Chapter (non-refereed)

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Trends in Ozone, Sulphur Dioxide and Nitrogen Oxides at a Semi-Rural Site in South East Scotland

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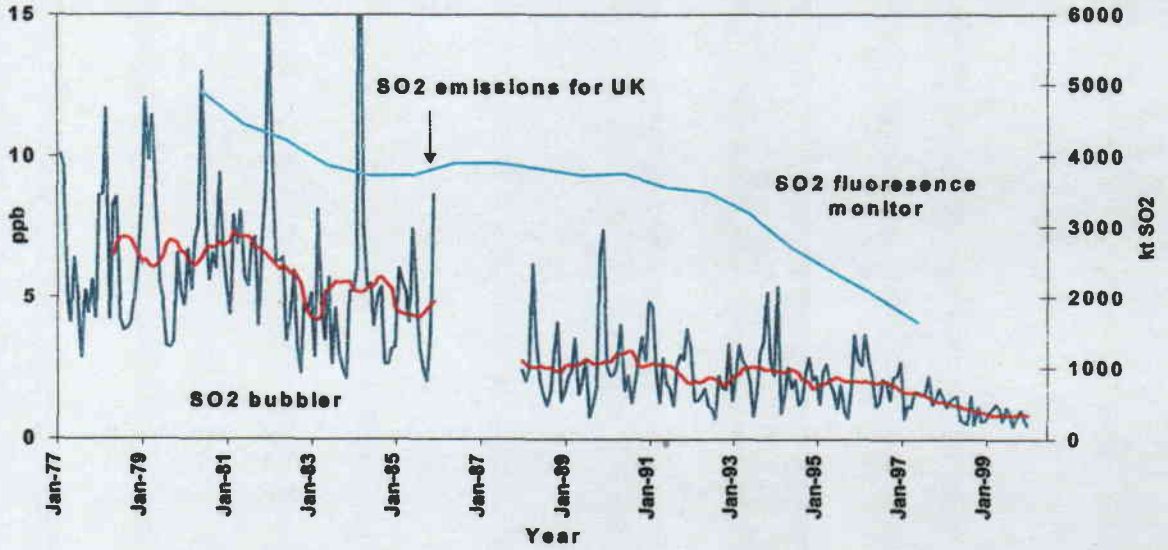
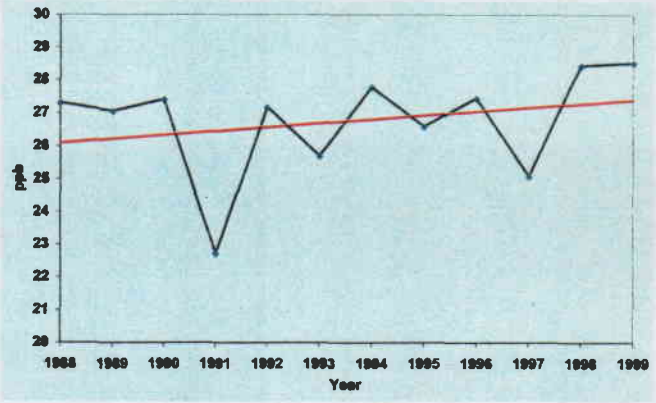
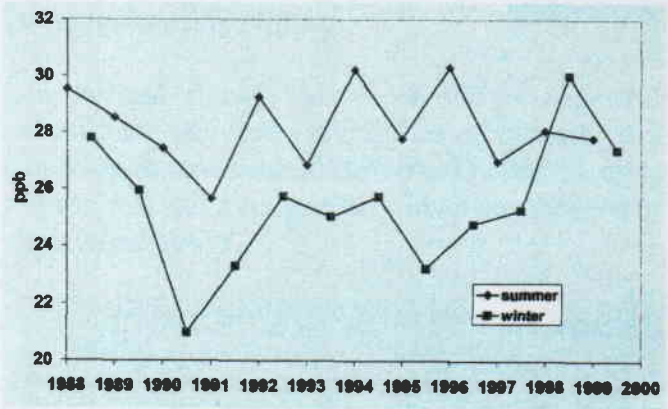
Continuous long-term measurements of ozone (O_3), nitric oxide (NO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and meteorological parameters were made at a site in a semi-rural location at the foot of the Pentland Hills, 12 km south of the city of Edinburgh. The site is part of the UK National Air Quality Network. Twenty-one years of SO_2 data have been obtained. Ozone and nitrogen oxides (NO_X) have been measured since 1988.

Reduction in sulphur dioxide (SO_2) concentrations 1977 to 1999 is mainly the result of a reduction in coal burning, flue gas desulphurisation of power stations and reduced sulphur in vehicle fuels. Total UK emissions have fallen from 4910 kt SO_2 in 1980 to 1656 kt SO_2 in 1997. Annual average SO_2 concentrations have fallen from 6 ppb in 1977 to less than 1 ppb by 1999. Peak values of SO_2 have also reduced as both local sources and continental long range transported air has become less polluted.



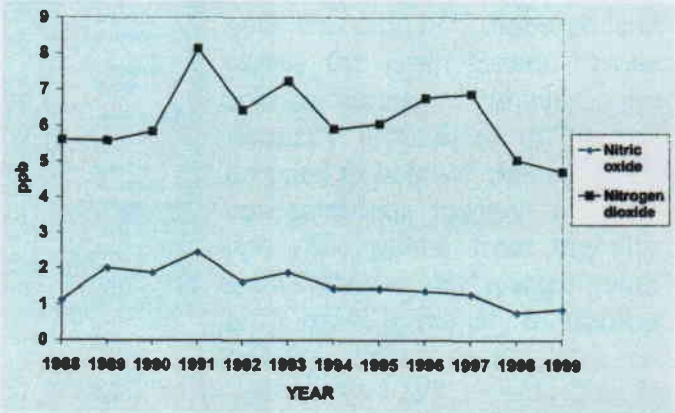
Annual average ozone concentrations show a very small upward trend but this is insignificant by comparison with the inter-year variation. The Bush Estate is in a semi-rural location such that the measurements are affected by the City of Edinburgh and other local sources. Nitric oxide from these local sources reduces annual mean ozone concentrations compared to more remote rural sites.

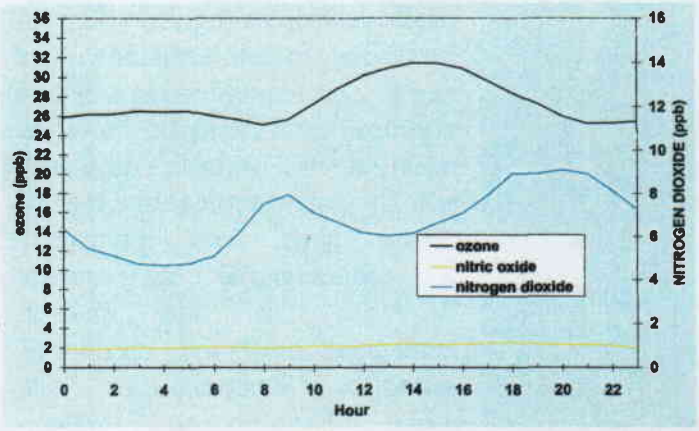




Mean summer ozone concentrations are higher than those observed in winter. Long day-lengths shift the photostationary state (assuming an absence of competing interconversion reactions) towards ozone production because NO_2 is photolysed to NO by sunlight with consequent regeneration of ozone.

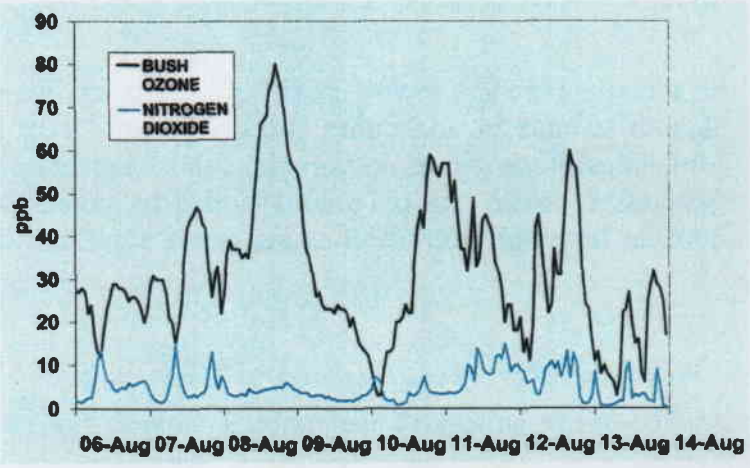
Annual mean concentrations of nitric oxide and nitrogen dioxide peaked in the early 1990's (2.5 and 8.1 ppb respectively in 1991) before the introduction of catalysts on new petrol-engined vehicles during 1993. Concentrations of both species at Bush Estate are now at their lowest since measurements began with an annual mean in 1999 of 0.9 and 4.7 ppb respectively.



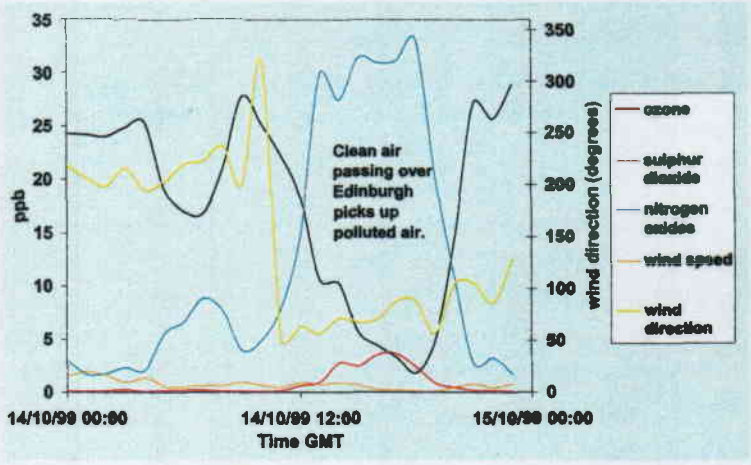


The annual mean diurnal cycle of ozone and nitrogen dioxide for 1996 shows a characteristic pattern. The morning "rush hour" is evident centred around 08:30 with the reduction in ozone due to the NO + O_3 reaction producing elevated concentrations of NO_2. During the midday period, greater mixing of air during daylight hours enhances ozone concentrations before a rather more prolonged evening traffic peak when ozone is depleted again.

Ozone concentrations can be abnormally high in air originating from Europe and southern England. These peak concentrations occur in the summer months by the long-range transport of polluted air, trapped for several days under a high pressure system. August 1997 was the second hottest on record (since 1659) with higher than average sunshine figures.

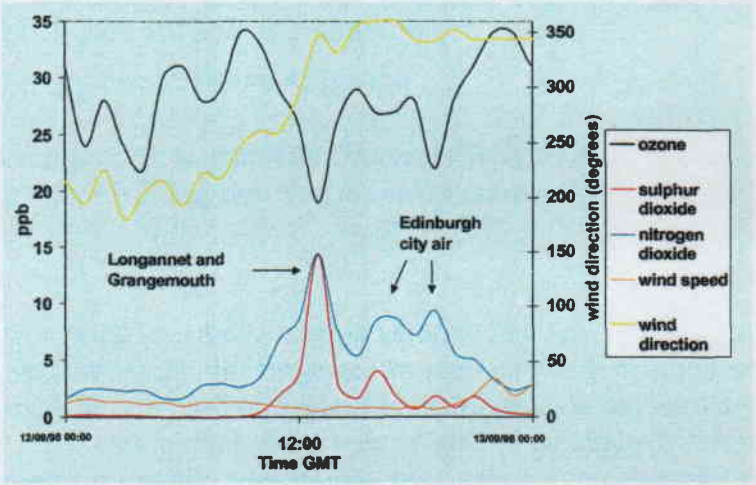


In the case shown, between 6 and 14 August 1997, high concentrations of ozone built up during the day under the influence of sunlight and photochemical production, despite rapid deposition to terrestrial surfaces. During the night, ozone was deposited to the ground as wind speed fell and a temperature inversion formed, separating air near the ground from the well-mixed air above.



A high pressure system centred over the British Isles on 14 October 1999 bringing clean arctic air down from the north over the city of Edinburgh and across the Bush Estate. Ozone concentrations, which are normally around 20 to 30 ppb dropped to below 5 ppb and NO_2 concentrations reached over 30 ppb. The plume from the city shows ozone is reacted with nitric oxide in the city to produce NO_2.

Predominant south-west winds normally bring background (clean air) concentrations of pollutants over the measurement site. When the wind direction is in northerly directions plumes can be seen from local sources such as the Longannet coal fired power station, the Grangemouth oil refinery and the city of Edinburgh. Air from Longannet and Grangemouth refineries contains proportionally more sulphur dioxide than city air where the reduction in the sulphur content of automotive fuels has reduced concentrations in recent years.



Longannet power station emissions are presently the largest power station emissions in Scotland (48.8 kt a^{-1} SO_2 and 19.2 kt a^{-1} NO_2). Further reductions in sulphur dioxide emissions will be possible with the introduction of desulphurisation equipment scheduled for 2005. New limit values for sulphur content of petrol (150mg/kg) and diesel (350mg/kg) came into force on 1st January 2000 and these limits are to be further tightened in 2005 (50mg/kg for both petrol and diesel).

References

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The Co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe Website at www.emep.int/index.html