

Current Greenhouse Gas Concentrations

T.J. Blasing and Sonja Jones, revised and updated October 2002

Gases typically measured in parts per million (ppm), parts per billion (ppb) or parts per trillion (ppt) by volume are presented separately to facilitate comparison of numbers. All pre-1750 A.D. concentrations, Global Warming Potentials (GWPs), and atmospheric lifetimes are from [Table 4.1](#) of (Intergovernmental Panel on Climate Change) IPCC 2001 unless otherwise indicated. Additional material on greenhouse gases can be found in CDIAC's [Reference Tools](#).

Sources of the current atmospheric concentrations are given in the footnotes. The concentrations given are frequently derived from data available via the CDIAC web pages; many corresponding links are given in the footnotes below. These data are contributed to CDIAC by various investigators, and represent considerable effort on their part. We ask as a basic professional courtesy that when you refer to any of these data you acknowledge the sources. Guidelines for proper acknowledgment are found at the end of the page for each link, except for the [ALE/GAGE/AGAGE](#) database where acknowledgment guidelines are given in the "readme" files; links to those "readme" files are given in footnote 9, below.

GAS	Pre-1750 concentration ¹	Current ² tropospheric concentration	GWP (100-yr time horizon) ³	Atmospheric lifetime (years) ⁴	Increased radiative forcing ⁵ (W/m ²)
Concentrations in parts per million (ppm)					
carbon dioxide (CO ₂)	280 ^{6,7,8}	370.3 ⁷	1	variable ⁴	1.46
Concentrations in parts per billion (ppb)					
methane (CH ₄)	730 ⁸ /688 ⁸	1842 ⁹ /1729 ⁹	23	12 ⁴	0.48
nitrous oxide (N ₂ O)	270 ^{8,11}	316 ⁹ /315 ⁹	296	114 ⁴	0.15
tropospheric ozone (O ₃)	25	34 ⁴	n.a. ⁴	hours-days	0.35 ^{4,5}
Concentrations in parts per trillion (ppt)					
FC-11 (trichlorofluoromethane) (CCl ₃ F)	zero	262 ⁹ /259 ⁹	4,600	45	0.34 for all halocarbons collectively, including many not listed here.
CFC-12 (dichlorodifluoromethane) (CCl ₂ F ₂)	zero	546 ⁹ /539 ⁹	10,600	100	
CFC-113 (trichlorotrifluoroethane) (C ₂ Cl ₃ F ₃)	zero	82 ⁹ /82 ⁹	6,000	85	
carbon tetrachloride (CCl ₄)	zero	97 ⁹ /95 ⁹	1,800	35	
methyl chloroform (CH ₃ CCl ₃)	zero	47 ⁹ /46 ⁹	140	4.8	
HCFC-22 (chlorodifluoromethane) (CHClF ₂)	zero	146 ¹⁰	1700	11.9	
HFC-23 (fluoroform) (CHF ₃)	zero	14 ¹¹	12,000	260	
perfluoroethane (C ₂ F ₆)	zero	3 ¹¹	11,900	10,000	

sulfur hexafluoride (SF ₆)	zero	4.7 ¹⁰	22,200	3,200	0.002 ⁵
trifluoromethyl sulfur pentafluoride (SF ₅ CF ₃)	zero	0.12 ¹²	~ 18,000	~ 3,200 (?)	< 0.0001 ⁵

¹Following the convention of IPCC (2001), inferred global-scale trace-gas concentrations from prior to 1750 are assumed to be practically uninfluenced by human activities such as increasingly specialized agriculture, land clearing, and combustion of fossil fuels.

²For most gases, concentrations for year 2000 or 2001 are given, as indicated more specifically in the footnotes below. Estimates for 1998, from IPCC (2001), are given for CHF₃, C₂F₆, and SF₅CF₃. The current (2001) concentration of SF₅CF₃ is probably around 0.14 or 0.15 parts per trillion (see footnote 12). Atmospheric concentrations of some of these gases are not constant throughout the year. Global annual arithmetic averages are given.

³ The GWP provides a simple measure of the radiative effects of emissions of various greenhouse gases, integrated over a specified time horizon, relative to CO₂ emissions. It is calculated using the formula:

$$\text{GWP} = \frac{\int_0^n a_i c_i dt}{\int_0^n a_{\text{CO}_2} c_{\text{CO}_2} dt}$$

where a_i is the instantaneous radiative forcing due to a unit increase in the concentration of trace gas, i , c_i is concentration of the trace gas, i , remaining at time, t , after its release and n is the number of years over which the calculation is performed.

Formula taken from page 58 of IPCC 1990: *Climate Change: The IPCC Scientific Assessment*. J.T. Houghton, G.J. Jenkins, and J.J. Ephraums (eds.). Cambridge University Press, Cambridge, UK, 365 pp.

Unless otherwise indicated, GWP's taken from: IPCC 2001. *Climate Change 2001: The Scientific Basis*. J.T. Houghton, L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell. Cambridge University Press, Cambridge, UK, 944 pp. (see [Technical Summary \(TS\)](#) of the Working Group 1 Report, page 47).

⁴The atmospheric lifetime is defined as: "the burden (Tg) divided by the mean global sink (Tg/yr) for a gas in a steady state (i.e., with unchanging burden)" (IPCC 2001, [page 247](#)). That is, if the atmospheric burden of gas x is 100 Tg, and the mean global sink is currently 10 Tg/yr, the lifetime is 10 years. The atmospheric lifetime of carbon dioxide is difficult to define because it is exchanged with reservoirs having a wide range of turnover times; IPCC 2001, ([page 38](#)) gives a range of 5-200 years. In contrast, most CH₄ is removed from the atmosphere by a single process, oxidation by the hydroxyl radical (OH). The atmospheric lifetime of a gas is relatively easy to define when essentially all of its removal from the atmosphere involves a single process. However, some complications still arise. For example, the effect of an increase in atmospheric concentration of CH₄ is to reduce the OH concentration, which, in turn, reduces destruction of the additional methane, effectively lengthening its atmospheric lifetime. An opposite sort of feedback applies to N₂O: an increase induces chemical reactions leading to an increase in ultraviolet radiation available to photolyze the N₂O, thereby shortening its atmospheric lifetime (IPCC 2001, [Section 4.1.4](#)). Such feedbacks are accounted for in the above table. The short atmospheric lifetime of ozone (hours-days) precludes a globally homogeneous distribution; ozone concentrations, and associated radiative effects, are greatest near

its sources. The "current" value given is an estimate of the globally averaged value, from IPCC (2001), [Table 4.1](#).

⁵Increased radiative forcing is the change in the rate at which additional energy is made available to the earth-atmosphere system over an "average" square meter of the earth's surface due to increased concentration of a "greenhouse" gas, or group of gases, since 1750. Energy is measured in Joules; the rate at which it is made available is in Joules/second, or Watts; hence, radiative forcing is measured in Watts per square meter (W/m^2). Numerical values for the radiative fluxes are given in [Table 6.11](#) on page 393 of IPCC (2001).; note particularly the discussion of the uncertainty of the radiative forcing for tropospheric ozone (cf. note 4, above). Radiative forcing values for SF_6 and SF_5CF_3 were calculated as the products of the radiative efficiency values given in [Table 6.7](#), and the concentrations given in [Table 4.1](#), of IPCC (2001). This calculation assumes that the radiative efficiency has not changed with time, for these small concentrations (cf. Mitchell 1989). For more details on SF_5CF_3 , see also W.T. Sturges et al. (2000).

⁶The value given by IPCC 2001, page 185, is 280 ± 10 ppm. This is supported by measurements of CO_2 in old, confined, and reasonably well-dated air. Such air is found in bubbles trapped in annual layers of ice in Antarctica, in sealed brass buttons on old uniforms, airtight bottles of wine of known vintage, etc. Additional support comes from well-dated carbon-isotope signatures, for example, in annual tree rings. Estimates of "pre-industrial" CO_2 can also be obtained by first calculating the ratio of the recent atmospheric CO_2 increases to recent fossil-fuel use, and using past records of fossil-fuel use to extrapolate past atmospheric CO_2 concentrations on an annual basis. Estimates of "pre-industrial" CO_2 concentrations obtained in this way are higher than those obtained by more direct measurements; this is believed to be because the effects of widespread land clearing are not accounted for. The record derived from the "[DSS Antarctic ice core](#)", which covers the period from about 1000-1750, indicates an average "natural background" concentration of 280.05 ppm.

⁷Current CO_2 concentration (370.3 ppm) is the average of the 2001 annual values at Barrow, Alaska; Mauna Loa, Hawaii, American Samoa, and the South Pole (one high-latitude and one low-latitude station from each hemisphere). Refer to [C.D. Keeling and T. P. Whorf](#) for records back to the late 1950s. Ice-core records provide records of earlier concentrations. For concentrations back to about 1775, see [A. Neftel et al.](#); for concentrations back to about 1000 A.D., see [D.M. Etheridge et al.](#); and for over 400,000 years of ice-core record from Vostok, see [J.M. Barnola et al.](#) All these data are available from CDIAC.

⁸Pre-industrial concentrations of CH_4 are evident in the "1000-year" ice-core records in CDIAC's *Trends Online* (See [D.M. Etheridge et al.](#)) However, those values need to be multiplied by a scaling factor of 1.0119 to make them compatible with the AGAGE measurements of current methane concentrations, which have already been adjusted to the Tohoku University scale. Therefore, pre-industrial values calculated from the ice-core data have been multiplied by 1.0119 before insertion in the above table. Thousand-year records of CH_4 , CO_2 and N_2O , from ice-core data, are also presented graphically in IPCC 2001, ([page 6](#)).

⁹The first value represents Mace Head, Ireland, a mid-latitude Northern-Hemisphere site, and the second value represents Cape Grim, Tasmania, a mid-latitude Southern-Hemisphere site. For CH_4 , these values can be compared with the thousand-year ice-core records from Greenland and Antarctica, respectively, discussed in the preceding footnote. "Current" values given for these gases are annual arithmetic averages based on monthly non-pollution concentrations for year 2000. These data are compiled from data on finer time scales in the [ALE/GAGE/AGAGE](#) database (R. Prinn et al.). These data represent the work of several investigators at various institutions; guidelines on citing the various parts of the [AGAGE](#) database are found in two README files (http://cdiac.ornl.gov/ftp/ale_gage_Agage/AGAGE/gc-md/readme.agA and http://cdiac.ornl.gov/ftp/ale_gage_Agage/AGAGE/gc-ms/readme.agA) within the [ALE/GAGE/AGAGE](#) database, also available via anonymous [ftp](#).

¹⁰Source: Climate Monitoring and Diagnostics Laboratory (CMDL) 2002, [Section 5.2.1](#). For SF₆, see Figure 5.7. For HCFC-22, see Figure 5.10 and Table 5.4. Data are global annual averages for year 2000. Concentrations of SF₆ through 1999, obtained from Antarctic firn air samples, can be found in [W.T. Sturges et al.](#) See also W.T. Sturges et al. (2000).

¹¹Source: IPCC (2001), [Table 4.1](#); The pre-1750 value for N₂O is consistent with ice-core records shown graphically on page 6 of that document. Estimates of "current" (1998) concentrations of CHF₃ and C₂F₆ are based on a variety of sources, including emissions rates and annual growth rates. Data on CHF₃ through 1995 can be found in [D.E. Oram et al.](#)

¹²Taken from [Table 4.1](#) of IPCC (2001); it is an estimate for year 1998. Assuming a ratio of SF₆/SF₅CF₃ of 32; the current (2001) concentration of SF₅CF₃ would be about 0.147 ppt. Extrapolating previous ice-core data gives about 0.14 ppt. Concentrations of SF₅CF₃ through 1999, obtained from Antarctic firn air samples, can be found in [W.T. Sturges et al.](#) See also W.T. Sturges et al. (2000)

REFERENCES

CMDL 2002. Climate Monitoring and Diagnostics Laboratory Summary Report No. 26, 2000-2001, D.B. King and R.C. Schnell (eds.). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Climate Monitoring and Diagnostics Laboratory, Boulder CO, 184 pp.

IPCC 1990. *Climate Change: The IPCC Scientific Assessment*. J.T. Houghton, G.J. Jenkins, and J.J. Ephraums (eds.). Cambridge University Press, Cambridge, UK 365 pp.

IPCC 1995. *Climate Change 1994: Radiative Forcing of Climate Change, and An Evaluation of the IPCC IS92 Emission Scenarios*. J.T. Houghton, L.G. Meira Filho, J. Bruce, Hoesung Lee, B.A. Callander, E. Haites, N. Harris, and K. Maskell (eds.). Cambridge University Press, Cambridge, UK 339 pp.

IPCC 1996. *Climate Change 1995: The Science of Climate Change*. J.T. Houghton, L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell (eds.). Cambridge University Press, Cambridge, UK 572 pp.

IPCC 2001. *Climate Change 2001: The Scientific Basis*. J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson, (eds), Cambridge University Press, Cambridge, UK, 881 pp.

Mitchell, J.F.B., 1989. The "greenhouse" effect and climate change. *Reviews of Geophysics* 27(1), 115-139.

Sturges, W.T., T. J. Wallington, M.D. Hurley, K.P. Shine, K. Sihra, A. Engel, D.E. Oram, S.A. Penkett, R. Mulvaney, and C.A.M. Brenninkmeijer, 2000. A potent greenhouse gas identified in the atmosphere: SF₅CF₃. *Science* 289, 611-613.