



*Supplement of*

## **Accounting for the black carbon aging process in a two-way coupled meteorology–air quality model**

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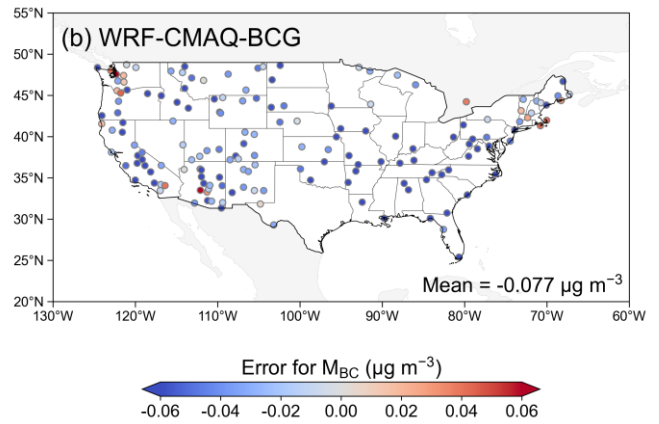
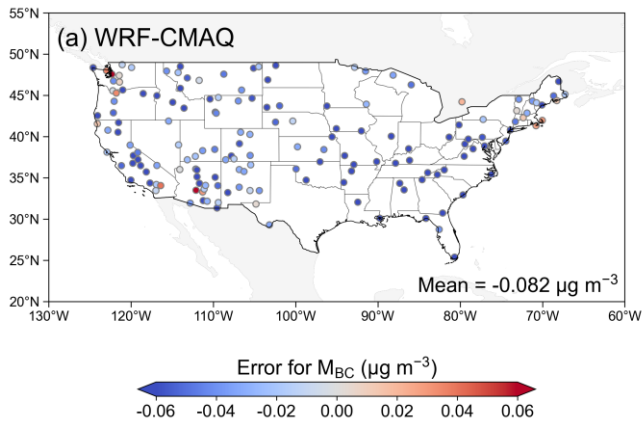
## Evaluation of Regional Simulations

To evaluate accuracy of the models' regional-scale results, we compared several common variables, as shown in Table S1. These include BC mass concentration ( $M_{BC}$ ) data from the Interagency Monitoring of Protected Visual Environments (IMPROVE) measurement network,  $O_3$ ,  $SO_2$ , and other gas concentration data from the Air Quality System (AQS) surface dataset, and Aerosol Optical Depth (AOD) data obtained from the Polarization and Directionality of the Earth's Reflectances (POLDER) satellite observations.

**Table S1. Performance Evaluation of WRF-CMAQ and WRF-CMAQ-BCG Models.**

Results Variables	Observation	WRF-CMAQ				WRF-CMAQ-BCG			
	Mean	Mean	MBE	RMSE	NMB	Mean	MBE	RMSE	NMB
$M_{BC}$ ( $\mu\text{g m}^{-3}$ )	0.199	0.117	-0.082	0.139	-0.412	0.123	-0.077	0.137	-0.382
$O_3$ (ppb)	33.391	35.048	1.657	6.370	0.050	35.063	1.672	6.367	0.050
$SO_2$ (ppb)	1.934	1.740	-0.194	4.202	-0.100	1.740	-0.194	4.202	-0.100
$NO$ (ppb)	1.910	1.952	0.042	2.573	0.022	1.947	0.037	2.573	0.019
$NO_2$ (ppb)	6.539	7.795	1.256	4.290	0.192	7.787	1.248	4.277	0.191
$AOD_{533}$	0.143	0.0586	-0.0844	0.146	-0.590	0.0585	-0.0845	0.146	-0.591

10 With the mean, mean bias error (MBE), root mean square error (RMSE), and normalized mean bias (NMB) metrics presented in Table S1, it can be seen that both the WRF-CMAQ and WRF-CMAQ-BCG models simulated accurately. In addition, the mean error of  $M_{BC}$  simulated by the new model is  $-0.077 \mu\text{g m}^{-3}$ , which is closer to the observations compared to the original model's values of  $-0.082 \mu\text{g m}^{-3}$ , indicating a slight improvement in alignment with the observation (Fig. S1). Overall, the new model, while adding new functionalities and enhancing the accuracy of optical calculations, does not  
15 compromise the simulation of other variables and slightly improves the simulation of BC mass concentration.



**Figure S1: Comparison of BC mass concentration ( $M_{\text{BC}}$ ) errors between simulations and observations: (a) the WRF-CMAQ model, (b) the WRF-CMAQ-BCG model.**