Answer to B. van Diedenhoven

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I would like to provide a specific comment to the paper "Trends in cloud top height from passive observations in the oxygen A-band" by L. Lelli, A. A. Kokhanovsky, V. V. Rozanov, M. Vountas, and J. P. Burrows (acpd-13-31409-2013). It is not my intent to provide a full review of the paper.

In Figure 1 of their paper, Lelli et al. show time series of cloud top heights retrieved using oxygen A-band measurements of GOME, SCIAMACHY and GOME-2. Offsets between the time series are apparent. The authors hypothesize that this may be due to differences in sensor footprint sizes.

However, I think the presence of calibration errors is a far more likely explanation for these offsets. In our paper van Diedenhoven et al. (2005), we tested the calibration of GOME and SCIAMACHY measurements in the oxygen A-band by retrieving surface pressures in cloud-free conditions and validating them using meteorological data. Over a wide range of surface albedos, a consistent positive bias of 20 hPa in the SCIAMACHY results, compared to those of GOME, was apparent in the data. Furthermore, the GOME results agreed much better with the validation set after accounting for the effects of aerosol on the retrievals. For an average cloud height of 6 km and a atmospheric scale height of 7.4 km, a 20 hPa offset would translate in a ?0.3 km negative bias in the SCIAMACHY cloud top height, which seems very consistent with the offsets in the global results shown in Figure 1.

In van Diedenhoven et al. (2005), we interpreted this offset as resulting from an off-set (rather than scaling) bias in the oxygen A-band measurements and recommended adding 0.86% of the continuum reflectance at 756 nm to the SCIAMACHY reflectance measurements in the oxygen A-band. This correction is apparently consistent with a correction advised by Noël (2004) at the University of Bremen. If these conclusions are accepted it appears that GOME-2 has a greater calibration offset than SCIAMACHY. I would recommend taking such calibration errors into account when interpreting the data.

We acknowledge that in the manuscript no information was given on the version of L1 data used for the generation of the L2 cloud record. For instance, at the time of processing, the ingested SCIAMACHY L1 data were version 7.03, consolidation degree U (year 2010). These L1 data already contain the necessary radiometric key data for correction of calibration offsets pointed by van Diedenhoven et.al, 2005. Please, look at the newest version of the applicable technical note [Noël 2005]) for the actual key data. In its revised form, the manuscript will contain information on the version of L1 data as well as the version of cloud fraction used.

Additionally, we provide Fig. 1. Here the SACURA algorithm's sensitivity to three different calibration errors is portrayed. The input radiance in the O_2 A-band represents a single-layer cloud placed at 5 km (top) and 4 km (bottom altitude) for a optical thickness of 20. COT is set equal to 20 because its global distribution peaks about this value (see [Lelli et al., 2012, Fig. 19, p. 1565]). Solar zenith angle is set equal to 60° with a dark underlying surface.
From top to bottom of Fig.1, the relative error (%) in COT, the absolute error [km] in CTH and CBH are plotted, respectively. For the black curves, the radiance is perturbed only at λ=758

nm. For the red curves, a constant offset has been added in range 758-772 nm, meaning a shift of the whole band. For the blue curves, a wavelength-dependent offset has been added to the whole band. The spectral behavior of the calibration error has been taken from [Noël 2005, Fig. 9, p. 35] and is considered linear from λ=758 nm ($\pm$0.86%) throughout λ=772 nm ($\pm$0.80%). Clearly, this last error parameterization is also the most realistic, as compared to the single-channel perturbation in the continuum outside the band.

From Fig. 1, some conclusions (relevant to the scope of this paper) can be drawn:

(1) Spectral-dependent calibration errors have almost no impact in the retrieved CTH. The CTH bias (mid plot, blue curve) is stable about a value of $\approx$250 m, which is the error introduced by the forward model (please, see [Lelli et al., 2012, Fig. 1, p. 1556]). This is a feature of the algorithm, which is based on spectral ratios and on the concurrent fit of CTH and CBH.
(2) In case of calibration errors, CBH is the influenced parameter. The bottom plot clearly shows that CBH becomes noisier.
(3) The COT error doesn't affect the retrieved CTH.

Therefore, we think that the primary role in the shifts among time series of absolute values (Fig. 1 in the manuscript) is played by the different spatial resolution among the instruments and not by radiometric calibration.

References

[Lelli et al., 2012] Lelli, L., Kokhanovsky, A. A., Rozanov, V. V., Vountas, M., Sayer, A. M., and Burrows, J. P.: Seven years of global retrieval of cloud properties using space-borne data of GOME. Atmos. Meas. Tech., 5, 1551-1570, doi:10.5194/amt-5-1551-2012, 2012.

[Noël 2005] Noël S.: Determination of Correction Factors for SCIAMACHY Radiances and Irradiances, Technote IFE-SCIA-SN-20050203_IrrRadCorrection (Issue 5.2), `http://www.iup.uni-bremen.de/sciamachy/SCIA_CAL/irrad_corr.pdf`, 2005.

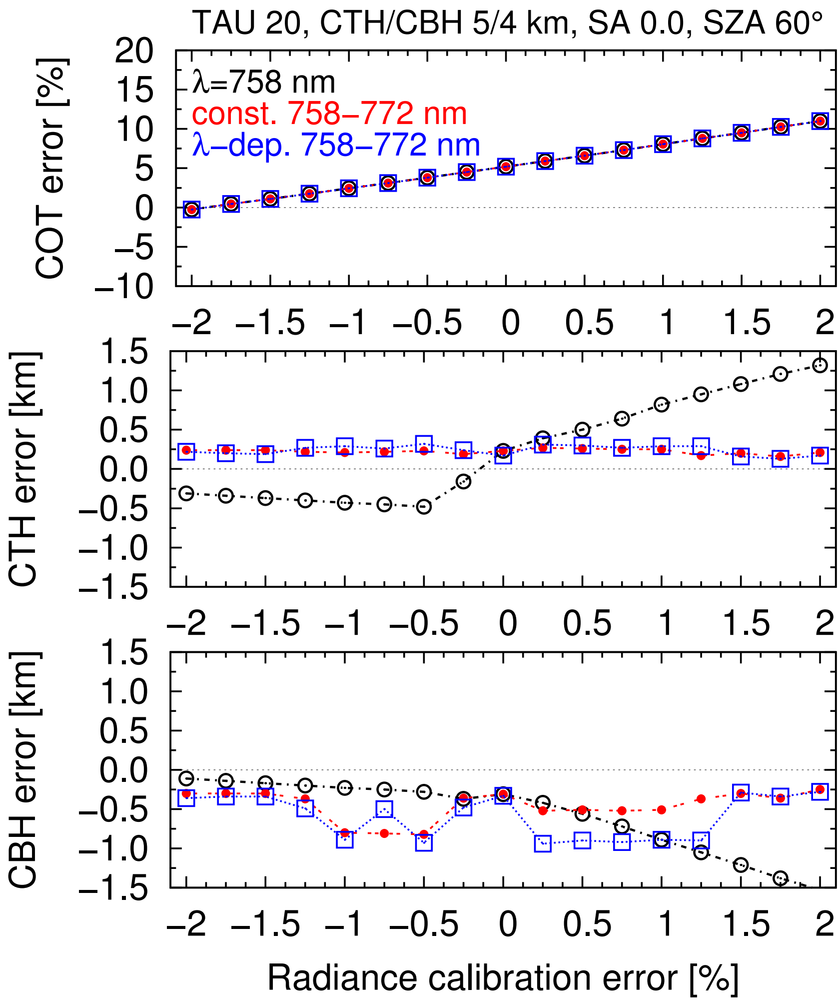

Figure 1: Errors in retrieved cloud optical thickness (%, top plot), cloud top and bottom height (km, mid and bottom plot) for a single-layered cloud, placed at 5-4 km altitude and optically dense 20, above a dark surface. Three different offsets in radiance are applied: single-channel at λ=758 nm (black curves); constant, added along the whole band (red curves); spectral-dependent, as described in [Noël 2005](blue curve).