Are ecological and hydrological dynamics important in modelling ecohydrological processes?

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Alicia García-Arias[1] (algarar2@upv.es), Guiomar Ruiz-Pérez[2], Félix Francés[1]

[1] Research Institute of Water and Environmental Engineering, Universitat Politècnica de Valencia (UPV), Valencia, Spain
[2] Department of Crop Production Ecology, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden

APPROACH

VEGETATION ⟳ HYDROLOGY (Both act as driver variables in relevant processes of each other)

Traditional modelling strategies *vs* **ECOHYDROLOGICAL APPROACHES**

- Science gaps: **hydrological modelling** → effects of the **interception** and the **evapotranspiration**
  riparian vegetation modelling → effects of the **water balance in the soil** and the **water table relative position**
- Objectives:
  - To demonstrate the **pivotal role of the vegetation** on the water cycle through an ecohydrological modelling approach
  - To achieve a better understanding of the **hydrological systems** by considering the appropriate **ecohydrological processes related to plants**
- **Main conclusion of this research**: the **capabilities to predict plant behaviour and water balance increase** when **interception** and **evapotranspiration** are taken into account in the soil water balance

Case study 1: main role of vegetation in the water balance

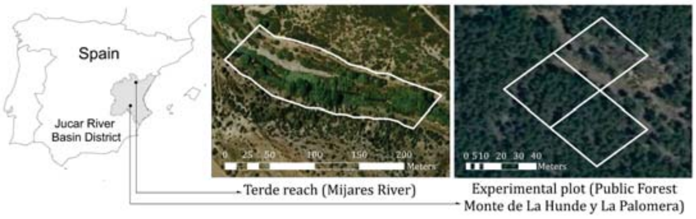
TETIS-VEG (plot scale, terrestrial areas)→ key ecological processes in determine the hydrological fluxes (Pasquato et al., 2015; Ruiz-Pérez et al., 2016)

- Implementation → **Aleppo pine experimental plot of 30X30m** sited in the Public Forest *Monte de La Hunde y La Palomera*, province of Valencia, East part of Spain

Case study 2: main role of the water cycle in the vegetation dynamics

RVDM model (river reach scale, riparian areas) → key hydrological processes determine the vegetation dynamics (García-Arias and Francés, 2016)

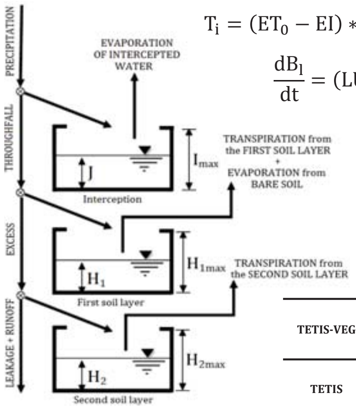
- Implementation → **river reach of 230 m length** located in the area called ***Terde, Mijares River***, province of Teruel, East part of Spain



CS1: PLOT SCALE – TERRESTRIAL AREAS

MODELLING APPROACH → hydrological sub-model: **TETIS** (Francés *et al.*, 2007) → tank-based + dynamic vegetation **LUE model** → **TETIS-VEG**

- Different **storages in the soil water column** (each tank)
- Water intercepted by canopy → max. **interception capacity** ∝ **LAI simulated**
  water extraction = f (evaporation) (Pasquato *et al.*, 2015)
- Effective root zone: divided, two superimposed layers similar to Scanlon and Albertson (2003) → **transpiration** (both layers) based on FAO recommendations (Allen *et al.*,1998): ***f*** **(LAI simulated)** → **state of vegetation affects the hydrological fluxes and the water storage**



$$T_i = (ET_0 - EI) * \boxed{\min(1, LAI)} * \zeta * Z_i$$

$$LAI = B_l * SLA * f_c$$

(William and Albertson, 2005)

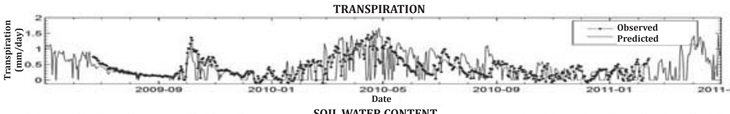
$$\frac{dB_l}{dt} = (LUE * \varepsilon * APAR - Re) * \varphi_l - k_l * B_l$$

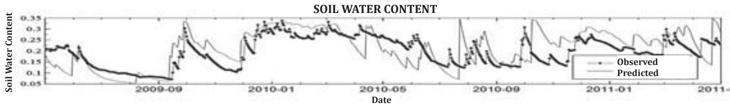
T_i :transpiration from the i soil layer, **EI**: evaporation of the intercepted water, Z_i: % roots in the i soil layer, **min(1,LAI)**: replaces the crop factor, ζ : water stress factor, **APAR**: absorbed photosynthetically active radiation, **LUE**: light use efficiency **ε**: reduction in LUE due to stress, **Re**: respiration, φ_l: fractional leaf allocation, k_l: leaf natural decay factor (senescence), **SLA**: specific leaf area, f_c: vegetation fractional cover

RESULTS:

	Flows	Dry year (2005) mm	Dry year (2005) %	Wet year (2010) mm	Wet year (2010) %
TETIS-VEG	PPT	188.00		739.00	
	ET (EI+T+Es)	165.18	91.0	431.87	56.9
	Excess	16.34	9.0	326.93	43.1
	Blue/Green	0.098		0.757	
TETIS	PPT	188.00	0.8	739.00	
	ET (EI+T+Es)	147.00	0.3	385.37	50.9
	Excess	33.47	2.5	370.99	49.1
	Blue/Green	0.227		0.963	

↑ Observed precipitation (**PPT**), evapotranspiration (**ET**) as sum of evaporation of the interception (**EI**), transpiration (**T**) and evaporation from the bare soil (**Es**), and the remaining of water or excess (mm) and as a percentage of the precipitation simulated by the **TETIS-VEG** and the **TETIS** models respectively. Finally, the **blue/green** water ratio.



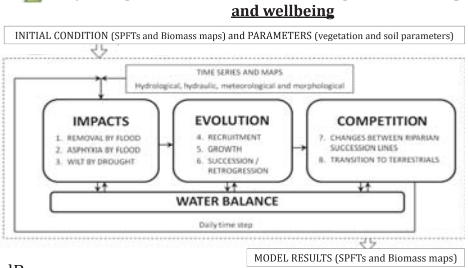


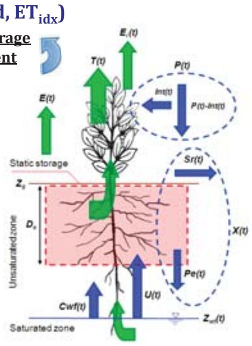
CS2: REACH SCALE – RIPARIAN AREAS

MODELLING APPROACH → riparian hydrodynamics + vegetation dynamics: **CASiMiR-veg** (Benjankar *et al.*, 2011) **flood impacts** approach + **RibAV** (García-Arias *et al.*, 2014) **water balance** approach + other **impacts-evolution-competition processes** modelling → **RVDM**

- Transpiration from **different water sources** → **unsaturated** and **saturated** soil layers (two main fluxes from the saturated zone: the hydraulic lift and the upward capillary water flow)
- water intercepted by canopy → max. **interception capacity** ∝ **fc**
- **Transpiration** is only allowed under **no limiting stress conditions**
  f **(water content, water table relative position to the roots effective and max. depths).** Vegetation growth: ***f*** **(LAI simulated, ET_{idx})**

Vegetation affects the hydrological fluxes and the water storage
Hydrological fluctuations affect the vegetation development and wellbeing





$$\frac{dB_l}{dt} = (LUE * \boxed{ET_{idx\,l}} * APAR - Re) * \varphi_l - k_l * \varepsilon * B_l$$

$$\boxed{ET_{idx\,l} = \frac{T_u + Ts}{f_c\, ET_0 - EI}}$$

Evapotranspiration index (García-Arias *et al.*, 2014)

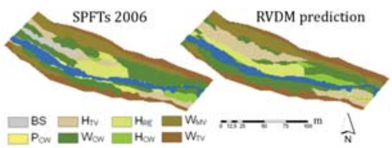
$$T_u = r_u\, f_c\, (ET_0 - EI)\, H_{rel}$$

$$T_s = \mathrm{Min}\left| \begin{array}{l} f_c\,(ET_0 - EI) - T_u \\ r_s\, f_c\,(ET_0 - EI)\, Z_{rel} \end{array} \right.$$

T_u: transpiration from the unsaturated zone, T_s: transpiration from the saturated zone, H_{rel}: relative water content, *f*(water content, optimum threshold and wilting point limit), Z_{rel}: relative depth of the saturated zone, *f*(water table position relative to the asphyxia, effective and maximum root depths), **ε**: stress factor that consider hydrological extremes

Particular case: **effective root depth connected to the water table** → **T_u at maximum rate** ($H_{rel} \rightarrow Z_{rel}$)

RESULTS: RVDM **calibrates** and **validates better** *(see oral presentation at Room B, session 10)* than other accepted modelling approaches (CASiMiR-veg, RibAV) under ≠ **hydrological conditions**, in **different river systems**



Calibration period: 2000-2006, Terde reach

Plant Classification	O. F	CASiMiR-veg	RibAV	RVDM
Model	*CCI*	0.378	0.541	0.670
	k	0.321	0.301	0.589
Phases	*CCI*	0.673	0.742	0.764
	k	0.356	0.297	0.479
Lines	*CCI*	0.652	0.464	0.715
	k	0.502	0.248	0.601
RI-TV-MIX	*CCI*	0.764	0.622	0.795
	k	0.635	0.372	0.679

CONCLUSIONS

1. In arid and semi-arid areas, the **ET** may account > 90% annual P → **key flux of the water cycle**, should not be neglected or poorly modelled
2. At plot scale, **TETIS-VEG** was able to **reproduce the soil water content as well as the transpiration** using **simple equations** and a **limited amount of parameters**. Overestimations of the B/G ratio (i.e. overestimation of the actual available water) were observed when neglecting vegetation dynamics. This pointed out the **key role played by plants in the water balance**
3. At reach scale, **RVDM** improved the **riparian vegetation prediction** taking into account **daily soil moisture** and detailed **ecohydrological processes** related to the interaction between the vegetation dynamics and the water balance. This is a **more complex modelling approach** → convenience on the choice shall be evaluated in each case of study before neglecting less complex models as **CASiMiR-veg** or **RibAV**

ACKNOWLEDGEMENTS AND REFERENCES

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