Review of 'Perspectives on future sea ice and navigability in the Arctic' by Chen et al.

In this paper, the authors use CMIP6 simulations to assess the navigability in the Arctic until the end of the 21st century. I think the topic of this manuscript is very interesting and timely. Although the manuscript has the potential to be a nice scientific contribution, I find that it requires a lot of work and substantial revisions. The authors need to clarify many aspects of their methodology. Moreover, I find that the figures require a lot of work; there are typos, captions are incomplete and readability is difficult due to the font size. Finally, I really think the english should be improved. This manuscript could be considered for publication in The Cryopshere once the authors have addressed the following comments.

A: Thanks for the constructive comments. The methodology and figures were revised for the issues addressed in your comments. An English naive speaker from AJE was invited to improve the quality of writing. We sincerely hope our endeavor could meet your approbation.

Major comments

- Q1: Section 2.1: the authors need to better explain how they selected a subset of CMIP6 models for their study.
- A1.1: The selection of CMIP6 models was explained as below in the revised manuscript. "This study selected models by comparing the historical trend of Arctic sea ice extent in simulation with remote sensing observation during 1979–2012. The observation data comes from Sea Ice Index in the National Snow & Ice Data Center. The selected models are those the correlation coefficient between original simulation and observation greater than 0.8 (0.7 for March). Five-point moving averages of simulations were made in Figure 1."
- -For a given model, did you use all the members or just the ensemble mean? What do we see in Figure 1?
- A1.2: The ensemble means were used in this paper. Figure 1 shows the variation of sea ice extent in observation and five-point moving averages of simulations during 1979–2012.

- -I don't understand why the authors base their selection on the correlation coefficients and not on the trends of the sea ice extent. Is the correlation calculated in detrended time series or on the original ones? I guess on the original ones, the correlation in fact measures the quality of the trend. Please clarify. Note that another way to select a subset of models would be to follow the approach of Notz and SIMIP community GRL 2020.
- A1.3: Notz and SIMIP community, 2020 selected a subset of models for estimating a best guess of the future evolution of the Arctic sea-ice cover with strict approach if the ensemble spread of model includes the observational record, considering observational uncertainty. It has great revelation for our future work. Previous studies to the Arctic navigability directly used the average of multi-model. In this paper, a simple selection was made to filter out the models with large deviation. Correlation coefficient is a statistical variable to indicate the relationship of the trends between the simulation and observation. It was calculated on the original ones and clarified in the revised manuscript as "The selected models are those the correlation coefficient between original simulation and observation and observation greater than 0.8".
- -In Figure 1, there is more variability in the observations than in the CMIP6 time series. Is it because the averaging window (5 points) is not applied to the observations? Please clarify.
- A1.4: We want to show the actual changes of sea ice extent during 197-2012. So the averaging window is not applied to the observations in Figure 1. The caption was revised as "The observations and five-point moving average of sea ice extent in March and September during 1979–2012".
- -For many analyses and figures (e.g. figure 6) it is not clear if the authors use the multimodel ensemble mean? Please clarify.
- *A1.5:* Thanks for your reminding. It was clarified as "Variables in figures and tables were from the ensemble means of selected models" in the revised manuscript.

Q2: Section 2.2: the authors need to clarify equations (1), (2) and (3).

- -what are the ice types in equation (1)? Do you get these from the CMIP6 simulations? I would be surprised. I guess you get concentration and thickness. Related to this, please make sure you use the thickness (h) and not the mean thickness in a grid cell or in other words the volume (h*concentration).
- A2.1: Thanks for your question and reminding. Ice types do not represent the named types of sea ice, such as pack ice and first-year ice in Equation (1). They are ice within a range of thicknesses corresponding to IMs in equation (2). This sentence was revised as "a, b, and n, are ice within a range of thicknesses corresponding to IMs in equation (2)." in case of confusion. We are sure the thickness is not h*concentration.
- -once you find an IM (e.g. equation (2)), how do you calculate IN in equation (1)? Is it the same IM for all the ice types? This needs to be clarified.
- A2.2: As explained in A2.1, IM is same for ice within corresponding range of thickness.
- -what do you show in Figure 6? Is it IN? Why is it called Arctic navigability then? Also explain how you define navigable area. Is it where IN is greater than 0?. Please clarify.
- A2.3: The caption of Figure 6 was revised as "INs for OW ships under SSP5-8.5 in September". The navigable area was clarified as "It is the percentage of grids where INs are greater 0." In the revised manuscript.
- Q3: The figures need to be improved. Here are some comments related to that.
- -all the figure captions need to be reworked. At the moment, they don't provide enough details.
- A3.1: Thanks for your suggestion. All of figure captions were reworked as follows. Figure. 1. The observations and five-point moving averages of sea ice extent in March and September during 1979–2012.
 - Figure. 2. Sea ice extent under multiple scenarios and observation trends in March and September

Figure. 3. Linear trends and probability distributions (PD) of Arctic sea ice extent (SIE) in March and September Figure. 4. Linear trends of sea ice thickness and concentration under SSP5-85 in September

Figure. 5. The changes in sea ice volume and age under SSP5-85
Figure. 6. INs for OW ships under SSP5-8.5 in September
Figure. 7. Total navigable areas for OW ships and PC6 ships under SSP2-4.5 and

SSP5-8.5

Figure. 8. Navigable areas for OW ships and PC6 ships under SSP2-4.5 and SSP5-8.5 within different latitudes

-use units and labels that are commonly used. Example, in figures 1 and 2, the units on the y axis should be M km2 and the label should be September sea ice extent (not remaing ice in September...with the typo in remaining).

A3.2: Thanks for your suggestion. Figures 1 and 2 were revised as bellow.





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-increase the font size for the text. It is often very difficult to look at these figures.

- A3.3: The font size was increased in some Figures. The resolution of Figure was reduced when it was inserted into paper. The original Figures (600 dpi) will be submitted to journal.
- -figure 3: wouldn't it be better to use a histogram instead?
- A3.4: Thanks for your suggestion, but histogram cannot cover all the information shown in Figure 3.
- -there are lines or features emanating from the North Pole in many figures (e.g. figures 4 and 6). Is it the interpolation that is used? I am sure the authors can do better than this.
- A3.5: Yes, it was resulted by interpolation. The lines in Figure 4 and Figure 6 were eliminated.



- Q4: lines 250-255 and lines 306-310: the authors show an abnormal decrease in the navigable area at high latitudes in September. They mention it but argue that this is difficult to explain. As the navigability depends on the concentration and thickness, I think they can explain it if they investigate it a bit further.
- A4: Firstly, we checked all of data and programs, and did not find any error in calculation. According to Figure 8, this abnormal point results from the decrease within 85°N–90°N. It directly attributes to the increase of sea ice thickness transiting from lower than 120cm to be equal or greater than 120cm. However, further reasons on physical mechanisms are hard for us to explore. We can only use multi-model data released by CMIP6, and respect the abnormal result from calculations and show it to the public and researchers, but cannot conduct tests for it. We sincerely hope the development teams of models could give an explanation for this.

Minor comments

- Q1: lines 42-44: the authors describe a mix of two physical mechanisms in the same sentence. Sea ice reflects a significant fraction of the solar radiation because it has a high albedo. It also reduces the heat transfer between the ocean and the atmosphere as it acts as an insulator.
- *A1: Thank you. This sentence was revised by divided into two parts as you mentioned above.*
- Q2: line 103 (and at other places): replace 'excellent models' by 'selected models'.
- A2: Replaced.
- Q3: usually the discussion comes before the conclusions. Given the fact that the discussion is really short, I would combine it with the conclusions and name the section: Discussion and concluding remarks.
- *A3:* Two of sections was combined and named as Discussion and concluding remarks in the revised manuscript.