How relevant is the interannual vegetation's dynamic in the water cycle at catchment scale?

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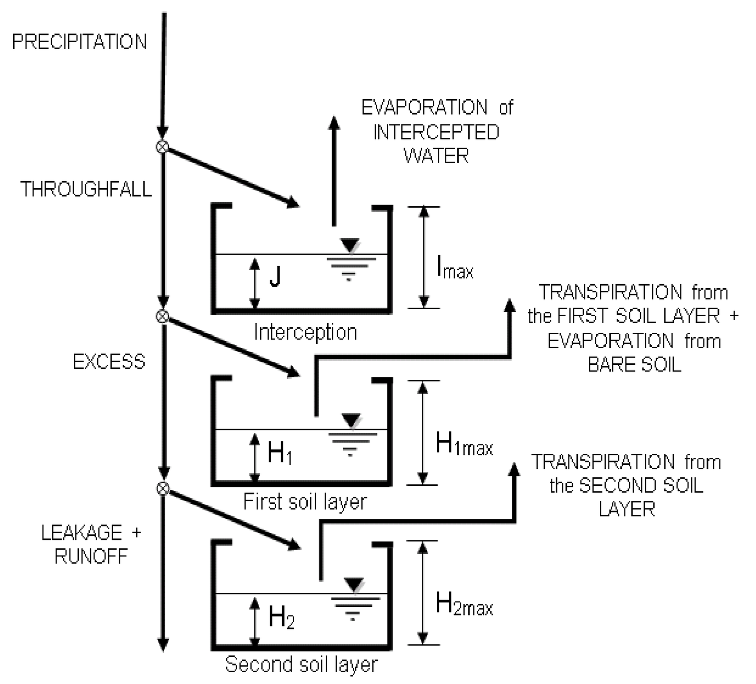
INTRODUCTION

A better understanding of the components of catchments' water balance has traditionally been one of the main objectives of the hydrological community. To this end, it is certainly well-known that the vegetation plays a key role in a catchment's water balance particularly in semi-arid areas (Laio et al., 2001). The vegetation key role on controlling the hydrological cycle is such that the actual evapotranspiration may account for more than 90% of the precipitation (Pilgrim et al., 1988; Huxman et al., 2005). From here that 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 (Andersen, 2008).

In this work we want to analyze the differences between the water balance simulated by using a dynamic vegetation model or a static vegetation model. We calculate the annual runoff coefficient and the blue-green ratio in order to answer the question: should the vegetation be included as a state variable in hydrological modelling?

HYDROLOGICAL 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 MODEL

LUE-Model

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

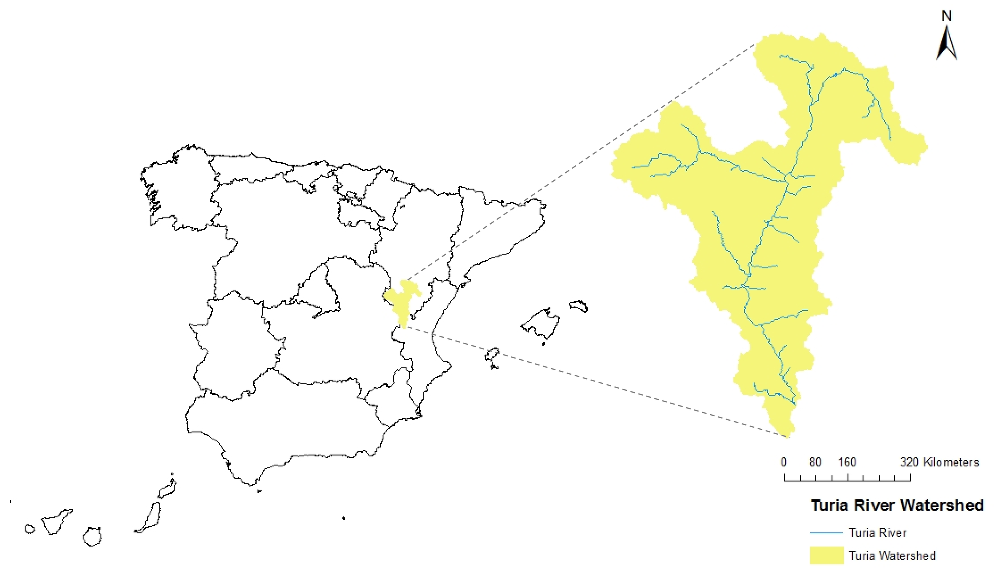
$$\varphi = 1 - \frac{LAI}{LAI_{max}}$$

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

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

B: leaf biomass [kg DM m^{-2} ground]
LUE: light use efficiency [kg DM MJ^{-1} m^{-2}]
APAR: absorbed photosynthetically active radiation
Re: maintenance respiration [kg DM m^{-2} d^{-1}] [3]
φ: fractional leaf allocation
k: leaf turnover factor
ζ: water stress [2] ζ_{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]

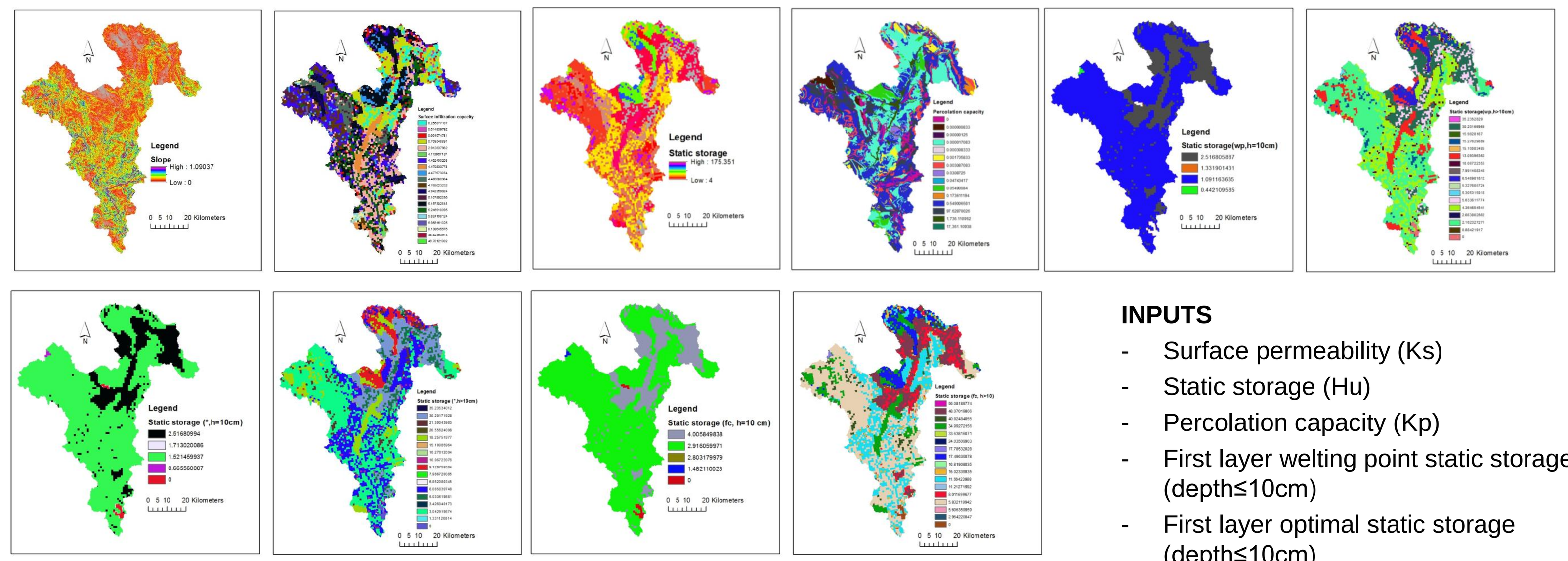
STUDY AREA

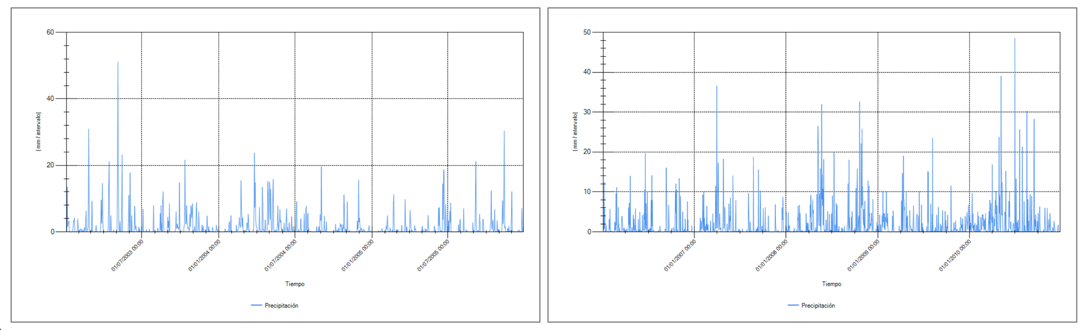


Characteristics

- Drainage length = 449.61 km
- Area = 4295 km^2
- Gauges = 105
- Temperature stations = 105
- ET stations = 105
- Radiation Stations = 16
- Reference period=2003-2010
- Regions:
  - Comunidad Valenciana
  - Castilla la Mancha
  - Aragón

DATA AND IMPLEMENTATION



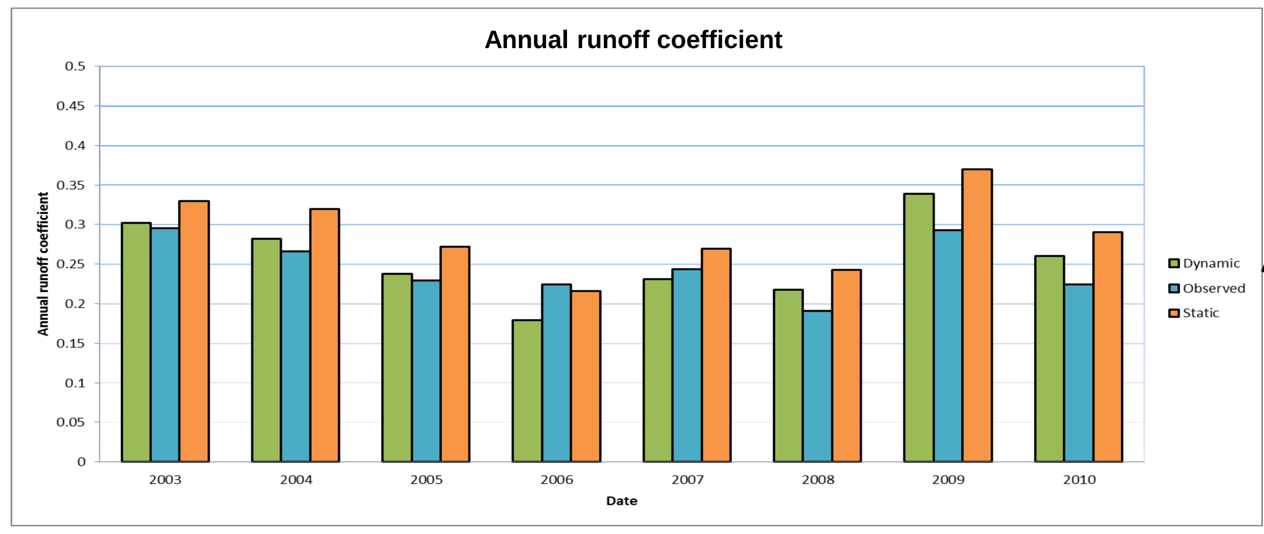


INPUTS
- Surface permeability (Ks)
- Static storage (Hu)
- Percolation capacity (Kp)
- First layer welting point static storage (depths≤10cm)
- First layer optimal static storage (depths≤10cm)
- First layer field capacity static storage (depths≤10cm)
- Second layer welting point static storage (depth >10cm)
- Second layer optimal static storage (depth >10cm)
- Second layer welting point static storage (depth >10cm)
- Precipitation (2003-2010)

RESULTS

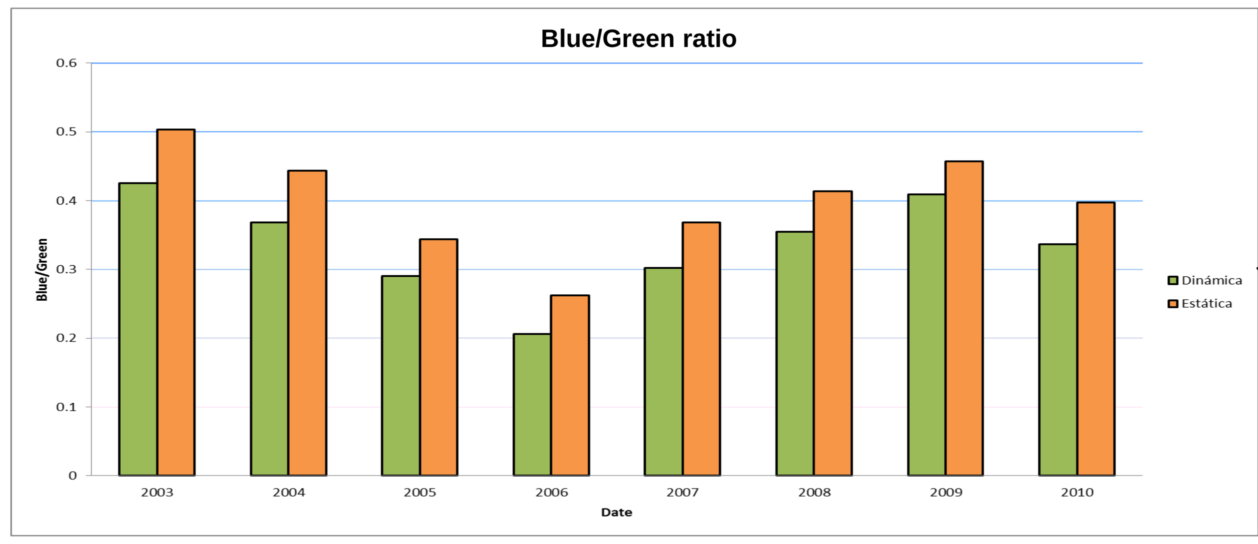
Runoff coefficient:

- The ratio of annual precipitation to runoff
- It can be used to characterize the potential health of the basin
- >0.4 → water rich area
- <0.4 → water stressed area



Blue/Green ratio:

- Available amount of water
- Blue: water in liquid form used for the human needs or which flows out the ecosystems
- Green: water vapor form resulting from evaporation and transpiration processes



STATIC VEGETATION MODEL: UNDERESTIMATION OF THE GREEN WATER

CONCLUSIONS

- Not considering the vegetation's dynamic in semiarid conditions results in the underestimation of the amount of green water.
- Static vegetation model introduces uncertainty in the resulting water balance in present conditions, but also in future climate change scenarios.
- For Water Resources Planning, it is important to consider the dynamic of vegetation, to obtain a better approximation of the amount of the available water along different climatic conditions, also in predictions.
- The inclusion of vegetation as a state variable, will allow the use of satellite information concerning vegetation during the calibration stage.

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