[A large impact of cooking organic aerosol (COA) on particle hygroscopicity and CCN activity in urban atmosphere]

[Jieyao Liu[1], Fang Zhang[1], Weiqi Xu[2], Lu Chen[1], Jingye Ren[1], Sihui Jiang[1], Yele Sun[2], Zhanqing Li[3]]

[[1] College of Global Change and Earth System Science, Beijing Normal University, Beijing 100875, China

[2] State Key Laboratory of Atmospheric Boundary Layer Physics and Atmospheric Chemistry, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China

3 Earth System Science Interdisciplinary Center and Department of Atmospheric and Oceanic Science, University of Maryland, College Park, MD, USA]

Contents of this file

Methods

The size-resolved κ from the measured hygroscopic growth factor (κ_{gf}) is calculated according to κ-Köhler Theory (Petters and Kreidenweis, 2007),

$$\kappa_{gf} = (Gf^3 - 1)(\frac{\exp\left(\frac{A}{D_d Gf}\right)}{RH} - 1) \quad , \tag{1}$$

$$A = \frac{4\sigma_{s/a} M_w}{RT\rho_w} \quad , \tag{2}$$

where Gf is hygroscopic growth factor measured by the Hygroscopic Tandem Differential Mobility Analyzer (HTDMA) system, RH is the relative humidity in the HTDMA (90%), D_d is the dry diameter of the particles, $\sigma_{s/a}$ is the surface tension of the solution/air (assumed to be the surface tension of pure water, $\sigma_{s/a} = 0.0728$ N m^{-2}), R is the universal gas constant, T is the absolute temperature, M_w is the molecular weight of water, and ρ_w is the density of water. The bulk κ of particles can be obtained by averaging size-resolved κ.

From the mixing rule of chemical volume fractions according to Petters and Kreidenweis (2007) (equation 3), the bulk κ of organic components, κ_{org} (equation 4) is derived:

$$\kappa_{gf} = \kappa_{chem} = \sum_i \varepsilon_i \kappa_i \quad , \tag{3}$$

$$\kappa_{org} = (\kappa_{gf} - \varepsilon_{inorg}\kappa_{inorg} - \varepsilon_{BC}\kappa_{BC})/\varepsilon_{org} \quad , \tag{4}$$

where κ_i and ε_i are the hygroscopicity parameter and volume fraction for the individual (dry) component in the mixture, respectively. According to the measured mass concentration of inorganic ions combined with the ion pairing scheme (Gysel et al., 2009), the molarity of main inorganic chemical components was obtained. The

inorganic components mainly considered $(NH_4)_2SO_4$ and NH_4NO_3 (Petters and Kreidenweis, 2007). The values of κ are 0.48 for $(NH_4)_2SO_4$ and 0.58 for NH_4NO_3 (Petters and Kreidenweis, 2007). We derived the volume fraction of each species by dividing mass concentration by the density. The density is 1.77 g cm^{-3} for $(NH_4)_2SO_4$ and 1.72 g cm^{-3} for NH_4NO_3. The volume of organic matter and black carbon (BC) in aerosols were calculated according to their mass concentration and density. The densities of primary organic aerosol and secondary organic aerosol were assumed to be 1.0 g cm^{-3} and 1.4 g cm^{-3}, respectively. The κ and density of BC were assumed to be 0 and 1.7 g cm^{-3}.
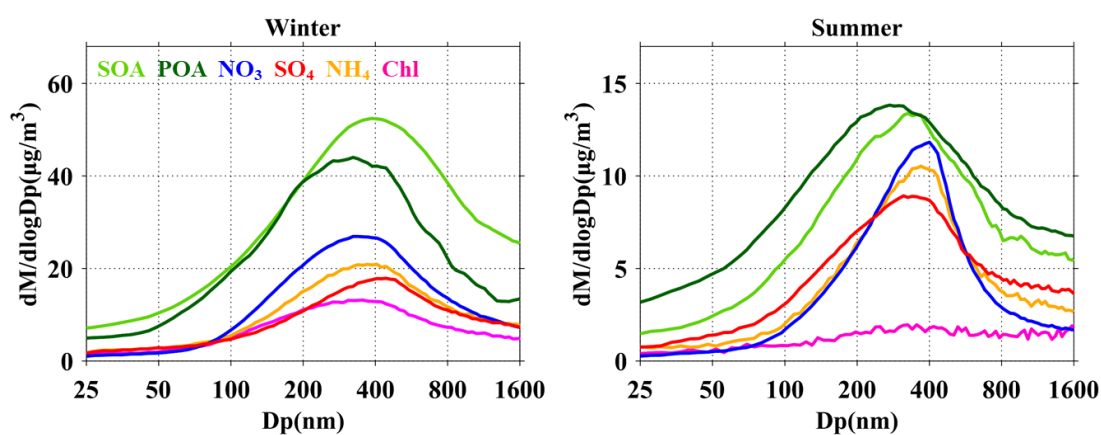

Figure S1. Average size distributions of PM$_1$ species, primary organic aerosol (POA), and secondary organic aerosol (SOA) measured in winter and summer.
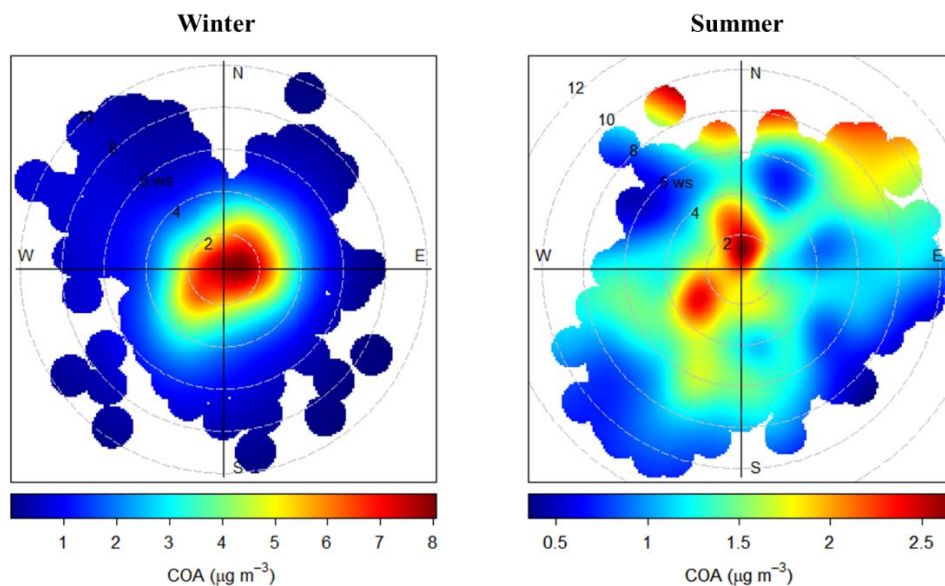
Figure S2. Bivariate polar plot of cooking organic aerosol (COA) concentrations (μg m^{-3}) in winter and summer. Wind direction (WD) and wind speed (WS) measured 100 m above the ground.
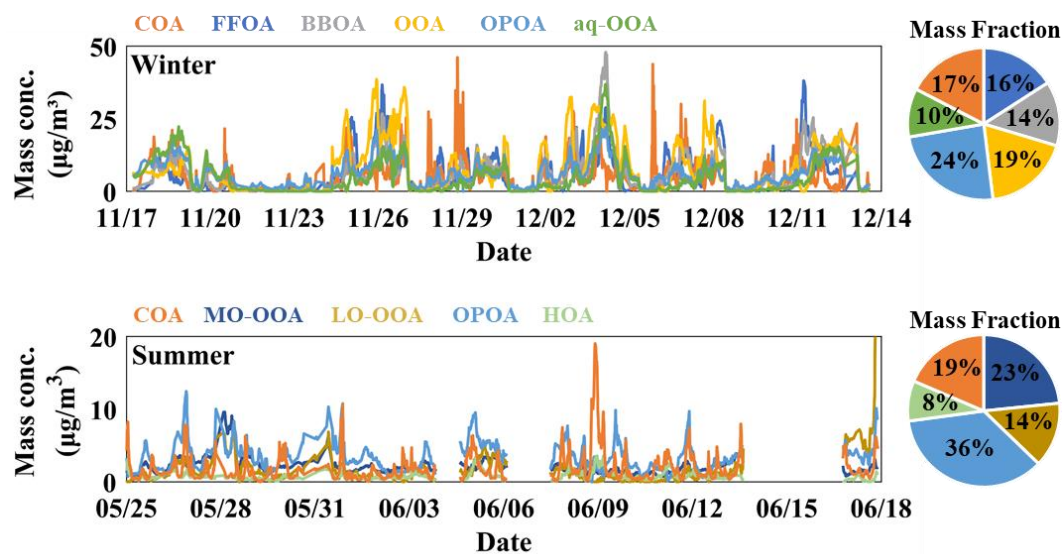

Figure S3. Winter and summer time series of mass concentration of each organic aerosol (OA) factor. The pie charts represent the mean mass fraction of OA. COA = cooking OA; FFOA = fossil fuel-related OA; BBOA = biomass burning OA; OOA= oxygenated OA; OPOA = oxidized primary OA; aq-OOA= aqueous-phase OOA; MO-OOA = more-oxidized oxygenated OA; LO-OOA= less-oxidized oxygenated OA;
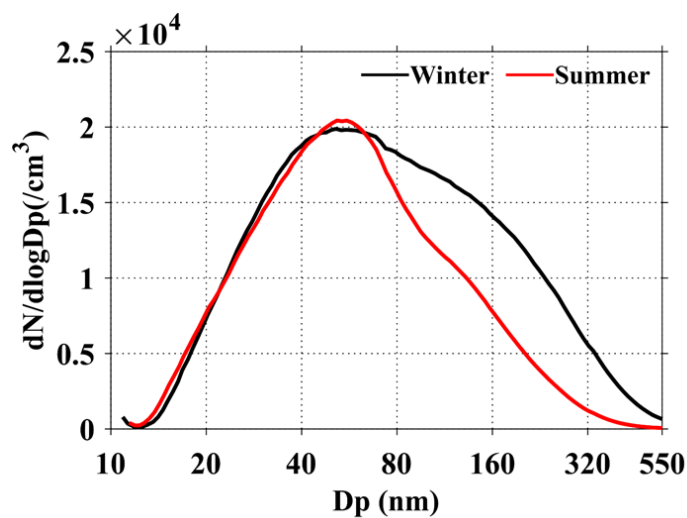
HOA = hydrocarbon OA.

Figure S4. Average distribution of particle number spectrum during dinner time (18:00-

21:00 local time) in winter and summer.

References

Gysel, M., McFiggans, G. B., & Coe, H. (2009). Inversion of tandem differential

mobility analyser (TDMA) measurements. *Journal of Aerosol Science*, *40*(2), 134-

151. https://doi.org/10.1016/j.jaerosci.2008.07.013

Petters, M. D., & Kreidenweis, S. M. (2007). A single parameter representation of

hygroscopic growth and cloud condensation nucleus activity. *Atmospheric Chemistry*

and Physics, *7*(8), 1961-1971. https://doi.org/10.5194/acp-7-1961-2007