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Climate change and water resources in northern Mongolia

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Mongolia is facing a large number of water-related problems, such as adverse natural conditions, increasing water withdrawals, scarce environmental information and a lack of structures which control the appropriate distribution and protection of water. Since 2010, we conduct a monitoring programme in northern Mongolia which aims at better understanding the climatic characteristics, the freshwater generating processes as well as the impact of environmental change on the water resources in a semi-arid environment. Focus is on the meso-scaled Kharaa catchment (14,500 km^2) north of Ulaanbaatar which includes the transition belt between the extended steppe ecotone, the Siberian taiga as well as the alpine tundra of the Khentii Mountains which act as the major freshwater generating area of the region. Based on the information gained during our field studies, we successfully applied the hydrological HBV-D model to simulate the discharge at the outlet of the basin and for a number of sub-basins. We could show that runoff within the study region is strongly influenced by the high climate variability. For example, the observed runoff in the basin shows a sudden decrease in the middle 1990s. At the same time, precipitation is decreasing and temperature is strongly increasing. The study is based on data from only six meteorological stations. Therefore, output from Global Climate Models has been considered as another potential data source. Accordingly, the HBV-D model was driven with WATCH forcing data for the years 1901-2000. This made it possible to simulate the runoff for years where no runoff observations exist. The results show that mean annual air temperature (MAT) has been strongly rising during the last 100 years (for example, between 1940 and 2001 MAT increased by 1.7°C) while precipitation shows strong, long-term oscillations. Accordingly, simulated mean annual discharge shows a high temporal variability with high fluctuations during the first half of the 20th century when air temperature was relatively low. Furthermore, in order to address the hydrological impacts of future climate change, the HBV-D model was applied on WATCH scenario data for the years 2001-2100, including the output from three GCMs driven by two IPCC emission scenarios. Results indicate that the clear increase of MAT is projected to continue over the coming 100 years while mean annual precipitation appears to slightly increase. However, simulated discharge shows a decrease, evidently as an effect of increasing evapotranspiration and possibly changing precipitation characteristics.