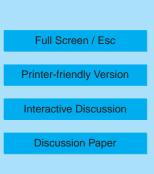**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "Global distribution of mean age of stratospheric air from MIPAS SF$_6$ measurements" *by* G. P. Stiller et al.

G. P. Stiller et al.

We would like to thank the referee for his/her suggestions which definitely help to improve the paper (referee comments included *in italics* for convenience).

General Comments: This paper presents a new global data set of SF$_6$ VMR profiles obtained from the MIPAS satellite instrument between September 2002 and March 2004. The data set has been validated against in situ measurements obtained with a balloon-borne whole- air sampler. The global distribution of the apparent mean age of air has been calculated from the MIPAS SF6 data and compared to results from the KASIMA chemical transport model to understand the impact of intrusions of mesospheric air into the stratospheric vortex on the age of air results. This work is appropriate for publication in ACP after revisions to address the comments below. The

paper provides important details on the retrieval process and bias corrections used to produce this new global SF$_6$ data set. The global age of air distributions from SF$_6$ are a useful contribution to the scientific literature.

Specific Comments:

Page 13663, Lines 6-10. Section 3.3 describes the bias due to imperfect gain calibration that has been corrected in the SF6 data set. It should be made very clear at the end of this section that subsequent references to "bias-corrected" data mean that the gain calibration correction has been made. (Maybe the term "gain bias correction" could be used.) It took a couple of readings of Sections 3.2 and 3.3 to figure that this is what the authors meant.

In order to make clear which bias has been corrected and which one not, we will add at the end of section 3.3 the following sentences: "For further use, daily and monthly zonally averaged SF$_6$ data have been corrected for the systematic contributions from the radiance baseline oscillations according to the method described in the Appendix. All daily and monthly averages of SF$_6$ vmrs and age-of air data presented in the following sections are corrected for the bias caused by the radiance baseline oscillations (called gain-bias in the following)."

Page 13665, Lines 3-9. I found the description of how the SF$_6$ results were converted into mean ages to be too short. I think that this section should be expanded to provide more detail on how the calculation was done.

The description will be extended and some discussion on the assumptions made will be provided. In response to the other referee's remark on the assumed linearity of the trend we will extend the time range of Fig. 7 to the period 1996 to 2006 in order to demonstrate that the NOAA/ESRL/GMD measurements indeed provide a fairly linear trend, and add some comments on this point. Further we will include the linear regression lines for the flask and in situ measurements, and the extrapolation to 1996 - 2006 of the quadratic growth function derived by Geller et al. (1997) for the period 1987 - 1996. We will add the following sentences to Section 6:

Interactive
Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

"The MIPAS-derived linear increase has been used to convert SF_6 global distributions into mean age of stratospheric air by assigning the SF_6 vmr difference observed in the troposphere and at some location in the stratosphere, respectively, to the time lag since the troposphere showed the mixing ratio measured in the stratosphere, according to the following linear relationship:

$$\text{age} = \text{t} - \text{t}_0 - \frac{SF_6 - a}{b} \qquad (1)$$

with t = time of the observation (in years), t_0 = 2002.0 (i.e. 1 January 2002), a = 4.89 pptv (the tropical tropospheric vmr on 1 January 2002 as derived from Fig. 7), b = 0.230 pptv/yr (the yearly tropical tropospheric increase as derived from Fig. 7).

By doing this we implicitly assume that the yearly increase of the tropical tropospheric SF_6 vmr as derived from MIPAS has remained linear and constant within the relevant period given by the actual ages observed in the atmosphere, i.e. for about 10 to 15 years. For about 8 years, this assumption is confirmed by the time series of ground-based NOAA/ESRL/GMD measurements covering the years 1996 to 2006, since the time series of the globally averaged SF_6 vmr is well consistent with a linear increase (see Fig. 7, dotted lines). For the period 1987-1996, Geller et al. (1997) found that the surface SF_6 increase was consistent with an overall quadratic growth rate, where the quadratic term, however, was rather small compared to the linear term (the coefficients are 0.0049 pptv/yr^2 (quadratic term) vs. 0.2376 pptv/yr (linear term)), while Maiss and Levin (1994) found Southern hemispheric SF_6 observations between 1970 and 1991 to be consistent with a purely quadratic increase described by $0.004763 \times (\text{t} - 1968.82)^2$. The extrapolation of the Geller et al. (1997) parameterization to the 1996-2006 period is shown for comparison in Fig. 7 as light-blue line. It is obvious that the yearly increase in the 1996 - 2006 period is smaller and more linear than the extrapolation from the previous 10 years. For the period 1987 - 1996, however, the extrapolation of the linear trends from MIPAS and NOAA/ESRL/GMD will overestimate the steepness of the SF_6 increase, introducing a systematic error into

the age-of-air assessment from these trends. If we assume that the SF_6 increase is described well by the quadratic prameterization derived by Geller et al. (1997) for the period 1987-1996 and by the MIPAS-derived linear increase since 1996, and we use the MIPAS-derived linear increase for age-of-air assessment for ages between 6 and 15 years, we underestimate the inferred ages by at most 1.2 years, i.e. for 15 year old air the MIPAS linear increase would provide an age of 13.8 years. If we correct the Geller et al. growth parameterization by an additive term of +0.14 pptv in order to better match the most recent NOAA/ESRL/GMD global mean flask data of 1 Jan 1996 (3.58 pptv, from the regression line), we estimate that the MIPAS linear trend will underestimate the inferred ages even by up to 1.7 years (for 15 years of "real" age). However, one should keep in mind that SF_6-derived ages higher than 6 to 8 years have been observed within polar vortices only; the respective low SF_6 vmrs are due to intrusions of mesospheric air which had undergone mesospheric SF_6 loss processes (see Section 7.3); the assessment of real age of air from these SF_6 observations suffers from further uncertainties like the details of mesospheric loss modelling in chemistry transport models.

We used the MIPAS-derived increase instead the NOAA/ESRL/GMD trend in order to account for the small additive bias between MIPAS and the ground-based measure-ments which is apparent by the vertical shift of the MIPAS regression line (red solid line in Fig. 7) versus the NOAA/ESRL/GMD global mean time series (middle green and violet solid lines and dotted regression lines in Fig. 7)."

Section 7.2. The discussion of interannual variability and seasonal variation is quite difficult given the relatively short time period of the MIPAS observations (less than 2 years). I think that the authors should clarify this section by talking about differences within their specific data set.

We tried to be careful in the original version not to give the impression that we deduce long-term trends or climatological variabilities from the 19-months MIPAS data set. In the revised version we will take even more care to talk about differences between

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

EGU

years, seasons, or hemispheres, and not to indicate any conclusions on climatological variability or even trends.

Technical Corrections: Page 13658, Lines 11-2. It appears that the acronym KOPRA does not match the name given. I thought that it was the "Karlsruhe Optimized and Precise Radiative transfer Algorithm".
The referee is right. Thank you for pointing this out.

Page 13660, Lines 25-26. Has an "all-zero ﬂat a priori profile" been used SF_6 in the retrieval? This does not correspond to the "first guess profile" shown in Figure 2. This should be clarified.
In our retrieval set-up the a-priori profile and the initial guess profile are not identical. The MIPAS a priori profiles are flat all zero profiles, and they act, along with the first order differences regularization operator, only as a smoothing constraint. Since we iterate until convergence is achieved, the initial guess profiles chosen as starting point (which in our retrieval are distinct from the a priori profiles) have no influence on the result. We will clarify this point in the paper.

Page 13660, Line 9. The abbreviation vmrs has already been defined and should be used consistently.
"pseudo-vmr" will be changed to "vmrs".

Page 13661, Line 14. In the line "...which contributes with approximately 5"
We don't understand what the referee means here; maybe part of the sentence is missing?

Page 13663, Line 17. "Kiruna, Sweden" should be used.
Page 13664, Line 1. "using" should be used in place of "on basis of".

Interactive
Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

EGU

Page 13664, Line 22-24. The acronym NOAA/ESRL/GMD has already been defined for this name and should be used consistently.
Page 13666, Line 12. "a ges" should be "ages".
Page 13668, Footnote 1. "stratospshere" should be "stratosphere".
Page 13669, Line 15. "w e" should be "we"
Page 13669, Lines 15-16. The captialization of "KArlsruhe SImulation model of the Middle Atmosphere" should be used to explain the abbreviation better.
Page 13673, Line 7. "...restrict ourselves to correcting..."
Page 13673, Line 10. "Equally distributed" should be used in place of "equidistributed".
All these technical corrections will be applied in the revised version.

Fig. 1, 2, 4, 9, and 13. The font seems very small and the readability of the plots would be improved if the font size could be increased.
This will be done.

Fig. 3. It is unclear from the caption how the relative differences were calculated. Is it relative to the standard retrieval?
This information will be added to the caption. Percentage differences are given relative to the retrieval which fully considers CO_2 non-LTE emissions which is considered as the reference, i.e. (non-LTE - standard)/ non-LTE is shown.

Fig. 7. Green traces are quite faint. The line thickness should be increased to make these more visible.
This will be improved.

References

Geller, L.S., Elkins, J.W., Lobert, J.M., Clarke, A.D., Hurst, D.F., Butler, J.H., and Meyers, R.C., Tropospheric SF_6: Observed latitudinal distributions and trends, derived emissions and interhemispheric exchange time, Geophys. Res. Lett., 24, 6, 675-678,

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

1997.

Maiss, M., and Levin, I., Global increase of SF_6 observed in the atmosphere, Geophys. Res. Lett., 21, 569-572, 1994.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 13653, 2007.

Interactive
Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

EGU