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Statistical-dynamical long-range seasonal forecasting of streamflow with the North-American Multi Model Ensemble (NMME)

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There are two main approaches to long-range (monthly to seasonal) streamflow forecasting: statistical approaches that typically relate climate precursors directly to streamflow, and dynamical physically-based approaches in which spatially distributed models are forced with downscaled meteorological forecasts. While the former approach is potentially limited by a lack of physical causality, the latter tends to be complex and time-consuming to implement. In contrast, hybrid statistical-dynamical techniques that use global climate model (GCM) ensemble forecasts as inputs to statistical models are both physically-based and rapid to run, but are a relatively new field of research. Here, we conduct the first systematic multimodel statistical-dynamical forecasting of streamflow using NMME climate forecasts from eight GCMs (CCSM3, CCSM4, CanCM3, CanCM4, GFDL2.1, FLORb01, GEOS5, and CFSv2) across a broad region.

At several hundred U.S. Midwest stream gauges with long (50+ continuous years) streamflow records, we fit probabilistic statistical models for seasonal streamflow percentiles ranging from minimum to maximum flows. As predictors, we use basin-averaged values of precipitation, antecedent wetness, temperature, agricultural row crop acreage, and population density. Using the observed data, we select the best-fitting probabilistic model for every site, season, and streamflow percentile (ranging from low to high flows). The best-fitting models are then used to obtain streamflow predictions by incorporating the NMME climate forecasts and the extrapolated agricultural and population time series as predictors.

The forecasting skill of our models is assessed using both deterministic and probabilistic verification measures. The influence of the different predictors is evaluated for all streamflow percentiles and across the full range of lead times. Our findings reveal that statistical-dynamical streamflow forecasting produces promising results, which may enable water managers to make practical decisions about water supply and allocation, reservoir operation, flood risk, urban planning, navigation and crop forecasting.