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Utility of statistical downscaling and high-resolution hydrologic modeling for climate change studies

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The impact of climate change on the catchment hydrologic cycle is typically quantified through a prediction chain where outputs of global climate models are first dynamically and/or statistically downscaled and, then, used to force a hydrologic model. In the Mediterranean region, basins are typically characterized by small areas ($<$1000 km^2) and a complex hydrologic response that can be potentially captured by process-based hydrologic models. Despite this capability, sophisticated hydrologic models have been rarely adopted in climate change studies because they require high-resolution forcings (a few km, sub-daily) that dynamical and most of the statistical downscaling techniques do not currently provide. In this talk, we present simulations of the hydrologic impacts of climate change in a Mediterranean catchment of 475 km^2 in Sardinia, Italy. For this aim, a process-based hydrologic model is applied to reproduce the wide range of runoff generation mechanisms typical of the basin. The high-resolution forcings are generated from climate projections of four combinations of global and regional climate models, which are first bias-corrected and, then, downscaled with a multifractal model that reproduces the small-scale variability of precipitation in space (5 km) and time (1 h). We first show how future climate projections are expected to impact the different components of the water budget and the occurrence of hydrologic extremes at distributed basin locations. Next, we evaluate the utility of statistical downscaling tools by repeating the hydrologic simulations with forcings directly provided by bias-corrected outputs of a regional climate model (25 km, daily), as often done in climate change studies. We compare these simulations with those produced using high-resolution downscaled forcings and demonstrate how adopting statistical downscaling tools that can effectively capture the small-scale precipitation variability is crucial to inform process-based hydrologic models, especially when simulating flood events.