Final Report for Task # J2350097304 (September 2009- December 2010)

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1. Introduction and Overview

The public visits national parks and wilderness areas to enjoy nature in an unblemished setting. Air pollutants can adversely affect that visitor experience by degrading the vistas they come to see and by affecting the natural ecosystems of these areas. The National Park Service (NPS) and Colorado State University (CSU) scientists are working together to better understand the scientific basis of these issues and to make that information available to regulatory agencies and interpret it for the public.

Particles and gases in the atmosphere scatter and absorb light, affecting the view one has of a scene. This project analyzes particle data collected through the Interagency Monitoring of Protected Visual Environments (IMPROVE) program to determine its origins, electro-optical properties and better understand its chemical makeup. These analyses will be published in the scientific literature, presented at scientific meetings, and made available with the data through the world-wide-web. The electro-optical properties of aerosols ultimately affect how the particles impair visibility. However, it is difficult for the public to visually interpret the meaning of changes in electro-optical variables used to quantify changes in scene appearance under different atmospheric particulate loading conditions. The most effective ways to present the effects of pollutants on scenic vistas are by photographic imaging techniques that accurately depict how the scene will appear under various illuminations, meteorological and pollutant conditions, through video productions, that demonstrate pollutant effects on a scene over time, and by regional air quality simulation modeling. An image-based depiction of visibility reduction due to pollutants is dependent on a firm understanding of the electro-optical characteristics of pollutants, on state-of-the-art measuring techniques, on a valid understanding of how chemicals are transformed as they travel through the atmosphere, on the ability to simulate accumulated effects, and on professional quality image and video production techniques. The aforementioned analyses and techniques are the key elements of successfully carrying out this cooperative project.

Healthy ecosystems are critical to having a natural, unblemished visitor experience. Ecosystem changes due to atmospheric deposition of nitrogen compounds have been documented at Rocky Mountain National Park. The origins, chemical makeup, and temporal scales of changes in the deposition are not well understood. Field measurements were made during a year-long study in 2009 (RoMANS II) to provide data to enhance our understanding. This project analyzes some of these data and utilizes four-dimensional chemical transport models to assess atmospheric nitrogen deposition at the park.

2. Major Activities Completed by CIRA/NPS

Aerosol Research

We continued work on the apportionment of light extinction among chemical species using statistical and deterministic methods. We investigated the roles of particle composition, size distribution, and relative humidity on the optical effects of aerosols. When appropriate, we applied new models derived from special studies that reflect the latest state of the science in air pollution and visibility. We also continued to identify reasons for differences between reconstructed and measured fine particle mass and between reconstructed and measured and light extinction. Understanding these differences is necessary for the accurate prediction of visibility degradation. We also continued research on organic carbon aerosols, including their measurement, characterization, and source attribution.

We continued research into aerosol source apportionment techniques, which include trajectory mass balance, source contribution functions, conditional probabilities, and empirical orthogonal functions to assess the appropriateness of using these techniques for pollutants such as ozone and organic and elemental carbon. We also continue to develop and use receptor models to determine transport pathways and estimate the proportion of a measured pollutant that can be attributed to each of several sources.

We continued research into understanding biases in fine particle speciation measurements using statistical methods.

We collaborated in the calibration and development of visibility monitoring equipment (e.g., transmissometers and nephelometers) at the CSU optical monitor test facility.

IMPROVE Program

We continued the QA/QC and data management activities for the Interagency Monitoring of Protected Visual Environments (IMPROVE) program and its vast data resources continue to be a significant effort. Accomplishments this task period include the following:

- Data through December 2009 data received and ingested into the VIEWS (Visibility Information Exchange Web System)/IMPROVE database.
- Presentations were made at the IMPROVE steering committee meeting at Stevenson, Washington.
- Continued work on the integration of IMPROVE and CSN (Chemical Speciation Network) network-wide data.
- Computed short and long-term trends of IMPROVE speciated aerosol concentration data.

- Prepared a draft of the next IMPROVE report (IMPROVE Report V) that includes analyses of spatial and seasonal patterns in speciated aerosol composition from 2005-2008.

Investigations of Smoke Aerosols

We continued analyses of data collected during special monitoring studies at the USDA Forest Service Missoula Fire Laboratory (FLAME I and II studies) designed to understand and improve the monitoring of smoke from forest wildfire, especially its physical and optical properties and particularly the hygroscopicity of smoke aerosols. Specifically we are investigating f(RH) measurements, chemical composition, and single particle morphology measurements from various forest fire fuels. Results from these analyses were accepted for publication [Hand et al., 2010; Carrico et al., 2010].

We continued work to fingerprint smoke from forest wildfire and prescribed fire on aerosol filters, developing better emissions information about these types of fire. In addition, models will be used to investigate the impacts of smoke on regional haze levels.

Rocky Mountain Atmospheric Nitrogen and Sulfur Study (ROMANS)

The objective of the 2006 (RoMANS I) and 2009 (RoMANS II) study is to determine the fate and origin of nitrogen and sulfur species in Rocky Mountain National Park, specifically, to develop and refine emission estimates of ammonia, nitrogen oxides, and sulfur oxides and determine the relative contribution of long-range transport vs. local emissions to ambient and deposited ammonium, nitrates, and sulfates levels in Rocky Mountain National Park. This is planned to be accomplished by apportioning the relative contribution of these species between mobile and stationary sources such as power plants, other industrial activity, feedlots, and fertilizer applications.

Continued data and model analyses from the 2009 field campaign included

- Continued testing of filter-based method for sampling and monitoring of organic nitrogen containing aerosols.

- Continued testing of a modified commercially available NO_x instrument

- Continuation of laboratory analysis of filter, denuder, and precipitation samples from the 2009 field study.

- Continued analysis of real-time gas and particle data collected during RoMANS II study.

- Maintained and operated several measurement sites for the ROMANS II study.

- Completed analysis of data from NH_3 measurement study, comparing individual species to establish data consistency between samplers and between modified sampling system, and summarizing in a final report.

- Completed the analyses of the model output from the CAMx regional air quality model used to simulate concentrations during the 2006 RoMANS field campaigns. Specifically, process analyses were performed to understand the model performance during RoMANS and results were accepted for publication (Rodgriguez et al., 2010).

- Completed comparisons of model performance between the regional air quality models CAMx and CMAQ. CMAQ was run at UNC as a part of a different project.

- Continued performing CAMx model runs for periods in 2009 to further understand nitrogen deposition in the Rocky Mountain National Park region.

- Completed the transition the mesoscale meteorological modeling from the older MM5 model to the newer Weather Research and Forecasting (WRF) model and ran the model for 2009.

- Completed back trajectory analyses for 2009 (RoMANS II).

- In support of back trajectory analyses, and mesoscale meteorological modeling, continued to maintain and add to a collection of observational and analyzed meteorological data sets.

Data and Display Dissemination

The program activities pertaining to the media center and web development included the following:

- We maintained and improved access to resources, including the CIRA/NPS/IMPROVE web site and an FTP server for dissemination of data and summary reports, for the general public.

- We continued implementation and development of the IMPROVE website, including developing an interactive database, allowing users to download data and selected analyses of these data, including appropriate quality assurance information, directly from the web, a display of current IMPROVE graphics, up-to-date information about the visibility regulations, and a growing bibliographic reference site for visibility and IMPROVE scientific information. (http://vista.cira.colostate.edu/improve)

- We continued to develop and implement the interactive multimedia program "Introduction to Visibility". We completed the "Impacts of Haze" section. This web document will introduce basic visibility science and monitoring concepts as well as the regional haze regulations to the regulatory community and the general public.

- We continued to provide graphics support, graphs, posters, etc., to the NPS researchers in the Air Resources Division and CIRA.

- We produced videos and CDs showing the impact of pollution on various parks. We generated park service training films. We duplicated and distributed videos and CDs as necessary. We develop custom graphic materials for presentation purposes.

- We produced the 2011 IMPROVE calendar.

- We completed a draft of a multimedia program on climate change education and outreach.

- Conducted field visits to national park sites for inventory and quantification of night sky visibility. Provided other technical assistance as needed to agency on topics such as light pollution physics, outdoor lighting mitigation, ecological impacts of artificial light, and outreach strategies.

Project Deliverables

Deliverables for this project include conference presentations and publications (see reference list).

PUBLICATIONS

Barna, M. G. and M. A. Rodriguez, Modeling nitrogen deposition at Rocky Mountain National Park: The RoMANS study. Presented at the Atmospheric Chemistry Division seminar series, National Center for Atmospheric Research, Boulder, October 13, 2009.

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Duriscoe, D. M. and C. A. Moore, Dark sky parks and outdoor lighting. Presented to the Death Valley National Park management team and Xanterra Parks and Resorts management team, Death Valley National Park, November 12, 2009.

Duriscoe, D. M., C. A. Moore and T. G. Jiles, National Park Service Night Sky Program update. Presented to the International Dark Sky Association Annual Meeting, Tucson, November 15, 2009.

Farnes, P. and J. M. Huddleston, Montana precipitation map: Use of elevation as a multivariate parameter in interpolation algorithms to estimate 30 year precipitation averages. Presented at the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) Hydrology Workshop, Helena, July 27-29, 2010.

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