



Supplement of

Population exposure to outdoor NO₂, black carbon, and ultrafine and fine particles over Paris with multi-scale modelling down to the street scale

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Table S1. Summary of measurement stations. Latitude and longitude are in decimal degrees.

	Stations	Latitude	Longitude	Operator	Measurements
Background stations	PA01H	48.862411	2.342397	Airparif	NO ₂ , eBC, PM ₂₅ , PNC
	TREMBLAY	48.955446	2.574190	Airparif	NO ₂ , eBC
	BOBIGNY	48.902411	2.452617	Airparif	NO ₂ , PM ₂₅
	GONES	48.990858	2.444772	Airparif	NO ₂ , PM ₂₅
	RURSE	48.456239	2.679397	Airparif	NO ₂ , PM ₂₅
	PA07	48.857194	2.293278	Airparif	NO ₂
	PA12	48.837194	2.393806	Airparif	NO ₂
	PA13	48.828472	2.359558	Airparif	NO ₂
	PA15L	48.830389	2.269886	Airparif	NO ₂
	PA18	48.891728	2.345575	Airparif	NO ₂ , PM ₂₅
	AUBERV	48.903944	2.384722	Airparif	NO ₂
	ARGENT	48.951185	2.220357	Airparif	NO ₂
	CHAMPIGNY	48.816692	2.516669	Airparif	NO ₂
	EVRY	48.827639	2.326711	Airparif	NO ₂
	LOGNES	48.840317	2.634661	Airparif	NO ₂
	MANTES	48.996225	1.703297	Airparif	NO ₂
	MELUN	48.528103	2.653947	Airparif	NO ₂
	MONTGERON	48.706583	2.457083	Airparif	NO ₂
	NEULLY	48.881333	2.277317	Airparif	NO ₂
	Traffic stations	GEN	48.929822	2.291413	Airparif
VITRY		48.775663	2.374005	Airparif	NO ₂ , PM ₂₅
PRG		48.827778	2.380562	ACROSS campaign	eBC, PNC
RURN		49.108286	2.153188	Airparif	PM ₂₅
SIRTA		48.709890	2.147938	SIRTA	PNC
HAUSS		48.873339	2.329603	Airparif	NO ₂ , eBC, PM ₂₅
BP_EST		48.838556	2.412694	Airparif	NO ₂ , eBC, PM ₂₅
AUTEUIL		48.850175	2.252322	Airparif	NO ₂ , PM ₂₅
CELES		48.852611	2.360125	Airparif	NO ₂
ELYS		48.868781	2.311633	Airparif	NO ₂
BONAP	48.856289	2.334467	Airparif	NO ₂	
SOULT	48.837961	2.408061	Airparif	NO ₂	
RN2	48.902006	2.390628	Airparif	NO ₂	
BASCH	48.827639	2.326711	Airparif	NO ₂	
HdV	48.855745	2.351848	sTREEt campaign	NO ₂ , eBC	

Table S2. Statistical indicators for NO₂ concentrations simulated at the background stations in the REF, SEN, and EMEP simulations. Statistics in green text indicates that the most-strict criterion is met ($|\text{FB}| < 0.3$, $0.7 < \text{MG} < 1.3$, $\text{NMSE} < 3$, $\text{VG} < 1.6$, $\text{NAD} < 0.3$, and $\text{FAC2} > 0.5$). Statistics in blue text indicate the the less-strict criterion is met ($|\text{FB}| < 0.67$, $\text{NMSE} < 6$, $\text{NAD} < 0.5$, and $\text{FAC2} > 0.3$), while statistics in red text indicates that the criterion is not met.

	Stations	Obs.	Sim.	FB	MG	NMSE	VG	NAD	FAC2	R	RMSE	NMB (%)	NME (%)
REF & SEN	PA01H	17.5	16.2	-0.07	0.98	0.10	1.08	0.12	0.98	0.70	5.5	-7	23
	TREMBLA Y	15.7	10.8	-0.36	0.70	0.27	1.27	0.20	0.87	0.22	6.8	-31	34
	BOBIGNY	18.0	15.9	-0.12	0.94	0.18	1.14	0.15	0.91	0.37	7.2	-11	29
	GONES	15.0	17.5	0.15	1.20	0.11	1.11	0.13	0.97	0.65	5.5	17	28
	RURSE	4.0	4.3	0.09	1.11	0.12	1.13	0.13	0.93	0.50	1.4	10	28
	PA07	22.5	18.1	-0.22	0.82	0.13	1.12	0.14	1.00	0.64	7.2	-20	25
	PA12	14.0	18.5	0.27	1.38	0.19	1.25	0.17	0.88	0.53	7.0	31	40
	PA13	14.6	17.4	0.17	1.23	0.11	1.12	0.13	0.98	0.63	5.3	19	29
	PA15L	13.4	15.6	0.15	1.21	0.12	1.13	0.14	1.00	0.65	5.1	17	30
	PA18	20.5	17.2	-0.18	0.89	0.18	1.12	0.14	0.93	0.56	7.9	-16	26
	AUBERV	20.6	21.2	0.03	1.09	0.11	1.10	0.13	1.00	0.60	6.9	3	26
	ARGENT	17.1	12.4	-0.32	0.76	0.37	1.29	0.22	0.81	0.55	8.9	-27	38
	CHAMPIG NY	16.1	12.2	-0.28	0.76	0.23	1.24	0.17	0.88	0.28	6.7	-25	30
	EVRY	13.9	16.0	0.14	1.20	0.14	1.19	0.15	0.90	0.38	5.6	15	33
	LOGNES	13.3	12.8	-0.04	0.97	0.09	1.08	0.11	0.98	0.53	4.0	-4	22
	MANTES	11.8	6.4	-0.60	0.57	0.71	1.55	0.30	0.60	0.62	7.3	-46	47
	MELUN	10.0	15.2	0.42	1.52	0.30	1.35	0.22	0.82	0.39	6.7	52	55
	MONTGE RON	9.9	8.4	-0.16	0.88	0.22	1.19	0.16	0.88	0.34	4.3	-15	30
NEULLY	16.1	26.9	0.50	1.84	0.39	1.66	0.28	0.58	0.71	13.1	67	74	
GEN	16.2	14.3	-0.13	0.96	0.20	1.11	0.14	0.92	0.75	6.8	-12	26	
VITRY	14.4	12.2	-0.16	0.88	0.16	1.13	0.14	0.97	0.47	5.3	-15	27	
EMEP	PA01H	17.5	20.0	0.13	1.20	0.10	1.13	0.13	0.95	0.65	6.0	14	29
	TREMB	15.7	19.1	0.20	1.22	0.14	1.15	0.14	0.95	0.42	6.4	22	31
	BOBI	18.0	19.2	0.06	1.12	0.15	1.15	0.15	0.93	0.40	7.1	7	30
	GONES	15.0	15.5	0.03	1.02	0.16	1.14	0.15	0.95	0.53	6.0	3	31
	RURSE	4.0	5.3	0.29	1.35	0.22	1.23	0.18	0.88	0.48	2.2	35	43
	PA07	22.5	21.6	-0.04	0.98	0.08	1.08	0.10	0.97	0.58	6.2	-4	20
	PA12	14.0	21.2	0.40	1.60	0.27	1.43	0.22	0.72	0.46	9.0	51	55
	PA13	14.6	22.3	0.42	1.59	0.26	1.35	0.22	0.78	0.57	9.1	52	56
	PA15L	13.4	21.9	0.48	1.73	0.33	1.49	0.25	0.75	0.64	9.9	64	65
	PA18	20.5	21.2	0.03	1.09	0.11	1.12	0.13	0.98	0.60	6.9	3	27
	AUBERV	20.6	19.4	-0.06	0.99	0.12	1.09	0.12	0.98	0.62	6.8	-5	23
	ARGENT	17.1	12.5	-0.31	0.76	0.29	1.20	0.19	0.96	0.73	7.8	-27	32
	CHAMPIG NY	16.1	14.2	-0.13	0.89	0.14	1.13	0.14	0.93	0.35	5.7	-12	25
	EVRY	13.9	22.0	0.45	1.66	0.32	1.48	0.24	0.71	0.42	9.9	59	61

LOGNES	13.3	13.6	0.03	1.04	0.09	1.09	0.12	0.98	0.49	4.1	3	23
MANTES	11.8	9.3	-0.23	0.83	0.25	1.16	0.17	0.93	0.64	5.2	-21	30
MELUN	10.0	13.2	0.27	1.33	0.18	1.21	0.16	0.88	0.39	4.8	32	37
MONTGERON	9.9	12.0	0.19	1.26	0.20	1.24	0.18	0.85	0.34	4.9	21	39
NEULLY	16.1	24.7	0.42	1.72	0.33	1.59	0.25	0.65	0.64	11.4	54	64
GEN	16.2	16.9	0.04	1.12	0.16	1.13	0.13	0.95	0.70	6.6	4	27
VITRY	14.4	22.4	0.43	1.62	0.29	1.40	0.23	0.68	0.49	9.7	55	59

Table S3. Statistical indicators for eBC_{2.5} concentrations simulated at the background stations in the REF, SEN, and EMEP simulations. Statistics in green text indicates that the most-strict criterion is met ($|\text{FB}| < 0.3$, $0.7 < \text{MG} < 1.3$, $\text{NMSE} < 3$, $\text{VG} < 1.6$, $\text{NAD} < 0.3$, and $\text{FAC2} > 0.5$). Statistics in blue text indicate the the less-strict criterion is met ($|\text{FB}| < 0.67$, $\text{NMSE} < 6$, $\text{NAD} < 0.5$, and $\text{FAC2} > 0.3$), while statistics in red text indicates that the criterion is not met.

	Stations	Obs.	Sim.	FB	MG	NMSE	VG	NAD	FAC2	R	RMSE	NMB (%)	NME (%)
REF	PA01H	0.44	0.42	-0.06	1.01	0.13	1.12	0.14	0.97	0.64	0.16	-6	27
	TREMB	0.50	0.29	-0.52	0.61	0.55	1.48	0.28	0.64	0.25	0.28	-41	44
	GEN	0.52	0.36	-0.37	0.76	0.47	1.22	0.21	0.83	0.69	0.30	-31	36
SEN	PA01H	0.44	0.39	-0.11	0.96	0.15	1.12	0.14	0.97	0.64	0.16	-11	27
	TREMB	0.50	0.28	-0.55	0.59	0.60	1.55	0.29	0.63	0.23	0.29	-43	46
	GEN	0.52	0.34	-0.42	0.72	0.55	1.27	0.23	0.85	0.68	0.31	-35	38
EMEP	PA01H	0.44	0.64	0.37	1.57	0.24	1.39	0.21	0.76	0.60	0.26	46	53
	TREMB	0.50	0.46	-0.07	0.97	0.13	1.12	0.14	0.95	0.48	0.18	-7	26
	GEN	0.52	0.54	0.03	1.14	0.18	1.15	0.15	0.98	0.71	0.23	3	31

Table S4. Statistical indicators for eBC₁ concentrations simulated at the background stations in the REF, SEN, and EMEP simulations. Statistics in green text indicates that the most-strict criterion is met ($|\text{FB}| < 0.3$, $0.7 < \text{MG} < 1.3$, $\text{NMSE} < 3$, $\text{VG} < 1.6$, $\text{NAD} < 0.3$, and $\text{FAC2} > 0.5$). Statistics in blue text indicate the the less-strict criterion is met ($|\text{FB}| < 0.67$, $\text{NMSE} < 6$, $\text{NAD} < 0.5$, and $\text{FAC2} > 0.3$), while statistics in red text indicates that the criterion is not met.

	Stations	Obs.	Sim.	FB	MG	NMSE	VG	NAD	FAC2	R	RMSE	NMB (%)	NME (%)
REF	PRG	0.25	0.36	0.33	1.49	0.24	1.36	0.21	0.78	0.38	0.15	40	51
SEN	PRG	0.25	0.35	0.32	1.48	0.23	1.35	0.21	0.78	0.38	0.14	38	50
EMEP	PRG	0.25	0.49	0.63	2.06	0.56	2.00	0.31	0.48	0.21	0.26	91	92

Table S5. Statistical indicators for PM_{2.5} concentrations simulated at the background stations in the REF, SEN, and EMEP simulations. Statistics in green text indicates that the most-strict criterion is met ($|\text{FB}| < 0.3$, $0.7 < \text{MG} < 1.3$, $\text{NMSE} < 3$, $\text{VG} < 1.6$, $\text{NAD} < 0.3$, and $\text{FAC2} > 0.5$). Statistics in blue text indicate the the less-strict criterion is met ($|\text{FB}| < 0.67$, $\text{NMSE} < 6$, $\text{NAD} < 0.5$, and $\text{FAC2} > 0.3$), while statistics in red text indicates that the criterion is not met.

	Stations	Obs.	Sim.	FB	MG	NMSE	VG	NAD	FAC2	R	RMSE	NMB (%)	NME (%)
REF	PA01H	9.30	6.48	-0.36	0.73	0.29	1.19	0.18	0.92	0.73	4.2	-30	31
	BOBI	6.14	6.80	0.10	1.19	0.10	1.15	0.13	0.93	0.73	2.0	11	27
	GONES	7.47	6.57	-0.13	0.90	0.08	1.07	0.10	0.98	0.73	2.0	-12	19
	RURSE	5.88	8.15	0.32	1.41	0.24	1.24	0.18	0.85	0.65	3.4	39	44
	PA18	9.54	6.53	-0.37	0.71	0.26	1.20	0.19	0.88	0.73	4.0	-31	32
	GEN	7.10	6.36	-0.11	0.97	0.20	1.13	0.14	0.97	0.68	3.0	-10	27
	VITRY	6.67	6.11	-0.09	0.98	0.16	1.11	0.13	0.97	0.71	2.6	-8	25
	RURN	5.49	7.09	0.25	1.39	0.24	1.31	0.19	0.85	0.62	3.1	29	43
SEN	PA01H	9.30	6.34	-0.38	0.72	0.31	1.21	0.19	0.90	0.73	4.3	-32	33
	BOBI	6.14	6.69	0.09	1.17	0.10	1.14	0.12	0.93	0.73	2.0	9	26
	GONES	7.47	6.51	-0.14	0.89	0.09	1.07	0.10	0.98	0.73	2.0	-13	19
	RURSE	5.88	8.12	0.32	1.40	0.24	1.23	0.18	0.87	0.65	3.4	38	43
	PA18	9.54	6.38	-0.40	0.69	0.28	1.23	0.20	0.88	0.73	4.2	-33	33
	GEN	7.10	6.23	-0.13	0.95	0.21	1.13	0.15	0.95	0.69	3.0	-12	27
	VITRY	6.67	5.99	-0.11	0.96	0.17	1.11	0.13	0.97	0.72	2.6	-10	25
	RURN	5.49	7.06	0.25	1.39	0.24	1.31	0.19	0.85	0.62	3.0	29	43
EMEP	PA01H	9.30	7.20	-0.25	0.82	0.21	1.13	0.15	0.93	0.71	3.7	-23	26
	BOBI	6.14	6.86	0.11	1.20	0.11	1.16	0.13	0.93	0.71	2.1	12	27
	GONES	7.47	6.99	-0.07	0.95	0.07	1.06	0.10	0.98	0.71	1.9	-6	19
	RURSE	5.88	8.59	0.37	1.48	0.28	1.29	0.21	0.78	0.64	3.8	46	51
	PA18	9.54	7.25	-0.27	0.79	0.19	1.14	0.16	0.95	0.69	3.6	-24	28
	GEN	7.10	6.81	-0.04	1.05	0.18	1.13	0.14	0.97	0.67	2.9	-4	28
	VITRY	6.67	7.00	0.05	1.13	0.14	1.13	0.14	0.93	0.71	2.5	5	29
	RURN	5.49	7.64	0.33	1.49	0.30	1.39	0.21	0.82	0.60	3.5	39	50

Table S6. Statistical indicators for PNC concentrations simulated at the background stations in the REF, SEN, and EMEP simulations. Statistics in green text indicates that the most-strict criterion is met ($|FB| < 0.3$, $0.7 < MG < 1.3$, $NMSE < 3$, $VG < 1.6$, $NAD < 0.3$, and $FAC2 > 0.5$). Statistics in blue text indicate the the less-strict criterion is met ($|FB| < 0.67$, $NMSE < 6$, $NAD < 0.5$, and $FAC2 > 0.3$), while statistics in red text indicates that the criterion is not met.

	Stations	Obs.	Sim.	FB	MG	NMSE	VG	NAD	FAC2	R	RMSE	NMB (%)	NME (%)
REF	SIRTA	6,041	5,909	-0.02	1.10	0.15	1.37	0.15	0.94	0.57	2,318	-2	31
	PRG	9,276	10,474	0.12	1.16	0.07	1.09	0.10	1.00	0.53	2,639	13	22
	PA01H	9,212	8,137	-0.12	0.91	0.07	1.06	0.10	1.00	0.67	2,310	-12	20
SEN	SIRTA	6,041	5,892	-0.02	1.09	0.15	1.37	0.12	0.98	0.57	2,323	-2	31
	PRG	9,276	10,411	0.12	1.15	0.07	1.09	0.15	0.94	0.53	2,607	12	22
	PA01H	9,212	8,111	-0.13	0.90	0.07	1.06	0.10	1.00	0.67	2,321	-12	20
EMEP	SIRTA	6,041	6,521	0.08	1.19	0.15	1.39	0.11	1.00	0.56	2,390	8	30
	PRG	9,276	12,477	0.29	1.39	0.17	1.23	0.12	0.98	0.16	4,393	35	39
	PA01H	9,212	12,834	0.33	1.43	0.16	1.21	0.17	0.92	0.60	4,287	39	41

Table S7. Statistical indicators for NO₂ concentrations simulated at the traffic stations in the REF and SEN simulations. Statistics in green text indicates that the most-strict criterion is met ($|FB| < 0.3$, $0.7 < MG < 1.3$, $NMSE < 3$, $VG < 1.6$, $NAD < 0.3$, and $FAC2 > 0.5$). Statistics in blue text indicate the the less-strict criterion is met ($|FB| < 0.67$, $NMSE < 6$, $NAD < 0.5$, and $FAC2 > 0.3$), while statistics in red text indicates that the criterion is not met.

	Stations	Obs.	Sim.	FB	MG	NMSE	VG	NAD	FAC2	R	RMSE	NMB (%)	NME (%)
REF & SEN	HAUSS	37.6	41.4	0.10	0.85	0.14	1.16	0.15	0.92	0.53	14.8	10	31
	BP_EST	50.5	45.1	-0.11	1.02	0.20	1.22	0.17	0.87	0.47	21.2	-11	33
	AUT	72.1	41.7	-0.53	1.71	0.39	1.38	0.27	0.87	0.70	34.4	-42	42
	CELES	42.5	51.8	0.20	0.79	0.10	1.14	0.14	0.95	0.63	15.0	22	31
	ELYS	26.6	24.3	-0.09	1.04	0.16	1.10	0.12	0.95	0.57	10.1	-9	23
	BONAP	31.7	31.2	-0.01	0.96	0.08	1.09	0.11	0.97	0.69	8.9	-1	22
	SOULT	29.0	27.8	-0.03	0.97	0.09	1.10	0.11	0.97	0.70	8.6	-3	22
	RN2	38.7	41.6	0.07	0.88	0.12	1.15	0.14	0.93	0.50	14.1	8	30
	BASCH	41.8	37.3	-0.12	1.08	0.09	1.07	0.10	1.00	0.73	12.1	-11	20
	HdV	29.9	41.2	0.35	0.65	0.18	1.31	0.18	0.81	0.81	15.0	43	45

Table S8. Statistical indicators for eBC concentrations simulated at the traffic stations in the REF and SEN simulations. Statistics in green text indicates that the most-strict criterion is met ($|\text{FB}| < 0.3$, $0.7 < \text{MG} < 1.3$, $\text{NMSE} < 3$, $\text{VG} < 1.6$, $\text{NAD} < 0.3$, and $\text{FAC2} > 0.5$). Statistics in blue text indicate the the less-strict criterion is met ($|\text{FB}| < 0.67$, $\text{NMSE} < 6$, $\text{NAD} < 0.5$, and $\text{FAC2} > 0.3$), while statistics in red text indicates that the criterion is not met.

	Stations	Obs.	Sim.	FB	MG	NMSE	VG	NAD	FAC2	R	RMSE	NMB (%)	NME (%)
REF	HAUSS	0.79	0.89	0.11	0.84	0.14	1.19	0.15	0.93	0.43	0.32	11	33
	BP_EST	2.31	1.92	-0.19	1.11	0.19	1.19	0.17	0.88	0.50	0.91	-17	31
	HdV	0.68	0.97	0.33	0.66	0.27	1.32	0.24	0.85	0.31	0.42	40	57
SEN	HAUSS	0.79	0.81	0.01	0.92	0.15	1.16	0.15	0.95	0.42	0.31	1	30
	BP_EST	2.31	1.62	-0.35	1.31	0.31	1.27	0.22	0.81	0.51	1.08	-30	38
	HdV	0.68	0.87	0.21	0.75	0.23	1.21	0.20	0.92	0.29	0.36	24	44

Table S9. Statistical indicators for PM_{2.5} concentrations simulated at the traffic stations in the REF and SEN simulations. Statistics in green text indicates that the most-strict criterion is met ($|\text{FB}| < 0.3$, $0.7 < \text{MG} < 1.3$, $\text{NMSE} < 3$, $\text{VG} < 1.6$, $\text{NAD} < 0.3$, and $\text{FAC2} > 0.5$). Statistics in blue text indicate the the less-strict criterion is met ($|\text{FB}| < 0.67$, $\text{NMSE} < 6$, $\text{NAD} < 0.5$, and $\text{FAC2} > 0.3$), while statistics in red text indicates that the criterion is not met.

	Stations	Obs.	Sim.	FB	MG	NMSE	VG	NAD	FAC2	R	RMSE	NMB (%)	NME (%)
REF	HAUSS	10.14	7.80	-0.26	1.28	0.13	1.10	0.13	0.95	0.78	3.3	-23	24
	BP_EST	10.22	12.11	0.17	0.80	0.09	1.14	0.12	0.93	0.66	3.3	18	26
	AUT	13.26	9.83	-0.30	1.33	0.15	1.13	0.15	0.97	0.73	4.4	-26	27
SEN	HAUSS	10.14	7.25	-0.33	1.38	0.18	1.15	0.17	0.95	0.78	3.7	-28	28
	BP_EST	10.22	9.91	-0.03	0.99	0.07	1.08	0.11	0.98	0.70	2.6	-3	22
	AUT	13.26	8.52	-0.44	1.55	0.27	1.26	0.22	0.92	0.73	5.5	-36	36

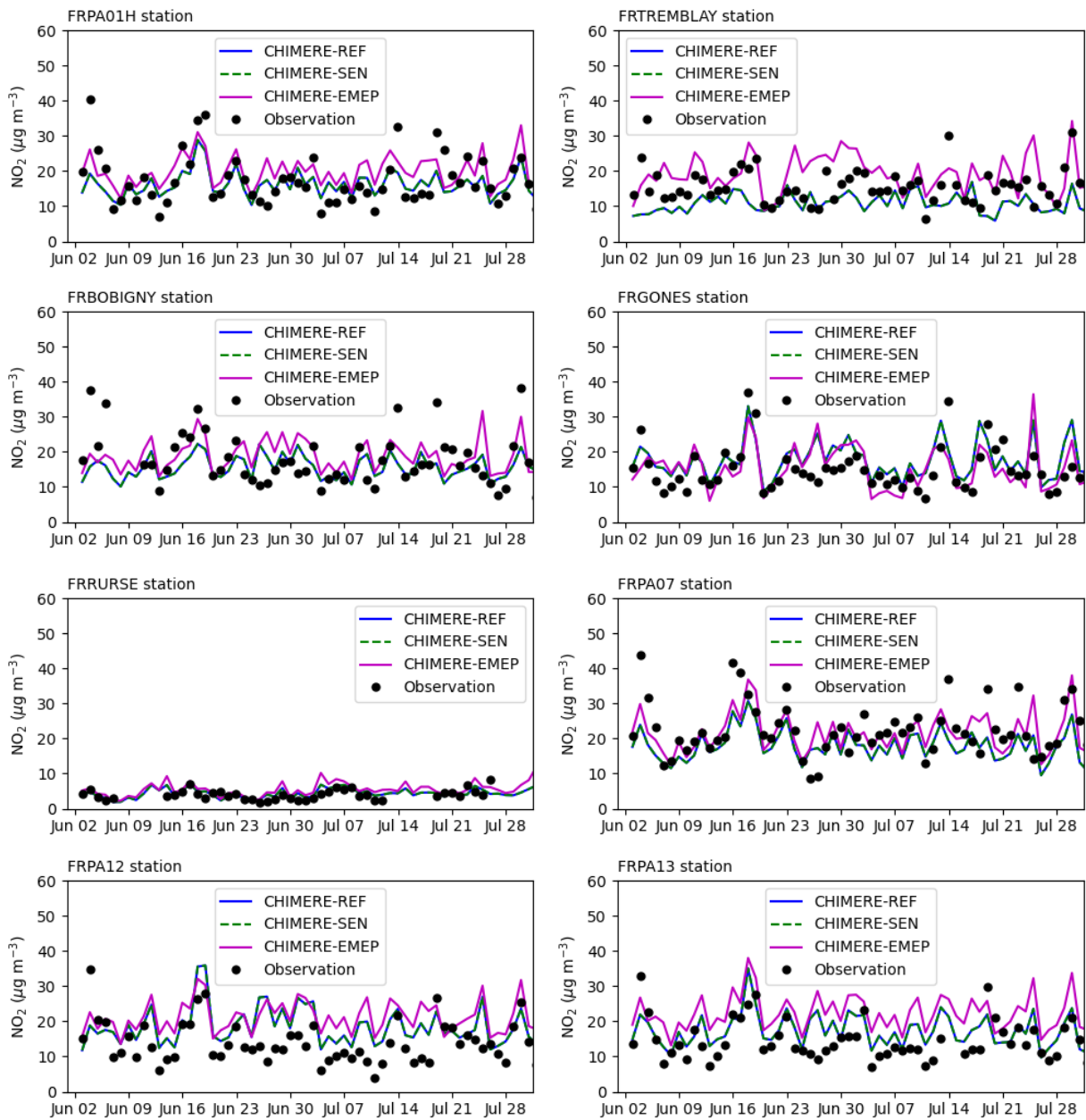


Figure S1. Time series of measured and simulated NO₂ concentrations at background stations.

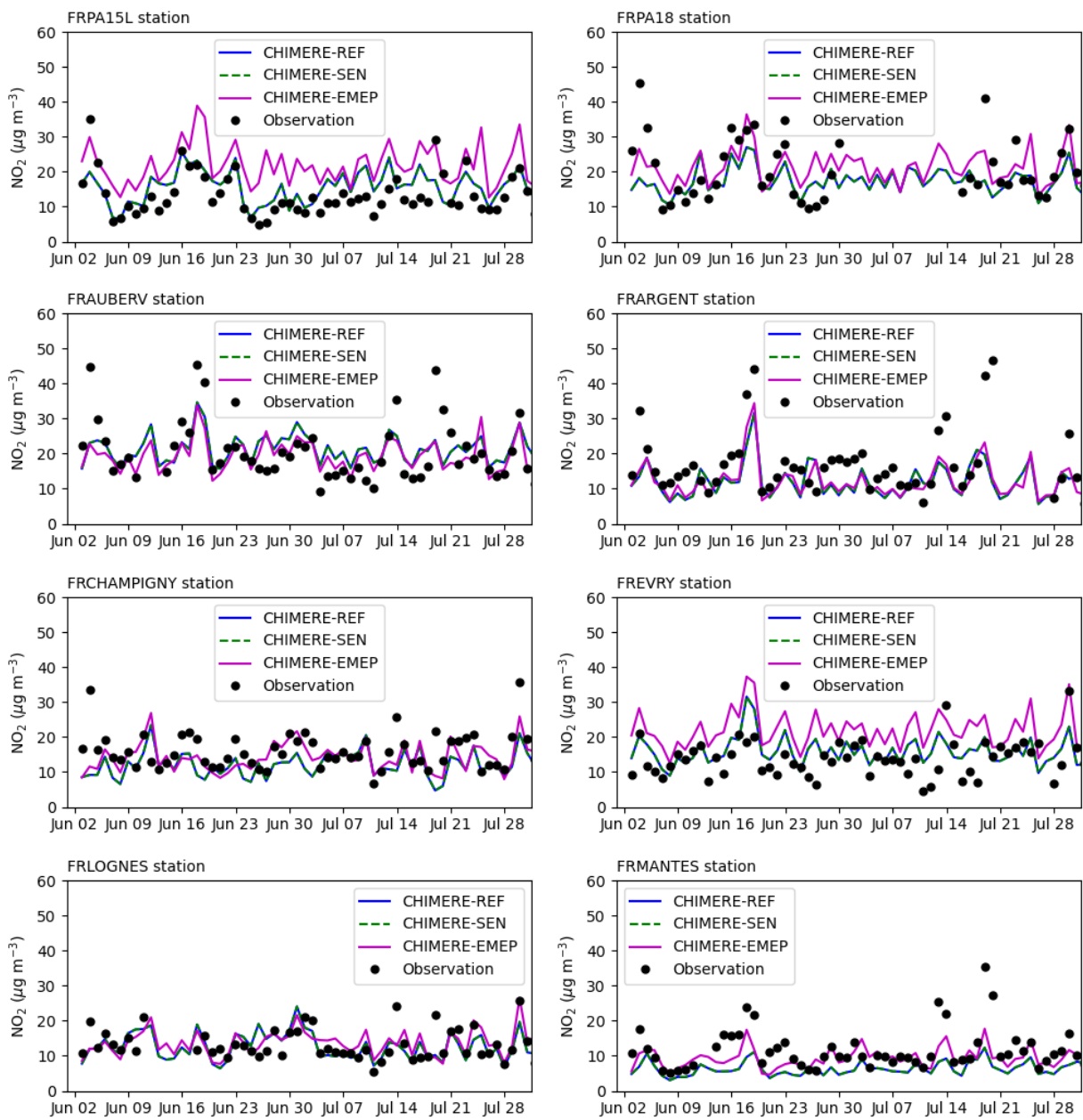


Figure S1. (continue)

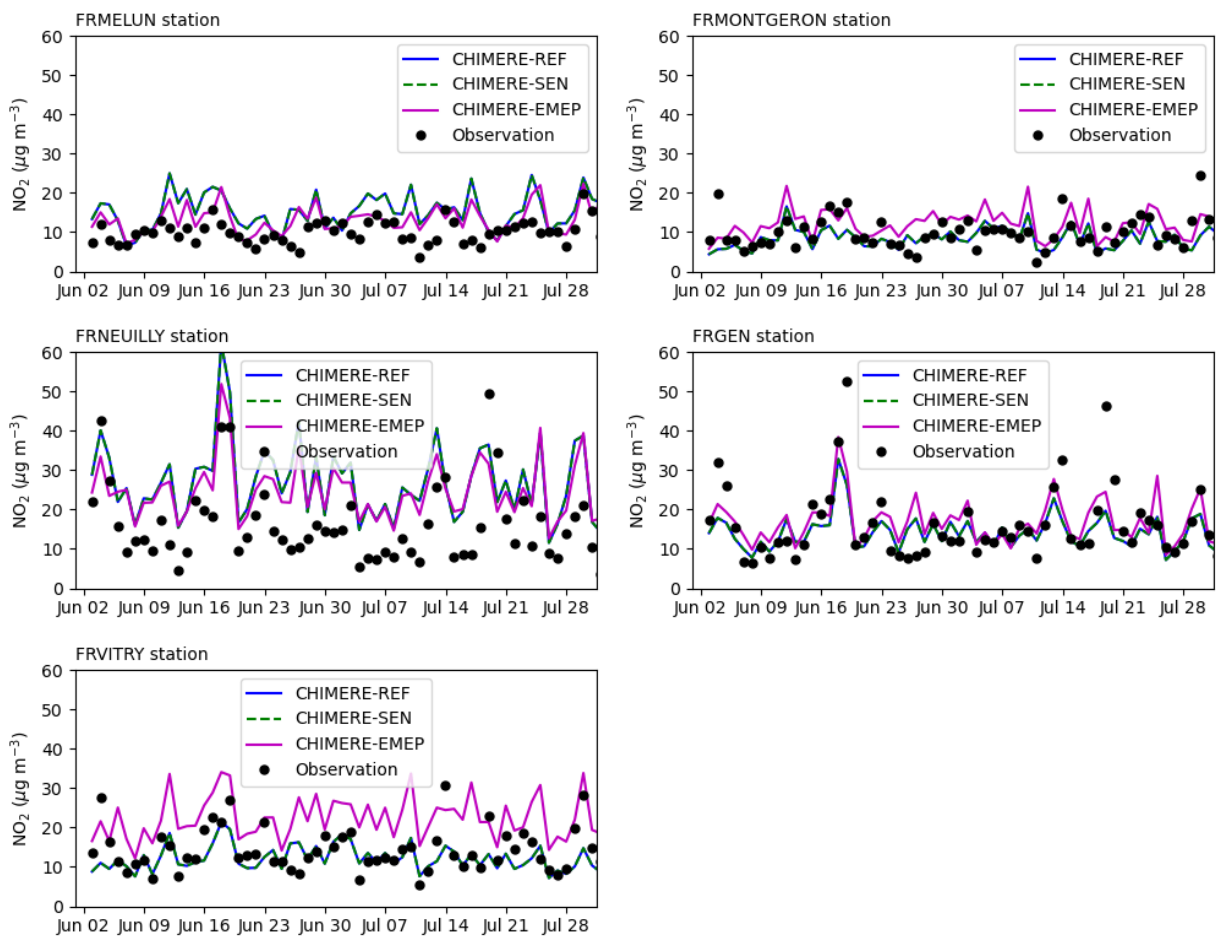


Figure S1. (continued, end) Time series of measured and simulated NO₂ concentrations at background stations.

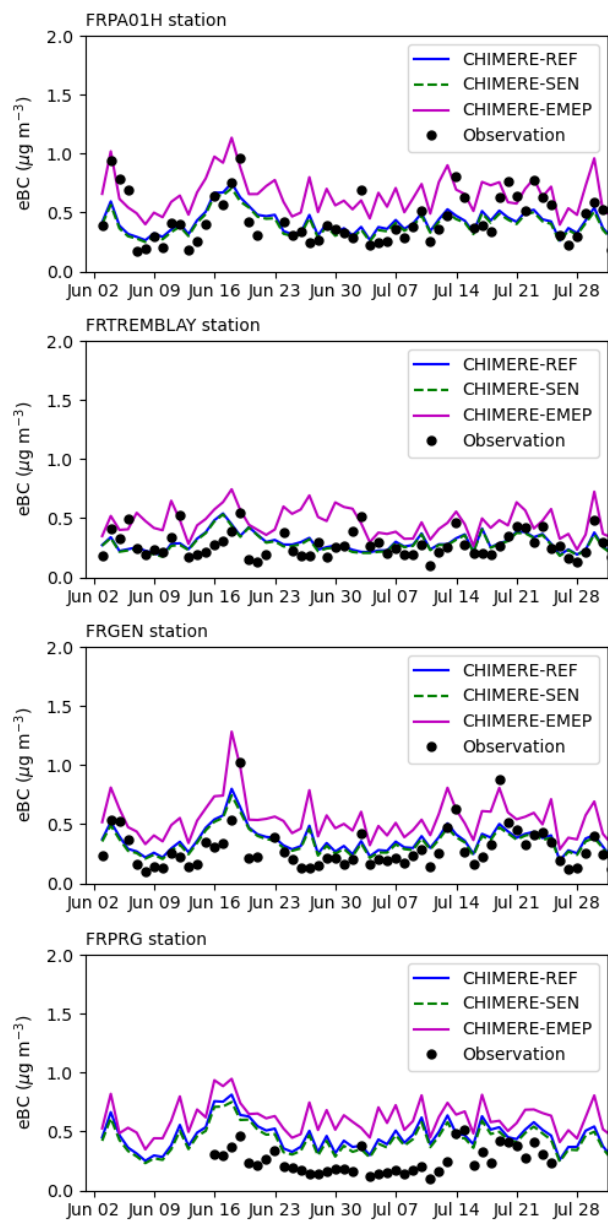


Figure S2. Time series of measured and simulated eBC concentrations at background stations.

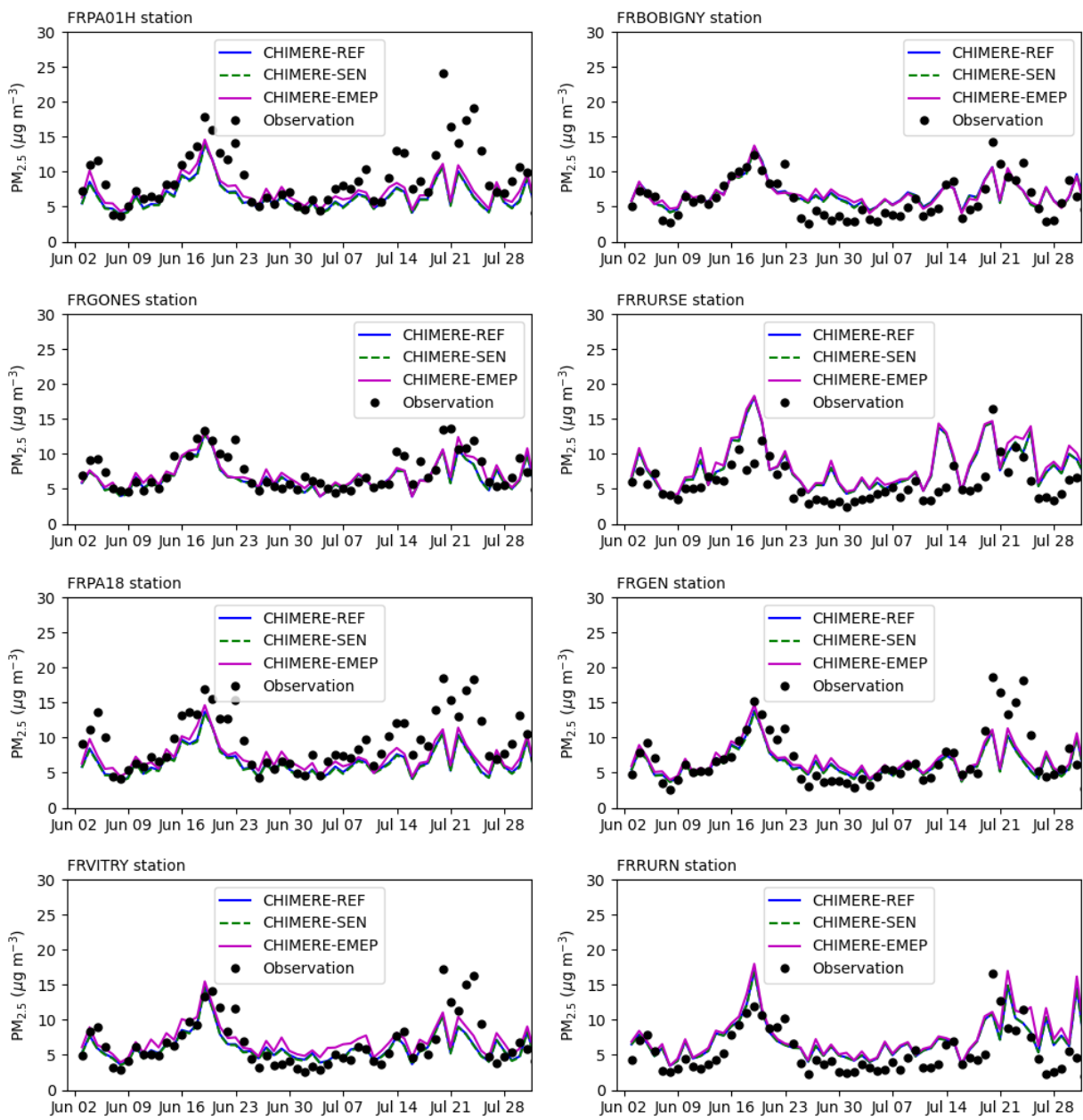


Figure S3. Time series of measured and simulated $PM_{2.5}$ concentrations at background stations.

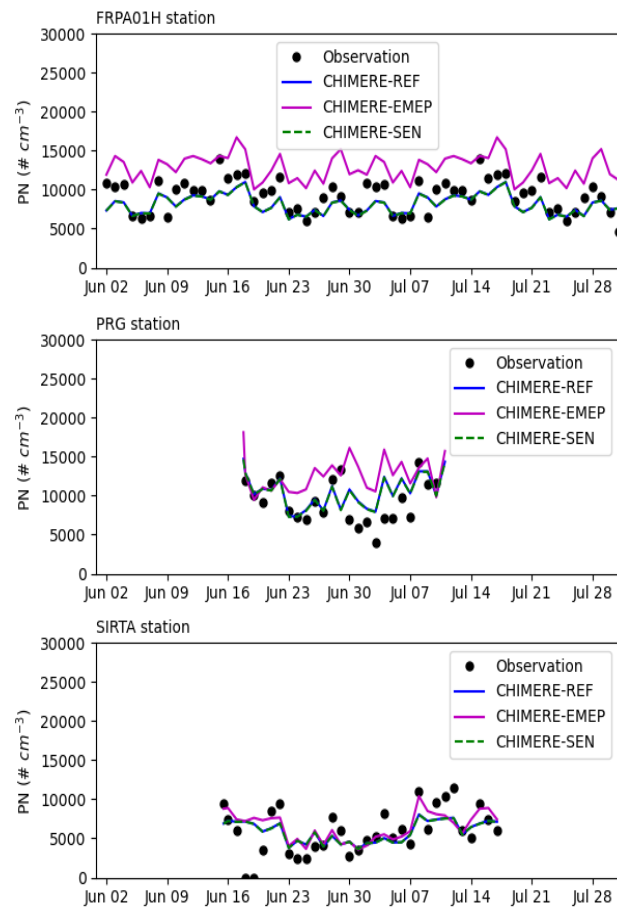


Figure S4. Time series of measured and simulated PN concentrations at background stations.

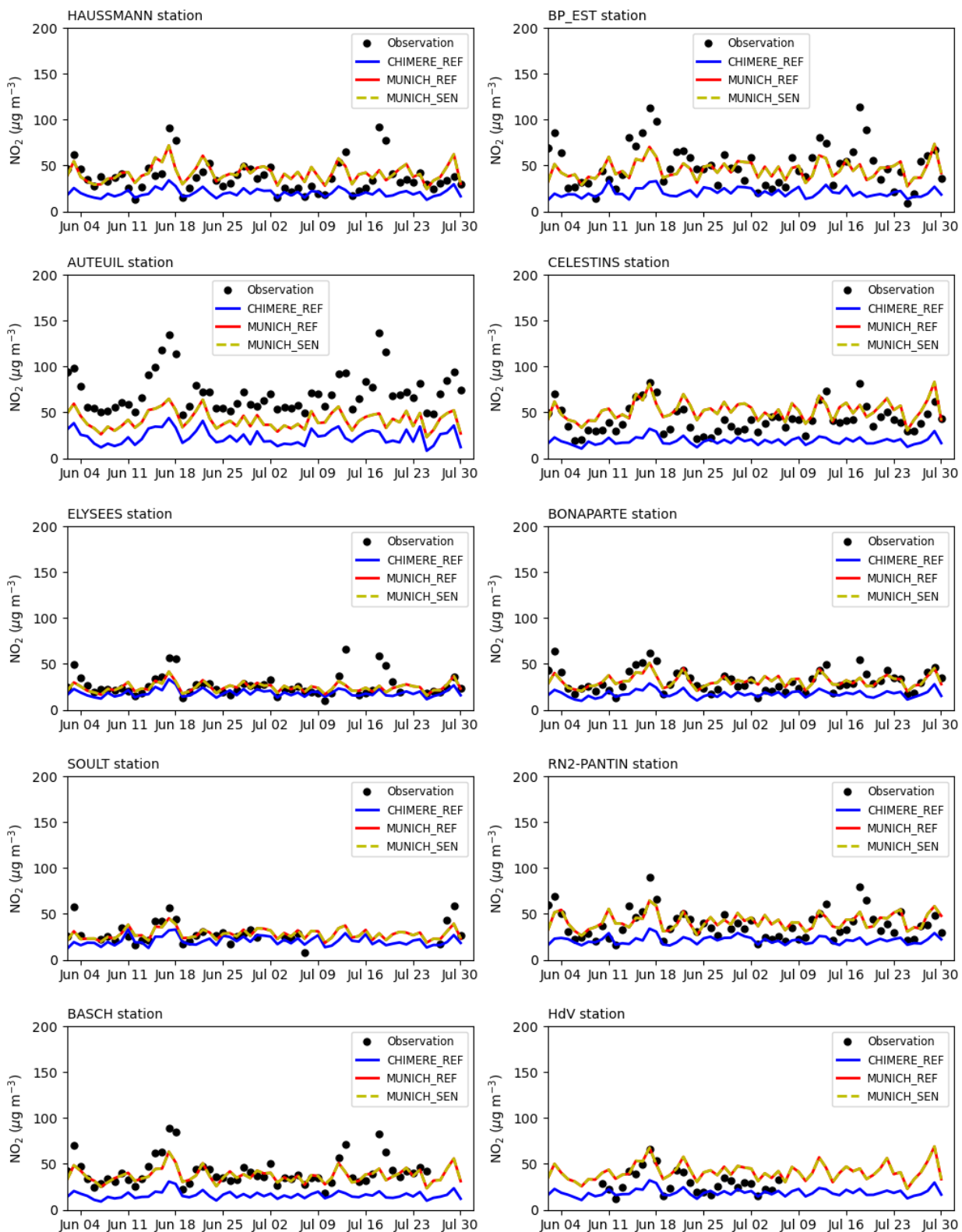


Figure S5. Time series of measured and simulated NO₂ concentrations at traffic stations.

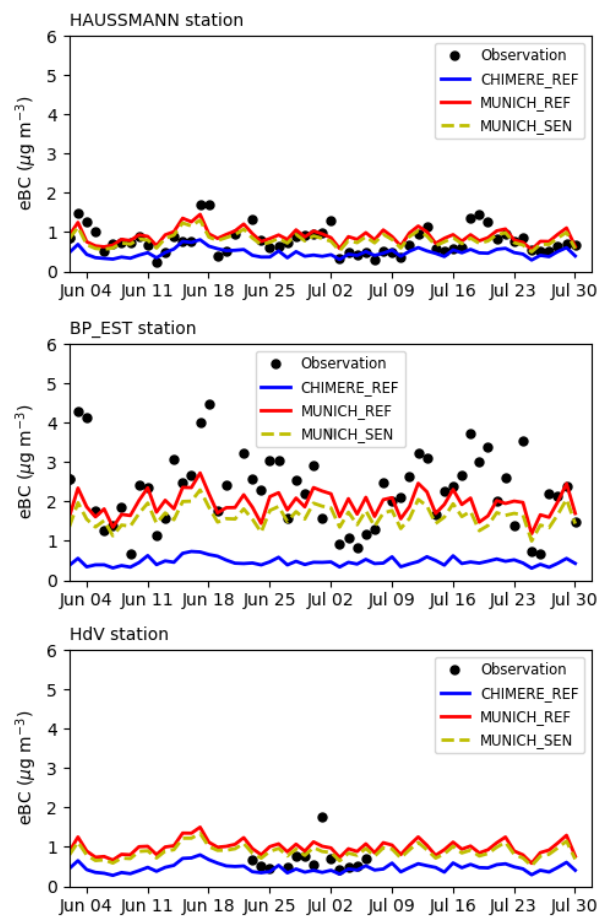


Figure S6. Time series of measured and simulated eBC concentrations at traffic station.

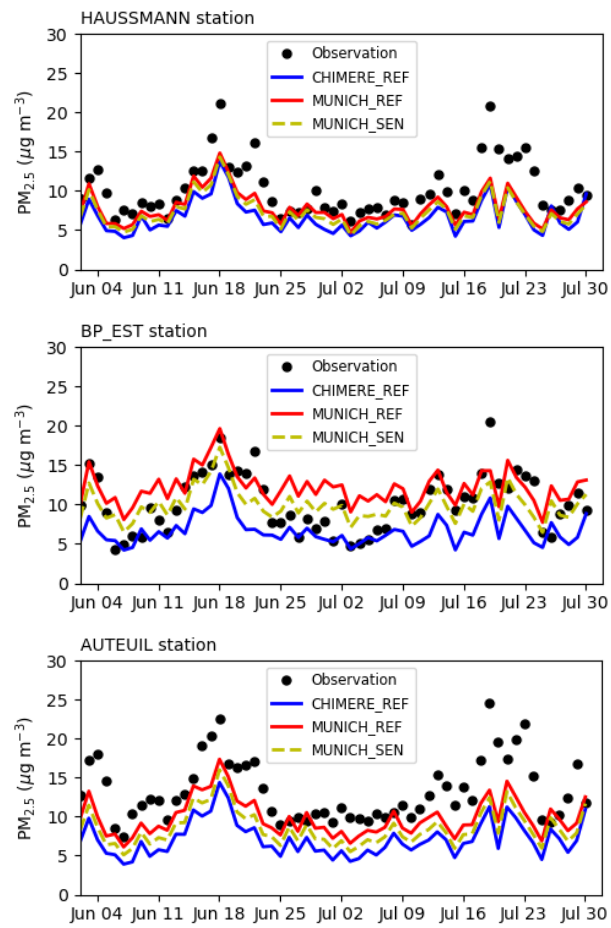


Figure S7. Time series of measured and simulated PM₂₅ concentrations at traffic station.