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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Transport mechanisms for synoptic, seasonal and interannual SF_6 variations in troposphere" *by* P. K. Patra et al.

P. K. Patra et al.

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We thank the reviewer for appreciating the work presented in the article. Below we have provided replies to the comments.

On the first important point:
We plan to modify Figure 4 by replacing Potential Temperature (Θ) contours by Age, and show Θ plus altitude as a reference on seperate panels.
Generally, the SF_6 distribution also shows large merdional gradients around the mixing barriers in the lower-middle troposphere ($\Theta <\sim$ 360 K), where age is yonger than $\sim$30 days. The major differences between the age and SF_6 distributions are due to the location of emission regions: for the age tracer it is in the tropics and for SF_6 it is in NH mid- and high latitude. In the mid- and high latitudes regions of the upper

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troposphere the age and SF_6 isopleths are parallel to each other, indicating their transport similarities away from the source region (age older than $\sim$100 days).

On the second important point:
The model-observation mismatches in April are mainly caused by the variability in the Samoa (SMO) site data. This site is situated between the Inter-Tropical Convergence Zone (ITCZ) and South-Pacific Convergence Zone (SPCZ) and is significantly influenced by El-Nino Southern Oscillation (ENSO)-induced transport variability. For instance, we find smallest dC_s/dt values at SMO during 2001 and 2002 April, which is coincident with a period of sharp increase in Multivariate ENSO Index (MEI).
If we omit the such anomalies in our averaging calculation, the inter-hemispheric exchange time comes out as 2.7, 2.1 and 1.8 years based on observations for Case 1, 2 and 3, respectively; and those based on the model are 2.3, 1.6 and 1.5 years, respectively. The low concentration during El Niño events results from more southeasterly flow at the surface over SMO, because the SPCZ shifts northwards (Hartley and Black, GRL, 1995).
We plan to add this discussion in the revised version.

Replies (starting with 'Reply') to the Specific Comments (starting with 'Comment'):

Comment:
Section 2.3 - What was the length of the mean age simulation?
Reply:
Since 1960 - this sentence will be added to the revised ms. "Simulation of all the tracers was started on 01 January 1960, and analysis presented here corresponds to the period of continuous SF6 observations."

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Comment:
Section 3.1 - Figures 2 and 3 are very low resolution and very difficult to read.
Reply:
This problem is caused during the ACPD/EGU processing. We have provided EPS formatted files for all figures. We will pay special attention to this in the next phase of publication.

Comment:
Section 3.2 - There is not enough contrast between the color contours on the lower half of the scale in Figure 3. This makes it hard to see the large age gradients that indicate mixing barriers. Again, there is no discussion of how the features in the age distribution affect SF6 transport. Since there are no vertical profiles of SF6 presented for direct comparison, this should probably be done as part of the discussion in Sections 3.4 and 3.5.
Reply:
In the revised plot (see our reply to the first important point), we have used blue-red colour scale for better clarity. Also we have employed slightly different contour intervals for closer contour intervals, in particular below an age of 20 days.
The SF6 transport will be discussed along with the age of air in this section, for the reader's convenience. For this purpose the sub-section title will be changed to "Mean 'age of air' in troposphere and its relation to tracer transport"

Comment:
Section 3.3, P. 12749 lines 23-27 and P. 12750 lines 24-28 - Case 5 clearly has larger seasonal variability than Case 2 and is closer to the observed variability using the station data for Case 2. The transport component analysis could be used to diagnose the reason for the low variability in the exchange time seen in the model for these stations, and included as part of the discussion in Section 3.5.

Reply:
We hope we understood your point correctly here.
First of all, we would like to stress that it may not be fair to compare Case 2 (based on mixing ratio at 4 sites) and Case 5 (based on hemispheric mass). That is the reason why we have shown the results in two seperate panels in the ACPD paper.
On the other hand, the difference between Case 2 and Case 4 is not significant - a point which we wanted to make here.
We apologise if the use of two different y-axis ranges and unclear definition of the Cases led to this comment. We will insert the following text into the figure caption: ‘Note the difference between the two y-axis scales’. In addition, all 5 cases will be identified in the legends. The transport component analysis is unlikely to isolate specific sources of difference between Case 2 and Case 4.

Comment:
Section 3.4, P. 12751 lines 22-24 The height limit for convection should be explicitly tied to the gradient in mean age.
Reply:
The average height limit for convection is located around 14 km, coinciding with the occurrence of largest age gradient ($>$25 day/km) below the tropical tropopause (altitude range of 14-16 km).
We plan to add a sentence to this effect in the revision.

Comment:
Section 3.4, P. 12752 lines 19-27 How does the meridional advection relate to the mixing barriers diagnosed by the age tracer?
Reply:
The location of mixing barriers, particularly over the NH, determine the intensity of meridional tracer advection. When the NH mixing barrier is located at about 15^{o}N

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during January (at the downwelling branch of the Hadley circulation), we find weakest transfer of mass across the Equator. In fact, the strong subsidence leads to reduction (enhancement) of high SF_6 in the upper (lower) troposphere. The situation is opposite during July, when the NH mixing barrier is located over 40^oN (the region of strongest SF_6 emission). The upwelling branch of the Hadley circulation (between 0-25^oN latitude) transfers SF_6 rich air to the upper troposphere from lower troposphere, which is then transported to the SH by the meriodional branch of the Hadley cell in the height range of 150-250 mb.

Comment:
Technical Comments: P. 12742, lines 27,28 - the description of the decomposition of the time series is somewhat confusing because the minus signs are indistinguishable from the hyphens. The authors may consider substituting the word "minus" for "-".
Reply:
It looks fine in our LaTeX output. We will determine at the final ACP typesetting whether the use of $-$ or 'minus' is preferred.

Comment:
P. 12750, line 28 - "Timming" should be corrected and "are" should be inserted in "maxima altered".
Reply:
This correction will be made in the revised version.

Comment:
Supplement, Line 31 - Should read "shows a comparison of".
Reply:
This correction will be made in the revised version.

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Interactive comment on Atmos. Chem. Phys. Discuss., 8, 12737, 2008.

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