

# Matchup Strategy for Sensors Cross Calibration

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# Problem presentation

Present method:

$$\left| \theta_V^1 - \theta_V^2 \right| < \partial\theta_V$$
$$\left| \theta_S^1 - \theta_S^2 \right| < \partial\theta_S$$
$$\left| (\varphi_S^1 - \varphi_V^1) - (\varphi_S^2 - \varphi_V^2) \right| < \partial\varphi$$

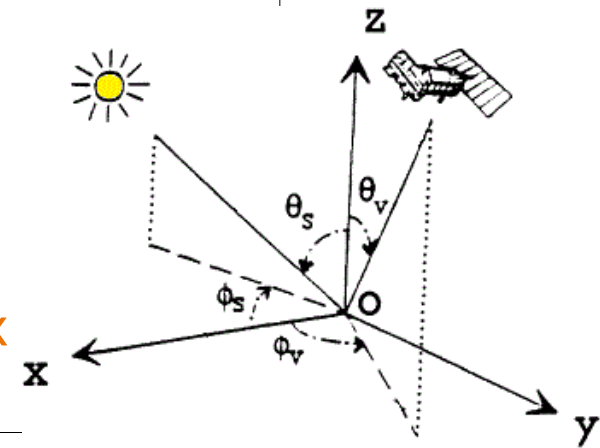
with two types of box:  $(\partial\theta_V, \partial\theta_S, \partial\varphi) = (2^\circ, 2^\circ, 5^\circ)$  or  $(5^\circ, 5^\circ, 10^\circ)$

## Problem:

- Some geometries need a smaller or a bigger box

## Aims:

- Find an algorithm able to adapt the size of the box
- Use an adjusted BRDF model (here: Snyder)
- Criterion: less than 1% of BRDF variation



# Chosen algorithm

Equations of the problem:

$$\min f(\theta_S, \phi_S, \theta_V, \phi_V) = \begin{cases} d(\theta_{SREF}, \phi_{SREF}, \theta_S, \phi_S) \\ d(\theta_{VREF}, \phi_{VREF}, \theta_V, \phi_V) \end{cases}$$

s. t.

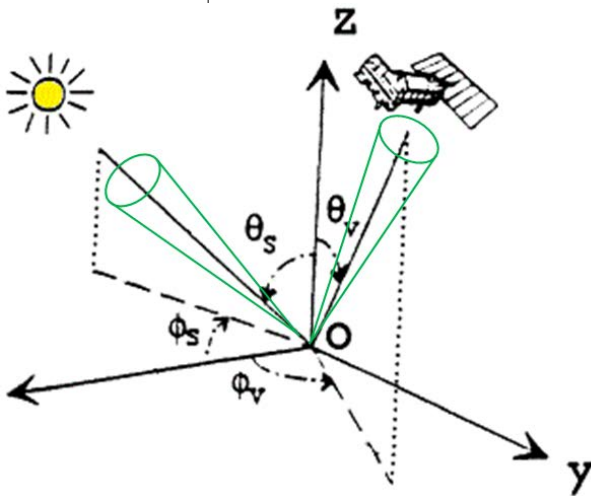
$$\frac{|\rho_{BRDF}(\theta_{SREF}, \phi_{SREF}, \theta_{VREF}, \phi_{VREF}) - \rho_{BRDF}(\theta_S, \phi_S, \theta_V, \phi_V)|}{\rho_{BRDF}(\theta_{SREF}, \phi_{SREF}, \theta_{VREF}, \phi_{VREF})} \leq 1\%$$

$$\phi_S \in [0^\circ, 360^\circ]$$

$$\theta_S \in [0^\circ, 70^\circ]$$

$$\phi_V \in [0^\circ, 360^\circ]$$

$$\theta_V \in [0^\circ, 70^\circ]$$



Technique used: a multi-objective optimization using genetic algorithm (NSGA-2) and creating a Pareto front between the two distances, formed by a specified number of points

Distance used: orthodromic distance

$$d(\theta_1, \phi_1, \theta_2, \phi_2) = R * \arccos(\sin(\theta_1) \sin(\theta_2) \cos(\phi_2 - \phi_1) + \cos(\theta_1) \cos(\theta_2))$$

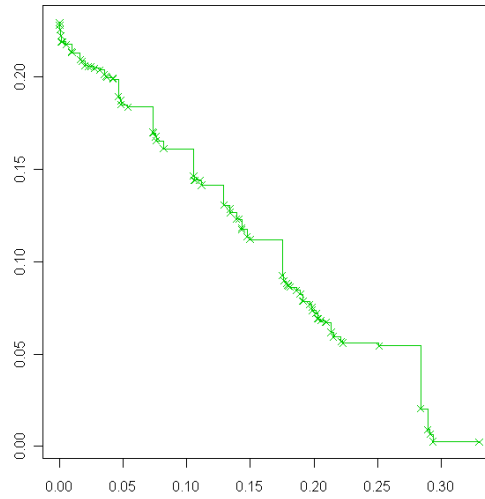
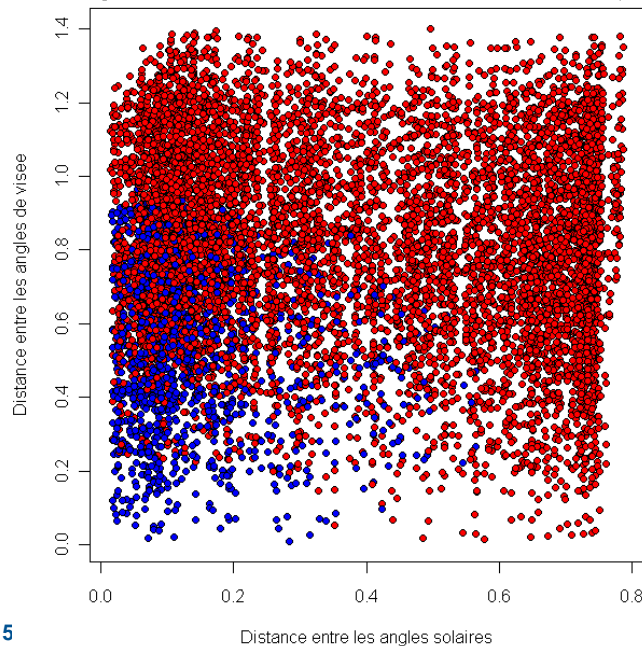
# Algorithm details

## Justifications for the NSGA-2 algorithm:

- Distance computed in the spherical coordinate system
- Automatic and multiband algorithm (constraints on the BRDF variation can be applied on multiple spectral bands)

Distances entre le point de référence et les mesures du site Algerie\_3 pour la bande 565

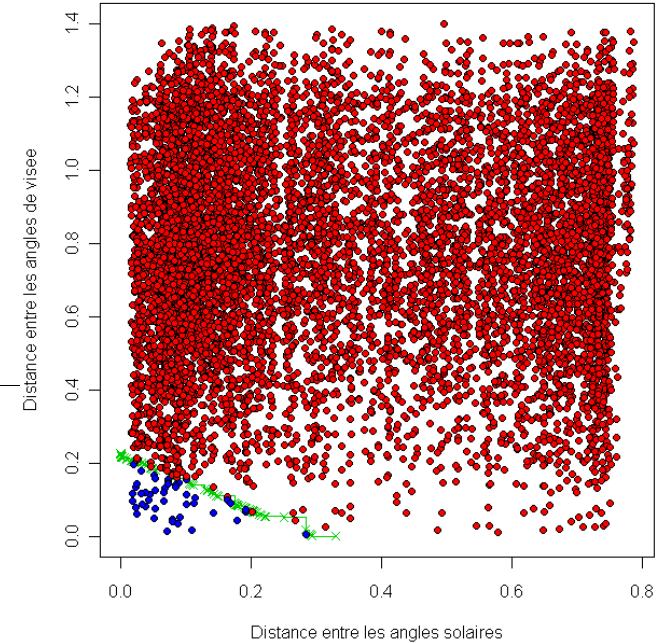
En rouge la différence de BRDF est inférieure a 0.005 et en bleu elle est supérieure



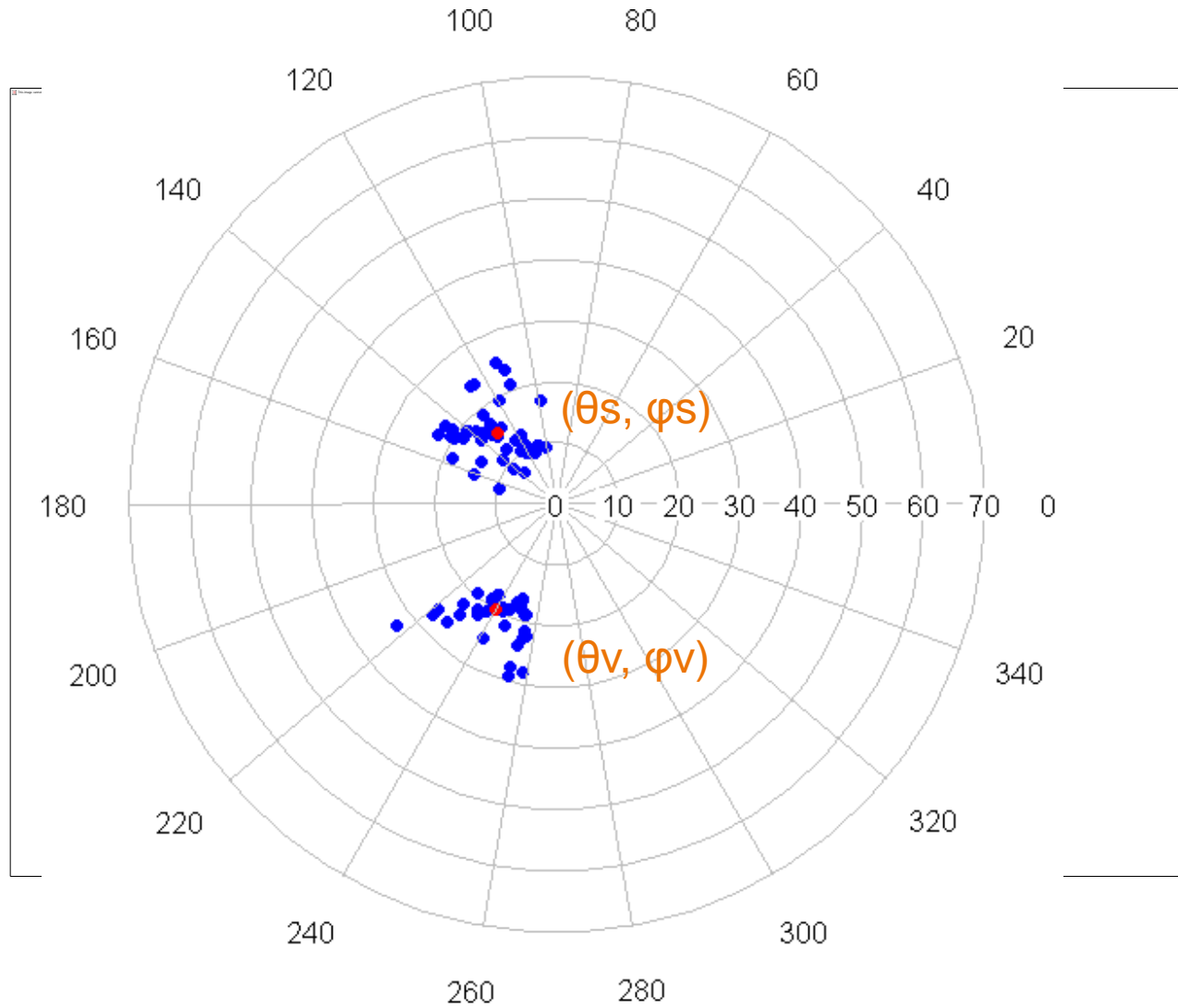
Pareto front

Frontiere entre les mesures du site Algerie\_3 pour la bande 565

En vert la frontiere ; en bleu les mesures choisies et en rouge les mesures rejetees



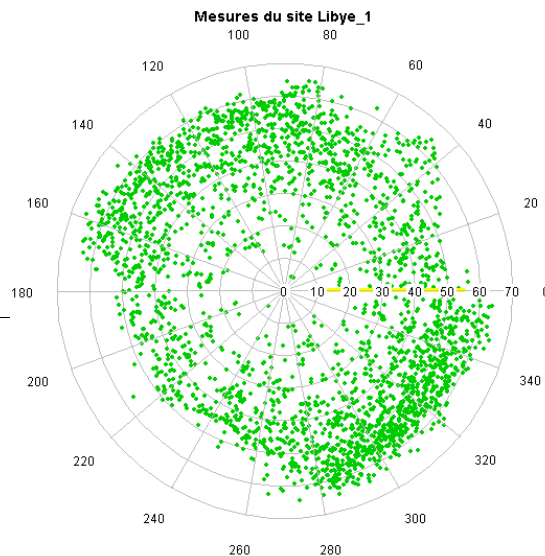
# Algorithm details



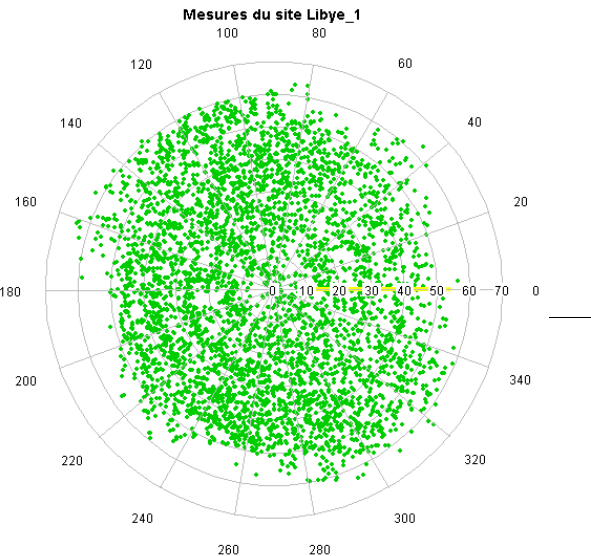
# Results

	Algorithm	Total number of couples	Number of matched measurements	Number of available measurements	Percentage of matched measurements
<b>POLDER / PARASOL</b>	Box [2°,2°,5°]	3474	2722	10332	26.35%
	Algorithm with criterion on bands 670 and 865	12886	4401	10332	42.60%
	Algorithm with criterion on bands 565, 670 and 865	5863	2666	10332	25.80%
<b>VGT1 / VGT2</b>	Box [2°,2°,5°]	10614	2009	2178	92.24%
	Algorithm with criterion on bands 670 and 865	59964	1969	2178	90.40%
<b>MODIS / MERIS</b>	Box [2°,2°,5°]	25	11	460	2.39%
	Algorithm with criterion on bands 670 and 865	11319	211	460	45.87%
	Algorithm with criterion on bands 565, 670 and 865	6805	179	460	38.91%

## Localization: POLDER/PARASOL ( $\theta_v, \Delta\phi$ )



PARASOL\_POLDER , methode : boite

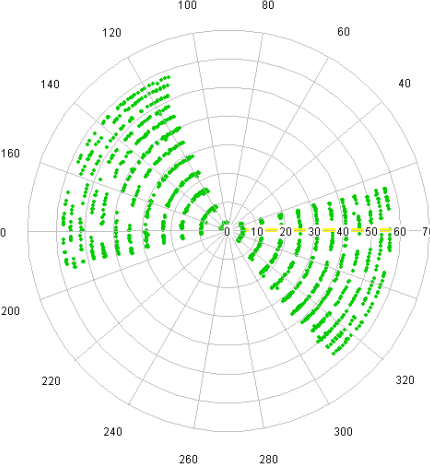


PARASOL\_POLDER , nouvelle methode sur bandes 670 et 865

# Results

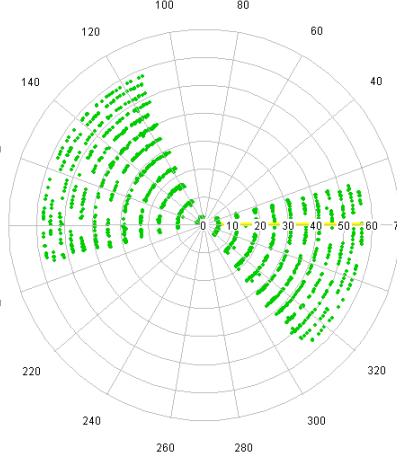
## Localization: VGT1/VGT2 ( $\theta_v, \Delta\phi$ )

Mesures du site Libye\_1



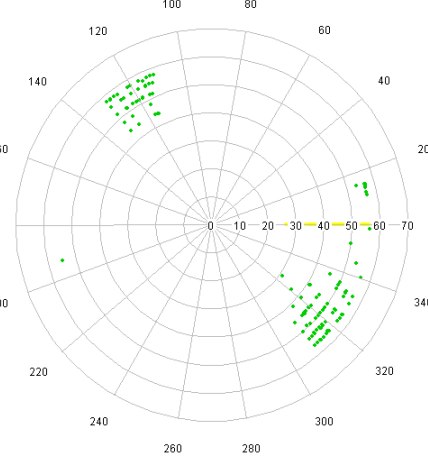
VGT2\_VGT1 , methode : boite

Mesures du site Libye\_1



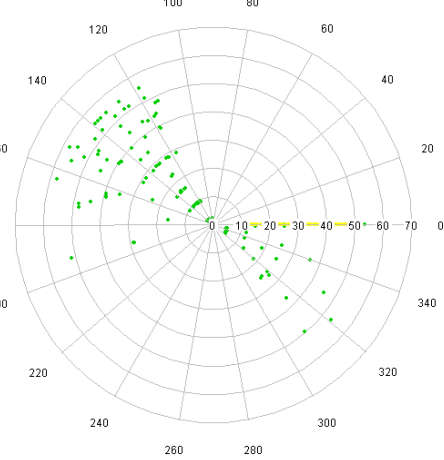
VGT2\_VGT1 , nouvelle methode sur bandes 670 et 865

Mesures du site Libye\_1



VGT2\_VGT1 , mesures selectionnees avec boite mais pas avec nouvelle methode

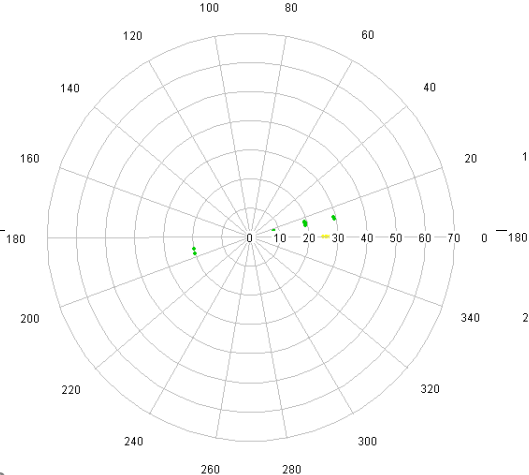
Mesures du site Libye\_1



VGT2\_VGT1 , mesures selectionnees avec nouvelle methode mais pas avec boite

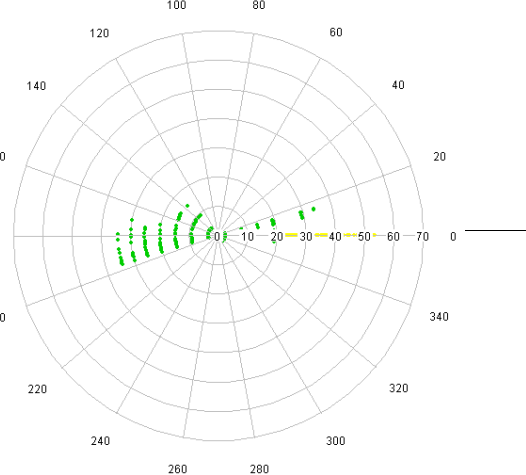
## Localization: MODIS/MERIS ( $\theta_v, \Delta\phi$ )

Mesures du site Libye\_1



MERIS\_MODIS , methode : boite

Mesures du site Libye\_1



MERIS\_MODIS , nouvelle methode sur bandes 670 et 865



# Conclusion

Matched measurements seem to be more stable from a radiometric point of view (more measurements are matched on low zenith angles)

The method is generic: parameters can be modified (spectral bands, BRDF model, percentage of BRDF variation, sensors, type of calibration site, ...)

Requirement: Adjustment of BRDF model on the studied site for each spectral band

Performance: Around 4 seconds per measurement on a laptop with R

Next step: comparing calibrations coefficients obtained by these two techniques

**Thank you for your attention**