Geophysical Research Abstracts
Vol. 18, EGU2016-1582, 2016
EGU General Assembly 2016

A spatially consistent seamless predictions of continental-scale hydrologic fluxes and states

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One of the major challenges in the contemporary hydrology is to establish a continental-scale hydrologic model that can provide spatially consistent, seamless prediction of hydrologic fluxes and states to better characterise extreme events like floods and droughts. This requires, among other things, 1) a robust parameterization technique that allows the model to seamlessly operate across a range of spatial resolutions and 2) an efficient parameter estimation technique to derive a representative set of spatially consistent model parameters that avoid inconsistencies in simulated hydrologic fields (e.g., soil moisture). In this study, we demostrate the applicability of a mesoscale hydrologic model parameterized using a multiscale regionalization technique to derive daily gridded fields of hydrologic fluxes/states over the Pan-EU domain since 1950. A multi-basin parameter estimation (MBE) strategy that utilizes observed streamflows from a set of hydrologically diverse basins is introduced to infer a representative set of regional calibration parameters which is applicable over the entire domain. We tested three sampling schemes to select a set of calibration basins incremented sequentially from 2 to 20 basins, based on the 1) random selection procedure, 2) gradient along the hydro-climatic regimes, and 3) diversity in hydro-climatic and basin physiographical properties (e.g., terrain, soil, land cover properties).

Results of the MBE approach are contrasted against the benchmark at-site calibration strategy across 400 EU basins varying from approximately 100 to 500,000 km^2. At-site calibrated parameters performed best for site-specific streamflow predictions, but their transferability to other sites resulted in poor performance. Moreover, the at-site calibration strategy generated a patchy, spatially inconsistent distribution of parameter fields that further induced large discontinuities in simulated hydrologic fields of soil moisture among other sates/fluxes. These limitations were overcome by the MBE strategy that provided a compromise solution with improved model performance compared to at-site cross-validated estimates. The gridded fields of hydrologic parameters, states and fluxes from MBE were spatial continuos and much more meaningful compared to those of the at-site calibration strategy. The selection of calibration basins that include diversity in both hydro-climatic and basin physical properties provided consistently better results compared to other two strategies. Overall, our study highlights the limitations of the at-site calibration strategy and demostrate the potentials of the MBE strategy as a way forward for a spatially consistent seamless predictions of continental hydrological fluxes and states.