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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The magnitude of the snow-sourced reactive nitrogen flux to the boundary layer in the Uintah Basin, Utah, USA" *by* Maria Zatko et al.

Anonymous Referee #2

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The manuscript of Zatko et al uses measured snow nitrate concentrations along with nitrogen isotopes to infer the flux of reactive nitrogen from irradiated snowpack and compare the magnitude of this flux to other nitrogen sources within the Uintah Basin. It was determined that the reactive nitrogen flux from snow was minimal when compared to the much larger anthropogenic NOx (primary) sources within the basin. Studies of this nature are important to constrain reactive nitrogen sources, as well as to better understand ground-level ozone chemistry, which has been shown to be impacted by the presence of snowpack in winter in the Uintah Basin. The data presented are unique and high quality and will be of potential broad interest to ACP readership. The measurement and modeling methods used are appropriate and justified. The results, for

the most part, support the interpretations and conclusions made (with a few questions I present below that could use clarification). However I think some improvements in organization and presentation would significantly strengthen the manuscript, as outlined below.

1) In the current form, the manuscript is a bit unwieldy and verbose. I think much of the language can be tightened up and the overall length of the manuscript shortened without losing meaning.

2) During the first read, my first impression was that it was dominated by experimental and model descriptions. I kept asking myself "when do we get to the good stuff?" The major focus of the results is predicated on the nitrate concentrations and isotope results, so I would suggest cutting back on the details of the other measurements (perhaps moving to supplemental?) and summarizing more succinctly those results within the discussion.

3) Throughout the manuscript there are references to gas phase N chemistry, changing sources, etc but no mention of e.g. gas phase NOx measurements, magnitudes, etc. I presume there are coupled gas phase measurements that were made by someone during the field campaign? If so, bringing them into the discussion (with back trajectories?) could help strengthen arguments about deposition of nitrate from less polluted regions surrounding the basin, etc.

4) Do you have measurements of nitrite in the snow? It's been shown that the nitrite photolysis channels can also be a significant source of nitrogen oxides from snow (see e.g. Jacobi et al., EST, 2014 based from Barrow, AK). It doesn't appear this is included in your flux calculations/model, only the nitrate channel (reaction E1). A quick sensitivity study could help you rule in/out the importance of reactions E3-E5.

5) Related to the idea of shortening the paper – is Figure 3 necessary? Essentially the same data are presented in Figure 8 as well. Also, figures 2, 4 and 5 could potentially be combined into a multi-panel figure. 6) From the methods, it appears you quantified

BC and LAI via absorption properties, rather than actual chemical measurements (e.g. EC/OC, DOC, etc). As such, I would question the wording of lines 598-599 where you state "concentrations of LAI in the snow photic zone are at least five orders of magnitude higher in Utah compared to Antarctica and Greenland". While I do not doubt there are more light absorbing species in Utah v Antarctica, unless it is based on chemical measurements it is misleading to relate this directly to concentrations. Same argument goes for lines 616-617. The absorption cross sections might just be very different amongst sites/times, while concentrations might not be orders of magnitude different. If you do have measurements of DOC, etc it would be very useful to include reference to these.

7) Line 616: reword as "concentrations in the surface layer"...

8) At line 623 I would redefine F(Nr(z)) since you haven't mentioned it since beginning of manuscript.

9) Line 712: correct the wording, choose either "differ by" or "vary by"

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