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Interactive comment on "The Polar Amplification Model Intercomparison Project (PAMIP) contribution to CMIP6: investigating the causes and consequences of polar amplification" *by* Doug M. Smith et al.

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Many thanks for your comments. Please see our replies below.

Anonymous Referee #2 Received and published: 13 July 2018 This manuscript proposed several experiments for the PAMIP, one of the subset of CMIP6, in order to better understand the causes and consequences of polar amplification. I find this paper is well-written and only have some minor comments, as follows:

1. Caveat on AMIP simulations (tier 1 and tier 5) One interesting but controversial

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question in this area is whether observed recent Arctic sea ice loss since 1979 has significantly affected the jet stream and caused more winter cold extremes in the mid-latitudes (or the debate on \u201cWarm Arctic, Cold Continents\u201d). I am just wondering if PAMIP wants to touch on this question in tier 1. Tier 5 is very nice, but I am a little worried that the member size might be not enough to derive the forced sea ice loss effect for individual models. Sun et al. (2016) analyzed 50-member AMIP experiments to examine the \u201cWarm Arctic, Cold Continents\u201d hypothesis. Initially when they only had 10-member simulations, there was some cooling over Eurasia in response to Arctic sea ice loss. However, it turns out that is just internal variability because the cooling signal disappears when the ensemble size increases to 30. Similarly here, I suspect that 3 members might be not enough to show the forced response to Arctic sea ice loss for a single model. In other words, one should be able to use all available model ensemble to examine overall whether models show any response signal to observed sea ice loss but we may not be able to look at the sea ice loss effect in single models because of the large internal variability.

Reply: Understanding the impact of sea ice loss on the atmospheric circulation (and hence the “Warm Arctic Cold Continents” pattern) is indeed a key focus of PAMIP. This will be addressed in tier 1, but using idealised sea ice forcing from the differences between pre-industrial (pi), present day (pd) and future (fut) conditions. This choice (arrived at after much debate) provides multiple estimates (e.g. pd-pi, fut-pd, fut-pi) and is easily expanded to investigate additional aspects including the pattern of forcing and the roles of coupling and the background state. Improved understanding achieved through these experiments will provide much information on the role of sea ice in driving the Warm Arctic Cold Continents pattern. Experiment set 5 is optional, but provides additional focus on the recent period. We fully agree with the reviewer that a larger ensemble would be beneficial but we are wary of putting groups off by specifying experiments that are very costly, and take the view that any contributions would be welcome and would contribute to a larger multi-model ensemble. However, we have modified the text to highlight that larger ensembles are preferable if groups

have the resources to provide them.

2. Caveat on the coupled model experiments (tier 2 and tier 6). The design of tier 2 experiment appears to be different from most previous fully coupled ocean-atmosphere studies (Deser et al. 2015, 2016; Tomas et al. 2016; Smith et al. 2017; Oudar et al., 2017; Blackport and Kushner, 2017). From the point view of attribution study, I think the tier 6 more represents the full sea ice loss effect because in reality and in projected CMIP simulations the ocean will be allowed to justify when the sea ice declines (in other words sea ice reduction occurs gradually and ocean can adjust to that). Given the reason above, I feel that tier 2 can be used to demonstrate the role of quick ocean-atmosphere coupling but one has to look at tier 6 to understand the role of full ocean-atmosphere coupling (tier 2 might be more like slab-ocean coupled results to some extent).

Reply: We agree, and have noted this text.

Another small point: 100 years appear to be too short for tier 6. 200 years might be necessary because the first 100 years or so might need to be discarded due to model spin-up (ocean adjustment).

Reply: We agree that longer simulations would be beneficial and have added a note to encourage groups to provide them if possible.

3. Page 5 lines 5, 10: Liu et al. 2012 and Mori et al. 2014 are both modeling studies. Therefore, they probably should go to the next lines on “diverge considerable on the dynamical response”, together with other studies that suggested recent Arctic sea ice loss did not significantly affect the jet stream and “Warm Arctic, Cold Continents” may simply reflect the atmospheric internal variability (e.g. Sun et al. 2016; Ogawa et al. 2018). These are comparable studies which all conducted AMIP-type simulations by prescribing recent Arctic sea ice loss.

Reply: We have included the additional references as suggested.

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4. Page 7 line 10: isolating the response to sea ice (loss or change?). Also maybe I didn't fully understand the argument of "additional forcings". I thought we are discussing the effect of sea ice loss-alone. McCusker et al. (2017) have presented evidence that the atmospheric circulation response to sea ice loss and greenhouse gas forcing are remarkably linear. Thus it probably does not matter much.

Reply: We have clarified that additional steps are needed to isolate the impacts of sea ice in experiments that also include other forcings.

5. Page 9 Line 10: Blackport and Kushner, 2017

Reply: Corrected – thanks.

6. Figure 5b): there is a weird box in the bottom left

Reply: Corrected – thanks.

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