What emissions reductions can solve current UK air pollution problems?

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Project background
Poor air quality is a major issue, not just for its adverse effects on human health and quality of life but also for its impacts on natural and crop ecosystems. The air pollutants with greatest burdens on health are particulate matter (PM), nitrogen dioxide (NO$_2$) and ozone (O$_3$), whilst for ecosystems they are O$_3$ and the dry and wet deposition of nitrogen and sulphur.

Regional-scale atmospheric chemistry transport models are an important tool for understanding and quantifying the chemical and meteorological linkages between the wide diversity of sources of emissions of pollutants into the air and the concentrations and deposition of both primary and secondary pollutants at locations away from the emissions (Fig. 1). Such models are essential when it comes to simulating how different potential actions to mitigate air pollution will change future air quality. Given that far-reaching policy decisions are based on evidence from these models, it is crucial there is as much confidence as possible in their accuracy. This project will use the EMEP4UK atmospheric chemistry transport model, which is a UK-focused high-resolution version of the EMEP model that is widely used for European air quality policy evidence [1,2].

One approach to model validation is historic back testing, i.e. evaluation of the extent to which the model can simulate past temporal, and spatial, trends in air pollutant concentrations and deposition. The UK, and much of the rest of Europe, now have up to a few decades of pollutant measurements, against which model simulations of past conditions can be compared using past meteorological fields and best estimates of past emissions. These evaluations provide particularly stringent tests of the performance of a model for describing the non-linear processes associated with secondary pollutants such as ozone, and the ammonium nitrate and ammonium sulphate components of PM and of N and S deposition, against the backdrop of different rates of decline in the NO$_x$, VOC, SO$_2$ and NH$_3$ precursor emissions. Historic back testing of the model for these secondary pollutants will form the initial focus of investigation. However, the project has potential to develop in a number of directions relating to policy-relevant simulations of air quality, according to the student’s interests, including for example those associated with the carbonaceous component of PM [3,4].

Key research questions
- Can we assure robustness of current state-of-the-art atmospheric chemistry transport models for scientific support of air quality policy development?
- How can the UK most effectively mitigate its current deleterious air quality?
Methodology

0-6 months: Literature review of air pollution chemistry and past trends in air quality; training and familiarity in use of the EMEP4UK (atmospheric chemistry transport) and WRF (numerical and weather forecast) models.

6-24 months: collation of historic estimates of primary precursor emissions; model simulations of past trends for ozone and for the N and S components of PM and deposition; comparison of model output against observational datasets of historic temporal and spatial air pollutant concentrations and deposition for the UK, and elsewhere in Europe; identification of the nature of non-linearities and the investigation of the causes of any model-observation discrepancies (by the nature of open-ended research, the project description cannot be prescriptive here, since the outcome of the evaluation is not known).

24-36 months: model simulations for potential future emissions reductions; preparation and submission of journal papers.

36-42: continued preparation of journal papers and thesis write-up.

Training

A comprehensive training programme will be provided comprising both specialist scientific training and generic transferable and professional skills. The latter includes a programme focused on personal effectiveness, communication, and career management, as well as courses on project management, literature searching, oral presentations, and paper and thesis writing. The student will undergo intensive training in the operation of the EMEP4UK-WRF atmospheric chemistry transport model, and also in tools and methods for data and statistical analysis (e.g. NCL, Python, and R). Depending on their background, the student will attend relevant atmospheric and meteorology courses in the UoE Schools of GeoSciences & Chemistry, and will have full access to the E3 DTP training programme. The student will also receive training in undergraduate laboratory demonstrating and project supervision, and, if they wish, in areas such as schools or public outreach activities. The student will also have the option to attend various external PhD training events laid on by NERC and other institutions. The supervisors, together with other colleagues at CEH, regularly interact with air quality policy-makers and other stakeholders so there is a wealth of supervisory expertise available.

Requirements

Candidates should have a good undergraduate or Master’s degree with a strong numerical background in environmental, physical or chemical sciences, preferably with atmospheric knowledge. Experience with Linux and/or operating complex computer models would be distinctly advantageous.

References


Project summary

This project will evaluate the EMEP4UK atmospheric chemistry transport model for simulation of air pollutant concentrations and deposition in the context of historic and potential future changes in pollutant emissions.