Modeling gas, hydrates, and slope stability on the U.S. Atlantic margin during Pleistocene glaciations

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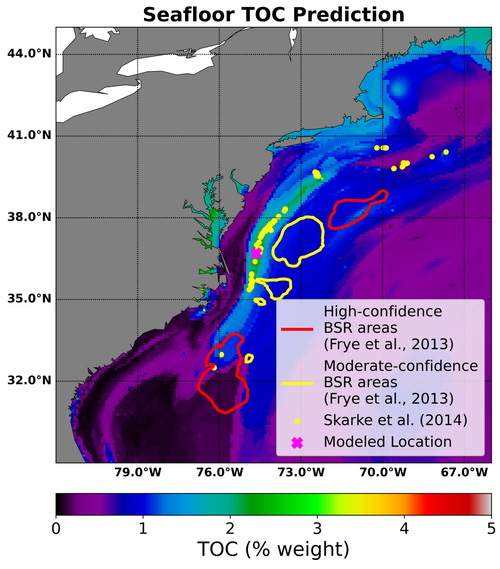
Introduction

- There is a documented history of landslides and gas seeps along the U.S. Atlantic margin
- These align with an region of high seafloor total organic carbon (TOC) predictions
- Methane hydrates can form in high pressure, low temperature environments where sufficient methane is present
- We are interested in methane gas and hydrates at the edge of stability (water depth around 500 m)



- We modeled methane gas and hydrate formation over a 120,000-year period
- We modeled factor of safety (FS) to determine slope stability over time, focusing on the continental slope
- Hydrate dissociation and gas formation is not solely responsible for past landslides in the area

Research Goal

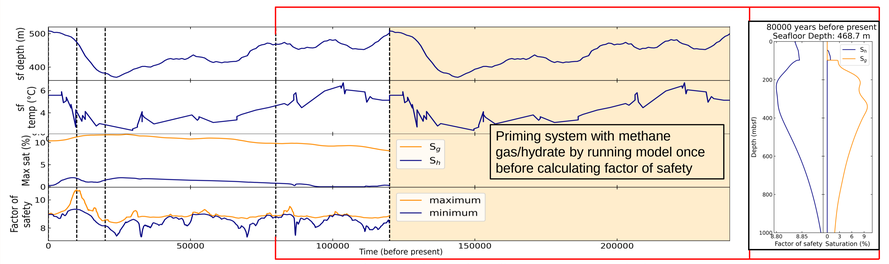
Does the factor of safety of sediments on the U.S. Atlantic Margin decrease enough due to changing pressure and temperature conditions over the last 120,000 years for slope failure to occur or is another variable needed to initiate slope failure?

Methods

- Methane gas and hydrate formation were modeled using a 1-D microbial methanogenesis model (PFLOTRAN) at locations with seafloor depths between 200-1000 m
- Each location was modeled over a 120,000-year glacial cycle
- Factor of safety (FS) was calculate every 100 years
- FS compares shearing and resisting stresses of a slope to determine if failure is likely to occur

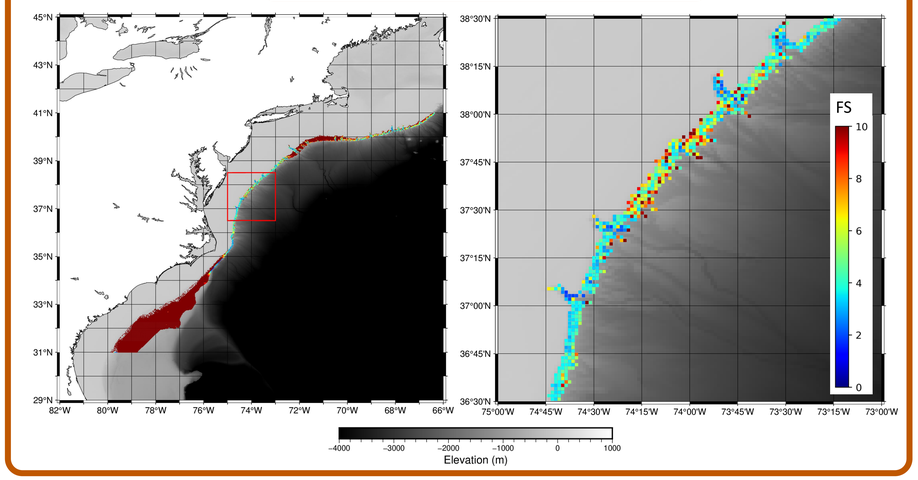
$$\mathrm{FS} = \frac{c + [(\sigma'_{vh}\cos^2\theta) - P^*]\tan\phi_f}{\sigma'_{vh}\cos\theta\sin\theta + F_{eq}}$$

- We used Lonestar6 to model hydrate formation and FS at 16044 individual locations in the region between 29°N – 45°N and 82°W – 66°W



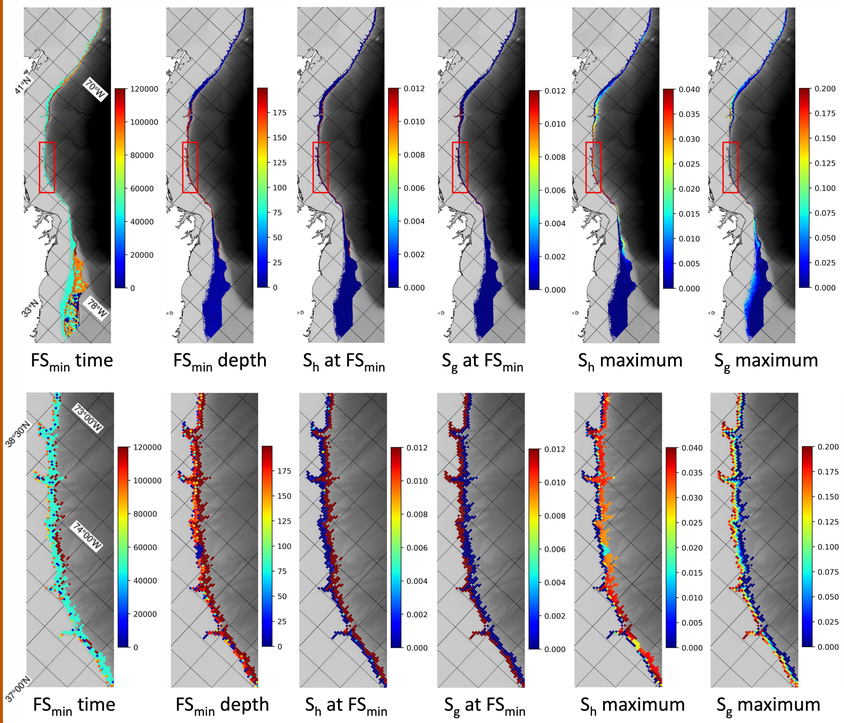
Example simulation at 36.7°N, -74.6°W and profile at 80,000 years before present

Factor of Safety



Other Results

- Timing of minimum FS and associate hydrate and gas saturations (S_h, S_g) as well as maximum hydrate and gas saturations



Conclusion

- Lowest factor of safety calculations correspond with high seafloor TOC and greater slopes
- This area also had higher maximum hydrate and gas concentrations
- Hydrate dissociation did not lower the factor of safety below 1
- Some other force is needed to initiate slope failure and landslides in the area
- The depth of the minimum FS increases as we model down-dip as gas is deeper here

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