Interagency Monitoring of Protected Visual Environments (IMPROVE)

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IMPROVE Program Goals and ARL’s Role

Goals to meet the monitoring requirements associated with the visibility protection provisions of the Clean Air Act (as amended in 1977)
- Monitoring representative of 156 large National Parks and Wilderness Areas (see map below)
- Monitoring is required to determine visibility levels, track impairment trends and to conduct at some sites (see map below)
- Conducted at all sites:

ARL’s Role: assist EPA, states and federal land managers who have the primary responsibility for federal visibility protection by
- Developing the initial monitoring plan and national network design
- Leading the multi-agency steering committee
- Providing continued technical support as the network evolved over the last 25 years

1. Started with 20 sites in 1987, currently over 160 sites including 50 sites not representative of protected areas.

Split-Photo Display of IMPROVE Measured 20-Year Trend

Monitoring Approach

Aerosol monitoring conducted at all sites:
- 24-hour duration sampling every third day
- \( \text{PM}_{2.5} \) samples collected by three sampling modules on filter substrate compatible with subsequent mass and composition analysis
- \( \text{PM}_{10} \) and \( \text{PM}_{2.5} \) mass concentration on Teflon filters
- \( \text{PM}_{10} \) ions by IC on nylon filters behind a carbonate denuder to scrub HNO₃
- \( \text{PM}_{2.5} \) organic and elemental carbon by thermal-optical analysis on quartz filters
- Collocated sampling conducted to determine data precision for mass and composition data

Optical monitoring conducted at some sites (see map below):
- Continuous particle light scattering (b Donetsk) plus temperature and relative humidity measurements
- Performs auto zero calibrations (6-hrs)
- Requires manual span (7-14 days)

Some monitoring conducted at some sites (see map below)
- Visibility Camera sites today use high resolution digital cameras
- Most active visibility cameras feed an agency web site
- Before the introduction of digital cameras and other optical monitoring equipment, 35mm slide film was used to capture images for analysis

Indicators of Success

- Consistently greater than 90% data-recovery by calendar quarter over the 25-year data record
- IMPROVE visibility and aerosol composition data used by EPA in the last three reviews of the \( \text{PM}_{2.5} \) Federal standards (1997, 2006, and 2011)
- 1999 Regional Haze Rule requires IMPROVE data (or equivalent) for progress tracking
  - Five-year baseline (2000 to 2004) mean values for visibility-protected areas – used to establish current conditions for every state's Regional Haze Rule State Implementation Plans
  - Second 5-year (2005 to 2009) mean values – currently available for state assessments of progress in meeting Regional Haze Rule
- Data have been used in hundreds of papers, journal articles and reports for
  - Spatial and temporal trends assessment
  - Air quality model verification
  - Episode analysis
  - Source attribution assessment
  - Providing spatial and temporal context for air quality special studies
  - International air pollution transport analysis
  - Black carbon’s role as a short-term climate change forcing agent

Four-Year Mean (2004 – 2008) Aerosol Composition Maps (\( \mu \text{g/m}^3 \) and % of PM2.5)

Information and Data Availability

- IMPROVE website includes background, management, and technical information and data
  - http://vista.cira.colostate.edu/IMPROVE
- Quarterly newsletter beginning from March 1992
- Fifth IMPROVE Summary Report available Spring 2011