**Reply to the reviewers' comments on:**

**"A Robust Aerosol Impact on Clouds Along the Subtropical to Tropical Transition"**

We would like to thank the reviewers for their constructive and thoughtful reviews that helped us improve this paper.

Below please find a point-by-point reply to all of the reviewers' comments (in blue). Citations from the paper are in italic with new additions in bold.

**Reviewer #2:**

General comments:

Aerosol impacts on cloud and precipitation has been investigated substantially in both observations and modeling studies. However, it is relatively rare for clouds along the subtropical to tropical transition, especially toward deep convection regime. In addition, aerosol effects are generally hard to be isolated because of its co-variability with meteorological conditions in observations, but this could be better resolved in model simulations by prescribing meteorological conditions. This study is unique in both regards with well-designed observational analyses and modeling approaches. The figures are well prepared with good presentation, but a better interpretation of results would strengthen the work.

**Reply:** We would like to thank the reviewer again for providing these constructive comments. Below, we have addressed all of the reviewer's comments.

Specific comments:

I have some comments and questions to be addressed before acceptance.

It is noted that SST is higher in polluted scenarios, especially toward later days (Fig. 3a). but why?

**Reply:** Thank you for this comment. There are two main factors that contribute to the SST difference between clean and polluted conditions:

1. **Seasonality:** The simulations sample a range of environmental states that include naturally varying seasonal insolation and large-scale circulation. In many cases the polluted trajectories coincide with periods of inherently higher surface heating (i.e., stronger solar forcing) compared to the cleaner trajectories. This co-variability between aerosol conditions and background meteorological state can lead to systematic SST differences that are not a direct effect of the aerosols themselves but rather reflect the broader sampling of seasonal conditions.
2. **Meteorological co-variability:** In our framework, aerosol perturbations are imposed on real observed large-scale meteorological trajectories. Because both aerosols and SST evolve with the background weather and climate state, SST in the polluted scenarios may be higher simply because those particular trajectories advect into warmer environmental regimes. In other words, the SST differences arise from covariation with large-scale meteorology rather than from a microphysical aerosol effect on surface energy balance.

This is now better explained in the revised manuscript:

***"Here, the SST differences between the groups reflect co-variability with the large-scale meteorological and seasonal background state rather than a direct aerosol effect on SST."***

The LES simulation setup and configuration can be better described. For example, for the model setup, it is mentioned that large-scale wind forcing is prescribed using the observed zonal (u) and meridional (v) wind components. However, the moisture and temperature advection is not mentioned?

**Reply:** Thank you. We added the relevant information regarding the model setup to the revised manuscript: *" ...* ***large-scale temperature and humidity advection were not included."***

Although limitation of prescribed CCN in the simulation is mentioned, its potential impact on the thermodynamic conditions can be included with some references for a more complete view.

**Reply:** Thank you. Following this comment, the following was added to the revised conclusion section: *"In addition, our model simulations rely on idealized setups with prescribed CCN perturbations and a limited domain size … **In addition, future work should use prognostic aerosols, rather than prescribed CCN, and hence represent better the full spectrum of ACI and its impact on the thermodynamic conditions (Arieli et al., 2025, Xue et al., 2010, Leung et al., 2023)."***

The difference between observations and modeling is large (Fig. 9). Although this has been briefly noted in the text, but it would be more revealing with more description and explanation. For example, it would provide more information if the difference could be described by accounting for the different regimes (Sc-Cu-DC). Another point to note is that the qv difference is not only larger in observations, but also reaching higher altitudes than modeled. This deserve more description and explanation, especially for the deep convection regime.

**Reply:** Thank you. In response to this comment, we have extended the description and interpretation of Fig. 9, specifically clarifying the differences between the observational analysis and the model results. The additions to the main text: *"In the observational record … **with the signal reaching higher altitudes compared to the model results."***

*"In the observations (Fig. 9a)**, the early days (days 1–3) show relatively shallow moistening confined near the boundary layer top (~1–2 km), whereas later on (days 5–8) the moist anomaly strengthens and peaks at ~4–6 km. This progressive deepening of the moist layer is consistent with a transition from stratocumulus-dominated conditions to more convective regimes.**"*

## References

Arieli, Y., Khain, A., Gavze, E., Altaratz, O., Eytan, E., & Koren, I. (2025). The impact of regenerated aerosols on the microphysics of cumulus clouds. Journal of the Atmospheric Sciences, 82(11), 2491-2503.

Leung, G. R., Saleeby, S. M., Sokolowsky, G. A., Freeman, S. W., & van den Heever, S. C. (2023). Aerosol–cloud impacts on aerosol detrainment and rainout in shallow maritime tropical clouds. Atmospheric Chemistry and Physics, 23(9), 5263-5278.

Xue, L., Teller, A., Rasmussen, R., Geresdi, I., & Pan, Z. (2010). Effects of aerosol solubility and regeneration on warm-phase orographic clouds and precipitation simulated by a detailed bin microphysical scheme. Journal of the atmospheric sciences, 67(10), 3336-3354.