Studies of Recent Tropospheric Ozone Trends using the UKCA Chemistry Climate Model

Paul Griffiths, James Keeble, Matthew Shin, Luke Abraham, John Pyle and Alex Archibald

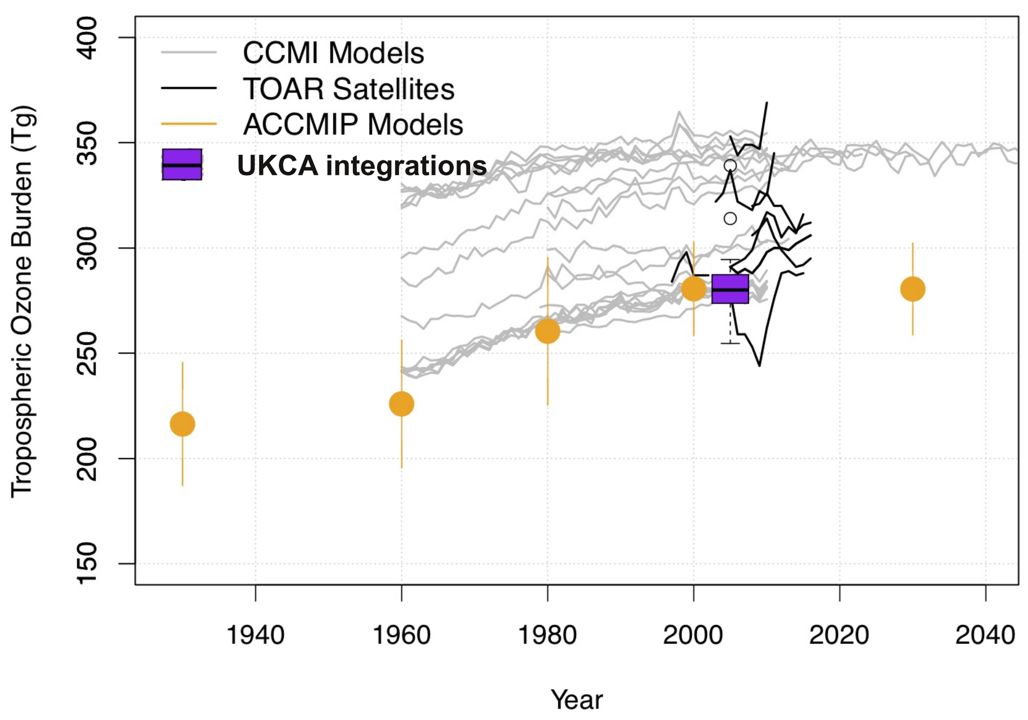
National Centre for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL

Centre for Atmospheric Science, Cambridge University and NCAS-Climate

Our understanding of tropospheric ozone depends on our quantitative understanding of the ozone budget terms. The current generation of state-of-the-art models struggle to reproduce observed ozone trends (Parrish et al., 2014): models overestimate absolute O3 mixing ratios, on average by ~5 to 17 ppbv in the year 2000, and capture only ~50% of O3 changes observed over the past five to six decades. In this poster, we ask, What do current models have to say about the ozone burden and what processes might control the budget tropospheric ozone burden and its overall trend?

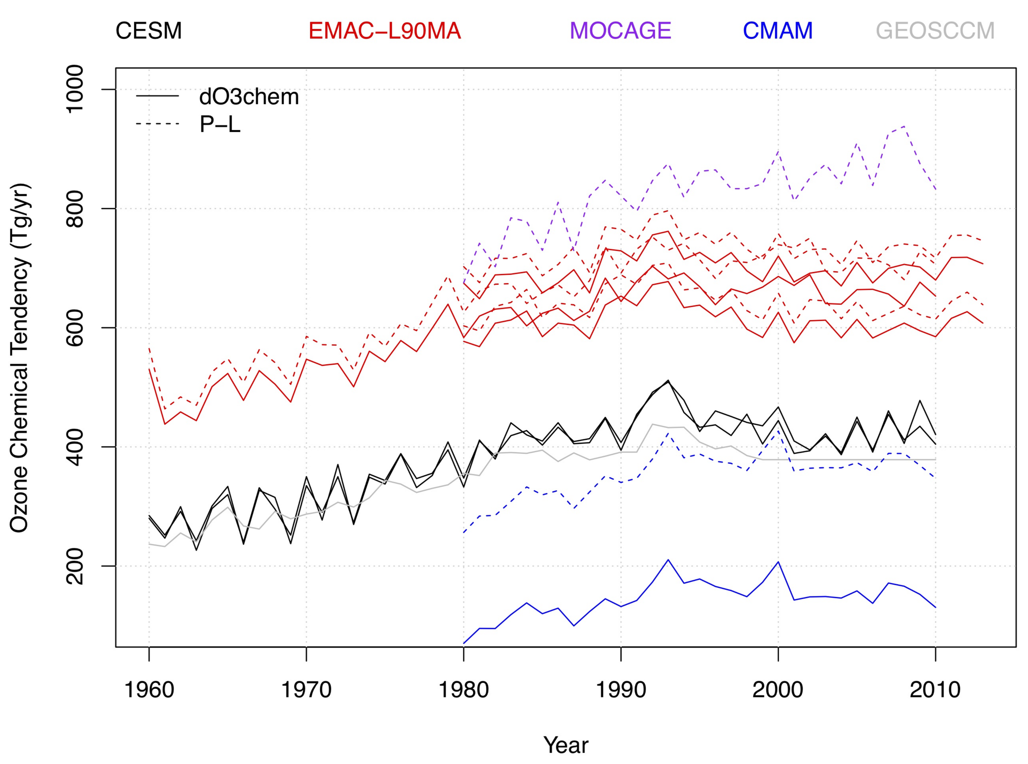
How well do models reproduce the ozone buden? Results from the TOAR Assessment

Comparison of models and TOAR data (+/−60 deg.) (using 125 ppb ozonapause)

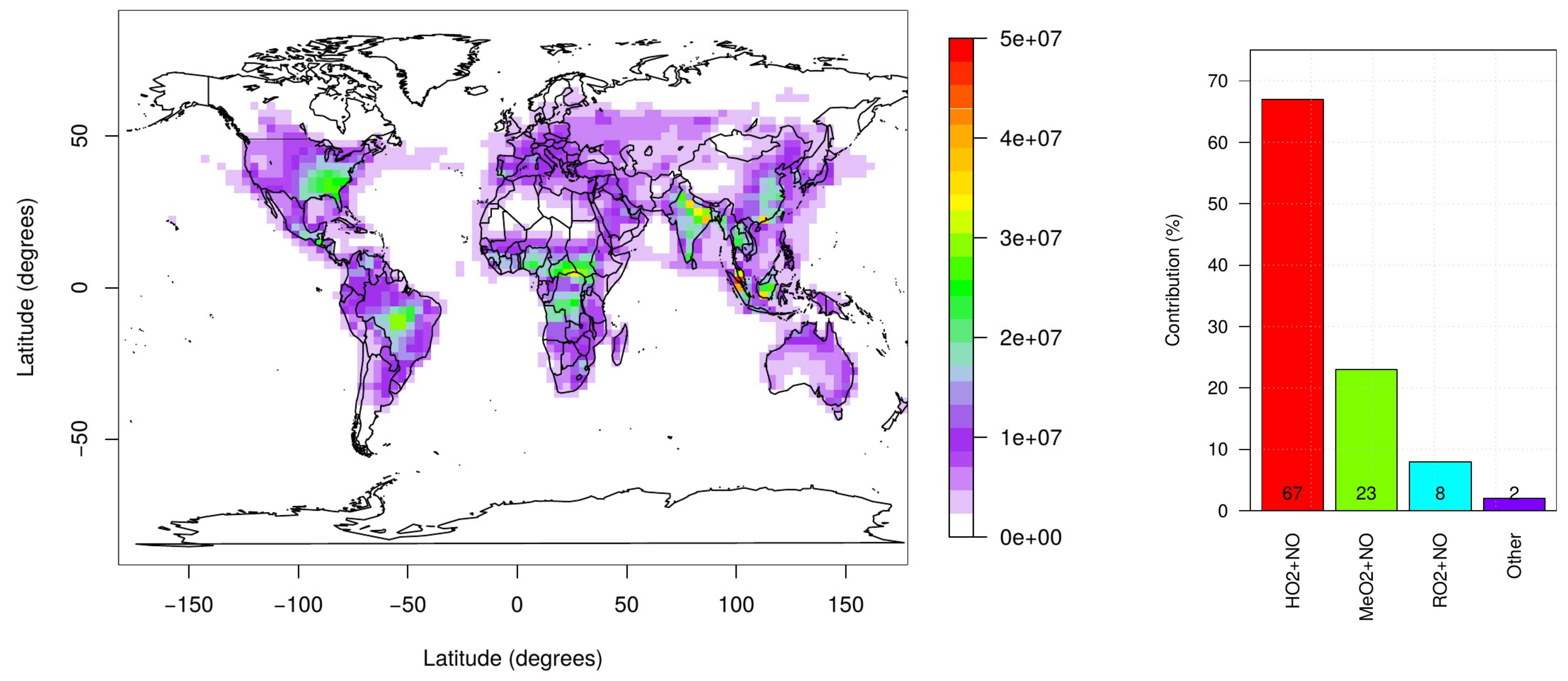


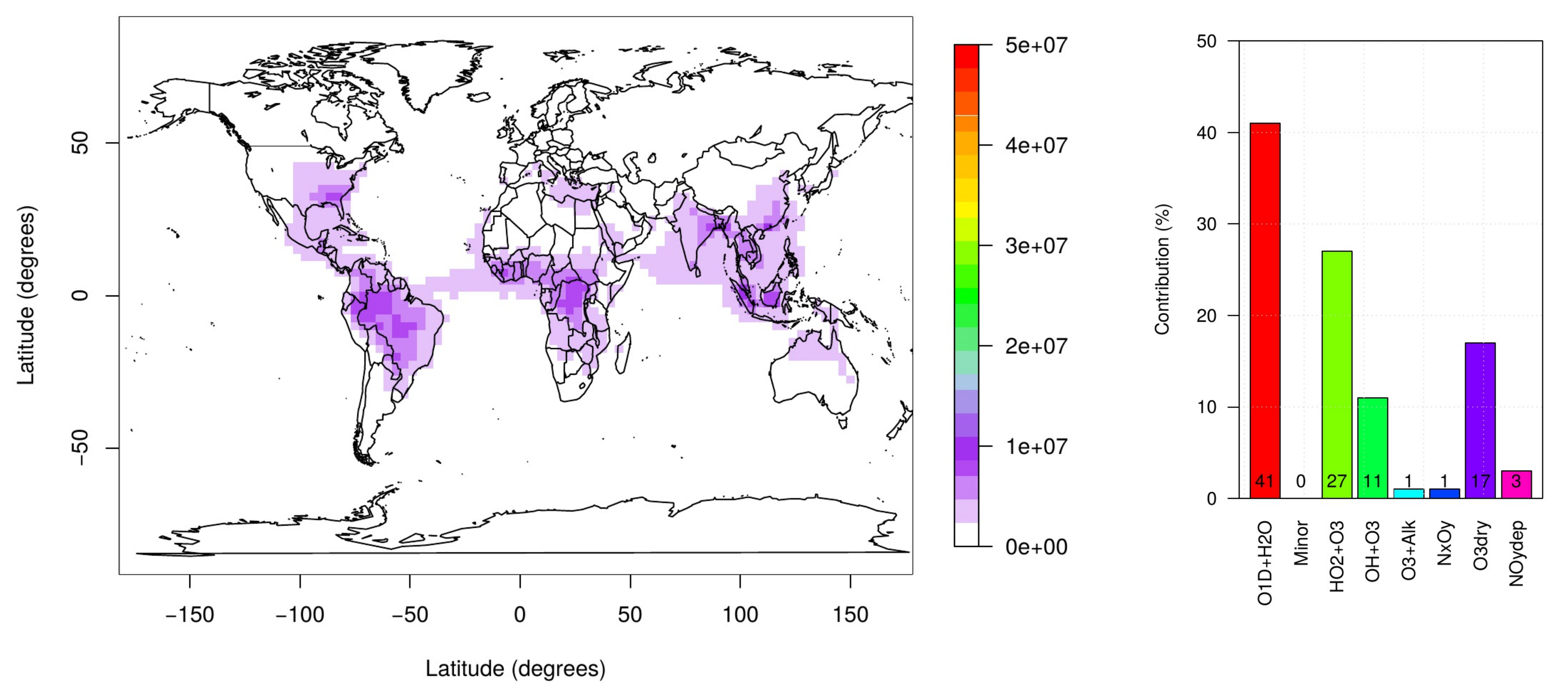
- ACCMIP used time slice integrations, leaving gaps between points
- Could not quantify, in a muliti model sense, the reasons for the increase in ozone (only 4 models produced diagnostics)
- CCMI allows transient changes to be quantified in multimodel sense.
- Big improvement in number of models reporting TropO3 diagnostics but differences between models (emissions, configuration) hampers progress in quantifiying role of chemical vs dynamical changes.

Tropospheric ozone production



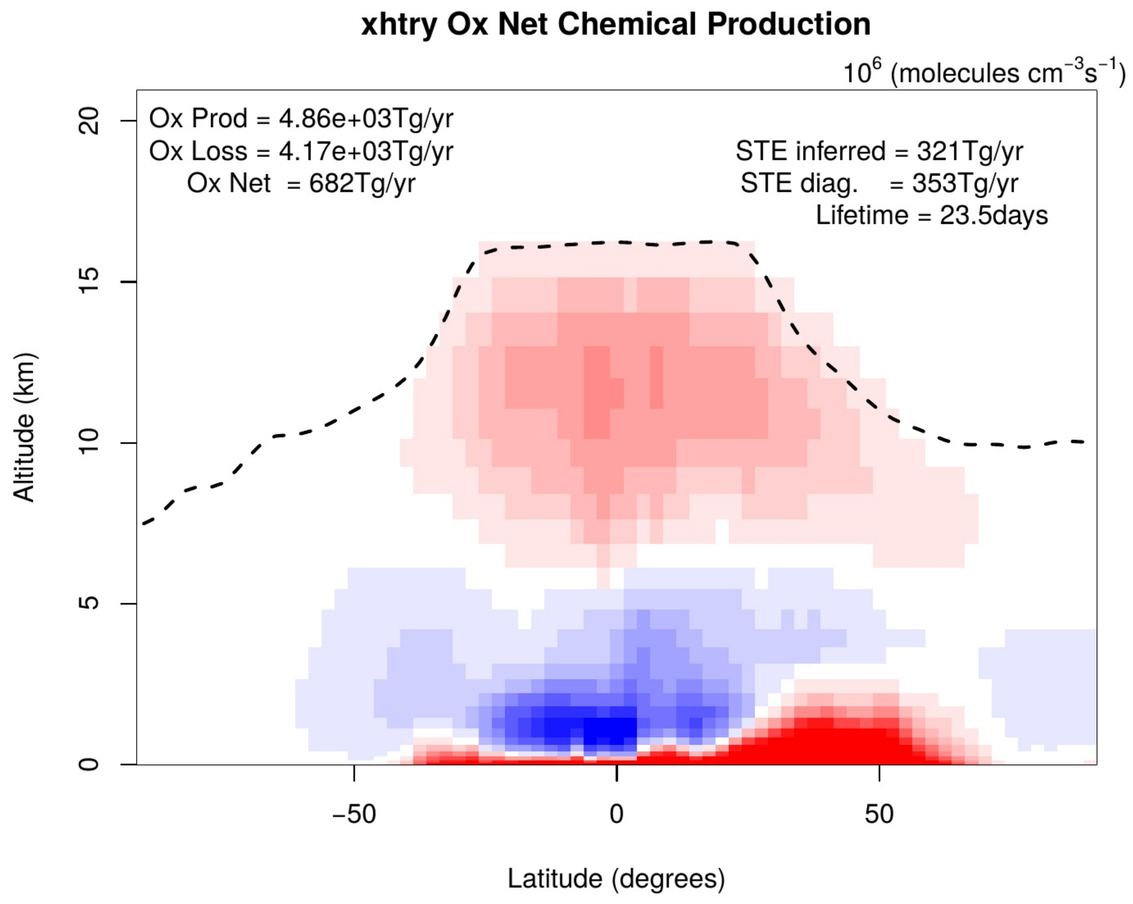
- Generally P-L matches dO3chem but there are significant differences for some models: P-L needs to close the budget - detailed analysis required
- CCMI ozone burdens show an increase in O3 burden over last 40 years.
- Seems to correlate with increase in net chemcal production.
- Huge range in magnitude of NCP: 100-900 Tg yr^{-1} !!





Tropospheric surface ozone loss (lower) and production (upper panel) (cm-3 s-1), and fractional contribution of Ox prod/loss channels.

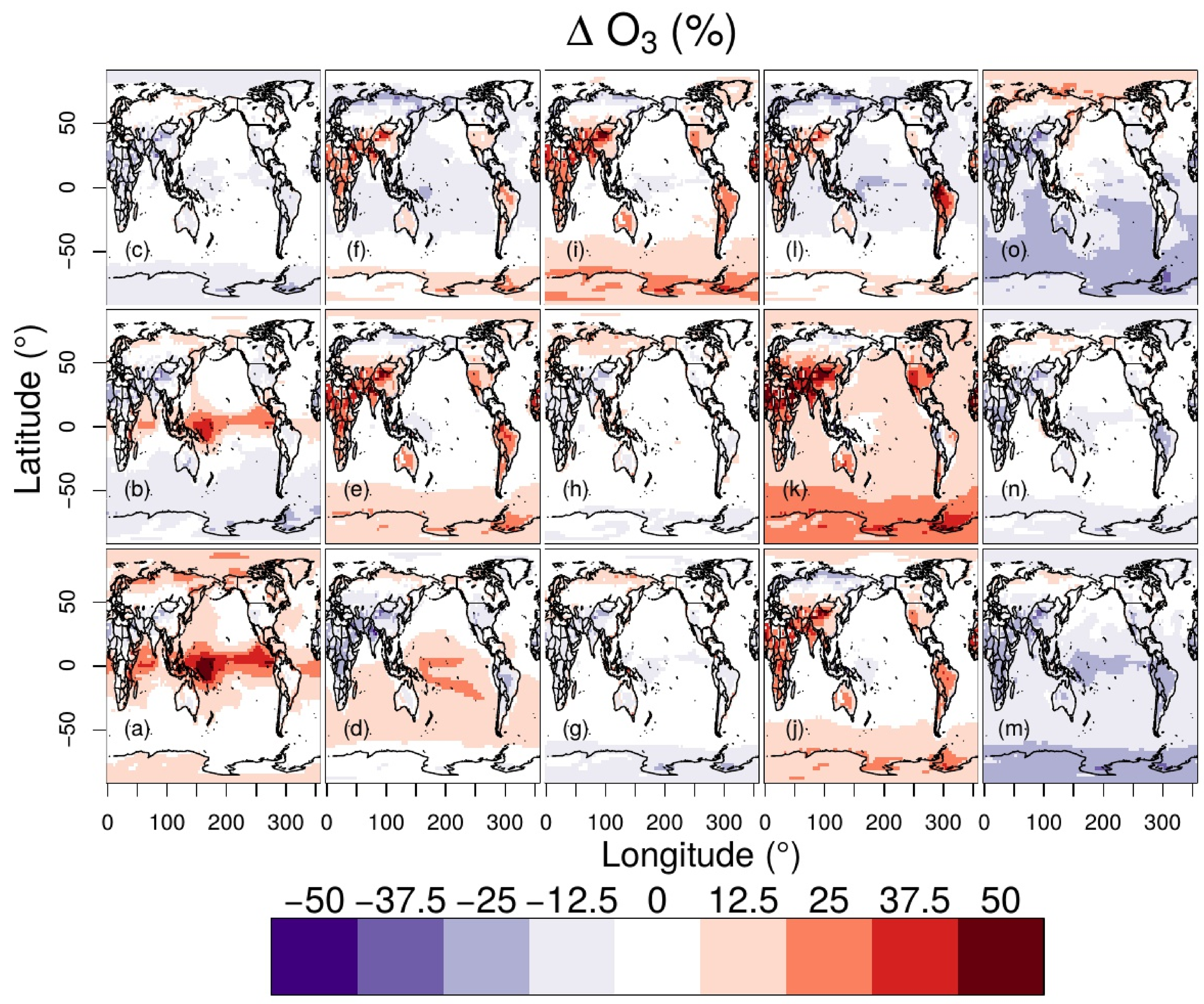
xhtry Ox Net Chemical Production



Net chemical ozone production (cm-3s-1)

Perturbed ensembles using UKCA

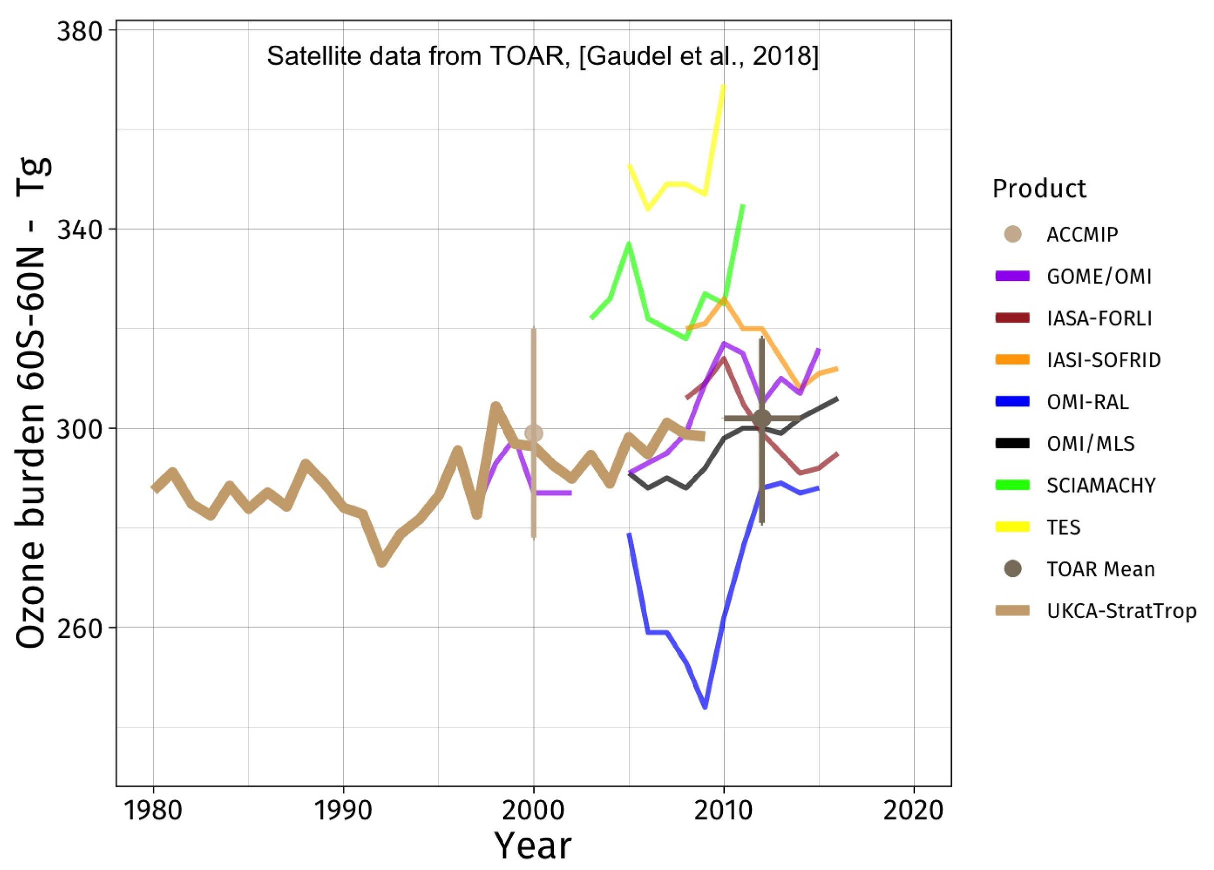
ATA performed 15 timeslice integrations for year 2000 using UM-UKCA at version 7.3 with varying initial conditions and different photolysis schemes, emissions, deposition and chemistry rate coefficients.

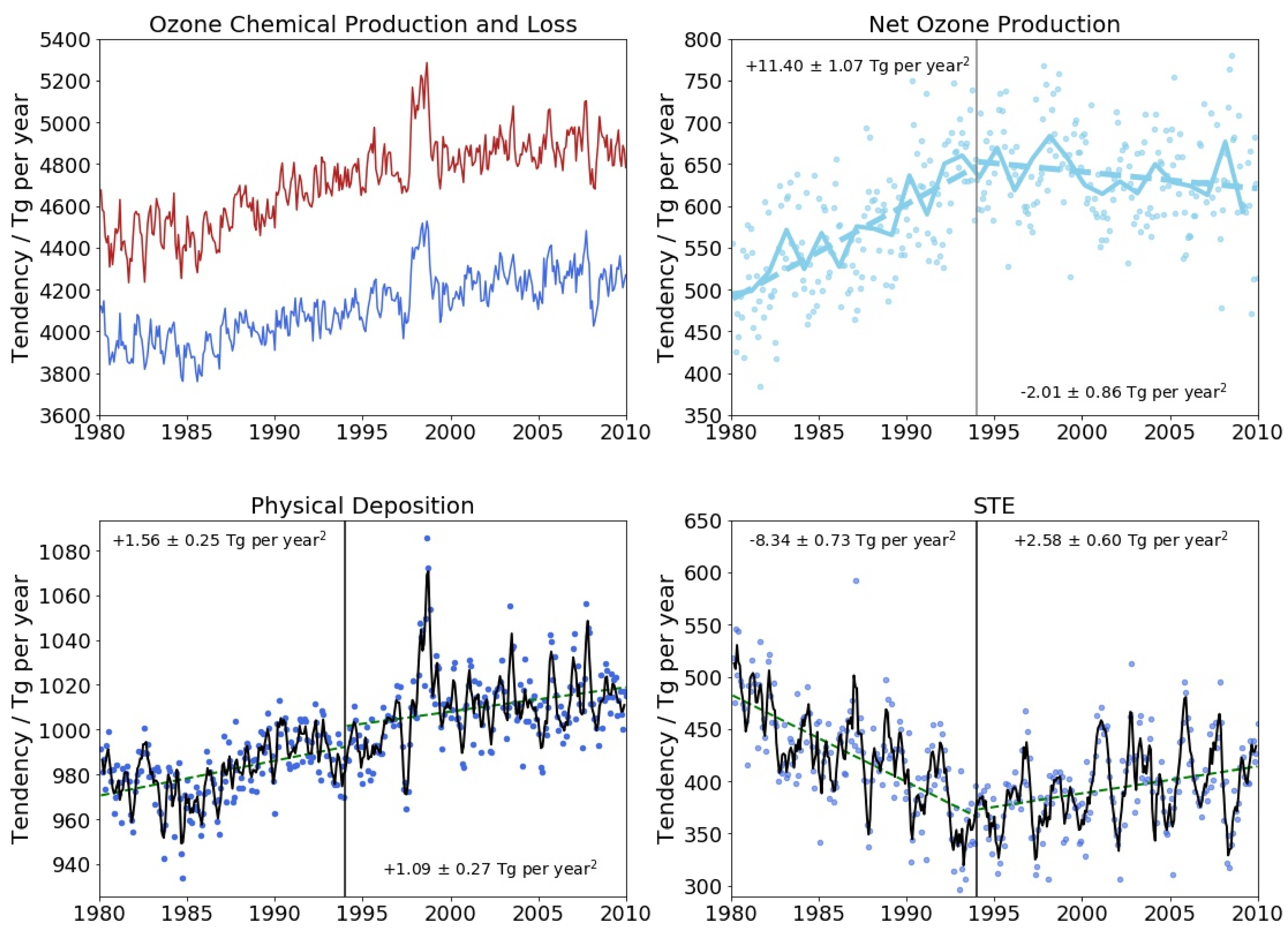


The ensemble mean is used to assess variability between experiments. Each plot shows the relative difference in percent at the surface for a given experiment, relative to the ensemble mean. For ozone, variations in emissions lead to variation in ozone which is similar to multi-model variability. Other signficiant perturbations arise from NOx reservoir formation and photolysis scheme.

The ozone burden and budget in recent historical transient integrations

The figure below shows a comparison of UKCA from CCMI and CMIP6 transient integrations together with the TOAR burden estimates from Gaudel et al, 2018.





Acknowledgements

We thank the National Centre for Atmospheric Science for financial support, and Fiona O'Connor, Owen Cooper, Beatrice Jose for useful discussions.