Dear Reviewer,

thank you very much for your time and suggestions for improving our manuscript. Please see our responses (*in italics*) to your comments (**in bold**) below:

1. The physical mechanisms presented in this manuscript would seem obvious conclusions based on the physics, however, they represent a gap in the literature where these relationships have not been directly assessed. Sea ice is both a byproduct and barrier in ocean and atmosphere interaction in the poles. The difference in relationship between the seasons is a shift between the ocean and atmospheric interactions and forcings with sea ice. For this reason, it would be beneficial to include some additional analysis with SST.

We agree on the role of sea ice as both a byproduct and a barrier in ocean–atmosphere interactions. We also agree that seasonal differences reflect shifts in the relative importance of oceanic and atmospheric forcing.

Considering impacts on air temperature and specific humidity, the key controlling factor in marine conditions (saturated surface) is the surface temperature forcing. From the atmospheric perspective, the response is governed by the surface temperature itself, rather than by whether the anomaly originates from SST, ice surface temperature (IST), or a change in surface type (sea ice versus open water).

In regions of high sea-ice concentration (SIC), SST remains close to the freezing point, and variability in surface temperature is primarily driven by IST (except during the melt season, when also IST is near the melting point). In contrast, SST anomalies become more relevant in regions of low SIC during summer, where SST can exceed the freezing point and contribute more substantially to surface temperature variability. A fully consistent treatment of the effects of surface temperature would therefore require a parallel analysis of the effects of SST and IST, as both contribute to the surface temperature field, the strength of contribution depending on the season and sea-ice regime. Including such analyses would significantly expand the scope of the manuscript and shift its focus away from the role of sea-ice concentration.

To address the concern related to SST while maintaining a clear focus on the effects of SIC, we have expanded the Discussion section to more explicitly describe the roles of SST and IST across different SIC regimes and seasons based on literature, among others our earlier paper (Uhlíková et al., 2024).

2. The work seems to be a little limited by method, for example, the central Arctic correlations being impacted by variability. Is there a way this could be addressed or another method that could be used for this region?

The issue does not lie with the statistical methods employed, but rather with the very limited variability of SIC in the Central Arctic (see e.g. Fig. 7). This variability is so small that its influence on grid-averaged T2m and Q2m cannot be distinguished from noise generated by *other, non–SIC-related factors. Identifying SIC-driven effects in regions with such a low SIC variability would require information on the subgrid-scale distributions of T2m and Q2m. However, such data are not available at a circumpolar scale over multi-decadal periods. Consequently, no alternative method can be applied under the constraints imposed by the spatial resolution of reanalyses and the limited availability of observational data.*

3. There are some limitations with using reanalysis for statistical relationship work, in that reanalysis models are built on statistical relationships, leading to biases. This should be addressed within the text further.

Reanalysis models are not built on statistical relationships. Instead, reanalyses are based on a combination of observations and results from models that are based on physical principles. We do agree that reanalyses have biases but they are due to inaccuracies in model physics, limited data available for assimilation, assumptions in the assimilation, and changes in observational coverage over time. In any case, reanalyses represent the best available circumpolar-scale information on meteorological and sea ice conditions over the period since 1979.

We have extended the text in Section 2.

4. An addition to this work, that would show these relationships clearer in a physical sense, rather than statistical, would be analysis of the turbulent heat flux, both sensible and latent, perhaps assessing the dominating flux in each season, further showing the direction of the relationship.

We carried out such a study (Uhlíková et al., 2024). Its results are cited and applied in interpretation of the results of the present manuscript. Sea-ice concentration directly affects the turbulent surface fluxes of sensible and latent heat (Uhlíková et al., 2024), and the fluxes further affect the air temperature and specific humidity over the marine Arctic.

Reference:

Uhlíková, T., Vihma, T., Karpechko, A. Y., and Uotila, P.: Effects of Arctic sea-ice concentration on turbulent surface fluxes in four atmospheric reanalyses, The Cryosphere, 18, 957–976, https://doi.org/10.5194/tc-18-957-2024, 2024.