UKCA Tropospheric Chemistry

Evaluation and Sensitivity to Climate Change

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- Motivation and Description of UKCA
- Evaluation of Tropospheric Chemistry
- Impact of Climate Change
- Conclusions and Future Work
To build and evaluate a new UK community chemistry-aerosol model

- Flexible global model
- Coupled to Hadley Centre climate model, HadGEM1
  - Encompassing both Troposphere and Stratosphere
- Distributed as part of the Met Office’s Unified Model
<table>
<thead>
<tr>
<th></th>
<th>TOMCAT</th>
<th>TOMCAT + Sulphur</th>
<th>TOMCAT + Mainz Isoprene Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tracers</td>
<td>26</td>
<td>27</td>
<td>40</td>
</tr>
<tr>
<td>Species</td>
<td>44</td>
<td>47</td>
<td>58</td>
</tr>
<tr>
<td>Ethane, propane</td>
<td>Relatively explicit</td>
<td>Relatively explicit</td>
<td>Relatively explicit</td>
</tr>
<tr>
<td>Isoprene</td>
<td>None</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>Other non-CH4 VOCs</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Stratosphere</td>
<td>Prescribed</td>
<td>Prescribed</td>
<td>Prescribed</td>
</tr>
</tbody>
</table>

Other chemistry mechanisms are being developed within the QUEST programme.
Comparison with Surface Observations

- Barrow (71N, 157W)
- Mace Head (53N, 10W)
- Niwot Ridge (40N, 106W)
- Bermuda (32N, 65W)
- Mauna Loa (20N, 156W)
- Barbados (13N, 59W)
- Samoa (14S, 171W)

Correlation

Standard deviation of model (normalised)

Standard deviation of model

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Comparison with Ozone sondes (1)

Ozoneonde Comparison in January

Seasonal Cycle at 100 mbar

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Comparison with Ozonesondes (2)
Impact of Climate Change

A. Control Experiment (2000)

B. Climate Change Experiment

2100 Atmosphere (SRES A2 scenario)

Stratospheric Ozone Recovery

No change in surface emissions
OH increases almost globally and in both seasons. Global annual methane lifetime changes from 9.55±0.02 years to 7.67±0.08 years.
Global tropospheric ozone burden is unchanged. However, significant differences occur both seasonally and regionally.
### Tropospheric Ozone Budget

<table>
<thead>
<tr>
<th></th>
<th>Present Day Atmosphere</th>
<th>2100 Atmosphere</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chemical Production</strong> (Tg/year)</td>
<td>2414 ± 9</td>
<td>2638 ± 18</td>
</tr>
<tr>
<td><strong>Chemical Destruction</strong> (Tg/year)</td>
<td>2733 ± 7</td>
<td>3181 ± 20</td>
</tr>
<tr>
<td><strong>Dry Deposition</strong> (Tg/year)</td>
<td>671 ± 3</td>
<td>605 ± 4</td>
</tr>
<tr>
<td><strong>Strat-Trop Exchange</strong> (Tg/year)</td>
<td>1174 ± 18</td>
<td>1234 ± 17</td>
</tr>
<tr>
<td><strong>Trop Burden</strong> (Tg)</td>
<td>292 ± 1</td>
<td>288 ± 2</td>
</tr>
</tbody>
</table>

- ~10%
- ~16%
- ~10%
- ~5%
Conclusions

- Infrastructure of UKCA is complete

- UKCA has run with different chemical schemes

- Evaluation has been carried out using:
  surface observations
  ozonesonde climatology
  regional profiles compiled from aircraft

- First future simulation with tropospheric UKCA
  strong regional and seasonal changes in O3
  significant increase in global annual OH
Further Work

- Development of Chemistry/Aerosols
  Addition of STOCHEM chemistry
  Heterogeneous chemistry (Leeds)
  Aerosol chemistry: nitrate and ammonium, SOA (QUEST)

- Exploitation of Nudged Model
  Evaluation against MOZAIC and other aircraft observations
  Evaluation against OMI, SCIAMACHY, and MOPPITT

- Transport Processes
  Assess S-T exchange at various resolutions
  Assess impact of SLICE on STE and tracer conservations
Transformed Eulerian Mean Diagnostics

Comparison with multi-model ensemble from Butchart et al., Clim. Dyn., 2006

HadGAM1 N48L38

Annual mean at 70 hPa

Seasonality at 70 hPa
Stratosphere-Troposphere Flux Diagnostics

Comparison of inferred and explicit stratospheric influx of ozone

Diagnosis of combined PV-Theta tropopause

Inf: 990 +/- 16 Tg O3
Exp: 1170 +/- 14 Tg O3
HadGAM1-ECMWF T and Q Biases

For more details on HadGAM1 and biases, see Martin et al., J. Climate, 2006