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Contribution of lateral thermoerosion and thermodenudation to the coastal retreat at Yugorsky Peninsula, Russia

A. Gubarkov, A. Khomutov, and M. Leibman

Earth Cryosphere Institute, Russian Academy of Sciences, Siberian Branch, Moscow-Tyumen, Russian Federation (agubarkov@gmail.com)

We suggest that in relation to the strong fluctuations in the air temperature and ice cover of the seas, especially in recent years, traditional concepts of the mechanisms of coastal retreat require more accurate analysis. It follows from the literature that coastal thermoerosion (thermoabrasion) and thermodenudation are the leading processes of the destruction of Arctic coasts. Lateral thermoerosion, nivation, landsliding, rock falls, and aeolian processes are also developing along the coasts, but their role is secondary. Our observations evidence that thermodenudation with different mechanisms dominate in the conditions of widely distributed tabular ground ice, while the role of thermoabrasion is less important. Field study in summer 2007 demonstrated that climatic fluctuations may result in a significant role of lateral thermoerosion. This process was never considered as the leading one in coastal destruction. An essential increase in lateral thermoerosion transversal to coastal bluffs is related to an increase in the level of winter atmospheric precipitation and accumulation of thick snow patches.
Instrumental observations undertaken in mid-July, 2007 evidenced that snow covered about 50% of the coastline protecting the coasts from thermoabrasion. Thus processes of lateral thermoerosion started to dominate, the role of cryogenic landslides increased as well. This was induced also by melting of snow and intense water discharge during the period of snowmelt. Cryogenic landslides and mud flows actively developed together with the lateral thermoerosion due to water saturation in the starting active layer.
The volume of material transported as a result of thermoerosion and cryogenic landslides was calculated. It appeared that the activity of processes estimated by the volume of material transported from one kilometer of the coastline is greater at the higher bluffs and less at the lower ones.
Comparison of the new data with the results of A.I. Kizyakov for the same territory (he states that the volume of the transported material is 13 000–26 000 m3/km during the warm period) demonstrated that during 13 days of snowmelt, lateral thermoerosion and landsliding transported more than 35% of the volume of material (up to 2773–10111 m3/km over 13 days) compared to their amount over the entire warm period of any year of observations starting from 2001. The specific index (normalized to 1 day) of coastal retreat in July 2007 3–6 times as much as the mean value of 1-day coastal retreat over the warm period in 2005–2007.
Since the Yamal Peninsula, which is also formed of frozen dispersed rocks with tabular ground ice, is a coast of the Kara Sea, let us compare the rate of coastal retreat and transport of material in two regions. After A.A.Vasiliev, the rate of thermodenudation (cryogenic landslides) is on average up to 0.4 m/year (25% of the total retreat). The mean transport of material in the Kara Sea calculated by A.A.Vasiliev including the rocky coasts is approximately 1000 m3/yr from 1 km of the coastline. For the Yugorskii Peninsula, which is distinguished for thick layers of tabular ground ice and correspondingly more active thermodenudation compared to Yamal, the transport of material is 13–26 times higher. According to our data, during the year of intense participation of lateral thermoerosion in the destruction of the coast and increased role of cryogenic landslides, the transport of material even during the much shorter period of 13 days 3–10 times as much as the annual transport from the coast of Yamal. Since we are considering a periodic phenomenon: the peak thickness of the snow cover, it is useful to estimate its recurrence. According to the data of meteorological stations, winters with high snow precipitation repeat approximately once every 30 years. It is clear from climatic predictions that a clear trend to increasing of the snow cover thickness is observed on the coast of the Kara Sea. Hence, a critical thickness of snow would occur more and more frequently. The role of different processes in the coastal retreat allows developing an algorithm for calculating material transport from land to sea. Field measurements increase the reliability of the quantitative estimate of material transport along the entire Arctic coast of Russia and other countries.