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Supplement of

Simulated impacts of vertical distributions of black carbon aerosol on meteorology and $PM_{2.5}$ concentrations in Beijing during severe haze events

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Table S1. The values of *hs* for each flight.

Flight date and time	*hs* value
2016/12/11 16:20	N/A
2016/12/12 13:05	0.82
2016/12/12 15:39	0.96
2016/12/16 15:47	0.53
2016/12/17 15:59	0.35
2016/12/18 14:22	0.79
2016/12/19 16:09	0.48

Table S2. Statistical metrics for $PM_{2.5}$, SO_2, NO_2, CO and O_3 on clean days and in two haze events.

Periods	Variables	SIM	OBS	R	MB	NMB	MFB
Clean days	$PM_{2.5}$ (μg m^{-3})	64.4	35.3	0.15	29.1	82.5%	84.1%
	SO_2 (ppbv)	5.5	3.6	-0.02	1.9	53.4%	18.8%
	NO_2 (ppbv)	28.8	20.8	0.55	7.9	38.0%	38.5%
	CO (ppmv)	11.0	14.2	0.64	-3.1	-22.0%	-50.7%
	O_3 (ppbv)	0.9	0.7	0.18	0.2	30.0%	37.6%
Two haze events	$PM_{2.5}$ (μg m^{-3})	186.1	179.8	0.64	6.3	3.5%	8.0%
	SO_2 (ppbv)	9.1	9.9	0.29	-0.7	-7.4%	-13.5%
	NO_2 (ppbv)	57.2	48.2	0.70	8.9	18.5%	12.5%
	CO (ppmv)	4.6	3.2	0.88	1.4	43.0%	-39.4%
	O_3 (ppbv)	2.2	2.4	0.30	-0.2	-9.3%	-8.4%

Table S3. Statistical analyses of the performance of CTRL (with original BC vertical profiles) and that of VerBC_obs (with modified BC vertical profiles) in simulating meteorological parameters. The values in RED indicate better performance in VerBC_obs than in CTRL.

		Obs/Sim			MB		NMB	
		Obs	CTRL	VerBC_obs	CTRL	VerBC_obs	CTRL	VerBC_obs
The first pollution event	T2 (℃)	0.2	0.4	0.2	0.2	0.0	N.A.	N.A.
	RH2 (%)	65.5	65.6	67.7	0.0	2.2	0.0%	3.3%
	WS10 (m s^{-1})	1.8	1.4	1.8	-0.4	-0.1	-22.9%	-2.6%
	WD10 (°)	105.2	109.0	116.1	3.8	10.9	3.6%	10.4%
	PBLH (m)	152.2	197.2	181.2	45.0	29.0	29.6%	19.0%
The second pollution event	T2 (℃)	-1.1	0.0	0.2	1.2	1.3	N.A.	N.A.
	RH2 (%)	65.3	55.2	57.3	-10.1	-8.0	-15.5%	-12.3%
	WS10 (m s^{-1})	1.4	1.4	1.1	0.0	-0.3	-0.1%	-19.7%
	WD10 (°)	196.2	165.7	173.0	-30.5	-23.2	-15.5%	-11.8%
	PBLH (m)	101.9	145.6	135.8	43.7	33.9	42.9%	33.3%

Table S4. Statistical analyses of the performance of CTRL (with original BC vertical profiles) and that of VerBC_obs (with modified BC vertical profiles) in simulating $PM_{2.5}$ concentrations. The values in RED indicate better performance in VerBC_obs than in CTRL.

	Obs/Sim			R		MB		NMB	
	Obs	CTRL	VerBC_obs	CTRL	VerBC_obs	CTRL	VerBC_obs	CTRL	VerBC_obs
Dec 11	159.7	214.1	235.9	0.81	0.93	54.4	76.2	34.1%	47.7%
Dec 12	212.3	185.9	189.6	0.04	0.24	-26.4	-22.7	-12.4%	-10.7%
Dec 16	100.7	117.7	115.3	0.56	0.65	17.0	14.6	16.9%	14.5%
Dec 17	184.7	190.8	192.9	0.63	0.82	6.0	8.2	3.3%	4.4%
Dec 18	219.5	190.4	199.8	0.38	0.38	-29.1	-19.6	-13.2%	-9.0%
Dec 19	208.4	217.8	220.5	0.84	0.89	9.4	12.1	4.5%	5.8%

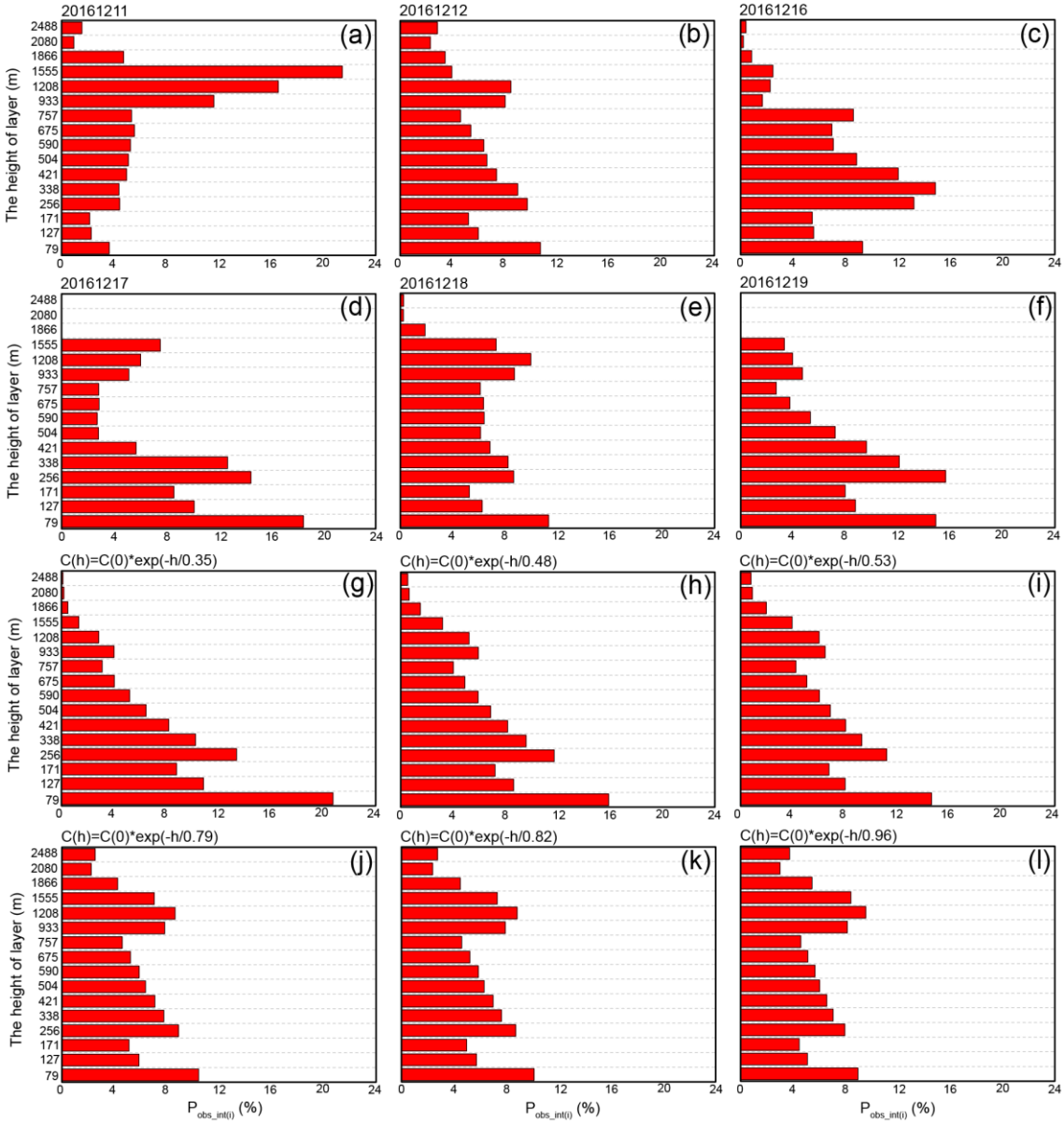
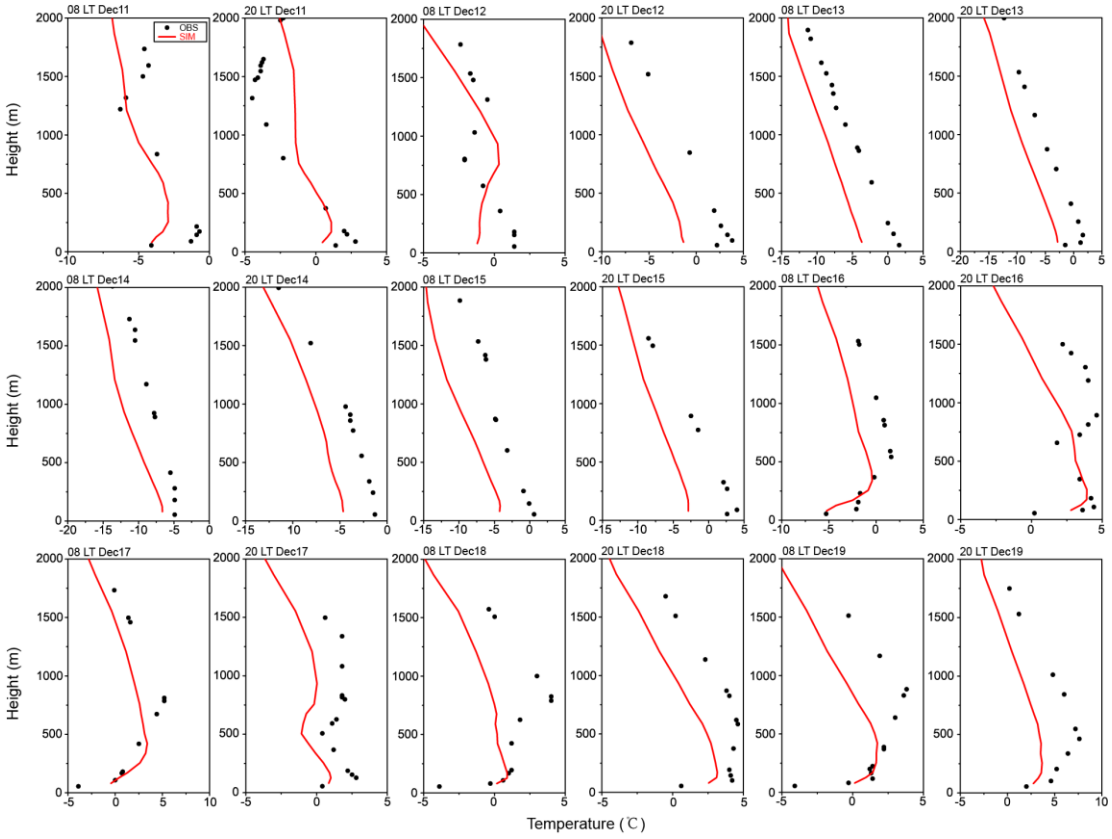


Figure S1. The calculated percentage of BC mass column burden in each layer below 2488 m in the model during the severe haze events by observed BC vertical profiles (a-f) and different exponential decline functions (g-l).



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44 **Figure S2.** Observed (black dot) and simulated (red line) temperature (℃) profiles in

45 Beijing at 8 am and 8 pm LT during 11-19 December 2016.

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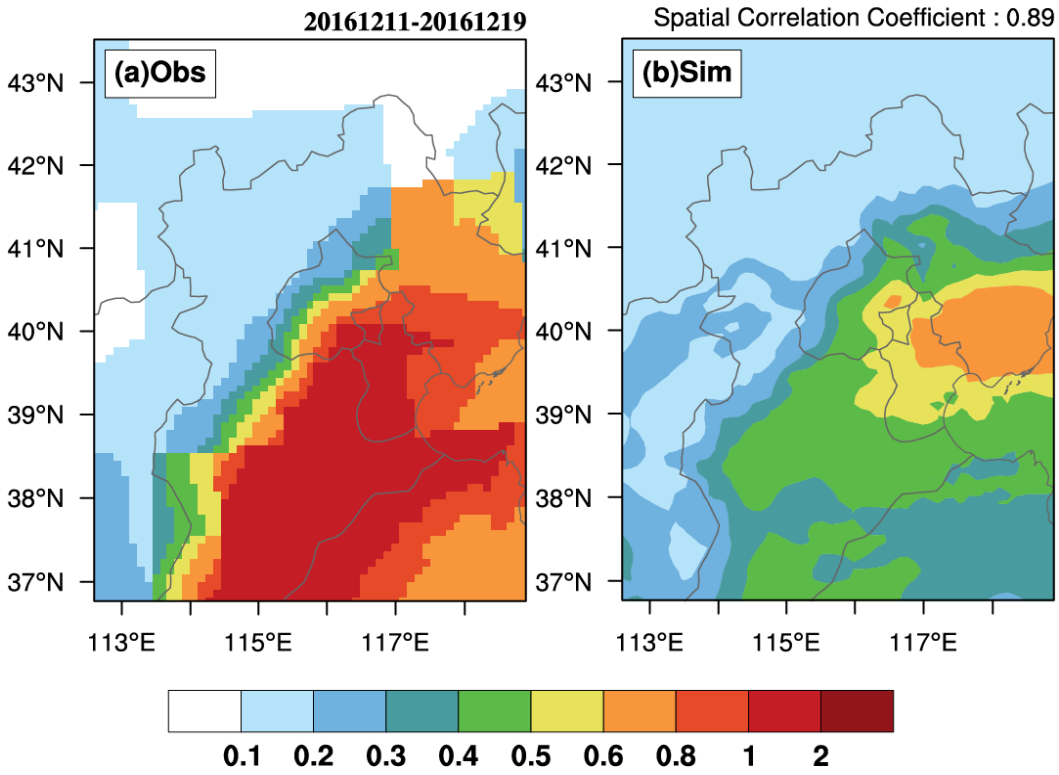

Figure S3. Horizontal distribution of observed and simulated AOD at 550 nm averaged 11-19 December 2016.

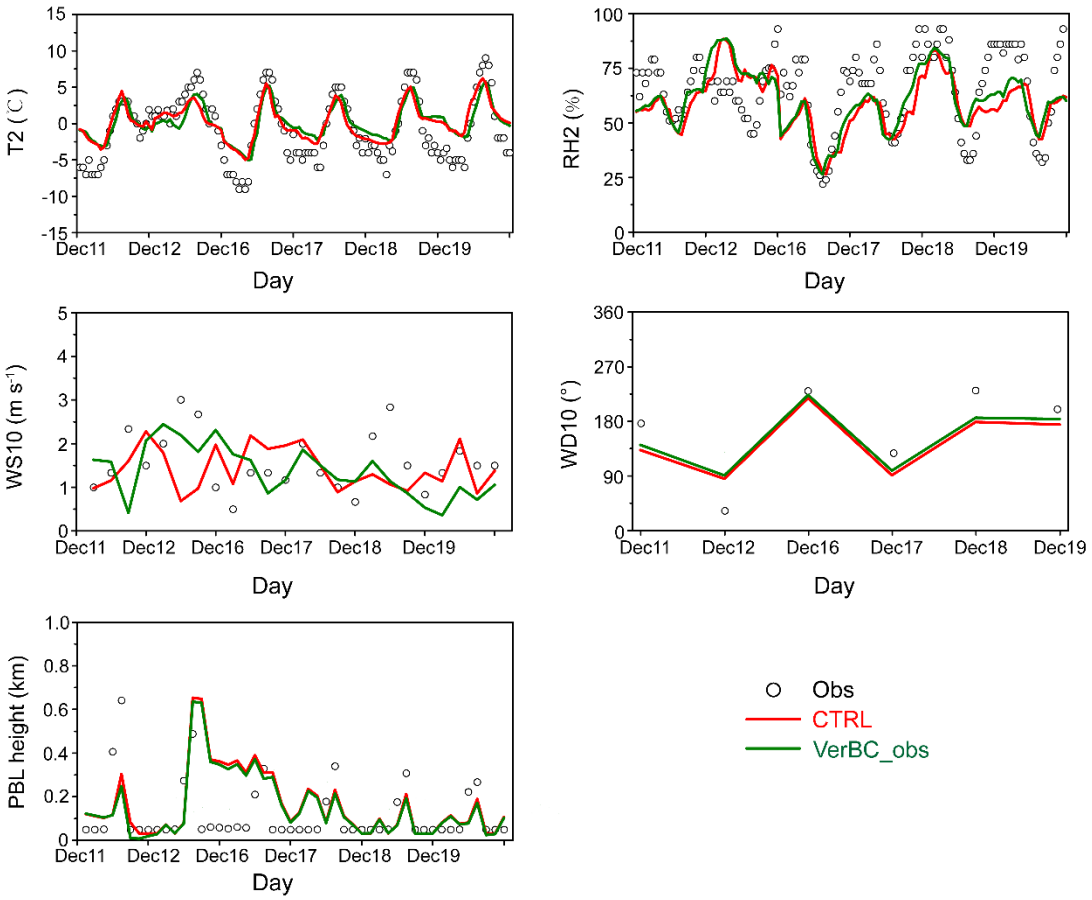

Figure S4. Comparisons of simulated hourly T2 (℃), hourly RH2 (%), 3-hourly PBL height (m), 6-hourly WS10 (m s^{-1}) and daily WD10 (°) from CTRL (original BC vertical profiles; red lines) and VerBC_obs (modified BC vertical profiles; green lines) experiments with observations (black circles) in Beijing during two pollution events (11-12 December and 16-19 December 2016).

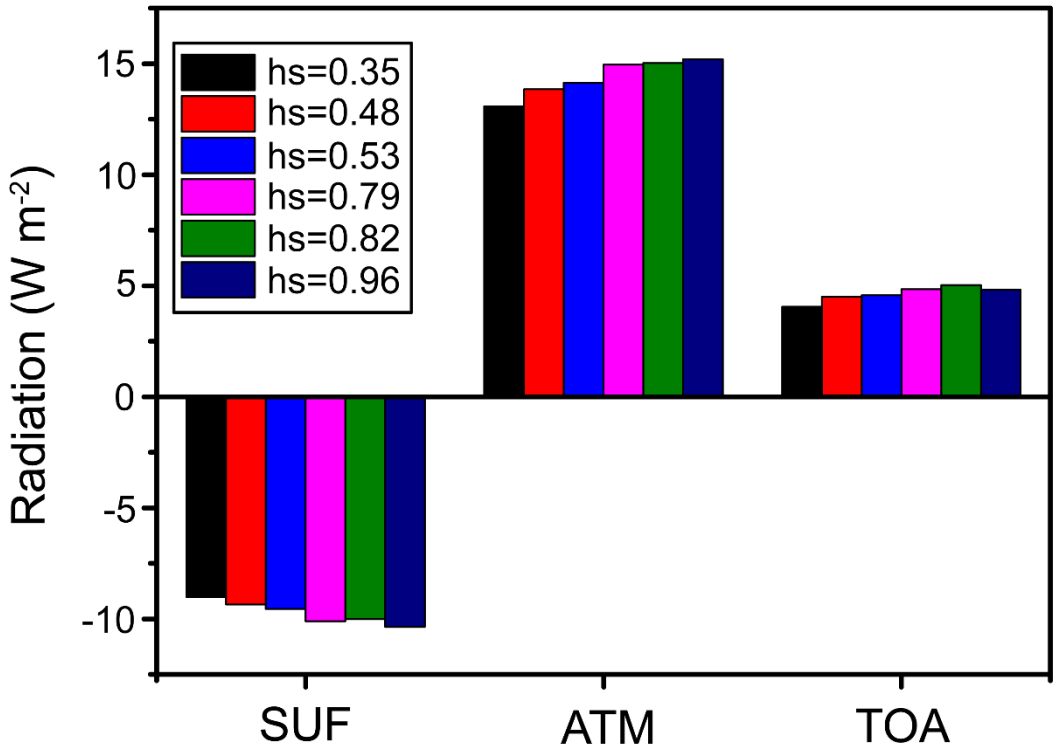

Figure S5. Direct radiations of BC at the surface (SUF), in the atmosphere (ATM) and at the top of atmosphere (TOA) in Beijing averaged 12 and 16-19 December in six sensitivity experiments (VerBC_hs1-6).

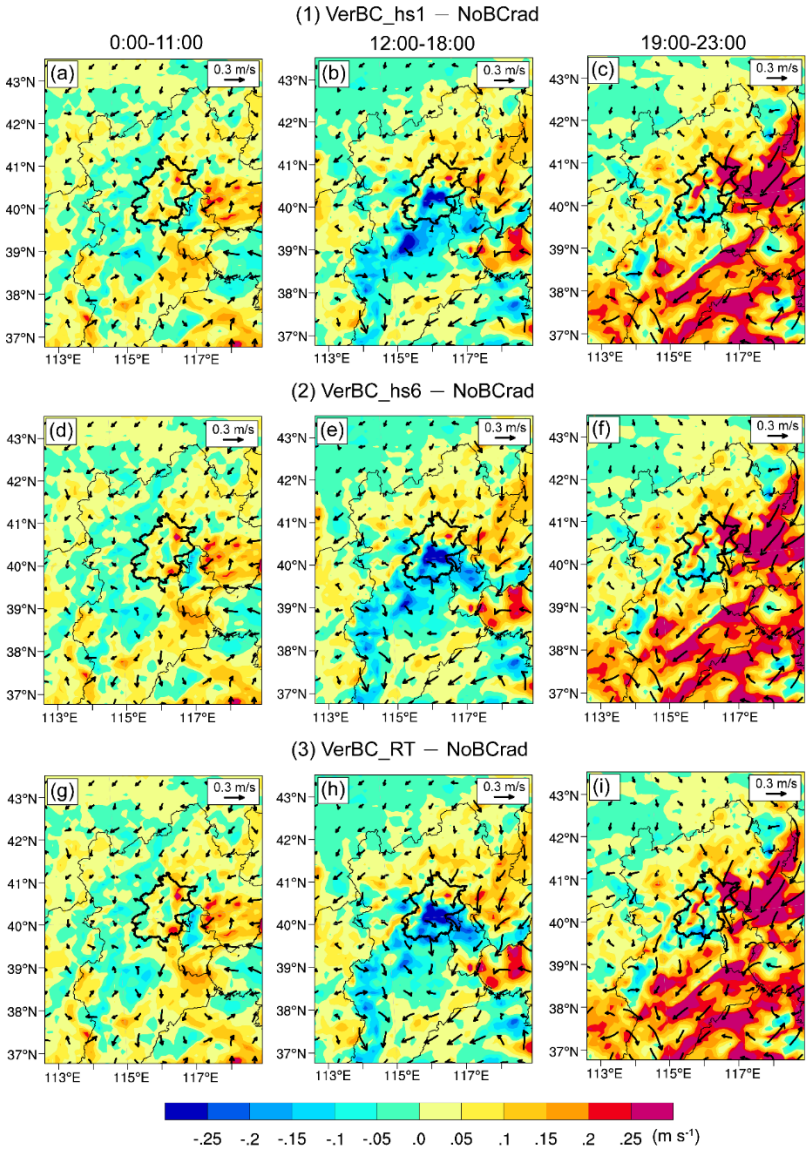

Figure S6. The spatial distributions of changes in wind at 10 m due to BC DRE with two exponential functions (VerBC_hs1,6 minus NoBCrad) and one observed transport vertical profile (VerBC_RT minus NoBCrad) average 0:00-11:00 LT (a, d, g), 12:00-18:00 LT (b, e, h), and 19:00-23:00 LT (c, f, i).