A WRF-Chem modeling study of a PM$_{2.5}$ episode over Yangtze River Delta region

Presented by Cui Jian

10/18/2013
Outline

- Introduction
- Objectives
- Method and Data
- Preliminary results
- Summary and future work
Introduction

• \( \text{PM}_{2.5} \):
  ✓ Solid particles or liquid droplets with diameter less than or equal to 2.5 micrometers in size. (Raes et al., 2000)

• Source:
  ✓ Industrial, biomass combustion, wind-blown (mineral dust), and natural.

• Components:
  ✓ Elemental carbon, organic carbon, sulfate, nitrate, and so on.
Introduction (con.)

• Impact on climate changes:
  ✓ Direct radiative forcing: scattering of solar radiation and absorption/emission of terrestrial radiation.
  ✓ Indirect radiative forcing: effects of aerosols on cloud properties.

• Impact on human health:
  ✓ One of major air pollutants.
Motivation and objectives

• Motivation
  - \( \text{PM}_{2.5} \) is becoming more and more serious in YRD; the transparency of atmosphere is getting worse; there is long-standing aerosol cloud.
  - Modeling \( \text{PM}_{2.5} \) and other species is challenged because an accurate and comprehensive emission inventory is lacking.

• Objectives:
  To set up WRF/Chem simulation for better understanding of \( \text{PM}_{2.5} \) episodes’ mechanism in Yangtze River Delta Region.
Method and Data

- Brief description of WRF-Chem
- Configurations of the simulation
- The emission of David Street
WRF-Chem model

WPS \rightarrow WRF \rightarrow Chem

Meteorological field

Feedback

Results
Chemical mechanisms

- Four choices for gas-phase chemical mechanisms: RADM2, RACM, CB-4 and CBM-Z
- Three choices for photolysis schemes: Madronich, Fast-J, F-TUV
- Four choices for aerosol schemes: MADE/SORGAM, MADE/VBS, MOSAIC and GOCART
- Three scheme match:
  RADM2 & MADE/SORGAM,
  RACM & MADE/SORGAM and CBMZ & MOSAIC
- I used CBM-Z and MOSAIC

(From WRF-Chem Version 3.4 User’s Guide)
Chemical Modules

- emissions_driver
- optical_driver
- photolysis_driver
- dry_dep_driver
- grelldrivet
- mechanism_driver
- cloudchem_driver
- aerosols_driver
- wetscav_driver
- sum_pm_driver
Steps to run WRF-Chem

1. Chem Module
2. Compile WRF
3. Compile WPS
4. Run WPS
5. Run WRF
6. loop to 4
7. Emission
8. Postprocessing
Model configurations

d1: 36km
d2: 12km
d3: 4km
Vertical levels: 40
Simulated time: 20120508-20120509
The emission of David Street

- A new inventory of air pollutant emissions in Asia in the year 2006 is developed to support the Intercontinental Chemical Transport Experiment-Phase B (INTEXB) funded by the NASA. (D.G. Streets et al. 2003)
Definition of the inventory domain

Source: D.G. Streets et al. 2003
Summary of the INTEX-B Asia emission inventory dataset

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain</td>
<td>22 countries and regions in Asia, see Fig. 1</td>
</tr>
<tr>
<td>Species</td>
<td>( \text{SO}<em>2, \text{NO}<em>x, \text{CO}, \text{NMVOC}, \text{PM}</em>{10}, \text{PM}</em>{2.5}, \text{BC}, \text{OC} )</td>
</tr>
<tr>
<td>VOC speciation</td>
<td>by mechanism: CB04, CB05, RADM2, SAPRC99, SAPRC07</td>
</tr>
<tr>
<td>Sectors</td>
<td>power plants, industry, residential, transportation</td>
</tr>
<tr>
<td>Representing Year</td>
<td>2006</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>30 min ( \times ) 30 min</td>
</tr>
<tr>
<td>Seasonality</td>
<td>monthly</td>
</tr>
<tr>
<td>Data availability</td>
<td>available online at <a href="http://mic.greenresource.cn/intex-b2006">http://mic.greenresource.cn/intex-b2006</a></td>
</tr>
<tr>
<td></td>
<td><a href="http://www.cgrer.uiowa.edu/EMISSION_DATA_new/index_16.html">http://www.cgrer.uiowa.edu/EMISSION_DATA_new/index_16.html</a></td>
</tr>
</tbody>
</table>

(Source: D.G. Streets et al. 2003)
Emission of PM$_{2.5}$
Emission of PM$_{2.5}$
Emission of NO\textsubscript{X}
Preliminary results

• Spatial patterns

• Comparison with observation
Simulated PM$_{2.5}$ of Domain 1
Simulated PM$_{2.5}$ of domain 2
Simulated PM$_{2.5}$ of Domain 3
Comparison of simulated PM$_{2.5}$ with observed in SuZhou
Comparison of simulated NOx with observed in SuZhou
Comparison of simulated SO$_2$ with observed in SuZhou
Comparison of simulated O$_3$ with observed in SuZhou
Comparison of four simulated matters

![Graph showing comparison of four simulated matters](chart.png)
Summary

• WRF-Chem has been set up to simulate particulate matter and other species over the Yangtze River Delta region. A 24-hour simulation was completed.

• The results show that the PM$_{2.5}$ was significantly overestimated by our simulations, especially for time after 12:00 (possible causes need to be investigated)
Future Work

- To investigate the reasons causing the over-predictions such as emission issue, initial/boundary conditions for chemical species.

- To improve our simulations by including other emission sources.
Thank you!