Climate
of the Past
Discussions

EGU

Interactive comment on "The relevance of mid-Holocene Arctic warming to the future" *by* Masakazu Yoshimori and Marina Suzuki

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Thank you very much for carefully reading the manuscript and for bringing up some important points. In the following, reviewer's comments are indicated by [RC]. Response to the comment and perspective on the revision are indicated by [AC].

[RC] This paper discusses the decomposition of the changes in surface temperature into local and global feedback contributions, related to the different components of the surface energy balance. This decomposition is performed both for Mid-Holocene (compared to pre-industrial) and future warming (under RCP4.5 scenario). As a general comment I would say that I found the paper difficult to read, although I cannot figure out exactly the reason (either the topic or the language).

[AC] Taking also the suggestions by other reviewers into account, we will change following points to improve the readability.

(1) We will change the abstract to be more informative with emphasis on the specific new findings.

(2) We will write terms in Eq. (4) explicitly after combining with Eq. (2), so that each term corresponds exactly to the description in Table 3 and each component in Figs. 5 and 10.

(3) We replace Lambda in Eq. (7) by T so that it is obvious that the symbol represents temperature.

(4) In Sect. 4.3 in "Results", we will describe the results season by season first, and then state important points afterward so that the reader can grasp the overall results in the sequential order first.

(5) In Sect. 4.5 in "Results", we will describe the results season by season first, and then state important points afterward for the same reason as (4).

[RC] I also found that the discussion is not really a discussion, but rather a perspective and conclusion. After reading the manuscript, and although I acknowledge similarities in climate changes between MH and the future, I still do not understand the 'relevance of mid-Holocene Arctic warming to the future '. This should be the major item in the discussion.

[AC] We will enlarge the discussion and conclusion with emphasis on the relevance in the Arctic response between the MH and future (RCP4.5). The discussion will be substantially enlarged with separate points (1) in terms of the ensemble mean response, and (2) in terms of the model spread. We will also increase discussion for the difference between the MH and future (when and how).

[RC] The conclusion of the paper is not very new. It has already been repeated many times that 'improvement of the ability of the model to simulate the past will increase the

confidence in their ability to simulate the future'. I would suggest to identify a 'crispier' conclusion.

[AC] We will make the conclusion more specific and reduce weight for general statements. The main points will be:

(1) It is found that many of the dominant processes that amplify Arctic warming over the ocean from late autumn to early winter are common between the two periods, despite the difference in the source of the forcing (insolation vs. greenhouse gases).

(2) A chain of processes responsible for the warming trend from summer to autumn is elucidated by the decomposition to factors associated with sea surface temperature, ice concentration, and ice surface temperature changes.

(3) The downward clear-sky longwave radiation is one of major contributors to the model spread throughout the year. Other controlling terms vary with the season, but they are similar between the MH and the future in each season.

(4) The MH Arctic change may not be directly relevant to the future in some seasons (spring in particular) when the temperature response differs, but it is still useful to constrain the future Arctic projection (partly new addition to the original manuscript).

(5) The significant cross-model correlation found between summer albedo feedback and autumn-winter surface temperature response in both forcing cases suggests that feedbacks in preceding seasons, sea ice cover in particular, should not be overlooked as a constraint (new addition to the original manuscript).

[RC] The manuscript is missing a data availability section. Moreover, data citations are also missing (in addition to the references that are indeed given). This is the case, at least for the data of Bartlein et al (2011) and Sundqvist et al (2010). Moreover, the code used to extract the values displayed in figure 5 should be made publicly available as well (with a reference in the data availability section).

[AC] We will add Data Availability section. We will also make the computer codes used

for the analysis in Fig. 5 available upon acceptance of the paper and upon request.

[RC] Specific comments. P1-l29 : is it solar forcing?

[AC] Marshall et al. (2014) suggests stratospheric ozone forcing. To be precise, we will change to "stratospheric ozone change and cloud feedbacks play some roles".

[RC] P2-l1 : I assume that the 'scenario' refers to RCP scenarios. This should be made clear.

[AC] Change will be made to "RCP scenario".

[RC] P4-l16 and P7-l13 : there is a reference to Sect. 3a, which does not exist (at least as such).

[AC] "3a" should be "3.1", and will be corrected.

[RC] P6-l33 : According to my reading of the figure, the simulated warming only occurs in the northern North Atlantic and Arctic oceans, where there is no data. It is therefore very difficult to say if it is under- or over-estimated. Or do the authors call 'warming' the negative values in the figure?

[AC] We will change it to "the warming indicated by the reconstruction is not captured by the model mean in January as well as in the annual mean."

[RC] P7-l16 : 'plays an important role'. According to my reading, this is only true in JJA.

[AC] We will make it more precise.

[RC] P7-l32 : 'exhibits a large contribution'. This does not really seem to be the case for MH.

[AC] The reviewer is correct. We will clarify this point.

[RC] P8-l9 : could the authors make the label coherent (Dtas in the text, Dta in the figure).

[AC] The correction will be made to the text.

[RC] P10-l11 : PMIP3 instead of PMIM3

[AC] Will be corrected. Thank you.

[RC] P10-l22 : The authors should make their conclusion readable by itself. It should be said that the Arctic warming is for the future (under RCP4.5).

[AC] We will make the conclusion readable by itself by adding some words.

[RC] P10-l33 : 'seeking possible analogues between physical processes in the past and future climate'. Do the authors mean that the climate processes are time dependent? I thought that they were based on basic physical principles valid through time. Moreover, as we do not know the future climate it is hard to look for analogues there and then.

[AC] While physical principles are same throughout the time, what we meant is, it is not trivial that the dominating processes for the climate variations are the same for different climate forcing and change cases. We will rephrase the sentence.

[RC] P15 : A reference is missing here.

[AC] We will add the reference.

[RC] P 21 : The figure is misleading because the Y-axis (scale) is not the same for MH and RCP4.5.

[AC] We will add the note on the caption. The difference in magnitude does not preclude the use of these two different time periods, and rather it is of interest that such different climate responses still share the similar dominant processes.

[RC] P23-l4 : I do not see two (black and blue dashed) lines. Are they exactly superimposed? In that case, this should be mentioned in the caption.

[AC] They are black polygonal solid-line and blue polygonal dashed-line. We will make the caption more precise (and text).

[RC] P24-26 : Figures 6-8 are not using the same number of models. (1) the name of the models used should be mentioned. (2) Not using all the models (and not always the same models) may introduce a bias in the interpretation. Would the conclusion be the same if only the models (and their outputs) available for all the figures were used?

[AC]

(1) All model names were given in Table 2, but the models used for Fig. 7 was only written in text. We will refer Table 2 for Figs. 6 and 8, and write names explicitly for Fig. 7 in the caption.

(2) The main results shown in Figs. 5 and 10 are benefitted the most by using the models as many as possible (10 models), but all variables are available only for 5 models: 5 models are missing for Fig. 7 and 1 model is missing for Fig. 8 (It was mistakenly written that 2 models were missing in the caption of Fig. 8. We will correct it). We checked the consistency of Figs. 5, 7 and 8 by reducing the model numbers to 5. Figs. 5 and 8 were not qualitatively affected by this reduction. We also checked all figures by reducing the model numbers to 5: a few small terms lost their statistical significance in Fig. 10, but the conclusion remains the same.