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Disentangling the uncertainty of hydrologic drought characteristics in a multi-model century-long experiment in continental river basins

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The quantification of the predictive uncertainty in hydrologic models and their attribution to its main sources is of particular interest in climate change studies. In recent years, a number of studies have been aimed at assessing the ability of hydrologic models (HMs) to reproduce extreme hydrologic events. Disentangling the overall uncertainty of streamflow -including its derived low-flow characteristics- into individual contributions, stemming from forcings and model structure, has also been studied. Based on recent literature, it can be stated that there is a controversy with respect to which source is the largest (e.g., Teng, et al. 2012, Bosshard et al. 2013, Prudhomme et al. 2014). Very little has also been done to estimate the relative impact of the parametric uncertainty of the HMs with respect to overall uncertainty of low-flow characteristics.

The ISI-MIP2 project provides a unique opportunity to understand the propagation of forcing and model structure uncertainties into century-long time series of drought characteristics. This project defines a consistent framework to deal with compatible initial conditions for the HMs and a set of standardized historical and future forcings. Moreover, the ensemble of hydrologic model predictions varies across a broad range of climate scenarios and regions. To achieve this goal, we use six preconditioned hydrologic models (HYPE or HBV, mHM, SWIM, VIC, and WaterGAP3) set up in seven large continental river basins: Amazon, Blue Nile, Ganges, Niger, Mississippi, Rhine, Yellow. These models are forced with bias-corrected outputs of five CMIP5 general circulation models (GCM) under four extreme representative concentration pathway (RCP) scenarios (i.e. 2.6, 4.5, 6.0, and 8.5 Wm^{-2}) for the period 1971-2099.

Simulated streamflow is transformed into a monthly runoff index (RI) to analyze the attribution of the GCM and HM uncertainty into drought magnitude and duration over time. Uncertainty contributions are investigated during periods: 1) 2006-2035, 2) 2036-2065 and 3) 2070-2099. Results presented in Samaniego et al. 2015 (submitted) indicate that GCM uncertainty mostly dominates over HM uncertainty for predictions of runoff drought characteristics, irrespective of the selected RCP and region. For the mHM model, in particular, GCM uncertainty always dominates over parametric uncertainty. In general, the overall uncertainty increases with time. The larger the radiative forcing of the RCP, the larger the uncertainty in drought characteristics, however, the propagation of the GCM uncertainty onto a drought characteristic depends largely upon the hydro-climatic regime. While our study emphasizes the need for multi-model ensembles for the assessment of future drought projections, the agreement between GCM forcings is still weak to draw conclusive recommendations.

References:

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