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Comment on gmd-2021-199

Anonymous Referee #2

Referee comment on "Geometric remapping of particle distributions in the Discrete Element Model for Sea Ice (DEMSI v0.0)" by Adrian K. Turner et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-199-RC2, 2021

The manuscript „Geometric remapping of particle distributions in the Discrete Element Model for Sea Ice (DEMSI v0.0)" by Adrian Turner and colleagues discusses a very important aspect of discrete-element sea ice modeling, related to difficulties with parameterizing ice deformation/ridging processes and the associated necessity of remapping of element properties during simulations.

Undoubtedly, the issues analyzed in the manuscript are very relevant to the current sea ice research, in particular to the future applications of DEMs in large-scale sea ice modelling. The manuscript presents in a very detailed way the remapping method newly developed by the authors, as well as results of simulations demonstrating the performance of the new algorithm in several simple configurations. Overall, I find this study very valuable and the manuscript suitable for publication in GMD after the authors address the comments below.

Major comments:

- Lines 32-33 ("Capturing the relevant physics of this process using DEM sea ice models has proven to be a challenge"): I'd strongly recommend citing the works by Marnix van den Berg and colleagues, related to their non-smooth DEM (NDEM) developed at NTNU, in particular, https://doi.org/10.1016/j.coldregions.2018.07.001 and http://dx.doi.org/10.1016/j.marstruc.2019.01.011 (it's not self-advertisement, I'm not related to the work of NTNU group). One of several advantages of NDEM is that it produces realistic forces during simulations of compliant floe-floe and floe-structure contacts, for floes of any shape – a feature very important from the point of view of problems discussed in the present manuscript (and, especially, for the future developments of DEMSI).
- Related to the previous comment: The contact forces and overlaps computed from the Hookean model are known to have several serious limitations, in particular they are

extremely sensitive to the time step used in simulations and to the time stepping method used. Those issues are not the main focus in this manuscript, of course, but they should be mentioned.

- As far as I know, even if 2D simulations are performed in LAMMPS, the model assumes that the discrete elements are spheres, not disks. In particular, contact forces are computed for circular, not rectangular contact area, element mass is proportional to r^3, not r^2, etc. Did the authors implement disk shaped elements in their model and forgot to mention that in the text, or are the simulations performed with the original LAMMPS code? If the second is true, please state it clearly and explain the consequences.
- Is the angular momentum equation in LAMMPS turned off? Only the linear momentum equation is mentioned in the text.
- After having read the whole manuscript and my own comments above, my conclusion is that the significant weaknesses of this work are mostly related to the particular DEM used to perform the computations illustrating the remapping method, rather than to the remapping method itself. Therefore, I have two suggestions:
  - The title of the manuscript is misleading, because it suggests that a new sea ice DEM is presented, which is not the case. In fact, it is the very opposite: the DEM used here is much more primitive than several published ones, including those cited in the introduction, and it is not suitable to simulate ridging processes due to the limitations of the very simple contact model used (mentioned above) and several other limitations of LAMMPS (not mentioned and, unfortunately – if the authors are planning to use that model in the future – hard or even impossible to overcome). I'd suggest changing the title to something like "Geometric remapping of particle distributions for discrete element sea ice models", so that it is clear what the paper contains and what its strengths are. Note that the acronym DEMSI is not used even once in the main text! (only in the abstract and acknowledgements).
    I know that GMD requires a name for the model being presented, but here it's the remapping algorithm that deserves a name, not the sea ice DEM!
  - State it clearly in the last part of the introduction that the performance of the new method is illustrated based on simple simulations with a DEM that can be replaced with a "serious" one later on, and that the limitations of the DEM are not very crucial for the cases analyzed (in fact, the first 1D and 2D tests with translation and/or rotation of elements do not require any momentum equations/contact models, do they?).

Minor, mostly technical comments:

- Lines 44-48: I'd suggest changing "collisions" to "contacts" everywhere in this fragment, as not all contacts are of the collision-type (especially during ridging, of interest here). (The term "collision detection" actually comes from early molecular-dynamics type models, where the discrete elements were assumed infinitely rigid, so that each contact was by definition a short-lived collision.)
- Lines 315-316: "there are no empty elements, representing open water". Actually, why not? What happens when the ice from a given polygon disappears, is that element removed from the simulation? Would it be advantageous to have no-ice polygons?
  It is discussed briefly around line 380, but it is assumed that those effects are relevant at the ice edge only. What about situations when many open water patches are present

within the ice cover? Would the conclusion regarding unimportance of open water elements remain the same?

- (47) and line 348: The symbol c is used here for the drag coefficient, and has been used earlier as ice concentration. c_w is used for drag coefficient further in line 356.
- Line 414: 500 m/s?
- Figure 5 and the following colour figures: explain in their captions what the colour scale shows.