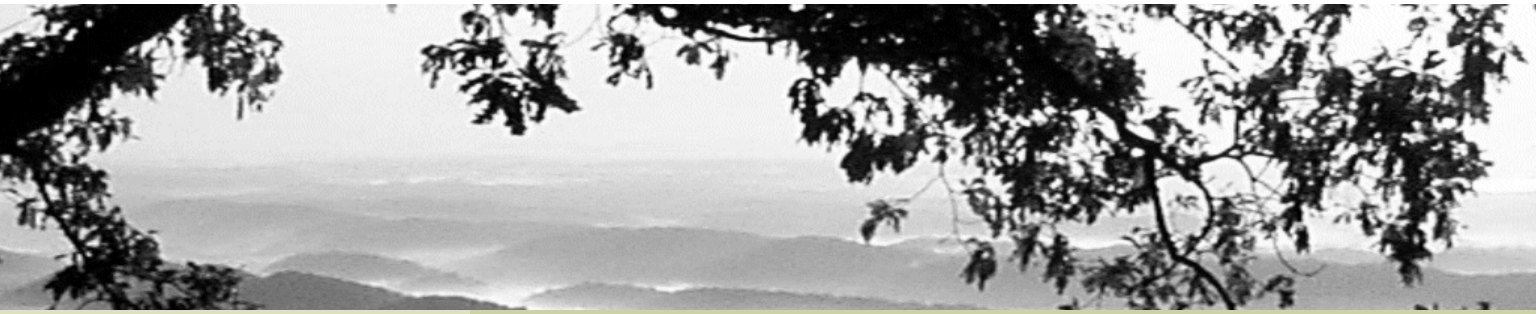


# On the Air

Technical Notes on Important Air Quality Issues

*June 2003*


## The Challenge of Improving Visibility

**Science:** Declines in visible range measurements in America's scenic areas are attributed to increased airborne concentrations of fine particles that scatter light and produce a hazy view. Particles emitted by combustion sources are often at or below the critical size range for light scattering. But high relative humidity can enlarge some of the ultra fine particles--linking emissions and weather to visibility impairment. Models that can predict the impact of various power plant emissions scenarios on visibility are being tested and revised. A major challenge is to improve our understanding of what controls a critical component - particle size distributions.

**Policy:** TVA is a participant in a regional collaborative effort called VISTAS. VISTAS was established by state and tribal governments and federal agencies to plan and coordinate activities with the U.S. EPA to develop plans for achieving "natural" levels of visibility across the U.S. within 60 years. One of VISTAS' first tasks will be to evaluate an air quality model for predicting the impact of different emission control strategies on visibility.

100 miles visibility

15 miles visibility

**Figure 1. Examples of good and poor visibility, using photographs from the identical location at the Look Rock, Tennessee site.**

Every time someone looks at a mountain in the distance, admires a colorful sunset or photographs a spectacular waterfall, the experience is affected by visibility. Light follows an unimpeded path when in a vacuum such as outer space. But in Earth's atmosphere, light interacts with molecules and particles in the air. Both gas molecules and particles scatter or absorb light--reducing the amount that reaches an observer,

dimming the object, and decreasing visual contrast between the object and its background. Thus, an atmosphere filled with particles produces "washed out" or hazy vistas (Figure 1). When molecules and particles absorb one wavelength of light more strongly than others, the color of the vista is also altered.

Particle size is a very important characteristic determining whether particles will interfere with visibility. Ultra-fine particles less than 0.1 µm in diameter and "coarse" particles greater than 2.5 µm diameter are inefficient at scattering light and thus have little impact on visibility. But particles whose sizes are intermediate (> 0.1 µm and < 1 µm), i.e. near the wavelengths of visible light (0.4 - 0.7 µm), scatter light efficiently and reduce visibility the most. Windblown dust is often larger than this critical size range, whereas particles emitted by combustion sources, or formed in the atmosphere through photochemical processes, are often at or below the critical size range. However, ultra-fine particles from combustion sources are frequently hygroscopic, and at high relative humidity condensing water enlarges them to a size that is efficient at scattering light (Figure 2). Understanding the interaction between air pollution emissions and weather is an essential step towards predicting the impact of emissions on atmospheric visibility.

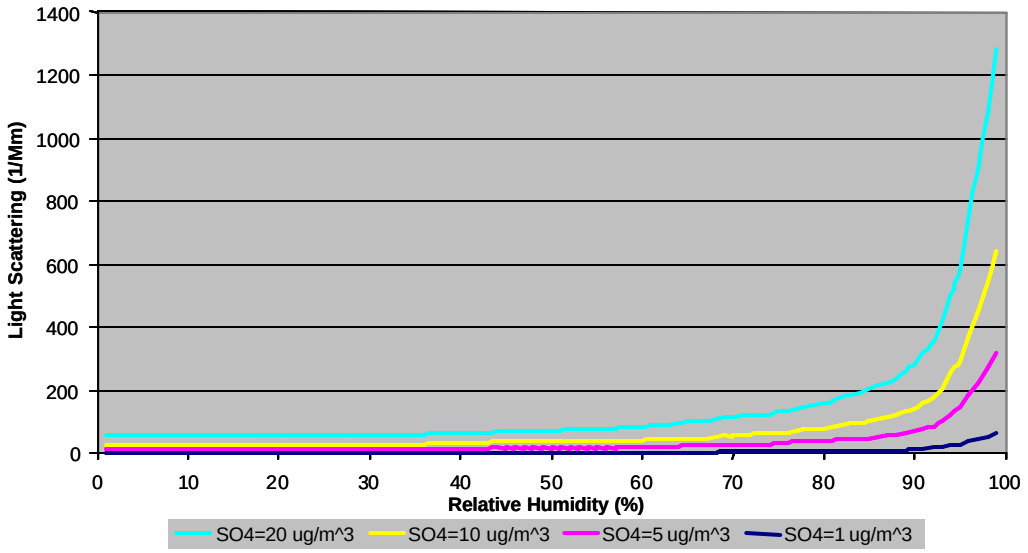


**Figure 2. Relationship between light scattering and sulfate concentration for different values of relative humidity. Light scattering curves for four different sulfate concentrations in the air are depicted.**

## Why VISTAS?

The Clean Air Act established as a goal the prevention of future impairments and the remedying of existing impairments in visibility in national parks and wilderness areas. To achieve this goal, the U. S. Environmental Protection Agency (U.S. EPA) issued Regional Haze Regulations (40 CFR Part 51, July 1999) that called for the development of a plan for achieving "natural" levels of visibility across the U.S. within 60 years. Under the U.S. EPA plan, each state must demonstrate that reasonable progress will be made by each decade toward the 60-year visibility goal. The Visibility Improvement State and Tribal Association of the Southeast (VISTAS) was formed as a regional planning organization (RPO) to help implement the EPA and state plans. It is a collaborative effort established to coordinate activities associated with the management of regional haze and other air quality issues in the southeastern United States.

VISTAS is directed by representatives from the various member state environmental management agencies, tribes within the region, and the Region IV office of the U.S. EPA, with limited participation by representatives of stakeholder groups. The VISTAS region includes all of the TVA power service area. TVA is participating in VISTAS meetings and data collection activities.

VISTAS will soon test an air quality model to determine its suitability for estimating impacts of different emission control strategies on visibility. To evaluate strategies, VISTAS contractors must (i) create a visibility data base, (ii) select air quality modeling episodes, (iii) develop an emissions data base, and (iv) perform meteorological and air quality modeling.

**Current Issues.**

TVA is conducting research, in cooperation with many organizations, to address the primary technical issues faced by VISTAS. These issues are summarized as follows:

1. An air quality model must be selected to perform the analyses needed for testing different emission control strategies. The model must be scientifically sound, robust (that is, perform well under a variety of conditions), and flexible. Model testing is needed to simulate conditions and rates for the enlargement of very fine particles to the critical size for scattering light. Limited testing has so far found no model that performs particularly well. While the U.S. EPA's Models-3 is the leading candidate, other models should be compared to provide information on model uncertainty.

2. State-of-the-art continuous, chemically-speciated particle data are needed to test the performance of air quality models. Three sites have been selected for the first year of intensive monitoring: Cape Romain on the coast of South Carolina, Millbrook near Raleigh in North Carolina, and Look Rock in the Great Smoky Mountains. Look Rock (Fig. 1) is a visibility research station first established by TVA in 1980.

3. Multi-day periods, or episodes, must be selected for intensive atmospheric modeling. Such episodes must represent a range of conditions across a large geographic region. Ideally, the states would like to select episodes that provide them the opportunity to address both visibility and regional fine particle (PM2.5) attainment issues. This mix of purposes presents a huge technical challenge in identifying a limited number of episodes that can reasonably be examined.

To date, TVA research at Look Rock has provided much data on the prevalence and chemical composition of fine particles. As a visibility monitoring site that is part of the national IMPROVE network (Interagency Monitoring of Protected Visual Environments), it will probably play a major role in episode selection. Finally, Look Rock data will play a central role to any visibility assessment and strategy development for the southern Appalachian region.

TVA continues to evaluate the performance of models in order to identify weaknesses, determine their root causes, and find potential solutions. Aerosol modules are an

important component of the Models-3 package. Work is now underway at the U.S. EPA and the Electric Power Research Institute (EPRI) to update Models-3 and similar models to include simulation of fine particles in point source plumes.

**A Hazy Future.**

The physical processes that control regional haze and visibility degradation are well understood. Our understanding of the physical and chemical processes that govern secondary particulate formation is, however, incomplete.

What remains hazy is our ability to model:

- How particles form in the atmosphere
- What controls their size distribution and ability to scatter light
- How they are removed from the atmosphere

It is precisely those linkages between emissions and the production of particles that impede visibility which we understand most poorly. We must understand the processes that lead to elevated levels of particles in the size range that scatter light efficiently, and which in turn lead to degraded visibility. Ultimately, the success of any modeling depends on understanding these details in order to accurately project the benefits to visibility from specific emission reductions.

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