2.12 Ozone

Ned Dwyer, Peter Simmonds, Gerard Jennings, Simon O'Doherty, Colin O'Dowd and Keith Lambkin

Ozone (O_3) is the third most important greenhouse gas in terms of radiative forcing. The influence of O_3 on climate is complex with different impacts in the upper and lower atmosphere. Although human activities do not emit ozone directly, atmospheric pollution, for example from industry, transport and the burning of vegetation, can create the conditions for enhanced ozone formation. As well as influencing the climate, surface O_3 can affect the human respiratory system and damage crops and other vegetation.

Photo: © Karen Commane

Map 2.12. Location of total column and ground ozone observation stations.

'The influence of O_3 on climate is complex with different impacts in the upper and lower atmosphere.'

Measurements

Total column O_3[11] has been measured at Valentia Observatory, Co. Kerry (red) since 1993 using ground-based optical equipment. Since 1994 vertical ozone profiles are routinely measured using equipment carried on weather balloons to heights greater than 30 km.

11 Represents the total amount of O_3 in a column from the surface of the Earth to the top of the atmosphere.

A ground-based O_3 observational network has been established with 11 sites around the country (blue), including Valentia Observatory (red).

Measurements of O_3 from satellites have been made since the 1970s with different sensors operating in the ultraviolet, visible and microwave part of the spectrum. Both total column and profiles of O_3 at different heights in the atmosphere have been retrieved. *In situ* measurements are required to validate these satellite observations.

'Ozone levels in the upper atmosphere are observed to be slowly recovering since CFCs were banned in 1987.'

Time-series and Trends

Although a number of human activities lead to atmospheric O_3 formation, the emission of CFCs to the atmosphere causes O_3 reductions in the upper atmosphere (stratosphere) and has led to the formation of the 'ozone hole'. This 'hole' is biggest over the Antarctic where stratospheric ozone is severely depleted during the period August to October every year. This allows more harmful ultraviolet radiation to reach the Earth's surface. Since these chemicals were banned under the Montreal Protocol (1987), O_3 levels in the upper atmosphere are slowly recovering.

At Valentia Observatory measurements of total column O_3 vary throughout the year with a maximum reached in the Northern Hemisphere's spring season and a minimum in late autumn as illustrated in Fig. 2.22. Recent analysis of these data show trends of about 1.5% increase per decade at an average O_3 level of 325 Dobson Units (DU).

A recent analysis across the ground-level observation network notes a decrease in O_3 concentrations, in particular since 2000. This may be due to a decrease in the levels of regional-scale photochemical ozone production. However, analysis of ground level O_3 measurements at Mace Head Co. Galway (Fig. 2.23) shows that average annual O_3 amounts in the lower atmosphere increased over the period from 1987 to 1997 followed by a step change during 1997–1999 and relatively constant levels since. The red line shows a

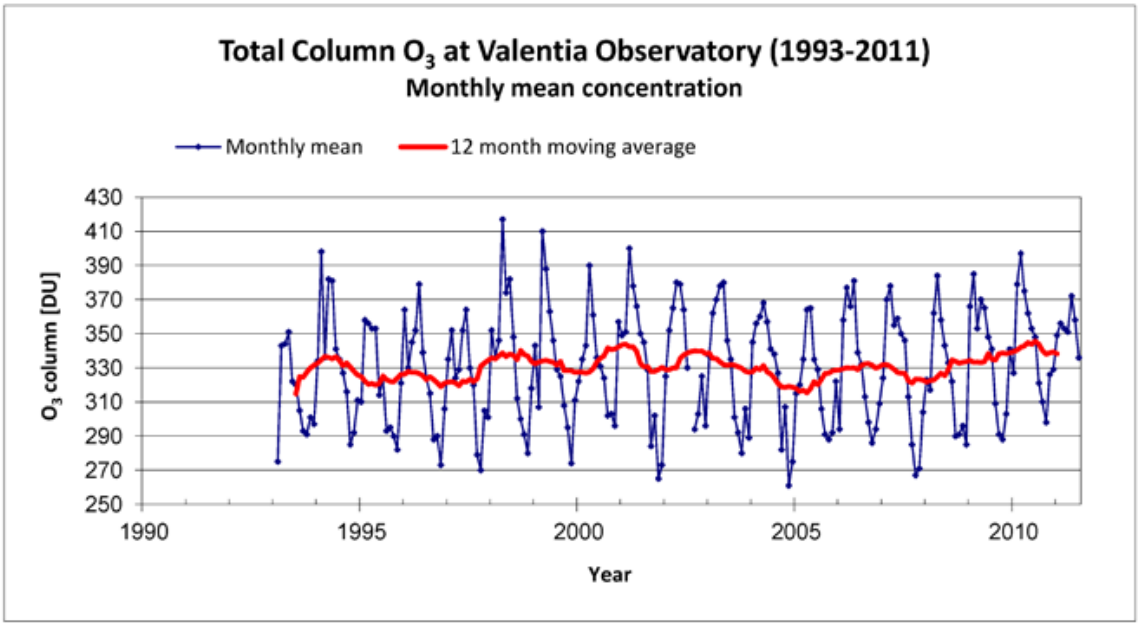

Figure 2.22. Monthly mean total column ozone concentration observed at Valentia Observatory (1993–2011).

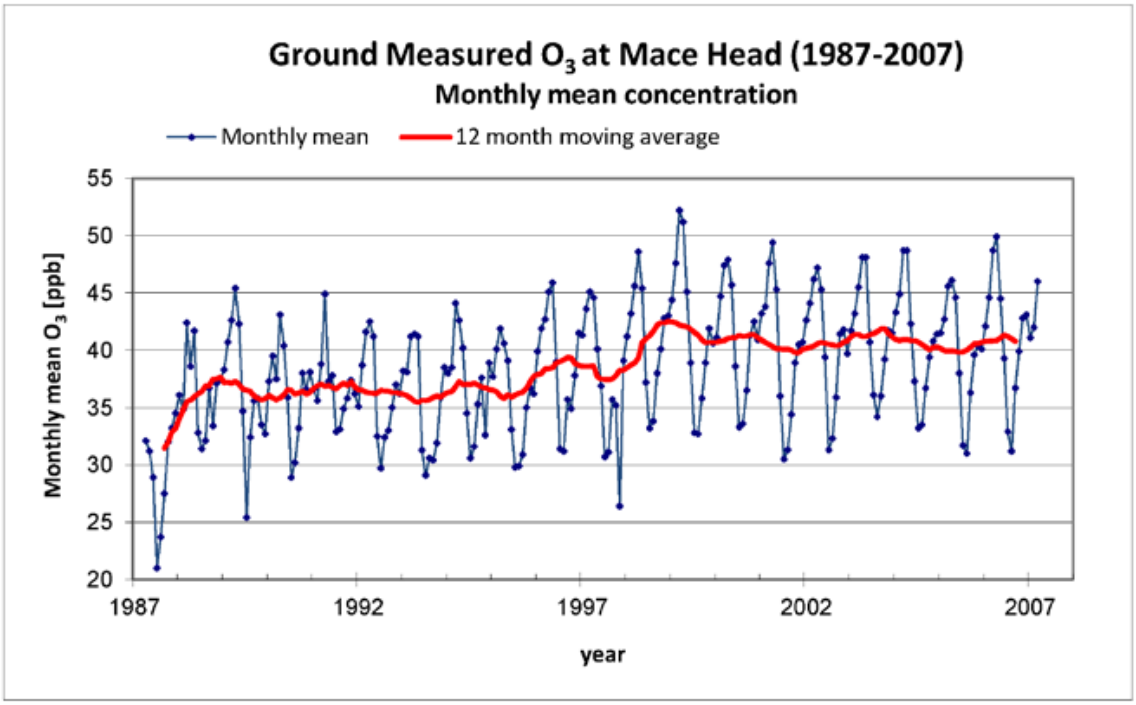

Figure 2.23. Monthly mean ground-level ozone concentration observed at Mace Head (1987–2007).

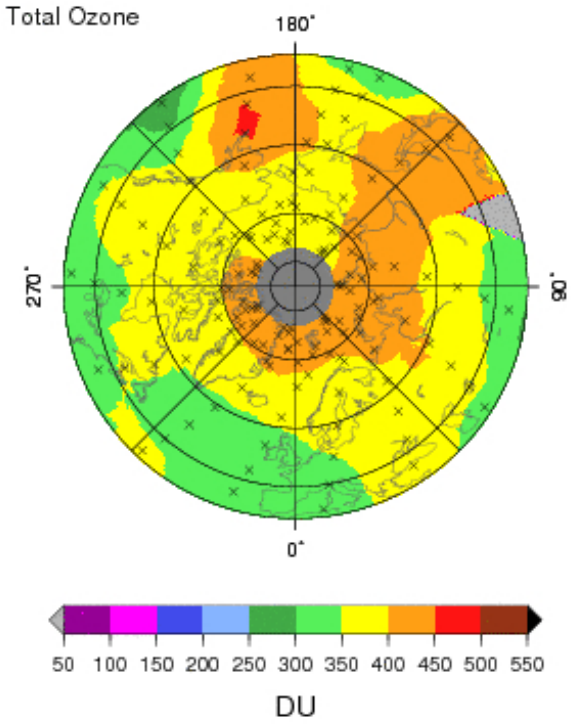

Figure 2.24. Polar view of total amount of ozone integrated from ground to top of the atmosphere, as determined by the SCIAMACHY instrument on board *ENVISAT*, 1 May 2010. Ireland can be seen toward bottom-centre of image, to the west of 0° longitude.

12-month running average over the period. The sharp increase in 1998/99 has been associated with large vegetation fires in the northern hemisphere during that period. Mace Head observations are strongly influenced by Atlantic marine air masses.

Maintaining the Observations

Funding for O_3 observations at Valentia Observatory is provided from Met Éireann's operational budget. However, the programme lacks long-term committed financing. Equipment maintenance and data handling is carried out by highly skilled on-site Met Éireann staff. Funding for observations at Mace Head was originally from the UK's DEFRA and since 2007 has been funded by the DECC. Equipment maintenance and data handling are carried out by highly skilled staff from the National University of Ireland Galway. The ground-based network is primarily for air quality monitoring and is maintained and funded by the EPA. Satellite-based sensors such as the Ozone Mapper Profiler Suite (OMPS) on board NASA's *Suomi* NPP satellite launched in January 2012 will ensure the continuity of stratospheric ozone observations.

Further Information and Data Sources

Derwent, R.G., Simmonds, P.G., Manning, A.J. and Spain, T.G. (2007) Trends over a 20-year period from 1987 to 2007 in surface ozone at the atmospheric research station, Mace Head, Ireland, *Atmospheric Environment*, Vol. 41, pp. 9091–8.

Keim, C., Eremenko, M., Orphal., J., Dufour, G., Flaud, J.-M., Höpfner, M., Boynard, A., Clerbaux, C., Payan, S., Coheur, P.–F., Hurtmans, D., Claude, H., Dier, H., Johnson, B., Kelder, H., Kivi, R., Koide, T., López Bartolomé, M., Lambkin, K., Moore, D., Schmidlin, F.J. and Stübi, R. (2009) Tropospheric ozone from IASI: comparison of different inversion algorithms and validation with ozone sondes, *Atmospheric Chemistry and Physics,* Vol. 9, pp. 9329–47.

Tripathi, O.P, Jennings, S.G., O'Dowd, C.D., Colman, L., Leinert, S., O'Leary, B., Moran, E., O'Doherty, S.J. and Spain, T.G. (2010) Statistical analysis of eight surface ozone measurement series for various sites in Ireland, *Journal of Geophysical Research,* Vol. 115, D19302, doi:io.1029/2010JD014040.

Tripathi, O.P., Jennings, S.G., O'Dowd, C.D., Lambkin, K. and Moran, E. (Submitted) Recent trends in stratospheric ozone at a mid-latitude observing station at Valentia, Ireland (51.94^0 N, 10.250 W) through ground-based and ozonesonde measurements from 1994 to 2009, *Journal of Atmospheric Science.*

Tripathi, O.P., Jennings, S.G., Colman, L., Lambkin, K., Moran, E. and O'Dowd, C.D. (2012) *Ozone Levels, Changes and Trends over Ireland – an integrated analysis*, EPA, pp. 137: http://www.epa.ie/downloads/pubs/research/air/name,33696,en.html

EPA Air Monitoring Programme: http://www.epa.ie/whatwedo/monitoring/air/

Global Atmosphere Watch (GAW) research at the World Meteorological Office on atmospheric ozone: http://www.wmo.int/pages/prog/arep/gaw/ozone/index.html

University of Bremen, Institute of Environmental Physics, SCIAMACHY archive: http://www.iup.uni-bremen.de/scia-arc/

World Ozone and Ultraviolet Radiation Data Centre (WOUDC): http://www.woudc.org.