INTERAGENCY MONITORING OF PROTECTED VISUAL ENVIRONMENTS

IMPROVE

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IMPROVE MONITORING UPDATE

Preliminary data collection statistics for the Fall 1993 season (September - November) are:

Data Type	Collection Percentage
Aerosol Data	97%
Optical (transmissometer) Data	88%
Scene (photographic) Data	86%

Figure 1 is a map of the current IMPROVE and IMPROVE Protocol sites. The CASTNet program has adopted IMPROVE optical and scene monitoring protocols, but is using different aerosol monitoring techniques.

Network changes in the last quarter included the installation of NGN-2 ambient nephelometers at two USFS sites, Mount Zirkel and Lone Peak Wildernesses.

Aerosol data for the Spring 1993 season is complete and seasonal summaries have been submitted to the NPS. Analyses of Summer 1993 data are underway.

See Page 3 for the latest VISIBILITY NEWS

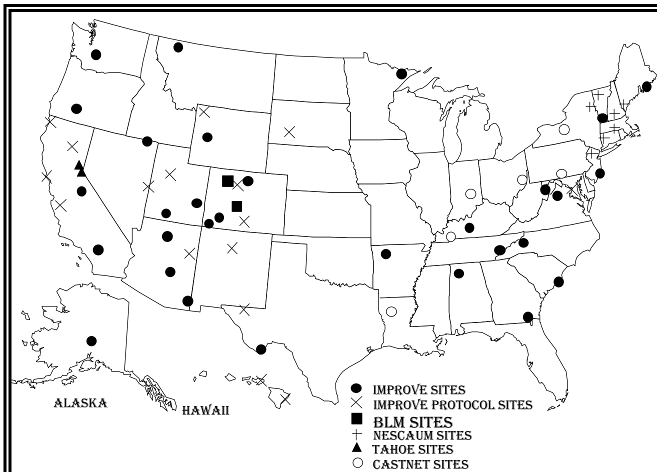


Figure 1. IMPROVE and IMPROVE Protocol Sites January 1994

SPECIAL STUDIES UPDATE

A Project MOHAVE data analysis meeting was held on December 16 and 17, 1993, in Fort Collins, Colorado. The meeting reviewed the status of all Project MOHAVE related data analysis and modeling efforts. The next data analysis meeting will be in early spring 1994.

Feature Article

VISUAL AIR QUALITY SIMULATION TECHNIQUES - COMPUTER IMAGING

by John V. Molenar, William C. Malm, Ph.D., and Christopher E. Johnson

INTRODUCTION

How does air pollution affect the visual appearance of a scene? The answer to this question remains a challenge to scientists and decision-makers. New emission sources, changes in emission controls, urban growth, and many other factors influence the amount and type of pollutants released into the atmosphere. It is possible, with varying degrees of accuracy, to model or monitor the effect that optical properties of pollutants have on various visual qualities such as contrast, equivalent contrast, chromaticity, color difference, modulations transfer, or just-noticeable-change. However, it is difficult to accurately judge what the numerical results of visibility monitoring and modeling programs mean without a visual reference.

The ideal solution would be to employ an intense network of aerosol and optical instruments to measure the chemical and physical properties of the ambient atmosphere within a specific vista. Monitoring would include high-quality color photographs of the scenic vista to document the relationship between measured values and the appearance of the scenic resource. Although this approach is potentially the most accurate, it requires an extensive, long-term monitoring program. Even if such a program were logistically and financially possible, the data collected might not provide answers to how various control or growth strategies might affect the future visual conditions of the vista.

One alternative solution is to merge aerosol and optical models with modern image-processing techniques; a system that generates synthetic images to visually display the results of modeled air quality conditions. This system has been in development for the past 15 years. Initially, a lack of computational power limited visual air quality simulations to simple models that displayed Gaussian plumes or uniform haze conditions. Recent availability of low cost, high-powered computer technology has allowed the development of sophisticated models that incorporate realistic terrain, multiple scattering, non-uniform illumination, varying spatial distribution, concentration and optical properties of atmospheric constituents, and relative humidity effects on aerosol scattering properties.

A PC-based computer image processing system has been implemented by the National Park Service. The system incorporates state-of-the-art modeling and image simulation techniques. This article highlights the main components and applications of this system.

IMAGING continued on page 2

IMAGING (continued from page 1)

VISIBILITY COMPUTER IMAGE-PROCESSING SYSTEM

The major steps in computer image-processing, diagrammed in Figure 2, are briefly discussed below:

Original Image

The original image is a properly exposed and composed 35mm color slide taken during the season and at the same time of day that the scene is to be modeled. The exact location of the camera, view azimuth, lens size, type of film, date, and time of the exposure should be known. A slide with a cloudless sky under the cleanest visual air quality conditions possible is ideal.

Digitize Image

The original image is digitized using a high-resolution scanning microdensitometer and three wide-band filters (red, green, and blue). Density measurements of every 20-micron square picture element (pixel) are made with each filter. Each color file consists of 1200 rows by 1800 columns of density values.

Color Calibration

The system must be color calibrated to account for the characteristics of the original slide film, the digitizer, the image output device, and the film used to reproduce the final imaged product.

Distance Masking

Each terrain pixel is assigned a specific distance, elevation angle, and azimuth angle with respect to the observer position. This is accomplished using the geometry of the scene, high-resolution topographic maps, and an interactive image-processing system to identify (mask) every pixel.

Atmospheric Aerosol Model

A sophisticated model computes the characteristics of the atmospheric aerosols that are affecting, or might affect, the scene. The effect that relative humidity has on aerosol growth can also be simulated. The numerical data generated by this model are used by the radiation transfer model.

Radiation Transfer Modeling

The digital files from the original slide represent the original radiance fields. An equilibrium radiation transfer model, the distance mask, and original radiance fields are combined to simulate the terrain radiance fields for the modeled scenario. A Monte Carlo radiation transfer model uses original radiance fields, modeled aerosol optical properties, solar illumination, terrain reflectivity, and the spatial distribution of aerosols to simulate the sky and path radiance fields for the modeled scenario.

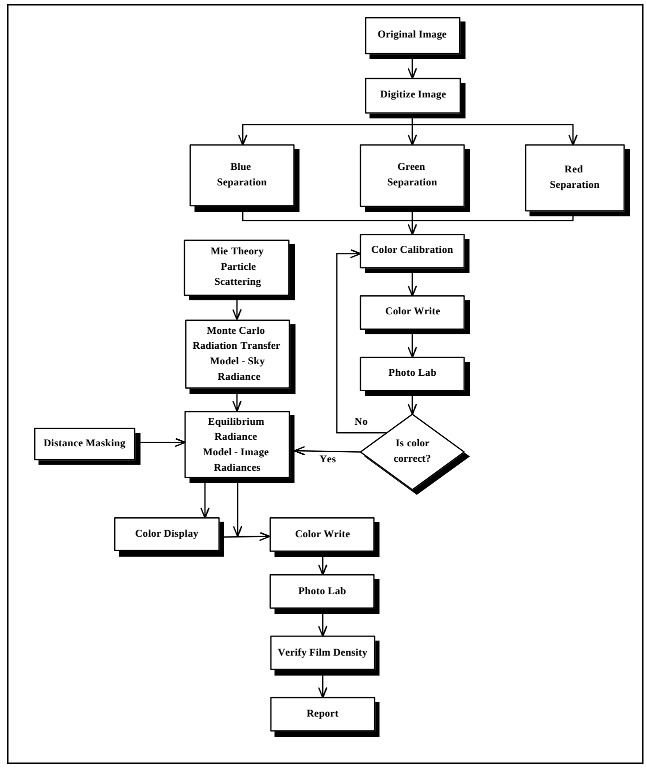


Figure 2. The Visibility Image-Processing System.

Output Modeled Image

The radiance fields are combined to output a simulated image of the modeled scenario. A video display permits interactive viewing of the modeled scene. The output image can also be transferred to film. The final product is a computer-generated color slide that represents the modeled scenario.

Review and Verification

Finally, each computer-generated slide is scanned with a microdensitometer to verify the accuracy of the simulated image. Perceptual indices such as contrast changes, extinction changes, deciview and just-noticeable-changes can be calculated from the final density values. Carefully controlled duplicate slides or prints can be created from the original slide; however, the accuracy of the film density must be verified for each reproduction.

EXAMPLES

Washington, D.C. provides an easily recognized scene for a computer imaging example. The left portion of Figure 3 represents a mean summer visual air quality typical to much of the urban eastern United States. The visual range is 17 km (b_{ext} = 0.230 km^{-1}, deciview = 31.4). However, if Washington, D.C. could assume the mean visual air quality of the rural western United States, a typical summer day would look like the image on the right, with a visual range of 155 km (b_{ext} = 0.025 km^{-1}, deciview = 9.2). The difference is easily apparent even in this lower quality black and white reproduction of the original high-quality color simulation.

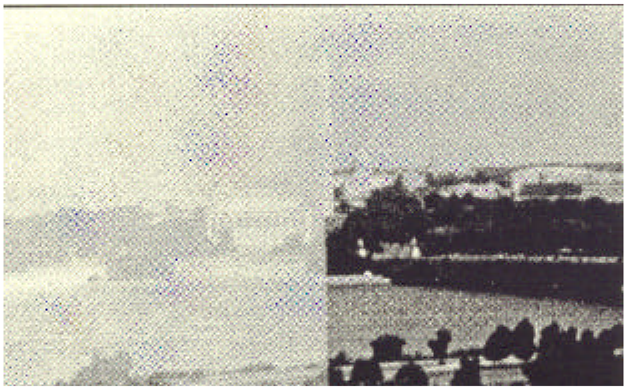


Figure 3. Example Simulation of Uniform Regional Haze: Washington, D.C. with average eastern and western visual air quality.

Computer simulation is being used to support a variety of applications and research efforts including:

- Evaluating how regional emission reduction scenarios (e.g. SO_2 reductions) would affect selected scenic vistas.
- Estimating how various development or control strategies for a single source would affect nearby vistas.
- Displaying how visibility changes with humidity for assumed aerosol loadings.
- Generating controlled images to support human perception and cost benefit studies.
- Creating a series of images that illustrate how the visual appearance of a scene changes with incremental changes in deciview.
- Displaying how the appearance of plumes, layers, or regional hazes vary depending on illumination and viewing angle.

CONCLUSIONS

A system that incorporates image-processing techniques and state-of-the-art aerosol and radiation transfer models has become a valuable tool for the presentation of visual air quality conditions. The system provides a means for testing various scenarios, including both the reduction and increase of emissions. The photographic products produced by the system can be easily interpreted by scientists, policy-makers, and the public.

The NPS and IMPROVE program continue to support the development and validation of computer imaging techniques. For more information on computer imaging, contact John Molenar, William Malm, or Chris Johnson through the NPS office in Fort Collins, Colorado. A comprehensive paper on computer imaging by Molenar, Malm, and Johnson will soon be published in Atmospheric Environment.

VISIBILITY NEWS.......

GRAND CANYON VISIBILITY TRANSPORT COMMISSION (GCVTC)

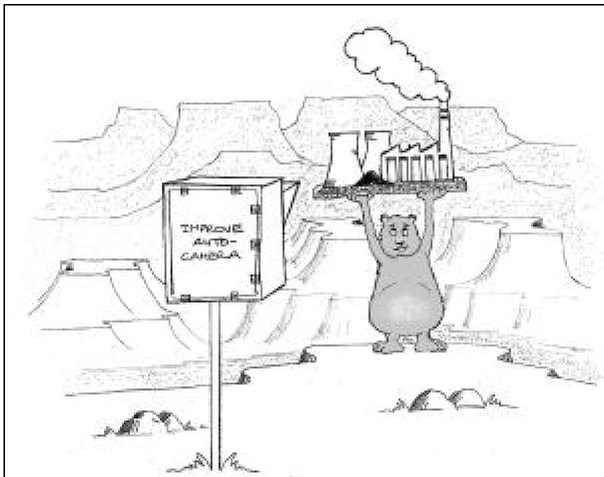
The Public Advisory Committee of the GCVTC is sponsoring a series of public meetings to review the emission management options and criteria for evaluation of options. The cities and dates where the meetings will be held are listed below:

Phoenix, AZ	Jan. 18	Denver, CO	Jan. 25
Grand Junction, CO	Jan. 19	Santa Fe, NM	Jan. 25
Las Vegas, NV	Jan. 19	Portland, OR	Jan. 25
Moab, UT	Jan. 19	Diamond Bar, CA	Jan. 26
Rock Springs, WY	Jan. 19	St. George, UT	Jan. 26
Flagstaff, AZ	Jan. 20	Las Cruces, NM	Jan. 27
Salt Lake City, UT	Jan. 24		

For more information on the exact locations of the meetings or for additional information, contact the GCVTC executive office at the Western Governor's Association, 303-623-9378.

AEROSOLS AND ATMOSPHERIC OPTICS CONFERENCE - CALL FOR PAPERS

Papers are now being solicited for the international specialty conference, "Aerosols and Atmospheric Optics: Radiation Balance and Visual Air Quality", to be held from September 25-30, 1994 at Snowbird, Utah. The purpose of the conference is to bring together scientists working in the fields of visibility and global climate to share their common interest in aerosols and atmospheric optics. For more information or to request a brochure, contact Dr. Delbert Eatough, telephone 801-378-6040, or FAX 801-378-5474.



Primitive Computer Imaging

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PREVIEW OF UPCOMING ISSUE . . .

The next IMPROVE Newsletter will be published in April 1994, and will include:

- Network Status for the Winter 1994 Season.
- **FEATURE ARTICLE:** Tahoe Regional Planning Agency (TRPA) Visibility Monitoring Program

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