Evaluation of WRF-CMAQ performance for air quality simulation over the whole China

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【Background】Extremely high levels of airborne particulate matter (PM) in China have been reported as a result of the rapid economic growth and urbanization without sufficient controls on pollutant emissions. Sustained exposure to air pollution causes respiratory diseases and significantly reduces life expectancy. In this study, the Community Multiscale Air Quality model (CMAQ) was driven by the Weather Research and Forecasting model (WRF) to simulate the air quality over the whole China.

【Methodology】In this study, an air quality simulation was performed with WRF v3.5.1 and CMAQ v5.0.2. The model domain is discretized into 128x88 horizontal grid cells (45-km resolution) and 30 vertical layers (between the surface and 100 hPa). The anthropogenic emissions for gaseous and PM species are taken from INTEX-B v1.2 and REAS v1.11. Biogenic emissions come from the Model of Emissions of Gases and Aerosols from Nature (MEGAN) v2.04. The simulation period is from December 27, 2013 to August 31, 2014. Simulated concentrations of $PM_{2.5}$, PM_{10}, CO, SO_2, NO_2, O_3 were compared to observed data in 31 provincial capital cites of China to evaluate the WRF-CMAQ model performance.

【Result】The results show that despite some biases the WRF-CMAQ reproduces the chemical concentrations reasonably well in all 8 months. WRF-CMAQ successfully performs $PM_{2.5}$ simulation in most cities and with slight overpredictions in Hangzhou, Chongqing, Nanjing and Zhengzhou. Large underpredictions of NO_2, O_3 and CO are found in many cities. The model can well reproduce PM_{10} in most sites, but show difficulties in capturing the peak concentration in Lanzhou. Moderate overpredictions of SO_2 are found in some eastern cities, whereas the model underpredicts the western cities of Xining, Lasa and Urumqi. These biases may be attributed to inaccurate emissions and for other reasons. Therefore further researches, including revision of emission data, verification of physical and chemical subprocesses are needed.

Table 1

Performance statistics of gaseous and PM predictions

	Mean obs	Mean sim	R	MBE	MAE	RMSE	IA
O_3,ppb	47.0	41.9	0.4	-5.2	18.1	23.9	0.6
NO_2,ppb	19.8	13.4	0.5	-6.4	9.8	12.1	0.7
SO_2,ppb	11.0	22.8	0.3	11.7	16.4	24.9	0.4
CO,ppb	944.9	481.0	0.4	-463.9	499.8	677.1	0.5
PM_{10},μg/m3	107.9	79.9	0.5	-28.0	48.9	73.1	0.7
$PM_{2.5}$,μg/m3	62.1	72.8	0.7	10.8	28.0	41.4	0.8

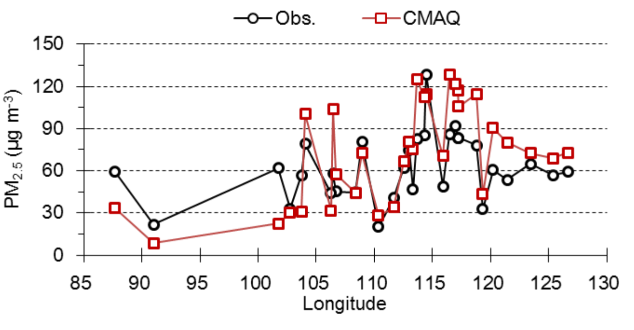

Fig.1. Longitude distribution of simulated and observed 8 months average $PM_{2.5}$ concentrations at 31 sites