Atmos. Meas. Tech. Discuss., 6, C1625–C1629, 2013
www.atmos-meas-tech-discuss.net/6/C1625/2013/

Atmospheric Measurement Techniques Discussions

Interactive comment on "Ten years of MIPAS measurements with ESA Level 2 processor V6 – Part I: retrieval algorithm and diagnostics of the products" *by* P. Raspollini et al.

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Received and published: 15 July 2013

We thank referee #2 for the detailed reading of the paper and for his/her comments that surely have helped to improve the paper. Authors' replies are reported after each referee's comment.

>General comments >Please consider using less acronyms, perhaps spelling Gaussian Newton, Covariance >Matrix, Averaging Kernel, and Error Consistency.

The paper has been modified as suggested.

>Please explain the advantages / reasons more clearly for using the regularizing

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Interactive Discussion

Discussion Paper

>Levenberg-Marquadt method and then an a-posteriori regularization, rather than using just a regular Levenberg->Marquardt method with a smoothing term.

The standard Levenberg-Marquardt method (with final lambda equal to 0) with a fixed smoothing term inside the iterations was not adopted because, as described in the paper, it had to be applied to large set of profiles with variable noise error without direct user supervisor. The choice was for a self-adapting method that determines the regularization strength according to the error of the scan under consideration. In particular, the Error Consistency method determines the regularization strength imposing that the difference between the regularized and the un-regularized profile (i.e. the profile retrieved before the a posteriori regularization) is of the order of the error of the regularized profile. To this purpose, the un-regularized profile is needed before performing the regularization. The un-regularized profile is in turn obtained exploiting the regularizing effect of the Levenberg-Marquardt approach that is again self-adapting, since the Levenberg-Marquardt parameter is increased or reduced according to the increase or reduction of the chi-square at each iteration. The error-consistency method could also be used within the iterations, always combined with the regularizing Levenberg-Marquardt approach, and indeed this was tested, but this makes the retrieval more instable and the convergence slower.

In the revised paper, lines 17-22 at pag.478 has been replaced by: ' By application of the regularization after a preceding Levenberg-Marquardt retrieval , a completely self-adapting approach is possible that exploits the profile obtained by the regularizing Levenberg-Marquardt method to compute the retrieval error dependent regularization strength. A posteriori regularization was preferred to the use of the regularization within the iterations because the interaction of the two adaptive approaches (Levenberg-Marquardt and regularization with Error Consistency method) makes the retrieval more instable and the convergence slower.

>Consider adding synthetic retrievals to proof the validity of your negative VMRs or a >more in depth discussion.

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The theory of the retrieval does not foresee any constraint in the VMR. Furthermore negative values of the VMR within their retrieval error are physically acceptable. In the previous versions of the algorithm the constraint to the VMR to be non-negative was introduced only to avoid crashes in the program. In ML2PP V6 processor we have simply removed this constraint that may be responsible of a positive bias in the retrieved values of the profile when these are comparable with the random error.

We have made a comparison between the average of a statistically significant number of retrieved profiles of CH4 and N2O species at high altitudes obtained by two different versions of the ESA processor: IPF V4.1 (containing the constraint of non-negative VMR) and ML2PP V6 (without the constraint of non-negative VMR). The results are that the new version without the constraint of positive VMR has reduced the mean value of CH4 above 60 km and of N2O above 50 km of an amount comparable with the reported positive bias between MIPAS and ACE. This result has been reported in the revised paper.

>Specific Comments >p467 line 13: Why were the MW selected to get similar random and systematic errors >for the two phases of the mission rather than to decrease as much as possible the >random and systematic errors. Even if this led to different values between the phases >isn't that preferable?

We agree that the sentence in the paper is not appropriate, also because it does not correspond to what has really been done. The selected spectral points are chosen to minimize the total error. Random error decreases with increasing numbers of considered points whilst conversely the systematic errors might increase as the number of considered points increases. A compromise is adopted that minimizes the total error. In the revised paper the sentence 'In order to get similar random and systematic errors and computation time in the two phases' becomes 'In order to minimize the total error .....'

>p468 line 4: It is not clear if the NOM mode is the NOM mode for FR or OR, I would

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>make the distinction clearly. If the NOM mode described is the FR one, the boundaries >are 6 to 68 km.

The general scientific objectives of the different measurement modes described at the beginning of Sect. 2 are the same for the corresponding modes of both phases of the mission. This is now explained in the revised paper. Table 1 provides the details of the most used measurement modes in the two phases and now also the number of scans (see next comment).

>p468 line 22: The UA mode is the only mode where the number of scans is given. >Please provide the number of scans for the rest of the measurements.

Ok, see previous reply.

>p477: Doesn't the error consistency method implies a varying vertical resolution from >profile by profile?

It is true that the vertical resolution varies from profile to profile, but this applies to any regularizing retrieval scheme where any optimality criterion is applied to each single profile retrieval. In particular, the change of vertical resolution from profile to profile is also characteristic for the widely used "optimal estimation" scheme, and for the Tikhonov regularization scheme with fixed strength. The fact that in our retrieval the strength of the regularization is adapted to each scan according to its random error ensures that the relative weight of the measurements and the constraint in the cost function is maintained approximately constant, and hence the same relative regularization is applied even when the random error increases significantly for particular seasons and latitudes. As a consequence, the variation of the vertical resolution for different latitude bands and seasons is smaller than for other retrieval schemes. A figure has been added in Sect. 4.2 where the Ozone vertical resolution profile, averaged in the latitude band 65°S-90°S, is reported for the four seasons of year 2008. A very small variation of the vertical resolution is found also when a large seasonal variability is observed in the noise error.

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In Sect. 3.3 the following sentence has been added to the revised paper: " By ensuring that the relative weight of the measurements and the constraint in the cost function to be minimized is maintained approximately constant, the same relative regularization is applied even when the information content of the measurements changes significantly, with a consequent small variation of the vertical resolution."

>p479: Since no regularization is applied to the water vapor retrievals, is this data still >influenced by unphysical oscillations?

Yes, it is. This problem has been solved now and next version of the ESA processor will provide regularized profiles also for water vapor.

>p485 line 1 / 2: There is no introduction to the MIPAS bands, add a table with the five >bands (either in section 1 or 2) with their spectral range, measurement noise (for FR >and OR), and with the more abundant molecules measured / retrieved with each of >them.

This table has been added in Sect. 1 of the revised paper.

>p484: For completeness, add a brief description of how the systematic uncertainties >were computed.

This description has been added.

>Minor / technical comments The revised paper has been modified according to all referee's suggestions.

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 461, 2013.