Reply on RC1

Overview

I appreciate the authors' careful revisions and detailed responses to my comments.

Specific comments:

Dear editor and reviewers,

Thank you for your thorough review of the manuscript again. We have read the reviewer's comments carefully, and have responded and taken your comments into consideration and revised the manuscript accordingly. All the changes have been highlighted in the revised manuscript. Our detailed responses, including a point-by-point response to the reviews and a list of all relevant changes, are as follows:

1. **Authors' response to General Comment #3 and Specific Comment #1, 16: The authors state in their response that "the introduction of the on-line aerosol-IN nucleation scheme leads to temperature increases below 4 km, with changes of about 0.16 to 0.52 K". I would like to know what is the reason for the warming of atmosphere below 4 km due to the improvement of ice nucleation.**

A: Thank you for your careful review of the manuscript. To further examine the cause of the warming below 4 km, we diagnosed the latent heating associated with the main cloud microphysical phase transitions in this layer, including vapor-to-liquid, liquid-to-solid, and vapor-to-solid conversions.

Our analysis shows that, after introducing the on-line aerosol–IN nucleation scheme, the latent heating associated with different phase transitions changes in different ways in T_IN relative to T_CTL. Specifically, the latent heating associated with vapor-to-solid conversion is about 54%–88% of that in T_CTL, vapor-to-liquid conversion is about 29%–181%, and liquid-to-solid conversion is about 95%–152%. However, the total latent heating released by these three processes is about 73%–94% of that in T_CTL, lower than that of T_CTL.

Our diagnostics show that, although the total latent heating released by cloud microphysical processes below 4 km is overall weaker in T_IN than in T_CTL, the temperature term itself is higher in T_IN during the simulation. This suggests that the warming below 4 km is not directly caused by cloud microphysical processes with the on-line aerosol–IN nucleation schemes, but is more likely related to the changed cloud properties which may affect those processes of radiation, atmospheric transport, or planetary boundary layer (PBL) dynamics.

2. **Authors' response to Specific Comment #17: The equation (9) includes parameter "V" while the description of variables refers to a parameter "V_n". Please clarify whether these represent the same variable.**

A: Thank you for pointing out this inconsistency. In Eq. (9), V and V_n refer to the same variable, i.e., the wind component normal to the selected cross section. Specifically, for the north–south cross section along 116 °E (33 °–50 °N), V_n is taken as the zonal wind component (u); for the west–east cross section along 33 °N (103 °–116 °E), V_n is taken as the meridional wind component (v).

The manuscript has been revised in line 330-337:

The horizontal hydrometeor fluxes shown in Section 3.3 are calculated using a grid-based mass transport formulation. For each model layer, the flux is computed as

$$F = \rho_{air} q_x V_n \Delta z \Delta s \quad (9)$$

where F is the hydrometeor flux (kg s-1), ρ_{air} is the air density (kg m^{-3}), q_x is the mass mixing ratio of the hydrometeor species (kg kg^{-1}), V_n is the wind component normal to the cross section (m s^{-1}). Specifically, for the north–south cross section along 116 °E (33 °–50 °N), V_n is taken as the zonal wind component; for the west–east cross section along 33 °N (103 °–116 °E), V_n is taken as the meridional wind component. Δz is the layer thickness (m), and Δs is the horizontal grid spacing along the cross section (m).