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Impact of the plant competition for water use on the Soil Water Balance of a Water-limited Mediterranean Ecosystem

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With the objective of modeling the dynamic interactions between land surface processes and vegetation dynamics recent efforts of land surface models (LSM) and vegetation dynamic models (VDM) coupling have been achieved.

In heterogeneous ecosystems, such Mediterranean ecosystems, contrasting plant functional types (PFTs, e.g., grass and woody vegetation) compete for the water use. In these ecosystems evapotranspiration (*ET*) is the leading loss term of the root-zone water budget with a yearly magnitude that may be roughly equal to the precipitation. 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 VDM-LSM model 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. A VDM predict vegetation dynamics, including spatial and temporal distribution/evolution of the root systems in the soil of each PFT. In the coupled model the root water potential is the key term, governing both the sink term of the Richards' equation and the plant transpiration. An innovative solution for the estimate of the root water potential is developed.

The model is applied to 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. Land-surface fluxes and CO_2 fluxes are estimated by an eddy correlation technique based micrometeorological tower. Soil moisture profiles were also continuously estimated using water content reflectometers and gravimetric method, and periodically leaf area index (LAI) estimates of PFTs are made using the Accupar LP-80 by Decagon Devices Inc. The soil thickness varies from 15-40 cm, bounded from below by a rocky layer of basalt.

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.

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.