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Comparing dynamical, stochastic, and combined downscaling approaches. Lessons from a case study in the Mediterranean

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Various downscaling techniques have been developed to bridge the scale gap between global climate models (GCMs) and finer scales required to assess hydrological impacts of climate change. Two approaches to downscaling exist. The deterministic dynamical downscaling (DD) nests a regional climate model (RCM) into the GCM to represent the atmospheric physics with a higher grid box resolution within a limited area of interest. The stochastic statistical downscaling (SD) establishes statistical links between large scale weather models and local scale observations available at a finer spatial resolution. SD is traditionally seen as an alternative to DD. With the increasing reliability and availability of RCM scenarios, recent works on statistical downscaling have aimed to combine the benefits of these two approaches. The overall objective of this study is to examine the relative benefits of each downscaling approach and their combination in making the GCM scenarios suitable to feed hydrological impact models. The case-study presented here focuses on the Apulia region (South East of Italy, about 20,000 km^2), characterized by a typical Mediterranean climate: the monthly cumulated precipitation and monthly mean of daily minimum and maximum temperature distribution were examined during the period 1953-2000. The adopted GCM is the fifth-generation ECHAM model from the Max-Planck-Institute for Meteorology, and the DD was carried out with the Protheus system (ENEA) as RCM. The SD was performed through a monthly quantile-quantile transform. A further common step of statistical interpolation (SI) was applied to obtain spatial homogenization of the different downscaling combinations. The SD is efficient in reducing the mean bias in the spatial distribution at both annual and seasonal scales, but is not able to correct the mis-modeled non-stationary components of the GCM dynamics. The DD provides a partial correction by enhancing the trends spatial heterogeneity and time evolution predicted by the GCM. However, the comparison with observation is still underperforming. Best results were obtained through the combination of both DD and SD approaches.