DISCRETE-ELEMENT MODELING OF SELECTED ASPECTS OF SEA ICE DYNAMICS AND FRACTURE

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In terms of numerical modeling of sea ice dynamics, recent years have witnessed a certain revival of discrete-element methods, in which sea ice is represented as an assemblage of individual, interacting floes. Combined with new approaches to the analysis and interpretation of modeling results, inspired by methods of modern statistical physics and complex-network science, these tools provide new insights into the 'microscopic' (floe-level) and 'macroscopic' (large-scale, emergent) phenomena observed in sea ice. A crucial property of sea ice in this context is its extreme polydispersity. On the one hand, the floe-size distribution (FSD) results from sea ice deformation, breaking and healing (freezing) history. On the other hand, the FSD itself substantially influences the sea ice mechanical properties and thus its response to forcing and deformation. Both aspects of these relationships are only poorly understood at present.

In this talk, selected aspects of sea ice dynamics and fragmentation will be presented, based on results of simulations performed with a Discrete-Element bonded-particles Sea Ice model DESIgn [1]. The examples will include: force networks in deformed ice and their role in transmitting stress; wave-induced stress and floe breaking in the marginal ice zone, and the resulting floe-size distributions; and evolution of floe sizes and shapes due to 'grinding' of ice floes in shear zones (Fig. 1). In most examples, mutual interactions between the sea ice polydispersity and dynamics are responsible for complex, nontrivial behavior of the modeled system. Robust character of that behavior, occurring without any tuning within a very wide range of model parameters, hints at its universal character and suggests that similar mechanisms are at play in real-world sea ice as well.

The code and documentation of DESIgn are freely available at http://herman.ocean.ug.edu.pl/LIGGGHTSseaice.html. The model is implemented as a toolbox for the open-source numerical library LIGGGHTS (http://www.cfdem.com/).

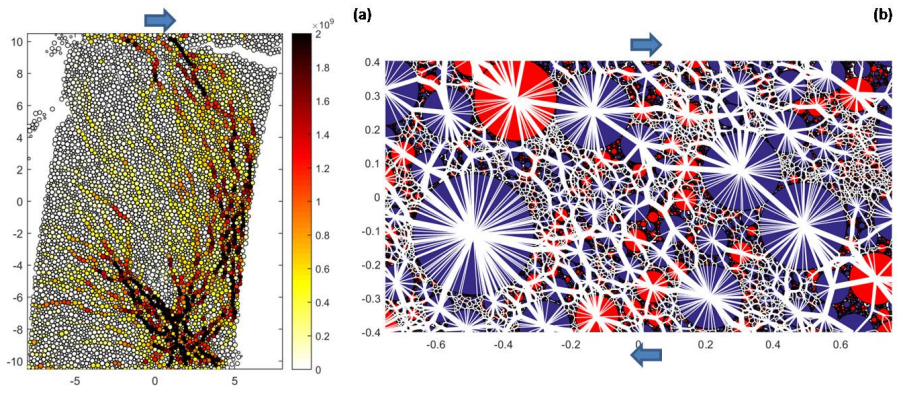

Figure 1. Example applications of the DESIgn model to the analysis of shear deformation of sea ice: grain–grain forces in a rectangular, bonded sample (a), and force networks in densely packed, unbonded ice pack composed of floes with a power-law size distribution (b). In (b), line thickness corresponds to the force strength, and grain colors show the direction of rotation of the grains.

References

[1] Herman, A., Discrete-Element bonded-particle Sea Ice model DESIgn, version 1.3 – model description and implementation. *Geosci. Model Dev. Discuss.*, **8**, 5481-5533, doi:10.5194/gmdd-8-5481-2015 (2015).