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A numerical modelling tool for assessing the impact of climate change and management options on water supply systems

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Conditions of scarcity for a water supply system occur when the available resource are not able to satisfy the connected demands. They can arise both from a decreasing of the inflow to the exploited resources and/or from a increasing of the demand. Such conditions can be assessed by a water balance model able to simulate both the hydrological processes describing the relationships between the meteorological forcing (precipitation) and the inflows to the exploited reservoir, and the intra- and inter-annual time distribution of the connected demand and the reservoir management policies. We present a numerical modelling tool, developed for the management of the Maggiore Lake, that computes at daily scale the water budget of such reservoir taking into account 1) the monthly precipitation over the watershed basin and the related inflow; 2) the seasonal demand for irrigation and 3) the operative hydrometric levels constraints to the lake water withdrawal. The model represents precipitation over the basin through the space mean of the standardized precipitation indices computed at different aggregation scales using observed time series. The relationship between the precipitation regime and the inflow to the reservoir is obtained through a simple multilinear regression model, considering the SPI computed at 1, 3 and 6 months as independent variables: this allows to take hydrological processes into account featuring different characteristic times and to simulate both the historic inflow regime and the possible conditions forecast by climate scenarios. The regression model is validated on the precipitation and lake inflow observations in the period 1996-2013 using a leave-one-out cross validation. The seasonal irrigation demand is assigned based on the extensions of crops fed by the lake water and regardless of the climate conditions; the actual supply is limited by the operative hydrometric range of allowable water levels, which stop water distribution when the lake level is below a given threshold. This hydrometric condition defines the onset of water scarcity for the irrigation water supply system: such conditions and the associated possible non stationarity are analysed in terms of occurrence, duration and intensity considering both the mean and the extreme values of reliability, resiliency and vulnerability through an overall scarcity risk index. Results from the Maggiore lake case study for the period 1994-2013 are presented and discussed.