Assessment of FVC and LAI ground measurement's uncertainties and estimation of reference maps for the validation of LSA SAF products over the Barrax cropland area

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OBJECTIVES

- **Evaluation of ground measurement's uncertainties**

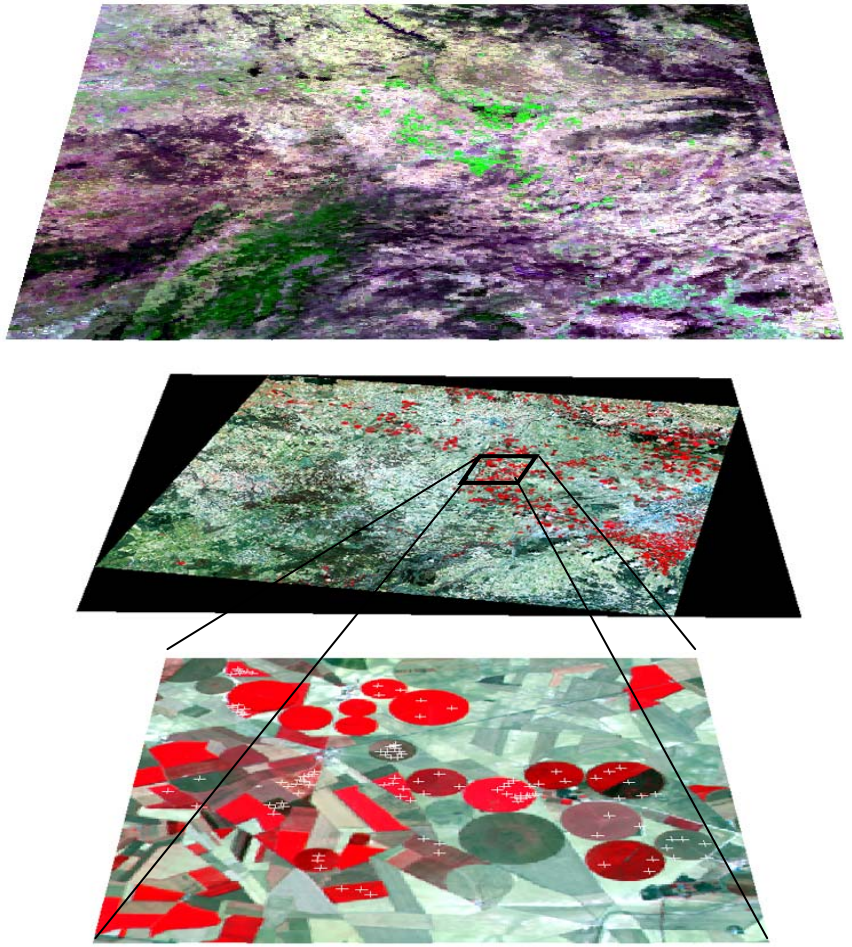
- **Characterization of FVC and LAI over the Barrax cropland area from ground measurements and a high resolution Landsat-TM image** by using:

(i) empirical transfer functions

(ii) operational remote sensing methods (SMA / LSA SAF (García-Haro et al., 2006), Chen / GLOBCARBON (Chen et al., 2002) and NDVI / JRC (Bartholomé et al., 2002))

in order to **assess the accuracy** achieved using the proposed remote sensing approaches and evaluate their capability to estimate reference maps for the **validation** of vegetation products at coarse satellite resolution (LSA SAF products).

Up-scaling



Validation of LSA SAF products

Medium and Coarse

Biophysical products

Agregation of high -resolution maps

High – Resolution biophysical maps

Empirical TF

Spatial extension of local measurements

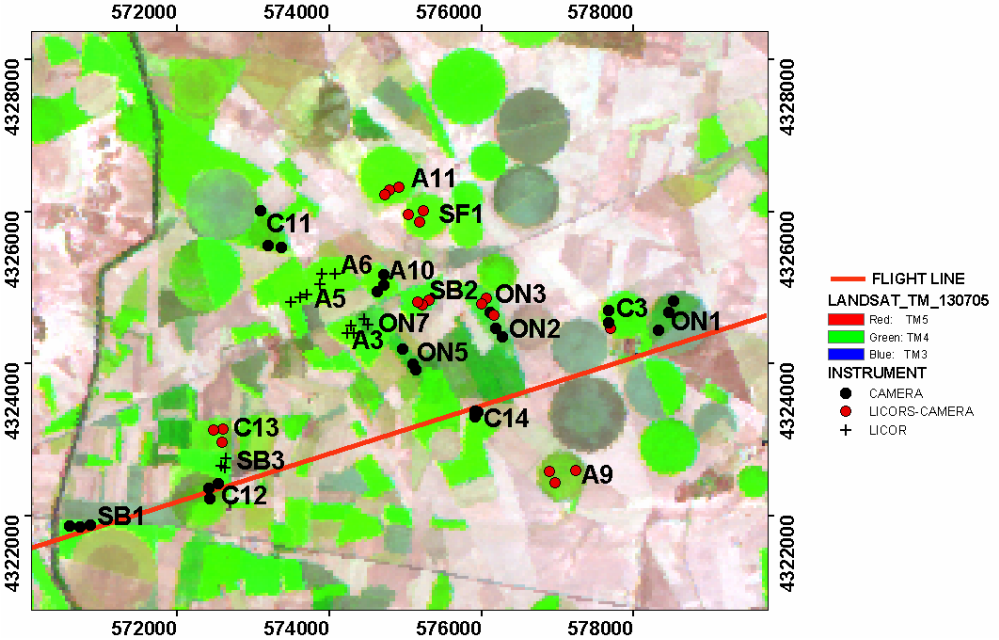
Operational RS methods

Landsat TM-5 13 July 05 image

Appropriate Ground Data Set

LAI/FVC

SEN2FLEX 2005



SEN2FLEX campaign
11-13 July, 2005

Barrax (39.07º N, 2.13º W)
Area: 10 x 10 km^2
65% dry land
35% irrigated land
ESU: 20 x 20 m^2

Stratified random sampling method

Two different **sampling strategies inside the ESU** were followed:

LICOR LAI2000

3 replications per ESU (↑↓↓↓↓↓↓↓↓).

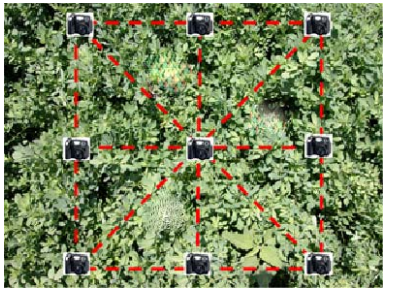
The replications were distributed **randomly** within the ESU

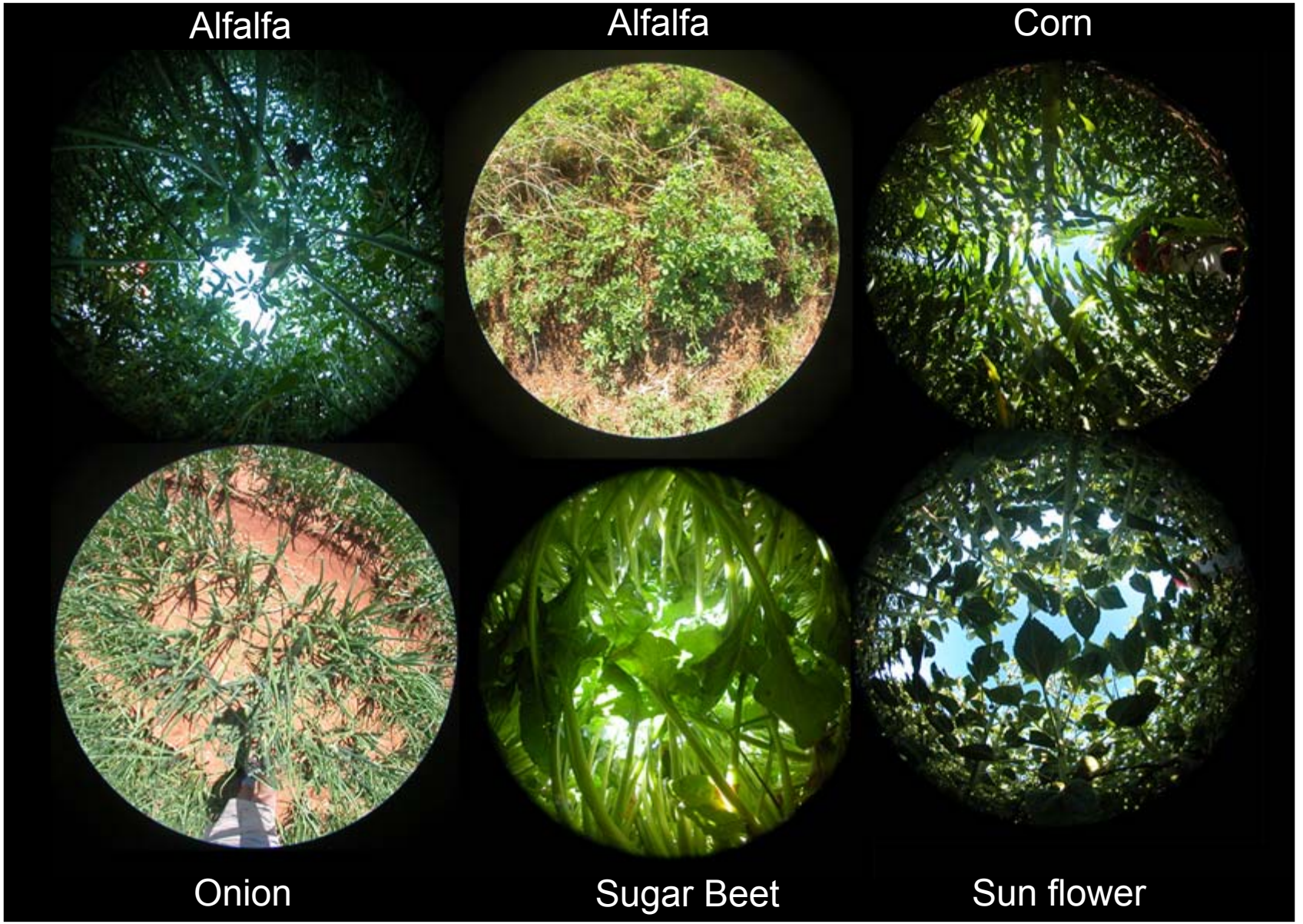
Hemispherical camera (DHP)

Sampling design → VALERI methodology.

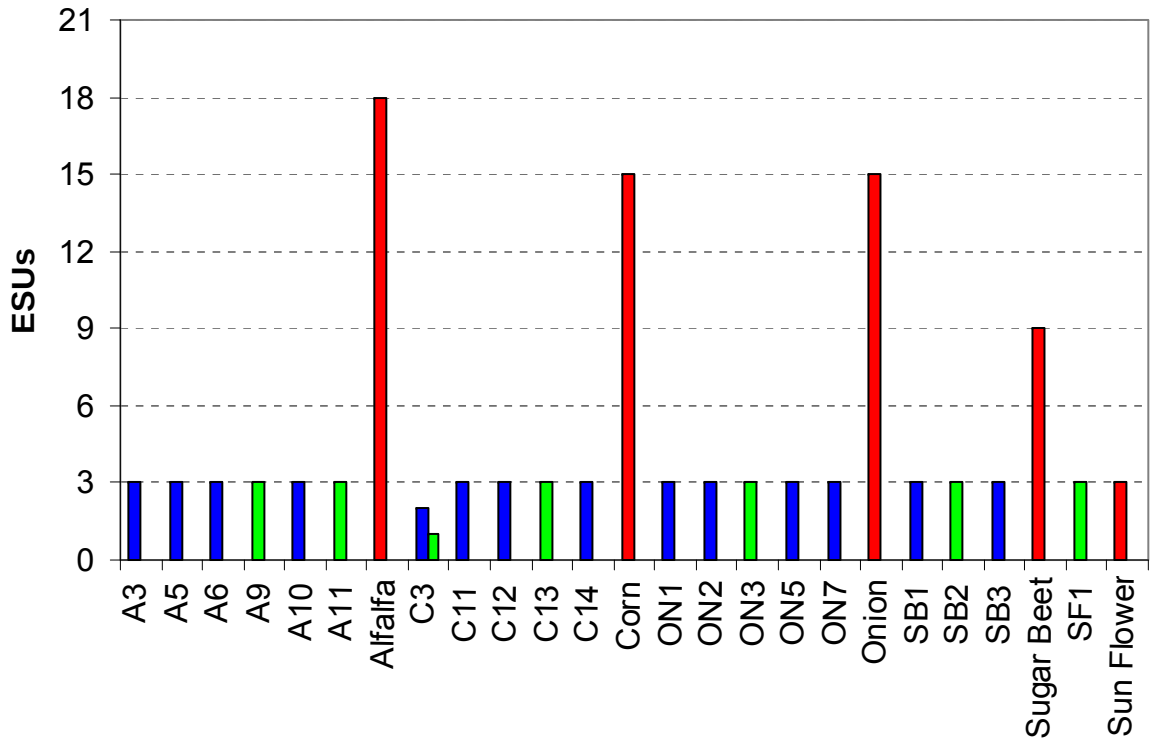
9 Photographs per ESU

Processed with




Alfalfa
Alfalfa
Corn
Onion
Sugar Beet
Sun flower

Instrument	nº ESUs
CAMERA	26
LICOR A	7
LICOR B	8
SIMULTANEOUS	19
TOTAL	60



5 crops: Alfalfa, Corn, Onion, Sugar Beet and Sun Flower

Different fields per a same crop were sampled. The number of **ESUs** ranges between **3 and 18**.

Spatial Extension to High resolution

The empirical Transfer Function (TF) is based on an iteratively re-weighted least square algorithm (IRLS) (Weiss, 2004; Martínez et al., 2006).

The TF was selected based on the lowest **RW** (Weighted Root Mean Square Error), **RC** (Cross Validation RMSE) and null weights.

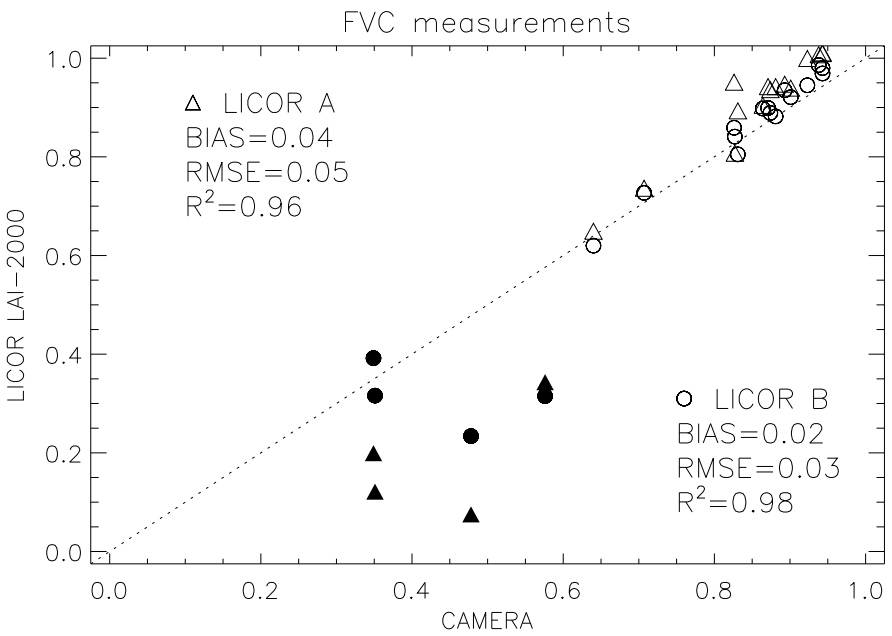
TRANSFER FUNCTION	RW	RC
FVC=-0.45+1.26*NIR-1.70*R-2.41*G	0.09	0.10
LAI=-2.27+12.50*NIR-10.18*RED	0.9	0.9

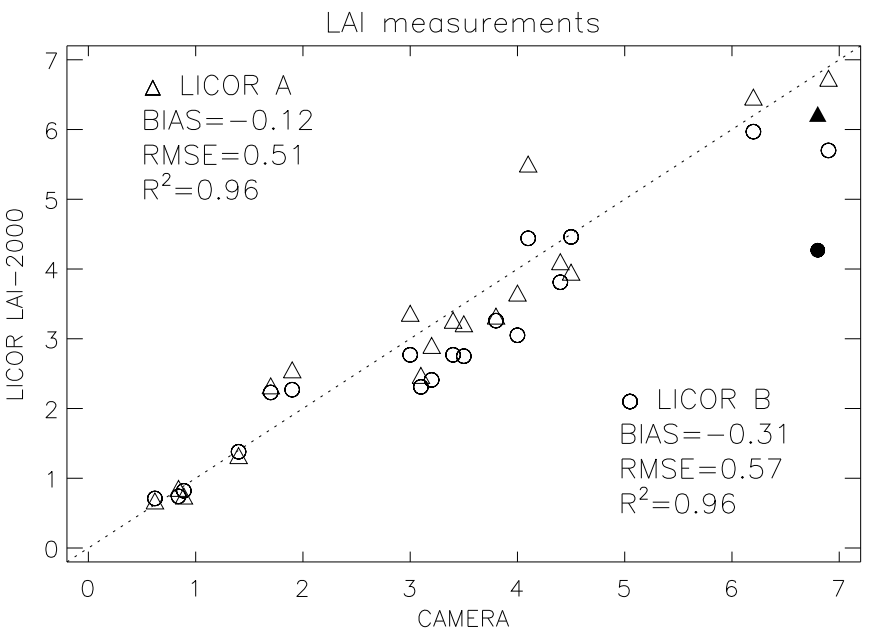
Errors of the same order that those found with SPARC03 and 04 transfer functions.

ESTIMATED PARAMETER	MODEL	DESCRIPTION	SPECTRAL INFORMATION	FIXED PARAMETERS
Green FVC	SMA [1]	Standardised SMA technique + Probabilistic model based on Bayesian Theorem $M_k = \{f_{sol}(k), f_{veg}(k')\} \rightarrow r_j = S \cdot f_{sol} + V \cdot f_{veg} + \varepsilon$ $FVC = \sum_{k=1}^{N} p(M_k \mid r_j) \cdot FVC(M_k)$	Six TM atmospherically corrected reflectances [5] (B,G,R,NIR,SWIR)	Endmembers selection (4 EMs soil + 4 EMs vegetation)
	NDVI [2]	Empirical NDVI re-scaled in apparent green FVC. $\mathrm{FVC} = \frac{(\mathrm{NDVI} - \mathrm{NDVI}_{soil})}{(\mathrm{NDVI}_{max} - \mathrm{NDVI}_{soil})}$; $\mathrm{FVC} = 1.45 \cdot NDVI - 0.26$	R, NIR	NDVI limits
Effective LAI	SMA+RL [3]	LAI retrieval from FVC/SMA + RL semi-empirical relationship $LAI = \frac{-1}{b \cdot G(\theta_s) \cdot \Omega} \ln\left(\frac{a_o - FVC}{a_o}\right)$	B, G, R, NIR, SWIR	B=0.945 $G(\theta_s)$ =0.5 clumping index, Ω=1 a_0 =1.05
	RSR [4]	Empirical RSR vegetation index adjusted to TM $RSR = \frac{NIR}{\mathrm{R}}\left(1 - \frac{SWIR - SWIR_{min}}{\mathrm{SWIR}_{max} - \mathrm{SWIR}_{min})}\right)$; $LAI = RSR / F$	R, NIR, SWIR	SWIR limits Free parameter, F

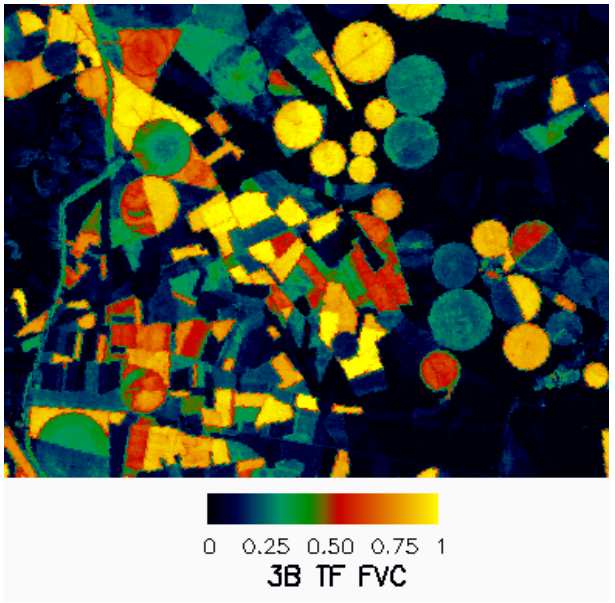
[1] García-Haro, J, Camacho-de Coca, F. and Meliá, J.. 2006. Product User Manual. Vegetation Parameters FVC and LAI. *SAF/LAND/UV/PUM-VEGA/1.0.*
[2] Gutman, G. and Ignatov, A. 1998. The derivation of the green vegetation fraction from NOAA/AVHRR data for use in numerical weather prediction models. *International Journal of Remote Sensing*, 19(8):1533-1543.
[3] Roujean, J. L. and Lacaze, R. 2002. Global mapping of vegetation parameters from POLDER multiangular measurements for studies of surface-atmosphere interactions: A pragmatic method and its validation. *Journal of Geophysical Research,2002(107D):10129-10145.*
[4] Chen et al. 2002. Derivation and validation of Canada-wide coarse relolution leaf area index maps using high-resolution satellite imagery and ground measurements. *RSE, 80:165-184*
[5] Guanter, L., Gonzalez-Sampedro, M. C., and J. Moreno. 2006. A method for the atmospheric correction of ENVISAT/MERIS data over land targets. *International Journal of Remote Sensing*. In press.

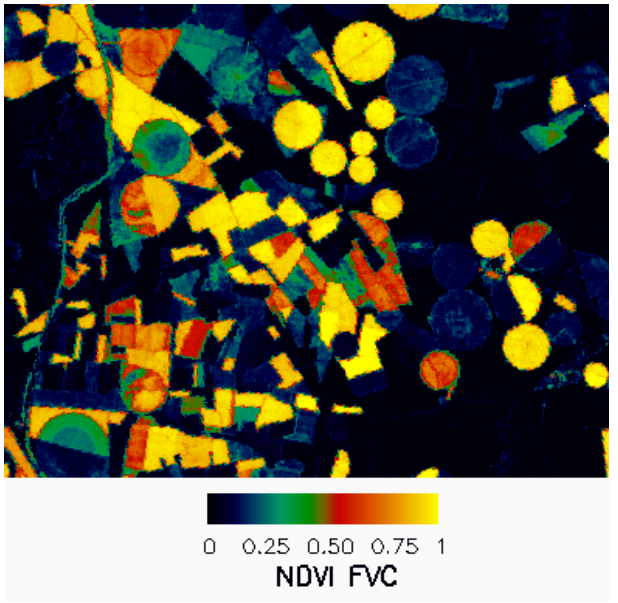
RESULTS Uncertainty assessment of *in-situ* measurements

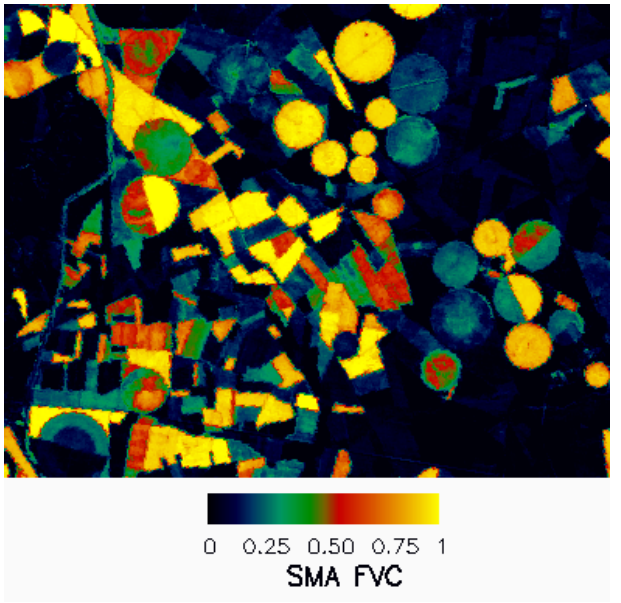


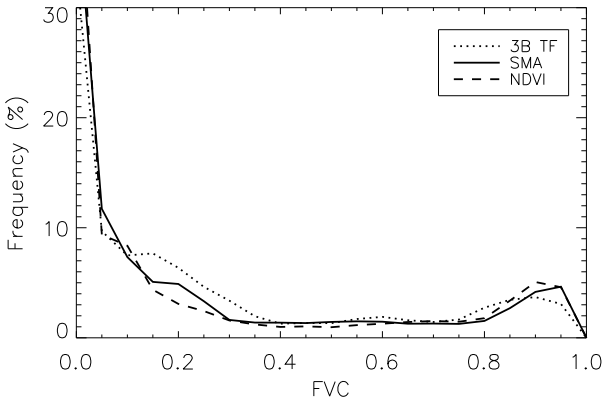


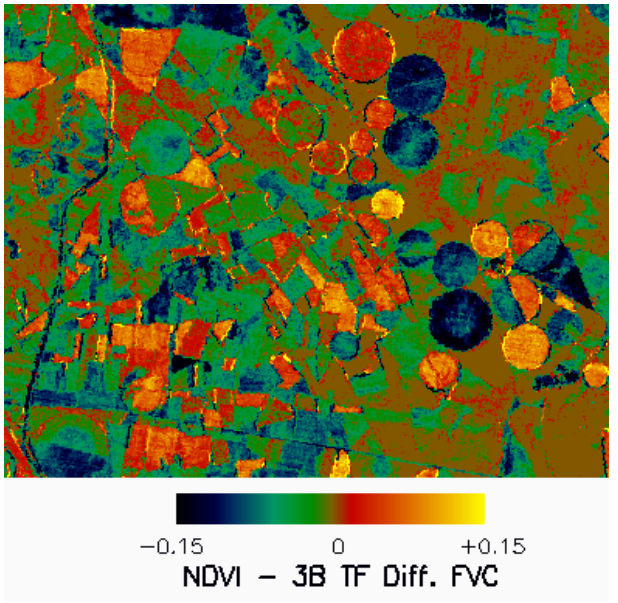
Relative RMSE (%)				
	LICOR-A	**LICOR-B**	**CAMERA**	**Mean**
FVC	3	1.5	3	3
LAI	13	15	18	15

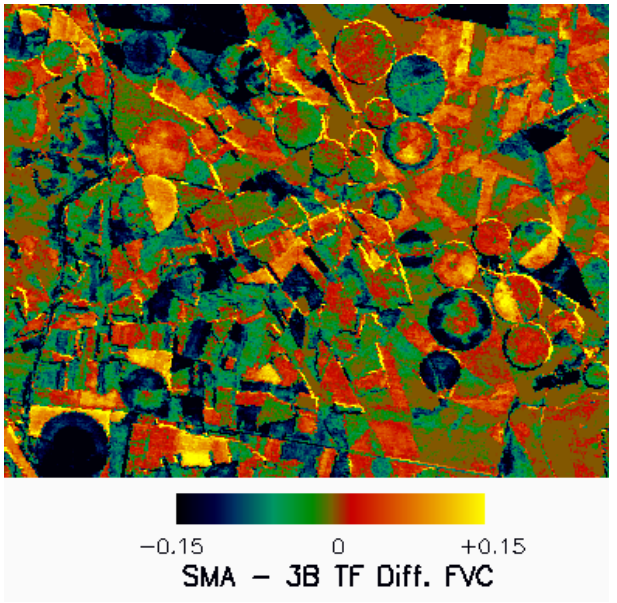

0 0.25 0.50 0.75 1
3B TF FVC

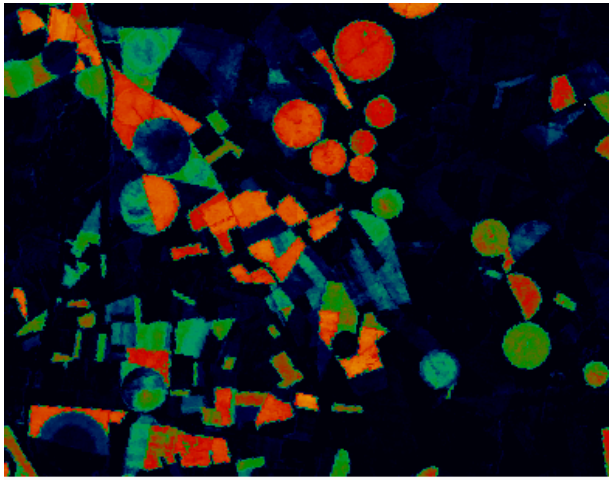

0 0.25 0.50 0.75 1
NDVI FVC


0 0.25 0.50 0.75 1
SMA FVC

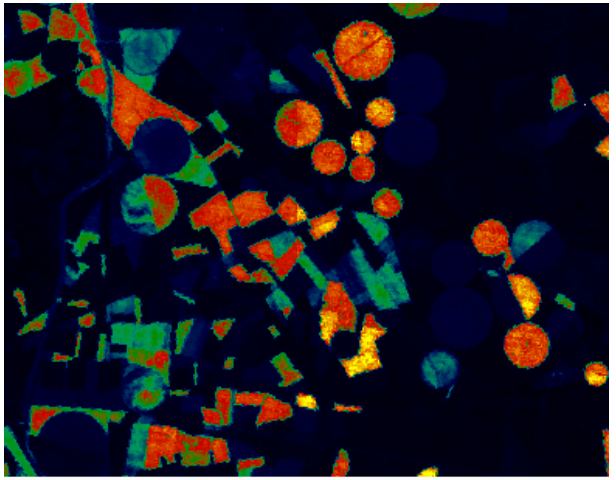

3B TF
SMA
NDVI
Frequency (%)
FVC
0
10
20
30
0.0
0.2
0.4
0.6
0.8
1.0


−0.15 0 +0.15
NDVI − 3B TF Diff. FVC

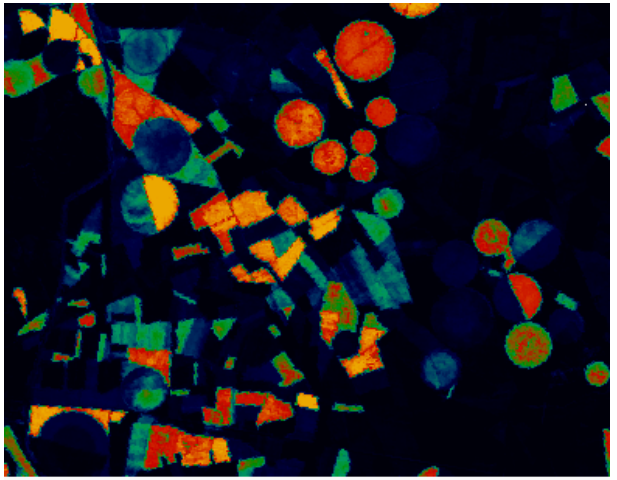

−0.15 0 +0.15
SMA − 3B TF Diff. FVC



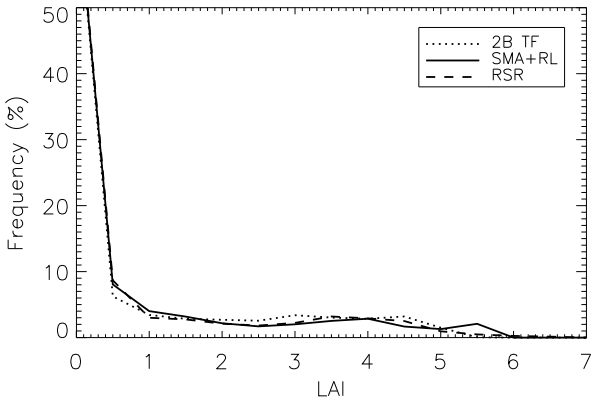
0 3.5 7
2B TF LAI

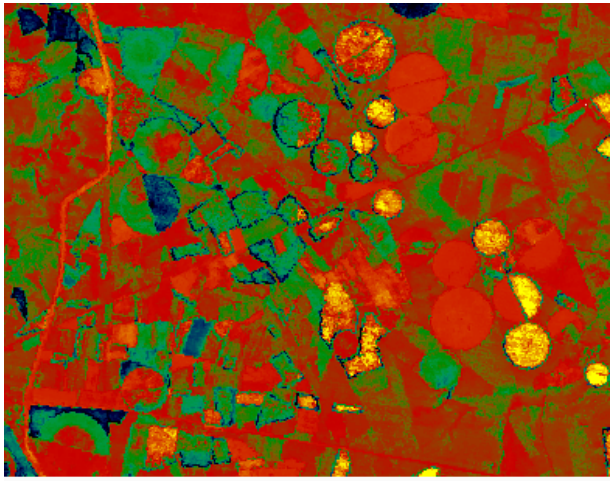


0 3.5 7
RSR LAI



0 3.5 7
SMA+RL LAI

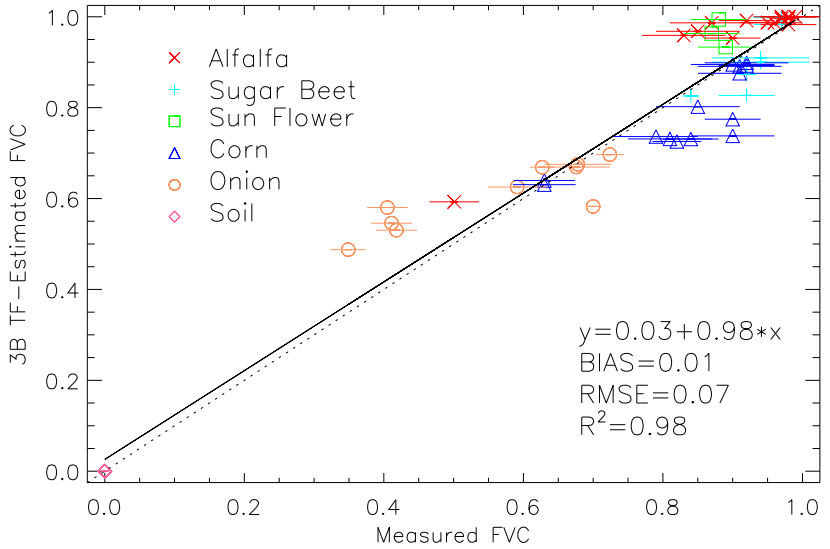


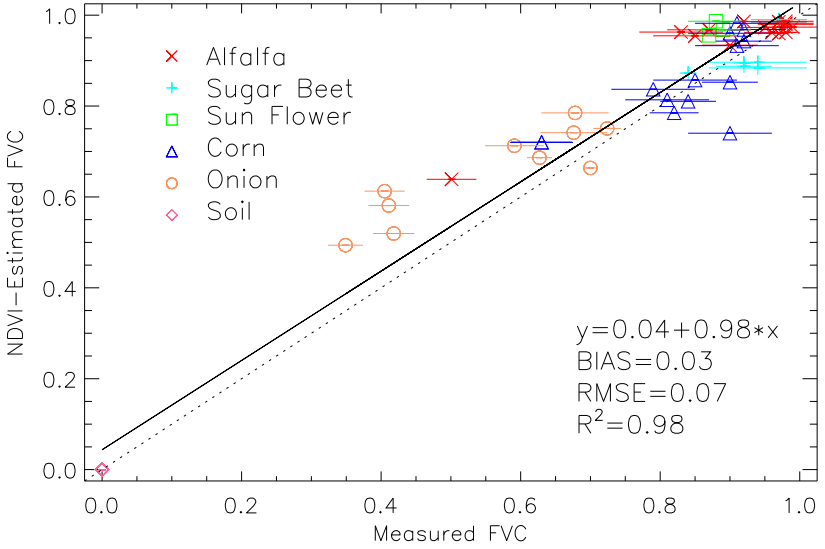


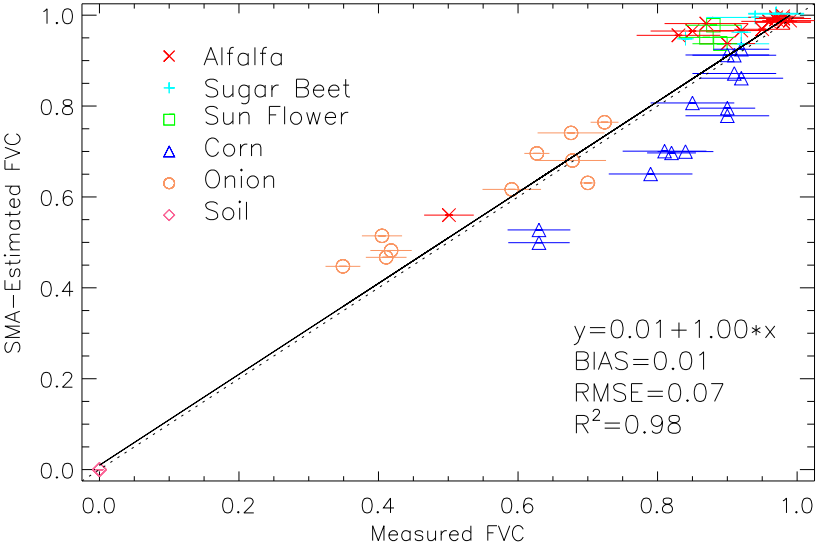
−2 −1 0 +1 +2
RSR − 2B TF Diff. LAI

−3 −1.5 0 +1.5 +3
SMA+RL − 2B TF Diff. LAI

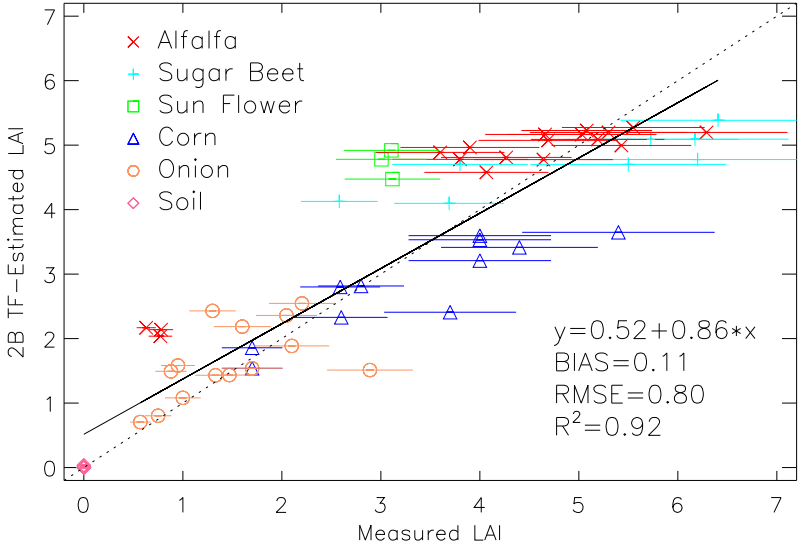
Comparison of retrievals with ground measurements

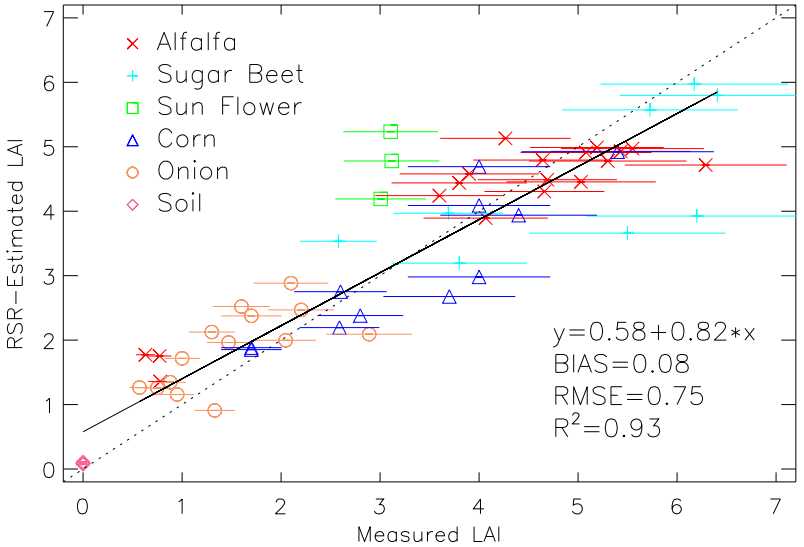


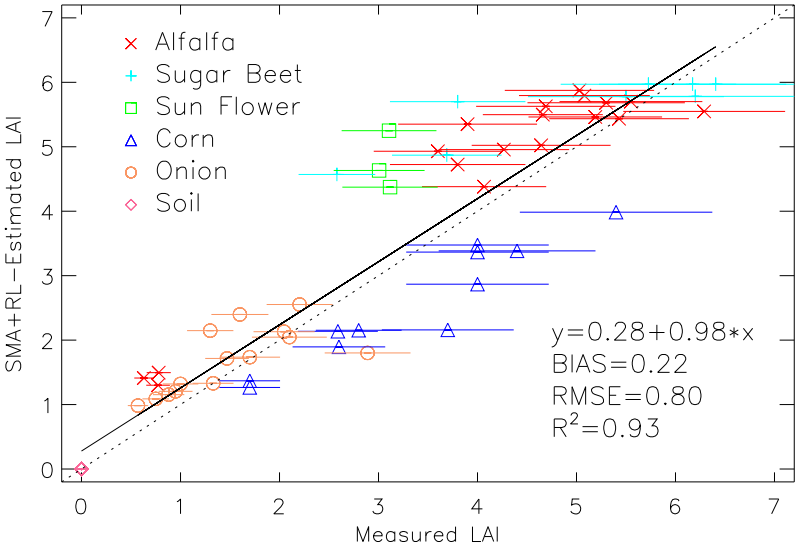




Comparison of retrievals with ground measurements







CONCLUSIONS

Assessment of FVC and LAI ground measurement's uncertainties

98 vegetation measurements were performed in 60 ESUs of 5 different crop types with two LI-COR LAI 2000 instruments and one hemispherical camera

19 ESUs → inter-comparison measurements

- FVC and LAI measurements performed with different instruments are comparable and consistent
- Typical relative RMSE~15% for LAI and 3% for FVC

CONCLUSIONS

Comparison of FVC and LAI RS retrievals with ground measurements

		Linear fit / BIAS / RMSE / Relative RMSE (%) / R^2)
FVC	3B TF-	y=0.03+0.98*x/ 0.01/ 0.07 / 10 / 0.98
	NDVI-	y=0.04+0.98*x / 0.03 / 0.07 / 10 / 0.98
	SMA-	y=0.01+1.00*x / 0.01 / 0.07 / 10 / 0.98
LAI	2B TF-	y=0.52+0.86*x / 0.11 / 0.8 / 30 / 0.92
	RSR-	y=0.58+0.82*x / 0.08 / 0.8 / 30 / 0.93
	SMA+RL-	y=0.28+0.98*x / 0.22 / 0.8 / 30 / 0.93

- Similar bounds for different methods
- The accuracy achieved is 10% for FVC and 30% for LAI
- LSA SAF algorithm is consistent with VI approaches and empirical TF
- Potential of operational RS methods to estimate reference high resolution FVC and LAI maps of the cropland area for multitemporal validation of LSA SAF products

Open issues:

- Limits of RS estimations?
- Is realistic to reach the user required accuracy of 15% for LAI at global scale?

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