Supplement of Geosci. Model Dev., 9, 1201–1218, 2016
http://www.geosci-model-dev.net/9/1201/2016/
doi:10.5194/gmd-9-1201-2016-supplement

Geoscientific Model Development
Open Access
EGU

Supplement of

Air quality modeling with WRF-Chem v3.5 in East Asia: sensitivity to emissions and evaluation of simulated air quality

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Table S1. Ratios used to create hourly emissions for each pollutant in this study. The diurnal variation is adapted from the East Asian Air pollutant Emission Grid Database (EAGrid2000, http://www.cger.nies.go.jp/db/eagrid/eagrid_index_e.html)

Hours	CO	NO_x	NMVOC	SO_2	NH_3	PM/BC/OC
0	0.015	0.023	0.019	0.033	0.021	0.021
1	0.015	0.023	0.019	0.033	0.021	0.021
2	0.015	0.023	0.019	0.033	0.021	0.021
3	0.015	0.023	0.019	0.033	0.021	0.021
4	0.015	0.023	0.023	0.033	0.021	0.025
5	0.030	0.031	0.023	0.033	0.025	0.031
6	0.038	0.046	0.028	0.038	0.029	0.040
7	0.075	0.061	0.056	0.038	0.038	0.048
8	0.068	0.061	0.075	0.043	0.042	0.063
9	0.060	0.061	0.075	0.047	0.050	0.063
10	0.060	0.061	0.071	0.052	0.067	0.062
11	0.057	0.054	0.066	0.052	0.084	0.060
12	0.057	0.058	0.066	0.052	0.092	0.058
13	0.060	0.058	0.066	0.052	0.084	0.062
14	0.060	0.058	0.066	0.052	0.076	0.060
15	0.060	0.058	0.056	0.052	0.063	0.060
16	0.064	0.054	0.056	0.047	0.050	0.058
17	0.060	0.046	0.053	0.043	0.042	0.046
18	0.042	0.038	0.028	0.043	0.034	0.042
19	0.034	0.031	0.028	0.043	0.025	0.035
20	0.030	0.031	0.023	0.040	0.025	0.029
21	0.026	0.028	0.023	0.038	0.025	0.027
22	0.026	0.025	0.023	0.036	0.021	0.025
23	0.015	0.023	0.023	0.033	0.021	0.023

Table S2: Air Pollution Index (API) and corresponding daily mean PM_{10} concentrations (Source: http://jcs.mep.gov.cn/hjzl/200604/t20060426_76155.htm).

API	Daily mean PM_{10} (ug m^{-3})
50	50
100	150
200	350
300	420
400	500
500	600

Table S3a. Description of API derived PM_{10} observation sites from the website of Ministry of Environmental Protection of P. R. China, http://datacenter.mep.gov.cn/

Site	Province	Region	Latitude (ºN)	Longitude (ºE)
Anshan	Liaoning	Northeast	41.11	122.99
Baoji	Shanxi	North	34.36	107.24
Beihai	Guangxi	South	21.48	109.12
Beijing	Beijing	North	39.9	116.4
Changchun	Jilin	Northeast	43.83	125.32
Changde	Hunan	Central	29.03	111.7
Changsha	Hunan	Central	28.23	112.94
Changzhi	Shanxi	North	36.2	113.12
Chengdu	Sichuang	Southwest	30.57	104.06
Chifeng	Neimengg	North	42.26	118.89
Chongqin	Chongqin	Southwest	29.56	106.55
Dalian	Liaoning	Northeast	38.91	121.62
Datong	Shanxi	North	40.07	113.3
Deyang	Sichuang	Southwest	31.12	104.4
Fushun	Liaoning	Northeast	41.88	123.96
Guangzhou	Guangdon	South	23.13	113.26
Guiyan	Guizhou	Southwest	26.65	106.63
Haerbin	Heilongj	Northeast	45.8	126.54
Haikou	Hainan	South	20.02	110.33
Hangzhou	Zhejiang	East	30.27	120.16
Hefei	Anhui	East	31.82	117.23
Huhehot	Neimengg	North	40.84	111.75
Jinan	Shandong	East	36.65	117.12
Jingzhou	Hubei	Central	30.33	112.24
Jining	Shandong	East	35.42	116.59
Jiujiang	Jiangxi	East	29.71	116
Kaifeng	Henan	Central	34.8	114.31
Kunmin	Yunnan	Southwest	24.88	102.83
Lanzhou	Gansu	Northwest	36.06	103.84
Lhasa	Xizang	Southwest	29.65	91.14
Liuzhou	Guangxi	South	24.32	109.42
Luzhou	Sichuang	Southwest	28.87	105.44
Mianyan	Sichuang	Southwest	31.46	104.68
Mudanjiang	Heilongj	Northeast	44.55	129.63
Nanchang	Jiangxi	East	28.68	115.86
Nanchong	Sichuang	Southwest	30.83	106.11
Nanjing	Jiangsu	East	32.06	118.8
Nanning	Guangxi	South	22.82	108.37
Ningbo	Zhejiang	East	29.86	121.54
Pingding	Henan	Central	33.77	113.19
Qingdao	Shandong	East	36.08	120.38
Qiqihaer	Heilongj	Northeast	47.35	123.92

Quanzhou	Fujian	East	24.87	118.68
Guilin	Guangxi	South	25.27	110.29
Qujing	Yunnan	Southwest	25.49	103.8
Rizhao	Shandong	East	35.47	119.4
Shanghai	Shanghai	East	31.22	121.46
Shantou	Guangdon	South	23.29	116.54
Shaoguan	Guangdon	South	24.81	113.6
Shenyang	Liaoning	Northeast	41.81	123.43
Shenzhen	Guangdon	South	22.54	114.06
Shijiazhuang	Hebei	North	38.04	114.5
Shizuishan	Ningxia	Northwest	38.98	106.38
Taian	Shandong	East	36.2	117.09
Tianjin	Tianjin	North	39.2	117.4
Weifang	Shandong	East	36.71	119.16
Weinan	Shanxi	North	34.5	109.51
Wuhan	Hubei	Central	30.59	114.31
Wuhu	Anhui	East	31.35	118.43
Urumqi	Xinjiang	Northwest	43.83	87.62
Xiamen	Fujian	East	24.52	118
Xian	Shanxi	North	34.25	109.09
Xining	Qinghai	Northwest	36.62	101.78
Yangquan	Shanxi	North	37.86	113.58
Yantai	Shandong	East	37.46	121.44
Yinchuan	Ningxia	Northwest	38.49	106.23
Zaozhuang	Shandong	East	34.81	117.32
Zhanjiang	Guangdon	South	21.26	110.36
Zhengzhou	Henan	Central	34.74	113.63
Zibo	Shandong	East	36.81	118.06
Zigong	Sichuang	Southwest	29.34	104.78

Table S3b. Description of observation sites with direct measurements.

Site	Country or Region	Latitude (ºN)	Longitude (ºE)
Lulin[1]	Taiwan	23.46	120.87
Happo[1]	Japan	36.68	137.8
Hedo	Japan	26.85	128.26
Oki	Japan	36.28	133.18
Rishiri	Japan	45.12	141.24
Sado-seki	Japan	38.25	138.4
Tappi	Japan	41.27	141.35
Yusuhara[1]	Japan	33.38	132.93
Xiamen	China	24.467	118.133
Jinyunshan[1]	China	29.820	106.382
Zhuhai	China	22.267	113.567
Godavari	Nepal	27.609	85.352

Note1: The altitude is 2860m for Lulin, 1850m for Happo, 790m for Yusuhara, and 800m for Jinyunshan.

Table S4. Provincial differences of monthly emissions and provincial difference of 14-day mean concentrations between REAS and EDGAR in July 2007.

Provinces in China	Emission difference (REAS-EDGAR) / EDGAR (%)				Concentration difference (REAS-EDGAR) / EDGAR (%)			
	PM_{10}	CO	SO_2	NO_x	PM_{10}	O_3	SO_2	NO_2
Anhui	61.8	56.4	-26.2	50.6	48.0	18.0	-28.0	43.7
Beijing	98.4	238.1	-42.3	32.0	43.8	19.5	-21.1	27.1
Chongqing	46.1	57.8	78.5	59.5	39.3	19.6	69.3	46.7
Fujian	-10.5	62.0	-49.9	74.6	8.5	11.8	-54.1	60.1
Guangdong	43.0	67.0	-20.2	49.0	14.2	9.5	-25.7	51.0
Gansu	37.1	24.7	-31.7	27.6	1.7	13.6	-22.2	28.6
Guangxi	23.7	141.9	45.8	21.2	15.8	9.4	45.0	28.3
Guizhou	21.5	205.7	244.2	68.9	25.1	13.7	220.8	58.7
Hainan	-10.2	19.8	11.4	60.5	-1.1	-8.4	13.6	61.8
Hebei	150.6	548.6	45.2	92.8	48.2	20.7	28.0	65.9
Henan	135.0	104.7	22.2	107.3	66.6	17.8	22.5	95.2
Heilongjiang	9.9	90.0	-51.4	65.8	17.0	13.3	-52.3	57.7
Hunan	73.4	92.9	5.1	59.0	25.4	18.7	1.5	53.3
Hubei	6.0	-49.9	44.9	76.6	41.9	23.8	15.1	51.2
Jilin	51.9	131.4	-13.2	109.0	43.0	19.2	-1.3	111.9
Jiangsu	74.2	311.8	-3.0	108.1	45.9	13.0	-5.4	95.6
Jiangxi	84.8	57.0	11.3	36.6	25.6	20.0	6.9	54.5
Liaoning	80.7	14.4	1.6	68.5	43.9	16.2	-8.4	52.5
Inner Mongolia	-0.4	11.4	-57.4	37.7	4.3	13.9	-47.5	32.1
Ningxia	41.5	84.4	62.6	86.5	4.2	13.2	25.9	66.3
Qinghai	3.2	-48.0	-59.2	-44.8	-5.6	4.2	-45.9	-41.9
Shaanxi	8.3	29.5	-4.4	16.6	20.9	16.1	-8.6	11.9
Sichuan	33.9	94.0	-1.9	11.0	25.0	11.0	6.9	13.7
Shandong	118.6	344.8	98.1	143.9	70.3	19.9	75.3	118.1
Shanghai	36.2	340.8	55.9	193.5	33.9	1.3	67.2	258.2
Shanxi	160.1	98.4	74.9	122.8	35.7	15.9	31.2	79.1
Tianjin	-27.5	295.9	-54.1	-8.8	52.0	24.7	-23.0	6.5
Xinjiang	3.3	18.8	32.7	58.3	2.1	11.2	26.5	54.8
Tibet	-53.1	5.1	-79.2	-69.1	1.9	4.1	-64.3	-58.1
Yunnan	111.4	93.4	182.8	84.7	15.6	13.5	175.6	75.8
Zhejiang	52.6	144.2	-37.6	74.6	29.9	26.1	-39.4	66.0

Table S5. Statistical performance of WRF-Chem-REAS based simulations for meteorology. Daily meteorological observations at 194 stations in 2007 are obtained from the website of National Climate Data Center of China Meteorological Administration (http://data.cma.cn/).

Meteorological items	Count	Obs.	Model	*r*	MB	ME	NMB	NMSE
2 m temperature (degree C)	23841	11.51	9.83	0.97	-1.68	2.43	-14.57	0.1
2 m relative humidity (%)	23862	61.77	66.1	0.71	4.34	12.34	7.02	0.06
10 m wind speed (m/s)	23857	2.18	3.48	0.52	1.29	1.49	59.35	0.47

Table S6. Statistical measures for seasonal variation of modeled and observed PM_{10} in the year 2007. Statistical indicators and associated units are described in Table 3.

Month	Regions	Count	Obs	Model	*r*	NMB	MFB	MFE	NMSE
Jan	Central China	176	147	142.10	0.30	-3.09	-2.02	35.75	0.18
Jan	Eastern China	475	127	120.17	0.29	-5.23	-7.29	36.66	0.26
Jan	Northern China	232	166	123.97	0.22	-25.24	-29.88	50.57	0.50
Jan	Northeastern China	202	172	98.99	0.51	-42.47	-65.69	75.73	0.74
Jan	Northwestern China	107	208	102.10	-0.06	-50.85	-58.95	73.55	1.63
Jan	Southern China	155	86	63.70	0.10	-25.85	-29.27	43.90	0.33
Jan	Southwest China	234	118	76.82	0.32	-35.02	-52.89	66.07	0.53
Jan	Japan	107	25	14.73	0.44	-40.32	-58.99	70.53	0.95
Jan	Nepal	30	75	21.75	0.53	-70.83	-102.01	102.01	2.49
Apr	Central China	192	113	107.56	0.30	-4.95	-5.95	36.89	0.22
Apr	East China	492	107	96.38	0.18	-9.78	-10.40	36.60	0.45
Apr	North China	291	109	98.65	0.28	-9.14	-13.42	41.69	0.36
Apr	Northeast China	197	105	72.54	0.31	-30.96	-45.51	58.48	0.56
Apr	Northwest China	129	135	139.64	0.26	3.69	-1.88	47.57	0.58
Apr	South China	106	84	65.18	0.23	-22.83	-31.27	48.11	0.35
Apr	Southwest China	265	92	64.71	0.23	-30.02	-39.51	51.82	0.42
Apr	Japan	104	37	21.61	0.77	-42.18	-53.85	61.46	1.46
Apr	Nepal	29	62	22.47	-0.39	-63.56	-82.94	82.94	1.84
Jul	Central China	170	91	86.11	0.20	-5.05	-13.70	48.60	0.34
Jul	East China	463	84	91.66	0.18	8.91	0.07	41.79	0.30
Jul	North China	286	98	97.49	0.32	-0.92	-6.02	40.39	0.24
Jul	Northeast China	216	102	85.54	0.45	-16.14	-30.40	52.68	0.34
Jul	Northwest China	108	74	84.18	-0.02	14.02	3.30	41.86	0.44
Jul	South China	38	62	63.01	0.25	0.86	-16.51	53.12	0.44
Jul	Southwest China	195	74	47.34	0.05	-35.70	-50.11	60.12	0.58
Jul	Japan	83	16	36.52	-0.25	121.53	45.31	77.71	5.10
Jul	Nepal	30	13	19.28	0.52	47.67	40.12	40.51	0.20
Oct	Central China	188	119	120.32	-0.02	1.35	0.18	41.20	0.29
Oct	East China	478	94	101.39	0.33	7.99	2.51	37.30	0.22
Oct	North China	259	101	104.89	0.22	4.25	0.98	43.25	0.32
Oct	Northeast China	211	99	93.75	0.26	-5.18	-24.59	58.77	0.56
Oct	Northwest China	118	94	91.94	0.09	-1.68	-12.28	52.02	0.48
Oct	South China	153	83	78.42	0.23	-5.93	-10.37	41.00	0.25
Oct	Southwest China	240	93	60.87	0.36	-34.88	-49.39	59.95	0.50
Oct	Japan	115	22	14.48	0.38	-33.57	-44.13	54.72	0.50
Oct	Nepal	NA	NA	NA	NA	NA	NA	NA	NA

Table S7. Statistical measures for seasonal variation of model simulations and observation in the year 2007. The unit of Obs and Model is μg m^{-3} for PM_{10}, and ppbv for O_3, SO_2 and NO_2. Other statistical indicators and associated units are described in Table 2.

Species	month	Count	Obs	Model	*r*	NMB	MFB	MFE	NMSE
PM_{10}	Jan	1718	132.33	100.03	0.39	-24.41	-32.95	53.25	0.56
	Apr	1805	101.43	86.45	0.37	-14.77	-22.81	45.71	0.46
	Jul	1589	82.45	80.40	0.37	-2.49	-9.86	48.13	0.36
	Oct	1762	92.42	89.19	0.38	-3.50	-13.43	46.69	0.36
O_3	Jan	185	42.96	46.49	0.27	8.22	8.94	15.34	0.04
	Apr	181	60.50	54.31	0.51	-10.23	-9.55	16.87	0.05
	Jul	168	35.18	43.58	0.78	23.87	25.98	30.16	0.10
	Oct	169	40.59	47.21	0.43	16.31	18.20	25.10	0.08
SO_2	Jan	294	13.29	10.57	0.70	-20.43	-22.85	59.42	1.17
	Apr	286	6.67	7.44	0.70	11.60	7.69	61.58	1.25
	Jul	251	4.82	8.25	0.74	71.14	30.77	74.02	1.90
	Oct	269	5.80	8.91	0.54	53.67	24.42	69.58	2.17
NO_2	Jan	124	27.43	20.23	0.43	-26.25	-56.20	76.37	0.71
	Apr	120	22.58	13.43	0.61	-40.52	-67.90	74.07	0.72
	Jul	124	17.54	12.17	0.73	-30.60	-54.99	62.01	0.47
	Oct	124	20.56	14.12	0.53	-31.32	-40.78	66.88	0.68

Table S8. Statistical measures for O_3 at the Lulin site in different months.

Month	Obs	Model	*r*	NMB	MFB	MFE	NMSE
Jan	32.97	48.39	0.63	46.80	37.99	37.99	0.17
Apr	50.80	53.40	0.38	5.11	4.95	17.63	0.05
Jul	21.14	35.16	0.48	66.35	49.60	49.60	0.33
Oct	23.40	44.42	0.35	89.84	62.80	62.92	0.51

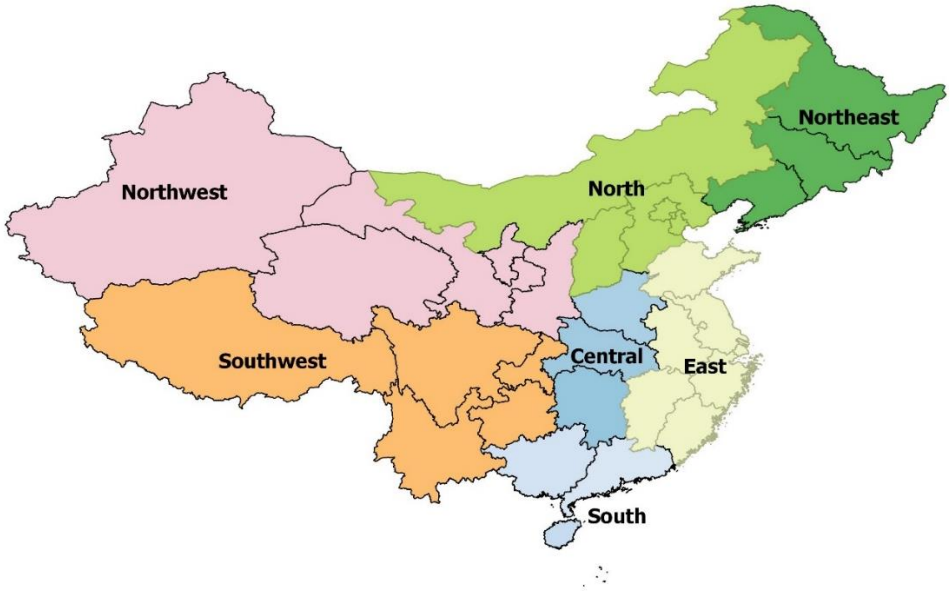

Figure S1. The seven regions in mainland China used for analysis in this paper.

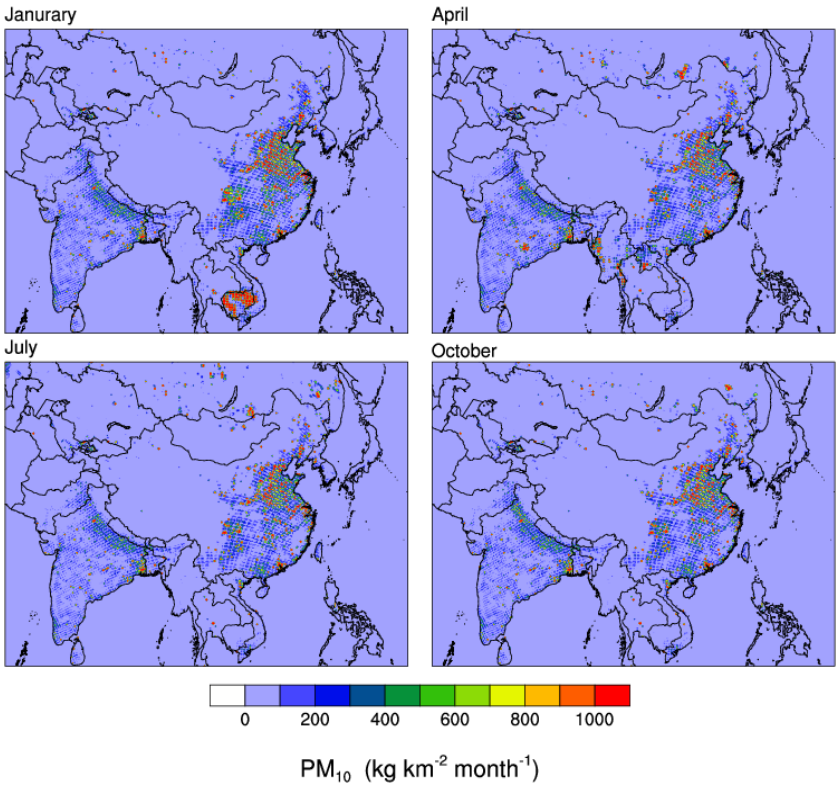

Figure S2. Monthly emissions of anthropogenic primary PM_{10}.

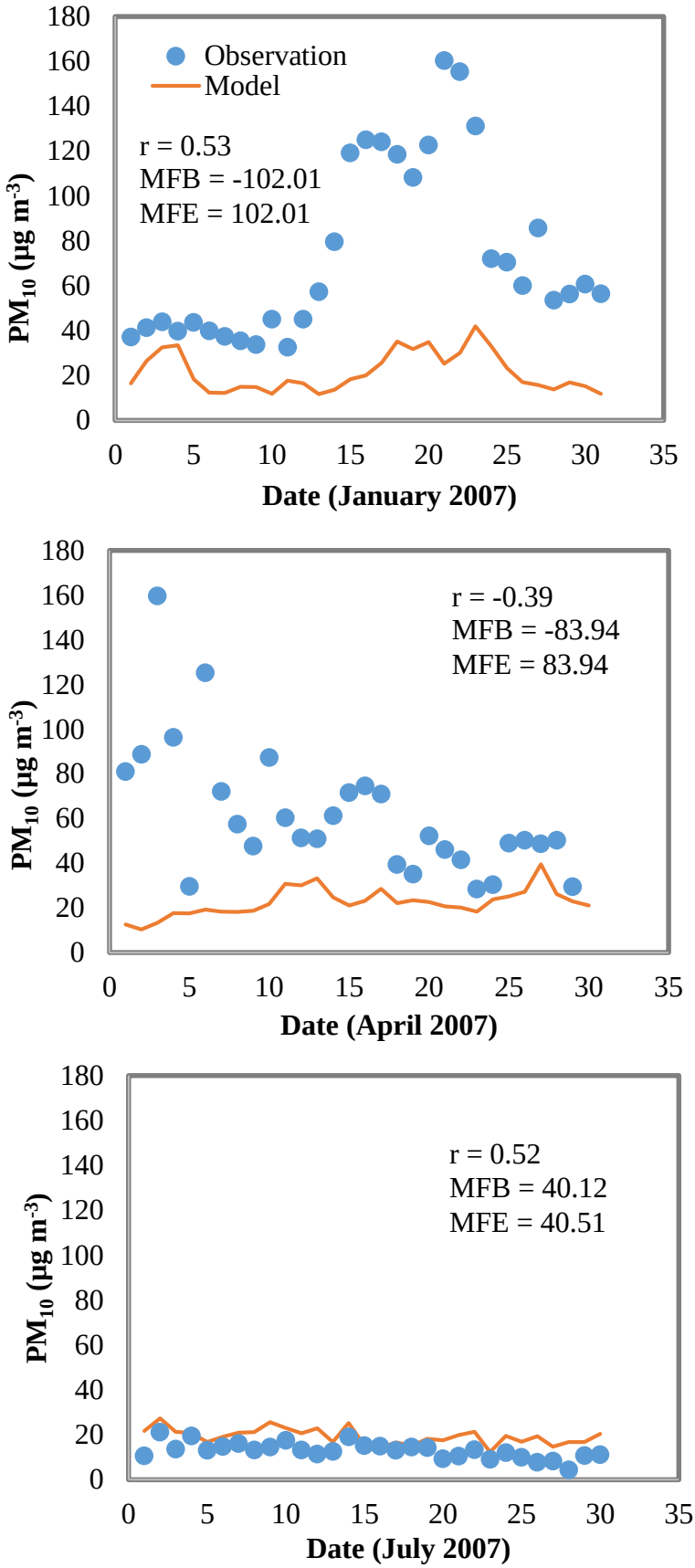

Figure S3. Comparison of observed (blue) and simulated (orange) daily mean PM_{10} concentrations in January (top), April (middle), and October (bottom) 2007 at Godavari , Nepal.