A Generic Retrieval Package for Land Parameters applied to Surface Albedo Products

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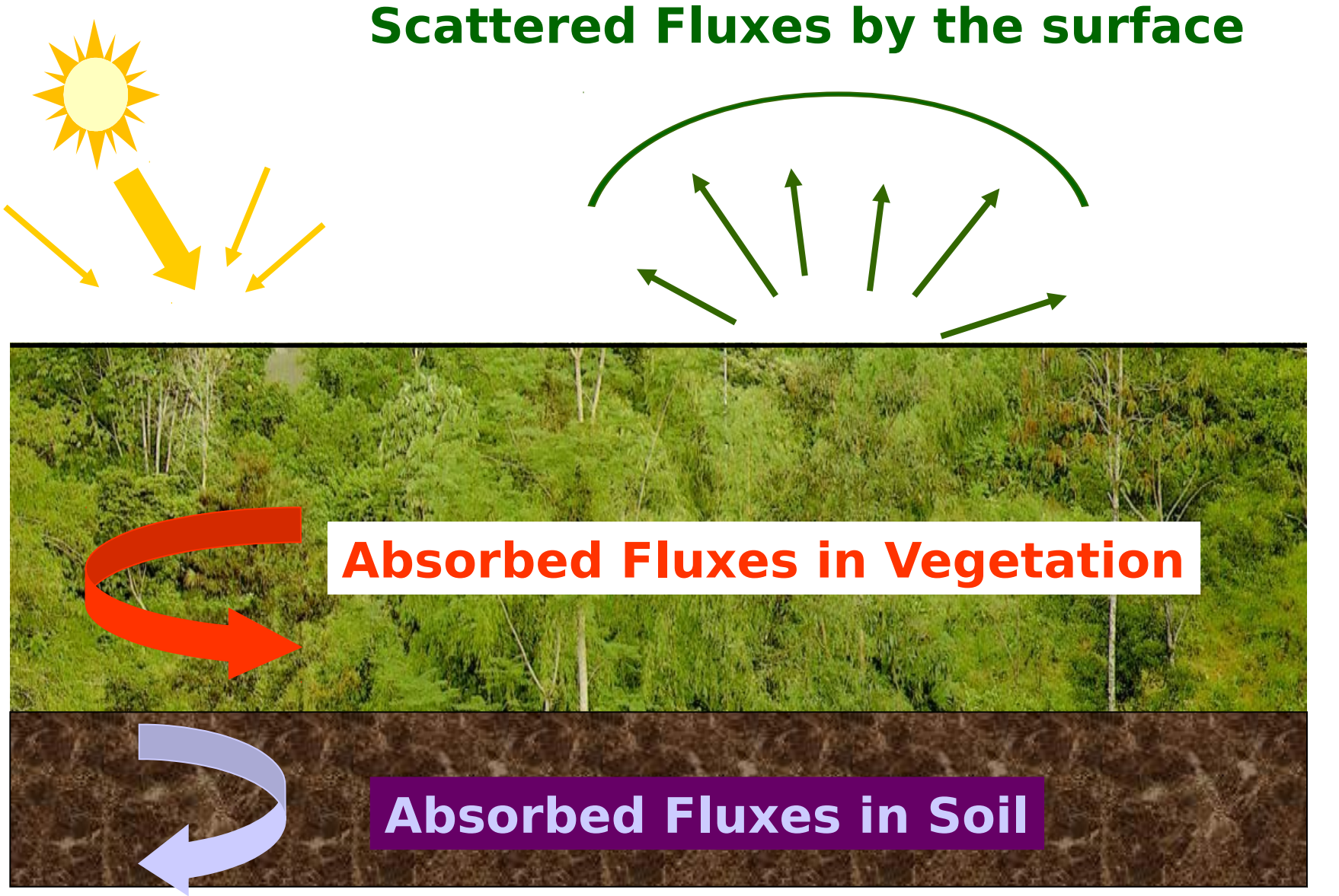
Outline

Twostream

Inverse Problem

Applications

Two-stream model to partition the Sun energy between the atmosphere, the vegetation and soil



Pinty etal., (2006): Journal of Geophysical Research, doi:10.1029/2005JD005952

Two-stream model parameters

- 3 (effective) parameters of the canopy:

Leaf Area Index — ***amount of leaf material***

Canopy reflectance + transmittance

Canopy reflectance/transmittance

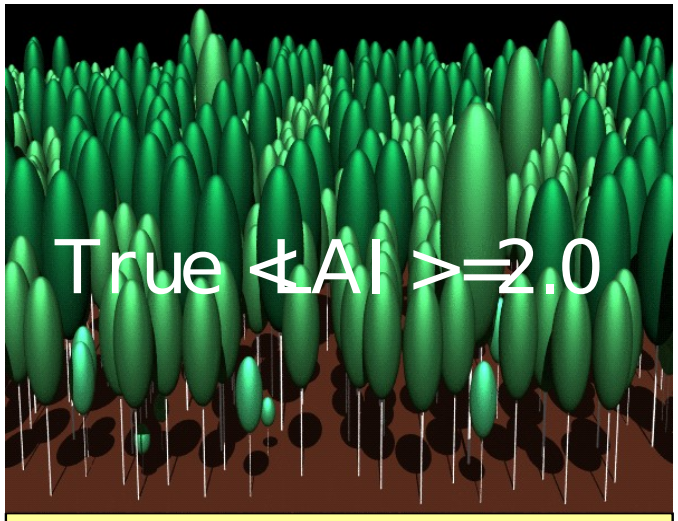
} ***canopy color***

- 1 (true) parameter of the background:

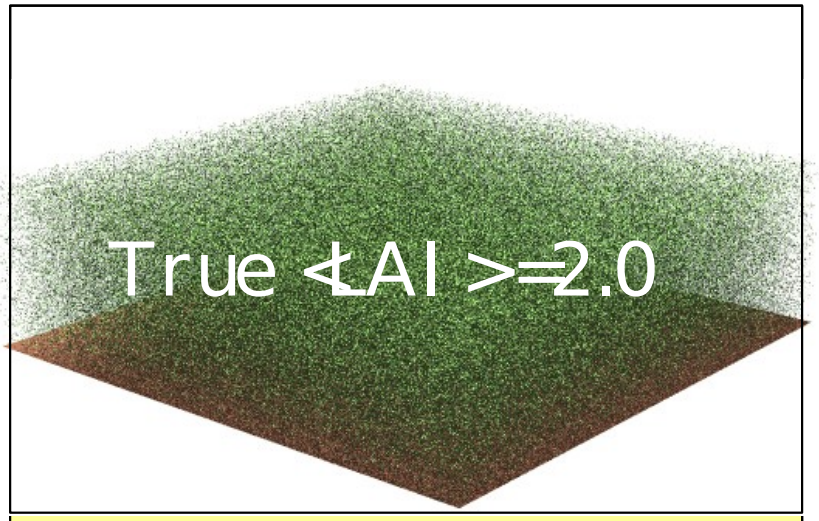
background Albedo — ***soil color***

Pinty etal., (2006): Journal of Geophysical Research, doi:10.1029/2005JD005952

The concept of effective LAI



3-D heterogeneous system



1-D system representation

Direct transmission at 30 degrees Sun zenith angle,

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

Direct transmission at 30 degrees Sun zenith angle,

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

$$T_{1-D}^{direct}\left(LAI^{eff}\right) = \exp\left(-\frac{LAI^{eff}}{2\mu_0}\right) = \exp\left(-\frac{<LAI>\xi(\mu_0)}{2\mu_0}\right) = T_{3-D}^{direct}(<LAI>)$$

Can be observed in the field

Structure factor

JRC-TIP Inversion Algorithm

$$J(\mathbf{X}) = \frac{1}{2}\left[(M(\mathbf{X}) - \mathbf{d})^T \mathbf{C}_d^{-1}(M(\mathbf{X}) - \mathbf{d}) + (\mathbf{X} - \mathbf{X}_{prior})^T \mathbf{C}_{X_{prior}}^{-1}(\mathbf{X} - \mathbf{X}_{prior})\right]$$

Model parameters

2-stream model

measurements

Parameter knowledge

Uncertainty measurements+ model

Uncertainty parameters

$$PDF(X) \approx \exp\left(-\frac{1}{2}(X - X_{post})^T C_{X_{post}}^{-1}(X - X_{post})\right)$$

a posteriori uncertainty covariance matrix

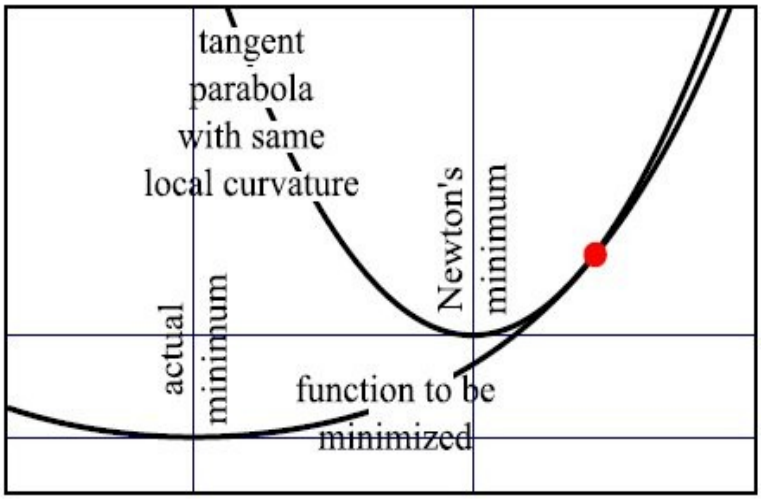
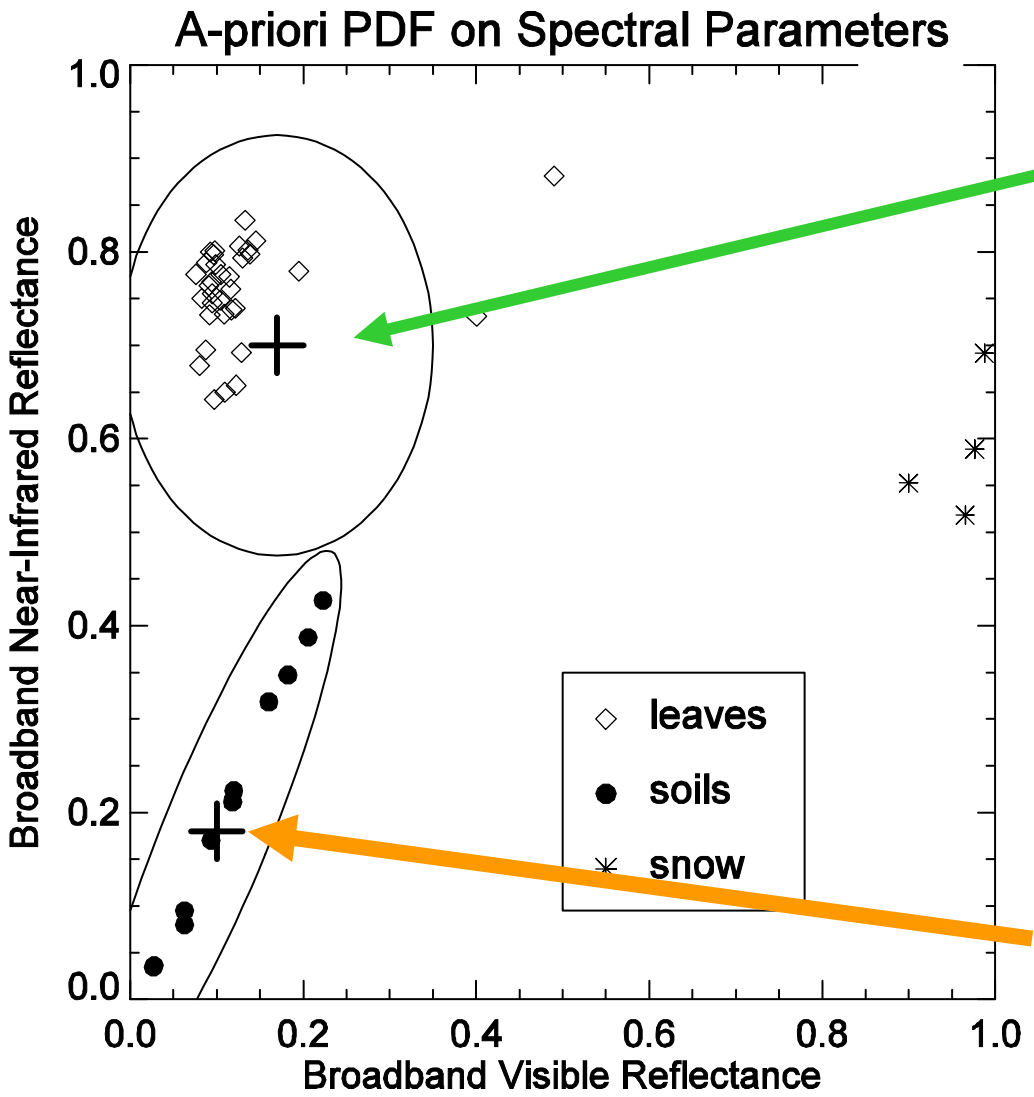


Fig: Tarantola (2005

$$C_{post}^{Flux} = \mathbf{M'}\mathbf{C}_{X_{post}}\mathbf{M'}^T$$

Pinty etal., (2007): JGR, doi:10.1029/2006JD008105

prior knowledge on model parameters

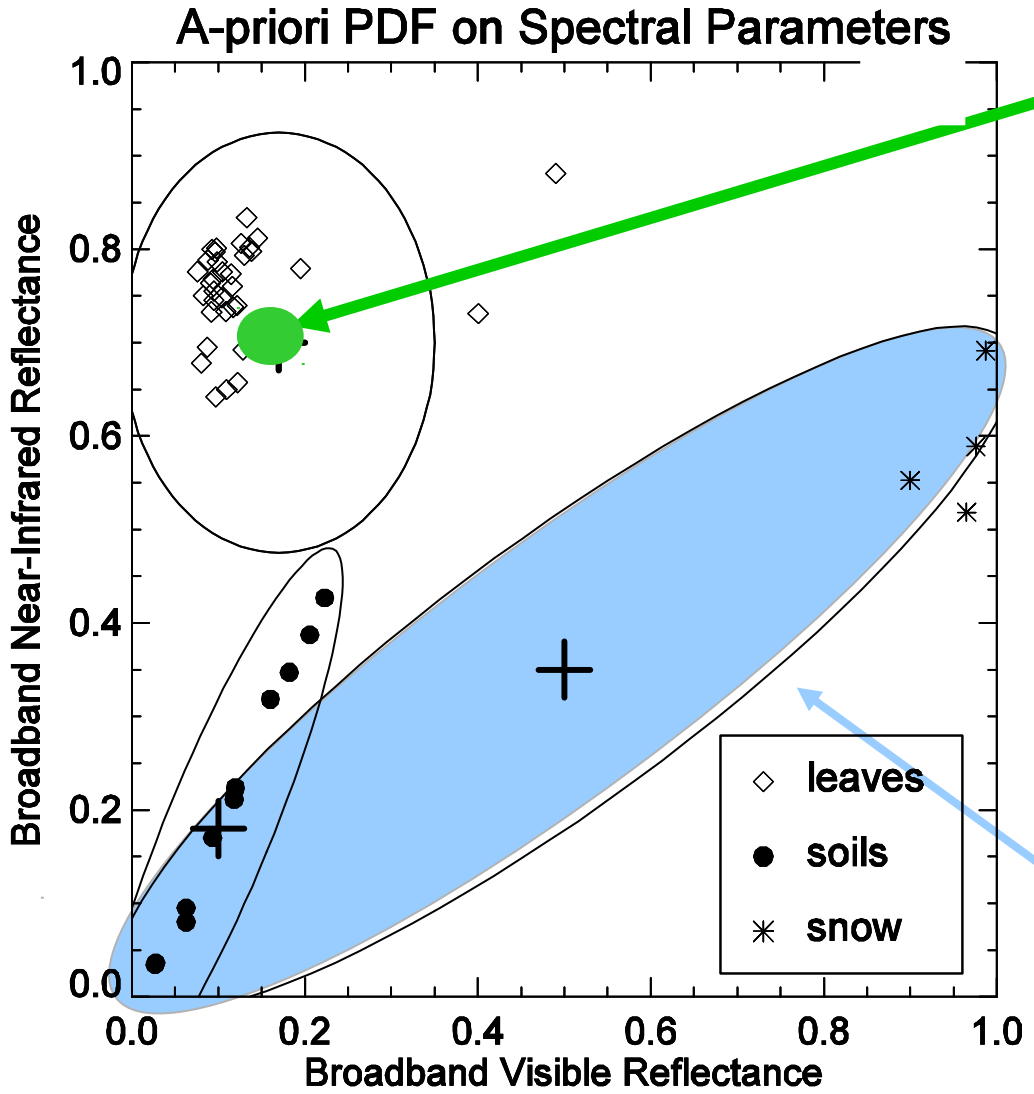


$$LAI_{prior} = 1.5$$

$$\sigma_{prior}(LAI) = 5.0$$

Pinty etal., (2007): Journal of Geophysical Research, doi:10.1029/2006JD008105

prior knowledge on model parameters



with 'green' leaves

$$LAI_{prior} = 1.5$$

$$\sigma_{prior}(LAI) = 5.0$$

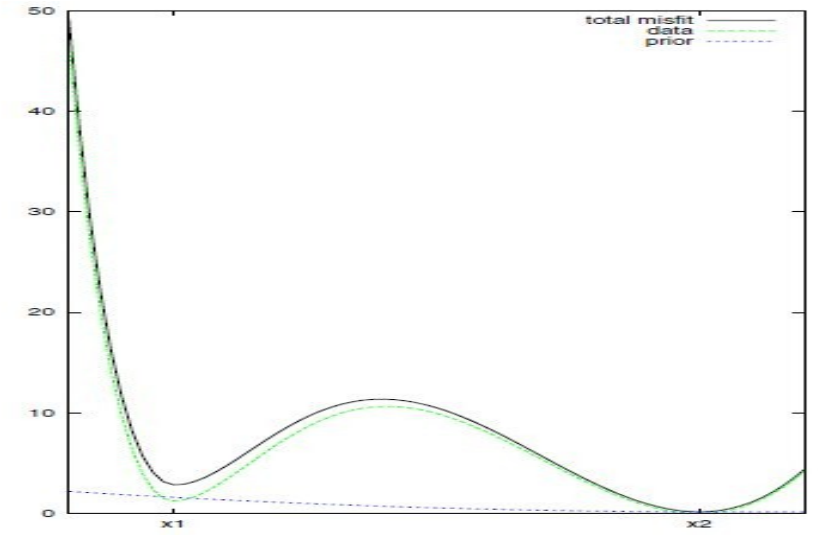
in case snow occurs

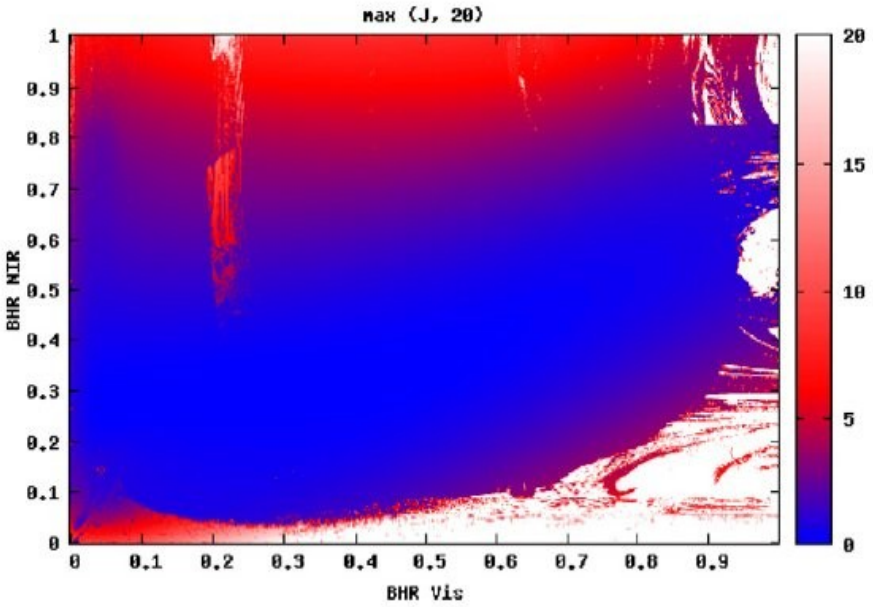
Pinty etal., (2007): Journal of Geophysical Research, doi:10.1029/2006JD008105

Setting up for operational processing

- Multiple starting points
- Smooth dependency of solutions on observed fluxes
- Typical configuration: Observed BHRs in two large wave bands (VIS and NIR)
- Compute table of solutions over fine discretisation of observation space

→ Efficiency and Robustness (reduction of # outliers)

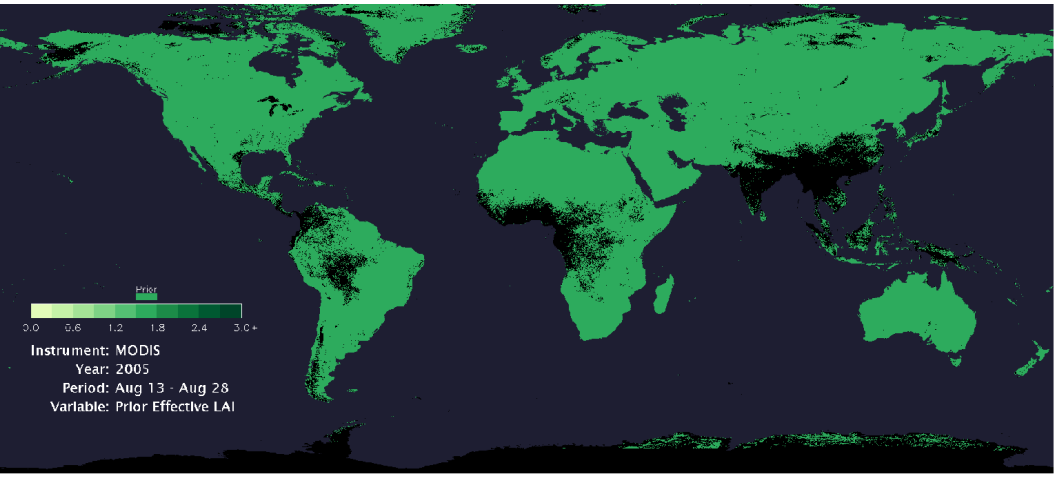


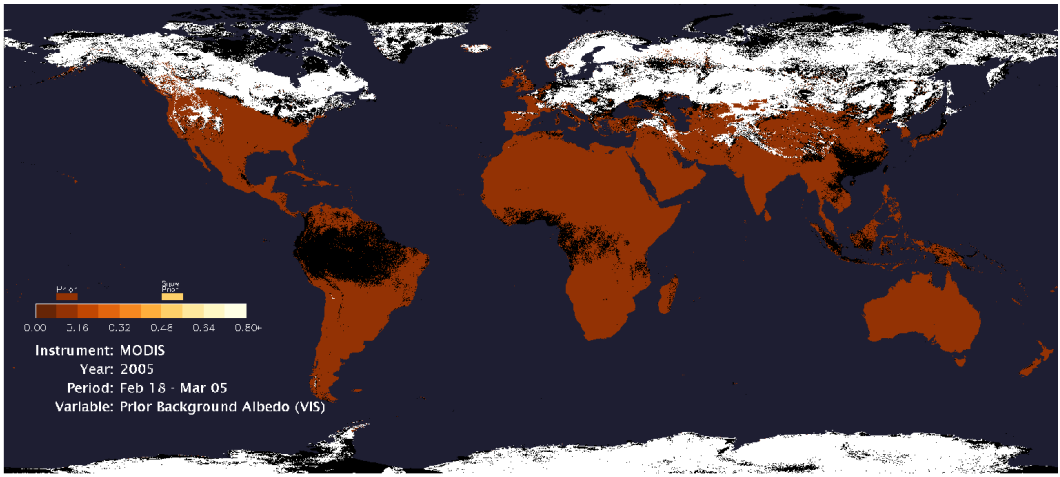


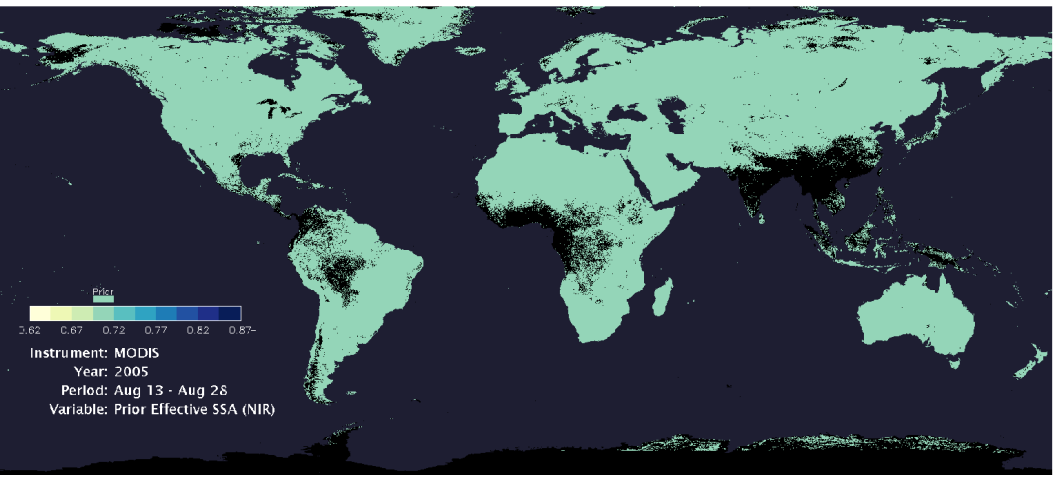
Vossbeck et al. (2010)

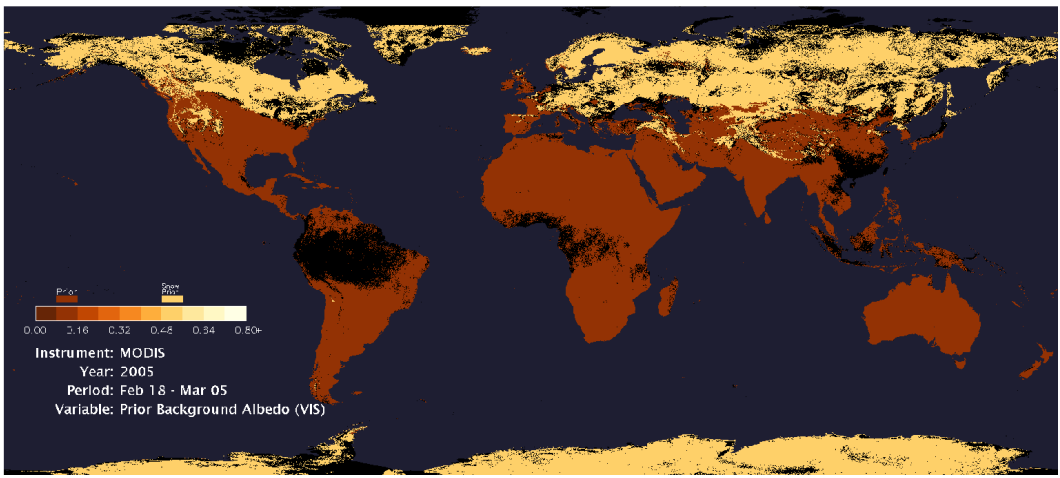
prior knowledge on model parameters

TIME and SPACE INVARIANT



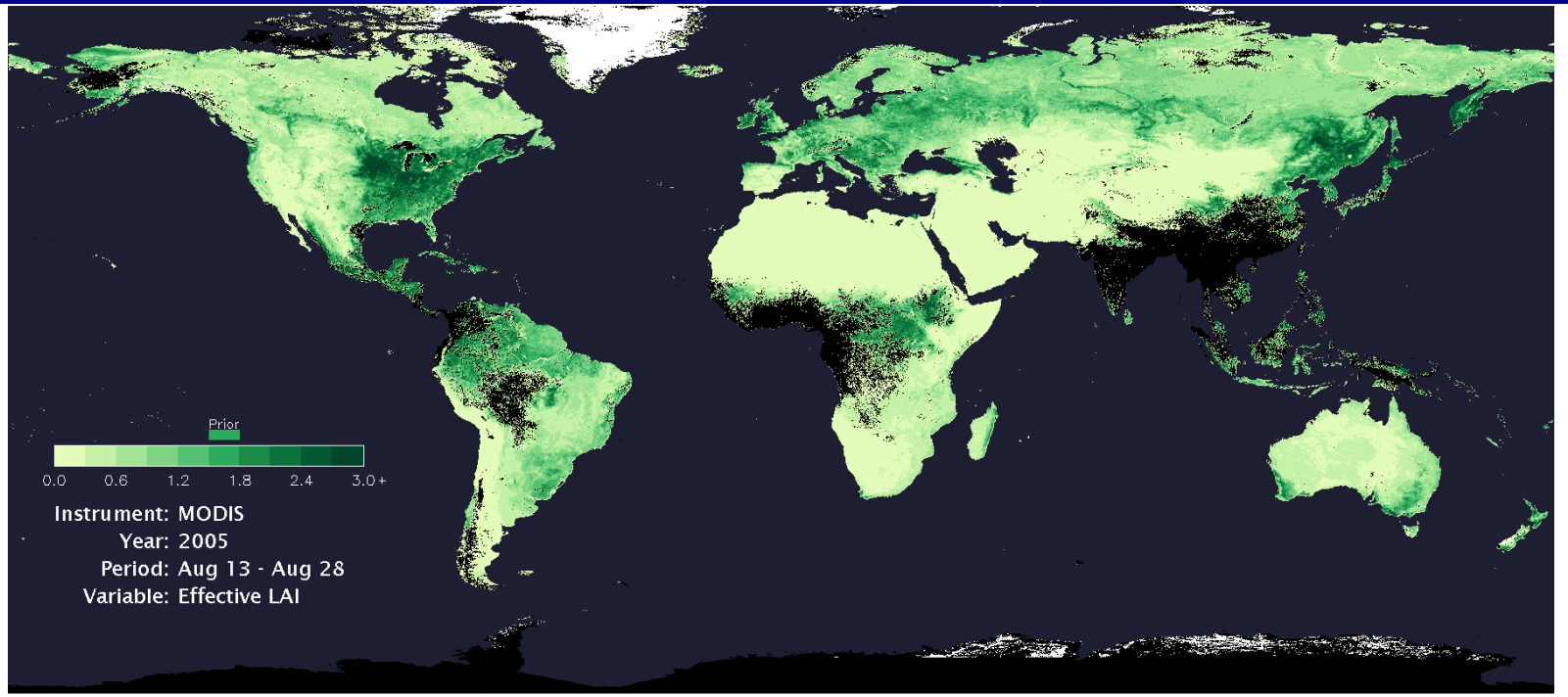


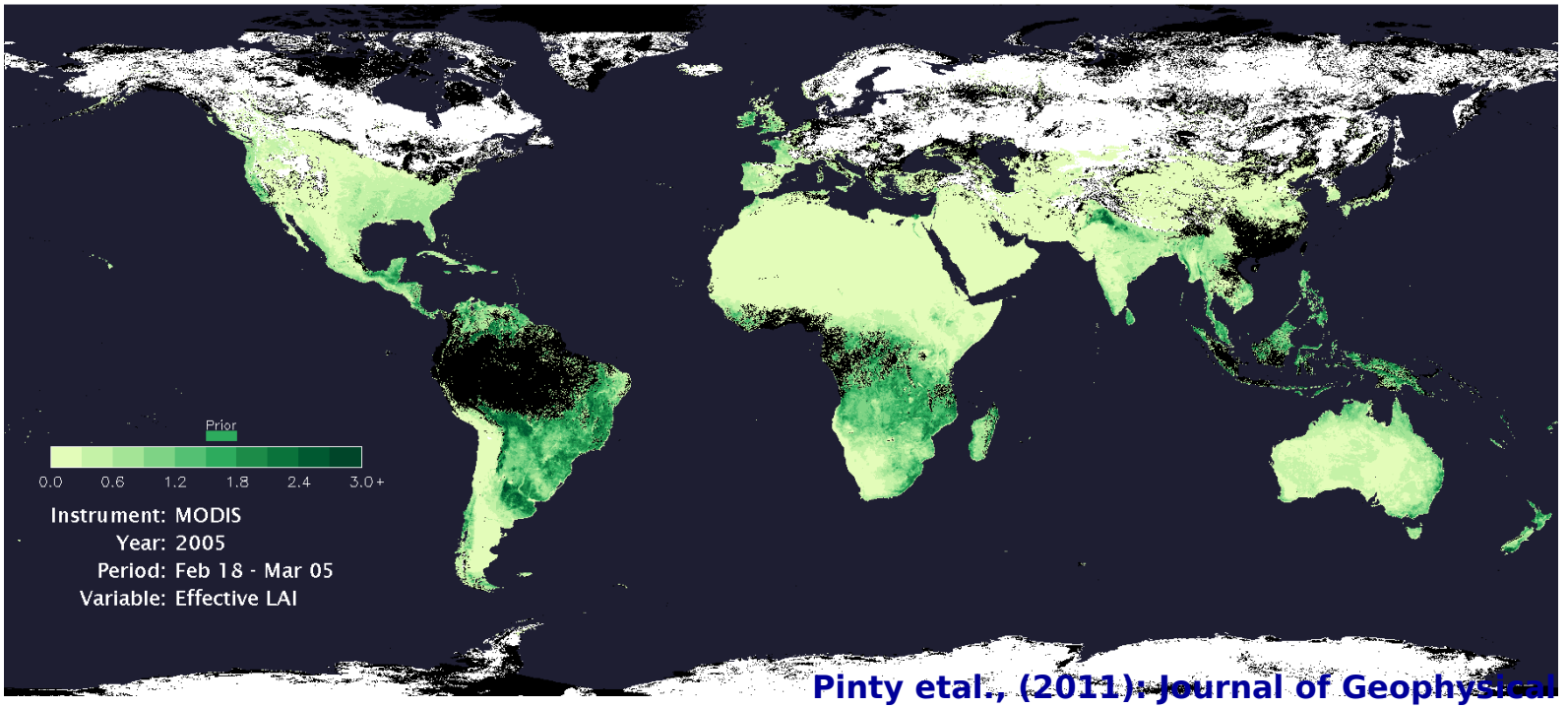




Pinty etal., (2011): Journal of Geophysical Research

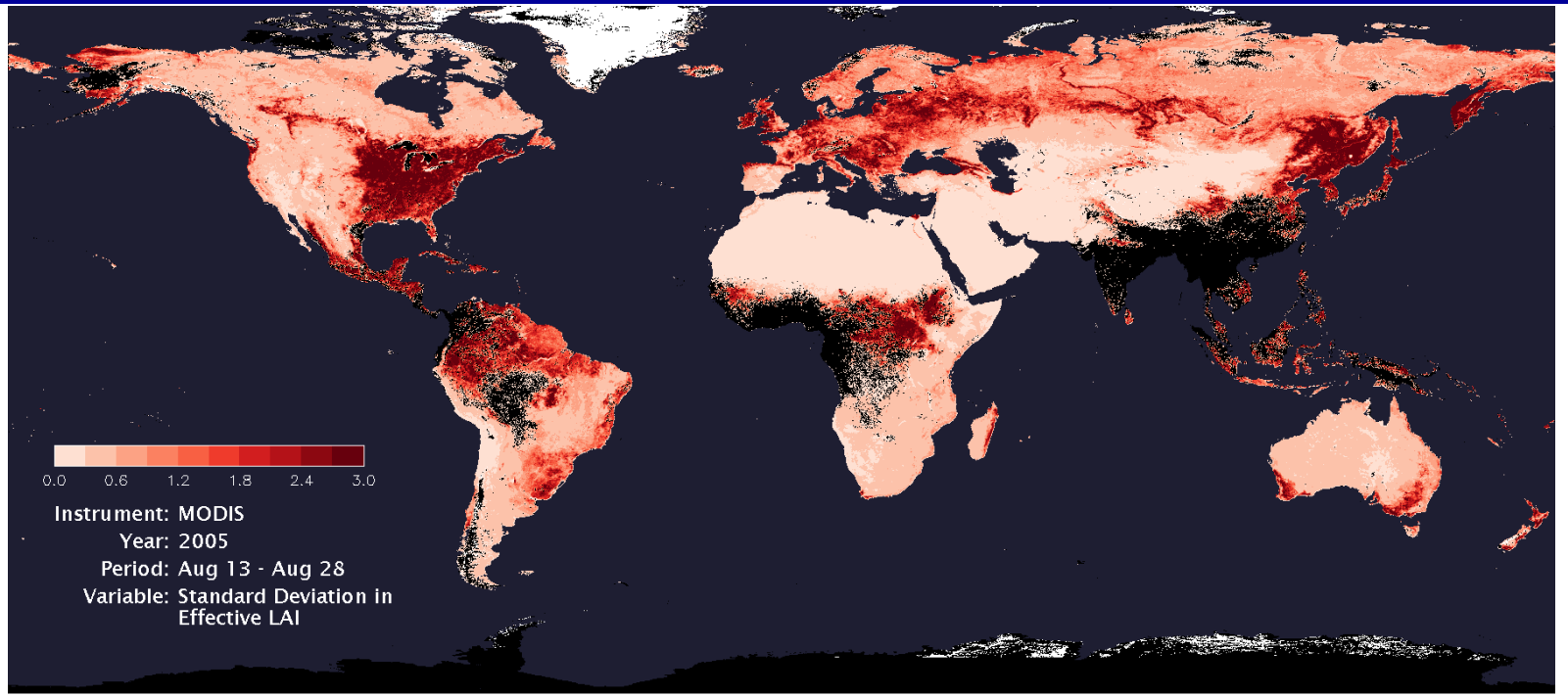
effective Leaf Area Index

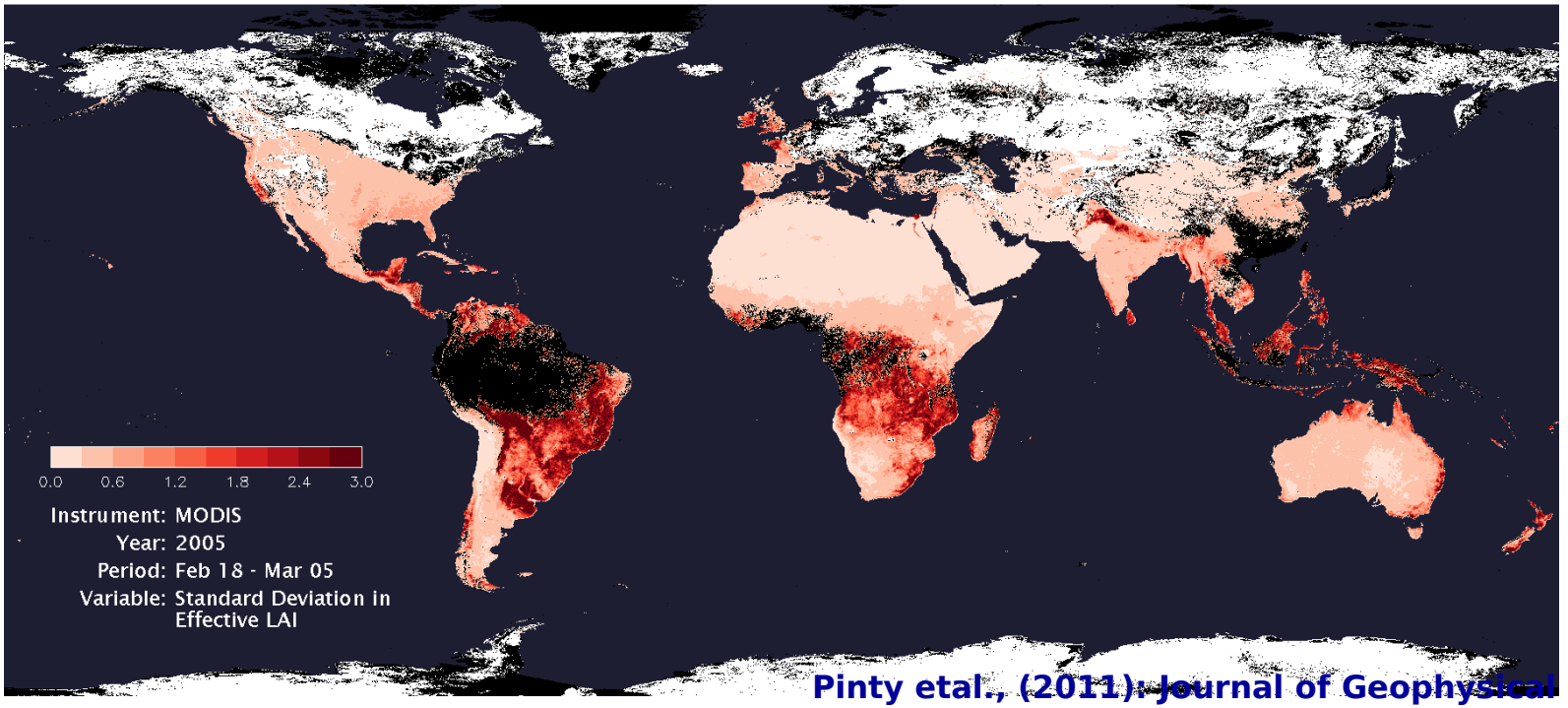




Pinty etal., (2011), Journal of Geophysical Research

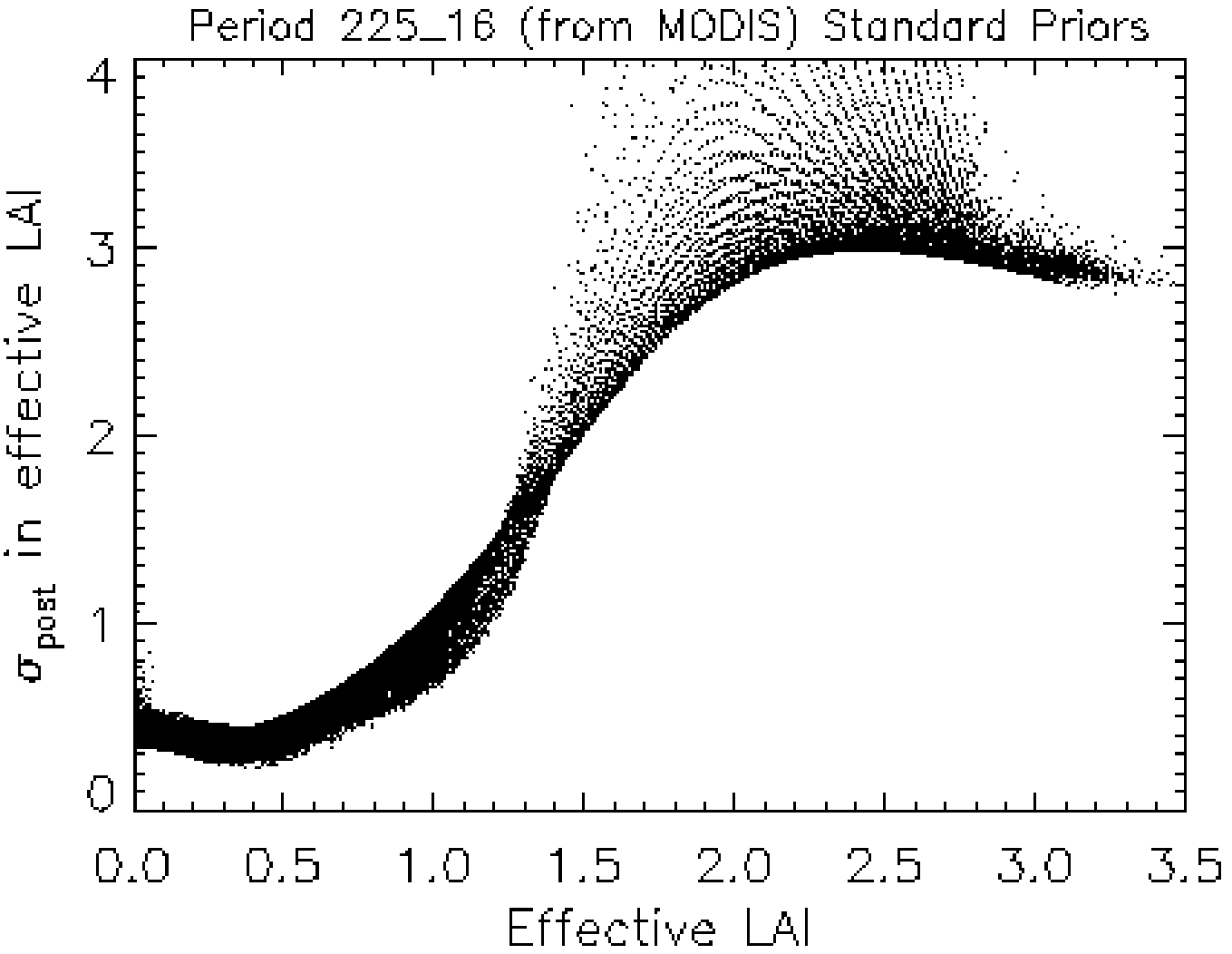
uncertainties in effective LAI





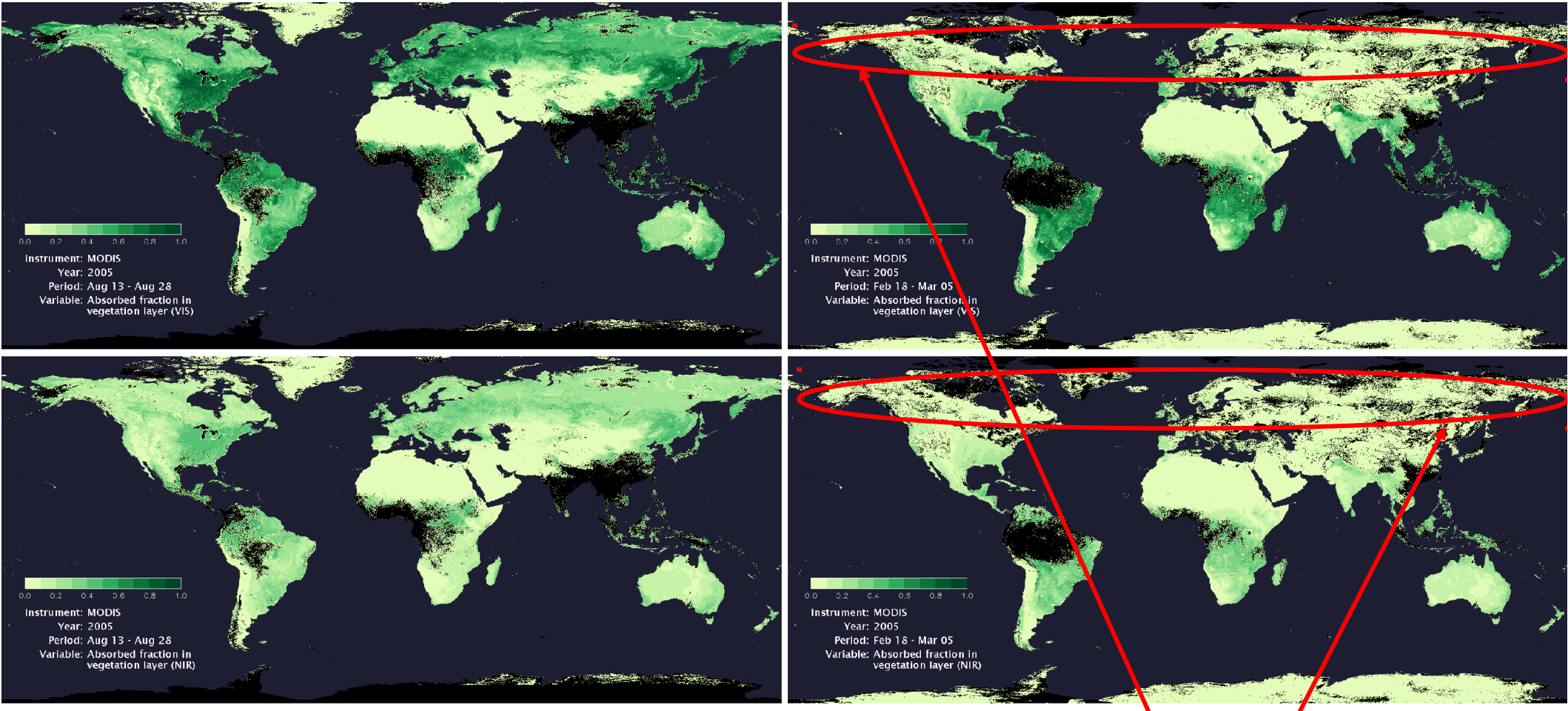
Pinty etal., (2011): Journal of Geophysical Research

uncertainties in effective LAI (2)



Pinty etal., (2011): Journal of Geophysical Research

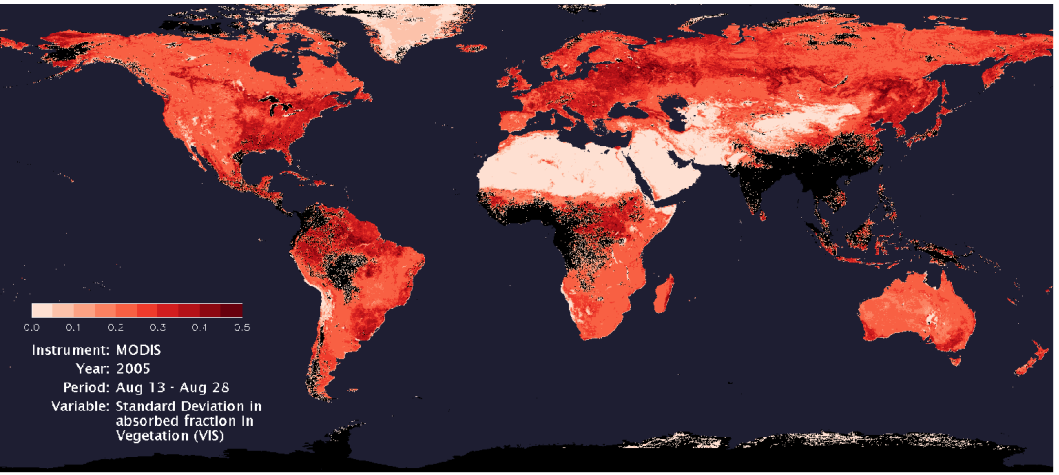
Examples of TIP generated products: Absorbed fraction in the VIS and NIR

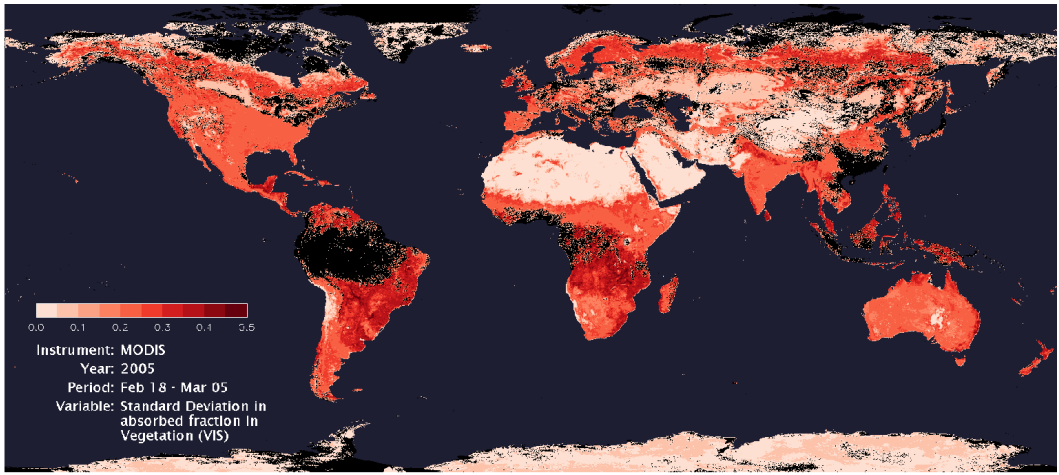


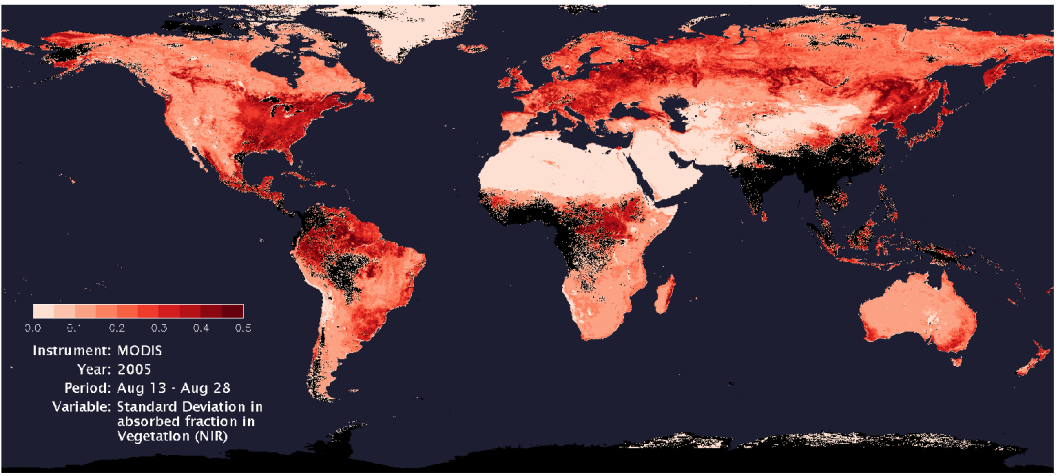
snowy conditions

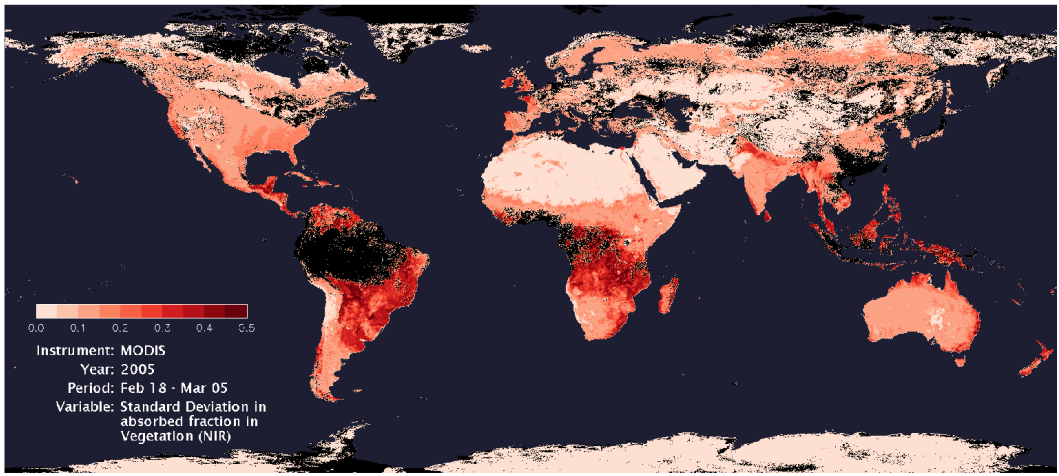
Pinty etal., (2011b): Journal of Geophysical Research

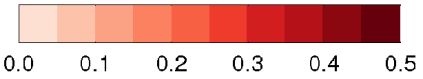
Examples of TIP generated products: Uncertainties on absorbed fractions







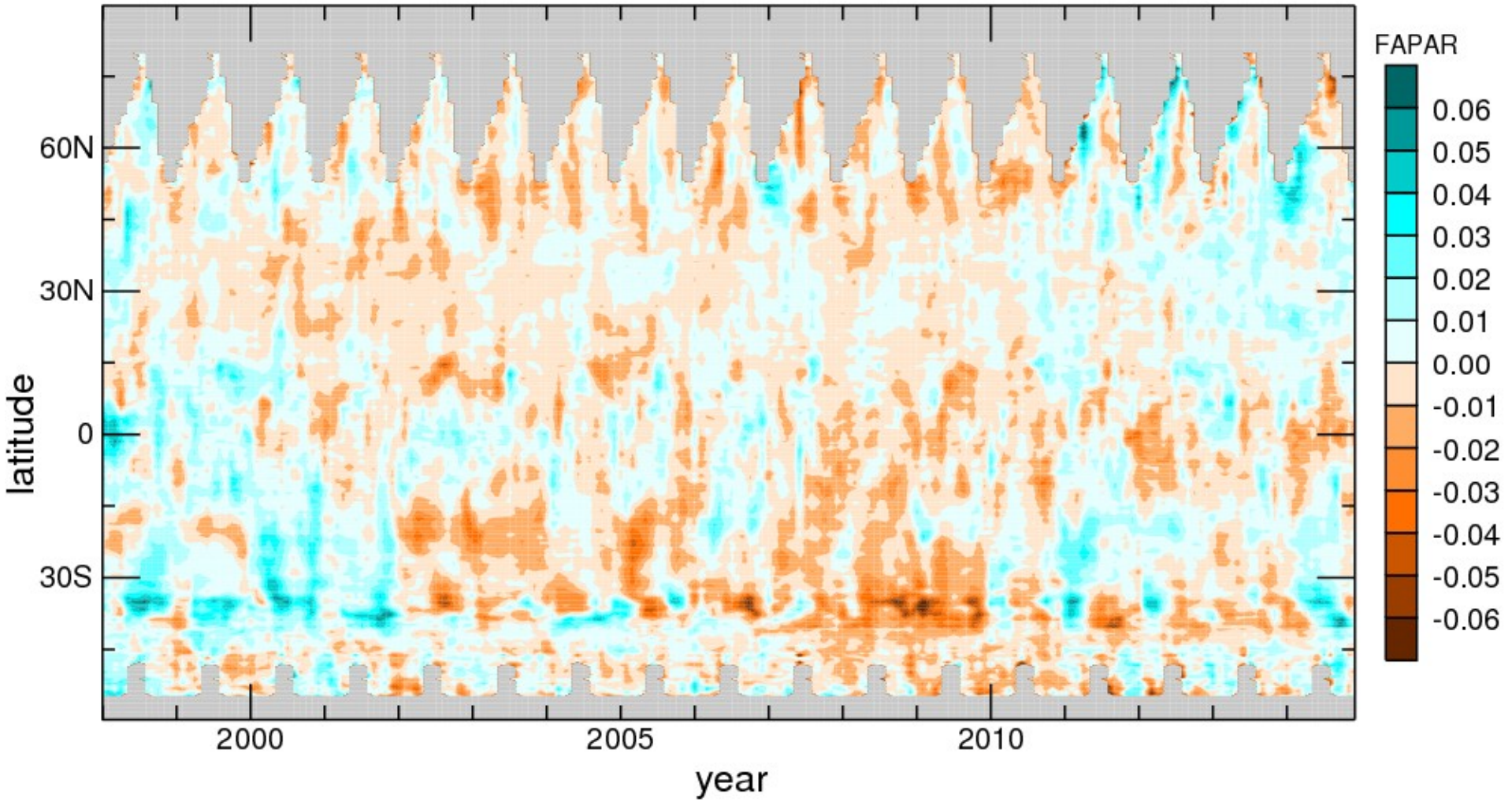




Complete set of TIP-JRC products from 2000-2014 available on demand

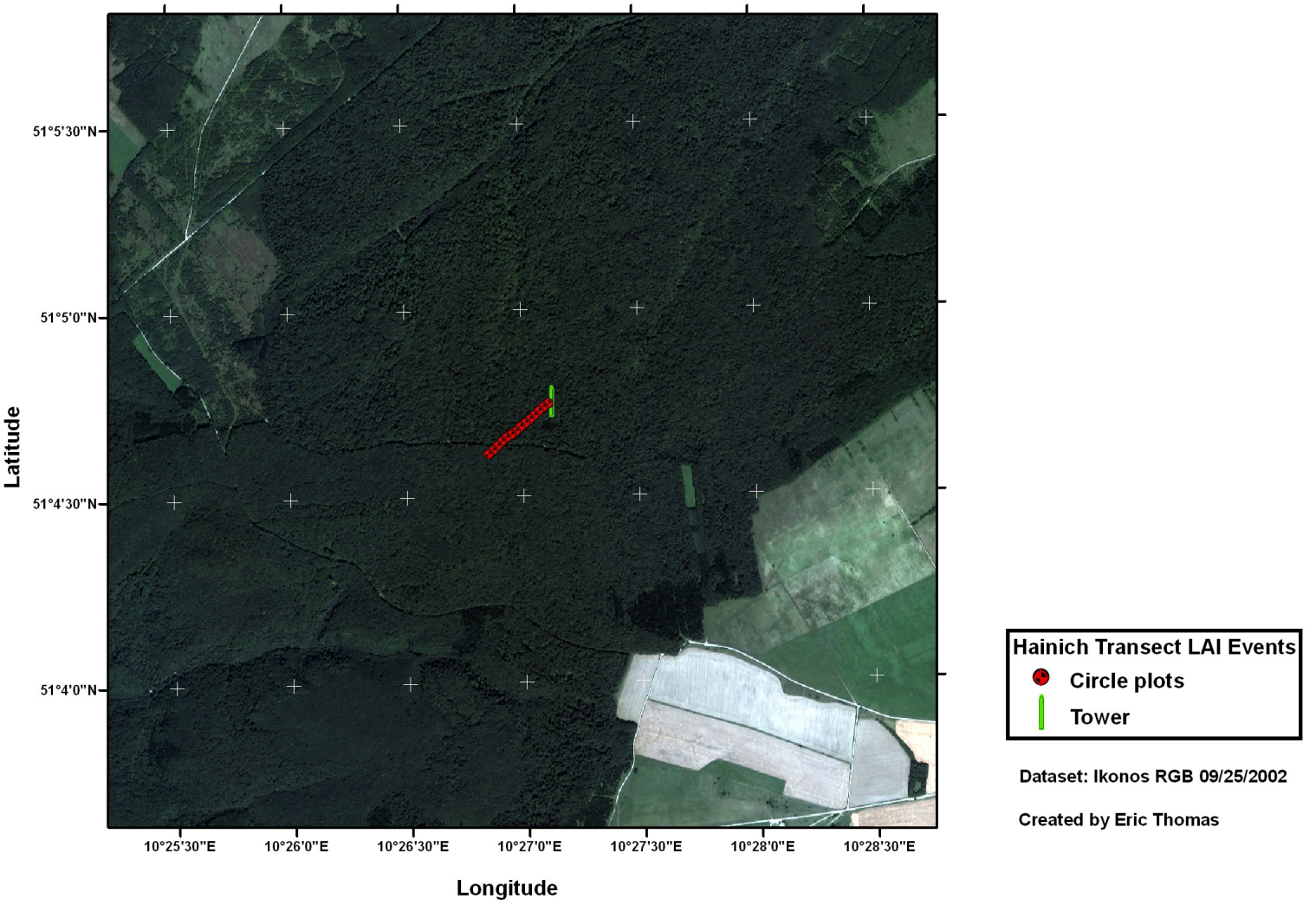
Pinty etal., (2011b): Journal of Geophysical Research

Zonally averaged monthly anomalies
Use of SeaWiFS, MERIS FAPAR and MODIS TIP ABSVIS (Green Assumption)



Gobron, 2015: [Global Climate] Terrestrial vegetation dynamics during 2014 [in "State of the Climate in 2014"]. Bull. Amer. Meteor. Soc., in print

Validation over Hainich forest site

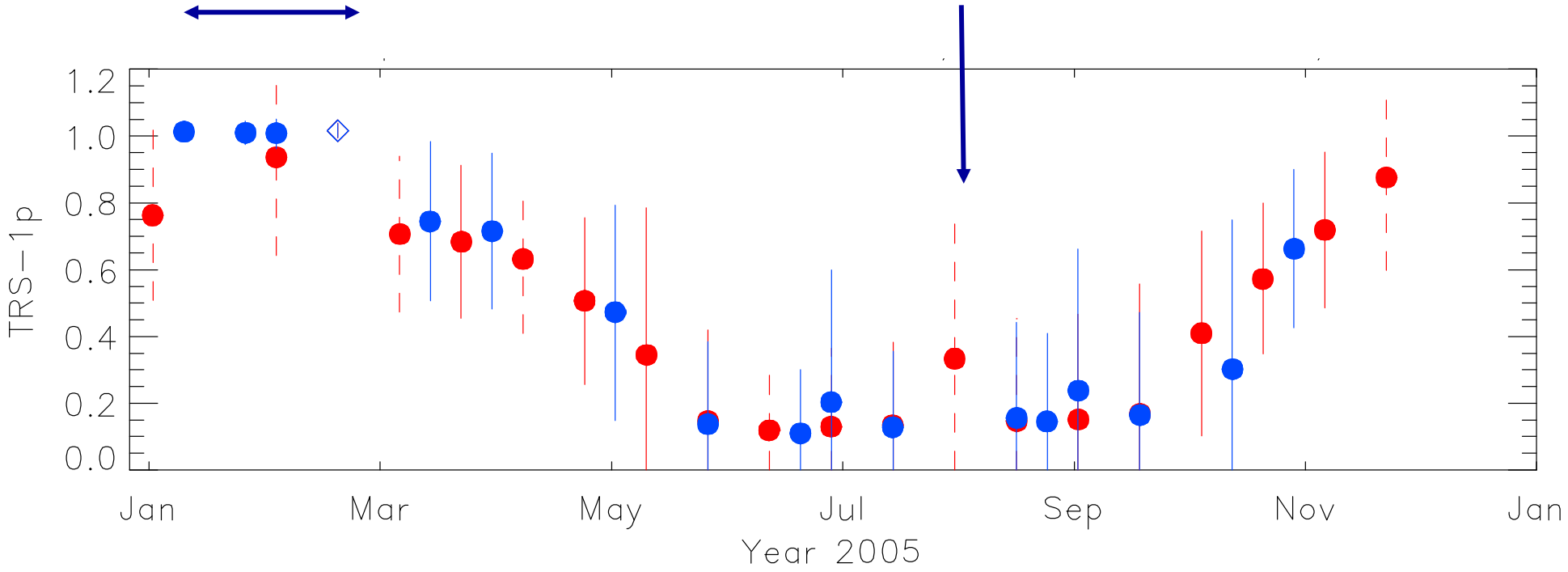


Pinty etal., (2011): Remote Sensing of Environment

TIP transmission (VIS) from MODIS & MISR derived BHRs

Probable snow contamination

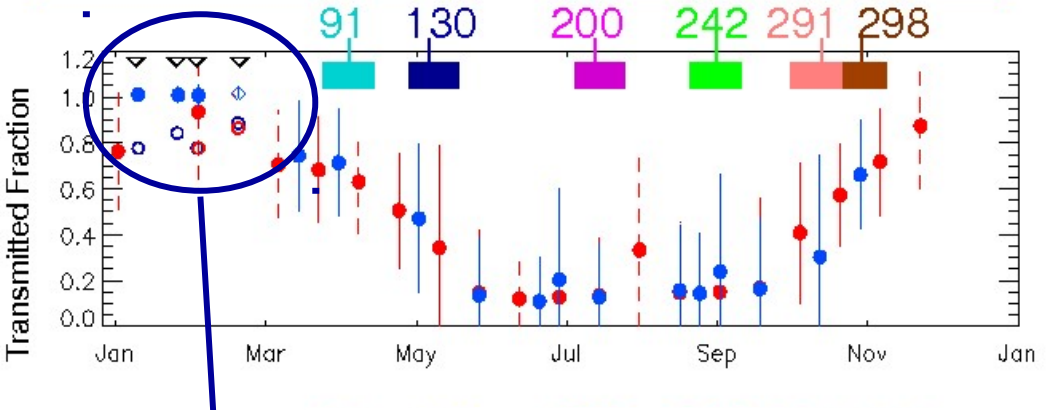
Probable cloud contamination



MODIS 16-day

MISR 8-day

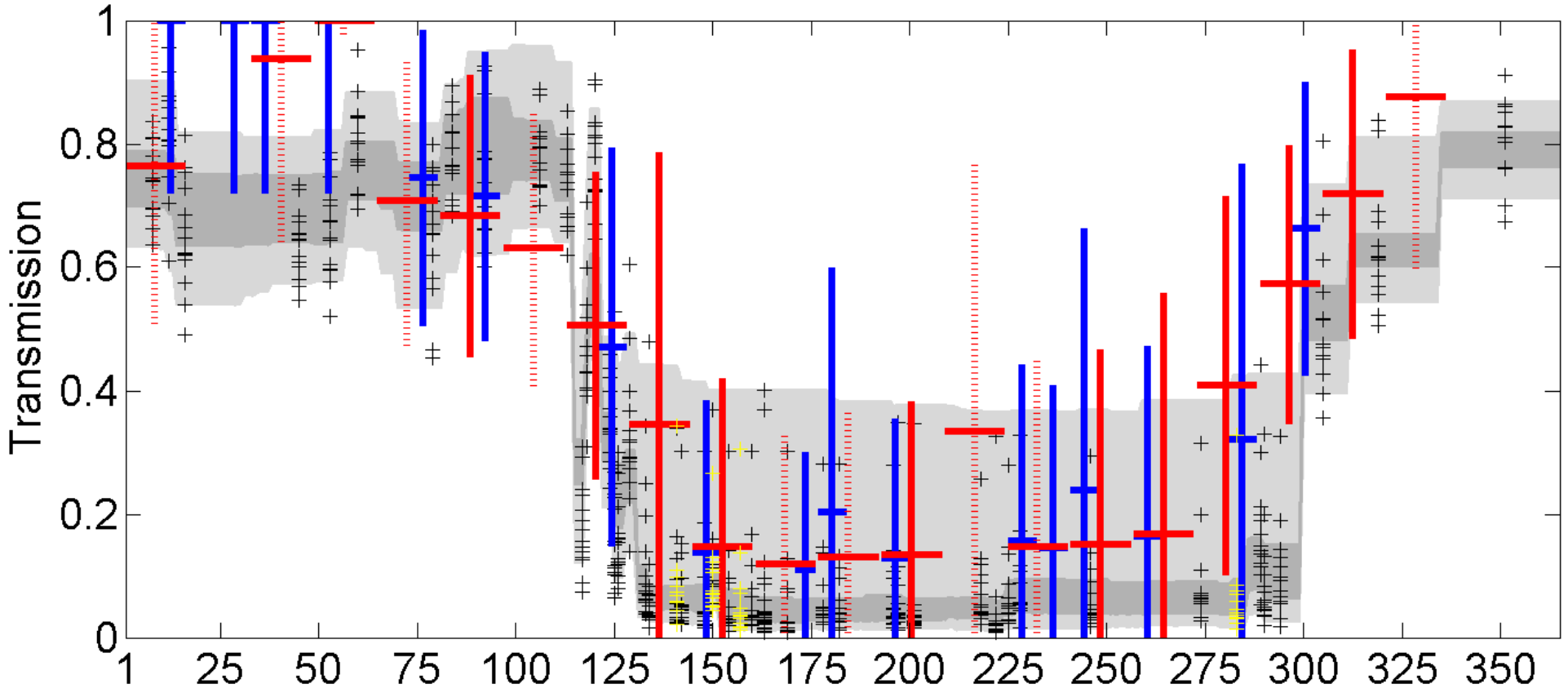
Pinty etal., (2011): Remote Sensing of Environment



assuming TIP prior conditions associated with presence of snow on the background

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

Comparison between TIP retrieved transmission and in-situ estimates

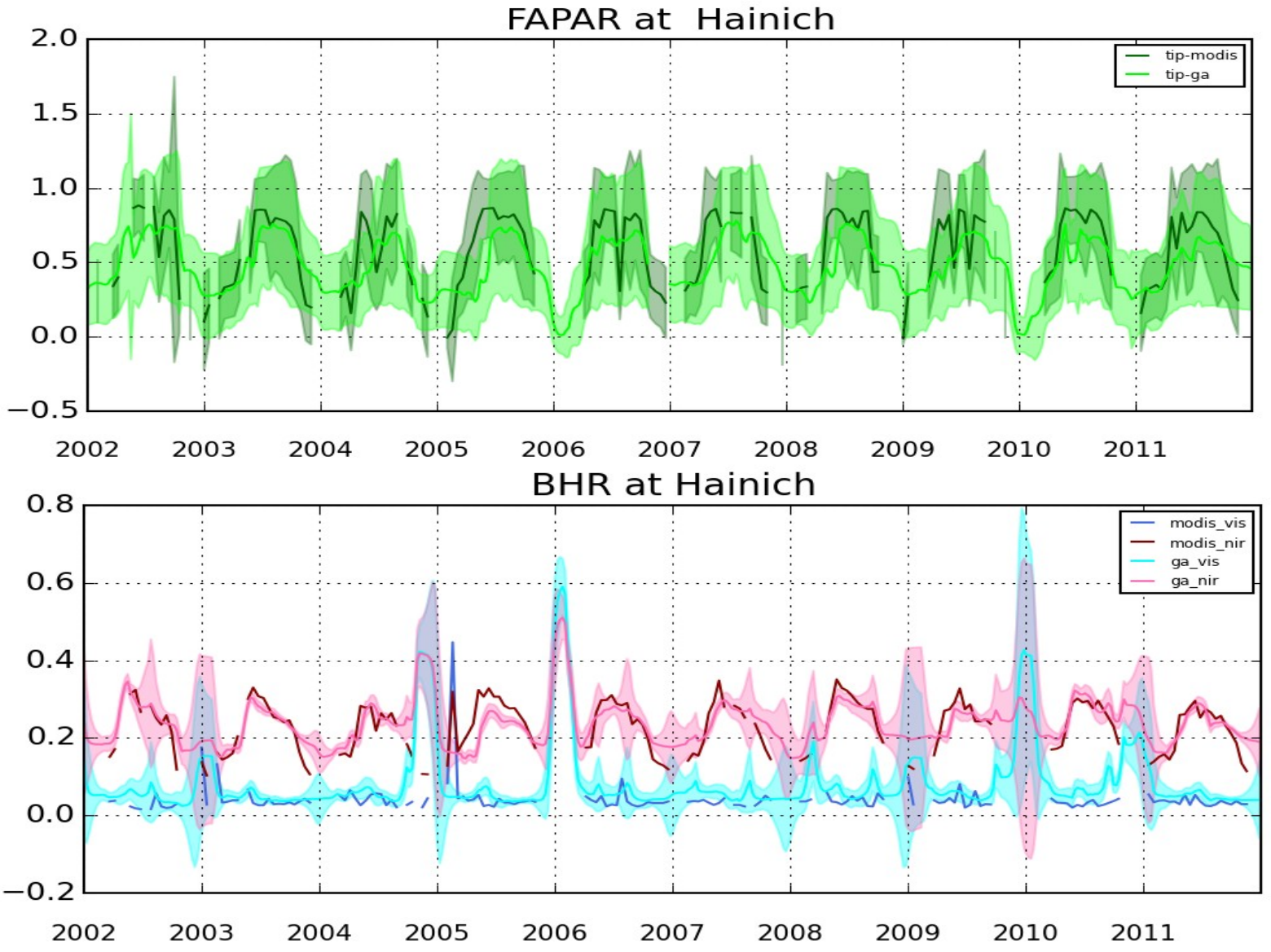


Pinty etal., (2011): Remote Sensing of Environment

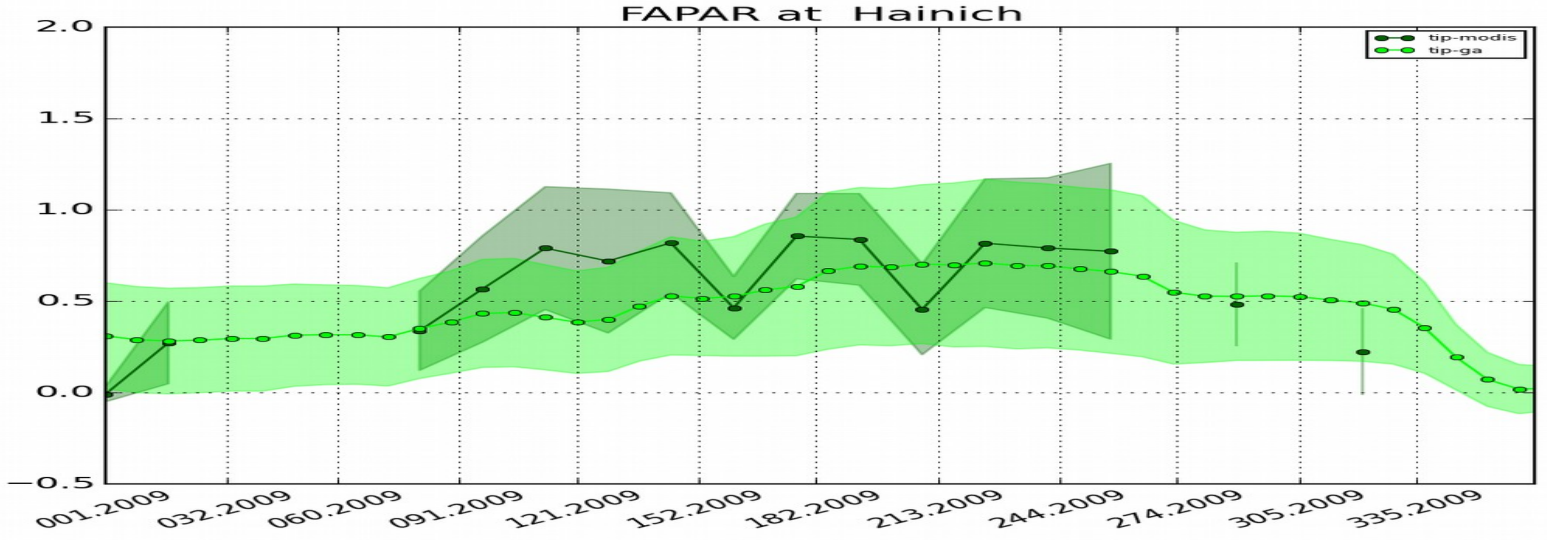
TIP on Globalbedo

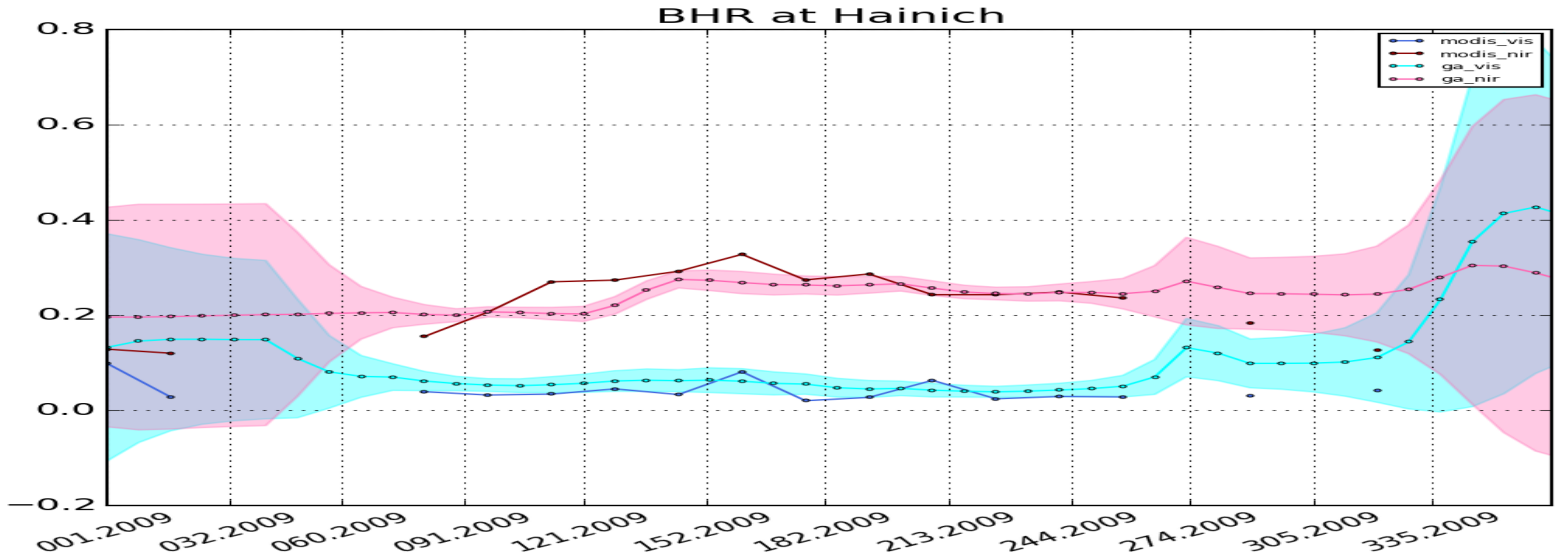
- Albedo input to TIP based on MERIS, VEGETATION, and AATSR; MODIS used as prior
- 1km native resolution
- 2002-2011 globally, 8-day integrals
- using snow fraction
- uncertainty information used in very large bins
- LAI and FAPAR available on globalbedo.org

TIP on Globalbedo

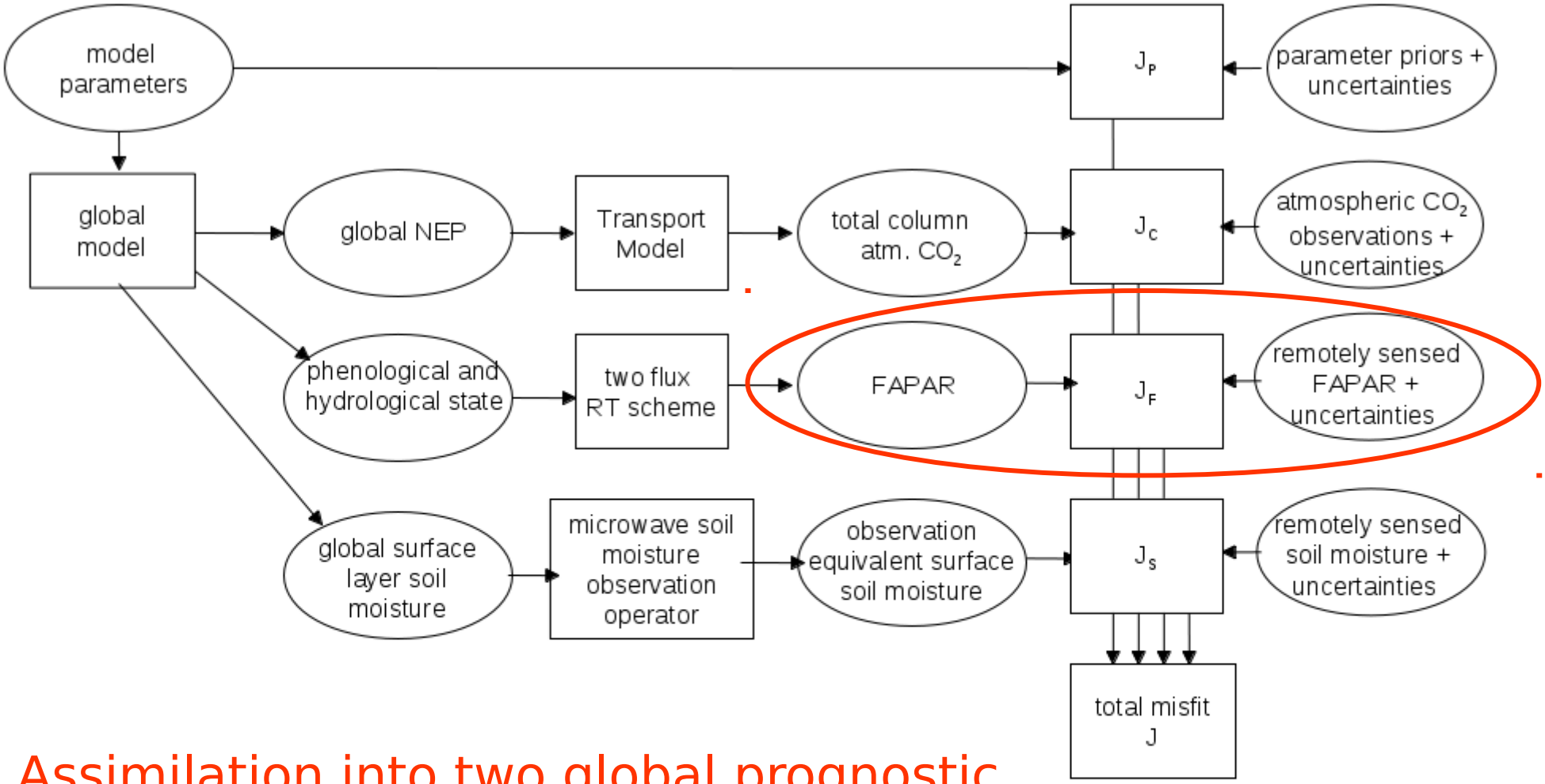


TIP on Globalbedo





Assimilation of TIP products



Assimilation into two global prognostic models of the terrestrial carbon cycle

Kaminski et al., (2013): JGR

Summary

- generic retrieval package for land surface variables
- can control prior assumptions
- can assimilate any combination of broadband, narrowband or hyperspectral radiation fluxes
- physically consistent set of products
- includes estimate of uncertainty ranges, with full covariance across spectral domains and between state variables and fluxes → suitable for data assimilation
- demonstrated for various albedo input products → MISR, MODIS, Globalbedo (MERIS, VEGETATION, AATSR)
- validation at site level

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