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Validation of Regional Climate Models for Hydrological Impact Studies at the Catchment-Scale

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Traditionally, simulations of global climate models (GCMs) have been the basis of hydrological impact studies. Progress in regional climate models (RCMs) has recently made the use of these simulations as a basis for hydrological studies more attractive. RCMs allow transferring the large-scale information from GCMs to scales which are closer to the catchment scale. However, the use of RCM simulations for hydrological studies is often challenging. Although RCMs simulate hydrological variables in addition to climate variables, these simulations do often not agree with runoff observations and, thus, might not be directly useful to assess hydrological impacts. Therefore, usually RCM output data is used in off-line mode to force a hydrological model. Considerable biases in the RCM simulations often make this approach challenging.

To demonstrate the biases of and the variability between different RCMs, we analyzed data from the control-run period of 14 different RCMs for five Swedish catchments. The control-run performance is important as the ability of RCMs to correctly reproduce current conditions provides confidence in the simulation of future scenarios. Simulated temperature and precipitation series for present climate conditions were compared directly to observations. However, we were mainly interested in the combined effect of RCM temperature and precipitation on runoff simulations. Thus, we simulated the runoff with help of the HBV model by means of RCM-simulated temperature and precipitation. Different bias correction methods were tested in order to correct RCM temperature and precipitation by accounting for systematic errors in the climate models.

There are significant differences in the ability of RCMs to reproduce temperature and precipitation parameters under current climate conditions. Performances of the RCMs depended largely on the investigated climate parameter and the catchment location. Consequently, bias correction was needed, because a bias in RCM-simulated variables would lead to unrealistic hydrological simulations of river runoff. Our results show that RCMs are to a certain extent only able to provide sufficient data for the HBV runoff simulations. Although the HBV-simulated runoff fitted partly well with observations in terms of spring and autumn flood timing, the magnitude differed significantly with up to $\pm 100\%$ deviations for several RCM model simulations. Simulations of extreme floods in spring and autumn also showed a large variability between the different RCM simulations. The results of this multi-RCM approach for runoff simulations of meso-scale catchments in Sweden clearly demonstrated the inter-model variability of RCMs. This underlined the importance of using a bias correction and an ensemble of different RCMs for hydrological impact studies.