Unravelling the origin(s) of methane in sea ice using stable isotope ratios

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Methane (CH_4) plays an important role in the Earth's climate system. The atmospheric CH_4 concentration has increased in concert with the industrialization, but since the mid 80's the CH_4 growth rate decreased to reach a near-zero level in 2000 and started to increase again from 2007 on. However, the underlying variations in sources and/or sinks that cause these variations are to date not well understood. To predict future climate, it is essential to unravel the processes controlling the CH_4 cycle, especially in the Arctic regions, which are highly vulnerable to climate change and contain large CH_4 reservoirs. Recently, an unexpected CH_4 excess has been reported above Arctic sea ice showing that sea ice might play a significant role in the CH_4 cycle. Nonetheless, the nature of the process leading to CH_4 production in or nearby sea ice has not yet been identified.

A new multi-proxy approach was applied merging atmospheric chemistry, glaciology and biogeochemistry to understand and quantify the processes responsible for the CH_4 excess above sea ice. We performed CH_4 isotope ($\delta^{13}C$ and δD) analyses on sea ice samples, as well as geochemical measurements, to determine the possible pathways involved in CH_4 production and removal in or nearby sea ice.

We present results from ice samples collected above the shallow shelf nearby Barrow (Alaska) from January to June 2009 as well as in the landfast ice of McMurdo Sound (Antarctica) in 2011 and 2012. It has long been thought that CH_4 present in seawater would oxidize in or under the sea ice, but our first stable isotope sea ice profiles show no significant oxidation pattern. However, a clear difference in isotopic signature between the two sites is observed. We show that landfast sea ice from both sites is supersaturated in CH_4, but that for the ice overlying the shallow shelf of Barrow the concentrations are larger and the origin of CH_4 is clearly biogenic, thus likely coming from the sediment. For the Mc Murdo Sound ice, the isotope signature is enriched in heavy isotopes in comparison with the atmospheric burden and we show that under specific conditions CH_4 might be produced in the ice.