Summary:
This manuscript discusses how dropsondes from the HALO-AC3 campaign were used to observe subsidence along a lagrangian trajectory of a MCAO and subsequently used to constrain a modeling study. The authors find that as the boundary layer grows, with a rate controlled by subsidence, there is first a peak in supercooled water followed by an increase in graupel and precipitation which causes decoupling of the boundary layer. Subsidence slows boundary layer growth and delays the transition to open-cells. I recommend that this manuscript be accepted with minor revisions.

Minor Comments:
Line 18: A cold air mass does not need to move southward to be a MCAO. MCAOs can happen in both hemispheres. Additionally, MCAOs in the Arctic can occur with zonal winds too, for example westerly flow behind a cold front off of the sea ice east of Greenland.

Line 31: Polar lows also require other mechanisms such as convergence, topography, deeper thermodynamic support. I don't think they should be included in this list

Line 48: I was under the impression that increased subsidence strengthens the inversion which inhibits entrainment. The wording of this sentence reverses my understanding of the cause and effect.

Line 67: COMBLE did not observe conditions in the Fram Strait, it sampled downstream conditions at Bear Island and Andenes.

Line 67: CAESAR could also be mentioned

Line 86: Current wording "Arctic west of Norway and the Fram Strait" doesn't make clear that the domain of the campaign was only over the ocean and sea ice. Could rephrase to: "Norwegian/Greenland Seas and the Fram Strait".

Line 97: Suggest changing to: "Both days were characterized by persistent northerly wind of about …". "Persistent" and "steady" are redundant. I don't necessarily agree with the classification of the wind speed (reaching 10 m/s or 20 kts) as "slow".

Line 99: "MCAO" used 3 times in the same sentence. Sentence should be reworked.

Lines 100-102: This sentence is confusing. A weak MCAO between two strong MCAOs? How is that different from a week + of persistent MCAO conditions?

Line 110: Clarify that this location in the "high north" is over the sea ice

Line 124: Cite ISLAS

Lines 177-179: CCN concentrations (and their effect on droplet size) are identified as being important for a closed to open-celled transition in Abel et al. 2017. Since your prescribed choice of CCN is held constant throughout your experiments, your experimental design is reasonable for what you are testing, however, I recommend discussing (either here or in the analysis) how not accounting for aerosols could affect your results.

Line 180: What temperature are those INP concentrations at?

Line 183: Other SIP mechanisms, such as ice-ice collisions and drizzle freezing fragmentation, are identified as important for reproducing observed ice particle concentrations in Karalis et al 2022, Schafer et al. (2024) and Sotiropoulou et al. (2020). Since SIP is held constant throughout your experiments, your experimental design is reasonable for what you are testing, however, I recommend discussing (either here or in the analysis) how not accounting for other SIP mechanisms could affect your results.

Line 199: How trajectories for flight planning were calculated was not previously discussed. Should remove: “As described in Section 2.1”

Line 201: ERA5 3-D winds should potentially be added to Table 1

Line 202: “matching the circle locations on March 30, 2022” is confusing wording

Line 229: 0.025 cm/s error sounds unrealistically small. Does this error estimate assume both that dropsondes are all released simultaneously and that dropsondes fall straight downward with no drift? If so, those could be large sources of additional error and the above caveats should be mentioned.

Line 280: I suggest adding a figure where you show snapshots of outgoing longwave from the simulation with side by side snapshots of satellite imagery. For example, something similar to the VIIRS vs DHARMA pseudo-albedo plot in the COMBLE MIP preprint. (Juliano et al 2026; Figure 6)

Line 308: What do you mean by % agreement? Does this depend on what units (K vs C) are used in that calculation? If this complement of percent error, I’m not sure that is an appropriate metric. For example: if the truth is 273K and that is modeled as 263K, that is only a ~4% error (96% agreement), however, being 10K off is significant. Portraying that agreement as 96% is misleading to the reader.

Lines 313-316: These sentences could be consolidated

Lines 337-339: Line 337 implied that the model underestimates q by 0.3 g/kg in the boundary layer, but line 339 states that the model underestimates q by 0.2 g/kg below the inversion. Why are these numbers different?

Line 426: Is 21 W/m2 the simulated value using the new method? This sentence seems to imply that this is the difference between the two methods.

Figure 1: Could add ERA5 MSLP contours from a timestamp of your choosing to help the reader understand the large scale flow. Add lat/lon labels.

Figure 2: For temperatures, I suggest using a multispectral colormap. For example, as currently plotted it is impossible to distinguish where SSTs are 1C and where they are 4C.

Figure 6: For q, the x-axis should be cut off at zero since negative q is unphysical

Technical Comments:

Line 96 and other locations: The abbreviation "Fig." should be used when it appears in running text and should be followed by a number unless it comes at the beginning of a sentence, e.g.: "The results are depicted in Fig. 5. Figure 9 reveals that...".

Line 96 and other locations: Date should be in the format: dd month yyyy hh:mm:ss (29 March 2022 and 30 March 2022 respectively)

Line 100 and other locations: A citation within parentheses should be shown as (Slattberg et al., 2025) not (Slattberg et al., (2025)).

Line 108: foehn effect -> Foehn Effect

Line 131: air humidity -> relative humidity

Line 182: 200 L -> 200 L^{-1}

Line 261: $EUREC^4A$ -> $EURECA^4$

Line 271: Initialisation -> initialization

Line 338: strong humidity -> high humidity