This study investigates how dust aerosols influence precipitation in China using an improved online aerosol–ice-nucleation (aerosol-IN) scheme implemented in the GRAPES/CUACE regional model. The topic is interesting and important in the field of aerosol–cloud–precipitation interactions. However, in many parts of the manuscript, the authors draw conclusions without sufficient observational evidence. This is the major drawback of the study. Therefore, I am on the negative side regarding publication of this paper.

Dear reviewers,

Thank you for your thorough review of the manuscript. We 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. **While the study focuses on the mechanisms of dust's impact on ice nuclei, the abstract provides limited discussion on this aspect. Relevant conclusions should be supplemented.**

A: Thank you for this valuable comment. In the revised manuscript, we have supplemented the abstract to explicitly state how dust modifies ice nucleation processes by reducing cloud ice nucleation efficiency, altering the heterogeneous nucleation and deposition growth of cloud ice, and subsequently influencing precipitation development. These additions aim to better highlight the mechanistic focus of this study while remaining consistent with the detailed analyses presented in the main text.

In line 16 -41:

To investigate the impact of ice nuclei (IN) activated by dust aerosols on precipitation over China, this study uses regional Global/Regional Assimilation and Prediction System – China Meteorological Administration Unified Atmospheric Chemistry Environment (GRAPES/CUACE). The original temperature-dependent IN nucleation scheme is improved by incorporating an on-line aerosol–IN nucleation one. The INs are then fed on-line into the Double-Moment 6-Class (WDM6) cloud microphysics scheme to study in a typical dust affected precipitation event in East Asia.

Dust modifies the spatial distribution and density of IN, impacting heterogeneous nucleation. Compared with the systematic underestimation in original WDM6, the peak values of nucleated INs can reach 10-4 L-1 with the improved scheme, which is closer to observations. Cloud ice is reasonably formed between 4 and 7 km in height.

Dust can inhibit the development of clouds. Above 7 km, dust suppresses the growth of cloud ice (both heterogeneous nucleation and deposition growth), and the total production rate of cloud ice drops to less than 24% of that in the control test T_CTL, promoting snow formation and ultimately reducing the total ice-phase hydrometeor content to 70–85% of T_CTL. Between 4 and 7 km, dust enhances heterogeneous nucleation of cloud ice, but suppresses cloud ice deposition growth, resulting in the total ice-phase hydrometeor content decreasing to 85–91% of T_CTL. Below 4 km, dust suppresses the conversion of water vapor to cloud water and of cloud water to rain, reducing the liquid-phase hydrometeor content to 90–95% of T_CTL.

Dust also modulates the precipitation distribution closer to observations. It suppresses precipitation near dust source areas, where mean precipitation decreased by about 4.5 mm, while the downstream event-mean precipitation increased by about 1.1 mm.

2. **The manuscript contains several formatting issues that require careful revision. For example, the font in "2.2 WDM6 microphysics scheme" is noticeably inconsistent.**

A: Thank you for pointing out these formatting issues. We have carefully checked the entire manuscript and corrected the inconsistent fonts, formatting errors, and typographical issues, including those in Section 2.2 (“WDM6 microphysics scheme”).

3. **In Section 3, the analysis should focus more on phenomena and mechanisms. Descriptions of figures and tables, such as those in lines 298-304, can be directly included in the captions.**

A: Thank you for this valuable suggestion. Following this comment, and in combination with suggestions from other reviewers, we have substantially revised Section 3 to strengthen the discussion of physical phenomena and underlying mechanisms.

In the revised Section 3, the analysis now explicitly links the evolution of activated ice-nucleating particle concentrations to changes in cloud hydrometeor budgets, and further examines how dust aerosols regulate the transformation and redistribution of hydrometeors within the cloud system. In particular, we analyze how dust-induced suppression of cloud ice formation and the concurrent enhancement of snow and graupel production modify the hydrometeor composition and transport pathways. Please refer to the revised Section 3 for details.

4. **In lines 430-440, the improved on-line model simulates significantly higher ice crystal concentrations compared to the WDM6 results. What causes this? This is a key highlight of the study, yet the authors did not provide an in-depth or systematic explanation in Section 3. The authors should systematically analyze the mechanisms behind the improved simulation performance after the model enhancement.**

A: Thank you for pointing out this important issue.

In the revised manuscript, we have clarified the distinction among activated INP concentration, cloud ice number concentration, and ice-phase mass concentration, and systematically analyzed their relationships using combined diagnostics of INP activation, cloud ice number, hydrometeor mass, and microphysical budget terms. Our results show that:

Above 7 km, dust suppresses the growth of cloud ice (both heterogeneous nucleation and deposition growth), and the total production rate of cloud ice drops to less than 24% of that in the control test T_CTL, promoting snow formation and ultimately reducing the total ice-phase hydrometeor content to 70–85% of T_CTL. Between 4 and 7 km, dust enhances heterogeneous nucleation of cloud ice, but suppresses cloud ice deposition growth, resulting in the total ice-phase hydrometeor content decreasing to 85–91% of T_CTL. Below 4 km, dust suppresses the conversion of water vapor to cloud water and of cloud water to rain, reducing the liquid-phase hydrometeor content to 90–95% of T_CTL.

A systematic explanation of these mechanisms has now been added to Section 3, with explicit references to the relevant figures and microphysical process rates.

5. **Finally, this study focuses on the impact of dust processes on ice nuclei and precipitation, utilizing model simulations. However, the analysis in Sections 3 and 4 provides limited discussion on the influence of the dust event, which is only described in "2.4 Case description and test design." The analysis of model results should incorporate the evolution of the dust process, rather than merely analyzing the simulated ice crystal and precipitation outcomes. In summary, this is a highly meaningful study, and the authors are encouraged to strengthen the analysis of the model results.**

A: Thank you for this constructive suggestion. We agree that the dust event itself should play a more explicit role in interpreting the simulated cloud and precipitation responses.

In the revised manuscript, we have strengthened the linkage between the dust process and the microphysical and precipitation responses in Sections 3 and 4 in the following ways.

In section 3.1 and 3.2, We reorganized the discussion of cloud microphysical processes to emphasize their dependence on dust-induced IN perturbations, particularly in the mid- and upper-tropospheric layers where dust influence is strongest. The diagnosed changes in cloud ice, snow, and associated budget terms are now interpreted in the context of the evolving dust plume rather than as isolated microphysical outcomes.

In section 3.3, the discussion of precipitation responses has been revised to highlight how dust-driven modifications in hydrometeor mass budget and hydrometeor flux and during the dust–precipitation period contributes to the spatial redistribution of precipitation, rather than changes in total precipitation alone.