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Climate-dependent propagation of precipitation uncertainty into the water cycle

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Precipitation is a crucial variable for hydro-meteorological applications. Unfortunately, rain gauge measurements are sparse and unevenly distributed, which substantially hampers the use of in-situ precipitation data in many regions of the world. The increasing availability of high-resolution gridded precipitation products presents a valuable alternative, especially over gauge-sparse regions. Nevertheless, uncertainties and corresponding differences across products can limit the applicability of these data. This study examines the usefulness of current state-of-the-art precipitation datasets in hydrological modeling. For this purpose, we force a conceptual hydrological model with multiple precipitation datasets in >200 European catchments. We consider a wide range of precipitation products, which are generated via (1) interpolation of gauge measurements (E-OBS and GPCC V.2018), (2) data assimilation into reanalysis models (ERA-Interim, ERA5, and CFSR) and (3) combination of multiple sources (MSWEP V2). For each catchment, runoff and evapotranspiration simulations are obtained by forcing the model with the various precipitation products. Evaluation is done at the monthly time scale during the period of 1984-2007. We find that simulated runoff values are highly dependent on the accuracy of precipitation inputs, and thus show significant differences between the simulations. By contrast, simulated evapotranspiration is generally much less influenced. The results are further analysed with respect to different hydro-climatic regimes. We find that the impact of precipitation uncertainty on simulated runoff increases towards wetter regions, while the opposite is observed in the case of evapotranspiration. Finally, we perform an indirect performance evaluation of the precipitation datasets by comparing the runoff simulations with streamflow observations. Thereby, E-OBS yields the best agreement, while furthermore ERA5, GPCC V.2018 and MSWEP V2 show good performance. In summary, our findings highlight a climate-dependent propagation of precipitation uncertainty through the water cycle; while runoff is strongly impacted in comparatively wet regions such as Central Europe, there are increasing implications on evapotranspiration towards drier regions.