IVOS 34 – PICSCAR presentation
Reston VA - 31/08/2022

Patrice Henry, Béatrice Berthelot, Daria Malik

PICSCAR Initiative

- **PICS** can be used to evaluate the long-term stability of an instrument and to facilitate inter-comparison of multiple instruments

- IVOS 27 recommendations (Nov 2015)

- ***To establish a new task group/project to coordinate the communities work on PICS. A detailed work plan will be defined by its chair and expert members with an initial focus likely to include the means to improve the characterisation of the sites***

- 2 actions at IVOS 28 (July 2016)
  - Objective 1 :Need to know the PICS usage (questionnaire sent on September, 2016)
  - Objective 2: Collect data over Libya4 site

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Database V1.0

- Dataset has been collected to achieve the site characterisation thanks to CNES, RAL, JPL, NASA, SDSU, VITO, CMA, Argans (for ESA)
  - Site stability
  - Spectral characterisation (Hyperion)
  - Site directional effects (POLDER)

- Focus on Libya 4 site (standard and small site)
- **66** datasets
- Long time series mainly from 2002 to 2019 for Low/Medium spatial resolution sensors
- Time series for High spatial resolution sensors since 2013 (Landsat 8) and June 2015 (S2A)

V1 content (format csv): Date, mean, standard deviation of TOA reflectances, solar and view geometries

Database V2.0

- Need to improve the site characterisation and intercalibration capacities

- ➜ Extend and upgrade the v1.0 database
  - Information at pixel level
  - Include atmosphere characteristics for atmospheric correction and forward modelling
  - Cloud mask
  - Quicklook to visualize the acquisition quality

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Evolution of PICSCAR database (V2.0)

- Need to update the database (to get the last reprocessing)
- Achieved for Libya 4 standard and small sites

	PICSCAR V1 2016-2019	PICSCAR V2.0 from 2021	Database completion	Site name
VEGETATION 1/2	Collection 1	Collection 2	1999-2013	Standard
ProbaV	Collection 1	Collection 2	2013-2021	Standard
MERIS	3rd	4th (FR)	2002-2012	Standard
AATSR	3rd reprocessing	3rd reprocessing	2002-2012	Standard
MODIS Terra	Collection 5	Collection 6.1	2000-07/2022	Standard
MODIS Aqua	Collection 5	Collection 6.1	2002-07/2022	Standard
OLCI A / B	Collection 1	Collection 2	2016-06/2022	Standard
SLSTR		Collection 4	2016-06/2022	Standard
POLDER1/2/3	Calibration 1	Calibration 2	1996/2013	Standard
S2A/S2B MSI	Baseline 3	Baseline 4.0	2015-2022	Small

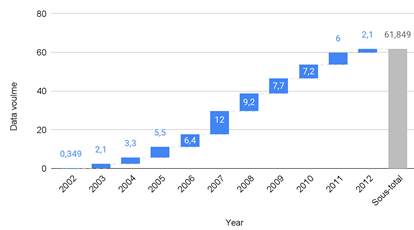# V2.0 Database content (1/3)

ENVISAT MERIS

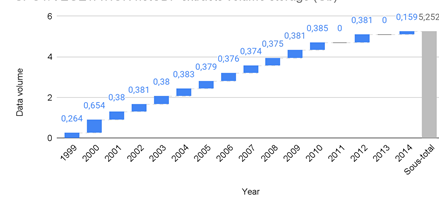| Product Level:	Processing version:	Spatial Resolution:	Total number of products:
Level 1	V4	260x290m	1928 (2002 - 2012)

ENVISAT MERIS netCDF extracts volume storage (Gb)
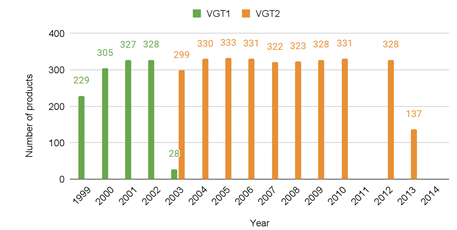

Number of MERIS products covering Libya4 site
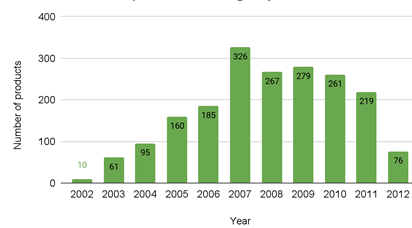
SPOT/VEGETATION

Product Level:	Processing version:	Spatial Resolution:	Total number of products:
VGT P products	V3	1 000 m	4 279

SPOT/VEGETATION netCDF extracts volume storage (Gb)

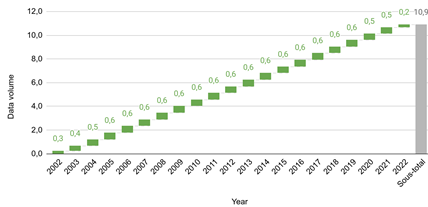Number of SPOT/VEGETATION products covering Libya4 site

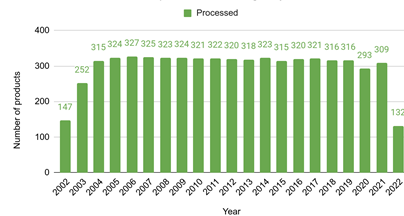**All products for the Libya4 site were entirely processed.**

MODIS AQUA

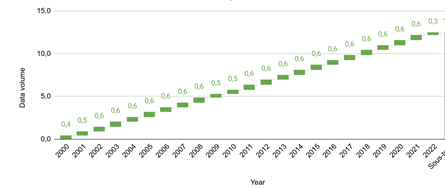| Product Level:	Processing version:	Spatial Resolution:	Total number of products:
Level 1	6.1	1 000 m	6 260 (2002 - 2022)

MODIS AQUA netCDF extracts volume storage (Gb)
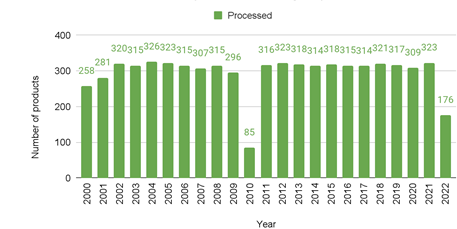

Number of MODIS AQUA products covering Libya4 site

MODIS TERRA

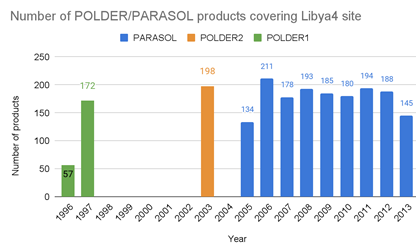| Product Level:	Processing version:	Spatial Resolution:	Total number of products:
Level 1	6.1	1 000 m	5 990 (2000 - 07/2022)

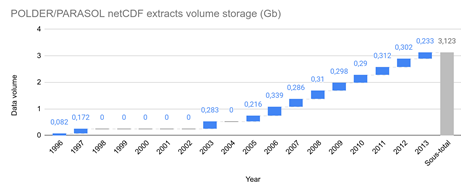MODIS TERRA netCDF extracts volume storage (Gb)

Number of MODIS TERRA products covering Libya4 site

V2.0 Database content (2/3)

POLDER/PARASOL

Product Level:	Processing version:	Spatial Resolution:	Total number of products:
Level 1	V1-01	6 km	2 035

POLDER/PARASOL netCDF extracts volume storage (Gb)

Number of POLDER/PARASOL products covering Libya4 site

All products for the Libya4 site were entirely processed.

PROBA-V

Product Level:	Processing version:	Spatial Resolution:	Total number of products:
Level 2A	V101, V102	1 000 m	2 347

PROBA-V netCDF extracts volume storage (Gb)

Number of PROBA-V products covering Libya4 site
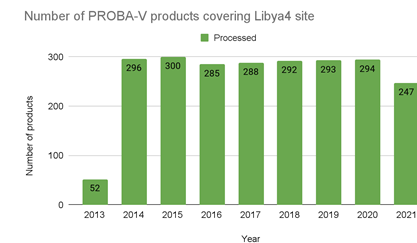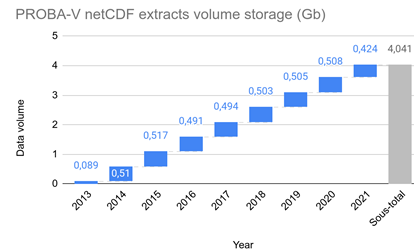
All products for the Libya4 site were entirely processed.

SENTINEL-3 OLCI

Product Level:	Processing version:	Spatial Resolution:	Total number of products:
Level 1	002	294x270m (Full Resolution)	1 587

Sentinel-3 OLCI netCDF extracts volume storage (Gb)

Number of S3-OLCI products covering Libya4 site
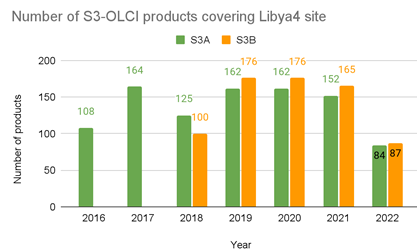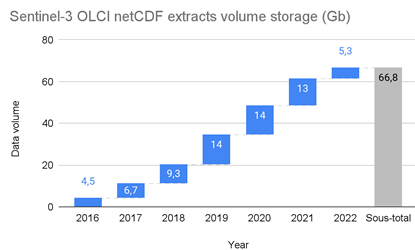
All products for the Libya4 site were entirely processed.

SENTINEL-3 SLSTR

Product Level:	Processing version:	Spatial Resolution:	Total number of products:
Level 1	003	500, 1 000 m	887 (2016 - 2020)

Sentinel-3 SLSTR netCDF extracts volume storage (Gb)

Number of S3-SLSTR products covering Libya4 site
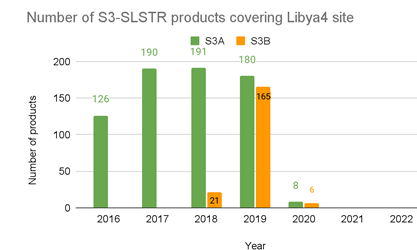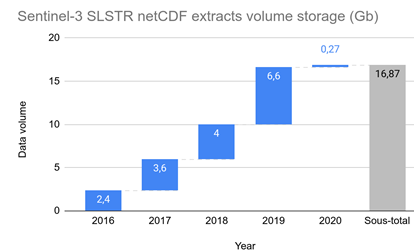
V2.0 Database content (3/3)

LANDSAT

Product Level:	Processing version:	Spatial Resolution:	Total number of products:
Level 1TP	02	15, 30 m	218

LANDSAT (8,9) netCDF extracts volume storage (Gb)
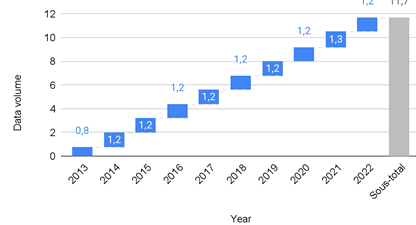
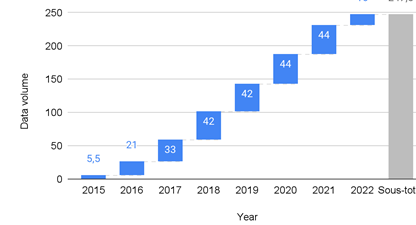Number of LANDSAT (8,9) products covering Libya4 site
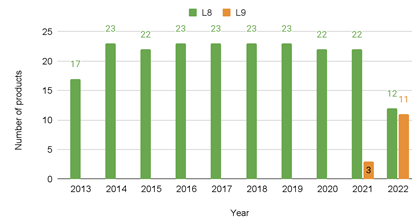
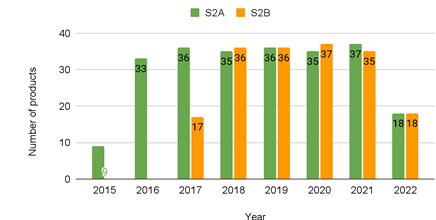**All products for the Libya4 site were entirely processed.**

SENTINEL-2 MSI

Product Level:	Processing version:	Spatial Resolution:	Total number of products:
Level 1C	Processing baseline from 02.01 to 04.00	10,20,60 m	404

Sentinel-2 netCDF extracts volume storage (Gb)

Number of S2-MSI products covering Libya4 site

**All products for the Libya4 site were entirely processed.**

New

PICSCAR web site will be upgraded to add tools to visualise, analyse and distribute the time series. Registration will be requested.

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Database format and content

- ## Version 1: CSV file
  - Content : date of acquisition, mean and standard deviation of TOA reflectance, solar and view geometries

- ## Version 2.0 : NETCDF file
  - Content : a file per acquisition (NETCDF) and a quicklook
    - All fields extracted at pixel level
      - TOA reflectances, official cloud mask, solar and view geometry, ozone, water vapour content, pressure from ERA5 (interpolated)
    - Statistics (mean and standard deviation)
    - Scene quicklook

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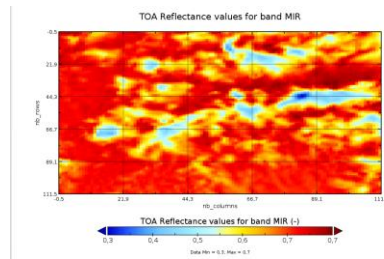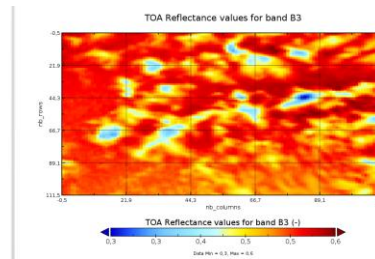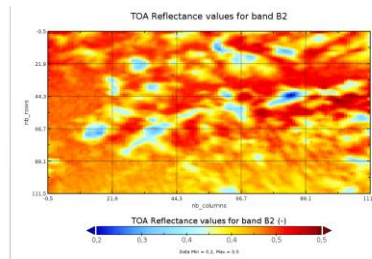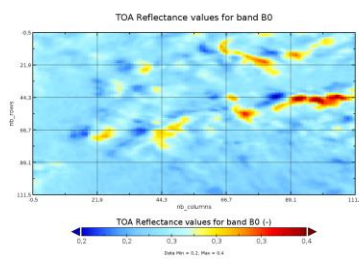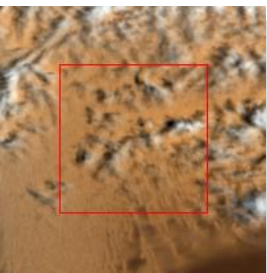
Database completion

- PICSCAR infrastructure ready for other site extraction in order to extend the database to the 5 other CEOS sites requested by users
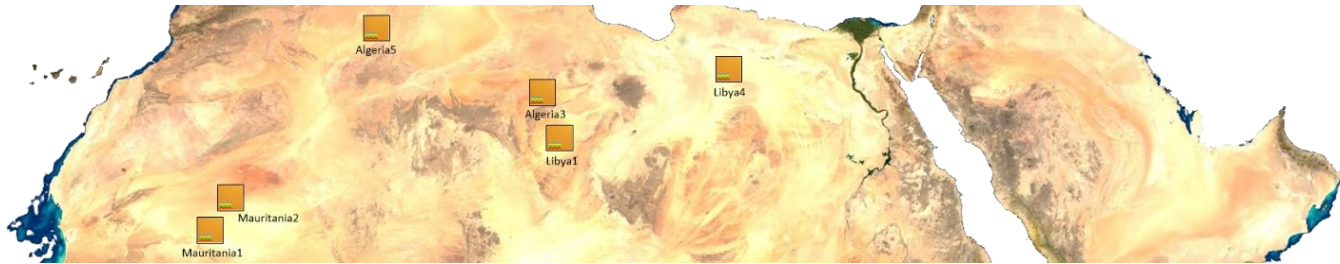
User site selection interest
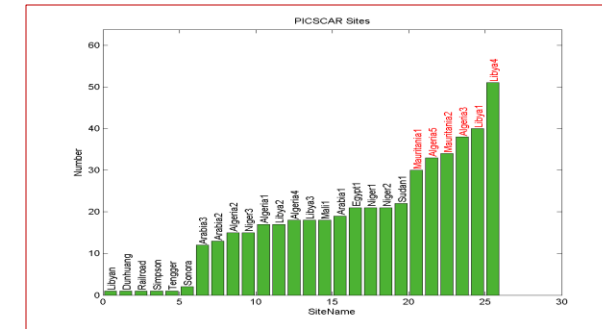

- And therefore to consolidate and compare intercalibration results using combination of sites

Target : end of year 2022

2. Database v1.0 and v2.0 comparison and monitoring of site stability

Patrice Henry & Béatrice Berthelot

PICSCAR database v1.0 vs v2.0

- Main differences between v1.0 and v2.0:

  - Time span (up to 2022 for v2.0)

  - Reprocessing level

  - Extraction process

  - Cloud screening

- Processing applied for BoA comparison:

  - Atmospheric correction performed using SMAC method

  - Cloud coverage < 20%

  - BRDF model based on PARASOL data fitted for $\theta v < 50°$

  - Normalisation applied with $d\phi=0$ and $\theta s = 30°$

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MERIS - Picscar v1.0 (top) vs Picscar v2.0 (bottom)
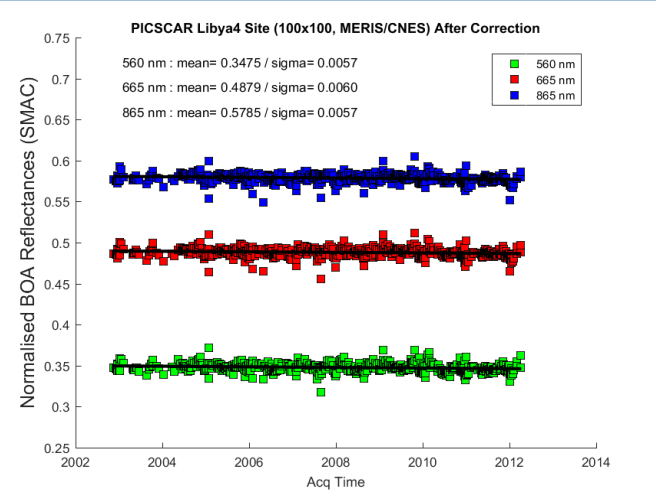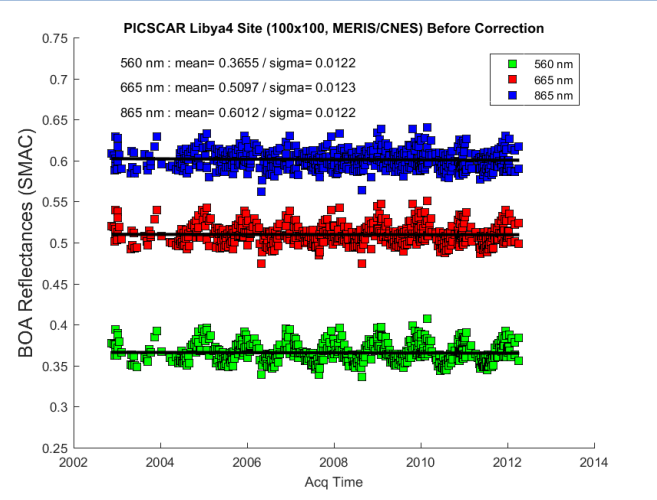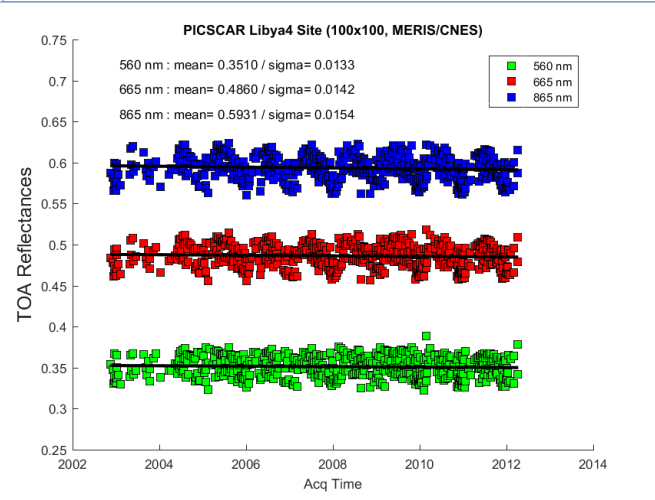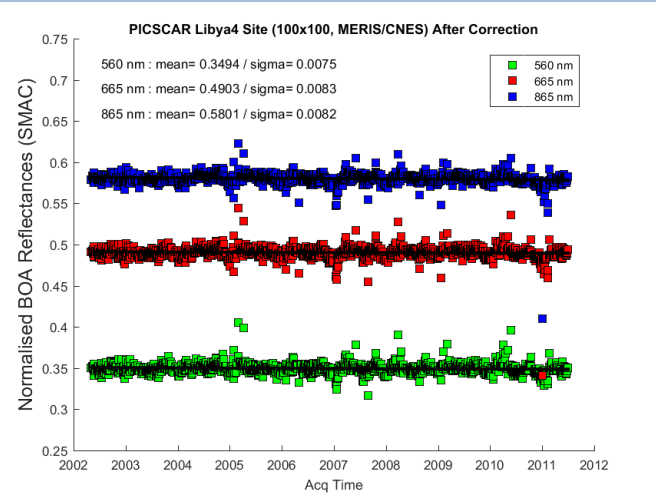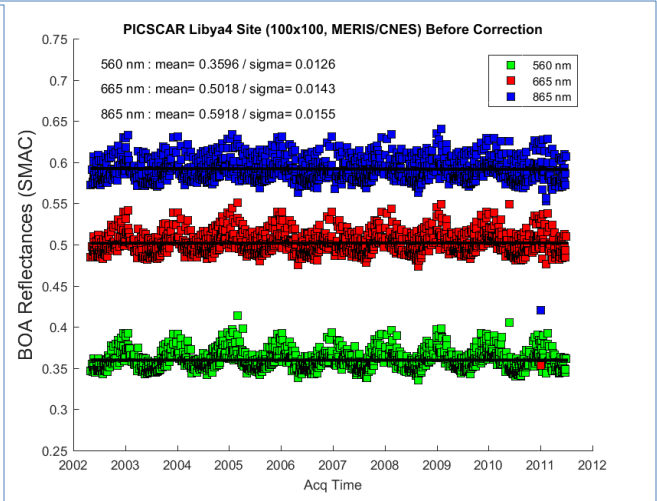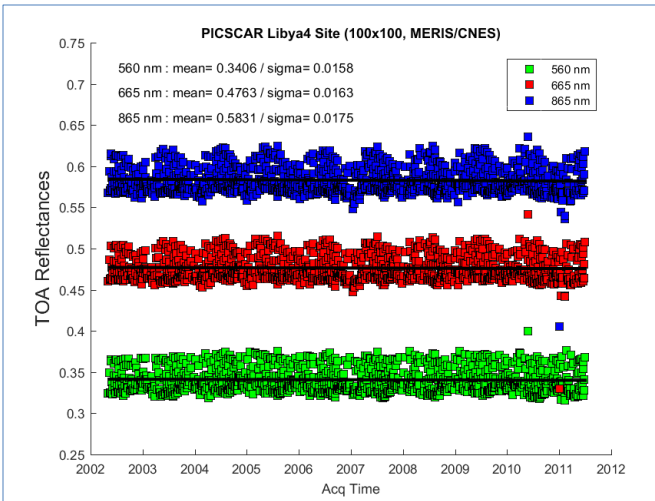
V1.0 : MERIS 3rd reprocessing
V2.0 : MERIS 4th reprocessing

31/08/2022

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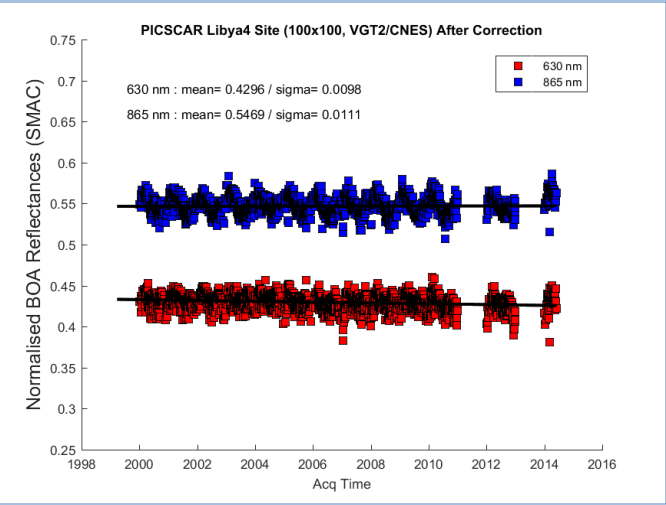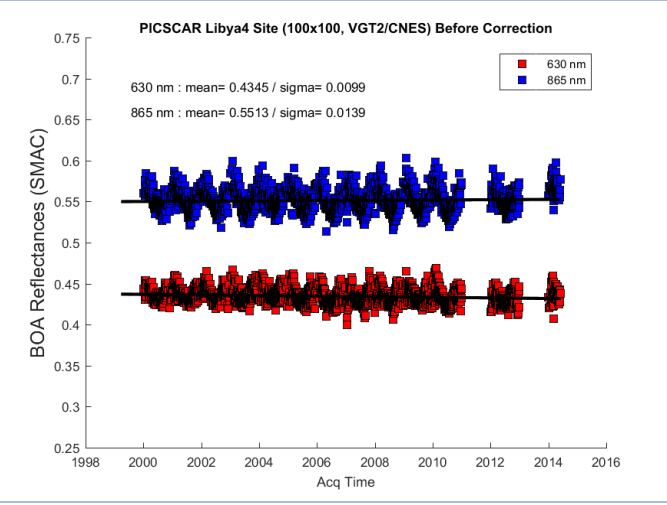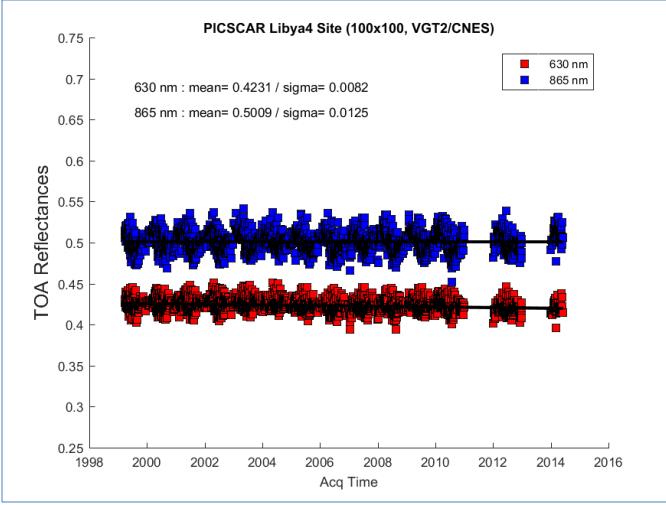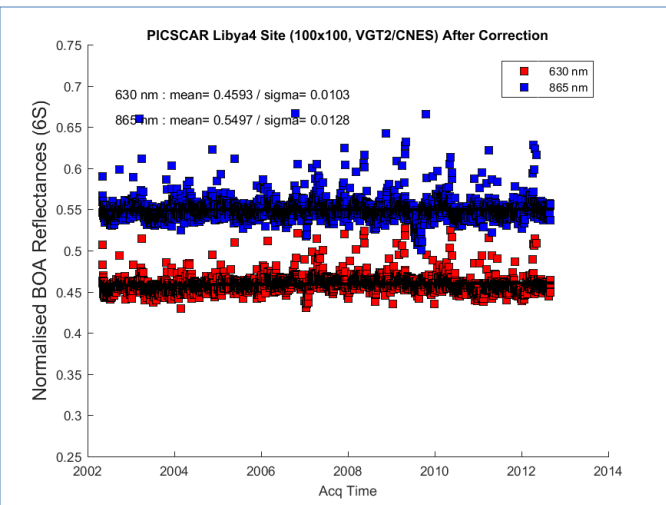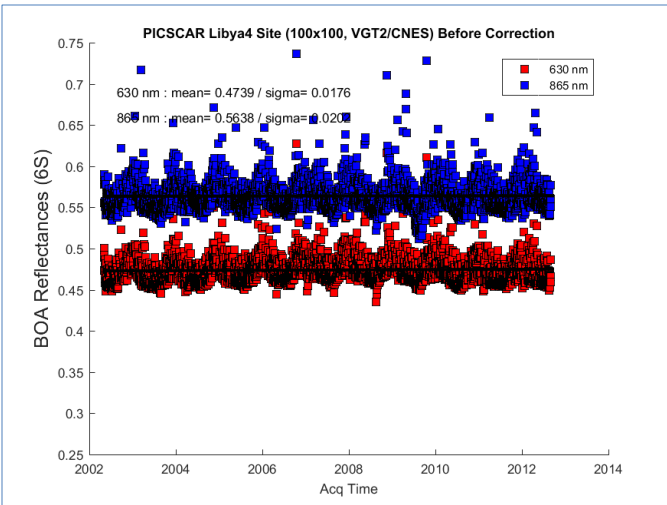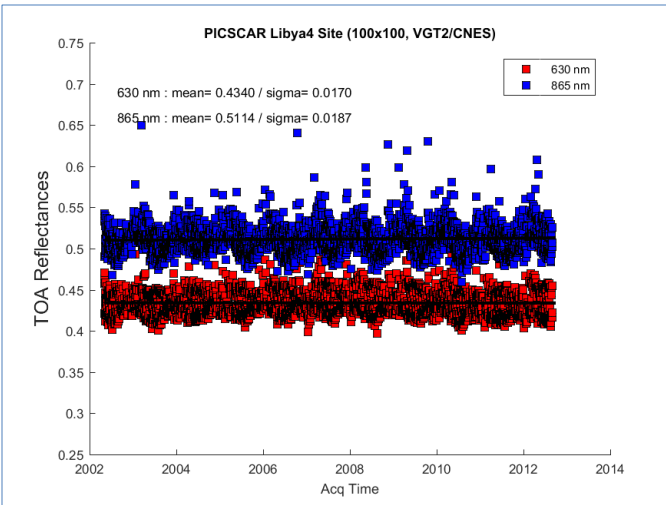
V1.0 : VGT collection 1
V2.0 : VGT collection 2

31/08/2022

MODIS AQUA - Picscar v1.0 vs Picscar v2.0 (bottom)
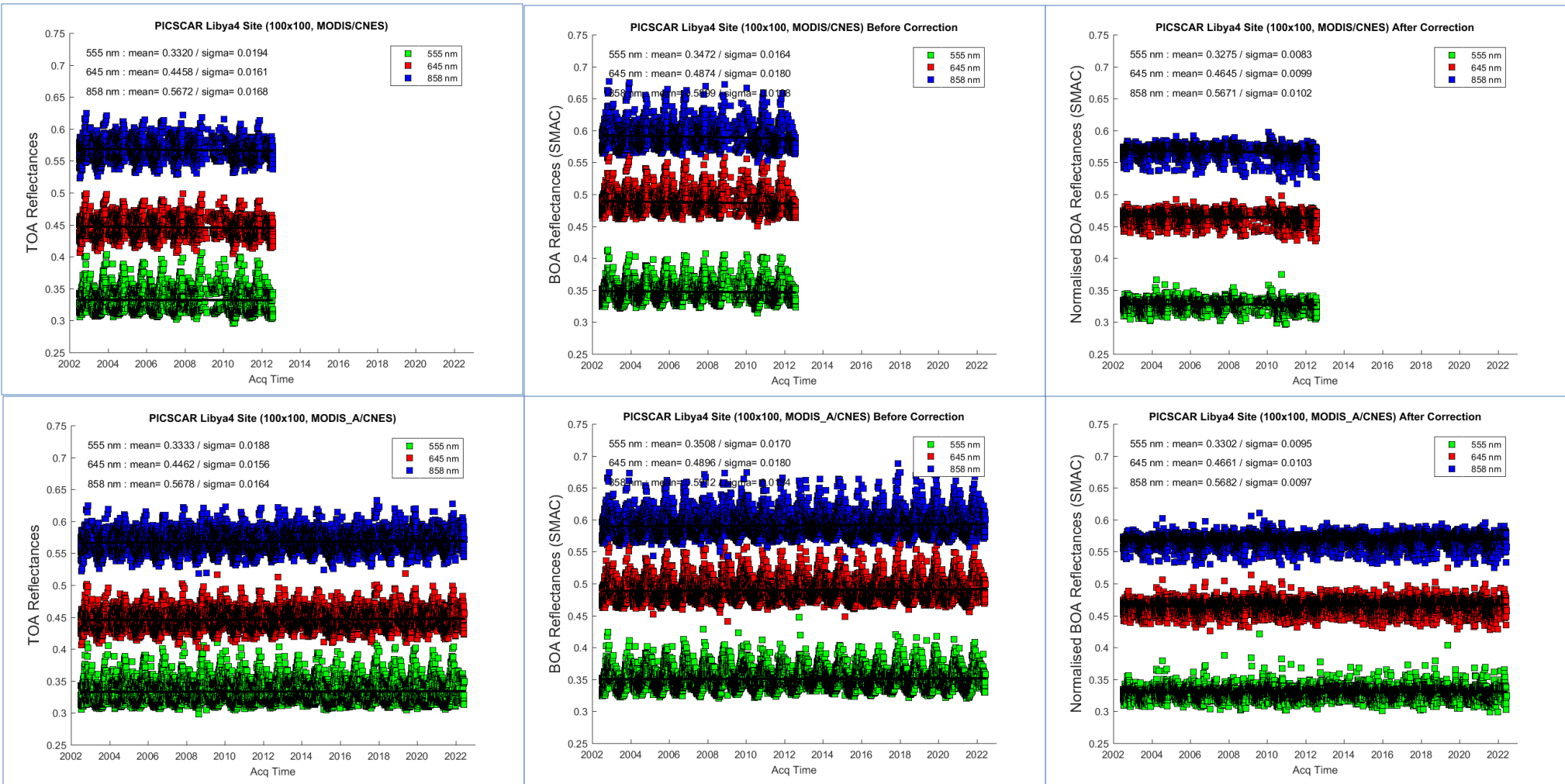
V1.0 : MODIS collection 5
V2.0 : MODIS collection 6.1

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Monitoring site stability

- PICSCAR database v2 is used to monitor site stability with MERIS, Vegetation 1/2 and MODIS Aqua long time series of normalised BOA reflectance (20 years)

- Very good stability but accuracy difficult to assess

- BDRF correction reduces the reflectance scattering and correct the seasonal effects

- BRDF model need to be upgraded

Comparison of S2A BOA without/with BRDF corrections

S2A 490 nm

BOA without BRDF Correction : $\sigma=0.0050$

BOA with BRDF Correction : $\sigma=0.0030$

S2A 560 nm

BOA without BRDF Correction : $\sigma=0.0064$

BOA with BRDF Correction : $\sigma=0.0031$

S2A 665 nm

BOA without BRDF Correction : $\sigma=0.0049$

BOA with BRDF Correction : $\sigma=0.0036$

S2A 865 nm

BOA without BRDF Correction : $\sigma=0.0037$

BOA with BRDF Correction : $\sigma=0.0046$
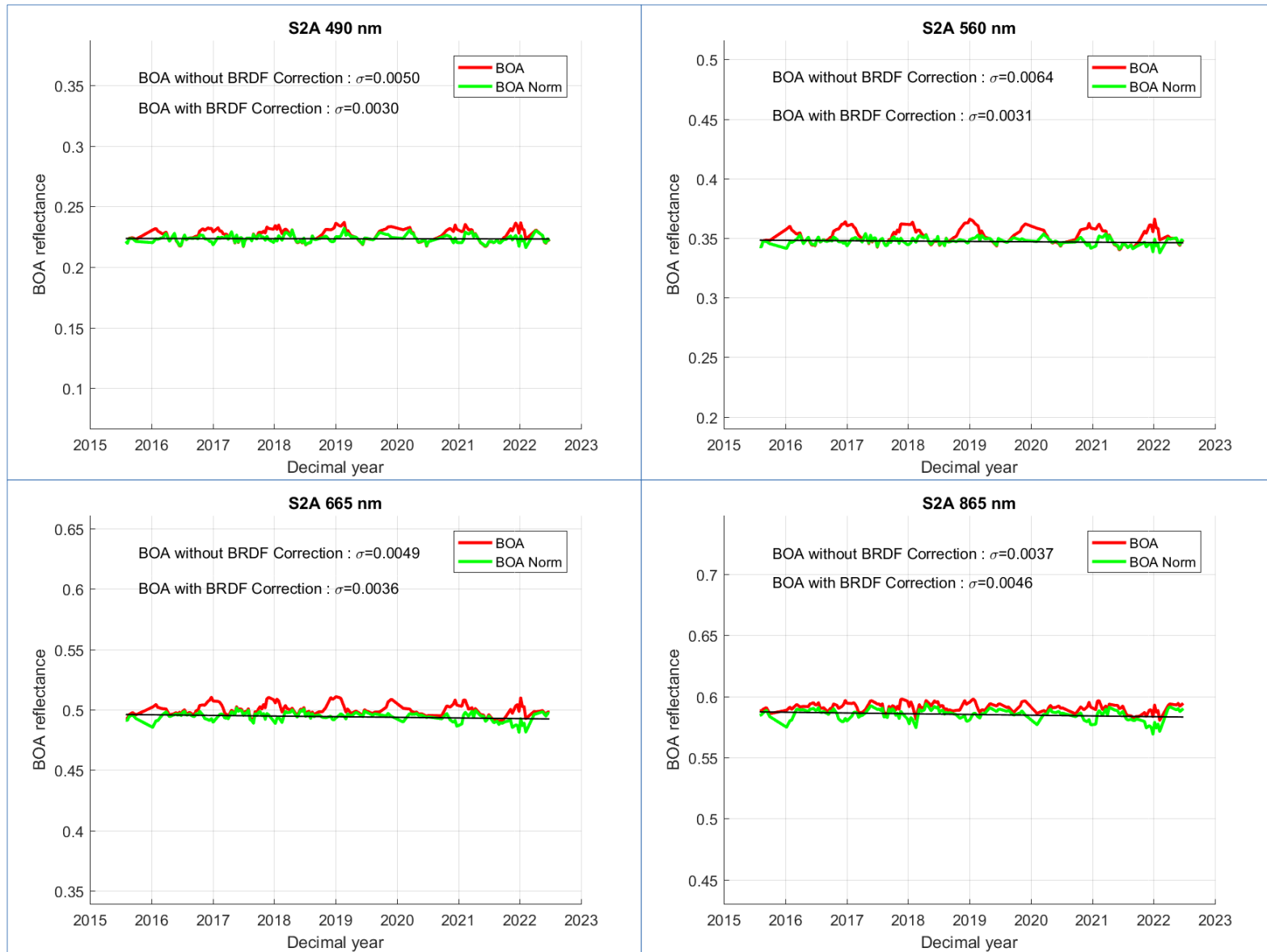
Comparison of L8 BOA without/with BRDF corrections

L8 482 nm

BOA without BRDF Correction : σ=0.0039

BOA with BRDF Correction : σ=0.0030

Legend: BOA, BOA Norm

L8 562 nm

BOA without BRDF Correction : σ=0.0061

BOA with BRDF Correction : σ=0.0033

Legend: BOA, BOA Norm

L8 655 nm

BOA without BRDF Correction : σ=0.0057

BOA with BRDF Correction : σ=0.0039

Legend: BOA, BOA Norm

L8 865 nm

BOA without BRDF Correction : σ=0.0042

BOA with BRDF Correction : σ=0.0046

Legend: BOA, BOA Norm
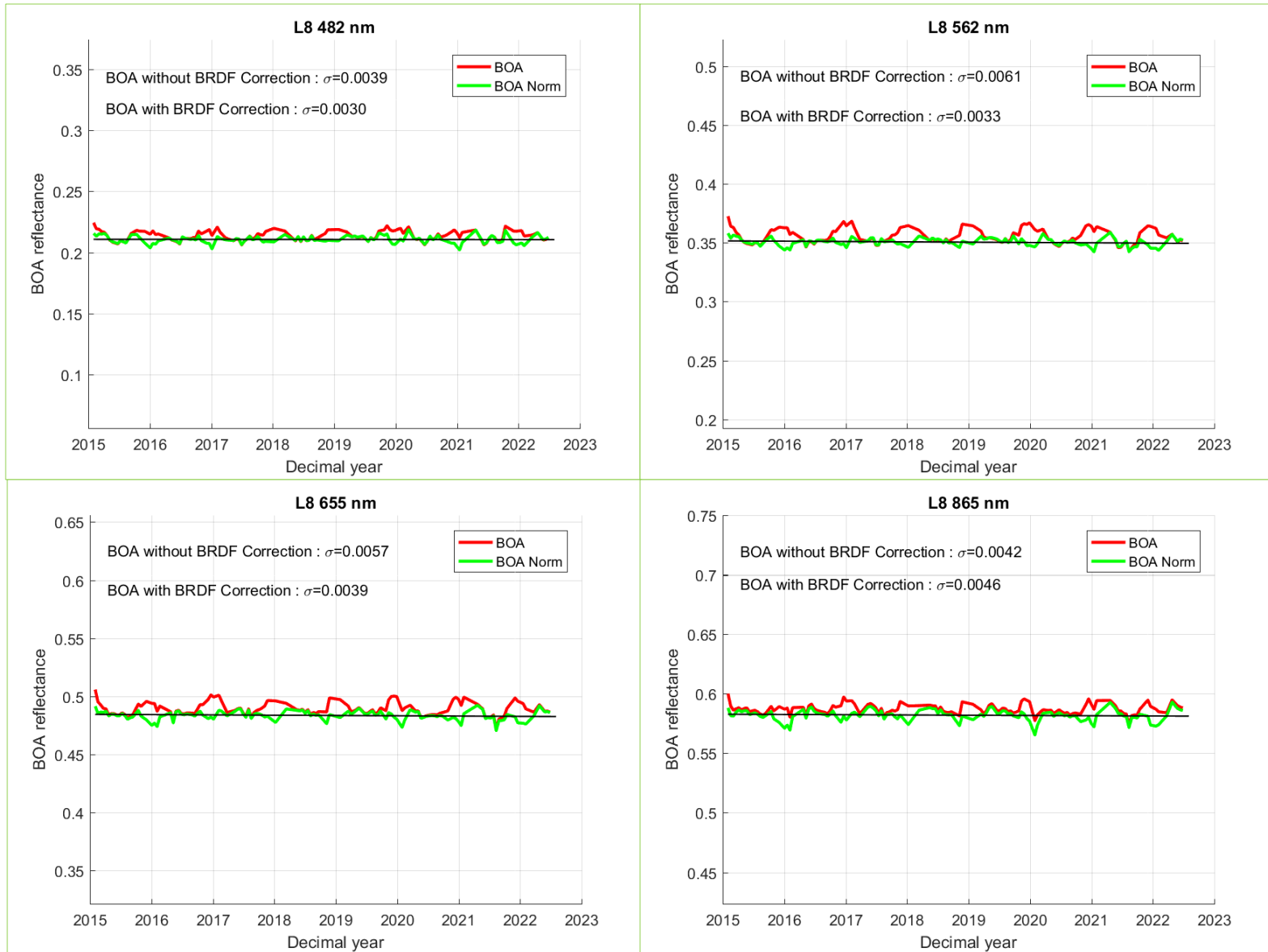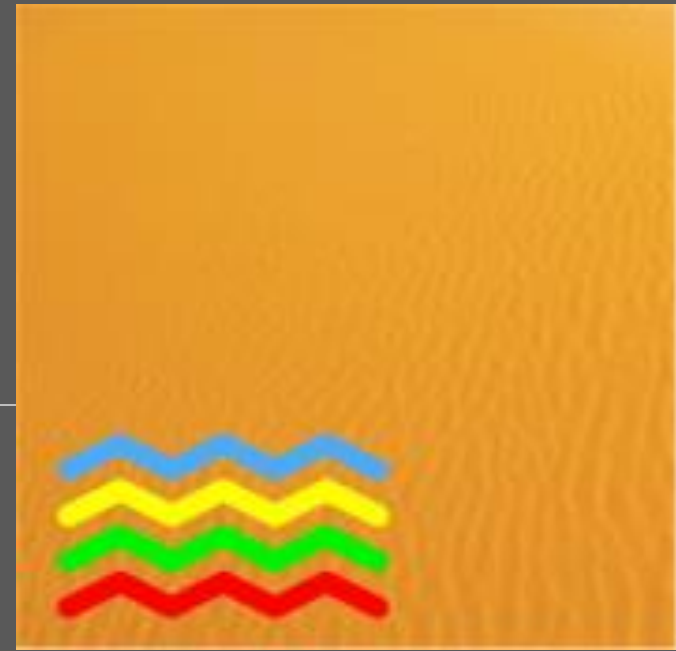
3. Monitoring of OLI/L8 vs S2A/MSI intercalibration   over Libya4 site in the frame of PICSCAR activity

Patrice Henry & Béatrice Berthelot

- The activity started on January 2018 with the intercomparison exercice on the intercalibration of Landsat8/OLI with Sentinel 2A/MSI over Libya 4 small site.

- The activity results on an agreement between SDSU, CNES, and PICSCAR initiative to publish the results regularly (every 6 months)*.

- Time series of cloud free TOA reflectances are provided by SDSU every six months.

*Still waiting for ESA monitoring results

The dataset

Libya4 Small site 20 x 20 km^2 centered on 28.55 °N, 23.89 °E

Summary Chart PICSCAR L8/S2A ratio Libya4s

Band 490 nm Slope=1.0073 Intercept= 0.00010 mean=1.0077 σ=0.0034 σ/m= 0.33%
Band 560 nm Slope=0.9932 Intercept= 0.00001 mean=0.9933 σ=0.0024 σ/m= 0.24%
Band 665 nm Slope=0.9963 Intercept= 0.00028 mean=0.9974 σ=0.0022 σ/m= 0.22%
Band 705 nm Slope=0.9925 Intercept= 0.00049 mean=0.9944 σ=0.0029 σ/m= 0.29%

Produced by PICSCAR on : 20220818T170308

Summary Chart SDSU L8/S2A ratio Libya4s

Band 490 nm Slope=1.0148 Intercept=-0.00042 mean=1.0134 σ=0.0048 σ/m= 0.47 %
Band 560 nm Slope=1.0024 Intercept=-0.00008 mean=1.0022 σ=0.0058 σ/m= 0.58 %
Band 665 nm Slope=0.9949 Intercept= 0.00003 mean=0.9950 σ=0.0059 σ/m= 0.59 %
Band 705 nm Slope=0.9961 Intercept=-0.00004 mean=0.9960 σ=0.0053 σ/m= 0.53 %

Produced by PICSCAR on : 20220818T170308

Summary chart CNES L8/S2A ratio Libya4s

Band 490 nm Slope=1.0016 Intercept=-0.00117 mean=0.9957 σ=0.0055 σ/m= 0.55 %
Band 560 nm Slope=1.0163 Intercept=-0.00163 mean=1.0082 σ=0.0062 σ/m= 0.61 %
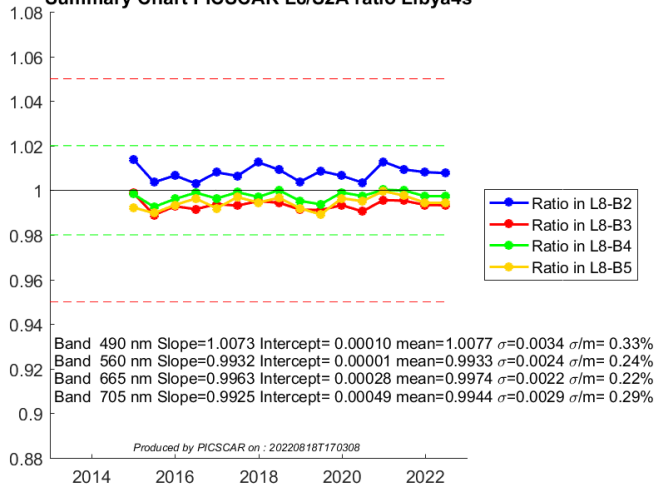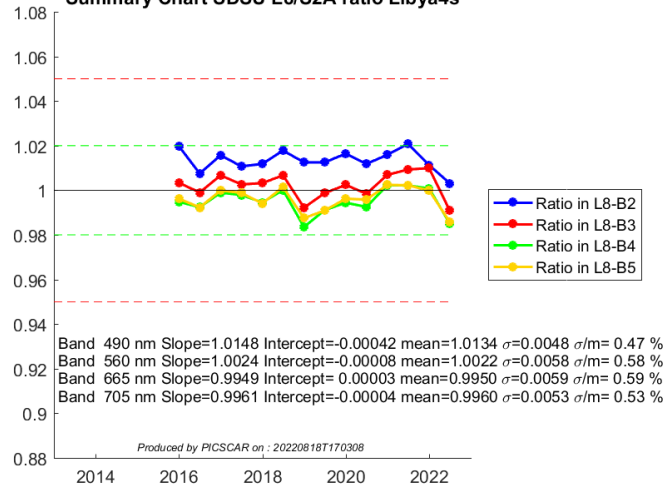Band 665 nm Slope=1.0058 Intercept=-0.00120 mean=0.9998 σ=0.0048 σ/m= 0.48 %
Band 705 nm Slope=1.0011 Intercept=-0.00097 mean=0.9963 σ=0.0039 σ/m= 0.39 %

Produced by PICSCAR on : 20220818T170308

No IC comparison is performed in B1, B6, and B7 bands due to the lack of BRDF model.

References : B. Berthelot and P. Henry, Monitoring the Intercalibration of L8/OLI with S2A/MSI over Libya4 PICS in the frame of PICSCAR CEOS/IVOS initiative, 4th Sentinel-2 validation team meeting, 15-17 March 2021

References: Morakot Kaewmanee, Esad Micijevic, Dennis Helder, Md Obaidul Haque, Julia Barsi, Radiometric Comparison of Sentinel 2A, Sentinel 2B and Landsat-8: Lifetime Trending, Cross Calibration and Absolute Calibration Assessment Over the Libya 4 PICS, JACIE Workshop 2018, College Park, Sep 17-19, 2018 https://calval.cr.usgs.gov/apps/sites/default/files/jacie/S2AS2BOLIJACIE2018v.1.6.pdf.

References: Lacherade, S., Fougnie, B., Henry,P., & Gamet, P.(2013). Cross calibration over desert sites: Description, methodology, and operational implementation. IEEE Transactions on Geoscience and Remote Sensing, 51, 10981113, doi:10.1109/TGRS.2012.2227061
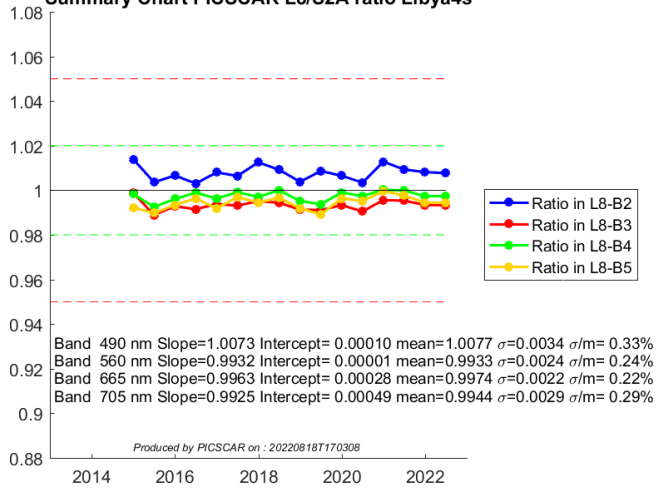
Temporal stability is better than 1%

Differences for absolute values observed between methods

Clouds screening ? Atmospheric correction ? Spectral correction ? BRDF correction ?
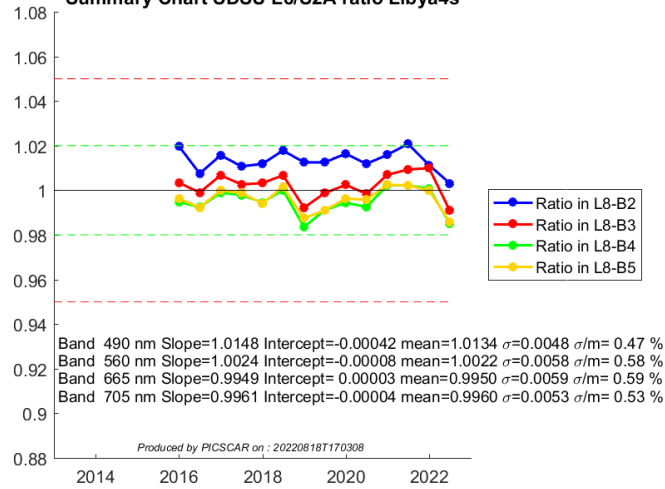
Summary Chart PICSCAR L8/S2A ratio Libya4s

Band 490 nm Slope=1.0073 Intercept= 0.00010 mean=1.0077 σ=0.0034 σ/m= 0.33%
Band 560 nm Slope=0.9932 Intercept= 0.00001 mean=0.9933 σ=0.0024 σ/m= 0.24%
Band 665 nm Slope=0.9963 Intercept= 0.00028 mean=0.9974 σ=0.0022 σ/m= 0.22%
Band 705 nm Slope=0.9925 Intercept= 0.00049 mean=0.9944 σ=0.0029 σ/m= 0.29%

Produced by PICSCAR on : 20220818T170308

Summary Chart SDSU L8/S2A ratio Libya4s

Band 490 nm Slope=1.0148 Intercept=-0.00042 mean=1.0134 σ=0.0048 σ/m= 0.47 %
Band 560 nm Slope=1.0024 Intercept=-0.00008 mean=1.0022 σ=0.0058 σ/m= 0.58 %
Band 665 nm Slope=0.9949 Intercept= 0.00003 mean=0.9950 σ=0.0059 σ/m= 0.59 %
Band 705 nm Slope=0.9961 Intercept=-0.00004 mean=0.9960 σ=0.0053 σ/m= 0.53 %

Produced by PICSCAR on : 20220818T170308

Summary chart CNES L8/S2A ratio Libya4s

Band 490 nm Slope=1.0016 Intercept=-0.00117 mean=0.9957 σ=0.0055 σ/m= 0.55 %
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Produced by PICSCAR on : 20220818T170308

No IC comparison is performed in B1, B6, and B7 bands due to the lack of BRDF model.

References : B. Berthelot and P. Henry, Monitoring the Intercalibration of L8/OLI with S2A/MSI over Libya4 PICS in the frame of PICSCAR CEOS/IVOS initiative, 4th Sentinel-2 validation team meeting, 15-17 March 2021

References: Morakot Kaewmanee, Esad Micijevic, Dennis Helder, Md Obaidul Haque, Julia Barsi, Radiometric Comparison of Sentinel 2A, Sentinel 2B and Landsat-8: Lifetime Trending, Cross Calibration and Absolute Calibration Assessment Over the Libya 4 PICS, JACIE Workshop 2018, College Park, Sep 17-19, 2018 https://calval.cr.usgs.gov/apps/sites/default/files/jacie/S2AS2BOLIJACIE2018v.1.6.pdf.

References: Lacherade, S., Fougnie, B., Henry,P., & Gamet, P.(2013). Cross calibration over desert sites: Description, methodology, and operational implementation. IEEE Transactions on Geoscience and Remote Sensing, 51, 10981113, doi:10.1109/TGRS.2012.2227061
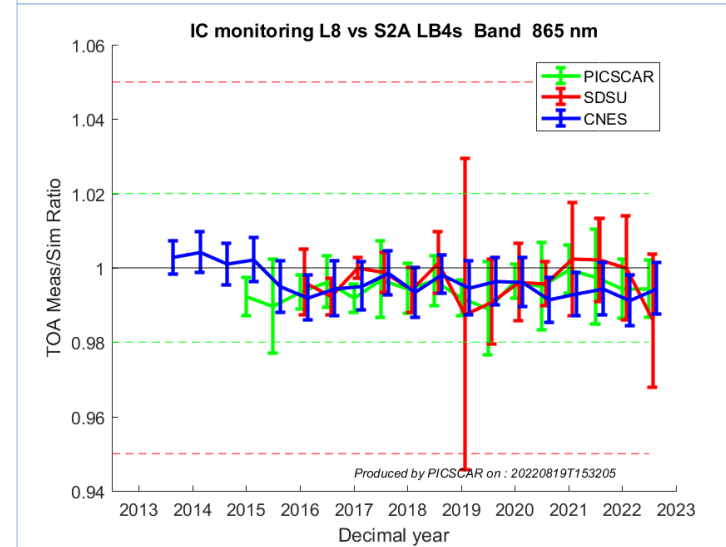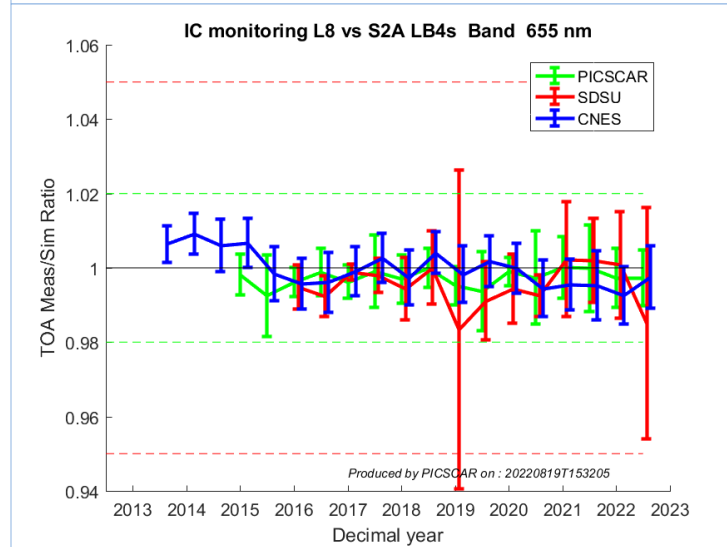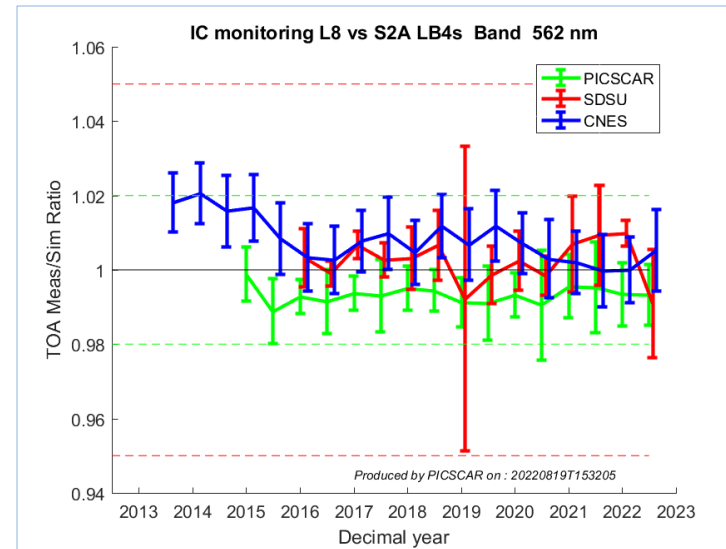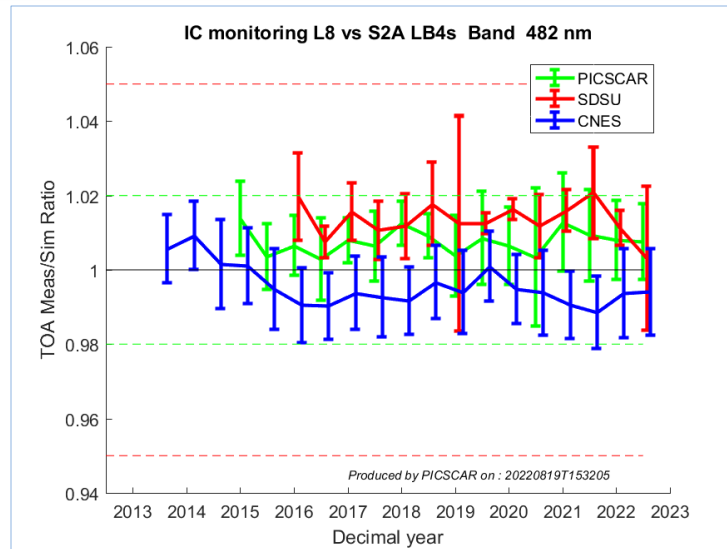
Temporal stability is better than 1%

Differences for absolute values observed between methods*

Clouds screening ? ~~Atmospheric correction ?~~ Spectral correction ? ~~BRDF correction ?~~

*Methods are documented on the portal

Summary chart by spectral band for [July 2015- June 2022] period

Overall consistency within 2% and much better for Red and NIR bands

- Analysis shows the good consistency of the results of the three independent methods used for Inter Calibration of L8 versus S2A sensors over Libya4 site.
    - Useful to analyse the consistency of the methods
    - Useful for anomalies detection
    - It is an asset to publish these results on PICSCAR portal (and continue to publish them)
        - Results are compared using the same statistics,
        - It provides a reference for other teams.
- Ready to include L9/OLI and S2B over Libya4 and other CEOS selected sites

Results publication on https://picscar.magellium.com

- Results are available as Graphs and Tables showing:
  - Comparison for selected bands
  - Comparison for selected periods
  - Mean results over all dates and tables
  - Results for each period over all dates and Tables
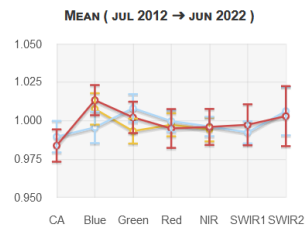- Registration is requested

Next short-term steps

- Completion of the v2.0 database
  - VIIRS and MISR (other ?)
  - Other CEOS PICS sites

- Sites characterisation

  - New BRDF model computation (PARASOL + other sensors)

  - Spectral characterisation (CNES ?)

  - Uniformity characterisation

- Need for a PICSCAR virtual meeting before end 2022

31/08/2022