# RMIB GERB Processing: Overview

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This document is outdated and does not represent the current state of the GERB processing.

## Contents

CHANGE RECORD

| Issue | Date | Changed by | Reason for change |
| --- | --- | --- | --- |
| Version 1 | 08/07/1999 | | new document |
| | 08/10/1999 | Steven Dewitte | inserted section 2 on requirements , modified section “Work Organisation” |
| | 21/08/2000 | Steven Dewitte | added section on auxiliary programs |
| Version 1.1 | 06/03/2003 | Luis Gonzalez | section “Auxiliary programs” removed, some corrections and updates, section “Resource requirements” removed |

# 1 Introduction

## 1.1 Purpose of this document

The purpose of this document is to give a general overview of the RMIB near real time GERB processing system. It explains why and how the complete processing system is divided in different subsystems and how the data flows between these subsystems.

## 1.2 Scope of this document

In this document only a limited description of the different subsystems is given.

The SEVIRI processing subsystem is described in more detail in MSG-RMIB-GE-TN-0005, MSG-RMIB-GE-TN-0007 and MSG-RMIB-GE-TN-0008 the GERB processing subsystem is described in more detail in MSG-RMIB-GE-TN-0006, the resolution enhancement subsystem is described in more detail in MSG-RMIB-GE-TN-0003.

The organisation of the data flow between the different subsystems is described in more detail in MSG-RMIB-GE-TN-0009.

The output data products and the data distribution server are described in more detail in MSG-RMIB-GE-IF-0001.

# 2 Acronyms, abbreviations and definitions

## 2.1 Acronyms and abbreviations

Not all these acronyms may appear in this document.

| | |
|---|---|
| AD | Applicable Document |
| ADM | Angular Dependency Model |
| ASI | Agency Spatiale Italiano |
| BATS | Belgian Advanced Technology Systems |
| BB | Broad Band |
| BDRF | Bidirectional Reflection Function |
| CERES | Clouds and the Earth's Radiant Energy System |
| CNRS | Centre Nationale de la Recherche Scientifique |
| DCT | Discrete Cosine Transform |
| ERB | Earth Radiation Budget |
| ERBE | Earth Radiation Budget Experiment |
| EUMETSAT | EUropean organsiation for the exploitation of METeteorological SATellites |
| FTP | File Transfer Protocol |
| Gb | Gigabit |
| GB | GigaByte |
| GERB | Geostationary Earth Radiation Budget |
| GGSPS | GERB Ground Segment Processing System |
| GIST | GERB International Science Team |
| GKSS | GKSS research centre |
| HD | High Density |
| HDF | Hierarchical Data Format |
| HRIT | High Rate Information Transmission |
| ICD | Interface Control Document |
| ICSTM | Imperial College of Science Technology and Medicine |
| IFR | Instantaneous Filtered Radiance |
| kb | kilobit |
| kB | kiloByte |
| LARC | LAngley Research Centre (NASA) |
| LU | Leicester University |
| LOS | Line Of Sight |
| LW | Long Wave |
| Mb | Megabit |
| MB | MegaByte |
| NANRG | Non Averaged, Non Rectified, Geolocated |
| NB | Narrow Band |
| NERC | Natural Environment Research Council |
| OSTC | Office for Scientific, Technical and Cultural Affairs |

| | |
|---|---|
| PSF | Point Spread Function |
| qlt | quick look time |
| RAL | Rutherford Appleton Laboratory |
| RD | Reference Document |
| RMIB | Royal Meteorological Institute of Belgium |
| RGP | RMIB Gerb Processing |
| ROLSS | RMIB On Line Short term Services |
| ScaRaB | Scanning Radiometer for radiation Budget studies |
| SEVIRI | Spinning Enhanced Visible and InfraRed Imager |
| SOL | Start Of Line |
| SBDART | Santa Barbara Discrete ordinate Atmospheric Radiative Transfer see http://arm.mrcsb.com/sbdart |
| SW | Short Wave |
| TAR | Tape ARchive |
| TBC | To Be Confirmed |
| TBD | To Be Determined |
| TOA | Top Of Atmosphere |
| TRMM | Tropical Rainfall Measurement Mission |
| UKMO | United Kingdom Meteorological Office |
| VIRS | VIsible and InfraRed Scanner |
| wrt | with respect to |
| WWW | World Wide Web |

## 2.2 Definition of terms

**Autorised Users**

Authorised users will include RMIB, members of the GIST, GERB operations staff based at RAL, EUMETSAT and others. In order to become an Autorised user, users will be required to register with RMIB according to the rules established by the GERB Project Steering Group (TBC). Once the registration is approved the user will be able to obtain products from the ROLSS, and will be given their unique ROLSS account details, from which they will be able to get access to the products.

**near real time (or NRT or nrt)**

Between EUMETSAT and the GGSPS near real time means that the GGSPS at RAL will receive GERB data within 60 minutes (TBC) of the actual time at which the data was generated on board the GERB instrument.

**quick look time (or QLT or qlt)**

Between the GGSPS and RMIB, quick look time means that the RMIB will receive GERB data products within 4 hours of the actual time at which the corresponding data was generated on board the GERB instrument.

**short term**

Short term data usage refers to usage of the data within one month after their measurement.

**long term**

Long term data usage refers to usage of the data more than one month after their measurement.

**Reference Earth Ellipsoid**

(TBD)

**GERB data loss**

A GERB data loss is one for which the L1.5 radiances have not been obtained within the QLT.

**SEVIRI data loss**

A SEVIRI data loss is one for which the L1.5 SEVIRI images have not been received through the HRIT system within the QLT.

**climate data**

GERB climate data means the GERB products that are generated at RMIB for long term archival and data distribution at RAL.

**near real time data**

Near real data means the GERB products that are generated at RMIB and distributed for short term usage through the ROLSS server.

**ROLSS server**

The ROLSS server will be the RMIB based ftp server for near real time data distribution.

**near real time processing**

Near real time processing will be the processing that has to be done at RMIB as soon as a GERB or SEVIRI data file arrives.

**daily, weekly, monthly processing**

Daily, weekly, monthly processings will be the processings that have to be done at RMIB less frequently than the near real time processing, but that still need to be done on a regular basis.

**casual processing**

Casual processings will be those that have to be done at RMIB infrequently and irregularly, e.g. calibration table updates.

**solar**

Solar means relating to reflected solar radiation only.

**thermal**

Thermal means relating to emitted thermal radiation only

**short wave**

Short wave means radiation from the wavelengths below a cutoff wavelength of approximatively 4 micron.

**long wave**

Long wave means radiation from the wavelengths above a cutoff wavelength of approximatively 4 micron.

**total wave**

Total wave radiation means combined short wave and long wave radiation.

**unfiltered**

Unfiltered refers to a spectral integral of either solar or thermal radiation without spectral attenuation.

**'GERB filtered' or simply 'filtered'**

GERB filtered refers to a spectral integral, either over the short wave or over the long wave or over the total wave spectral interval, of radiation multiplied (filtered) with the GERB spectral response.

**imager resolution**

Imager resolution refers to SEVIRI pixel resolution

**high resolution**

HIgh resolution refers to 3 x 3 SEVIRI pixel resolution, this the highest resolution at which fluxes are derived

**GERB resolution**

GERB resolution refers to GERB footprint resolution

**SEVIRI based products**

SEVIRI based products refers to broadband radiance or flux estimates estimated from SEVIRI narrowband pixel data only.

**level 2 fluxes**

Level 2 fluxes refers to fluxes derived from combined GERB and SEVIRI data.

**spectral unfilter factor**

Ratio between the unfiltered broadband radiance and the filtered broad band radiance.

**angular conversion factor**

Ratio between the broad band flux and the unfiltered broad band radiance.

**correction factor of SEVIRI by GERB**

Ratio of the filtered broad band radiance measured by GERB and the same quantity model based on SEVIRI narrow band radiances.

# 3 RMIB GERB Processing Requirements

A RMIB GERB Processing system should be developed which is capable to

- receive level 1.5 NANRG GERB radiances from the RAL based GGSPS in near real time
- receive level 1.5 SEVIRI rectified radiance images - disseminated through the HRIT system -, and/or METEOSAT rectified radiance images in near real time
- make available the headers of the level 1.5 SEVIRI rectified images to the RAL based GGSPS
- produce GERB resolution and high resolution fluxes from the combined GERB and SEVIRI or METEOSAT radiance images in near real time
- make available GERB resolution fluxes to the RAL based GGSPS
- make available high resolution fluxes for near real time users

# 4 Processing Overview

The overall RMIB GERB processing system has two sets of input data coming from two different paths (see figure 1): the NANRG Level 1.5 GERB data from RAL through the Internet and the rectified Level 1.5 SEVIRI data received at the RMIB from EUMETSAT through the HRIT system. Two kinds of output products are made available by ftp to users: the climate data and the near real time data. Both are 15 minutes products. The near real time products must be available every 15 minutes so that they can be used in weather monitoring or forecasting programs. The climate data is made available for ftp pickup by RAL on a monthly basis. The near real time data is distributed through the Internet, using the ROLSS ftp server.

The climate data is obtained at GERB footprint spatial resolution (nominally 50 km x 50 km at nadir). The near real time data will be obtained at two spatial resolutions: at GERB footprint spatial resolution and at 3 x 3 SEVIRI pixel resolution (nominally 9 km x 9 km at nadir).

The processing that must be done as soon as the data arrives will be called near real time processing. But there are also some parts of the image processing that must be realized - not in near real time - for determination of slowly changing parameters and values. These processings are called daily, weekly, monthly processing if they occur daily, weekly, monthly. If the occurrence of a processing is not programmed in a repetitive way it is called casual processing. This is the case for some calibration parameters that are updated in flight.

## 4.1 Data Acquisition

Rectified images from 12 spectral bands are received from EUMETSAT each 15 minutes. They are:

| Name | Spectral range ($\mu$m) |
|---|---|
| HRV | 0,6-0,9 |
| VIS 0.6 | 0,56-0,71 |
| VIS 0.8 | 0,74-0,88 |
| IR 1.6 | 1,50-1,78 |
| IR 3.9 | 3,40-4,20 |
| IR 6.2 | 5,35-7,15 |
| IR 7.3 | 6,85-7,85 |
| IR 8.7 | 8,30-9,10 |
| IR 9.7 | 9,38-9,94 |
| IR 10.8 | 9,80-11,80 |
| IR 12 | 11,00-13,00 |
| IR 13.4 | 12,40-14,40 |

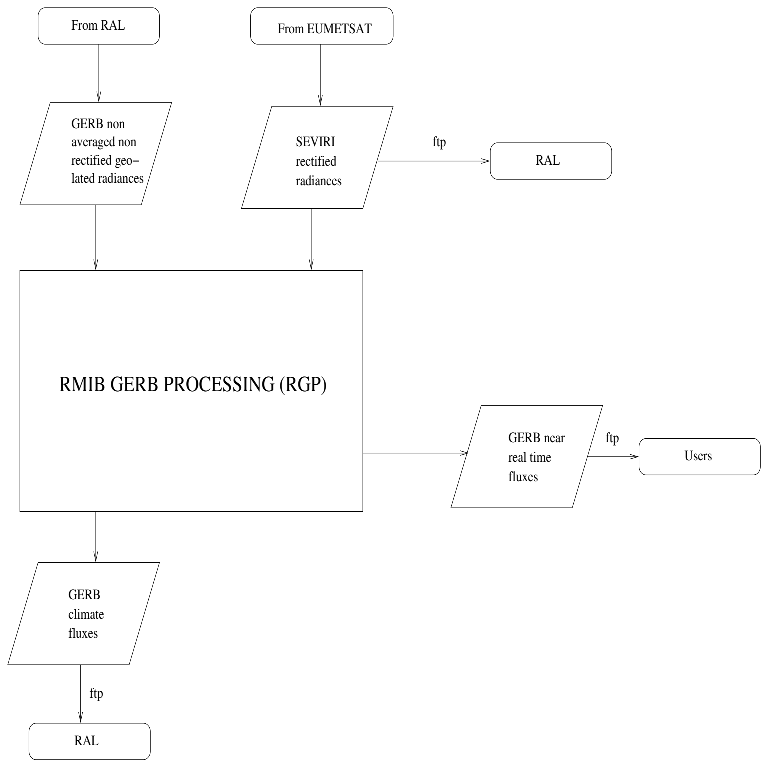


Figure 1: Interfaces of RMIB GERB Processing (RGP)

The images HRV, VIS 0.6, VIS 0.8 and IR 1.6 are in the spectral range of the sun. We will call them solar band images. IR 3.9 is in an intermediate window. The 7 last ones, IR 6.2 to IR 13.4, will be called thermal images since the measured radiation comes from thermal emission by the earth and the atmosphere.

## 4.2 Division into subsystems

The RMIB part of the GERB ground segment consists in total of three subsytems: 'RMIB SEVIRI procesing', 'RMIB GERB processing' and 'Resolution enhancement', to be executed in sequential order. See also figure 2.

The subsystem 'RGP SEVIRI Processing' has as input full resolution SEVIRI spectrally narrowband radiances and as output SEVIRI pixel resolution filtered radiance estimates and broadband unfiltered radiance and flux estimates. Those outputs are referred to as 'high resolution SEVIRI based products'.

The subsystem 'RGP GERB Processing' has as input the GERB measured filtered broadband radiances as well as the high resolution SEVIRI based products, and as output GERB broadband unfiltered fluxes. Those outputs are referred to as 'level 2 GERB resolution fluxes'.

The subsystem 'Resolution enhancement' has as input the high resolution SEVIRI based flux estimates and the level 2 GERB resolution fluxes and as output fluxes at 3 x 3 SEVIRI pixel resolution that are compatible with the level 2 GERB resolution fluxes. Those outputs are referred to as 'level 2 high resolution fluxes'. In a following section a brief description of the function of the subsystems is given. In order to situate these functions, first an overview of the general methodology is given.

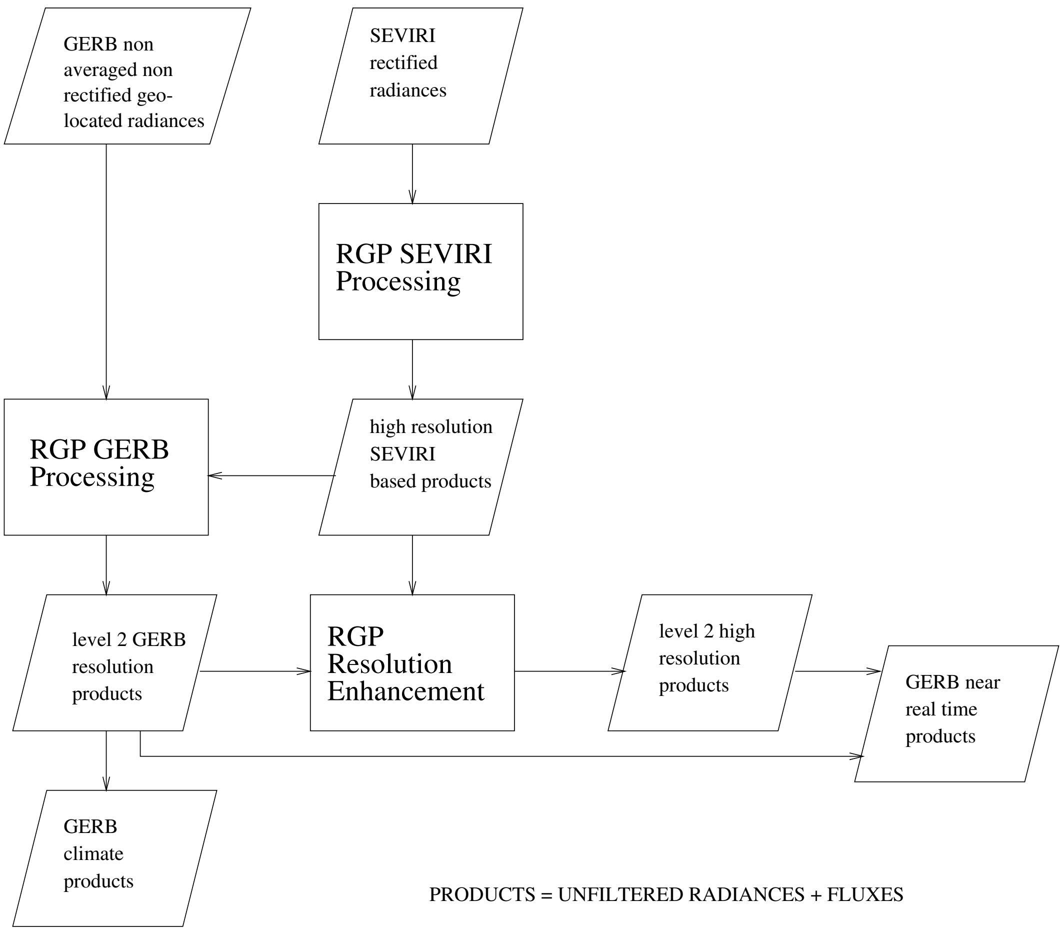


Figure 2: Division into susbsystems of the RMIB GERB Processing. The three blocks 'RGP SEVIRI Processing', 'RGP GERB Processing' and 'RGP Resolution Enhancement' are executed in sequential order.

# 5 General methodology

## 5.1 Inheritance of previous ERB missions

The estimation of reflected solar and emitted thermal fluxes from single satellite broadband radiance measurements has been done previously for the ERBE, ScaRaB and CERES missions. Experience has learned that the following processing steps are required to obtain flux estimates from the raw satellite measurements:

- The calibration of the broadband radiances. Usually a 'total' radiance is measured in the spectral range 0-50 micron and a 'shortwave' radiance is measured in the spectral range 0-4 micron. The measured radiances are referred to as *filtered radiances* $L^f$.

  For the GERB instrument, the calibration of the broad band radiances will be performed at RAL.

- Separation of the reflected solar and the emitted thermal radiances. A synthetic 'longwave' radiance is usually computed by subtraction of the shortwave from the total radiance. Approximatively, the shortwave radiance can be associated with the reflected solar radiance and the longwave radiance can be associated with the emitted thermal radiance. The approximation consists in neglecting the solar contribution to the longwave radiance and the thermal contribution to the shortwave radiance.

- The removal of the effects of the non flat spectral responses of the shortwave and the synthetic longwave channel. This involves a modelling of the spectral distribution of the observed radiation. The estimated radiance that would be measured with an ideally flat spectral response is referred to as the *unfiltered radiance* $L^{uf}$. The ratio $\frac{L^{uf}}{L^f}$ is referred to as the *unfilter factor*.

- The estimation of the fluxes from the observed radiances. This involves the modelling of the angular distribution of the observed radiation. This results in the estimation of a *flux* $F$. The ratio $\frac{F}{L^{uf}}$ is referred to as the *angular conversion factor*.

  The angular conversion factor depends on the viewing angles and the surface type along which the radiance is observed. For the GERB instrument, the angular conversion factor will be different for each footprint.

Errors made in these steps contribute to the errors made in the instantaneous flux estimation. Usually errors made in the last step, which result in angular and scene type dependent errors, dominate.

In order to obtain the best possible quality of the resulting flux estimate, the best possible Angular Dependency Model (ADM) has to be used to convert the radiances to fluxes in the last step. Currently it is foreseen that the best possible ADM's available for the processing of GERB data will be the ADM's derived from the CERES instrument on the TRMM satellite, using the VIRS imager for scene identification.

## 5.2 Unfiltering and angular conversion methodology

Maximally accurate flux estimates are obtained from a combination of GERB and SEVIRI data. GERB provides accurate broad band measurements. SEVIRI provides good scene identification, which forms a *necessary condition* for appropriate ADM selection. A rational way to obtain the best combined estimate of the broad band flux $F_{GERB/SEVIRI}$ is given by equation 1. The term "unfiltered" is used to refer to an ideal broad band measurement, obtained with a flat spectral response.

$$F_{GERB/SEVIRI} = \frac{F_{SEVIRI} L^f_{GERB}}{L^f_{SEVIRI}} \tag{1}$$

$L^f_{GERB}$ is the basic filtered broad band GERB radiance measurement. The term "filtered" is used to refer to filtering by the actual GERB spectral response, which is not perfectly flat. $L^f_{SEVIRI}$ is the *estimate* of the filtered broad band GERB measurement, estimated from the SEVIRI spectral radiances only. $F_{SEVIRI}$ is the corresponding estimate of the unfiltered broad band flux, estimated from the SEVIRI spectral radiances only.

Equation 1 can be interpreted in two, strictly equivalent, ways:

- The GERB broad band radiance measurement $L^f_{GERB}$ is converted to a broad band unfiltered flux by multiplication with the SEVIRI derived unfiltering and angular conversion factor $\frac{F_{SEVIRI}}{L^f_{SEVIRI}}$. This unfiltering and angular conversion factor is the product of a SEVIRI derived unfiltering factor $\frac{L^{uf}_{SEVIRI}}{L^f_{SEVIRI}}$ and a SEVIRI derived angular conversion factor $\frac{F_{SEVIRI}}{L^{uf}_{SEVIRI}}$ .
- The SEVIRI estimated broad band flux $F_{SEVIRI}$ is corrected by the factor $\frac{L^f_{GERB}}{L^f_{SEVIRI}}$, which corrects the SEVIRI based spectral modelling by the GERB measurement.

## 5.3 Contributions of the reflected solar and emitted thermal radiation to the filtered radiances

From the SEVIRI thermal images the contributions of the emitted thermal radiation to both the filtered SW radiance and the filtered synthetic LW radiance are modelled.

Separately, from the SEVIRI solar band images the contributions of the reflected solar radiation to both filtered radiances can be calculated.

The SEVIRI estimated filtered SW radiance $L^f_{SW,SEVIRI}$ is calculated as the sum of the reflected solar contribution $L^f_{SW,sol,SEVIRI}$ and the emitted thermal contribution $L^f_{SW,th,SEVIRI}$.

$$L^f_{SW,SEVIRI} = L^f_{SW,sol,SEVIRI} + L^f_{SW,th,SEVIRI} \tag{2}$$

The SEVIRI estimated filtered LW radiance $L^f_{LW,SEVIRI}$ is calculated as the sum of the emitted thermal contribution $L^f_{LW,th,SEVIRI}$ and the reflected solar contribution $L^f_{LW,sol,SEVIRI}$.

$$L^f_{LW,SEVIRI} = L^f_{LW,th,SEVIRI} + L^f_{LW,sol,SEVIRI} \tag{3}$$

$L^f_{SW,th,SEVIRI}$ and $L^f_{LW,sol,SEVIRI}$ are small quantities.

## 5.4 GERB/SEVIRI coregistration

$L^f_{SEVIRI}$ and $F^{uf}_{SEVIRI}$ are calculated for every 3x3 SEVIRI pixels square (nominal resolution at nadir: 9 km), i.e. at high resolution compared to the GERB pixel (nominal resolution at nadir: 50 km). They are separately integrated over the GERB pixel, by convolution with the GERB pixel Point Spread Function (PSF).

$$\begin{array}{l} L^f_{SEVIRI}(x_G, y_G, t) = \int PSF_{(x_G,y_G)}(x_S, y_S) L^f_{SEVIRI}(x_S, y_S, t) dx_S dy_S \\ F_{SEVIRI}(x_G, y_G, t) = \int PSF_{(x_G,y_G)}(x_S, y_S) F_{SEVIRI}(x_S, y_S, t) dx_S dy_S \end{array} \tag{4}$$

$(x_G, y_G)$ are the spatial coordinates of a GERB pixel, $(x_S, y_S)$ are the spatial coordinates of a SEVIRI pixel. $t$ is the time.

The SEVIRI and the GERB images are taken at different times. To obtain an estimate at a GERB acquisition time $t = t_G$, from SEVIRI images at SEVIRI acquisition times $t = t_S$, a time interpolation is necessary.

$$\begin{array}{l} L^f_{SEVIRI}(x_G, y_G, t_G) = \sum_{t_S} I(t_G, t_S) L^f_{SEVIRI}(x_G, y_G, t_S) \\ F_{SEVIRI}(x_G, y_G, t_G) = \sum_{t_S} I(t_G, t_S) F_{SEVIRI}(x_G, y_G, t_S) \end{array} \tag{5}$$

$I(t_G, t_S)$ are the time interpolation weights.

Equation 1 is applied at the GERB footprint level. The used $L^f_{SEVIRI}$ and $F_{SEVIRI}$ are the values obtained after the PSF convolution (equation 4) and time interpolation (equation 5) of the values of $L^f_{SEVIRI}$ and $F_{SEVIRI}$ at SEVIRI pixel level.

## 5.5 Correction of SEVIRI by GERB

The second interpretation of equation 1 shows that the SEVIRI modelled broad band filtered radiance is corrected by the GERB measurement of the filtered radiance (see section 5.2). At the GERB footprint level a *correction factor of SEVIRI by GERB*, $c(x_G, y_G, t_G)$, can be defined.

$$c(x_G, y_G, t_G) = \frac{L^f_{GERB}}{L^f_{SEVIRI}(x_G, y_G, t_G)} \tag{6}$$

This correction factor can be spatially interpolated to produce correction factors $c(x_S, y_S, t_G)$ at SEVIRI spatial resolution.

$$c(x_S, y_S, t_G) = \sum_{(x_G,y_G)} I(x_S, y_S, x_G, y_G)c(x_G, y_G, t_G) \tag{7}$$

$I(x_S, y_S, x_G, y_G)$ is the spatial interpolation function.

Equation 1 can now be extended for flux estimates at *SEVIRI spatial resolution*:

$$F_{GERB/SEVIRI}(x_S, y_S, t_G) = F_{SEVIRI}(x_S, y_S, t_G)c(x_S, y_S, t_G) \tag{8}$$

The same correction factors are applied to the unfiltered radiance estimates, if those are a wanted output quantity.

$$L^{uf}_{GERB/SEVIRI}(x_S, y_S, t_G) = L^{uf}_{SEVIRI}(x_S, y_S, t_G)c(x_S, y_S, t_G) \tag{9}$$

It is usefull to have those unfiltered radiances for validation purposes, e.g. for comparison of GERB and CERES unfiltered radiances.

## 5.6 Temporal averaging

The signal to noise ratio of single GERB radiance measurements is not sufficient to meet the science requirements [DA]. Averages of three consecutive GERB measurements have to be taken. These averages are taken for the *output* fluxes.

For the GERB resolution output product, an average over three consecutive GERB pixels is taken. Before the time interpolation, a rectification on a standard grid is done:

$$F_{GERB/SEVIRI}(x^R_G, y^R_G, t_G) = \sum_{x_G,y_G} g(x^R_G, y^R_G, x_G, y_G)F_{GERB/SEVIRI}(x_G, y_G, t_G) \tag{10}$$

$$F_{GERB/SEVIRI}(x^R_G, y^R_G, \bar{t}_G) = \frac{1}{3}\sum_{t_G} F_{GERB/SEVIRI}(x^R_G, y^R_G, t_G) \tag{11}$$

For the SEVIRI resolution output product, only the correction factors $c(x_S, y_S, t_G)$ are averaged. The result is a 'snapshot' flux at the SEVIRI acquisition time $t_S$ instead of a real average flux[1].

$$F_{GERB/SEVIRI}(x_S, y_S, t_S) = F_{SEVIRI}(x_S, y_S, t_S)\frac{1}{3}\sum_{t_G} w(t_S, t_G)c(x_S, y_S, t_G) \tag{12}$$

The average of the correction factor is calculated for a 15 minute interval centered on the SEVIRI acquisition time $t_S$. $w(t_S, t_G)$ is the associated weighting function.

[1] In order to avoid spatial discontinuities that would be visible at high resolution, time interpolation of $F_{SEVIRI}(x_S, y_S, t_S)$ should be avoided.

Snapshot high resolution unfiltered radiances can be obtained similarly as the snapshot high resolution fluxes.

$$L^{uf}_{GERB/SEVIRI}(x_S, y_S, t_S) = L^{uf}_{SEVIRI}(x_S, y_S, t_S)\frac{1}{3}\sum_{t_G} w(t_S, t_G)c(x_S, y_S, t_G) \tag{13}$$

# 6 Processing subsystem description

## 6.1 SEVIRI Processing

In this subsystem the spectral modelling, as well as the scene identification and the associated angular modelling will be done on the basis of SEVIRI data.

The inputs for this subsystem are the SEVIRI images.

The spectral modelling consists in obtaining the estimate of the broad band filtered radiance $L^f_{SEVIRI}(x_S, y_S, t_S)$ and of the unfilter factor $\frac{L^{uf}_{SEVIRI}(x_S,y_S,t_S)}{L^f_{SEVIRI}(x_S,y_S,t_S)}$. The spectral modelling as well as the longwave angular modelling will be based on plane parallel radiative transfer modelling. The SBDART radiative transfer tool is used.

The angular modelling consists in modelling the angular conversion factor $\frac{F_{SEVIRI}(x_S,y_S,t_S)}{L^{uf}_{SEVIRI}(x_S,y_S,t_S)}$.

For the shortwave angular modelling, the ADM's derived from the CERES/VIRS combination on TRMM will be used. Cloud optical properties will be derived from every SEVIRI pixel, with resolution at nadir of 3 km, comparable with the determination of cloud optical properties from every VIRS pixel on TRMM, with resolution at nadir of 2 km. For cloudy scenes the ADM's will be applied over windows of 3x3 SEVIRI pixels, which have a similar spatial resolution - around 10 km at nadir - as the CERES broadband radiometer on TRMM.

The outputs of this subsystem are SEVIRI based estimates of the GERB filtered radiances, the unfiltered radiances, as well as the unfiltered broadband fluxes at SEVIRI pixel resolution. Thus the outputs are images of $L^f_{SEVIRI}(x_S, y_S, t_S)$, $L^{uf}_{SEVIRI}(x_S, y_S, t_S)$ and $F_{SEVIRI}(x_S, y_S, t_S)$.

In this subsystem all the *physical scene modelling* is concentrated.

## 6.2 GERB Processing

In this subsystem, GERB broad band radiance measurements are combined with SEVIRI based models.

The inputs for this subsystem are the images of the GERB radiances $L^f_{GERB}(x_G, y_G, t_G)$ and the images of the SEVIRI based estimates of these radiances $L^f_{SEVIRI}(x_S, y_S, t_S)$ and of the fluxes $F_{SEVIRI}(x_S, y_S, t_S)$.

The GERB processing compares the SEVIRI based estimate of the GERB filtered broad band radiances and the GERB measured filtered broad band radiances. The GERB measurements are used to "calibrate" the SEVIRI based filtered radiance estimates. The result is a set of spectral correction factors at GERB spatial resolution. Those correction factors are applied to the SEVIRI based flux estimates to produce level 2 fluxes.

The outputs for this subsytem are the images of the correction factors $c(x_G, y_G, t_G) = \frac{L^f_{GERB}}{L^f_{SEVIRI}(x_G,y_G,t_G)}$ at GERB footprint level and of the level 2 15 minute mean fluxes $F_{GERB/SEVIRI}(\overline{x}_G, \overline{y}_G, \overline{t}_G)$ at GERB footprint resolution.

In this subsystem all the *GERB-SEVIRI coregistration* is concentrated.

## 6.3 Resolution Enhancement

In this subsystem, the resolution of the level 2 fluxes is improved by use of SEVIRI high resolution information.

The inputs for this subsystem are the correction factors at GERB spatial resolution $c(x_G, y_G, t_G) = \frac{L^f_{GERB}}{L^f_{SEVIRI}(x_G, y_G, t_G)}$ and the high resolution SEVIRI based estimates of the unfiltered radiance $L^{uf}_{SEVIRI}(x_S, y_S, t_S)$ and of the flux $F_{SEVIRI}(x_S, y_S, t_S)$ .

To apply the correction factors - found in the GERB processing - at SEVIRI spatial resolution an upsampling is realised. The upsampled correction factors are applied on images at SEVIRI resolution.

The outputs for this subsytem are the level 2 15 minute snapshot high resolution fluxes $F_{GERB/SEVIRI}(x_S, y_S, t_S)$ and unfiltered radiances $L^{uf}_{GERB/SEVIRI}(x_S, y_S, t_S)$.

In this subsytem all the *resolution enhancement of GERB by SEVIRI* is concentrated.

# 7 Work Organisation

Several persons will work in parallel. A standardization of the work is essential in order to avoid to duplicate work. The use of a library where the functions will be archived is a good practice. Two possibilities are available. The first one is the creation of a specific library for the application starting from the existing one. There is an other option: the use of a general library[2] that will be a base for function development. This library is also available with the source. This solution is clearly the best one if several different applications will be implemented using the same basic processing. An other advantage is if standard processing (e.g. functions from Numerical Recipes) is needed they are already implemented and debugged as the data structures to use them. Nevertheless the management is clearly heavier and the programmers must adhere to the philosophy. The advantage of the specific library is that it is fitted to the work already done.

The availability of the source code is also an important point. The library must have been written by scientists and not by software engineers because they can have very different views of what is important.

The developpers will tried to develop reusable software following the philosophy of the BATS library.

The following paragraphs can be considered as requirements of the implementation.

## 7.1 Language

The choosen language is C. The C++ has been rejected because of the lack of standard[3] and reliability. The programs in C are generally quicker but this seems not to be a feature of C but depends on specific writing style and on less optimised compilers. Nevertheless some C++ features are clearly slowing down the speed (e.g. overloading) because they add additionnal steps at execution time. The overall slowing down is quite complex to estimate and this estimation is outside the scope of the project.

Futhermore it will be avoided to use script languages since their implementation depends on the system.

## 7.2 Documentation

The programs are documented at two levels. A description of the algorithmic/scientific solution and the program description including a user manual. If a program is incorrectly used, a simple help has to be displayed.

Each function is documented with the following information: name of the function, parameters, description, author, version and history. Similar documentation is done for the "define"s and the structures.

[2]The BATS library is a C library of mathematical, signal, image processing and pattern recognition functions.

[3]There is an ANSI standard but many of the features are still in discussion and C++ compilers do not support exactly the same features. Since we prefer to postpone the purchase of the final computer, we need to be as portable as possible and C is a best choice.

## 7.3 Portability

All of the programs should be UNIX compliant (run on any UNIX). This task is clearly impossible. So ANSI C will be used and script languages (shell, perl, tcl/tk, ...) will be avoided in order to minise the adaptation to other UNIX.

## 7.4 Software Tools

No recommendation for software tools is given. Nevertheless latex and its GUI lyx and klyx has shown to be very productive. Also the use of GNU software is encouraged as they have shown to be more reliable in the long term and less subject to incoherent commercial upgrades.

## 7.5 Reliability

The reliability is of major concern for this project. Every application must be tested extensively. No test procedure will be defined because it seems too heavy to define and to manage. The test procedure of each part will be implicitly the documentation of this part. In other words, what is write on the documentation is what has been implemented and tested. This is not trivial if the software developpement is done with a classical procedure: requirements before implementation and then testing.

Since the aim of the project is to shown the usefulness of the GERB data, scientific issues are of first concern. Interruption of the process will be acceptable for scientific reasons. The requirements of ğ7 of document [GGS][4] will be followed on a best effort basis.

## 7.6 Version Control

Version control softwares as RCS will not be used. They are hard to manage for nearly no backtracking needed. The function documentation is the implicit version control. Futhermore we have several utilities that permit to compare huge amount of source in an automatic way. When a new version is available, a back-up of the sources will be done. The version of the programs will be related to the compilation time that must correspond to the back-up time. The estimated size of the source is less than 5 MBytes in compressed format. So even if with a modification every day, this size is negligeable in comparison to the data images (several GBytes per day).

## 7.7 Optimization

The time to process all the data is limited. The program optimization can be done in two ways: exact optimization and non-exact optimization. Non-exact optimization changes the results of the program but in an acceptable way. Starting from a code written without the processing time taken as a design goal, exact optimization can improve the time by a factor of 6 and non-exact by a factor of 20.

## 7.8 Data Flow

There are two sets of data coming from two different paths: the GERB data from RAL by Internet or ISDN connection and the SEVIRI data furnished by the electronic laboratory of the RMIB which receives the data from EUMETSAT. The transmission will be done through an ethernet connection. A new set of data is available each 15 minutes. Then the complete processing time can not be greater than 15 minutes but the processing is near real-time. So the time between the

[4]"The purpose of GERB ground system is to deliver products to scientists. It is not an operational system and does not aim to be 100% reliable in as much as the failure of a computer or a network connection may result in the delay in the availability of some data products. However, it does aim to be completely reliable in that any GERB data that is received by EUMETSAT will eventually result in the corresponding processed data being placed in the GERB archive, if the relevant SEVIRI data are also available."

data arrival and the product availability is not of major concern. Nevertheless it has to be inferior to 15 minutes.

### 7.9 Log and error tracking

(see [DF])

### 7.10 Operator User Interface

No user interface will be developped for the operator. The UNIX style of developement will be applied: command line programs and if a user interface seems necessary, it will only be an interface to the command line programs. Furthermore modifications of the programs for user interface requirements will be avoided.

## References

[DF] “RMIB GERB Processing: Data Flow”, L. Gonzalez, MSG-RMIB-GE-TN-0009

[GGS] “The GERB Ground Segment Concept”; P. Allan, MSG-RAL-GE-PL-0019

[SD] “Local Instantaneous Radiation Budget, Measured from Geostationary and Polar Satellites”, Steven Dewitte, 1997, PhD.

[DA] “RMIB GERB Processing: Data products accuracy estimation”, S. Dewitte, MSG_RMIB-GE-TN-0011