UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Re-ForeST research group in forest science and technology

Instituto de Ingeniería del Agua y Medio Ambiente

Mediterranean Vegetation-Water Interactions: A Model Comparison At Different Scales

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THE ROLE OF RESEARCH

Introduction

- **The vegetation plays a key role** in a catchment's water balance particularly in Mediterranean 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
  - Consequently, groundwater recharge

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

Introduction

- Traditionally, very few hydrological models had incorporated the **vegetation dynamics**
- But, in the last decades, the number of hydrological models taking into account the vegetation development has increased substantially

COMPLEX MODELS	SIMPLE MODELS
➢ Accurate description of the processes ➢ Sensation of total reliability ➢ High number of parameters ➢ High data requeriment	➢ Processes are schematised ➢ Low number of parameters ➢ Low high data requirement

Research questions

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

- Is a parsimonious and simple model suitable to reproduce properly the fluxes of the water cycle?

- In which scale can this model be used?

Methodology/outline

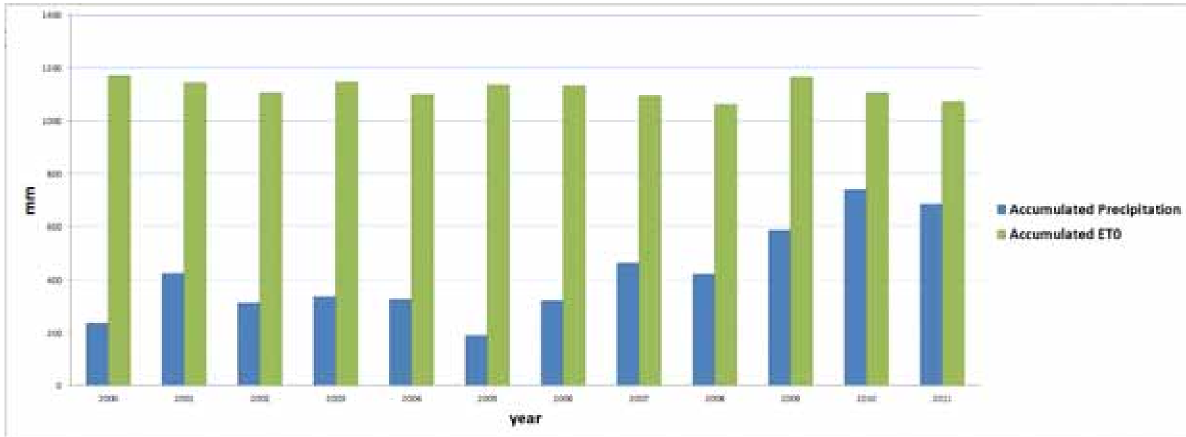
- Description of the case study:
  - Study area: Aleppo pine experimental plot in La Hunde forest (East Spain)
  - Proposed parsimonious vegetation model (LUE-Model)
  - Selected complex vegetation model with successful results in the study area (Biome-BGC)
- Implementation of both models using field data
  - Transpiration
  - Soil Water Content
- Analysis of results and conclusions

Study Area

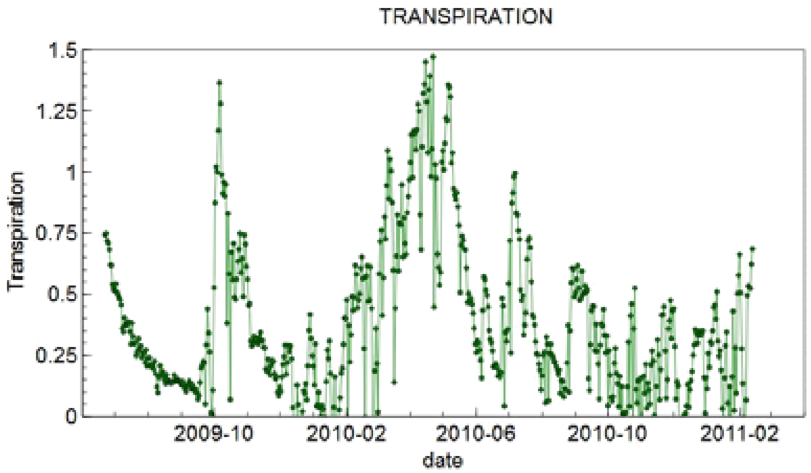
- Mediterranean semiarid climate:
  - Water-controlled area
  - Seasonality
- Aleppo pine

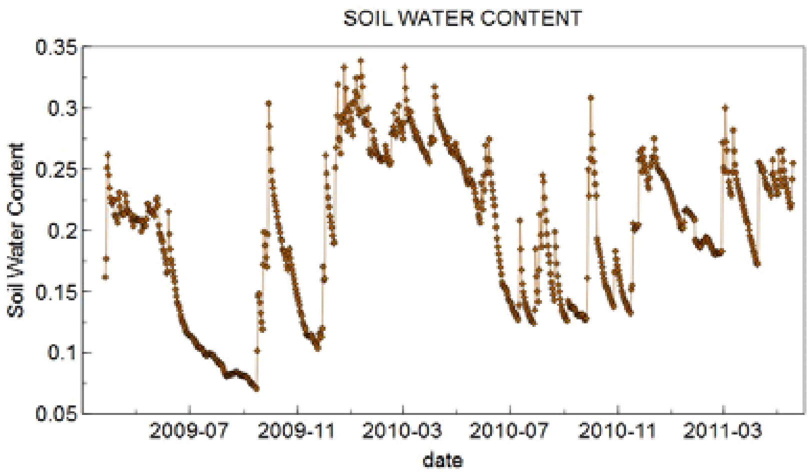
Experimental plot location

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



Field data





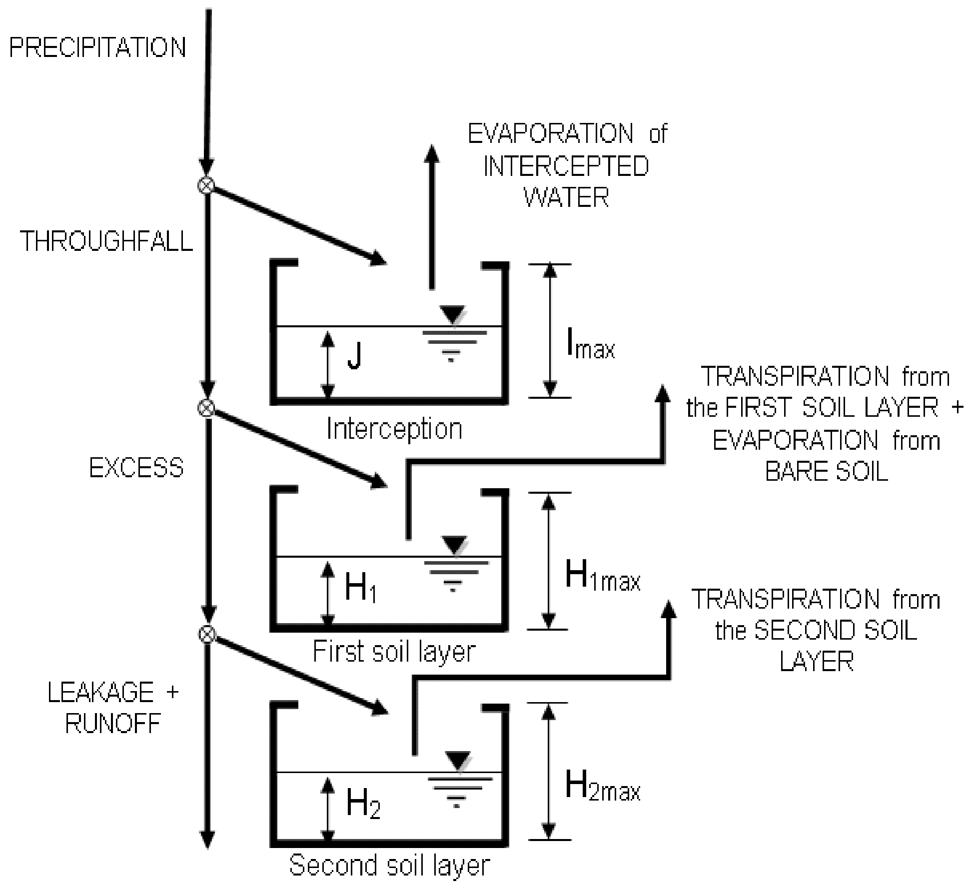
TRANSPIRATION

- Sap flow sensors
  → Heat-Ratio Method
- 4 Trees. Three theoretical diameter classes

SOIL WATER CONTENT

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

Hydrological sub-model



Water balance

First soil layer

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

Second soil layer

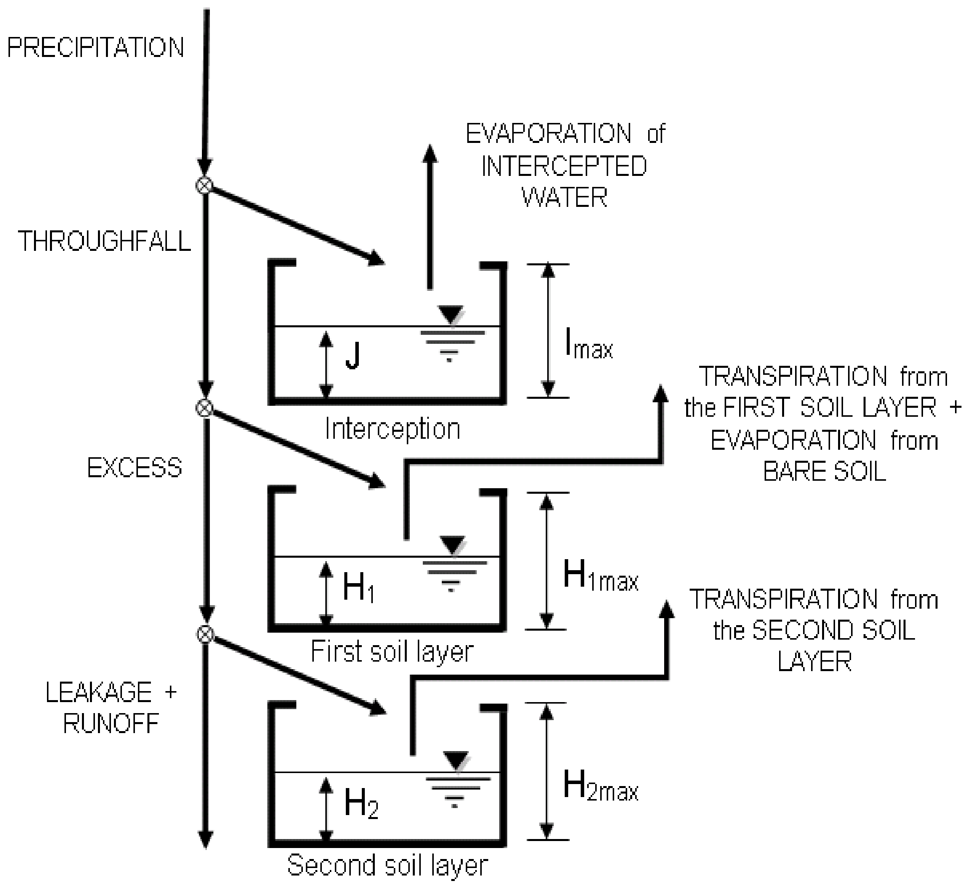
$$\frac{dH_2}{dt} = D - L - T_2$$

Interception storage

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

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

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

$$\varphi = 1 - \frac{LAI}{LAI_{\max}}$$

LEAF BIOMASS
B_l [kg DM m^{-2} vegetal cover]

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

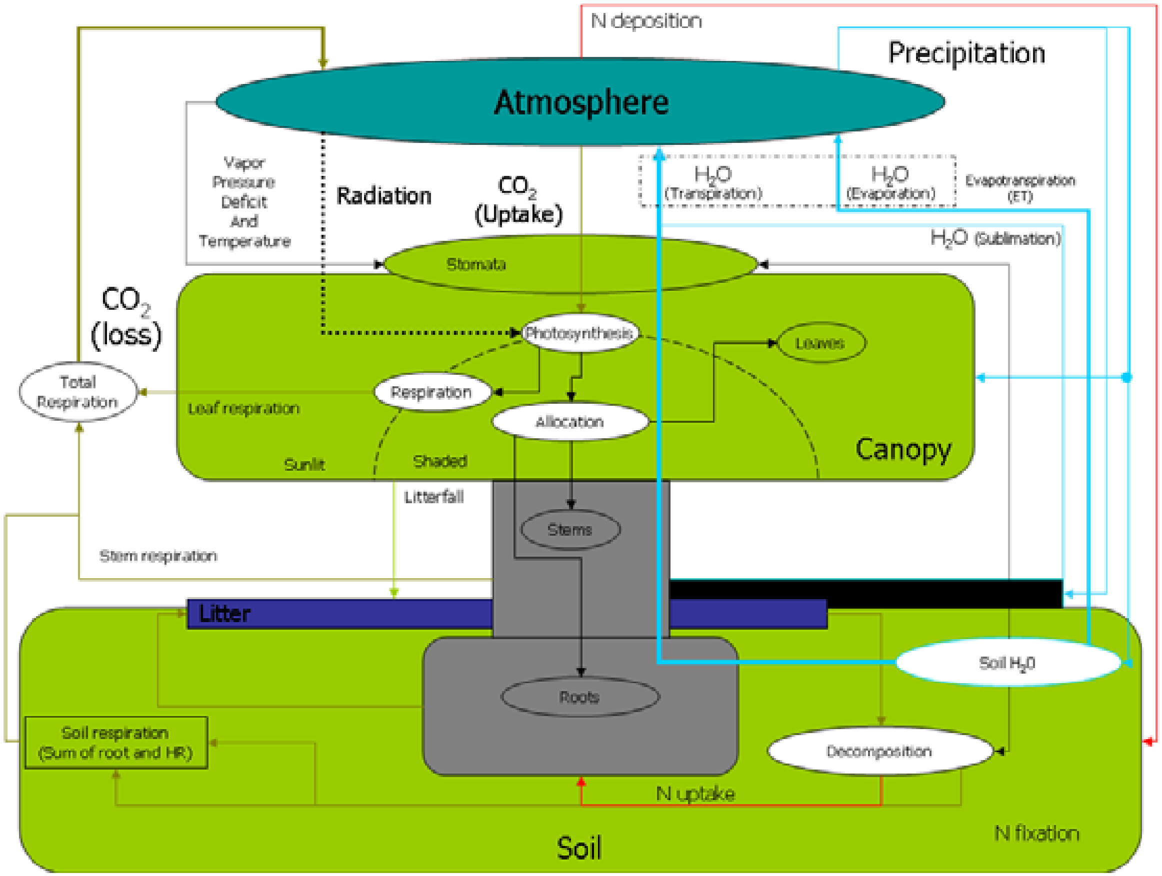
ε depends on:

- Water Stress => connection with hydrological model
- Temperature

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

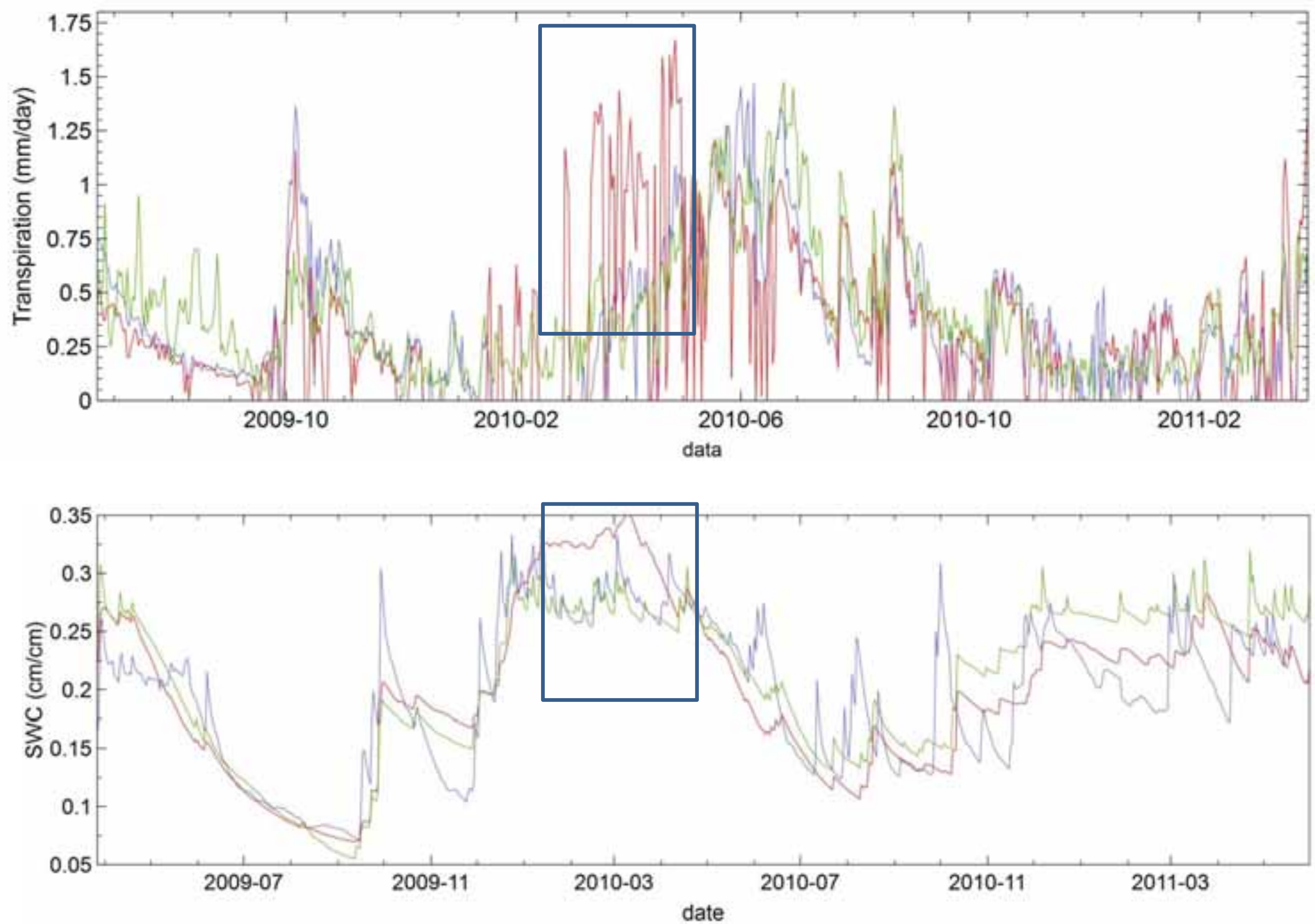
Biome-BGC model

Ecosystem Process Model ⟶ Physical and Biological Processes



Source: Numerical Terradynamic Simulation Group. Montana University.
http://www.ntsg.umt.edu/project/biome-bgc.

Implementation of the models



LUE-MODEL
RMSE= 0.360 E=0.34

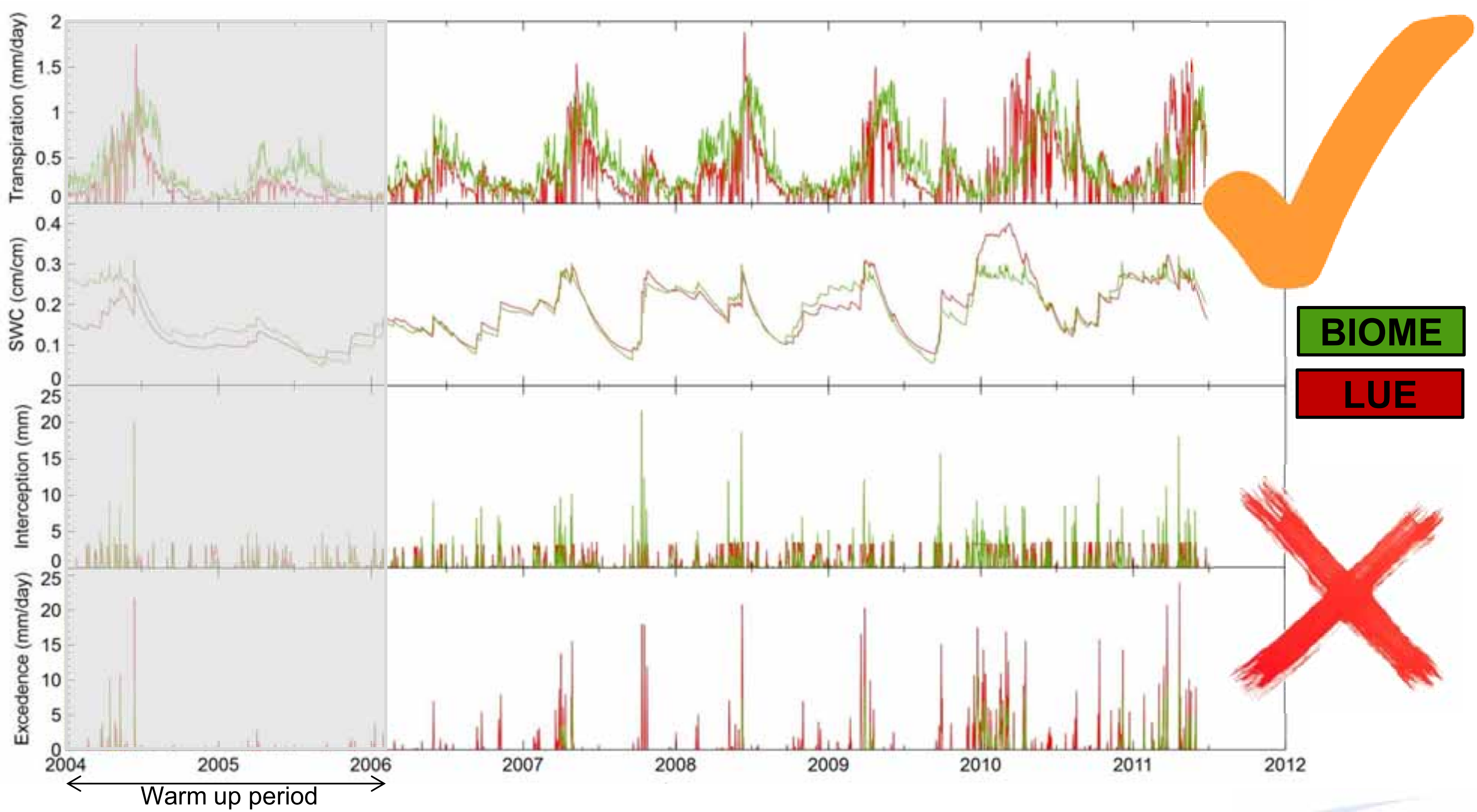
BIOME-BGC
RMSE= 0.282 E=0.64

LUE-MODEL
RMSE= 0.06 E=0.42

BIOME-BGC
RMSE= 0.05 E=0.517

FIELD **BIOME** **LUE**

Comparison between models



Comparison between models

LUE-MODEL
Applied at plot scale

Flows	Dry year (2005)		Wet year (2010)	
	mm	%	mm	%
Ppt	188		739	
ET (EI+T+Es)	165.18	87.86	431.87	58.44
Excedence	16.34	8.69	326.93	44.24
Blue/Green	**0.098**		**0.757**	

BIOME-BGC
Applied in one tree

Flows	Dry year (2005)		Wet year (2010)	
	mm	%	mm	%
Ppt	188		739	
ET (EI+T+Es)	208.46	110.883	543.87	73.59
Excedence	0	0	202.67	27.42
Blue/Green	**0**		**0.373**	

Comparison between models

LUE-MODEL
Applied at plot scale

Flows	Dry year (2005)		Wet year (2010)	
	mm	%	mm	%
Ppt	188		739	
ET (EI+T+Es)	165.18	87.86	431.87	58.44
Excedence	16.34	8.69	326.93	44.24
Blue/Green	**0.098**		**0.757**	

BIOME-BGC
Average of various trees

Flows	Dry year (2005)		Wet year (2010)	
	mm	%	mm	%
Ppt	188		739	
ET (EI+T+Es)	156.30	83.14	408.80	55.32
Excedence	16.34	8.69	330.10	44.67
Blue/Green	**0.104**		**0.807**	

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

- A parsimonious model is able to adequately reproduce the dynamics of vegetation and also reproduces properly the soil moisture variations

- The parsimonious LUE-model must be used at plot scale as shown with the comparison between the LUE and Biome-BGC models

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Thanks for your attention

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