Application of a simple dynamic vegetation model to an experimental plot and validation through satellite data and field observation

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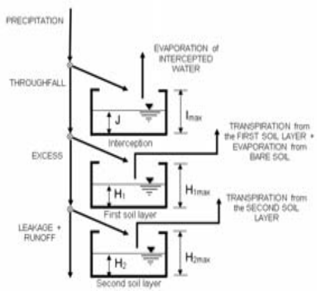
INTRODUCTION

It is important to include the vegetation development as a state variable in the hydrological models. Frequently, these models are complex and they need normally high parameter requirements and they need not always available information. Therefore, parsimonious models, together with available remote sensing information, can be valuable tools to predict vegetation dynamics.

we have focused on the use of the parsimonious and dynamic vegetation LUE-model proposed by [1]. The model was applied in a semi-arid experimental plot covered predominantly by an Aleppo pine forest and it was implemented using remote sensing data (in particular NDVI satellite products) and field observations (transpiration and soil moisture). The main objectives of this work were: (1) calibrate and validate the LUE model using both, satellite and field data; and (2) check the capability of the model to reproduce the vegetation dynamic and hydrological behavior (soil moisture and transpiration).

HYDROLOGICAL SUB-MODEL



Water balance:

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

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

Interception storage:

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

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

Transpiration:

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

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

Bare Soil Evaporation:

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

VEGETATION DYNAMIC SUB-MODEL

LUE-Model

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

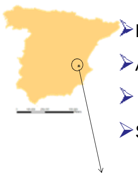
$$\varphi = 1 - \frac{LAI}{LAI_{max}}$$

ε depends on:
Water Stress: **connection with hydrological model**
Temperature

$$LAI = B \cdot SLA \cdot f_t \qquad LAI_r = LAI \cdot \left(1 - \overline{\zeta_{10}}\right)$$

B: leaf biomass [kg DM m^{-2} ground]
LUE: light use efficiency [kg DM MJ^{-1} m^{-2}]
APAR: absorbed photosynthetically active radiation
Re: maintenance respiration [kg DM m^{-2} d^{-1}] [3]
φ: fractional leaf allocation
k: leaf turnover factor
ζ: water stress [2] $\overline{\zeta_{10}}$: 10-days average water stress
LAI_{max}: maximum LAI supported by the system
f_t: fractional vegetation cover
SLA: specific leaf area [m^2 leaf kg^{-1} DM]

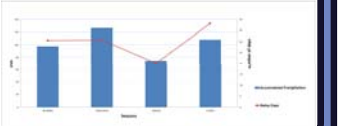
STUDY AREA



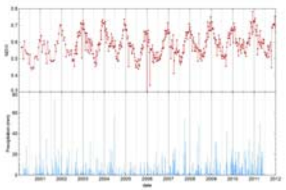
- Mediterranean climate
- Aleppo pine
- Water-controlled area
- Seasonality

Experimental plot location

Annual average precipitation → 419mm
Annual average ET_0 → 1118mm

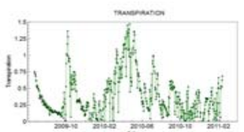


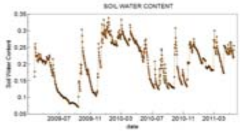
SATELLITE AND FIELD DATA



NDVI
- Maximum values → Winter
- Minimum values → Summer
- Related to chlorophyll content[2]
- To be compared with LAIr:

Chlorophyll content is sensitive to water stress[1]

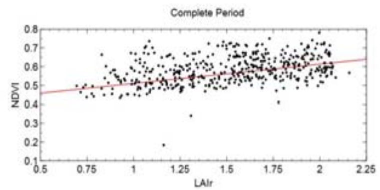




TRANSPIRATION
- Sap flow sensors → Heat-Ratio Method
- Three theoretical diameter classes:
  - Big: 1 selected tree
  - Medium: 2 selected tree
  - Small: 1 selected tree

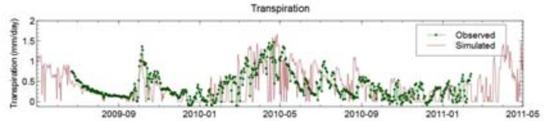
SOIL WATER CONTENT
- Soil Moisture sensors
- 30cm depth
- 9 sensors: 6 with tree's direct influence and 3 without

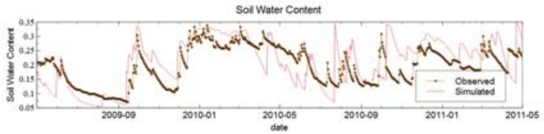
RESULTS

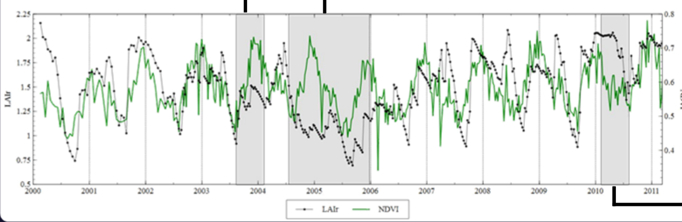


SATELLITE DATA RESULTS
- Complete Period: 01/01/2000 – 30/06/2011
- Calibration Period: 01/06/2009 – 31/03/2011
- Temporal interval:
  - Model → daily
  - Satellite data → weekly
- Correlation coefficient between LAIr and NDVI:
  - Complete Period → 0.499
  - Calibration Period → 0.635

FIELD DATA RESULTS
- Correlation coefficient between observed and simulated:
  - Transpiration: 0.717
  - Soil Water content: 0.859







Very dry periods
↓
The model underestimates the vegetation state

Rainy period
↓
The model overestimates the vegetation state

CONCLUSIONS

Field
- The tested dynamic vegetation model managed to reproduce observed transpiration evolution.
- The model is also capable to reproduce soil moisture dynamics.

Satellite
- NDVI is related to chlorophyll content, which is sensitive to water stress in the analyzed vegetation, resulting in minimum values during summer.
- Taking into account water stress dynamics, the model output LAIr satisfactory reproduces NDVI behaviour.
- The worst results occurs in the most extreme periods (very dry or very wet periods).

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REFERENCES

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