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The state of greenhouse gases in the atmosphere using global observations through 2013

Oksana Tarasova (1), Hiroshi Koide (2), Ed Dlugokencky (3), Stephen A. Montzka (3), Ralph Keeling (4), Toste Tanhua (5), and Laura Lorenzoni (6)

(1) World Meteorological Organization, Geneva, Switzerland, (2) WMO World Data Centre for Greenhouse Gases, c/o Japan Meteorological Agency, Tokyo, Japan, (3) NOAA, Earth System Research Laboratory, Global Monitoring Division, Boulder, Colorado, USA, (4) The Scripps Institution of Oceanography, La Jolla, California, USA, (5) GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, German, (6) University of South Florida, St. Petersburg, Florida, USA

We present results from the tenth 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), and for the first time, it includes a summary of ocean acidification. 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. The summary of ocean acidification and trends in ocean pCO_2 was jointly produced by the International Ocean Carbon Coordination Project (IOCCP) of the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), the Scientific Committee on Oceanic Research (SCOR), and the Ocean Acidification International Coordination Centre (OA-ICC) of the International Atomic Energy Agency (IAEA).

The tenth Bulletin included a special edition published prior to the United Nations Climate Summit in September 2014. The scope of this edition was to demonstrate the level of emission reduction necessary to stabilize radiative forcing by long-lived greenhouse gases. It shows in particular that a reduction in radiative forcing from its current level (2.92 W m^{-2} in 2013) requires significant reductions in anthropogenic emissions of all major greenhouse gases.

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 carbon dioxide, methane and nitrous oxide derived from this network reached new highs in 2013, with CO_2 at 396.0 ± 0.1 ppm, CH_4 at 1824 ± 2 ppb and N_2O at 325.9 ± 0.1 ppb. These values constitute 142%, 253% and 121% of pre-industrial (before 1750) levels, respectively. The atmospheric increase of CO_2 from 2012 to 2013 was 2.9 ppm, which is the largest year to year change from 1984 to 2013. The rise of CO_2 concentration has been only about a half of what is expected if all the excess CO_2 from the burning of fossil-fuel stayed in the air. The other half has been absorbed by the land biosphere and the oceans, but the split between land and oceans is not easily resolved from CO_2 data alone. As described in the Bulletin, O_2 measurements have been used to estimate the magnitude of the terrestrial biosphere sink.

For N_2O the increase from 2012 to 2013 is smaller than the one observed from 2011 to 2012 but comparable to the average growth rate over the past 10 years. Atmospheric CH_4 continued to increase at a rate similar to the mean rate over the past 5 years. The National Oceanic and Atmospheric Administration (NOAA) Annual Greenhouse Gas Index shows that from 1990 to 2013 radiative forcing by long-lived greenhouse gases increased by 34%, 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 479 ppm (http://www.esrl.noaa.gov/gmd/aggi).

Uptake of anthropogenic CO_2 by the ocean results in increased CO_2 concentrations and increased acidity levels in sea-water. During the last two decades ocean water pH decreased by 0.0011 – 0.0024 per year, and the amount of CO_2 dissolved in see water (pCO_2) increased by 1.2 - 2.8 μatm per year for time-series from several featured ocean stations.