Modeling Continuous Sea Ice Floes with the Discrete Element Method

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The Arctic has undergone significant changes in recent decades due to climate change, with substantial reductions in sea ice extent and multiyear ice, leading to thinner ice that is susceptible to breakup [1]. This so called "New Arctic" presents many challenges including, but not limited to, accurately modeling sea ice dynamics, lead (crack) development, and ridge formation (sea ice floe collision). Particle methods, such as the discrete element method (DEM), can provide detailed descriptions of sea ice dynamics that explicitly model fracture and ridging, which can be difficult with typical continuum sea ice modeling approaches. However, large sea ice floes can deform and break up under external forcing, which presents challenges for the DEM to model these important dynamics accurately. In this talk, we present our current efforts in extending sea ice DEM formulations to be able to model continuous floe mechanics. We will focus on two formulations, (1) a lattice-spring like model called a "cohesive beam" [2], and (2) a novel sea ice peridynamic-DEM hybrid model [3]. We will present results on idealized tests that examine the ability of the models to predict effective continuous sea ice properties including effective stress and strength. Lastly, using our two approaches we discuss results from simulations of sea ice dynamics through the Nares Strait. Realistic particle initial configurations are generated by discretizing MODIS satellite imagery into polygonal floes that are made up of many smaller discrete polygonal particles. The sea ice is forced externally using wind and ocean drag functions in combination with realistic wind and ocean velocities in the Nares Strait region. We compare our simulation results to optical satellite imagery and discuss the models predictive capability.

REFERENCES

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