

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2021-284

Anonymous Referee #1

Referee comment on "Reassessing seasonal sea ice predictability of the Pacific-Arctic sector using a Markov model" by Yunhe Wang et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-284-RC1>, 2021

General Comments:

This manuscript investigates the predictability of seasonal sea ice in the Pacific-Arctic sector. The authors develop and use a regional linear Markov model with a suite of atmosphere-ocean variables. They find that prediction skill of this model is improved relative to a similar previous pan-Arctic model and that there are key sources of predictability for sea ice in different seasons of the Pacific-Arctic sector. The paper is well-written, the structure makes sense, and the figures are clear. I find the use of this regional statistical model interesting and the results are clear and novel, but I think there are a few flaws in the development of this model that may have an impact on the key results.

The main concern I have is if the authors are missing a key source of predictability for summer Arctic sea ice: sea ice thickness. Numerous studies going back to the seminal work by Blanchard-Wrigglesworth et al., (2011) have shown that sea ice thickness is a key source of predictability for summer Arctic sea ice. In this Markov model, it is excluded, with no clear reason why. I think the authors should add this variable or motivate why it is excluded in a clear fashion. For instance, rather than stating in words why it is not included, it would be nice to see supporting figures that show what happens when it is included. Or, the main figures of the paper should be revised/updated with this variable included. Similarly, the authors exclude subsurface ocean heat content as a variable. This too has been shown to be a key source of predictability for wintertime Arctic sea ice. In the detailed comments below I have suggested how the authors can improve this by including SIT (PIOMAS) or OHC (ORAS5).

Specific Comments:

Data and Methodology:

The Model:

L147-148: It seems this spatial domain (40°N to 84°N, 120°E to 240°E) captures much (if not all) of the Pacific-Arctic sector. But, it feels a bit arbitrary where exactly the longitudinal domains end. For instance, if the same analysis is performed from 90°E to 270°E, are the results similar? Given that the authors base some of this domain choice on regions that exhibit different sea ice variability (i.e., Figure 1), if the authors instead calculated regional sea ice area domains and computed the standard deviation of each region, then grouped the regions by similar magnitudes of variability, will the results be similar? To me this seems like a more precise way of quantifying the Pacific-Sector as regions like the Canadian Archipelago or Laptev Sea could be included or excluded. Basically, I'd like for the authors to conduct this sensitivity analysis and either provide a short explanation of why the results are insensitive to the exact domain or add some supporting information to justify this choice.

L148-149: Similarly, can the authors perform the same analysis on sea ice concentration from 0 to 100% instead of 15% to 95%? It is unclear why the authors chose this limit. I can understand the 15% threshold (eliminating area and extent), but why 95%? It would be nice to see the analysis performed without these cutoffs and if they differ, an explanation as to why.

L159-161: I can understand why the authors chose this combination of atmospheric and oceanic variables. But, it appears one key variable is missing: sea ice thickness. Why have the authors omitted this variable? Over the past few years, numerous studies have shown that sea ice thickness is a key source of predictability of Arctic sea ice, particularly for the summer. This, to me, is my biggest concern with this manuscript. I'd like the authors to include sea ice thickness (SIT; from PIOMAS most likely) in their analyses, as I think the results will be different. Perhaps this model may even be more skillful.

This also pertains to the ocean domain. What about including sub-surface ocean heat content (OHC)? This has also been shown to be an important source of predictability for Arctic sea ice, particularly on the Pacific side in the wintertime. The authors can include this variability using Ocean Reanalysis System 5 (ORAS5). I think including this variable will improve the weaknesses of the model (as stated in Lines 590-594).

Finally, it is shown that SIC contributes to the trends and gives prediction skill. But, why even include this at all? It would be more interesting if the authors could develop this regional Markov model without SIC so that it is predicting SIC/SIA. Perhaps I am missing the motivation to include this. If that is the case, please add a justification in this section.

L166-186: The introduction of the Markov model could be slightly more clear. In particular, the bolded variables are not present in Eqs. (2)-(4). Does that make them not

matrices? As it stands, I think they should be matrices.

Model construction and assessments:

Construct an optimal model for each season:

L280-283: I think this cross-validation experiment will be greatly impacted by the addition of SIT and OHC (and/or removal of SIC). This section may need to be reworked with these variables included.

Conclusions:

L521: I think this paper would benefit from a clear "Discussion" section and then the "Conclusion" section can be streamlined and the results would be clearer.

Technical Comments:

Introduction:

L17: Add hyphen to Pacific-Arctic? Also, consider keeping it uniform across the paper: Pacific-Arctic instead of switching to Arctic-Pacific

L41: Consider changing "shrinking" to "decreasing" and adding extent, so that it states "The decreasing Arctic sea ice extent contributes..."

L48: Consider changing to "The rapid retreat of summer Arctic sea ice extent has also created..."

L60: Change "which" to "and".

L88: This sentence does not make sense. Can the authors reframe this? I am not sure what "is initialized in the spring". Is this in reference to the spring predictability barrier?

L522: Add hyphen (check hyphens throughout the manuscript)