

## ***Interactive comment on “Arctic Ocean acidification over the 21<sup>st</sup> century co-driven by anthropogenic carbon increases and freshening in the CMIP6 model ensemble” by Jens Terhaar et al.***

**Claudine Hauri (Referee)**

chauri@alaska.edu

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Terhaar et al., use 14 Earth System Models from CMIP6 to assess Arctic Ocean acidification and how these CMIP6 results compare to earlier results from the CMIP5 generation models. The CMIP6 models project a reduced uncertainty in aragonite and calcite saturation states compared to CMIP5, which is mainly due to compensation of over or underestimation of  $\text{Ca}^{2+}$  through over or underestimation of freshening and reduction of alkalinity. Overall, CMIP6 models improved on simulating max. sea surface densities and therefore better simulate the transport of  $\text{Ca}^{2+}$  into the Arctic Ocean.

The manuscript is well written. There were a few sections that need some clarifications

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(see comments below), but in general I think this manuscript can be accepted with minor revisions.

Page 1: Lines 35 – 37: I think this sentence should be rephrased. This could be misinterpreted to “freshening reduces the difference in a way that carbonate ion concentration will be zero”

Page 2, Line 48. There are two Bates et al., 2009 references in this manuscript, so it is not clear which one the authors refer to with Bates et al., 2009. Also, I doubt Bates is the right reference here since he is a biogeochemist and not a mammal biologist.

Page 2, Line 49: delete “ocean”

Page 3, Lines 55- 61. This first paragraph could be used to explain emergent constraints a bit better. It becomes clear on lines 66 -69, but readers who are not familiar with this methodology could be easily lost in this section.

Lines 69 and 70: This is confusing. I thought emergent constraints were already applied to CMIP5 models in a previous publication (Terhaar et al., 2020a)?

Page 4, Lines 110 – 112: Was the difference based on annual means, monthly means? Would be good to clarify here.

Page 5: Line 137: How were historical atmospheric CO<sub>2</sub> concentrations refined? Reference?

Overall, I think the methodologies would become clearer if the authors included a more detailed explanation on how emergent constraints were used on the CMIP6 models. I realize that there was a section on emergent constraints in the introduction, but 1) I found this section hard to follow, and 2) it wasn't clear whether this was only applied to CMIP5 or also CMIP6.

Page 7, Lines 177 -183: Since results from the historical simulation were compared to CMIP5 it might make sense to compare the 21st century results to CMIP 5 as well? Or

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even better all together move this comparison to the section dedicated to CMIP5 and CMIP6 comparison later on (see comment below)

Page 10, Line 201: “the first 1000m of the Arctic Ocean” does not make sense. This could be interpreted horizontally or vertically. It also needs to be clarified whether it is from the surface or bottom.

Line 209: reword “first 1000 m”

Line 212: maybe change to “between 100 and 1000 m from the surface”

Page 11, section 3.3 Since you are comparing CMIP5 and CMIP 6 results here, I would get rid of the comparison you do at the beginning of the results to avoid repetition and simplify everything.

Page 17, line 360: first comma does not seem necessary

Line 378: “area” does not seem necessary in combination with refugia.

Line 380: As mentioned earlier, I’m not sure Bates is the right reference here.

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