Responses to Reviewer's Comments for Manuscript egusphere-2024-4092

Correcting Errors in Seasonal Arctic Sea Ice Prediction of Earth System Model with Machine Learning

Addressed Comments for Publication to

The cryosphere

by

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Authors' Response to Reviewer #1

Comment 1

Overall, the authors responded comprehensively and satisfactorily to my concerns. They substantially expanded the discussion regarding the online vs. offline approach comparisons, the ML correction vs. pure data-driven comparison, and potential future improvements. I also commend that the title and abstract have been improved to be clearer.

Response: We sincerely appreciate the reviewer's thoughtful and encouraging comments and are pleased to hear that the revisions have adequately addressed the reviewer's concerns.

Below, we provide detailed, point-by-point responses to further comments of the reviewer. For clarity, reviewer comments are shown in blue boxes, and the corresponding revisions in the manuscript are highlighted in gray boxes.

Comment 2

One thing I'm still a little confused about is that the authors mention that only considering latitude information for features, and not using longitude, is taking into account that 0 and 360 can't portray that it's actually the same location. So why not convert to a polar stereographic projection grid? That way (lon, lat) is converted to (x, y) coordinates, which can reasonably characterize the actual distance.

Response: We fully agree with the reviewer that using a polar stereographic projection to convert (lon, lat) to (x, y) coordinates can better capture spatial relationships, especially around the 0°/360° discontinuity. We will consider adopting this approach in future studies to further improve our model's spatial feature representation.

Comment 3

Additionally, I suggest that the authors carefully revise the manuscript one final time before final resubmission. The language is not necessarily incorrect, but I found a lot of locations where it could be more succinct and precise. A (non-comprehensive) list of edits is below:

Response: We sincerely thank the reviewer for the valuable feedback regarding the language of the manuscript. In response, we have thoroughly revised the text to enhance clarity, readability, and conciseness. We have carefully addressed all of the reviewer's specific suggestions and have also conducted a comprehensive final review of the manuscript. Additionally, we enlisted the help of Marianne Williams-Kerslake, a native English speaker and colleague at NERSC, who provided a detailed review and refinement of the English language throughout the manuscript.

Comment 4

Line 26: Not sure if I missed something, but I did not find any statement like "must further improve ..." in Bushuk et al. (2024). Perhaps the following expression is closer to the meaning of the original: the improvement on initialization and model resolution is expected to facilitate the predictions.

Response: As suggested, we have adjusted the sentence to better reflect the original meaning as follows (L26-L27 in the manuscript):

Bushuk et al. (2024) also suggested that improving initialization and model resolution is expected to facilitate predictions.

Comment 5

Lines 42-55: I didn't understand the necessity of splitting it into two paragraphs because it's all about the implications of online correction.

Response: As suggested, we have merged them into a single paragraph to improve the coherence and readability of the text as follows (L42-L53 in the manuscript):

> In the context of the online error correction, ML is applied to correct errors in the instantaneous model state (i.e., initial conditions for the following model integration) and sequentially applied to update the instantaneous model state during simulation (e.g., Brajard et al., 2021), referring to an ML-dynamical hybrid model (purple line in Figure 1). Such online error correction approaches have been investigated in both an idealized framework (e.g., Watson, 2019; Brajard et al., 2021) and real applications (e.g., Watt-Meyer et al., 2021). Watson (2019) examined the tendency error correction approach in the Lorenz 96 model. Brajard et al. (2021) explored the resolvent error correction approach in the two-scale Lorenz model as well as in a low-order coupled ocean-atmosphere model called the Modular Arbitrary-Order Ocean-Atmosphere Model (MAOOAM, De Cruz et al., 2016). Watt-Meyer et al. (2021) demonstrated that the online error correction can improve the short-term forecasting skill and accuracy of precipitation simulation while the dynamical model can run indefinitely without numerical instabilities arising. Gregory et al. (2024) applied ML to correct sea ice errors in an ocean-ice coupled model and demonstrated that ML can effectively reduce sea ice bias in a 5-year simulation. So far, the ML-based online error correction method has not been tested for seasonal sea ice prediction in an Earth system model.

Comment 6

Lines 63 and 65: "In this study" repeated in two consecutive sentences could be rephrased. Or, remove the sentence in lines 54-55 and 63-64, as lines 65-67 already express the same meaning.

Response: We sincerely thank the reviewer for the valuable suggestions. As suggested, we have removed these sentences.

Comment 7

Line 420: This sentence, "Therefore, there is still . . . framework." could be removed as the previous paragraph has a similar statement (line 406).

Response: As suggested, we have removed this sentence.

References

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De Cruz, L., Demaeyer, J., and Vannitsem, S.: The modular arbitrary-order ocean-atmosphere model: MAOOAM v1. 0, Geoscientific Model Development, 9, 2793–2808, 2016.

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