Ocean Sci. Discuss., 7, C744–C750, 2011
www.ocean-sci-discuss.net/7/C744/2011/

Ocean Science Discussions

Interactive comment on "The effect of tides on dense water formation in Arctic shelf seas" *by* C. F. Postlethwaite et al.

C. F. Postlethwaite et al.

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We thank the referee for his constructive comments (shown in "quotes").

Text:

1) Introduction:

"The Rossby radius and M2 tidal wavelength are given as 315km. Perhaps typical GCM grid sizes from AR4 could be given for comparison."

-Typical grid size for AR4 models was 110 – 220 km. This is now mentioned in the text.

""hence leads are represented by sub-grid scale advection". Could this be expanded? I don't understand it's relation to the previous line."

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Interactive Discussion

Discussion Paper

-We agree that this is confusing and it has been removed from the manuscript.

2) Model description

"Why was only one ice category used?"

-This was to ease comparison with previous tide/ice studies which also used single ice category models (e.g. Holloway and Proshutinsky,2007). We acknowledge that a multicategory ice model could better represent the thickness distribution of Arctic sea ice and would be interesting for further investigation.

"Are open boundaries possible on all sides in the standard version of CICE 3.14?"

-The reviewer is correct, this is not standard in CICE 3.14. This was introduced as part of the coupling with POLCOMS.

"What is the size of the grid? (Nx by Ny)"

-Nx=109, Ny=141. This is now stated in the revised text.

2.1) Surface and boundary forcing

"What are the details of the ice/ocean coupling? If this is just the standard version of CICE presumably this is some kind of McPhee turbulent model. If so, were the turbulent coupling parameters increased with extra mixing from tides, or was the only effect from tides on the coupling due to an increase in the far field temperature? Perhaps this could be mentioned?"

-The ice ocean heat fluxes are calculated using the standard mixed layer model in CICE. This has been adapted so that the ocean temperatures used in the calculations are the temperatures in the surface box of the ocean model. The revised text has been amended to mention this.

"Could some details be given of the sea ice relaxation at the boundary of the sea ice model. This is a non-standard feature as far as I'm aware."

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-At the open boundaries of the model there is a relaxation zone, in which the simulated ice concentration and ice volume are combined with the boundary forcing data from PIPS to create a weighted mean of the POLCOMS/CICE model data and the boundary data. This means that the model cell at the boundary only contains information from the forcing data and as you move away from the open boundary the contribution from the forcing data decreases. As the relaxation zone is 100 km wide this occurs over 4 grid cells. The ice concentration (A(i,j)) at the grid points p=0:3 from the open boundary are given by

A(i+p,j)=r.AO(i+p,j)+(1-r).A(i+p,j), r=(4-p)/4

Where (i,j) relate to the grid position and AO is the concentration supplied by the external forcing data for grid point (i+p,j). This is also applied to ice thickness.

"It is unclear to me what tidal model is used in this study. Is the model run before the coupled ice and ocean model run with the tidal results used as some kind forcing for the ice/ocean? Or, is the tidal part given by the free surface ocean model with the open boundaries forced by the tidal model (i.e. there is no tidal model interior to the domain)? As someone unfamiliar with tidal models what was actually done with the tidal model is unclear."

-The elevations use a flux/radiation boundary condition, with the elevations provided by the tidal model of Egbert and Erofeeva, 2002. There is no tidal potential within the interior of the model domain.

3) Results

"Why are results for salinity given for the bottom grid cell rather than the vertical average?"

-Salinity results were used for the bottom grid cell in order to determine whether salinity changes affect the full depth of the water column. We acknowledge that vertically averaged salinity is also of interest but this is encompassed in the analysis of the

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vertically integrated salt content.

"By how much is M2 the main tidal constituent?"

-M2 comprises on average 0.8 of the total semidiurnal signal. The semidiurnal signal is in turn approximately 7 times larger than the total diurnal signal (averaged over the domain).

"The open area in the Pechora sea increased from what area to what area?"

-It increased from 1.7 x 10ˆ4 kmˆ2 to 2.5 x 10ˆ4 kmˆ2.

4) Discussion

"Explicitly state that the increase in open water leads to ice production which is compensated by the increased precipitation."

-This is not quite what was meant here. The increased open water does lead to increased ice production and increased precipitation reaching the ocean but one does not fully compensate the other as the magnitudes do not match (in the model the precipitation reaching the ocean is proportional to (1-aice) but the new ice production is affected by additional parameters (i.e. SST) . The revised text has been amended to explain this.

"Could this sentence be more clearly phrased. How can a mass of salt be step shaped? What distillation process?"

-This has been rephrased as follows: In the White and Pechora Seas the annual cycle of salt sourced from ice covered regions is step shaped, with a large input of salt during freezing followed by a much smaller decrease of salt during melting. Including tides in the model increases the salt input by brine rejection significantly while making little change to the decrease in salt during melting.

"Wouldn't freezing of any speed not just rapid result in salt rejection?"

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-Yes it is true that in the model the speed of freezing does not affect the amount of salt rejected. However, it does affect the amount of ice formed. If freezing does not occur rapidly in leads created during tidal divergence then only a small amount of ice will form and hence only a small amount of brine will be rejected. As the tidal divergence changes to convergence, the lead disappears and the ocean is no longer exposed to the atmosphere.

Tables 1 & 2:

"Could the values of thickness increase per year be added?"

-The values of ice volume increase (decrease) per unit area of subdomain has been added to the existing tables (see supplement Table.pdf). This can be interpreted as the thickness increase (decrease) caused by this much freezing (melting) if spread equally over the entire subdomain.

Figures:

"Figure 1: While a schematic showing the discussed processes is useful and a good idea, it is unclear on the diagram what part is for Redistribution. Perhaps the flat ice under the "Redistribution" label could have a ridge put into it."

-The figure has been amended (Fig. 1).

"Figure 6: Could two more plots showing thickness as well as area and volume be added?"

-We have prepared this figure but do not feel it is helpful to include it in the paper. Averaging ice thickness (ice volume per unit area of ice) over a domain can be misleading. For example, the regional mean ice thickness can increase due to creating thicker ice when the ice concentration remains constant or alternatively to the removal of thin ice, thus decreasing the ice concentration.

"Figure 7: State in caption whether this is for tide or no tides model."

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-This is for the no-tides run (which we call the control run). This is already mentioned in the caption but the revised text now explicitly states that it is for the run without tides.

"Figure 9: Parts a and b - is this the tidal model or the non-tidal? Can that be stated in the figure caption."

-The revised text now states that it is for the non tide run.

"Figure 10: Add plots of the difference between salt production in the tides and no tides case."

-We feel that the existing way of presenting the information in Fig 10 is the most informative. Adding another figure to show the same information seems unnecessary.

Please also note the supplement to this comment:
http://www.ocean-sci-discuss.net/7/C744/2011/osd-7-C744-2011-supplement.pdf

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Interactive comment on Ocean Sci. Discuss., 7, 1669, 2010.

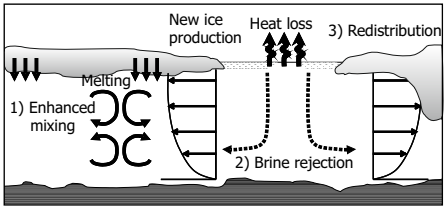

Figure 1

Fig. 1. Schematic highlighting the interaction between sea ice and tides.

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