Response to anonymous referee #3

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

Our responses are detailed below, and the manuscript has been revised accordingly. In the following, the reviewer's comments are in black, and our answer to each comment is in red.

Specific comments

1. On p. 4, lines 124-126: the authors state, "A "Was_Cleared_Flag_1km" SDS is now available in the V4 IIR product, which reports the number of CALIOP single-shot clouds in the atmospheric column seen by the 1-km IIR pixel that were cleared from the 5-km layer products."
Spell out 'SDS'.
For simplicity, we replaced 'SDS' with 'parameter'.

2. On p. 5, Fig. 1b: at εeff,12 < ~0.4, dTk,BG = 0.1 K (red dashed line) deviates more from 0 than dTk,BG = 1 K (black dashed line). This is opposite to what I expect. Why?
The red dashed line corresponds to $dT_{12,BG}$ = 0 K and $dT_{k,BG}$ = 0.1 K. Channel k is biased but not channel 12, and as a result, the inter-channel 12-k effective emissivity difference is biased.

The black dashed line corresponds to $dT_{12,BG}$ = 1 K and $dT_{k,BG}$ = 1 K. Both channels are biased by the same quantity in terms of brightness temperature, but this induces anyway a bias in the inter-channel 12-k effective emissivity difference, but which differs from the other bias shown in red.

3. On p. 6, lines 211-212: the authors state, "Underestimating Tr (and therefore TOA TBB) yields under-estimates in εeff,12 and the microphysical indices." What is difference between 'radiative temperature Tr' and 'TOA TBB'?
"TOA T_{BB}' is the Top Of Atmosphere blackbody brightness temperature corresponding to the TOA blackbody radiance determined from T_r and the FASRAD model. These quantities are defined in Sect. 3.1. The difference between T_{BB} and T_r depends on the atmospheric absorption above the cloud.

4. On p. 7, lines 246-247: the authors state, "In contrast, the V3 median 10-12 and 08-12 interchannels biases were up to - 0.7 K and –1.8 K, respectively, at IWVP = 5 g.m-2.". '5 g.m-2'
should be '5 g.cm-2'.
Fixed.

5. On p. 8, lines 270-271: the authors state, "In V4, the mean absolute inter-channel differences are smaller than 0.1 K globally.". What is the difference between 'mean absolute inter-channel difference' and 'mean absolute deviation (MAD) of the differences between observed and computed brightness temperatures' in Table 2?
Indeed, this is confusing.
We replaced "the mean absolute inter-channel differences are smaller than 0.1 K globally"
with
"*the absolute values of* the mean inter-channel differences are smaller than 0.1 K globally"

Fig. 3(j) and Fig. 4(a): In summer, peak of V4 daytime (red) is more deviates more from 0 than peak of V3 daytime (red). Why?

BTDoc(12) is overall less latitude-dependent in V4 than in V3, owing to the reduced bias related to IWVP in V4. In these two cases, it seems that the biases related to IWVP in V3 and those related to sea surface temperature are of opposite signs and such that V3 deviates less than V4. Note that the V3 distributions are nevertheless larger than the V4 distributions, suggesting larger biases related to IWVP in V3.

7. On p. 14, lines 379-380: the authors state, "For daytime data, both Tr and Tm are lower in the apparent cloud than at night, and even below (Tm > Tbase), which is at least in part due to the smaller daytime apparent thickness.". However, for daytime data, both Tr and Tm are higher than at night in Fig. 7(c). How do you reconcile these opposite facts?
We checked both the text and Fig. 7c, and we think that there is no mistake.
In Fig. 7c, both T_r and T_m have $(T-T_{top})/(T_{base}-T_{top})$ larger for daytime data than at night, which means that both T_r and T_m are closer to the base for daytime data than at night, and therefore that both T_r and T_m are lower in altitude for daytime data than at night.

8. On p. 16, lines 431 and 435: '$\beta_{12/k}$' should be '$\beta_{eff12/k}$'.
Fixed

9. On p. 19, lines 493-494: the authors state, "For a given De, βeff12/10 is notably larger when N(D)1 is not modified (blue and red solid lines) than when N(D)1 is forced to zero (blue and red dashed lines), because the presence of small particles in the unmodified PSD increases βeff12/10 faster than De.". 'faster' should be rephrased.
"Faster" has been replaced with "more rapidly".

10. On p. 22, Eq. (12): Define the IIR weighting function WFIIR(z) used in Eq. (12).
We added a new equation to define the IIR weighting function and re-organized the beginning of this section as follows (changes in italic). In the new text, we refer to a new Eq. (5) which has been added in Sect. 3.4.2 after comments by referee #1. The notations not specified here are introduced with Eq. (5):

"The IIR retrievals are all tied to the retrieved effective emissivities. As demonstrated in G15, $\varepsilon_{eff,k}$ is the vertical integration of an attenuated effective emissivity profile, which can be determined from the CALIOP extinction profile, $\alpha_{part}(z)$. *Looking at Eq. (5) used to derive the cloud radiative temperature and ultimately establish the correction functions presented in Sect. 3.4.2, we see that we can define an IIR weighting function* $WF_{IIR}(i)$ *as*:

$$WF_{IIR}(i) = \frac{1-e^{-\left[\alpha_{part}(i)\cdot\delta z / r\right]}}{\varepsilon_{eff,k}} \cdot e^{-\sum_{j=i+1}^{j=n+1}\left[\alpha_{part}(j)\cdot\delta z / r\right]} \quad (14)$$

This applies to semi-transparent clouds whose true base is detected by CALIOP. This concept has been used in M18 to compute an equivalent effective thickness seen by IIR, ΔZeq, derived from the geometric thickness, ΔZ, as:

$$\frac{1}{\Delta Zeq} = \frac{1}{\Delta Z} \times \frac{1}{\tau_{vis}} \times \sum_{i=1}^{i=n} \alpha_{part}(i).WF_{IIR}(i).\delta z \quad (15)$$

11. On p. 25, Eq. (A4): Define $\varepsilon_{12,x}$ and $\varepsilon_{k,x}$ used in Eq. (A4).
This was a mistake.

The term $\varepsilon_{12,x}$ should be $\varepsilon_{eff,12}$ and likewise $\varepsilon_{k,x}$ should be $\varepsilon_{eff,k}$
The corrected equation is:

$$\frac{\left(d\beta_{eff}12/k\right)_x}{\beta_{eff}12/k} = \frac{-d\varepsilon_{12,x}}{\left(1-\varepsilon_{eff,12}\right)\ln(1-\varepsilon_{eff,12})} + \frac{d\varepsilon_{k,x}}{\left(1-\varepsilon_{eff,k}\right)\ln(1-\varepsilon_{eff,k})} \quad \text{(A4)}$$

Technical corrections
1. On p. 8, line 252: the authors state, "Over-plotted in green in the median MERRA-2 surface temperature; (b): number of IIR pixels.". 'in the median' should be 'is the median'.
Fixed

2. On p. 28, line 748: the authors state, "in the 10-mm window region". '10-mm' should be '10-µm'.
Fixed