

## ***Interactive comment on “Tropospheric ozone and its precursors at Summit, Greenland: comparison between observations and model simulations” by Yaoxian Huang et al.***

### **Anonymous Referee #1**

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This paper describes an evaluation of tropospheric ozone and its precursor species simulated by the GEOS-Chem global chemical transport model (CTM) at the Summit observatory station in Greenland. Based on evaluation of the standard GEOS-Chem model, and deficiencies identified through comparison with observations, a number of model changes are implemented (mostly to emissions) which are shown to improve the model performance. The paper serves as a useful documentation of Greenland surface ozone, NO<sub>y</sub> and VOC sensitivity to a number of key processes, and highlights processes that warrant further investigation to improve understanding of the surface Arctic ozone budget. These issues are important in light of recent studies demonstrating poor model performance for Arctic tropospheric ozone, as cited by the authors.

C1

The paper is generally well written, logically structured and is suitable for the journal. I would recommend publication of this manuscript in ACP, once the following minor issues have been addressed.

- 1) Paragraph beginning Line 69. The discussion of ethane appears a bit out of the blue. The authors should explain more clearly in the manuscript the importance and relevance of ethane to the previous discussion. i.e. give some context for how ethane is relevant to the study - which is motivated by understanding Arctic tropospheric ozone. i.e. as has been done for NO<sub>x</sub>, PAN.
- 2) Lines 109-112: It is unclear here what is meant by fully coupled aerosol? Does this include size-resolved modal aerosol for example? Heterogeneous chemistry, semi-volatile nitrate..?
- 3) Lines 112-115: Discussion of previous GEOS-Chem evaluation. It would be helpful here to provide a few sentences for a brief but more critical review of what has been shown in terms of model performance with previous studies specifically using GEOS-Chem in the Arctic. e.g. sensitivity analysis by Christian et al., (2107), the recent POLMIP evaluation (see Monks et al., 2015). These have shown some important limitations and strengths that it would be useful to point out for context.
- 4) Discussion of model NO<sub>x</sub> bias (first paragraph of page 5). Perhaps here quote the obs/model slope or model bias. You give figures for the slopes / correlations in the panels of Fig 3 but don't mention the numbers in the text.
- 5) Lines 206-208: Is the magnitude of the snowpack NO<sub>x</sub> reservoir depletion of right order to explain this? Is the source linearly dependent on the reservoir? Would it be hard to test this in the model to see if it improves the model bias? i.e. can you scale the monthly emissions according to this finding? Perhaps not necessary, but a brief discussion of the order of magnitude of depletion and how that relates to the model bias would be helpful.

C2

6) Does this model include the PAN budget updates from the Fischer et al. study that is mentioned? This should be stated clearly. Arnold et al., (2105) showed that GEOS-Chem produces less PAN relative to CO than other models in Arctic air masses influenced by fires. It would be useful to refer back to this here to give context to the model performance relative to that found for other models.

Typographical / editorial corrections:

Line 58: “. . .while PAN mixing ratios were lower in fresh boreal fire plumes.” This sentence is unclear. Lower than observed? Lower than in other air mass types simulated in the model?

Line 82: “. . . that the snowpack emits..”

Paragraph beginning Line 141 contains mixed (past / present) tenses. Please adjust the text to make it consistent.

Line 156: “ not observed in the data.” Better to simply say “. . . not observed”.

Line 161: Omit word “mannually” (which should be spelled “manually” in any case).

#### References

Arnold, S. R., Emmons, L. K., Monks, S. A., Law, K. S., Ridley, D. A., Turquety, S., Tilmes, S., Thomas, J. L., Bouarar, I., Flemming, J., Huijnen, V., Mao, J., Duncan, B. N., Steenrod, S., Yoshida, Y., Langner, J., and Long, Y.: Biomass burning influence on high-latitude tropospheric ozone and reactive nitrogen in summer 2008: a multi-model analysis based on POLMIP simulations, *Atmos. Chem. Phys.*, 15, 6047-6068, <https://doi.org/10.5194/acp-15-6047-2015>, 2015.

Christian, K. E., Brune, W. H., and Mao, J.: Global sensitivity analysis of the GEOS-Chem chemical transport model: ozone and hydrogen oxides during ARCTAS (2008), *Atmos. Chem. Phys.*, 17, 3769-3784, <https://doi.org/10.5194/acp-17-3769-2017>, 2017.

C3

Monks, S. A., et al., Multi-model study of chemical and physical controls on transport of anthropogenic and biomass burning pollution to the Arctic, *Atmos. Chem. Phys.*, 15, 3575- 3603, [doi:10.5194/acp-15-3575-2015](https://doi.org/10.5194/acp-15-3575-2015), 2015.

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Interactive comment on *Atmos. Chem. Phys. Discuss.*, <https://doi.org/10.5194/acp-2017-463>, 2017.

C4