UKCA Tropospheric Chemistry

Evaluation and Sensitivity to Climate Change

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Outline

- Motivation and Description of UKCA
- Evaluation of Tropospheric Chemistry
- Impact of Climate Change
- Conclusions and Future Work

Motivation

To build and evaluate a new UK community chemistry-aerosol model

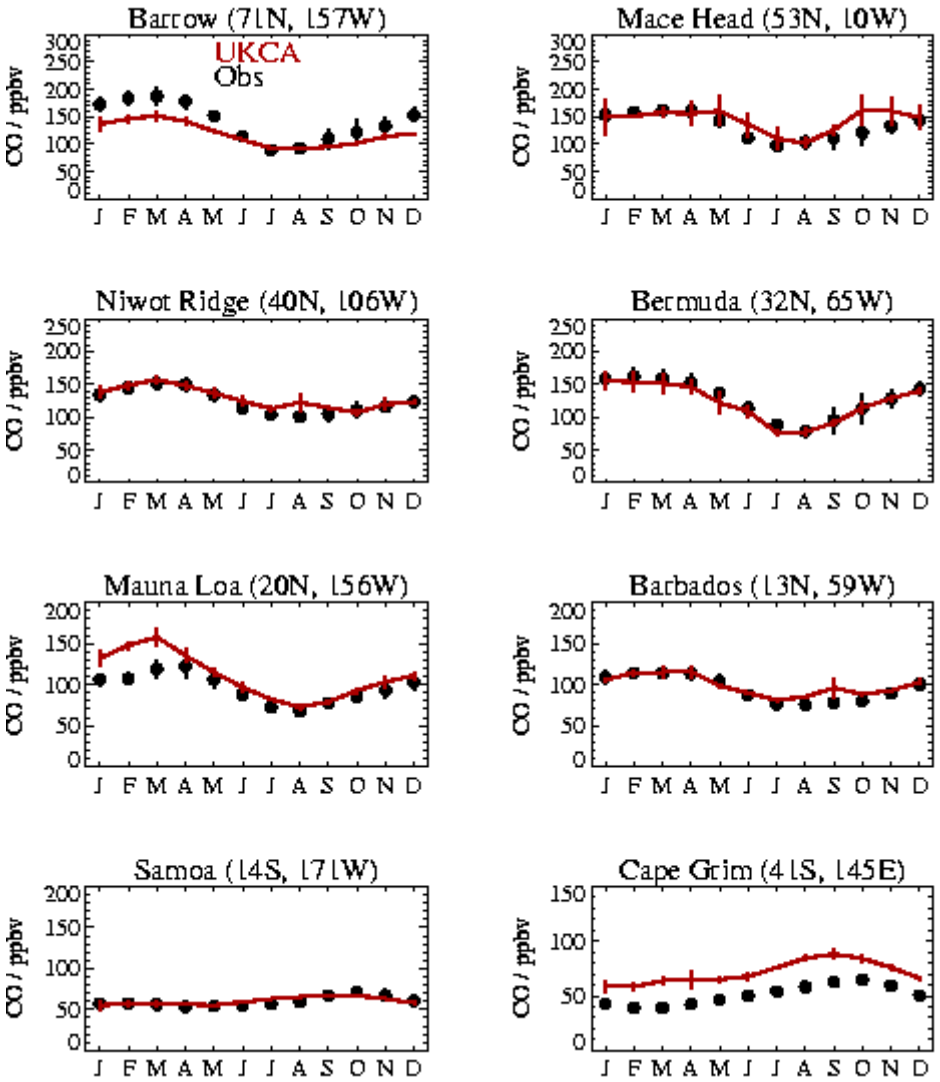
- Flexible global model
- Coupled to Hadley Centre climate model, HadGEM1
    - Encompassing both Troposphere and Stratosphere
- Distributed as part of the Met Office's Unified Model

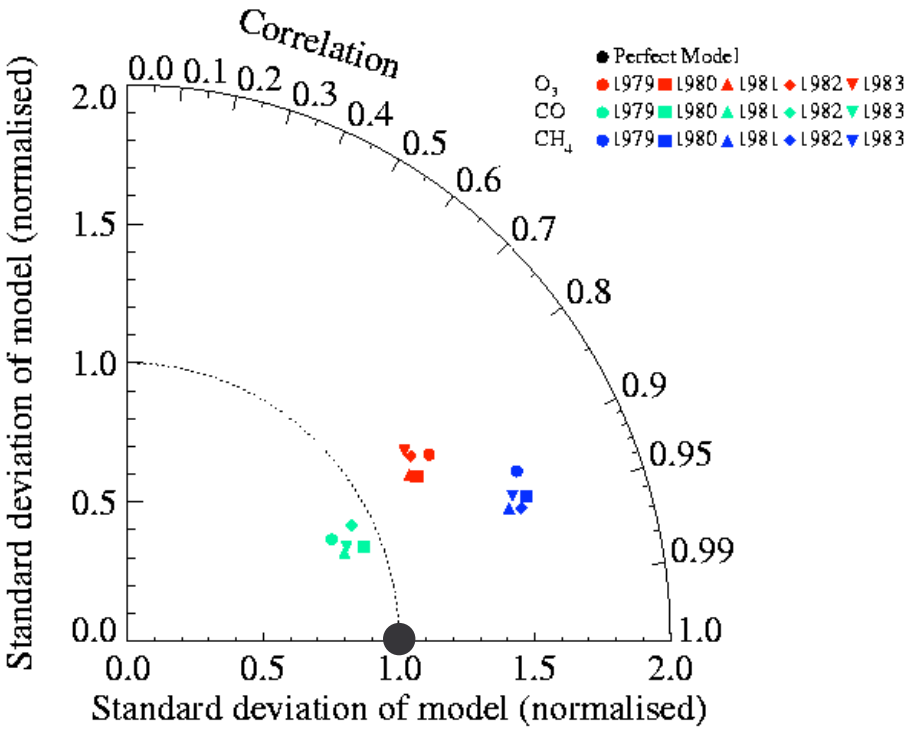
Tropospheric Chemistry Schemes

	TOMCAT	TOMCAT + Sulphur	TOMCAT + Mainz Isoprene Mechanism
Tracers	26	27	40
Species	44	47	58
Ethane, propane	Relatively explicit	Relatively explicit	Relatively explicit
Isoprene	None	None	Yes
Other non-CH4 VOCs	None	None	None
Stratosphere	Prescribed	Prescribed	Prescribed

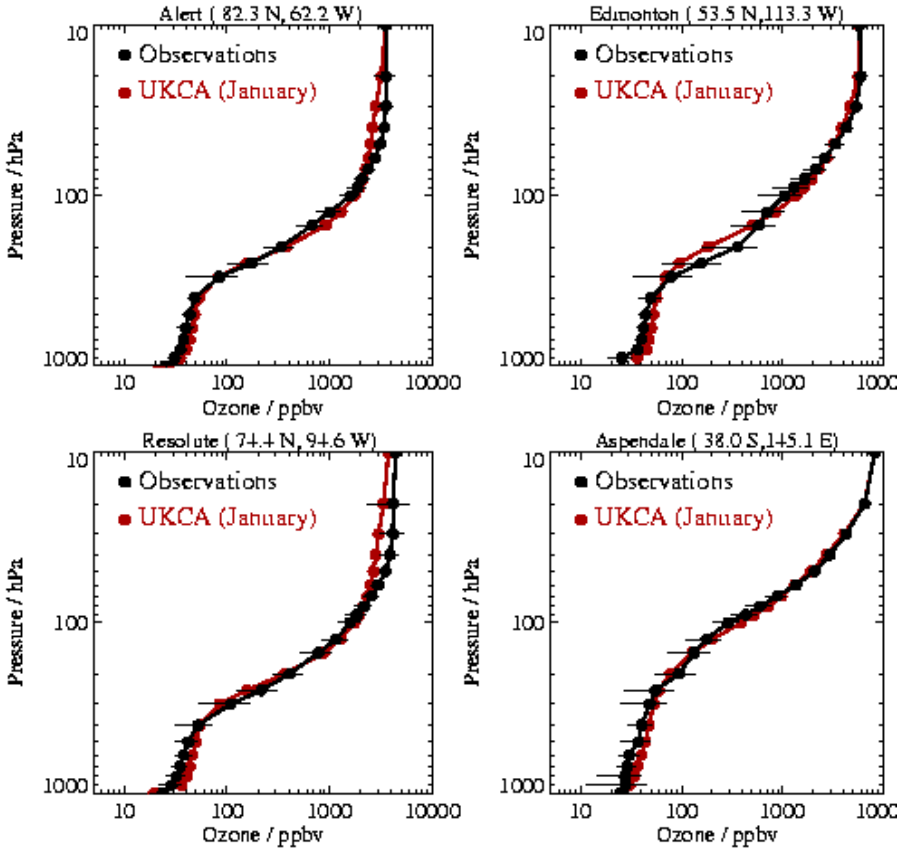
Other chemistry mechanisms are being developed within the QUEST programme

Comparison with Surface Observations

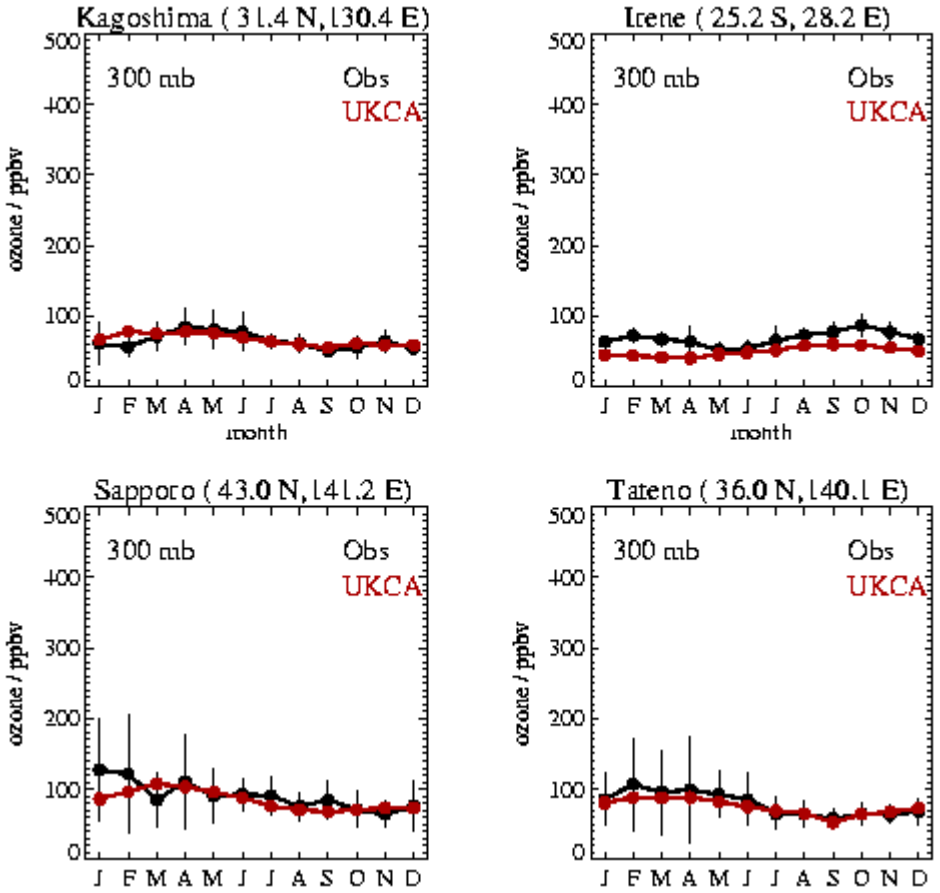




Comparison with Ozonesondes (1)

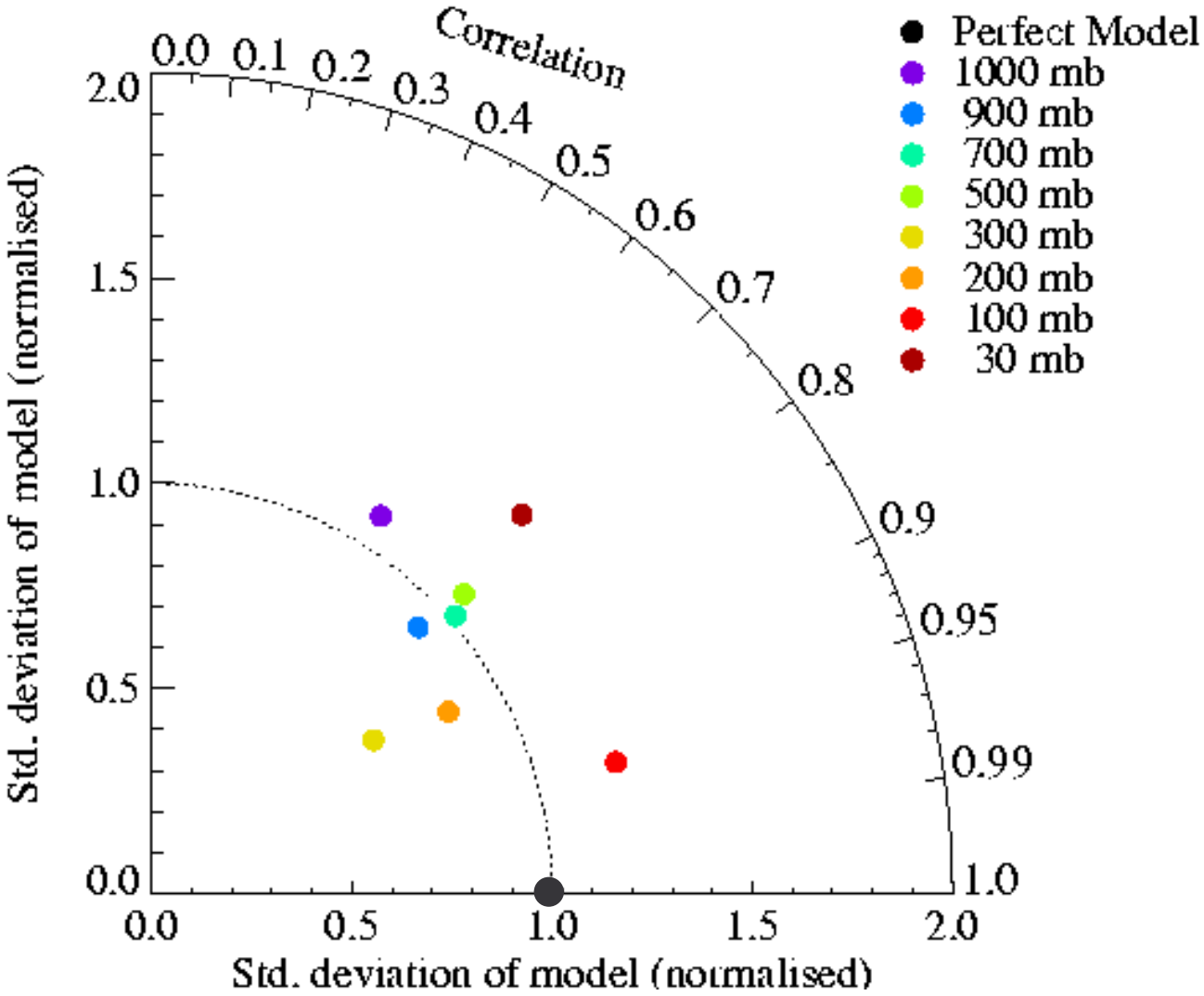


← Ozonesonde Comparison in January



Seasonal Cycle at 100 mbar →

Comparison with Ozonesondes (2)



Impact of Climate Change

A. Control Experiment (2000)

B. Climate Change Experiment

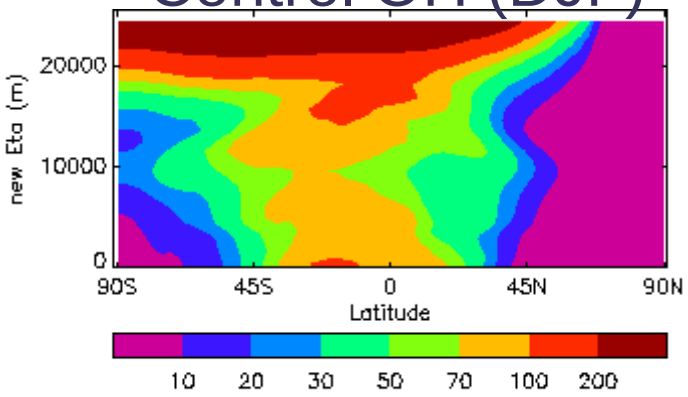
2100 Atmosphere (SRES A2 scenario)

Stratospheric Ozone Recovery

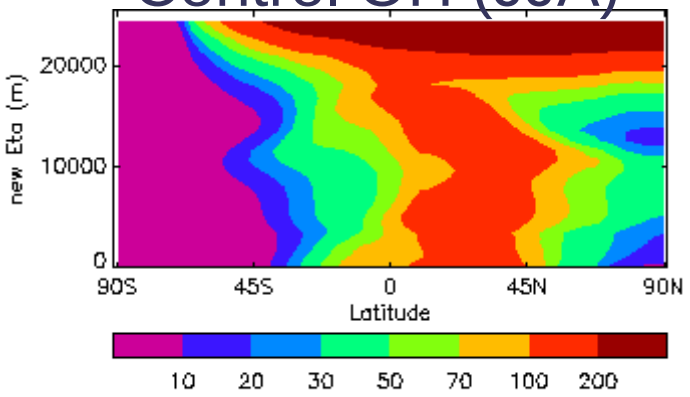
No change in surface emissions

Change in OH (DJF and JJA)

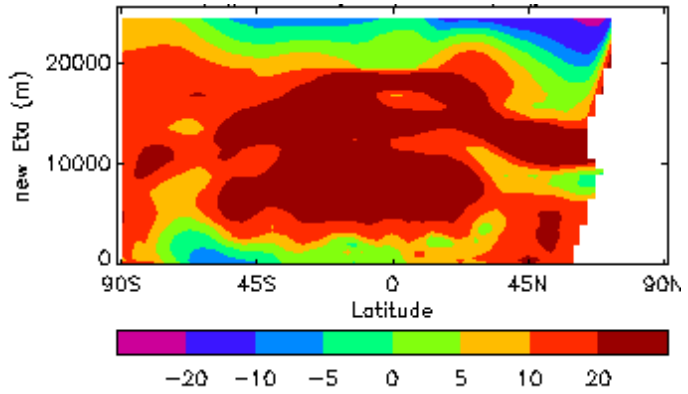
Control OH (DJF)



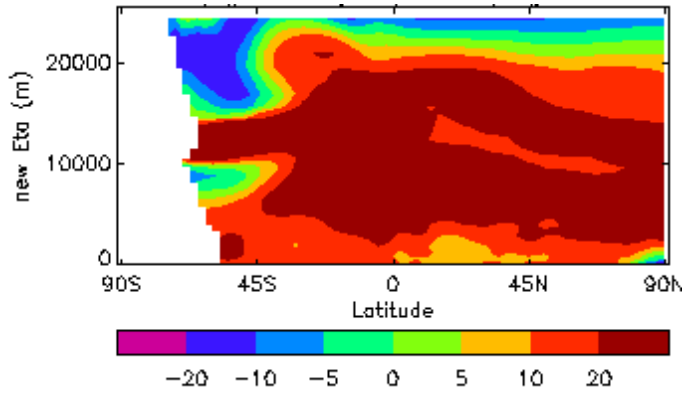
Control OH (JJA)



Rel. Diff. in OH (DJF)



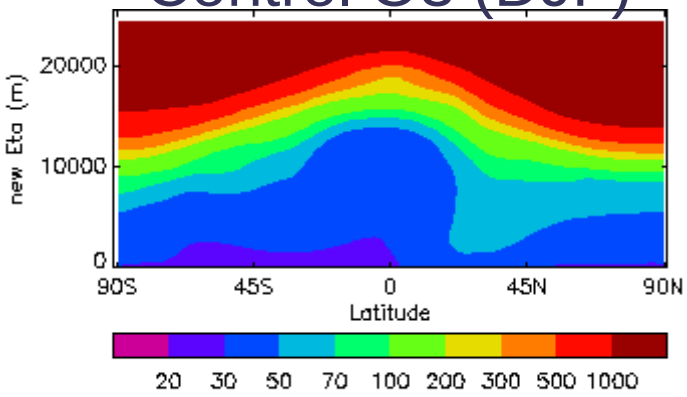
Rel. Diff. in OH (JJA)



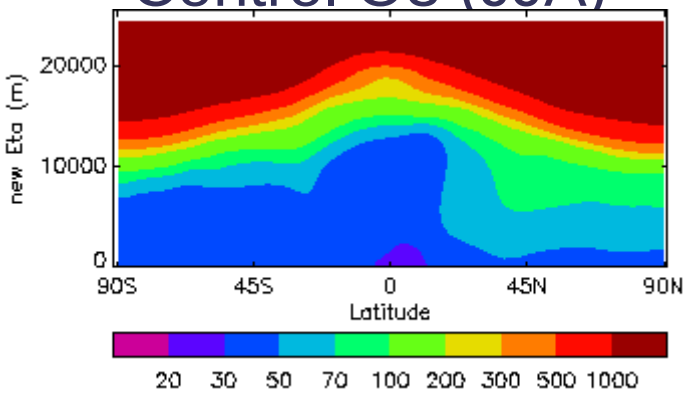
OH increases almost globally and in both seasons. Global annual methane lifetime changes from 9.55±0.02 years to 7.67±0.08 years

Change in Ozone (DJF and JJA)

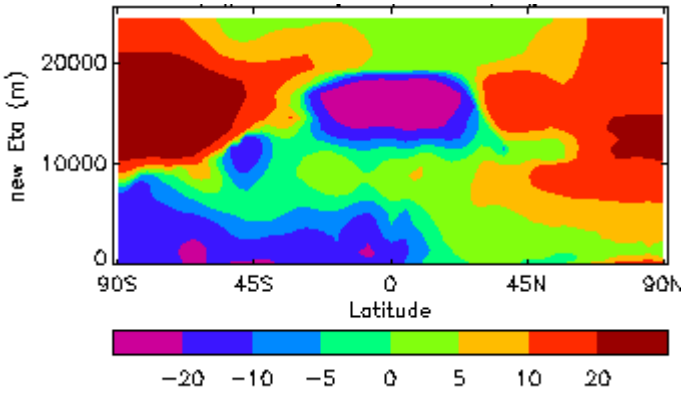
Control O3 (DJF)



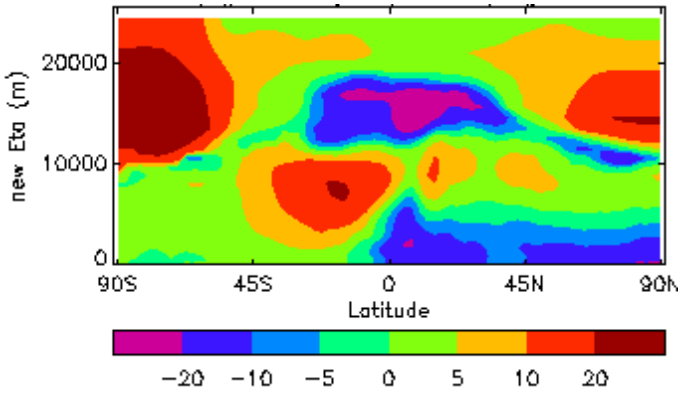
Control O3 (JJA)



Rel. Diff. in O3 (DJF)



Rel. Diff. in O3 (JJA)



Global tropospheric ozone burden is unchanged. However, significant differences occur both seasonally and regionally.

Tropospheric Ozone Budget

	Present Day Atmosphere	2100 Atmosphere	
Chemical Production (Tg/year)	2414 ± 9	2638 ± 18	↑ ~10%
Chemical Destruction (Tg/year)	2733 ± 7	3181 ± 20	↑ ~16%
Dry Deposition (Tg/year)	671 ± 3	605 ± 4	↓ ~10%
Strat-Trop Exchange (Tg/year)	1174 ± 18	1234 ± 17	↑ ~ 5%
Trop Burden (Tg)	292 ± 1	288 ± 2	

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

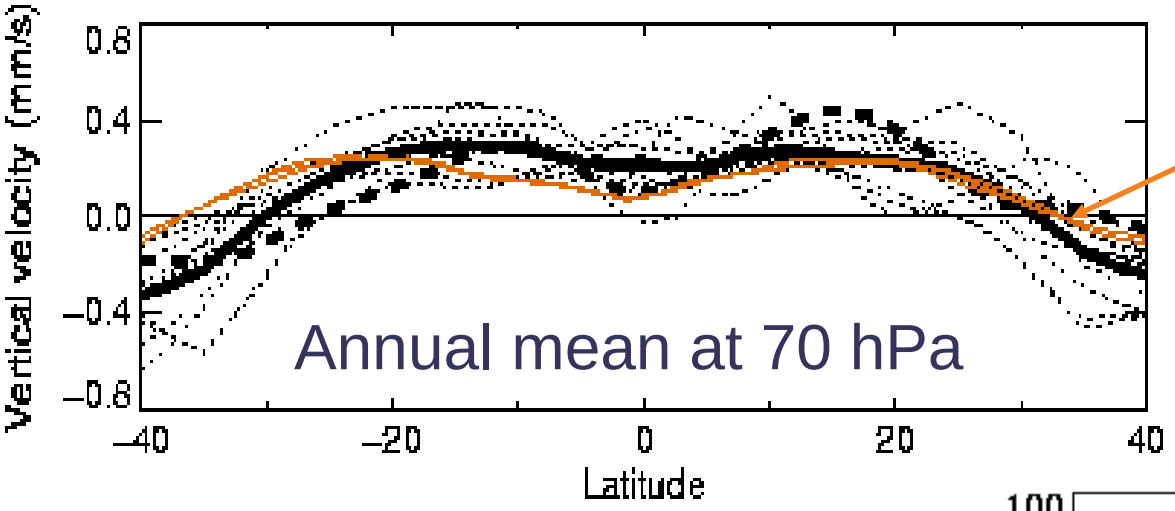
Further Work

- **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

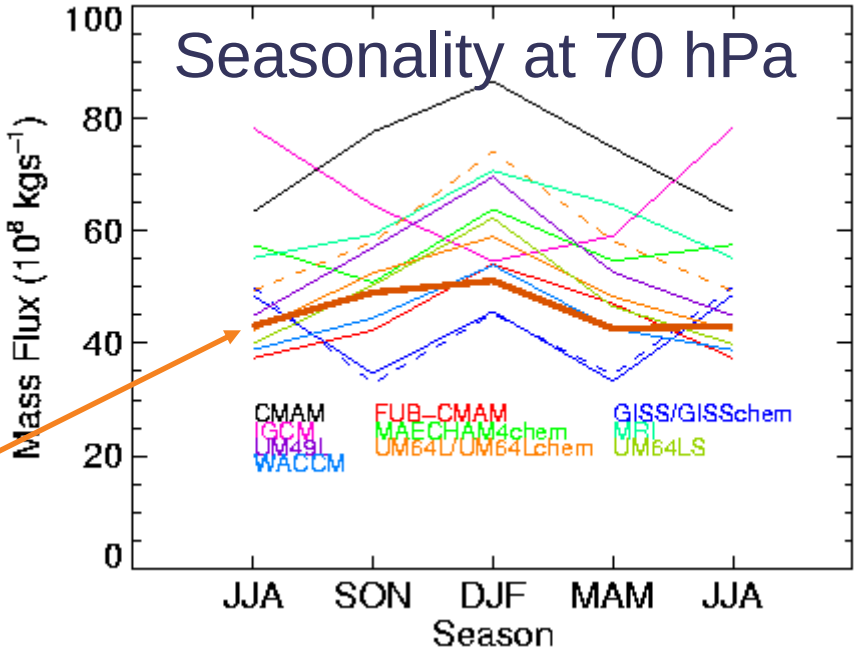
Transformed Eulerian Mean Diagnostics



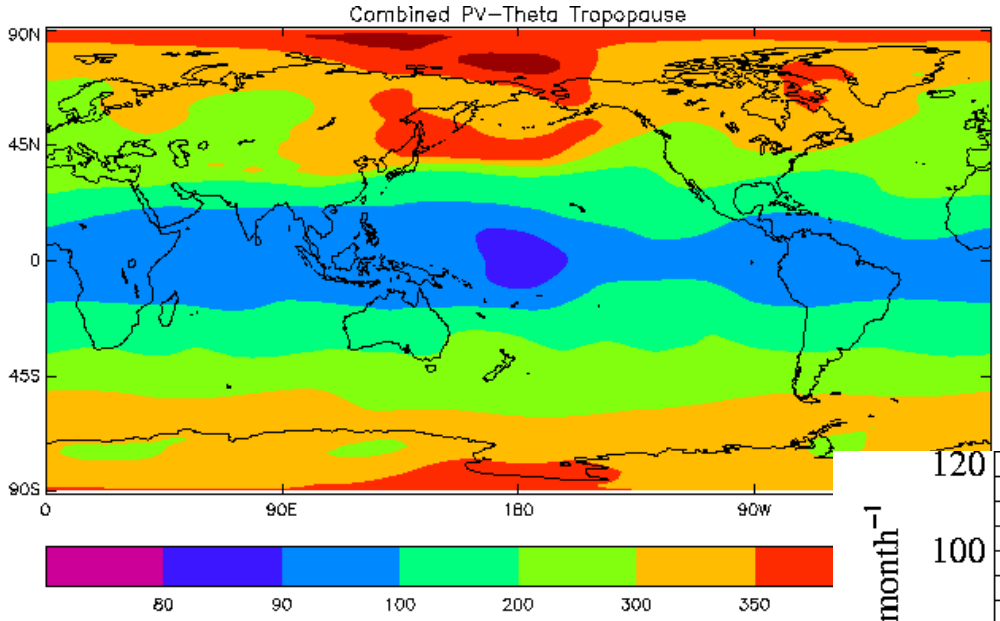
HadGAM1 N48L38

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

HadGAM1 N48L38

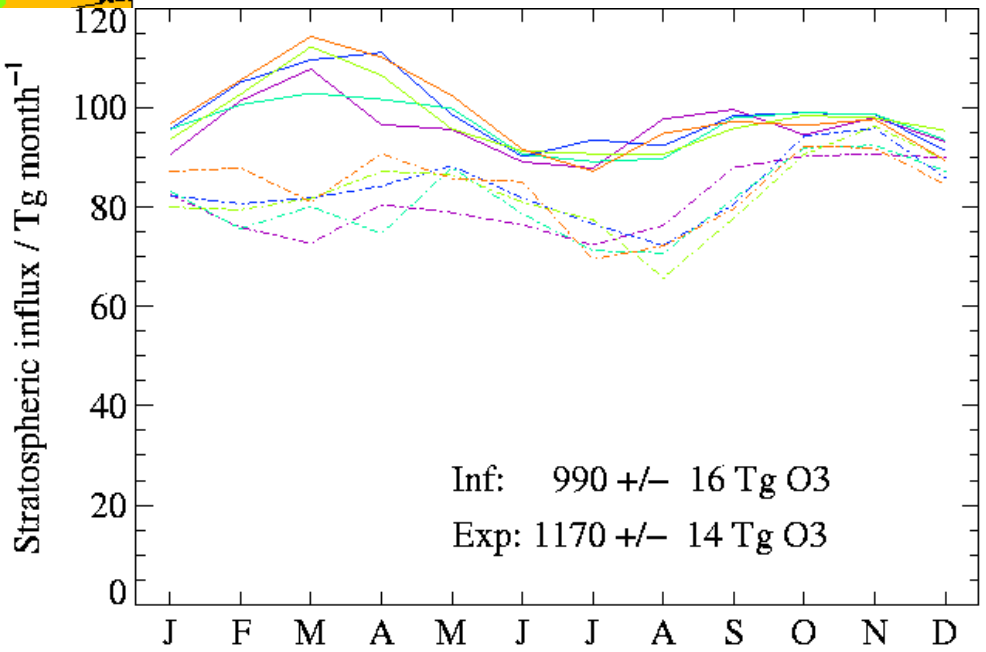


Stratosphere-Troposphere Flux Diagnostics

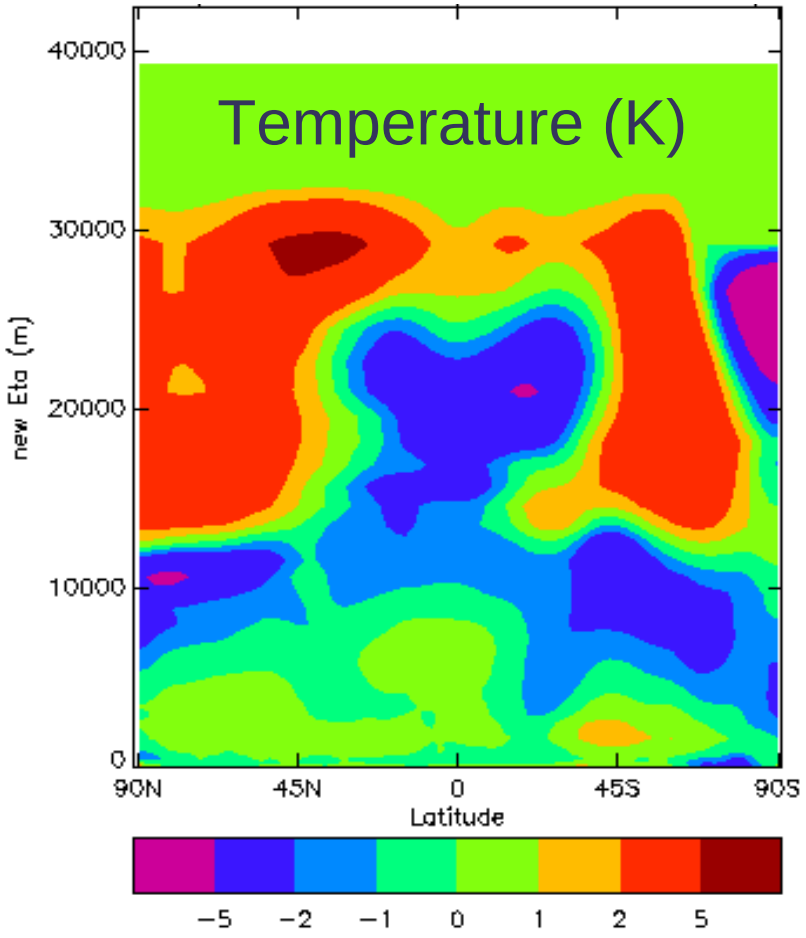


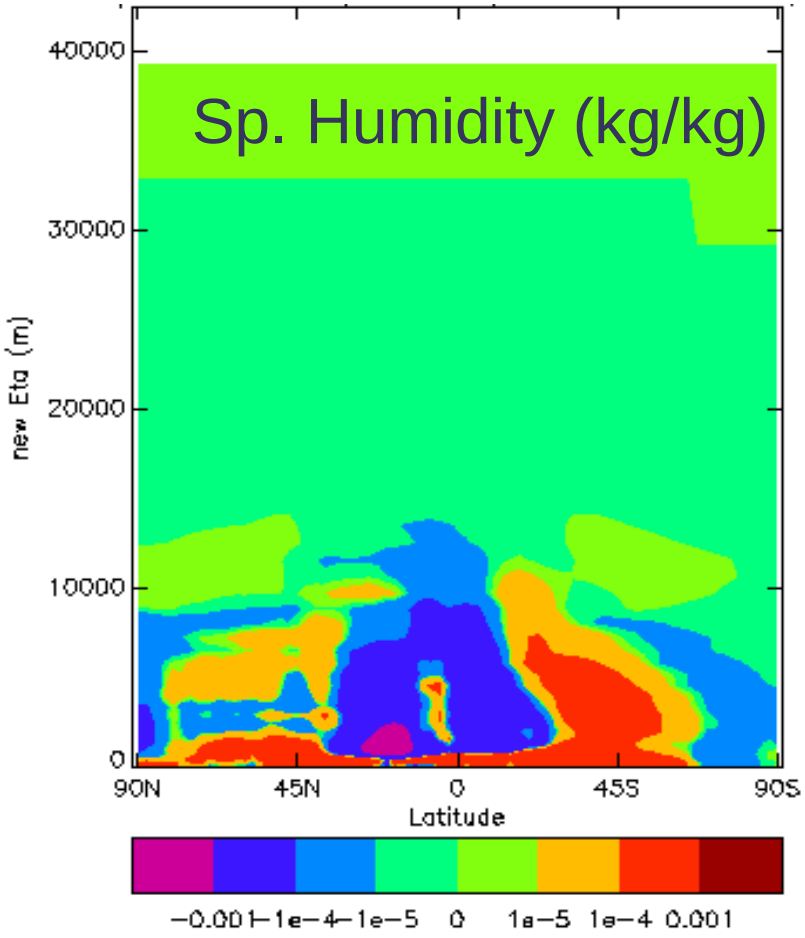
← Diagnosis of combined PV-Theta tropopause

Comparison of inferred and explicit stratospheric influx of ozone →



HadGAM1-ECMWF T and Q Biases





JJA

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