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Atmospheric Measurement Techniques Discussions

# *Interactive comment on* "Footprint-scale cloud type mixtures and their impacts on Atmospheric Infrared Sounder cloud property retrievals" *by* Alexandre Guillaume et al.

**Anonymous Referee #2**

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In this paper AIRS measurements are combined with Cloudsat observations to obtain statistics of the variation of cloud types within the AIRS field of view. These are then used to study the variation of cloud properties per cloud scene and the sensitivity of ice cloud properties retrievals to the variation of cloud types within the pixels.

The study is interesting and the methods are generally sound. However, some issues with the presentation and the analysis need to be addressed before the paper can be accepted for publication. Below the major and minor comments are listed:

1) The Cloudsat cloud types are used. However, these type names are not very quantitative. Please indicate how the different types are defined and summarize how they



are derived from Cloudsat observations. The reader should not have to dig through other papers to be able to understand the data presented here. For instance, what are the altitude boundaries distinguishing low, middle and high clouds? It is also not clear to me how cumulus and stratus can be distinguished using a single radar profile.

2) Please be consistent with cloud type names throughout the paper. For example, sometimes "As" is used and sometimes "AlSt". Sometimes "clear sky" is used, sometimes "nc". Also, mixtures are denoted with commas, although clear-sky is left out in this notation. I suggest to indicate mixtures of cloud types and clear sky consistently, e.g., "As, nc". To give an example how this is confusing: Looking at Fig. 6, It was unclear how cumulus can have a length scale of 400 km, but I guess that's possible because clear-sky is mixed in. This can be made clearer by naming this mixture "Cu, nc" (This then excludes pure "Cu" cases. If these are included too, then I suggest using something like "Cu + Cu, ns").

3) Two different footprint sizes are considered, namely the AIRS/AMSU footprint of $\sim$45 km and the AIRS footprint of $\sim$15 km. It is a bit unclear throughout the paper which analysis is applied to which of the two footprints. In any case, the two different scales need to be addressed more consistently throughout the paper (in addition to the abstract). For example, Section 3.1 focuses on the AMSU footprint but not on the AIRS footprint. If I'm not mistaken, the AIRS cloud retrievals are performed on the AIRS $\sim$15 km footprint, so the last section focuses only on that scale (If so, state this clearly in the paper.) Please expand the discussion in section 3.1 to the AIRS footprint as well and add a figure similar to figure 1 for the AIRS footprint. Furthermore, I assume Fig. 2 is showing statistics for the AMSU footprint. If this is true, please state that in the paper. I suggest adding figures similar to Fig 2. for the AIRS footprint, or at least discussing the (lack of) differences between AIRS and AMSU global distributions. In fig. 3, 4 and 6, indicate the size of AIRS and AMSU pixels.

4) If my interpretation is correct, one goal is to compare AIRS cloud retrievals for cases with a single cloud type in the footprint with clear sky mixed in versus without clear

sky. However, a comparison is made between 1) cases with a single cloud type in the footprint and no clear sky and 2) cases with a single cloud type in the footprint either with and without clear sky. Thus, the case 2 set also contains the case 1 set in addition to the mixture of clear sky and a single cloud type. Therefore, the differences in properties listed in the paper are not representing the differences between cases without clear sky mixed in versus those with clear sky mixed in. From the information in the paper, we cannot deduce the relative number of cases per cloud type with versus without clear sky mixed in. If, for example, the number of cases without clear sky mixed in is much larger than those with clear sky, then the small differences shown between table 2 and 3 and figures 7 and 8 are surely expected. I suggest the following: 1) Include a table or figure showing the relative number of single type cases with and without clear sky mixed in. 2) For the single types listed in table 3 and figure 8 include only cases that also include clear sky. (Or add a table and figure showing this, leaving table 3 and fig. 8 as is.) To include a complete comparison between table 2 and 3 and figures 7 and 8, I suggest to also include the deep convection type (mixed with clear sky) in table 3 and figure 8. 3) Adjust the discussion of the differences accordingly.

Minor comments:

At the start of Page 11 it is stated that "the AIRS footprint ( $\sim$ 15 km ) is commensurate with the dimension of a single cloud so that the most frequent observations involve the characteristics of one cloud." What is meant by this statement? Many clouds, for example cumulus, have typical scales much smaller than that.

Table 1 and 2: Mean optical thicknesses are given here, but these are biased low because AIRS is not sensitive to any variation past an optical thickness of $\sim$5. Please make this clear in the text. The true mean optical thickness of most types will be larger than the AIRS-retrieved means shown here.

I think the caption of figure 4 is missing the word "scenes" at end of first sentence. It is noted in the text that Fig. 4b and 4d are similar to Fig. 3, but it is not directly clear what



the difference in the calculations are. Please explain.

I noted that the statistics listed in Table 3 are different than in Fig. 1, and this might be due to the different scales of AIRS vs AMSU. (See main comments.) However, for the ice properties to be retrieved, the phase needs to be identified as ice, so are these proportions for ice clouds only? Is that also explaining the difference in statistics compared to figure 1? Please explain in the text.

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