UNITED KINGDOM

OBSERVATIONAL ACTIVITIES

Column measurements of ozone and other gases/variables relevant to ozone loss

The UK Government's Department for Environment, Food and Rural Affairs (Defra) funds an on-going monitoring programme that records total values of stratospheric ozone at two UK locations. Measurements with a Dobson instrument are taken at the long-term Lerwick Observatory in the Shetland Islands (N of Scotland) and a Brewer spectrophotometer is used at the Reading site in Berkshire (S England). The latter site replaced the Camborne Observatory site in Cornwall at the end of 2003, where a Dobson instrument had been used for ozone measurements. The spectrophometers are used to record daily values, except when weather conditions prevent values from being recorded and during the winter at Lerwick when the sun is too low in the sky. Column ozone measurements which are made (but funded separately) at the University of Manchester (N England), using a Brewer instrument, are also made available for this monitoring programme. Days where the processed total ozone is below two standard deviations less than the long-term average mean for that month are designated as 'low ozone' events and are reported to the UK government immediately along with additional analysis.

The British Antarctic Survey (BAS), which is funded by the Natural Environment Research Council (NERC), runs a Dobson spectrophotometer at the Halley station and a SAOZ spectrometer at the Rothera station, in Antarctica. The BAS also supports the ozone monitoring programme run by the Ukrainian Antarctic Research Centre at Vernadsky station.

A SAOZ zenith sky visible spectrometer is operated at a site near Aberystwyth, Wales to measure mean values of total ozone (and nitrogen dioxide) both at sunrise and sunset on a daily basis.

Profile measurements of ozone and other gases/variables relevant to ozone loss

Defra has provided support for projects that monitor ozone-depleting substances by analysing ground-based measurements at Mace Head, County Galway (Ireland). High frequency, real time measurements of the principal halocarbons and radiatively active trace gases have been made at Mace Head since 1987, as part of the Global Atmospheric Gases Experiment (GAGE) there. For about 70% of the time the measurement station, which is situated on the Atlantic coast, monitors clean westerly air that has travelled across the North Atlantic Ocean. For about 30% of the time, Mace Head receives substantial regional scale pollution in air that has travelled from the industrial regions of Europe. The site is therefore uniquely situated to record trace gas concentrations associated with both the Northern Hemisphere background levels with the more polluted air arising from Europe.

Using the Mace Head data and a Lagrangian dispersion model NAME (Numerical Atmospheric dispersion Modelling Environment), driven by the output from the U.K. Met Office's Numerical Weather Prediction model, it is possible to estimate Northern Hemisphere baseline concentrations for each trace gas and their European and UK emission distributions. Analysis of the Mace Head data provides valuable information on quantifying Northern Hemisphere and European emissions of gases and identifying sources of and trends in ozone formation from different areas. This work will also involve a comparison of observed data with expected trends, and identify any new substances with ozone depleting or radiative forcing properties. The possible use and analysis of any data coming from other sites that could be of policy relevance is currently under consideration.

UV measurements

Broadband measurements

The solar UV index is measured at seven sites in the UK by the Radiation Protection Division of the Health Protection Agency. The Department of Health provides support for this UV monitoring work, which provides information for the Global Solar UV Index in association with WHO, WMO, UNEP and the International Commission on Non-Ionizing Radiation Protection.

Narrowband filter instruments
No instruments of this type are currently being used in the UK.

Spectroradiometers
Two UV monitoring sites are in operation, at a green-field site at Reading (funded by Defra) and a city site in Manchester. At Reading the Bentham DM150 UV spectroradiometer is calibrated on site and the site has been providing regular measurements since 1993. This instrument takes spectra from 290nm to 500nm at 0.5nm resolution every half-hour, between - 85deg < Zenith < +85deg. every day of the year. Periodic international comparisons with other UV spectroradiometers have provided consistently good results. The Manchester instrument provides five minute averages in each of five narrow wavebands (305, 313, 320, 340, 380nm). Apart from calibration periods, the latter instrument has been in continuous operation since 1997, and provides a southern site in the Nordic network of GUV radiometers.

Calibration activities
The Brewer instruments were calibrated in 2005 and 2007 at the Regional Brewer Calibration Centre-Europe (RBCC-E) inter-comparison exercises in El Arenosillo, Southern Spain. The current recommendation is to re-calibrate every two years.

The Dobson spectrophotometer inter-comparison took place at El Arenosillo in September 2007. This forms part of the World Meteorological Organisation's QA/QC programme to assure the quality of the measurements and to assess the performance of the instruments. All instruments are carefully maintained and checked monthly.

At the end of 2005, the BAS Dobson spectrophotometer was upgraded with modern electronics and recalibrated, at the European Centre at Hoenpeissenberg. BAS's old SAOZ spectrometer was replaced by a new one in 2007, which became the operational instrument in 2008 after a period of overlap.

RESULTS FROM OBSERVATIONS AND ANALYSIS

The long term monthly means and standard deviations for column ozone levels at both the Lerwick and Reading monitoring sites are shown in Figures 1 and 2.

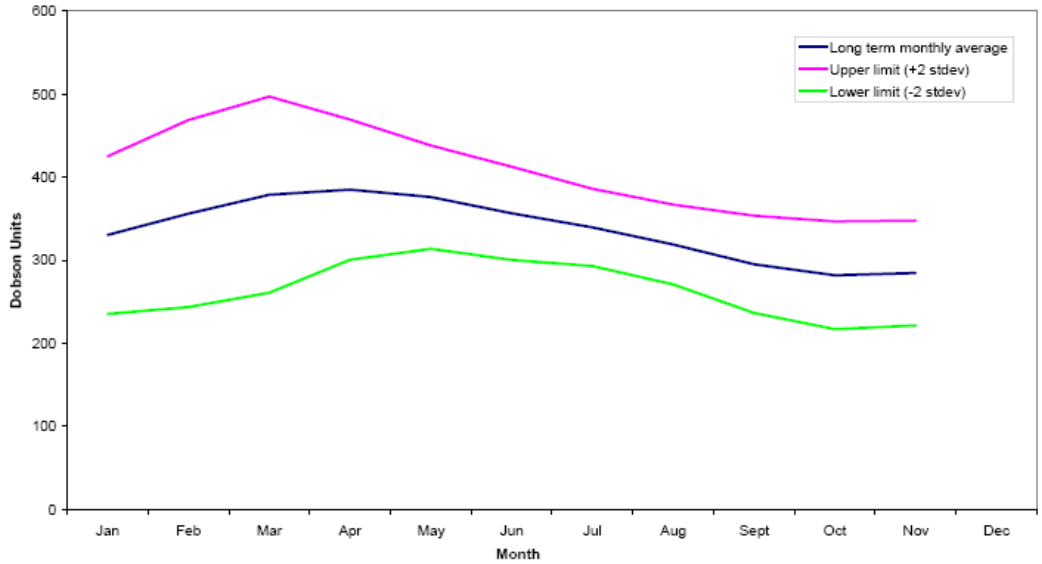

Figure 1: Ozone Climatology data, Lerwick, based on 1981-2007.

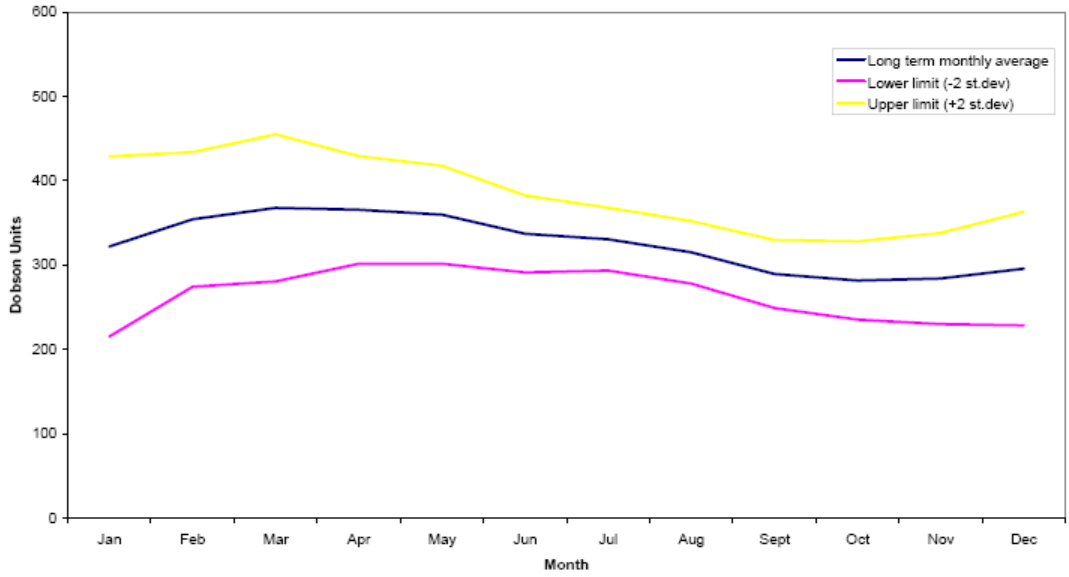

Figure 2: Ozone Climatology data, Reading, based on 2003-2007.

THEORY, MODELLING, AND OTHER RESEARCH

No activities to report.

DISSEMINATION OF RESULTS

Data reporting

The ozone monitoring data from Lerwick and Reading are processed daily by the local operators and then quality checked and disseminated. A number of checks are performed in order to ensure the integrity of these data, including comparison of daily results with OMI satellite measurements and the nearest ground-based measurements. Dissemination involves uploading a 'best daily average' to a dedicated web page (www.ozone-uv.co.uk) on the internet and issuing the results to the World Ozone and Ultra Violet Data Centre (WOUDC) Real-time Mapping Centre. Monthly data are submitted to the WOUDC for inclusion on their archive.

Data from the BAS Dobson and SAOZ spectrometer measurements are published in near real time on the BAS ozone web page (http://www.antarctica.ac.uk/met/jds/ozone/.
The Dobson measurements are also submitted to the WOUDC and WMO.

The UV measurement data from Manchester and Reading are submitted to the WOUDC.

Information to the public

Ozone monitoring results from the Lerwick and Reading sites are publicly available on the website (http://www.ozone-uv.co.uk/).

UV information and forecasts from the HPA broadband UV monitoring network are made available on the HPA and Meteorological Office websites. Data from the Reading monitoring site, converted into a simple UV index comparable with the HPA results, is also made available via the website (http://www.ozone-uv.co.uk/) in near real-time for public information.

Relevant scientific papers

Quarterly and annual reports are produced on the ozone and UV monitoring programme.

PROJECTS AND COLLABORATION

As part of the UK monitoring project, Defra funds some analysis of the ozone data collected at Reading and Lerwick. This research focuses on identifying low ozone events, and predicting how the frequency of low ozone events could alter as stratospheric levels change.

There are a number of NERC-funded ozone research projects that have either recently been completed or are currently ongoing. The Upper Troposphere/ Lower Stratosphere (UTLS) OZONE Programme, from 1999 to 2006, aimed to improve understanding of the causes of ozone change in the UTLS in the past, present and future. Ozone has been changing in this region of the atmosphere but the causes have been uncertain. A wide number of scientific research projects were funded, with topics ranging from transport of trace gases on annual and seasonal timescales, dynamical processes occurring on short-timescales, studies of chemical processes in the atmosphere and the laboratory and modelling studies of chemistry-climate interactions. This research has led to an improved understanding of chemical composition and structure in the UTLS region between 6 and 20km. Results from the Programme have shown, in particular, that interactions between dynamics (meteorology) and chemistry in the atmosphere play an important role in governing the distribution of ozone and other trace gases in the UTLS.

A 1-year NERC project, which ended in 2007, looked at understanding the climate response to stratospheric ozone depletion. The project, led by the University of East Anglia, identified particular processes involved in the tropospheric cooling response to ozone depletion over Antarctica. A 3-year research study, started in 2007 and also led by the University of East Anglia, is modelling climate change in the Southern Hemisphere, according to predictions of future ozone change.

NERC is funding a 5-year coordinated study, which started in 2007, on the influences of solar variability on atmospheric composition and climate. The SOLCLI consortium is led by Imperial College, with partners at the Universities of Cambridge, Leeds and Reading and the British Antarctic Survey and with collaborators in Germany, Japan, the USA and the UK Met Office. Study topics include: variability over the past 150 years in solar spectral irradiance; detection of solar signals throughout the lower and middle atmosphere; response of stratospheric composition, specifically ozone, to varying UV; mechanisms for stratosphere-troposphere dynamical coupling; and better representation of solar effects in climate models.
(see http://www.sp.ph.ic.ac.uk/~ssparrow/Solcli_web/solcli_home.htm).

The European Commission (EC) research programmes encourage collaborative projects involving research groups in different countries. The European Ozone Research Co-ordinating Unit (EORCU), based at the University of Cambridge, was set up in 1989 to coordinate stratospheric ozone research in Europe from both the national research programmes and the European Union research programme. There have been numerous joint projects between European scientists, the particular project described below is coordinated by a UK institution (University of Cambridge).

Stratospheric-Climate links with emphasis On the Upper Troposphere and lower stratosphere (SCOUT-O3) is a 5-year EC Integrated Project, ending in April 2009, which has 59 partner institutions and over 100 scientists involved from 19 countries. SCOUT-O3's aim is to provide predictions about the evolution of the coupled chemistry/climate system, with emphasis on ozone change in the lower stratosphere and the associated UV and climate impact. These forecasts will be major European contributions to international assessments of ozone depletion and climate change prepared in support of policy such as the WMO-UNEP ozone assessments (Montreal Protocol) and the IPCC reports (Kyoto protocol). The forecasts will be built on models, which are being refined and improved in this study by exploitation of existing data for model testing and validation and by the provision of new data on fundamental processes. These forecasts will represent a considerable improvement on current predictions, being based on the significantly improved descriptions of the upper troposphere and stratosphere which the project will achieve. To meet these goals, SCOUT-O3 is split into 10 project objectives and eight activities (see http://www.ozone-sec.ch.cam.ac.uk/scout_o3/). Significant contributions from this project have already been made to the 2006 WMO-UNEP Ozone Assessment and to a number of initiatives

organized within the international programme Stratospheric Processes And their Role in Climate (SPARC).

The EORCU is currently, or has recently been, involved in a number of other projects, including: the QUANTIFY Integrated Project and the ATTICA assessment project, both of which are concerned with emissions from different forms of traffic; and the CANDIDOZ project.

The Met Office Hadley Centre (MOHC), at Exeter, is working on the modelling of stratospheric and tropospheric ozone and their relationship to climate change, as part of its Defra and Ministry of Defence funded Integrated Climate Programme (ICP). The MOHC co-leads a work package on model validation and comparison for the EU SCOUT-O3 project and is represented on the coordinating/planning committees of two of the WCRP's SPARC modelling initiatives: CCMVal (Chemistry-Climate Model Validation) and DynVar (Modelling the Dynamics and Variability of the Stratosphere-Troposphere System). The MOHC group made major modelling and co-author contributions to the 2006 WMO/UNEP ozone assessment report. The MOHC is currently combining its stratospheric and tropospheric ozone models, in collaboration with the Universities of Cambridge and Leeds, to develop a whole atmosphere chemistry model UKCA (United Kingdom Chemistry and Aerosols). This will be combined with the MOHC's climate and ecosystem models to create a full Earth-System Model to predict the climate feedbacks involving ozone between climate, chemistry and ecosystems. This links in strongly with the NERC QUEST programme, its earth-system modelling (QUESM), the atmospheric chemistry component (QUAAC) and the land surface component (JULES).

FUTURE PLANS

Defra does not have any plans at present to provide direct government funding for any additional ozone, UV or ODS monitoring sites in the UK. The current basic levels of monitoring will, however, be continued.

Defra is keeping future research needs for policy development on stratospheric ozone under review.

NERC is continuing to provide some funding support for new research projects on ozone.

NEEDS AND RECOMMENDATIONS

There is a key need for further research on the interactions between stratospheric ozone and climate change. The capability of climate models to represent stratospheric (including stratospheric ozone) processes and interactions needs further development. More research is also required to understand the basic physical processes involved in ozone-climate links. The impacts of aviation on stratospheric chemistry and climate may also need further consideration.

Further work should be undertaken to clarify recent findings on the photolysis rate for dichlorine peroxide (Cl_2O_2), in view of its implications for the chemical model of ozone destruction.

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