Performance of high resolution (400 m) $PM_{2.5}$ forecast over Delhi

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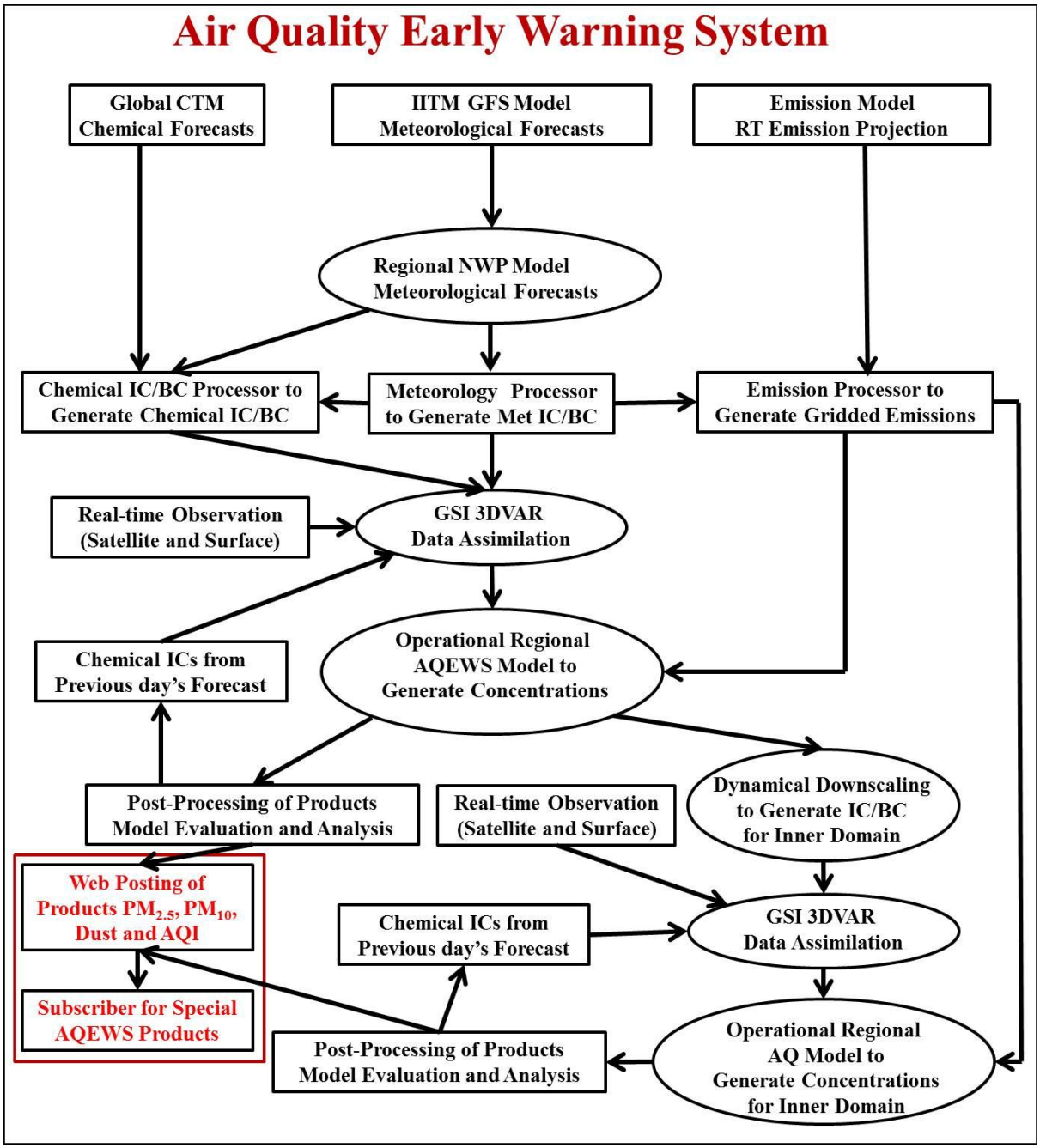

Figure S1: Architecture of the very-high resolution air quality early warning system.

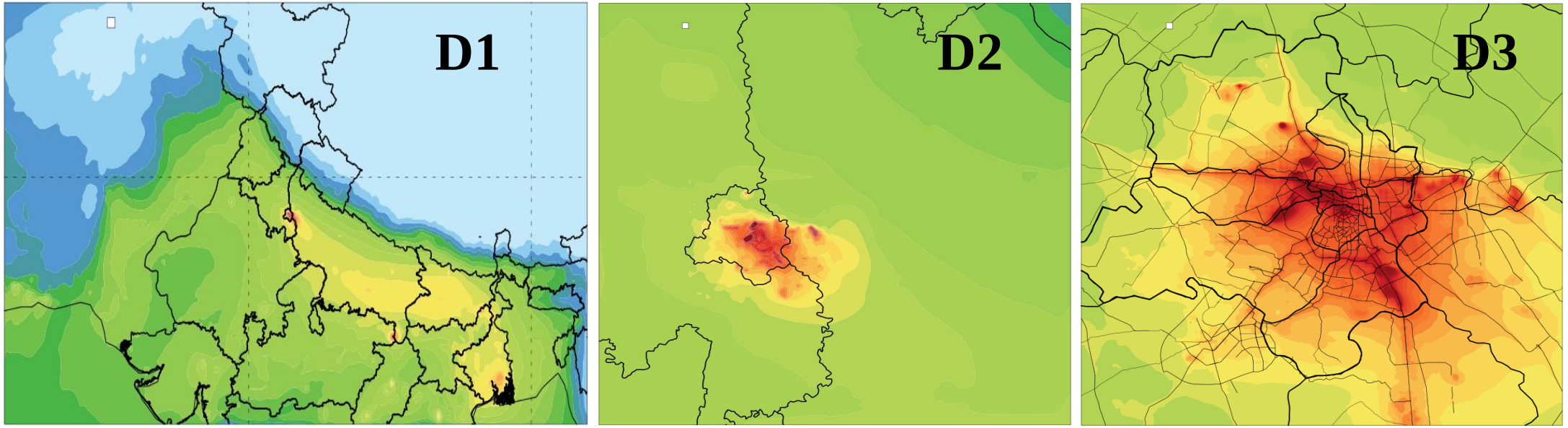

Figure S2: Map of model simulation domain (D1: 10 km horizontal grid spacing, D2: 2 km horizontal grid spacing and D3: 400 meter horizontal grid spacing). We have used ncl/6.6.2 software to create the images (https://www.ncl.ucar.edu/).

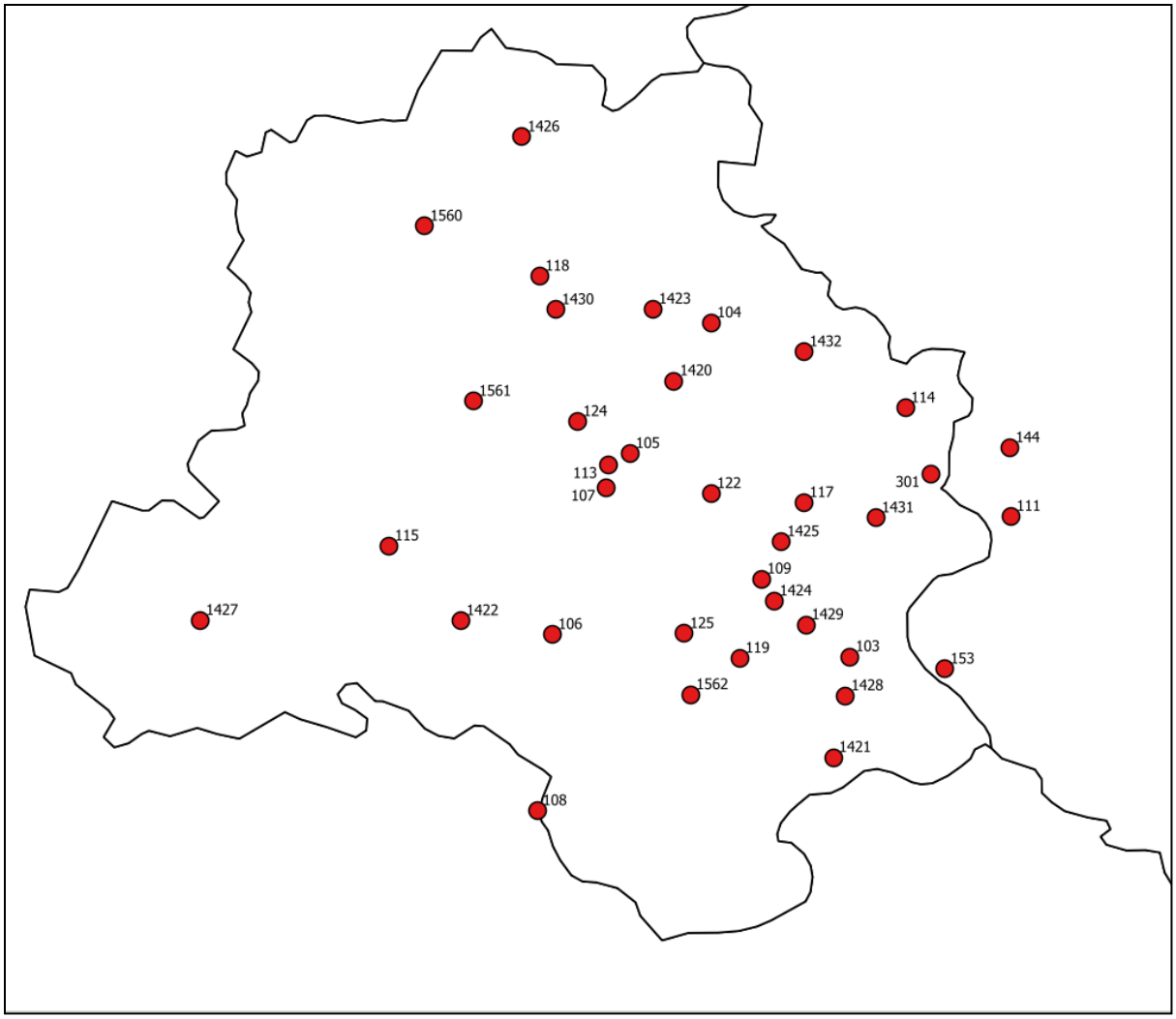

Figure S3: Geographical locations of 37 air quality monitoring stations (stations names associated with the numbers are provided in Table ST2)

Figure S4: Spatial distribution of High-resolution Delhi Emission Inventory (HrDEI) of $PM_{2.5}$ anthropogenic emissions (unit: 10^{10} kg/m^2/s) at 400 m horizontal resolution. We have used ncl/6.6.2 software to create the image (https://www.ncl.ucar.edu/).

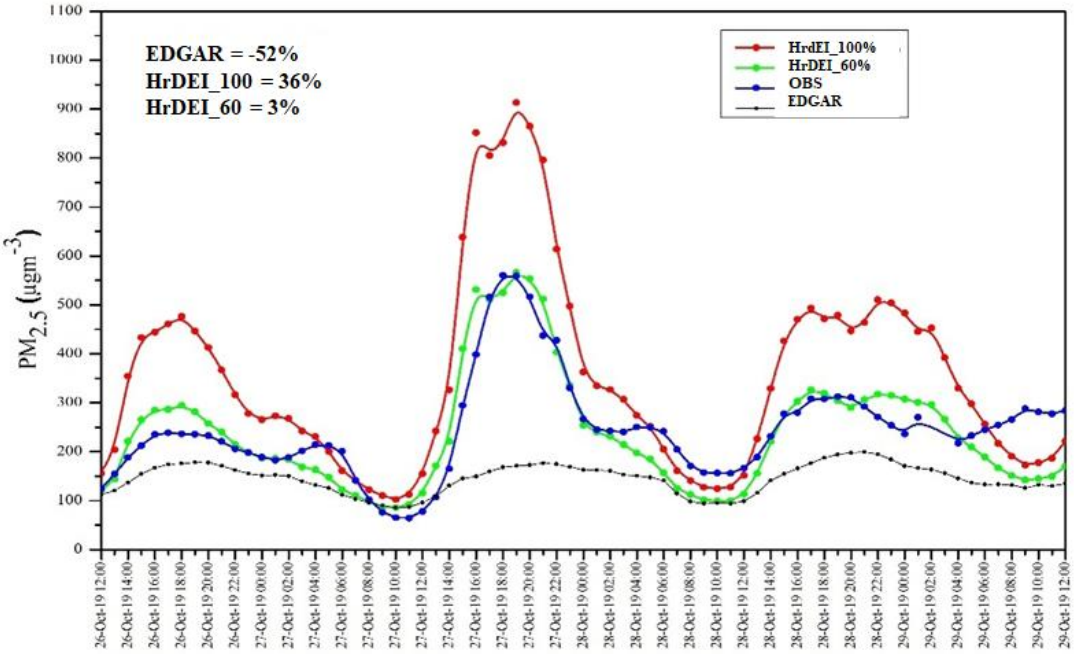

Figure S5: Sensitivity simulations for different emission inventory over Delhi.

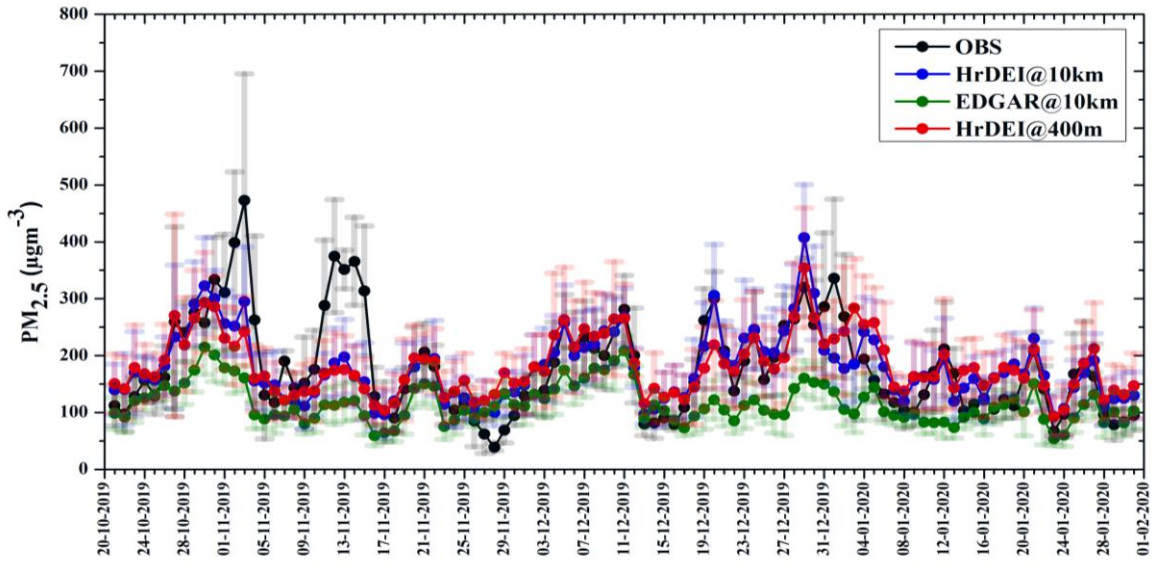

Figure S6: Time-series of daily surface-level $PM_{2.5}$ concentrations from a) observations (black line) (average of 37 stations across Delhi) b) model simulations with EDGAR emissions inventory and with 10 km x 10 km grid-spacing (green line) c) model simulations with High-resolution Delhi Emission Inventory (HrDEI) and with 10 km x 10 km grid-spacing (blue line) and d) model simulations with HrDEI emissions' inventory and with 400 m x 400 m grid-spacing (red line) of 1st day forecast.

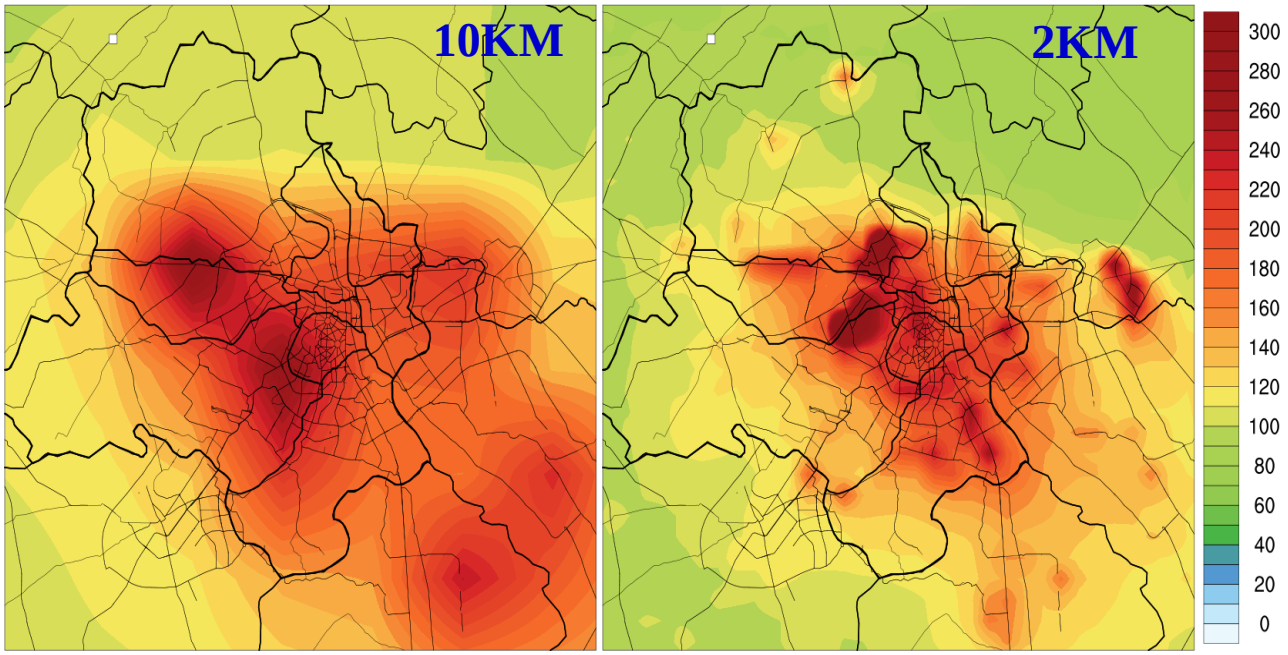

Figure S7: Spatial distribution of average $PM_{2.5}$ of 1st day forecast for 400 meter grid spacing during 21 October 2019 to 01 February 2020 at 10 km grid spacing (left) and 2 Km Horizontal grid spacing (right). We have used ncl/6.6.2 software to create the images (https://www.ncl.ucar.edu/).

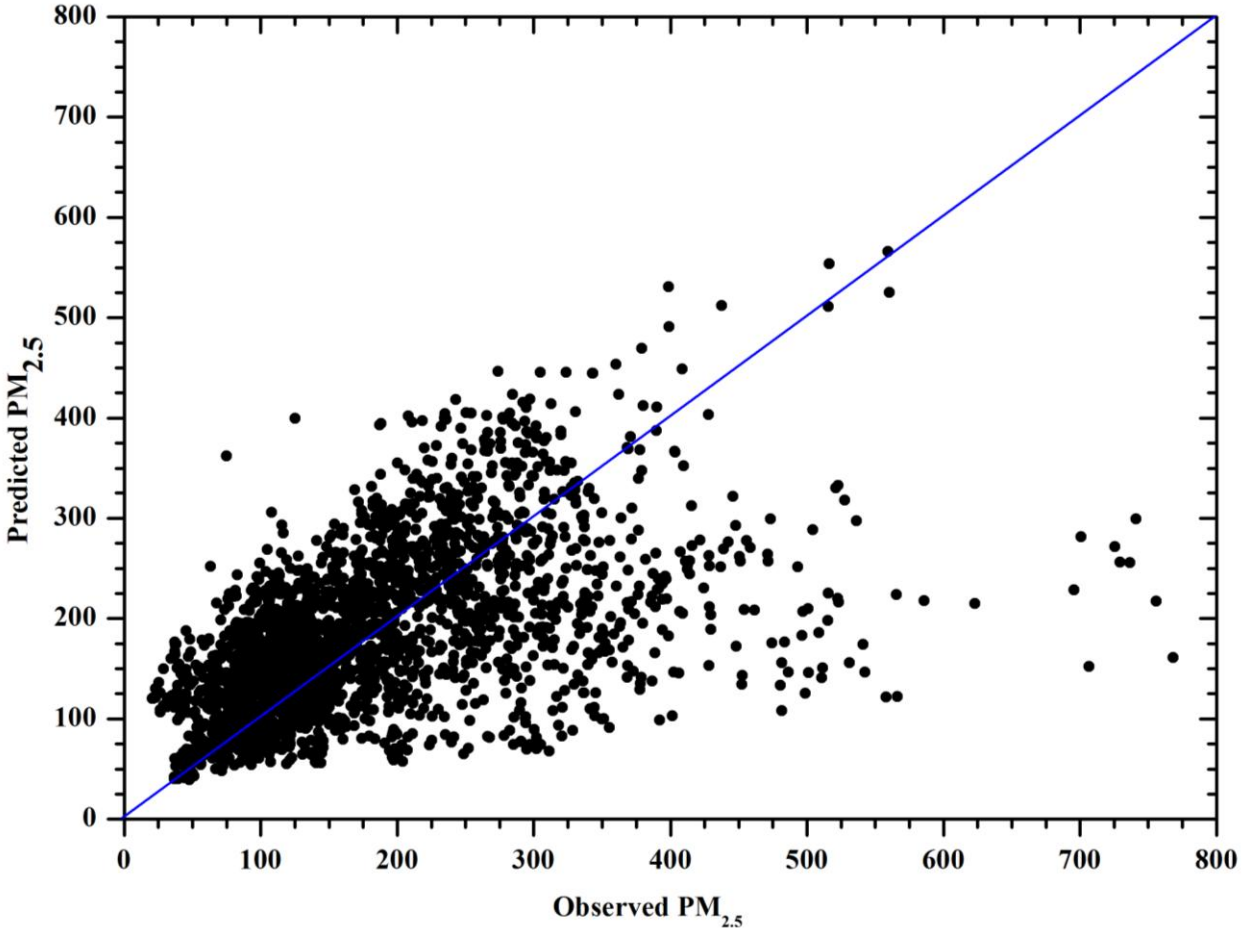

Figure S8: Correlation between hourly mean observed and predicted $PM_{2.5}$ in Delhi.

Table ST1: Selected atmospheric physical and chemical parameterizations

Atmospheric Process	Parameterization
Cloud Microphysics	WRF Single-Moment 6-class scheme (WSM6)[1]
Short- and Long-wave radiation	Rapid Radiative Transfer Model for GCMs[2]
Surface Layer	Monin-Obukhov (Janjic Eta)Scheme[3,4]
Land Surface model	Unified Noah Land-surface model[5]
Planetary Boundary Layer	MYNN2.5[6]
Cumulus	Grell-Freitas ensemble scheme[7]
Gas-phase Chemistry	Model for Ozone and Related Tracers[8]
Aerosol Processes	Goddard Global Ozone Chemistry Aerosol Radiation and Transport (GOCART)[9]

Table ST2: Performance statistics for mean PM2.5 forecast for different emission inventory and different grid spacing of 1st day forecast over Delhi.

State Variables	Emission Variables	MB	NMFB (%)	NMFE (%)	r
PM_{25}_hourly	**EDGAR@10km**	**-63.1**	**-42.6**	**51.1**	**0.5**
	HrDEI@10km	**-0.3**	**-0.2**	**33.1**	**0.6**
	HrDEI@400m	**2.5**	**1.3**	**36.3**	**0.5**
PM_{25}_daily	**EDGAR@10km**	**-64.9**	**-43.8**	**47.8**	**0.5**
	HrDEI@10km	**-1.0**	**-0.5**	**23.2**	**0.7**
	HrDEI@400m	**1.8**	**1.0**	**25.6**	**0.6**

Table ST3: Performance statistics for simulated $PM_{2.5}$ at different monitoring sites in Delhi during 21 October 2019 to 01 February 2020 at 400 m horizontal grid-spacing.

State	Station name	Latitude	Longitude	MB	NMB (%)	RMSE	R
Delhi	CRRI Mathura Road (103)	28.5512005	77.2735737	158.7	87.6	249.9	0.4
	Burari Crossing (104)	28.7256504	77.2011573	-60.2	-31.0	149.5	0.3
	North Campus DU (105)	28.6573814	77.1585447	68.4	40.8	181.6	0.3
	IGI-Airport-T3 (106)	28.5627763	77.1180053	-12.6	-8.1	106.0	0.4
	Pusa IMD (107)	28.639645	77.146262	115.2	83.4	208.1	0.3
	DTU (118)	28.7500499	77.1112615	-95.6	- 45.6	161.2	0.3
	R K Puram (124)	28.674045	77.131023	59.4	37.2	154.0	0.4
	Shadipur (113)	28.6514781	77.1473105	104.4	65.5	177.0	0.6
	NSIT Dwarka (115)	28.60909	77.0325413	-36.1	- 20.7	92.4	0.5
	Mandir Marg (122)	28.636429	77.201067	52.2	29.1	174.3	0.2
	Punjabi Bagh (125)	28.563262	77.186937	-0.5	- 0.2	122.1	0.5
	Sirifort (119)	28.5504249	77.2159377	-12.4	- 6.3	120.4	0.4
	Lodhi Road (109)	28.5918245	77.2273074	34.4	23.3	127.8	0.3
	ITO (117)	28.6316945	77.2494387	20.0	10.7	144.4	0.3
	Anand Vihar (301)	28.646835	77.316032	-52.3	- 25.0	145.2	0.5
	Sector – 62 (111)	28.6245479	77.3577104	-33.5	-17.3	133.8	0.3
	IHBAS-Dilshad-Garden (114)	28.6811736	77.3025234	13.3	8.5	118.5	0.4
	Aya Nagar (108)	28.4706914	77.1099364	-23.8	-15.7	110.8	0.4
	Vasundhara (144)	28.6603346	77.3572563	-31.5	- 14.0	140.5	0.4
	Sector 125 (153)	28.5447608	77.3231257	-14.9	- 7.5	140.9	0.3
	Ashok_Vihar (1420)	28.695381	77.181665	26.1	24.3	79.0	0.2
	DKSS_Stadium (1421)	28.498571	77.264840	-48.0	- 24.5	137.8	0.3
	Dwarka Sector8 (1422)	28.57	77.07				
	Jahangirpuri (1423)	28.732820	77.170633	-81.1	- 35.9	151.5	0.3
	Jawaharlal Nehru Stadium (1424)	28.580280	77.233829	3.0	1.5	116.8	0.5
	MDC National Stadium (1425)	28.611281	77.237738	32.7	19.2	140.0	0.3
	Najafgarh (1427)	28.570173	76.933762	46.1	85.3	59.3	0.1
	Narela (1426)	28.822836	77.101981	-49.4	- 38.8	66.8	0.1
	Nehru Nagar (1429)	28.567890	77.250515	-9.2	- 3.8	145.3	0.5
	Okhla Phase2 (1428)	28.530785	77.271255	17.4	14.7	77.6	0.2
	Patparganj (1431)	28.623748	77.287205	28.7	16.0	122.5	0.4
	Rohini (1430)	28.732528	77.119920	-88.6	- 39.1	163.0	0.4
	Sonia Vihar (1432)	28.710508	77.249485	-44.6	- 25.8	114.3	0.3
	Sri_Aurbindo_Marg (1562)	28.531346	77.190156	2.6	3.1	53.5	0.1
	Mundak (1561)	28.684678	77.076574	19.0	18.8	50.8	0.6
	New_collectorate (1569)	28.974801	77.213357	-83.3	- 46.4	142.2	0.4
	New_mandi (1550)	29.4723508	77.7194031	-65.0	- 44.9	109.6	0.4
	Bawana (1560)	28.776200	77.051074	-92.6	- 41.9	163.4	0.4

Table ST4: Model performance goals used to evaluate the model performance for $PM_{2.5}$ (Morris et al., 2005)

Fractional Bias	**Fractional Error**	**Comment**
≤ ± 15%	≤ 35%	A level of model performance that would be considered excellent
≤ ± 30%	≤ 50%	A level of model performance that would be considered good
≤ ± 60%	≤ 75%	A level of model performance that would be considered average and hope each PM species could meet for regulatory modeling
> ± 60%	> 75%	At or exceeding this level of performance indicates fundamental problems with the modeling system

Table ST5: AQI category and corresponding break-point concentrations ranges for $PM_{2.5}$ based on National Ambient Air Quality Standard (NAAQS)**.**

AQI Category	**AQI**	**$PM_{2.5}$ Concentration range**
Good	**0 - 50**	**0 - 30**
Satisfactory	**51 - 100**	**31 - 60**
Moderately	**100 - 200**	**61 - 90**
Poor	**201 - 300**	**91 - 120**
Very poor	**301 - 400**	**121 - 250**
Severe	**401 +**	**250+**

Table ST6: Performance statistics of different $PM_{2.5}$ AQI forecast category

State	PM_{25} AQI Category	Variables	10km			2km			400 meter		
			MB	**NMFB (%)**	**NMFE (%)**	**MB**	**NMFB (%)**	**NMFE (%)**	**MB**	**NMFB (%)**	**NMFE (%)**
Delhi	Poor (201-300)	1st day	51.1	18.4	19.3	66.2	23.2	23.3	62.9	22.1	22.3
		2nd day	30.4	11.4	20.8	56.1	20.0	22.6	53.6	19.2	22.2
		3rd day	16.3	6.2	23.2	42.4	15.4	20.9	44.6	16.2	20.2
	Very Poor (301-400)	1st day	4.2	1.2	6.4	12.3	3.5	7.4	8.2	2.3	6.8
		2nd day	-17.7	-5.3	9.1	0.2	0.1	6.7	-2.7	-0.8	6.9
		3rd day	-27.5	-8.3	11.4	-13.7	-4.0	8.9	-13.4	-3.9	8.7
	Severe (401-above)	1st day	-47.1	-11.1	15.6	-55.5	-13.3	16.2	-58.0	-13.9	16.3
		2nd day	-89.0	-22.1	22.2	-70.2	-17.1	17.5	-70.8	-17.2	17.8
		3rd day	-105.0	-26.7	26.7	-86.2	-21.4	21.8	-83.6	-20.7	20.9

Table ST7: A contingency table and equations used to calculate the different skill score for different category of AQI forecast.

Forecast \ Observation	YES	NO
YES	a	b
NO	c	d

Statistic name	What it measures	Equation	unit	How to interpret
Accuracy (A)	Percent of forecasts that correctly predicted the event or non-event.	A=(a+d)/(a+b+c+d) *100	%	Higher numbers are better
False Alarm Rate (FAR)	The percent of times a forecast of high pollution did not actually occur.	FAR = (b/(a+b)) *100	%	Smaller values are best
Probability of Detection (POD) or Hit rate	Ability to predict high pollution events (i.e., the percentage of forecasted high pollution events that actually occurred).	POD = (a/(a+c)) * 100	%	Higher numbers are best
Critical Success Index (CSI), also called Threat Score	How well the high-pollution events were predicted. Useful for evaluating rarer events like high-pollution days. It is not affected by a large number of correctly forecasted, low pollution events.	CSI = (a/(a+b+c)) * 100	%	Higher numbers are best

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