Anonymous Referee #1, 13 Dec 2023

This is an excellent overview of the CALIPSO CALIOP lidar and very useful information on the global distribution of high clouds. This is an outstanding article that describes the 1) processing of CALIOP Level 3 monthly gridded ice cloud data, 2) the use of 10 years of data to characterize the global distribution of clouds through an optical depth of about 2, 3) its limitations, and 4) the comparison of CALIOP processed data to two other retrieval algorithms that use a combination of CALIOP and CloudSat radar data. The figures are very informative and very well done. I highly recommend acceptance of the article with minor suggestions and corrections.
***Citation**: https://doi.org/10.5194/essd-2023-373-RC1*

The authors thank the reviewer for the outstanding appraisal and encouragement. The paper is intended to provide an insightful overview of CALIOP Level 3 Ice Cloud Product to help users better understand and use this product.

1. *Eq. (1). In the article cited, was ρ included in their derivation? I thought that an effective density, derived from direct measurements of the ice water content, was used in the development of the temperature-dependent equations.*

   Yes. In Heymsfield et al. (2014), the density of solid ice ρ , which is set to 0.91 g/cm3, is included in the derivation.

2. *What is the effect of contrails on the summary of CALIOP data, especially in the northern hemisphere?*

   This is an interesting question but is outside the scope of this paper. We have not tried to discriminate contrails from natural cirrus in the CALIPSO Ice Cloud Product but several studies have used CALIOP data to investigate contrails. For example:

   - Marjani et al., 2022: "Satellite Observations of the Impact of Individual Aircraft on Ice Crystal Number in Thin Cirrus Clouds", *Geophys. Res. Lett*., 49, https://doi.org/10.1029/2021GL096173.
   - Iwabuchi et al., 2012: "Physical and optical properties of persistent contrails: Climatology and interpretation", *J. Geophys. Res*., 117, https://doi.org/10.1029/2011JD017020

3. *Line 234, Figures 4 and 20. Shouldn't negative extinction coefficient values be rejected, as would be negative IWC values? Likewise, for the bins with negative IWC values.*

While negative extinction and IWC values are nonphysical, they appear in the CALIPSO data product as a result of signal noise. As explained in Section 3.2, negative extinction coefficients can be found in weakly backscattering layers when background signal noise is large. Rejecting those negative extinction coefficients or IWC values would result in a positive bias when calculating mean and medians. Therefore, they should be retained.

4. *Section 4.2, specifically ice cloud occurrence. Perhaps a better descriptor would be ice cloud fraction.*

   To avoid confusion, ice cloud occurrence/fraction is replaced by “ice cloud occurrence frequency”.

5. *Figure 12. I'm not quite clear about the results shown, because the IWC generally decreases with temperature. Perhaps a bit more discussion would be helpful.*

   As shown in Eq 8, the maximum IWP reported in L3-ICE is driven by the requirement that overlying optical depth < 2 and the parameterized ratio of IWC to extinction, which decreases with temperature. To clarify the text, we have changed “corresponding maximum IWP” to “corresponding maximum IWP based on Eq. 8” and have changed “the maximum retrievable IWP is about …” to “the maximum IWP corresponding to an overlying optical depth of 2 is about …”

6. *Section 6. This is a very interesting way to evaluate CALIPSO data quality by comparing the products to two products which retrieve most of the vertical column using a combination of lidar and radar.*

   The authors thank the reviewer for the encouraging comment.

7. *Question Lines 440-442 You may want to mention that attenuation of the CloudSat W band radar can be significant, leading to errors in the DARDAR and 2C-ICE products.*

   The authors thank the reviewer for this great comment. A sentence has been added to Line number 430: “In strong convection, however, attenuation of CloudSat W-band can be significant, leading to errors in the DARDAR and 2C-ICE products.”

8. *Line 112. IWC directly measured*

   As suggested, “IWC measured in situ” is changed to “IWC directly measured in situ”.

9. *142: "underlying clouds"*

No change. Optically thick clouds overlying (above) the black areas are responsible for completely attenuating the lidar return signal.

10. Figure 10 is really interesting as it shows the changes due to the view angle of CALIOP.

Indeed changing view angle of CALIOP led to more detection of randomly orientated ice cloud layers.

11. Fig. 17. I don't see the black dots.

In the revision, a new color scheme is utilized to make black dots standout.

12. Figure 21 is very informative and insightful.

The authors thank the reviewer for the good comment.