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Long-term hydro-climatic changes in the Selenga river basin, Central Asia

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Climatic changes can lead to altered hydrological conditions, which in turn can impact pollutant loading patterns to the terminal recipient of a considered basin. Lake Baikal is the deepest and largest freshwater reservoir on Earth. The lake and its surroundings have been declared an UNESCO World Heritage Site due to its unique ecosystem with numerous endemic animal and plant species. The Selenga river basin, which is located in northern Mongolia and southern Siberia in Russia, is the largest sub-basin of the Lake Baikal. Mining is well developed in the region and has been identified to be the main pollution source for the water system in the sparsely populated region. We investigate long-term historic and projected future hydro-climatic conditions in the Selenga river basin with the aim to improve the understanding of such underlying conditions in the basin. This understanding is fundamental for preventing degradation of Lake Baikal's unique ecosystem from for instance mining activities. Specifically, our objective is to identify observed historical hydro-climatic changes during the 72-year period of 1938-2009. In addition, we assess multi-model ensemble means of the Coupled Model Intercomparison Project, Phase 5 (CMIP5) in order to also consider future projections of hydro-climatic changes for a near future period (2010-2039) and a more distant future period (2070-2099). The results show that there has been an observed increase in mean annual temperature in the basin by about 1.5°C during the period 1938-2009. Moreover, a longer seasonal period of temperatures above zero (especially due to increasing spring temperatures) is detected. For the annual water balance components of precipitation, evapotranspiration and runoff, relatively small temporal changes are observed. However, in recent years there has been a detected decrease in runoff, with 10-year running averages reaching their lowest levels within the whole investigation period. In particular, there has been a decrease in peak discharges during summer and an increase in winter base flow. Such decreased intra-annual variability may be an indication of permafrost thawing, associated with increased active layer depth and thereby decreased subsurface storage of (liquid and frozen) water. Future projections indicate a continued large increase in temperature for the long distance future (2070-2099), from a mean annual temperature of -2.5°C for the period 1961-1990 to a mean annual temperature of 3°C for the period 2070-2099. Such a shift from mean annual temperatures below zero to well above zero may lead to further permafrost thawing. The magnitude of precipitation, evapotranspiration and runoff are expected to increase in the future. However, especially the projection for runoff is highly uncertain due to large variation in projections from individual models and an overall poor performance of the models to capture the observed trend.