Dear Referee #2,

Thank you for your thoughtful and constructive comments on our manuscript "Tracking In-Situ Snow Accumulation at Neumayer, Coastal Antarctica: Signs of Climatic Changes in the past 30 Years?". We greatly appreciate the depth of your review and agree that the analyses you highlight are important.

Several of them are already planned as central components of the first author's PhD thesis. The manuscript presented here represents the first step in quantifying snow accumulation and exploring its causes. While some of the suggested analyses will be pursued in the course of the PhD, we address all comments below, explaining where and why certain analyses fall outside the scope of the current study.

The text of your review is given in Roman font, while our responses are in italics. Line numbers refer to the lines in the submitted manuscript.

Major Comment 3: While the authors attempted to link SAM and ENSO to variations in snow accumulation, mechanistic explanations are currently lacking. It is recommended that the authors expand the results or discussion section to clarify how different phases of SAM may affect snow accumulation through modifications in regional atmospheric circulation, moisture and heat transport, and katabatic wind activity. Similarly, they should address how ENSO (e.g., El Niño events) could establish teleconnections between tropical sea surface temperature anomalies and snow accumulation in Dronning Maud Land. In summary, a clearer description of the physical mechanisms linking these circulation modes to local accumulation is needed.

- *We thank the reviewer for highlighting the need for a clearer mechanistic explanation linking SAM and ENSO to the local snow accumulation variability. We agree that the physical processes should be described more explicitly. To address this comment, we propose changes to Section 4.2.5:*

"The correlation analysis reveals a weak but statistically significant negative correlation between monthly accumulation at Süd and the SOI ($r = -0.13$, $p < 0.01$), indicating only a minor ENSO influence on local accumulation. In contrast, the SAM shows a moderate and significant positive correlation ($r = 0.55$, $p < 0.01$), suggesting that approximately 30 % of the variance in monthly accumulation can be linearly explained by SAM variability. TE values <=0 for all indices indicate that neither SAM nor ENSO provides additional predictive information at the monthly time scale beyond the intrinsic variability of the accumulation series itself (van der Gaag and Meyer,1998).
The statistical relationships can be interpreted in light of the underlying atmospheric dynamics. SAM modulates the latitudinal pressure gradient and thereby the strength and position of the circumpolar westerlies (Fogt and Marshall, 2020). During positive SAM phases, strengthened westerlies near 60°S enhance zonal flow, reducing meridional heat and moisture transport (Marshall et al., 2022). This more zonally organised circulation limits atmospheric blocking, which favors onshore moisture advection, leading to reduced snowfall in DML (Ayabilah et al., 2026). Conversely, negative SAM phases favour Rossby wave amplification and meridional moisture intrusions, increasing the likelihood of intense snowfall events and positive SMB

anomalies (Schlosser et al., 2010; Boening et al., 2012).
The absence of significant TE despite the moderate SAM correlation suggests that SAM conditions snowfall occurrence but does not exert deterministic control on monthly accumulation, which remains strongly influenced by synoptic variability.
ENSO affects Antarctic climate through tropical–polar teleconnections involving Rossby wave trains that modulate the Amundsen Sea Low (ASL) (Li et al., 2021). While El Niño events can weaken the ASL and alter moisture transport in West Antarctica, their influence on East Antarctica and DML is indirect and highly event-specific (Ayabilah et al., 2026). El Niño periods coincide with negative SMB anomalies in DML, and no consistent signal emerges during La Niña. This supports previous findings that ENSO impacts on Antarctic SMB are regionally heterogeneous and generally weaker than those associated with SAM (Macha et al., 2024; Ayabilah et al., 2026; King et al., 2023; Medley and Thomas, 2019).
Overall, the comparatively strong correlation with SAM and the weak, non-predictive ENSO relationship indicate that SAM represents the dominant large-scale driver of accumulation variability in DML."

Major Comment 6: It would be more meaningful to compare the results with studies on changes in snow accumulation rates in nearby regions (or inland) in the discussion.

- *Thank you, we suggest to add a section 4.2.3 "Regional comparison with other Studies" containing the following text:*

"To the best of our knowledge, no comparable long-term in-situ accumulation record from the coastal DML region has been published, making direct comparisons limited. Recent studies from DML and adjacent regions indicate that snow accumulation trends are spatially heterogeneous and method-dependent. Model simulations suggest a long-term increase in accumulation across DML, with Dalaiden et al. (2020) reporting a 17 % rise between 1850 and 2014. Similarly, inland ice core records near Kohnen Station show recent snowfall increases that are unprecedented over the last two millennia Medley et al. (2018). Coastal evidence is more mixed: at Derwael Ice Rise, Philippe et al. (2016) observed a 32 % increase in SMB during 1991–2011 relative to the long-term mean, whereas earlier firn core studies at coastal stations reported no significant long-term trend and emphasised strong interannual variability Schlosser and Oerter (2002). Satellite gravimetry and regional climate modelling further suggest episodic mass gains in coastal DML during the late 2000s (Boening et al., 2012), while RACMO2 simulations indicate no statistically robust SMB trend since 1980 (Lenaerts et al.,2013).
In comparison, our accumulation records do not reveal a significant long-term trend from 1990 onwards but exhibit pronounced interannual variability. The apparent discrepancies between studies likely reflect differences in spatial representativeness (coastal vs. inland), temporal coverage, and methodological approach (models, satellite data, ice cores, in situ measurements)."

Major Comments 1, 2, 4, 5: *We thank the reviewer for these suggestions and would like to explain, why we consider these comments beyond scope.*

1. The authors could attempt to explain the recent trends in snow accumulation from both dynamic and thermodynamic perspectives, distinguishing whether the changes primarily originate from shifts in atmospheric circulation or from enhanced moisture availability due to warming. Such an analysis would offer a clearer response to the question posed in the abstract—namely, whether these trends are dominated by global warming or natural variability modes, and what their relative contributions are.

- *While distinguishing between dynamical and thermodynamical drivers of snow accumulation would indeed provide valuable insight into the relative contributions of atmospheric circulation changes and enhanced moisture availability in a warming atmosphere, a detailed attribution analysis is beyond the scope of the present study. Our work focuses on in-situ accumulation measurements and the characterization of temporal variability and trends. A key finding in this regard is that local meteorological variables show no significant correlation with accumulation at the study site. This result motivates a natural next step: identifying large-scale, far-field atmospheric drivers that govern local accumulation (events). In the PhD project, we will leverage reanalysis products and regional climate model output to identify remote atmospheric predictors of local snow accumulation, thereby addressing the dynamical and thermodynamical attribution the reviewer rightly highlights. Moreover, identifying climate-change-induced extremes beyond natural variability requires a thorough understanding of the latter. In the coastal region, the present study represents a first step toward establishing that baseline.*

2. A key consideration is the spatial representativeness of the observed time series—specifically, to what degree the snow accumulation trends at Neumayer Station reflect broader regional changes. This distinction is essential for identifying the primary drivers of the trends. If the observations mainly reflect local-scale processes, then factors such as topography, local temperature, and wind patterns likely dominate. Conversely, if the variations are representative over larger spatial scales, the influence of large-scale atmospheric circulation may be more significant. For reference, the authors may consult methodologies such as those presented by Zhai et al. (2023) or similar studies.

- *To address this concern, we conducted a preliminary analysis correlating basin-integrated ERA5 snowfall rates with the Neumayer time series. The results suggest that the observed variability is representative of larger spatial scales, supporting the role of large-scale atmospheric forcing. A comprehensive point-to-grid correlation analysis is planned as a central component of a dedicated follow-up study.*

4. Additional regional circulation patterns also play important roles in influencing snow accumulation (e.g., Clem et al., 2020; Zhai et al., 2023). These include features such as the Weddell Sea low and the South Atlantic high. It is recommended that the authors incorporate further analysis to substantiate the influence of these circulation features.

- *We thank the reviewer for highlighting the importance of regional circulation patterns. We note that Zhai et al. (2023) identify a pronounced autumn SLP anomaly pattern over the Southern Hemisphere during 2008–2020, characterized by an enhanced Weddell Sea low and a blocking high near the Drake Passage. This pressure dipole favors enhanced meridional moisture transport into high latitudes. Interestingly, both South Pole and Neumayer show their strongest accumulation trends during austral autumn, suggesting a potentially consistent dynamical mechanism. While a dedicated SLP-based diagnostic analysis is beyond the scope of the present study, we will expand the discussion to acknowledge this potential linkage and highlight it as a promising avenue for future research.*

1. The exceptionally high snow accumulation rates observed in 2021 and 2023 represent a compelling point of interest. These anomalies may be linked to extreme atmospheric circulation patterns, atmospheric river events, or enhanced meridional moisture transport pathways. Conducting preliminary analyses from these perspectives would significantly contribute to elucidating the mechanisms driving variability in snow accumulation

- *We agree that the exceptionally high accumulation rates observed in 2021 and 2023 may be linked to extreme atmospheric circulation patterns, including atmospheric river events and enhanced meridional moisture transport. A dedicated event-based analysis of these mechanisms would indeed provide valuable process-level insight. However, such diagnostics require a comprehensive synoptic and moisture transport analysis that goes beyond the observational focus of the present study. We will expand the discussion to acknowledge these potential drivers and highlight them as a priority for future work.*
  We suggest to include a paragraph at the end of 4.2.2, where we discuss the drivers of 2021 and 2023 in more depth and add a paragraph:

  "Such synoptic-scale transport may manifest in the form of extreme precipitation events, including atmospheric rivers, which have been shown to deliver substantial moisture to coastal Antarctica (Wille et al, 2021). The pronounced monthly extremes observed in 2023, as well as the persistent above-average conditions in 2021, may be consistent with recurrent or sustained meridional moisture transport episodes. Identifying the contribution of atmospheric rivers and other extreme precipitation events to annual accumulation variability represents an important next step toward a process-based understanding of these anomalies."

  For all these major comments, we moreover suggest to add a note in a new last paragraph of the conclusion, that will list these limitations of the study as outlook to our upcoming work

Minor Comment 1: The figures could be improved as follows. Figure 1: The vector arrows are currently too small to be clearly visible. Additionally, the representation of the ice sheet could be enhanced by adopting a more conventional color palette instead of a uniform gray. It is recommended that the authors use a gradient color scale to better depict topographic variations.

- *Thank you. We have made the following improvements to the figure (including recommendations from Reviewer 1):*
- *The color scale in the figure below does not represent topography, but ice flow velocity, which is directly relevant to the trajectory reconstruction of the stake farms. Topographic variations are instead depicted through isohypses/contour lines derived from the RAMP2 digital elevation model, which we consider a sufficient representation in this context.*

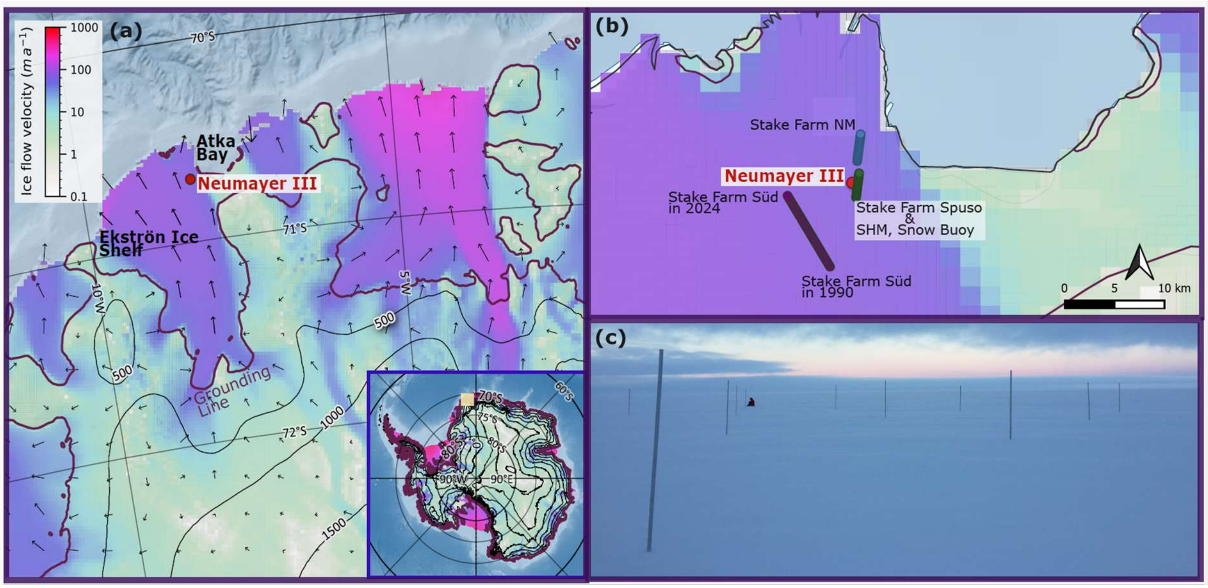

Figure 1: (a): Inset: Map of Antarctica with a yellow rectangle indicating the study area. Main map: Zoom-in on the Neumayer Station site. Black lines represent isohypses from the RAMP2 digital elevation model, and ice flow velocity from the MEaSUREs dataset is shown as color-codeding and vectors. (b): The Stake Farms Süd, NM, Spuso and the SHM and Snow Buoy are located on the moving Ekström Ice Shelf; the series of dots indicates the reconstructed, interpolated trajectory of the three stake farms over their respective measurement periods. Basemap and datasets from Quantarctica v3. (c): Photograph of the stake farm Spuso. Photo: Linda Ort, used with permission.

Minor Comment 2: In the introduction, it is recommended that the authors further strengthen the overview of the current research of snow accumulation observations, such as the application of various observation methods, as well as the spatial distribution and temporal coverage of currently available data. The study by Wang et al. (2021) may be useful, as they compiled SMB datasets for the region.

- *In our initial draft, we included such statements in the introduction. However, as the manuscript evolved, we considered that they went too far and consequently removed them. While we would prefer not to include them, we would appreciate a statement from the editor on this matter.*