

## ***Interactive comment on “Global distribution of mean age of stratospheric air from MIPAS SF<sub>6</sub> measurements” by G. P. Stiller et al.***

### **Anonymous Referee #3**

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### Summary and General Comments

This paper reports a new, less biased retrieval of SF<sub>6</sub> observations from the MIPAS instrument on Envisat for the period Sept 2002 to March 2004. The new retrieval method is discussed in detail, with further elaboration in an appendix; comparisons for the sake of validation are made with ground-based and balloon observations. The KASIMA model is used to demonstrate that mesospheric loss processes are essential for correct interpretation of stratospheric air derived from the SF<sub>6</sub> measurements. The SF<sub>6</sub> observations are used to identify episodes of descent of mesospheric air in to the polar vortices in winter.

The paper contains valuable new measurements of SF<sub>6</sub> which give us 'observations' of

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stratospheric age. The comparison with the model is also important for demonstrating the importance of losses and thus in the calculation of the correct age of air. A considerable fraction of the paper is spent discussing the details of the retrieval. I suppose it is important to document this, but it may not be that interesting for many readers. The authors frequently interpret their 1.5 year data set in terms of trends and interannual variability. This data set is far too short for such interpretation and those aspects of the paper need to be eliminated or modified.

While I think it is very useful, especially to the chemistry-climate modeling community, to have empirical age of air for the entire stratosphere, I rather dislike that the figures are nearly always of 'apparent' mean age rather than the true age calculated when the mesospheric loss is included. Someone skimming this paper may come away thinking that stratospheric high latitude age is much greater than it really is. This aspect may not be something you want to change, but I think this paper would serve its readers better with an emphasis on true age rather than apparent age.

This paper makes a valuable contribution and should be published after revisions.

#### Specific Comments

p. 13656, lines 24-26. Since the MIPAS retrievals do not go below 6 km, how is it possible to compare with ground-based measurements? Are you comparing the lowest MIPAS measurements (~6-9 km kernel?) with ground data? If so, please state so explicitly and comment on the validity of comparing boundary layer and mid-tropospheric observations.

p. 13662, all of Section 3.2: This section talks about a CO retrieval using CO<sub>2</sub> non-LTE modeling and the implications for the SF<sub>6</sub> retrieval. This is implied but not stated and led to confusion the first few times I read this. The paragraph from line 8-14 never actually refers to SF<sub>6</sub>, but in talking about biases of pptv you must be referring to SF<sub>6</sub>. Please be clear here. This will make it much easier to follow your argument about low biases in SF<sub>6</sub> leading to high biased aged, and vice-versa.

p. 13664, beginning of Section 5. In two preceding sections, 2 different biases are discussed, one of which is corrected for (the one caused by oscillations) and the other which is not (the one requiring a full non-LTE calculation). However, this section begins with the statement 'Global distributions of SF6 on basis of bias-corrected data have been derived...'. This is misleading because the data are not fully bias corrected. Please acknowledge this here and be clear about what has not been corrected at this time.

p. 13664, Figure 6. I find it hard to extract useful information from this figure. The information on seasonal and latitudinal variation that you wish to convey is already contained in Figure 8. Figure 6 can be eliminated.

p. 13664, lines 18-20. Just to be clear, the MIPAS-derived trend is a mid or free tropospheric trend, correct?

p. 13665, lines 6-8. This statement that the MIPAS-derived trend has been used to convert SF6 into mean age cannot be completely true. To get stratospheric ages of 10-12 years requires 10-12 years of tropospheric measurement. Since the MIPAS dataset is only 1.5 years, you must be relying on 1) the ground measurements, or 2) the assumption that MIPAS SF6 trends are perfectly linear going back at least 10 years. I think this should be clarified and I think it would be useful to include 10-12 years of SF6 surface data in Figure 7 so the reader to see how linear the data actually are.

p. 13665, l. 15: In contrast to the statement about tropical ascent being greatest in summer, the greatest tropical ascent by the Brewer-Dobson circulation occurs during northern winter. This figure shows relatively low SF6 in the tropical middle stratosphere in summer; could this be an effect of the QBO circulation?

p. 13665, l. 19: What point are you making when you say '...providing nearly mid-latitudinal conditions in the polar region'? Are you referring to chemical composition? Certainly temperature and sunlight are not like the midlatitudes here.

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p. 13666, l. 23, interannual variation: This dataset has only 1 full SH winter and most of 2 NH winters. It is unreasonable to talk about interannual variability! You may point to differences between one year and the next, but you cannot draw conclusions about interannual variability. It is unreasonable to talk about 'increasing impact of mesospheric intrusions'; based on this scant data set. Do not forget that 2002 was an extremely anomalous winter/spring in the southern hemisphere, and thus to use 2002 as a baseline for comparisons would be wrong.

Figure 9: How would the uncorrected biases increase the uncertainties in these 3 mean age plots?

p. 13666, Figure 10. I like this figure even less than Figure 6: too busy, too hard to extract information. However, Figure 11 conveys much of this information in an easier-to-interpret format (the contour plots). I suggest you eliminate Fig. 10 and add 1 or 2 levels (say 900K and 1200K) to figure 11. This will better show the altitude, seasonal, and meridional variability.

p. 13668, l. 20: With such a short data set, there is no basis for commentary about whether something is unusual in the NH. A very interesting paper on the subject of interannual variability in mesospheric descent in the NH and SH, based on UARS data and using trajectory calculations, is Rosenfield and Schoeberl ("On the origin of polar vortex air", JGR 2001). Please check this out; it may help the discussion.

p. 13669, l.1: '...the mean age of air seems to increase with time'. Between the uncorrected bias and the short data set, it is too speculative to make such a statement. Please remove all statements about age trends and interannual variability from the discussion and conclusions.

p. 13670, l. 3: '...in the first case'. It would be clearer if you said which case you meant, for example, 'for the simulation with mesospheric loss,...'.

p. 13670, l, 26: here it says 'a potential bias of up to 1 year...', but earlier it was stated

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that above 35 km there were biases of 2 years. Please be consistent.

p. 13671, lines 25-27. It is not necessary to state the obvious, namely, that you cannot detect change in middle atmosphere circulation with a 1.5 year data set.

#### Language/grammar issues

Abstract, line 26: change 'considerable amount' to 'considerable degree'.

p. 13661, l. 4: 'Further contributing model parameter...'. Suggested rewording: Additional contributions to model parameter errors include uncertainties in...

p. 13661, l. 8: 'Other model parameter errors were found to be negligible.' Unnecessary statement and can be deleted.

p. 13663, l. 17: use 'Kiruna, Sweden'. North Sweden is not a country.

p. 13664, l. 2: Change 'on basis of' to 'using'.

p. 13664, lines 3-4: Change 'Figure 5 provides as an example' to 'Figure 5 shows...'

p. 13664, lines 9-10: change 'The SF6 vmr is decreasing both' to 'The SF6 vmr decreases...'. Also, remove the word 'traveling' from in front of time.

p. 13665, l. 17: Use 'both' polar vortices, not 'all'.

p. 13667, l. 11: unrealistically, not unrealistic.

p. 13667, l. 21: not 'severe' transport. Perhaps try strong or far-reaching.

p. 13673, lines 2-6: 'artifact' not 'artefact'. There might be other occurrences of this, including Fig. 16 caption.

p. 13673, l. 7: Change to 'correcting the affected...'

p. 13673, l. 10: I don't think 'equidistributed' is a word. Try equally distributed.

#### Figures

I know that the figures in ACPD are smaller than they would actually appear in ACP, however, there are some legends and labels in the figures that I think may be too small to be readable even in ACP. Please recheck all font sizes, especially for Figures 1, 2, 4, 9.

Fig. 1: There are more than 20 species in the legend (too small to read!) but no way are 20 species visible on the plot (bottom panel). Please reduce this list to match the figure and make the font larger.

Fig. 7: Thicker lines would be better.

Fig. 8: Month labels atop each panel would make this figure easier to understand at a glance.

Fig. 11: Same comment as above, but needs theta labels.

Fig. 12: Same comment as above, but needs latitude range labels.

Fig. 13: Same comment. Please title each plot for quicker understanding (e.g., 'MI-PAS', 'with SF6 Loss', 'without SF6 loss').

Fig. 15: The caption refers to a 2nd, 3rd, and 4th line but I only see one in the plot.

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