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Atmospheric Measurement Techniques Discussions

Interactive comment on "MIPAS IMK/IAA CFC-11 (CCl_3F) and CFC-12 (CCl_2F_2) measurements: accuracy, precision and long-term stability" *by* E. Eckert et al.

Anonymous Referee #2

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The paper describes the validation of MIPAS IMK /IAA CFC-11 and CFC-12 measurements with respect to other satellite measurements (ACE, HIRDLS and ILAS) and measurements from balloon borne instruments (Cryosampler, Mark IV, MIPAS-balloon), stratospheric aircraft (MIPAS-STR) and ground based instruments (Halocarbon and other atmospheric trace species (HATS)). Measurements of the two species are validated distinguishing between the two phases of MIPAS mission, the so-called Full Resolution and Optimised Resolution phases. The paper is very long, since it describes, in the case of some balloon borne measurements, separately the comparison of the MIPAS collocated measurements for the different flights of these instruments. But then

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in general it lacks of a global discussion of all results of comparison aimed to quantify MIPAS bias with respect to all correlative measurements in the two different phases of MIPAS mission.

Furthermore, some comparisons are only qualitative, while it would be very useful to quantify the differences and to compare them with the ones relative to other instruments. In particular for the Cryosampler instrument, that is known to be characterized by an accuracy significantly better than MIPAS, no plot of the mean difference is reported.

An attempt of characterizing precision of the measurements is performed, but not all contributing errors to the random error have been included in the error budget and comparison of the retrieval error with the standard deviation of the differences does not provide determined results since atmospheric variability may contribute and it is difficult to quantify.

The study of the temporal drift on the measurements induced by time dependent non-linearities has been performed.

Given the importance of the study of CFCs for climate studies and studies on ozone hole recovery, the validation of these measurements is needed before using them for climate studies, but major revisions addressing a better characterization of the bias and of the precision in the two phases are needed before publishing the paper.

General comments

1)The title mentions the characterization of accuracy, precision and long term stability of CFC-11 and CFC-12 measurements. Actually, the characterization of the precision is not adequate (see below) and also the bias is not always quantified. It would be probably better just to mention the validation of CFC-11 and CFC-12 measurements and its long term stability.

2) Concerning the characterization of the bias between MIPAS and correlative mea-

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surements, for some instruments only the qualitative agreement between MIPAS and correlative measurements is evaluated, and in general no effort has been done for summarizing the results coming from the comparison of the different instruments. Furthermore no mention is done of the estimated systematic errors of both MIPAS and correlative measurements that would help to understand if the detected bias can be explained by their estimation.

3) Concerning the characterization of precision, only the retrieval error is considered, but this error, as written in the paper, is not the only contribution to the random error. The authors generally come to the conclusion that the retrieval error is an underestimation of the random error, if compared with the standard deviation of the differences, and this is due also to the fact that atmospheric variability, that is difficult to quantify, contributes to the standard deviation of the differences. More accurate methods are available in the literature that allow to estimate the precision (see for example Piccolo and Dudhia, ACP(2007)).

4) In Kelmann et al., ACP (2012) it is said that a discontinuity is present for both CFC-11 and CFC-12 at same altitudes between the two phases of MIPAS mission, as expected due to the different spectral and vertical resolution. Here this discussion is completely missing, while it would be very important to quantify possible biases between MIPAS measurements in the two phases. Without this discussion, the need of distinguishing between the two phases is hard to be justified.

5) In general, it is not sufficient to see if the agreement between MIPAS on ENVISAT and the correlative measurements is good, excellent or bad, it is needed to know how small is the bias at the different altitudes.

6) Sect. 4.1.1 The Cryosampler instrument is known to be characterized by an accuracy significantly better than the MIPAS one. The different flights are discussed separately and no plots of the differences are reported. Instead, it would be useful to provide plots containing the mean of the differences of all collocated measurements

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of the different flights of this instrument. This would allow to quantify the bias of MIPAS measurements with respect to measurements of this instrument at the different altitudes in both the phases.

Specific comments

Introduction: This Section is very long, but it is mainly focused on the importance of measuring CFCs and only hints to the problems of validation, availability of other data, previous validation. Probably it should be mentioned the paper by Engel et al., Long term validation of ESA operational retrieval (version 6.0), AMTD, validating four species including CFC-11 and CFC-12 from MIPAS ESA processor with Cryosampler measurements.

Line 13, pag. 7578 I would add that the fact that 'more scans in the vertical are performed per profile in the RR period' leads to an improved vertical resolution.

Sect.2.1 Line 8, pag. 7579: It is said that MIPAS spectral resolution in the first phase of measurements (until March 2004) is 0.035 cm-1, while it is 0.0625 cm-1 in the second phase. Actually, 0.035 cm-1 is the FWHM of the Instrument Line shape (ILS) in the full resolution phase, while 0.0625 cm-1 is the distance between two consecutive nodes of the ILS (or the spectral sampling) in the second phase of the mission(1/(2 MPD), with MPD being the Maximum Path Difference of the interferometer, equal to 20 cm in the FR phase and to 8 cm in the second phase). I suggest to use the same approach to define the spectral resolution in the two cases, i.e. the spectral sampling: 0.025 cm-1 for the FR phase and 0.0625 cm-1 for the Optimized resolution one.

Line 11, pag. 7579 The second phase of MIPAS measurements starting in January 2005 is mentioned in the paper as 'Reduced Resolution' (RR) phase, while MIPAS Quality Working Group agreed to call it 'Optimized Resolution' phase. Indeed, the discontinuity in MIPAS measurements that occurred in January 2005 does not involve only a change in the spectral resolution, but also a change in the vertical and horizontal resolution. The reduction in the measurement time due to the lower spectral resolution

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was exploited to perform more measurements both in the vertical and in the horizontal domain. This change allowed to obtain, at least for the original target species, an optimized compromise between spectral and spatial resolution. It is recommended to change Reduced Resolution (RR) to Optimised Resolution (OR) in all sections of the paper.

Sect. 2.2.3 L.11: It is said that the spectral resolution of MIPAS balloon is equivalent to the satellite version: considering that the spectral resolution is different in the two phases of MIPAS on ENVISAT mission, I would recommend to write explicitly the spectral resolution of MIPAS balloon instrument.

Line 18 You should also cite Arnone, E., Castelli, E., Papandrea, E., Carlotti, M., and Dinelli, B. M.: Extreme ozone depletion in the 2010–2011 Arctic winter stratosphere as observed by MIPAS/ENVISAT using a 2-D tomographic approach, Atmos. Chem. Phys., 12, 9149-9165, doi:10.5194/acp-12-9149-2012, 2012.

Sects. 4.2.1, 4.5.1 It would be useful to have the plots of the mean differences, including all collocations of the two flights, together with the standard deviation of the mean.

Sect. 4.1.3 Why are the results of the two flights not combined in order to reduce the effect of random errors and to have a clearer determination of the bias? Probably you want to distinguish between different latitudes, but since results are very similar, the combination of all collocated differences would allow to reduce the random error. Why are systematic errors of the two instruments not shown? They could be compared with the detected bias between the two instruments!

Sect. 4.1.6 Line 5: what does it mean that 'the ACE-FTS errors were estimated directly from the fit residuals'?

Line 8, pag. 7600. 'The drift estimate due to the detector aging is only based on drifts between 35°N and 35°N DUE TO THE LACK OF DATA?. It is not clear

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what 'lack of data' means. Actually, the full mission L1 dataset was released on the 22nd of May 2015 (https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/envisat/news/-/article/envisat-mipas-level-1b-dataset-processed-with-ipf-version-7-11-is-available), so the full mission L1 data with Non-linearity correction were available for the comparison with L1 V5 without this correction. Or do the authors refer to the particular orbits provided for the study of the drifts?

Last sentence: 'The agreement between MkIV and MIPAS is similarly good for FR and OR': I think we can learn more from these comparisons. For OR measurements MkIV is larger than MIPAS (and it is said that MkIV has a positive bias), for FR measurements MkIV is generally smaller than MIPAS. If MkIV can be considered a stable instrument, I think that this is a clear indication of a discontinuity between FR and OR CFC-11 (as also asserted by Kelmann et al., ACP, 2012)

Sect. 4.2.4 Line 23: 'Even though all values of the HATS measurements lie within the standard deviation of the MIPAS ENVISAT measurements': actually most of the HATS measurements are outside the standard deviation of MIPAS measurements. Please clarify.

Sect 4.3 I partly agree with the conclusions reported in this section. First of all it is not easy to extract numbers from the two maps, and a map where the ratio between drift and trend is reported would help. Surely the estimation of the instrumental drift is done only for altitude regions where the CFC-11 relative trend is the lowest, less than 10%, while the drift estimation is not smaller than 1%. Furthermore, the error in the trend estimation is surely larger than 10% in these regions. For the regions where the trend is larger, there is no estimation of the drift. And the instrumental drift is expected to be altitude dependent. In summary, the correction in the trend due to the drift is not negligible where the drift has been measured, nothing can be said in the regions where the drift has not been measured.

Sect 4.4.1 See comment done for Sect. 4.1.1

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Sect 4.4.3 See comment done for Sect. 4.1.3

Sect. 4.4.6 Should the bump at the upper end of the profile be reduced if the mean of the profiles was computed weighting each profile with cosine of latitude?

Sect. 4.4.7 Line 2, pag. 7613 : due to lack of data: see comment relative to Sect. 4.1.6

Sect. 4.5.1 I would highlight the common features in the results with ACE and HIRLDS, positive bias of MIPAS below 18 km, negative bias above.

Sect. 5 Summary and conclusions A discussions on the MIPAS bias with respect to the different instruments at the different altitudes, trying to find the common features and comparison between FR and OR measurements is missing. In Kelmann et al., ACP, 2012 it is said that a discontinuity is present for both species at same altitudes. Here this discussion is completely missing, even if this would justify the need of distinguishing between the two phases.

Technical corrections

Sect. 2.2.4 L.3 of pag. 7584: 'The shown 1-sigma error of the MIPAS-STR'. Where is it shown?

Sect. 4.1.5 Line 14, pag. 7596: please write that the combined error is reported in the left panel.

Sect. 4.2.1: Line 3, pag. 7601: MkIV measurements is represented by the 'black' curve.

Sect. 4.2.2. Lines 25-26: I guess that you refer to the standard error of the mean, not to the standard error of the differences. The sentence starting with 'Even though ...' is very confusing, please make it clearer.

Sect. 4.1.4 line 2, pag. 7595: 'showing minimum values around 16-17 km ..'. Please specify: minimum values in the differences

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Sect 4.4.3 Line 26-27: probably you should write ' standard deviation of the mean 'instead of standard deviation of the differences.

See Sect. 4.1.2 The reference to Fig. 28 is missing.

Sect. 4.5.4 Line 12, pag. 7615: please replace: 'at an order' with 'of the order'.

Sect. 4.6 Line 1, pag. 7615 Please remove the comma.

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 7573, 2015.