Master thesis projects in the research group "Air Quality Modelling" at IASS Potsdam

This document describes three possible master thesis projects at IASS Potsdam under joint supervision of Prof. Dr. Tim Butler. Details of each project can be further discussed based on interest. Additional ideas for research projects are also welcome.

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Two projects on ozone Source/Receptor relationships

Tropospheric ozone pollution is harmful to animals and plants. Tropospheric ozone is not directly emitted, but rather produced in the atmosphere through chemical reactions involving emitted precursors NOx (oxides of nitrogen) and VOC (Volatile Organic Compounds). Ozone and some of its precursors can be transported over long distances. There are both natural and anthropogenic sources of NOx and VOC. To devise control measures to reduce ozone pollution it is necessary to understand the contribution of different sources of NOx and VOC, and possibly also the ozone production regime (NOx- or VOC-limited) in the source and receptor regions. Several methods have been developed to attribute modelled ozone to its emitted precursors. Two such methods are the perturbation method, in which model sensitivity runs are performed with altered emissions of ozone precursors, and the tagging method, in which special tracers are introduced to a model to represent and track the production of ozone from specific emissions. Both methods produce a source/receptor (S/R) matrix relating the modelled ozone in receptor regions to the emissions of precursors in source regions. Two projects are available on this topic.

1) **Comparison of ozone source attribution methods**

This project will compare the ozone attribution from the perturbation and tagging methods in an existing dataset of model output. Both perturbation and tagging runs have been performed at IASS Potsdam using the CAM-chem model in the context of the HTAP2 multi-model exercise. Additional output from perturbation runs is available from other models which participated in the exercise. Research questions:

- Do the perturbation and tagging methods give similar S/R relationships?
- Under what circumstances are the S/R relationships from tagging similar or different from perturbation studies?
- How are the previous questions affected by the choice of ozone impact metric (eg. annual average, MDA8, etc…)

Strong programming skills, with a focus on analysis and visualisation of large datasets, are required for this project.

Literature is available on request.

2) **Rapid assessment of emission scenarios using source-receptor relationships**

This project will be carried out in cooperation with colleagues at the US-EPA and other cooperating institutions. The project will contribute to the development of the OpenFASST rapid assessment tool. OpenFASST contains a database of pre-calculated S/R relationships, and effectively emulates the ensemble of 3D Chemical Transport Models which was used to calculate these relationships. OpenFASST is still under development. Possible projects could focus on:

- Updating the S/R relationships to account for nonlinearities in the response of ozone to precursor emissions.
- Additional projects in consultation with colleagues at the US-EPA.

To satisfy the research requirements of the master program, the OpenFASST tool will also be applied for assessment of emission scenarios.

Strong programming skills, with a focus on software development and databases, are required for this project.

Additional information is available on request, through consultation with the cooperation partners involved in this project.

Long-term trends in the health impacts of ozone and NO2 in European cities

Ozone and NO2 are closely chemically related to each other through the Photostationary Steady State (PSS) relationship. Ozone reacts rapidly with NO, forming NO2, while NO2 is rapidly photolyzed, re-forming ozone. Changing emissions of NO can thus alter the ratio of ozone to NO2. Under a VOC-limited chemical regime, lower emissions of NO can lead to lower concentrations of NO2 and higher concentrations of ozone. Emissions of NO have been declining in the EU since about 1990. A corresponding increase in ozone and decrease in NO2 in urban areas has also been noted. Part of this trend may however be due to changes in long-range transport of background ozone. Examining the sum of ozone and NO2, Ox, can be used to distinguish between changes in background ozone and changes in local chemistry. Both ozone and NO2 have impacts on human health.

- What are the long-term trends of ozone, NO2, and Ox in urban areas?
- What chemical regimes are present and how have they changed?
- How has background ozone changed over the measurement period?
- Does the reduction in urban NO2 offset the health impact of increasing urban ozone?

Long-term measurements for Europe are available from the European Environment Agency's AirBase database. The World Health Organisation's "AirQ+" tool can be used to calculate the health impacts of ozone and NO2.

A good background in programming, with a focus on timeseries analysis, is advisable for this project.

Literature is available on request.