Carbon dioxide and methane fluxes in a mangrove creek driven by tidal pumping: Insights from cavity ring down spectrometry

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Tidally-mediated export of carbon sediments via groundwater exchange is now recognised as a major carbon export pathway from mangroves. We hypothesize that a combination of hourly and weekly groundwater–surface water exchange processes drive surface water pCO_2 and CH_4 concentrations in mangrove creeks over a spring-neap-spring tidal cycle. Automated *in situ* instrumentation captured high-resolution surface water pCO_2, CH_4 and ^{222}Rn data at the creek mouth, and ~500 m upstream in a sub-tropical mangrove ecosystem over a spring-neap-spring tidal cycle. The pCO_2 ranged from 385 to 26,106 µatm, CH_4 from 1.8 to 889 nM, and ^{222}Rn from 280 to 108,172 dpm m^{-3}. The creek displayed significant spatial variability over the short 500 m length, with average surface water pCO_2, CH_4 and ^{222}Rn 4-fold higher at the upstream station. Surface water fluxes of CO_2 and CH_4 ranged from 9.4 to 629.2 mmol CO_2 m^{-2} d^{-1} and 13.1 to 632.9 µmol CH_4 m^{-2} d^{-1} depending upon the gas transfer model used and station location. Creek pCO_2, CH_4 and ^{222}Rn displayed changes over both semi-diurnal and spring–neap–spring tidal scales. Semi-diurnally, all gases had a significant inverse relationship with water depth. Over the spring–neap–spring cycle, all gases exhibited an inverse relationship with tidal amplitude, with higher values during neap tides than spring tides. Thus, estimated fluxes, porewater observations, and the significant positive relationship between surface water pCO_2 and CH_4, and ^{222}Rn suggests groundwater exchange (i.e., tidal pumping) drives pCO_2 and CH_4 within the mangrove creek over two distinct temporal regimes – 1) Semi-diurnally, flushing of crab burrows leads to high pCO_2 and CH_4 concentrations at low tide, and 2) During the spring–neap–spring cycle, older groundwater enriched in CO_2, CH_4 and ^{222}Rn seeps into the creek as tidal amplitude decreases, leading to higher concentrations at neap tides.