Review:

Global cloud top height retrieval using SCIAMACHY limb spectra: model studies and first results

by K.U. Eichmann et al.

General:

The paper presents a detailed analysis for SCIMACHY limb measurements of cloud top heights. The study addresses honestly difficulties and advantages of limb measurements of cloud structures in the troposphere up to tropopause region and lower stratosphere. However, sometime I miss a clearer statement on the advantages compared to nadir passive and active methods. A better discussion on the detection sensitivity for example in terms of ice water content or volume densities would help to rank the capabilities of SCIAMACHY compared to the other sensors.
AMT is exactly the correct journal to publish the results. The paper needs a couple of improvements and clarifications, but taken these into account I would suggest accepting the paper with its next improved version.

Major comments:

1) Cloud detection: The authors should address in more detail the detection threshold of 1.4. Why they choose this number, and is there a sensitivity of this threshold with respect to season of the year, background emission (aerosols/trace gases), or S/N issues.

2) The authors use a couple of times the term 'cloud fraction' (CF) for the limb analyses. In my opinion, CF is a difficult and not a real meaningful quantity for limb measurements. The authors nicely address the caveats caused by the long limb path through the potentially cloudy atmosphere, where somewhere along the LOS a cloud is detected. But, is it not only the lowest TH measurement which senses the complete atmosphere (all layers) and can specify a kind of limb CF. Taken all tangent heights (TH) above into account may detect the same cloud in one profile potentially a couple of times at lower THs and would results in an overestimation of the limb cloudiness.
   Consequently, I have doubts, that Fig. 8b is a meaningful result. Please, explain in more detail how you compute CF and why it is an important quantity to present. If you like to compare a limb CF with nadir measurements than I guess it is only sensible to analyse the minimum TH of SCIAMACHY with respect to cloudiness. The height resolved CF like presented in section 5.2 is the more reliable quantity.
   I have also problems to follow the discussion on a vertical area-of-sight (section 4.1). Please rewrite this section and explain in more detail quantities like the path length ratio (*x(3,3)* indices=?).

3) Figure 13: A similar comparison of means of CTH with MIPAS and/or SAGE II would be valuable to highlight similarities or differences in detection sensitivity. Using a minimum observation height of for example 10 km allows a comparison of limb sensors with different sampling and minimum tangent heights.

4) Section 6.2: Validation with MIPAS
   This section needs some revision. How do you handle coincidences where only one sensor sees a cloud and not the other? The coincidences seems excellent, but why you do not restrict the miss-time and distance to a fixed value (e.g. 200 km and 30min) to exclude outliers.

Why can the minimum TH of 10 km for MIPAS explain the differences and why the different sampling step size. Is the result not a clear indicator for a better sensitivity of MIPAS?
Please revise this section and take a better focus on detection sensitivity. You can model a similar sampling for MIPAS like SCIAMACHY by simply taking only every second altitude step in a MIPAS profile (dz=1.5km to 3km) to prove the sampling issue. This item needs to be investigated in more detail.

Minor comments:

P8296 l27: please specify for what quantity an agreement of 1 km is achieved.

Section 2.1.1 and Fig. 2: please explain if SCIAMACHY measures 'vertical' profiles or specify the horizontal offset between two successive THs (spectra).

P8309 L8: The computation of the area-weighted factor is not clear to me. Is this only a geometrical estimate? Please explain in more detail.

P8310 L14: An optical thickness of 5 is much denser than the high limb sensitivity. How does the model cope with these tin clouds?

P8314 L4: Here the reader may wonder if SCIAMACHY can differentiate between aerosol and ice clouds. Please comment.

P8315 L2: It is difficult to understand the a and x quantities and what is the real benefit of them. Why you overestimate the CTH and why CF is increased?

P8317: Have the authors taken in to account the 'shadowing effect' of cloud tops above the actual TH. A cloud above should usually reduce the number of observation at lower altitudes, because an independent information of cloudiness is missing below.

P8318 L17: please, correct PSC season 'a few month around July' usually (May-Sep/Oct)

P8320 L23: Please, give a few more details why the Nadir measurements observe the high clouds above Tibetian Plateau and Andes. Is this a potential artefact? The limb sounder should see these clouds as well.

P8327 L20: The authors need to revise this section and formulate some statement on differences in detection sensitivity (see major comment 4)

Figure 5: please add a non-cloudy profile for comparison.

Figure 6: why did you show the modelled CIR values and not the gradient used for detection as well? Please explain.

Figure 11: I would expect to see also volcanic signals in the SH of the Puyehue-Cordón Caulle eruption in 2011. Is the signal too weak for SCIAMACHI to detect? Please comment in the manuscript.

Figure 12+13: The structures of the annual mean of SACURA nadir CTH+1sig are a bit confusing, especially in the sub-tropics. I would leave this Figure out. The quantitative comparison of Fig. 13 is more illustrative. I would also suggest a similar Figure like Fig. 9 with the corresponding MIPAS results and for comparison – if available – the SAGE II climatology of Wang et al., (JGR, 1996).

Technical comments:

P8298: please introduce once the indices *n* and *l* for nadir and limb for the optical depth.

P8343, Fig 7: Please change ‘overplotted red rectangles’ to ‘the superimposed black rectangles’.

P8345, Fig.9: Why does SCIAMACHY measures such a high CF over the North Pole between 6.5 and 10 km. Please comment in the corresponding section of the manuscript.