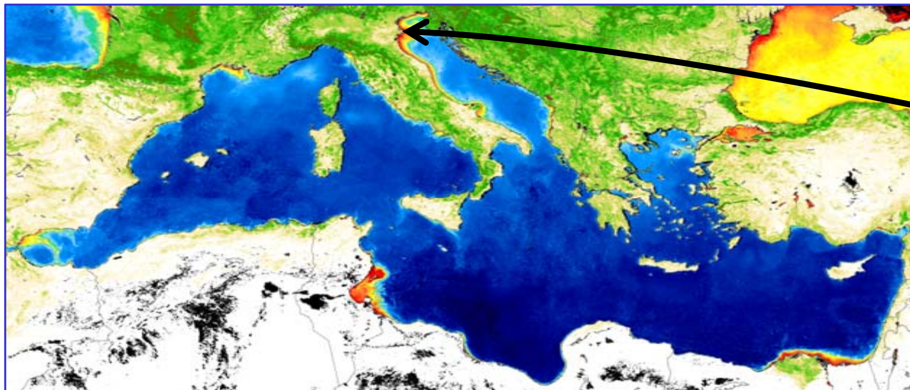
JRC
EUROPEAN COMMISSION

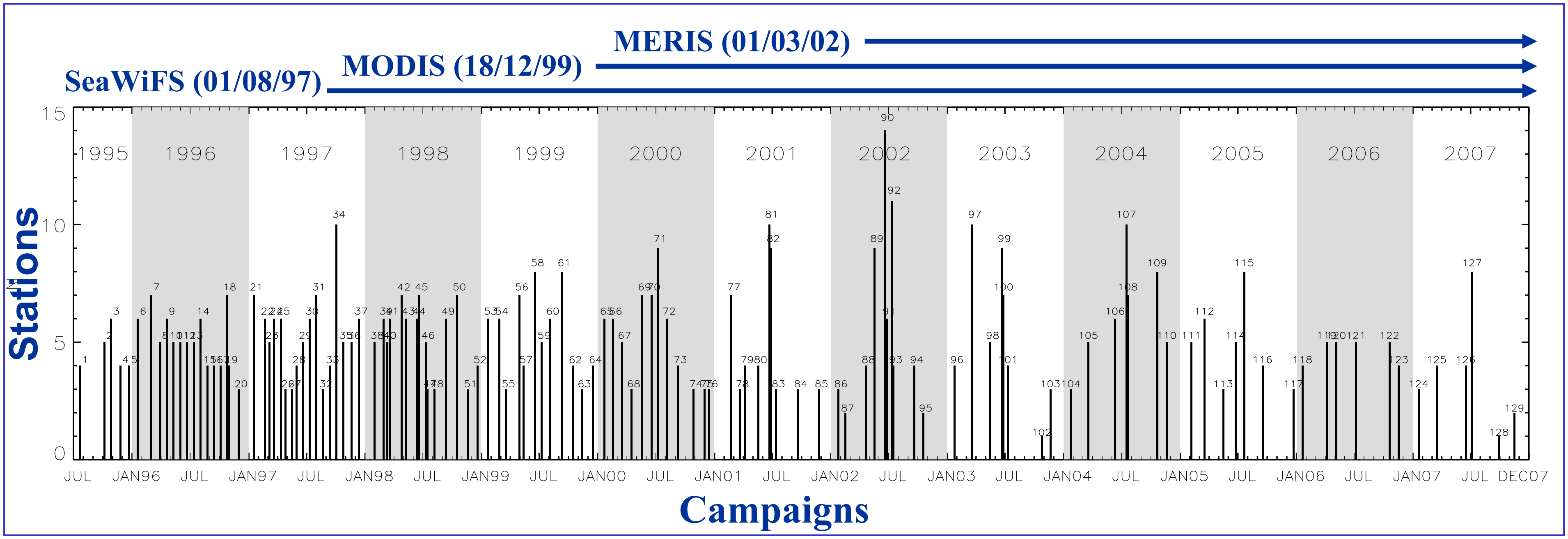
EC Joint Research Center report for CEOS WGCV

J-L. Widlowski, N. Gobron, B. Pinty, G. Zibordi & colleagues

Coastal Atmosphere and Sea Time Series (CoASTS)



Monthly Chla composite from SeaWiFS imagery (September 1998)

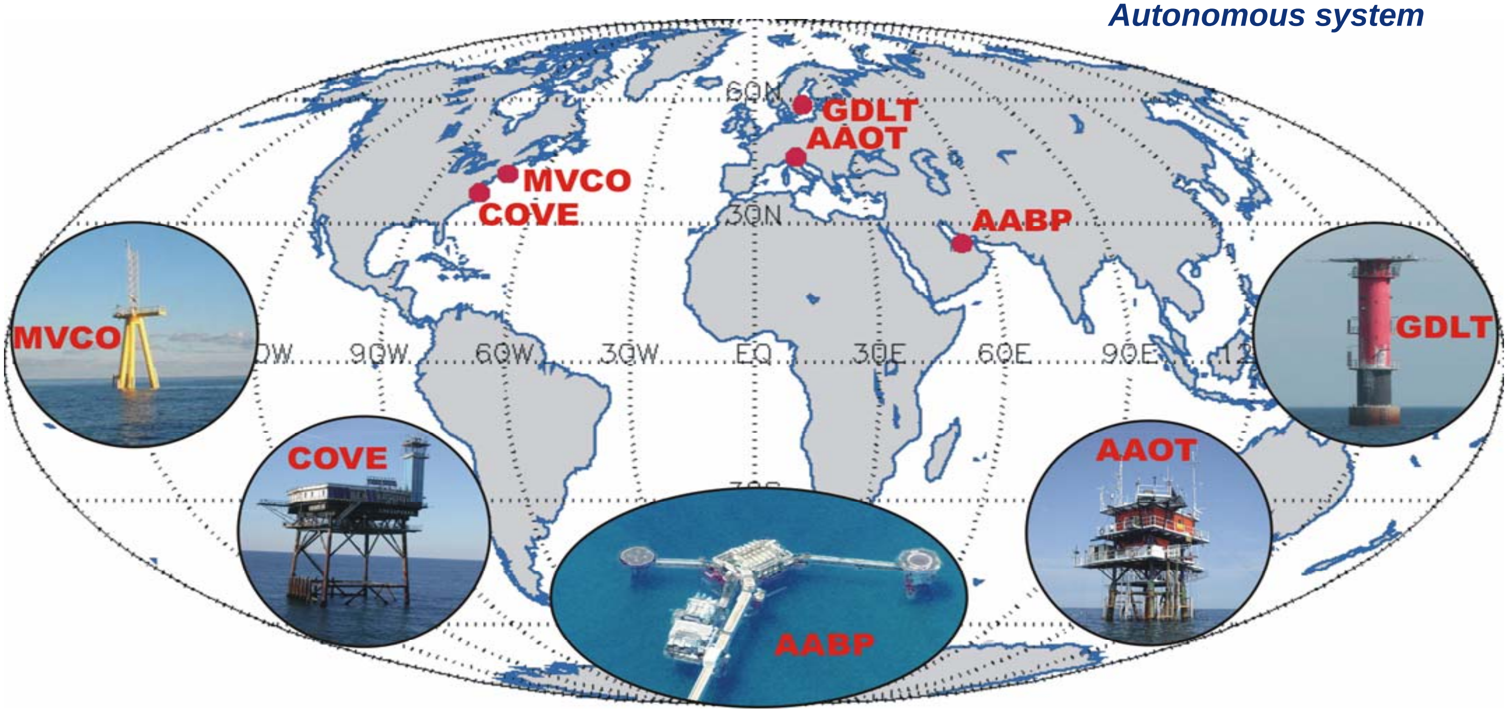


G.Zibordi, J.F.Berthon, J.P.Doyle, S.Grossi, D. van der Linde, C.Targa, L.Alberotanza. Coastal Atmosphere and Sea Time Series (CoASTS), Part 1: A long-term measurement program. NASA Tech. Memo. 2002-206892, v. 19, S.B.Hooker and E.R.Firestone, Eds., NASA Goddard Space Flight Center, Greenbelt, Maryland, 2002, 29 pp.

AERONET – Ocean Color

AERONET-OC is an integrated network supporting ocean color validation with highly consistent time-series of standardized $L_{WN}(\lambda)$ measurements.

Autonomous system



G.Zibordi et al. A Network for Standardized Ocean Color Validation Measurements. Eos Transactions, 87: 293, 297, 2006.

JRC
EUROPEAN COMMISSION

surface albedo product intercomparison

Surface Albedo: various quantities

BHR : Bi-Hemispherical Reflectance is the ratio between the upward and the downward radiant fluxes, that is, accounting for the downwelling diffuse intensities from the sky.

Depends on both surface and atmospheric radiative properties and …the solar zenith angle.

DHR: Directional Hemispherical Reflectance is the ratio between the upward flux and the downward collimated flux coming from one single direction.

Depends on surface radiative properties and …the solar zenith angle.

Ref: Pinty et al. (2005) Journal of the Atmospheric Sciences

Surface Albedo: some issues

• If the downwelling diffuse intensity from the sky is assumed fully **isotropic** then the BHR is equal to the integral of the DHR over all incoming directions and,

the BHR becomes a BHRiso called White Sky albedo by MODIS and depends on surface radiative properties only and …the solar zenith angle.

•The DHR boils down to a single integral of BRF on all the outgoing directions, called Black Sky albedo by MODIS where

the BRF, a Bidirectional Reflectance Factor expressing the probability for radiation coming from one particular direction to be scattered in a specific outgoing direction

All quantities can be defined monochromatic or broadband

• MISR delivers DHRs and BHRs as flux ratios but under ambient conditions and for the Sun illumination conditions at time of observations
as well as all information needed to reconstruct the DHRs at any other solar zenith angle and the BHRiso

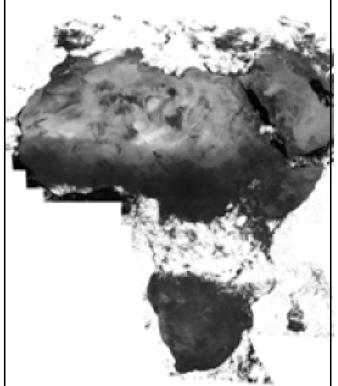
• EUMETSAT delivers DHRs for a fixed Sun angle
and all information needed to reconstruct the DHRs at any other solar zenith angle as well as the BHRiso

• MODIS delivers DHRs and BHR*iso*
to reconstruct the BHRs may require substantial investments or some level of assumption

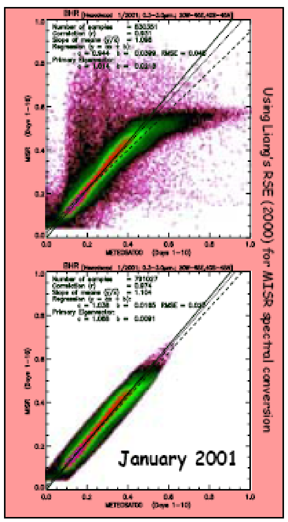
The albedo products may also differ with respect the spectral bands of integration they refer to.

MISR versus Meteosat

MSA product year 2001, 11-20

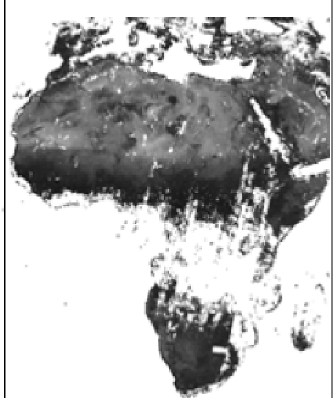


BHR_{iso} after the spectral conversion to an ideal 0.3-3.0 μm band

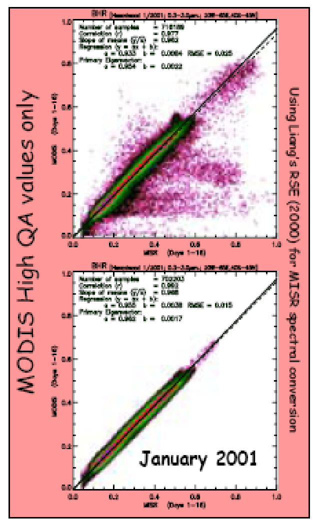


MISR versus MODIS

MISR product year 2001, 7-23

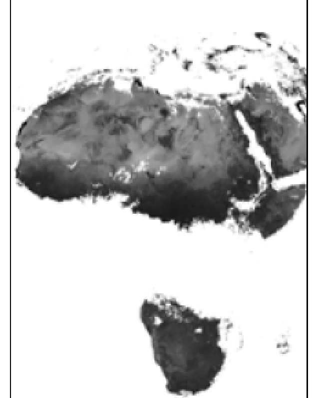


BHR_{iso} after the spectral conversion to an ideal 0.3-3.0 μm band

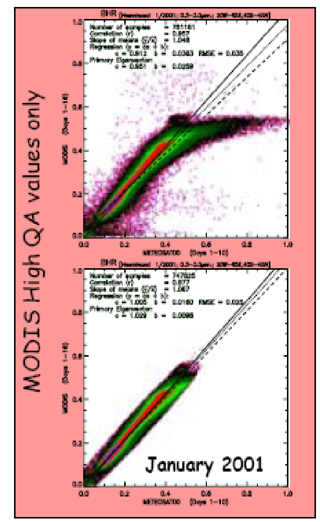


MODIS versus Meteosat

MODIS product year 2001, 1-16



BHR_{iso} after the spectral conversion to an ideal 0.3-3.0 μm band

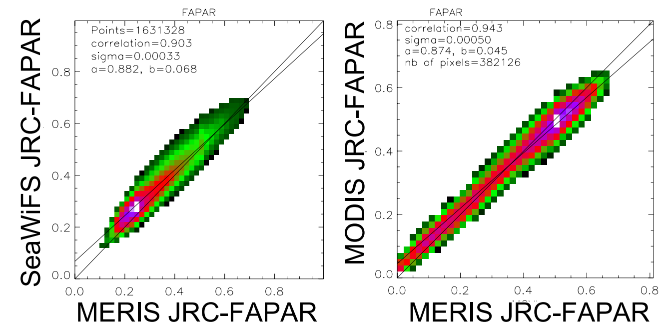


Pinty et al., 2007

JRC-FAPAR

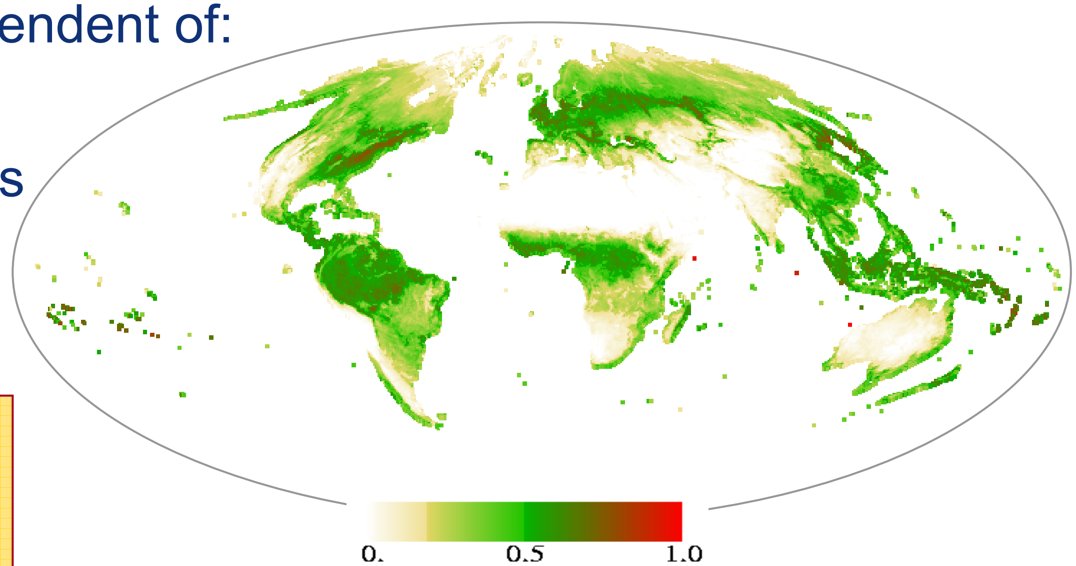
JRC-FAPAR products exist at different spatial and temporal resolutions for various sensors:

- **SeaWiFS** (Sep 1997 - Jun 2005) ⇒ http://fapar.jrc.it/
- **MERIS** (2002 - end of mission) ⇒ http://envisat.esa.int/
- **MODIS, MISR, GLI, MOS, VEGETATION** (case by case)



JRC-FAPAR algorithm accounts for spectral band specifics to make JRC-FAPAR product independent of:

- Instrument/sensor characteristics
- Viewing and illumination conditions
- Atmospheric conditions
- Background brightness



Fraction of Absorbed Photosynthetically Active Radiation

JRC-FAPAR products:

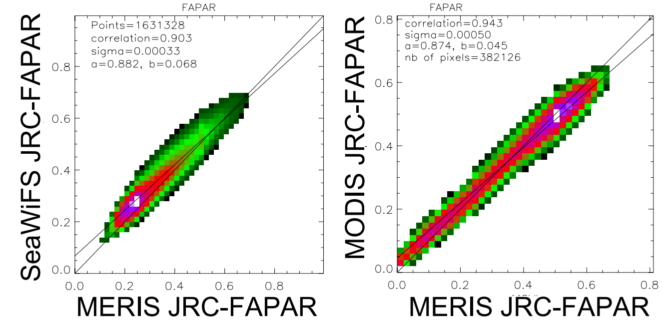
- instantaneous (θ_0,φ_0) direct only
- 'green' material only
- error ±0.1 absolute

N. Gobron et al. (1999, 2005) IJRS; N. Gobron et al. (2000) IEEE TGRS; N. Gobron et al. (2005, 2006) ASR; N. Gobron et al. (2006) JGR, N. Gobron et al. (2008) RSE;

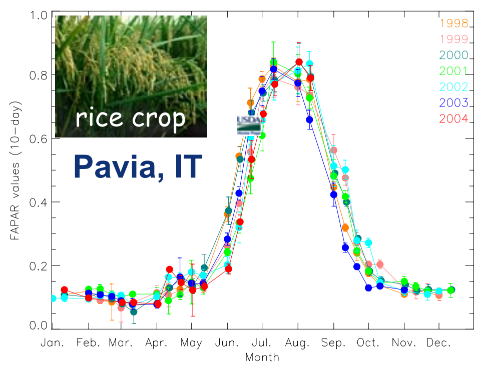
JRC-FAPAR validation

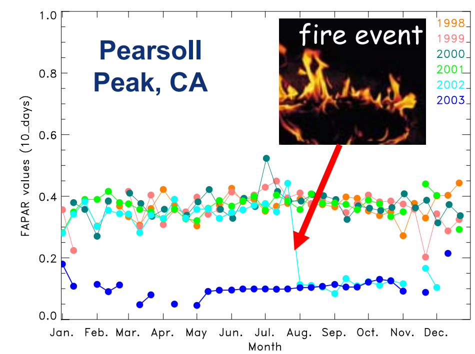
JRC-FAPAR products exist at different spatial and temporal resolutions for various sensors:

- **SeaWiFS** (Sep 1997 - Jun 2005) ⇒ http://fapar.jrc.it/
- **MERIS** (2002 - end of mission) ⇒ http://envisat.esa.int/
- **MODIS, MISR, GLI, MOS, VEGETATION** (case by case)



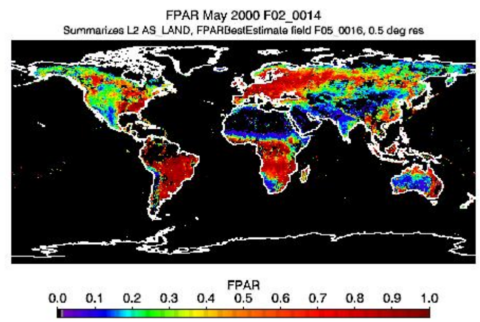
- **FAPAR dynamics**
- **FAPAR magnitude**

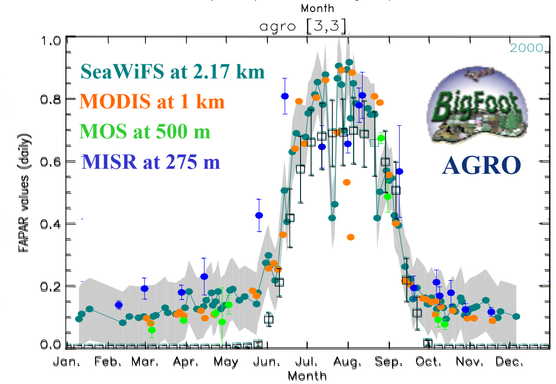




JRC-FAPAR products:

- instantaneous (θ_0,φ_0) direct only
- 'green' material only
- error ±0.1 absolute



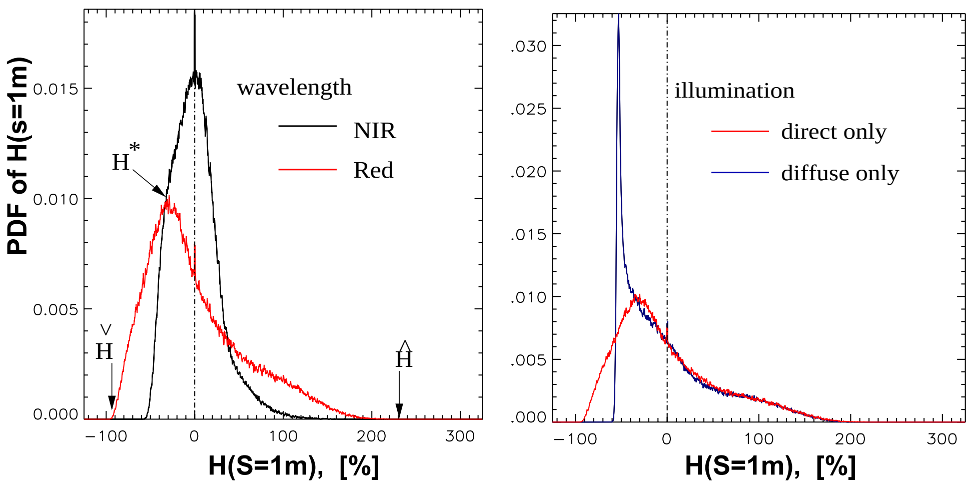


http://eosweb.larc.nasa.gov/

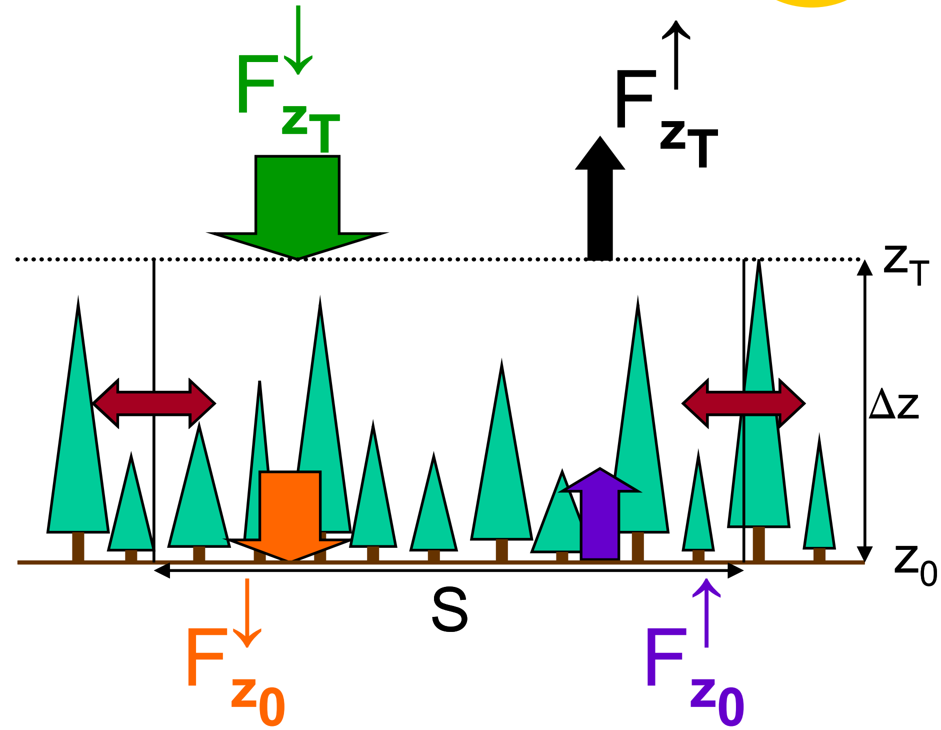
N. Gobron et al. (1999, 2005) IJRS; N. Gobron et al. (2000) IEEE TGRS; N. Gobron et al. (2005, 2006) ASR; N. Gobron et al. (2006) JGR, N. Gobron et al. (2008) RSE;

Ground-based FAPAR estimation

total FAPAR is the fraction of incident radiation that a given canopy volume (excluding soil) absorbs in the PAR (0.4-0.7μm)



$$A_{PAR} = 1 - T_{PAR} + (\alpha T)_{PAR} - R_{PAR} + H_{PAR}$$



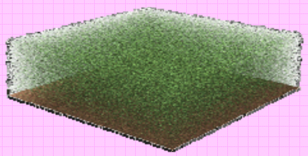
impact of H depends on:

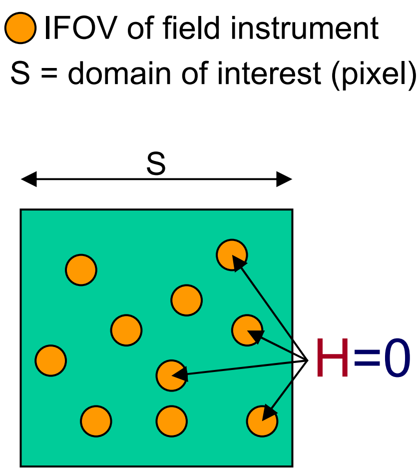
- canopy structure
- canopy height, Δz
- spatial resolution, S
- spectral properties, ω, α
- illumination conditions, θ_0

Widlowski et al., (2006) 'Horizontal Radiation Transport in 3-D Forest Canopies at Multiple Spatial Resolutions: Simulated Impact on Canopy Absorption', Remote Sensing of Environment, 103, 379-397, doi:10.1016/j.rse.2006.03.014.

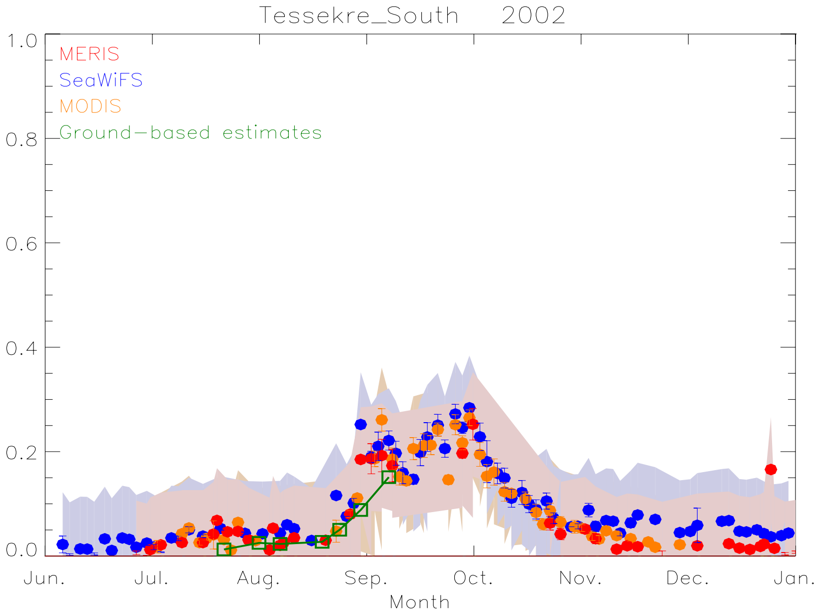
Categorization of land validation sites

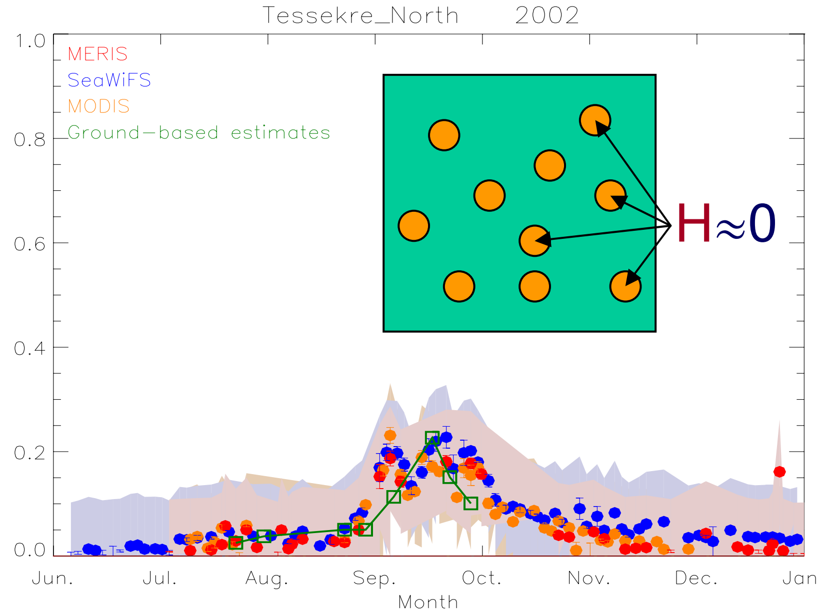
Radiation transfer regime after Davis & Marshak (2004) JQSRT	Internal variability of extinction coefficient (leaf densities)	Types of vegetation at the resolution of the investigation
"Fast" variability 1-D RT theory on full domain	Statistically homogeneous (Poisson-like)	Short vegetation and tall but rather dense canopy layers One type of vegetation covers the whole domain

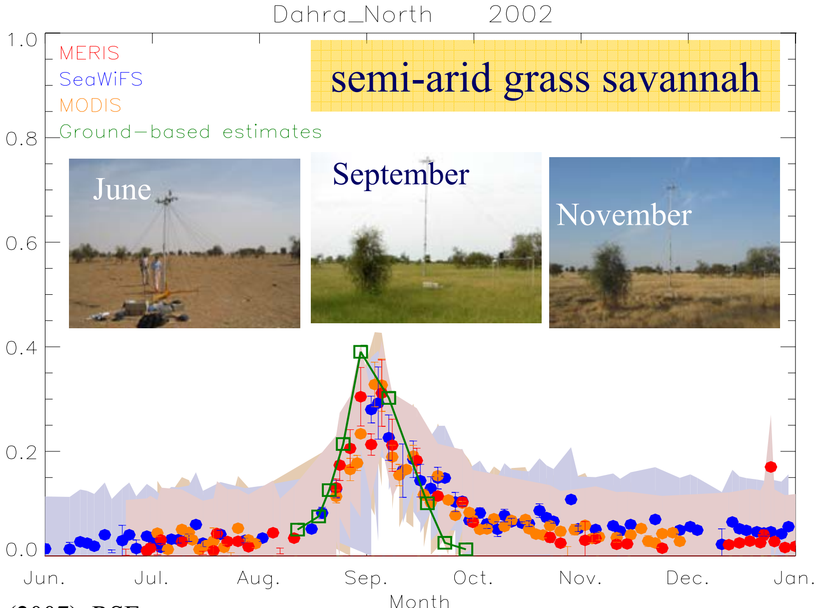


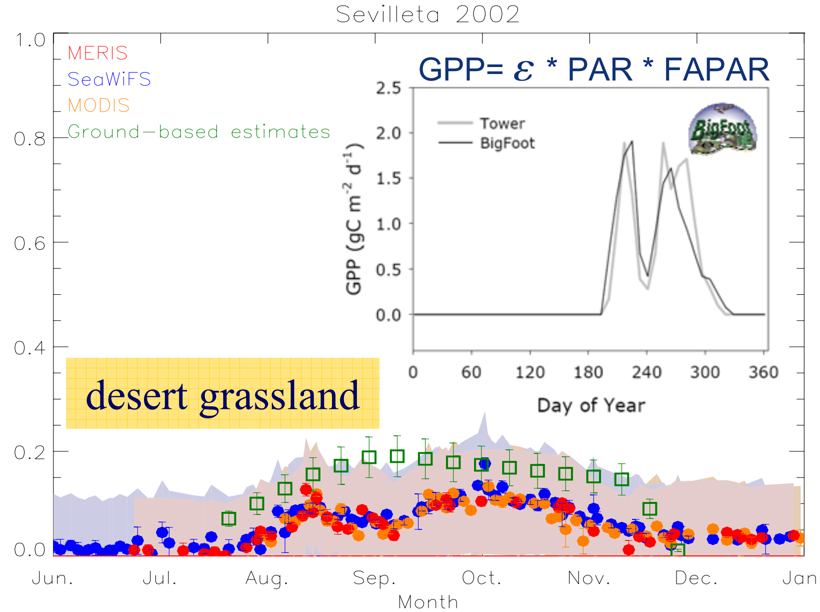


JRC-FAPAR Validation: “1D” RT theory



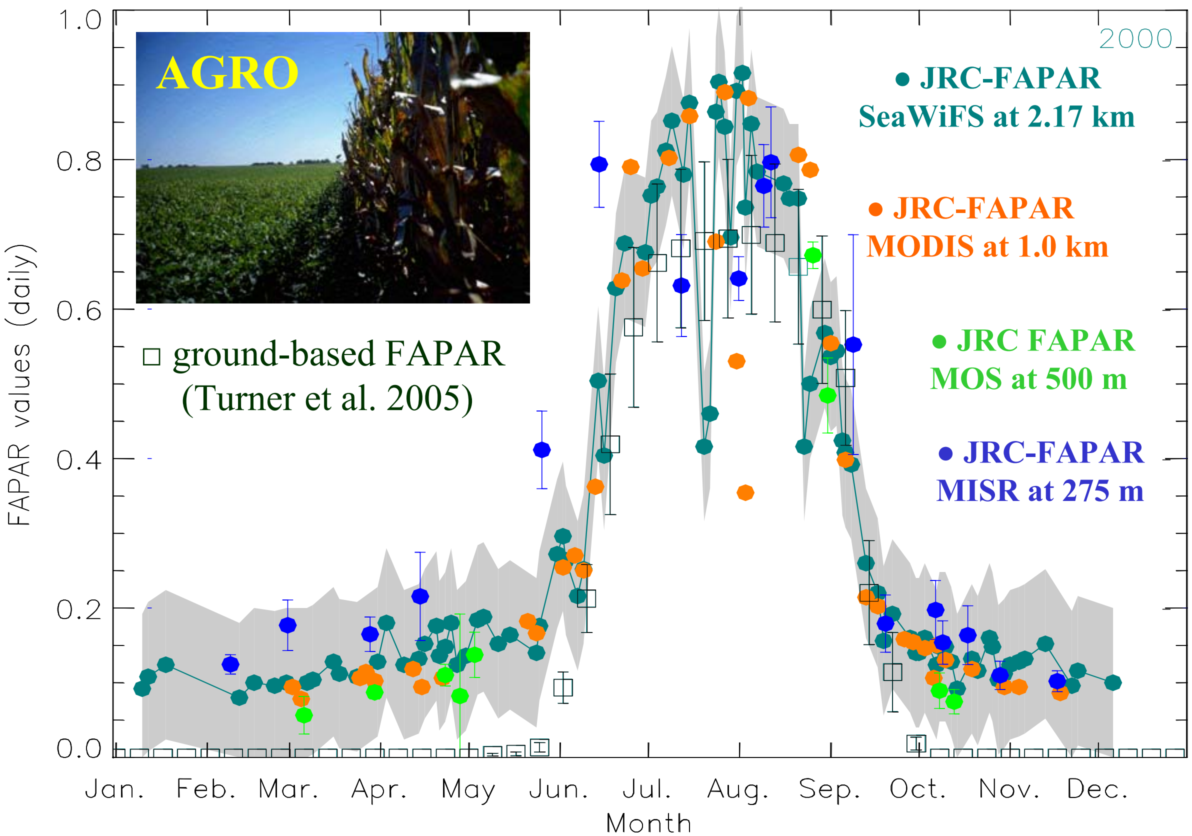


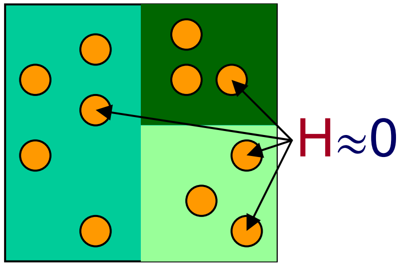


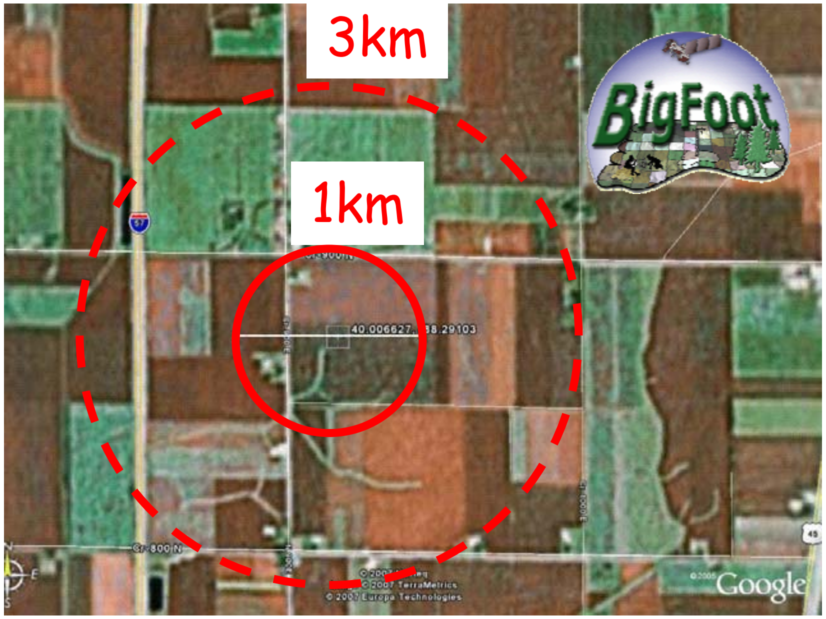


Gobron N. et. al. (2007), RSE

JRC-FAPAR Validation: "IPA" (local 1D)

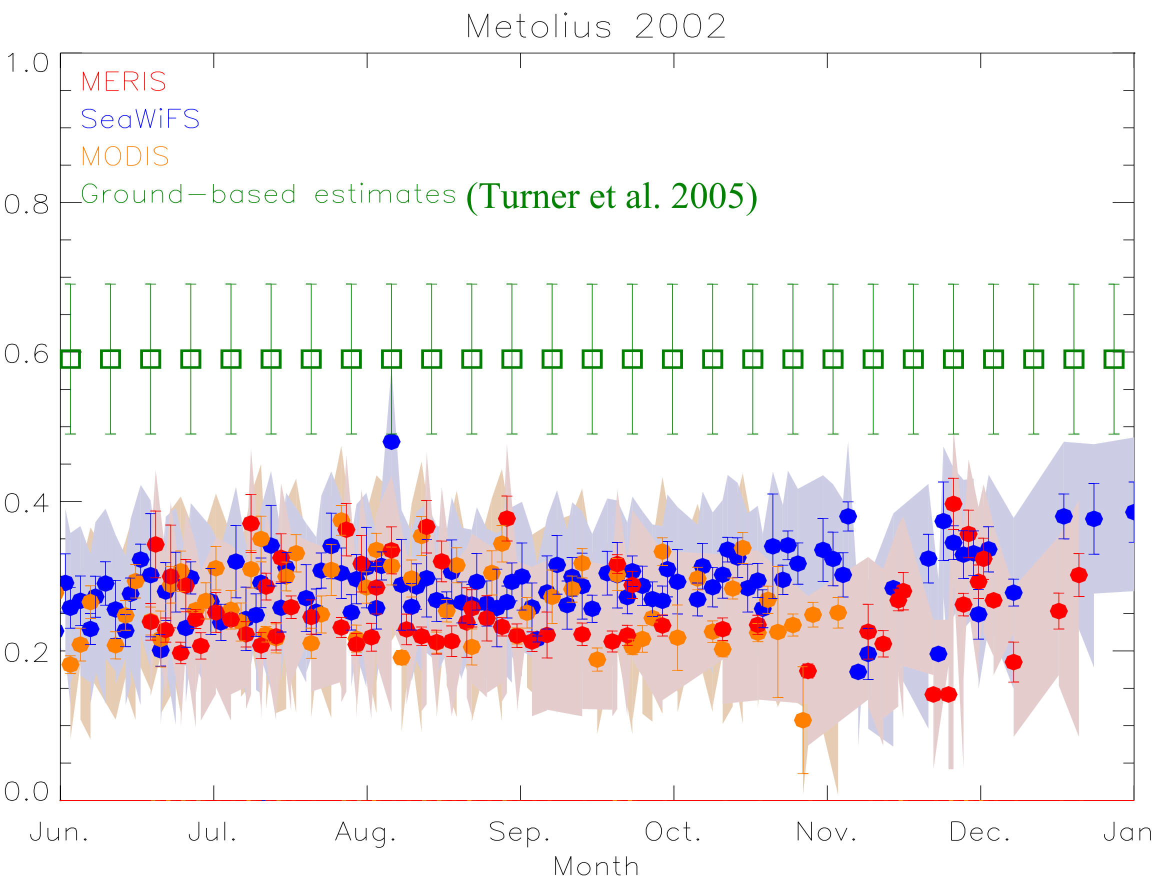


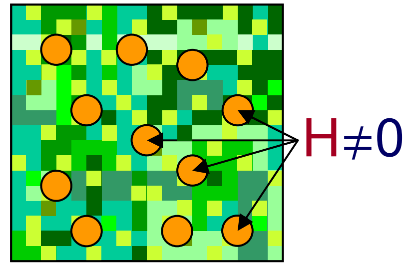




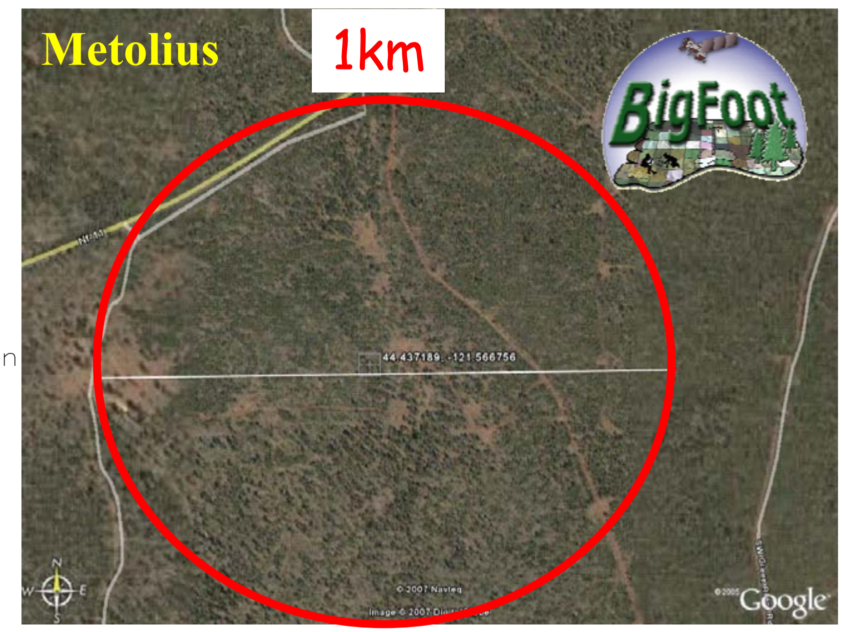
Gobron N. et. al. (2006) 'Evaluation of FAPAR Products for Different Canopy Radiation Transfer Regimes: Methodology and Results using JRC Products Derived from SeaWiFS and Ground-based Estimations', *JGR, 111, D13110, DOI 10.1029/2005JD006511*

JRC-FAPAR Validation: “3D” RT theory





dry needle-leaf forest



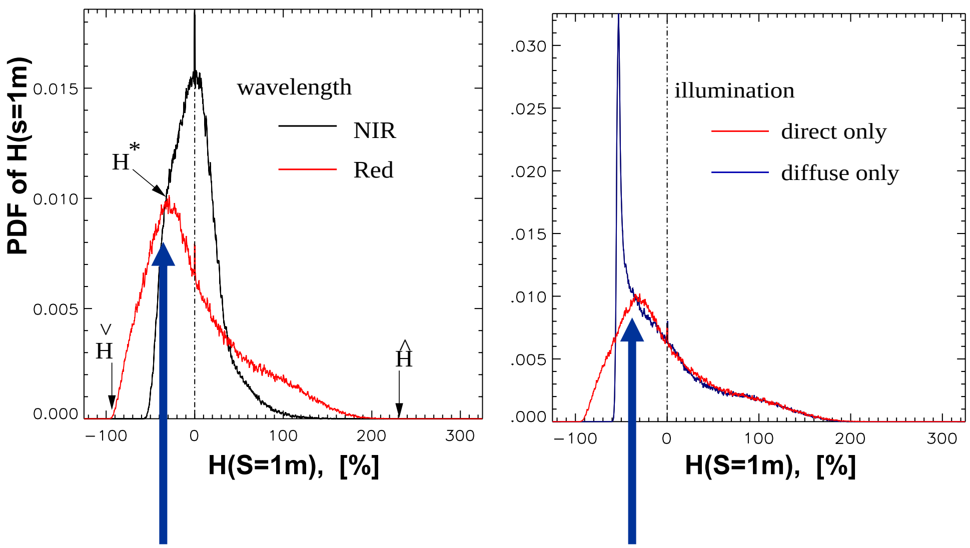
Ground measured FAPAR ≈ 1.-exp(-0.5<LAI>)
where <LAI> comes from PCA_LICOR sensor
Advanced procedure for spatio-temporal change of <LAI>

Gobron N. et. al. (2007), RSE

Use 3D RT models to understand possible issues with ground-based FAPAR validation @ Metolius

Ground-based FAPAR estimation caveats

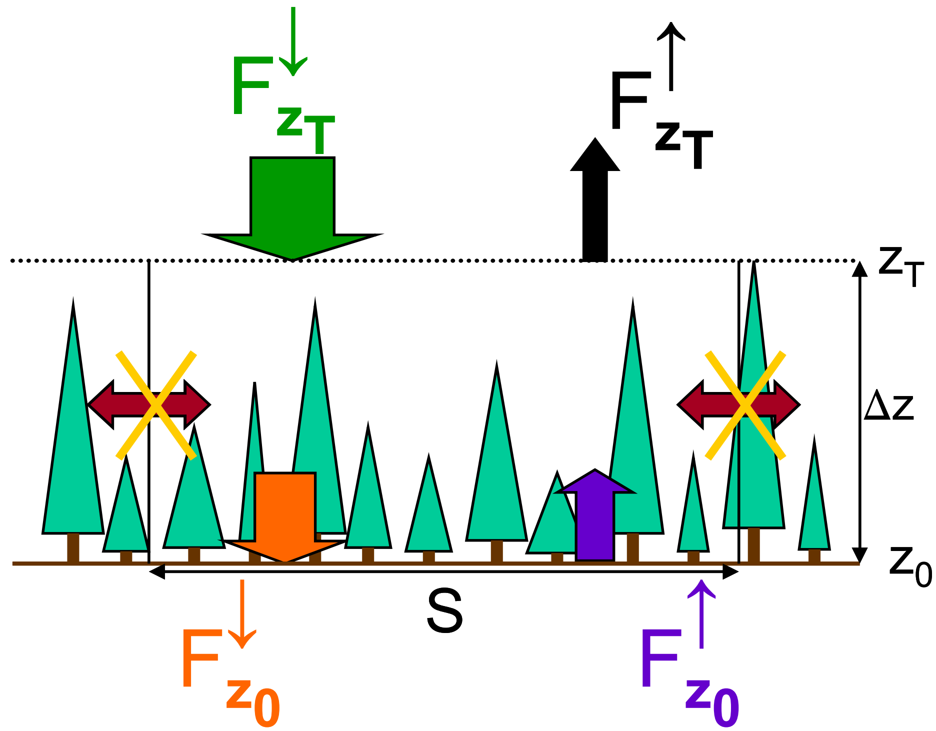
total FAPAR is the fraction of incident radiation that a given canopy volume (excluding soil) absorbs in the PAR (0.4-0.7μm)



Most likely value H* is -0.3 to -0.6

4 flux estimate:

$$A^{\updownarrow}_{PAR} = 1 - T_{PAR} + (\alpha T)_{PAR} - R_{PAR} + H_{PAR}$$



Widlowski et al., (2006) RSE

Inappropriate sampling may lead to

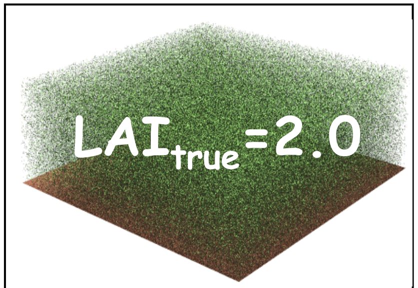
$A^{\updownarrow}_{PAR}(S) > FAPAR(S)$

i.e., local absorption estimates that overestimate the true absorption

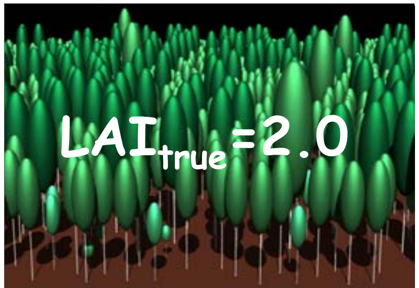
JRC EUROPEAN COMMISSION

Ground-based FAPAR estimation caveats

total FAPAR is the fraction of incident radiation that a given canopy volume (excluding soil) absorbs in the PAR (0.4-0.7μm)



1D homogeneous system



3D heterogeneous system

$\kappa = LAI_{true} * G(\mu_0)$ $\kappa = LAI_{eff}(\mu_0)*G(\mu_0)$

Example: $LAI_{true} = 2.0$; $\theta_0 = 30°$; $G(\mu_0)=0.5$

- $T^{dir}_{3D}(LAI_{true}) = 0.596$
- $T^{dir}_{1D}(LAI_{true}) = \exp\left(\frac{-LAI_{true}}{2\,\mu_0}\right) = 0.312$

true FAPAR(3D) < 1 - $T_{1D}(LAI_{true})$

2 flux estimate:

$A^{\downarrow}_{PAR} = 1 - T_{PAR} + (\alpha T)_{PAR} - R_{PAR} + H_{PAR}$

$A^{\downarrow}_{PAR} = FIPAR^{*}$

$A^{\downarrow 0}_{PAR} = FIPAR = 1 - T^{dir}_{PAR}$

$T^{dir} = \exp[-\kappa / \mu_0]$

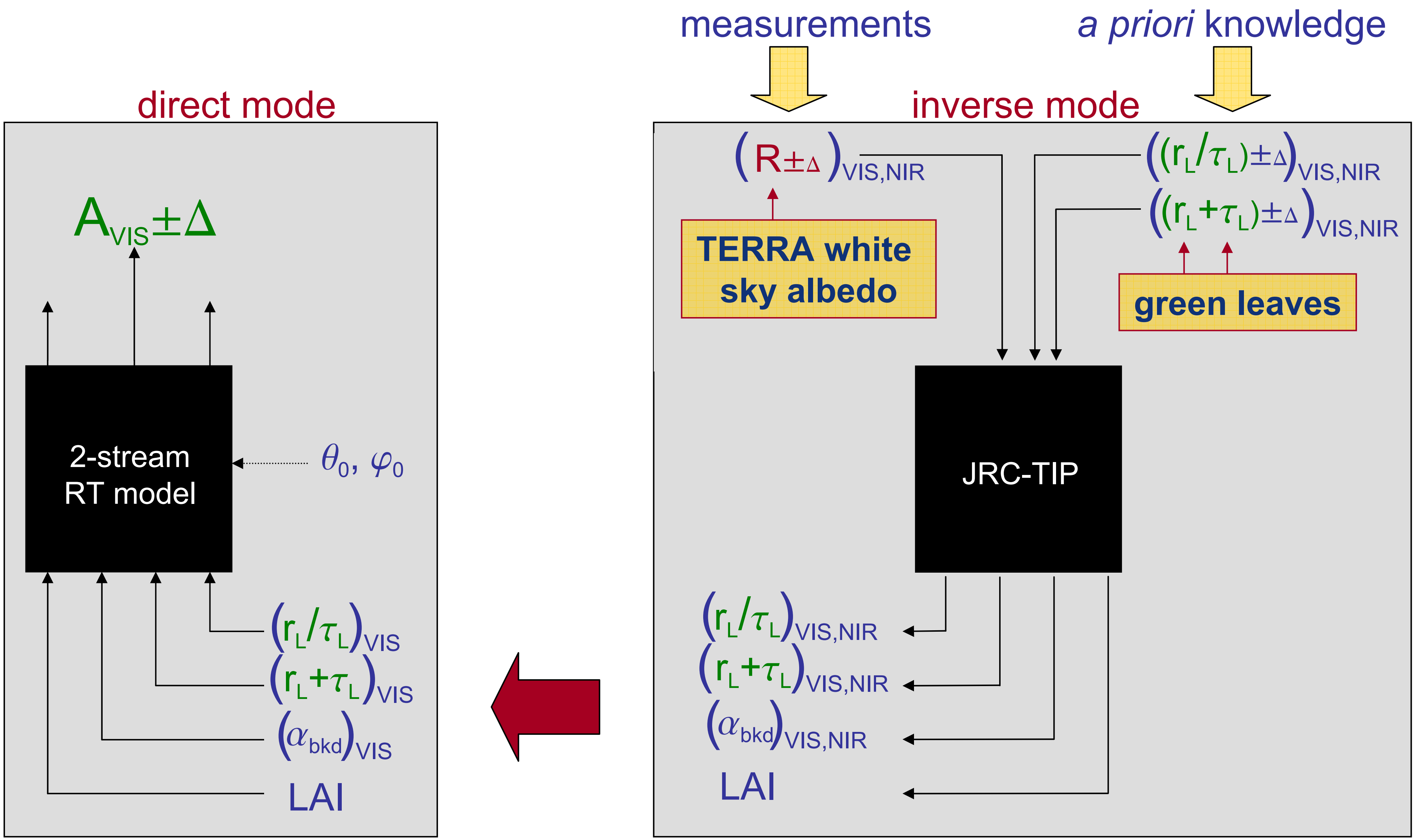
$LAI_{eff}(\mu_0) = LAI_{true} * \xi(\mu_0)$

- wood / foliage area ratio
- clumping (of shoots, branches, crowns, trees within FOV)

Pinty et. al. (2006), *JGR*

Use a different RT model, a different set of remote sensing data and generate the same FAPAR product

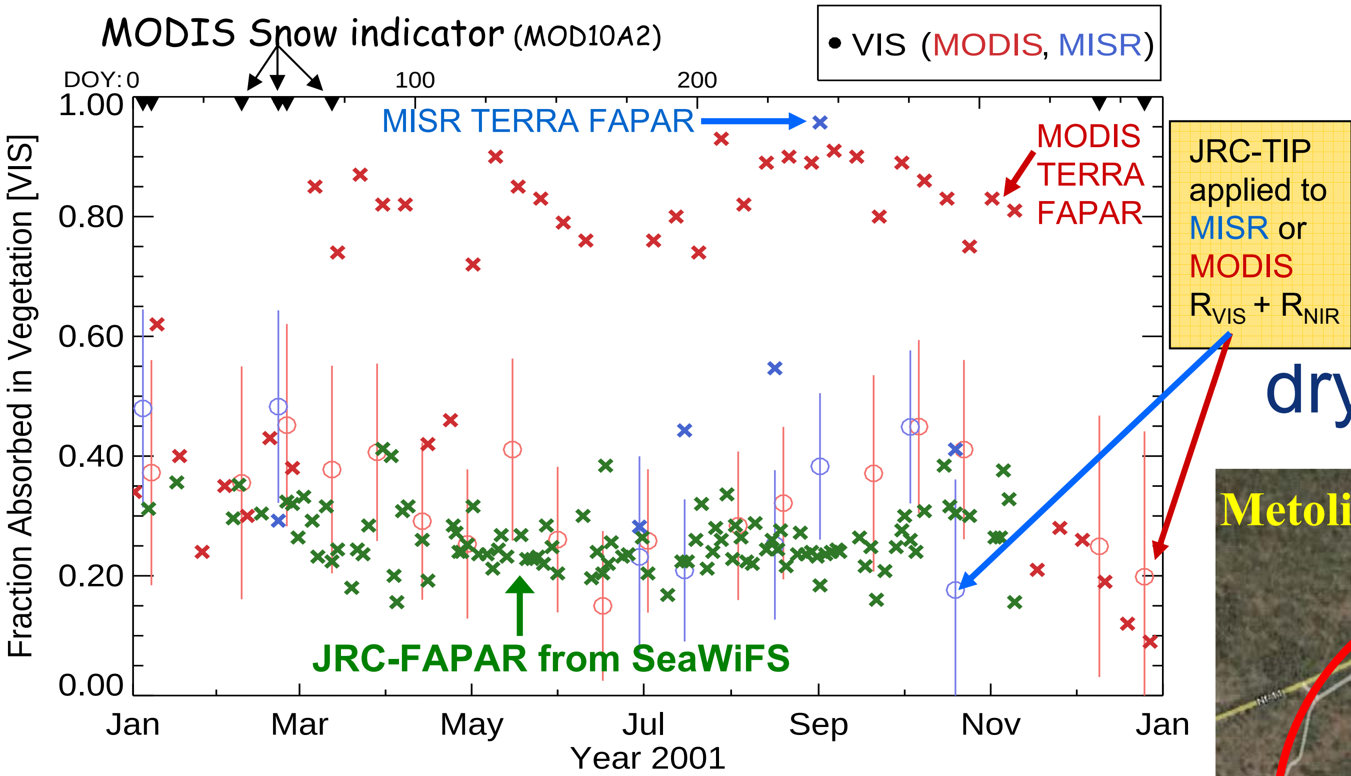
JRC-FAPAR validation using JRC-TIP



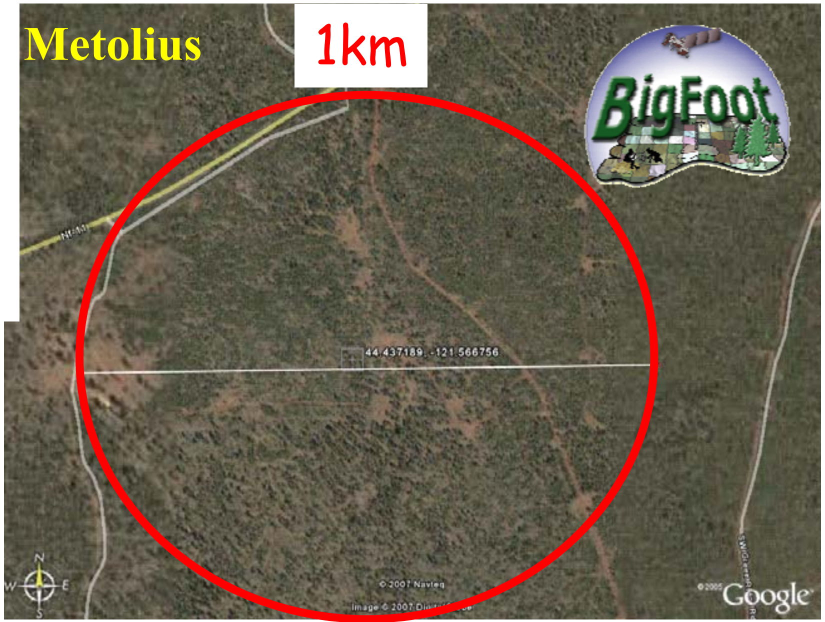
Pinty etal., (2006): JGR, doi:10.1029/2005JD005952

Pinty etal., (2007): JGR, *doi:10.129/2006JD008105*

JRC-TIP application over METOLIUS



dry needle-leaf forest



Pinty etal., (2007): JGR, *doi:10.129/2006JD008105*

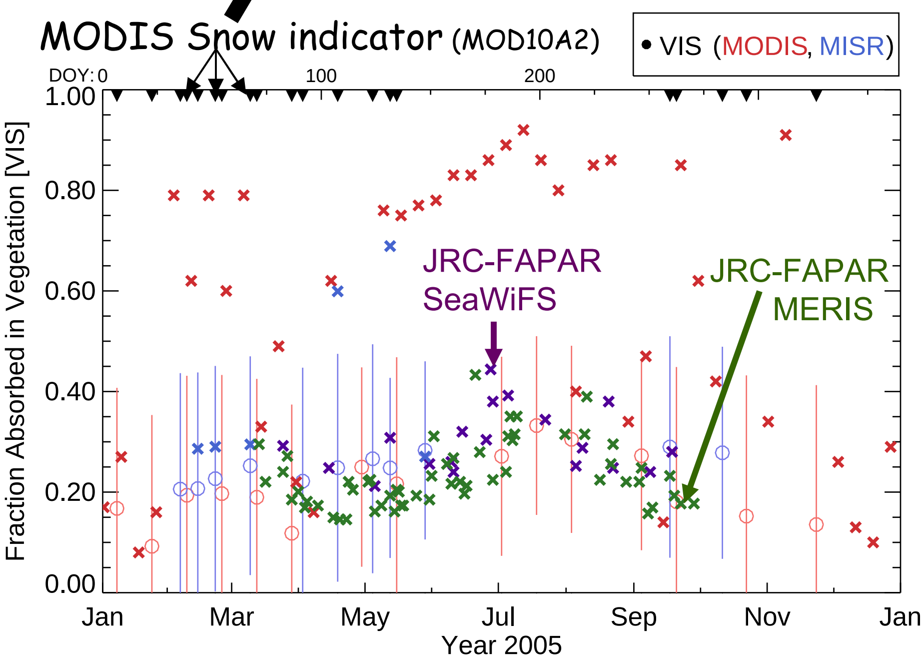
Ground measured FAPAR ≈ 1.-exp(-0.5<LAI>)
where <LAI> comes from PCA_LICOR sensor
Advanced procedure for spatio-temporal change of <LAI>

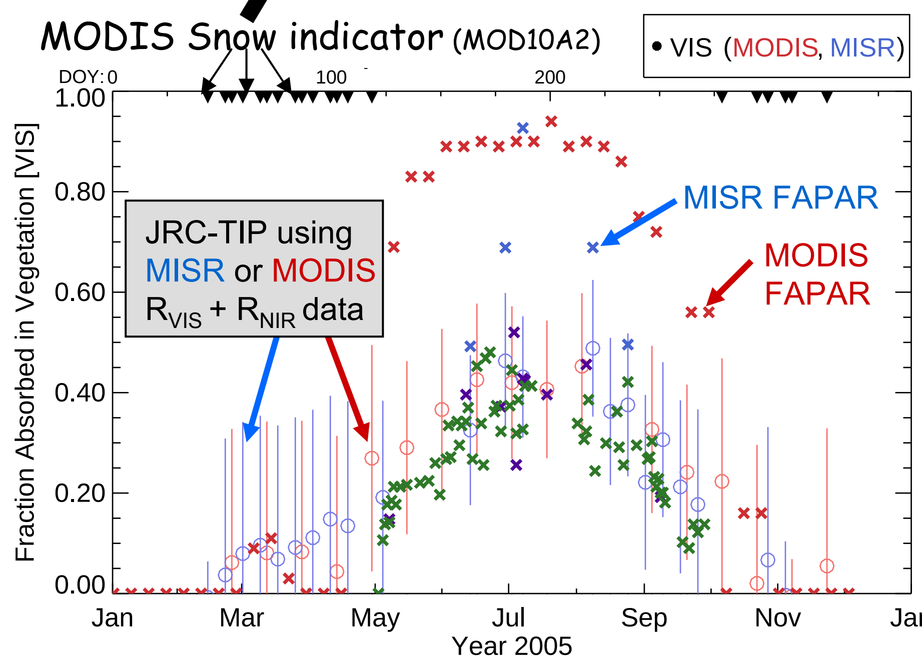
JRC-FAPAR validation using JRC-TIP

BOREAS NSOBS: needle-leaf forest

JRC-TIP
uses *a priori*
green leaves

Yakutsk forest: deciduous needle-leaf





Pinty et al., (2008): Journal of Geophysical Research, doi:10.129/2007/JD009096

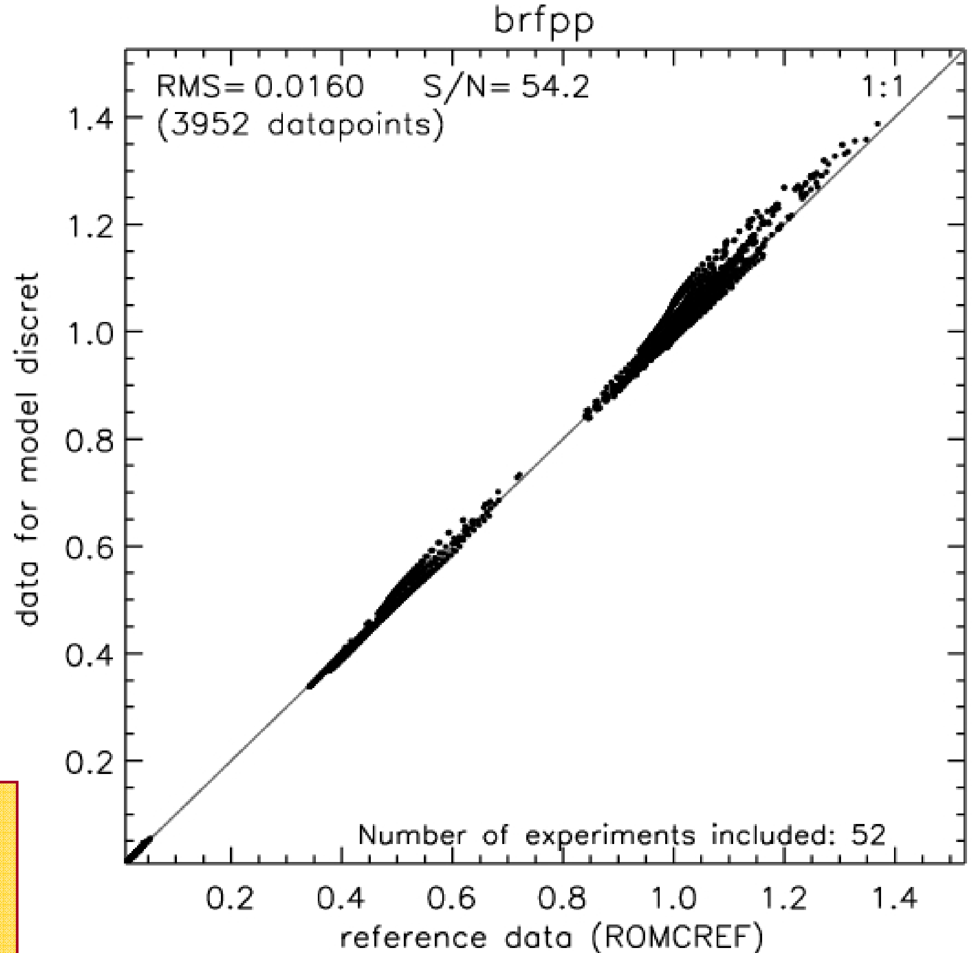
How reliable are these three RT models?

RAdiative transfer Model Intercomparison

Purpose of RAMI:

- to act as common platform for intercomparison efforts of canopy reflectance models,
- to document uncertainties and errors among models,
- to establish protocols for the evaluation of RT models,
- to foster scientific debate.

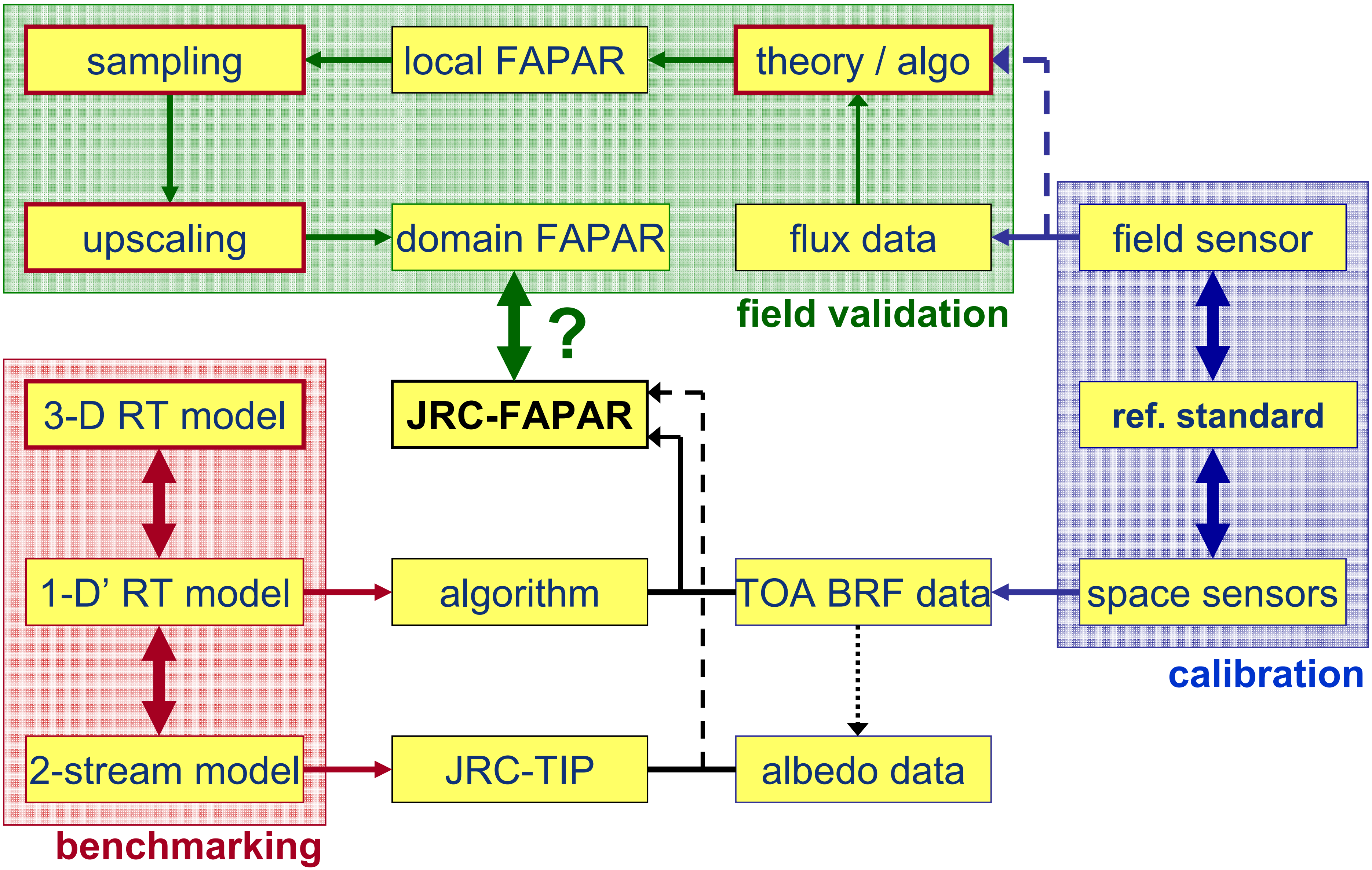
Generation of **reference data** set from simulations of six 3-D MC models that agree within 1%



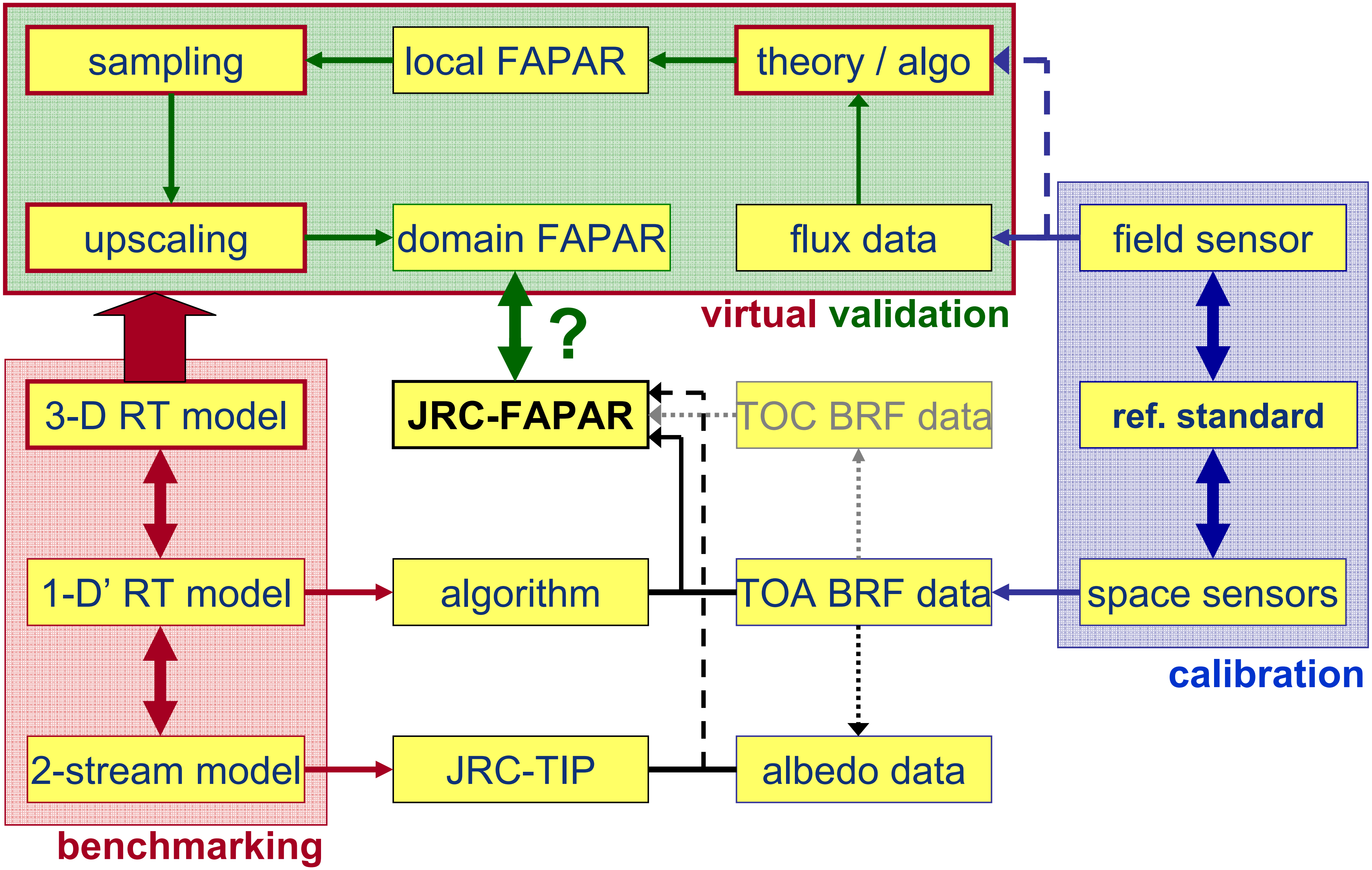
RAMI Online Model Checker

RAMI-1 (1999) RAMI-2 (2002) RAMI-3 (2005)

JRC-FAPAR VALIDATION OVERVIEW



JRC-FAPAR VALIDATION OVERVIEW



Thank you!