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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Cloud type comparisons of AIRS, CloudSat, and CALIPSO cloud height and amount" *by* B. H. Kahn et al.

Anonymous Referee #2

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GENERAL COMMENTS: Passive remote sensing observations from space provide today over 20 years of cloud height and amount statistics. Such measurements are extremely useful to enhance our knowledge in cloud processes, as they are known to be the primary source of uncertainty in current day climate feedback studies. Cloud boundaries along with cloud water content are essential quantities that control cloud radiative feedbacks. Hence reliable statistics of these quantities derived from observations are necessary to evaluate the capability of GCMs to reliably reproduce cloud structure, cloud properties and cloud radiative impacts.

Even though passive remote sensing measurements have been available for over 20 years, researchers are still very active in the evaluation of cloud occurrence and cloud height retrievals based on those measurements. The construction of unbiased cloud vertical distribution statistics remains a challenge today as no single instrument is capable of providing unbiased retrievals of all possible hydrometeors contained in the atmosphere.

The present paper makes use of the recent cloud radar (CloudSat) and cloud lidar (CALIPSO) missions, that are designed to have enhanced skills for cloud detection and vertical structure estimation, to evaluate cloud products derived from the Atmospheric Infrared Sounder (AIRS) measurements. The paper is original is the sense that space-borne cloud radar and lidar measurements have not been used before to evaluate AIRS cloud retrievals, as CloudSat and CALIPSO cloud products were released at the end of 2006 and . Prior AIRS retrievals (or that of other profilers or imagers) have been confronted to ground-based cloud radars and lidars, but those studies were naturally limited geographically.

COMMENTS REGARDING THE USE OF CLOUDSAT AND CALIPSO DATA AS REFERENCE.

The authors state that ?CloudSat and CALIOP generally provide more direct and easily interpreted observations of cloud detection and cloud structure than passive methods.?. While this is generally true because active remote sensing is intended to provide an accurate information of the location of the scattering or reflecting particles, several effects can limit the ?direct? and ?easy? interpretation. For example, cloud radar reflectivities are very sensitive to particle size, so clouds with small ice crystals or liquid droplets may not be detected. This will certainly affect cloud top height detection. Conversely, precipitation below clouds will also yield reflectivities that cannot always be distinguished from the cloud itself. 94 GHz cloud radars are attenuated by liquid water and very dense layers will induce multiple scattering. This will affect cloud base height detection. Lidar backscatter is sensitive to very small concentrations of particles, and hence can serve as a reference for layer top altitude detection. However the CALIPSO level 2A cloud mask detection documentation states that some clouds may be mislabeled as aerosols and vice versa. This will affect cloud detection. Additionally, the lidar signals are subject to very strong attenuation and multiple scattering which can affect cloud base identification.

So this reviewer suggests that the authors develop a thorough discussion in Section 2 to address the following issues: 1. What are the known limitations of CloudSat cloud occurrence and cloud height detections in the current 2B-GEOPROF product? What are the known limitations of CloudSat cloud type detections in the current 2B_CLDCLASS product? 2. What are the known limitations of CALIPSO cloud occurrence and height in the current Level 2A? 3. What are the justifications for using ?unvalidated? satellite products, or satellites that are currently going through a validation process? to validate other satellite products? 4. How will these issues affect the outcome of the study?

COMMENTS REGARDING THE ANALYSIS OF AIRS CLOUD OCCURRENCE AND CLOUD HEIGHT PRODUCTS:

The central point of the analysis presented in this paper is that the evaluation of AIRS cloud occurrence and cloud top height is done separately for 7 different cloud types, while most previous studies provided results for all cloud types alike. This is interesting because the optical properties and vertical positions in the atmosphere render the different cloud types more or less accessible to the different remote sensing techniques compared in this paper. AIRS, CloudSat, and CALIPSO have different detection skills for the different cloud types. This is illustrated well in Figure 2 and discussed briefly in Section 2.4.

As the authors propose a cloud-type by cloud-type analysis of AIRS products, this reviewers suggests that CloudSat should be used as reference only for those cloud types for which CloudSat has the best skills. Similarly CALIPSO should be used as a reference for the cloud types for which CALIPSO has the best skills.

This is at issue in Section 3.1 and throughout Section 4.

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Section 3.1 - The authors find 9.5% (8.8%) false detection by AIRS compared to CloudSat (CALIPSO). This includes ?false? false detections due to poor CloudSat/CALIPSO skills for certain cloud types (e.g. thin cirrus for CloudSat, scattered clouds for CALIPSO). This reviewer finds that an average number for all cloud type leaves a false impression on the detection skills of AIRS. The reviewer suggests that the author discuss false detection for each cloud type in order to establish a more accurate evaluation of AIRS skills.

Section 3.2 - ?The evaluation of retrievals of Za and fa and their discrepancies are more problematic in Polar latitudes??. Please explain why or provide reference. - ?First, the peak frequency in the tropical upper troposphere is zonally offset between AIRS and CloudSat by 5°.? This is not evident from Figure 6. Analysis of differences between the various panels of Figure 6 would be made easier if the figures included a grid. - ?Second, AIRS retrieves? Third, ? Fourth, ??. Are CloudSat and CALIPSO cloud height products validated enough to know which retrieval is biased and which one is not? - ?The lower frequency of lidar-detected clouds from 5°S-5°N? narrow vertical range resulting in fewer detected clouds?. The opacity of clouds should not affect the detection of cloud tops and hence their frequency of occurrence.

Section 4.1 - Discussions of Figures 7, 8, 9 are comprehensive. The main results and sources of discrepancies for each cloud type that emerge from the comparison should be summarized in a paragraph or in table 4. E.g. Explain what specific skills are missing for detection of Ci, Cu, ? - Discussion should be limited to cloud types where the reference (CloudSat or CALIPSO) is known to have the necessary skill OR estimate what part of the difference (e.g. table 4) is due to CloudSat and/or CALIPSO uncertainty. - Discussion of V4 vs V5 results is split between this Section (Figure 10) and Section 4.3. The reviewer suggests to combine the discussion of Figure 10 and Section 4.3.

Section 4.3 - This section could be significantly shorter. The technical details of the difference between V4 and V5 can be described thoroughly in a technical report. -

The discussion on use of handling of CO_2 and its effect on Ci detection is interesting and feeds back to discussion of Figure 10. The effect on Ci should be compared to CALIPSO retrievals rather than to CloudSat retrievals.

Conclusions: - Substantial conclusions are reached, but an objective conclusion on the skill of both reference datasets (CloudSat and CALIPSO) for each cloud type would be welcome

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