PICSCAR Status

Radiometric Calibration Workshop for European Missions

31/08/2017

Béatrice Berthelot (Magellium)
Patrice Henry (CNES)
Characterisation of PICS

• PICS are widely and successfully used for on orbit radiometric trending for more than 20 years. Vicarious radiometric calibration methods rely on PICS ...

• Conclusions from CEOS/WGCV and GSICS are that there remains the prospect for improvement in the usage of PICS and then better understand sensor and inter sensor performance.

• **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 (BRDF, Spectral reflectance etc)

• **Leadership** has been taken by Patrice Henry (CNES) with the objective to facilitate the coordination and help prioritise research on PICS and their usage.
PICSCAR Initiative

• **2 Actions at IVOS 28** (July, 2016)
  – Need to know the PICS usage (Questionnaires sent by Nigel Fox on September, 9th, 2016)
  
  – Collect data over Libya4 site for the large site (100 x 100 km2) and small site (20 x20 km2) centered on 28.55N/23.89E

This activity is carried out as an activity under the auspices of CEOS/WGCV/IVOS. Participation is opened.
PICS usage : Questions overview

• The questionnaire aims to identify the state of art, methods, data
• 5 questions are addressed :

• **Question 1**: Could you provide the **PICS site name(s)** that you use for radiometric calibration processes?

• **Question 2**: In order to define a priority of sites to concentrate community research efforts, could you please indicate the names of the PICS that you would like us to focus on? (Not more than 20) and the characteristics for which you’d like to have information *(Stability, BRDF, Spectral characterization, spatial homogeneity properties, atmospheric and cloud properties…)* If you are able to list them in a priority order that would also be valuable
Questions overview

• Question 3: What data is available for the site(s)?
• Question 4: Is the data accessible? (No Intellectual Property Rights to use it)
• Question 5: Could you describe the project/activity in which the data is used/will be used?
• Question 6: What is your interest in using the data acquired over PICS? e.g. sampling studies, scaling, seasonality corrections …..
• Additional comments
### Operational Calibration Monitoring

<table>
<thead>
<tr>
<th>Organization</th>
<th>Logo</th>
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<tbody>
<tr>
<td>CNES</td>
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</tbody>
</table>

### Future sensors

- AIST
  - ![AIST Logo]

### Specific studies

- Rayference
  - ![Rayference Logo]
- TPZ
  - ![TPZ Logo]
- Onera (sand)
  - ![Onera Logo]
# 30 Sites of Interest

<table>
<thead>
<tr>
<th>Site name</th>
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<th>Site name</th>
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<tbody>
<tr>
<td>Algeria1</td>
<td>Arabia2</td>
<td>Dunhuang</td>
<td>Libyan</td>
<td>Niger3</td>
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<tr>
<td>Algeria2</td>
<td>Arabia3</td>
<td>Egypt1</td>
<td>Mali1</td>
<td>Railroad</td>
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<td>Algeria3</td>
<td>Dome_C</td>
<td>Libya1</td>
<td>Mauritania1</td>
<td>Simpson</td>
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<td>Algeria4</td>
<td>Dome_1</td>
<td>Libya2</td>
<td>Mauritania2</td>
<td>Sonora</td>
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<td>Algeria5</td>
<td>Dome_2</td>
<td>Libya3</td>
<td>Niger1</td>
<td>Sudan1</td>
</tr>
<tr>
<td>Arabia1</td>
<td>Dome_3</td>
<td>Libya4</td>
<td>Niger2</td>
<td>Tengger</td>
</tr>
</tbody>
</table>
• Saharian sites
Location overview (2/6)

- Saharian sites
• Australian site
Location overview (4/6)

- Chinese sites
• US sites
• Antarctic site
Question 1: Sites ranking

PICSCAR Sites

Number

SiteName

Dunhuang, Libyan, Simpson, Tengger, Sonora, Dome 1, Dome 2, Dome 3, Railroad Dome C, Arabia 1, Arabia 2, Algeria 1, Algeria 2, Algeria 3, Algeria 4, Libya 1, Libya 2, Libya 3, Libya 4, Mauritania 1, Mauritania 2, Mauritania 3, Mauritania 4, Libya 1, Libya 2, Libya 3, Libya 4.
Question 2: Define a priority of sites and needed information.
Overview of the top 3 ranking
Overview of the top 3 ranking (1/3) : Algeria3 – 20 km x 20 km

Location 1°x1°

PICS User CNES
Satellite: MERIS
Satellite: MODIS
TERRA_AQUA
Satellite: LANDSAT7_ETM
Satellite: LANDSAT8_OLI
Satellite: PleiadesPHR1A_1B
Satellite: Sentinel2_MSI
Satellite: SPOT6_7

PICS User VITO
Satellite: ProbaV
Overview of the top 3 ranking (1/3) : Algeria3 – 100 km x 100 km

PICS User DLR
Satellite: AVHRR

PICS User ARGANS
Satellite: ASTR_ATSR2_AATSR
Satellite: MERIS
Satellite: MODIS
TERRA_AQUA
Satellite: OLCI
Satellite: LANDSAT8 OLI
Satellite: Sentinel2 MSI

PICS User Esa
Satellite: ASTR_ATSR2_AATSR
Satellite: MERIS
Satellite: MODIS
TERRA_AQUA
Satellite: OLCI
Satellite: PARASOL
Satellite: ProbaV
Satellite: SLSTR

PICS User ONERA
Satellite: Sentinel2 MSI

PICS User CNES
Satellite: ASTR_ATSR2_AATSR
Satellite: AVHRR
Satellite: MERIS
Satellite: MODIS
TERRA_AQUA
Satellite: OLCI
Satellite: PARASOL
Satellite: POLDER_1_2
Satellite: SeaWiFS
Satellite: KOMPSAT1_2
Satellite: LANDSAT5 TM
Satellite: LANDSAT7 ETM
Satellite: Sentinel2 MSI
Satellite: SPOT1 2 3 4 5
Satellite: Thaichote

PICS User AIST
Satellite: ASTER
Overview of the top 3 ranking (1/3): Algeria3 – All locations
Overview of the top 3 ranking (2/3) : Libya1– 20 km x 20 km
Overview of the top 3 ranking (2/3) : Libya1– 100 km x 100 km

PICS User ARGANS
Satellite:
ASTR_ATSR2_AATSR
Satellite: MERIS
Satellite: MODIS
TERRA_AQUA
Satellite: OLCI
Satellite: LANDSAT8_OLI
Satellite: Sentinel2_MSI

PICS User SDSU
Satellite: Hyperion
Satellite: LANDSAT7_ETM
Satellite: LANDSAT8_OLI
Satellite: Sentinel2_MSI
Satellite: Thaichote

PICS User ESA
Satellite:
ASTR_ATSR2_AATSR
Satellite: MERIS
Satellite: MODIS
TERRA_AQUA
Satellite: OLCI
Satellite: PARASOL
Satellite: ProbaV
Satellite: SLSTR

PICS User CNES
Satellite:
ASTR_ATSR2_AATSR
Satellite: AVHRR
Satellite: MERIS
Satellite: MODIS
TERRA_AQUA
Satellite: OLCI
Satellite: PARASOL
Satellite: POLDER 1_2
Satellite: SeaWIFS
Satellite: Formosat
Satellite: KOMPST1_2
Satellite: LANDSAT7_ETM
Satellite: Sentinel2_MSI
Satellite: SPOT1_2_3_4_5

US Dept of State geographer
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Image Landsat / Copernica
Overview of the top 3 ranking (2/3): Libya 1 - All locations

Libya 1

- VITO
- CNES
- CNES
- ARGANS, ESA
- JPL
- SDSU
- AIST
Overview of the top 3 ranking (3/3) : Libya4 – 20 km x 20 km

PICS User CNES
Satellite: MERIS
Satellite: MODIS
TERRA_AQUA
Satellite: LANDSAT7_ETM
Satellite: LANDSAT8_OLI
Satellite: PléiadesPHRIA_1B
Satellite: Sentinel2_MSI

PICS User SDSU
Satellite: Hyperion
Satellite: LANDSAT7_ETM
Satellite: LANDSAT8_OLI
Satellite: Sentinel2_MSI
Satellite: Worldview
Satellite: Thaichote

PICS User JPL
Satellite: MISR

PICS User NOAA-NESSDIS-STAR
Satellite: VIIRS

PICS User VITO
Satellite: ProbaV

PICS User FoSense
Satellite: DMC

CEOS SITE REFERENCE LOCATION 1°x1°
Overview of the top 3 ranking (3/3) : Libya4– 100 km x 100 km
Overview of the top 3 ranking (3/3): Libya 4 – All locations

11 users
7 different site locations
Question 2: Information need

<table>
<thead>
<tr>
<th>Temporal stability</th>
<th>BRDF</th>
<th>Spectral characterisation</th>
<th>Spatial homogeneity</th>
<th>Atmospheric and cloud properties</th>
<th>Other</th>
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</thead>
<tbody>
<tr>
<td>15</td>
<td>15</td>
<td>15</td>
<td>13</td>
<td>15</td>
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</tbody>
</table>

Additionnal points

- Hyperspectral characterisation
- Number of sites: [5 – 10]
Roadmap: Main areas of concern (IVOS 29)

- Priority subjects to address (Discussed at last PICSCAR meeting, Tucson, March, 2017)
  - BRDF
  - Spectral characterization
  - Atmosphere properties
  - Temporal Stability
  - Combining multiple sites calibration results
  - Revisiting the sites
PICSCAR first priority

- Interest is given first to site stability

- Why site stability?
  - Long term calibration monitoring (strong requirement)
  - Sensor inter-calibration (depends on the method used)

- How to define ‘site stability’?
  - Linear trend (evolution slope per year)
  - Year to year variability
  - Inter-annual variation
  - ....
Site Stability monitoring

• Libya 4 test site is used as a reference test site for 11 users, 30 satellites

• Baseline is CNES study which objective was to assess the stability by computing a normalised reflectance thanks to the BRDF model computed using PARASOL data (Quang, K., technical report, 2017).

• Application to the dataset collected in the first phase of the initiative
Data collection description

**PICSCAR Libya4 Site: Dataset collection**

- 1: CNES,MERIS,100x100:1059
- 2: ESA,MERIS,100x100:1713
- 3: ARGANS,MERIS,100x100:1710
- 4: ARGANS,MERIS,20x20:1535
- 5: ARGANS,S2AMSI,20x20:61
- 6: CNES,S2AMSI,20x20:46
- 7: CMA,FY3,20x20:157
- 8: CMA,FY3,100x100:149
- 9: JPL,MISR,100x100:378
- 10: JPL,MISR,20x20:378
- 11: VITO,PROBAV,100x100:625
- 12: VITO,PROBAV,20x20:825
- 13: CNES,VIQT2,100x100:2338
- 14: CNES,MODIS,100x100:1919
- 15: CNES,L8,20x20:60
- 16: CNES,MERIS,20x20:1128
- 17: CNES,SZBMSI,20x20:5
- 18: CNES,S3AOLCI,100x100:97
BRDF model

- Dataset: PARASOL
  - Data acquired from 2005 to 2013
  - Large site (100 x 100 km²)

- BRDF modelling using Snyder modelling
  - Linear model
  - 7 parameters
  - Fitted in GREEN, RED, NIR wavelengths
  - Limited to $\theta v < 50^\circ$
Libya-4 BRDF model Validation

• Objectives: Assess the site stability
  – Use the BRDF model (based on Snyder) derived from PARASOL data (V2) to data collected during phase 1 of the initiative together with the questionnaire to assess the Libya4 site stability
  – Apply the model to bands:
    • RED (~555 nm),
    • GREEN (~630 nm),
    • NIR (~865 nm)
Libya-4 BRDF model Validation

• Method

  – Apply atmospheric correction to TOA reflectances using 6S (or SMAC) and ECMWF ERA Interim meteorological data for ozone and water vapour contents
  – BOA reflectances are normalised to a reference geometry ($\theta_s = 30^\circ$, $\theta_v = 0^\circ$) thanks to the BRDF model.
Results: BRDF normalization with a directional model derived from Parasol data

- Application to data collected

  - FY-3, MERIS, VGT2, PROBAV, S2A/MSI, S2B/MSI

  - Long time series MODIS, MERIS and VGT2 acquired over the same period (jan. 2003 to dec. 2010)

  - Compute an annual slope
Comparisons of Acquisition geometries for the collected data

SENSOR

SUN

PARASOL

FY-3/VIRR
• FY-3/VIRR Chinese sensor
Normalisation of the BRDF on FY-3

PicSAR Libya-4 Site (100x100, FY3/CMA)

- 555 nm: mean = 0.3069, sigma = 0.0218
- 630 nm: mean = 0.4037, sigma = 0.0190
- 865 nm: mean = 0.4810, sigma = 0.0249
Normalisation of the BRDF on FY-3

PICSCAR Libya4 Site (100x100, FY3/CMA) Before Correction

- 555 nm: mean = 0.3082 / sigma = 0.0211
- 630 nm: mean = 0.4322 / sigma = 0.0209
- 865 nm: mean = 0.5183 / sigma = 0.0235
Normalisation of the BRDF on FY-3

PICSCAR Libya4 Site (100x100, FY3/CMA) After Correction

- 555 nm: mean = 0.2967 / sigma = 0.0142
- 630 nm: mean = 0.4190 / sigma = 0.0120
- 865 nm: mean = 0.5050 / sigma = 0.0153
Normalisation of the BRDF on FY-3

- Details on Azimuth Plans separations

TOA

BOA

BOA-Norm
Comparisons of Acquisition geometries for the collected data

- SENSOR
- SUN

PARASOL

MERIS
Normalisation of the BRDF on MERIS
Normalisation of the BRDF on MERIS

PICSCAR Libya4 Site (100x100, MERIS/CNES) TOA

TOA Reflectances

Acq Time


560 nm
865 nm
Normalisation of the BRDF on MERIS

560 nm: mean = 0.3604 / sigma = 0.0116

665 nm: mean = 0.5023 / sigma = 0.0133

865 nm: mean = 0.5918 / sigma = 0.0144
Normalisation of the BRDF on MERIS

560 nm: mean = 0.3507 / sigma = 0.0046
665 nm: mean = 0.4914 / sigma = 0.0048
865 nm: mean = 0.5806 / sigma = 0.0044
MERIS – $34.9 < \theta v < 36.5$ – 20x20 km vs 100x100
Comparisons of Acquisition geometries for the collected data

SENSOR

SUN

PARASOL

PROBA-V
Normalisation of the BRDF on PROBAV

PICSCAR Libya4 Site (100x100, VITO/PROBAV)

- 455 nm: mean = NaN, sigma = NaN
- 630 nm: mean = 0.4408, sigma = 0.0121
- 865 nm: mean = 0.5207, sigma = 0.0172

TOA Reflectances

Acq Time

Jan13  Jul13  Jan14  Jul14  Jan15  Jul15  Jan16  Jul16  Dec16  Jul17  Jan18
Normalisation of the BRDF on PROBAV

**PICSCAR Libya4 Site (100x100, VITO/PROBAV) Before Correction**

- **455 nm**: mean = NaN, sigma = NaN
- **630 nm**: mean = 0.4758, sigma = 0.0163
- **865 nm**: mean = 0.5643, sigma = 0.0224

The graph shows the BOA reflectances over time, with different markers representing different wavelengths.
Normalisation of the BRDF on PROBAV

PICSCAR Libya4 Site (100x100, VITO/PROBAV) After Correction

455 nm: mean = NaN, sigma = NaN
630 nm: mean = 0.4615, sigma = 0.0110
865 nm: mean = 0.5512, sigma = 0.0195

Normalized BOA Reflectances

Acq Time

Jan13 Jul13 Jan14 Jul14 Jan15 Jul15 Jan16 Jul16 Dec16 Jul17 Jan18
Normalisation of the BRDF on VGT2 (including PROBAV)

PICSCAR Libya4 Site (100x100, VITO/PROBAV) After Correction

- 455 nm: mean = NaN / sigma = NaN
- 630 nm: mean = 0.4584 / sigma = 0.0069
- 865 nm: mean = 0.5479 / sigma = 0.0092
Comparisons of Acquisition geometries for the collected data

- SENSOR
- SUN

PARASOL

S2A/MSI
Normalisation of the BRDF on S2A/MSI
Normalisation of the BRDF on S2A/MSI
Normalisation of the BRDF on S2A/MSI

PICSCAR Libya4 Site (20x20, S2AMSI/CNES) Before Correction

BOA Reflectances

Acq Time

2015.5 2016 2016.5 2017 2017.5
Normalisation of the BRDF on S2A/MSI

PICSCAR Libya4 Site (20x20, S2AMI/CNES) After Correction

Acq Time

Normalized BOA Reflectances

- 550 dphi=180
- 630 dphi=180
- 865 dphi=180

31.08.2017
Normalisation of the BRDF on S2B/MSI

PICSCAR Libya4 Site (100x100, S2BMSI/CNES) After Correction

Normalized BOA Reflectances

Acq Time


555 dphi=180
630 dphi=180
865 dphi=180
Trend analysis: Evolution slope per year

- (Bands VGT2 & MERIS shifted by 0.1)

Surface Reflectance—Libya4—After 670 nm BRDF correction

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Equation</th>
<th>Slope</th>
<th>Intercept</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>VGT2: band B2</td>
<td>$Y = -6.60243e^{-07} \times X + 0.458538$</td>
<td>$-0.05%$</td>
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</tr>
<tr>
<td>MODIS: band 645</td>
<td>$Y = 8.05779e^{-07} \times X + 0.470568$</td>
<td>$0.06%$</td>
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<td></td>
</tr>
<tr>
<td>MERIS: band 665</td>
<td>$Y = 8.34796e^{-07} \times X + 0.490833$</td>
<td>$0.06%$</td>
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</table>
Status

• Work in progress
  – Statistics needs to be computed for all data received, in particular for all long time series received (including MISR data (14 years))

  – Analysis
    • Can the BRDF model be used for large and small site?
    • Extension to SWIR ? Blue ? wavelengths
    • Extension to other sites
    • ...

  – Portal to compile the information on PICS
• For questions, information, requests, participation

• Please contact picscar@magellium.fr