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Modeling Permafrost Dynamics in the East Siberian Arctic Shelf

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The ESAS sub-sea permafrost stability is a key element in controlling methane flux from the seabed deposits to the water column and further to the atmosphere. Currently, there is very few observational data on the ESAS sub-sea permafrost state and thermal regime. We present a model of permafrost dynamics to explain limited observations and to gain insight in the future permafrost evolution within ESAS.

The sub-sea permafrost dynamics is modeled by solving the non-linear heat equation with the phase change in 1-D and 2-D computational domains. Permafrost dynamics is computed for the latest climatic cycle and is based on the paleo-geographic scenario, glacio-eustatic ocean water level, geological model, initial temperature distribution, and geothermal heat flux. We conduct a sensitivity analysis with respect to the soil properties, ocean bottom temperature and inundation timing, and consequently show that the soil salinity and parametrization of the unfrozen water content on temperature are among other critical factors influencing sub-sea permafrost dynamics.

This model was tested and obtained good agreement with existing permafrost models and multi-year observational data collected in Dmitry Laptev Strait. We apply the developed model to simulate permafrost dynamics within and outside of the inundated thermokarst depressions, existing rift zones, river paleo-canyons in ESAS and areas underlain with shallow Arctic hydrate deposits.