H13-148
TOWARDS SMARTER AIR QUALITY ANALYSIS

Duncan Whyatt[1], Andy Malby[1] and Roger Timmis[2]

[1]Lancaster Environment Centre, Lancaster University, United Kingdom
[2]Environment Agency for England and Wales, United Kingdom

Abstract: This presentation describes the remit of a 3-year knowledge exchange project which aims to develop, disseminate and ultimately promote uptake of smarter forms of air quality analysis for more effective air quality management. Two "smarter" techniques are introduced then used to characterise modelled and monitored impacts of a large coal-fired power station on a down-wind monitor.

Key words: *Knowledge Exchange, Visualisation, Conditional Analysis*

INTRODUCTION
The UK Natural Environment Research Council (NERC) is funding two complementary air-quality informatics projects called "AirTrack and "Openair" under its Knowledge Exchange (KE) scheme. KE projects promote sharing of knowledge, people, skills and expertise between the research base and user communities. *AirTrack* (http://airtrack.lancs.ac.uk) is based at Lancaster University, and is developing better methods of air-quality analysis that resolve more clearly the performance of models, sources and controls, and is disseminating these methods to the air-quality community through a series of case studies, technical notes and workshops. *Openair* (http://www.openair-project.org) is led by King's College London in collaboration with Leeds University, and is providing free, open-source tools for innovative data analysis in "R" – a programming language designed for rapid and consistent data analysis. Both projects are helping practitioners to use "smarter" techniques for air-quality analysis and performance tracking, which previously have resided in the research base.

This poster introduces two techniques developed by the *AirTrack* team, namely i) bi-polar plots the visualisation of source impacts and ii) a dispersion calendar for the analysis of impacts in dispersion space. These techniques are used in combination to gain deeper insight into the sources and conditions leading to elevated SO_2 concentrations at a monitor located between three large coal-fired power stations. The dispersion calendar is subsequently used to assess the ability of an industry standard dispersion model to reproduce these elevated concentrations for 'the right reasons' based on a conditional dissection of dispersion space. This approach to model validation contrasts strongly with conventional approaches that tend to assess performance under composite as opposed to specific conditions.

Our ultimate aim is to promote the use of smarter techniques of air quality analysis within the community for more timely, cost-effective and intelligent air quality management. Our success, in part, will be measured in terms of awareness and uptake within the user community. The HARMO 13 conference has attracted air quality specialists from 39 countries. Conference delegates are encouraged to study our posters (H13-133 and H13-148), discuss our techniques, and provide feedback on how these might be promoted and adopted within their own countries.

RATIONALE FOR 'SMARTER' ANALYSIS
Ambient air quality data is typically expensive to collect yet its informatics potential is seldom fully exploited. For example, the majority of local authorities in the UK simply use hourly data to plot time-series and compute summary statistics for compliance monitoring. Tools for smarter forms of analysis have been around for many years, however, they have not been widely adopted by the user community for a variety of reasons. Smarter forms of analysis have many advantages over traditional forms of analysis – they can be used to readily distinguish between source effect and meteorological noise in ambient data, they can be used to provide early evidence of changes in air quality due to policy intervention, and can be used to derive broad 'airshed' as opposed to localised 'hotspot' information on air quality, an important consideration in light of new legislation on exposure reduction.

In the context of dispersion modelling, there are a number of tried and trusted means of assessing model performance. However, these tend to assess performance under composite as opposed to specific dispersion conditions, making it difficult to assess whether models get the right results for the right reasons. Considerable additional insight may be gained through analysing model performance under specific conditions, defined by parameters such as meteorology, time of day and the degree of activity associated with a given source (e.g., industrial process) or activity (e.g., road transport).

Here we demonstrate how smarter forms of air quality analysis can be used to isolate then subsequently characterise the impacts of a large power station on a down-wind monitor, and how the performance of an industry-standard dispersion model can be verified through comparison with monitored data in dispersion space.

CONDITIONAL ANALYSIS OF MONITORING DATA
The Aire Valley contains three large coal-fired power stations (Ferrybridge, Eggborough and Drax) with a combined generating capacity of 7.8 GW. Locations of power stations and corresponding monitoring sites are shown in Figure 1a.

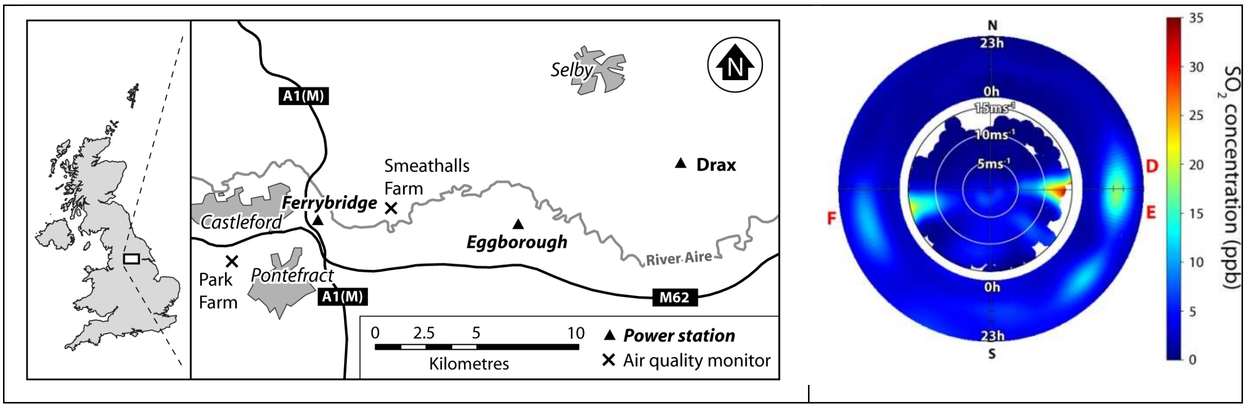

Figure 1. a) Location of power stations and monitoring sites in the Aire Valley, West Yorkshire, UK and b) bi-polar plot showing wind speed and directional dependence of ambient SO_2 concentrations recorded at the Smeathalls Farm monitor in 2001.

Figure 1b demonstrates the informatics value of combining an annual time-series of pollution data from the Smeathalls Farm monitor with equivalent hourly meteorological data obtained from a nearby weather station. The bi-polar plot clearly shows the impact that Ferrybridge makes on ambient SO_2 concentrations recorded at the Smeathalls Farm monitor when the wind is blowing from the west-southwest, and the combined impacts of Drax and Eggborough when the wind is blowing from the east. The inner plot reveals that these elevated concentrations tend to be associated with wind speeds in excess of 10 ms^{-1}. The outer plot reveals that the elevated concentrations tend to occur during the middle of the day.

In this example a bi-polar plot can clearly be used to separate the impacts of Ferrybridge power station from other local and more distant sources. Malby *et al.* (2009) have gone on to extract data from the Smeathalls Farm monitor for a number of years, and through analysing data for a limited directional (250-270 degrees) and wind speed range (8-12 ms^{-1}) have been able to confirm changes in fuel management at the power station.

At the HARMO 11 conference Malby *et al.* (2007) introduced the Dispersion Calendar as a means of plotting ambient concentrations as a function of season, time of day, wind speed and cloud cover. Here we use the calendar to plot top decile SO_2 concentrations recorded at the Smeathalls Farm monitor in 2001. The 11.00-15.00 section of the Dispersion Calendar is shown in Figure 2. The upper plot, labelled monitoring, plots where the highest concentrations occurred in dispersion space. The numbers in the individual cells of the calendar relate to frequency of occurrence, expressed in hours per year. The cells are colour-coded by dispersion class in this instance, as defined by the Pasquill-Gifford scheme, but could equally be coloured by magnitude of monitored concentration. The calendar reveals that there are a greater number of raised impacts in spring and summer months than there are in autumn and winter months. The calendar also reveals that spring and summer impacts tends to be associated with convective (plume looping) conditions whilst autumn and winter impacts tend to be associated with high wind speed (plume knock down) conditions. The calendar therefore provides additional insight into the nature of the processes delivering raised impacts, which has clear implications for modelling.

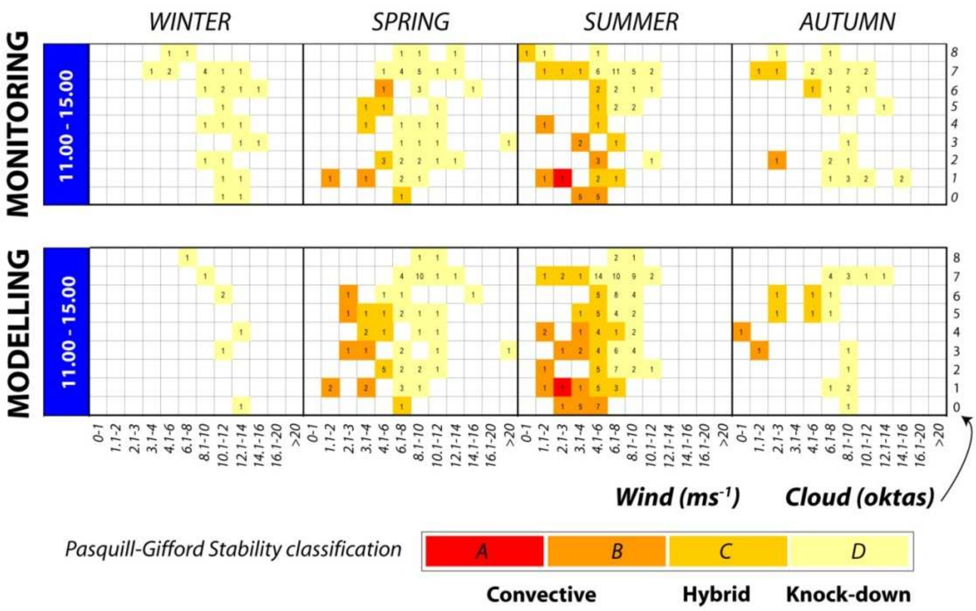

Figure 2. Dispersion Calendar for 11.00-15.00 showing modelled (upper) and monitored (concentrations) in dispersion space expressed in terms of stability class.

CONDITIONAL ANALYSIS OF MODELLED DATA

The dispersion model ADMS 4.1 (CERC, 2007) was used to model the impact of a large elevated point source located at Ferrybridge on concentrations at the Smeathalls Farm receptor. Since detailed emissions data for Ferrybridge were not available to us at the time of this study we assumed constant unit emissions and plotted top decile modelled SO_2 concentrations in the Dispersion Calendar. The lower plot in Figure 2, labelled modelling, shows that on this occasion the model predicts a similar number of elevated concentrations, with similar seasonal distribution and similar number of hours per stability class.

In the event of emissions data being made available a more rigorous comparison of monitored and modelled concentrations could be undertaken. At present, whilst we conclude that the model produces a similar number of top decile events which show a similar distribution to monitored data when plotted in the Dispersion Calendar, we have no means of assessing the magnitude of modelled impacts. These impacts could be much larger or smaller than those modelled here, and could occupy different positions in dispersion space. Discrepancies between modelled and monitored concentrations in dispersion space would lead us to examine specific parameters and processes in more detail, to gain a deeper understanding of model limitations under specific dispersion conditions.

CONCLUSION

AirTrack is a knowledge exchange project which aims to promote the use of smarter forms of air quality analysis throughout the user community. It aims to achieve this through engaging with selected users in a series of high profile case studies, and developing new techniques to fully exploit the informatics potential of modelled and measured ambient air pollution time-series. Case study methods and outcomes of analysis will be disseminated to the wider air quality community via a dedicated web site (http://airtrack.lancs.ac.uk) and presentations at appropriate academic and professional forums.

The success of our project will be measured in terms of awareness, understanding and uptake from the user community. Ultimately this may lead to techniques being routinely adopted and embedded in 'best practice' guidance notes. The main purpose of this poster is to draw the project to the attention of HARMO conference delegates. Beyond the conference we hope that delegates will develop an interest in our activities, visit our website, and provide feedback on the techniques we are developing.

REFERENCES

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