UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Instituto de Ingeniería del Agua y Medio Ambiente

On the importance of remote sensing data to implement a dynamic vegetation model applied to a semi-arid experimental plot

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Introduction

- **The vegetation plays a key role** in a catchment's water balance, particularly in semi-arid areas (Laio et al., 2001)
- In these water-controlled areas, the vegetation controls the water cycle through (Rodriguez-Iturbe et al., 2001):
  - Interception
  - Infiltration
  - **Evapotranspiration**

  => Surface runoff

  => Groundwater recharge

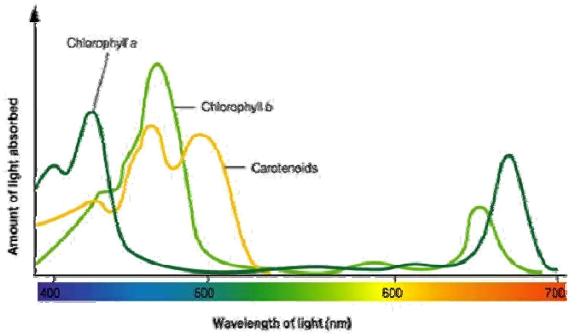
In semi-arid regions, the actual evapotranspiration may account for more than 90% of the precipitation → The proper knowledge of this process is vital (Andersen, 2008)

Introduction

- Traditionally, most of hydrological models assume an **static vegetation**
- But, in the last decades, the number of hydrological models taking into account the **vegetation dynamics** has increased substantially

COMPLEX MODELS	SIMPLE MODELS
➢ Accurate description of the processes ➢ Sensation of total reliability ➢ High number of parameters ➢ High data requirement	➢ Processes are schematised ➢ Low number of parameters ➢ Lower data requirement + Remote Sensing Data

Introduction



- The advantages of **remote sensing** (including vegetation) are:
  - Spatial coverage
  - Allows gathering information about inaccessible sites
  - Replaces costly data collection on the ground
  - Nowadays, some time series are relatively large
- Disadvantage: higher uncertainty than field observations
- The use of remote sensing data in calibration leads to improved the prediction (Zhang et al., 2011)
- Most of the studies → satellite data combined with field data

Research questions

- Is a parsimonious and simple model **suitable** to reproduce vegetation dynamics in semi-arid environments?

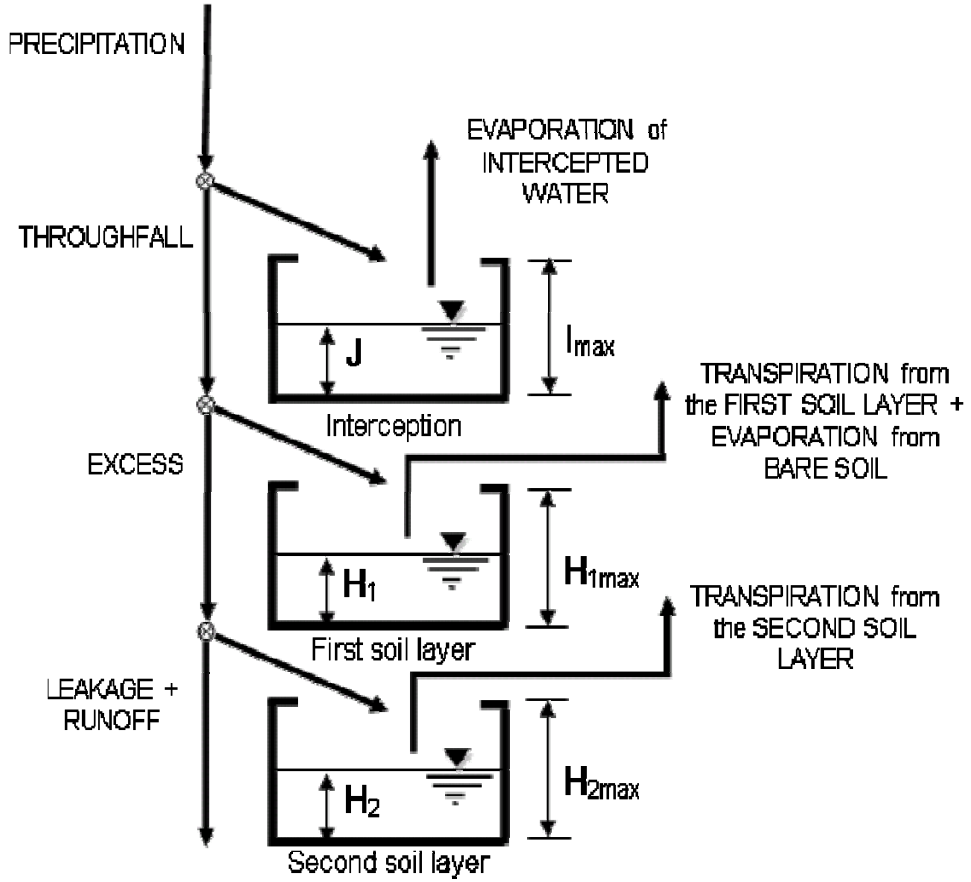
- Can we really use **satellite data alone** to implement this simple dynamic vegetation model?

Methodology/outline

- Description of the case study:
  - selected parsimonious vegetation model (for semi-arid environments)
  - study area: Aleppo pine experimental plot in La Hunde forest (East Spain)
- Calibration of the model using satellite data
- Validation of the results using field data:
  - Transpiration
  - Soil Water Content
- Analysis of results and conclusions

LUE model

Hydrological sub-model



Water balance:

Interception storage

$$\frac{dJ}{dt} = I - \min\left(ET_o \cdot f_t, J\right)$$

First soil layer

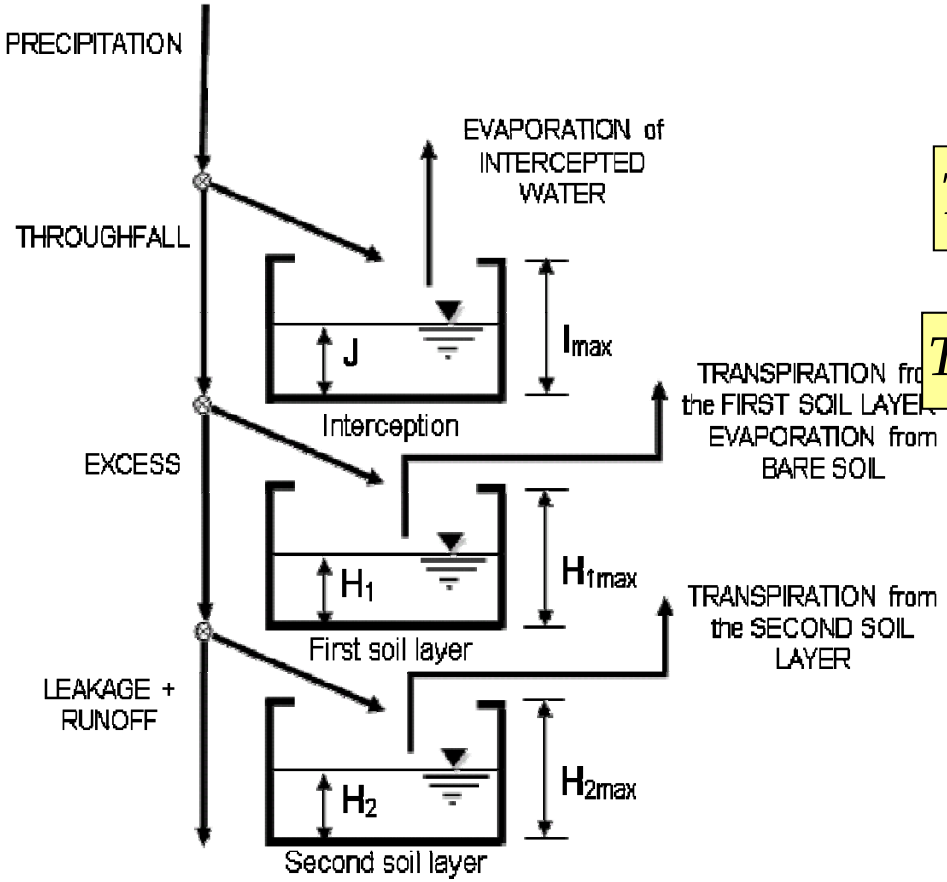
$$\frac{dH_1}{dt} = \left(P - I\right) - D - E - T_1$$

Second soil layer

$$\frac{dH_2}{dt} = D - L - T_2$$

LUE model

Hydrological sub-model



Transpiration

FAO: $T = ET_o \cdot \lambda_v \cdot \lambda_s$

$$T_1 = ET_o \cdot f_t \cdot \min\left(LAI, 1\right) \cdot \beta_t\left(H_1\right) \cdot r_1$$

$$T_2 = ET_o \cdot f_t \cdot \min\left(LAI, 1\right) \cdot \beta_t\left(H_2\right) \cdot \left(1 - r_1\right)$$

Bare Soil Evaporation

$$E = ET_o \cdot f_b \cdot \beta_b\left(H_1\right)$$

LUE model

Dynamic Vegetation sub-model

$$\frac{dB_l}{dt} = \left(LUE \cdot \varepsilon \cdot APAR - \mathrm{Re}\right) \cdot \varphi_l - \kappa_l \cdot B_l$$

LEAF BIOMASS

B_l [kg DM m^{-2} veg cover]

LIGHT USE EFFICIENCY

LUE [kg DM m^{-2} MJ^{-1}]

ε depends on:

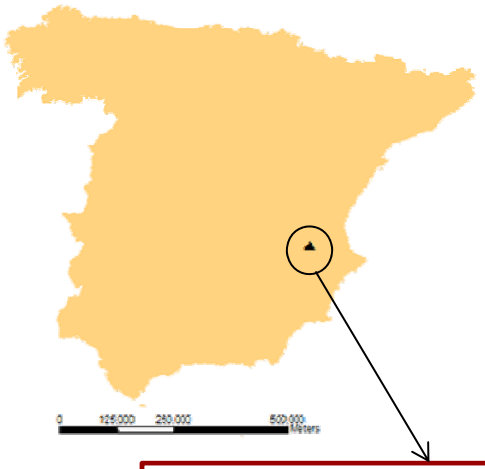
- Water Stress => connection with hydrological model
- Temperature

$$LAI = B \cdot SLA \cdot f_t$$

$$LAI_r = LAI \cdot \left(1 - \overline{\zeta_{10}}\right) \longrightarrow$$

Corrected to be compare with NDVI

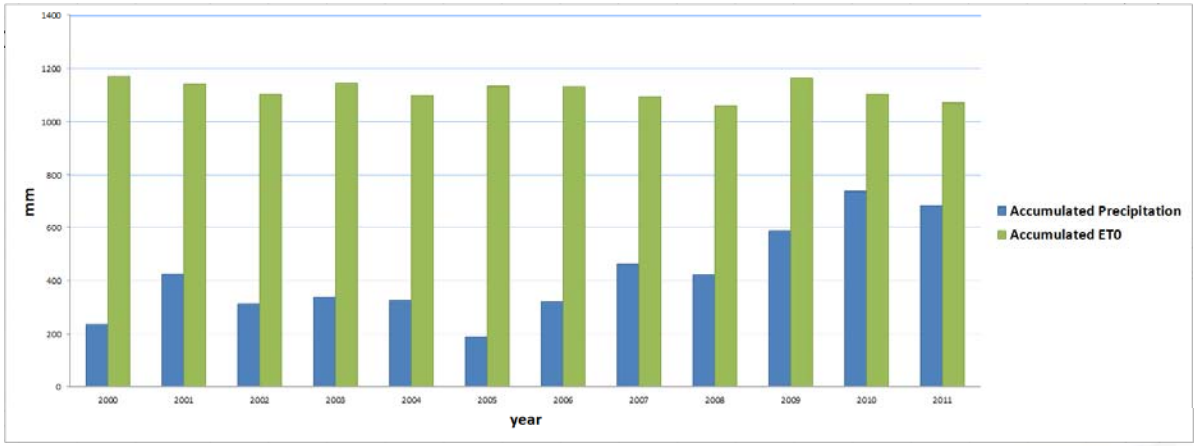
Study Area



- Mediterranean semiarid climate:
  - Water-controlled area
  - Seasonality
- Aleppo pine

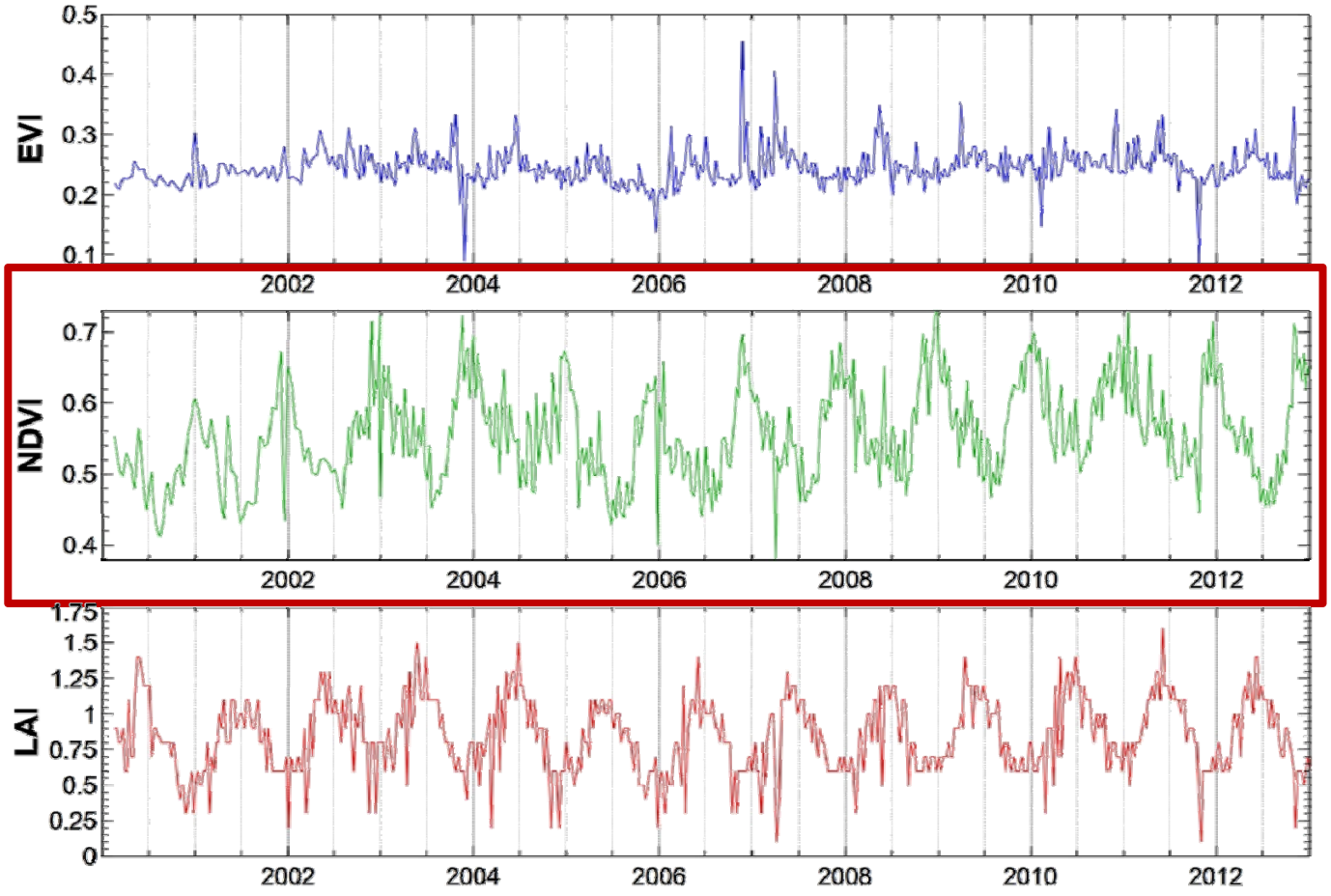
Experimental plot location

Annual average **precipitation** → 419mm
Annual average **ET_0** → 1,118mm



Satellite Data

MODIS PROCESSED DATA BY NASA:



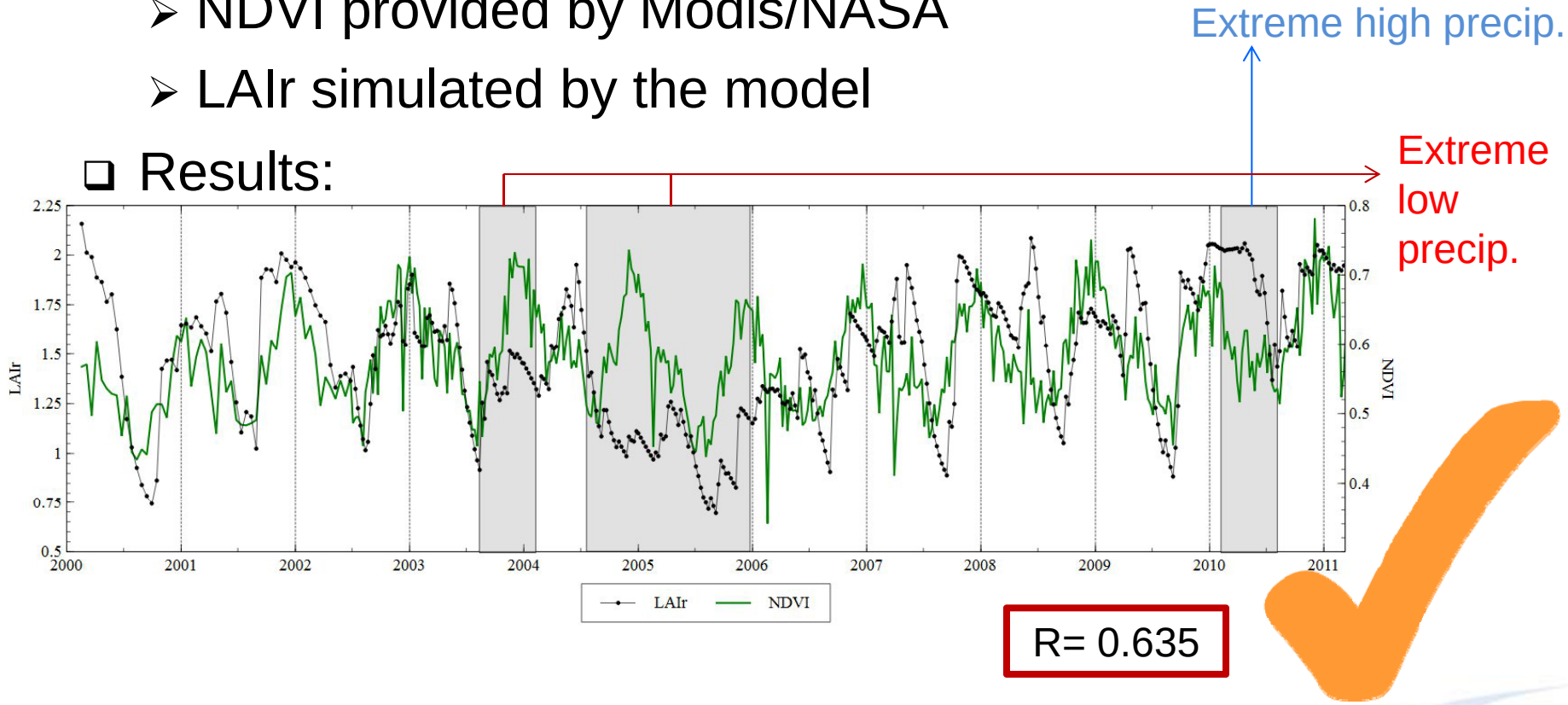
EVI
250m; 16days
No sense!

NDVI
250m; 16days
max_1: Nov/December
max_2: April/May
min: July/August

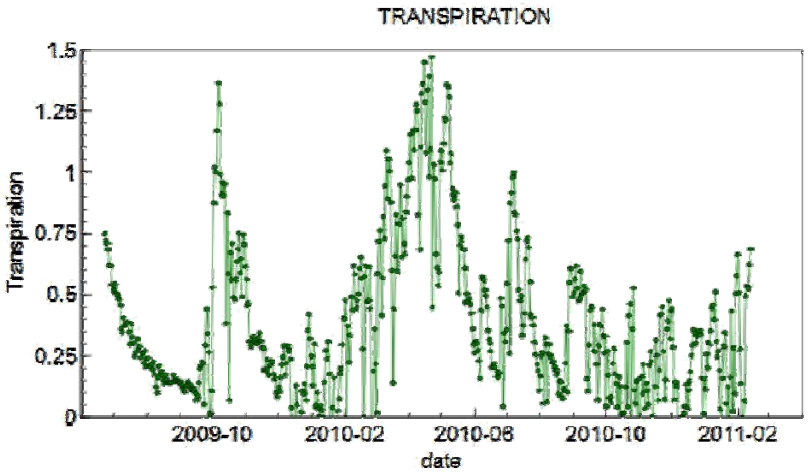
LAI
1km; 16days
max: March/May
min: Nov/January
Inconsistent with field data!

Calibration

- Automatic calibration using a genetic algorithm (Evolver)
- Objective function: Pearson correlation coefficient
  - NDVI provided by Modis/NASA
  - LAIr simulated by the model
- Results:



Field data



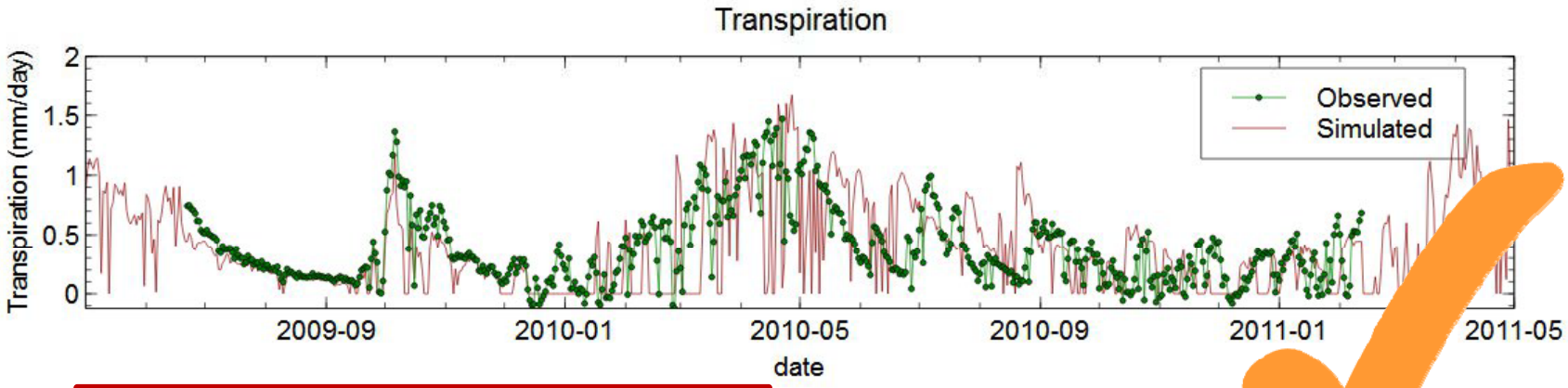
TRANSPIRATION

- Sap flow sensors → Heat-Ratio Method
- 4 trees with 3 diameter classes

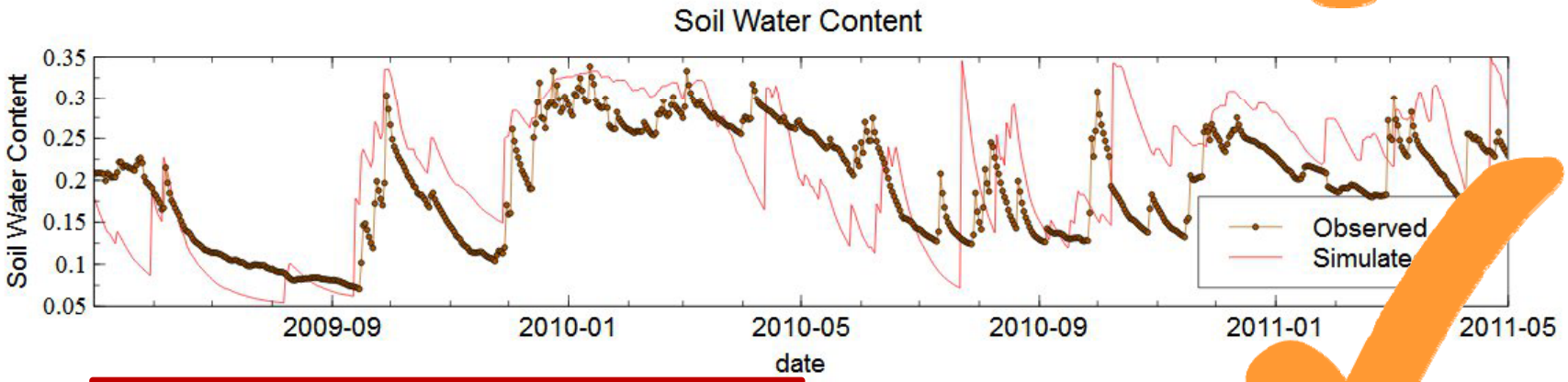
SOIL WATER CONTENT

- Soil moisture sensors
- 30cm depth
- 9 sensors: 6 with tree's direct influence and 3 without

Validation



R= 0.69 RMSE= 0.274 E=0.34



R= 0.72 RMSE= 0.05 E= 0.65

Conclusions

- Is a dynamic model of vegetation really necessary?

DYNAMIC VEG.

Flows	Dry year (2005)		Medium year (2008)		Wet year (2010)	
	mm	%	mm	%	mm	%
Ppt	188		420.6		739	
ET (EI+T+Es)	165.18	**91.0**	331.84	**77.6**	431.87	**56.9**
Excedence	16.34	9.0	95.88	22.4	326.93	43.1
Blue/Green	**0.098**		**0.289**		**0.757**	

STATIC VEG.

Flows	Dry year (2005)		Medium year (2008)		Wet year (2010)	
	mm	%	mm	%	mm	%
Ppt	188		420.6		739	
ET (EI+T+Es)	147.00	**81.4**	302.32	**70.6**	385.37	**50.9**
Excedence	33.47	18.6	126.02	29.4	370.99	49.1
Blue/Green	**0.227**		**0.417**		**0.963**	

Conclusions

- Reliable estimates of spatial and temporal variations of actual evapotranspiration as well as precipitation are vital to obtain reliable estimates of the available water resources => in some situations it can be necessary to deal with the **vegetation dynamics**
- A **parsimonious model** is able to adequately reproduce the dynamics of vegetation and also reproduces properly the soil moisture variations
- **NDVI data alone** can be used to implement this model, including hydrological parameters. Satellite data is an alternative to calibrate models at ungauged or inaccessible areas/catchments

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Many thanks for your attention

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