EnMAP mission overview: In-orbit Calibration

D. Marshall, M. Pato, E. Carmona

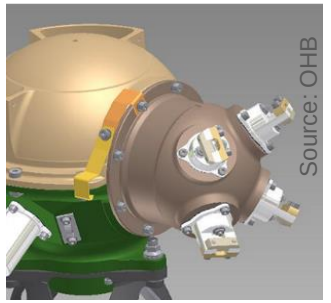
EnMAP Ground Segment, Processor and Calibration Segment
German Aerospace Center (DLR), Earth Observation Center, Oberpfaffenhofen

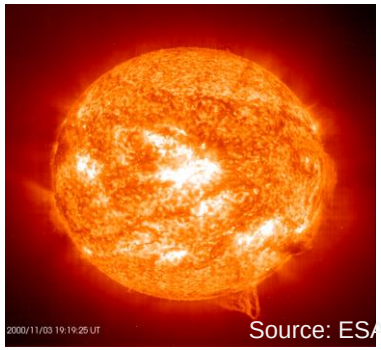
Infrared and Visible Optical Sensors (IVOS) 35
CEOS, Working Group on Calibration and Validation (WGCV)
Oberpfaffenhofen, 27.09.2023

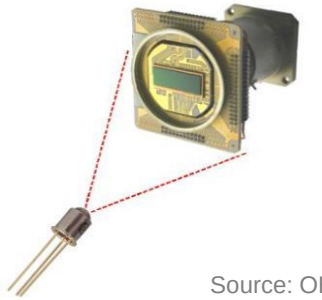
Federal Ministry for Economic Affairs and Climate Action

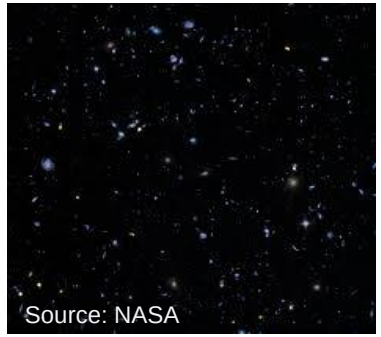
EnMAP Onboard Calibration

1. 

2. 

3. 

4. 

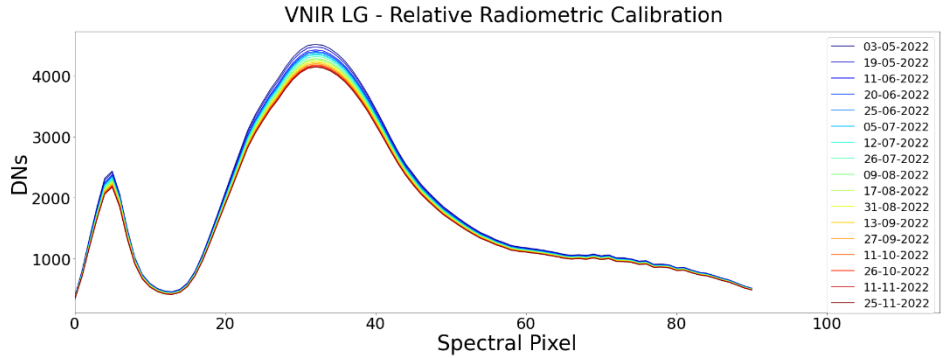
5A. 

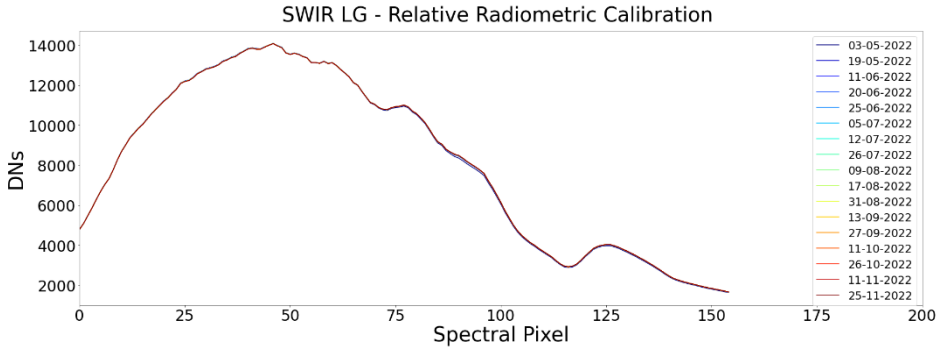
5B. 

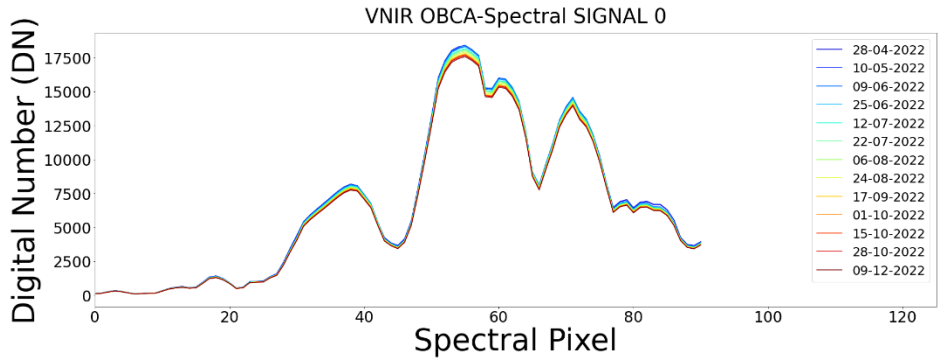
1. **OBCA-Radiometric Stability** Lamp calibration with white spectralon sphere, frequency: weekly
2. **OBCA-Spectral** Spectral calibration with doped spectralon sphere, frequency: 2 weeks
3. **Absolute Radiometric** Sun calibration with sun diffuser, frequency: monthly
4. **Linearity Calibration** with LEDs in front of focal plane, frequency: monthly
5. **A. Shutter Calibration Mechanism** Deep Space calibration, frequency: monthly
5. **B. Shutter Calibration Mechanism** dark measurement, frequency: before and after every image acquisition

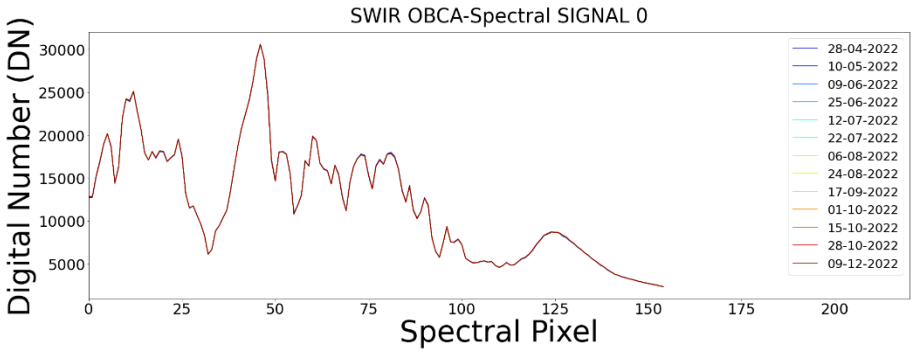
Change in Calibration Measurements – April-December 2022

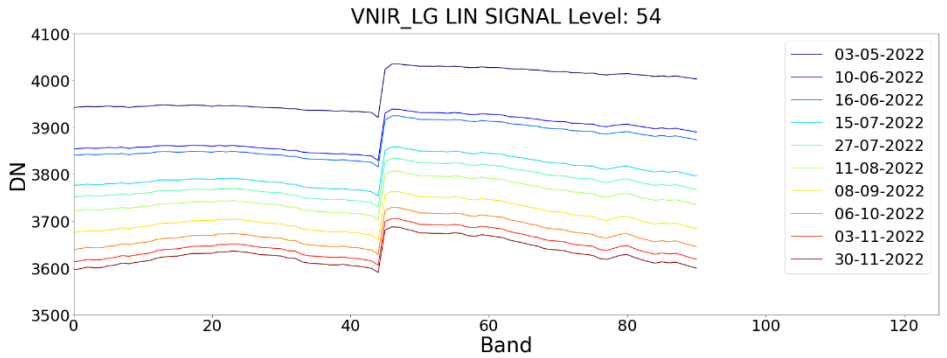
- OBCA-Radiometric Lamp
- OBCA-Spectral
- Linearity

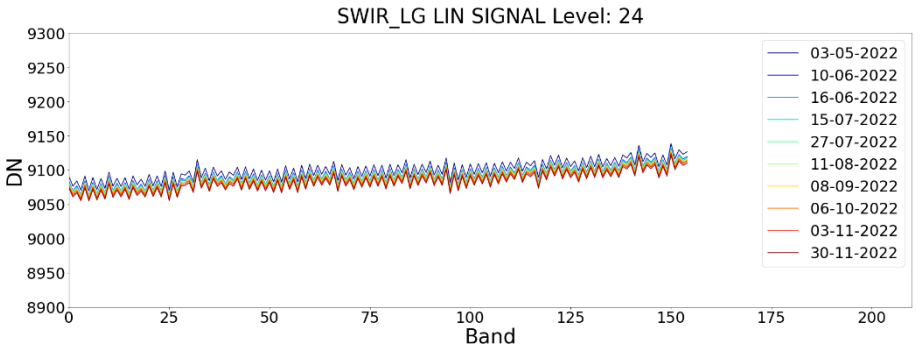






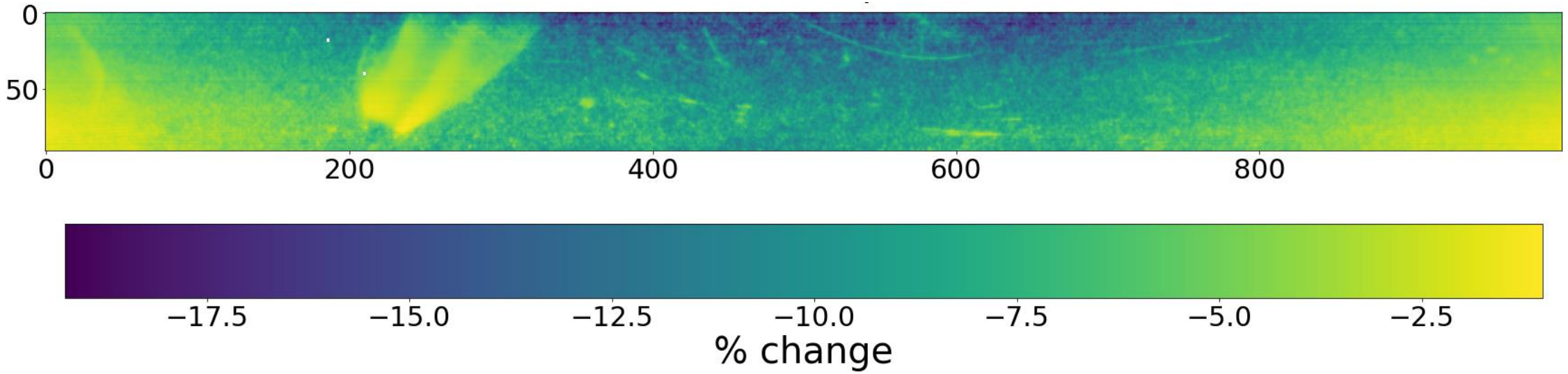




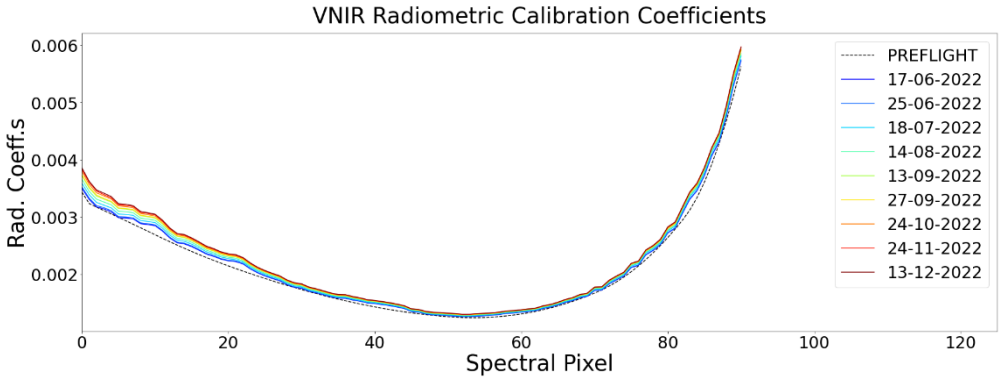


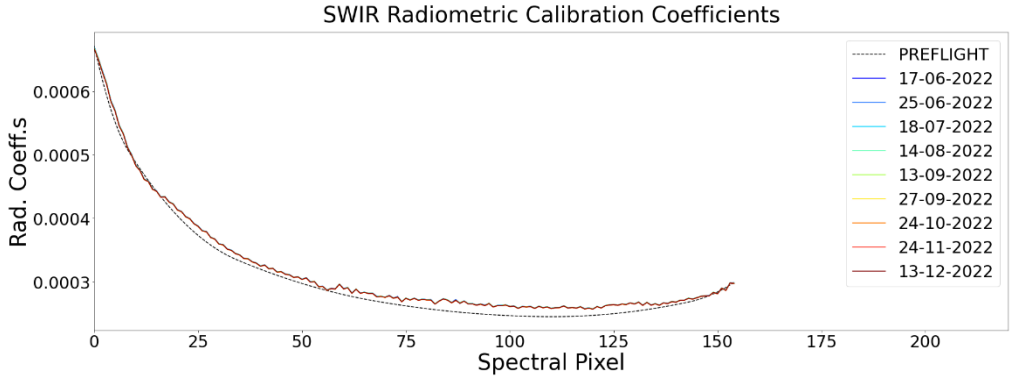
Degradation Distribution Pattern

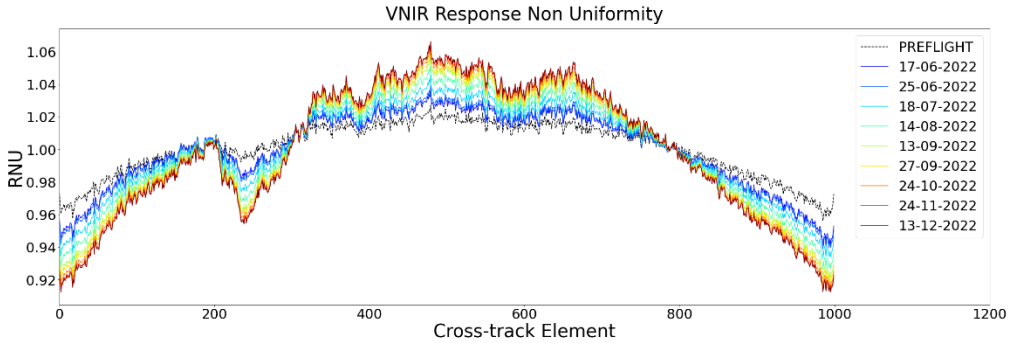
- Degradation map from OBCA-Radiometric Lamp in VNIR HG
- Percentage change from May – November 2022

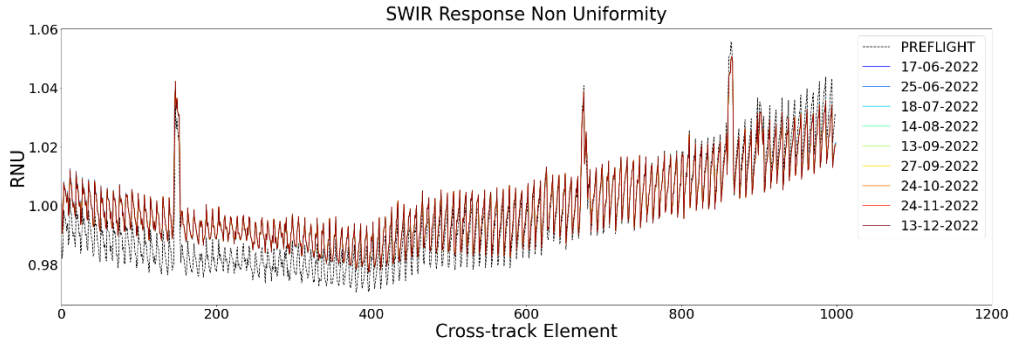


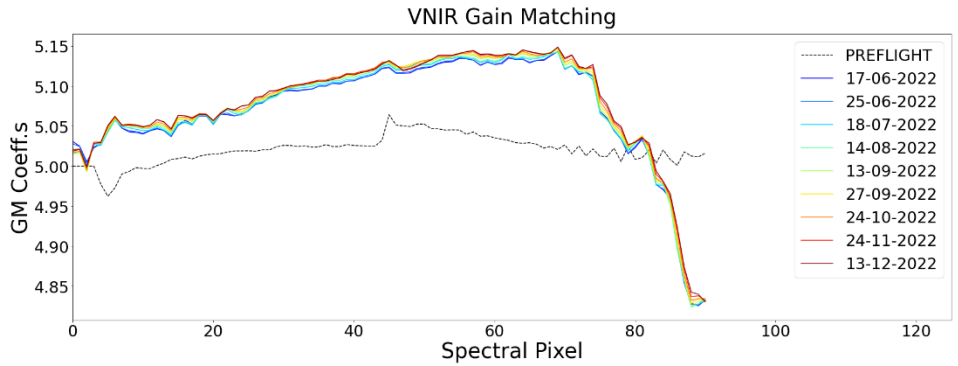
Absolute Radiometric Calibration Coefficients – April-December 2022

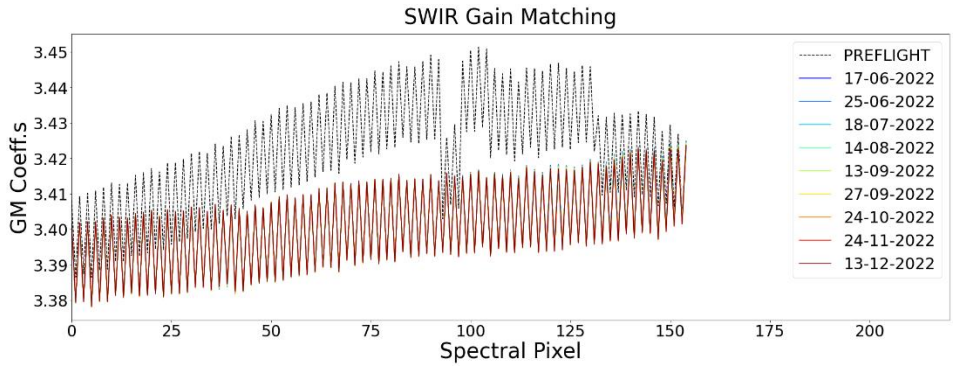










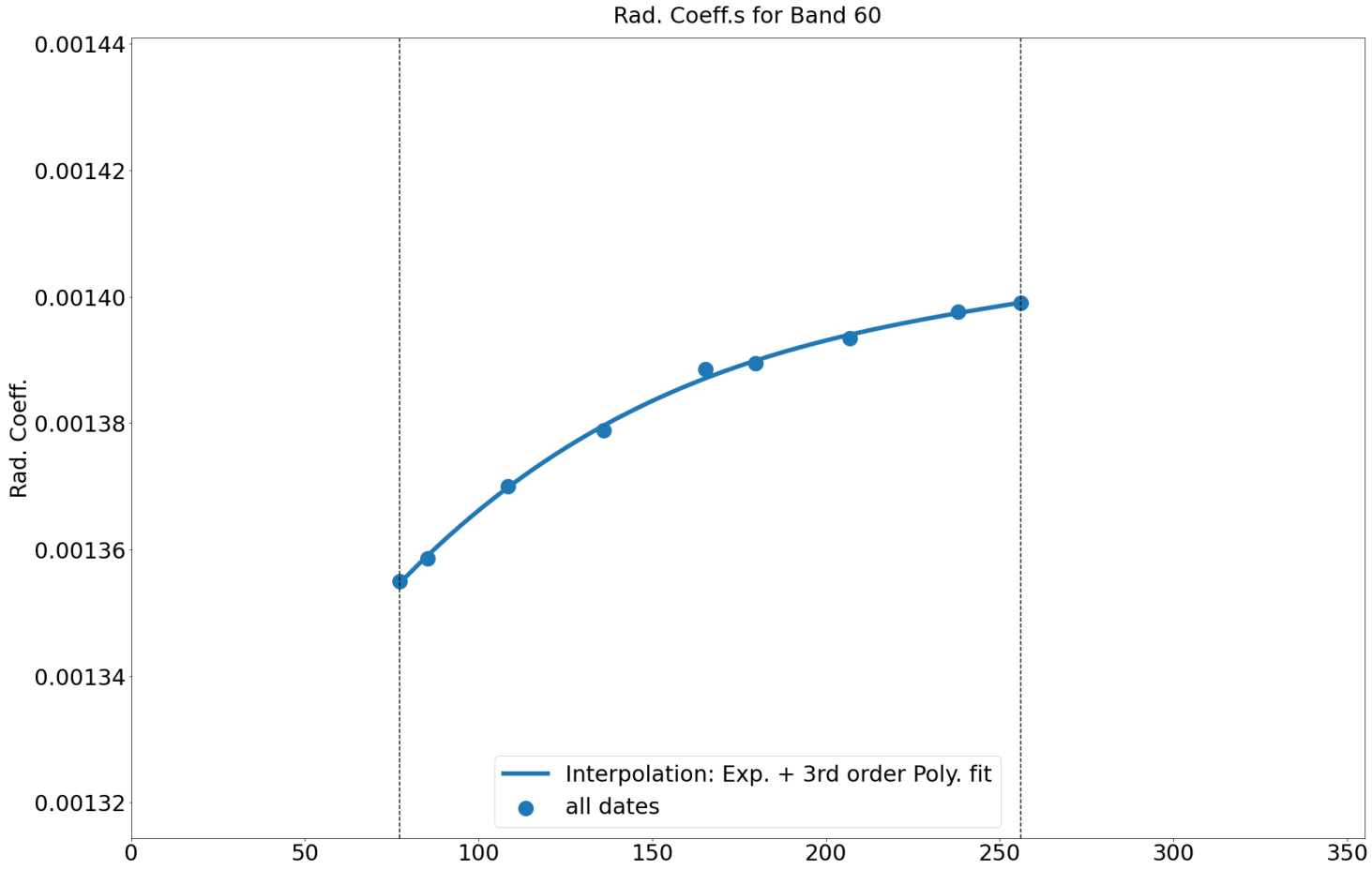


Dynamic Coefficients

Due to fast degradation in VNIR sensor, calibration tables used in L1B processing could become outdated quickly

Solution: model VNIR RNU and radiometric behaviour with „Dynamic Coefficients“ from an exponential-polynomial function

Dynamic Coefficients are used between April – December 2022 rather than coefficients in calibration tables

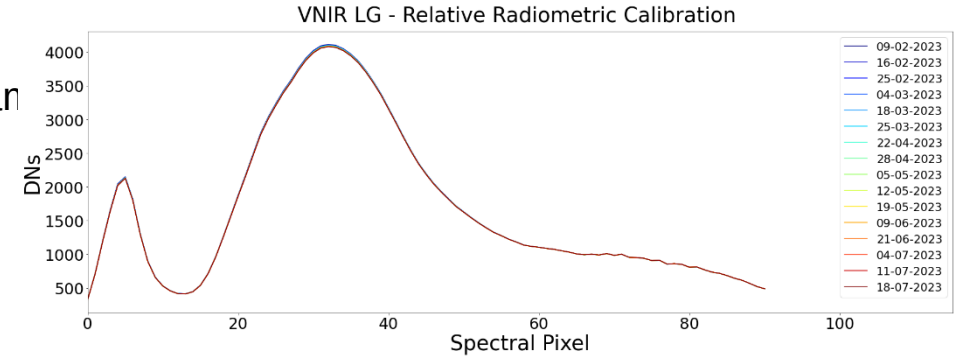


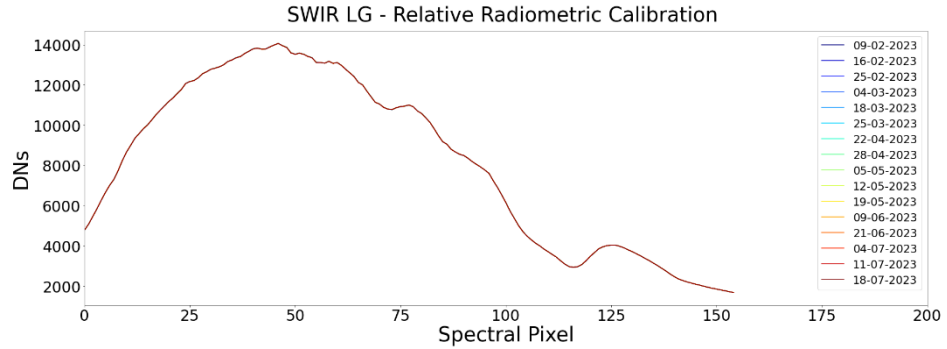
$$Coefficient^{RNU/CC} = Ae^{Bx} + Cx^3 + Dx^2 + Ex + F$$

X is days from 1st April 2022

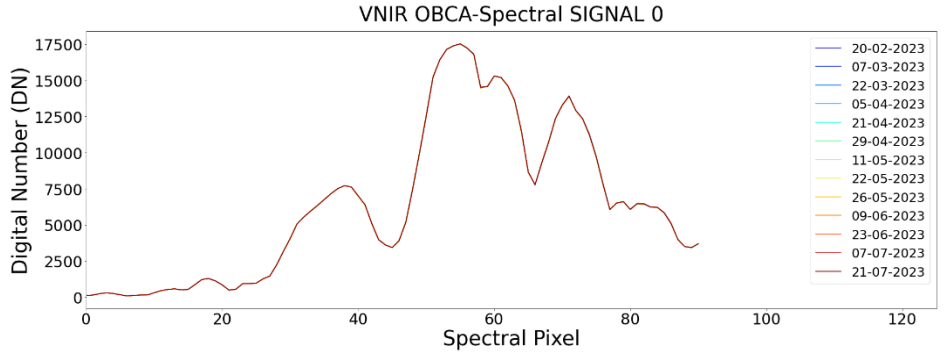
Change in Calibration Measurements – February-July 2023

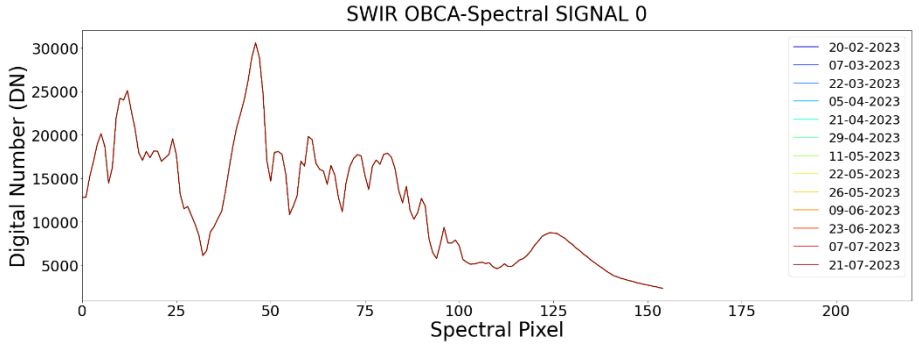
- OBCA-Radiometric Lan



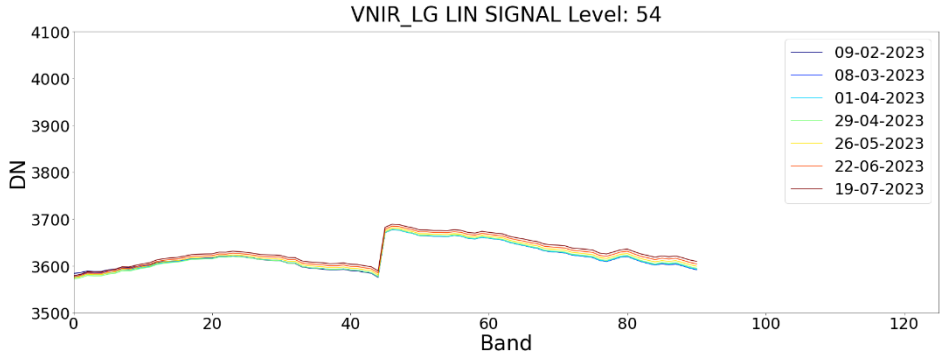


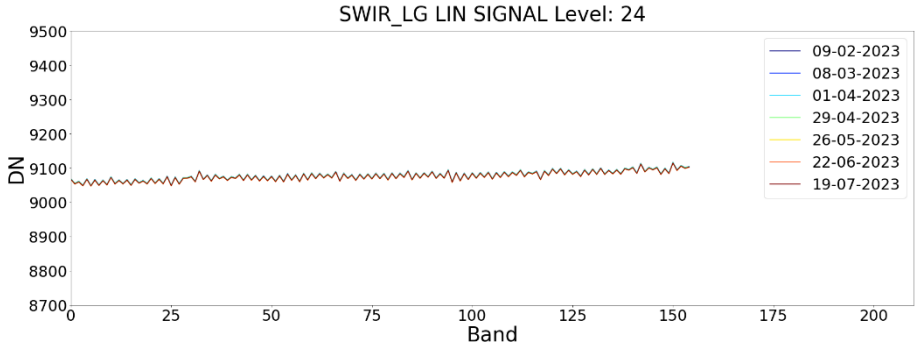
- OBCA-Spectral



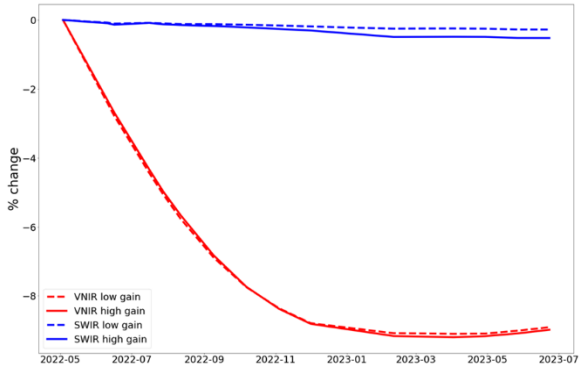


- Linearity

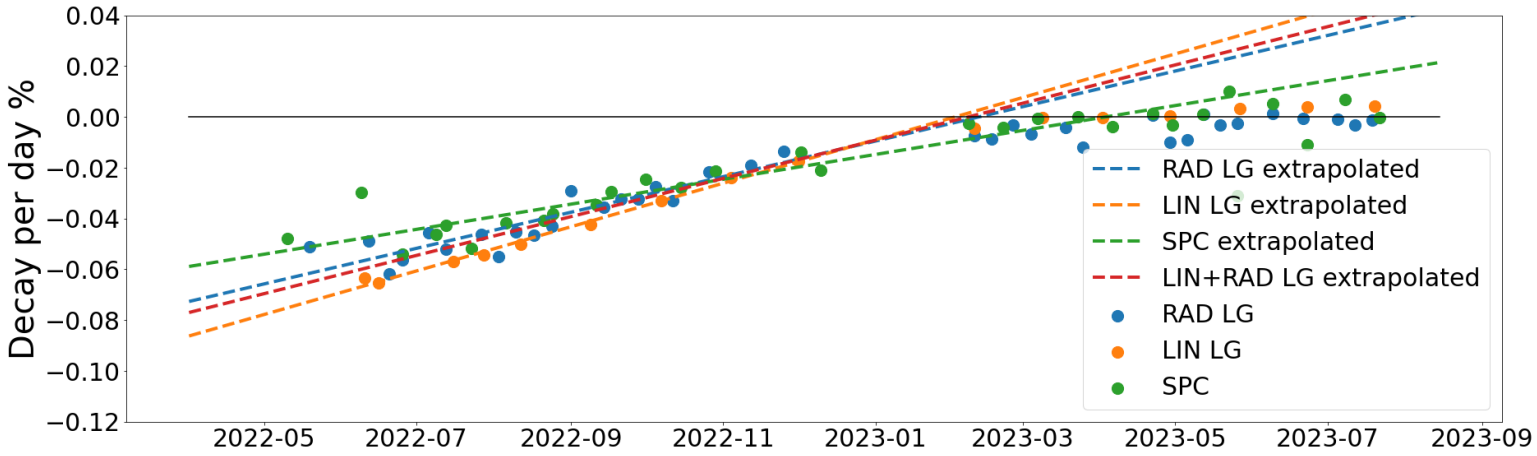


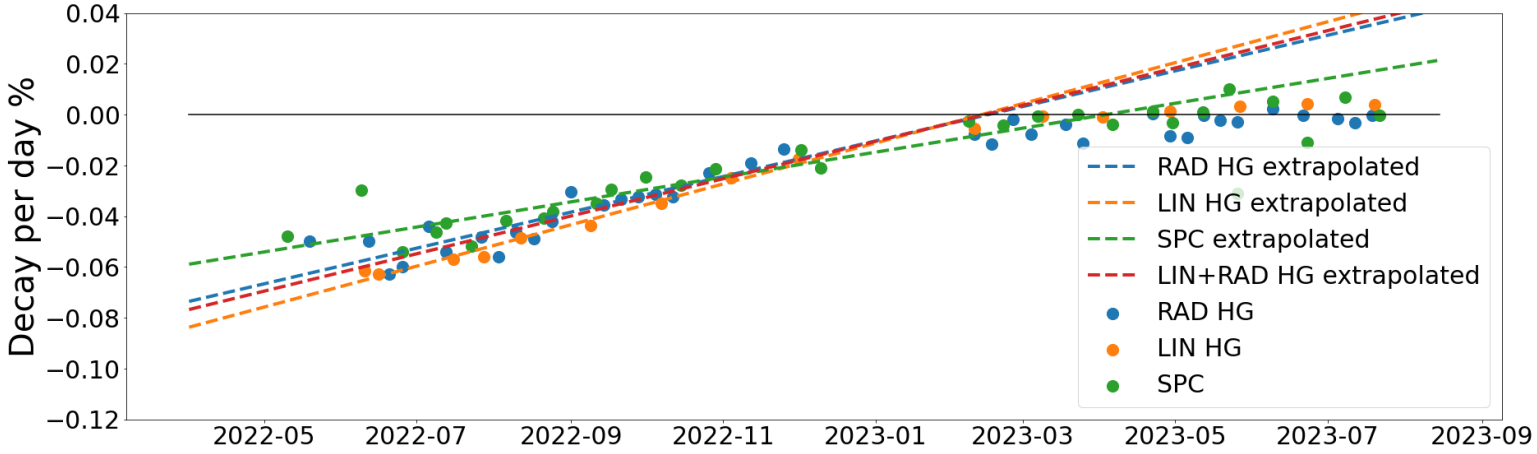


Change in Degradation per Day

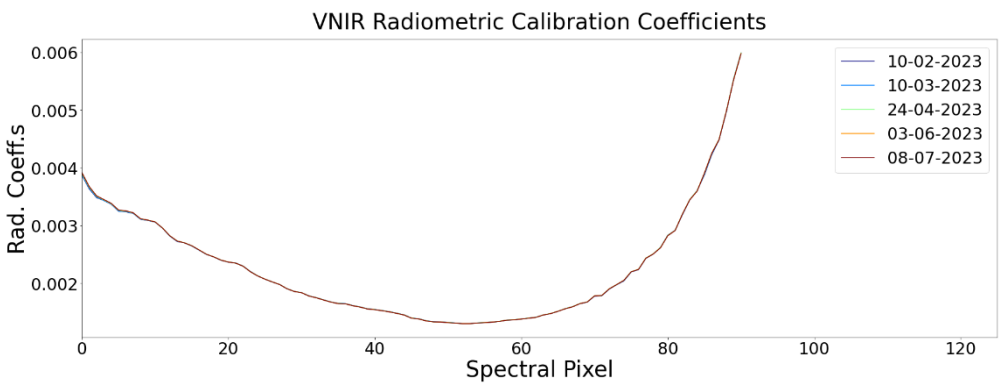


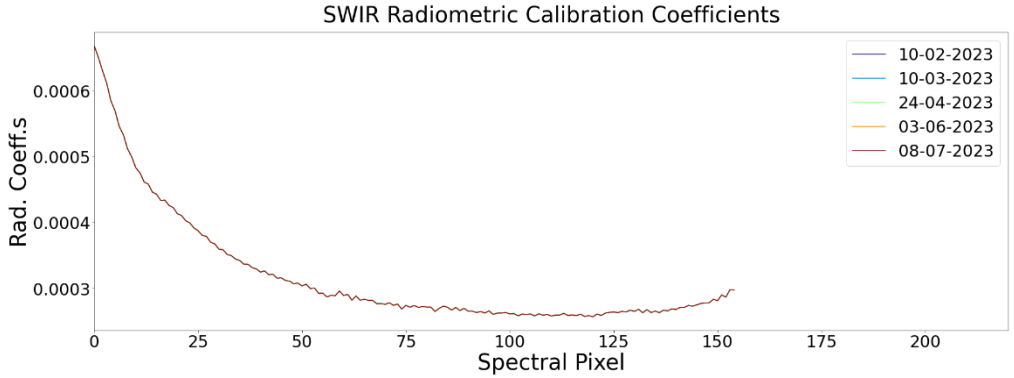
- Degradation per day calculated from OBCA-Radiometric, OBCA-Spectral and Linearity measurements
- Large values during Commissioning Phase (-0.05% per day)
- Values decreasing over time
- Approximately zero degradation now (with some variability)
- Cause still unknown
- Total loss around 10%

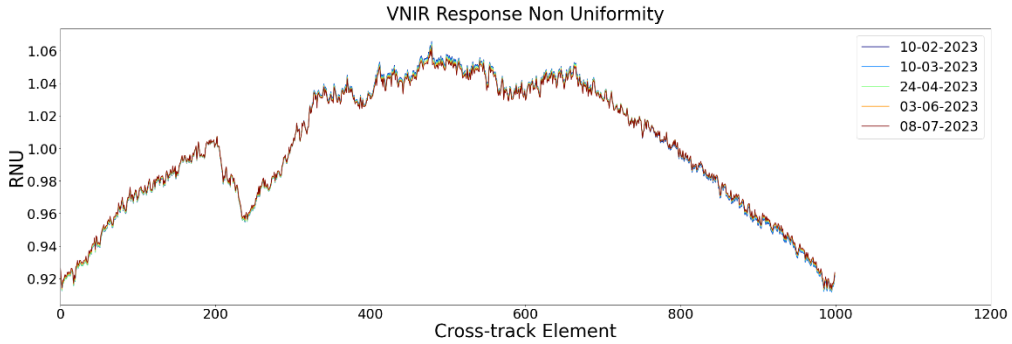


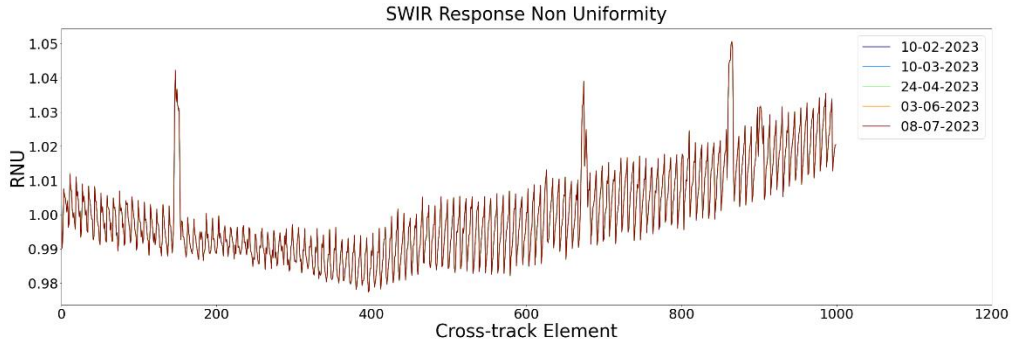


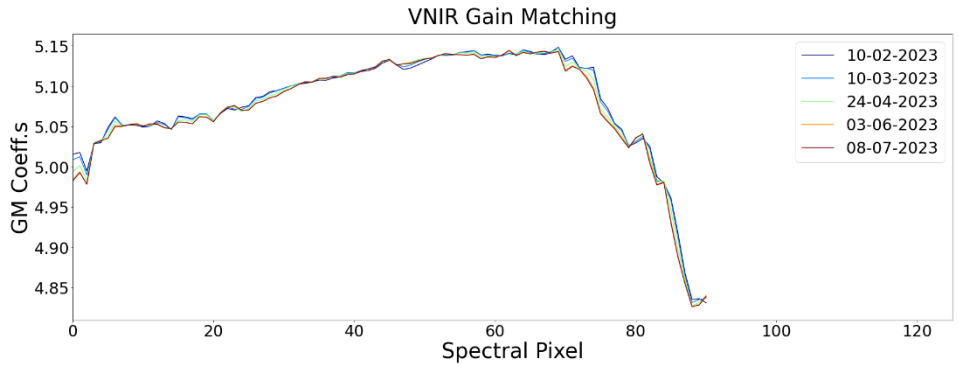
Calibration Coefficients

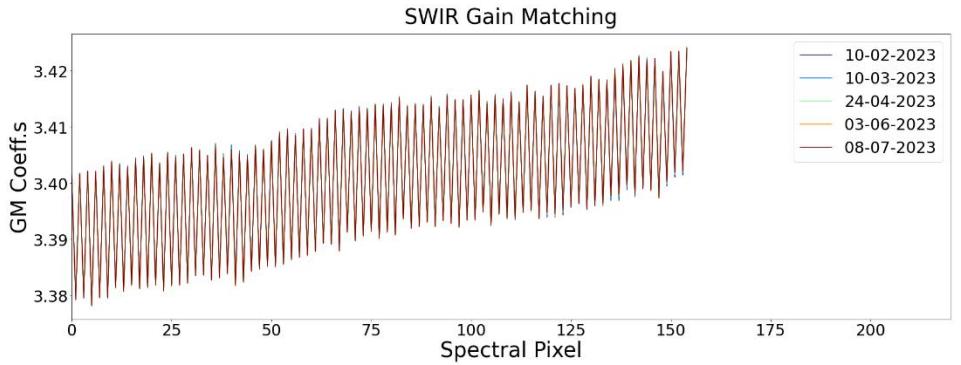




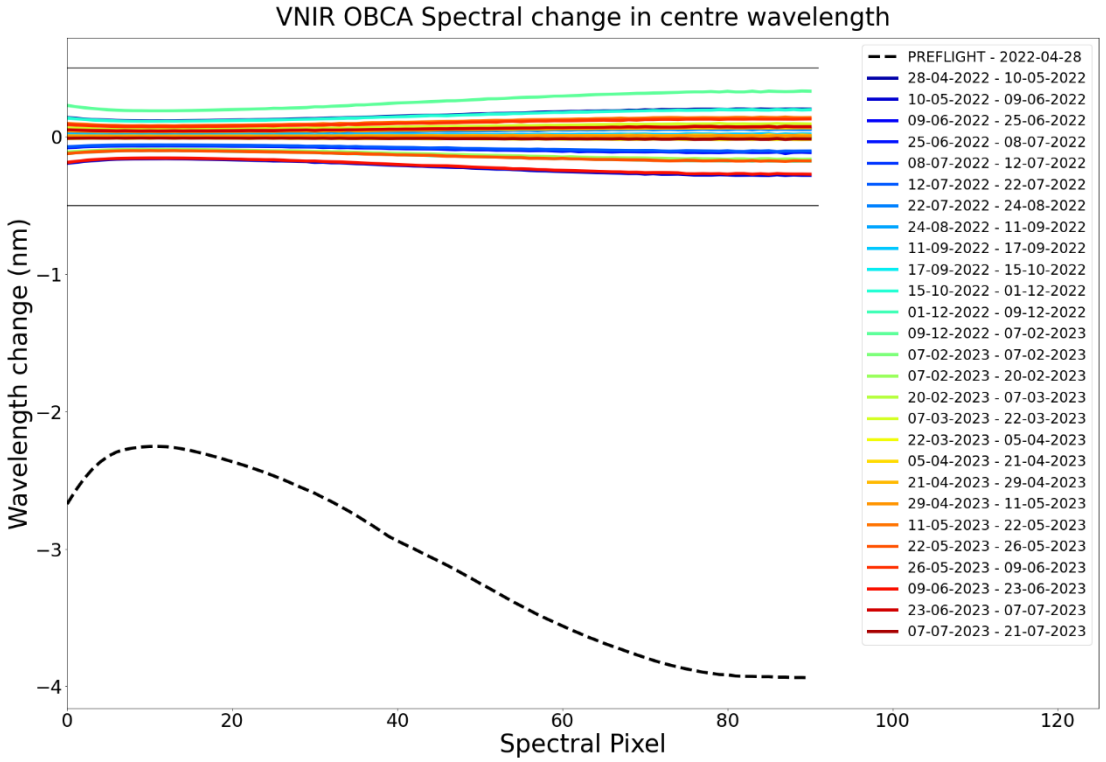


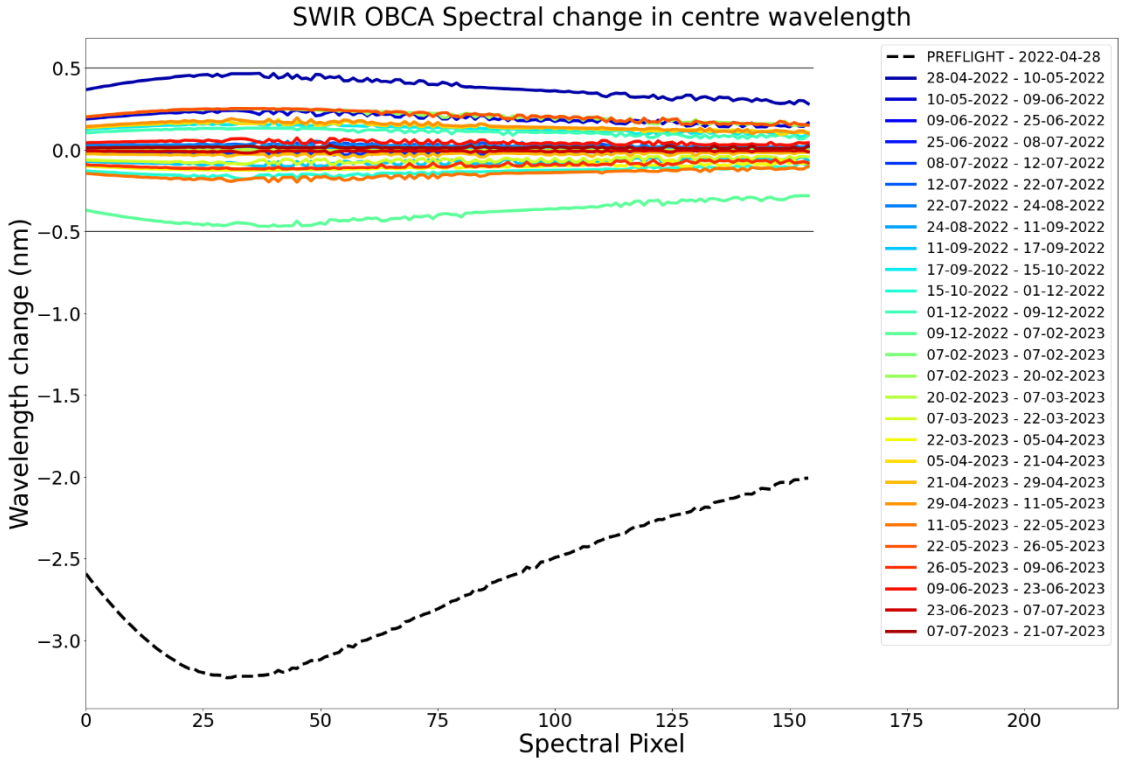






Spectral stability





- Good spectral stability: within requirements (0.5 nm VNIR, 1.0 nm SWIR)
- 6 spectral updates during mission (4 during Commissioning, 1 after outage, 1 for SWIR band swap)

Summary

	April – December 2022	January 2023 – Present
VNIR sensor	Degradation (10%)	Stable
VNIR radiometric calibration coefficients	Changes due to degradation, dynamic coefficients used	Stable (meets 2.5% requirement between observations), calibration tables used
SWIR sensor	Stable after launch	Stable
SWIR radiometric calibration coefficients	Stable after launch (meets 2.5% requirement between observations)	Stable (meets 2.5% requirement between observations)
Dark Signal	Stable	Stable
VNIR spectral calibration	Stable after launch (meets 0.5 nm requirement)	Stable (meets 0.5 nm requirement)
SWIR spectral calibration	Stable after launch (meets 1.0 nm requirement)	Stable (meets 1.0 nm requirement)