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Interactive comment on "The role of subpolar deep water formation and Nordic Seas overflows in simulated multidecadal variability of the Atlantic overturning" *by* K. Lohmann et al.

Anonymous Referee #2

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General Comments

The authors use a small ensemble of millennial climate model simulations to address the relative roles of subpolar and Nordic dense water masses on Atlantic overturning. The models are similar in most respects, although BCM does feature a different (isopycnal) vertical coordinate, and it is useful to show the different links (in BCM) between the two water masses and overturning across a range of latitudes. The metrics used by the authors are clearly defined in the appendices, and these are well justified. The combination of statistical analysis (section 3) and model experiments (section 4) is sensible and complementary, allowing more firm conclusions to be reached. As the authors claim, the virtue of this paper is in co-evaluating two different influences on the

AMOC, which are often considered in isolation.

A minor concern is the focus on a particular class of climate models that are becoming outdated (perhaps within 5 years). Given the long integrations, these models necessarily have typical coarse resolution of around 1 degree, with the exception of an alternative version of the model with an MPI-OM ocean, for which resolution is around 0.5 degree. Even the finer resolution is barely eddy-permitting, and one would not expect much improvement in realism in the corresponding simulation. Several studies using forced ocean models with more eddy-permitting and (most recently) eddy-resolving meshes, spanning only a few decades, have revealed that the AMOC is quite different in character (mean state and variability), in particular across the mid-latitudes that are the focus here. There are some admissions of model flaws, in particular the unrealistic spreading of ISRO waters in all but KCM. Widely ranging patterns of deep winter mixed layers in the subpolar latitudes are also evident. I suspect that some of these differences/flaws would be substantially altered/improved with higher horizontal and vertical resolution (including bathymetry).

While the authors (and nobody else for that matter) can not yet use higher resolution for millennial simulations that fully sample multi-decadal variability, the important caveat of resolution should be acknowledged in Section 5. Also, an obvious opportunity is to more critically compare the results in Figs. 1-6 for MPI-ESM-CR (low resolution) and MPI-AO-LR (high resolution). Specifically, at higher resolution: the AMOC is more intense (Fig. 1b), deeper (shallower) winter mixed layers are found in subpolar latitudes (Nordic Seas) (Fig. 2b); stronger lag correlation coefficients between AMOC and SDWI extend to higher mid-latitudes (Fig. 3b); stronger lag correlation coefficients between AMOC and DSO extend into the subtropics (Fig. 4b); weaker lag correlation coefficients between AMOC and ISRO (Fig. 5b); stronger AMOC standard deviations (Fig. 6b).

In summary, the manuscript is well written (no typos!) and results are clearly presented. It should be suitable for publication in Ocean Science, subject to technical corrections

or appropriate responses, in regard to the specific comments listed below.

Specific Comments

1. p.1907, line 10: In closing this section, the reduced explained variability at 30 deg N could and should be attributed to the local (subtropical) influence of variable Ekman transport, although it is not necessary to analyse variability of this component in each model.

2. p.1908, line 22: For clarity, re-label section “4.2 Results of sensitivity experiments”

3. p.1912, line 14: either here, or earlier in Section 5, the caveats associated with coarse resolution should be considered and discussed.

4. p. 1922, Figs. 1 and p. 1928, Fig. 6: Can the AMOC mean and SD be shown northward of $\sim$63 deg N? It may be impractical to re-plot, but one is left wondering how the MOC closes (and varies) in the Nordic Seas, as this region is frequently discussed in the text.

Interactive comment on Ocean Sci. Discuss., 10, 1895, 2013.