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Atmospheric Chemistry and Physics Discussions

Interactive comment on "High efficiency of livestock ammonia emission controls on alleviating particulate nitrate during a severe winter haze episode in northern China" *by* Zhenying Xu et al.

Anonymous Referee #2

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This is a straightforward and concise analysis of the sensitivity of particle nitrate loadings to winter haze episodes in Northern China. It addresses an important question – how to effectively reduce particle loadings under conditions of very bad air quality. The authors argue that because a significant proportion of Northern China's NH3 emissions during the winter come from livestock, and because current agricultural practices lead to high emissions which could be reduced relatively easily (by 60% through adopting practices more common in Europe and the U.S.), that reducing total NH3 emissions by 40% in the winter in achievable. Based on this argument, the paper pursues two

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complimentary approaches to testing the sensitivity of particle nitrate to reductions of NH3. In the first, they use thermodynamic modelling of a comprehensive observational dataset obtained from measurements at a single site. While the modelling is not perfect, especially in terms of its performance for gas phase species, the authors make the case that the model results are robust for the particle phase and thus reliable for predictions when particle mass loadings are high. By applying a consistent 40% reduction to total ammonia (TA) mass loading, they find a significant reduction in particle nitrate that grows in absolute and relative terms over the course of a 4-day haze event.

To take a more holistic approach, the authors also perform WRF-Chem simulations over a domain centred on Northern China, performing a base case run and one in which NH3 emissions from livestock were decreased by 60%. The authors make the argument for this more sophisticated approach in part because the non-linear relationship between ammonia and nitrate could change lifetime of nitrate. The authors miss an opportunity to test whether this is true under their conditions. I would encourage them to calculate the change in total nitrate (TN) burden (and/or lifetime) as a result of changing the NH3 emissions. They should also calculate the change in TA burden (and/or lifetime) to determine in a reduction in concentration of 40% is the result. Because the WRF-Chem simulations do a relatively poor job in representing TA at the observation site, confidence in the model predictions is undermined. In part 3.3, the authors use the metric of molar ratio (R) to explain under what conditions particle nitrate is sensitive to reductions in TA vs TN. It would be useful if they could place their model simulation results in the context of this framework. If the model is biased in TA (or TN) but occupies a relatively 'flat' part of the isopleth diagram, then its predictions could still be robust. But if biases in the model lead to changes in R near 1, then the predictions may not be as reliable.

Specific comments

In the abstract and throughout the text, the authors consistently focus on the reduction in particle nitrate loading that results from reductions in NH3 emissions, but particle

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ammonium levels also change. While the absolute change in mass loading of ammonium will be less than nitrate due to its lower molecular weight, it would still be worth it in a couple of instances to calculate and report the total reduction in PM2.5 mass from nitrate AND ammonium.

Section 2.2 More information should be provided about the inventory. Over what geographic area are the emissions quoted for? 'North China' is referred to several times, but it would be useful to be more specific. Is the region under study the totality of the six provinces shown in Figure 2, or just the area within the blue box in Figure 2? Or the domain in Figure S3? Also, is the inventory used in this work archived and available for public access?

Figure 2 – I suggest adding a third panel that shows either the absolute difference between the two model runs or the percent decrease. It would be useful to see the spatial pattern of the change in nitrate.

Figure S3 – Is it kg of N in NH3 or kg of NH3 itself?

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