Introduction and model details

The Met Office Hadley Centre is contributing to CCMI using an advanced prototype of the state-of-the-art HadGEM3-ES earth system model which includes a combined stratosphere-troposphere chemistry scheme developed under the United Kingdom Chemistry-Aerosol (UKCA) project. HadGEM3-ES is a non-hydrostatic model with semi-Lagrangian advection, an atmospheric resolution 1.875° longitude x 1.25° latitude, and 85 vertical levels extending to 85km.

Preliminary results are shown from the REF-C1 integration, run atmosphere only, and the REF-C2 integration, run coupled to the NEMO ocean model with 1° resolution (finer in the tropics) and 70 vertical levels.

Model improvements since CCMVal2

An 8K warm bias in the tropical tropopause temperature meant stratospheric water vapour had to be prescribed in CCMVal2. This bias is largely corrected in the CCMI model.

The CCMI model thus shows a "tape-recorder" signal in water vapour (averaged 20S-20N). Stratospheric water vapour is still too high, but lies within model uncertainty.

Along with water vapour, the age of air is known to impact stratospheric chemistry. Age of air was around 2 years too old in CCMVal2, but is close to observations in the CCMI model.

Increased variability in coupled model stratosphere

Global mean temperature at 50hPa shows that the effects of Pinatubo and the long term climate trend are both well captured by the model.

The standard deviations of the monthly timeseries (in K) are: REF-C1 = 0.68, REF-C2 = 0.73, ERA40 = 0.77. Thus the coupled ocean model is more variable, and closer to the variability seen in the reanalysis, than is the atmosphere only model.

In the southern hemisphere, zonal mean U(10hPa) and polar cap average T(50hPa) are good proxies for the interannual variability in polar cap average column ozone \[\rightarrow \text{no need to calculate PSC area/volume}\].

The timeseries above (and corresp table below) show detrended anomalies for SON and illustrate this point.

<table>
<thead>
<tr>
<th></th>
<th>Correlations with column ozone (SON)</th>
<th>Interannual standard deviations (SON)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T(50hPa)</td>
<td>U(10hPa)</td>
</tr>
<tr>
<td>REF-C1</td>
<td>0.89</td>
<td>-0.82</td>
</tr>
<tr>
<td>REF-C2</td>
<td>0.93</td>
<td>-0.85</td>
</tr>
<tr>
<td>ERA-I</td>
<td>0.73</td>
<td>-0.80</td>
</tr>
</tbody>
</table>

The model with a coupled ocean (REF-C2) shows higher correlations and higher variability than the atmosphere only model (REF-C1). Interestingly, both simulations show higher correlations than those in the reanalysis data (possibly due to there being no sensitivity of mass/wind to ozone in ERA-I).

References:

Acknowledgements:
The work of all authors was supported by the Joint DECC/Defra Met Office Hadley Centre Climate Programme (GA01101). ERA-I analysis data used in this study was provided by ECMWF.