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Atmospheric Measurement Techniques Discussions

Interactive comment on "Retrieval of water vapor vertical distributions in the upper troposphere and the lower stratosphere from SCIAMACHY limb measurements" *by* A. Rozanov et al.

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Response to reviewer comments (J.-L. Bertaux)

Dear Jean-Loup,

thank you very much for your helpful comments. Please find our detailed response below.

1. The method relies on the fact that the observed spectral region is quite opaque to radiation which comes from the ground, because of the strong absorption by H2O in

the band considered. However, when there is a high altitude cloud below the tangent point, it may change the spectrum in an unforeseen manner. This is a limitation of the method, which is addressed in the main text, but not at all in the conclusions. It should be mentioned in the Conclusions, and perhaps discussed a little more in the main text.

Your are right, it is quite important to discuss possible errors due to high altitude clouds. A subsection on this issue is added to the manuscript.

*2. Generally speaking, the "sun normalized intensity" must be more precisely defined. The concept of "radiance factor" Rf is useful in this context, and I would recommend to use it. The radiance factor is the ratio of the observed radiance (intensity) to the radiance B0 that would be observed when observing a plane surface with an albedo of 1, scattering as a Lambert law, and illuminated perpendicularly by the sun. In the such a case, the intensity emitted by the surface is isotropic, and is: B0=F/pi where F is the solar flux (say, in watt/cm2 nm s, or photons/cm2 nm s) The radiance factor when observing a surface with albedo A is Rf=A. Whatever is the target observed (surface or thin atmosphere) the radiance factor is defined, for a target providing a brightness B (or intensity, or radiance, these are all the same), is: B=Rf * F/pi. Therefore, Rf=B/B0. So, my question is: what does mean the "sun normalized intensity" for the authors? I hope that it is the radiance factor as it is defined above, and in this case it should be mentioned; otherwise, I would recommend to adopt the radiance factor as the unit of "sun normalized intensity". Note that some authors are using the expression (I/F) for the radiance factor, while I say it is pi*I/F. These authors mean the same thing as me, but they take out the pi factor, probably a remnant of the time when astrophysicists where calling the solar flux pi*F ! It is time to stop the confusion, and use the concept of radiance factor. This is relevant to the text and to Figures 1, 2, 3.*

We agree that the notation "sun normalized intensity" in not strictly defined. It is however widely used in the limb retrieval community. In fact the quantity we are using coincides with the radiance factor according to your definition (pi*I/F) whereas the "sun normalized intensity" is usually defined as I/F. Our opinion is that the notation "radiance factor" is also not common and can easy be misunderstood. To prevent the reader form being confused we have change the description of the quantity to "radiance" under assumption of F=pi W/m^2/μm.

3. It may appear a little paradoxical to be able to retrieve the H2O profile at altitudes which are not observed (below the lowermost tangent point of 12 km) and to retrieve H2O at more altitude points than the 5 measurement points at altitudes 12, 15.3, 18.9, 21.9 and 25.2 km. The author could comment on this aspect. In fact, nadir observations are also providing H2O values (as well as ozone), with only one direction of sight. Observations at the limb of solar backscattered radiation provide information elsewhere, in contrast to occultations, where the number of retrieved points cannot exceed the number of measurements.

The information from the altitudes below the lowest tangent height is due to the multiple scattering (see Sect. 4.1). One can get more vertical points than measurement tangent heights because the points are not independent (see Fig. 7).

Detailed comments: p.4012, lines 7 and 8: . . . the emitted infra-red radiation. . . as written, it suggests that it is the IR thermal emission of the ground, or the gas that is observed. I think that it is rather the solar backscattered radiation in the middle infra red. Can you check?

AIRS measures definitely the emitted radiation. It is also stated in the ATBD of the AIRS retrieval algorithm that the scattered solar radiation is neglected in the radiative transfer model because of its insignificance. For IASI there is no clear statement about the origin of the measuring radiation. The instrument measures, however, in the same spectral range as AIRS. Thus, the assumption about a dominating contribution from the emitted radiance should also be valid for IASI.

p.4013, line 26: Signal to noise ratio of 400 to 700: is it per spectral element? (spectel) or for the whole band, and what is the associated spectral sample and time of integration?

Sure it is per spectral segment as we do not work with the entire band. The spectral sampling (0.75 nm) and integration time (1.5/4 s) are given in Sect. 2.

P.4018: lines 16, 17. How is determined the polynomial fit? I presume it is the one giving the best fit to the logarithmic spectrum. It should be mentioned.

Yes, it is a least squares fit of logarithmic spectra. The statement is included in Sect. 3.2.1

P.4019, paragraph lines 15 to 19: imposing a positive value will produce a bias when the quantities to be retrieved are quite small, compared to the error bar.

Yes, but we have to accept this to keep the retrieval stable.

P.4022, line 7. It is not clear to which spectrum the parameter Csol applies. I assume that it must be the solar spectrum as measured each day by SCIAMACHY. It should be mentioned here.

It is clear from Eq. (18) that this parameter is applied to the solar spectrum. The latter is defined at the beginning of Sect. 3.2.1 (your assumption is correct).

p.4025, line 22. . . . shown by the blue line. I assume that this simulation is with an albedo 0.5. It should be written here in this sentence, as well as on Figure 3, after "single scattering", and also in the figure caption for clarity.

Single scattering radiance do not depend on the surface albedo (reflection from the ground is not included into the single scattering term).

p.4025-4026, figure 3. The red line seems to be absent from the figure 3. The caption for figure 3 suggests that it is almost identical to the cyan line, and therefore cannot be seen on the figure. I do not understand such a similarity. Both calculations are with no aerosols (only Rayleigh scattering), and only multiple scattering. The only difference is the albedo: 0 and 0.5. Let B0 the radiance observed in the case A=0. An optically thin estimate of the radiance is: B0= F tau/ 4 pi, where F is the solar flux, and tau *the Rayleigh optical thickness along the line of sight (neglecting the phase function). With an albedo A=0.5, and a solar zenith angle of 69°, the brightness B coming from below is: B= A F cos(sza)/pi. (Lambert law) The flux received by one gas molecule (or one aerosol particles) coming from below may be computed in integrating B over the whole downward hemisphere (2 pi steradian). It is therefore 2 AF cos(sza), which is F cos(sza)=0.36 F for A=0.5. Therefore, changing the albedo from 0 to 0.5 will increase the observed intensity by 36%. Possibly the authors have normalized, for this not by F, as they should have done, but by F+ 2 AF cos(sza). Or it means that no light at all come from the ground, because of strong absorption by tropospheric water vapor?*

Yes, it means that no light at all comes from the ground. The optically thin estimate is not valid here.

In this case, the same simulations done outside the band, say around 1300nm, would show a larger sensitivity to surface albedo?

Sure, see e.g., Fig. 1.

And what happens when there is a cloud with high albedo at high altitude, like 8 km?

This case is analyzed now in section 4.4.

Technical corrections:

All technical corrections are implemented as suggested.

Interactive comment on Atmos. Meas. Tech. Discuss., 3, 4009, 2010.