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Interactive comment on “An evaluation of the CMAQ reproducibility of satellite tropospheric NO₂ column observations at different local times over East Asia” by H. Irie et al.

Anonymous Referee #3

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The aim of this paper is to evaluate CMAQ simulation of NO₂ against tropospheric NO₂ columns from 3 satellite instruments. The study focuses on two months in 2007 over East Asia. The authors performed CMAQ simulation at various resolutions and conducted some sensitivity simulations in an attempt to understand the reproducibility of satellite retrievals of tropospheric NO₂ by CMAQ. They report overall agreement in July simulation and a large discrepancy in December.

I share similar concerns as other reviewers that the manuscript in its current form is not conclusive. Without additional analyses and interpretation, the manuscript is merely reporting the differences and is not providing any significant results.

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GENERAL COMMENTS:

(A) As pointed out by other reviewers, the authors should expand their analyses considering various uncertainties associated with model simulation. Several questions remain unanswered. For example, how do CMAQ simulations with various emissions and loss processes compare with satellite retrievals? Does CMAQ include all NO_x emissions (e.g. lightning and aircraft NO_x emissions)? You have changed emissions by 20%. Are there any justifications for selecting this value? Do you change emissions by 20% for all sources or just for anthropogenic sources? What are the resolutions of emissions? How reliable is mixing height depth in CMAQ and how does that affect the diurnal variation? Are there any issues in CMAQ regarding loss processes?

(B) Comparison of model simulation with satellite retrievals is affected by a-priori profiles used in the retrievals. Satellite algorithms require a-priori NO₂ vertical profiles which are taken from a global simulation at resolution much coarser than offered by regional models such as CMAQ. Besides, the profiles used in retrievals may be based on old emissions. Asian emissions are undergoing rapid changes which likely affect NO₂ vertical profile shapes, to which satellite NO₂ retrievals are sensitive. This may be a large effect, which needs to be accounted for while comparing model simulations with satellite retrievals. Moreover, the effect could be seasonally varying. Therefore, I suggest authors to recalculate tropospheric NO₂ from satellite using CMAQ profiles (using vertical sensitivity such as averaging kernel information), and then repeat the analyses.

(C) From the discussion, methodology is not clear enough. There might be spatial and temporal differences in sampling between model and satellite observations. The three satellite instruments have different foot-print size. For OMI, the pixel size changes with scan position. Different pixel sizes lead to different levels of spatial smearing. Model spatial resolution is different from satellite spatial resolution and they hardly match in spatial coverage. How did you account for those effects? Local time and local equator crossing time may differ by as much as 1 hour. You indicated that model simulations

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were interpolated to local times and from table 3, it appears that the temporal interpolations are for local equator crossing times, not actual local times. If the interpolation was performed for actual time of measurements which differ each day within a repeat cycle of the satellite, it should be clarified. For winter time, satellite retrievals may be affected by ice and snow. Cloud parameters and therefore satellite retrievals are likely erroneous in those conditions. Excluding such observations may lead to limited number of satellite observations to compare with model. Same cloud fraction threshold applied to different satellite may affect the sampling size. While creating monthly means, did you use the same selection criteria for model as for satellite observations?

SPECIFIC COMMENTS:

1. Section 2 (CMAQ): Does CMAQ include emissions from lightning and aircraft? How do these emissions affect the observed discrepancies between satellite retrievals and model simulation and the discrepancies in diurnal changes?
2. What is the spatial resolution of emissions? What is the temporal resolution of emissions and where does this information come from?
3. What is the year of anthropogenic emissions (REAS)? How does it compare with other emission inventories (e.g. from Streets et al and Zhang et al)?
4. Page 14043, line 2: Please, provide average equator crossing time, not the range as the information could be misleading.
5. Page 14043, lines 11-12: Wasn't 1×10^{15} molec cm^{-2} the error in slant column, not the vertical column?
6. Page 14044, lines 7-8: You brought the issue of satellite instrument degradation. Are there any instrument degradation effects in satellite retrievals of NO_2 ?
7. Page 14044, line 10: Why are these regions selected? Was the selection motivated by any issues related to emissions or retrievals?

8. Page 14044, lines 24:26: Are there any reasons for the increase in tropospheric NO₂ retrievals with cloud fraction? Why was 0.2 cloud fraction threshold was selected?

9. Page 14049, lines 14-17: This statement may be incorrect. Should not stratospheric NO₂ be larger in summer than in winter?

10. Figure 1: What is the sampling time of CMAQ simulation? Which day, month, year?

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 14037, 2013.

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