THE GERB GROUND SEGMENT PROCESSING SYSTEM (GGSPS)

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ABSTRACT

The first Geostationary Earth Radiation Budget (GERB) experiment was launched on the Meteosat Second Generation (MSG-1) satellite in August 2002. GERB exists to make high accuracy measurements from geostationary orbit of the outgoing components of the Earth radiation budget at high temporal resolution. GERB has undergone commissioning starting in December 2002, and is now operational.

The GERB Ground Segment is distributed between EUMETSAT, the Rutherford Appleton Laboratory (RAL), the Royal Meteorological Institute of Belgium (RMIB) and Imperial College. RAL designed and operates the GERB Ground Segment Processing System (GGSPS), which generates Level 1.5 filtered radiance products from raw data, whilst the RMIB system performs higher level processing to generate Level 2 fluxes. Both processing systems operate in near real time, generating products within four hours of data acquisition. It is planned that the GGSPS will also generate monthly means from the Level 2 fluxes. The GGSPS maintains a long-term archive of products at all levels; registered users will be able to access GERB data products via the GGSPS web pages and catalogue search tool.

Here we describe the design and implementation of the RAL GGSPS, experience of operating the GGSPS system over the first year of GERB and MSG commissioning and operations, and plans for data release and user access to GERB data.

1. THE GERB INSTRUMENT

The GERB instrument uses a columnar (N-S) detector of 256 pixels and a three-mirror anastigmatic telescope to view the Earth. Since MSG is a spin-stabilised satellite, rotating at approximately 100 rpm, a de-spin scan mirror is needed to steady the image for the 40 milliseconds required for each Earth view reading.

One column of an Earth view image is acquired on each rotation of MSG (i.e. one column every 0.6 s). One scan of the Earth is built up from 282 columns, in just over 2.5 minutes. The E-W position of each column is stepped 0.07° by adjusting the phase of the scan mirror relative to the MSG rotation, building up a complete 18° image over the scan. Alternate scans are either SW (filter in) or TOTAL channel (filter out).

Three consecutive scans in each channel are averaged to achieve the required signal to noise (i.e. one product in each channel every 15 minutes).

2. OVERVIEW OF GERB OPERATIONS AND DATA PROCESSING

The GERB Ground Segment is distributed between EUMETSAT, the Rutherford Appleton Laboratory (RAL) the Royal Meteorological Institute of Belgium (RMIB) and Imperial College. Figure 1 illustrates the data flows in the distributed ground segment.

All communication with the GERB instrument is handled via the EUMETSAT Mission Control Centre at Darmstadt, Germany. The UK and Belgium are responsible for GERB operations and data processing.

GERB raw data are transmitted from the MCC to the RAL GERB Ground Segment Processing System (GGSPS), which archives the raw data and performs a first stage of processing to generate Level 1.5 filtered radiance products.

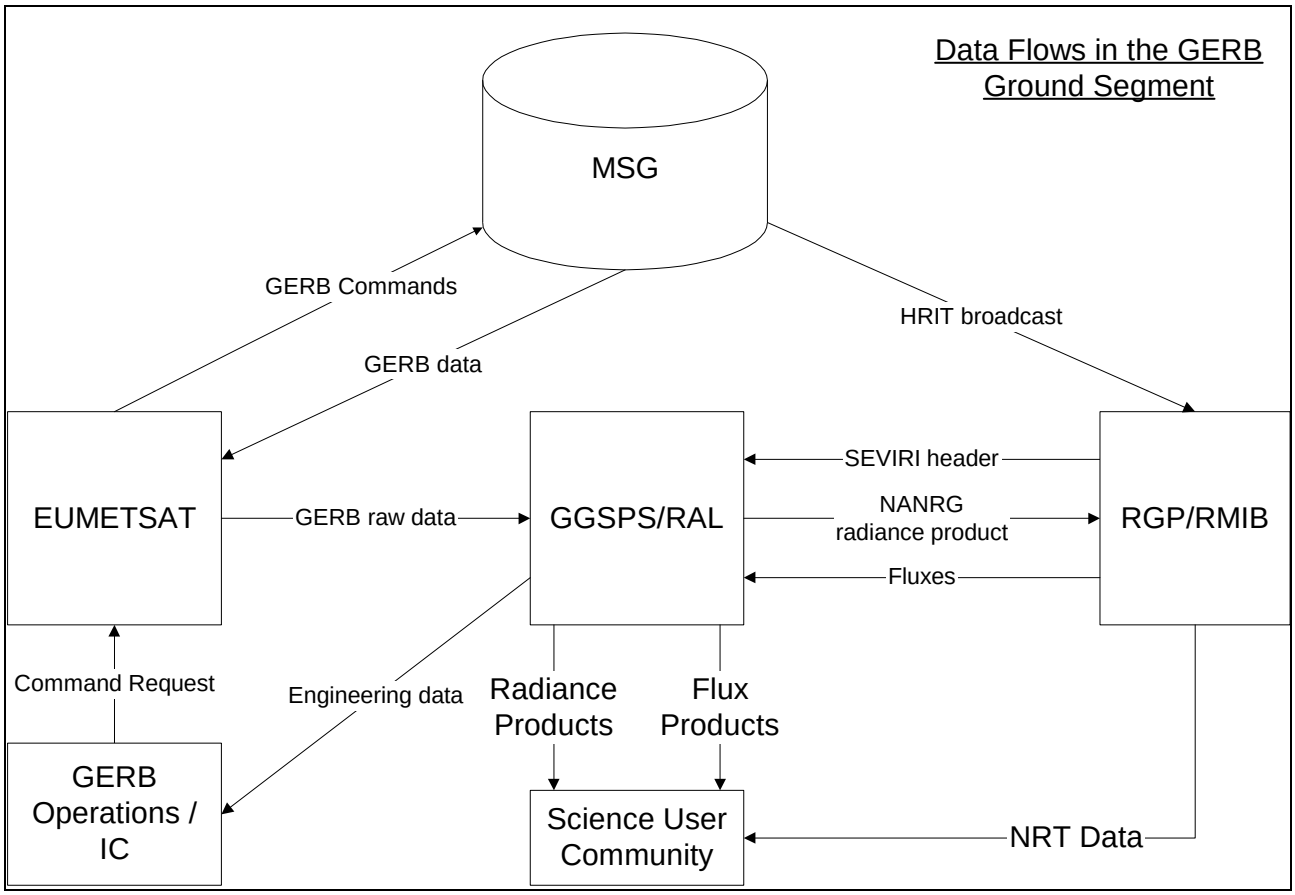

Figure 1: Overview of data flows in the distributed GERB ground segment.

The filtered radiance products are transmitted to the RMIB GERB Processing System (RGP) at the Royal Meteorological Institute of Belgium. Here the GERB images are combined with SEVIRI images in a second stage of processing, to generate flux products. The processing is carried out in quick look time, such that data products are available within four hours of generation by the GERB instrument: the GGSPS typically generates its Level 1.5 products within 30 minutes of measurement by GERB.

Scientists can obtain the GERB data products from archives maintained at the respective institutes. The data archive at RMIB is a rolling archive, so selected flux products generated by the RGP are also archived long-term by the GGSPS.

An operations team at Imperial College (IC) monitors raw and processed engineering data supplied by the GGSPS to check the performance of the GERB instrument. They can issue commands to the GERB instrument via the EUMETSAT MCC.

3. THE RAL GERB GROUND SEGMENT PROCESSING SYSTEM (GGSPS)

The GGSPS is required to archive incoming GERB data, process this data to filtered radiance products, and maintain an archive of GERB products for GERB scientists. The GGSPS is divided into several logically separate sub-systems, identified by functional decomposition in the software requirements phase of the system design. The principal sub-systems involved in the near-real time processing of GERB raw data to Level 1.5 are shown in Figure 2 and described below.

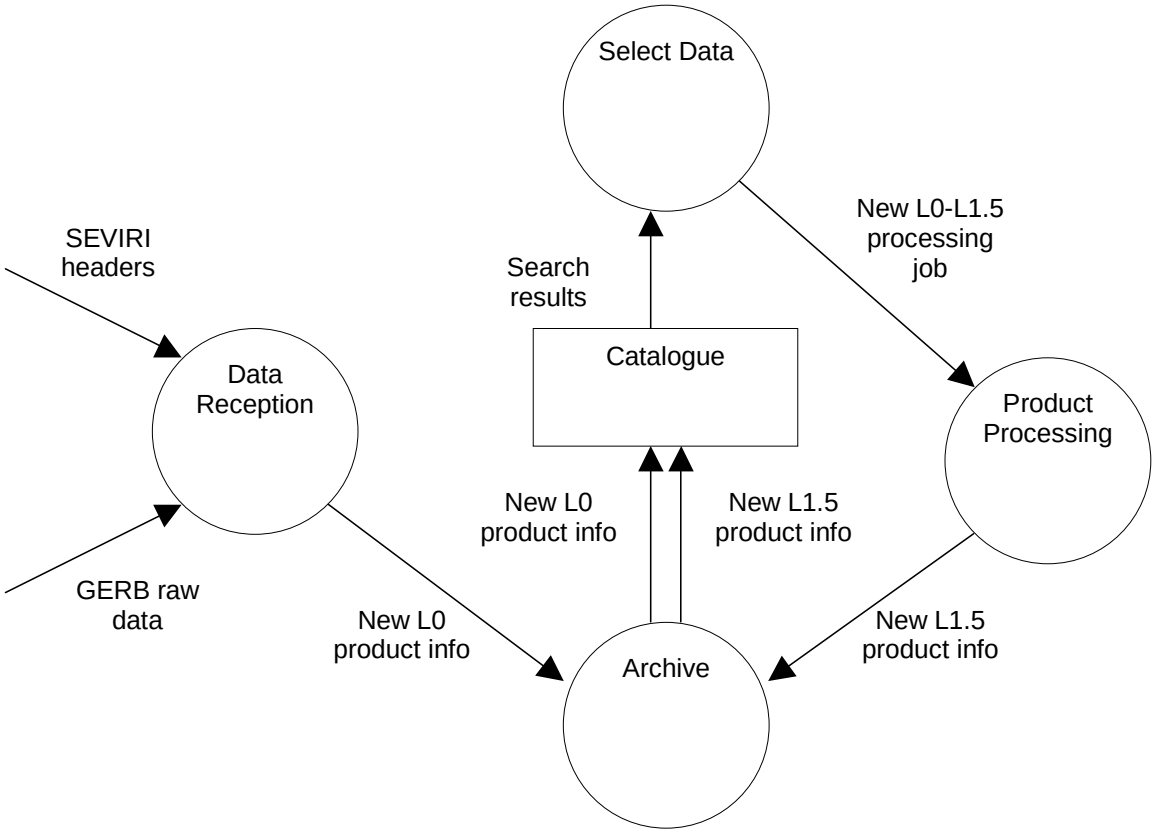

Figure 2: GGSPS near-real time processing (simplified view).

The software is implemented in C/C++ under Tru 64 UNIX, making use of the existing standard UNIX library tools where possible.

Data Reception handles incoming GERB raw data and other data from external sources, such as the SEVIRI headers required for Level 1.5 processing and sent from RMIB. GERB raw data are transferred from EUMETSAT over a standard TCP/IP connection, held open constantly by Data Reception.

Archive maintains a disk archive of all incoming data and generated products, and also maintains a catalogue of these data. The GGSPS Catalogue is an INGRES database (a commercial database management system). Every data product archived by the GGSPS has an entry in the catalogue. The catalogue is used by the GGSPS software to locate data and track processing, and provides users with the ability to select data for download.

Select Data for Processing uses information from the catalogue to identify new groups of input data to be processed. Product Processing processes input data to generate higher-level data products.

There are several additional sub-systems not shown in the figure, such as Process User Requests, which is responsible for handling catalogue queries and product requests from users.

The GGSPS is a near-real time system, driven by data and asynchronous messages. It is designed to run continuously, unattended. Messages are passed between software components using the UNIX Inter-Process Communication and Synchronization libraries, enabling fast, efficient, asynchronous NRT processing.

4. OPERATIONS, PROBLEMS AND LESSONS LEARNED

In development, the GGSPS software was tested with simulated data and with the small quantities of real GERB data available from ground tests. The transition from testing to commissioning and operation of the GGSPS with large quantities of real GERB data revealed several problems, as would be expected with any software system. An additional difficulty was created by incompleteness of the processing system following suspension of development work due to the MSG launch delay, and a late re-start. Although the core, near-real time processing functionality was available at launch, the nature of the instrument commissioning period placed more pressure on the system and its operators than is experienced in routine operations, resulting in a high initial rate of problem detection. During commissioning, the GGSPS supported operation of the instrument in unusual modes, as well as coping with changes made to the planned modes of instrument operation in the light of experience.

Early in operations of the instrument it became apparent that the software team's understanding of the instrument's behaviour when changing modes was insufficient, resulting in some short periods (of the order of a few seconds) of lost housekeeping data.

Problems in handling data from instrument calibration modes with unusually long scans could have been revealed before launch, had the system been tested with a wider range of realistic data.

Once large amounts of data (over a year) were present in the system, problems with the catalogue database began to emerge. Given the large amounts of data involved it is unlikely that such problems could have been detected pre-launch.

The GGSPS relies on the use of ancillary data from SEVIRI product headers for its Level 1.5 processing. These headers are stripped off the SEVIRI broadcast products and transferred to the GGSPS by the RMIB processing system. During MSG commissioning no SEVIRI broadcast data was available, and a temporary, alternative means of ingest of the required ancillary data had to be implemented.

In general, the performance and availability of the leased network line between RAL and EUMETSAT have been sufficient for the purpose. However, some problems have been experienced, and tracing outages has occasionally proved to be difficult due to the number of different organisations involved in the provision and support of an international line.

As these and other problems are solved, the development team find new, lower-level problems. However the system is running well and has operated for periods of several weeks without intervention.

5. LEVEL 1.5 PROCESSING

Processing the GERB data to Level 1.5 involves calibration, geolocation, rectification and averaging. In the calibration step, the GGSPS software converts pixel counts to filtered radiances. The GGSPS level 1.5 processing continuously updates the ground calibration measured at Imperial College. Gains and offsets are recalculated using data from an internal warm black body, viewed every rotation (0.6 s), and from views of deep space obtained at the beginning and end of each Earth scan (i.e. every 2.5 minutes).

Geolocation is the process of assigning a longitude and latitude to each pixel in the GERB image. The GGSPS uses satellite position, alignment and timing information to determine where the GERB line of sight intersects the Earth.

Rectification involves two steps: (1) correcting the perspective of the image to be as seen from an idealised satellite position, rather than from its actual position; (2) interpolating these corrected measured positions onto idealised grid points.

In a final step, the three images in each channel are also time-averaged to produce one 15-minute image in each channel.

6. DATA PRODUCTS

The end-user products generated by the GGSPS are the Level 1.5 NANRG and ARG products. In addition the GGSPS maintains a long-term archive of selected Level 2 flux products generated by RMIB. It is also planned to produce monthly averages of Level 2 fluxes.

Level 1.5 radiance products

L1.5 NANRG – Non-Averaged, Non-Rectified, Geolocated. The L1.5 NANRG product contains instantaneous filtered radiances from 3 SW and 3 TOTAL scans. This product forms the basis for RMIB's L2 processing.

L1.5 ARG – Averaged, Rectified, Geolocated. The L1.5 ARG product contains rectified averages of filtered radiances from 3 SW and 3 TOTAL scans. Averaging over 3 scans gives the required signal to noise.

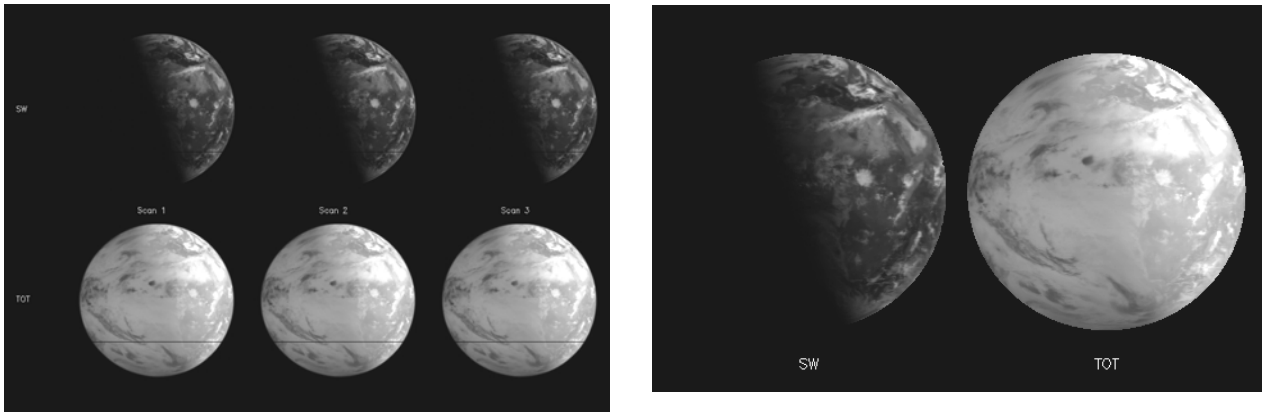

Figure 3: Level 1.5 NANRG (left) and ARG (right) products.

Level 2 flux products

The RMIB GERB Processing (RGP) system generates several types of product with different spatial resolution and time averaging. At present the GGSPS archives the Level 2 Averaged, Rectified, Geolocated (ARG) products. There are separate solar and thermal (SW and LW) ARG product files, containing unfiltered radiances and fluxes generated from GERB (L1.5 NANRG) and SEVIRI data.

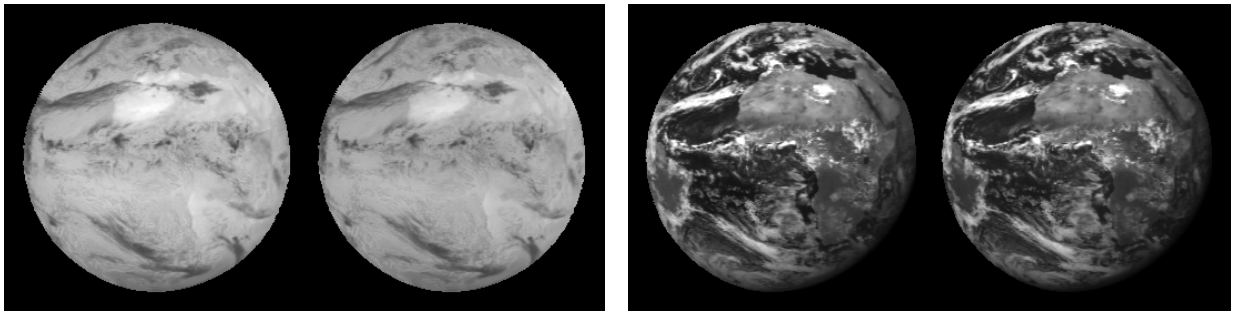

Figure 4: Unfiltered radiance and flux images from Level 2 LW (left) and SW (right) products.

The synthetic "long wave" radiance is obtained by subtraction of the short wave from the total radiance. The unfiltered radiances are then obtained by removal of the effects of the non-flat spectral responses in the short wave and synthetic long wave channels. Fluxes are estimated by modelling the angular distribution of

the observed radiation. The RGP makes use of SEVIRI data in conjunction with the GERB radiances to obtain the unfiltered radiance and flux values.

7. ACCESS TO GERB DATA

Registered users can access data products via the GGSPS web pages: **http://ggsps.rl.ac.uk/.** The web pages also provide access to background information, such as Product User Guides. A searchable catalogue with a form interface allows selection of data based on date and time, product type and instrument mode. Users can download the resulting list of products individually or as a gzipped tar archive.

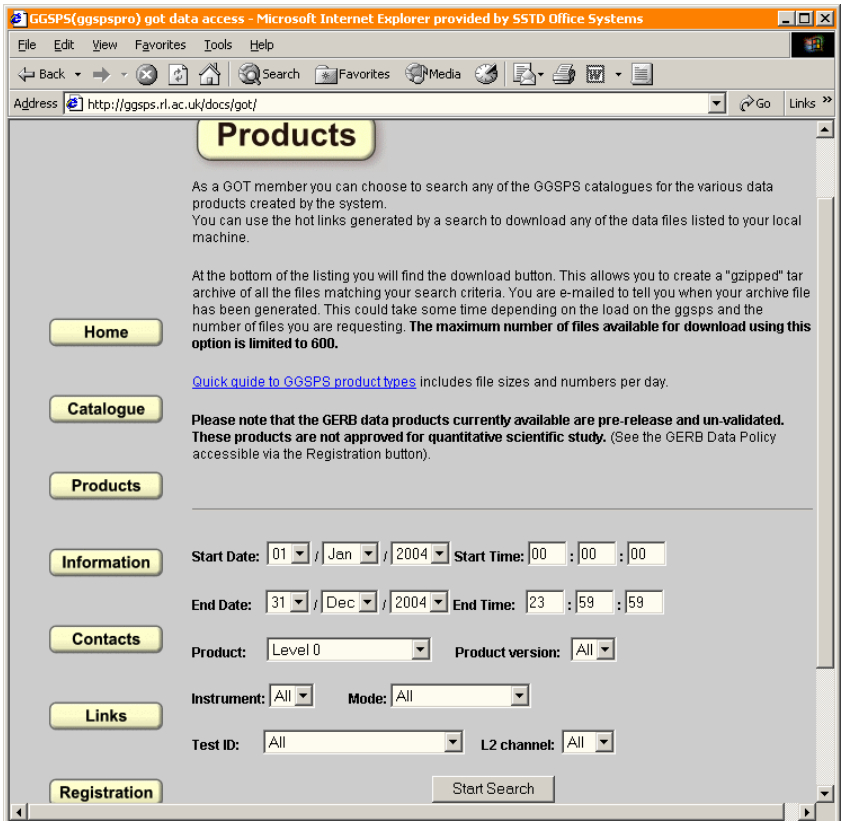

Figure 5: GGSPS product download web page.

8. DATA RELEASE

Currently, pre-release, unvalidated data are available to GERB International Science Team members only. Improvements to data processing are ongoing and completion of product validation is planned for late 2004.

At the time of writing, release plans are still in development, but it is likely that the first validated data should be available for release in late 2004 or early 2005. The initial release will cover only new data generated on or after the release date. After initial release, earlier data will be re-processed ready for release. Subject to funding, monthly averaged Level 2 products are to be developed in 2005.

9. ACKNOWLEDGEMENTS

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