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Linking greenhouse gas release to subsurface biogeochemistry in coastal wetlands

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Vegetated coastal wetlands play an important role in the global carbon cycle as they bury organic carbon at a high rate (111.4 Tg C y^{-1}), both aboveground and belowground. Organic carbon in these ecosystems is decomposed by microorganisms, releasing the greenhouse gases carbon dioxide (CO_2) and in some cases, methane (CH_4). To predict how the emissions of these greenhouse gases will change with increasing sea level rise and temperature, it is essential to understand what drives the degradation of organic carbon in coastal wetlands under current conditions. The factors controlling organic carbon decomposition and thus the release of greenhouse gases in salt marshes, a type of coastal wetland, are poorly understood. In these ecosystems, the oxidation of organic carbon by microorganisms may be coupled to the reduction of oxygen, Fe(III) minerals, and/or sulfate, whose availability depends on the tidal regime and depth. The objectives for this project, therefore, are to 1) elucidate biogeochemical processes occurring in salt marsh sediment, 2) identify if the organic carbon degradation is limited by the availability of electron acceptor or, 3) by the availability and quality (identity) of the electron donor, i.e., the organic carbon. To this end, we quantified the possible biogeochemical processes in the field by conducting high-resolution microscale measurements to detect changes of redox-active geochemical species within the sediment profile using microsensors. Furthermore, porewater and sediment were analyzed to identify the carbon content and quality as well as iron and sulfur speciation at different depths. These measurements were then linked to measured gas fluxes. Complementary to field measurement results, we designed laboratory incubation experiments. By adding an electron donor or acceptor, we test the effects on porewater dynamics and greenhouse gas emissions. Thereby, we intend to identify the limiting factor for the decomposition of organic carbon in a salt marsh. The results of the project will contribute to a better understanding of carbon decomposition and the release of greenhouse gases in the Wadden Sea and form the basis for predictions on how the carbon stored in this ecosystem will react to climate-related changes.