Improvement of Stable Atmospheric Boundary Simulation with High-Spatiotemporal-Resolution Nudging over the North China Plain

Tingting Xu[1,2,*], Zhuohao Peng[1], Yan Wang[1], Chaoyue Wan[1], Shenlan Liu[1], , Shuqiao Jiang[1], Xiaolu Tang[1], Xilin Zhao[1]

[1] College of Ecology and Environment, Chengdu University of Technology, Chengdu, 610059 China

[2] College of Architecture and Environment, Sichuan University, Chengdu, 610065, China

[*] Correspondence: xutingting19@cdut.edu.cn

$$MB=\frac{1}{N}\sum_{1}^{N}(sim\text{-}obs) \qquad \text{Equation S1}$$

$$RMSE=\sqrt{\sum_{1}^{N}(sim\text{-}obs)^{2}/N} \qquad \text{Equation S2}$$

$$R=\frac{\frac{1}{N}\sum_{i=1}^{N}(sim_i-\overline{sim_1})(obs_i-\overline{obs_1})}{\sqrt{\frac{1}{N}\sum_{i=1}^{N}(sim_i-\overline{sim_1})^{2}}\sqrt{\frac{1}{N}\sum_{i=1}^{N}(obs_i-\overline{obs_1})^{2}}} \qquad \text{Equation S3}$$

where N is the number of comparison samples, sim is the simulation value, and obs is the observation value.

Table S1. WRF model configuration options and settings.

Domain settings	
Center latitude and longitude	37.1°N, 116.4°E
D01 horizontal grid	50╳50
D01 grid spacing	30km╳30km
D02 horizontal grid	99╳120
D02 grid spacing	10km╳10km
Vertical levels	40
Projection	Lambert conformal conic
Configuration options	
Data assimilation	High-resolution OBS-nudging
Longwave radiation	RRTMG
Shortwave radiation	RRTMG
Cumulus parameterization	Grell–Deveny
Land surface	Noah
Boundary layer	Yonsei University
Microphysics	Lin et al.
Photolysis	Fast-J

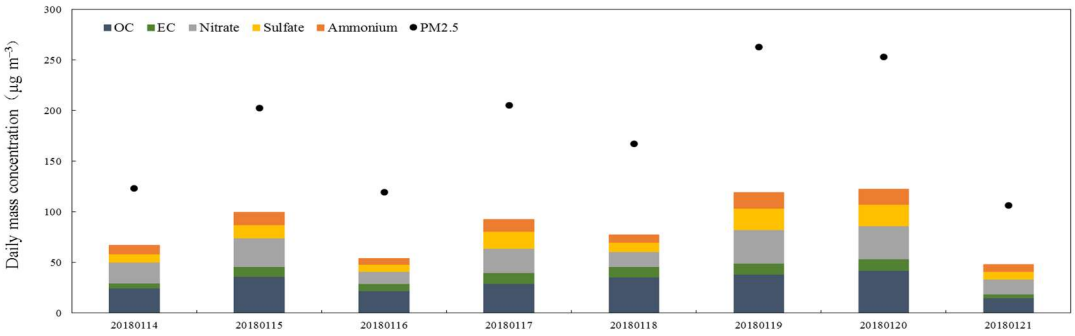

Figure S1. Daily concentration of $PM_{2.5}$ and its components at Pingyuan station from 14 to 21 January 2018.

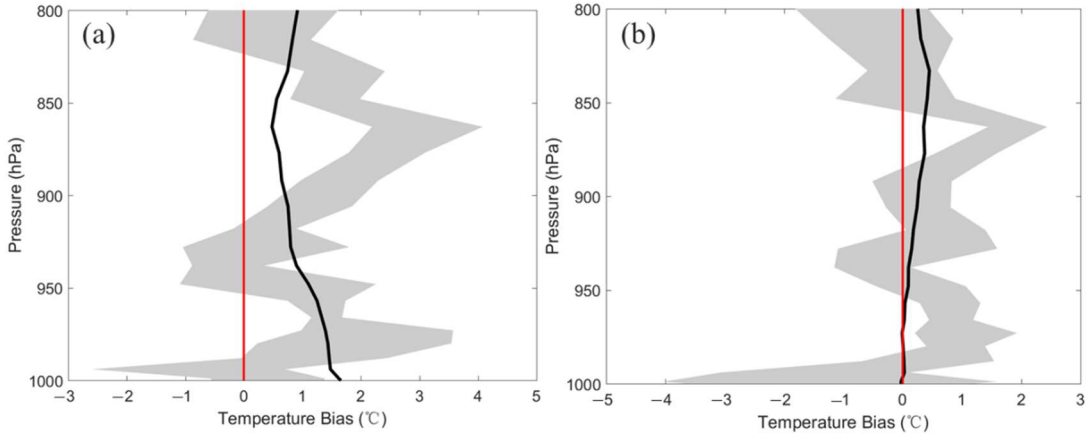

Figure S2. Temperature bias between WRF-BS (a) and WRF-OBS (b) and observed values during heavy pollution. The shaded part represents the difference of 25 and 75 quantiles.

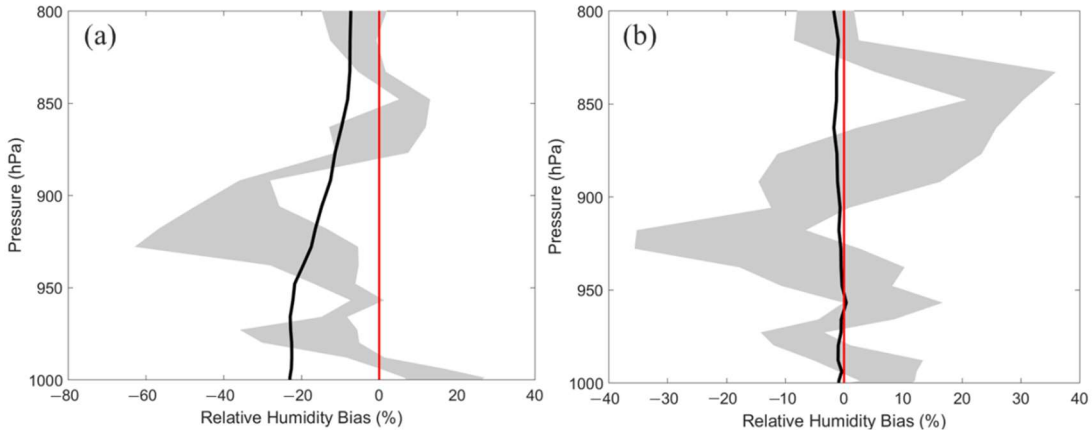

Figure S3. Relative humidity bias between WRF-BS (a) and WRF-OBS (b) and observed values during heavy pollution. The shaded part represents the difference of 25 and 75 quantiles.

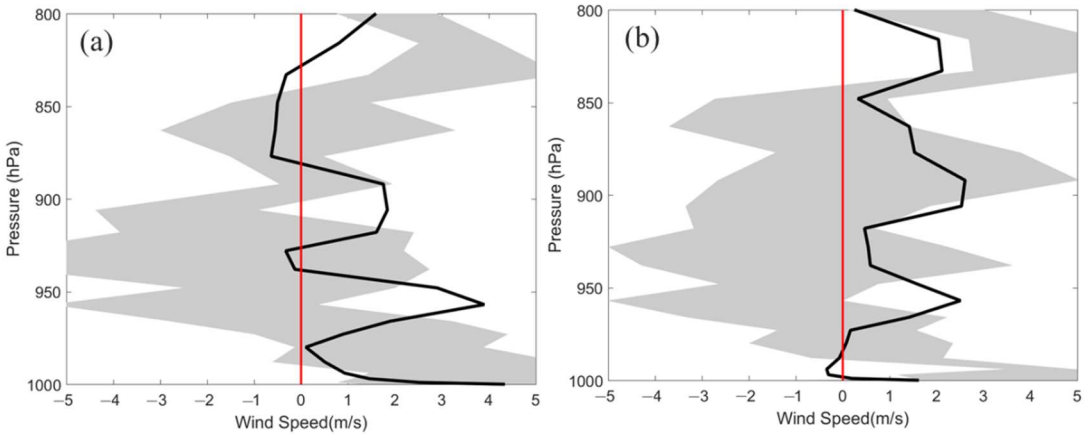

Figure S4. Wind speed bais between WRF-BS (a) and WRF-OBS (b) and observed values during heavy pollution. The shaded part represents the difference of 25 and 75 quantiles.

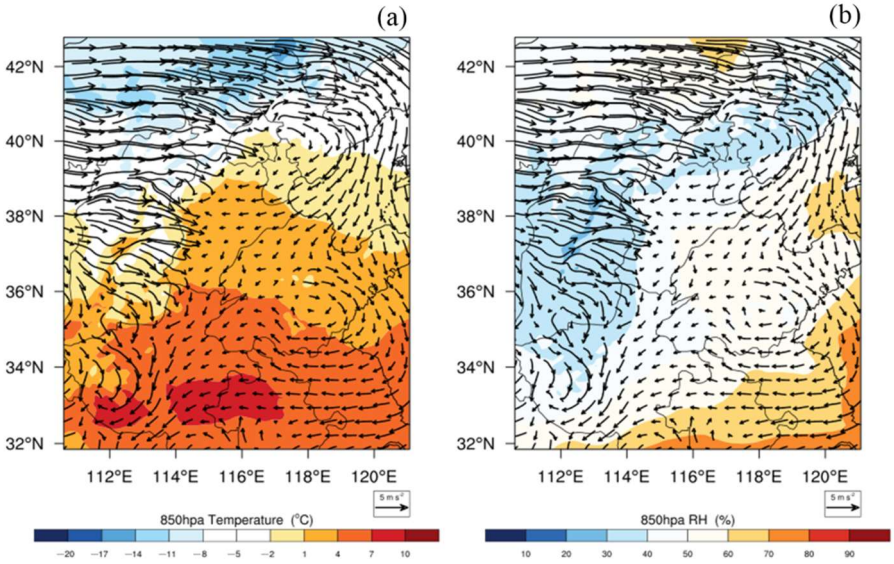

Figure S5. Spatial distributions of temperature (a), relative humidity (contour) and wind (black vectors) at 850 hPa during heavy polluted period.

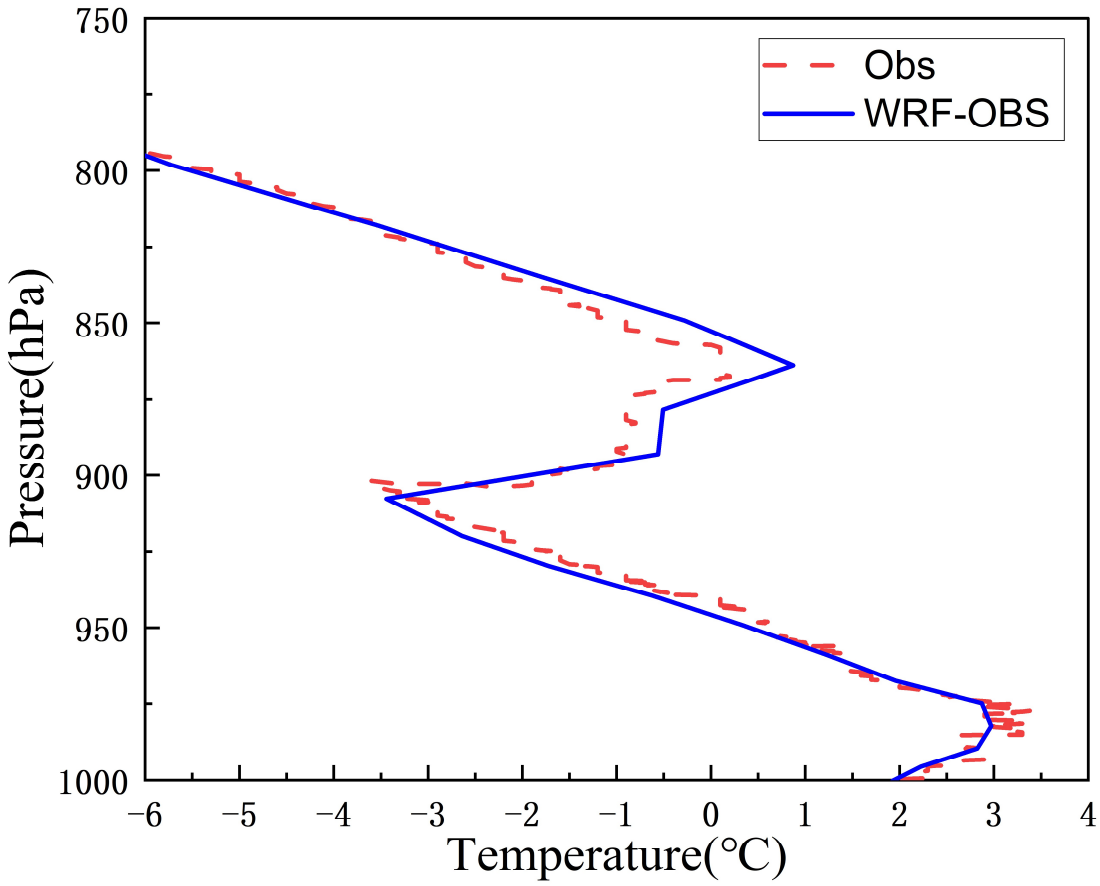

Figure S6. simulated and observed vertical temperature profile at 18:00 UTC in January 20, 2018 at Pingyuan station.

Table S2. List of abbreviations and corresponding full forms.

Abbreviations	Full name
SBL	Stable boundary layer
NCP	North China Plain
WRF-OBS	Weather Research and Forecasting with Observational Nudging Module
WRF-BS	Unassimilated Weather Research and Forecasting model
MOST	Monin-Obukhov similarity theory
WRF	Weather Research and Forecasting

WRF-Chem	Weather Research and Forecasting with Chemistry
OBS-nudging	Observational nudging
WRF-CMAQ	Weather Research and Forecasting with Community Multiscale Air Quality
$PM_{2.5}$	Fine particulate matter
T2	2 m temperature
RH2	2 m relative humidity
WS10	10 m wind speed and direction
BLH	Boundary layer height
NCEP	National Centers for Environmental Prediction
FNL	Final Analysis
MB	Mean bias
ERA5	European Center for Medium-Range Weather Forecasts Reanalysis v5
RMSE	Root mean square error
R^2	Pearson correlation coefficient