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A semi-distributed eco-hydrological model for the estimation of the effect of the climate change on a Mediterranean forest

Serena Sirigu[1], Roberto Corona[1], Nicola Montaldo[1], Marcello Airi[2], and Maurizio Mallocci[2]
[1]Cagliari, Engineering, DICAAR, Italy (serena.sirigu@unica.it)
[2]Agenzia forestale Regionale per lo sviluppo del territorio e dell'ambiente della Sardegna (Fo.Re.S.T.A.S), Cagliari, Italy

Over the past century, climate change altered precipitation and temperature regimes worldwide. Recently, Montaldo and Sarigu (2017) showed that Sardinia runoff decreased over the 1975-2010 period, with mean annual values 40% lower than the 1922-1974 period.

These trends may have dramatic consequences on basin water resources, impacting forest sustainability. Forests are frequently exposed to periods characterized by a reduced water availability and increasing temperature that influence the evapotranspiration process (ET),and may increase tree mortality and change tree spatial distribution and density.

The Marganai forest, located in the South-West of Sardinia (Italy), is a Long-Term Ecosystem Research (LTER) Italian site and a European Site of Community Importance (Natura 2000) managed by the Sardinian forest authority (FORESTAS). Trees are mainly Quercus Ilex and historical data are available from 1924, with rain from 16 stations, and runoff one the at the Fluminimaggiore basin section (area of 83 km^2). A persistent decrease trend of winter precipitation (Mann-Kendall t of -0.14) impacted runoff (t of -0.26). A distributed hydrological model at basin scale has been developed, which computed runoff, ET and predicted grass and tree leaf area index (LAI). The model has been successfully calibrated for runoff and ET estimation for the 1925–2020 period, confirming a dangerous trend in soil moisture and water availability for the trees.

The hydrologic water balance of the basin were also investigated under future IPCC climate change scenarios. From the General Circulation Models of Flato et al. (2013), we selected the HadGEM2-AO that simulates reasonable approximation of observed past seasonal precipitation and air temperature changes in Sardinia. Using the distributed eco-hydrologic model and future climate scenario we predicted both hydrologic water balance terms (soil moisture, runoff, ET).

The future scenario predicted a reduction of annual precipitation, an increase of rain intensity and extreme events, and an increase of temperature and VPD.

The model predicted a significant decrease of tree LAI (t of -0.79) and runoff (t of -0.11), mainly due to VPD increase. Future scenario predicting further dry will require new strategies in both forestal and water resources planning and management.