
NOVELTIS
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LSCE

# Exploitation of the CEOS Pseudo Invariant Calibration Sites (PICS) for Vicarious Calibration of Optical Imagers

## CEOS/WGCV/IVOS presentation

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# Outline

- **Context & objectives**
- Actions description
- Collaborations/Discussion

# Context & objectives

- Revisit the list of Pseudo-Invariant Calibration Sites (PICS) over desert areas defined 20 years ago by Cosnefroy et al. (1996) based on more recent multi-spectral remote sensing data with enhanced temporal and spatial coverages and resolutions

- Collect sand samples from an ensemble of identified sites and analyze in laboratory their physical (mineralogy and grain size analysis) and optical (spectro-directional reflectance) properties

- Build a database combining the sand optical properties estimated from the sampled collected with other databases available in the literature

- Build a climatology of aerosol optical properties over the PICS selected, combined with other atmospheric variables

- Summarize the PICS characterisation results and provide final recommendations.

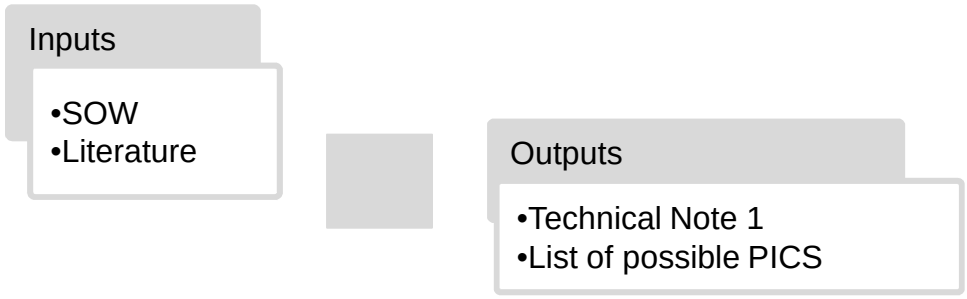
# Outline

- Context & objectives
- **Actions description**
- Collaborations/Discussion

# Revision of the PICS locations

## Objectives

- Determination of a list of possible PIC sites
- Definition of selection criteria
- Retrieval and processing of the most valuable remote sensing data & ancillary data

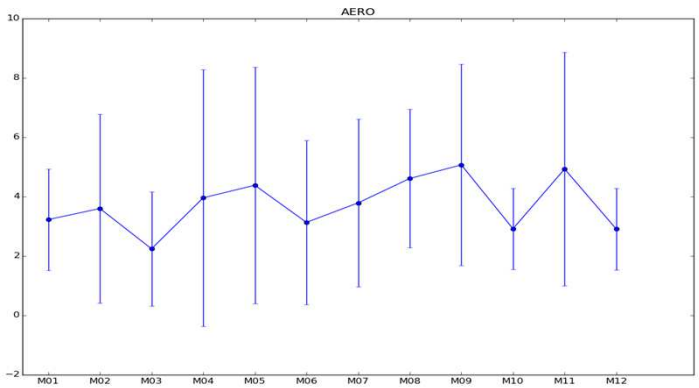


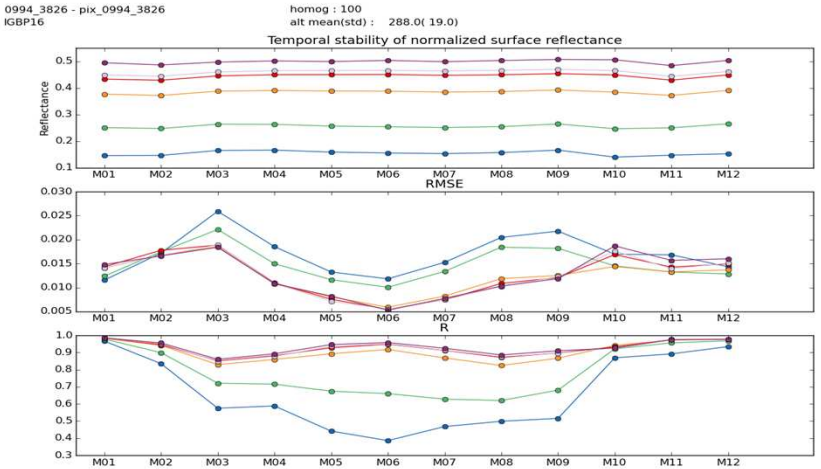

- The final list of sites will contain PICS imposed by ESA:
  - 2 Saharan PICS. In order of priority: Libya-4, some among the 6 CEOS PICS sites, some among the Saharan sites identified by Cosnefroy et al. (1996) or in the vicinity
  - 1 site in the Arabian Peninsula
  - 1 site in Namibia
  - 1 site in Australia

# Revision of the PICS locations

## Action 1.1 : Determination of the selection criteria

- **Literature review of the PICS**
- **Definition of selection criteria**
  - spatial homogeneity
  - weak / well characterized directional effects
  - temporal stability of their optical properties
  - weak cloud cover and low aerosol load
  - proximity of meteorological / AERONET stations
  - accessibility
  - CEOS cal/val activities



# Revision of the PICS locations

## Action 1.2 : Determination of the satellite data to be used

### Objectives with respect to the site location

- assess if the 20 PICS identify by Cosnefroy et al. (1996) are still optimal with respect to the selection criteria
- identify if sites identified in other activities are suitable for vicarious calibration (Namibia, Australia, Chile, United States)
- identify other possible calibration sites

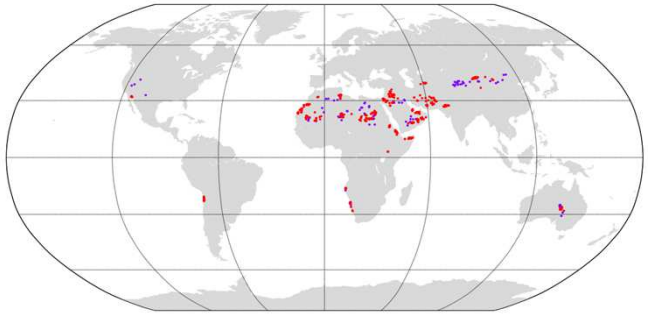
### Retrieval of relevant satellite ToC data and ancillary information

- for selection
  - first selection using POLDER/PARASOL L2 TOC products➔ temporal stability of the BRDF
  - MODIS / MERIS & AATSR TOC products (spatial homogeneity at the km scale)
- after selection
  - High spatial resolution products (SPOT, Landsat TM): Data available in the CEOS/WGCV/IVOS frame ?
  - DEM

# Revision of the PICS locations

## Action 1.3 : Processing of the site selection

PARASOL
Rad/Cal sites



### Automated processing of the satellite products

### Use of normalized reflectance data

- first coarse selection
  - –POLDER
- selection refining
  - –MODIS/MERIS at medium spatial resolution

### Ancillary information

- Flatness (DEM at 1 km or higher spatial resolution)
- Cloudiness (MODIS cloud mask at 1km and 250 m / DARDAR at 1 km)
- Aerosol & atmosphere characterization

# Spectro-directional characterization of the PICS surface

## Objectives

- Collecting sand samples from the PICS identified in Action 1
- In lab characterization of their spectral-BRDF
- In lab characterization of their physical properties
- Determination / delivery of a spectral database of soil/sand spectral BRDF
- Modelling of the sand/PICS spectral BRDF

**Inputs**

- TN1
- Literature
- List of PICS

**Outputs**

- TN2 to TN7
- database of soil spectral BRDF

## Action 2.1 : Literature review on sand spectral BRDF measurements

### Identify existing measurement facilities & datasets

- Several facilities identified so far :
  - EGO (Solheim I. Et al., 1996)
  - "Banc de BRDF grands échantillons" facility - ONERA (Serrot G. et al., 1998)
  - FiGOS (Sandmeier et al., 1999)
  - a facility in Florida (USA) for multispectral BRDF measurements (Voss et al., 2000)
  - PARABOLA (Bruegge CJ. et al., 2000)
  - FIGIFIGO ( Kaasalainen S. et al., 2005)
  - GRASS (Pegrum H. et al., 2006)
  - CLabSpeG (Biliouris D. et al., 2007)
  - a prototype using LEDs for multispectral BRDF in Asia (Ben-Ezra M. et al., 2008)
  - ASG (Painter T. H. et al., 2008)
  - CHAMELON facility - ONERA
  - ULGS (Coburn et al., 2016)
- Complementary search on other facilities and best practices for measurements

### Document of the factors that impact the BRDF

- dependency of reflectance with grain size/mineralogy
- landscape scale (dunes)

## Action 2.1 : Literature review on sand spectral BRDF measurements

**Identify databases to be used further in the building of the PICS DB**

- USGS
- JPL (ASTER)
- Consortium's collaborations, CEOS/WGCV/IVOS collaborations
- Others (von Schönermark et al., 2004)

# Action 2.2 : Collection of sand samples from the PICS

## Define the sampling protocole

- How to perform the sand extraction
- How many sample must be collected to characterize the lanscape heterogeneity
- How to package and ship the samples
- Gather relevant site informations:
  - Photos
  - GPS coordinates
  - etc.

## Sand extraction

- sand extraction "layer by layer", width of each layer being determined by its homoneneity
- each layer to be store in a hermetic container
- the quantity of sand extracted for each level should enable to rebuild a sand sample
  - a diameter of 30 cm at least ; a width of at least 3 cm
  - if the first layer is thin, additional sand samples for this layer will be extracted and stored apart (quantity for a sand sample with at least a diameter of 30 cm and a width of at least 1 cm)

# Action 2.2 : Collection of sand samples from the PICS

## Identify local contacts

- ONERA contacts with DGA (Mali for instance)
- Contact with CNES for the Namibian site (CNES RadCalNet activites) :
- Contacts with CSIRO (Cindy Ong & Ian Lau, Adrian Chappel)
- Contact with SDSU (Algodones Dunes)
- Other possible contacts identified so far:
  - Arabian peninsula: Dr Mounir Salhi (KSA)
  - Chile: (Universidad de Chila, Académicos del Departamento de Geofísica)

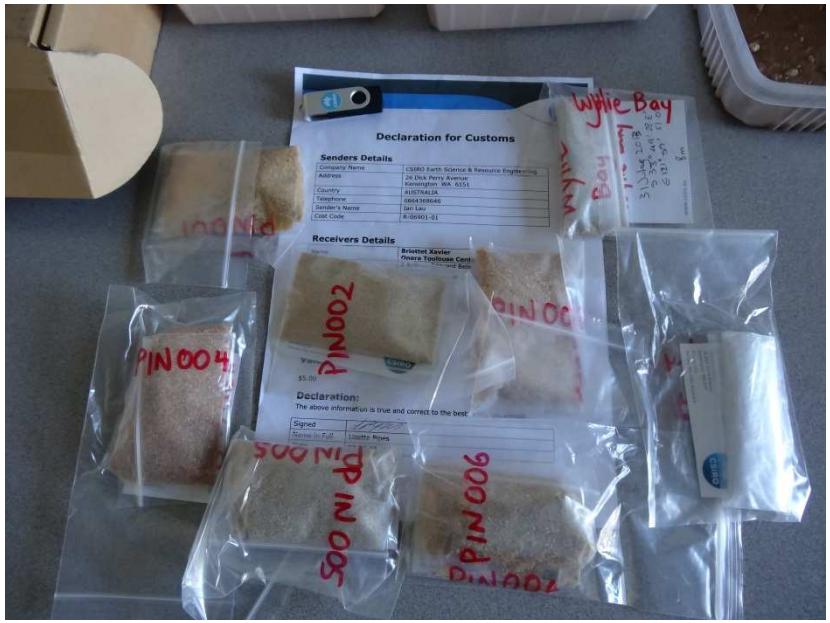
- Support from ESA (M. Bouvet)
- Support from CEOS/IVOS/WGCV/IVOS

# Spectro-directional characterisation of the PICS surface

- Initiated contacts
  - **DGA**: no answer with 1srt contact, trial with another one
  - **CNES**: a 1,5 l bottle of sand from Namibia
  - **CSIRO** : 8 very small samples of various sands from Australia + photos + in-situ or in-lab measurements
  - **Zurich Geographic Univ** (M. Schaepman) : ~300g sand from Libya (Erg Ubari)
  - **FGI**: Y. Peltoniemi mentions in his email measurements on Sahara samples but they do not appear in the database . Discussion needed
  - **ASAL**: File to build.
  - **INGV**: own measurements from South Algeria in the frame of the set-up of a calibration site with University of Algiers (contact Fabrizia Buongiorno)

# Spectro-directional characterisation of the PICS surface

- Samples
  - CNES: a 1,5 l bottle of sand from Namibia
  - CSIRO: 8 very small samples of various sands from Australia
  - Zurich Geographic Univ: around 300g of sand fromLibya(Erg Ubari)
  - ONERA: Alg 3 and Alg4

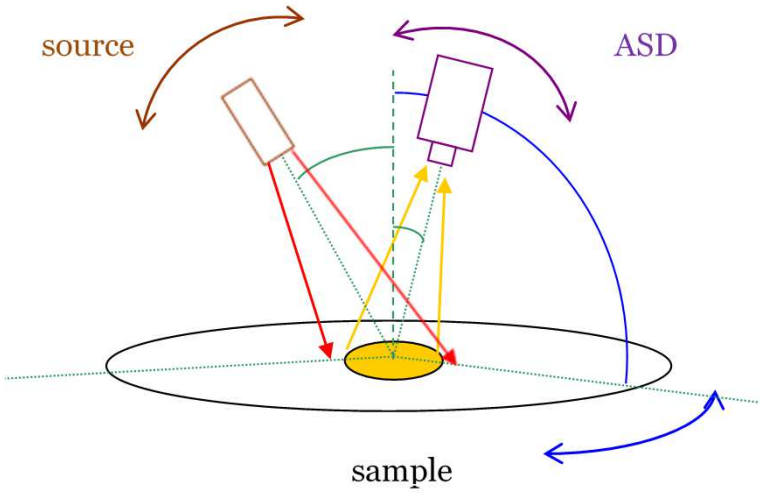



# Action 2.3 : Measurements of sand spectral BRDF

## Spectral-BRDF measurements

- at ONERA using the "banc de BRDF grands échantillons"
  - –350 to 2500 nm (ASD spectroradiometer)
  - –varying illumination and viewing angles (up to 60°)

- Follow international guidelines of measurement quality procedures
  - –error budget following the QA4EO guidelines



# Action 2.3 : Measurements of sand spectral BRDF

## Mineralogy & grain size distribution

-mineralogy: scanning electron microscope - SEM or by an X ray diffractometer
-grain size distribution: laser granulometer

# Action 2.4 : Database of sand spectral BRDF

## Make available an homogeneized database to the scientific community

- online on the CEOS cal/val portal

## Database content

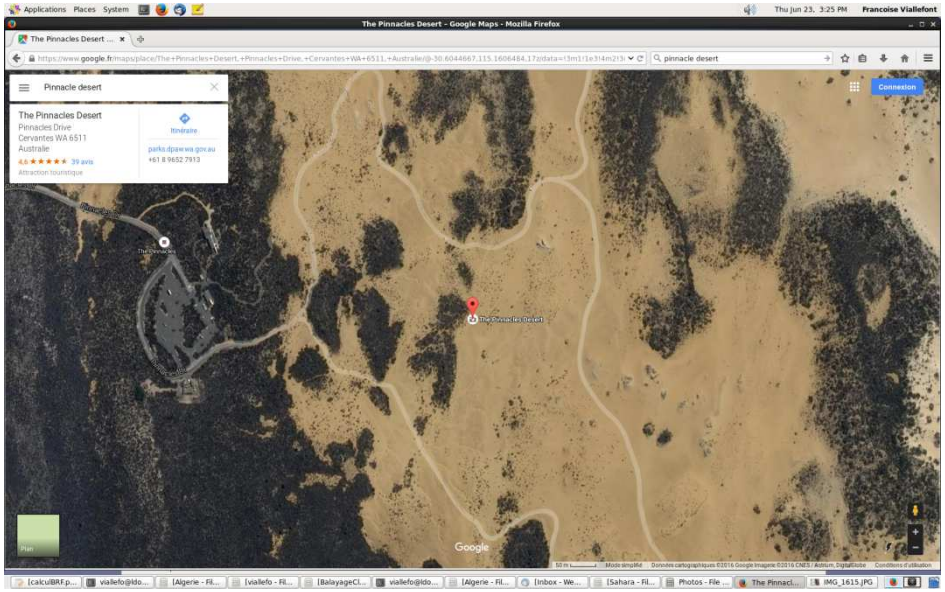
- measurements performed in this study
- measurements from the literature
  - –data distribution policy to be defined with ESA representative

## Database structure and exploration

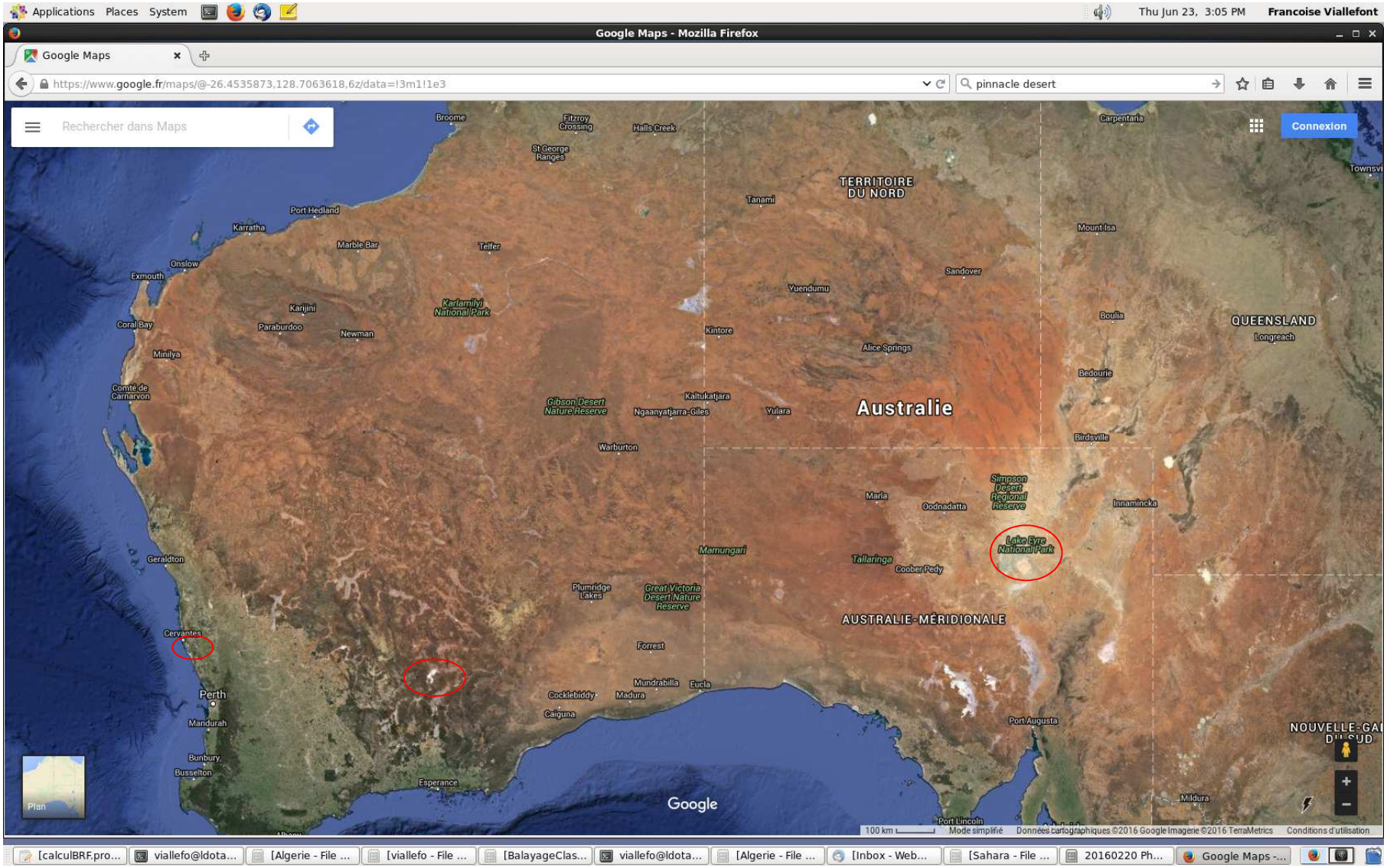
- numerical reflectance values (text or netCDF files)
- metadata (graphs, pictures…), information on the sample properties, experimental conditions
- Development of a simple web interface
  - –easy exploration of the database structure + instantaneous display of all available information for a given sample
  - –*html* file available with the dataset archive + hosted on NOVELTIS servers
  - –functionalities to be defined by the consortium together with ESA (M. Bouvet)

# Spectro-directional characterisation of the PICS surface

- Spectral database
  - •CSIRO in-situ or in-lab measurements (Pinnacle desert, Willie bay, Lucky Bay, Lake Eyre, Lake Lefroy)
  - •FGI ?
  - •BRDF data base of the book "Reflection properties of vegetation and soil" : few sands and one named Sahara coming from Tunisia



# Spectro-directional characterisation of the PICS surface

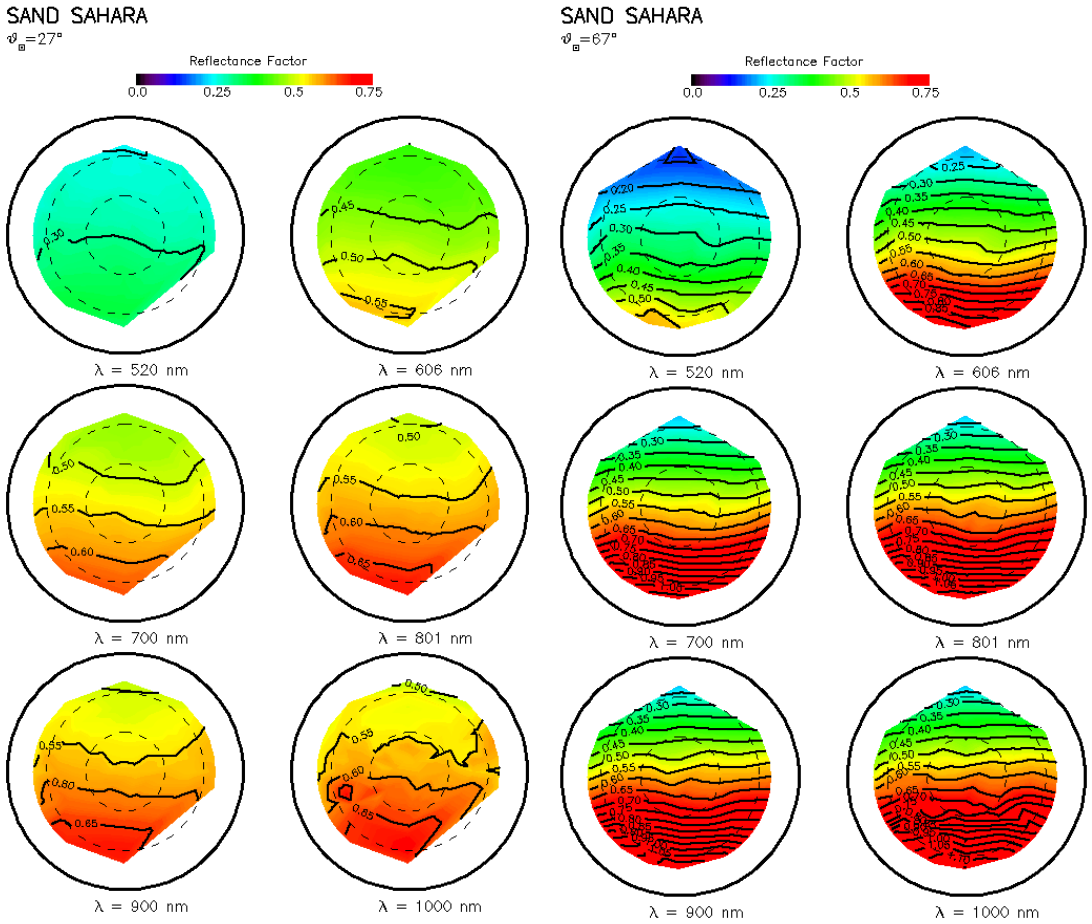


# Spectro-directional characterisation of the PICS surface

## Status

### Spectral database

- Tunisia :
- sz = 27, 38, 47 and 67°
- for each sz, 2 measurements (one named "rough" for its surface)
- 225 wavelengths between 368 and 1028 nm
- Vz from 10 to 70°(step 10°)
- Az 0, 80 to 320° (step 10°few cases are missing)



## Action 2.5 : Modelling of sand spectral BRDF

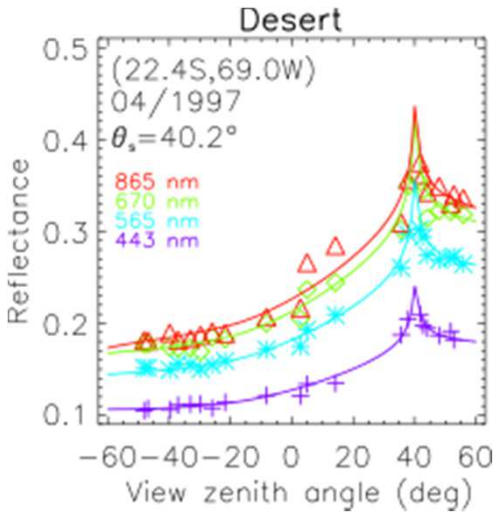
- **Evaluate the performances of semi-empirical models to fit the BRF measurements**
- **10 BRDF models (linear / non-linear) at least to be considered:**
  - Hapke (Hapke and Wells, 1981)
  - MRPV (Engelsen et al., 1996)
  - Roujean (Roujean et al., 1992)
  - Ross Thick (Wanner et al., 1995)
  - Ross-Li (Lucht et al., 2000)
  - Ross-Li-Maignan (Maignan et al., 2004)
  - RPV (Rahman et al., 1993)
  - modified Walthall (Walthall et al., 1985; Nilson and Kuusk, 1989)
  - Snyder (Snyder and Wan, 1998)
  - Oren-Najar (Oren and Najar 1995)

- **Evaluate the model *wrt* their *fitting* and *extrapolation* performances**

## Action 2.6 : Characterization of PICS BRDF from satellite data

**Evaluate the fitting performances of the same BRDF models of POLDER/PARASOL TOC image time series**

- Assess the effect of spatial scale
- Gauge the "quality" of the PICS wrt their directional signatures
  - PICS with low / well described directional effects could be favored



# Aerosol & atmosphere characterisation over the PICS

## Objectives

- Characterize mean atmosphere conditions over the PICS and identify cases where atmosphere "contamination" could limit the PICS potentials for in flight calibration
- Determination of a climatology of aerosol and atmosphere conditions over the PICS from remote sensing products (aerosols and trace gas) and weather numerical re-analyses (atmosphere)
- Comparison of the aerosol climatology derived from remote sensing data over the PICS with nearby AERONET data when available
- Possible revision of some of the PICS location

**Inputs**

- Literature (Fougnie et al., 2014)
- List of PICS
- AERONET data

**Outputs**

- Possible revision of the PICS location
- TN8: Aerosol properties over the PICS

# Action 3.1 : Aerosol climatology over the PICS

**Characterize the variability of aerosol load and their physical properties, which are a strong criteria for site selection**

**Approach of Fougnie et al. (2014)** based on PARASOL and MODIS data to characterize the temporal variability in the type, aerosol optical depth (AOD) and particle size parameter for the sites identified in Action 1

**Building of a monthly climatology**

- MODIS "deep blue" products
  - Fougnie et al. (2014): from the Giovanni database, at 1°x1° ; likely collec. 5
  - use the up-to-date coll. 6 products at 10 km x 10 km
- PARASOL
  - assess the potentials to provide complementary information on the fine aerosol mode over land (directional and polarized observation)
- Comparison to AERONET data in the vicinity of the sites

# Action 3.2 : Atmosphere climatology over the PICS

**Provide complementary information of the site meteorology and other atmosphere gases that impact the radiometric measurements in the solar domain**

**Climatology of the main meteorological variables**

- wind, precipitation, surface pressure, temperature, etc.
- Fields derived from the ERA-Interim gridded meteorological forcing available 0.72° and over the period 2000-2010

**Evaluation of the variability of main trace gas**

- in particular $O_2$, $H_2O$, $O_3$
- estimated at coarse spatial resolution from meteorological re-analysis (ECMWF for instance) or satellite products (OMI for instance)

# Summary on the PICS characterisation and final recommendations

## Action 4.1 : Synthesis scientific article

- Manuscript to be submitted to a peer-review journal

## Action 4.2 : Summary and final recommendations

- Recommendations with respect for further studies aiming at improving the characterisation of the PICS surface, their use for cross-calibration, the modelling of TOA signal

**Inputs**

- TN1 to TN8

**Outputs**

- Executive summary report
- Update of TN1
- Article

# Outline

- Context & objective
- Technical points
- **Collaborations/Discussion**

# Collaborations/Discussion

## Action 1.2 : Determination of the satellite data to be used

- High spatial resolution products (SPOT, Landsat TM): Data available in the CEOS/WGCV/IVOS frame ?

## Action 2.1 : Literature review on sand spectral BRDF measurements

- Identify databases to be used further in the building of the PICS database: CEOS/WGCV/IVOS collaborations

- Complementary search on other facilities and best practices for measurements

## Action 2.2 : Collection of sand samples from the PICS

- CEOS/WGCV/IVOS contacts or contribution

## Other