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Assessment of the calibration performance of satellite visible channels using cloud targets: Application to Meteosat-8/9 and MTSAT-1R

By: Seung-Hee Ham and B.J. Shon

Overall Recommendation

This paper presents the calibration performance of the 0.6 micron channel of the SEVIRI instrument on-board of Meteosat-8 and Meteosat-9, and the 0.7 micron channel on-board MTSAT. The authors evaluate the calibration accuracy against three calibration methods i.e. i) Ray-matching, ii) cloud properties, and iii) deep convection. The focus of the study is in inter-comparing these three calibration methods. The results show that these methods are capable in finding general biases in calibrations. However, the underestimations of reflectances found in this study differ considerably between the three calibration methods i.e., for METEOSAT-9 the underestimation varies between -3.9 and -6.1%, whereas for MTSAT the underestimation varies between -.3.9 and –18.1%.

Finding a reliable calibration procedure is of great importance for climate research, and thus justifies the importance of this paper. The desired accuracy to study long term trends, for example in cloud physical properties, is about 2%. The results presented in this paper give a clue on possible approaches, but they do not meet the desired margin of 2% calibration accuracy. Although the authors used satellite data of different years, they did not evaluate the inter-annual variations in calibration. This would be a very interesting exercise, especially if performed using the different calibration methods proposed.

The paper is generally well written, but the presentation of the results can be improved. The dataset used seems to be rather small, which may explain part of the deviations found. The temporal evolution of the calibration is not presented, but would provide very valuable information to users of METEOSAT and MTSAT data. In addition, it would be useful to evaluate the capability of the calibration methods in detecting trends in calibration. The paper needs major revisions before it can be published.

MAJOR CRITICISMS

Point A (Dataset)

- The size dataset seems small. Evaluation period is presented, but it is not clear how much data have been used. This needs to be clarified.

Point B (Satellite characteristics)

- The position of Meteosat-8 is latitude 0 degrees and longitude -3.4 degrees. Although EUMETSAT provides it's level 1.5 data as if the satellite was positioned at lat 0.0 and lon 0.0, the observed radiances are not modified, and represent the values for lat = 0.0 and lon = -3.4. Did the authors take viewing conditions into account ?
- The sample size of Meteosat-8 is 3x3 km at nadir, and thus images are provided at a 3x3km resolution at nadir. Indeed, the true sampling size is 4.8x4.8 km. However, taking into account the Spatial Response Function, the majority of the observed radiance comes from a smaller area (see Deneke and Roebeling, 2010, ACPD). Please comment on this.

Point C (Method 3, use of deep convective clouds)

- Method 3. Clouds with CTT < 197 are assumed to have a COT = 200 and re = 20. First, how sensitive are the results to variation in assumed re? Second, I can not imagine water clouds exist with CTT < 197 k. Third, what is done to ascertain that the anvil is not disturbing the signal? Please comment.

Point D (Sensor degradation)

- The authors do not present temporal changes in calibration as observed by the different calibration methods. This would be a valuable addition to the results, both from a scientific as from a user's perspective.

MINOR CRITICISMS

Introduction

- **Page 4 (line 10):** *"…minimizing the influence of aerosols in the calculation of radiance at the satellite altitude"*. This sentence is not clear. Explain this better in the text.
- **Page 4 (line 15):** *"…,thus, the intended simulation accuracy may be tolerated with the degree of input accuracies."* . This sentence is not clear. Explain this better in the text.
- **Page 5-6:** The authors provide information on the observation period for which the re-calibration methods were tested. However, it is not clear how much data were really used in the analysis of each method. The scatter plots suggest that the number of data pairs studied is not large. It should be clarified: how much data are used and if the same overpasses were used for each method.
- **Page 5:** SEVIRI data are provided at a spatial resolution of 3x3 km (see major comment above).
- **Page 6:** Indicate how the MTSAT and METEOSAT data are synchronized with the MODIS overpass times. Do the authors take into account the time needed to scan a full disk images (about 15 minutes from south to north for METEOSAT).

Methodology

- **Page 10 (line 1-10):** Replace "former" and "latter" by "first" and "second"

- **Page 10 (line 25):** give the std values that were used to screen on cloud homogeneity in the IR and VIS observations
- **Page 11 (line 1):** For the RTM simulations of the DCC targets the authors assume a COT=200 and re =20 micron. Here it is not clear if ice or water clouds are assumed. Moreover, it would be good present the sensitivity of the simulated reflectances to assumptions in COT (200 ± 50), effective radius (20 ± 10) and cloud phase (water or ice).

Results

- **Fig 1,2,3,4 and 5:** Also give number of data pairs and standard deviation of the differences between measured reflectance and simulated or MODIS equivalent.
- Include table that summarize the results of the three recalibration methods. Also here bias and standard deviation of the differences.

  For example:

  Table: Bias and standard deviation of differences for the three re-calibration methods

	Meteosat-8	*Meteosat-9*	*MTSAT*
Method 1	-6.9 % (std_diff??)	-4.1%	+3.9%
Method 2	-5.2%	-3.9%	-13.4%
Method 3	-7.3%	-6.4%	-18.1%

- **Page 13 (line 11):** *"Note that the results for ray-matching … around 2~3%"* In this sentence the authors argue why a larger bias is expected from the DCC method. However, table 1 shows that the bias of the Meteosat reflectances shows hardly any increase with increasing reflectance (-7.8 to -7.3 (meteosat-8) and -4.0 to –6.4 (meteosat-9). So this table does not explain the higher bias at reflectances close to 1. In addition, it is remarkable that the biases in this table are always larger than the mean biases presented in the scatterplots (-6.9 and –4.0).

Summary

- Discuss how the findings of this study are related to findings of earlier studies and explain reasons for the observed differences between the methods.
- The results of ray-matching in table 1 contradict with the mean biases given in the scatterplots. As mentioned above, this should be explained
- Page 16 (line 25): *"Overall, the three calibration methods showed agreement within 2 to 3% …"* This is the case for METEOSAT but not for MTSAT. That should be clarified better.

Annex

- The difference between the calculation of Rsim(<tau>) and <Robs (tau)> is difficult to understand.
- The authors present in table A1 two methods: the PPH method and the LN-ICA method. The PPH method is mentioned first in the section that presents with the LN-

ICA method. To improve the readability it would be good to also introduce the PPH method also clearly in the previous paragraphs.

- The authors find no systematic effect due to 3-D cloud structures, This contradicts with the findings of Loeb, Varnai, and Winker, 1998 (JAS), who found an systematic increase of reflectance for bumpy cloud field in backward scattering direction. Please check this.

Grammatical slips

In general the paper is clearly written. Still some grammatical slips and spelling errors remain. Below some of these are listed.

- **Page 8 (line 19)**: "*influence*" should be "*influences*"
- **Page 13 (line 3)**: "*smaller those observed*" should be "*smaller than those observed*"