Geophysical Research Abstracts
Vol. 17, EGU2015-10550, 2015
EGU General Assembly 2015

Fluxes of dissolved methane from the seafloor at the landward limit of the gas hydrate stability zone offshore western Svalbard

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Seepage of methane from seafloor sediments offshore Svalbard may partly be driven by destabilization of gas hydrates as a result of bottom water warming. As the world's oceans are expected to continue to warm, in particular in the Arctic, destabilization of hydrate may become an important source of methane to ocean bottom waters and potentially to the overlying atmosphere where it contributes to further warming. In order to quantify the fate of methane from seafloor seeps, we have determined the distribution of dissolved methane in the water column on the upper slope and shelf offshore western Svalbard during three research cruises with RRS James Clark Ross (JR253) in 2011 and R/V Maria S. Merian (MSM21/4) and Heincke (HE387) in 2012. Combining discrete depth profile methane concentration data and surface seawater concentrations from an equilibrator-online system with oxidation rate measurements and atmospheric methane observations allows insight into the fate of methane input from the seafloor, and evaluation of the potential contributions of other methane sources. A simple box model considering oxidation and horizontal and vertical mixing indicates that the majority of seep methane is oxidized at depth. A plume of high methane concentrations is expected to persist more than 100 km downstream of the seepage area in the rapid barotropic West Spitsbergen Current, which flows northward towards the Arctic Ocean. We calculate that the diffusive sea-air flux of methane is largest on the shallow shelf, reaching 36 μmol m^{-2} day^{-1}. Over the entire western Svalbard region there is a persistent, but small, source of methane from surface seawater to the overlying atmosphere. Measurements of the atmospheric methane carbon isotope signature indicate that the seafloor seeps do not make a significant contribution to atmospheric methane in this region, which is consistent with earlier studies. Observations downstream of the seepage region are necessary to further constrain potential for transport of previously hydrate-bound methane to the atmosphere, which would require a mechanism for enhanced vertical mixing of dissolved methane from bottom waters into the surface mixed layer.