A Discrete Element Sea-Ice Model for Climate Applications

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Abstract

The current sea-ice component of the Department of Energy's Energy Exascale Earth System Model (E3SM) approximates the sea-ice cover as a continuous material rather than as a series of discrete floes and assumes sufficient cracks exist within each model to ensure an isotropic distribution of crack orientations. Such models were developed for grid resolutions of ∼100 km, whereas current models, including E3SM, are routinely applying these physics at much higher model resolutions of ∼5 km. Evidence from both remote sensing and in situ observations suggest ∼10 km represents a transition scale below which the dynamics of individual floes dominates the dynamics of sea ice [1]. To correct the deficiencies of the current E3SM sea ice model, we are developing a new sea ice dynamical core based on the Discrete Element Method (DEM). In this method collections of floes are explicitly modeled as discrete elements, contact forces between the elements are determined and equations of motion for individual elements are integrated in time [2]. This new model uses the Large-scale Atomic/Molecular Massively Parallel Simulator (LAMMPS) model for its dynamical core [3]. Here, we describe the development of the model, including the development of element contact models suitable for sea ice at climate scales, attempts to improve model performance by using the Kokkos framework to allow efficient computation on heterogeneous computing architectures, and progress on methodologies to ameliorate the effect of element distortion during deformation.

References

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