Preface to special section on Global Aerosol System

D. Tanré,[1] Y. Kaufman,[2] T. Nakajima,[3] and V. Ramanathan[4]

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[1] This special issue brings together papers that were presented in a workshop of experts on the global aerosol system and its impacts on climate. Aerosols originate as urban haze and rural haze, and owing to long range transport of pollutants, becomes widespread aerosol layers across the globe.

[2] Atmospheric aerosols play a dual role in the climate system and the hydrologic cycle (see reviews in the work of *Ramanathan et al.* [2001] and *Kaufman et al.* [2002]). Their first role is interaction with solar and thermal radiation: by scattering sunlight and reflecting a fraction of it back to space aerosols cool the climate system; by absorbing sunlight in the atmosphere aerosols further cool the surface but warm the atmosphere, changing the temperature and humidity profiles and the conditions for cloud development.

[3] Aerosol particles play a second role by affecting the hydrologic cycle: serving as cloud condensation nuclei and ice nuclei, aerosols control the cloud droplet concentration and size. Higher number concentrations of submicron pollution aerosol tend to decrease the cloud droplet size and prevent or delay development of precipitation. Supermicron sea-salt particles can reintroduce precipitation and oppose the effect of pollution aerosol. These processes may cause changes in precipitation patterns to which the human civilization adapted during the last millennium, changes in cloud cover, and possible changes in the frequency of extreme events.

[4] No less important is the aerosol effect on health, air quality, and agriculture that brought policy responses in Europe and North America in the last century and is affecting policy decisions in east and southern Asia today. Therefore advancements in aerosol science, together with research on the effect of greenhouse and trace gases and increased ability to predict the impact of human activity on the regional and global aerosol, can be expected to have direct impact on energy use and economic activities in nations around the world.

[5] Unraveling these aerosol effects is still difficult because of the high spatial and temporal variability of sources, complex interaction of aerosol with atmospheric trace gases and clouds, and the short lifetime of aerosol of about a week, owing to wet and dry depositions. A single aerosol particle over the Mediterranean Sea can include anthropogenic sulfate and carbonaceous material from Europe, coating natural dust particle from Africa.

[6] Today's aerosol assessments of climate are based on aerosol chemical transport models and climate models that cannot yet resolve the aerosol interaction with clouds with their microscale physical and chemical exchanges. Models make good progress in capturing aerosol evolution, but source characterization is difficult. Accurate assessments of aerosol distribution and composition, the anthropogenic component, and the impacts on radiation and water cycle therefore require orchestrated observations of aerosol, precursor trace gases, clouds and precipitation from satellites, networks of surface-based instruments, laboratory studies, and dedicated field experiments. The observations require sufficient information content, accuracy, and global coverage to permit their integration into and testing of aerosol chemical transport, assimilation, and climate models [*Intergovernmental Panel on Climate Change* (*IPCC*), 2001].

[7] In the last decade, research of the global aerosol system was invigorated by an array of new measurements in several temporal and spatial scales, the fruits of which we start to see in this special issue, and the development of new models:

[8] 1. Global, daily, and multidaily observations of aerosol, clouds, and their properties derived from satellite measurements of the scattered solar light, utilizing its spectral, angular, and polarization properties.

[9] 2. Satellite measurements of the vertical distribution of aerosol, clouds, and precipitation using lidars and radars and thermal infrared and microwave radiometers.

[10] 3. Surface networks that continuously measure in situ and remotely (both passive radiometers and active sensors) the aerosol physical and chemical properties, distribution of solar radiation, clouds, and precipitation.

[11] 4. Intensive field campaigns that concentrate the measurement power in a given region for a limited period of time and help understand the aerosol sources and aerosol and cloud processes.

[12] 5. Laboratory analysis of aerosol particles and measurements of aerosol processes.

[13] 6. Development of transport models that start to mimic the aerosol distribution measured from satellite and surface networks.

[14] 7. Assimilation of the aerosol models and measurements into climate models to study the effects of aerosol on

[1]Laboratoire d'Optique Atmospherique, Villeneuve d'Ascq, France.
[2]NASA Goddard Space Flight Center, Greenbelt, Maryland, USA.
[3]Center for Climate System Research, University of Tokyo, Tokyo, Japan.
[4]Center for Clouds, Chemistry and Climate, Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California, USA.

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global circulation and climate and the feedback from climate change on the aerosol.

[15] These new measurements and models are now starting to develop new understanding. The papers in this special issue summarize some of the progress in the following fields.

[16] 1. Remote sensing of aerosol and validation using the new satellite instruments: POLDER [*Herman et al.*,2005], Moderate Resolution Imaging Spectroradiometer (MODIS) [*Ichoku et al.*, 2005], Multiangle Imaging Spectroradiometer (MISR) [*Kahn et al.*, 2005], Global Ozone Monitoring Experiment (GOME) [*Kusmierczyk-Michulec and de Leeuw*, 2005], Sea-viewing Wide Field-of-view Sensor (SeaWiFS) [*Wang et al.*, 2005], combining several instruments like MISR and MODIS [*Abdou et al.*, 2005] or including satellites with a long record such as advanced very high resolution radiometer (AVHRR) and Total Ozone Mapping Spectrometer (TOMS) [*Jeong and Li*, 2005], or MODIS and AVHRR [*Jeong et al.*, 2005].

[17] 2. Preparation for remote sensing with the to be launched satellites that will be part of the A-train POLDER+ CALIPSO [*Waquet et al.*, 2005; C. Cattrall et al., Variability of aerosol lidar, backscatter and extinction ratios of key aerosol types derived from selected AERONET locations, submitted to *Journal of Geophysical Research*, 2005].

[18] 3. Use of the new satellite and ground network data with models to infer regional and global aerosol distribution and impacts dust transport and deposition [*Kaufman et al.*, 2005; *Liu et al.*, 2005], regional and global aerosol burden [*Massie et al.*, 2004; *Omar et al.*, 2005; *Liu et al.*, 2005; *Reddy et al.*, 2005], aerosol global absorption [*Schuster et al.*, 2005; *Torres et al.*, 2005], derivation in conjunction with CO measurements [*Edwards et al.*, 2004], and interaction between aerosol and clouds [*Krüger et al.*, 2004; M. Jin et al., Urban aerosols and their variations with clouds and rainfall: A case study for New York and Houston, submitted to *Journal of Geophysical Research*, 2005; V. N. Kapustina et al., On the determination of CCN from satellite: Challenges and possibilities, submitted to *Journal of Geophysical Research*, 2005].

[19] 4. Inferring the aerosol radiative forcing of climate [*Vant-Hull et al.*, 2005; *Kim et al.*, 2005; *Zhang et al.*, 2005a, 2005b].

[20] We can anticipate that in the next several years the data from the present and newly launched satellites will come into full fruition. Plans are underway for several new spaceborne missions for advanced aerosol, clouds, and precipitation measurements, increasing the spectral, angular, and polarization resolution, and introducing new active radar and lidar measurements. Data from these mission, if successfully executed together with developments in atmospheric modeling, are expected to advance our understanding of the interaction of aerosols, clouds, and precipitation and their effect on the hydrological cycle and climate.

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