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The Climate change impact on the water balance and use efficiency of two contrasting water limited Mediterranean ecosystems in Sardinia

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Mediterranean ecosystems are commonly heterogeneous savanna-like ecosystems, with contrasting plant functional types (PFT) competing for the water use. Often deforestation activities have been more intensive along the plan and alluvial river valleys, where deep soils are well suited for agricultural and grass became the primary PFT, while more natural woody vegetation (trees and shrubs) survived in the steep hillslopes and mountain areas, where soil thickness is low, i.e. less attractive for agricultural. Hence, Mediterranean regions are characterized by two main ecosystems, grassland and woodland, which for both natural and anthropogenic causes can grow in soils with also different characteristics (texture, hydraulic properties, depth), highly impacting water resources.
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. At the same time air temperature increased during the spring-summer season, when the precipitation slightly increased.
The IPCC models predicts a further increase of drought in the Mediterranean region during winter, 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.
Sardinia island is a very interesting and representative region of Mediterranean ecosystems. It is low urbanized, and is not irrigated, except some plan areas close to the main cities where main agricultural activities are concentrated. The two case study sites are within the Flumendosa river basin, with similar height a.s.l., and close (distance of 4 km). But the first site is a typically grass site located on an alluvial plan valley with a soil depth more than 2m, while the second site is a patchy mixture of Mediterranean vegetation types with wild olive trees and C3 herbaceous (grass) species and the soil thickness varies from 15-40 cm. In both sites land-surface fluxes and CO_2 fluxes are estimated by eddy correlation technique based micrometeorological towers. Soil moisture profiles were also continuously estimated using water content reflectometers and gravimetric method, and periodically leaf area index (LAI) PFTs are estimated from 2003.
An ecohydrologic model is successfully tested to the case studies. 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). Model is first used for simulating historically land surface fluxes from 1922 at the two sites.
Climate change scenarios are then generated using a stochastic weather generator. It simulates hydrometeorological variables from historical time series altered by IPCC meteorological change predictions.
The VDM-LSM predicts soil water balance and vegetation dynamics for the generated hydrometeorological scenarios at the two sites.
Results demonstrate that contrasting climate change effects (decrease of winter precipitation vs increase of spring-summer air temperature) are significantly impacting land surface interactions (evapotranspiration and runoff dynamics) but with different effects on the two contrasting sites, due to the key role of the soil depth. Water resources predictions are worrying in both sites, with further decrease of runoff and water resources.