Fate of Dissolved Methane from Ocean Floor Seeps

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Methane is an important greenhouse gas, with a global warming potential that is far higher than that of CO2. Methane from seafloor seeps, whether naturally occurring or in relation to petroleum infrastructure, has been suggested to be a significant contribution to greenhouse gas releases. Here, we investigate the fate of methane from seeps by means of open-source numerical models for dissolution of methane from rising bubbles, mixing and biodegradation of dissolved methane, and mass transfer to the atmosphere. For seeps deeper than about 50 meters, most of the methane dissolve before reaching the surface. The ultimate fate of the dissolved methane is then found to depend on the balance between microbial oxidation in the water column on the one hand, and vertical mixing and escape to the atmosphere via mass transfer on the other.

There is considerable uncertainty in microbial oxidation (biodegradation) rates, with published values in the literature varying by three or more orders of magnitude. From the modelling study, we present results as a function of biodegradation half-life, treating this as a free parameter to reflect the considerable span in values reported in the literature. For some selected cases, representative of conditions on the Norwegian Continental Shelf, we show how the fate of the methane, averaged over the year, varies with assumed biodegradation rates.

Experimental studies of methane biodegradation were also performed, and the results used to guide the modelling. For the three different cases considered, we find that if the biodegradation half-life of methane is in the range 9 - 16 days, as suggested by our experiments, then about 57–68% of the released methane will biodegrade in the water column from a seep at 65 m depth. For deeper locations of 106 and 303 m, we find respectively 75–83%, and more than 99% biodegradation.

The modelling framework presented is based on open-source models and can be run with openly available ocean and atmosphere data as input. The model is lightweight enough that extensive sensitivity and uncertainty analysis can be done, which means the model can be used to suggest further research to help reduce uncertainty.