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Change in streamflow characteristics over Boreal Southern Siberian catchments

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There has been an accelerated and over-proportional rate of warming in the dry mid-latitudes and boreal forests of Southern Siberia. Associated changes affect permafrost distribution, the occurrence of wild fires and hydrological dynamics. Given that the Boreal ecotone occupies roughly 20 million km^2 of the global land surface, it can be assumed that these changes are of major interest with regard to the Earth's freshwater resources. However, since long-term hydro-meteorological time series are often not available, the impact of climate and environmental change on flow dynamics and water availability can only be roughly estimated.
To gain insight into these challenging questions, we try to quantify the discharges and their temporal developments from two large-scale river basins. In a first step, we determine associated variabilities and trends of the major influencing factors, such as air temperature, precipitation and evapotranspiration. The selected catchments represent the variety of the climatic, landscape and permafrost patterns of that region: (1) Selenga River is the largest sub-basin of Lake Baikal, with a catchment size of about 440,000 km^2. The basin covers the transition belt between the dry mid-latitudes and the Boreal Zone and is mostly underlain by discontinuous permafrost. (2) Aldan River is a tributary of the Lena River. It drains an area of approx. 750,000 km^2, which is completely attributable to the Boreal ecotone and the continuous permafrost zone. Our analysis is based on long-term historical (1946-2015) hydro-meteorological time series, large-scale gridded data sets, as well as modeling simulations. The data undergoes extensive testing to detect anomalies, trends and multiple dependencies.
The strong increase in air temperature during last 60 years may result in permafrost degradation and a decrease in seasonal frost occurrence, which is evident from the decreasing intra-annual variability of discharge in both catchments. However, the changes in river discharge show different directions: while the mean discharge of Selenga has decreased significantly, the mean discharge of Aldan shows a significant increase over the long-term period (based on the Mann Kendall test at a 95% confidence level). There also exist substantial seasonal shifts in the flow dynamics over both areas. These drastic and highly significant changes can be partly (but not fully) explained by precipitation and air temperature variabilities and trends. It is therefore likely that changes in landscape patterns, such as permafrost degradation and large-scale forest fires, are of great significance for the hydrological changes. Moreover, increasing water withdrawals due to a growing population, accelerated urbanization and a highly dynamic mining sector in the Selenga basin are factors that contribute to decreasing streamflow trends. To further clarify these relationships, our investigations will be extended to neighboring catchments, and our simulation studies will include an ensemble of hydrological models.