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Impact of meteorological forcing datasets on regional scale water fluxes and drought characteristics over Germany

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Accurate representation of regional-scale water fluxes is crucial for hydrological assessments of societally relevant events such as droughts. Hydrologic models are now commonly used to derive gridded estimates of land surface water budgets, i.e. soil moisture, runoff, in the absence of long-term observations. Consequently, the skill of such models depends on the quality of their driving data, particularly the choice of meteorological forcing data.

In this study, we provide a comprehensive assessment of regional-scale water fluxes and states over Germany since 1950 using a well-established mesoscale hydrologic model (mHM). The goal is to analyze uncertainties in the representation of hydrologic fluxes and large-scale drought characteristics based on the choice of meteorological forcing data. A long-term (1950-2012) country wide hydrological simulation of the land surface water budgets at a 0.25° spatial resolution was carried out with mHM using (a) the publicly free E-OBS data set (v8.0) from the European Climate Assessment & Dataset project and (b) the gridded product based on the relatively dense station network (over 5500 rainfall gauges and 1100 weather stations) operated by the German Weather Service (DWD). These simulations serve to characterize historical agricultural and hydrological drought events based on soil moisture (SMI), and surface runoff (SRI) indices, respectively.

Simulated water fluxes and states (e.g., runoff, evapotranspiration, soil moisture) with different meteorological data sets generally showed a high degree of correspondence to each other at annual and seasonal time scales. However, substantial regional differences emerged in the northeast part of Germany (in the Elbe river basin), where the E-OBS-based simulations produced drier conditions than those of the DWD based simulation. Despite similar covariances between both data sets for major historical drought events (1953-54, 1959-60, 1962-65, 1972-74, 1975-78, 1991-93, 1995-97, 2003-05), other drought statistics such as the severity, duration, areal extend, persistence varied substantially, with more severe, persistent E-OBS derived droughts than those using the DWD product. For some interior regions of Germany, differences in drought indices were so great that they failed to identify a common drought event roughly 40 to 60% of the time, with poor agreement (r^2 = 0.4-0.8) in drought severity classification. These results emphasize the importance of meteorological uncertainty in drought monitoring.