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Vegetation Dynamics Effects on the Soil Water Budget of a Water-Limited Mediterranean Ecosystem: the Flumendosa Basin Case Study

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The structure and function of the vegetation regulates the exchange of mass, energy and momentum across the biosphere-atmosphere interface. Vegetation dynamics are usually neglected, other than seasonal phenology, in land surface models (LSMs). However, changes in vegetation densities, influencing the partitioning of incoming solar energy into sensible and latent heat fluxes, can result in long-term changes in both local and global climates (e.g., precipitation and temperature), which in turn will feedback to affect the vegetation growth. In semi-arid regions, this may result in persistent drought and desertification, with substantial impacts on the human populations of these regions through reduction in agricultural productivity and reduction in quantity and quality of water supply.

With the objective to investigate the role of vegetation dynamics on soil water budget and land-surface fluxes (e.g., groundwater recharge, evapotranspiration, infiltration) in a water-limited ecosystem, a simple vegetation dynamic model (VDM) is developed. It computes the change in biomass over time as difference between the rate of production (e.g., photosynthesis) and the rate of destruction (e.g., respiration and senescence). The model incorporates two plant functional types (grass and trees), using basic rules regarding competition for a limiting resource. The vegetation dynamic model is then coupled to a LSM, with the vegetation model providing the green biomass and the leaf area index (LAI) evolution through time, and the LSM using this information in the computation of the land surface fluxes and updating the soil water content in the root-zone.

The case study is a Mediterranean water-limited field in Orroli , situated in the mid-west of Sardegna within the Flumendosa river watershed, which is considered one of the most important water supply resources to the island. The landscape is a mixture of Mediterranean patchy vegetation types: trees, including wild olives and cork oaks, different shrubs and herbaceous species. An extensive field campaign started in April 2003. Land-surface fluxes and CO_2 fluxes are estimated by an eddy correlation technique based agro-meteorological tower, equipped with a Campbell Scientific CSAT-3 sonic anemometer and Licor-7500 infrared gas analyzer. Three infrared transducers were used to measure the surface temperature of the different land cover elements (i.e. bare soil or grass, tree and composite surface), while incoming and outcoming shortwave and longwave radiation components were measured by the CNR-1 (Kipp & Zonen) integral radiometer positioned at 10 m with a hemispherical field of view. Photosynthetic active radiation (0.4 to 0.7 mm) was also measured using a Quantum sensor positioned at 5 m above the ground, and soil heat flux were also measured. Soil moisture profiles were continuously estimated using seven - frequency domain reflectometer probes (CS615 soil moisture probes of Campbell Sci.), and periodically LAI estimates of both plant types are made using the Accupar LP-80 by Decagon Devices Inc.

Results show that the coupled VDM-LSM model is able to predict LAI dynamics of both the functional types in the experimental field case study. Results also highlight the importance of including the plant growth model in the LSM when studying the climate-soil-vegetation interactions, and the impact of watershed management practices on the scarce water resources over moderate to more long time scales.