SECTION 7

RECOMMENDATIONS FOR FUTURE RESEARCH

This section provides a list of topics for future research in visibility studies. The list is organized according to the same six topics as in the Findings and Conclusions (Section 6.2):

1. measurement methods and data bases
2. existing and natural background conditions for visibility/aerosols
3. historical visibility trends
4. contributions to light extinction
5. characterization of visibility effects, and
6. climate effects.

7.1 MEASUREMENT METHODS AND DATA BASES

- Research should be intensified to develop methods that minimize particle sampling artifacts (especially for organics) and to develop *in situ* techniques for liquid water monitoring. There is also a need for nephelometers that do not modify the aerosol and for accurate methods to measure aerosol absorption.
- Additional intercomparison studies should be undertaken to aid in the evaluation of monitoring methods (especially for organics and elemental carbon). Monitoring reference methods should be developed that would promote the collection of comparable aerosol and visibility data nationwide.
- State-of-the-art visibility and aerosol monitoring should be geographically extended to allow a full national assessment of patterns and cause/effect relationships for visibility. Currently, there is a lack of comprehensive data sets for the northern half of the West, the southern part of the East, and the wintertime throughout the East.

7.2 EXISTING AND NATURAL BACKGROUND CONDITIONS FOR VISIBILITY/AEROSOLS

- National visibility maps and seasonal plots based on airport observations need to be updated with recent data, using appropriate techniques for handling the distribution functions and treating urban and rural areas separately. The spatial and seasonal visibility patterns based on airport data should be compared and reconciled with results based on the latest instrumental techniques for measuring visibility.
- Statistical distributions of visibility should be characterized using data from the latest instrumental methods.
- At least one year, preferably several years, of comprehensive visibility and aerosol data should be acquired at a few remote southern hemisphere sites to help provide a better understanding of natural background conditions.

7.3 HISTORICAL VISIBILITY TRENDS

- Visibility monitoring by the National Weather Service should be evaluated with respect to usefulness for visibility research. Prior to the replacement (in a few years) of human visibility observations at airports by forward scattering monitors, the impact of the change on trend analysis should be investigated.

7.4 CONTRIBUTIONS TO LIGHT EXTINCTION

- Data should be collected or assembled to allow the formulation of light extinction budgets for worst-case and best-case conditions as well as average conditions.
- Further work should be done to characterize the potential nonlinearities in the relationship between light scattering and concentrations of aerosol components.
- There is a need to compare light extinction budgets with total visibility budgets that include consideration of path radiance effects. The relative importance of fine-particle scattering, coarse-particle scattering, and absorption on path radiance should be characterized, and an empirical procedure should be developed for combining path radiance and extinction effects in a total visibility index.

7.5 CHARACTERIZATION OF VISIBILITY EFFECTS

- There is a need to quantify the role that path radiance plays in visibility impairment under a variety of lighting and atmospheric conditions. There is also a need to quantify the practical implications of path radiance in regard to control strategies directed at extinction coefficient.

- The laboratory work on "just noticeable" changes should be verified with field studies of the relationship between perceptible changes and air pollution levels.
- Field verification should be conducted regarding image processing techniques for visibility. The relationship between photographs and natural scene perception needs to be better understood.

7.6 CLIMATE EFFECTS

- The turbidity network should be improved and upgraded with stable instruments. Turbidity data should be interfaced with satellite measured irradiance to provide ground truth for the latter.
- A standard instrument is needed for measurement of cloud condensation nuclei. Such an instrument should be widely deployed to investigate the factors controlling population of cloud condensation nuclei.
- Turbidity, cloud condensation nuclei, and other climatological instruments should be acquired in a consistent manner over a decade or more for long-term trend analysis.
- Meteorological consequences of changes of heat balance due to regionally distributed aerosol should be investigated.
- Effects of climate changes on agronomy should be investigated.

SECTION 8

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