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Atmospheric Measurement Techniques Discussions

Interactive comment on "Potential sources of a priori ozone profiles for TEMPO tropospheric ozone retrievals" *by* Matthew S. Johnson et al.

Anonymous Referee #2

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In this paper, the authors compare ozone profile data from three TOLNet stations across the USA with A) an ozone climatology and ozone data from various transport models, and B) a simulated retrieval result where the climatology and models are used as a priori values.

The authors use a formula from the book by Rodgers (2000) to linearise the calculations of the effect of the a priori on a potential retrieval. While Rodgers uses the formula in Chap 3 and Chap 10 of his book, using this formula to make a selection on a preferred a priori brushes over the potential issues you often get with real satellite data.

The first question that comes to mind is: how representative are these simulated retrievals for real world situations. Or is Eq 1 limited to be used for an error / sensitivity

study? My impression is that the error component is not used in the paper. Please give your reasons for using this method.

In retrievals of ozone profiles, an a priori consists of a profile shape and an associated error profile. Because the retrieval of ozone profiles is under-determined (more than one profile shape can be retrieved from the same spectrum), an a priori is used in an Optimal Estimation (OE) based retrieval to constrain the outcome to reasonable values. The a priori profile shape is a reference, and the profile error gives the retrieval the freedom to differ from that reference shape based on the input spectrum to minimise the cost function.

In a real retrieval, when either the error on the a priori is set to zero, or the error on the measured / simulated spectrum is too large then the OE retrieval result will reproduce the a priori almost exactly. In this case no information is gained from the spectrum during the retrieval. In other words: the spectrum contains no useful information and the degrees of freedom from the signal (DFS) will be low.

The authors seem to come to the conclusion that TEMPO ozone profile retrievals in the troposphere and LMT require an a priori that already matches the general shape of the observations in order for the required accuracy to be obtained in the retrieval. If the a priori already needs to be so close to the shape and magnitude of the outcome of the retrieval, then one could conclude that the TEMPO spectra do not contain sufficient information for the retrieval, or the retieval is over-constrained.

How do the authors see these issues, in light of the need of their conclusion that the a priori needs to be close to the true profile? Please clarify.

Another way of looking at it is by looking at Eq 1. If the a priori Xa closely matches the true Xt, then what is 'retrieved' is mainly the a priori, as the second term in the equation falls to zero. It is therefore not surprising that an a priori that more closely matches the true profile will also do well in the simulated retrievals. Those a priori profiles already have the advantage in Eq 1. How does this advantage play out with real retrievals? Is it really necessary to have an a priori so close to the true state of the atmosphere to get a good retrieval? If so, what is the added value of a retrieval in this case?

Textual / other remarks:

Line 104: You mention an error margin of the TOLNet measurements of 10% in the lower troposphere and 20% in the upper troposphere. The words 'lower' and 'upper' are not defined in this context, while you use the terms LMT (0-2km) and tropospheric (0-10km). Please be more specific about the applicable altitude ranges of the errors of the TOLNet DIAL lasers.

In sect 2.2/2.2.1 it would be helpful to have a little more information on the input data. Please elaborate on the setup you use to generate the artificial / simulated TEMPO data (the AK's, the Gain matrices, etc). What other relevant sources of information did you use, like temperature, albedo's, cross sections, solar and viewing angles, reference spectra, etc.

In section 2.2 the authors mention the use / adaptation of the SOA retrieval algorithm for TEMPO to do retrievals. But it is not clear to me whether the SOA algorithm played a role in this paper at all. In the second part of 2.2 a simple vector/matrix based formula is used to calculate the simulated retrieved profile. Did the authors use the SAO model for any of the ozone profile retrievals or was it used in the set-up of the kernels? If it was not used, is it then relevant to for this paper?

Line 141: In Eq 1, there is a component for the effect of noise. Please explain how you treat the last term in the equation. How does this component affect the retrievals and what are the expectations on its effect on the ranking of the a priori sources used?

Line 168 and Fig 3: Yellow is a color that is hard to see on a white background. Please use a color with more contrast.

Line 193: 'due to data constraints'. What kind if data constraints? Is it an issue of lack of sensitivity at the lower troposphere of most existing satellite instruments? Please

clarify.

Line 244: In this section you evaluate the straight model output with the TOLNet profiles, outside the context of use as an a priori. The remark that GEOS-Chem is the 'the only potential source of a priori profiles ...' is out of place here. You address the use of the various models as an a priori in sections 3.2.x.

In lines 248 and 249 the authors give a few aspects that may be the reasons why GEOS-Chem compares better to TOLNet than the other models. It would be insightful to the reader to learn which of these aspects contributes the most to the better comparison.

Section 3.1.2: In this section the authors make an evaluation of how well the climatology and the models can reproduce the daily variability of the lidar measurements. Please elaborate on the time step / time resolution of the models. Is there a reasonable expectation that the models can actually follow the daily cycle, or are the climatology and model fields spaced to far apart in time?

Please consider enlarging your time series plots.

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