Response to Editor Report

(Note: editor comments in black and our reply in blue)

I appreciate the authors attempts to revise the manuscript according to the reviewers comments. However I feel that while it is useful to have all 46 CMIP5 models evaluated and referenced someplace, and have both the Arctic and Antarctic evaluated, the current manuscript is not up to the standard for a manuscript in The Cryosphere.

Reply: We appreciate the editor to give a report and valuable comments to this manuscript. We tried our best to revise the manuscript to up to the standard of The Cryosphere.

Part of the problem stems from the methodology. First off, only looking at extent and/or volume is not all that useful. The spatial maps shown are helpful for the ice concentration, but what should also be shown are the spatial maps of the CMIP5 thickness fields. A recent paper by Stroeve et al. (2014) published in The Cryosphere already showed that while the Arctic ice volume in CMIP5 are comparable to that in PIOMAS, the spatial pattern of where the models have thick vs thin ice is not well represented in the CMIP5 models. I also feel that you need to show in this paper that the standard deviation between different ensemble members from the same model are comparable, not just in terms of total extent and volume, but also the spatial patterns. The Turner et al. (2013) paper only looked at the Antarctic and they didn't use as many models. Since one of your points for why this paper is important is that all 46 models are evaluated, then I feel that more robust analysis of the variability for all those models is required. Also, some discussion as to the 1979-2005 time-period is warranted. While it is the period of observations (and therefore, a useful comparison), it is additionally important to discuss the results in the context of not expecting the models to necessarily be in phase with the natural variability seen in the observations. This is likely very important in your discussions of Antarctic sea ice.

Reply: The spatial patterns of each CMIP5 model simulated sea ice concentration and

sea ice thickness are added in the revised manuscript. We also added more analysis of the variability of CMIP5 models in the revised manuscript. In order to illustrate the standard deviation between different ensemble members from the same model are comparable, we plot the spatial patterns of SIC in February and September from different ensemble member from GISS-E2-R which has 15 ensemble members in the revised manuscript. We can see that the differences between different ensemble members are very small and much smaller than that from different models. We totally agree with you that models are always out of phase with the natural variability seen in the observations, so the model internal variability is important to access, especially in the Antarctic. In the revised manuscript we added a paragraph as follows. "In this study, satellite observations, PIOMAS and GIOMAS data during 1979-2005 are used to access the sea ice simulations from CMIP5 models. We always expect the models can capture the observed trends during this period. But we should note that simulations without data assimilation are always out of phase with the natural variability seen in the observations. So the differences between simulations and observations can either be due to model biases or natural climate variability (Stroeve et al., 2014)."

It is not correct to state that sea ice thickness data are primarily ship based observations. Do you mean submarine data? There are also thickness data from aircraft and satellite. Stroeve et al. (2014) compared the thickness data in the Arctic with that of PIOMAS and reasoned that PIOMAS provided useful estimates of ice thickness/volume to compare with the CMIP5 models. Can you not make a similar assessment of the accuracy of GIOMAS for the Antarctic? Some basis for using GIOMAS is needed here.

Reply: Thank you for your suggestions. In the revised manuscript we correct our description of observed sea ice thickness. "The observed sea ice thickness records are mainly from submarine, aircraft and satellite" is used. When we talk about Arctic SIV we cite Stroeve et al. (2014) to ensure the accuracy of PIOMAS output. But it is very difficult for us to assess the accuracy of GIOMAS in the Antarctic, since it is hard to get enough observation in the Antarctic. In the revised manuscript, the sentence of

"What we should keep in mind is that GIOMAS sea ice thickness is not from observations and may also have large uncertainty" is added.

There should be some statistical assessment as to whether the CMIP5 MME trends in SIE and SIV are statistically different from those observed and modeled by PIOMAS and GIOMAS.

Reply: For Antarctic, satellite observed SIE and GIOMAS modeled SIV trends are 1.29×10^5 km^2 $decade^{-1}$ and 0.45×10^3 km^3 $decade^{-1}$ during 1979-2005. CMIP5 MME trends are -3.36×10^5 km^2 $decade^{-1}$ and -0.36×10^3 km^3 $decade^{-1}$, respectively. Both SIE and SIV trends are incorrect. For Arctic, satellite observed SIE and PIOMAS modeled SIV trends are -4.35×10^5 km^2 $decade^{-1}$ and -2.14×10^3 km^3 $decade^{-1}$ during 1979-2005. CMIP5 MME trends are -3.71×10^5 km^2 $decade^{-1}$ and -1.45×10^3 km^3 $decade^{-1}$, respectively. CMIP5 MME trends are slower than observations and PIOMAS simulations.

The Tables could be made more useful if the models that had statistically different trends were highlighted somehow (i.e. via shading).

Reply: During our analysis, models have statistically different metrics are highlighted with bold font in the Table 1 and 2.

In general, I do not find that much new information on Arctic and Antarctic sea ice representation in CMIP5 models is given beyond previous studies. Figure 11 may be the most interesting part of the paper and should be expanded upon.

Reply: Most of previous studies used parts of the CMIP5 models. Our analysis shows that if we focus on MME, more 22 CMIP5 models can give good MME as all of the 49 CMIP models.

Finally, we hope to express our sincere thanks again for all these valuable comments and suggestions.