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Quantification of climate change signals and uncertainty in hydrological change simulations for Denmark

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This paper investigates some of the uncertainties related to the use of regional climate model (RCM) data in hydrological simulations at the local scale, and the significance of regional hydrological change predictions considering climate model uncertainties. In Denmark, future changes in climate are expected to result in more extreme hydrological conditions. Higher precipitation is predicted in winter resulting in flooding and water logging in low lying areas, whereas reduced precipitation and higher evapotranspiration are predicted during summer resulting in decreasing water tables, dry root zones and reduced low flows in streams. For a relatively small country like Denmark (approximately 43,000 km2) with climate largely influenced by the ocean, dynamically downscaled RCM outputs are appealing for use in studies of climate change impacts on water resources at the national scale. However, RCMs are subject to systematic errors and their outputs, especially precipitation, require further downscaling prior to use in hydrological simulations. Climate change and hindcast simulations from the period 1961 – 2100 are used from the recently completed EU project ENSEMBLES, which makes available a matrix of transient climate change scenarios for all of Europe at a 25 km2 grid scale. Multiple pairings of GCMs and RCMs in ENSEMBLES allow for differences both between multiple climate models and the uncertainty of the individual model predictions to be quantified in impact studies. The statistical bias correction method developed and validated by the EU Water and Global Change (WATCH) program is applied to 15 climate change simulations for Denmark, comprised of pairings between three GCMs and nine RCMs from the ENSEMBLES project. The WATCH method for correcting climate model output is based on intensity distributions of daily observations and does not distinguish between seasons. Observed station data from 1961 – 2009 in addition to 10 km2 gridded data from 1989 – 2009 is utilized in bias correction of the simulated climate outputs. Climate change signals for Denmark are quantified and compared between the 15 dynamically downscaled RCM scenarios and the bias corrected scenarios, and further comparison is made between RCMs and GCMs and bias correction based on observed station data and gridded data. The amount of uncertainty associated with climate model choice and bias correction method is represented by the spread of the climate change signal. The significance of these results on hydrological change is evaluated by investigating how these uncertainties propagate throughout the Danish National Water Resources Model (DK-model).