Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., referee comment RC1
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Peer-Review Comment on acp-2022-140

Anonymous Referee #1

Referee comment on "Impacts of active satellite sensors' low-level cloud detection limitations on cloud radiative forcing in the Arctic" by Yinghui Liu, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-140-RC1, 2022

This is an interesting application of GV data to understand how satellite data cloud masks could lead to uncertainty in radiation forcing estimates. The author develops an application of the Quickbeam simulator to the high-temporal resolution ground validation. Uncertainties in the radiative fluxes due to the missed detection of clouds from simulated CloudSat and CALIPSO cloud masks were estimated. They found that the seasonal cycle has a large impact on the magnitude of CRF biases due to changes in cloud microphysics, temperature structure, and surface albedo characteristics. For monthly averages, the combined CloudSat-CALIPSO mask provides the best match to surface observations, however, errors can get large when comparing 1-minute case data. Uncertainties in the cloud detection methods are described in the final section. This work is useful for the community as uncertainty estimates in Arctic regions are needed; the work, however, has numerous issues that need to be tackled first before publication.

More significant comments:

1.

Results in Table 4, Table 5, Figure 10, and Figure 6 are difficult to interpret because of the sampling strategy presented. The author mentions that many cloud types are omitted from the study (snow, drizzle, liquid cloud+drizzle, rain, haze, or uncertain retrievals). It is important to understand how often these cases occur and how their exclusion impacts the results presented here. The CRF results are needed, however, if the sampling represents a small fraction of the total CRF they would not be representative of the total population of clouds. It would be helpful to understand the frequency of occurrence of each type mentioned here to get an idea of what is being sampled.

Further, radiative calculations are performed once per hour. Why not compute all profiles? One of the main advantages of ground validation data is the high temporal resolution and a once per hour sampling lowers the accuracy of the data. If a subset of clouds is being examined, clouds could be missed and random errors could become large. It would be helpful to demonstrate that increased sampling does not impact the results (i.e. 6 times per hour or 10 times per hour).

2.

As stated in the uncertainty section, the results presented are based on a single-shot cloud mask (on profile at a time). The combined CloudSat and CALIPSO cloud masking products as well as the cited 2b-FLXHR-lidar products use averaged data along the satellite track to better detect clouds that might be missing in a one-shot case. The cloud mask results derived in the current study would represent a worst-case scenario for cloud detection errors from the satellite perspective. As demonstrated in figures 20 and 21, a large portion of clouds could be detected if a small change is made in the retrieval. This uncertainty, however, is not translated back to the radiation. It is, therefore, difficult to relate how this uncertainty impacts results and makes it hard for the reader to interpret. It would be helpful to take a month of data, such as when errors are large, to demonstrate a range of CRF uncertainty due to changes in cloud mask thresholds.

3.

Something seems off about the optical depth calculations shown in Figure 1. Previous studies using SHEBA data display column optical depth ranges up to ~30, with most clouds having column optical depths < 10 (Turner 2005; Zuidema et al 2005). If the vertical resolution is 63 m., Figure 1 shows optical depths greater than 5 for each vertical bin in the 15-20 bins below cloud top. This would lead to a column optical depth > 100 and does not seem physical for such a geometrically thin cloud. Given that the optical depth is used in the radiative transfer calculations as well as the CALIPSO cloud mask it would also lead to large uncertainty in the results as it prevents the CALIPSO cloud mask detections. This needs to be investigated to make sure the correct calculations have been made throughout the study.

Turner, D. D. (2005). Arctic Mixed-Phase Cloud Properties from AERI Lidar Observations: Algorithm and Results from SHEBA, Journal of Applied Meteorology, 44(4), 427-444

Zuidema, P., Baker, B., Han, Y., Intrieri, J., Key, J., Lawson, P., Matrosov, S., Shupe, M., Stone, R., & Uttal, T. (2005). An Arctic Springtime Mixed-Phase Cloudy Boundary Layer Observed during SHEBA, Journal of the Atmospheric Sciences, 62(1), 160-176

5.

There are a large number of tables and figures in the paper. Figures or tables that are not necessary could be removed or added to supplemental. For example, the surface albedo figures are not needed as their source is described in the text. Further, the tables showing the raw numbers for vertical profiles could be included in the supplemental.

Specific Comments

Paper Title: The title is too vague and suggests a global study when the spatial sampling is limited to ground validation sites in the Arctic. I would include the Arctic in the title to make it more specific or mention the use of SHEBA data.

Pg 1 Line 22: Change "modulator of the radiation flux" to "modulator of radiation".

Pg 4 Line3: I would make this clearer that phrases such as "with every 63 m from 150 to 1050 m" is talking about changes in vertical resolution.

Fig 1b: A log-scale color bar would make some of the finer details of the cloud optical depth pop out a little more and limit the saturated COD above 5 (see comment 3 above as well).

Pg 7 Line 5. I would move the description of the radiative terms being calculated after the description the two sets of profile experiments.

Pg 7: Line 18: The use of "cloud layers" or "layers" gets jumbled here. I would describe cloud layers as layers with cloud data and total layers (50 or 125) as just "layers".

Pg 9: Line 21: Please introduce Figure 6 first.

Pg 9 Line 28: remove "very" from high optical depths.

Pg 11 Line 2: Should this reference Fig 6e?

Fig 8: Is "all" the surface observations? This should be made clear.

Pg 12 Line 12. With a difference of only a few percent, I would mention that the combined retrieval captures the majority of clouds above 1 km.

Fig 6. The Julian Day labeling is a bit confusing and would be easier to interpret if months could be added.

Pg 16 Line 10: This is mostly due to the lack of sunlight during many months leading to the LW heating being the dominant term.

Pg 28 Line 5: This caveat along with the one for CloudSat needs to be listed in the cloud mask description in section 2.