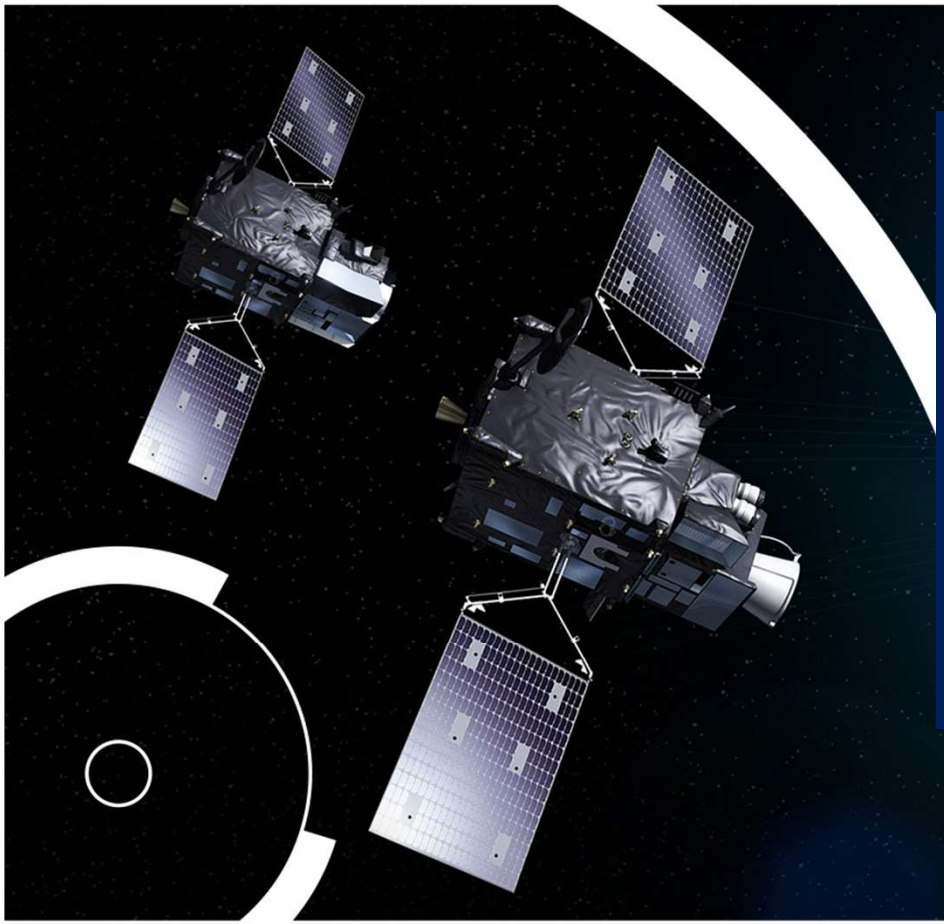
EUMETSAT



Outcomes of the MTG-I1 FCI and LI Cal/Val

***Mounir Lekouara*, Alessandro Burini, Bartolomeo Viticchie, Jochen Grandell, Johannes Mueller, Janja Avbelj, Christoph Straif, Ali Mousivand, Stephan Stock, Andrea Meraner , Sven-Erik Enno, Sebastien Wagner, Steven Hadesty, Johan Strandgren, Daniele Innorta, Gary Fowler**
EUMETSAT (Germany)

2025 GSICS annual meeting- Changchun (China) – 18.03.2025

Agenda

MTG-I commissioning & Cal/Val

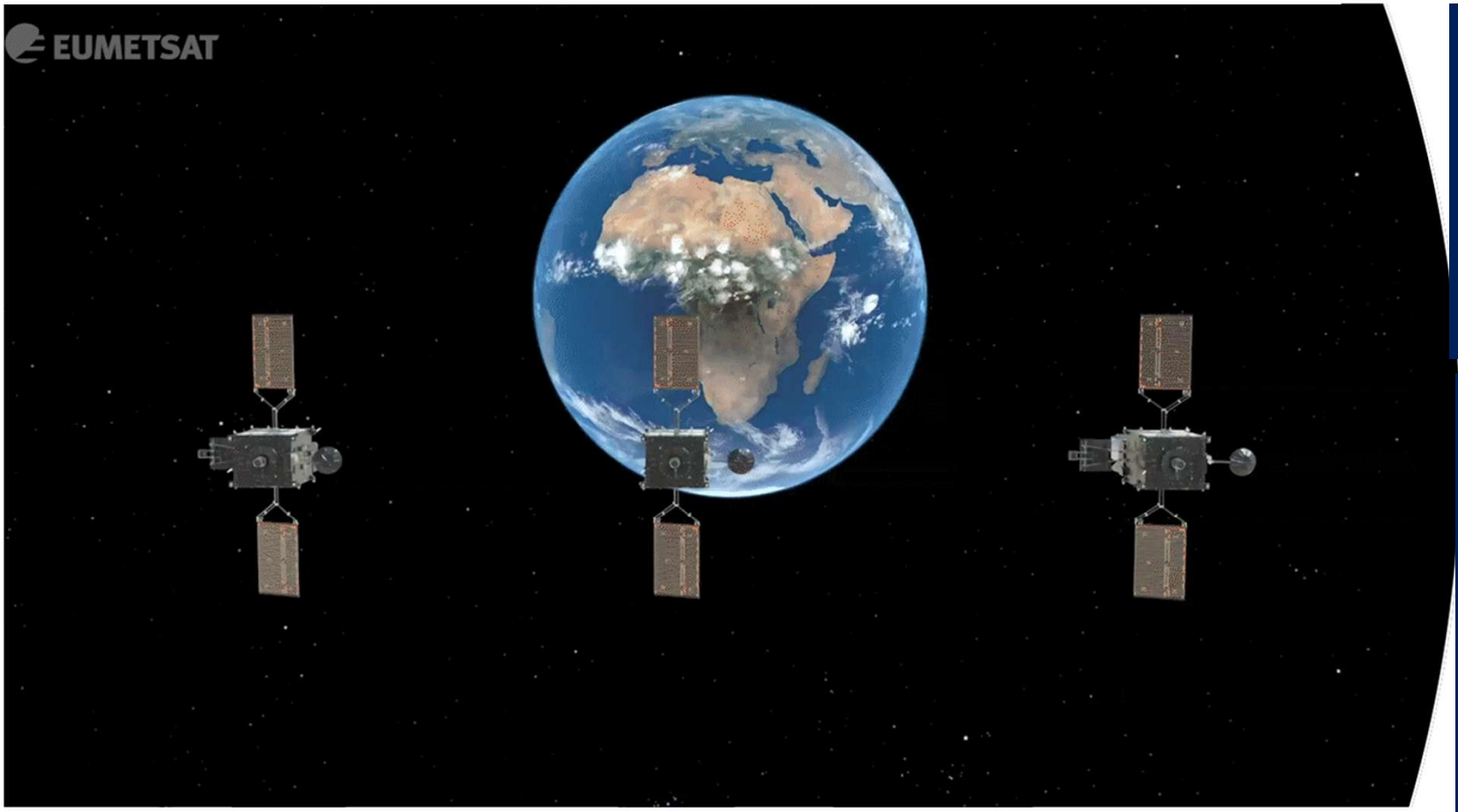
Timeline

Achievements

Issues

Mitigations

MTG in orbit configuration



Three satellites configuration

Combination of an imaging mission (2 MTG-I) and a sounding mission (1 MTG-S)

MTG-I

- Launched first S/C in Dec 2022
- Operational exploitation: 2024-2047

MTG-S

- First launch mid-2025
- Operational exploitation: 2026-2046

MTG-I1 timeline

- December 2022: MTG-I1 launch with Ariane-5 in Kourou
- May 2023: release of the FCI first images (L1 prototype)
- July 2023: release of the LI first images (L1 prototype)
- November 2023: trial dissemination of FCI Level-1c products (L1 operational processor)
- December 2023: Satellite Commissioning Result Review (CRR) successful (L1 prototype)
- January 2024: FCI in survival mode due to COM anomaly
- May 2024: FCI switched on without on-board calibration
- July 2024: pre-operational dissemination of FCI Level-1c and LI Level-2 products (L1 operational processor)
- October 2024: operational dissemination of lightning products
- December 2024: operational dissemination of FCI Level-1c and L2 pre-operational

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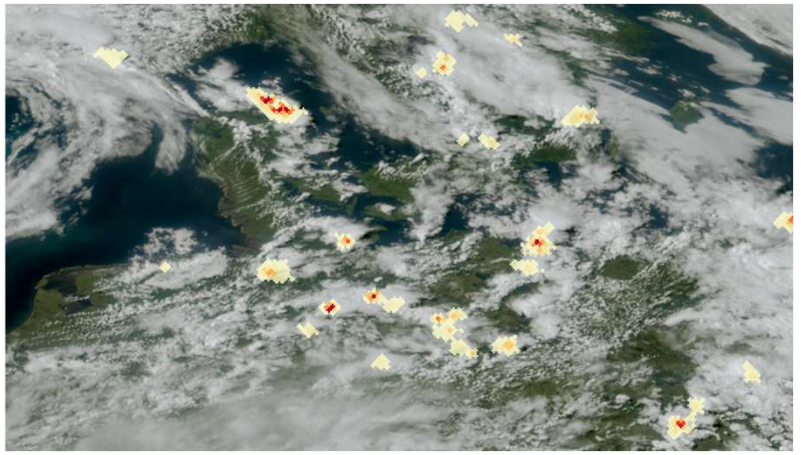


MTG-I1 FCI commissioning: geometry

Activities completed

- Scan encoder calibration
- Tuning of the INR processing:
  - observables processing (stars, landmarks, ranging);
  - Geometric calibration: daily deformations measured with stars;
  - Kalman filter;

Issues spotted and corrected:

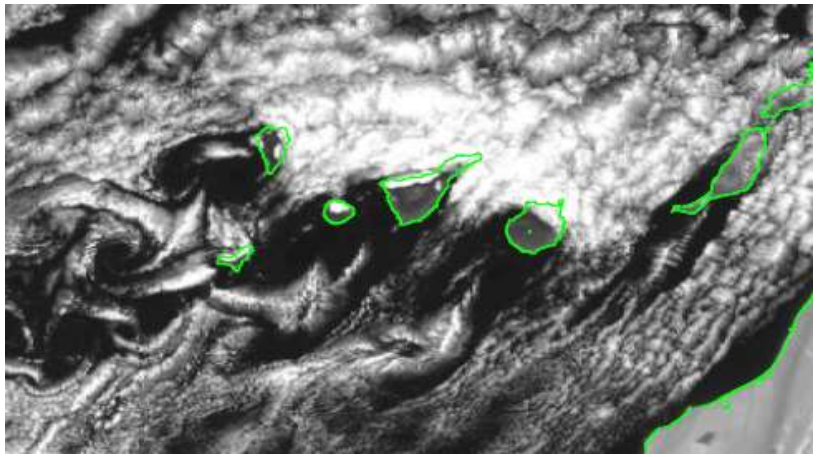
- distortion law
- scanner datation bias
- small co-registration issue on a few IR channels at swath edges

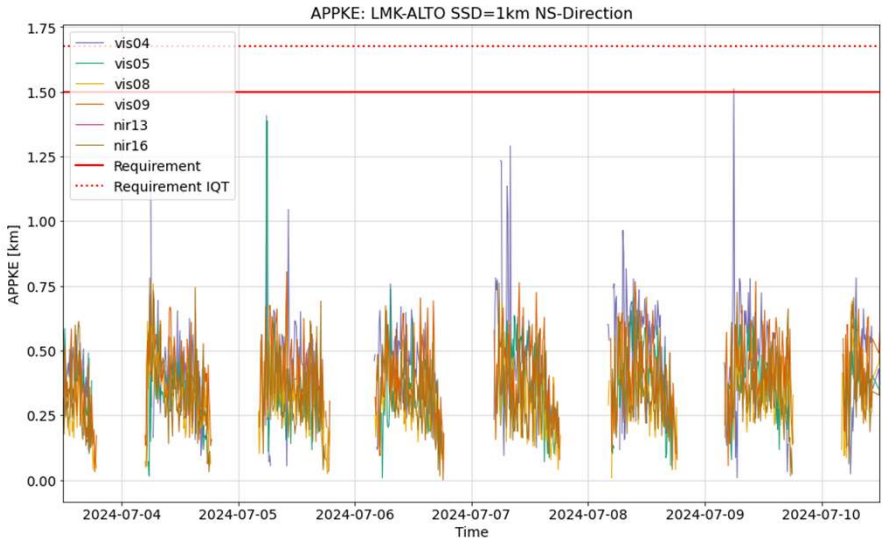
Remaining issues under investigation:

- small jitter effect (in specification)

Performance metrics are OK:

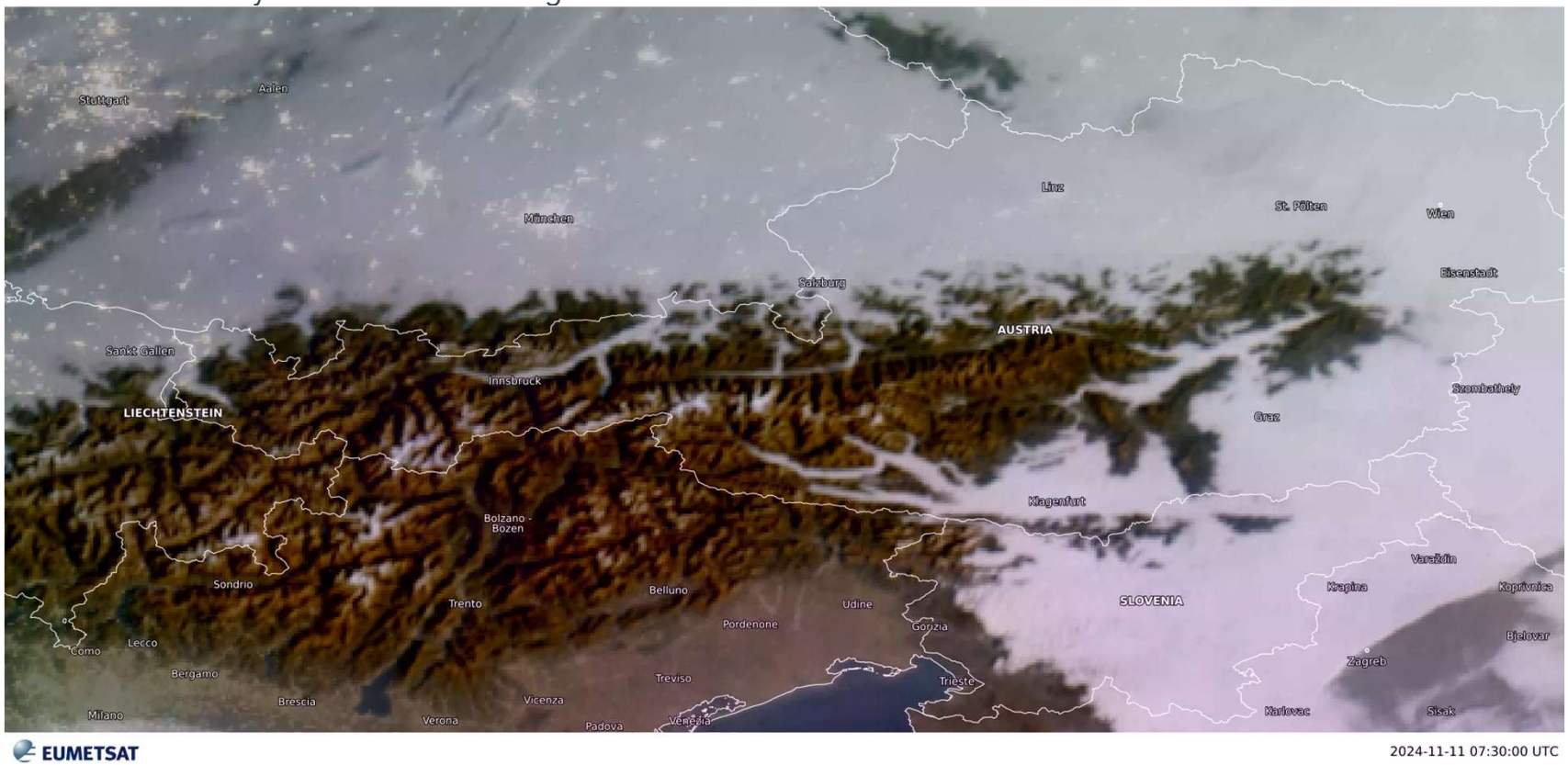
- Absolute navigation error;
- Channel to Channel relative navigation error (with limitation above);
- Image to Image relative navigation error;
- Coverage;





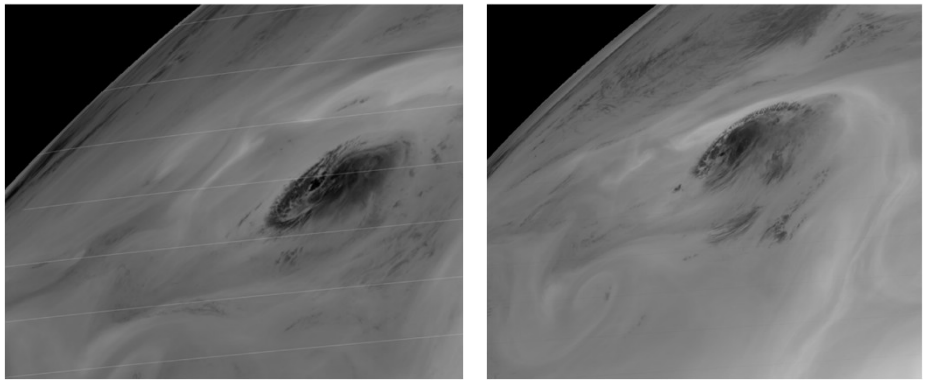
Known Limitation: Jitter Issue

- The FCI imagery, particularly when animated, shows a continuous movement ("shakiness"/"jitter") from image to image. This movement is quantified to be up to just below 1km, thus still within requirement, but still affecting the usability of local scale timeseries of data. Some users (e.g. fire monitoring) already complained and requested improvement of performances;
- The root cause was likely identified and is being addressed.

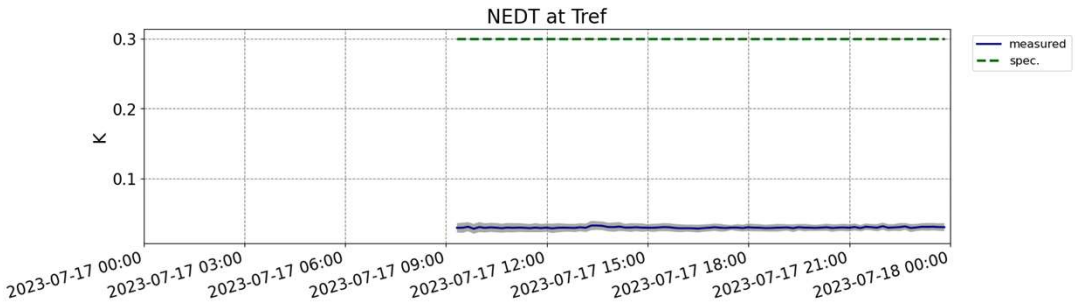


MTG-I1 FCI commissioning: radiometry

Main FCI IR radiometric requirement	
Noise	*NedT at reference signal better than 0.1 to 0.3 K depending of the channel (1 K for the IR3.8 fire channel)*
Dynamic range	*The FCI radiometric range shall be sized such that the minimum and maximum signals are detectable (i.e. > 1 LSB12 and < 4095 LSB12).*
Medium term radiometric stability	*Radiometric stability better than 0.1 K over 10 min*

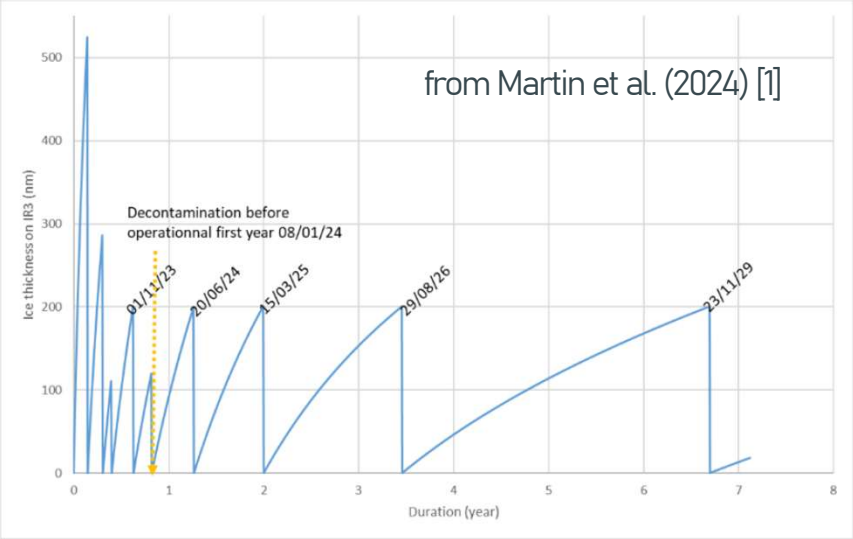


striping

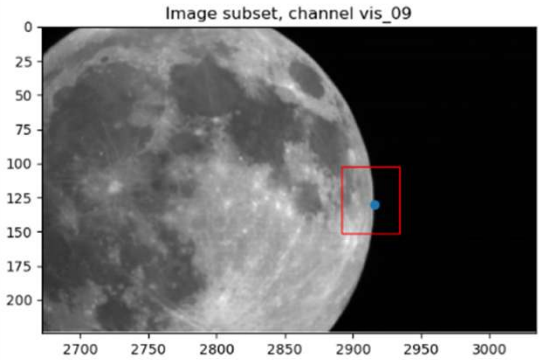


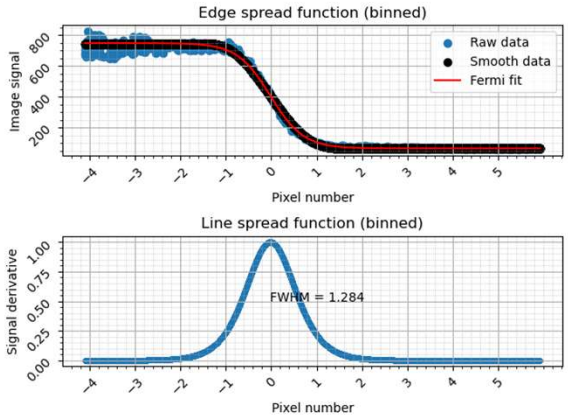
NEDT for IR6.3

MTG-I1 FCI commissioning: radiometry

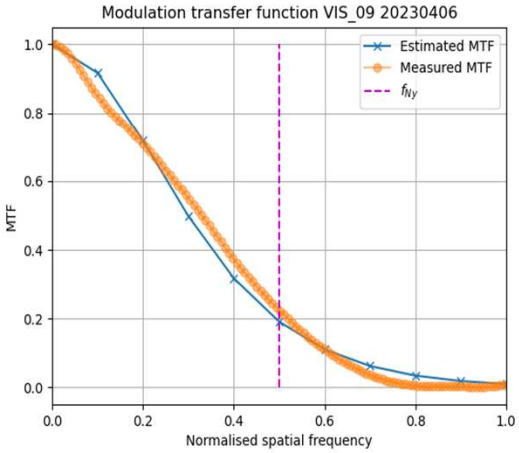


Icing model update for ice-decontamination planning



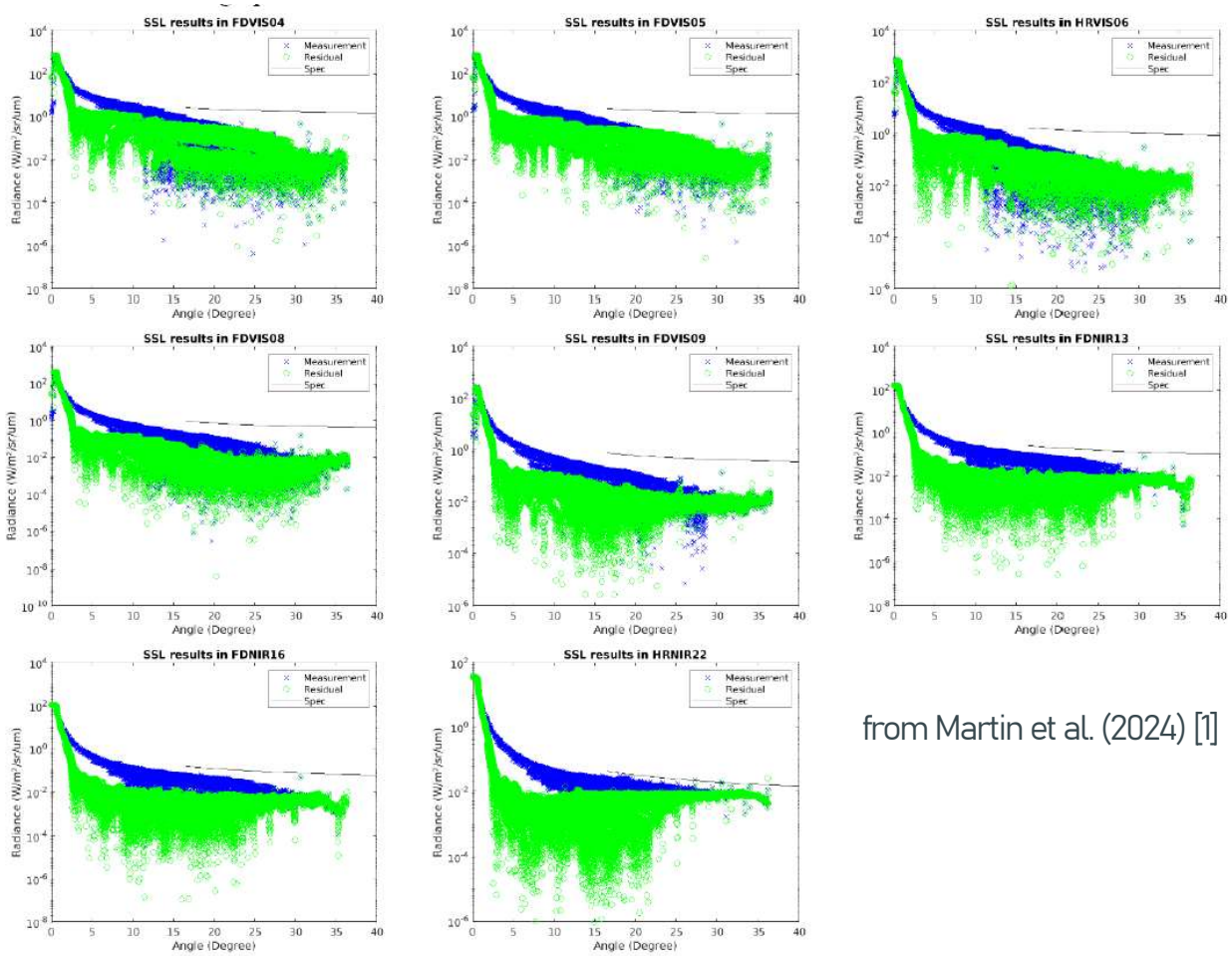


MTF in-orbit assessment



+ A huge effort in 2024 to enhance the Earth Stray Light algorithms and kernels to remove all related artefacts in IR bands

MTG-I1 FCI commissioning: radiometry

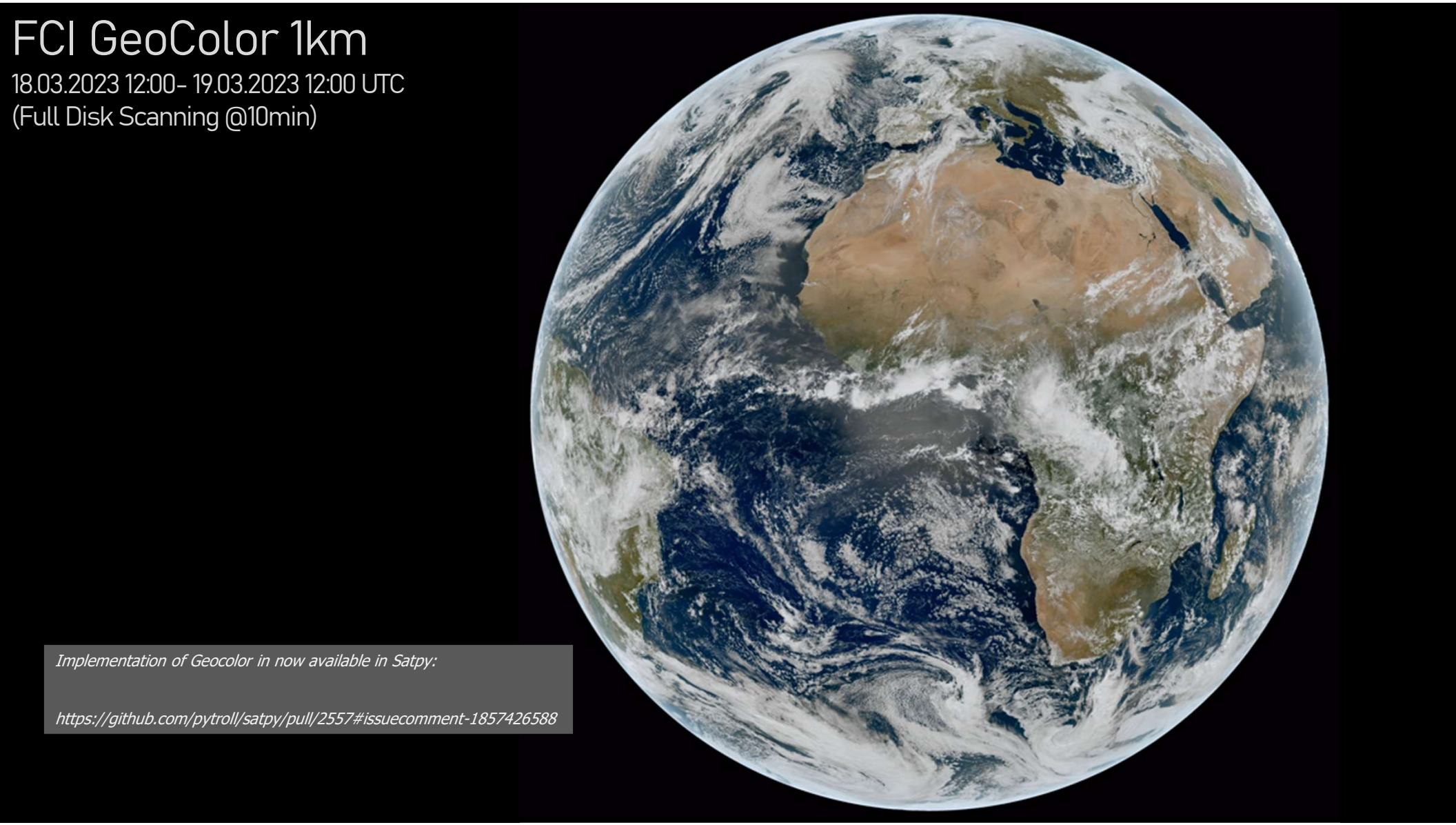


from Martin et al. (2024) [1]

Sun Stray Light characterisation and correction

FCI GeoColor 1km

18.03.2023 12:00- 19.03.2023 12:00 UTC
(Full Disk Scanning @10min)

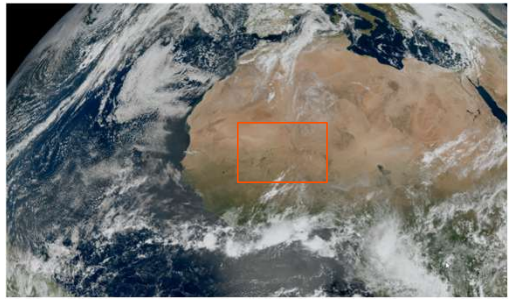


Implementation of Geocolor in now available in Satpy:

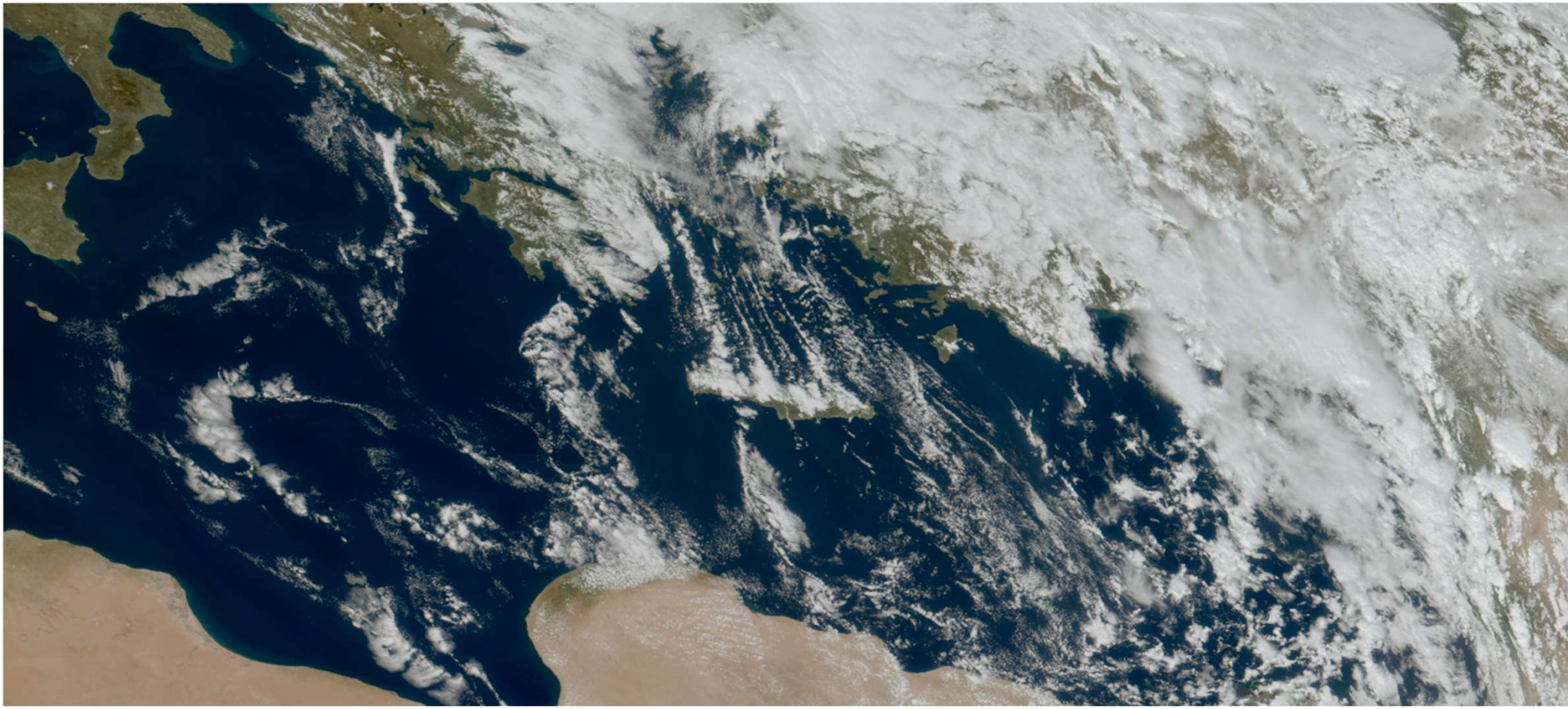
https://github.com/pytroll/satpy/pull/2557#issuecomment-1857426588

FCI observing Fires in Central Africa

- 18.03.2023
  15:40 UTC
- Fire temperature visualised using IR3.8 + NIR2.2 signal

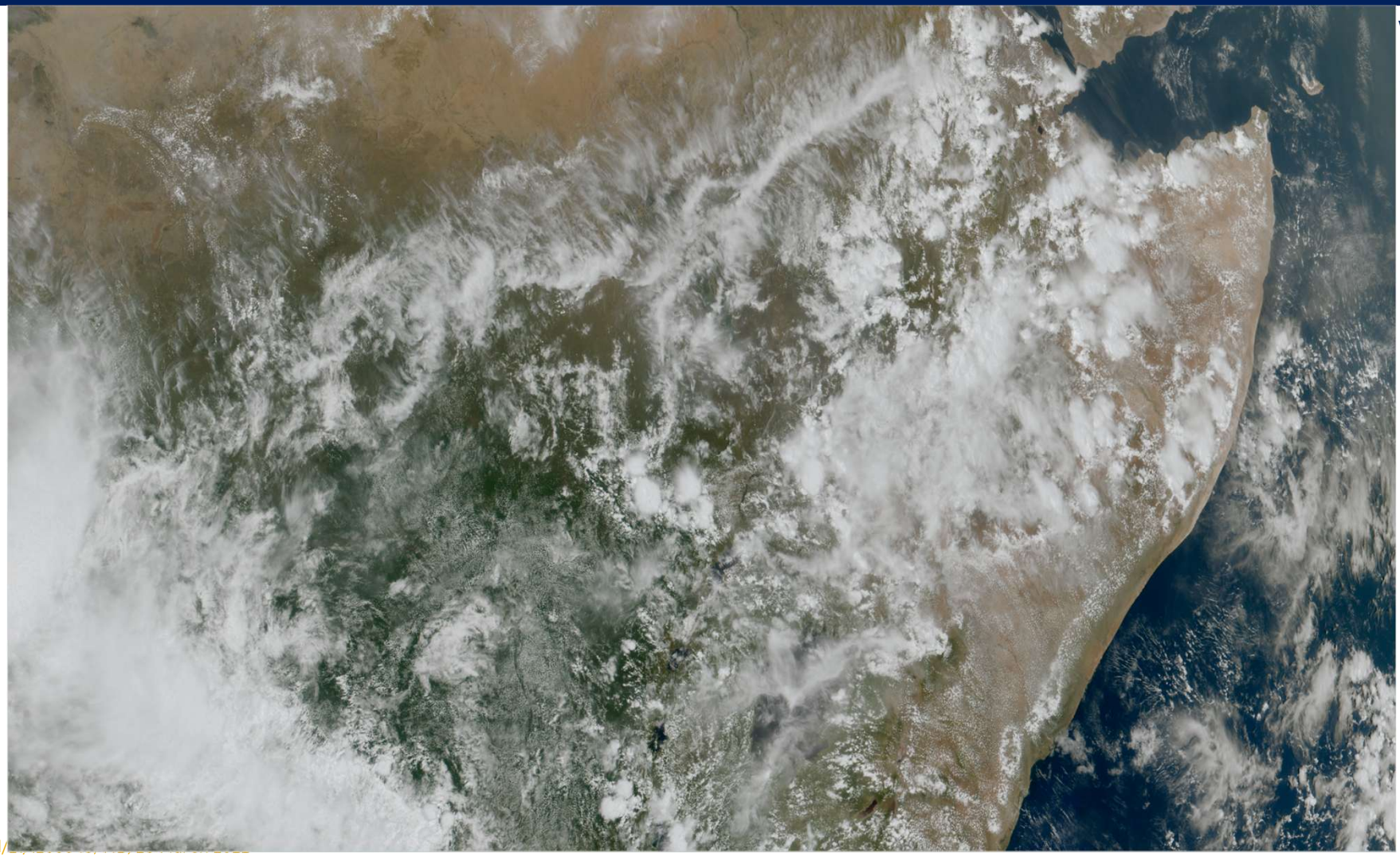


Can you spot the differences?

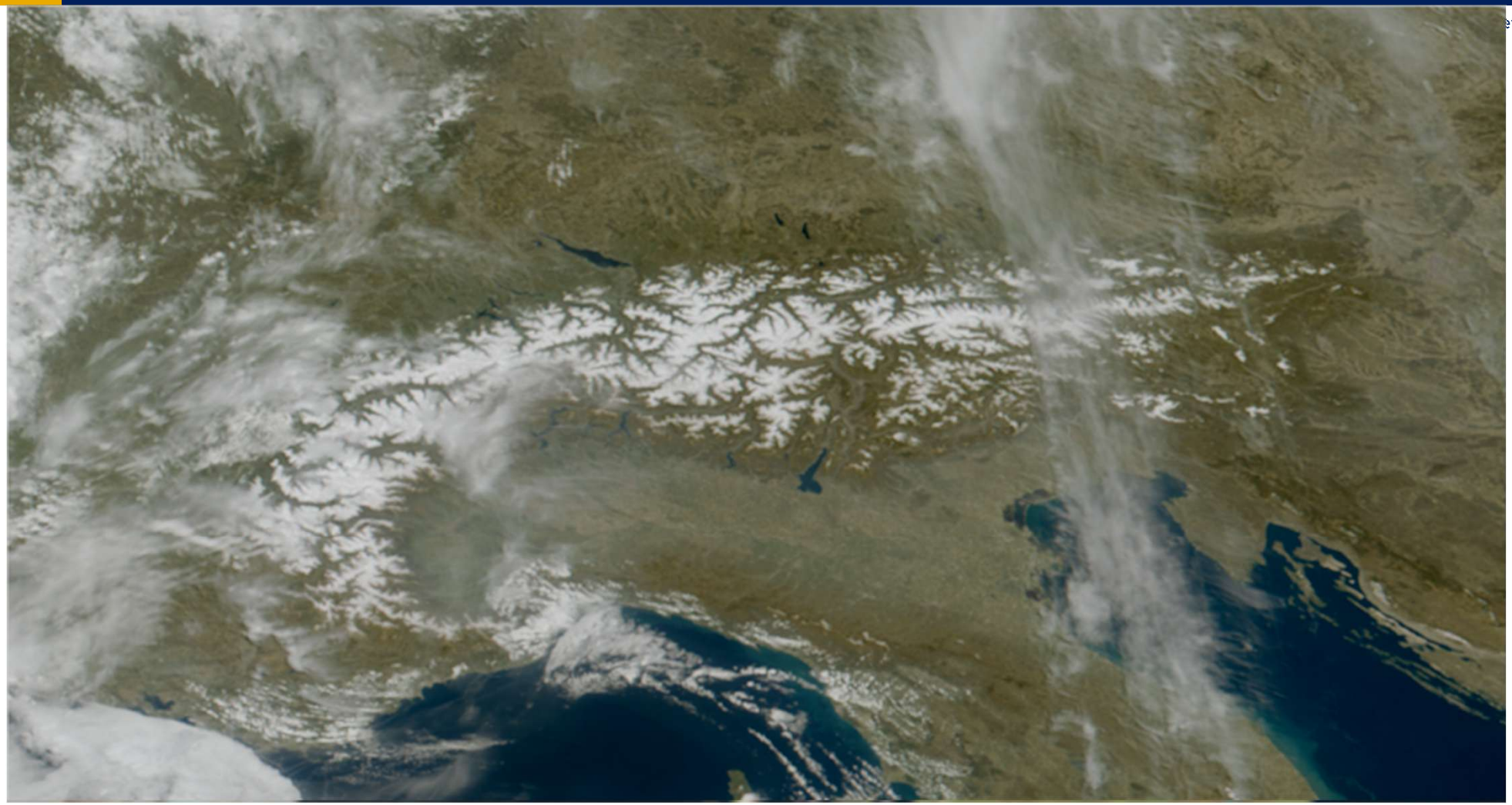


Can you spot the differences?

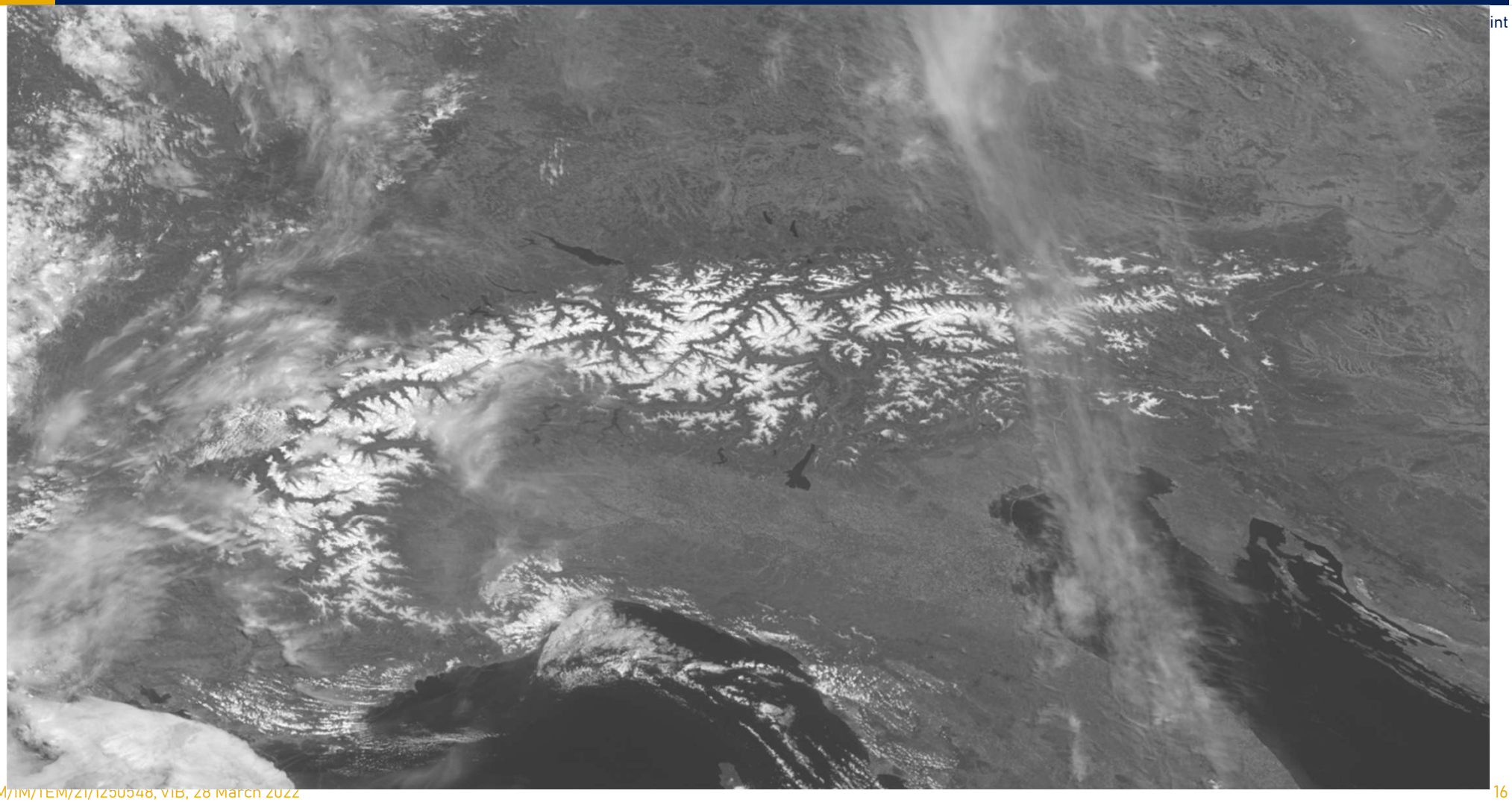
Can you spot the differences?



Can you spot the differences?

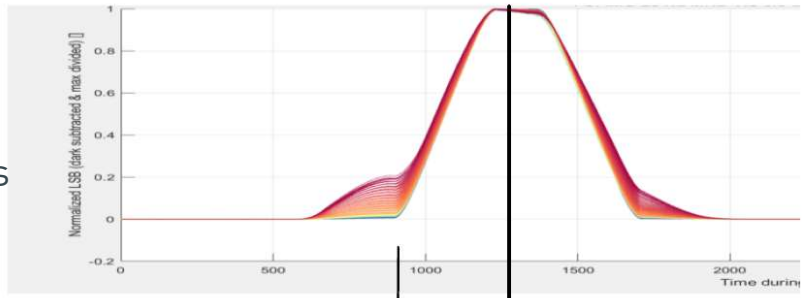


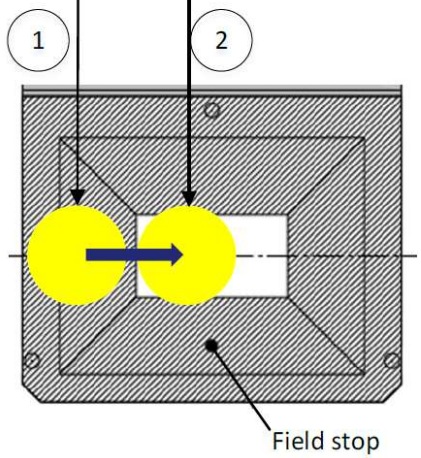
Can you spot the differences?



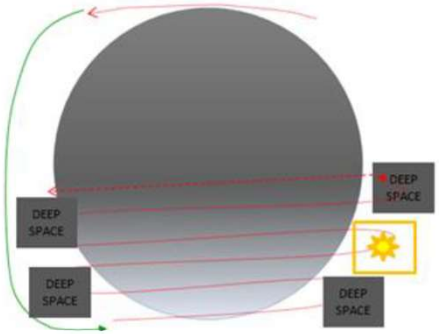
MTG-I1 FCI commissioning issues : VIS-NIR calibration straylight

- The FCI VIS-NIR in-orbit radiometric calibration relies on the on-board Metallic Neutral Density filter, which allows to acquire attenuated Sun signal 4 times a year (during eclipse).
- The first MND acquisitions exhibited an unexpected signal just before the Sun is scanned.
- Investigations have identified a straylight path (back-scatter on the field-stop and then on non-blackened mechanical surfaces) affecting VIS channels.
- The straylight path could not be established on-ground.
- The NIR channels are not affected.

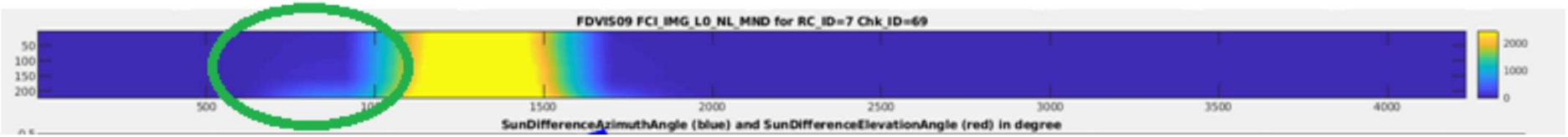




Acquisitions with MND



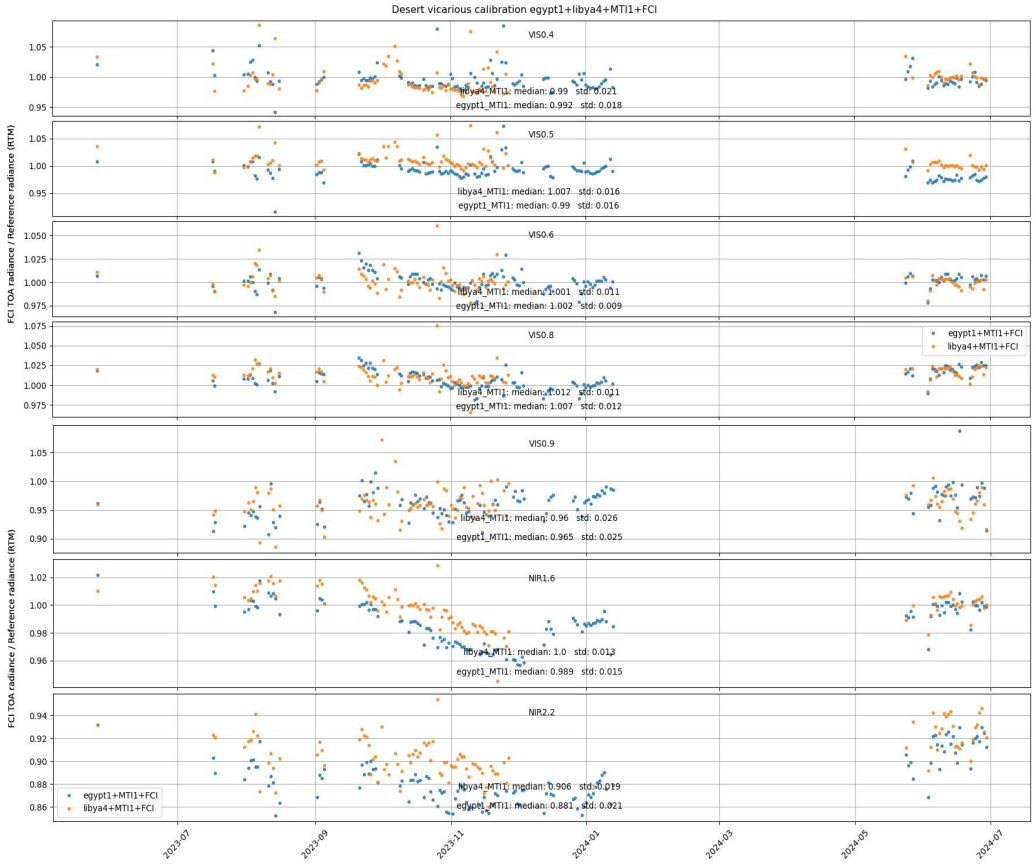
from Martin et al. (2024) [1]



MTG-I1 FCI commissioning issues : VIS-NIR calibration straylight

- MICMICS analyses (desert vicarious, Deep Convective Clouds and lunar) have established that the pre-launch calibration coefficients were still accurate post-launch.

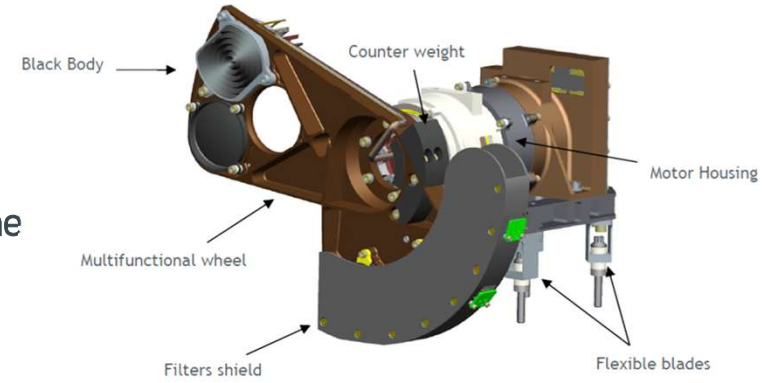
- Thus the first MND acquisition can be used to characterise the unexpected MND straylight signal for the VIS channels.

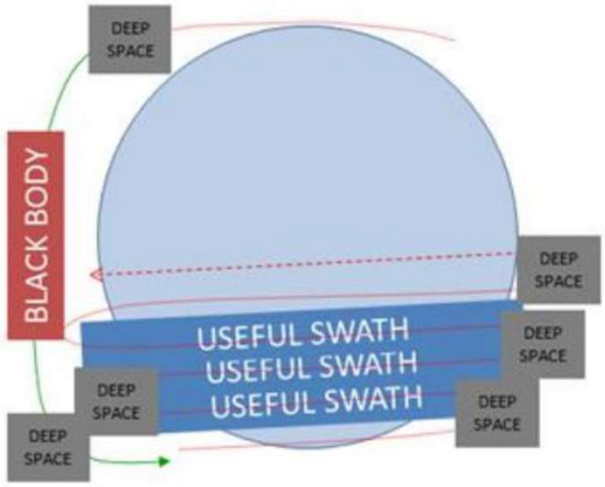


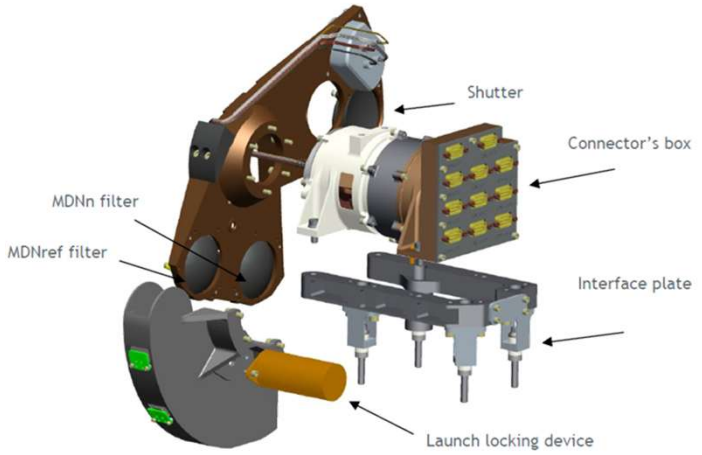
VIS-NIR radiometric performance using MICMICS Desert Calibration Algorithm

MTG-I1 FCI commissioning issues : FCI COM anomaly

- An anomaly in the on-board drive electronics chain of the calibration mechanism of the MTG-I1 FCI was detected in January 2024.
- The instrument resumed observation mode on 23 May 2024.
- Current results of the investigation show that redundancy on the calibration and obturation mechanism of the FCI has been lost. **In order to safeguard the quality of the data and the lifetime of the mission, EUMETSAT have decided to operate the instrument without the on-board calibration mechanism and relying on external calibration techniques.**







MTG-I1 FCI commissioning issues : FCI COM anomaly

Background:

- Due to ice buildup on the detector plate, the instrument's response varies and is no longer compensated by BB calibration.
- This causes a drift in measured BT and errors up to ~2K/month, particularly in channels 10.5, 12.3, and 13.3, while the drift is slower in other channels.
- This directly impacts User Requirements and the entire L2 products, RGBs, and Data Assimilation.

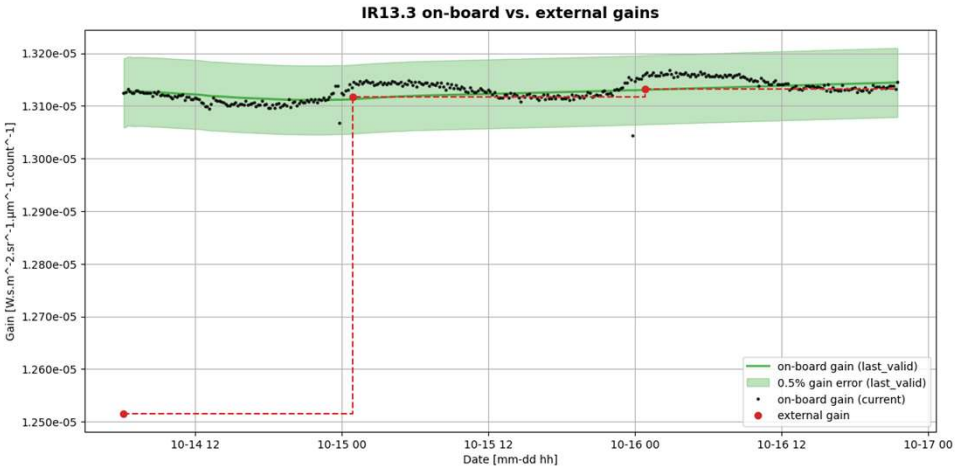
Mitigation:

- Use the MICMICS implementation of the GSICS GEO-LEO (inter-calibration with Metop-B/C IASI) to estimate the FCI IR channel-averaged gains.

Challenges

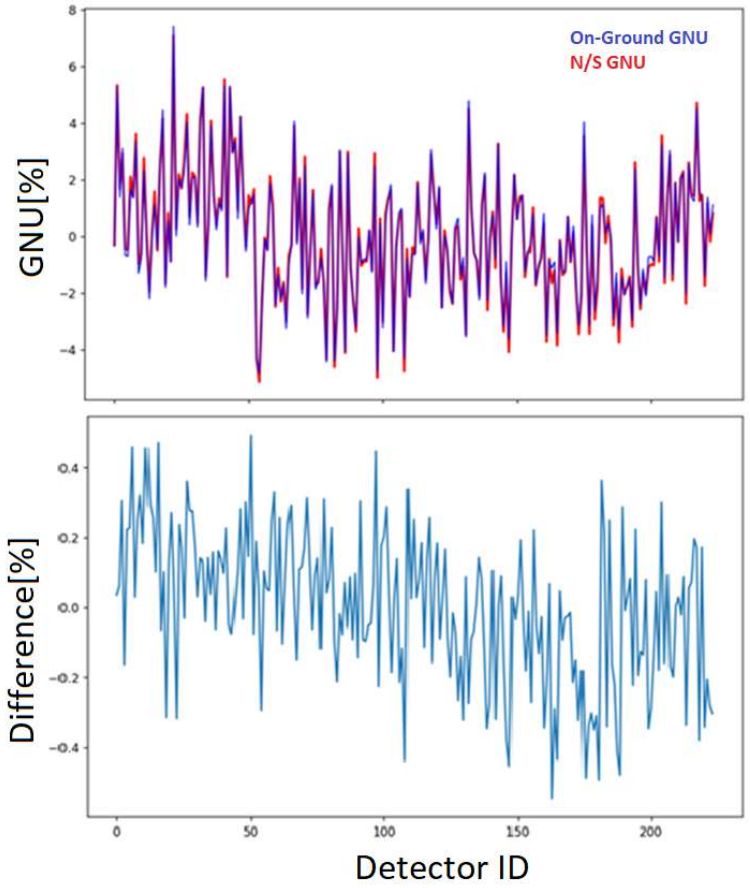
- Adaptation of the GEO-LEO algorithm to work on a shorter temporal window: 30 days -> 1 day
- Monitoring and characterization of the FCI IR channels Gain Non Uniformity (GNU)
- Prediction of the gains for the next few days
- Initialization of the L1 operational processor (IDPF-I) with faulty radiometry and ingestion of daily/hourly gains

MTG-I1 FCI commissioning issues : FCI COM anomaly



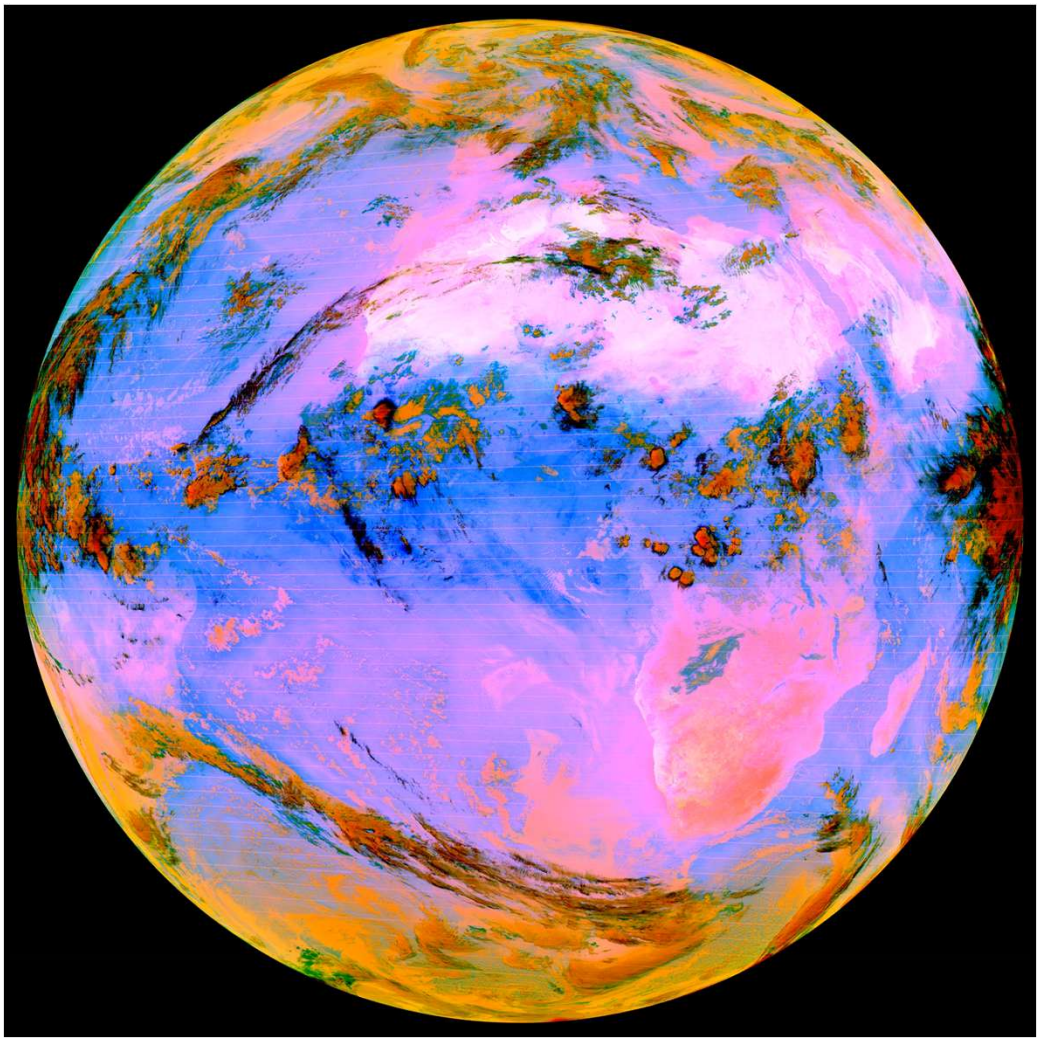
Comparison between retrieved gains using MICMICS (red) and the actual gains derived from the black-body measurements (black) for 13.3 micron channel.

Item 5b



Item 5h

Comparison between on-ground GNU and GNU extracted using the N/S scan (top), the absolute difference between the on-ground and extracted GNUs (bottom).

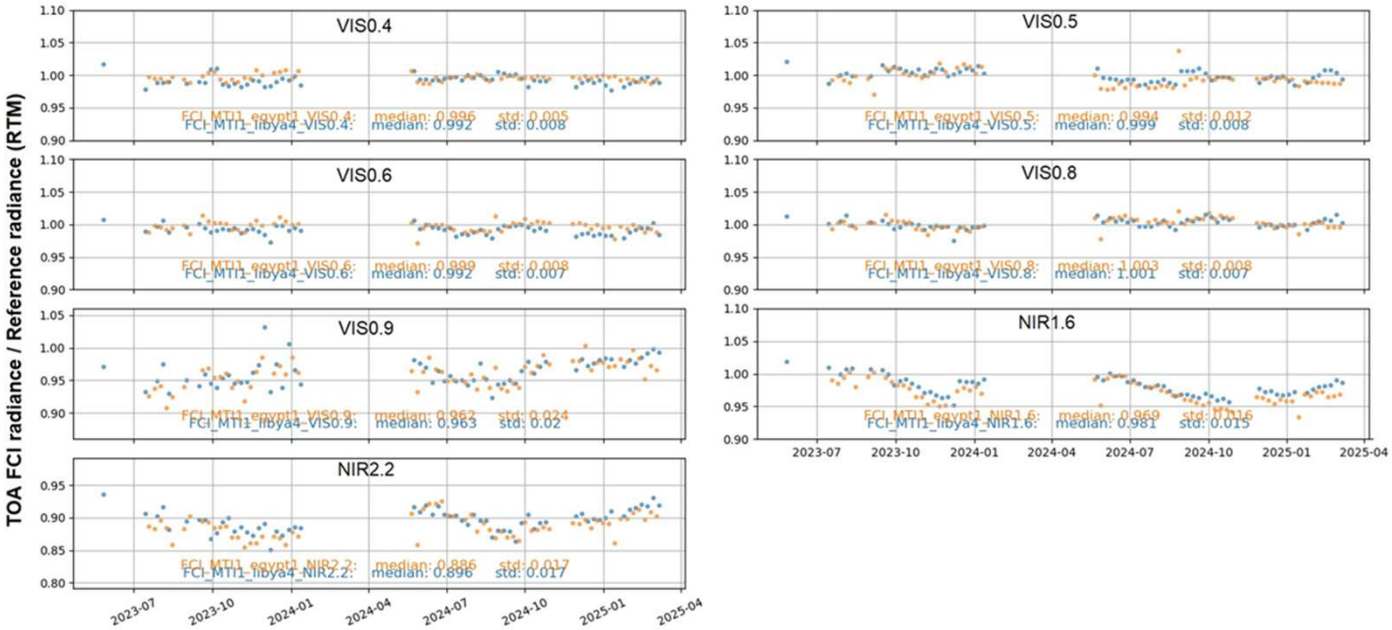


FCI IR investigations

- Non-linearity tables issues spotted with MICMICS and fixed
- IR7.3 NL-like error: on-going
- FCI IR gain prediction model, recovery after decontamination, efficient handling of active pixel swaps
- ECMWF monitoring (FCI vs NWP), including diurnal gain variations: on-going
- Earth Stray Light and striping: very well optimized.
- On many aspects the in-orbit monitoring and investigations derived improvements will benefit the recurrent satellites with on-board calibration (e.g. striping and dependencies on ESL, NL errors)

FCI NIR drift

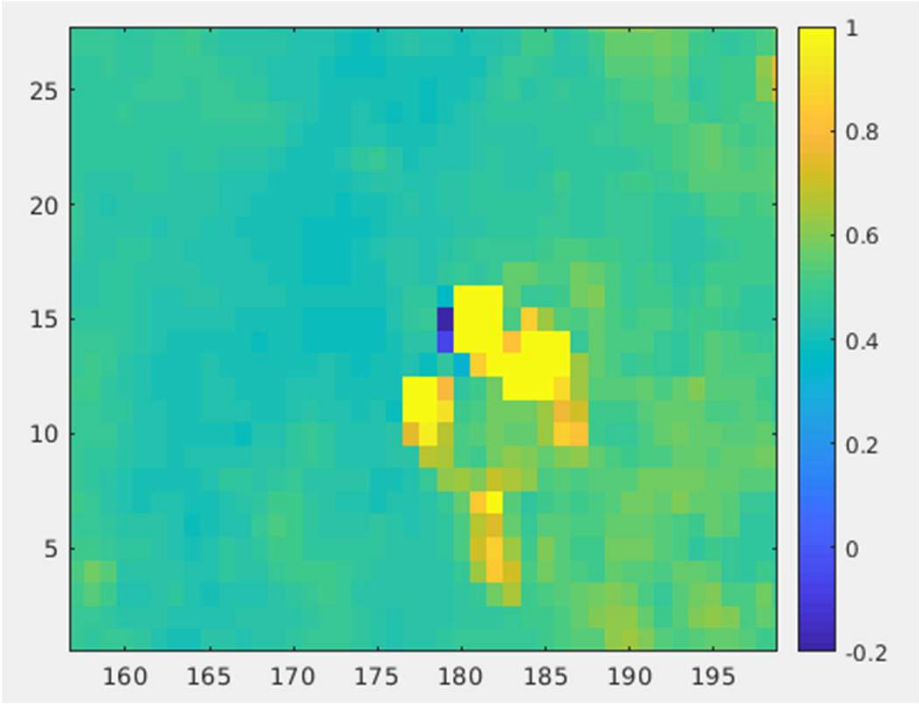
- A slow drift of the NIR1.6 and NIR2.2 channels have been measured with MICMICS deserts methods (see figure) and GEO-GEO, with unexpected impact of instrument decontamination. Investigations on-going. Item 4d
- Lunar calibration is crucial for NIR1.3, but require a special Earth Stray Light correction engine (on-going). Item 2h

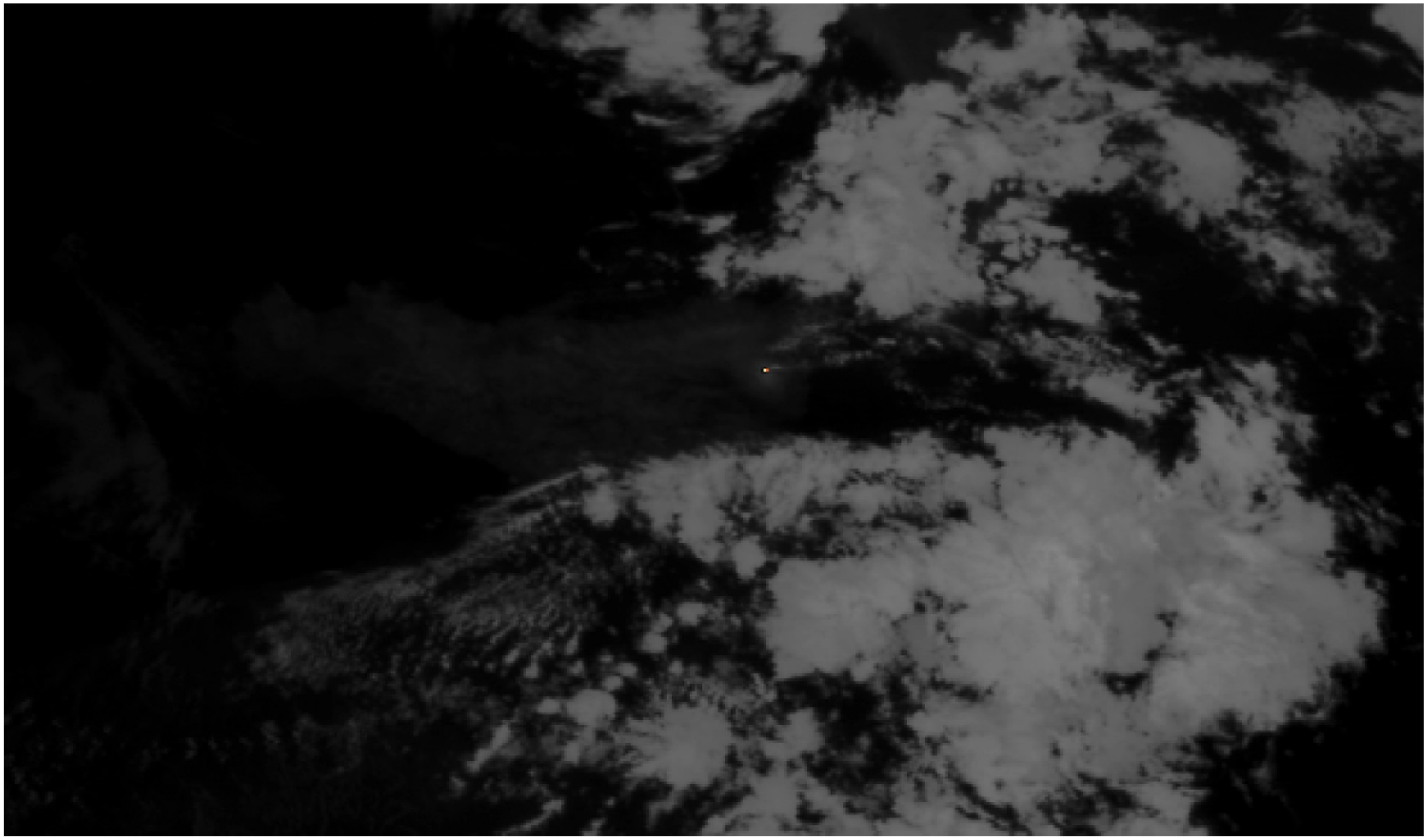


Fire Channel 3.8 – Invalid Radiances

- When a high-radiance fire hotspot is present, the resampling algorithm tends to “overshoot” and produce negative/low-level faulty pixel values in the vicinity of it;

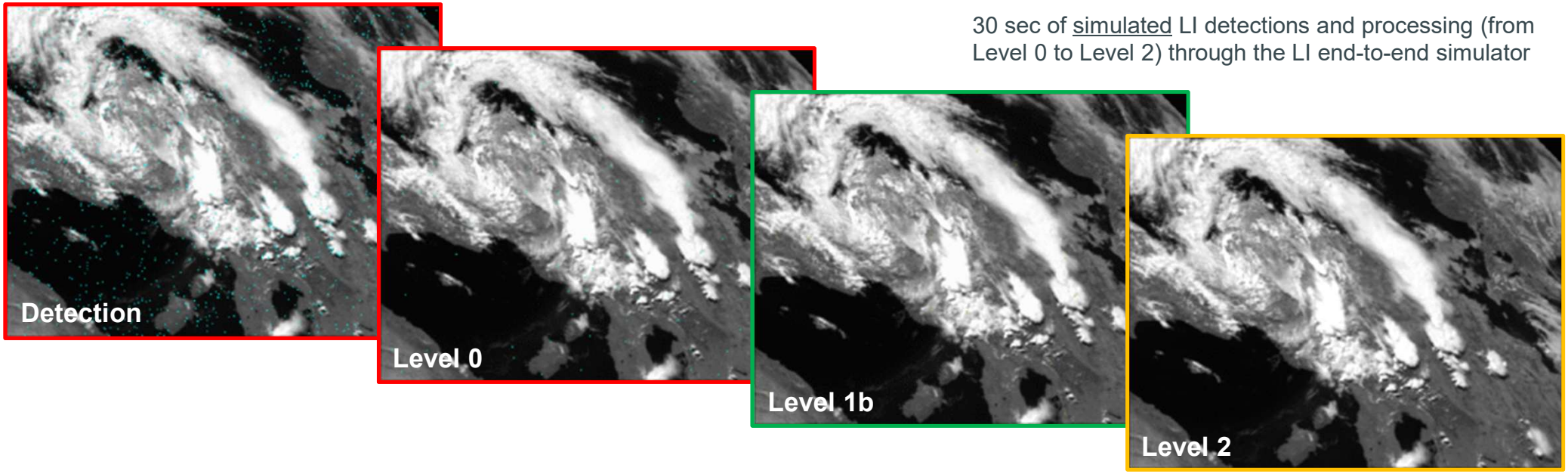
- This issue is preventing the correct analysis of wildfires, including the total Fire Radiative Power (FRP) and fire position/perimeter computation.





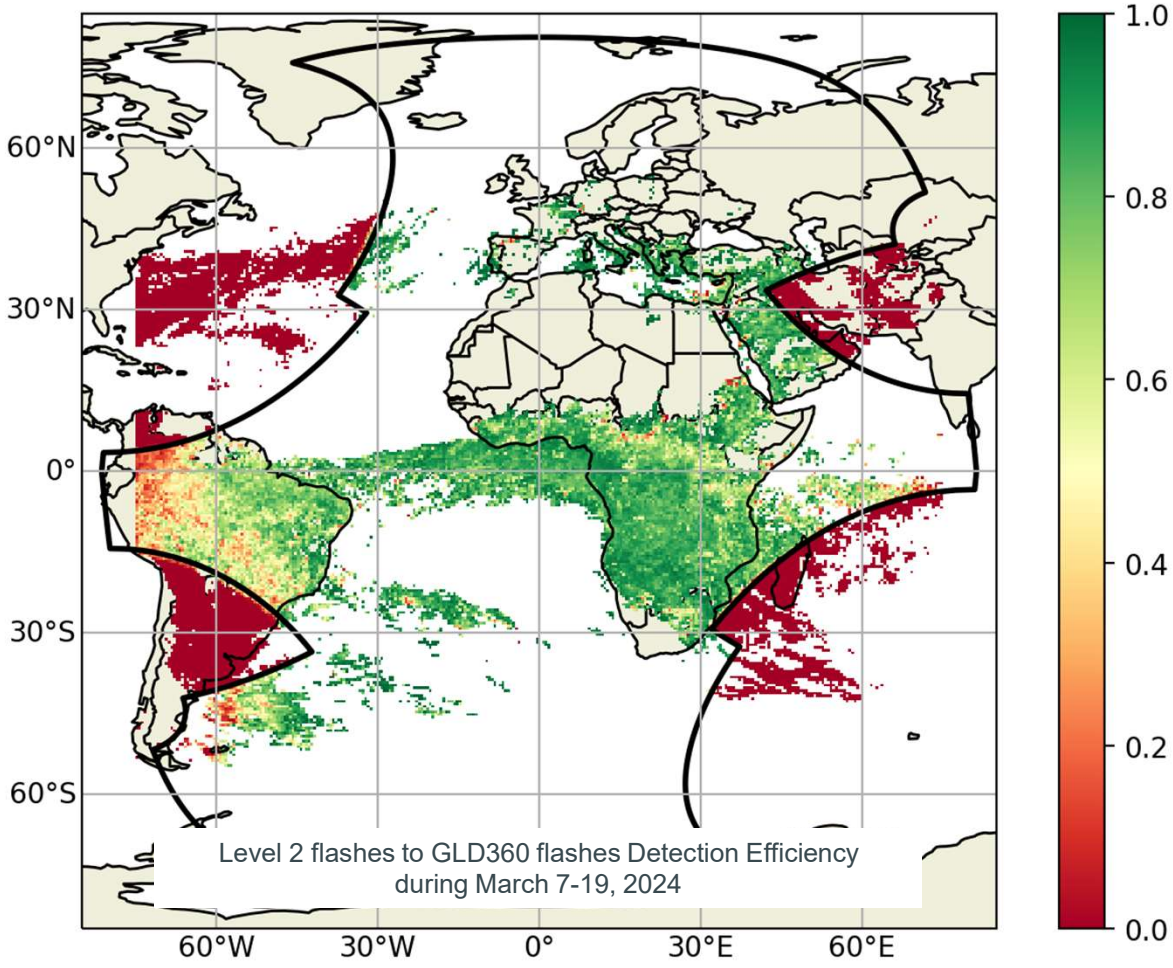
LI System: processing principle

30 sec of simulated LI detections and processing (from Level 0 to Level 2) through the LI end-to-end simulator



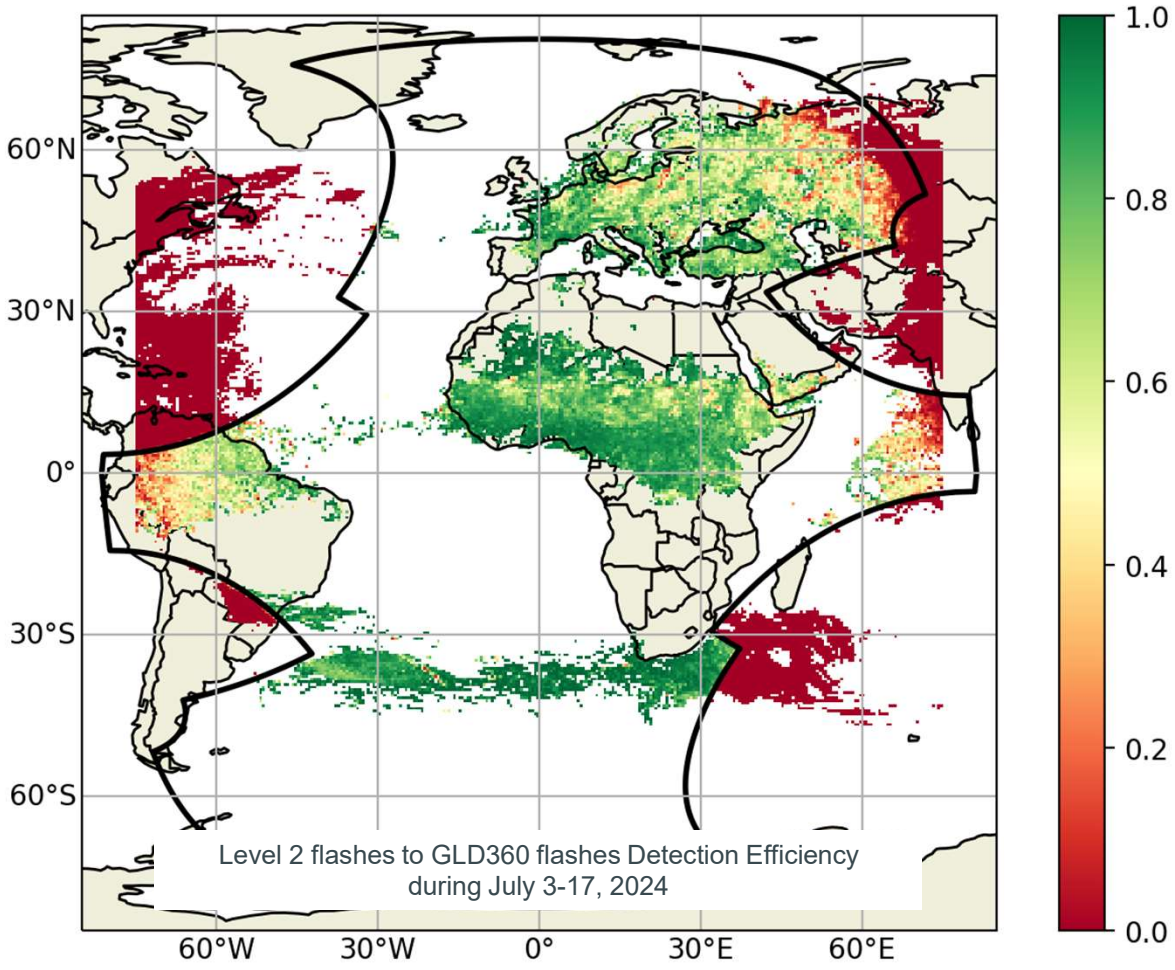
- Three processing steps take place on-board: detection + filtering of false events (Single-Detection Filter + Micro-for the production of Level 0 data;
- The ground processing (Level 1b + Level 2) removes the remaining false events;
- **EUMETSAT has the possibility of accessing and monitoring all levels of processing**.

Level 2 flash to GLD360 flash Detection Efficiency



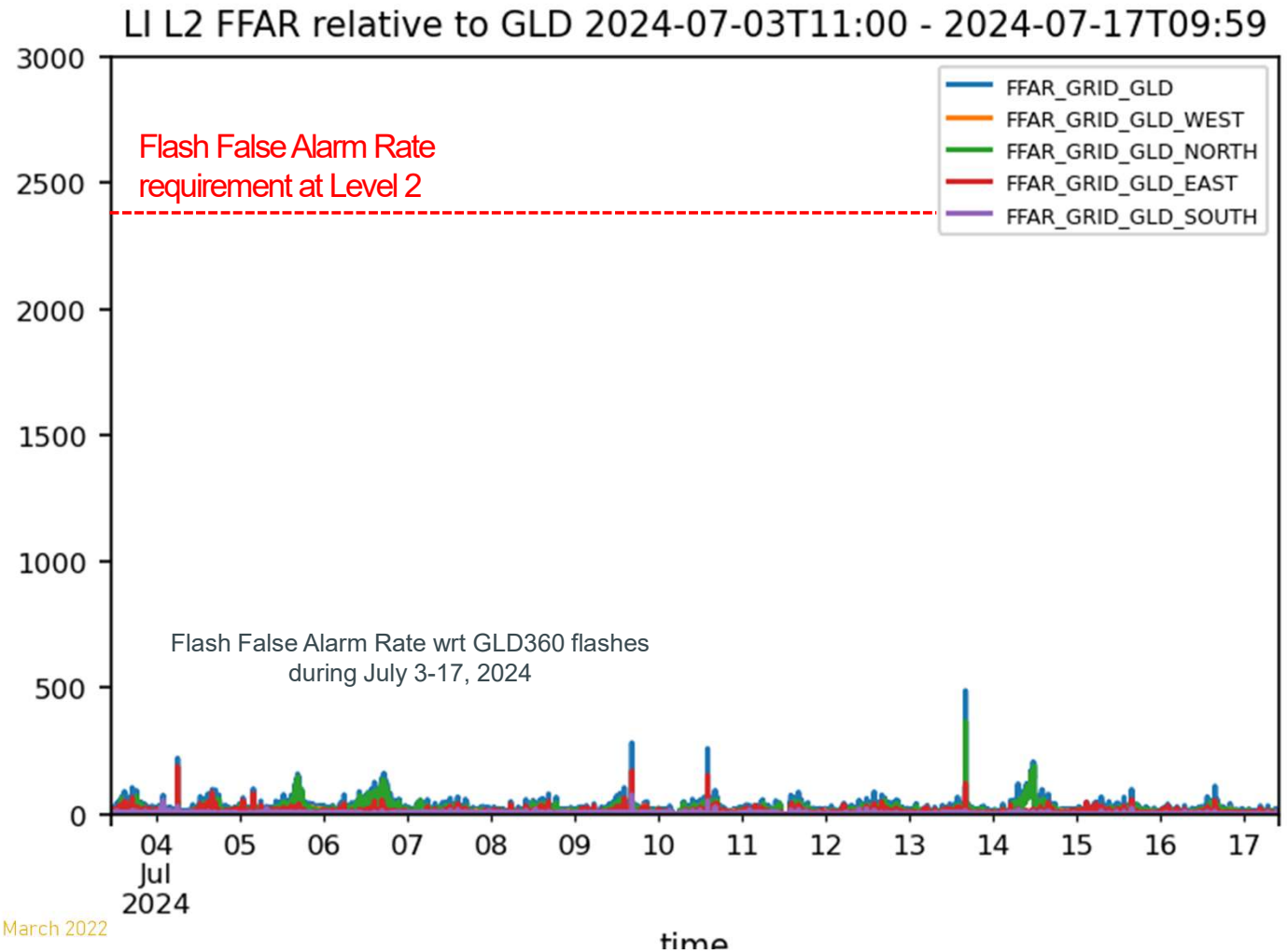
Level 2 flashes to GLD360 flashes Detection Efficiency
during March 7-19, 2024

Level 2 flash to GLD360 flash Detection Efficiency

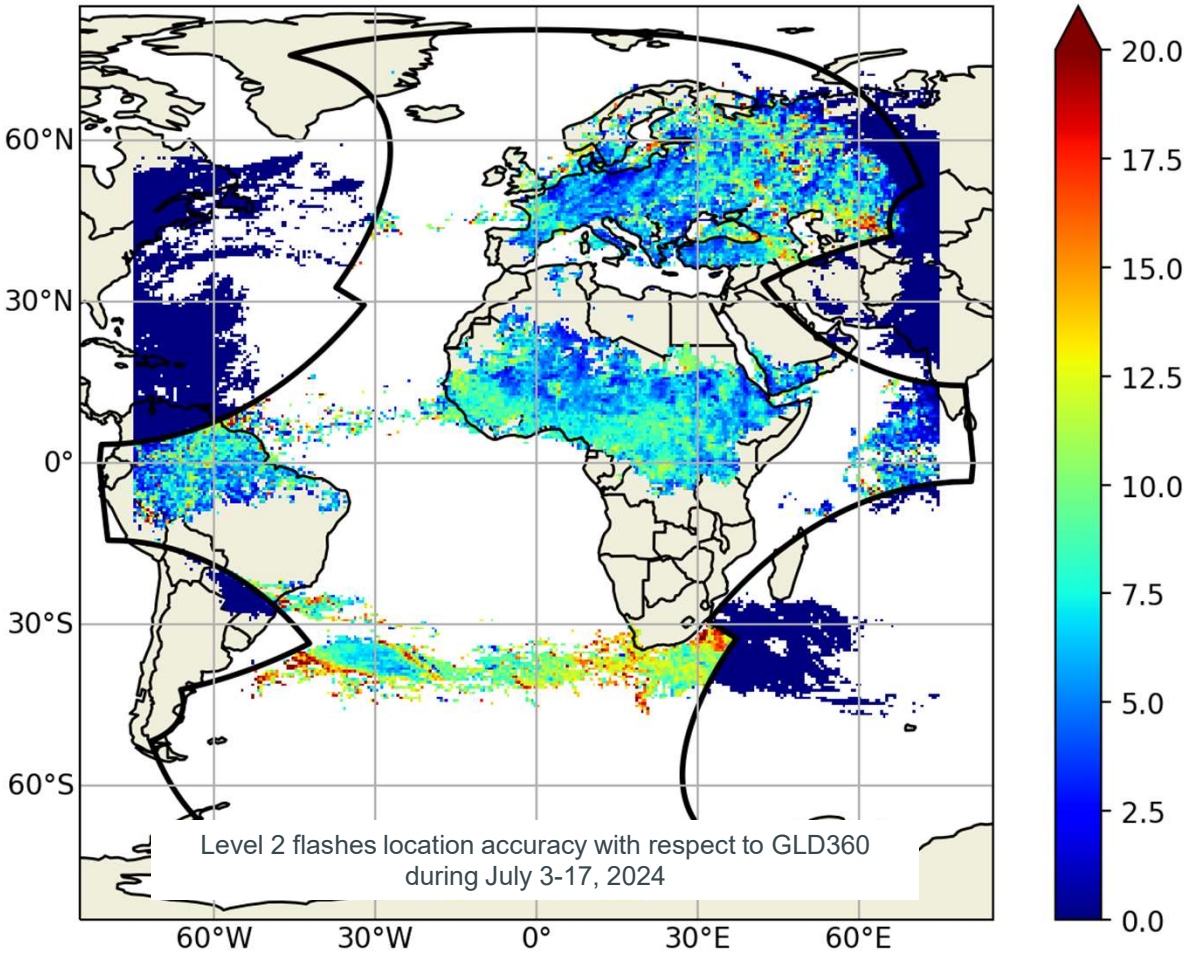


Level 2 flashes to GLD360 flashes Detection Efficiency
during July 3-17, 2024

Level 2 Flash False Alarm rate



Level 2 flash to GLD360 navigation performance



Level 2 flashes location accuracy with respect to GLD360 during July 3-17, 2024

LI Performances

ASPKE (navigation)

- Navigation is generally compliant, with a slightly degraded performance at dawn. Occasionally, the navigation of LI is significantly out of specification and can only be recovered by a re-start of IDPF-I (mitigations on-going).

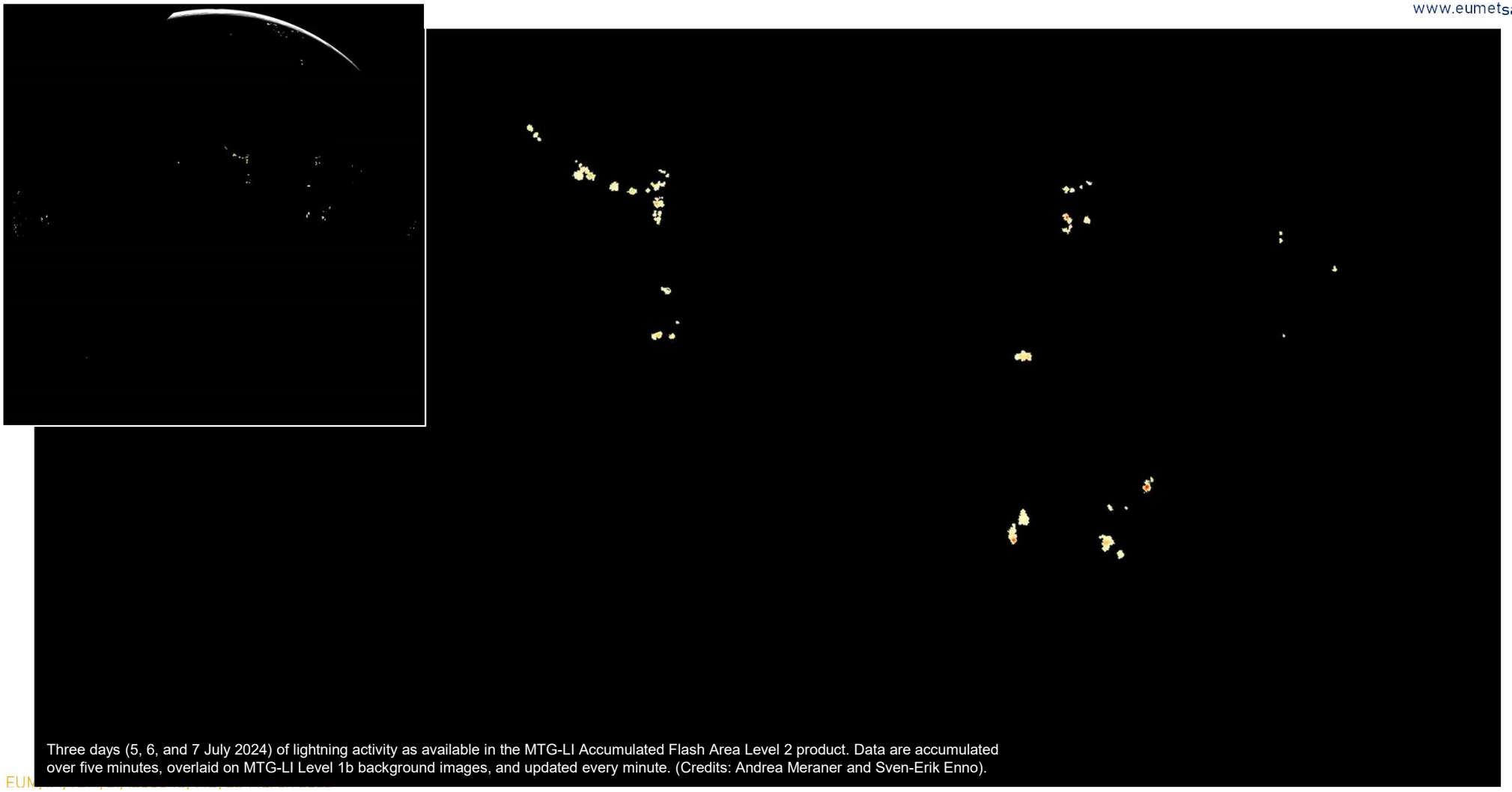
Radiometric Accuracy

- In specification on absolute and relative radiometric accuracy.

DE and FAR

- Excellent detection performances (Detection Efficiency and False Alarm Rate).
- During night-time, Flash DE is very close to the theoretical upper limit (84%);
- During day-time, the 70% DE is not always met: further optimisation on-going.
- The Flash FAR is almost constantly below 1/sec and there is the perspective of further reducing it..

LI System: Level 2 LI-2-AFA product



Three days (5, 6, and 7 July 2024) of lightning activity as available in the MTG-LI Accumulated Flash Area Level 2 product. Data are accumulated over five minutes, overlaid on MTG-LI Level 1b background images, and updated every minute. (Credits: Andrea Meraner and Sven-Erik Enno).

Summary

- MTG is the new generation of European geostationary meteorological satellites providing imagery for the early detection of fast-developing severe weather, weather forecasting and climate monitoring.
- The innovations and new stringent capabilities come with high complexity and novelty, which have posed a remarkable challenge for the commissioning of MTG-I1.
- A lot has been achieved thus far for the MTG-I1 commissioning, including
  - the tuning of the instruments/platform/processors
  - the refinement of Level-1 processing
  - the stability of the operational processors
  - the development and implementation of the mitigations for the FCI COM anomaly
- EUMETSAT multi-mission tools, SEVIRI and GSICS heritage, inter-calibration know-how and FCI instrument expertise and excellent IASI calibration enabled the recovery of the FCI radiometric calibration following the COM anomaly and the MND straylight issue.
- FCI L1c and LI were declared operational, FCI L2 is still pre-operational
- Continuous monitoring of the performance and stability of the FCI and LI is performed by EUMETSAT experts, and the system will continue to be improved in the next years.
- MTG-S1 launch is planned for July 2025.

Acknowledgements and references

ESA: MTG Space-Segment

TAS-France: MTG-I prime, FCI prime, IDPF-I prime

Leonardo: LI prime

OHB: MTG-S prime, IRS prime

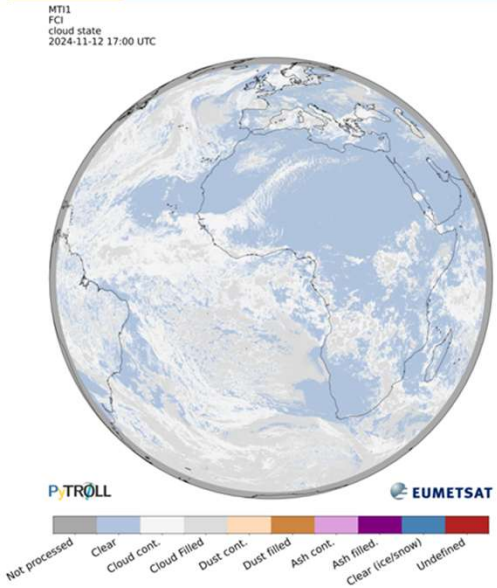
ADS: UVN prime

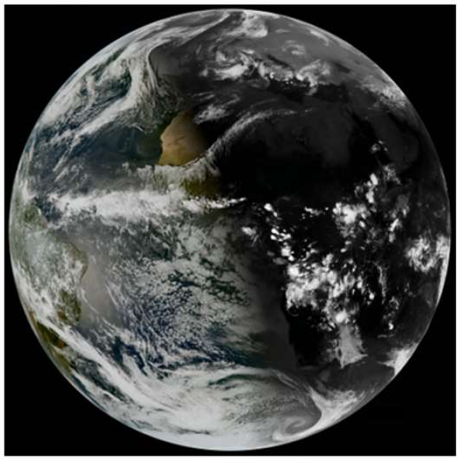
[1] Philippe MARTIN, Francis OLIVIER, Emeric HACHE, Vincent SOULIGNAC, Laurent PIRSON, Pieter Van den BRAEMBUSSCHE, Pierre KOKOU, Alex PALACIOS, Gary FOWLER, Mounir LEKOUARA, Alessandro BURINI, "*FCI Mission – Main Satellite Commissioning Results*", ICSO 2024

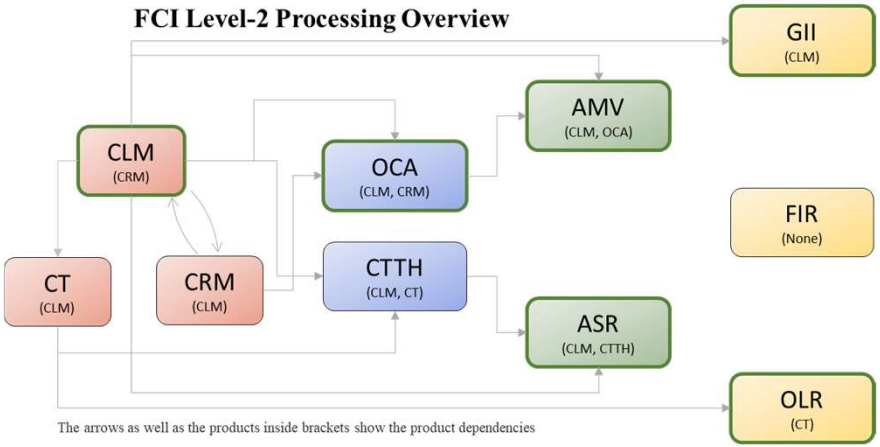
Thank you!

Questions are welcome.

Flexible Combined Imager: Status of Level-2







- Level – 2 products PVRB pre-operational on 3.12.24;
- Full Validation Report available : FCI L2 pre-operational products release note (first batch).docx;
- The products object of the first batch were:
  - CLM – Cloud Mask;
  - OCA – Optimal Cloud Analysis;
  - ASR – All Sky Radiances;
  - AMV – Atmospheric Motion Vectors (declared as demonstrational);
  - GII – Global Instability Indices;
  - OLR – Outgoing Longwave Radiation;
- Products underwent a standardised testing approach:
  - Sanity Check;
  - Verification against reference data;
  - Stability of processing and product accuracy;
  - Description and characterisation of known limitations.

Level-2 Product Assessment – Findings and limitations

- CLM
  - Good agreement with reference data – SEVIRI;
  - Configuration settings still to be optimised (detection of low-level clouds);
  - Several spectral tests are still not enabled (day-2 activity).

- OCA
  - Scientifically meaningful retrieval;
  - Quality in line with OCA-SEVIRI and stability is demonstrated;
  - Tuning of the algorithm is still on-going to mitigate some known weak points (e.g. over-estimation of cloud top height, detection of thin ice clouds over low compact stratocumulus).

- ASR
  - Scientifically meaningful retrieval;
  - Quality in line with ASR-SEVIRI.

Level-2 Product Assessment – Findings and limitations

- AMV
  - Product are scientifically meaningful, but the quality shall be assessed with longer dataset;
  - Occasional stripes in the WV AMV;
  - The pressure standard deviation value is not reliable;
  - Decided to be labelled as “demonstrational” due to the short testing period.

- GII
  - Product scientifically meaningful;
  - In line with GII-SEVIRI and radiosondes;
  - Affected by limitations of CLM and by the processor itself.

- OLR
  - Product scientifically meaningful;
  - Inline with OLR data and CERES instrument.