Reply to comments by reviewer #1:

(our replies are boldfaced)

REF1: amtd-8-C3039-2015

Q1.1: 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.

- **The threshold was chosen to avoid influences from aerosols in the lower atmosphere. For clouds above about 6 km the CIR is generally much higher than 1.4 (see Fig.8a). Aerosols generally reduce the CIR and shift the maximum CIR to higher tangent heights. To support this we have added two more figures 6 (a-d) and adapted the corresponding text. The season of the year and S/N are of minor influence to the CIR. Season mainly change the SZA/SAA. S/N is generally high for this wavelength bands.**

Q1.2: 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.

- **This is a good point. The term was changed to cloud occurrence frequency for the height resolved results in accordance with MIPAS nomenclature (e.g. Spang, 2011). For the overall results (Fig. 8b) the term 'cloud detection rate' was chosen.**

Q1.3: 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.

- **We have to deal with cloud normally below 18km except for stratospheric clouds in winter time in the polar regions. A high cloud in the tropics of 1200km (about 10 deg latitude distance) diameter might influence the retrieval of the next limb state and the one before. This indeed leads to an enhancement of the detection rate.**

Q1.4: 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.

- **We changed CF to a more meaningful term "cloud detection rate" and changed the colour coding to improve the quality. As a cloud fraction Fig. 8b would not be meaningful. The figure is useful to get a global view where we even find difference along the coast lines despite the large footprint of a single measurement.**

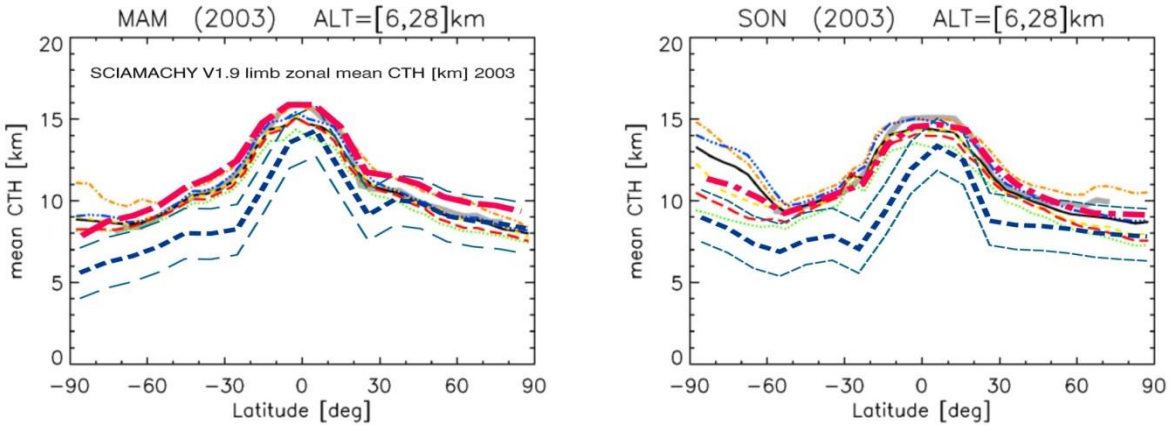
Q1.5: I have also problems to follow the discussion on a vertical area-of-sight (section 4.1). Please rewrite this section and explain in more detail quantities like the path length ratio (*x(3,3)* indices=?).

- **Rewritten with more comprehensive explanations. This paragraph is moved to the appendix, as it is only an argument for the low resolution in line-of-sight direction.**

Q1.6: 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.

- **This has been done using the SAGE II/MIPAS figure from Spang et al. (2012) and then added the SCIAMACHY results. I can add that figure to the supplements. When using the full vertical resolution of SCIAMACHY the comparisons were not optimal (thick blue dashed line). Excluding SCIAMACHY data below 6 km, the agreement is good (thick red**

dashed line).



Q1.7: 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?

- **These coincidences are excluded from comparisons. Comments were added to the text.**

Q1.8: 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.

- **We look for coincidences for all detections of clouds between 8.5 km and 25 km with lowest distance and time differences. MIPAS has a higher spatial measurement rate and looks into the other direction of the satellite. Thus we find a rather fixed measurement time difference of less than 990 sec (16-17min). The average distance between the tangent ground points can be as low as 30 km with an average of about 90 km and 130 km standard deviation (April 2010). A reduction in maximum distance to 300km reduces the number of coincidences by 10% with only an insignificant reduction in CTH differences between both sensors.**

Q1.9: 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.

- **I do not believe that it is necessary to reduce MIPAS resolution. MIPAS has a better vertical sampling which is needed for the verification of SCIAMACHY. One reason for differences is that MIPAS has a narrow swath of 30 km in horizontal direction, much smaller than SCIAMACHY (240km). It can therefore be more sensitive to horizontally smaller clouds.**
- **The main reasons seems to be sensitivity differences due to water vapour. SCIAMACHY using a scattering differences approach is not affected, while MIPAS also detects emissions from water vapour in the tropics, leading to false cloud detections. Reference of Greenhough (2005) added.**

Minor comments:

Q1.10: P8296 l27: please specify for what quantity an agreement of 1 km is achieved.Section 2.1.1

- **Now specified in paper: Good global agreement of about 1km CTH difference was found, which is smaller than the vertical field of view of both instruments.**

Q1.11: Fig. 2: please explain if SCIAMACHY measures 'vertical' profiles or specify the horizontal offset between two successive THs (spectra).

- **The SCIAMACHY limb profiles are not exactly vertical, which will be true for every scanning instrument. Due to the scanning pattern the tangent point varied from one tangent height to the next in both directions. The consecutive tangent (height) points can be roughly 50 km apart. Maximum difference between 2km and 18km tangent is e.g. 60km with about 40 km in longitude direction and 44 km in latitude direction.**
- **E.G: orbit 46209 time 00:34:26**
  TH [km]: 1.9 5.1 8.4 11.6 14.9 18.1

Lat [°]	**16.7**	**16.5**	**16.3**	**16.4**	**16.5**	**16.3**
Lon[°]	**139.4**	**139.8**	**139.4**	**139.8**	**139.4**	**139.8**

Q1.12: 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.

- **The area-weighted factor is indeed a geometrical estimate of the vertical/along-track area. This has been calculated to compare the different areas (volume when taking the across-track extent of the FOV into account) along the light path.**
  These areas do not differ a lot. Consequently also the limb optical thickness does not change significantly when a cloud of a small dimension would be moved along the line-of-sight. Thus the retrieval method cannot decide where the cloud is situated.

Q1.13: P8310 L14: An optical thickness of 5 is much denser than the high limb sensitivity. How does the model cope with these tin clouds?

- **An OT of 5 means for limb viewing a very high limb OT. SCIATRAN was used to test the retrieval method. It is capable of dealing with cloud and aerosol optical thicknesses from very low values to optically thick layers.**

Q1.14: P8314 L4: Here the reader may wonder if SCIAMACHY can differentiate between aerosol and ice clouds. Please comment.

- **Yes, this is later explained in the aerosol section. But here for a background aerosol case the effect is negligible**.

Q1.15: 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?

- **Improved the paragraph**

Q1.16: 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.

- **Yes, this can be detected in Fig. 9. The model stores the highest cloud height, which means that lower cloud layers will be missing. This is one of the reasons for the large deviations to Nadir measurements (Fig. 13).**

Q1.17: P8318 L17: please, correct PSC season 'a few month around July' usually (May-Sep/Oct)

- **Corrected**

Q1.18: 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.

- **This is not seen in the nadir CTH distribution and comes from a high standard deviation.**

Q1.19: P8327 L20: The authors need to revise this section and formulate some statement on differences in detection sensitivity (see major comment 4)

- **Detection sensitivity has been addressed in the conclusions.**

Q1.20: Figure 5: please add a non-cloudy profile for comparison.

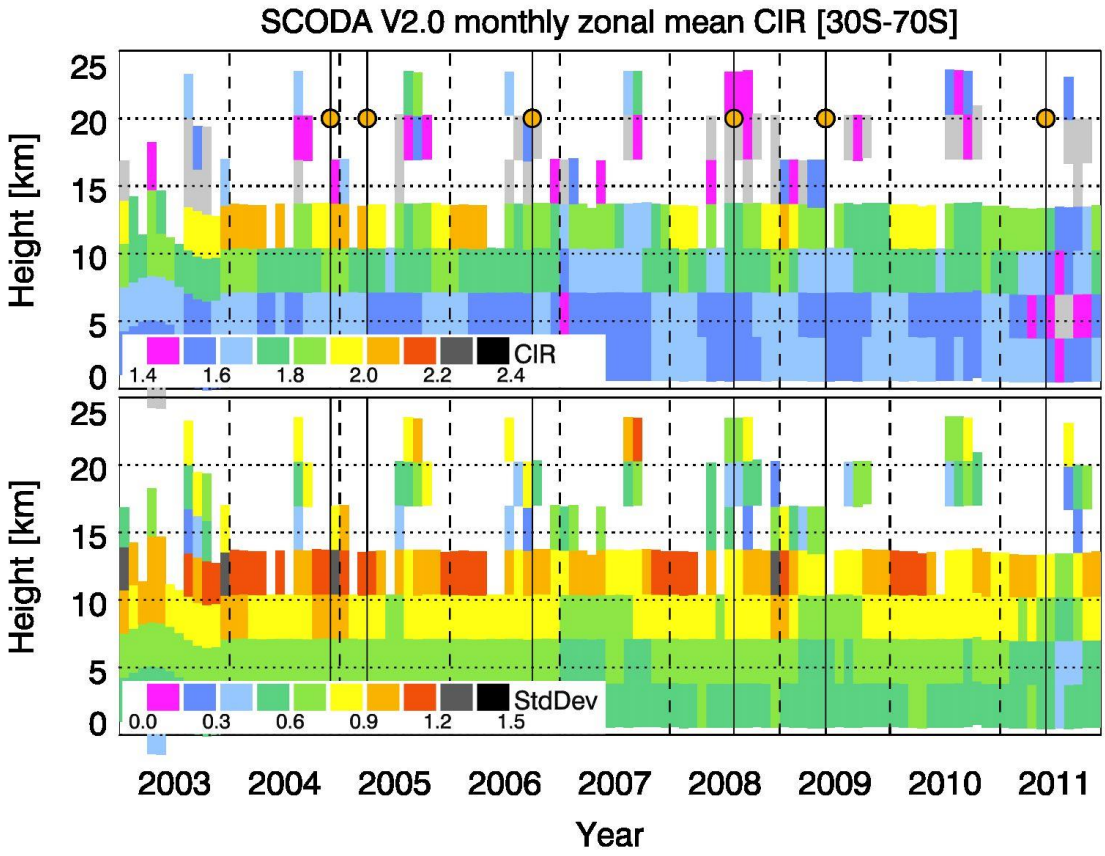
- **Added.**

Q1.21: Figure 6: why did you show the modelled CIR values and not the gradient used for detection as well? Please explain.

- **With the updated figure we only show the maximum CIR at the retrieval height where we would expect the cloud top. If the CIR is found at another height (mainly Fig.6a), no results were shown. The CI at retrieval height would not add any new information and displaying the full CI profile would be confusing.**
- **We added more explanations in the corresponding section.**

Q1.22: 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.

- **They are visible but not as pronounced as the northern volcanoes. The height of the aerosol layers seems to be considerably lower (13km) and mostly ash was ejected. But the effect on the CIR is clearly seen,**
- **This figure shows the monthly zonal mean CIR for 30-70°S as a function of retrieval tangent height. We detect a reduction in CIR and standard deviation after June 2011 for heights between 6-14 km that suggests the influence of an optically thin aerosol layer.**



- **I will add this figure and the corresponding NH band which shows the same behavior for the northern volcanoes to the supplements.**

Q1.23: 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 figure 12 gives a good overview of the discrepancies that has to be expected between the two measurement geometries. As only the highest cloud tops in limb were used we tried to simulate a similar effect in nadir with adding 1sig. But still we find differences because of detection sensitivities and measurement problems.**

Q1.24: 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).

- **A figure copied from Spang was used to overlay our results showing good agreement (see above).**

Q1.25: P8298: please introduce once the indices *n* and *l* for nadir and limb for the optical depth.

- **Corrected**.

Q1.26: P8343, Fig 7: Please change 'overplotted red rectangles' to 'the superimposed black rectangles'.

- **Corrected.**

Q1.27: 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.

- **This is a very interesting question. Although stray light is taken into account for calibrating the level 1c data, it seems to have an effect on the measurements in the polar regions with high SZA. We have updated the figures removing the first 5 limb states after the highest latitude was reached. This reduced the effect but it is still visible.**
- **Comments were added and reference to stray-light given (Langowski, 2015).**