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Impact of ice cover loss on sediment transport processes in seasonally frozen rivers

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In more than half of Earth's rivers, ice cover is observed at some point during the hydrological year. Ice cover influences rivers' hydrological and geomorphological processes, with altered flow properties leading to reduced sediment transport capacity. The duration of river ice cover has been observed to be shortening, a trend predicted to continue in the future. As a result of climate change, freezing and breakup times, as well as the length of river ice cover periods, are shifting. Consequently, sediment transport processes are also changing, with relatively unknown effects on environments where ice cover has historically been a recurring phenomenon.

This study aims to quantify the effects of shorter river ice cover periods and complete ice cover loss on sediment transport in seasonally freezing rivers. To achieve this, we employ hydraulic modelling to analyse these impacts. We use known discharge and weather event data to model how wintertime sediment transport is influenced by changing freeze-thaw cycles and the shortening or complete disappearance of permanent ice cover periods. To assess the potential for sediment erosion, transport, and deposition under changing river ice conditions, we use HECRAS 1D and 2D models to gain insights into sediment transport processes. Preliminary modelling results are presented to evaluate current sediment dynamics and predict future scenarios under evolving river ice conditions.

The study focuses on three Finnish watersheds to represent regional differences. The first site, the Tana River in northern Finland, is a boreal sub-Arctic, snow-dominated watershed with an ice-covered period from October to May or June. The second site, the Oulanka River in northeast Finland, currently changing from a snow-dominated to a rain-dominated regime, with ice cover from November to early May. The third site, the Uskela River in southern Finland, is a hemiboreal, rain-dominated watershed with varying ice cover depending on seasonal frost and thaw cycles. The rivers differ in sediment properties: Tana has a gravel bed, Oulanka has a sand bed, and Uskela has a clay bed. Field campaigns at these sites collected data for hydraulic modelling, including airborne laser scanning, discharge measurements, and water level monitoring.