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Atmospheric Chemistry and Physics Discussions

Interactive comment on "What drives the observed variability of HCN in the troposphere and lower stratosphere?" *by* Q. Li et al.

Anonymous Referee #1

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This paper presents results from a chemistry transport model (GEOS-Chem) simulation of HCN, focusing on comparisons with observations, and understanding the variability of HCN in the troposphere and lower stratosphere. The model simulation includes a detailed distribution of HCN emissions from biomass and biofuel burning, and photochemical and oceanic surface sink terms (following previous model and observational studies of HCN). I like the comparisons to the column HCN observations from Jungfraujoch, which demonstrates a reasonable simulation over NH midlatitudes. However, there are several other aspects of the model analysis and data comparisons which are problematic, and are not convincing regarding interpreting observed HCN variability. I think this work can be published at some point, buy I recommend the authors more critically evaluate their comparisons and conclusions, with focus on the following points:

1) The column HCN comparisons for Jungfraujoch in Fig. 1 are impressive. However, the Kitt Peak comparisons do not convince me of any model skill at simulating variability (beyond having an appropriate average value). What is the correlation coefficient for the model vs. observations in Fig. 2b? The Mauna Loa comparisons (Fig. 2c) are relatively useless in terms of model validation, because of the very limited amount of observations.

2) Fig. 4 shows little to convince the reader that the model simulation is realistic. The MLS data in Fig. 4c have very large biases over most of the globe (and an unrealistic vertical structure), and comparisons with the model are very poor except for a small altitude range over the tropics (this simply demonstrates that the MLS HCN data have substantial bias problems). The comparisons with ACE data (Figs. 4 a-b) shows overall poor agreement in terms of detailed latitude or altitude gradients (vertical gradients in the tropics are very different, and there is little hemispheric asymmetry in the upper troposphere, despite such a reference in the text). Overall these comparisons are questionable for constraining the quality of the model simulation, and I think the authors should be much more critical in their assessments.

3) I think there are important limitations in the model simulation in the upper troposphere and stratosphere, and I am unconvinced by Figs. 5-6 that the model accurately simulates a 2-year cycle in the stratosphere. The model simulations in Fig. 6 suggest a strong increasing HCN trend in the stratosphere over the 6-year model simulation, and because the photochemical lifetime of HCN in the stratosphere is very long (> 5 years) I think this is evidence that the model is not equilibrated. Furthermore, the authors focus on comparing 2 years of observations from ACE and MLS with the model (Fig. 5), and propose to explain a 2-year cycle with only 2 years of data. Why not extend the comparisons to the > 4 years of data now available from ACE and MLS? The comparisons in Fig. 5 are also worrisome because of the focus on anomalies, rather than actual values; I understand that anomaly comparisons are most appropriate for the MLS data (which have large biases), but not so for the ACE measurements (with

small biases, i.e. Fig. 4). Note that the ACE data also extend to altitudes lower than 100 hPa. Overall my feeling is that the model – observed comparisons are done in such a way as to minimize differences, rather than critically evaluate the model.

4) I have to say that I like the sensitivity experiments in Fig. 7, where the simulations are run with constant emissions and constant meteorology to determine causes of the model interannual variability. I think this is convincing that emissions variations are most important. But the fact that the stratospheric data comparisons are only shown for 2 years makes the connection of the model simulations to the satellite observations less convincing.

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