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A new eco-hydrological distributed model for the predictions of the climate change impact on water resources of Mediterranean water-limited basins: the Mulargia basin case study in Sardinia.

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In the last three decades, climate change and human activities increased desertification process in Mediterranean regions, with dramatic consequences for agriculture and water availability. For instance in the main reservoir systems in Sardinia the average annual runoff in the latter part of the 20th century decreased of more than 50% compared with the previous period, while the precipitation over the Sardinia basin has decreased, but not at such a drastic rate as the discharge, with an high precipitation elasticity to streamflow, highlighting the key role of the rainfall seasonality on runoff production.
IPCC climate change scenarios predict a further decrease of winter rainfall, which is the key term for runoff production in these typical Mediterranean climate basins, and air temperature increase, which can potentially impact on evapotranspiration, soil moisture and runoff. Only the use of an accurate ecohydrological physically based distributed model allow to well predict the impact of the climate change scenarios on the basin water resources.
A new eco-hydrological model is developed that couples a distributed hydrological model of and a vegetation dynamic model (VDM). The hydrological model estimates the soil water balance of each basin cell using the force-restore method, the Philips model for infiltration estimate and the Penman-Monteith equation for evapotranspiration estimate. The VDM evaluates the changes in biomass over time for each cell and provides the leaf area index (LAI), which is then used by the hydrological model for evapotranspiration and rainfall interception estimates.
Case study is the Mulargia basin (Sardinia, basin area of about 70 km2), where an extended field campaign started from 2003, with rain and discharge data observed at the basin outlet, periodic field measurements of soil moisture and LAI all over the basin, and evapotraspiration estimates using an eddy correlation based tower. The Mulargia basin case study is a very interesting laboratory of Mediterranean basins, thanks to its typical Mediterranean climate, its typical physiografic characteristics, its low human activities and influences and its attractive hydrologic database. The model has been successfully and deeply calibrated for the 2003 and validated for the 2004-2005 period, using both field data and satellite Modis data.
Three future climate change scenarios has been generated using a stochastic model (Richardson, 1991), opportunely adapted for accounting the future changes of climate conditions. The scenarios (A1-A1B-A2) assume that in the next century there will be a drastic reduction of precipitation (with maximum reduction of 30% in A2) and that will continue the warming process. A reduction of soil moisture (about 40%) is predicted, especially during winter month and also the LAI will drastically decrease (more than 50% for woody vegetation and 75% for grass especially during the spring). Runoff will decrease even more (up to 70%) during the winter season, which is the key season for the water resource management and planning of these Mediterranean basins. These results anticipate a dramatic reduction of water resources availability, a change of vegetation species and ecosystems, increasing the desertification process in this typical Mediterranean area.