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Modelling the effects of climate and land use change on the hydrological system of Urumqi, Northwest China

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This case study is about the hydrological system of Urumqi City, Northwest China, where the effects of climate change and land use change until 2050 are modelled. The research is part of the BMBF-funded project "RECAST Urumqi – Meeting the Resource Efficiency Challenge in a Climate Sensitive Dryland Megacity Environment". Northwest China is a region where notable climate change takes place. Regional climate has shifted during the last 30 years to a wetter regime, while at the same time exhibiting rising temperatures. The provincial capital Urumqi is a fast expanding economic and industrial centre, leading to enforced and notable land use change around the city. The hydrological effects of both drivers have to be assessed to allow customized adaptation to the inevitable changes.

The hydrological model is based on the water balance equation and uses partly physically based modules e.g. to calculate potential evapotranspiration with the Penman–Monteith formula and partly index based modules e.g. to simulate snow melt water and surface runoff. The main challenge when applying the model was the lack of field research and hydrological data such as measured runoff or groundwater recharge. Hence, input data was almost completely collected from afar, from climate and soil databases and remote sensing (land use and cover, spatial distribution of land surface temperature and precipitation). The hydrological model was calibrated at one of the upper sub-catchments with good results for the total annual runoff volume but low values for the Nash–Sutcliffe model efficiency coefficient. In order to assess the annual water balance, the methodology was transferred to the whole catchment area. The hydrological behaviour of the other sub-catchments was assumed to be comparable to the calibrated one, applying the concept of predicting ungauged basins based on similar characteristics of the hydrological system.

Future scenarios that were modelled include on the one hand the projection of local climate change and on the other hand future land use planning issued by the local authorities. The effect of a warmer and wetter climate is discussed including the assumption that a future precipitation increase might exceed the change of actual evapotranspiration due to temperature increase. These findings are then compared to the impact of land use changes which are smaller due to their lesser spatial extent. However, on the local scale, their effects on the local hydrological system are noteworthy.