INITIAL RESULTS FROM THE VALIDATION OF THE METEOSAT-8 SEVIRI CALIBRATION

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ABSTRACT

Meteosat-8 (MSG-1) is the first of a series of four geostationary satellites developed and procured by the European Space Agency (ESA) on behalf of the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). Meteosat-8 was launched on 29 August 2002 by an Ariane 5 rocket. During the commissioning phase, dedicated SEVIRI instrument tests have been conducted to verify the instrument functionality and performances. This paper summarises the initial main results from the SEVIRI calibration validation tests executed during commissioning. Meteosat-8 raw images are of excellent quality and the noise performance requirements are met with margin. Blackbody calibrations allow for a precise compensation of the instrument drifts. The expected slow degradation of radiometric response so far is fully recovered after decontaminations. The absolute accuracy of the calibration has been assessed by comparison with vicarious calibration and with other satellites.

1. INTRODUCTION

Meteosat Second Generation (MSG) is a series of four geostationary satellites developed and procured by the European Space Agency (ESA) on behalf of the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). The first satellite (MSG-1) was launched on 29 August 2002 by an Ariane 5 rocket.

SEVIRI supports 12 spectral channels in the visible/near infrared region (around 0.6, 0.8, and 1.6µm plus the High Resolution Visible (HRV) channel) and in the IR (around 3.9, 6.2, 7.3, 8.7, 9.7, 10.8, 12.0 and 13.4µm). Each channel is equipped with three detectors (HRV: 9 detectors) (e.g. SCHMETZ et al, 2002).

The MSG imaging mission consists of continuous image taking of the Earth in all 12 spectral channels with a baseline repeat cycle of 15 minutes. The Image Processing Facility (IMPF) rectifies raw SEVIRI image data and analyses the data with respect to their geometric accuracy and their radiometric noise. The IMPF also performs the radiometric calibration and provides blackbody and vicarious calibration information to the user via the Level 1.5 image header (EUMETSAT, 2003). Information on the imaging performance can be found in HANSON et al (2003 a) whereas the calibration process is described in HANSON et al (2003 b). During the commissioning phase, in addition to the dedicated SEVIRI instrument tests, the radiometric calibration of the Level 1.5 image products has been carefully evaluated.
2. VISIBLE/NEAR INFRA RED CHANNEL CALIBRATION

There is no on-board calibration for the HRV and the visible/near infra red ("solar") channels. Therefore, a vicarious calibration method is used. The SEVIRI Solar Channel Calibration (SSCC) is based on radiative transfer modelling over bright desert and clear ocean. It has been described in GOVAERTS (2003). The accuracy is about 5%. Normally, it is performed every 45 days. It is applied in the Level 1.5 image as follows:

1. Baseline conversion into radiances. (Channels are linear. Changes of the detection chain settings on-board, if any, are corrected for).

2. Equalisation

3. Scaling (in practise level 1.5 pixels are very close to the raw count value.)

4. Vicarious calibration: cal_slope and cal_offset are determined by vicarious calibration and put into the Level 1.5 Header.

3. THERMAL IR CHANNEL RADIOMETRIC PROCESSING

The radiometric processing of the thermal IR channels is slightly different from the solar channels and therefore, for comparison, it is outlined below:

1. Linearisation

2. Baseline conversion into radiances. (Changes of the detection chain settings on-board, if any, are corrected for.)

3. Equalisation
4. Blackbody Calibration

5. Scaling: apply predefined "cal_slope" and "cal_offset".

4. COMPARISON OF THE IR WINDOW CHANNELS WITH VICARIOUS CALIBRATION

The vicarious calibration for the window channels (IR 10.8 µm and IR 12.0 µm) is of sufficient accuracy for calibration validation. The blackbody calibration and the vicarious calibration agree within their uncertainties (Figure 1). For the blackbody calibration, the accuracy estimate is limited by the expected accuracy of the vicarious calibration, which is assumed to be about 1 K in the window channels but not precisely known. From the results obtained, it can be concluded that the blackbody calibration accuracy is not worse than 1.7% (1.4 K) in the IR 10.8 µm and IR 12.0 µm channels. Assuming that the blackbody calibration is wavelength independent, one can infer that the requirements are also met in the other channels. This is supported by the results obtained from the comparison with the HIRS instrument, where all channels agree better than 0.9 K with the exception of IR 9.7 µm channel (1.5 K, the IR 8.7 channel does not have a corresponding channel on HIRS).

![Blackbody Calibration Results Chain](image)

Figure 2. Blackbody Calibration for IR 12 µm Middle Detector. Minor variations of the reduced gain (left y-axis in raw counts/mW m^2 sr^-1 (cm^-1)^3) are clearly visible. The straight line is a linear interpolation performed during a larger period and shows the clear downward trend. For comparison, the temperature of the Mirror M2 – Mirror M3 assembly within SEVIRI is shown (right y-axis, in Kelvin).
5. CONTAMINATION

The gain depends on the detection chain electronic settings. There are various steps of electronic amplification. To compare the instrument performance independently from the actual choice of electronic settings, a "reduced gain g0" is introduced. It corresponds to the total gain, divided by all adjustable factors and therefore does not show any gain setting changes but all instrument degradations.

The detection chains show a nearly linear trend in time towards lower response (Figures 2 and 3). The speed of degradation tends to increase with wavelength. The degradation is mainly due to collection of contaminants at the cold part of the optics. This can be removed by a short heating period for the cold optics to evaporate the contaminants. A first decontamination was performed shortly after launch before the start of the imaging mission. The second decontamination was performed between 18 March and 24 March 2003. A third decontamination was performed between 11 and 14 August 2003. Typically, SEVIRI is imaging on the HRV, VIS and NIR channels during such an event. After resuming imaging with the IR channels, new adjustments to the detection chains are necessary. So far, the degradation of radiometric response observed was fully recoverable after the decontamination (HANSON et al, 2003b).

6. INFRARED CHANNELS GAIN VARIATIONS

On top of the continuous drift there is a pseudo-periodic oscillation with a period of about 2-3 hours (Figure 2). The strength of the signal depends on the chain. In some channels the amplitude exceeds the allowed drift between images so that a new calibration is necessary. A similar oscillation can be observed in the front optics temperature. However, the amplitude and the phase seem not to correlate with the gain. During the eclipse season, there is also an expected 24-hour period oscillation (see Figure 3). This is clearly due to the temperature variations over the day and is accounted for in the blackbody calibrations.

For some part of the eclipse season, it is necessary to perform blackbody calibrations with the scan mirror pointing south (i.e. after retrace) rather than north (i.e. before retrace). This is to avoid an overheating due to the combined effects of blackbody heating and solar reflect from the scan mirror. It was observed that the calibration results are significantly different between both configurations (Figure 4). The difference varies with channel but is fully reproducible. The instrument manufacturer has analysed these findings and states that this effect is due to the angular dependence of the scan mirror reflectivity. Thus, the true instrument gain
is higher when observing the Northern Hemisphere than in the Southern Hemisphere. The effect is negligible for the IR 3.9 channel but can be as large as 0.9% in the IR 13.4 channel. The calibration results therefore are correct, but only accurate for the mirror position at which they were taken. Possibilities to correct for this effect in the Level 1.5 image are currently being investigated.

7. SUMMARY

The agreement between vicarious and blackbody calibrations is 1.4 K in the IR 10.8 and IR 12.0 channels (=1.7%). This is about the expected uncertainty of the vicarious calibration (+/- 1 K) so that the radiometric accuracy requirement is not exceeded. Assuming that the blackbody calibration is wavelength independent, one can infer that the requirements are also met in the other channels. This is supported by the results obtained from the comparison with the HIRS instrument.

The effects of contamination effects are found fully recoverable after a decontamination.

The observed minimal variation in the region of 2-3 hours define the maximum allowed time between blackbody calibrations. During the eclipse season, the daily variations caused by the strong temperature signal are fully removed by blackbody calibrations. When the blackbody calibration is performed before or after retrace the calibration is affected. Solutions to this problem are currently being investigated.

8. REFERENCES

EUMETSAT (2001), Level 1.5 Data Format Description. EUM/MSG/ICD/105 (available from EUMETSAT).

