Integration of canopy biophysical variables infered from hyperspectral data into SVAT models

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COST Action ES0903

EUROSPEC: Spectral Sampling Tools for Vegetation Biophysical Parameters and Flux Measurements in Europe

http://cost-es0903.fem-environment.eu/

Four Working Groups:

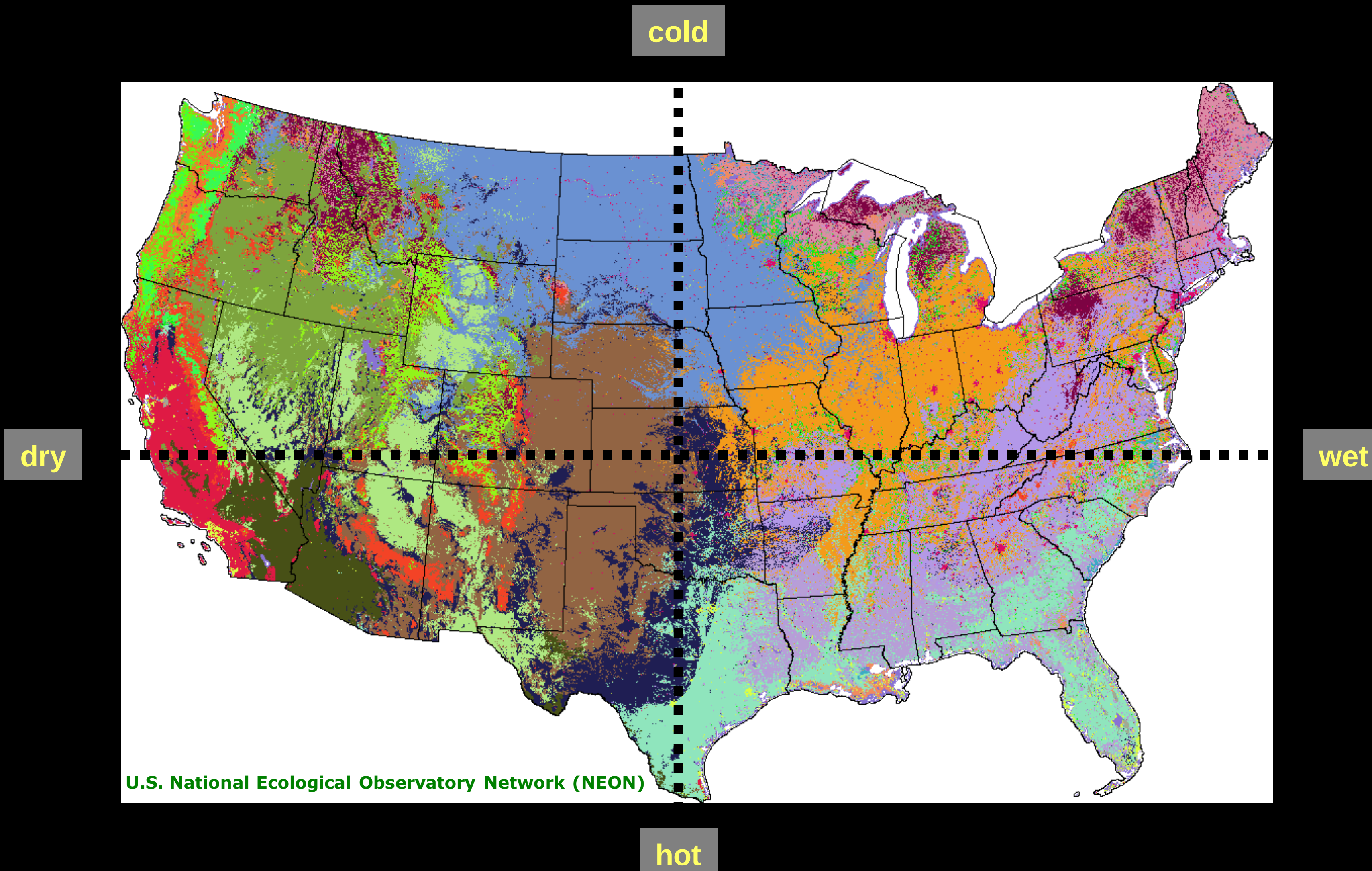
WG1) State of the art of the optical sampling networks, protocol definition

WG2) Intercomparison: instrument characterization, standardization, intercalibration and measurement protocol issues

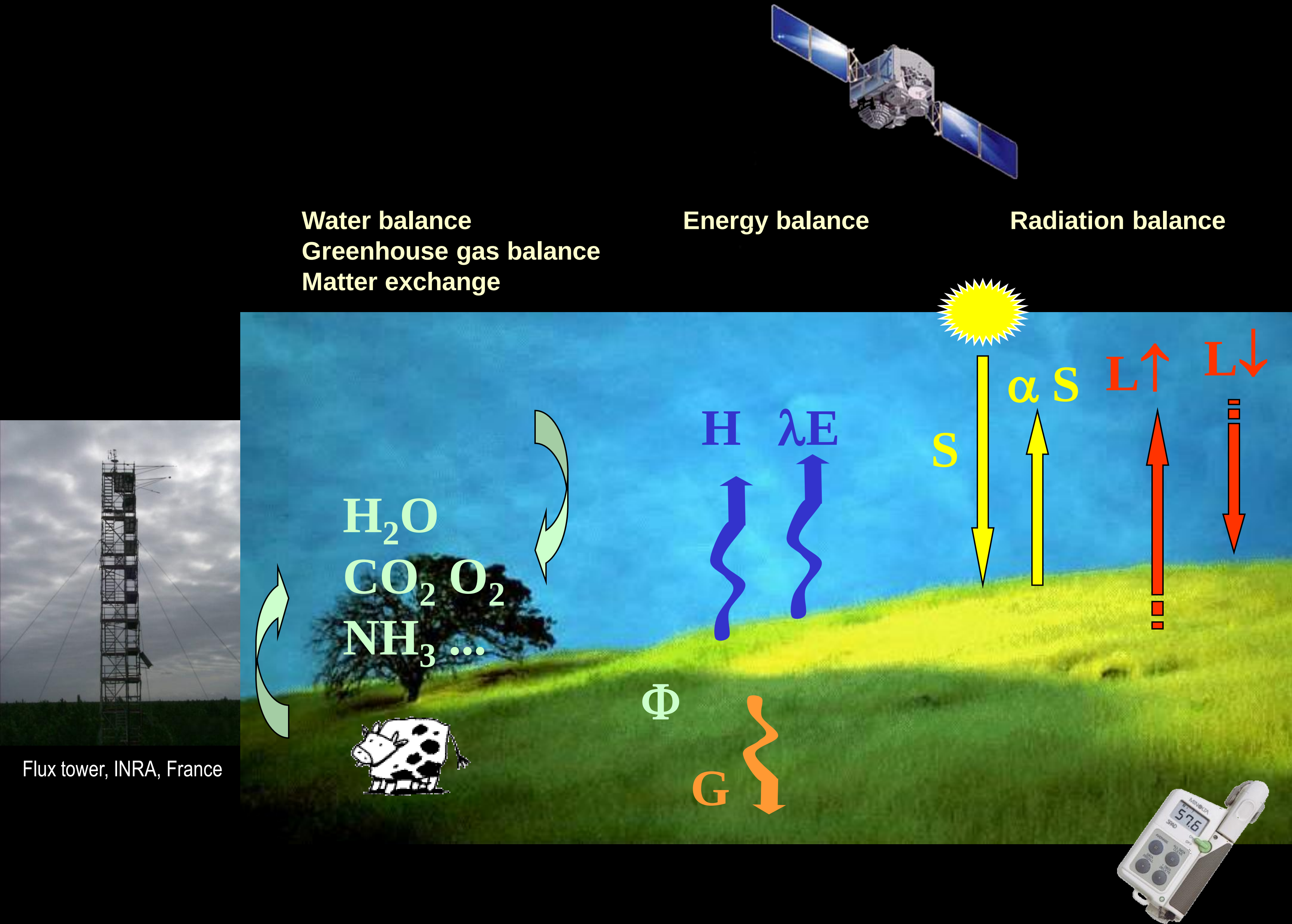
WG3) New instruments development

WG4) Upscaling biophysical parameters and fluxes from the ecosystem at upper levels

Description of the ecosystem geography (ecoregions) of the United States



http://www.fs.fed.us/land/ecosysmgmt/index.html

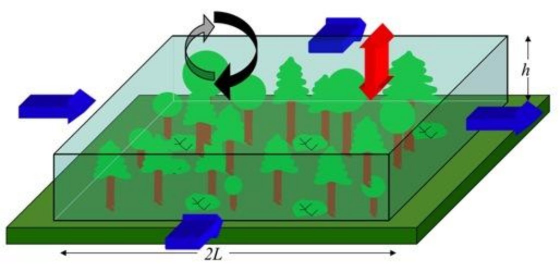

Water balance
Greenhouse gas balance
Matter exchange
Energy balance
Radiation balance
H₂O
CO₂ O₂
NH₃ ...
H
λE
S
α S
L↑
L↓
Φ
G
Flux tower, INRA, France

Soil-Vegetation-Atmosphere Transfer (SVAT) models

Input variables

- Atmospheric variables
- Soil physical properties
- Vegetation biophysical characteristics

SVAT models (ISBA, SiSPAT, ORCHIDEE)



Output variables

- Surface energy fluxes
- Water balance
- Soil and vegetation temperature
- Photosynthesis
- VOCs, Nox
- Net ecosystem production

Description of physical and biological mecanisms

GCM models

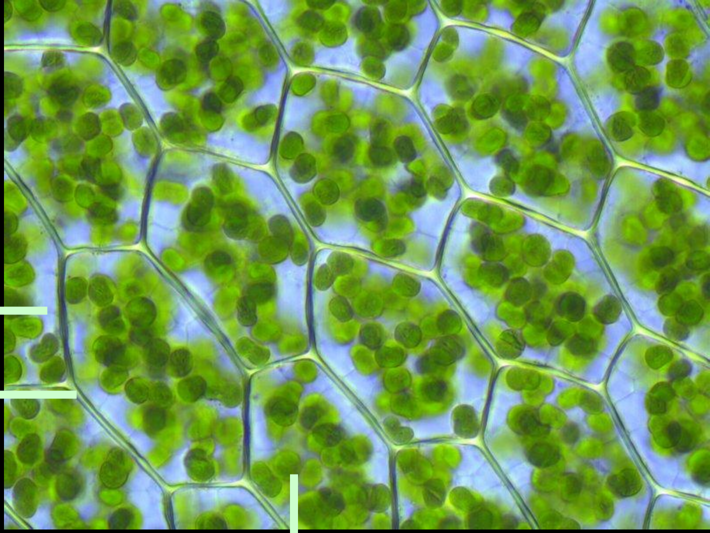
Calvet et al. (1998), *Agricultural and Forest Meteorology*, 92:73–95 ; Olioso et al. (2005), *Irrigation and Drainage Systems*, 19:377–412.

Main processes involved in net ecosystem production

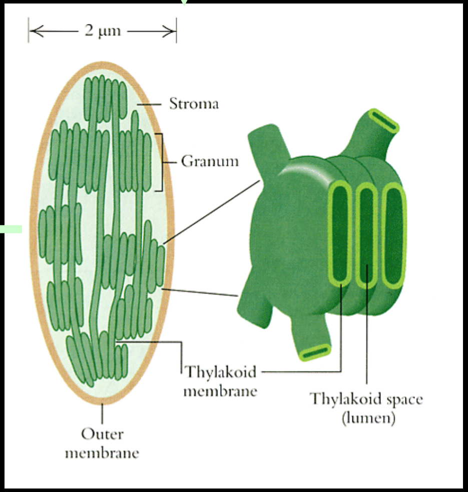
Biophysical processes	*Ecophysiological variables*
Interception of solar radiation	fAPAR Green LAI Canopy structure
Photosynthesis / Respiration	LAI Leaf pigment and water content Leaf anatomy
Decomposition of organic matter	Soil water content Leaf C:N ratio
Evapotranspiration	fCover LAI Albedo Soil water content Leaf water content
Plant species / Biodiversity	LAI Canopy structure Leaf chemical content

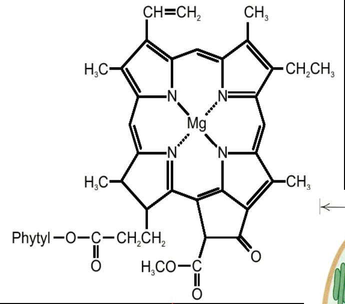
Rautiainen et al. (2010), *Scandinavian Journal of Forest Research*, 25:325–339.

Leaf chemical composition

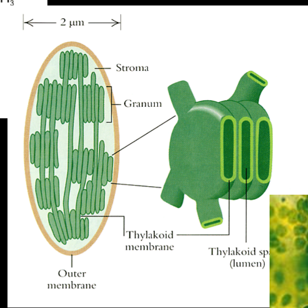


- water (vacuole) : 90-95%
- dry matter (cell walls) : 5-10%
  - cellulose: 15-30%
  - hemicellulose: 10-30%
  - proteins: 10-20% ⇔ N
  - lignin: 5-15% ⇔ C
  - starch: 0.2-2.7%
  - sugar
  - etc.
- wax (cuticle)
- chlorophyll *a* and *b* + carotenoids (chloroplasts)
- other pigments (cytoplasm)
  - anthocyanins
  - flavons
  - brown pigments
  - etc.

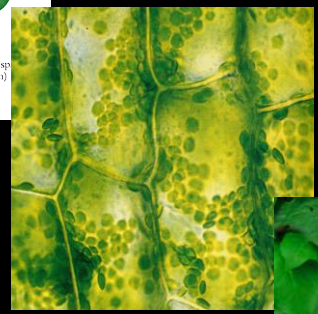


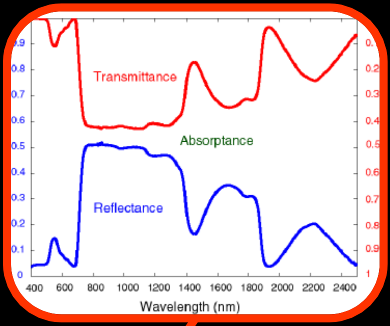


CH=CH2
CH3
H3C
CH2CH3
Mg
N
H3C
CH3
Phytyl—O—C—CH2CH2
O
H3CO—C
O
O

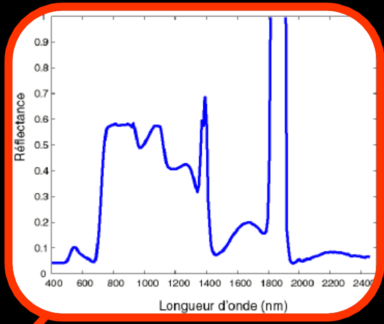


2 µm
Stroma
Granum
Thylakoid membrane
Thylakoid space (lumen)
Outer membrane

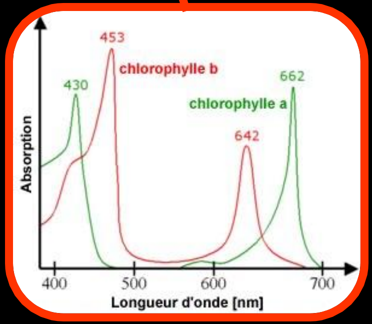




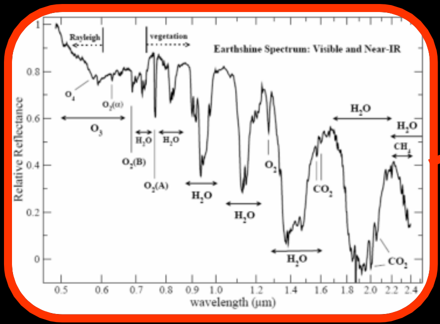
Transmittance
Absorptance
Reflectance
Wavelength (nm)
400 600 800 1000 1200 1400 1600 1800 2000 2200 2400



Réflectance
Longueur d'onde (nm)
400 600 800 1000 1200 1400 1600 1800 2000 2200 2400



Absorption
453
chlorophylle b
430
662
chlorophylle a
642
400 500 600 700
Longueur d'onde [nm]



Earthshine Spectrum: Visible and Near-IR
Rayleigh
vegetation
Relative Reflectance
wavelength (µm)
O3
O2(B)
O2(A)
H2O
O2
CO2
CH4

Extraction of canopy biophysical parameters

- ♦ Combination of narrow bands

- ♦ Absorption band depth

- ♦ Spectral shifts

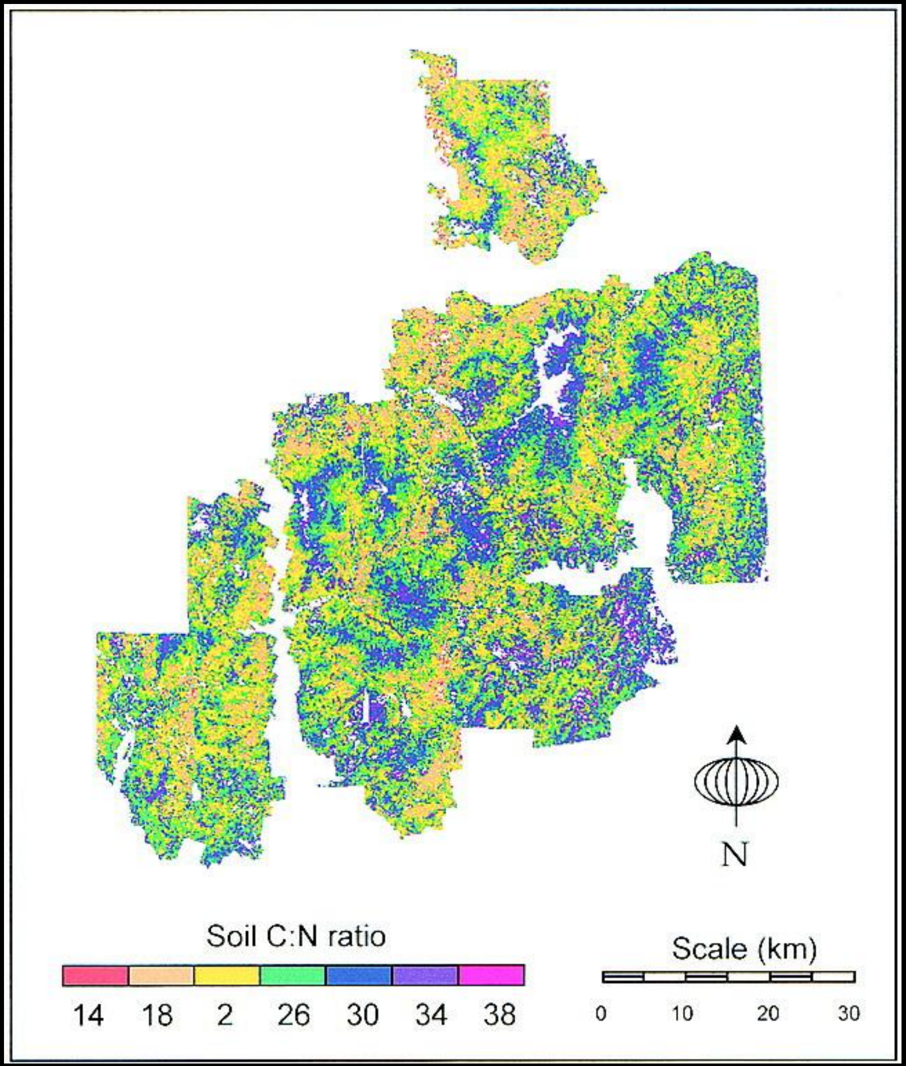
- ♦ Statistical approach
  Multiple linear regression model
  Stepwise linear regression analysis
  Partial least square regression

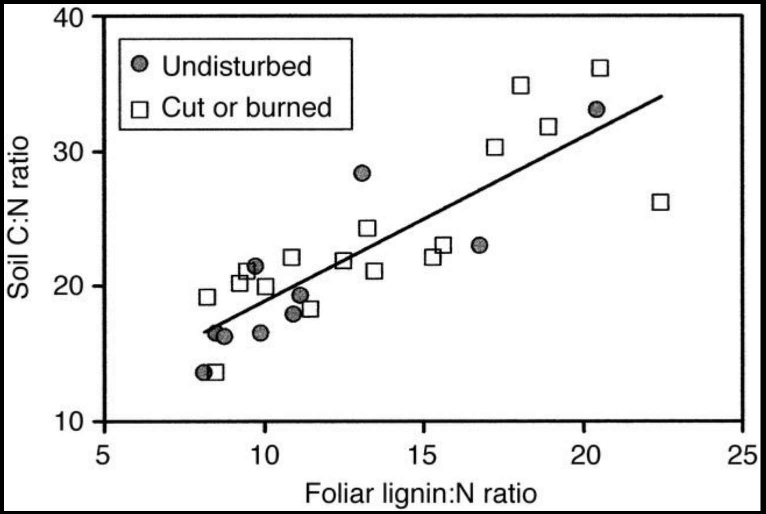
- ♦ Wavelet decomposition

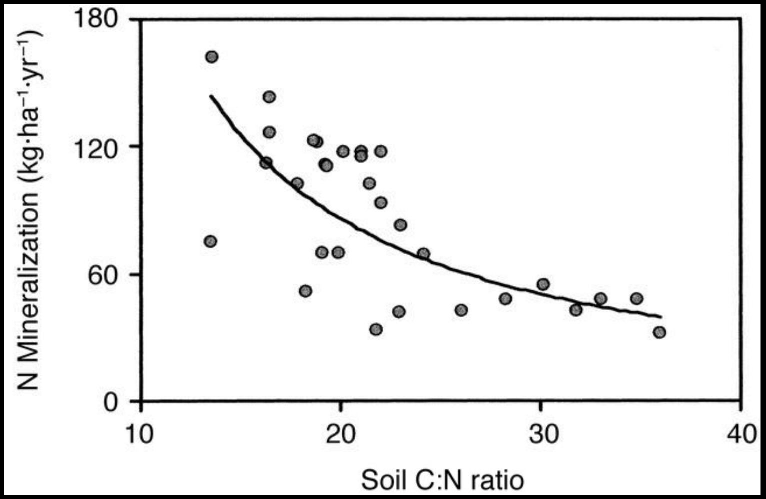
- ♦ Spectral mixture analysis
  Principal components analysis
  Multiple endmember mixture model
  Hierarchical foreground-background analysis

- ♦ Model inversion
  Approaches based on the observation space: iterative, look-up-table
  Approaches focusing on the space of leaf variables: artificial neural networks

Estimation of soil C:N ratio using partial least squares regression





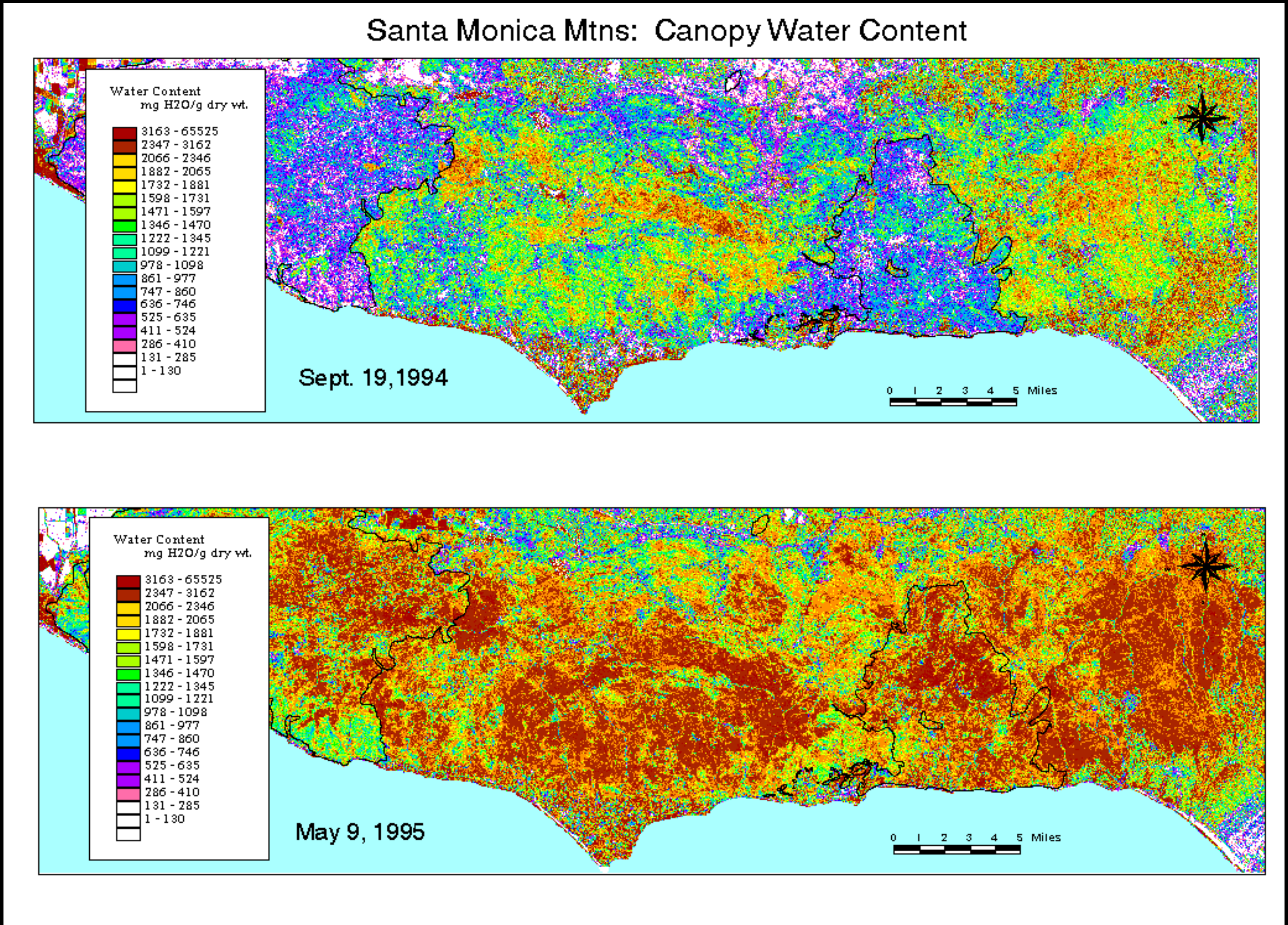


Predicted soil C:N ratios (organic plus mineral) for the White Mountain National Forest of New Hampshire, USA

Wessman et al. (1988), *Nature*, 335:154–156 ; Ollinger et al. (2002), *Ecology,* 83:339–355.

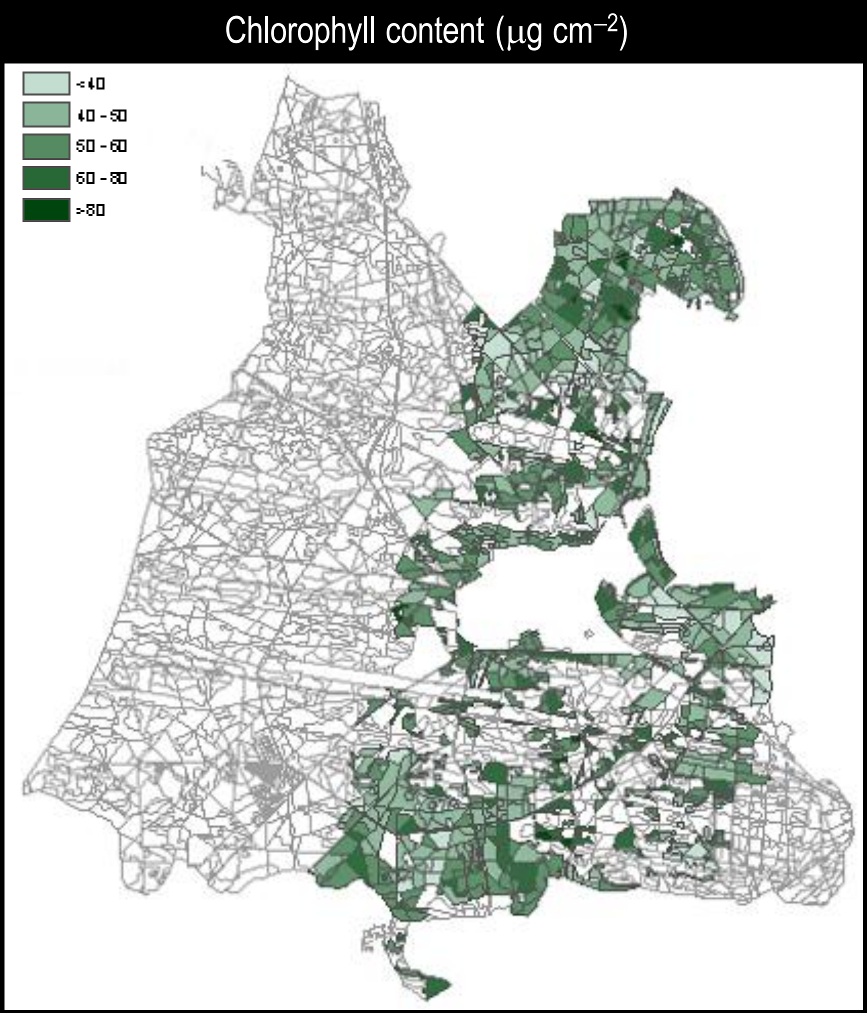
Estimation of canopy water content using hierarchical foreground-background analysis

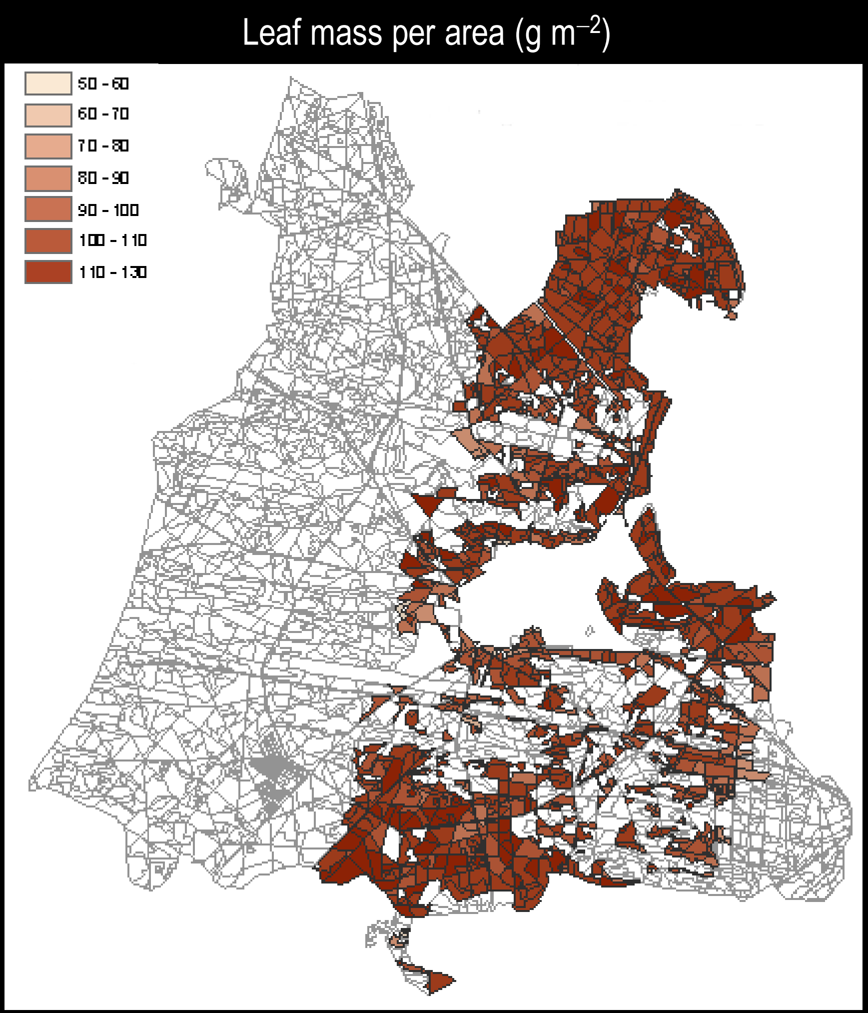
Water content (mg H_2O / g dry weight)



Ustin et al. (1998), *Remote Sensing of Environment*, 65:280–291.

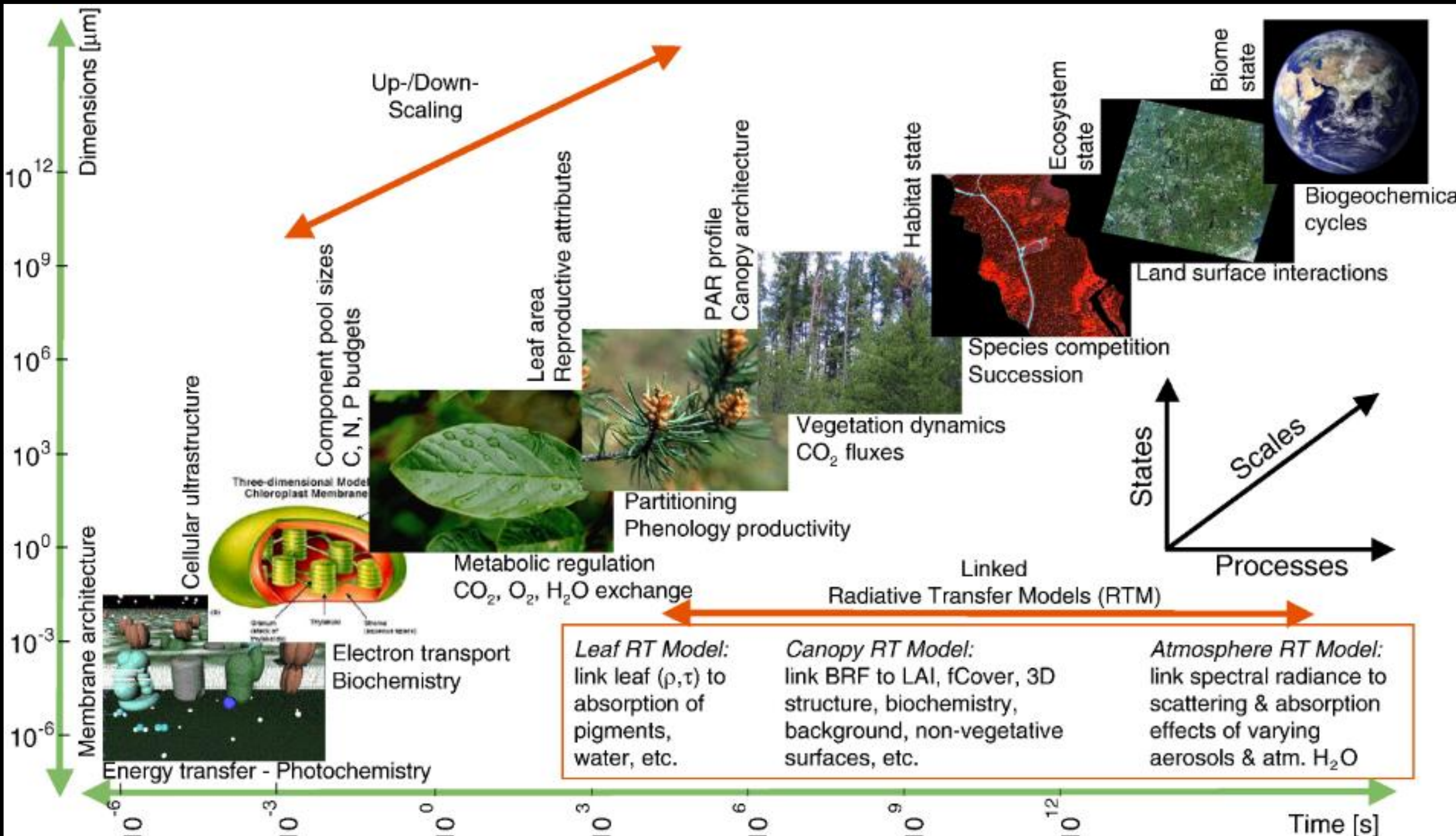
Estimation of leaf chlorophyll content and SLA using optimized vegetation indexes





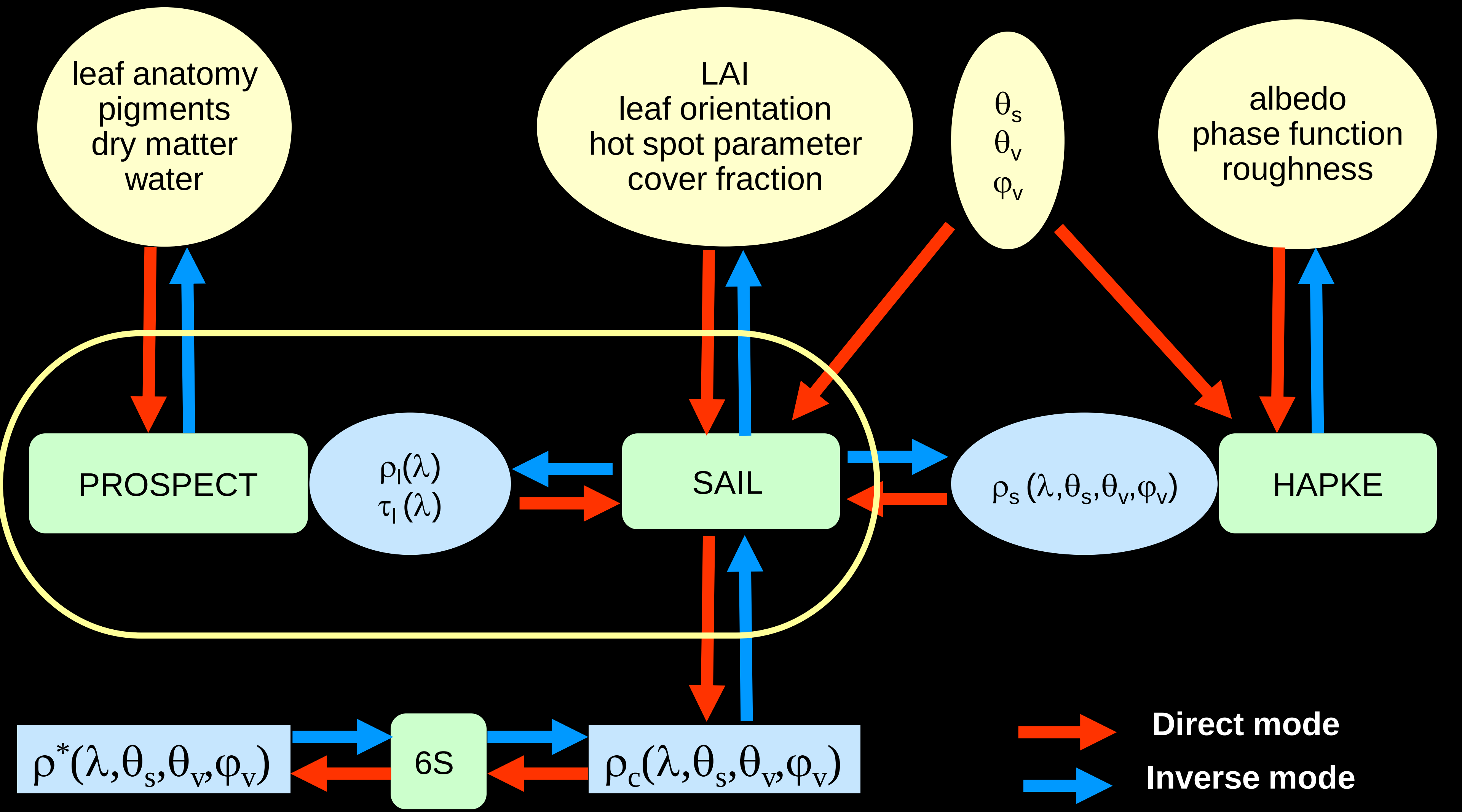
Le Maire et al. (2008), *Remote Sensing of Environment*, 112:3846–3864.

Coupled states, processes and scales



Schaepman et al. (2009), *Remote Sensing of Environment*, 113:S123–S137.

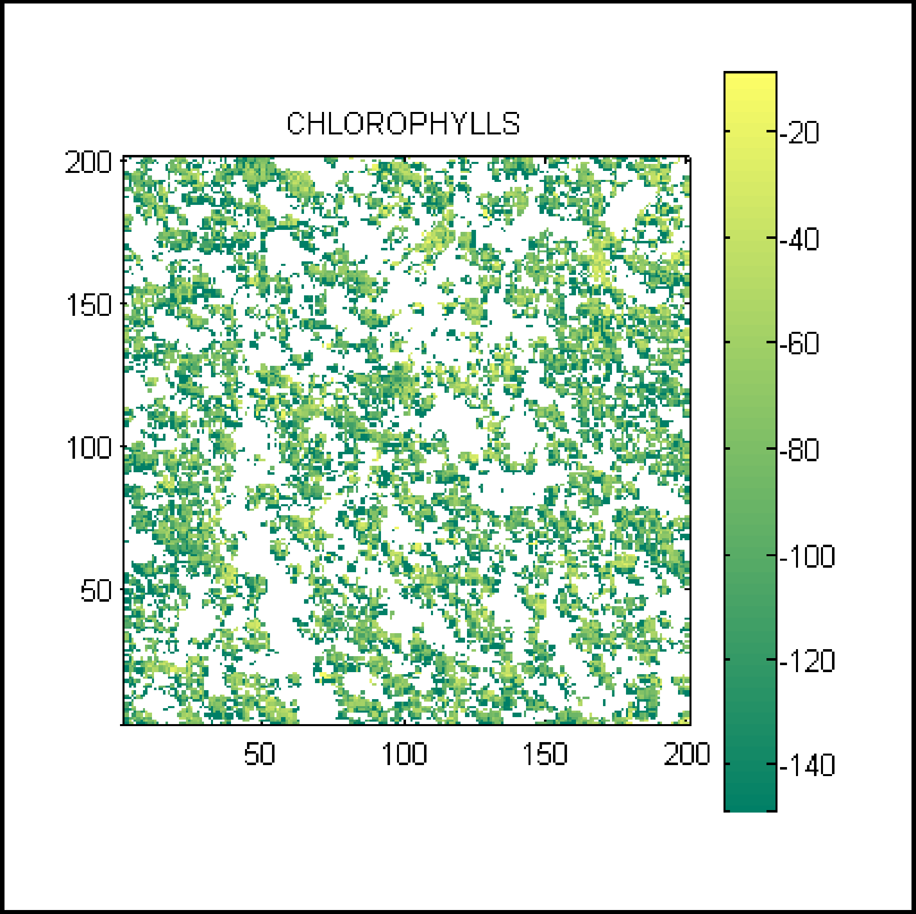
PROSPECT + SAIL = PROSAIL

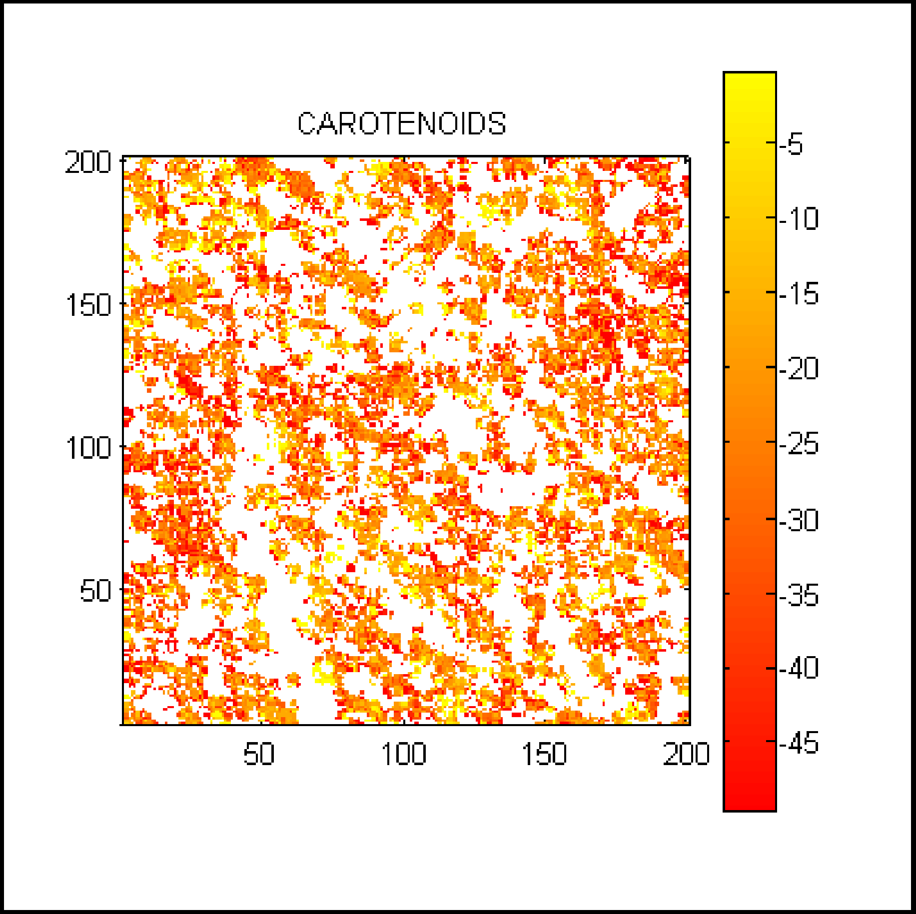


Jacquemoud et al. (2009), *Remote Sensing of Environment*, 113:S56–S66.

http://teledetection.ipgp.fr/prosail/

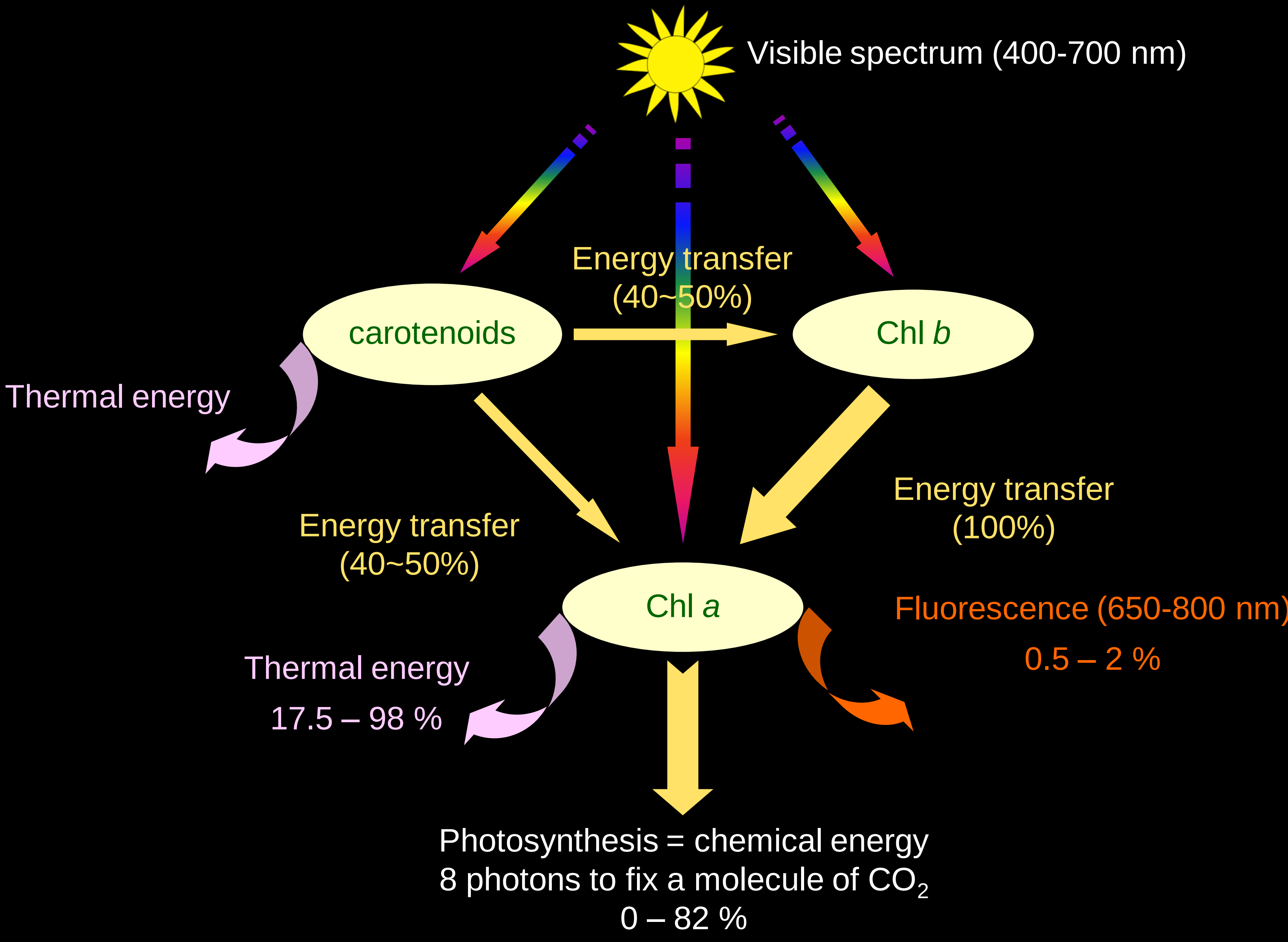
Estimation of leaf pigment content by inversion of PROSAIL



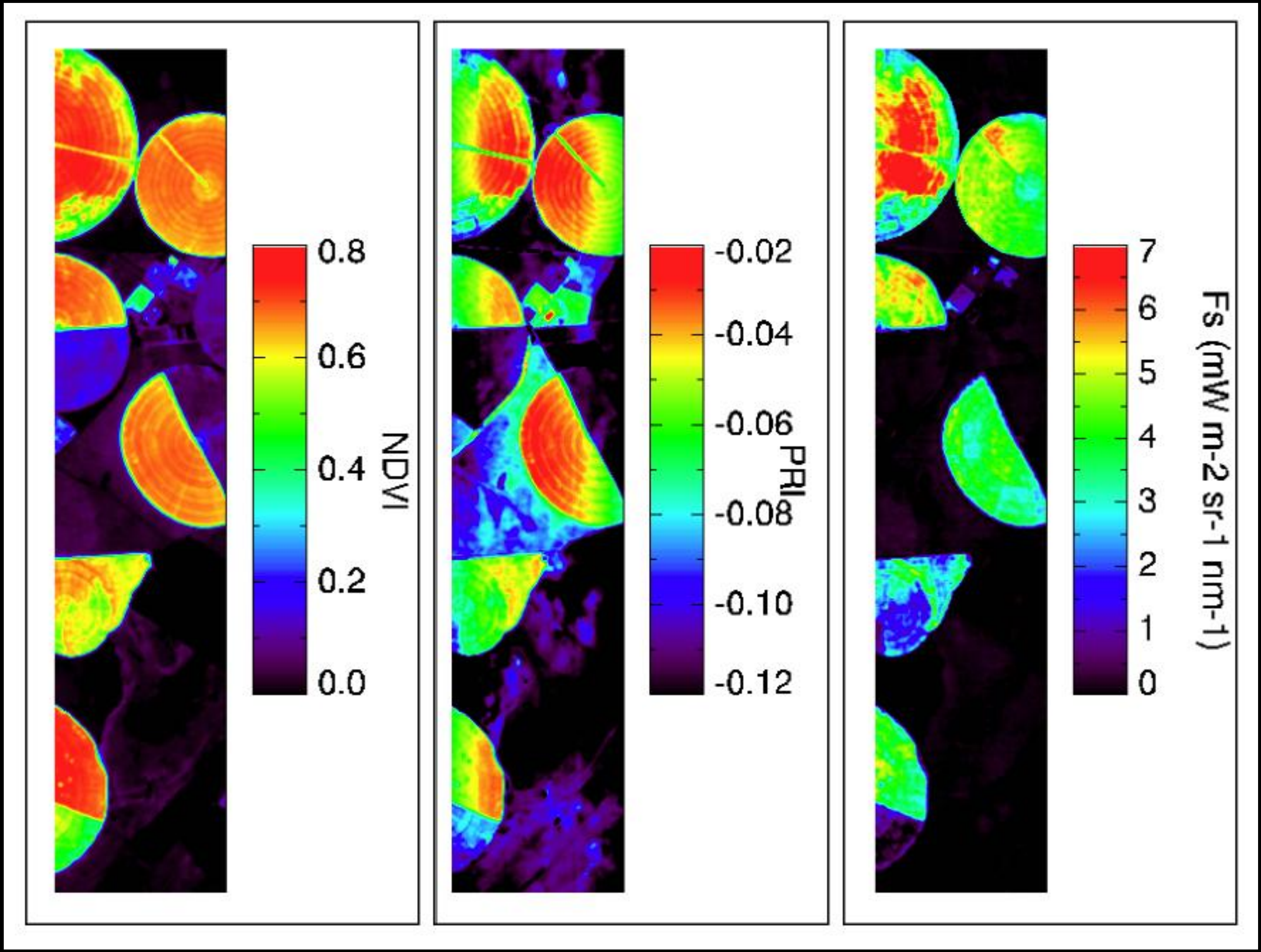


Féret et al. (2011), *Remote Sensing of Environment*, in preparation.
http://cao.stanford.edu/

Photosystem = antenna complex + reaction centrer

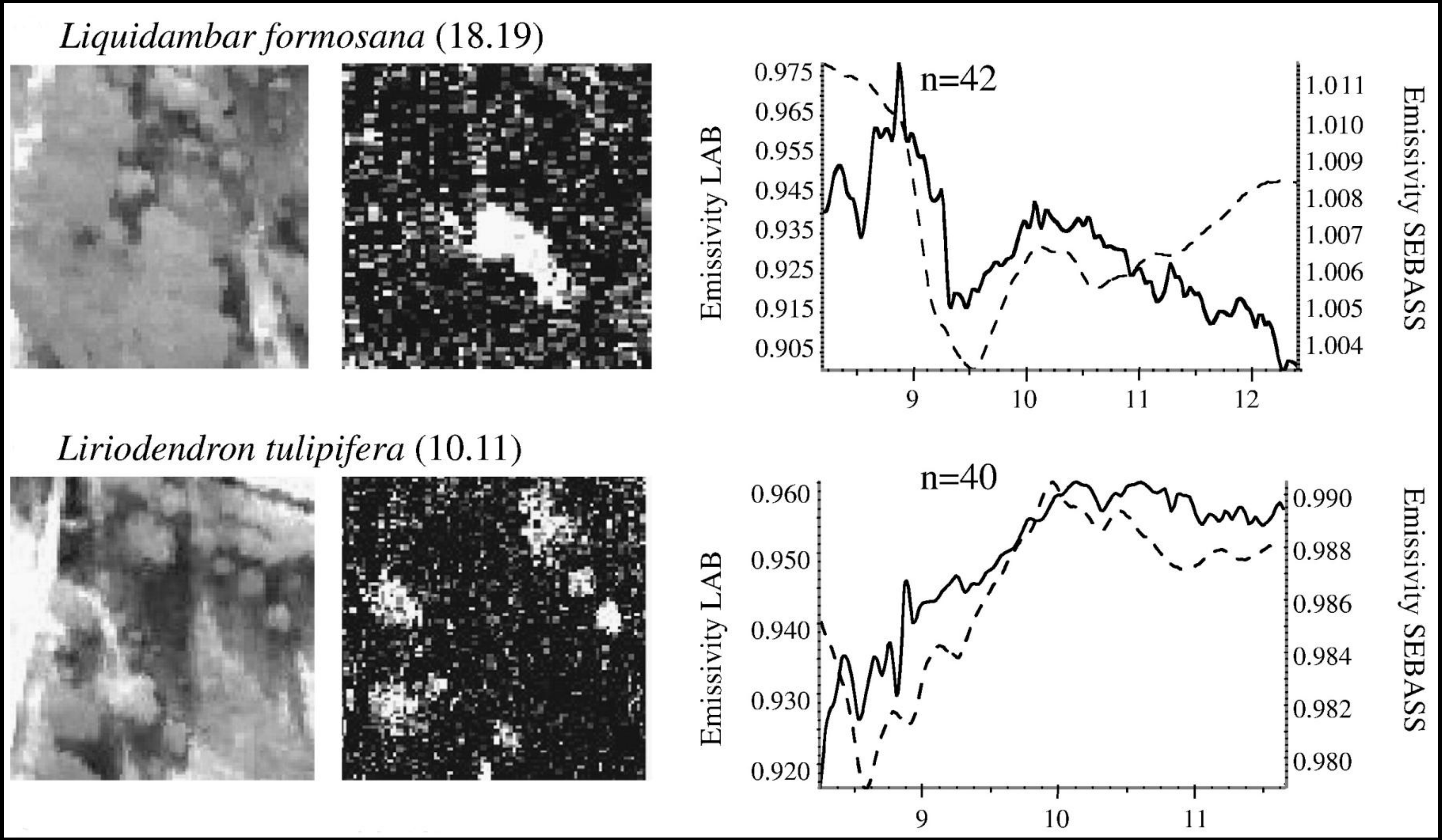


The photochemical reflectance index (PRI) versus solar-induced fluorescence

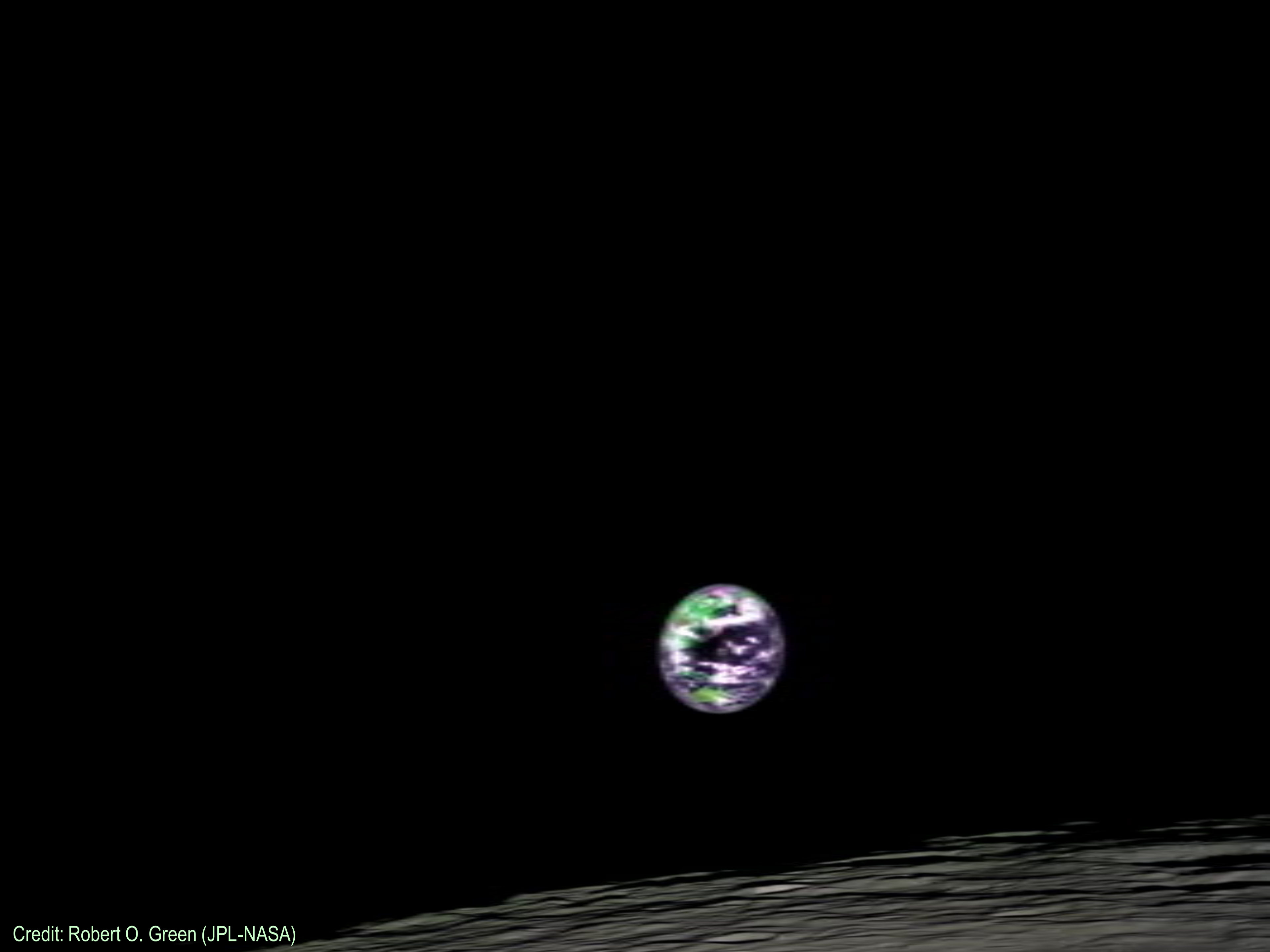


ESA (2008), Flex – fluorescence explorer, Report for Assessment, ESA SP-1313/4, 126 pp.

Determination of plant biodiversity using thermal infrared spectroscopy



Ribeiro da Luz & Crowley (2010), *Remote Sensing of Environment,* 114:404–413 ; Gerber et al. (2011), *Remote Sensing of Environment*, 115:404-414.


Credit: Robert O. Green (JPL-NASA)