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Atmospheric methane emissions coupled to a CO_2-sink at an Arctic shelf seep area offshore NW Svalbard: Introducing the "Seep-Fertilization Hypothesis"

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Documented warming of intermediate waters by ∼1C over the past 30 years along the western Svalbard margin has been suggested as a driver of climate-change induced dissociation of marine methane hydrate. However, recent evidence suggests methane release has been occurring for thousands of years near the upper limit of methane hydrate stability zone and that seasonal changes in bottom water temperature may be more important than longer-term warming of intermediate waters. However, the existence of hydrates at the upper limit of the gas hydrate zone has been based on modeling results only and gas hydrates have not been sampled successfully.

Yearly studies, undertaken during RV Helmer Hanssen cruises as part of CAGE have shown that no significant amount of methane reaches the upper water column and is being released towards the atmosphere from this ca. 400m deep sites. The same is true for a very active seep area at the shelf break in 240m water depth where detailed hydroacoustic studies show fluctuating fluxes between 71 and 114 T/yr in total.

Here we focus on studies conducted with the USGS Gas Analysis System (USGS-GAS). Continuous surface water methane and carbon dioxide concentrations and associated data are used to calculate sea-air fluxes with this cavity ring-down spectrometer-based analytical system. Only the shallow seep site (∼90 m water depth) had appreciable methane in surface waters. We conducted an exhaustive survey of this site, mapping the full extent of the surface methane plume. To provide three-dimensional constraints, we acquired 65 vertical dissolved methane profiles to delineate the vertical and horizontal extent of the subsurface methane plume.

The USGS-GAS data show that methane beyond the 'normal' background fluxes of ∼1 μmol m-2 d-1 is elevated at the intensively bubbling shallow seep site (max. 35 μmol m-2 d-1) and near the shallow coastal zone where the fluxes over a large area reach 25 μmol m-2 d-1. Comparing coastal and seep fluxes on a base of 100km2 shows that coastal CH4-fluxes are higher than the seep-infested shelf. With fluxes of 10.2 kg d-1 of 100km2 of coastal area compared to 8.4 kg d-1 of the seeping shelf, both fluxes are limited. In sheep-equivalents (SE, one sheep releases about 15g CH4 into the atmosphere a day), the studied seeping shelf of 187 km2 equals 1100 SE.

Even more surprising, we found a clear correlation between CH4 supersaturation and CO_2 undersaturation in surface waters of the shallow seep. First budget calculations show that the seep area, like the coastal zone, is a net greenhouse gas sink. We hypothesize that an as yet unknown product or process associated with the emanation of methane from the seafloor stimulates primary production that leads to enhanced CO_2 undersaturation in the vicinity of the seep. Upcoming studies are planned to test this 'Seep Fertilization Hypothesis' and consider the fate and cycling of other components of the seep-associated carbon cycle.