Evaluate Wildfire Emissions in the Canadian GEM-MACH Air Quality Forecast System

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Objective

• Air quality forecast with impact of wildfire emissions

  ▪ smoke dispersion information
  ▪ visibility information
  ▪ input for the Air Quality Health Index (AQHI)
    – calculated based on relative risks of $O_3$, $PM_{2.5}$ and $NO_2$.  

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GEM-MACH System

- Meteorological & chemical models
  - GEM-MACH
    - Multi-scale weather forecast model with in-line chemistry module
    - Gas, aqueous-phase chemistry and 2-bin representation of PM size and 9 PM components.
    - Twice daily (00z, 12z), resolution 15-km and 58 vertical levels (up to 0.1 hpa)
  - GEM-MACH emissions:
    - Area sources
    - Mobile sources
    - Point sources
    - Biogenics calculated online (BEIS3)
- Canadian wildfires ~1.9 million hectares/yr (2001-2011)
Edmonton without smoke
Edmonton, August 19, 2010, 11:35 AM

(Hourly PM2.5 ~80 μg/m³)
Edmonton, August 19, 2010, 2:00 PM
(Hourly PM2.5 ~250 μg/m³)
PM2.5 Surface Measurements

Hourly PM2.5 for Stations in Alberta

For 19 stations with average period concentration > 10 ug/m3

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Real-time Fire Information

BlueSky Framework -- US Forest Service

• SMARTFIRE (US fire information, STI)

• CWFIS (Canadian Wildland Fire Information System)
  – runs daily during fire season;
  – includes:
    ▪ landuse databases;
    ▪ Hotspot detection;
    ▪ FBP (Fire Behavior Prediction);
    ▪ Fuel consumption / fire type
Canadian Wildland Fire Information System

- [http://cwfis.cfs.nrcan.gc.ca](http://cwfis.cfs.nrcan.gc.ca)
Case Study

• Wildfire event in Central British Columbia (Cariboo Region)
• Two week simulation: August 10 – 24 2010

• Fire emissions modelled as major point sources
  (1) Briggs plume rise algorithm within GEM-MACH
  (2) Normalized profile under PBL

• PM$_{2.5}$ results compared with operational forecast predictions
Fire Emissions

Episode Emissions (tons)

<table>
<thead>
<tr>
<th></th>
<th>BC+AB Fire</th>
<th>BC+AB Anthropogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>654,122</td>
<td>126,541</td>
</tr>
<tr>
<td>PM2.5</td>
<td>59,608</td>
<td>9,032</td>
</tr>
<tr>
<td>PM10</td>
<td>70,337</td>
<td>41,552</td>
</tr>
</tbody>
</table>
Aug. 19 surface PM$_{2.5}$ difference (fire minus no-fire) vs. MODIS

- Williams Lake, BC
- Edmonton, AB
Average hourly PM2.5 for 40 stations in BC

<table>
<thead>
<tr>
<th></th>
<th>Obs. Avg.</th>
<th>NoFire</th>
<th>+ Fire Briggs’</th>
<th>+ Fire NPBL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM2.5 [μg/m³]</td>
<td>19</td>
<td>6</td>
<td>12</td>
<td>11</td>
</tr>
</tbody>
</table>

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Average hourly PM2.5 for 25 stations in AB

<table>
<thead>
<tr>
<th>Obs. Avg.</th>
<th>NoFire</th>
<th>+ Fire Brig’s</th>
<th>+ Fire NPBL</th>
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<tbody>
<tr>
<td>27 μg/m³</td>
<td>5 μg/m³</td>
<td>8 μg/m³</td>
<td>8 μg/m³</td>
</tr>
</tbody>
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Operational Test Case

A test system was setup to run alongside the current operational forecast for summer 2012.

Same configuration as operational forecast

Preliminary analysis:
- Good spatial distribution of PM$_{2.5}$

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GEMMACH-15
PM2.5 difference

Western Bluesky
BC Environment:
http://www.bcairquality.ca/bluesky

GOES Satellite Product
Conclusions

• the goal of this project is to enhance the capacity of Environment Canada’s GEM-MACH operational air quality forecasting system to include wildfire emissions

• preliminary results show that fires produce large amount of emissions can impact PM$_{2.5}$ forecast results

• GEM-MACH captured general PM$_{2.5}$ trends but underestimated magnitudes, especially for receptors further downwind

• Simple plume-rise parameterization influenced PM$_{2.5}$ near the source but ineffective for receptors downwind
Ongoing Work

- Update GEM-MACH science parameterizations
- Continue evaluation of model system

New case study with BORTAS measurements for Sioux Lookout fire in Ontario (Jul. 15-30 2011)

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*Now at Scion Research Institute, New Zealand
Thank You