Atmos. Chem. Phys. Discuss., 2, S607–S616, 2002
www.atmos-chem-phys.org/acpd/2/S607/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Application of the Spectral Structure Parameterization technique: retrieval of total water vapor columns from GOME" *by* R. Lang et al.

R. Lang et al.

Received and published: 14 November 2002

Here follows our response to some of the more specific and technical comments of referee #2 and how we addressed them in the revised version of the paper.

1. Response to additional comments by referee #2

1.1. GOME F_o measurements

The text has been modified to correct this point.

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1.2. Profile constraints

The definitions of 'low', 'medium', and 'high' refer to the *expected* WVC because no *a priori* columns are used. Therefore they are used for geolocations, where the WVC can be *expected* to be lower than 1×10^{22}, 1×10^{23} and 2×10^{23}. This results in three latitudinal regions for the northern and the southern hemisphere, as described in the APCD version of the paper. We added additional information on this point in the revised version.

1.3. Section 8

1.3.1. Paragraph 1 and 3

Section 8 of the paper (concerning the results of a single GOME pass) has been re-written to correct errors and provide a more lucid description of the OACS comparison. Although the referee suggests the inclusion of a schematic diagram in the form of an additional figure, and we agree that the original description of the track could have been misinterpreted, we feel that this GOME pass may now be visualized from the additional information we have provided in the text and from the additional figures provided (see 2.1 and 2.3 of author comments part#1).

1.3.2. Paragraph 2

See 1.3 of author comments part#1.

ACPD

2, S607–S616, 2002

1.3.3. Paragraph 4

See 1.2. SSP retrieves sub-column profiles and not total columns, meaning that the fit is multi-layered. The total WVC is calculated by summing up the sub-column values.

1.3.4. Figure 7

In the APCD version of the paper the figure caption states the exact definition of the residuals for both WVC and albedo (note the change of the sign). The plot also shows that they are very well correlated. From this it follows that "an underestimation of the surface albedo leads to an overestimation in the retrieved WVC" relative to the same OACS-derived quantities. In this case the values given by OACS are taken as a reference. In the revised version of the paper we added an appropriate sentence to clarify this latter point.

1.4. Section 9

1.4.1. Pt1

As stated above we used east, west and center GOME pixels. No backwards scanning pixel are used. Therefore there are three types of pixels. This results in the use of a total of 47000 GOME ground pixel when accounting for the data gaps.

1.4.2. Pt2

In the revised version of the paper we refer to the 'bias-corrected results'.

ACPD

2, S607–S616, 2002

1.4.3. Pt3

See 1.3 of author comments part#1.

1.4.4. Pt4

The additional references have been added according to the wishes of the referee.

1.5. Figure 8

1.5.1. Pt1

Most of the gaps in the global WVC coverage are a consequence of the 10% cloud-fraction limit imposed in our definition of 'cloud-free' pixels. We have added more clarity on this in the revised version of the paper.

1.5.2. Pt2

'Extrapolation' is, indeed, the appropriate term. The period was chosen due to the availability of ECMWF and OACS data, and the relative low cloud contamination of the single GOME pass, for which temporal overlap was also needed.

1.5.3. Pt3

See 1.2 and 2.3 of author comments part#1. We feel that calculating correlation coefficients for data tuples which have no temporal correlation is not very informative in

ACPD
2, S607–S616, 2002

terms of validating the data. Variations in the concentration of water vapor can occur at specific locations over relatively short times. For this reason we perform our comparison only for two GOME passes (SSP results and additional data for comparison of one of such passes is shown in Fig. 6 in the APCD version) which have both spatial *and* temporal overlap.

1.6. Figure 9

See 1.2 of author comments part#1. In the revised version of the paper we include a complete regression analysis stating Pearson's r number and the 95% confidence limits, as requested by the referee.

1.7. Section 10

1.7.1. Pt1

Indeed an error can be given related to the fitting uncertainties as explained in 2.1 and 1.1 of our author comment part#1. In the revised version this error has been added to the results for the single GOME pass, and discussed both in the text and in additional figures. However, we feel that it is very important to emphasize that no exact quantitative and qualitative conclusion can be drawn from such an systematic error for cloud affected retrievals. This is because the specific light paths in such cases are unknown.

ACPD

2, S607–S616, 2002

1.7.2. Pt2

There appears to be a misunderstanding regarding the cloud-cover fraction numbers and how they differ for different products. We wanted to emphasize that the differences are not relative but absolute. We have amended this in the revised version of the paper.

1.8. Section 11

1.8.1. Pt1

We corrected this in the revised version and make clear that this holds for all GOME retrievals.

1.8.2. Pt2

ECMWF data is expanded to yield global coverage using a data assimilation model *based* on partly ground measurements but also other sources. These ECMWF results are stated to be relevant for a specific time and day. For the *in time* correlation we refer explicitly to the single GOME pass and the scatter plot in the current version of the paper. Those possess a temporal overlap of $\pm$1 hour.

1.8.3. Pt3

When Pearson's r number is very close to 1 the correlation may be called *good*. By presenting Pearson's r numbers for the correlation in the revised version of the paper we will quantitatively support the more qualitative statement we made for the ACPD version, where we interpreted the gradients of the linear fits to the scatter data.

ACPD

2, S607–S616, 2002

2. Technical Corrections

2.1. General

The manuscript has been thoroughly rechecked for sentences which could be considered too long and, where appropriate, these have been fragmented. The words 'utilized' and 'respectively' have been amended in line with the authors comments. We checked the usage of the terms *optical thickness*, *optical depth* and *optical density* and revised the paper where their usage was not consistent with their textbook definitions .

2.2. Typographical errors, textual changes and clarifications

The majority of the points made by the referee have now been addressed. For brevity we only highlight certain points which we feel need further comment:

2.2.1. Pt 4

The intended meaning was that the radiative transfer method maybe called 'exact' for nonhomogeneous atmospheres and in cases where photons are reflected at the surface or undergo a single-scattering event before they are detected. We clarified this for the revised version of the paper.

2.2.2. Pt 6

To the best of our knowledge, there is no official reference for the water vapor product of the ECMWF data. We added the best possible reference, which is a paper by

ACPD
2, S607–S616, 2002

Vesperini, 1998.

2.2.3. Pt 11

The albedo values stated in the text do relate to the worst case scenarios. The text has been modified to add clarity.

2.2.4. Pt 20

The constraints are step-functions over altitude, which are decreasing from low to high altitudes. In addition, we use different step functions with the same shape for the three latitudinal regions as explained in APCD. The text has been modified to add clarity.

2.2.5. Pt 24

The sentence concerning the worst case scenarios has been re-written to improve clarity.

2.2.6. Pt 26

The w value is different for every layer of the atmosphere due to the effects of both temperature and pressure on the WV absorption spectra, i.e. Doppler and collisional broadening effects (Fig. 2). However, in our model we use for each individual light path the w value at the lowest point (in altitude) of the path. This value, which we call $w_{\max}$, is always higher than the w-values, which the photons encounter at other positions along the paths.

ACPD

2, S607–S616, 2002

Interactive Comment

2.2.7. Pt 33

The start of this section has been revised in line with the referees comments.

2.2.8. Pt 36

The DAM model does not compute all components of the Stokes vector. This is the reason why we wrote in the ACPD version of the paper that the DAM model only solves the *scalar* radiative transfer equation.

2.2.9. Pt 45

We feel that both the aerosol distribution with respect to height (i.e. distribution of extinction) and the size distribution of the particles may have an effect on the overall accuracy of the WVC retrieval. Although the effect of the variability in such parameters warrants further study we feel that including such a sensitivity study will detract from the overall focus of the paper. Moreover, for a global retrieval such profiles would not be readily available for a specific time and geo-location, meaning that some type of aerosol climatology would be needed.

2.2.10. Pt 49

The GOME derived surface albedo product has, to the best of our knowledge, not yet been tested for other GOME retrievals. GOME and/or MODIS land products might indeed be an option for use in future improved SSP retrievals.

ACPD

2, S607–S616, 2002

2.3. Section 3.3 Figures

All the comments made by the referee have been addressed.

2.3.1. Figure 7

See 1.3.4.

2.4. Section 3.4 References

All the comments made by the referee have been addressed.

References

[*Vesperini et al*, 1998] Vesperini, M., Humidity in the ECMWF model: Monitoring of operational analyses and forecasts using SSM/I observations, *Q. J. R. Meteorol. Soc., 124,* pp.1313-1327, 1998.

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