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Comment on gmd-2021-355

Anonymous Referee #3

Referee comment on "MPAS-Seaice (v1.0.0): sea-ice dynamics on unstructured Voronoi meshes" by Adrian K. Turner et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-355-RC3, 2021

Review on "MPAS-Seaice (v1.0.0): Sea-ice dynamics on unstructured Voronoi meshes" by Adrian K. Turner et al.

The article describes the sea ice model MPAS, which is used as a sea ice model in the climate model E3SM.

A distinguishing feature of the model is the use of Voronoi grids. The ice velocities are specified in the nodes of the cells, the tracers in the midpoints. The grids can be thought of as dual grids to triangular grids, for example. However, MPAS also offers the possibility to use quadrilateral grids.

The main focus of the article is the discretization of the local differential operators for setting up the moment equation. Two different approaches are presented and discussed here. Later, numerical test calculations are also carried out.

In the further course, the authors describe an adapted advection scheme and discuss the embedding of the dynamical model into a climate model and present different numerical experiments.

The article is insteresting and clearly written and gives very good documentation of the aspects of discretization, technical details and clearly highlights the implications of different discretization approaches.

I clearly recommend acceptance of the paper for publication and have only a few comments. Some minor inaccuracies as well as typos have already been pointed out in other reviews.

Some remarks:

- (4), (5), (6), etc. Is there the index 'd' missing in the enumeration of u_1,u_2,... ?

- 148-150 and (13). This property of a basis is usually called "Lagrangian" or "Lagrange Form"

- The EVP approach, using distinct variables for the stresses, is similar to a "mixed formulation" or approximation of of the VP model. For reasons of stability, an optimal choice would be to choose as function space for the stresses sigma the gradient of the velocity function space. At least in a standard finite element formulation, using the same order for both velocity and stresses would not be succesful since the inf-sup condition would be violated. Specifically I am for instance referring to (22), (23). This could the origing of some instabilities that later need to be any kind of stabilization, e.g. by a subsequent averaging.

- I find it very difficult to discern the exact meaning and significance of Figure 4.

- l 447-448: "This is understandable ..." what exactly do you mean here by the one-sided stencil and the "weak operator stencil surrounds ..."?

- In the summary, the authors do not sound as if they are completely convinced of their new model. Possibly this is just a realistic assessment, but the usual enthusiasm is missing when it comes to praising one's own work to the skies. Is there a clear winner when it comes to the two approaches "weak" and "variational"? Or does this essentially depend on the respective purpose. Major new developments were necessary in particular because the switch to unstructured grids was made. Here, too, I miss a final assessment: is this step worthwhile and can the advantages be used?