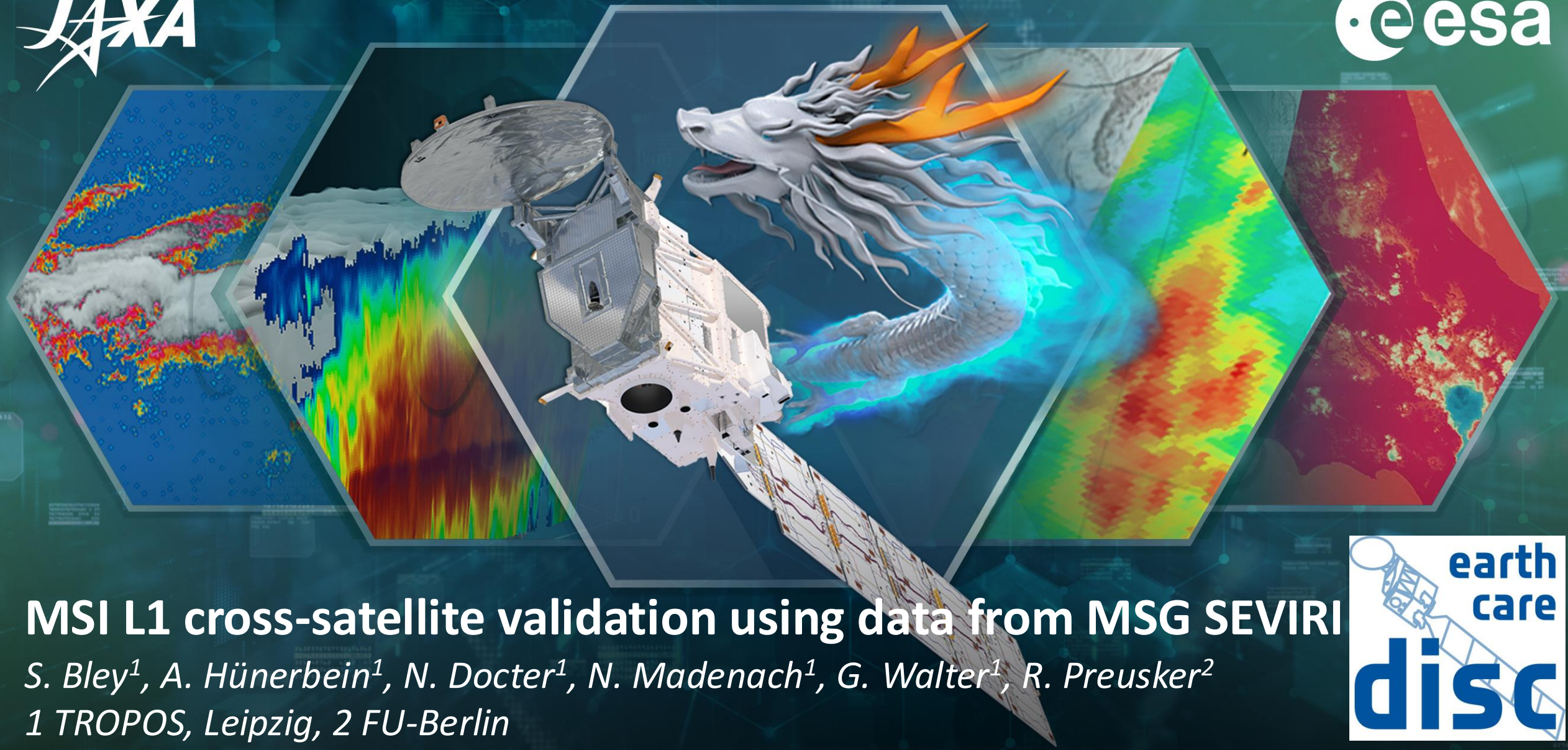


MSI L1 cross-satellite validation using data from MSG SEVIRI

S. Bley[1], A. Hünerbein[1], N. Docter[1], N. Madenach[1], G. Walter[1], R. Preusker[2]

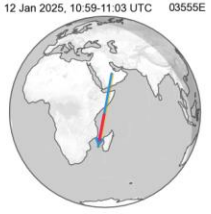
1 TROPOS, Leipzig, 2 FU-Berlin

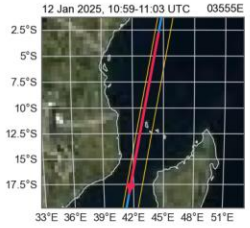
1st ESA-JAXA EarthCARE In-Orbit Validation Workshop

14 – 17 January 2025 | VIRTUAL EVENT

Introduction – Case study 12 Jan 2025

frame 03555E





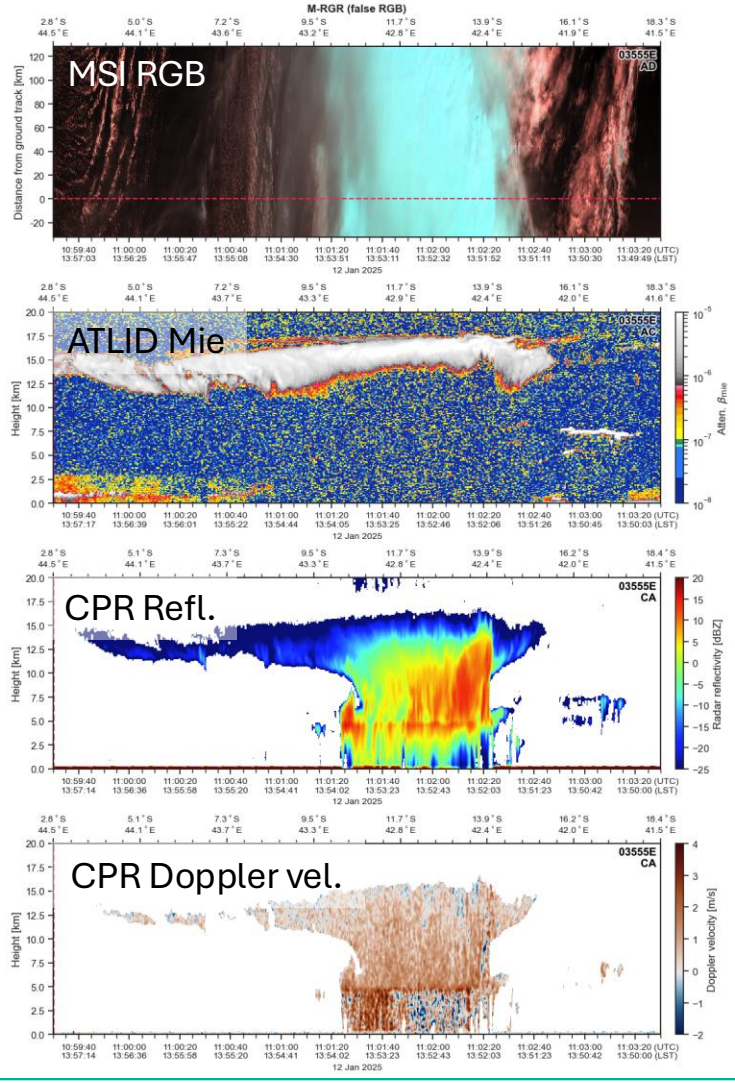
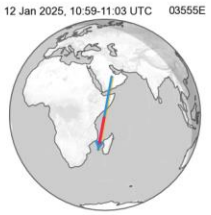
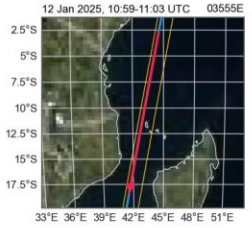


Image created by Leonard König, TROPOS

Introduction – Case study 12 Jan 2025

frame 03555E





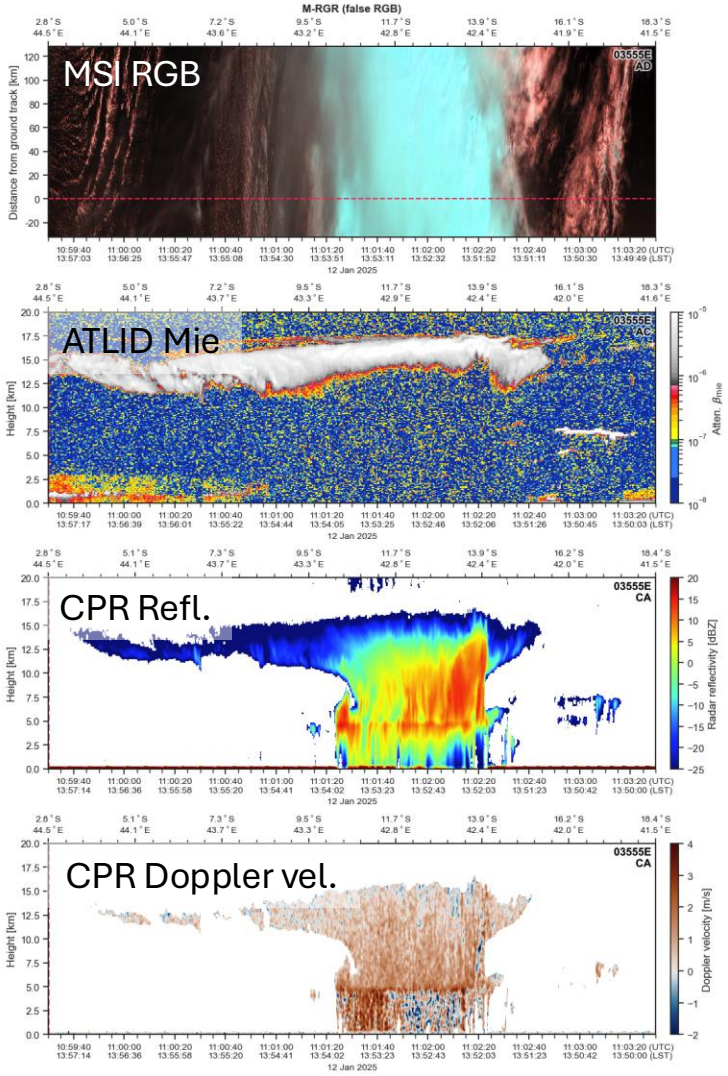
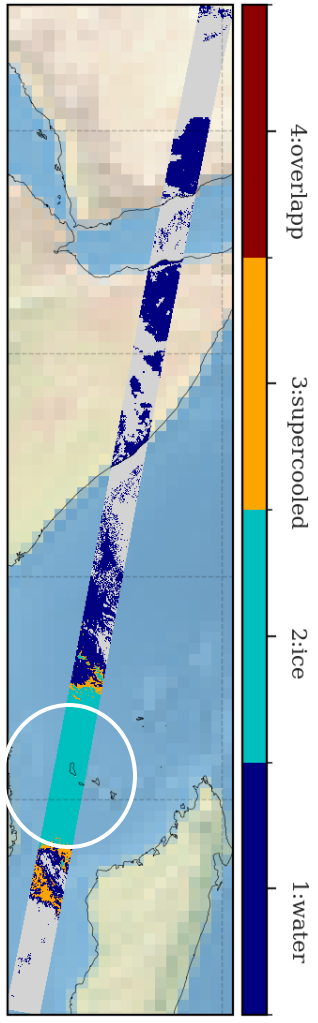


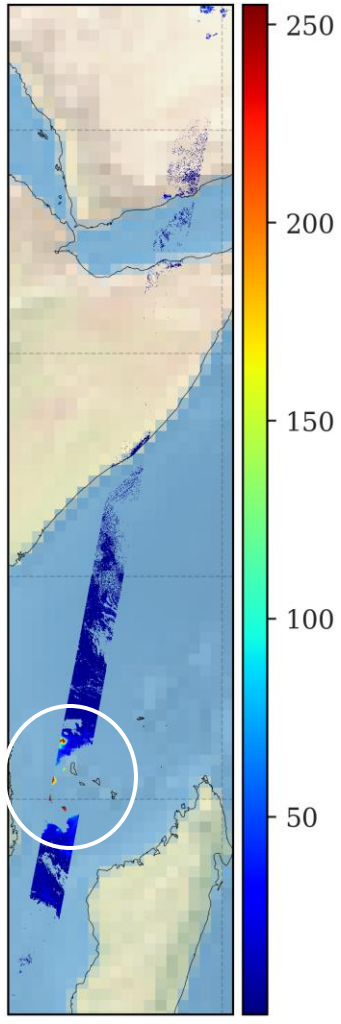
Image created by Leonard König, TROPOS

MSI L1 RGB

MSI L2a M-CM
Cloud phase



MSI L2a M-COP
Cloud optical thickness



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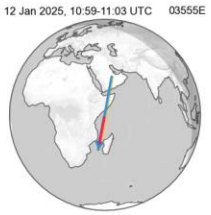
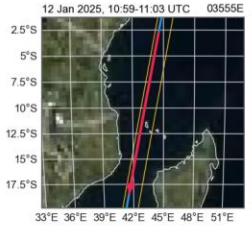
Introduction – Case study 12 Jan 2025

frame 03555E





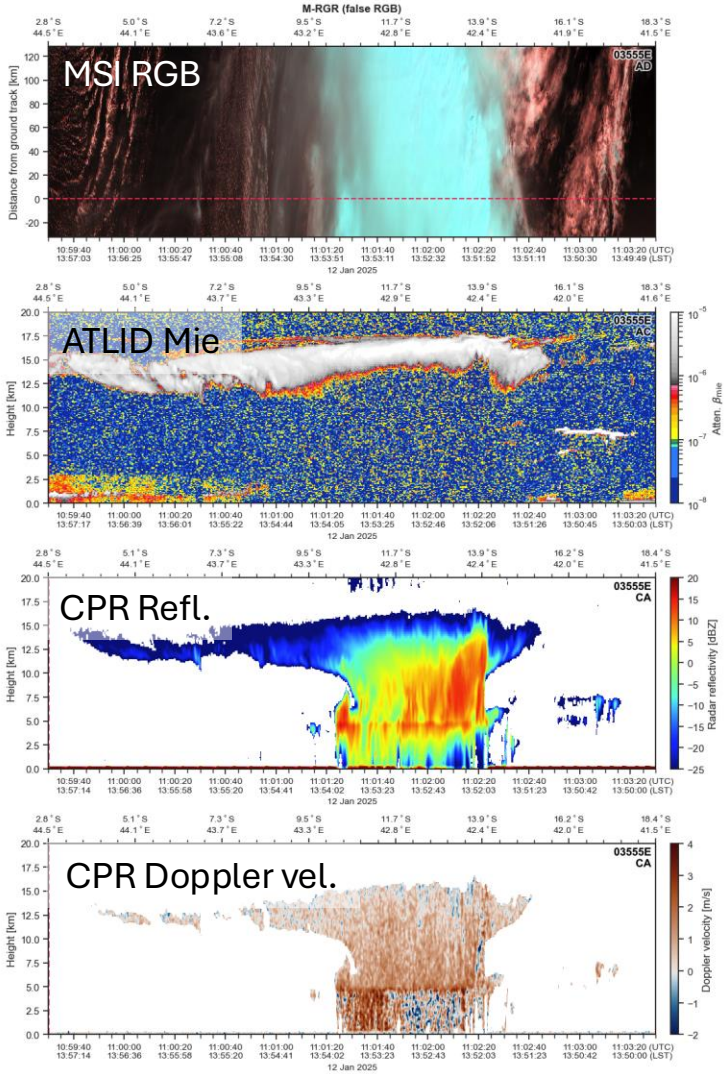
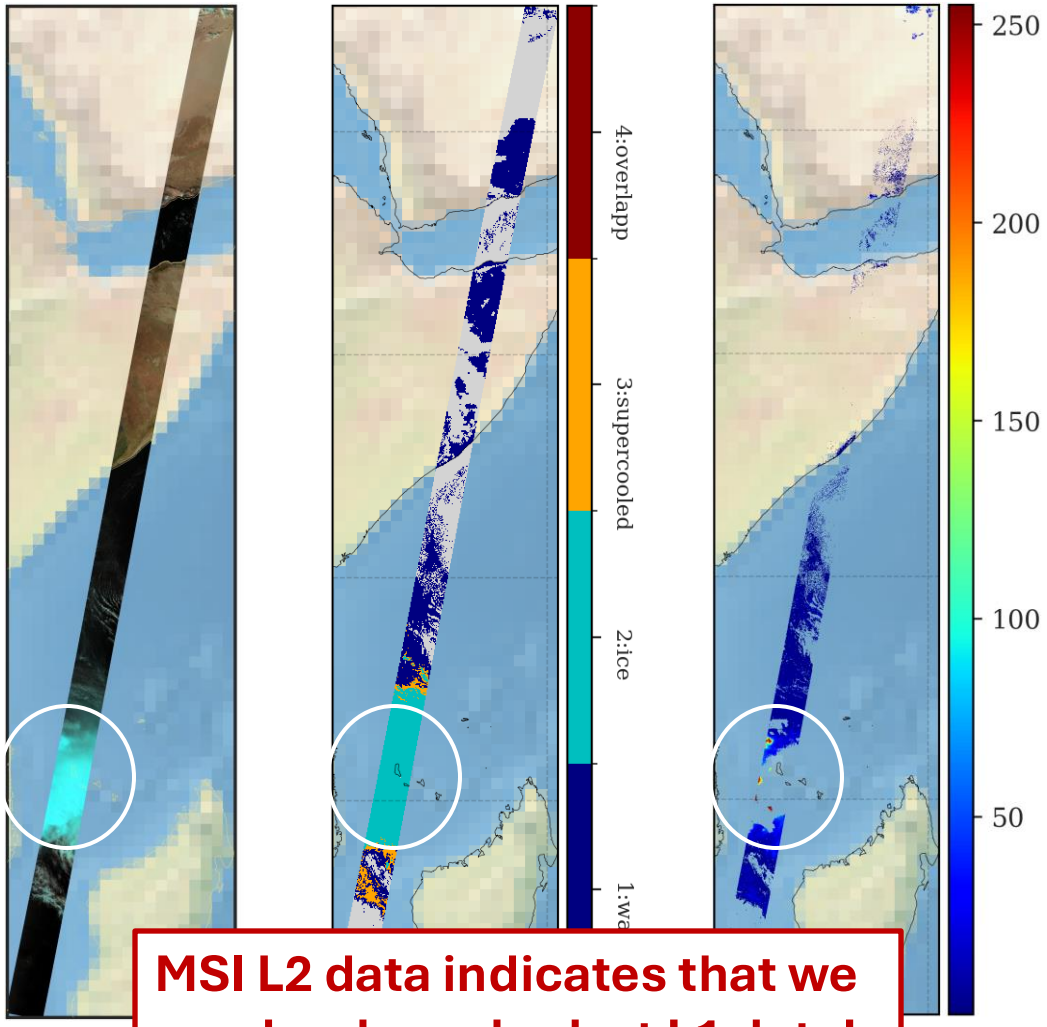


Image created by Leonard König, TROPOS

MSI L1 RGB

MSI L2a M-CM Cloud phase

MSI L2a M-COP Cloud optical thickness



MSI L2 data indicates that we need a closer look at L1 data!

→ see talk by Anja Hünerbein

TROPOS

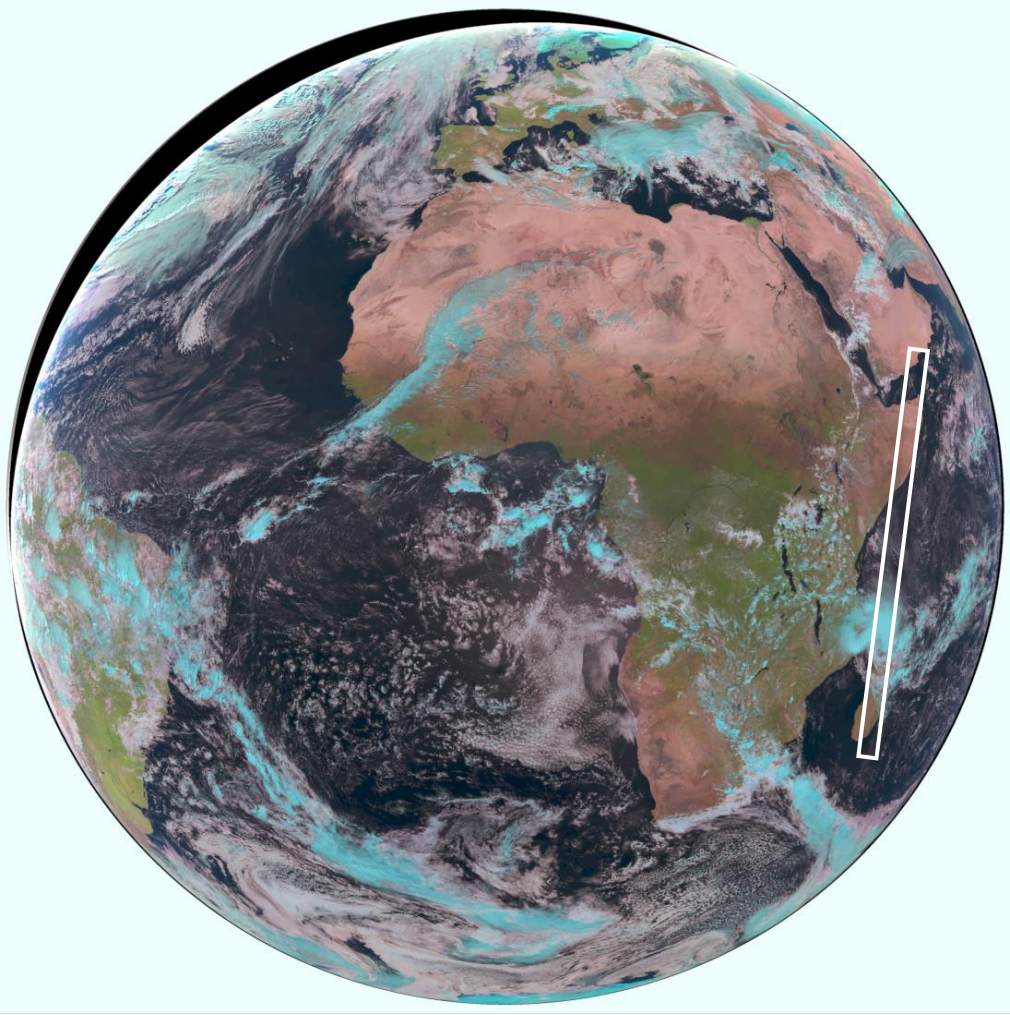
Introduction – MSI versus SEVIRI

Putting the 150 km MSI swath into a better context with SEVIRI in the background…

MSI L1 RGB

Introduction – MSI versus SEVIRI

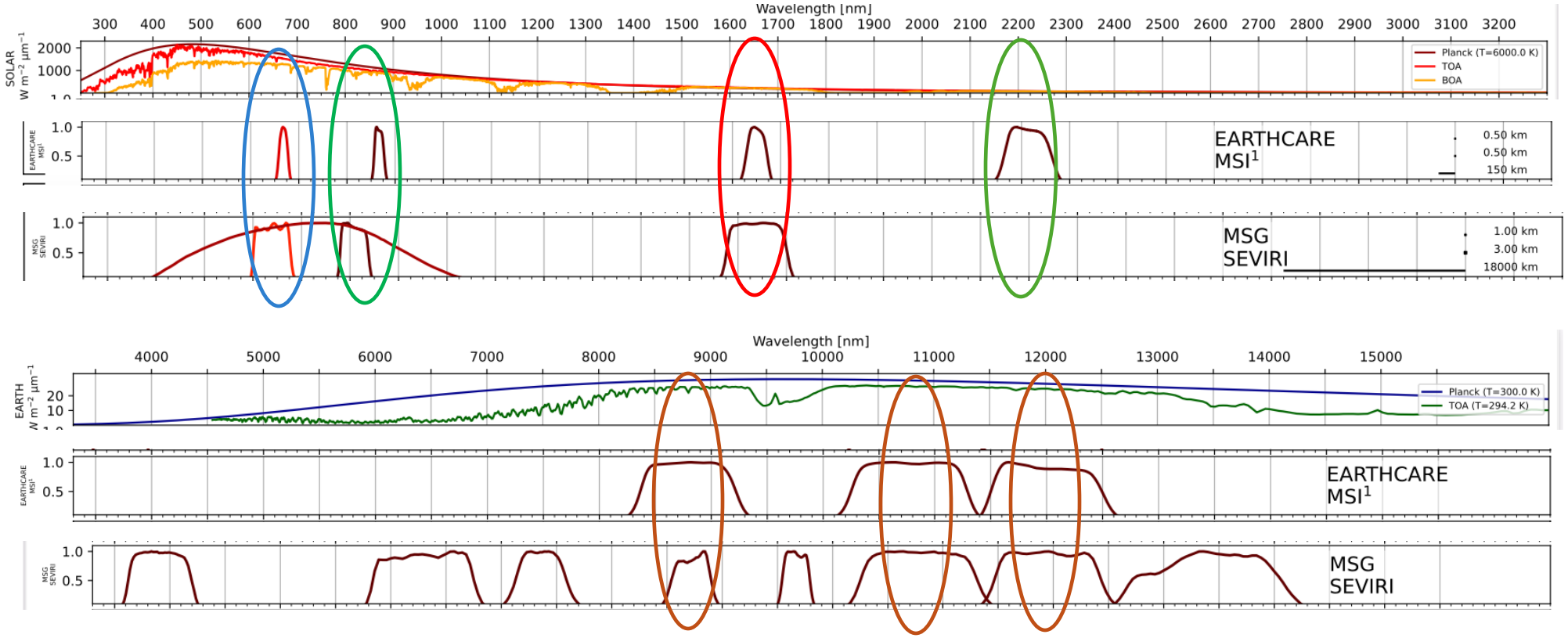
MSG SEVIRI RGB – full disc



MSI L1 RGB

- SEVIRI measures onboard geostationary satellite Meteosat Second Generation (15 min repeat cycle)
- Multiple MSI frames crossing the SEVIRI full disc every day → perfect spatiotemporal collocation
- SEVIRI's spectral channels well characterized and calibrated (operating since 2002 and still ongoing)
- Very similar spectral channels between both instruments

Introduction – MSI versus SEVIRI



Visible, Near and Short-wave infrared

Thermal InfraRed

Courtesy of Jan R. El Kassar (FU Berlin)

→ Very similar filter functions between MSI and SEVIRI spectral channels

Introduction – MSI versus SEVIRI

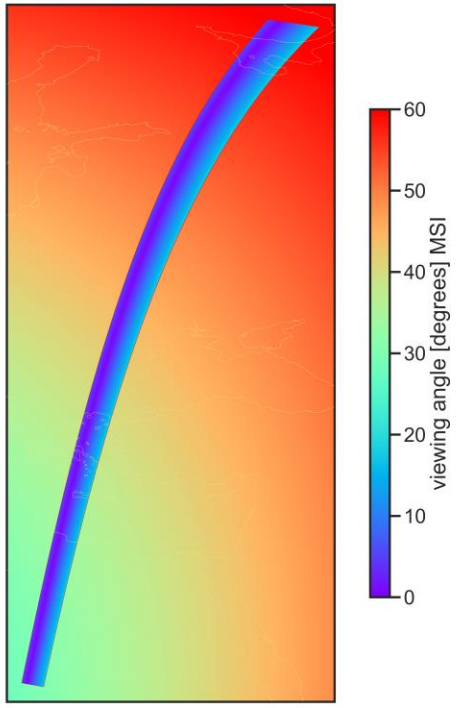
Challenges

- Much stronger viewing geometry dependency for SEVIRI compared to MSI

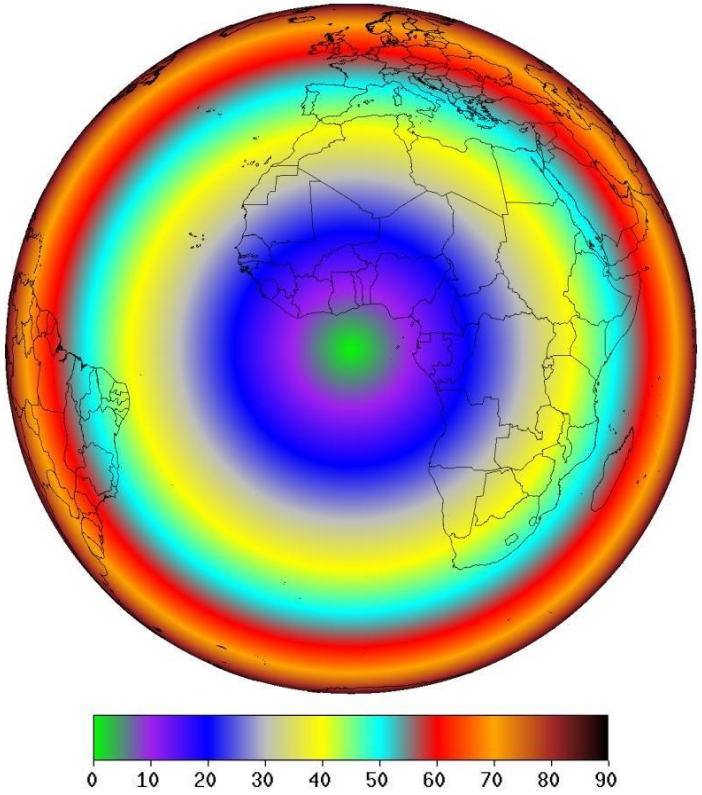
→ Limit validation to similar viewing geometry

→ SEVIRI sub-satellite point (Tropics-ITCZ) covers warm ocean, very bright and cold clouds, vegetation and desert → suitable for L1 validation

MSI viewing angle compared to SEVIRI for frame D over Europe



MSG SEVIRI viewing geometry



Viewing geometry of SEVIRI on MSG-2 satellite located at 0 deg W, Neukermans, 2012.

Introduction – MSI versus SEVIRI

Challenges

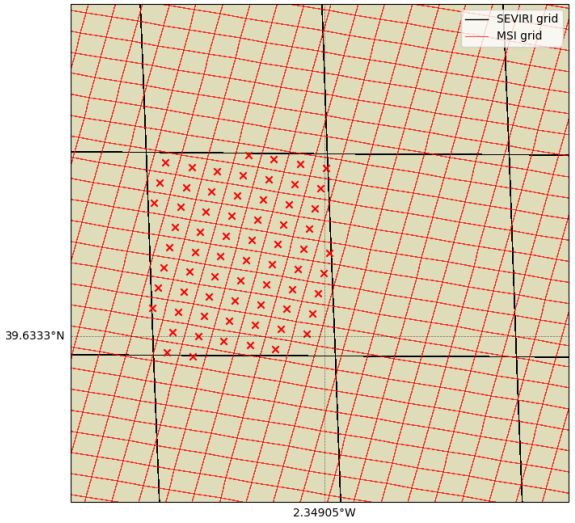
- Much stronger viewing geometry dependency for SEVIRI compared to MSI

→ Limit validation to similar viewing geometry

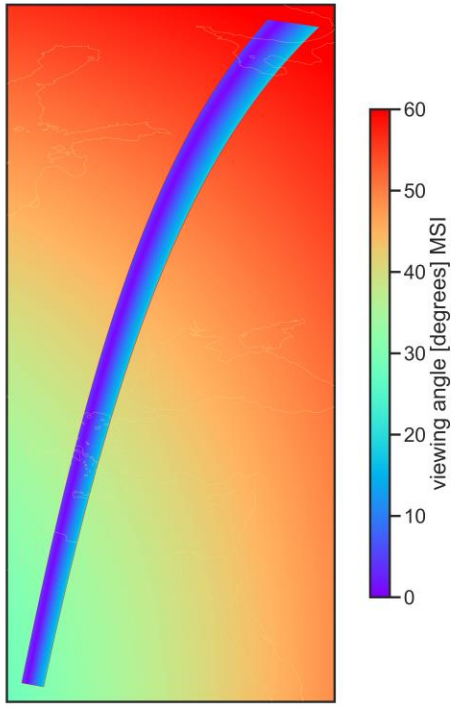
→ SEVIRI sub-satellite point (Tropics-ITCZ) covers warm ocean, very bright and cold clouds, vegetation and desert → suitable for L1 validation

- Spatial resolution: 3x3 km for SEVIRI versus 0.5x0.5 km for MSI

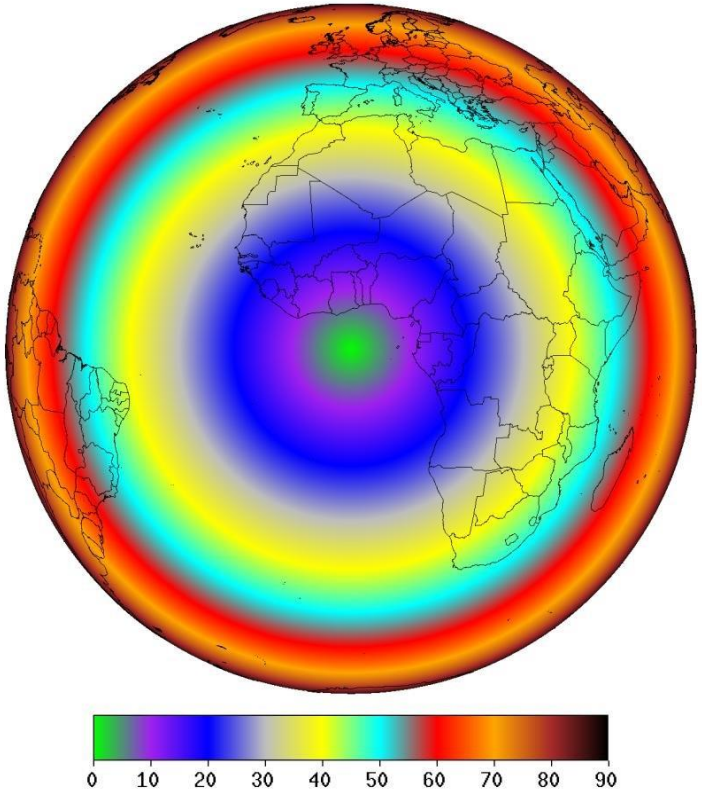
→ Minimum of 36 MSI pixels within one SEVIRI pixel → sub-pixel inhomogeneity



MSI viewing angle compared to SEVIRI for frame D over Europe



MSG SEVIRI viewing geometry



Viewing geometry of SEVIRI on MSG-2 satellite located at 0 deg W, Neukermans, 2012.

Introduction - Cross-satellite calibration

- Cross-satellite or inter-satellite validation and calibration has proven to work for many missions like recently for the Flexible Combined Imager (FCI) onboard Meteosat Third Generation (see presentation James Champion, EUMETSAT conference 2024)
- In contrast to MODIS, SEVIRI VIS (0.6 µm) is 8% too low, while channel 1.6 µm is 3.5% too high
- Comparison between SEVIRI and AVHRR demonstrates 6% higher VIS (0.6 µm) and 26% higher SWIR-1 (1.6 µm) for SEVIRI reflectances (Roebelling and Stammes 2006, JGR)
- Radiative transfer calculations of the effect of trace gas absorption on top-of-atmosphere reflectances can be used to correct for differences in spectral response functions (Meirink et al. 2013, AMT)

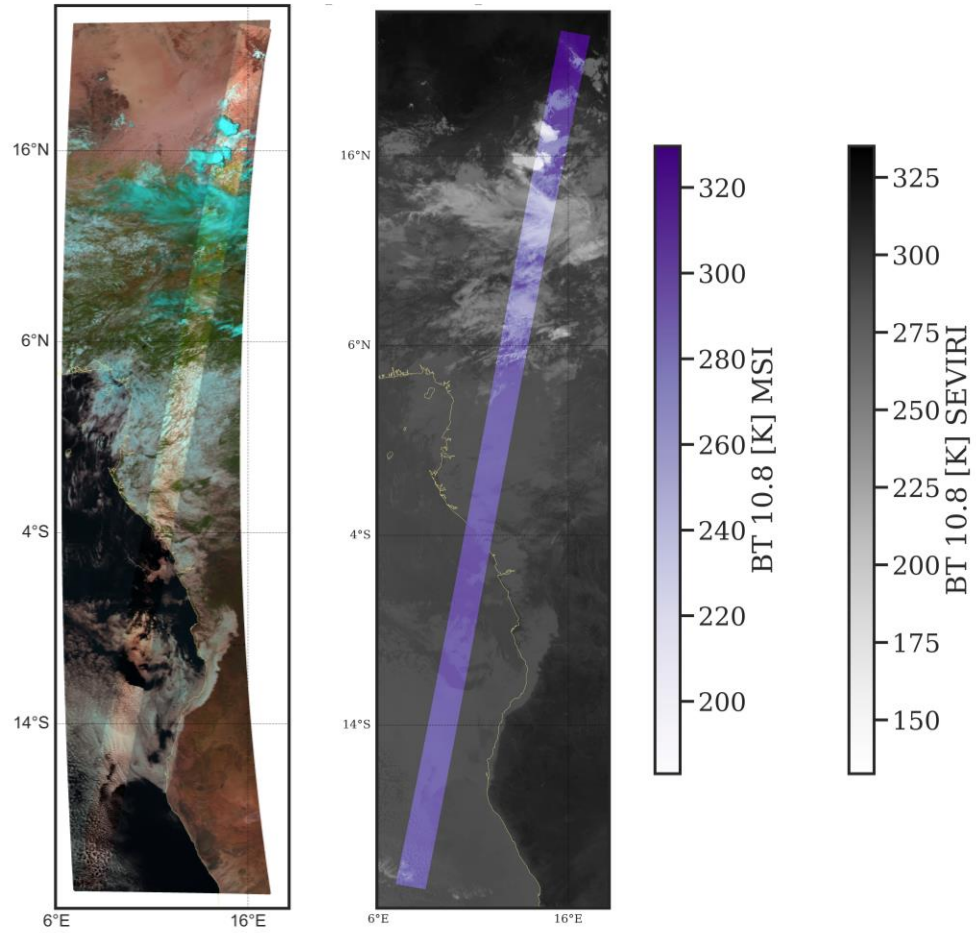
→ MSI L1 calibration verification during the commissioning phase has shown that vicarious calibration is needed to improve L1 data (particularly for VNS)

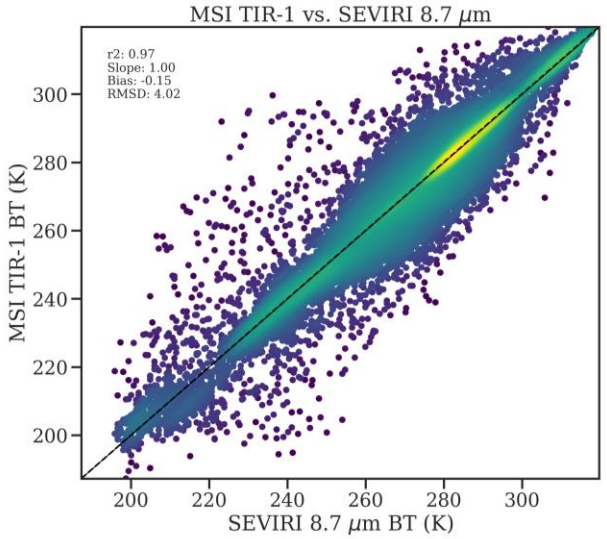
Intercomparison of MSI TIR channels

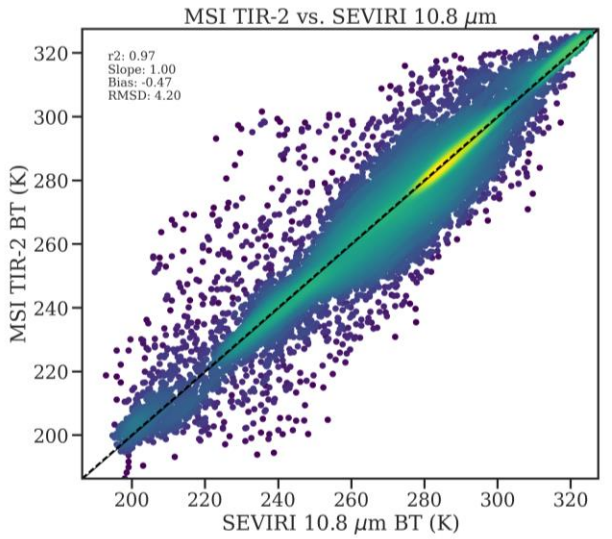
frame 01067E

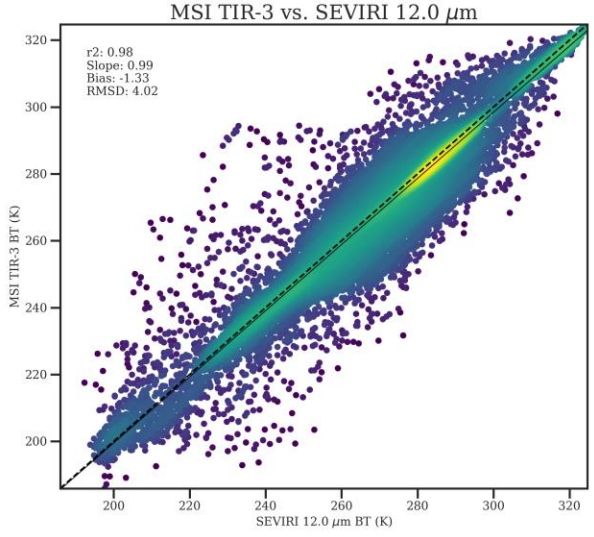
ECA_EXAA_MSI_RGR_1C_20240805T130956Z_20240805T144606Z_01067E

SEVIRI_20240805T131510Z_20240805T132742Z









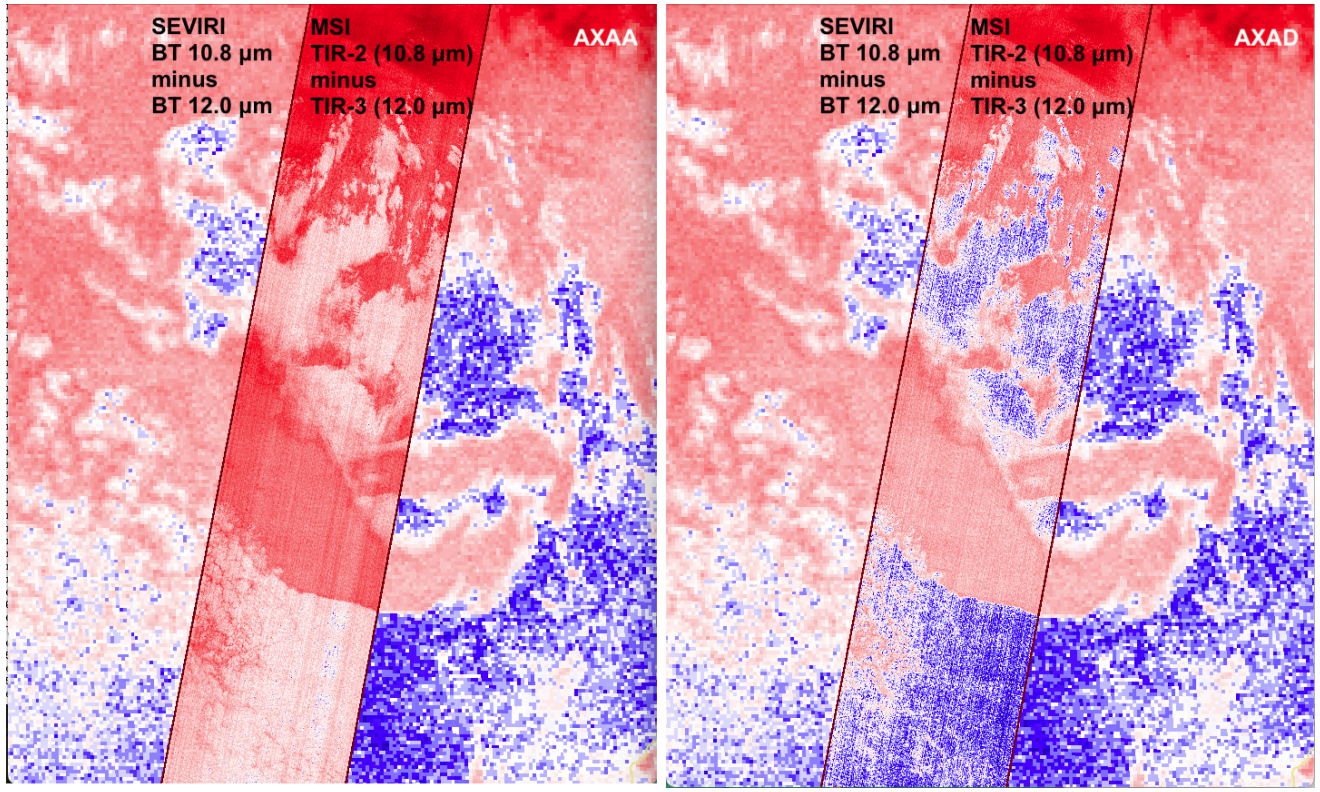
TIR-3 too cold (-1.33 K) in version EXAA

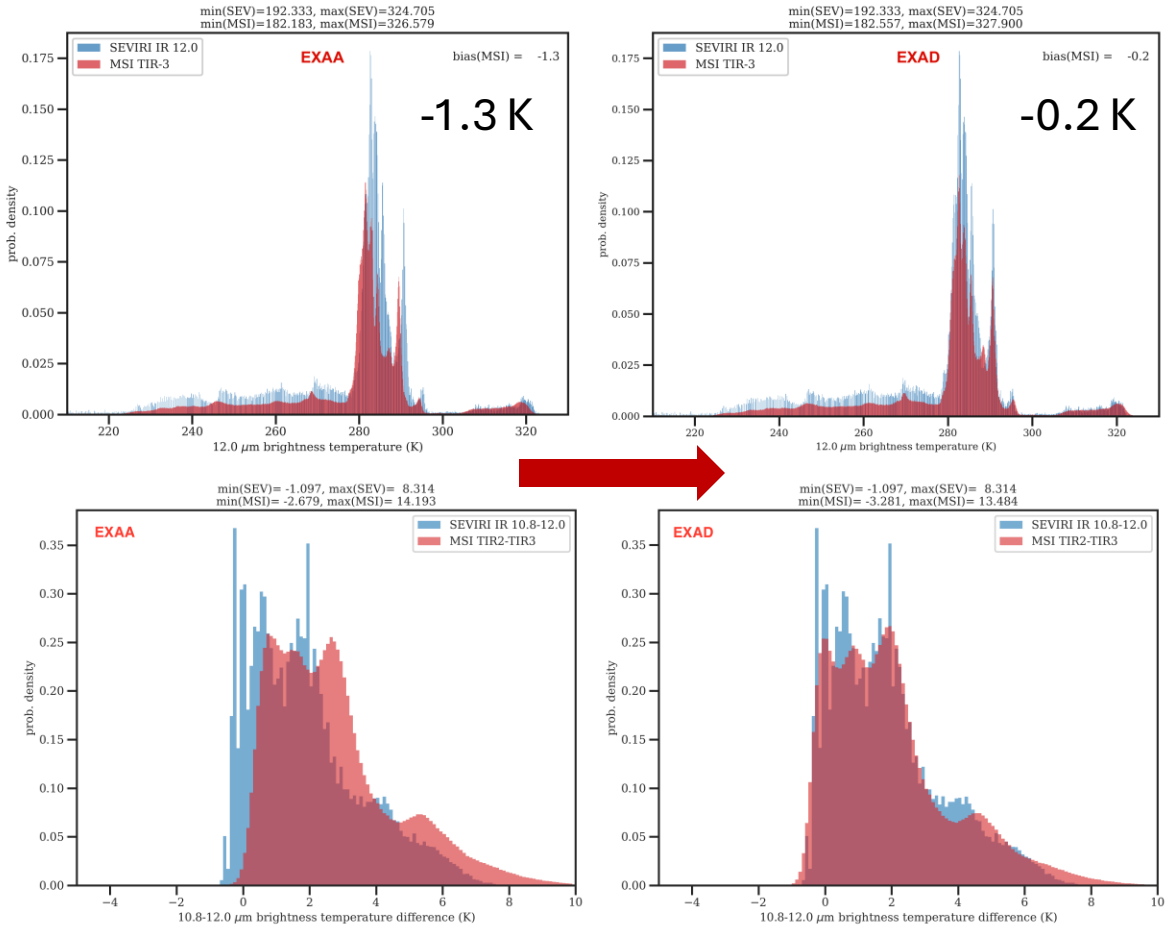
↓

Direct impact on brightness temperature differences

Intercomparison of MSI TIR channels

frame 01067E





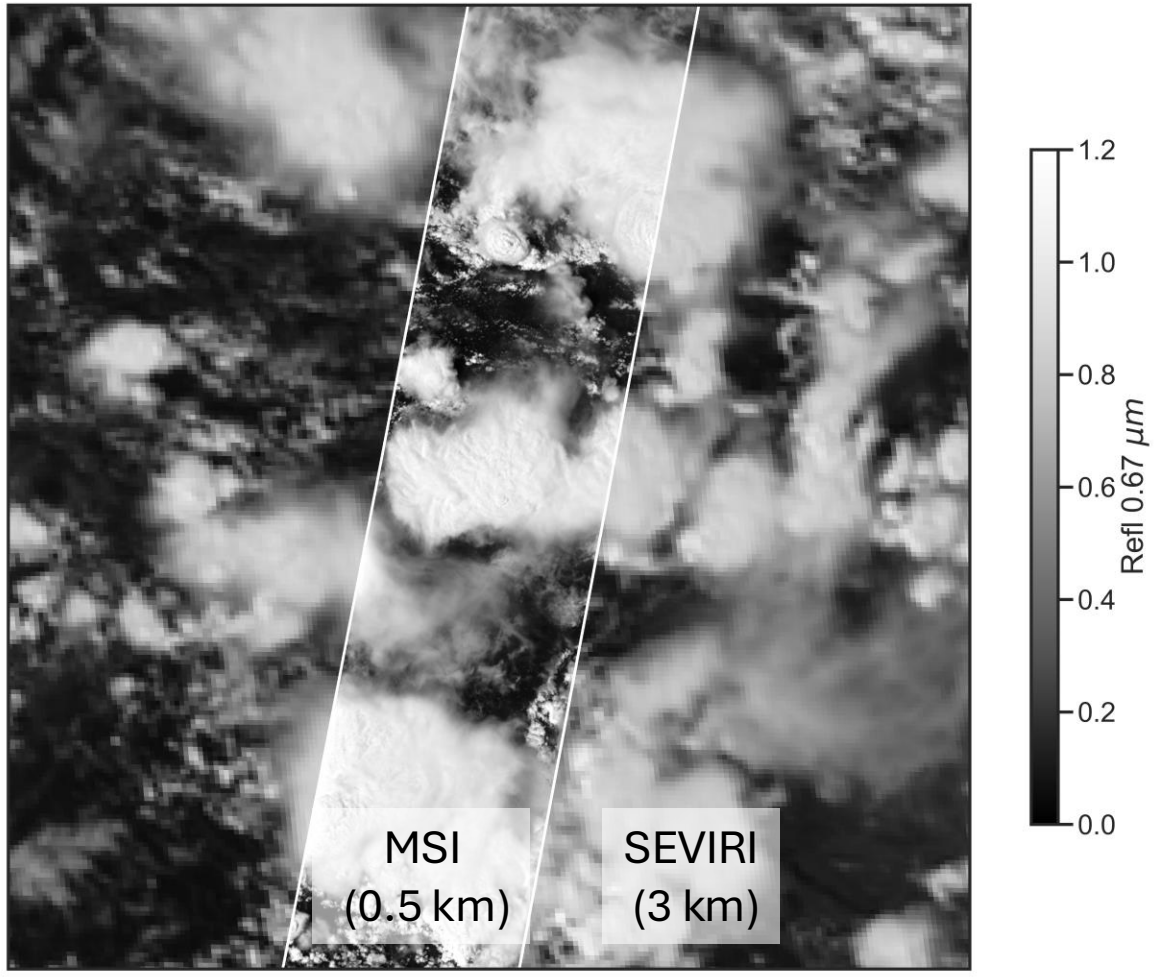
- MSI TIR-3 calibration significantly improved in version EXAD
- BT differences have direct impact on cloud and aerosol detection and L2 products

Intercomparison of MSI VNS channels

frame 2778E

ECA_EXAD_MSI_RGR_1C_20241123T122712Z_20241123T140049Z_02778E

SEVIRI_20241123T123011Z_20241123T124243Z



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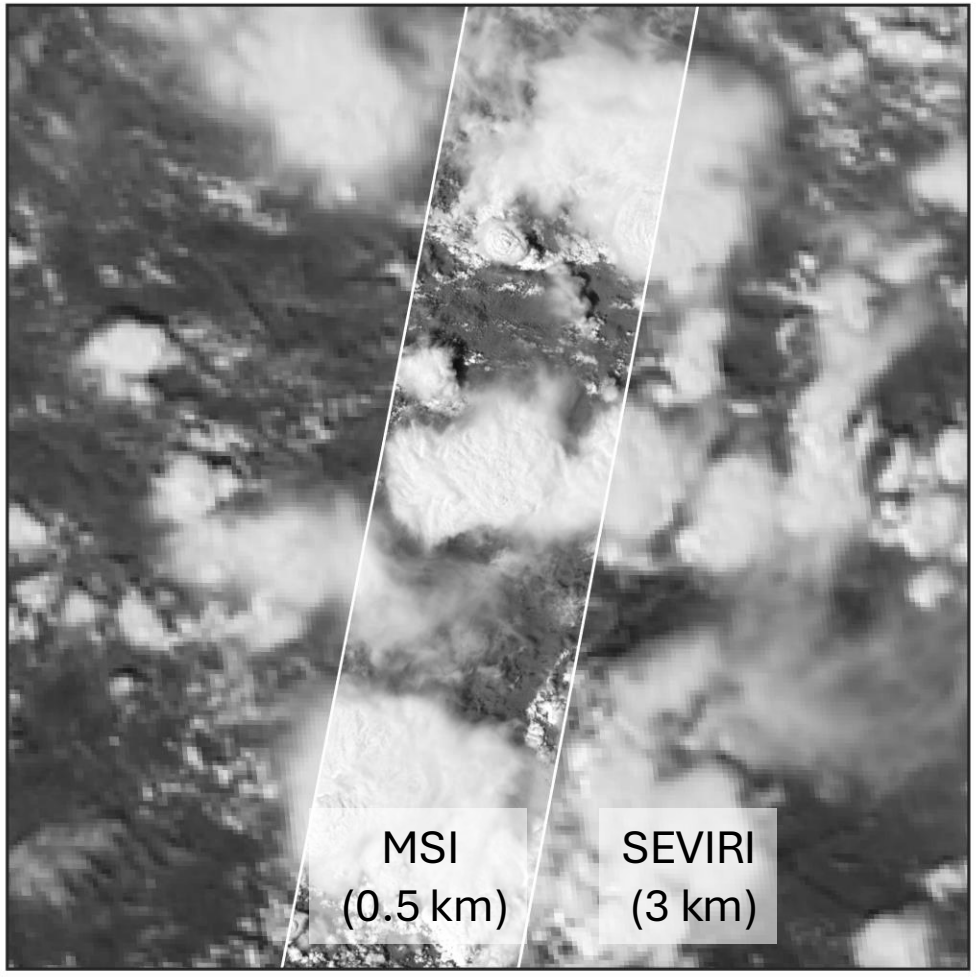
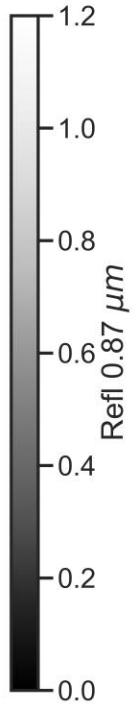
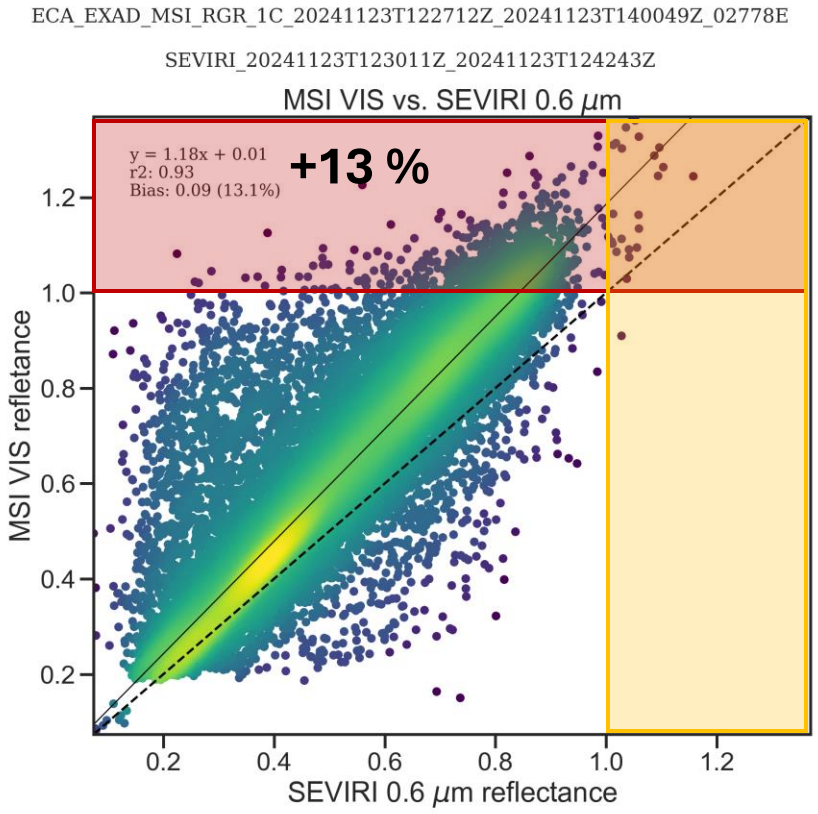
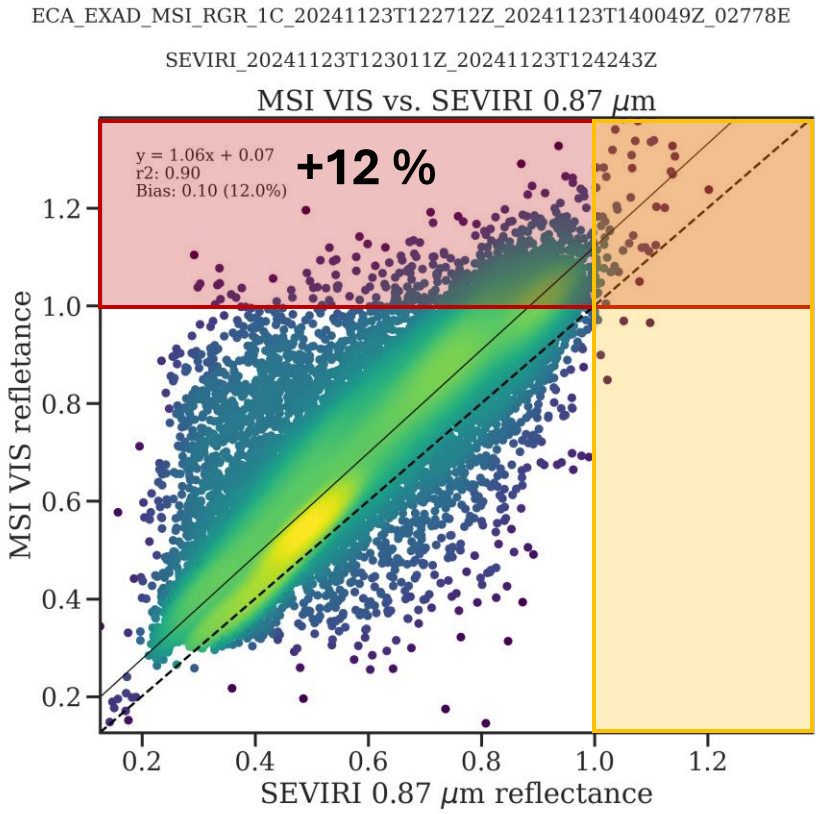
SEVIRI_20241123T123011Z_20241123T124243Z

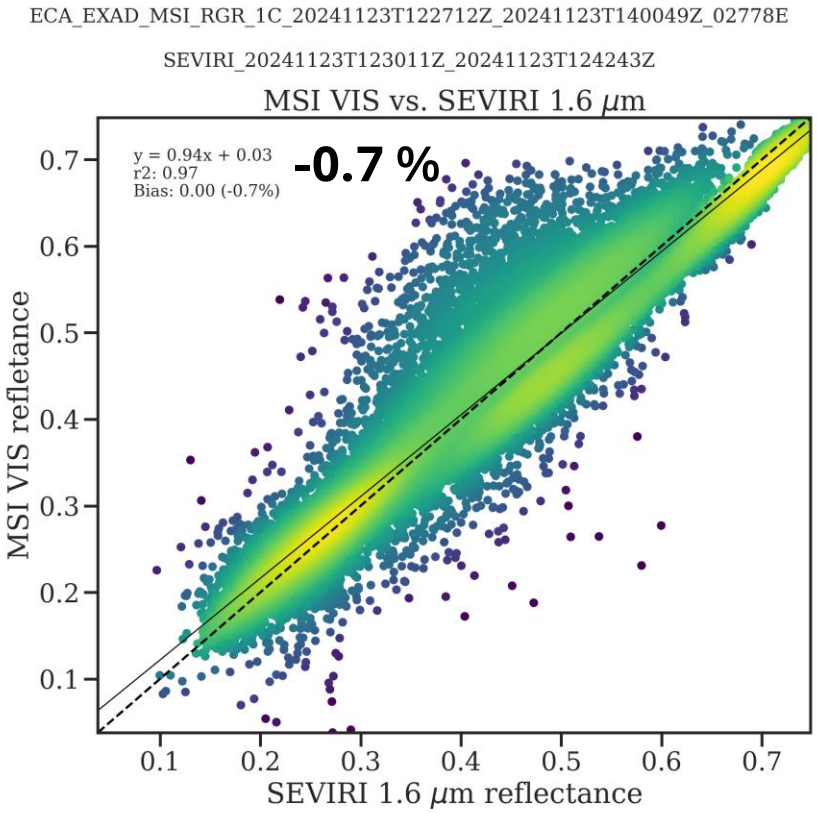




Intercomparison of MSI VNS channels

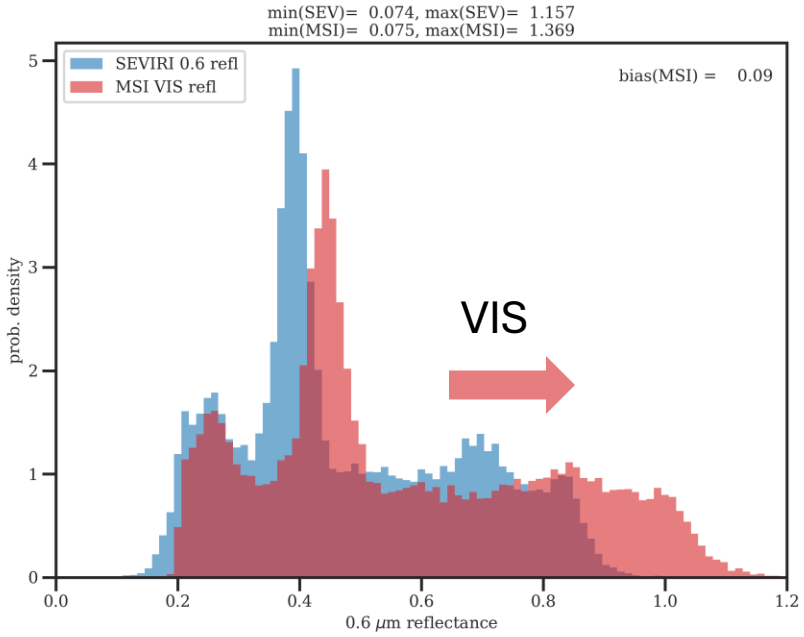


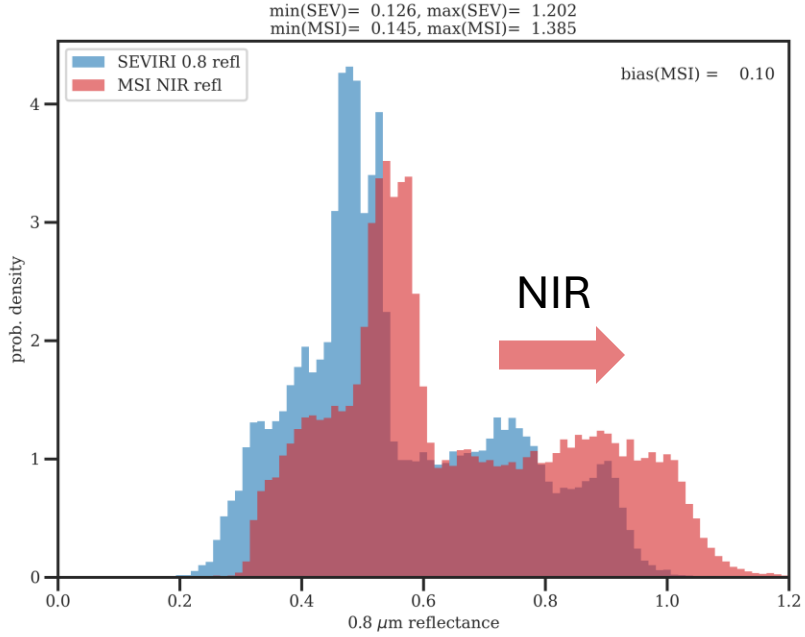


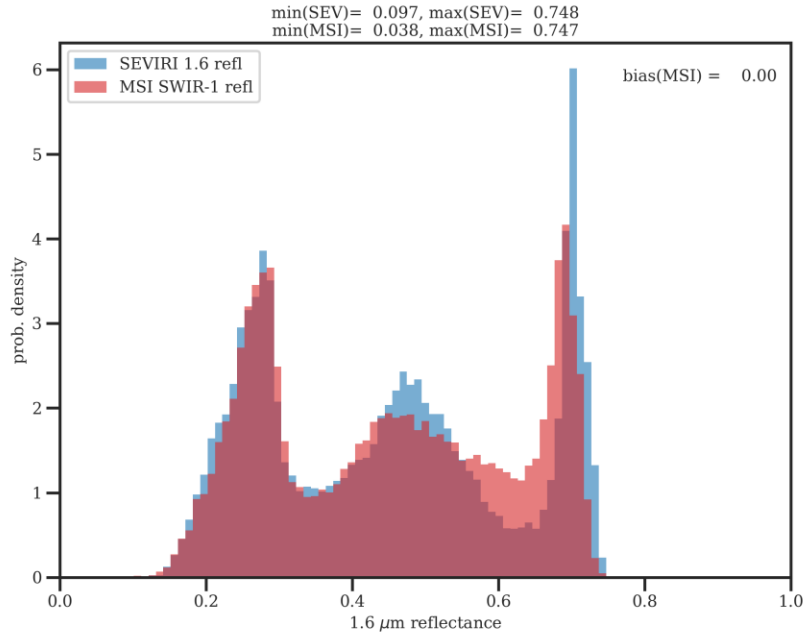


- Averaging of collocated MSI L1 pixels to match SEVIRI resolution
- Scatter plot only for consistent cloud fraction > 0.95

Intercomparison of MSI VNS channels





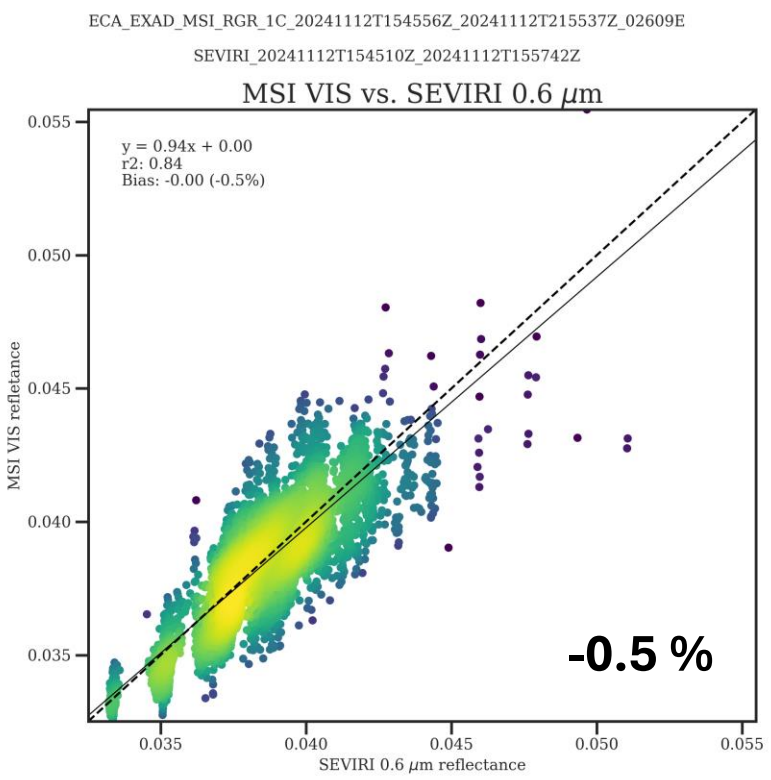


→ MSI VIS-NIR-SWIR1 cloud reflectance seems too high in comparison to SEVIRI

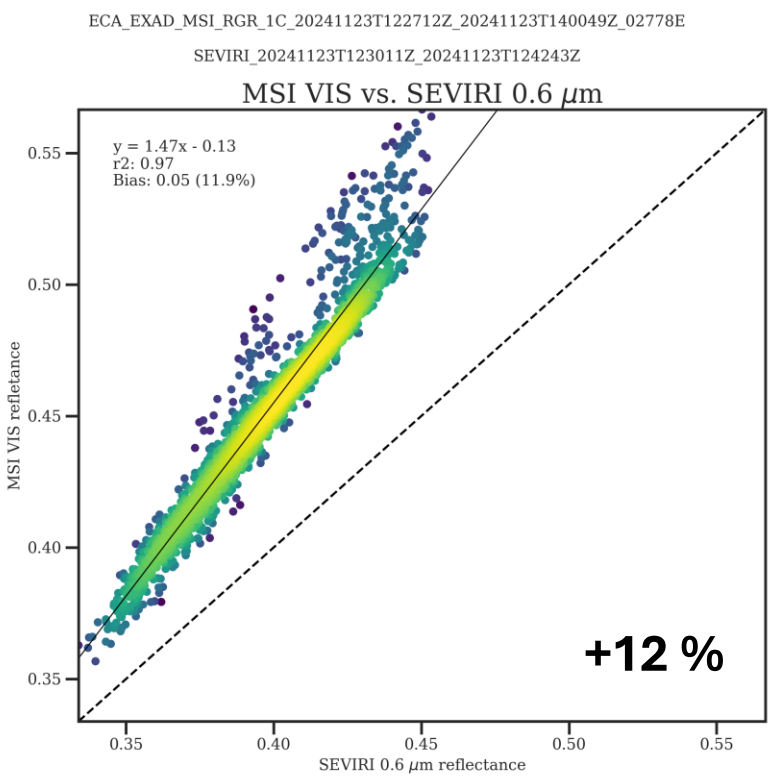
→ Ongoing work to quantify the impact of different spectral channel characteristics using the MSI tool

Intercomparison of MSI VNS channels (VIS)

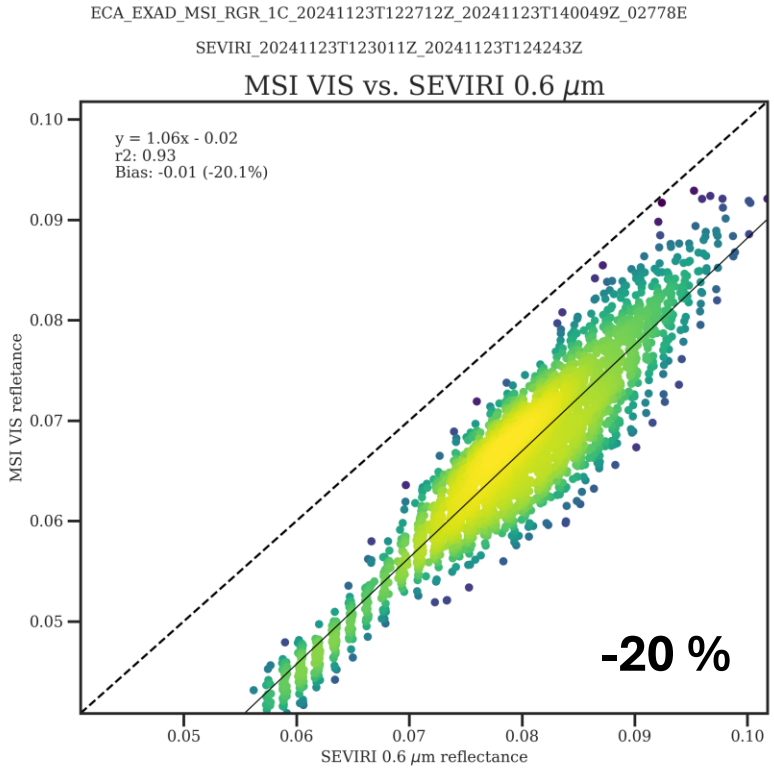
Clear sky ocean (frame 02609E)



Clear sky desert (frame 02778E)



Clear sky vegetation (frame 02778E)



- Comparison indicates that vicarious calibration using geo satellites is needed (**FCI** has been recently successfully cross-satellite calibrabrated)
- Carefully account for differences in spectral response functions → **Radiative transfer simulations using the MSI tool**

Conclusion

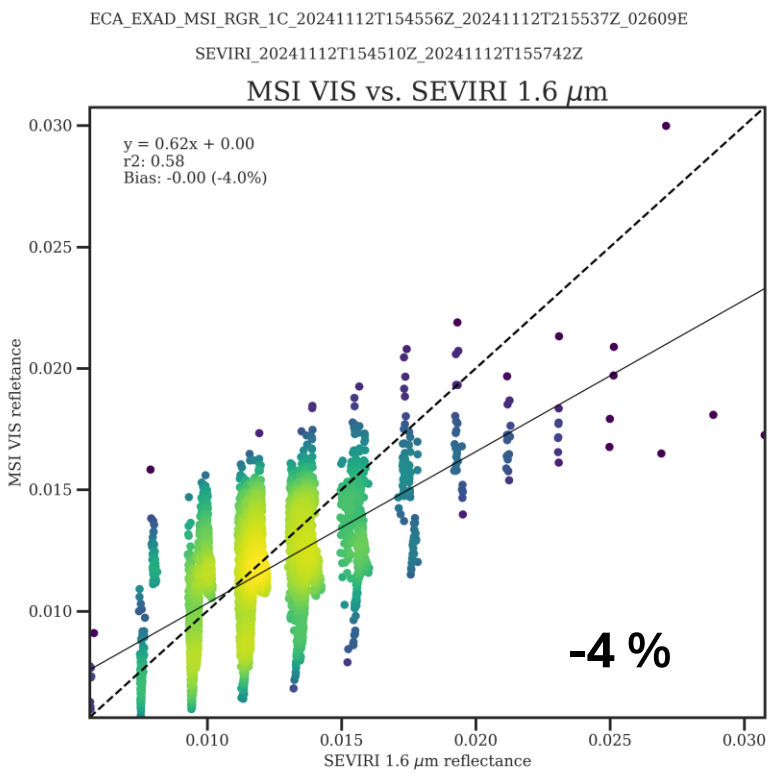
- MSI L1 cross-satellite validation shows that the three TIR channels are well calibrated
- VNS calibration (VIS-NIR-SWIR) does not work as expected due to the imperfect pre-flight calibration
- First comparison against MSG SEVIRI indicates that systematic biases can potentially be corrected using cross-satellite calibration
- Focus now on FCI onboard MTG with similar spatial resolution like MSI (0.5x0.5 km)
- Vicarious calibration using MTG‘s Flexible Combined Imager (FCI) still needs to carefully consider differences in spectral response functions (apply radiative transfer simulations with the MSI tool)

- **Calibrations are performed in reflectance space** (correction factors improve across track solar irradiance)
- **→ Do not use MSI VNS radiances but reflectances instead**

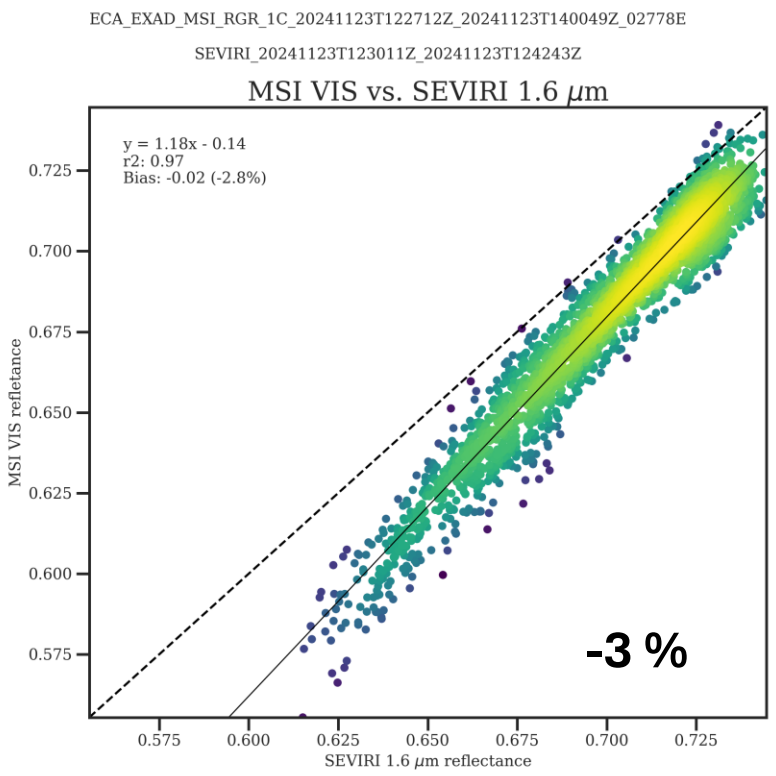
Thank you!

Intercomparison of MSI VNS channels (SWIR-1)

Clear sky ocean (frame 02609E)



Clear sky desert (frame 02778E)



Clear sky vegetation (frame 02778E)