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.

General Comments:

This paper presented a detailed assessment of the IIR calibration that can be very important in many applications. Stability of the measurements over time, as well as consistency and agreement of multiple sensors are key elements in many fields of the atmospheric sciences from climate studies to weather forecasting.

My only major question is about the use of MODIS Collection 5 instead of the most recent C6. In Section 5.2.2 the authors report that the IIR-MODIS BTD increase when the scene temperature decreases. The MODIS Characterization Support Team has analyzed the differences in performances between C5 and C6. In general the differences for Aqua MODIS are small or negligible, but two notable exceptions are bands 31 and 32 when cold scenes are considered [1]. This alone is certainly not sufficient to completely account for the differences reported in Section 5.2.2 but it may contribute to the overall bias observed when cold and warm scenes are compared. Do the authors have any comment on this? Would it be feasible to compute the IIR-MODIS differences using the Collection 6 data for a single day to verify if the changes between C5 and C6 are relevant for the results of this paper? Given the stability over time of the IIR-MODIS differences, especially at the tropics, I don't think that more than one day would be needed.

[1] http://tinyurl.com/MODIS-CAL

Response

We are thankful to the reviewer for bringing up this question and for pointing us to this presentation [1]. Back in 2006, we started this analysis using MODIS Collection 5 (C5) and we chose to continue with C5 because our first concern was to evaluate the calibration of the IIR instrument. We understand that it will be important to assess the differences between IIR and MODIS Collection 6 (C6) for the IIR2-MODIS31 and IIR3-MODIS32 pairs at cold temperature.

First, we want to point out that the discussion in Sect.5.2.2 about cold scenes and Fig. 9 have been revised after comments by referees #2 and #1 (see response to referee #2). The conclusion is now that both IIR and MODIS inter-channel BTDs are close to zero at 190-200 K, the coldest range of temperature, showing internal consistency of the calibration within each instrument. On the other hand, IIR-MODIS BTD is about 1.6 K for the three pairs of channels at 190-200 K, indicating a warm bias of IIR with respect to MODIS.

The revised Sect. 5.2.2 and the revised Fig. 9 still use MODIS C5, for consistency within the manuscript. At 190-200 K and for the same months of 2008 as in the new Fig.9, we find that MODIS29 is mostly unchanged in C6, but that MODIS31 is reduced by 1.4 K and that

MODIS32 is reduced by 1.2 K. Thus, the median MODIS31-MODIS32 BTD is still close to zero at 190-200 K in C6, but the median MODIS29-MODIS32 BTD is around 1.2 K, so that the internal consistency between the three MODIS channels seen in C5 is not seen in C6 anymore. The IIR2-MODIS31 and IIR3-MODIS32 BTDs are around 2.8-3 K in C6, whereas the IIR1-MODIS29 BTD is still 1.6 K as in C5.

Changes in manuscript

The following text will be added in the conclusion:

"At the coldest temperatures (190-200 K), for which similar brightness temperatures are expected, each IIR channel is unambiguously warmer than its MODIS companion channel, by about 1.6 K, whereas both IIR and MODIS inter-channel BTDs are close to zero, showing internal consistency within each instrument. This could be explained by a systematic bias in the IIR calibration at very cold temperature. Initial comparisons between MODIS C5, used for this analysis, and the most recent Collection 6 (C6) for several months in 2008 show little changes at warm temperature. However, MODIS31 and MODIS32 are colder in C6 than in C5 by at least 1 K at 190-200 K, so that the internal consistency between the three MODIS channels is not seen in C6 anymore at the coldest temperatures. A more detailed assessment for cloudy scenes will be conducted in the future using the description of the cloud vertical structure provided by CALIOP measurements and cloud microphysical models, following the same approach as in the IIR Level 2 algorithm (Garnier et al., 2012, 2013). The analysis will be carried out using both MODIS C5 and C6."

Overall, the work is well organized and presents some important results. I recommend it to be accepted after the following comments are addressed or answered.

Minor Comments:

1. page 8, lines 1-2: Do the authors have any thoughts on why B32 differences with TIGR_BTD are so large compared to the other bands?

Response

For a given pair of companion channels, the TIGR_BTD results from the difference in shape and position of the paired ISRFs and from the inherent different sensitivity to various atmospheric or surface parameters.

For the three IIR-MODIS pairs considered here, we see a clear relationship when plotting, for each atmosphere, the TIGR_BTD versus the corresponding total precipitable water (TPW). This dependence is also clearly seen in Table 3 having in mind that TPW ranges from 0.4 to 8.13, from 0.19 to 3.66, from 0.19 to 2.40, from 0.06 to 0.6, from 0.06 to 1.29 for the TIGR tropical, mid-lat1, mid_lat2, polar1, polar2 air masses respectively. Furthermore, it indeed appears that the TIGR_BTD are larger for the IIR3-MODIS32 pair than for the two other pairs. We explain this specificity by the following correlated points: i) due to the differences in shape and position of the ISRFs, MODIS32 does not receive any information from the 760-810 cm^{-1} nor from the 860-900 cm^{-1} spectral intervals, whereas IIR3 is sensitive to these two spectral intervals; ii) as indicated by the Geisa spectroscopic database used in our simulations, 120 water vapour lines with intensity up to 1.0e-22 (cm^{-1}/molec.cm^{-2} at 296 K) lie in the 760-810 cm^{-1} spectral range and 60 with intensity of 1.0e-23 in the 860-900 cm^{-1} spectral range; iii) in addition, a

contribution to the absorption is expected from the water vapour continuum and there are also small contributions from the wings of CO_2 branches lying in the 760-810cm^{-1} domain.
A number of simulations made with and without water vapor lines and with and without the water vapour continuum show that the water vapour absorption lines in the 760-810cm^{-1} spectral range explain up to 90% of the “large” IIR3-MODIS32 TIGR_BTDs. As an example, for a nadir viewing angle of a TIGR atmosphere having a TPW of 3.87, the IIR3-MODIS32 TIGR_BTD is -1.15K.

Changes in manuscript
The sentence page 7 lines 26-28 in Sect. 3.2.3 will be modified as follows:
“The TIGR_BTDs for each pair of companion channels and their variations with the TIGR air mass type encompass the difference in shape and position of the paired ISRFs and the inherent different sensitivity to surface temperature, temperature and water vapour profiles, and other absorbing atmospheric constituents.”

2. page 11, lines 14-15: MODIS bands 29, 31 and 32 are calibrated for typical scene temperatures of 300 K. For extremely cold scenes such as those of the bottom panel of Figures 3-7 a lower SNR can be another factor that contributes to the increase of the standard deviations.
Response
Thank you.

Changes in manuscript
This sentence in Sect. 5.1 will read as follows:
“Standard deviations increase up to 1.1 K in the tropics at the coldest temperatures generally associated to a larger instrumental noise, and also possibly due in part to larger inhomogeneity of cloudy scenes and to parallax effects at larger MODIS viewing angles.”

3. page 12, line 15: please change “pour” with “for”
Response
Will be fixed

4. page 13, section 5.2.3: Could the authors report the average uncertainties along with the average trends in the text?

Response
Yes. We are taking this opportunity to report also the trend seen at 290-300 K in the tropics in the text, because this value is the most relevant for the discussion in Sect. 6.2.1.

Changes in manuscript

It is (-0.019 ± 0.0002) K/year at 290-300 K in the tropics and (-0.02 ± 0.0004) K/year on average.