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Contribution rates of source waters to Arctic river discharge quantified by end-member mixing analysis and model simulation

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The global warming is further accelerating the Arctic water cycle, which is especially identified by the increasing trend of observed river discharge. The increase was significant in the cold season, associated with the impacts of warming permafrost. The warming climate has also advanced the snowmelt timing, with increasing summer rainfall. Changes in these processes are primarily implicated to the alternation of seasonal origin waters, especially forcing river discharge. Here the origin of river discharge is likely separated to underground ice meltwater (or groundwater), snowmelt, and rainfall of warm season. These source waters are mixed in different proportions with seasonal fluctuations forming river discharge, but quantitative evaluation has not yet been conducted. Therefore, we quantitatively evaluated the seasonal changes in each source water in discharges of the Lena and Mackenzie Rivers, based on the observational records.

Water was sampled at the outlets of the Lena and Mackenzie Rivers during the period 2004–2007 and analyzed the oxygen stable isotope ratio and tritium concentration of the discharge as end members, which were used to quantify the ratio of each source water to the river discharge. The results of the end-member mixing analysis indicated that rainfall of the warm season portioned large fraction of the summer river discharge and snowmelt water was large during the snowmelt period. On the other hand, groundwater contributed a large proportion to the winter discharge, interestingly even around June of the next year, which seems to be the impact of river ice freezing after seeping to the surface in winter. These observational results were consistently identified by model simulations conducted by a hydrological model coupling the water isotopic tracer scheme. The model quantified the contribution rates of source waters to seasonal and interannual variability of discharge in the pan-Arctic river system during the past decades. This study provides a possibility to distinguish quantitatively the changes in the Arctic discharge processes, resulting from the future climate warming.