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# Timing of methane release from hydrate dissociation on the west Svalbard margin

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The release of methane from methane hydrate has been invoked as a contributing agent to rapid climate change. In 2008, plumes of methane bubbles were observed emanating from the seabed in an area of the West Svalbard margin that has undergone about 1°C of warming of the bottom water at about 400-m depth, over the last 30 years. The locations of the bubble plumes, spreading upslope from the present upper limit of the methane hydrate stability zone, indicate that the gas in the plumes could be methane from warming-induced hydrate dissociation in the sediment beneath the area from which the hydrate stability zone has retreated.

Through numerical modelling, we investigated the controls on the time lag between the increase in seabed temperature and gas flow from the seabed. The lag results from the time taken for heat diffusion, hydrate dissociation and gas migration. These are dependent on the distribution and concentration of hydrate and on sediment permeability, among other parameters. We investigated possible scenarios in which plumes could be explained by recent warming. If the top of the hydrate was initially 5 m below seabed, in sediment with permeability $10^{-14}$ $m^2$, we would expect the time lag to be 40 years, which is too long to explain current gas emission. The temperature history of the area is key. A 60-year time series, constructed from extrapolation of more southerly oceanic temperature records, shows that prior to the last 30 years warming, the area was cooling from a warm period in the early 1960s. So, a period of warming longer than 30 years is not the sole explanation for the present-day methane release.

When hydrate is initially less than 2 m below the seabed, gas from hydrate dissociation can reach the seabed in less than 30 years from the onset of warming. Generally, hydrate would not be found as shallow as this, because diffusion acts to transport methane from the sediments to the ocean, removing hydrate close to the seabed. Under conditions of locally high background methane flux, greater than 100 $mol.m^{-2}.yr^{-1}$, however, hydrate can exist close to the seabed and thus be a source of the gas in the observed bubble plumes. The warm period in the early 1960s could have brought gas close to the seabed, which, during the subsequent cooling, formed hydrate close to the seabed. This process could have occurred many times in the past, although we have no direct instrumental record of the temperature change at the seabed to confirm this conjecture. Cyclic variation of the temperature of the seabed over periods of tens of years, driven by periodic changes in the North Atlantic Current has the potential to influence the distribution of hydrate within the sediment, leading to hydrate formation at depths shallower than predicted from models with linear or no change in temperature with time. At locations where there is significant input of gas beneath the hydrate stability zone, this temperature cycling creates conditions for a ‘rapid’ response to increases in the temperature of the water in the depth range 300-500 m.