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Siberian-Arctic Subsea Permafrost and Methane: Spatial variability and isotope-based source apportionment

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There are only a few Earth System processes that can cause a net transfer of carbon from land/ocean to the atmosphere (as CO_2 and CH_4) on the century timescale– top candidates are thawing permafrost and collapsing CH_4 hydrates in the Arctic. Nevertheless, there are huge uncertainties regarding the composition, inventories and functioning of these different Cryosphere-Carbon pools.

Most investigations of Arctic CH_4/CO_2 releases have studied inland permafrost (PF), yet there is increasing attention towards coastal and subsea permafrost and hydrates. The East Siberian Arctic Ocean (ESAO) is the target area as it is experiencing among the highest climate warming and because of its vast, yet poorly constrained stores of vulnerable carbon. The ESAO is the largest yet shallowest shelf of the World Ocean, being a seaward extension of the Siberian tundra that was flooded during the Holocene transgression 7-15 kyr ago.

Recent drilling campaigns of the Laptev Sea subsea permafrost have provided the opportunity for progress in understanding its current state, composition and functioning. The temperature profiles of the PF underneath the coastal waters were in general much higher and close to zero, compared to nearby still on-land permafrost. Several sites that were drilled 30 years ago were recently re-drilled, which revealed that the thaw horizon has been moving down by several meters in just a few decades. There is thus both a potential for degradation of the organic matter (including to methane) in this subsea PF as well as an increasing permeability for pre-formed methane to penetrate toward the surface.

Methane in the ESAS water column is over extensive scales present at concentrations much above what would be predicted from equilibrium with overlying atmospheric mixing ratios. The spatial patterns can now start to be compared with geophysical data on the composition of the

sediments. The water column to atmosphere transfer of methane is affected both by the relative importance of diffusive exchange of dissolved methane and through ebullition. Storm-induced ventilation of the water column is shown to be an important process.

The relative contributions of different subsea compartments to the methane fluxes is also approached through isotopes. We are exploring triple isotope fingerprinting of bottom water methane to apportion its sources (i.e. $d^{13}C/dD/D^{14}C\text{-}CH_{4.}$). Preliminary results from two active seep regions, one in Laptev Sea and one in the East Siberian Sea will be presented.