Geophysical Research Abstracts, Vol. 8, 08068, 2006
SRef-ID: 1607-7962/gra/EGU06-A-08068

Vegetation Dynamics Effects on the Soil Water Budget of a Water-Limited Mediterranean Ecosystem also in the Context of Inter-annual Rainfall Variability

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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 parsimonious and robust 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 (PFTs, 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. 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 micrometeorological tower. Soil moisture profiles were also continuously estimated, and periodically LAI estimates of both plant types are made using the Accupar LP-80 by Decagon Devices Inc.

The coupled VDM-LSM model is successfully tested for the current meteorological conditions of the 2003-2005 period. Simplified scenarios of inter-annual rainfall variability are also generated for investigating the role of the vegetation dynamics on the soil water balance. The inclusion of the VDM in the LSM is demonstrated to be essential for assessing the impact of inter-annual rainfall variability and land use changes on the water resources of semi-arid regions.