

Supplementary Material

Sampling and chemical components analysis

The sampling site was in Beijing located on the rooftop of a building at Beijing Normal University (BNU), about 45 m above the ground level; the sampling site in Tangshan was located on rooftop of the building of Tangshan Municipal Environmental Monitoring Center (TMEMC), about 20 m above the ground level (Fig. 2). The PM_{2.5} samples were simultaneously collected on the quartz filters (Whatman Inc., Maidstone, UK) and the Whatmans 41 filters (Whatman Inc., Maidstone, UK) using samplers with flow rate of 100 L min⁻¹, respectively. The sampling was on a 24-h basis. The quartz and Whatmans 41 filters were used for the OC/EC and elements/ions analysis, respectively. The samples collected were put in the polyethylene plastic bags right after sampling and reserved in a refrigerator. All the filters were weighed before and after sampling under constant temperature (20±5 °C) and relative humidity (40±2%). One or two respective months in per season were selected for the PM_{2.5} samplings. A total number of 353 and 331 samples were collected in Beijing and Tangshan, respectively (Table S1).

Table S1 The sampling date and sample numbers in Beijing and Tangshan

City	Season	Sampling date	Sample number
Beijing	Spring	2011.03.11-2011.03.22	75
		2011.04.09-2011.04.30	
		2012.03.17-2012.03.24	
		2013.03.30-2013.05.07	
	Summer	2011.07.20-2011.07.29	68
		2011.08.07-2011.08.30	
		2012.07.02-2012.07.30	
		2013.07.01-2013.08.02	

	Autumn	2011.10.09-2011.11.15 2012.10.04-2012.11.02 2013.10.06-2013.10.28	82
	Winter	2010.12.09-2010.12.31 2011.02.20-2011.02.28 2011.11.16-2012.02.01 2013.01.04-2013.02.15	128
	Spring	2011.03.01-2011.03.24 2011.04.11-2011.04.28 2013.04.09-2013.05.08	64
	Summer	2011.06.20-2011.06.30 2011.07.26-2011.07.29 2011.08.18-2011.08.31 2012.07.02-2012.07.31 2013.07.02-2013.07.26	71
Tangshan	Autumn	2011.09.02-2011.09.05 2011.10.10-2011.10.31 2011.11.07-2011.11.15 2012.10.05-2012.11.08	66
	Winter	2010.12.08-2011.01.27 2011.02.21-2011.02.28 2011.12.02-2011.12.31 2012.01.04-2012.01.29 2013.01.05-2013.02.04	130

Ions including SO_4^{2-} , NO_3^- and NH_4^+ were analyzed by ion chromatograph (IC, Metrohm 861 Advanced Compact IC). Twenty-three elements were measured based on ICP-MS (7500a, Thermo) (for Na, Mg, Al, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Sr, Cd, Sb, Ce, Eu, and Pb) and ICP-AES (Ultima, Jobin Yvon Co., Ltd., France) (for S). The uncertainty range was within 10% for most of the elements, except for Se, As and Sb ($\pm 15\%$) (Hsu *et al.*, 2009, 2010; Zhang *et al.*, 2007). The OC and EC were measured using a Thermal/Optical Carbon Analyzer (DRI, Model

2001). The primary organic carbon (POC) and secondary organic carbon (SOC) were estimated by the minimum ratio of OC/EC. The primary organic aerosol (POA) and SOA were further calculated by multiplying the POC and SOC by the often-adopted factor 1.4. This is to account for the unmeasured atoms, such as hydrogen, oxygen, and nitrogen in organic materials (Yang *et al.*, 2011).

Model verification

Because the observation concentration for NH₃ and VOCs could not be obtained, the simulation performance of WRF-CAMx-PSAT could not be verified. The comparison between the simulation concentrations obtained by WRF-CAMx-PSAT and the observation results for SO₂ and NO₂ in Beijing and Tangshan was listed in Table S2. It could be found that the bias between the simulation and observation concentration was ~ 10.0%. The correlation coefficient (R) between simulation and observation result was more than 0.8 for SO₂ and NO₂ in Beijing and Tangshan. This indicated that the model performance was acceptable in Beijing and Tangshan.

Table S2 Comparison between simulation and observation results for SO₂ and NO₂

Area	Beijing		Tangshan	
	SO ₂	NO ₂	SO ₂	NO ₂
Pollutant				
Observation mean (μg/m ³)	26.1	52.4	109.2	66.3
Simulation mean (μg/m ³)	24.1	48.3	96.3	59.8
Bias ^a	-7.8%	-7.8%	-11.9%	-9.7%
RMSE ^b (μg/m ³)	8.5	9.7	25.7	14.1

^a Bias=(Observation-Simulation)/Simulation*100%

$$^b \text{RMSE} = \sqrt{\frac{\sum_i^n (C_{\text{simulation},i} - C_{\text{observation},i})^2}{n}}$$

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