FAPAR: In-situ protocol(s)

Nadine Gobron[1] and Arturo Sanchez-Azofeifa[2]

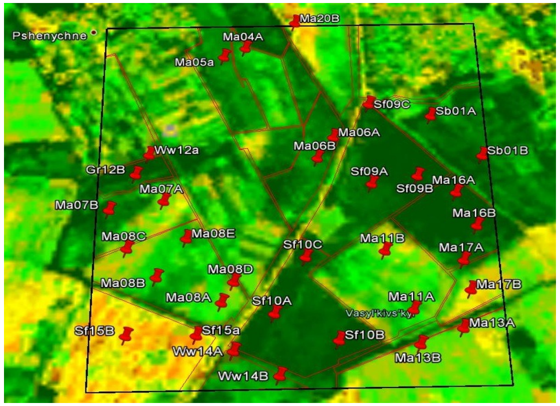
(1) EC-JRC / Institute for Environment and Sustainability, Ispra, Italy
(2) Centre for Earth Observation Science (CEOS), University of Alberta , Edmonton, Alberta, Canada

Single Date/Data Protocol

European Commission

Guidelines for field campaigns are provided considering up-scaling needs for validation of 1 km products

- Size of the site: 3x3 km
- Number of ESUs: 30- 50 sampling units
- Size of the ESU: ~15 m (SPOT5)
- Sampling the site: Stratified, based on land cover
- Sampling the ESU: 10 -12 shots
- Instruments: Digital Hemispherical Photography (DHP)
- Processing: CAN-EYE software (INRA-Avignon)



Sampling the site

$$fAPAR^{BS}(\theta_s) = P_o(\theta_s)$$

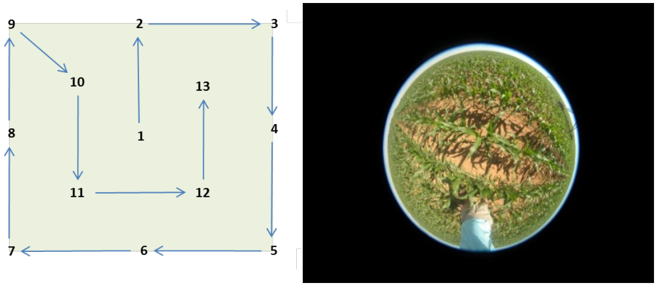
fAPAR ~ fIPAR

$$fAPAR^{BS}_{Day} = \frac{\int_{sunset}^{sunrise} \cos(\theta) P_o(\theta) d\theta}{\int_{sunset}^{sunrise} \cos(\theta) d\theta}$$

Black Sky

$$fAPAR^{WS} = \frac{1}{\pi} \int_0^{2\pi} \int_0^{\pi/2} P_o(\theta) \cos\theta \sin\theta d\theta d\varphi = 2 \int_0^{\pi/2} P_o(\theta) \cos\theta \sin\theta d\theta$$

White Sky



Sampling the ESU - DHP

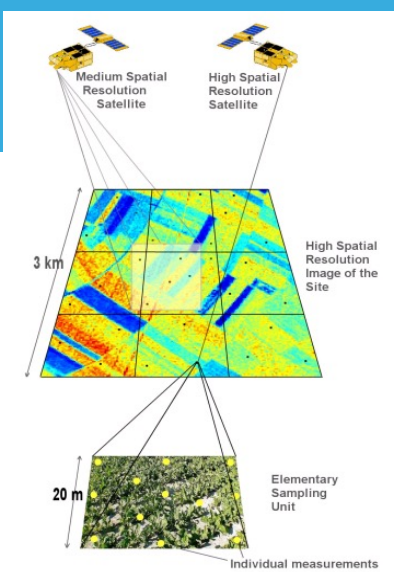
Source: Camacho, FAPAR Workshop, 2014

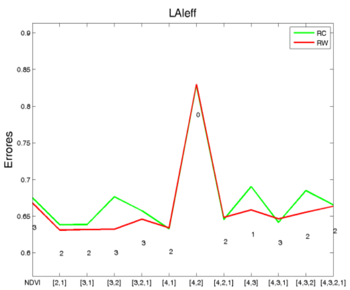
Joint Research Centre

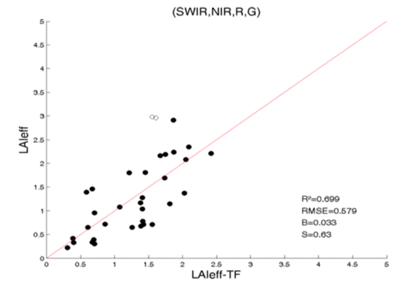
Single Date/Data
Data processing

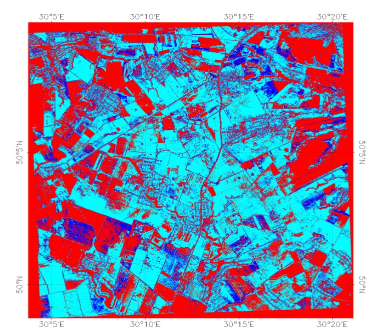
Generating ground-based maps

- HR (SPOT5) images are acquired supported by ImagineS, Global Land Service and Take5 initiatives.
- Up-scaling (VALERI)
  - Evaluation of the sampling
  - Regression method: iteratively re-weighted least squares algorithm
  - Selection of band combination (lower RMSE)
  - Convex Hull: Quality Flag
  - Application to high resolution imagery
  - High resolution maps are produced and distributed









Source: Camacho, FAPAR Workshop, 2014

EOS Data Set

Ground-based estimations are categorized with respect to their anticipated radiation transfer regime to better understand sources of uncertainties.

RT regime (adapted from Davis and Marshak, 2004)	Field Site Identification	Land cover type
"Fast" variability 1-D RT theory on full domain 	Dahra and Tessekre (Fensholt et al. 2004) Sevilletta (Turner et al. 2005)	semi-arid grass savannah desert grassland
"Slow" variability 1-D RT theory locally and Independent Pixel Approximation (IPA) on full domain	Bondville (Turner et al. 2005) Harvard (Turner et al. 2005) De Inslaag (Gond et al. 1999) Konza (Turner et al. 2005)	corn and soybean conifer/broad-leaf forest conifer/broad-leaf/shrub forest Grassland/shrub-land/cropland
"Resonant" variability 3-D RT theory	Metolius (Turner et al. 2005) Mongu (Huemmrich et al. 2005)	dry needle-leaf forest shrub land/woodland

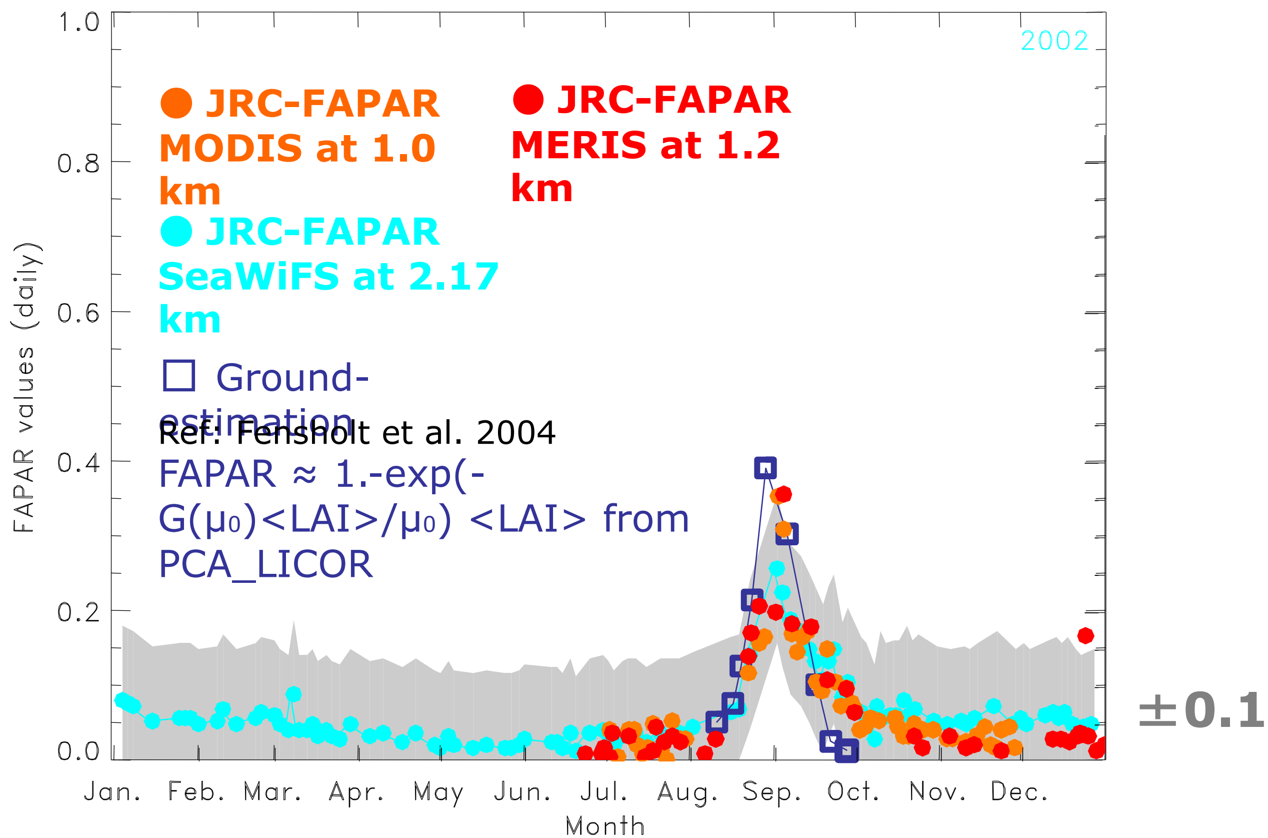
Gobron N., et. al. (2006) 'Evaluation of FAPAR Products for Different Canopy Radiation Transfer Regimes: Methodology and Results using JRC Products Derived from SeaWiFS and Ground-based Estimations', *JGR, 111, D13110, DOI 10.1029/2005JD006511*

Validation of FAPAR

bsorbed ctive adiation raction of hotosynthetically

"Fast" variability

European Commission



The FAPAR values are very small over this semi-arid grass savannah, and agree with ground estimations within the predefined daily accuracy of **±0.1**

Gobron N. et. al. (2008) 'Uncertainty estimates for the FAPAR operational products derived from MERIS – Impact of TOA radiance uncertainties and validation with field data', RSE, Vol. 112, pp 1871–1883, doi:10.1016/j.rse.2007.09.011.

Joint Research Centre

Validation of FAPAR (Fraction of Absorbed Photosynthetically Active Radiation)

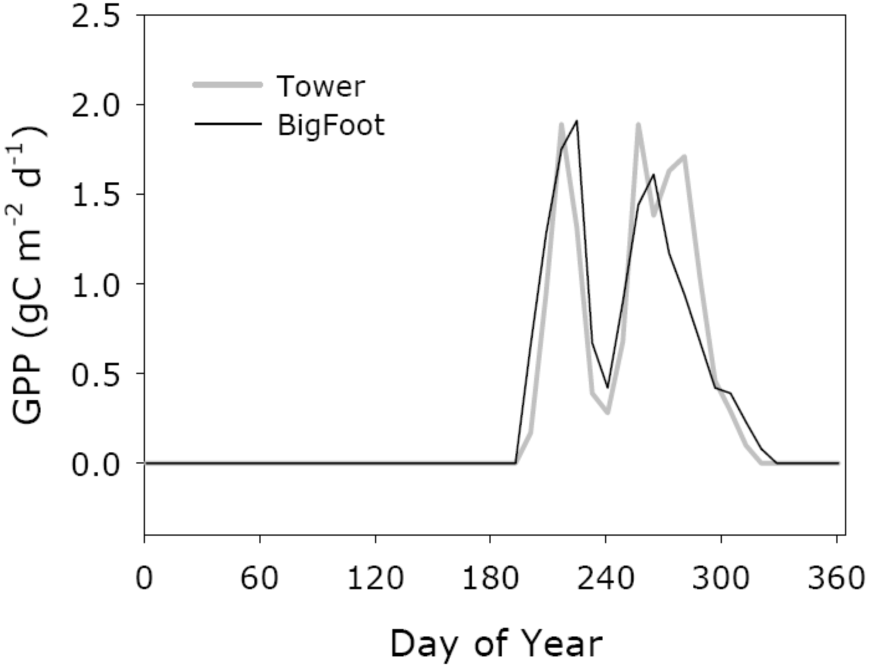
“Fast” variability

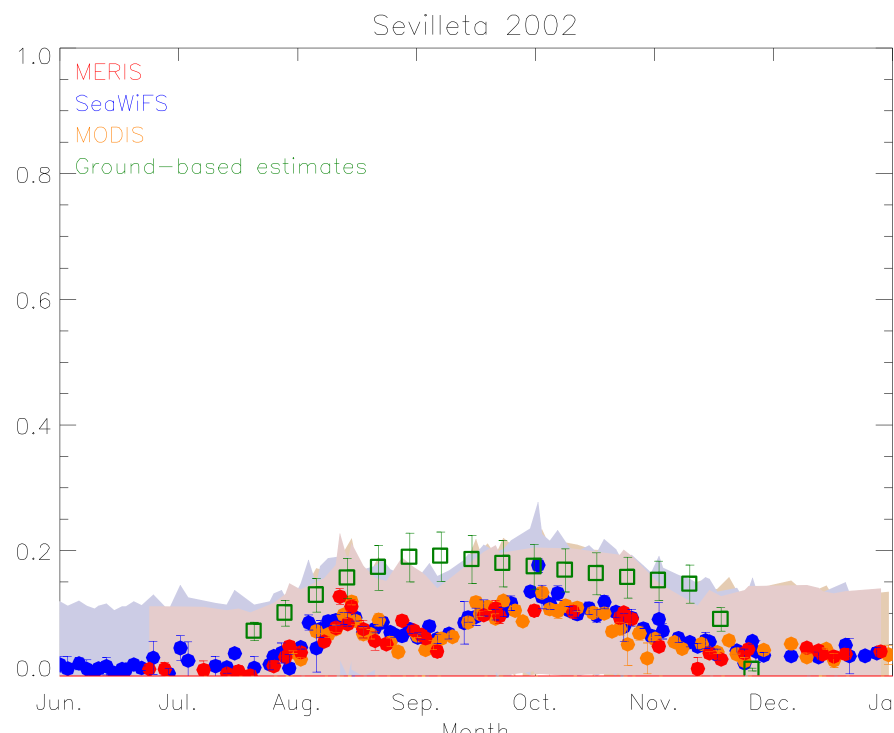
Ref: Turner et al. 2005

FAPAR ≈ 1.-exp(-0.5<LAI>)

<LAI> from PCA_LICOR

Advanced procedure for spatio-temporal changes of local LAI

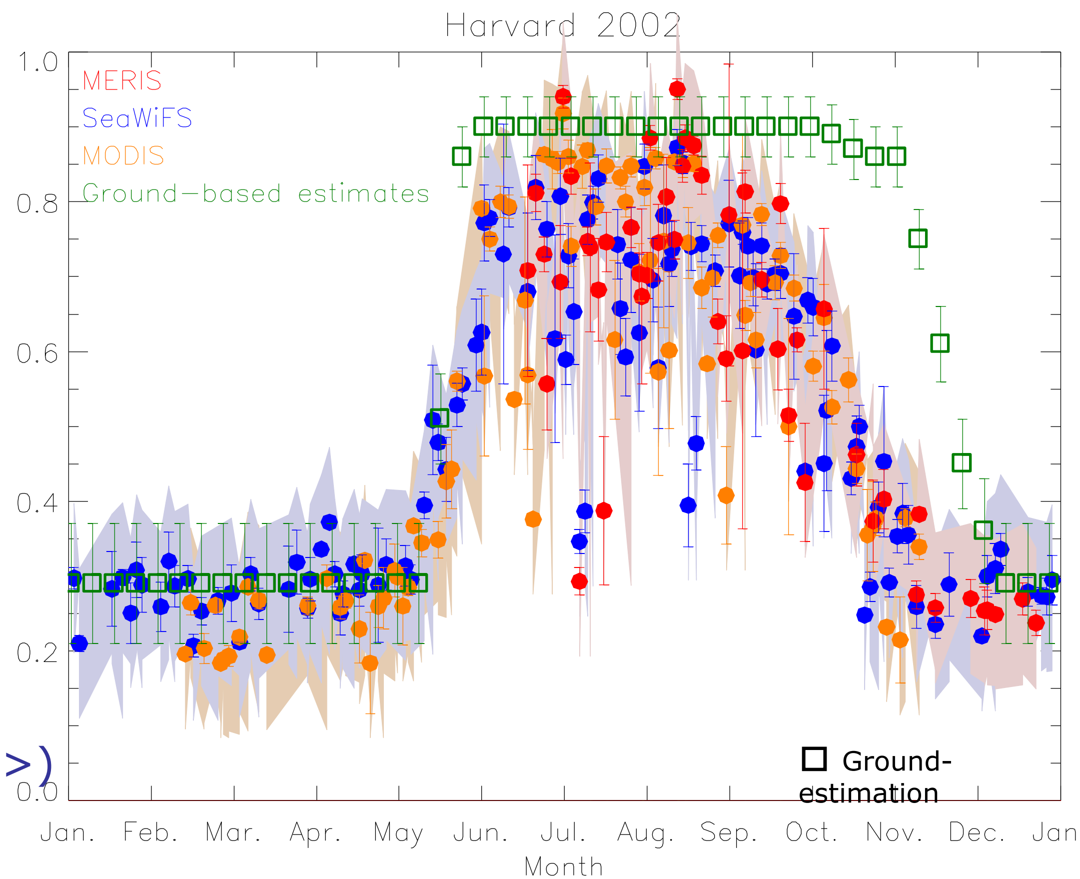




Gobron N. et. al. (2008) ‘Uncertainty estimates for the FAPAR operational products derived from MERIS – Impact of TOA radiance uncertainties and validation with field data’, RSE, Vol. 112, pp 1871–1883,

Validation of FAPAR

“Slow” variability



Ref: Turner et al. 2005

FAPAR ≈ 1.-exp(-0.58<LAI>)

<LAI> from PCA_LICOR

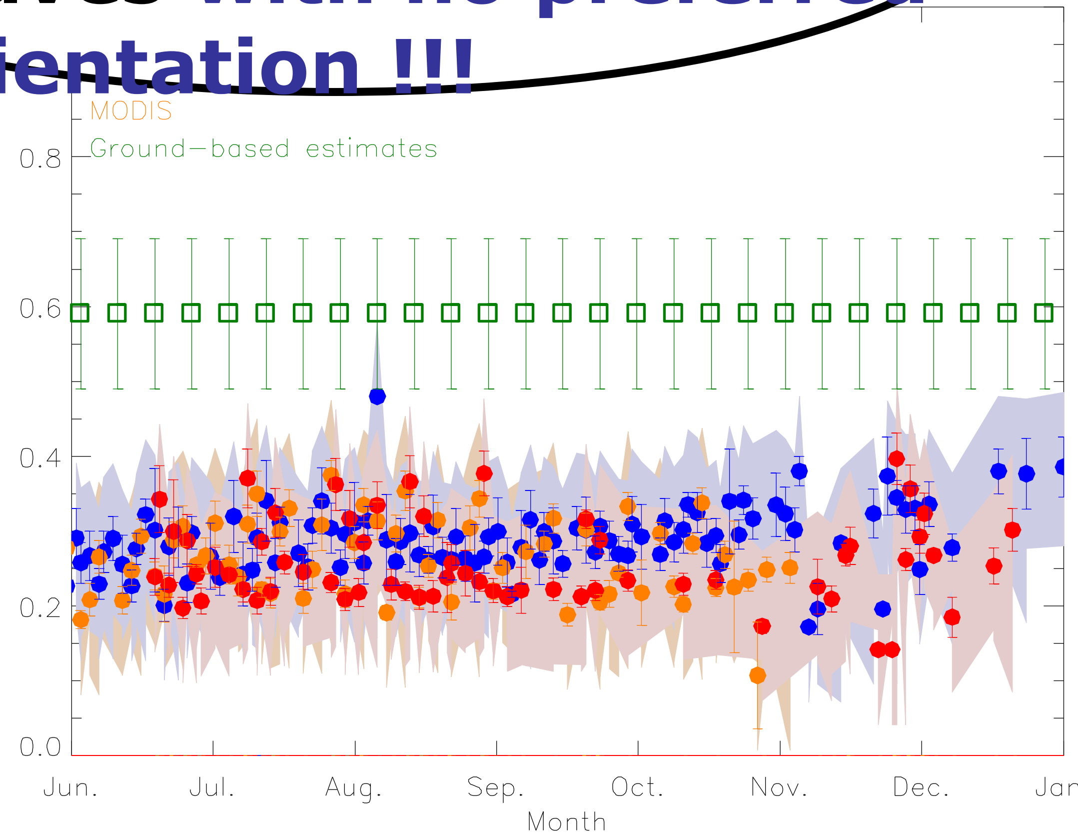
Advanced procedure for spatio-temporal changes of local LAI

Gobron N. et. al. (2008) ‘Uncertainty estimates for the FAPAR operational products derived from MERIS – Impact of TOA radiance uncertainties and validation with field data’, RSE, Vol. 112, pp 1871–1883,

Validation of FAPAR

"Resonant"

assumes random distribution of black leaves with no preferred orientation !!!



Ref: Turner et al. 2005

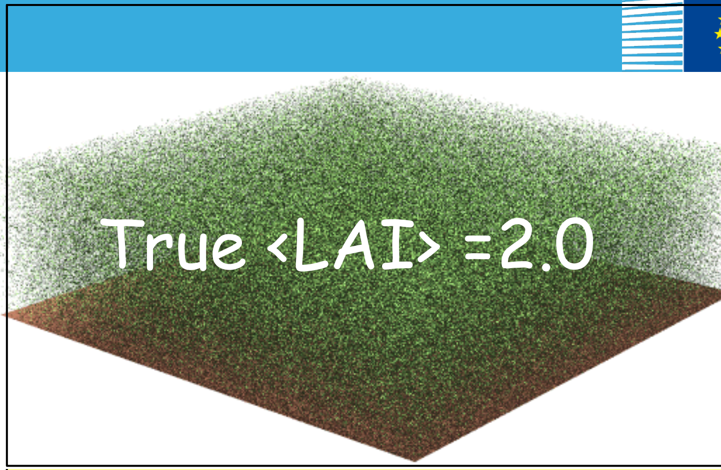
FAPAR ≈ 1.-exp(-0.5<LAI>)

<LAI> from PCA_LICOR

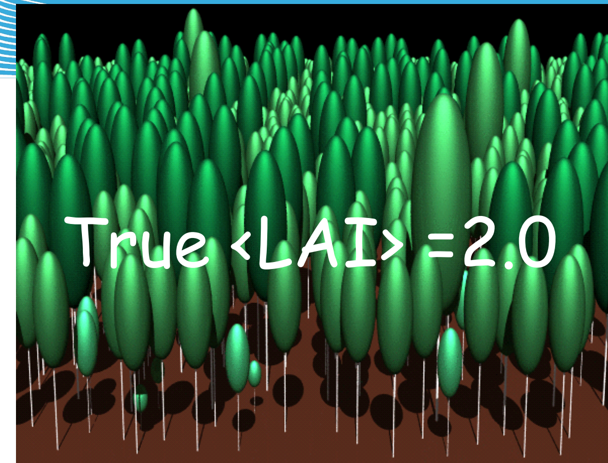
Advanced procedure for spatio-temporal changes of local LAI

Gobron N. et. al. (2008) 'Uncertainty estimates for the FAPAR operational products derived from MERIS – Impact of TOA radiance uncertainties and validation with field data', RSE, Vol. 112, pp 1871–1883,

Problem related to clumping (1)



1-D system representation



3-D heterogeneous system

Direct transmission at 30 degrees Sun zenith angle,

$$T_{1-D}^{direct}(<LAI>) = \exp\left(-\frac{<LAI>}{2\mu_0}\right) = 0.312$$

Direct transmission at 30 degrees Sun zenith angle,

$$T_{3-D}^{direct}(<LAI>) = 0.596$$

1-D ← 3-D ≈ 0.688 ← 0.404

$$T_{3-D}^{direct}(<LAI>) = T_{1-D}^{direct}(<LAI> \xi(\mu_0))$$

Domain-averaged structure factor

Pinty B. et. al. (2006) 'Simplifying the interaction of land surfaces with radiation for relating remote sensing products to climate models', JGR,

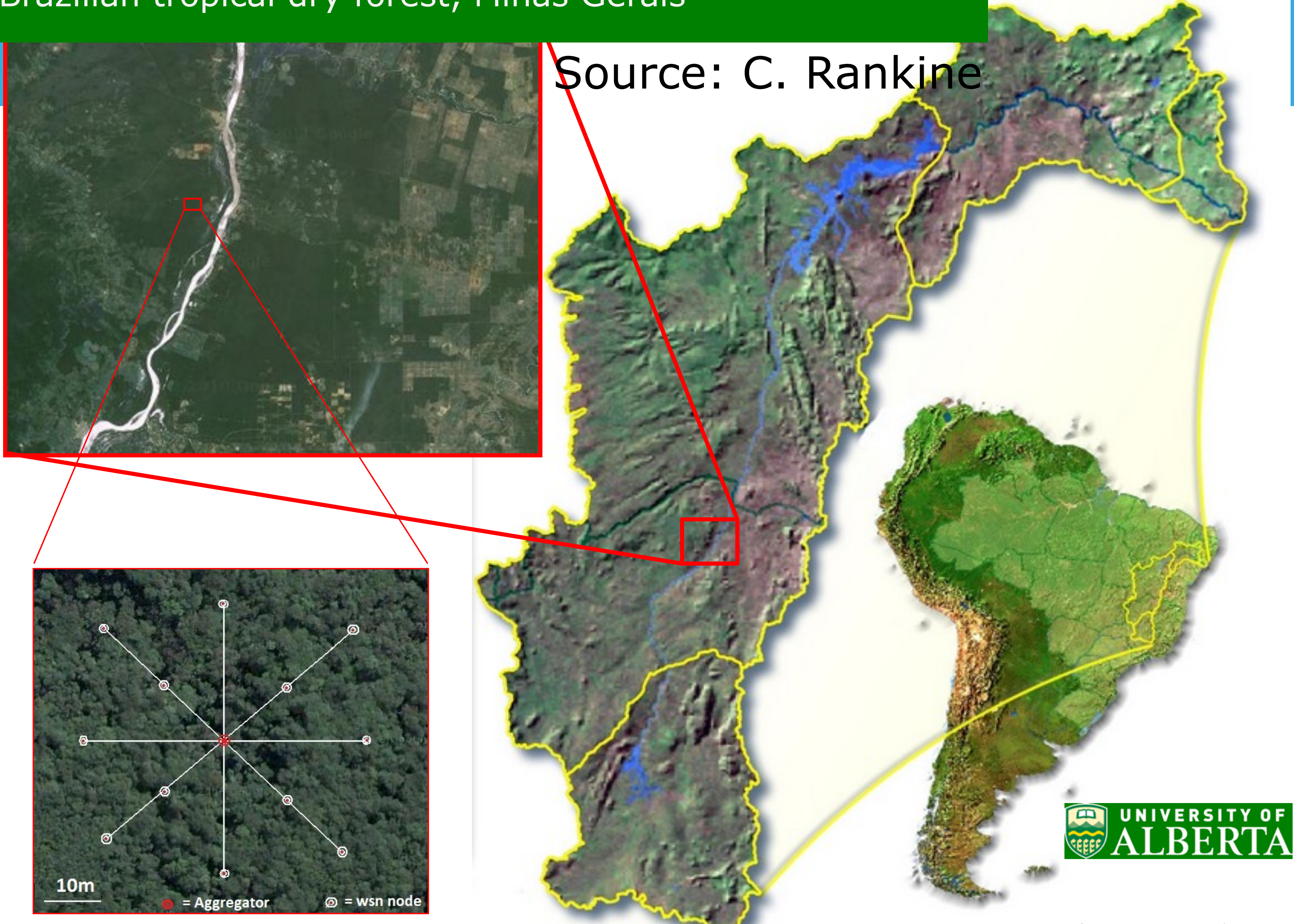
Do we have real networks oriented to advance FAPAR research?

We have several international initiatives around the world, but…

- FAPAR is not their main objective,
- FAPAR is seen as sub-product of other measurements,
- Measurements are in many cases restricted to single sensors/instruments,
- No comprehensive standardized FAPAR database exists to promote inter-comparison between different networks,
- Funding agencies put little or no priority on funding FAPAR initiatives as a whole but they have to be part of other larger initiatives.

Brazilian tropical dry forest, Minas Gerais

Source: C. Rankine



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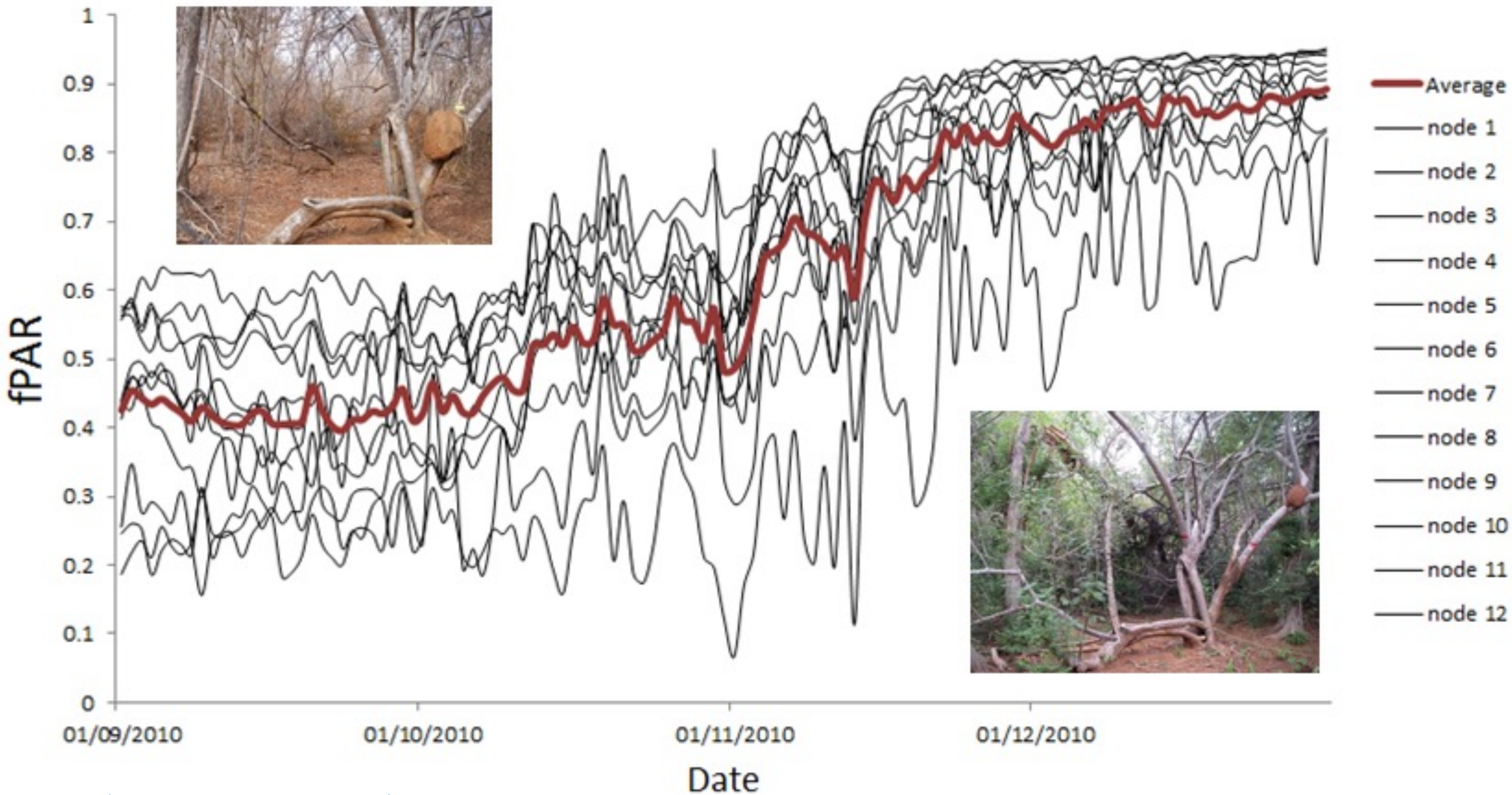
projects.csg.uwaterloo.ca

FAPAR During Leaf Flush

European Commission

40% woody area FAPAR variability across network in dry



Sanchez at el., 2011 IEEE eScience

Brazilian tropical dry forest, Minas Gerais

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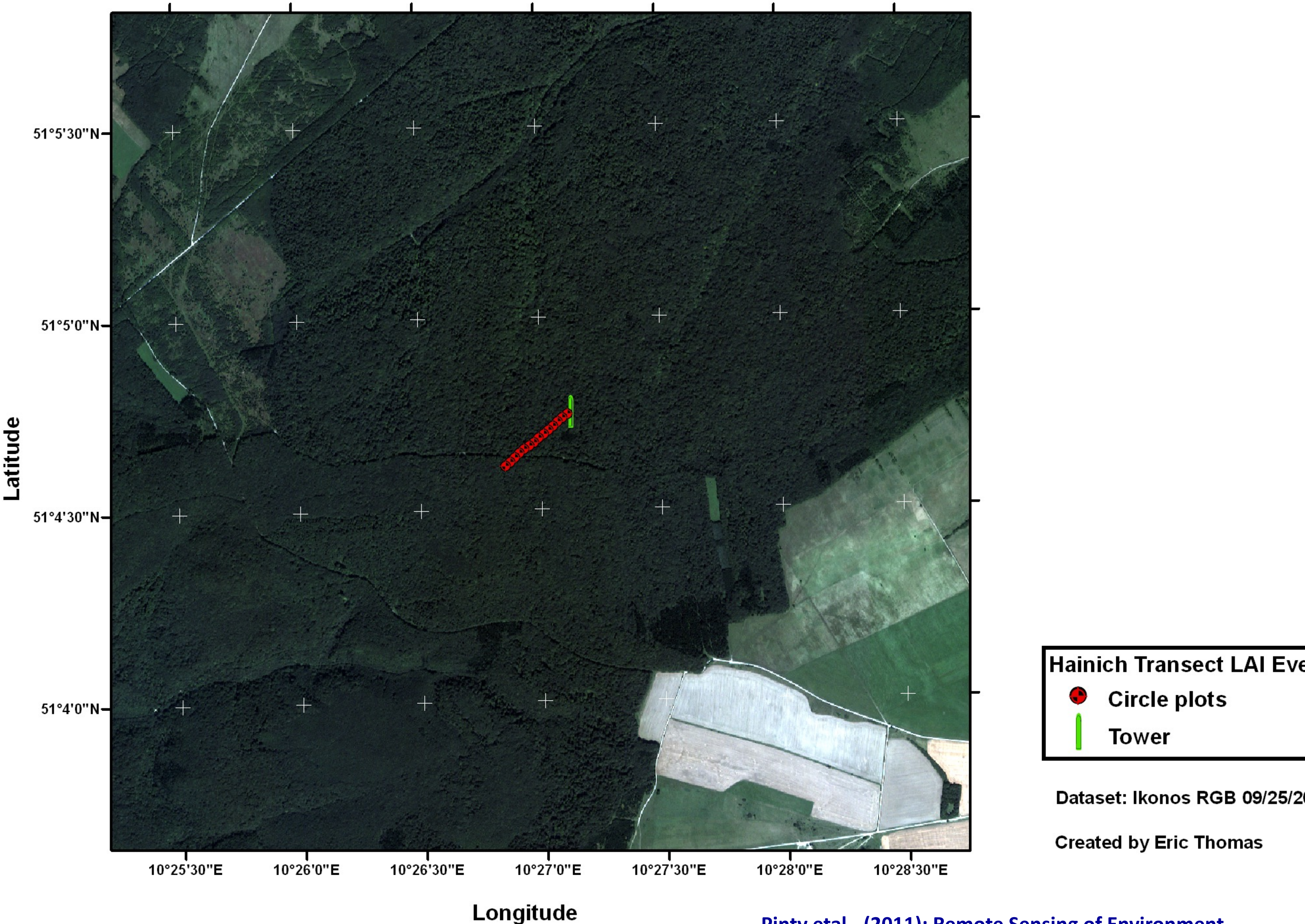
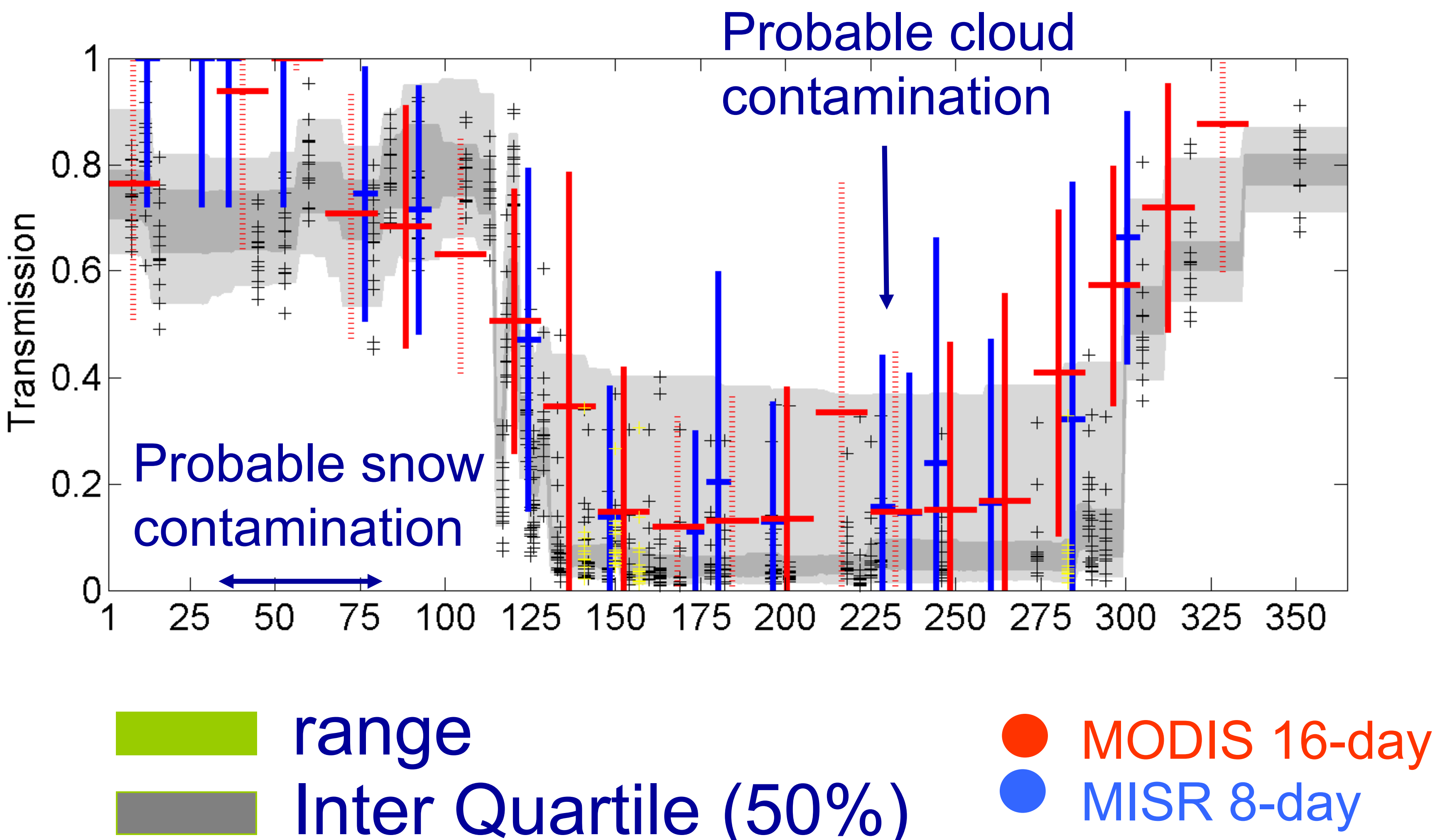


Pinty etal., (2011): Remote Sensing of Environment

Comparison between TIP retrieved transmission and in-situ estimates



Pinty etal., (2011): Remote Sensing of Environment

FAPAR Strategy Validation

Ground-based Knowledge	Product	Retrieval
Capitalize on FAPAR/FIPAR(*) acquired over multiple years to reconstruct at least over one vegetation seasonal cycle.	**Validation with expected accuracy < ± 0.1 (< GCOS!) Seasonal verification**	
Measurements of background albedo simultaneously with transmission (spatial sampling along transect). Webcam to assess variability in effective scattering albedo (linked to leaf colors) of the canopy in the VIS and NIR.	**Simulated ground-based and EO data using 3-D RT over typical land cover scenes. Validation taken into account definition and assumption.**	
Structural knowledge (using Lidar, etc ...) – possible only over few sites	**Simulated ground-based and EO data using 3-D RT over realistic scenes. Validation taken into account definition and all assumptions.**	

(*) Use (and support) current networks, such as Fluxnet or Direct, etc … with a complete description of measurement protocol.

Visual assessment of 1Km² Google Maps cutouts:

- Number and extension of Plant Functional Types in MODIS pixel
- PFT of the tower location equal to dominant PFT of the area
- confidence in classification (low, medium, high)
- qualitative estimation of landscape heterogeneity (low, medium, high)

Accepted

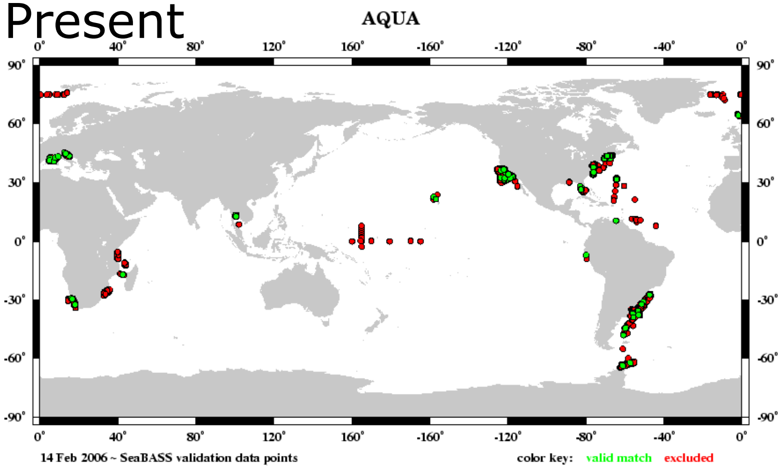
Rejected

A. Cescatti, 2012

Source: SeaDAS Training ~ NASA Ocean Biology Processing Group

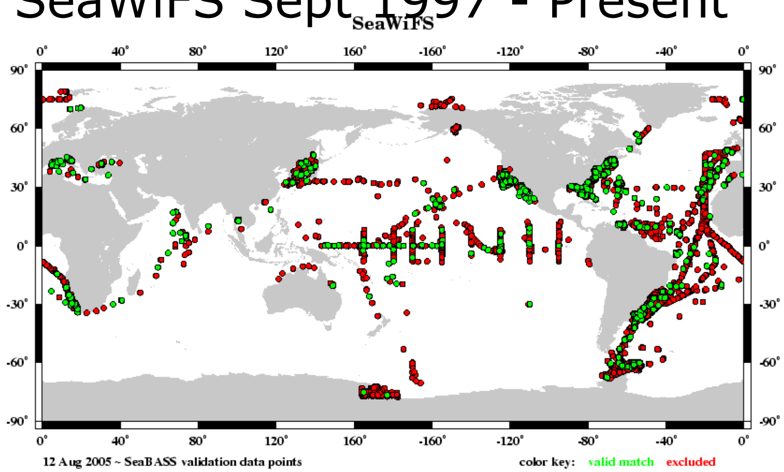
European Commission

MODIS-Aqua July 2002 - Present



color key: valid match excluded

SeaWiFS Sept 1997 - Present



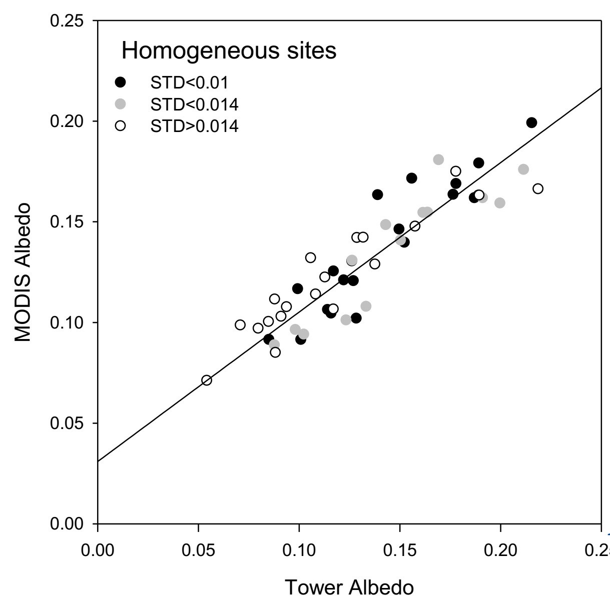
"match-up" defined as:

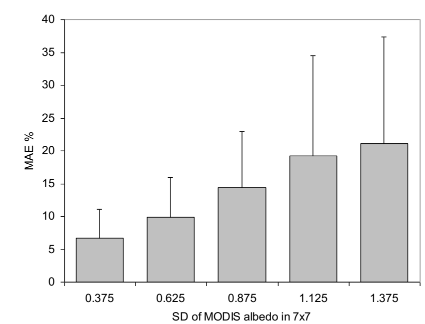
(1) in situ measurement collected within +/- 3 hours of satellite overpass

(2) 5x5 satellite pixel box centered on in situ lat/lon target

(3) homogeneity and sensor/solar geometry tests applied

(4) filtered median of valid (non-flagged) pixels, if >50% remain





A. Cescatti, 2012

In-situ measurements (1)

European Commission

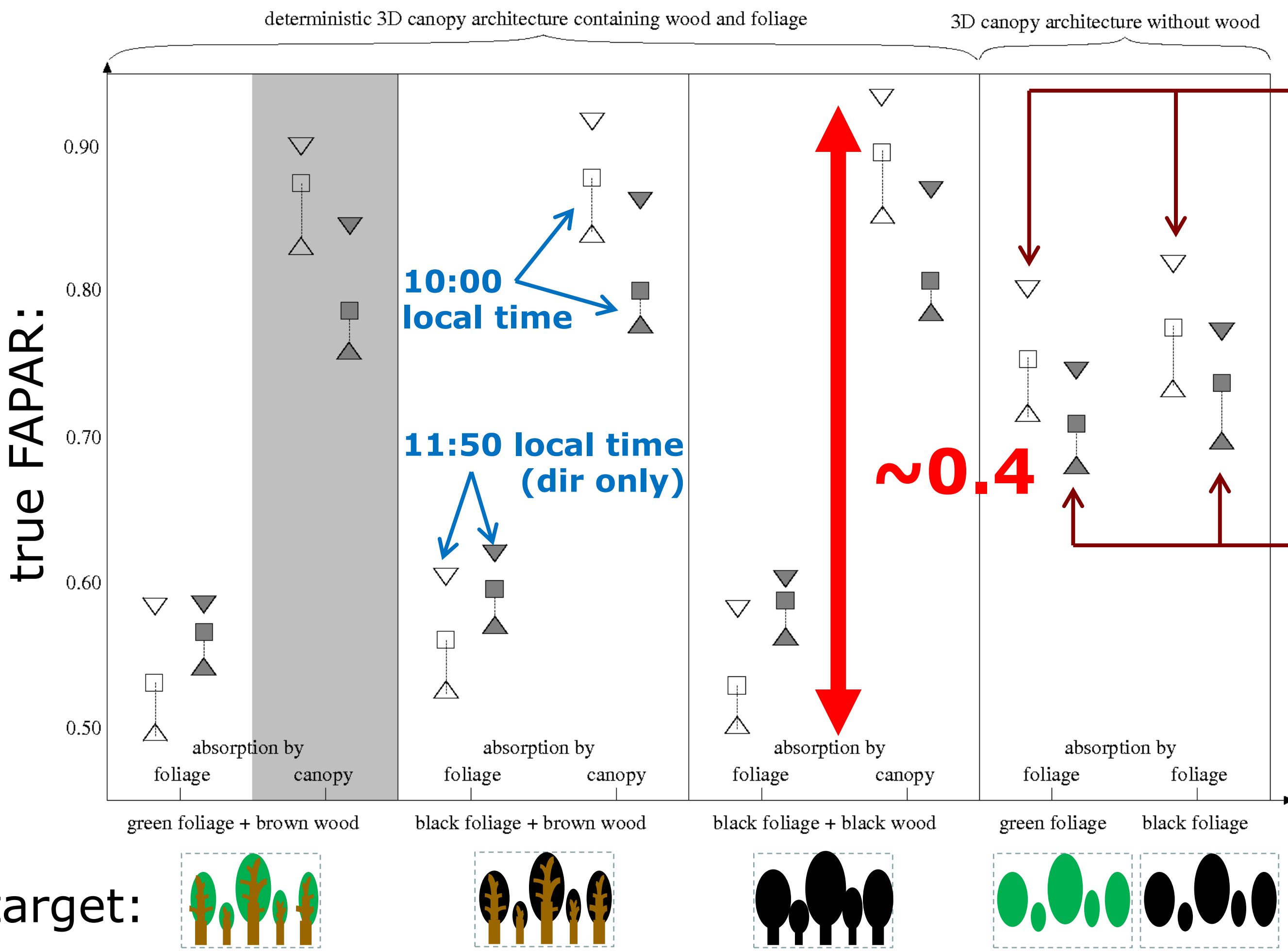
Criteria that define **what do we want to measure** that influences the calibration/validation of a given spaceborne sensor.

- Linkages to spatial and spectral resolution of the sensor(s) to be calibrated/validated.

FAPAR estimations

European Commission

"Choice of 'truth' strongly impacts validation results."



RAMI-IV Estonia

March 15th, pine stand+snow

July 15th, mixed birch stand

Widlowski et al, Env. Sci. Pol., 2013 (in review)

In-situ measurement (1)

Criteria that define **what do we want to measure** that influences the calibration/validation of a given spaceborne sensor.

- Linkages to spatial and spectral resolution of the sensor(s) to be calibrated/validated.

Sensor specification:

- Characterization of sensor spectral and angular response.
- Definition of minimum requirements.
  - Development of intercomparison of different sensors
- Look at detector properties and intercomparison

Calibration and maintenance:

- Absolute values and consistency on setups.
- Sensor frequency change important for sensors looking up.
- Look at indoor vs outdoor stability → related to calibration issues.

In-situ measurement (2)

European Commission

Spatial:

- Recommendation for geostatical approaches for sensor deployment → two stage approach: sampling the pdf (dynamic)
- Preliminary evaluation of the FPAR field using Hemispherical Cameras for the identification of sensor deployment → two stage approach

Temporal:

- Requirements for temporal sampling.
- Related to product that wants to be validated.

Error estimates:

- Stability and variability of sensors produced by the same company
- Meteoc2: intercomparison of PAR sensors at ISPRA (2015)
- How good the methods area.