

## **Review 2<sup>nd</sup> round – “Contribution of meridional overturning circulation and sea ice changes to large-scale temperature asymmetries in CMIP6 overshoot scenarios”**

I thank the authors for their detailed responses to my previous comments and for the substantial work invested in revising the manuscript. The revisions have improved the clarity and structure of the paper, and the added explanations help strengthen the overall narrative. That said, I believe further work is still needed before the manuscript can be accepted. I recommend **moderate revisions**: the manuscript is publishable after clarifying the role of internal variability, slightly expanding the interpretation of MLD–AMOC links, and refining some methodological justifications. Improvement of the text, particularly in the captions of the figures, is also needed, and minor comments are provided.

### **Moderate comments**

1. While Fig. 1 and Appendix A help, the rationale for including/excluding certain basins in the main analysis could be explained earlier in the methods section.
2. It would be helpful to justify why Atlantic-only asymmetries are not given more prominence given the strong AMOC focus.
3. The paper notes the role of internal variability (e.g., differences between ensemble members in Figs. 9d and 10h), but a more quantitative assessment would strengthen the argument. For example, could a formal separation of forced vs. internal variability be attempted (e.g., through signal-to-noise ratios)?
4. The analysis shows strong correlations between climatological MLD and AMOC slowdown, but the causal mechanisms could be better explained. Are high MLD models more sensitive to buoyancy forcing, or is this an artefact of model resolution/parameterization? A brief physical interpretation would be useful.
5. The  $R^2$  values are low for the ensemble means, yet the text emphasizes a link in some models. It would be useful to present a table summarizing which models exhibit statistically significant relationships and under which scenario.
6. The SMOC–SSW/SSE asymmetry link is weaker (low  $R^2$ ). Could eddy compensation or wind stress changes be confounding factors here? Even a brief discussion of alternative explanations would strengthen the section.
7. The multi-model means give equal weight to each model regardless of ensemble size. While this is reasonable, the authors could comment on whether weighting by number of realizations changes the conclusions.
8. The manuscript is generally well written but could be tightened in places to avoid repetition (e.g., several paragraphs restate that responses are model-dependent and linked to MLD climatology).

## **Minor comments**

### **General:**

- Sometimes “mid-latitudes” and other times “medium latitudes” are used — standardize to “mid-latitudes.”
- Several long sentences would benefit from breaking into two for readability, especially those containing multiple subordinate clauses (e.g., the sentence starting “The analysis of these scenarios shows that even if global temperatures revert...”).
- Keep tenses consistent when describing findings from the literature — mix of present (“is characterized”) and past (“was associated”) could be harmonized.

### **Abstract:**

- line 6: “at regional level” → “at the regional level”
- line 7: “the situation post-overshoot may differ from the situation pre-overshoot...” → “... regional conditions post-overshoot may still differ from those pre-overshoot...”
- line 3 and 10 “the sea-ice” → “sea-ice”

### **Introduction:**

- In the paragraph line 53 starting by “However, there are large uncertainties in these changes, with responses of the AMOC to forcing changes that strongly depend on the model considered (Sgubin et al., 2017), please include the papers from Bellomo, 2021 <https://www.nature.com/articles/s41467-021-24015-w>
- move Table 1 to after the section titre “Method”
- line 25: “recovering the pre-overshoot temperatures” → remove “the” → “recovering pre-overshoot temperatures”.
- line 37: “hemispherical temperature asymmetries” → should be “hemispheric temperature asymmetries”
- line 44: “Relevant hysteresis mechanisms have been found on the large-scale hydrology” → “on” → “in”.
- line 54: “a decrease of OHT” → should be “a decrease in OHT”. In the the text, I found 6 other occurrences of “a decrease of”, please change it to “in” pages 14, 17 (twice), 20, 21, 23

### **Method:**

line 89: “Focus” was used in the sentence before. This paragraph is hard to follow. The term “stabilization”, “pre overshoot state” or “post overshoot state” have not been defined before, and we get a bit lost with the different periods. Consider adding a simple scheme (timeline) to help visualise.

## Results:

**Figure 2 and others:** Caption still needs to be a lot reduced. For example, change: “The minimum-to-maximum spread comprised by the individual simulations within each ensemble is included with a shading” by “enveloppes are the min-max values”. If EXT and ALL ensembles have been defined in “Method”, there is no need to repeat the definition in the caption. Colors for ALL and CNRM model are too similar, change CNRM model to brown for instance. Unclear why we have “CanESM5-EXT” only, and not the extended model simulations. In multi-panel figures (e.g., Fig. 3, Fig. 7), it might help to label subplots with the asymmetry name directly (EN–ES, ENM–ENH, SSW–SSE) for faster reading.

line 148: "Less discrepancies exist" → "Fewer discrepancies exist"

line 160: “Atlantic ocean” → “Atlantic Ocean”

line 173: "has been also identified" → "has also been identified"