Assessing a parsimonious eco-hydrological model implementation to an Aleppo pine semiarid forest through available remote sensing data

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Instituto de Ingeniería del Agua y Medio Ambiente

Marta Pasquato (marpas@posgrado.upv.es), Chiara Medici (cmedici@princeton,edu) and Félix Francés (ffrances@hma.upv.es)

ABSTRACT

The performance of a parsimonious dynamic vegetation model is tested against MODIS NDVI and EVI satellite information for a semi-arid Aleppo Pine forest area in the SE of Spain.

The model succeeds in reproducing the vegetation dynamics inferred from the satellite data.

INTRODUCTION

Arid and semi-arid climate areas represent hot spots in terms of Global Change consequences. In fact, the ecosystems are controlled by water availability, inducing a tight interconnection between the hydrological cycle and the vegetation dynamics [5]. Hence, it is essential to model these two systems concurrently. However, frequently, the available information is quite limited. Therefore, satellites are a valuable source of information that can be used to assess vegetation condition and model performance. Remote-sensing data, however, supply indirect information that need to be carefully interpreted.

MODEL

$$\frac{dB}{dt} = (LUE \cdot \varepsilon \cdot APAR - \mathrm{Rc}) \cdot \varphi - k \cdot B$$

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

Connection with hydrological model

$$LAI_{mod} = B \cdot SLA \cdot f_c \qquad LAI^*_{mod} = LAI_{mod} \cdot (1 - \overline{\zeta_{10}})$$

B: leaf biomass [kg DM m^{-2} ground]

LUE: light use efficiency [kg DM MJ^{-1} m^{-2}]

APAR: absorbed photosynthetically active radiation [MJ m^{-2} d^{-1}]

Re: maintenance respiration [kg DM m^{-2} d^{-1}] [6]

φ: fractional leaf allocation

k: leaf turnover factor

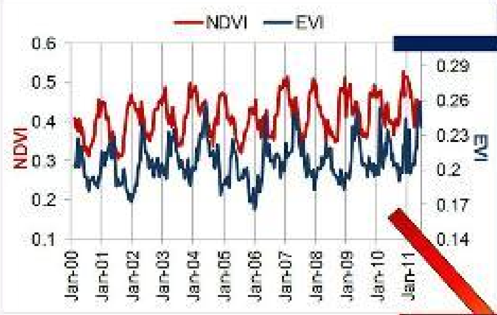
ζ: water stress [4]; $\overline{\zeta_{10}}$: 10-days average water stress

LAI_{max}: maximum LAI supported by the system

f_c: fractional vegetation cover

SLA: specific leaf area [m^2 leaf kg^{-1} DM]

SATELLITE DATA



NDVI

maximum values → winter

minimum values → summer

Related to chlorophyll content [2]

To be compared with simulated LAI_{mod} (chlorophyll is sensitive to water stress) [1]

EVI

maximum values → spring

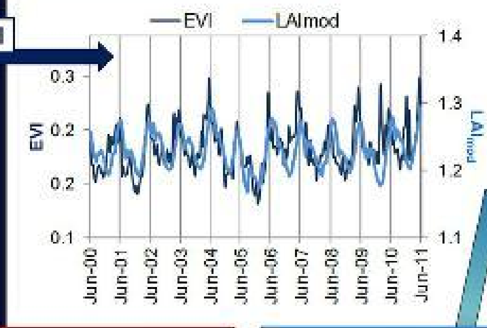
minimum values → winter

Related to vegetation structure and LAI [2]

To be compared with simulated LAI^*_{mod}

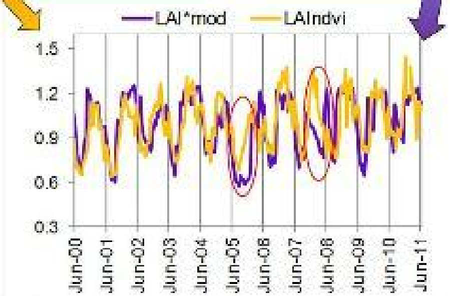
RESULTS

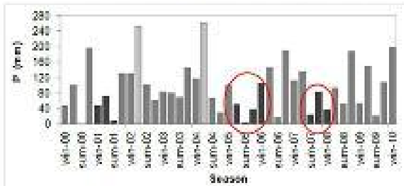
EVI



$$LAI_{NDVI} = -\frac{1}{k} \ln \frac{NDVI_{sat} - NDVI}{NDVI_{sat} - NDVI_{back}} \; [3]$$

$$LAI^*_{mod} = LAI_{mod}\left(1 - \overline{\zeta_{10}}\right)$$





Pearson correlation coefficient:

LAI_{mod} vs. EVI → r = 0.57

LAI^*_{mod} vs. LAI_{ndvi} → r = 0.60

Both LAI_{mod} and LAI^*_{mod} manage to reproduce behaviour and seasonal timing of EVI and LAI_{ndvi} respectively.

CONCLUSIONS

- EVI dynamics are known to reflect LAI changes. In fact, in the study area peaks were registered in spring in accordance with Aleppo Pine local phenology;
- NDVI is related to chlorophyll, which is sensitive to water stress in the analyzed vegetation, resulting in minimum values during summer;
- The tested vegetation model managed to reproduce LAI (and EVI) evolution through the variable LAI_{mod};
- Taking into account water stress dynamics, the model output LAI^*_{mod} satisfactorily reproduce NDVI behaviour .

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