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The evolution of aerosol mixing state derived from a field campaign in Beijing: implications for particle aging timescales in urban atmospheres

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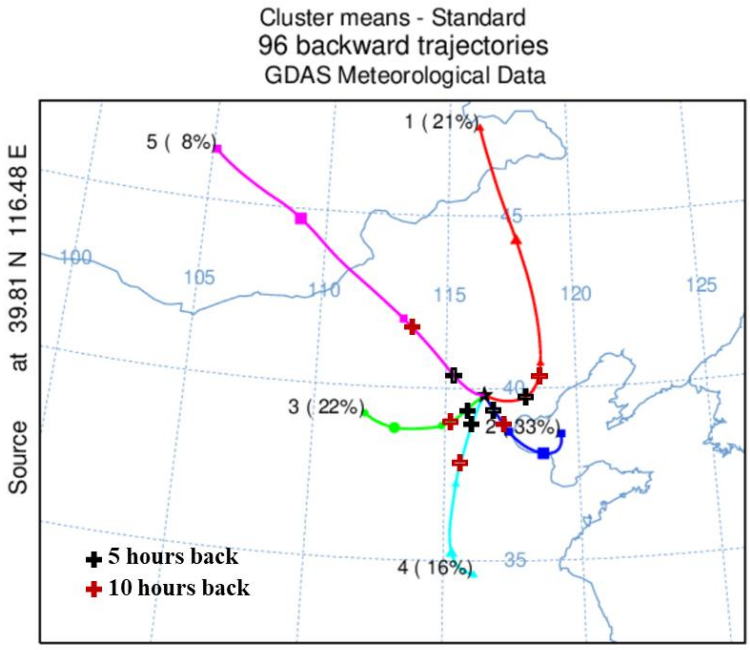

Figure S1. The 48-hour mean air mass backward trajectories for five clusters arriving at the sampling site in Beijing. The black and red crosses indicate the locations of the air parcels 5 and 10 hours prior to the measurement site, respectively.

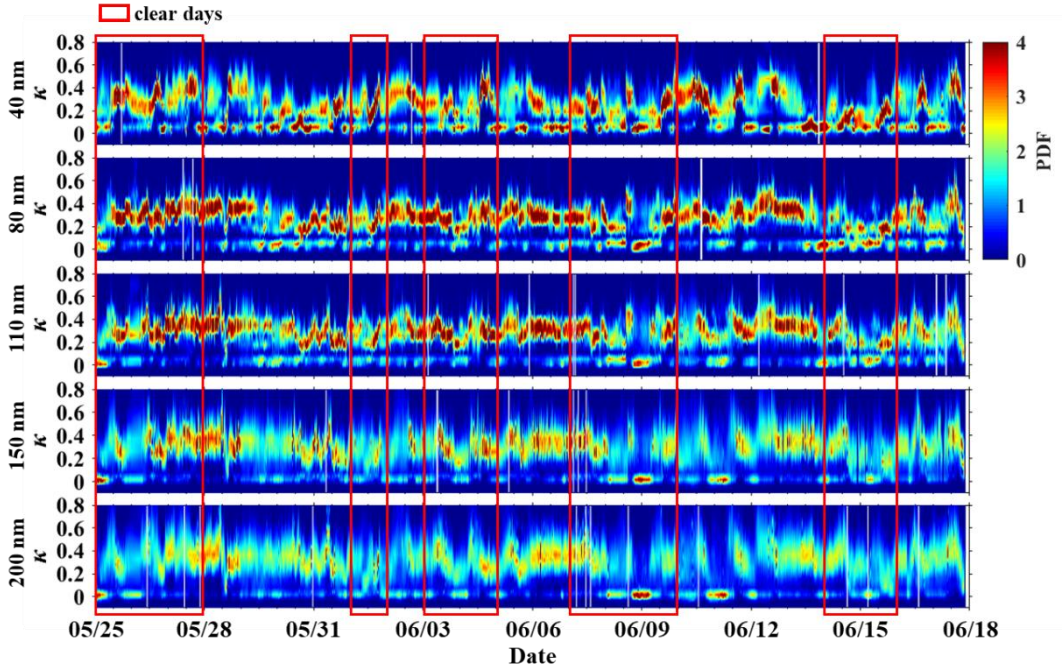

Figure S2. Time series of the probability density function of hygroscopic parameter (κ-PDF). Red rectangles denote clear days, and others are cloudy days.

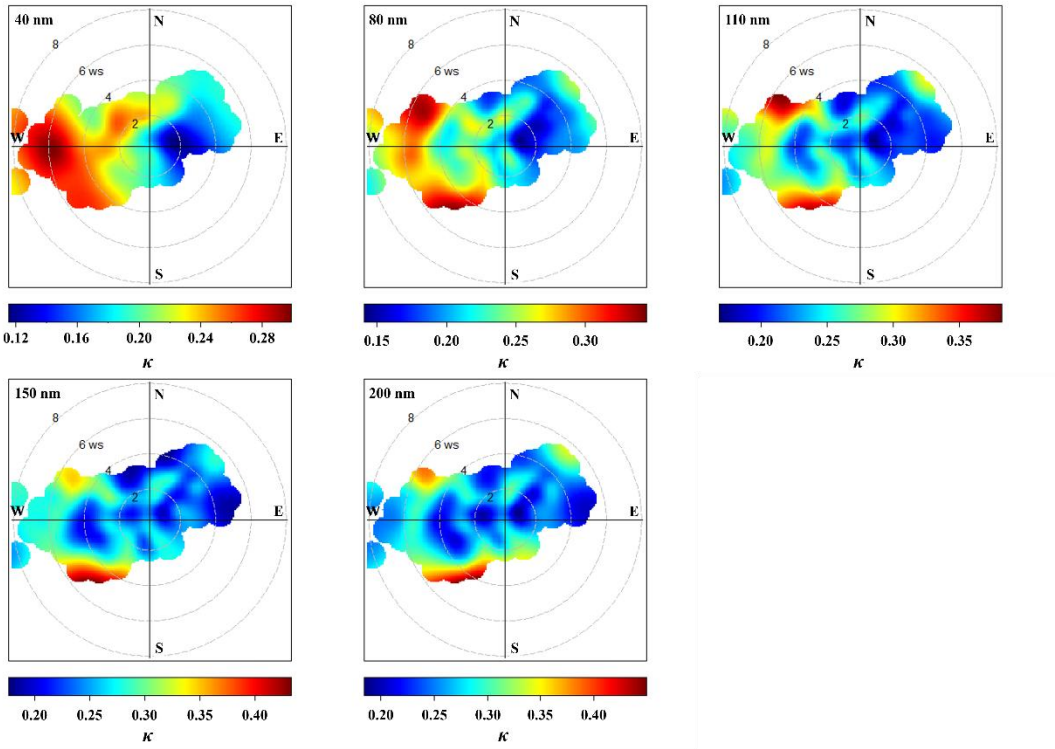

Figure S3. Bivariate polar plot of the κ of particles at the five sizes during the campaign.

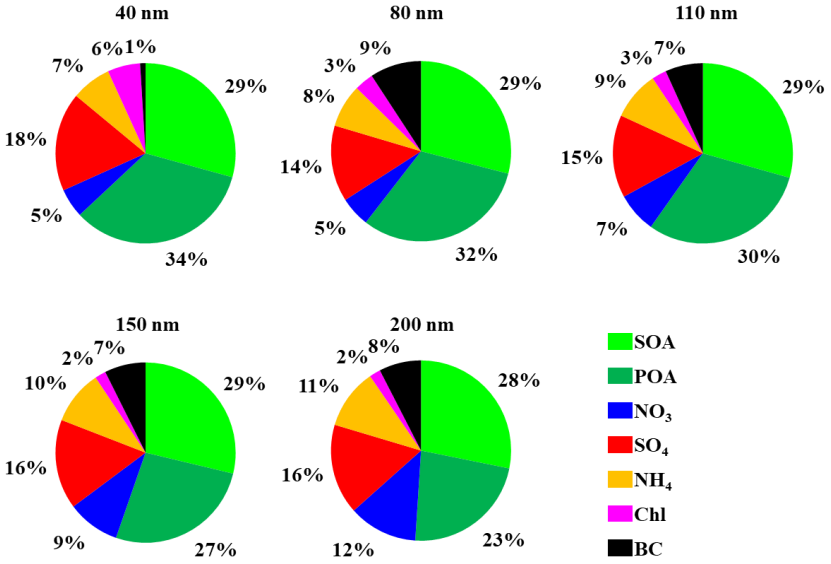

Figure S4. The size-resolved chemical mass fraction at five particle sizes.

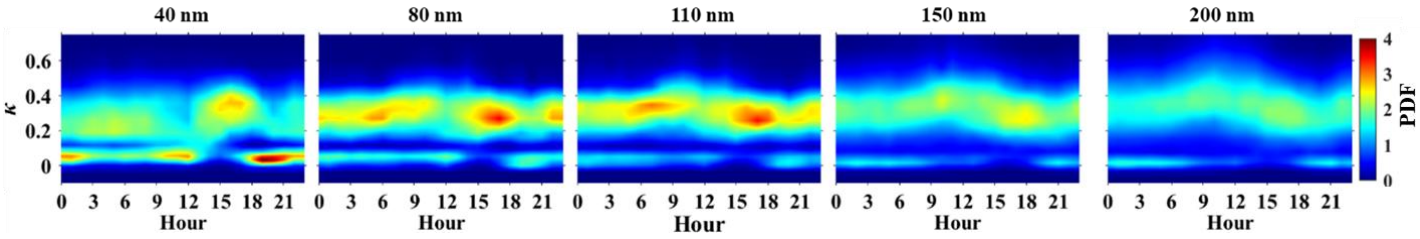

Figure S5. Campaign-averaged diurnal variations in κ-PDFs for all measured particle sizes (40–200 nm) at Beijing site.

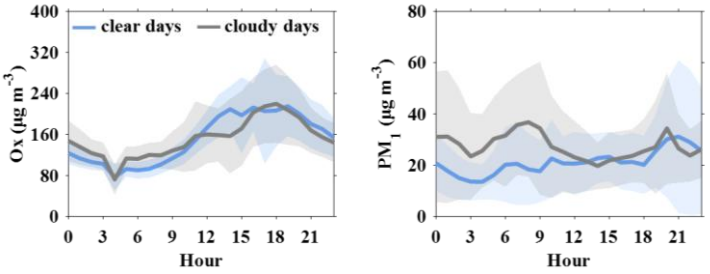

Figure S6. Diurnal variations of the pollutant concentrations of O_x ($O_x = NO_2 + O_3$) and PM_1 mass concentrations on clear and cloudy days.

Table S1. The aging timescale of particles reported in literatures.

Region	Method	Aerosol type	Aging timescale	Aging indicators	Rreference
global (model default)	GCM model	carbonaceous aerosols	1.15 days	hygroscopicity	Cooke et al., 2002
	GISS-GCM model	carbonaceous aerosols	1.15 days	hygroscopicity	Chung and Seinfeld, 2002
	GISS-GCM model	BC	1 day	hygroscopicity	Koch and Hansen, 2005
	TOMAS model	carbonaceous aerosols	1.5 days	hygroscopicity	Pierce et al., 2007
	GEOS-Chem model	carbonaceous aerosols	1.2 days	hygroscopicity	Yu and Luo, 2009
	GEOS-4 model	carbonaceous aerosols	2.5 days	hygroscopicity	Colarco et al., 2010
	GFDL-AM3 model	BC	20 days	the rate of hygroscopic aging is depended on the sulfuric acid gas concentration	Liu et al., 2011
	RegCM4 model	carbonaceous aerosols	1.15 days	hygroscopicity	Ghosh et al., 2021
south-western Germany	KAMM/DRAIS model	soot	daytime: 2-8 h nighttime: 10-40 h	mixing state	Riemer et al., 2004
global	GEOS-Chem model	carbonaceous aerosols	3.1 days	hygroscopicity	Huang et al., 2013
central-eastern China	NAQPMS+APM model	BC	12 h-7 days	hygroscopicity	Chen et al., 2017
Beijing			2 h		
south Asia	RegCM4 model	carbonaceous aerosols	7.6-167.6 h	hygroscopicity	Ghosh et al., 2021
Mexico City	Field measurement ATOFMS	soot	3 h	optical properties	Moffet and Prather, 2009
California	Field measurement SP2	BC	~4 h	fraction of thickly coated rBC	Akagi et al., 2012
Los Angeles	Field measurement SP2	BC	~3 h	fraction of thickly coated rBC	Krasowsky et al., 2016

Beijing Houston	Environmental chamber approach	BC	2.3 h & 4.6 h 9 h & 18 h	morphology & absorption amplification	Peng et al., 2016

Rreference:

Akagi, S. K., Craven, J. S., Taylor, J. W., McMeeking, G. R., Yokelson, R. J., Burling, I. R., Urbanski, S. P., Wold, C. E., Seinfeld, J. H., Coe, H., Alvarado, M. J., and Weise, D. R.: Evolution of trace gases and particles emitted by a chaparral fire in California, Atmos. Chem. Phys., 12, 1397–1421, https://doi.org/10.5194/acp-12-1397-2012, 2012.

Cooke, W., Ramaswamy, V., and Kasibhatla, P.: A general circulation model study of the global carbonaceous aerosol distribution, J. Geophys. Res.-Atmos., 107(D16), https://doi.org/10.1029/2001JD001274, 2002.

Colarco, P., Silva, A., Chin, M., and Diehl, T.: Online simulations of global aerosol distributions in the NASA GEOS-4 model and comparisons to satellite and ground - based aerosol optical depth, J. Geophys. Res.-Atmos., 115, D14207, https://doi.org/10.1029/2009JD012820, 2010.

Chen, X., Wang, Z., Yu, F., Pan, X., Li, J., Ge, B., Wang, Z., Hu, M., Yang, W., and Chen, H.: Estimation of atmospheric aging time of black carbon particles in the polluted atmosphere over central-eastern China using microphysical process analysis in regional chemical transport model, Atmos. Environ., 163, 44–56, https://doi.org/10.1016/j.atmosenv.2017.05.016, 2017.

Chung, S., and Seinfeld, J.: Global distribution and climate forcing of carbonaceous aerosols, J. Geophys. Res.-Atmos., 107(D19), 4407, https://doi.org/10.1029/2001JD001397, 2002.

Ghosh, S., Riemer, N., Giuliani, G., Giorgi, F., Ganguly, D., and Dey, S.: Sensitivity of carbonaceous aerosol properties to the implementation of a dynamic aging parameterization in the regional climate model RegCM, J. Geophys. Res.-Atmos., 126, https://doi.org/10.1029/2020JD033613, 2021.

Huang, Y., Wu, S., Dubey, M. K., and French, N. H. F.: Impact of aging mechanism on model simulated carbonaceous aerosols, Atmos. Chem. Phys., 13, 6329–6343, https://doi.org/10.5194/acp-13-6329-2013, 2013.

Koch, D., Hansen, J.: Distant origins of Arctic black carbon: A Goddard Institute for Space Studies Model experiment, J. Geophys. Res.-Atmos., 110, D04204, https://doi.org/10.1029/2004JD005296, 2005.

Krasowsky, T., McMeeking, G., Wang, D., Sioutas, C., Ban-Weiss, G.: Measurements of the impact of atmospheric aging on physical and optical properties of ambient black carbon particles in Los Angeles, Atmos. Environ., 142, 496-504, https://doi.org/10.1016/j.atmosenv.2016.08.010, 2016.

Liu, J., Fan, S., Horowitz, L., and Levy II, H.: Evaluation of factors controlling long - range transport of black carbon to the Arctic, J. Geophys. Res.-Atmos., 116, D04307, https://doi.org/10.1029/2010JD015145, 2011.

Moffet, R., and Prather, K.: In-situ measurements of the mixing state and optical properties of soot with implications for radiative forcing estimates, P. Natl. Acad. Sci. USA, 106(29), 11872-11877, https://doi.org/10.1073/pnas.0900040106, 2009.

Peng, J. F., Hu, M., Guo, S., Du, Z. F., Zheng, J., Shang, D. J., Zamora, M., Zeng, L. M., Shao, M., Wu, Y. S., Zheng, J., Wang, Y., Glen, C., Collins, D., Molina, M., and Zhang, R. Y.: Markedly enhanced absorption, and direct radiative forcing of black carbon under polluted urban environments, P. Natl. Acad. Sci. USA, 113, 4266–4271, https://doi.org/10.1073/pnas.1602310113, 2016.

Pierce, J. R., Chen, K., and Adams, P. J.: Contribution of primary carbonaceous aerosol to cloud condensation nuclei: processes and uncertainties evaluated with a global aerosol microphysics model, Atmos. Chem. Phys., 7, 5447–5466, https://doi.org/10.5194/acp-7-5447-2007, 2007.

Riemer, N., Vogel, H., and Vogel, B.: Soot aging time scales in polluted regions during day and night, Atmos. Chem. Phys., 4, 1885–1893, https://doi.org/10.5194/acp-4-1885-2004, 2004.

Yu, F. and Luo, G.: Simulation of particle size distribution with a global aerosol model: contribution of nucleation to aerosol and CCN number concentrations, Atmos. Chem. Phys., 9, 7691–7710, https://doi.org/10.5194/acp-9-7691-2009, 2009.