Field spectroscopy for monitoring vegetation biophysical parameters in a dehesa ecosystem: BIOSPEC and FLUXPEC activities

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I jornada usuarios ASD *Madrid 29 Junio 2016*

"Linking spectral information at different spatial scales with biophysical parameters of Mediterranean vegetation in the context of global change"

Monitoring changes in water and carbon fluxes from remote and proximal sensing in a Mediterranean "dehesa" ecosystem

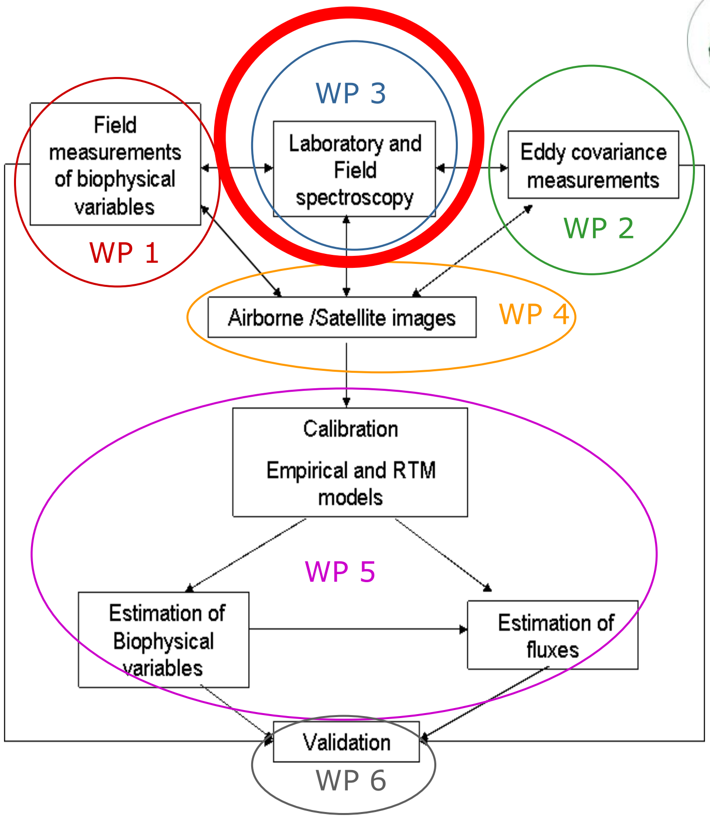
- BIOSPEC
  - National funded project: Ministry of Science and Innovation
  - 2009-2012

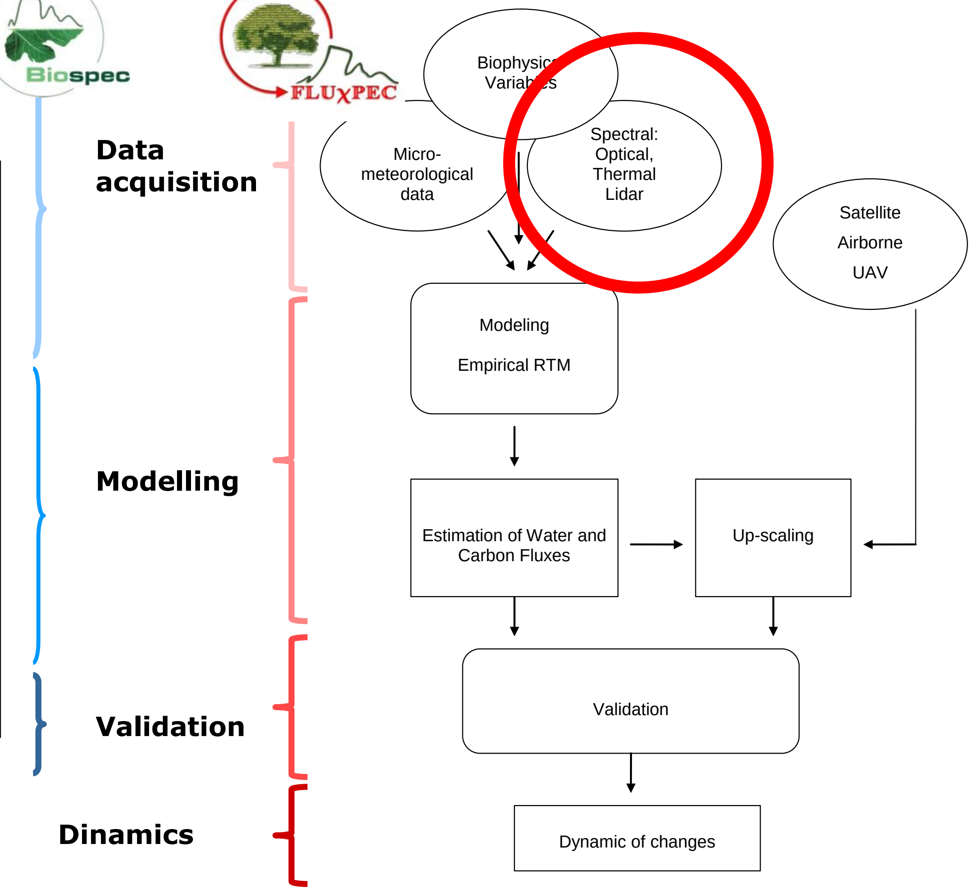
- FLUXPEC
  - National funded project: Ministry of Economy and competitiveness
  - 2013-2016

Partners

Key collaborators

Field spectroscopy in Biospec and Fluxpec projects





Field spectroscopy in Biospec and Fluxpec projects

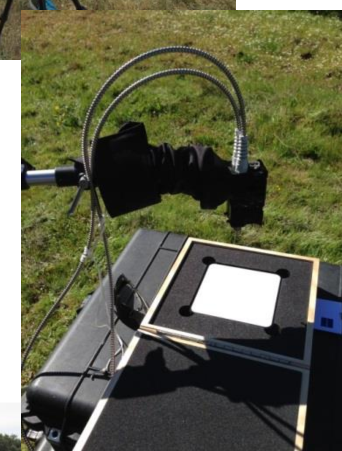
Calibration hyperspectral airborne images and validation of satellite images



Calibration/validation of empirical/RTM models for the estimation of biophysical variables



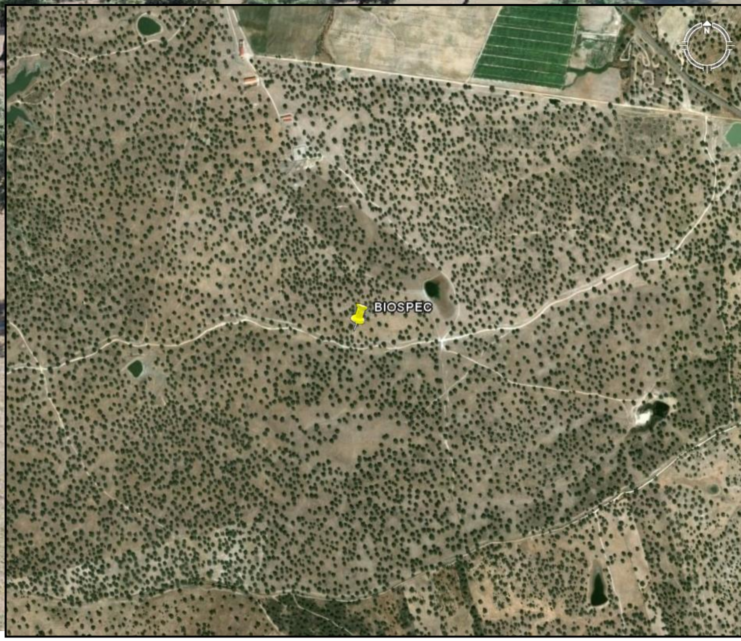

Sensor´s intercalibration


Biospec

FLUXPEC

Las Majadas del Tietar (39° 56‘29'' N, 5° 46'24’’ W), Extremadura, Spain



<u>Ecosystem:</u> ***dehesa*** **Mediterranean Holm Oak open woodland (Savanna)**

<u>Mediterranean Climate:</u> annual T = 16.7 ºC, annual Prec = 550 mm   LAI = 0.4 (trees) + 1-1.5 (grass)

<u>Soil:</u> Stagnic Alisols, depth > 2m. Texture: sandy loam. soil C is 8.5 g/kg and soil N is 0.82 g/kg (0-20cm layer).

<u>Tree canopy:</u> 98% *Quercus Ilex;* 25 tree/ha; mean DBH = 45cm; canopy height = 7-10 m; canopy fraction = 20%

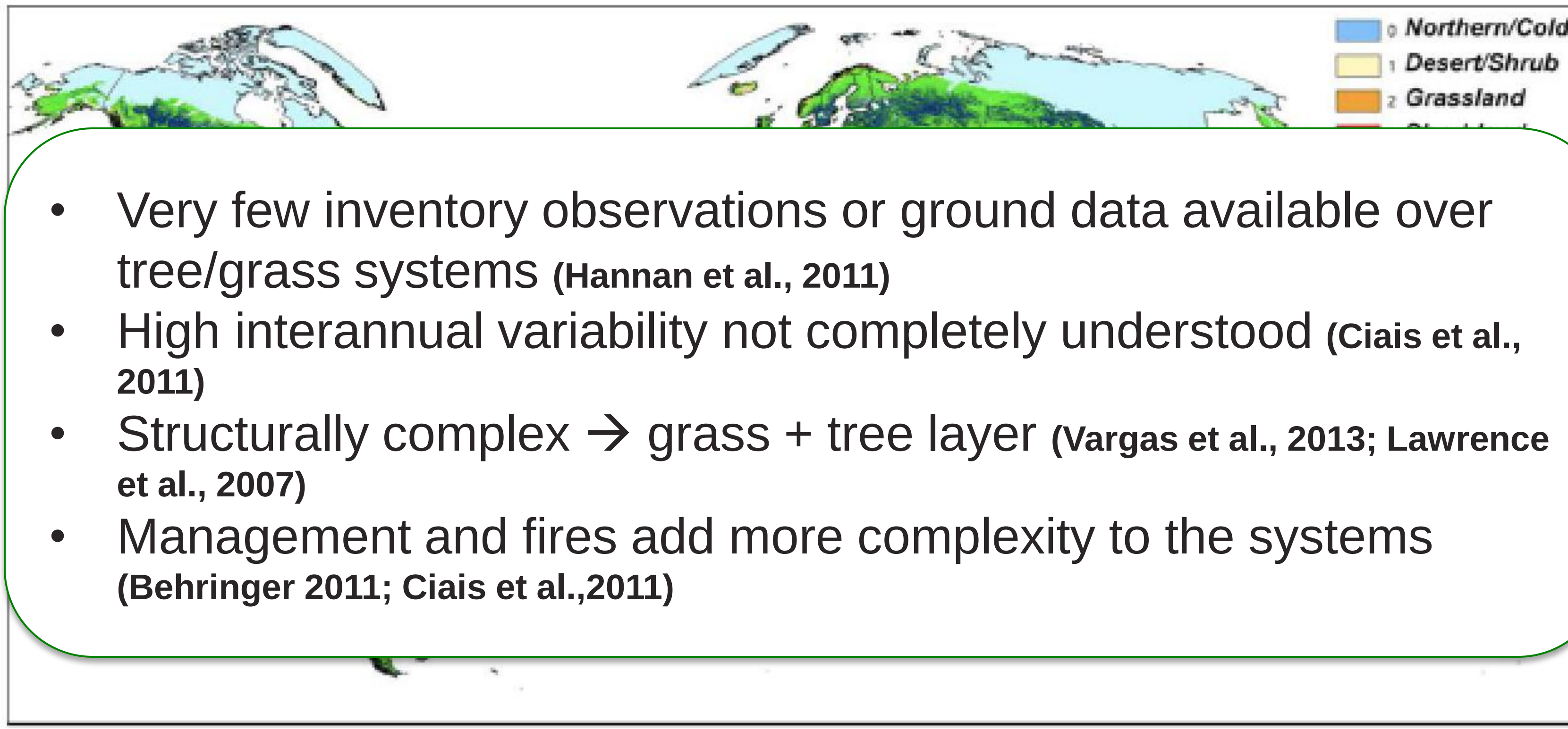
Management: tree pruning every 25 years to optimize acorn production

<u>Herbaceous layer:</u> high biodiversity (easy to find > 20 species within 4 m^2); ≠ composition below tree / open;

Management: continuous grazing (cows)

Tree-grass ecosystems

- **Wide global distribution (~16-35%)**
- Earth observation systems and earth system models poorly adapted for tree-grass systems



- Very few inventory observations or ground data available over tree/grass systems **(Hannan et al., 2011)**
- High interannual variability not completely understood **(Ciais et al., 2011)**
- Structurally complex → grass + tree layer **(Vargas et al., 2013; Lawrence et al., 2007)**
- Management and fires add more complexity to the systems **(Behringer 2011; Ciais et al.,2011)**

Figure 1. Global distribution of tree-grass mixtures based on classification of MODIS Vegetation Continuous Field (VCF) data. The 'tree-grass' map used the 2005 VCF product (Hansen et al., 2005) which

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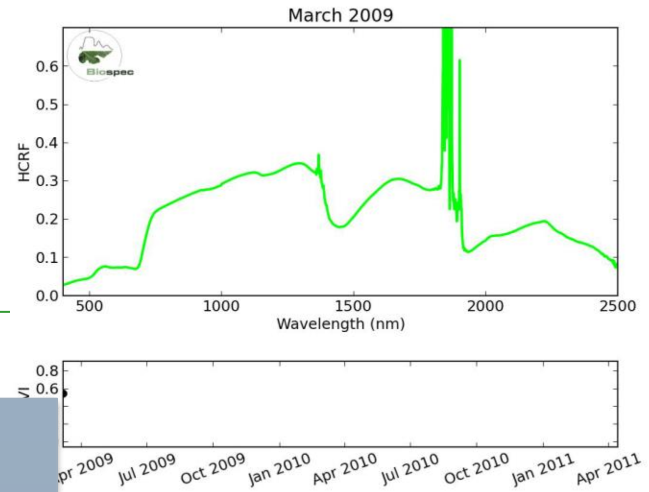
Vegetation biophysical variables

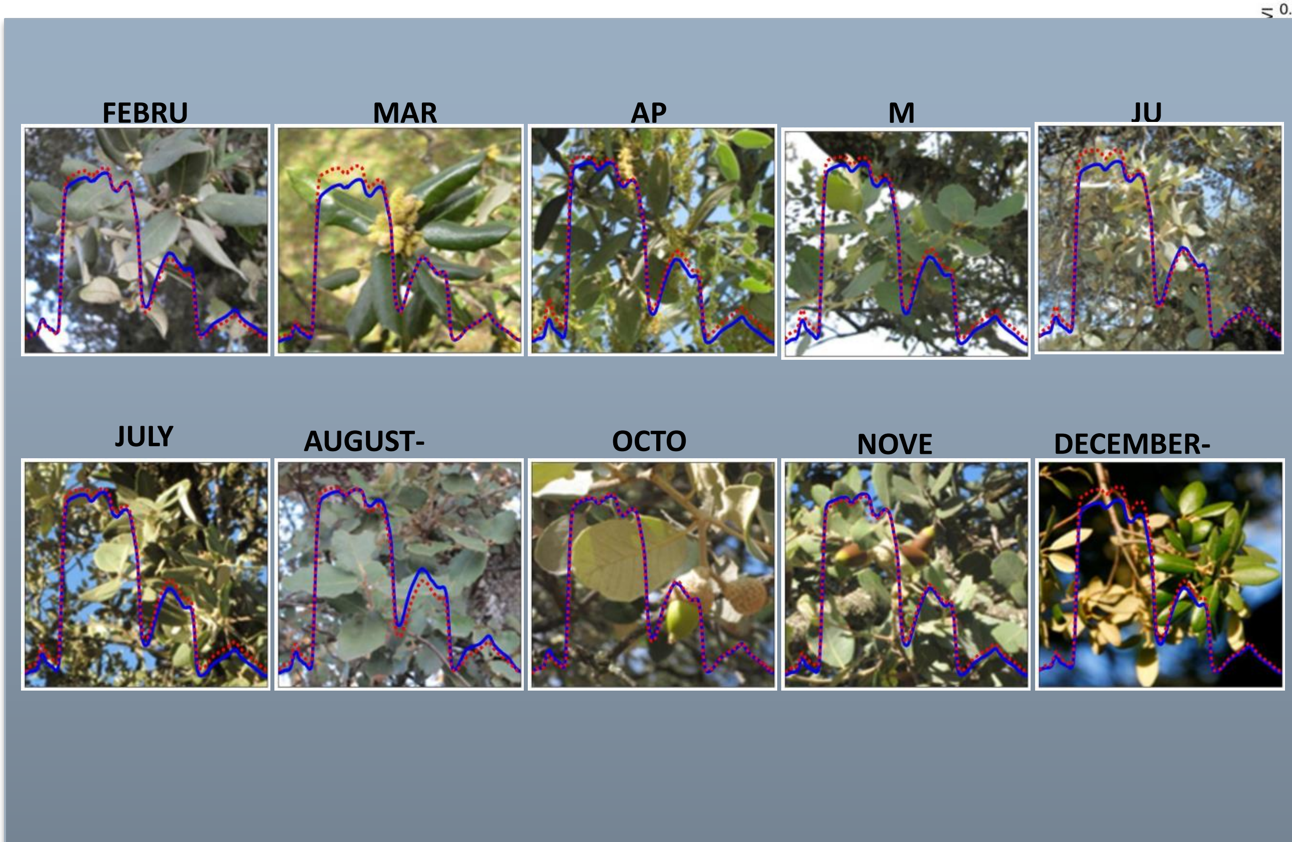
	Parameter	Measurement scale	Sampling interval	Field Measurement tool/method
Block 1: vegetation spatial distribution and phenology	LAI	Canopy/ecosystem	Seasonally adapted (~6/year)	Destructive sampling + hemispherical photo + terrestrial lidar+ Apogee MQ-306
	fCover	Canopy/ecosystem	once (Biospec)	Aerial Photography
	canopy structure + vegetation height	Canopy/ecosystem	Once (Biospec) + AMSPEC-MED area	Forest inventory sampling + LIDAR (PNOA)
Block 2: Vegetation condition/status	Chlorophyll	Leaf (only trees)	Seasonally adapted (~6/year)	SPAD+ spectrophotometer (calibration)
	water content (EWT, CWC, FMC)	Leaf	Seasonally adapted (~6/year)	Destructuvie sampling, gravimetric methods
	Biomass	Canopy	Seasonally adapted (~6/year)	Destructive sampling
	Carbon and Nitrogen and other nutrients	Leaf	Seasonally adapted (~6/year)	Destructuctive sampling + laboratory

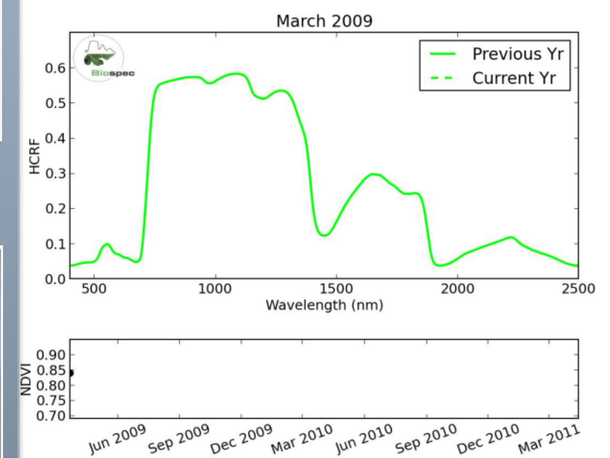
Field spectroscopy. Starting point! Where, when, how to measure?

- Temporal sampling:
  - Phenology
  - Simultaneous to other spectral measurements
    - Calibration
    - Upscaling
  - Meteo conditions
- Spatial sampling:
  - Spatial variability of the target vegetation parameteres
  - Spatial distribution of the calibration targets according to flight plan and spatial resolution of the images
- Data acquisition protocols
  - Leaf level (Plant probe + leaf clip)
    - Leaf area
  - Canopy level: grass and tree canopies
    - Transects, point measurements…..
    - Logistic problems with trees

Temporal sampling: Grassland/tree phenology

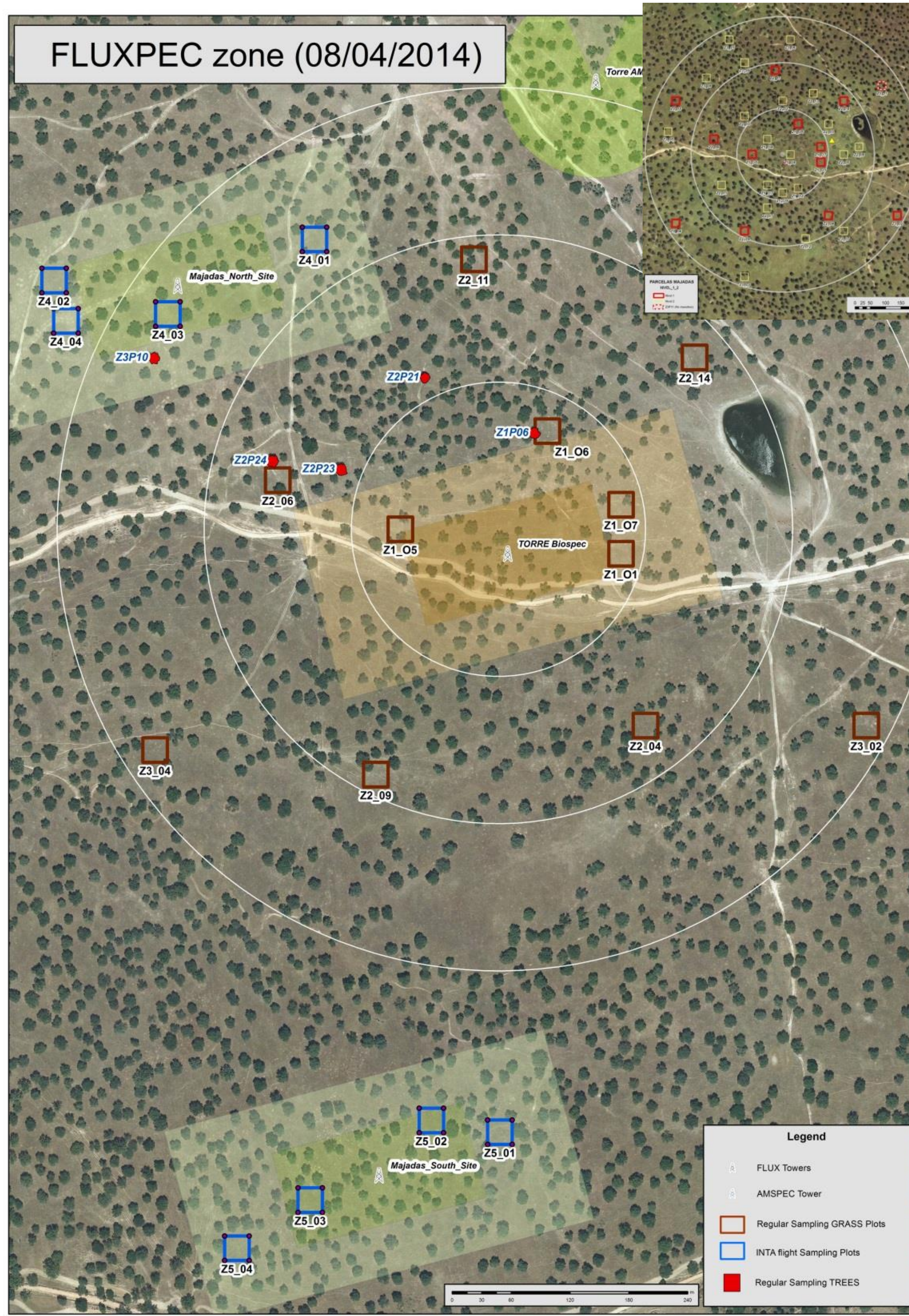






Spatial sampling: spatial variability

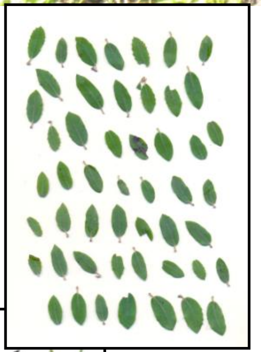
- 25x25 m plots
- Started with 40
- Currently 11 (main tower) + 8 (North and south towers)

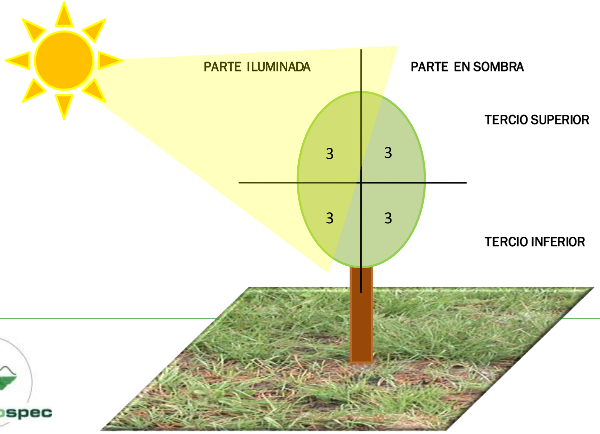


Biospec

How to measure?: definition of protocols

- Different protocols for grassland and trees
- Adapted to research objectives and ecosystem characteristics
  - Difficulties derived from multi-objective projects
- Take into account simultaneous measurements of ancillary data
  - Spectral
  - Other
- Evaluate instrumental and logistic limitations





Grass Plots (regular sampling)

- Instrument: ASD Fieldspec 3 (400-2500 nm)
- 11 plots (+ 4+4) + 2 calibration plots
- 25 x 25 m
  - 2 transects: NE-SW & NW-SE
- Midday measurements
- Full spectra into shaded grass
- About 10-15 spectra per transect
- Adapted protocols under consideration for new project (SynerTGE)

Biospec (2009-2011)
42 days of field work
508 averaged vegetation spectra selected after quality check
- 250 grass plots
- 256 Holm oak leaves

Biospec

FLUXPEC

Holm Oak (regular sampling)

- Leaf level (Leaf clip + plant probe)
  - 10/5 Trees
    - North / South
    - Current / Previous year

    } 6 Leaves/type
- Canopy level
  - Crane: logistic problems
  - Dedicated campaigns
  - UAV mounted miniaturized system will be used in new project SynerTGE to try to
  - overcome this problem

Estimation of biophysical variables using field spectroscopy

- Water content grasslands
- Nitrogen content trees

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doi:10.5194/bg-12-5523-2015

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Seasonal variation in grass water content estimated from proximal sensing and MODIS time series in a Mediterranean Fluxnet site

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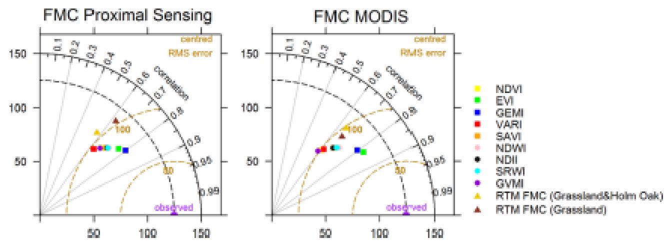

Figure 7. Comparison of empirical vs RTM models to estimate FMC with proximal sensing (left) and MODIS (right). RTM FMC (Grassland) obtained from the LUT proposed by (Yebra et al., 2008b). RTM FMC (Grassland & Holm Oak) obtained from the LUT proposed by Jurdao et al. (2013).

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Understanding the optical responses of leaf nitrogen in Mediterranean Holm oak (*Quercus ilex*) using field spectroscopy

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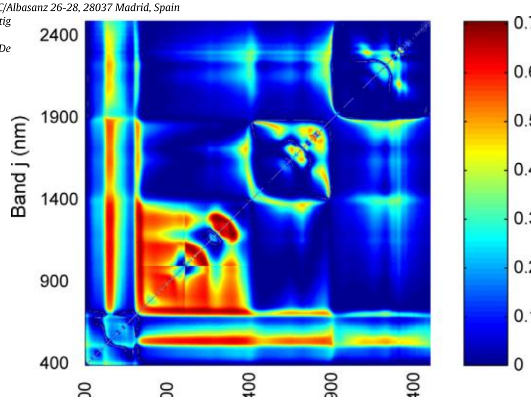
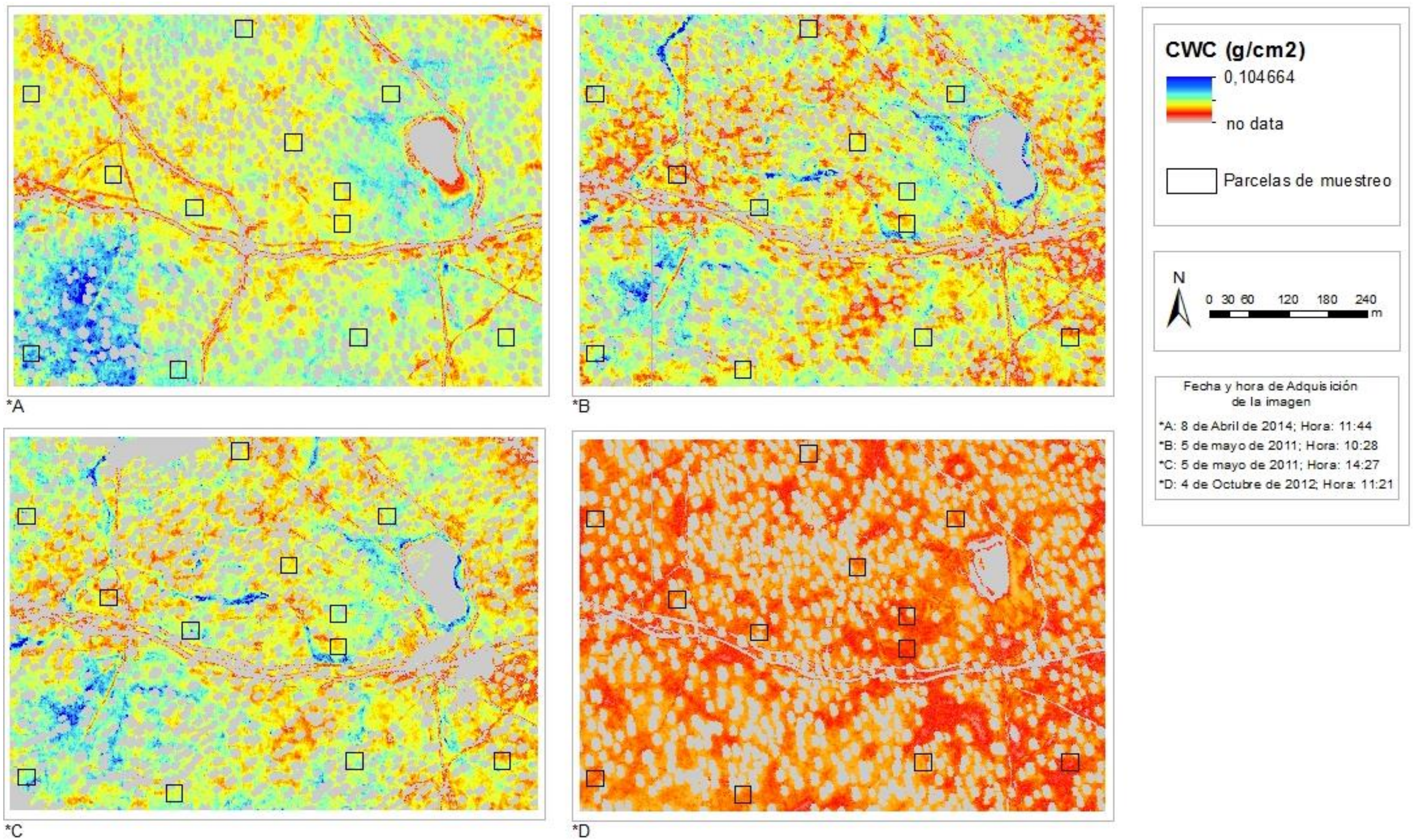


Table 3
Validated NDIs. Band combinations with the highest coefficients of determination. Absorption bands found at 10 nm distance from the index bands can be related to [P] Protein, [N] Nitrogen bond, [C] Cellulose, [L] Lignin, [O] Others (Source: Burns and Ciurczak, 2008; Curran, 1989; Fourty et al., 1996), [p] protein, [d] cellulose + lignin, [w] water (Source: Jacquemoud et al., 1996, Féret et al., 2008).

Band *i* (nm)	Band *j* (nm)	R^2	RMSE (%) calibration	RMSE (%) validation	Validated indices
735	1285	0.67; [0.54,0.79]	11.07; [8.51,13.93]	8.38	98
825	1120[L]	0.60; [0.44,0.71]	12.13; [9.65,15.31]	10.57	74
915[P]	920[P]	0.67; [0.57,0.78]	11.15; [8.43,14.20]	10.24	110
1050[O]	1100	0.69; [0.55,0.81]	10.76; [7.70,13.58]	11.81	170
1200[C,L,O]	1290	0.71; [0.58,0.80]	10.46; [8.00,13.18]	10.58	270

Biospec

Mapping biophysical parameters of grassland using airborne hyperspectral CASI images



Validation of MODIS products: LAI

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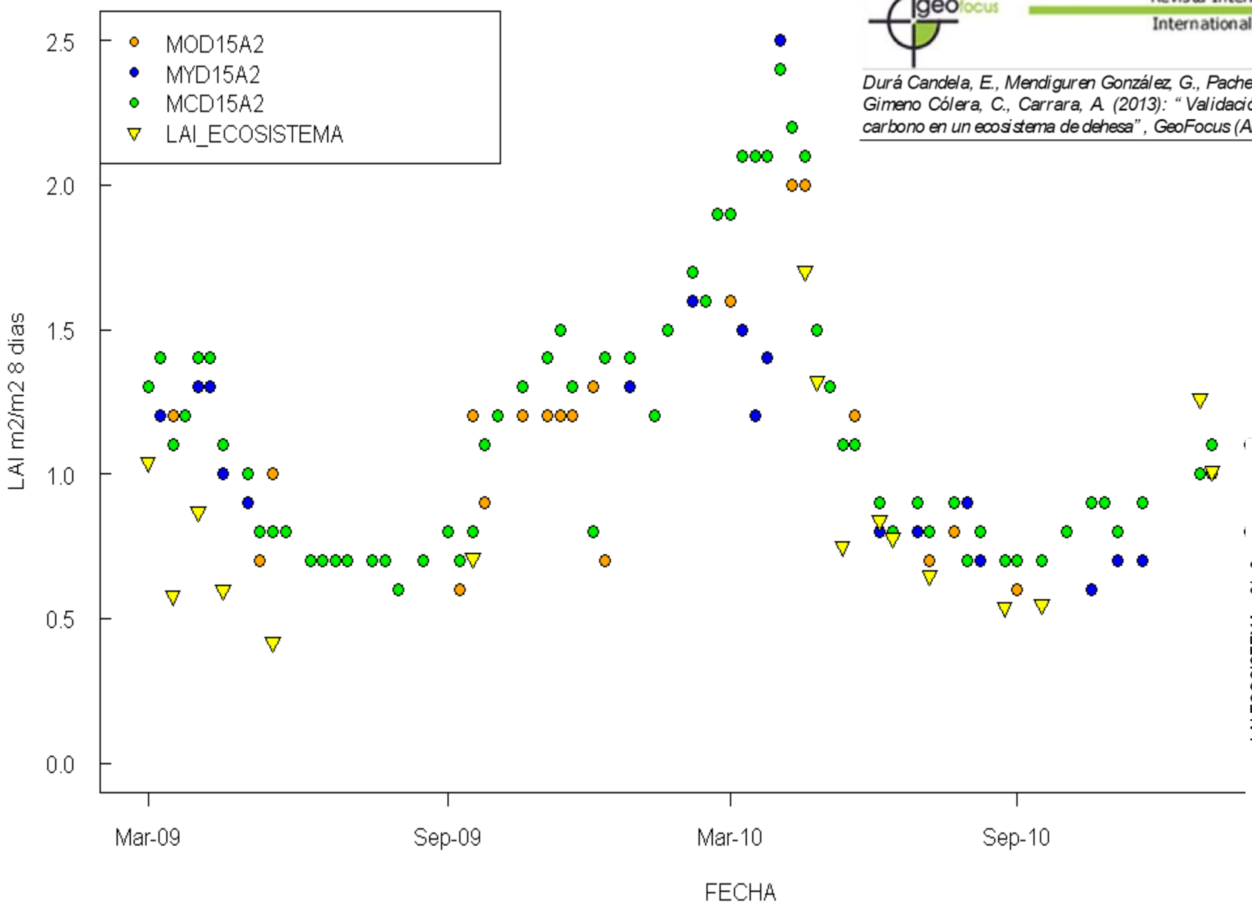
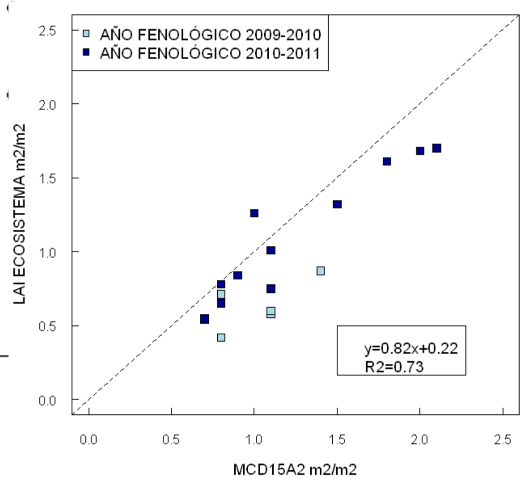
International Review of Geographical Information Science and Technology

Durá Candela, E., Mendiguren González, G., Pacheco Labrador, J., Martín Isabel, M. P., Riaño, D., Iturrate García, M., Gimeno Cólera, C., Carrara, A. (2013): "Validación de productos MODIS relacionados con la estimación de flujos de carbono en un ecosistema de dehesa", GeoFocus (Artículos), nº 13-1, p. 291-310. ISSN: 1578-5157



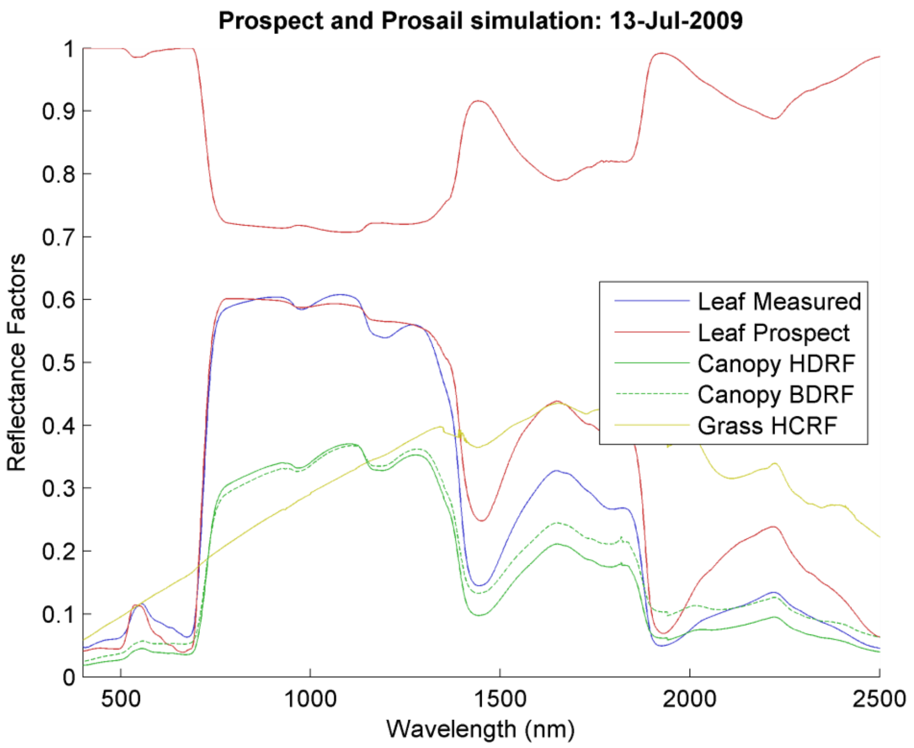


Modeling Carbon fluxes

- Modeling GPP through (field) spectral information using LUE and Spectral Vegetation Index based models
- Using BIOSPEC field spectral data
  - 22 Field campaigns
    - Including 12 measurements in the calibration plots (PCAL)
  - Modelling Ecosystem Reflectance
    - Mean grass spectra
    - Simulated Holm oak canopy reflectance (Validation with Landsat imagery)

$$\rho_{Eco} = 0.2 \cdot \rho_{HDRF\,Trees} + 0.8 \cdot \rho_{HCRF\,Grass}$$

    - Ecosystem reflectance
  - GPP estimated using different models and sensors



Pacheco-Labrador, J., Martín Isabel, M.P., (2014). Up-scaling gross primary production in a Mediterranean savanna (dehesa) ecosystem using field spectroscopy and radiative transfer models, ForestSat 2014, 4-7 November 2014. Riva del Garda, Italy.

THANKS FOR YOUR ATTENTION!

Questions?

http://www.lineas.cchs.csic.es/biospec/

http://www.lineas.cchs.csic.es/fluxpec/