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# ***Interactive comment on “Modeled Arctic sea ice evolution through 2300 in CMIP5 extended RCPs”***

**by P. J. Hezel et al.**

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## **General comments**

The manuscript describes the sea ice evolution in the extended RCPs in the CMIP5 archive. It shows interesting results on the summer and winter sea ice decline past 2100 in the RCP4.5 and RCP8.5, and the sea ice recovery in the RCP2.6, as simulated by several CMIP5 models. As the first analysis of the extended sea ice simulations from several CMIP5 models, this analysis will be very relevant and novel, and it puts earlier studies with individual CMIP5 models into context of the other CMIP5 models. The methods used are well described, and the results are by themselves novel and should be published. Before publication, the manuscript text needs some careful editing for better clarity and to remove several statements that are not fully supported by data

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and/or are confusing. In some places the manuscript also lacks statements as to why things are as seen in the CMIP5 models and I hope the authors can add these, giving the paper more substance. I recommend publication after these relative minor revisions and look forward to reading the final paper.

### Specific comments

**Page 1384; Line 9-12:** It is unclear to me how the RCP2.6 and RCP4.5 “imply that summer sea ice extent could begin to recover if and when radiative forcing from greenhouse gas concentrations were to decrease”, when it is said before that in the RCP4.5 the sea ice continues to decline (as forcing only stabilizes, not declines). This sentence therefore needs to be removed or rephrased, as it is only true for RCP2.6, but not RCP4.5.

**Page 1384; Line 26; Page 1385, line 1:** It needs to be made clear here that this manuscript documents the first analysis of the sea ice simulation past 2100 in a suite of CMIP5 models, by adding “from these extended RCPs in a suite of CMIP5 simulations in this paper”, as other authors have analyzed the sea ice past 2100 in individual CMIP5 models (these are cited later, but it needs to be made clearer how this paper is new).

**Page 1385, Line29:** I do not believe this statement is true as written: “The CMIP5 archive itself does not constrain the dates of possible sea ice disappearance”. What I assume the authors mean, is that it does not constrain the date of sea ice disappearance satisfactorily, but it does gives a range, so it does constrain it. Please rephrase this statement.

**Page 1388, Line 20:** Please add that this is to be expected and why (because why would a multi-model mean be expected to match the single realization observed in the real world?), or remove this statement, as it makes it sound like this finding is surprising, which it is not.

**Page 1390, Line 14/15:** This change between ice-free and “perennial” ice cover isn’t worth talking about in my opinion, as it is just a change across an arbitrary line (1 million km<sup>2</sup>). I would remove this sentence here and in the conclusions, as it makes

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it sound like as if there is something big and interesting going on, while all it is is interannual variability in sea ice extent (a variable that changes easily by a lot, due to its definition) that happens to cross some not-significant (in nature) threshold. The Arctic is already summer ice-free for all relevant purposes at 1.5 million km<sup>2</sup>, and calling it “perennially ice covered” when it is slightly above 1 million km<sup>2</sup> only leads to confusions (even if correct by the definition of an ice-free state at 1 million km<sup>2</sup>).

**Page 1390, Line 16/17:** Please add a sentence giving some physical insight into why this is seen, i.e. because as the ice gets thinner and more open water area exists, the wind can change the ice extent more than when the ocean is already covered by close to 100% of sea ice and the ice is thicker. Physical statements like this are somewhat lacking in the manuscript in my opinion and should be added where appropriate to make it stronger.

**Page 1392, Line 25:** This was also described by Jahn and Holland (2013), in respect to the greenhouse gas forcing, and this agreement with previous work should be mentioned here.

**Page 1394, Line 17:** Please add “summer” before ice-free Arctic, as it clearly refers to that, and it is important to note that it does not refer to Arctic sea ice in general, because the stabilization in the RCP4.5 does not lead to winter ice free conditions in any of the models.

**Page 1394, Line 17/18:** Please remove this sentence “Five models exhibit oscillatory behavior after 2100 alternating between seasonally ice-free and ice-covered states”. As noted earlier, the Arctic is still basically ice-free (and defiantly not in an “ice-covered state” even at 1.1-1.5 million km<sup>2</sup>, and someone who just reads the conclusion gets the wrong idea here.

**Page 1394, Line 25:** I don’t think the analysis supports the use of the word “rapidly” here, as before it was said that the trends are close to zero until 2100, and that it takes up to 60 years to see a recovery in some models. “Rapid” implies something faster than 60 years in my mind. Please remove “rapid”, then this sentence is okay.

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## Technical corrections

**Page 1384; Line 15:** I would add a “the” before reversibility here, to make the sentence clearer.

**Page 1385, Line 3:** Please add “of sea ice loss” after reversibility, and a “the” before reversibility, to make this sentence easier to understand.

**Page 1385, Line 15:** It should be “slow adjustment of the climate system” (not slower, as there is no comparison made to something that response faster as far as I can tell).

**Page 1386, Line 16:** Please add “summer” before sea ice here, as that is what is being talked about.

**Page 1386, Line28:** Please rephrase or split this sentence, it is too long and unclear towards the end. For example, “... into an ice free state. This is true both for annually ice free conditions achieved through radiative forcing (...) and for seasonally ice-free conditions by imposed removal (...”).

**Page 1393, Line 2:** This sentence needs to be rewritten and shortened, as it is difficult to follow. For example “which follows a future trajectory of increasing followed by decreasing radiative forcing” needs to be “which follows a future trajectory of increasing radiative forcing, followed by decreasing radiative forcing” or something similar. Please rephrase.

**Figures:** The figures are too small in the print version of the discussion paper, and I hope they can be printed larger in the final print-version on the manuscript.

TCD

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Interactive comment on The Cryosphere Discuss., 8, 1383, 2014.

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