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Response of a Large Periglacial River to the current Climate Change

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Recent evidence has shown that Arctic regions have warmed about twice as much as elsewhere on the planet over the last decades, and that high-latitude periglacial processes and hydrological systems are deeply impacted by rising temperatures. The study presents recent results concerning the fluvial dynamics of a large periglacial river, the Lena River. The Lena river drains a large basin (2.9 million km²) entirely occupied by permafrost (77% with a deep and continuous permafrost). We had previously demonstrated that in the Lena basin, the climate change induces important increase in the river water discharge, that destabilizes the fluvial bed. Here we focus on the fluvial islands dynamics by examining islands with permafrost and islands without permafrost, such comparison being considered as a good indicator of the sensitivity of the hydrosytem to climate change. Island changes are precisely examined: morphological parameters of about 100 islands are surveyed using a GIS on seven series of aerial photographs and satellite images of a 100 km-long reach, for the 1967 – 2017 period. Furthermore, data obtained on several monitored islands allow to analyze the control factors.

Field surveys and monitoring of islands shows that within a zone of thick and continuous permafrost, the Lena floodplain is far from being thermally and geomorphologically homogenous: the floodplain rather consists of a juxtaposition of seasonally frozen islands and permanently frozen islands. First, the analysis demonstrates that the two types of islands present different dynamics in terms of erosion and sedimentation. A major change is observed for islands with permafrost at the beginning of the 21st century: they clearly underwent a stronger erosion for the last twenty years. During the same period, numerous small and non-frozen islands have been formed. Second, the morphological parameters are analyzed with respect to factors that play a major part: water discharge (duration of bar-full, bankfull and flood discharges, number and season of flood peaks…) and temperature of the river water and of the island ground. The submersion of islands during flooding do not deeply modify the thermal regime within the island ground. However, the duration of the discharge exceeding the bar-full level can induce a marked erosion of island bank, especially in summer. Thus, our study highlights the complexity of large river responses across Arctic periglacial environments.