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Large-Scale Simulation of Oceanic Gas Hydrate Dissociation in Response to Climate Change

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Paleooceanographic evidence has been used to postulate that methane from oceanic hydrates may have had a significant role in regulating past climate. However, the behavior of contemporary oceanic methane hydrate deposits subjected to rapid temperature changes, like those now occurring in the arctic and those predicted under future climate change scenarios, has only recently been investigated. A recent expedition to the west coast of Spitsbergen discovered substantial methane gas plumes exiting the seafloor at depths that correspond to the upper limit of the receding gas hydrate stability zone. It has been suggested that these plumes may be the first visible signs of the dissociation of shallow hydrate deposits due to ongoing climate change in the arctic.

We simulate the release of methane from multiple oceanic deposits, including the effects of fully-coupled heat transfer, fluid flow, hydrate dissociation, and other thermodynamic processes in a large-scale, 2-D system representative of segments of the continental margin. The model encompasses a cross section of marginal sediments from the upper extent of the hydrate stability zone down to depths beyond the expected range of century-scale temperature changes. We impose temperature changes corresponding to predicted rates of climate change-related ocean warming and examine the possibility of hydrate dissociation and the formation of hydrate-fed gas plumes. The 2-D evolution of the system is tracked, as well as the location and magnitude of any aqueous or gaseous methane release at the seafloor. We simulate the consequences of continued warming over the coming centuries, and examine the sensitivity of dissociation and release to subseafloor properties. We also consider the consequences of methane release into the water column and the biochemical and ecological consequences.

The simulation results are consistent with the hypothesis that dissociating shallow hydrates may contribute to the formation of the observed plumes. These results also indicate the possibility that hydrate dissociation and methane release may be both a result and a cause of climate change. This modeling also establishes realistic bounds for methane release along the arctic continental shelf for potential hydrate dissociation scenarios, and may help confirm whether climate change is already impacting the stability of the vast oceanic hydrate reservoir.