Methane processing in arctic shelves and the role of anaerobic methane oxidation

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Fluxes of methane to the ocean and atmosphere from sea floor gas hydrates are a key forcing of Earth's climate. It is believed that massive hydrate dissolution events have contributed to pronounced global warming and environmental crises of past climate and may do the same in the future. If this released sedimentary methane is oxidized aerobically, it results in loss of seawater dissolved inorganic carbon (DIC) and alkalinity (ALK) and $CaCO_3$ dissolution. The effect can be opposite if anaerobic oxidation of methane takes place. It is therefore worth examining whether anaerobic oxidation of methane released by the thermal dissociation of gas hydrates can alleviate or exacerbate the future global warming due to the anthropogenic CO_2 emissions. In this study we model global ocean water column dynamics with an Earth system model of intermediate complexity – GENIE – and present steady state fields of the relevant variables (organic matter flux to the sediment water interface (SWI), bottom water oxygen content, DIC and ALK content of the water column, etc). The modern pre-anthropogenic ocean is modeled with a 16 slab ocean configuration and 10° x 10° resolution. We couple the Earth system model GENIE to a 1-D biogeochemical reaction network simulator (BRNS) of sedimentary dynamics – which includes all relevant early diagenetic processes of the coupled cycles of C, O, N, S and Fe as well as all relevant advective diffusive and non-local transport processes. We identify high latitude shelf environments known for high methane hydrate concentrations and apply the GENIE values at these sites as boundary conditions to the BRNS sedimentary model. We further impose bottom advective fluxes of methane on the sediment column based on hydrate dissolution estimates and quantify the pathways of methane transformation – aerobic vs. anaerobic. We then compute benthic fluxes of DIC and alkalinity and study the response of the benthic anoxic diagenesis cycle (AOM, methanogenesis) subjected to the proposed forcings and its feedback onto the inorganic carbon cycle.