SUPPLEMENT C

In order to solve condensation and nucleation concurrently, we use a method developed by Jacobson (2005), which solves these processes over a discrete time step h. Here we have modified the method to solve these processes for two compounds, sulphuric acid and nucleating organic compound.

Jacobson (2005) assumed that the mass transfer rate of compound q in the smallest size bin is the sum of mass transfer rate of condensation and mass transfer rate of homogeneous nucleation (Equation (16.73) in Jacobson (2005)). Since in our model, the smallest diameter in the size distribution is 3 nm, we modify this equation so that the mass transfer rate in the smallest size bin is the sum of mass transfer rates of condensation $k_{q,cond}$ and mass transfer rate of 3 nm particle formation $k_{q,form}$.

$$k_{q,1,t-h} = k_{q,cond,1,t-h} + k_{q,form,1,t-h}. \tag{1}$$

The mass transfer rate of compound q during formation of 3 nm particles is analogous to homogeneous nucleation mass transfer rate (Equation (16.74) in Jacobson (2005)):

$$k_{q,form,1,t-h} = \frac{\rho_q v_1}{m_q} \left(\frac{J_{3,q}}{C_{q,t-h} - S'_{q,1,t-h} C_{q,s,1,t-h}} \right), \tag{2}$$

where ρ_q is the mass density, m_q is the molecular weight of compound q, v_1 is is the volume of a 3 nm particle, $C_{q,t-h}$ is the gas phase concentration, $S'_{q,1,t-h}$ is the Kelvin effect, and $C_{q,s,1,t-h}$ is the equilibrium concentration at the particle surface. We assume the equilibrium concentration to be zero for both condensing compounds. $J_{3,q}$ is the contribution of compound q (sulphuric acid SU and organic OC) to the formation rate of 3 nm particles, J_3

$$J_3 = J_{3,\mathrm{SU}} + J_{3,\mathrm{SU}} = \frac{(n^*_{\mathrm{SU}} + n_{3,\mathrm{SU}})v_{\mathrm{SU}}}{v_1} J_3 + \frac{(n^*_{\mathrm{OC}} + n_{3,\mathrm{OC}})v_{\mathrm{OC}}}{v_1} J_3 \tag{3}$$

where n^*_q is the number of molecules in the critical cluster, $n_{3,q}$ is the number of molecules in a 3 nm particle, v_q is the molecular volume. The number of molecules of individual compounds in a 3 nm particle is assumed follow the ratio of gas phase concentrations

$$n_{3,\mathrm{SU}} v_1 \approx \frac{C_{\mathrm{SU},t-h} v_{\mathrm{SU}}}{C_{\mathrm{SU},t-h} v_{\mathrm{SU}} C_{\mathrm{OC},t-h} v_{\mathrm{OC}}} (v_1 - v^*), \tag{4}$$

where v^* is the volume of the critical cluster.

Now, gas and size-resolved aerosol mole concentrations can be solved using equations (16.67)-(16.72) by Jacobson (2005). The new number concentration of particles in the smallest size bin is

$$n_{1,t} = n_{1,t-h} + \sum_{q=1}^{2} \mathrm{MAX}\left[(c_{q,1,t} - c_{q,1,t-h}) \frac{m_q}{\rho_q v_1} \frac{k_{q,form,1,t-h}}{k_{q,1,t-h}}, 0 \right], \qquad (5)$$

where c_q is the mole concentration of compound q in the particle phase.

Jacobson, M. Z. (2005). *Fundamentals of Atmospheric Modeling, Second Edition.* Cambridge University Press, New York.