Global Warming Potentials as revised in 2013

In preparation for the Fifth Scientific Assessment Report (AR5) by the Intergovernmental Panel on Climate Change (IPCC), the published literature concerning the Radiative Efficiencies (REs) of halogen containing greenhouse gases was systematically reviewed. Revised atmospheric lifetimes for carbon dioxide were used and so resulted in changes to the global warming potentials calculated for a range of compounds.

The information here is condensed from:
Hodnebrog, Ø., M. Etminan, J. S. Fuglestvedt, G. Marston, G. Myhre, C. J. Nielsen, K. P. Shine and T. J. Wallington (2013), Global warming potentials and radiative efficiencies of halocarbons and related compounds: A comprehensive review, Rev. Geophys., 51, doi:10.1002/rog.20013

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The Global Warming Potential (GWP) of a gas is the ratio of the time-integrated radiative forcing of a pulse emission of the gas (the absolute GWP, or AGWP) relative to the radiative forcing of a similar pulse of carbon dioxide (CO_2) over the same time interval. For the purposes of the Kyoto Protocol, the time interval ("horizon") is 100 years.

$$GWP = AGWP_{GHG} / AGWP_{CO2}$$

The time-integrated radiative forcing takes account of the reduction in atmospheric concentration of the gas (related to its Atmospheric Lifetime) and is equal to the concentration integrated over 100 years multiplied by the Radiative Efficiency (RE).

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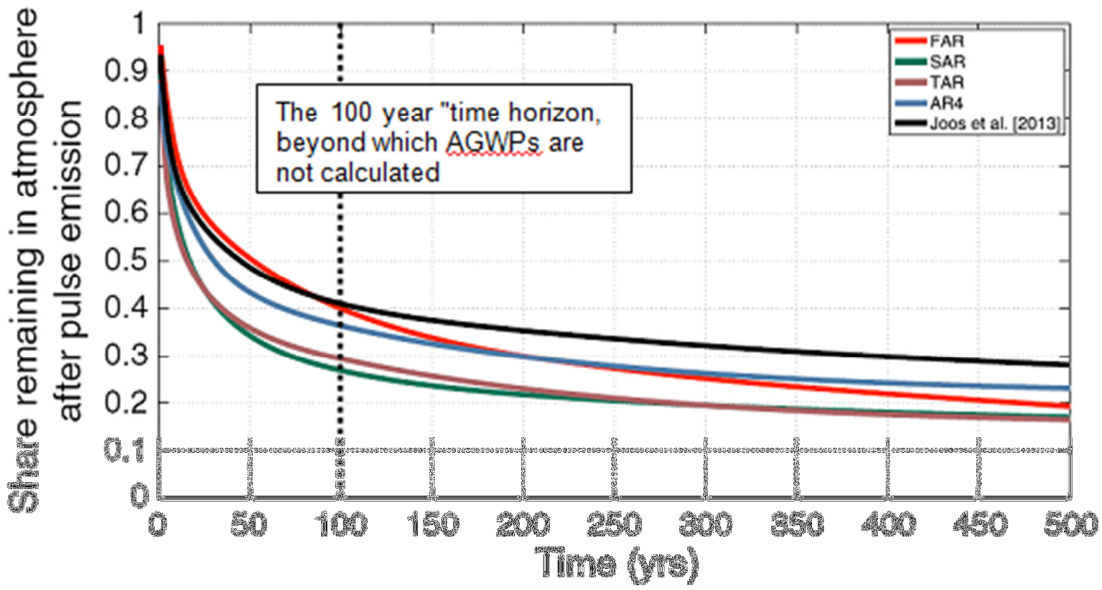

Figure 1: The decays in atmospheric concentration of a pulse emission of carbon dioxide used for the First, Second, Third and Fourth Assessment Reports (FAR, SAR, TAR and AR4, respectively) and the values from Joos et al. 2013 [1]

This relationship works for both the greenhouse gas and for carbon dioxide. But carbon dioxide has many different atmospheric loss processes, each contributing to its atmospheric lifetime. This is the subject of ongoing reassessment and Figure 1 shows the values that have been used in each of the previous Assessment Reports, together with the latest data used here. These latest data show significantly more carbon dioxide remaining in the atmosphere after an emission than had been estimated previously and the calculated AGWP of carbon dioxide is correspondingly larger. The effect is to reduce the calculated GWPs of the other greenhouse gases relative to the values given in the second, third and fourth Assessment Reports (SAR, TAR and AR4).

The paper provides a comprehensive and self-consistent set of new calculations of Radiative Efficiencies (REs) and global warming potentials (GWPs) for more than 200 compounds and claims to be the most comprehensive review of the radiative efficiencies and global warming potentials of halogenated compounds performed to date. For 49 of the compounds, the calculations yield REs significantly (> 5%) different from those in the IPCC Fourth Assessment Report and the study also presents new RE values for more than 100 gases which were not included in AR4. These revised values were adopted in the Fifth Assessment Report of IPCC (AR5).

The calculations of RE used infrared absorption spectra from:

- databases,
- individual studies,
- experimental studies and
- ab initio computational studies;

selecting data with the highest spectral resolution.

The calculated REs were corrected to account for non-uniform distribution of the substances in the atmosphere; a particular concern for short lived gases.

Table 1 shows the values of atmospheric lifetime, RE and GWP of a selection of the more important halogen containing greenhouse gases, with data for CFCs, HCFCs and other ozone depleting substances, together with HFCs, SF_6 and fluorinated olefins (HFOs). Where the GWP values are significantly different from those in AR4, the numbers are shown in bold type.

In general, GWPs for CFCs and HCFCs are either the same as or lower than those in AR4. Similarly, for HFCs the calculated GWPs are almost all the same or lower; particularly important for HFC-23 (down from 14800 to 12400) and HFC-134a (1430 reduced to 1300). The exceptions are HFC-143a, the GWP of which is increased from 4470 to 4800, and 152a (124 increased to 138).

HFOs were not included in AR4 and have been shown by this work to have insignificantly small GWPs, in fact less than that of carbon dioxide. This is a direct consequence of their very short atmospheric lifetimes which result in concentrations integrated over 100 years that are tiny compared to the amount of carbon dioxide that can remain in the atmosphere after an emission.

Table 1: Data for a selection of CFCs, HCFCs, HFCs, SF_6, chlorocarbons and HFOs (Bold type denotes that the GWP values calculated in the paper are significantly different from those in AR4).

Substance	Atmospheric Lifetime (years)	Radiative Efficiency (W/m^2.ppb)		GWP over 100 years	
		AR4	The paper recommends	AR4	The paper recommends
CFC-11	45	0.25	0.26	4750	4660
CFC-12	**100**	**0.32**	**0.32**	**10900**	**10200**
CFC-13	640	0.25	0.25	14400	13900
CFC-113	85	0.30	0.30	6130	5820
CFC-114	**190**	**0.31**	**0.31**	**10000**	**8590**
CFC-115	1020	0.18	0.20	7370	7670

Substance	Atmospheric Lifetime (years)	Radiative Efficiency (W/m².ppb)		GWP over 100 years	
		AR4	The paper recommends	AR4	The paper recommends
HCFC-22	11.9	0.20	0.21	1810	1760
HCFC-123	1.3	0.14	0.15	77	79
HCFC-124	**5.9**	**0.22**	**0.20**	**609**	**527**
HCFC-141b	**9.2**	**0.14**	**0.16**	**725**	**782**
HCFC-142b	**17.2**	**0.20**	**0.19**	**2310**	**1980**
HCFC-225ca	1.9	0.20	0.22	122	127
HCFC-225cb	**5.9**	**0.32**	**0.29**	**595**	**525**
HFC-23	**222**	**0.19**	**0.18**	**14800**	**12400**
HFC-32	5.2	0.11	0.11	675	677
HFC-125	**28.2**	**0.23**	**0.23**	**3500**	**3170**
HFC-134a	**13.4**	**0.16**	**0.16**	**1430**	**1300**
HFC-143a	**47.1**	**0.13**	**0.16**	**4470**	**4800**
HFC-152a	**1.5**	**0.09**	**0.10**	**124**	**138**
HFC-227ea	38.9	0.26	0.26	3220	3350
HFC-236cb	**13.1**	**0.23**	**0.23**	**1340**	**1210**
HFC-236fa	**242**	**0.28**	**0.24**	**9810**	**8060**
HFC-245ca	6.5	0.23	0.24	693	716
HFC-245fa	**7.7**	**0.28**	**0.24**	**1030**	**858**
HFC-365mfc	8.7	0.21	0.22	794	804
HFC-43-10-mee	16.1	0.40	0.42	1640	1650

Substance	Atmospheric Lifetime (years)	Radiative Efficiency (W/m^2.ppb)		GWP over 100 years	
		AR4	The paper recommends	AR4	The paper recommends
SF_6	3200	0.52	0.57	22800	23500
Methyl chloroform	**5.0**	**0.06**	**0.07**	**146**	**160**
Carbon tetrachloride	**26.0**	**0.13**	**0.17**	**1400**	**1730**
Methyl chloride	**1.0**	**0.01**		**13**	**12**
Dichloromethane	0.4	0.03		9	9
Chloroform	**0.4**	**0.11**	**0.08**	**31**	**16**
1,2-Dichloro-ethane	0.2		0.01		<1
(Z)-HFO-1225ye	**0.02**		**0.02**		**<1**
(E)-HFO-1225ye	**0.01**		**0.01**		**<1**
(Z)-HFO-1234ze	**0.03**		**0.02**		**<1**
HFO-1234yf	**0.03**		**0.02**		**<1**
(E)-HFO-1234ze	**0.04**		**0.04**		**<1**
HFO-1243zf	**0.02**		**0.01**		**<1**
HFO-1345zfc	**0.02**		**0.01**		**<1**

Reference

1. Joos, F., et al. (2013), Carbon dioxide and climate impulse response functions for the computation of greenhouse gas metrics: a multi-model analysis, Atmos. Chem. Phys., 13, 2793–2825, doi:10.5194/acp-13-2793-2013.