Lunar Activities at VITO

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CEOS WGCV IVOS 35 – 25-29/09/2023 – DLR - Munich

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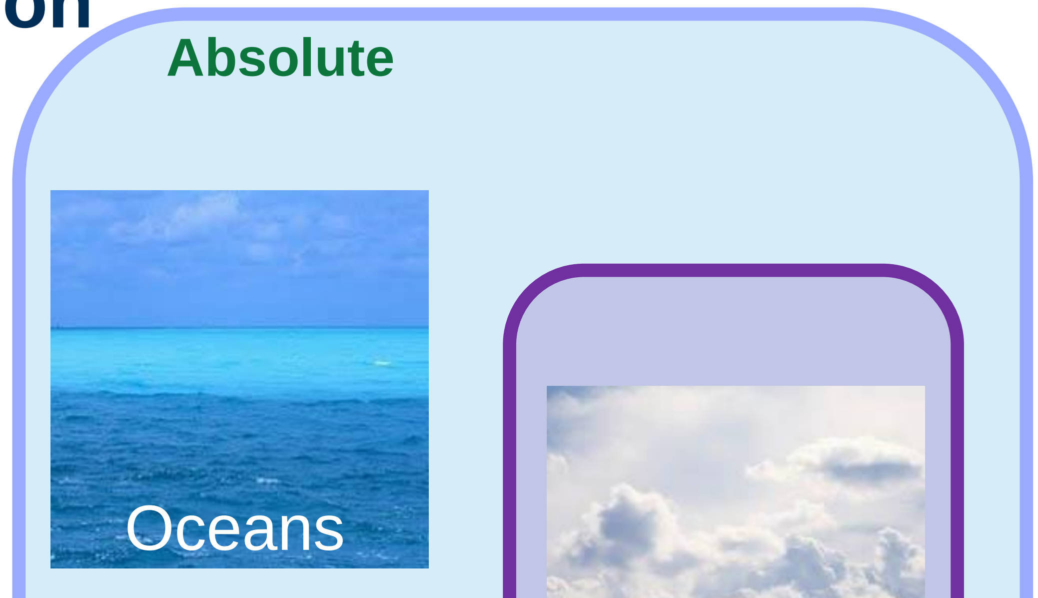
  - Straylight
- LIME
- CalibrEO

Introduction : Radiometric Calibration

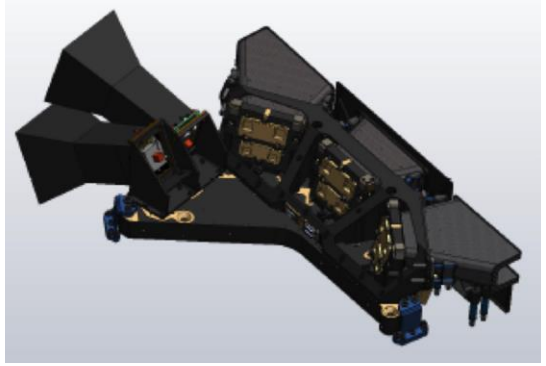
Overview

- Started around 2010
- Direct need : PROBA-V launch in 05/2013
- Setup the OSCAR facilities from scratch



PROBA-V

Vegetation instrument



- Operational :
  - From 11/2013 (2.5y intended)
  - Daily global coverage
  - Calibration Scenes (2 lunar acquisitions per month)

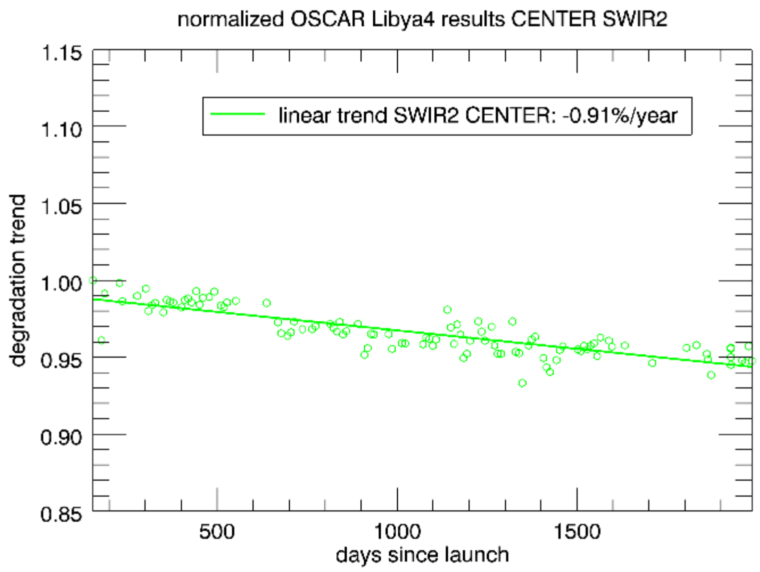
- Extended limited operational
  - From 07/2020
  - imaging over Europe and Africa only
  - Calibration Scenes
  - increasing the number of Lunar acquisition
    - Include cycles (-90.0 -> 90.0 phase angle)

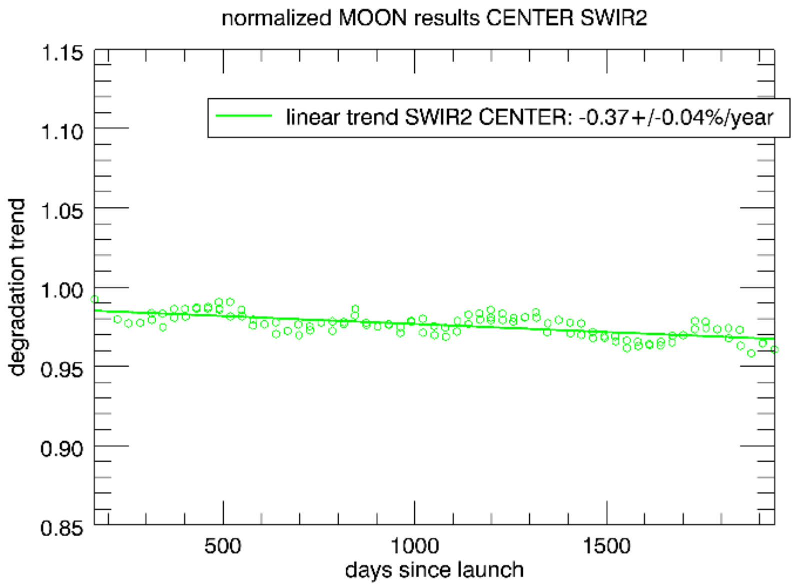
- Experimental
  - From 11/2021
  - Dark current and RadCalNet (Railroad and Gobabeb) : limited amount of acquisitions
  - Due to power limitations and temperature control : currently only moon acquisitions

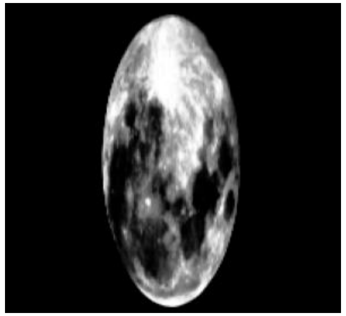
- 3 Cameras
- 2 focal planes:
  - VNIR with 3 bands
  - SWIR with 1 band but staggered strips

PROBA-V Operational

Trend monitoring

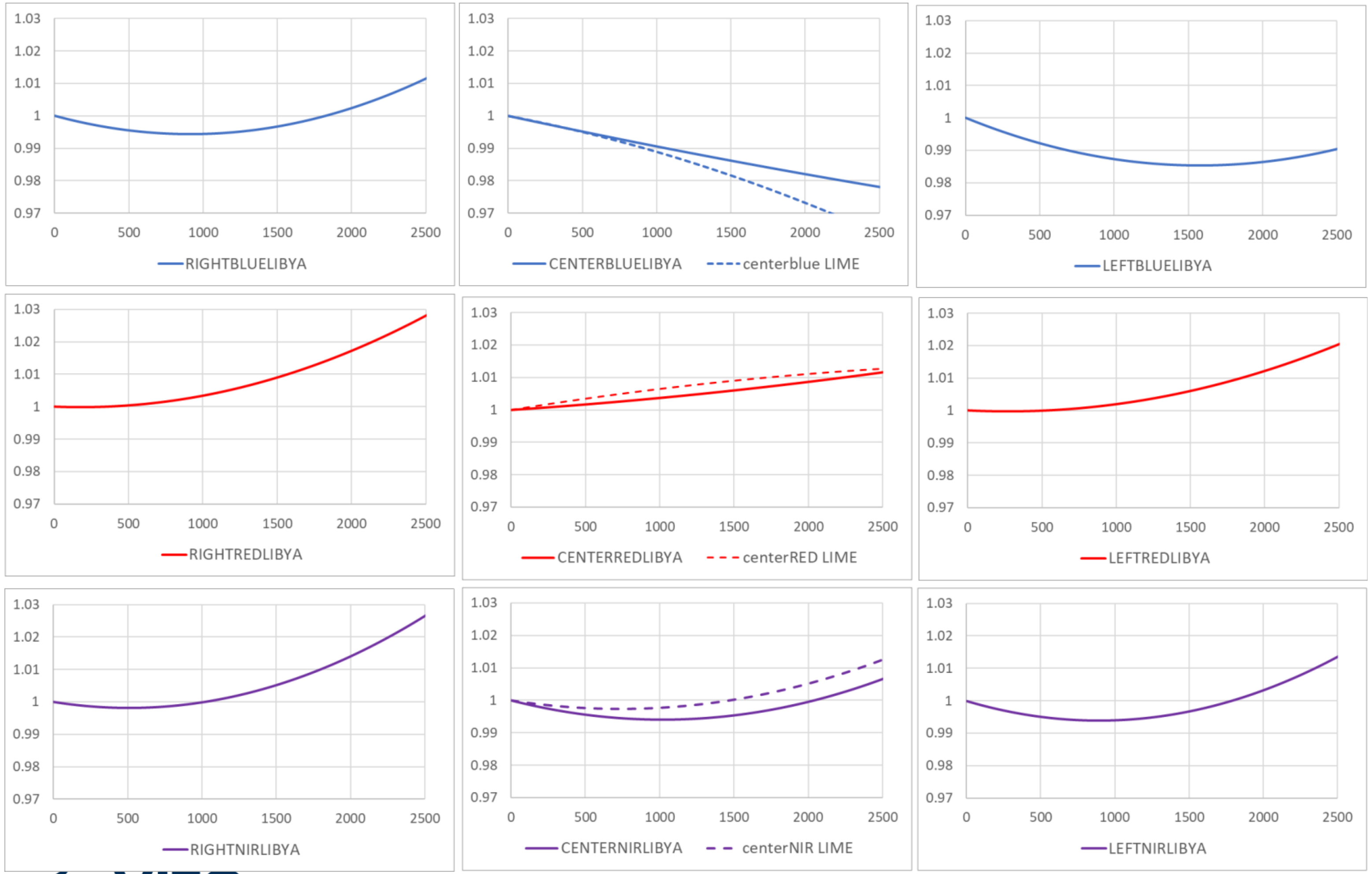






PROBA-V Operational

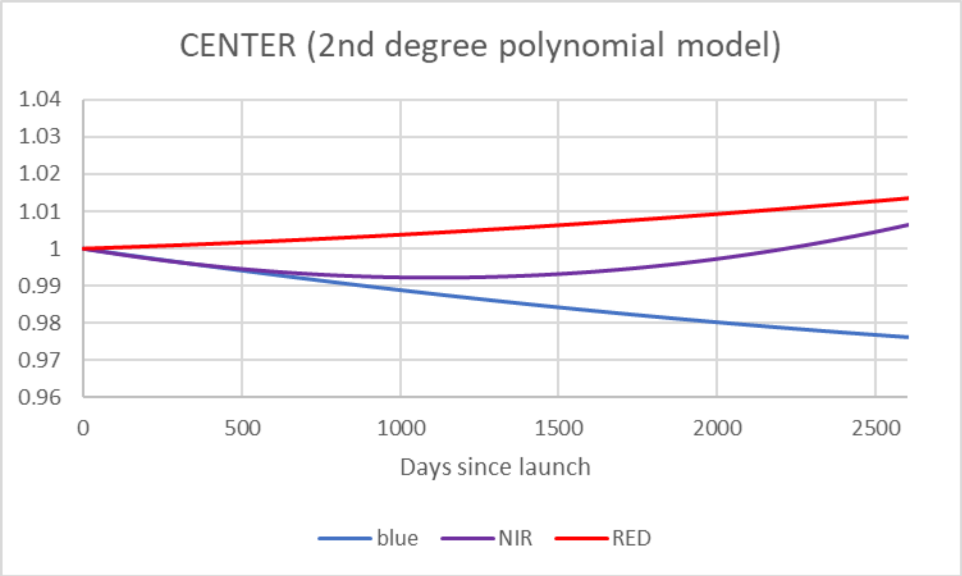
Degradation model : Collection 2

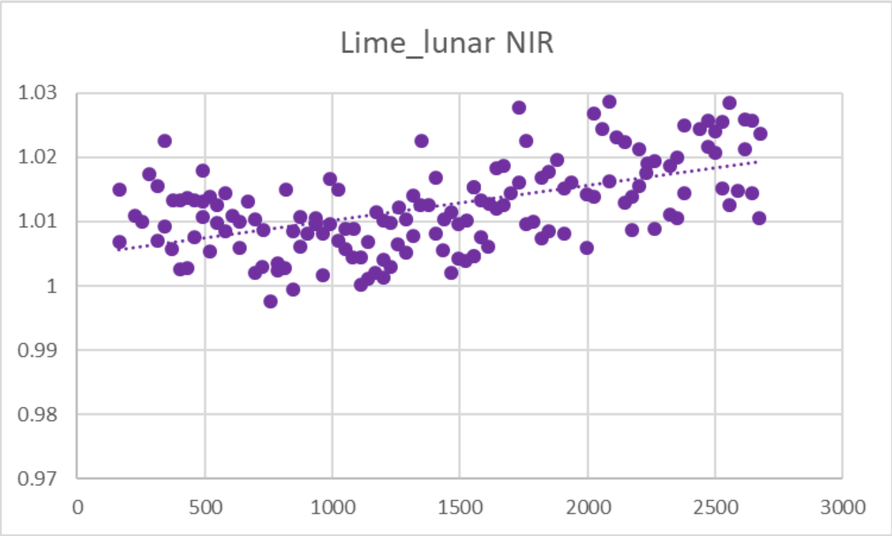


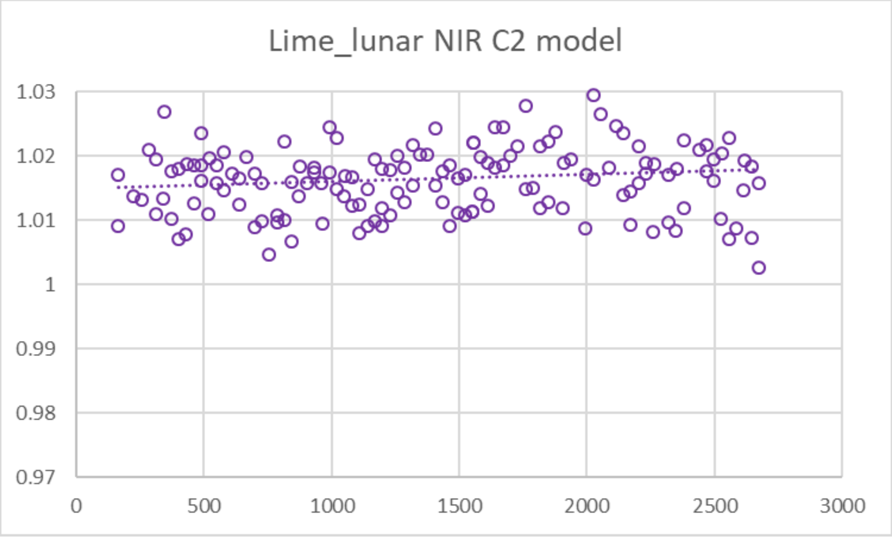
- For C2 :
  - Updated degradation models (2nd deg poly)
  - Based on PICS Lib4
  - Center models checked with lunar results (against LIME)

PROBA-V Operational

Degradation model : Collection 2







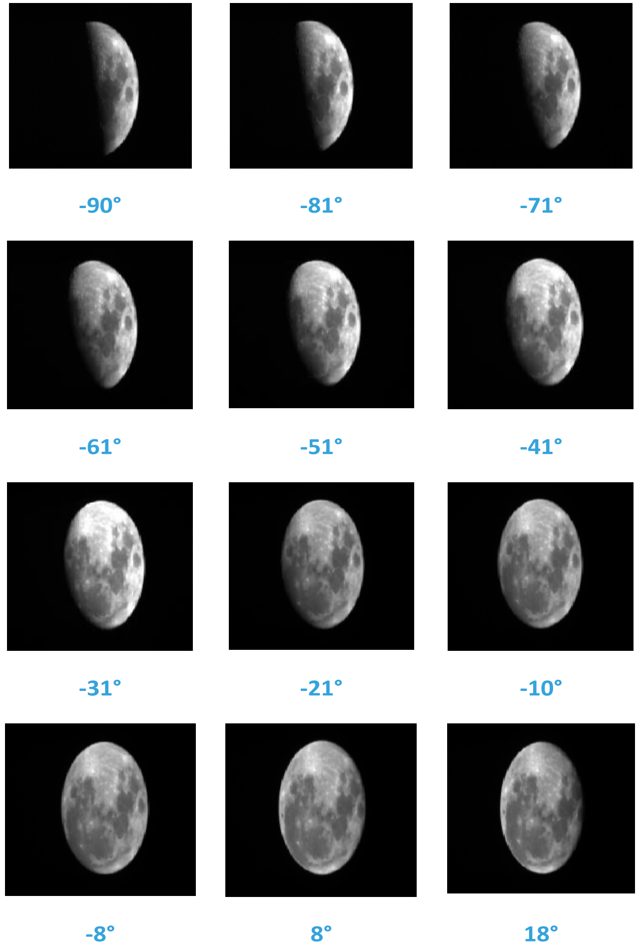
PROBA-V Experimental

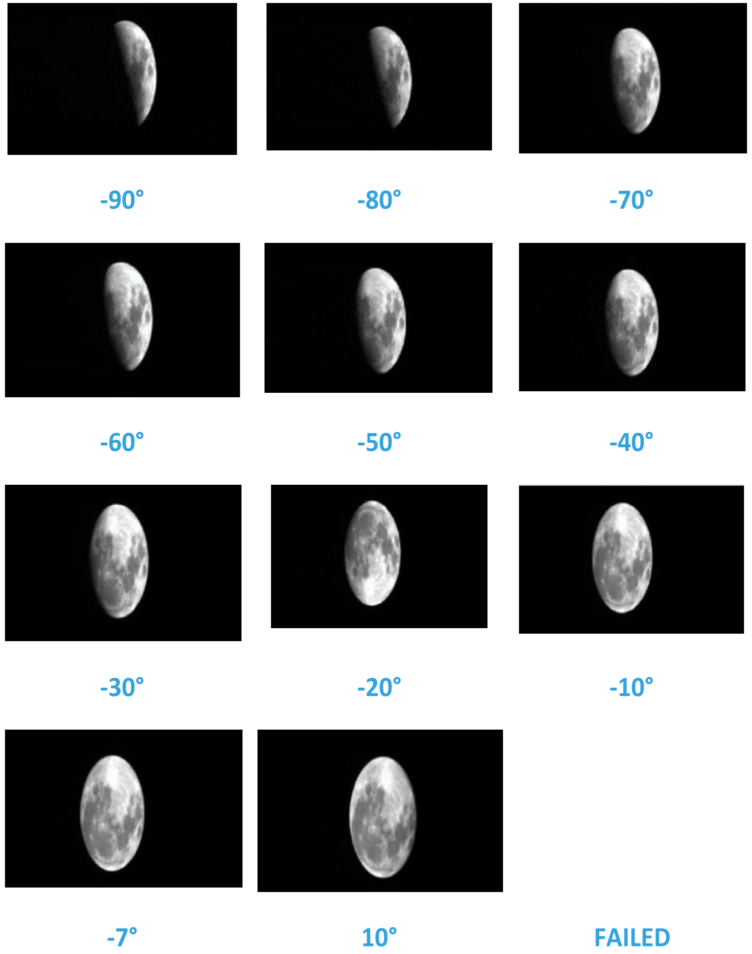
Experimental Phase

- Since November 2020 PROBA-V taking complete lunar phases (-90 / + 90 phase)
- About 20 cycles have been (partially) captured
- In total about 400 lunar acquisitions
  - 158 nominal (approx. 7 years) at +/-7 degrees
  - 234 experimental (different phases)
- (and counting …)

PROBA-V : Experimental

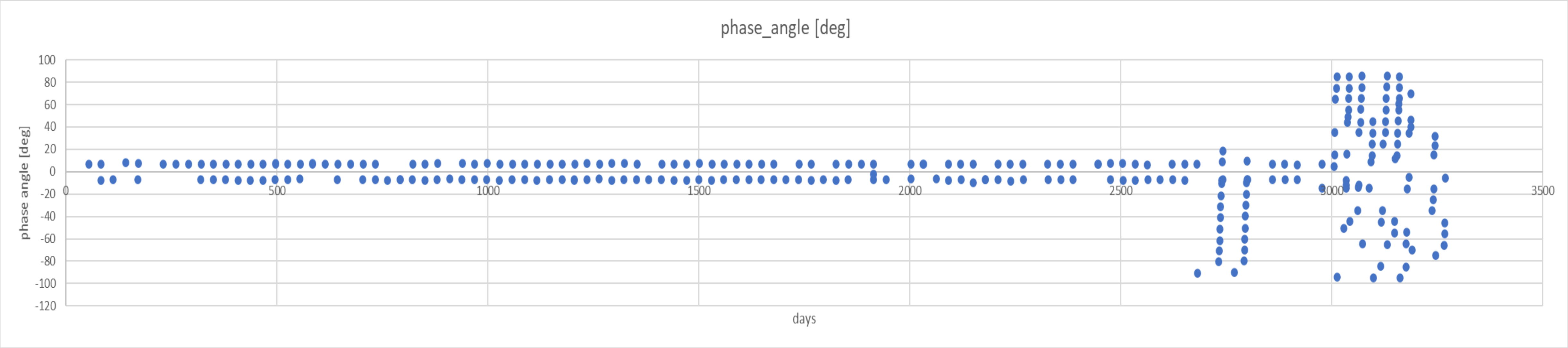
Experimental phase





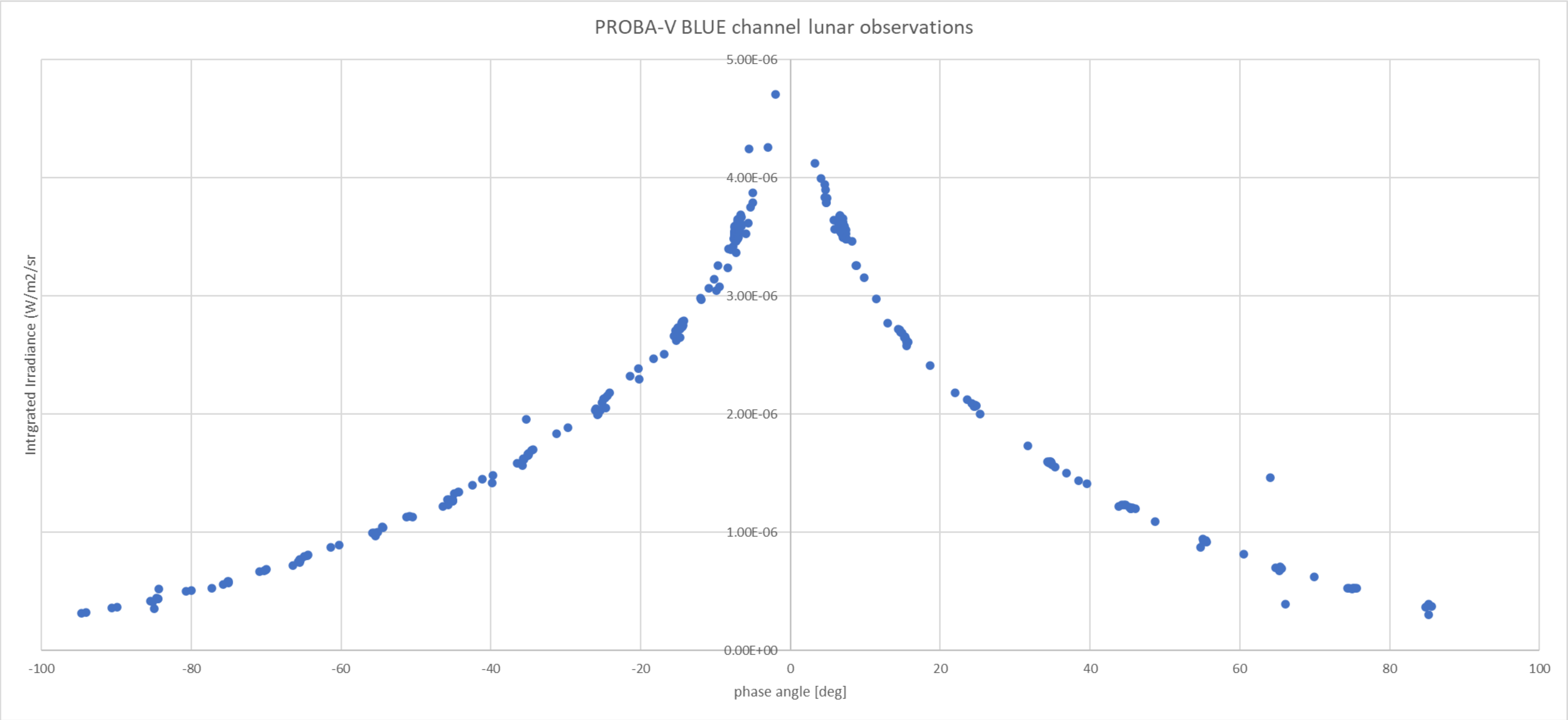
PROBA-V

Geometry



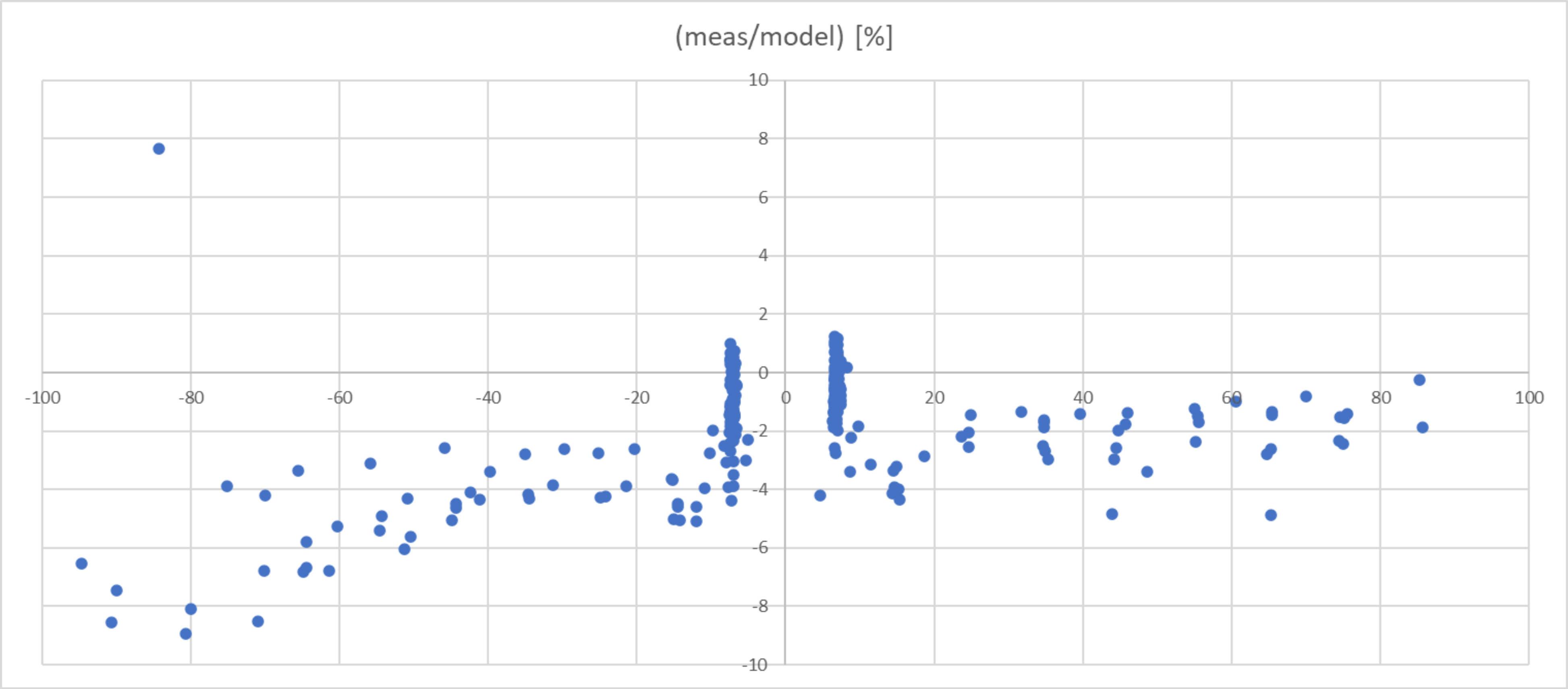
PROBA-V Experimental

Integrated lunar irradiance



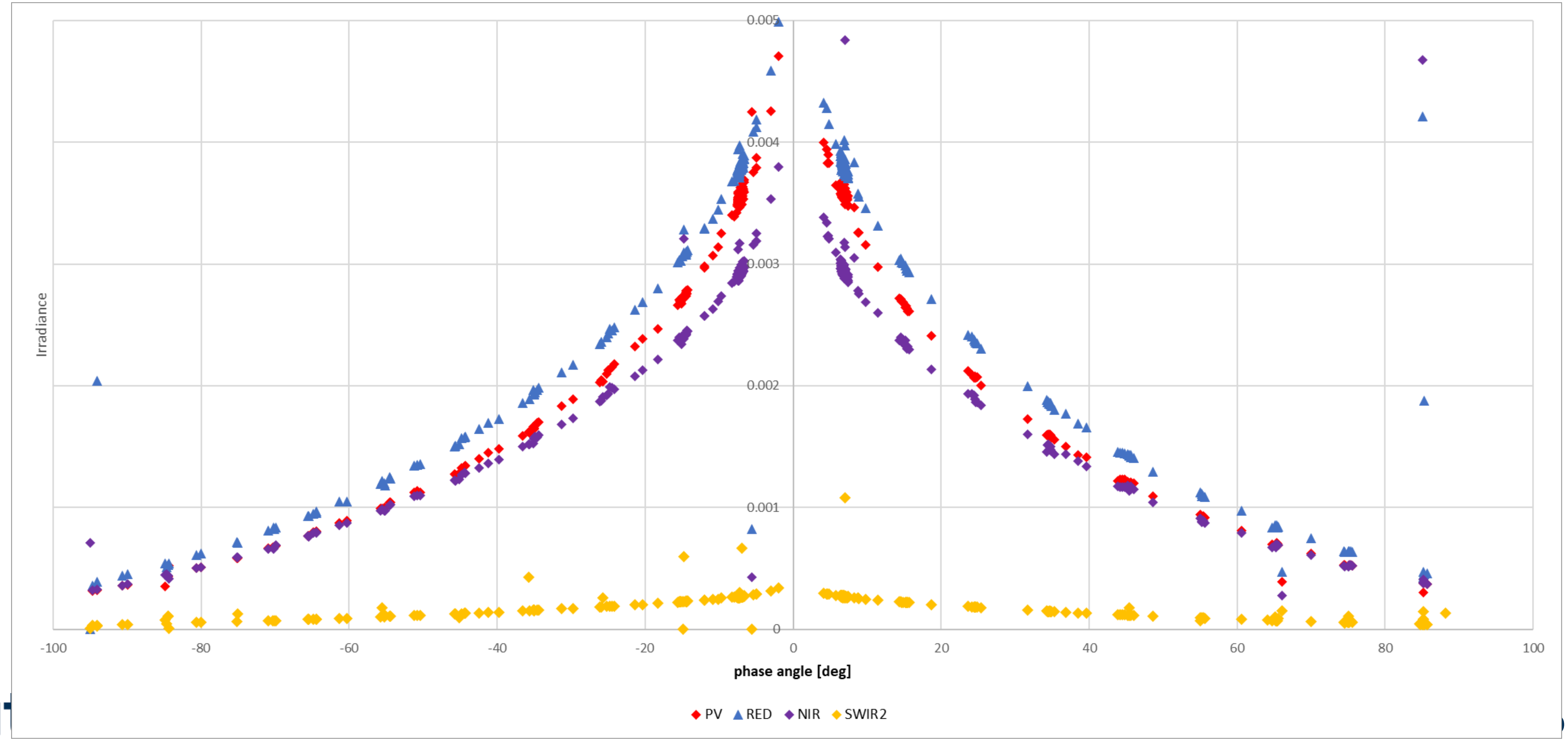
PROBA-V Experimental

Integrated lunar irradiance



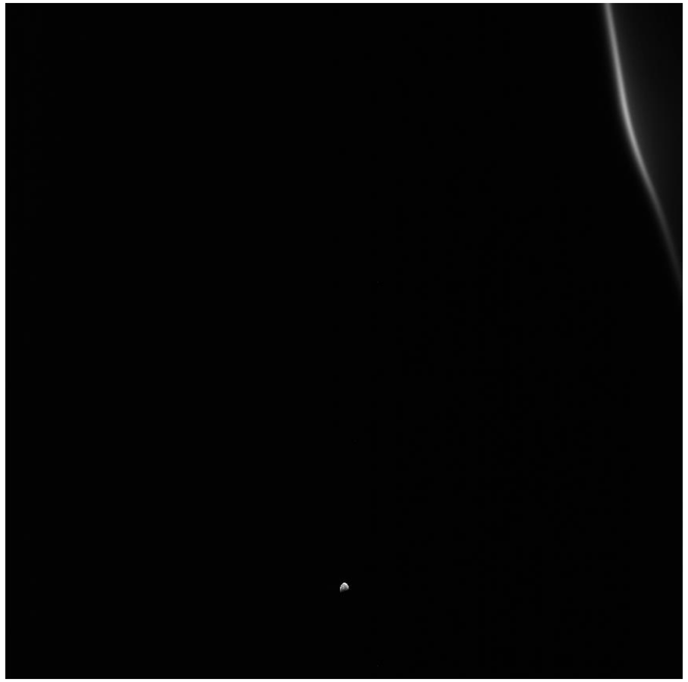
PROBA-V

Integrated lunar irradiance



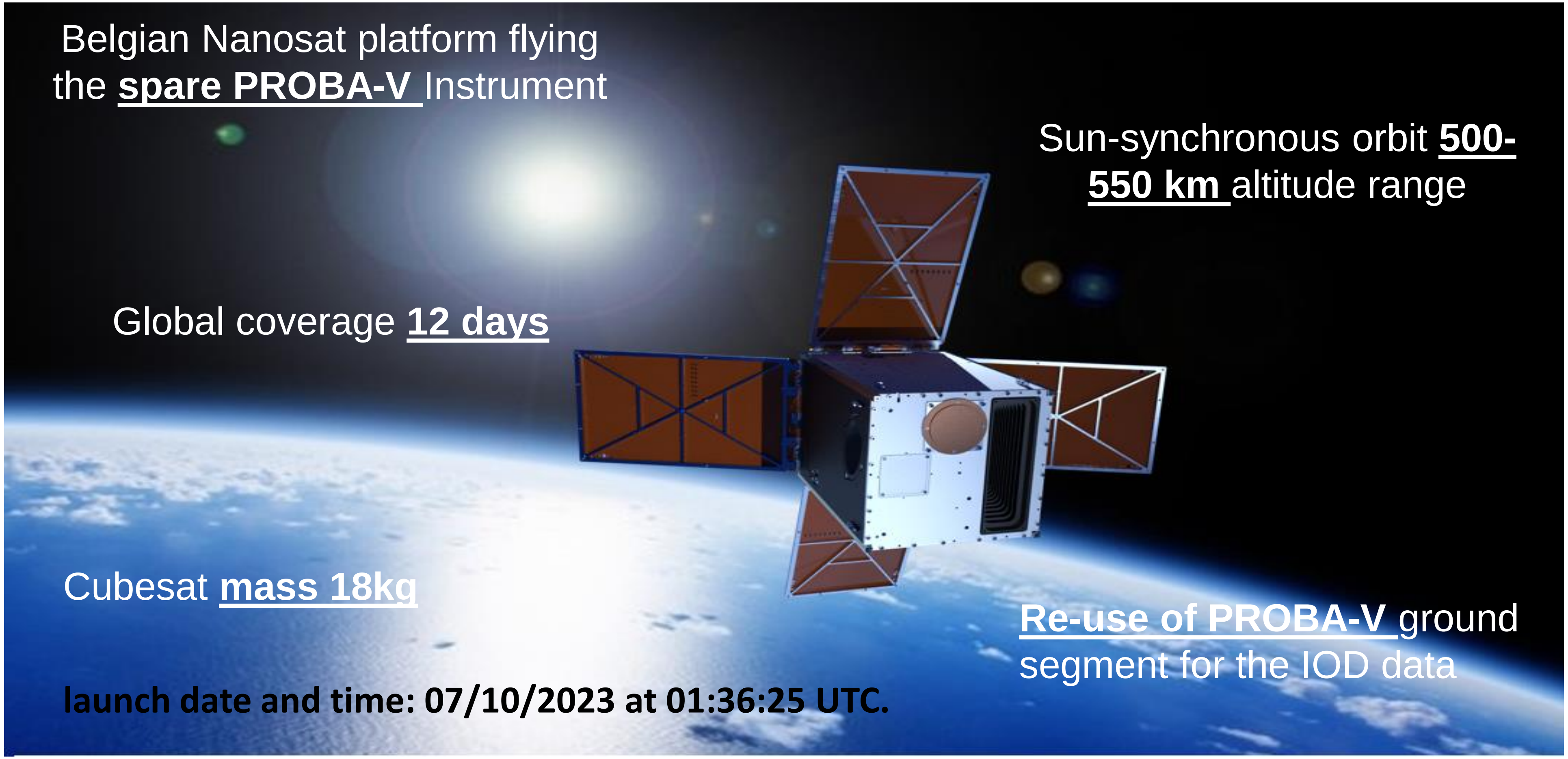
PROBA-V

Experimental



PV-CC

Continuation



Belgian Nanosat platform flying the **spare PROBA-V** Instrument

Sun-synchronous orbit **500-550 km** altitude range

Global coverage **12 days**

Cubesat **mass 18kg**

Re-use of PROBA-V ground segment for the IOD data

launch date and time: 07/10/2023 at 01:36:25 UTC.

vito

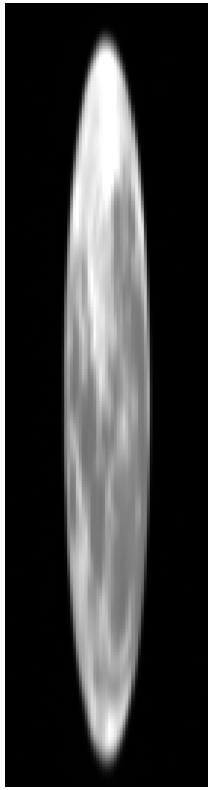
Aerospacelab

OIP Sensor Systems

esa

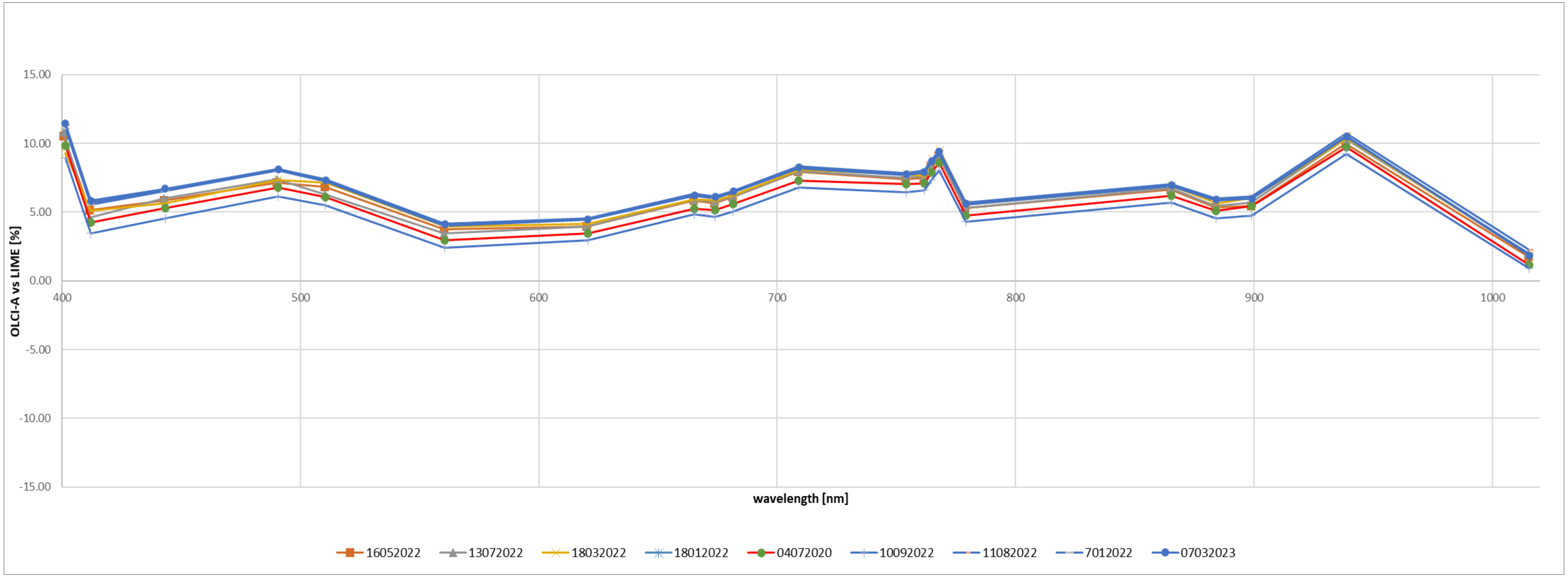
O-MPC : S3 OLCI

- Comparison between OLCI A/B and LIME
- 9 acquisitions for both both OLCI-A and OLCI-B
- Oversample factor +/- 9

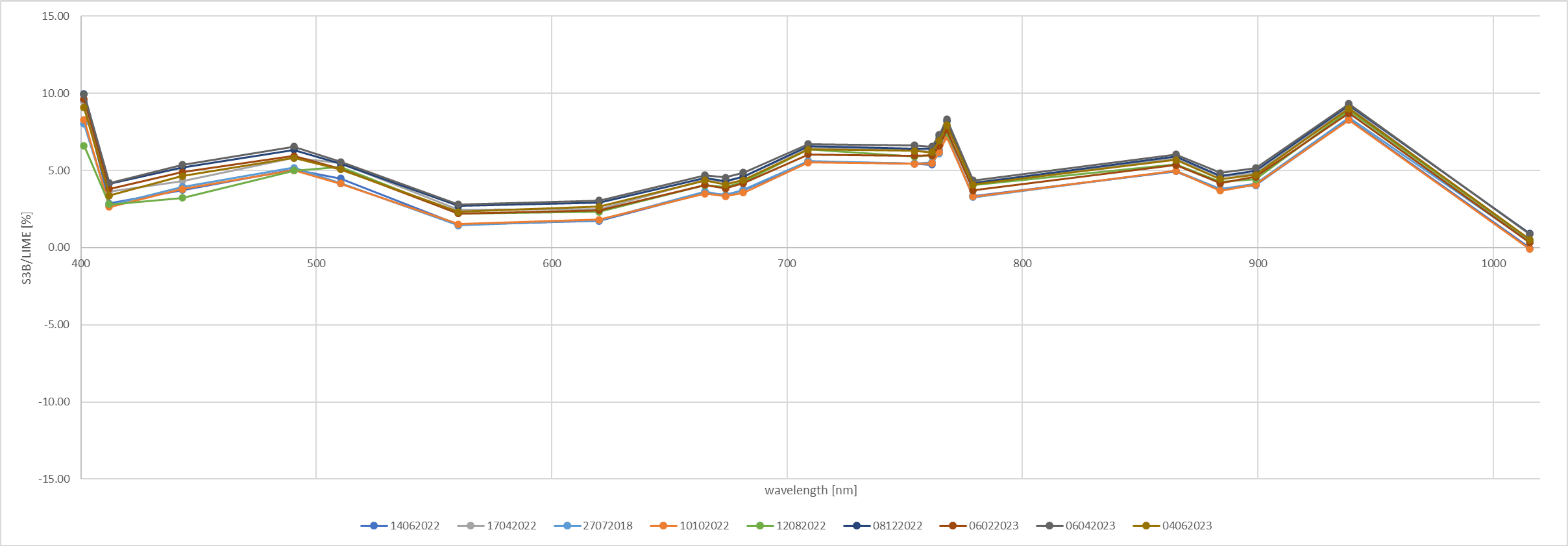


S3-OLCI-A vs LIME

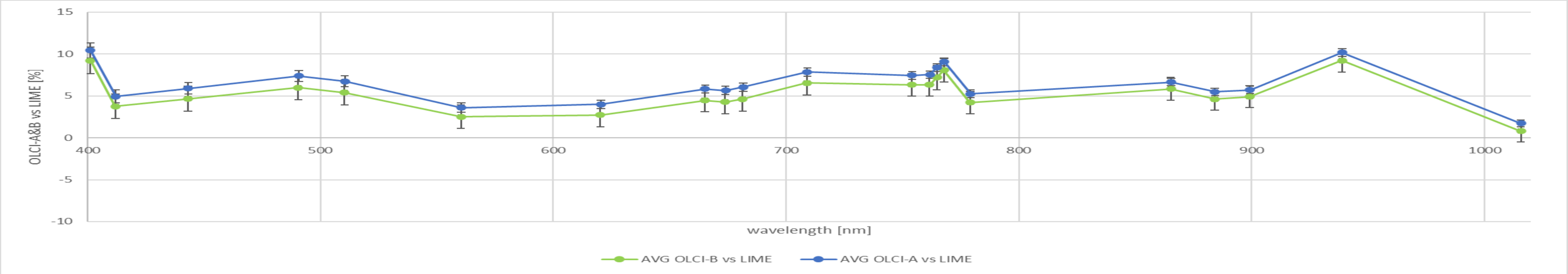
Integrated lunar irradiance

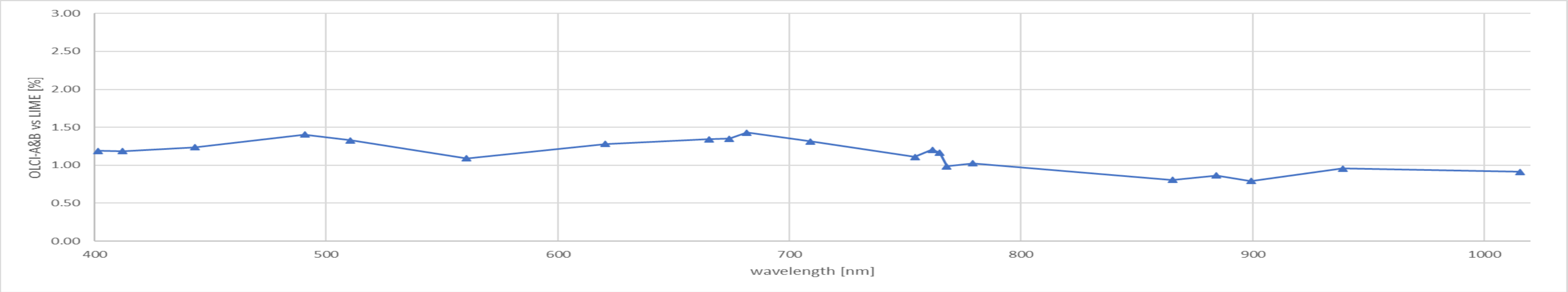


S3-OLCI-B vs LIME



S3-OLCI-A/B vs LIME





S3-OLCI-A/B vs LIME

Moon

band	cwl [nm]	%diff
Oa01	401.328	1.191
Oa02	412.106	1.185
Oa03	443.260	1.238
Oa04	490.712	1.406
Oa05	510.535	1.328
Oa06	560.524	1.091
Oa07	620.551	1.281
Oa08	665.296	1.345
Oa09	674.021	1.350
Oa10	681.575	1.430
Oa11	709.116	1.315
Oa12	754.150	1.110
Oa13	761.734	1.203
Oa14	764.808	1.166
Oa15	767.886	0.986
Oa16	779.210	1.026
Oa17	865.378	0.807
Oa18	884.247	0.865
Oa19	899.215	0.795
Oa20	938.812	0.957
Oa21	1015.583	0.912

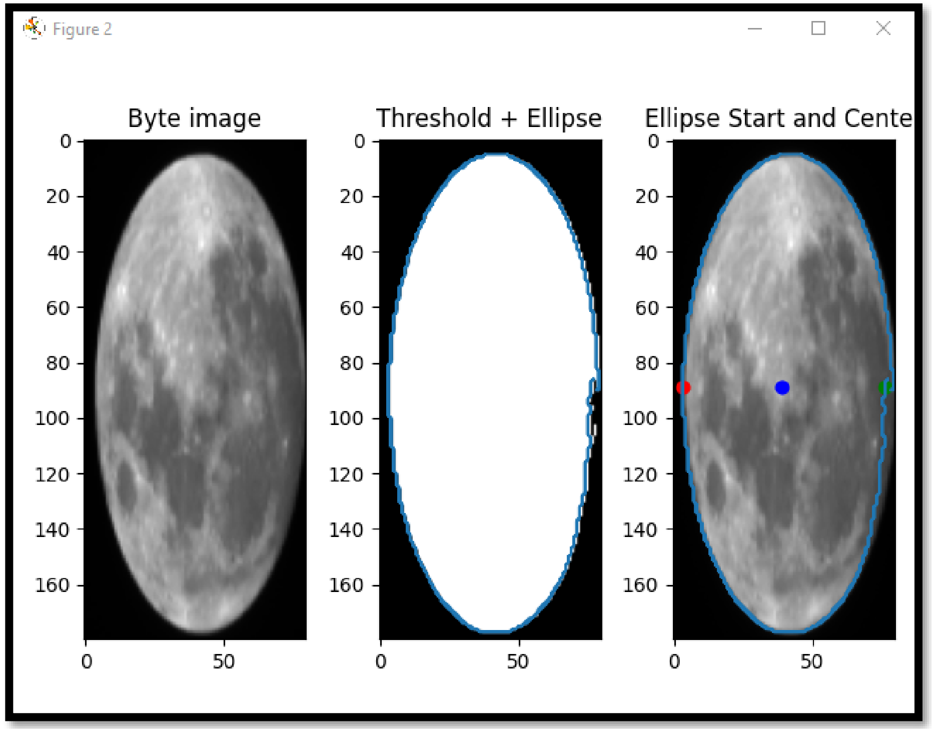
Glitter

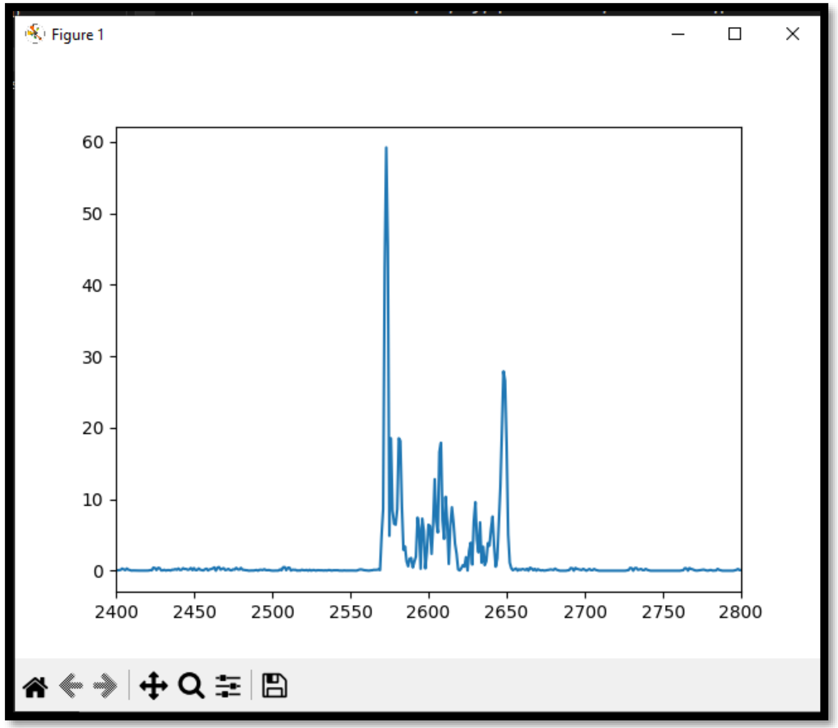
OLCI band	Wavelength	Oscar Glitter OLCIA		Oscar GLitter OLCIB		% difference OLCIA and OLCIB
	(nm)	avg	stdev	avg	stdev	
Oa04	490	1.041	0.007	1.022	0.007	1.85%
Oa05	510	1.021	0.004	1.005	0.005	1.59%
Oa06	560	1.014	0.003	1.003	0.004	1.07%
Oa07	620	1.010	0.001	0.999	0.002	1.03%
Oa08	665	1.016	0.000	1.007	0.000	0.91%
Oa09	673.75	1.019	0.001	1.009	0.002	0.98%
Oa10	681.25	1.017	0.001	1.008	0.001	0.92%
Oa12	753.75	1.014	0.005	1.006	0.006	0.75%
Oa16	778.75	1.005	0.002	0.997	0.003	0.75%
Oa17	865	1.011	0.007	1.004	0.009	0.69%
Oa18	885	1.007	0.008	1.000	0.010	0.65%
Oa21	1020	1.035	0.011	1.032	0.014	0.34%

Verification

MTF

- Use the edge of the moon to verify in orbit MTF

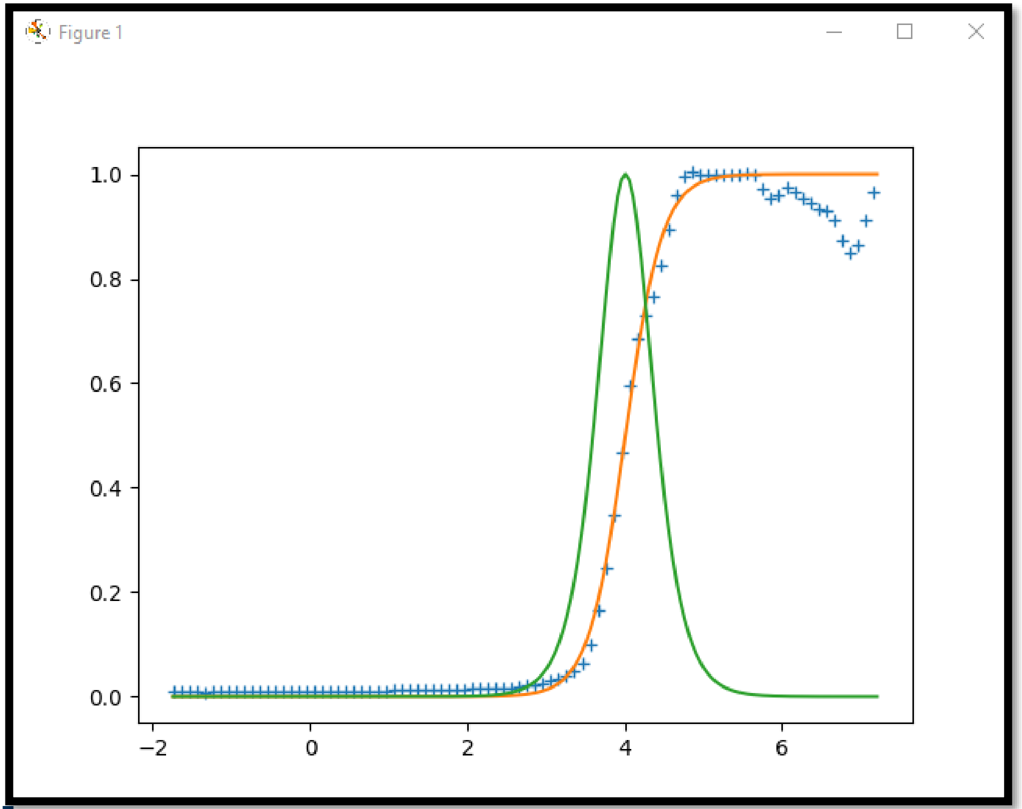


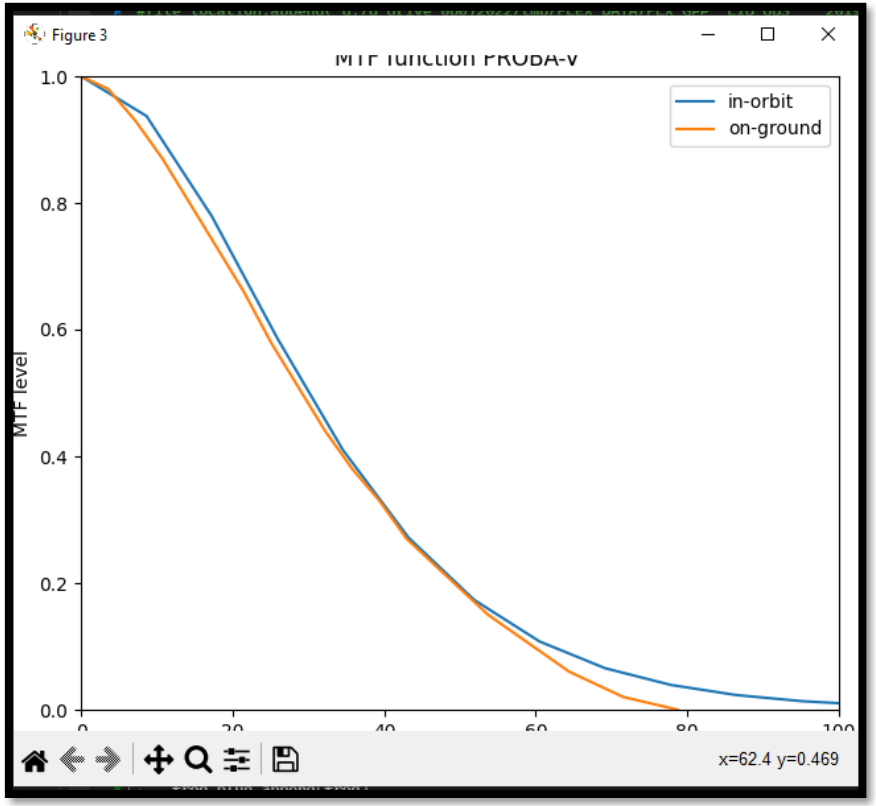


Verification

MTF

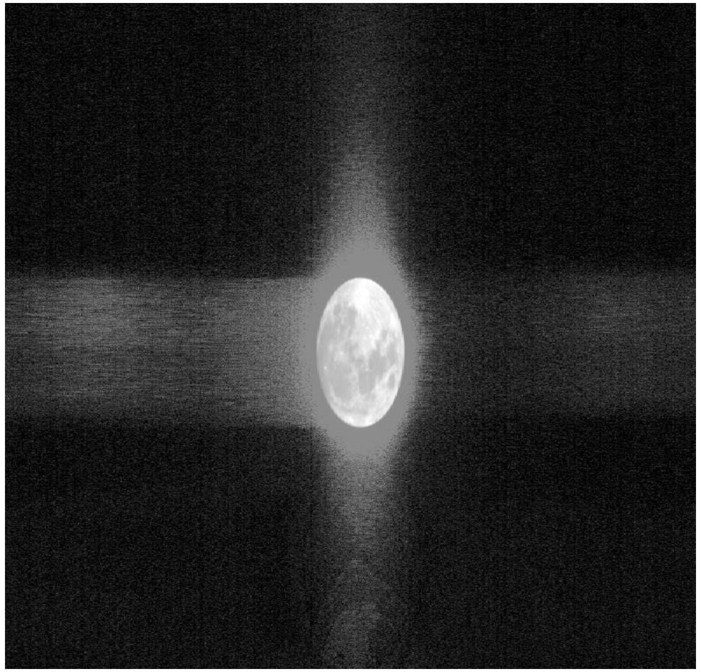
- Reconstruction of ESF and LSF

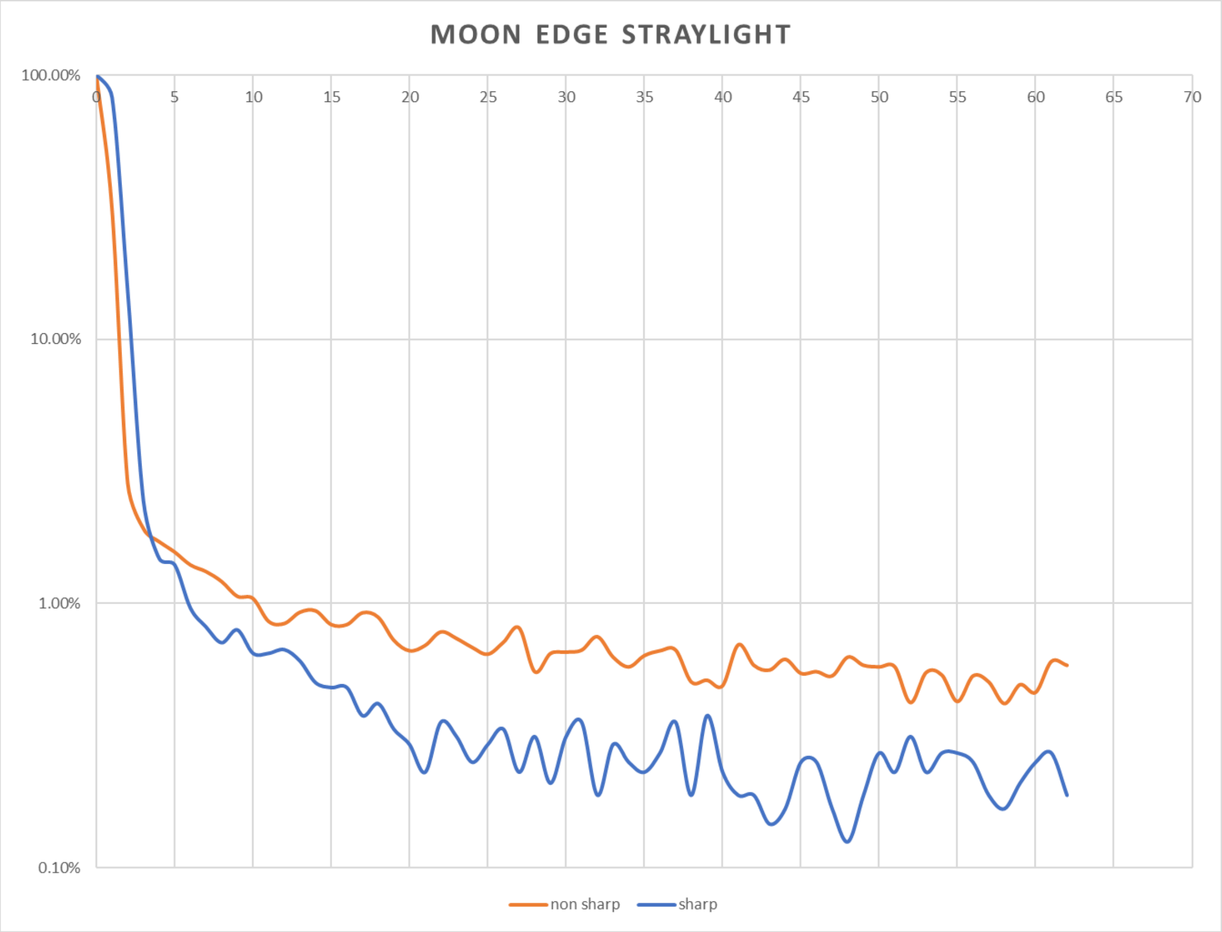




Verification

Straylight



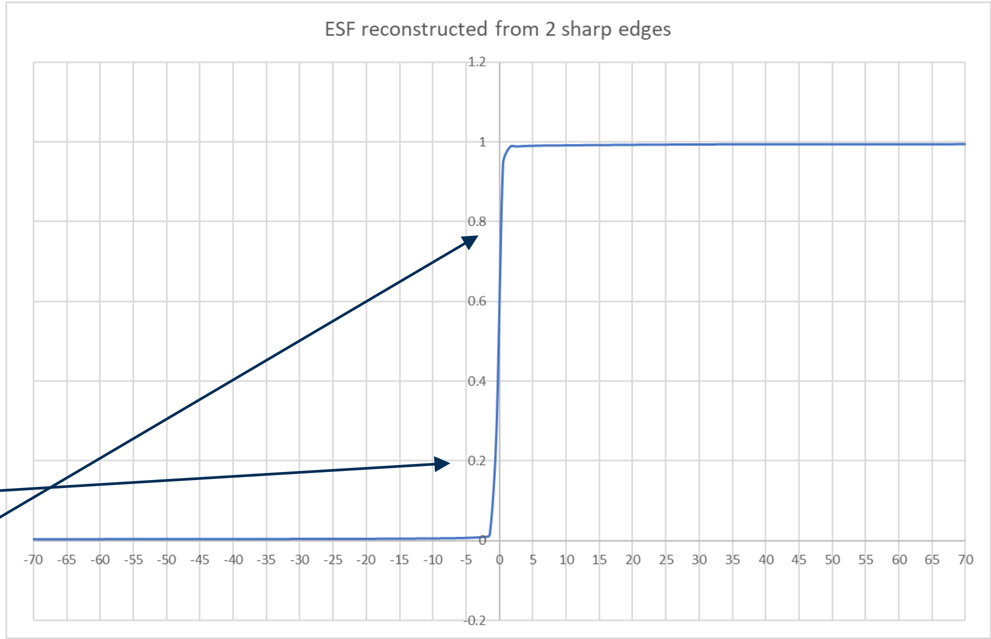


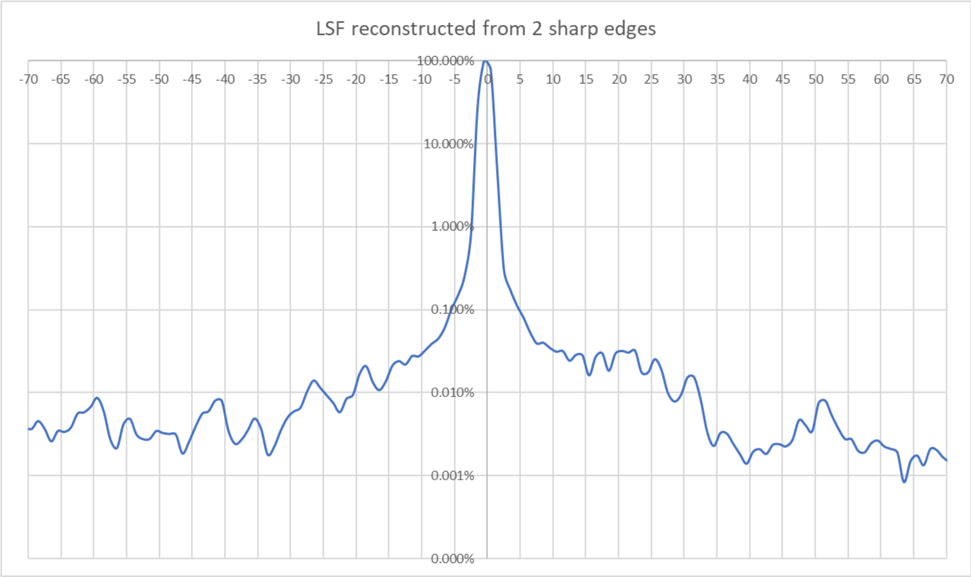
Verification

Straylight

-7 DEG

7 DEG



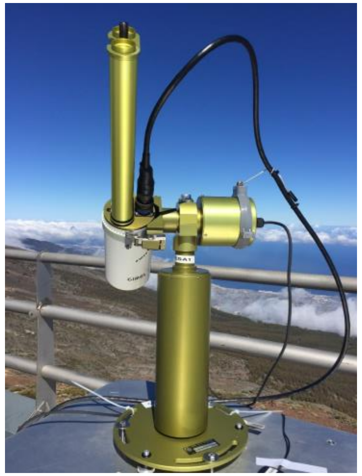


LIME

Lunar Irradiance Model ESA

- LIME is based upon ROLO model
- Derived using SI-traceable ground-based measurements acquired with CIMEL 318-TP9 photometer from high altitude location at Teide Peak and Izaña Atmospheric Observatory in Tenerife
- Characterization and calibration at NPL and University of Valladolid
- Uncertainty computation based on Monte Carlo simulations accounting for calibration, modelling and measurement uncertainties
- Perform ASD measurements as well for spectral characterization reflectance

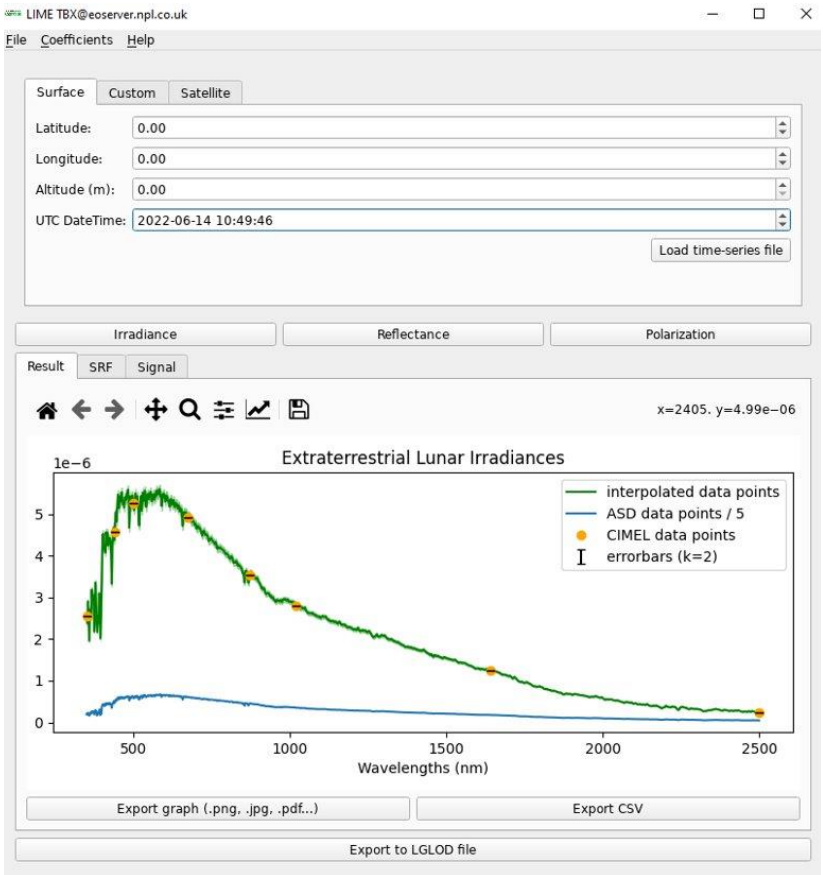
LUNAR IRRADIANCE MODEL OF ESA



LIME

Lunar Irradiance Model ESA

LUNAR IRRADIANCE MODEL OF ESA



- Ongoing development allowing to simulate lunar irradiance based on LIME for any sensor position/spectral bands.
- Expected end 2023.
- Available to the community

LIME

Lunar Irradiance Model ESA

- Comparison with many different sensors
  - including AIR-LUSI

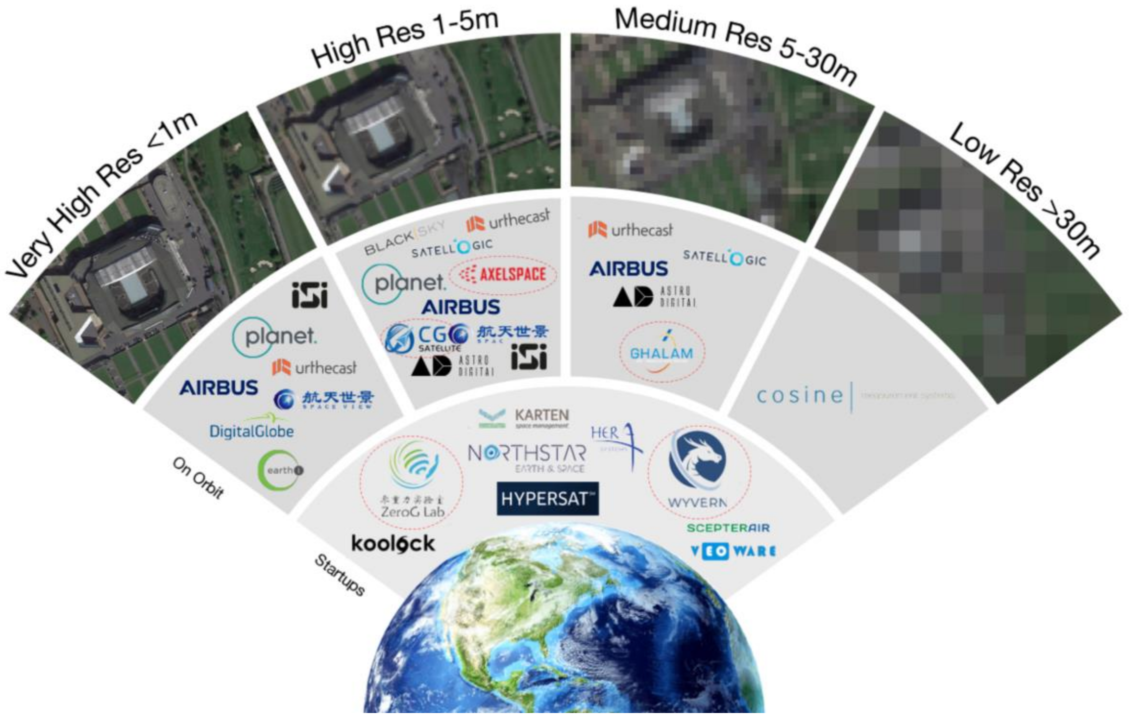
- Usage of the TSIS-1 model to evaluate :
  - Derivation of the lunar model itself
  - Impact on results

CalibrEO

- Developing a unique calibration system for each EO mission is good to reach optimal quality for a single mission **but insufficient to ensure cross-consistency across multiple missions**

- **Need for consistent calibration across missions**

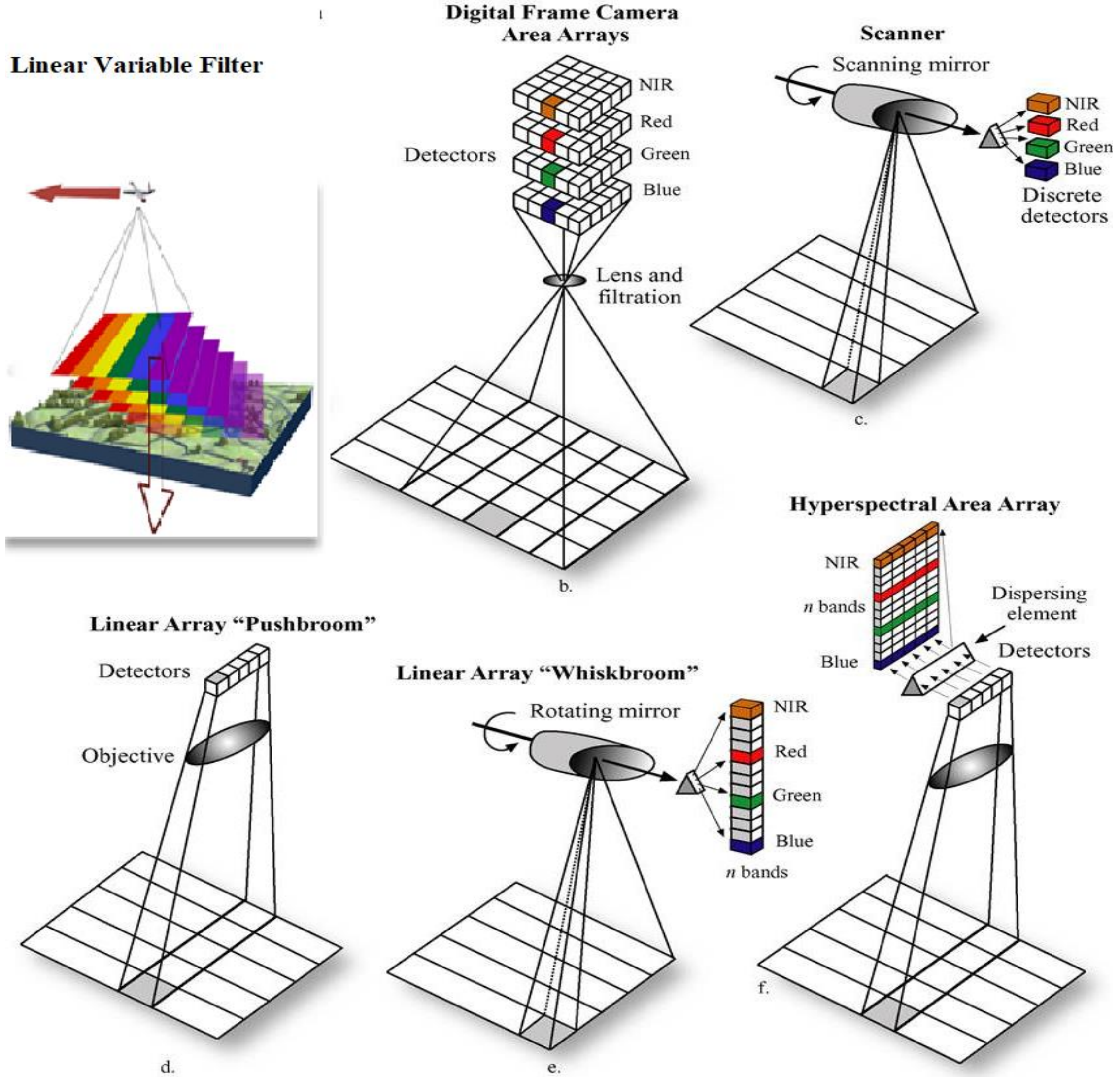
- **Generic solution** as an alternative for use across several EO mission with minimal adaptation



Source: Radiant Earth Foundation Commercial-EO-satellites-2019.

CalibrEO

- CalibrEO aims to be **generic**
- Support many **different techniques** that provide multi- or hyperspectral imaging



Thank you !