1 BLACKBODY CALIBRATION

see UPDATE of 1 December 2003

Since 29th May 2000 this improved method for the calibration of the Infra Red Channels of Meteosat-7 is used operationally. The new method is an absolute calibration, based on the on-board black body calibration mechanism. The method was updated on 4th January 2001, where the values of the angles to the primary and secondary mirror changed slightly. This caused the calibration of the infra red channels to become about 1 K warmer, reducing biases with respect to other spacecraft observations to a similar level as from the vicarious calibration.

The black body calibration mechanism consists of two black bodies with known temperatures, which can be viewed sequentially. The observed counts (IR and WV) can then be related to the known radiance in the two channels, resulting in two black body calibration coefficients. However, as the front optics are not part of the optical path during a black body observation, and as the viewing geometry is different when performing a black body observation with respect to nominal Earth observation, a correction model has been designed allowing for these effects. Hence, the corrected black body calibration will be used as operational calibration.

1.1 The Black Body Calibration Mechanism

The black body observations are performed at least once a day. The mechanism uses two black bodies: one having the ambient spacecraft temperature and one heated to about 50 K above it. First the black body at ambient spacecraft temperature is viewed, and forms the reference signal. Then the heated black body is viewed, and the temperature difference between both black bodies is used to obtain the response of the detectors. The obtained response is converted into counts and transmitted to earth. For both channels (IR and WV) the observed black body counts (C_{bb}) and the known radiances (R_{bb}) are related to each other via a linear relationship (similar to the one for the present vicarious calibration) of which the slope gives the black body calibration coefficient (α_{bb}):

$$R_{bb} = \alpha_{bb} (C_{bb} - C_{space\ count})$$

1.2 Correction Model

The viewing of the black bodies is performed by moving a mirror into the nominal optical path of the radiometer, between the optical block and the front optics. Therefore, the front optics of the radiometer is not included into the optical path of the black body calibration mechanism. In addition the viewing geometry is not similar for black body and Earth view. Hence, the pure black body calibration coefficients cannot be used directly for calibration of the infra red channels. A correction model has been designed allowing for the following corrections:

- Correcting for the impact of the response functions of the mirrors of the front optics that is not viewed during a black body observation.
- Correcting for the viewing geometry. For a black body observation the viewing geometry is limited by the pupil of the optical block. For an Earth scan the viewing geometry is defined by the geometry of the 1st mirror, which is partly occulted by the 2nd mirror.

The correction model for the black body calibration coefficients (α_{bb}) is described by:

$$\alpha = \alpha_{bb} / ((\cos \boldsymbol{A}_1 - \cos \boldsymbol{A}_2) / (\mathbf{K} (1 - \cos \boldsymbol{A}_3)))$$

In which the following parameters are used:

α = The absolute calibration coefficient (IR or WV)

α_{bb} = The black body calibration coefficients (IR or WV)

A_1 = The maximum angle under which the detector can see the 1st mirror.

A_2 = The maximum angle under which the detector can see the 2nd mirror.

A_3 = The maximum angle under which the detector can see the black body, which is determined by the pupil of the optical block.

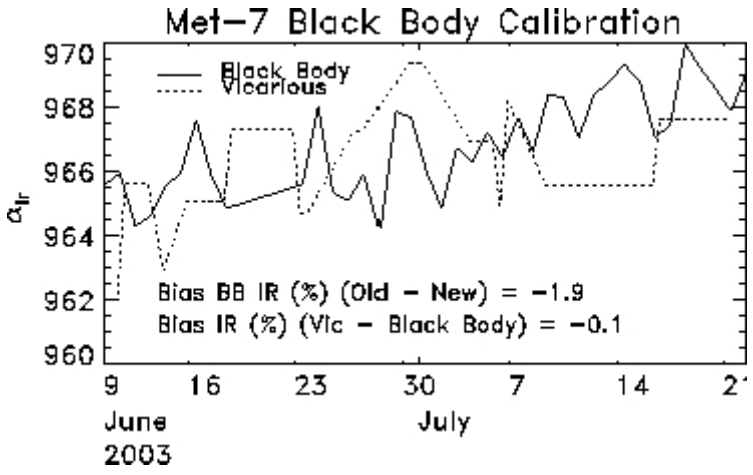
K = A constant factor used to remove the response function of the front mirrors that are not viewed during a black body scan.

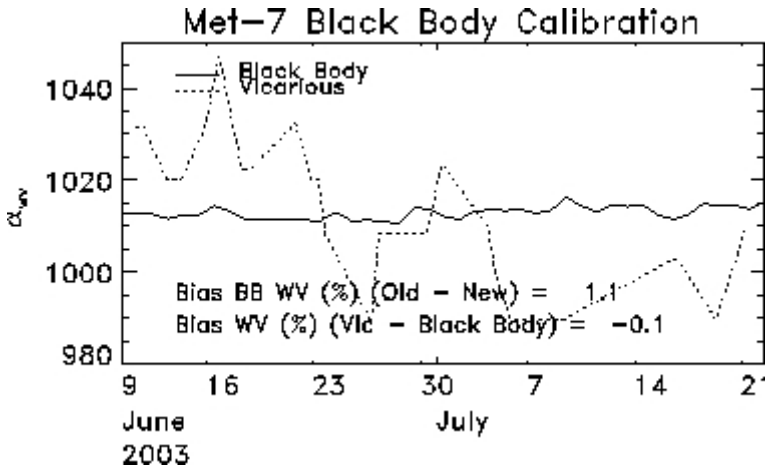
1.3 Validation

A validation showed only a bias of 0.8 % (Present Calibration – Black Body Calibration) over long periods. However, the black body calibration of the Water Vapour Channel is more stable in time than the present operational calibration. A comparison of the wind products with radiosonde observations showed no significant differences in the product quality.

2 ADJUSTMENT OF THE METEOSAT-7 BLACKBODY CALIBRATION 1 DECEMBER 2003

In June 2003 the Image Analysis Scheme in the Meteorological Product Extraction Facility (MPEF) was replaced. The old scheme used a multi-spectral histogram analysis technique on areas of 32x32 pixels. This was a pure statistical technique, which had the disadvantage that the pixel information was lost. The new scheme is based on the MSG scene classification, which is a pixel classification algorithm based on threshold techniques (e.g. Saunders and Kriebl, 1988). The validation of the new image analysis scheme showed that the vicarious IR calibration had a 1 % warm bias with respect to the present operational black body calibration. Hence, a readjustment of the latter is required. The adjustment was performed over the period 9 June till 7 July 2003. The results using this adjusted front optics correction model over a somewhat longer period (till 22 July 2003) are presented in the figures below.





The results of this tuning can be summarised for the IR channel as:

- Bias between vicarious calibration and the new black body calibration is about -0.1 %
- Bias between old and new black body calibration is about -1.9 %

For the WV channel the results can be summarised as:

- Bias between vicarious calibration and the new black body calibration is about -0.1 %
- Bias between old and new black body calibration is about +1.1 %

The new black body calibration will also lead to a decrease of the biases between e.g. Meteosat and HIRS, and Meteosat and ECMWF first guess.

Since the calibration of the infra red channels of Meteosat-5 is based on an intercalibration between Meteosat-5 and Meteosat-7, the same impact as described above for Meteosat-7 is expected for Meteosat-5. For Meteosat-6 imagery a constant calibration coefficient is used for both the IR and the WV channel.

2.1 Validation on MPEF Products

The MPEF AMV and CSR products were validated against the ECMWF forecast and independant radiosonde observations (AMV).

The results for the comparison of the AMV product against the ECMWF forecast indicate that less AMV's are generated with a slightly better quality. The comparison of ECMWF against their first guess shows a smaller bias for the VIS and WV winds, while the impact on the IR winds is very small. The quality of the AMVs compared to collocated radiosonde observations, indicate no statistically significant change in the product quality for the first two weeks of August 2003.

For the CSR product the results of the ECMWF comparison to the first guess showed the following results:

- A reduction of the bias (about –3.0 K) in the IR channel with about 1.0 K
- A reduction of the bias (about +3.5 K) in the WV channel with about 0.5 K

2.2 Reference

- van de Berg L., Heinemann T., Szyndel M., von Bremen L., König M., Rogers C., Pili P., and Yildrim A. (2003) The Calibration of the infrared channels of Meteosat first and second generation spacecraft: EUMETSAT Meteorological Satellite Conference October 2003 Weimar, Germany