The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC2
https://doi.org/10.5194/tc-2022-201-RC2, 2022

Comment on tc-2022-201

Anonymous Referee #2

Referee comment on "Modulation of the seasonal cycle of the Antarctic sea ice extent by sea ice processes and feedbacks with the ocean and the atmosphere" by Hugues Goosse et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-201-RC2, 2022

Review of "Modulation of the seasonal cycle of the Antarctic sea ice extent by sea ice processes and feedbacks with the ocean and the atmosphere" by Goosse et al. in The Cryosphere

General comments:

The seasonal cycle of Antarctic sea ice extent is greatly asymmetric, with a much slower phase of ice advance in austral fall than the rapid ice retreat in spring. Understanding this asymmetry in Antarctic sea ice extent is of fundamental importance, as it provides insight into processes linking the ice with the ocean and the atmosphere. As discussed in the manuscript, a substantial advancement has been made recently (Roach et al., 2022), showing that the asymmetry is ultimately induced by the incoming solar radiation. However, the modulation of the asymmetry by other processes that could be responsible, for example, for interannual variations in the asymmetry, remain poorly understood.

The study by Goosse et al. provides novel insight into this process by exploring the role of sea ice processes (dynamics and thermodynamics) and exchange processes with the ocean and atmosphere in driving a modulation of the seasonal asymmetry of the Antarctic sea ice cycle. They use a suite of model experiments to show that ice anomalies during the period of ice advance are largely controlled by the initial conditions in summer and the thermodynamic growth of the ice induced by heat loss at the surface. In contrast, anomalies during the phase of ice retreat vary substantially depending on the processes that are altered in the model. In particular, the role of changes in surface albedo and sea ice transport stand out as processes controlling anomalies during the ice retreat.

This is a very timely and insightful study that is of importance to the sea ice community, but also the wider climate and modeling community. It is well written, and the conclusions seem robust and supported by the analysis presented. I only have few minor questions and comments listed below and I recommend the publication of this manuscript after they are addressed. I congratulate the authors on this interesting work and making a valuable contribution to the field.

Specific comments:

1)

A) P6L193ff: "This simulation thus has no interannual variability […]" -> I have difficulties understanding why this should be the case. I understand that there is no interannual variability in the forcing since it is simply one specific year applied consecutively. However, why shouldn't there be any interannual variability developing in the ocean or sea ice? While the forcing certainly imposes some constrained, the ocean and ice are still free running models that can develop a certain level of variability.

B) P6L206: "in contrast to NEMO alone" -> As for the comment above, I wouldn't understand why that should be the case. Probably the interannual variability in NEMO is dampened compared to PARASO by the imposed atmospheric forcing.

C) P16-18: If I understand correctly the approach presented in this section assumes that there is no interannual variability in the ocean and ice in the NEMO simulation. Given my comment above, I wonder how this calculation and the conclusions of this section were affected if indeed there was some interannual variability in the ocean and ice in NEMO?

2) In some instances, I found it difficult to depict the signals described in the text from the figure because the lines appear close to each other. May I suggest to show the full seasonal cycles in Figure 1 as is, but for all other seasonal cycle plots (Figures 2, 3, 4, 8, and Supplementary) to show the anomalies with respect to the seasonal cycle. If the full seasonal is currently shown to distinguish the ice advance and retreat seasons that could be still retained by shading the background accordingly or similar. I think that would greatly help the reader to better identify the signals in the Figures.

3) P19L539-L540:

A) I guess here a reference to Figure S3 is missing.

B) Looking at that figure, I was surprised that the overall ThinIce experiment shows a cooling in winter, whereas the cooling really is confined to a very narrow stretch along the coast and most of the rest of the pack ice region experiences a substantial warming. Given the large region of warming and the small region of cooling, I am wonder how it is possible to still get a cooling overall in Figure 8.

C) Also, it seems counterintuitive to me why both ThickIce and ThinIce experience a warming for most of the pack ice region (Figure S3). Why would they respond in the same way, even if the perturbation is intended to have an opposing effect?

4) P19L568-L604: In this section, I am wondering what role "noise" (on any time scale) in the simulations might play in leading to variations in gamma that are difficult to interpret as the ones described here. Couldn't the "unexplainable" variations in gamma also be due to the fact that there are no ensemble simulations run for these experiments?

5) P23L693-L644: I am wondering if the ice transport may also be pointed out here as a possible reason for large model biases during the retreat season, given that models do have substantial biases in the transport and, as shown here, this process seems to be fundamental for anomalies during this season.

6) Section 5: Even though, as described, it is difficult to directly compare the simulations to the observed seasonal cycle in Antarctic sea ice and its changes due to the idealized nature of the experiments, I am wondering if anything could be learned from comparing the findings of this study with the findings by Holland (2014; https://doi.org/10.1002/2014GL060172). That study specifically investigated the seasonality of the observed sea ice trends, their relation, and some of the driving mechanisms.

7) Code and data availability: Is the model output available somewhere?

Technical corrections:

- P2L30: "[…] configuration, including […]"

- P2L33: “This perturbation is […]”
- P3L58: Please use “—” instead of “-” (hyphen) for inserting the thought in this sentence and no spaces or commas before and after
- P5L154: “referred to as NEMO”
- P7L235-L253: This two paragraphs describe some underlying processes and it is not directly obvious to the reader if these are hypotheses or actual well understood processes in literature. In the latter case, some references would be helpful here.
- P9L297-L300: Even after reading this sentence several times, I have troubles following the thought. Could you please split it up and simplify/clarify a little?
- P15L424, Figure 5 (and Supplementary): I assume that the purpose of showing these property vs. property scatter plots is to infer some sort of relation. If so, it would be good to also show the corresponding correlation coefficients and their statistical significance.
- P16L441, Figure 6 (and Supplementary): I am afraid that the colorbar used in this figure is not an appropriate scientific colorbar and should not be used in scientific literature. For detailed reasons and tools to generate an appropriate colorbar in Matlab, please see for example this paper by Stauffer et al. (2015; https://doi.org/10.1175/BAMS-D-13-00155.1)
- P18L530: “on average”
- P18L530: Lower case “s” for “south”
- P19L536: I have difficulties seeing a more than 3K warmer atmosphere in the PARASO ThickIce experiment. Even when zooming in on the screen, it looks to me more like 1K, but it is difficult to say due to the scale at which this data is presented (see my comment 2 above).
- P19L553: “This interpretation is […]”
- P19L556/L560…and elsewhere: Not sure what “This” is referring to here. Please specify.
- P20L593-L592: Please remove “(” and “)”
- P22L617: Please delete “key” as it is difficult to judge what it actually means
- P24L705: “allows”
- P24L719: “dampen”?

References:

Stauffer, R., Mayr, G. J., Dabernig, M., & Zeileis, A. (2015). Somewhere Over the Rainbow: How to Make Effective Use of Colors in Meteorological Visualizations, Bulletin of the American Meteorological Society, 96(2), 203-216. https://doi.org/10.1175/BAMS-D-13-00155.1

Holland, P. R. (2014), The seasonality of Antarctic sea ice trends, Geophys. Res. Lett., 41, 4230– 4237, doi:10.1002/2014GL060172.