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Comment on acp-2022-487

Anonymous Referee #1

Referee comment on "Particle number concentrations and size distributions in the stratosphere: implications of nucleation mechanisms and particle microphysics" by Fangqun Yu et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-487-RC1, 2022

Manuscript by Fangqun et al studies nucleation in the stratospheric condition by evaluating different nucleation schemes against CLOUD laboratory measurements and ATom observations in the southern hemisphere stratosphere. Study showed that in the recently developed kinetic nucleation model nucleation rate is much better in agreement with measurements compared to widely used binary homogeneous nucleation. This paper is exactly the type of research that modelers of stratospheric aerosols need, especially if you are studying stratospheric aerosol injections. Good indicator for excellent study is that after reading the paper, you want to take something from it to your own research. In this case it is the nucleation scheme.

Manuscript is well written, and when questions came to my mind, those were answered in the following lines. Or at least as well as possible. Overall this is an interesting and excellent study and it is difficult to find any major or even minor issues. I have just few very minor comments which would clarify some specific points:

Model and data section:
It would be interesting to know how competition between nucleation and condensation for sulfuric acid vapor is done in GC-APM.

P6 L206, After reading the abstract and introduction I got the impression that in this paper only the BHN of Vehkamäki and new BIHM scheme are evaluated. This line is the first time where BHN of Yu et al. (2020) is mentioned. I think it would be good to somehow introduce this nucleation scheme earlier (just by 1 or few line(s)) and say with just few words how it differs from the BHN of Vehkamäki (new look up tables(?) I assume).

P6 Figure 1 (and later figures): Really minor thing but it would be more clear if (a) and (b) were upper left of the panel and not in the title and that order would be a-b-c in upper panels and not a-c-e as in figs 2-3.

P7 L246 and later in the text, at least I am not familiar with "std" in units. Could this be opened up?

P7 L251 and L253, brackets in [H2SO4]

P11 L349 You could clarify that here you refer to measurements even though it is obvious after reading the next couple of lines.

P12 L361-368 I have been struggling with this and I am not sure if the standard deviation in the largest model is surprisingly large or is it even large or not. Number concentration in AccuM2 is much lower compared to AccuM1 and Aitken modes and thus in the linear scale the size range of the standard deviation bar is not actually large as it seems to be in logarithmic scale.

Figures 5 and 6 and captions: There abbreviation of particle number size distribution is "PSD" while in the text it is "PNSD"

P13 L389-391 I think this is kind of expected as there is lower nucleation rate in BIMN compared to BHN_V2002, there is more available sulfuric acid vapor for condensation. However, the BHN-V2020 line is lower than BIMN and BHN_V2002 regardless of the size of the aerosol, which is interesting. It means that particulate sulfate (+small amounts of some other species) burden is lower in BHN-V2020 compared to others. Where is this "missing" sulfate in BHN-Y2020? In the gas phase, or in some other location, or removed from the atmosphere? If you could easily give an answer to this, it would be interesting to know.

P13 L408 I find this bi-mode structure of accumulation size region really interesting. What do you think, should this be taken into account in modal aerosol schemes especially in stratospheric conditions and add one extra mode between usually used accumulation and coarse mode? Your results are not the only case which would speak for it. Of course then in the modal scheme bi-mode structure would be artificial, as it still remains unknown what is causing it.

P14 L439 Is there bi-mode structure of accumulation mode in a volcano perturbed atmosphere? I would say that there is the coarse mode and one accumulation mode.