Response to Reviewer #1 (our response in **colour**)

We thank the reviewer for the constructive comments to help us further improve the manuscript. Please see the detailed responses to your comments below.

The authors answered the main questions raised by reviewers and the revised manuscript is well improved. To make the readers get more understanding on this study, I recommend the authors can added some quantitative discussions based on the observations in China and simulation studies using other models and model configurations where necessary before the paper is accepted for publication.

Thanks for the suggestions. We have added several recent observational studies on the chemical composition of ultrafine particles and CCN in China, as well as related simulation studies in the manuscript. Please see the detailed information below, as well as in the revised manuscript.

Lines 419-422:

"*Recent observations conducted in Beijing also indicated that particles at 8–40 nm are mainly composed of organic matter (with mass fraction of ~80%) and sulfate (with mass fraction of ~13%), while nitrate content is very low (with mass fraction of ~3%) (Li et al., 2022)*"

Lines 566-570:

"Similarly, based on observational data in northern China in summer, Wang et al. (2023) found that CN in 2020 is lower than that in 2014 due to particulate pollution control, however, the particles become more easily activated, attributable to the larger extent of decrease in organic matters compared to inorganics, leading to enhanced particle hygroscopicity and more conducive to activation.".

Lines 605-608:

"For instance, by adding the formation chemistry associated with multi-generational oxidation, Zhao et al. (2020) found improved simulations of vertical aerosol profile in the Amazon free troposphere compared to the simplified VBS mechanism.".

Response to Reviewer #2 (our response in **colour**)

We thank the reviewer for the constructive comments to help us further improve the manuscript. Please see the detailed responses to your comments below.

1. It's not clear what the last sentence "The substantial contribution of new particle formation to CCN under low SS and SI-SOA is applicable to other mechanisms such as kinetics." is talking about. Please rewrite it to clarify the message.

Thanks for the suggestions, and the discussion of contribution of new particle formation to CCN under other mechanisms has been added in the third paragraph of the conclusions.

2. The author's new simulations by adopting the kinetic nucleation rate suggest that both high and low SI-SOA schemes yield a positive contribution of NPF to CCN. This is distinct from using the out-of-date activation scheme which suggested the high SI-SOA yield was the problem causing the under-estimation of NPF to CCN.

Therefore, the question becomes: is the SI-SOA the problem or the nucleation mechanism the problem causing the estimation of NPF to CCN in models? I think the authors may have realised this potential (major) problem but so far I see insufficient discussions about SI-SOA yield vs. nucleation mechanisms. The paper has not changed its root which states SI-SOA yield is the core of the problem (which I'm not so sure about anymore).

However, I agree with the authors that this subject is still very open and more work is needed to tackle the uncertainties. So I would accept the manuscript if the authors properly formulate that the NPF to CCN contribution is affected both by SI-SOA yield and the adopted nucleation mechanisms in their manuscript. They should highlight this key information both in their abstract and conclusions instead of just adding one sentence which does not reflect their new findings during the revisions.

Thanks for the suggestions, and we have added the relevant discussions in the revised

abstract and conclusions (third paragraph). Please see the detailed information below, as well as in the revised manuscript.

Lines 57-60

"*The bias-corrected model is robustly applicable to other schemes, such as quadratic-H_2SO_4 nucleation scheme, in terms of CN and CCN, though the dependence of CCN on SI-SOA yield is diminished likely due to changes in particle composition.*"

Lines 687-696

"*In addition to activation nucleation scheme, we have also tested a few other schemes such as the quadratic-H_2SO_4 nucleation scheme (e.g., kinetics nucleation scheme). Under this scheme, the bias-corrected method abovementioned is applicable to improving the simulations of concentrations of CN and CCN. It is noteworthy that the dependence of CCN on the SI-SOA yield is diminished, showing that under both high and low yields of SI-SOA, there are positive contributions of NPF to CCN. This is likely due to the increase in the amount of sulfuric acid involved in nucleation, making it more hygroscopic and easier to activate to CCN, and the high content of inorganic species makes them less sensitive to changes in SI-SOA yield, which deserves further investigation.*"