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Numerical simulation of ice-rich coast erosion rates under climate changes (Baydaratskaya Bay, Kara Sea)

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Arctic coast is a dynamical system which is very sensitive to external changes. Coastal destruction depends on many factors including thermal and wind-wave energy. Bluff retreat is very irregular and closely related to the features of geocryological structures of the coast. The variation of the main parameters and properties of the soils should be responsible for the irregularity of erosion rates due to thermodenudation. In order to understand the processes which influence on thermal denudation rates, numeric simulations were performed using Qfrost software (finite-element model). The model utilized by Qfrost is based on the heat balance equation and the Stefan formula.

Our investigation was carried out along the western part of Baydaratskaya bay coast, Kara Sea, Russia. Boundary conditions were set using the heat transfer coefficients. Historical records of Marre-Sale weather station, which is located about 95 km to the north from the study area, were used as climatic parameters. Air temperature records were averaged monthly for the observation period 1973 – 2016. Applied for simulations physical soil's parameters were obtained via laboratory tests of the soils samples collected in the field. Clays, silts or sands were as ground materials in the model. Since erosion rate, caused by thermodenudation, strongly depends on slope cleaning process, we simulated different regimes of removal of the thawed layer.

Numeric experiments with resection of the thawed soils indicated that coastal retreat strongly depends on the the ice content and cleaning mode of the slope. The highest erosion rates were obtained when thawed material was resected immediately after the thawing. The estimated rates ranged between 5 and 10 m for sandy coasts and between 3 to 7.5 m for silty and loamy bluffs. These results demonstrate the crucial influence of slope cleaning mode, ice content in the soils and their reaction under climate changes on the erosion rates caused by thermodenudation.

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