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Modeling the local effects of sub-sea permafrost degradation on Arctic marine biogeochemistry

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Methane is a strong greenhouse gas and its emission from thawing permafrost could cause an accelerating effect on global warming and acidification in the ocean. To better understand the consequences for Arctic marine environments, we use a complex biogeochemical model to explore the local effects of methane seeps caused by permafrost thawing. Permafrost found in the outer part of Eastern Siberian Arctic Shelf (ESAS) has mostly degraded and represents an area where methane fluxes are very high. For that reason, we focus on simulating the biogeochemical changes in the water column resulting from methane seeps for the ESAS region.
Bubbles from a single seep area tend to dissolve at about the same depth above the seafloor, resulting in the formation of methane-rich layers within the water column. At the same time, parts of ESAS are seasonally covered by ice, serving as an almost impermeable lid for methane fluxes and promoting the formation of methane-rich layers in the surface waters. To explore the state of the water column we use a 1D Ice-Pelagic-Benthic transport model (IPBM) coupled to the biogeochemical models Bottom RedOx Model (BROM) and the European Regional Seas Ecosystem Model (ERSEM). The chosen region is located within the Laptev Sea area. In the current stage, we use a data known from a literature to adjust ERSEM and therefore represent roughly a composition of a local ecosystem, while BROM provides estimations for the methane biogeochemistry. IPBM makes it possible to set a source of methane within a sediment column and track it through sediments, water, and ice domains.
The results show some local impacts of the subsea methane source on marine biogeochemistry on seasonal timescales and the importance of accounting for the methane source from the permafrost. As subsea permafrost thawing is expected to continue over the coming decades, our modeling approach may also be useful for parameterizing long-term impacts on Arctic marine biogeochemistry.