Reply to Reviewers:

We would like to thank the two reviewers for their valuable comments and suggestions in this second round of revision, which helped to further improve the quality of our study. Kindly find below in blue our response point-by-point to their inputs.

Reviewer #1:

The authors have attempted to address all of my comments and the manuscript is improved from the initial submission. However, I think some points of clarification are still needed.

REPLY: We are glad to know the reviewer is happy with the changes made to the manuscript in the previous round of revision considering his/her feedback. Below we list the further comments/suggestions made and reply to each separately, highlighting where in the text modifications are implemented.

1. In my opinion, the SIMBA observations show a measly impact of AR on SIT and ST and the simulation results also fail to reproduce the ST variation. But this study does provide a thorough analysis in AR, including large-scale atmospheric patterns and PolarWRF simulation. Hence, please consider if the title of this article is appropriate and weakening the analysis of SIT and ST variations.

REPLY: In light of the reviewer's comment, we have rephrased the title to "*Drivers of Observed Winter-Spring Sea-Ice and Snow Thickness at a Coastal Site in East Antarctica*". As the reviewer points out, any explicit reference to atmospheric rivers in the title is not justified given the findings of the study, and the mention of atmospheric dynamics is also not appropriate as we partially attribute the changes in SIT to ocean forcing (lines 381-384). The new title just mentions the study delves into the mechanisms behind the variability of the *in-situ* measured SIT and ST at a coastal site in East Antarctica, which is the central aim of the work. The Abstract has also been rephrased to highlight this (lines 24-26).

2. The relationship between AR, Foehn winds, and katabatic winds should be clear stated. Because the authors sometimes use Foehn winds to explain the variation of ST and sometimes use katabatic winds to explain it.

REPLY: We thank the reviewer for raising this important issue. We have considered the methodology proposed by Francis et al. (2023) to identify Foehn events during our study period of July - November 2022 (lines 359-365). In particular, and at a given grid-point, a timestamp is denoted as a Foehn timestamp if the 2-m temperature exceeds its 60th percentile, the 2-m relative humidity drops below its 30th percentile, and the 10-m wind speed exceeds its 60th percentile. For the 2-m temperature, monthly hourly thresholds are used to account for the annual cycle, while for the other variables the percentiles are extracted for the full period. Foehn timestamps are shaded in purple in Figs. 3d and 3j. As we note in the text (lines 402-403), Foehn effects are distinguished from katabatic winds as they have to meet the criteria above for the three variables. We have updated the discussion of Fig. 3 accordingly (lines 396-399 and 419-422).

3. The authors attribute the model's inability to predict the variation of ST to less favourable conditions for Foehn events in the model. But I think it is also important for what processes of snow redistribution are included in the model.

REPLY: The reviewer makes a very good point. Indeed, the land surface model (LSM) used in the PWRF simulations, Noah LSM, features a single snow layer and a simplified representation of the snow accumulation, sublimation, and melting processes (Lim et al., 2022). In contrast, the more sophisticated

Noah LSM with multiparameterization options (Noah-MP), also available in PWRF, includes up to three snow layers, represents the percolation, retention, and refreezing of meltwater within the snowpack, and accounts for snow metamorphism and compaction (Niu et al., 2011). PWRF simulations have shown the Noah-MP gives more skillful predictions over Antarctica compared to the Noah LSM for fields such as 2-m temperature and 10-m wind speed (Xue et al., 2022). We have stated this in the text (lines 672-682) and suggest that future work should include considering a more detailed representation of snow processes in the model (lines 855-857). The need for a higher spatial resolution to better simulate the atmospheric dynamic and thermodynamic processes including the Foehn event and cloud microphysical processes as highlighted by Gilbert et al. (2025) is also noted (lines 666-669 and 857-859).

REFERENCES:

Francis, F., Fonseca, R., Mattingly, K. S., Lhermitte, S., Walker, C. (2023) Foehn winds at Pine Island Glacier and their role in ice changes. The Cryosphere, 17, 3041-3062. https://doi.org/10.5194/tc-17-3041-2023

Gilbert, E., Pishniak, D., Torres, J. A., Orr, A., Maclennan, M., Wever, N., Verro, K. (2025) Extreme precipitation associated with atmospheric rivers over West Antarctic ice shelves: insights from the kilometre-scale regional climate modeling. The Cryosphere, 19, 597-618. https://doi.org/10.5194/tc-19-597-2025

Lim, S., Gim, H.-J., Lee, E., Lee, S., Lee, W. Y., Lee, Y. H., Cassardo, C., Park, S. K. (2022) Optimization of snow-related parameters in the Noah land surface model (v3.4.1) using a micro-genetic algorithm (v1.7a). Geoscientific Model Development, 15, 8541-8559. https://doi.org/10.5194/gmd-15-8541-2022

Niu, G.-Y., Yang, Z.-L., Mitchell, K. E., Chen, F., Ek, M. B., Barlage, M., Kumar, A., Manning, K., Niyogi, D., Rosero, E., Tewari, M., Xia, Y. (2011) The community Noah land surface model with multiparameterization options (Noah-MP): 1. Model description and evaluation with local-scale measurements. Journal of Geophysical Research, 116, D12109. https://doi.org/10.1029/2010JD015139

Xue, J., Xiao, Z., Bromwich, D. H., Bai, L. (2022) Polar WRF V4.1.1 simulation and evaluation for the Antarctic and Southern Ocean. Frontiers of Earth Science, 16, 1005-1024. https://doi.org/10.1007/s11707-022-0971-8

Reviewer #2:

The author has carefully revised the manuscript, and the improved presentation is clearer. However, the following issues still require further refinement before publication:

REPLY: We are happy to know the reviewer is satisfied with the revised version of the manuscript. Below we list the two lingering issues raised in this second round of revision and reply to each separately, highlighting where in the text changes are made.

(1) Firstly, the introductory statements are overly redundant and should be streamlined. Secondly, the logical flow between paragraphs is unclear. For example, while the third paragraph effectively elaborates on the importance of extreme weather for studying the sea-ice-snow-air coupling system, the fourth paragraph abruptly shifts to discussing buoy observation methods without a smooth transition, making the narrative seem disjointed. The author is advised to either add transitional sentences or restructure the fourth paragraph by first clarifying the research objectives before delving into methodological details.

REPLY: In light of the reviewer's comment, we have added a transitional sentence at the start of the fourth paragraph of the Introduction (lines 103-105) to ensure a logical flow between the third and fourth paragraphs. In particular, we highlight that having *in-situ* measurements of SIT and ST is crucial to understand the effects of the atmospheric forcing on the sea-ice-snow-air coupling system and then proceed to state the goals of the work. We have also streamlined the Introduction by removing sentences that mostly repeat what has been mentioned before and merging those that complement each other, with an overall 10% reduction in the number of words in this section.

(2) The main figure contains several subfigures, but the descriptions of these subfigures in the text exhibit logical jumps, e. g. Figure 3, which may hinder reader comprehension. The author is recommended to describe the subfigures sequentially.

REPLY: We agree with the reviewer and have changed the order of the panels in Figs. 3 and S5 to ensure that each subfigure is discussed sequentially. In both, the top panels show the observed SIT and ST measurements, followed by the different SMB terms, and finally by the meteorological fields (namely air temperature, relative humidity, wind speed and direction). The text has also been updated accordingly (lines 367-436 and 662-675). The order of the panels of Fig. 1 has also been updated to ensure a sequential discussion in the text. We believe the presentation of the figures is now much clearer and would like to thank the reviewer again for his/her comment.