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Soil Water Balance and Vegetation Dynamics in a Water-limited Mediterranean Ecosystem on Sardinia under climate change scenarios

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Mediterranean ecosystems are commonly heterogeneous savanna-like ecosystems, with contrasting plant functional types (PFT) competing for the water use. At the same time the structure and function of the vegetation regulates the exchange of mass, energy and momentum across the biosphere-atmosphere interface, influencing strongly the soil water budget.

Mediterranean regions suffer water scarcity produced in part by natural (e.g., climate variations) influences. For instance, in the Flumendosa basin water reservoir system, which plays a primary role in the water supply for much of southern Sardinia, the average annual input from stream discharge in the latter part of the 20th century was less than half the historic average rate. The precipitation over the Flumendosa basin has decreased, but not at such a drastic rate as the discharge, suggesting a marked non-linear response of discharge to precipitation changes. Indeed, precipitation decreased in winter months, which are crucial for reservoirs recharge through runoff.

The IPCC models predicts a further increase of drought in the Mediterranean region, increasing the uncertainty on the future of the water resources system of these regions.

Hence, there is the need to investigate the role of the PFT vegetation dynamics on the soil water budget of these ecosystems in the context of the climate change, and predict hydrologic variables for climate change scenarios.

The case study is in the Flumendosa basin. The site 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 May 2003. More than six years of data of a micrometeorological tower are available now. Land-surface fluxes and CO_2 fluxes are estimated by the 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) PFTs are estimated.

An ecohydrologic model is successfully tested to the case study. It couples a vegetation dynamic model (VDM), which computes the change in biomass over time for the PFTs, and a 3-component (bare soil, grass and woody vegetation) land surface model (LSM).

Hydrometeorological change scenarios are then generated using a stochastic weather generator. It simulates hydrometeorological variables from historical time series (available from 1922 for this basin) altered by IPCC meteorological change predictions.

The calibrated VDM-LSM predicts soil water balance and vegetation dynamics for the generated hydrometeorological scenarios.

Results demonstrate that vegetation dynamics are strongly influenced by the variability of atmospheric forcing, with vegetation density changing significantly according to seasonal rainfall amount. At the same time the vegetation dynamics affect the soil water balance, and the runoff. Water resources predictions are worrying, with further decrease of runoff.