

Interactive comment on “The fate of NO_x emissions due to nocturnal oxidation at high latitudes: 1-D simulations and sensitivity experiments” by P. L. Joyce et al.

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We appreciate the constructive comments by Anonymous Referee #1 for improving the manuscript. The reviewer had the following specific comments:

p7392, l24: The referee is correct in that sulfuric acid is not considered to be directly emitted from combustion processes, but a small fraction of oxidized sulfur is emitted as SO₃, which readily hydrolyses to form H₂SO₄. In our modeling, we treat this process as a direct source of sulfuric acid in the aerosol particles, even though the detailed process is more like the referee indicates. We have modified the discussion on p7392

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of the discussion paper to incorporate the referee's comments. The referee also indicates a recent study in Southern California (Nowak et al., 2012), where the emissions ratio between ammonia and carbon monoxide was measured. That emissions ratio, 0.033 +/- 0.013 mol NH₃ / mol CO can also be used to constrain ammonia emissions. However, Fairbanks has both automotive and smoldering woodstove emissions of carbon monoxide, and the automotive CO is partially from cold starts during wintertime. Fairbanks has had serious CO problems since the 1970s when monitoring started and was designated a non-attainment area for carbon monoxide in 1991, but last violated in 1999 and became a maintenance area in 2004. The main change in carbon monoxide emissions during this period was that in the 1990s automotive cold starts and older emissions technologies were addressed, reducing the automotive CO source. In the 2000's increased energy costs have been increasing the reliance on wood as a heating source, likely increasing the woodstove CO fraction. Therefore, it is difficult to constrain ammonia emissions based upon carbon monoxide. This information was used to increase the discussion on ammonia emissions in Fairbanks.

p7401, l14: We fixed this typo.

p7404, l25027: We modified this argument's wording, which was not clear. It is the rate of formation of NO₃ that slows with cooling temperatures. That leaves a larger fraction of NO_x as un-reacted at colder temperatures.

p7406, l20: We added this clarification and agree that the small contribution of NO_x is only in Fairbanks non-attainment urban area due to titration of air masses by excess NO in the highly polluted areas.

p7406, l24: Ammonia dry deposition is included in the Wesely parameterization used in this model. A result of the model is that there is a short delay (hours) over which time gas-phase ammonia encounters and neutralizes acidic aerosol particles, which gives time for the still gas-phase ammonia to deposit before neutralizing the acid particles.

Figure 4: We increased font sizes on this figure and additionally on Figure 3. We feel

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the figures are now more readable.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 7385, 2014.

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