Matchup Strategy for Sensors Cross Calibration

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Problem presentation

Present method: $\left|\theta_V^1 - \theta_V^2\right| < \partial\theta_V$

$\left|\theta_S^1 - \theta_S^2\right| < \partial\theta_S$

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

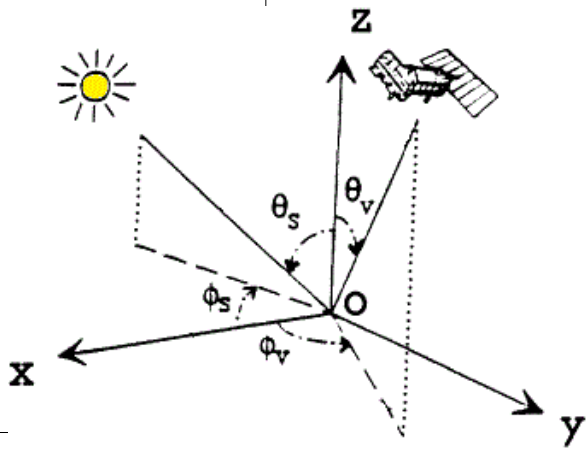
with two types of box: $(\partial\theta_V, \partial\theta_S, \partial\varphi)$= (2°,2°,5°) or (5°,5°,10°)

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:

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

$$s.t.$$

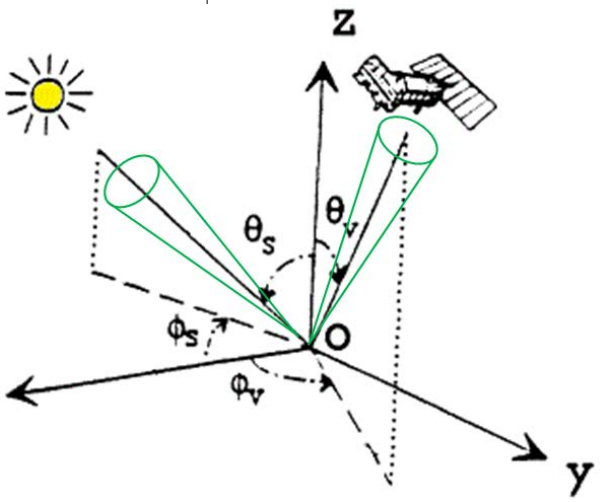
$$\frac{|\rho_{BRDF}(\theta_{S_{REF}}, \phi_{S_{REF}}, \theta_{V_{REF}}, \phi_{V_{REF}}) - \rho_{BRDF}(\theta_S, \phi_S, \theta_V, \phi_V)|}{\rho_{BRDF}(\theta_{S_{REF}}, \phi_{S_{REF}}, \theta_{V_{REF}}, \phi_{V_{REF}})} \leq 1\%$$

$$\phi_S \in [0°, 360°]$$

$$\theta_S \in [0°, 70°]$$

$$\phi_V \in [0°, 360°]$$

$$\theta_V \in [0°, 70°]$$



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

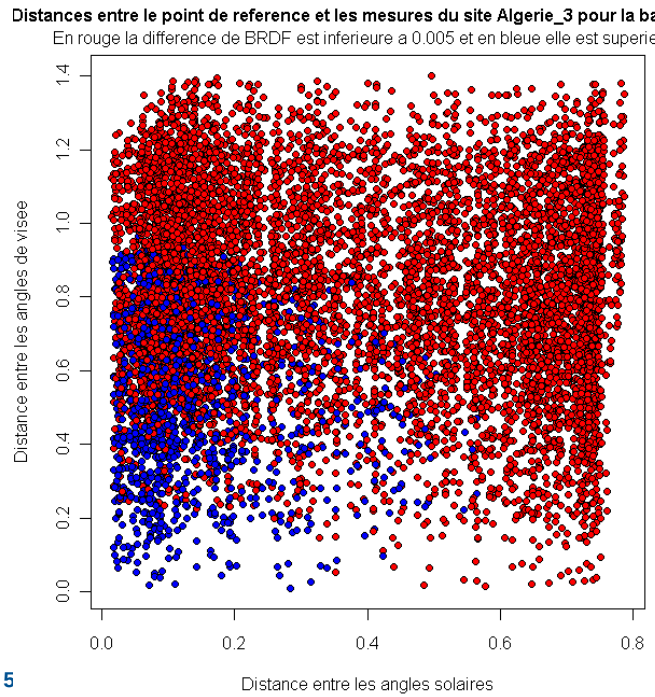
Distance used: orthodromic distance

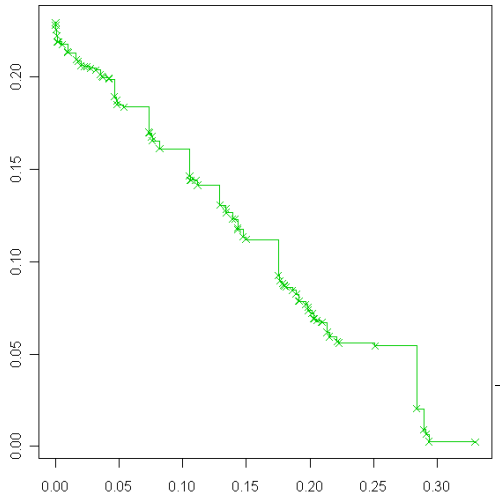
$$d(\theta_1, \varphi_1, \theta_2, \varphi_2) = R * \arccos(\sin(\theta_1)\sin(\theta_2)\cos(\varphi_2 - \varphi_1) + \cos(\theta_1)\cos(\theta_2))$$

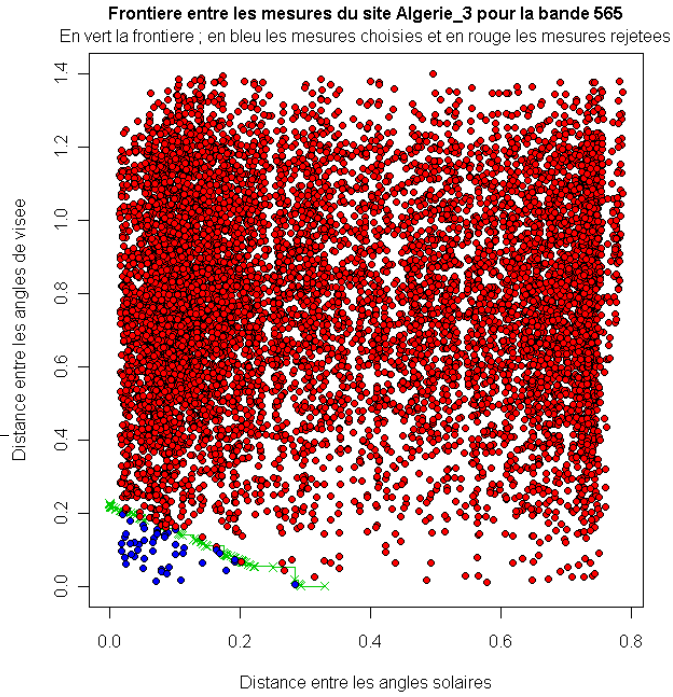
Algorithm details

Justifications for the NSGA-2 algorithm:

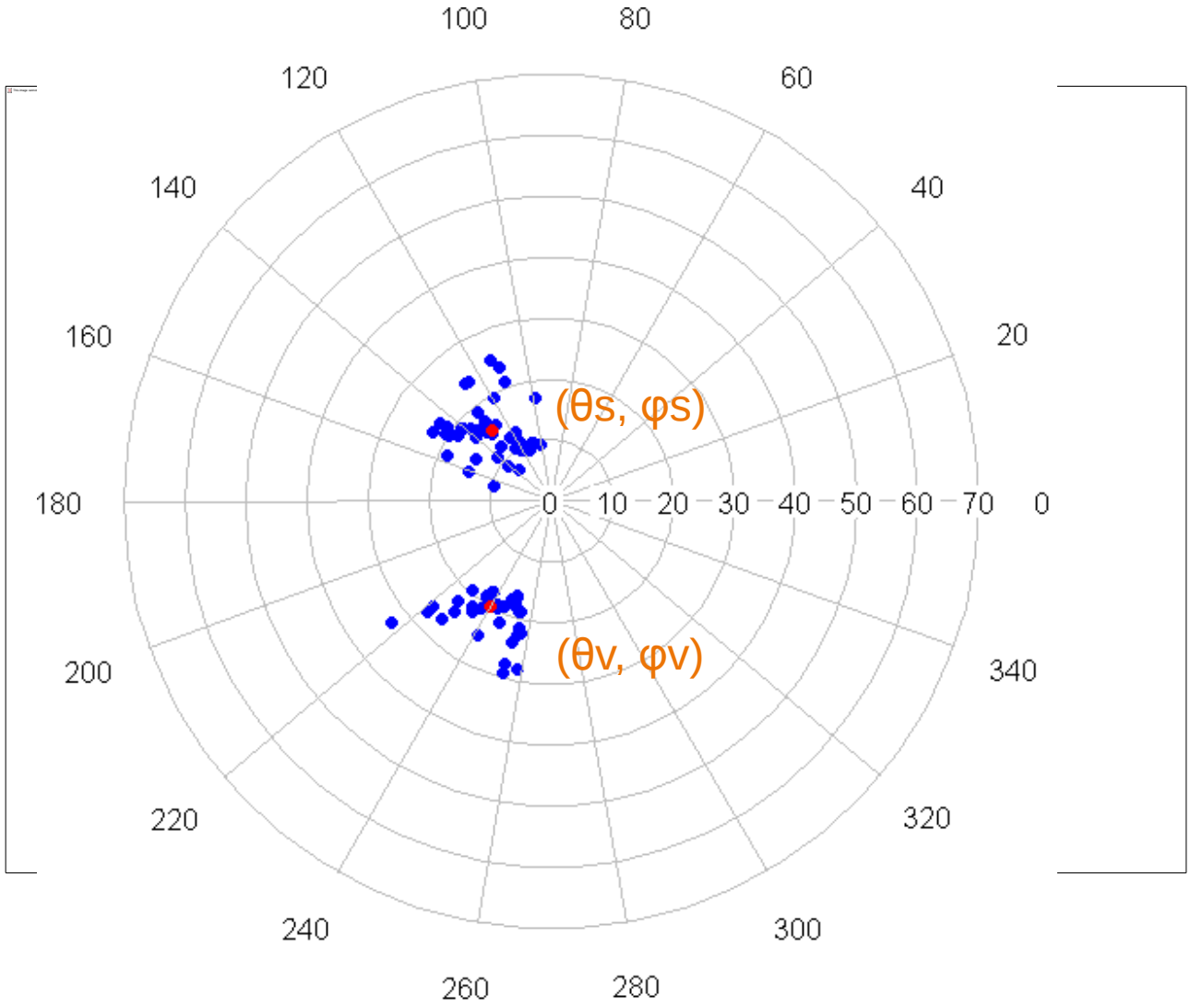
- Distance computed in the spherical coordinate system
- Automatic and multiband algorithm (constraints on the BRDF variation can be applied on multiple spectral bands)







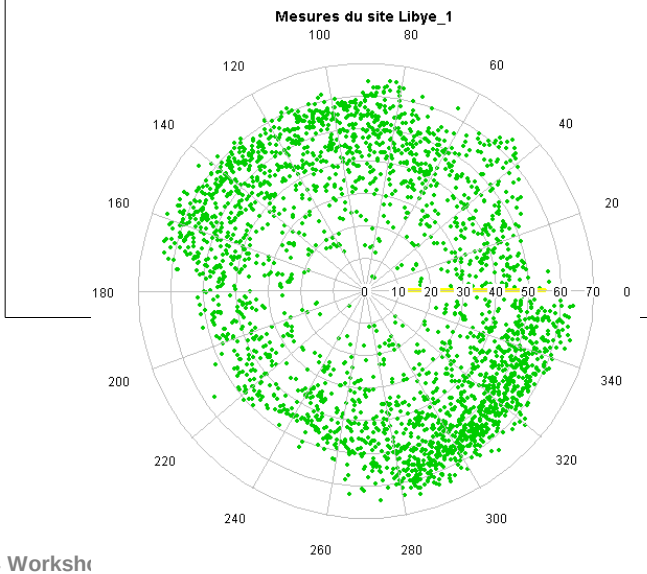
Algorithm details



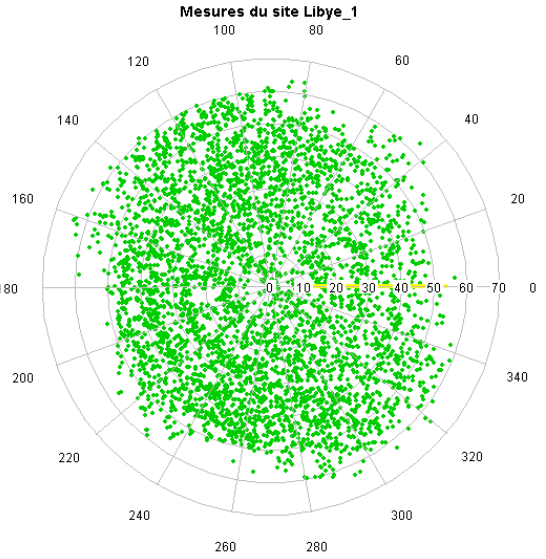
Results

	Algorithm	Total number of couples	Number of matched measurements	Number of available measurements	Percentage of matched measurements
POLDER / PARASOL	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 86	5863	2666	10332	25.80%
VGT1 / VGT2	Box [2°,2°,5°]	10614	2009	2178	92.24%
	Algorithm with criterion on bands 670 and 865	59964	1969	2178	90.40%
MODIS / MERIS	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 86	6805	179	460	38.91%

Localization: POLDER/PARASOL (θv,Δφ)



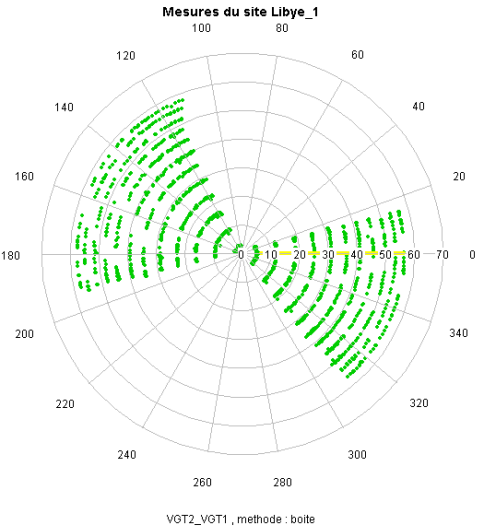
PARASOL_POLDER , methode : boite



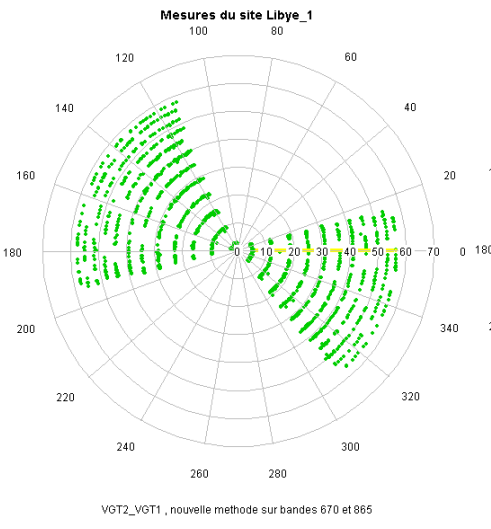
PARASOL_POLDER , nouvelle methode sur bandes 670 et 865

Results

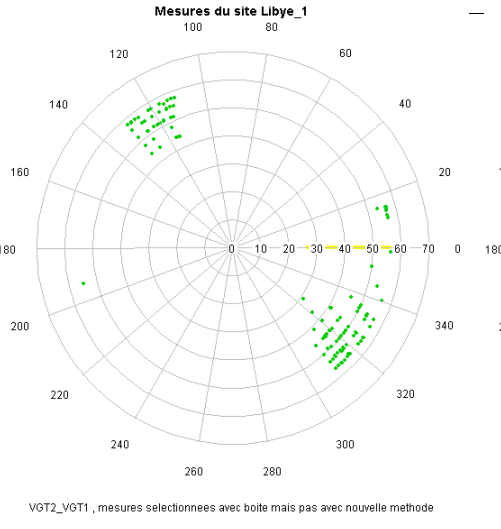
Localization: VGT1/VGT2 (θv,Δφ)



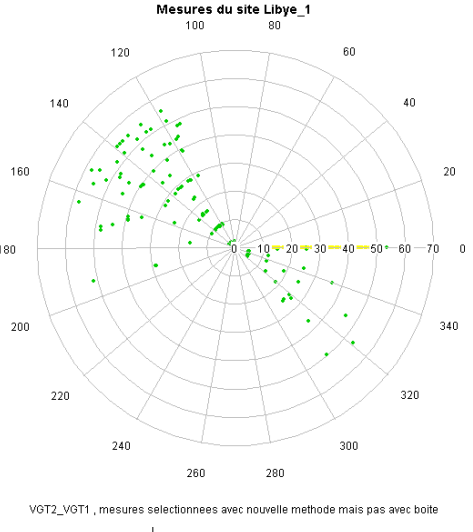
VGT2_VGT1 , methode : boite



VGT2_VGT1 , nouvelle methode sur bandes 670 et 865

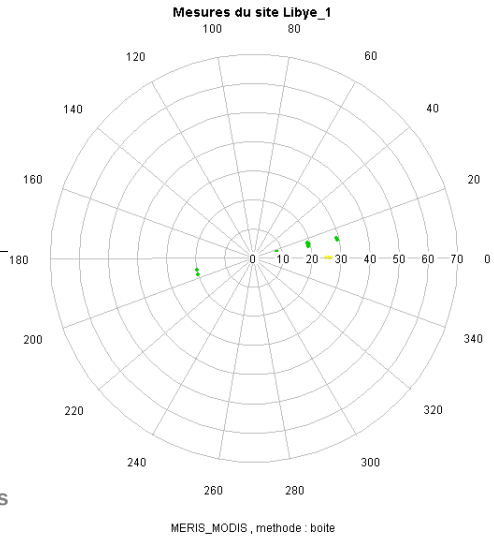


VGT2_VGT1 , mesures selectionnees avec boite mais pas avec nouvelle methode

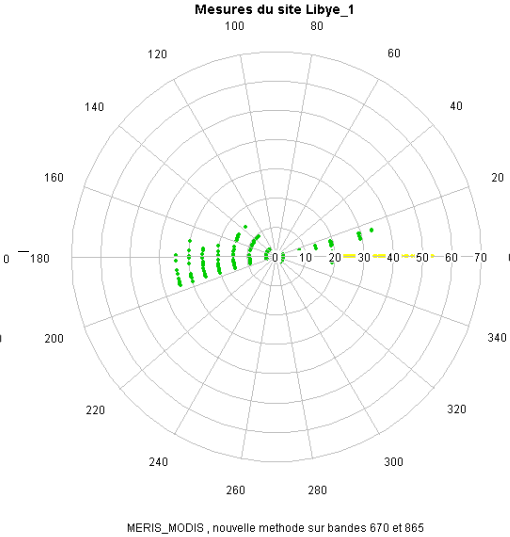


VGT2_VGT1 , mesures selectionnees avec nouvelle methode mais pas avec boite

Localization: MODIS/MERIS (θv,Δφ)



MERIS_MODIS , methode : boite



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