"The effect of organic nucleation on the indirect radiative forcing with a semi-explicit chemical mechanism for highly oxygenated organic molecules (HOMs)" by Shao et al. is a science development that evaluates the aerosol, cloud, and radiative forcing changes in the CAM-Chem model using a newly developed organic chemistry mechanism from Xu et al. (2022) and a new HOM nucleation scheme developed by Shao et al. (2024). The paper is succinct and has an overall organized structure, although I think some key information on the critical insights should be discussed earlier in the introduction section instead of in Sect. 4 (see the second comment below), especially because this insight appears throughout the whole manuscript but is not explained early on. Many comments of mine are requests for clarification. I would suggest major revision for this paper, which can be accepted after addressing the comments below. The manuscript can also be benefited by some rewriting to improve grammar and readability.

Lines 28-29: The readability of the sentence is not good since the reader is not clear what Gordon 2016 concluded. It may make the sentence clearer by rephrasing the sentence as "The reduction is mainly driven by ..., instead of the findings of Gordon et al. (2016) that the ~1 nm nucleation drives the reduction."

Line 48: new particle formation can be replaced by NPF.

Lines 72-73: It is not clear to the reader why there is a reduction in the magnitude of the radiative forcing. This is explained at the very end of the manuscript in Sect 4, but readers are confused here, so the importance of HOM-driven NPF in line 68 could be illustrated here in line 72. Some of the information in lines 280-285 could be covered here.

Lines 81-83: The sentence is not clear here by themselves. Reader is curious and wants more details on what the specific advances in Xu 2022 and Shao 2024 are, and why they are better than Vehkamaki 2002, Gordon 2016, and other relevant paper. Please use a few sentences here to give a summary. You have more details in Sect. 2, but I think more details are needed here as well.

Lines 177-178: Why is H_2SO_4 overestimated over Brazil, Barrow, and Graciosa but not other places? Please also explain why H_2SO_4 concentration is overestimated in CAM-Chem.

Line 179-180: It is not clear whether the Shao 2024 organic nucleation scheme (Inorg_Org) has increased CCN across the whole globe compared to the Inorg run. It looks like some

places have worsened underestimations (such as Azores for 0.5%SS and 1%SS), which requires an explanation.

Fig. 1: According to Fig. 1, the improvements of the Shao 2024 organic nucleation scheme (Inorg_Org) is not very significant and distinguishable from the Inorg run. It does not appear to the reader that the data points are significantly close to the 1:1 line or the NMB is largely reduced. Also, reader is curious about the correlation coefficient, which might not show significant improvements either. Please include correlation coefficients for all panels.

Multiple measurements still have predictions several orders of magnitude off from the 1:1 line. Overall many data points are stacked together so it is hard to examine the comparison region by region. From reader's perspective, this figure is not showing the merits of the new nucleation scheme.

Lines 185-186: Why does 0.2% SS in Fig. 1b has much fewer CCN number concentrations than other panels in Fig. 1?

Lines 194-195: This sentence does not make much sense to reader. Why would a CCN map (Fig. 2) with a much wider area coverage than the coverage of an aerosol burden map (Figs. S11-S12) be due to the slower removal rate of larger aerosol particles? Please rewrite and clarify.

Lines 254-255: Do you have mode-specific values to let readers understand the changes in the indirect forcings for each mode?

Lines 81-83: The sentence is not clear here by themselves. Reader is curious and wants more details on what the specific advances in Xu 2022 and Shao 2024 are, and why they are better than Vehkamaki 2002, Gordon 2016, and other relevant paper. Please use a few sentences here to give a summary. You have more details in Sect. 2, but I think more details are needed here as well.