



ONERA



ONERA



## PICS characterisation – New development

# Workshop on Radiometric Calibration for European Sensors

ESA: M. Bouvet  
Consortium: NOVELTIS: C. Bacour  
ONERA: F. Viallefont, X. Briottet, Y. Boucher  
LSCE: F.-M. Bréon

- **Context & objectives**
- Description of the sites selection
- Results
- Conclusion

- **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.

- Context & objectives
- **Description of the sites selection**
  - Objectives
  - Criteria
  - Decision tree
  - Inputs
  - Processing and decision tree
- Results
- Conclusion

## ● Objectives

### Redefinition of location of the PICS:

- Define selection criteria to identify sites suitable for vicarious calibration;
- Evaluate if some sites, out of the 20 PICS identified by Cosnefroy et al. (1996), are still optimal with respect to the new selection criteria;
- Determine to which extent some possible areas identified in other activities are suitable for vicarious calibration, and if so, precise the location of most relevant sites. Such possible areas are located in Namibia, Australia, Chile, United States (White sands);
- Identify other possible calibration desert sites elsewhere on the globe
- Consider medium (100 km) and small (20 km) size sites.

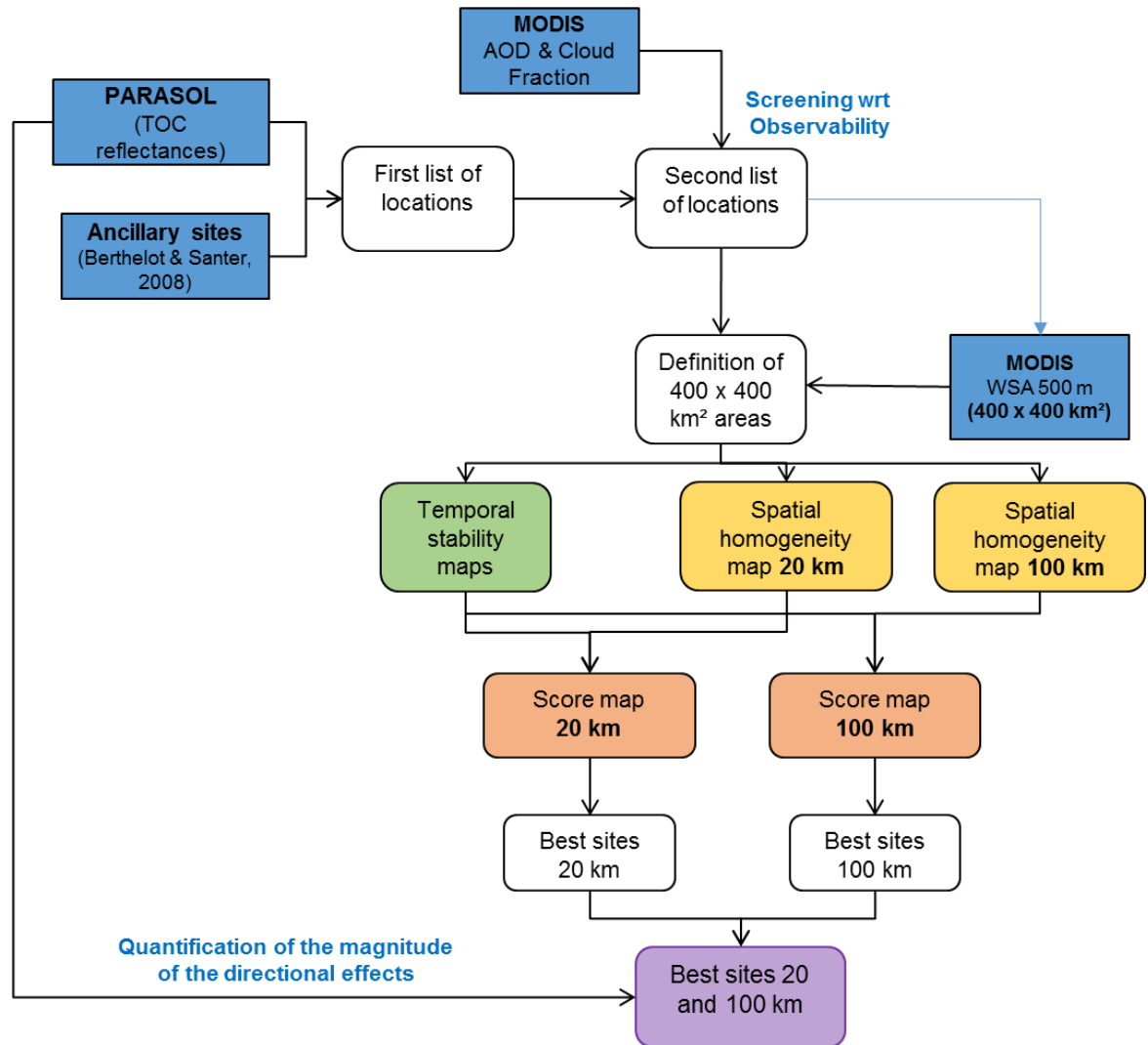
## ● Criteria

- temporal stability of their optical properties (std < 4% as a starting value)
- spatial homogeneity (std < 3% as a starting value)
- weak / well characterized directional effects
- weak cloud cover and low aerosol load and well characterized aerosol type
- proximity of meteorological / AERONET stations
- accessibility
- CEOS cal/val activities

## Decision tree

Global scale identification of candidate sites

Refinement of the optimal locations



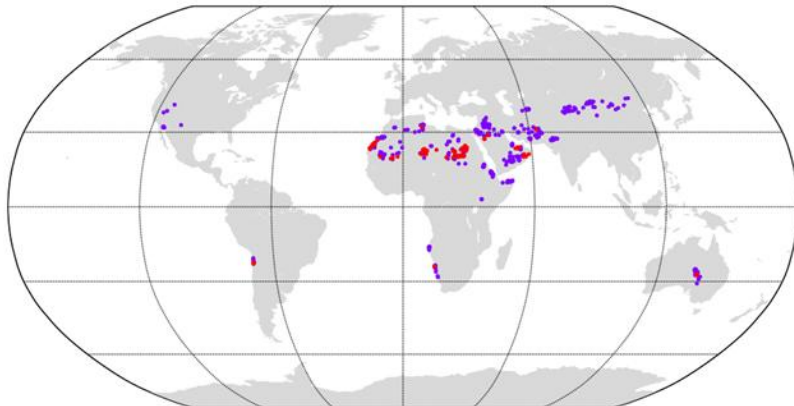
### ● Global scale identification of candidate sites

#### ➤ Datasets

- **POLDER/PARASOL** (@ GSD = 6km, year 2008) → Temporal stability and reproducibility of the directional signature
- **IGBP classification** (1km) → thematic homogeneity (threshold: 100% of Barren or sparsely vegetation)
- **GTOPO30 DEM** (1km) → topography/flatness (std < 50m)
- **MODIS MYD04\_L2** (10km, 2003-2015) → observability (AOD and cloud fraction:)

#### ➤ POLDER/PARASOL processing

- Selection of monthly clear observations
- Fit of the BRDF Li Maignan model at 670 and 865 nm with the monthly selected measures and threshold on the mean quality of the fit over the year
- Temporal stability after BRDF correction: 
$$TVar\lambda = \frac{\sigma(\rho_\lambda - \overline{\rho_\lambda})}{\overline{\rho_\lambda}} < 0,014$$



- Without temporal stability → 430 purple locations
- With temporal stability → 93 red locations

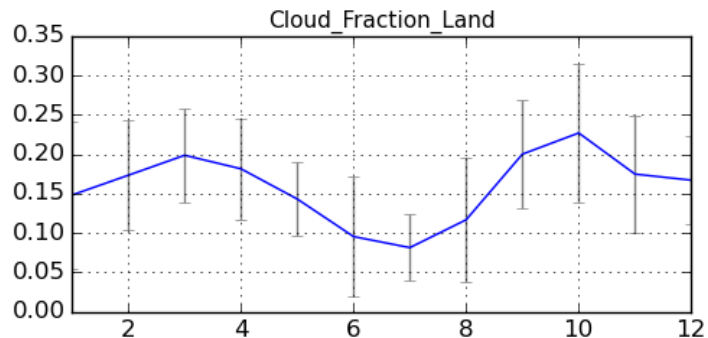
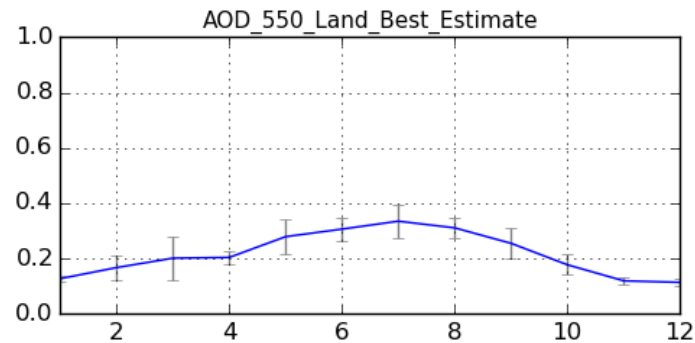
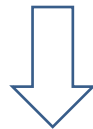
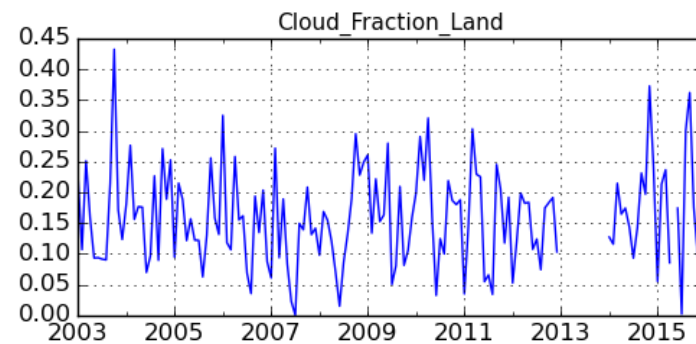
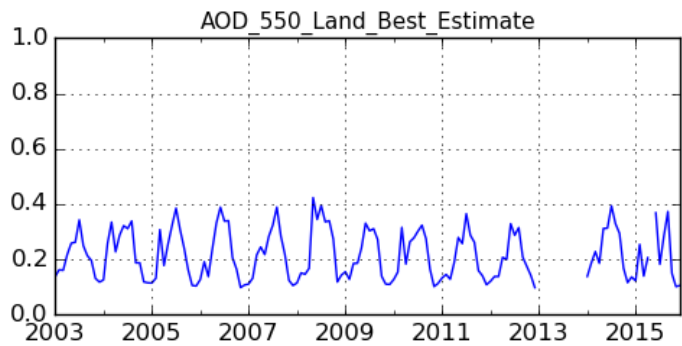


## ● Global scale identification of candidate sites

- Complement these candidate locations by those of desert sites used in Rad/Cal activities (Berthelot and Santer [2008])
- Screening with respect to AOD and cloud fraction (MODIS MYD04\_L2 products)
  - Selection if at least 35 available data per month and at least more than 5 months in a year are detected

**→ in total ~125 locations selected**

## ● Atm features



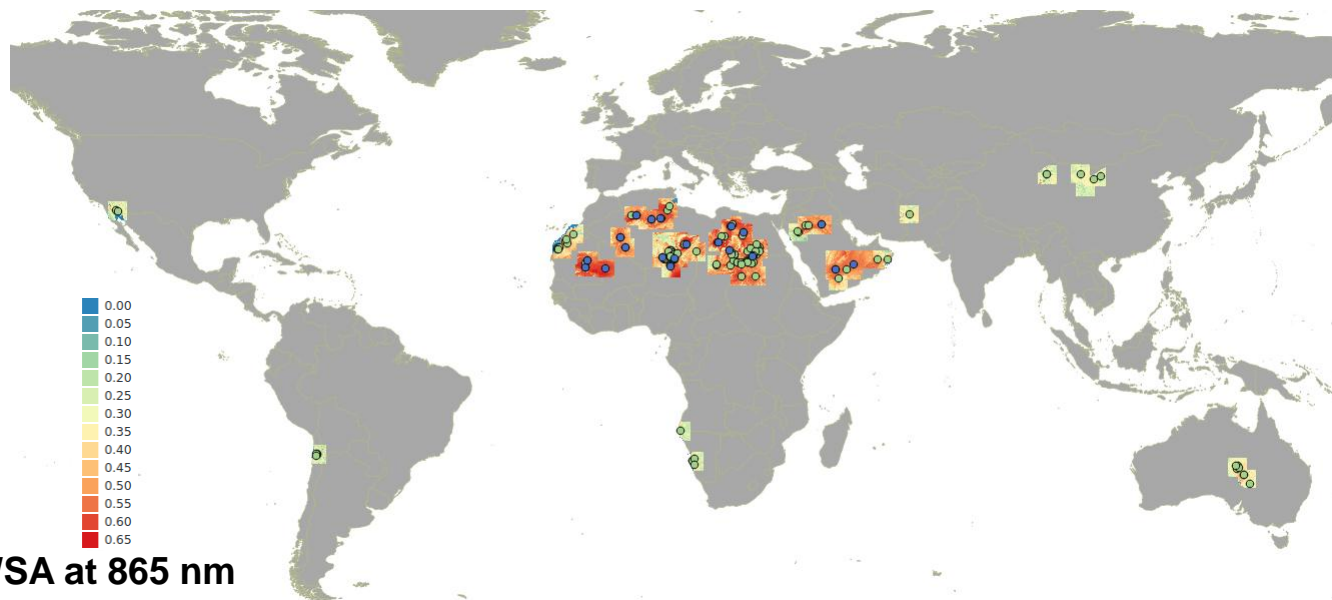
## ● Refinement of the optimal locations

### ➤ Datasets

- **MODIS MCD43A3 white sky albedo (WSA)**

- Medium spatial resolution (@ GSD = 500m)
- 2011-2015 period (weekly)

### ➤ Definition of 73 regions of 400 x 400km<sup>2</sup> encompassing the 125 candidate locations



### ➤ Characterization of the temporal stability and spatial homogeneity over these regions

### ➤ MCD43A3 WSA processing

For each location, at 865 nm, maps of:

- **Spatial homogeneity:**  $homog = \frac{\sigma(\rho_n)}{\rho_n}$  using moving windows of size = 20x20 and 100x100 km<sup>2</sup>

- **Temporal stability**  $TVar\lambda = \frac{\sigma(\rho_\lambda - \overline{\rho_\lambda})}{\overline{\rho_\lambda}}$

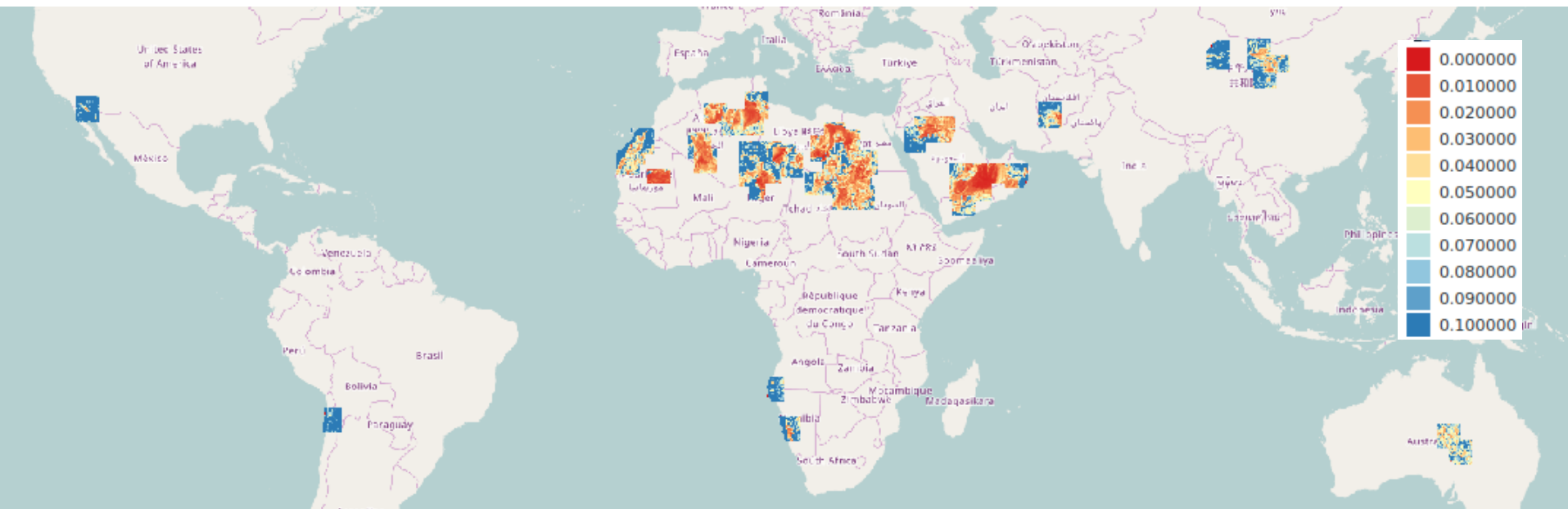
- **Score at 20/100/20+100 km:**

$$Score_{20km} = 2 * \overline{TVar_{\lambda,20km}} + homog_{20km}$$

$$Score_{100km} = 2 * \overline{TVar_{\lambda,100km}} + homog_{100km}$$

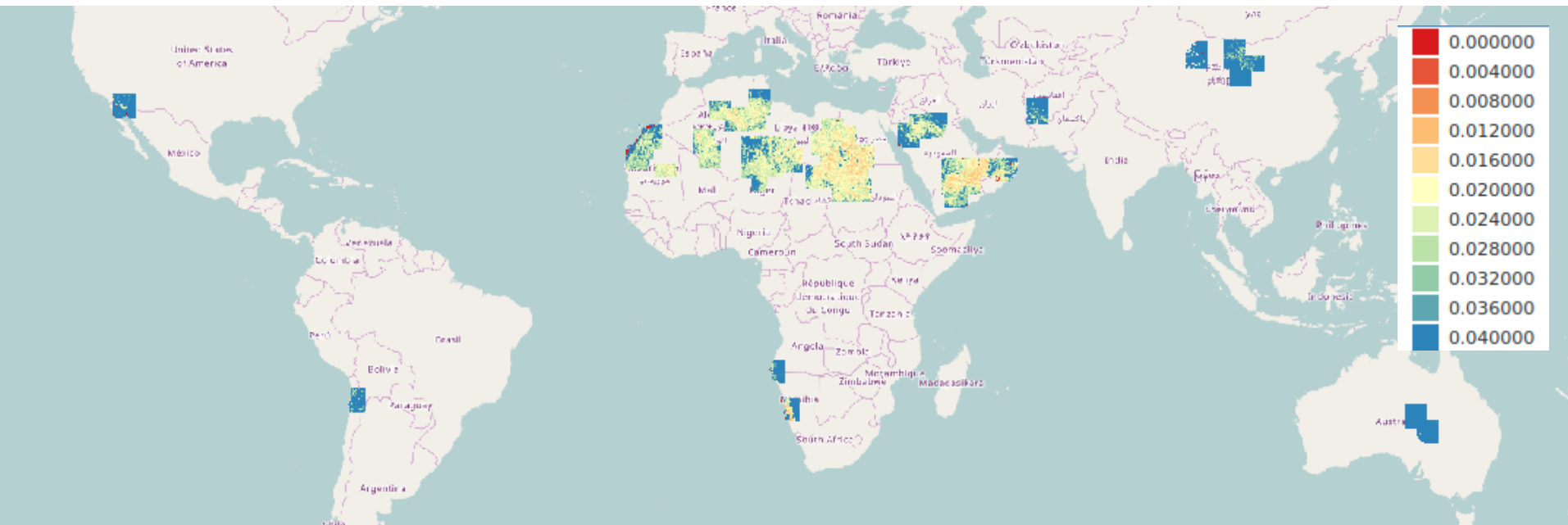
$$Score_{20+100km} = Score_{20km} + Score_{100km}$$

## Map of spatial homogeneity (20km): $homog_{20km}$



- Best spatial homogeneity: Sahara, Namibia, Middle-East,
- Others area are not selected for the following reasons: spatial uniformity higher than 3% and insufficient spatial extent

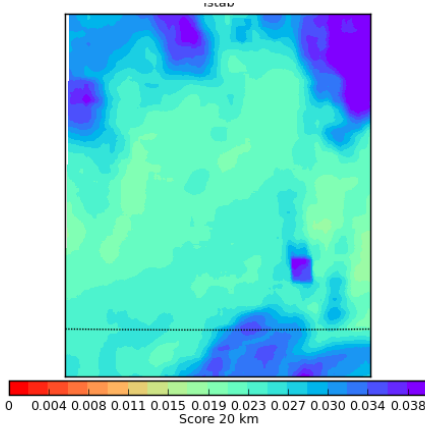
## Map of temporal stability: $TVar_{\lambda}$



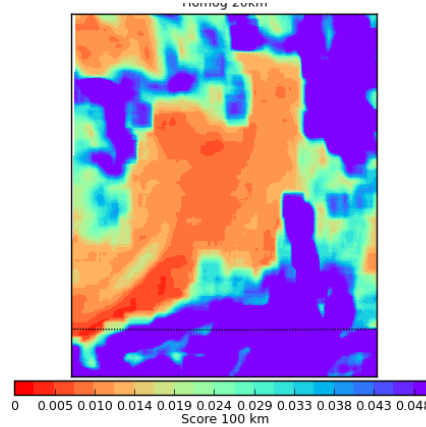
- Best temporal stability: Sahara, Namibia, Middle-East
- Criteria above a temporal stability of 4% and an insufficient spatial extent excluded USA, China; Australia and Chile area

## Determination of the optimal location: illustration for Algeria 5

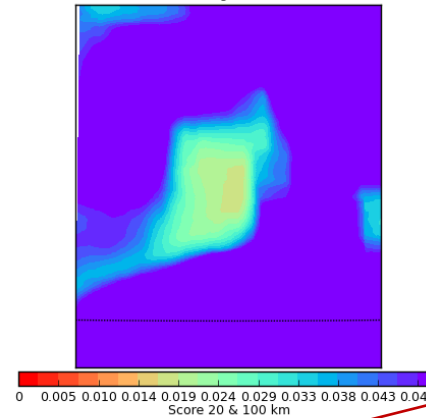
TVar20km map



Homo20 map

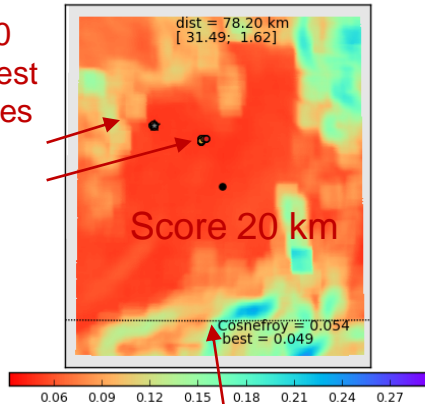


Homo100 map

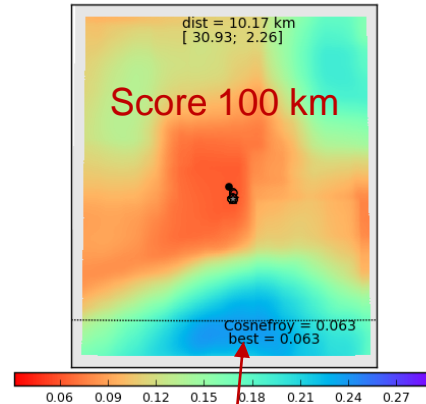


Distance between the best pixel and the central coordinates for the considered score

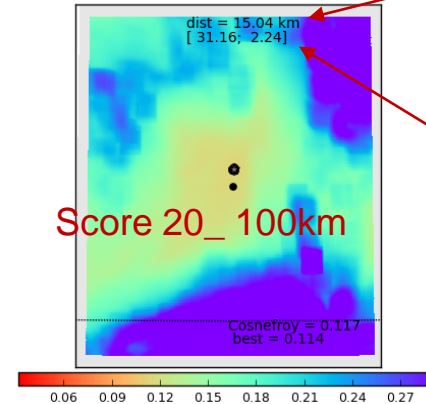
Locations of 30 pixels with the best considered scores



Score for central pixel



Mean score over the 10 best pixels



Coordinates of the best pixel for the considered score

## ● Synthesis for the Cosnefroy locations

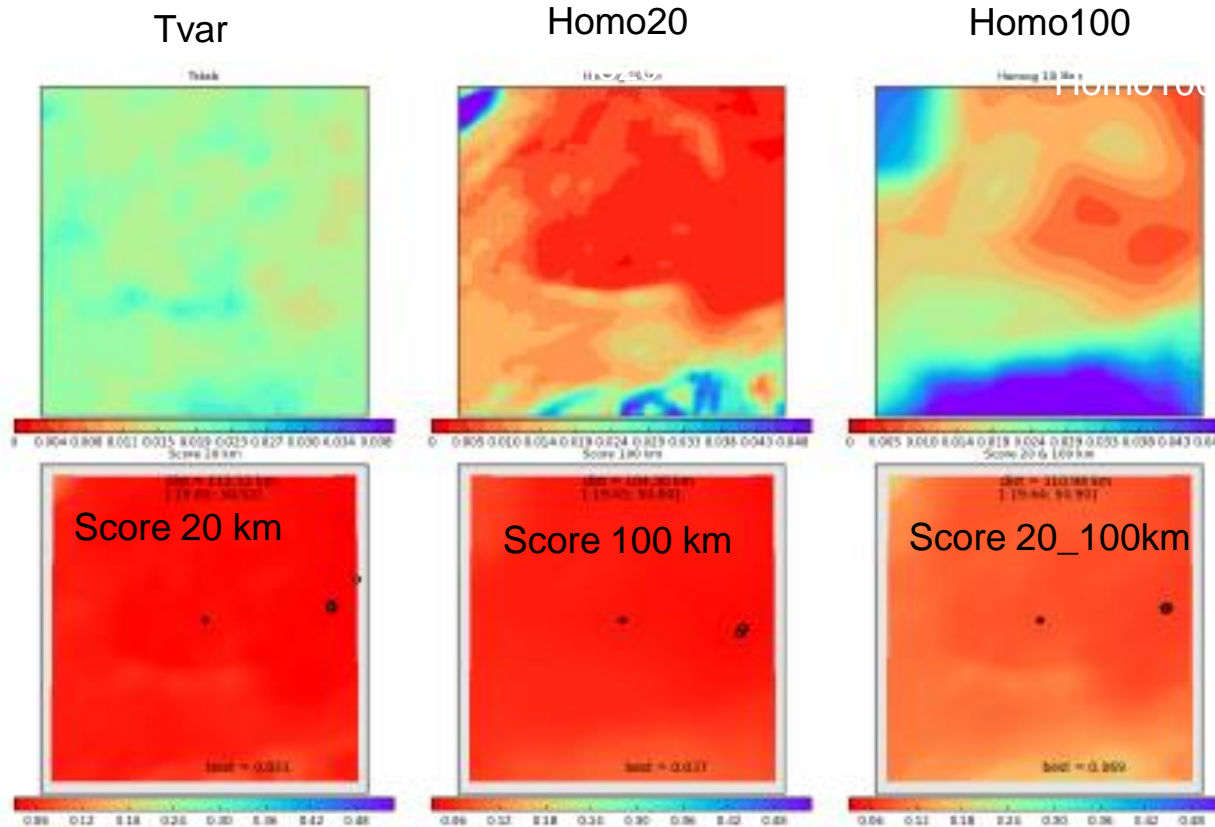
Score 20 km		Score 100 km		Score 20+100 km	
Cosnefroy site	Optimal location	Cosnefroy site	Optimal location	Cosnefroy site	Optimal location
Arabia2 (0.034)	Arabia2 (0.029)	Arabia2 (0.042)	Arabia2 (0.034)	Arabia2 (0.076)	Arabia2 (0.065)
Sudan1 (0.039)	Libya3 (0.032)	Sudan1 (0.048)	Sudan1 (0.044)	Sudan1 (0.087)	Sudan1 (0.081)
Arabia1 (0.046)	Arabia1 (0.033)	Arabia1 (0.054)	Arabia1 (0.049)	Arabia1 (0.100)	Arabia1 (0.088)
Mauritania2 (0.049)	Sudan1 (0.034)	Egypt1 (0.054)	Egypt1 (0.050)	Egypt1 (0.105)	Egypt1 (0.094)
Libya2 (0.050)	Algeria4 (0.040)	Libya2 (0.057)	Libya2 (0.055)	Libya2 (0.107)	Libya3 (0.098)
Libya4 (0.050)	Egypt1 (0.042)	Mauritania1 (0.060)	Mali1 (0.055)	Algeria3 (0.111)	Libya2 (0.104)
Egypt1 (0.050)	Libya2 (0.044)	Mali1 (0.060)	Algeria3 (0.056)	Mauritania1 (0.112)	Algeria3 (0.105)
Algeria3 (0.050)	Mauritania2 (0.044)	Algeria3 (0.060)	Mauritania1 (0.056)	Libya4 (0.112)	Mauritania1 (0.105)
Mauritania1 (0.052)	Mauritania1 (0.045)	Libya4 (0.062)	Libya4 (0.057)	Mauritania2 (0.115)	Mali1 (0.107)
Libya1 (0.052)	Niger1 (0.045)	Algeria5 (0.063)	Algeria1 (0.058)	Algeria5 (0.117)	Libya4 (0.108)
Algeria5 (0.054)	Algeria3 (0.046)	Algeria1 (0.065)	Mauritania2 (0.059)	Algeria1 (0.119)	Niger1 (0.108)
Algeria1 (0.055)	Algeria1 (0.047)	Mauritania2 (0.066)	Algeria4 (0.059)	Algeria4 (0.121)	Algeria1 (0.108)
Algeria4 (0.055)	Libya1 (0.047)	Niger2 (0.066)	Niger1 (0.059)	Niger2 (0.121)	Mauritania2 (0.109)
Niger2 (0.055)	Mali1 (0.047)	Algeria4 (0.066)	Libya1 (0.060)	Mali1 (0.122)	Algeria4 (0.111)
Niger1 (0.055)	Algeria2 (0.048)	Libya3 (0.068)	Libya3 (0.061)	Niger1 (0.125)	Libya1 (0.112)
Mali1 (0.061)	Libya4 (0.048)	Algeria2 (0.068)	Algeria2 (0.062)	Libya1 (0.127)	Algeria5 (0.114)
Niger3 (0.062)	Arabia3 (0.049)	Niger1 (0.069)	Algeria5 (0.063)	Algeria2 (0.136)	Algeria2 (0.116)
Algeria2 (0.069)	Algeria5 (0.049)	Libya1 (0.075)	Niger2 (0.065)	Libya3 (0.139)	Niger2 (0.117)
Libya3 (0.071)	Niger2 (0.050)	Niger3 (0.080)	Niger3 (0.080)	Niger3 (0.143)	Niger3 (0.141)
Arabia3 (0.113)	Niger3 (0.057)	Arabia3 (0.121)	Arabia3 (0.084)	Arabia3 (0.234)	Arabia3 (0.151)

### CEOS/IVOS sites

- The scores confirm Cosnefroy' sites selection for most sites
- Improvements may be possible for Arabia3 (all scales) and Libya3 (20 km scale)

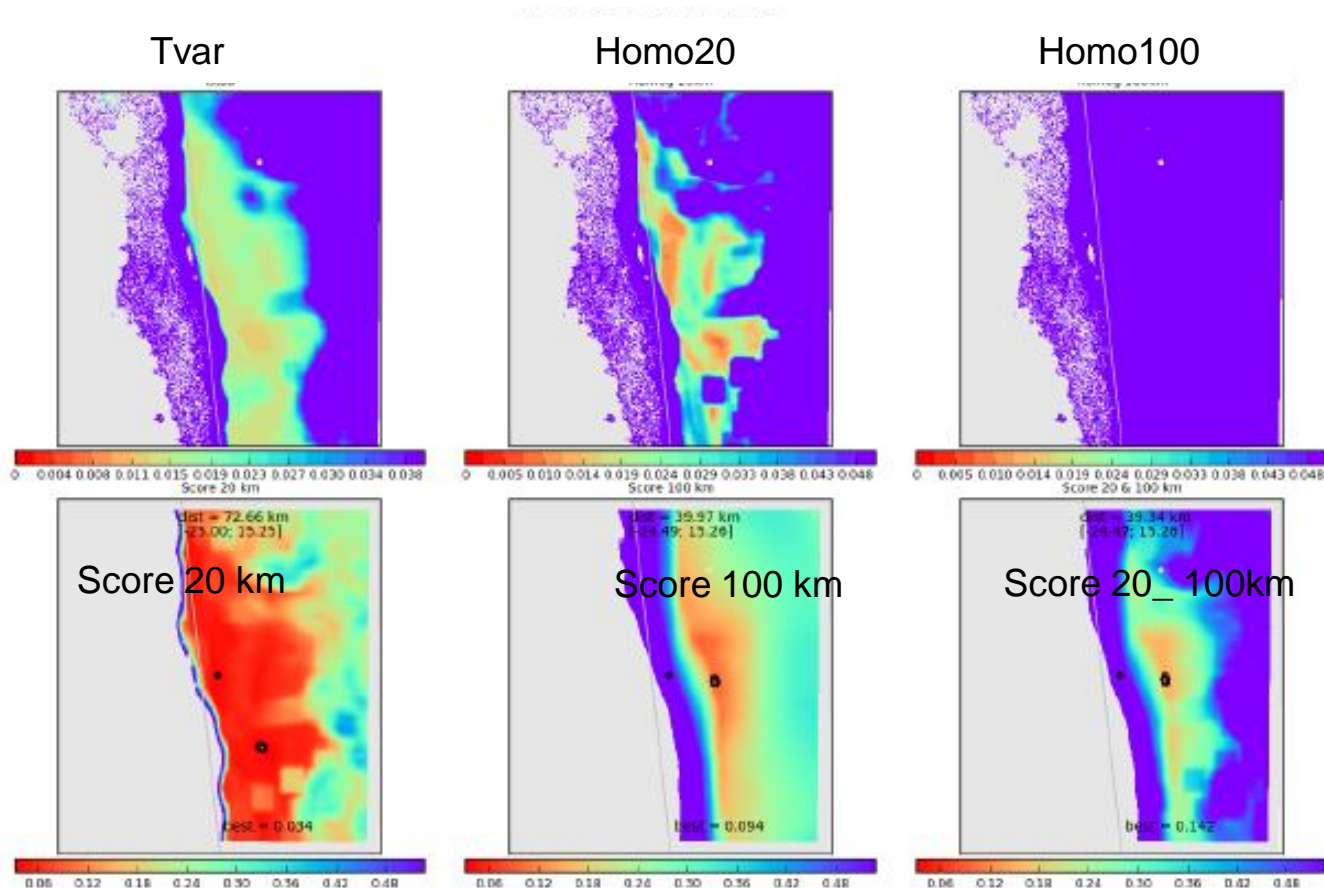


- **Additional sites of interests**
  - **in Arabia**



- Scores :
  - 20km : among the 25% best Cosnefroy sites
  - 20+100 km: among the 50% ones
- Site located 280km East from Arabia3
- **New proposal for Arabia4**

- **Additional sites of interests**
  - **in Namibia**



- Score at 20km similar to that of Arabia2 (best score among the Cosnefroy sites)
- Site located 162 km at the south-east from Gobabeb
- **New proposal for Namibia1**

- Context & objective
- Description of the site selection
- Results
- **Conclusion**

## ● Sites selection

- Our study confirms the list of Cosnefroy sites list, although some improvements in terms of optimal location could be achieved, in particular for Libya 3 and Arabia3
- The 6 IVOS sites have good scores but some Cosnefroy's site have better scores
- New sites are being identified, in particular in Namibia (Namibia1), Arabia (Arabia4)

## ● Collection of sand samples from the PICS

- The current foreseen list of sites (score + accessibility) for sample collection is

	Coordinates	Score 20 km	Score 100 km	Score 20+100 km
<b>Cosnefroy sites</b>				
Algeria3	[ 30.32°, 7.66°]	0.050	0.060	0.111
Algeria4	[30.04°, 5.59°]	0.055	0.066	0.121
Algeria5	[ 31.02°, 2.23°]	0.054	0.063	0.117
Arabia1	[ 18.88°, 46.76°]	0.046	0.054	0.100
Arabia2	[ 20.13°, 50.96°]	0.034	0.042	0.076
Mauritania1	[ 19.40°, -9.30°]	0.052	0.060	0.112
Mauritania2	[ 20.85°, -8.78°]	0.049	0.066	0.115
<b>New locations</b>				
Arabia4	[ 29.26°, 40.91°]	0.043	0.068	0.114
Namibia1	[-25.00°, 15.25°]	0.034	0.253	0.287

- Site selection also depending on accessibility / collaborations

## ● Future works: Sand spectral database

- A spectral [0,4-2,5  $\mu\text{m}$ ] and directional reflectance database will be defined with
  - Collected samples which will be measured by ONERA
  - Existing measurements
  - We are open for any contributions of the community
- This database will be hosted by ESA (CaVal Portal) with a free access





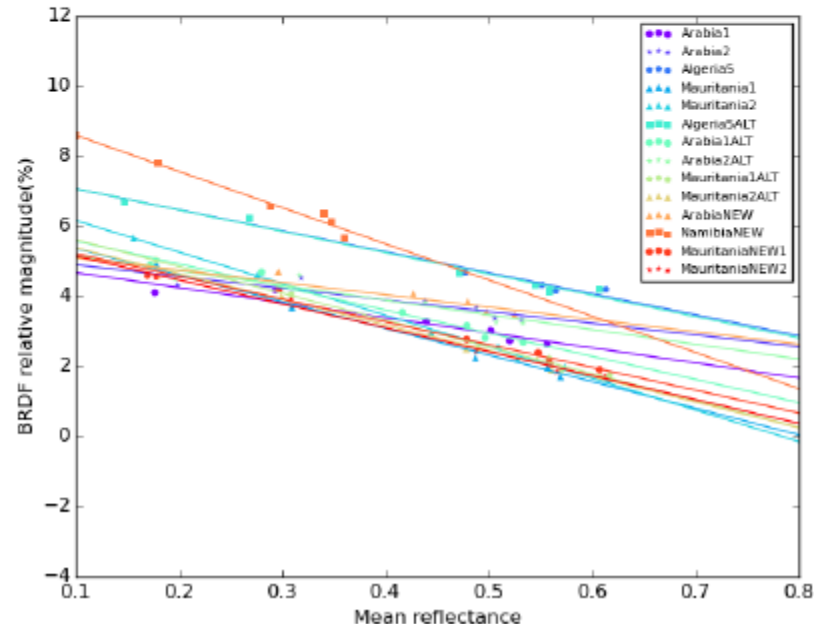
ONERA



Thanks for your attention !

## ● Quantification of the directional effects

- ▶  $BRDF_{magnitude_{\lambda}} = \frac{\sigma(\rho_{\lambda} - \bar{\rho}_{\lambda})}{\bar{\rho}_{\lambda}}$  with reflectance in the principal planes calculated with the Ross-Li-Maignan model fitted on PARASOL data (year 2008). View zenith angles between  $-60^{\circ}$  /  $60^{\circ}$  (without  $\pm 10^{\circ}$  around the averaged sun zenith angle).
- ▶ NamibiaNEW and Algeria5ALT are those that display the more pronounced surface anisotropy. Still, their magnitude is below 10 %.



MauritaniaPics1 [ 20.01 ; -8.87]

