Seasonal, Interannual and decadal variability of North Atlantic Ozone: Comparison of UM-UKCA and remote sensing observations

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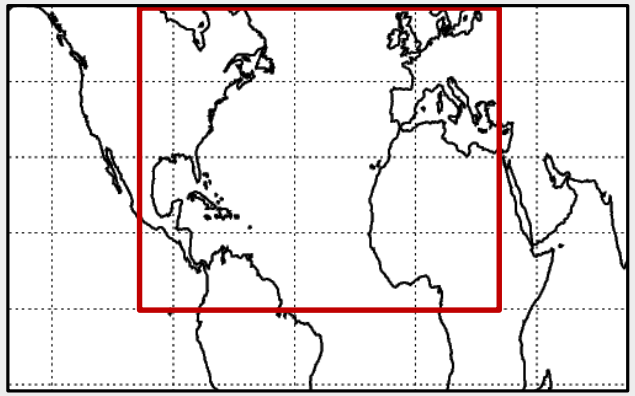
Motivation:

Tropospheric ozone is a greenhouse gas and a pollutant (harmful to people and vegetation). Past studies have suggested that ozone in the troposphere has increased globally throughout much of the 20th century due to increases in anthropogenic emissions and transport (Cooper et al. 2014). However, more recent ozone trends are not always positive and can vary regionally (Ziemke et al. 2019). In this work we investigate changes in tropospheric ozone in the North Atlantic at different time scales and how well the atmospheric chemistry component of UKESM1 can reproduce these changes.

Methodology:

- Observations and model simulations are compared over 2005-2017 period and over the North Atlantic domain, as shown to the right.

NA DOMAIN: (100E:30W; 0:60N)



Observations:

- OMI-MLS for tropospheric column, surface to tropopause
- OMI for lower tropospheric column, surface to 450hPa (~5.5km)
- OMI for upper tropospheric/lower stratospheric column, 170-50hPa

Model Simulations:

- UM-UKCA, nudged dynamics (Jan 1982 – Dec 2017) and Reynolds SST
- Monthly mean satellite averaging Kernel and a priori information used to sample model for comparison with OMI

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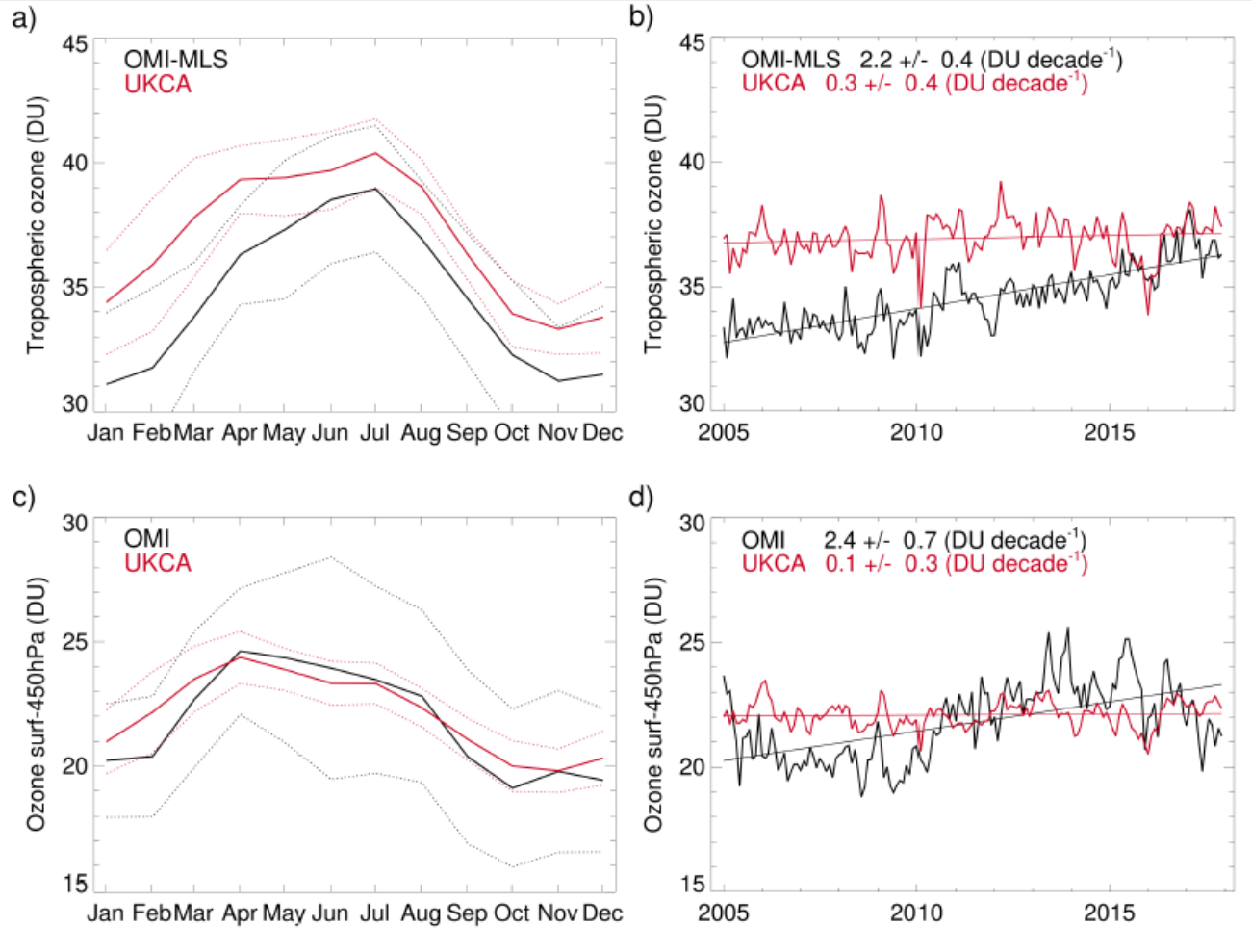
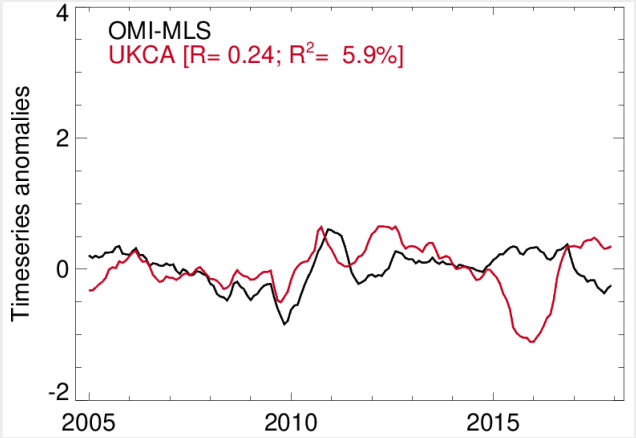
Seasonal variability

Decadal variability and trend

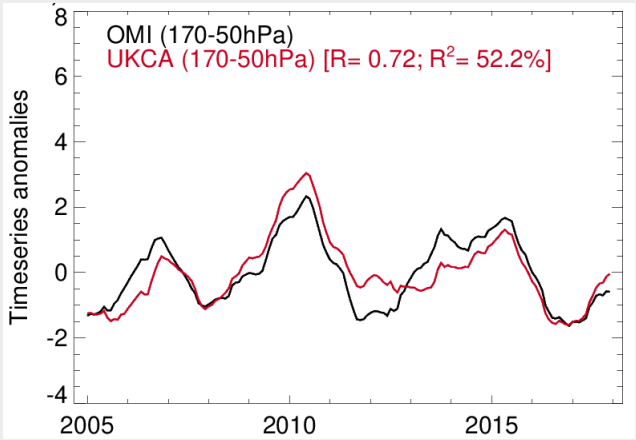


- Model captures seasonal variation but overestimates observed ozone. Further analysis indicates this is mainly in the Tropical upper troposphere.
- Observations show positive trends but model does not.

Interannual variability



Modelled tropospheric ozone column over the NA shows only a small temporal correlation with observed OMI-MLS tropospheric ozone column.



Modelled lower strat. ozone shows a strong correlation with observed OMI data indicating that the processes controlling interannual variability in stratospheric ozone are well represented in the model.

Possible reasons for discrepancies in the troposphere include possible problems with emissions of ozone precursors and stratosphere to troposphere transport of ozone.

Summary and Conclusions:

- UKESM can reproduce the seasonal cycle of tropospheric ozone in the troposphere.
- UKESM overestimates tropospheric ozone in the NA (specifically in the tropical upper troposphere) and this seems to be linked to the model being overly sensitive to emissions of NOx from lightning.
- Both observational datasets show a positive trend in tropospheric ozone in the NA for the period 2005-2017, however UKESM shows little change over the same period.
- The interannual variability of tropospheric ozone in the NA is the result of a number of physical, chemical and transport processes and UKESM fails to reproduce the observed temporal variability of tropospheric ozone.
- On the other hand, the interannual variability of upper tropospheric and lower stratospheric ozone in the NA is well captured by UKESM.

References

Cooper et al. 2014: http://doi.org/10.12952/journal.elementa.000029
Ziemke et al. 2019: https://doi.org/10.5194/acp-19-3257-2019

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