Progress Report
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Executive Summary

We have implemented a sediment transport scheme to the hydrate model, in which sediment is introduced to the water column at the coast, and is advected offshore as it sinks in the water column. The scheme allows us to predict and track the grain size in the sediment, which will ultimately feed back to the permeability and fluid transport. We have also been working on the computation of thermal diffusivity in the model as a function of the sediment composition and porosity, and on stabilizing the code with the new vertical coordinate system. The project has been joined by Patrick McGuire, a planetary geochemist and computation specialist who has been getting up to speed on the code and has begun making independent progress in its development.

Approach

The sediment transport scheme is a simple one but its like has been used before to simulate the evolution of the shelf and slope on continental margins. A bottom stress is calculated for each grid point depending on the water depth. Each grain size of sediment introduced into the water column as the coast is allowed to deposit on the bottom if the critical shear stress for the grain size is larger than the shear stress at the bottom. We also added a sea-floor slope dependence to the decision whether to deposit sediment or not, with the result that the maximum sea floor slope that model generates is around 10%, similarly to observations.

The thermal diffusivity model now incorporates sediment composition and porosity by tracking the volume fraction of each component of the sediments, and then computing a volume-weighted average of the thermal diffusivity over the components. For each component, the thermal diffusivity is the ratio of the thermal conductivity to the heat capacity. Thus far, we have tested an additive average of thermal diffusivities, though other averaging methods can be easily incorporated into the code: i.e., multiplicative averages. For the thermal diffusivity model, we have tested a three component average: averaging over the thermal diffusivities of solid sediment, seawater and hydrate. We will soon add a fourth thermal component: methane bubbles. At shallow depths below the seafloor, the pores are larger and filled by seawater, so the thermal diffusivity turns out to be 2-3 times lower than at the deepest depths, where the pores are smaller and there is not as much space for the seawater with its lower thermal diffusivity. Such spatial heterogeneity of the thermal diffusivity can affect the emergence and stability of hydrate deposits in our model.

Conclusions

We are making good progress toward formulating and ground-truthing the model components that will be necessary to simulate the first of our archtype scenarios, the passive margin as exemplified by the east coast of the United States. These components (thermal diffusivity, sediment transport, etc) will be crucial for the other scenarios as well, which will build on the first.