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Dissolved methane plume mapping using Membrane Inlet Mass-Spectrometry (MIMS) at a blow out site in the North Sea

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A blow out site in the North Sea (well 22/4-b, UK EEZ) in a water depth of 83 m, served as a test area to demonstrate MIMS as a powerful tool for the continuous measurement of dissolved methane simultaneously to the partial pressure of carbon dioxide, nitrogen and oxygen as well as other gases. A pump-CTD arrangement was used to generate a continuous water stream through a 2.5 cm thick tube to the ship laboratory and was analyzed using a membrane inlet quadrupole mass spectrometer (GAM 200, InProcessInstruments). The pump-CTD was further equipped with calibrated HydroC CH4/CO_2 sensors. The MIMS measurements were conducted under fully controlled temperature conditions and were calibrated for CH4, N2, O_2, and pCO_2. The pump-CTD arrangement was towed along transects across the blow out and dissolved gas concentrations as well as physical water column data were synchronized and geo-referenced. The transects were repeated in three different depth layers, including a bottom layer of $\sim$ 2 m above the sea floor, 60 m above the sea floor just below the thermocline and a third plane in 10 m water depth. During the tows water samples were taken for later onboard methane analysis and cross-calibration with the MIMS and HydroC data. After data selection under consideration of the tidal regime lateral and vertical plume dimensions of dissolved methane were constructed. Dissolved methane concentrations ranged between background and up to about 18μM. Below the thermocline, which represents an effective barrier for the vertical distribution of dissolved methane, methane distinctively spreads laterally. Only at locations were the gas bubble stream and concurrently advected water from below the thermocline reaches the sea surface enhanced methane emission into the atmosphere took place.