Ozone trend analysis from 1980-2015: Models vs observations

Motivation

Ozone (O\(_3\)) is a secondary greenhouse gas in the atmosphere. Known facts about O\(_3\):
- It is important for climate (greenhouse gas).
- It impacts human health and ecosystems.
- It impacts visibility.

These led to an EU Directive for a long-term threshold of 120\(\mu\)g/m\(^3\) (8h daytime) not to be exceeded more than 25 days per year.

Its secondary nature makes it hard to control through emission mitigation.

The following questions subsequently arise:
- What are the background O\(_3\) tendencies over the past 4 decades?
- What is driving them?

Models Description

The TM4-ECPL and TM5MP models are used to simulate O\(_3\) concentration in the global atmosphere.

The model has:
- Horizontal resolution:
  - TM4-ECPL: 3\(^\circ\)x2\(^\circ\) Ion x lat
  - TM5MP: 1\(^\circ\)x1\(^\circ\) Ion x lat
- Vertical resolution:
  - 34 hybrid pressure levels up to 0.1hPa (~65 km)
- TM4-ECPL emissions:
  - Anthropogenic and Biomass Burning from ACCMIP[1]
  - Biogenic from MEGAN-MACC[2]
  - Dust from AEROCOM [3]
  - On-line sea salt and marine POA
- TM5MP emissions:
  - CMIp6
  - Biogenic from MEGAN
  - On-line dust calculation
  - On-line sea salt
- TM4-ECPL Analytical chemistry
  - 120 tracers
  - 186 thermal reactions
  - 44 photolysis reactions
  - 48 aqueous phase reactions
- TM5MP – CBM5 chemistry
  - 54 tracers
  - 109 chemical reactions
  - 89 thermal, 20 photolysis
  - Driven by ERA-Interim Meteorology [4]
  - Validated in AEROCOM [5]
  - Description of TM4-ECPL: Daskalakis et al., ACP, 2014.
  - Description of TM5MP: Huijnen et al., GMD, 2010.

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Conclusions

- Understanding background O\(_3\) is important for AQ improvement.
- TM4-ECPL model captures the stratospheric intrusions in late winter and spring seen in the observations
- TM4-ECPL captures the convective summer minimum.
- Lower tropopause in TM4-ECPL model than the observations in a subset of the measurements locations.
- Trends in O\(_3\) depend on location and season.

Measurements and model evaluation

Data from the EMEP monitoring network, the WDCGG network together with individual studies were used to evaluate the TM4-ECPL performance. The map shows the locations of the measurements (blue dots) used in the validation of the surface simulated values.

The table shows the summary of the statistical analysis of the comparison between the simulations and the ground based measurements. TM4-ECPL captures satisfactorily the interannual variability (not shown) and overestimates the absolute values by 17% on average.

Simulated O\(_3\) Trends

The figure to the right shows the annual O\(_3\) surface concentration trends as simulated for the years 2000-2010 including (top panel) and excluding (bottom panel) the impact of anthropogenic emission change. Higher O\(_3\) trends, more pronounced in the NH are calculated over areas with high anthropogenic activity (enhanced precursor species).

Analyzing the seasonal trends for the same period (figure above) shows that the high trend over central Africa and Indonesia are dominated by the JJA (June-July-August, left panel) trends attributed mainly to O\(_3\) precursor emissions by wildfires. Similarly for the NH winter (December-January-February, DJF, right panel) higher trends are simulated mainly attributed to higher anthropogenic activity. The trend tendencies over the southern oceans with minimal anthropogenic activity reveal the dependency of O\(_3\) to meteorology and climate with lower values on winter.

References