Second Reviewer

Comment on egusphere-2022-324
Anonymous Referee 2

Referee comment on "Rapid Sea Ice Changes in the Future Barents Sea" by Ole Rieke et al., EGUsphere, https://doi.org/10.5194/e
2022-324-RC2, 2022

This study investigates the trends of sea ice decline and variability, in the Barents Sea, as represented by climate models. More specifically, the study tries to relate the sea ice variability in the Barents Sea to its drivers, such as ocean or atmospheric forcing. The work is relevant, and deserves publication, but the manuscript needs to be clarified because it is difficult to follow the method or the conclusions. Basically, one gets the impression some important work has been done, but assembled in a messy way. If this manuscript is mostly the work of its first author, I would suggest the co-authors to review the manuscript as if they were reviewers, if it is a collective job then the manuscript could be reviewed by a colleague before submitting a revised version. I really think the work is interesting, but I recommend major revision because the manuscript needs clarification.

We thank the reviewer for the valuable feedback! We have revisited the manuscript and changed text and figures accordingly. Following the reviewer's suggestions, we have in particular tried to improve the text. This includes a thorough review by all co-authors and an English-speaking colleague. We hope the reviewer finds our manuscript improved and easier to follow.

Please find below a detailed response to each comment.

- Line 63 : F is not the advective heat flux per unit volume, but rather the advection of temperature per unit volume.
  This is correct! We have changed this accordingly.

- Line 57 : Can you rephrase this sentence, super heavy to read. You could reverse it. Trends in ocean heat transport via the Barents Sea Opening (BSO), sea ice area transport between Franz Josef Land and Novaya Zemlya (eastern gateway) and between Svalbard and Franz Josef Land (northern gateway), net surface heat fluxes, sea level pressure....
  We have rewritten this sentence.

- Section 2. Data and Methods :
  This section is very confusing. Each bit does have a meaning, but all the bits together are really hard to follow because you switch from one to the other. Could you split in subsections, or at least make paragraphs : basically it starts with the model references, then explains how you define RICEs, then the fluxes etc.
  We have rearranged the paragraphs in the section following the reviewer's suggestion, as well as moved some text from the results section to the methods section. A description of the models used is now followed by the methodology. We believe that the section is now more clearly structured and easier to follow for the reader.

- It is difficult to understand the concept of external forcing, can you explicitate as this idea comes back several times in the manuscript, there are references but it would be good to have a substantial description within the manuscript. Especially, how do you arrive at the conclusion that within the number of members taken, the mean represents only the external forcing ?
  We have rewritten that part to be more specific about the approach. We now state the following in the manuscript:
  "Using multi-member ensemble experiments allows for a detailed investigation of internal variability. The setup of the individual simulations differs only in slightly perturbed initial atmospheric conditions. Since the external forcing is the same for each simulation, the differences between the individual simulations are thus solely a result of internally-generated variability (Deser et al., 2020). The externally-forced contribution of e.g., sea ice change, is thus defined as the ensemble mean change (either from the 40 members of the CESM-LE or each CMIP6 model). To isolate the internal variability, we subtract the ensemble mean from each ensemble member."

This approach is one of the major advantages of large ensemble simulations and has been used in several studies before (Deser et al., 2012, 2014, 2020; Bonan et al., 2021).

- In the middle of the section you already refer to Fig.2 in which the distribution of something obviously is plotted, but the reader does not even know what (although obvious for you). The beginning of the section describes models used, then you switch to methods to estimate events, and then at the end you switch back to model qualities... such a mess, please rewrite the entire section to split ideas so that the reader can follow.
As mentioned above we have rearranged this section. The reference to Figure 2 has been removed.

- Section 4:
Could you explain why the mean internal trend is not zero in Figure 2, this sounds strange as you mention these are only deviations from the ensemble mean, which suggests it is substracted. This appears to be confusing even further later in Line 92.
The black line in Figure 2 does not represent the mean of the internally-driven sea ice trends, but rather the externally-forced sea ice loss in CESM-LE. The latter is, as explained above, based on the ensemble mean sea ice concentration, i.e., the thick orange line in Figure 1b. We have changed the notation following line 92 to avoid confusion.

- The distribution of observed trends after 1920 is shown for comparison, and is similar to both, the historical simulations of CESM-LE (not shown) and the future simulations between 2007 and 2025 (Fig. 2a). I guess you refer to the Observations in Fig. 2a, make it clear by using similar words.
Yes, this is correct. We have modified this in the text.

- Line 115 : you switch here to the main interest of the paper, the underlying processes behind the RICEs. I would create another section, or a subsection. **Good idea! We have added a new subsection as suggested.**

- Line 120 : heavy notation since you use twice semi-columns, I would suggest to switch to a bullet list or use sub-sub-sections. Add for each forcing its abbreviation so one identifies it when reading Figure 4 without reading the caption.
We have added bullet points with abbreviations as suggested.

- A general comment about the method, the relation with the underlying processes is presented is only presented here as a kind of correlation. I think it would give more added value to your work if you could show you can actually reconstruct the signal of RICEs through an empirical function, it is just a recommendation but i do not think it is a lot of work to do. This would permit to dis-entangle processes which are, as you suggest, counted twice as for example a strong temperature anomaly in the atmosphere can also be related with a stronger heat transport through the BSO. You could show that you can reconstruct the signal of RICEs with the same accuracy or almost by eliminating one of the processes.
This is a good suggestion and we agree that this would add value to our analysis. However, although most RICEs are clearly related to trends in the chosen drivers, their strength does not show a strong relationship (in a way that particularly strong RICEs would be related to stronger trends in e.g. OHT). Thus, reconstructing the magnitude of RICEs using multiple linear regression did not prove to be successful. We have added this result to the manuscript. We note that our method of relating a fraction of RICEs to specific drivers are in line with the approach of Auclair and Tremblay (2018) who studied rapid ice loss events (in summer) and its relation to OHT.

- Section 5 and Conclusions : Too many number to read in Section 5, it's difficult to follow. Can you sustain a bit further in terms of processes all the differences between models ?
To improve readability, we have reduced the amount of numbers in the text. The number of RICEs is, for example, now rather displayed in Figure 6.
As stated in the manuscript, we analyse RICEs in five CMIP6 models in order to assess whether the number of RICEs in CESM, and their future change, is representative. To understand the differences between the models, in terms of their mean sea ice state, their variability, and their

sensitivity to forcing, would require a detailed mechanistic analysis that is beyond the scope of this study.

- I'll coment further on this part on the revised version.
- 7.7 10^4 km2yr1 and such numbers : Do not use the * sign, and put some spacing. Check in other articles of the same journal on how such number are written.
  We have changed the notation of this numbers and now use spacing between and before units.
- dd some dots in some places before beginning a new phrase: based on Walsh et al., 2017). Please check sentences in general, and avoid long sentences.
  This has been fixed.
- Check the case according to journal requirements, I suspect eastern gateway should be written Eastern gateway (this is just an example, directions in general should be writen East, North, etc. I believe).
  The English language guidelines of the journal recommend to write east, northern, etc. using small letters unless part of a name ("North America") or established expression. Our writing follows these guidelines.

References

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