A network of sites for ground biophysical measurements in support of Copernicus Global Land Product Validation

RAQRS-IV, Torrent

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Outline

- **CONTEXT – Why a network of sites?**
- **VARIABLES – What to Measure ? Which devices?**
- **PROTOCOLS – How to measure/process data?**
- **NETWORK – Where to measure ?**
- **RESULTS – What we have measured?**
- **EXPLOITATION – How to exploit this dataset?**

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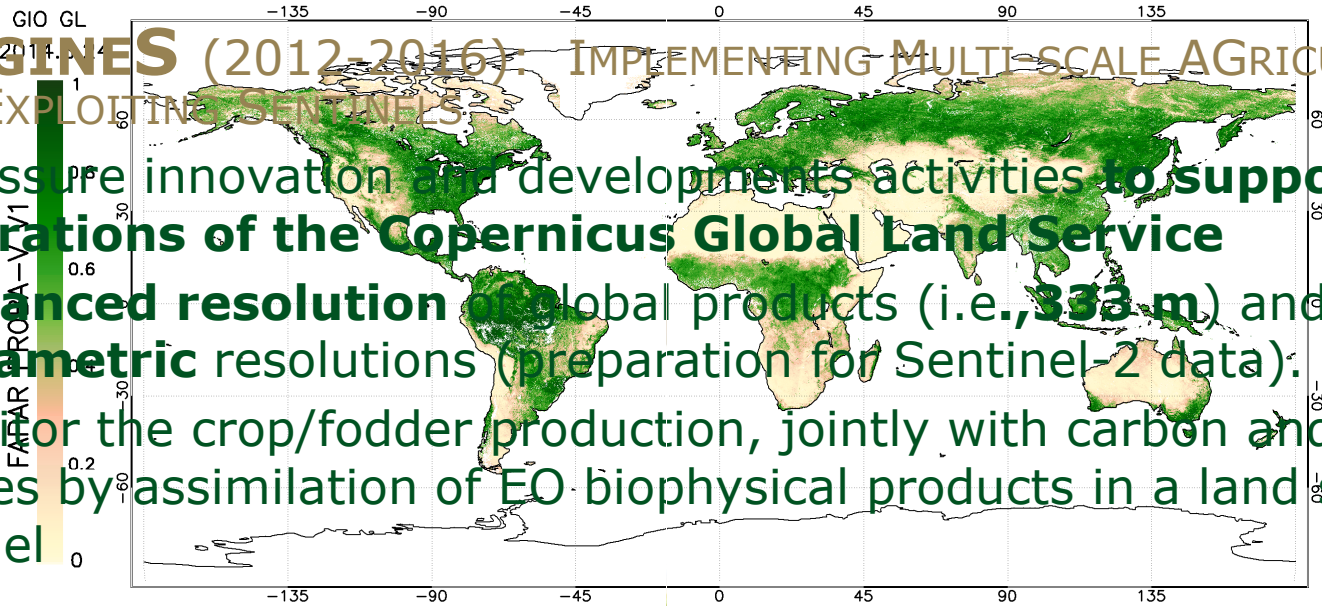
Context - Global Land Service / ImagineS

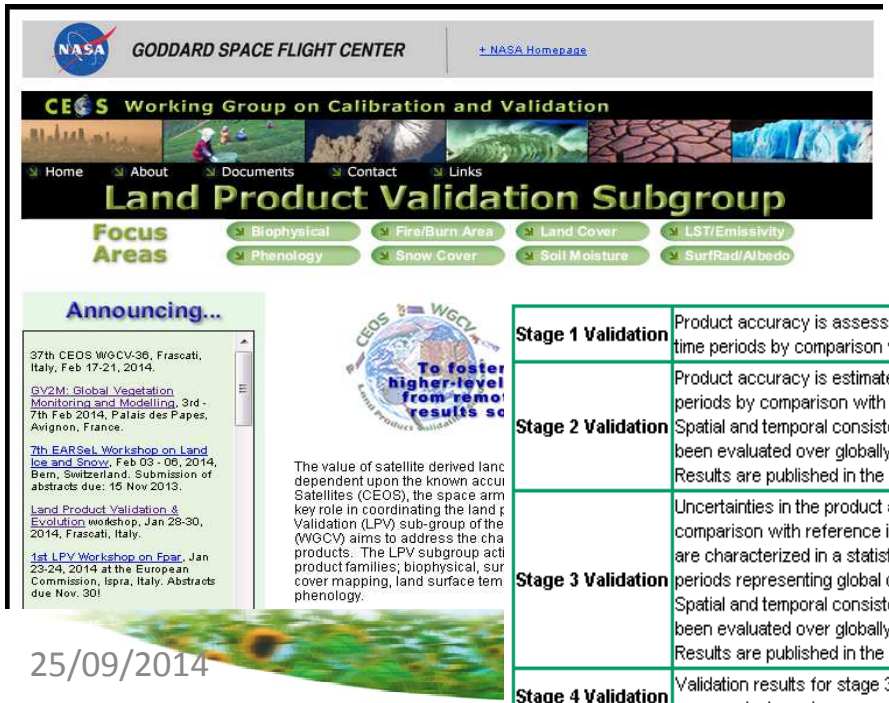
- **COPERNICUS GLOBAL LAND SERVICE**
  - Global geobiophysical products (LAI, FAPAR, Fcover, Albedo…) are produced every 10 days at 1 km resolution.

- **FP7 IMAGINES** (2012-2016): IMPLEMENTING MULTI-SCALE AGRICULTURAL INDICATORS EXPLOITING SENTINELS
  - To assure innovation and developments activities **to support the operations of the Copernicus Global Land Service**
  - **Enhanced resolution** of global products (i.e., **333 m**) and variables at **decametric** resolutions (preparation for Sentinel-2 data).
  - Monitor the crop/fodder production, jointly with carbon and water fluxes by assimilation of EO biophysical products in a land surface model

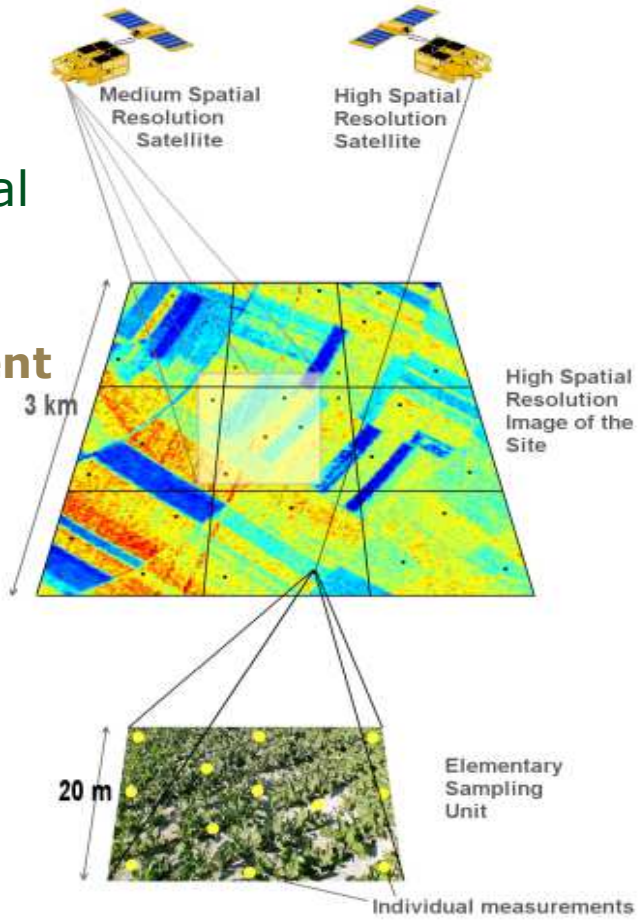


Context- Validation needs

- **Copernicus Global Land products must be validated according to CEOS LPV best practices**
  - Product accuracy should be assessed trough a significant set of locations and time periods
  - None of the existing networks are oriented to global LAI/FAPAR product validation
- **Need for ground LAI/FAPAR data processed according to CEOS LPV for validation of satellite products from the current and coming missions**



Stage 1 Validation	Product accuracy is assessed from a small (typically < 30) set of locations and time periods by comparison with in-situ or other suitable reference data.
Stage 2 Validation	Product accuracy is estimated over a significant set of locations and time periods by comparison with reference in situ or other suitable reference data. Spatial and temporal consistency of the product and with similar products has been evaluated over globally representative locations and time periods. Results are published in the peer-reviewed literature.
Stage 3 Validation	Uncertainties in the product and its associated structure are well quantified from comparison with reference in situ or other suitable reference data. Uncertainties are characterized in a statistically robust way over multiple locations and time periods representing global conditions. Spatial and temporal consistency of the product and with similar products has been evaluated over globally representative locations and periods. Results are published in the peer-reviewed literature.
Stage 4 Validation	Validation results for stage 3 are systematically updated when new product versions are released and as the time-series expands.



Outline

- CONTEXT – WHY A NETWORK OF SITES?
- **VARIABLES – What to Measure ?**
- PROTOCOLS – How to measure ? Process?
- NETWORK – Where to measure ?
- RESULTS – What we have measured?
- EXPLOITATION – How to exploit data ?

Variables / Devices

- **Main Variables**
  - Leaf Area Index
  - Fraction of Absorbed PAR
  - Fraction of Vegetation Cover

" Green

- **Indirect methods**

  1) Gap fraction (P_0)

  — **DHP** (CAN-EYE software)

PAIeff

$$P_0(\theta_v,\varphi_v) = e^{-N\cdot(\theta_v,\varphi_v)} = e^{-G\cdot(\theta_v,\varphi_v)\cdot\frac{PAI}{\cos(\theta_v)}}$$

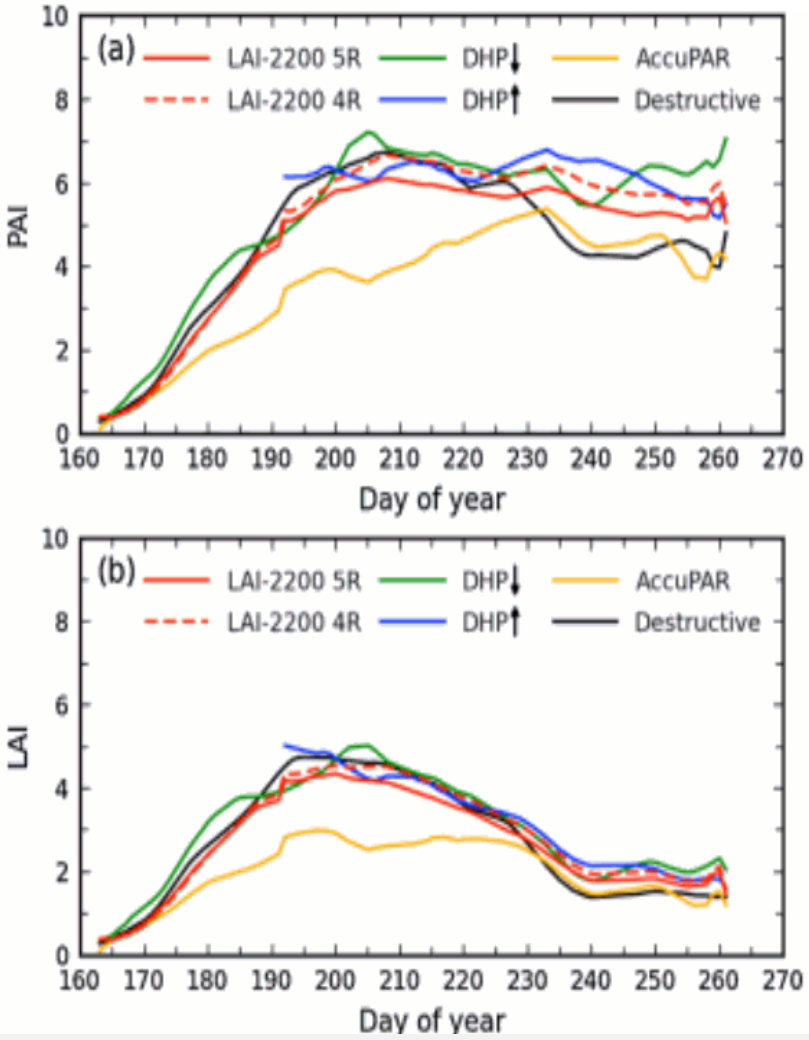
$$FAPAR^{BS}(\theta_s) = 1 - P_0\cdot(\theta_s)$$

$$FCOVER = 1 - P_0\cdot(0-10°)$$

  — **LICOR LAI 2200** (Miller's method)

$$PAI_{eff} = 2\int_0^{\pi/2} -\ln P_o(\theta)\cos\theta\sin\theta d\theta$$

Rice, Honghe Farm,China



3)

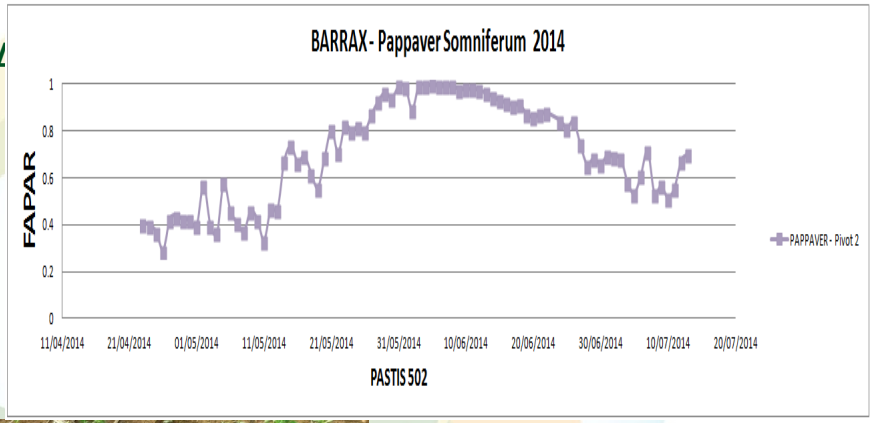
L ex

H. Fang et al. / Agricultural and Forest Meteorology 198–199 (2014) 126–141

Ground uncertainties should be quantified

Variables / Devices

- **PASTiS –PAR (PAI Autonomous System from Transmittance Sensors in the PAR domain)**
  - Developed at INRA
  - It allows continuous monitoring of PAI and FAPA
  - Data logger with 6 hemispherical PAR sensors
  - Easy to install and maintain
  - FAPAR ~1 – Transmittance (PAR balance)



Poster Session
M. Weiss “Monitoring Plant area index at ground level with PASTiS”

Context - Global Land Service / ImagineS

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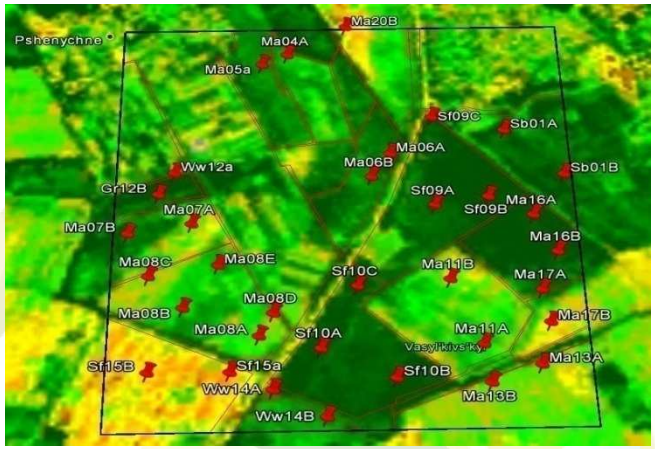
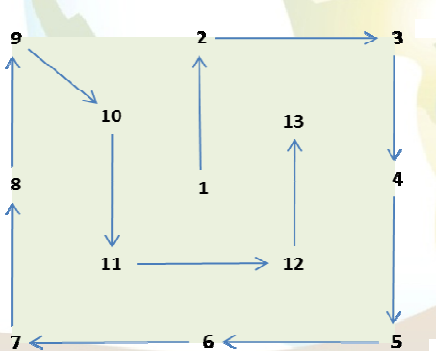
Protocol- Field Measurements

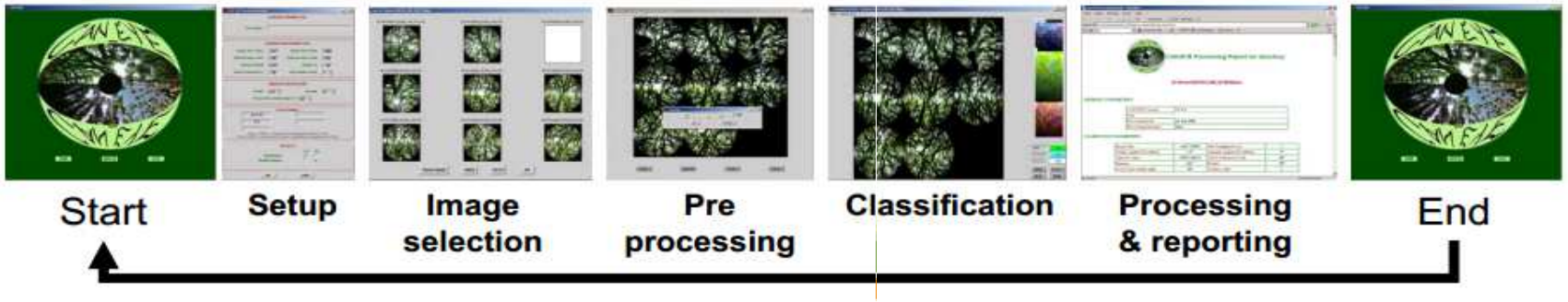
- **Guidelines for field campaigns are provided considering up-scaling needs (VALERI heritage)**
  - Size of the site: 3x3-km
  - Number of ESUs: 30- 50 sampling units
  - Size of the ESU: ~ 20x20 m (GPS at centre)
  - Sampling the site: Stratified, based on land cover
  - Sampling the ESU: 13 shots
  - Instruments: Digital Hemispherical Cameras (DHP)
  - Processing: CAN-EYE software (INRA)

Sampling the site



Sampling the ESU - DHP





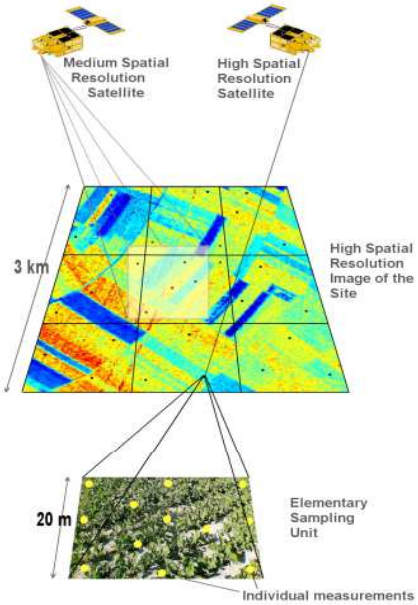
Protocol - Reporting

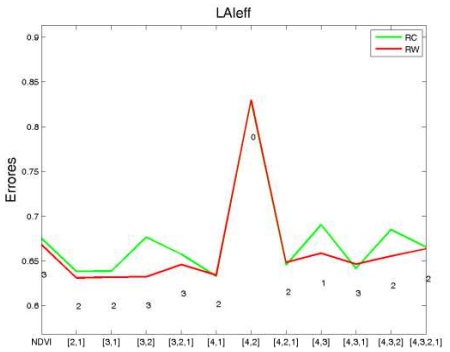
- **Comprehensive Database**
  - Header information
  - Ground dataset
  - Summary table
    - protocols, devices, summary

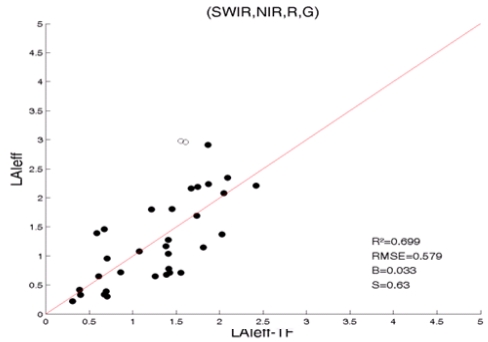
Column	Var.Name		Comment
1	Plot #		Number of the field plot
2	Plot Label		Label of the plot
3	ESU #		Number of the Elementary Sampling Unit (ESU)
4	ESU Label		Label of the ESU in the campaign
5	Northing Coord.		Geographical coordinate: Latitude (º), WGS-84
6	Easting Coord.		Geographical coordinate: Longitude (º), WGS-84
7	Extent (m) of ESU (diameter)		Size of the ESU (1)
8	Land Cover		Detailed land cover
9	Start Date (dd/mm/yyyy)		Starting date of measurements
10	End Date (dd/mm/yyyy)		Ending date of measurements
11	LAI	Method	Instrument
12		Nb. Replications	Number of Replications
13		LAIeff	Computed from the gap fraction as a function of the view zenith angle
14		Uncertainty	LAIeff standard deviation
15		LAI	LAItrue = LAIeff/clumping index
16		Uncertainty	LAItrue standard deviation
17	FAPAR	Method	Instrument
18		Nb. Replications	Number of Replications
19		FAPAR	Measured daily integrated FAPAR under direct Ilumination conditions at a given solar position
20		Uncertainty	FAPAR standard deviation
21	FCOVER	Method	Instrument
22		Nb. Replications	Number of Replications
23		FCOVER	Retrieved from gap fraction. fCover = 1-Po(0-10º)
24		Uncertainty	FCOVER standard deviation
25	WATER CONTENT	Method	Instrument
26		Nb. Replications	Number of Replications
27		Leaf WC (g/m2)	Leaf WC = (FWT-DWT)/Aleaf
28		Uncertainty	Leaf WC uncertainty
29		Canopy WC (kg/m2)	Canopy WC = leaf WC * LAI
30		Uncertainty	Canopy WC uncertainty
31	CHLOROPHYLL CONTENT	Method	Instrument
32		Nb. Replications	Number of Replications
33		Leaf Ch (microg/cm2)	Leaf Chlorophyll Content
34		Uncertainty	Leaf Chlorophyll Content standard deviation
35		Canopy Ch (mg/m2)	Canopy Chlorophyll Content = leaf Ch * LAI
36		Uncertainty	Canopy Chlorophyll Content uncertainty
37	OTHER	LAI57eff	Effective leaf area index calculated at the 57.5 zenith angle from DHP
38		FAPAR (white sky)	white sky (or diffuse) FAPAR
39		FWT (g)	Sample fresh weight. Sample includes aprox. 95% of leaves and 5% of steams
40		DWT (g)	Sample dry weight
41		Aleaf (m2)	Sample area
42		Unclassified pixels (%)	Unclassified pixels in the estimation of sample area (%)
43	COMMENTS		Additional commets

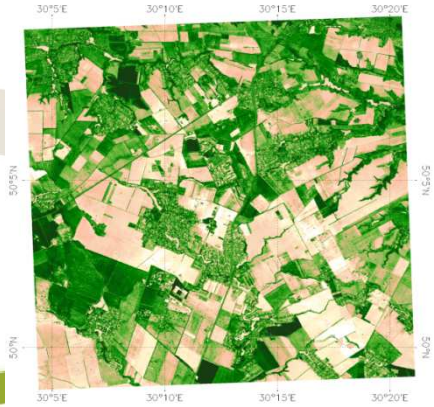
Protocol – Upscaling

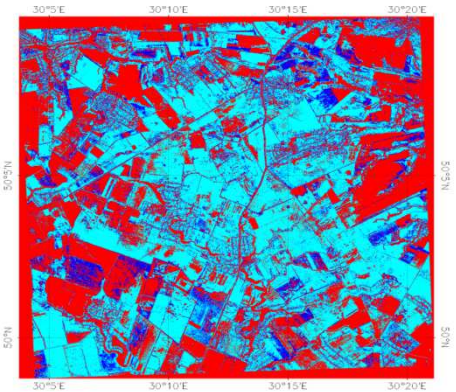
- **Ground-based maps according to CEOS LPV best practices for up-scaling (VALERI)**
  - High resolution imagery (SPOT-5, Landsat-8)
  - Evaluation of the sampling
  - Regression method: iteratively re-weighted least squares algorithm
  - Selection of band combination (lower RMSE) – Transfer Function
  - Convex Hull: Quality Flag
  - TF is applied to HR data for upscaling and empirical maps are produced











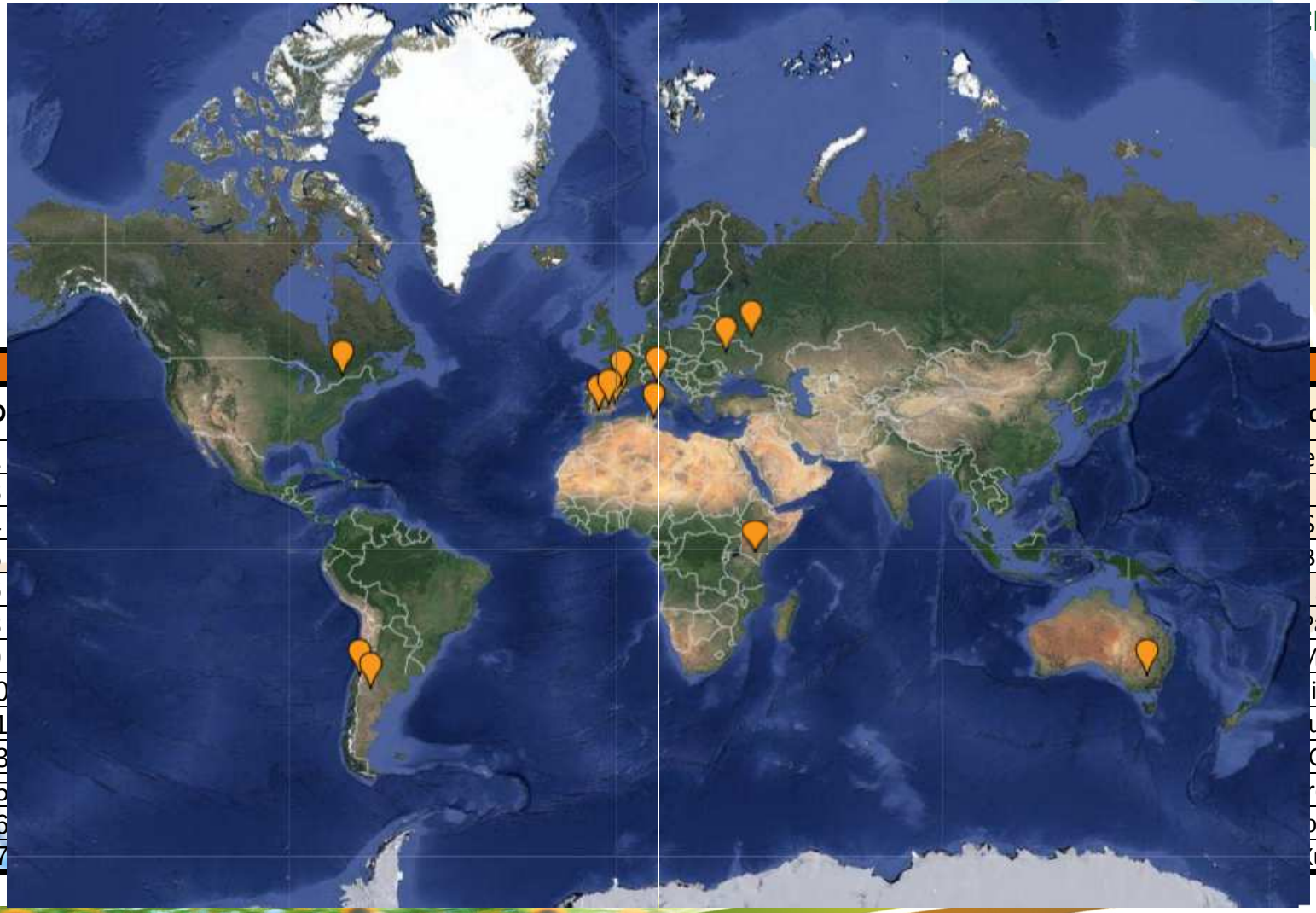
Outline

- CONTEXT – Why a network of sites?
- VARIABLES – What to Measure ?
- PROTOCOLS – How to measure ? Process?
- **THE NETWORK – Where to measure ?**
- RESULTS – What we have measured?
- EXPLOITATION – How to exploit data ?

The Network

- **ImagineS Network of demonstration sites**

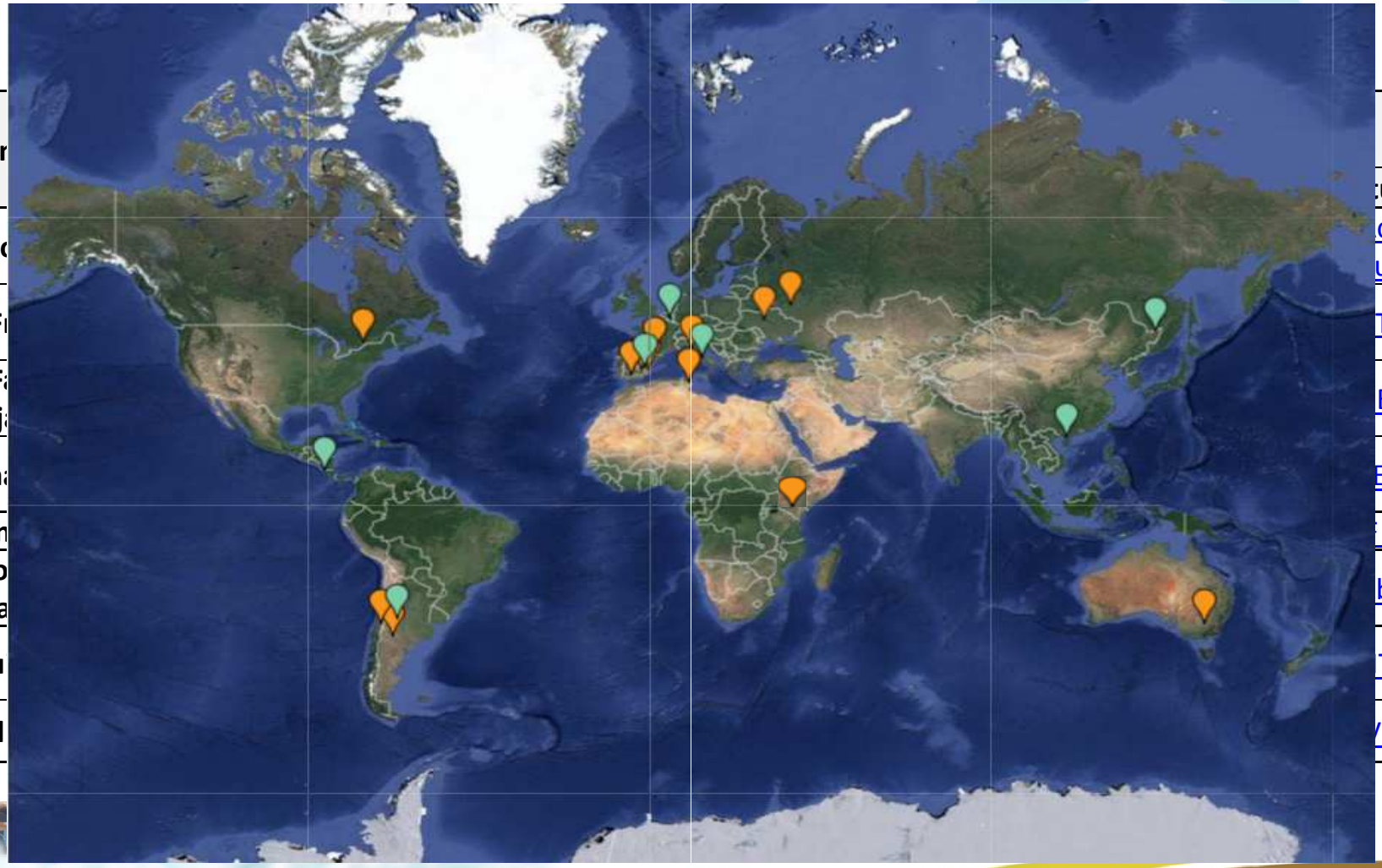
croplands /



No	ID	onsible
1	1	emarez
2	3	la Cruz
3	4	Savin
4	5	Bossio
5	6	Zribi
6	8	Pattey
7	9	Mattar
8	10	i Bella
9	11	udiger
10	13	González
11	15	rcía-Haro
12	16	oschetti
13	17	Kussul

The Network

- **Collaboration with other sites**



Site Nar	ution
Guangdo	cademy of ulture
Belgium-Fl	TO
Honghe Fa Heilongji	EIS
Capitana	ECRA
Collelon	CNR
SantaRo Guanaca	berta
San Lu	TA
Utiel	VEG

Outline

- CONTEXT – Why a network of sites?
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- NETWORK – Where to measure ?
- **RESULTS– When / How much we have measured?**
  - Examples Field Campaigns and data processing
- EXPLOITATION – How to exploit data ?

Results – Summary of Measurements

Measurements

- 2013
  - 5 sites
  - 25 campaigns
  - 436 ESUS.
- 2014
  - 7 sites
  - 25 campaigns
  - 661 ESUS.

Overall

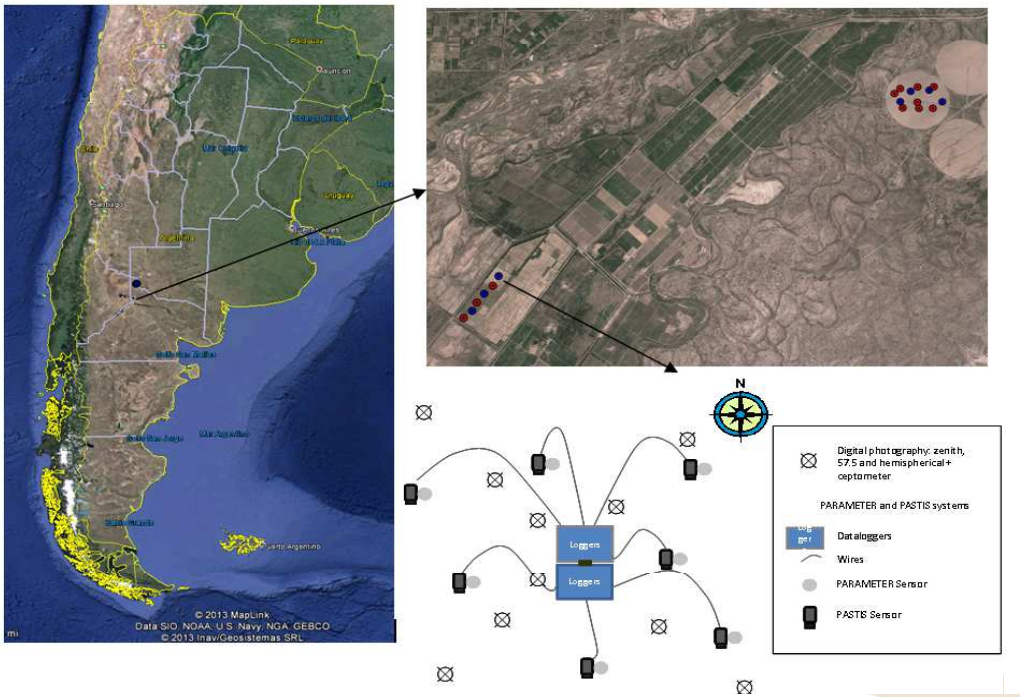
- 11 sites
- 50 field campaigns
- 1097 ESUs
- 1.849 LAI Measurements
- >12.000 DHP taken
- > 5.000 Accupar/LAI-2200 measures

ID	SITE	COUNTRY	Northing Coord	Easting Coord	CAMPAIGNS#	ESUS #	ESUS per campaing #	DATES			MEASUREMENTS 2013
								DAYS	MONTH	YEAR	TOTAL
1	**SW France**	France	43.48	1.27	5	113	26	19-26	June	2013	26
							21	09--11	July	2013	21
							23	24-29	July	2013	23
							22	16-20	August	2013	22
							21	2--6	September	2013	21
6	**Merguellil**	Tunisia	35.75	10.08	9	91	6	31	January	2013	6
							9	20	February	2013	9
							14	8	March	2013	14
							17	26	March	2013	17
							7	11	April	2013	7
							8	17	April	2013	8
							18	3	May	2013	18
							5	15	May	2013	5
							7	19	December	2013	7
8	**Ottawa**	Canada	45.30	-75.50	4	34	12	10--26	June	2013	12
							14	3--31	July	2013	14
							4	15,26	August	2013	4
							4	10,18	September	2013	4
17	**Pshenichne**	Ukraine	50.075	30.11	3	102	31	14-17	May	2013	31
							34	12--15	June	2013	34
							37	14-17	July	2013	37
B14	**Guagdong-xuwen**	China	20.87	110.08	4	100	25	9	April	2013	25
							25	6	May	2013	25
							25	26	May	2013	25
							21	19	June	2013	21

ID	SITE	COUNTRY	Northing Coord	Easting Coord	CAMPAIGNS#	ESUS #	ESUS per campaing #	DATES			MEASUREMENTS
								DAYS	MONTH	YEAR	TOTAL
3	**Barrax**	Spain	39.03	-2.07	1	30	30	29-30	May	2014	30
4	**Tula**	Russia	53.08	37.23	5	155	31	9	April	2014	31
							31	23	May	2014	31
							31	26	June	2014	31
							31	25	July	2014	31
							31	3	September	2014	31
6	**Merguellil**	Tunisia	35.75	10.08	6	77	15	21	January	2014	15
							15	14	February	2014	15
							13	21	March	2014	13
							15	15	April	2014	15
							15	8	May	2014	15
							4	28	May	2014	4
10	**La Pampa**	Argentina	-37.90	-67.73	1	44	44	7-9th	February	2014	44
13	**Cordoba**	Spain	37.78	-4.73	1	55	55	19-20	May	2014	55
15	**Albufera**	Spain	39.274369	-0.316439	9	257	34	17	June	2014	65
							26	24-25	June	2014	64
							28	29	June	2014	84
							19	6	July	2014	57
							36	15	July	2014	96
							27	22	July	2014	131
							27	31	July	2014	159
							36	7	August	2014	219
							24	22	August	2014	160
16	**Rosasco**	Italy	45.253	8.562	1	43	43	3--4	July	14	43

Field Campaigns and Data Processing
25 Mayo - La Pampa

- **25 Mayo (La Pampa) : Water Balance Assessment in the 'Rio Colorado' Basin**

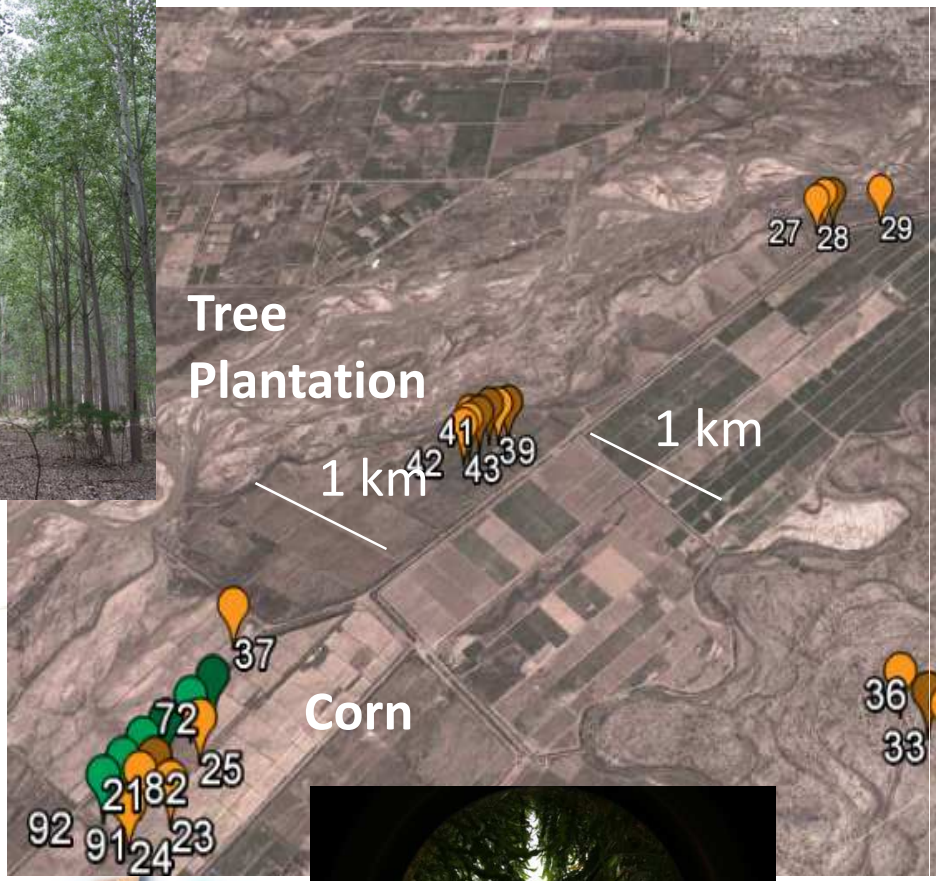


Semi-desertic area with irrigated alfalfa pastures

- Contact:
  - Carlos Di Bella (INTA)
  - INTA-25 Mayo
- Instrumentation:
  - PAR@METER & PASTIS sensors
  - DHP for intercomparsion & uncertainty estimate
- Sampling/Protocol:
  - Two plots (5-10 ESUs each) with PAR@METER & PASTIS sensors
  - IMAGINES protocol for DHP
- Planned acquisitions:
  - Continuous growing season 2014 and 2015
  - Intensive Field campaign (EOLAB) February 2014

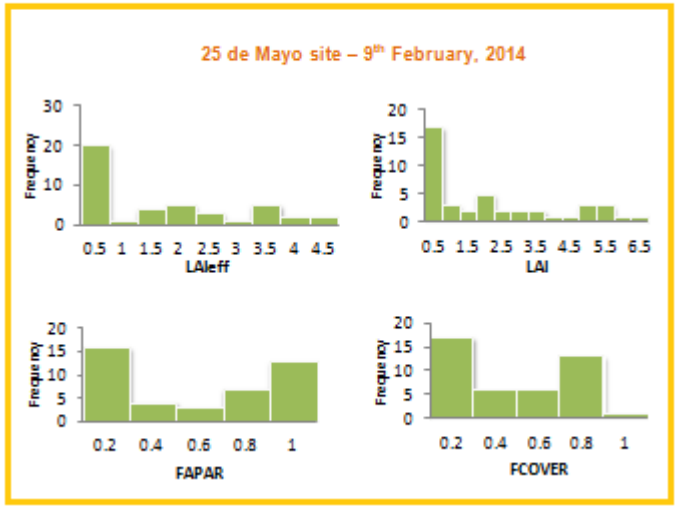
Field Campaigns and Data Processing
25 Mayo - La Pampa

- **Spatial sampling**



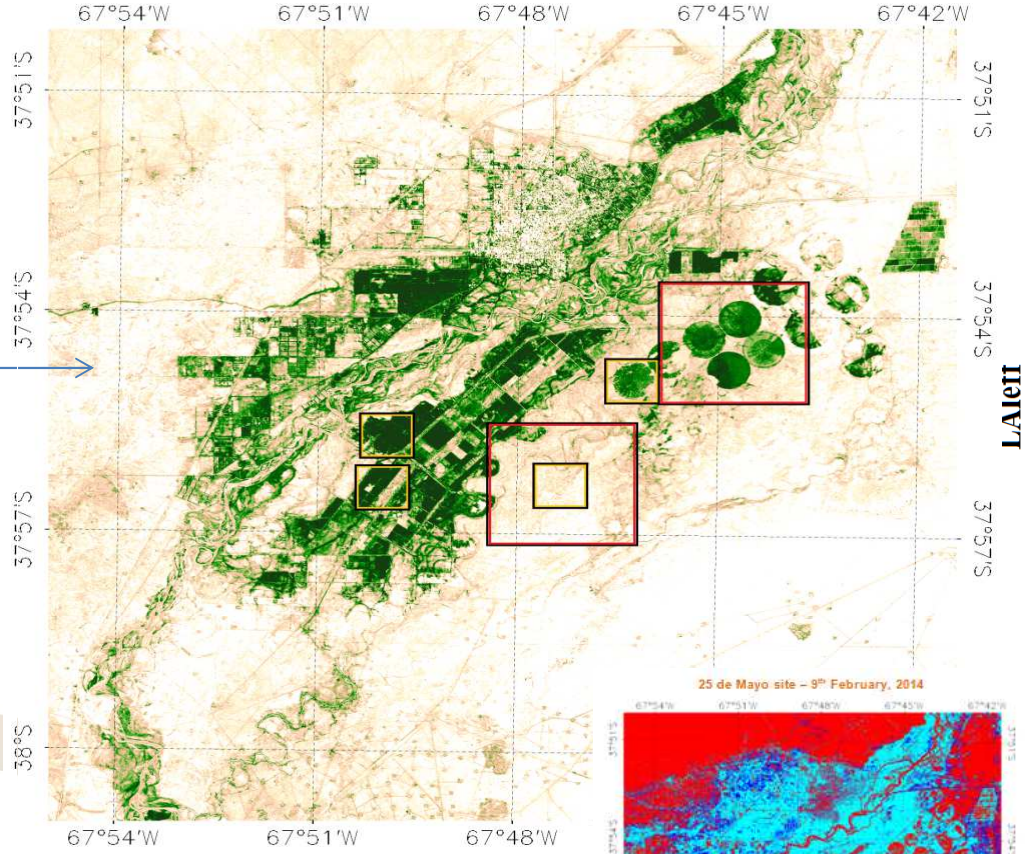
Field Campaigns and Data Processing
25 Mayo - La Pampa

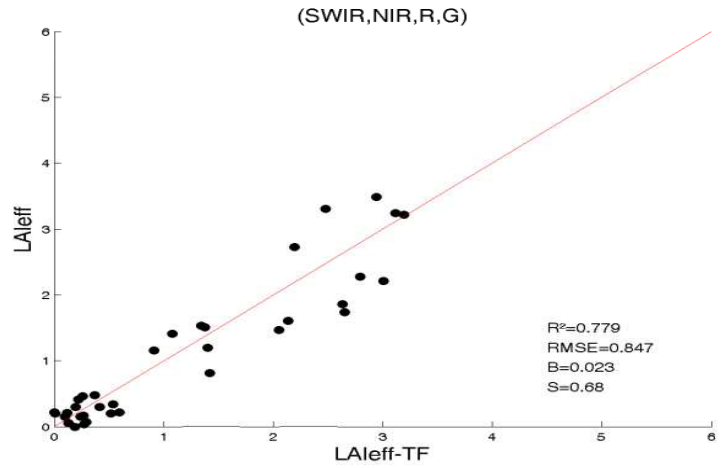
- **Ground based maps using SPOT-5**

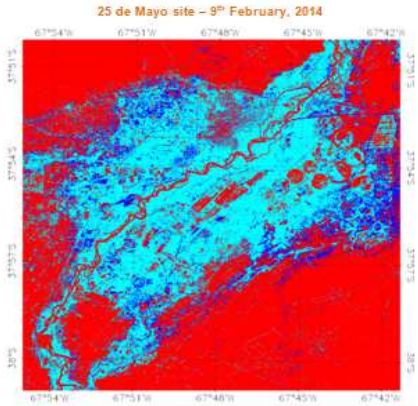


SPOT-5

Selected validation areas



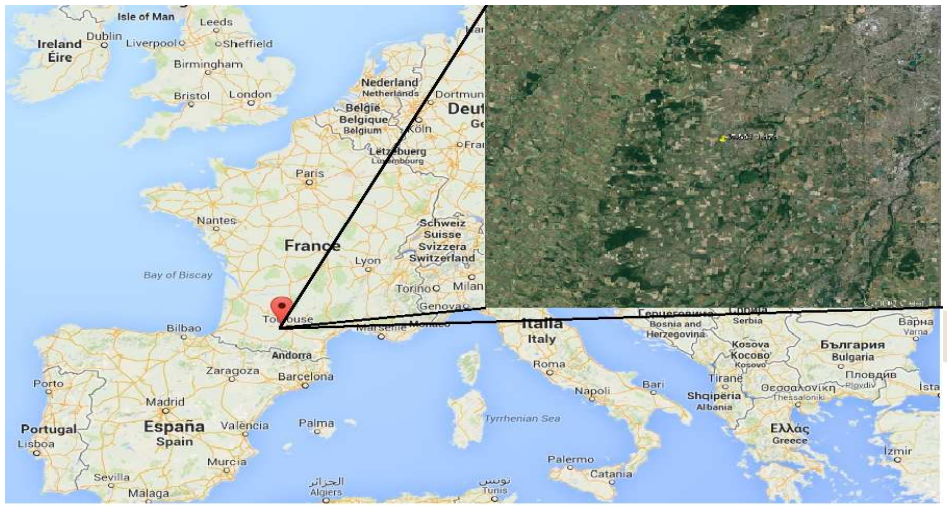




Field Campaigns and Data Processing South West 2013

- **1- South West – FRANCE 2013**
  - Contact:
    - Valerie Demarez (CESBIO)
  - Instrumentation / software:
    - DHP (CAN-EYE)
  - Sampling:
    - Multi-temporal acquisitions
    - ~ 25 ESUs

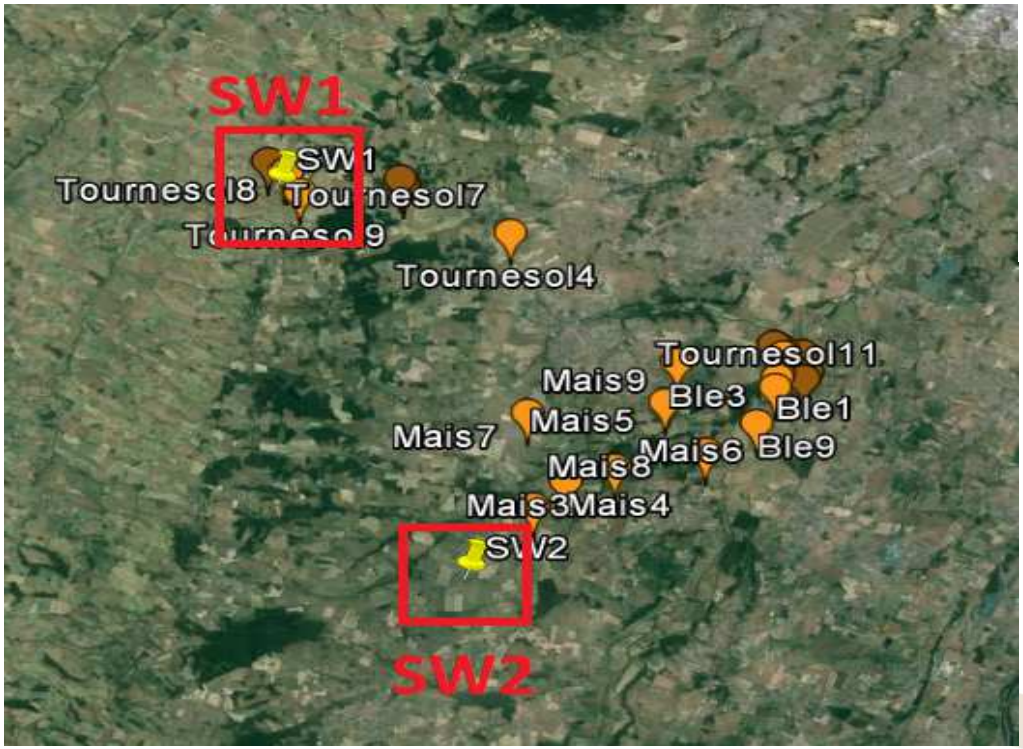
- Multi-temporal field data was grouped in five campaigns.
- SPOT5 and Landsat-8 imagery used for up-scaling the ground data



CAMPAIGN	DATES	IMAGERY
First campaign	19th to 26th of June 2013	LANDSAT8 TOA (26.06.2013)
Second campaign	9th to 11th of July 2013.	SPOT5 TOA (15.07.2013)
Third campaign	24th to 29th of July 2013	SPOT5 TOA (25.07.2013)
Fourth campaign	16th to 20th of August 2013	LANDSAT8 TOA (20.08.2013)
Fifth campaign	2nd to 6th of September	LANDSAT8 TOA (29.08.2013)

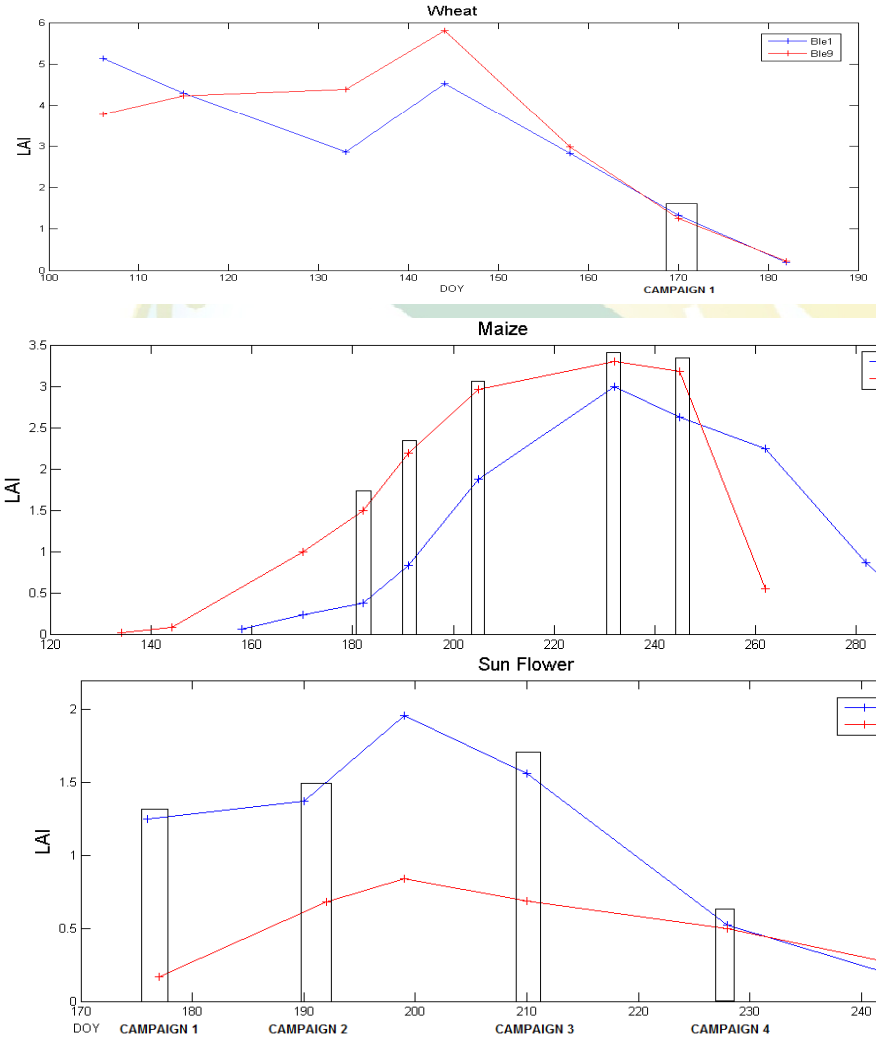
Field Campaigns and Processing South West 2013

- **Spatial sampling**



SouthWest is quite heterogeneous, but TF was applied to a large area, and two 3x3 km homogeneous areas were selected

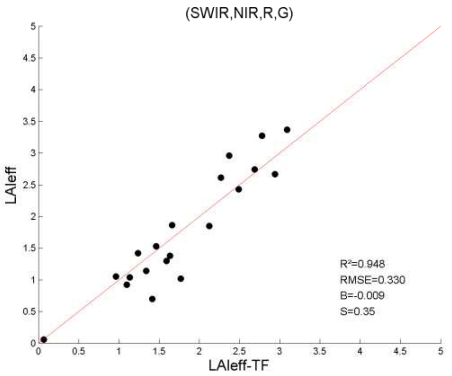
Temporal sampling

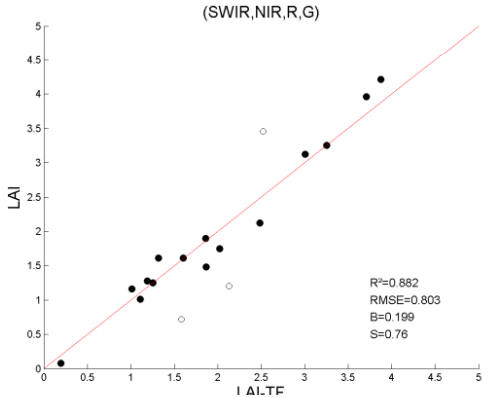


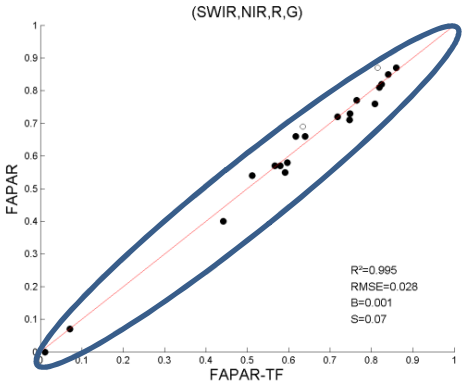
Multi-temporal field data was grouped in five campaigns.

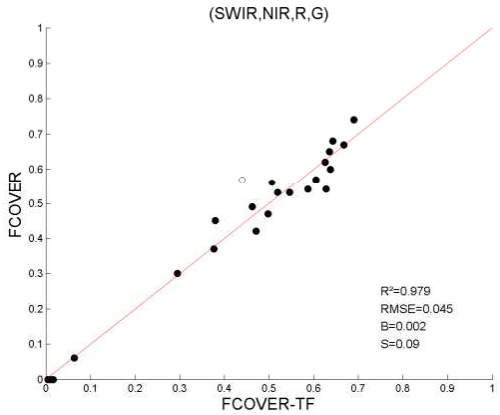
Field Campaigns and Data Processing South West 2013

Third campaign (SPOT-5)

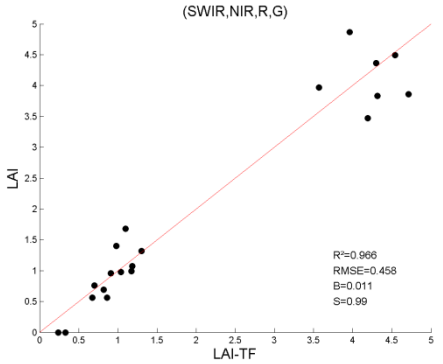


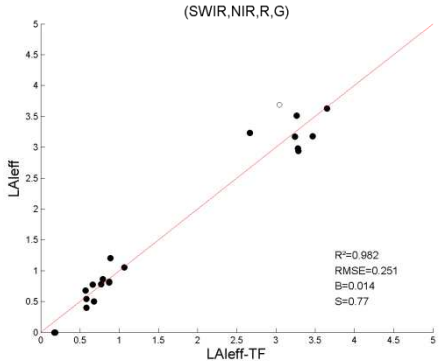


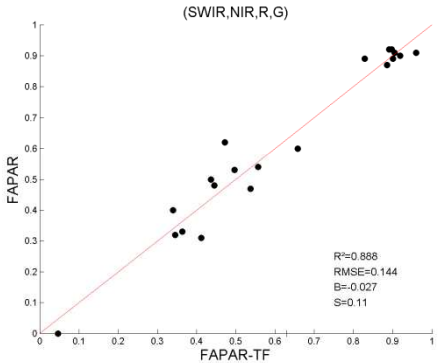


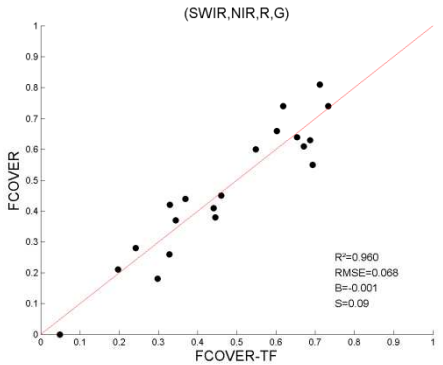


Fourth campaign (Landsat-8)







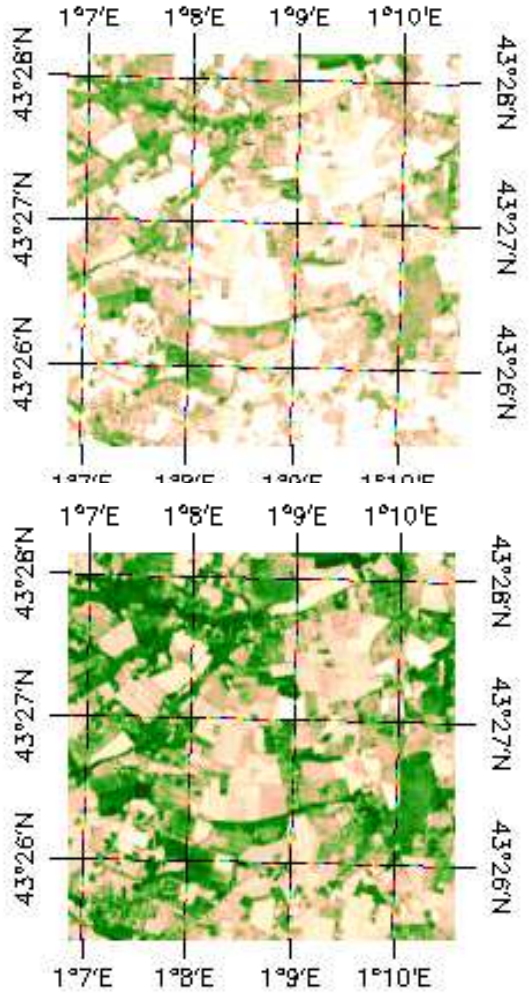


Very good transfer functions were obtained with very low RMSE (better for SPOT.-5)

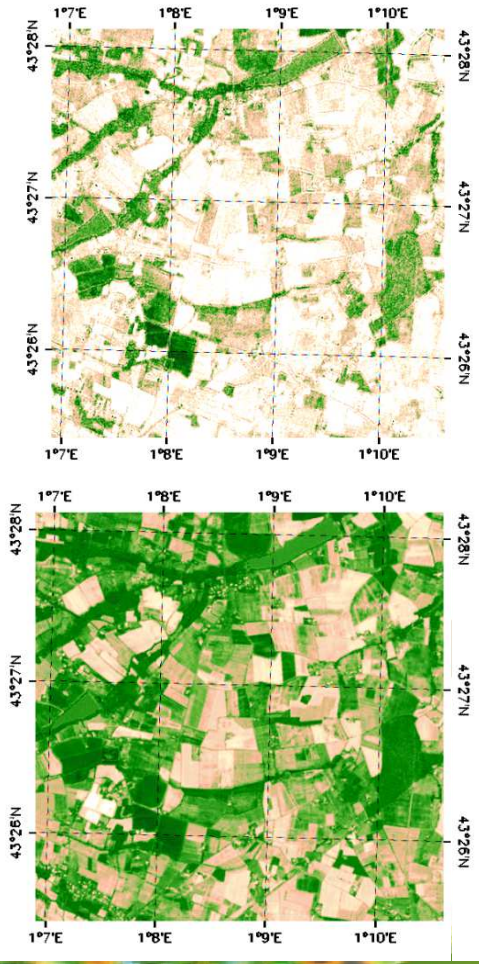
Field Campaigns and Data Processing South West 2013

Ground-based maps: SPOT-5 vs Landsat-8 (third campaign)

Landsat-8

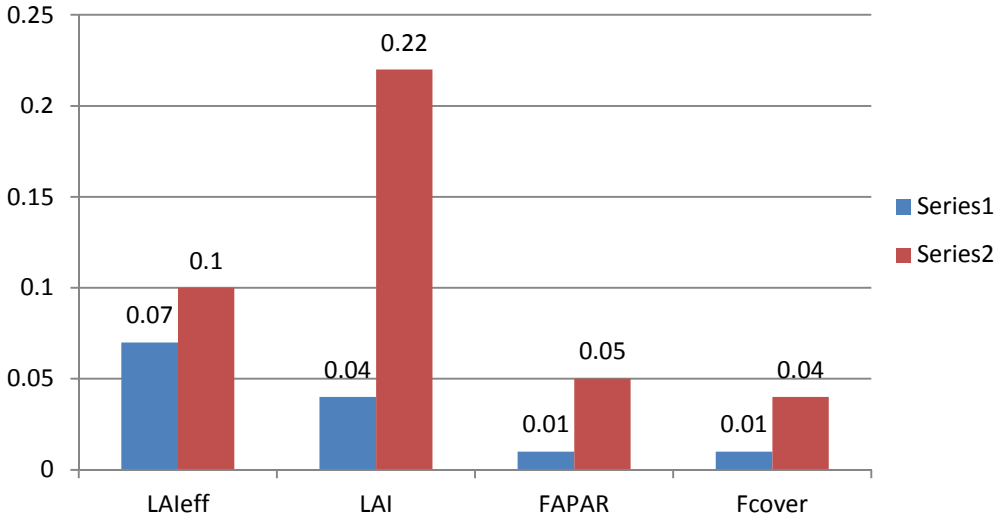


SPOT-5



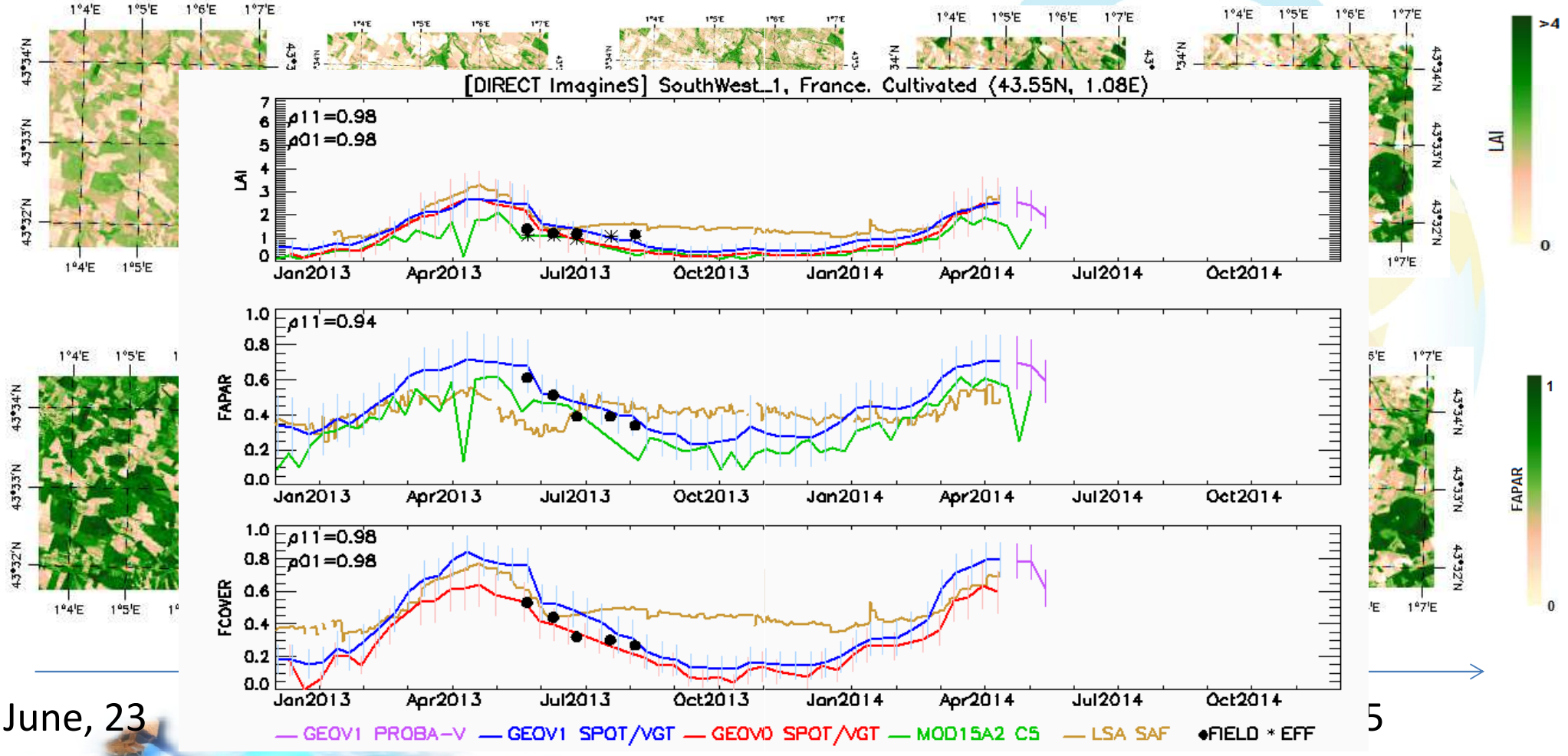
Absolute differences in mean values are very low.
Relative differences in mean values are ranging between 3% and 9%

Differences in aggregated values (3x3-km)



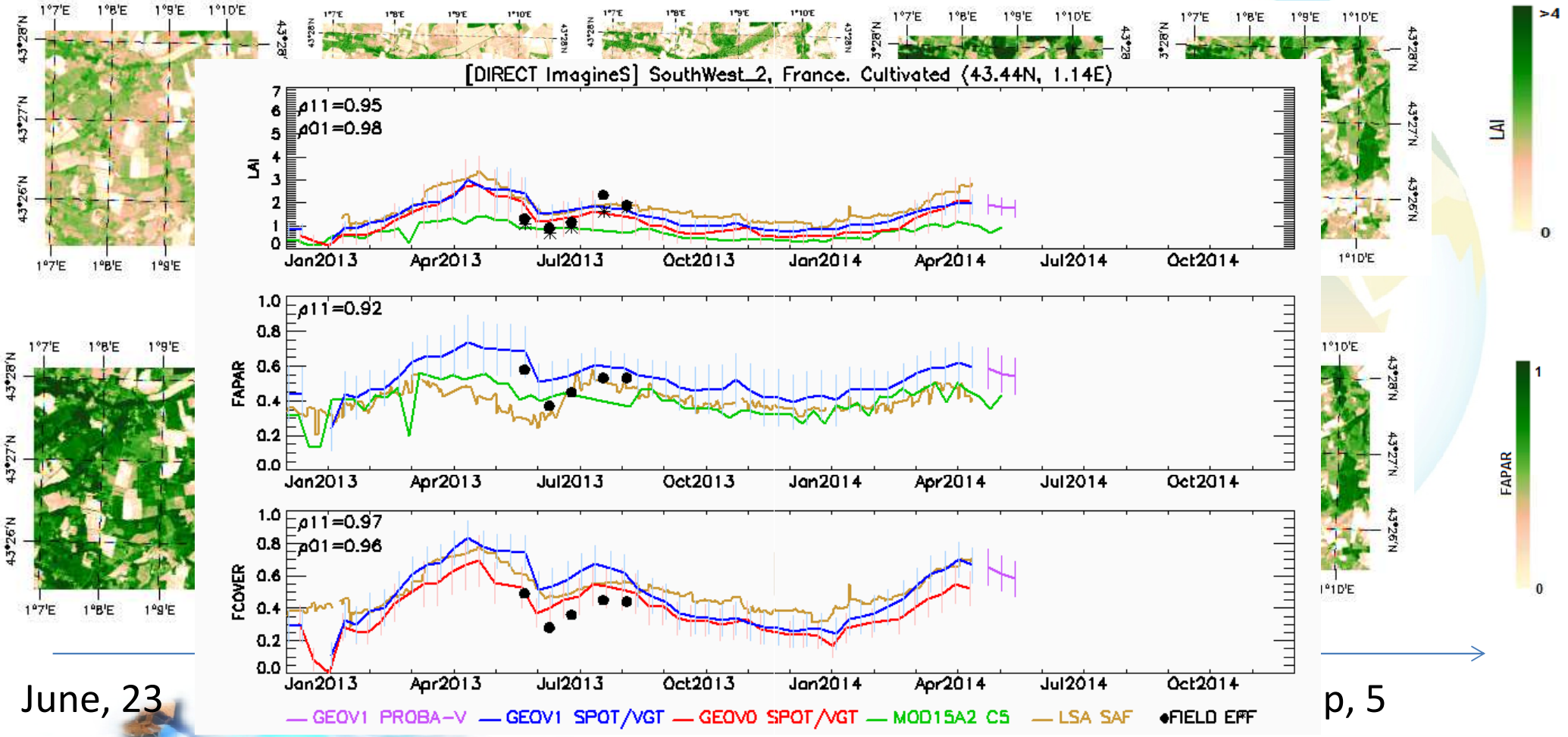
Field Campaigns and Data Processing South West 2013

Ground-based Maps: South West_Zone 1 (Spring crops)



Field Campaigns and Data Processing South West 2013

Ground-based Maps: South West_Zone 2 (Summer crops)



Field Campaigns and Data Processing
La Reina- Córdoba

- **13- La Reina -Córdoba (SPAIN)**

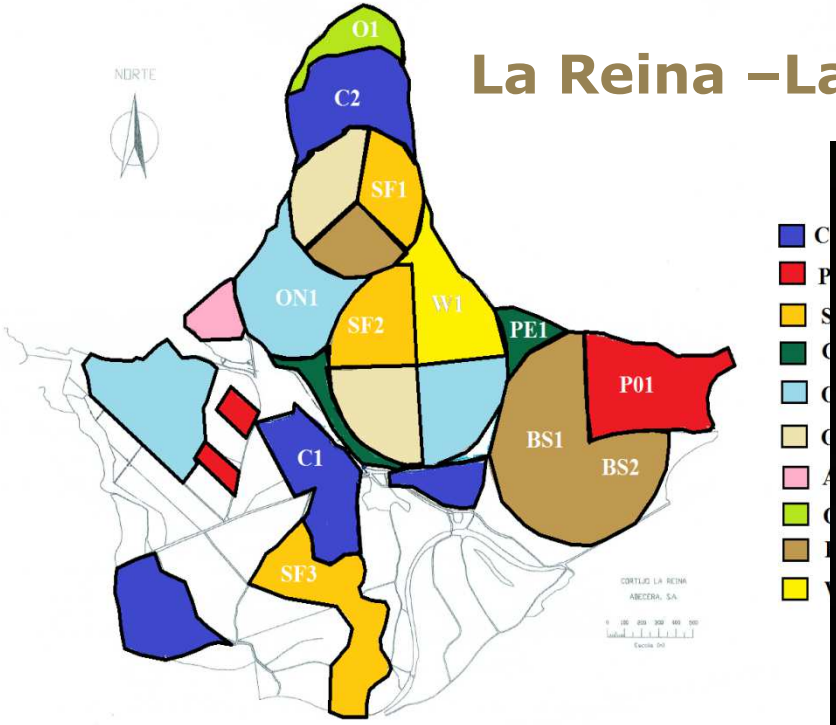
- Contact:
  - M.Pat González (IFAPA)
- Application
  - Irrigation Advisory System
- Instrumentation:
  - DHP
- Field campaign:
  - 19-20 May
- Sampling/Protocol:
  - 55 ESUS /IMAGINES for DHP

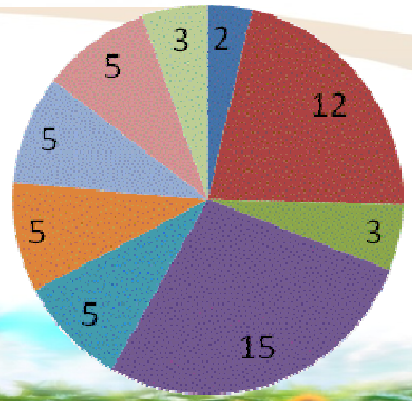
Flat cropland area where IFAPA is developing an space assisted advisory agriculture service

IFAPA

Field Campaigns and Data Processing
La Reina- Córdoba

La Reina –Land Use



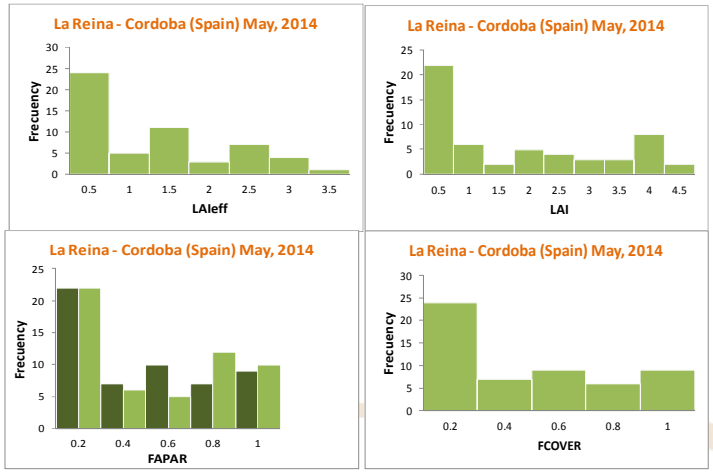


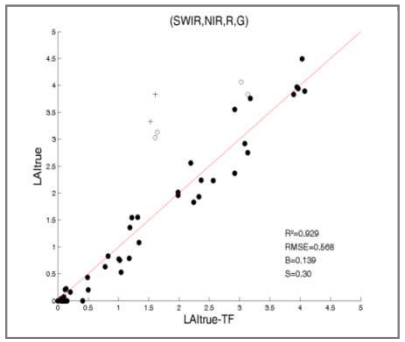
Total of 55 ESUs

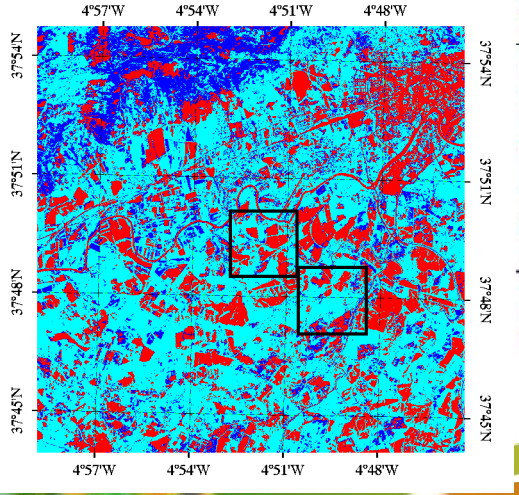
Spatial sampling

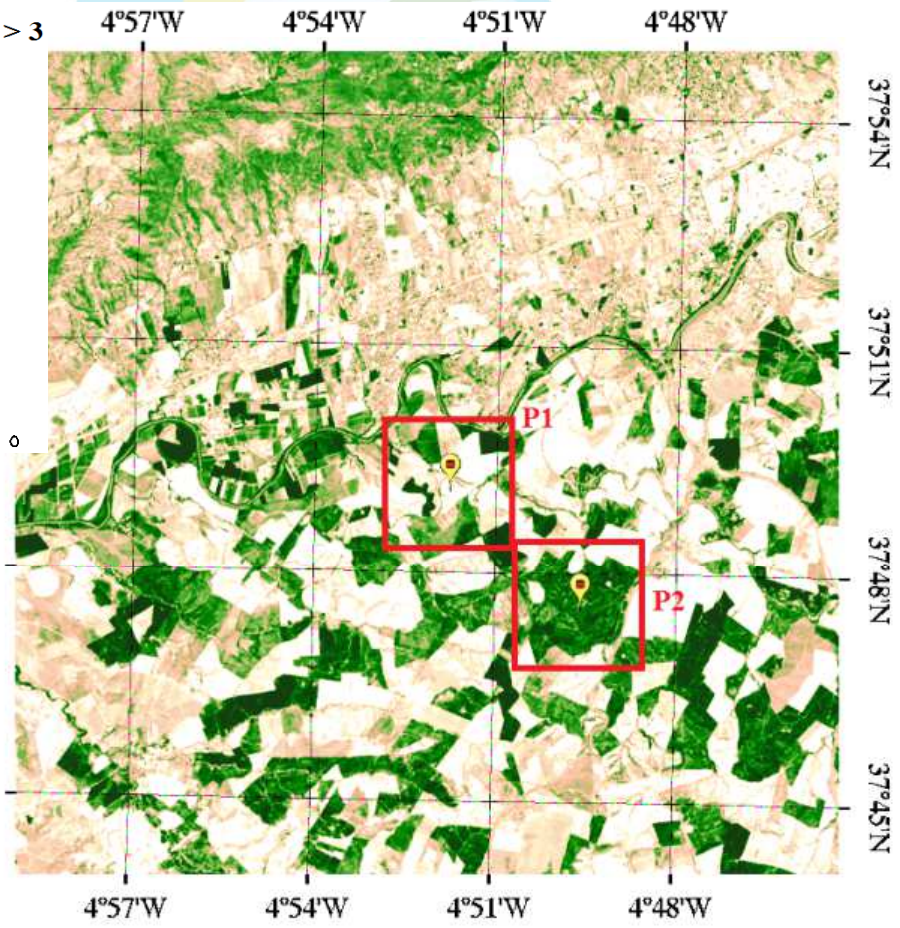
Field Campaigns and Data Processing
La Reina- Córdoba

From ground data to ground-based maps (Landsat-8)







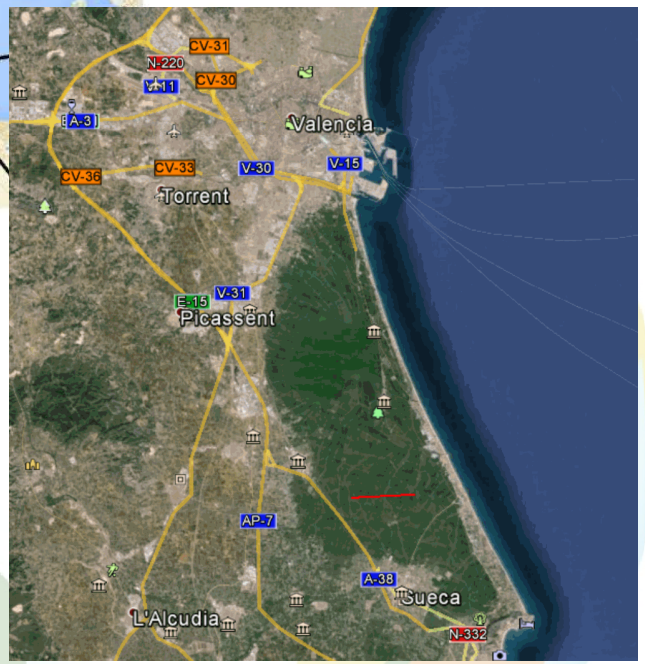


Field Campaigns and Data Processing
La Albufera, Valencia

15 – La Albufera, Spain

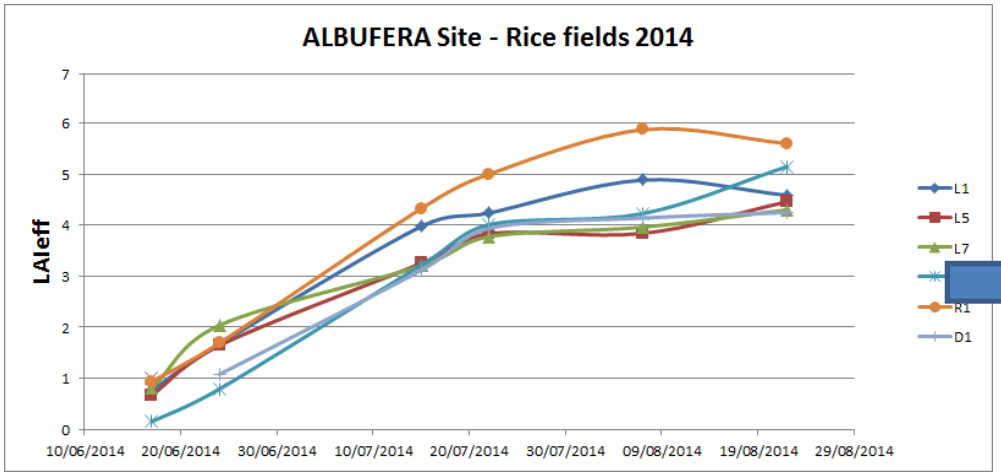
Collaboration with ERMES project

- Contact:
  - Javier Garcia-Haro (UVEG)
- Instrumentation:
  - DHP (two cameras)
  - LAI2000 & LAI2200
  - Accupar
  - App movil
- Sampling/Protocol:
  - 10 campaigns (June-Sept)
  - 20-35 ESUs per campaign

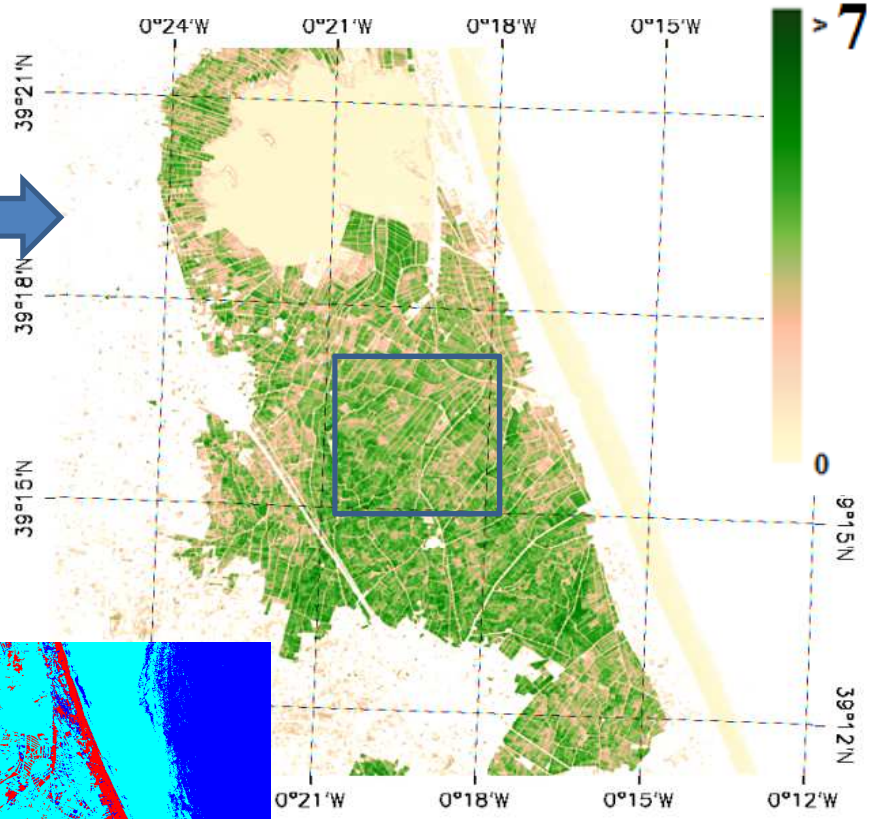


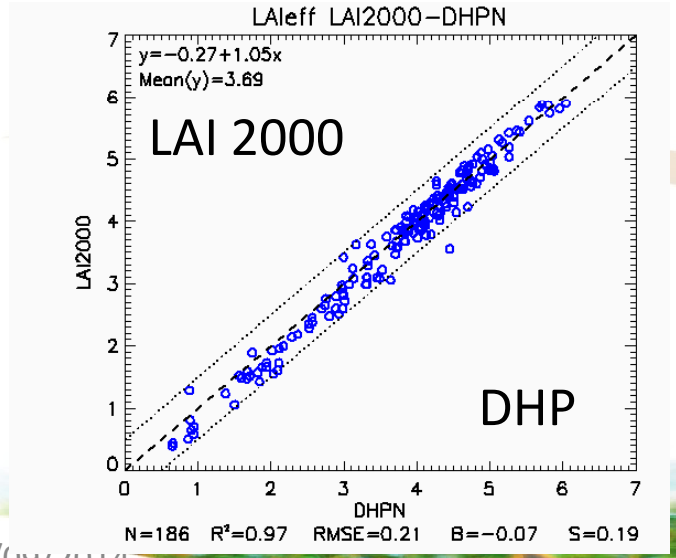
Field Campaigns and Data Processing Ongoing activities

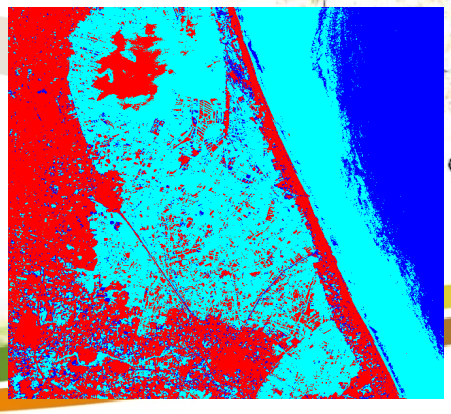
- **Ground data**



Ground-based HR map (Landsat-8) 15 July



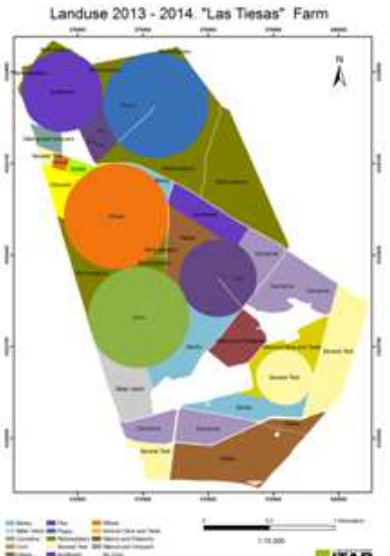


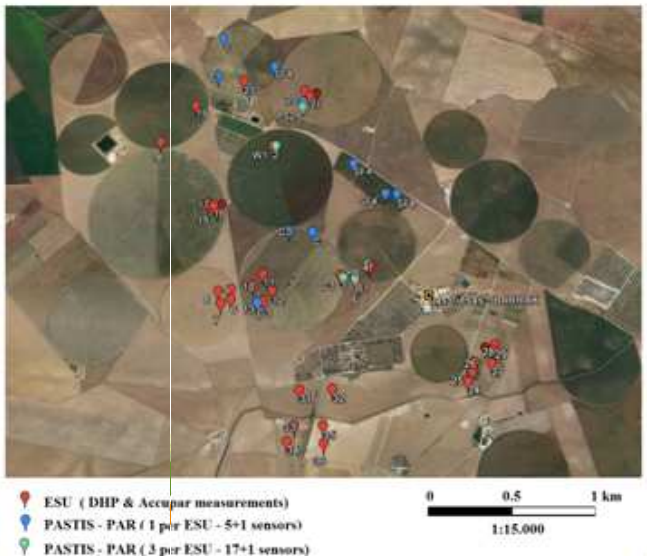


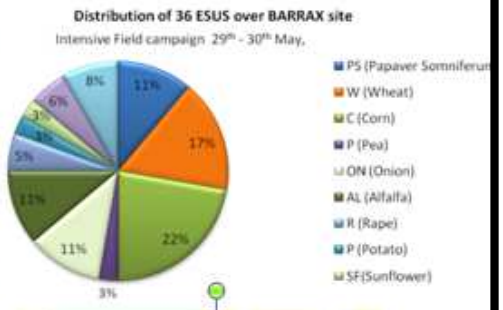
Field Campaigns and Data Processing
Ongoing activities

Field Campaigns and Data Processing
Barrax, Spain

- **Field campaign**
  - Intensive field campaign 29th -30th May 2014 (DHP and Accupar) 36 ESUS
  - PASTiS- PAR systems (two different samplings)



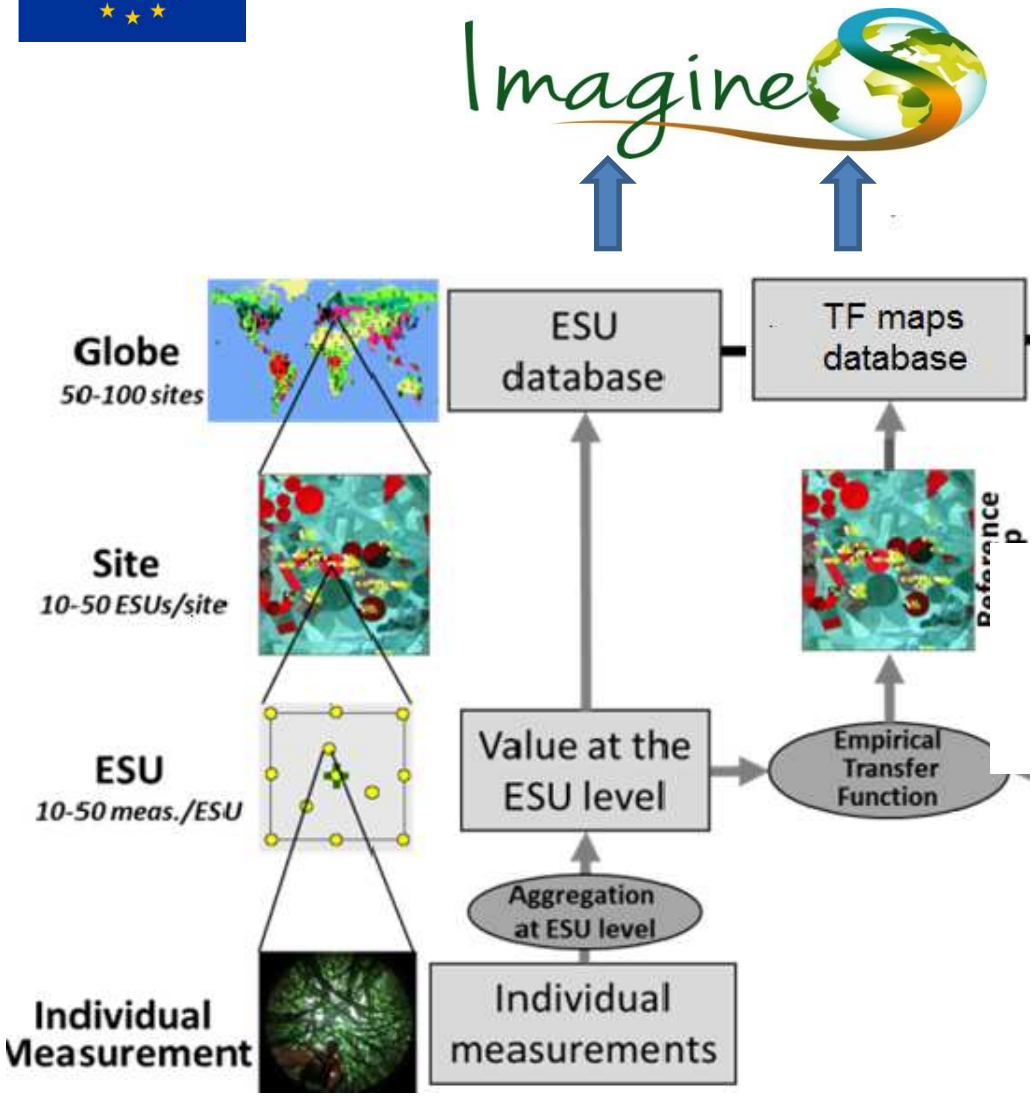




Outline

- CONTEXT – Why a network of sites?
- VARIABLES – What to Measure ?
- PROTOCOLS – How to measure ? Process?
- NETWORK – Where to measure ?
- RESULTS – When / How much we have measured?
  - Examples Field Campaigns and data processing
- **EXPLOITATION – How to exploit this dataset ?**

Data Exploitation



Mean values

- **ESU database**
  - Accuracy of decametric products
  - Temporal consistency
- **Reference maps database**
  - Accuracy of decametric products
  - Accuracy of medium resolution products (333, 1km)
  - Temporal consistency

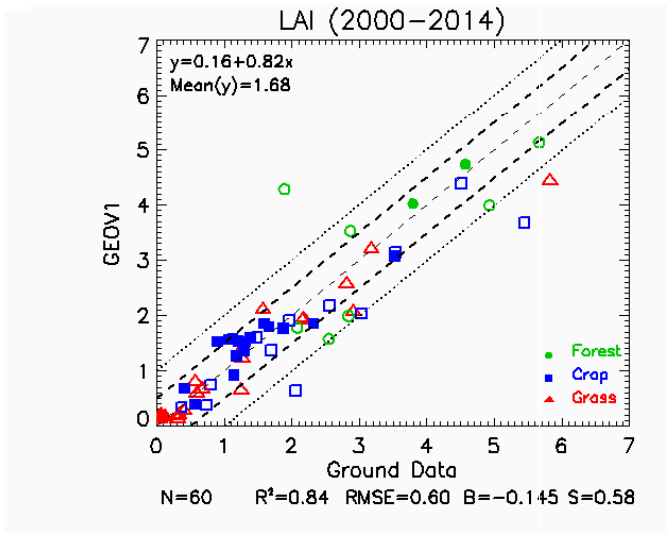
Data Exploitation

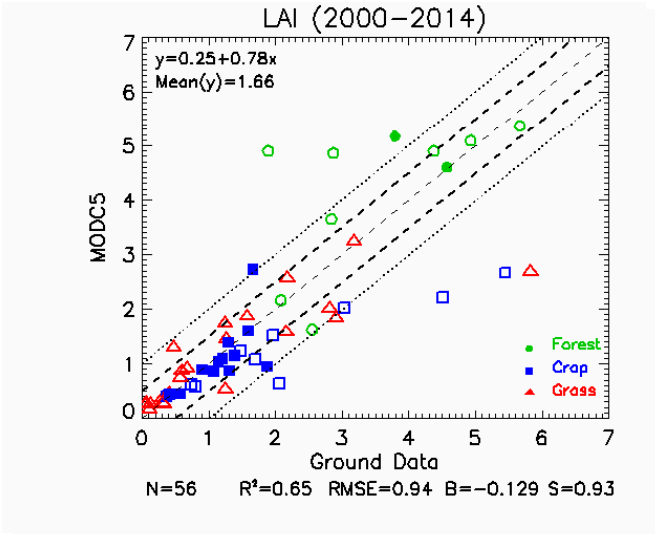
SEVENTH FRAMEWORK PROGRAMME

SPOT/VGT GEOV1

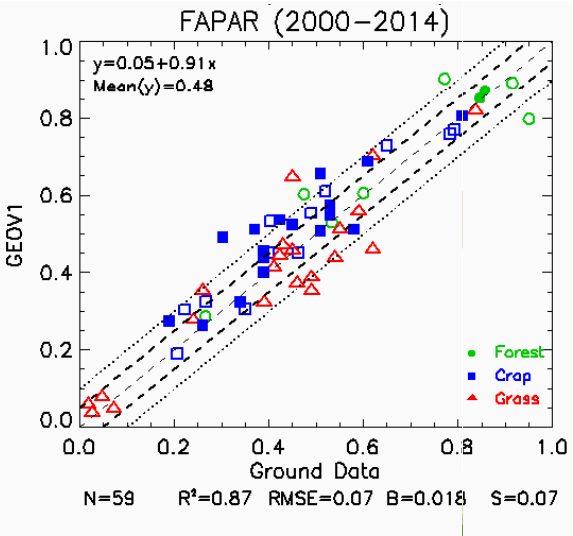
MODIS C5

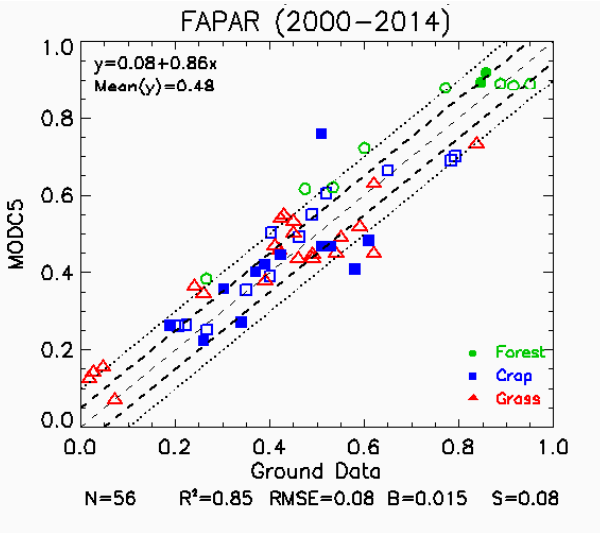
LAI





FAPAR





Summary

- A network of sites (17) over cropland/grassland sites was established within ImagineS for validation of PROBA-V (1 km, 333 m) biophysical products of Copernicus Global Land and decametric products.
- Protocols for ground acquisitions and up-scaling well-established (VALERI heritage).
- PASTiS system have been installed to acquire continuous PAR data
- Since 2013, more than 50 field campaigns in 11 demonstration sites
  - >1000 ESUs sampled >12.000 DHP taken
  - 20 ground reference HR maps already available.
- Untill the end of the project:
  - San Fernando (Chile), Upper Tana Basin (Kenya) to be sampled
  - Strength collaborations with other teams to increase the number of sites and vegetation types.
  - Share ground datasets trought ImagineS and OLIVE.

Thanks for your attention!

Special thanks to all researchers and institutions involved in the collection of ground data sets