Supplementary Information

Seasonal Circulation and Transboundary Air Pollution in South Asia: Implications for Air Quality and Civilization in Bangladesh

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Overview

The statistics in this paper (Table S1, S2, S3) indicate the average daily air quality observing criterion pollutants in Rangpur and Barisal, respectively, and the average estimated $PM_{2.5}$ in Dhaka using GAM modelling. This paper also presents figures observing the overall impact of certain factor's seasonal concentration over the IGP region and the seasonal effect of these pollutants during the period 2015 – 2021 in the 2 cities (Rangpur and Barisal) of Bangladesh.

Figures S1, S2 and S3 presents the climatological sea level pressure, NO and NO_2, horizontally, spatially and temporally distributed over the IGP region observed using GrADS downloaded from ECMWF website. Figures S4-S9 represents the seasonal effect of CO, NO, NO_2, O_3, $PM_{2.5}$ and PM_{10} in Barisal during the period 2015-2021 using ground-based observation. Similarly, Figures S10-S15 represents the seasonal effect of CO, NO, NO_2, O_3, $PM_{2.5}$ and PM_{10} in Rangpur during the period 2020-2021 using ground-based observation.

Table S1. Daily air quality and MET from Rangpur transboundary site

Variables	Mean	Geometric Mean	Median	Min	Max	StDev	10th	90th
$SO_2(\mu g/m^3)$	14.396	12.643	12.248	4.648	58.168	8.378	7.101	28.428
$NO(\mu g/m^3)$	0.388	0.355	0.388	0.145	4.043	0.254	0.214	0.413
$NO_2(\mu g/m^3)$	2.402	2.272	2.400	0.593	16.499	0.996	1.405	2.400
NOx ($\mu g/m^3$)	1.253	1.112	1.252	0.154	11.109	0.773	0.603	1.421
CO 8hr(mg/m^3)	0.878	0.788	0.877	0.123	2.231	0.379	0.365	1.461
O_3 8hr($\mu g/m^3$)	25.684	24.345	25.683	4.684	73.134	8.666	15.618	30.688
$PM_{2.5}(\mu g/m^3)$	112.704	89.328	104.538	12.778	330.900	70.732	30.549	216.208
$PM_{10}(\mu g/m^3)$	157.062	127.194	156.861	22.609	561.879	96.344	45.381	290.375
Wind Speed(m/s)	0.658	0.655	0.658	0.375	1.497	0.075	0.634	0.658
Temperature(°C)	23.943	23.684	23.956	9.282	31.213	3.299	19.274	28.159
RH%	83.202	82.965	83.215	49.230	99.410	6.100	75.902	90.918
Solar Radiation (W/m^2)	358.977	337.363	358.938	35.934	1011.858	145.661	251.824	383.686
Pressure (mb)	931.485	888.064	931.419	40.124	1013.408	167.280	931.419	1007.913
Rainfall (mm)	0.081	0.081	0.081	0.062	0.129	0.004	0.081	0.081

Table S2. Daily air quality and MET from Barisal Bay site

Variables	Mean	Geometric Mean	Median	Min	Max	StDev	10th	90th
$SO_2(\mu g/m^3)$	25.371	15.385	24.657	0.385	661.774	49.240	4.548	29.251
$NO(\mu g/m^3)$	13.848	8.132	8.890	0.284	244.371	21.802	2.238	26.572
$NO_2(\mu g/m^3)$	15.658	11.788	12.713	1.336	101.706	14.359	4.515	30.103
NOx ($\mu g/m^3$)	20.883	12.824	13.914	0.347	300.098	29.029	3.927	37.086
CO 8hr(mg/m^3)	1.279	1.210	1.298	0.168	4.443	0.427	0.746	1.684
O_3 8hr($\mu g/m^3$)	19.446	17.874	19.948	0.841	73.040	7.602	10.051	26.347
$PM_{2.5}(\mu g/m^3)$	78.040	66.614	74.229	8.278	300.709	44.665	30.688	143.180

$PM_{10}(\mu g/m^3)$	116.064	101.909	117.145	17.587	375.750	57.331	45.557	197.885
Wind Speed(m/s)	0.711	0.620	0.673	0.049	3.906	0.449	0.369	1.250
Temperature(°C)	27.393	27.142	27.360	12.370	35.866	3.510	22.010	31.205
RH%	79.823	79.505	79.260	49.050	97.898	6.958	71.642	88.631
Solar Radiation (W/m^2)	165.764	157.929	166.164	10.010	480.241	46.721	105.925	227.886
Pressure (mb)	996.770	986.919	1002.807	81.795	1019.548	80.146	998.360	1013.849
Rainfall (mm)	0.430	0.371	0.429	0.004	5.376	0.262	0.220	0.602

Table S3. Estimated PM2.5 by GAM model from Dhaka site and Degree of Freedom (df) for covariates.

	Estimated $PM_{2.5}$						Degree of Freedom			
Session	min	max	mean	Sd	10th	90th	K_trend (df)	K_temp (df)	K_RH (df)	K_rad (df)
Overall	5.24	339.93	90.22	55.27	32.61	163.86	150	112	18	8
Pre-Monsoon	21.41	332.88	74.02	33.09	39.79	120.59	120	14	15	11
Monsoon	3.41	249.22	36.627	25.78	9.17	62.74	100	50	4	4
Post-Monsoon	13.14	338.15	84.96	43.17	36.34	139.01	120	14	15	11
Winter	22.41	417.68	155.69	54.06	96.96	228.48	150	56	6	8

Figures of IGP region

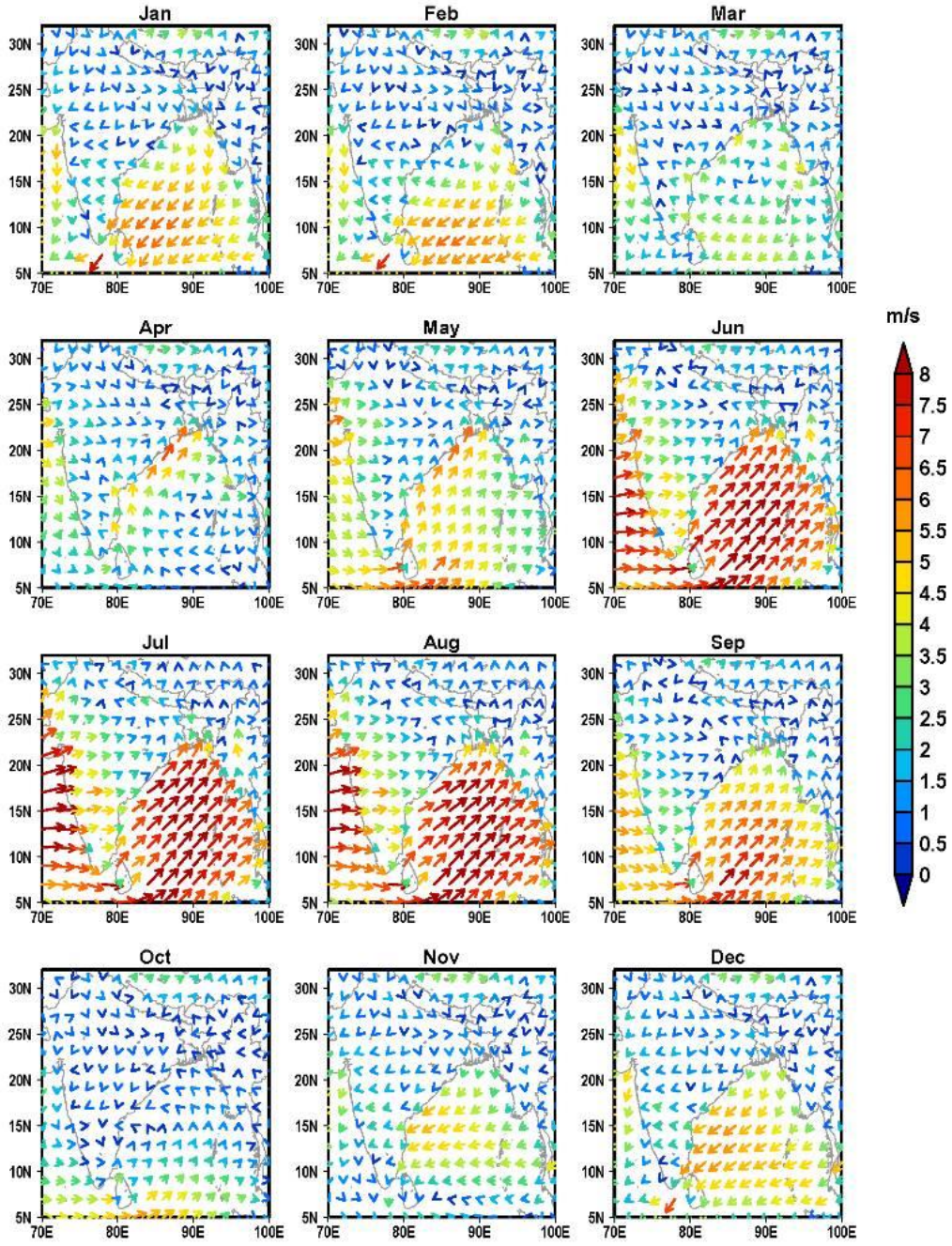

Figure 1. Long term wind dispersion over 2015 - 2021 from ECMWF ERA5 data repository

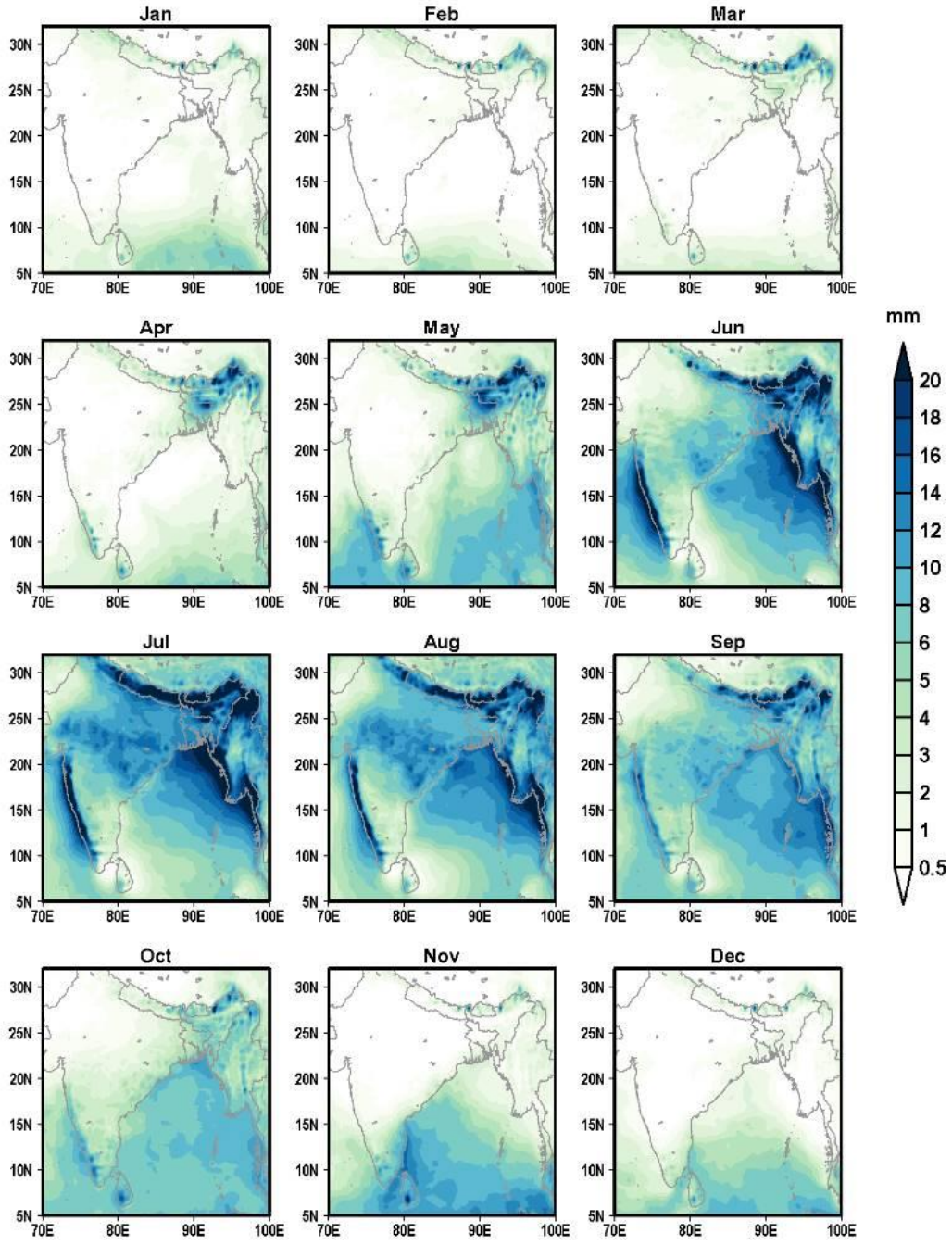

Figure 2. Long term rainfall over 2015-2021 retrieved from ECMWF ERA5 data repository.

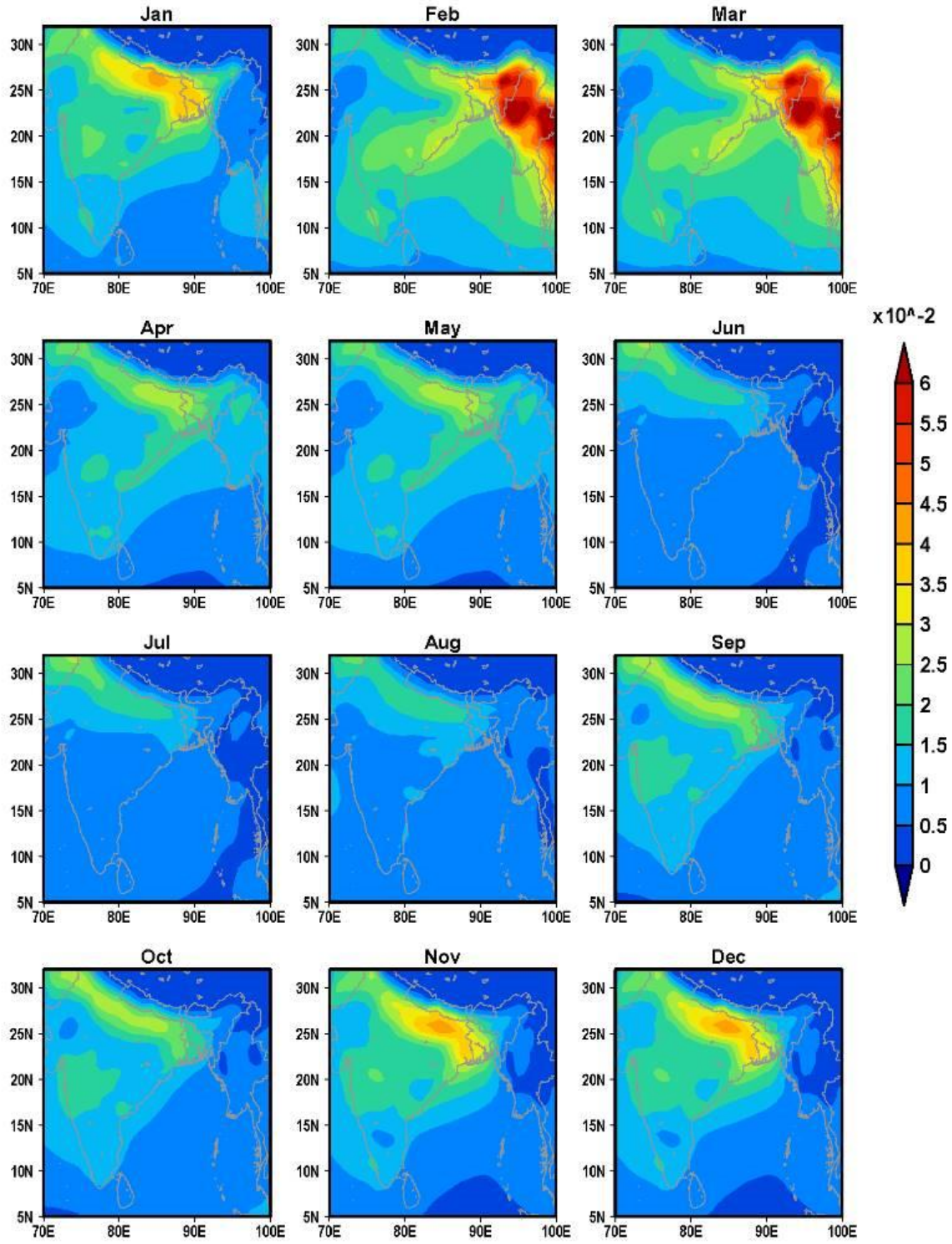

Figure 3. Black carbon retrieved from AOD at 550 nm over 2015-2021

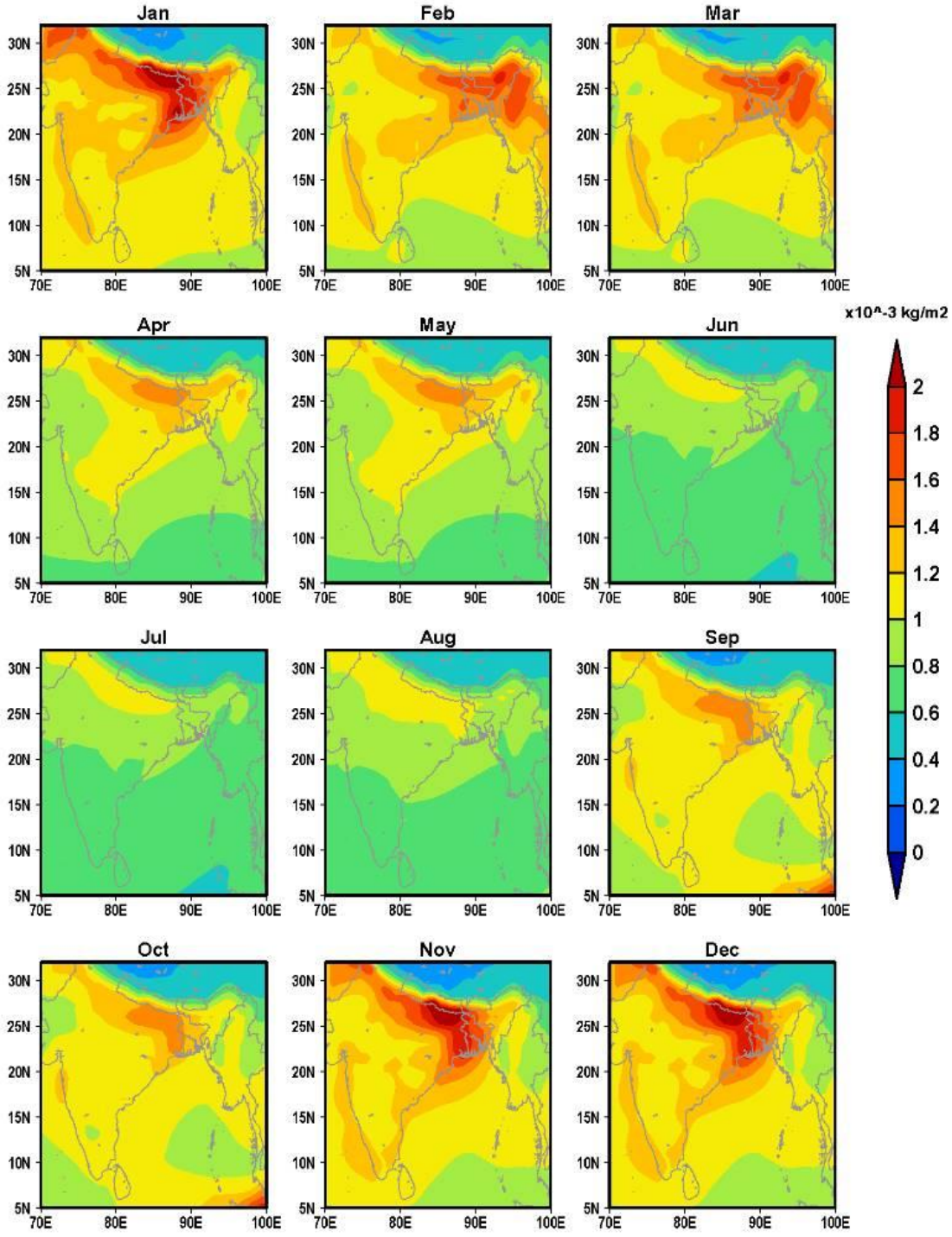

Figure 4. Long term CO variation from 2015 to 2021

Figures of Dhaka

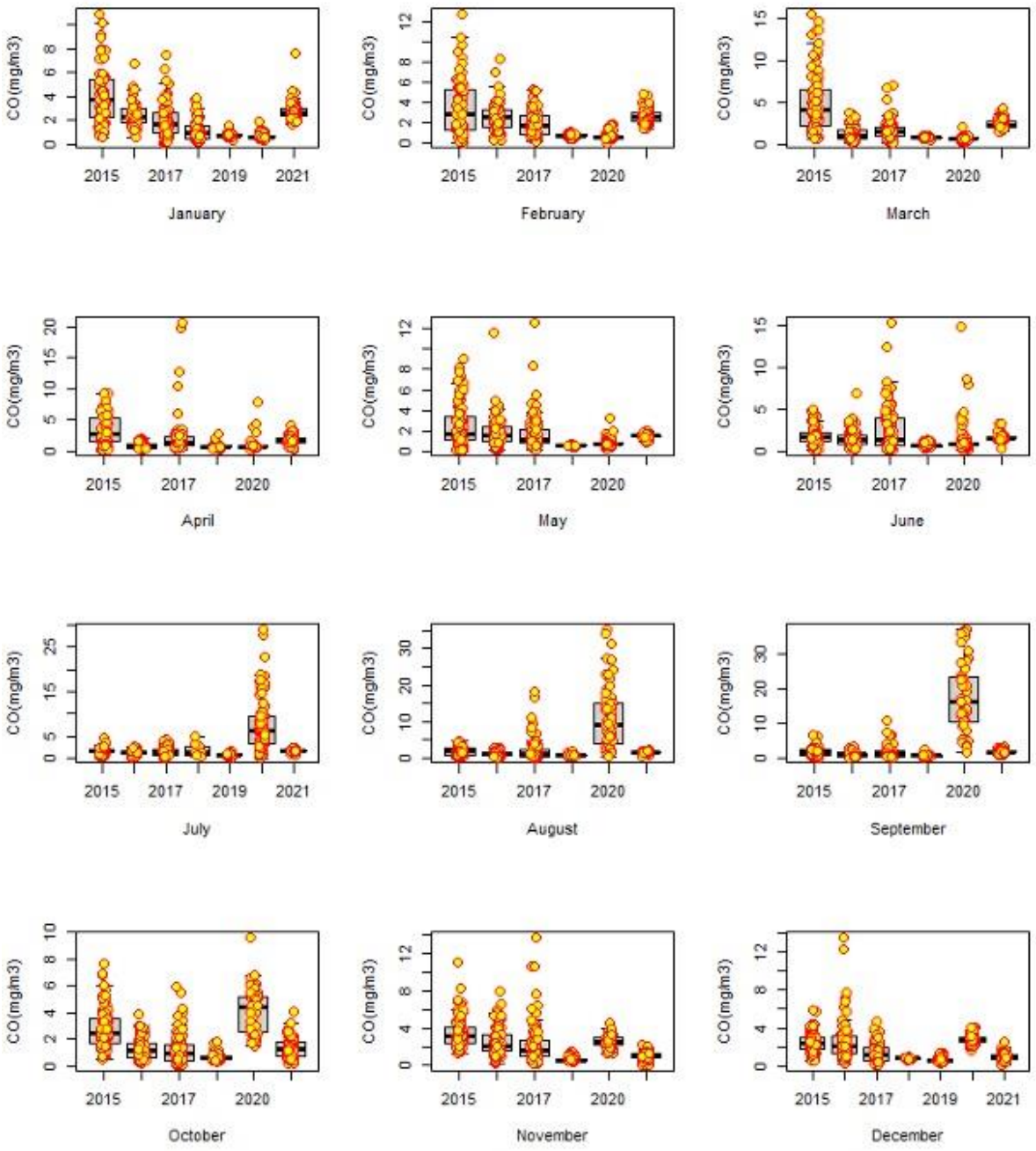

Figure 5. Long term variation of CO from 2015 -2021 in Dhaka

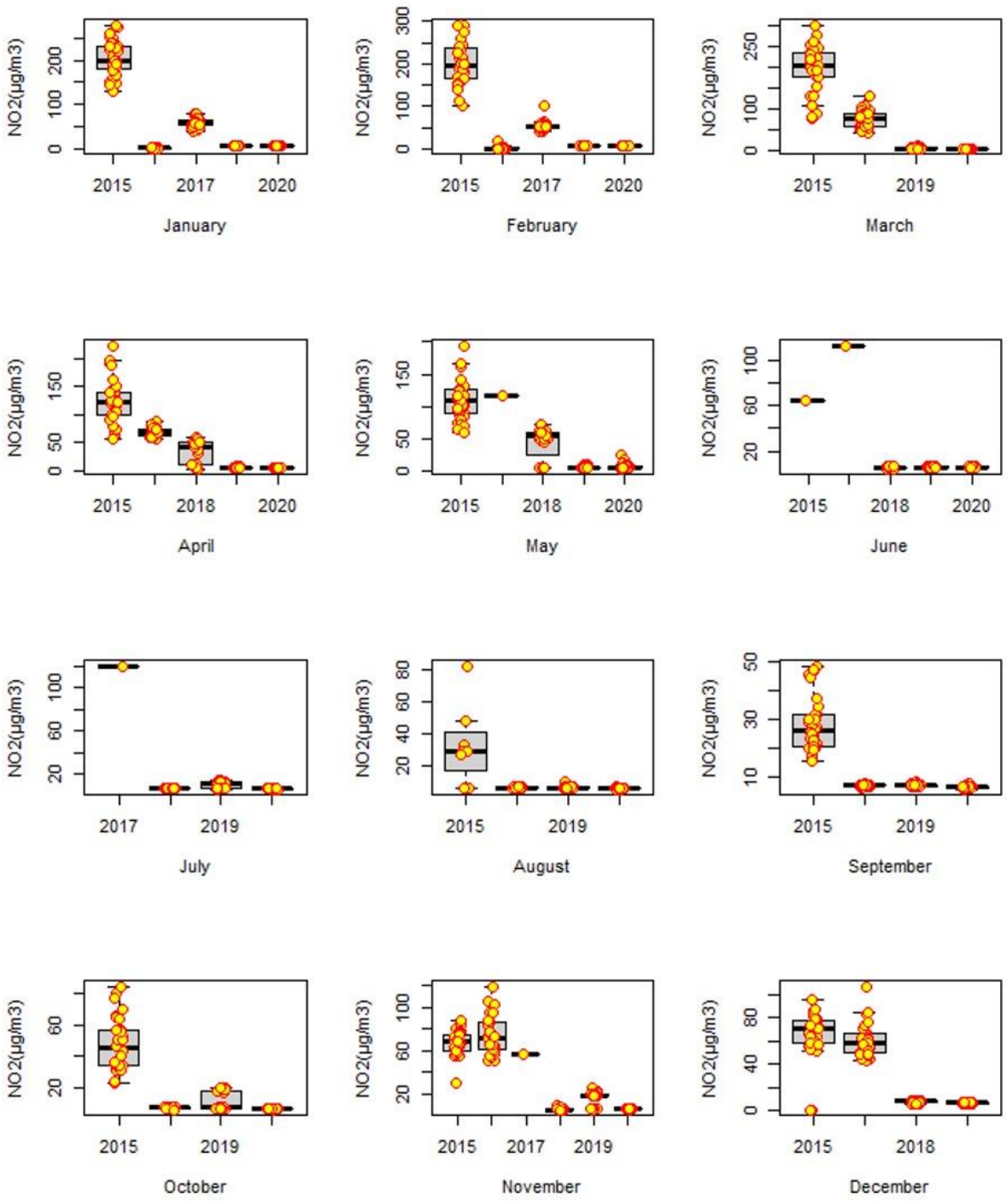

Figure 6. Long term variation of NO2 from 2015 -2020 in Dhaka

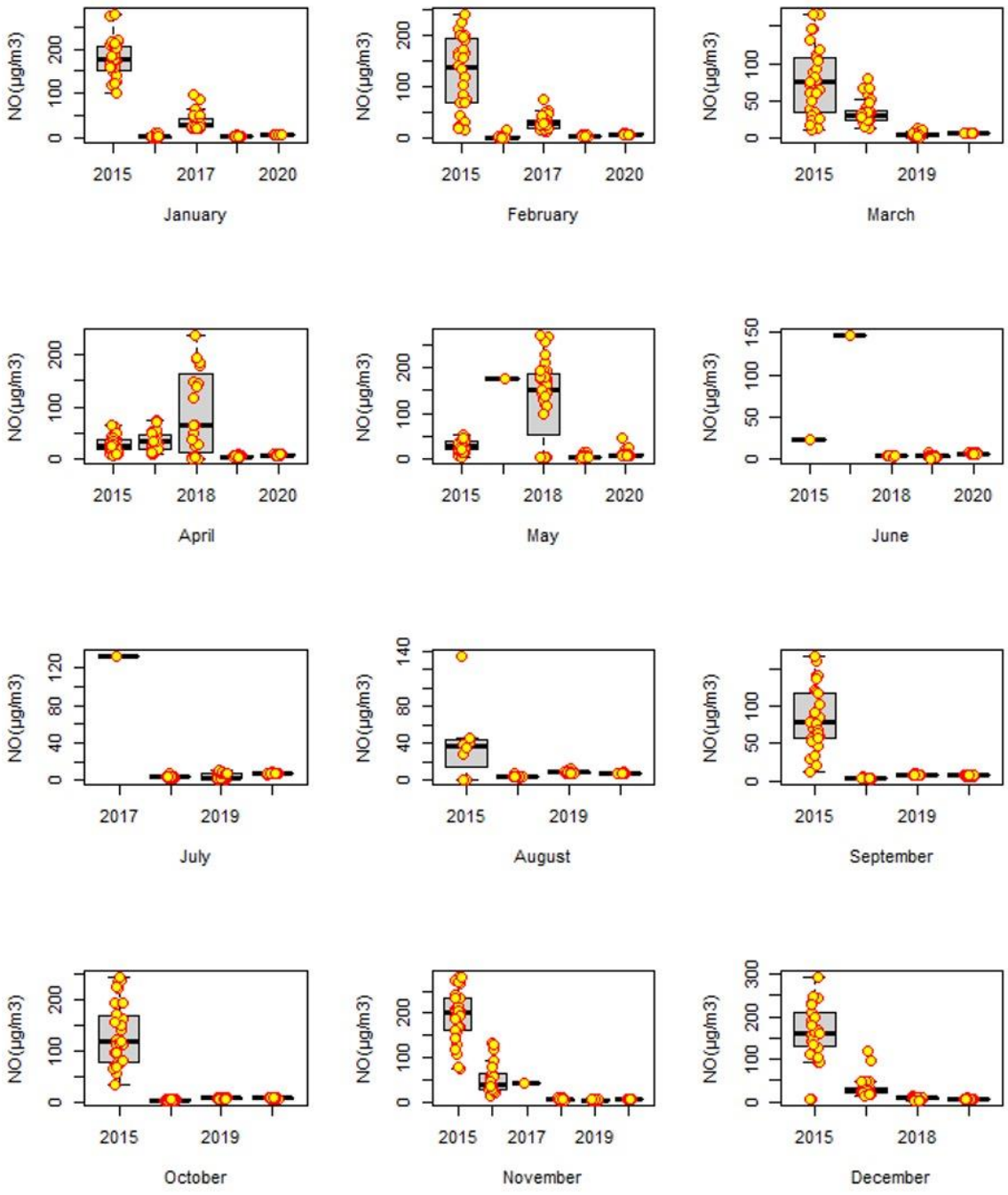

Figure 7. Long term variation of NO from 2015 -2020 in Dhaka

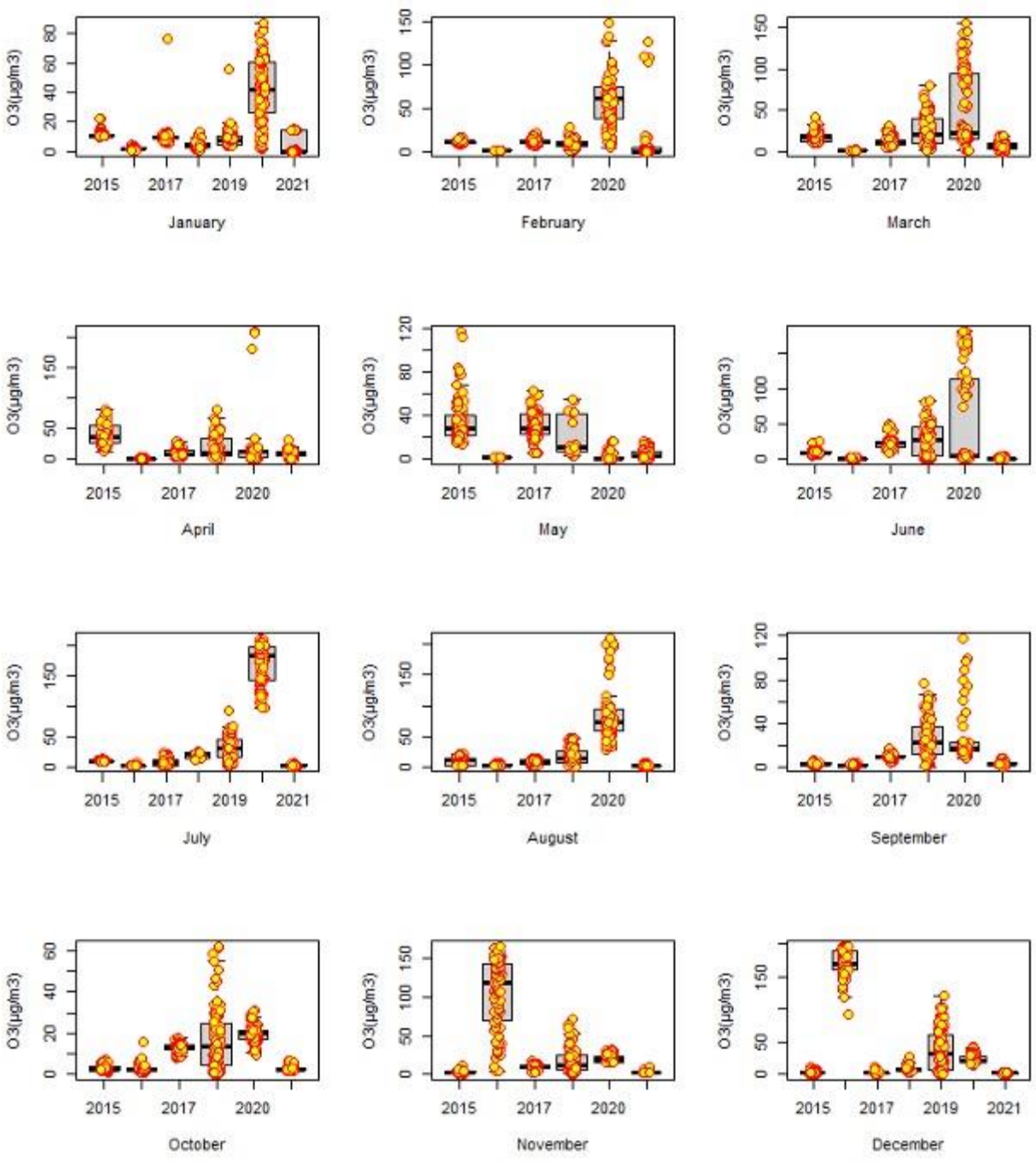

Figure 8. Long term variation of O3 from 2015 -2021 in Dhaka

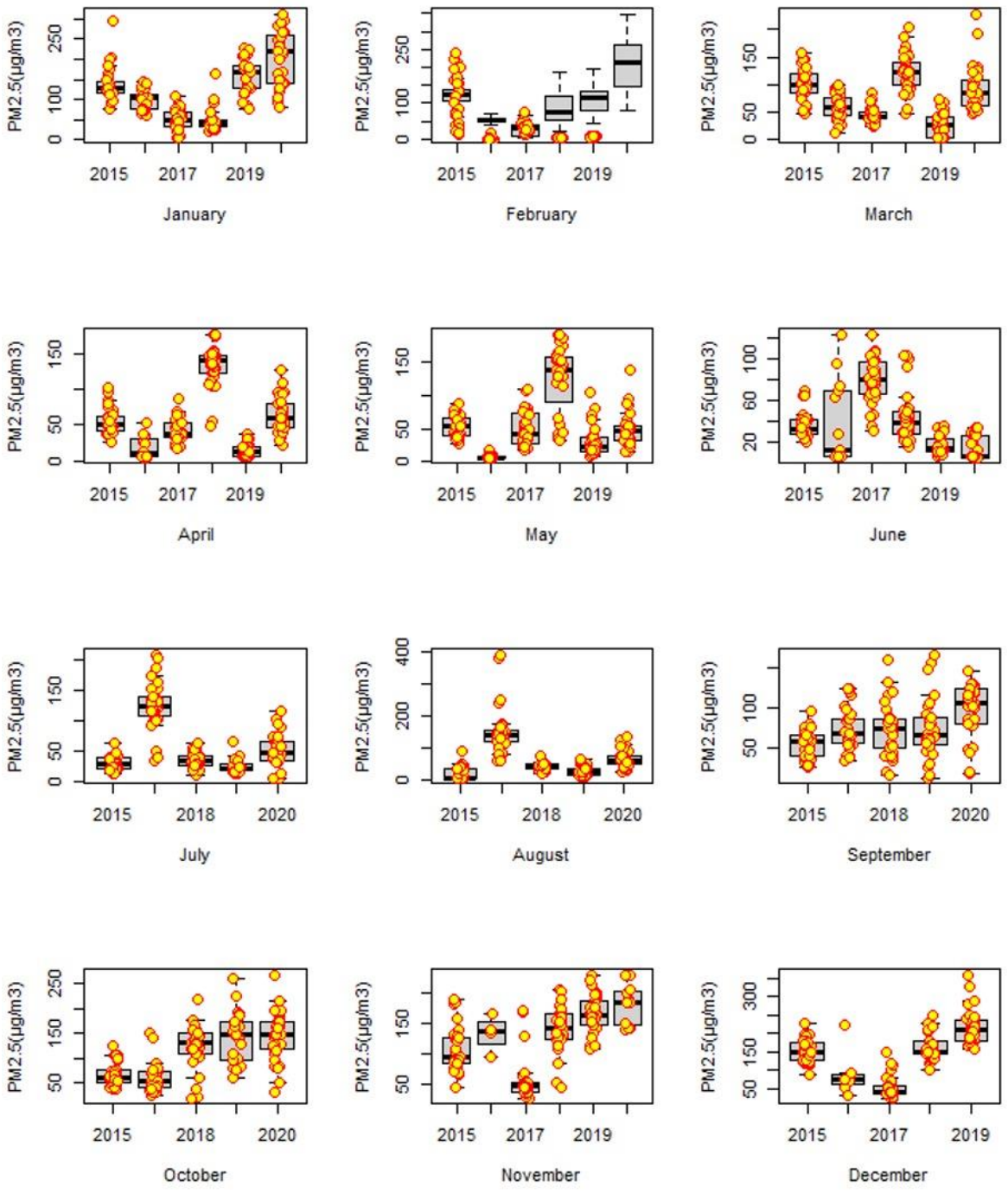

Figure 9. Long term variation of PM2.5 from 2015 -2020 in Dhaka

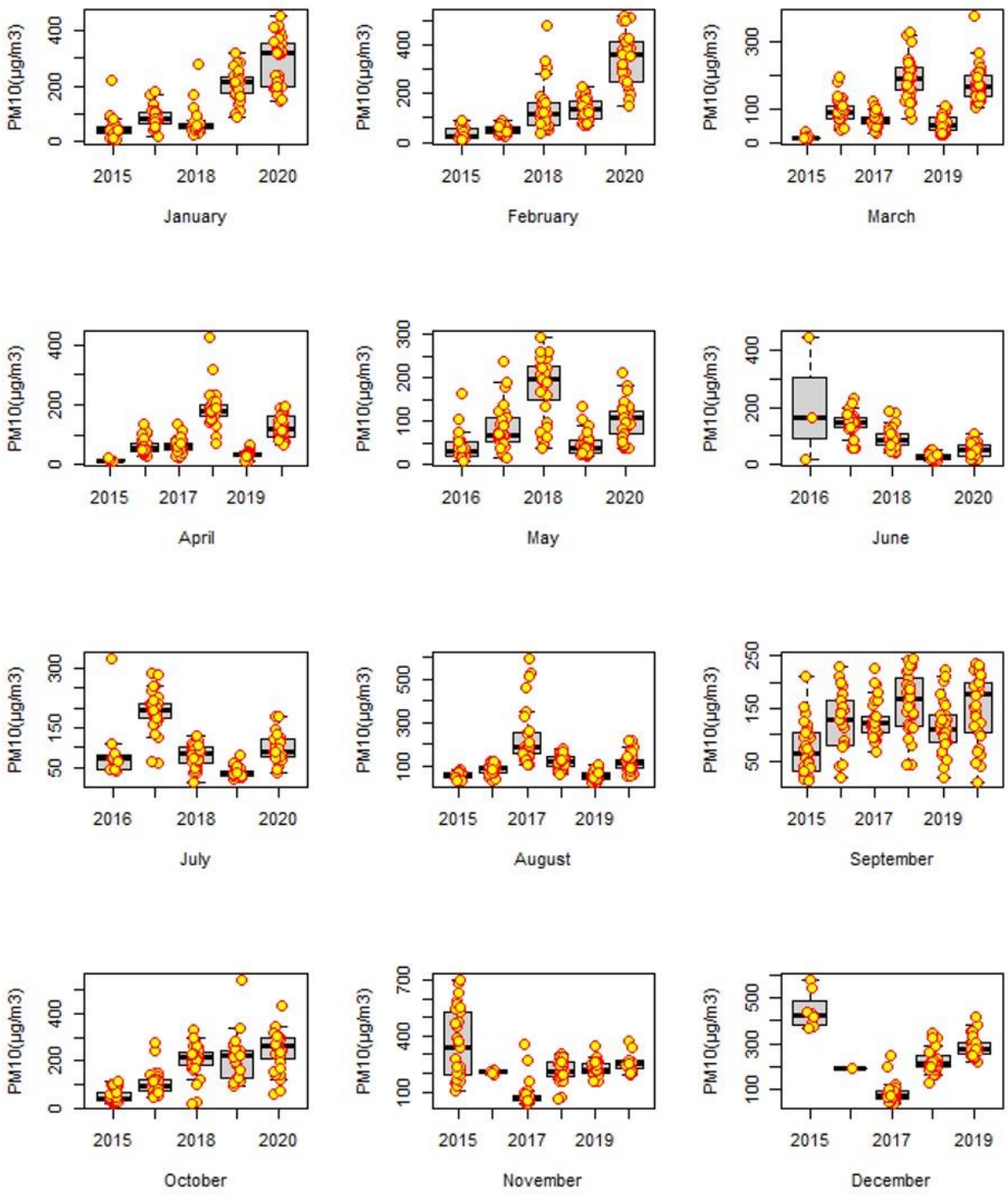

Figure 10. Long term variation of PM10 from 2015 -2020 in Dhaka

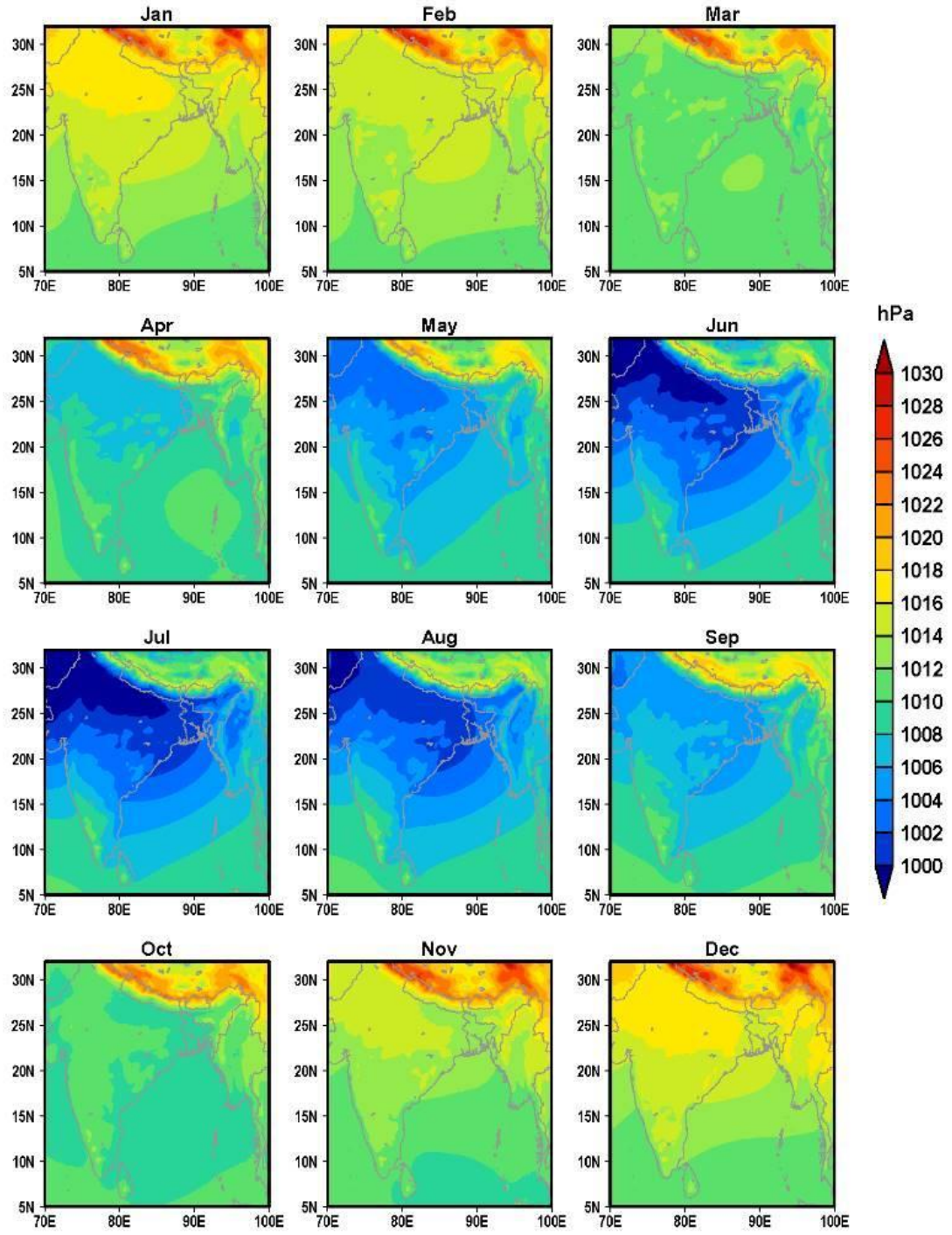

Figure S1. Climatological sea level pressure (hPa)

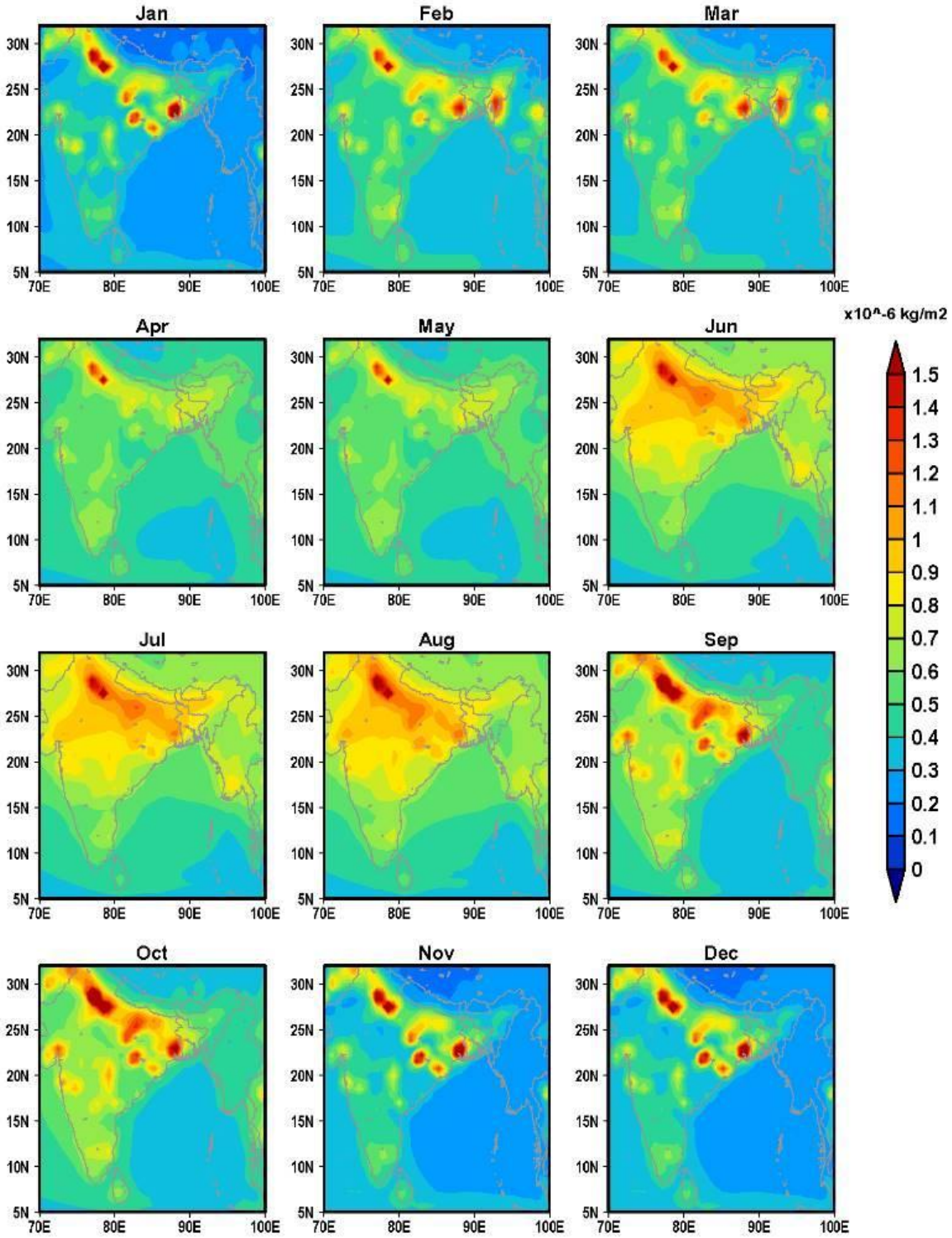

Figure S2. Climatological NO column (kg/m2)

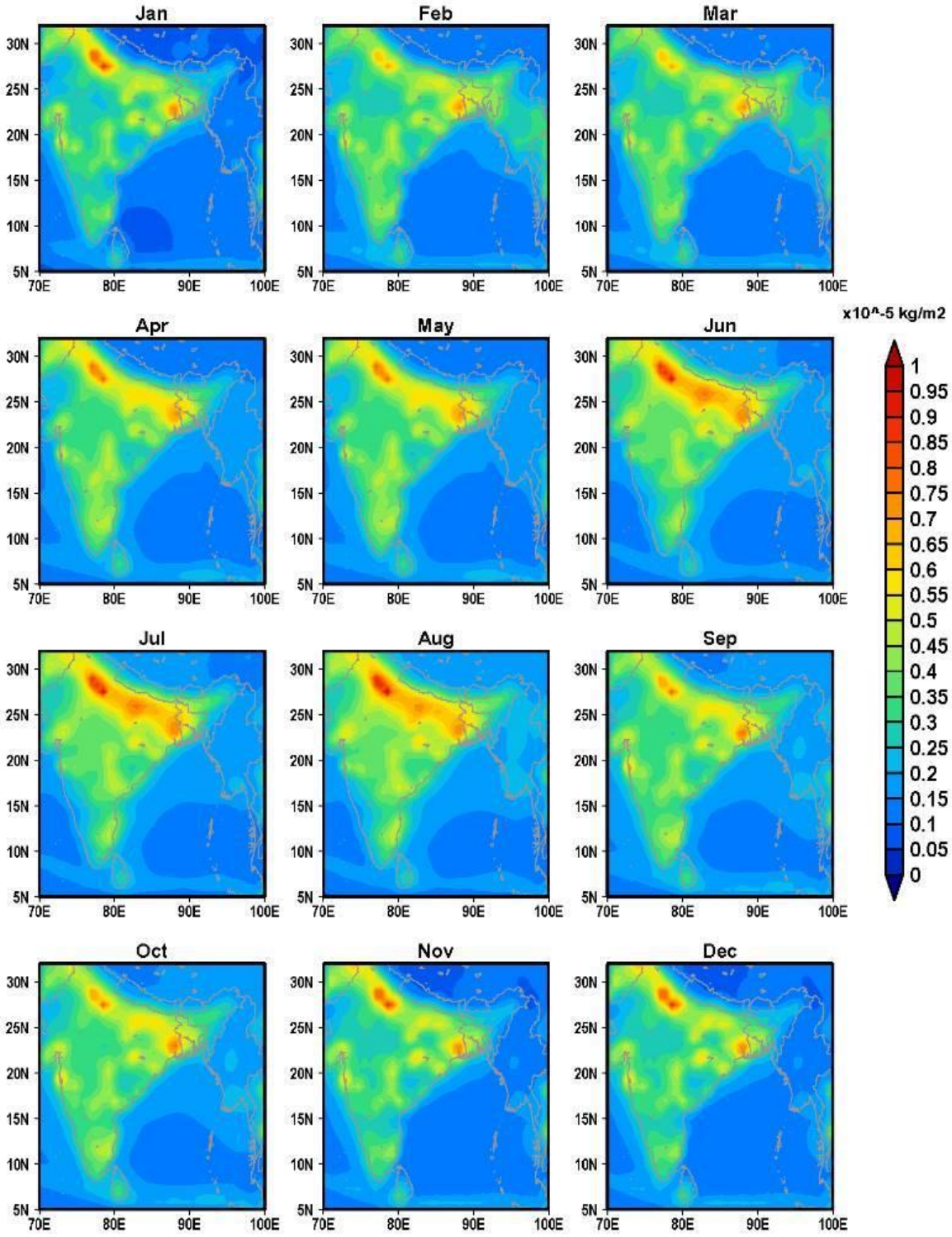

Figure S3. Climatological NO2 column (kg/m2)

Figures of Barisal

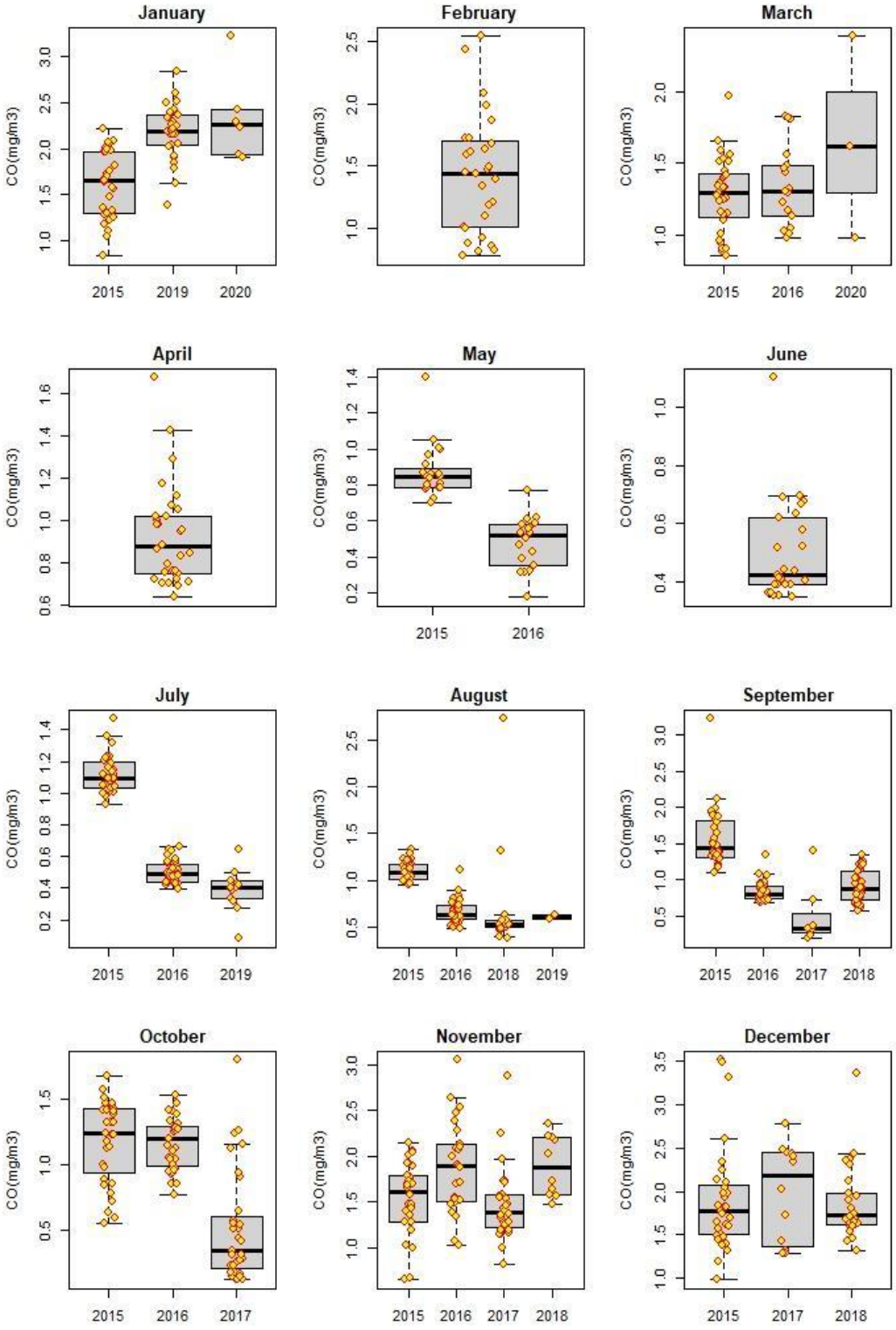

Fig.S4. Long term CO variation from 2015 - 2021 in Barisal

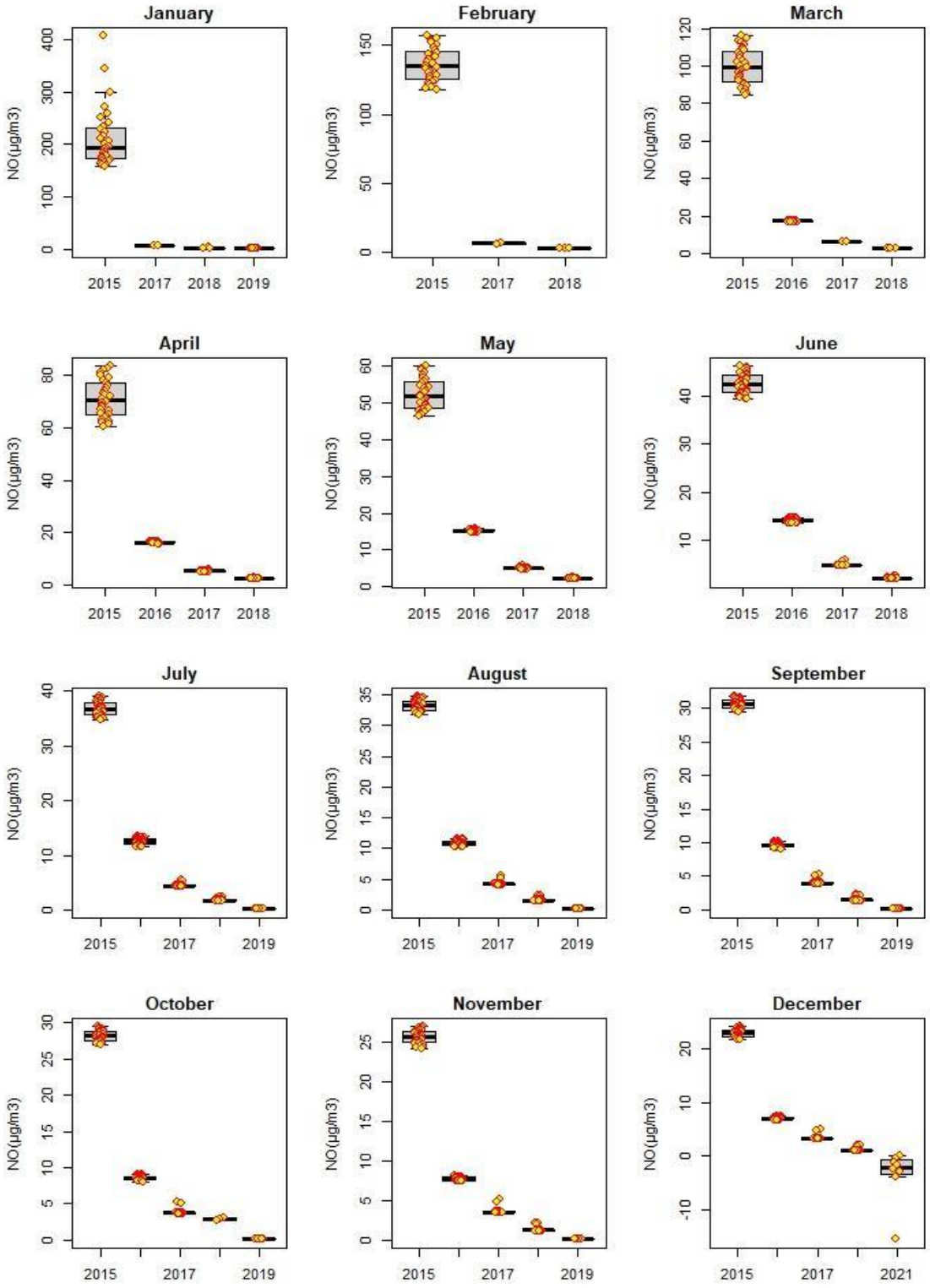

Fig. S5. Long term NO variation from 2015 to 2021 in Barisal

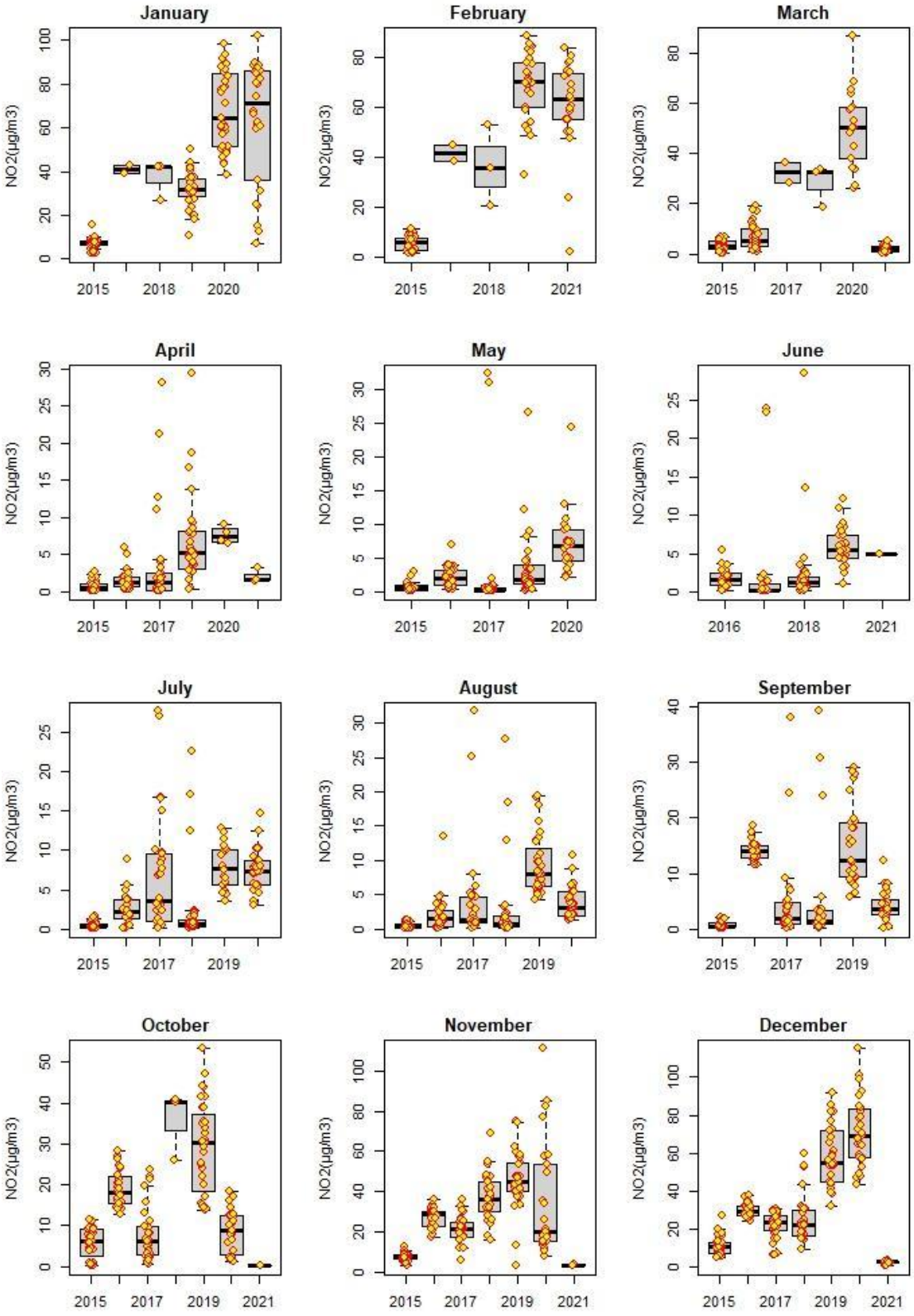

Fig.S6. Long term NO2 variation from 2015 to 2021 in Barisal

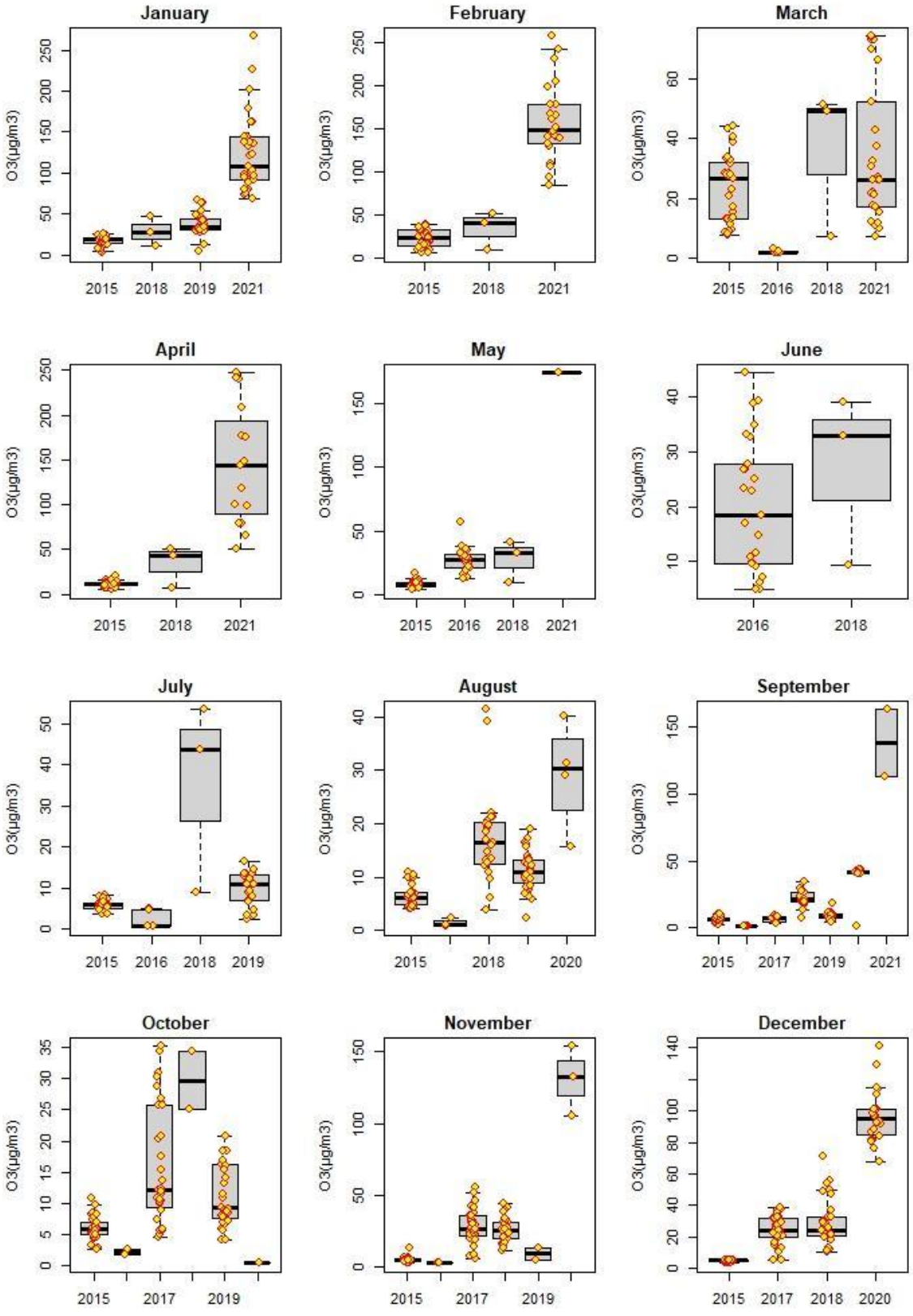

Fig.S7. Long term O3 variation from 2015 - 2021 in Barisal

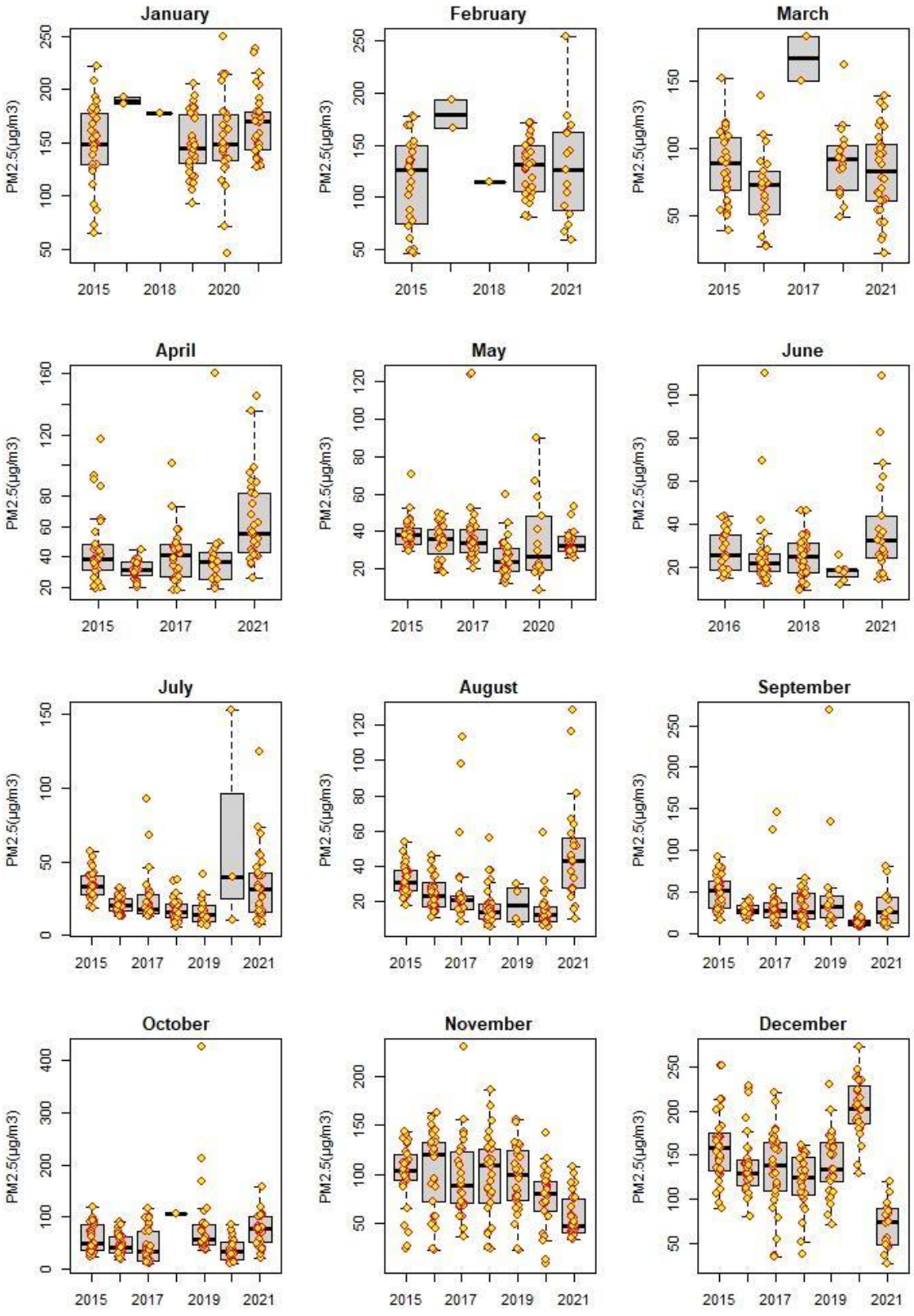

Fig.S8. Long term variation of PM2.5 from 2015 - 2021 in Barisal

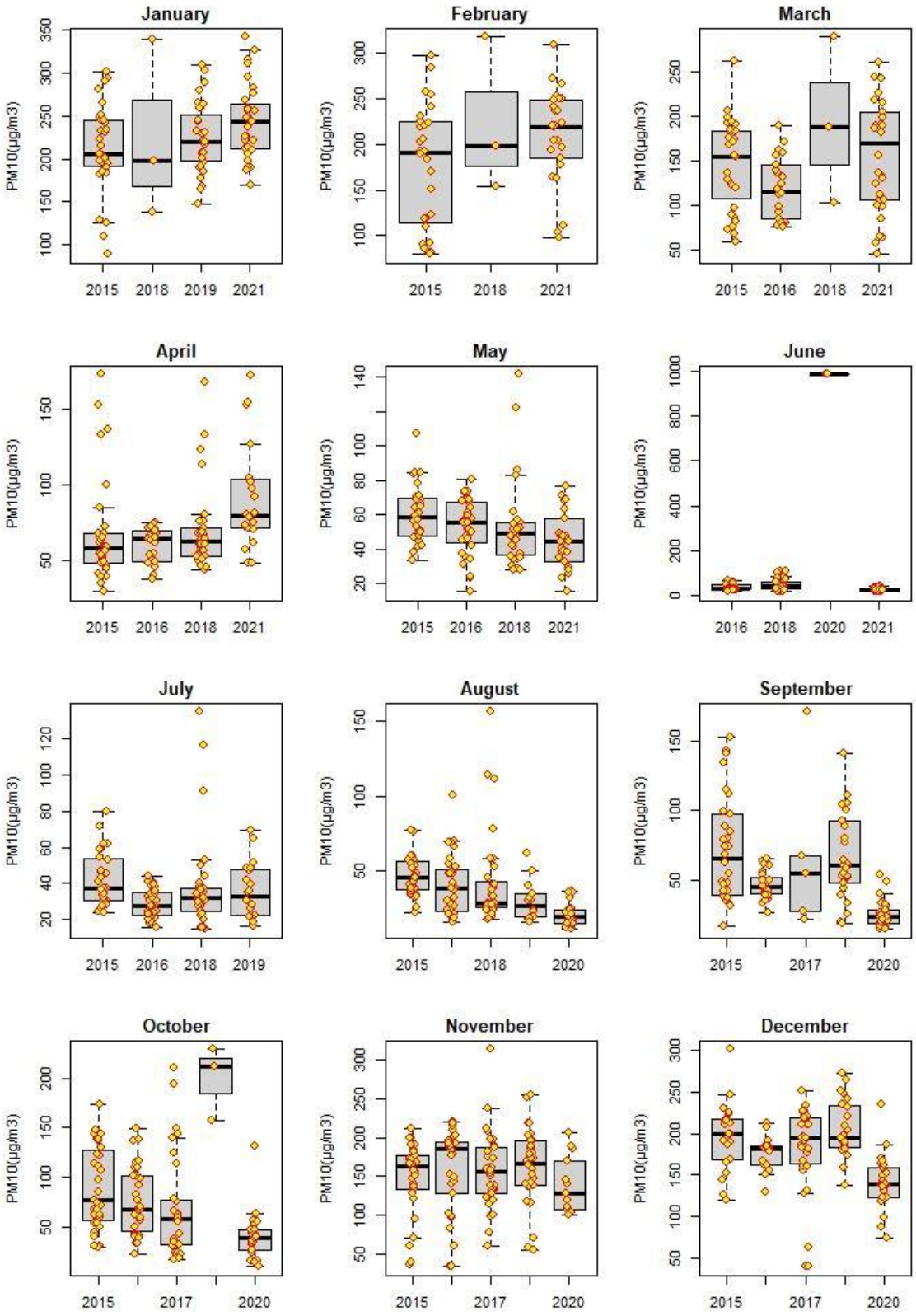

Fig. S9. Long term variation of PM10 from 2015 - 2021 in Barisal

Figures of Rangpur

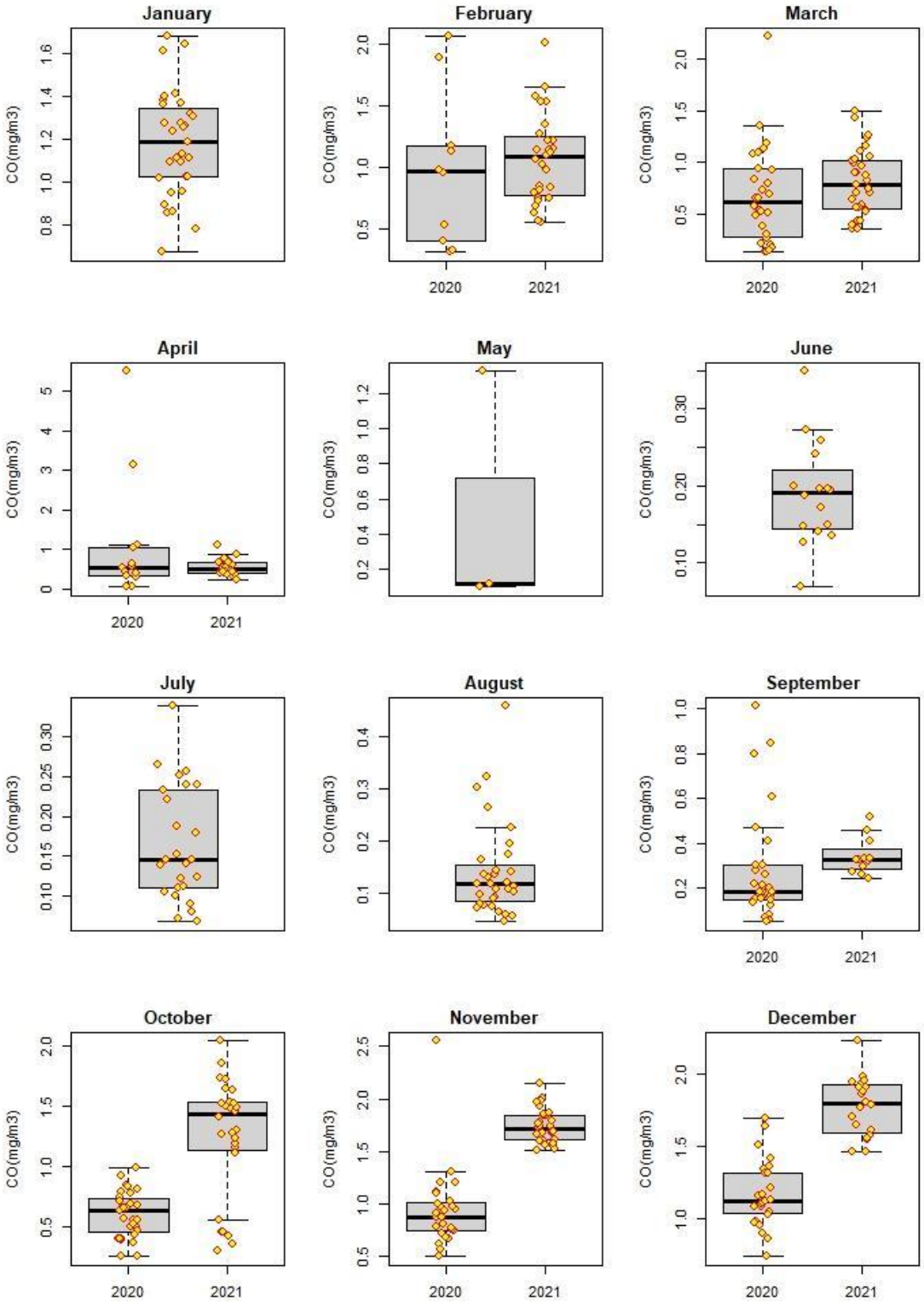

Fig.S10. Long term CO variation from 2020 - 2021 in Rangpur

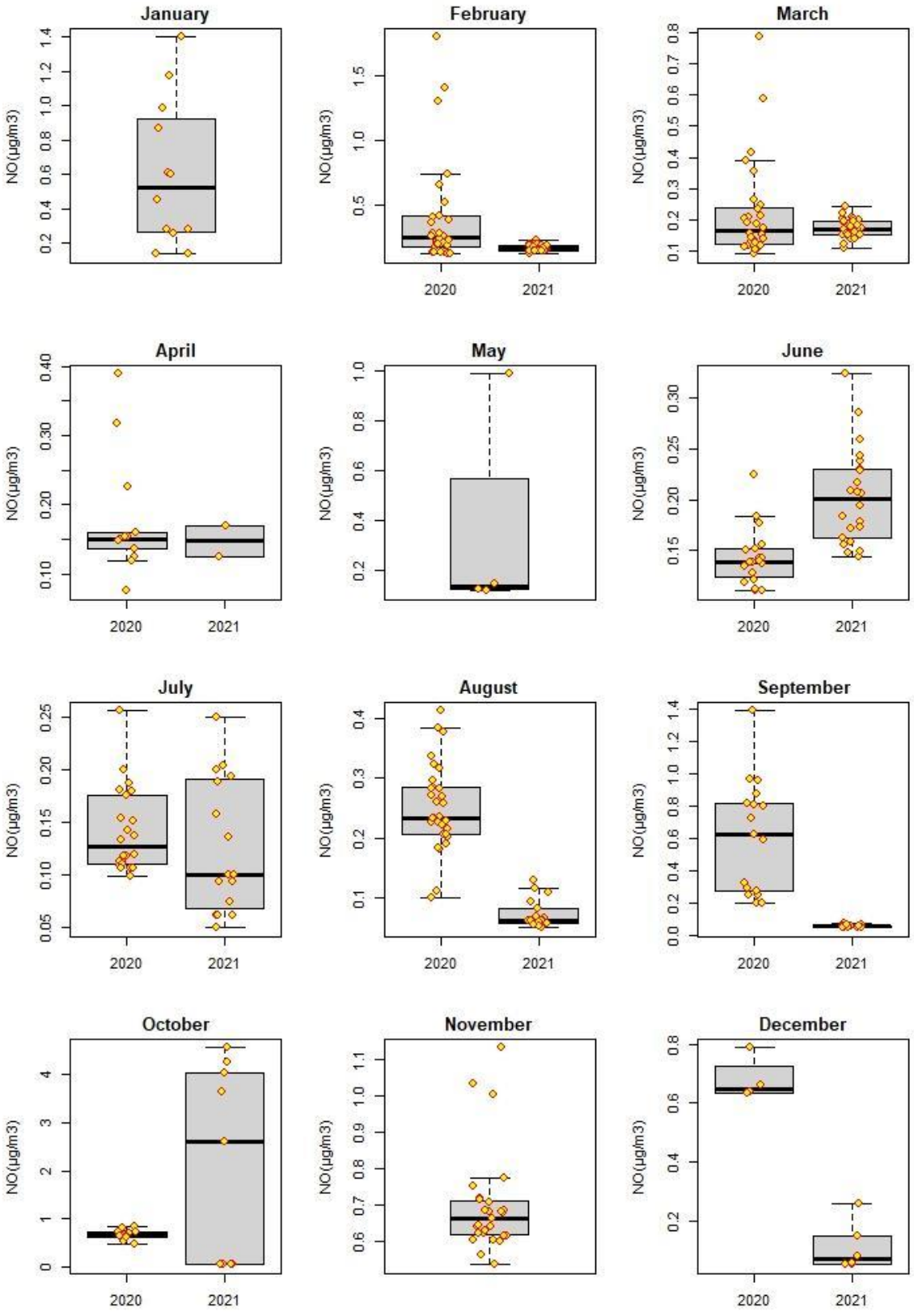

Fig.S11. Long term variation of NO from 2020 - 2021 in Rangpur

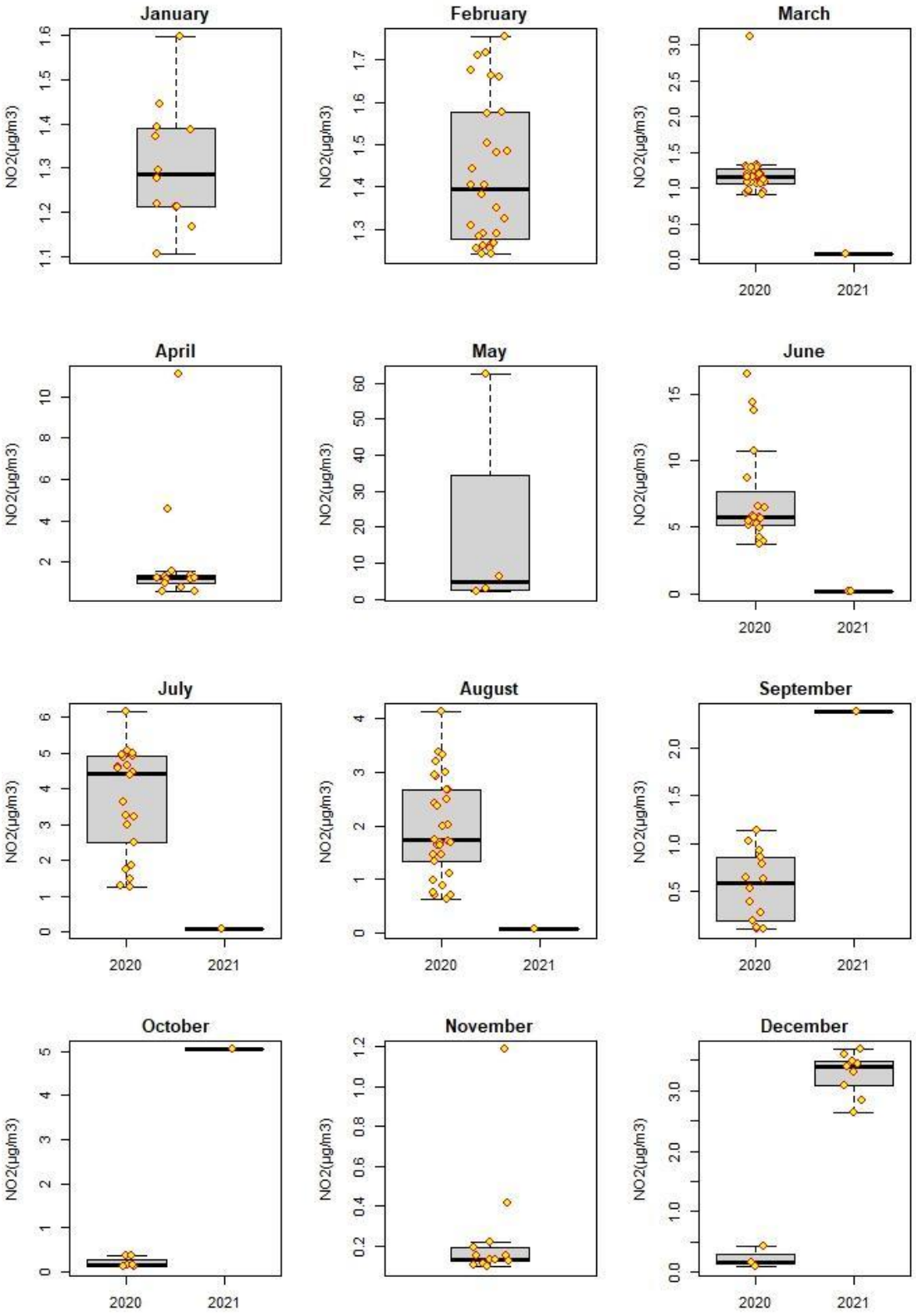

Fig.S12. Long term variation of NO2 from 2020 -2021 in Rangpur

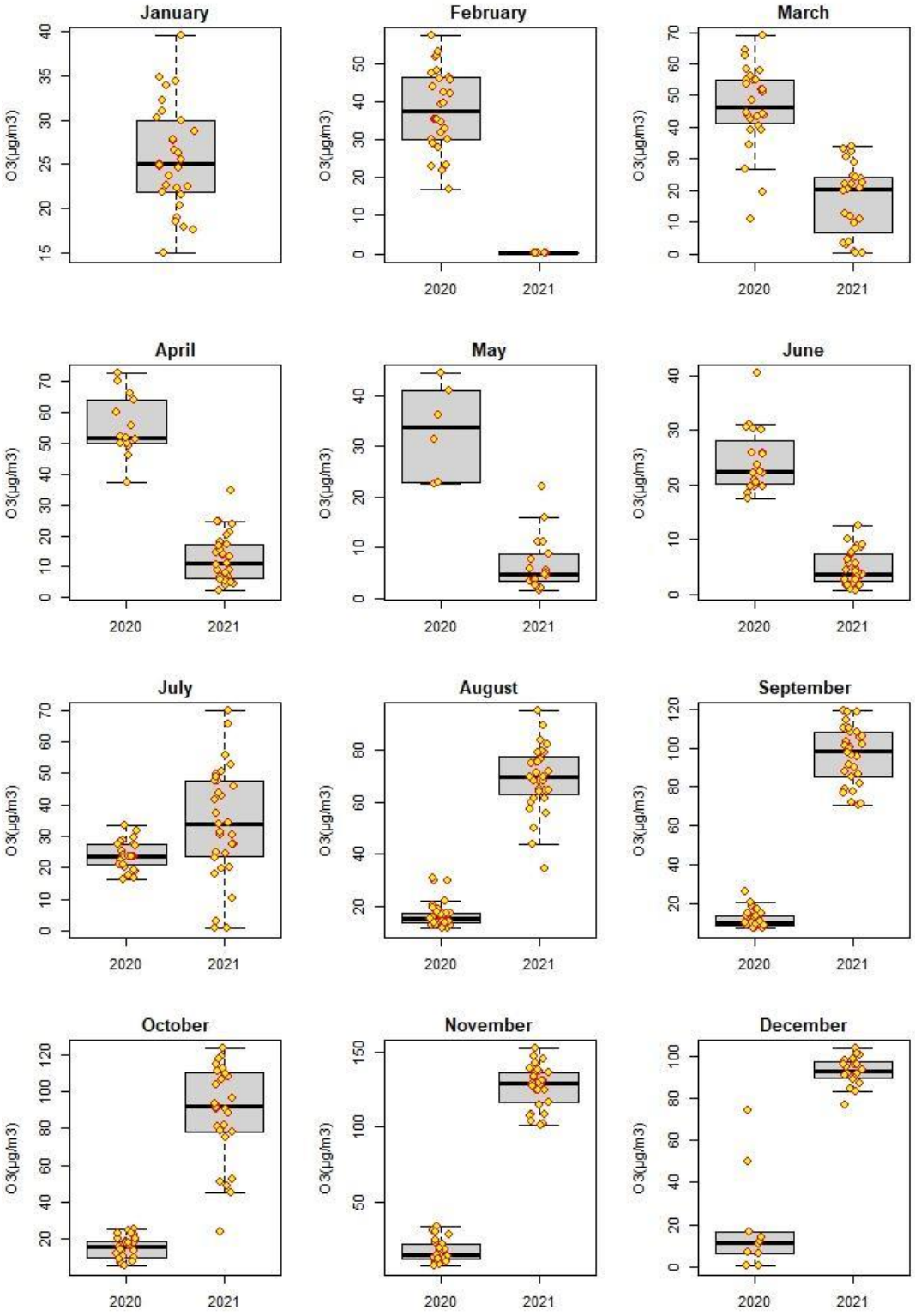

Fig.S13. Long term variation of O3 from 2020 -2021 in Rangpur

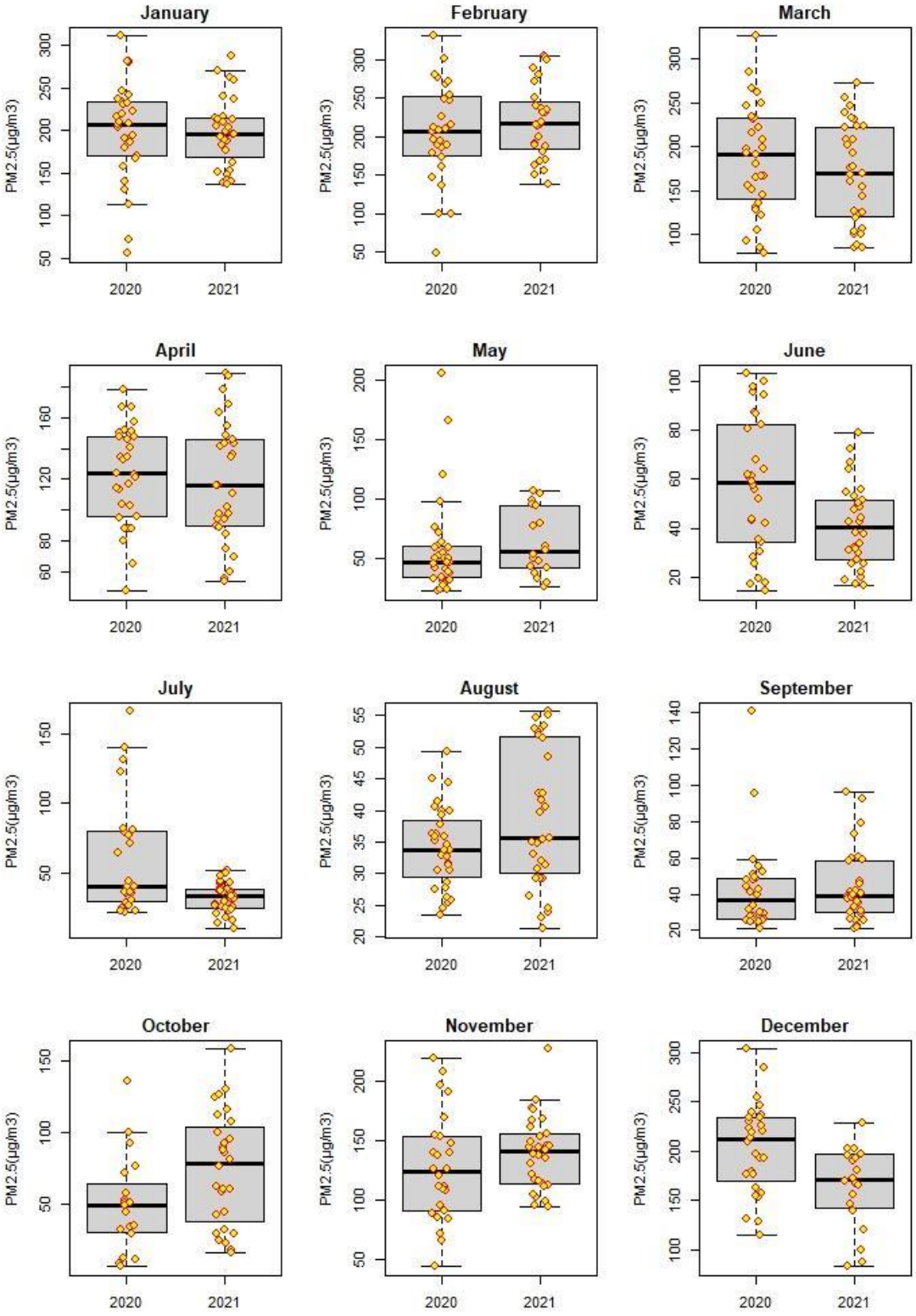

Fig .S14. Long term variation of PM2.5 from 2020 - 2021 in Rangpur

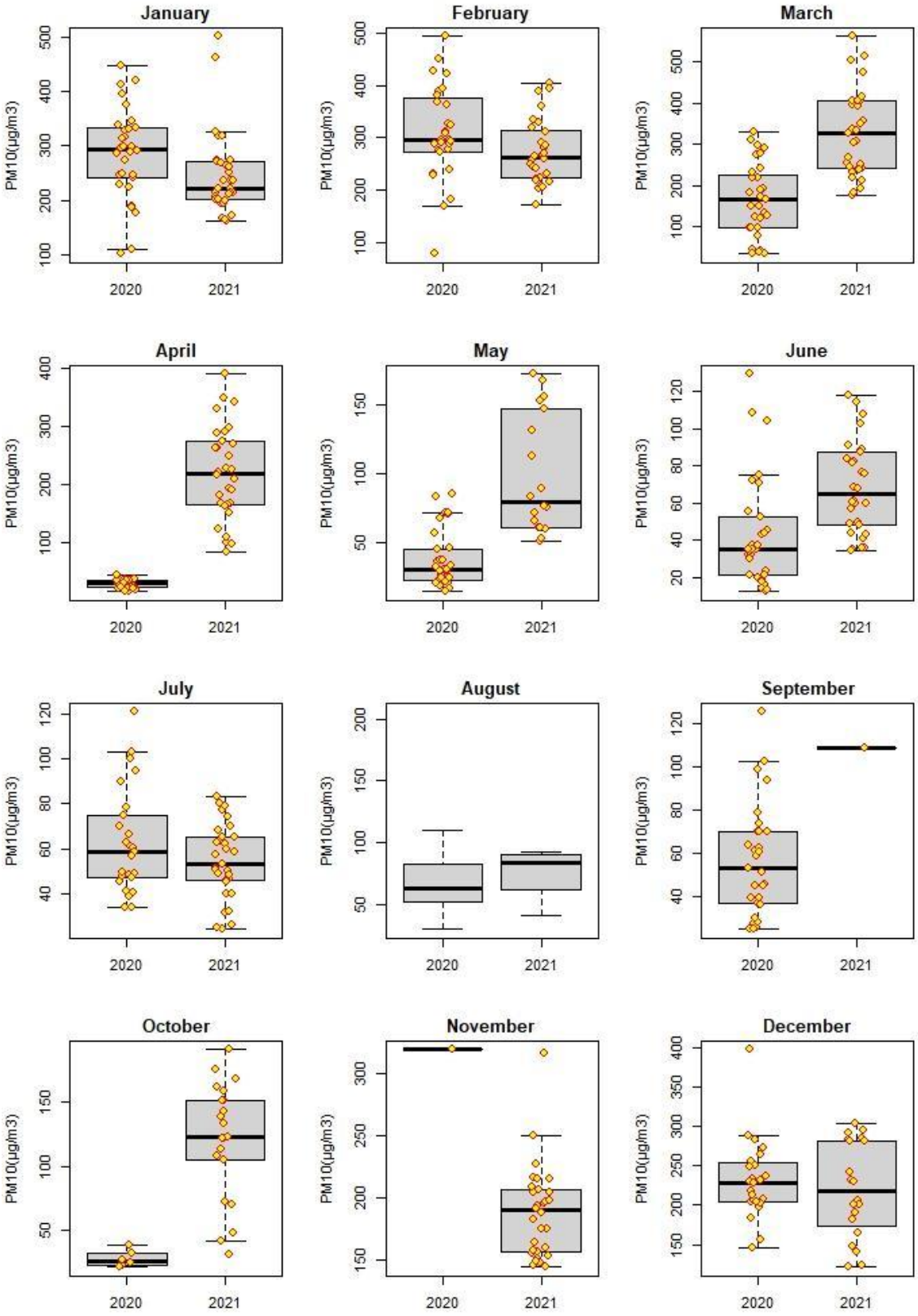

Fig. S15. Long term variation of PM10 from 2020 -2021 in Rangpur

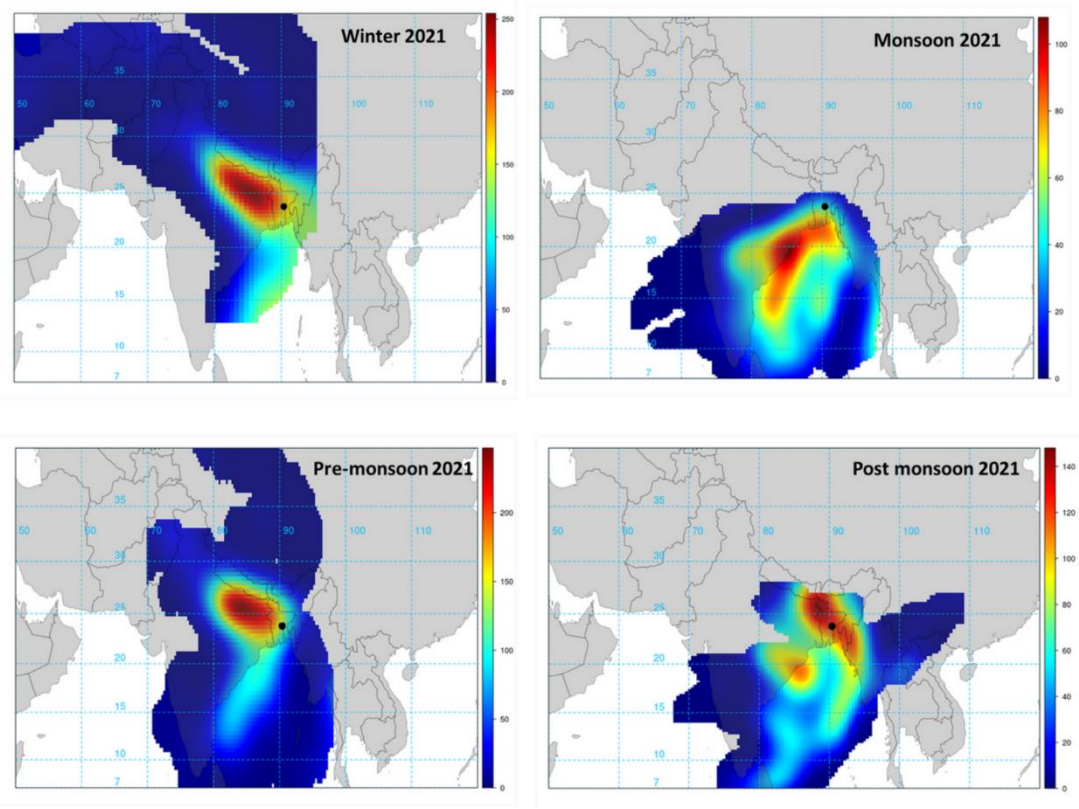

Figure S16. Seasonal $PM_{2.5}$ Using Concentration weighted Trajectory (CWT)

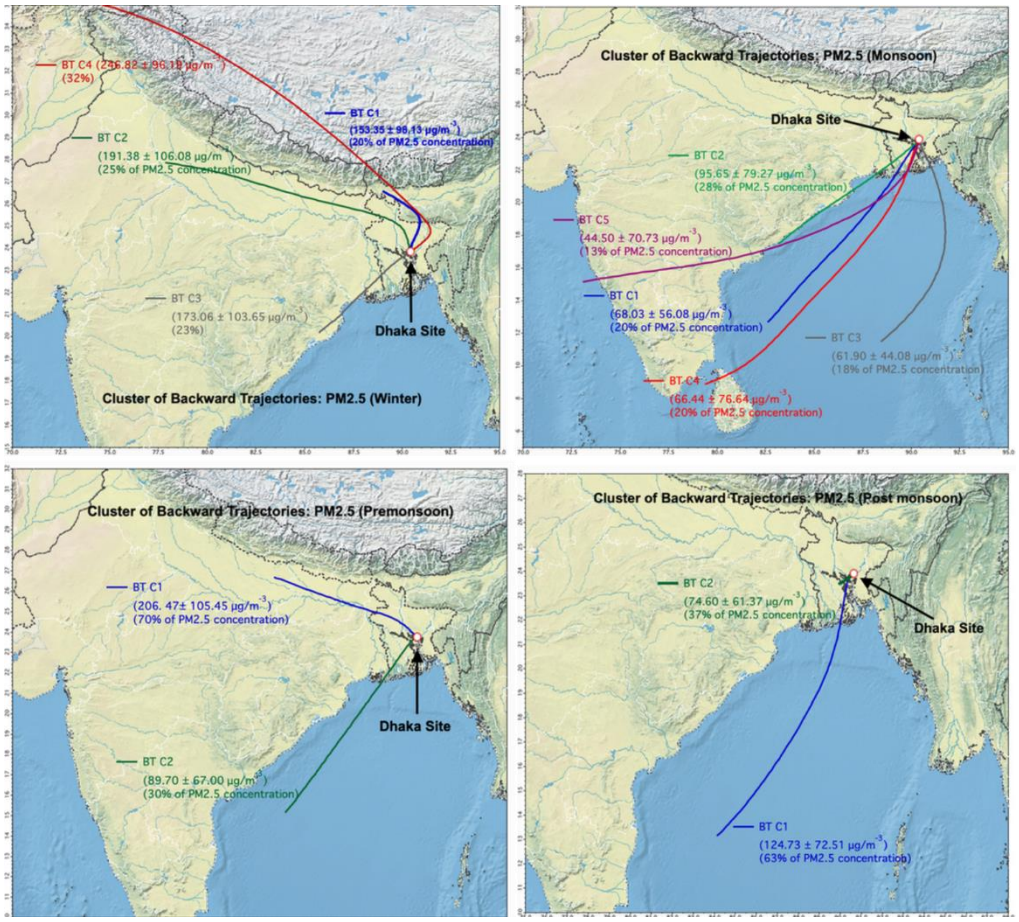

Figure S17. Air mass clusters coupled with seasonal $PM_{2.5}$ concentration