Monitoring Ambient Air 2017

Air Quality - the wider picture
Current Issues and New Technologies

Conference with
Posters and Exhibition

Organised by the
Automation and Analytical Management Group -
Royal Society of Chemistry

Wednesday 13th & Thursday 14th December 2017

at The Royal Society of Chemistry,
Burlington House, Piccadilly
London W1J 0BA

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Wednesday 13th and Thursday 14th December 2017
The Royal Society of Chemistry, Burlington House, London

Day 1 - Wednesday 13th December

09:30 Registration

10:25 Welcome and Introductory Remarks

Session 1: Recently Published AQEG Reports

Chair: **Paul Monks** - University of Leicester, UK

10:30 Presentation of the AQEG Biomass report
Alison Tomlin, *University of Leeds, UK*

11:00 Discussion of report conclusions

11:20 Presentation of the AQEG shipping report
Mathew Heal, *University of Edinburgh, UK*

11:50 Discussion of report conclusions

12:10 Presentations by exhibitors

12:40 **Lunch - exhibition & posters**

Session 2: Assessment of the Effects of Interventions

Chair: **Paul Monks** - University of Leicester, UK

13:40 Introduction to and scope of the AQEG report
David Carslaw, *University of York / Ricardo, UK*

14:10 A tale of two cities: is air pollution improving in London and Paris?
Anna Font, *King's College London, UK*

14:40 Towards the optimum solution to poor urban air quality caused by motor vehicles
Nick Molden, *Emissions Analytics Ltd, UK*

15:10 Tea / Coffee - Exhibition & Posters

15:40 Measurements and source apportionment of airbourne particulate matter in the vicinity of Heathrow airport
Roy Harrison, *University of Birmingham, UK*

16:10 Recent findings from vehicle emission remote sensing from UK measurements
Rebecca Rose, *Ricardo Energy and Environment, UK*

16:40 Bad Emitting Vehicles: Once spotted can we fix them?
Karl Ropkins, *University of Leeds, UK*

17:10 Close of Day One

Day 2 - Thursday 14th December

09:30 Coffee and Exhibition

Session 3: Measurement Technologies

Chair: **Gary Fuller** - King's College London, UK

10:00 A new online instrument to quantify reactive oxygen species (ROS) in atmospheric aerosol
Markus Kalberer, *University of Cambridge, UK*

10:20 Activities to improve calibration for PM and black carbon measurements in the EMPIR programme
Paul Quincey, *National Physical Laboratory, UK*

10:40 New method and instrumentation to measure and characterize aeroslolized carbon
Martin Rigler, *Aerosol d.o.o, Slovenia*

11:00 Tea / Coffee - Exhibition & Posters

11:30 Developments in occupational air monitoring techniques for assessing exposure to diesel engine emissions and the potential for harmonization with techniques used in monitoring ambient air
Owen Butler, *Health and Safety Laboratory, UK*

11:50 Light absorption versus evolved carbon - a new way to look at elemental and organic carbon analysis
Eleonora Nicolosi, *King's College London, UK*

12:10 A synthetic zero air reference material
Ruth Pearce, *National Physical Laboratory, UK*

12:30 The use of low cost sensors to monitor air quality
Kate Smith, *University of York, UK*

12:50 Lunch - Exhibition & Posters

Session 4: Current Topics

Chair: **Paul Quincey -** National Physical Laboratory, UK

13:50 Investigation of organic aerosol during high pollution events in Beijing
William Dixon, *University of York, UK*

14:10 Impact of European motor vehicle emissions control directives on ground level ozone
Richard Derwent, *RD Scientific, UK*

14:30 Health benefit and economic cost of building interventions to reduce indoor exposure to outdoor pollution in Beijing, China
Zhiwen Luo, *University of Reading, UK*

14:50 The October 2017 red sun phenomenon over the UK: a satellite perspective
David Moore, *University of Leicester, UK*

15:10 Closing Remarks

15:15 Tea / Coffee - Close of Conference

ABSTRACTS

The Potential Air Quality Impacts from Biomass Combustion in the UK

Alison S. Tomlin and AQEG committee members

ABSTRACT

Biomass combustion features within several UK pathways to a low carbon economy and is an increasing source of secondary domestic heat as part of a part of a lifestyle choice since it is considered to be a renewable and therefore "green" fuel. A recent EEA report[1] suggested that burning biomass for home heating increased by 56% from 1990-2011, raising potential concerns for impacts on human health due to pollutant emissions. Biomass is also used within district heating and combined heat and power (CHP) schemes, as well as being co-fired for electricity production within UK power stations. AQEG recently published a report[2] investigating whether such ongoing changes in fuel usage are likely to impact on UK air quality. The findings of the report will form the basis of the presentation.

The combustion of biomass leads to a broad range of pollutants including NO_x, particulates (predominantly $PM_{2.5}$), and a mixture of VOCs including PAHs and dioxins. The composition and scale of emissions is highly variable and depends on a range of factors such as:

- scale and operation of combustion technology which affects mixing and oxygen availability and therefore particulate and NO_x formation
- mitigation measures installed, which to a large extent are driven by legislative requirements and the scale of the technology
- the quality of the wood/biomass including moisture content and pre-treatment
- trace components within the fuel such as nitrogen, potassium, chlorine etc.

The report found that small scale combustion using domestic open fire places and stoves is likely to lead to higher emissions of PM per unit of fuel burned than larger scale units due to incomplete combustion, poor fuel quality and the lack of effective mitigation technologies. Emissions from large-scale sources such as from co-firing within power stations can be estimated with lower uncertainties than for smaller scale sources. The data for domestic scale combustion is highly uncertain; but even taking into account these uncertainties, the National Atmospheric Emissions Inventory (NAEI) suggests that where biomass combustion represents fuel switching from gas (e.g. for domestic or community scale heating or CHP) an overall increase in UK PM emissions is likely to result. The NAEI suggests that the largest increases in PM_{10} and $PM_{2.5}$ that have occurred since 1990 come from the domestic burning of biomass. In addition, whilst ambient air quality studies which can specifically identify pollution due to biomass burning are fairly scarce, there have been a number of short term measurement campaigns that suggest a strong seasonal signal in biomass related tracer compounds which indicates sources related to heat provision. Studies performed by Fuller et al.[3] and as part of the ClearfLo campaign suggest an annual mean contribution of woodsmoke to PM_{10} of around 1 μg m^{-3} in London.

The NAEI suggests a far lower contribution of biomass burning to UK total NOx emissions (~1%), although the increasing use of solid biomass boilers for primary heat or combined heat and power applications may influence NOx concentrations at a local scale.

1. EEA, 2013a, Annual European Union greenhouse gas inventory 1990–2011 and inventory report 2013, Technical report No 8/2013, European Environment Agency, Copenhagen, Denmark.
2. The Potential Air Quality Impacts from Biomass Combustion, AQEG, available at: https://uk-air.defra.gov.uk/assets/documents/reports/cat11/1708081027_170807_AQEG_Biomass_report.pdf
3. Fuller, G.W., Tremper, A.H., Baker, T.D., Yttri, K.E., Butterfield, D., Contribution of wood burning to PM10 in London. Atmos. Environ. 87, 87–94, 2014.

Presentation of the AQEG report: Impacts of shipping emissions on UK air quality

Mathew Heal
University of Edinburgh

ABSTRACT

Shipping is a growing sector but one of the least regulated sources of emissions of atmospheric pollutants. It makes significant contributions to emissions of NO_x and SO_2 gases, and to primary and secondary particulate matter (PM) including black carbon, with impacts on health and on N and S deposition. Owing to the UK's extensive coastline, relative contributions of emissions from shipping is greater for the UK than for most of the rest of Europe.

This presentation will present the principal findings from a report on the impacts of shipping emissions on UK air quality published in 2017 by the Air Quality Expert Group. The report was finalised some time prior to its publication so evidence cited in the report does not date beyond the end of 2014. Defra asked AQEG to address a number of questions, brief answers to which are summarised below.

(1) There is no evidence that local air quality exceedances are being driven predominantly by local shipping emissions. However, modelling studies attribute ~0.6 µg m^{-3}, equivalent to approximately 6%, of UK population-weighted background $PM_{2.5}$ to emissions from shipping, the majority via secondary inorganic rather than primary $PM_{2.5}$. This is about one-quarter of the UK background $PM_{2.5}$ that derives from non-UK emissions. Future reductions due to projected large decreases in shipping SO_2 emissions are to some extent negated by the projected increases in shipping NO_x emissions. A similar % of UK-average NO_x is estimated to derive from shipping. In contrast, shipping emissions contribute ~20% of the deposition of oxidised S and N in the UK. The impacts on concentrations and deposition are not geographically homogeneous being greater in south and east UK and near major ports.

(2) Analyses of historic time-series of measurements of SO_2 concentrations close to a port (Dover) and shipping lanes (Lullington Health) have shown convincing evidence of a step-change reduction in ambient SO_2 coincident with introduction of legislation reducing levels of S in shipping fuel.

(3) Current monitoring is not adequate to identify shipping emissions trends going forward, in respect of: monitoring locations; the pollutants (SO_2, NO_x and BC) and meteorological variables measured; instrumentation limit of detection; and time resolution.

(4) There are a number of requirements and challenges for improvement of shipping emission inventories. The current method for calculating spatially disaggregated emissions uses port data as proxies for trends in movement data together with a spatial distribution from a bottom-up inventory compiled in 2007. The spatial aspects of the inventory require regular updating. Inventory accuracy is also limited by the lack of detailed emission factors across the range of, and changes in, fuel quality, engine types and exhaust abatement technologies.

(5) Considerations of climate and air quality impacts of shipping emissions are insufficiently integrated. Controls on radiative forcing aspects of shipping emissions have only relatively recently been introduced into International Maritime Organisation processes via regulations on energy efficiency; holistic evaluation of the energy and pollutant aspects of shipping fuel needs to be addressed. Ships also emit black carbon and the climate impacts of a short-lived climate pollutant like black carbon are greater in areas of higher emission. There is currently no regulation specifically addressing black carbon from ships.

A tale of two cities: is air pollution improving in London and Paris?

***Anna Font*[1]**, Lionel Guiseppin[2], Véronique Ghersi[2] and Gary Fuller[1]

[1]MRC PHE Centre for Environment and Health, King's College London, UK
[2]Agence de surveillance de la qualité de l'air, AIRPARIF, France

ABSTRACT

London and Paris are Europe's two mega cities with more than 10 million people each. Both cities experience poor air quality. They currently exceed the European Limit Value for nitrogen dioxide (NO_2) which has been in force since 2010. A large number of policy initiatives have been taken: some of these were European-wide; (e.g. Euro emission standards on new vehicles); others were only local (e.g. Low Emission Zone). To evaluate how effective these policies were, trends in air pollutants were analysed.

We calculated trends in background and roadside locations of nitrogen oxides (NO_X), NO_2 and Particulate Matter (PM_{10}, $PM_{2.5}$) for 2005-2016 in Paris (44 sites) and London (130 sites). Trends in roadside increments were also calculated (14 and 79 sites in Paris and London, respectively). Trends were calculated using the Theil Sen estimator adjusted for seasonality. Results from individual roads were combined and overall means were calculated using the random-effects model. Trends in traffic counts and the distribution in Euro standards for diesel vehicles were also evaluated.

There was an overall increase in roadside NO_2 in 2005-2009 in both cities reflecting the growing evidence on real world emissions from diesel vehicles(1). Conversely, NO_2 decreased by ~5% in both cities from 2010. Downward trends were associated with the introduction of Euro IV and V Heavy Duty Vehicles (HDVs). Despite ambient NO_2 concentrations decreasing, at current rates roads in Paris and London will need more than 10 and 21 years, respectively, to achieve the Limit Value. London showed faster downward trends in roadside PM_{10} from 2010 (10% $year^{-1}$) compared to Paris (5% $year^{-1}$) probably due to the introduction of the Low Emission Zone in 2008 and the replacement of old Euro II and III HDVs with new standards fitted with diesel particles.

(1) Carslaw et al 2015 Atmos Env 105, 70-77

Towards the optimum solution to poor urban air quality caused by motor vehicles

Nick Molden
Chief Executive Officer, Emissions Analytics Ltd

ABSTRACT

Cities across Europe suffer from legally non-compliant urban air quality, in particular for nitrogen dioxide. The principal source of NO_2 in most cases is road vehicles, for which the combined volume of nitric oxide (NO) and NO_2 is regulated.

The options for achieving this compliance may be either highly costly, too slow, politically unpalatable or unlikely to be effective. Total bans on diesel passenger cars and light commercial vehicles from cities would be quick, but the cost in terms of lost utility for vehicle owners and lost value in the vehicles themselves would make this an expensive and politically difficult option, with potentially unfair economic distributional effects.

There are many policy options that have been considered, including encouraging driver behaviour change, modal shift, taxation and scrappage schemes. “Clean Air Zones” within urban areas have been proposes by the UK Government in its recent Air Quality Plan.

This issue is that the efficacy of these zones rests upon the quality of information as to real-world emissions. If consumers are given misleading data, the behaviour change will be wrongly directed. If access restrictions are not based on the truly high-emitting vehicles, then some low-emitting vehicles will be prohibited and other high-emitting vehicles permitted.

This presentation will consider the potential to use alternatives to the official Euro standards for access criteria. Specifically, the opportunity of using the EQUA® Index from Emissions Analytics will be quantified in terms of speed, cost and ability to reduce real-world emissions, through targeted local policy interventions in cities.

Measurements and Source Apportionment of Airborne Particulate Matter in the Vicinity of Heathrow Airport

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ABSTRACT

Two air sampling campaigns were conducted in the summer of 2014 and winter of 2014/15 at Harlington, 1.2 km north of the northern runway of Heathrow Airport. Measurements included particle number size distributions by Scanning Mobility Particle Sizer, particle number concentrations by Condensation Particle Counter and black carbon by aethalometer. Filter samples were also collected for subsequent chemical analysis of a range of analytes and hourly data for NO, NO_2, NO_x, O_3, PM_{10} and $PM_{2.5}$ were available from co-located AURN instruments. The SMPS spectra were reduced into a smaller number of representative clusters, each containing size distributions of similar shape using k-means cluster analysis. This yielded five clusters from each campaign which could be tentatively linked with different source categories in the vicinity of the airport. Receptor modelling using Positive Matrix Factorisation was also applied to a combination of size differentiated particle number data and chemical composition revealing the same six factors in both the summer and winter season data. These were attributed to the following predominant sources: airport, fresh road traffic, aged road traffic, urban accumulation mode particles and two secondary aerosol categories. The source factors relating to the airport were characteristic of aircraft emissions, showing a peak in the number size distribution below 20 nm mobility diameter, a diurnal pattern similar to that of aircraft activity and a predominant direction associated with winds from the airport. This factor represented 32% and 33% of the particle number concentration in summer and winter respectively, but only 1.2% and 1.7% of the particle volume concentration within the size range 14-673 nm. Road traffic was the largest contributor to particle number (46% and 54% in summer and winter), but secondary particles accounted for >50% of the particle mass.

Acknowledgement

The authors gratefully acknowledge financial support from the European Union and the Natural Environment Research Council.

Recent Findings from Vehicle Emission Remote Sensing from UK Measurements

***Rebecca Rose*[1]**, Ben Fowler[1], Tom Green[1], Dan Willis[1] and David Carslaw[1,2]

[1]Ricardo Energy & Environment, [2]University of York

ABSTRACT

We report up to date measurements from vehicle emission remote sensing campaigns conducted across the UK over a six-month period from March to September 2017. These measurements were made at about 10 different sites of differing characteristics such as vehicle speed and acceleration, fleet composition and road slope. The measurements have been made during an important period for vehicle emissions legislation with the recent introduction of Euro 6/VI vehicle in the fleet. The presentation will focus on the emerging evidence relating to the emissions performance of Euro 6/VI vehicles in relation to older generations of vehicle in the fleet. The measurements include a unique set of experiments that aim to quantify the effect of cold-starting on both the emissions NO_x and NO_2. These comprehensive measurements of >13,000 passenger cars provide new insights into the importance of cold starting for diesel vehicles and the emissions of NO_2, which likely have important implications for ambient concentrations of NO_2.

We also highlight the effect of vehicle after-treatment technology used on Euro 6 diesel passenger cars on emissions of NO_x and consider whether Euro 6 emissions performance is improving with time as manufacturers prepare to introduce RDE-compliant vehicles. Finally, the database of measurements is used to quantify the effect of ambient temperature on emissions of NO_x to understand the extent to which emission factors need to take account of ambient temperature effects.

A new online instrument to quantify reactive oxygen species (ROS) in atmospheric aerosol

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ABSTRACT

It is often hypothesised that negative health effects of aerosol particles in polluted air are due to particle-bound reactive oxygen species (ROS). Established methods to quantify ROS rely on filter collection, followed by offline chemical analysis. These methods have time resolutions of hours to days, which limit the comparison with other fast changing atmospheric components. In addition, a long delay between collection of particle-bound ROS and their analysis might underestimate true total ROS concentrations because many ROS components are highly reactive and thus short-lived. To overcome these limitations, we developed an instrument to allow on-line, continuous measurement of particle-bound ROS using the fluorescence probe DCFH. A high time resolution of about 10 min allows tracking fast concentration changes. We show that up to 80% of ROS in organic aerosol has a short lifetime of only about 15min, emphasising the need for fast online techniques to obtain reliable ROS quantification data. We will present ROS analyses of laboratory-generated aerosol and ambient measurements at urban locations in London and Beijing, China.

Activities to improve calibration for PM and black carbon measurements in the EMPIR programme

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(on behalf of the EMPIR AEROMET and Black Carbon consortia)

ABSTRACT

The EMPIR programme consists of projects with a metrology focus, co-funded by the EU and National Metrology Institutes, and coordinated by EURAMET, the European Association of National Metrology Institutes.

Two projects that started in 2017 aim to address some outstanding issues relating to measurements of PM_{10}, $PM_{2.5}$, and black carbon. For PM, the activity is centred on creating a set of well-characterised aerosols for chamber-testing of automatic instruments that will avoid the need for lengthy field equivalence trials alongside reference instruments. For black carbon, the calibration of filter-based instruments presents a different set of challenges, as the response of such instruments depends not just on the property being measured, the aerosol absorption coefficient, but on other physical properties that affect the combined optical properties of the aerosol particles and the filter.

Each case highlights the importance of making the measurements both traceable, so that the units used to express the results are linked to their definitions, and standardised, so that all factors affecting the results are controlled sufficiently that measurements made by different methods will be comparable.

New Method and Instrumentation to Measure and Characterize Aerosolized Carbon

***Martin Rigler*[1]**, L. Drinovec[1,2], A. Vlachou[3], G. Stefenelli[3], J. G. Slowik[3], A. S. H. Prévôt[3], C. Hüglin[4], A.D.A. Hansen[5], J.L. Jaffrezo[6], I. Stavroulas[7], J. Sciare[7], I. Kranjc[8], J. Turšič[8], Griša Močnik[1,2]

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ABSTRACT

The carbonaceous aerosol fraction often dominates the concentrations of fine particulate matter (PM). The composition is highly heterogeneous and presents challenges for the analysis.

The presented new TC-BC method combines an optical method for measuring black carbon (BC), by the Aethalometer AE33, and a thermal method for total carbon (TC) determination, by the newly developed Total Carbon Analyzer (TCA), resulting in equivalent EC and equivalent OC concentrations:

equivalent EC = b.BC

equivalent OC = TC – b.BC

The TCA operates on the principle of rapid combustion of PM collected on a quartz filter to create a CO_2 pulse detected above the background CO_2, with ambient air being used as carrier gas and source of oxygen for combustion. The method is highly time-resolved.

We performed comparisons of off-line and on-line data. Ambient 24 hours filter PM2.5 samples from sites in Switzerland and Slovenia analyzed for OC/EC using the standard method (EN 16909, EUSAAR 2) were compared to the TCA 24-hour averages. High R2 values confirm the adequacy of the method comparing it to thermal-optical OC/EC analyzers and allowed us to demonstrate the equivalence between b*BC and EC, and OC and TC-b*BC. Additionally we show the highly time resolved comparison between the TCA and aerosol mass spectrometers (AMS) and demonstrate how to determine the AMS collection efficiency.

Developments in occupational air monitoring techniques for assessing exposure to diesel engine emissions and the potential for harmonization with techniques used in monitoring ambient air

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ABSTRACT

Since the mid 1990's, the Health and Safety Executive (HSE) has supported HSL, its own in-house laboratory, in developing air monitoring techniques for use in worker exposure assessment studies. Developments here included a field-based methodology that could be used by industry, in particular by those working in the mining and quarrying industries where diesel engine emissions into poorly ventilated workspaces could be of concern. In more recent years, HSE has asked HSL to evaluate emerging monitoring techniques and one aspect of this work is to look for compatibility, where possible, with measurement technologies deployed for ambient air monitoring. In summary the aims of this presentation are to:

- Describe developments in laboratory combustion-based techniques for the determination of elemental carbon in filter samples taken from the workplace
- Present an overview of developments in wearable filter-based air samplers and a reflectometer for field use in the mining and quarrying industries
- Describe more recent work evaluating the potential utility of wearable optical-based sensors for black carbon measurements
- Summarise developments in techniques for the personal monitoring of NO_2
- Present a very brief overview of other measurement approaches that HSL is currently exploring and
- Show that measurement developments here are complimentary to those developed for ambient air monitoring.

Light absorption versus evolved carbon – a new way to look at elemental and organic carbon analysis

***E.M.G. Nicolosi*[1,2],** P. Quincey[2] and G.W. Fuller[1]

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ABSTRACT

The Attenuation Versus Evolved Carbon (AVEC) plot is a new way to represent thermal-optical EC/OC analysis data. Unlike the thermogram, the usual method of presenting the analysis data, it provides information about the sample properties. The plot can be used to refine the determination of organic carbon (OC) and elemental carbon (EC) split point, and to investigate the optical properies of the particles.

In the AVEC plot the accumulated carbon concentration is plotted against the attenuation (ln (I_0/I)) as the analysis proceeds. The gradient of the AVEC plot curve in the oxygenated phase provides information about the mass absorption cross section (σ) of the particles leaving the filter. The split point determination relies on two assumptions: either the pyrolysed carbon (PC) has the same σ as the EC, or all PC evolves before the EC. Many results in the literature demonstrate that neither of the assumptions is valid. A Sunset Laboratory Thermal-Optical Carbon Analyser was used for the OC/EC analysis.

149 samples from the London area were analysed uisng two different protocols. We investigated the effect of PC concentration on the σ values. We found out that although the Quartz protocol produced more increased attenuation than the EUSAAR_2 protocol, the PC concentration (in μg.cm^{-2}) calculated by the instrument was comparable. This suggests that the σ of the PC was higher in the Quartz samples than the EUSAAR samples, with implications for how this type of analysis is interpreted.

A Synthetic Zero Air Reference Standard

Ruth E. Hill-Pearce, Kate V. Resner, Paul J. Brewer

National Physical Laboratory

ABSTRACT

The purity analysis of both the major and minor components in zero air is a significant contributor to the uncertainty in preparing reference materials of high impact greenhouse gases and is a barrier in the progress towards underpinning measurements for global networks to assess climate trends. We have produced a synthetic zero reference material which closely matches the composition of oxygen, nitrogen and argon in naturally occurring air. The amount fraction of carbon dioxide, methane and carbon monoxide, which exist in the mixture at trace amount fractions, have been accurately quantified using a novel dilution device for generating gaseous reference materials of these components. This development will have a significant impact in addressing the requirements for accurately quantified matrix gas in the preparation of gaseous reference materials and for baseline calibrations of instrumentation.

The use of low cost sensors to monitor air quality

***Kate R. Smith*[1],** Pete Edwards[1], and Alastair C. Lewis[1]
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POSTER ABSTRACT

Low cost sensors are commercially available for use by the public and provide an economically viable method for local authorities to monitor the quality of air in the surrounding region. Sensors are advantageous because they exhibit a fast-response to changing concentrations of common atmospheric pollutants, they are portable, robust and can provide in-situ measurements very easily. However, problems such as significant cross interferences, temporal drift and noise mean that the information on the target compounds can be obscured. Extensive laboratory and field work has been conducted to aid our understanding on how best to deploy and calibrate the sensors to selectively monitor important pollutants. Taking a methodical approach to calibrating these sensors for individual and multicomponent atmospheric mixtures means that we can establish the true capabilities of these sensors. These experiments show cross sensitivities which would impact their use as ambient pollution monitors. We also find that a single deployed sensor gives highly variable measurements, but the use of multiple co-located sensors significantly improves the quality and reproducibility of observations.

Studies from Beijing, China show that implementation of the clustering approach of both electrochemical (EC) and metal oxide sensors (MOS) can yield improved results that can be used to complement and support the established reference methods. Electrochemical sensors were used to monitor carbon monoxide (CO), nitrogen dioxide (NO_2) and ozone (O_3) and volatile organic compounds (VOCs) were observed with MOS.

Investigation of organic aerosol during high pollution events in Beijing

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ABSTRACT

Air pollution, particularly from particulate matter of 2.5 microns or less ($PM_{2.5}$) in diameter, has detrimental effects on human health. Beijing, a Mega-city, and has a population of over 20 million; recent news has brought to light the scale of pollution in Beijing; official estimates of $PM_{2.5}$ are 86 μg m^{-3} annually. The organic fraction of the aerosol has multiple sources, leading to a very complex mixture of compounds leading to a variety of negative effects.

This study examines the composition of organic aerosol from the winter of 2016 in Beijing using an extensive database built from literature and known compounds from chamber experiments. A high throughput method of UHPLC and orbitrap high resolution mass spectrometry was used to integrate peaks from the chromatograms and compared against the library to identify compounds. An automated program is used to produce time series, quantify commonly observed compounds and produce common aerosol metrics to visualise the broader composition; this automation drastically reduces analysis times.

127 filter samples were collected, including high time-resolution sampling (hourly) to highlight finer details in the evolution of the aerosol mass. 643 compounds from the library were found present in the filter samples; ranging from C2 to C22 and containing between 1 and 13 oxygens. A significant proportion of the aerosol was observed to be from organosulfates and nitro-aromatics. Modern data mining and statistical analysis will be used to identify patterns and begin to outline source apportionment through co-variance comparison with tracer compounds, gas-phase measurements and particle measurements.

Impact of European Motor Vehicle Emissions Control Directives on Ground Level Ozone

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ABSTRACT

European-wide legislation during the 1990s mandated the availability of lead-free petrol and the fitting of three-way catalysts and evaporative canisters to petrol-engined motor vehicles. The Defra (originally DoE) Hydrocarbons Monitoring Network was established in 1993 to monitor the levels of 25 C_2 – C_8 hydrocarbons at 13 stations (established at 2 rural stations, 1 heavily-trafficked site and 10 urban background sites). Levels of individual hydrocarbons have shown downwards trends at all stations in excess of -10% to -20% per year. Overall, total hydrocarbon concentrations (excluding ethane and propane) at the London Eltham urban background station have declined by close to an order of magnitude over the 1993 – 2012 period. This observed trend closely matches the NAEI road traffic VOC emission inventory trend over the same period showing that the impact of the three-way catalysts and evaporative canisters on real-world VOC emission inventories is described accurately in VOC emission inventories. When these VOC emission inventory trends are fed into the UK Photochemical Trajectory Model, a strong decline in episodic peak ozone levels is predicted for south east England over the 1990 – 2015 period exactly matching the observed trends. The impact of the European-wide motor vehicle emissions control directives applied to petrol-engined motor vehicles has been to decrease VOC emissions and hence to reduce the episodic peak levels of ground-level ozone in the rural areas of the British Isles.

Health benefit and economic cost of building interventions to reduce indoor exposure to outdoor pollution in Beijing China

Zhiwen(Vincent) Luo

School of the Built Environment
University of Reading

ABSTRACT

Beijing, the capital city of China, has been suffering severe ambient air pollution nowadays. As people spend the majority of time indoors, the indoor air pollution being transferred from outdoors has more effect on health. It is therefore important to understand what is the best beneficial yet economic building intervention to reduce indoor exposure to outdoor pollution. In this study, we consider 15 ventilation scenarios by combining air tightness levels (ATLs) of building external envelopes and different PM2.5 filtration efficiencies (PFEs) of mechanical ventilation system. The hourly indoor PM2.5 concentrations and corresponding monetary effects of mortality case change and energy consumption cost are analyzed.

Results show that in urban Beijing, the indoor exposure to PM2.5 will increase with ATL< 5 while PFE<70%. The annual average indoor PM2.5 concentration will be smaller than 10μg/m^3 (the threshold concentration set by the World Health Organization) only with ATL > 7 conjunction with PFE>90%. The total monetary effect combining health and energy shows that 3 scenarios with combination of high ATL and PFE (ATL=7 and PFE=90%, ATL=5 and PFE=99%, and ATL=7 and PFE=99%) can achieve obvious economic benefits, while adopting mechanical ventilation system with PFE below 70% will lead to an increase of total monetary cost.

We also apply the same approach into four other typical mega cities in China (Shenyang, Shanghai, Chengdu, and Guangzhou). It shows that the economic benefits become less sensitive to ATL from north to south, while cities without central heating are more sensitive to PFE, among which Chengdu and Guangzhou can hardly achieve economic benefits with mechanical ventilation.

The October 2017 red sun phenomenon over the UK: a satellite perspective

David Moore

National Centre for Earth Observation

ABSTRACT

As the old saying goes, a red sky at sunset will likely herald fair weather on the following day. On the 16th October 2017 the saying needed to include a new clause as the ex-Hurricane Ophelia reached the shores of the British Isles, bringing exceptionally strong winds and rainfall to much of the Western UK, but also a peculiar haze to the skies of Central and Eastern UK with reports of the sun turning red for a time.

Hurricane Ophelia had already made the news as being the most-Easterly hurricane ever recorded, driven by the above-average temperatures in the waters of the North-Eastern Atlantic Ocean. As the system moved north towards the UK, the system lost some energy, but maintained very high-winds across much of Ireland and the western half of the UK. During the morning and early afternoon on the 16th October, central and eastern regions of the UK started to notice the sky turning a yellow and orange colour. This work attempts to apportion the causes of this: scattering of sunlight by wildfire smoke particles and Saharan dust. Alongside the optical phenomenon observed at the surface, it will be shown that space-born remote sensing provided a unique vantage point to monitor other key pollutants enhanced during the event. Observations showed that there was a large increase of carbon monoxide and aerosols across much of Central and Southern England transported from Portuguese and Spanish wildfires which the affected mainland Europe over the subsequent days.

POSTER ABSTRACTS

Integrated air quality monitoring technology for high-volume, low-cost measurements of indoor and outdoor air quality

Douglas Booker

NAQTS

POSTER ABSTRACT

National Air Quality Testing Services (NAQTS) has developed an integrated air quality monitor (NAQTS V1000) incorporating the latest developments in low-cost sensor technologies, alongside a regulatory grade Condensation Particle Counter (CPC), thermal desorption tubes (TD), and other environmental measurements. Users can interact with the device using a HTML GUI and a database management system that can be directly uploaded to the cloud.

The NAQTS V1000 measures Particle Number (CPC), CO2 (NDIR), CO, NO2, and VOCs (Metal Oxide and Electrochemical), and is also fitted with Temperature, Pressure and Relative Humidity measurements. External GPS and Noise (dBA) measurements are available through USB ports on the back of the equipment.

NAQTS' use of dual technologies for key gaseous measurements enables cross sensitivity correction algorithms to be employed, and an orthogonal calibration procedure to be employed. NAQTS' regulatory compliant CPC allows users to measure ultrafine particles (<100nm, with a lower detection limit of 10nm), whilst keeping fluid consumption low due to an integrated solvent recovery system. The novel integration of TD tubes for GC-MS into a real-time air pollution monitoring device allows low-cost sensors to be used as triggers for VOC speciation, adding another layer to potential analyses.

The NAQTS V1000 unit is a portable air quality monitoring station designed to be easy-to-use for high-volume, low-cost measurements, facilitating a holistic understanding of indoor and outdoor air pollution.

Ultrasensitive gas sensors and ultrafast method for CO and NO_2 emissions monitoring

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POSTER ABSTRACT

Toxic gases, such as nitrogen dioxide (NO_2) and carbon monoxide (CO), are an increasing problem for air quality in our cities. These gases have a negative impact on our health and the environment and are mainly created by the combustion of fossil fuels in internal combustion engines. We report here on the results of a study into the response of nanostructured tungsten trioxide (WO_3) and metal-doped tin dioxide (Pt/Pd-SnO_2) based low-power MEMS gas sensors to NO_2 and CO at lower levels of oxygen than normal ambient conditions. This environment of *lean* oxygen is one that has not been widely investigated for metal oxide (MOX) gas sensors and it normally occurs after a combustion process lowers oxygen levels. It was found that the resistive gas sensors not only have a high sensitivity to NO_2 (7.0%/ppb vs. 0.2%/ppb for commercial MOX) and CO (2.0%/ppm) but can still operate reliably at lower oxygen levels (0.5-2%) albeit with slightly longer response and recovery times. The optimal operating temperature was determined to be *ca.* 350°C and so easily within the capability of a MEMS-based SOI CMOS substrate. Apart from a static measuring mode, we have also designed a more effective temperature modulation technique and a method of transient frequency analysis to detect these gases. This smart analysis combined with CMOS micro-hotplate sensors could lead to a new generation of low-cost gas sensors with embedded software that could be used e.g. for combustion emission monitoring in the real world where fast indication of pollutants is required.

First year of operation of the new southern EMEP UK supersite: Assessing the impact of the relocation

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POSTER ABSTRACT

The Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) is one of a series of bodies under the UNECE Convention on Long Range Transboundary Air Pollutants (CLRTAP). Over 40 years EMEP has measured at regular time intervals in many locations across the member states to visualise the regional and spatial trends in air pollution. The monitoring data provides the scientific evidence for underpinning legislation and mitigation of atmospheric pollutants.

Increased interest from political bodies in the relationship between air quality and human health has caused the programme to evolve from observing acidifying and eutophying species (e.g. NO_x, NH_3 and SO_2), to now including pollutants which have a direct negative effect on humans: particulate matter, heavy metals and species that contribute to the formation of tropospheric ozone.

The United Kingdom is committed to have two level II/III “supersites” at rural locations under EMEP, one in the north (Auchencorth Moss) and south of the country. Until 2015 the latter was situated in Harwell, Oxfordshire (North East of London), but due to redevelopment the supersite has relocated further south to the Chilbolton Observatory, Hampshire (South West of London).

The aim of this study is to provide an informative overview of the atmospheric composition of the species recorded at Chilbolton during the first complete year of measurements (2016), with a comparison to the most recent available data from Harwell (2015), highlighting any discrepancies that could cause noticeable changes in the trends of the UKs background atmosphere.

Volatile organic compound fluxes and mixing ratios above Beijing in winter 2016 and summer 2017

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POSTER ABSTRACT

Volatile organic compounds (VOCs) play a significant role in tropospheric chemistry and hence, air quality through secondary organic aerosol (SOA) formation and facilitating the formation of tropospheric ozone. These compounds are emitted from numerous sources including vegetation and anthropogenic sources such as fossil fuel combustion, biomass burning and the evaporation of petroleum products. As well as their indirect impact on human health via the formation of ozone and SOA, some VOCs, including benzene, directly affect human health adversely.

Here we present VOC fluxes and mixing ratios recorded in Beijing during two 5 week intensive field campaigns (11-12/2016 and 05-06/2017). Fluxes of VOCs were recorded for the first time in Beijing using Proton Transfer Reaction-Time of Flight-Mass Spectrometry. We use these preliminary VOC flux estimates to make comparisons between VOC emissions in Beijing and those previously recorded in London. This shows that while the mixing ratios of many compounds, for example benzene, are higher than those recently recorded in London (especially during the winter haze events) the emission rates of many VOCs in central Beijing appear comparable to those observed in London.

This work was carried out as part of the Sources and Emissions of Air Pollutants in Beijing (AIRPOLL-Beijing) work project within the Air Pollution and Human Health in a Developing Megacity (APHH-Beijing) research programme. APHH-Beijing is a large multi-institutional study which aims to record the concentrations and identify the sources of urban air pollutants in Beijing, determine exposure, understand their effects on human health, and to identify solutions.

Investigating the drivers of air pollution and personal exposure within informal settlements in Nairobi, Kenya

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POSTER ABSTRACT

A recent study in Nairobi, Kenya has shown that urban background sites frequently exceed the 24-hour limit value of 25 µg m^{-3} for particulate matter of 2.5 µm or less ($PM_{2.5}$) set by the World Health Organisation. Previous studies in Nairobi have not investigated the composition of PM or the role that reactive nitrogen gases may have in urban air pollution, in particular nitrogen dioxide (NO_2) and ammonia (NH_3). It is estimated 60% of the Nairobi's population now live within informal settlements. Residents of informal settlements are thought to be particularly exposed to air pollution, where potential sources include dust, human and animal waste, cooking, burning of waste, transport and local industries.

Here we present a pilot study to investigate the feasibility of using a combination of low cost static air quality monitoring and personal exposure methodologies to gain knowledge on personal and community exposure within an informal settlement. Background monitoring is being carried out at two stations using a Denuder for Long-Term Atmospheric sampling (DELTA) which measures both reactive trace gases (NH_3, HNO_3 and SO_2) and their counterpart aerosols (NH_4^+, NO_3^-, SO_4^{2-}). Within the informal settlement, static monitoring by NO_2 and NH_3 passive samplers and mobile personal exposure studies (Dylos) are achieved using a citizen science approach based on the methodologies of Steinle *et al*. (2015) and West *et al*. (*in prep)*. The initial results from this study including a discussion on the applicability of low cost approaches for studying air quality in Sub-Saharan Africa will be presented.

Understanding Dock and Shipping Emissions and their Effects on Health

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POSTER ABSTRACT

14 of the world's 20 most populous cities are port cities. These are vital hubs for global trade, 90% of which is transported by sea. Within the relatively confined region of port cites there are large cargo ships and cruise ships carrying several thousand passengers and crew, with associated land-side road and rail movements, as well as refineries and processing plants for oil and other raw materials. Emissions from these port-associated sources may contribute significantly to the urban air pollution load, thus representing a potential health risk to residents. Southampton is one of the UK's largest cargo ports and the largest cruise port in Europe, with these activities directly adjacent to the city centre and residential areas. Southampton is also one of six UK cities recently mandated to introduce a Clean Air Zone, but the measures to be implemented will not apply to the port. Our poster details a number of multidisciplinary projects currently in progress to improve understanding of the sources and potential health risks of air pollution in port cities, using Southampton as a test site. These include the physicochemical and toxicological characterisation of particulate matter (PM) from a number of sites in the port to better understand different PM sources, the use of isotope analysis of PM collected by various methods around Southampton as tracer of pollution source, and the development of a low-cost sensor network to generate data for integration with road and ship traffic and meteorological datasets to better understand pollution sources and distribution.

Investigating the effect of large waste fires on air quality

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POSTER ABSTRACT

Large waste fires are harmful to the environment. The extent of this harm is being investigated, in particular regarding the effect on air quality and health.

A 2014 House of Commons report found that 5.3% of deaths in the UK were attributable to long term exposure to atmospheric pollution. Particulate matter and other pollutants from large waste fires are likely to be contributing to this, but at present, there is a lack of data. Recently, there has been significant growth in the number and size of fires from waste storage and treatment facilities.

In the UK, approximately 450 large fires occur at industrial or agricultural premises annually, with around 350 of those occurring at waste management sites. These fires can take days or weeks to extinguish and in some cases, months or years. At present, there is no regulation on situating waste sites close to housing or schools, or any robust methodology for quantifying the toxicants which may be released.

Government agencies need to know how to quantify the harmful effect of these fires on UK air quality and the health of individuals living nearby. Once the toxic components of waste fires have been characterised, then production of guidance on reducing the emissions, extinguishing strategies, and dealing with their adverse effects can be addressed.

A review of the literature has been carried out with a view to developing a methodology for direct sampling from the plumes of large waste fires using a novel sensor package.