MODELLED LONG TERM TRENDS OF SURFACE OZONE OVER SOUTH AFRICA

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Background – research group

CSM&EH - Air quality

- Focus on ozone
- Secondary pollutant
- Comprehensive modelling
- CAMx
The CAMx model

- CAMx – *Photochemical* dispersion model
- Able to simulate ozone, particulate matter and other air toxics
- Regional to continental scale
- Used extensively in the United States for air quality management
Framework for retrospective studies – MM5/CAMx

Past

Future?

MM5 → CAMx in NRE → Retrospective Air quality
New framework for air quality forecast – CCAM/CAMx

CCAM

CAMx
in NRE

Future Air quality

Past ✓

Future ✓
Current research focus

- The response of air quality to changes in climate
- Simulations on longer time scales
- Drive air quality models with long term forecasted meteorology
- Need a baseline (1989 – 2009)
- To date: Initial testing and 2 years (2003 and 2006)
Development of ccamcamx

MM5 → mm5camx → CAMx
CCAM → ccamcamx → CAMx
The CCAM model

- Conformal-Cubic Atmospheric Model (CCAM)
- Developed by CSIRO (e.g. McGregor, 2005)
- May be run on a global and regional scale simultaneously
- CCAM provides much of what CAMx needs, but not all variables

CCAM quasi-uniform C48 grid with resolution about 210 km
## The CCAM/CAMx system

<table>
<thead>
<tr>
<th>CAMx requirement</th>
<th>Direct from CCAM</th>
<th>Derived from CCAM</th>
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</thead>
<tbody>
<tr>
<td>Land-use</td>
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<tr>
<td>Topography</td>
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<tr>
<td>3D layer interface height</td>
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<tr>
<td>3D layer average pressure</td>
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<td>3D layer average U Wind</td>
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<td>3D layer average V Wind</td>
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<tr>
<td>2D rain precipitation</td>
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<tr>
<td>3D layer average temperature</td>
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<tr>
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<td>3D layer average graupel water content</td>
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<td>Column cloud optical depth</td>
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<tr>
<td>3D layer interface vertical diffusivity</td>
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</tr>
</tbody>
</table>
Initial testing

Initial testing (7 day run)

- Comparison of CCAM/CAMx with
  - MM5/CAMx – performance against well tested system
  - Measured (monitored) data – performance in real world

- MM5/CAMx – previous ozone modelling study focused on SA Highveld, 2006

- Keeping all CAMx inputs “standardized”, leaving only meteorology as a variable
CAMx data flow

- Haze & albedo
- USGS surface data
- Photolysis rates
- Met model
- Emissions
- Initial & boundary

CAMx
The emissions inventory

- Developed for a previous project (MM5/CAMx)
- Year 2006
- Pollutants – SO$_2$, PM, CO, NH$_3$, NOx and VOC
- Spatial domain – South Africa, at a resolution of 12 km
- Contains following categories
  - Residential – Domestic fuel burning
  - Transportation – Road vehicles, diesel trains and airport ground vehicles
  - Large Industry – Sasol, Eskom and refineries
  - Smaller Industry – Smaller more disperse industry
  - Biogenic – Vegetation and soils
Model domain

- **CCAM**: 335x335 @12km
- **MM5**: 81x52 @36km
- **CAMx**: 150x135 @12km

[Map of South Africa with model domains and a station marked as Camden]
Initial results

• A comparison of surface ozone between
  • CCAM/CAMx vs MM5/CAMx
  • CCAM/CAMx vs monitored data

• Time period – 7 day (11 – 17 December 2006)
Surface ozone: CCAM/CAMx vs MM5/CAMx vs monitored

Average bias (ppb)
MM5/CAMx ~ -3
CCAM/CAMx ~ -4
Spatial difference – average over 7 days

$$\left( \overline{O_3}^{\text{CCAM/CAMx}} \right) - \left( \overline{O_3}^{\text{CCAM/MM5}} \right)$$
2003 annual average
• Framework performs reasonably well for this analysis

• Room for improvement
  • Include land use variables from CCAM

• Benefits of CCAM
  • Computationally fast
  • Regional and global scale (long range influences)
  • Forecast at climate change timescale
  • Capacity to provide output
Thank you for your time