Answer to referee 2

December 20, 2013

We would like to thank referee 2 for the suggestions and sophisticated discussion and would like to answer to the individual points in the following.

Suggestions for technical corrections

1.) Cloud heterogeneity and 3D radiative effects: This is am important point of course, we did not include an analysis in the article since it is indeed out the scope of this paper and also has been addressed by many other researchers.

The heterogeniety of clouds has naturally an effect on the retrieval, many researchers quantified the 3D effects, mainly the plan-parallel effect which arises when neglecting the varying spatial structure of a cloud within a pixel and also the shadowing effect. But these effects depend strongly on the real formation of the cloud fields. So most studies consider the average error or have to limit the studies with certain constraints (for example study only cloud field that are at least 25 km contiguous but not patched fields). Marshak et al. 2006 found out, that the sign of the differences in effective radius and cloud optical thickness depends on the cloud structure and on the viewing conditions, in particular the sun zenith angle and can be either positive or negative. The bias differs also with the cloud's spatial structure (in terms of heterogeneity, e.g. stratiform as opposed to cumulus). Maybe it would be possible to define distinct classes of clouds in terms of their horizontal heterogeneity and derive a measure of the 3D impact. Unfortunately we are just not capable of carrying out this research and mingle it with the statistics presented in this paper and quantify the impact on the LWP retrieval. We included a paragraph on 3 D effects and LWP retrieval at the end of section 3.1 in the revised article.

2.) Mixed-phase: for our comparisons with the microwave climatology we chose the low cloud region at Angola/Namibia because those clouds should be free of ice or mixed-phase, or at least the errors would be minimal compared to other regions. So we believe that the comparability is given at least in this region.

3.) We mentioned the possibly too high LWP-values of SEVIRI and also discussed the deviations from SEVIRI-derived LWP to the climatology.

4.) We compared the cloud detection for SEVIRI to CALYPSO measurements and found, that best results are achieved if clouds with COT < 0.3 are not considered, but starting from COT $= 0.1$. Clouds that were detected by CALIOP could also be seen by SEVIRI (we compared the 5 km product of CALIOP with SEVIRI and collocated two months of data, all matching pixel were compared). In our analysis we did not remove the cloud edges, since we wanted to compare the full cloud fields as they are retrieved from our algorithms. Also this should give the best consistency with the O'Dell climatology where a mixed signal from cloudy and cloud-free portions is measured.

5.) Figure 3:
We included the following sentence:
"The full disc data can be found to the right. On the full disc the proportion of the cloud types middle level, high opaque and fractional do not change vigorously during the year 2009, but in the summer month the low cloud class fraction increases to exceed the high semitransparent one. In Europe, the monthly variation for all cloud types is generally bigger compared to the results for the full SEVIRI disc with one exception: the seasonal variation of low clouds is bigger for the SEVIRI disc. Most noticeable in the European seasonal variation...."

6.) Thank you for the hint, we did not clarify this enough. Reasons for deviations can be:
-the problems with viewing zenith angles and the low number of pixels that were incorporated in the averaging of SEVIRI data (even though we tried to exclude pixels close to sunrise)
-the climatology of O'Dell is the average over 20 years + the results were fitted with a sine curve, which can lead to increasing differences where sin(x) is close to 1. We added the discussion in the text in section 3.2

7.) We have a discussion on the diminishing number of pixel in section 3.2 in 2 paragraphs and showed the number of pixels in Figures 6 and 8. To clarify the contribution of the SZA to the number of observed pixel and also the error we added a sentence in the discussion of the respective figures. The value of the threshold SZA is 72 and mentioned as well as discussed in section 2.2 and 3.2.

8.) No, they are not detected as liquid in the algorithm for the microphysics, but the cloud top temperature (CTT) provided from algorithm 1 is not entirely

the same as the CTT that was used in algorithm 2. Therefore some discrepancies in individual pixels can occur with CTT < -38 degrees C and cloud phase set as liquid. The number of falsely classified pixel is very low, about $4.0 \cdot 10^{-3}$ % in our considered months.

9.) Rim errors: The line of sight of SEVIRI is more slanted towards the rims of the field of view, i.e. gaps between clouds cannot be seen properly any more because one cloud field obscures another. Therefore the overall cloud fraction is detected too high towards the rims of the disc. Since the liquid water path is a volumetric variable, it is affected by the obscuring of cloud gaps and the impossibility of detecting inhomogeneities within clouds along the line of sight. So the retrieval error for LWP is not systematical but depends on the spatial structure of the cloud fields. A stratiform, homogeneous field will have a smaller error than a cumulus cloud cover, particularly with sub-pixel homogeneity. A more extensive evaluation on the rim effects, e.g. error depending on cloud types, will be done in the future.

10.) With this discussion, we wanted to make the reader aware, that single clouds can change their classes during their development, for example through convection. This has to be kept in mind when inspecting the diurnal cycle of for example middle level clouds. A dip in the diurnal cycle does not necessarily mean that the clouds have vanished, also transitions into other forms are possible during a single day and very likely. We chose this particular regions for the experiment because this is a spatial constant cloud field, and changes in the number of clouds of a certain type can likely be attributed to transitions from one type to another. We agree that the discussion is rather general but we consider this part to give valuable information to the reader on how to interpret the average diurnal cycles that we present in the paper.

11.) SEVIRI is a passive imager and the applied algorithm is based on radiance thresholds, so SEVIRI cannot detect multi-layer clouds. Low clouds below higher clouds are not detected and not included in the discussion. It is also possible, that high clouds shade neighbouring pixels with lower cloud fields, this is one effect of the viewing geometry problems and depends on the viewing zenith angle of SEVIRI. We included the information in section 2.1, 3.1 and 4.

12.) Missing acronyms declarations: Thank you for the advice, we explained the acronyms at their first appearance.

13.) unclear figures and use of colours without symbols: Admittedly we did not think of that and changed the line plots 3, 6, 7, 8 and 11 to be more clear.

The points indicated in the discussion paper itself are accepted and changed at the respective positions.