

Table AC.3 Atmospheric Concentrations of Greenhouse and Ozone-Depleting Gases

Source: Carbon Dioxide Information Analysis Center

Years	Carbon Dioxide (CO2) (ppm)	Methane (CH4) (ppb)	Nitrous Oxide (N2O) (ppb)	Carbon Tetra-Chloride (CCl4) (ppt)	Methyl Chloro-form (CH3CCl3) (ppt)	CFC-11 (CCl3F) (ppt)	CFC-12 (CCl2F2) (ppt)	CFC-113 (C2Cl3F3) (ppt)	Total Gaseous Chlorine (ppt)
Preindustrial (1860)	286-288 a	848 b	285 c	0	0	0	0	0	0
1965	320	X	X	X	X	X	X	X	X
1966	321	X	X	X	X	X	X	X	X
1967	322	X	X	X	X	X	X	X	X
1968	323	X	X	X	X	X	X	X	X
1969	324	X	X	X	X	X	X	X	X
1970	326	X	X	X	X	X	X	X	X
1971	326	X	X	X	X	X	X	X	X
1972	327	X	X	X	X	X	X	X	X
1973	330	X	X	X	X	X	X	X	X
1974	330	X	X	X	X	X	X	X	X
1975	331	X	X	X	X	X	X	X	X
1976	332	X	X	X	X	X	X	X	X
1977	334	X	X	X	X	X	X	X	X
1978	335	X	298 d	88 d	57 d	139 d	257 d	X	1,453 e, f
1979	337	X	298	87	62	147	272	X	1,522 f
1980	339	X	299	89	69	158	293	X	1,624 f
1981	340	X	299	90	75	166	305	X	1,692 f
1982	341	X	301	92	81	175	325	26 g	1,865 h
1983	343	X	302	93	85	182	341	28	1,939
1984	344	X	303	94	88	190	355	31	2,016
1985	346	X	304	96	92	200	376	36	2,121
1986	347	1,600 i	305	97	96	210	394	40	2,216
1987	349	1,610	305	99	98	221	413	48	2,322
1988	351	1,619	306	100	103	231	433	53	2,425
1989	353	1,641	306	100	107	240	452	59	2,524
1990	354	1,645	306	101	110	249	470	66	2,620
1991	355	1,657	307	101	113	254	484	71	2,685
1992	356	1,673	308	101	116	259	496	77	2,751
1993	357	1,671	308	101	112	260	503	80	2,764
1994	359	1,674	309	100	106	261	512	81	2,769
1995	361	1,681	309	99	97	261	518	82	2,753
1996	363	1,684	310	98	85	261	523	82	2,725
1997	364	1,690	311	97	73	260	528	83	2,693
1998	367	1,693 j	311 j	96 j	64 j	259 j	530 j	82 j	2,664 j

Notes: All estimates are by volume: ppb = parts per billion, ppm = parts per million, and ppt = parts per trillion. a. Historical CO2 record from the Siple Station and Law Dome ice core records. b. Historical CH4 record from the Law Dome (East Side, "DE08" site), Antarctica, ice core. c. Historical N2O record from the Law Dome (Summit, "BHD" site) ice core. d. Annual average only includes the months of July through December. e. Annual average only includes the months of July through December for carbon tetrachloride, methyl chloroform, CFC-11, and CFC-12. f. Annual average only includes carbon tetrachloride, methyl chloroform, CFC-11, and CFC-12. g. Annual average only includes the months of June through December. h. Annual average includes carbon tetrachloride, methyl chloroform, CFC-11, CFC-12, and CFC-113. The CFC-113 figure only includes data from June through December. i. Annual average only includes the months of May through December. j. Annual average only includes the months of January through September.

Table AC.3 Atmospheric Concentration of Greenhouse and Ozone-Depleting Gases

Source: Carbon dioxide: Charles D. Keeling and T.P. Whorf, Carbon Dioxide Information Analysis Center (CDIAC), Atmospheric CO₂ Concentrations—Mauna Loa Observatory, Hawaii, 1958–1998 (revised July 1999), ORNL/CDIAC-25, NDP-001/R9 (Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, July 1999). Data are accessible online at: <http://cdiac.esd.ornl.gov/ftp/ndp001/maunaloa.co2>. Preindustrial concentration for carbon dioxide: Neftel et al., 1994, Historical Carbon Dioxide Record from the Siple Station Ice Core (Physics Institute, University of Bern, Switzerland) and data from the Law Dome ice core record. More details on the Law Dome ice core record may be found online at: <http://cdiac.esd.ornl.gov/trends/co2/lawdome.html>. Preindustrial concentration for methane: Etheridge et al., 1994, Concentrations of CH₄ from the Law Dome (East Side, “DE08” Site) Ice Core (Commonwealth Scientific and Industrial Research Organisation Aspendale, Victoria, Australia). Preindustrial concentration for nitrous oxide: Etheridge et al., 1988, Concentrations of N₂O from the Law Dome (Summit, “BHD” Site) Ice Core (Commonwealth Scientific and Industrial Research Organisation Aspendale, Victoria, Australia). Other greenhouse and ozone-depleting gases data: Atmospheric Lifetime Experiment (ALE) / Global Atmospheric Gases Experiment (GAGE) / Advanced GAGE (AGAGE) Network (updated and revised May 1999), CDIAC, Environmental Sciences Division, Oak Ridge National Laboratory, DB-1001 (an Internet-accessible numerical database), available online at: <http://cdiac.esd.ornl.gov/ndps/alegagage.html> (ALE/ GAGE/AGAGE Monthly Readings at Cape Grim, Tasmania), originally R.G. Prinn, R.F. Weiss, F.N. Alyea et al., “Atmospheric CFC-11 (CCl₃F), CFC-12 (CCl₂F₂), and N₂O from the ALE-GAGE Network,” in T.A. Boden, D.P. Kaiser, R.J. Sepanski et al., eds., Trends '93: A Compendium of Data on Global Change (ORNL/CDIAC-65, CDIAC, Oak Ridge, Tennessee, 1994), pp. 396–420.

The greenhouse and ozone-depleting gases listed destroy atmospheric ozone, contribute to the greenhouse effect, or both. Carbon dioxide (CO₂) is emitted to the atmosphere by natural and anthropogenic processes. Due to the large concentration of CO₂ in the atmosphere compared to concentrations of other greenhouse gases, it is second only to water vapor in its potential effect on global warming. For further details, see the Source, and Technical Notes for Data Table EI.1.

Atmospheric CO₂ concentrations are monitored at many sites worldwide; the data presented here are from Mauna Loa, Hawaii (19° 32' North latitude, 155° 35' West longitude). Trends at Mauna Loa reflect global trends, although CO₂ concentrations differ significantly among monitoring sites at any given time. For example, the average annual concentration at the South Pole in 1997 was 2.3 parts per million lower than at Mauna Loa. The preindustrial concentration of CO₂ was estimated from an Antarctic ice core.

Annual means disguise large daily and seasonal variations in CO₂ concentrations. During the summer, photosynthetic plants store larger amounts of carbon than in the winter, resulting in seasonal variation in measurements. Some annual mean figures were derived from interpolated data. Data are revised to correct for drift in instrument calibration, hardware changes, and perturbations to “background” conditions. Details concerning data collection, revisions, and analysis are contained in C.D. Keeling, et al., “Measurement of the Concentration of Carbon Dioxide at Mauna Loa Observatory, Hawaii,” in W.C. Clark, ed., Carbon Dioxide Review: 1982 (Oxford University Press, New York, 1982).

Data for all other gases are from values monitored at Cape Grim, Tasmania (45° 41' South latitude, 144° 41' East longitude) under the ALE, GAGE, and Advanced GAGE. As with CO₂, gas

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concentrations at any given time vary among monitoring sites; the data reported here reflect global trends. Cape Grim generally receives unpolluted air from the Southeast and is the ALE/GAGE/AGAGE station with the longest, most complete dataset. Air samples were collected 4 times daily for ALE and 12 times daily for GAGE/AGAGE. The annual values shown here are averages of monthly values calculated by CDIAC. Missing values were interpolated. Preindustrial concentrations for nitrous oxide and methane were estimated from an Antarctic ice core.

Methane (CH₄) is emitted through the release of naturally occurring methane gas and as one of the products of anaerobic respiration. Emission sources associated with human activities include waste management (landfills), livestock management (enteric fermentation in ruminants), anaerobic respiration in the soils associated with wet rice agriculture, and combustion of fossil fuels and biomass (wood fuel and cleared forests). Sources of anaerobic respiration include the soils of moist forests, wetlands, bogs, tundra, and lakes. CH₄ acts to increase ozone in the troposphere and lower stratosphere. On a molecule-for-molecule basis, methane is 21 times more powerful than CO₂ at trapping heat in the atmosphere.

Nitrous oxide (N₂O) is emitted by aerobic decomposition of organic matter in oceans and soils, by bacteria, by combustion of fossil fuels and biomass (wood fuel and cleared forests), by the use of nitrogenous fertilizers, and through other processes. N₂O is an important depletor of stratospheric ozone and is 310 times more powerful than CO₂ at trapping heat in the atmosphere.

Carbon tetrachloride (CCl₄) is an intermediate product in the production of CFC-11 and CFC-12. It is also used in other chemical and pharmaceutical applications and for grain fumigation. Compared with other gases, CCl₄ makes a small contribution to the greenhouse effect and to stratospheric ozone depletion.

Methyl chloroform (CH₃CCl₃) is used primarily as an industrial degreasing agent and as a solvent for paints and adhesives. Its contribution to the greenhouse effect and to stratospheric ozone depletion also is small.

CFC-11 (CCl₃F), CFC-12 (CCl₂F₂), and CFC-113 (C₂Cl₃F₃) are potent depletors of stratospheric ozone. In addition, their cumulative effect on global warming may equal one-fourth that of CO₂. CFCs are used as solvents and in many applications including refrigeration, air conditioning, foam blowing, and cleaning of electronics components.

Total gaseous chlorine is calculated by multiplying the number of chlorine atoms in each of the chlorine-containing gases (carbon tetrachloride, methyl chloroform, and CFCs) by the concentration of that gas. Chlorine and bromine act as catalysts in the destruction of ozone. Chlorine is not consumed in the reaction and thus can react with and destroy ozone molecules many times over.