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Assessment of operating rule modification for adaptation to climate change at the regional level: An application of the generic tool on the Mediterranean basin

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The main purpose of the study is to evaluate the impacts of climate change on water resources while taking into account man-made reservoirs and changes in reservoir operating rules. Arid regions characterized by a high temporal and spatial variability of hydroclimatic parameters like Mediterranean basins, are already experiencing an important temporal and spatial variation of water resources. For the Mediterranean area,climatic models, despite the uncertainty, indicate a change in precipitation regime with an increased drought risk. In our study we realize a regional assessment of change in water scarcity. A generic model operating at the river catchment scale is constructed, based on information available at a regional scale. The methodology follows the following steps:
1.water demands are localized and projected;
2.reservoirs are localized and available water quantity is computed at each site;
3.links between reservoirs and demands are determined;
4.operating rules are determined.
All the existing Mediterranean reservoirs are localized based on the International Commission of Dams and Reservoirs and Aquastat. Runoff is taken from the outputs of climatic models from the European program CIRCE. Results will be presented for the five regional climatic models of CIRCE: INGV-CMCC, Meteo- France, CNRS-IPSL, ENEA, MPI-HH models. Sub-basin flow accumulation zone of each reservoir is determined based on a Digital Elevation Model (hydro1k). With the information above the available quantity of water at each site is computed.
On the demand side, domestic water use, and irrigation demands are taken into account. Future domestic demand, a rather small demand compared to irrigation demand, is computed based on a constant rate of consumption per habitant and population projections from the United Nations. For irrigation, current irrigated areas, taken from the Global Map of Irrigation Areas and current productions, taken from agromaps are used. Two methodologies are used for the determination of crops phenology, either the growing degree days method, or fixed length phases. Irrigation is set to the quantity of water needed to fill the deficit between evapotranspiration and effective precipitation.
To determine the links between supply and demand, in absence of precise informations, a cost minimisation is performed. Each demand is associated with a reservoir, and the cost corresponding with this link takes into account the distance between the demand and the reservoir stream, and the height climbed up along the path to stream. The total cost is minimized, while checking that the mean demands may be satisfied by the mean runoff in the resulting network.
Operating rules are determined by minimizing the risk of non satisfaction of forecasted demands. For reservoirs in series, first upper demands are satisfied and the most downstream reservoir is first emptied. For reservoirs in parallel, a fitted generalization of the space rule is used, such that the the probability of spill is minimized.
According to our preliminary results, the North Africa region displays some heterogeneity in the response to climate change. The modelling used here results in slight changes with decreasing and increasing water demands. More precisely, in the Nile basin the demand is decreasing because the effect of the decrease in the growing season length is more pronounced than the evapotranspiration increase, with rain being negligible with and without climate change. In north Africa, where the Mediterranean influence is predominant, the demand increases, because the reductions in precipitation lead to a need for more irrigation water.
Concerning reliability, where the Mediterranean influence is important, reliability is mostly decreasing, both because of increased demand and decreased precipitations. In the Atlantic domain (Morocco) and in the Nile basin (where inflow is determined by the changes in tropical and equatorial precipitations) there is no change in reliability.