Development of an Offline WRF/Chemistry model

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Structure

- Concept of an “Offline” Model
- Design of the Offline WRF/Chem
- Implementation Overview
- Online-Offline Comparisons
- Current Status
Need for an Offline Chemistry Model

When realtime meteorology and feedback not significant, and repeated chem runs. e.g.

- Model Development: introduction/ improvement of chemical schemes
- Testing, Sensitivity studies
- Regulatory application (evaluation of emission control strategies)

Community request for comparison to other offline models

Comparison to online runs
Design of Offline WRF/Chem

- Seamless (Chem shouldn’t know whether it is online or offline)
- Uniformity in Spatial resolution, schemes, parameterizations
- Use time averaged fields for interpolated meteorology to drive WRF/Chem CTM (mass consistent)
- Fully integrated in WRF Software Framework
- User-friendly, mainly runtime controls
Implementation Overview

- Code & data flow analysis
  - Identify Met – Chem dependency & exchanges
  - Variables used by chem. and when to output (in given timestep)
- New advection scheme (FIT, W. Skamarock) for chemical species in offline (and online)
- Algorithm for Time averaging based on the timestep and desired frequency of output
Implementation Overview

- Routines for averaging and output (Online); input and time interpolation (Offline)
- Integration into WRF Framework:
  - which operation goes into what layer
  - I/O using existing WRF streams and API
  - required variables defined in separate registry
  - compilation controlled by Environment variable
  - “Normal”, “Online” and “Offline” controlled by namelist variable
- Pre processing: output & input timestamp matching
Flow Diagram for Offline Runs

Initialization

Mediation layer

Solver

Solve_em
Solve_em_fit
Chem_driver

Time Averaging & Output

Finalization

WRF/Chem Online Run

Input & Time Interpolation

Mediation layer

Solver

Solve_em_fit
Chem_driver

Wrfch_offline_d<domain>_d<date>

Finalization

WRF/Chem Offline Run
Online - Offline Comparisons
60 km North-east US domain, hourly averaged

### Diurnal Variation of Surface O3 (Coastal)

<table>
<thead>
<tr>
<th>Hour of Day</th>
<th>Offline</th>
<th>Online</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.020</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.030</td>
<td></td>
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<tr>
<td>7</td>
<td>0.035</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0.040</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>0.045</td>
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</table>

### Diurnal Variation of Surface O3 (Inland)

<table>
<thead>
<tr>
<th>Hour of Day</th>
<th>Offline</th>
<th>Online</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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<td>9</td>
<td>0.035</td>
<td></td>
</tr>
</tbody>
</table>

### System Comparison

<table>
<thead>
<tr>
<th>System</th>
<th>Online</th>
<th>Offline</th>
<th>Single offline run</th>
<th>10 online runs</th>
<th>10 offline runs</th>
<th>Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xeon, Linux (4 cpu)</td>
<td>1200 s</td>
<td>1020 s</td>
<td>2220 s</td>
<td>12000 s</td>
<td>11400 s</td>
<td>15 %</td>
</tr>
<tr>
<td>IBM, AIX (4 cpu)</td>
<td>1856 s</td>
<td>1440 s</td>
<td>2296 s</td>
<td>18560 s</td>
<td>16256 s</td>
<td>13 %</td>
</tr>
</tbody>
</table>
Online - Offline Comparisons
12 km, New England, multiple averaging periods

Accuracy varies with averaging time at high resolutions.
Need more sensitivity studies before use.
Current Status and Future work

- Implemented in WRF/Chem 2.2 – testing for repository inclusion
- Official release expected with WRF 3.0
- Improvements to FIT advection scheme (W. Skamarock)
- Online-offline sensitivity runs for different resolutions, chemical schemes
- Documentation and User guide
Thank You

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