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Climate-sensitive subsea permafrost and related gas expulsions on the South Kara Sea shelf. Field studies and modeling results.

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Thawing subsea permafrost controls methane release bearing a considerable impact on the climate-sensitive Arctic environment. Significant expulsion of methane into shallow Russian shelf areas may continue to rise into the atmosphere on the Arctic shelves in response to intense degradation of relict subsea permafrost. The release of formerly trapped gas, essentially methane, is linked to the permafrost evolution. Modeling of the permafrost at the West Yamal shelf allowed describing its evolution from the Late Pleistocene to Holocene. During the previous work we detected extensive emissions of free gas into the water column at the boundary between today's shallow water permafrost and deeper water non-permafrost areas. These gas expulsions formed seismic and hydro-acoustic anomalies on the high-resolution seismic records. We supposed that in the water depths <20m continuous ice-bearing permafrost plays a role of a seal through which gas can not migrate. We integrate 1D modeling results of relict permafrost distributions with these field data from the South Kara Sea. Modeling results suggest a highly-dynamic permafrost system that directly responds to even minor variations of lower and upper boundary conditions, e.g. heat flux from below and/or bottom water temperature changes from above. We present several scenarios of permafrost evolution and show that potentially minimal modern extent of the permafrost at the West Yamal shelf is limited by $\sim$17 m isobaths, whereas maximal probable extent coincides with $\sim$100 m isobaths. The model also predicts seaward tapering of relict permafrost with its maximal thickness 275-390 m near the shore line. We also present sensitivity analysis which define the wider range of modeling results depending on the changing input parameters (e.g. geothermal heat flux, bottom water temperature, porosity of the sediments). The model adapts well to corresponding field data, providing crucial information about the modern permafrost conditions, current location of the upper and lower permafrost boundaries and its possible impact on both the hydrosphere and atmosphere in a warming Arctic.