# Preliminary Comparison of O3-CO Correlations between TES data and 3 different Models

**P. Telford, A. Voulgarakis, P. Braesicke, D. Shindell and J.A. Pyle**

*Centre for Atmos. Science, NCAS, Chemistry Department, University of Cambridge*
*NASA Goddard Institue for Space Studies, Columbia University, New York*

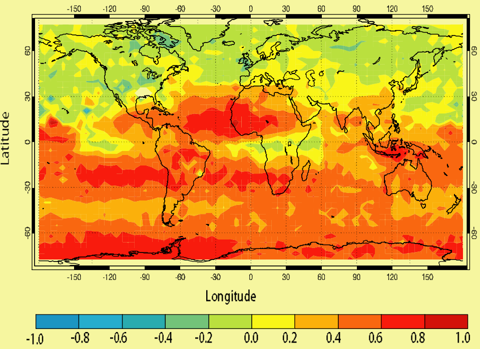
National Centre for Atmospheric Science, NATURAL ENVIRONMENT RESEARCH COUNCIL
National Aeronautics and Space Administration, Goddard Institute for Space Studies, New York, N.Y. 10025
National Centre for Earth Observation, NATURAL ENVIRONMENT RESEARCH COUNCIL

## Introduction:

In addition to simply comparing variables between models and data we can employ more sophisticated validation techniques. One such technique is to look at the correlations between tracers. We correlate carbon monoxide (CO) and ozone (O3) in the free troposphere, comparing results from the TES instrument on the NASA AURA satellite with the output from a range of models (UKCA, p-TOMCAT and GISS). This can improve our understanding of how polluted, CO rich air, influences O3 concentrations building on the work of Zhang et al. (2006), but over a more extended period. We present some preliminary results and discuss common features and differences. We speculate on the causes of these differences and outline strategies to determine their causes.

## Satellite Data from TES:

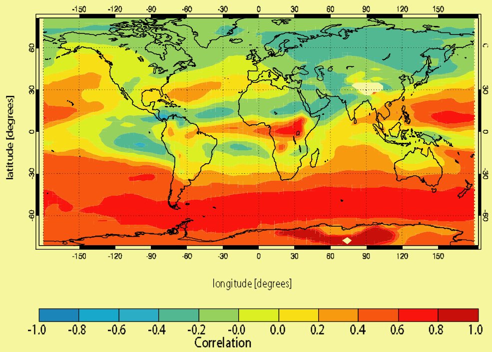
The TES (Tropospheric Emissions Spectrometer) instrument was launched on the NASA AURA satellite in July 2004. Its focus lies from the Earth's surface through to the stratosphere. We take the values of CO and O3 at 618 hPa from the satellite representing the free troposphere and correlate them from 2004 to the end of 2008. We then plot the correlation co-efficients as a function of latitude and longitude as shown below.




The main features is a clear difference between the correlation in the northern and southern hemispheres, with high correlations in the southern hemisphere.

## Correlations in the UKCA Model

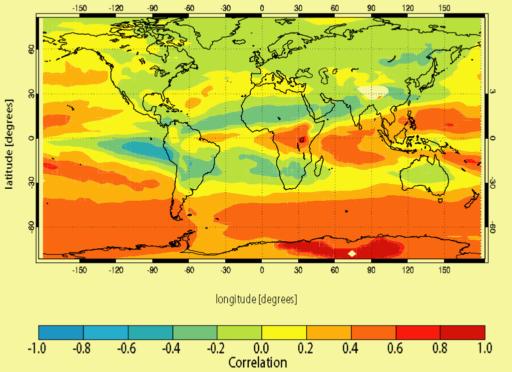
We can produce a similar correlation map at 618 hPa using the tropospheric flavour of the UKCA model. This is a chemistry climate model based upon the Met Office's UM (see Abraham 2009). To capture the meteorology from the 2004-2008 period we nudge to ECMWF analyses (Telford et al 2008).



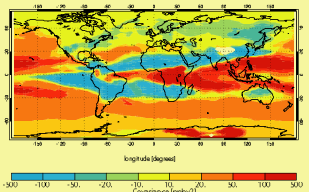

Broadly the model captures the features of the data, with the same north/south split. However the behaviour in the tropics is significantly different. Some of this may be attributed to sampling differences (e.g. clouds) which will be removed when the TES observation operators are applied to the model.

## Removing the Annual Cycle

We look at the effect of seasonal variation by removing an annual cycle from both the CO and O3 UKCA model output. We then re-calculate the correlation map at 618 hPa as shown below.



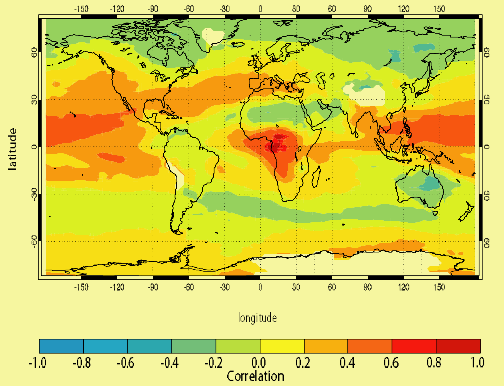

Removing the annual cycle makes little difference to the results. The main difference is that the correlation values tend to be reduced, especially in the mid to high latitudes. Both the other models exhibit similar behaviour, suggesting that the correlation patterns are not dominated by seasonal variations.




We can also plot the covariance (left) between the two variables. The higher values of the tracers in the tropics makes the features there appear more pronounced.

## Correlations in the GISS Model

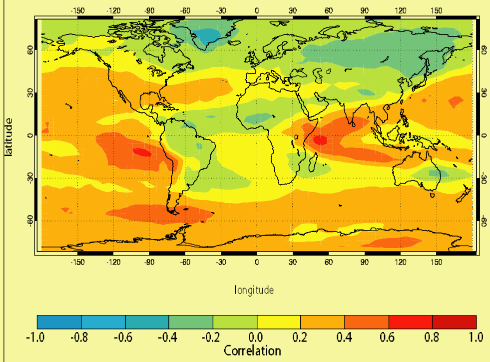
The GISS model is another chemistry climate model (Shindell et al, 2006) which we also run in nudged mode from 2004-2008. We calculate the deseasonalised correlations between O3 and CO at 618 hPa from the model output and map them below.




Both models have the same hemispheric asymmetry as the data. They also have a tongue of higher correlation values stretching across the Atlantic. The correlation values in the GISS model tend to be lower than in the UKCA model, though there are common features in regions such as Central Africa. Possible causes of the differences could be the photolysis schemes, emissions data sets or the treatment of methane.

## Correlations in late 1990s

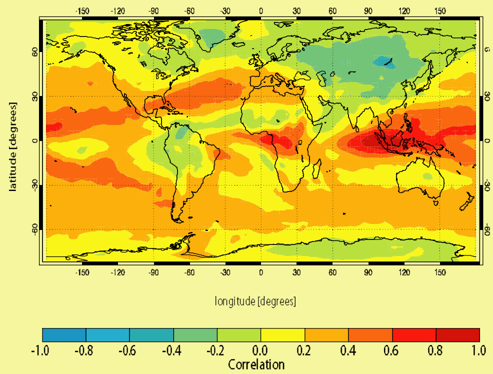
We also investigate the late 1990s, a period with a strong El Nino and La Nina. This allows us to compare to previous runs made with the p-TOMCAT CTM. We display the deseasonalised correlations in the GISS and p-TOMCAT models. The GISS model set up is slightly different in these runs, with the most notable change being a different emissions data set. However the model is broadly the same. The GISS deseasonalised correlations between 1996-2000 are mapped first




Interestingly the GISS correlations now look more like those from the UKCA model, which may reflect the changes in emissions or the circulation. More controlled experiments are required to pinpoint the causes of the changes.

## p-TOMCAT Correlations

The p-TOMCAT model is a CTM running on the ECMWF analyses (Voulgarakis et al 2009). Unlike the other two models it includes interannually varying emissions from the RETRO dataset. The deseasonalised correlations between 1996-2000 are mapped below.




The correlations look similar to those observed in the GISS model. The main exception is over Indonesia which probably relates to the inclusion of strongly varying emissions with the changes in ENSO.

## Initial Conclusions

- Models broadly capture the correlation patterns in the satellite data. At the moment waiting for TES observation operators to be able to compare like with like.
- Models share some common features (eg location of North Atlantic storm tracks, high correlations over Indian Ocean).
- However also regions where behaviour is different (eg Indonesia, Eastern Pacific).
- Have some ideas about causes of differences (interactive photolysis, differences in emissions) but need to test in a systematic manner
- Model set up appears to be a greater factor than period chosen
- Demonstrates potential of the technique to distinguish between different model set ups

## References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- P. Telford et al., ACP, 8 1,701-1,712 (2008)
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**Contact:**
paul.telford@atm.ch.cam.ac.uk
http://www.atm.ch.cam.ac.uk

**Summary:** We present preliminary results of a comparison between CO-O3 correlations from the TES satellite and 3 different models. We demonstrate that the major cause of the correlations is independent of seasonal variations. The models all pick up the broad features in the correlation maps, but retain differences with the data and each other. We wait for further model runs and more detailed analysis to make definite statements of the causes of these differences.