Public justification (visible to the public if the article is accepted and published):

We sincerely appreciate the editor for the valuable comments, which have helped to further improve the quality of the manuscript. We have carefully revised the manuscript in response to these comments and believe that the revised version is improved. Please refer to our point-by-point responses in blue text, and note that revisions in the manuscript are indicated in italic text.

Please correct the following minor comments:

- Add in the abstract to the second sentence (or before) ("However...) that this is a modelling challenge for flight-icing forecast/prognosis (the context is otherwise not so clear).

We have revised the sentence to:

"However, accurately quantifying aerosol emission inventories and their spatiotemporal distributions, as well as simulating supercooled liquid water and predicting in-flight icing, remains a major challenge, particularly in high-aerosol environments such as the Sichuan Basin in China."

- Line 36 in the track changes document: split the sentence after "(CAMS)" - it otherwise gets too long and hard to read.

We have revised the sentence to:

"Three aerosol configurations are examined: the scheme's default settings representing clean conditions; climatological aerosol values representing polluted conditions; and aerosol fields from the Copernicus Atmosphere Monitoring Service (CAMS), representing near-real-time polluted conditions. The CAMS aerosol mass concentrations are converted to number concentrations using typical densities and size parameters of major East Asian aerosol species."

- Line 481 in the track changes document: please rewrite: the aerosol concentrations have been used in the microphysics scheme, but were not designed by it.

We have revised the sentence as follows:

"Using the Thompson–Eidhammer aerosol-aware microphysics scheme, three numerical experiments are designed with different initial aerosol number concentrations. The results show that all three experiments are capable of reproducing the weather-scale spatial distribution of SLW."

- Line 503-504 in the track changes document: The suggestion here does not necessarily make sense. If the IN from the climatology are used (higher IN values), the IN are most likely prescribed in the model, and no IN parameterization is used, so it can't be the IN parameterization scheme that is the problem? Please rewrite/explain.

We still consider this discrepancy to be primarily attributable to the ice nucleation parameterization, and the manuscript has been revised accordingly as follows:

"This discrepancy may be related to the temperature at this altitude being higher than −5 °C. In the Thompson–Eidhammer aerosol-aware microphysics scheme, ice nucleation is based on the Cooper (1986) parameterization, which permits ice crystal formation only under saturated conditions and at temperatures below −5 °C, potentially limiting ice nucleation at warmer temperatures."

References

Cooper, W. A.: Ice Initiation in Natural Clouds, Meteor. Monogr., 21, 29–32, https://doi.org/10.1175/0065-9401-21.43.29, 1986.

- line 91 in the track changes document: median volume diameter = cloud droplet median volume diameter? Please add (you use later MVD everywhere, which is ok after introducing it here).

Added

- line 102 in the track changes document: What is the Common Community Physics Package? Please explain.

The Common Community Physics Package (CCPP) is designed to facilitate the implementation of physics innovations in state-of-the-art atmospheric models, enable the use of multiple models for physics development, and accelerate the transition of physics innovations to operational NOAA models. The CCPP consists of a library of physical parameterizations (CCPP-Physics) and an infrastructure component (CCPP-Framework) that enables the connection of these physics schemes to a host model. For details, please refer to the following link: https://dtcenter.org/software-tools/common-community-physics-package-ccpp. We have clarified this in the manuscript as follows:

"Li et al. (2024) incorporated aerosol fields from the Common Community Physics Package (a library of physical parameterizations and suites that are used operationally in the NOAA's Unified Forecast System Atmosphere) to improve precipitation simulations over Europe and North America."

- The answer to the reviewer's question: "If I understand correctly, only the initial conditions are varied within all the experiments. Does this mean that there are no emissions during the simulation? Could this lead to specific biases when

comparing to the observations?" was incomplete/badly phrased (incomplete sentences). Can you please double-check if the approach you used is clearly stated in the manuscript?

In the Thompson–Eidhammer aerosol-aware microphysics scheme, a constant-in-time surface aerosol emission is calculated using the mean surface wind and the initial near-surface number concentration of water-friendly aerosols (WFA), and is implemented as a variable lower boundary condition according to the following relation:

$$dN_{wfa}/dt = 10^{[\log(N_{wfa})-3.69897]}$$

N_{wfa} represents the initial near-surface number concentration of WFA. As demonstrated by Thompson and Eidhammer (2014), this treatment is preferable to maintaining fixed initial aerosol concentrations throughout the simulation. We have added this clarification at the end of Section 2.5 (Model Configuration) as follows:

"When reanalysis datasets are used as inputs for the initial aerosol concentrations, a simplified treatment is adopted in which a constant-in-time surface aerosol emission is calculated based on the mean surface wind and the initial near-surface number concentration of WFA, and is implemented as a variable lower boundary condition. As demonstrated by Thompson and Eidhammer (2014), this approach maintains aerosol number concentrations close to climatological conditions over most regions, indicating that it is preferable to keeping the initial aerosol concentrations fixed throughout the simulation."

- The arrow in Fig. 1 is still not clearly visible. Please add the arrow next to the flight track to improve the figure's clarity, as suggested by reviewer 2.

In the revised figure, white arrows have been added alongside the flight track for clarity.
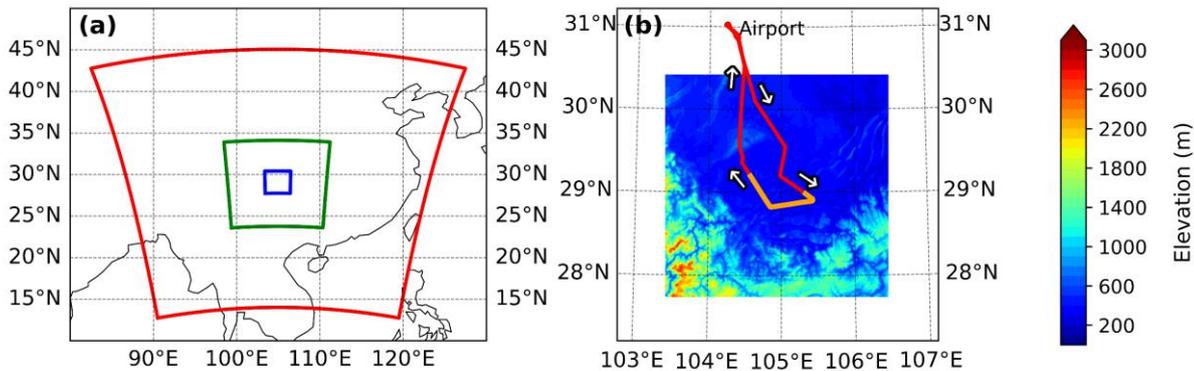
- The reviewer's comment: "Finally, these conclusions are all for a single case study. Can we consider this case study "normal" to generalize the conclusions? If not, how can you caution the readers about particular features that may not occur in other cases." was not sufficiently addressed. It would improve the manuscript if you could state in the case description

how representative that case is for the region. Additionally, you should add in the conclusions that the conclusions are limited by the investigation of one case study only (here it might fit to again state if that case is representative etc.).

We discussed the representativeness of this case in Section 2.2 as follows:

"Subsequent analyses of the distributions of SLW, temperature, and aerosol concentrations, together with the synoptic patterns and cloud-system features identified in previous studies (Yuan et al., 2005, Fig. 4), indicate that this case is representative of typical wintertime cloudy and highly polluted meteorological conditions in the Sichuan Basin."

We also discussed the limitations of this study in Section 4 as follows:

"Finally, while this case study is representative of the region, it remains subject to limitations inherent to single-case analyses."

- line 196: Can you state (or is there stated) how the SLW path was derived based on these ERA5 variables? if not, please add to where it fits best in the text.

We have provided the following clarification in the manuscript.

"The ERA5 variables used in this work include three-dimensional temperature, cloud liquid water content, and geopotential height, SLW path is derived by vertically integrating the cloud liquid water content, enabling comparison with the model output."