

This thesis addresses the complexities of conducting hydrological climate change impact assessments in mountainous, highly glacierised catchments by developing and validating a glacier dynamics module for the hydrological model SWIM. It provides the first integrated climate change impact assessment for the five headwaters of the Tarim River, NW China/Kyrgyzstan, Central Asia, overcoming the region's severe data-scarcity.

The region's heterogeneity and limited data availability is characterised, with a focus on the quality of precipitation datasets. After using the original SWIM model for an analysis of observed glacial lake outburst floods and highlighting the model's insufficiencies for long-term assessments, a new glacier dynamics model of intermediate complexity is developed, bridging catchment and glacier scales. This new model implements all major glacier processes, including ice movement, avalanching, sublimation and sub-debris melting. It is validated in one of the data-scarce Tarim River headwater catchments as well as the data-abundant Upper Rhone catchment, Switzerland. The model is then implemented in all five Tarim headwaters and calibrated to discharge, glacier hypsometry and mass balance, using an automatic multi-objective approach. The model provides a correction of the high mountain precipitation, a driving variable shown to be highly uncertain. It is then used to assess three IPCC climate change scenarios for the 21st century using an ensemble of eight global and one regional climate model. Impacts on glacier area and volume as well as discharge are explored, including their climate model and calibration parameter uncertainties.

Results show current catchment precipitation to be 1.4–4.3 times greater than observation datasets suggest, a finding in-line with climate model simulations and remote sensing based datasets. Under a generally warmer and wetter climate, glacier cover is expected to recede and discharge may experience large increases as a consequence, especially in the near future. Uncertainties are large, however, mainly owing to climate model variability.