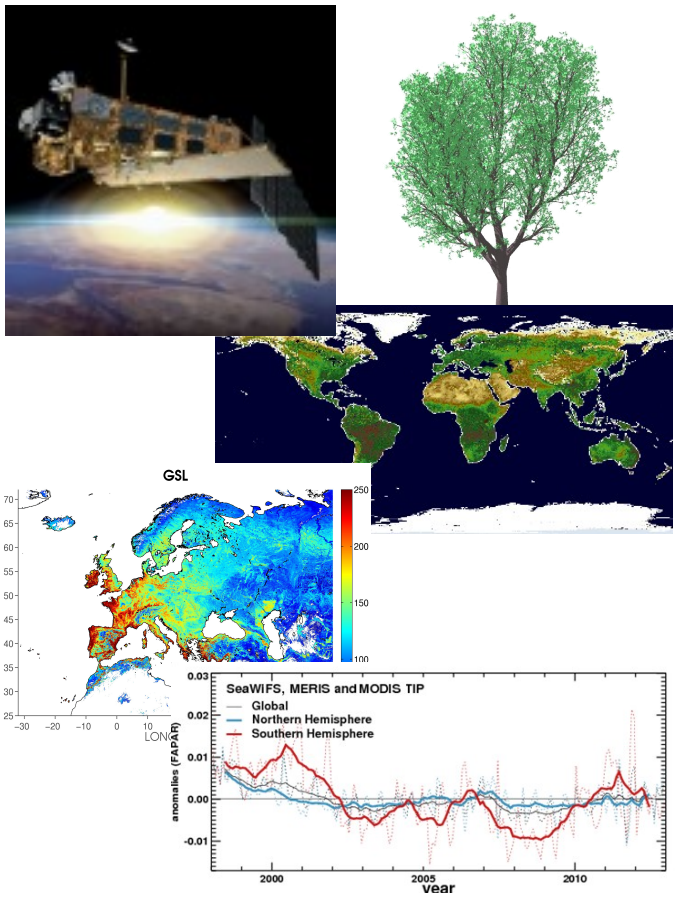
European Commission

The CEOS/WGCV LPV strategy for defining FAPAR inter-comparison and validation protocols



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Joint Research Centre

1st CEOS LPV FAPAR Workshop

European Commission

FAPAR

Fraction of Absorbed Photosynthetically Active Radiation

European Commission > JRC > IES > GEM > FAPAR > Events

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First Workshop CEOS LPV FAPAR sub-group

The **Land Product Validation Biophysical** **FAPAR** sub-group co-chaired by **Nadine Gobron** of the **EC Joint Research Centre** and **Arturo Sanchez-Azofeifa** of the **University of Alberta** are pleased to announce the

1ST FAPAR SUB-GROUP WORKSHOP

that will be held on the **23-24 JANUARY 2014** at European Commission - Joint Research Centre at **ISPRA**, **ITALY**.

Joint Research Centre

Purpose

This workshop offered an open community discussion forum on product validation, in-situ measurements and

what are the best practices in each sub-topic:

- FAPAR products Inter-comparison
- FAPAR In-situ Measurements: Existing Network and Specific Site
- Validation of space products algorithm and ground-based method.

GCOS requirements

Horizontal Resolution	Vertical Resolution	Temporal resolution	Accuracy	Stability
250 m	n/a	2-weekly averages (based on daily sampling)	Max(10%;0.05)	Max(3%;0.02)

"Both black-sky (assuming only direct radiation) and white-sky (assuming that all the incoming radiation is in the form of isotropic diffuse radiation) FAPAR values **may be considered**. Models describing the primary productivity of plants and the energy balance of the land surface require either a characterization of the **diurnal evolution of FAPAR or the daily integrated value of FAPAR, depending on the time step used**. Other applications may only **require cumulative or aggregated values over longer periods**." (GCOS 154)

FAPAR: which definition?

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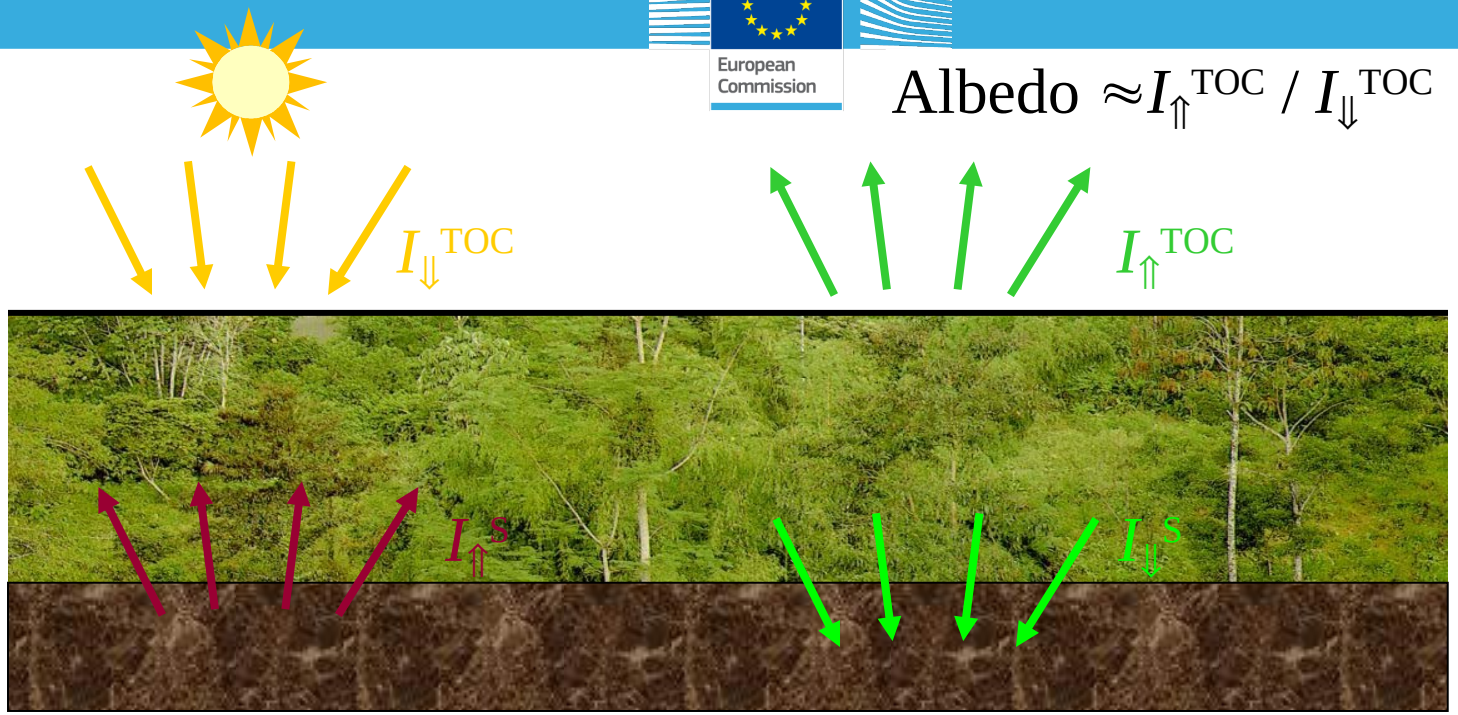
Albedo $\approx I_{\Uparrow}^{TOC} / I_{\Downarrow}^{TOC}$



$$FAPAR(\theta s) \approx [(I_{\Downarrow}^{TOC}(\theta s) + I_{\Uparrow}^{S}(\theta s) - (I_{\Uparrow}^{TOC}(\theta s) + I_{\Downarrow}^{S}(\theta s)] / I_{\Downarrow}^{TOC}(\theta s)$$

The Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) can be computed, or measured, in different way …

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Global RS FAPAR products

Projects/Institution Sensors/Period	Input data	Output product	Retrieval Method	References
JRC-FAPAR SeaWiFS ESA MERIS (07/97-04/12)	Top of Atmosphere (TOA) BRFs in blue, red and near-infrared bands	Daily Instantaneous green FAPAR based on direct incoming radiation	Optimization Formulae based on Radiative Transfer Models	Gobron et al (2000, 2006, 2008)
NASA MODIS LAI/FPAR (00-on going)	Surface reflectance in 7 spectral bands and land cover map.	8-days FAPAR with direct and diffuse incoming radiation	Inversion of 3D Model versus land cover type with backup solution based on NDVI relationship)	Knyazikhin et al. (1998b)
NASA MISR LAI/FPAR (00-on going)	Surface products BHR, DHR & BRF in blue, green, red and near-infrared bands + CART	8-days FAPAR with direct and diffuse incoming radiation.	Inversion of 3D Model versus land cover type with backup solution based on NDVI relationship)	Knyazikhin et al. (1998a)
GLOBCARBON	Surface reflectance red, near infrared, and shortwave infrared	Instantaneous FAPAR (Black leaves)	Parametric relation with LAI as function as Land cover type.	Plummer et al. (2006)
CYCLOPES VEGETATION	Surface reflectance in the blue, red, NIR and SWIR bands	FAPAR at 10:00 solar local time	Neural network based on 1D model	Baret et al (2007)
JRC-TIP MODIS/MISR (00-On going)	Broadband Surface albedo in visible and near-infrared bands.	8-(16) days Standard FAPAR or/& Green FAPAR for direct or/& diffuse incoming radiation	Inversion of two-stream model using the Adjoint and Hessian codes of a cost function.	Pinty et al. (2007)
GEOLAND2 VEGETATION (99-2012)	Normalized surface reflectance in red and near-infrared bands	FAPAR at 10:00 solar local time	Neural network based on CYCLOPES and MODIS products	Baret et al (2010)

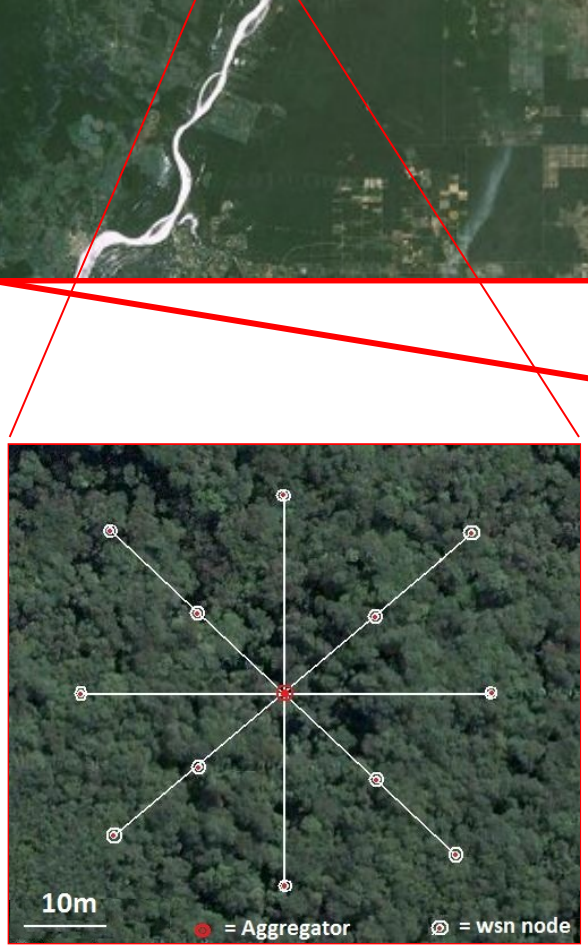
Do we have real networks oriented to advance FAPAR research?

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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FAPAR During Leaf Flush

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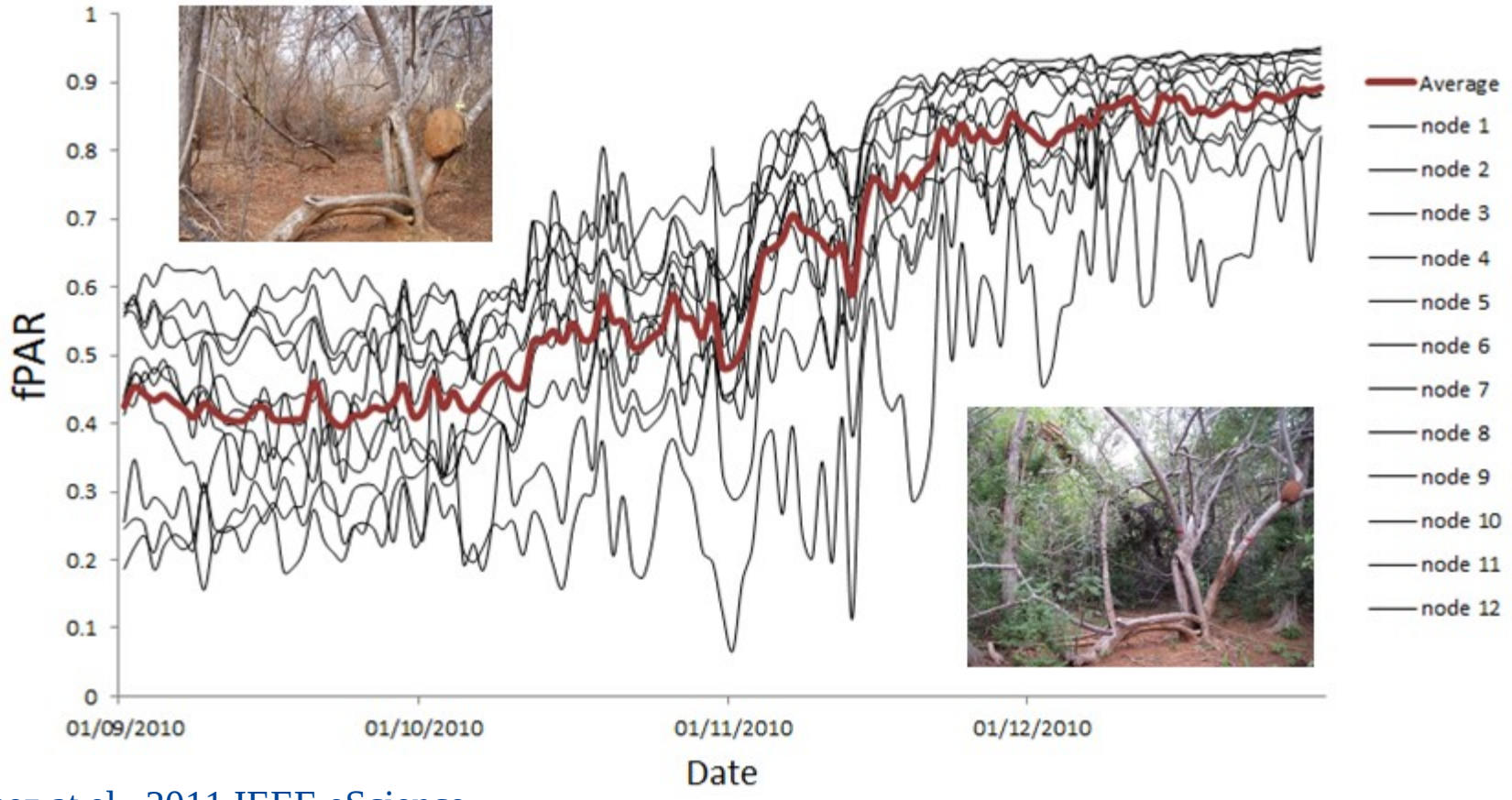
40% woody area FAPAR variability across network in dry



Sanchez at el., 2011 IEEE eScience

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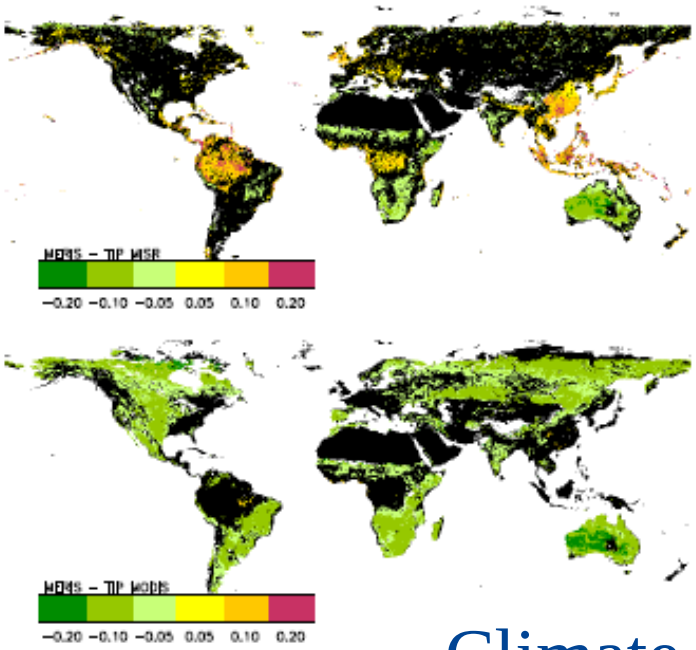
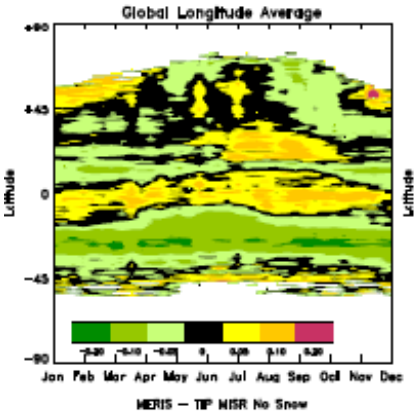
Brazilian tropical dry forest, Minas Gerais

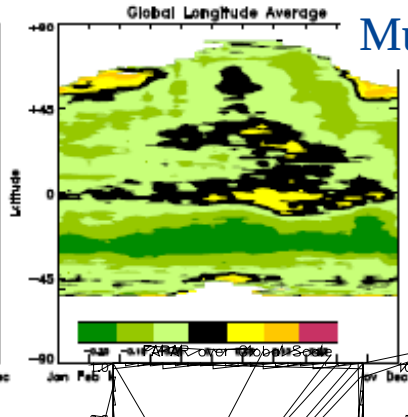
Inter-comparison with similar products: from global to local scale.

Scale	What do we get?
Global/Continental 10-days/monthly Long time series	+: Provide information on products stability and performance when same retrieval algorithm is used with different sensors. +: fast check of difference of products (spatial and seasonal) -: aggregation method and time composite may be different
Regional scale at nominal resolution (~1km)	
Site Level at nominal resolution (~1km) - Daily	

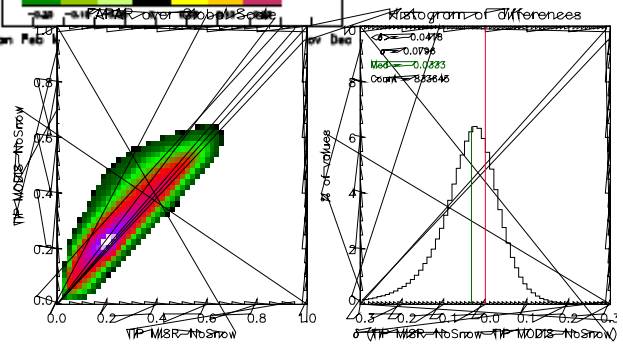
Inter-comparison with similar products - global scale



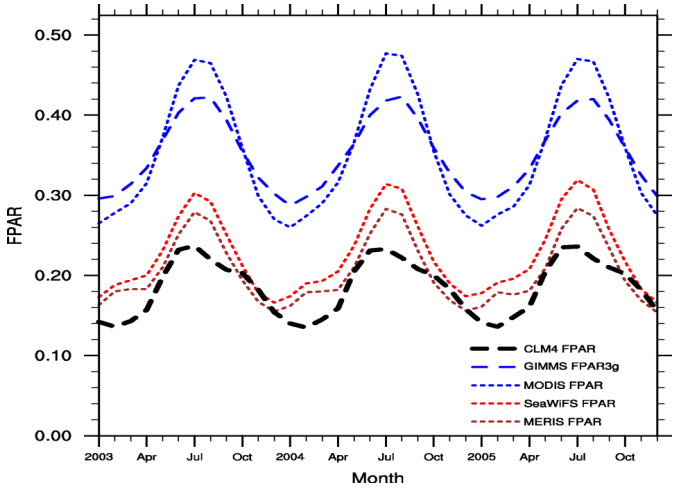


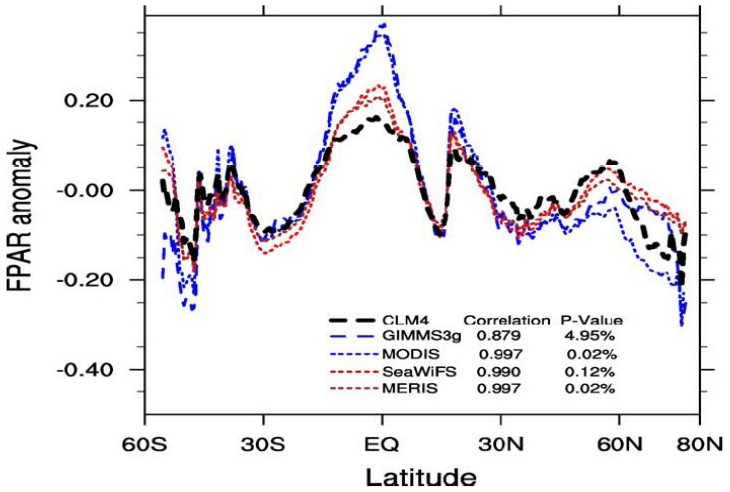


Musial et al., 2012



Climate Land Model





Wang K. et al. (2013)

Inter-comparison with similar products: from global to local scale.

Scale	What do we get?
Global/Continental 10-days/monthly Long time series	+: Provide information on products stability and performance when same retrieval algorithm is used with different sensors. +: fast check of difference of products (spatial and seasonal) -: aggregation method and time composite may be different
Regional scale at nominal resolution (~1km)	+: Provide information, if disagreements, on quality of input data or/and pre-processing step. -: remapping method, geo-reference.
Site Level at nominal resolution (~1km) - Daily	

Comparison metrics

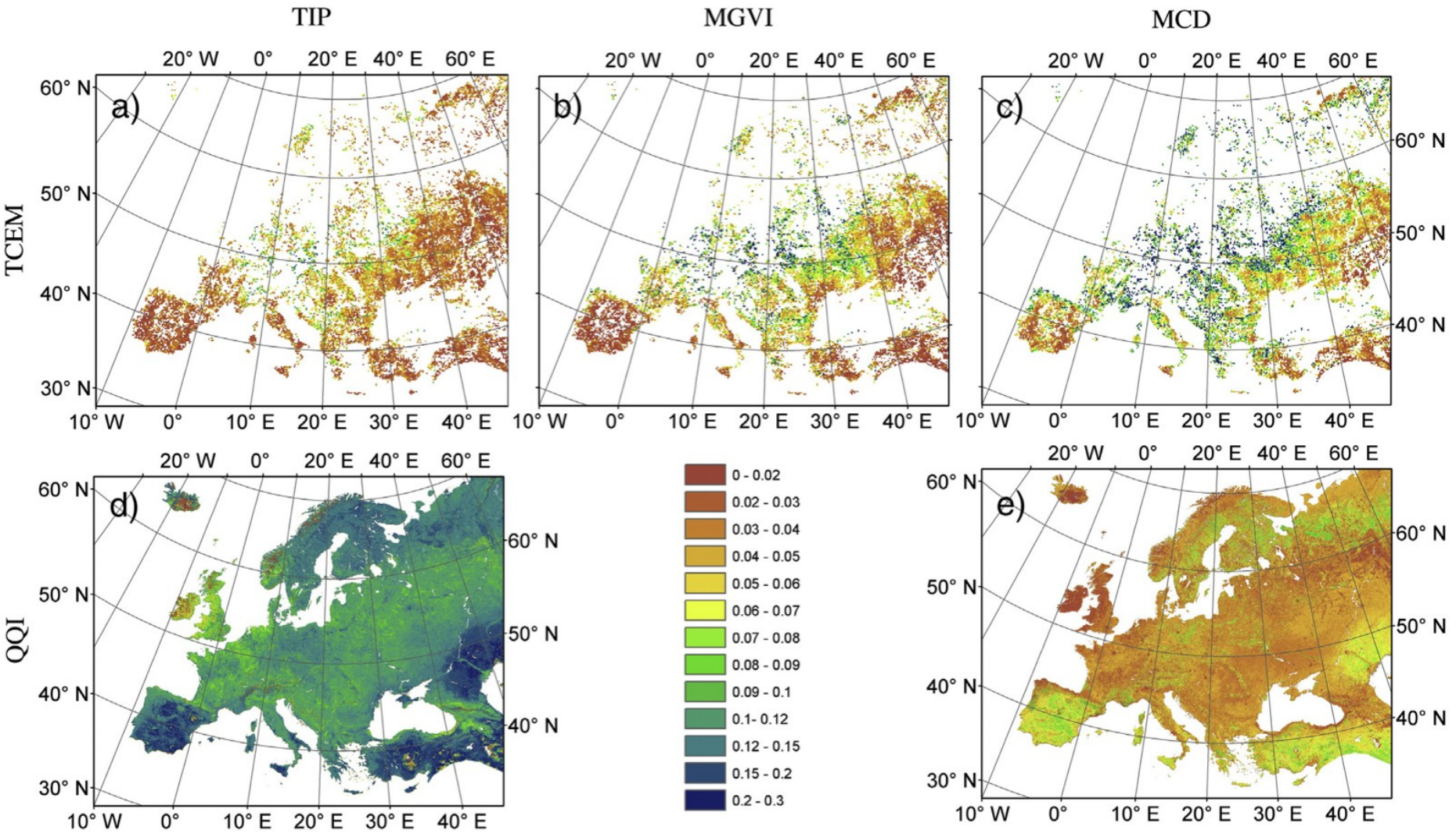


Fig. 6. Comparison of uncertainties retrieved by the Triple Collocation Error Model (TCEM) (a–c) and uncertainties provided with the products' Quantitative Quality Indicators (QQIs) (d, e). Temporal resolution: a–e) July monthly composites for the years 2009–2011. Spatial resolution (pixel size): a–c) 18 × 18 km, d–f) 1 × 1 km.

Dodorico et al., 2014, RSE

Inter-comparison with similar products: from global to local scale.

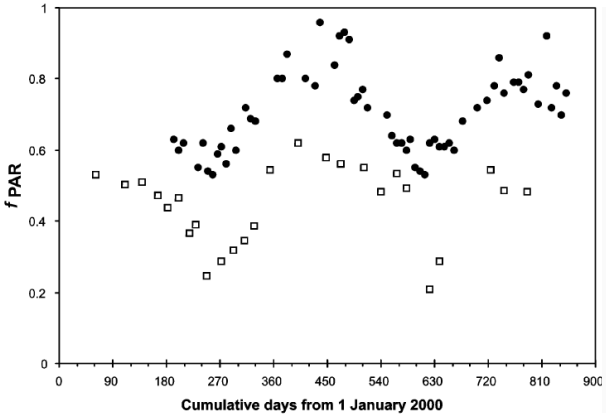
Scale	What do we get?
Global/Continental 10-days/monthly Long time series	+: Provide information on products stability and performance when same retrieval algorithm is used with different sensors. +: fast check of difference of products (spatial and seasonal) -: aggregation method and time composite may be different
Regional scale at nominal resolution (~1km)	+: Provide information, if disagreements, on quality of input data or/and pre-processing step. -: remapping method, geo-reference.
Site Level at nominal resolution (~1km) - Daily	+: Provide information on products stability and performance. +: Provide accuracy only with ‘validation’ step information

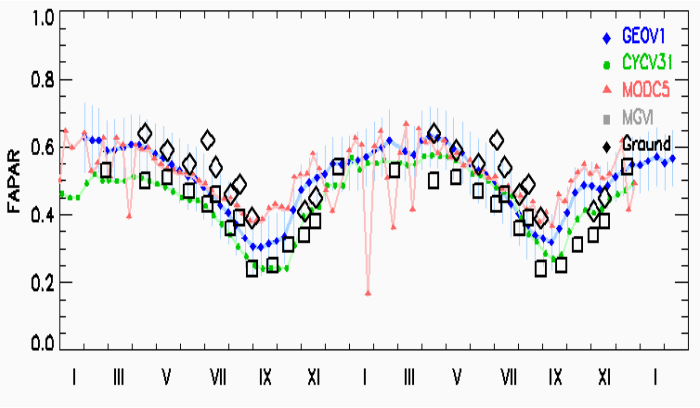
EO Validation

European Commission

Mongu: Shrubland/woodland

Cernicharo et al., 2011



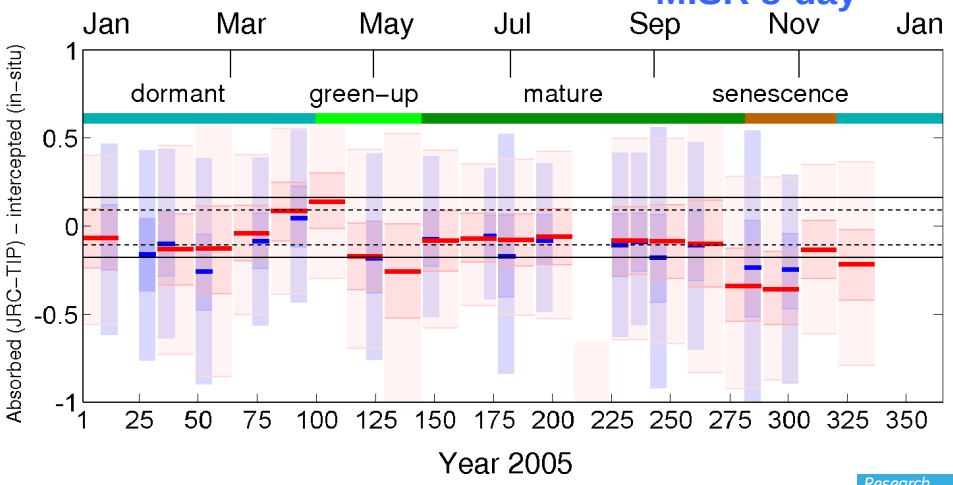


Hummerich et al., 2005

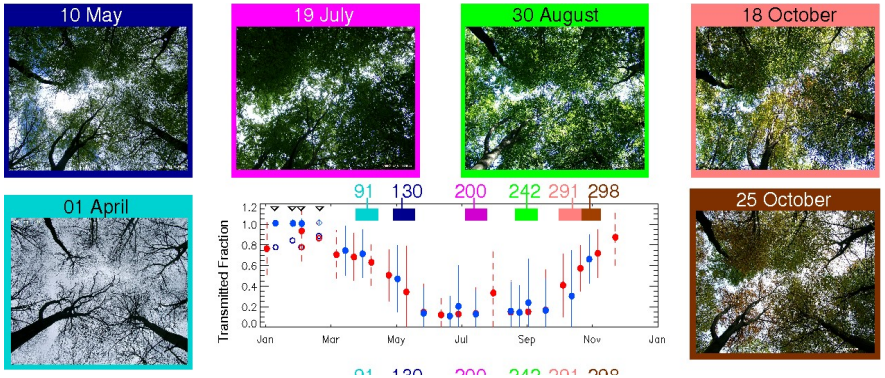
Figure 1. f_{PAR} values for the Mongu site over time. f_{PAR} data from ground measurements (□) and derived from MODIS observations (●).

MODIS 16-day

MISR 8-day



Hainich: deciduous forest

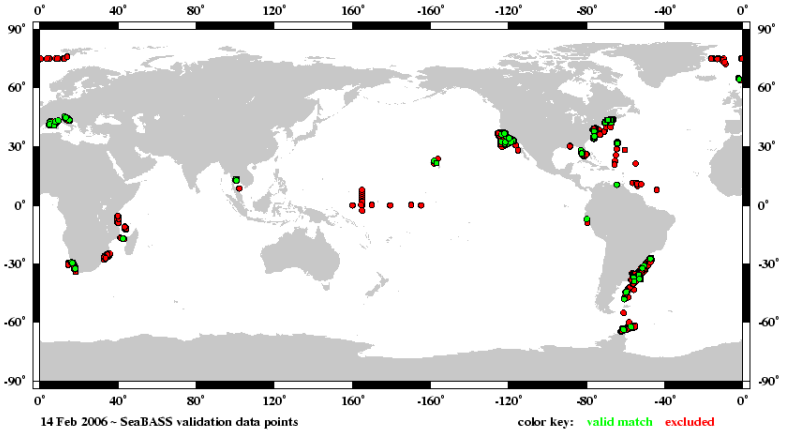


Pinty et al., 2011

Research Centre

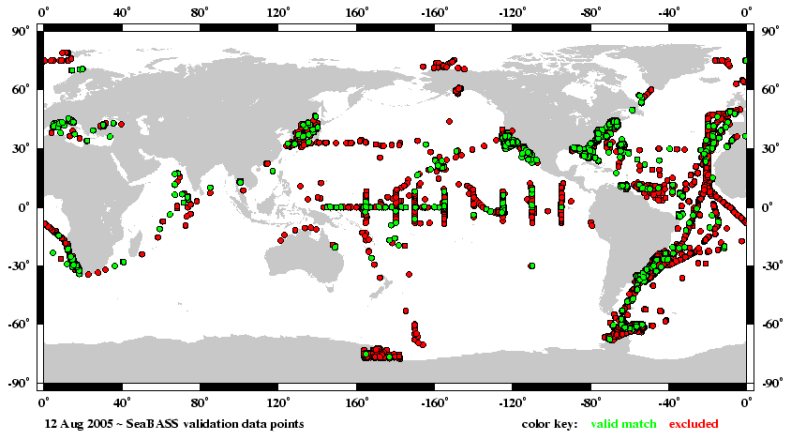
Source: SeaDAS Training ~ NASA Ocean Biology Processing Group

MODIS-Aqua July 2002 - Present



color key: valid match excluded

SeaWiFS Sept 1997 - Present



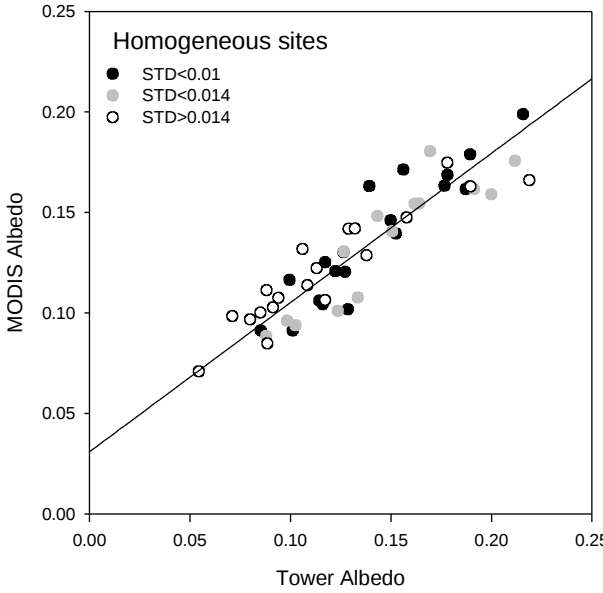
"match-up" defined as:

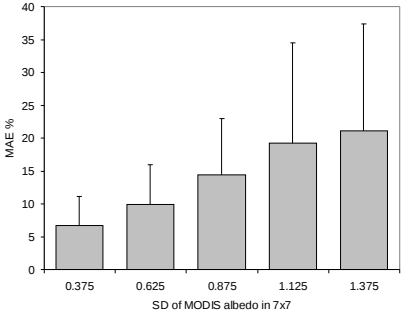
(1) in situ measurement collected within +/- 3 hours of satellite overpass

(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

CEOS LPV Strategy: Inter-comparison

Scale	Goals	Metrics or/and Tools
Global/Continental 10-days/monthly Long time series	Access quality of products Temporal and spatial consistency	Quality Working Group Difference taken into account uncertainties with annual maps, Hovmuller-plot, scatter-plots, etc …
Regional scale at nominal resolution (~1km)	Temporal and spatial consistency	Correlation, Temporal bias, Root Mean Square Difference (Unsystematic & Systematic) Agreement Coefficient (AC) Etc …
Site Level at nominal resolution (~1km) - Daily	Temporal and spatial consistency Assessment of actual accuracy	Match-Up when reference ground-based measurements exist.

CEOS LPV 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.

Near-Future actions

Toward a CEOS LPV FAPAR network (based on actual ones)

- Best practices for field deployments.
- Best practices for sharing and distribution of field data etc …

Toward inter-comparison metrics

- Best practices for inter-sensor comparison
- Role of OLIVE
- Best practices for inter-comparison of algorithms.

Future steps

- Modeling in support of error and uncertain assessment
- Emerging tools for FPAR monitoring (sensors, UAVs).

Conclusions

European Commission

- Global/Regional comparison of products : Agencies have to make an effort for providing global and regional and match-up products to the 'validation' community

- Validation and comparison of EO products (& ground-based data) **and their retrieval method/protocol are mandatory**.

- Simulated EO data and ground-based measurements using 3-D RT over realistic scenes (RAMI sites)

- Actual EO data from various instruments to run a round-robin exercise

Algorithm Benchmark

- Invitation Letters to main products providers of both EO products and ground-based data with a survey

Thanks to the 1st CEOS LPV FAPAR Workshop Participants:

CASTRO Saulo, RANKINE Cassidy, SANCHEZ-AZOFEIFA Arturo, BARET Fred, WEISS Marie ORIGO Niall, ONO Yusaku, EKLUNDH Lars, CAMACHO Fernando, LOPEZ-BAEZA Ernesto, MARTINEZ Beatriz GOVAERTS Yves, TAGESSON Torbern, CLAVERIE Martin,
WIDLOWSKI Jean-Luc, CESCATTI Alessandro, DUVEILLER Gregory, GRUENING Carsten, MERONI Michele, PEKEL Jean-François, CECCHERINI Guido DOWELL Mark, ROBUSTELLI Monica

QA4ECV

User Requirements Survey for Quality Information in Satellite-derived CDR's

http://qa4eo.org/survey/