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Effects of climate model radiation and humidity estimates on hydrological impact assessments

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The hydrological effects of climate change have been given much attention for many years. The estimates of these effects depend heavily on the meteorological input data used. Unfortunately, due to the systematic errors of climate models, their output is often not directly applicable as input for hydrological models. Hence, use of the delta change method or statistical bias correction of climate model output for historical and future time periods have been proven necessary. Precipitation and temperature are likely the most important forcing variables in hydrological models, and bias correction of these variables has traditionally been given much consideration. However, other forcing variables also influence evapotranspiration, runoff, snow accumulation and melt. Here, the focus is on humidity, shortwave and longwave radiation, and how differences in these variables across climate models influence resulting water fluxes and states in hydrological model simulations globally, and especially their effects on evapotranspiration estimates. Responses to output from three climate models for three large-scale hydrological models participating in the EU WATCH project have been analysed and compared to simulation results using meteorological data based on observations and reanalysis; i.e. the baseline simulation. The hydrological models, MPI-HM, WaterGAP and VIC, have implemented the Thorntwaite, Priestley-Taylor and Penman-Monteith equations for evapotranspiration, respectively. The models are shown to be increasingly sensitive to the meteorological input data. MPI-HM only depends on precipitation and temperature. WaterGAP is in addition dependent on radiation values, whereas VIC is additionally dependent, as direct input or internally estimated, on radiation and humidity, as well as wind speed. The choice of evapotranspiration scheme and input forcing variables clearly results in different sensitivity to the climate model outputs, with increasing sensitivity the more variables used. A simple bias correction method, comparable to commonly used methods for bias correction of precipitation and temperature, is developed, implemented and tested. The results indicate that bias correction of radiation and humidity values can successfully be used to match baseline simulation result. Finally, historical and future model simulations resulting from the bias corrected forcings are compared to the non-bias corrected results.