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The state of greenhouse gases in the atmosphere using global observations through 2010

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The Global Atmosphere Watch (GAW) Programme of the World Meteorological Organization (WMO) provides a framework for observing and assessing the state and development of environmental issues related to atmospheric composition, including greenhouse gases. It puts stringent requirements on the quality of the observations; these requirements are reviewed by the greenhouse gas science and measurement community at biennial WMO/IAEA Meetings on Carbon Dioxide, Other Greenhouse Gases, and Related Tracer Measurement Techniques. The 16th meeting was held in Wellington, New Zealand, on 25 – 28 October 2011 (http://www.niwa.co.nz/our-science/atmosphere/ggmt-2011). Surface observations are made at more than 100 stations worldwide for CO_2 and CH_4 and at a smaller number of stations for many other greenhouse gases. Results of the latest global analysis were published in the WMO/GAW Greenhouse Gas Bulletin in November 2011. It highlights the importance of N_2O, the third most important long-lived greenhouse gas in the atmosphere. Globally averaged dry-air mole fractions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) reached new highs in 2010, with CO_2 at 389.0 ppm, CH_4 at 1808 ppb and N_2O at 323.2 ppb. These values are greater than those in pre-industrial times (before 1750) by 39%, 158% and 20%, respectively. An increase of the annual mean CO_2 mole fraction from 2009 to 2010 amounted to 2.3 ppm, which is higher than the average growth rate for the 1990s ($\sim$ 1.5 ppm/yr) and the one for the past decade ($\sim$ 2.0 ppm/yr). The growth rate of CH_4 decreased from $\sim$ 13 ppb/yr during the early 1980s to near zero from 1999 to 2006. Since 2007, atmospheric CH_4 has been increasing again. The 19 ppb rise from 2006 to 2009 was followed by a 5 ppb rise in 2010. The growth rate of N_2O in 2010 was 0.8 ppb/yr which is comparable to the average over the last 10 years (0.75 ppb/yr). The NOAA Annual Greenhouse Gas Index (AGGI) shows that from 1990 to 2010, radiative forcing from nearly all long-lived greenhouse gases increased by 29% and reached $2.81 W/m^2$, with CO_2 accounting for nearly 80% of this increase. This radiative forcing corresponds to a CO_2-eq mole fraction of 469.7 ppm, which falls in the middle of the IPCC AR4 category I scenario with CO_2-eq in the range 445-490 ppm (corresponding to the projected global average temperature rise above pre-industrial level at equilibrium in the range of 2-2.4 degree C). The radiative forcing of N_2O now exceeds that of CFC-12.