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Air-sea CO_2 and CH4 gas transfer velocity in Arctic sea-ice regions from eddy covariance flux measurements onboard Icebreaker Oden

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The Arctic Ocean is an important sink for atmospheric CO_2, and there is ongoing debate on whether seafloor seeps in the Arctic are a large source of CH4 to the atmosphere. The impact of warming waters, decreasing sea-ice extent and expanding marginal ice zones on Arctic air-sea gas exchange depends on the rate of gas transfer in the presence of sea ice. Sea ice acts as a near-impermeable lid to air-sea gas exchange, but is also hypothesised to enhance gas transfer rates through physical processes such as increased surface-ocean turbulence from ice-water shear and ice-edge form drag. The dependence of the gas transfer rate on sea-ice concentration remains uncertain due to a lack of in situ measurements.

Here we present the first direct estimates of gas transfer rate in a wide range of Arctic sea-ice conditions. The estimates were derived from eddy covariance CO_2 and CH4 fluxes, measured from the Swedish Icebreaker Oden during two expeditions: the 3-month duration Arctic Clouds in Summer Experiment (ACSE) in 2014, a component of the Swedish-Russian-US Arctic Ocean Investigation on Climate-Cryosphere-Carbon Interactions (SWERUS-C3) in the eastern Arctic Ocean shelf region; and the Arctic Ocean 2016 expedition to the high latitude Arctic Ocean.

Initial CO_2 results from ACSE showed that the gas transfer rate has a near-linear dependence on sea-ice concentration, and that some previous indirect measurements and modelling estimates overestimate gas transfer rates in sea-ice regions. This supports a linear sea-ice scaling approach for assessments of polar ocean carbon fluxes. Air-sea gas transfer model assumptions (e.g. Schmidt number dependence) will be examined using simultaneous CO_2 and CH4 measurements, and observations in different ice conditions (e.g. summer melt, autumn freeze up, central Arctic and marginal ice zones) will be compared.