# STATUS OF THE SEVIRI LEVEL 1.5 DATA

**Christopher Hanson** [(1)], **Johannes Mueller** [(1), (2)]

[(1)] *EUMETSAT, Am Kavalleriesand 31, D-64295 Darmstadt, Germany, Email: hanson@eumetsat.de*
[(2)] *VEGA IT GmbH, Hilpertstraße, 20A, D-64295 Darmstadt, Germany, Email: muellerj@eumetsat.de*

**ABSTRACT/RESUME**

This paper reports on the current status of the SEVIRI Level 1.5 image data processing. It describes the quality and availability of the Level 1.5 image data obtained during the first 6 months of Meteosat-8 (MSG-1) routine operations. The status of the calibration is also addressed. Finally, plans to further improve the quality in some areas are presented.

## 1. INTRODUCTION

Meteosat Second Generation (MSG) is a series of 4 geostationary satellites developed and procured by the European Space Agency (ESA) on behalf of the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). The first satellite (MSG-1) was launched on 29th August 2002 by an Ariane 5 rocket.

The main instrument on the MSG spacecraft is the Spinning Enhanced Visible and InfraRed Imager (SEVIRI). SEVIRI supports 12 spectral channels in the visible/near infra red region (around 0.6, 0.8, and 1.6µm plus the High Resolution Visible (HRV) channel) and in the IR (around 3.9, 6.2, 7.3, 8.7, 9.7, 10.8, 12.0 and 13.4µm). Each channel is equipped with 3 detectors (HRV: 9 detectors, e.g. [1]). The MSG imaging mission consists of continuous image taking of the Earth in all 12 spectral channels with a baseline repeat cycle of 15 minutes.

During the commissioning phase, dedicated SEVIRI instrument tests were conducted to verify the instrument functionality and performances ([2] and [3]). The Image Quality Ground Support Equipment (IQGSE), which is an image processing system specifically designed to assess SEVIRI performances during commissioning, was also used to support the Meteosat-8 Dissemination Trial while the operational image processing system (IMPF) was undergoing a final tuning and operational validation. The IMPF replaced the IQGSE on 28th October 2003 and all Level 1.5 data disseminated to the user community since this date have been generated by the IMPF. Following the relocation of Meteosat-8 from its commissioning longitude (10°W) to its operational longitude (3.4°W) in January 2004 routine operations with Meteosat-8 started on 28th January 2004.

## 2. IMAGE PERFORMANCE

### 2.1. Nominal Images

The results of the SEVIRI functionality and performance tests obtained with the IQGSE during the first part of commissioning have been presented in [2] and [3] and will not be repeated here. This paper concentrates on the SEVIRI imaging performances as observed with the IMPF. A nominal quality Level 1.5 image is one that:

- Is based on a nominal quality Level 1.0 image (see below).
- Meets the Level 1.5 Geometric quality requirements.
- Meets the Level 1.5 Radiometric quality requirements.
- Meets the requirements for timeliness of delivery.

A nominal Level 1.0 image is one that meets the Level 1.0 requirements for:

- Completeness
- Geometric quality
- Radiometric quality

The Level 1.0 geometric and radiometric image quality has been extensively verified during the commissioning phase and found to meet the requirements ([2] and [3]). The only factor therefore having a significant influence on Level 1.0 image quality is the completeness of the image. Level 1.0 images are considered to be complete if they exhibit:

- Less than 18 (54 for HRV) missing or corrupted detector lines in total and

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- Less than 12 (36 for HRV) consecutive missing or corrupted detector lines, in the region of interest (the scanned Earth disc) for any given spectral channel.

Hence, Level 1.0 images are generally of nominal quality provided that they are received with a sufficient level of completeness by the IMPF.

The generation of Level 1.5 images from nominal Level 1.0 images has been shown to not adversely affect the radiometric quality (noise). Hence a Level 1.5 image based on a nominal Level 1.0 image will be of nominal quality provided that it has accurate absolute calibration and meets the Level 1.5 geometric quality requirements. These are:

- The absolute accuracy of one image shall be of less than 3 km SSP (sub-satellite point) (1 pixel SSP)
- The relative accuracy between 2 consecutive images shall be of less than 1.2 km SSP (0.4 pixel SSP)
- The relative accuracy within an image on 500 samples shall be of less than 3 km SSP (1 pixel SSP)
- The relative accuracy within an image on 16 samples shall be of less than 0.75 km SSP (0.25 pixel SSP)
- The maximum residual mis-registration shall be of less than 0.6 km SSP (0.2 pixel SSP) for the visible and near infra-red group of channels and 0.75 SSP (0.25 SSP) for the remaining channels

These quality indicators are routinely monitored and used to derive figures for the availability of nominal Level 1.5 images at the output of the IMPF (the output of the IMPF corresponds to the input to the image dissemination and the product extraction systems).

## 2.2. Performance Figures

IMPF image availability in this paper is defined as:

$$\frac{\text{raw (rectified) images of nominal quality available at the IMPF input (output)}}{\text{number of scheduled images}} \quad (1)$$

When deriving the availability figures, the image quality is ignored inside the allowed outage periods (12 hours after the start of an eclipse and 3 hours after the start of a manoeuvre).

At the output of the IMPF, the availability figures are (July 2004):

- raw image availability: 99.7 %
- rectified image availability: 99.4 %

Please note that these figures are at IMPF level and are not end-to-end figures.

## 2.3. Eclipse Performance

As briefly mentioned above, the performance specifications allow a 12 hour period of reduced quality after an eclipse. In practice, the outage period after an eclipse is typically much less than 12 hours.

The METEOSAT-8 satellite can experience two types of eclipse:

- Sun eclipse, when the Earth interposes between the satellite and the Sun
- Moon eclipse, when the Moon interposes between the satellite and the Sun

During the autumn 2003 eclipse season it was shown that the IMPF could generally process nominally the SEVIRI images taken during an eclipse. Two main effects were noticed:

- An East-West image jump immediately after eclipse up to 3 pixels
- Stray light contamination in some channels, particularly IR 3.9

For both effects, currently improvements to the IMPF are envisaged.

## 2.4. MANOEUVRE PERFORMANCE

The performance specifications allow a 3 hour period of reduced quality after a manoeuvre. In practice, the outage period after a manoeuvre is typically less than 3 hours.
The following manoeuvres have been performed:

- $13^{th}$ May 2003 - East-West station keeping manoeuvre
- $14^{th}$ January 2004 - Start of the relocation manoeuvre (2 separate burns)
- $27^{th}$ January 2004 - Stop of the relocation manoeuvre (2 separate burns)
- $6^{th}$ April 2004 - East-West station keeping manoeuvre

- 7th September 2004 - East-West station keeping manoeuvre

### 2.5. Radiometric Performance

The radiometric calibration of the IR channels has been compared to the vicarious calibration provided by the Meteorological Product Extraction Facility (MPEF). The agreement between vicarious and blackbody calibrations is 1.4K in the IR 10.8 and IR 12.0 channels (= 1.7%). This is about the expected uncertainty of the vicarious calibration (+/- 1K) so that the radiometric accuracy requirement is not exceeded [4]. Assuming that the blackbody calibration is wavelength independent, one can infer that the requirements are also met in the other channels. This is supported by the results obtained from the comparison with the HIRS instrument.

There is no on-board calibration for the solar channels. Therefore, a vicarious calibration is used. The SEVIRI Solar Channel Calibration (SSCC) is a vicarious method that uses radiative transfer modelling over bright desert and clear ocean Results are provided in the image L15 header using the MPEF Calibration Feedback Mechanism. The values are updated every 45 days. The accuracy of results is of the order of 5% [5].

## 3. IDENTIFIED PROBLEMS AND PLANNED IMPROVEMENTS

### 3.1. Scan Angle Dependency of Calibration

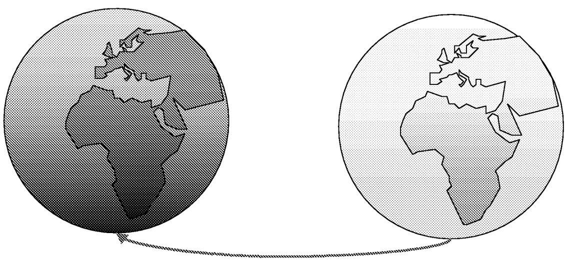


Fig. 1 Scan Angle Dependency of Calibration

At some period during the eclipse season, it is necessary to perform blackbody calibrations with the scan mirror pointing South (i.e. after retrace) rather than North (i.e. before retrace). This is to avoid an overheating due to the combined effects of blackbody heating and solar reflex from the scan mirror. It was observed that the calibration results are significantly different between both configurations. The difference varies with channel but is fully reproducible. An example is given in Tab. 1.

| | |
|---|---|
| IR 3.9 | 0.0% |
| IR 6.2 | 0.1% |
| IR 7.3 | 0.1% |
| IR 8.7 | 0.5% |
| IR 9.7 | 0.2% |
| IR 10.8 | 0.2% |
| IR 12.0 | 0.3% |
| IR 13.4 | 0.9% |

Tab. 1 Gain Change When Changing from Calibration After Retrace to Calibration Before Retrace. Positive values indicate larger gain in the nothern hemisphere. data collected on 13. May 2004

It has to be pointed out that the magnitude of the effect pointed out in Tab. 1 does not exceed the requirements of the image radiometric stability and hence the level 1.0 images are still nominal. The instrument manufacturer has analysed these findings and states that this effect is due to the angular dependence of the scan mirror reflectivity. Thus, the true instrument gain is higher when observing the Northern Hemisphere than in the Southern Hemisphere (Fig. 1). The effect is negligible for the IR 3.9 channel but can be as large as 0.9% in the IR 13.4 channel. The calibration results therefore are correct, but only accurate for the mirror position at which they were taken. During the autumn eclipse season 2004, the calibration was manually adjusted when calibrating in the South to guarantee a consistent radiometric performance.

Analysis of the data available revealed that the angular dependence of the reflectance of the scan mirror could be effectively modelled as a linear change with angle. This allows for an accurate correction of the effect within the IMPF. This correction is currently being developed and is expected to be in place before the next eclipse season. However, data for correction is only available for the IR channels with wavelengths from 3.9 µm and larger.

### 3.2. WV 6.2 Alignment Problems

An East-West “zigzag” or “jitter” in the WV 6.2 images has been observed on some occasions. Also, the North - South co-registration of the WV 6.2 channel with the window channels was also sometimes incorrect. This problem was identified to be an incorrect modelling of the telescope focal plane. The fact that the geometric accuracy of the absorber channels cannot be monitored using landmarks plus a low contrast in the horizons is considered to be the reason.

Currently, the focal plane model is manually corrected to avoid the problem. An update to IMPF has been developed and is currently under test.

### 3.3. East-West Jump After Eclipse

It has been demonstrated that the IMPF meets its requirements for the availability of nominal Level 1.5 images after an eclipse event. However, the above mentioned East-West "jump" after eclipse gives scope for further improvement. It has been observed that the "jump" of the image is very regular. Hence, an empirical model could be derived to correct for the effect. This model is also currently (autumn eclipse season 2004) under test and is expected to be in place for the next eclipse season.

### 3.4. Stray Light Processing

Although the IMPF has been shown to meet its requirements for the availability of nominal Level 1.5 images, it is planned to try to reduce the impact of stray light around eclipses.

The stray light comes mainly from the Sun when it is close to or within the field of view, as it is the case close to eclipse.

Although the SEVIRI is designed to minimise the stray light, when the Sun is closer than 10 degrees to the line of sight, stray light affects some channels. The presence of stray light under these conditions was foreseen and so the instrument radiometric performance specification is not applicable under these conditions. Hence, a Level 1.0 or Level 1.5 image that is affected by stray light when the Sun is closer than 10 degrees to the line of sight is still deemed to be of nominal quality. Nonetheless, the IMPF provides a mechanism to model and subtract the stray light, although the stray light correction has not yet been implemented. Stray light data has been collected from pre-defined off-Earth raw image areas, starting from the beginning of February 2004 until the end of April 2004. Preliminary results show that the visible channels and the IR 3.9 channel are significantly affected in the Sun eclipse season. All data available have been analysed and a stray light correction is currently (autumn eclipse season 2004) under test.

### 3.5. HRV Image Alignment

An error in the HRIT/LRIT image navigation information has been identified. Until 2nd September 2004, the LOFF parameter (see [6]) for the HRV was set incorrectly. The correct value of 5866 was introduced at 9:15 repeat cycle on that day.

In this context, it might be worthwhile to recall the nominal alignment of the low and high resolution pixels of a Level 1.5 image with respect to the geographical co-ordinates and with respect to each other. Fig. 2 and Fig. 3 may be of help.

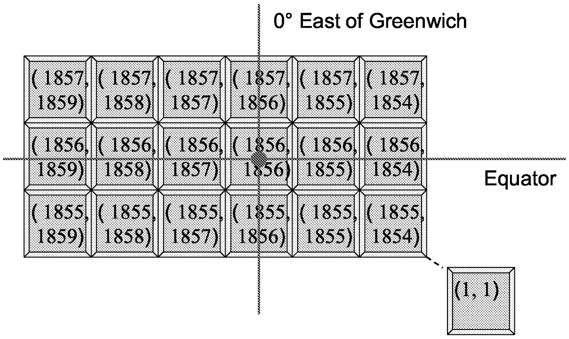


Fig. 2 Alignment and Numbering of Low Resolution Pixels

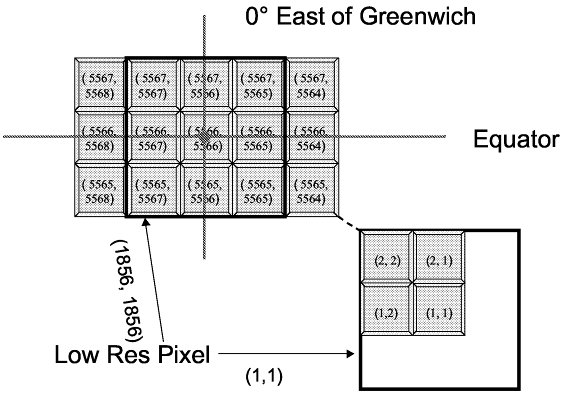


Fig. 3 Alignment and Numbering of High Resolution Pixels (Southern Window, no East West Delay)

## 4. SUMMARY

During the commissioning and the first months of routine operation the SEVIRI on-board METEOSAT-8 has provided the MSG ground segment with raw image data of excellent quality. The operational image processing facility, IMPF, is running in a stable way.

The IMPF produces nominal Level 1.5 images as per the system and facility requirements. Among the issues to be addressed in the near future is the correction of the angle dependency of the scan mirror reflectance, introduction of a stray light correction, improvement of the absorber channel co-alignment, and correction of the East-West "jump" post eclipse.

Overall, the experience with the IMPF during the first months of routine operations has shown that the IMPF achieves a high level of availability of nominal Level 1.5 images, both under nominal and special (eclipse, manoeuvre) operational conditions.

## 5. REFERENCES

1. Schmetz, J., P. Pili, S. Tjemkes, D. Just, J. Kerkmann, S. Rota and A. Ratier, An Introduction to Meteosat Second Generation (MSG), *Bull. Amer. Meteor. Soc.*, 977 – 992, 2002.

2. Hanson, C. G., J. Mueller, P. Pili, D. M. A. Aminou, B. Jacquet, S. Bianchi, P. Coste, F. Faure, Meteosat Second Generation: SEVIRI Imaging Performance Results from the MSG-1 Commissioning Phase, *The 2003 EUMETSAT Meteorological Satellite Conference*, Weimar, Germany: 29 September – 3 October 2003

3. Hanson, C. G., J. Mueller, P. Pili, D. M. A. Aminou, B. Jacquet, S. Bianchi, P. Coste, F. Faure, Meteosat Second Generation: SEVIRI Radiometric Performance Results from the MSG-1 Commissioning Phase, *The 2003 EUMETSAT Meteorological Satellite Conference*, Weimar, Germany: 29 September – 3 October 2003

4. Mueller, J., C.G. Hanson, Y. Govaerts, T. Heinemann and M. König, Initial Results From The Validation of the Meteosat-8 SEVIRI Calibration, *The 2004 EUMETSAT Meteorological Satellite Conference*, Prague, Czech Republic: 31 May – 4 June 2004

5. Govaerts, Y.M., and M. Clerici, Operation Vicarious calibration of the MSG/SEVIRI Solar Channels, *The 2003 EUMETSAT Meteorological Satellite Conference*, Weimar, Germany: 29 September – 3 October 2003

6. EUMETSAT, HRIT/LRIT Mission Specific Implementation, EUM/MSG/SPE/057, available from EUMETSAT, Am Kavalleriesand 31, D-64295 Darmstadt, Germany, 2004.