Preliminary results of the WRF model over Midwest USA

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INTRODUCTION
Reducing uncertainty of spatial and temporal variability of ammonia (NH₃) emissions from chemical agricultural fertilization and bi-directionality of NH₃ fluxes in the presence of canopies has been identified, as a factor for improving air quality modeling predictions of PM₂.₅ concentrations.

Our research group works on improving spatial and temporal resolution of NH₃ emissions to be used as input to Chemical Transport Model (CTM) to predict regional air quality effects of chemical agriculture fertilization and bi-directionality of NH₃ from chemical agricultural fertilization and bi-directionality of NH₃ and Meridional mean wind speed at 10m (U₁₀, m/s) are compared with observational data.

OBJECTIVE
The objective of the research presented here is to install, run and validate the Weather Research and Forecast (WRF) model for a domain over the U.S. Midwest corn belt.

WRF DATA FLOW CHART

- Input parameters
- Terrestrial data
- Gridded data
- WRF
- WRF output
- Evaluation
- CTM
- Visualization

ACNOWLEDGMENTS
- US National Science Foundation, NSF Award No AGS-1236814, Collaborative Research with Dr. LaToya Myles, NOAA/ATDD, Oak Ridge, TN
- Dr. Christopher Lehmann, Illinois State Water Survey, NADP
- WRF-ARW and MET Development Team
- Air Quality Engineering and Science (AQES) and Nitrogen Group

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WRF MODEL CONFIGURATION

Code:
- WRF Preprocessing System (WPS) 3.5.1
- WRF-ARW 3.5.1
- Unified Post Processor (UPP) 2.2
- Model Evaluation Tools (MET) 4.1

Selected physics options:

<table>
<thead>
<tr>
<th>Atmospheric process</th>
<th>scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microphysics</td>
<td>WSM3</td>
</tr>
<tr>
<td>Longwave radiation</td>
<td>RRTM</td>
</tr>
<tr>
<td>Shortwave radiation</td>
<td>Dudhia</td>
</tr>
<tr>
<td>Land surface model</td>
<td>Thermal diffusion</td>
</tr>
<tr>
<td>Planetary boundary layer</td>
<td>ACM2</td>
</tr>
</tbody>
</table>

Data source:

- Input North American Mesoscale (NAM) 218 from National Operational Model Archive and Distribution System
- Observations Global Upper Air and Surface Observations (DS 337.0) and Earth System Research Laboratory SURFRAD Network.

EVALUATION RESULTS OVER NESTED DOMAIN

Simulation period from 16 April 2011 to 20 April 2011, with an additional 24 hour spin-up time from 15 April to 16 April. Downward shortwave and longwave radiative flux at surface (DSW and DLW, W/m²), Temperature at 2m (T₂, °C), Zonal mean wind speed at 10m (U₁₀, m/s) and Meridional mean wind speed at 10m (V₁₀, m/s) are compared with observational data.

Table 1 Statistics performance of WRF output

<table>
<thead>
<tr>
<th></th>
<th>DSW, W/m²</th>
<th>DLW, W/m²</th>
<th>T₂, °C</th>
<th>U₁₀, m/s</th>
<th>V₁₀, m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Observation</td>
<td>155.78</td>
<td>325.13</td>
<td>5.90</td>
<td>-0.65</td>
<td>-0.59</td>
</tr>
<tr>
<td>MB</td>
<td>-4.03 (16.62)</td>
<td>12.75 (-16.6)</td>
<td>2.54 (-0.02)</td>
<td>0.56 (-0.05)</td>
<td>0.69 (-0.04)</td>
</tr>
<tr>
<td>RMSE</td>
<td>151.64 (32.40)</td>
<td>34.32 (23.54)</td>
<td>4.54 (1.83)</td>
<td>2.48 (0.97)</td>
<td>3.37 (0.85)</td>
</tr>
<tr>
<td>NMB, %</td>
<td>-2.59 (8.91)</td>
<td>3.92 (-5.63)</td>
<td>42.01 (-0.38)</td>
<td>-85.8 (-452)</td>
<td>-117.1 (26.2)</td>
</tr>
<tr>
<td>NME, %</td>
<td>51.07 (12.91)</td>
<td>8.62 (6.79)</td>
<td>55.43 (21.34)</td>
<td>-299.9 (6471.8)</td>
<td>-405.6 (423)</td>
</tr>
</tbody>
</table>

Values in parentheses are obtained from a WRF evaluation paper to provide a reference value. Results suggested that overall performance is not so good as that in the reference paper, especially in terms of RMSE. T₂ is generally underestimated. Large NME and NMB in wind speed may due to the near zero mean value of the observations.

Figure 1 Aggregated scatter plots of estimated vs observed values of DSW, DLW, T₂, U₁₀ and V₁₀, from left to right

SUMMARY
In this case study, WRF model was run over Midwest U.S.A.. Evaluation results suggest that the WRF output over the considered domain still needs improvement, possibly by modifying physics options to make WRF better interpret the atmospheric process.

FUTURE RESEARCH
- Evaluate different combination of physics options to improve the WRF output.
- Validate WRF output with a coarse (12×12 km) resolution and compare CTM performance between fine (4×4 km) and coarse resolution.

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