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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Midlatitude stratosphere – troposphere exchange as diagnosed by MLS O_3 and MOPITT CO assimilated fields" *by* L. El Amraoui et al.

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First, we really want to thank both reviewers for the excellent report they have provided. Their remarks and comments have been of great importance for us to improve the quality of the paper, and also to give us more insight for further work in particular regarding the characterization of the mixing layer during a STE event.

General comments:

This manuscript presents a case study of chemical data assimilation application using

a stratospheric intrusion event. Analyses presented focus on the upper troposphere and lower stratosphere (UT/LS) ozone and CO fields from MOCAGE CTM with and without satellite data assimilation. The results show that chemical data assimilation significantly improves the model's ability to represent the dynamical variability of chemical tracer fields in the UT/LS region. The potential of MLS ozone and MOPPITT CO data assimilation for STE studies is discussed in the conclusion.

The manuscript is well organized and clearly written. The results are interesting and made a very good case for integrating models and satellite observations. There are several weaknesses in the manuscript. The analysis presented are not consistently quantitative in all cases and can be easily improved. The interpretation of the resulting ozone and CO fields has some ambiguity and needs clarification. The final discussion on the implication of this work to STE studies can also be strengthened. In particular the two assimilated tracers are discussed largely in an isolated fashion, while this pair of tracers is known to work well together in STE studies.

Specific suggestions are given below for the authors' consideration.

Specific comments

1. The main conclusion of the paper, a significant improvement of UT/LS tracer representation after integrating satellite data and CTM, will be better supported if the improvements are quantified. An example is figure 6. In this case, ozone total column from the free CTM and the data assimilation run are compared with OMI. This figure can be done in the same way as the CO field in fig 10. Visually from fig 6 the free run did not produce enough Ozone and the assimilation run produced too much. The discussion (p20692 para 1) states that the assimilated field and OMI are nearly the same in the area of interest, which is ambiguous. If this is really the case, a three-way comparison of profiles from free run, assimilation run and the ozonesonde

measurement (figure 1) will provide a strong quantitative statement

⇒ **Figure 6 is now changed in the same way as the CO field in Figure 10. We also added a new figure (Figure 7 in the paper) showing the three vertical profiles (ozonesonde, model and O_3 assimilation. This new figure clearly supports the improvement of the model via the assimilation, especially between 300 and 150 hPa.**

2. The improvement of CTM with data assimilation can also be shown more quantitatively in the validation comparisons. For example, authors may consider including free running CTM in Figure 5 and figure 8. In figure 9, it would be much more relevant to show the statistical differences between the modeled and observed profiles before and after data assimilation, rather than showing the profile statistics from the model and the observations.

⇒ **The model has been added to all these figures including the corresponding statistics with regard to the observations.**

3. In figure 11, the color scale for panels a) c) and b) d) are different. The choice is such that the enhanced ozone variability after satellite data assimilation at the 315 K level is visually significant in panel c) but not at all visible in panel d). Similarly, Figure 13 a) can choose the color scale differently to show the relevant ozone gradient in the tropopause region. The statement of "under-estimate" (page 20695) would be much better supported if the 3-way profile comparison is made.

⇒ **Figures 12 (a, c) and (b, d) do not have the same projection. The figure on the left is a longitude-latitude map whereas the figure on the right is a longitude-pressure cross section. It is therefore quite logical that the choice of the colour code is different for the two different projections. The choosing colour code for each type of projection has been made to represent the variability of the species within the considered domain (min, max). Whatever, we**

have reduced the colour code for the 'longitude-pressure' projection in order to have some details about the vertical gradient of ozone during the stratospheric intrusion event (see new figures).

4. In the final discussion, the authors emphasize the effectiveness of CO assimilation in providing the stratospheric signature, compensating the under representation of ozone in the intrusion. Since the motivation of representing stratospheric intrusion in the model is largely about its impact on tropospheric ozone budget, the "weaker" result in ozone assimilation and the "stronger" result in CO assimilation lead to an ambiguity of how much the model's applicability in STE studies is improved. In addition to the previous suggestions of quantifying ozone change after assimilation, it is worth considering the opportunity here to examine the O_3-CO correlation with and without assimilation. If the use of MOPPITT CO indeed adds more information to CTM for the UT chemical tracer field, more effectively than using the MLS ozone field alone, this may be quantified by looking at the changes in tracer correlations. A significant number of studies using aircraft data have documented the statistical features of the tracer relationship and can be taken advantages here (e.g. Pan et al., 2007; Strahan et al., 2007). This additional analysis should strengthen the conclusion of this work.

⇒ **We agree that the examination of the CO-O_3 correlation would give a little more weight to the paper. However, it should be noted that:**

1- The main objective of this paper is *i)* to show the capability of data assimilation to improve the distribution of O_3/CO in the UTLS region, and *ii)* to demonstrate the capability of MOPITT CO measurements to capture a deep stratospheric intrusion event. We used a tropospheric tracer (CO) and a stratospheric tracer (O_3) via data assimilation in order to evaluate their added value concerning a STE event. Assimilation outputs better represent the distributions of O_3 and CO in the UTLS compared to the free run of MOCAGE.

2-It should be noted also that the assimilation experiments of ozone and CO are done separately, moreover both species do not cover neither the same area nor the same altitude domain (stratospheric O_3 ; tropospheric CO) their area of overlap is very limited. Because we assimilated separately O_3 and CO, then we logically have to analyse them separately. Actually, in one hand we are working in the interpretation of the modelled CO versus the assimilated O_3, and in the other hand the assimilated CO versus the modelled O_3. We had some first results (see fig.1 below), but we estimated that we should push further our analysis with other diagnostics (e.g., Zahn et al., 200; Hoor et al., 2002; Pan et al., 2004-2007) before quantifying the contribution of each assimilated species in the mixing process on the UTLS. These analyses would be the subject of an ongoing work. This has been added in the conclusion as a perspective for this work.

Minor comments

- Labels in several figures are too small. In particular, labels in figure 3 must be enlarged. Figs. 6 and 10 can use larger font size too.

⇒ **All figures have been revised with a larger font size. Nevertheless, we can't do anything about how small the figures appeared. This is due to the ACPD style during the publication process.**

- "modelled" -> "modeled" ?

⇒ **The English and the notations used in the paper correspond to those of the British English.**

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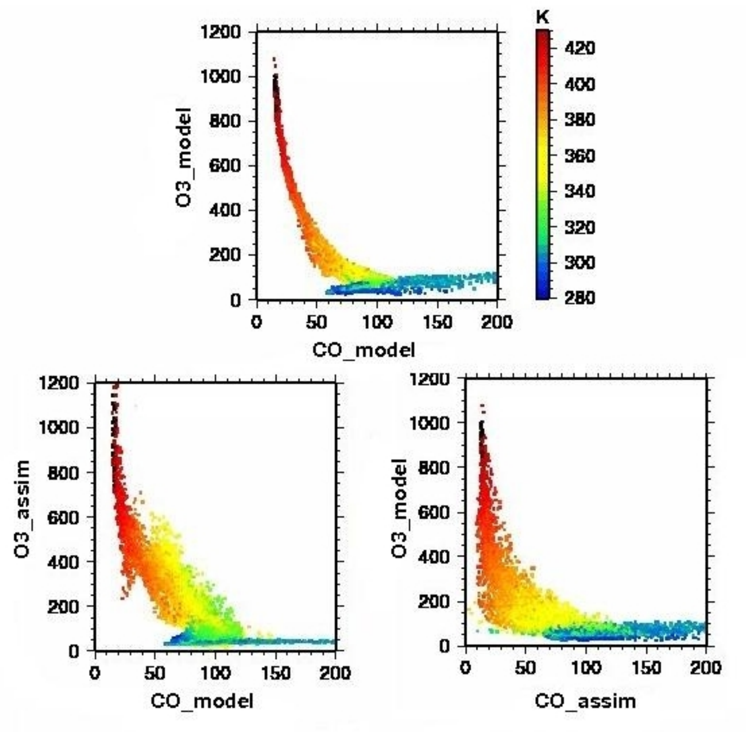

Fig. 1. Top: Modelled O3 Vs modelled CO; Left: Assimilated O3 Vs modelled CO; Right: Modelled O3 Vs assimilated CO. The colour code is the same and refers to the potential temperature in K. O3 & CO are in ppb