Review

Title: Smoothed Particle Hydrodynamics Implementation of the Standard Viscous-Plastic Sea-Ice Model and Validation in Simple Idealized Experiments

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The manuscript presents a realization of the viscous-plastic rheology with an elliptical yield curve and normal flow rule in context of the Smoothed Particle Hydrodynamics meshfree method. The authors describe the basics of the SPH method and derive the formulation of sea ice dynamics within this concept. The SPH method is evaluated on 3 simple test cases. Before reading the manuscript, I did not know the SPH method, but I am very familiar with sea ice dynamics, especially with the viscous-plastic model. I need to say that not knowing the SPH method it was hard to follow the argumentation in the paper (quite technical). Based on the presented manual I could not understand the theoretical derivation of the wave speed in Section 3.1. Looking at the numerical results it is not clear to me if the SPH approach can capture simple sea ice drift. I suggest that the authors simulate standard idealized benchmark tests of the viscous-plastic model to demonstrate that the implementation is correct and simple large-scale drift can be simulated (see main comment). I strongly recommend that the paper is reviewed by another person with a strong background on the SPH method.

Main comment:

I would expect that the SPH realization roughly reflects the drift of the VP model. Therefore, I would first show that simple idealized drift can be reproduced to demonstrate that the implementation is correct and the model does with one expects. In this sense the arch experiment is a bit unfortunate as the SPH method behaves different than the VP model.

I suggest to solve the benchmark problem of Hunke 2001, which has been solved by Danilov et al. 2015 with removed islands. Another candidate for an evaluation would be the benchmark problem of Mehlmann et al. 2021, where the viscous-plastic model has been solved by several institutes. The formation of LKFs has been studied in this paper. It would be of interest to see if your model captures the large-scale drift and produce LKFs, which are large scale features (as the ice arches) that are coming from a small scale.

Further comments:

l. 20 I think the way that the sentence is phrased is not correct. Hunke does not use a classical FDM. A sub-grid discretization is applied for the approximation of the stresses. I would rephrase the sentence to: Traditionally finite difference methods haven been applied to solve the VP model.

l. 188 Why do I need the information on the time step limitation? Can you please add a sentence that explains where this information is used in the ongoing analysis?

l. 257 Please add an equation number to Gamma. The relation is used frequently in the manuscript.

l. 266 Why does it makes sense to assume that the perturbation behaves like a wave solution?

l. 267 'the set of equations' which set? Please add equation numbers.

l. (49)-(51) Please add a comment where the hat notation is coming from.

l. 273 Please add more details. Why can the summation be written in the integral form. There is no integrant in the integral. Is the integrant 1?

l. 116 Consistency to what?

l. 275 How do you get to the righthand side in equation (52). Can you please add some more steps?

l. 279 It is unclear to me how the wave speed is derived by looking add equations (49)-(53). I stopped reading 3.1 at this line.

l. 351 I think to state that numerical convergence is observed, you need to ensure that even with longer simulations no overshoots occur in fig 5 (a). Is the solution with 200[h] still approached?

l. 338. There are serval definitions of MIZ. How do you define MIZ in your setup?

l 338. How do A and h vary in time? Based on eq. (28) and (29)? Please add some information here.

l.372 Why would you expect a similar sensitivity of the DEM and SPH approach? They are based on different rheologies.