Geophysical Research Abstracts
Vol. 15, EGU2013-5479, 2013
EGU General Assembly 2013

How much water will glaciers in the Chon Kemin valley (Tien Shan mountains, Kyrgyzstan) provide in the future?

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Climate-driven changes in glacier-fed streamflow regimes have direct implications on freshwater supply, irrigation and hydropower potential. Reliable information on current and future glaciation and runoff is thus crucial for water allocation. In summer-dry regions like Central Asia, glaciers play an important role in streamflow regimes, as meltwater from glaciers is released when other sources such as snowmelt are depleted. This situation is well reflected by the Chon Kemin River, an important tributary to the Chu River providing Kyrgyzstan‘s capital Bishkek with freshwater. Today, glaciers cover around 8% of the Chon Kemin valley (118 of 1’438 km2) and 30% of the headwater catchment (49 of 165 km2), but these glaciers in the low-altitude northern periphery of the Tien Shan mountains are melting particularly fast. Glacier shrinkage has considerable impacts on the seasonal and overall availability of water: In a first instance, shrinking glaciers supply ample quantities of water in the form of increased glacial runoff, but reduced glacier volume will ultimately result in a decrease in both glacier-fed and total runoff, if no other sources can offset reduced glacier melt. Although crucial for efficient water planning, it is largely unknown if the Tien Shan rivers have already passed this tipping point (“peak water”), or, if not yet, when this will happen.

In our study, we assess past and future runoff changes in the Chon Kemin River to elucidate the timing of “peak water” and to quantify water availability in coming summers, when precipitation is expected to be even more scarce than today. Meteorological and hydrological data suggest that total runoff has increased in the past decades, particularly during summer and fall, probably as a result of increasing glacial meltwater. Annual fluctuations in precipitation and runoff have shown an asynchronous behavior in a first phase (1936 until early 1960s), but have then changed to a synchronous pattern (early 1960s until 2005), which might indicate that the Chon Kemin River already underwent a transformation from a glacial-nival to a nival-pluvial runoff regime.

To quantify future runoff from Chon Kemin River, we use the glacio-hydrological model GERM. The model includes transient glacier changes and calculates glacier mass balance and runoff in daily time-steps. The refined multi-variable-calibration allows a realistic reproduction of each runoff component and an accurate simulation of discharge and mass balance over time. Calibration and validation include snowcover duration from MODIS/AVHRR (1985-2012), mass balance data from Tuyuksu glacier in the neighboring valley (1957-2009), changes in glacier extent and surface elevation from aerial photographs (1956 and 1988), glacier length changes (1977-1990) and measured daily runoff (1936-2005). After calibration, the model is run with daily precipitation and temperature data from a downscaled regional climate model (IPCC scenario A1B) until the end of the 21st century. In order to produce realistic results, we address uncertainties in terms of amount, seasonal distribution and form of future precipitation in detail, as well as feedback mechanisms, such as a changing snow cover.