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The state of greenhouse gases in the atmosphere using global observations through 2014

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We present results from the eleventh annual Greenhouse Gas Bulletin (http://www.wmo.int/pages/prog/arep/gaw/ghg/GHGbulletin.html) of the World Meteorological Organization (WMO). The results are based on research and observations performed by laboratories contributing to the WMO Global Atmosphere Watch (GAW) Programme (www.wmo.int/gaw).

The Bulletin presents results of global analyses of observational data collected according to GAW recommended practices and submitted to the World Data Center for Greenhouse Gases (WDCGG). Bulletins are prepared by the WMO/GAW Scientific Advisory Group for Greenhouse Gases (http://www.wmo.int/pages/prog/arep/gaw/ScientificAdvisoryGroups.html) in collaboration with WDCGG.

Observations used for global analysis are collected at more than 100 marine and terrestrial sites worldwide for CO_2 and CH_4 and at a smaller number of sites for other greenhouse gases. Globally averaged dry-air mole fractions of CO_2, CH_4 and N_2O derived from this network reached new highs in 2014, at 397.7±0.1 ppm, 1833±1 ppb and 327.1±0.1 ppb respectively. These values constitute 143%, 254% and 121% of pre-industrial (before 1750) levels.

The atmospheric increase of CO_2 from 2013 to 2014 was 1.9 ppm, which is smaller than the increase from 2012 to 2013 and the average growth rate for the past decade (∼2.06 ppm per year), but larger than the average growth rate for the 1990s (∼1.5 ppm per year). Smaller growth in 2014 compared with other recent years is most likely related to a relatively small net change in large fluxes between the atmosphere and terrestrial biosphere. The rise of atmospheric CO_2 has been only about a half of what is expected if all excess CO_2 from burning fossil-fuels stayed in the air. The other half has been absorbed by the land biosphere and the oceans, leading to ocean acidification.

For both CH_4 and N_2O the increases from 2013 to 2014 were larger than those observed from 2012 to 2013 and the mean rates over the past 10 years. The National Oceanic and Atmospheric Administration (NOAA) Annual Greenhouse Gas Index shows that from 1990 to 2014 radiative forcing by long-lived greenhouse gases increased by 36%, with CO_2 accounting for about 80% of this increase. The radiative forcing by all long-lived greenhouse gases in 2013 corresponded to a CO_2-equivalent mole fraction of 481 ppm (http://www.esrl.noaa.gov/gmd/aggi).

The Bulletin cover story explains the role of the water vapor in the greenhouse effect. In spite of water vapor being a strong greenhouse gas, it is the non-condensable greenhouse gases affected by human activities that serve as climate forcing agents; water vapor and clouds act as fast feedbacks. The strong water vapor feedback means that for a doubling of CO_2 abundance from preindustrial conditions (from about 280 to 560 ppm), water vapor and clouds lead to a global increase in surface thermal energy that is about three times that of long-lived (non-condensable) greenhouse gases.