Who's to blame for bad air?

Controlling our own emissions is a good idea, but plenty of the pollution problems most nations face come from abroad. Stefan Reis, Massimo Vieno and Eiko Nemitz explore the role of transboundary air pollution in local air quality, and the need for international action to tackle it.

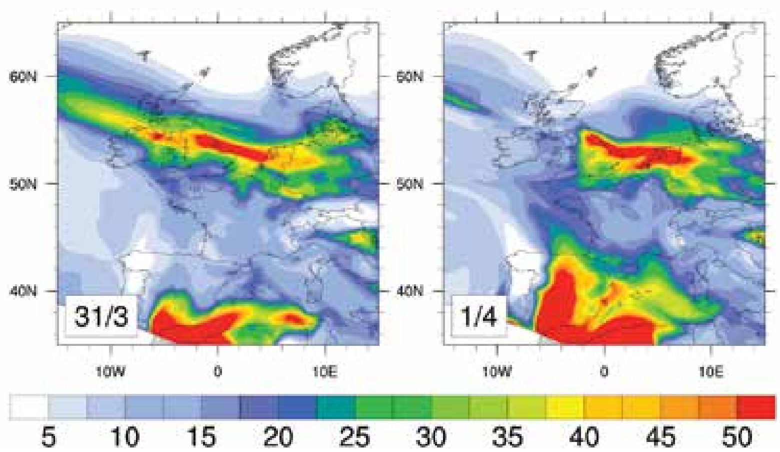
In March and April 2014, the British media ran a story about a developing episode of very high air pollution near the surface across large parts of the UK. The culprit was quickly identified as a dust cloud which originated in the Sahara, made its way north and covered parts of France, reaching up across the British Isles. Even the prime minister referred to this 'naturally occurring event' in an interview and, like many Britons, refrained from exercising outdoors to avoid breathing in fine particulate matter (PM) at potentially harmful levels.

Yet a more thorough analysis, using both computer models to simulate how air pollutants move through the atmosphere and advanced measurement techniques, revealed a more complex story. A Saharan dust cloud was indeed covering part of the UK, but models showed it was high above the surface for most of the time PM concentrations were high.

At the same time, a major plume of PM formed by the combination of emissions of nitrogen oxides and ammonia, known as secondary inorganic aerosols – in this case, mainly ammonium nitrate – was blown across the Channel from northern France, the Benelux region, northern Germany and Denmark.

This plume was observed by measurements at the heavily-instrumented EMEP 'supersite' at Harwell, where the different components of PM concentrations are routinely analysed. Model simulations, utilising the EMEP4UK-WRF model framework, illustrated the source regions and the movement of this plume, as well as those of the Saharan dust cloud. By combining the model results and the observations, a clearer picture emerged. This episode of high PM concentrations at ground level wasn't a natural phenomenon; it happened because man-made emissions combined with weather conditions which brought them to the UK.

High emissions of ammonia from farmland across north-western continental Europe, caused by the application of animal manure and mineral fertilisers, coincided with a general meteorological pattern channelling continental air masses north across the UK. This is not a rare event. Nor is it limited to the UK, as similar episodes of particle pollution over Paris and other European cities have shown in recent years.



Modelled daily-mean surface concentration of PM2.5 (in micro-grammes per cubic metre) for 31 March and 1 April 2014, showing ammonium nitrate plume stretching from northern continental Europe across much of the UK. CEH

Agricultural soils inevitably release ammonia if conditions like temperature and soil moisture are right following the application of manure or mineral fertilisers that contain reactive nitrogen compounds. Stables and storage facilities for manure and slurry also emit it. While ammonia itself is typically deposited within a few hundred metres of its source, as soon as it combines with the oxidation products of nitrogen oxides or sulphur dioxide and forms secondary inorganic aerosol, it can be carried hundreds of kilometres. Ammonium nitrate evaporates at higher temperature, so it contributes to secondary aerosol formation mainly during periods of cold or cool weather. Pollution episodes involving nitrate aerosol are much rarer in summer or warmer parts of Europe.

An unnatural phenomenon

This has profound implications for environmental policy. The notion of a 'naturally occurring phenomenon' suggests there's nothing we can do. Yet with agriculture contributing around 82 per cent of ammonia emissions (UK National Atmospheric Emission Inventory, 2013) and road transport or other fossil fuel burning accounting for most nitrogen oxides emissions across Europe, the formation of secondary inorganic aerosols is well within human control.

This episode and others like it also show that health risks across Europe are influenced by the movement of air pollution across national borders. We need to act together to cut emissions to combat the harm to people's health.

While emissions of sulphur dioxide and nitrogen oxides have been reduced substantially since the 1970s (by 91 and 70 per cent respectively according to the UK National Atmospheric Emission Inventory), ammonia emissions have remained relatively stable. But there are things we could do to reduce emissions from agriculture, and they are often free or cheap compared to costly measures to reduce nitrogen oxide emissions from road transport and other combustion sources (see p12).

The Task Force on Reactive Nitrogen, set up under the 'Air Convention' of the United Nations Economic Commission for Europe (UNECE), has compiled a document detailing measures to reduce agricultural ammonia emissions, and what they would cost.

They include using nitrogen more efficiently and exploiting advanced technologies to inject liquid manure or formulations of mineral fertilisers into the ground, so less ammonia escapes into the atmosphere. They vary in applicability, cost and effectiveness depending on each farm's size, type and local conditions, as well as on the way agricultural production systems are set up and operated at national and regional scale.

Our economies are interconnected by trade and material flows, and this intricately links the processes that contribute to transboundary air pollution problems to potential solutions. So international air pollution-control policies have a vital role to play, and have made substantial improvements in recent decades.

A recent report of the 'Air Convention' of the UNECE summarises these achievements, and highlights the challenges that remain. It concludes: 'Because transboundary sources are often major contributors to urban pollution, many European cities will be unable to meet WHO guideline levels for air pollutants through local action alone. Even national and Europe-wide action may not be enough in some cases.'

The 2014 episode illustrates the need to find out more about the underlying causes of such events, and of bad air quality more generally. But we don't only need to have the right tools available to make such assessments – the way scientific evidence is communicated to policy decision makers is equally important.

The episode wasn't a natural phenomenon; it happened because of man-made emissions.

The 'science-policy interface' is vital to ensure that scientific findings are taken into account when policies are designed, but equally to safeguard that researchers understand policy priorities and needs when conducting analyses. And despite the improvements in air quality since the times of the London smog in the 1950s or acid rain in the 1970s, air pollution is not quite a problem of the past. Much of Europe's vegetation is not yet protected from the effects of acid and nitrogen pollution, to which ammonia makes a major contribution, despite reductions in unprotected European land in the past 30 years since the peak of acid deposition.

The forthcoming sixth edition of the UN Global Environment Outlook statement says: 'Air pollution is now the greatest health risk in [Europe], with more than 95 per cent of the EU urban population exposed to levels above WHO guidelines, for example. Over 500,000 premature deaths in the region were attributable to outdoor air quality and 100,000 to indoor air quality in 2012.'

This also highlights that transboundary air pollution and climate change have to be addressed in an integrated way. Only by working across national boundaries can we avoid unintended consequences and contribute to a substantial and lasting improvement of public health by reducing exposure to harmful air pollution levels.

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