Supplementary material

S1 Equivalence between integrated response to a pulse emission and a timepoint response to an emission step.

If the ozone depletion response function is given by $R(t)$, then the integrated response up to a time horizon H from a pulse emission $E\delta(t)$ (δ is the Dirac delta-function) is the integral of the convolution of R with δ:

$\int_0^H \int_0^t R(t-t')E\delta(t')\mathrm{d}t'\,\mathrm{d}t = E\int_0^H R(t)\,\mathrm{d}t$; Equation S1

The response at time horizon H to a step emission $e\theta(t)$ (θ is the Heaviside step function) is the convolution of R with θ:

$\int_0^H R(H-t')e\theta(t')\mathrm{d}t' = -e\int_H^0 R(t)\,\mathrm{d}t = e\int_0^H R(t)\,\mathrm{d}t$; Equation S2

S2 Fill Factor

Fill factors (ratios of average to surface concentrations) for the species in table 3 of Volk et al. (1997) are shown in figure S1 as a function of τ_{strat}. An empirical function

$\frac{\bar{C}}{C} = 1 - Ae^{-\frac{\tau_{\mathrm{strat}}}{\mathrm{T}}}$, equation S3

is found to fit the data with $A = 0.113$ and $\mathrm{T} = 130$ years (see figure S1).

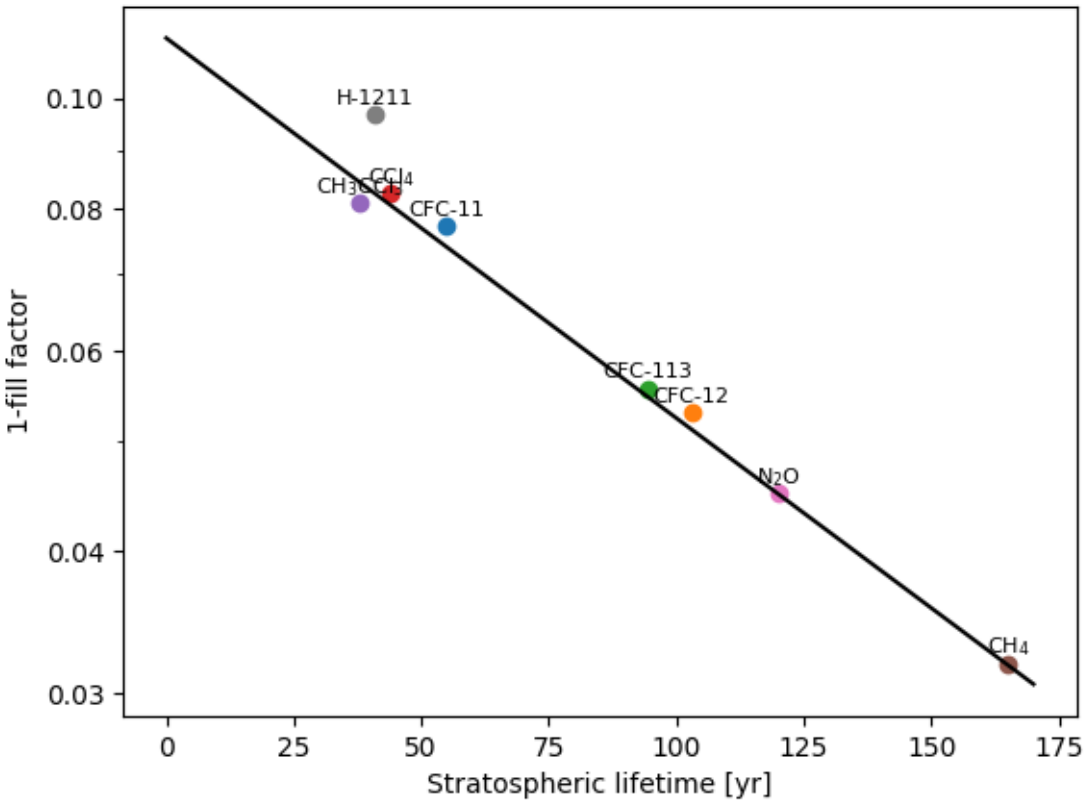

Figure S1 1-$\frac{\bar{C}}{C}$ against τ_{strat} for species in table 3 of Volk et al. (1997)**. Note logarithmic *y*-axis. Values of $\frac{\bar{C}}{C}$ are from** Volk et al. (1997)**, values of τ_{strat} for halocarbons are from** WMO (2022)**, those for CH_4 and N_2O are from . The line shows the fit $1-\frac{\bar{C}}{C} = 0.113e^{-\frac{\tau_{strat}}{130\ years}}$.**

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S3 Time delay

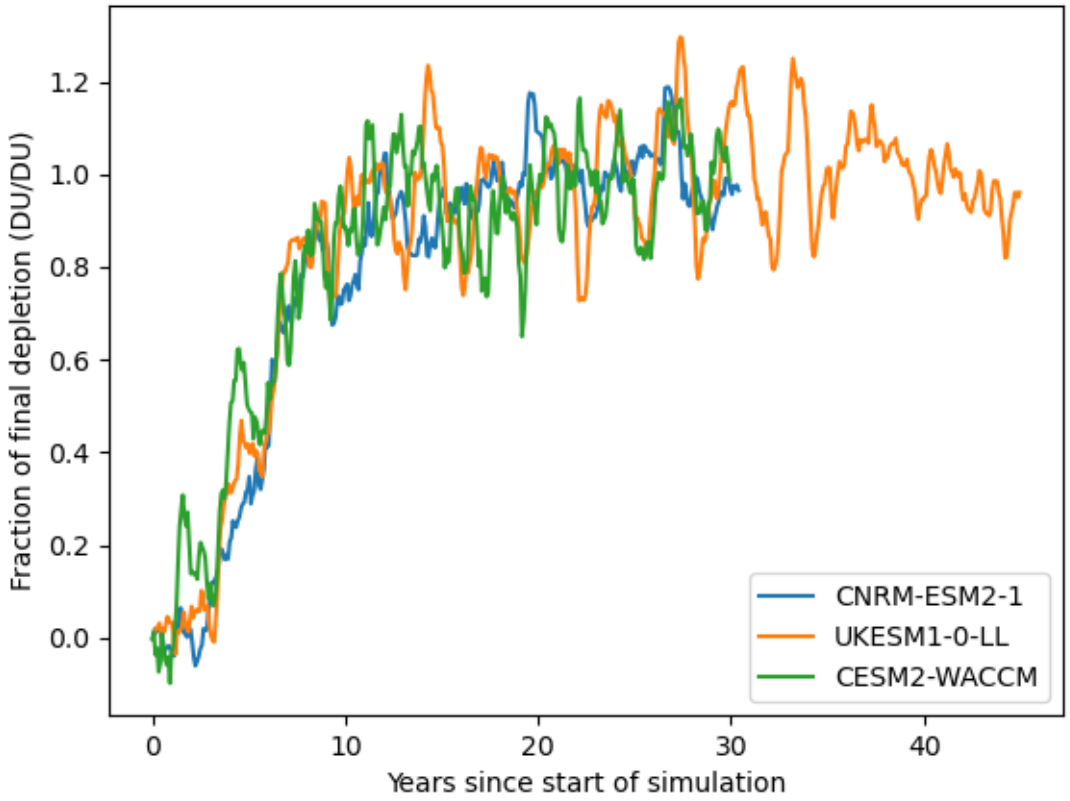

Figure S2, Time evolution of ozone depletion (difference in total ozone column with 2014 halocarbon concentrations vs 1850 halocarbon concentrations) as a fraction of the final depletion (averaged over the final 10 years) for the three models where the atmospheric concentrations halocarbons are not initialised to 2014 values.

S4 Tables

Table S1 Change in concentrations of halocarbons in parts per trillion by mole (ppt) as used in the ESMs. Also shown are observational-based values from Meinshausen et al. (2017) M17**.**

	CFC-11	CFC-12	CFC-113	CFC-114	CFC-115	CCl_4	CH_3CCl_3	CH_3Cl	HCFC-141b	HCFC-142b	HCFC-22	CH_3Br	H-1211	H-1301	H-2402
M17	233	521	72.7	16.3	8.4	83.0	3.68	82.5	23.8	22.1	229.5	1.4	3.75	3.30	0.431
CESM2-WACCM	233	521	72.7	16.3	8.4	83.1	3.68	82.8	23.8	22.1	229.5	1.4	3.76	3.30	0.431
CNRM-ESM2-1	233	521	72.7			83.0	19.6	82.5			229.5	6.4	4.61	3.30	
GFDL-ESM4	232	514	71.7			47.6	3.68	63.8			228.6	1.4	3.75	3.30	
UKESM1-0-LL	399	764										9.3			
GISS-E2-1-G	505	1129													
MRI-ESM2-0	293	654				104.4		189				1.8	3.98	3.50	

Table S2 Equivalent emission changes needed (using equation 3) to achieve the concentration changes in Table S1. Values expressed in Tg(Cl) yr^{-1}.

	CFC-11	CFC-12	CFC-113	CFC-114	CFC-115	CCl_4	CH_3CCl_3	CH_3Cl	HCFC-141b	HCFC-142b	HCFC-22	CH_3Br	H-1211	H-1301	H-2402
CESM2-WACCM	0.078	0.061	0.014	0.001	0.000	0.064	0.013	0.528	0.031	0.008	0.119	0.599	0.083	0.016	0.011
CNRM-ESM2-1	0.078	0.061	0.014			0.064	0.068	0.526		0.000	0.119	2.738	0.102	0.016	
GFDL-ESM4	0.084	0.064	0.015			0.040	0.014	0.447		0.000	0.124	0.660	0.090	0.017	
UKESM1-0-LL	0.134	0.090										3.986			
GISS-E2-1-G	0.184	0.139													
MRI-ESM2-0	0.106	0.081				0.088		1.325				0.853	0.096	0.018	

Table S3 Increase in stratospheric chlorine production in Tg(Cl) yr^{-1}

	CFC-11	CFC-12	CFC-113	CFC-114	CFC-115	CCl_4	CH_3CCl_3	CH_3Cl	HCFC-141b	HCFC-142b	HCFC-22	CH_3Br	H-1211	H-1301	H-2402	Total
CESM2-WACCM	0.074	0.060	0.014	0.001	0.000	0.044	0.002	0.016	0.006	0.001	0.012	0.018	0.032	0.016	0.007	0.302
CNRM-ESM2-1	0.074	0.060	0.014			0.044	0.009	0.016			0.012	0.083	0.040	0.016		0.367
GFDL-ESM4	0.080	0.063	0.014			0.027	0.002	0.013			0.012	0.020	0.035	0.017		0.284
UKESM1-0-LL	0.127	0.089										0.121				0.337
GISS-E2-1-G	0.174	0.138														0.312
MRI-ESM2-0	0.101	0.080				0.060		0.039				0.026	0.037	0.018		0.361

Table S4 Total increase in stratospheric chlorine production (from table S3), change in total ozone column, efficiency of chlorine to destroy ozone (*K*), ozone stratospheric temperature adjusted radiative forcing, and (stratospheric temperature adjusted) radiative efficiency of ozone. Uncertainties are the standard deviation of the model values.

	Cl production (Tg(Cl) yr^{-1})	ΔO^3 (DU)	K (DU yr Tg(Cl)$^{-1}$)	O_3 SARF (Wm^{-2})	ϕ_{O_3} (mWm^{-2} DU^{-1})
CESM2-WACCM	0.30	-14.4 ±0.4	47 ± 1	-0.06	4.2
CNRM-ESM2-1	0.37	-23.4 ±0.8	64 ± 2	-0.18	7.7
GFDL-ESM4	0.28	-24.8 ±0.2	87 ± 1	-0.19	7.7
UKESM1-0-LL	0.34	-40.3 ±0.6	120 ± 2	-0.33	8.2
GISS-E2-1-G	0.29	-26.7 ±0.2	91 ± 1	-0.09	3.4
MRI-ESM2-0	0.36	-13.8 ±.05	38 ± 1	-0.04	3.1
Multi-model mean	0.32 ± 0.03	-23.9 ±8.9	74 ± 27	-0.15 ± 0.10	5.7 ± 2.2

Table S5 Total increase in stratospheric chlorine production (from table S3), fractional change in methane lifetime, methane feedback factor and implied methane (effective) radiative forcing. Uncertainties are the standard deviation of the model values.

	Cl production (Tg(Cl) yr^{-1})	$\Delta\tau_{CH4}/\tau_{CH4}$	f	CH_4 RF (Wm^{-2})
CESM2-WACCM	0.30	-0.089	1.19	-0.113
GFDL-ESM4	0.28	-0.076	1.30	-0.105
UKESM1-0-LL	0.34	-0.050	1.32	-0.070
GISS-E2-1-G	0.29	-0.006	1.26	-0.008
MRI-ESM2-0	0.36	-0.024	1.31	-0.033
Multi-model mean	0.32 ± 0.03	-0.049 ± 0.031	1.28 ± 0.05	-0.066 ± 0.040

Table S6 Change in EESC for extra-polar and polar latitudes in ppt(Cl) corresponding to the changes in concentration in table S1.

		CFC-11	CFC-12	CFC-113	CFC-114	CFC-115	CCl_4	CH_3CCl_3	CH_3Cl	HCFC-141b	HCFC-142b	HCFC-22	CH_3Br	H-1211	H-1301	H-2402	Total
CESM2-WACCM	Extra-polar	329	250	65	4	1	186	7	36	16	4	34	50	149	63	34	1229
	Polar	692	906	199	13	2	332	11	75	43	14	101	90	248	178	56	2960
CNRM-ESM2-1	Extra-polar	329	250	65			186	36	36			34	230	183	63		1413
	Polar	692	906	199			332	58	75			101	411	304	178		3256
GFDL-ESM4	Extra-polar	327	247	65			107	7	28			34	50	149	63		1077
	Polar	690	895	196			190	11	58			101	90	248	178		2656
UKESM1-0-LL	Extra-polar	563	367										335				1265
	Polar	1186	1331										598				3116
GISS-E2-1-G	Extra-polar	713	542														1255
	Polar	1501	1964														3466
MRI-ESM2-0	Extra-polar	413	314				234		83				65	158	67		1334
	Polar	870	1138				418		172				116	263	189		3167

Table S7 Total change in EESC (polar and extra-polar), ozone stratospheric temperature adjusted radiative forcing, (stratospheric temperature adjusted) radiative efficiencies for polar and extra-polar ozone per ppt of EESC, effective radiative forcing from methane and methane (effective) radiative efficiency per ppt of (extra-polar) EESC.

	EESC extra-polar (ppt (Cl))	EESC polar (ppt (Cl)))	O_3 SARF (Wm^{-2})	$\phi_{O_3}^{\text{extra-polar}}$ (mWm^{-2} $ppt(Cl)^{-1}$)	$\phi_{O_3}^{\text{polar}}$ (mWm^{-2} $ppt(Cl)^{-1}$)	CH_4 RF (Wm^{-2})	ϕ_{CH_4} (mWm^{-2} $ppt(Cl)^{-1}$)
CESM2-WACCM	1229	2960	-0.06	-0.030	-0.008	-0.113	-0.092
CNRM-ESM2-1	1413	3256	-0.18	-0.076	-0.022		
GFDL-ESM4	1077	2656	-0.19	-0.106	-0.029	-0.105	-0.098
UKESM1-0-LL	1265	3116	-0.33	-0.157	-0.042	-0.070	-0.055
GISS-E2-1-G	1255	3466	-0.09	-0.043	-0.010	-0.008	-0.006
MRI-ESM2-0	1334	3167	-0.04	-0.019	-0.005	-0.033	-0.027
Multi-model mean	1262 ± 103	3103 ± 252	-0.15 ± 0.10	-0.07± 0.05	-0.02 ± 0.01	-0.066 ± 0.04	-0.056 ± 0.035

Table S8 Direct and indirect GWP100 values for a range of ODSs. The direct radiative efficiencies, atmospheric lifetimes and stratospheric lifetimes are taken from WMO (2022) table A5. Species in bold font have net negative GWP100 (central value).

Name	Direct	Ozone	Methane	Total
Chlorofluorocarbons				
CFC-11	**6565 ± 756**	**-6963 ± 1922**	**-1458 ± 876**	**-1855 ± 2244**
CFC-12	12510 ± 1441	-4010 ± 1107	-840 ± 505	7660 ± 1886
CFC-13	15567 ± 1793	-537 ± 148	-112 ± 68	14917 ± 1800
CFC-112	**4691 ± 540**	**-5957 ± 1645**	**-1248 ± 749**	**-2514 ± 1886**
CFC-112a	**3643 ± 420**	**-6396 ± 1766**	**-1339 ± 805**	**-4092 ± 1985**
CFC-113	6571 ± 757	-4071 ± 1124	-853 ± 512	1647 ± 1448
CFC-113a	**4019 ± 463**	**-5063 ± 1398**	**-1060 ± 637**	**-2103 ± 1604**
CFC-114	9243 ± 1064	-1854 ± 512	-388 ± 233	7000 ± 1204
CFC-114a	7418 ± 854	-2770 ± 765	-580 ± 349	4068 ± 1198
CFC-115	9188 ± 1058	-345 ± 95	-72 ± 43	8771 ± 1063
CFC-216ba	8506 ± 979	-1851 ± 511	-388 ± 233	6267 ± 1129
CFC-216ca	7479 ± 861	-1851 ± 511	-388 ± 233	5240 ± 1028
(E)-R316c	4345 ± 500	-2453 ± 677	-514 ± 309	1379 ± 897
(Z)-R316c	5696 ± 656	-1946 ± 537	-407 ± 245	3343 ± 882
1,2,3,4-Tetrachlorohexafluorobutane (TCHFB)	**4257 ± 490**	**-4498 ± 1242**	**-942 ± 566**	**-1183 ± 1450**
Hydrochlorofluorocarbons				
HCFC-21	**167 ± 19**	**-445 ± 123**	**-93 ± 56**	**-372 ± 136**
HCFC-22	1890 ± 218	-446 ± 123	-93 ± 56	1351 ± 256
HCFC-31	**88 ± 10**	**-205 ± 57**	**-43 ± 26**	**-160 ± 63**
HCFC-121	**61 ± 7**	**-472 ± 130**	**-99 ± 59**	**-511 ± 143**
HCFC-121a	**171 ± 20**	**-837 ± 231**	**-175 ± 105**	**-841 ± 255**
HCFC-122	**60 ± 7**	**-322 ± 89**	**-67 ± 41**	**-330 ± 98**
HCFC-122a	**257 ± 30**	**-650 ± 179**	**-136 ± 82**	**-530 ± 199**
HCFC-122b	**797 ± 92**	**-1851 ± 511**	**-388 ± 233**	**-1441 ± 569**
HCFC-123	**95 ± 11**	**-266 ± 73**	**-56 ± 33**	**-227 ± 81**
HCFC-123a	406 ± 47	-334 ± 92	-70 ± 42	2 ± 112
HCFC-123b	**1248 ± 144**	**-1144 ± 316**	**-240 ± 144**	**-135 ± 376**
HCFC-124	593 ± 68	-164 ± 45	-34 ± 21	394 ± 85
HCFC-124a	2028 ± 233	-308 ± 85	-64 ± 39	1656 ± 251
HCFC-131	**34 ± 4**	**-299 ± 83**	**-63 ± 38**	**-328 ± 91**
HCFC-131a	**187 ± 22**	**-647 ± 179**	**-136 ± 81**	**-595 ± 198**
HCFC-131b	**133 ± 15**	**-701 ± 194**	**-147 ± 88**	**-715 ± 213**
HCFC-132	**129 ± 15**	**-262 ± 72**	**-55 ± 33**	**-187 ± 81**
HCFC-132a	**74 ± 9**	**-277 ± 77**	**-58 ± 35**	**-261 ± 85**

HCFC-132b	**338 ± 39**	**-360 ± 99**	**-75 ± 45**	**-98 ± 116**
HCFC-132c	**354 ± 41**	**-577 ± 159**	**-121 ± 73**	**-344 ± 180**
HCFC-133	301 ± 35	-152 ± 42	-32 ± 19	117 ± 58
HCFC-133a	379 ± 44	-183 ± 50	-38 ± 23	159 ± 71
HCFC-133b	828 ± 95	-220 ± 61	-46 ± 28	561 ± 116
HCFC-141	**50 ± 6**	**-264 ± 73**	**-55 ± 33**	**-269 ± 80**
HCFC-141a	**17 ± 2**	**-170 ± 47**	**-36 ± 21**	**-188 ± 51**
HCFC-141b	**827 ± 95**	**-1217 ± 336**	**-255 ± 153**	**-645 ± 381**
HCFC-142	**192 ± 22**	**-172 ± 48**	**-36 ± 22**	**-17 ± 57**
HCFC-142a	**120 ± 14**	**-148 ± 41**	**-31 ± 19**	**-60 ± 47**
HCFC-142b	2148 ± 247	-457 ± 126	-96 ± 58	1595 ± 284
HCFC-151	**12 ± 1**	**-118 ± 33**	**-25 ± 15**	**-131 ± 36**
HCFC-151a	**60 ± 7**	**-169 ± 47**	**-35 ± 21**	**-145 ± 52**
HCFC-221aa	**42 ± 5**	**-416 ± 115**	**-87 ± 52**	**-460 ± 126**
HCFC-221ab	**118 ± 14**	**-868 ± 240**	**-182 ± 109**	**-931 ± 264**
HCFC-221ba	**48 ± 6**	**-490 ± 135**	**-103 ± 62**	**-545 ± 149**
HCFC-221da	**196 ± 23**	**-1011 ± 279**	**-212 ± 127**	**-1027 ± 307**
HCFC-221ea	**193 ± 22**	**-1060 ± 293**	**-222 ± 133**	**-1089 ± 322**
HCFC-222aa	**66 ± 8**	**-435 ± 120**	**-91 ± 55**	**-460 ± 132**
HCFC-222ab	**164 ± 19**	**-770 ± 213**	**-161 ± 97**	**-768 ± 235**
HCFC-222ac	**542 ± 62**	**-2084 ± 575**	**-437 ± 262**	**-1979 ± 635**
HCFC-222ba	**62 ± 7**	**-435 ± 120**	**-91 ± 55**	**-464 ± 132**
HCFC-222bb	**167 ± 19**	**-871 ± 240**	**-182 ± 110**	**-887 ± 265**
HCFC-222ca	**76 ± 9**	**-505 ± 139**	**-106 ± 64**	**-534 ± 154**
HCFC-222da	**327 ± 38**	**-1135 ± 313**	**-238 ± 143**	**-1046 ± 347**
HCFC-222db	**317 ± 37**	**-1163 ± 321**	**-244 ± 146**	**-1090 ± 355**
HCFC-222ea	**305 ± 35**	**-1176 ± 325**	**-246 ± 148**	**-1117 ± 358**
HCFC-223aa	**63 ± 7**	**-372 ± 103**	**-78 ± 47**	**-387 ± 113**
HCFC-223ab	**255 ± 29**	**-685 ± 189**	**-144 ± 86**	**-574 ± 210**
HCFC-223ac	**764 ± 88**	**-1784 ± 492**	**-374 ± 224**	**-1394 ± 548**
HCFC-223ba	**102 ± 12**	**-404 ± 112**	**-85 ± 51**	**-387 ± 123**
HCFC-223bb	**214 ± 25**	**-685 ± 189**	**-144 ± 86**	**-615 ± 209**
HCFC-223bc	**748 ± 86**	**-2009 ± 555**	**-421 ± 253**	**-1681 ± 616**
HCFC-223ca	**94 ± 11**	**-432 ± 119**	**-91 ± 54**	**-429 ± 132**
HCFC-223cb	**267 ± 31**	**-869 ± 240**	**-182 ± 109**	**-784 ± 266**
HCFC-223da	**569 ± 65**	**-1182 ± 326**	**-247 ± 149**	**-861 ± 364**
HCFC-223db	**433 ± 50**	**-1311 ± 362**	**-274 ± 165**	**-1152 ± 401**
HCFC-223ea	**501 ± 58**	**-1280 ± 353**	**-268 ± 161**	**-1047 ± 393**

HCFC-223eb	**480 ± 55**	**-1311 ± 362**	**-274 ± 165**	**-1105 ± 402**
HCFC-224aa	**245 ± 28**	**-595 ± 164**	**-125 ± 75**	**-474 ± 183**
HCFC-224ab	**1060 ± 122**	**-1382 ± 382**	**-289 ± 174**	**-611 ± 437**
HCFC-224ba	**94 ± 11**	**-310 ± 85**	**-65 ± 39**	**-281 ± 95**
HCFC-224bb	**352 ± 40**	**-436 ± 120**	**-91 ± 55**	**-175 ± 138**
HCFC-224bc	**1074 ± 124**	**-1382 ± 382**	**-289 ± 174**	**-597 ± 437**
HCFC-224ca	**147 ± 17**	**-357 ± 99**	**-75 ± 45**	**-285 ± 110**
HCFC-224cb	**120 ± 14**	**-245 ± 68**	**-51 ± 31**	**-176 ± 76**
HCFC-224cc	**1214 ± 140**	**-1857 ± 513**	**-389 ± 234**	**-1032 ± 581**
HCFC-224da	1100 ± 127	-845 ± 233	-177 ± 106	77 ± 286
HCFC-224db	**833 ± 96**	**-1182 ± 326**	**-247 ± 149**	**-596 ± 371**
HCFC-224ea	**879 ± 101**	**-1153 ± 318**	**-241 ± 145**	**-515 ± 364**
HCFC-224eb	**653 ± 75**	**-1375 ± 380**	**-288 ± 173**	**-1010 ± 424**
HCFC-225aa	1059 ± 122	-862 ± 238	-181 ± 108	16 ± 289
HCFC-225ba	353 ± 41	-222 ± 61	-47 ± 28	84 ± 79
HCFC-225bb	1646 ± 190	-631 ± 174	-132 ± 79	883 ± 269
HCFC-225ca	**142 ± 16**	**-237 ± 65**	**-50 ± 30**	**-145 ± 74**
HCFC-225cb	562 ± 65	-310 ± 85	-65 ± 39	188 ± 114
HCFC-225cc	1613 ± 186	-1003 ± 277	-210 ± 126	399 ± 357
HCFC-225da	1612 ± 186	-639 ± 176	-134 ± 80	839 ± 268
HCFC-225ea	1695 ± 195	-608 ± 168	-127 ± 77	959 ± 269
HCFC-225eb	1291 ± 149	-961 ± 265	-201 ± 121	129 ± 327
HCFC-226ba	1596 ± 184	-225 ± 62	-47 ± 28	1324 ± 196
HCFC-226ca	508 ± 58	-120 ± 33	-25 ± 15	363 ± 69
HCFC-226cb	2543 ± 293	-263 ± 72	-55 ± 33	2225 ± 303
HCFC-226da	2561 ± 295	-311 ± 86	-65 ± 39	2185 ± 310
HCFC-226ea	2613 ± 301	-289 ± 80	-60 ± 36	2264 ± 313
HCFC-231aa	**29 ± 3**	**-343 ± 95**	**-72 ± 43**	**-385 ± 104**
HCFC-231ab	**83 ± 10**	**-596 ± 165**	**-125 ± 75**	**-638 ± 181**
HCFC-231ac	**102 ± 12**	**-754 ± 208**	**-158 ± 95**	**-810 ± 229**
HCFC-231ba	**19 ± 2**	**-242 ± 67**	**-51 ± 30**	**-274 ± 74**
HCFC-231bb	**117 ± 13**	**-804 ± 222**	**-168 ± 101**	**-855 ± 244**
HCFC-231da	**21 ± 2**	**-231 ± 64**	**-48 ± 29**	**-258 ± 70**
HCFC-231db	**54 ± 6**	**-536 ± 148**	**-112 ± 67**	**-594 ± 163**
HCFC-231ea	**29 ± 3**	**-327 ± 90**	**-68 ± 41**	**-366 ± 99**
HCFC-231fa	**355 ± 41**	**-1605 ± 443**	**-336 ± 202**	**-1586 ± 489**
HCFC-232aa	82 ± 9	-49 ± 14	-10 ± 6	23 ± 18
HCFC-232ab	**46 ± 5**	**-374 ± 103**	**-78 ± 47**	**-406 ± 113**

HCFC-232ac	**175 ± 20**	**-638 ± 176**	**-134 ± 80**	**-596 ± 195**
HCFC-232ad	**152 ± 18**	**-649 ± 179**	**-136 ± 82**	**-632 ± 198**
HCFC-232ba	**50 ± 6**	**-362 ± 100**	**-76 ± 46**	**-388 ± 110**
HCFC-232bb	**175 ± 20**	**-638 ± 176**	**-134 ± 80**	**-597 ± 195**
HCFC-232bc	**227 ± 26**	**-895 ± 247**	**-187 ± 113**	**-856 ± 273**
HCFC-232ca	**28 ± 3**	**-260 ± 72**	**-55 ± 33**	**-287 ± 79**
HCFC-232cb	**288 ± 33**	**-1047 ± 289**	**-219 ± 132**	**-978 ± 319**
HCFC-232da	**45 ± 5**	**-302 ± 83**	**-63 ± 38**	**-320 ± 92**
HCFC-232db	**93 ± 11**	**-461 ± 127**	**-97 ± 58**	**-465 ± 140**
HCFC-232dc	**161 ± 19**	**-746 ± 206**	**-156 ± 94**	**-741 ± 227**
HCFC-232ea	**42 ± 5**	**-306 ± 85**	**-64 ± 39**	**-328 ± 93**
HCFC-232eb	**114 ± 13**	**-595 ± 164**	**-125 ± 75**	**-606 ± 181**
HCFC-232fa	**746 ± 86**	**-1919 ± 530**	**-402 ± 241**	**-1575 ± 588**
HCFC-232fb	**760 ± 88**	**-2099 ± 579**	**-439 ± 264**	**-1778 ± 643**
HCFC-233aa	**164 ± 19**	**-495 ± 137**	**-104 ± 62**	**-434 ± 151**
HCFC-233ab	**169 ± 19**	**-486 ± 134**	**-102 ± 61**	**-419 ± 149**
HCFC-233ac	**316 ± 36**	**-625 ± 172**	**-131 ± 79**	**-439 ± 193**
HCFC-233ba	**143 ± 16**	**-332 ± 92**	**-69 ± 42**	**-259 ± 102**
HCFC-233bb	**74 ± 8**	**-324 ± 89**	**-68 ± 41**	**-318 ± 99**
HCFC-233bc	**407 ± 47**	**-530 ± 146**	**-111 ± 67**	**-233 ± 167**
HCFC-233bd	**317 ± 37**	**-625 ± 172**	**-131 ± 79**	**-438 ± 193**
HCFC-233ca	**74 ± 9**	**-324 ± 89**	**-68 ± 41**	**-317 ± 99**
HCFC-233cb	**384 ± 44**	**-728 ± 201**	**-152 ± 92**	**-497 ± 225**
HCFC-233cc	**519 ± 60**	**-1121 ± 309**	**-235 ± 141**	**-837 ± 345**
HCFC-233da	**44 ± 5**	**-267 ± 74**	**-56 ± 34**	**-278 ± 81**
HCFC-233db	**187 ± 22**	**-351 ± 97**	**-74 ± 44**	**-238 ± 109**
HCFC-233dc	**291 ± 33**	**-608 ± 168**	**-127 ± 76**	**-444 ± 187**
HCFC-233ea	**60 ± 7**	**-286 ± 79**	**-60 ± 36**	**-286 ± 87**
HCFC-233eb	**171 ± 20**	**-457 ± 126**	**-96 ± 57**	**-381 ± 140**
HCFC-233ec	**326 ± 38**	**-802 ± 221**	**-168 ± 101**	**-644 ± 246**
HCFC-233fa	**1649 ± 190**	**-1999 ± 552**	**-419 ± 251**	**-769 ± 635**
HCFC-233fb	**1139 ± 131**	**-2606 ± 719**	**-546 ± 328**	**-2012 ± 801**
HCFC-234aa	**476 ± 55**	**-593 ± 164**	**-124 ± 75**	**-241 ± 188**
HCFC-234ab	**300 ± 35**	**-398 ± 110**	**-83 ± 50**	**-181 ± 125**
HCFC-234ba	**264 ± 30**	**-258 ± 71**	**-54 ± 32**	**-47 ± 84**
HCFC-234bb	381 ± 44	-311 ± 86	-65 ± 39	4 ± 104
HCFC-234bc	699 ± 81	-391 ± 108	-82 ± 49	226 ± 143
HCFC-234ca	**204 ± 23**	**-232 ± 64**	**-49 ± 29**	**-77 ± 74**

HCFC-234cb	**120 ± 14**	**-242 ± 67**	**-51 ± 30**	**-173 ± 75**
HCFC-234cc	903 ± 104	-478 ± 132	-100 ± 60	325 ± 178
HCFC-234cd	**681 ± 78**	**-602 ± 166**	**-126 ± 76**	**-47 ± 199**
HCFC-234da	**201 ± 23**	**-229 ± 63**	**-48 ± 29**	**-76 ± 73**
HCFC-234db	555 ± 64	-343 ± 95	-72 ± 43	140 ± 122
HCFC-234ea	**64 ± 7**	**-198 ± 55**	**-41 ± 25**	**-176 ± 61**
HCFC-234eb	**249 ± 29**	**-236 ± 65**	**-49 ± 30**	**-37 ± 77**
HCFC-234ec	**536 ± 62**	**-510 ± 141**	**-107 ± 64**	**-81 ± 167**
HCFC-234fa	3685 ± 424	-1184 ± 327	-248 ± 149	2252 ± 556
HCFC-234fb	3376 ± 389	-2480 ± 685	-519 ± 312	377 ± 847
HCFC-235ba	768 ± 88	-172 ± 48	-36 ± 22	559 ± 103
HCFC-235bb	675 ± 78	-155 ± 43	-32 ± 19	488 ± 91
HCFC-235ca	809 ± 93	-184 ± 51	-38 ± 23	586 ± 109
HCFC-235cb	411 ± 47	-124 ± 34	-26 ± 16	262 ± 60
HCFC-235cc	1534 ± 177	-230 ± 64	-48 ± 29	1256 ± 190
HCFC-235da	681 ± 78	-160 ± 44	-33 ± 20	488 ± 92
HCFC-235ea	661 ± 76	-157 ± 43	-33 ± 20	471 ± 90
HCFC-235eb	346 ± 40	-108 ± 30	-23 ± 14	215 ± 52
HCFC-235fa	5721 ± 659	-568 ± 157	-119 ± 71	5034 ± 681
HCFC-241aa	**55 ± 6**	**-486 ± 134**	**-102 ± 61**	**-532 ± 148**
HCFC-241ab	**24 ± 3**	**-308 ± 85**	**-65 ± 39**	**-348 ± 94**
HCFC-241ac	**333 ± 38**	**-1289 ± 356**	**-270 ± 162**	**-1226 ± 393**
HCFC-241ba	**33 ± 4**	**-317 ± 87**	**-66 ± 40**	**-350 ± 96**
HCFC-241bb	**496 ± 57**	**-1802 ± 497**	**-377 ± 227**	**-1683 ± 550**
HCFC-241da	**19 ± 2**	**-226 ± 62**	**-47 ± 28**	**-254 ± 68**
HCFC-241db	**21 ± 2**	**-213 ± 59**	**-45 ± 27**	**-237 ± 65**
HCFC-241dc	**29 ± 3**	**-302 ± 83**	**-63 ± 38**	**-336 ± 92**
HCFC-241ea	**11 ± 1**	**-168 ± 46**	**-35 ± 21**	**-191 ± 51**
HCFC-241eb	**44 ± 5**	**-419 ± 116**	**-88 ± 53**	**-463 ± 127**
HCFC-241fa	**20 ± 2**	**-216 ± 60**	**-45 ± 27**	**-241 ± 65**
HCFC-241fb	**73 ± 8**	**-532 ± 147**	**-111 ± 67**	**-571 ± 162**
HCFC-242aa	**102 ± 12**	**-472 ± 130**	**-99 ± 59**	**-469 ± 144**
HCFC-242ab	**85 ± 10**	**-427 ± 118**	**-89 ± 54**	**-431 ± 130**
HCFC-242ac	**676 ± 78**	**-1258 ± 347**	**-264 ± 158**	**-846 ± 390**
HCFC-242ba	**111 ± 13**	**-356 ± 98**	**-74 ± 45**	**-319 ± 109**
HCFC-242bb	**51 ± 6**	**-323 ± 89**	**-68 ± 41**	**-340 ± 98**
HCFC-242bc	**721 ± 83**	**-1258 ± 347**	**-264 ± 158**	**-801 ± 391**
HCFC-242ca	**58 ± 7**	**-329 ± 91**	**-69 ± 41**	**-340 ± 100**

HCFC-242cb	**1144 ± 132**	**-2210 ± 610**	**-463 ± 278**	**-1530 ± 683**
HCFC-242da	**70 ± 8**	**-295 ± 81**	**-62 ± 37**	**-287 ± 90**
HCFC-242db	**32 ± 4**	**-239 ± 66**	**-50 ± 30**	**-257 ± 73**
HCFC-242dc	**75 ± 9**	**-284 ± 78**	**-59 ± 36**	**-268 ± 87**
HCFC-242dd	**49 ± 6**	**-272 ± 75**	**-57 ± 34**	**-281 ± 83**
HCFC-242ea	**32 ± 4**	**-238 ± 66**	**-50 ± 30**	**-255 ± 72**
HCFC-242eb	**76 ± 9**	**-352 ± 97**	**-74 ± 44**	**-350 ± 107**
HCFC-242ec	**109 ± 13**	**-475 ± 131**	**-99 ± 60**	**-465 ± 145**
HCFC-242fa	**41 ± 5**	**-241 ± 67**	**-51 ± 30**	**-251 ± 73**
HCFC-242fb	**118 ± 14**	**-400 ± 110**	**-84 ± 50**	**-366 ± 122**
HCFC-242fc	**298 ± 34**	**-883 ± 244**	**-185 ± 111**	**-770 ± 270**
HCFC-243aa	**186 ± 21**	**-383 ± 106**	**-80 ± 48**	**-277 ± 118**
HCFC-243ab	**693 ± 80**	**-807 ± 223**	**-169 ± 101**	**-282 ± 257**
HCFC-243ba	**214 ± 25**	**-300 ± 83**	**-63 ± 38**	**-148 ± 94**
HCFC-243bb	**170 ± 20**	**-257 ± 71**	**-54 ± 32**	**-140 ± 80**
HCFC-243bc	1614 ± 186	-790 ± 218	-165 ± 99	659 ± 303
HCFC-243ca	**217 ± 25**	**-270 ± 75**	**-57 ± 34**	**-109 ± 86**
HCFC-243cb	**88 ± 10**	**-256 ± 71**	**-54 ± 32**	**-221 ± 78**
HCFC-243cc	2101 ± 242	-1565 ± 432	-328 ± 197	208 ± 533
HCFC-243da	**129 ± 15**	**-225 ± 62**	**-47 ± 28**	**-143 ± 70**
HCFC-243db	**83 ± 10**	**-201 ± 55**	**-42 ± 25**	**-160 ± 62**
HCFC-243dc	**166 ± 19**	**-228 ± 63**	**-48 ± 29**	**-110 ± 72**
HCFC-243ea	**109 ± 13**	**-207 ± 57**	**-43 ± 26**	**-141 ± 64**
HCFC-243eb	**52 ± 6**	**-206 ± 57**	**-43 ± 26**	**-197 ± 63**
HCFC-243ec	**123 ± 14**	**-212 ± 59**	**-44 ± 27**	**-133 ± 66**
HCFC-243ed	**175 ± 20**	**-304 ± 84**	**-64 ± 38**	**-192 ± 94**
HCFC-243fa	**40 ± 5**	**-187 ± 52**	**-39 ± 23**	**-186 ± 57**
HCFC-243fb	**209 ± 24**	**-237 ± 66**	**-50 ± 30**	**-78 ± 76**
HCFC-243fc	**538 ± 62**	**-551 ± 152**	**-115 ± 69**	**-128 ± 178**
HCFC-244ba	388 ± 45	-152 ± 42	-32 ± 19	204 ± 64
HCFC-244bb	1731 ± 199	-296 ± 82	-62 ± 37	1372 ± 219
HCFC-244ca	485 ± 56	-168 ± 46	-35 ± 21	282 ± 76
HCFC-244cb	317 ± 36	-136 ± 37	-28 ± 17	153 ± 55
HCFC-244cc	3533 ± 407	-457 ± 126	-96 ± 57	2981 ± 430
HCFC-244da	315 ± 36	-134 ± 37	-28 ± 17	153 ± 54
HCFC-244db	180 ± 21	-112 ± 31	-23 ± 14	44 ± 40
HCFC-244ea	205 ± 24	-112 ± 31	-23 ± 14	69 ± 41
HCFC-244eb	140 ± 16	-106 ± 29	-22 ± 13	12 ± 36

HCFC-244ec	288 ± 33	-119 ± 33	-25 ± 15	144 ± 49
HCFC-244fa	201 ± 23	-112 ± 31	-23 ± 14	65 ± 41
HCFC-244fb	968 ± 111	-185 ± 51	-39 ± 23	744 ± 125
HCFC-251aa	**38 ± 4**	**-394 ± 109**	**-83 ± 50**	**-439 ± 120**
HCFC-251ab	**77 ± 9**	**-465 ± 128**	**-97 ± 59**	**-486 ± 141**
HCFC-251ba	**52 ± 6**	**-330 ± 91**	**-69 ± 41**	**-347 ± 100**
HCFC-251bb	**46 ± 5**	**-355 ± 98**	**-74 ± 45**	**-383 ± 108**
HCFC-251da	**23 ± 3**	**-251 ± 69**	**-53 ± 32**	**-281 ± 76**
HCFC-251db	**10 ± 1**	**-148 ± 41**	**-31 ± 19**	**-168 ± 45**
HCFC-251dc	**26 ± 3**	**-188 ± 52**	**-39 ± 24**	**-202 ± 57**
HCFC-251ea	**15 ± 2**	**-173 ± 48**	**-36 ± 22**	**-194 ± 52**
HCFC-251eb	**37 ± 4**	**-248 ± 68**	**-52 ± 31**	**-262 ± 75**
HCFC-251fa	**10 ± 1**	**-120 ± 33**	**-25 ± 15**	**-136 ± 37**
HCFC-251fb	**19 ± 2**	**-165 ± 46**	**-35 ± 21**	**-180 ± 50**
HCFC-251fc	**27 ± 3**	**-237 ± 65**	**-50 ± 30**	**-259 ± 72**
HCFC-252aa	**88 ± 10**	**-335 ± 93**	**-70 ± 42**	**-317 ± 102**
HCFC-252ab	**302 ± 35**	**-564 ± 156**	**-118 ± 71**	**-380 ± 175**
HCFC-252ba	**97 ± 11**	**-268 ± 74**	**-56 ± 34**	**-227 ± 82**
HCFC-252bb	**190 ± 22**	**-302 ± 83**	**-63 ± 38**	**-175 ± 94**
HCFC-252ca	**139 ± 16**	**-281 ± 78**	**-59 ± 35**	**-201 ± 87**
HCFC-252cb	**80 ± 9**	**-261 ± 72**	**-55 ± 33**	**-236 ± 80**
HCFC-252da	**41 ± 5**	**-201 ± 55**	**-42 ± 25**	**-202 ± 61**
HCFC-252db	**52 ± 6**	**-210 ± 58**	**-44 ± 26**	**-201 ± 64**
HCFC-252dc	**53 ± 6**	**-186 ± 51**	**-39 ± 23**	**-172 ± 57**
HCFC-252ea	**52 ± 6**	**-201 ± 55**	**-42 ± 25**	**-191 ± 61**
HCFC-252eb	**27 ± 3**	**-174 ± 48**	**-36 ± 22**	**-183 ± 53**
HCFC-252ec	**68 ± 8**	**-226 ± 62**	**-47 ± 28**	**-206 ± 69**
HCFC-252fa	**74 ± 8**	**-208 ± 57**	**-43 ± 26**	**-178 ± 64**
HCFC-252fb	**34 ± 4**	**-177 ± 49**	**-37 ± 22**	**-180 ± 54**
HCFC-252fc	**64 ± 7**	**-197 ± 54**	**-41 ± 25**	**-173 ± 60**
HCFC-252fd	**50 ± 6**	**-189 ± 52**	**-40 ± 24**	**-179 ± 58**
HCFC-253ba	235 ± 27	-152 ± 42	-32 ± 19	51 ± 53
HCFC-253bb	717 ± 83	-219 ± 60	-46 ± 28	453 ± 106
HCFC-253ca	287 ± 33	-161 ± 44	-34 ± 20	92 ± 59
HCFC-253cb	322 ± 37	-148 ± 41	-31 ± 19	143 ± 58
HCFC-253da	**99 ± 11**	**-115 ± 32**	**-24 ± 15**	**-40 ± 37**
HCFC-253db	**64 ± 7**	**-102 ± 28**	**-21 ± 13**	**-59 ± 32**
HCFC-253ea	**84 ± 10**	**-111 ± 31**	**-23 ± 14**	**-50 ± 35**

HCFC-253eb	**95 ± 11**	**-112 ± 31**	**-23 ± 14**	**-40 ± 36**
HCFC-253ec	**106 ± 12**	**-104 ± 29**	**-22 ± 13**	**-20 ± 34**
HCFC-253fa	161 ± 19	-118 ± 33	-25 ± 15	19 ± 40
HCFC-253fb	**67 ± 8**	**-103 ± 28**	**-21 ± 13**	**-57 ± 32**
HCFC-253fc	147 ± 17	-112 ± 31	-23 ± 14	12 ± 38
HCFC-261aa	**39 ± 4**	**-284 ± 79**	**-60 ± 36**	**-305 ± 86**
HCFC-261ba	**92 ± 11**	**-306 ± 84**	**-64 ± 38**	**-278 ± 93**
HCFC-261da	**8 ± 1**	**-138 ± 38**	**-29 ± 17**	**-159 ± 42**
HCFC-261db	**15 ± 2**	**-142 ± 39**	**-30 ± 18**	**-157 ± 43**
HCFC-261ea	**13 ± 2**	**-164 ± 45**	**-34 ± 21**	**-185 ± 50**
HCFC-261eb	**10 ± 1**	**-94 ± 26**	**-20 ± 12**	**-104 ± 29**
HCFC-261fa	**22 ± 3**	**-175 ± 48**	**-37 ± 22**	**-189 ± 53**
HCFC-261fb	**9 ± 1**	**-101 ± 28**	**-21 ± 13**	**-113 ± 31**
HCFC-261fc	**44 ± 5**	**-188 ± 52**	**-39 ± 24**	**-184 ± 57**
HCFC-262ba	245 ± 28	-173 ± 48	-36 ± 22	35 ± 60
HCFC-262ca	217 ± 25	-168 ± 46	-35 ± 21	13 ± 57
HCFC-262da	**30 ± 3**	**-116 ± 32**	**-24 ± 15**	**-110 ± 35**
HCFC-262db	**31 ± 4**	**-108 ± 30**	**-23 ± 14**	**-99 ± 33**
HCFC-262ea	**32 ± 4**	**-114 ± 31**	**-24 ± 14**	**-105 ± 35**
HCFC-262eb	**39 ± 4**	**-109 ± 30**	**-23 ± 14**	**-93 ± 33**
HCFC-262fa	**41 ± 5**	**-113 ± 31**	**-24 ± 14**	**-95 ± 34**
HCFC-262fb	**51 ± 6**	**-115 ± 32**	**-24 ± 14**	**-88 ± 35**
HCFC-262fc	**119 ± 14**	**-124 ± 34**	**-26 ± 16**	**-31 ± 40**
HCFC-271ba	363 ± 42	-250 ± 69	-52 ± 31	61 ± 87
HCFC-271da	**5 ± 1**	**-57 ± 16**	**-12 ± 7**	**-64 ± 17**
HCFC-271ea	**7 ± 1**	**-62 ± 17**	**-13 ± 8**	**-68 ± 19**
HCFC-271fa	**7 ± 1**	**-70 ± 19**	**-15 ± 9**	**-78 ± 21**
HCFC-271fb	**23 ± 3**	**-102 ± 28**	**-21 ± 13**	**-101 ± 31**
Chlorocarbons and Hydrochlorocarbons				
Methyl chloroform	**169 ± 19**	**-1181 ± 326**	**-247 ± 149**	**-1259 ± 359**
Carbon tetrachloride	**2213 ± 255**	**-6795 ± 1876**	**-1423 ± 855**	**-6005 ± 2077**
Methyl chloride	**6 ± 1**	**-234 ± 65**	**-49 ± 29**	**-277 ± 71**
1,1,1,2 tetrachloroethane	**133 ± 15**	**-1151 ± 318**	**-241 ± 145**	**-1259 ± 350**
Bromocarbons, Hydrobromocarbons and Halons				
Methyl bromide	**2 ± 0**	**-7670 ± 2117**	**-1606 ± 965**	**-9273 ± 2327**
Halon-1201	**388 ± 45**	**-26082 ± 7201**	**-5462 ± 3281**	**-31156 ± 7913**
Halon-1202	**222 ± 26**	**-15846 ± 4375**	**-3318 ± 1994**	**-18942 ± 4808**
Halon-1211	**2052 ± 236**	**-57300 ± 15819**	**-11999 ± 7209**	**-67247 ± 17386**

Halon-1301	**7539 ± 868**	**-116536 ± 32173**	**-24404 ± 14661**	**-133401 ± 35366**
Halon-2401	**205 ± 24**	**-13372 ± 3692**	**-2800 ± 1682**	**-15968 ± 4057**
Halon-2402 isomer	**2450 ± 282**	**-156186 ± 43119**	**-32707 ± 19649**	**-186443 ± 47386**
Halon-2402	**2334 ± 269**	**-121901 ± 33654**	**-25527 ± 15336**	**-145095 ± 36984**
Halogenated Ethers				
HCFE-235ca2 (enflurane)	655 ± 75	-98 ± 27	-21 ± 12	536 ± 81
HCFE-235da2 (isoflurane)	545 ± 63	-129 ± 36	-27 ± 16	389 ± 74
2-chloro-1,1,2-trifluoro-1-methoxyethane	167 ± 19	-90 ± 25	-19 ± 11	58 ± 33

References

Meinshausen, M., Vogel, E., Nauels, A., Lorbacher, K., Meinshausen, N., Etheridge, D. M., Fraser, P. J., Montzka, S. A., Rayner, P. J., Trudinger, C. M., Krummel, P. B., Beyerle, U., Canadell, J. G., Daniel, J. S., Enting, I. G., Law, R. M., Lunder, C. R., O'Doherty, S., Prinn, R. G., Reimann, S., Rubino, M., Velders, G. J. M., Vollmer, M. K., Wang, R. H. J., and Weiss, R.: Historical greenhouse gas concentrations for climate modelling (CMIP6), Geosci Model Dev, 10, https://doi.org/10.5194/gmd-10-2057-2017, 2017.

Volk, C. M., Elkins, J. W., Fahey, D. W., Dutton, G. S., Gilligan, J. M., Loewenstein, M., Podolske, J. R., Chan, K. R., and Gunson, M. R.: Evaluation of source gas lifetimes from stratospheric observations, Journal of Geophysical Research Atmospheres, 102, 25543–25564, https://doi.org/10.1029/97JD02215, 1997.

WMO: Scientific Assessment of Ozone Depletion: 2022, GAW Report No. 278, Geneva, 509 pp., 2022.