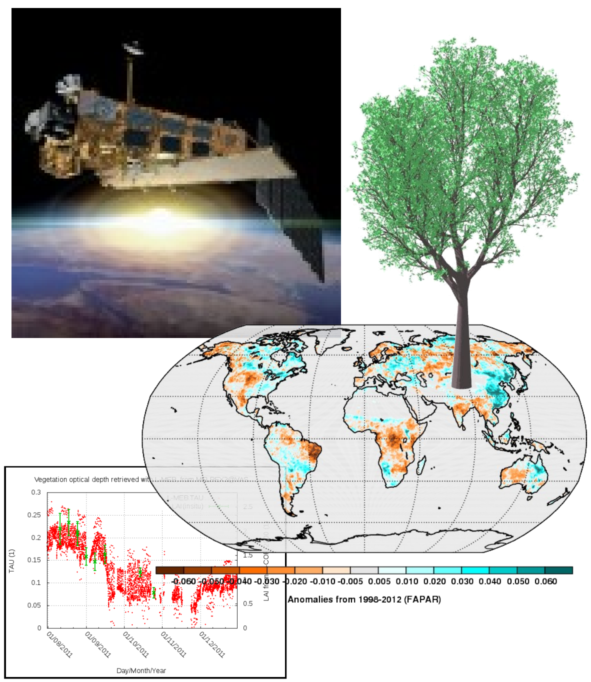
European Commission

Sentinel-3 OLCI Land Validation (OLCI-Land-Val)



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Anatoly Gitelson - University of Nebraska-Lincoln
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Alessandro Cescatti & Carsten Gruening – EC/JRC

3D-RT Modeling:

Jean-Luc Widlowski- EC- Joint Research Center

Joint Research Centre

Operational land OLCI products (1)

MERIS Terrestrial Chlorophyll Index (MTCI) → OTCI

Use of the high spectral resolution of the Medium Resolution Imaging Spectrometer to track the position of the Red Edge (Dash and Curran, 2004 Dash 2012).

$$MTCI = \frac{R_{Band10} - R_{Band9}}{R_{Band9} - R_{Band8}}$$

The magnitude of the MTCI is positively related to the total chlorophyll content.

This, in turn, is a function of chlorophyll

concentration and leaf area index which

MERIS (OLCI) Global Vegetation Index (MGVI/OTCI)

Use information in blue, red and near-infrared for deriving the Fraction of Absorbed Photosynthetic Active Radiation (Gobron et al., 1999, Gobron, 2012).

$$g_n[\tilde{\rho}(\lambda_i), \tilde{\rho}(\lambda_j)] = P(\lambda_i, \lambda_j) / Q(\lambda_i, \lambda_j)$$

$$P(\lambda_i, \lambda_j) = l_{n1}(\tilde{\rho}(\lambda_i) + l_{n2})^2 + l_{n3}(\tilde{\rho}(\lambda_j) + l_{n4})^2 + l_{n5}\,\tilde{\rho}(\lambda_i)\,\tilde{\rho}(\lambda_j)$$

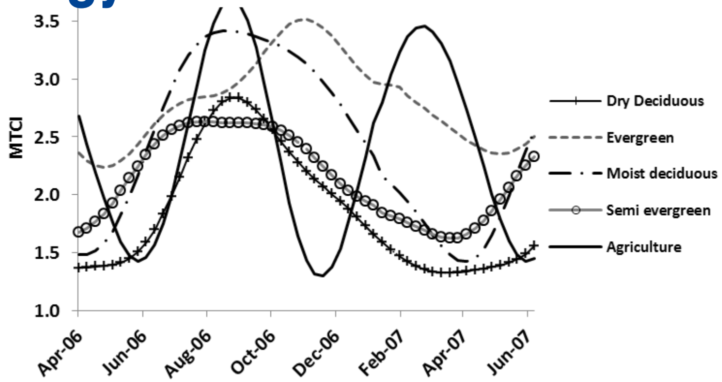
$$Q(\lambda_i, \lambda_j) = l_{n6}(\tilde{\rho}(\lambda_i) + l_{n7})^2 + l_{n8}(\tilde{\rho}(\lambda_j) + l_{n9})^2 + l_{n10}\,\tilde{\rho}(\lambda_i)\,\tilde{\rho}(\lambda_j) + l_{n11}$$

$$\text{FAPAR} = g_0(\rho_{Rred}, \rho_{Rnir}) = \frac{l_{01}\rho_{Rnir} - l_{02}\rho_{Rred} - l_{03}}{(l_{04} - \rho_{Rred})^2 + (l_{05} - \rho_{Rnir})^2 + l_{06}}$$

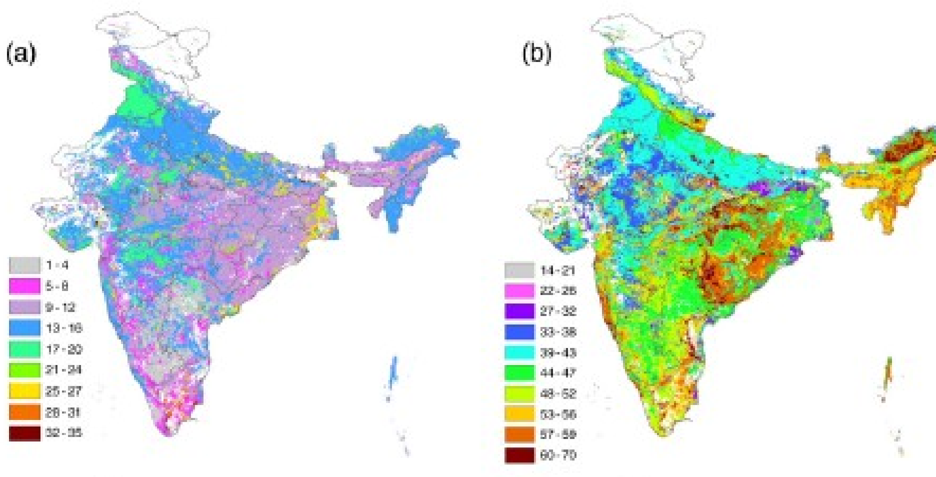
Operational land OLCI products (2)

European Commission

Phenology Assessment



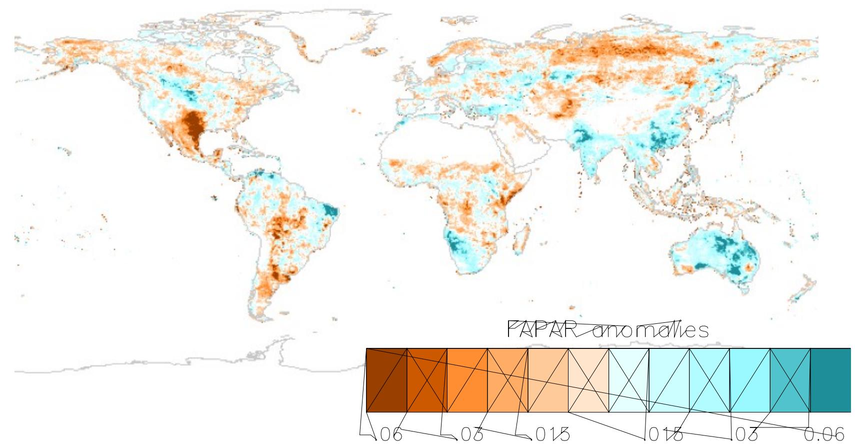
MTCI time series profile for major natural vegetation types and double cropping agricultural land in India.

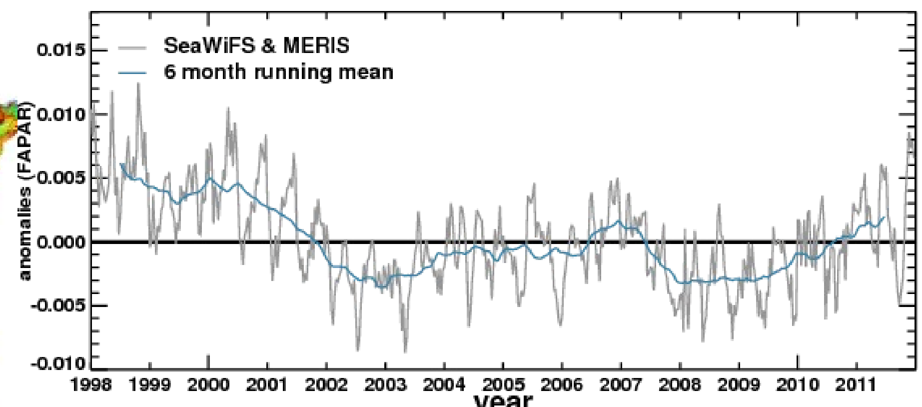


(a)Onset of greenness and (b) end of senescence in India

Dash, J. et al. 2010 The use of MTCI to study spatio-temporal variation in vegetation phenology over India, Remote Sensing of Environment, 114, 388-1402, doi:10.1016/j.rse.2010.01.02

Monitoring land surface changes





Gobron, 2012: [Global Climate] Terrestrial vegetation dynamics during 2011 [in "State of the Climate in 2011"]. Bull. Amer. Meteor. Soc., 93 (7), S53-S54.

Joint Research Centre

MTCI–Validation

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Measuring leaf area index

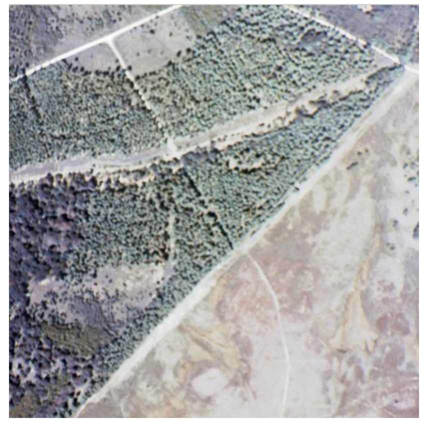
MERIS chlorophyll data proves positive

30 January 2007

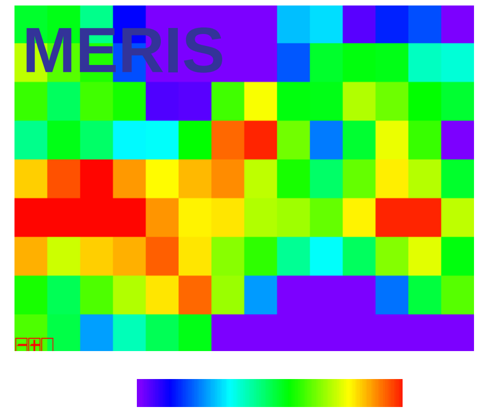
Scientists have, for the first time, devised and tested a method for correlating spaceborne data derived from Envisat's MERIS instrument on the amount of chlorophyll present in terrestrial vegetation with actual chlorophyll measured in field experiments. Positive correlations further confirm that MERIS is providing an accurate picture of the health our planet.

MTCI-Validation

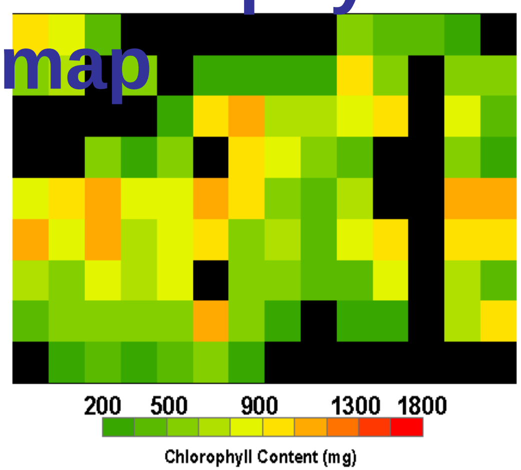
New Forest, UK (forest) **(MERIS, CASI, Field)** **(Dedicated)**

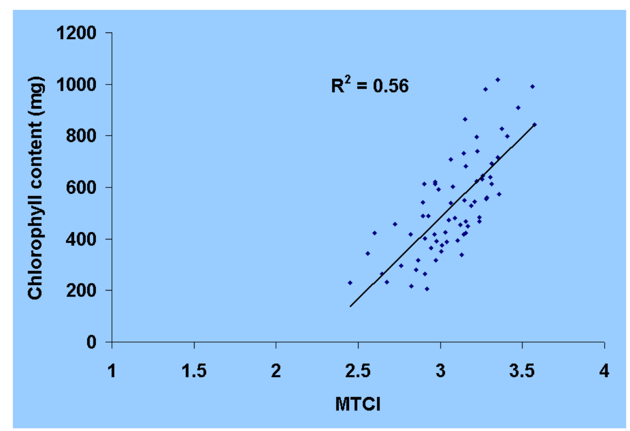


MTCI from MERIS



Chlorophyll map





Dash et al., 2010

MERIS FAPAR – Validation

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 111, D13110, doi:10.1029/2005JD006511, 2006

Evaluation of fraction of absorbed photosynthetically active radiation products for different canopy radiation transfer regimes: Methodology and results using Joint Research Center products derived from SeaWiFS against ground-based estimations

Nadine Gobron,[1] Bernard Pinty,[1] Ophélie Aussedat,[1] Jing M. Chen,[2] Warren B. Cohen,[3] Rasmus Fensholt,[4] Valery Gond,[5] Karl Fred Huemmrich,[6,7] Thomas Lavergne,[1] Frédéric Mélin,[1] Jeffrey L. Privette,[6] Inge Sandholt,[4] Malcolm Taberner,[1] David P. Turner,[8] Michel M. Verstraete,[1] and Jean-Luc Widlowski[1]

Received 18 Jul

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Remote Sensing of Environment 112 (2008) 1871–1883

Remote Sensing of Environment

www.elsevier.com/locate/rse

Uncertainty estimates for the FAPAR operational products derived from MERIS — Impact of top-of-atmosphere radiance uncertainties and validation with field data

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Received 20 March 2007; received in revised form 14 September 2007; accepted 15 September 2007

Abstract

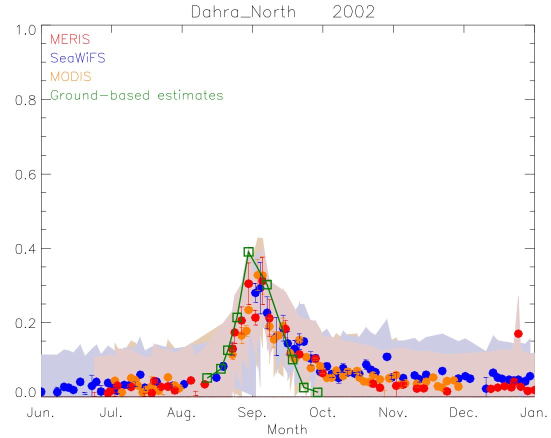
This paper discusses the accuracy of the operational Medium Resolution Imaging Spectrometer (MERIS) Level 2 land product which corresponds to the Fraction of Absorbed Photosynthetically Active Radiation (FAPAR). The FAPAR value is estimated from daily MERIS spectral measurements acquired at the top-of-atmosphere, using a physically based approach. The products are operationally available at the reduced spatial resolution, *i.e.* 1.2 km, and can be computed at the full spatial resolution, *i.e.* at 300 m, from the top-of-atmosphere MERIS data by using the same algorithm. The quality assessment of the MERIS FAPAR products capitalizes on the availability of five years of data acquired globally. The actual validation exercise is performed in two steps including, first, an analysis of the accuracy of the FAPAR algorithm itself with respect to the spectral measurements uncertainties and, second, with a direct comparison of the FAPAR time series against ground-based estimations as well as similar FAPAR products derived from other optical sensor data. The results indicate that the impact of top-of-atmosphere radiance uncertainties on the operational MERIS FAPAR products accuracy is expected to be at about 5–10% and the agreement with the ground-based estimates over different canopy types is achieved within ±0.1.

semi-arid grass savannah

Ref: Fensholt et al. 2004

FAPAR ≈ 1.-exp(-G(μ0)<LAI>/μ0)

<LAI> from PCA_LICOR



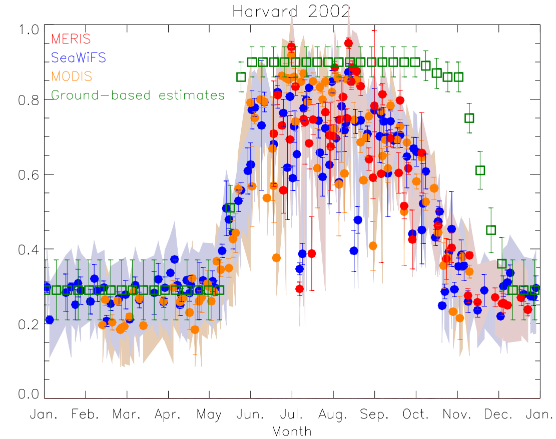
conifer/broad-leaf forest

Ref: Turner et al. 2005

FAPAR ≈ 1.-exp(-0.58<LAI>)

<LAI> from PCA_LICOR

Advanced procedure for spatio-temporal changes of local LAI



Main goal for OLCI validation

Independent strategy for making use of

1) ground-based measurements over a large sample of vegetation types distributed around the globe

2) assessing theoretical accuracies from both space and in-situ retrieval algorithms with radiative transfer modeling

MTCI and FAPAR together!

Work Plan

- **Field instrument calibration round robins**: dedicated experiences are foreseen to make comparison of several ground-based measurements (pre-launch) (Ispra, New Forest, or/and Spain).

- Review past and current types of ground-based measurements which can be used for a) direct validation, i.e. comparison with space products and b) serve as inputs to radiative transfer modeling. (**Test using MERIS FR products …** match-up extraction is currently done by Brockman's consult)

- Make use of the available data for making validations taking into account retrieval space and in-situ assumptions.

- Prepare field campaigns including a ground-based protocol to be used across all sites to reduce the bias, which may be due to different definitions/estimations that can be separated into a sampling error and a transfer bias.

- A dedicated web. page OLCI-ValLand under fapar.jrc.ec.europa.eu is foreseen.

- One team meeting is foreseen in spring 2014.

New 3D RT model capabilities

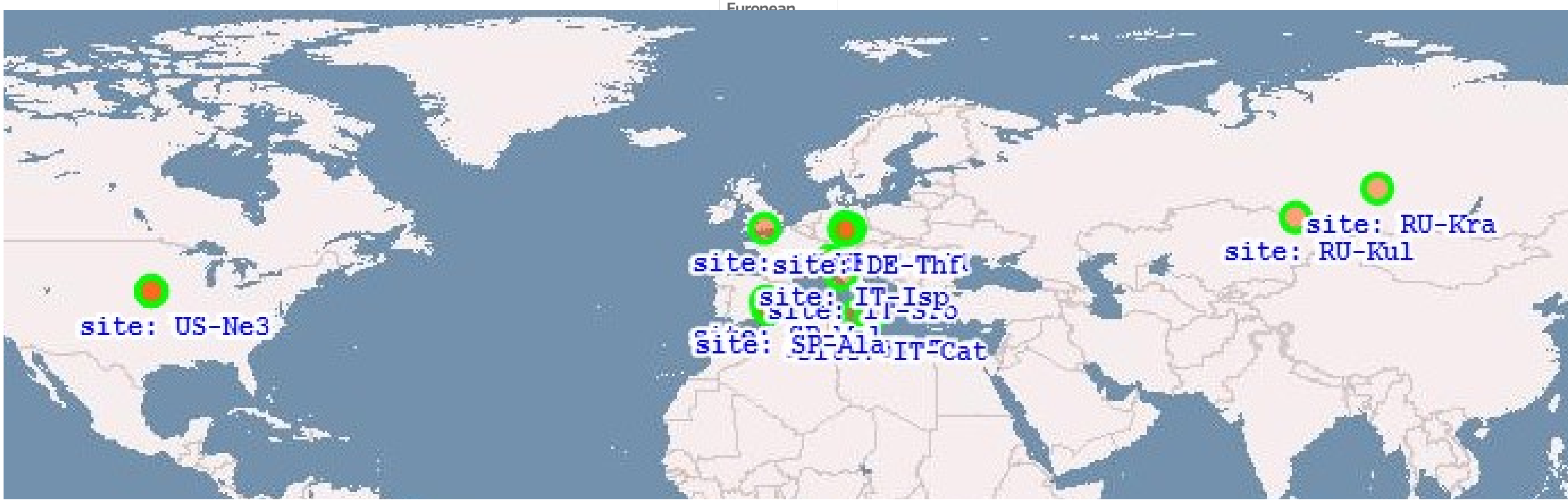
Raytran is now capable to simulate satellite as well as in situ observations. Absolute radiance measurements are possible. New measurement types were added: radiometer, LAI2200, lidar, camera…

Example output of camera looking at Savanna scene at 650nm

pseudo-turbid RGB image (650,550,450nm)

pseudo-turbid foliage in voxelised crowns

OLCI-Land-Val Sites

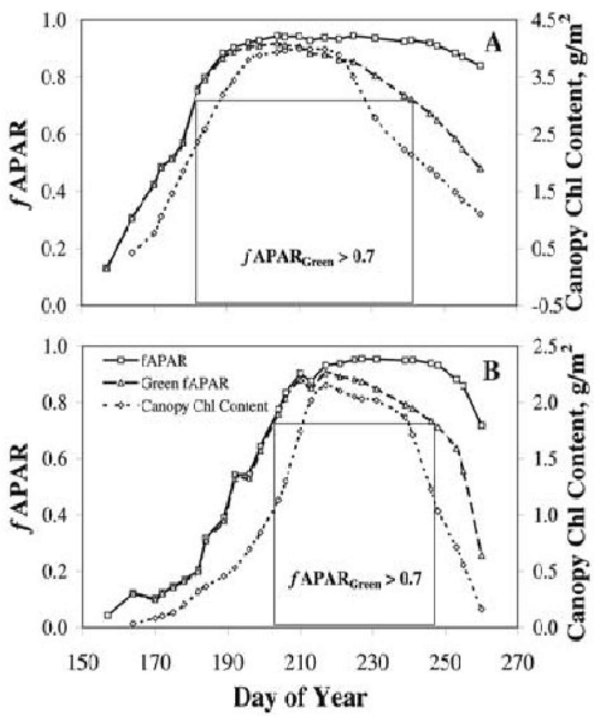


- The sites are different in term of land processes and sample (semi)-arid, agricultural cover and various forest types. They are either part of long term networks (Fluxnet, ICOS) or MTCI validation campaign or others EO satellite core sites.

OLCI-Land-Val Sites (1)

Fluxnet

Name	IGBP LC	Lat.	Long.	Contact
US-Ne1	Croplands (Maize)	41.1650	-96.4766	AG
US-Ne2	Croplands (Irrigated Maize Soybean rotation)	41.1648	-96.4701	AG



fAPAR total, fAPAR green, green LAI, total LAI, leaf chlorophyll, total canopy chlorophyll

Reflectance spectra measured 6 m above the top of canopy

fAPAR: 4 fluxes during 12 growing seasons

Crop phenology, VF, crop geen and total biomass

reflectance with 2 nm resolution at least one time per 10 days.

OLCI-Land-Val Sites (2)

ICOS

Name	IGBP LC	Lat.	Long.	Contact
IT-Sro	Water (Pinus pinea)	43.7278	10.2844	AC/CG
IT-Isp	Mixed Forest (Quercus Robur)	45.8128	8.6345	AC/CG

- LAI: hemispheric photography;
- FaPAR: PAR: 1 inc. & 1 refl. above canopy; 15 upwards & 5 downwards looking below canopy,
- surface albedo: net radiometer

European Commission

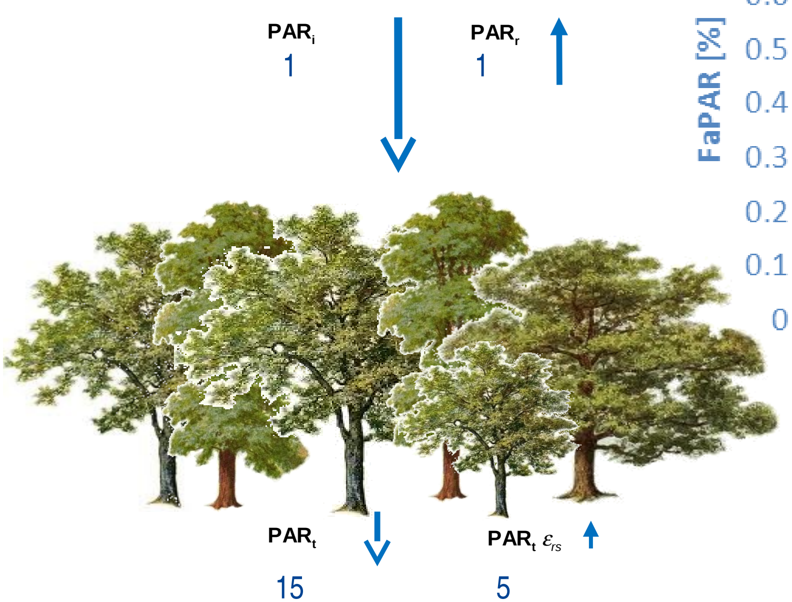
ICOS

FaPAR system at ABC-IS

$$\mathrm{FaPAR} = 1 - \frac{\mathrm{PAR_r}}{\mathrm{PAR_i}} - (1 - \varepsilon_{rs})\left(\frac{PAR_t}{PAR_i}\right)$$

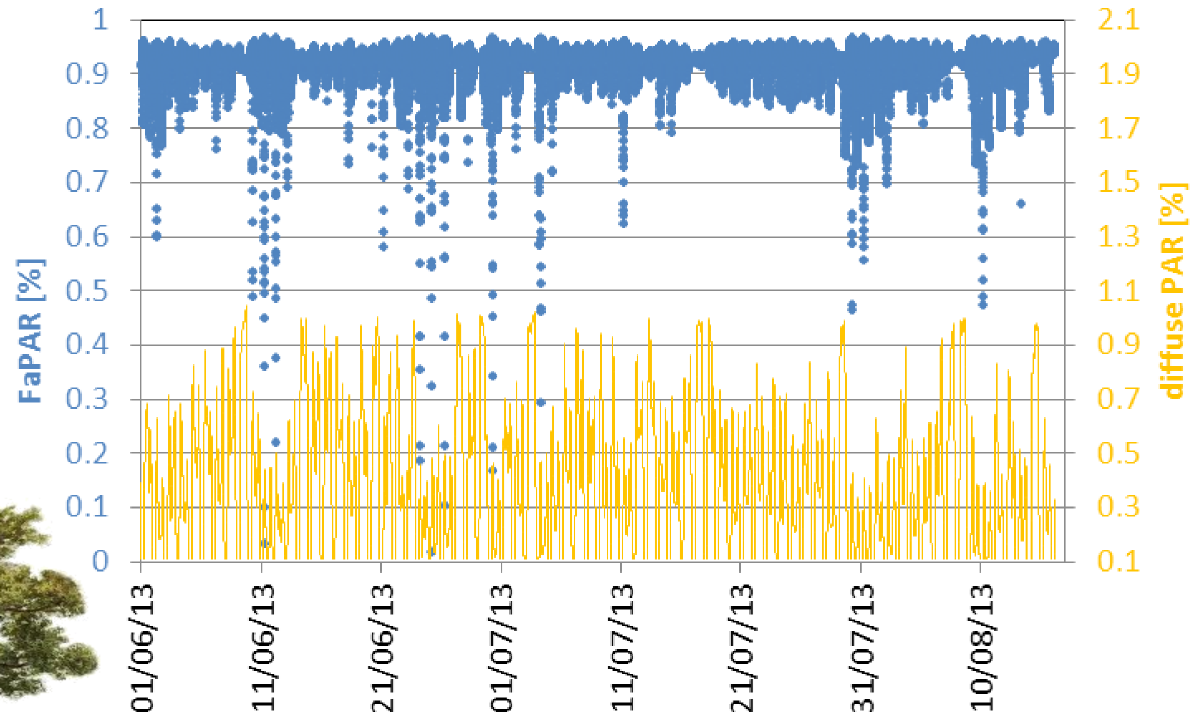
Where:

PAR_i	PAR incident
PAR_r	PAR reflected
PAR_t	PAR transmitted
ε_{rs}	soil reflectance



Measurement:

- 1 minute averaging time
- on forest ground: 15 upwards & 5 downwards facing sensors
- on tower top: 1 upward & 1 downward facing sensor



remark: preliminary data

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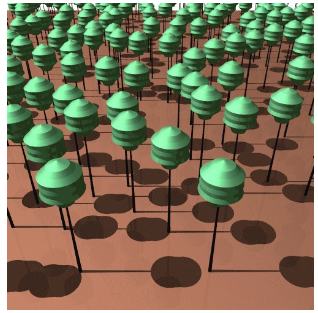
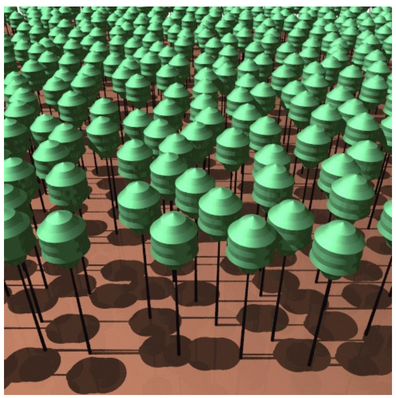
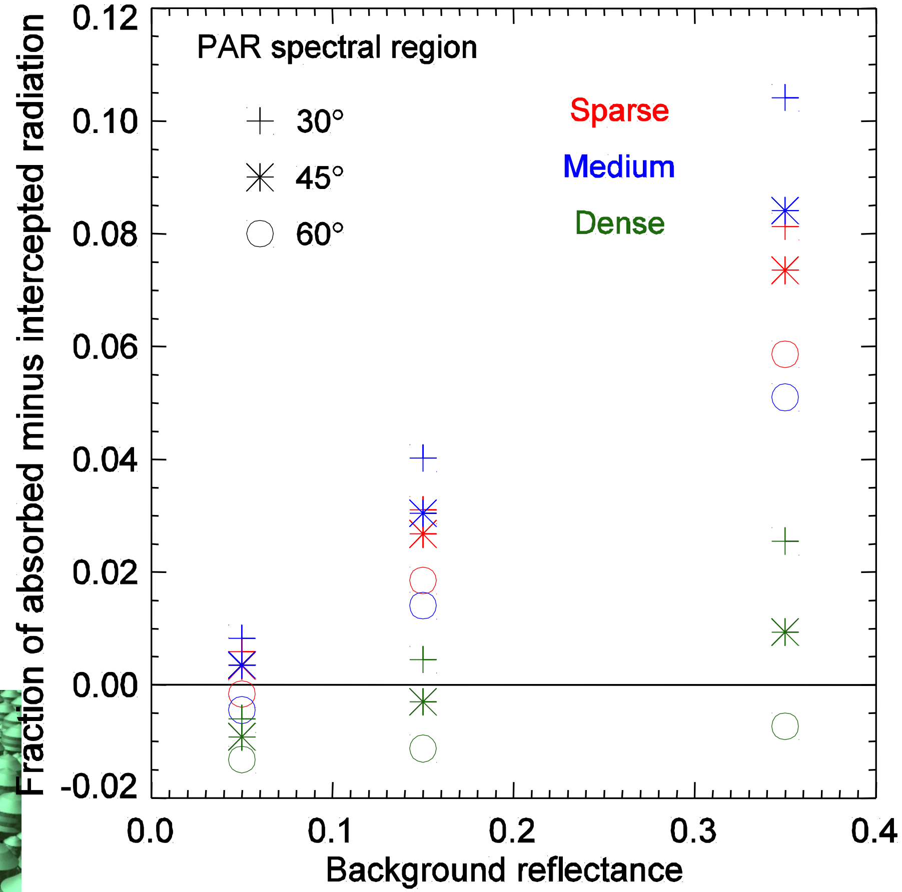
FAPAR (μ_0) - FIPAR (μ_0)

Sparse
<LAI> = 1.24

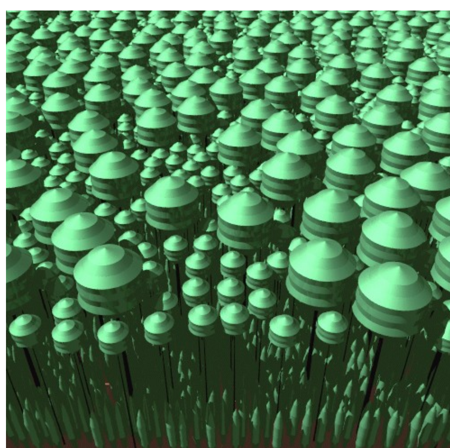




Medium
<LAI> = 2.00

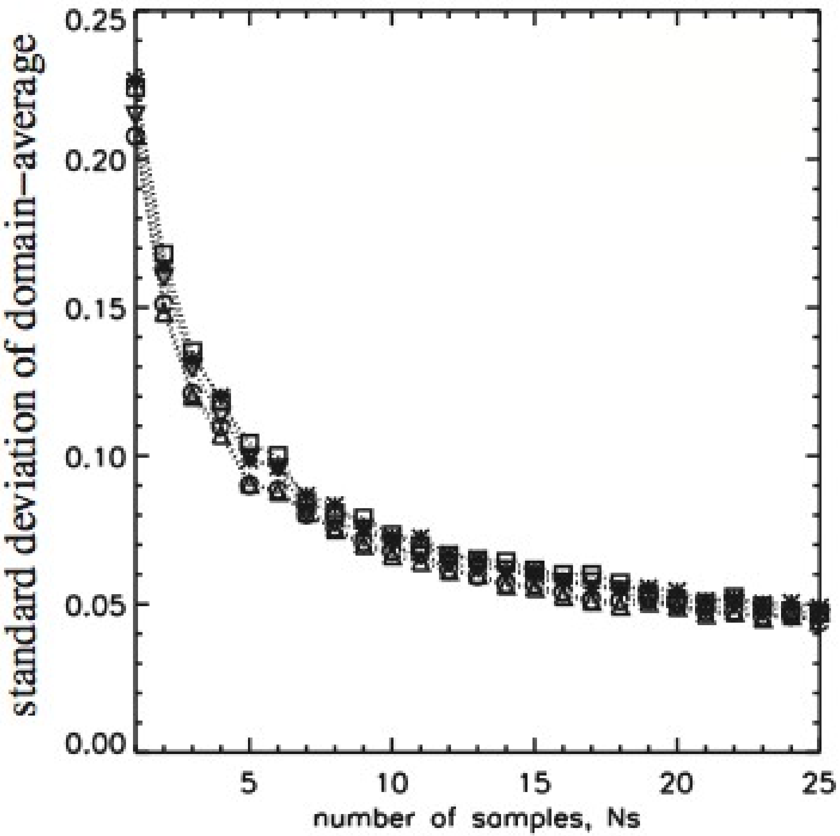


Dense
<LAI> = 4.82



Gobron N., et. al. (2006) 'Evaluation of FAPAR Products for Different Canopy Radiation Transfer Regimes: Methodology and Results using JRC Products Derived from SeaWiFS and Ground-based Estimations', *JGR, 111, D13110, DOI 10.1029/2005JD006511*

European beech (120 stems/ha)



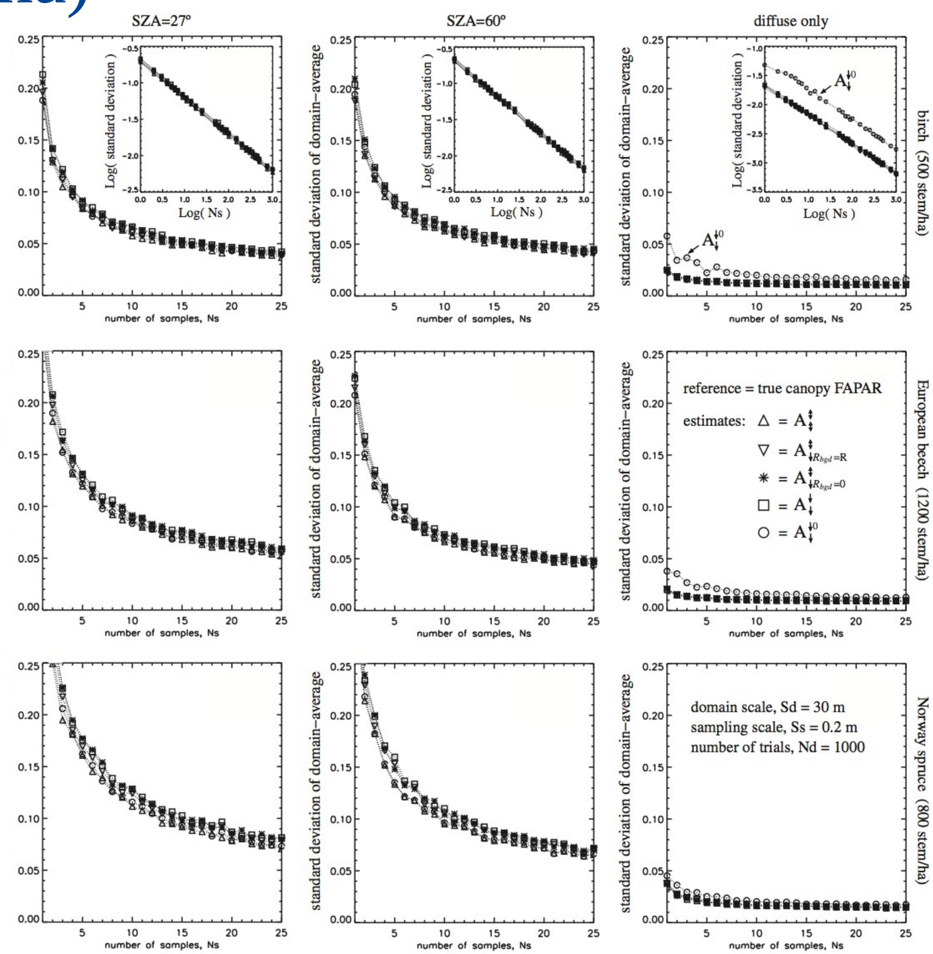


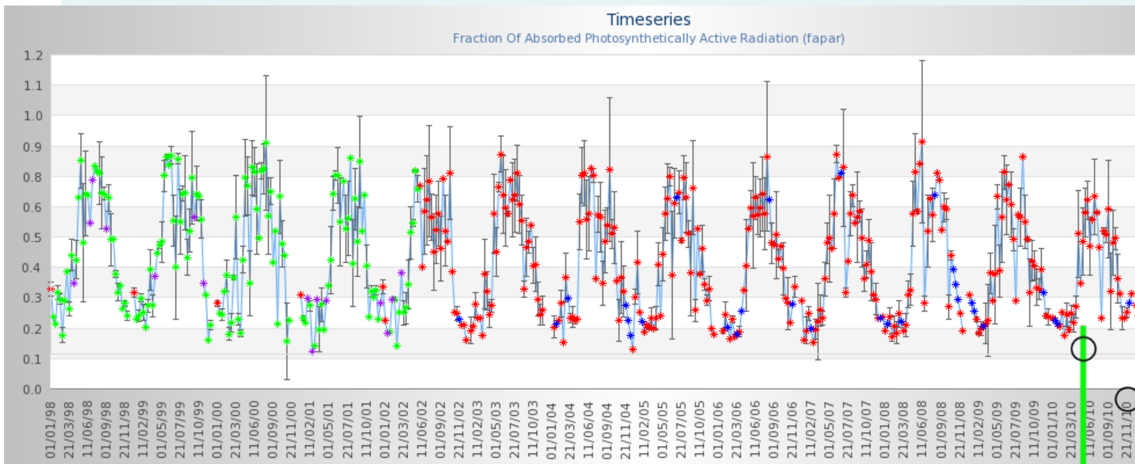
Fig. 10. The standard deviation of the FAPAR bias as a function of the number of flux measurements (Ns) for several FAPAR estimators, i.e., $A^{\updownarrow}_{\updownarrow}$ (△), $A^{\updownarrow}_{\downarrow R_{bgd}=R}$ (▽), $A^{\updownarrow}_{\downarrow R_{bgd}=0}$ (*), $A^{\downarrow}_{\downarrow}$ (□), and $A^{\downarrow 0}_{\downarrow}$ (○). Inlaid graphs in top row show a log-log plot of the same variables as in the main panels (slope = – 0.5).

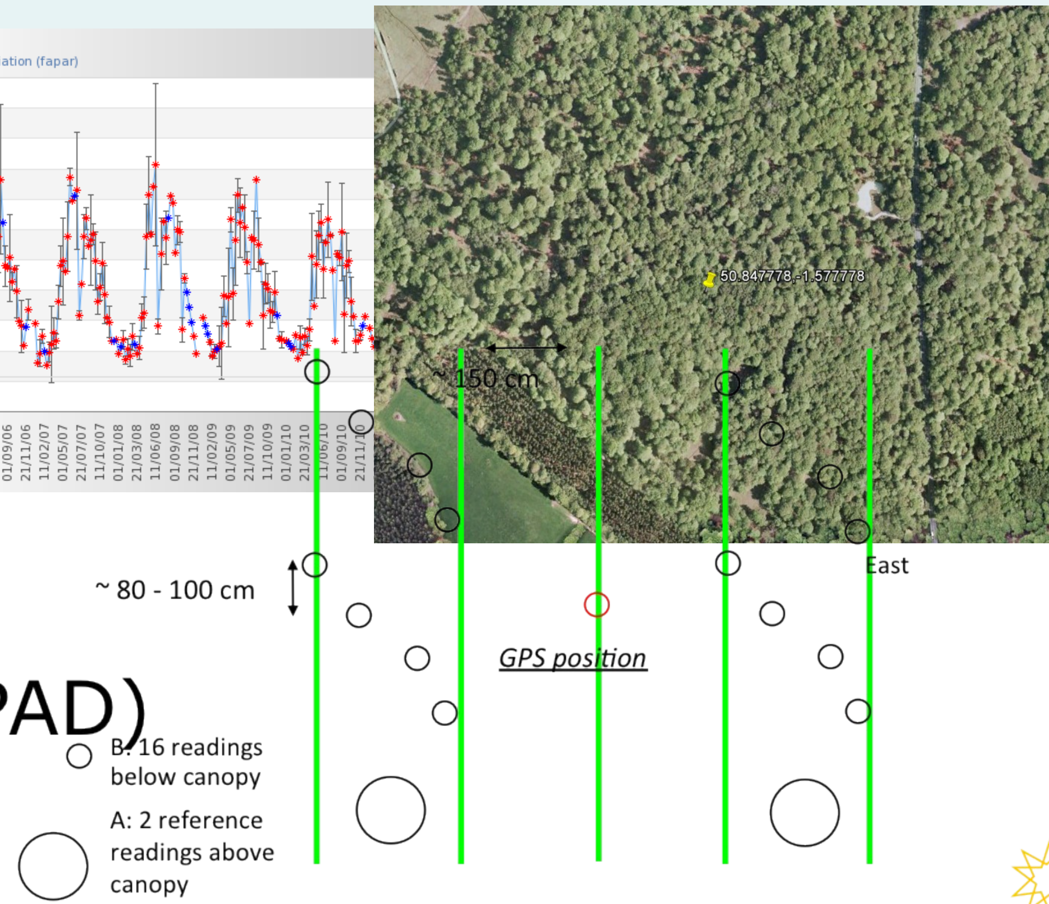
validation of remote sensing products
3D radiative transfer models

canopy forest stands t
bias associated with tl
relates to the impact o
the quality of the theory that relates these measurements to the actual canopy FAPAR.
Among the various methods tested it was the 2-flux FAPAR estimator $(1 - T_{PAR})$ that performs best in

OLCI-Land-Val Sites (4)

Name	IGBP or land use	Lat.	Long.	Contact
UK-NFo	Natural deciduous forest	50.845053	-1.539841	JD



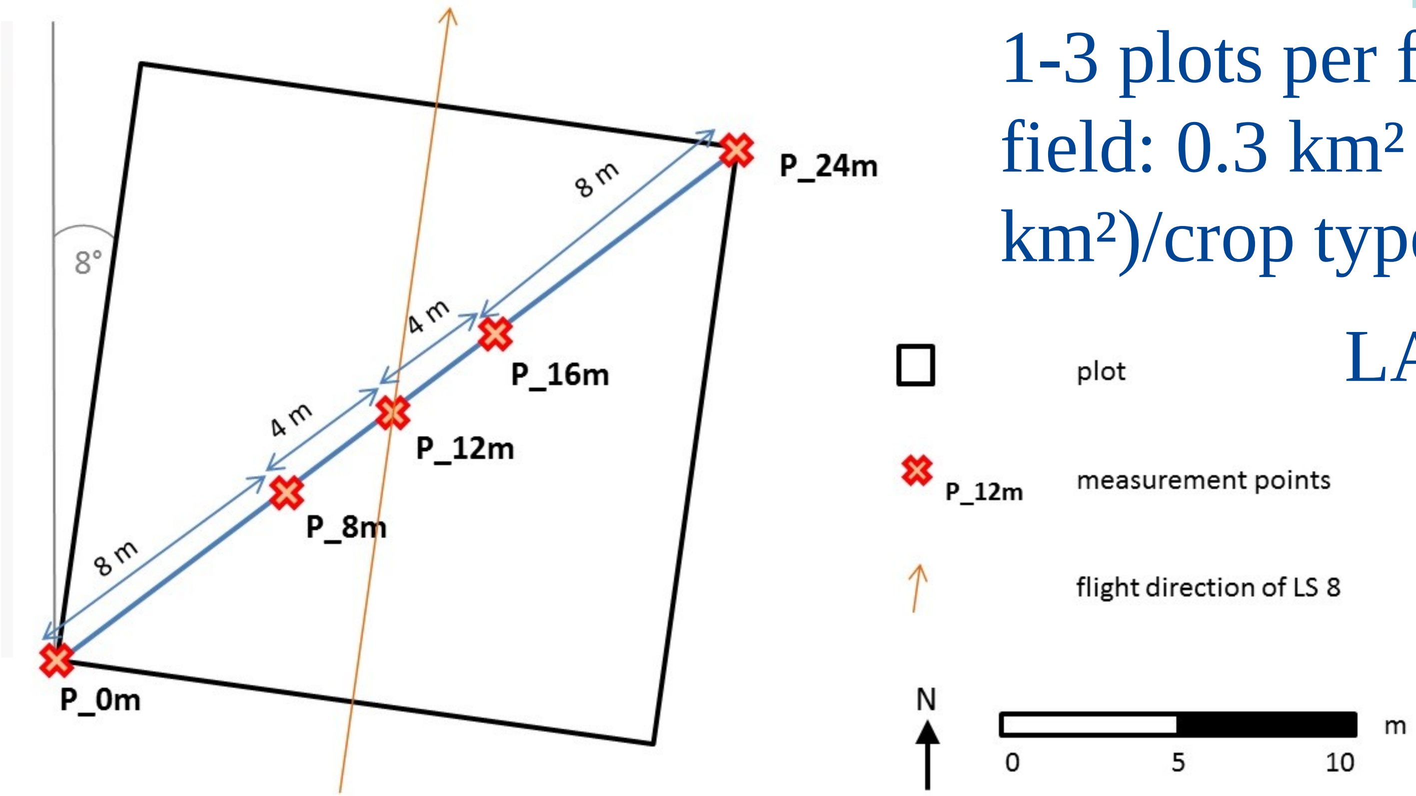


LAI, chlorophyll (SPAD)

OLCI-Land-Val Sites (5)

European Commission

Name	IGBP LC	Lat.	Long.	Contact
DE-Geb	Croplands (winter wheat, spring wheat, winter barley, durum wheat, potatos)	51,0891 N	10,9096 E	CS

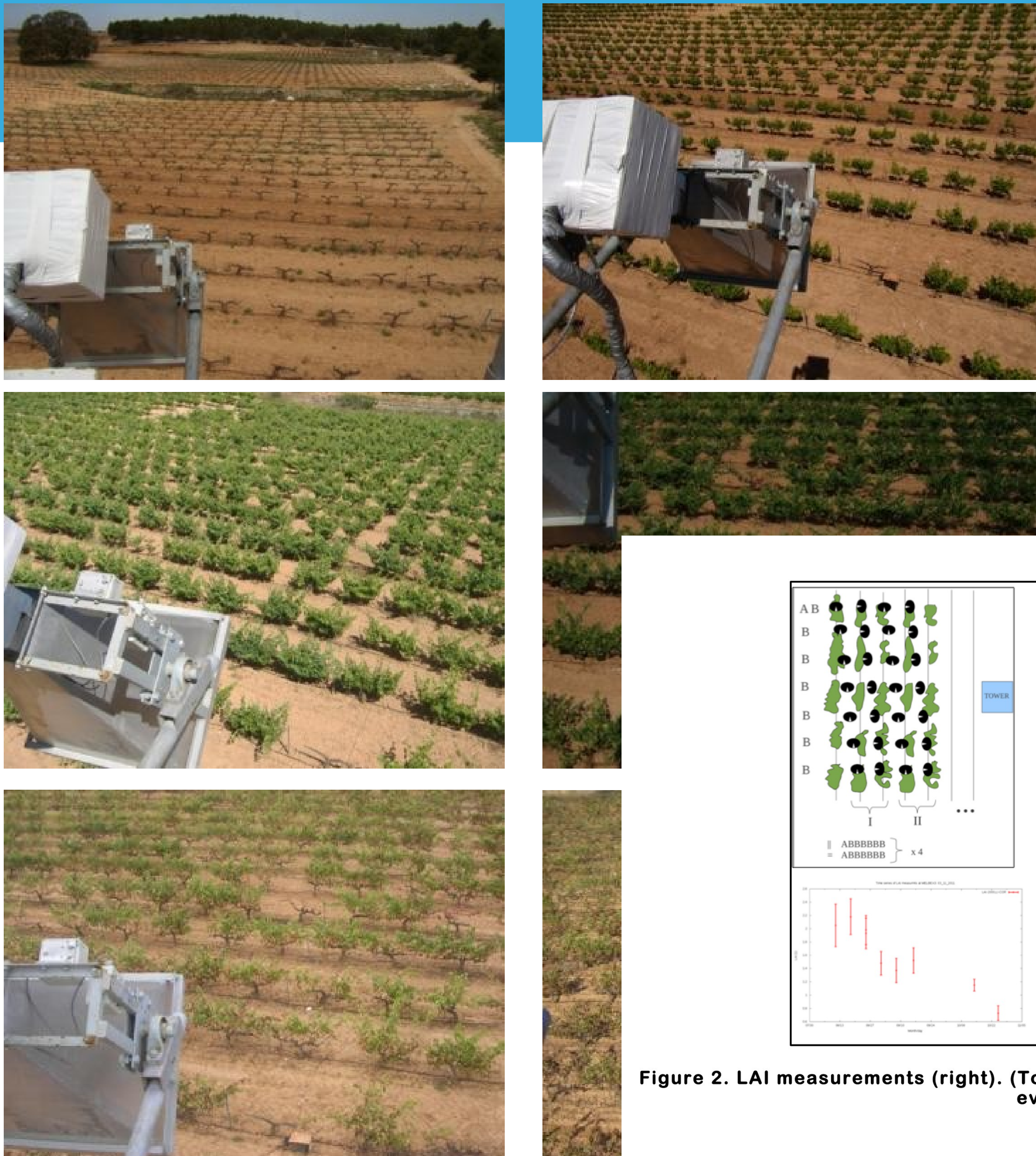


1-3 plots per field (area per field: 0.3 km² - 0.6 km²)/crop type

LAI, chlorophyll

OLCI-Land-Val Sites (7)

Name	IGBP or land use	Lat.	Long.	Contact
IT-Tra (2 sites)	Croplands (Vineyards and olive trees)	37°38'44.02”	12°51'9.85”	JD
IT-Cat	Croplands (Orange)	37°16'42.71”	14°52'59.74”	JD
SP-Val	Semi-arid Mediterranean	39°34'14.64”	1°17'17.52”W	EB
SP-Ala	Semi-arid Mediterranean	38°27'5.60”N	1° 3'52.40”W	EB



Monitoring vineyard evolution: left to right, top to bottom: 19 Apr, 29 May, 22 Jun, 14 Jul, 2 Oct, 19 Oct. 2007

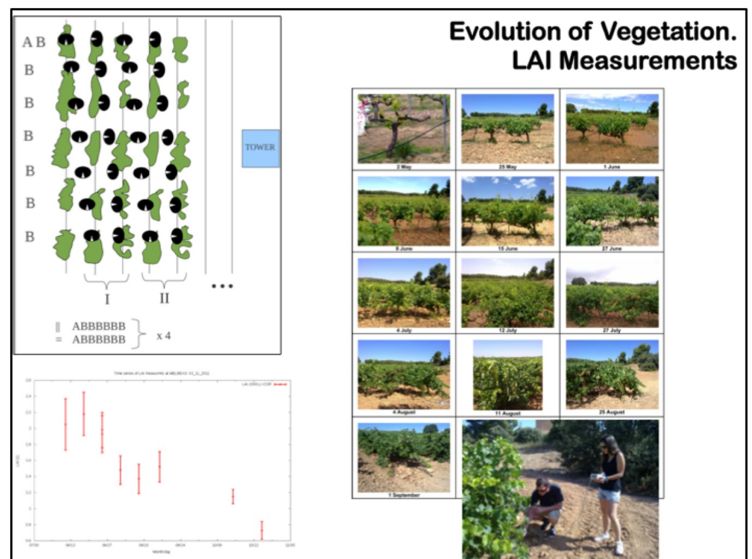


Figure 2. LAI measurements (right). (Top left) measuring protocole, (bottom left) vine LAI evolution, 2011

Conclusions

1. Validate the algorithm from both ground-based data and satellite data: characterizing errors in fiducial measurements.
2. 14 sites were selected: pre-launch validation activities with MERIS FR.
3. Round Robin for ground-based measurements (with LST group): Inter comparison of field instruments and cross calibration.

4. Dedicated campaign during the E1 phase (ESA support with airborne acquisition)
5. Check the temporal consistency at Level 3 products.
6. Use of Sentinel 2 (?)