Atmos. Chem. Phys. Discuss., 5, S5603–S5608, 2005
www.atmos-chem-phys.org/acpd/5/S5603/
European Geosciences Union

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Stratosphere-troposphere exchange in a summertime extratropical low: analysis" *by* J. Brioude et al.

J. Brioude et al.

Received and published: 23 February 2006

This work presents a case study of the STE within a summertime low. Two MOZAIC flights provide in situ measurements within the mesoscale system. Back trajectories and RDF analysis are used to diagnose the exchange using model analyses. Many case studies of cyclone related STE have been presented in the past, but emphasis has typically been on wintertime systems. The authors claim that this is the first to examine a summertime system. Overall, the study is relatively complete but a few major and minor points should be addressed before publication.

Major Issues:

The authors imply that the tropopause demarcation is the 2 PVU surface. How sensitive are the results to other values that could be used? In a case study such as this it might be more appropriate to use a layer (such as 2 to 3.5 PVU or similar) to designate the tropopause. A parcel must then cross the complete layer to be considered STE. Not much indication is given in this work about how much the PV changes other than the parcels that decrease from anything greater than 2 PVU to much less.

Reply: We wouldn't have to reclassify the origin of air masses if we changed the threshold for a stratospheric origin from 2 to 4 pvu using the RDF technique. The dynamical tropopause in large scale analyses, such as the ones produced by the system of the ECMWF, generally appears to vertically span a layer with potential vorticity ranging from about 2 to 4 pvu. We implied that the tropopause demarcation is the 2 pvu surface in the RDF analyses, not in the ECMWF analyses. In all places of the aircraft data sampling, figures of the paper show that an intrinsic property of the RDF technique is to tighten the potential vorticity gradient at the tropopause. Accordingly, the results are not sensitive to the RPV threshold that is chosen in the range 2 to 4 pvu. The reason for which not much indication is given in this work about how much the PV changes comes from the lack of realism, with regard to the meso-scale, of the potential vorticity field deduced from ECMWF analyses. At flight altitudes close to the the tropopause level, all PV values range from 2 to 4 pvu (see the solid line on Fig. 5 bottom) and are not informative with regards to the origin of air masses. [Exceptions are for flight sections S1, S2 and S3 where PV in excess of 4 pvu clearly indicates a lowermost stratospheric origin.] The use of the Lagrangian RDF technique aims at offseting this lack of realism on the basis of the potential vorticity conservation along the back-trajectories, which prevents from investigating PV changes for parcels

ACPD

5, S5603–S5608, 2005

involved in STE. The modelling of this case study would be a proper way to compute the PV changes that come with stratosphere-to-troposphere transport, but this was out of the scope of the present study.

It is claimed that this work is important since it examines a summertime case. However, a direct comparison of how this case is similar to or differs from wintertime case studies should be discussed.

Reply: We agree. Elements of the following discussion have been added in revised version of the paper. The mechanisms of upper-level frontogenesis leading to the stratosphere-troposphere transport are the same for either summertime or wintertime cyclones. However, net stratosphere-troposphere exchange in a summertime cyclone is less than in a wintertime cyclone because summertime cyclones are typically weaker and because there is less ozone in the lowermost stratosphere during summer. As summertime cyclones generally track further north than wintertime cyclones, STE exchanges then take place further north during summer. Another difference between summer and winter STE comes from the role of deep convection. The discussion on the origin of group 3 suggests that deep frontal convection offers other pathways than the ones evidenced with relative flows on isentropic surfaces (Danielsen et al., 1968) for stratospheric intrusions to be irreversibly mixed in the upper troposphere. Such a difficulty to identify the origin of ozone in the troposphere further reduces the accuracy of the tropospheric ozone budget for summertime cyclones Other case studies and modelling work on the role of deep convection on the fate of stratospheric summertime intrusions will be needed to further reduce the uncertainty on the relative contributions of the net photochemical production and the stratospheric source in tropospheric ozone budget studies.

ACPD

5, S5603–S5608, 2005

Interactive Comment

Minor Issues:

P12467, L5: "...apparently..." Was the Assessment uncertain or the authors of this work?

Reply: The stratospheric source was the driving force of the tropospheric ozone budget for the models participating to this assessment exercise. Large variations of this source in individual modelling components made the assessment uncertain. We have removed the word "apparently" in the sentence.

P12467, L11-12: "...inferred input term..." It is usually only inferred in tropospheric models. Many STE and budget studies have been done with stratospheric models and now combined models are becoming more prevalent.

Reply: Ok, the second part of the sentence has been removed and becomes: "Still, the stratospheric source has a large standard deviation".

Section 2.1: The lengthy presentation of the "synoptic situation" is almost de rigueur for these case studies. While obviously a description of the event is needed, there is much that is not needed in the context of this work. For instance, such extensive descriptions of the cloud structures are not required to obtain the results presented. Much of that is easily seen in the figures.

Reply: Section 2.1 has been shortened by removing superfluous comments

P12471, L18: It would be much easier for the reader if the airpath was also shown on at least one of the panels of figure 2.

Reply: A flight track has been added on figure 2c.

P12475, L26-28: Is it possible that the high ozone measurements might be of tropospheric origin?

ACPD

5, S5603–S5608, 2005

Interactive Comment

Reply: We do not think a purely tropospheric origin is possible for group 3. The double constraint on high (low) volume mixing ratios of O3 (CO) prevents to refer to a polluted air mass. A mixing with stratospheric origin air is very likely.

Figures:

Many of the figures are hard to read due to their size. In particular, figures 1 and 7 would benefit from a slight size increase. Reply: Size increase of fig. 1 and 7 have been proposed through the latex file to the journal editor.

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found myself wanting to compare figure 1 with figure 2a but they are not at the same time. Is the NCEP analysis available at 17 July 12:00 UTC? That should be used in figure 1b for this comparison. This is also much closer to the time of the MOZAIC flight as shown in Figure 5.

Reply: We agree. Fig. 1b now shows the NCEP surface analysis superposed on the satellite image.

Figure 3: Please indicate the overunning dry air is shown within the green dashed line.

Reply: Caption has been changed for this indication.

Figure 5: Caption should indicate that the flight time progresses from right to left.

Reply: Caption has been changed

Figure 6: Please label axes.

ACPD

5, S5603–S5608, 2005

Reply: Axes are labelled.

Figure 7: Once again could benefit from increased size. It is impossible to read the color bar labels.

Reply: Size increase of fig. 7 has been proposed through the latex file to the journal editor.

Technical Issues:

Some grammer and spelling need to be addressed. A few examples are given below.

P12466, L17: prevents to identify -> prevents identification

Reply: Corrected

P12466, L23-26+: This sentence is very cumbersome.

Reply: The new sentence is: An accurate knowledge of transport processes is of great importance for budgets of trace gas in global chemistry-transport models (CTMs). These models are the tools used to quantify the tropospheric ozone budget and to provide information to policy makers.

P12467, L7: od -> of

Reply: Corrected

P12468, L9-10: This sentence isn't needed. It sounds like it was accidentally left from a previous version!

Reply: We agree. It has been removed.

Interactive comment on Atmos. Chem. Phys. Discuss., 5, 12465, 2005.