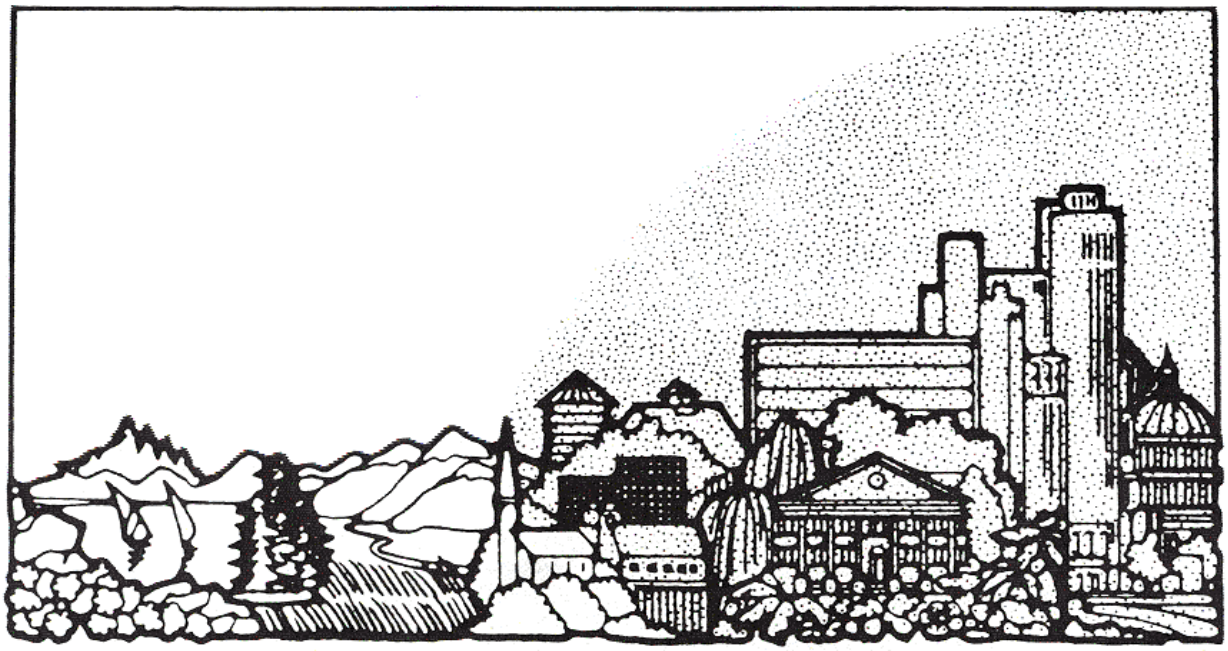
**Transactions**

# Visibility And Fine Particles

Edited By C.V. Mathai



An A&WMA/EPA International Specialty Conference

**TRANSACTIONS**

# VISIBILITY AND FINE PARTICLES

Edited By

C. V. Mathai
Environmental Department
Arizona Public Service Company
Phoenix, Arizona 85072

An AWMA/EPA International Specialty Conference

Sponsored by

AWMA's AB-6, AB-1, EP-1, EM-2, and EM-3 Committees
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## THE EDITOR

Dr. C. V. Mathai is the Group Leader of Air Quality Programs in the Environmental Department at Arizona Public Service Company in Phoenix AZ. He directs the activities of the Group and provides technical expertise in various air quality matters with special emphasis on the environmental effects of pollutant emissions from power plants. Most recently, he has been engaged in assessing the potential impacts of proposed amendments to the Clean Air Act on the electric utility industry.

Dr. Mathai received his Bachelors and Masters degrees in Physics an Mathematics from India before coming to the U.S. about 21 years ago. He received a second Masters in Physics and Mathematics from the University of Minnesota and a Ph.D. in Atmospheric Physics from the University of Oklahoma in 1976.

Prior to joining APS in 1984, he worked as a Post Doctoral Research Associate with the University of Calgary in Canada for about 3 years and as Senior Scientist with AeroVironment Inc., Monrovia, California, for about five years. He has published numerous articles on atmospheric aerosols and their effects, especially on visibility. Dr. Mathai and David Stonefield of the EPA edited the Transactions of the 1988 APCA/EPA International Specialty Conference, "PM-10: Implementation of Standards." He holds a U.S. Patent for designing an developing a device to control fugitive dust.

Dr. Mathai is an active member of AWMA, both at the national and local levels. He is a member of the AWMA Technical Council and Vice-Chairman of the Basic Science Division. He is also a past Chairman of the Particulate Committee. At the local level, he is the Chairman of the Arizona Chapter of AWMA.

Dr. Mathai is a member of the Research Advisory Committee of the Electric Power Research Institute's Environmental Department and of the Arizona Department of Environmental Quality for its "Phoenix Brown Cloud Study."

## ACKNOWLEDGEMENTS

Organizing the Conference and publishing this Transactions have been a major challenge because of the voluntary nature of the tasks by the authors, the Conference organizers, the peer-reviewers, and the editor. The successful completion of these tasks is the result of dedicated efforts and cooperation of a large number of people: members of the Technical Program Committee (see page xv), Session Chairs and Peer Review Panel (page xvi), AWMA Headquarter staff (page xvi), and the Conference Local Arrangements Committee (page xvi). On behalf of AWMA, I would like to express my appreciation to all those individuals for their time and efforts. I am grateful to the authors for presenting their work at the Conference and their cooperation during the preparation of the Transactions.

Similar to the "PM-10: Implementation of Standards" Conference (which I organized a couple of years ago), the U.S. Environmental Protection Agency's Office of Air Quality, Planning and Standards sponsored this Conference and provided AWMA a grant. This grant enabled the AWMA to offer a number of travel grants to authors and to reduce the Conference registration fee for government employees. On behalf of AWMA, I want to thank OAQPS management and in particular, Bruce Jordan and Bruce Polkowsky, for EPA's role in the Conference. I also want to express AWMA's appreciation of the Conference cosponsorship by a number of public and private organizations and government agencies (see listing on page xvii).

I would like to acknowledge the support made available to me by the management of Arizona Public Service Company over the past year relating to my efforts to organize the Conference Technical Program and in publishing this Transactions. I am also thankful to Ms. Eva Begaye and Mr. Calvin Brown of my office for secretarial support during the editing of this Transactions.

Most of all, I want to express my special gratitude to my family members who made many sacrifices during those evenings and weekends while I was working on the organization of the Conference and publication of this Transactions. I am grateful to my wife, Susy and my children, Suma Mary and Sabu George for letting me take so much of the time which rightfully belonged to them.

C. V. Mathai
Editor

# PREFACE

The United States Congress in the 1977 amendments to the Clean Air Act adopted a national goal of protecting atmospheric visibility in certain national parks and wilderness areas. In order to make "reasonable progress" toward this national goal, the U.S. Environmental Protection Agency (EPA) decided to promulgate visibility protection regulations in a phased approach. Accordingly, the EPA promulgated Phase I visibility regulations in 1980 to address "plume blight" or visibility impairment whose source(s) can be reasonably attributed. The EPA also decided to indefinitely postpone promulgation of Phase II regulations to deal with uniform, regional haze pending further progress in the state-of-the-science cause/effect relationships of such impairment.

The establishment of the national visibility goal and the subsequent promulgation of the EPA's visibility regulations have triggered much interest in atmospheric visibility research. Significant progress has been made during the past dozen years in our understanding of the measurement and modeling of fine particles and gases that contribute to visibility impairment. However, we have a long way to go in our ability to quantify an individual source's contribution to visibility impairment in a vista located far from that emission source.

In order to disseminate the results of visibility research in a timely manner, the Air and Waste Management Association (and its predecessor, APCA) and the EPA have sponsored a series of International Specialty Conferences/Symposium over the past decade: "View On Visibility" (Denver, 1979); "Plumes and Visibility: Measurements and Model Components" (Grand Canyon National Park, 1980), "Visibility Protection: Research and Policy Aspects" (Grand Teton National Park, 1986); and "Visibility And Fine Particles" (Estes Park, 1989). The Transactions of the 1989 conference are documented in this volume.

The Visibility And Fine Particles conference was held during October 16-19, 1989. It consisted of a keynote session, sixteen regular sessions, a poster session, and a concluding panel discussion. The conference papers underwent a peer-review process as rigorous as that for a journal publication. Eighty five of the 119 papers presented at the conference are included in this Transactions. Additionally, a brief discussion about one of the papers (WHITEX) and the author's response, a summary of the panel discussion, and the keynote address are also included in the Transactions. (These three items were not peer-reviewed or edited).

The papers included in the Transactions are divided into eight groups: 1) Policy and Regulatory Issues; 2) Visibility and Fine Particle Measurements in Nonurban Areas; 3) Visibility and Fine Particle Measurements in Urban Areas; 4) Meteorological Factors Affecting Visibility; 5) Human Perception of Visibility; 6) Economics of Visibility; 7) Visibility and Fine Particle Modeling; and 8) Source Apportionment of Visibility Impairment.

The authors and peer-reviewers deserve much credit for their support and cooperation in completing the Transactions in a relatively short time. I am confident that the Transactions will be a valuable resource for those of us engaged in visibility and fine particle work.

C.V. Mathai
Editor

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Remarks by

**Bruce C. Jordan**

Chief, Ambient Standards Branch
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency

Before the AWMA/EPA International Specialty Conference
Visibility and Fine Particles

Estes Park, Colorado
October 15, 1989

Good morning. It is a special privilege for me to address this conference on visibility and to share with you where we in EPA see the visibility program going over the next few years. Visibility is a special interest to me both professionally and recreationally. Professionally, because I am in the business of setting the national ambient air quality standards (NAAQS) and by law am required to protect public welfare. Recreationally, because as a hobby I am a competition acrobatic pilot. Believe me when you are tumbling through the sky, loosing altitude at a phenomenal rate, and the horizon is your chief reference for safe recovery, you gain a great deal of respect for good visibility. Having lived in the southeastern part of the U.S. for most of my life, I do not need to be convinced that visibility has deteriorated. I know what a milky hazy sky does to the enjoyment of our natural environment.

At a conference similar to this in 1986, Craig Potter explained some of the complexities with attempting to develop a regulatory program to protect visibility. I would certainly not try to diminish those complexities. In fact I would probably further amplify them based upon first hand experience. Yet viewing the world from a slightly different vantage point, I must confess a sense of frustration with our visibility program. Frustration - not with the science - not with the modeling not with the analyses - but frustration with the seemly roller coaster political and public interest in visibility. A quick review of our history with visibility will confirm this on-again off-again approach to dealing with an important environmental problem.

This sense of frustration must also be felt by many of you who have worked so hard to put together the science to support a program to protect visibility. In fact many of you have openly expressed such frustration to me. Today, however, I believe we stand at a very important crossroads with respect to visibility programs. Two actions this year, in my opinion, have set the course for the visibility program over the next decade. These actions are the WHITEX study and the proposed acid rain bill that President Bush has submitted to Congress. In both cases, work done by the people represented here today has been instrumental in setting the stage for the future of the proposed courses of action. In the brief moments I have with you this morning I would like to challenge your conference to think in a strategic sense what these programs mean for the future for the visibility program.

Strategic planning for the next five-to-ten years needs to be done now. Failure to do this planning will mean that we are leaving the future of the visibility to chance. If history provides any indication, this is something we do not want to do. Let me briefly say why I believe the WHITEX and the President's acid rain bill will set the stage for the future. First, with the WHITEX study we are now in a position to assess the local impacts on visibility by sources far from the receptors of concern. Secondly, the WHITEX study and EPA's actions subsequent to it puts increased emphasis on the importance of visibility and on the law to protect it. Thirdly, there are numerous other WHITEX type problems just waiting to surface. Thus, if WHITEX leads to regulatory action, we are going to have to deal with other such problems, many of which will occur in the West.

Secondly, the President's proposed Clean Air Act Amendments, if enacted, will become a primary mechanism for reducing regional haze in the East over the next 10 years. The provisions in Title V of the amendments would reduce sulfur oxide emissions by some 10 million tons primarily in the East. In addition to achieving our deposition goals reductions of this magnitude will also have an impact on regional visibility.

Thus, I see the WHITEX effort getting us focused on the local visibility problems in the West and the acid rain bill carrying us forward in addressing the regional haze problem in the East. However, there still remains the region problem in the West which neither of these actions will adequately address and we should not overlook this.

There is another major program I am involved with that will also benefit visibility protection and it is the program for attaining the ozone national ambient air quality standard. We know from our visibility monitoring that organic fine particles are a part of the pollutant mix that causes visibility impairment. Since virtually every major urban area is not attaining the ozone standard, EPA will be seeking reductions in pollutant emissions that directly contribute to formation of organic fine particles.

In carrying out the strategic planning, this group needs to begin to think beyond understanding the science. As scientist, analyst, and economist, you must also understand the political process which causes action to be taken or not taken in this country. You must accept that without public pressure, the political system will simply not elevate problems like visibility. In most of the public's eye, visibility does not carry the same priority as health. Thus, as you look at the future this week, try to keep in mind that even with perfect science, public indifference to a problem becomes a major stumbling block to action. Do not fool yourselves by believing that action is imminent because you have the law and science on your side. The halls of bureaucracy heaven are lined with the skins of bureaucrats with that mind set. I am fully convinced that future benefits of the WHITEX study or the acid rain bill will be greatly diminished without full public support for the regulatory actions. Thus a major part of your conference this week should be devoted to thinking about public involvement and how to assess what value the public puts on visibility.

To support a visibility program, the public must be convinced that it is to their benefit to have good visibility. They cannot be expected to understand the value of good visibility unless they understand what is being lost as visibility deteriorates. Some of the work that the

economists are doing in attempting to assess public value holds a great deal of promise, ***but their work needs full support of the scientific community***. It seems to me that the work already accomplished provides a strong indication that the public places a high value on good visibility and is willing to pay the price to have it.

I am also convinced that strategic planning requires that we approach visibility protection in an integrated way within the broader context of the air quality management program. This is not to say that specific research on visibility and specific regulatory programs to protect visibility, such as current Clean Air Act Section 169A regulations, are not required, certainly they are. But, I feel strongly that it is important to recognize that existing regional visibility impairment patterns will change substantially over the next decade under the programs for ozone reduction and acidic deposition control. The visibility research and program community must provide the necessary tools to analyze those changes, so that choices faced during the implementation of the other programs are made in a manner that will most benefit visibility. And, most importantly, as these other programs are implemented we must be able to identify specific visibility programs that may be needed in order to assure that our remaining national visibility goals are met.

To begin answering these questions, emphasis on visibility research at EPA has recently been focused on developing analytical tools. We have, with major funding and participation from the National Park Service, developed and deployed a visibility monitoring system for Class I areas which now defines the state-of-the-art in monitoring techniques. This monitoring system establishes a good baseline of existing visibility levels, especially in the most sensitive areas of the West. The Park Service has also developed and implemented source apportionment techniques for studying impairment of Class I areas of a sub-regional scale. This expands our technical capabilities for pollutant-impairment analysis. The use of these techniques in making our regulatory decisions for the Arizona State Implementation Plan will contribute to improvements and refinements in the methodology.

EPA has begun work on expanding the output of regional models developed under NAPAP to predict visibility conditions in the East. Initial reviews of limited episode days indicate a good match between the predicted particle and visibility levels compared with measured data. We believe this work will eventually lead to the capability to study effects of regional emission reduction strategies on visibility effects in particular locations.

Over the past three years EPA has collected fine particle data, specificly to assess visibility in the East. These data should provide some answers on the role of organics in visibility impairment in the East.

Efforts to assess how people perceive visibility changes and to measure the public's value of visibility changes have been a modest but have continued over the past five years. We have studied the value of visibility in scenic areas, as well as eastern and western urban areas.

While these efforts have been small in comparison with other programs, they provide key tools for reaching decisions on future visibility regulatory efforts. Certainly I do not mean to imply that all our work has been completed. We need to match in the East our understanding of existing western visibility conditions through a comprehensive national approach to monitoring visibility. We need to fully develop models to allow accurate analysis of various emission control strategies in the West as well as the East. We need to develop confidence in our ability to assess the value of visibility in all areas. These are not insignificant efforts.

This brings me back to strategic planning. Development of the tools I just mentioned is critical because the expected improvements in visibility levels will need to be confirmed during implementation of Title V of the Clean Air Act Amendments. Other areas of visibility impairment such as urban scale problems and the rural West are unlikely to be addressed by Title V and will need to be assessed for specific regulatory efforts, perhaps under Section 169A. What Title V implementation can do is bring visibility protection, as a environmental goal worth consideration and investment, to the eyes of Agency top management. From my perspective that has already begun. The work done by the people in this room over the past three years has added much to our understanding of mechanisms of visibility impairment. In the current political climate we will see the beginnings of a regional approach to air pollution control. Because we in the Office of Air Quality Planning and Standards care very much about visibility protection, we hope to use the upcoming period of regional program development to establish a sound and balanced approach to protecting visibility in areas of scenic wonder, such as where we are today, and in areas once thought lost in a permanent haze, such as Washington, D.C. The level of effort and dedication I have seen in my short period of coordinating regional visibility protection programs leaves me with little doubt that we are well on our way. The path is not going to be easy and the frustration is not yet over, but ladies and gentlemen I intend to have my horizon clear.

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Please contact the author(s) directly for copies of their manuscripts]

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