***Table 6.1:** Pre-industrial (1750) and present (1998) abundances of well-mixed greenhouse gases and the radiative forcing due to the change in abundance. Volume mixing ratios for CO_2 are in ppm, for CH_4 and N_2O in ppb, and for the rest in ppt.*

Gas	Abundance (Year 1750)	Abundance (Year 1998)	Radiative forcing (Wm^{-2})
	Gases relevant to radiative forcing only		
CO_2	278	365	1.46
CH_4	700	1745	0.48
N_2O	270	314	0.15
CF_4	40	80	0.003
C_2F_6	0	3	0.001
SF_6	0	4.2	0.002
HFC-23	0	14	0.002
HFC-134a	0	7.5	0.001
HFC-152a	0	0.5	0.000
	Gases relevant to radiative forcing and ozone depletion		
CFC-11	0	268	0.07
CFC-12	0	533	0.17
CFC-13	0	4	0.001
CFC-113	0	84	0.03
CFC-114	0	15	0.005
CFC-115	0	7	0.001
CCl_4	0	102	0.01
CH_3CCl_3	0	69	0.004
HCFC-22	0	132	0.03
HCFC-141b	0	10	0.001
HCFC-142b	0	11	0.002
Halon-1211	0	3.8	0.001
Halon-1301	0	2.5	0.001

***Table 6.2:** Simplified expressions for calculation of radiative forcing due to CO_2, CH_4, N_2O, and halocarbons. The first row for CO_2 lists an expression with a form similar to IPCC (1990) but with newer values of the constants. The second row for CO_2 is a more complete and updated expression similar in form to that of Shi (1992). The third row expression for CO_2 is from WMO (1999), based in turn on Hansen et al. (1988).*

Trace gas	Simplified expression Radiative forcing, ΔF (Wm^{-2})	Constants
CO_2	$\Delta F = \alpha \ln(C/C_0)$ $\Delta F = \alpha \ln(C/C_0) + \beta(\sqrt{C} - \sqrt{C_0})$ $\Delta F = \alpha(g(C) - g(C_0))$ where $g(C) = \ln(1+1.2C+0.005C^2+1.4 \times 10^{-6} C^3)$	$\alpha=5.35$ $\alpha=4.841$, $\beta=0.0906$ $\alpha=3.35$
CH_4	$\Delta F = \alpha(\sqrt{M} - \sqrt{M_0}) - (f(M,N_0) - f(M_0,N_0))$	$\alpha=0.036$
N_2O	$\Delta F = \alpha(\sqrt{N} - \sqrt{N_0}) - (f(M_0,N) - f(M_0,N_0))$	$\alpha=0.12$
CFC-11[a]	$\Delta F = \alpha(X - X_0)$	$\alpha=0.25$
CFC-12	$\Delta F = \alpha(X - X_0)$	$\alpha=0.32$

$f(M,N) = 0.47 \ln[1+2.01\times10^{-5} (MN)^{0.75}+5.31\times10^{-15} M(MN)^{1.52}]$
C is CO_2 in ppm
M is CH_4 in ppb
N is N_2O in ppb
X is CFC in ppb
The constant in the simplified expression for CO_2 for the first row is based on radiative transfer calculations with three-dimensional climatological meteorological input data (Myhre *et al.*, 1998b). For the second and third rows, constants are derived with radiative transfer calculations using one-dimensional global average meteorological input data from Shi (1992) and Hansen *et al.* (1988), respectively.
The subscript 0 denotes the unperturbed concentration.
[a] The same expression is used for all CFCs and CFC replacements, but with different values for α (i.e., the radiative efficiencies in Table 6.7).

The values of CFC-115 and CCl_4 have been substantially revised since the IPCC (1994) report, with a lower and higher radiative forcing estimate, respectively. Highwood and Shine (2000) calculated a radiative forcing due to chloroform ($CHCl_3$) which is much stronger than the SAR value. They suggest that this is due to the neglect of bands outside 800 to 1,200 cm^{-1} in previous studies of chloroform. Highwood and Shine (2000) found a radiative forcing due to HFC-23 which is substantially lower than the value given in the SAR.

6.3.4 Total Well-Mixed Greenhouse Gas Forcing Estimate

The radiative forcing due to all well-mixed greenhouse gases since pre-industrial times was estimated to be 2.45 Wm^{-2} in the SAR with an uncertainty of 15%. This is now altered to a radiative forcing of 2.43 Wm^{-2} with an uncertainty of 10%, based on the range of model results and the discussion of factors leading to uncertainties in the radiative forcing due to these greenhouse gases. The uncertainty in the radiative forcing due to CO_2 is estimated to be smaller than for the other well-mixed greenhouse gases; less than 10% (Section 6.3.1). For the CH_4 forcing the main uncertainty is connected to the radiative transfer code itself and is estimated to be about 15% (Section 6.3.2). The uncertainty in N_2O (Section 6.3.2) is similar to that for CO_2, whereas the main uncertainties for halocarbons arise from the spectroscopic data. The estimated uncertainty for halocarbons is 10 to 15% for the most frequently studied species, but higher for some of the less investigated molecules (Section 6.3.3). A small increase in the concentrations of the well-mixed greenhouse gases since the SAR has compensated for the reduction in radiative forcing resulting from improved radiative transfer calculations. The rate of increase in the well-mixed greenhouse gas concentrations, and thereby the radiative forcing, has been smaller over the first half of the 1990s compared to previous decades (see also Hansen *et al.*, 1998). This is mainly a result of reduced growth in CO_2 and CH_4 concentrations and smaller increase or even reduction in the concentration of some of the halocarbons.

6.3.5 Simplified Expressions

IPCC (1990) used simplified analytical expressions for the well-mixed greenhouse gases based in part on Hansen *et al.* (1988). With updates of the radiative forcing, the simplified expressions