CGMS-XXIX EUM-WP-14
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# RESULTS FROM EUMETSAT IR AND WV SATELLITE INTERCALIBRATION WORK

A routine cross calibration has been established to compare the IR-window and WV channels of Meteosat-7 and Meteosat-5 (at 63° E) with channels 8 and 12 of the HIRS instrument on NOAA-14.

- The IR window cross-calibration gives biases (Meteosat-HIRS) of about –1 K.
- The WV cross-calibration gives biases (Meteosat-HIRS) of about +3 K.

Biases are similar for both Meteosat-7 and –5, which is not surprising because Meteosat-5 is operationally calibrated to Meteosat-7 via a cross-calibration.

Sources of the biases are not clear. Potential explanations include: errors in the operational calibrations, uncertainties in the instrument characterisation, especially in the spectral response functions.
It is suggested that CGMS operators make an effort to document the characterisation of their instruments.

# RESULTS FROM EUMETSAT IR AND WV SATELLITE INTERCALIBRATION WORK

## 1 INTRODUCTION

This paper responds to Action 28.23 of CGMS XXVIII requesting satellite operators to regularly perform satellite cross-calibration.

Previous papers from EUMETSAT to CGMS have reported on satellite intercalibration. Specifically, CGMS XXVIII EUM-WP-16 and WP-19 completely described the intercalibration method used at EUMETSAT and listed comparisons of Meteosat to AVHRR, HIRS, and GOES.

In this paper, recent results of comparisons between both Meteosat-5 and Meteosat-7 to the respective IR and WV channel of the HIRS instrument (onboard NOAA-14) are presented. It should be noted that since 31 May 2001, the EUMETSAT operational calibration of Meteosat-5 is performed via an intercalibration with Meteosat-7 (for both the IR and the WV channel). This implies that there is no bias between the two Meteosat satellites, which is also reflected in the comparisons to HIRS. The EUMETSAT operational calibration of Meteosat-7 relies entirely on the internal blackbody. The Meteosat calibration coefficient is of unit $W/m^2/ster/count$.

## 2 SHORT DESCRIPTION OF METHOD

The key elements of the EUMETSAT cross-calibration method are:

(a) find collocated pixels of the two satellites
(b) use only those pixels where the viewing angle difference is less than 5 deg
(c) correct the radiance of the HIRS instrument for differences in filter function using a theoretical relation based on radiative transfer calculation for a representative set of atmospheric profiles
(d) relate this corrected radiance to the measured Meteosat count to get a local calibration coefficient
(e) for one intercalibration case, i.e. for one NOAA orbit, average all the local calibration coefficients to obtain a mean coefficient for that Meteosat image

The coefficients to correct for the differences in filter function are listed in the Annex.

For the HIRS comparisons, all collocated pixels meeting condition (b) were used, whether they were cloudy or not. The presented results are all for orbits where the time difference between the observations never exceeded 10 minutes and were for most of the cases within 5 minutes. As stated in CGMS XXVIII EUM-WP-16, this provides sufficient accuracy for the ‘all-sky’ method.

## 3 RESULTS FOR METEOSAT-7

A total of 47 cases were collected and processed between April and early August 2001. Figure 1 and Figure 2 show the time series of the obtained cross-calibration coefficients together with the EUMETSAT operational coefficients for the IR and the WV channel, respectively.

The following observations are noteworthy:

(a) The operational coefficient is very stable in time. The cross-calibration coefficient shows some more variability, but that can easily be explained by the variability in different orbits (number of possible collocations change, time difference between the images is not constant, cloud situation is always different). These small variations are much less than the uncertainty due to scatter of the local cross-calibration coefficients as indicated by the error bars.

(b) The IR coefficients are rather close, and the operational coefficient is practically always within the error bounds of the cross-calibration coefficient. There is, however, a clear indication that the cross-calibration coefficient is a little higher. This difference lies between 1.5 – 2%, which in terms of temperature implies that Meteosat-7 is by about 1K colder than HIRS. Although a difference of 1K is within the expectations for different IR sensors, the consistency of the bias may warrant bias corrections. These are required if merged data sets area analyzed. How a bias correciton should be done in practice is an open question.

(c) The WV calibration coefficients, however, disagree by about 14% which translates into a temperature difference of about 3K by which Meteosat-7 is warmer that HIRS. Here the operational coefficients are ouside the standard deviation of the cross-calibration values.

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Figure 1: Comparison of the operational calibration coefficient of the Meteosat-7 IR channel (crosses) with results from an intercalibration with channel 8 of HIRS (asterisks) onboard NOAA-14. Error bars show the standard deviation due to scatter of individual cross-calibration targets.

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Figure 2: Comparison of the operational calibration coefficient of the Meteosat-7 WV channel (crosses) with results from an intercalibration with channel 12 of HIRS (asterisks) onboard NOAA-14. Error bars show the standard deviation due to scatter of individual cross-calibration targets.

## 4 RESULTS FOR METEOSAT-5

A total of 39 cases were collected between June and early August 2001. Figure 3 and Figure 4 show the time series of the coefficients for the two channels. As the Meteosat-5 calibration relies on a crosscalibration with Meteosat-7, the findings are the same as for Meteosat-7: IR calibration differences are around 2%, thus HIRS indicates a by 1K higher temperature, while the WV coefficients suggest again a by 3 K colder temperature.

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Figure 3: Comparison of the operational calibration coefficient of the Meteosat-5 IR channel (crosses) with results from an intercalibration with channel 8 of HIRS (asterisks) onboard NOAA-14. Error bars show the standard deviation due to scatter of individual cross-calibration targets. The large jump in early July is due to a different radiometric gain setting onboard the satellite.

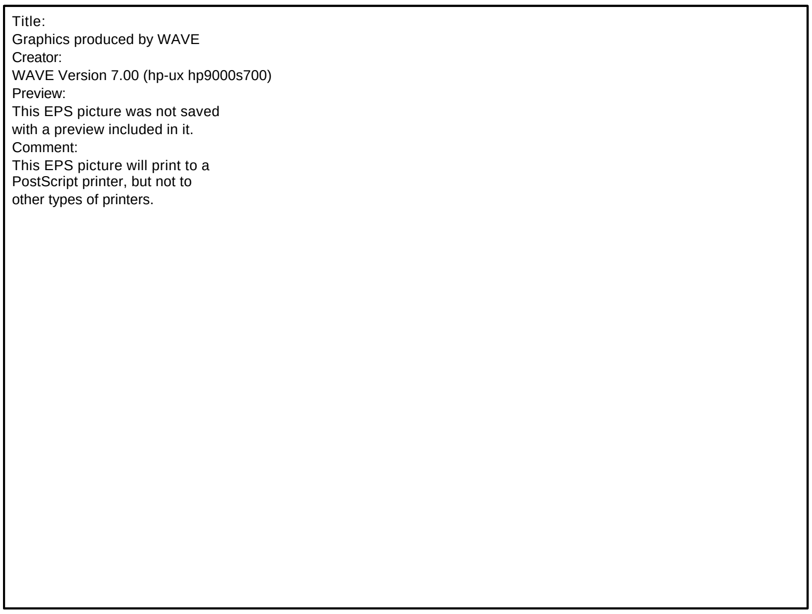


Figure 4: Comparison of the operational calibration coefficient of the Meteosat-5 WV channel (crosses) with results from an intercalibration with channel 12 of HIRS (asterisks) onboard NOAA-14. Error bars show the uncertainty due to scatter of individual cross-calibration targets. The large jump in early July is due to a different radiometric gain setting onboard the satellite.

## 5 CROSSCALIBRATION TARGETS

Figure 5 shows a typical geometry of a cross-calibration case between Meteosat-7 and HIRS: The orbital track of the NOAA satellite goes from south to north and is thus in line with the scan direction of Meteosat. In this case, the orbit covered the half hour between 1700 and 1730 (on 4 June 2001), so that the collocated Meteosat image is the 1730 image; the Meteosat scan of that image started at 1700 in the south. The individual crosscalibration targets are shown as the two strips of data points to the left and right of the subsatellite track. Its curvature is due to the constraint that the respective viewing angles should be within 5 deg. The gaps in the target strips show the internal calibration lines of the HIRS instrument which were of course excluded from the processing.

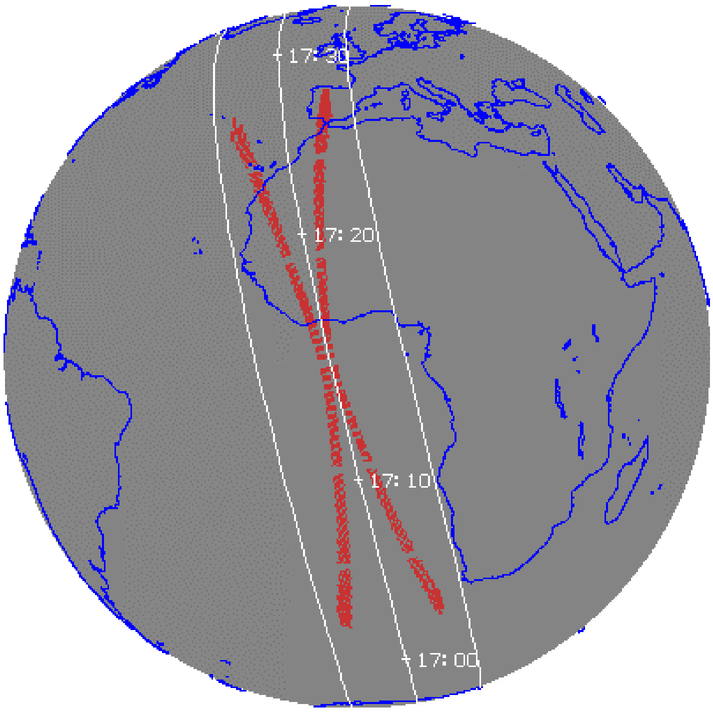


Figure 5: Example of Meteosat-7 versus NOAA-14 comparison: Shown are the NOAA orbital track and coverage projected on a Meteosat view. Used calibration targets are shown as the two curved strips to the left and right of the subsatellite track. Times along the track refer to the NOAA satellite.

## 6 CONCLUSIONS

A routine cross calibration has been established to compare the IR-window and WV channels of Meteosat-7 and Meteosat-5 (at 63° E) with channels 8 and 12 of the HIRS instrument on NOAA-14.

- The IR window cross-calibration gives biases (Meteosat-HIRS) of about –1 K.
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Biases are similar for both Meteosat-7 and –5, which is not surprising because Meteosat-5 is operationally calibrated to Meteosat-7 via a cross-calibration.

Sources of the biases are not clear. Potential explanations include: errors in the operational calibrations, uncertainties in the instrument characterisation, especially in the spectral response functions.

It is suggested that CGMS operators make an effort to document the characterisation of their instruments.

**ANNEX**

Coefficients of the linear relation to convert HIRS (NOAA-14)m, channels 8 and 10 into Meteosat-7and Meteosat-5 IR/WV radiances. Coefficients correct for differences in spectral filter response function and are based on radiative transfer simulations:

Meteosat radiance = <intercept> + <slope> * HIRS radiance

where the radiance units are $mW/m^2/ster/cm^{-1}$

| **Meteosat-7** | **HIRS channel 8** | **HIRS channel 12** |
|---|---|---|
| Intercept | 3.4668 | -0.20596 |
| Slope | 1.0007 | 0.73529 |
| **Meteosat-5** | **HIRS channel 8** | **HIRS channel 12** |
| Intercept | 2.1559 | -0.28090 |
| Slope | 0.99803 | 0.65754 |