RMIB GERB Processing: Data products accuracy estimation

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CHANGE RECORD

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1 Introduction

1.1 Purpose of this document

The purpose of this document is to give an estimation of the accuracy of the GERB data products that will be generated by the RMIB GERB Processing.

1.2 Scope

The effect of the different known error sources which contribute to the GERB data product errors are collected, and their combined effect is estimated.

2 Error sources

The RMIB GERB Processing derives unfiltered radiances and fluxes from geolocated filtered radiances. Multiple error sources contribute to the errors on the final products. The error sources that are inherent to process of flux estimation from a broad band radiometer are:

- calibration of filtered radiances
- thermal/solar radiance separation
- spectral unfiltering
- radiance to flux conversion

Particular additional error sources are:

- effect of different spectral responses for different detector cells
- footprint determination
- effect of non repeatability of pointing

For these error sources, an estimation of the induced errors will be given.

3 Error quantification numbers

For every error source the maximum absolute error (error on an absolute scale) and the root mean square error (noise level) will be estimated. If no direct estimate of the maximum absolute error is available, it will assumed to be equal to three times the root mean square error.

For the combination of errors, the maximum absolute errors are summed, and the square of the root mean square errors are summed.

4 Errors inherent to the flux estimation process

4.1 Calibration of filtered radiances

The basic quantities measured by the GERB instrument are filtered radiances. Their calibration relies on the on-ground calibration of the GERB instrument, and is maintained in flight using the on-board calibration sources. The errors for the filtered radiances, from [2], are given below.

	filtered long wave *	filtered short wave
error on absolute scale	0.25 % (spec. 0.3 %)	0.53 % (spec. 0.6 %)
noise level	0.28 % = 0.22 W/m2sr	0.06 % = 0.14 W/m2sr
Full scale value (100 %)[1]	77 W/m2sr	240 W/m2sr

*: defined as (total filtered radiance) - A (short wave filtered radiance), see [3], assuming that there are no collocation problems.

4.2 Thermal/solar radiance separation

See [5].

	thermal long wave*	solar short wave
3 sigma	0.092 W/m2sr	0.053 W/m2sr
noise level (1 sigma)	5.7 % = 0.031 W/m2sr	7.7 % = 0.018 W/m2sr
Full scale value for error (100 %)	1.695/3.14 W/m2sr	0.720/3.14 W/m2sr

* The error -which is caused by solar contamination-is evaluated at a mean solar zenith angle of 50 degrees.

	thermal long wave*	solar short wave
3 sigma	0.092 W/m2sr = 0.12 %	0.053 W/m2sr = 0.08 %
Mean value for radiance (100 %)*	235/3.14 W/m2sr	2*107/3.14 W/m2sr

* from ERBE global daily means: SW flux = 107 W/m2, LW flux: 235 Wm2, see [8]

4.3 Spectral unfiltering

See [7] with use of all SEVIRI channels.

	thermal radiance	solar radiance
3 sigma	0.09 %	1.14 %
noise level (1 sigma)	0.03 % = 0.02 W/m2sr	0.38 % = 0.26 W/m2sr
Mean value for radiance (100 %)*	235/3.14 W/m2sr	2*107/3.14 W/m2sr

* from ERBE global daily means: SW flux = 107 W/m2, LW flux: 235 Wm2, see [8]

4.4 Summary of error on unfiltered radiance

	thermal radiance	solar radiance
error on absolute scale	0.46 %	1.75 %
noise level (1 sigma)	0.22 W/m2sr	0.30 W/m2sr

4.5 Radiance to flux conversion

See [9] for the thermal flux and [10] for the solar flux.

for nadir view:

	thermal flux	solar flux
3 sigma	7.83 %	8.91 %
noise level (1 sigma)	2.61 % = 6.13 W/m2	10 W/m2 =2.97 %
Reference value for flux(100 %)	235 W/m2 *	0.3*cos(35 degrees)*1366 W/m2 **

* from ERBE global daily mean

** assuming mean earth albedo of 0.3

for viewing zenith angle of 50 degrees (~Europe):

	thermal flux	solar flux
3 sigma	1.23 %	4. 46 %
noise level (1 sigma)	0.41 % = 0.97 W/m2	5 W/m2 = 1.49 %
Reference value for flux(100 %)	235 W/m2	0.3*cos(35 degrees)*1366 W/m2

4.6 Summary of error on flux

for nadir view:

	thermal flux	solar flux
error on absolute scale	8.3 %	10.7 %
noise level (1 sigma)	6.2 W/m2	10 W/m2

for viewing zenith angle of 50 degrees (~Europe):

	thermal flux	solar flux
error on absolute scale	1.7 %	6.2 %
noise level (1 sigma)	1.2 W/m2	5.1 W/m2

5 Additonal errors

5.1 Effect of different spectral responses for different detector cells

The spectral responses of the different detector cells are slightly different. This is taken into account in the measurement of the factor A for every detector cell. In the spectral unfiltering process, a mean spectral response function for all detector cells is assumed. The induced error depends on the dispersion between the different spectral response curves.

The dispersion between the different spectral curves has been estimated from the measured spectral responses for the different detector cells. After separate normalisation of the SW part with a black body of 5800 K, and of the LW part with a black body of 300 K - see [3]- a relative dispersion of 2.9 % in the SW and 3.8 % in the LW exist.

5.2 Footprint determination

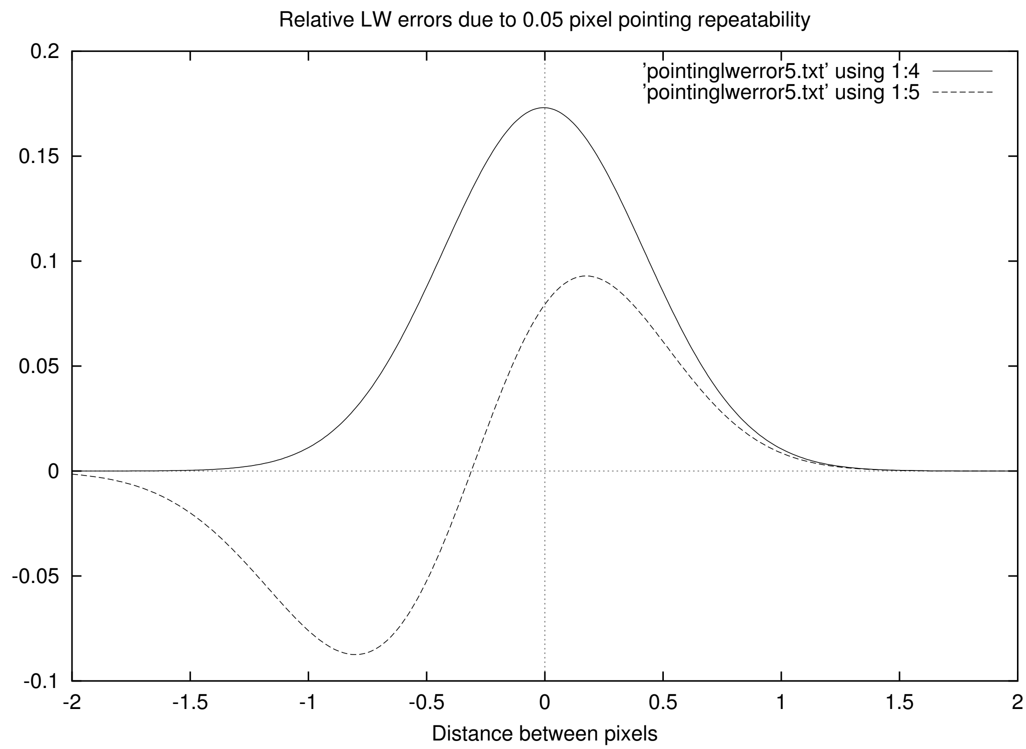
The radiance measured for one GERB pixel, is a spatially weighted average of a scene radiance. If the actual position - the geolocation - or the actual shape - the Point Spread Function - of the spatial averaging function are different from what they are believed to be, this results in an equivalent error of the GERB measured radiance. The magnitude of the error depends on the spatial variability of the observed scene. E.g. in [4] this kind of error is considered.

5.3 Effect of non repeatability of pointing

The longwave filtered radiance must be calculated as the difference between a total radiance and A times a short wave radiance. The total radiance and the short wave radiance are measured by the same detector at different times. In between, according to the instrument specifications, the pixel can move by 1/20 th of its nominal size. If a simple difference between pixels is calculated, a spurious short wave contribution remains in the calculated long wave radiance. In [6], the resulting error is calculated for the worst case, this is the most contrasted short wave scene - a bright cloud over ocean with overhead sun. It is supposed that neirest neighbour pixel values are subtracted.

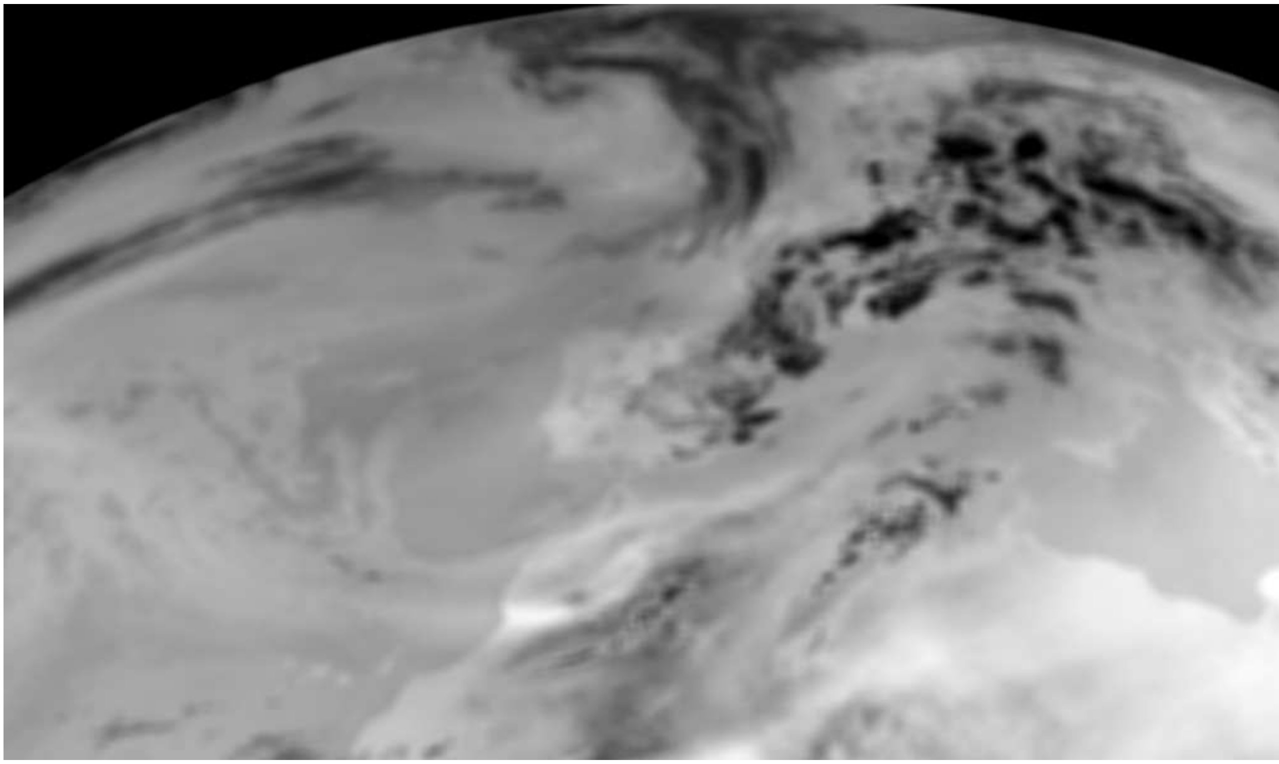
	long wave radiance
max.error	**15 % = 13 W/m2sr**
full scale (100 %)	(82.3+91.3)/2 W/m2sr

In the RMIB GERB Processing, this effect is somehow mitigated since linear spatial interpolation is used before the subtraction, see [11]. The underlying graph shows the theoretical for a sharp transition between a bright cloud and dark ocean in function of the position of the transition between cloud and ocean - see [6]. The upper curve gives the neirest neighbour case - with a maximum error around 15 %. The lower curve gives the linear interpolation case - with maximum error arround 10 %. In all these cases the GERB PSF has been simulated as a Gaussian with a full width at half height equal to one pixel.

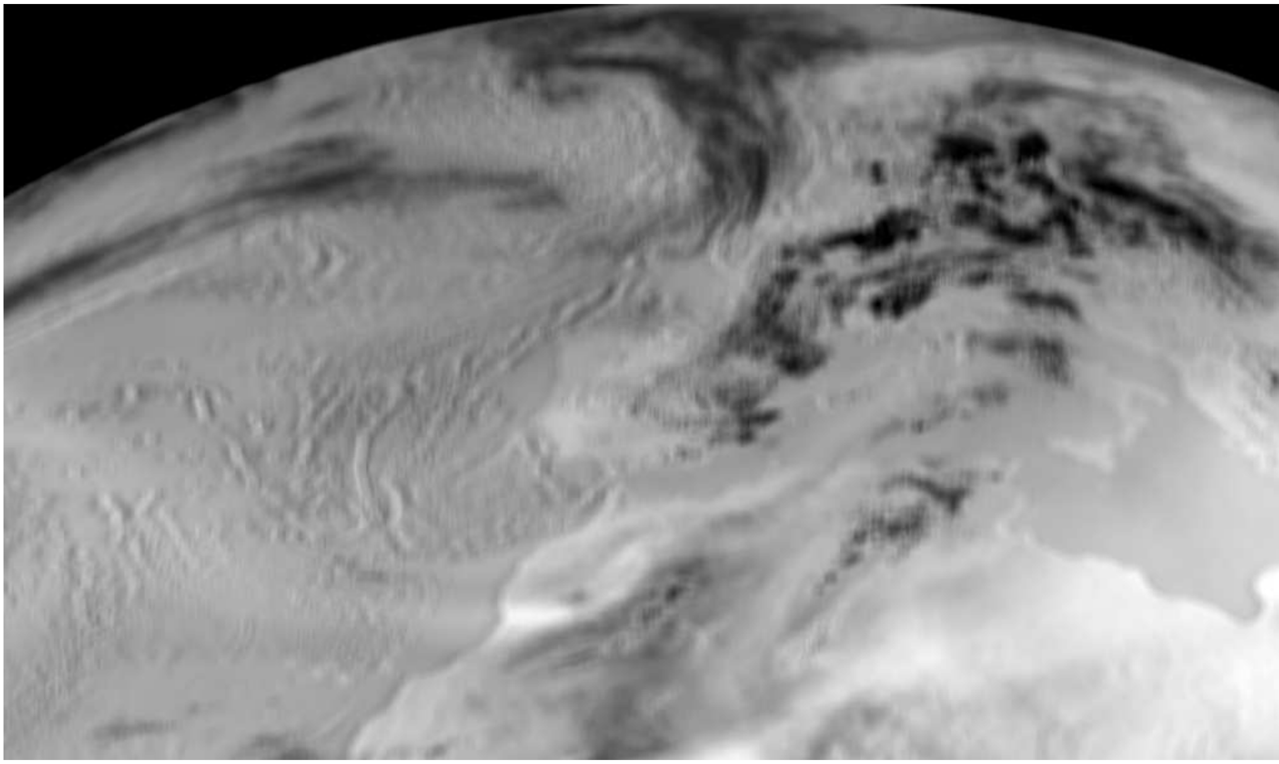


In order to visualise the error, simulations have been done with METEOSAT based estimates for 1999, day 194, hour 1400.

The GERB resolution has been simulated by calculating a moving mean over 50 km x 50 km at nadir. The resulting LW image over Europe (METEOSAT B format) is shown below.



In GERB, non repeatability of the pointing will cause contamination of this kind of images with a gradient of the SW image. The worst case result, occuring at overhead sun, is shown below.



	long wave flux
max.error	**34.0 W/m2** = 9.9 %
RMS error	5 W/m2
full scale (100 %)	343 W/m2

These errors are unacceptably high. As an alternative purely SEVIRI based LW estimates can be used during daytime. These SEVIRI estimates can be trained during night time - when the SW contamination does not occur - by GERB. Assuming that the regression error for a noiseless imager - 0.61 %, see [5]- is reached, the errors for the purely SEVIRI based approach are:

	long wave flux
max.error	**8.2 W/m2** = 2.4 %
RMS error	1.6 W/m2
full scale (100 %)	343 W/m2

A mixed solution is also possible: those GERB measurements which deviate by less than 3 sigma from the SEVIRI estimate - this happens in 83 % of the cases - are believed to be correct, the other ones are replaced by the SEVIRI estimate. The simulated worst case errors in this scenario are:

	long wave flux
max.error	**10.2 W/m2** = 3.0 %
RMS error	1.96 W/m2
full scale (100 %)	343 W/m2

References

[1] GERB science requirements specificaton, MSG-RAL-GE-SP-0001, J. Delderfield

[2] Calibration error budget, excell sheet from R. Mossavati

[3] GERB baseline calibration algorithms, MSG-ICL-GE-TN-0005, J. Mueller

[4] Radiometric error due to NS smear, MSG-RAL-GE-TN-0124, M. Caldwell

[5] RMIB GERB Processing - SEVIRI processing : Spectral modelling, MSG-RMIB-GE-TN-0005, N. Clerbaux, S. Dewitte

[6] Pointing repeatability - effect on longwave error,MSG-RAL-GE-TN-0111, M. Caldwell

[7] Improving the retrieval of broad band radiances using the imager, report WP 3200 for the study "requirements for synergetic use of the ERM imager", N. Clerbaux, S. Dewitte

[8] CERES brochure

[9] RMIB GERB Processing: Angular Dependency Models, MSG-RMIB-GE-TN-0008, N. Clerbaux, S.Dewitte

[10] report WP 3300 for the study "requirements for synergetic use of the ERM imager", A. Ipe

[11] "RMIB GERB Processing: GERB Processing"