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Methane cycling within sea ice; results from ice drifting during late spring, north of Svalbard

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Methane is a potent greenhouse gas whose atmospheric concentration has increased over the last decades, contributing to global warming. Regional amplification effects of global warming have led to a sharp retreat of sea ice in the Arctic Ocean during the last decades. Further, a thinner sea ice and increasing areas with fractional sea ice cover in summer are becoming a common situation. This may have pronounced and unknown effects on the methane pathways between the sea ice and the seawater below. It has been shown that the Siberian shelf areas, which represent the major areas of sea ice formation, are a significant source of methane. Large amounts of this methane are transported across the Arctic Ocean by the drifting sea ice, into areas remote from the source. This methane could be subject to microbial transformations. The residual methane either remains stored in the sea ice or is released into the seawater or atmosphere.

The aim of our study is to identify major methane pathways between sea ice and seawater, and to identify the potential processes modifying the methane concentration within sea ice. Combined analyses of methane concentrations and its isotopic composition coupled with measurements of nutrient concentrations and physical variables were performed in seawater as well as in sea ice samples in late spring 2017 north of Svalbard during an expedition onboard RV Polarstern.

Our results show an increase of dissolved methane in seawater during a melting event which corresponds to oversaturation relative to the atmospheric equilibrium. This was coincident with a shift of the isotopic composition of methane which became more enriched in 13C. Both changes indicate a release of methane from sea ice into the seawater underneath. We observed low methane concentrations together with a shift of the isotopic composition of methane in rafted and ridged sea ice in comparison to first year ice.

Our results highlighted two main processes that may have modified the stable carbon isotopic signature of methane in ice during the journey from its source region to the study area (Fram Strait). First, kinetic isotopic fractionation at the sea ice/water interface during the ice formation may offset the isotopic signature in the ice compared to the water. This signature may remain stored during the winter. Second, microbial methane consumption while the ice is growing and drifting, would also lead to shifts in the isotopic signature.

Changes in ice cover are thus likely to change the methane pathways in the Arctic Ocean.