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Uncertainty of empirical downscaling methods in quantifying the hydrological impact of climate change

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General Circulation Models (GCMs) are widely used to simulate global and regional climate systems and to assess the impact of climate change. However, the resolution of GCMs is too coarse to properly assess impacts at the fine scale such as commonly required in many applications such as hydrology modeling. Empirical, statistical and dynamical downscaling techniques have been developed to meet this requirement. Empirical downscaling is one of the most commonly used approaches due to the ease of its implementation. These downscaling approaches have shown to give similar results to those from much more complicated downscaling approaches. Several empirical downscaling approaches have been recently proposed and there is a need to assess whether the choice of one versus the other contributes (or not) to overall uncertainty. This work investigates the uncertainty of six empirical downscaling methods in quantifying the hydrological impact of climate change over two North America watersheds with different climate conditions (with and without snow). The six empirical downscaling methods are grouped into change factor (two methods) and bias correction (four methods) approaches. Future (2041-2065) hydrological regimes simulated with one empirical lumped hydrology model are compared to the reference period (1971-1995) using eight hydrology criteria. The results show that the uncertainty due to empirical downscaling is not important in predicting mean streamflow statistics such as annual and seasonal mean discharges. However, it is important for extreme statistics such as summer and winter extreme flood. The uncertainty linked to the choice of an approach (change factor vs. bias correction) is much larger than within each group. Comparing the uncertainty envelope of empirical downscaling methods to the one resulting from climate projections indicates that the former is much smaller and may largely be considered insignificant when assessing the hydrological impacts of climate change.