EC Joint Research Centre presentation for CEOS WGCV-30

J-L. Widlowski,

with contributions from
H. Eva, B. Pinty, F. Achard, N. Gobron, G. Zibordi

Cal/Val activities at the JRC

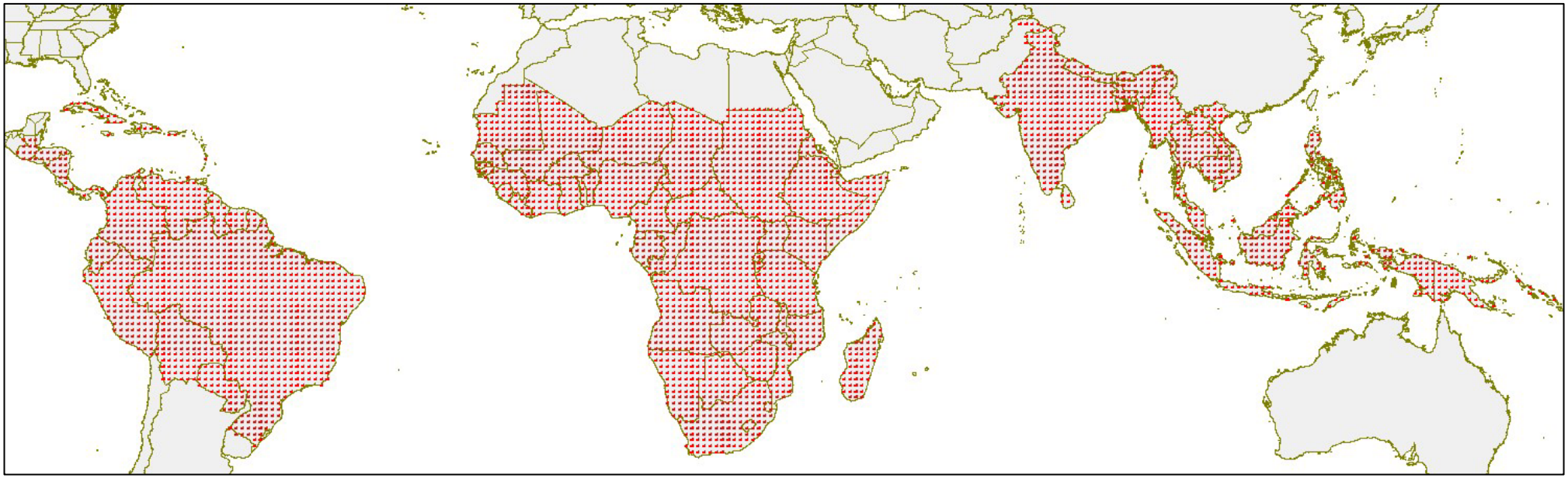
- ocean colour
- surface albedo
- FAPAR
- land cover
- model verification

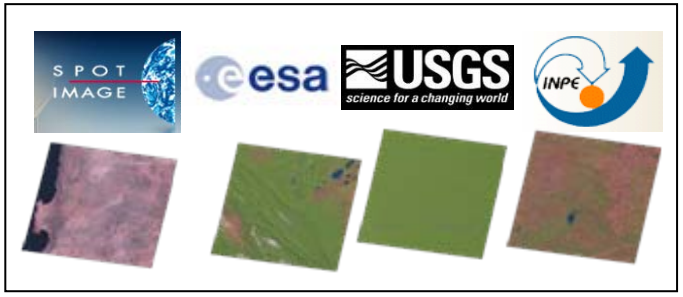
JRC contribution to:
Forest Resource Assessment report 2010
REMOTE SENSING SURVEY

- Regional, biome and global monitoring of forests 1975-1990-2000-2005:
  - forest maps
  - area change statistics
  - information on land use dynamics
- Baseline data for research & modeling
- Capacity building

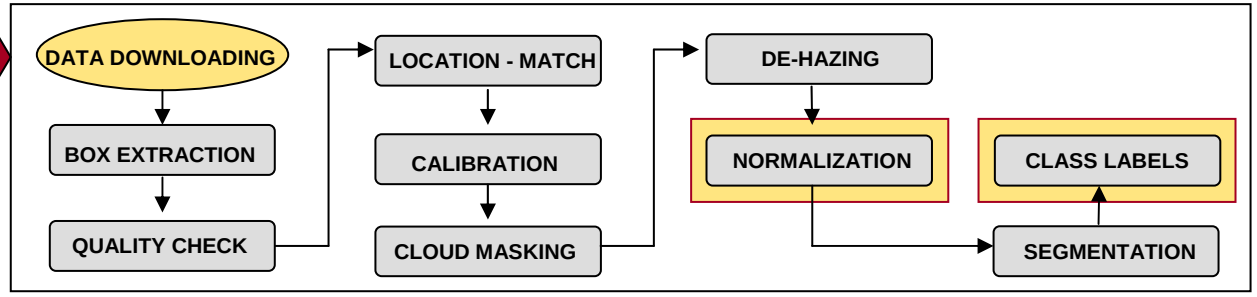
Methodology

The methodology is based on analysis of 1º systematic grid of 20x20 km² sites for which Landsat-type satellite data (~30 m) are collected.





Satellite image providers



JRC processing chain

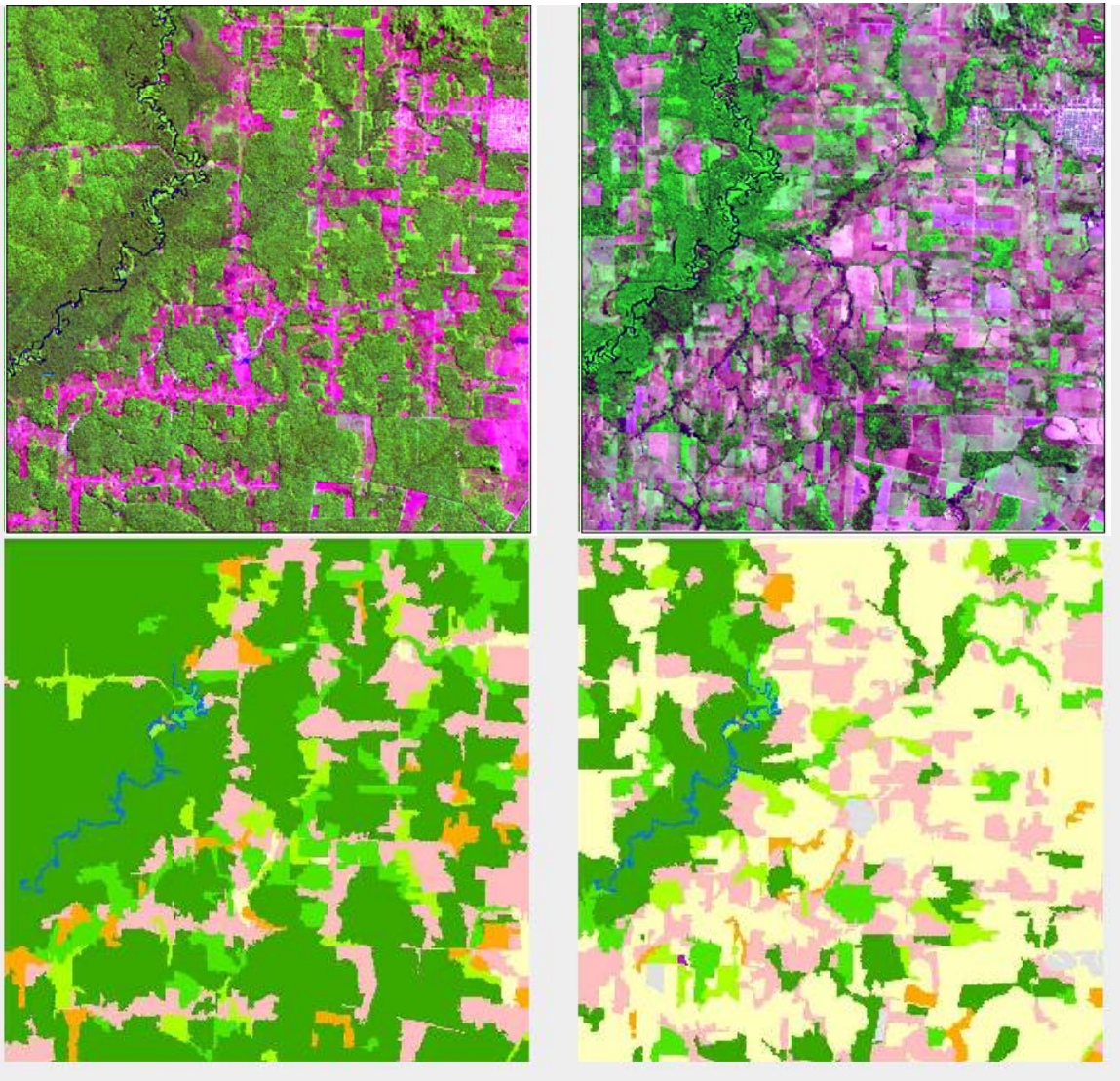
Achard et al., Bodart et al., & Gerrand et al., - Proc. 33rd ISRSE conf., Stresa, Italy, 4-8 May 2009

Example of automatic labelling: Mato Grosso

1990 2000

normalised RGB images of SWIR,NIR,Red

Results of automatic classification



South: 10° - West: 55°

Legend

- TREE COVER
- TREE COVER MOSAIC - HIGH %
- TREE COVER MOSAIC - LOW %
- SHRUB COVER
- SHRUB REGROWTH
- OTHER VEGETATION COVER
- NON-TREE COVER MOSAIC
- BURNT
- BARE & ARTIFICIAL
- WATER
- CLOUD & SHADOW
- NO DATA

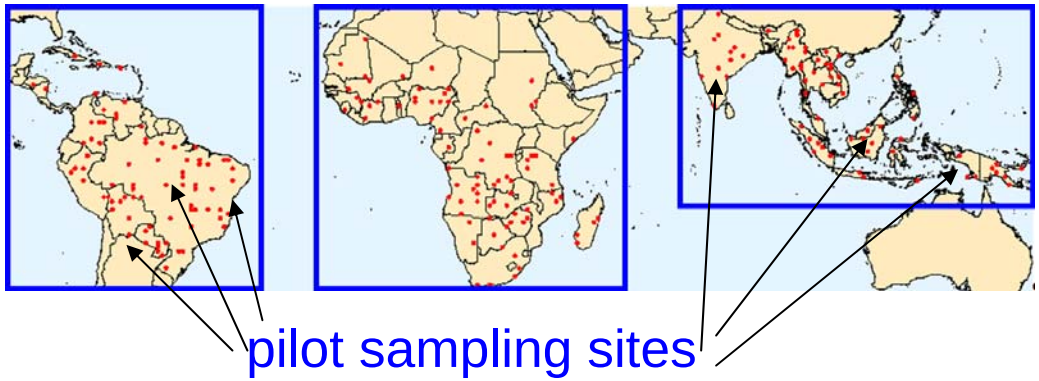
Achard et al., Bodart et al., & Gerrand et al., - Proc. 33rd ISRSE conf., Stresa, Italy, 4-8 May 2009

Regional validation by forestry experts

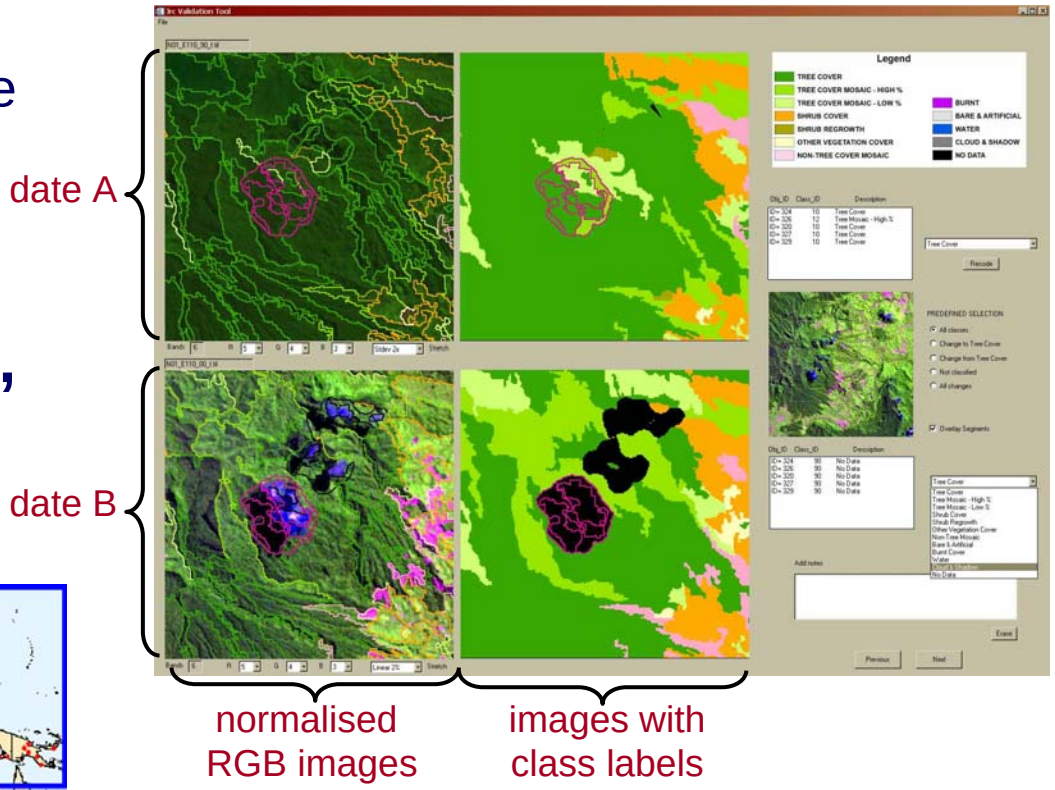
'Validation' sessions will be held at JRC or in the country/region with regional forestry experts:

- Forest cover change results will go through a first harmonisation phase for each tropical region
- Corrections will be applied to the land cover maps where necessary

Potential partners (Brazil, India, Indonesia, Venezuela, …) have been contacted



Validation tool for experts



FRA-2010 due in 2011

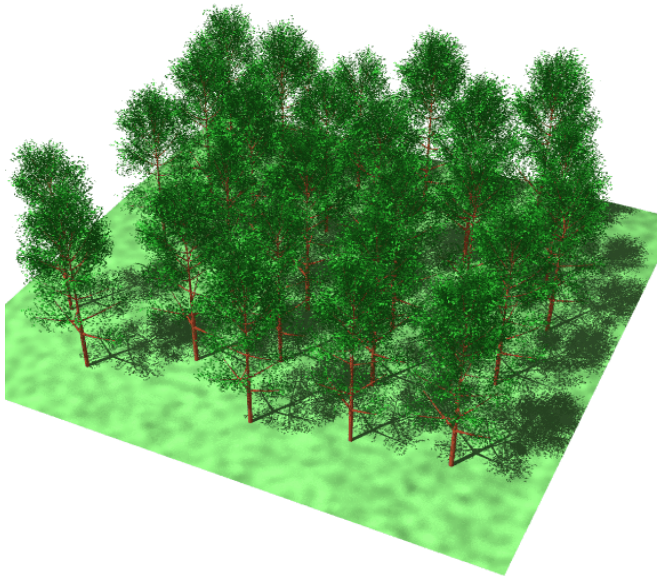
Cal/Val activities at the JRC

- ocean colour
- surface albedo
- FAPAR
- land cover
- model verification

RT model verification

- In **forward mode** RT models can simulate the directional reflectance and transmission properties of canopy targets.
- In **inverse mode** RT models can retrieve quantitative information on structural and spectral canopy properties.

canopy target

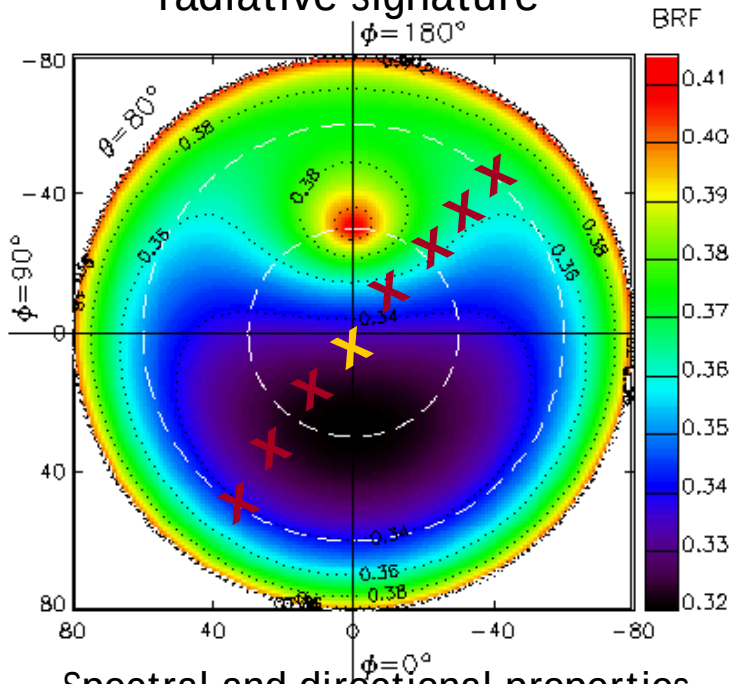


illumination and viewing geometry

Radiative Transfer model

Look-Up Table(s)

radiative signature



Spectral and structural canopy properties in area of interest.

Spectral and directional properties of canopy target in area of interest

Anisview: Peter Vogt & Michel Verstraete, JRC

Reasons for RT model verification…

1) RT models are used in development of quantitative surface retrieval algorithms:
   - ESA - MERIS - FAPAR,
   - NASA - MODIS/MISR - LAI+FAPAR,

2) RT models are used in concept studies for new space missions (and sensors)

3) RT models feature in offline-studies addressing 'science questions' through analysis of remote sensing data

Model verification must be part of QA for 1) *operational products*, 2) *future mission studies,* and 3) *research funding.*

The JRC's RAMI strategy

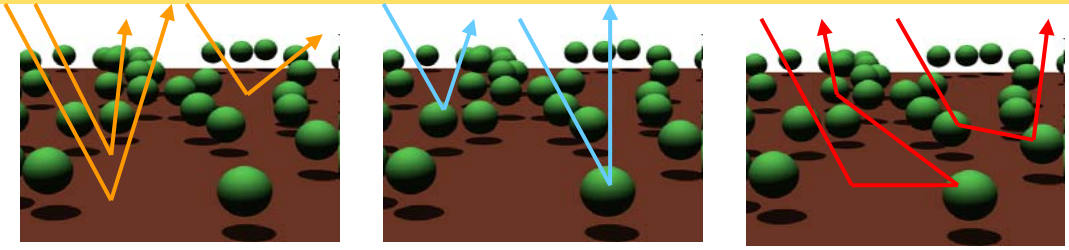
1) work under **controlled experimental conditions**
(i.e., no comparison with laboratory or *in situ* data)

- vertical and spatial structure of medium
- spectral + directional scattering properties
- intensity and directionality of illumination

} known exactly

2) verify also **sub-components** of target RT quantities
(i.e., quantities that cannot be measured in practice)

BRF_{tot}= uc+co+mlt



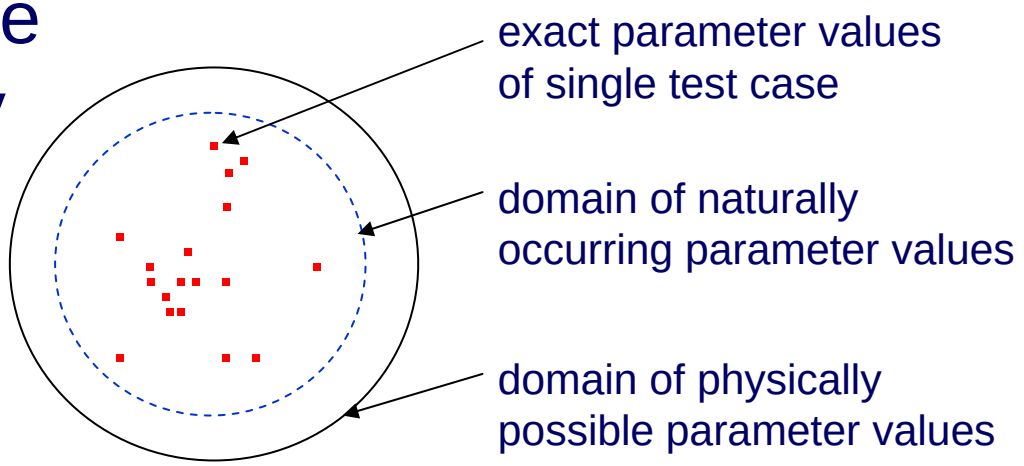
3) test also **extreme** but physically-meaningful situations
(i.e., scenarios that cannot be encountered in the field)

http://rami-benchmark.jrc.ec.europa.eu/

How do you verify computer models ?

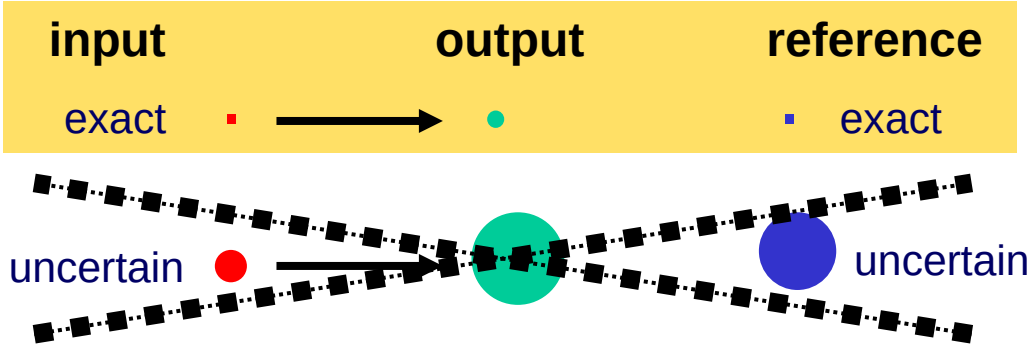
Models can not be validated. They can only be invalidated!

- verify if models handle the **physics** correctly
- expand the number of tests to cover the **complete range** of parameter values



Model verification limited by accuracy of input and reference

- **reduce the uncertainty** in the input parameters and the reference data



RAMI tests

1) Self consistency

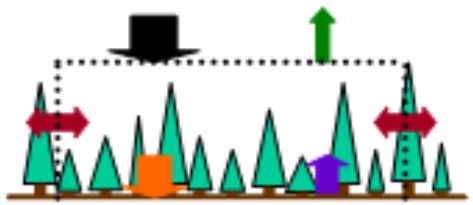
- Energy conservation:
  - -Fluxes: 1=A+R+T-αT-H
  - -BRFs: total=uc+co+mlt
- Sub-component ratii:
  - $-uc_{red}/uc_{NIR} = \alpha_{red}/\alpha_{NIR}$
  - $-T^{dir}_{red}/T^{dir}_{NIR} = 1$

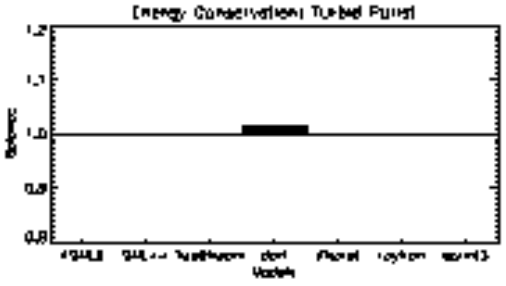
2) Absolute performance

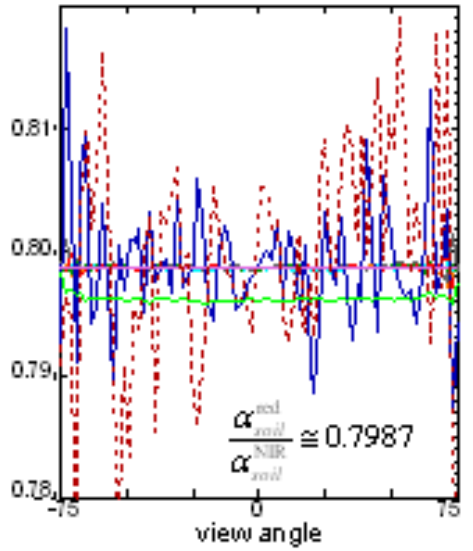
- Purist corner fluxes:
  - -A=0 and R=1
- Analytical solutions:
  - -HOM_TUR_UNI: uc, co

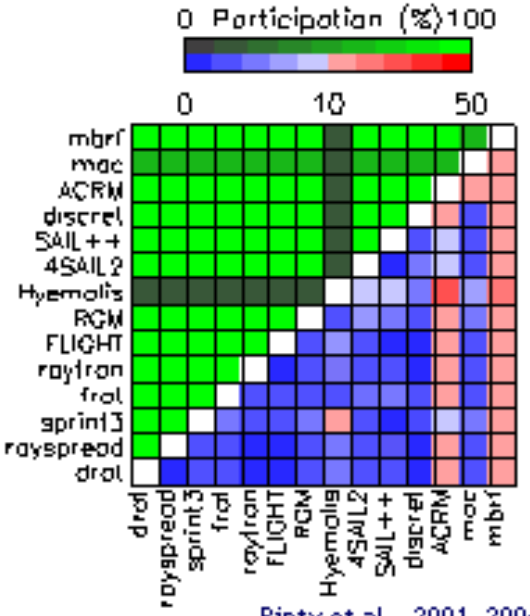
3) Relative performance

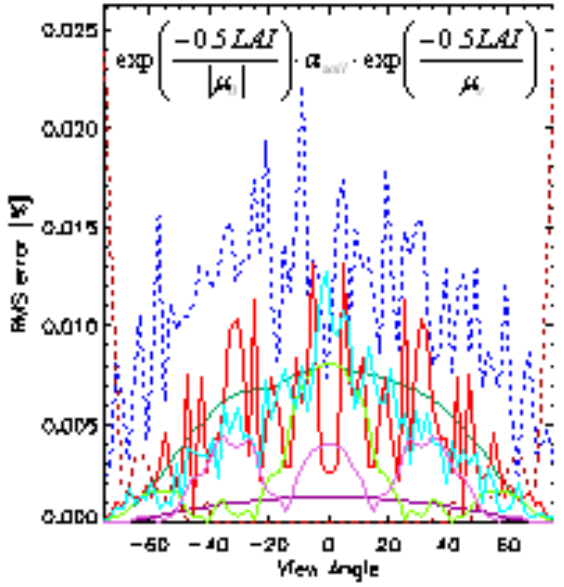
- model to model
- model to ensemble









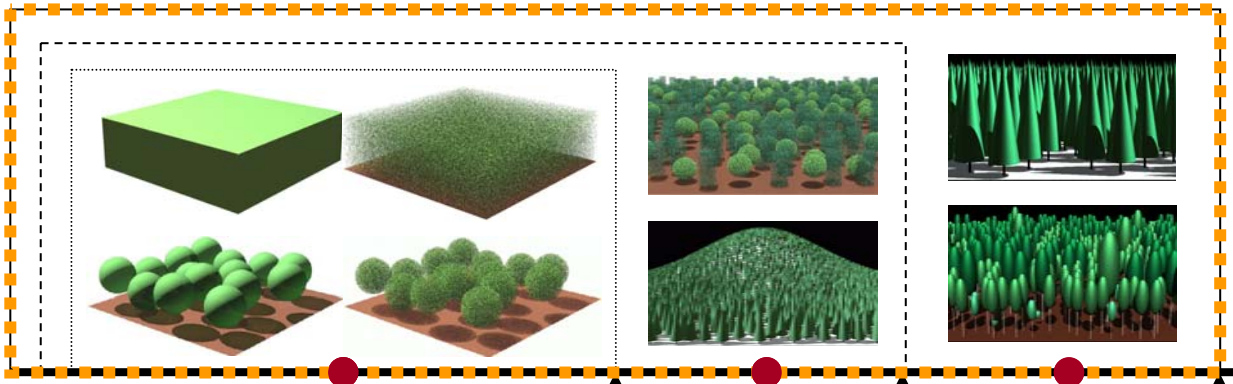


Pinty et al., 2001, 2004 (JGR); Widlowski et al., 2007 (JGR), 2008 (RSE);

RAMI evolution

automate benchmarking process

RAMI On-Line Model Checker (ROMC)



reference data sets

- RAMI-3 scenarios (results known)
- New test cases (result unknown)

(2007)

RAMI-1 (1999)

RAMI-2 (2002)

RAMI-3 (2005)

8 models

substantial differences amid 1D and 3D models

13 models

still differences amid the 3D models

18 models

excellent agreement; especially for 3D MC models

Set of 6 'credible' 3D Monte Carlo models (~1% deviation)

- satisfy energy conservation
- identical to analytical solutions
- versatile and few assumptions

Pinty et al., 2001, 2004 (JGR); Widlowski et al., 2007 (JGR), 2008 (RSE);

'RAMI On-line Model Checker' Usage

Journal of Quantitative Spectroscopy & Radiative Transfer 110 (2009) 1–21

Contents lists available at ScienceDirect

Journal of Quantitative Spectroscopy & Radiative Transfer

journal homepage: www.elsevier.com/locate/jqsrt

The impact of common assumptions on canopy radiative transfer simulations: A case study in *Citrus* orchards

J. Stuckens *, B. Somers, S. Delalieux, W.W. Verstraeten, P. Coppin

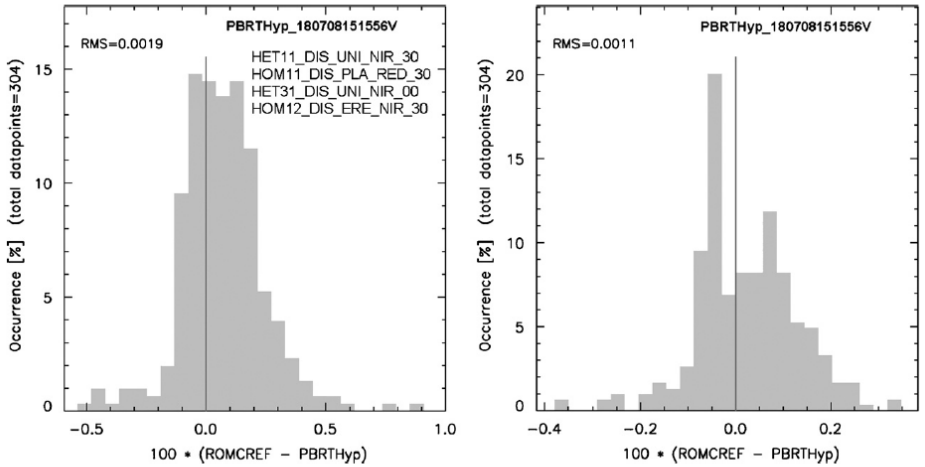


Fig. 6. Histogram of difference in reflectance (%) between PBRT and the ROMC reference for four homogeneous and heterogeneous validation scenarios for the principal plane (left) and the orthogonal plane (right). Results were obtained from the RAMI On-line Model Checker (ROMC) available at http://romc.jrc.ec.europa.eu/.

Available online at www.sciencedirect.com

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Remote Sensing of Environment 112 (2008) 173 – 185

Remote Sensing of Environment

www.elsevier.com/locate/rse

A coupled 1-D atmosphere and 3-D canopy radiative transfer model for canopy reflectance, light environment, and photosynthesis simulation in a heterogeneous landscape

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Received 9 February 2007; received in revised form 21 April 2007; accepted 21 April 2007

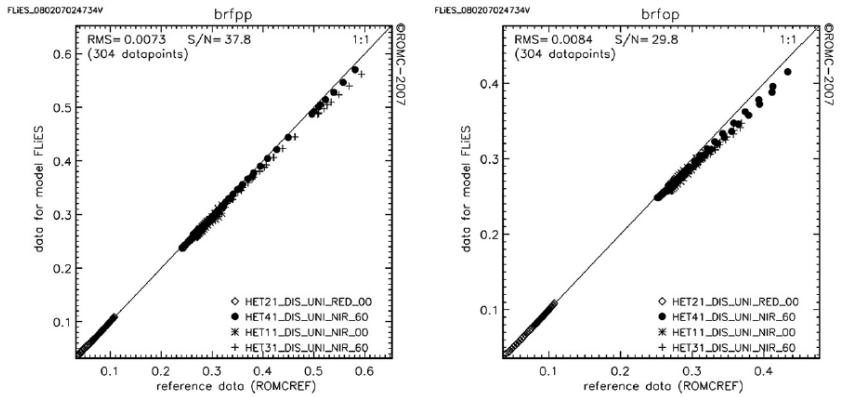


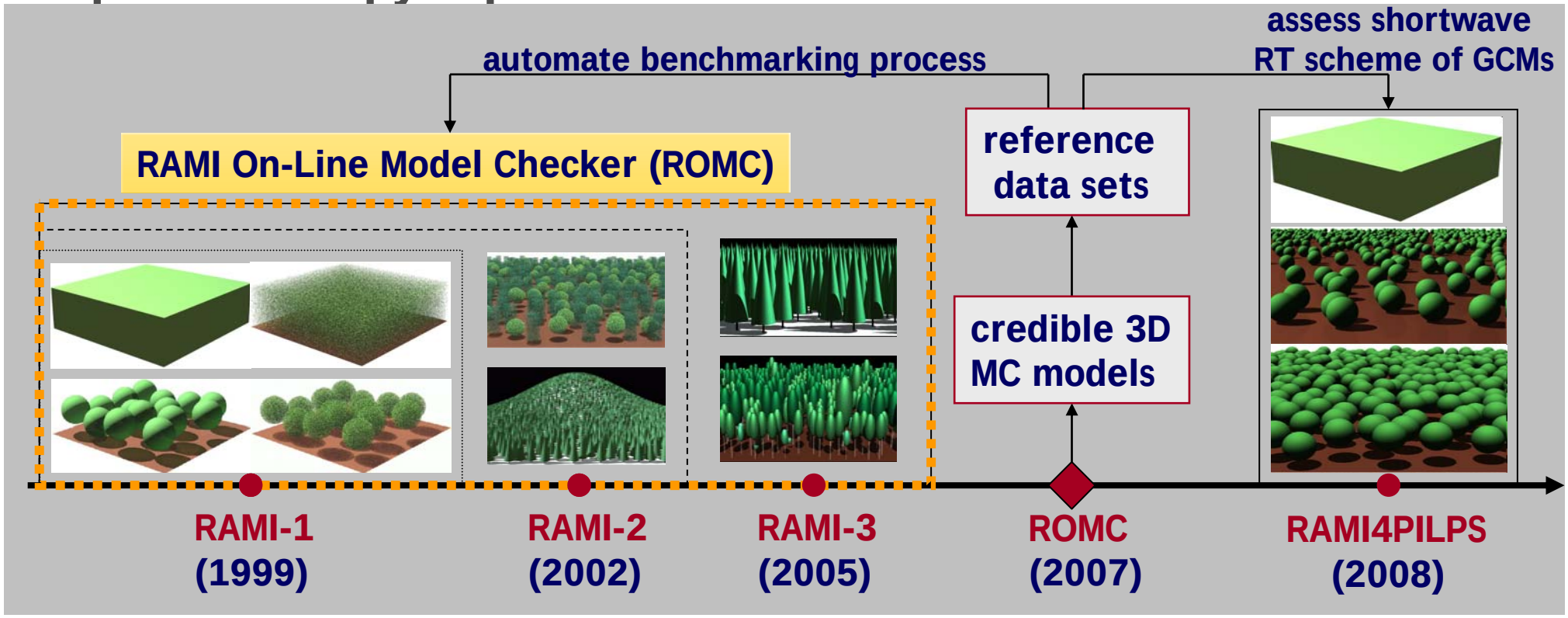
Fig. 9. ROMC generated graph of the BRF simulations of our model (FLiES) and the reference data (ROMCREF). The left panel refers to BRF simulations in the principal plane that were shown in Fig. 8, the right panel refers to simulations in the orthogonal plane. Indicated are also the root mean square error (RMS) and the signal to noise ratio (S/N).

Currently 31 models registered in ROMC: http://romc.jrc.ec.europa.eu/

Widlowski et al., 2008 (RSE);

RAMI evolution (cont.)

Simplified canopy representations



Systematic model verification essential to:

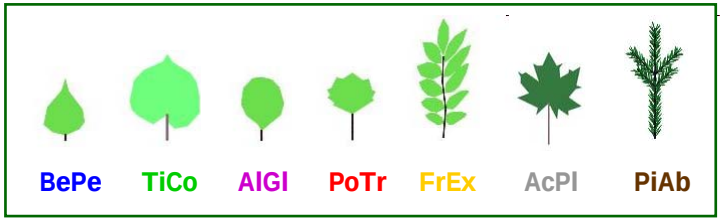
- document progress in RT modeling
- identify 'credible' 3D RT models
- generate 'reference' data sets
- develop web-based verification tools

Pinty et al., 2001, 2004 (JGR); Widlowski et al., 2007 (JGR), 2008 (RSE);

increase realism of scenes:

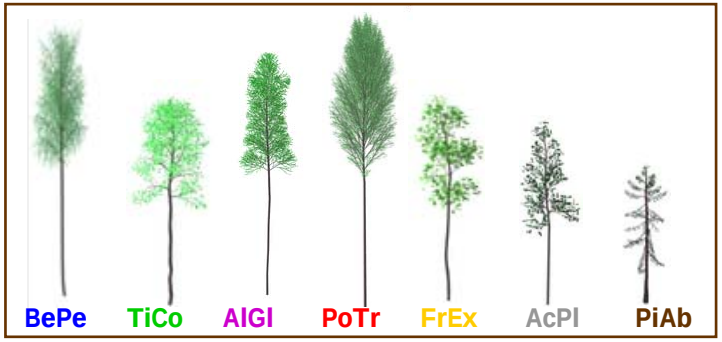
- **structural** information from detailed stand inventory data

Leaf level



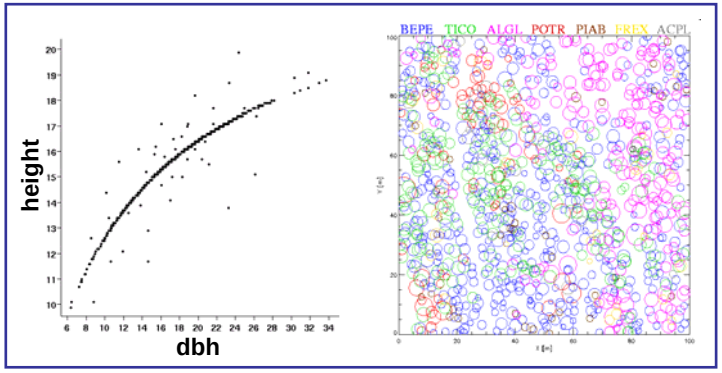
shape & size

Tree level



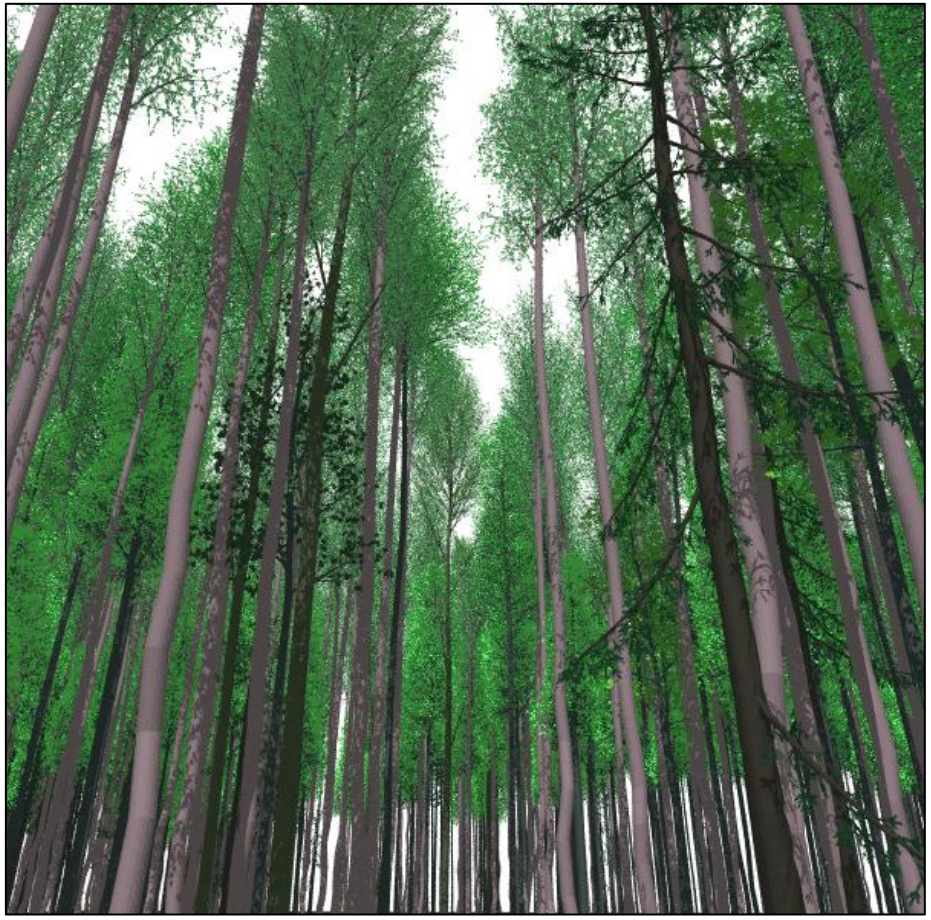
3D shape & structure

Stand level



allometry & positions

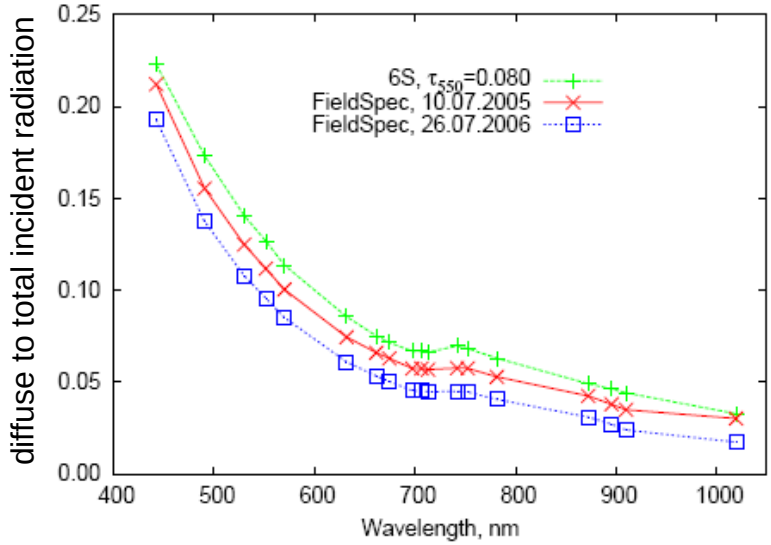
RAMI-IV: summer birch stand



http://rami-benchmark.jrc.ec.europa.eu/

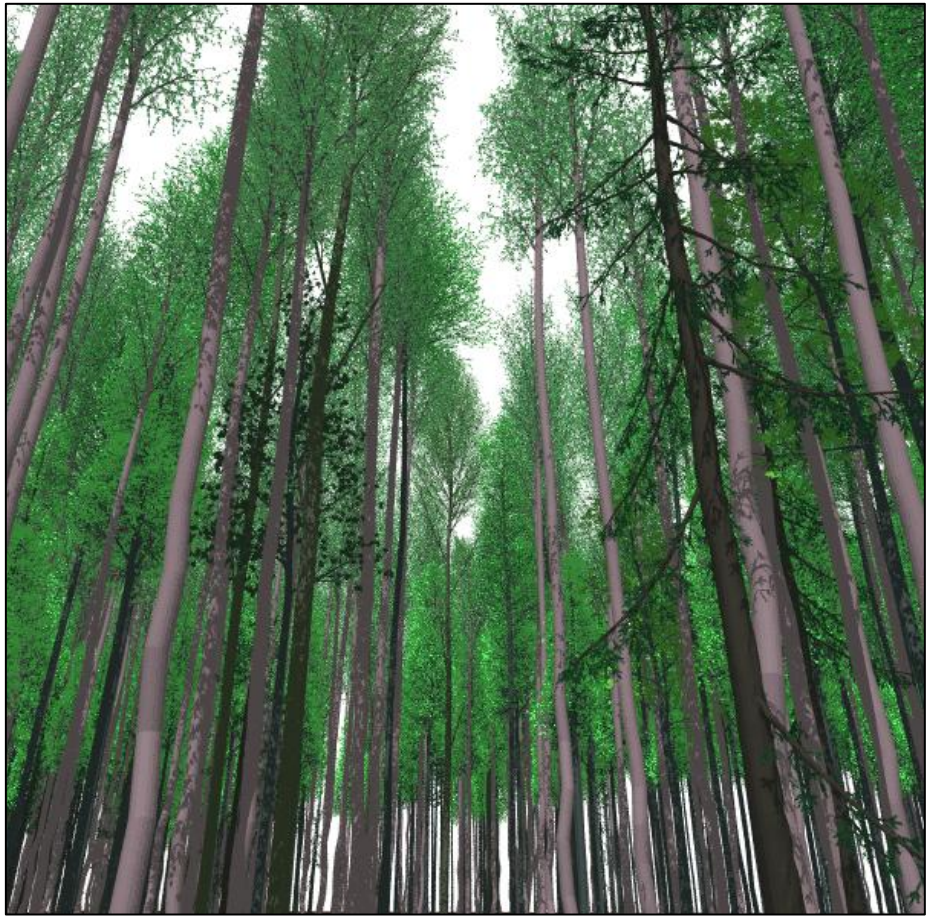
increase realism of scenes:

- **structural** information from detailed stand inventory data
- **spectral** information from laboratory + field campaigns
- **illumination** conditions based on available AERONET data and in-situ measurements



Kuusk et al, 2008, RSE

RAMI-IV: summer birch stand



http://rami-benchmark.jrc.ec.europa.eu/

increase realism of scenes:

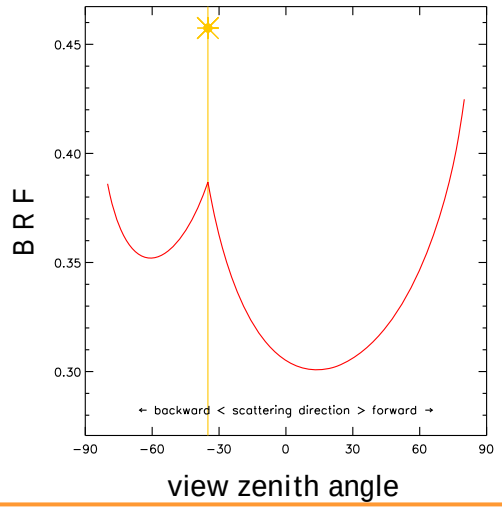
- **structural** information from detailed stand inventory data
- **spectral** information from laboratory + field campaigns
- **illumination** conditions based on available AERONET data and in-situ measurements

increase measurement realism:

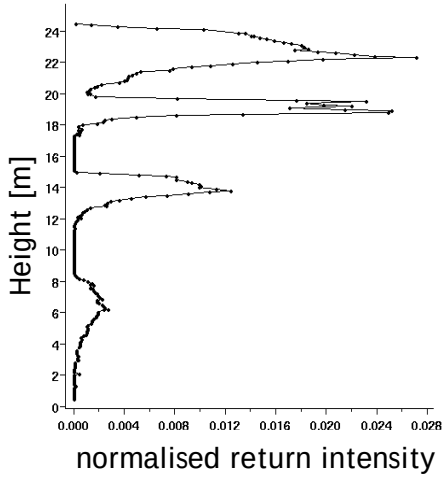
- **spaceborne** observations
  - passive (multi-angular and multi-spectral: 18+1 bands)
- **airborne** observations
  - active (waveform Lidar)
- **ground-based** observations
  - hemispherical photography
  - direct transmission (TRAC)

domain level

multi-angular observations



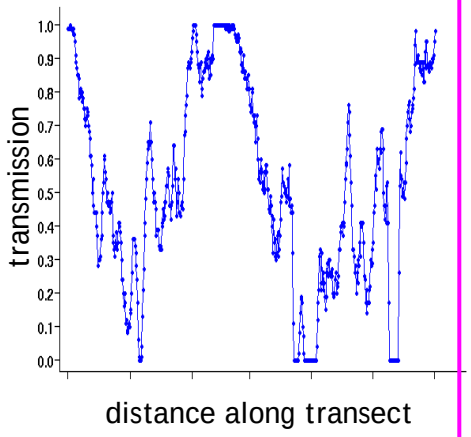
LIDAR profiles of canopies



local level

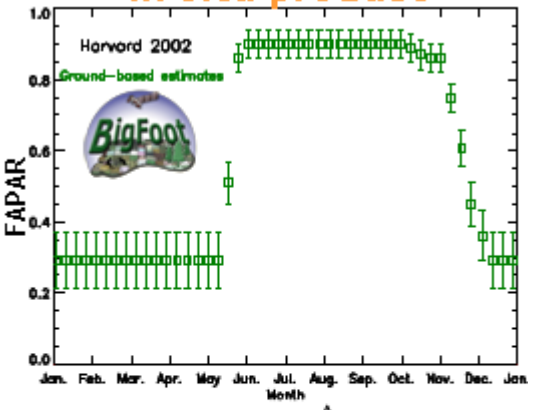
thresholded fisheye image

direct transmission transect



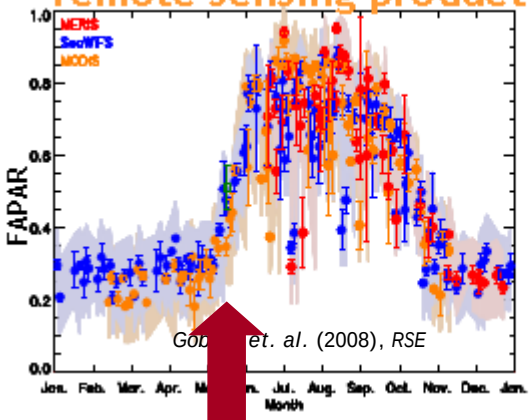
relevance to WGCV and QA4EO

in-situ product



? validation

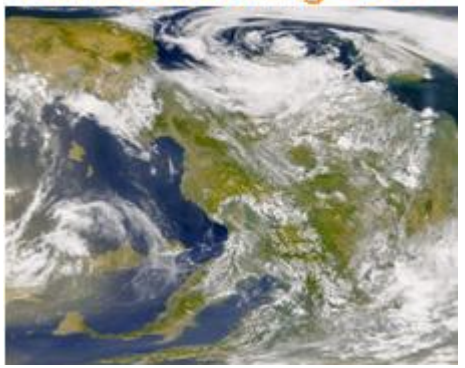
remote sensing product



Gob… *et. al.* (2008), *RSE*

retrieval algorithm

remote sensing data



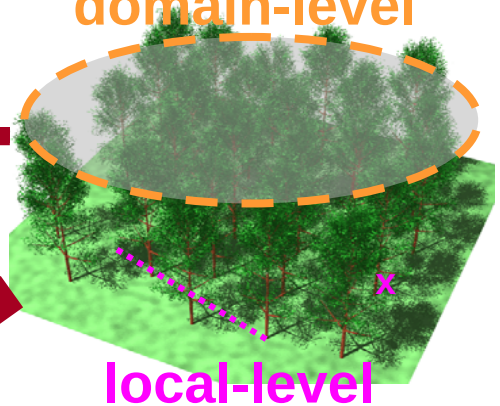
QA

QA

retrieval & upscaling algorithm

support

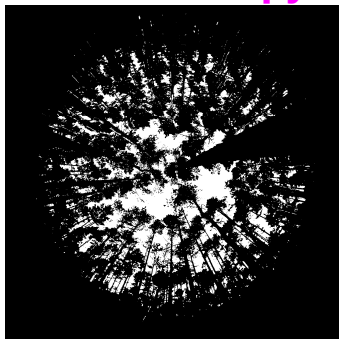
domain-level



contribute

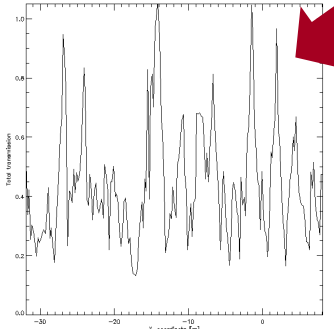
upscaling & vicarious calibration

canopy in-situ data



thresholded fisheye

x



transmission transect

local-level

forest stand

regenerated within a 'credible' 3D RT model

atmosphere in-situ data

goniometer

cimel/aeronet

RAMI outlook

RAMI-IV: submission deadlines: june & october 2009

RAMI-V: QA4EO-support experiment of actual forest site

- Identify existing forest validation site
  - Coniferous (part of larger area of similar structure)
  - Medium tree density (not too old but slow growth rate, obvious allometry)
  - Little understorey (homogeneous background)
- Replace statistical trees by "exact" copies
- Acquire spectro-directional inventory data (also atmosphere)
- Apply variety of existing field validation approaches
- Simulate actual space sensor measurements (TOC / TOA)
- Simulate actual in-situ measurements (existing sensor specs)
- Attempt vicarious calibration over forest targets (IVOS,ACSG)
- Attempt evaluation of field validation methodology (LPV)
- Possibility to involve 3D tree backscatter models (SAR,MWS)

Recommendations

- **Need agency support for measurement campaigns necessary to enable the RT model-based QA4EO-support experiment.**
- **Make better use of web-based benchmarking tools for outreach and education activities.**
- **Need long term support for *systematic* model verification activities: new WGCV subgroup ?**

Thank you!

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