

The In-Orbit Commissioning of the first METImage Instrument on board the Metop-SG A1 Satellite

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ABSTRACT

A key payload of the Metop Second Generation A Satellites is the METImage instrument. METImage is a multi-spectral imaging passive radiometer that delivers high-quality visible and infrared image data to support numerical weather prediction, climate monitoring, and environmental applications through high-resolution cloud, atmospheric, land and ocean products. The instrument is developed under a partnership between DLR and EUMETSAT, with Airbus Defence and Space Friedrichshafen as prime contractor.

The METImage instrument is a whisk-broom type scanning instrument that observes Earth with an across-track swath of 2560 km and a ground sampling distance of 500 m at nadir, enabling global coverage within 12 hours. Three focal planes acquire information across 20 spectral channels spanning wavelengths from 0.4 μm to 13.5 μm . The METImage instrument employs a two-point calibration methodology that encompasses the entire optical and electrical chain. This is achieved by using a deep-space viewport, an internal blackbody, and two reflective Sun diffusers.

The METImage Proto-Flight Model was launched on board the Metop-SG A1 satellite from Kourou, French Guiana on 12 August 2025. This paper provides an overview of METImage's in-orbit commissioning, encompassing both the initial three-month in-orbit verification test campaign and the subsequent calibration and validation campaign. The in-orbit verification test campaign commenced with a systematic functional evaluation of the instrument, which facilitated the acquisition of its initial first light images. Afterwards, performance evaluations were carried out. These involved the characterisation and comparison with previous on-ground measurements of the detector response at sub-pixel level, the across-track radiometric variation, and the visible detector non-linearity.

The calibration and validation campaign started after the successful conclusion of the in-orbit verification test campaign. The performance of the METImage instrument was compared to ground sensors and other Earth observation satellites. Further, special manoeuvres were conducted to characterise the METImage solar diffusers. This contribution concludes by presenting a summary of the initial findings from the calibration and validation campaign.

Keywords: Operational Remote Sensing, Multispectral Imaging Radiometer

1. INTRODUCTION

The mission of the EUMETSAT Polar System Second Generation (EPS-SG) is to provide global observations from which information on variables of the atmosphere, ocean and land surfaces can be derived, using satellite-based sensors from Low Earth Orbit (LEO). To fulfil its mission, it is required to deploy sustained capabilities to acquire, process, and distribute environmental data to downstream application users and second-tier processing centres. The data cover a broad spectral range (from ultraviolet light to millimetre-wave radiation), related to different spatial coverage (global and regional), and over a variety of different timescales, thereby continuing and enhancing the services offered by the EPS first generation [1].

The space segment of EPS-SG consists of two series of satellites (Metop-SG A and Metop-SG B). Three models of each satellite provide continued services from a mid-morning polar orbit from 2025 to 2046+, expanding the 20+ years of climate data records initiated in 2006 with the first generation of the European Polar System. The six instruments on board the Metop-SG A satellites mainly focus on optical imaging and sounding, whereas the five instruments on board the Metop-SG B satellites focus on microwave sounding and imaging.

The METImage instrument is a whisk-broom type scanning instrument that observes Earth with an across-track swath of 2560 km and a ground sampling distance of 500 m, enabling global coverage within 12 hours. Three focal planes (Visible

and Near-Infrared (VNIR), Short-Wave Infrared (SWIR), and Long- and Very-Long Infrared (LVWIR)) acquire information across 20 spectral channels spanning wavelengths from 0.4 μm to 13.5 μm . The SWIR and LVWIR focal planes are cooled to less than 60 K with two cryocoolers operating in hot-redundant mode.

The METImage instrument employs a two-point calibration methodology that encompasses the entire optical and electrical chain. This is achieved with a deep-space view port, an internal blackbody, and two reflective Sun diffusers.

The scan mirror rotation enables observation of the full swath on Earth, the internal blackbody for calibration of the thermal channels and the deep-space view port for calibration of all spectral channels every 1.7 seconds. The Sun can theoretically be monitored once per orbit close to the South Pole through either the nominal Sun diffuser or the monitoring Sun diffuser. In practice, the nominal diffuser is exposed every two weeks and the monitoring diffuser every three weeks to limit aging. Two diffusers are employed with different solar exposure frequencies to be able to monitor diffuser degradation.

The scan mirror rotates around the telescope optical axis, which requires a derotator unit within the optical path that compensates for the off-axis image rotation. The derotator rotates at half the speed of the scan mirror and consists of a five-mirror assembly to limit polarisation effects.

The performance capabilities of METImage are a significant step forward for the EUMETSAT Polar System, when comparing key metrics of METImage with those of its predecessor AVHRR-3. Table 1 shows that its SNR/NeDT is significantly improved, while offering increased spatial resolution and 20 instead of 6 spectral channels. However, the instrument is also significantly larger and heavier, illustrated by an approximately tenfold increase in mass.

Table 1: Comparison of METImage with its predecessor AVHRR-3 on Metop.

	AVHRR-3	METImage
Instrument Type	Cross-track scanner with deep-space and internal calibration views	Cross-track scanner with deep-space and internal calibration views
Swath	2900 km	2560 km
Instantaneous Field of View (iFOV)	1.1 km @ Nadir	0.5 km @ Nadir
SNR/NeDT Values not directly comparable due to different spectral bands and scaling assumptions	SNR = 9/20 @ 0.5% albedo NeDT 0.120 K @ 300 K	SNR > 30/60 NeDT <0.018 K @ 300 K for AVHRR-3 channels
Spectral Channels	6 (from 0.6 μm to 12.5 μm)	20 (from 0.4 μm to 13.5 μm)
Mass	33 kg	≤ 316 kg
Power (orbital average)	27 W	≤ 481 W

The satellite Metop-SGA1 was successfully launched on an Ariane 62 launcher from the Guiana Space Centre on 12 August 2025 and reached its target sun-synchronous orbit (SSO) with an altitude of 831 km and an LTAN of 21:30, carrying the METImage Proto-Flight Model (PFM).

The focus of this contribution is to provide an overview of the METImage PFM commissioning activities, with a focus on performance and aspects relevant to instrument development. The METImage PFM commissioning started after launch and early operations activities and is currently ongoing with the finalisation of data product validation activities.

2. OVERVIEW OF THE METIMAGE COMMISSIONING ACTIVITIES

The commissioning phase is divided into the Satellite In-Orbit Verification (SIOV) phase, during which the instruments are sequentially activated and verified, and the Calibration and Product Validation (Cal/Val) phase. Figure 1 shows a flow diagram of the activities performed during SIOV and Cal/Val. The boxes outlined in green are described in more detail below. The selection has been made based on the rationale to provide a comprehensive picture of the commissioning activities while focusing on aspects that are of particular interest for the development of optical instruments. The performance checks, calibration, and data validation activities often ran quasi-parallel in their respective phases to collect sufficient statistical data or due to repetitions of individual activities.

The beginning of the SIOV phase required substantial coordination of activities. SIOV activities of six instruments and the platform were conducted in parallel and needed to share ground station passes. Multiple operations rehearsals before the launch and continuous re-planning of activities allowed the team to efficiently cope with unexpected anomalies and developing demands during the SIOV phase.

During the METImage commissioning, multiple ground data processors were used in parallel. Each data processor has a different specialisation, which helped perform cross-checks between teams. It further enabled agile adaptation and bug fixing to progress the SIOV and Cal/Val activities with reduced formalism compared to that ultimately required for an operational data processor. The Airbus-developed Ground Processing Prototype was most closely aligned with the instrument through the on-ground calibration campaign although it was not optimised for computational speed. The

EUMETSAT-developed Internal Processing Prototype is used as a processor by EUMETSAT scientists and data processing experts to test algorithm adaptations before they are specified for the temporary ground processor system with real-time capabilities and the final operational ground processor that delivers the full feature set required from an operational processor. The ground processors have been supported by dedicated performance assessment tools that were developed to analyse SIOV and Cal/Val-specific activities.

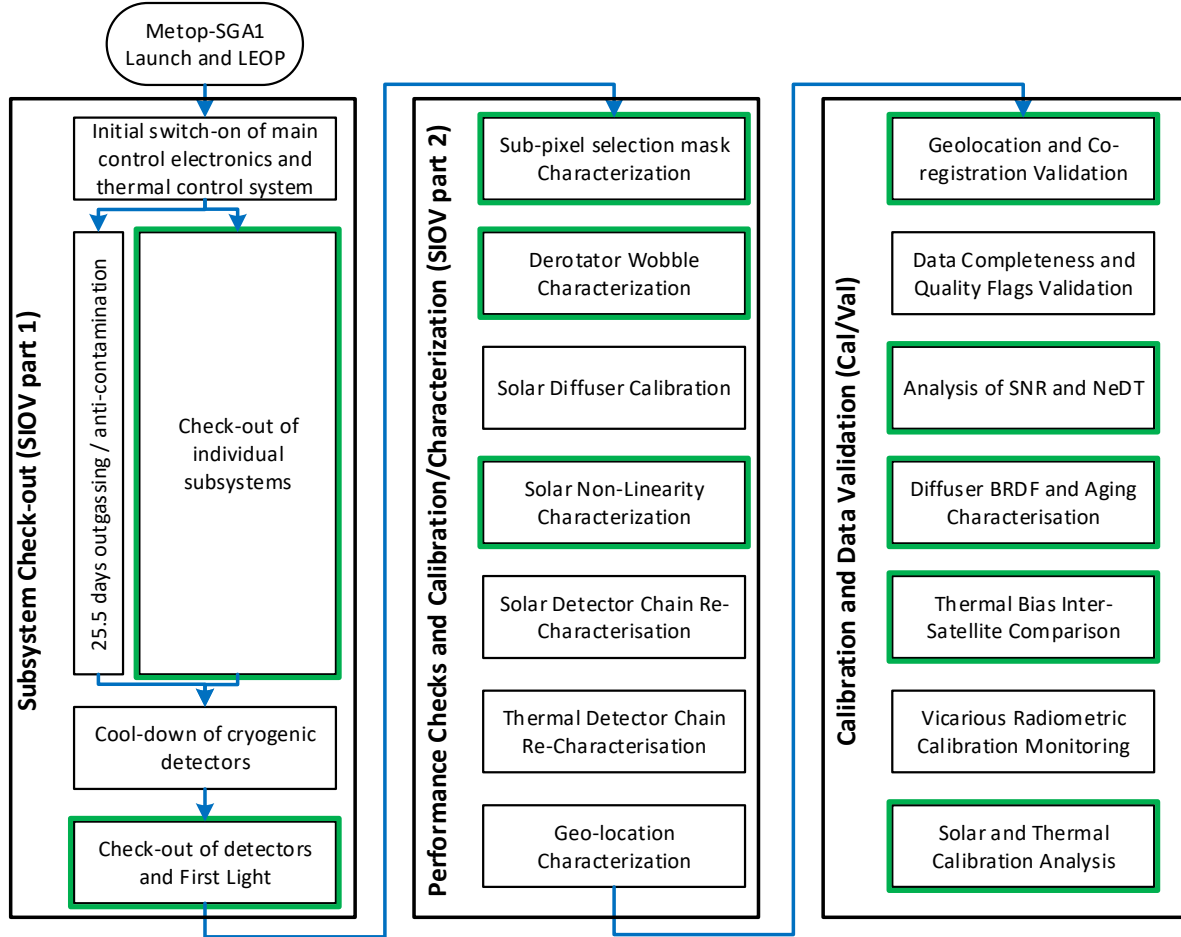


Figure 1: Excerpt of the METImage Commissioning Activities. Duplications of activities across different phases and repetitions are not considered. Calibration and characterisation activities are partially performed in parallel, especially for statistical analysis. Activities in green boxes are further explained in this paper.

3. SATELLITE IN-ORBIT VERIFICATION

3.1 Subsystem Check-out

At the beginning of the SIOV phase, the main control electronics and the thermal control system were checked out to verify their proper functionality. This step was necessary to start the outgassing/anti-contamination phase. During this phase, the critical optical components of METImage, and in particular the detector cavities were warmed up to temperatures between 20 °C and 30 °C for a duration of 25.5 days. The cryogenic detector cavities are exposed to space, allowing the slow diffusion of residual water vapour remaining within the detector cavities despite stringent humidity control requirements. As discussed in Section 4.5, the slow build-up of an ice layer on the infrared detector surfaces has performance-relevant impact after several months. Regular de-icing is performed to counteract the build-up.

In parallel to the outgassing/anti-contamination phase, the subsystems of METImage were checked out by individually testing the functionality of the cryocooler electronics, the science data formatting unit, the rotation control module that operates the scanner, derotator, and solar diffusers, and the front-end electronics without detectors.

After the outgassing/anti-contamination phase ended, the infrared detectors were cooled to operational temperature, allowing the functional check-out of the detector and the creation of the first light images of the METImage instrument.

3.2 First Light Image

The very first light image of METImage was captured on 24 September 2025, 43 days after launch. Its capture was timed so that Europe could be imaged; see Figure 2 for the True Colour RGB. The image reveals intricate cloud structures linked

to a cold front over central Europe, storm activity developing over the Adriatic and central Mediterranean, surface features, such as the forests of the Carpathian and Balkan Mountains, and stark contrasts between North Africa's deserts and greener terrain. Further information is available in the official press release [2].

The Severe Storms RGB in Figure 3 is a composite image designed to highlight thunderstorms by detailing the cloud-top microphysics of high clouds. It brings together data from three METImage channels that detect moisture patterns high in the atmosphere, how clouds reflect light, and the thermal emission from the clouds. This image was created by combining thermal channel data processed with the Airbus Ground Processor Prototype and visible channel data from the EUMETSAT Internal Prototype Processor, using the strengths of each processor available at that time.



Figure 2: METImage first light True Colour RGB image



Figure 3: METImage first light Severe Storm RGB image

The first light images were processed with on-ground calibration coefficients without accounting for ground-to-orbit effects and other calibrations that need to be performed regularly in orbit. The following sections describe three SIOV characterisation activities that need to be regularly performed during routine operations.

3.3 Sub-pixel Selection Mask Characterisation

The METImage instrument bins individual detector pixels within the instrument electronics to so-called macro-pixels that align with the required Instantaneous Field of View (IFOV). For the VNIR detector, this is a one-stage process from 4×4 $250 \mu\text{m}$ readout pixels to one macro-pixel. For the infrared detectors, it is a two-stage process from 3×3 $30 \mu\text{m}$ sub-pixels to readout pixels that are then 3×3 aggregated to macro-pixels, corresponding to the IFOV. The binning is done within the instrument to reduce the downlink data rate.

For the thermal detectors, not all sub-pixels should be included in the aggregation as some are noisy or Random Telegraphic Signal (RTS) pixels, defective (e.g. no photo-responsivity or too bright), or the illumination from the field mask is too faint. Some of these effects are not constant and sub-pixel behaviours change every time the detectors are warmed up and cooled down again. As a result, a sub-pixel selection mask characterisation needs to be performed after every cool-down of the detectors. After data evaluation, new sub-pixel selection masks need to be uploaded to the instrument and considered in the data processing.

The sub-pixel selection mask characterisation is performed through a dedicated diagnostic mode that allows readout of the infrared detectors at sub-pixel level while staring into deep-space. From this measurement, the sub-pixel selection mask is created based on a sub-pixel classification, as exemplarily shown below for the SMWIR and LVWIR detectors (Figure 4). The LVWIR detector requires the exclusion of considerably more pixels than the SMWIR detector, as expected.

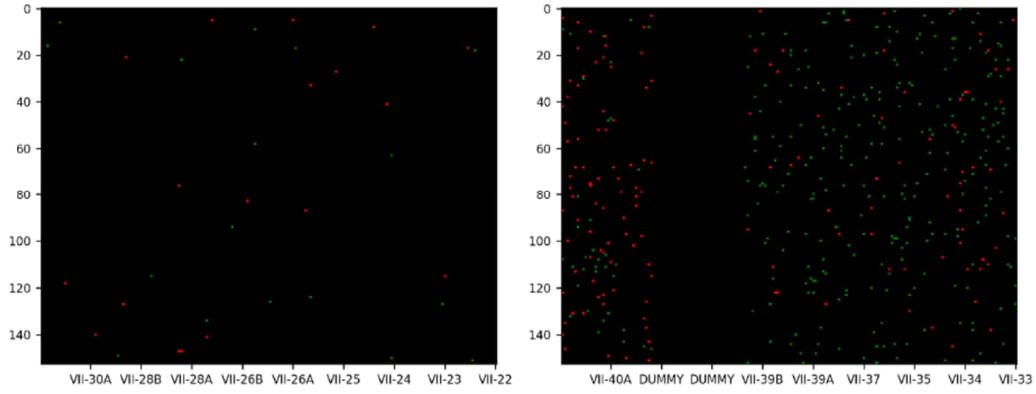


Figure 4: Exemplary sub-pixel classification as bright (red) or noisy (green) on SMWIR (left) and LVWIR (right) detectors

A similar readout-pixel characterisation for the VISNIR detector is also available for health checks and diagnostic modes and is utilised for the analysis, described in Section 5.1.

3.4 Derotator Wobble Characterisation

During the on-ground calibration campaign it was found that the residual wobble of the derotator has non-negligible radiometric impact on the LVWIR channel performance. The wobble is an instrument-specific effect that arises from a slight change of the pupil illumination caused by the derotator. As a result, a wobble correction has been implemented. The wobble characterisation was repeated and refined with the SIOV activities. The wobble correction is performed by staring at the thermal blackbody and deep-space for multiple rotations of the derotator. The rotations are accumulated in an interleaved fashion to reduce the impact of noise. This measurement was repeated at different orbital positions, showing an additional dependence of the derotator wobble on the optics temperature. Figure 4 and Figure 5 illustrate the signal dependence on derotator angle and optics temperature for two representative spectral channels. The temperature dependence is sufficiently small that no correction is required.

The derotator wobble characterisation needs to be repeated, and its calibration parameters need to be updated in the data processing, each time a new sub-pixel selection mask is characterised.

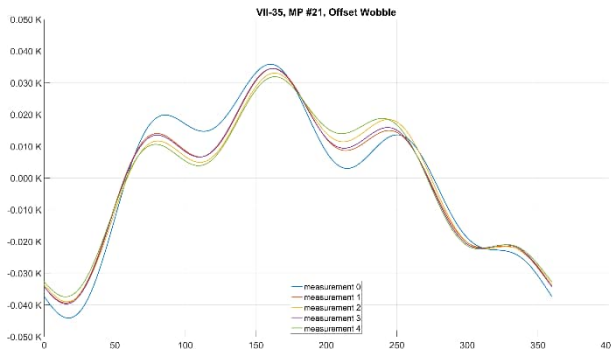


Figure 5: Wobble curves [K] for VII-35 ($8.5 \mu\text{m}$) macro-pixel 21 for different temperatures [K]

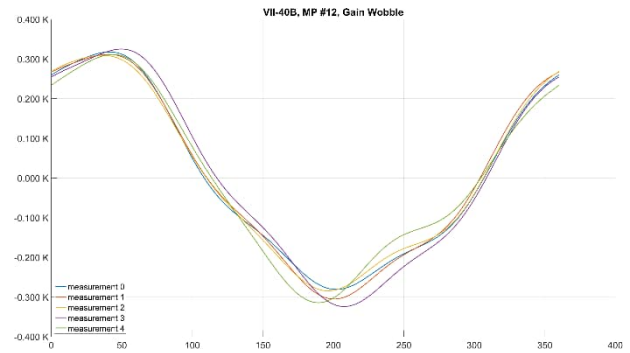


Figure 6: Wobble curves [K] for VII-40B ($13.345 \mu\text{m}$) macro-pixel 12 for different temperatures [K]

3.5 Non-linearity Re-Characterisation

On-ground ageing tests on hardware showed that the non-linearity response of the VNIR detector changes over time due to radiation. A non-linearity calibration is planned every six months to limit the impact on the performance. Operational experience will determine whether the frequency can be lowered. The driving requirement is inter-channel homogeneity.

The non-linearity re-characterisation is performed in orbit using solar diffuser calibrations at different integration times. Different integration times are used because the Sun is the only stable calibration source that can expose the detector to different light levels. On ground, radiation-flux-dependent calibration curves were recorded. However, radiation-flux/integration-time equivalence could not be demonstrated for non-linearity. Therefore, in post-processing, the recorded integration-time-dependent non-linearity curve needs to be corrected with on-ground calibration data to a radiation-flux-dependent non-linearity curve that is relevant for Earth scenes. The contribution [3] to this conference details the on-ground part of the non-linearity re-characterisation.

The non-linearity re-characterisation requires measurements with 150 different integration times. Ten integration times can be measured in a single solar diffuser exposure. In total, 15 solar diffuser exposures need to be performed over

consecutive orbits to generate the required calibration data. The signal levels during a solar diffuser exposure depend on the time of year due to different Sun-Earth distances and Sun azimuth angles. The non-linearity calibration is most precise if signal levels similar to those measured during the on-ground calibration campaign are reproduced in orbit. Thus, before these 15 solar diffuser calibrations are performed, an individual solar diffuser exposure is required to adjust the scan mirror angle so that the signal levels on the detector are as similar as possible to those during the on-ground calibration.

The results of the calibration are non-linearity curves relative to a linear response, as exemplarily shown in Figure 7 for channel VII-15 (752 nm) and macro-pixel 1. The in-orbit data fit the on-ground data with residuals below 0.1%, showing that the method is suitable. The pinkish area is outside of the dynamic range of METImage.

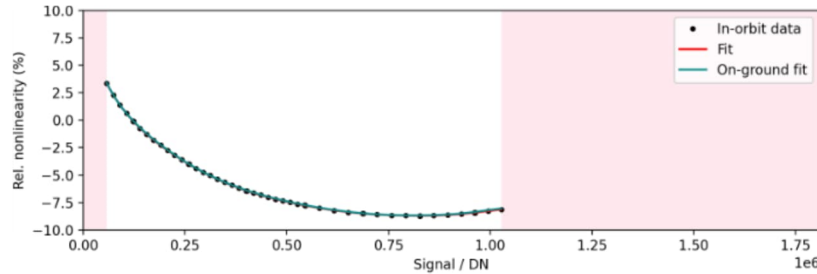


Figure 7: Exemplary relative non-linearity curve of channel VII-15 for macro-pixel 1

4. METIMAGE CALIBRATION AND VALIDATION ACTIVITIES

The METImage L1B product quality reached pre-operational status in July 2026. The product quality is approaching expected performance, and the validation is nearly complete. Limitations have been identified and considered non-critical. Residual limitations are documented. The product validation report and user documentation are largely available, which allows data access to be progressively extended from a limited user group to all registered users.

4.1 Geolocation and Co-registration Validation

Geolocation analysis was performed during SIOV on a reduced number of samples across 27 one-minute data takes. This analysis showed that the measured alignment angles are similar to the on-ground measurements and differences can be explained by ground-to-orbit effects and measurement uncertainty. Including the measured instrument pointing bias in the L1B processing and re-running the analysis already provided preliminary evidence that the geolocation is compliant.

This analysis was extended using a larger dataset to increase the statistical significance of the analysis. The analysis used the areas of interest shown in Figure 8 and demonstrated that 90% of test samples meet the 500 m requirement, well above the 68% threshold. The results of the statistical analysis for VII-12 (668 nm) are depicted exemplarily in Figure 9.

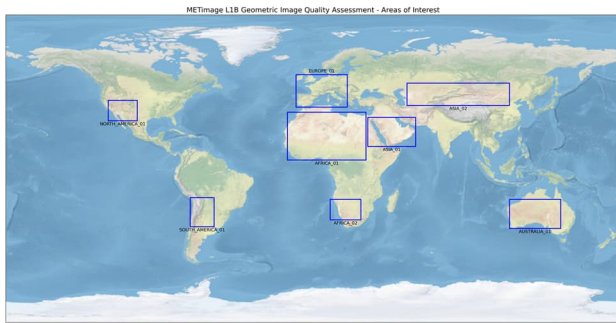


Figure 8: Areas of interest during two weeks of geolocation analysis

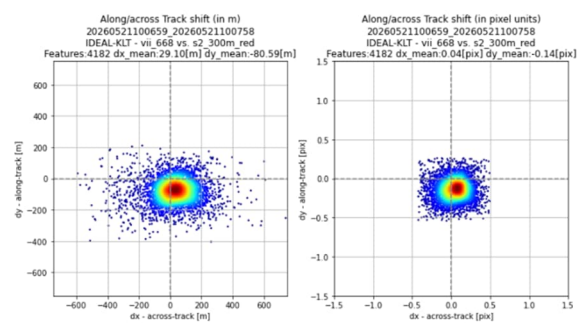


Figure 9: Exemplary analysis results for channel VII-12 (668 nm)

The spatial co-registration of all channels across the three focal planes was verified for plausibility during SIOV and statistically analysed within Cal/Val. All tested spatial co-registration results are within the requirement $(1 - \Delta_{\text{scan}})(1 - \Delta_{\text{track}}) > X$, where Δ_{scan} and Δ_{track} are the channel spatial sample mis-registrations in the across- and along-track directions and X is 0.79 or 0.78, depending on the compared channel combinations.

4.2 Analysis of SNR and NeDT

The analysis of Signal-to-Noise Ratio (SNR) for the solar channels and Noise equivalent Delta-Temperature (NeDT) for the thermal channels was performed during SIOV and continued as a trending analysis in Cal/Val. No trends were detected, and the noise performance is mostly compliant, with very low noise levels for the thermal channels; see Table 2. Non-compliances have been discussed with the user representatives for METImage and are considered acceptable.

The figures obtained during the on-ground calibration [4] indicated worse noise performance of METImage for the solar channels compared to the values measured in-orbit. The better in-orbit performance can be attributed to higher signal levels measured in orbit than on ground. The root cause investigation showed that the signal of the calibration lamps degraded faster than expected and measured signal levels were underestimated. The higher signal level in orbit resulted in a modification of the non-linearity calibration factor for high signal levels and reduced margin/slight non-compliance for VII-8 (0.555 μm) within the dynamic range.

Table 2: Signal-to-Noise (SNR) performance for the solar channels and Noise equivalent Delta-Temperature (NeDT) performance for the thermal channels of METImage.

Solar Channels					Thermal Channels				
Channel	Wavelength h [μm]	Required SNR @ E_ref [-]	Measured SNR @ E_ref [-]	Margin @ E_ref [-]	Channel	Wavelength [nm]	Required NeDT @ T_ref [mK]	Measured NeDT @ T_ref [mK]	Margin @ E_ref [-]
VII-4	0,443	221	225	2%	VII-26	3,740	73	24	68%
VII-8	0,555	215	186	-13%	VII-28	3,959	105	37	65%
VII-12	0,668	66	65	-2%	VII-30	4,050	104	36	66%
VII-15	0,752	400	424	6%	VII-33	6,725	93	50	46%
VII-16	0,763	400	390	-3%	VII-34	7,325	104	32	69%
VII-17	0,865	60	70	17%	VII-35	8,540	57	13	77%
VII-20	0,914	250	369	48%	VII-37	10,690	55	15	73%
VII-22	1,240	75	182	143%	VII-39	12,020	54	17	69%
VII-23	1,375	300	369	23%	VII-40	13,345	239	109	54%
VII-24	1,630	300	426	42%					
VII-25	2,250	110	152	38%					

4.3 Diffuser BRDF and Ageing Characterisation

The Bidirectional Reflectance Distribution Functions (BRDFs) of the nominal and monitoring diffusers were characterised at component level and instrument level to compensate for the varying azimuth angle of the solar diffuser exposure and, to a lesser extent, its elevation-angle dependence. The solar diffuser sees the Sun at a different azimuth angle depending on the time of year. The ground calibration had some difficulties achieving the required characterisation accuracy of this dependence due to limited time and calibration lamp failures.

The diffuser calibration can also be performed in orbit through a set of manoeuvres. The Sentinel-5 instrument on Metop-SG also required such a diffuser calibration. Figure 10 illustrates the concept behind the diffuser calibrations. Following the launch of Metop-SG in August 2025, the SIOV campaign lasted until the end of November 2025. The manoeuvres could only be performed after the SIOV campaign concluded. Due to orbital constraints, these manoeuvres could not be performed around the winter solstice. Figure 10 shows, with the green background, the times of the year when they could be performed. The goal of the manoeuvres is to cover all Sun azimuth angles so that the impact of different azimuth angles can be separated from diffuser ageing.

For Sentinel-5, the approach was to observe the current azimuth angle once a month and directly afterwards, rotate the spacecraft with a manoeuvre so that the same centre azimuth angle is always observed (stars in the image). For METImage, the approach was to perform manoeuvres over a short period, ideally over consecutive orbits to sample the full range of azimuth angles. Finally, ten azimuth angles were recorded in two sets at the end of March 2026 and in mid-April 2026.

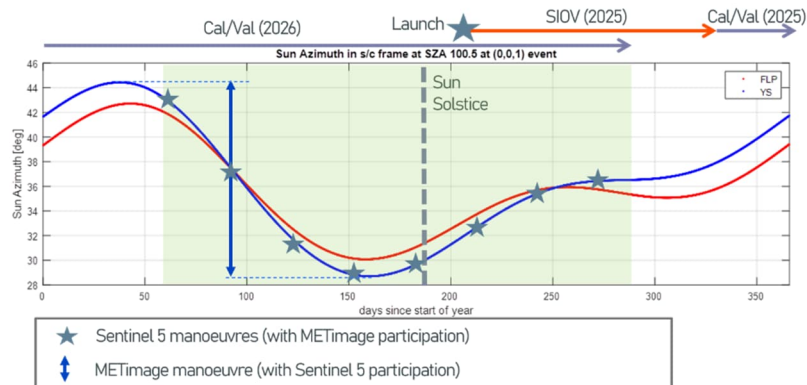


Figure 10: METImage and Sentinel-5 manoeuvres for solar diffuser characterisation

The results of the preliminary analysis are shown in Figure 11. The upper figure shows the solar calibration points with detector signal fit as background, depending on elevation and azimuth angles. Each cluster corresponds to a manoeuvre. The data are restricted to the centre elevation range as it is only used for nominal solar calibrations. The lower plot shows the fitting residuals to a second-order 2D polynomial. The residuals are generally between $\pm 0.1\%$ for all spectral channels. Data from the Sentinel-5 manoeuvres will be incorporated into the data analysis once all Sentinel-5 manoeuvres are concluded in September 2026.

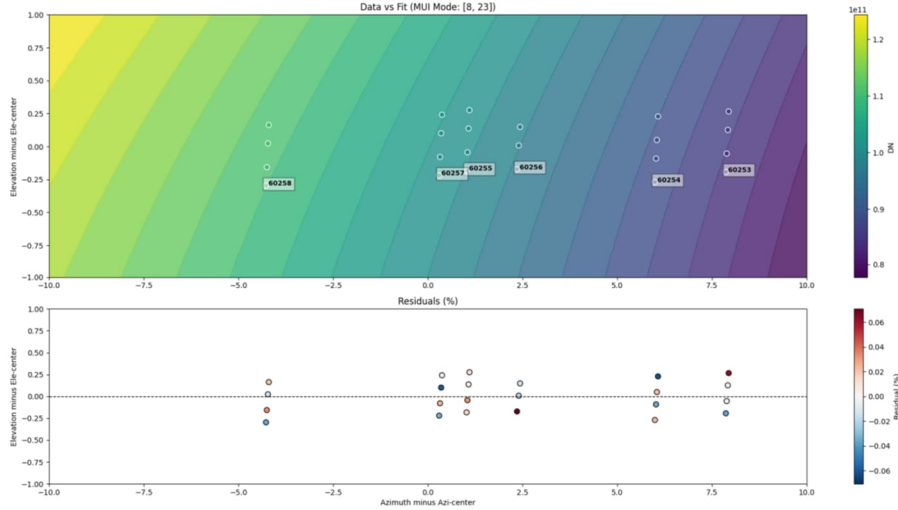


Figure 11: Top: Solar calibration points depending on elevation and azimuth angle. Each cluster represents one manoeuvre. The background is the actual signal. Bottom: Residuals of the calibration fitting curve for each calibration point. Data shown exemplarily for VII-23 ($1.375 \mu\text{m}$) macro-pixel 23.

4.4 Thermal Bias Inter-Satellite Comparison

The thermal bias inter-satellite comparison is described as an example of an Inter-Calibration method performed during METimage Cal/Val. During a period of two months, the Metop-SGA1 satellite was positioned in a tandem configuration with the operational Metop-3 satellite. The thermal channels of METimage were compared with IASI reference data. The methodology of the Inter-Calibration is described in [5].

Figure 12 shows the results of the comparison. The upper left value is the number of data-points used for the Inter-Calibration, the lower-left equation is the residual linear fit and the lower-right value is the brightness temperature bias for the reference radiance (vertical green line). METimage is in excellent agreement with IASI with biases below 0.12 K at the reference radiance.

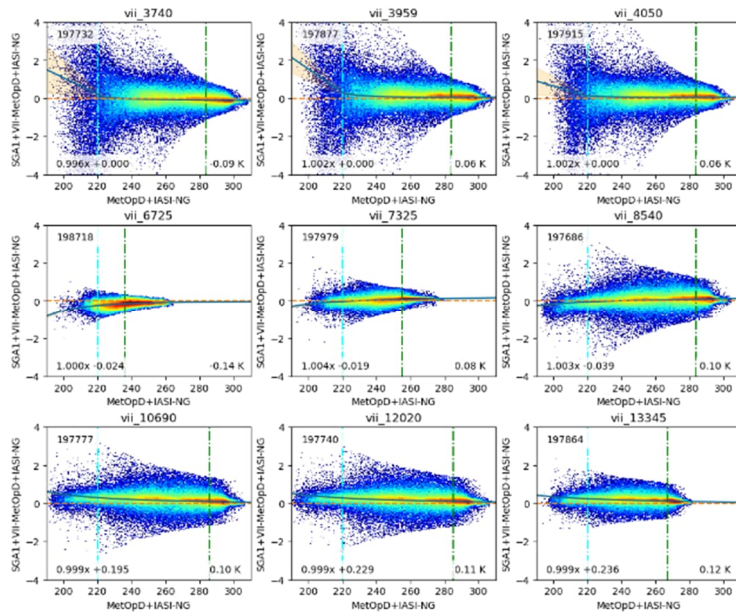


Figure 12: Thermal bias of METimage compared to IASI for the thermal channels

Achieving this excellent agreement for all channels required considerable effort. The thermal bias is strongly influenced by the Instrument Spectral Response Function (ISRF) in channels that are affected by spectral signatures, for example from water vapour or Carbon Dioxide. Channels VII-33 (6.725 μm), VII-37 (10.690 μm), and VII-40 (13.345 μm) could only be measured with limited precision in the instrument level ground calibration campaign due to water absorption within the optical path of the optical ground support equipment for VII-33 and VII-37, and due to state-of-the-art technology limitations for VII-40, resulting in higher uncertainty in the ISRF derived from component-level measurements. Initial analysis results extracted from the MICMIS tool [6] indicated biases up to 0.5 K for VII-33 and 1.5 K for VII-40. Extensive investigations on the instrument and data-processing side finally allowed corrections to the ISRF to be identified. A lesson learned from this is that the ISRF should ideally be characterised on instrument level with the complete optical system under vacuum. In practice, this needs to be balanced with complexity, cost, and schedule considerations.

4.5 Thermal Transmission Trending

Section 3.1 already introduced the need for regular de-icing to limit the impact of ice build-up on the thermal detectors, which lowers the optical transmission. The transmission has been trended since shortly after the end of the outgassing/anti-contamination phase. The transmission degradation depends on the spectral channels and is most pronounced for channels VII-39 (12.020 μm) and VII-40 (13.345 μm), as seen in Figure 13 for the MWIR channels and in Figure 14 for the LVWIR channels. Over about 4.5 months, these two channels degraded by about 4% in transmission relative to initial measurements. At this point, de-icing was performed, resetting the transmission to values similar to the start. For VII-40, it reset to an even higher value than at the beginning of the SIOV, which may be explained by the build-up of a small ice layer between the end of the outgassing/anti-contamination phase and the first measurement. The transmission-loss gradient decreased after the first de-icing, indicating that water molecules diffused into cold space. It is expected that the need for de-icing cycles decreases with instrument age. Further information on humidity control strategies during instrument development and the in-orbit outgassing/anti-contamination/de-icing activities is presented in a conference contribution [7].

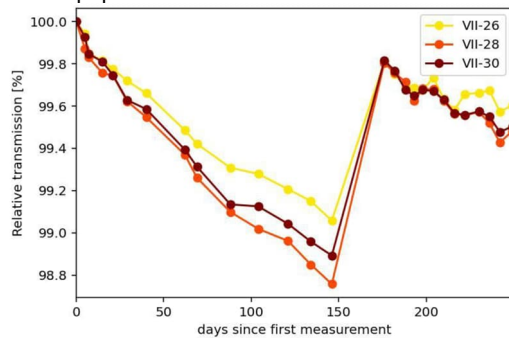


Figure 13: Transmission degradation for MWIR channels relative to first measurement

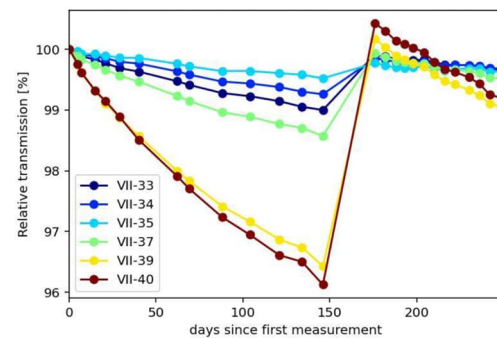


Figure 14: Transmission degradation for LVWIR channels relative to first measurement

5. ANOMALIES

Two anomalies detected during SIOV and Cal/Val, together with their mitigation actions, are briefly described in this section.

5.1 Cryocooler Anomaly

The METImage instrument has two cryocoolers with independent electronics. The second cryocooler had rebooted five times during SIOV and Cal/Val, resulting in a loss of cooling and sometimes in a communication freeze. Investigations with the supplier indicate that the most likely root cause is an electronics-unit-specific radiation susceptibility and is considered to be a one-off. The first cryocooler has now been operated for almost a year without any anomalies.

Failure detection and recovery procedures have been implemented to reboot the second cryocooler in a clean state so that cooling is interrupted only minimally without performance impact. The detector temperatures spike in the order of 100 mK. As a long-term risk mitigation measure, single cryocooler operation is being prepared in case the anomaly becomes more frequent.

5.2 Particle in Optical Path

At the end of October 2025, two VII-22 (1.240 μm) macro-pixels experienced an SNR loss and a decrease in solar gain during solar calibration (a low gain means higher digital amplification). After the decontamination cycle, the two macro-pixels of VII-22 recovered and three other macro-pixels of this channel became affected.

The root cause investigation made significant use of the procedure for sub-pixel selection mask characterisation to observe the degradation at sub-pixel level. An exemplary plot is shown in Figure 15, depicting the signal difference between March 2026 and October 2025. The grey boxes are an overlay visualising the positions of the macro-pixels. The change in signal can be clearly seen for the area in red that partially impacts two macro-pixels.

The investigation concluded that the most likely reason for the gain drop is a particle between the field mask and the detector (inside the cryostat). Its size is estimated to be between 0.5 mm and 2 mm.

The solar calibration automatically corrects for any bias caused by the particle by reducing the solar gain. However, less signal still reaches the detector and reduces the SNR. Currently, the SNR of the worst-affected pixel is reduced by about 30%, and that of the other two pixels to a lesser extent.

Monitoring in the ground processing is being implemented as a mitigation action to promptly detect any further particle movement and trigger a solar calibration.

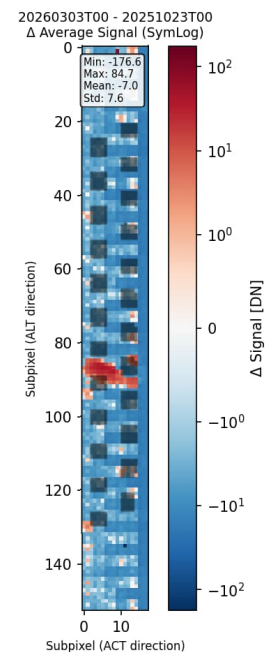


Figure 15: Signal comparison for VII-22 (1.240 μm) between March 2026 and October 2025

6. CONCLUSION AND NEXT STEPS

The METimage Proto-Flight Model was launched in August 2025 and has undergone extensive verification and characterisation activities since then during the SIOV and Cal/Val phases.

In July 2026, the L1B product quality reached pre-operational status with products being distributed to a wider user group. The Cal/Val activities are being finalised with a focus on the analysis of an additional VNIR detector non-linearity characterisation conducted in September 2026 and the detailed analysis of the diffuser BRDF characterisation and its ageing.

Overall, the METimage Proto-Flight Model delivers good performance, operates reliably, and is a major improvement over AVHRR on Metop First Generation.

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