Review comment for ‘The Importance of Initial Conditions in Seasonal Predictions of Antarctic Sea Ice’ submitted to *The Cryosphere* (Manuscript ID: *EGUSPHERE-2025-6049*)

In this study, Campitelli et al. investigated the importance of initial condition on seasonal prediction of Antarctic sea ice. Two versions of Australian Bureau of Meteorology’s ACCESS seasonal forecast system are employed, with one assimilating sea ice concentration (SIC) data (ACCESS-S1) while another not (ACCESS-S2). Based on more than 20 years hindcasts, the authors performed a detailed analysis of model climatology, interannual variability, and the prediction skill across different months and regions.

Overall, the author found that ACCESS-S1 exhibits better prediction skill than the ACCESS-S2, which is attributed to the SIC data assimilation, particular for summer- and autumn-initialized predictions. In contrast, the benefit of SIC assimilation is limited for winter-initialized predictions. The author also found that the ACCESS-S2 shows larger interannual variability of sea ice extent (SIE) than the ACCESS-S1 possibly due to its thinner ice, which is more sensitive to the atmospheric and oceanic forcing.

I find this manuscript to be generally well written, and the figures are clearly and carefully presented. However, several aspects requires further clarification and investigation, and the scientific novelty could be strengthened. I therefore recommend major revision to this manuscript. My detailed comments are listed as below.

General comments:

1) the authors quantify the importance of initial conditions on seasonal prediction by comparing two versions of ACCESS model. However, the data assimilation scheme of these two versions is different in multiple aspects. This raises the question of which components of the initial conditions are truly responsible for the skill differences. In this manuscript, the authors mostly examine the role of sea ice initial condition but the potential influence of other variables appears to be underexplored and should be discussed more explicitly.

2) It remains unclear whether the interannual variability of SIE increases with lead time in ACCESS-S2, while this behavior is not evident in ACCESS-S1. The authors suggest that the thinner ice in ACCESS-S2 is responsible for this difference; however, sea ice becomes thinner with lead time in both systems. The authors then propose that data assimilation may lead to an imbalanced state. Could the authors provide a clearer conclusion or more direct evidence to explain the contrasting behavior between ACCESS-S1 and ACCESS-S2?

3) Many climate models suffer from systemical bias, and bias correction is often applied prior to forecast evaluation. Have the authors examined whether bias correction would lead to substantial differences in the reported results? Clarifying the role of model bias in the skill assessment would strengthen the robustness of the conclusions.

Specific comment:

P5 Line146, I have a careful reading on the textbook by Murphy and Daan (1985) and found that the skill score **S** is defined based on the MSE rather than the RMSE (see equation 23 in the textbook), despite I believe these two definitions won't lead to dramatic difference in conclusion.

P7 Line 175, according to my observe, the period should be from April to September?

P12 Line 200, here the authors suggest that the decrease in interannual variability with increasing lead month in ACCESS-S2 is responsible for the improvement in RMSE. However, I found that for some months (e.g., July, August, September) the interannual variability increase with the lead time. Could the authors clarify how this explanation applies to these months?

P12 Line 206, how does the sea ice thickness adjust when assimilating the sea ice concentration?

P12 Line 210, please consider examining the role of the ocean in the bias of sea ice concentration magnitude. I understand that the ocean conditions are nudged toward a referrence dataset only when SST excceds 0 degree. It is therefore possible that, in the regions of interest, SST remains below this threshold, in which case the nudging wouldn't effectively remove ocean-related model biases.

P12 Line 211, which doesn't assimilate

P12 Line 214, sea ice concentration anomaly

P15 Line 245, should it be the June that cannot be forecasted better than the benchmarks? In addition, the metric employed in Libera et al (2022) was ACC, which is slightly different from the RMSE used in this study.

P17 Line 255, Is the eastward propagation feature also evident in December? Are there any criteria used to determine whether eastward propagation is present?

P22 Line 289, subseasonal to seasonal.

Figure

Figure 1: Could the author clarify why the maximum lead time in ACCESS-S1 varies between 213 and 216 days. Was this choice intended to align with the ACCESS-S2?

Figure 5: what does the word in the bracket represent, e.g., (CI: 0.04…0.27). The confidence interval? Then which confidence level? I recommend adding the asterisk to show the result is significant or not.

Figure 6, how do you compute the 95% confidence level? Is it based on an assumption of normal distribution for the ratio of SIE between the prediction and the reference?

Figure 9, I found that the RMSE of ACCESS-S2 mostly overlay with that of climatology. Does this imply that the oceanic and atmosphere data assimilation provide limited benefit to the prediction? What role does the model bias play in this prediction error?

Figure 10-11, please consider clarifying whether this skill score is significant or not