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Integrating Hydro-Climatic and Socio-Economic Data into Hydrological Models for Data-Scarce Mountain Regions - A Case Study in the Santa River Catchment, Peru

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Catchments in high mountain areas, like in the Santa River catchment in the Andes of Peru, are considered as climate sensitive. Therefore, water resources play an important role for local communities, urban centres, small- and large-scale agriculture and hydropower. A comprehensive analysis of water supply and demand in these areas considering possible hydro-climatic and socio-economic changes is therefore of particular importance. In this context, an integrated water balance model is a useful tool for simulating current and future water availability. But a serious problem in such high mountain areas is data availability and quality.
To address these challenges, available time series of hydro-climatic data (runoff, precipitation and temperature) were analysed and tested for consistency. A major issue in the study area is missing data, especially between 1995 and 2010. These data gaps were infilled using a novel approach based on copulas. This approach however depends on correlation between neighbouring observations. Due to the high temporal and spatial variability of the hydro-climatic parameters correlations between daily data are too low. Therefore, the data was aggregated to monthly values for infilling because on this time scale the correlations are higher. The infilled data were used to set up a conceptual hydrological model for the study region. This model simulates hydrological processes on a daily resolution, thus the infilled time series had to be disaggregated again. Several disaggregation methods were tested to analyse the effect on the performance of the model. In addition, the model is further developed to include water demand data, such as agricultural and domestic water uses as well as the water consumption by hydropower. For estimating future changes in hydro-climatology, monthly CORDEX scenarios are downscaled for the catchment area and also disaggregated to daily time series. To assess future development in water availability, the climate scenarios are combined with three consistent socio-economic scenarios, which were developed by applying a cross-impact-balance analysis (CIB), a method used for analyzing impact networks. This method utilizes local stakeholder knowledge to design specific scenarios for the study area. The combined climate and socio-economic scenarios provide an important basis for modeling future water supply and demand and for analysing potential water scarcity and associated water risk hotspots. Our model framework builds a useful tool for local decision-making of long-term water management under limited data and process understanding and, thus, high uncertainties.