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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Envisat MIPAS measurements of CFC-11: retrieval, validation, and climatology" *by* L. Hoffmann et al.

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"Envisat MIPAS measurements of CFC-11: retrieval, validation and climatology" Hoffmann et al, ACPD 2008.

General Comments

The paper describes a new retrieval technique for analysing MIPAS spectra based on (a) using a spectrally-averaged radiance, effectively synthesising a filter radiometer, and (b) using a band-averaged forward model, both of which represent significant differences from the approaches used by other groups (ie using measurements at their full spectral sampling and monochromatic forward models).

The advantage of such a technique is speed, although it is limited to molecules whose emission features dominate particular regions of the spectrum (ie those which could

also be retrieved using a filter radiometer). As presented here, it is applied to the retrieval of CFC-11 and relies on retrievals of pressure, temperature and the main absorbing molecules from the ESA operational retrievals. It is not clear whether the technique could be used as an alternative to the entire ESA retrieval, in which case the CPU saving could be significant, or whether it simply represents a faster technique for retrieving particular additional species, in which case the speed is less important.

While there is no reason to expect that this will be better than the conventional approach to retrieving CFC-11 from MIPAS spectra, the validation results presented show that it appears to be consistent at the 10% level with other measurements and retrievals.

This builds on earlier work by the same group (Hoffmann et al 2005), which describes a retrieval of both CFC-11 and CFC-12, but includes a more comprehensive error analysis and validation. However, by continuing to synthesise a simple broad-band filter from the MIPAS spectra using a box-car function, I feel that they have missed an opportunity in developing the theory further: better use could be made of the spectral resolution avaialable from MIPAS by constructing a "customised" filter, eg increasing the relative response to regions of the spectrum where the target molecule emission dominates and reducing it where interfering species dominate. Such an approach would have allowed better precision and accuracy, and extend the number of potential target species.

Specific Comments

1) Abstract should give vertical range over which statements relating to retrieval accuracy and a priori contributions apply.

2) Section 2: discusses MIPAS in the present tense. While some statements are appropriate, eg MIPAS still measures over the range 685-2410cm-1, other statements belong in the past tense, such as spectral resolution and those relating to the limb scanning sequence 6-68km. To make sense of this, it should be stated here that MIPAS is currently operating at a reduced resolution with a different scanning sequence. p4565, line 8:

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MIPAS is now operating continuously again, and hasn't been in "campaign-orientated" mode since Feb 2007.

3) Section 3 Retrieval of CFC abundance p4565, line 20: I wasn't aware of a CFC-11 band from 910-960cm-1, and nothing seems to be listed in the HITRAN database. If there were such a feature it might be promising for a retrieval since this generally a cleaner part of the atmospheric window than 800-885cm-1.

4) p4566, lines 10-14: The given percentages do not total 100% so what are they percentages of? There are several different ways in which the contributions of different absorbers can be defined (eg radiance of an atmosphere containing one absorber only, or change in radiance if one absorber is removed). What has been assumed here ? I would have liked to have seen a spectral plot showing the contributions of the different absorbers at some representative tangent height.

5) p4566 lines 26: are these S/N values (3.1-190) for the CFC-11 retrieval or the continuum retrieval? Presumably CFC-11 is also retrieved from the "continuum" window but it's not clear from what has been written.

6) p4567/68 Data pre-processing Apodisation and spectral averaging are both linear processes, ie the end product, spectrally averaged radiance over a microwindow, is a linear function of the set of (unapodised) L1B radiances within the microwindow. I don't understand why each points has to be apodised, rather than simply applying a trapezoidal-like function to the raw spectra which is (a) much faster and (b) mathematically identical. See also comment (11).

7) p4568/4569 Optimal Estimation Retrieval For those not familiar with OE, some equations would be clearer than attempting to explain in words. Similarly for the discussion of correlation lengths in covariance matrices (p4569 line 8).

8) p4569 lines 12-17: strictly speaking, most of these terms are errors in the forward model parameters rather than in the measurements, but are conveniently combined

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into the "measurement" covariance matrix.

9) p4569 line 18: "A priori atmospheric state". "A Priori" is conventionally used to refer to parameters which are then retrieved, and therefore also have a different "a posteriori" value. However in this case it seems to be used to refer to both parameters which are retrieved (CFC-11 and aerosol) and those which remain fixed (ESA products, other species profiles). Similarly p4575 line 26: reference to Temperature as "a priori".

10) p4569 line 25: why did is climatological data used from just this limited set of atmospheres when Remedios also provides the MIPAS "initial guess" atmospheres conveniently divided into season and latitude?

11) p4570 line 22: In order to justify the 1/sqrt(n) scaling it is also assumed that the noise is uncorrelated between adjacent spectral points, from which it follows that it is also uncorrelated between different windows and different altitudes (as stated subsequently). This is a reasonable assumption for unapodized spectra and should also hold for simply-averaged apodised spectra.

12) p4570 line 28-29: Is there any justification for this 10cm-1 spectral correlation length? Since there are only two spectral windows it seems safer, and simpler, just to assume the worst case of no correlation. Vertical correlation is slightly more problematic, but if these really are calibration errors wouldn't they apply to all tangent altitudes (ie infinite vertical correlation length)?

13) p4571 line 17: Spectroscopic data - why 10km vertical correlation length? If it's basically a 3% uncertainty in the band strength shouldn't it be fully correlated at all altitudes and between both spectral windows? Ie this should translate directly to a 3% uncertainty in the CFC-11 retrieval error.

14) p4571 There are significant errors (˜10%) associated with the ESA L2 estimates of H2O, HNO3, O3 etc - where are these? Given that O3 and HNO3, in particular, contribute ˜10s% to the radiance I'm surprised if these are minor.

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15) A more sophisticated representation of the measurement+forward model covariance matrix is used in this retrieval than elsewhere: usually just the random noise term is used. However I don't have any indication of whether the extra complication significant changes the mean value of the retrieved profiles. Was it necessary?

16) p4571 Smoothing Error: while it is no longer possible to use the a priori covariance to determine the smoothing error, it seems it should be possible to determine how the retrieval would smooth an atmosphere of the more appropriate CFC-11 a priori covariance matrix, hence determine the "correct" smoothing error, albeit not by the direct method.

17) p4572/73 Vertical Resolution: I wasn't aware of this definition of vertical resolution (most people use width of the averaging kernel functions) but it seems plausible, and a more easily-defined quantity.

18) p4573 Internal Quality Measures An equation defining chi2 would be clearer here.

19) p4574 line 3: "significance at the 0.1% confidence level" sound like a low degree of confidence in the significance. I guess what is meant is that a high-ish value of chi2 has been used that would be expected to exclude only 0.1% of data generated by purely random statistics.

20) p4574 lines 6-7: By the "chi2/m distribution for the initial guess" I assume that this means just the (y-f(a))ˆT Syˆ{-1} (y-f(a)) part of the chi2 function since the (x-a)ˆT Saˆ{-1} (x-a) component is identically zero? (an equation would have been clearer).

21) p4574 line 7: states that the final chi2/m distribution shows that the majority of the retrieval results are consistent, but consistent with what? If the a priori and measurement covariance distributions were correct I would expect a peak value of around 1, yet the peak appears to be between 0.3 and 0.4, suggesting that either or both of the covariance matrices are over-pessimistic. It is earlier stated that the a priori covariance is multiplied by a factor 3, so is this sufficient to explain the position of the peak assum-

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ing that the measurement covariance is accurate? A better test would be to evaluate the chi2/m statistic assuming the more realistic a priori covariance and see if the peak is indeed near 1.

22) p4574 lines 8-11: the number of iterations required for convergence is mentioned, but there is no mention of what convergence criterion has been used. Obviously the tighter the criterion the more iterations will be required.

23) p4574 OPERA: it is said that OPERA deals with average radiances, similar to this model, but doesn't this just refer to the OPERA inverse model? Is the difference that OPERA performs forward model calculations using spectral integration whereas this is a simpler band model?

24) p4574/75: it is stated that OPERA results agree within 2-3% but no plots are shown. How many scans were compared? Given the only similarity between the two models is the treatment of the measurements as an average radiance I am surprised that such a degree of similarity is obtained - I would expect at least as much discrepancy between the forward model calculations alone.

25) p4575 lines 22-24: In the text a systematic differences of +/- 6pptv is converted to a few percent "below 25km". However, with CFC-11 varying rapidly with altitude above 15km (from Fig.8) I would be more convinced if Fig 7 were plotted with a % scale on the x-axis instead of pptv. Similarly with the statement regarding statistical deviations (I assume this means "standard deviations"?) and p4576 line 9 "3.5% or less" systematic difference with the IMK data. For consistency, Figs 4 would also be better plotted with %error as the x-axis.

26) p4575 lines 25-29: A simple model of temperature error just assumes that the radiance error is proportional to the change in Planck function, ie of the order of 3%/K for these wavelengths and temperatures. So it is unlikely that a discrepancy larger than 3% can be explained by the difference in temperatures and, in any case, the shape of the temperature differences does not really resemble the mirror image of the shape

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of the CFC-11 differences. The temperature differences will obviously contribute, but I doubt if it is the major contribution here (again, having Fig 7(a) on a % x-axis would help).

27) p4578 line 10: the 6% difference (˜15pptv) compared with tropospheric values is within the systematic error budget of a single profile, but this error is largely composed of gain, temperature and pressure errors all of which would be expected to vary pseudo-randomly over the entire MIPAS dataset - these terms would be much reduced when discussing the systematic error budget of the dataset as a whole.

28) p4578 4.5 Comparison with ground measurements: There seems to be a single global tropospheric mean value being used for the comparison. Since one would expect the tropospheric concentrations to vary as a function of latitude, rather than compare the tropospheric values retrieved from individual latitude bands with this global average, it would make more sense to construct the equivalent global mean value from the retrieved dataset as a whole and just compare this number.

29) p4578 Latitudinal distribution The cited Remedios climatology consists of 6 latitude bands and 4 seasons. If the intention is to provide an update for this, why isn't the data classified in the same way? The 6 month averages for polar conditions seem particularly coarse.

Technical Corrections

p4564 line 4: French GUIANA

P4564 line 5: Envisat web-site (http://envisat.esa.int/category/index.cfm?fcategoryid=61) gives inclination as 98.55 deg, which is closer to 99 deg than the 98 deg quoted here.

p4565, line 12: by "permanent" I think you mean "routine".

p4568 line 6: "distance of the spectral windows" Since there are only two windows used, it might be clearer if you said "spectral separation between the two windows".

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