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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Assimilation of satellite NO_2 observations at high spatial resolution" *by* Xueling Liu et al.

Anonymous Referee #1

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In their paper, X. Liu and co-authors discuss the impact of future geostationary NO2 observations on air quality models and the potential of these observations to improve estimates of emissions.

General assessment:

The highlight of this paper is a documentation of the sensitivity of NOx emission estimates on the quality of the meteorological fields and the winds in particular. As shown, these issues are especially critical when the resolution of the observations and the models advances to the km scale. This sensitivity is demonstrated in a clear way, and to my opinion is an important aspect to keep in mind for the development of future regional analysis systems. As such, I am in favor of publishing these results in ACP.

The paper is well written, has a good introduction, but the overview of the method

and tools is very short and condensed. The implementation of the OSSE setup is not provided with enough detail for other groups to repeat the experiment, see my detailed comments below. I therefore would urge the authors to expand these parts of the paper.

In order to judge the importance of the meteorological uncertainties for emission estimates, it is important to provide estimates of real-life uncertainties in state-of-the-art regional weather analysis systems, and to compare these uncertainties with the OSSE setup. This would be a valuable addition to the conclusions section.

It seems the authors make very optimistic assumptions on the uncertainty of the TEMPO retrievals. Is this justified and are the conclusions sensitive to the choice made for the observation error?

Detailed:

Abstract:

Last line p2: 3.3 to 5 molecules/cmˆ2 ?

p3, l27: "idealized profile setting provided by WRF-Chem." This is unclear and needs to be explained.

p4, top: Please discuss the state augmentation approach for NOx in more detail: how are the emissions perturbed as compared to the inventory, and how is the ensemble constructed.

p5, l1: "We chose the 10 km distance based on sensitivity experiments" How are these experiments done?

p5, l26: "We calculate a layer dependent Box-Air Mass Factor (BAMF) . . . follow the latest version of the NASA . . ." It is unclear from the text how this is done. If the authors compute this themselves, then which RTM is used? How is the geometry computed? What about the terrain parameters. Please provide these details.

p6, l3: “The other parameters are sampled from the model run”. Which parameters ?

p6, l14: The mean uncertainty of 7.5 % seems very optimistic. Is this justified somehow? Would the results be very sensitive to this choice?

p6, l29: “scaled to be 70%” A uniform scaling is very idealized, and may be more easily recovered in a DA system than spatially-varying emission perturbations. It seems logical to add also a more random perturbation in emissions to reflect the uncertainty in the emission spatial distribution. Would this impact the conclusions?

p7, l29: Please discuss explicitly the formula to compute the uncertainty. In line 31 the RMS is defined, but “uncertainty” is unclear.

p8, l11: “initial uncertainty of 41.70 mol/(km2Âůhr)”. What is this absolute number? Is it an average over the red domain in Fig. 1?

Fig.3: It would be helpful to indicate with symbols at what times an analysis is produced (for the green and blue curves).

p8, l18: Please explain how this correlation is computed.

p9, l3: “future TEMPO NO2 observations will enable us to constrain surface emissions on a city scale”. I would claim that this is not fully demonstrated by the authors, because the OSSE setup is still idealized. In particular, the same model is used to construct reality (the nature run), and emissions are idealized, which will lead to too optimistic results. Please formulate the conclusions in a more careful way.

Please also report on typical wind uncertainties which are within reach in present-day high-resolution regional meteorological analysis systems. This may be compared with RMS and uncertainty values as reported in table 2. Is a performance like reported for e.g. ENS-H feasible in reality?

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