**Impacts of Atmospheric Iodine upon Tropospheric Composition and Chemistry**

**Supervisor: Dr William Bloss Contact: w.j.bloss@bham.ac.uk**

**Abstract**

The potential impact of halogen species upon lower atmospheric (tropospheric) composition has been widely recognized. Reactions of iodine, released from marine sources, can perturb the abundance of other reactive atmospheric components, in particular leading to "ozone depletion events", when local ozone levels drop to zero in a few hours. Attempts to simulate the observed ozone loss with models frequently fail, as the details of many of the iodine reactions occurring are not known, and are hard to study individually in the laboratory. The aim of this project is to directly measuring the iodine-driven ozone destruction rate, using a new laboratory approach which circumvents the limitations of previous studies. The project will involve modification of an existing instrument to perform iodine measurements, application of the system to simulate atmospheric iodine-ozone interactions, and interpretation of the results obtained using numerical models of atmospheric chemistry, for comparison with field observations. This project will be laboratory based, however it is likely that the student will have the opportunity to participate in field measurement activities during the course of their studies. The project will be supervised by Dr Bloss, with day-to-day support available from other researchers currently working in the group (see www.atmos.bham.ac.uk), and will be able to collaborate with colleagues whose interests span environmental chemistry, meteorology, climatology, atmospheric chemistry and air quality. Depending upon their background, the student will also attend selected modules from MSc courses in Applied Meteorology & Climatology and Air Pollution Management & Control, taught within the School, which will provide broader context to the project.

**Introduction:** Halogen species are widely associated with the destruction of the stratospheric ozone layer; however recently their potential impact upon lower atmospheric (tropospheric) composition has been widely recognized. Reactions of iodine, released from marine sources, can lead to catalytic ozone destruction, perturb the abundance of other reactive atmospheric components such as $HO_x$ and $NO_x$ species, and lead to the production of new particles, which potentially can increase cloud condensation nuclei concentrations and hence affect climate. However, many details of these processes are uncertain, limiting our ability to quantify the role of iodine upon the atmosphere. In particular, iodine species have been implicated in "ozone depletion events", when local ozone levels drop to zero in a few hours. Attempts to simulate the observed ozone loss with models frequently fail, as the details of many of the iodine reactions occurring are not known, and are hard to study individually in the laboratory (*e.g.* Bloss *et al*., 2010). **The aim of this project** is to directly measuring the impact of iodine reactions upon atmospheric ozone, using a new approach which circumvents the limitations of previous studies. This will allow us to quantitatively determine the impact of iodine chemistry upon tropospheric ozone.

**Approach**: We are currently implementing a new analytical technique to measure the in situ local atmospheric chemical ozone production rate (OPR), and its dependence upon atmospheric conditions (Cazorla & Brune, 2010), funded through a NERC research grant. Briefly, the instrument comprises a pair of gas reaction cells, a reaction cell and a control cell. Within the cells the photochemical environment (photolysis spectrum, pressure, initial reagent conditions) may be independently varied, and the ozone level emerging from the two reactors compared, allowing the total impact of the chemical processes occurring to be determined. This approach implicitly integrates the real atmospheric complexity – as all the relevant atmospheric processes will naturally occur within the system. As currently developed, the system measures in situ atmospheric ozone *production*, in the context of urban air pollution. Within this PhD project, we will reverse the OPR concept, to extend the capabilities of the same instrument to measure the local in situ *ozone*

*destruction rate.* The system will then be used in the laboratory to measure the iodine-catalysed ozone loss rate, and explore the variation of this with iodine and ozone abundance, photolysis envelope (specific pathways can be precluded by removing sections of the artificial UV-Visible illumination spectrum through filtering) and pressure. These experiments will directly determine the atmospheric ozone loss rate resulting from a given iodine loading, which may then be compared with field observations and model simulations.

The **specific objectives** of this PhD project are to (i) extend the operating scope of the OPR instrument to measure ozone destruction rates (ii) validate the revised OPR system in the laboratory, (iii) to apply the revised OPR system to investigate the response of iodine-catalysed ozone loss to reactant level, pressure and photolysis intensity / spectral distribution and (iv) to compare the measured ozone loss rate with that observed in the atmosphere, and predicted by atmospheric chemical models.

**Project Outline**: Initially, the student will gain familiarity with atmospheric laboratory techniques, including the existing OPR instrument. Subsequently, the student will assess the changes to the OPR operating parameters necessary to measure the anticipated ozone loss rates. This is likely to involve re-design of the two parallel reactors used in the measurement to achieve an appropriate residence time. The modified OPR instrument will be tested in the laboratory against the (comparatively) well understood bromine-ozone system, and applied to the iodine system: The dependence of ozone loss rates upon iodine abundance, pressure and photolysis conditions will be studied, with experiments designed to replicate ambient atmospheric conditions. Interpretation of these data will involve use of computer simulations of the atmospheric chemical processes. This project will be laboratory based, however it is likely that the student will have the opportunity to participate in field measurement activities during the course of their studies.

**Background, Support and Training** A background in chemistry, physics or an equivalent environmental science is required. Full training in the specific laboratory techniques will be provided, led by Dr Bloss, with day-to-day help and guidance available from other researchers currently working in the group (see www.atmos.bham.ac.uk). The student will be able to collaborate with colleagues whose interests span environmental chemistry, meteorology, climatology, atmospheric chemistry and air quality. Depending upon their background, the student will also attend selected modules from MSc courses in Applied Meteorology & Climatology and Air Pollution Management & Control, taught within the School, which will provide broader context to the project. They will be encouraged to attend the NERC NCAS summer school on Atmospheric Science, in the first year of the project. The student will be supported in preparing their results for publication, both internally, and in academic journals and at national / international conferences. The student will also benefit from interaction with the wider atmospheric and environmental research activities in the school.

**For more information, please contact Dr William Bloss, w.j.bloss@bham.ac.uk**

References (open access) :

1. Bloss *et al.*, *Coupling of HOx, NOx and halogen chemistry in the Antarctic boundary layer, Atmos. Chem. Phys.* 10, 10187-10209, 2010.
2. Cazorla & Brune, *Measurement of Ozone Production Sensor*, *Atmos. Meas. Tech.*, 3, 545–555, 2010