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Interactive comment on "NEMO-ICB (v1.0): interactive icebergs in the NEMO ocean model globally configured at coarse and eddy-permitting resolution" *by* R. Marsh et al.

Anonymous Referee #3

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This is an interesting paper discussing the implementation of an iceberg model into the NEMO climate model framework. The iceberg model is based on the work of Bigg et al (1996, 1997) and the Fortran code written by Martin and Adcroft, ported from the CM2G climate model. After an initial discussion of the iceberg model, the paper outlines some of the differences (e.g. SST, SSS etc) in Control integrations run with and without icebergs.

Overall I would like to have seen much more validation of the iceberg model, especially as this is one of the first times icebergs have been simulated in ocean models configured at eddy resolving ocean resolutions. This work needs to be done before any conclusions are drawn about how icebergs alter the physical properties of the ocean

and also sea ice cover and thickness.

It would have been great to see some improves to the iceberg model when porting the code over to NEMO. The iceberg model still only considers ocean drag forces at the surface level of the ocean, which is inadequate when simulating icebergs in ocean models that are eddy resolving as these typically have vertical grid spacing of 10's of meters in the upper ocean. This would allow for a much more accurate calculation of ocean drag and I suspect it would change the drift patterns. A similar issue relates to melting. It appears the melt scheme only uses SSTs, rather than an average of temperature over the entire keel. Make these changes would improve the model.

Along similar lines, it would have been nice to see the code altered to include the interaction of icebergs with sea-ice, even if it was only 1-way so that icebergs in thick sea ice (>90%) drift with the pack ice (see Lighey and Hellmer, 2001). Such an addition to the model would probably be less than 5 lines of Fortran, and therefore minimal effort. Considering the extensive discussion of how icebergs influence sea ice growth and thickness it seems surprising that this was not done.

The snapshot in figure 2 of iceberg distribution leaves the reader with little sense of how accurate the iceberg drift patterns are in NEMO. How are we to know if the iceberg model is accurately simulating iceberg motion? The drift patterns must be accurate in order to make meaningful inferences about how icebergs change sea ice cover/thickness. I would suggest plotting iceberg density over a 5-10 year period to highlight the main pathways of the iceberg drift. There is also a 100 year record of the number of icebergs passing south of 48N off the coast of Newfoundland. A figure comparing the observed number of icebergs passing this latitude to both the high and coarse resolution versions of NEMO would be very useful for such validation.

Additional Comments I was not clear if runoff from the ice sheet was partitioned into both calved ice as well as basal liquid melt. For example, observations at calving margins suggest that runoff at ice stream terminus can be >50% liquid runoff. From

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reading the paper it sounds like your 186 Gt ice calved from Greenland each year is released entirely as ice, without any liquid component?

What is the temperature and salinity of freshwater released into the ocean from icebergs? How is freshwater input from icebergs to the ocean treated? Do icebergs release cold water to the ocean and cool it when they melt? Is sea surface height altered in anyway?

Over what period is ice calved from the ice sheets? For example, does the rate of calving increase in the summer or is it uniform throughout the year?

Do the icebergs roll over? And if so, what stability criteria are used. Please state this.

Ln 10, pg 5666: you write, “We also assume a given orientation for the iceberg relative to the wind....” What is it?

Why is spin-up time so much shorter for ORCA025?

Figure 1: Why is the total iceberg mass $\sim$1.25 times higher in ORCA2, compared to ORCA025?

Figure 2: As mentioned above, you should plot iceberg density instead of a snapshot of iceberg distribution. I was surprised to see so many icebergs clustering in central Arctic in ORCA025, which makes me concerned that the drift patterns are not realistic. I would have expected the icebergs to be more tightly constrained to narrow coastal boundary currents in ORCA025. In fact, ln 5, pg 5671 says "the majority of the icebergs follow the Labrdaor current”, but this is not obvious from the figure. In general I find it hard to get a sense of how accurate iceberg drift is simulated in this model. Getting the drift correct has huge implications for accurately simulating where iceberg freshwater is added to the ocean model and therefore how and where the ocean responds to iceberg freshwater input.

Ln 12, pg 5673: Why does the presence of icebergs only lead to small changes in sea ice around Greenland/Arctic? And what about the Labrador Seas?

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Ln 4, pg 5674: Please clarify what you mean by a ‘strong warmer’ by giving a percentage change. Similarly, on ln 7 of the same page you use the word ’extensive warming’. What order of magnitude classes as ’extensive’ warming?

Figure 6: Are +/- 0.1 m changes in ice thickness significant? And why are there such large differences in the changes at the two different spatial resolutions?

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