2.9 Carbon Dioxide

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Carbon dioxide (CO_2) is the most important human-emitted greenhouse gas in the atmosphere. Globally, the biggest sources of additional CO_2 emissions are fossil-fuel burning, deforestation, vegetation fires and land-use changes. In Ireland major sources include fossil-fuel burning caused by energy generation and road transport. Before the Industrial Revolution the concentration of CO_2 was approximately 270 ppm (parts per million). Since the late 1700s, this has increased by about 38% and today stands above 390 ppm. At the UN Climate Change talks in Durban in 2011 it was recognised that there is an urgent need to limit the rise in the Earth's average temperature to less than 2°C above the pre-industrial temperature. This will require a cut of 50% in emissions before 2050 compared to 1990.

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Map 2.9. Location of carbon dioxide observation stations.

'Current CO_2 concentrations of more than 390 ppm are higher than at any time over at least the last 400 thousand years.'

Measurements

Atmospheric CO_2 concentrations have been measured at the Mace Head Atmospheric Research Station, Carna, Co. Galway (red) since 1992. High-precision measurements are made on an hourly basis. This site is of global importance as the measurements are representative of the underlying concentration of atmospheric CO_2 in the northeast Atlantic region. CO_2

concentrations are also measured at Carnsore Point, Co. Wexford and Malin Head, Co. Donegal (blue) since 2009.

The amount of CO_2 in the atmosphere can be inferred from satellite observations, such as those from the Japanese GOSAT and previously from the European ENVISAT. Ground-based measurements are vital for the validation of these satellite observations.

Time-series and Trends

CO_2 concentrations in the atmosphere are currently higher than at any time over at least the last 400 thousand years. Before the industrial era atmospheric CO_2 concentration was approximately 270 ppm. Now it stands at above 390 ppm due to additional emissions from human activities.

Measurements in Hawaii since 1958 (illustrated in Fig. 2.15) show steadily increasing concentrations of atmospheric CO_2. This is replicated since measurements began in 1992 at Mace Head.[9] The signal at Mace Head is more variable due to proximity to Europe and the influence of North America where the uptake of CO_2 by growing vegetation and its subsequent release when the vegetation decays causes seasonal fluctuations.

Global maps of the average atmospheric CO_2 concentration for August 2009 and February 2010 (Fig. 2.16) illustrate seasonal variability. Concentrations are lower in the Northern hemisphere in summer due to absorption by growing vegetation. CO_2 is released during the autumn and winter when part of the vegetation dies and decays. This seasonal variability is also evident in the *in situ* observations from Mace

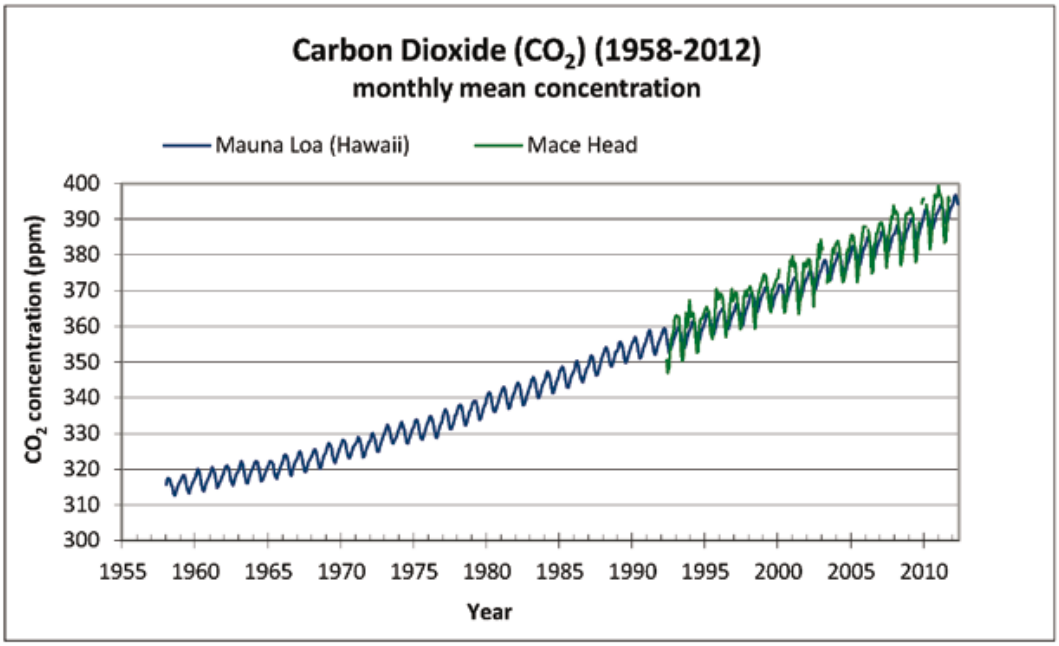

Figure 2.15. Monthly mean concentration of carbon dioxide at Mauna Loa, Hawaii (1958–2012) and Mace Head Research Station, Ireland (1992–2011).

9 Figure prepared from information courtesy of Dr Pieter Tans, NOAA/ESRL (Hawaii), Michel Ramonet, LSCE (France), and Colin O'Dowd, National University of Ireland Galway (Mace Head).

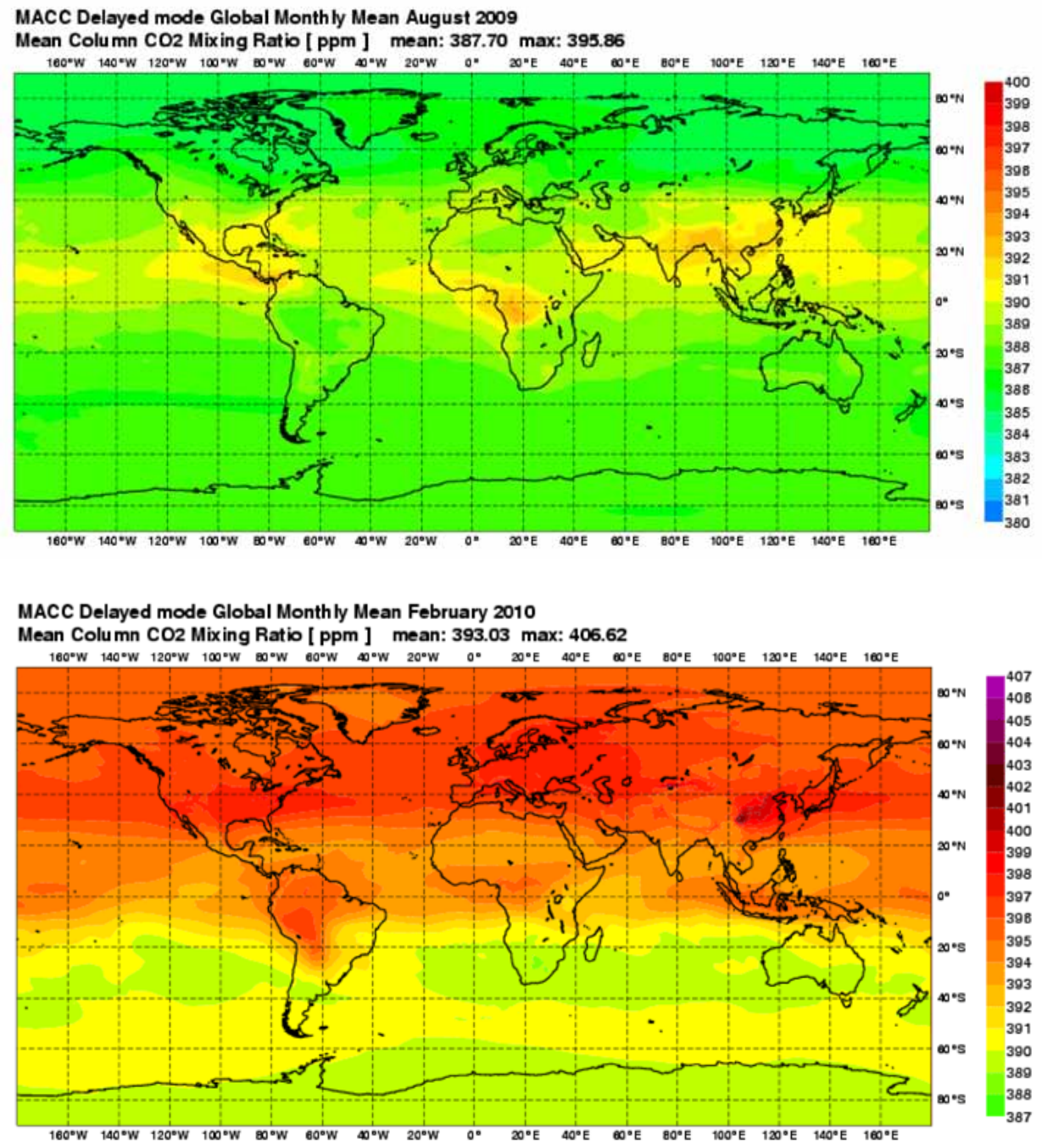

Figure 2.16. Example of global monthly mean carbon dioxide concentrations for August 2009 (top) and February 2010 (bottom) as derived from satellite observations.

Head (Fig. 2.15). These maps were generated by integrating satellite and ground-based observations as part of the Monitoring Atmospheric Composition and Climate (MACC) pre-operational atmospheric service of the European Global Monitoring for Environment and Security (GMES) programme.

'The Mace Head research station is of global importance as the CO_2 observations are representative of the underlying concentration in the northeast Atlantic region.'

Maintaining the Observations

Funding for CO_2 observations at Mace Head is from the Laboratoire des Sciences du Climat et de l'Environnement (LSCE – CEA/CNRS/UVSQ) in France. Equipment is maintained by the National University of Ireland Galway. The Earth System Research Laboratory of the National Oceanic and Atmospheric Administration (NOAA) in the US has carried out weekly air sampling of CO_2 at Mace Head since 1991 as part of a long-term programme. This provides the possibility to compare the NOAA and the LSCE observations. CO_2 observations at Carnsore Point and Malin Head are funded under an EPA research programme as part of the European Integrated Carbon Observation System (ICOS).

Further Information and Data Sources

Ramonet, M., Ciais, P. Aalto, T., Aulagnier, C., Chevalier, F., Cipriano, D., Conway, T.J., Haszpra, L., Kazan, V. Meinhardt, F., Paris, J.-D., Schmidt, M., Simmonds, P., Xueref-Rémy, I. and Necki, J.N. (2010) A recent build-up of atmospheric CO_2 over Europe. Part 1: observed signals and possible explanations, *Tellus*, Vol. 62B, No. 1, pp. 1–13.

World Data Centre for Greenhouse Gases (including data from Mace Head): http://ds.data.jma.go.jp/gmd/wdcgg/

Data and Trends in Atmospheric Carbon Dioxide from Mauna Loa (Hawaii) http://www.esrl.noaa.gov/gmd/ccgg/trends/

Information on the Integrated Carbon Observation System (ICOS): http://www.icos-infrastructure.eu/

Information and data from ESA's Climate Change Initiative greenhouse gas project: http://www.esa-ghg-cci.org/

Data products from SCIAMACHY at the University of Bremen: http://www.iup.uni-bremen.de/sciamachy/NIR_NADIR_WFM_DOAS/

Data products and information from GOSAT: http://www.gosat.nies.go.jp/index_e.html

Data and information on MACC: http://www.gmes-atmosphere.eu/