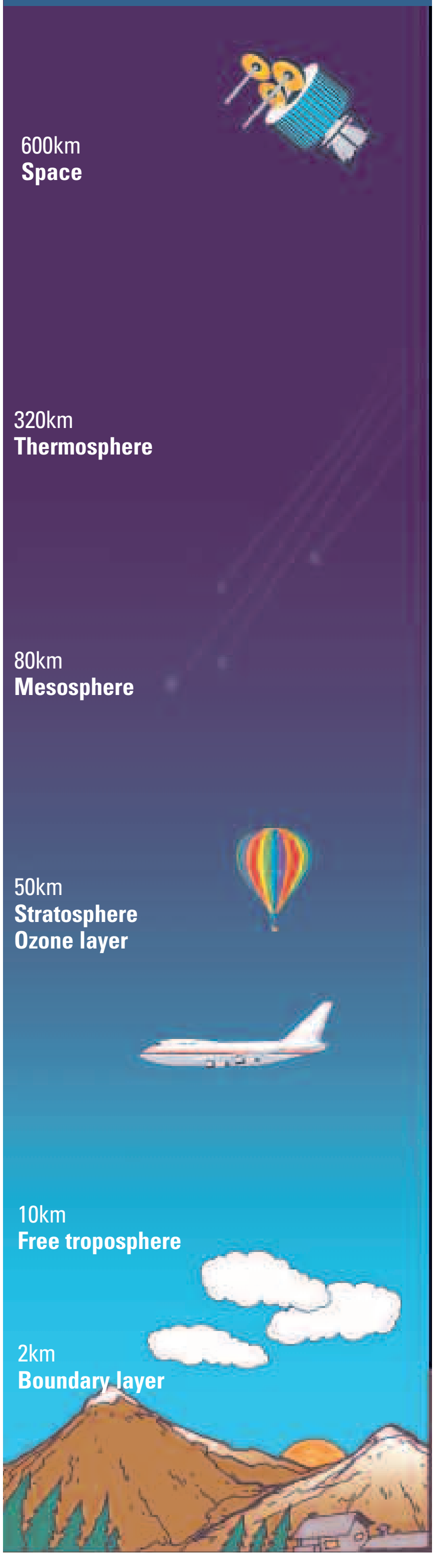
Our changing **atmosphere**

Four UK atmospheric science programmes wind up shortly. **Tony Cox, Keith Bower** and **Helen Rogers**, discuss some of the achievements.

Layers of the atmosphere



Emissions to the atmosphere from human activity are altering the climate system. The resulting climate change will affect all our lives. NERC invested £20 million in four research programmes to look at very specific areas of atmospheric chemistry and physics in an attempt to quantify the effects of greenhouse gases and other pollutants on the climate and air quality. These programmes, which are about to draw to a close, have focused specifically on: air quality, ozone, and clouds and water vapour, with one programme developing new instruments to improve analysis of atmospheric composition. In January we held an event in London to mark the end of these programmes.

So how will air quality change in a warmer world? We already know pollutants react with each other and with gases naturally present in the atmosphere, but these reactions are likely to change as the world heats up. Scientists working on the Polluted Troposphere programme were looking at just these issues. Indeed, they were fortunate enough to be monitoring north of London during the 2003 heatwave, giving them a unique and detailed insight into the key chemical and physical processes that cause smog on hot days.

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The team recorded very high concentrations of ozone, a respiratory irritant, near the ground. The source of the ozone surprised them all. Naturally-produced compounds from vegetation were partly to blame for the smog and reduced air quality in the region. The team showed that plants responded to heat stress by emitting large amounts of the organic vapour isoprene. This is a highly reactive chemical that contributes to high levels of ozone when combined with nitrogen oxides. Calculations showed that during the heatwave natural emissions, which increased because of the heat, accounted for 33 percent of regional ozone formation on average, and typically 40-45 percent on highest temperature days. The work demonstrates that the relationship between natural emissions and poor air quality is a major uncertainty in a changing climate.

On a national policy level there is an imperative to determine the links between air quality and climate policy. For example, the steps taken to reduce local and regional air pollution could be in conflict with climate goals (some pollutants such as particulates have a cooling effect on the planet) and similarly, the steps taken for climate mitigation could make local and regional air quality targets more or less attainable. Scientists and policy makers are now working together on these policy trade-offs.

Whilst ozone in the lower atmosphere reduces air quality, ozone in the stratosphere is essential to protect us from harmful UV radiation. NERC set up the Upper Troposphere Lower Stratosphere Ozone programme (UTLS Ozone) to examine the causes for mid-latitude ozone changes in the past, and our expectations for the future.

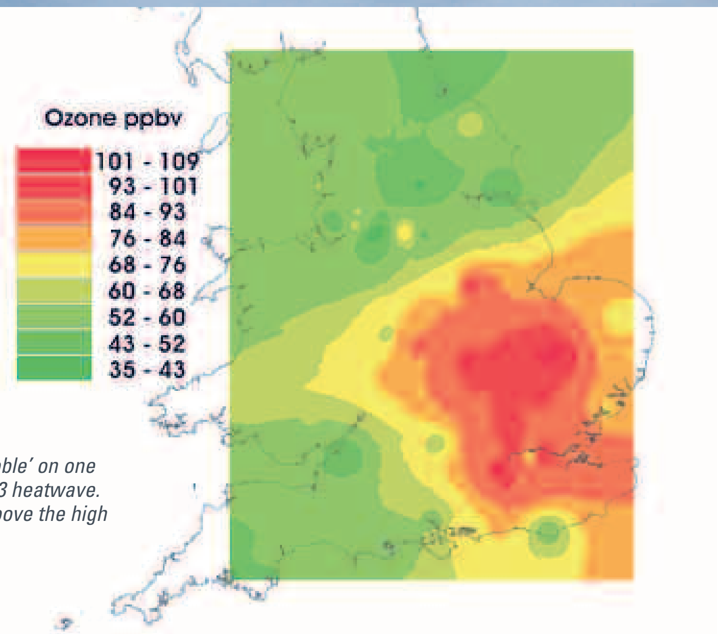
An investigation into the long-range transport of pollution provided an important contribution to this programme. Our understanding of how pollution travels long distances – between continents – relies heavily on computer models. In order to test these models the team asked the question: can we detect a polluted air mass leaving a city or region and follow this as it changes over

thousands of miles? This led to one of the largest international atmospheric chemistry experiments ever staged, involving 600 scientists and 100 research centres.

The consortium of scientists intercepted and sampled a mass of polluted air in the upper troposphere which originated from cities along the eastern seaboard of the USA. The researchers tracked its movement on a transcontinental scale, as it swept out over the Atlantic. UK scientists flew on the NERC/Met Office aircraft into the polluted air, providing key mid-Atlantic measurements. US researchers caught similar samples on previous days, and French and German scientists seized their opportunity on subsequent days as the air drifted over Europe. This was the first time scientists have successfully tracked a true source-to-receptor pathway for pollutants moving over intercontinental scales. By combining both measurements and models the project produced much more accurate estimates of emission strengths and long-range pollutant influence.

The Clouds, Water Vapour and Climate (CWVC) programme targeted the physical processes that determine humidity distribution and cloud structure. Clouds have a complex effect on climate: they can insulate the planet, preventing heat from escaping to space, but they can also reflect heat away from our planet. Climate change will change clouds, including their formation, type and thickness. The atmosphere also holds vast amounts of water vapour; a major greenhouse gas. As the atmosphere warms it can hold more water vapour thereby increasing the greenhouse effect.

By learning more about the structure and physics of clouds on a microscopic level we can improve rainfall forecasting, including extreme rainfall. Measurements from one team focused on a single storm,



UK ozone 'bubble' on one day of the 2003 heatwave. Levels rose above the high warning level.

P. Monks and M. Jacob, University of Leicester

'Hector', that formed over the Tiwi Islands north of Darwin, Australia. Results indicated that large numbers of small particles, known as aerosols, entering through the base of the cloud can influence intense thunderstorms and substantially change the ability of the clouds to scatter sunlight. Deep convection, where warm air rises and cool air sinks, in the tropical regions, produces large storms of importance to the Earth's radiation budget.

Finally, the Core Strategic Measurements in Atmospheric Science (COSMAS) programme demonstrated the importance of continuing laboratory experiments, developing new instruments and data acquisition. Of particular note, the team developed several new instruments based on gas chromatography and high performance infrared instruments to measure atmospheric radiation and chemical composition. New data and instruments developed through this programme have also successfully contributed to other NERC programmes, including those mentioned here, as well as international research studies and assessments.

At the event on the 23 January, held to mark the end of these programmes, both the government's chief scientific advisor, Sir David King, and NERC's Chief Executive, Professor Alan Thorpe, provided keynote addresses. The event gave scientists involved in the programmes the opportunity to discuss their work with government, industry and the general public, thereby providing a valuable opportunity for the dissemination of NERC-funded science.

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More information: www.nerc.ac.uk follow links from 'Our research'.NERC's British Atmospheric Data Centre stores data from these programmes. This data is available online: http://badc.nerc.ac.uk