CHINA GREENHOUSE GAS BULLETIN

The State of Greenhouse Gases in the Atmosphere
Based on Chinese and Global Observations through 2013

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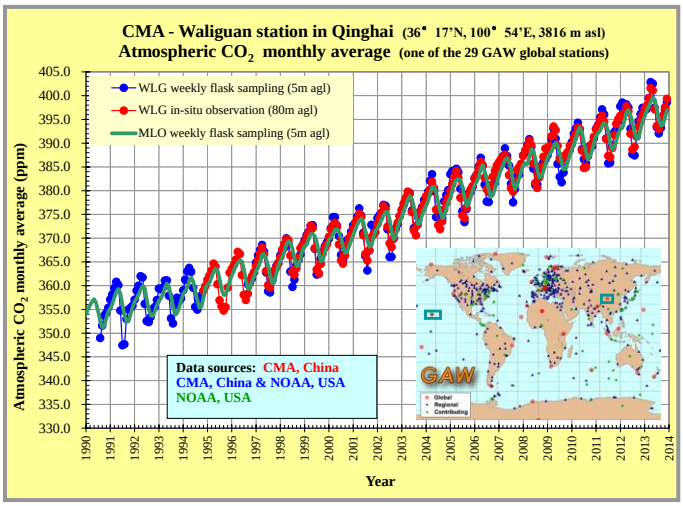
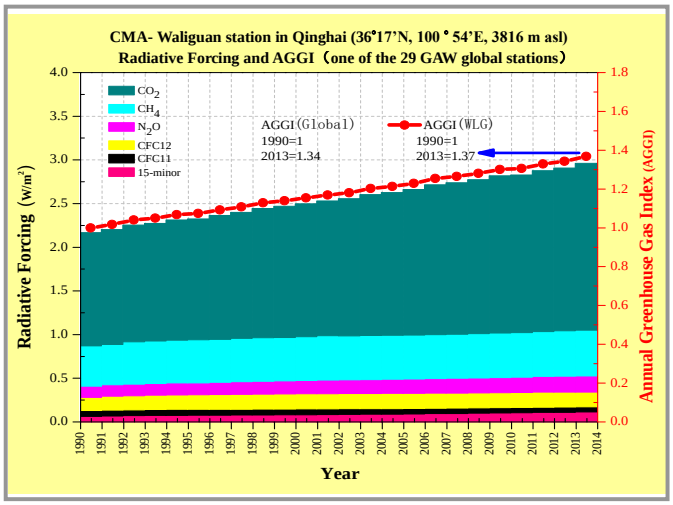
Climate Change Centre
China Meteorological Administration





Since 1980s, China Meteorological Administration (CMA) has put in place seven atmospheric background stations - Waliguan in Qinghai (WLG), Shangdianzi in Beijing (SDZ), Lin'an in Zhejiang (LAN), Longfengshan in Heilongjiang (LFS), Shangri-La in Yunnan (XGL), Jinsha in Hubei (JSA) and Akedala in Xinjiang (AKD), which represent a number of typical climatic, ecological and economic zones in China. Greenhouse gases and related tracers have been observed by network stations in a standard and consistent routine in response to the Kyoto Protocol and the Montreal Protocols. The upper left figure shows the monthly CO_2 mole fractions observed at the Waliguan station in Qinghai province, China and the Mauna Loa station in Hawaii, the United States of America. The upper right figure displays the atmospheric radiative forcing, relative to 1990, of LLGHGS at the Waliguan station (the CO_2-equivalent amounts[#] reached to 483 ppm in 2013) and the Annual Greenhouse Gas Index (AGGI)[##] based on the approach used by the WMO greenhouse gas bulletin.

Executive summary

The World Meteorological Organization (WMO) Greenhouse Gas Bulletin (2013) No. 10 released by WMO on 6 November 2014 shows that globally averaged mole fractions in atmospheric carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) continued to hit new highs in 2013, with CO_2 at 396.0 ± 0.1 ppm [1], CH_4 at 1824 ± 2 ppb [2] and N_2O at 325.9 ± 0.1 ppb. These values constitute 142%, 253% and 121% of pre-industrial (before 1750) levels.

As analyzed from observational data at the Waliguan station in Qinghai through 2013, averaged mole fractions in atmospheric CO_2, CH_4 and N_2O also hit new highs, registering 397.3 ± 0.8 ppm for CO_2, 1886 ± 3 ppb for CH_4 and 326.4 ± 0.4 ppb for N_2O. As a record high since the observation was started in 1990, they are roughly equivalent to the averaged mole fractions in the northern mid-latitudes, but are slightly higher than the global averages in all these components (396.0 ± 0.1 ppm, 1824 ± 2 ppb and 325.9 ± 0.1 ppb) over the same period. Global mole fractions in atmospheric CO_2, CH_4 and N_2O increased by 2.9 ppm, 6 ppb and 0.8 ppb in absolute terms, from 2012 to 2013, while those at Waliguan by 2.5 ppm, 8 ppb and 0.8 ppb. Global annual averages in atmospheric CO_2, CH_4 and N_2O over the past 10 years increased by 2.07 ppm, 3.8 ppb and 0.82 ppb in absolute terms, while those at Waliguan 2.15 ppm, 5.1 ppb and 0.81 ppb.

In 2013, valid monthly atmospheric CO_2, CH_4 and N_2O mole fractions at the 6 regional stations (Shangdianzi in Beijing, Lin'an in Zhejiang, Longfengshan in Heilongjiang, Shangri-La in Yunnan, Jinsha in Hubei and Akedala in Xinjiang) are mostly higher than those in 2012 and all higher than the observations made at Waliguan over the same period. The annually averaged mole fractions in atmosphere at the Shangdianzi, Lin'an and Longfengshan station were 401.9 ± 3.0 ppm, 409.9 ± 4.0ppm, and 402.4 ± 3.0 ppm for CO_2, 1911 ± 6 ppb, 1971 ± 18 ppb, and 1960 ± 6 ppb for CH_4, respectively. The annually averaged N_2O mole fraction at Shangdianzi station is 326.8 ± 0.6 ppb.

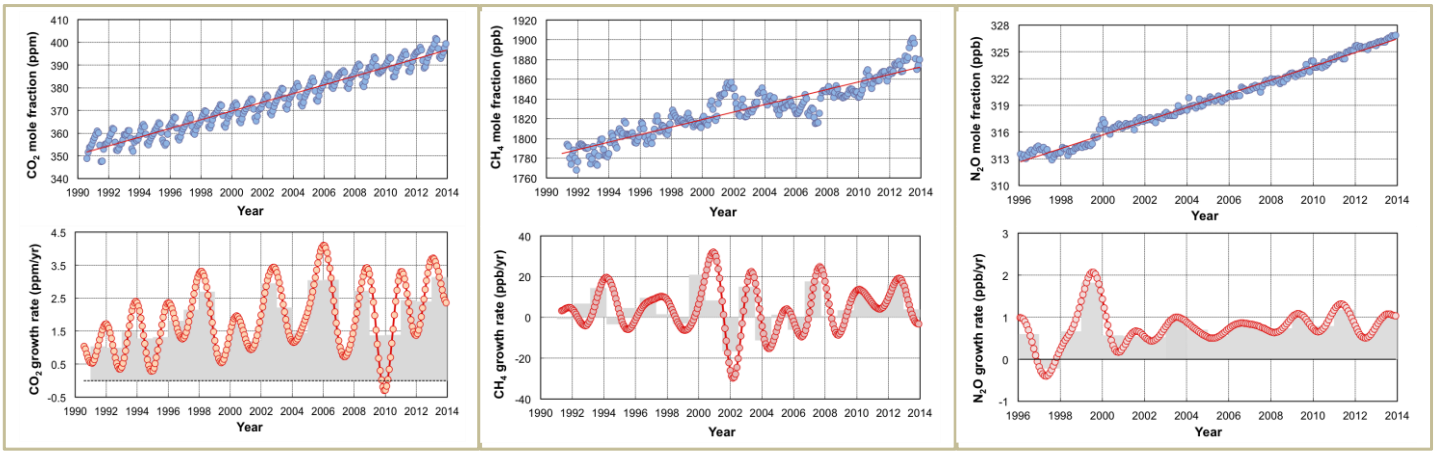
The atmospheric SF_6 mole fractions observed at Waliguan and Shangdianzi reached to 8.10 ± 0.12 ppt[3] and 8.12 ± 0.10 ppt in 2013, - the highest ever records since the observation was launched at the two sites.

Overview

The World Meteorological Organization's Global Atmosphere Watch (WMO/GAW) Programme coordinates the systematic observation and analysis of greenhouse gases (GHGs) and other trace species. Through the end of 2013, it enlists 29 global background stations, 400 regional background stations and over 100 contributing stations. Four stations (Waliguan, Shangdianzi, Lin'an and Longfengshan) operated by CMA have been listed in the WMO/GAW directory and the system of GHGs observation, analysis and calibration has been developed there in line with the international framework. Part of the observations by Waliguan and Shangdianzi are accessible to the World Data Centre for Greenhouse Gases (WDCGG) and the global database. The data was widely cited in relevant publications such as WMO GHGs Bulletins and scientific assessments by WMO, United Nations Environment Programme (UNEP) and Intergovernment Panel on Climate Change (IPCC).

The following table provides annually averaged mole fractions of the three major long-lived GHGs as recorded at global level and at Waliguan, China in 2013, and changes in these mole fractions since 2012 and in the last decade. The results are obtained from analysis of observational datasets that are traceable to the WMO World Reference standards.

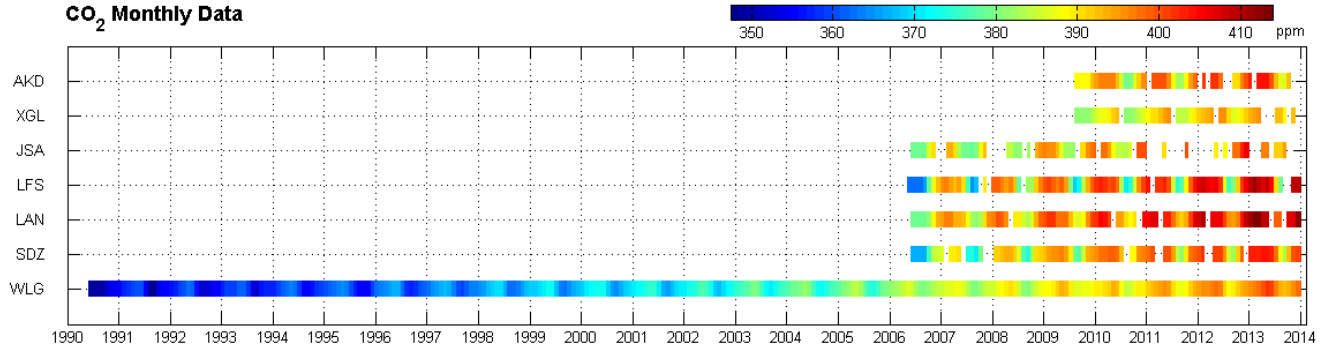
	CO_2		CH_4		N_2O	
	Global	Waliguan	Global	Waliguan	Global	Waliguan
Mean annual mole fraction in 2013	396.0 ±0.1 ppm	397.3 ±0.8 ppm	1824 ±2 ppb	1886 ±3 ppb	325.9 ±0.1 ppb	326.4 ±0.4 ppb
2013 mole fraction relative to year 1750	142%		253%		121%	
2012-2013 absolute increase	2.9 ppm	2.5 ppm	6 ppb	8 ppb	0.8 ppb	0.8 pbb
2012-2013 relative increase	0.74%	0.63%	0.33%	0.42%	0.25%	0.25%
Mean annual absolute increase during last 10 years	2.07 ppm /yr	2.15 ppm /yr	3.8 ppb/yr	5.1 ppb/yr	0.82 ppb /yr	0.81 ppb/yr



Time series and annual increases of the atmospheric CO_2, CH_4 and N_2O mole fractions recorded at Waliguan since its inception in 1990

Carbon dioxide (CO_2)

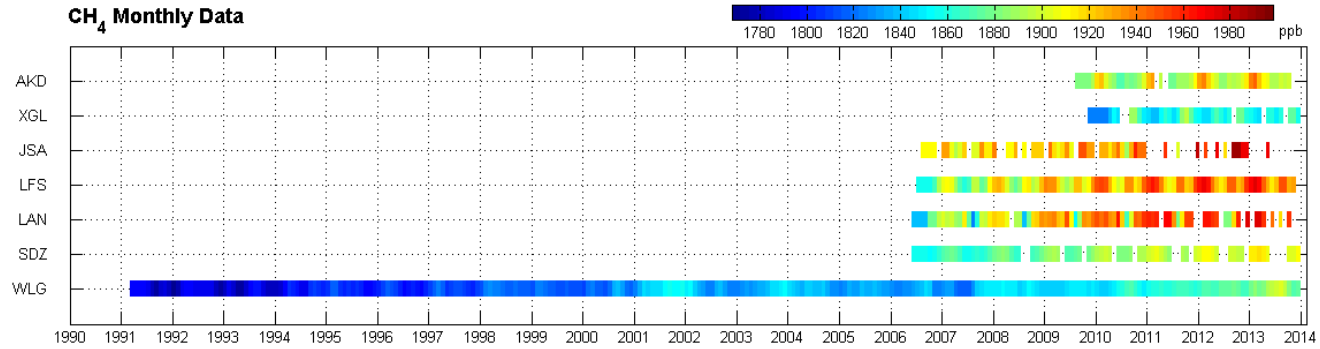
CO_2 is the most important anthropogenic GHGs in the atmosphere, contributing ~ 65%[4] to radiative forcing by long-lived GHGs. Anthropogenic sources include fossil fuel and biomass combustion, land-use change, etc. CMA began flask air sampling analysis in 1990 at Waliguan. Through 2013, there are seven stations collecting air samples and five stations making in-situ observations. Before the industrial revolution (1750), the globally averaged mole fraction of atmospheric CO_2 was maintained at ~ 278 ppm. Due to the rising impact of human activities, the globally averaged and the Waliguan averaged mole fractions of atmospheric CO_2 in 2013 stood at 396.0 ±0.1 ppm and 397.3 ±0.8 ppm, with the mean annual absolute increases during last 10 years at 2.07 ppm and 2.15 ppm. In 2013, valid monthly CO_2 mole fractions at 6 regional stations are mostly higher than those of year in 2012 and the observations made at Waliguan over the same period, with yearly average of 401.9 ±3.0 ppm, 409.9 ±4.0ppm and 402.4 ±3.0 ppm at Shangdianzi, Lin'an and Longfengshan station, respectively.



Monthly mean mole fractions of atmospheric CO_2 recorded at seven CMA background stations

Methane (CH_4)

CH_4 is one of the major GHGs that affect the Earth's radiation balance, contributes ～17% to radiative forcing by long-lived GHGs. The atmospheric CH_4 sources come from natural (e.g., wetlands and termites) and anthropogenic (e.g., coal mining, rice plantation, ruminant farming). CMA began to collect samples and make observations at Waliguan in 1990. Through 2013, there are seven stations collecting air samples and five stations making in-situ observations. Before the industrial revolution (1750), the globally averaged mole fraction of atmospheric CH_4 was maintained at ~ 722 ppb. Due to the rising impact of human activities, the globally averaged and the Waliguan averaged mole fractions of atmospheric CH_4 in 2013 stood at 1824 ±2 ppb and 1886 ±3 ppb, with the mean annual absolute increases during last 10 years at 3.8 ppb and 5.1 ppb. In 2013, valid monthly CH_4 mole fractions at 6 regional stations are all higher than those of year in 2012 and the observations made at Waliguan over the same period, with yearly average of 1911 ±6 ppb, 1971 ±18 ppb and 1960 ±6 ppb at Shangdianzi, Lin'an and Longfengshan station, respectively.



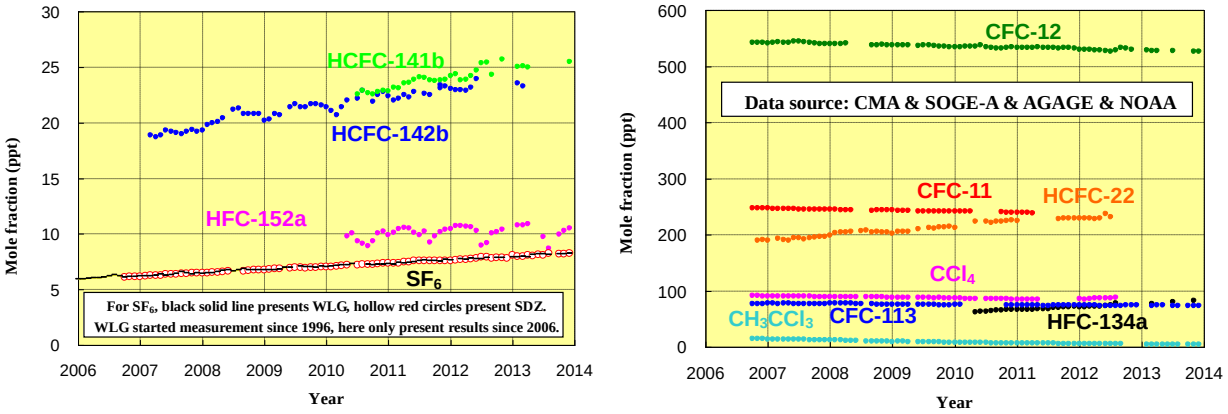
Monthly mean mole fractions in atmospheric CH_4 recorded at seven CMA background stations

Nitrous oxide (N_2O)

N_2O is the third most influential GHGs in the atmosphere, contributes ~ 6% to radiative forcing by long-lived GHGs. The increased N_2O in the atmosphere is mainly attributed to farmland soil emission resulting from the excessive use of agricultural nitrogen fertilizer. CMA began to collect samples and make observations at Waliguan in 1990. Through 2013, there are seven stations collecting air samples and four stations making in-situ observations. Before the industrial revolution (1750), the globally averaged mole fraction of atmospheric N_2O was maintained at ~ 270 ppb. Due to the rising impact of human activities, the globally average and the Waliguan averaged mole fractions of atmospheric N_2O in 2013 stood at 325.9 ±0.1 ppb and 326.4 ±0.4 ppb, with the mean annual absolute increases during last 10 years at 0.82 ppb and 0.81 ppb. In 2013, valid monthly N_2O mole fractions at 6 regional stations are mostly higher than those of year in 2012 and the observations made at Waliguan over the same period, with yearly average of 326.8 ±0.6 ppb at Shangdianzi station.

Halogenated greenhouse gases

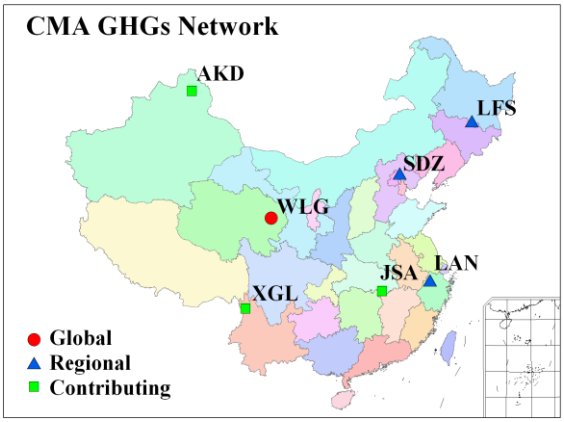
Halogenated GHGs refer to a group of GHGs that contain halogen atoms (fluorine, chlorine etc) in their molecules. Almost all generated from human activities and mainly used as refrigerants, blowing gents, aerosol agents, cleaning agents, fire extinguishing agents, solvents and insulators. In total they contribute ～12% to radiative forcing by long-lived GHGs, including sulphur hexafluoride (SF_6), HFCs and PFCs regulated by the Kyoto Protocol, and CFCs, HCFCs, etc, regulated by the Montreal Protocol. CMA began to collect samples and making observation of SF_6 at Waliguan in 1996. The in-situ observation of halogenated GHGs was begun at Shangdianzi in 2006 and weekly sampling at five stations since 2010. The ozone-depleting substances (ODS), which are being phased out in China, include CFCs, Halons, CH_3CCl_3 and CCl_4. These have all begun to decline, while their replacements, e.g. HCFCs and HFCs are increasing rapidly in the atmosphere. Among them, the atmospheric SF_6 mole fractions observed at Waliguan and Shangdianzi reached 8.10 ±0.12 ppt and 8.12 ±0.10 ppt in 2013 - the highest ever records observed at the two sites.



Monthly mean mole fractions of selected halogenated GHGs at Shangdianzi

Relevant information

CMA's GHG stations and their commencement year



Station	Carbon Dioxide (CO_2)	Methane (CH_4)	Nitrous Oxide (N_2O)	Sulfur Hexafluoride (SF_6)	Other halogeneted GHGs
Waliguan in Qinghai (WLG)	1990	1990	1996	1996	2010*
Shangdianzi in Beijing	2006	2006	2006	2006	2006
Lin'an in Zhejiang (LAN)	2006	2006	2006	2006	2010*
Longfengshan in Heilongjiang (LFS)	2006	2006	2006	2006	2010*
Shangri-La in Yunnan (XGL)	2009	2009	2009*	2009*	2011*
Jinsha in Hubei (JSA)	2006*	2006*	2006*	2006*	
Akedala in Xinjiang (AKD)	2009*	2009*	2009*	2009*	

Note: 1) * indicates weekly air sampling analysis only, while others indicate co-located weekly air sampling analysis and in-situ observation.
2) The Bulletin, released once per year, is based on observational datasets of GHGs that are traceable to the WMO World Reference Scales. These scientifically defensible data sets are produced with an approach consistent with WMO guidelines and recognized QA/QC procedures. They are regularly updated and periodically revised by small amounts should the international calibration scales be adjusted.

[1] ppm = number of molecules of the gas per million (10^6) molecules of dry air.
[2] ppb = number of molecules of the gas per billion (10^9) molecules of dry air.
[3] ppt = number of molecules of the gas per trillion (10^{12}) molecules of dry air.
[4] Refer to the WMO Greenhouse Gas Bulletin, this percentage is calculated as the relative contribution of the mentioned gas(es) to the increase in global radiative forcing caused by all long-lived gases since 1750.
CO_2-equivalent amounts: The equivalent CO_2 concentrations corresponding to the total radiative forcing of LLGHGS. It is derived with the relationship between CO_2 concentrations and radiative forcing from LLGHGS.
Annual Greenhouse Gas Index (AGGI): The ratio of the total direct radiative forcing due to long-lived greenhouse gases for any year for which adequate global measurements exist to that which was present in 1990.

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Sampling tower and GHGs lab at XGL

The **Shangri-La** (27°29′ N，99°00′ E, 3580m asl.), one of the three CMA's newly built regional stations, representing the regional atmospheric conditions of western part of the Yunnan-Guizhou Plateau. The GHGs flask sampling program started at 2009 and in-situ measurements started at 2010. Equipped with in-situ and air sampling systems, it observes such elements as CO_2, CH_4, CO, N_2O, SF_6 and other halogenated GHGs, and stable isotopes of CO_2.


CMA's Calibration Lab for GHGs (CCL-China)

CMA's Calibration Laboratory for Greenhouse Gases & Related Tracers **(CCL-China)** was responsible for sample analysis, calibration, system design & development, and procedure optimization of the observational network and scientific collaborative stations. The lab propagates and distributes working standards linked to the WMO-CCL and relevant international reference scales (signed CIPM-MRA in April 2010) and provides analyses and calibrations for CO_2, CH_4, N_2O, SF_6, HFCs, PFCs, CO, CFCs, HCFCs, Halons and stable isotopes of CO_2 with high accuracy and compatibility. The lab also provides services to domestic research communities.