# Numerical study of the PM2.5 emission control during APEC 2014 in Beijing by WRF-SMOKE-CMAQ model system


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## Introduction

In the year 2014, the 22nd Asia-Pacific Economic Cooperation (APEC) leaders' meeting was hold in Beijing, where the fine particulate matter (PM2.5) concentration is high and worried. In such a heavily air-polluted environment, people want access to reasonable air quality predictions, that the government can take necessary short-term emissions reduction measures to improve air quality.

According to Wu et al. (2014), the WRF-SMOKE-CMAQ model system with the enhanced 9km domain and base/control scenario emission inventory was established before APEC.

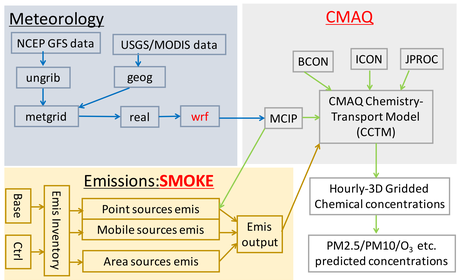


*Fig. 1 The framework of the WRF-SMOKE-CMAQ model system*

## Emission Scenarios

The emission model system developed from Wu et al., 2014, the SMOKE v2.1 model is applied to improve the emissions process and provides model-ready emissions for the air quality model. We consider the emissions as area, point and mobile sources in the model system.

And the baseline emission inventory has been updated in September 2014, while the control scenario emission inventory had been added in October 2014, before APEC meeting. The total emissions used in the model system are calculated from the daily report of the SMOKE model output, as shown in Table. 1.

*Table. 1 Emission of major anthropogenic species in Beijing (Unit: $10^3$ ton/yr )*

| Emis. Scen. | $SO_2$ | $NO_x$ | PM10 | PM2.5 | VOCs | CO |
|---|---|---|---|---|---|---|
| **Wu et al., 2014** | 78.8 | 200.0 | 162.1 | 59.1 | 244.2 | 1793.8 |
| **Baseline scenario** | 81.8 | 192.6 | 157.8 | 59.0 | 280.9 | 2153.0 |
| **Control scenario** | 53.7 | 83.6 | 62.8 | 28.2 | 120.7 | 886.3 |

As shown in Table. 1, the $SO_2$ emissions decreased 34%, and the $NO_x$ emissions decreased 57%, and the PM10 emissions decreased 60% and the PM2.5 emissions decreased 52% in Beijing. That is similar to the report at http://www.bjmemc.com.cn/g327/s962/t2137.aspx

## Model Performance in Baseline

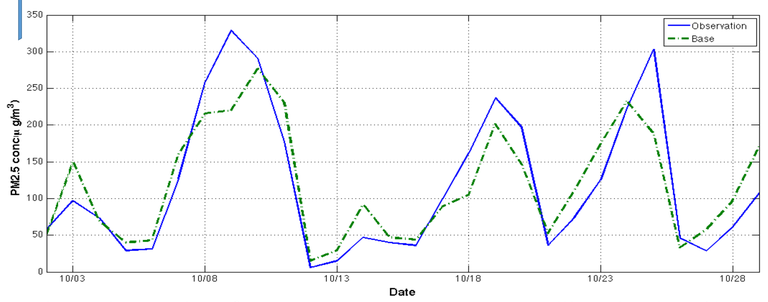


*Fig. 2 Time series of PM2.5 concentrations over Beijing simulated by WFR-SMOKE-CMAQ model system*

As a result, the model system plays good performance in October 2014:

1) The model catches four air pollution episodes in October, and has a high correlation coefficient of **0.89**.
2) The daily forecast of PM2.5 concentration reaches 277 μg/m$^3$ and close to the observed value (320 μg/m$^3$), but still a little underestimated.
3) The mean bias of the forecast to observed is **1.03** μg/m$^3$ and the normalized mean bias is 24.9%. The normalized mean square error between the forecast and observed is 0.137.

This result indicates the emissions inventory used in the model system is reasonable as baseline scenario, which scenario without any emission-sources reduction.

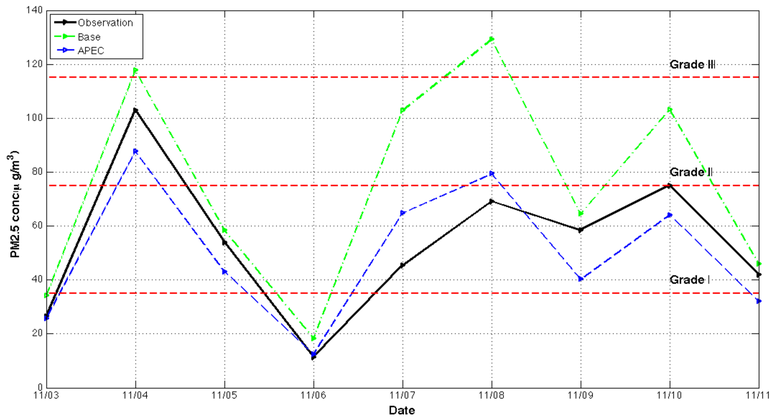


*Fig. 3 Time series of PM2.5 concentrations over Beijing simulated by WFR-SMOKE-CMAQ model system under the conditions of with (Blue) or without control (Green) during APEC period in Beijing. The black line shows the observed concentration of PM2.5 in the National Standard Air Quality Observation Stations (NSAQ Stations) published by Beijing Municipal Environmental Monitoring Center.*

## APEC control scenario

From 3 to 12 November, the emission-sources reduction measures, e.g. the factory cut production and closures, are carried step by step in Beijing and its surrounding areas. Those measures information is collected, corrected and used in the SMOKE model as shown in Table. 1. The same WRF-SMOKE-CMAQ model system, but be driven by the APEC control scenario, is used to simulate the air quality under such emission-sources reduction measures.

According to the results, the daily PM2.5 concentrations would reduce from **107** μg/m$^3$ in the baseline to **72** μg/m$^3$ in the APEC scenario, while the observed is 69 μg/m$^3$ on 8 November. From 6 to 10 November, the observation is lower than the forecast results in the baseline scenario, that indicates the emission-sources reduction measures effects in the air quality in Beijing, if we trust the model. We also found that the observation on 7-8 November even lower than the forecast results in the APEC control scenario, which indicates the emission reduction efforts more than expected.

## From "APEC Blue" to "Beijing Blue"

In the past year 2017, the Air Quality Improvement Goal in Beijing "King-60" has been achieved successfully, and the annual PM2.5 concentration reaches to 58 μg/m$^3$. And the "Beijing Blue" frequently appears in autumn and winter in 2017/2018.

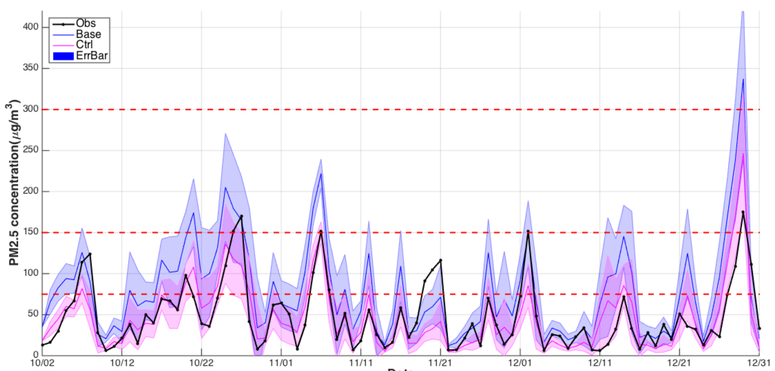


*Fig. 4 Time series of PM2.5 concentrations over Beijing simulated by the model system under the conditions of with (magenta) or without control (Blue) in Beijing. The black line shows the observed concentration of PM2.5 in the NSAQ Stations.*

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