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Discussions

Interactive comment on "Seasonal and regional variations of sinking in the subpolar North Atlantic from a high-resolution ocean model" *by* Juan-Manuel Sayol et al.

Anonymous Referee #2

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This manuscript analyzes the vertical velocity in the Atlantic north of 45N, using 15 years of a high resolution simulation forced by a repeating seasonal cycle. As shown in previous more idealized studies, there is net sinking in regions near the ocean boundary, which is highly correlated with the overturning streamfunction at 45N. The unique and original contribution of this manuscript is the examination of the spatial variability of the sinking. While the Labrador Sea is shown to provide a large fraction of the near-boundary downwelling, the Irminger sea has a more complicated signal, and the Newfoundland basin has a vertical motion largely driven by eddies in the interior. The temporal variability of the downwelling signals in these different regions is also different - the Labrador sea has a seasonal signal similar to that of the basin-wide overturning,

while the Newfoundland basin has non-seasonal temporal variability driven by eddies. Overflow regions are also shown to behave differently. This paper therefore provides an insight into where and how the downwelling necessary for the AMOC occurs. I therefore support publication. I do however have a few concerns and suggestions for the authors, requiring revision before acceptance.

General concerns

1. The overflows The authors indicate that while the overflow regions do contain significant and important downwelling (together producing as much downwelling as the Labrador sea), the overflow regions do not show the same downwelling mechanism controlled by the lateral boundaries as, for example the Labrador Sea. The authors briefly mention that a key distinction is that the downwelling in the overflow regions is more controlled by bathymetry. I would like to see more attempt to examine the mechanisms in the overflows. Rather than show downwelling aggregated by distance from the nearest land, what would be a better aggregation in the overflow regions - perhaps distance downstream from the sill? I also wonder if the boxes shown for the overflow regions are the best choices, since the downwelling dynamics downstream of the sills could be quite different from upstream. What is the rationale for the ISO box which extends far upstream into the GIN sea? If the DSO box extended further into the Irminger sea (e.g. as far as the region of traceable descent of the dense water downstream of the sill) perhaps the signal from the smaller remaining Irminger box would be less "contaminated"? In summary, I encourage more specific investigation of the overflow regions, using aggregation more suitable to the dynamics in these regions.

2. The overturning circulation The overturning circulation shown in figure 1A has several features which may not be realistic - e.g. the large decrease in stream function north of 35N, the very shallow depth, particularly north of 45N. See Dunne et al, 2012 JoClimate, figure 4 for examples of overturning which extend further north and deeper. What connection might there be between the diagnosed pattern of overturning, and the dominant horizontal and vertical locations of downwelling seen in this simulation?

3. Choice of aggregation by distance from the coast. For the overflows in particular, but also for some other regions (e.g. wide shelves compared to narrow shelves), I wonder if there might be a better method of aggregating the downwelling than by distance from the coast. For example, would bathymetric depth be more physically meaningful than distance from the coast? Figure 4 inset shows that distance from the coast gives undue influence to Jan Mayen island in the Greenland sea, for example. If the downwelling occurs next to the topography, we might expect to see a close relationship between the depth of maximum downwelling and the bathymetric depth, which is hidden when aggregating by distance from land.

4. Interpretation of upwelling I find it hard to interpret the upper ocean/near boundary upwelling seen in the Irminger sea (figure 7B and 9B), and the near boundary upwelling seen in the Denmark Straits (figure 9E). What does this imply physically - how is the circulation closed, where is the upwelled water going? Would a section, showing velocities binned by horizontal and vertical distance, help provide more information?

5. Small scale motion of alternating sign In figure 2A, I have difficulty seeing a clear signal of net downwelling in any region around the northern boundary because of the large amplitude signals of alternating sign. Whereas the mean Labrador sea signal in figure 7 is for near-boundary downwelling, the mean Irminger sea signal is for near-boundary upwelling, yet in figure 2A, the two regions look qualitatively similar, with large amplitude alternating signals. Is it possible to apply a spatial filter to the fields in figure 2A, to show what the vertical motion looks like when averaged over the eddy scales? It's also not clear to me why the Irminger sea alternating signal is suggested to be tied to topography - are there features in the bathymetry on these scales? If so, aggregating by bottom depth might be a way to clarify.

Specific comments

Page 2, Line 3: Insert "few" after "Over the last"

Page 2, Line 31: Change "looses" to "loses"

Page 3, Line 28: Change "and idealized eddy-resolving model" to "an idealized eddy-resolving model".

Page 4, line 3-4: "not adding even more complexity" - I'm not sure what you mean by this, perhaps not adding the additional complexity of historical variations in surface forcing?

Page 6, line 20-21: Change "Nevertheless it can be inferred a stronger transport in winter than in summer" to "Nevertheless, a stronger transport in winter than in summer can be inferred..."

Figure 2B: The depth color bar shows increasing depth upward, whereas it is more intuitive to show it downward on the color scale (a minor point, I know).

Figure 3: Given this downwelling in Sv, if you divided through by the area at each depth, what would this imply for the magnitude of the vertical velocity in m/s? How does this compare with the magnitudes shown in figure 2A? (I'm guessing that the noise shown in figure 2A is much greater than the mean signal).

page 10, line 4-5: If the W value is shown at a depth of 1139m, what do you do if the grid cell bathymetry is shallower than that value?

p11 discussion of figure 5, and figure 5: To see the context of the currents around 1250km-1000km south of Greenland, it would be helpful to show an inset of the surface currents over the whole North Atlantic. How is this "standing eddy" related to the North Atlantic Current?

page 26, lines 30-31: Change "limit us to find" to "prevents us from finding"

page 27, line 5: Change "isopycnals significantly fluctuate" to "isopycnals fluctuate significantly"

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