Figure S1: (left) Same as Fig. 1 but the CUPI-G and CPCB sites are depicted as white and colored circles, respectively. (right) Enlarged view of (left) near Delhi NCR. Sites in Delhi NCR are categorized as Delhi NCR for the site-mean values of CPCB, whereas nearby sites such as (24) Gurugram, (25) JNU, and (28) Faridabad are included as Delhi NCR for the site-mean values of CUPI-G, following the definition of Singh et al. (2023) (See Figs. 3, 4 7, and 8). The AERONET stations are marked as stars, including (pink in D01) Lahore and (yellow in D02) Amity University Gurgaon.

Table S1: List of CPCB and CUPI-G stations used in the study. Selected sites are marked with station numbers for PM$_{2.5}$ and CO in respective columns.

	Name	Long.	Lat.	PM$_{2.5}$	CO	Category
1	Kohali	74.70	31.71	1		
2	Khatrai Kalan	74.87	31.81			
3	Gaggar Bhana	75.28	31.61	3		
4	Sadarkot	75.18	30.95	4		
5	Budo Pandher	75.46	31.35	5		
6	PAU	75.82	30.90			
7	Rahon	76.15	31.01			
8	Thikriwala	75.54	30.45	8	-	CUPI-G, Source
9	Beauscape Farm	75.99	30.47	9		
10	Chajjli	75.83	30.03	10		
11	Nabha	76.12	30.34	11		
12	Patiala	76.34	30.39	12		
13	Chandigarh	76.76	30.75	13		
14	Khera	76.49	30.60	14		
15	Karsana	77.01	30.38			
16	Ruksana	76.67	29.66			
17	Taraori	76.92	29.81	17		
18	Lajwana Kalan	76.45	29.17	18		
19	Khanpur Kalan	76.80	29.16	19	-	CUPI-G, Intermediate
20	Pipalwali	77.03	29.62	20		
21	Dujana	76.61	28.67			
22	Sonipat	77.06	28.94	22		
23	Muzaffarnagar (UP)	77.64	29.34	23		
24	Gurugram	77.01	28.46	24		
25	JNU, New Delhi	77.17	28.54	25		
26	Meerut (U.P.)	77.73	28.99		-	CUPI-G, Delhi NCR
27	Gurugram (Sohna)	77.07	28.26			
28	Faridabad(Sector16)	77.32	28.41	28		
29	Aurangabad (UP)	77.96	28.50			
30	CRRI Mathura Road, Delhi - IMD	77.27	28.55	30		
31	Burari Crossing, Delhi - IMD	77.20	28.73	31		
32	North Campus, DU, Delhi - IMD	77.16	28.66	32		CPCB, Delhi NCR
33	IGI Airport (T3), Delhi - IMD	77.12	28.56	33		
34	Pusa_IMD, Delhi - IMD	77.10	28.61	34	34	
35	Aya Nagar, Delhi - IMD	77.11	28.47			

36	Lodhi_IMD, Delhi - IMD	77.23	28.59	36		
37	Shadipur, Delhi - CPCB	77.15	28.65			
38	IHBAS, Dilshad Garden, Delhi - CPCB	77.30	28.68	38	38	
39	NSIT Dwarka, Delhi - CPCB	77.03	28.61		39	
40	East Arjun Nagar, Delhi - CPCB	77.29	28.66			
41	ITO, Delhi - CPCB	77.24	28.63	41		
42	DTU, Delhi - CPCB	77.11	28.75			
43	Sirifort, Delhi - CPCB	77.22	28.55	43		
44	Mandir Marg, Delhi - DPCC	77.20	28.64			
45	R K Puram, Delhi - DPCC	77.19	28.56	45	45	
46	Punjabi Bagh, Delhi - DPCC	77.13	28.67	46		
47	Ashok Vihar, Delhi - DPCC	77.18	28.70	47		
48	Dr. Karni Singh Shooting Range, Delhi - DPCC	77.26	28.50	48		
49	Dwarka-Sector 8, Delhi - DPCC	77.07	28.57	49		
50	Jahangirpuri, Delhi - DPCC	77.17	28.73	50		
51	Jawaharlal Nehru Stadium, Delhi - DPCC	77.23	28.58	51		
52	Major Dhyan Chand National Stadium, Delhi - DPCC	77.24	28.61	52		CPCB, Delhi, NCR
53	Narela, Delhi - DPCC	77.10	28.82	53		
54	Najafgarh, Delhi - DPCC	76.93	28.57	54		
55	Okhla Phase-2, Delhi - DPCC	77.27	28.53	55		
56	Nehru Nagar, Delhi - DPCC	77.25	28.57	56		
57	Rohini, Delhi - DPCC	77.12	28.73	57		
58	Patparganj, Delhi - DPCC	77.29	28.62	58		
59	Sonia Vihar, Delhi - DPCC	77.25	28.71	59		
60	Wazirpur, Delhi - DPCC	77.17	28.70	60		
61	Vivek Vihar, Delhi - DPCC	77.32	28.67	61		
62	Bawana, Delhi - DPCC	77.05	28.78	62		
63	Mundka, Delhi - DPCC	77.08	28.68	63	63	
64	Sri Aurobindo Marg, Delhi - DPCC	77.19	28.53	64		
65	Pusa_DPCC, Delhi - DPCC	77.15	28.64	65		
66	Anand Vihar, Delhi - DPCC	77.32	28.65	66		
67	Alipur, Delhi - DPCC	77.15	28.82	67	67	
68	Chandni Chowk, Delhi - IITM	77.23	28.66			
69	Lodhi_IITM, Delhi - IITM	77.22	28.59			
70	Patti Mehar, Ambala - HSPCB	76.78	30.38	70		
71	Arya Nagar, Bahadurgarh - HSPCB	76.93	28.67	71		
72	Nathu Colony, Ballabgarh - HSPCB	77.32	28.34			CPCB, Haryana
73	H.B. Colony, Bhiwani - HSPCB	76.14	28.81	73		

#	Location					
74	Mini Secretariat, Charkhi Dadri - HSPCB	76.27	28.59	74		
75	Municipal Corporation Office, Dharuhera - HSPCB	76.80	28.21			
76	Sector- 16A, Faridabad - HSPCB	77.31	28.41	76		
77	New Industrial Town, Faridabad - HSPCB	77.30	28.39	77	77	
78	Sector 30, Faridabad - HSPCB	77.32	28.44			
79	Sector 11, Faridabad - HSPCB	77.32	28.38			
80	Huda Sector, Fatehabad - HSPCB	75.47	29.50	80		
81	Vikas Sadan, Gurugram - HSPCB	77.03	28.45			
82	NISE Gwal Pahari, Gurugram - IMD	77.15	28.42	82		
83	Teri Gram, Gurugram - HSPCB	77.15	28.43	83	83	
84	Sector-51, Gurugram – HSPCB	77.07	28.42			
85	Urban Estate-II, Hisar - HSPCB	75.74	29.14	85		
86	Police Lines, Jind - HSPCB	76.34	29.31	86		CPCB, Haryabna
87	Rishi Nagar, Kaithal – HSPCB	76.42	29.80	87		
88	Sector-12, Karnal - HSPCB	77.00	29.70	88		
89	Sector-7, Kurukshetra - HSPCB	76.88	29.97	89		
90	General Hospital, Mandikhera - HSPCB	76.99	27.90			
91	Sector-2 IMT, Manesar - HSPCB	76.94	28.36	91		
92	Shastri Nagar, Narnaul - HSPCB	76.11	28.06	92	92	
93	Shyam Nagar, Palwal - HSPCB	77.33	28.15		93	
94	Sector-6, Panchkula - HSPCB	76.85	30.71	94		
95	Sector-18, Panipat - HSPCB	76.99	29.50			
96	MD University, Rohtak - HSPCB	76.37	28.52			
97	F-Block, Sirsa - HSPCB	75.02	29.54			
98	Murthal, Sonipat - HSPCB	77.06	29.03	98	98	
99	Gobind Pura, Yamuna Nagar - HSPCB	77.29	30.15	99		
100	Golden Temple, Amritsar – PPCB	74.88	31.62	100		
101	Hardev Nagar, Bathinda - PPCB	74.91	30.23			
102	Civil Line, Jalandhar - PPCB	75.58	31.32	102		
103	Kalal Majra, Khanna - PPCB	76.21	30.74	103		
104	Punjab Agricultural University, Ludhiana - PPCB	75.81	30.90	104	104	CPCB, Punjab
105	RIMT University, Mandi Gobindgarh - PPCB	76.33	30.65	105	105	
106	Model Town, Patiala - PPCB	76.37	30.35	106		
107	Ratanpura, Rupnagar - Ambuja Cements	76.56	31.03	107		
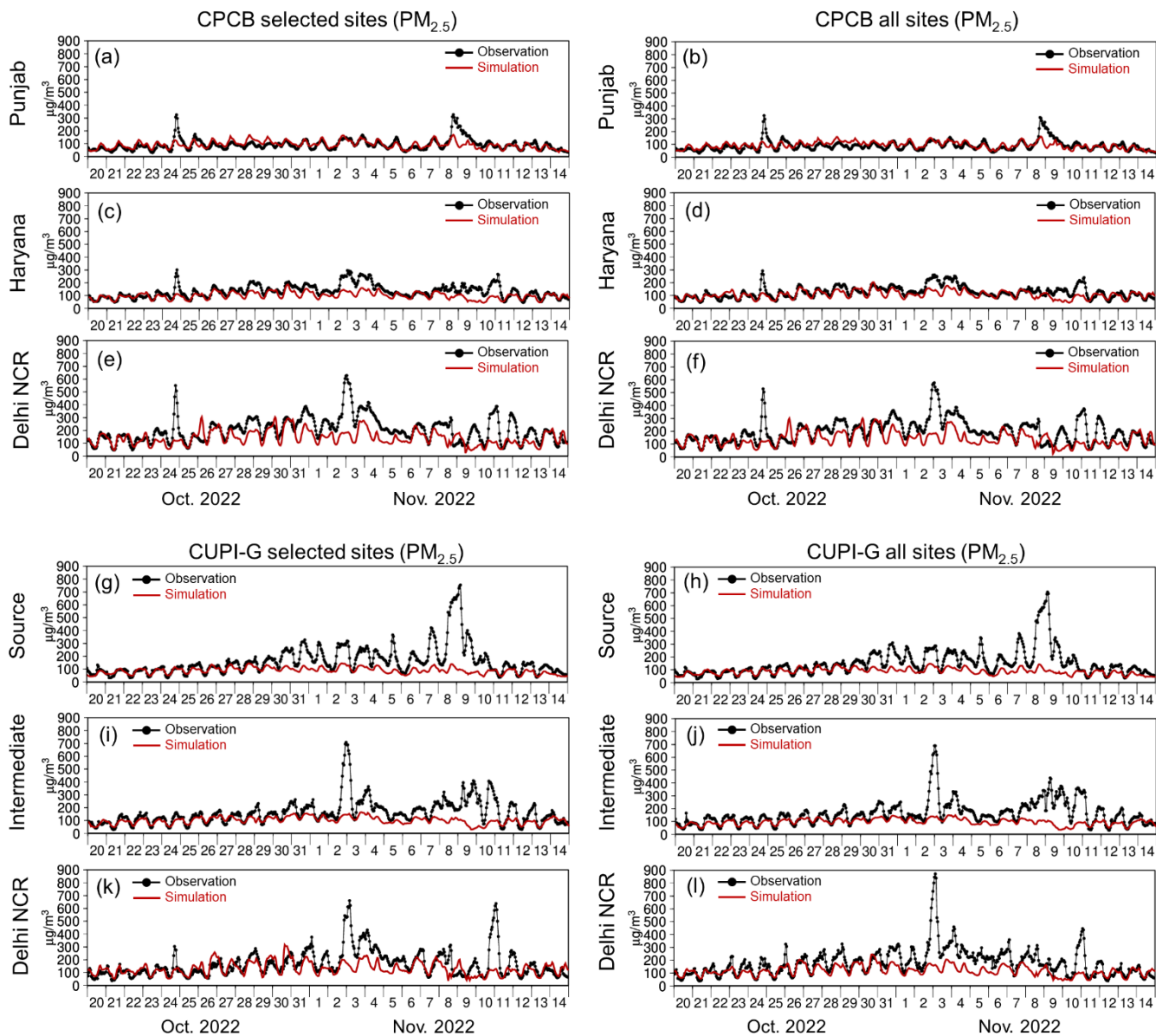
Figure S2: Same as Fig. 3 but for (left) selected stations and (right) all stations.
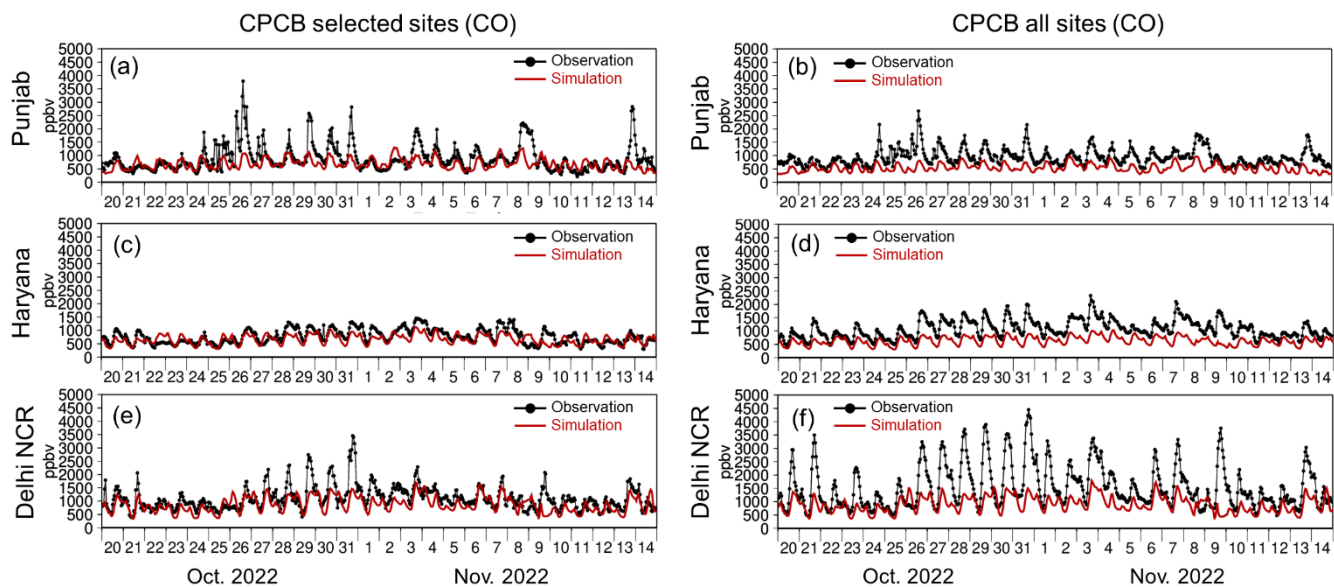
Figure S3: Same as Fig. S2 but for CO concentrations (ppbv) of CPCB stations.
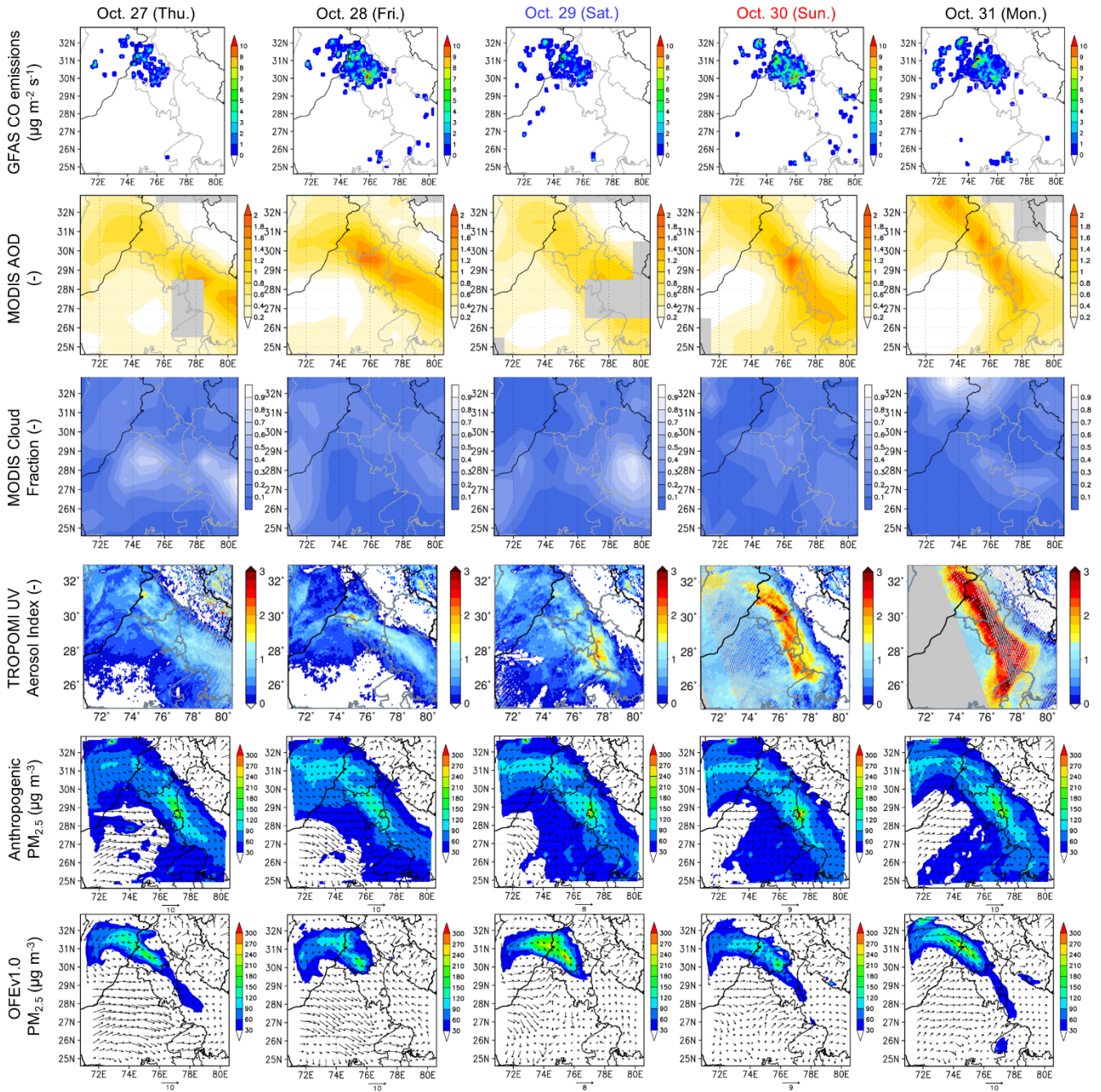
Figure S4: Spatial distribution of (top to bottom) daily mean GFAS CO emissions, MODIS AOD, MODIS Cloud Fraction, TROPOMI UV Aerosol Index, simulated surface concentrations of anthropogenic $PM_{2.5}$, simulated surface concentrations of CRB $PM_{2.5}$ using OFEv1.0 from October 27 to 31, 2022. The simulated surface wind vectors are also shown in the $PM_{2.5}$ maps. The Terra descending mode data (10:30 local time) is shown for MODIS. The time periods of the TROPOMI orbit shown in the figures are approximately 6:30–9:30 UTC (12:00–15:00 IST). The simulation time is 6:00 UTC (11:30 IST).
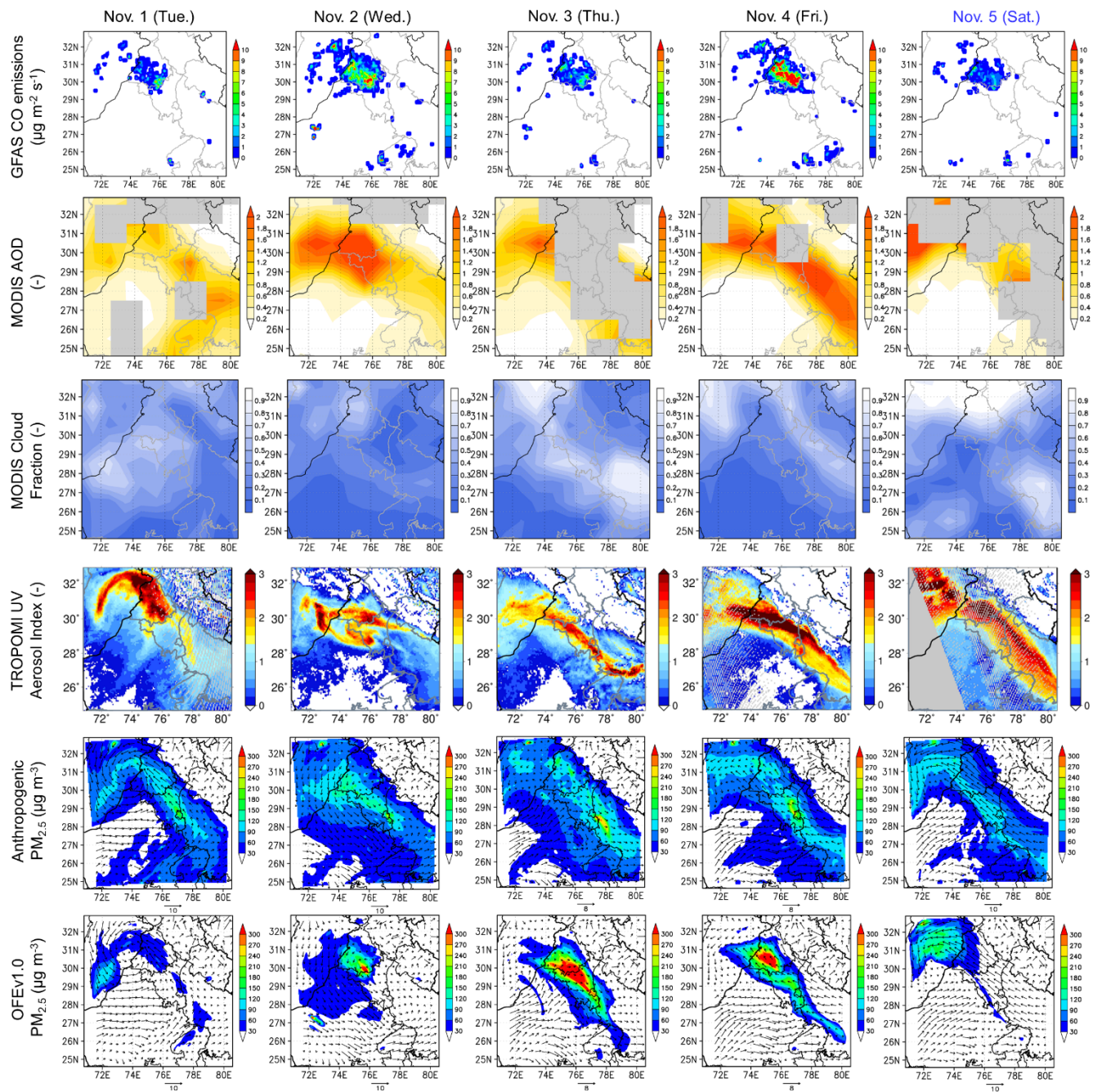
Figure S5: Same as Fig. S4 but from November 1 to 5, 2022.
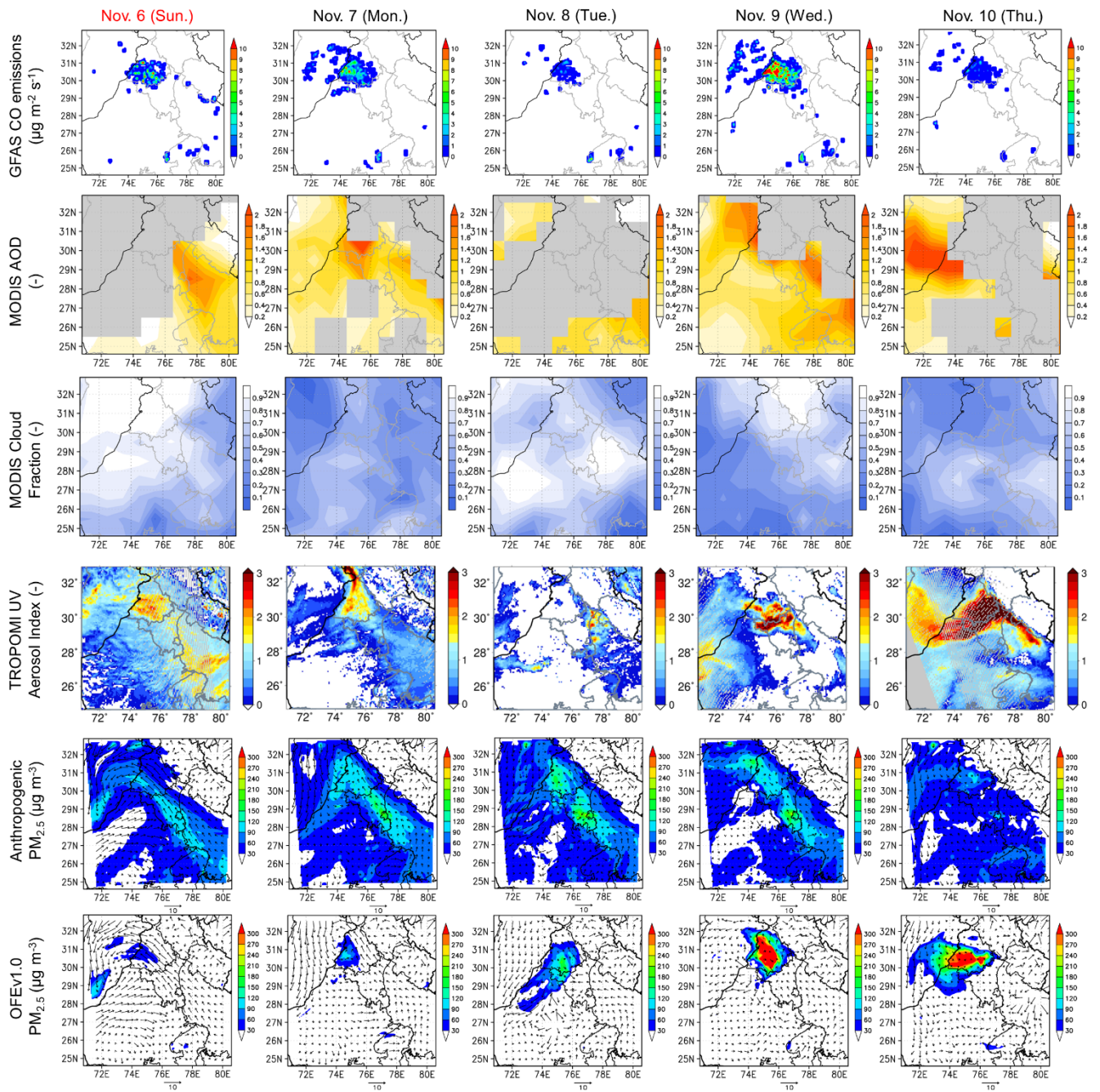
Figure S6: Same as Figs. S4 and S5 but from November 6 to 10, 2022.
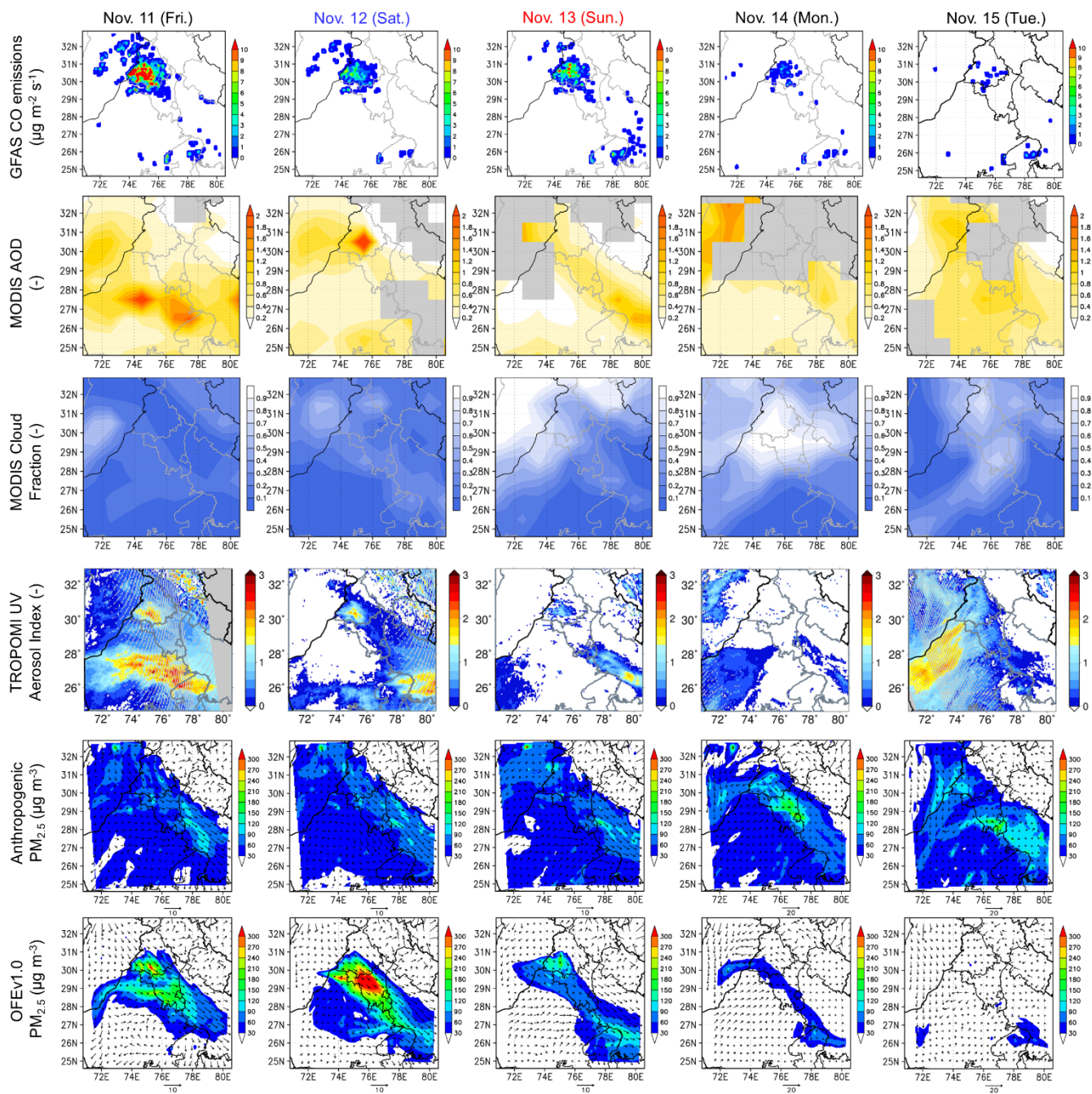
Figure S7: Same as Figs. S4–S6 but from November 11 to 15, 2022.
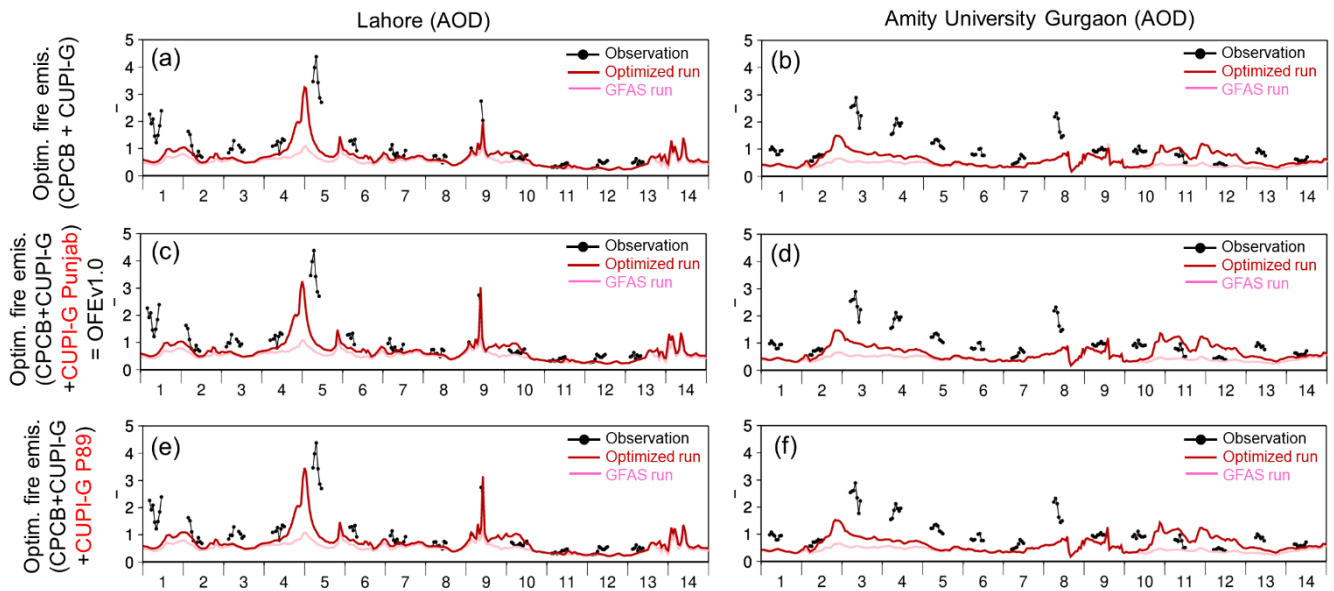
Figure S8: Time series of (black) AERONET observed and (red and pink) simulated AOD at 500 nm at (left) Lahore and (right) Amity University Gurgaon stations from November 1 to 15, 2022 (00:00 UTC). The red and pink lines indicate "Optimized" and "GFAS" runs, respectively.