Origin of the Reactive Nitrogen in the Greater Yellowstone Area

Where Are We Now?

Human activity, including fossil fuel combustion and agriculture, has greatly increased the amount of reactive nitrogen (RN) in the atmosphere and its subsequent deposition to land. Increases in deposition of RN compounds can adversely affect sensitive ecosystems and is a growing problem in many natural areas. Grand Teton's ecosystem is particularly sensitive to increased RN deposition and there is increasing evidence that changes are already occurring. However, additional information is needed to better understand the total RN deposited in the park and the sources responsible for this RN.

To address these information gaps, the National Park Service in conjunction with Colorado State University researchers and assistance from the Forest Service is conducting the Grand Teton Reactive Nitrogen Deposition Study (GrandTReNDS), to investigate nitrogen deposition pathways in the park during spring/summer 2011. This effort involved a field study to measure and characterizes the composition and magnitude of RN deposition in Grand Teton. In this work it was found that during the summer month's at the high elevation site Grand Targhee 62% of the nitrogen deposition was due to reduced nitrogen about equally split between dry and wet deposition, oxidized nitrogen accounted for 27% and the remaining was wet deposited organic nitrogen (Benedict et al., 2013). Subsequent monitoring of ammonia gas indicates that 2011 ammonia concentrations were atypically low and deposition of reduced N is likely higher in other years. Trajectory and surface wind analysis indicated that the Snake River valley and northern Utah, two large ammonia source regions were likely contributors to the reduced nitrogen fraction while biomass burning may have also contribution to reduced, oxidized and organic nitrogen deposition (Benedict et al., 2013, Prenni et al., 2013). However, no quantitative information on the contributions of source regions and source categories to the nitrogen deposition in Grand Teton exists.

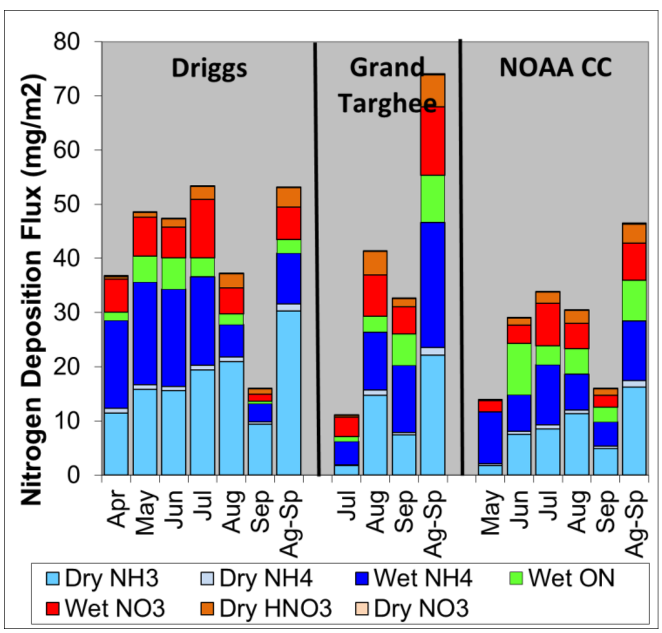

Figure 1. Reactive Nitrogen deposition budgets of measured species in Grand Teton during the GrandTrends study.

Teton National Park is part of the Greater Yellowstone Area (GYA), one of the last remaining large, nearly intact ecosystems in the northern temperate zones and home to a number of NPS, Forest Service (FS) and Fish and Wildlife (FWL) class I and II lands. Throughout the GYA there is increasing evidence of accumulating RN that may have crossed sensitive critical load thresholds. The levels of reactive N deposition and their origin are also not well understood.

Origin of Reactive Nitrogen in the GYA

The Greater Yellowstone Area is a remote region; however, there are a number of large sources within and source regions near its boundary that may contribute to the excess RN. This includes the agricultural intensive Snake River Valley and northern Utah to the west of Tetons and Yellowstone NP; oil and gas development in the upper green river basin at the western edge of the Bridger and Fitzpatrick wilderness areas; urban areas in UT, ID, WY and MT and wild and prescribed fires within and outside of GYA. The emissions from these more near-field source regions add to background concentrations from distant sources within and outside of the U.S.

To evaluate the contributions from these and other sources regions a chemical transport modeling assessment will be conducted. This assessment will use the CAMx model and its source apportionment tools to simulate 2011. 2011 wind fields and emission fields will be come from the EPA incorporating current wild and prescribed fire emission estimates and the best available oil and gas inventory. Modeling activities will include:

1) Evaluate model results against the GrandTReNDS data as well as IMPROVE NADP and CASTNET data in the region. If needed, the model will be calibrated against these data by adjusting emissions or physical parameters to better fit the measured data.
2) Use model results to estimate the total RN deposition throughout the GYA region and compare to those from the TDEP hybrid modeling effort.
3) Source Apportionment using the CAMx PSAT (Particle Source Apportionment Tools).
    a. Receptor sites will include all federal class I and II lands within the GYA
    b. Source categories to be simulated will include:
        i. Agriculture
        ii. Oil and gas
        iii. Wild/prescribed fires
        iv. Mobile
        v. Point
    c. Specific source regions will be simulated. The source regions will include individual states and subregions within each states including Snake River valley in ID, northern Utah and upper Green River Basin.
4) Hybrid modeling. The source apportionment results at the GrandTReNDS monitoring sites will be integrated with the measured data via hybrid modeling methods. This will be used to help evaluate and refine the source apportionment results during the summer of 2011.

Ammonia Deposition Processes

Dry deposition of ammonia is one of the largest inputs into the Teton NP and likely other sensitive regions in the GYA. However, ammonia dry deposition is poorly characterized and the deposition estimates were based on uni-directional deposition flux estimates. Ammonia deposition in these regions or upwind maybe bi-directional, i.e. deposited material is reemitted. Understanding and properly characterizing this is critical to estimating the total reduced nitrogen deposition and how this could change with changing emissions. Improper simulation of ammonia deposition may also be responsible for the CAMx models inability to simulate the ammonia diurnal cycle at Rocky Mountain NP (RMNP).

As part of the modeling effort the influence of ammonia deposition parameterization will be explored. This will include a comparison of CAMx model uni-directional model to CMAQ bi-direction model simulations. As well as the abilities of these models to simulate the ammonia diurnal cycle in RMNP and Teton NP. If the CMAQ bidirectional parameterization proves to be significantly better, then the use of the CAMx model for source apportionment will be reevaluated and CAMQ may be used instead.

Representativeness of GrandTReNDS study period and 2001

No year is typical; however, 2011 was more different than most in that it was a very heavy snow year in GYA and elsewhere. This may have impacted the RN deposition in the region. For example, subsequent monitoring of ammonia in Teton has shown that 2011 had lower concentrations than following years.

To place the year 2011 in a historical context, climatological analyses will be conducted. This will include an analysis of routine IMPROVE, CASTNET, NADP and other data in the region as well multiple years of airmass histories and meteorological data.

Audience

The results from these analyses will be written up in a report and journal articles. They will be shared with the Teton and Yellowstone National parks. They will also be shared with the GYA members and surrounding states and be used in presentations to further inform them of the RN issues and its causes in the region. The results will also be shared with stakeholders in the region and presented at scientific conferences. (Should we say anything about NPCA???)

Linkage to Other ARD Activities

The 2011 modeling will be used in the current assessment of the contributions of oil and gas to all natural park units. All GYA modeling activities will lay the foundation for this assessment.

The assessment of ammonia deposition processes will be done in conjunction with U.S. EPA scientist from the Atmospheric Modeling and Analysis Division of the National Exposure Research Laboratory. This group is currently responsible for the modeling and analysis work to estimate the total nitrogen and sulfur deposition estimates throughout most of North America for the NADP TDEP workgroup. This work will enhance our collaboration with this work and potentially feedback into improved nitrogen deposition maps developed by the TDEP workgroup. These TDEP data products are becoming a critical resource for ARD's deposition assessment in our national parks.

Ignore this

NOTES:

, followed by a modeling and assessment component using the measured and other data to estimate the contributions of sources to the deposited RN. Results of this study are anticipated to provide baseline information about transport and deposition of RN in the park, yield initial source apportionment information, and lay the groundwork for potentially additional future measurements if warranted.

Discuss greater yellow stone area and increasing reactive N deposition and crossing critical loads. Note that some class I and II federal lands are near population centers, intensive agricultural activity and oil and oil and gas fields. All that can contribution to excess N deposition. Note lack of source apportionment info

Deposition budget

New nh3 trends

Associations with winds (Tony and katie) and past modeling results

Needs

Understanding of contributions of oil and gas, agriculture, and other sources to N dep by state and sub source regions to ALL class I and II federal areas in the greater Yellowstone region.

Methods:

1) CAMx/CMAQ model simulations
2) Hybrid camx cmaq
3) Trajectory methods
4)

Other source apportionment methods that could be used, but maybe not

1) Application of particle dispersion model and FMBR
2) PMF/hybrid PMF

1) Dry deposition of ammonia is one of the largest inputs into the Teton and likely other sensitive regions in the GYA. However, ammonia dry deposition is poorly characterized and the deposition estimates are based on uni-directional deposition flux. Ammonia deposition in these regions or upwind maybe bi-directional, i.e. deposited material is reemitted. Understanding and properly characterizing this is critical to estimating the total reduced nitrogen deposition and how this could change with changing emission.
2) Ability of model to reproduce the diurnal cycle in Tetons and its implications
3) Differences between CAMx uni-directional model and CAMQ bi-di model
   a. How important is bi-di flux in modeling ammonia and quantifying reduced N deposition.

Organizational Cross fertilization

GYA, forest service fish and wildlife in the greater Yellowstone area

Atmospheric Modeling and Analysis Division of the National Exposure Research Laboratory at US EPA.

Source categories and subcategories that would be great to add to the list are:

1) Agriculture (most important)

   a. Confined animal feed operations (CAFO's)
   b. Fertilizer applications
   c. Other
2) Fires
   a. Wild fire
   b. Prescribed fire
   c. Agricultural fires.
3) Area sources
   a. Residential wood combustion
   b. Cooking (other high OC/VOC emitting processes)
   c. Water treatment/septic (maybe too fine grained but we get questions about this)
