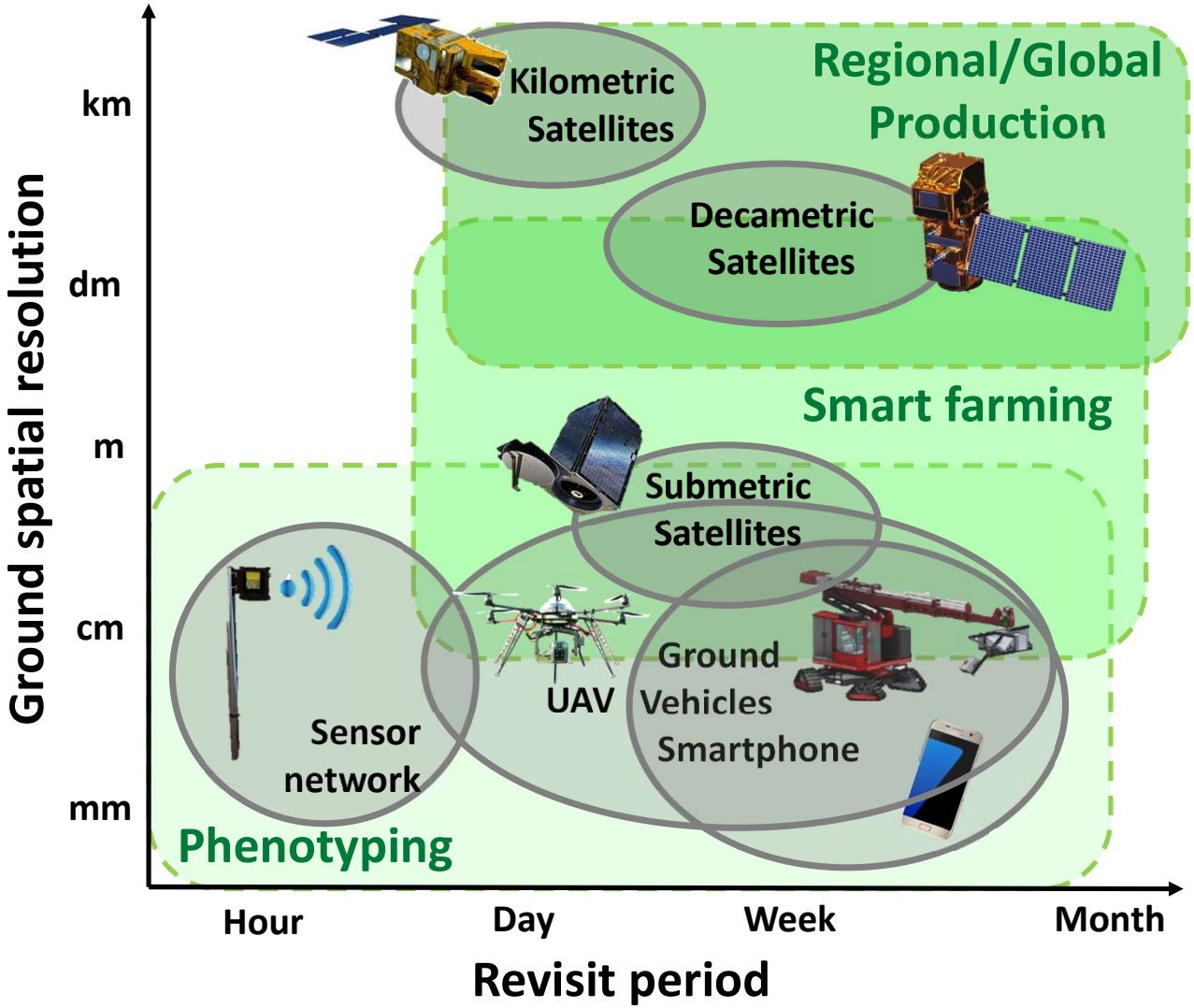
Suivi des surfaces par observation satellitaire

F. Baret

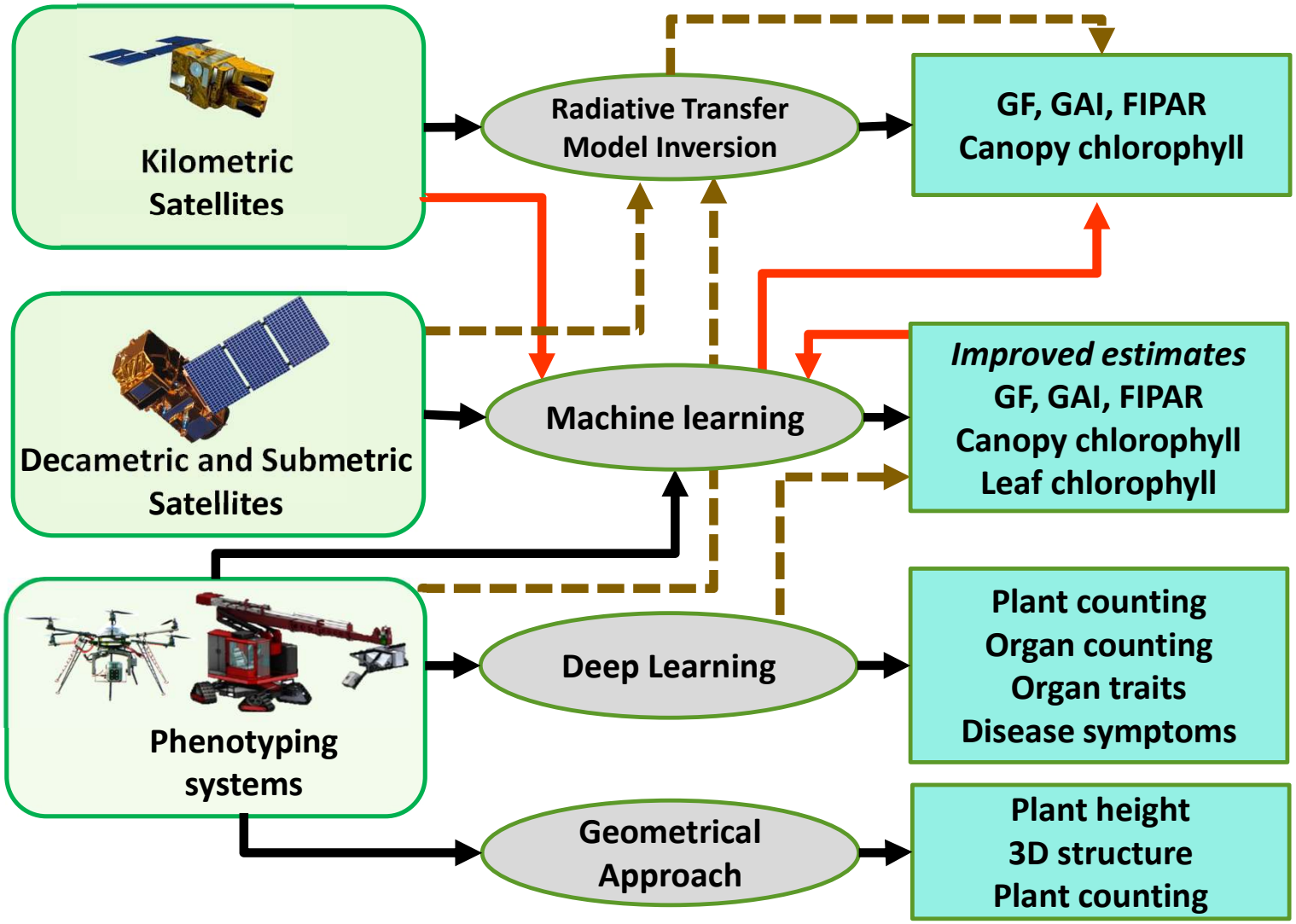
Outline

- Interest of biophysical variables
- Definition of variables
- Exploit all information available
  - Generic
  - Specific
- Climatologie GEOCLIM

Spatial and Temporal resolutions

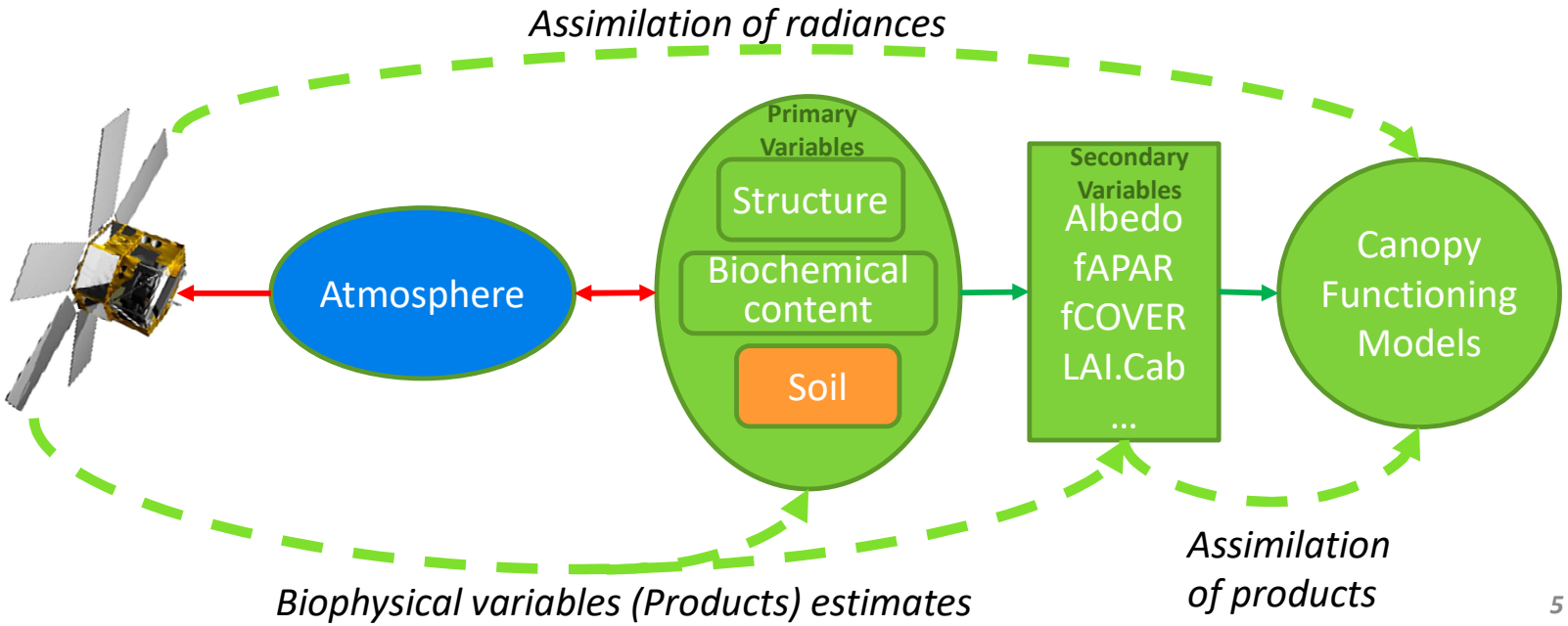


(R)evolution in the retrieval techniques



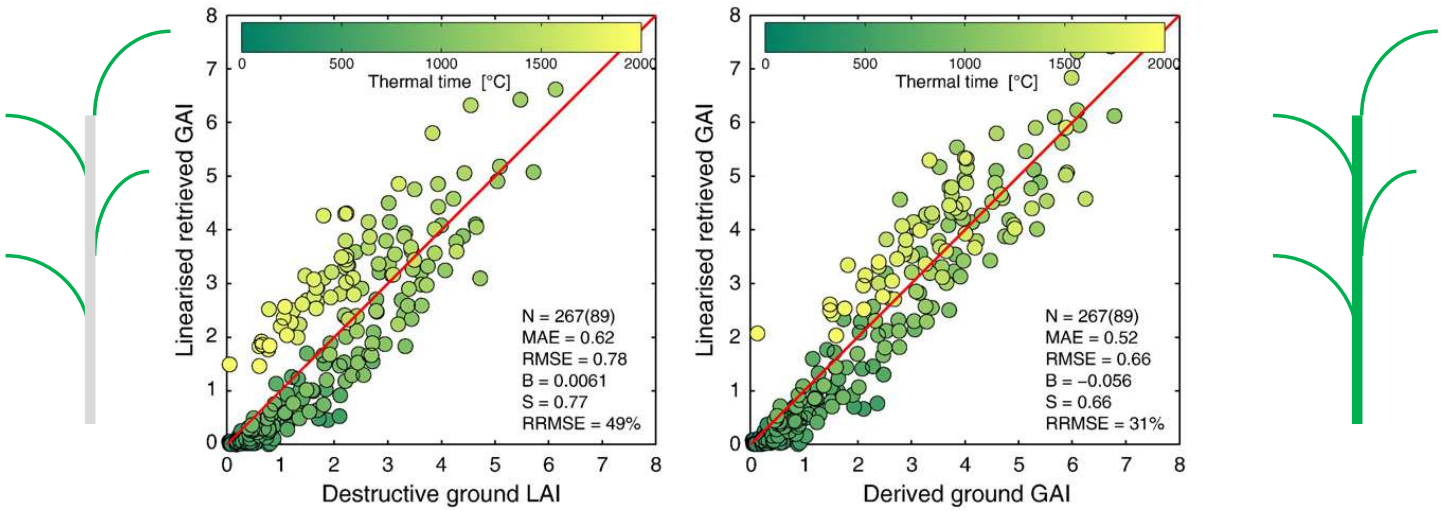
Interet des variables biophysiques

- **Need for biophysical variables** (LAI, fAPAR, fCover, Albedo) **and their dynamics**
  - Input to process models
  - Smooth expected temporal course (allows smoothing)
  - Allows validation
  - Provide uncertainties
- **Essential Climate Variables**: Albedo, LAI, fAPAR
  - Other variables potentially accessible fCover, Chloro, water, dry matter



Definition des variables principales

- LAI: *half the total developed green area per unit horizontal ground area*
  - ***PAI**: Plant Area Index (includes non green vegetation elements): observed from indirect measurements at the ground level*
  - ***GAI**: Green Area Index: not only leaves but other green elements*
  - ***Effective XAI**: assuming random distribution of the canopy elements XAIe=Ω.XAI ; 0.4<Ω<1*



- FIPAR*: fraction of intercepted photosynthetically active radiation: used for photosynthesis: green surfaces only (fortunately!!)*
  - *Depends on illumination conditions (sun position, diffuse fraction). Idem as for albedo*
  - *fIPAR (leaves assumed black)*

LAI: several definitions

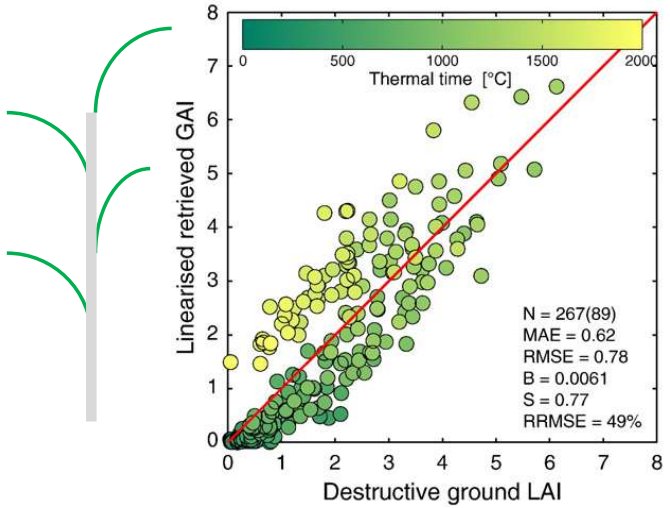
Destructive measurements

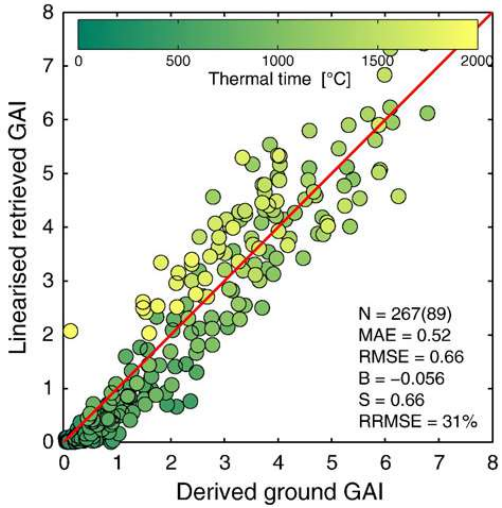
	Only leaf	All vegetation elem.
Green+non green	LAI	PAI
Green	GLAI	**GAI**

Upward looking Indirect methods

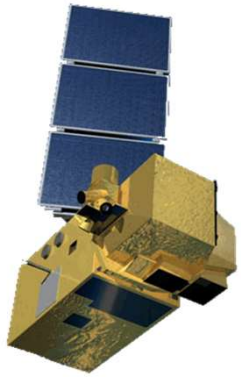
downward looking Indirect methods Incl. Remote Sensing

Destructive measurements





Modeling Radiative Transfer



Atmosphere

Structure
GAI
ALA

C_{ab}
C_{dm}
N_g

Leaf model *PROSPECT*

Leaf properties

6S,
MODTRAN
…

SAIL

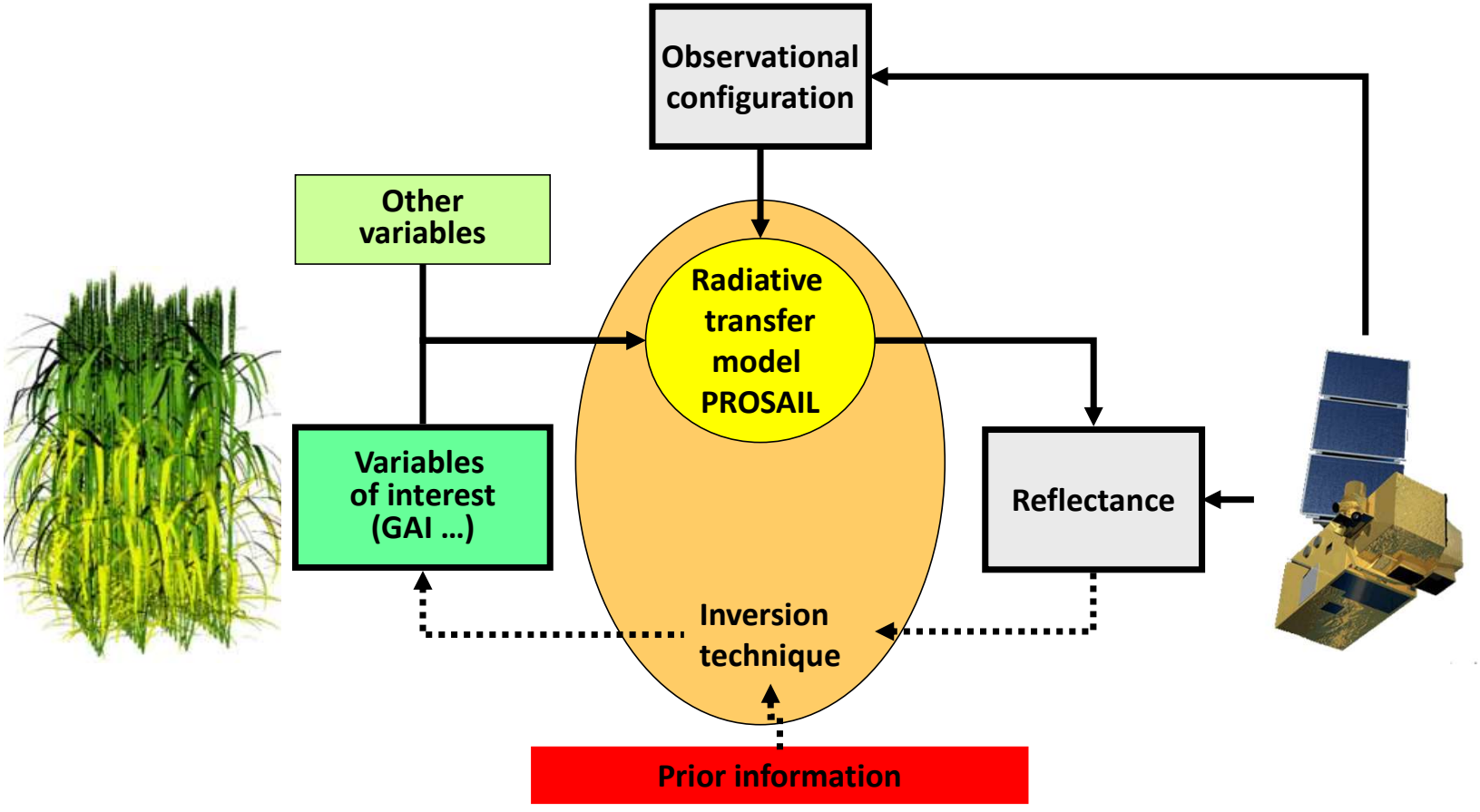
Soil reflectance

Sun / view geometry

Soil model *Hapke*

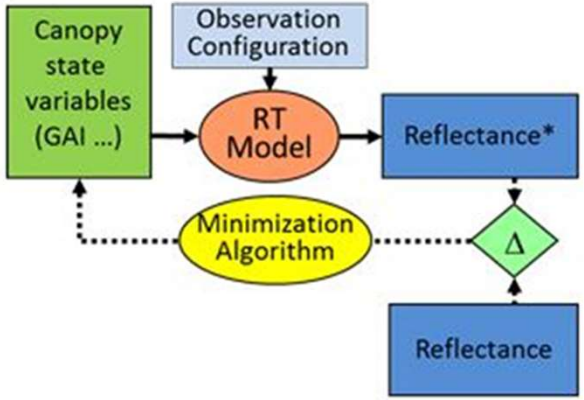
a, b

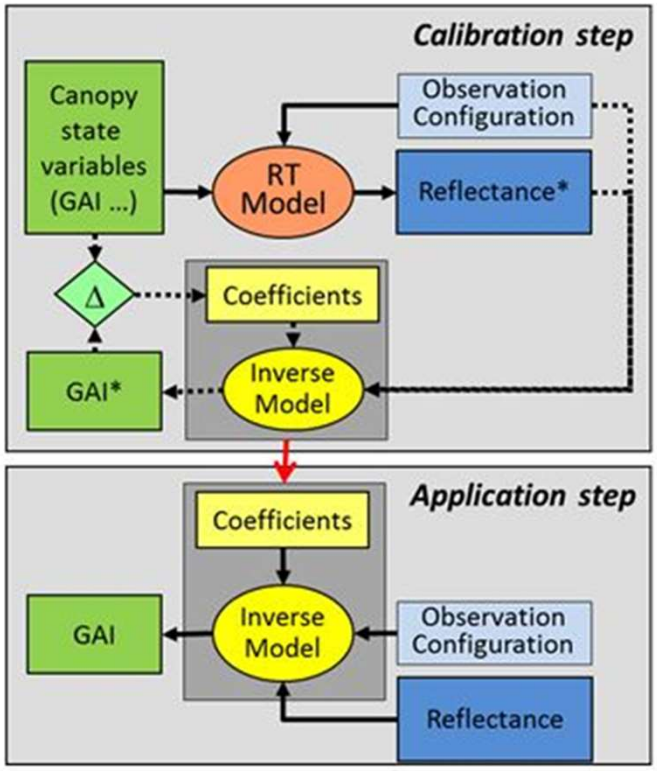
Le probleme inverse



Needed to counterbalance the limited dimensionality of observations

Deux grandes categories d'approaches inverses





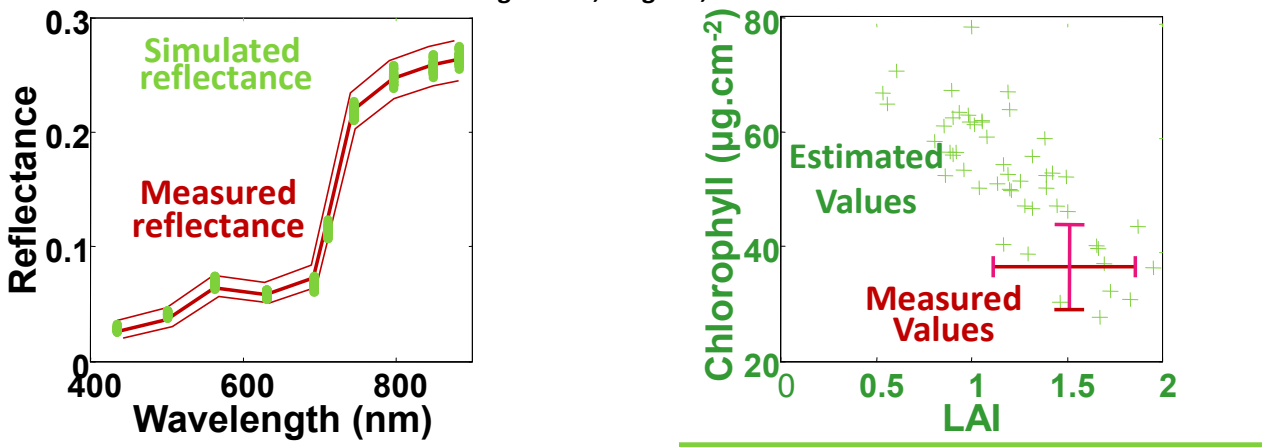
Focus on the observations
Iterative optimization / LUT

focus on the biophysical variables
Machine learning:

Possible combination of the two approaches

Le problème inverse est en général mal posé

Sugar beet, Grignon, 1990



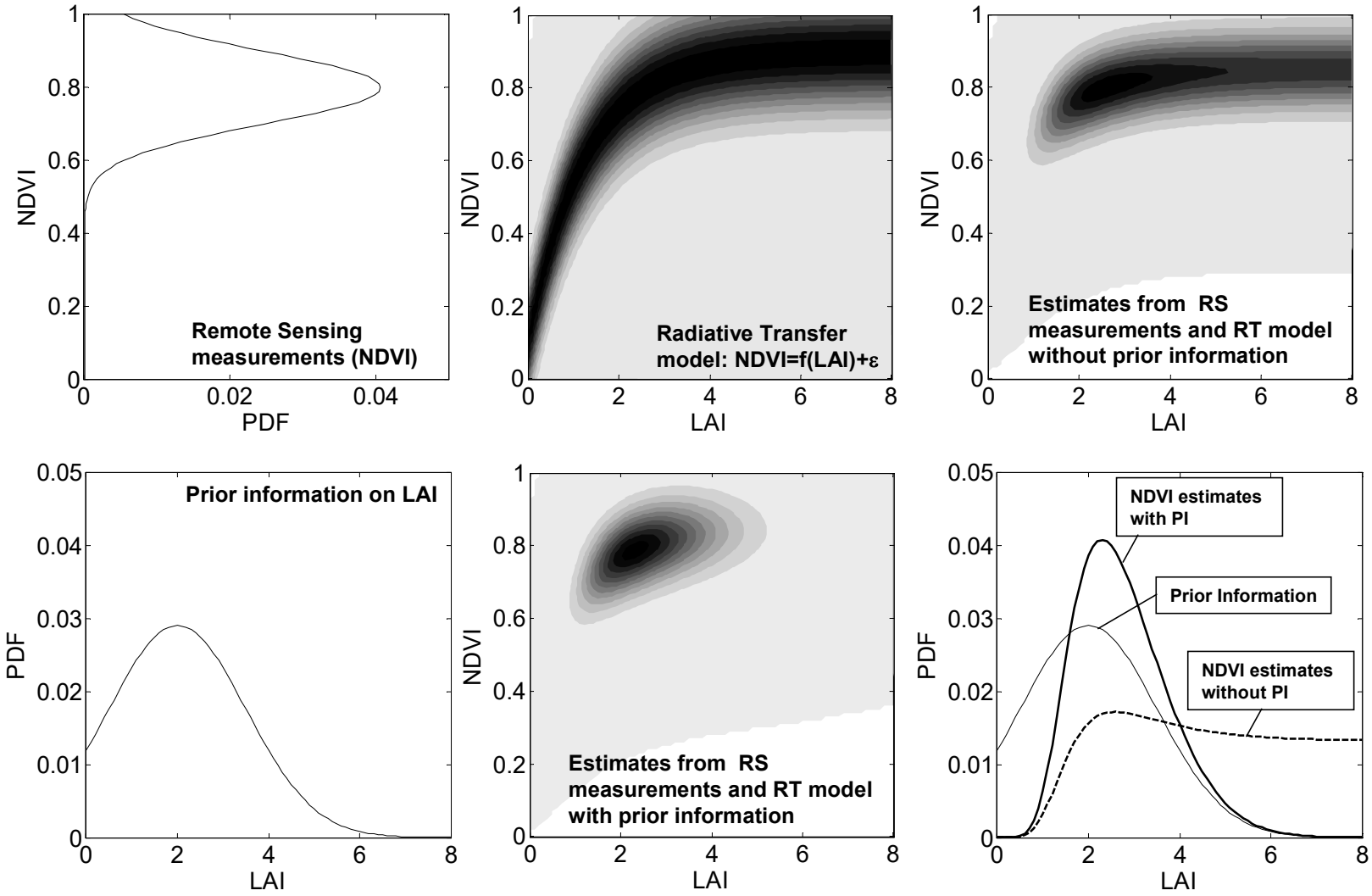
Measurement and Model uncertainties

An ensemble of variables provides similar match with observed reflectance

Regularization through constraints and prior information mandatory

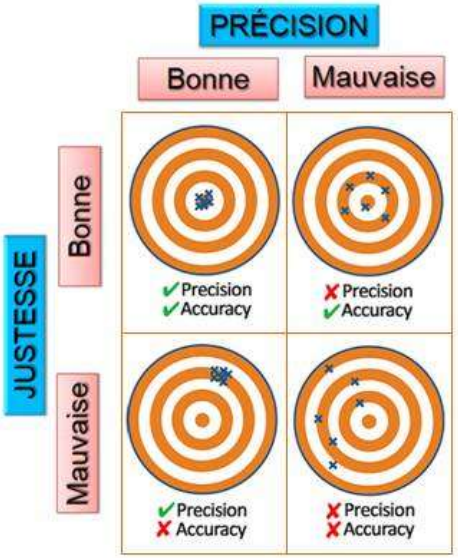
- ***Generic products***: minimum prior information
  maily temporal constraints
  Large scale products
- ***Specific products***: more detailed/reliable prior information
  spatial (within patches) & temporal constraints
  Regional/local scale products

Role de l'information a priori

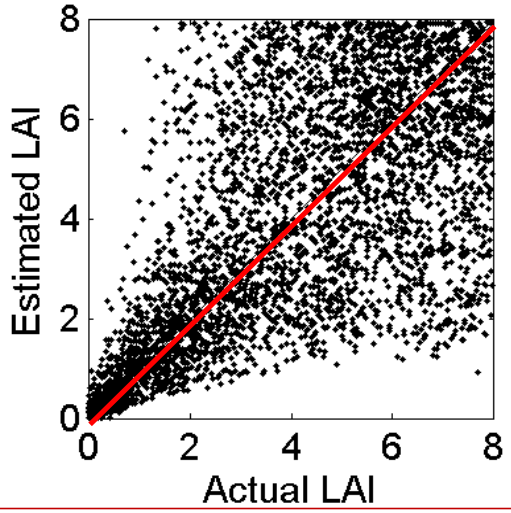


équilibre en précision (precision) et justesse (accuracy)

Selection of solutions within a Look Up Table (LUT). Measurement uncertainties

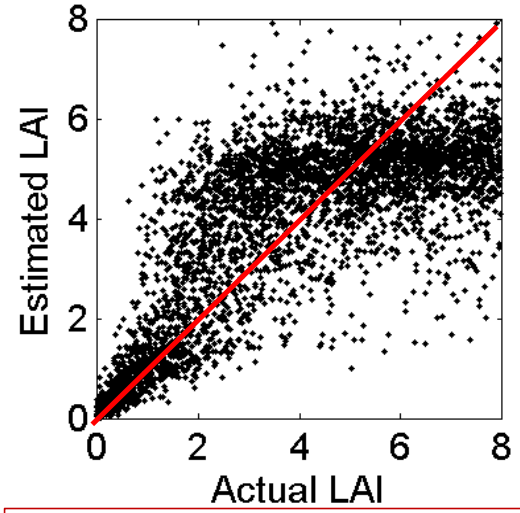


Best reflectance match



Very little biase but large scattering
Accurate, not precise

Median of cases within ±1σ

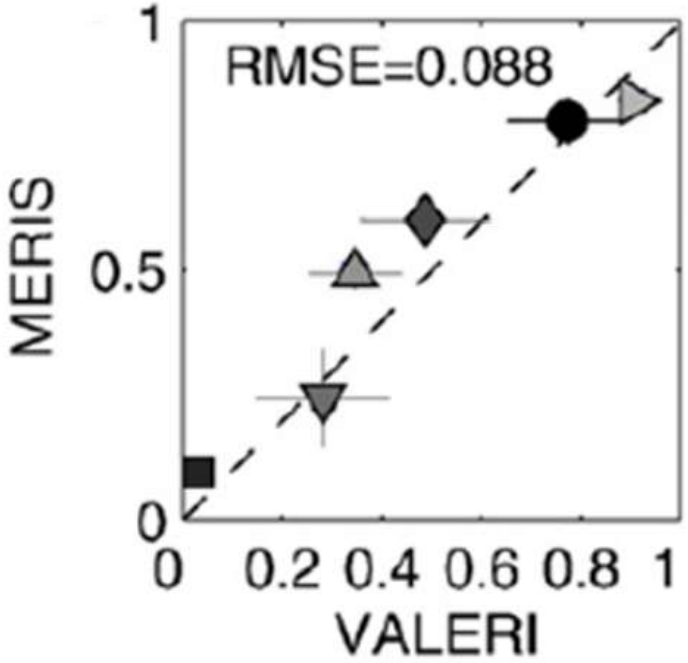


Smaller scattering but larger biases
Precise, not (always) accurate

Importance of:
- **the retrieval method**
- **the knowledge of uncertainties (model and measurements)**
- **the the prior distribution of input variables**

Examples of FAPAR estimates from RT inversion

ENVISAT/MERIS



SPOT/VEGETATION

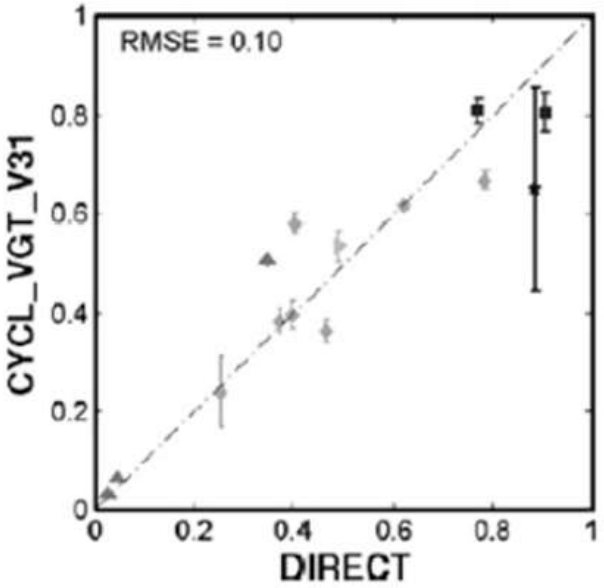
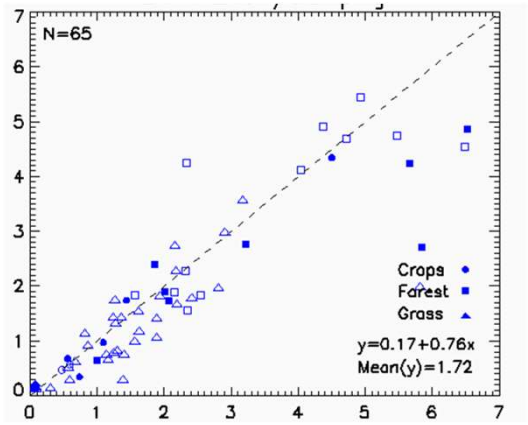


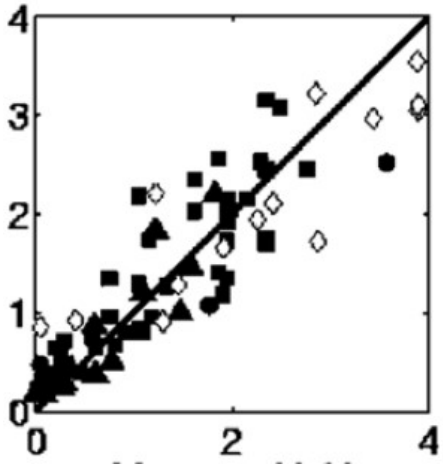
Figure 2. Comparison between ground measured FAPAR (VALERI and DIRECT) and FAPAR estimates from MERIS (left) from (Bacour *et al.*, 2006)) and VEGETATION (right) from (Weiss *et al.*, 2007).

Examples of LAI estimation

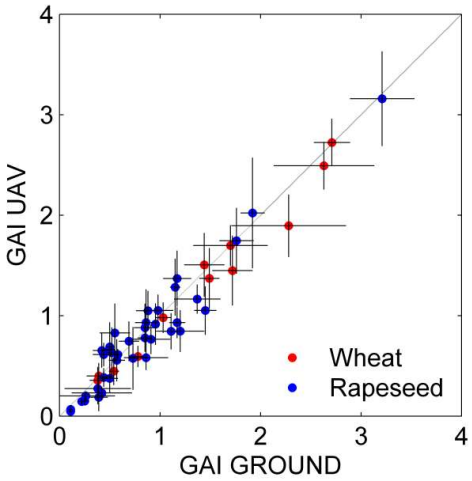
Satellites



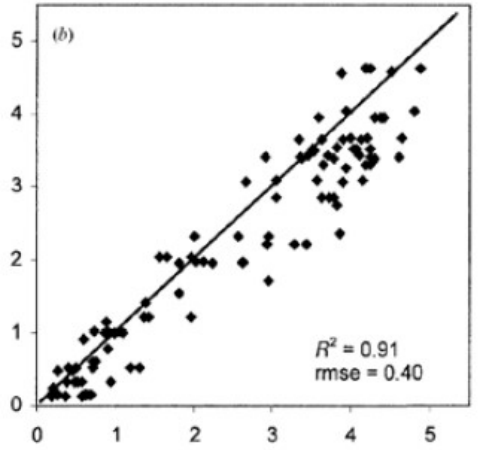
Airborne POLDER



UAV

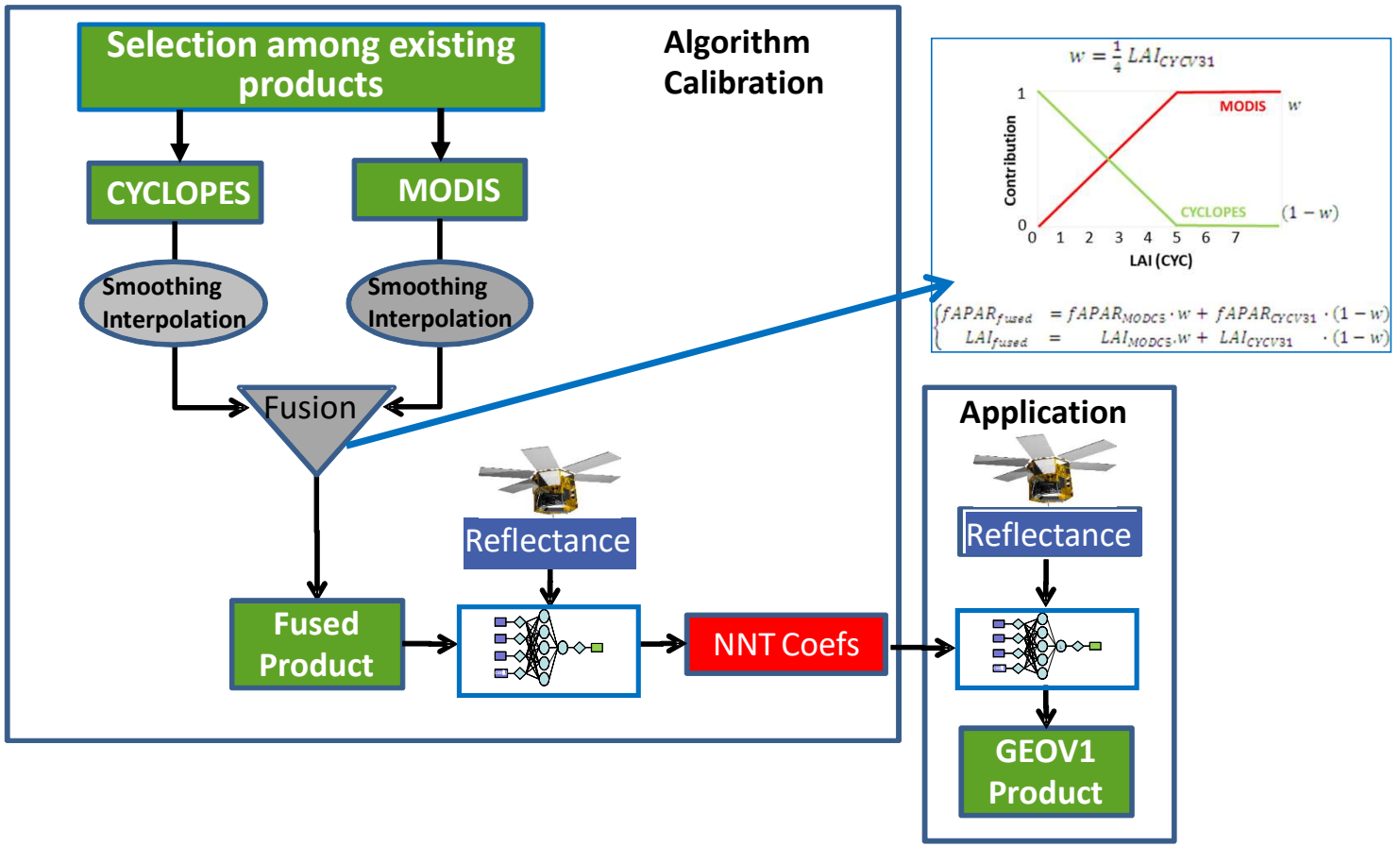


spectroradiometer



Development of generic biophysical products
Example of LAI at large scale

Several products already available, but not fully consistent
Capitalize on the work achieved on development and validation



On Line Interactive Validation Exercise

When you have a new product

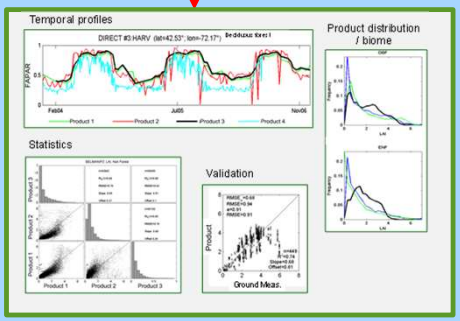
Extracts of Candidate Product over list of sites

http://calvalportal.ceos.org

Validation core code

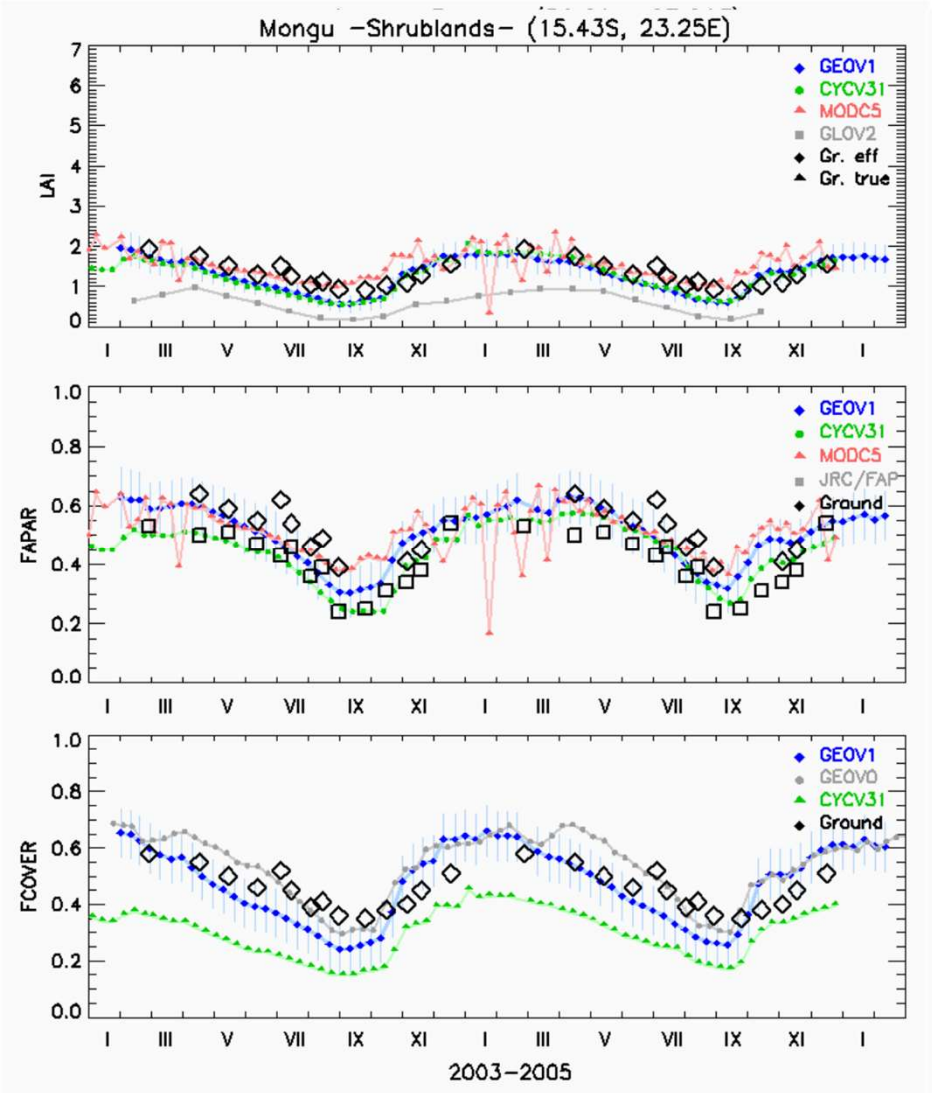
Other products

Ground measurements

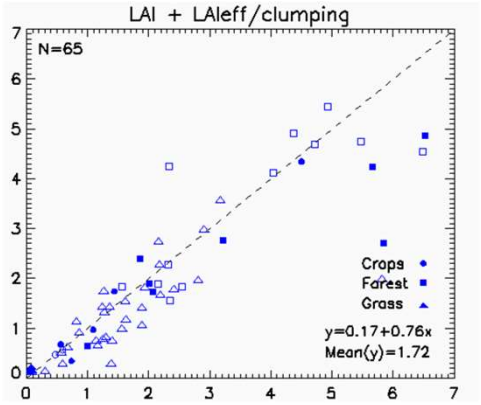


Results (report)

Temporal consistency



Accuracy assessment: LAI



Accuracy assessment: FAPAR

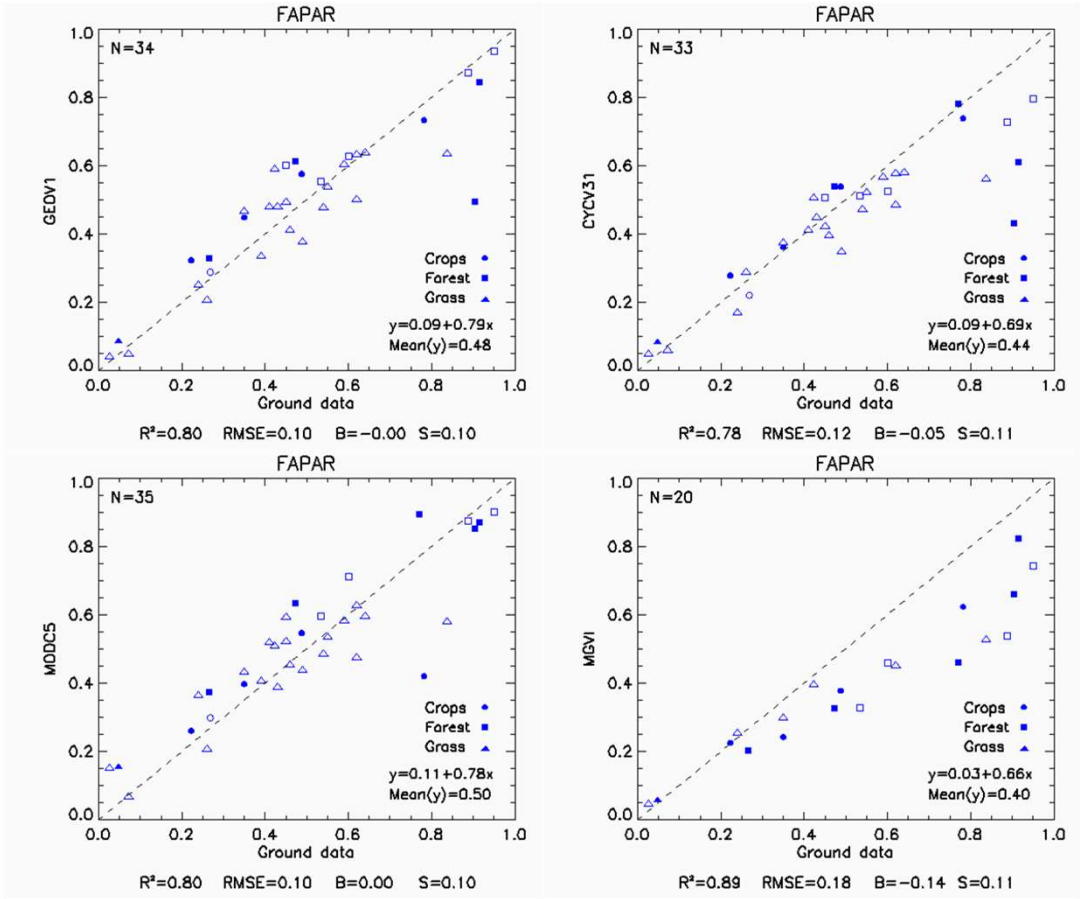
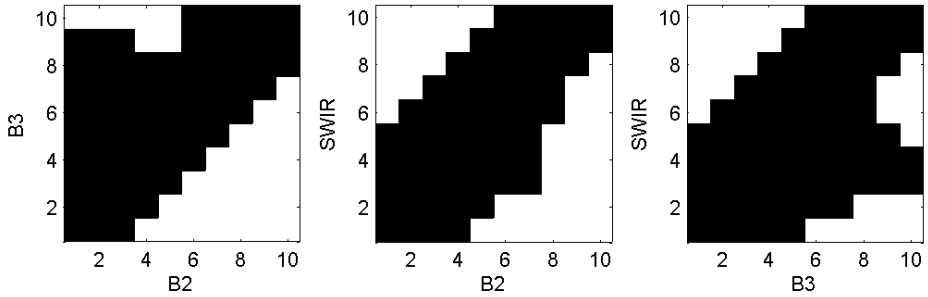


Figure 36. Direct validation:comparison of each FAPAR product with the FAPAR ground-based maps. Filled symbols refers to coincident year, unfilled symbols refers to a different year.

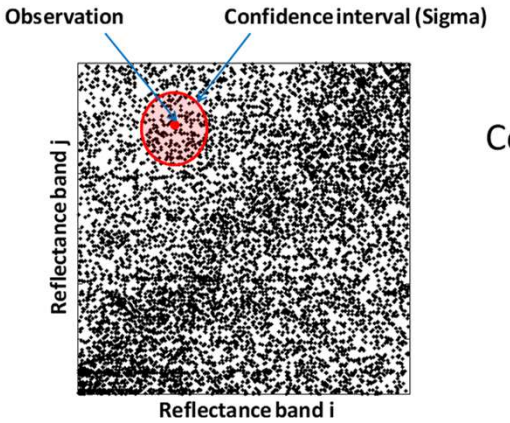
Associated QA and uncertainties

- **Valid input QA (same for output)**



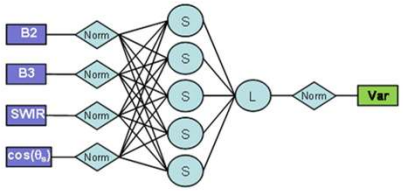
Convex hull of the definition domain

- **Quantified Uncertainties**

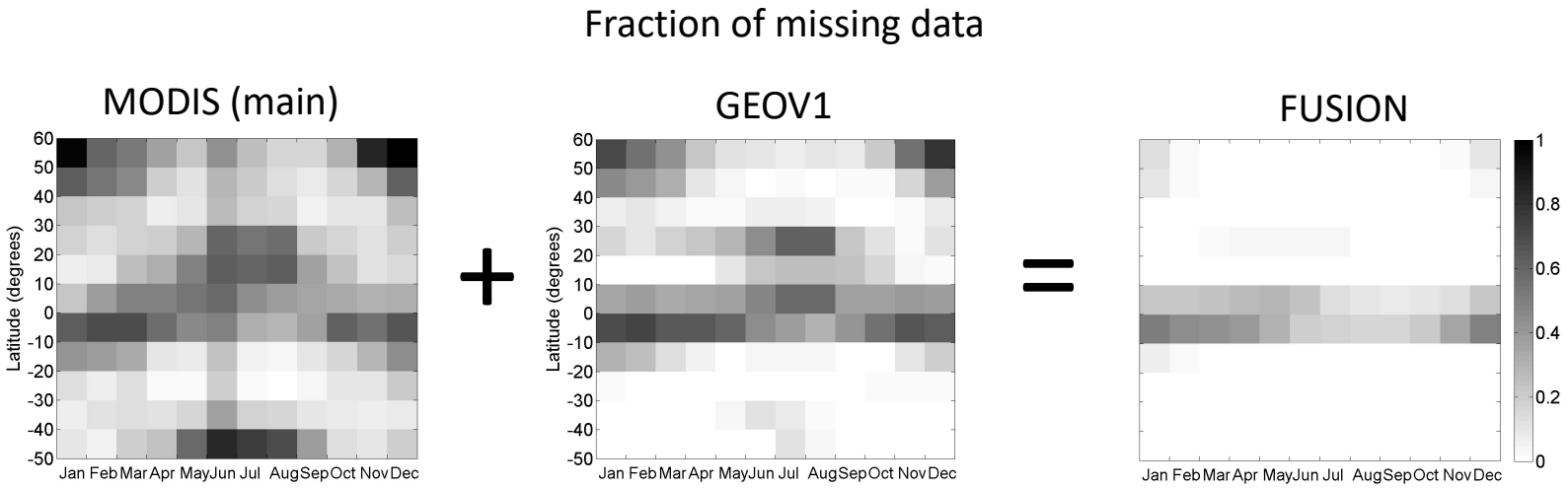


Corresponding products → RMSE

RMSE trained with NNT



Interest of combining sensors



Improved continuity (and consistency)

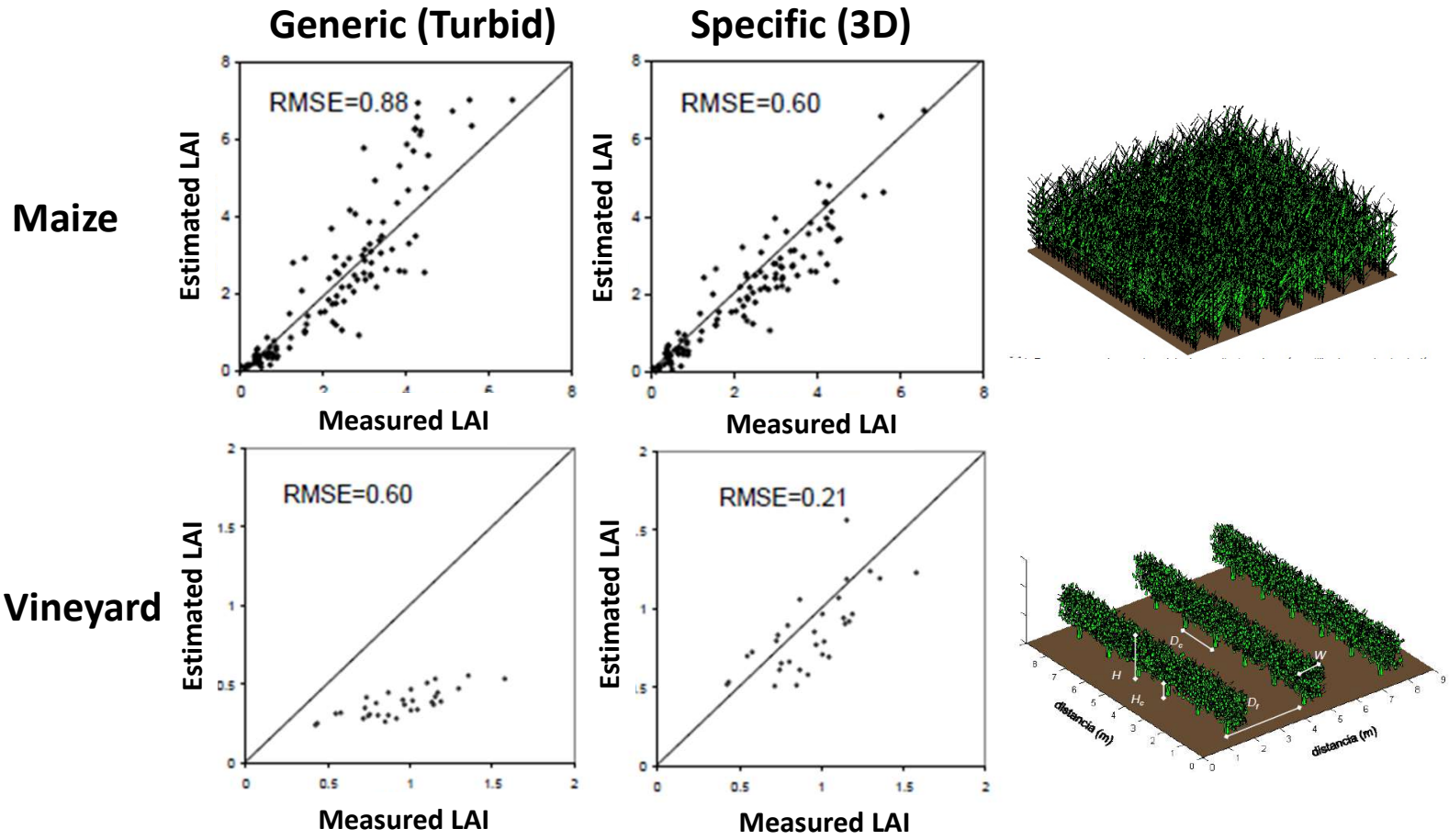
Specific products at decametric resolution (S2)

- **Most pixels are 'pure'**
  - capacity to get a priori a detailed description of properties from knowledge of type of canopy (up to species composition)
    - Structural traits (plant shape, leaf orientation, clumping …)
    - Optical propertie traits (Chlorophyll, dry matter, structure, water)
    - Phenology traits

- **pixel size closer to ground measurement footprint**
  - More easy access to calibration/validation

- **Capacity to have object (patch) approach:**
  - applying spatial constraints

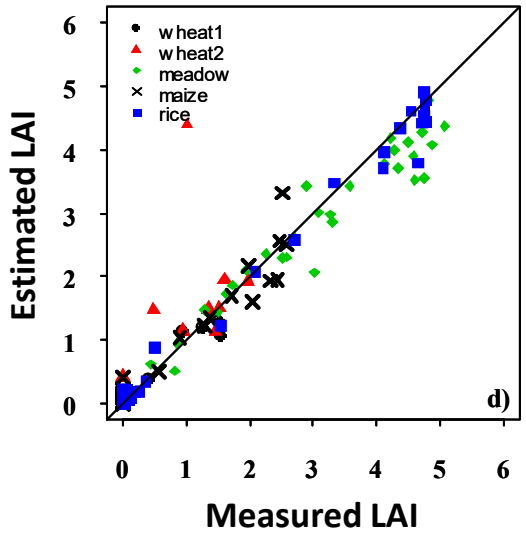
Interest of Specific (3D) approach



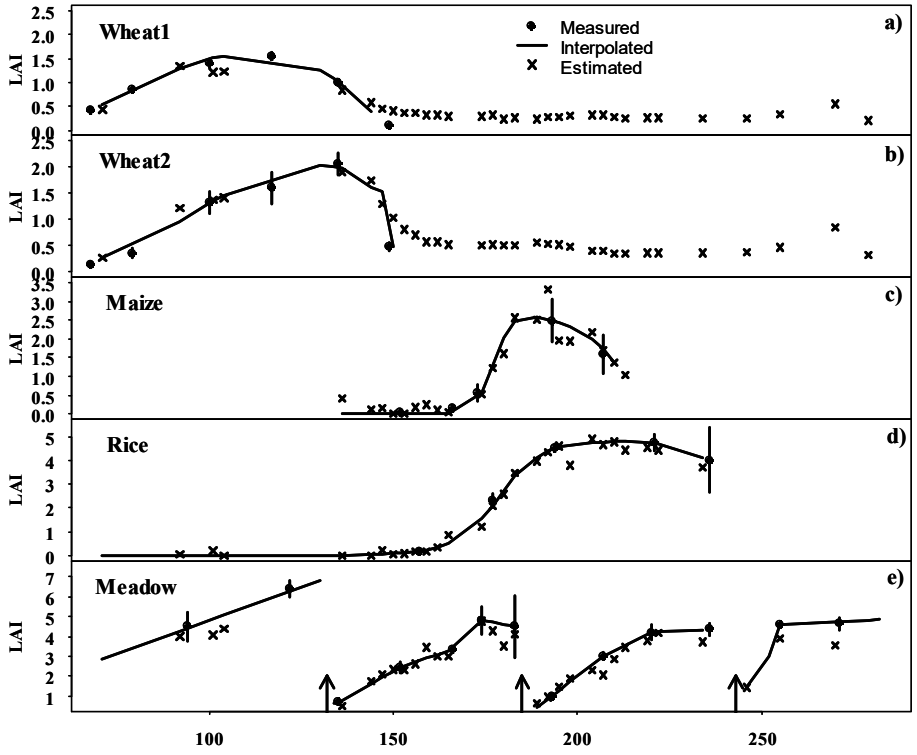
From Lopez-Lozano, 2007

Capacity to calibrate / validate

FORMOSAT 2 time series
Over la Crau (France)

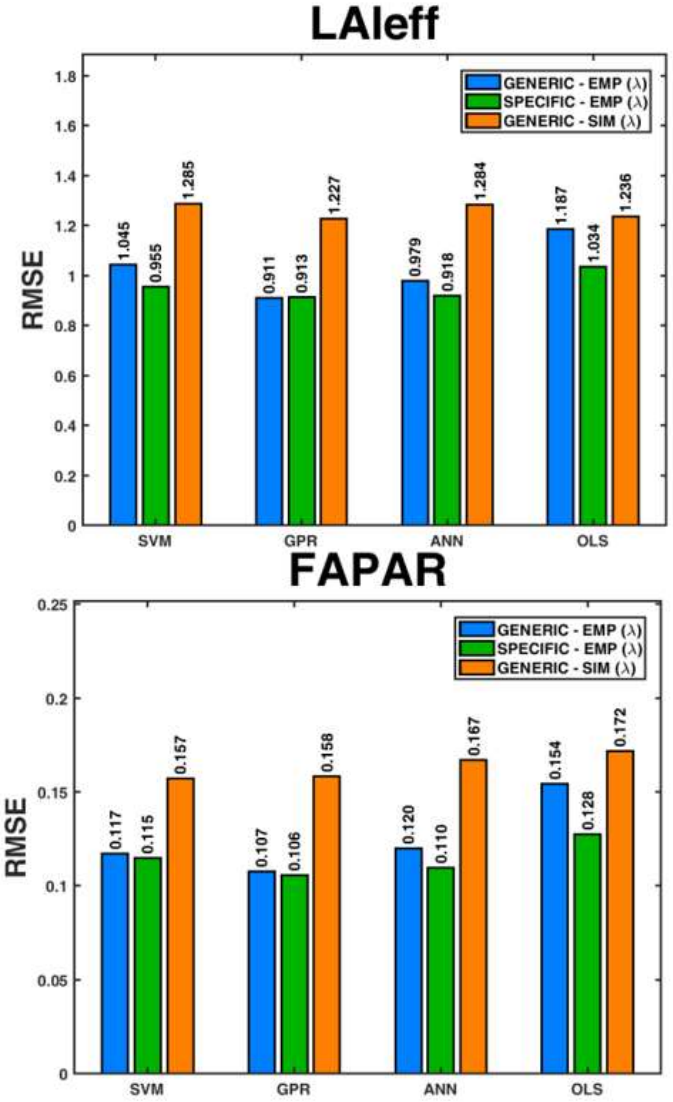


Calibration over
ground measurements



Derived temporal profiles

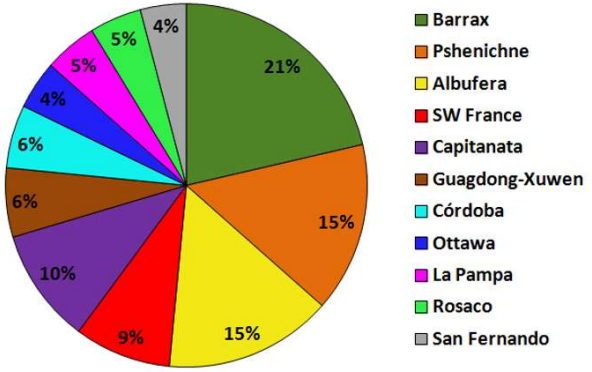
Amélioration des produits: approches spécifiques?

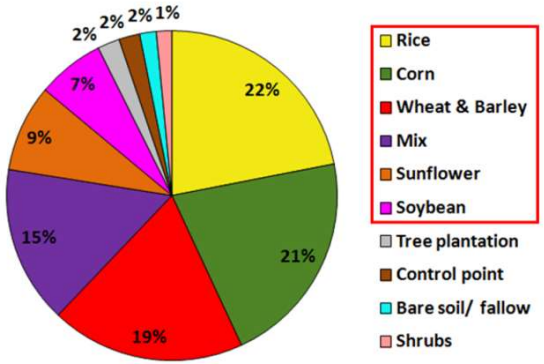


Comparison of empirical and physically-based methods for LAI and FAPAR retrieval over generic and specific crop types from Landsat-8 observations

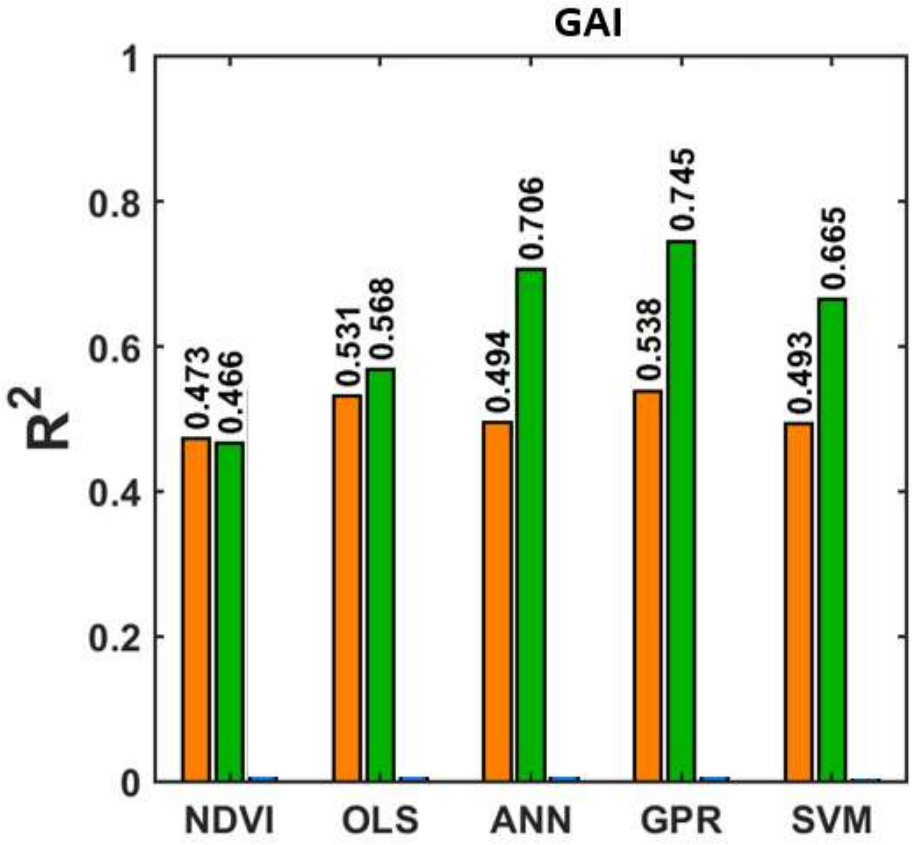
Fernando Camacho[1] [*], Fred Baret[2], Beatriz Fuster[1], Wenjuan Li[2], Sangram Ganguly[3], Marie Weiss[2], and Roselyne Lacaze[4]

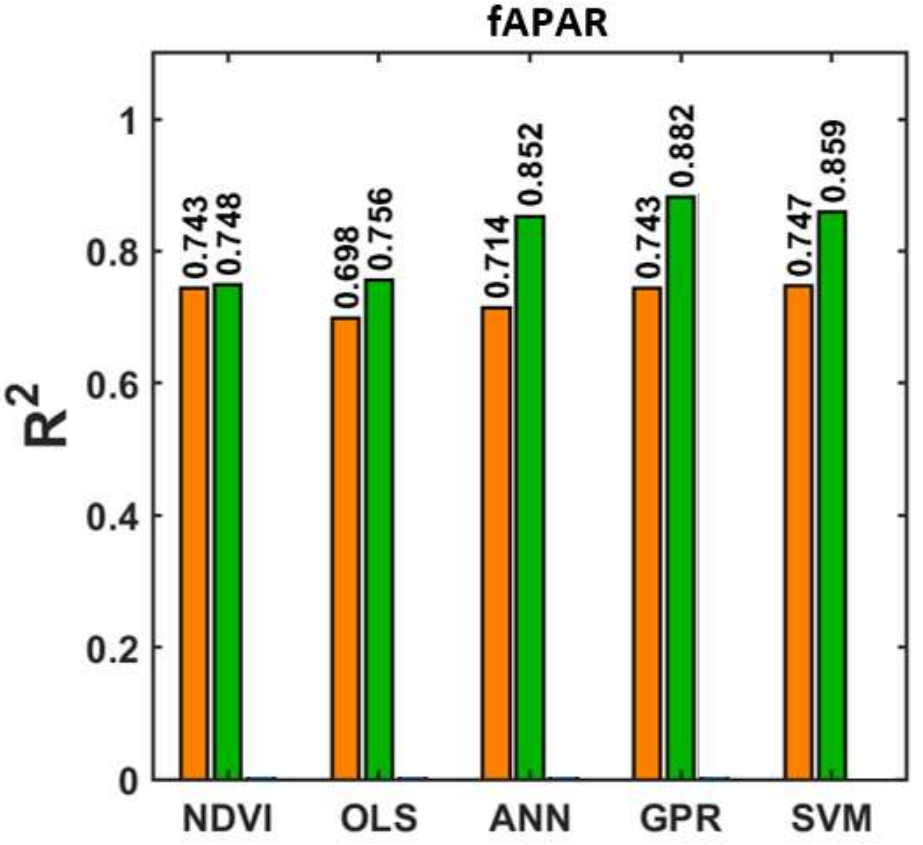
≈900 ESUs with ground measurements





Comparaison des méthodes MTR / empiriques

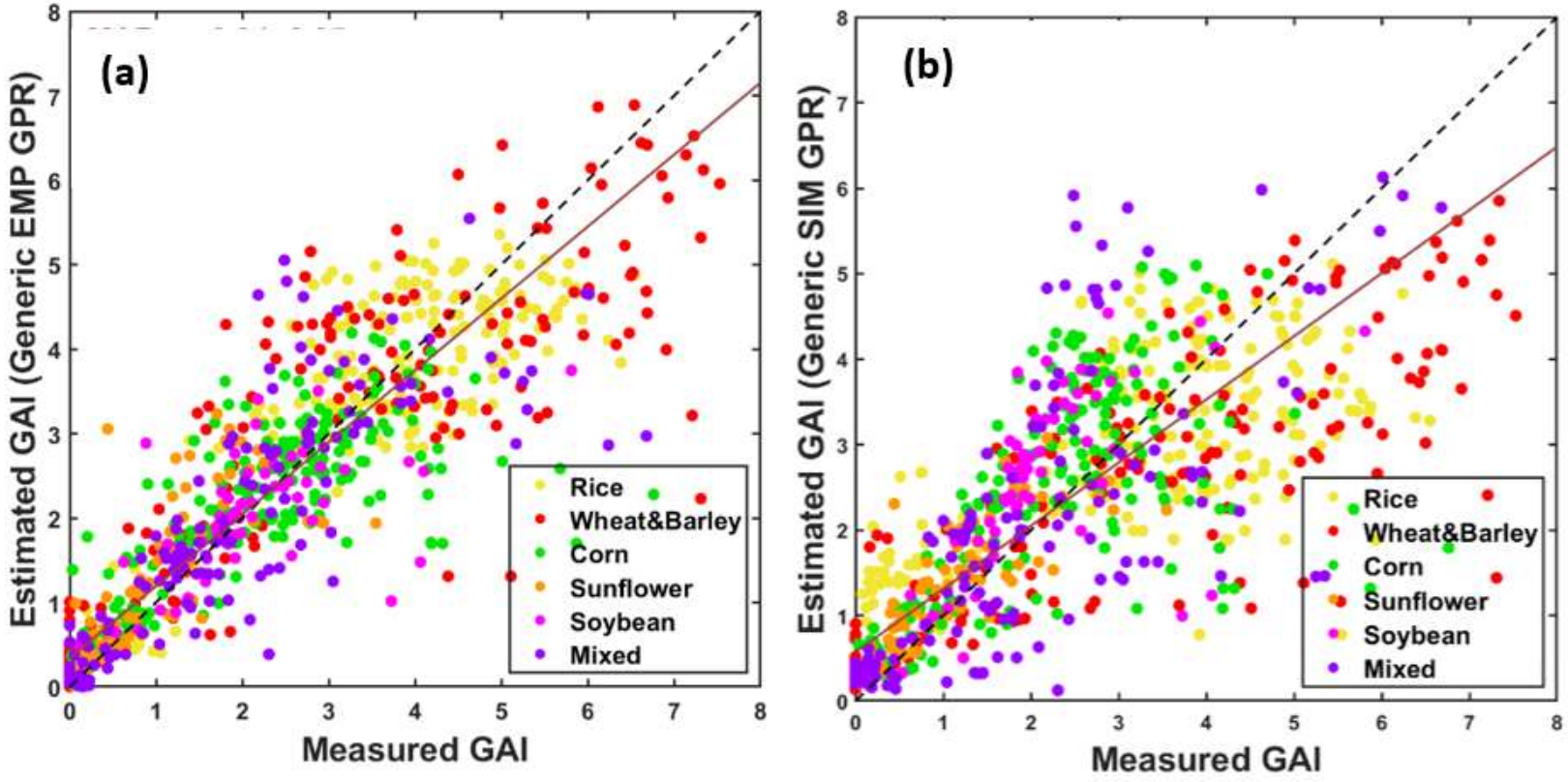




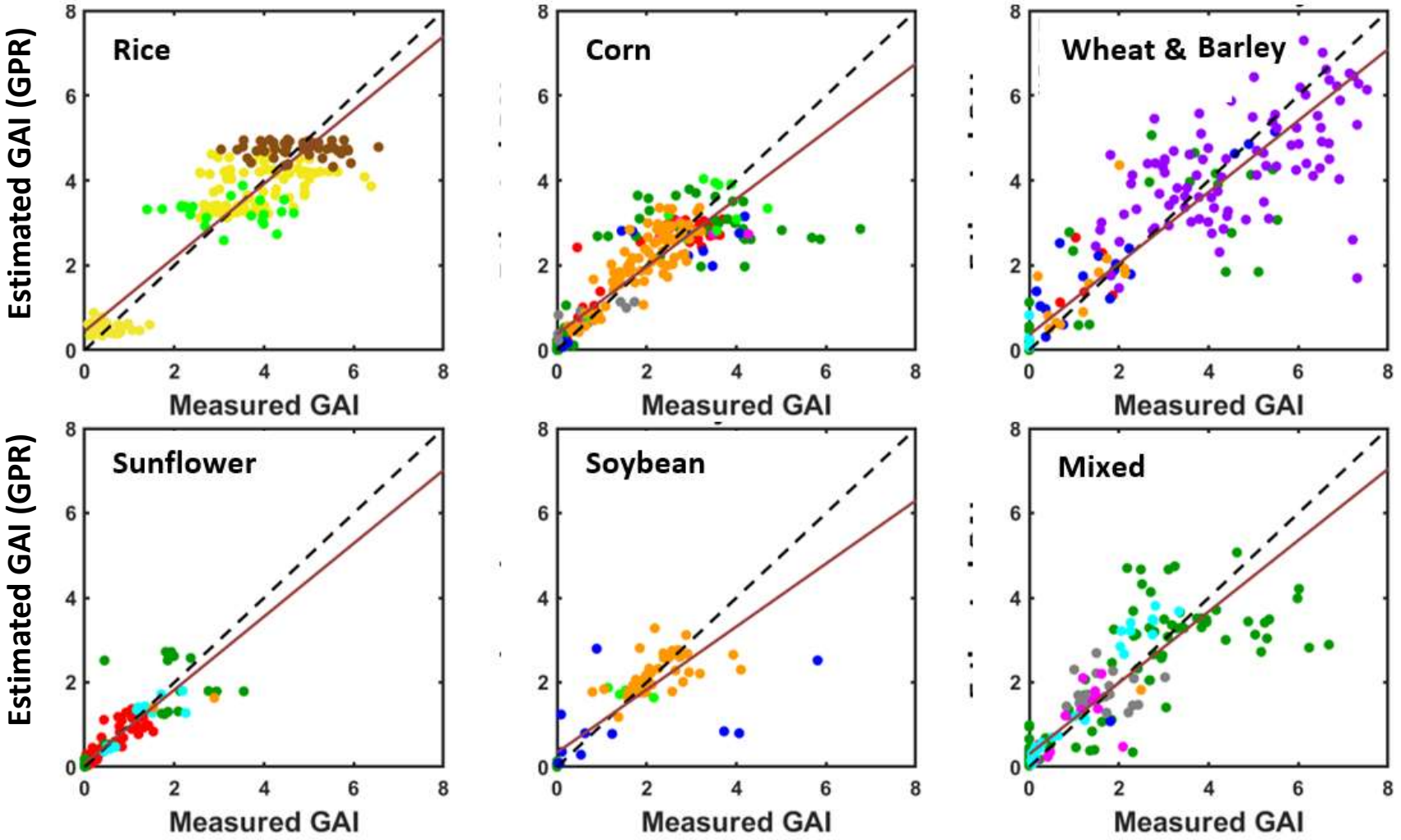
MTR

Emp

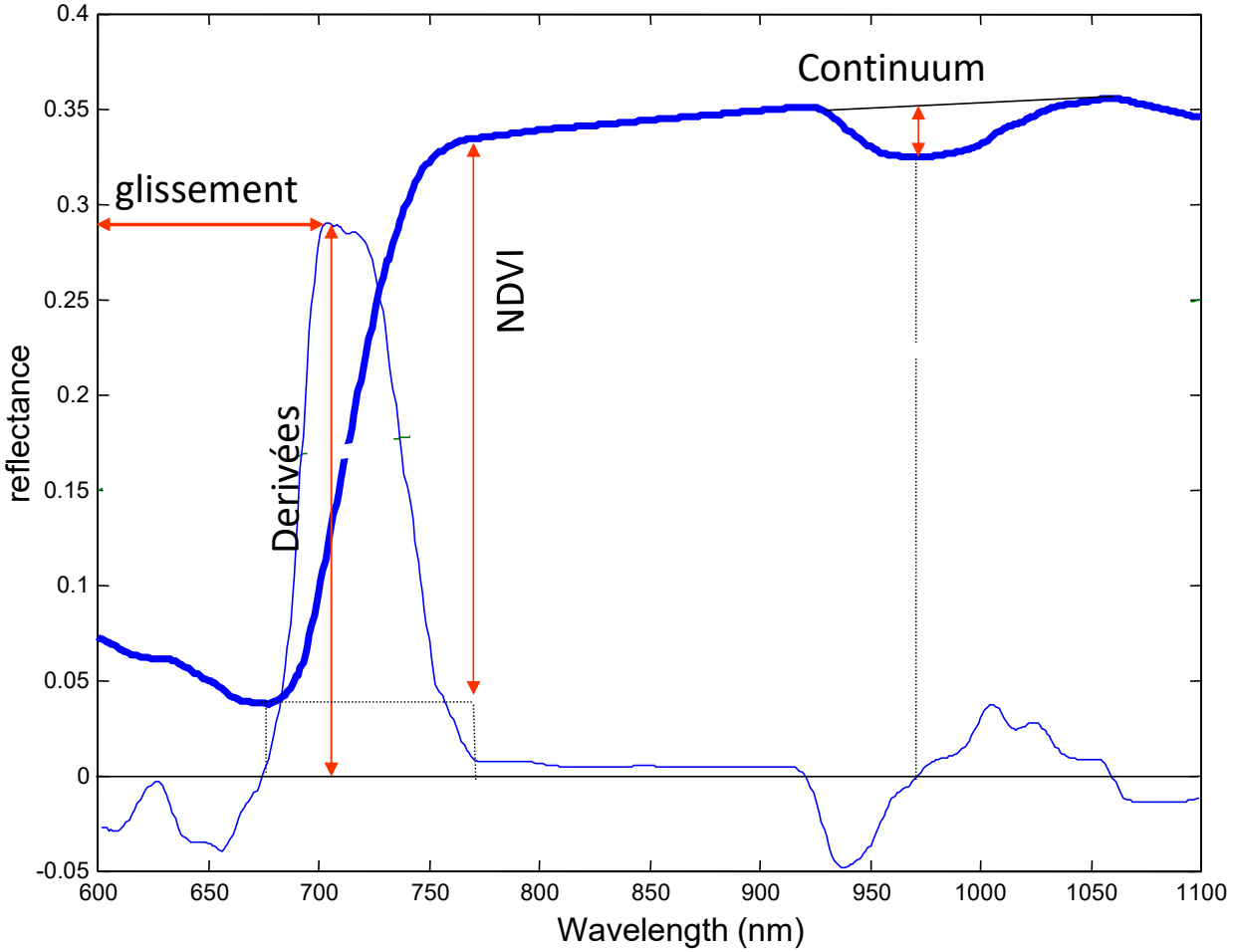
Approche générique



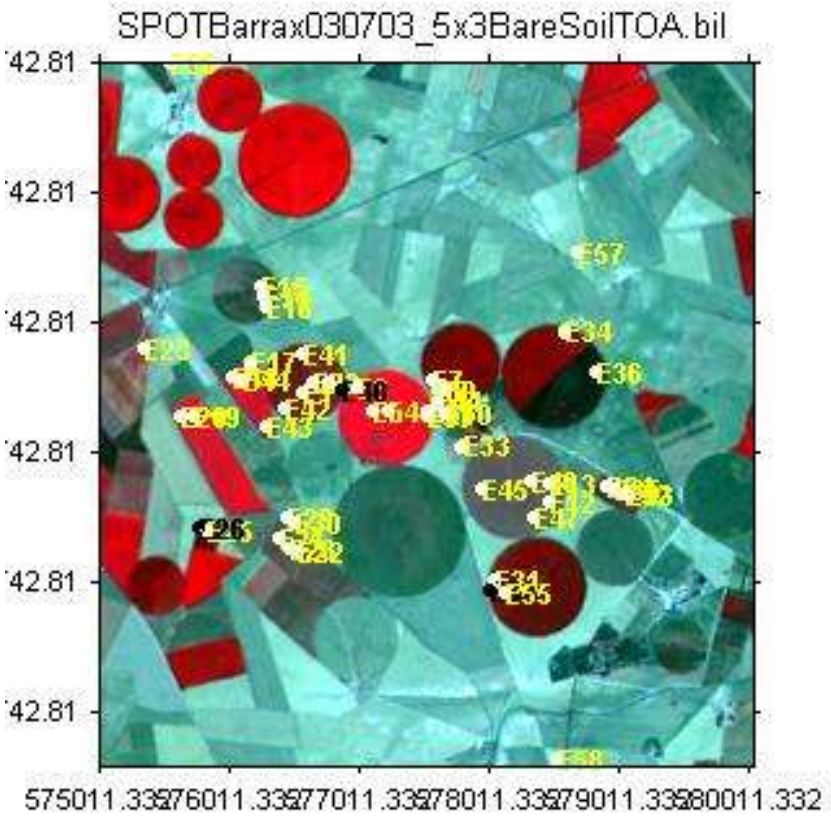
Approche spécifique

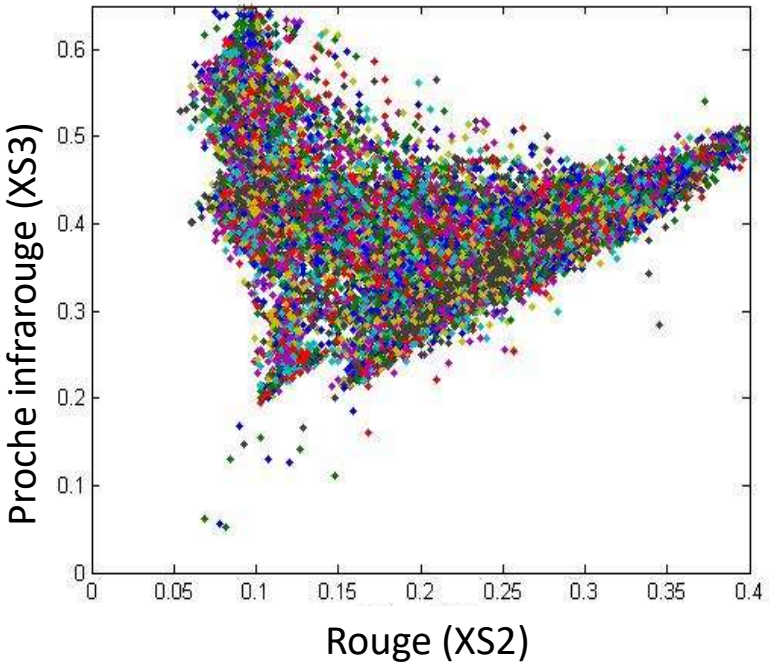


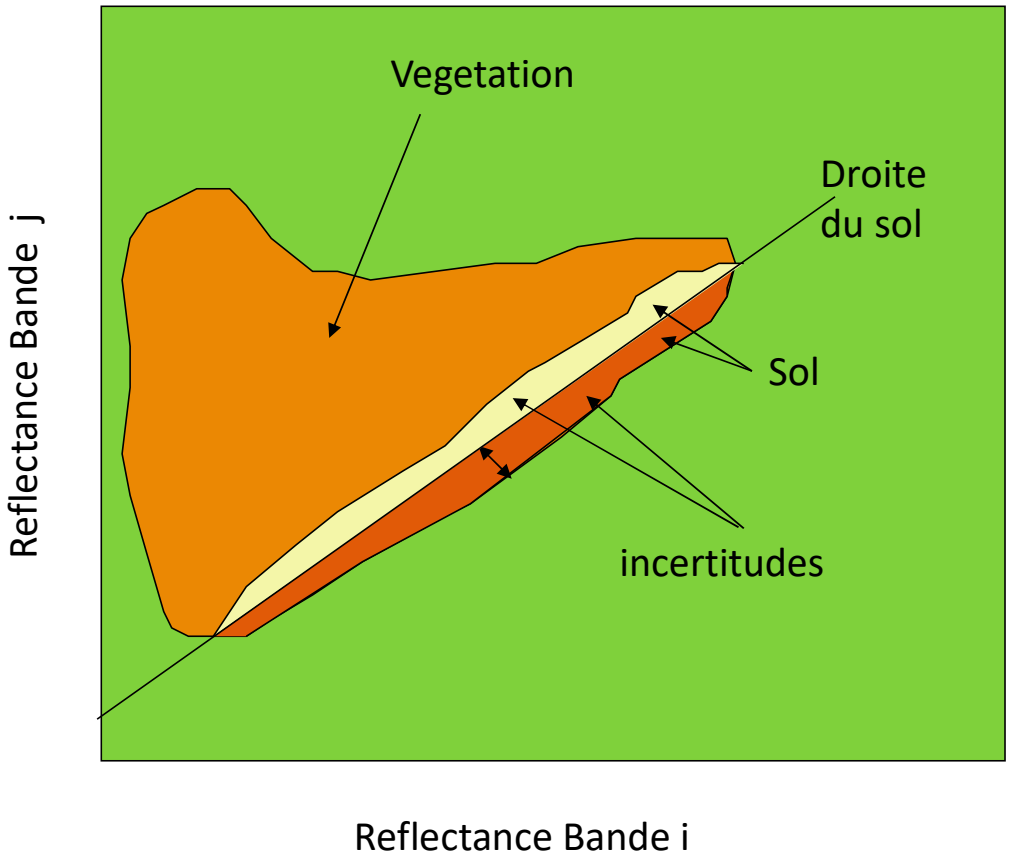
Indice de végétation: absorption différentielle



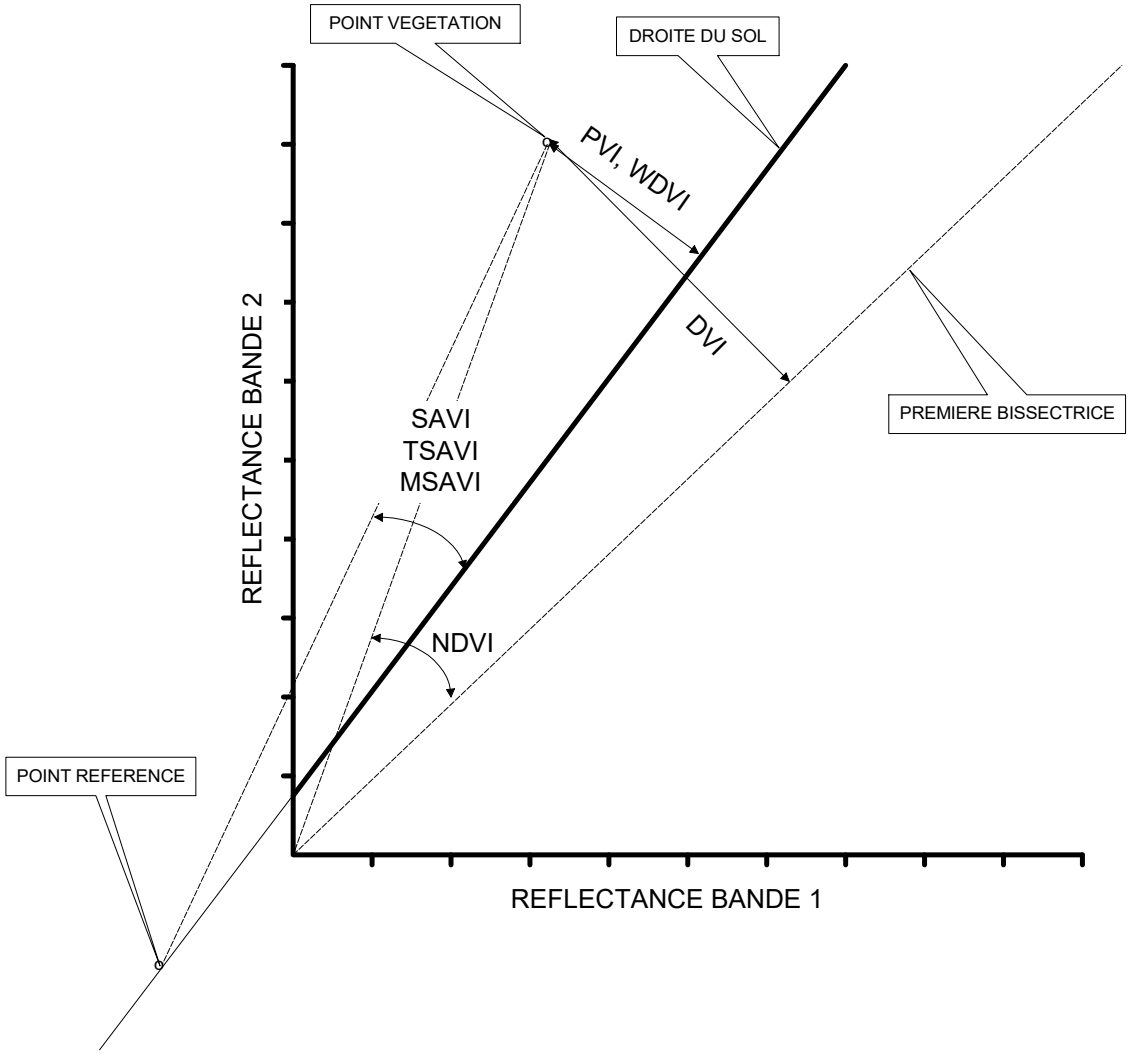
Relation entre bandes






Vegetation
Droite
du sol
Sol
incertitudes
Reflectance Bande j
Reflectance Bande i

Les indices de végétation

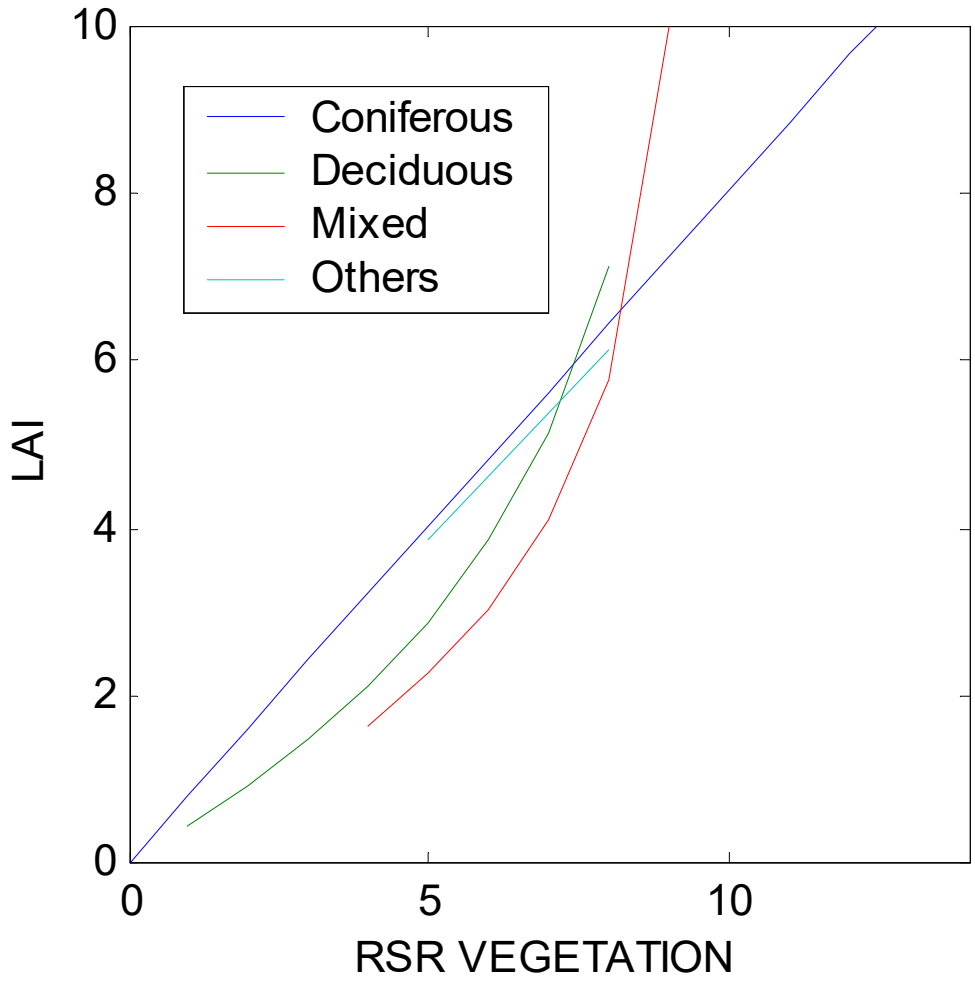


Indices de végétation

Table 2
Vegetation indices selected from the literature and their generic formulation.

Generic VI name	VI formulation	λ_{ref}	λ_1	λ_2	Actual VI name	References
SR	$\frac{R_{\lambda_1}}{R_{\lambda_{ref}}}$	780	550	–	$CI_{green} = SR - 1$	Gitelson et al. (2005, 2003, 2006)
		780	710	–	$CI_{red-edge} = SR - 1$	
mND	$\frac{R_{\lambda_{ref}} - R_{\lambda_1}}{R_{\lambda_{ref}} + R_{\lambda_2}}$	800	670	670	NDVI	Rouse et al. (1973)
		750	550	550	ND_{550}	Gitelson et al. (1996)
		750	705	705	ND_{705}	Gitelson and Merzlyak (1994)
SIPI	$\frac{R_{\lambda_{ref}} - R_{\lambda_1}}{R_{\lambda_{ref}} - R_{\lambda_2}}$	850	445	680	SIPI	Penuelas et al. (1995)
		445	750	705	mSR	Sims and Gamon (2002)
		709	754	681	MTCI	Dash and Curran (2004)

Exemple de relations empiriques



From Chen et al., 2002

Contents lists available at ScienceDirect

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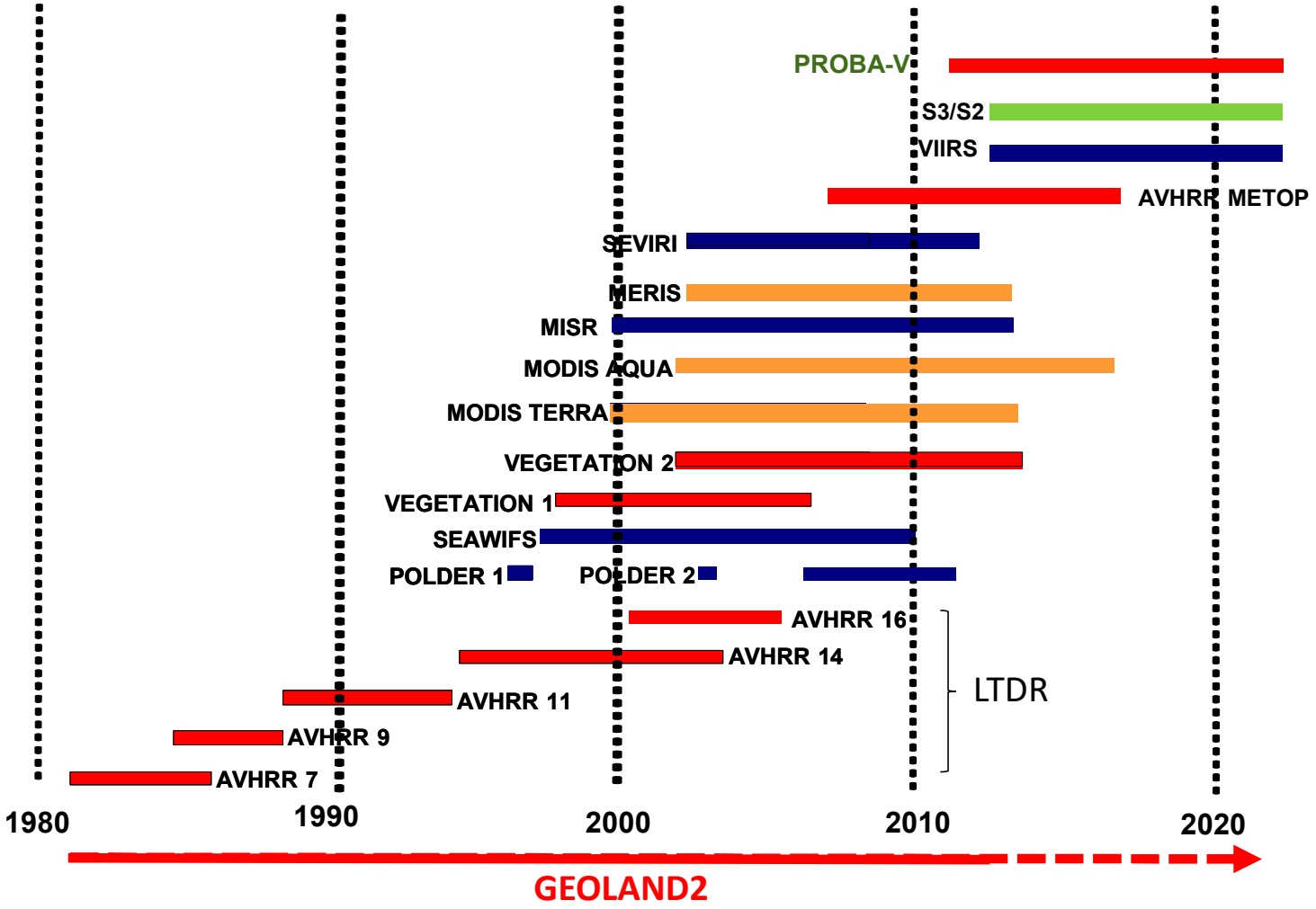
journal homepage: www.elsevier.com/locate/rse

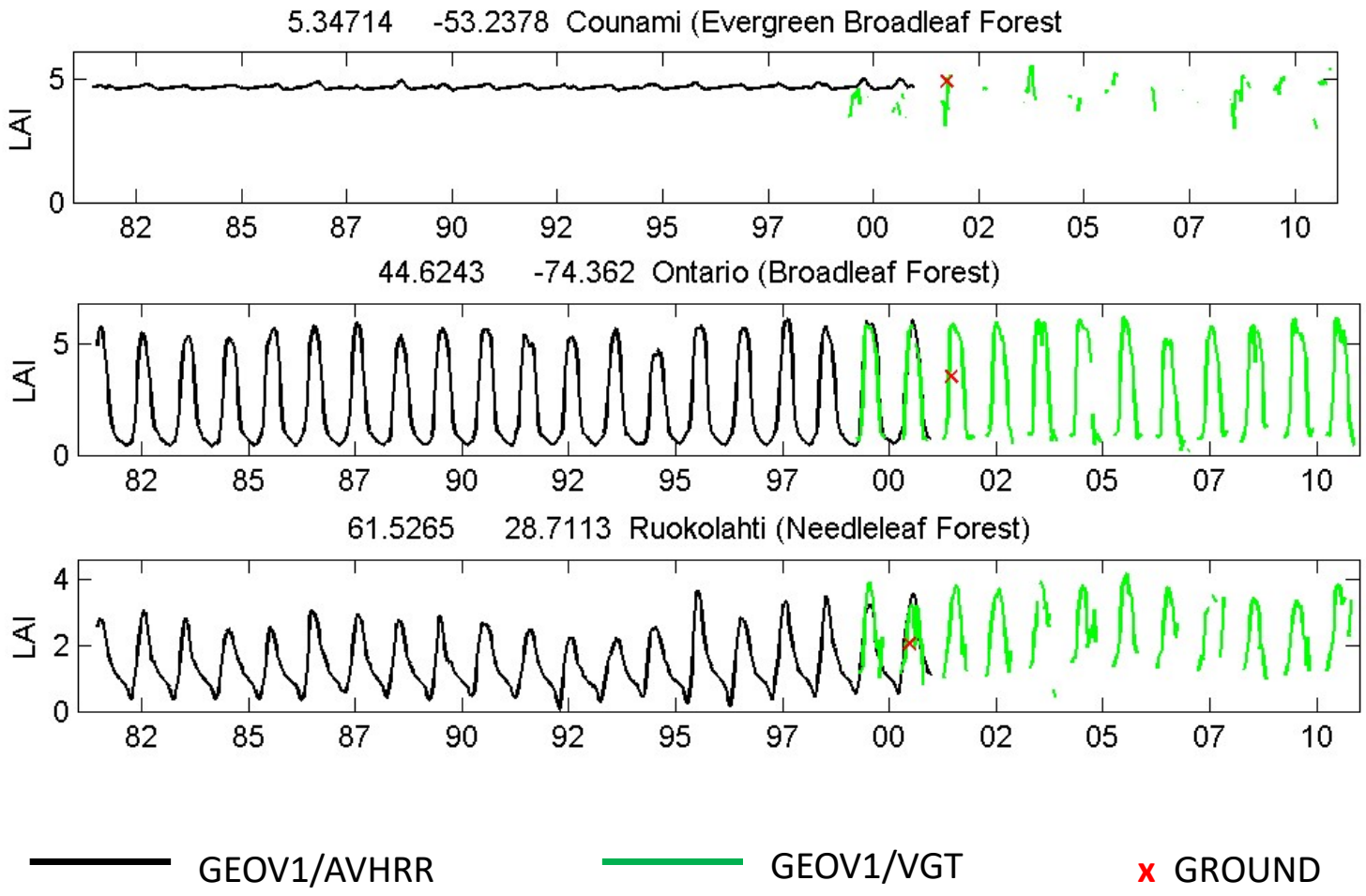
Vegetation baseline phenology from kilometric global LAI satellite products

Aleixandre Verger [a,b,c,*], Iolanda Filella [a,b], Frédéric Baret [c], Josep Peñuelas [a,b]

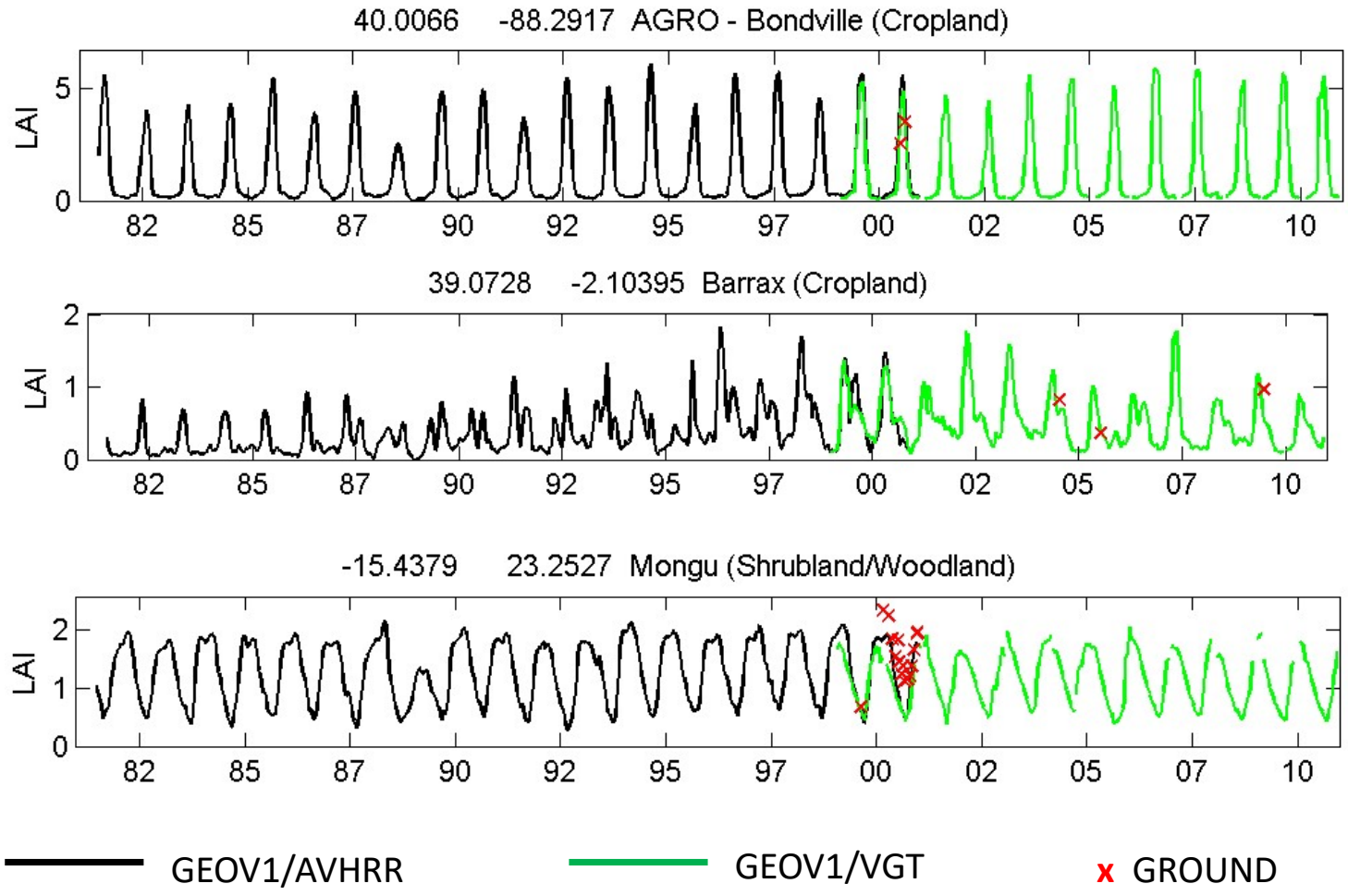
Continuity (and improvement) of observations



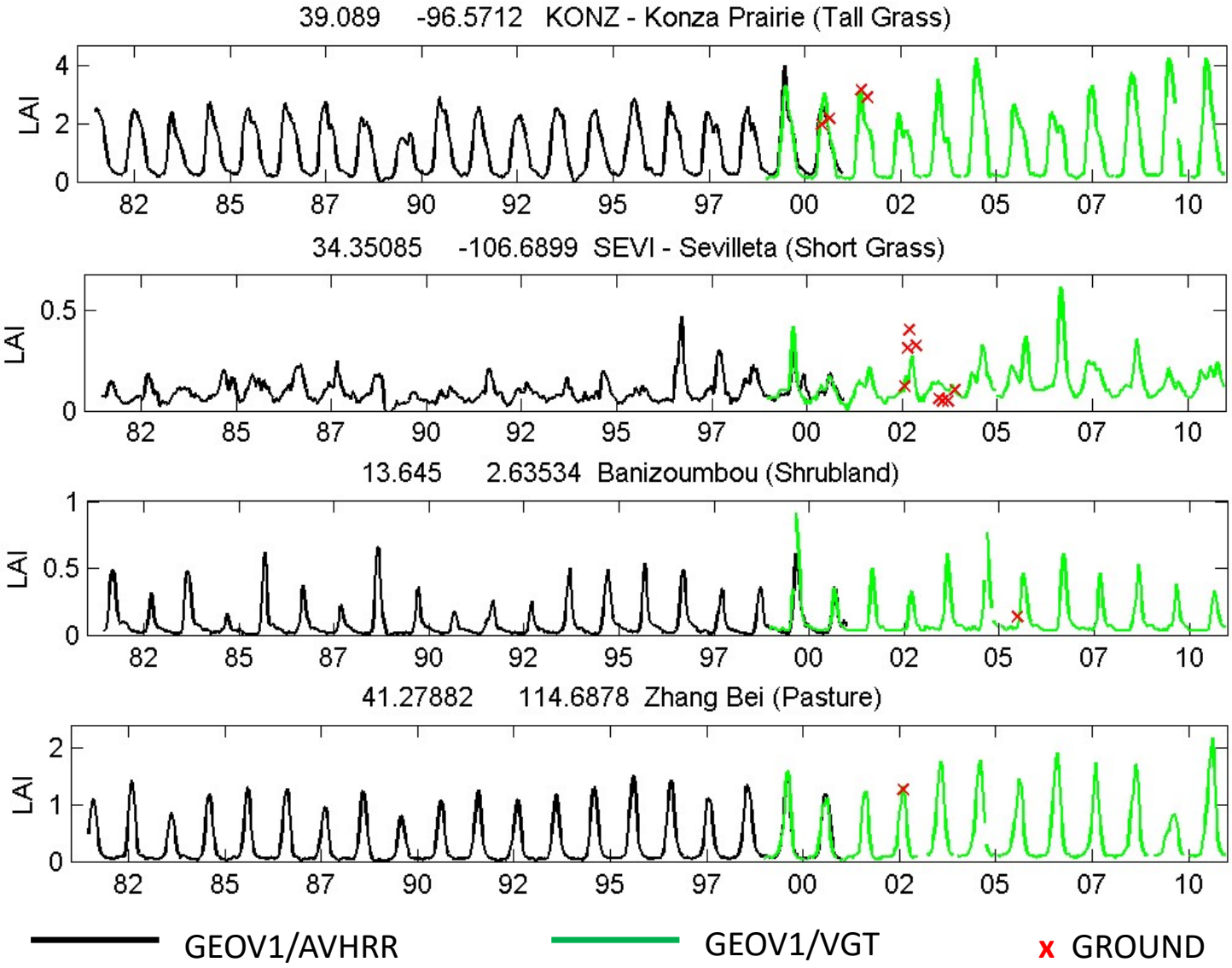
30 years of consistent global LAI GEOV1 products



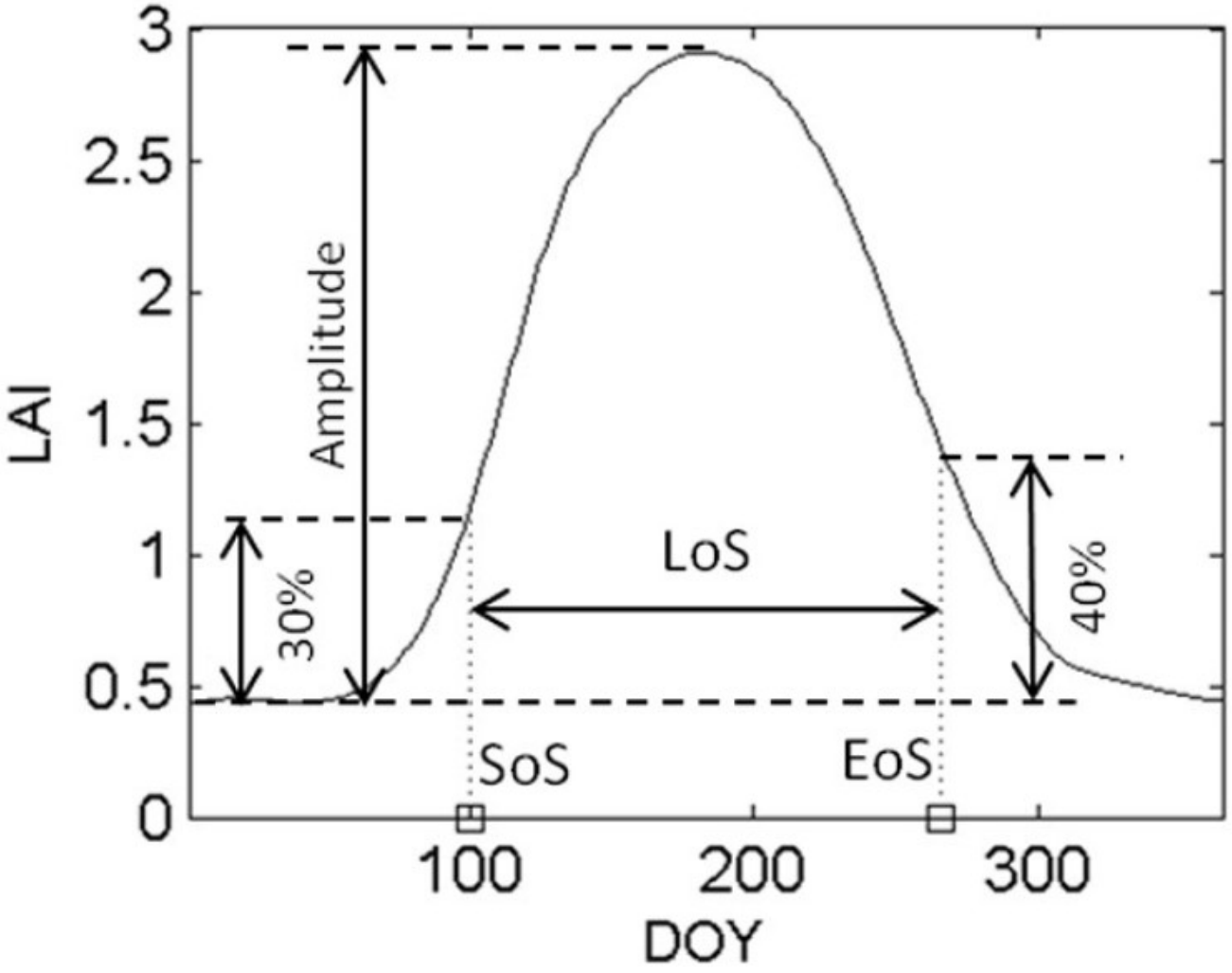
30 years of consistent global LAI GEOV1 products



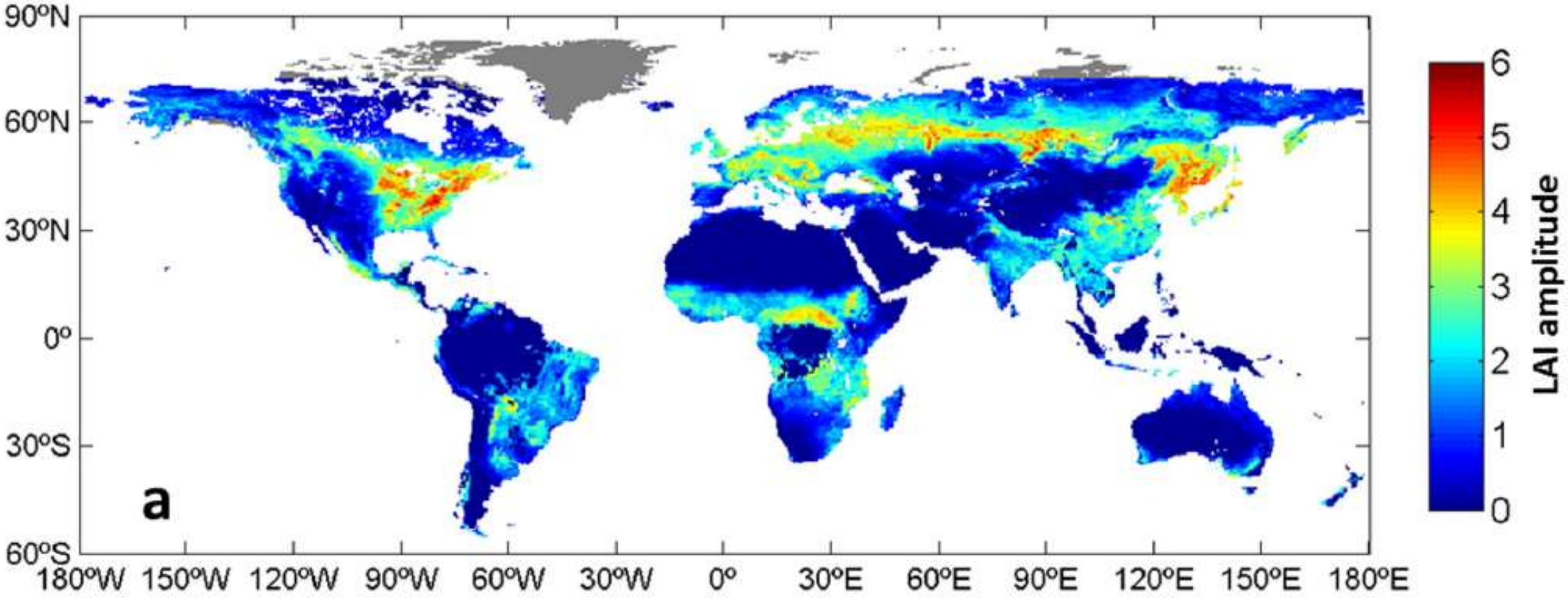
30 years of consistent global LAI GEOV1 products



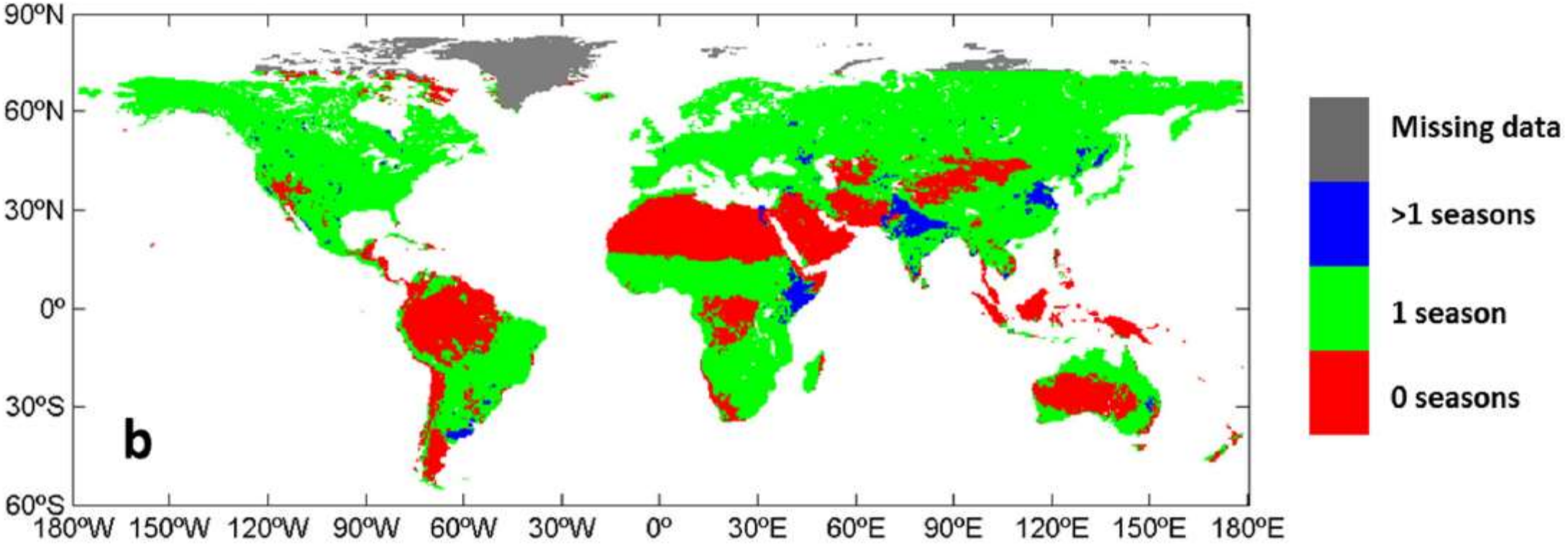
Caractérisation de la phénologie



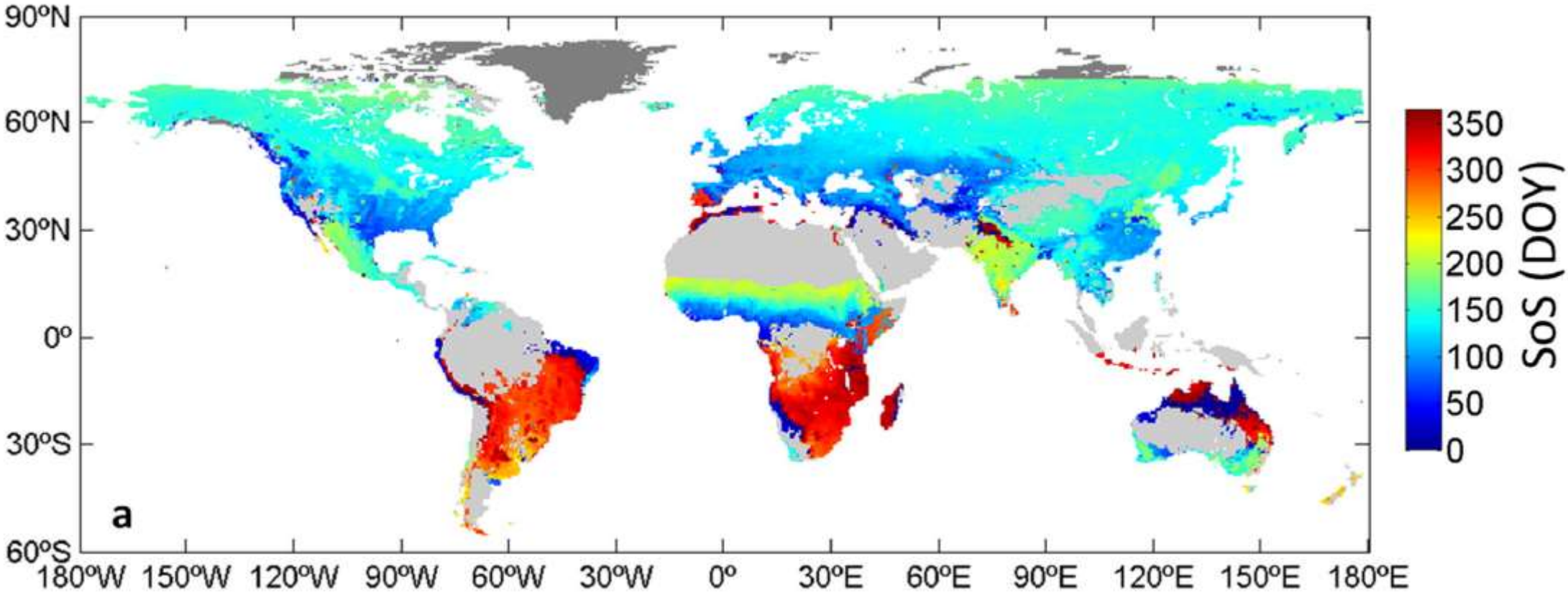
Caractérisation de l'amplitude de LAI



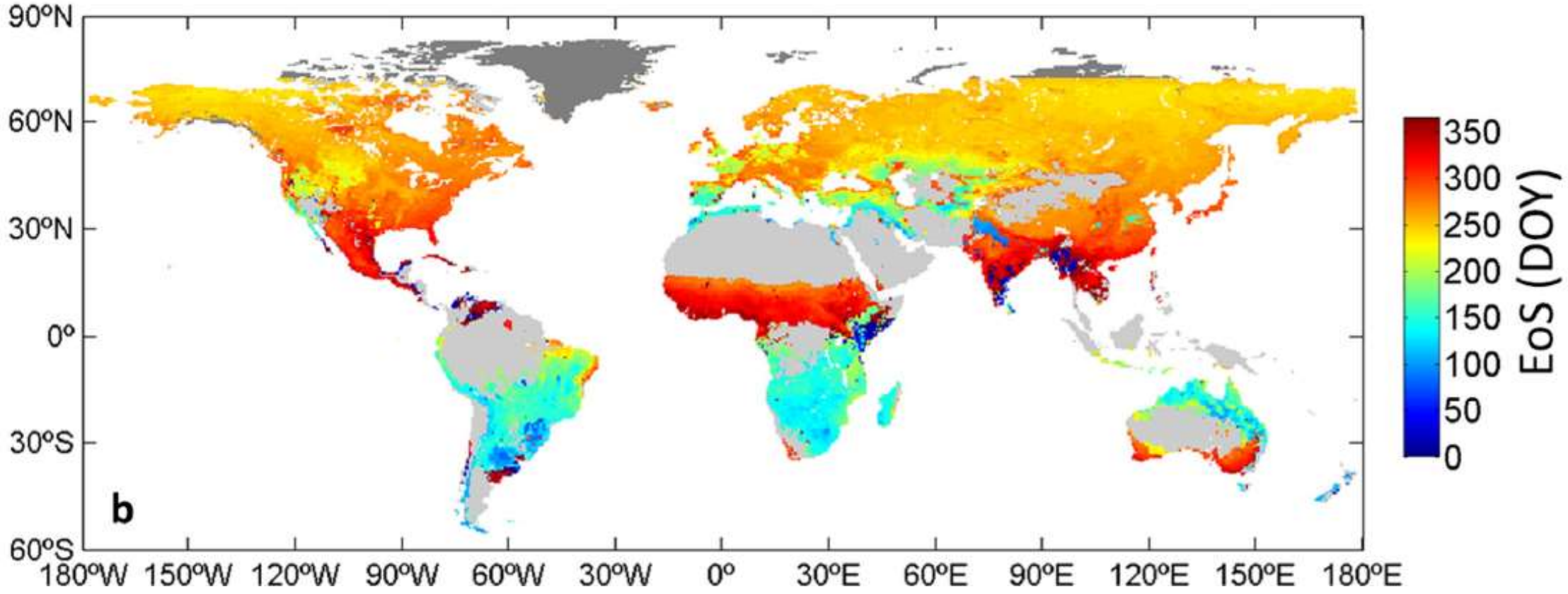
Nombre de saisons / an



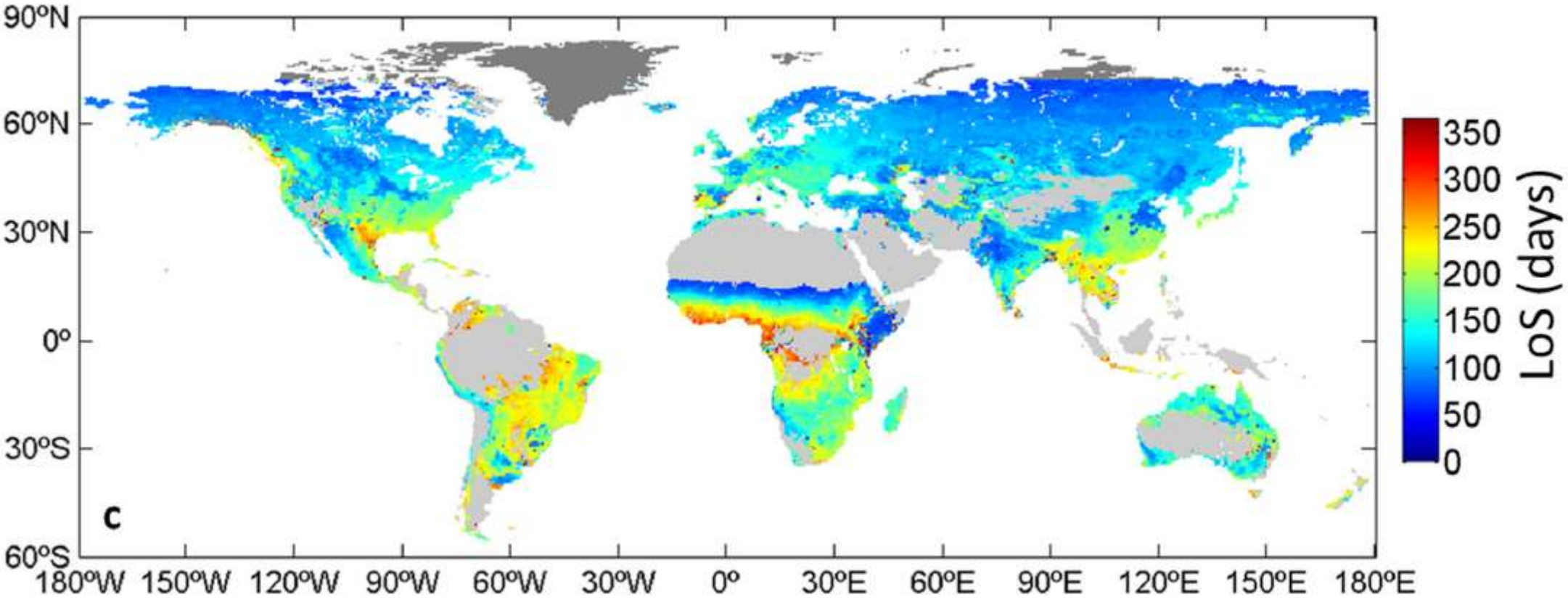
Start of Season



End of Season



Length of Season



Evaluation de la phenologie

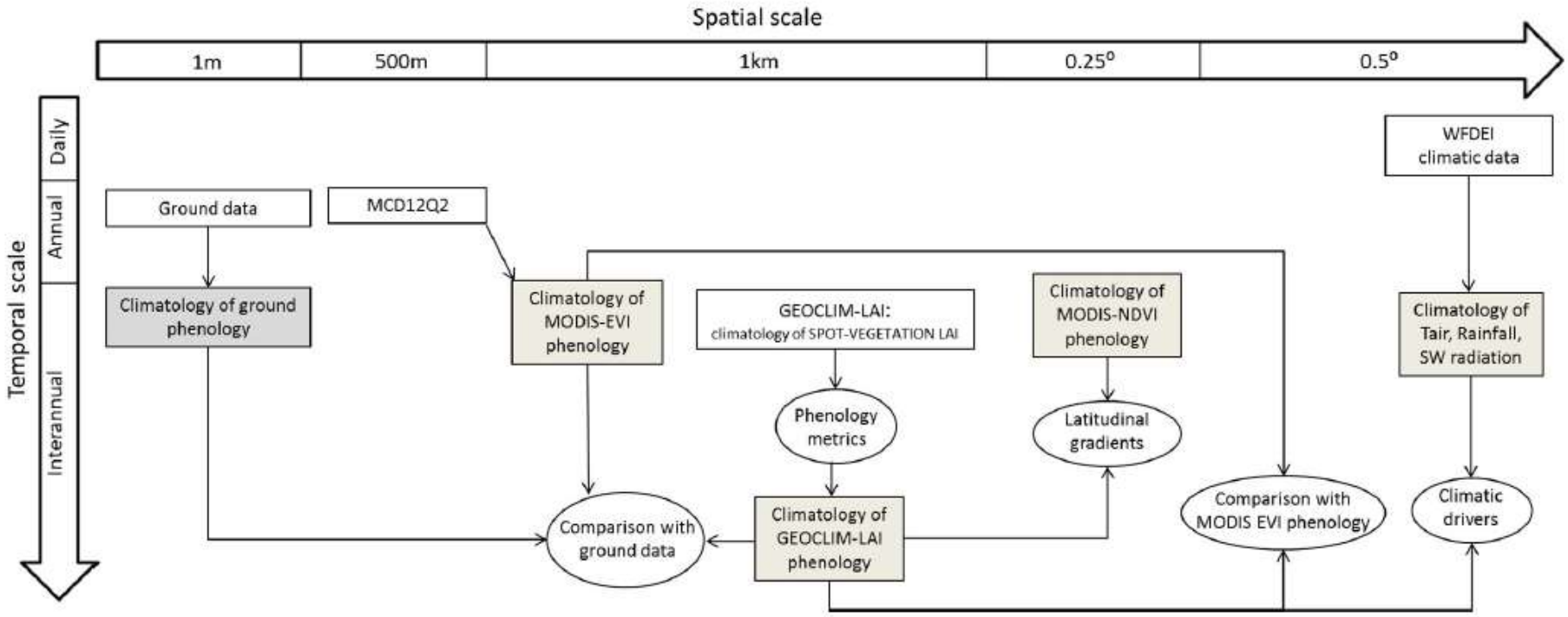
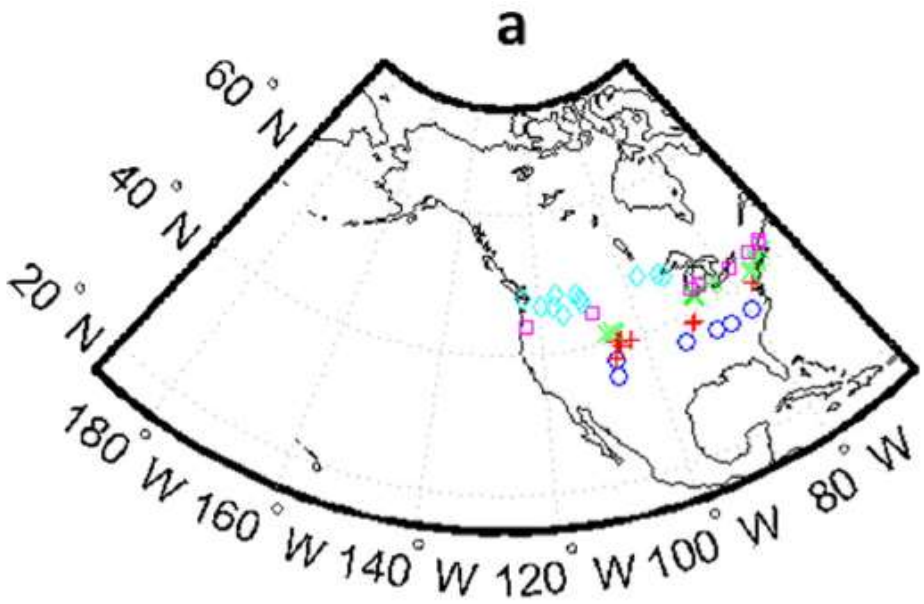
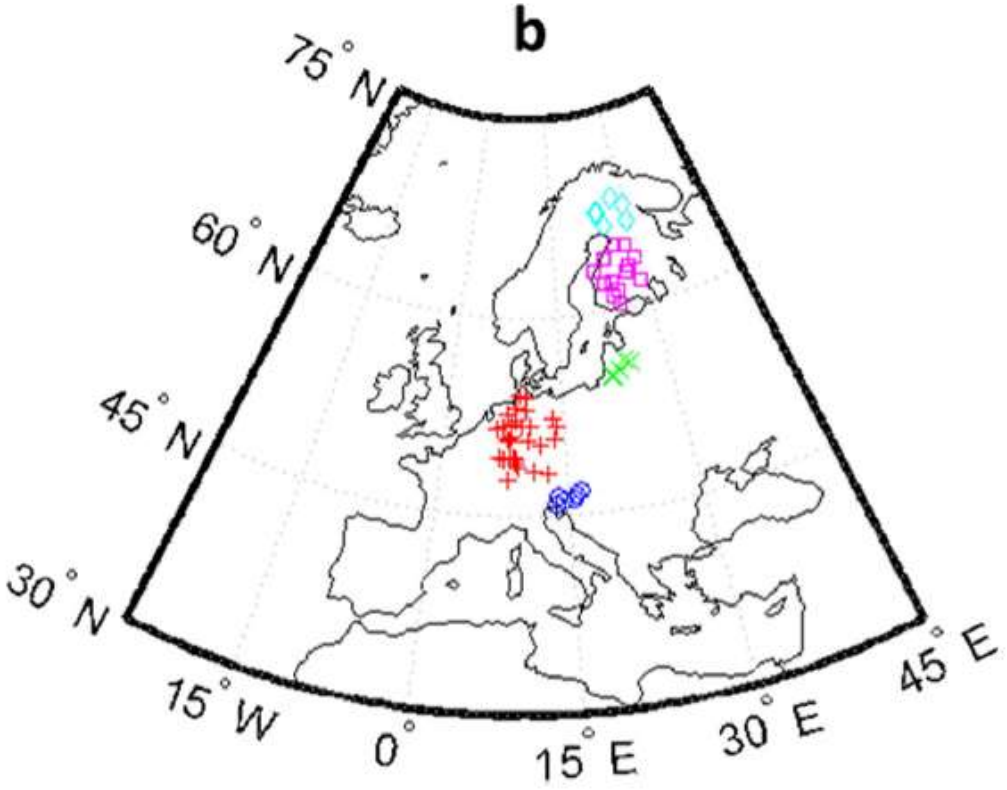


Fig. 3. Flow chart describing the approach for evaluating the climatologies (grey boxes) of phenological metrics derived from ground data, GEOCLIM-LAI, MODIS-EVI, MODIS-NDVI, and climatic variables (air temperature, rainfall and short-wave radiation). The original products are indicated in rectangular white boxes, the methods in ellipses. The horizontal and vertical arrows indicate the spatial and temporal scales, respectively.

Networks of ground observations available

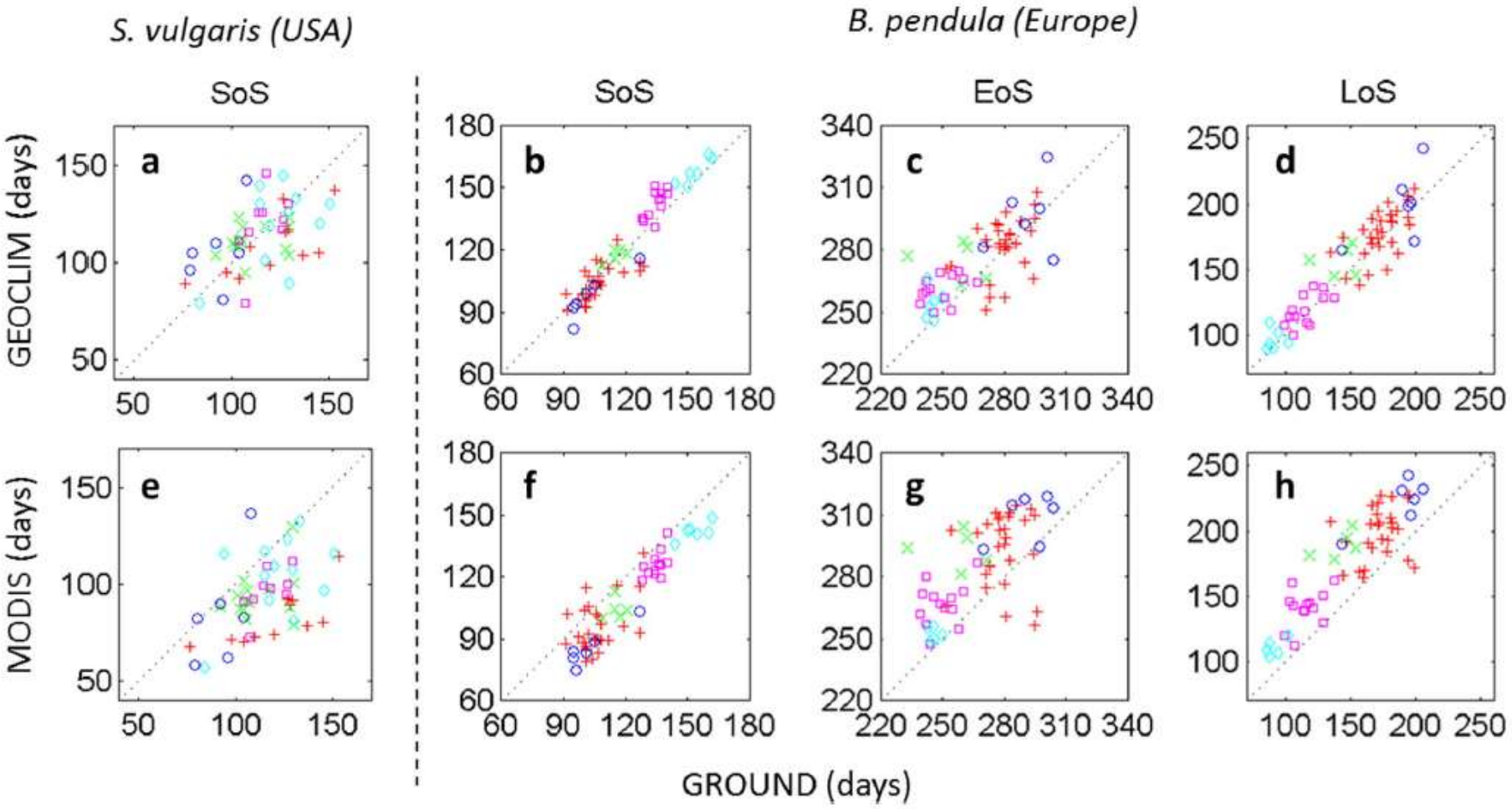


S. Vulgaris (Lila)

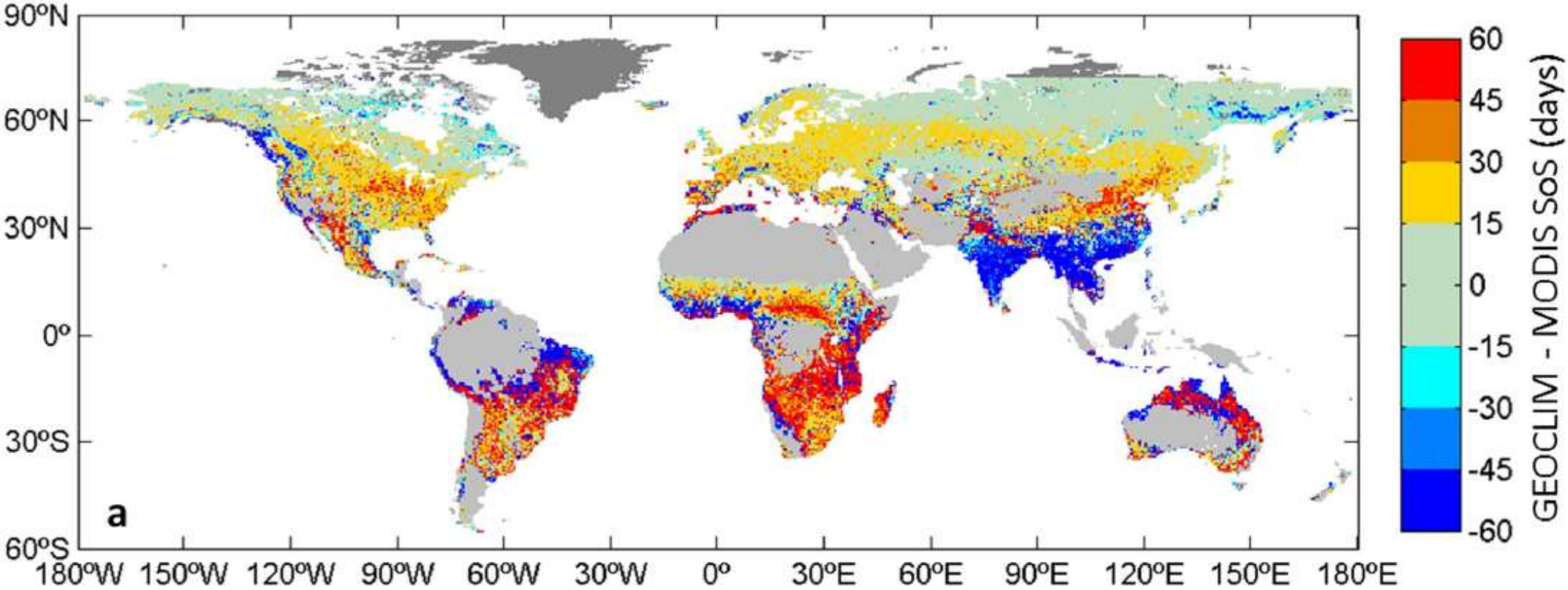


B. Pendula (Bouleau)

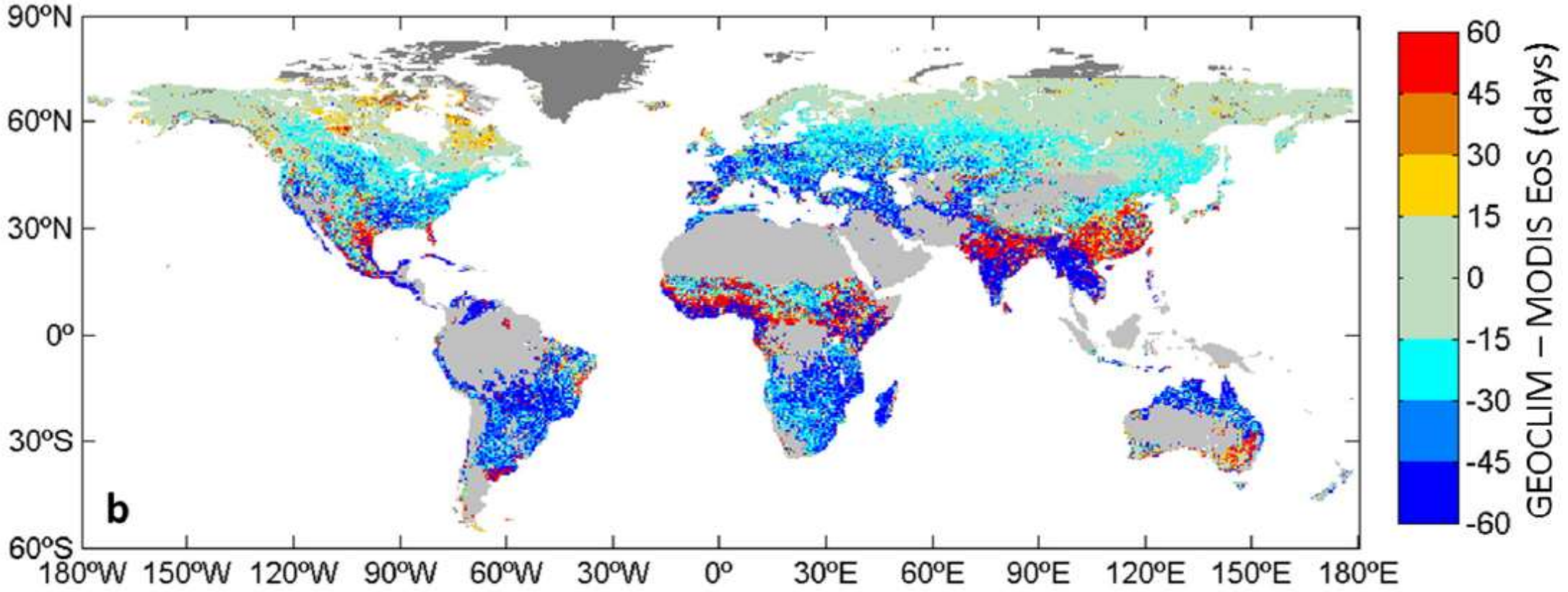
Comparaison aux observations au sol



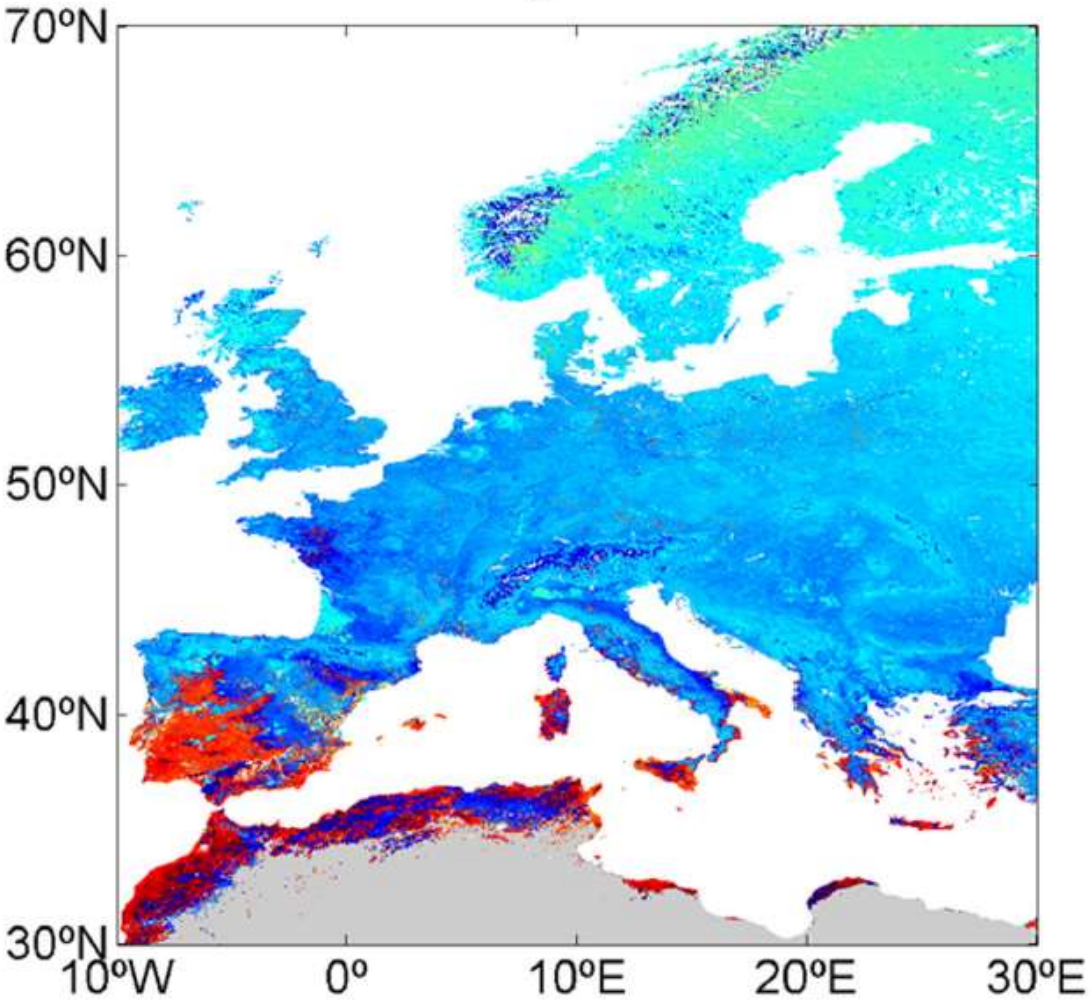
Comparaison à MODIS-EVI

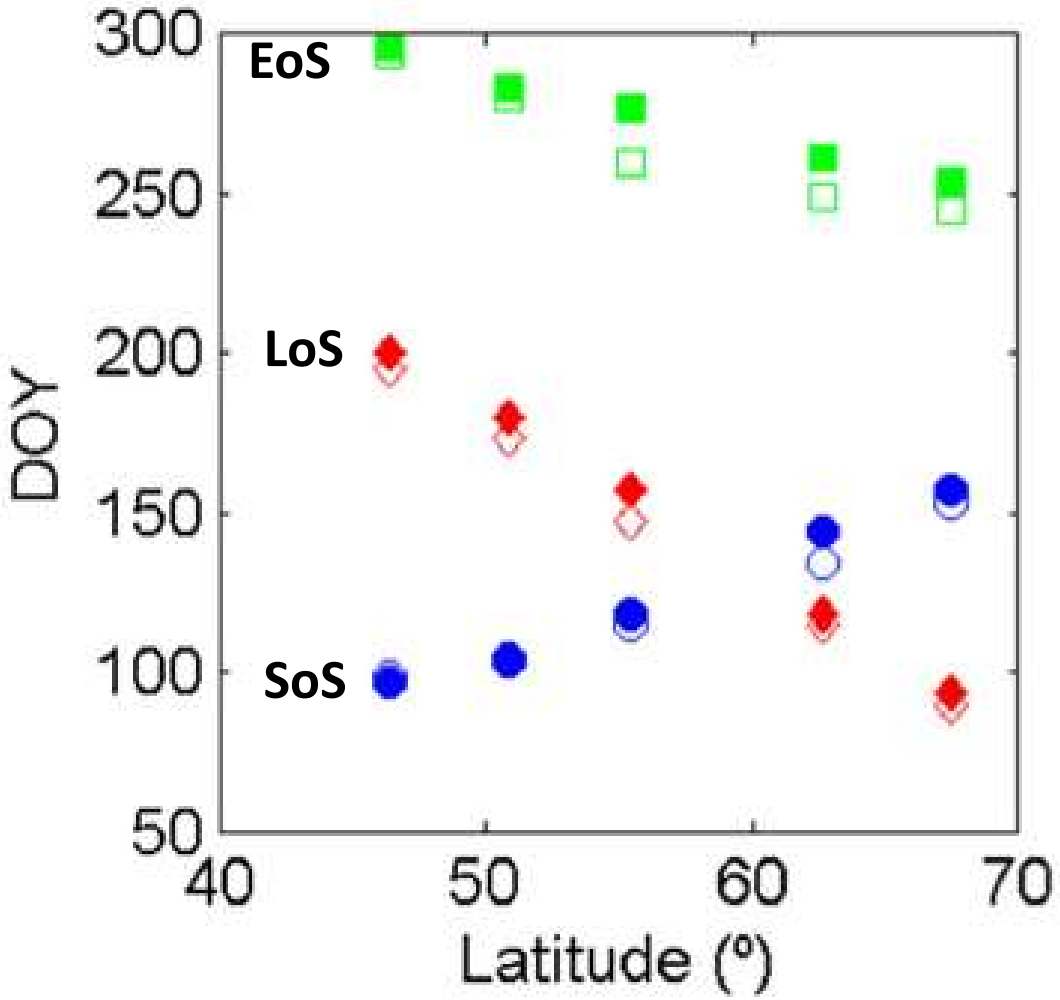


Comparaison à MODIS-EVI

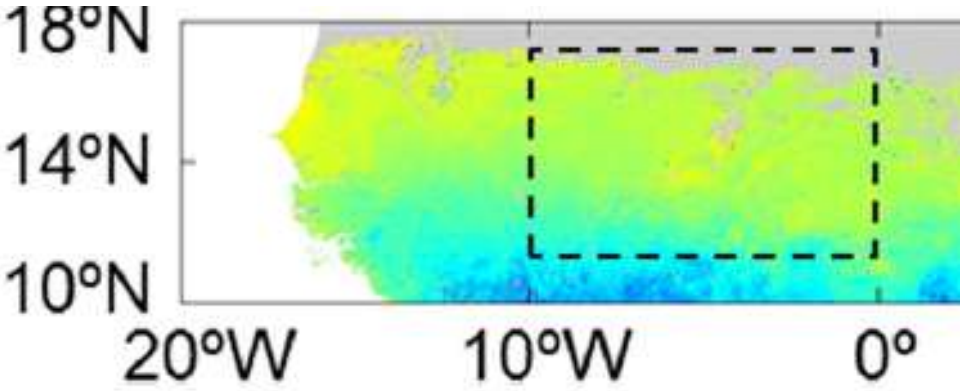


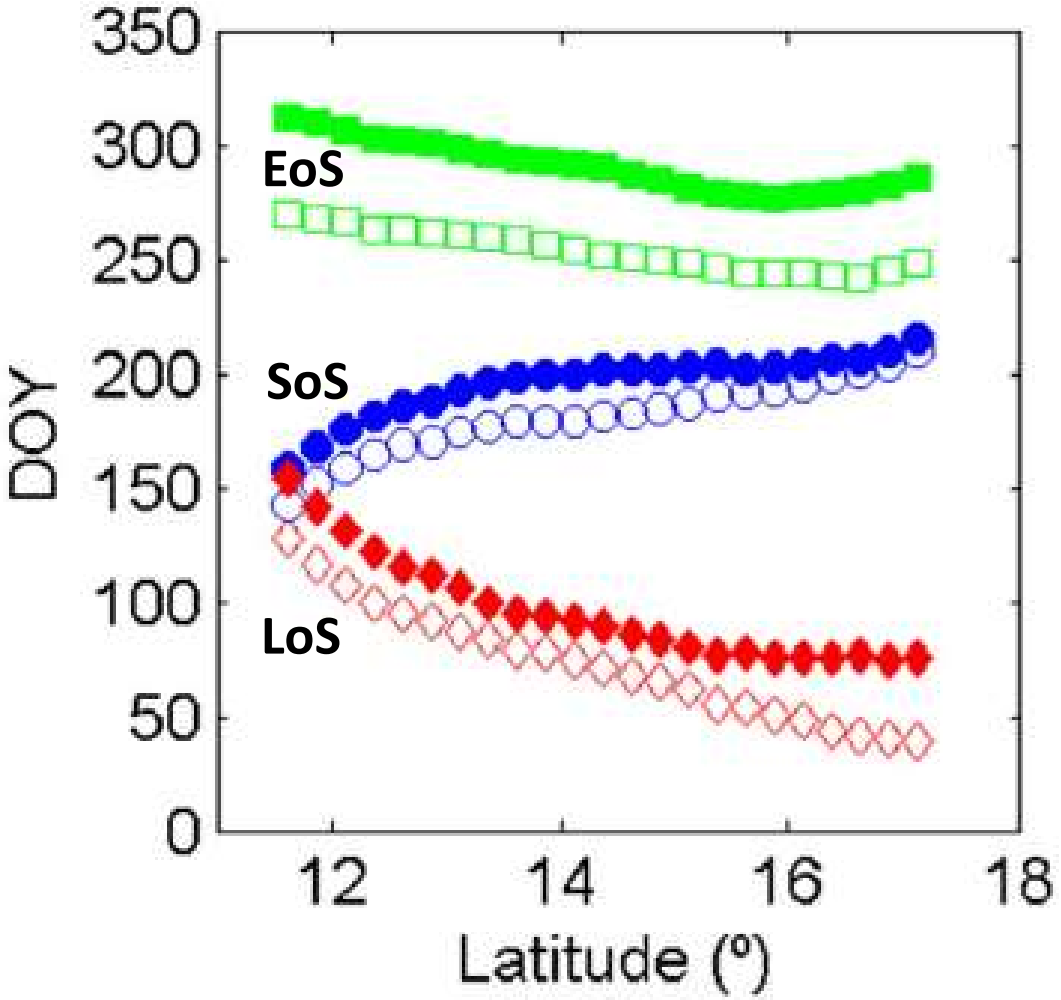
Gradients en latitude (Europe)





Gradients en latitude (Sahel)





Facteurs influençant la longueur de la saison