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Interactive comment on "Spatial and temporal characterization of SCIAMACHY limb pointing errors during the first three yearsof the mission" *by* C. von Savigny et al.

Anonymous Referee #2

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General Comments:

This manuscript addresses the problem of determining accurate reference tangent height information for the limb radiance data measured by the SCIAMACHY instrument on-board Envisat. It is to be included as part of an ACP special issue devoted to SCIAMACHY calibration and validation. Pointing accuracy is a critical issue in the retrieval of geophysical profiles from any limb pointing satellite instrument, particularly those employing the solar limb scattering technique. Altitude uncertainties are typically one of the dominant sources of error in the retrieved profiles, and therefore this paper

is of interest to the atmospheric remote sensing community in general, and appropriate for publication in this ACP special issue.

This study uses the well-known knee method for deriving tangent height (TH) information self-consistently from the measured radiance profiles. In this method an optimal tangent height is determined by using a forward model to fit the unique vertical shape of the radiance profiles at wavelengths in the UV-B spectral range. The authors pose a straightforward retrieval problem whereby a single TH error is retrieved for each SCIAMACHY scan. The error is defined relative to the default engineering tangent heights provided by the SCIAMACHY level 1 data. The retrieval uses an optimal estimation algorithm to find the altitude shift which minimizes the difference between the predicted and measured radiances between 35 and 50 km in the spectral region from 295 to 305 nm. For the technical details of this approach the reader is referred to Kaiser et al., [2004].

The primary focus of the paper is to characterize the spatial and temporal variation of the retrieved TH errors over the first three years of SCIAMACHY operations. The data are binned by month and then subjected to a regression analysis to derive a mean offset, linear trend, and sinusoidal (seasonal) variation. The results show significant systematic errors in the engineering pointing data, and do a good job of characterizing the seasonal and long-term trends in these errors.

These results of this study are presented clearly and convincingly, and will no doubt be very useful for both the SCIAMACHY team and other instruments on Envisat. I recommend that the paper be published in ACP, but think that it could be strengthened if the authors respond to the comments and questions listed below.

Specific Comments & Questions:

I have some technical concerns about the “knee method” technique being used to retrieve the TH offsets. As the authors point out, the technique depends critically on the input ozone profile used in the forward model. It is also sensitive to the bulk atmo-

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spheric state (total density profile), which determines the Rayleigh scattering component in the UV channels. Climatologies are used to define both of these components in the forward model radiative transfer code. At least for the atmospheric density profile, this seems to be an unnecessarily crude approximation. Have the authors considered using any of the stratospheric analyses available (e.g., UKMO, NCEP) for this purpose? Can they give an estimate of the expected TH errors due to errors in the climatological total density profile as compared to a daily analysis interpolated in time and space to the SCIAMACHY measurement points?

A more general aspect of the entire analysis which I find bothersome is the cyclical reasoning inherent in it. The authors lay out the sensitivities quite clearly - to retrieve ozone from SCIAMACHY data to within 5(10) % requires TH knowledge accurate to 250(500) m. (This is of course assumes no other error source in the retrievals other than altitude offsets - a best case scenario.) But the sensitivity studies of Kaiser et al. [2004] also show that retrieving altitude to within 500 m using the knee method requires independent knowledge of the ozone profile between 40 and 55 km to within 10 %. It seems to me that in this scenario the SCIAMACHY ozone retrieval adds little extra value to the ozone knowledge we already have. Maybe I'm missing some fundamental point - for example, SCIAMACHY retrievals should contribute significantly to determining the ozone in the lower stratosphere where the climatology will not be as good, and of course many other chemical species can be retrieved using well calibrated radiance data. But strictly from an ozone retrieval standpoint it seems the impact of SCIAMACHY data using this approach is limited.

Maybe the authors could elaborate more on this general point. Because other limb scattering instruments are using, or plan to use, similar approaches to determine pointing any general conclusions that can be reached about the limitations of this method could be very useful to the broader community beyond Envisat. One study that could be very useful is to compare the TH retrievals obtained from this approach with a sample set of events where coincident high-precision measurements (e.g., from SAGE,

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HALOE or POAM) can be used to constrain the ozone profile in the forward model. In a similar vein it would be instructive to compare the UGAMP ozone climatology directly with a large number of coincident sonde or satellite measurements. What is the statistical spread of these comparisons? Perhaps this study has already been performed, and if so a reference would be useful. In particular, how does this statistical uncertainty in the climatology map into the retrieved TH offsets, and ultimately to the SCIAMACHY ozone retrievals?

This approach is only able to determine a constant TH error for any given scan. What if the error in the engineering TH varies with altitude? There are many conceivable scenarios which could cause such an error (thermal gradients in the instrument, satellite attitude drift, etc). Is there reason to believe that this might be the case? Also, as the authors point out, limiting the TH retrieval to the equatorial regions to minimize the effects of horizontal gradients in the climatological ozone field precludes the possibility of studying latitudinal gradients in the TH errors. Is there reason to suspect that the TH errors vary systematically with latitude? I think the paper would be strengthened by a short discussion of exactly what is known about the causes of the SCIAMACHY pointing errors - what errors are predicted based on the instrument design and operation and how do these predictions compare with the TH errors retrieved from this analysis?

The paper states that the TH errors retrieved from SCIAMACHY are in good agreement with similar analyses from GOMOS and MIPAS on Envisat. This would be a good confirmation of the current analysis; particularly if the altitude retrieval algorithms used by these other instruments are completely independent of the SCIAMACHY retrieval. Is that the case, or do they depend on some common assumptions or modeling?

The coordinate system inconsistency mentioned in the last sentence of Section 3.2 seems to be a trivial and easily corrected error. If so, has it been corrected in the Envisat data processing?

The discussion in section 4 is very important; it is necessary to show the effect of

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the deduced TH offsets on the final SCIAMACHY retrievals. However, this discussion would be much more credible if more than a single lidar comparison were presented. Of course you can always find examples where the pointing correction improves the ozone retrieval significantly, but likewise there will also be cases where the corrected retrieval agrees worse with correlative measurements. What would be most useful to potential SCIAMACHY data users is to show a significant improvement of the ozone profiles, on average, using a statistically large set of coincident data. Such a study is probably beyond the scope of this paper, but perhaps it has been done elsewhere and can be referenced here?

One final point that needs to be clarified is the current status of the SCIAMACHY retrievals. Are the retrieved TH errors resulting from this analysis incorporated into the operational retrievals at all, or is the engineering TH data the only pointing information used operationally? If the altitude retrieval algorithm presented here is not being used, what are plans for future retrieval versions? Given the TH errors shown in Figures 1-3, it is obvious that any SCIAMACHY ozone data set that relies solely on the engineering tangent heights probably has unacceptably large systematic errors, so it is critical that some altitude correction be applied.

Interactive comment on Atmos. Chem. Phys. Discuss., 5, 3701, 2005.