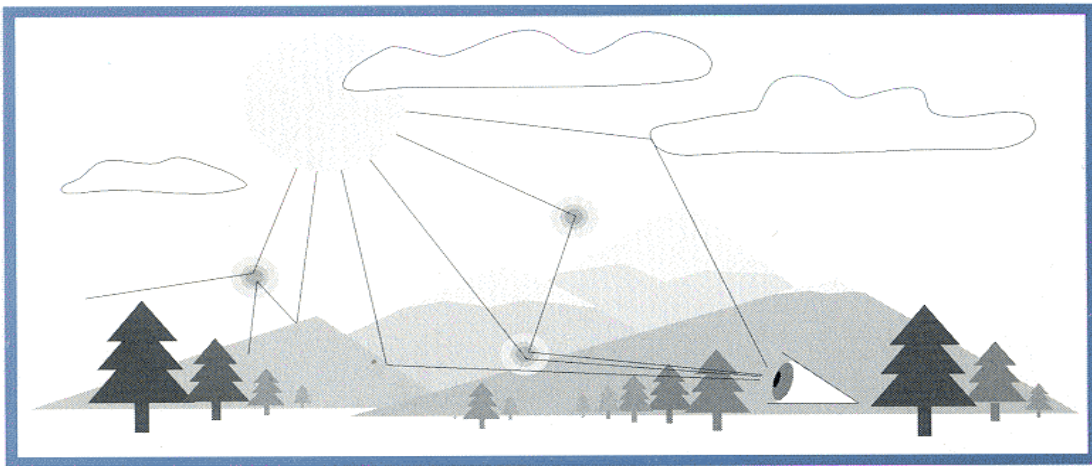


Aerosols and Atmospheric Optics: *Radiative Balance and Visual Air Quality*

Volume A



**AIR & WASTE MANAGEMENT
ASSOCIATION**

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Proceedings of the International Specialty Conference

**AEROSOLS AND ATMOSPHERIC OPTICS:
Radiative Balance and Visual Air Quality**

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Rocky Mountain States Section

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**Aerosols and Atmospheric Optics:
Radiative Balance and Visual Air Quality**

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PREFACE

The conference proceedings is meant to be a complete record of the papers presented; however, the papers have not been peer reviewed. In some cases, the proceedings include complete draft manuscripts; in other cases, only an extended abstract and the visuals used at the conference are presented. The table of contents is a road map not only to the conference proceedings, but also to the order in which the papers were presented.

For those authors that chose to publish their papers in a peer-reviewed journal format, arrangements were made with the Air & Waste Management Association and the American Geophysical Union for publication in special editions of their respective journals: Journal of Air & Waste Management Association and Journal of Geophysical Research. The technical co-chairs were appointed as guest editors for these journals.

The conference was organized around the interaction of radiation with aerosols and the resulting effect on visibility and global climate. Visibility has been of concern for many years, especially to the military where the ability to see a target was of vital importance. However, visibility in terms of the ability to clearly see landscapes and urban features has evolved as a critical issue in recent years. Every three to four years beginning in 1981, a visibility specialty conference has focused on issues pertaining to understanding how natural and manmade emissions impair our ability to see and appreciate the environment around us. These conferences have not only addressed the interaction of light with the atmosphere, but have also addressed the chemistry and physics of aerosol transport, transformation, and deposition. Because visibility involves the “seeing” and appreciating of urban or rural “vistas,” a portion of the conferences have always focused on the perceptual nature of the interaction between the human visual system and the visual environment, as well as on the value the human observer places on good visibility.

[NOTE: APCA sponsored an earlier Visibility Speciality Conference “View on Visibility – Regulatory and Scientific” in Denver, Colorado, on November 26-27, 1979]

More recently, global climate change has emerged as a societal concern. The role of aerosols on radiative balance and hence its effect on climate change is now recognized as an important area of global climate research. Radiative balance requires an understanding of how electromagnetic energy, including visible radiation or light, interacts with the atmosphere. As in the field of visibility, it is necessary to understand how particles and gases are formed and transported as a function of meteorology and emissions, and how these constituents absorb and scatter or redirect radiation from the incident direction.

Because research on visibility and global climate change have evolved somewhat independently of each other, scientists in their respective communities, although aware of one another’s work, have not consistently had the opportunity to exchange information on a detailed level. It was felt that a forum was needed to facilitate the open exchange of ideas and research results involving scientists from both fields. Therefore, a conference was organized around the general topics of aerosols and atmospheric optics as they relate to radiative balance and visual air quality.

The resulting International Specialty Conference, “Aerosols and Atmospheric Optics: Radiative Balance and Visual Air Quality,” was held September 26-30, 1994 at Snowbird, Utah, and was cosponsored by the Air & Waste Management Association and the American Geophysical Union. Snowbird, nestled high in the Wasatch Mountain Range, was an ideal location to report on the relationships between aerosols and atmospheric optics. The conference Technical Program Co-chairs were William C. Malm of the USDI-National Park Service and Peter K. Mueller of the

Electric Power and Research Institute, while the Program Chair was Delbert J. Eatough of Brigham Young University. More than 150 papers were submitted to the conference, with approximately 125 papers presented.

The conference was unique because it brought together scientists from many nations. Russia was well represented, with eight scientists and nine papers. Other countries and their representation were as follows: Canada, with four scientists and five papers; Australia, with two scientists and two papers; Estonia, with one scientist and one paper; Germany, with one scientist and one paper; Austria, with one scientist and one paper; England, with one scientist and two papers; Iran, with one scientist and one paper; The Netherlands, with two scientists and two papers; Italy, with one scientist and two papers; and Mexico, with four scientists present.

The conference was organized to cover five primary topics, each supported by sessions on key aspects and with an overview lecture by knowledgeable scientists in their respective areas. The topics were to be fundamental to the interests of both the visibility and global climate communities. The conference topics evolved into six major topics: 1) Field Observations, with Topic Co-chairs Peter H. McMurry and L. Willard Richards, and Session Chairs Peter K. Mueller, Peter H. McMurry, L. Willard Richards, and Antony D. Clarke; 2) Atmospheric Optics, with Topic Co-chairs Warren H. White and Graeme L. Stephens, and Session Chairs Warren H. White, Edward S. Macias, and Kirk A. Fuller; 3) Atmospheric Aerosols, with Topic Co-chairs Barry L. Huebert and Sonia M. Kreidenweis, and Session Chairs Barry L. Huebert and Sonia M. Kreidenweis; 4) a Joint Session between Optics and Aerosols, with Topic Co-chairs Sonia M. Kreidenweis and Kirk A. Fuller, and Session Chairs Kirk A. Fuller and Cynthia Twohy; 5) Atmospheric Dynamics, with Topic Co-chairs John G. Watson and Roger A. Pielke, and Session Chairs Judith C. Chow, Mark C. Green, and Christian Seigneur; and 6) Atmospheric Science as Applied to Societal Issues, with Topic Co-chairs Steven L. Rhodes and Ronald C. Henry, and Session Chair Ronald C. Henry. Papers in all sessions were presented in platform or poster format.

State-of-the-science lectures were presented by Peter H. McMurry and L. Willard Richards on measurements, Warren H. White and Patrick Minnis on atmospheric optics, Stephen E. Schwartz on atmospheric aerosols, John H. Seinfeld on atmospheric dynamics, and Ronald C. Henry and Robert Watson on atmospheric science as applied to societal issues.

The first session under field observations reviewed sampling methodologies and programs. Several papers emphasized the need for field observations as ground truth for theoretical models and the need for well-established data quality goals.

A second session on regional and spatial patterns reported on modeling and characterizing vertical optical and aerosol profiles, as well as on spatial and temporal patterns associated with a number of field studies. A session on determination of optical depth or albedo reported on measurements of extinction, aerosols, and optical depth over marine and terrestrial environments and introduced new measurement techniques.

The second topic, atmospheric optics, opened with a session on climate and aerosols. Discussion focused on the need for standard conventions for calculating extinction budgets to reduce ambiguities. Direct and indirect mechanisms of radiative forcing by atmospheric aerosols were reviewed, along with current estimates of magnitudes. A global climate model was used to estimate the effect of mineral dust on radiative forcing while other discussion centered around the use of radiative perturbation theory as a tool to parameterize radiative impacts in climate models. A session on visibility and extinction highlighted the potential importance of atmospheric absorption and associated carbonaceous material to atmospheric extinction and albedo. A visibility equilibrium model was used to estimate the effect of aerosols on climate, while other discussions addressed the

effect and calculational accuracy of aerosol size models as they related to optical properties. Other papers discussed the three-dimensional modeling of the relationship between aerosols and visibility effects. One presentation incorporated a full treatment of dispersion and radiative transfer calculations to show how a scene is modified using computer imaging techniques.

A session on radiative transfer featured several papers that discussed the relationship between aerosol size distribution and the scattering phase function. Papers addressed the need for radiative transfer algorithms that incorporate an accurate handling of multiple scattering effects. A paper was presented on new measurement technologies to measure the full matrix of aerosol and hydrosol consisting of nonspherical particles. The influence of aerosols on ground-level irradiance was discussed, along with the effect of crystalline clouds on scattering and absorption. One of the more interesting papers focused on lidar data collected from the space shuttle Discovery. Results from the experiment included the mapping of the eye of Typhoon Melissa and observations of smoke plumes from South American biomass burning and Saharan dust over the Atlantic Ocean.

The third topic was atmospheric aerosols. The first session, on hygroscopic aerosols, focused on the effect of mixed aerosols in variable humidity environments on their optical properties. Experiments on the theory of nucleation were presented, and the need for aerosol observations to validate models was emphasized. A session on sulfate aerosols described recent measurements of chemical speciation, size distributions, and hygroscopicity of particulate matter with an emphasis on sulfate, its degree of neutralization, and consequent impact upon light extinction. Results reported from a number of field studies re-emphasized the importance of sulfates to extinction, the role of heterogeneous chemistry in sulfate production, and seasonal variations in sulfate characteristics. They also indicated the need for better estimates of sulfur speciation and hygroscopicity. Some critical sampling needs that were identified included improved size resolved impactor measurements and elucidation of whether a non-extractable sulfur component exists.

A session on organic aerosols reported on new sampling strategies to minimize sampling artifacts. Another paper reported on organic measurements in the summer 1990 SJVAQS/AUSPEX study in California. In general, the results in this session pointed to the ubiquity of organic compounds in the atmosphere and their significant role in light extinction. Strategies for improved understanding of organic sampling artifacts and for minimizing such artifacts are urgently needed. There is also a need for more information on the speciation of particulate organic matter, which would assist in understanding hygroscopic behavior and scattering/absorption characteristics.

The fourth topic was a joint session between optics and aerosols. The lead session dealt with the chemistry and physics of single particles. Much of our current understanding of the properties of atmospheric aerosols is based on earlier studies conducted either theoretically or in controlled laboratory settings, often involving single particles. In this session, papers representing the state of the art in particle diagnostics were presented and fell roughly into two categories: 1) investigations of the optical properties of particles that cannot be completely described by the standard Lorenz-Mie theory for spheres, and 2) techniques for studying the chemistry and thermodynamics of single particles. A second session on aerosol/cloud interactions primarily dealt with how aerosol particles influence cloud microphysics by acting as cloud condensation nuclei (CCN). In particular, the apparent increase in droplet number and decrease in droplet size in marine stratus caused by particulate emission from ships was discussed. Other presentations dealt not with stratus clouds but with upper tropospheric clouds such as contrails and cirrus. A laboratory technique for studying the formation of supercooled droplets of ice was introduced, and observations of the condensation of individual water and sulfuric acid droplets at temperatures down to 233 °K were presented. Finally, the feasibility of using the counterflow virtual impactor for measuring condensed water was demonstrated.

The fifth topic, atmospheric dynamics, began with a session on source receptor relationships. A number of papers focused on the apportionment of extinction, sulfur, and other aerosol species to their sources in the Grand Canyon region of the southwestern United States, while other papers examined the application of chemical mass balance modeling for the apportionment of secondary and primary aerosols. Two papers examined the use of tracers of opportunity to apportion or identify source areas that contribute to visibility degradation on the Colorado Plateau. A personal computer implementation of a particle transport model was presented. A second session on the role of emissions, transport, and transformation on visibility in the Southwest included several papers that focused on source receptor relationships on or near the Colorado Plateau. Emission inventories, variation in regional and mesoscale wind fields as a function of interpolation schemes and first principal calculations, the effect of climatology on visibility, and clean air corridors were examined.

A final session on air quality and visibility models presented several new models for examining the effects of relative humidity, marine aerosol dynamics, and diurnal variations. A second-generation plume model was presented, along with a new source-oriented model for air pollutant (including organics) effects on visibility. Model validation needs were discussed.

The final topic was on atmospheric science as applied to societal issues. Considerable discussion centered on the role of the scientist in decision-making processes that affect the society in which we live. Decision makers make decisions with or without scientific input. Therefore, it is imperative that the scientist become involved in the decision-making process and that the decisions be based on good science, although it may be incomplete. Papers examined the level of haze that is just perceptible, the value people place on visibility as a function of haze, and the adequacy of scientific information to make a decision. The results of setting visibility standards at Lake Tahoe were discussed, and conceptual and functional definitions of clean air corridors were proposed.

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**Aerosols & Atmospheric Optics: Radiative Balance and Visual Air Quality
Snowbird, UT - 26-30 September 1994**

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