

*Review: Design and implementation of a Newtonian Relaxation Scheme in the NOAA GFDL Sea Ice Model (SIS2)*

The manuscript describes an implementation of a Newtonian relaxation scheme into the sea ice model SIS2. The study focus on a coupled system where SIS2 is coupled with the ocean model MOM6.

The results are demonstrated on two areas. A pan-Arctic and a west coast North America with a corner of the central Arctic. It applies the nudging for both lateral boundary conditions and as relaxation towards a climatology (in this case PIOMAS). It shows that the method in general works and the simulation has an ice cover that looks more like the product that is nudged towards when compared to the free run.

In general the manuscript is nicely written and describes the nudging, however I could wish for a consideration of which data, experiments etc. should be in the manuscript. For instance in figure 4 and 5 is it necessary to show all different experiments with different relaxation? Not all are in focus of the manuscript. I think that it would make the points more clear.

Redistribution. I am unsure why the model becomes unstable if all sea ice is put in the target category. Yes if the concentrations becomes very low as mentioned.

Secondly (step iv). How can one conserve volume and area when moving ice from the target category to thinner categories? This means that the ice thickness within each thickness category is reduced?

The introduction describes mismatch between ocean, sea ice and atmosphere and yet the authors have chosen to use two different products for the ocean and the sea ice. With the choice of the Glory's product for the ocean, ERA5 for the atmosphere and PIOMAS for the sea ice it seems as if the experiments have been unnecessary complicated as Glory's is forced by ERA5, and it contains a sea ice model which could have been used as the reference data instead of PIOMAS. Maybe the authors can elaborate on this? Rerunning the experiments seems to be beyond the scope.

Another topic that could be elaborated a bit more on is the limitations of using observations or forcing that do not contain all the fields that are required to constrain e.g the dynamics as this is often the case when applying nudging or other methods to assimilate/add lateral boundary conditions into the model.

I think that the manuscript can be accepted with minor corrections.

Specific comments

Line 40: Duarte et al implemented this in CICE V5. Strictly speaking it is not available in the main branch of CICE6 however a nesting module should soon be included in this. Different implementations do exist but they are outside the main branch.

Line 44 (and the section around) describes the challenges of nudging/boundaries if all parameters are properly described. I think that it is worthwhile to mention that often it is not possible to get for instance stresses for the nudging unless the large-scale model used for the forcing of the regional model originates from the same group (see also comment above).

Line 108: either list the barotropic and baroclinic timestep or skip the sentence with a baroclinic....

Line 257: How is salinity and enthalpy changed? Often these parameters are not known within the target values. If they are kept constant they should only be "unrealistic" if ice was not present before? A comment on this would be good.

Line 420: I would use a different word than error. In general most ice thickness products are associated with a relatively large bias/uncertainty. I would use bias instead.

Line 485: The high impact is likely due to the slow ice thickness evolution. There should be a comment on why

Line 535: Can you point to a reason. The ocean relaxation?

Line 560: It is likely that both the atmosphere and the Glorys nudging leads to similar cold biases as Glorys is forced with ERA5. The assimilated sea ice product within ERA5 and GLORYS are the same (OSISAF) whereas PIOMAS uses NSIDC (if I remember correct).

645 Year-end. Not sure. Would end of the year be better? If year end is used. The version should be decided. It is year-end here and year end in line 658.

Line 647 remove s from figures

Line 694 The problem often arise when adding "new" ice is to water above the freezing point. I think that the thickness is less important for instability as long as it is not very small but it may or may not influence the freshwater balance.

Table 1+Table 2

These are nice to know but I would put them in an appendix as most of the information here is not directly necessary for the point of the manuscript.

Table 3

Are all these experiments addressed? I am not entirely sure where relaxation domain and time scale belongs to. Maybe it is the split of the table on two pages but it is a bit difficult to link the headers of each column with content. I think that this can be improved. What is COBALT?

Figure 3: For the numbers underneath the color bar I would reference an equation from the figure text of figure 3c.

Figure 4. Last statement, where are the hours shown?

Figure 4+5: I think that it would be useful to show the PIOMAS as reference.

The Reference run for NEP10k ( e.g row 5a) is more an artifact of a setup that is difficult to use for sea ice predictions without boundaries.