Supplementary information for

The effectiveness of coagulation sink of sub-10 nm particles

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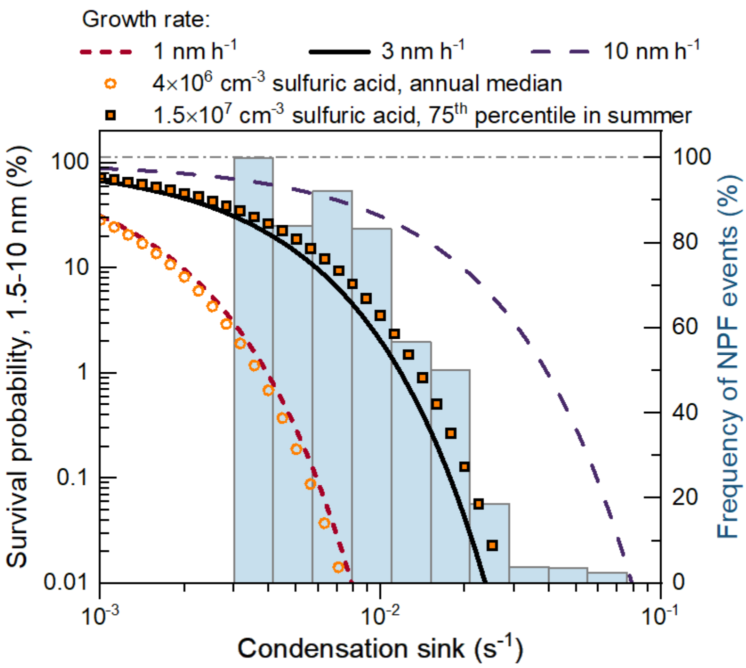

Figure S1. The theoretical survival probability of 1.5-10 nm new particles versus the measured frequency of new particle formation events in urban Beijing as a function of the condensation sink. The particle survival probability is calculated assuming an effective coagulation sink. The condensation sink characterizes the size-dependent coagulation sink during each new particle formation event. The NPF frequency is determined as the ratio of NPF days to all the measurement days within the given condensation sink range. The lower limits of the vertical survival probability axis in this figure and Figure 7 in the main text are determined according to the measured median survival probability of new particles and particle formation rate in urban Beijing.

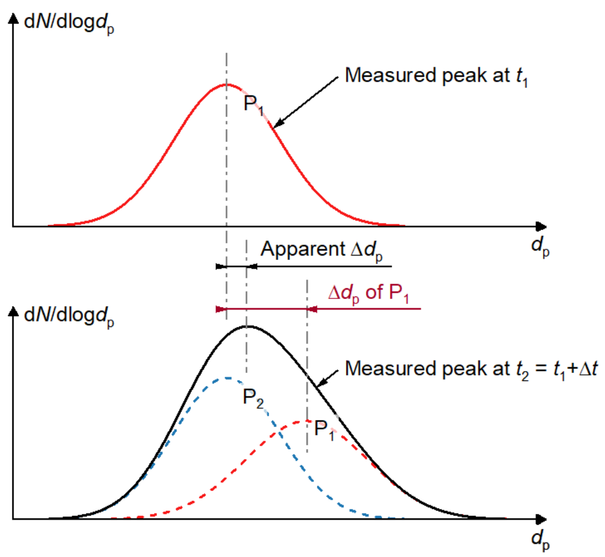

Figure S2. Schematic diagram for illustrating the underestimation of particle grow rate (GR) retrieved using the mode-fitting method. The mode-fitting method tracks the increase in a representative particle diameter (d_p) of a growing aerosol population (e.g., P_1) as a function of time (t). The representative d_p is usually the peak diameter of aerosol number size distribution ($dN/dlogd_p$). For instance, the peak diameter of aerosol population P_1 grows by Δd_p

after Δt, and GR can be estimated using $\Delta d_p/\Delta t$. This estimated GR can be further corrected to disentangle the influences of coagulation.

However, a particle source, e.g., nucleation, may cause a significant underestimation in the retrieved GR. As shown in this figure, assuming a new aerosol population P_2 is formed during Δt. The measured aerosol size distribution at t_2 is the sum of the distributions of P_1 and P_2. As a result, the apparent Δd_p calculated using the measured distributions is smaller than the Δd_p of P_1, causing an underestimated GR. A more complicated scenario with continuous particle formation and growth is given in Figure S2, which also shows an underestimation of the mode-fitting method due to the influence of particle source.

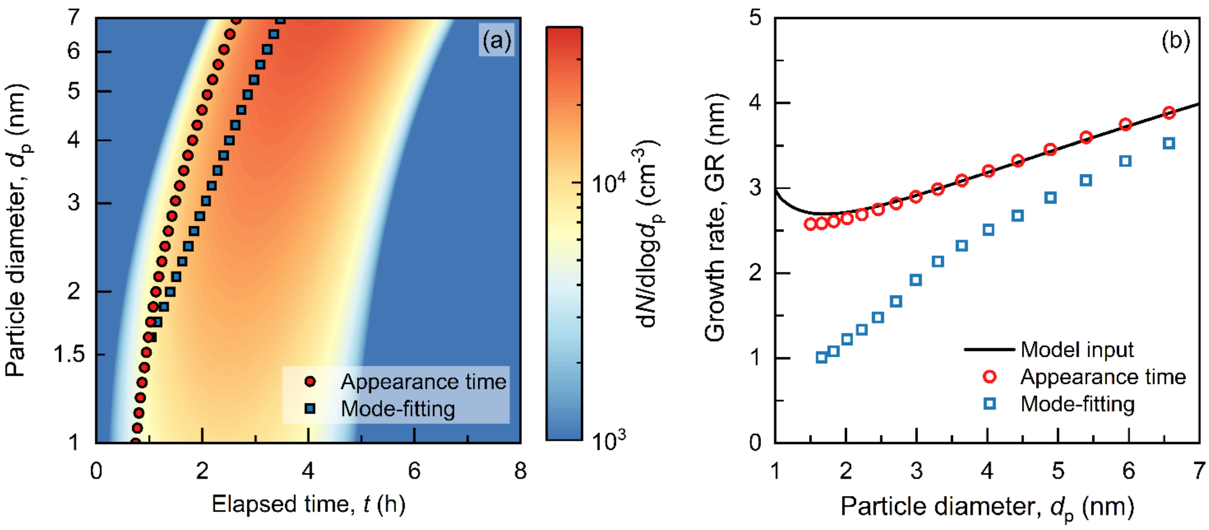

Figure S3. (a) Simulated particle size distribution ($dN/d\log d_p$) and diameter-time (d_p-t) relationship used for growth rate (GR) calculation. (b) Growth rates retrieved using the appearance time method and the mode-fitting method. The evolution of particle size distribution is simulated using a discrete aerosol model (Li and Cai, 2020). The input nucleation rate is time-dependent and the input particle growth rate (GR_{input}) is time-and-size dependent. The influences of coagulation on the GR retrieved using the appearance time method (GR_{app}) are corrected. The GR_{input} shown in panel (b) is calculated following the d_p-t relationship of the appearance time method. Due to the time-dependence of GR_{input}, the GR_{input} following d_p-t relationship of the mode-fitting method (not shown) is higher than that for the appearance time method, yet the difference is minor (5 % on average) for this simulation.

As shown in panel (b), GR_{app} is consistent with GR_{input}, indicating good accuracy of the appearance method for this simulation. The GR retrieved using the mode-fitting method (GR_{mode}) is significantly underestimated because of the influence of nucleation. This underestimation increases as the particle size decreases towards the critical cluster size, at which new particles are added to the simulation system.

Reference

Li, C., and Cai, R.: Tutorial: The discrete-sectional method to simulate an evolving aerosol, Journal of Aerosol Science, 150, 105615, 10.1016/j.jaerosci.2020.105615, 2020.