Table S1. Heterogeneous uptake coefficients.

Species	Gamma
N_2O_5	0.1
N_2O_5 dust	0.0
NO_3	0.1
NO_3 dust	0.0
NO_2	0.0001
NH_3	0.05
HO_2	1.0

Table S2. Time series correlation of each station's observed total $PM_{2.5}$ with the individual components of modeled dry $PM_{2.5}$, total dry $PM_{2.5}$, and total wet $PM_{2.5}$ in the grid cell the station is located within. The last two columns show the normalized mean bias (%) of modeled dry and wet $PM_{2.5}$. For each station, the component with the highest correlation is in bold.

	Correlation of modeled component with daily averaged observed $PM_{2.5}$										Normalized Mean Bias	
Site	Dust	Salt	BC	OM	SOA	NH_4	SO_4	NO_3	$PM_{2.5}$ (dry)	$PM_{2.5}$ (wet)	$PM_{2.5}$ (dry)	$PM_{2.5}$ (wet)
1	–0.36	–0.46	0.51	0.53	–0.18	0.53	–0.17	**0.67**	0.62	0.61	3.8	28.1
2	–0.36	–0.25	0.66	**0.66**	–0.33	0.50	–0.08	0.60	0.61	0.60	–32.7	–18.7
3	–0.40	–0.37	**0.60**	0.60	–0.32	0.44	–0.19	0.56	0.56	0.55	–23.9	–7.8
4	–0.20	–0.14	0.59	**0.60**	–0.13	0.43	–0.02	0.46	0.49	0.47	–57.7	–48.8
5	–0.24	–0.10	**0.41**	0.40	0.25	0.25	0.14	0.24	0.34	0.33	–26.0	–10.3
6	0.01	0.19	**0.47**	0.44	0.23	0.13	–0.11	0.09	0.24	0.21	–26.4	–10.3
7	–0.30	–0.21	0.63	**0.66**	–0.14	0.53	0.08	0.57	0.58	0.57	–34.2	–20.3
8	–0.34	–0.23	0.63	**0.65**	–0.14	0.52	0.05	0.55	0.56	0.55	–48.1	–37.2
9	–0.31	–0.21	0.51	**0.54**	–0.27	0.39	–0.08	0.44	0.45	0.44	–45.9	–34.6
10	–0.21	–0.19	0.25	0.23	–0.12	**0.25**	0.10	0.18	0.21	0.21	–31.2	–16.7
11	–0.29	–0.21	**0.32**	0.30	0.06	–0.14	–0.03	–0.24	–0.12	–0.13	–52.3	–45.6
12	–0.33	–0.24	0.66	**0.68**	–0.19	0.53	–0.03	0.55	0.57	0.56	–39.9	–27.2
13	0.27	0.07	0.23	0.21	**0.53**	0.21	0.27	0.22	0.28	0.27	–36.7	–23.9
14	–0.23	–0.16	**0.44**	0.43	–0.15	0.35	–0.11	0.36	0.35	0.34	13.4	38.8
15	–0.40	–0.30	0.45	**0.48**	0.10	0.38	0.09	0.41	0.37	0.36	–50.0	–39.0
16	–0.15	–0.22	0.29	**0.31**	0.05	0.18	–0.18	0.21	0.16	0.17	–47.5	–37.3
17	–0.38	–0.22	**0.66**	0.65	–0.26	0.54	–0.02	0.56	0.58	0.57	–30.5	–15.9
18	–0.35	–0.17	0.63	**0.64**	–0.18	0.50	–0.05	0.56	0.57	0.55	–21.0	–3.8
19	–0.25	–0.16	0.58	0.58	–0.25	0.53	0.06	**0.62**	0.59	0.58	–26.9	–11.0
20	–0.24	–0.20	**0.60**	0.60	–0.14	0.47	0.09	0.54	0.55	0.54	–24.7	–8.4
21	–0.36	–0.32	0.59	0.58	–0.10	0.61	0.21	0.64	**0.64**	0.64	–30.9	–15.8
22	–0.37	–0.20	0.52	**0.53**	–0.28	0.40	–0.15	0.49	0.47	0.46	–10.0	9.5

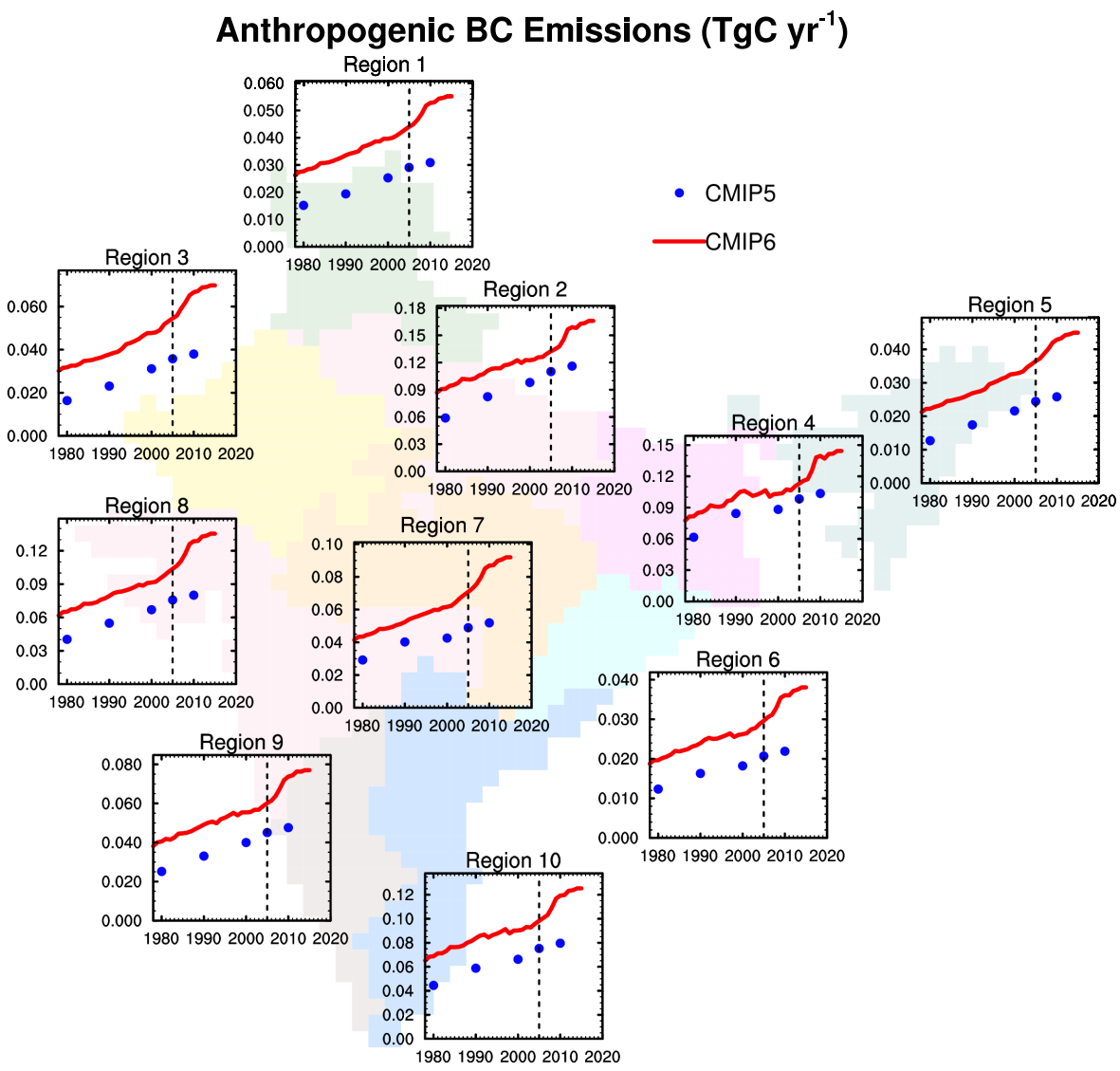

Figure S1. Time series (1980–2015) of anthropogenic black carbon emissions (TgC yr^{-1}) over 10 regions of India for the CMIP5 inventory (blue dots) and CMIP6 inventory (red lines).

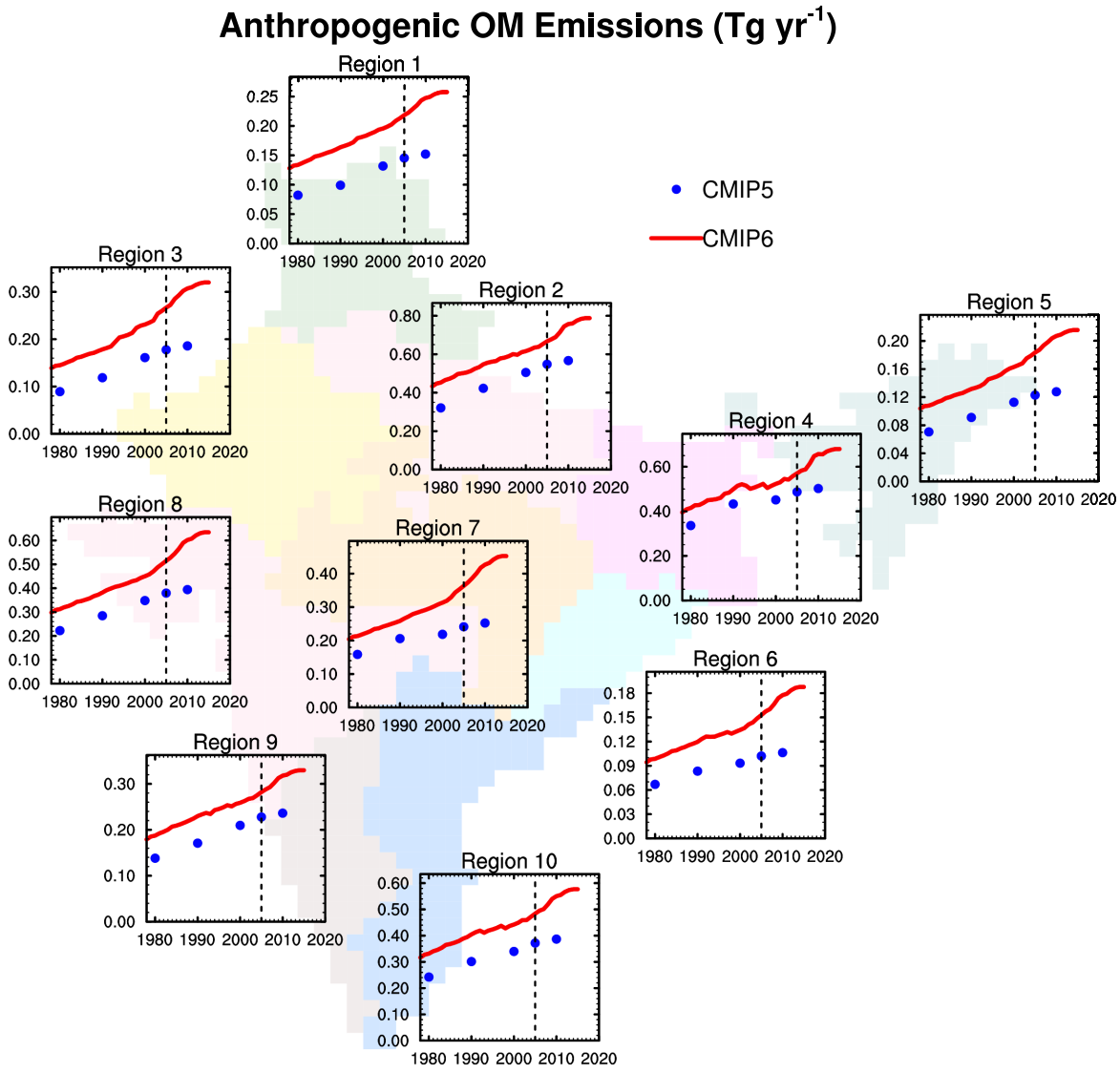

Figure S2. Same as Figure S1, but for organic matter (Tg yr^{-1})

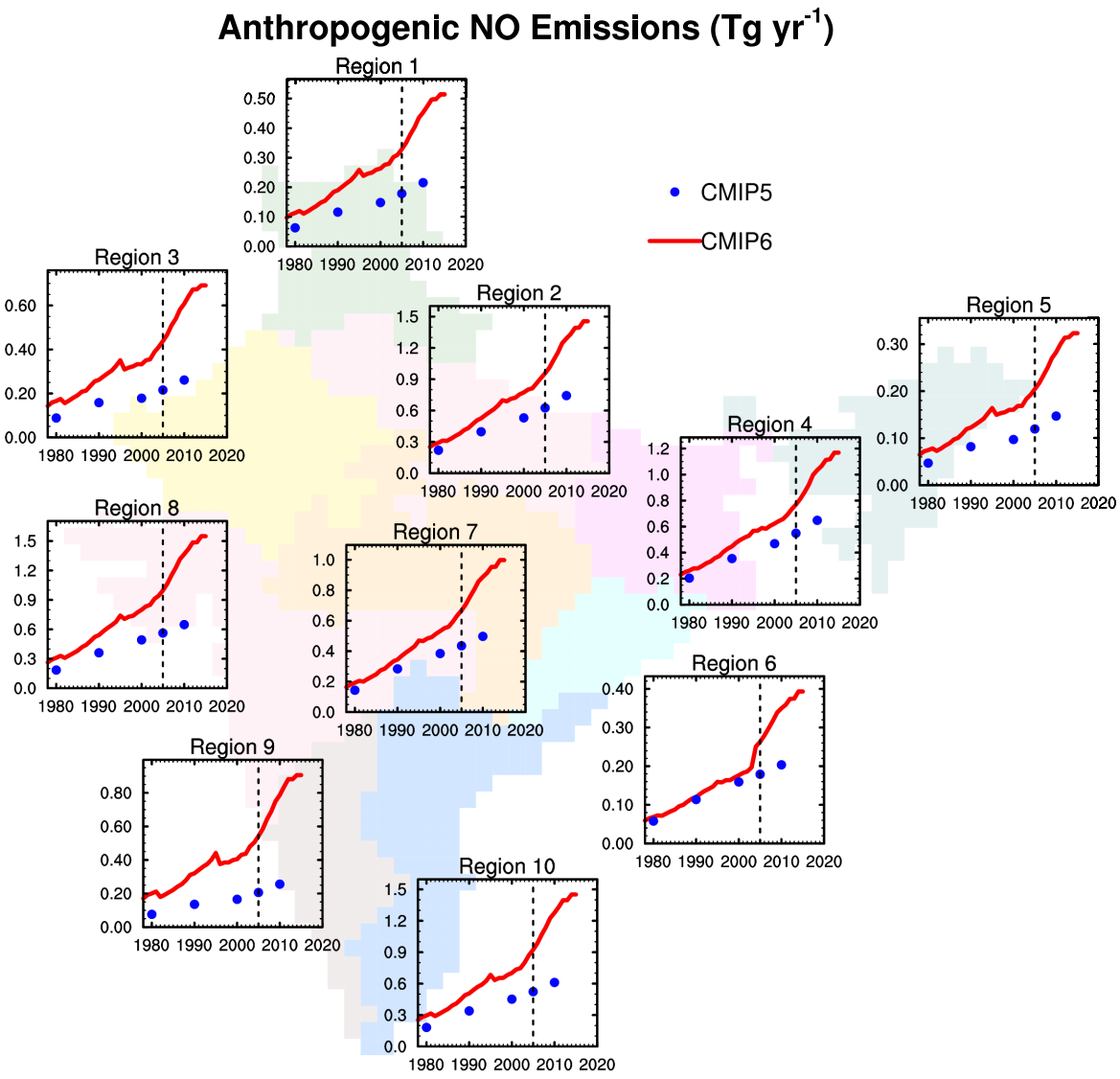

Figure S3. Same as Figure S1, but for NO (Tg yr^{-1})

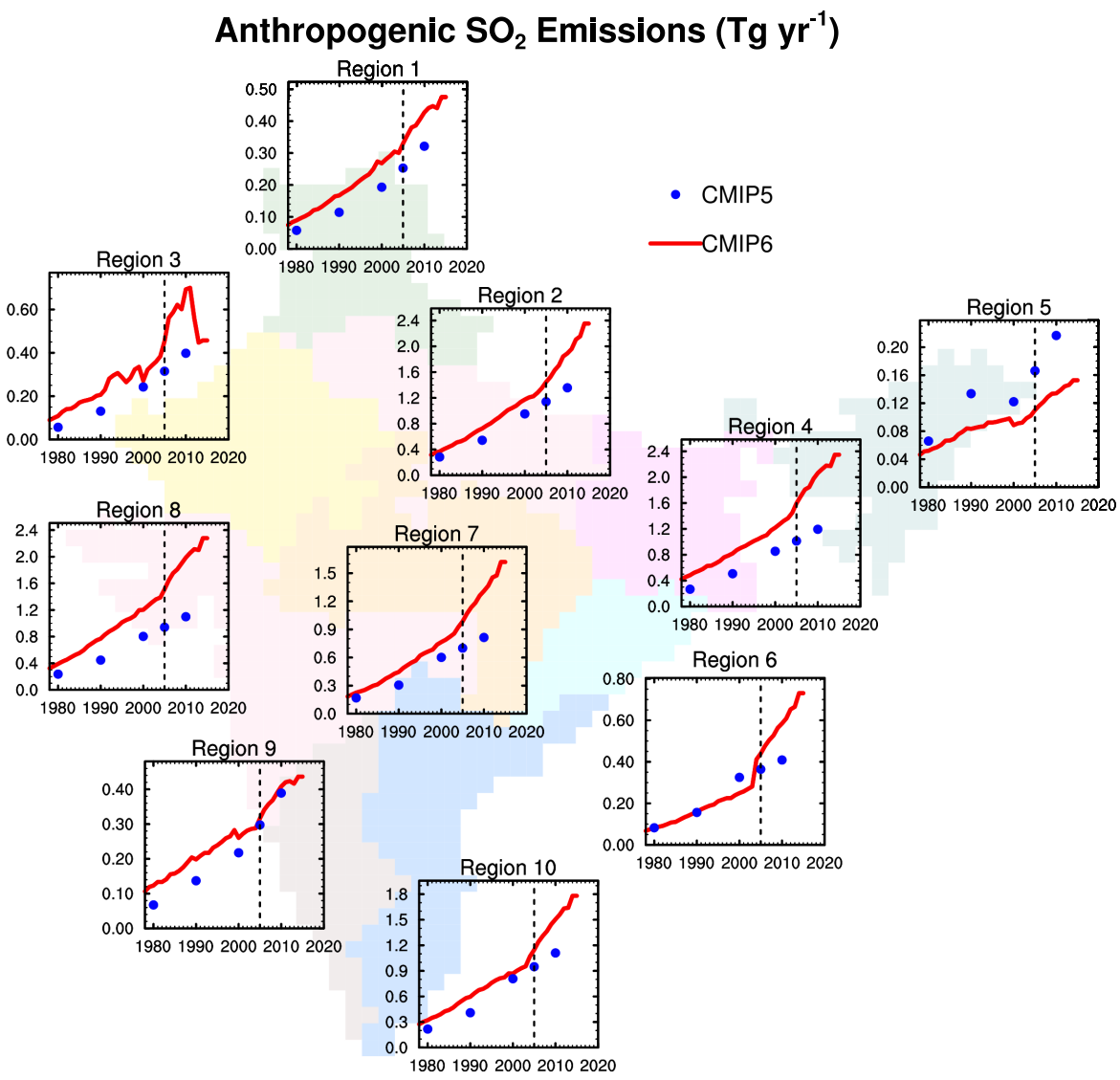

Figure S4. Same as Figure S1, but for SO_2 (Tg yr^{-1})

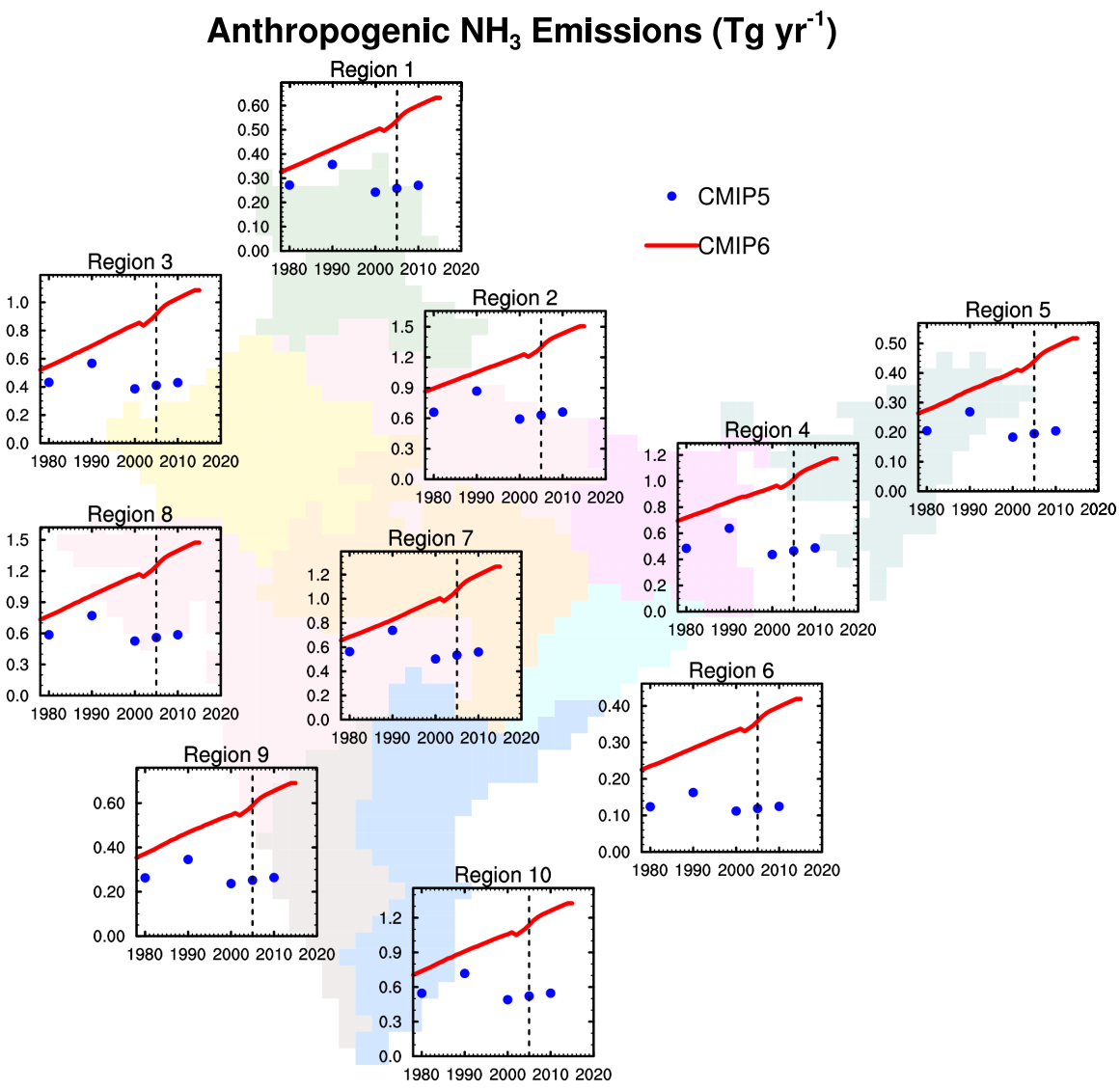

Figure S5. Same as Figure S1, but for NH_3 (Tg yr^{-1})

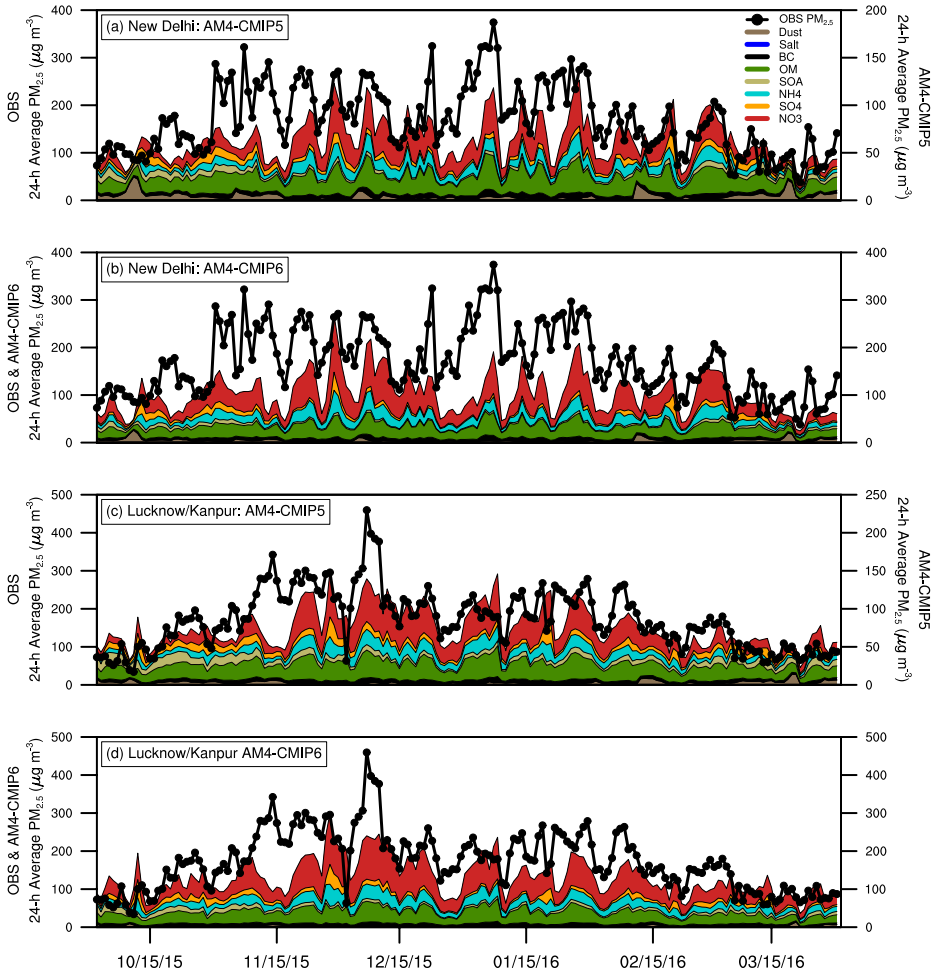

Figure S6. Six month time series of daily total observed $PM_{2.5}$ (black) and modeled components (colors) over (**a**, **b**) New Delhi and (**c**, **d**) Lucknow/Kanpur, Uttar Pradesh for AM4-CMIP5 (**a**, **c**) and AM4-CMIP6 (**b**, **d**). Note the different y-axis scales in (**a**) and (**c**) for the AM4-CMIP5 versus the observations.

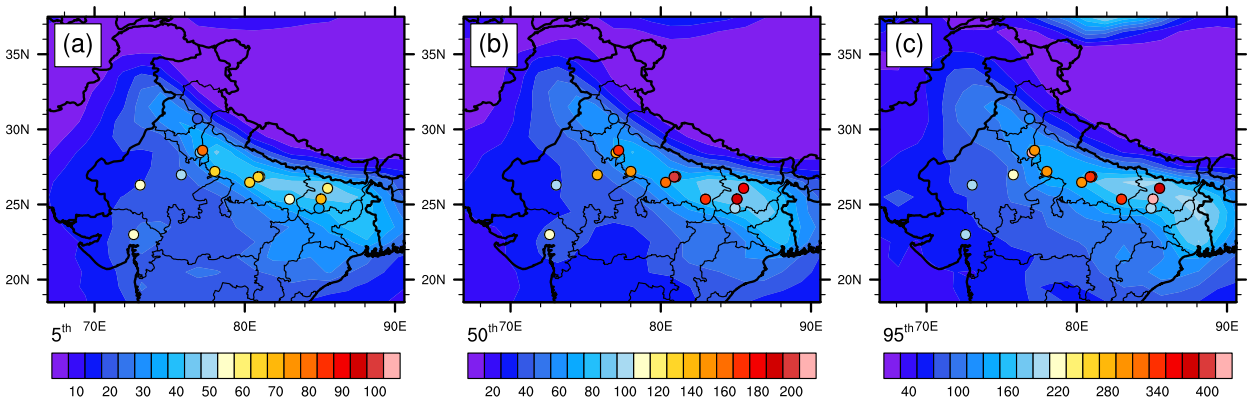

Figure S7. (a-b) 5th **(c-d)** 50th, and **(e-f)** 95th percentile of 24-h average $PM_{2.5}$ (μg m^{-3}) over 1 October 2015 – 31 March 2016 for the observations (circles), and the AM4-CMIP5-wet (grid).

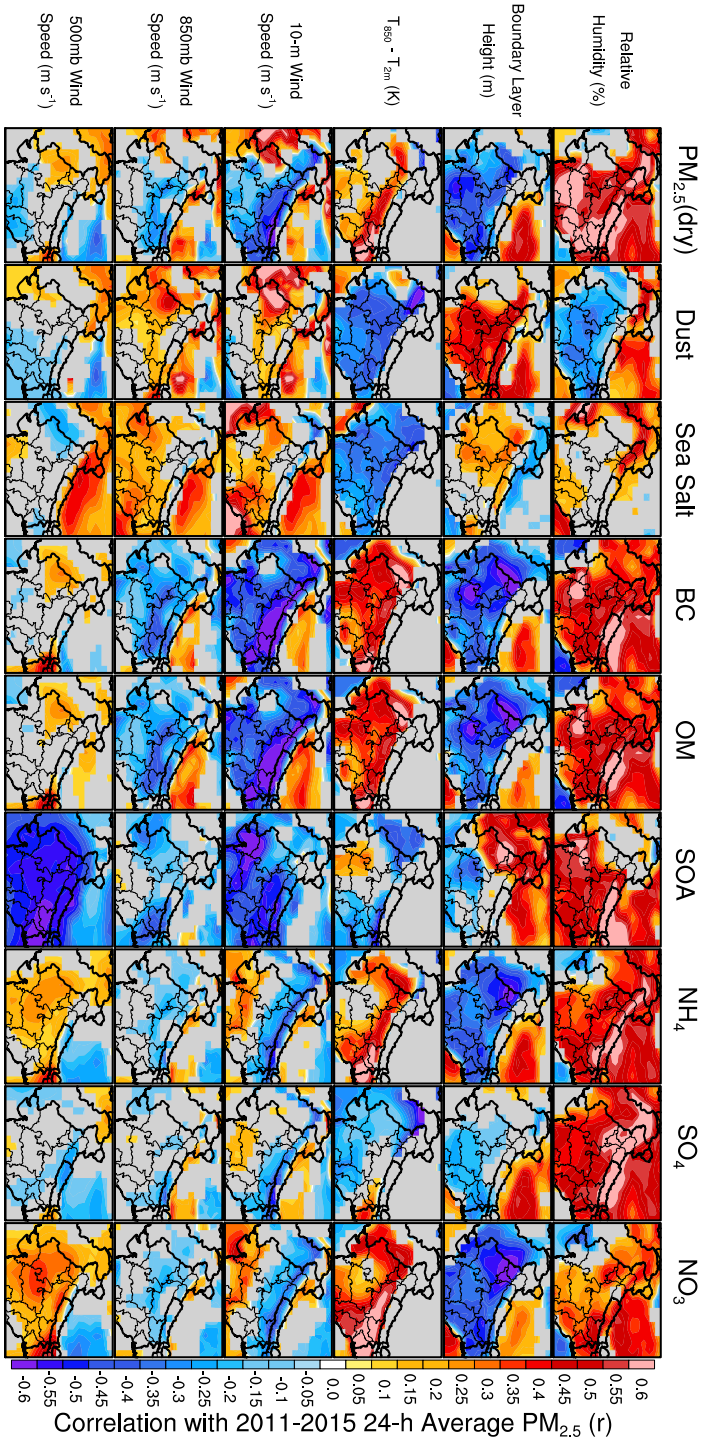

Figure S8. Correlation of daily average modeled dry $PM_{2.5}$ and its components (columns) with the meteorological variables shown in Figure 4 (rows) over October–March, 2011–2015. Gray areas are where the correlation is not significant at the 95% confidence level.

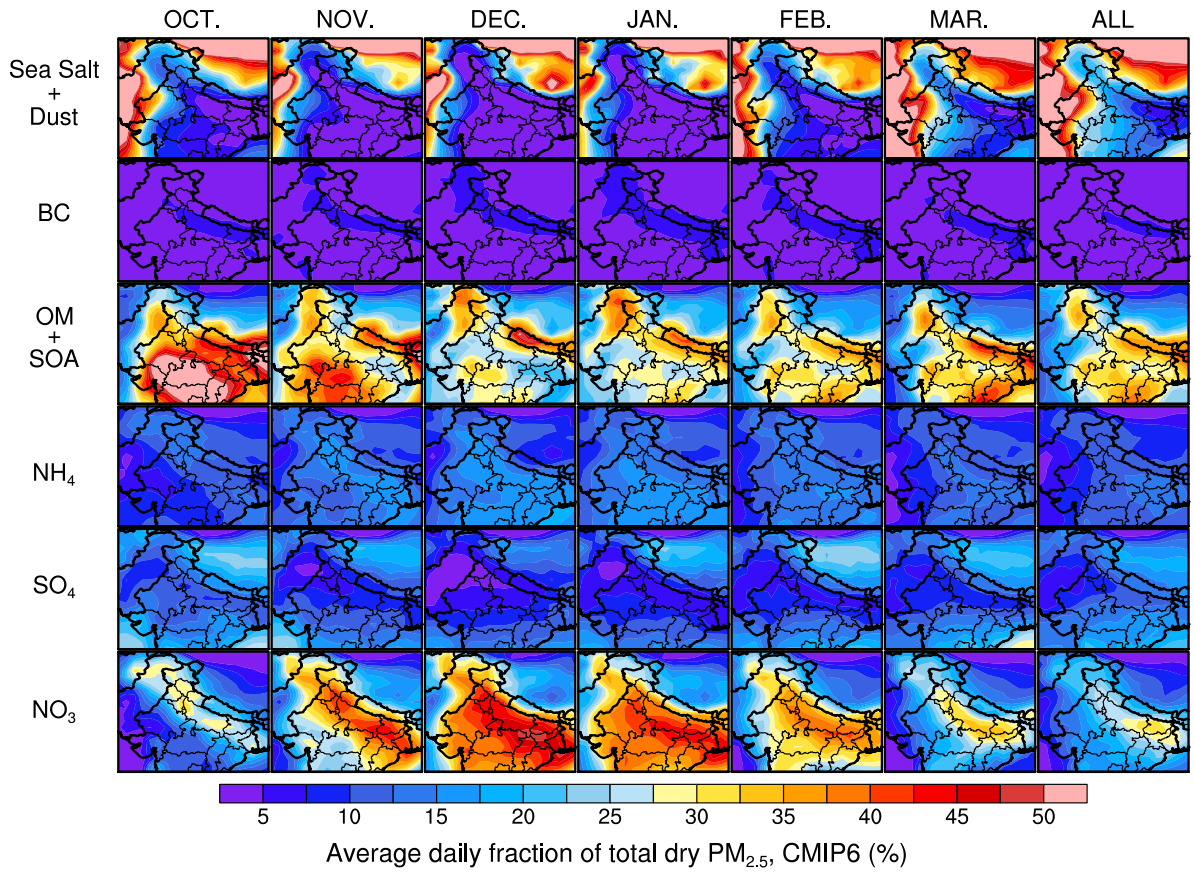

Figure S9. Average fraction of AM4-CMIP6 dry $PM_{2.5}$ for each of the major components (rows) for each month and the 6-month mean (columns) averaged over 2011–2015.

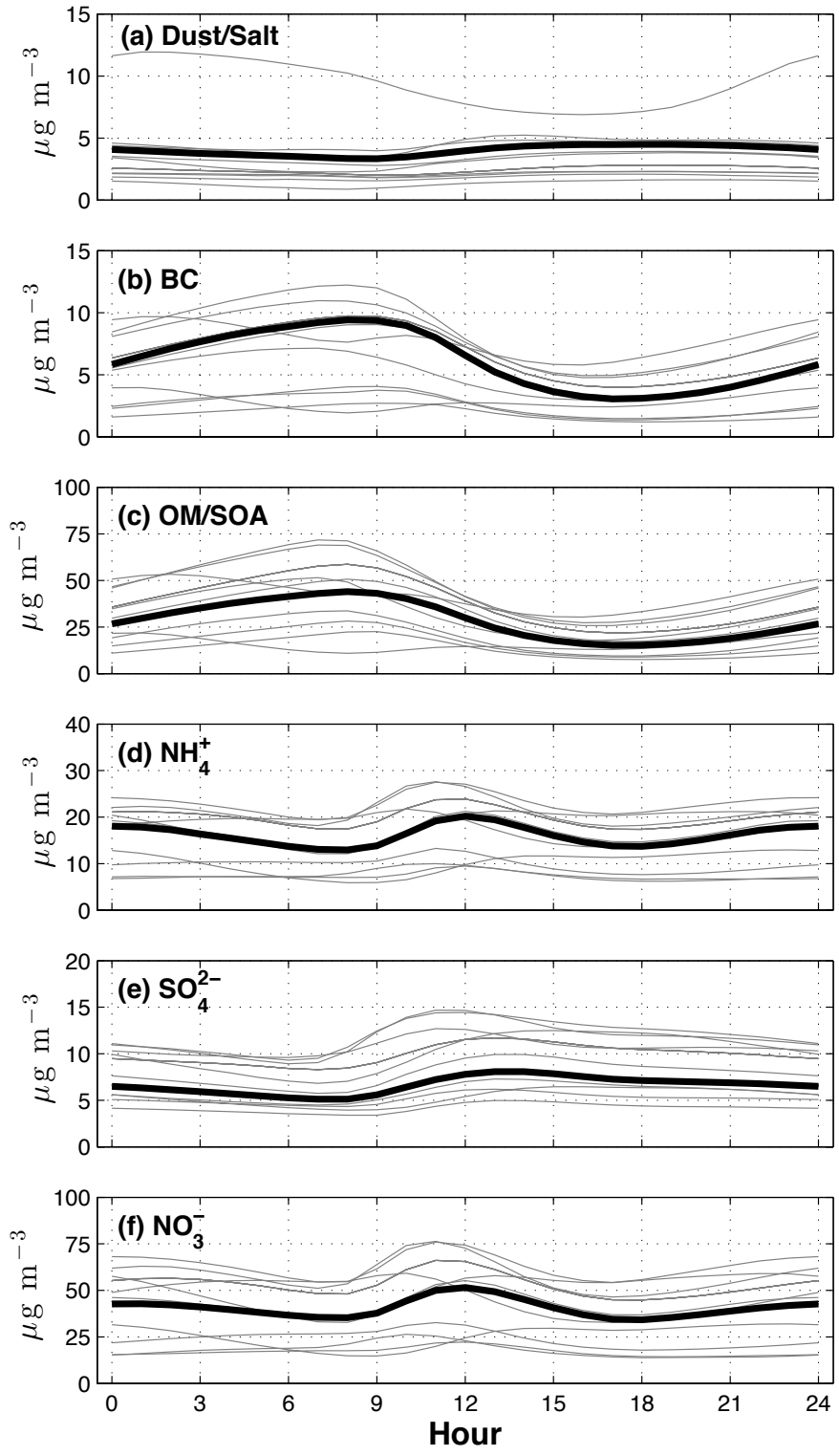

Figure S10. Diurnal cycles of the abundance (μg m^{-3}) of (**a**) dust and sea salt, (**b**) black carbon, (**c**) organic matter and secondary organic aerosol, (**d**) ammonium, (**e**) sulfate, and (**f**) nitrate in AM4-CMIP6 for the individual grid cells where observations are located (gray) and their median (black) averaged over 1 October 2015 – 31 March 2016.

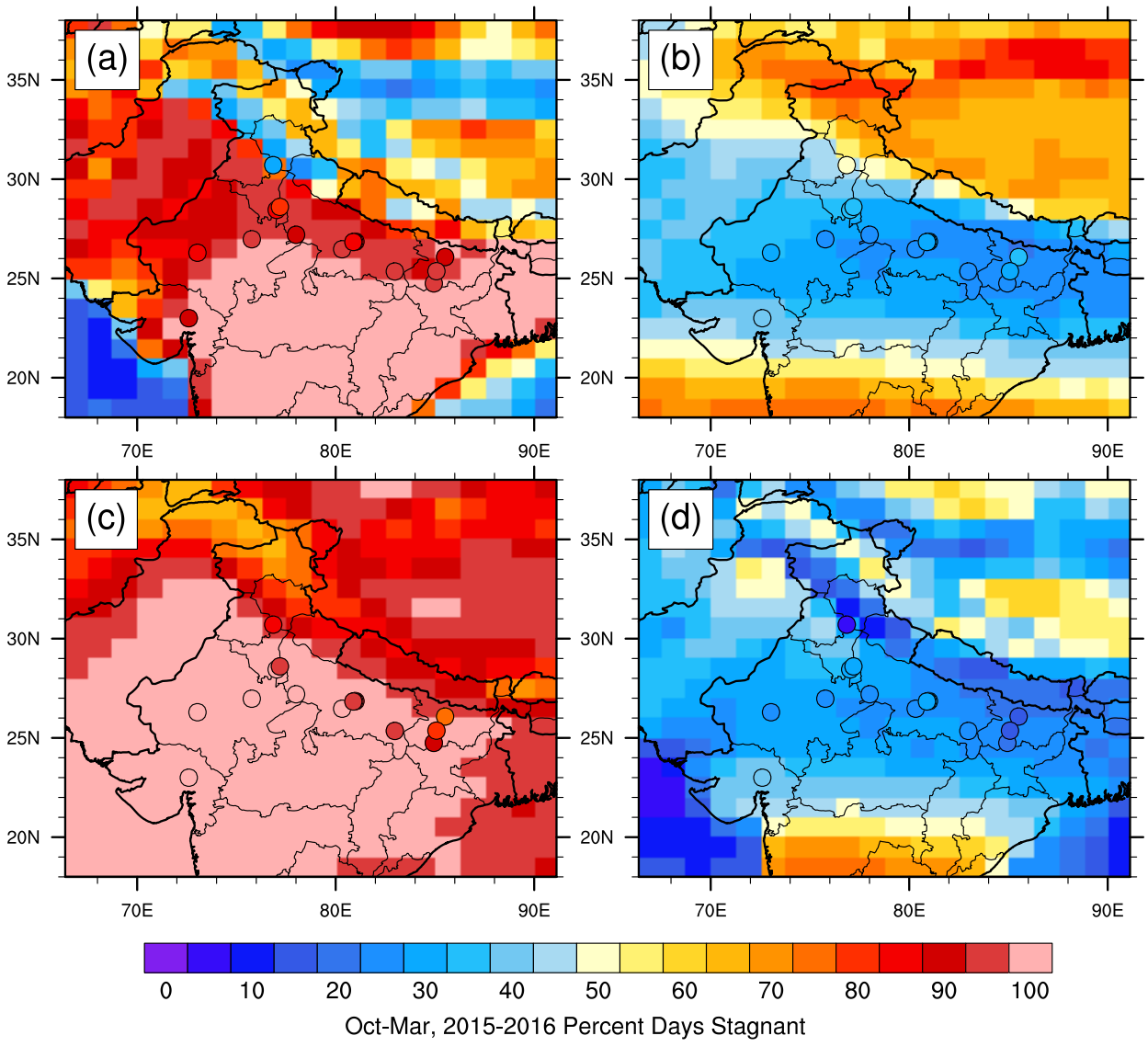

Figure S11. Percentage of October–March, 2015-2016 days that are considered stagnant with respect to (**a**) 10-m wind speed (< 3.2 m s^{-1}), (**b**) 500 mb wind speed (< 13.0 m s^{-1}), (**c**) precipitation (< 1.0 mm day^{-1}), and (**d**) all three; i.e. the ASI is met for the observations (circles) and the AM4-CMIP6 (background).

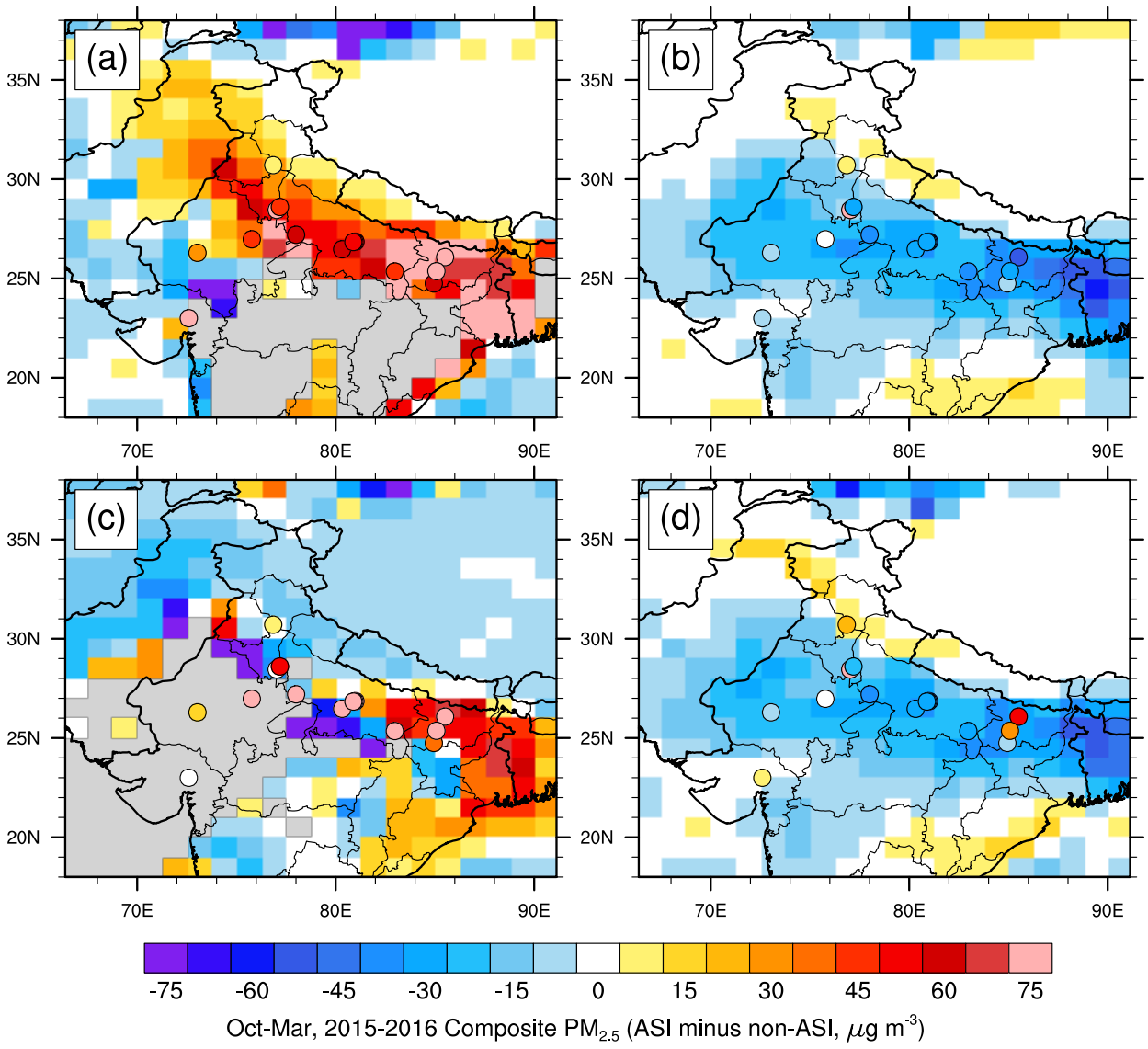

Figure S12. Composite of raw $PM_{2.5}$ on days when ASI components (**a**) 10-m wind speed, (**b**) 500 mb wind speed, (**c**) precipitation, and (**d**) total ASI are met minus days when they are not for October 2015 – March 2016. Gray areas are locations where a composite cannot be constructed since 100% of the days are considered stagnant.

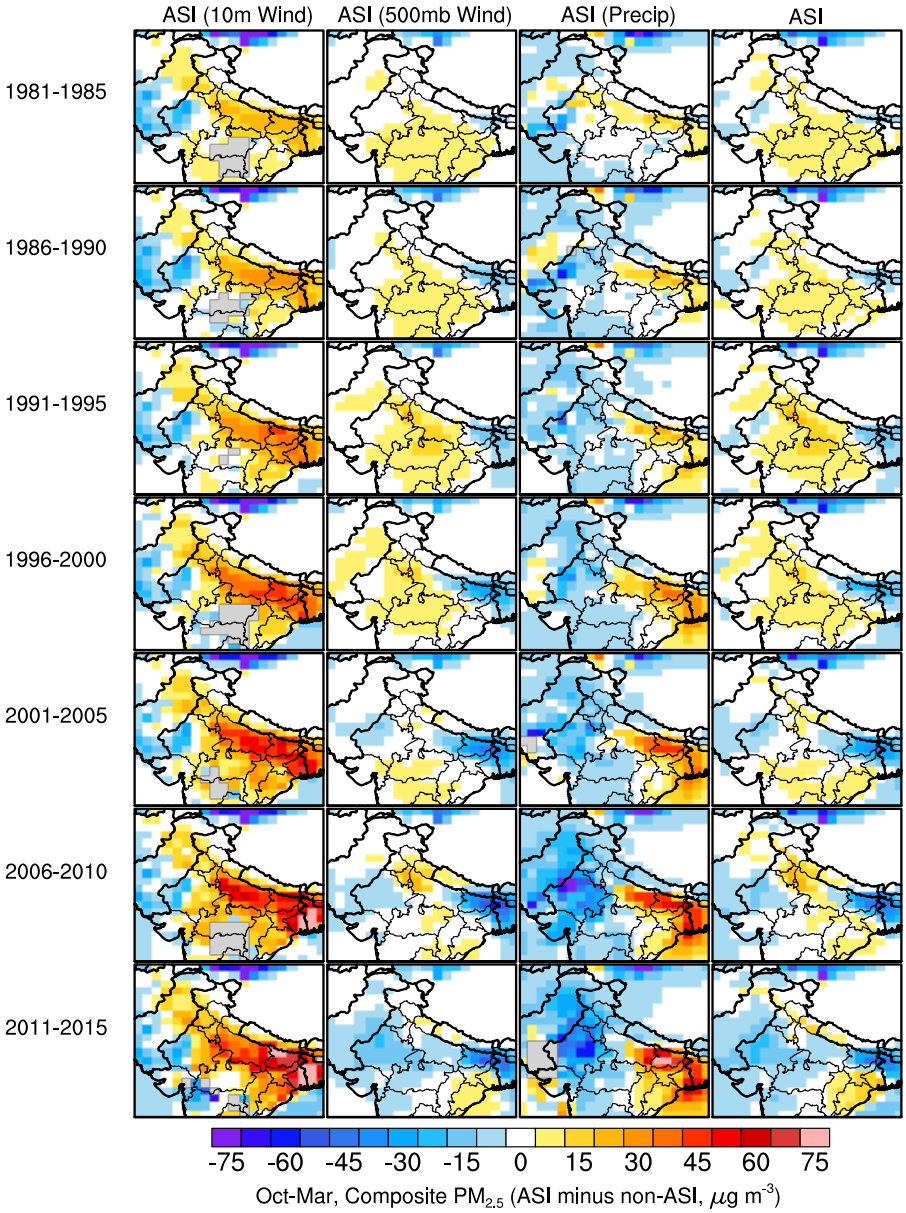

Figure S13. Composite of AM4-CMIP6 wet $PM_{2.5}$ on days when ASI components (first column) 10-m wind speed, (second column) 500 mb wind speed, (third column) precipitation, and (last column) total ASI are met minus days when they are not for October–March over seven 5-year intervals (rows). Gray areas are locations where a composite cannot be constructed since 100% of the days are considered stagnant.

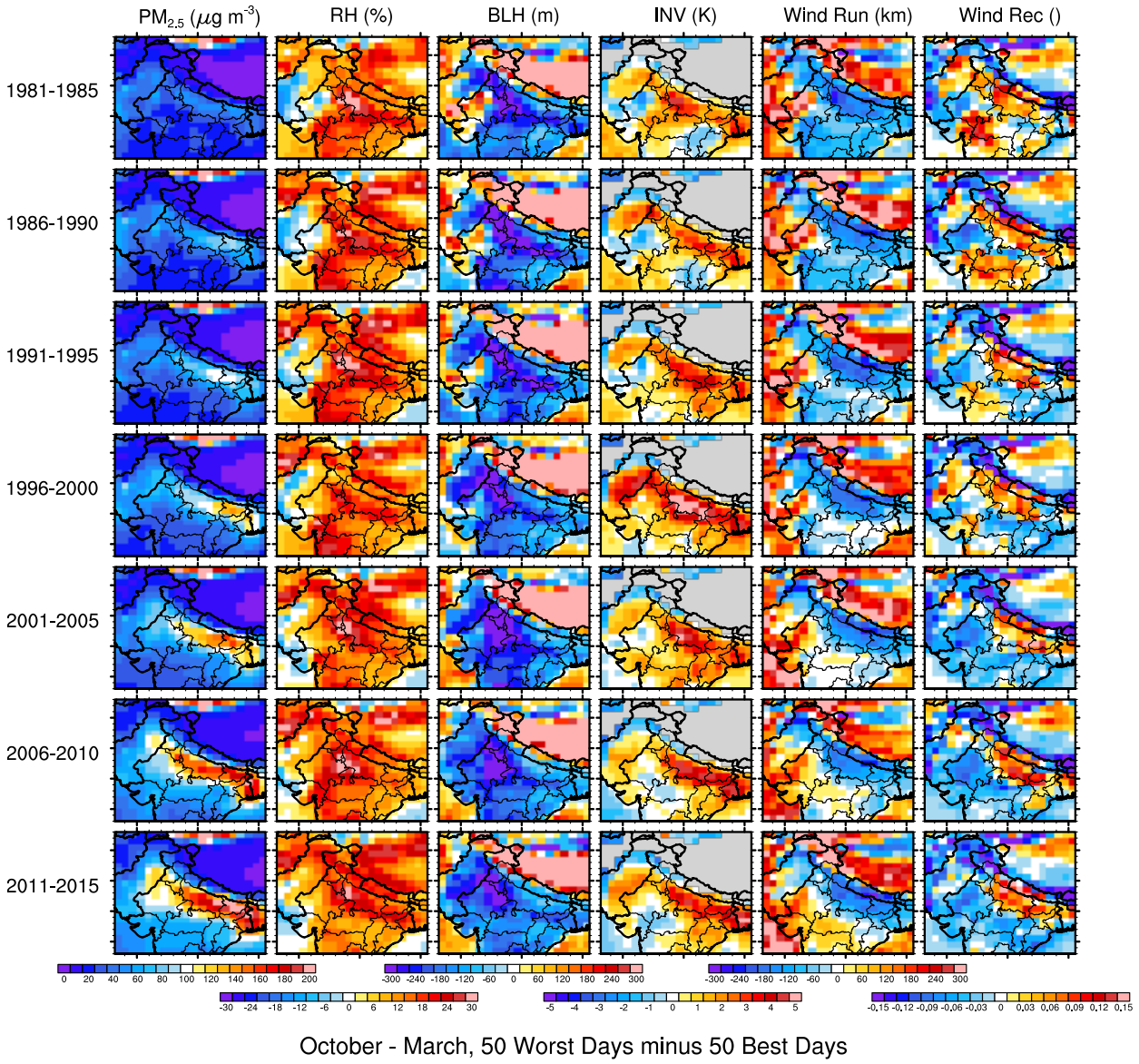

Figure S14. Composite of the 50 days with the highest $PM_{2.5}$ abundance minus the 50 days with the lowest for October – March over seven 5-year intervals (rows) for (first column) PM2.5 (wet, μg m^{-3}), (second column) relative humidity (%), (third column) boundary layer height (m), (fourth column) temperature inversion strength (K), (fifth column) wind run (km), and (sixth column) wind recirculation (unitless) for AM4-CMIP6-wet.