**Atmospheric
Measurement
Techniques**
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Discussions

Interactive comment on "Characterization of model errors in the calculation of tangent heights for atmospheric infrared limb measurements" *by* M. Ridolfi and L. Sgheri

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For clarity we include also the comments of reviewer #2 using *italic text*.

General comments

1) Limb sounding retrievals generally work in pressure coordinates so as to negate issues with the absolute tangent height. As such, a more accurate tangent height doesn't seem that important. This can clearly be seen in the final section, where in

order to obtain significant errors in MIPAS L2 retrievals, the pressure had to be forced to the calculated tangent height pressure.

Most limb sounding retrieval codes work in pressure coordinates, however not all of them retrieve also the tangent pressure / height of the measurements (see e.g. the 2D GMTR code described in Carlotti at al., Appl. Opt., 45, 716-727, 2006). In the ESA L2 processor the tangent pressures are retrieved and the tangent heights (except the lowermost) are adjusted using the hydrostatic equilibrium assumption. When tangent heights are not retrieved, their engineering estimates may be used to reconstruct the profiles altitude grid when required. Knowledge of the altitude grid is especially important when the retrieved profiles are compared (e.g. for validation purposes) to correlative profiles, such as those measured by lidars, that are intrinsically represented on an absolute altitude grid, with no associated pressure measurements. In the introduction of the revised paper we will better explain this issue.

2) The study seems completely focussed on MIPAS and may not be of much use to other instruments.

The algorithms investigated in the paper are applicable to the general problem of ray-tracing in an inhomogeneous transparent medium. This problem has to be tackled whenever modelling the radiances that reach a spectrometer (or a radiometer) observing the atmosphere. While we presented some tests based on the MIPAS observational configuration, the results of our study are applicable to a quite broad class of atmospheric experiments. In the revised paper we will introduce some sentences to better clarify this concept.

3) Since relative tangent height of sweeps within the same scan are more accurately known than the absolute tangent heights, why not calculate a best guess tangent height which relies on the levels above in the troposphere where the modelled atmospheric assumptions are more unreliable?

As shown in the paper, a wrong assumption of the atmospheric model may lead to tangent height errors as large as ± 200m at the lowest sounded altitudes in the troposphere. On the other hand we see that the tangent height errors are really small higher up in the stratosphere. This implies that a wrong assumption on the atmospheric model actually stretches the whole pattern of tangent heights, it does not only introduce a bias. Consequently, relative tangent heights of the sweeps within the same scan are also affected by the error we are studying in the paper. The ESA L2 code for MIPAS actually retrieves also pressure at the tangent points. In the measurements acquired after 2004, however, the spectral resolution (0.0625 cm^{-1}) is not so fine and the tangent pressure error resulting from an unconstrained retrieval would be quite large ($\approx 5\%$). In order to reduce this error, the retrieval algorithm constrains pressure using the tangent altitude increments provided by the engineering pointing system and assuming their value to be correct to within an a-priori uncertainty of ± 80m. This constraint reduces the retrieved pressure error to about 0.5%. Of course, a further reduction of this error could be obtained with a smaller uncertainty on the a-priori estimate of the relative pointing. Note that the stretching we observe in the test of Fig. 2 (b) of the paper is compatible with the a-priori uncertainty of ± 80m assumed in the retrieval.

We agree with the proposed strategy for the correction of the bias common to all tangent heights within the same scan. A similar approach is in fact adopted by ESA as a post-processing correction of the profile altitude grids. As explained above, however, relative pointing errors are also significant and, so far, remain uncorrected.

4) Explanations of the methods are very brief and sometimes confusing, although ultimately understandable. The methods appear to be correctly applied and the results are convincing.

As outlined in the replies to several reviewers' comments, the revised paper will include additional explanations. We hope these corrections will improve the overall readability of the paper.

Specific comments

P7702 L6–9 Errors of 200m are only in very small set of measurements in the troposphere. The errors in would only have a significant impact if pressure were not retrieved, which seems very unlikely in a decent retrieval scheme.

As explained above, accurate knowledge of the tangent heights helps to constrain the retrieval of pressure. This is especially useful if the spectral resolution is not sufficient to resolve the shape of the spectral lines and the measurements contain little information on pressure distribution.

P7707 L1–3 Not a sentence.

OK, we will better reword the sentence.

P7707 L20–26 Why did you not just take the position of the satellite instead of back tracing from the calculated tangent point?

While the satellite position and pointing angles are available, we do not have access to the algorithm calculating the L1b tangent heights but only to its results. We verified that the L1b tangent heights are very similar to the ones calculated from the satellite using Edlen's refraction model and the US76 atmosphere. There are however some minor differences, so we preferred to start from the L1b calculated tangent heights and back-trace the ray-path to avoid any inconsistencies with the values used in the ESA retrieval. In the revised paper we will justify this choice.

P7708 L1–9 This paragraph is very poorly explained.

OK, in the revised paper we will include some additional explanations of the method used.

P7708 L10 L13 "step-lenghts" should be "step-lengths".

OK.

P7708 L16–24 Why do you consider the Ciddor formula more accurate than the Edlen formula if the differences between the two are so small? Also, why do you need to bother with water vapour and CO2 in the refractive index model if the Edlen formula (which does not require these) has the same accuracy.

As outlined in Young (2011), Ciddor's model is generally considered more accurate, even if in our specific case the differences with respect to Edlen's formula are very small. Since the computing time required for the Ciddor's model is in any case negligible, we use this model as a basis and we use Edlen's formula as backup option, should the water profile be unavailable.

P7709 L6–8 Since this is the only mention in the paper of looking at the RO data, why do you bother mentioning it at all?

Even if very sparse, RO data offer the possibility to carry-out a test that confirms the reliability of the adopted refractivity models. Since this is the only chance we have to connect refractivity models with direct measurements, we prefer to keep mentioning this test in the paper.

P7710 L10–11 I can't think of any retrievals that would use a fixed tangent pressure.

The tests reported in Fig. 3 of the paper show that the retrieval of tangent pressures is able to compensate for possible errors in the assumed tangent heights. However, as mentioned above, not all codes retrieve tangent pressure.

P7714 Fig. 2 The squares / triangles are redundant given that the colour indicates whether a value is positive or negative.

We adopted this approach to make the plot understandable also if printed in black and white.

P7715 Fig. 3 The magenta line is completely obscured in both plots.

This is correct. While this fact is already stated in the text, we will mention it also in the figure's caption.

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