Rocky Mountain Biogenic Aerosol Study at the Manitou Experimental Forest

During July and August, 2011, atmospheric scientists converged on the Manitou Experimental Forest to study the role of tiny atmospheric particles in forest – atmosphere interactions. In total, over 30 principle investigators and twice that number of support staff, students, and postdocs participated in the Rocky Mountain Biogenic Aerosol Study (RoMBAS), which was organized jointly by the National Center for Atmospheric Research (NCAR) and the University of Colorado. The study is part of NCAR’s multi-year BEACHON (Bio-hydro-atmosphere interactions of Energy, Aerosols, Carbon, H2O, Organics) program. The major goals of BEACHON include improving model representations of the interactions between the earth’s biosphere, hydrosphere and atmosphere, with a current emphasis on water-limited regions. The site of the study was NCAR’s “Manitou Forest Observatory.” Constructed by NCAR and the USFS in 2008 and located 1 km west of the Manitou Experimental Forest office, the observatory features a 30 m scaffolding tower for atmospheric chemistry research, a 50 m flux tower for research on atmospheric turbulence, 700 square feet of moveable laboratory space, and 75 kilowatts of power. RoMBAS, with its large national and international participation, required temporarily increasing both space (tripling the lab space at the site) as well as power (adding almost 100 kilowatts additional power capacity).

The objective of RoMBAS was to study the impacts and feedbacks shown schematically in Figure 1, which depicts the possible mechanisms by which particles are created in the forest and the ways that may regulate and link the biogeochemical and water cycles. Water availability impacts both soil moisture and atmospheric humidity, and the ecosystem responses to dry conditions include the introduction of dust as well as primary biological particles such as bacteria, pollen, fungi, and leaf fragments. Water availability also controls organic vapors emitted by forest vegetation. These gases undergo chemical reactions in the atmosphere and as a result transform into “sticky” compounds that can condense to form secondary organic particles. Both primary biological and secondary organic particles can form the seeds upon which water can condense to form a cloud droplet, thus coupling biogeochemical and hydrological cycles. In general, primary biological particles are thought to be effective seeds for ice clouds, whereas secondary organic particles can form seeds for liquid water clouds.

The measurements during RoMBAS were chosen to address the research goals outlined above. Several researchers, such as Prof. Uli Poeschl from the Max Plank Inst. for Chemistry in Mainz, Germany, studied the emission of primary biological particles at Manitou and their relation to environmental conditions. Prof. Sonia Kreidenweis’ group from Colorado State Univ. also characterized these primary particles, but added a crucial measurement of their ability to form ice clouds. Several research groups measured the formation and properties of secondary organic particles, including some measurements that have not previously been attempted in a forest setting. The latter includes a suite of instruments developed by Profs. Bill Brune at Penn State Univ. and Jose Jimenez at the Univ. of Colorado called “Potential Aerosol Mass Chambers.” These devices sampled outside air into cells that expose the air to high levels of oxidizing gases, effectively subjecting the air to several days-worth of atmospheric reactions that lead to particle formation. Instruments then measured the organic vapors and particles that exited the chambers in order to determine the properties of these particles. Researchers also studied the
formation of new particles caused by the condensation of the previously mentioned “sticky compounds.” This phenomenon of the birth of new particles, a process called atmospheric nucleation, is frequently observed at Manitou forest.

Overall, the study brought together an unprecedented number of instruments to study important linkages between the forest and atmosphere. Even the weather cooperated in making a successful study, with periods of dry and wet weather allowing for the study of the impacts of humidity and soil moisture. Researchers are now starting to analyze their measurements; it is already clear, however, that BEACHON-RoMBAS will provide many unique insights into the interactions between forest and atmosphere.

Figure 1. Schematic of processes that regulate and link biogeochemical and water cycles.
Figure 1. Researchers gather for the weekly data meeting at the measurement site.

Figure 2. View of site showing two of four temporary buildings leased for the project. On the left are filter samplers that are collecting atmospheric particles for later laboratory analysis.