Response to referee #3

We are thankful to the reviewer for his/her useful comments that will contribute to greatly improve the manuscript. In the following, the reviewer's comments are in black and our response is in red.

This article analyses deficiencies in the calibration of the CALIPSO IIR sensor and proposes an empirical algorithm to mitigate them. The article is clearly presented, based on an exhaustive analysis (albeit within limited range of conditions) and goes into considerable detail. While the authors do not speculate on the underlying cause of the biases found, there are some clues in the results which could be worth further investigation. The benefits of the proposed mitigation algorithm are clearly demonstrated, and will lead to improvements in many applications using these satellite observations. I only have a few minor corrections and clarifications. Once at least the last two points below are addressed the article would be suitable for publication. The others I would not consider to be mandatory.

P.2 Line 7 - It would be helpful to mention the equator crossing time.

Response

The sentence will be modified as follows:

"……follows a Sun-synchronous orbit at an altitude of 705 km with ***an ascending node equator crossing time at 13:44 local solar time and*** *an inclination of 98.2°".*

P.2 Line 9 - How are these bandwidths defined?

Response

The IIR spectral response functions will be shown in a new Figure 1 which will be introduced in Sect. 2.1 where the IIR instrument is described. Below is this new figure.

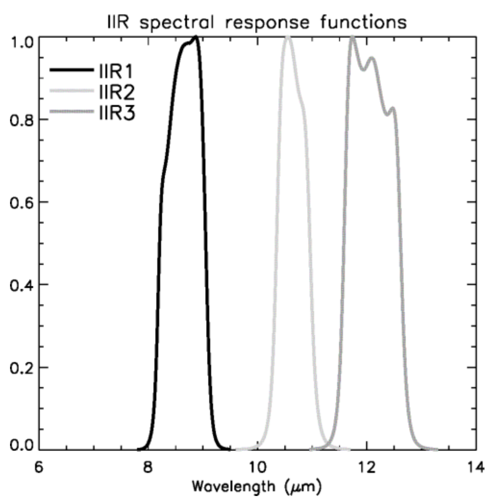

Figure 1: Spectral response functions in IIR channels IIR1 (black), IIR2 (light grey), and IIR3 (dark grey).

P.2 Line 12 - please provide a reference to full details of the definition of equivalent brightness temperature used here.

Response

The details will be given in a new Sect. 2.4 and in a new table (Table 2). The new Sect. 2.4 will read:

"2.4 Converting calibrated radiances to brightness temperatures

The calibrated radiances reported in the Level 1b product are further converted to brightness temperatures using the Planck's law and the spectral response functions shown in Fig. 1. For each IIR channel, a tabulated function relating radiance (R) in units of $W.m^{-2}.sr^{-1}.\mu m^{-1}$ and equivalent brightness temperature (BT) in units of Kelvin was produced for temperatures ranging between 170 and 330 K. Following a similar approach as developed for previous infrared instruments (e.g., among many others, Weinreb et al. 1997; EUMETSAT, 2012b), we find that for each channel, R can be converted to BT using the equation:

$$BT = a_0 + (1 + a_1) \cdot BT_{Planck}(R, \lambda_c) \qquad (3)$$

where $BT_{Planck}(R,\lambda_c)$ is the brightness temperature computed using the Planck's law at wavelength λ_c, and a_0 (in Kelvin) and a_1 (unitless) are regression coefficients. The values of λ_c, a_0 and a_1 are reported in Table 2 for each IIR channel. Brightness temperatures derived from Eq. (3) and from the tabulated function differ by less than 0.001 K."

The new Table 2 will be:

Table 2: Coefficients in Eq. (3) to convert IIR Level 1b radiances (in units of $W.m^{-2}.sr^{-1}.\mu m^{-1}$) to equivalent brightness temperatures (in units of Kelvin)

IIR channel	λ_c (μm)	a_0 (K)	a_1 (no unit)
IIR1	8.621	-0.768212	0.002729
IIR2	10.635	-0.302290	0.001314
IIR3	12.058	-0.466275	0.002299

P.2 Line 20 (and conclusions) - What are the requirements for IIR calibration?

Response

The required calibration accuracy is 1 K for each IIR channel. It is mentioned page 2 line 30, but for more clarity, it will be repeated in Sect 2.1 where we will add :

"The required calibration accuracy is 1 K for each IIR channel."

P.3 Line 2 - please add a reference to G17 here.

Response

A reference to G17 will be added and we will also add a referencing to Sect. 3.2. The text will read:

"Analyses revealed that this phenomenon originates from IIR and is due to warm biases in Version 1 nighttime IIR brightness temperatures in this latitude range ***(G17). These analyses are summarized in Sect. 3.2****."*

P.5 Line 18 - does the figure of -0.5K refer to both channel pairs shown?

Response

Yes, the figure of -0.5 K refers to both channels pairs. The text will be modified as follows:

"In this case, the negative anomaly in the inter-channel BTDs associated to the darker stripes is about -0.5 K ***for both pairs of channels****."*

P.9 Line 2 - This hysteresis effect is interesting. Any idea what could cause it?

Response

The following sentence will be added at line 32, page 8:

"Looking at the relationship between IIR cycle number and latitude in June (Fig. 2), the hysteresis effect indicates that the "global" bias appears after IIR cycle # 40 (35° N in the daytime ascent) and then increases up to cycle # 85 (35° N in the nighttime descent)."

P.10 Line 23 - Could the fact that this effect has the same impact on all three channels be a clue to the underlying cause?

Response

It could indeed be a clue to the underlying cause, and it could be a good starting point for further analyses of the instrument.

P.12 Line 1 - It could be helpful to include values for the standard deviations of the time series shown in Fig. 5 and 11. (The latter could include the former superimposed in feint symbols to highlight the impact.)

Response

Thank you for this recommendation. These figures (which will be Fig. 6 and 12 in the revised manuscript) have been revised as shown below.

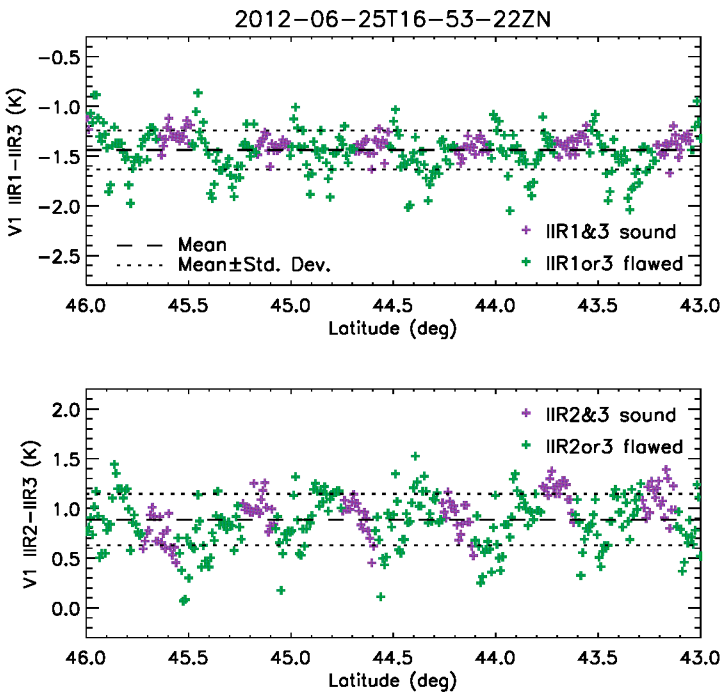

Figure 6: Version 1 IIR1-IIR3 (top) and IIR2-IIR3 (bottom) inter-channel BTDs along the CALIOP track for the same cloud-free scene over water surface on 25 June 2012 as in Fig. 3. Purple: sound rows in both channels; green: flawed rows in at least one channel. ***The horizontal lines show the mean value (dashed) and mean value ± standard deviation (dotted).***

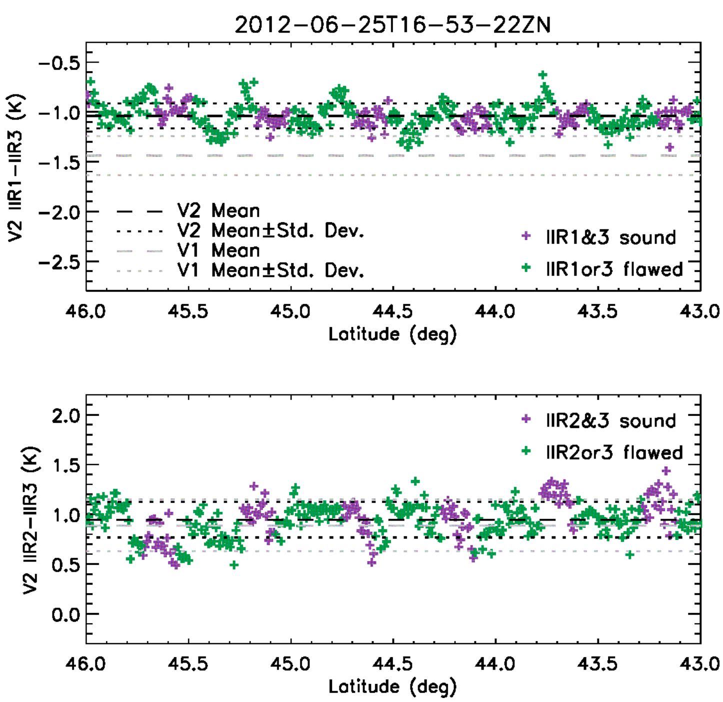

Figure 12: Version 2 IIR1-IIR3 (top) and IIR2-IIR3 (bottom) inter-channel BTDs in the same nighttime descending portion of the same orbit as in Figs. 3, 6, and 11. Purple: sound rows in both channels; green: flawed rows in at least one channel. ***The horizontal lines show the mean value (dashed) and mean value ± standard deviation (dotted) in Version 2 (black) and in Version 1 (grey).***

The text in Sect. 6.1 will be updated accordingly and will read:

"…….. The Version 2 IIR inter-channel BTDs along the CALIOP track for the same portion of the same orbit as in Fig. 11 are shown in Fig. 12 for comparison with Version 1 BTDs shown in Fig. 6. The negative peaks which were causing the darker stripes in Version 1 have disappeared. ***The standard deviation of the inter-channel BTDs is reduced by 40 % from 0.2 K in Version 1 to 0.12 K in Version 2 for the IIR1-IIR3 pair, and by 30 % from 0.26 K to 0.18 K for the IIR2-IIR3 pair. The smaller pixel-to-pixel variability in Version 2*** *indicates that the equalization correction applied in Version 2 has improved the relative calibration of the various rows within an image……."*

P.14 Line 20 - The last two sentences in this paragraph seem out of place here. They warrant a separate paragraph (including a reference to the actual radiometric performance required), and perhaps mention the abstract.

Response

We understand the referee's comment.

The first sentence ("*The uncooled micro-bolometer used in the IIR instrument was the first of its kind to be used for radiometric analysis"*) is factual information about the instrument. Therefore, we think that it can be moved to Sect. 2.1, which will start as follows:

"The IIR instrument (Corlay et al., 2000) includes three medium-resolution channels and one unique sensor: an uncooled microbolometer array (U3000A) manufactured by the Boeing company. ***The uncooled micro-bolometer used in the IIR instrument was the first of its kind to be used for radiometric analysis****."*

The second sentence is in part justified by previous work (e.g., G17) and seems indeed out of place in the conclusion of this paper. We chose to remove the sentence rather than to develop discussions that would be beyond the scope of this paper.