

Dear Referee,

Thank you for the time that you have spent on our manuscript and for the detailed “Referee comment” report. We are happy with the positive response and grateful for your comments and suggestions. These certainly contributed to improving the quality of our manuscript.

Below you will find a summary of the changes that we have made throughout the manuscript to address all of your suggestions. The replies to your comments are written in blue, while your comments are reproduced in black. Please, notice that all line, page and figure numbers mentioned in our rebuttal letter refer to the new version of the manuscript, unless stated otherwise.

Yours sincerely and on behalf of all co-authors,

Leandro Ponsoni

Anonymous Referee #2

Summary statement The motivation for this study is to contribute to an Arctic observing system by identifying key locations where sea ice thickness should be measured in order to have predictability. This study contributes to predictability and also to a stake-holder need (i.e., observationalists) of developing an efficient Arctic observing network. I feel the science is strong with really interesting (and useful) results and worthy of publication. The figures are well-prepared and understandable. My main critique is that the text needs to be smoothed out and clarified. I made detailed suggestions through about half of the document and these comments can be applied throughout the remaining parts of the paper. I have a few interpretation suggestions in the major comments. This paper is relevant for a broad science audience so the clarity of the writing is really critical for it to be broadly accessible.

Again, we thank the referee for her/his thorough review of the manuscript. We appreciated very much her/his detailed comments not only in terms of science but also regarding the writing style. Below, we answer point-by-point all major and minor comments.

Major Comments

1) It may be very useful to include stronger arguments as to why this is a model-only study. This can be strengthened in the introduction. (Page 3 lines 10-15, expand here in a way that puts it to rest). You want to be more convincing as to why this will be applicable in real life.

We have slightly changed the introduction to properly address this point. Now we have reinforced in this part of the text that observations of sea ice thickness, required for calculating the SIV, present limitations in the warmer seasons. Therefore, this variable is not made available year-round from the classical satellite campaigns [pg. 3, l. 17–19]. In the following paragraph [pg. 3, l. 20–23], we reemphasize that the models used in this work, which are cutting edge in terms of model physics and resolution, fairly represent the thermodynamic and dynamic sea ice processes linking predictors and predictand. In Sec. 4, we have added a discussion on how our study could be used in different ways by observationalists [pg. 26, l. 26–33].

2) It needs to be made clear when the models are described (bottom page 3) that these are coupled climate models and are not pegged to observed conditions. Also, Discuss the GHG scenarios used for these particular simulations because all this information will make it easier for the reader to understand the results. For climate people, these are known but this paper should be accessible by weather and observational scientists as well as potentially policy experts (since they will help formulate the Arctic observing network).

That is indeed a good point. These two aspects are now clarified in the first paragraph of Sec. 2.1. [pg. 4, l. 3–13].

3) Beginning of Section 2.2. This first paragraph lays out the methodology. I have read it twice and it is not easily understandable. Please revise this to be more precise and direct. I am not sure what to suggest specifically. Some thoughts a. Define anomaly earlier when you refer to fig 1. Just use it here. b. Move the sentence ‘Overall , two categories of predictors are tested...(line 18, page 5) to be the second sentence. c. Revise the first sentence of your paragraph (your topic sentence) to something like: ‘Potential predictor variables are identified for the empirical statistical model that predicts SIV anomalies.’ There are extra words in this sentence and the key point of the paragraph is getting lost.

We agree with the referee. All paragraphs from Sec. 2.2 were rewritten to bring clarity to the text. To make it easier for the reader, an explanation for the term “anomaly” is provided in the Introduction [pg. 2, l. 31–32] and also in Sec. 2.1 [pg. 4, 20–22].

4) I have some suggestions regarding the structure of the writing. a. Strengthen your ‘topic sentences’ that start each paragraph. This sentence should tell the reader what is in this paragraph without having to read the paragraph. The sentences in the paragraph provide the evidence or facts to support the topic sentence. This type of structure makes it easier for the reader to understand your paper quickly.

We thank the referee for the suggestion. We minutely addressed all the comments in this report taking into account this comment (4) and also the summary statement. We have promoted several changes throughout the text in order to make it clearer and easier to read for a non-specialized audience. Regarding this, we have asked for a few colleagues from different science fields to check whether or not the manuscript is understandable. Apparently, we have made the job. In any case, further comments on how to make this paper more accessible for a broader audience are always welcome.

5) It is not clear to me what the time scale for the predictions is in Section 2? (re: Fig 2, Table 1). It is one-month lead? Lag-0 is what I think it is but I did not see this explained clearly. In addition, further interpretation of the panels in Fig. 2 would be helpful because reading the 2.2 and 2.3, which refer back to Fig. 2, I see that I do not have a clear understanding or appreciation for what Fig 2 shows. It would be good to discuss each panel and provide interpretation of the panel.

It is indeed a lag-0 correlation. This is now clarified in the text [pg. 6, l. 13; Fig. 2’s caption]. As mentioned in the answer to item (3), we have rewritten Sec. 2.2. In the new text, we are providing a better explanation of Fig. 2, considering all panels.

6) Could OHT be a poor predictor in these models because of model biases such as too strong stratification in the Arctic ocean so that ‘heat’ never makes it to the upper layers? This may be worthy of the discussion.

We agree with the referee. This might be a potential reason why OHT is a poor predictor. This is an interesting point that could be investigated further with more detailed analysis. We brought this discussion to the text [pg. 23, l. 25–28].

7) Conclusions. The results are summarized very nicely in the model context. As an observationalist (BTW, I am a modeler), I would want to know how this is relevant in the real world. Some discussion on linking this to observations would be nice. I know this is not easy and I do not suggest that you do this research for this paper, but providing these insights will help you link it better to the people you want to use this work. If you can provide a framework that links this study to the observations, that would really strengthen the paper.

We envisage three main ways by which this work could support observationalists in a real-world observing system. The first is providing recommendations for optimal sampling locations. We believe that our multi-model approach provides a solid view of the sites that better represent the variability of the pan-Arctic SIV. Second, even if those regions are not taken into account for any reason (e.g., logistic, environmental harshness, etc), observationalists could still take advantage of the "region of influence" concept. By doing so, they avoid deploying two or more observational platforms that would provide relatively similar information in terms of pan-Arctic SIV variability. Third, considering that observational platforms are already operational, our SEM could be trained with model outputs (with the same or other state-of-the-art AOGCMs) and so fed with observational data to project future pan-Arctic SIV variability.

This discussion is now added to Sec. 4 [pg. 26, l. 26–33].

Minor Comments

1) Page 1, Line 24, change ‘proven to bring’ to ‘led to’

Changed [pg. 2, l. 5].

2) Page 2, Line 1, change ‘disturbance of’ to ‘disturbance in’

Changed [pg. 2, l. 8].

3) Page 2, line 1, split everything ‘which has also...’ into a separate sentence to make it easier to understand.

We have slightly reformulated the paragraph to accommodate this suggestion [pg. 2, l. 5–8]

4) Page 2, line 4, change ‘sailing routes’ to ‘ship routes’, not all of the ship may be sailboats.

Changed [pg. 2, l. 9].

5) Page 2, line 5, change ‘At global scale’ to ‘Globally’

Changed [pg. 2, l. 11].

6) Page 3, line 1, change ‘To the knowledge of the authors’ to ‘To the best of the authors’ knowledge’

Changed [pg. 3, l. 4].

7) Page 3, line 15-16, change ‘What are the performance ..’ to ‘What is the performance...’

Changed [pg. 3, l. 23].

8) Page 3, line 17, change ‘a large amount...’ to ‘a substantial (e.g., 70%) of the original..’

We have incorporated this suggestion, but in a slightly different way. We keep the info that 70% is an arbitrarily chosen threshold [pg. 3, l. 25].

9) Page 4, Figure 1 top panel is not even mentioned in the text. The figure panels have a and b on the right-hand side. I did not see them at first. It is standard to have them on the left corner. I suggest you edit this on all your figure panels.

We have made a proper reference to Fig. 1a. in the text [pg. 4, l. 19–22]. The panel index letter is now placed in the right-hand side in Fig. 1. Also in Figs. 4, 5, 11 and 12.

For Figs. 2, 6, 7 and 8 we preferred to keep the letter indicating the panel index centralized. We think the letters are easily spotted in that way.

10) Page 4, line 3, make it clear that the long-term trend and seasonal cycle has been removed. The text ‘(no long-term trend; no seasonal cycle)’ is somewhat vague. Was there never a trend? It is clear from the top panel that there are trends but it is helpful for the reader if the language is unambiguous.

We agree with the referee. Indeed the text “(no long-term trend; no seasonal cycle)” is somewhat vague and confusing. We excluded this piece of text (or similar) from the entire manuscript. In the new manuscript’s version, we have first defined SIV anomaly in the Introduction [pg. 2, l. 31–32]. This definition is recalled when describing Fig. 1 in Sec. 2.1 [pg. 4, 20–22].

11) Page 5, line 7, Clarify the geographical span of the different resolution. For a student, the changing resolution is confusing.

Indeed, this is an important point. The ocean resolution of **AWI-LR** varies from **24 to 110 km**, with **~25 km in the Arctic**. The ocean resolution of **AWI-HR** varies from **10 to 60 km**, with a refined resolution in dynamically active regions (e.g., ~10km in the vicinity of the Gulf Stream), and **~25 km in the Arctic**.

An important point recalled by Referee #1 is that the resolution difference between HR and LR in the Arctic is much lower in the AWI climate model compared to the other two systems. This point is clarified in the text. In addition, since the grid used by AWI is not trivial to understand without a supporting plot, we are directing the reader to Fig. 4 of Sein et al. (2016) [pg. 4, l. 33–34 to pg. 5, l.1–4].

12) Section 2.3 is written very clearly. It may be worth saying something about including SIV in the SEM. IT seems to me that SIV could dominate the results since the autocorrelation is so strong in SIV.

This is a good point. We have incorporated your suggestion to the last paragraph of Sec. 2.3 [pg. 7, l. 18–20 to pg. 8, l.1–6].

13) Section 2.4, numerous grammar issues in this section. This section is rough and needs revision.

To bring clarity to the text, we reviewed and rewrote the entire Section 2.4.

14) Fig. 10, the lag/lead time for the reconstruction is not clear to me, related to comments about Fig. 1.

As for Fig. 1, this is indeed a lag-0 comparison. This info is clarified in Sec. 3.2.2 [pg. 19, l. 7] and in the Fig. 10’s caption.

15) Page 22, line 30, remove ‘respectively’. I do not think that is needed here because the numbers are the same as highlighted by the word ‘both’.

Indeed, “respectively” was removed from the text [pg. 25, l. 9].