Author response
Luca Lelli (luca@iup.physik.uni-bremen.de)
April 16, 2014

I would like to forward your manuscript for acceptance in Atmospheric Chemistry and Physics following inclusion of the following material. Your response to Bastiaan van Diedenhoven addresses the important question of the extent to which the retrieved CTH signal is due to calibration drift. The same concern was held by Reviewer 2. Your response concludes that this is not a concern, but the analysis and accompanying figure is not part of the paper. I recommend including this discussion in the paper, perhaps as an appendix so that it does not distract from the paper's current flow.

The following section (together with Fig. 1) has been added to the manuscript and the text changed accordingly:

Action (Appendix A, l. 415–441)

Algorithm sensitivity to calibration drift

In this appendix we assess the sensitivity of the SACURA algorithm to three distinct calibration errors. The question to be answered is whether the shifts in the time series of absolute values of CTH (see Fig. 1) can be caused by calibration differences among the three sensors used in this work.

To this purpose, an input radiance in the O_2 A-band (in range 758–772 nm) is simulated, neglecting polarization, with the radiative transfer model SCIATRAN (Rozanov et al. 2014). It corresponds to a single-layer cloud, placed at 5 km (top) and 4 km (bottom altitude) and optically thick 20. COT is set equal to 20 because its global distribution peaks about this value (Lelli et al., 2012). The solar zenith angle is set equal to 60° with a dark underlying surface. From top to bottom of Fig. 15, 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 oxygen A-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 Noel (2005) 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 the analysis of Fig. 15, the following conclusions, relevant to the scope of this paper, can be drawn: first, spectral-dependent calibration errors have almost no impact on the retrieved cloud top height. The CTH bias (mid plot, blue curve) is stable about a value of $\approx$250 m, which is the error introduced by the analytical forward model (Lelli et al, 2012, Fig. 1, p. 1556). Second, in case of calibration errors, cloud bottom height is the affected parameter. The bottom plot clearly shows that CBH becomes noisier. It can also be seen that errors in retrieved cloud optical thickness (top plot) don't influence the retrieved CTH and that are independent on the applied error, because COT is retrieved at the single channel λ=758 nm, while CTH and CBH are retrieved across the whole A-band, after normalization to the average value of reflectance outside the band. Therefore, we conclude that the primary role in the shifts among time series of absolute CTH values (Fig. 1) is played by the different spatial resolution among the instruments and not by radiometric calibration.

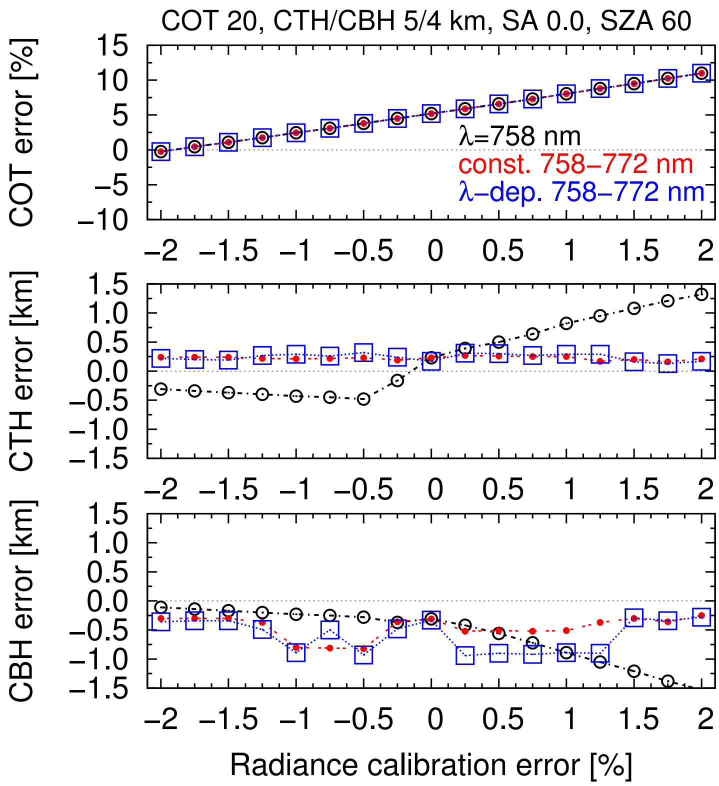

Figure 1: Errors in retrieved cloud optical thickness (%, top plot), cloud top and bottom height (km, mid and bottom plot) for a single-layered cloud, placed at 5-4 km altitude and optically dense 20, above a dark surface. Three different offsets in radiance are applied: single-channel at λ=758 nm (black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

References

Noel, S.: Determination of Correction Factors for SCIAMACHY Radiances and Irradiances, Tech. Rep. IFE-SCIA-SN-20050203 (Issue 5.2), Institute of Environmental Physics and Remote Sensing, University of Bremen, Germany, http://www.iup.uni-bremen.de/sciamachy/SCIA CAL/irrad corr.pdf, 2005.

Rozanov, V. V., Rozanov, A. V., Kokhanovsky, A. A., and Burrows, J. P.: Radiative transfer through terrestrial atmosphere and ocean: Software package SCIATRAN, J. Quant. Spectrosc. Rad., 133, 13-71, doi:10.1016/j.jqsrt.2013.07.004, 2014.