

Interactive comment on “A fast H₂O total column density product from GOME - validation with in-situ aircraft measurements” by T. Wagner et al.

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Received and published: 27 February 2003

The fast retrieval of total water vapor columns (TWVC) densities from GOME and SCIAMACHY - especially those from the visible region of the spectrum - is of particular interest for improvement of global water vapor (WV) data-sets, due to the current lack of high quality data above remote land regions (e.g.) the African subcontinent. Microwave sounders deliver good TWVC-data above the oceans but not over land due to their sensitivity to surface temperature variations. Infrared sounders are usually restricted to cloud-free land surfaces due to the relatively low surface reflectivity of the ocean. Some of the IR instruments show only weak sensitivity to the WV signal from the lower troposphere, where most of the WV is situated. Currently, there is no instrument measuring WV on a global scale with satisfactory sensitivity for most of the Earth surface types. WV retrievals exploiting the WV absorption signal in the visible region of the

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spectrum may provide the best compromise between sensitivity and global coverage by using a single instrument, providing the "cloud-issue" can be addressed in some satisfactory manner.

The paper by *Wagner et al.* is a very important contribution in terms of this latter issue and a major step towards a truly global TWVC product from both GOME and SCIAMACHY. The derivation of the AMF from the absorption signal of the O₂-dimer, instead of using the signal from the O₂-absorption, is a significant improvement in the treatment of multiple-scattering and aerosols in comparison to previous studies. However, some important questions remain unaddressed or are, in my opinion, not clearly stated in the paper in its current form.

- (1) What is the impact on the AMF used during the retrieval for local changes in pressure? The article states that an advantage of this kind of retrieval method is that it avoids the use of any *a priori* information about the state of the atmosphere. This is true providing the uncertainties introduced by using a climatology instead of, for example, pressure data from independent measurements (or data-assimilation databases like ECMWF) is small. In case of O₂ the latter might be true. In case of (O₂)₂, due to its quadratic dependence on local pressure, this uncertainty may significantly contribute to the total retrieval error and should therefore be quantified.
- (2) The authors do not consider the spectral dependency of the AMF, especially with respect to the contribution of the surface reflectivity. The spectral dependence of the single-scattering contributions might be considered as being relatively weak over the spectral areas used in this study (although some correction could possibly account for this). However, as far as the surface-albedo is concerned, spectral variation can be significant for windows as wide as 15 nm, which may cause the systematic higher TWVC with respect to ECMWF TWVC in the regions north of 30°N (i.e.) over North-America (Figure 6 of the paper). For this region the

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ECMWF data should be of high quality, due to the availability of a significant amount of radiosonde data. The spectral variability of the surface albedo may also be the reason for the significant drop in the TWVC values at 30°N at the transition from land to ocean, i.e. from potentially high spectral variability to smooth surface albedo.

- (3) *Wagner et al.* discuss in some detail on a number of problems like the difference between the $(O_2)_2$ and the WV-profile, cloud coverage, cloud type and cloud-top height. These are very important issues and all of them are very well addressed. However, they do not provide any assessment of the problem of the non-accessability of the region below the cloud (i.e.) the lower troposphere. It should be stated more clearly that in all optically thick cloud-fraction cases the retrieval results will be biased due to the lack of information from the region below the cloud. Alternatively, some comment should be made if there is a significant contribution of multiple-scattered light to the total signal from this region. This means that the retrieval accounts correctly (and better than other algorithms) for multiple-scattering caused by aerosols and clouds for the above-cloud and cloud-free fractions of the column. However, the question then arises as to why this expected bias (a significant drop in the column) is often not visible for much of the retrievals contaminated by cloud fractions of < 100%, nor for the retrievals presented here or for retrievals using a much simpler approach of treating multiple scattering from clouds and aerosols (as, for example, our own retrieval algorithm [[Lang et al., 2003](#)] to which the authors are referring to). I do realize, that this question may not be that easy to answer because it would require a sophisticated analysis of the individual light paths for many different situations, including cloud-types, cloud-top height, aerosol type and measurement geometry. Nevertheless, I think this question should be addressed a bit more in detail in this paper and should be subject of future studies.
- (4) In the introduction (p.326, l. 23) the authors seem to suggest that we are using a

priori information on aerosol content and ground albedo for our retrieval algorithm [Lang *et al.*, 2003]. This is not the case. The only *a priori* information used are pressure and temperature fields (from a climatology) as well as the contribution of background absorbers like O₃ retrieved from the same instrument. Surface albedo, as well as the contribution due to multiple-scattering, are free parameters and the effect of aerosols is not explicitly accounted for. Instead, error estimates for the impact of aerosols on the retrieval results are given using extreme case-studies and full solutions of the equation of radiative transfer for various aerosol types and Earth surfaces.

References

[Lang *et al.*, 2003] Lang, R., J. E. Williams, A. N. Maurellis, and W. J. van der Zande, Application of the Spectral Structure Parameterization Technique: Retrieval of Total Water Vapor Columns from GOME, *Atmos. Chem. Phys.*, 3, 145–160, 2003.

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