Atmospheric Chemistry and Physics Discussions

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# Comment on acp-2021-65

Anonymous Referee #2

Referee comment on "Non-linear response of $PM_{2.5}$ to changes in $NO_x$ and $NH_3$ emissions in the Po basin (Italy): consequences for air quality plans" by Philippe Thunis et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-65-RC2, 2021

In this work, Thunis et al. simulate and analyze sensitivities of $PM_{2.5}$ to $NO_x$ and $NH_3$ emissions over the Po valley in order to provide guidance for the designing of future air quality plans in the area. This study is of definite interest to the ACP audience since the Po basin is one of the most polluted regions in Europe and, therefore, it is of high importance to elucidate the complex chemical processes that lead to frequent exceedances of the EU $PM_{2.5}$ concentration limits. The manuscript is well written, the methodology is scientifically sound, and the discussion is clear. However, the authors need to provide more details regarding the underlying aerosol (both organic and inorganic) formation processes considered by their model which is a prerequisite for the thorough interpretation of the results presented in this study. Furthermore, the illustration of the results needs to be improved. Overall, I recommend this study for publication. Below are a few comments to be considered prior to publication.

**General comments:**

- The authors should include a description of the modelling framework used for the present study. The reader should be aware of the mechanistic details of the model in order to validate and interpret the simulated responses presented here. The model description should include the gas phase chemistry scheme used (including, if applicable, the heterogeneous chemistry), the thermodynamic aerosol model used for the formation of SIA, and the organic aerosol framework used for the formation of SOA (including the main NMVOCs used as SOA precursors and their photochemistry).
- It has been recently suggested that aerosol pH and liquid water content can be used to determine when PM is sensitive to $NH_3$ and/or $HNO_3$ availability (Nenes et al., 2020). It could be useful to directly compare (or at least discuss) the results of this method against the indicators presented here.

**Specific comments:**

- Page 1, line 21 (and hereafter): Place 2.5 as subscript in PM2.5 (i.e., $PM_5$).
- Page 2, line 55: Please rephrase. By definition, NMVOCs are not low-volatility.
- Page 2, lines 58-76: Important studies regarding the effectiveness of $NH_3$ reductions to control PM concentrations are Pozzer et al. (2017);Guo et al. (2018);Nenes et al. (2020).
- Page 2, line 81: You can also add Tsimpidi et al. (2016) for a detailed comparison of OA composition against AMS-measurements which elucidates important OA formation pathways that are still missing by the models
- Section 2: The methodology should include a model description. It is of prime importance to briefly present the details of the model such as the thermodynamic model used. A brief description of the organic aerosol framework is also important since the $NO_x$ reduction can impact the oxidant levels and thus the SOA formation.
- Pages 4, lines 170-176: Furthermore, low temperatures during winter favor the aerosol phase during the equilibrium partitioning of semi-volatile components (e.g. ammonium nitrate).
- Page 5, equations 5, 6: These belong to model description. Does the model include any heterogeneous chemistry?

- Page 5 line 208: Correct "of" with "or"
- Page 8, equations 10-15: Are these included in the model?
- Page 8, lines 327-335: Maybe it is worth drawing a map of the VOC/NOx concentration ratio to illustrate the NOx-limited (i.e., with ratio values higher than 5.5) and NOx-saturated areas of the model domain (Tsimpidi et al., 2008).
- Page 8, line 330: correct "that" with "than"
- Page 8, line 333: Does the model include heterogeneous or aqueous phase production of SOA as implied here?
- Page 17, Figure 1 (and hereafter): In order to improve the illustration of the plotted maps I suggest to increase the number of colors used, draw the border lines bolder, and move the color bars to the right of the figure (using only one instead of three).
- Pages 18-19, Figures 3, 5 (and thereafter): I suggest using diverging colors for the figures (e.g., shades of blue colors for negatives and shades of red colors for positives)
- Page 18, Figure 4: I suggest using diverging colors below and over the value of 1 for the G-ratio.
- Page 20, Figure 6: Values are missing on the y-axis for Summer. The color-bar title is also missing. Please add more value points in the color-bar as well.
- Page 21, Figure 7: The color-bar is missing
- Page 22, Figure 8: Please consider revising the map on the left. The way it is represented is not clear.
- Page 26, Figure 13: Color-bar is missing

References:

Guo, H., Otjes, R., Schlag, P., Kiendler-Scharr, A., Nenes, A., and Weber, R. J.: Effectiveness of ammonia reduction on control of fine particle nitrate, Atmos. Chem. Phys., 18, 12241-12256, 10.5194/acp-18-12241-2018, 2018.

Nenes, A., Pandis, S. N., Weber, R. J., and Russell, A.: Aerosol pH and liquid water content determine when particulate matter is sensitive to ammonia and nitrate availability, Atmos. Chem. Phys., 20, 3249-3258, 10.5194/acp-20-3249-2020, 2020.

Pozzer, A., Tsimpidi, A. P., Karydis, V. A., de Meij, A., and Lelieveld, J.: Impact of agricultural emission reductions on fine-particulate matter and public health, Atmospheric Chemistry and Physics, 17, 12813-12826, 10.5194/acp-17-12813-2017, 2017.

Tsimpidi, A. P., Karydis, V. A., and Pandis, S. N.: Response of Fine Particulate Matter to Emission Changes of Oxides of Nitrogen and-Anthropogenic Volatile Organic Compounds in the Eastern United States, J. Air Waste Manage. Assoc., 58, 1463-1473, 10.3155/1047-3289.58.11.1463, 2008.

Tsimpidi, A. P., Karydis, V. A., Pandis, S. N., and Lelieveld, J.: Global combustion sources of organic aerosols: model comparison with 84 AMS factor-analysis data sets, Atmos. Chem. Phys., 16, 8939-8962, 10.5194/acp-16-8939-2016, 2016.