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Modeling plant competition for water use in Water-limited Mediterranean Ecosystems

C. CORTIS and N. MONTALDO

Università degli studi di Cagliari, Dipartimento di Ingegneria del Territorio, Cagliari, Italy (ccortis@unica.it)

In heterogeneous ecosystems, such Mediterranean ecosystems, contrasting plant functional types (PFTs, e.g., grass and woody vegetation) compete for the water use. In these complex ecosystems current modeling approaches need to be improved due to a general lack of knowledge about the relationship between ET and the plant survival strategies for the different PFTs under water stress. Indeed, still unsolved questions are: how the PFTs (in particular the root systems) compete for the water use, the impact of this competition on the water balance terms, and the role of the soil type and soil depth in this competition.

For this reasons an elaborated coupled Vegetation dynamic model (VDM) – land surface model (LSM) model able to also predict root distribution of competing plant systems is developed. The transport of vertical water flow in the unsaturated soil is modelled through a Richards' equation based model. The water extraction (sink) term is considered as the root water uptake. Two VDMs predict vegetation dynamics, including spatial and temporal distribution/evolution of the root systems in the soil of two competing species (grass and woody vegetation). An innovative method for solving the unlinear system of predicting equations is proposed. The coupled model is able to predict soil and root water potential of the two competing plant species.

The model is tested for the Orroli case study, situated in the mid-west of Sardinia within the Flumendosa river watershed. The site landscape is a mixture of Mediterranean patchy vegetation types: trees, including wild olives and coark oaks, different shrubs and herbaceous species. In particular two contrasting plant functional types (grass and woody vegetation) have been included.

The model well predict the soil moisture and vegetation dynamics for the case study, and significantly different root potentials are predicted for the two PFTs, highlighting the root competition for the water use.

The soil depth is low in the case study, while the Flumendosa basin is characterized by soils of different type and depth (more silty and deep nearly the river valley), such as typical in Mediterranean basins. A sensitivity analysis to the soil depth and soil type is performed for investigating their influences on the PFT dynamics and soil water balance.

The influence of vegetation cover distribution of each plant type is also investigated.

Results show that the plant compete differently according to site soil characteristics, and the impact of vegetation dynamics on the soil water balance terms is significant and cannot be neglected in current hydrological approaches.