Quantifying natural variability of short-lived climate pollutants: a prerequisite to isolating anthropogenic trends.

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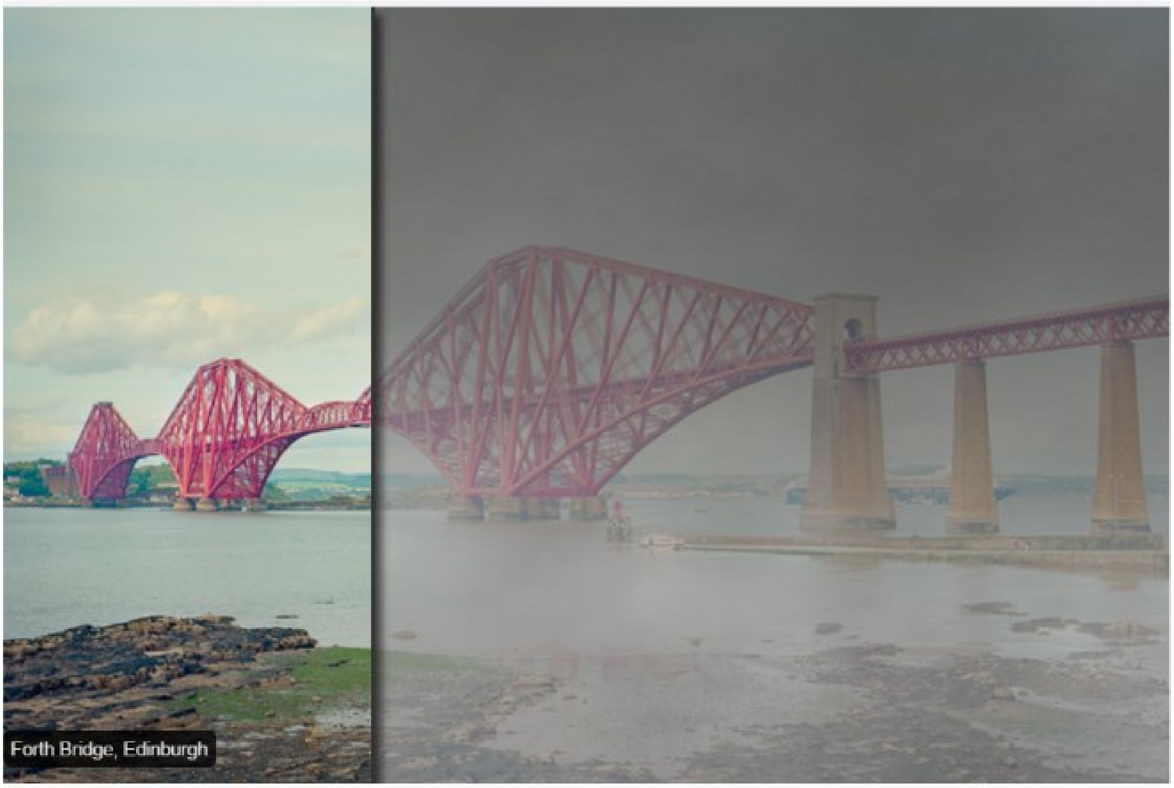
Background

Upwards trends of short-lived climate pollutants (SLCP; e.g., methane, tropospheric ozone and aerosols) are of serious concern for air quality, the health of the biosphere, and climate change. Consequently, they are high up the agenda of environmental policymakers. However, detection and attribution of trends presents a difficult scientific challenge, as SLCPs are influenced by a mixture of natural and anthropogenic emissions and processes that vary in time (diurnally, seasonally, inter-annually) and space. For example, the current generation of models struggles to simulate observed trends in tropospheric ozone (Cooper et al., 2014). A better understanding of the natural drivers of variability is an essential prerequisite to placing any anthropogenic influences in their proper context.



Simulated disappearance of the Forth Rail Bridge during a typical Beijing smog.

Methodology

This project will utilize and build upon recent developments of interactive emission, deposition and other related schemes in models. These include emissions of methane from wetlands and precursor emissions of ozone and particulate matter (PM) (e.g., NOx, VOCs and NH_3) from biomass burning, lightning, soils, vegetation, and the ocean, and deposition and cross-tropopause transport of ozone and oxidised nitrogen. Interactive/dynamic schemes (i.e. closely coupled to meteorological drivers) for many of these processes have been included or are being developed within the global atmospheric chemistry and aerosol model UKCA (O'Connor et al., 2014). This allows their natural variability to be much better captured than in previous model versions, where many of these processes were non-interactive, inherently lacking sources of variability. In this project the contributions of these processes to SLCP variability throughout the model domain will be investigated through a series of sensitivity experiments. State-of-the-art observational datasets (e.g., IAGOS ozone data from commercial aircraft; satellite NO_2 and NH_3 data) will be used to evaluate model performance. The focus will be on the last few decades, when more data were available. Armed with a better understanding of the natural variability of several SLCPs, the anthropogenic components of any trends will be easier to isolate and hence will become more amenable to effective policy interventions.

Key research questions

1. How much variability (diurnal, seasonal, inter-annual) in short-lived climate pollutant concentrations arises from natural processes?
2. How does this temporal variability vary spatially (globally)?
3. How well can global models simulate this spatial and temporal variability?
4. Does better quantification of natural variability improve detection of anthropogenic influences on SLCPs?

Timetable of research

Year 1: Literature review; assemble observational data; training in modelling; initial model experiments. 3-week visit to Boulder with focus on ozone observation data analysis. Writing.
Year 2: Model development and experiments to isolate individual processes that influence variability. 3-week visit to Boulder with focus on model-observation comparison for ozone. Writing papers and thesis.
Year 3: Fine tune and finalise model experiments and model-observation comparisons. Writing papers and thesis.

Training

A comprehensive support programme will be provided comprising both specialist scientific training and generic transferable and professional skills, including for UKCA modelling and in data analysis. You would be expected to spend some time (~6 weeks) working in Boulder, Colorado, to widen your experience. Throughout the project, you will be expected to write and publish your results in the scientific literature and present results at national and international science meetings. The ideal candidate will have a quantitative science/engineering/computing background, and a strong interest in atmospheric/Earth system science. Prior experience with atmospheric or Earth system modelling or data analysis is not essential.

References

Cooper, O. R., et al. (2014) Global distribution and trends of tropospheric ozone: An observation-based review, Elementa: Science of the Anthropocene, 2:000029, doi: 10.12952/journal.elemnta.000029

O'Connor, F. M., et al. (2014) Evaluation of the new UKCA climate-composition model – Part 2: The Troposphere, Geosci. Model Dev., 7, 41-91, doi: 10.5194/gmd-7-41-2014

30-word project summary for advertising:

Recent model developments allow natural variability of short-lived climate pollutants to be simulated in greater detail. Improved quantification of natural variability helps isolation of anthropogenic components, aiding mitigation policy development.