satisfy the Navy's long-term goal of a predictive capability for aerosols and EO propagation. This research also provides tools for the 6.1 and 6.2 aerosol research communities and the academic community. NAAPS will be transitioned to operations over the next year. Over the past years, collaborations have been initiated between NRL and University of Miami, U. Wisc., U. Alabama, NASA/GSFC, Chinese Academy of Sciences, University of Warsaw, MBARI, Université de Sherbrooke (Quebec) and others. NRL's continued participation in field programs will give us further opportunities for collaboration and access to important validation data.

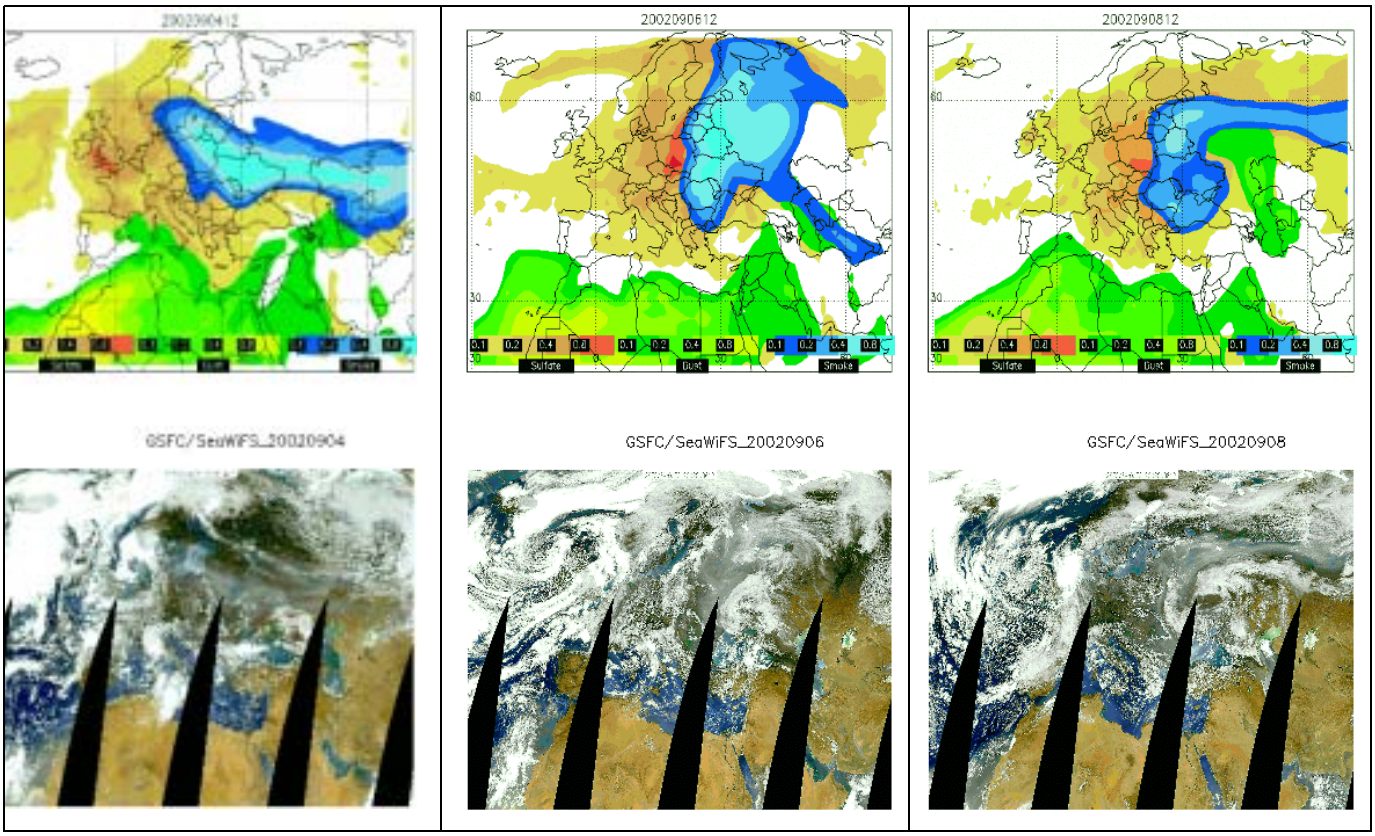

Figure 1. The evolution of aerosols over Africa, the Mediterranean, and Europe for September 4, 6, and 8, 2002 (left, center, and right, respectively.) The top panels show NAAPS simulations of sulfate (red shades), smoke (blue shades), and dust (green and yellow shades). The bottom panels show the SeaWiFS true color imagery for the same days. NAAPS accurately simulates the complicated evolution of the numerous plumes seen in the SeaWiFS and allows us to identify the composition of the plumes. Smoke from the Russian fires is advected northward and then strongly to the east but NAAPS shows that not all of the aerosol over Europe is smoke. Sulfate aerosol (red shades; an indicator of anthropogenic pollution) is pervasive over most of Europe and Saharan dust (green shades) makes repeated northward incursions across the Mediterranean and west over the Atlantic.

TRANSITIONS

None.

RELATED PROJECTS

The NRL 6.1 base *Atmospheric Physics* and the NRL 6.2 base *Improved COAMPS Land Boundary Layers* (includes COAMPS aerosol modeling) use NAAPS data and products and the satellite retrievals for investigations and validation. The ONR 6.2 *Atmospheric Aerosol Characterization* will also use NAAPS simulations for high energy laser research. The SPAWAR 6.4 *Improvement of Aerosol Prediction Capability* will transition NAAPS to operations and use it to generate products for use by the fleet.

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