SOMETHING IN THE AIR

IN 2011, MORE THAN 400,000 PEOPLE IN EUROPE ALONE DIED PREMATURELY AS THE RESULT OF AIR POLLUTION. WITH OTHER COUNTRIES JUST AS BADLY AFFECTED, IF NOT MORE SO. JAMES EDDY LOOKS BEHIND THE HEADLINES AND EXPLORES THE GROWING WORLDWIDE TREND OF AIR POLLUTION MONITORING AND MAPPING

In March, a report from the European Environment Agency (EEA) predicted huge numbers of Europeans will die from air pollution in the next 20 years. The 'State of the Environment Report for 2015' says Europe is falling behind on a range of environmental indicators, from air to water and biodiversity, with the stark warning that hundreds of people, perhaps millions, will suffer premature death in the next two decades because of toxic air if present trends continue. The EEA blames governments for inaction and says that in 2011 alone – the most recent year for which there is a reliable figure – more than 400,000 Europeans died prematurely from air pollution.

The problems facing both the governments and citizens of Europe are by no means unique. Air pollution in the US is a real problem in some areas. For example, in one neighbourhood in New York city, one in four children suffers from asthma, and rates of hospital admissions and death are respectively three and five times higher than the national average.

Meanwhile, a recent World Health Organization report ranked the top 20 polluted cities in the world and the number one position went to New Delhi, with 13 of the most polluted cities in the world in India. However, the report has some significant gaps. Big and fast growing cities in Africa – for example, Nigeria's capital Lagos – don't appear on the list. Is that because air pollution is minimal or is it because reliable air pollution monitoring equipment for assessing the problem is expensive?

Our understanding of air pollution can be defined in two ways: monitoring and mapping. Much of the global attention on this subject surrounds the former with huge advancements in the technology used to record levels of pollutants at given locations. The US has a country-wide network of static monitoring stations, as do many other countries including the UK. However, the latest trend revolves around community- and society-led monitoring projects.

In their simplest form these include static sensors mounted on homes, schools or other structures. One example, the Air Quality Egg, collects high resolution readings of nitrogen dioxide (NO_2) and carbon monoxide (CO). A small electronic sensor is simply plugged in and mounted outside where it collects regular readings. Using RF transmission these readings are wirelessly sent to an indoor base station where they are relayed to the internet via a wired Ethernet connection. Currently, there are more than 1,000 Eggs located around the world, transmitting readings to an open data service that stores and provides free access to the data. The service also includes embeddable graphs and the ability to generate triggers for Tweets and SMS alerts, as well as an API that allows developers to unlock the potential of this data by building mashups, maps and applications.

The Breathe Project in Pittsburgh in the US uses high definition cameras to enable residents to monitor air pollution. Four high-resolution cameras snap expansive panoramas of the city 24/7, capturing haze and air pollution activity alongside data from sensors on humidity, temperature and wind speed, as well as fine particles and sulphur dioxide levels. One reason this project – and others in Boston, Cleveland, London, Dublin and Amsterdam – are proving so popular and effective is that they allow residents to 'see' air pollution in way they couldn't before encouraging civic involvement and even community action against polluting companies.

Getting mobile

The latest trend in air pollution monitoring is a new generation of wearable high tech devices. Paired with apps on smartphones, or even Bluetooth or Wi-Fi enabled, these devices can be used to record a range of environmental data including air and water quality. Examples of such devices include the AirBot, a particle-counting robot developed by Carnegie Mellon University in the US that monitors airborne pollutants that can cause breathing problems. A sister product, WaterBot, has also been developed to test for water quality. Sensaris, described as the sensor you wear on your wrist, gives instant air quality measurements and the devices can use Bluetooth to send data to mobile phones making data transmission and sharing easy.

Smartphone apps are another big development area. Using the wide range of sensors now available on these phones, scientists can record and analyse large volumes of data collected around the clock and from a diverse range of locations. The AirProbe system, funded by the EU and tested by more than 300 people in Antwerp, Kassel, Turin and London, uses a small sensor box and an app to track exposure to ozone, black carbon and other pollutants. The Airprobe app uses a compact battery operated sensor box that can easily be carried in a backpack or bicycle basket, for example. After sucking in air the box sends readings, via Bluetooth, to your mobile phone, which is then transmitted to a central server. The app also includes social games promoting the sharing of information as well as interactive maps. Initial trials of the system recorded over 28 million air quality points as well as users' perceptions, feelings and feedback.

Next level

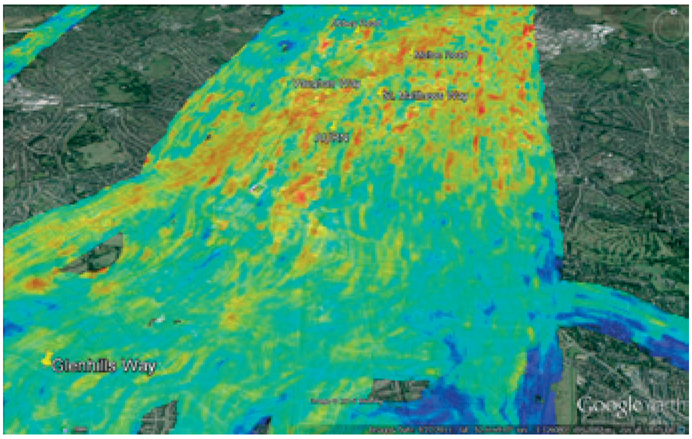
Scientists at the University of Leicester in the UK are developing and deploying technology to monitor air quality in urban environments. The CityScan project aimed to create a 'pollution radar' allowing for the virtual real time monitoring of pollution over entire cities. In partnership with Surrey Satellite Technology, scientists at the university developed and built scanning, imaging DOAS (differential optical absorption spectroscopy) systems. Each system can provide coverage of areas up to 25km square undertaking real time monitoring of NO_2 and aerosols at a spatial resolution of 50m. This technology has already been deployed on tall buildings in Leicester, Bologna and London during the 2012 Olympics.

Initial results from the instruments deployed in London as part of the Clearflo (Clean Air for London) project have been published in a number of papers. Comparing two intensive observation periods (winter 2012 and summer Olympics 2012) allowed the project partners to focus on the vertical structure of pollution and the evolution of the urban boundary. One paper concluded that mixing heights of pollution are deeper over London than in the rural surroundings and also the seasonality of the urban boundary controls when concentrations of pollution peak. The composition of pollution also reflects the seasonality of sources of pollution for example domestic burning.

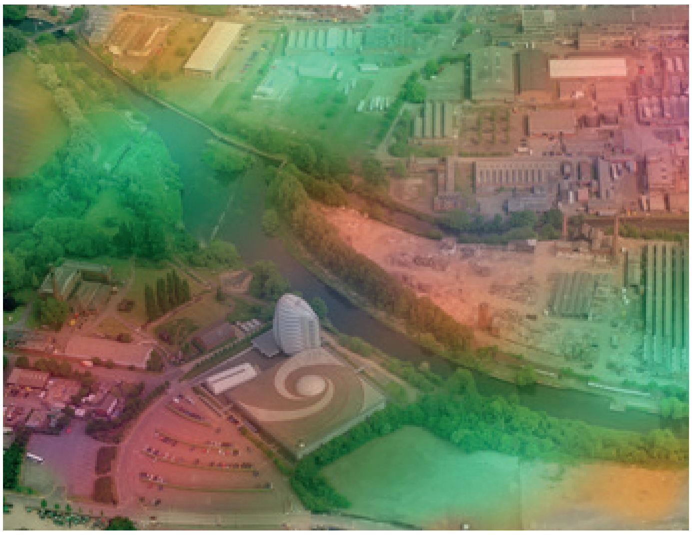
A natural spin out avenue for this technology was the development of an air or space-borne spectrometer. Scientists at the University of Leicester working with Bluesky and other project partners aim to create a fully operational and commercially viable solution for mapping air pollution over entire cities. In 2013, the university's Compact Air Quality Spectrometer was mounted on Bluesky's aerial survey plane. Trials of the technology were successfully completed over the skies of Leicester and a city-wide map of air pollution was created.

Results from the trials have confirmed concentrations of NO_2 in what may be considered 'obvious' places, such as major road junctions, industrial regions and commercial complexes. Other less expected find-

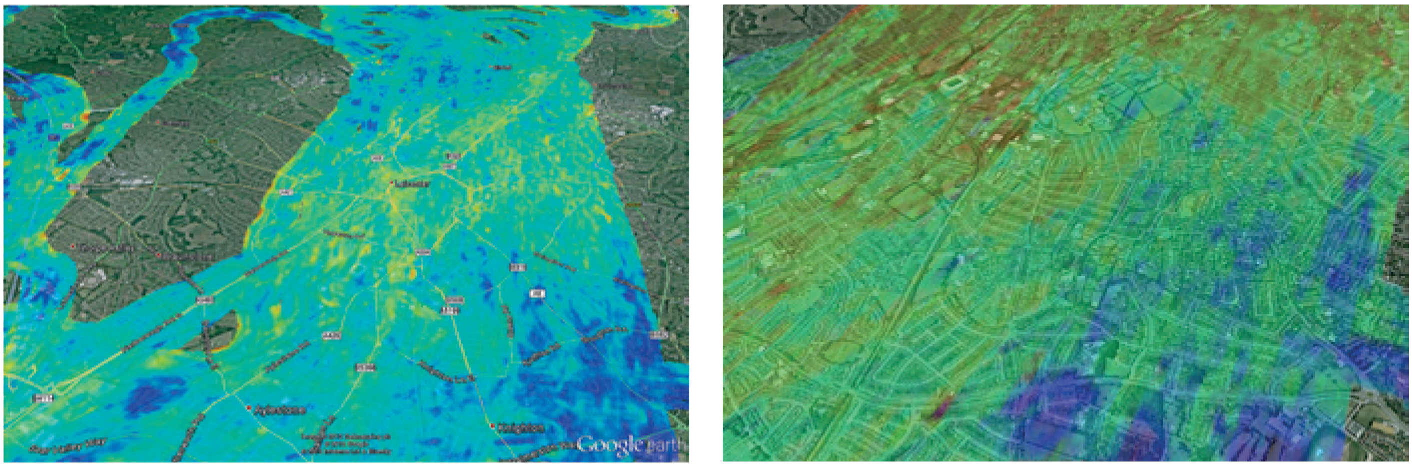
Locations of air quality monitoring stations providing in situ point measurements across Leicester



High resolution map of NO_2 providing a new spatially-resolved understanding of the pollution distribution across the city, filling in the large gaps between the point measurements



A graphical representation of pollution distribution over an oblique aerial photograph



Air quality data acquired over Leicester. Blue is low NO_2 and red is high (Imagery © Google Earth)

ings include clear pollution signatures from busy car parks and the positive effect of urban parks and other green spaces such as golf courses and leisure facilities. Clean air spaces over these land-use types were both apparent and distinct with the data and suggest faster chemical processes acting on the pollution present.

This system is by no means the final solution. Scientists are already integrating the aerial data with data from a network of low cost ground based air quality sensors and even sensors mounted on cars in order to understand the spatial context of monitoring locations. While point monitors offer a timeline of readings their fixed locations leave uncertainties over how representative their measurements are of potentially city-wide concentrations.

Further development work is also underway to improve the resolution of the instruments to 20mx20m and the system is currently being certified for commercial use. It is thought that additional test flights, planned for this summer, will further demonstrate the value of derived products such as indications of volume mixing and relative concentrations of NO_2 across wide areas. Potential applications of this data are expected to include identifying the impact of major air quality mitigation strategies, monitoring the impact of new traffic or industrial infrastructure changes, assessing city-wide population exposure to pollution and understanding the impact of individual point sources. It is hoped the data will also provide an excellent tool to help review the locations of fixed and mobile monitoring systems to further improve the understanding of pollution sources, movements and impact.

The future

So what does the future hold for air pollution monitoring and mapping? It is perhaps the combination of solutions that, as usual, will provide the answer. Improved understanding of how pollutants act over large areas, obtained by city-wide mapping projects, such as those being undertaken by Bluesky, will provide benchmark data for planners, architects and environmentalists. This data can be used to support planning decisions, develop green policies and hopefully reduce ambient levels of pollution.

Crowdsourced data at the micro level, either from portable or fixed monitoring devices, can supplement this baseline data. Providing timely alerts of potentially dangerous levels of pollution can inform day-to-day decision-making at a personal level and also in commerce, industry and government.

One question remains: having collected all this data what exactly do we do with it? The answer? Well, the European Commission has just awarded a project to Ricardo-AEA to develop a common method for presenting information on the levels of key pollutants. The project will see the review of member states' existing air quality information systems and, it is hoped, will propose a harmonised air quality index including a prototype data platform to ensure the data is easily accessible. It is hoped this will be ready for review next year.

IMPROVED UNDERSTANDING OF HOW POLLUTANTS ACT OVER LARGE AREAS, OBTAINED BY CITY-WIDE MAPPING PROJECTS, WILL PROVIDE BENCHMARK DATA FOR PLANNERS, ARCHITECTS AND ENVIRONMENTALISTS

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The Starchaser Tempest Rocket being readied for launch in Capesthorne Hall, UK. It has a small air quality sensor developed by the University of Leicester and Bluesky mounted in its nose cone