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Analysis of climate change impact on meteorological and hydrological droughts through relative standardized indices

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Southern Mediterranean basins are prone to droughts, due to the high temporal and spatial rainfall variability. In addition, semiarid Mediterranean regions emerge as noticeable climate change hotspots, with high uncertainty about the impacts of climate change on future droughts. Standardized drought indices have been traditionally used to assess and identify drought events, because of their simplicity and flexibility to compare the departure from normal status across regions at different timescales. Nevertheless, the statistical foundation of these indices assumes stationarity for certain aspects of the cli-matic variables, which could not be longer adopted under climate change. Thus, in recent years several modifications have been proposed in order to cope with these limitations.

This contribution provides a framework to analyze climate change impact on meteorological and hydrological droughts, considering the predicted shifts in precipitation and temperature and the uncertainty of the assumed distribution parameters. To characterize drought in a climate change context, relative standardized indices instead of the traditional ones are applied: Standardized Precipitation Index (rSPI), Standardized Precipitation Evapotranspiration Index (rSPEI) and a Standardized Flow Index (rSFI). The behavior of the rSPI versus the multiscalar rSPEI is contrasted. A modification of the Thornthwaite scheme is presented to improve the representation of the intra-annual variation of the potential evapotranspiration (PET) in continental climate areas. The uncertainty due to the selected hydrological model is assessed through the comparison of the performance and outcome of three conceptual lumped-parameter models (Temez, GR2M, and HBV-light). The Temez model was selected to obtain the runoff for the rSFI, given that it showed the best fitting in our case study. To address the uncertainty of the indices distribution parameters, bootstrapping was combined with the computation of the overlapping coefficient for each parameter.

This procedure was applied to the Jucar river basin, a Mediterranean basin in Eastern Spain with irregular hydrology and a high share of water use for agriculture (80%). Our results demonstrate that climate change could produce a general increase in the severity of both meteorological and hydrological droughts, owing to the combined effects of rainfall reduction and evapotranspiration increase. Although both rSPI and rSPEI show similar values for the historical period, under climate change scenarios the rSPI could underestimate the intensity and magnitude of the meteorological droughts.