CGMS-XXVII EUM-WP-35
Prepared by EUMETSAT
Agenda Item: II.2

CALIBRATION OF METEOSAT VIS CHANNELS

This paper reports on i) the vicarious calibration of Meteosat-5 and -6 solar channels with help of a radiative transfer model. The method compares counts from the radiometer with calculated radiances for cloud free ocean and desert, respectively; ii) the need to substitute Meteosat-5 and -6 radiometer spectral response functions (SRF) for the solar channels by the one for Meteosat-7, because the SRF originally provided by industry was incorrect. The SRF can be found on the EUMETSAT web site http://www.eumetsat.de.

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ABSTRACT

This paper reports on i) the vicarious calibration of Meteosat-5 and -6 solar channels with help of a radiative transfer model. The method compares counts from the radiometer with calculated radiances for cloud free ocean and desert, respectively; ii) the need to substitute Meteosat-5 and -6 radiometer spectral response functions (SRF) for the solar channels by the one for Meteosat-7, because the SRF originally provided by industry was incorrect. The SRF can be found on the EUMETSAT web site http://www.eumetsat.de.

1 INTRODUCTION

The quantitative retrieval of geophysical parameters from satellite observations requires the absolute calibration of the radiometer. Since the elements of a radiometer undergo changes like ageing and contamination, an in-flight calibration facility would be best to adequately provide calibration information for operational real-time applications. However the solar sensors of the current geostationary and polar orbiting meteorological satellites have no in-flight calibration device, and thus alternative methods have been sought.

The following two sections contain results from two studies, which have been published in the reviewed literature, hence the description will be brief. Section 2 provides results from a vicarious calibration of the Meteosat-5 and -6 VIS channels using a comprehensive radiative transfer model (Arriaga and Schmetz, 1999). Section 3 alerts CGMS to the fact that the SRFs of Meteosat-5 and -6 VIS channels originally proposed by industry should be replaced by the SRF of Meteosat-7 (Govaerts, 1999). It should be noted that the results of section 2 are not invalidated by the work of Govaerts (1999) since Arriaga and Schmetz (1999) derive calibration coefficients for specific scenes (desert and ocean), i.e. they directly relate a radiative transfer model result for a rectangular response function to the observed counts.

2 CALIBRATION OF THE METEOSAT-5/-6 VIS CHANNELS

The VIS channel of Meteosat can be calibrated with a linear relationship converting measured counts c into a radiance R:

$$R = \alpha \, (c - c_o) \qquad (1)$$

where α is the calibration coefficient and c_o is the count observed at space view which corresponds to the zero-offset. The linear relationship has been determined during pre-launch tests.

Our model based calibration was performed for desert and ocean target areas. Those were the same as used by Kriebel and Amann (1993) during the aircraft calibration campaign for Meteosat-5. For Meteosat-5. The radiation model was run for the very day and time of the airborne measurements over sea and desert. Two strips with 250 km and 120 km length were taken on July 28, between 12:08 and 13:08 UTC, over a large cloud free area of the Atlantic

Ocean, centred at about 36°N 8°W (South of Portugal). On July 31, between 12:26 and 12:48 UTC, the aircraft measurements were performed over a cloud free area of the Tunisian desert centred at about 33°N 9.5°E (West of Jerba). The rectified images in the VIS channel between 11:30 and 13:00 UTC have been used, to cover the time period of measurements with the airborne radiometer. The respective geographical locations in the satellite image under the path of the aircraft have been selected using the McIDAS software. The counts of the rectified images in the VIS channel were averaged over 3x3 pixels, corresponding to target areas about 15 km x 15 km for METEOSAT, which yields 18 target areas over sea and 2 target areas over the desert. The mean count for the deep space view has been taken as 4.5 ± 0.5 and was determined during satellite commissioning.

The spectral surface albedo (within the spectral interval 0.4-1.1 μm) of the Tunisian desert has been estimated as 40% in June and 45% in January, on the basis of satellite observations (Nacke, 1991). The radiosonde profiles of temperature and water vapour mixing ratio from nearby stations, in Gibraltar and Jerba, at 12 UTC, have been used as input to the radiation model. The available temperature and water vapour mixing ratio profiles were extended up to 100 km height with the standard atmosphere for mid-latitudes summer, and complemented with a standard profile of the ozone mixing ratio. The climatological aerosol profiles for maritime and desert atmospheres were adjusted to the observed surface visibility through a linear shift of the respective profiles below 2 km height. Surface meteorological reports at 12 UTC indicated a visibility of 20 km. In the case of the target areas over sea the surface wind speed was taken as 1 ms^{-1}. The total column ozone was measured as 320 DU, according to observations in the region. With those values, the theoretical outgoing radiances were computed for each target area over desert and sea, simulating the exact viewing geometry of the satellite with respect to the sun during the aircraft calibration campaign. The calibration coefficient is calculated from a weighted linear regression of model radiances against the mean counts of the target areas (corrected from the space count). The weights are represented by the inverse total error-variances within each target area. Such error-variances are estimated as the sums of the error-variance of model radiances and the corresponding variance of image counts (including the error-variance of the space count). Only the target areas with relative RMS of counts lower than 5% were used for the calculation of the calibration coefficient.

Table 1 presents the results of the calibration with the radiation model as compared with the calibration values from Kriebel et al. (1996). The values in brackets give the RMS error in percent. This RMS error estimation includes the error of the model calculations as well as the errors of the observed counts. Errors are taken as the square root of the variances. The last column provides the difference between the model calculated calibration coefficients and those determined by Kriebel et al. (1996).

Target	This Study	Kriebel et al. (1996)	Difference
Desert (33°N, 9.5°E)	1.03 (9.5 %)	1.10 (5 %)	6 %
Ocean (30°N, 8°W)	1.14 (7.5 %)	1.31 (5 %)	13 %

Table 1: Calibration coefficients (in $Wm^{-2}\ sr^{-1}\ count^{-1}$) for the METEOSAT-5 VIS channel and estimated RMSE (in brackets). The RMSE includes the radiance model errors as well as the errors in the observed counts.

Table 1 shows that the calibration coefficients for desert targets agree within estimated errors of 9.5 %. In the case of the calibration coefficients for ocean targets, the difference (13 %) exceeds the estimated 7.5% error of our calculated coefficient. The higher discrepancy for the ocean calibration could be expected due to the low radiance values over the ocean which results in a higher error in the calculation of the slope (calibration coefficient). Over bright target areas this effect is less pronounced which suggests that bright desert targets are best suited for a vicarious calibration with a model (e.g. Rao et al., 1997).

Following the procedure outlined above, Meteosat-6 VIS channels have also been calibrated. A sequence of VIS and IR images at 12 UTC of November 1996 has been analysed to identify two large cloud free areas. The selected regions are close to the ones previously used for calibrating Meteosat-5 over the Tunisian desert and the Atlantic Ocean. The mean count from the space view at 12 UTC for the rectified VIS images, was estimated as 5±1 counts. Table 2 presents the results together with the estimated errors.

Meteosat-6 VIS channel	Desert (33°N, 9.45°E)	Ocean (37.5°N, 9.5°W)
Calibration coefficient ($Wm^{-2}sr^{-1}count^{-1}$)	0.99	1.17
RMSE (%):	8.6	12.2

Table 2: Calibration coefficients for the Meteosat-6 VIS channel and estimated errors

3 CORRECTION OF THE METEOSAT-5/-6 RADIOMETER SPECTRAL RESPONSE FUNCTIONS

In a recent paper Govaerts (1999) demonstrates that the Meteosat-5/-6 VIS channels spectral response functions which were provided by industry to EUMETSAT in the first place are incorrect. As pointed out later the correct SRF to be used is the one for Meteosat-7. Govaerts (1999) shows that with the new SRF a vicarious calibration which uses desert and ocean targets and does include the SRF are more consistent since differences drop from 20% to 1%.
Since all VIS detectors for Meteosat-5 to -7 were produced in the same batch and SRF measurements for Meteosat-7 have been determined more accurately than for previous satellites it is concluded that measurements of the filter functions of Meteosat-5/-6 were not correct.

4 REFERENCES

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