Contents

Tables S1-S2 and Figures S1-S8

Overview

This *Supplementary Material* provides the hygroscopic growth factors used in the IMPROVE algorithm (Figure S1); the mapping of the WMO present-weather codes to the five weather categories (Table S1); the sample counts by weather records and VIS grade in the four representative cities (Table S2); hourly observed and simulated $PM_{2.5}$, RH, and precipitation corresponding to the regional and city-scale VIS evaluations (Figures S2 and S3); and observed and simulated $PM_{2.5}$, RH, and precipitation for EP1-EP3 (Figures S4-S6), the fog case (Figure S7), and the precipitation case (Figure S8).

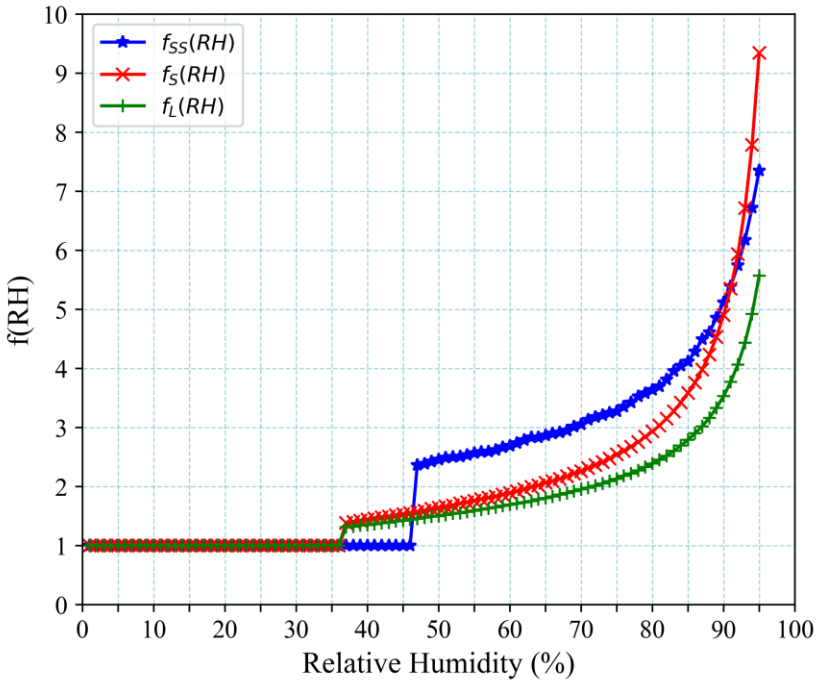


Figure S1. The hygroscopic growth factors ($f(RH)$) used in the revised IMPROVE algorithm.

Table S1. Mapping of WMO Code Table 4677 present-weather codes (ww) to the five weather categories used in this study.

Category	Present-weather codes (ww)	Included weather records
Haze	04–05	Smoke (04) and haze (05).
Fog	10–12, 40–49	Mist (10); shallow fog or ice fog, in patches (11) or more or less continuous (12); fog or ice fog at the time of observation (40–49).
Rain	20–21, 24–25, 50–69, 80–82	Drizzle or snow grains (20), rain (21, 25), freezing drizzle/rain (24) during the preceding hour; drizzle (50–55), freezing drizzle (56–57), drizzle and rain (58–59), rain (60–65), freezing rain (66–67), rain or drizzle and snow (68–69); rain shower(s) (80–82).
Snow	22–23, 26, 36–39, 70–79, 83–86	Snow (22), rain and snow or ice pellets (23), snow or rain-and-snow showers (26) during the preceding hour; blowing/drifting snow (36–39); solid precipitation not in showers (70–79); rain-and-snow mixed showers (83–84), snow showers (85–86).
Other	00–03, 06–09, 13–19, 27–28, 29–35, 87–99	Sky state (00–03), dust/sand phenomena (06–09, 30–35), lightning/squalls/funnel cloud (13, 18, 19), precipitation within sight not at the station (14–16), thunderstorm without precipitation (17), hail showers and preceding-hour phenomena (27–29), snow pellets/small hail and hail showers (87–90), thunderstorm(s) at the time of observation (91–99).

Table S2. Numbers of samples classified by weather records and observed VIS grades (VIS ≤ 1, 1 < VIS ≤ 3, 3 < VIS ≤ 10, and VIS ≤ 10 km) in Harbin (HRB), Beijing (BJ), Shanghai (SH), and Wuhan (WH) during November 2024.

City	VIS (km)	Haze	Fog	Rain	Snow	Other
HRB	VIS ≤ 1	-	27 (6.8%)	2 (0.5%)	3 (0.8%)	-
	1 < VIS ≤ 3	68 (17.1%)	1 (0.3%)	5 (1.3%)	14 (3.5%)	-
	3 < VIS ≤ 10	149 (37.5%)	16 (4.0%)	4 (1.0%)	15 (3.8%)	93 (23.4%)
	VIS ≤ 10	217 (54.7%)	44 (11.1%)	11 (2.8%)	32 (8.1%)	93 (23.4%)

City	VIS (km)	Haze	Fog	Rain	Snow	Other
BJ	VIS ≤ 1	4 (1.2%)	35 (10.3%)	6 (1.8%)	-	-
	1 < VIS ≤ 3	82 (24.1%)	25 (7.3%)	10 (2.9%)	-	24 (7.0%)
	3 < VIS ≤ 10	95 (27.9%)	8 (2.4%)	5 (1.5%)	-	47 (13.8%)
	VIS ≤ 10	181 (53.1%)	68 (19.9%)	21 (6.2%)	-	71 (20.8%)
SH	VIS ≤ 1	-	14 (5.8%)	-	-	-
	1 < VIS ≤ 3	6 (2.5%)	45 (18.6%)	9 (3.7%)	-	-
	3 < VIS ≤ 10	33 (13.6%)	43 (17.8%)	24 (9.9%)	-	68 (28.1%)
	VIS ≤ 10	39 (16.1%)	102 (42.2%)	33 (13.6%)	-	68 (28.1%)
WH	VIS ≤ 1	-	17 (4.0%)	-	-	-
	1 < VIS ≤ 3	13 (3.1%)	80 (19.0%)	9 (2.1%)	-	9 (2.1%)
	3 < VIS ≤ 10	75 (17.8%)	113 (26.8%)	15 (3.6%)	-	90 (21.4%)
	VIS ≤ 10	88 (20.9%)	210 (49.9%)	24 (5.7%)	-	99 (23.5%)

Note. The percentages in each category are calculated relative to the valid hourly samples with VIS ≤ 10 km for that city in November 2024, and the bottom row for each city gives the cumulative totals for VIS ≤ 10 km. A dash indicates that no valid samples were available.

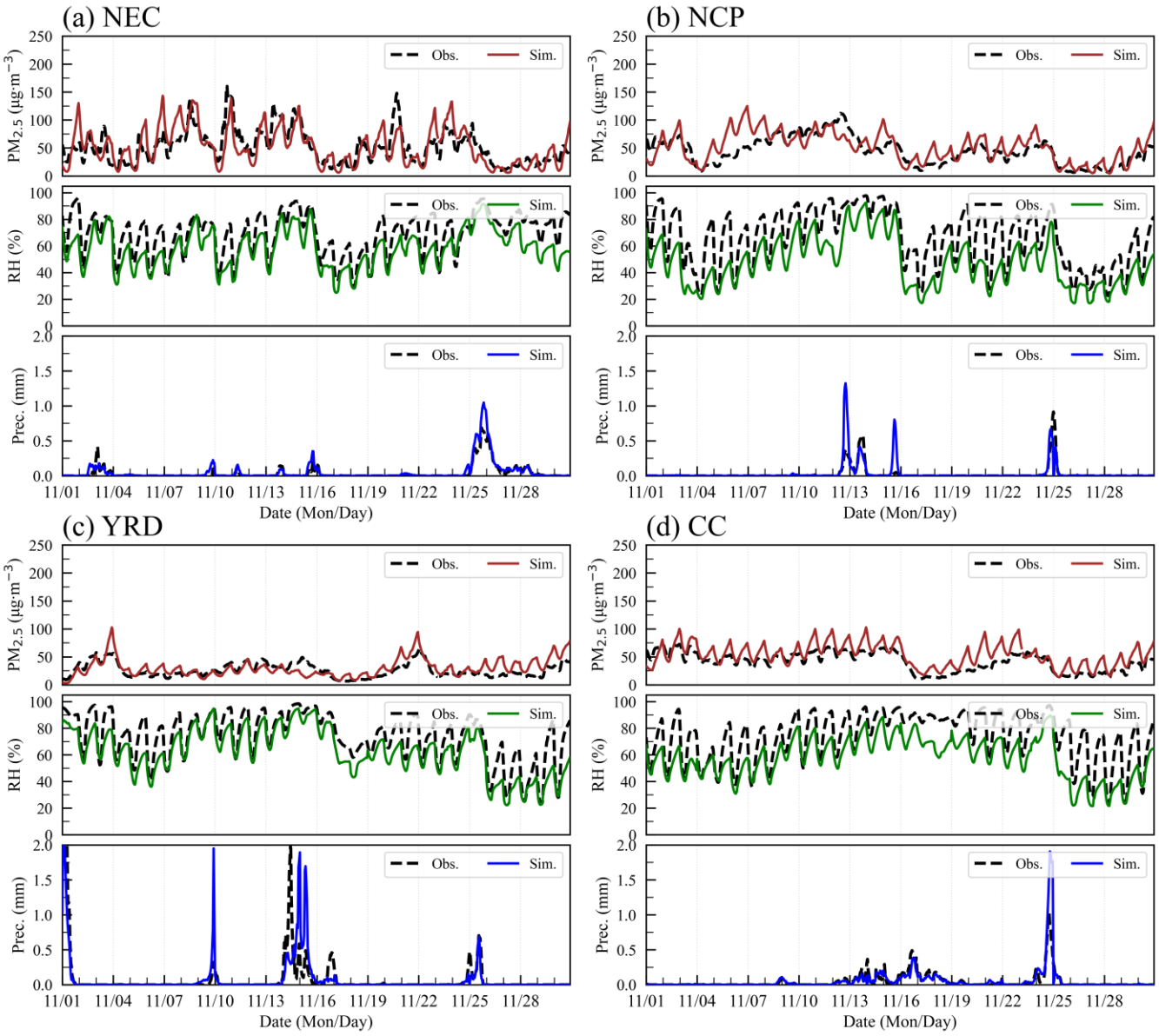


Figure S2. Hourly observed (Obs.) and simulated (Sim.) $PM_{2.5}$, relative humidity (RH), and precipitation (Prec.) in (a) Northeast China (NEC), (b) North China Plain (NCP), (c) Yangtze River Delta (YRD), and (d) Central China (CC) during November 2024.

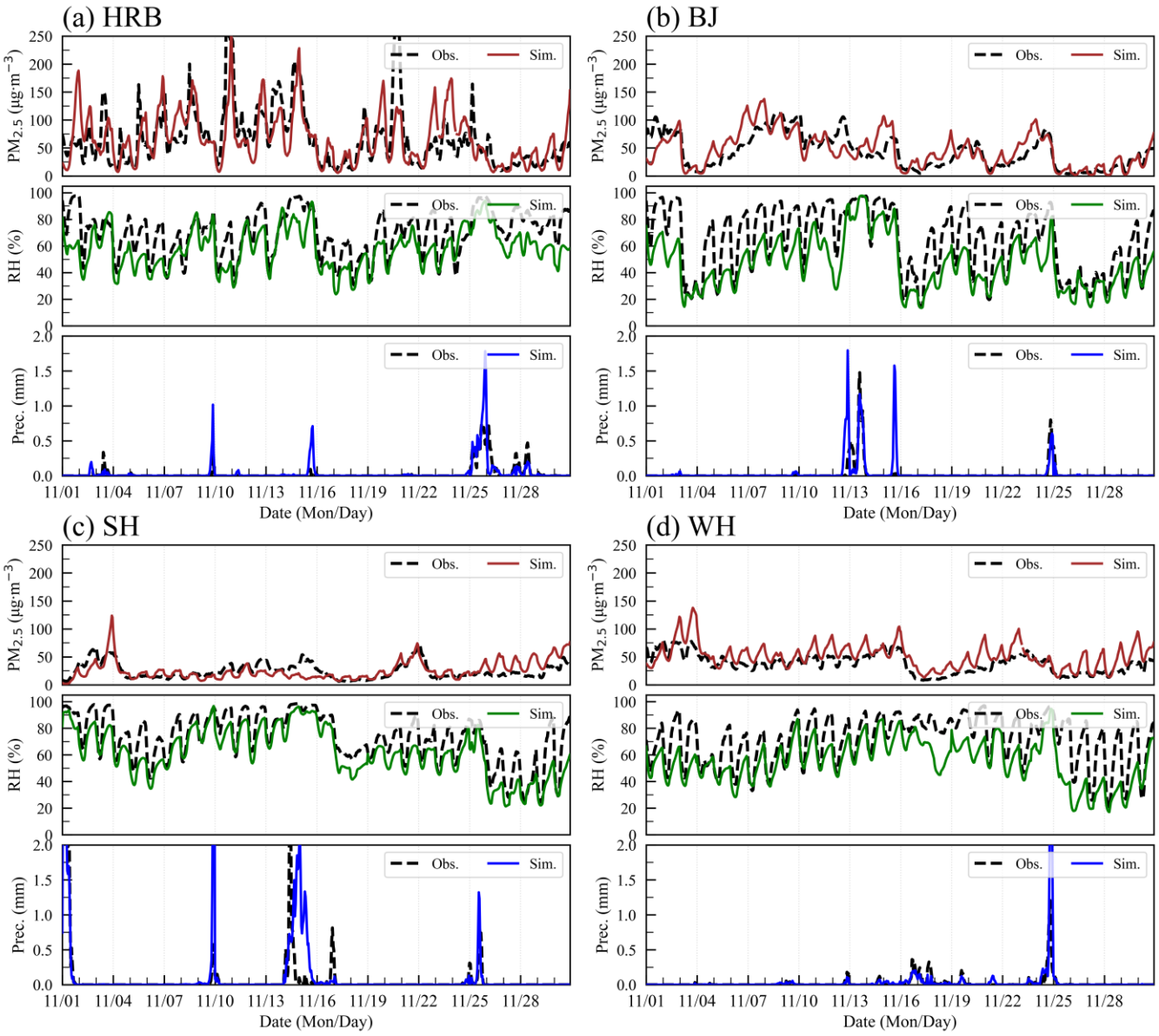


Figure S3. Hourly observed (Obs.) and simulated (Sim.) $PM_{2.5}$, relative humidity (RH), and precipitation (Prec.) in (a) Harbin (HRB), (b) Beijing (BJ), (c) Shanghai (SH), and (d) Wuhan (WH) during November 2024.

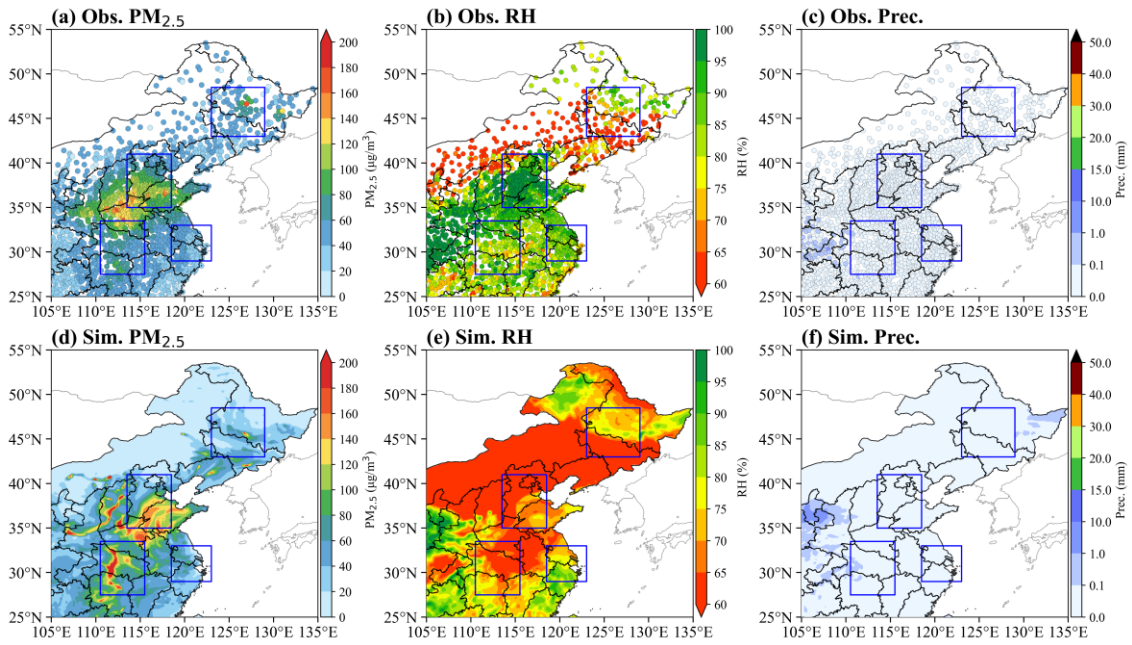


Figure S4. Mean (a) observed (Obs.) $PM_{2.5}$, (b) Obs. relative humidity (RH), (c) Obs. Precipitation (Prec.), (d) simulated (Sim.) $PM_{2.5}$, (e) Sim. RH, and (f) Sim. Prec. from 21:00 UTC 11 November to 03:00 UTC 12 November 2024.

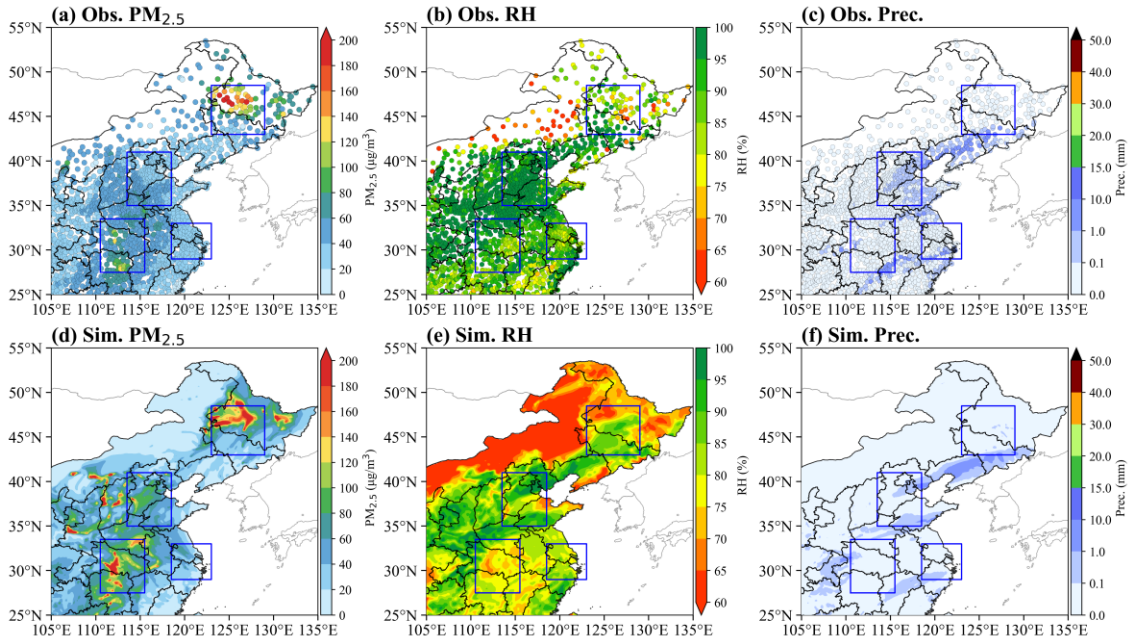


Figure S5. As in Figure S4, but from 21:00 UTC 13 November to 03:00 UTC 14 November 2024.

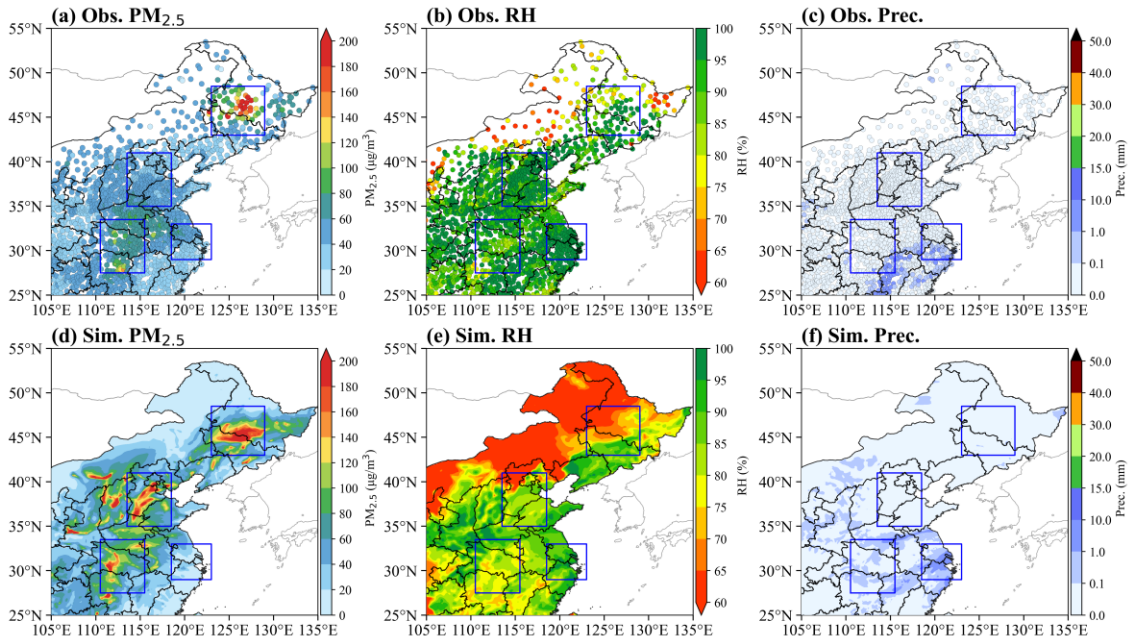


Figure S6. As in Figure S4, but from 21:00 UTC 14 November to 03:00 UTC 15 November 2024.

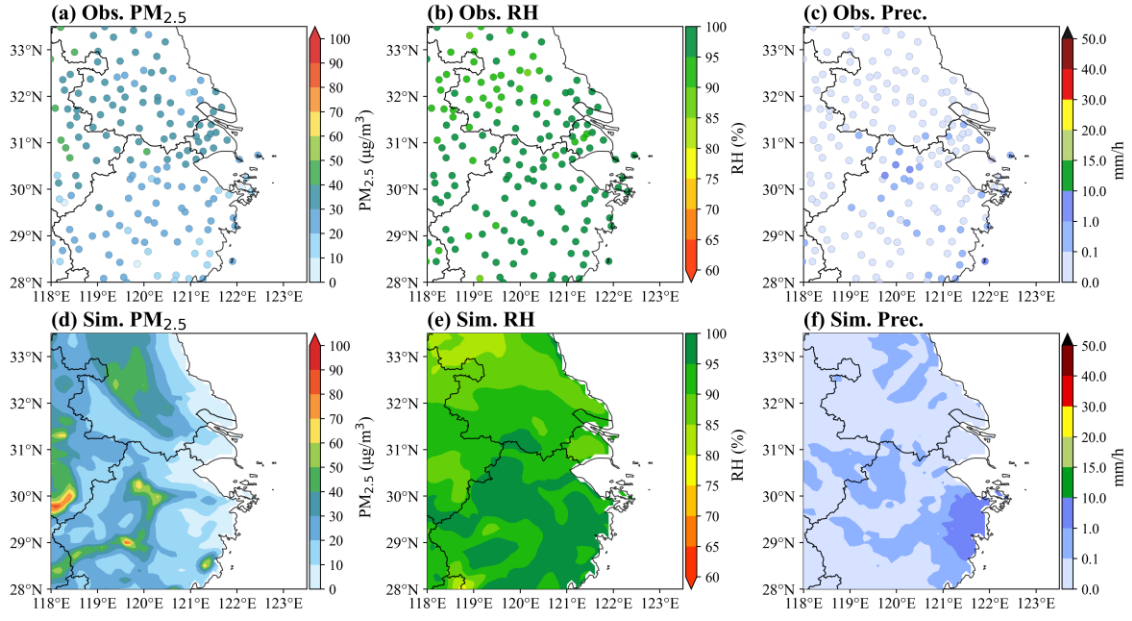


Figure S7. As in Figure S4, but from 21:00 UTC 15 November to 00:00 UTC 16 November 2024.

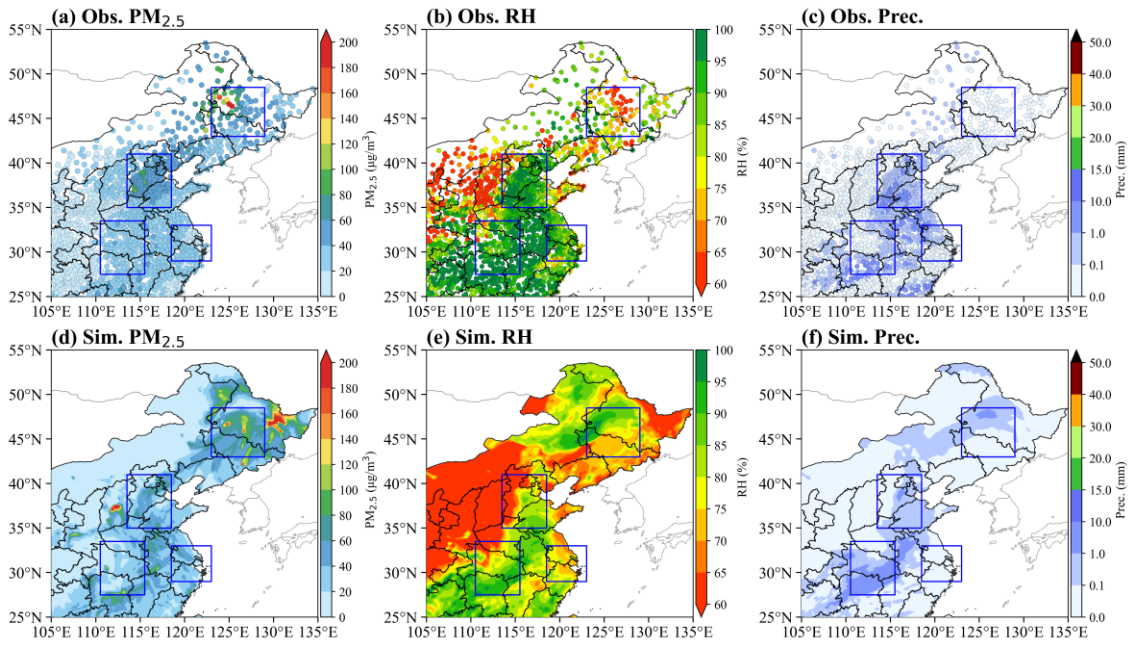


Figure S8. As in Figure S4, but from 22:00 UTC 24 November to 00:00 UTC 25 November 2024.