Deriving ECVs GAI and FAPAR from SPOT4 and LANDSAT8 sensors: evaluation of the consistency and comparison with ground measurements

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CNES, Toulouse, France

1. Introduction - Background

- **The green area index (GAI) and the fraction of photosynthetically active radiation absorbed by green vegetation (FAPAR) are essential climatic variables in surface process models.**

  MODIS, GEOV1, JRC-TIP, MERIS, etc. But with coarse resolution

- **SENTINEL-2 will be launched in the near future**

  Decametric resolution (20m)

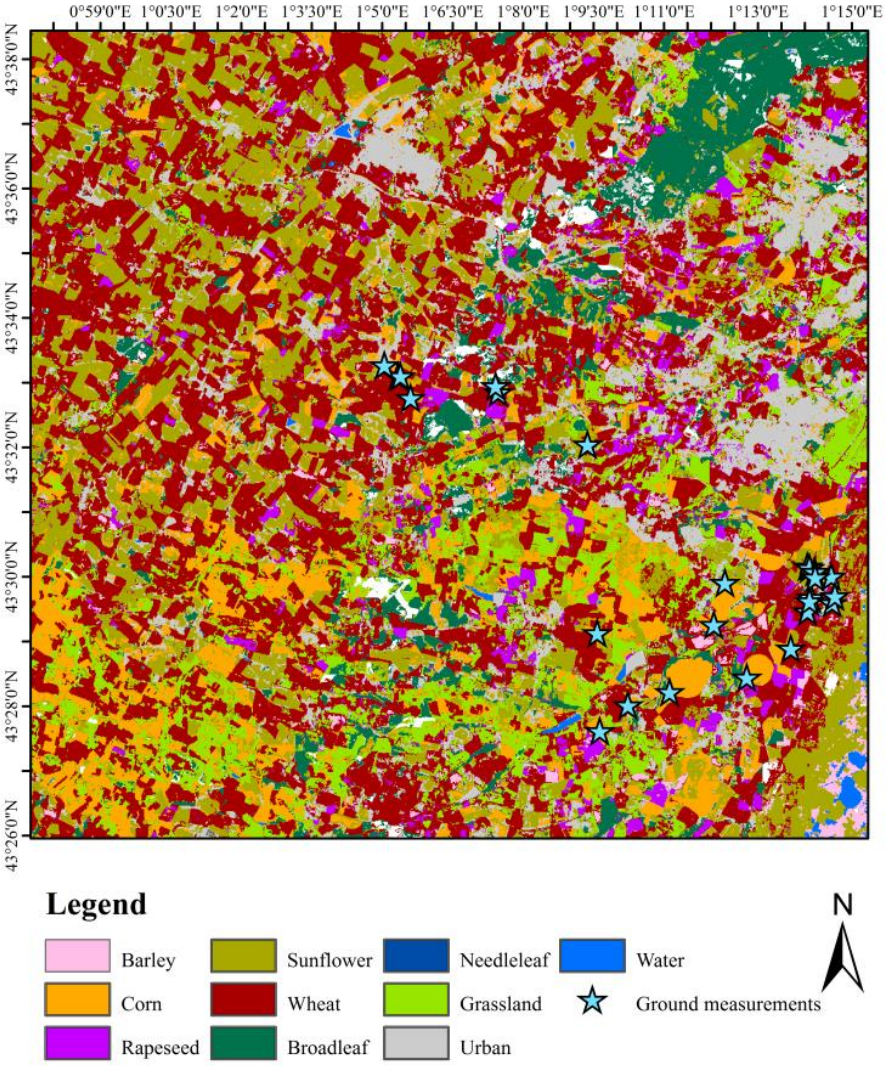
  High visit frequency (5 days)

1. Introduction – Objective

- **Use the combination of SPOT4 and LANDSAT8 data to get a similar SENTINEL2 dataset, thanks to the SPOT4(Take5) project.**

- **Test the feasibility of the algorithm to derive GAI and FAPAR products at SENTINEL2 spatial and temporal resolution.**

2. Study area



Site: Sud-Quest, France
(centered at: 43 ° 32 ′ N, 1 ° 7 ′ E)

Size: 24 km * 24 km
Overlap of SPOT4 and LANDSAT8

Land cover types: dominated by crops
(thanks Francois for the classification)

Location of the study area
SPOT4 image (17/04/2013)

3. Datasets – Satellite data

- **The surface reflectance data from SPOT4 and LANDSAT8 were used.**
- **Pixels contaminated by clouds or clouds shadow were firstly removed based on the cloud mask layer.**
- **Extract the region over the study area.**

Sensors	Spatial resolution	Temporal resolution	Temporal range	Scene
SPOT4	20m	5 days	2013.2.16 – 2013.6.16	16
LANDSAT8	30m	16 days	2013.4.14 – 2013.12.10	18

3. Datasets – Field measurements

- **The field measurements were conducted over three biomes from 16/04/2013 to 21/10/2013.**
- **Instruments: Digital Hemispherical Camera**
- **Software: CAN_EYE**
- **Variables: GAI and black-sky FAPAR**

Biomes	ESU	Dates (2013)
Wheat	5	4.16, 4.25, 5.13, 5.24, 6.7, 6.19, 7.1
Maize	9	5.14, 5.24, 6.7, 6.19, 7.1, 7.10, 7.24, 8.7, 8.20, 9.2, 9.3, 9.19, 10.9, 10.21
Sunflower	11	6.25, 6.26, 7.9, 7.11, 7.18, 7.29, 8.16, 9.6

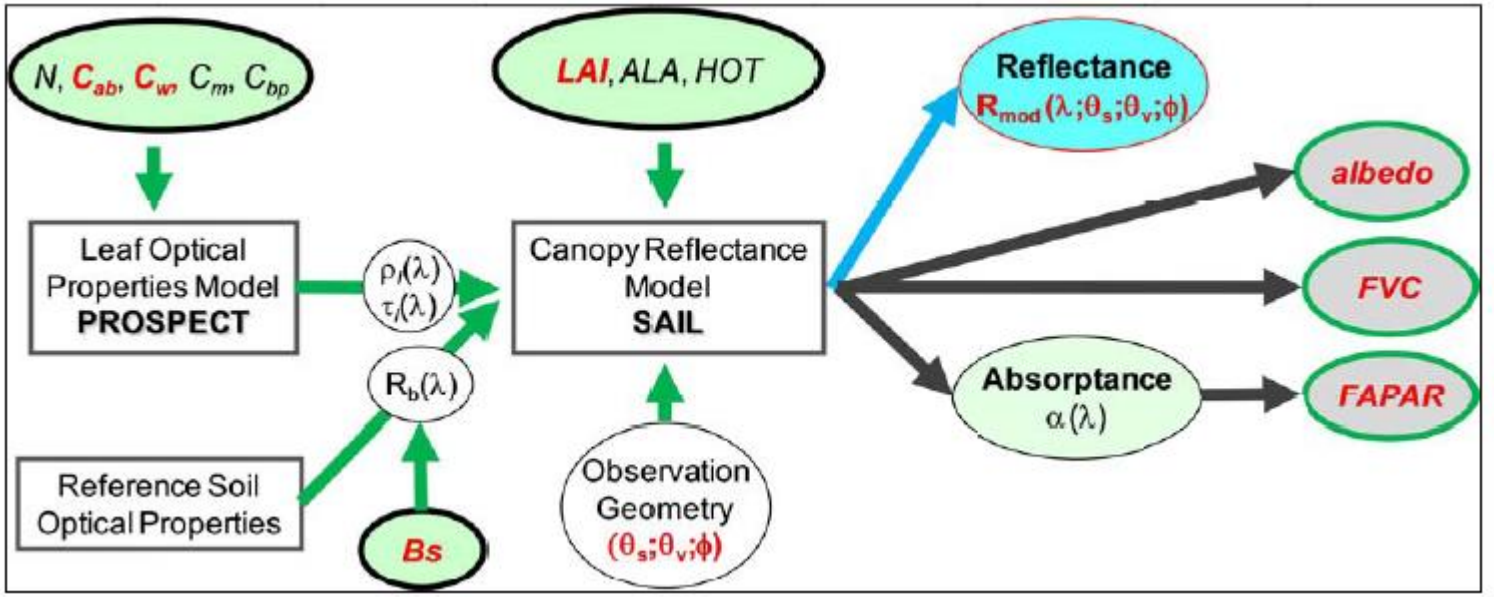
Thanks Valerie Demarez for the field datasets

4. Methods – Models

Canopy reflectance model: SAIL

Leaf optical properties model: PROSPECT

Background reflectance: soil brightness model

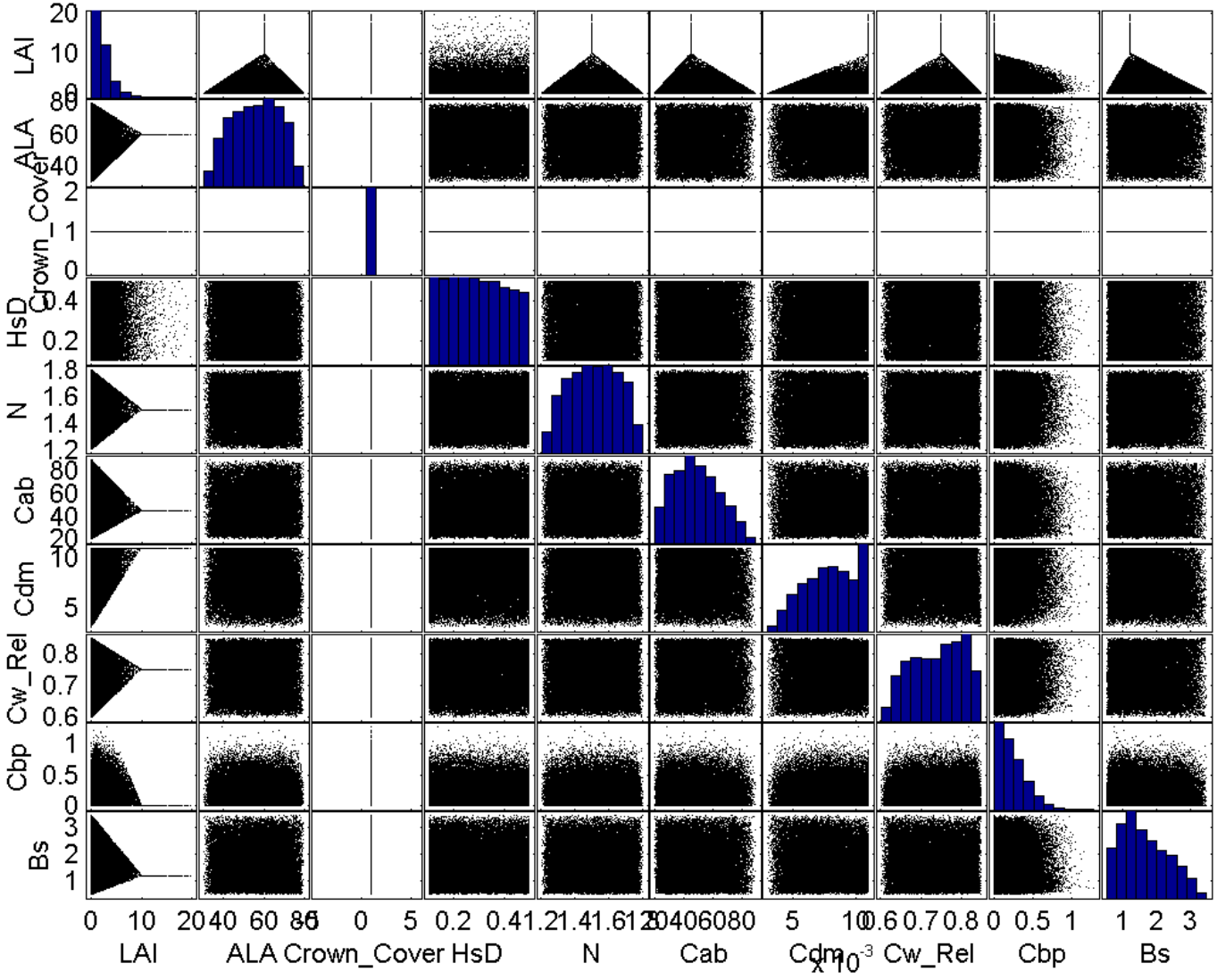


4. Methods – Distribution of input parameters

To better simulate the canopy reflectance, the actual distribution of the parameters should be considered.

	Variable	Minimum	Maximum	Mode	Std	Distribution
Canopy	**GAI**	0.0	15.0	2.0	2.0	Log_Gauss
	ALA (°)	30	80	60	20	Gauss
	Crown_Cover	1.0	1.0	0.8	0.4	Uniform
	HsD	0.1	0.5	0.2	0.5	Gauss
Leaf	**N**	1.20	1.80	1.50	0.30	Gauss
	Cab (µg.m^{-2})	20	90	45	30	Gauss
	Cdm (g.m^{-2})	0.0030	0.0110	0.0050	0.0050	Gauss
	Cw_Rel	0.60	0.85	0.75	0.08	Uniform
	Cbp	0.00	2.00	0.00	0.30	Gauss
Soil	**Bs**	0.50	3.50	1.20	2.00	Gauss

4. Methods – Distribution of input parameters



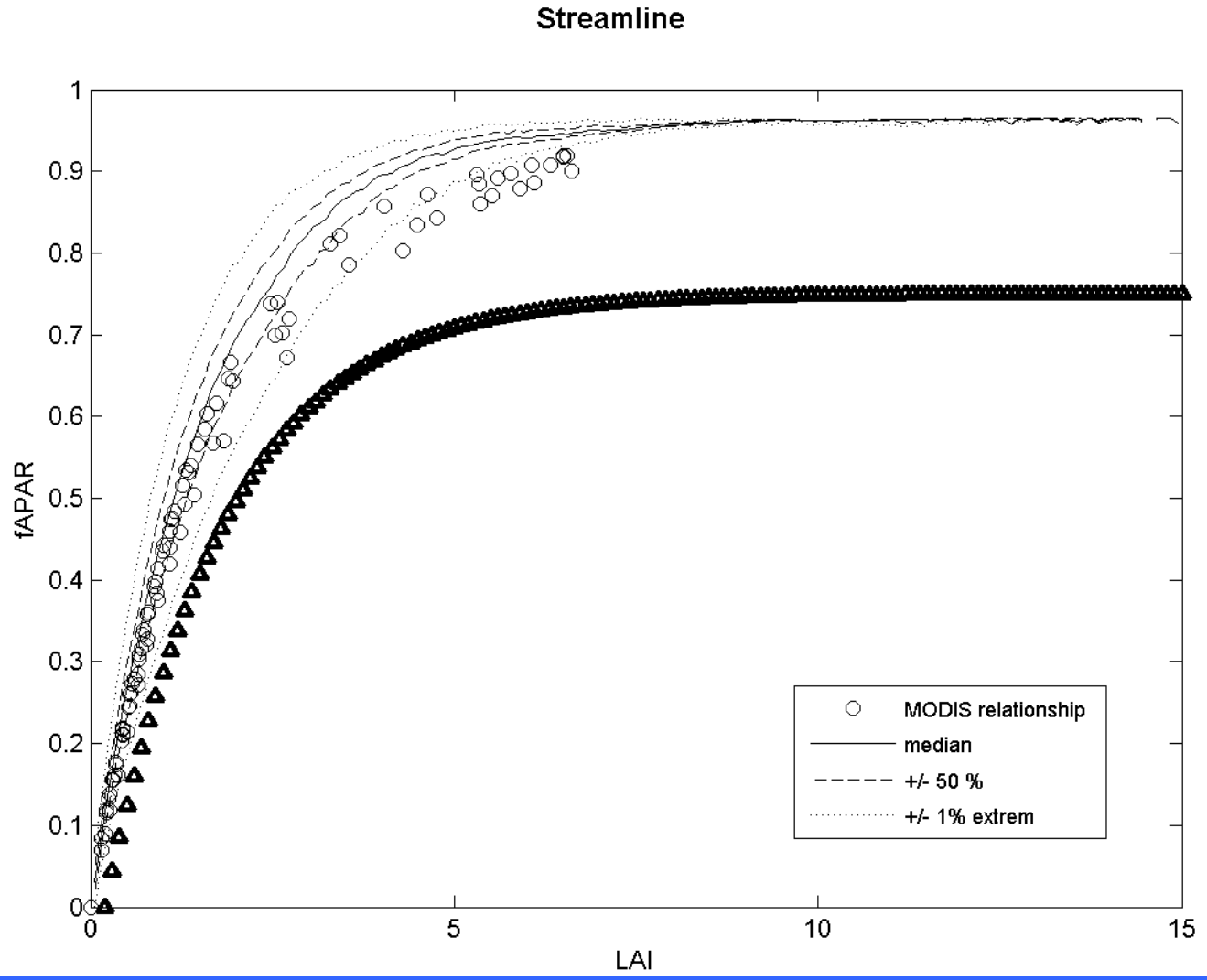
4. Methods – Train the neural network

- **In general, 41472 cases were simulated using the above models.**
- **To make the products from two sensors comparable, four common bands were selected.**

	SPOT4 (nm)	LANDSAT8 (nm)
Green	500-590	512-610
Red	610-680	625-691
NIR	780-890	829-900
SWIR	1580-1750	1515-1697

- **For each sensor (SPOT4 and LANDSAT8), two neural networks were trained for GAI and FAPAR, respectively.**

4. Methods - Train the neural network



4. Methods – Quality assessment

- **Only the vegetated pixels were inversed**
- **The input reflectance on each band should be within the range of the simulated reflectance (min, max)**
- **The output GAI and FAPAR should be within the range:**

	GAI	FAPAR
Minimum	0	0
Maximum	8	0.97
Tolerance	+-0.2	+-0.05

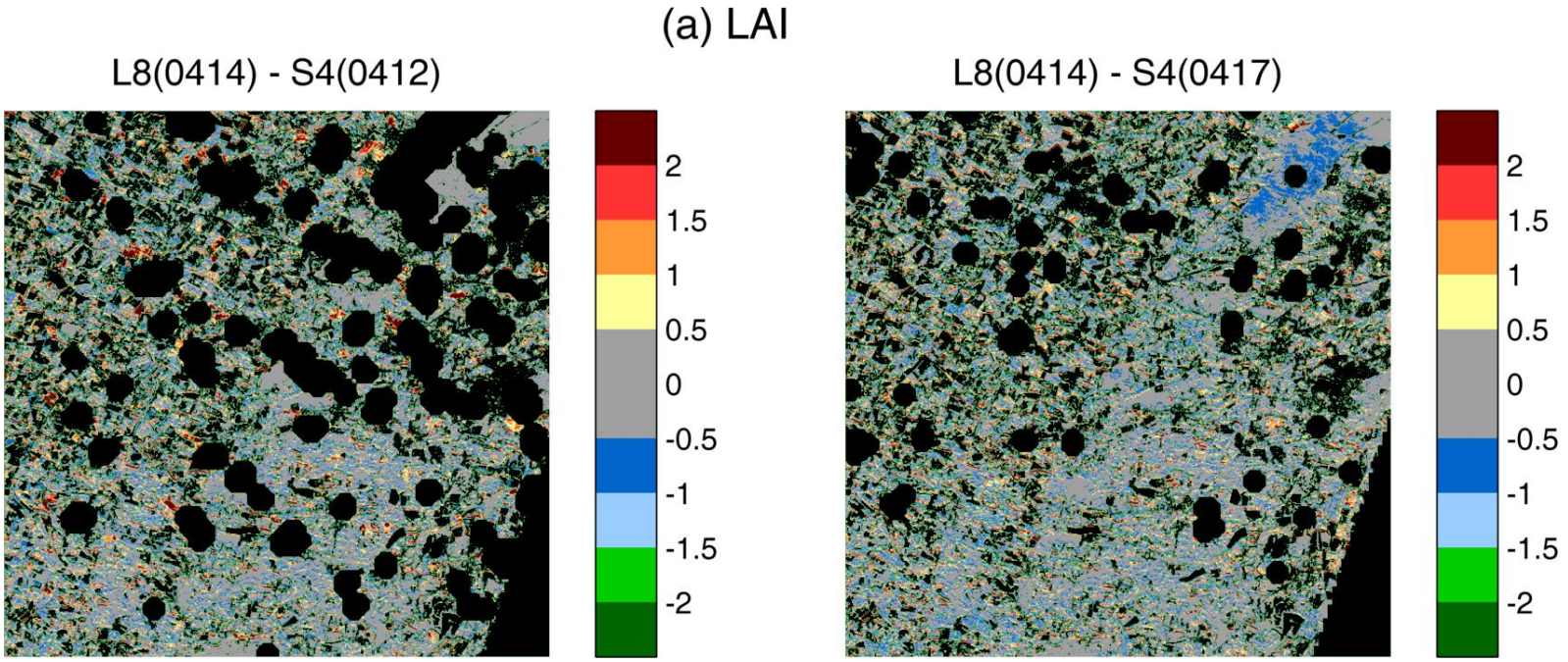
- **The per-pixel RMSE of the neural network inversion was reported as the uncertainty of the products**

4. Methods – Inversion

- **Inputs: sun zenith angle, sun azimuth angle, and reflectance on four bands**

- **Outputs: GAI or FAPAR and the uncertainty**

5. Results – Spatial consistency of GAI

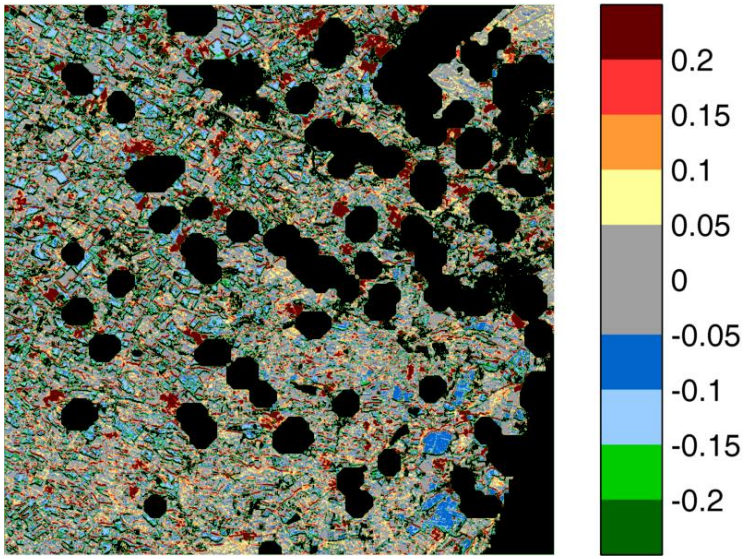


	Mean	% of pixels within +-0.5	% of pixels out of +-2
LANDSAT8 – SPOT4	-0.09	54%	8%

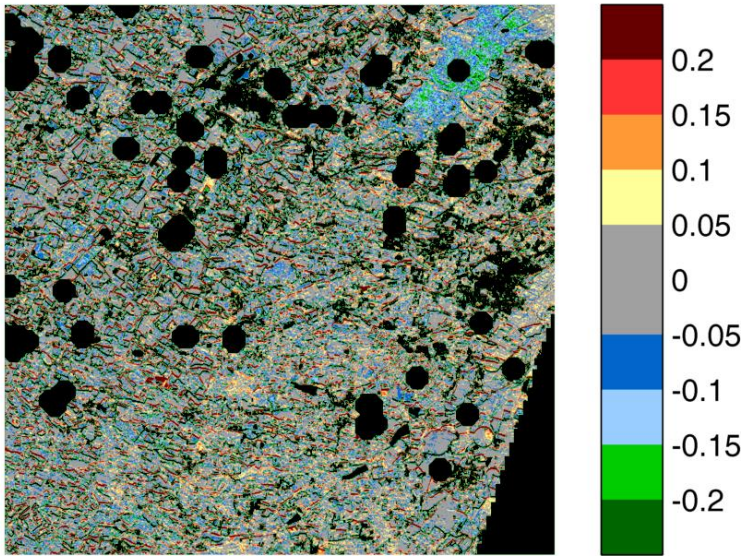
5. Results – Spatial consistency of FAPAR

(b) FAPAR

L8(0414) - S4(0412)

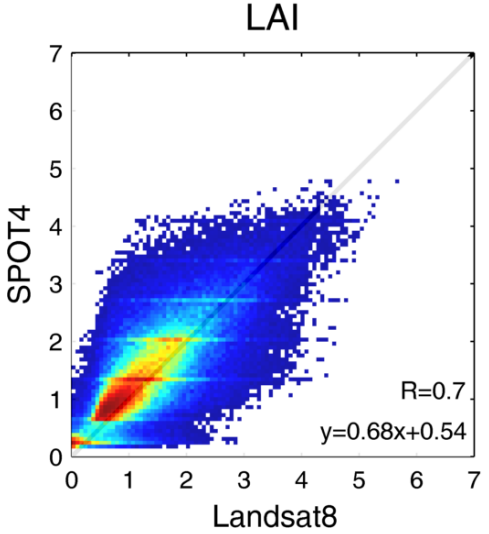


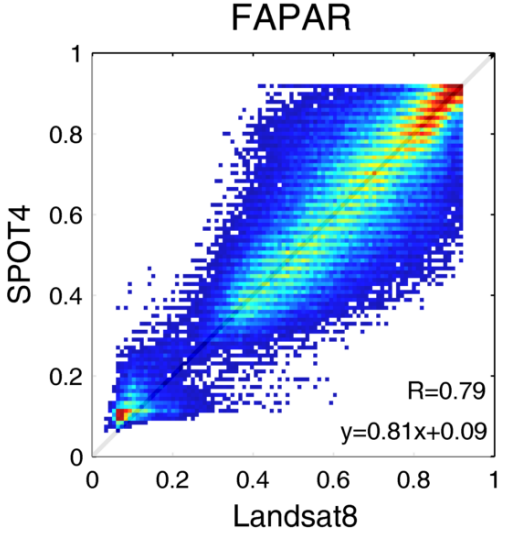
L8(0414) - S4(0417)



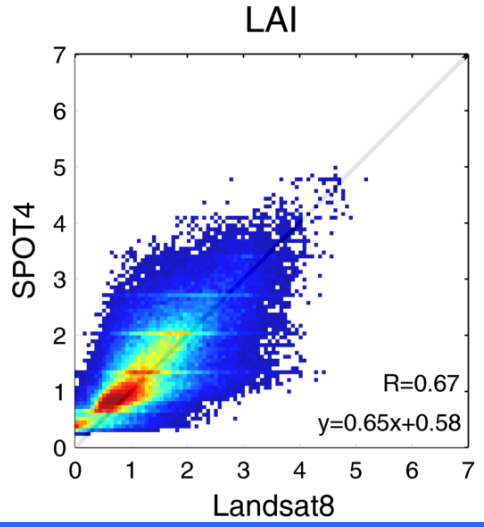
	Mean	% of pixels within +-0.05	% of pixels out of +-0.2
LANDSAT8 – SPOT4	-0.04	33.45%	7%

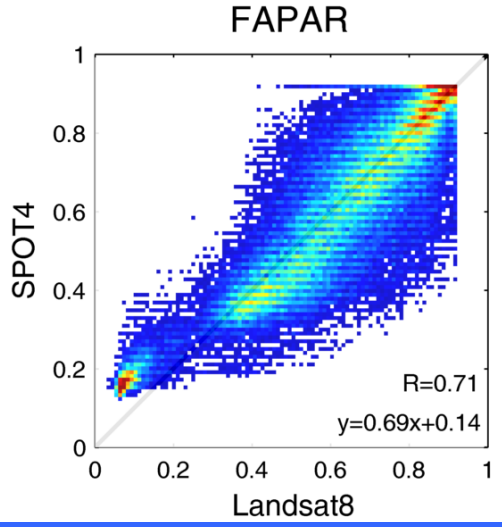
5. Results – Statistic comparison of two sensors





S4 (0412) vs. L8 (0414)

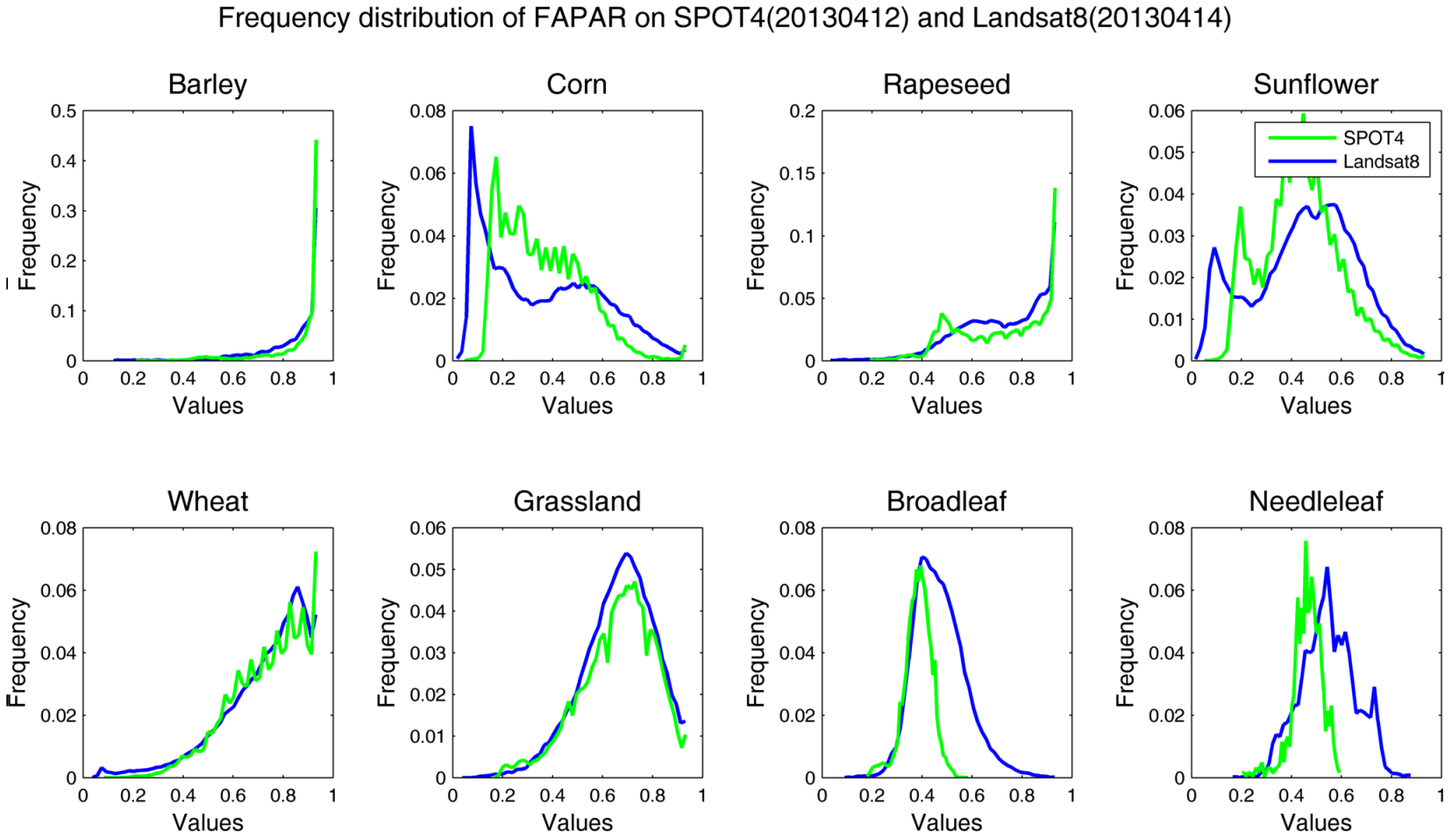




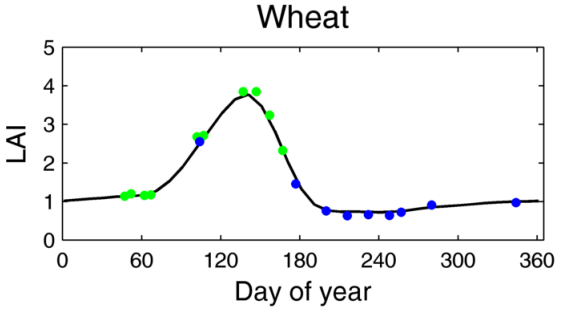
S4 (0417) vs. L8 (0414)

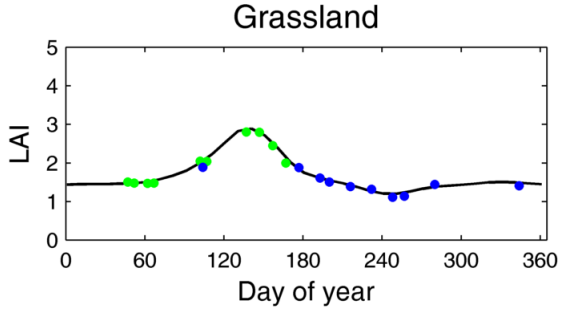
SPOT4 is slightly higher on small values

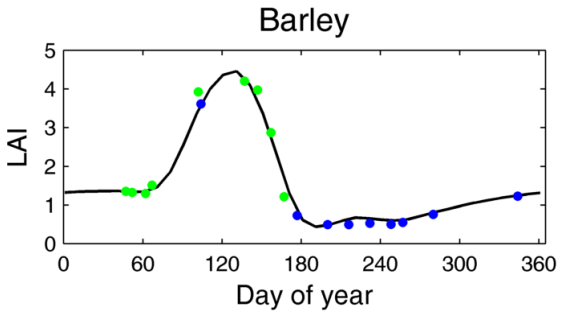
5. Results – Statistics on each biome

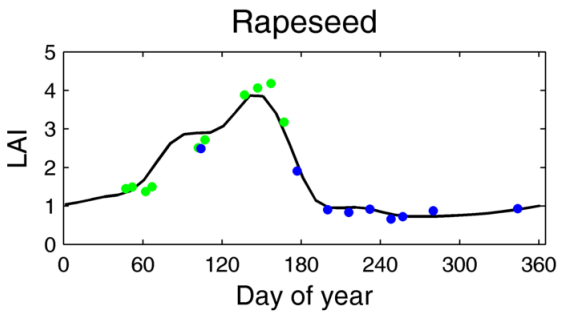


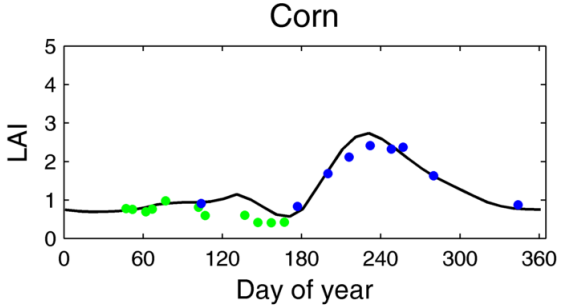
5. Results – Temporal consistency of GAI

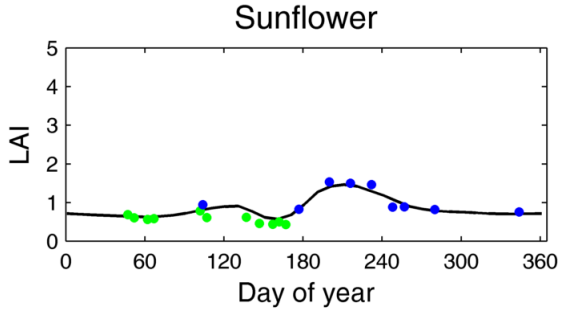


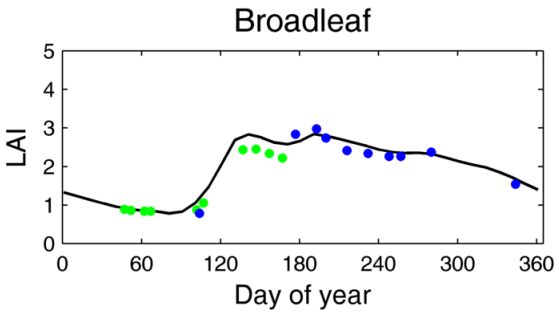


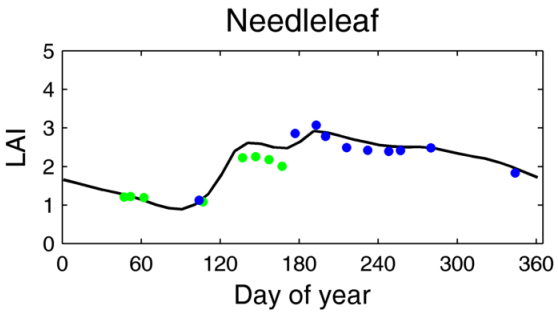






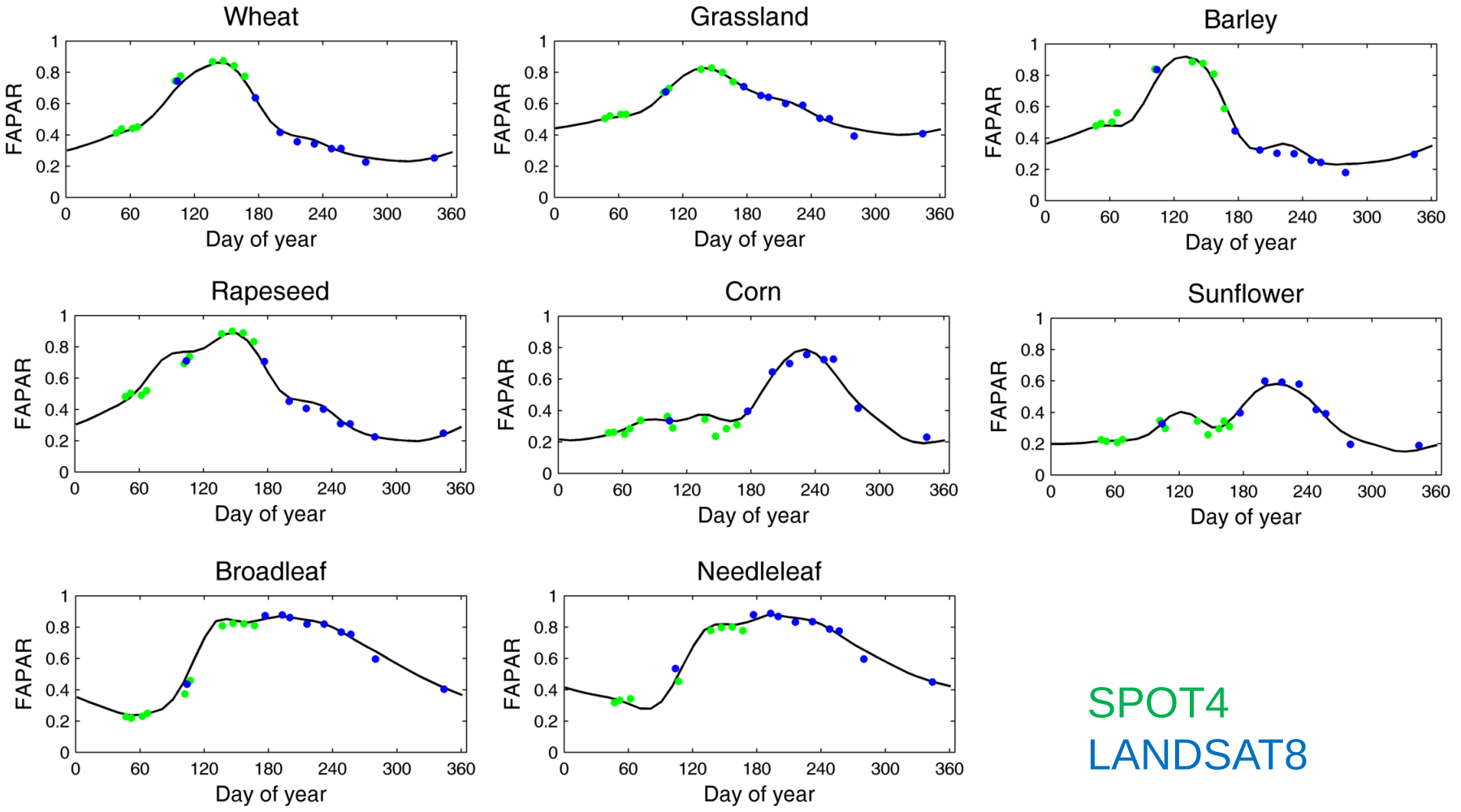






SPOT4
LANDSAT8

5. Results – Temporal consistency of FAPAR



The good temporal consistency captures the main seasonal variation.

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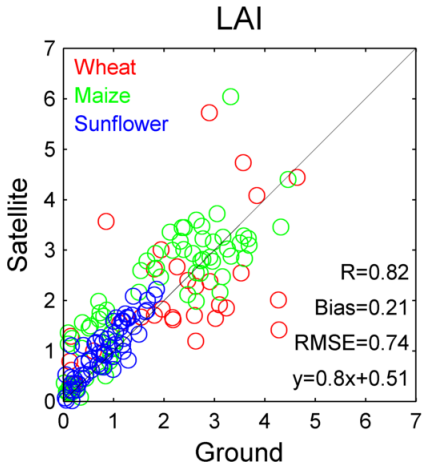
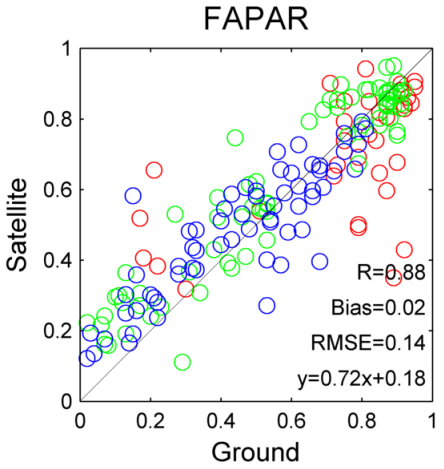
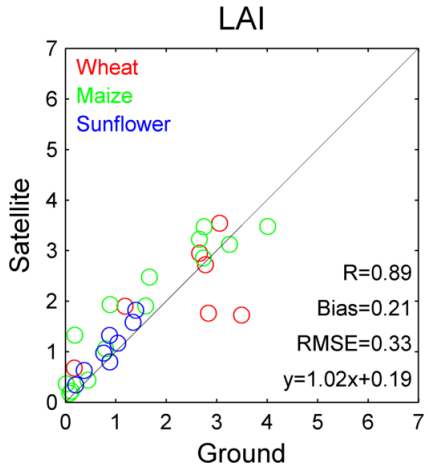
5. Results – Direct validation

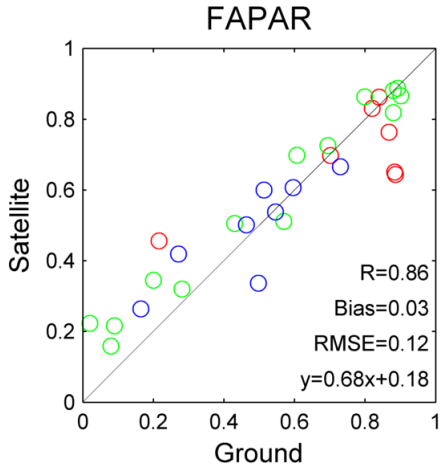




Comparison over each pixel

Satellite FAPAR is slightly higher for small values (during the stages of SPOT4 images)





Comparison over the average of all pixels in an ESU

6. Conclusions

- **The good seasonal profile from SPOT4 and LANDSAT8 allows to provide a good basis to derive a land cover based seasonal variation of the biophysical variables.**
- **In general, the algorithm applies well on the decametric spatial and high temporal resolution satellite data.**
- **Next, more sites and biomes will be involved to further validate the algorithm, especially for small FAPAR and LAI values, and for forests.**

Thank you!