

UGAMP-UKMO Tropospheric Chemistry Model Intercomparison

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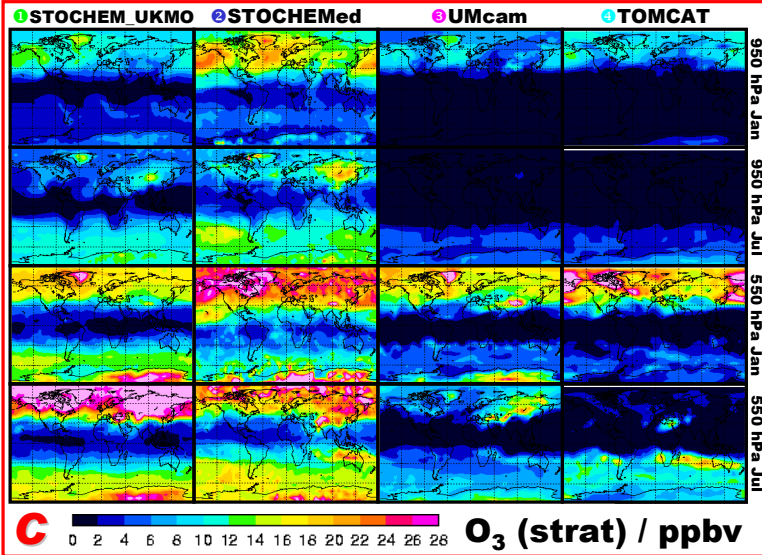
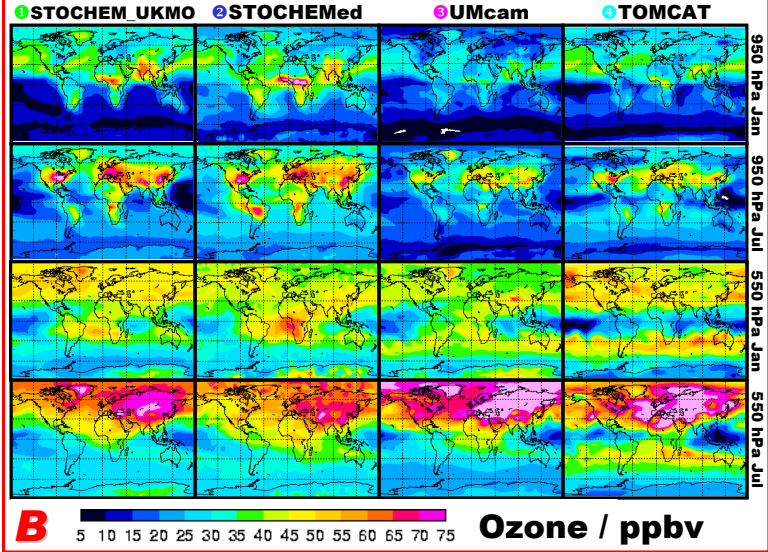
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Four global tropospheric chemistry models are currently being intercompared, focussing on their ozone budgets. Two models (STOCHEM_UKMO, STOCHEMed) have Lagrangian transport. The other two (UMcam, TOMCAT) are Eulerian. Three models have the Unified Model as their physical core, whilst TOMCAT is driven by ECMWF analyses. The models have a variety of resolutions and parameterisations (A), all of which affect their simulation of ozone.

A	1	2	3	4
	STOCHEM_UKMO	STOCHEMed	UMcam	TOMCAT
Meteorology resolution	HadAM4 3.75 x 2.5 x 38 (100000 parcels)	HadAM3 3.75 x 2.5 x 58 (50000 parcels)	HadAM3 3.75 x 2.5 x 19	ECMWF 5.6 x 5.6 x 31
Output resolution	5 x 5 x 20 (evenly spaced)	5 x 5 x 22 (detailed tropopause)	As above	As above
Convection	Lagrangian Mass flux scheme	Simple column mixing	UM Gregory & Rowntree (1990) Mass flux scheme	Tiedtke (1989) Mass flux scheme
Stratosphere	Li & Shine (1995) O ₃ > tropopause	Li & Shine (1995) O ₃ > tropopause	Camb-2D O ₃ < 50 hPa	Camb-2D O ₃ < 50 hPa
Chemistry	50 species 10 NMVOCs	70 species (Sul) 10 NMVOCs N ₂ O ₅ on S-aerosol	42 species 5 NMVOCs	42 species 5 NMVOCs
Dry deposition	Land/ Water/ice	Land/ Water/ice	Fores/Grass/ Water/ice	Fores/Grass/ Water/ice

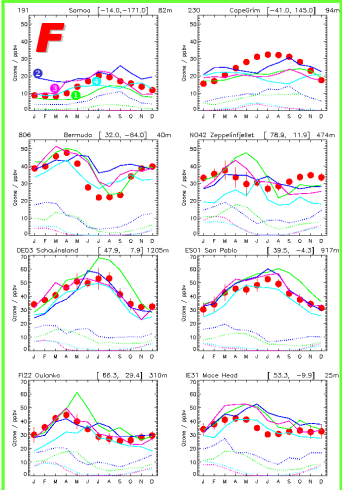


Each model used the IPCC OXCOMP emissions to simulate the present-day atmosphere. Models were spun up for 4 months, then integrated for a year. Ozone maps for January/July and the lower/mid-troposphere are compared in B. The models show differing ozone production efficiencies over (and downwind of) areas polluted by anthropogenic and biomass burning emissions. This may reflect boundary layer resolution (higher in 3 and 4) and/or long range transport of ozone precursors, such as NO_x, affected by NMVOC chemistry and PAN formation (stronger in 1 and 2). The fractions of tropospheric ozone originating in the stratosphere (C) are much higher in 2 and 1, particularly in the lower troposphere and the summer hemisphere. This appears to be due to faster rates of ozone destruction in the mid to lower troposphere in 3 and 4, rather than differences in stratospheric influx of ozone, which is much larger in 3 compared to 2. Differences in STE flux may reflect different meteorological resolutions around the tropopause, and/or Lagrangian vs. Eulerian transport. Tropospheric ozone budgets for these two models are shown in D, and show large differences.

Zonal mean NO_x for January is shown in E. The two STOCHEM models have very different distributions in the free troposphere in NH mid-latitudes. This seems to be due to the removal of NO_x in 2 through the reaction of N₂O₅ on sulphate aerosol. This reaction has a simple global rate constant in 1. Model 3 also has no heterogeneous reactions, but it does not have the same build up of NO_x as in 1. This may be because it generates very little PAN due to the limited NMVOC chemistry. The models also appear to show differences in their stratospheric NO_x sources.

D	Prod-Loss	Dry dep	STE
2	+998	-1452	+454
3	-625	-860	+1485

Summary
The results illustrate some of the many uncertainties associated with the present generation of global tropospheric chemistry models. These uncertainties are wide-ranging and fundamental. All of the models give plausible ozone distributions, but from varying sources, differing markedly in their ozone budgets. Differences in boundary layer and tropopause resolution, convection, chemistry, and the models upper boundary condition are all likely to strongly influence the resulting ozone distributions. The details of NMVOC and heterogeneous chemistry also appear to be important. Without an understanding of how models simulate the present-day atmosphere, it is difficult to know how good the models simulation of the past or future will be.



F shows surface ozone observations from several surface sites (red dots) compared with the four models. Stratospheric components are shown as dashed lines. Six-hourly resolution data are compared in G for Mace Head and show that 2 and 3 have quite different variabilities, reflecting their different transport and mixing schemes.

