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Interactive comment on "Low modeled ozone production suggests underestimation of precursor emissions (especially NO_x) in Europe" *by* Emmanouil Oikonomakis et al.

Anonymous Referee #2

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The authors' present an analysis assessing CAMx model under-predictions of ozone production in Europe, and arrive at the main finding that NOx emissions are likely under-predicted in existing emission inventories. Overall, the paper is well-written, clear, scientific methods appropriate, and in general findings/conclusions well-supported. I have a couple of critiques that hopefully will help strengthen this paper. First, I think the sensitivity analysis adjusting NOx emissions could be more specific to transportation emissions, rather than applied across total anthropogenic emissions. Second, the sensitivity analysis of wind speed seems to be in the opposite direction based on the model bias for this meteorological parameter. With revisions to the model test cases, I believe this manuscript could be considered for publication in Atmospheric

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General Comments

1. Section 2.3 ("Emissions"). The authors present a nice literature summary suggesting that transportation emissions of NOx are uncertain and may be underestimated by a factor of 2-4 (Page 5, Line 2). However, it appears that the authors' scaled all anthropogenic NOx emissions by a factor of 2 (Table 3) in sensitivity tests of the model. Based on Figure 2, scaling up road transportation emissions by a factor of 4 would roughly equal a factor of 2 increase in anthropogenic emissions. I suggest scaling the transportation sector only in the sensitivity analysis rather than all anthropogenic sources. First, it is not clear that point source emissions should exhibit uncertainties as large as the transportation sector. Second, the diurnal and day-of-week cycle in transportation emissions differ (Nassar et al., 2013) from point/area sources, which could affect diurnal and day-of-week patterns in the model and affect NO2 and O3 evaluations (Marr et al., 2002). Third, transportation emissions are likely more concentrated in urban cores relative to other sources of NOx (e.g., power generation/industry), which could affect the spatial distribution of emissions and model evaluations performed on rural background monitors (Page 6, Line 13).

2. Section 3.3 ("Sensitivity of ozone to meteorology"). The rationale behind increasing temperature by +4 degrees Celsius in the model (Table 3) makes sense based on systematic underestimates in temperature in the base case (Figure S3, also stated on Page 14, Line 3). However, why is wind speed reduced in the model rather than increased, when the model generally systematically underestimates wind speed in the base case (Table 4/Figure S4/Figure S6)? By increasing wind speed in the model, the ozone under-predictions will likely be worse, and a stronger argument can be made that meteorology is unlikely to explain the model discrepancies in relation to emissions.

Specific Comments

3. Section 2.3 (Page 4, Line 13). I think this paragraph could benefit from a description

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of why anthropogenic VOC emissions are uncertain at a ∼50% level, similar to the proceeding discussion of why anthropogenic NOx emissions are uncertain. One sentence here seems too brief.

4. Section 3.1 (Page 10, Line 13). "...the overestimation of higher ones..." I believe the authors' mean *underestimation* here.

5. Section 3.2 (Page 12, Second Paragraph). A summary point at the end of the paragraph would be helpful here. It seems that the authors' might want to emphasize that NOx emissions need to be increased across most regions to improve results.

6. Section 3.2 (Page 12, Lines 21-22). It would help to label the slopes of the dashed grey lines in Figure 9, to help the reader more clearly discern the points made in this paragraph.

7. Section 3.3 ("Temperature"). Figures S3 and S5 seem inconsistent. While Figure S3 shows a general under-prediction of temperature by the base case model, Figure S5 seems to be showing a lot stations being over-predicted in the model (yellow and orange markers). I'm wondering if this related to the under-predicted sites being blocked out by the over-predicted sites in the coloring scheme. Suggest revising the presentation of Figure S5.

8. Section 3.3 (Page 14, Lines 25-31). These sentences do not seem to support the sensitivity test performed in the model where wind speeds are decreased, since: (i) the model seems to be doing well already (Line 25), (ii) most observations show a model under-prediction in wind speeds rather than over-prediction (Line 28), and (iii) the low wind speed conditions where the model over-predicts wind speeds comprise a minor fraction of observations (Line 30). Suggest revising this sensitivity test for wind speed, to increase rather than decrease in the model.

9. Section 4 (Last Paragraph). I think this last statement made here could be stronger by performing a sensitivity test of transportation NOx emissions only, which would be

in line with the literature suggesting that this sector is consistently underestimated in Europe (Annenberg et al., 2017; Karl et al., 2017). Rather than draw attention to all anthropogenic emission sources, it would be helpful to identify which sectors specifically need the most improvements in emission inventories.

References

Anenberg, S. C., et al. (2017). "Impacts and mitigation of excess diesel-related NOx emissions in 11 major vehicle markets." Nature 545(7655): 467-+.

Karl, T., et al. (2017). "Urban eddy covariance measurements reveal significant missing NOx emissions in Central Europe." Scientific Reports 7.

Marr, L. C. and R. A. Harley (2002). "Modeling the effect of weekday-weekend differences in motor vehicle emissions on photochemical air pollution in central California." Environmental Science & Technology 36(19): 4099-4106.

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