Review of "*The Arctic Low-Level Mixed-Phase Haze Regime and its Microphysical Differences to Mixed-Phase Clouds*", by Manuel Moser, Christiane Voigt, Oliver Eppers, Johannes Lucke, Elena De La Torre Castro, Johanna Mayer, Regis Dupuy, Guillaume Mioche, Olivier Jourdan, Hans-Christian Clemen, Johannes Schneider, Philipp Joppe, Stephan Mertes, Bruno Wetzel, Stephan Borrmann, Marcus Klingebiel, Mario Mech, Christof Lüpkes, Susanne Crewell, André Ehrlich, Andreas Herber, and Manfred Wendisch, egusphere-2025-3876.

Response to the Community Comment

Dear Martina Krämer,

We sincerely thank you for your detailed and constructive community comment. We highly appreciate the careful comparison you provided between the PSDs observed in Costa-17 and those presented in Moser-25, as well as the broader context you offer for interpreting our results.
In the following, we address each of the recommendations. Our replies are highlighted in blue, and the corresponding revisions implemented in the manuscript are highlighted in orange.

Recommendations

1. To contextualize the study within the broader landscape of existing research, I recommend to include the comparison with Costa-17 into the manuscript, in particular to point out:

- a: the similarity of the PSDs found by Moser-25 and Costa-17
  Reply: We thank the CC1 for highlighting the direct comparison between the PSDs of the MPH and MPC regimes presented in Moser-25 and the mixed-phase cloud types reported in Costa-17. This comparison indeed shows a very good agreement between the respective PSD shapes. We fully acknowledge this point and now explicitly mention in the manuscript that the PSDs align closely with those identified by Costa-17. Following was added in line 229 to the manuscript:
  The PSDs of both the MPH and MPC regimes agree remarkably well with the two cloud types in the mixed-phase temperature regime identified by Costa et al. (2017). In particular, the PSD of the MPC regime closely resembles the "Type 1" or "coexistence" category of Costa et al. (2017), whereas the PSD of the MPH regime shows strong similarity to their "Type 2" or "large-ice/WBF" category. The Costa et al. (2017) dataset was obtained with comparable in-situ cloud instrumentation but includes a much broader range of meteorological and geographical conditions, including mid-latitude and tropical mixed-phase clouds as well as clouds outside the atmospheric boundary layer. In contrast, the microphysical interpretation of the small-particle mode in the MPH regime presented in this study is based exclusively on Arctic low-level measurements and therefore explains only a subset of the small particles observed in the Type 2 clouds of Costa et al. (2017).

- a1: indicating that the structures of the PSDs depend not on geography but on temperature and environmental conditions
  Reply: We agree that a key strength of Costa-17 lies in the large variety of environmental conditions sampled, covering a broad temperature spectrum and multiple latitudes. This supports the general notion that PSD shapes may be similar across different regions.
  However, we decided not to emphasize this point in the manuscript, as it could be misleading in the context of our study. A similarity in PSD shape does not necessarily imply similarity in microphysical composition. In contrast to Costa-17, we explicitly show that the small particle mode in the MPH regime consists of wet sea salt aerosol particles originating most likely from the ocean and sea ice surface. Clouds in other regions and situations than Arctic ABL in spring, are influenced by different aerosol sources, which are also represented in the Costa-17 dataset.
  It is therefore plausible that the “Type 2” category in Costa-17 includes multiple microphysical subtypes, where the small particles could include wet sea salt aerosol but also other wet aerosol types or small ice crystals (<20 µm).
  In our study, we specifically analyze only one case: Type 2 mixed-phase clouds within the Arctic boundary layer during spring conditions, for which we can characterize the small particle mode in detail.

- b: that the finding that the small mode particles (< 6 µm) are dissolved sea salt particles is confirmed by the asphericity measurements of Costa-17, and to discuss that Costa-17 found small aspherical particles up to ∼20 µm.
  Reply: We appreciate the suggestion to relate our findings to Costa-17 regarding the dissolved sea salt particles. However, we note that Costa-17 does not provide asphericity information for the size range relevant to the haze particles in the MPH regime. The asphericity analysis in Costa-17 is limited to particles between 20 and 50 µm, whereas the haze particles identified in our study are substantially smaller (< 10 µm). Costa-17 reports that particles in the 20–50 µm range are often aspherical. This is fully consistent with our understanding that small ice crystals can occur at sizes below 50 µm which could have influenced these measurements. In contrast, our measurements using the Polar Nephelometer (see Moser et al., 2023) show that the small mode particles in the MPH regime are spherical. Combined with the OPC and ALABAMA measurements, this allows us to identify them as wet sea salt aerosol.

2. I also recommend reconsidering the names of the mixed-phase cloud types.

Often, the -well known- two types of mixed-phase clouds are summarized under the acronym MPC. In Moser-25, MPC only includes the cloud type in which small liquid droplets coexist with large ice crystals.

For the completely glaciated mixed-phase clouds the, term MPH (mixed-phase haze) is introduced. This is somewhat misleading because ‘haze’ (in particular Arctic haze) refers commonly to a size spectrum of grown aerosol particles, not to a cloud. However, this type of completely glaciated cloud is usually considered as glaciated mixed-phase cloud with a very low concentration of large ice crystals, which, however, represent the dominant mass mode (see Figure 1, bottom panel).

Therefore, I would recommend names that make it clear that both types are clouds, maybe MPC coex for the Type 1 and MPC haze for the second?

Reply: We are thankful for this suggestion and agree that our terminology differs from that used in Costa-17, although the cloud types to which these terms refer partially overlap. The full term "MPH" refers to **Arctic low-level mixed-phase haze**, and this name reflects the conditions under which this cloud type is observed and the microphysical properties. The regime is measured exclusively in the Arctic, which motivates the term "Arctic," and it occurs only within the boundary layer, which is why we use "low-level." Microphysically, the cloud consists of a mixture of large ice crystals and smaller particles, similar to a classic mixed-phase cloud. However, unlike in a classic mixed-phase cloud, the small particles are unactivated cloud droplets and are commonly referred to as haze droplets.
We also note that the term "Arctic haze" is not related to our definition of MPH, which is explicitly clarified in the manuscript (line 343).
In order to connect the terminology used in Costa-17 and Moser-25, we now explicitly use the terms "Type 1; coexistence" and "Type 2; large ice/WBF" in the PSD discussion of the revised manuscript.

References:

Moser, M., Voigt, C., Jurkat-Witschas, T., Hahn, V., Mioche, G., Jourdan, O., Dupuy, R., Gourbeyre, C., Schwarzenboeck, A., Lucke, J., Boose, Y., Mech, M., Borrmann, S., Ehrlich, A., Herber, A., Lüpkes, C., and Wendisch, M.: Microphysical and thermodynamic phase analyses of Arctic low-level clouds measured above the sea ice and the open ocean in spring and summer, Atmospheric Chemistry and Physics, 23, 7257–7280, https://doi.org/10.5194/acp-23-7257-2023, 2023b.