Modeling the Time-Dependent Optical Properties of the Multicomponent Aerosols in the Marine Boundary Layer

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LONG-TERM GOALS

The ultimate goal of this project is to relate the time-dependent, frequency-dependent, radiative properties of multicomponent aerosols to their major physical and chemical transformation processes in the marine environment.

OBJECTIVE

Develop algorithms for the calculation of frequency-dependent optical properties of mineral dust accounting for its mineralogical composition, life cycle, and interaction with other atmospheric aerosols in ‘clean’ and polluted marine environment.

Develop simplified physically-based treatments of time-dependent aerosol radiative properties for global and regional aerosol transport models.

Apply the developed models to analyze high-spectral resolution remote sensing data.

APPROACH

Our approach combines analysis of empirical data on dust microphysical, optical, and radiative properties along with mathematical modeling based on an operational three-dimensional aerosol chemical-microphysical model.

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WORK COMPLETED

A new technique to model the spectral optical properties of mineral aerosol accounting for its composition and state of mixing developed under this project in FY98 was incorporated into a 3D aerosol chemical-microphysical model.

Our 3D aerosol chemical-microphysical model was updated with a new heterogeneous chemistry package, which includes the oxidation reactions of SO_2 and NOx, resulting in sulfate and nitrate formation on mineral aerosol.

We incorporated the simplified treatments of size-resolved dust production and wet removal into a global circulation model (GCM) driven by observed winds generated with the NCAR MATCH model. We simulated Saharan dust distribution over the North Atlantic Ocean during ACE-2 time frame (July, 1997).

We developed a radiative transfer code based on a discrete-ordinate technique that is capable of calculating upward radiances for the complex multi-layered vertical distributions of tropospheric aerosols and clouds.

Overall, we successfully completed all tasks planned for FY99.

RESULTS

Using our aerosol chemical-microphysical model, we showed that coagulation of dust with other aerosol particles as well as uptake of atmospheric gases on dust particle surfaces followed by heterogeneous chemical reactions may both result in the formation of multicomponent aerosols in the marine environment. Although the relative importance of the above processes varies and depends on many factors, we demonstrated that coating of dust particles could drastically alter their spectral optical properties and hence radiative effects from UV to IR wavelengths.

We demonstrated the importance of a multi-layered vertical distribution of tropospheric aerosols for the retrieval of column-averaged aerosol optical properties based on remote sensing at visible wavelengths.

IMPACT/APPLICATIONS

Our new techniques to model the spectral optical properties of multicomponent aerosol containing dust can be employed in various remote sensing applications and in aerosol chemical transport models.

TRANSITIONS

Our main results were published in peer-reviewed journals and presented at numerous scientific meetings.
Dr. Sokolik organized an international Workshop on Mineral Dust held in Boulder, Colorado, in June 1999, involving 95 scientists from 9 countries. Details of the workshop and abstracts of the 59 papers presented can be found on the Web http://irina.colorado.edu/workshop.htm

Accepted manuscripts will be published in a special issue of the Journal of Geophysical Research.

RELATED PROJECTS

We are currently independently funded under the NASA EOS-IDS program to construct an "event oriented" global model for atmospheric aerosols. The goal is to develop a tool, which can directly compare satellite observations of aerosols generated by specific events with output from a numerical model. This linkage should help with the satellite retrieval algorithms, allow observations by multiple satellites or ground campaigns to be intercompared for the same event, and give us greater confidence in our ability to simulate aerosol systems.

PUBLICATIONS

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