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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Atmospheric parameters in a subtropical cloud regime transition derived by AIRS+MODIS – observed statistical variability compared to ERA-Interim" *by* M. M. Schreier et al.

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Anonymous Referee #1

Using a synergistic combination of observation types and instruments to retrieve cloud parameters and vertical profiles is always welcome. The reviewer also very much welcomes the additional comparison with re-analysis data. So so far all good, aslo the writing of the manuscript is reasonable.

The authors are grateful to the reviewer for the insightful and constructive com-

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ments. We hope that we have satisfactorily addressed the reviewer comments below and with appropriate changes to the manuscript.

There are however 3 major points (in addition to the minor below) that must be addressed before the publication of the manuscript (a) the latitude mask on your statistics, one would not necessarily expect that for Cu and/or Sc cloud types

We agree that this latitudinal restriction imposes unnecessary limitations in the analysis. We removed it in the revised version and defined the cloud types entirely on cloud top height and cloud fraction (see new cloud type definitions in chapter 2.3 (page 7, line 32 to page 8,line 7). The major change was that it resulted in a larger amount of Sc, trans Cu and trade Cu for the AIRS/MODIS observations. This is seen in some subtle changes in Figure 2, with more minor changes in ERA-Interim data. We described the changed relationships on page 10, lines 14-22. Additionally, it resulted in slight changes in the variability of cloud parameters and moments as seen in Figure 3 and Table 1. Most significant is a broader distribution of lower tropospheric stability (see Figure 4 and Table 2). Another minor change is a change of moments between boundary layer and free troposphere (see Figures 5-8).

(b) the higher-order moments of the statistics you use, such as skewness and kurtosis. It must be made clear,and this is misleading in the manuscript that ERAI with a resolution of 80 km can in no way represent the positively skewed distribution of theta, q as this would be subgrid - this positively skewed distributions are due to narrow updrafts with diameter of O(1 km) or less. Negative skewness in Sc is due to stronger downdrafts due to cloud-top cooling Therefore I doubt it makes any sense to plot skewness and curtosis for ERA-Interim and plotting it for MODIS might be just ok but still at edge of resolution

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We agree with the reviewer that one might not necessarily expect variations in the higher moments in ERA-Interim because of the coarse spatial resolution, Convective updrafts and downdrafts are most likely the dominant processes on the kilometer and sub-kilometer scales. However, on the larger scales, the mescoscale circulations and free tropospheric structures are expected to cause possibly non-Gaussian behavior. Our analysis was therefore not intended to address the variability of thermodynamic variables and cloud cover due to convective drafts.

Our analysis aims on the fact that the resolution of ERA-Interim and AIRS is comparable ($\sim$80 km for ERA-Interim and $\sim$45 km for AIRS at nadir, and closer to $\sim$100 km at the highest scan angles). Therefore ERA-Interim should resolve similar features as AIRS retrievals if these data are to be used by the scientific community in detailed process studies that rely on the statistical description of temperature, water vapor and clouds. We added these thoughts to our introduction on page 4 (lines 24-31): "The coarse horizontal resolution of AIRS/AMSU is a fundamental weakness. The remote sensing data ($\sim$45 km) is only a factor of $\sim$2 higher than ERA-Interim resolution ($\sim$80 km). While it is impossible to resolve very small-scale features that will be effectively smeared over the 45km field of regard, the reanalysis is also subject to the assumptions imposed by subgrid-scale parameterizations, for which the satellite data is not subject to. Thus, there is value in comparing the two data sets. In this work, we ask if the remote sensing observations of θ, q, and cloud property PDFs are comparable to current state of-the-art reanalysis data, especially in the case of the stratocumulus (Sc) to trade cumulus (trade Cu) transition."

The bottom line is that the AIRS temperature and water vapor profiles show somewhat more non-Gaussian behavior than ERA-Interim (Figs. 5-8 in revised manuscript). However, ERA-Interim does show particular non-Gaussian features related to the MBL and are largely consistent with AIRS in terms of how they relate to the different MBL cloud types. We believe these results are important and relevant to

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the science community since these differences appear to depend on the cloud type – no single systematic difference exists for all cloud and scene types.

(c) please revise your Figures 5,6. These are not good quality anyway and tehre are too many lines. It might be necessary to check significance of skewness and curtosis for Modis , and it is up to you if you decide to keep it (at least I would remove kurtosis), but clearly ith makes no sense to keep ERAI skewness etc. and you should make this clear in text that for the ERAI resolution is too coarse

Per the reviewer's suggestion, we revised Figs. 5 and 6. They were split up into four figures: Figs. 5-8. The insets for the 800-1000 hPa layer now have their own subpanels and the full 200-1000 hPa profiles do as well. The quality of the figures and sharpness of the lines were improved. Given the discussion above, we have kept all of the statistical moments in the revised manuscript. Again, not all of the non-Gaussian behavior is driven only by O(1 km) circulations in the MBL, and we hope that the cited literature in the manuscript helps support this point.

For better visibility of the important aspects of the data we removed the dotted lines, which indicated day-to-day variability in all moments. We hope the revised plots improve the visibility of the figure content.

Detailed, mostly minor corrections:

p24052 L18: "helps"− >"help" L26: "and its influence in"− >"with their characteristic distributions"

Corrected.

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p24053 L7 "Bechthold"− >"Bechtold" L7: remove "strong" L8: "is ..pointed out by people like"− >"has been pointed out by" L27:"well-distributed, but limited time periods ... ", rewrite as "targeted in-situ aircraft observations over limited time periods"

Corrected.

p24054 L5: "located on the"− >"onboard" L6: "has made these kinds of observations"− >"has been operational" L10: remove "in the lower parts of the vertical structure" L16: "also located on"− >"onboard"

Corrected.

p24057 L16-17: remove "The centers of the boxes are given by latitude = -17 + (3×j) and longitude = 187 + (4×j), where 1< j < 12, and j is an integer"

Corrected.

p24058 L1-2: remove "To characterize the influence of the cloud type on this study" and start with "The"

Corrected.

L10-15: what do you mean by "clouds higher than 680 hPa pressure level"? their cloud top is below 680 hPa?

We meant clouds above 680 hPa in pressure coordinates. We made this clearer in the revised version.

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Also why do you also use a latitude mask for the cloud types,? It would be desirable not to have such a mask

The latitude restriction was removed in the revised version. Please see above discussion regarding the first mandatory change. We detail what changes occurred due to the removal of this restriction.

p24060 L2: better to say again in words what is ”re”,”tau_c”, ”T_c” L2-3: remove commas in ”, and” p24061 L6-7:”the relative occurrence and frequency of cloud fractions”, text as also in Figure legend is not correct, what you show is "annual mean evolution of relative occurence and frequency distribution of cloud fractions for the five cloud types” L19:”at 2005”->”in 2005”

Corrected.

p24062 L3-4:”The limited resolution (250m to 1 km) of MODIS may result in a shift of trade Cu pixels towards clear sky” or isn”t it the opposite? this can be conveniently checked with a toy data (pixel) model

This is an excellent point that the reviewer makes. We modified this paragraph and cited an additional reference (page 10, line 31 to page 11, line 2):
”The limited spatial resolution (250m to 1km) of MODIS may somewhat overestimate the trade Cu population in comparison to trans Cu or Sc (Zhao and Di Girolamo, 2006).”

L11-12:”decrease from Sc to trade Cu”, decrease of what? L14-15:”ERA-Interim has lower values of skewness”, lower values of what p24063 L10-11:”The calculation of re in ERA-Interim is calculated” strange expression, correct

”decrease from Sc to trade Cu” was corrected to ”A decrease in the mean τ_c is

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observed from Sc to trade Cu" "ERA-Interim has lower values of skewness" was corrected to "ERA-Interim has lower values of skewness and kurtosis for the distributions of τ_c compared to MODIS"

P24064 L10: remove "a priori assumptions or other imposed behavior in the cloud retrievals"

Corrected.

p24066 L22-23:"but does not reproduce the strong negative skewness seen in Zhu and Zuidema"s simulations of trade Cu" I thought one would especially from LES expect positively skewed distributions from LES

We thank the reviewer for pointing out this misinterpretation. We corrected the sentence therefore to:
"A comparison of Zhu and Zuidema (2009) with AIRS suggests similarities of θ_l and θ in positive skewness of observed high clouds, similar to the positive skewness seen in Zhu and Zuidema's simulations. However, AIRS cannot resolve the strong gradients at the top of the broken cloud layers shown in Zhu and Zuidema (2009)"

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