Supplementary Information

Formation, radiative forcing, and climatic effects of regional severe haze

Yun Lin^{1,2*}, Yuan Wang^{3*}, Bowen Pan^{1,4}, Jiayi Hu^{1,5}, Song Guo⁶, Misti Levy Zamora^{1,7},
Pengfei Tian^{1,8}, Qiong Su⁹, Yuemeng Ji^{1,10}, Jiayun Zhao¹¹, Mario Gomez-Hernandez¹¹, Min
Hu⁶, Renyi Zhang^{1,11*}

¹Department of Atmospheric Sciences, Texas A&M University, College Station, TX 77843, USA

²Joint Institute for Regional Earth System Science and Engineering (JIFRESSE), University of California at Los Angeles, Los Angeles, CA 90064

³Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125, USA

⁴Department of Atmospheric Science, Colorado State University, Fort Collins, CO, 80521, USA

⁵Cooperative Institute for Mesoscale Meteorological Studies, NOAA/OAR National Severe Storms Laboratory, Norman, OK, USA

⁶State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing, 10087, P.R. China

⁷Department of Environmental Health and Engineering, Johns Hopkins Bloomberg School of Public Health, 615 N. Wolfe St., Baltimore, MD 21205, USA

⁸Key Laboratory for Semi-Arid Climate Change of the Ministry of Education, College of Atmospheric Sciences, Lanzhou University, Lanzhou 730000, P. R. China

⁹Water Management & Hydrological Science, Texas A&M University, College Station, TX 77843, USA

¹⁰Guangzhou Key Laboratory of Environmental Catalysis and Pollution Control, School of Environmental Science and Engineering, Institute of Environmental Health and Pollution Control, Guangdong University of Technology, Guangzhou 510006, China

¹¹Department of Chemistry, Texas A&M University, College Station, TX 77843, USA

Correspondence: yunlin@ucla.edu; Yuan.Wang@caltech.edu; renyi-zhang@tamu.edu

Figure S1. Aerosol size distributions from observations and for modeling inputs. Aerosol size distributions taken from measurements on 25 and 28 September (a) and 2 and 5 October (b), 2013 (blue and red dot lines, respectively) and used as inputs for the simulations of the clean and the polluted periods (blue and red solid lines, respectively).

Figure S2. Comparison of model simulations with sounding observations. (a) temperature profile at 12Z 28 September 2013; (b) RH profiles at 12Z 28 September 2013. Black open circles denote sounding profiles and solid lines denote the simulations. Sounding data are available at <http://weather.uwyo.edu/upperair/sounding.html>.

Figure S3. MODIS AOD (a) and surface solar radiation (SSR) (b) averaged over all the hazy days in 2013. The megacities of Beijing (BJ), Baoding (BD) and Shijiazhuang (SJZ) are marked as squares.

Figure S4. Temporal evolutions of downward (a and e) and upward (b and f) shortwave radiation, and latent (c and g) and sensible (d and h) heat fluxes under different aerosol pollution conditions. Panels (a-d) are for EP1 and (e-h) for EP2. Blue solid lines represent clean case, red dot lines represent non-BC case, red dash lines represent fresh-BC case, and red solid lines represent the aged-BC case.

Table S1. Comparisons of aerosol forcing and BC forcing between this study and other studies.

Aerosol radiative forcing at TOA (W/m ²)						
Source	Q2003	R2007	L2009	W2009	D2016	This study
Method	Model+Obs.	Model	Obs.	Model+Obs	Model	Model
Region	China	Beijing	Xianghe	Beijing	China	Beijing
AOD	0.5~0.8	0.65	>0.2	1.78	-	3.1
Forcing	-1~-14	-20.7	2.4	-21	2.4	-5.6~-5.9
BC radiative forcing at TOA (W/m ²)						
Source	B2013	P2016	G2016	D2016		This study
Method	Model	Model	Model+Obs	Model		Model
Region	China	Beijing	Xianghe	Beijing		Beijing
Forcing	0.71	0.77	0.2~1	35.8		20.1~31.2

Q2003: Qian et al. (2003)
R2007: Ramanathan et al. (2007).
L2009: Li et al. (2007).
W2009: Wang et al. (2009).
D2016: Ding et al. (2016).
B2013: Bond et al. (2013).
P2016: Peng et al. (2016).
G2016: Gustafsson and Ramanathan (2016).