Dear Reviewer,

We gratefully thank you for your time spent making constructive remarks and suggestion, which helped us improve the quality of the manuscript. Each suggested revision and comment, brought forward by the reviewer was carefully considered and responded. Below the comments of the reviewer are responded point-by-point and the revisions are indicated.

Overview:

This manuscript describes studies to reduce satellite retrieved cloud fraction inconsistencies across different products over the Artic region. The inconsistencies can be attributed to differences in sensors, retrieval algorithms, orbital drifts, etc. The authors apply cumulative distribution function (CDF) matching and the Bayesian maximum entropy (BME) method to produce a synthetic monthly 1°×1° cloud fraction fusion dataset in the Arctic during 2000–2020, by utilizing CALIPSO-GEWEX and ground observations as truth data. It is known that there are large uncertainties in cloud fractions derived from passive satellite observations in the Arctic region. The fusion product from this study provides high quality data for the scientific community to use and makes an important contribution. The manuscript is organized and well written. I recommend to accept this manuscript subject to minor but necessary revisions.

Response: Thank you for your positive and constructive comments on our manuscript, which given us more confidence in our current and future researches. And we also appreciate your doubts, which helped us think more deeply about the value of this study and improve the quality of the manuscript. We carefully responded your questions about the time period of ICOADS, and we added the uncertainty estimates about the fusion cloud fraction, as well as other questions. We take a revision about the original manuscript according to your comments. Please see the point-by-point responses for details.

General comment:

1. The authors only studied sunlit months "because of the darkness of the Arctic winter". However, all the passive sensors and CALIPSO-GEWEX have cloud fraction data at nighttime. The manuscript mentioned that CRU TS data are from sunlit hours, but it seems the ocean data ICOADS are not limited. I would like to see some discussion on the availability and quality of ICOADS data, particularly at nighttime, and if possible to use ICOADS alone as ground truth to derive fusion data for the other months over the ocean.

Response: Thank you for comment. Our study had the objective of producing precise measurements of Arctic daytime cloud fraction. Consequently, we exclusively utilized cloud fraction data labeled as "daytime" from several satellite datasets. We agree with your perspective that "CRU TS data are from sunlit hours, but it seems the ocean data ICOADS are not limited". The ICOADS dataset contains cloud fraction observed in daytime and nighttime. In order to use daytime data as much as possible, we only applied the cloud fraction data with a "fraction of observations in daylight" exceeding

0.8. The data with the label of "fraction of observations in daylight" is also contained in the ICOADS dataset (https://psl.noaa.gov/data/gridded/data.coads.1deg.html). For the sake of clarity, we included a detailed explanation about this methodology in our manuscript. (**Lines197-199, Page5; Lines248-252, Page7**)

2. One important but sometime missing aspect of satellite products are the uncertainties of the retrieved variables. Are there any uncertainty estimates of the fusion cloud fraction from the CDF-BME methods? If yes, can the authors show some plots?

Response: Thank you for pointing this out. We have added the uncertainty estimates of the fusion cloud fraction in our manuscript. We use the error standard deviation which generated by the BME fusion process, please see section 5.3 (**Lines 743-756, Pages 29-30**). The contents are as follows:

To assess the fusion algorithm's reliability, we calculated the standard deviation of error within each grid value in the fusion process. Specifically, we determined the standard deviation of the predicted posterior probability density function on each grid point. Our findings demonstrate that, with the exception of the northern region of Greenland and part of the margin error, the standard deviation of error in other areas was within 3% (FIG. 4-16). We attribute these discrepancies primarily to the underestimation of ground and satellite observations by satellite data, particularly ISCCP-H data, by around 10-30% in the central zone of Greenland. Moreover, the CF of ISCCP-H was significantly overestimated beyond the Greenland margin. Such significant inconsistencies can adversely affect the fusion results. Moreover, because the CF of satellite data, particularly satellite data based on AVHRR, was significantly lower than that of ground observation data and active sensor data in April, and a significant difference existed between different datasets, the standard deviation of error after fusion marginally increased in April, with some areas at approximately 4%.

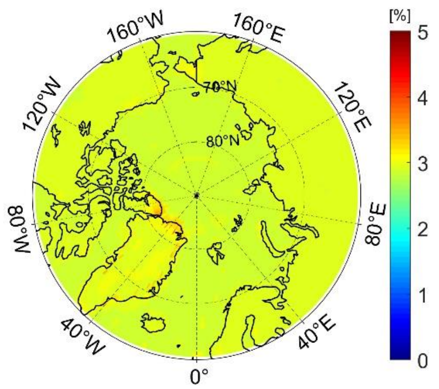

Figure 15. The mean error standard deviation of the fusion results

3. Four MODIS-sensor based products are used here (MYD35, MOD35, CERES Aqua, CERES Terra). Are the authors aware of the MODIS-VIIRS continuity product? The CLDPROP MODIS data from the continuity product can certainly add values to this study.

Response: We thank you for reminding us this important point. The NASA Aqua MODIS and Suomi National Polar-Orbiting Partnership (SNPP) Visible Infrared

Imaging Radiometer Suite (VIIRS) climate data record continuity cloud properties products (CLDPROP) were publicly released in April 2019 with an update later that year (Version 1.1). These cloud products, having heritage with the NASA Moderate-resolution Imaging Spectroradiometer (MODIS) MOD06 cloud optical properties product and the NOAA GOES-R Algorithm Working Group (AWG) Cloud Height Algorithm (ACHA), represent an effort to bridge the multispectral imager records of NASA's Earth Observing System (EOS) and NOAA's current generation of operational weather satellites to achieve a continuous, multi-decadal climate data record for clouds that can extend well into the 2030s. This product ensures continuity of approach through a common algorithm that is applicable to both MODIS and VIIRS data by leveraging only those spectral channels that are common to both instruments.
The L3 monthly Cloud Properties product is derived by aggregating the Aqua/MODIS D3 Cloud Properties product (CLDPROP_D3_MODIS_Aqua), which is a global gridded dataset that is produced daily. This monthly product contains 128 science data sets (SDS/parameters), as well as the daytime cloud fraction. Like CLDPROP_M3, the MYD08 Level-3 product is a 1° equal angle aggregation of the Level-2 pixel-level MODIS retrievals, but includes all MODIS Atmosphere Discipline datasets in addition to the cloud datasets. Though the codes and production facilities that produce the MYD08_M3 and CLDPROP_M3 aggregations are different, tests have shown that the CLDPROP_M3 results are indeed consistent with MYD08 when ingesting the MYD06 Level-2 products. We believe that the CLDPROP MODIS data from the continuity product can help us to extend the fusion cloud fraction over a longer period of time.
We intend to employ the CLDPROP MODIS data and other relevant datasets in our forthcoming research to enhance the fusion outcomes.

Other specific points:

1. Ln 278: 90% percentile -> 90 percentile

Response: Thank you for your careful check, we have corrected it (**Line 327, Page 9**).

2. Ln 289: add "of" after "the time series"

Response: We appreciate your attention to detail and we have now included the designated word (**Lines 339, Page 10**).

3. Ln 306-308, 418-420: It's unclear to me if the authors apply relationship derived from latitudes less than 82.5N to higher latitude beyond calipso coverage. And where are the bias to CPCF relationship plots? Figure 5 only shows bias and CF against SIC. Does Figure 5 indicate CF is stable as SIC increases and starts to decrease when SIC is very high? Why is that?

Response: We are sorry for the confusion brought to you. In this manuscript we implemented correction for the passive sensor data in regions with latitudes that exceed 82.5°N. The aforementioned amendment is rooted in a strong correlation identified between the bias present in the passive sensor data following and prior to CDF matching, and the cumulative percentage of CF (CPCF) and sea ice concentration (SIC) detected in sea ice regions situated within latitudes below 82.5°N. The CPCF means the average CF over an interval of SIC, and the interval, which in this manuscript is 1%. In Figure

5 the mean of bias increased with the SIC, the CPCF appeared to decrease with increasing SIC, a negative correlation between CPCF and bias was also evident. The depicted fitting curves in Figure 5 have considered the influence of CPCF. (**Lines 483-484, Page 17; Lines 489-493, Page 18**)

In regards to the last question, figure 5 does indicate that CF is stable (it's actually slightly decreased) as SIC increases and starts to decrease when SIC is very high. It was observed that the passive sensor's ability to detect clouds was impacted by higher levels of sea ice concentration. As a result, the sensor tended to underestimate CF, especially near the center of the Arctic Ocean. Finally, the relationship between the CPCF and SIC displayed a tendency to decrease as the sea ice concentration increased.

4. Ln 523-525: “original satellite data”, should they be fused data?

Response: We apologize for our confusing words and we have corrected it to “fused data”. We have conducted a comprehensive review of the complete manuscript to ascertain that any identical errors have been rectified. (**Line 594, Page 23; Line 595, Page 24**)

Thank you again for your constructive comments and suggestions on our manuscript. There is no doubt that these comments are valuable and very helpful for revising and improving our manuscript. We hope you will find our revised manuscript acceptable for publication.