M.S. Defense Announcement
Yixing Shao
February 20, 2018 at 9:00am

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Tuesday, February 20, 2018
9:00am

Defense
ATS Large Classroom (101 ATS)

Post Defense Meeting
Riehl Conference Room (211 ACRC)

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Atmospheric Reactive Nitrogen in Rocky Mountain National Park

The Front Range urban corridor in Colorado, located east of Rocky Mountain National Park (RMNP), includes a variety of urban sources of nitrogen oxides, while high emissions of ammonia are found in agricultural sources on the eastern plains of Colorado. The spatial distribution and temporal variation of ammonia and other reactive nitrogen species in the region is not well characterized. Periods of upslope flow can transport atmospheric reactive nitrogen from the Front Range and eastern Colorado, contributing to nitrogen deposition in the park. Deposition of excess atmospheric reactive nitrogen in Rocky Mountain National Park poses threats to sensitive ecosystems. It is important to characterize temporal variation and spatial distribution of reactive nitrogen in the region; understand the degree to which emission sources in the northeastern plains of Colorado impact RMNP, and how meteorological conditions are associated with transport of ammonia to the park.

Mobile and in-situ measurements of reactive nitrogen gases and particles were made between 2015 and 2016 in northeastern Colorado and RMNP. Gaseous ammonia was measured with high-time resolution instruments (the Picarro cavity-ring down spectrometer and the Air Sentry ion mobility analyzer); 24-hr integrated concentrations of trace gases and chemical composition of $PM_{2.5}$ in RMNP were measured by URG denuder/filter systems; wet nitrogen deposition was collected with an automated precipitation collector followed by lab analysis. Model outputs from The Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT) was also included for examining transport of ammonia plumes.

Diurnal and seasonal variability of ammonia concentrations and some other reactive nitrogen species was characterized with high time-resolution measurement data. Repeating diurnal cycles were found in Greeley and RMNP. It is shown that ammonia concentrations usually increase at sunrise and reach maxima around noon in RMNP, while the Greeley has ammonia builds up during the night time followed by a rapid decrease after sunrise. A seasonal pattern of ammonia level was revealed with higher concentrations observed during summer. When combined with wind data it is clear that elevated ammonia levels in RMNP were associated with easterly transport from the eastern plains of Colorado. Considerable ammonia variability was found in NE Colorado with higher concentrations measured close to CAFOs and source regions. The median daily averaged ammonia concentrations found in Greeley, Loveland and RMNP are 26.2 ppb, 6.3 ppb and 1.1 ppb respectively. This was particularly clear in the mobile NH_3 data where distinct plumes of ammonia were observed away from the confined animal feeding operation (CAFOs) sources. The spatial distribution, particularly in the north-south direction was observed to be strongly dependent on meteorology as highlighted by the HYSPLIT back trajectories.

This study also evaluates the pilot Early Warning System which informs agricultural producers of impending upslope events that are likely to transport nitrogen from eastern Colorado to the park, so that management practices may be implemented to reduce nitrogen emissions. The performance of the meteorological forecasting was evaluated using continuous measurements of atmospheric ammonia concentrations in the RMNP, as well as the wet nitrogen deposition data from 2015. It was found that the model showed capability in capturing some large wet nitrogen deposition events in the park.