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Skill assessment of a global hydrological model in reproducing extreme flows

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This study investigates the skill of the Macro-scale Hydrological Model (MHM) PCR-GLOBWB in reproducing past extremes in the discharges of 20 large rivers of the world, as an initial step in assessing the prospect of using the model for hydrological forecasting. The assessment provides a benchmark verification procedure with the best possible meteorological forcing. Global terrestrial hydrology is simulated for a historical period from 1958 until 2001 by forcing PCR-GLOBWB with daily meteorological data obtained by downscaling the CRU dataset to daily fields using the ERA-40 reanalysis, which can be considered to be the best representation of past weather. Simulated discharge values are compared with observed monthly streamflow records for a selection of 20 large river basins that represent all the continents, a wide range of climatic zones and latitudes as well as a variety of precipitation regimes.

Model skill is assessed in three ways. At first, the general performance of the model in simulations is evaluated. MSE skill scores that provide a quality measure relative to the mean climatology are calculated for each river basin, prior to and after bias correction. The coefficient of determination (R^2) and Nash and Sutcliffe's coefficient of efficiency (E) are also calculated. Secondly, model skill in reproducing significantly higher and lower flows than the monthly normals is assessed in terms of skill scores used for forecasts of categorical events. For each month, discharge is classified into low, normal and high flow; where normal flow is defined as the central 50% of the cumulative distribution. The skill in simulating these classes is assessed by constructing categorical contingency tables and applying Gerrity scores used in meteorology for ordinal categorical events. Thirdly, model skill in reproducing flood and drought events is assessed. Floods and droughts are regarded as simple binary events defined in terms of exceedences of threshold discharges corresponding to five-year return periods. The skill is assessed by constructing binary contingency tables for floods and droughts for each basin and applying Peirce's skill score.

The results show that the model does have skill in all three types of hindcasting. For most basins, the model skill in simulating hydrographs is higher than the climatology; and it is improved significantly by bias correction. The skill obtained by categorical hindcasts is quite high compared to that of an imaginary unskilled system. The model also performs better than an unskilled system in binary hindcasting, with a markedly higher skill in floods. The model skill in simulating anomalous flows is higher than that in reproducing five-year floods and droughts. Therefore, It can be said that the model can be used for forecasting anomalous flows with a higher degree of confidence rather than exact discharges or extreme events.

This assessment in hindcast represents a potential skill given the current MHM, with a meteorological forcing based on observations. The true skill can be assessed in forecasting mode using less certain meteorological forecasts from numerical weather prediction (NWP) models.