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Long-term Inflight Spectral and Radiometric Calibration of EnMAP

*David Marshall Ingram for the EnMAP GS PCV Team
German Aerospace Center (DLR), Earth Observation Center (EOC),
Weßling, Germany*



GFZ



OHB

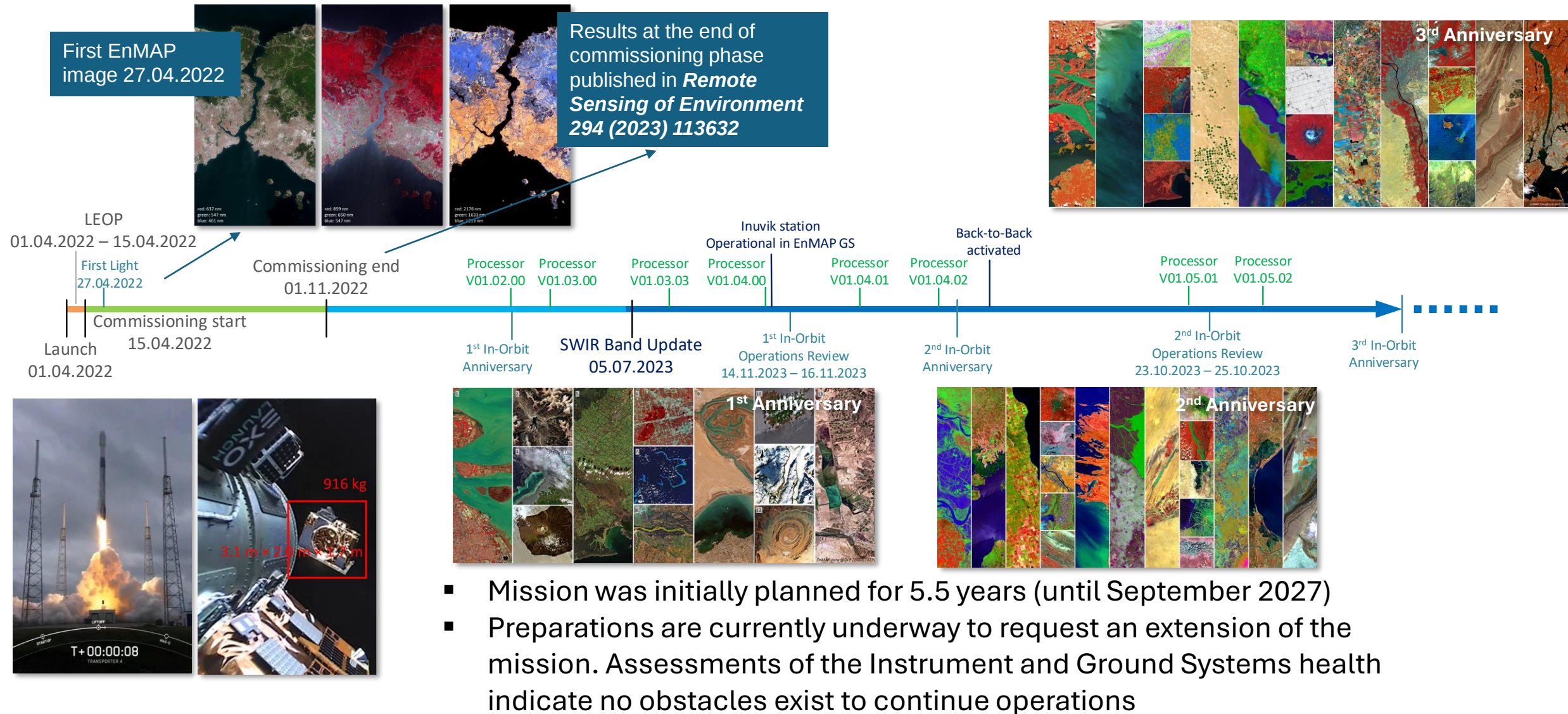


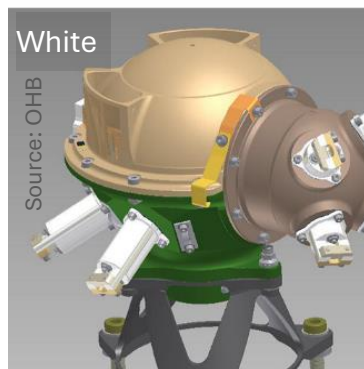
VH-RODA 2025

17 – 21 November 2025 | ESA-ESRIN | Frascati (RM), Italy

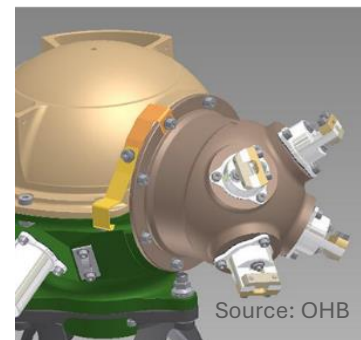
EnMAP Timeline

VH-RODA 2025 Workshop
17 – 21 November 2025 | ESA-ESRIN, Frascati (Rome), Italy

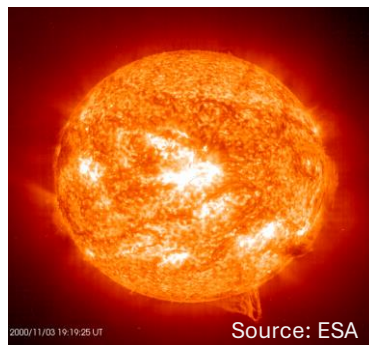




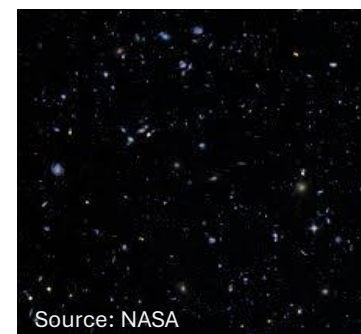
Relative Radiometric
Lamp and LEDs with white
spectralon sphere
Once per week



Spectral
Lamp with doped
spectralon sphere
Once every two weeks



Absolute Radiometric
Solar calibration with sun
diffuser
Once every two months



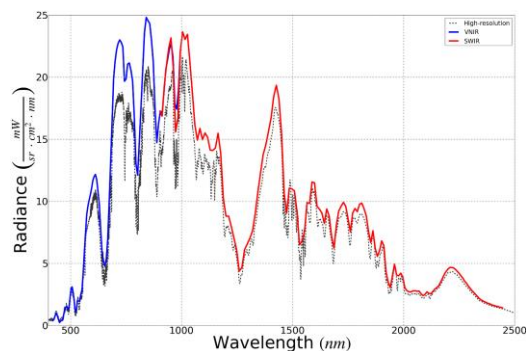
Deep Space
Dark observation to assess
shutter thermal emission
Once per month



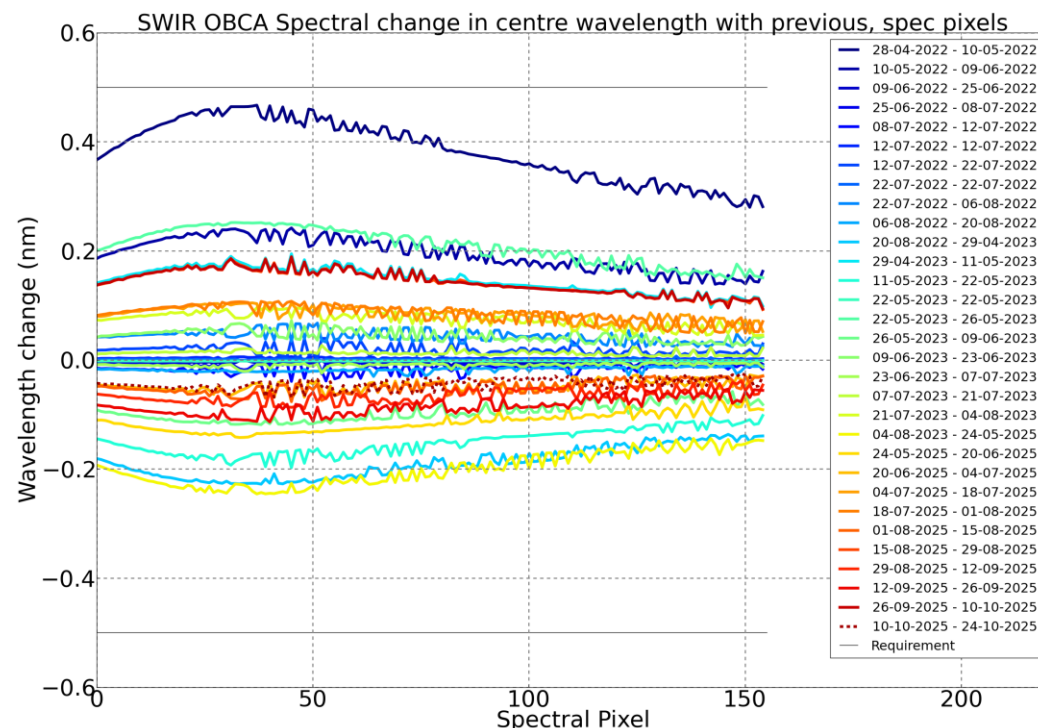
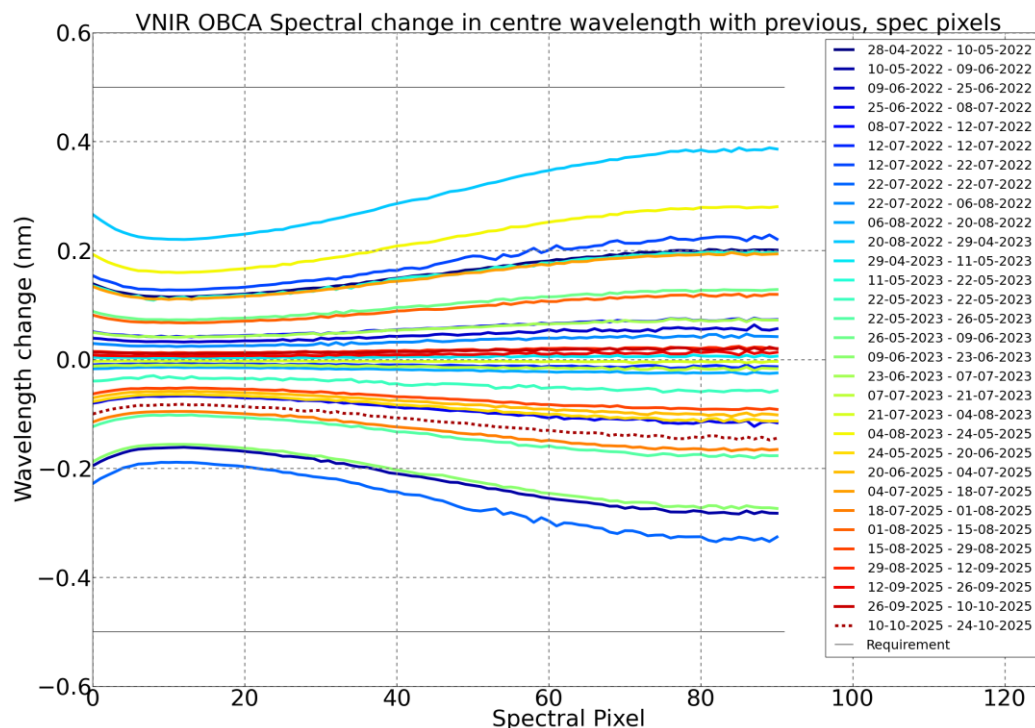
Linearity
LEDs before focal plane
with variable integration
times
Once per month



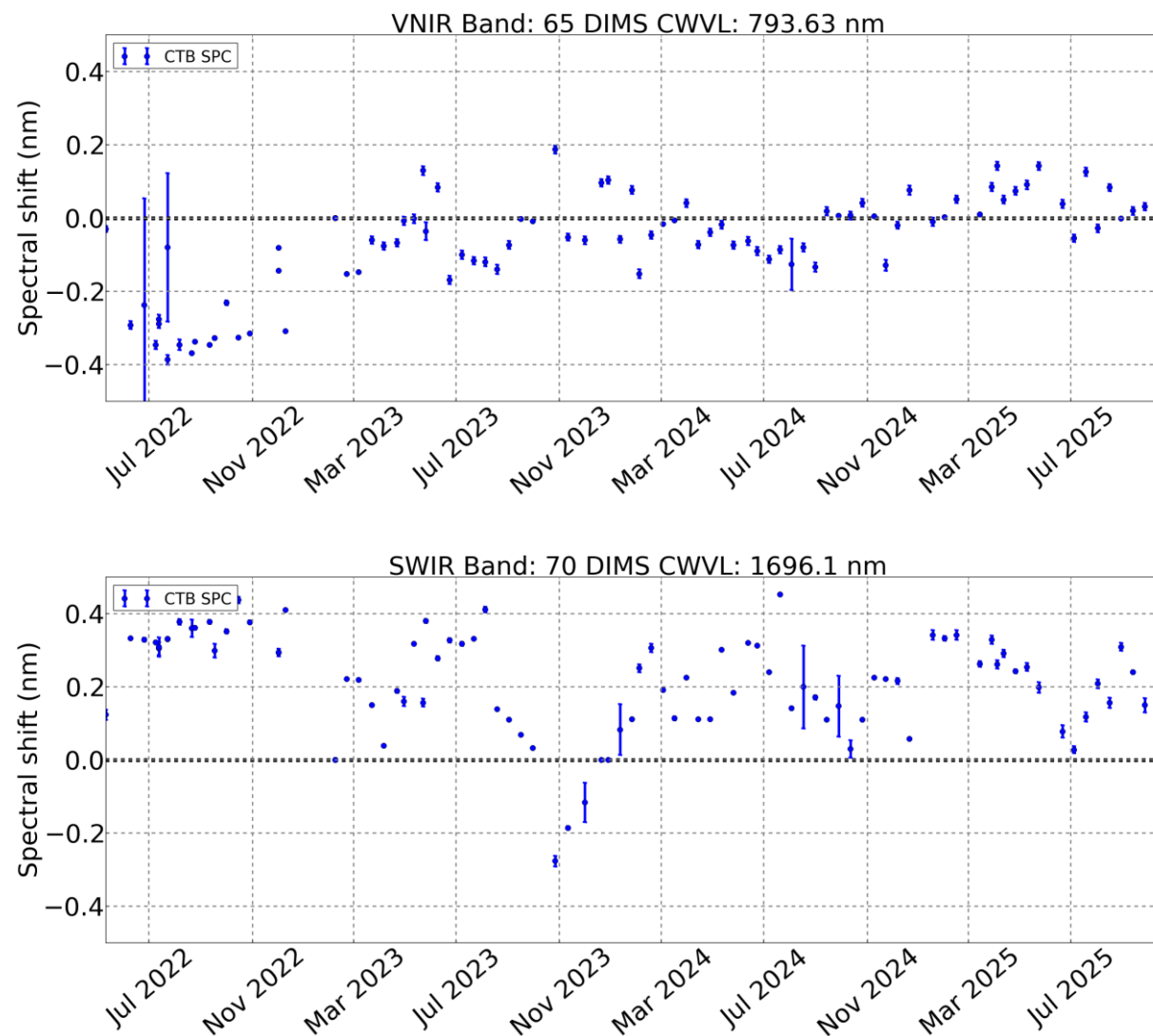
Dark
Dark signal measurement
**Before and after every
datatake**



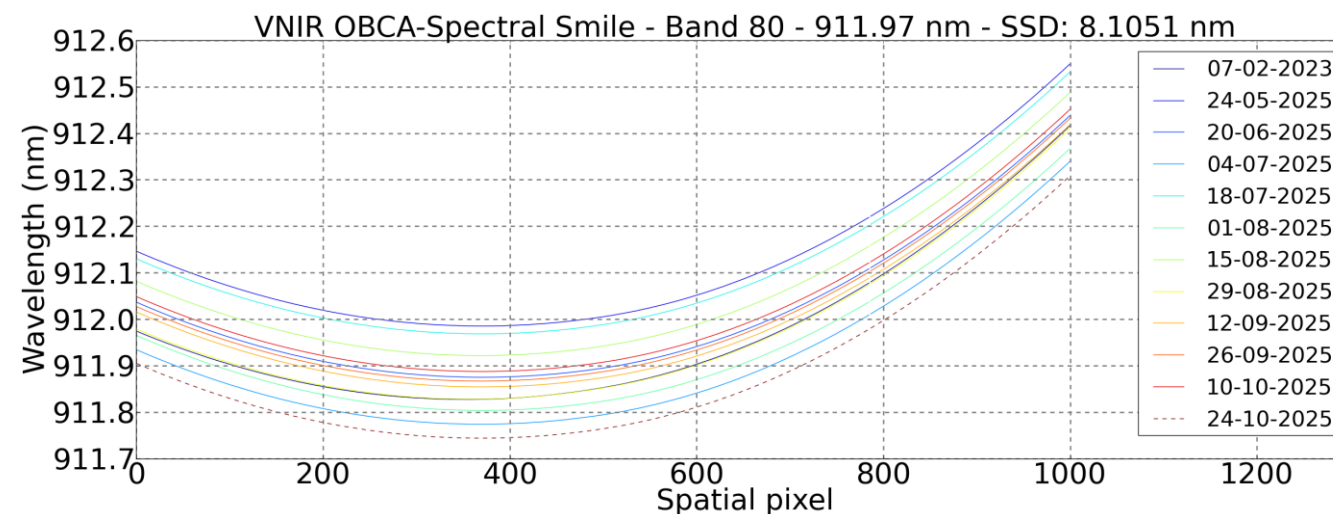
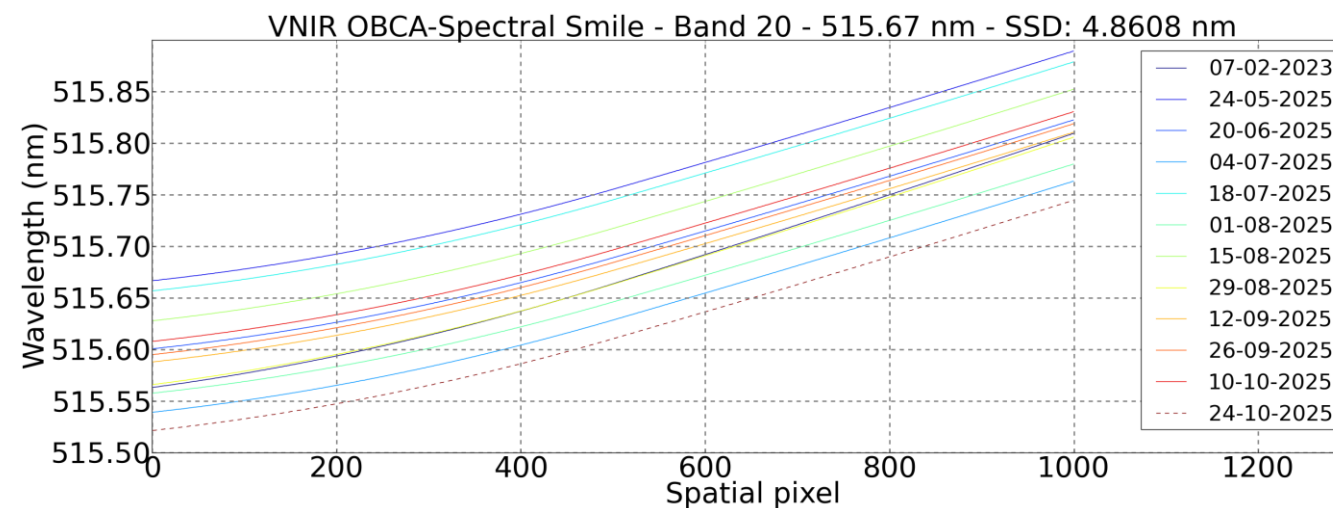
- New central wavelengths are calculated for each calibration measurement by shifting the spectrum so that the difference between the measured and reference spectrum is minimised
- Several calibration updates were made during commissioning phase
- Both sensors are well within the requirements since February 2023 (33 months)



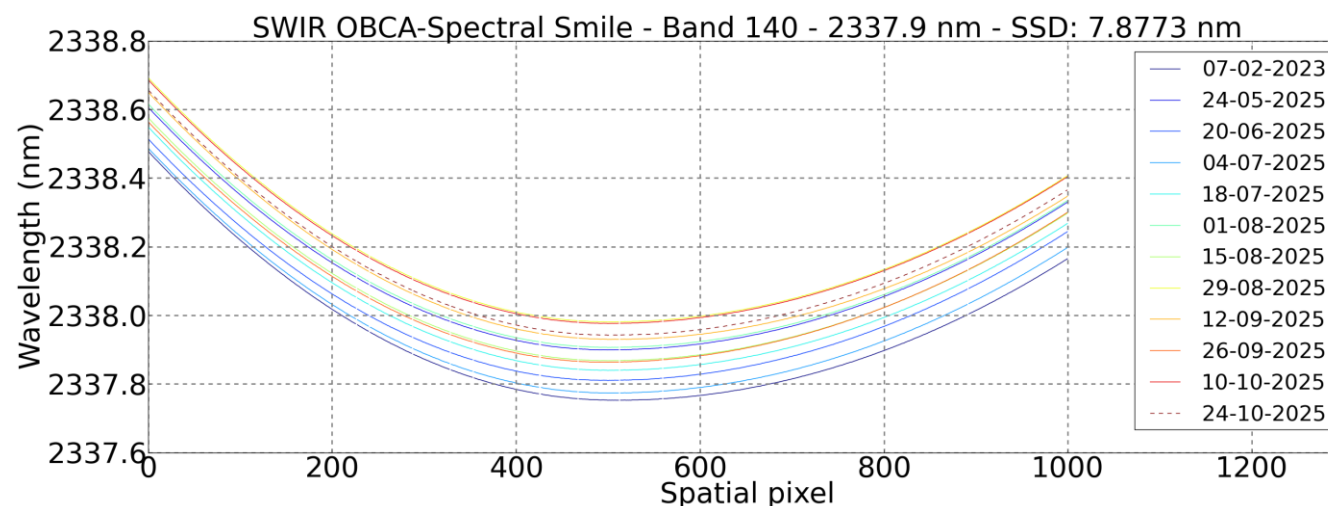
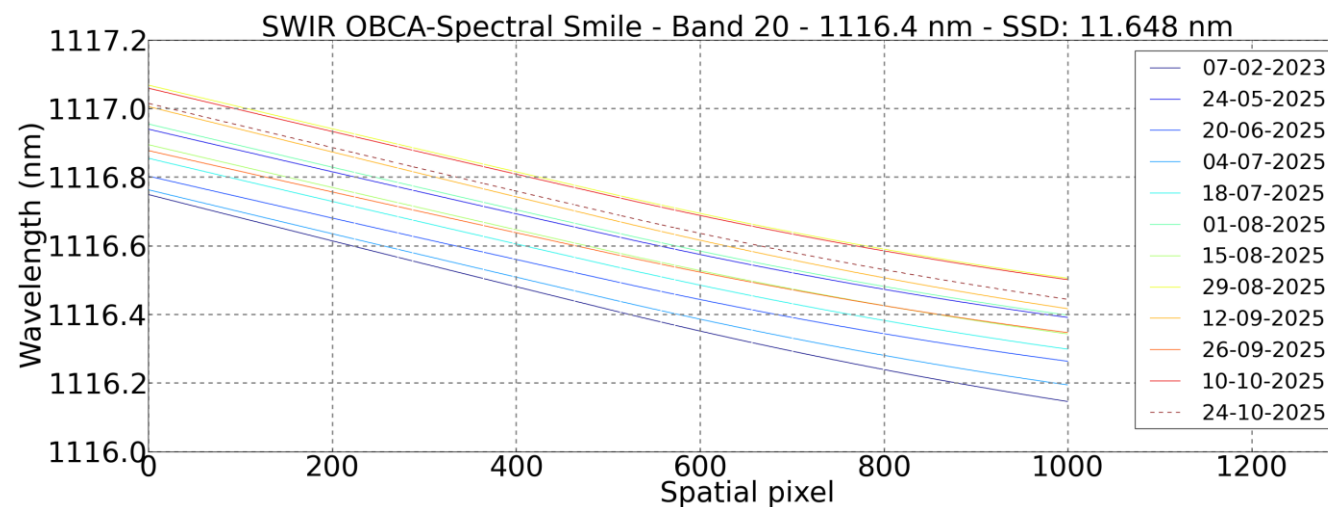
- Global spectral shifts are less than the 0.5 nm requirement
- VNIR spectral shifts are within 0.2 nm and average close to zero
- SWIR spectral shifts suggest that there is a +0.2 nm bias
- No update has been made as the shift is within the uncertainty of the method and spectral consistency for the users is important

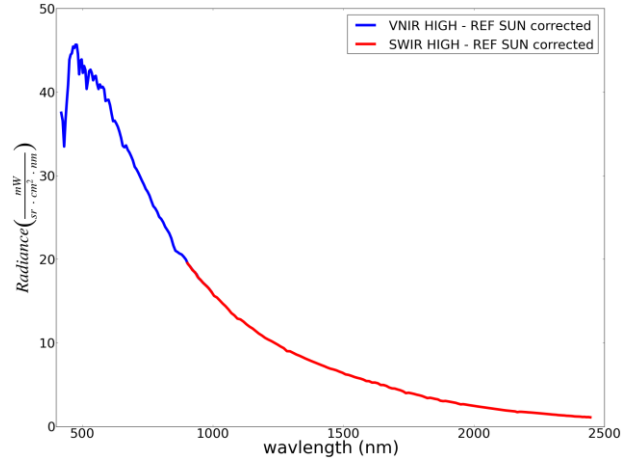


- **VNIR** and SWIR spectral smile in recent measurements
- The small global shifts are apparent but the overall shape in each band is stable
- The smile shape is not the same at every wavelength though
- Smile behaviour is within 20% linear displacement requirement

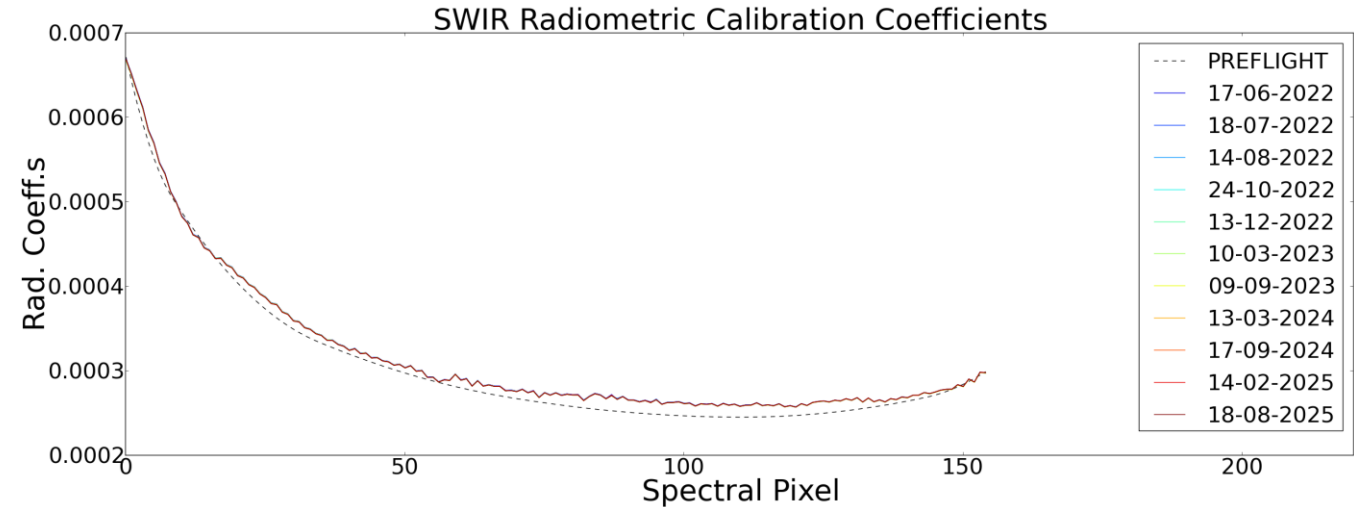
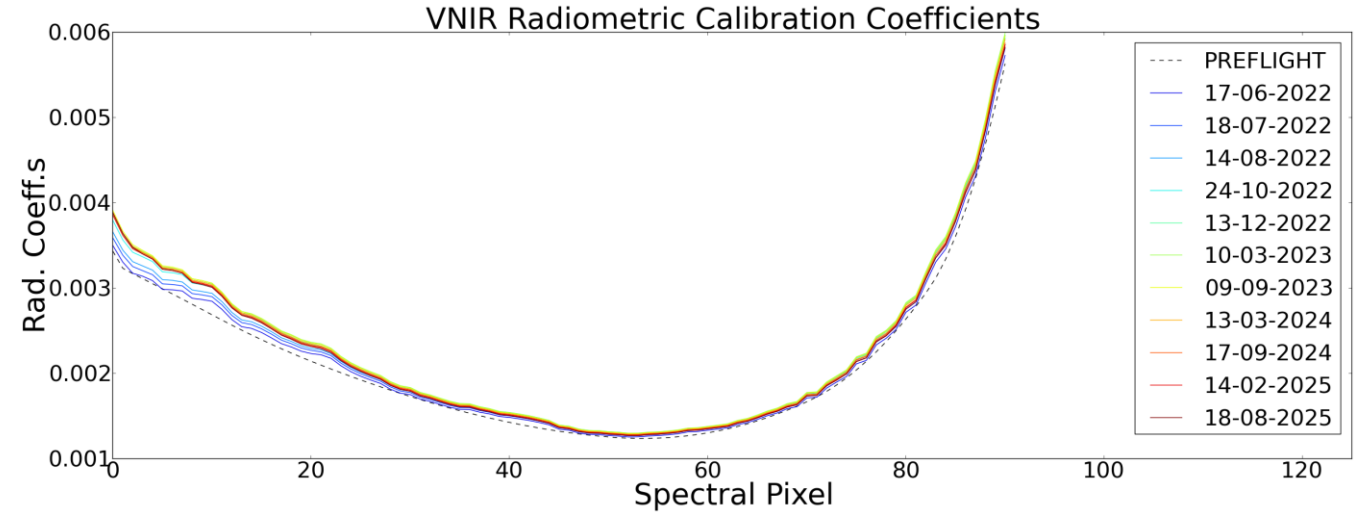


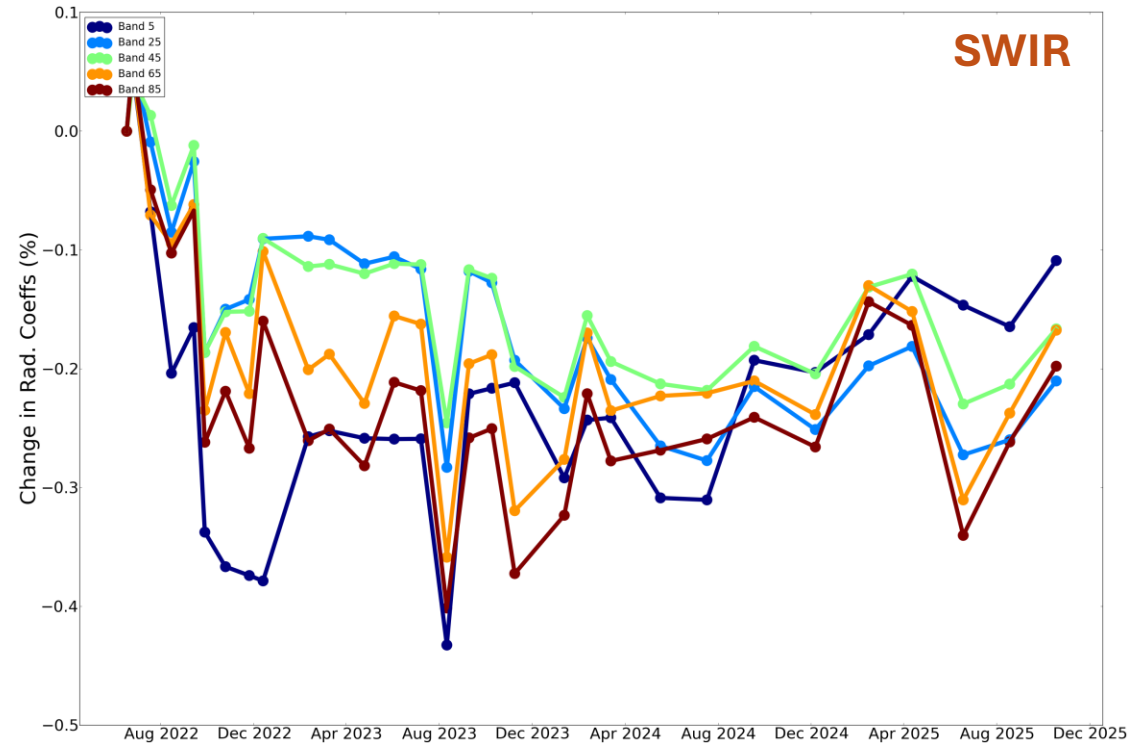
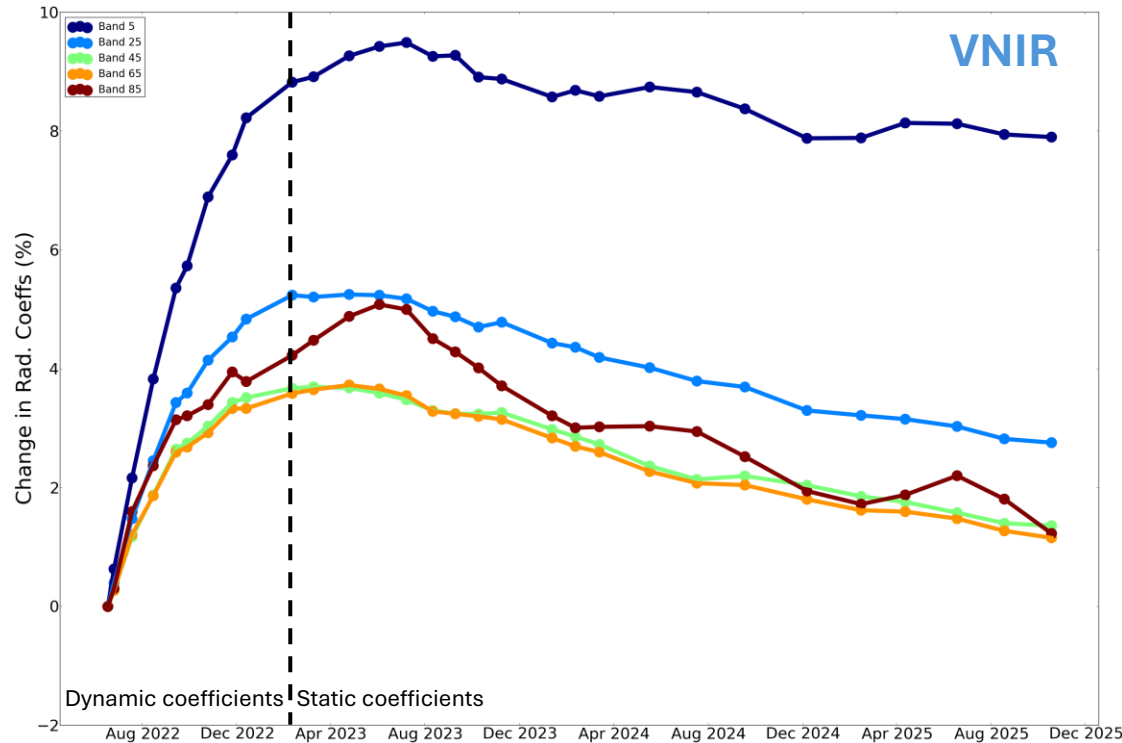
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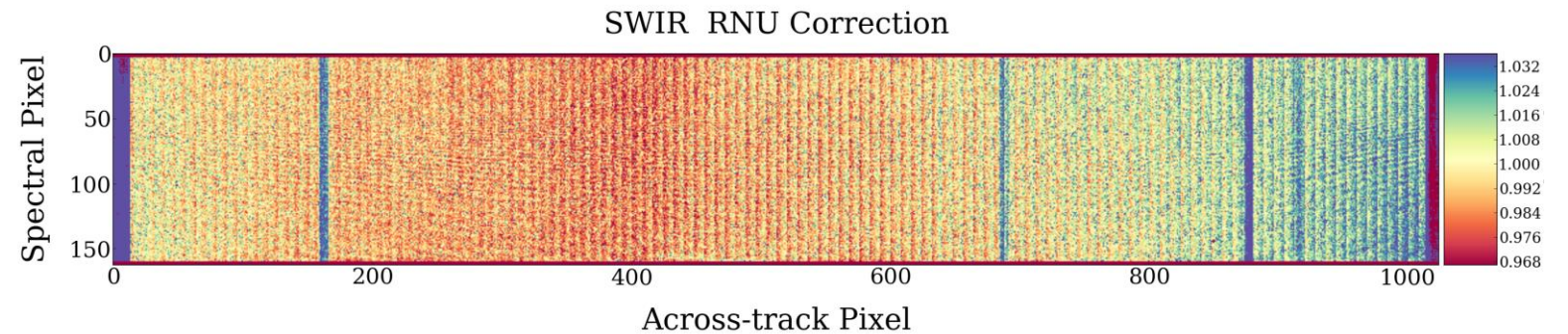
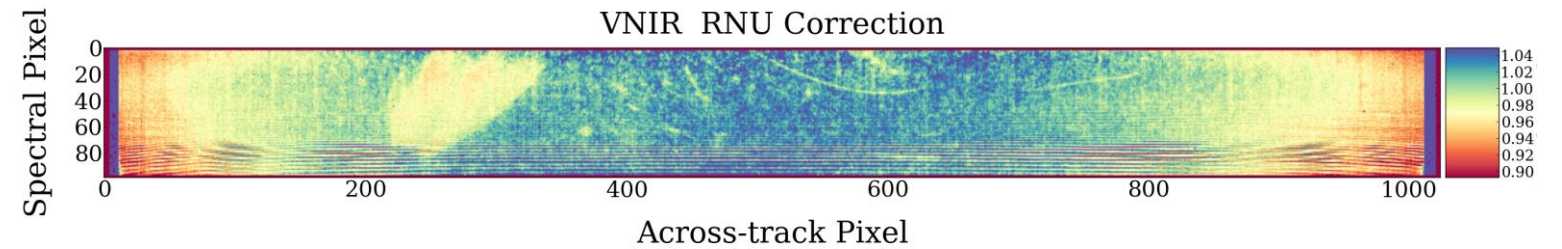
- The Absolute Radiometric calibration is determined from solar diffuser measurements
- The calibration coefficients changed from preflight measurements
- The VNIR coefficients have changed inflight



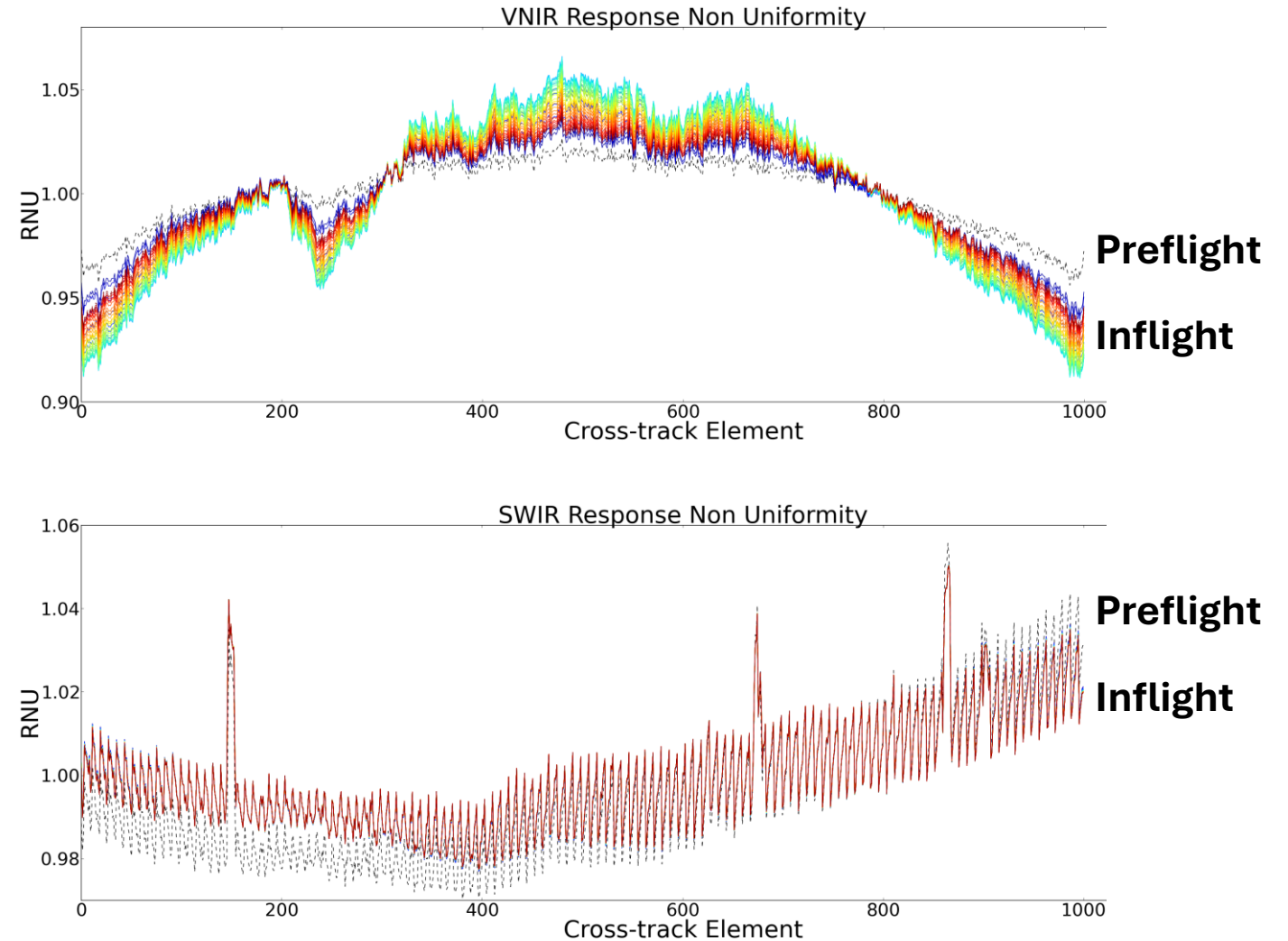


- The band averaged VNIR coefficients increased by up to 10% (band dependent) to compensate for changes in the measured signal and are still changing
- Dynamic coefficients were derived from a polynomial-exponential fit during the period of rapid change from April 2022 to February 2023
- The band averaged SWIR coefficients have been very stable since end of commissioning

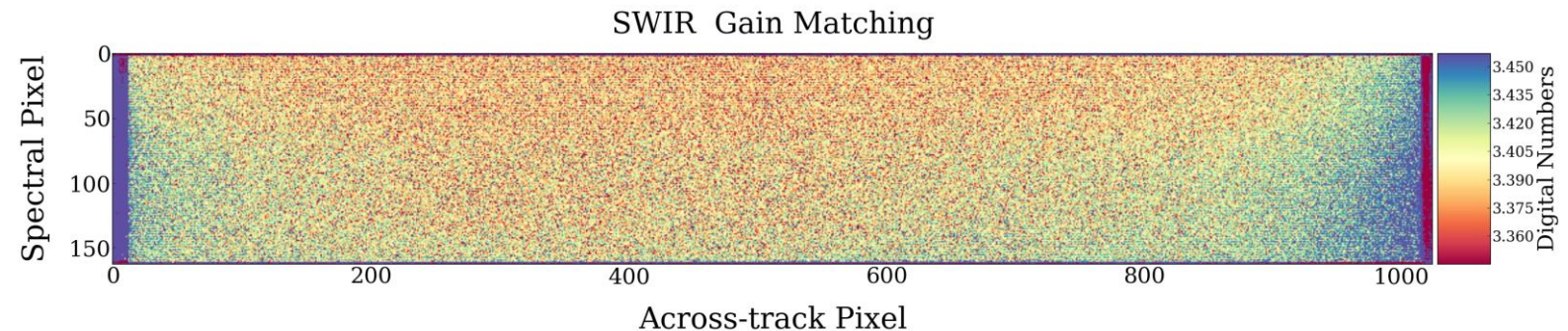
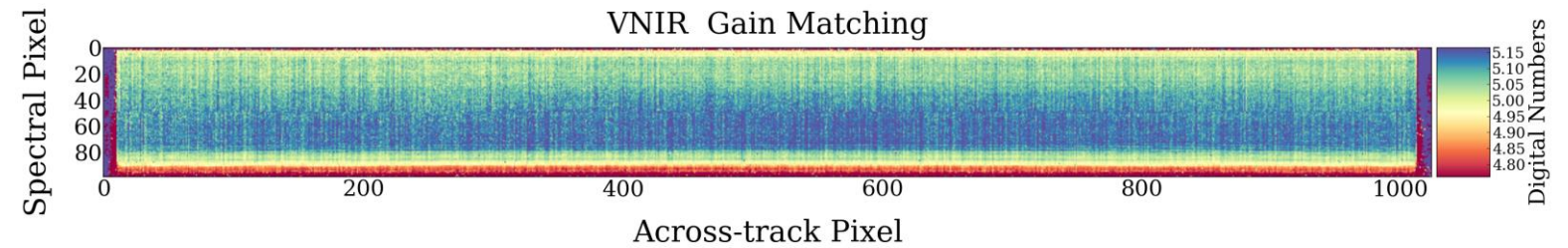
- A response non-uniformity (RNU) correction is applied
- There are strong features in VNIR focal plane

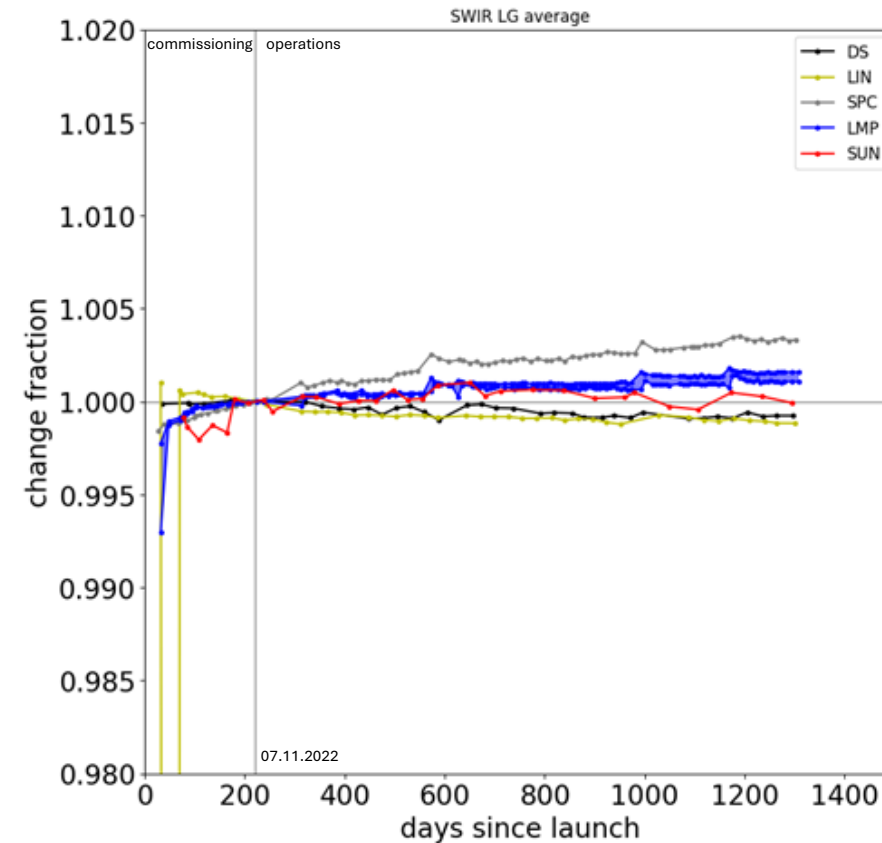
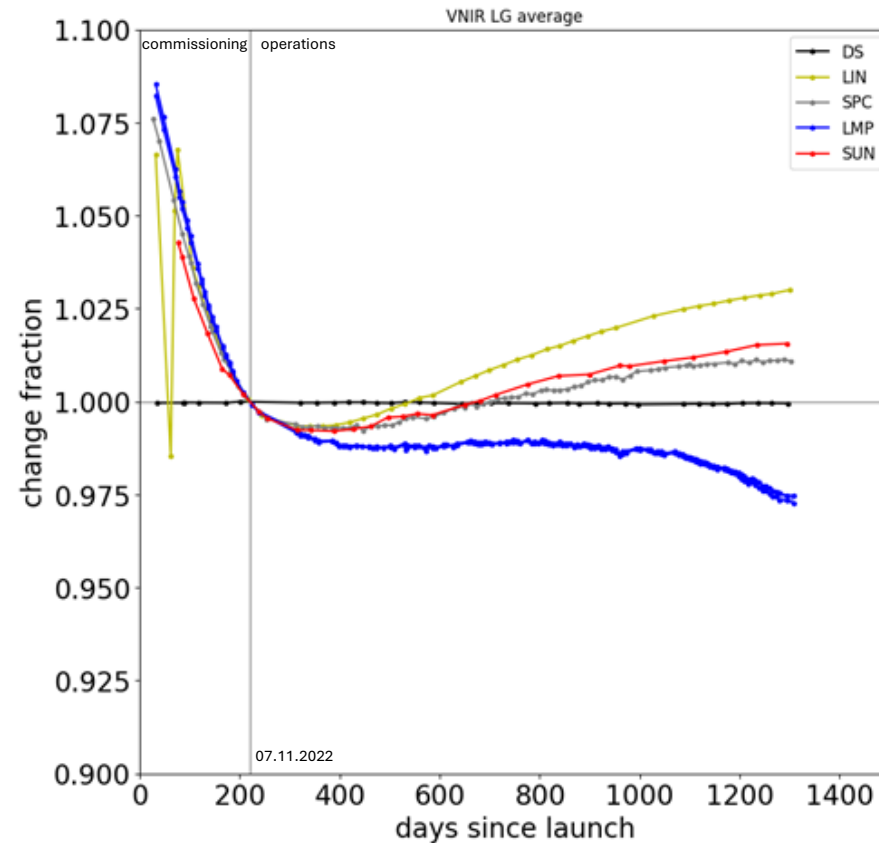


- A response non-uniformity (RNU) correction is applied
- There are strong features in VNIR focal plane
- The RNU changed from preflight measurements
- The VNIR RNU has continued to evolve over time
- The SWIR RNU has been stable inflight

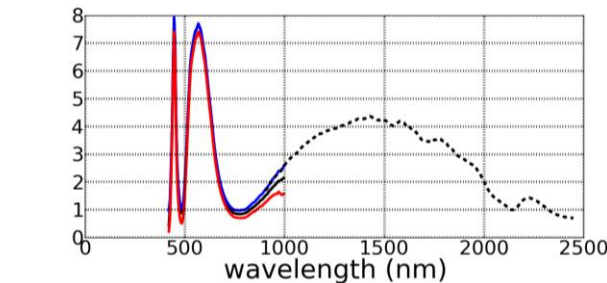
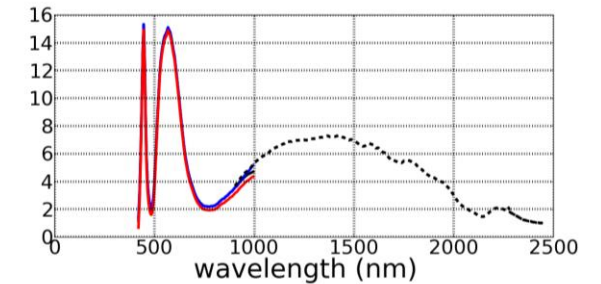
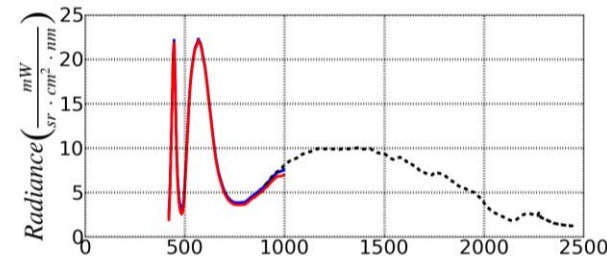
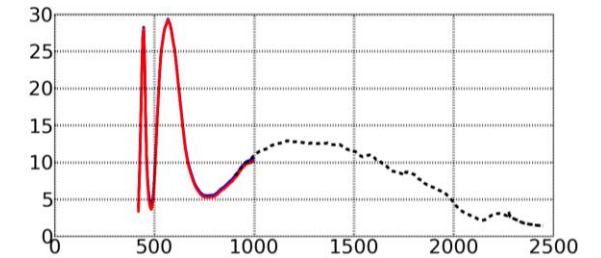
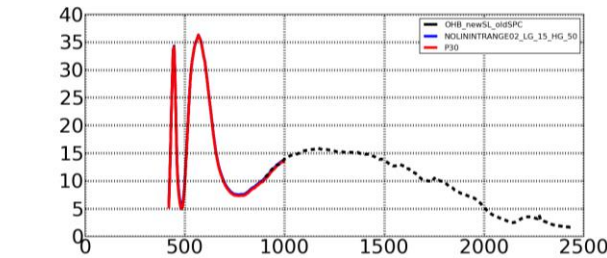
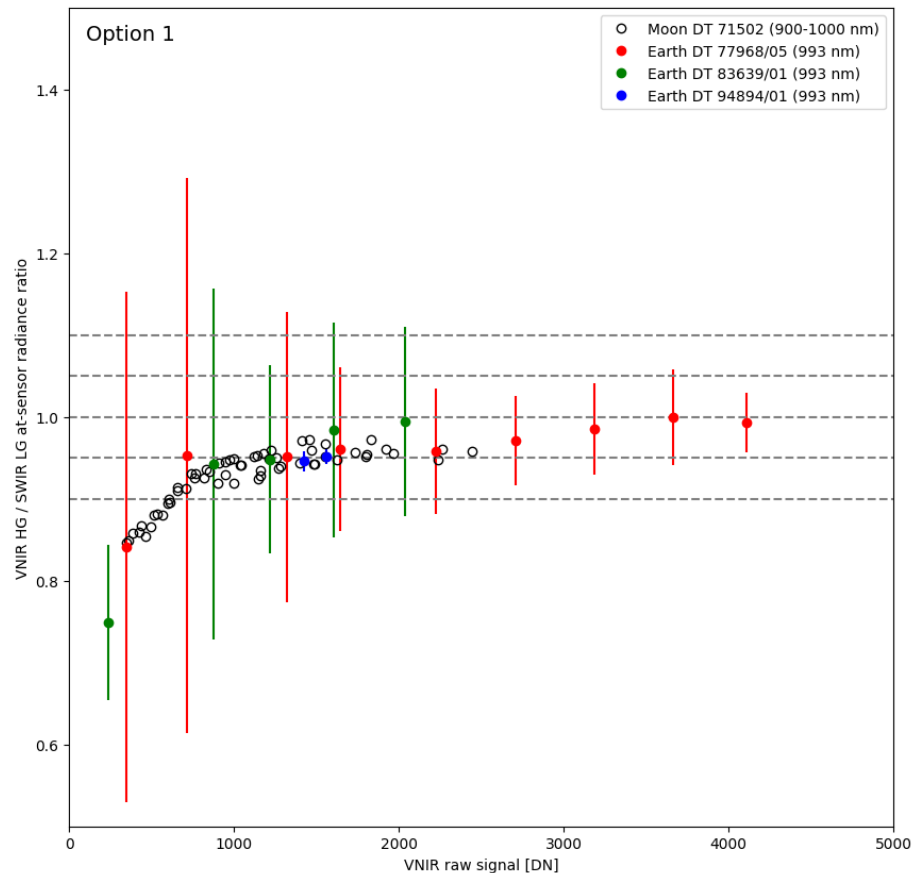


- The low gain mode is matched to the high gain mode
- The VNIR gain matching varies between spectral pixels (4.7-5.2)
- The SWIR gain matching is more constrained (3.3-3.5)





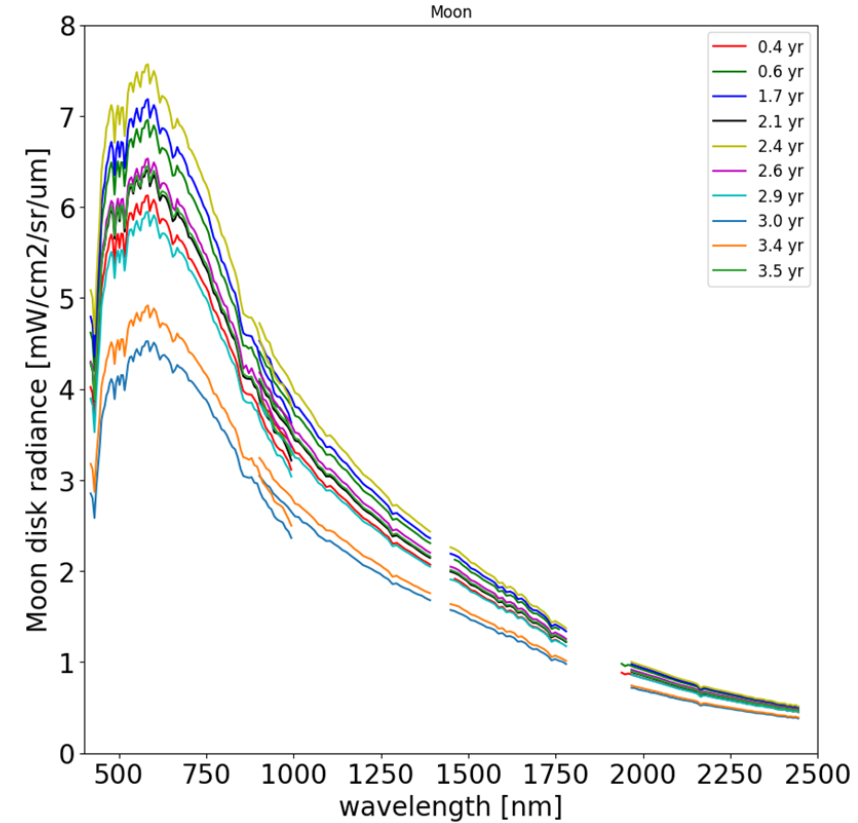
- The VNIR signal degraded during first year (the root cause is unknown but contamination has been discarded) but stabilised in early 2023
- The sensor signal is now recovering and the onboard lamp signal is degrading
- The SWIR calibration measurements are very stable over the mission lifetime



- Earth, Moon and calibration observations reveal a mismatch in the overlapping region (900-1000nm)
- Non-linearity at low VNIR signals is believed to be the root cause
- An improved linearity correction is currently under investigation to address the mismatch

DT0000115115 L1B VNIR

13.02.2025



L1B averaged over
Moon disk

- Moon observations are not part of the routine operations but are useful for Cal/Val activities
- Ten observations have been performed so far and committed to acquiring one every 2 months
- These measurements are useful for the VNIR-SWIR mismatch investigation, alternative radiometric validation approaches and diffuser aging assessment

	VNIR	SWIR
Spectral calibration	Stable (meets 0.5 nm requirement)	Stable (meets 0.5 nm requirement)
Radiometric calibration	Stable (meets 2.5% requirement between observations) but changes ongoing. Dynamic coefficients until Feb. 2022, Calibration tables since Feb. 2022	Stable (meets 2.5% requirement between observations) Calibration tables used throughout
Long term evolution	Changes in measured signal	Stable
Dark Signal Correction	Stable less than 1DN change since launch	Stable less than 1DN change since launch
SNR	596:1 at 495 nm for a radiance value of 36 mW/sr/cm ² /μm (better than requirement of 500:1)	201:1 at 2200 nm for a radiance value of 0.5 mW/sr/cm ² /μm (better than requirement of 150:1)
Linearity	Mismatch between VNIR-SWIR at 900 – 1000nm. VNIR non-linearity correction under investigation	

- After more than 3 years in space, EnMAP is in a mature phase with an extensive catalogue of data products and deep knowledge of the instrument performance
- The EnMAP data catalogue contains almost 20000 Earth acquisitions with almost 175000 Earth products archived and available for ordering
- A five-year mission extension (2027-2032) is currently being considered
- All onboard calibration assemblies as well as both VNIR and SWIR instruments are stable and functioning nominally
- Moon observations have been enabled and now routinely performed every two months, with the analysis taking place on a best-effort basis
- Useful links:
 - Tasking orders and catalog browsing:
 - <https://planning.enmap.org/>
 - Mission quarterly reports:
 - <https://www.enmap.org/mission/>
 - ICDs, ATBDs, FAQ, change log:
 - https://www.enmap.org/data_access/



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Thank you for listening

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