

# EUMETSAT Inter-Calibration of Meteosat/SEVIRI with Metop/IASI: GSICS Re-Analysis Correction (RAC) – ReadMe Quick Guide

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## Method

This document summarises the process of applying the GSICS Correction to inter-calibrate the infrared channels of SEVIRI on the Geostationary (GEO) Meteosat Second Generation satellites with the Infrared Atmospheric Sounding Interferometer (IASI) on Low Earth Orbit (LEO) Metop satellites.

The inter-calibration process [Hewison *et al.*, 2013] is based on the comparison of thousands of observations of the two instruments, collocated in space, time and viewing geometry, taken within  $\pm 14$  days from the observation date. These observations are transformed spatially and spectrally to allow direct comparison by linear regression to estimate the coefficients,  $a_r$  and  $b_r$ , required to convert GEO radiances,  $L_{GEO}$ , to the reference LEO radiances,  $L_{LEO}$ :

**Equation 1:** 
$$L_{GEO} = a_r + b_r L_{LEO}$$

This relationship can be inverted to apply the regression coefficients,  $a_r$  and  $b_r$ , to convert GEO radiances,  $L_{GEO}$ , into radiances consistent with the LEO reference instrument,  $\hat{L}_{LEO}$ ,

**Equation 2:** 
$$\hat{L}_{LEO} = -\frac{a_r}{b_r} + \frac{1}{b_r} L_{GEO},$$
 together with the estimated uncertainty:

**Equation 3:** 
$$\sigma_{\hat{L}_{LEO}}^2 = \left(\frac{\sigma_{a_r}}{b_r}\right)^2 + \left[\frac{(L_{GEO} - a_r)}{b_r}\right]^2 - 2\frac{(L_{GEO} - a_r)}{b_r}\sigma_{a,b_r},$$

The regression coefficients,  $a_r$  and  $b_r$ , and their uncertainties,  $\sigma_{a_r}$ ,  $\sigma_{b_r}$  and  $\sigma_{a,b_r}$  are given as variables *offset*, *slope*, *offset\_se*, *slope\_se* and *covariance*, respectively, in netCDF files, which are time-stamped according to the first date of the processing period – e.g. **W\_XX-EUMETSAT-Darmstadt,SATCAL+RAC+GEOLEOIR,MSG2+SEVIRI-MetOpA+IASI\_C\_EUMG\_20110101000000\_preop\_01.nc**. These files are downloadable from EUMETSAT’s GSICS Data and Products Server: <http://gsics.eumetsat.int>. The contents of these files follow the GSICS convention [EUMETSAT, 2012], with coefficients recalculated each day, stored in 2-D arrays of *number\_of\_channels* (8) x *date* (~1000).  $L$ , and  $a_r$  have units of  $mW/m^2/sr/cm^{-1}$ , following the Meteosat/SEVIRI radiance convention.

## Applicability

These inter-calibration results have been derived over the geographical domain of  $\pm 35^\circ N/S$ ,  $\pm 35^\circ E/W$ , using only night-time observations. Although strictly only applicable to these conditions, an analysis [Hewison *et al.*, 2013] suggest they are generally applicable, although diurnal variation in the bias of the IR3.9 channel is possible. Use the most recent RAC file and read the coefficients for the date of interest. Take great caution where no results are available within 14 days, as determined by the netCDF *validity\_period* variable.

## Typical Results

The mean bias of Meteosat-9 relative to IASI valid on 1 Jan 2013 is calculated for a standard scene radiance and given below, expressed as brightness temperature difference, together with its median uncertainty,  $\sigma_{\hat{L}_{LEO}}$  (also in K):

Channel	IR3.9	IR6.2	IR7.3	IR8.7	IR9.7	IR10.8	IR12.0	IR13.4	
Standard Scene $T_b$	284	236	255	284	261	286	285	267	K
Mean Bias, SEVIRI-IASI	-0.191	-0.220	+0.232	-0.033	-0.380	-0.009	-0.017	-2.296	K
Uncertainty ( $k=1$ )	0.004	0.004	0.003	0.006	0.003	0.004	0.004	0.006	K

An error analysis [Hewison, 2013] suggests the uncertainties quoted above and in the netCDF file underestimate the total uncertainty by a factor of ~2.

## Example Application

The Re-Analysis Correction is intended for reprocessing type analysis, as it has a longer latency time (15d) to allow more smoothing of the results by combining more collocations over a longer period.

The GSICS Correction can be used to correct the operationally produced radiance in the GEO Meteosat L1.5 data,  $L_{GEO}$ , so it's calibration is consistent with that of the LEO reference instrument, Metop/IASI,  $L_{LEO}$ .

The operational radiance,  $L_{GEO}$ , is calculated from the L1.5 counts as:

$$\text{Equation 4: } L_{GEO} = a_c + b_c C,$$

where  $C$  is the pixel count,  $a_c$  and  $b_c$  are the operational offset and slope calibration coefficients, respectively.

The GSICS Corrected radiance is then given by Equation 2, which may be re-written as

$$\text{Equation 5: } \hat{L}_{LEO} = \left( \frac{a_c - a_r}{b_r} \right) + \left( \frac{b_c}{b_r} \right) C,$$

where  $a_r$  and  $b_r$  are the coefficients of the GSICS Correction given in the netCDF file as *offset* and *slope*, respectively.

This is equivalent to changing the space count and calibration coefficient in Equation 4 to  $a_g = (a_c - a_r)/b_r$  and  $b_g = (b_c/b_r)$ , respectively.

For example, a typical scene radiance for Meteosat-9 IR13.4 channel might be  $C=620$  counts.

Using the operational calibration,  $a_c = -8.0376 \text{ mW/m}^2/\text{sr/cm}^{-1}$  and  $b_c = 0.1576 \text{ mW/m}^2/\text{sr/cm}^{-1}/\text{count}$  gives a radiance of  $L_{GEO} = 89.7 \text{ mW/m}^2/\text{sr/cm}^{-1}$ , corresponding to a brightness temperature of 267.0 K (close to the GSICS *standard scene radiance* for this channel).

Applying the formula in Equation 5 with example GSICS Correction coefficients,  $a_r = +2.04 \text{ mW/m}^2/\text{sr/cm}^{-1}$  and  $b_r = 0.95$ , gives the GSICS Corrected radiance,

$\hat{L}_{LEO} = 92.2 \text{ mW/m}^2/\text{sr/cm}^{-1}$ , corresponding to a brightness temperature of 268.8 K. i.e. an increase of +1.8 K compared to the operational calibration, to correct the standard bias of this channel of -1.8 K shown in the GSICS Bias Monitoring:

<http://www.eumetsat.int/Home/Main/DataProducts/Calibration/Inter-calibration/GSICSBiasMeteosatIRInter-calibration/index.htm?l=en&satellite=msg2>

## Radiance to Brightness Temperature Conversion

The netCDF file also contains global attributes which define the function to convert between radiances and brightness temperatures for each channel, *brightness\_to\_radiance\_conversion\_formula* and *radiance\_to\_brightness\_conversion\_formula*. The coefficients needed are also supplied as the variables *alpha*, *beta* and *wnc*.

## References

EUMETSAT, 2012: GSICS Product Format Templates, EUMETSAT Technical Note EUM/OPS/TEN/12/1447.

EUMETSAT, 2012: ATBD for EUMETSAT Pre-Operational GSICS Inter-Calibration of Meteosat-IASI, EUMETSAT Technical Note: EUM/MET/TEN/11/0268.

Hewison, T. J., "An Evaluation of the Uncertainty of the GSICS SEVIRI-IASI Inter-Calibration Products", *IEEE Trans. Geosci. Remote Sensing* accepted for publication, 2013.

Hewison, T. J., X. Wu, F. Yu, Y. Tahara, X. Hu, D. Kim and M. Koenig, "GSICS Inter-Calibration of Infrared Channels of Geostationary Imagers using Metop/IASI", *IEEE Trans. Geosci. Remote Sensing* accepted for publication, 2013.