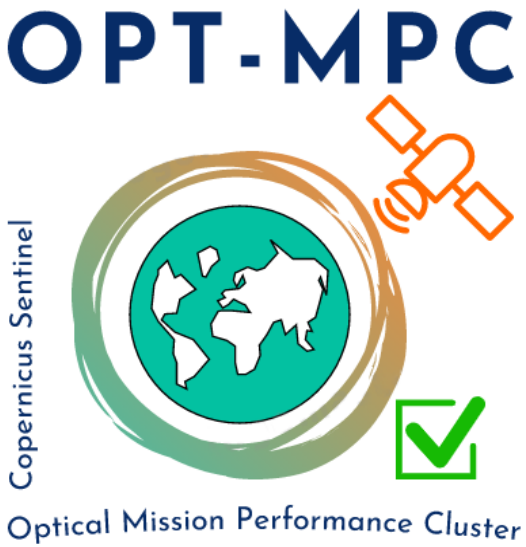


– CEOS-WGCV-IVOS 35 –
Copernicus sentinel-2 & 3 optical constellation L1-product radiometry validation status: Operational and S2-Collection-1

B. Alhammoud

balhammoud@argans.eu

26th September 2023

Video-conferencing

Agenda

- Dataset and Tools
- Level-1 Radiometry vicarious validation/verification
  - ✓ Sentinel-2/MSI
  - ✓ Sentinel-3/OLCI
  - ✓ Sentinel-3/SLSTR
- Cross-mission intercomparison
- Conclusion

Funded by the EU and ESA

European Union

The views expressed herein can in no way be taken to reflect the official opinion of the European Space Agency or the European Union.

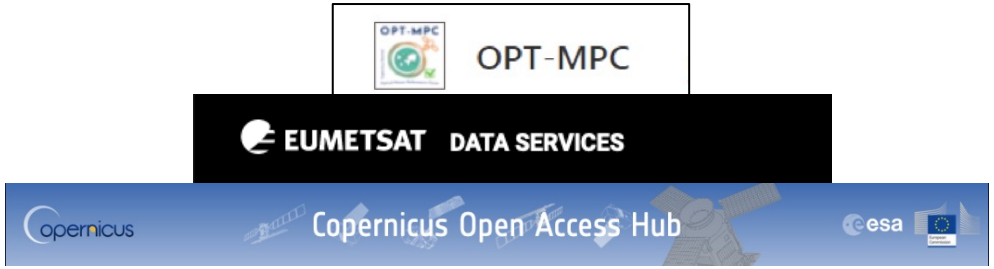
Datasets

17 CalVal sites are used

- L1C MSI-A & MSI-B: OPT-MPC-DAGC & https://scihub.copernicus.eu/

- L1TP LANDSAT-8 & 9: https://earthexplorer.usgs.gov/

- L1B OLCI-A & OLCI-B, SLSTR-A & B: OPT-MPC & https://scihub.copernicus.eu/



- RadCATs: are provided by the NASA Landsat Cal/Val Team as part of the ESA expert users effort / UoA

- RadCalNet: https://www.radcalnet.org/

CalVal sites available in DIMITRI-toolbox

17 CalVal sites are used

Bright sites:

Desert:

- 6 CEOS-PICS
- Gobabeb
- RRVP
- BSCN

Ice/Snow

- DOME-C

Dark sites:

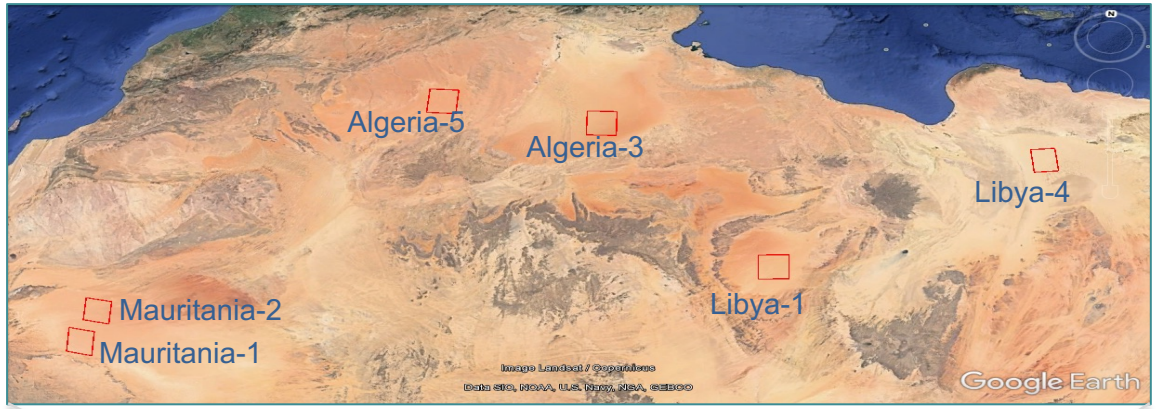
Land:

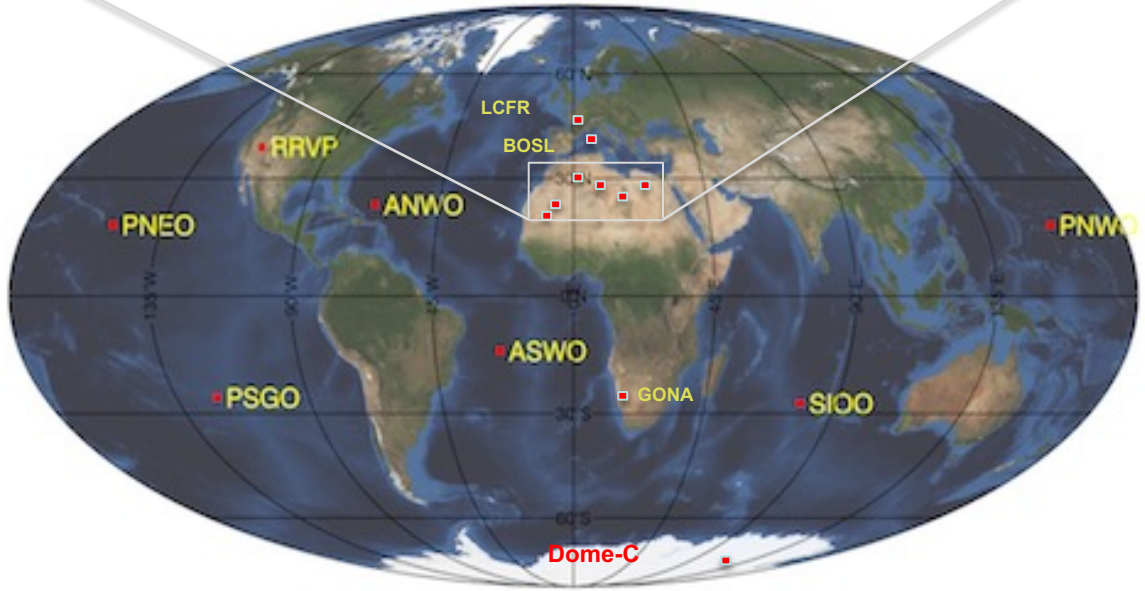
- La Crau

Water

- 6 Open Ocean
- Boussole (Costal)

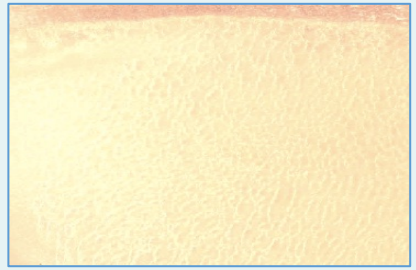
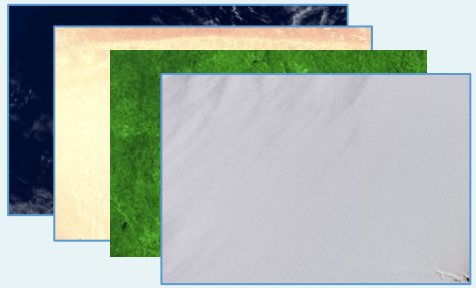
Site type	Water	La Crau	Desert	Snow
Reflectance range	0-0.2	0.2-0.3	0.2-0.7	0.7-0.9





Vicarious Methods in DIMITRI-toolbox

DIMITRI
Database for Imaging Multi-spectral Instruments and Tools for Radiometric Intercomparison

Rayleigh scattering calibration	Sun-Glint inter-bands calibration	Desert (PICS) calibration	Sensor-to-Sensor intercalibration
			
Absolute calibration coefficient: as ρ^{obs}/ρ^{sim}	**Absolute Inter-band calibration coefficient: as $\rho^{B(i)}/\rho^{B(ref)}$**	**Relative calibration coefficient: as ρ^{obs}/ρ^{sim} (MERIS as REF)**	**Absolute inter-calibration coefficient: as ρ^{obs}/ρ^{REF}**
- Over VIS bands - Uncertainty <5% - Very stringent criteria	- Over VNIR bands - Uncertainty <2% - Very stringent criteria	- Over VNIR bands - Uncertainty <5% - Uses surface BRDF	- VIS, NIR & SWIR - Uncertainty <5% - Limited matchups

https://dimitri.argans.co.uk

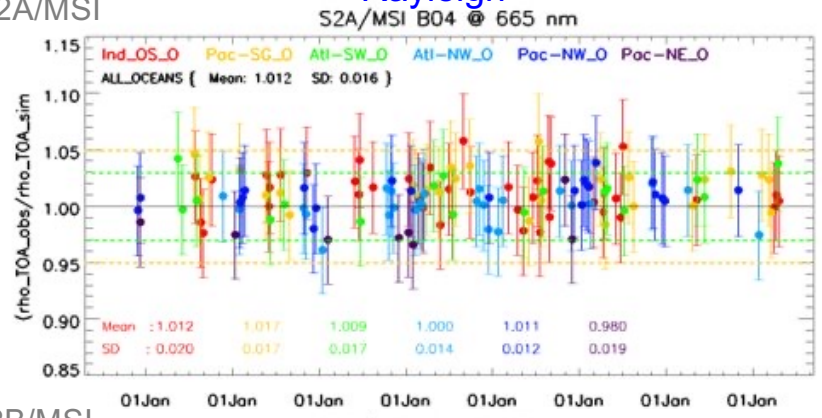
Sentinel-2/MSI Radiometry Vicarious Validation

Rayleigh & **Desert-PICS Methods:** 12 CalVal sites & time-series up to July 2023

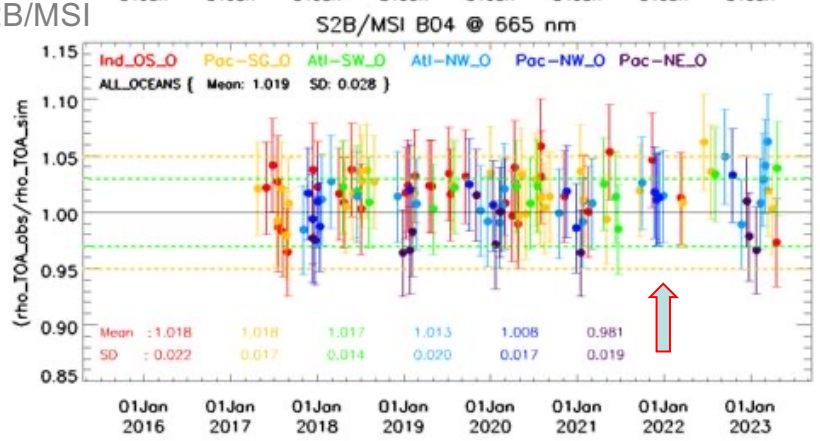
In-Situ measurements: 4 CalVal RadCalNet sites & time-series up to June 2023.

Rayleigh

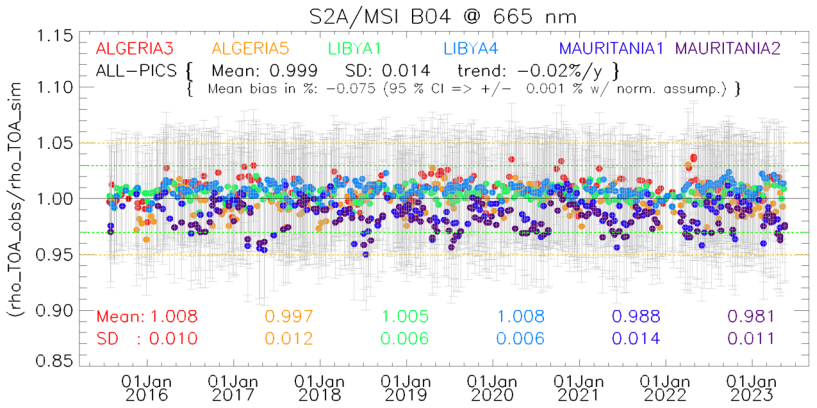
S2A/MSI

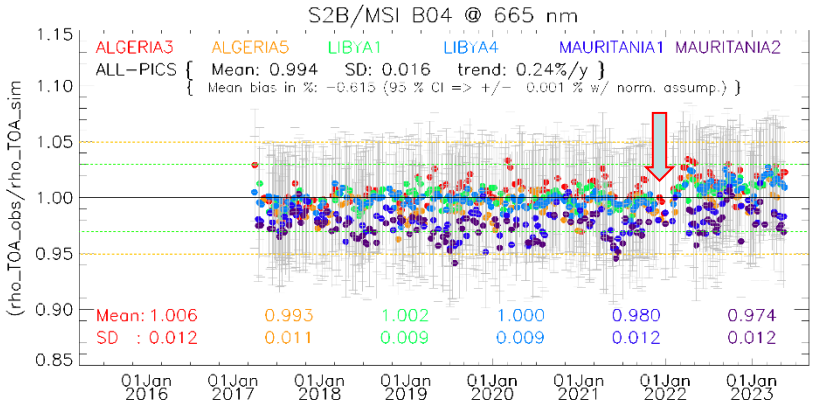


S2B/MSI

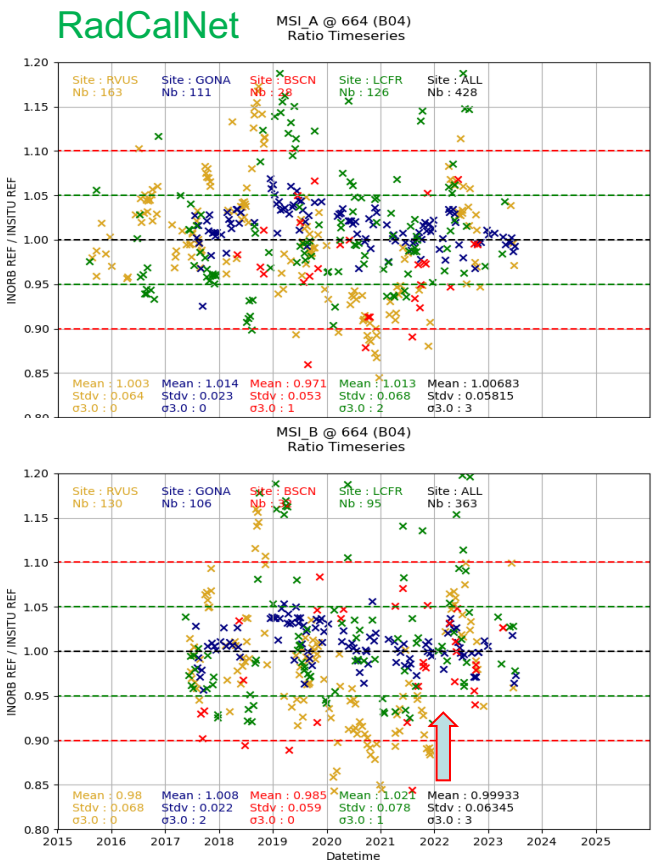


Desert-PICS





RadCalNet

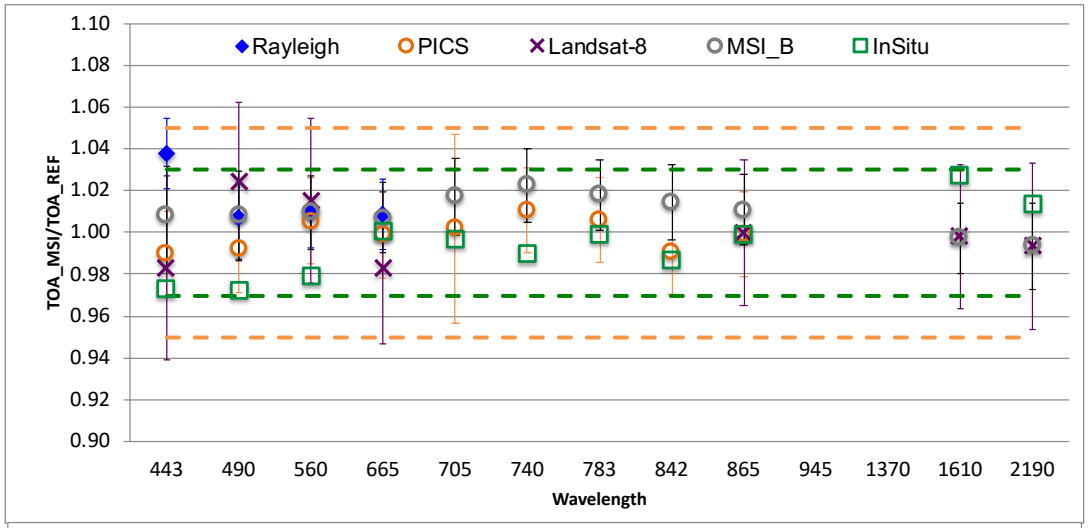


Synthesis of the Radiometry Vicarious Validation

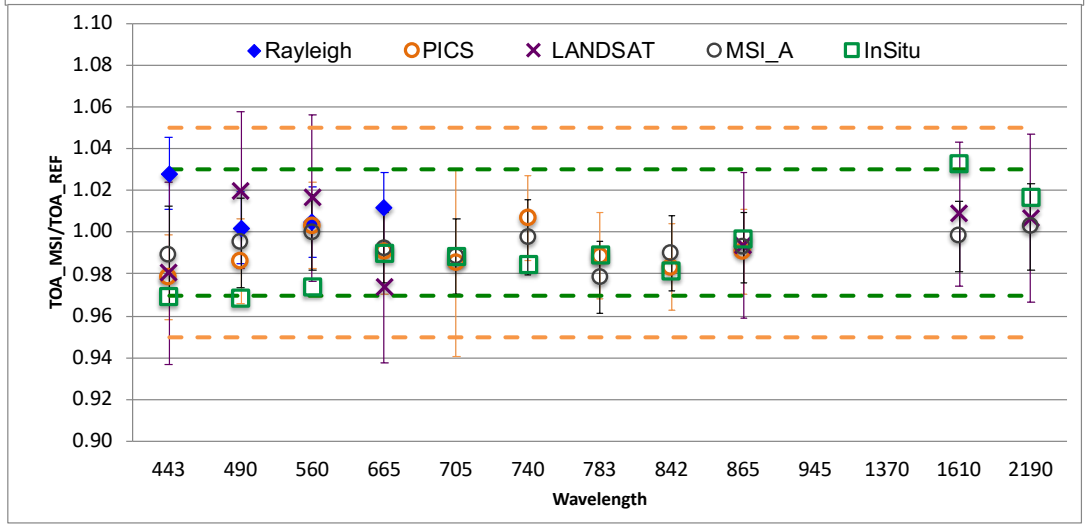
S2A

Results synthesis: Before 2022 (Bias correction)

- Good consistency over all the methods
- Results are within 3% (mission target req.)
- Maximum discrepancy is observed over
  - Rayleigh B01
  - Matchups with LS-8 B01 & B02
  - Matchups with In Situ B01, B02 & B11
- Good temporal stability (No trend detectable)
- Slight bias of MSI-A vs MSI-B of ~1% (Corrected since 25th Jan-2022)



S2B

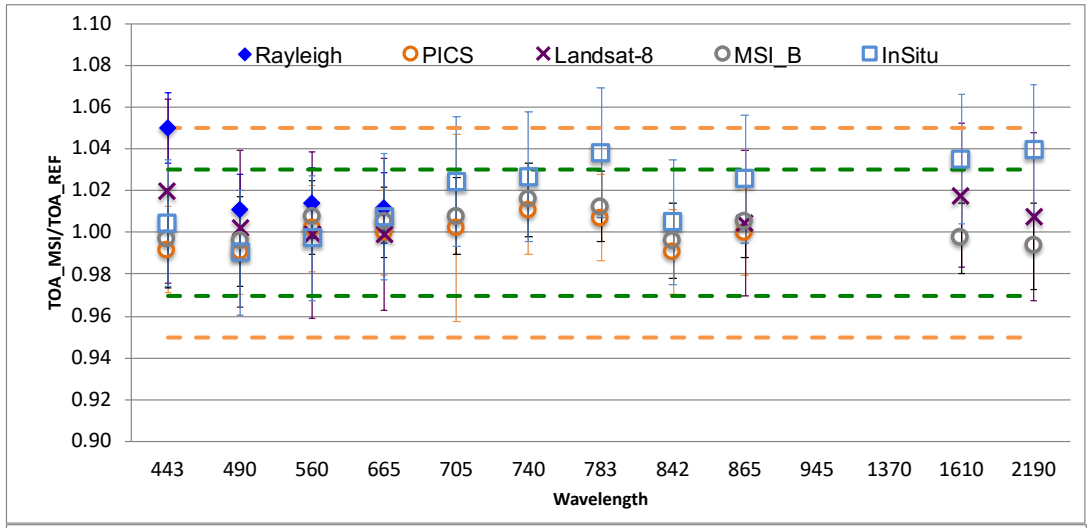


Synthesis of the Radiometry Vicarious Validation

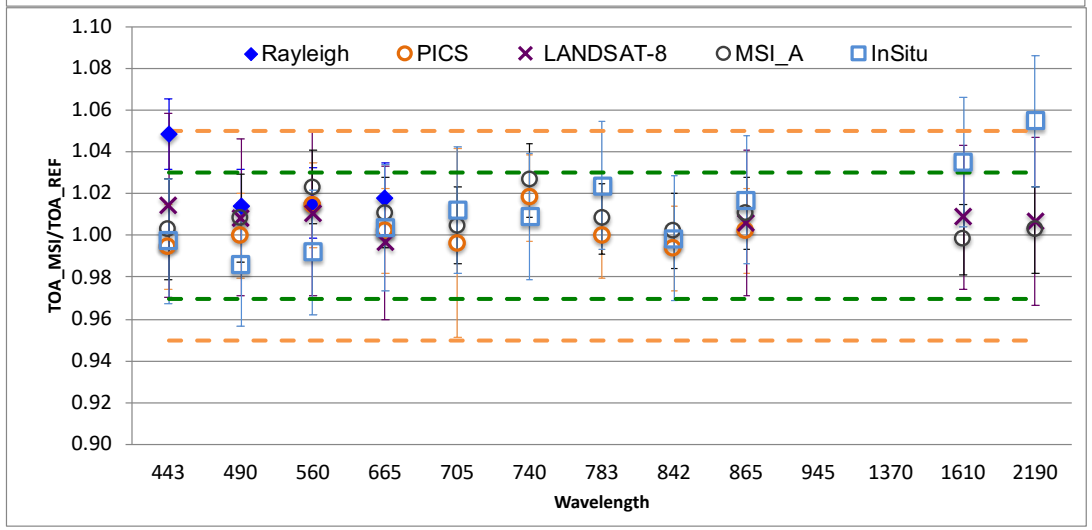
S2A

Results synthesis: After 2022 (Bias correction)

- **Good consistency over all the methods**
- **Results are within 3% (mission target req.)**
  - Except Rayleigh B01,
  - Except In-Situ (RadCalNet) SWIR1/2
- **Good temporal stability (No trend detectable)**
- **Good consistency with similar missions**
  - <2% over Libya4,
- **Successful MSI-B bias corrected since 25th Jan-2022**



S2B



Sentinel-2/MSI Radiometry Vicarious Validation: Collection-1

Why: **To achieve a consistent archive**

When: **The reprocessing of the S2 archive started in Q2 2022 & will last until Q4 2023**

For more details:

- ✓ Sentinel online: https://sentinels.copernicus.eu/web (Monthly/Annual DQRs)
- ✓ https://sentinels.copernicus.eu/web/sentinel/sentinel-data-access/sentinel-products/sentinel-2-data-products/collection-1-level-1c
- ✓ https://sentinel.esa.int/documents/247904/3519647/OMPC.ACR.APR.002+-+i1r1+-+S3+Optical+Annual+Performance+Report+2022.pdf
- ✓ IEEE-IGARSS (2023), 5th S2VT (2022), 6th S2VT (2023), and ESA-LPS (2023)

Sentinel-2/MSI Radiometry Vicarious Validation: Collection-1

Main evolutions on Level-1C:

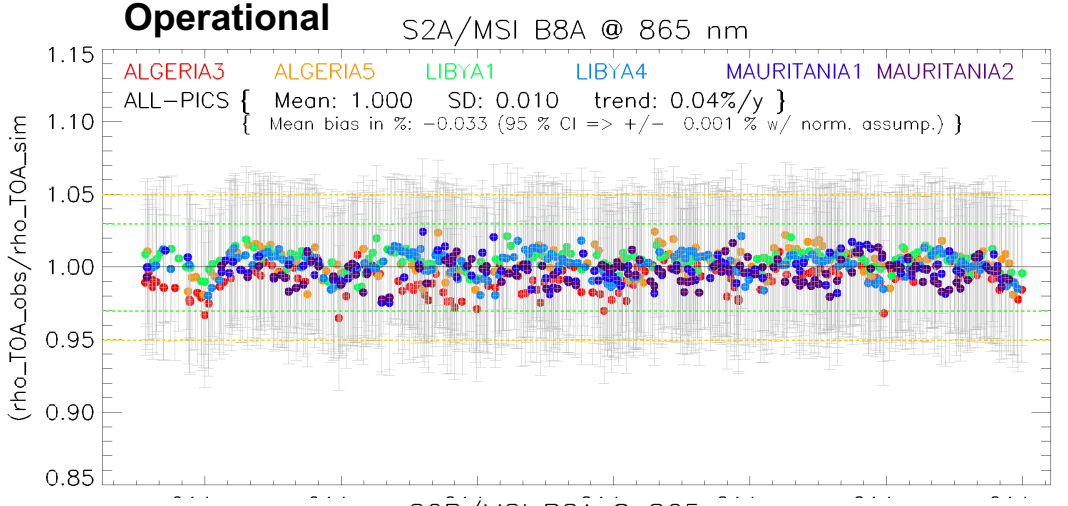
- ✓ the systematic use of the refining based on the Global Reference Image (GRI)
- ✓ radiometric bias correction of 1.1 % applied to Sentinel-2B VNIR bands B01 to B09
- ✓ Level-1C quality masks in raster format
- ✓ addition of a radiometric offset to Level-1C and 2A products to avoid truncation of negative reflectances due to noise on low signal,
- ✓ new ECMWF* and CAMS** auxiliary parameters embedded in L1C and 2A products,
- ✓ addition of the DOI (Digital Object Identifier) in the Level-1C and Level 2A (CEOS Analysis Ready Data for Land (CARD4L) compliant) metadata,

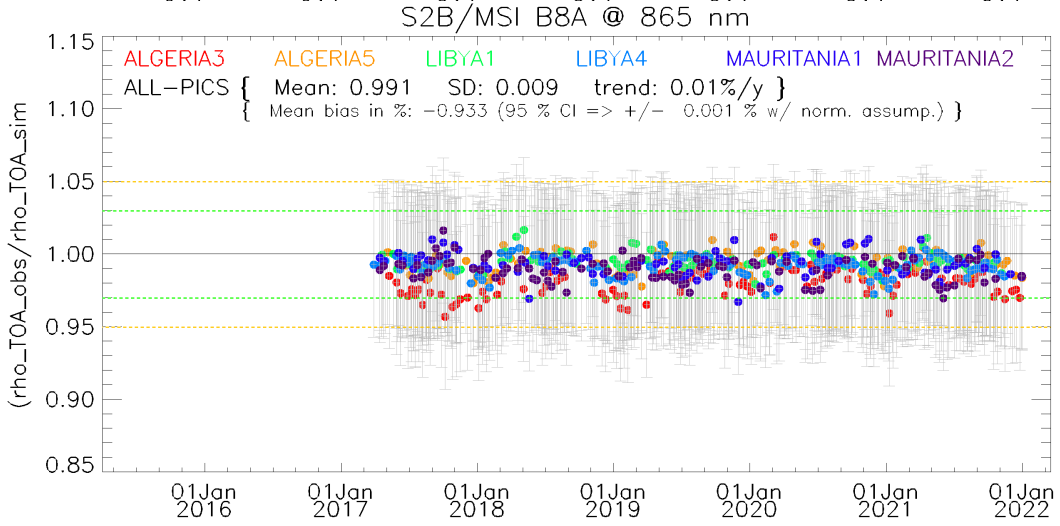
Sentinel-2/MSI Radiometry Vicarious Validation: Collection-1

- Desert-PICS : 6 CalVal sites

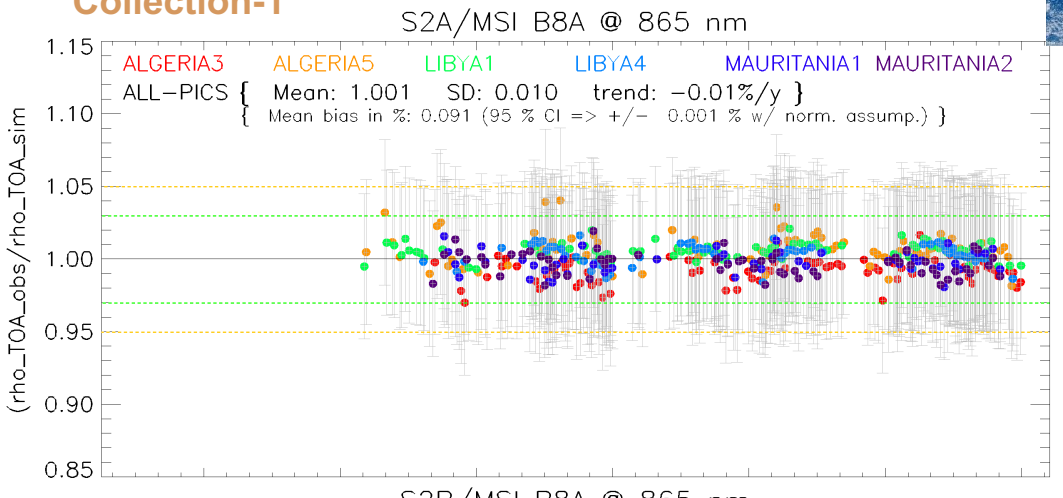
Collection-1: 2017-2021 **MSI-A: 432 & MSI-B: 422 Acqs**

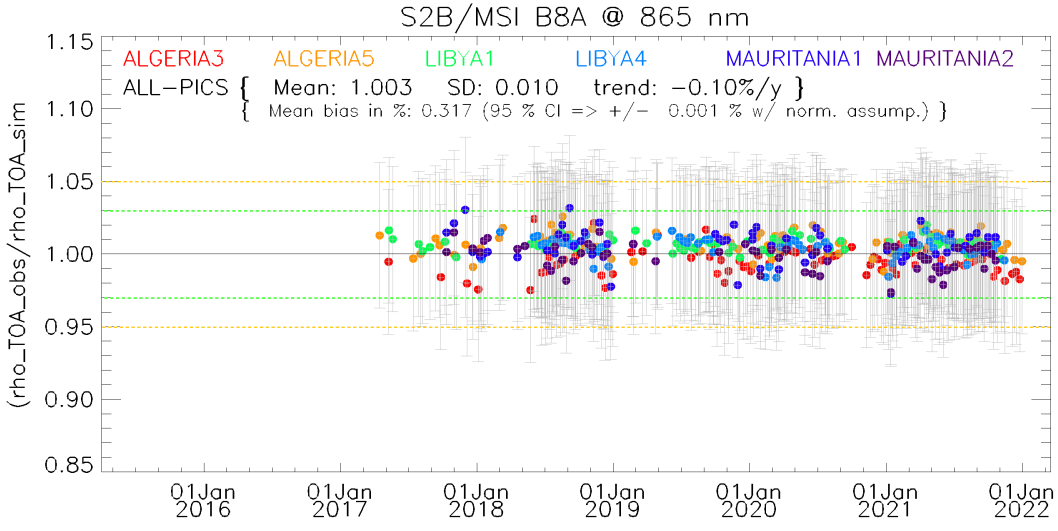
Operational





Collection-1





Sentinel-2/MSI Radiometry Vicarious Validation: Collection-1

- Desert-PICS : 6 CalVal sites over 2021

Wavelength (nm)	MSI-A OPER	MSI-A COLL-1	Diff
443	0.992	0.997	**0.005**
490	0.993	0.995	**0.002**
560	1.003	1.007	**0.004**
665	0.998	0.998	**0.000**
705	NA	NA	**NA**
740	1.010	1.011	**0.001**
784	1.006	1.007	**0.001**
842	0.992	0.993	**0.001**
865	1.000	1.000	**0.000**

MSI-A radiometry shows the same values as the operational one (**Diff < 0.005**)

Wavelength (nm)	MSI-B OPER	MSI-B COLL-1	Diff
443	0.981	0.992	**0.011**
490	0.987	0.998	**0.011**
560	1.002	1.013	**0.011**
665	0.990	1.001	**0.011**
705	NA	NA	**NA**
740	1.006	1.018	**0.012**
784	0.989	1.001	**0.012**
842	0.982	0.994	**0.012**
865	0.990	1.002	**0.012**

MSI-B radiometry shows higher values than the operational ones (**Diff = 0.011**)

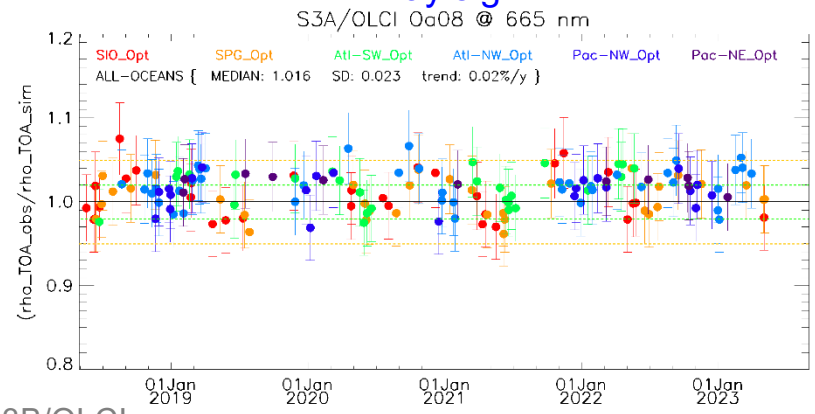
"Bias correction successfully performed".

Sentinel-3/OLCI Radiometry Vicarious Validation

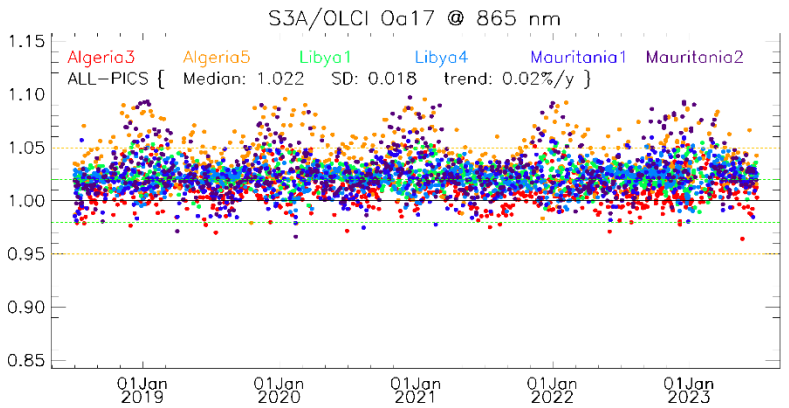
Rayleigh, Desert-PICS & Glint Methods: 12 CalVal sites & time-series up to July 2023

S3A/OLCI

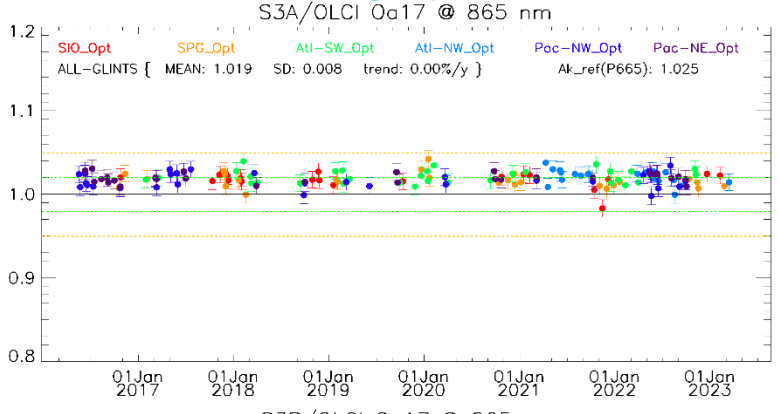
Rayleigh



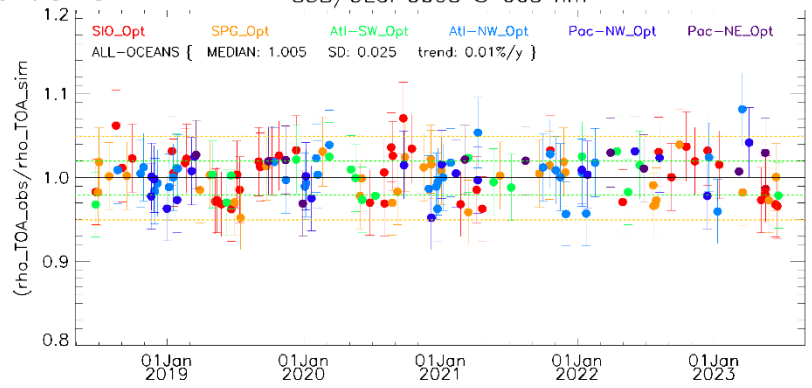
Desert-PICS

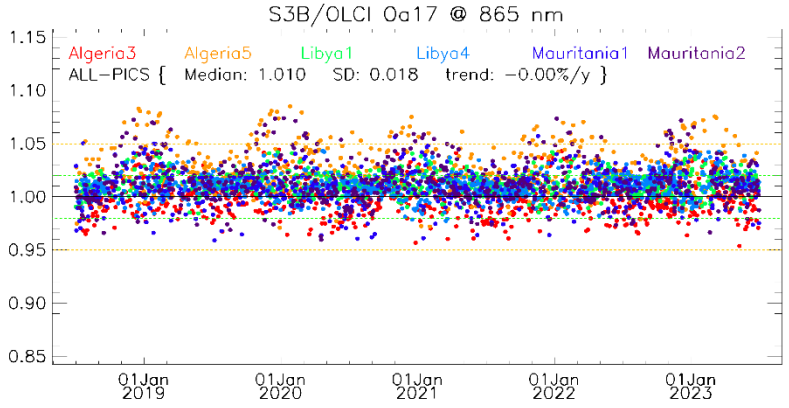


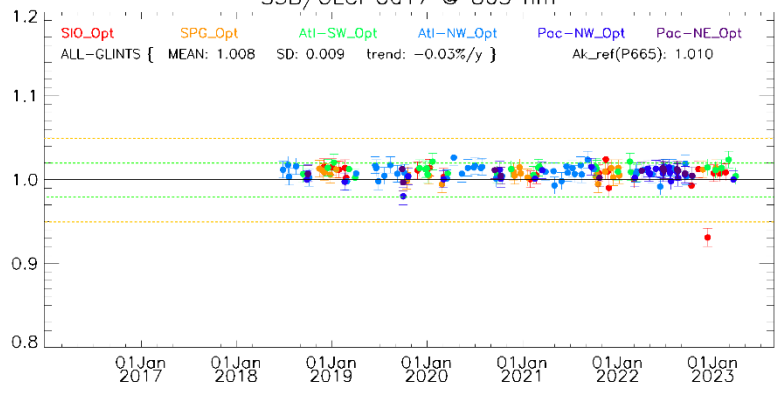
Glint



S3B/OLCI



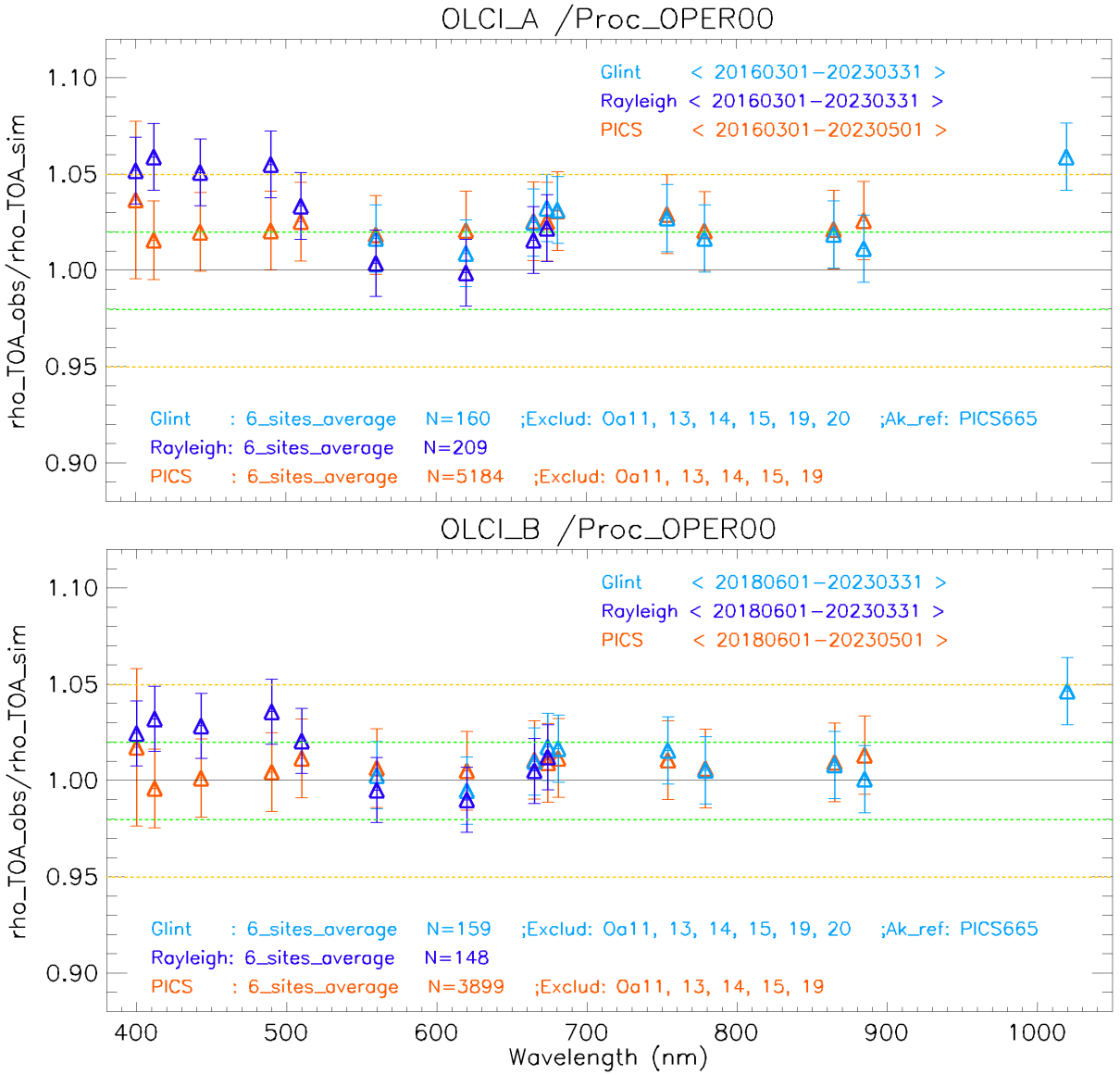




Synthesis of OLCI Radiometry Vicarious Validation

Results synthesis over Sentinel-3/OLCI

- **Good consistency over all the methods**
  - Except Rayleigh (short wavelength)
- **OLCI-A Results are within 5% (2% mission req.)**
  - Except Oa02, Oa04 & Oa21
- **OLCI-B Results are within 2% (2% mission req.)**
  - Except Oa02, Oa04 & Oa21
- **Good temporal stability (No trend detectable)**
- **OLCI-A shows slightly (1-2%) brighter TOA-reflecta wrt OLCI-B**



S3A

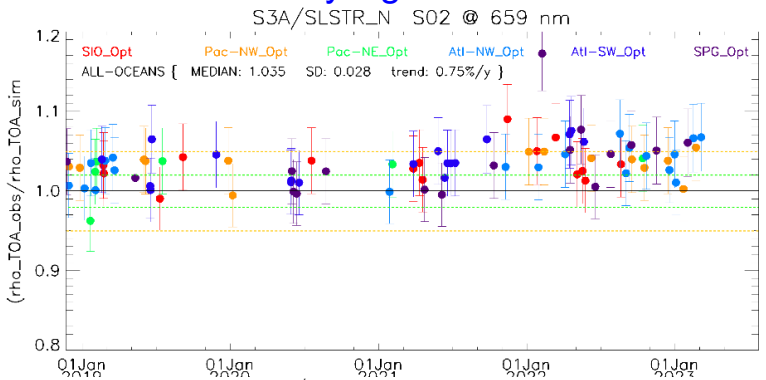
S3B

Sentinel-3/SLSTR Radiometry Vicarious Validation

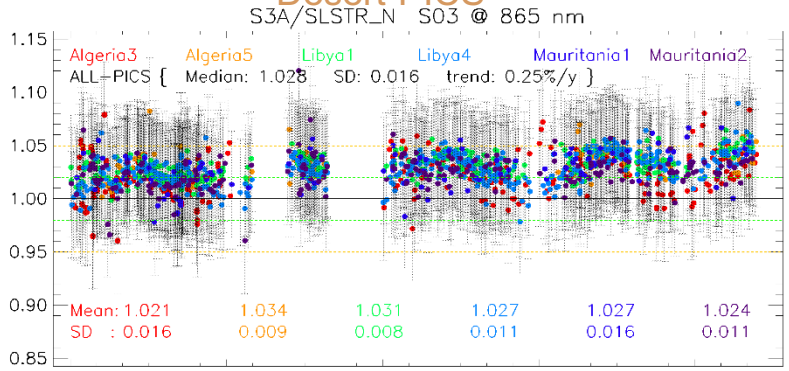
Rayleigh, Glint & Desert-PICS Methods 12 CalVal sites & time-series up to June 2023

S3A/SLSTR-N

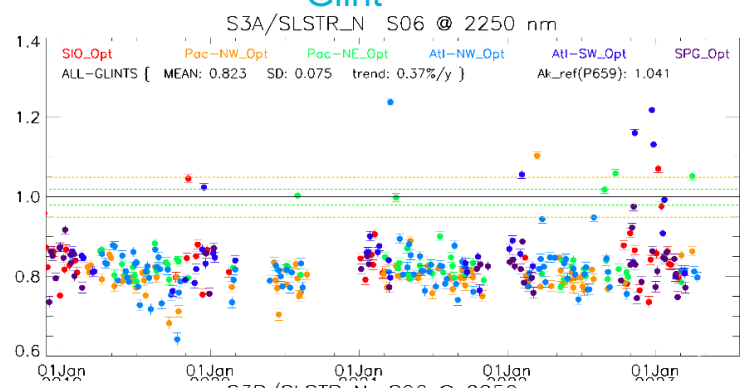
Rayleigh



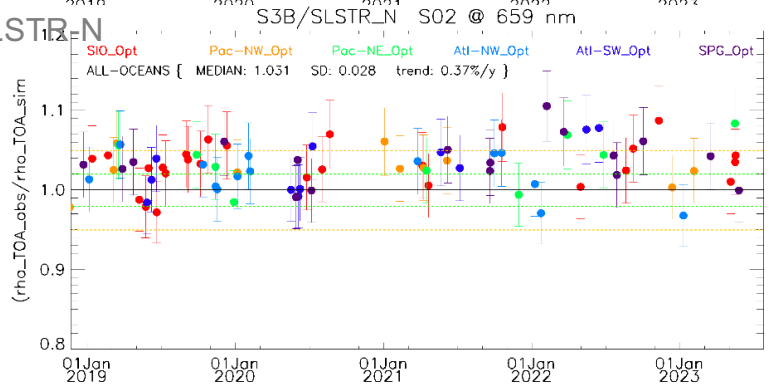
Desert-PICS

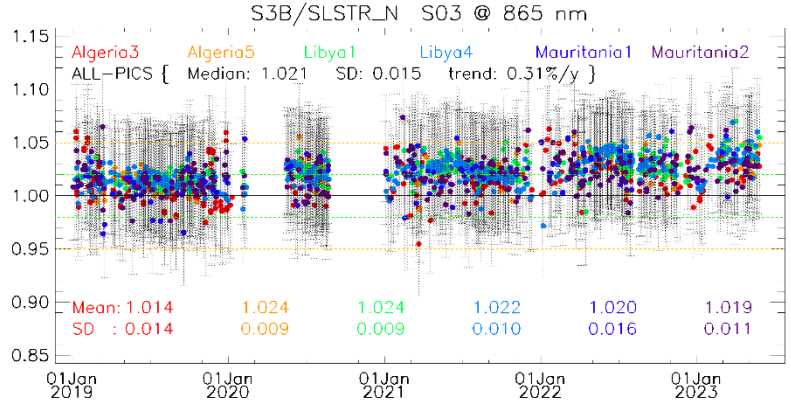


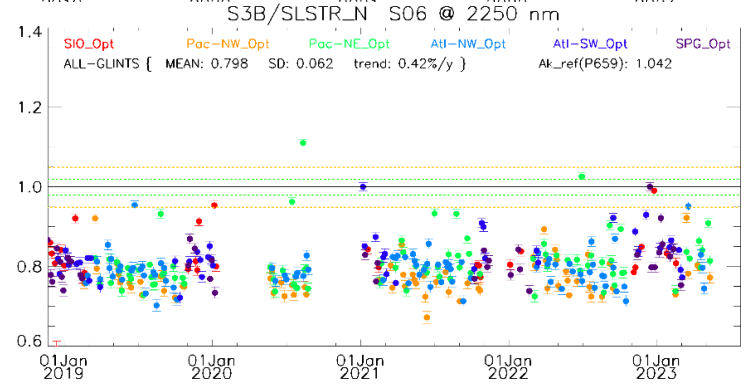
Glint



S3B/ SLSTR-N



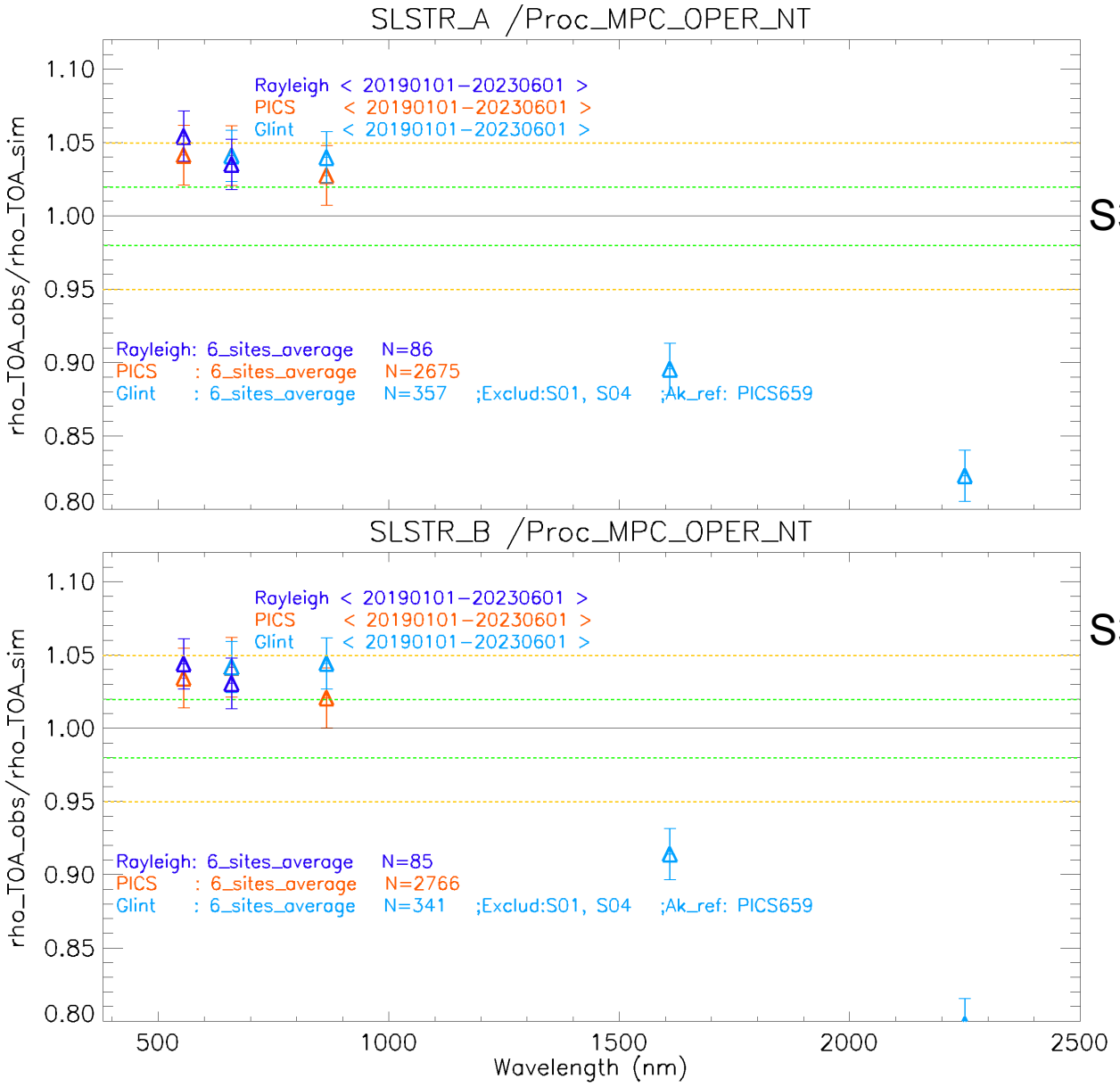




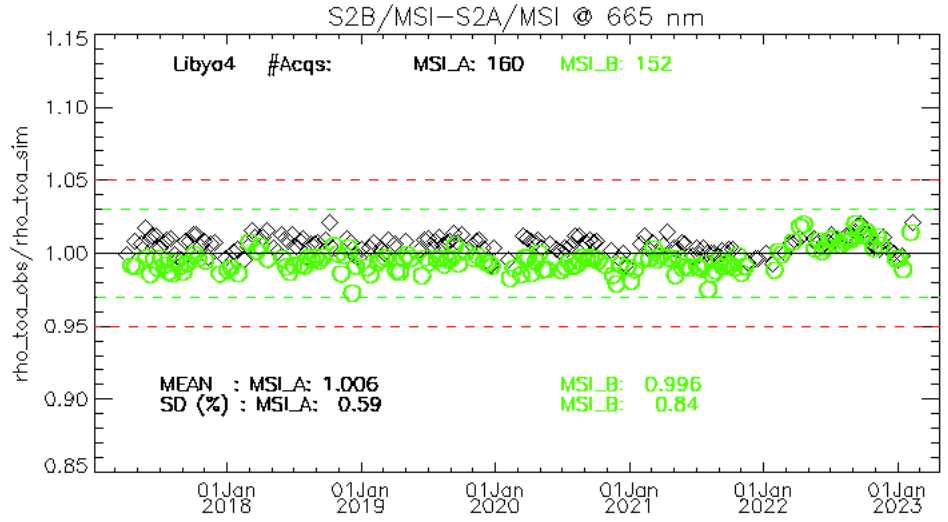
Synthesis of SLSTR Radiometry Vicarious Validation

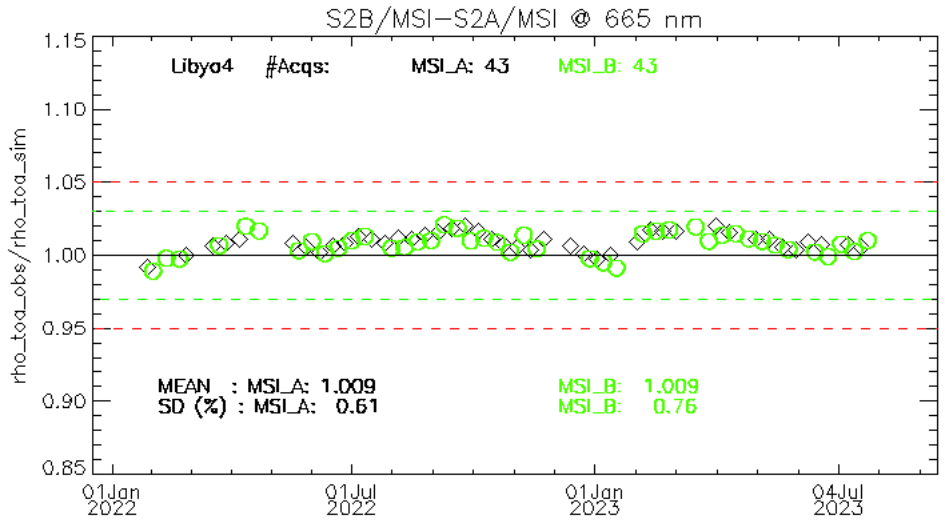
Results synthesis over Sentinel-3/SLSTR (N)

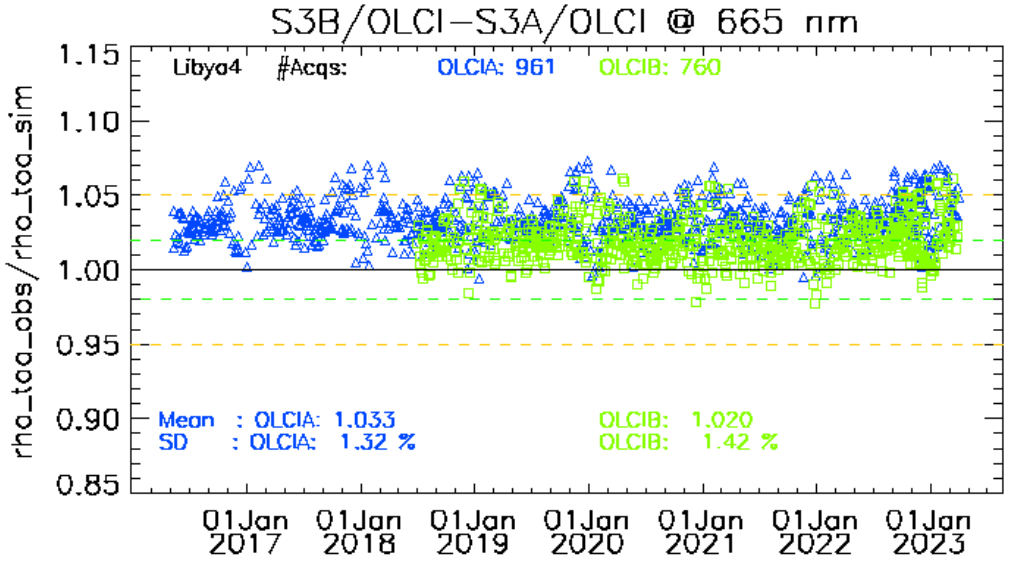
- **Good consistency over all the methods**
  - VNIR bands S01-S03
- **SLSTR-A/B Results are within is within 5% (NADIR) up to 7-8% (OBLIQUE)**
  - VNIR bands S01-S03
  - SWIR bands S05-S06
- **Good temporal stability (slight positive trend detectable)**
- **SLSTR-A & B show good agreement better than 1%**

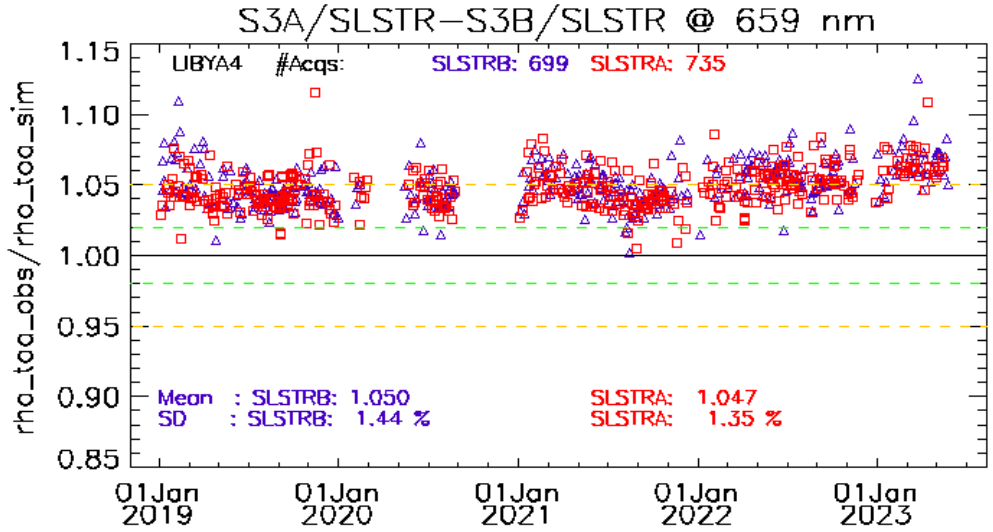


Radiometry cross-mission Intercomparison:
desert PICS-Method over Libya-4

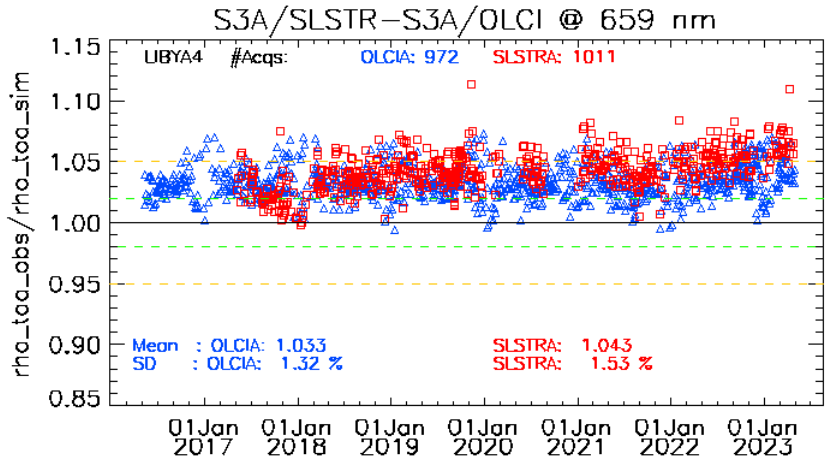


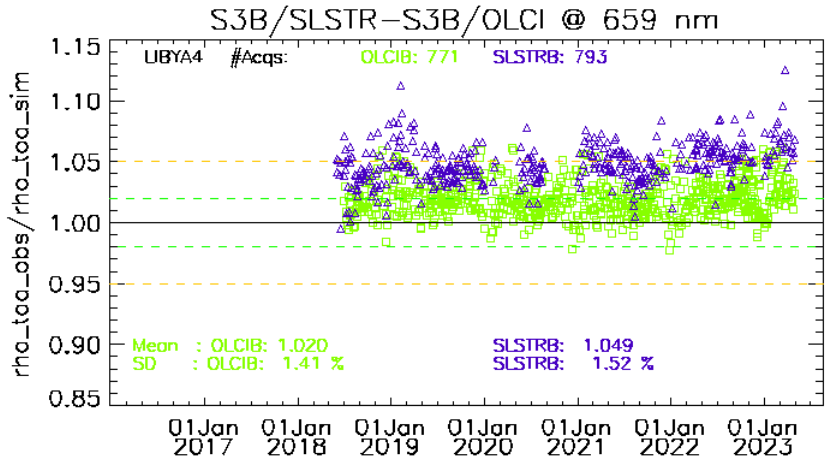


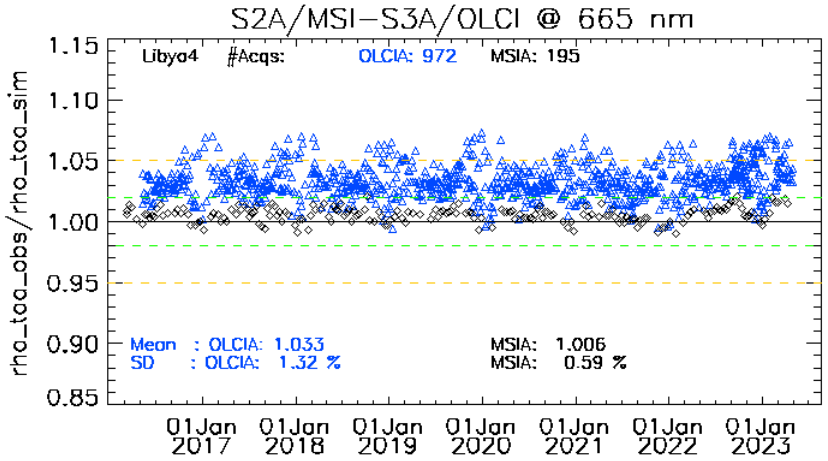


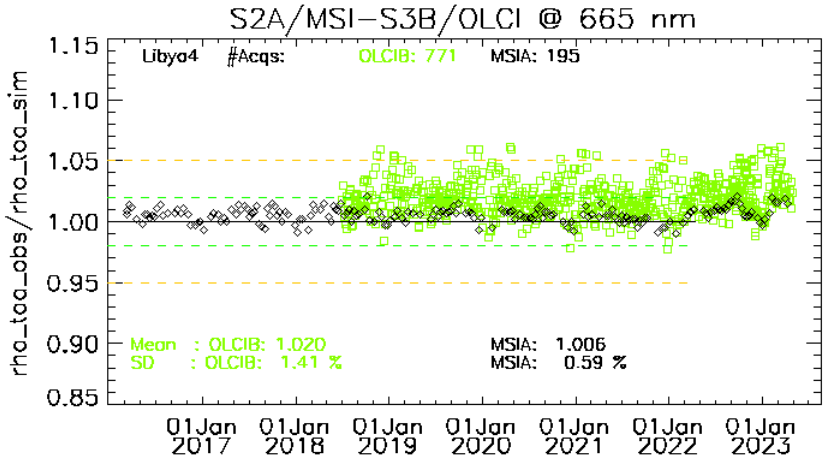


Radiometry cross-mission Intercomparison:
desert PICS-Method over Libya-4

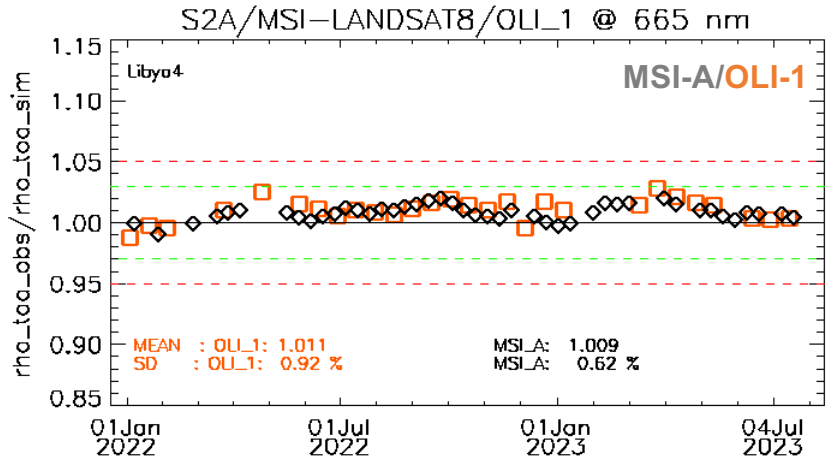


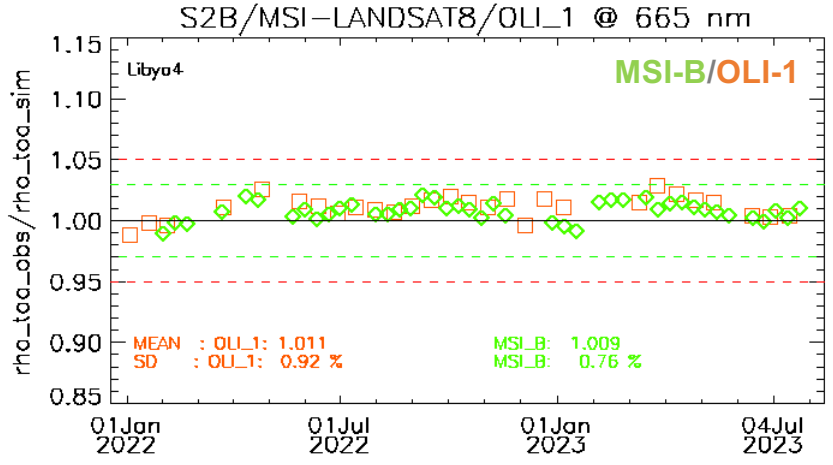


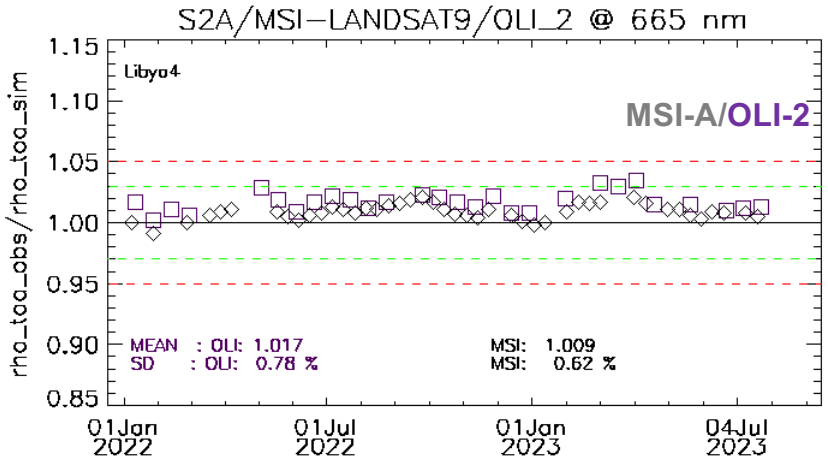


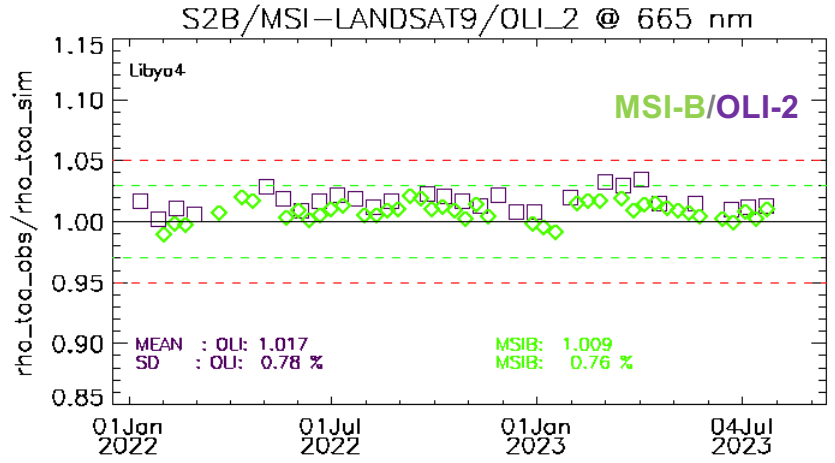


Radiometry cross-mission Intercomparison:
desert PICS-Method over Libya-4



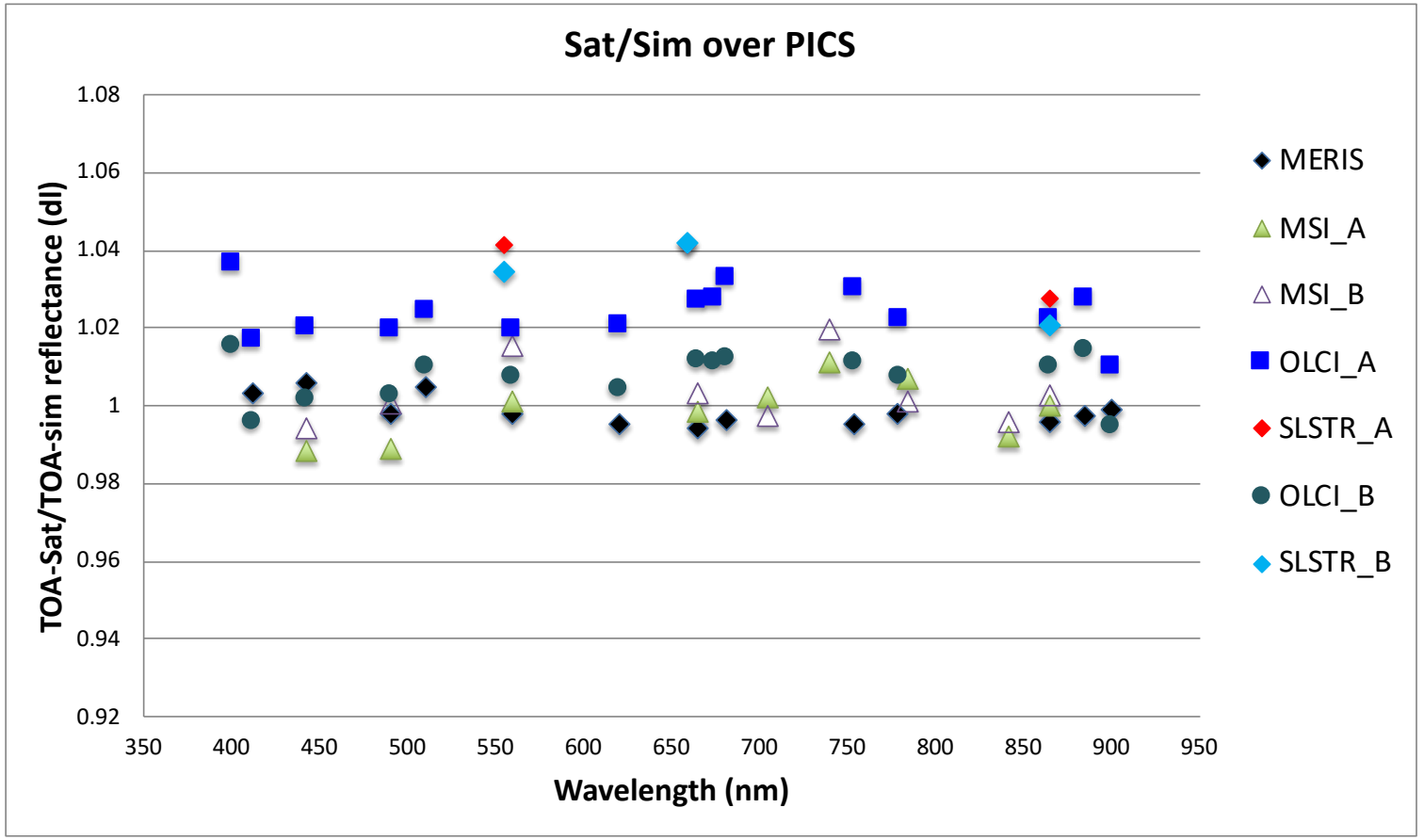






Radiometry cross-mission Intercomparison:
desert PICS-Method over 6 Sites

Ratio of observed TOA reflectance to simulated one for
(black) MERIS,
(pale-green) S2A/MSI,
(white) S2B/MSI,
(blue) S3A/OLCI,
(green) S3B/OLCI,
(red) S3A/SLSTR-NADIR, and
(cyan) S3B/SLSTR-NADIR
averaged over the six PICS test sites over different periods as a function of wavelength



Conclusions

- Good consistency over the results of the different methods: Rayleigh scattering, Glitter, and desert-PICS (over VNIR bands);
  - Except Rayleigh over blue-green bands

- MSI-A/B and OLCI-A/B show very good stability over the mission life-time, while SLSTR-A/B show slight positive trend

- MSI-A/B and SLSTR-A/B show excellent alignment, while OLCI-A shows brighter TOA-reflectance than OLCI-B over VNIR bands by 1-2%;

- Successful collection1 reprocessing of MSI-A/B

- Good agreement with similar missions (<2%) over Libya-4 PICS.

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- RadCalNet team for providing the dataset

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The views expressed herein can in no way be taken to reflect the official opinion of the European Space Agency or the European Union.