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IPCC Fourth Assessment Report: Climate Change 2007

Climate Change 2007: Working Group I: The Physical Science Basis

2.10.2 Direct Global Warming Potentials

All GWPs depend on the AGWP for CO_2 (the denominator in the definition of the GWP). The AGWP of CO_2 again depends on the radiative efficiency for a small perturbation of CO_2 from the current level of about 380 ppm. The radiative efficiency per kilogram of CO_2 has been calculated using the same expression as for the CO_2 RF in Section 2.3.1, with an updated background CO_2 mixing ratio of 378 ppm. For a small perturbation from 378 ppm, the RF is 0.01413 W m^{-2} ppm^{-1} (8.7% lower than the TAR value). The CO_2 response function (see Table 2.14) is based on an updated version of the Bern carbon cycle model (Bern2.5CC; Joos et al. 2001), using a background CO_2 concentration of 378 ppm. The increased background concentration of CO_2 means that the airborne fraction of emitted CO_2 (Section 7.3) is enhanced, contributing to an increase in the AGWP for CO_2. The AGWP values for CO_2 for 20, 100, and 500 year time horizons are 2.47 × 10^{-14}, 8.69 × 10^{-14}, and 28.6 × 10^{-14} W m^{-2} yr (kg CO_2)$^{-1}$, respectively. The uncertainty in the AGWP for CO_2 is estimated to be ±15%, with equal contributions from the CO_2 response function and the RF calculation.

Updated radiative efficiencies for well-mixed greenhouse gases are given in Table 2.14. Since the TAR, radiative efficiencies have been reviewed by Montzka et al. (2003) and Velders et al. (2005). Gohar et al. (2004) and Forster et al. (2005) investigated HFC compounds, with up to 40% differences from earlier published results. Based on a variety of radiative transfer codes, they found that uncertainties could be reduced to around 12% with well-constrained experiments. The HFCs studied were HFC-23, HFC-32, HFC-134a and HFC-227ea. Hurley et al. (2005) studied the infrared spectrum and RF of perfluoromethane (CF_4) and derived a 30% higher GWP value than given in the TAR. The RF calculations for the GWPs for CH_4, N_2O and halogen-containing well-mixed greenhouse gases employ the simplified formulas given in Ramaswamy et al. (2001; see Table 6.2 of the TAR). Table 2.14 gives GWP values for time horizons of 20, 100 and 500 years. The species in Table 2.14 are those for which either significant concentrations or large trends in concentrations have been observed or a clear potential for future emissions has been identified. The uncertainties of these direct GWPs are taken to be ±35% for the 5 to 95% (90%) confidence range.

Table 2.14. *Lifetimes, radiative efficiencies and direct (except for CH_4) GWPs relative to CO_2. For ozone-depleting substances and their replacements, data are taken from IPCC/TEAP (2005) unless otherwise indicated.*

Errata

				Global Warming Potential for Given Time Horizon			
Industrial Designation or Common Name (years)	**Chemical Formula**	**Lifetime (years)**	**Radiative Efficiency (W m^{-2} ppb^{-1})**	**SAR‡ (100-yr)**	**20-yr**	**100-yr**	**500-yr**
Carbon dioxide	CO_2	*See below[a]*	*[b]1.4x10^{-5}*	*1*	*1*	*1*	*1*
Methane[c]	CH_4	*12[c]*	*3.7x10^{-4}*	*21*	*72*	*25*	*7.6*
Nitrous oxide	N_2O	*114*	*3.03x10^{-3}*	*310*	*289*	*298*	*153*
Substances controlled by the Montreal Protocol							
CFC-11	CCl_3F	*45*	*0.25*	*3,800*	*6,730*	*4,750*	*1,620*
CFC-12	CCl_2F_2	*100*	*0.32*	*8,100*	*11,000*	*10,900*	*5,200*
CFC-13	$CClF_3$	*640*	*0.25*		*10,800*	*14,400*	*16,400*
CFC-113	CCl_2FCClF_2	*85*	*0.3*	*4,800*	*6,540*	*6,130*	*2,700*
CFC-114	$CClF_2CClF_2$	*300*	*0.31*		*8,040*	*10,000*	*8,730*
CFC-115	$CClF_2CF_3$	*1,700*	*0.18*		*5,310*	*7,370*	*9,990*
Halon-1301	$CBrF_3$	*65*	*0.32*	*5,400*	*8,480*	*7,140*	*2,760*
Halon-1211	$CBrClF_2$	*16*	*0.3*		*4,750*	*1,890*	*575*
Halon-2402	$CBrF_2CBrF_2$	*20*	*0.33*		*3,680*	*1,640*	*503*
Carbon tetrachloride	CCl_4	*26*	*0.13*	*1,400*	*2,700*	*1,400*	*435*
Methyl bromide	CH_3Br	*0.7*	*0.01*		*17*	*5*	*1*
Methyl chloroform	CH_3CCl_3	*5*	*0.06*		*506*	*146*	*45*
HCFC-22	$CHClF_2$	*12*	*0.2*	*1,500*	*5,160*	*1,810*	*549*
HCFC-123	$CHCl_2CF_3$	*1.3*	*0.14*	*90*	*273*	*77*	*24*
HCFC-124	$CHClFCF_3$	*5.8*	*0.22*	*470*	*2,070*	*609*	*185*
HCFC-141b	CH_3CCl_2F	*9.3*	*0.14*		*2,250*	*725*	*220*
HCFC-142b	CH_3CClF_2	*17.9*	*0.2*	*1,800*	*5,490*	*2,310*	*705*
HCFC-225ca	$CHCl_2CF_2CF_3$	*1.9*	*0.2*		*429*	*122*	*37*
HCFC-225cb	$CHClFCF_2CClF_2$	*5.8*	*0.32*		*2,030*	*595*	*181*
Hydrofluorocarbons							
HFC-23	CHF_3	*270*	*0.19*	*11,700*	*12,000*	*14,800*	*12,200*

HFC-32	CH_2F_2	*4.9*	*0.11*	*650*	*2,330*	*675*	*205*
HFC-125	CHF_2CF_3	*29*	*0.23*	*2,800*	*6,350*	*3,500*	*1,100*
HFC-134a	CH_2FCF_3	*14*	*0.16*	*1,300*	*3,830*	*1,430*	*435*
HFC-143a	CH_3CF_3	*52*	*0.13*	*3,800*	*5,890*	*4,470*	*1,590*
HFC-152a	CH_3CHF_2	*1.4*	*0.09*	*140*	*437*	*124*	*38*
HFC-227ea	CF_3CHFCF_3	*34.2*	*0.26*	*2,900*	*5,310*	*3,220*	*1,040*
HFC-236fa	$CF_3CH_2CF_3$	*240*	*0.28*	*6,300*	*8,100*	*9,810*	*7,660*
HFC-245fa	$CHF_2CH_2CF_3$	*7.6*	*0.28*		*3,380*	*1030*	*314*
HFC-365mfc	$CH_3CF_2CH_2CF_3$	*8.6*	*0.21*		*2,520*	*794*	*241*
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$	*15.9*	*0.4*	*1,300*	*4,140*	*1,640*	*500*
Perfluorinated compounds							
Sulphur hexafluoride	SF_6	*3,200*	*0.52*	*23,900*	*16,300*	*22,800*	*32,600*
Nitrogen trifluoride	NF_3	*740*	*0.21*		*12,300*	*17,200*	*20,700*
PFC-14	CF_4	*50,000*	*0.10*	*6,500*	*5,210*	*7,390*	*11,200*
PFC-116	C_2F_6	*10,000*	*0.26*	*9,200*	*8,630*	*12,200*	*18,200*

Table 2.14 (continued)

				Global Warming Potential for Given Time Horizon			
Industrial Designation or Common Name (years)	**Chemical Formula**	**Lifetime (years)**	**RadiativeEfficiency (W m–2 ppb–1)**	**SAR‡ (100-yr)**	**20-yr**	**100-yr**	**500-yr**
Perfluorinated compounds (continued)							
PFC-218		*2,600*	*0.26*	*7,000*	*6,310*	*8,830*	*12,500*
PFC-318		*3,200*	*0.32*	*8,700*	*7,310*	*10,300*	*14,700*
PFC-3-1-10		*2,600*	*0.33*	*7,000*	*6,330*	*8,860*	*12,500*
PFC-4-1-12		*4,100*	*0.41*		*6,510*	*9,160*	*13,300*
PFC-5-1-14		*3,200*	*0.49*	*7,400*	*6,600*	*9,300*	*13,300*
PFC-9-1-18		*>1,000d*	*0.56*		*>5,500*	*>7,500*	*>9,500*
trifluoromethyl sulphur pentafluoride		*800*	*0.57*		*13,200*	*17,700*	*21,200*
Fluorinated ethers							
HFE-125		*136*	*0.44*		*13,800*	*14,900*	*8,490*
HFE-134		*26*	*0.45*		*12,200*	*6,320*	*1,960*
HFE-143a		*4.3*	*0.27*		*2,630*	*756*	*230*
HCFE-235da2		*2.6*	*0.38*		*1,230*	*350*	*106*
HFE-245cb2		*5.1*	*0.32*		*2,440*	*708*	*215*
HFE-245fa2		*4.9*	*0.31*		*2,280*	*659*	*200*
HFE-254cb2		*2.6*	*0.28*		*1,260*	*359*	*109*
HFE-347mcc3		*5.2*	*0.34*		*1,980*	*575*	*175*
HFE-347pcf2		*7.1*	*0.25*		*1,900*	*580*	*175*
HFE-356pcc3		*0.33*	*0.93*		*386*	*110*	*33*
HFE-449sl (HFE-7100)		*3.8*	*0.31*		*1,040*	*297*	*90*
HFE-569sf2 (HFE-7200)		*0.77*	*0.3*		*207*	*59*	*18*
HFE-43-10pccc124 (H-Galden 1040x)		*6.3*	*1.37*		*6,320*	*1,870*	*569*
HFE-236ca12 (HG-10)		*12.1*	*0.66*		*8,000*	*2,800*	*860*
HFE-338pcc13 (HG-01)		*6.2*	*0.87*		*5,100*	*1,500*	*460*
Perfluoropolyethers							
PFPMIE		*800*	*0.65*		*7,620*	*10,300*	*12,400*
Hydrocarbons and other compounds – Direct Effects							
Dimethylether		*0.015*	*0.02*		*1*	*1*	*<<1*
Methylene chloride		*0.38*	*0.03*		*31*	*8.7*	*2.7*
Methyl chloride		*1.0*	*0.01*		*45*	*13*	*4*

Notes:

[a] The CO_2 response function used in this report is based on the revised version of the Bern Carbon cycle model used in Chapter 10 of this report (Bern2.5CC; Joos et al. 2001) using a background CO_2 concentration value of 378 ppm. The decay of a pulse of CO_2 with time t is given by

$$a_0 + \sum_{i=1}^{3} a_i \cdot e^{-t/\tau_i}$$

Where a_0 = 0.217, a_1 = 0.259, a_2 = 0.338, a_3 = 0.186, τ_1 = 172.9 years, τ_2 = 18.51 years, and τ_3 = 1.186 years.

[b] The radiative efficiency of CO_2 is calculated using the IPCC (1990) simplified expression as revised in the TAR, with an updated background concentration value of 378 ppm and a perturbation of +1 ppm (see Section 2.10.2).

[c] The perturbation lifetime for methane is 12 years as in the TAR (see also Section 7.4). The GWP for methane includes indirect effects from enhancements of ozone and stratospheric water vapour (see Section 2.10.3.1).

[d] Shine et al. (2005c), updated by the revised AGWP for CO_2. The assumed lifetime of 1,000 years is a lower limit.

[e] Hurley et al. (2005)

[f] Robson et al. (2006)

[g] Young et al. (2006)

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