

Supplementary Materials

The prediction skills of CHIMBO are quantified in terms of the normalized mean bias (NMB), the normalized mean error (NME), the mean bias (MB), the mean absolute gross error (MAGE), the fractional bias (FBIAS), and the fractional error (FERROR),

$$NMB = \sum_{i=1}^n (P_i - O_i) / \sum_{i=1}^n O_i ,$$

$$NME = \sum_{i=1}^n |P_i - O_i| / \sum_{i=1}^n O_i ,$$

$$MB = 1/n \sum_{i=1}^n (P_i - O_i) ,$$

$$MAGE = 1/n \sum_{i=1}^n |P_i - O_i| ,$$

$$FBIAS = 2/n \sum_{i=1}^n (P_i - O_i) / \sum_{i=1}^n (P_i - O_i) ,$$

$$FERROR = 2/n \sum_{i=1}^n |P_i - O_i| / \sum_{i=1}^n (P_i - O_i) ,$$

where P_i represents the model predicted value for data point i , O_i is the corresponding observed value and n is the total number of data points.

Table S1. Prediction skill metrics of CHIMBO against daily ground measurements from every single station of the 11 sites in Northern Italy listed in Table 2 during the 2019.

	Mean Observed ($\mu\text{g m}^{-3}$)	Mean Predicted ($\mu\text{g m}^{-3}$)	NMB (%)	NME (%)	MB ($\mu\text{g m}^{-3}$)	MAGE ($\mu\text{g m}^{-3}$)	FBIAS	FERROR	Percent within a factor of 2
BO									
PM10	25.58	19.49	-23%	49%	-6.01	12.44	-0.24	0.49	73%
Sulfate	1.65	1.11	-32%	50%	-0.53	0.82	-0.31	0.56	65%
Nitrate	4.10	3.14	-22%	52%	-0.91	2.12	-0.42	0.83	46%
Ammonium	2.08	1.31	-36%	48%	-0.75	1.00	-0.41	0.58	61%
EC	0.95	0.66	-31%	47%	-0.30	0.45	-0.21	0.46	77%
OC	3.82	3.34	-8%	55%	-0.31	2.08	-0.07	0.51	74%
SPC									
PM10	25.46	20.72	-17%	47%	-4.44	12.07	-0.14	0.48	75%
Sulfate	1.84	1.17	-37%	57%	-0.67	1.06	-0.31	0.65	54%
Nitrate	4.15	3.88	-8%	56%	-0.35	2.31	-0.16	0.71	52%
Ammonium	2.18	1.54	-30%	47%	-0.66	1.02	-0.36	0.57	63%
EC	0.72	0.69	-4%	57%	-0.03	0.41	0.21	0.57	64%
OC	3.95	3.45	-4%	58%	-0.15	2.27	0.01	0.54	73%
PR									
PM10	31.06	19.91	-36%	49%	-11.06	15.08	-0.41	0.58	63%
Sulfate	1.76	1.14	-36%	57%	-0.63	1.00	-0.38	0.64	64%
Nitrate	4.47	3.69	-24%	48%	-1.08	2.14	-0.25	0.63	62%
Ammonium	2.20	1.46	-37%	46%	-0.82	1.01	-0.44	0.57	61%
EC	0.76	0.66	-19%	47%	-0.15	0.36	-0.04	0.46	77%
OC	3.91	3.47	-4%	48%	-0.15	1.86	-0.06	0.46	73%
RI									
PM10	29.78	18.90	-36%	58%	-10.76	17.22	-0.42	0.63	55%

Sulfate	1.78	1.11	-38%	55%	-0.68	0.97	-0.35	0.60	62%
Nitrate	3.70	1.76	-50%	57%	-1.85	2.11	-0.82	1.00	29%
Ammonium	1.93	0.92	-51%	56%	-0.99	1.08	-0.58	0.67	52%
EC	0.97	0.62	-34%	56%	-0.33	0.54	-0.19	0.55	69%
OC	4.55	2.92	-28%	56%	-1.29	2.55	-0.25	0.54	65%
	Mean Ob- served ($\mu\text{g m}^{-3}$)	Mean Pre- dicted ($\mu\text{g m}^{-3}$)	NMB (%)	NME (%)	MB ($\mu\text{g m}^{-3}$)	MAGE ($\mu\text{g m}^{-3}$)	FBIAS	FERROR	Percent within a fac- tor of 2
AO									
PM10	-	7.14	-	-	-	-	-	-	-
Sulfate	1.03	0.48	-53%	71%	-0.55	0.73	-0.65	0.89	36%
Nitrate	1.57	0.48	-69%	72%	-1.09	1.13	-1.15	1.20	24%
Ammonium	0.21	0.33	55%	113%	0.12	0.24	0.51	0.89	39%
EC	1.18	0.22	-82%	82%	-0.97	0.97	-1.26	1.26	5%
OC	4.58	1.19	-73%	73%	-3.34	3.34	-1.15	1.15	14%
BS									
PM10	37.07	20.27	-46%	51%	-16.97	18.90	-0.58	0.63	55%
Sulfate	2.40	0.97	-56%	63%	-1.34	1.51	-0.73	0.81	39%
Nitrate	7.43	4.65	-29%	54%	-2.14	4.00	-0.38	0.72	52%
Ammonium	2.41	1.65	-22%	53%	-0.54	1.28	-0.12	0.58	62%
EC	1.41	0.80	-48%	52%	-0.68	0.74	-0.44	0.54	70%
OC	7.87	4.01	-51%	56%	-4.04	4.38	-0.62	0.68	53%
LO									
PM10	34.44	24.82	-14%	34%	-4.75	11.55	-0.06	0.35	85%
Sulfate	1.85	1.20	-44%	55%	-0.82	1.01	-0.50	0.67	46%
Nitrate	11.13	6.81	1%	51%	0.10	5.72	0.05	0.50	70%
Ammonium	3.16	2.28	5%	45%	0.17	1.43	0.20	0.51	74%
EC	0.68	0.88	70%	79%	0.47	0.54	0.44	0.54	59%
OC	6.97	4.47	-43%	49%	-3.02	3.40	-0.52	0.60	54%
MI_MA									
PM10	35.07	25.08	-28%	40%	-9.78	13.91	-0.29	0.43	77%
Sulfate	2.01	1.15	-38%	61%	-0.75	1.22	-0.39	0.73	53%
Nitrate	3.40	6.38	6%	70%	0.20	2.36	-0.18	0.77	49%
Ammonium	1.44	2.19	-4%	63%	-0.06	0.90	0.07	0.67	56%
EC	1.16	1.06	-17%	34%	-0.20	0.39	-0.14	0.36	88%
OC	5.35	4.99	4%	40%	0.19	2.15	0.00	0.38	90%
MI_SE									
PM10	35.07	25.49	-27%	39%	-9.35	13.66	-0.28	0.43	79%
Sulfate	1.93	1.17	-40%	58%	-0.78	1.12	-0.40	0.71	48%
Nitrate	4.54	6.66	32%	76%	1.47	3.43	0.16	0.80	50%
Ammonium	1.57	2.27	33%	75%	0.52	1.17	0.39	0.74	49%
EC	1.09	1.05	-3%	39%	-0.04	0.42	0.09	0.41	83%
OC	7.07	4.97	-29%	41%	-2.02	2.93	-0.36	0.49	74%
MI_PA									
PM10	31.29	25.67	-16%	37%	-5.08	11.73	-0.12	0.38	83%
Sulfate	2.18	1.16	-45%	57%	-0.98	1.24	-0.48	0.69	51%

Nitrate	6.54	6.66	6%	52%	0.38	3.41	0.13	0.65	59%
Ammonium	2.32	2.27	2%	50%	0.05	1.16	0.10	0.57	65%
EC	1.11	1.09	8%	53%	0.09	0.58	0.19	0.44	76%
OC	7.05	5.05	-28%	50%	-1.95	3.50	-0.27	0.52	70%

SCHI									
PM10	31.53	23.18	-26%	41%	-8.13	13.04	-0.25	0.44	76%
Sulfate	2.28	1.20	-47%	55%	-1.08	1.26	-0.55	0.69	51%
Nitrate	7.14	5.69	-20%	45%	-1.40	3.21	-0.12	0.63	61%
Ammonium	2.61	1.96	-24%	45%	-0.63	1.18	-0.11	0.51	74%
EC	0.59	0.83	52%	86%	0.31	0.50	0.46	0.63	57%
OC	6.07	4.09	-32%	53%	-1.95	3.20	-0.33	0.57	62%