Response to anonymous referee #3

The authors are thankful to the referee for his/her thorough review of the paper.

All the comments have been taken into account, as detailed below, and the manuscript will be revised accordingly. In the following, the reviewer's comments are in black, and our answer to each comment is in red.

This paper presents retrieval of cloud micro- and macro-physical properties over ocean using CALIOP Imaging Infrared Radiometer (IIR) Version 4 algorithm developed in Part I. It also shows the improvements over Version 3. However, there are several points to improve in the manuscript. The authors must revise their manuscript addressing my following specific comments.

Specific comments

1 On p. 4, Fig. 1: 'Latitude (°C)' should be 'Latitude (°)'.

Fixed.

2 On p. 5, lines 141-143: the authors state, "South of - 36.7° and down to - 37.2°, the portion of this cloud which is used as an opaque reference between - 36.45° and - 36.7° is included in a single opaque cloud of top altitude equal to 11.5 km, which extends down to the southernmost latitudes.". However, it seems to me that there is two-layer cloud between -36.7° and -37.2° in Fig. 1a. Why do the authors regard it as 'a single opaque cloud'?

The authors confirm that, as written at the beginning of the section, the classification is provided by the V4 CALIOP cloud and aerosol 5-km layer products. In this particular case, the CALIOP algorithm identified only one layer. More details are available in section 3.2.5.3. (Closing Gaps Between Features) in the CALIOP layer detection ATBD, which is available at https://www-calipso.larc.nasa.gov/resources/pdfs/PC-SCI-202_Part2_rev1x01.pdf.

3 On p. 5, lines 155-157: the authors state, "In Fig. 1 we find cloud systems composed of ROI only (flag = 1), liquid water (WAT) only (flag = 2), ice and WAT (flag = 4), and some systems that include at least one layer of unknown phase (flag = 9)." 'flag=4' should be 'flag=6'.

Fixed.

4 On p. 5, line 161: the authors state, "Effective emissivities in ST clouds vary between 0 and 0.9.". However, there are negative emissivities around -36.5° in Fig. 1f.

Thank you for pointing this out. We added the following sentence:

"The only exception is between -36.45° and -36.52°, where non-physical negative effective emissivities are retrieved because the computed background radiances are smaller than the observed radiances, and are therefore underestimated. In this case, the reference is an opaque cloud (see area highlighted in red in Fig. 1b), which is likely not sufficiently dense to behave as a blackbody source".

5 On p. 6, lines 188-190: the authors state, "Scenes with only ST layers are spread into three main categories: only one layer, two vertically overlapping layers, and multi-layer configurations with two non-overlapping layers or more than two layers.". What do you mean by 'two non-overlapping layers'? Explain it briefly.

The text now reads (new text in italic):
"Scenes with only ST layers are spread into three main categories: only one layer, two vertically overlapping layers *detected at different horizontal averaging resolutions where the top altitude of the lower layer is greater than the base altitude of the higher layer*, and multi-layer configurations with two non-overlapping layers or more than two layers."

6 On p. 8, lines 238-240: the authors state, "Overcorrections combined with uncertainties cause an increase of the fraction samples with εeff,12 > 1, from 3 % in V3 to 12 % in V4 at night, and from 1.2 to 3.3 % for daytime data.". Does this sentence mean that V4 is worse than V3 in terms of overestimation of εeff,12?

In opaque ice clouds, $\varepsilon_{eff,12}$ was underestimated in V3 and is increased in V4, with V4 distributions peaking at 0.99 and 0.97 for nighttime and daytime data, respectively, that is very close to 1. Because of unavoidable random uncertainties and possible overcorrections, the consequence is that the fraction of samples where $\varepsilon_{eff,12}$ is larger than 1 is increased in V4.
The text now reads (changes in italic):

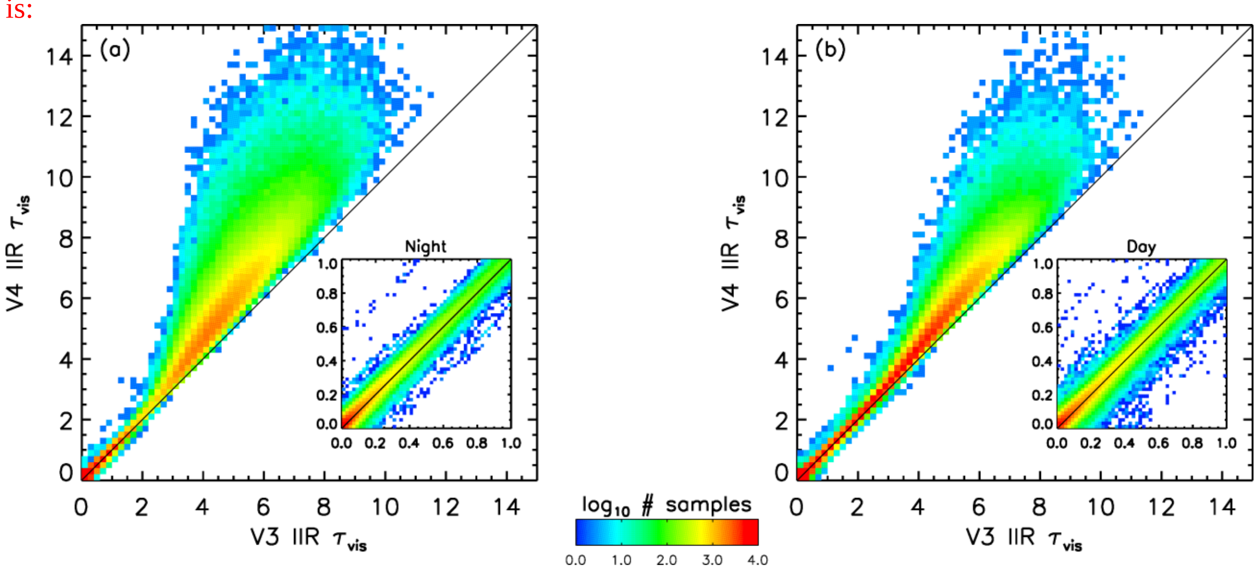
"Nighttime and daytime $\varepsilon_{eff,12}$ distributions peak at larger $\varepsilon_{eff,12}$ in V4 ($\varepsilon_{eff,12}$ = 0.99 and 0.97, respectively) than in V3 ($\varepsilon_{eff,12}$ = 0.94). *Consequently, random uncertainties and possible overcorrections cause an increase of the fraction samples with $\varepsilon_{eff,12}$ > 1, from 3 % in V3 to 12 % in V4 at night, and from 1.2 to 3.3 % for daytime data."*

7. On p. 9, lines 265-267: the authors state, "This indicates residual inter-channel biases smaller than 0.1 K in V4 according to the simulations shown in Fig. 1c of Part I, which is consistent with the residual inter-channel differences seen in clear sky conditions (Part I)." 'Fig. 1c' should be 'Fig. 1b'.

Fixed.

8 On p. 10, Fig. 4(a) and 4(b): 'color' is red (~4) at V3τvis = V4τvis = 1 in the whole plots, whereas 'color' is green (~2) at V3τvis = V4τvis = 1 in the embedded small plots. Why are these colors different at the same point? This comment is also applied to around V3τvis = V4τvis = 0.

In the whole plots, the minimum τ_{vis} was -0.5 and not 0, which introduced confusion. The revised figure is:



The bin sizes are 0.2 for the whole plots, and 0.02 for the small plots. This is now clarified in the text where we added the following sentence:

"The large plots where τ_{vis} ranges between 0 and 15 are built using bins equal to 0.2, and the embedded small plots show details for τ_{vis} smaller than 1 and bins equal to 0.02."

9. On p. 15, line 424: the authors state, "In this example, mean De increases from 17 μm at 185 K to 53 μm at 245 K.". In comparison to Fig. 15 of Heymsfield and Iaquinta (2000), De = 53 μm at 245 K is smaller than their observed ice crystal size around -35°C. How do the authors reconcile this difference?

The D_e and T_r parameters characterize a cloud layer. In semi-transparent clouds of optical depth smaller than about 3, IIR D_e is a layer "average" effective diameter. In opaque clouds, it is mostly representative of the portion of the cloud seen by CALIOP before the signal is totally attenuated. Thus, comparisons with in-cloud vertically resolved measurements are not straightforward. In Fig. 15 of Heymsfield and Iaquinta (2000), our understanding is that the ice crystals observed around -35 °C were near the base of the cloud layer, at about 7.5 km, while the top altitude was around 10.5 km. Because IIR retrievals characterize a layer or the upper part of a layer, depending on cloud optical depth, they might differ from observations near cloud bases.

10. On p. 18, Fig. 11(c) and 11(e): the same comment as the item #9 is applied to De around Tr = 245 K. The authors' retrieved De's are smaller than MODIS 2.1 De. Does this mean that the authors' De's are underestimated at higher temperatures?

This means that V4 IIR D_e is smaller than MODIS 2.1 and 3.7. We added the following sentence:

"At T_r > 220 K, IIR D_e is around 50-60 μm and smaller than both MODIS 2.1 and 3.7. We note that the agreement with MODIS would be improved using the parameterized functions derived from the unmodified in-situ PSDs that were presented in Sect. 3.4.3."

11. On p. 21, lines 574-576: the authors state, "Mean IIR De (Fig. 15b, red) increases steadily from 11 μm at 242 K to 18 μm at 270 K, while mean CALIOP particulate depolarization ratio (Fig. 15c) is constant and around 0.1.". However, Many researchers (e.g., Curry 1986, Garrett and Hobbs 1995, Nicholls and Leighton 1986, Noonkester 1984, Slingo et al. 1982, Stephens and Platt 1987) reported that cloud droplet effective radius increases from cloud base to cloud top. How the authors reconcile Fig. 15b with the opposite observations.

In this study, cloud centroid altitude is deliberately chosen > 4 km. The water clouds are in the free troposphere and most of them are composed of supercooled droplets. For this figure, the clouds are semi-transparent and median optical depth is only 0.9. As for ice clouds, the D_e and T_r parameters characterize a cloud layer. We could not find references with similar statistics for a similar population of clouds. We commented on the increase of D_e with temperature by adding the following sentence:

"It seems that these thin clouds would not be associated with strong updrafts, and the increase of layer average D_e with layer radiative temperature could indicate growth through vapor deposition. In addition, there is an increasing probability for supercooled droplets to freeze as temperature decreases and as their size increases."

For more clarity regarding this population of water clouds, we added median effective emissivity and median optical depth in Table 5, and added the following sentence after the presentation of Fig. 15 (previous Fig. 14, now Fig. 15 after comments by referee #4):

"Note that the IIR retrievals shown in Fig. 15 are for a population of very thin water clouds: median τ_{vis} is only 0.9 in ST clouds and between 4 and 5 in opaque clouds. "

12. On p. 23, Fig. 16: The same comment as the item #11 is applied to Fig. 16(c). In other words, dependence of De on temperature in Fig. 16(c) is opposite to the observed ones.

See our answer to item #11.

Note that in Fig. 16c and 16e (now Fig. 17c and 17e), both MODIS and IIR see an increase of D_e with temperature. We tried to improve the text, which now reads (changes in italic):

"As seen in Fig. 17a, T_r spans between 235 K and 280 K, *and most of these sampled clouds are composed of supercooled droplets*. In ST clouds, *the three datasets show an increase of median D_e (Fig. 17c) as T_r increases from 243 K to 270 K, but with different slopes*: IIR D_e increases with T_r from 10 to 20 µm whereas both MODIS 2.1 and 3.7 are larger than about 20 µm. *As seen in Fig. 17d, these supercooled water clouds have optical depths between 1 and 2*, with MODIS τ_{vis} overestimating IIR τ_{vis} by about 50 %."

Technical corrections

1. On p. 8, lines 235-236: the authors state, "these corrections have no to little impact for ST clouds". This sentence should be corrected.

The new text reads: "*these corrections have essentially no impact for ST clouds*".

2. On p. 17, lines 484-485: the authors state, "This could explain than IIR De is found…". 'than' should be 'that' in this sentence.

Fixed.

3. On p. 27, line 759: the authors state, "in the 10-mm window region". '10-mm' should '10-µm' in this sentence.

Fixed.

4. On p. 28, line 778: 'microphysics' should be 'Microphysics'.

Fixed.

5. On p. 29, line 852: 'Minimis' should be 'Minnis'.

Fixed.