Chapter 6 Supplemental Tables 1-4 and Photocomp 2008 Instructions

Table 6S-1. Chemical Species in CCMs (1=AMTRAC3; 2=CAM3.5; 3=CCSRNIES; 4=CMAM; 5=CNRM-ACM; 6=E39CA; 7=EMAC; 8=GEOSCCM; 9=LMDZrepro; 10=MRI; 11=NIWA-SOCOL; 12=SOCOL; 13=ULAQ; 14=UMETRAC; 15=UMSLIMCAT; 16=UMUKCA-METO; 17=UMUKCA-UCAM; 18=WACCM; 19= PSS model).

#		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	$O(^3P)$	Y	Y	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2	$O(^1D)$	Y	Y	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3	O_3	Y	Y	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
4	O_2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5	H	Y	N	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
6	OH	Y	Y	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
7	HO_2	Y	Y	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
8	H_2	N	Y	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
9	H_2O_2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
10	N	Y	Y	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
11	NO	Y	Y	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
12	NO_2	Y	Y	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
13	NO_3	Y	Y	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
14	N_2O_5	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
15	HONO	Y	N	N	N	N	Y	Y	N	N	N	N	N	N	Y	N	N	N	N	Y
16	HNO_3	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
17	HO_2NO_2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
18	Cl	Y	Y	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
19	ClO	Y	Y	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
20	Cl_2	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	N	N	N	Y	Y
21	OClO	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	Y
22	Cl_2O_2	Y	Y	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
23	HCl	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
24	HOCl	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

#		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
25	$ClONO_2$	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
26	Br	Y	Y	Y	Y	Y	Y*	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
27	BrO	Y	Y	Y	Y	Y	Y*	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
28	HOBr	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
29	HBr	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
30	$BrONO_2$	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
31	BrCl	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
32	Br_2	N	N	Y	N	N	Y*	N	N	N	N	N	N	N	N	N	N	N	N	Y
33	CH_4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
34	CH_3O_2	Y	Y	Y	Y	Y	Y	Y	Y*	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
35	CH_3OOH	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
36	CH_2O	Y	Y	Y	Y	Y	Y	Y	Y*	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
37	CO	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
38	H_2O	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
39	N_2O	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
40	CO_2	N	N	N	a	N	Y	Y	N	N	Y	Y	Y	Y	N	Y	Y	Y	Y	N
41	C_2H_6	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N	Y
42	CH_3Cl	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	Y	N
43	CFC-11	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N
44	CFC-12	N	Y	Y	Y	Y	Y	Y	Y	Y*	Y	Y	Y	Y	N	Y	Y	Y	Y	N
45	CFC-113	N	Y	Y	N	Y	N	*	Y	Y	N	Y	Y	Y	N	N	N	N	Y	N
46	HCFC-22	N	Y	Y	Y	Y	N	*	Y	Y	N	Y	Y	Y	N	N	N	N	Y	N
47	HCFC141b	N	a	N	N	N	N	*	a	a	N	Y	Y	a	N	N	N	N	a	N
48	HCFC142b	N	b	N	N	N	N	*	a	b	N	Y	Y	b	N	N	N	N	b	N
49	CCl_4	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	Y	N
50	CH_3CCl_3	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	N	N	N	Y	N
51	H-1202	N	c	N	N	N	N	N	N	c	N	N	N	c	N	N	N	N	c	N

#		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
52	H-1211	N	Y	Y	N	Y	N	Y	b	Y	Y	Y	Y	Y	N	N	N	N	Y	N
53	H-1301	N	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	Y	N
54	H-2402	N	d	N	N	N	N	N	b	d	N	Y	Y	d	N	N	N	N	d	N
55	CH_3Br	N	Y	Y	Y	Y	Y*	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N
56	NMHCs	N	e	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N	N

Notes:

Y = this species is explicitly derived. (O_2 specified as a constant volume mixing ratio).

N = this species is not explicitly derived.

NMHCs = the chemical mechanism includes a detailed representation of Non-Methane Hydrocarbons.

Notes specific to each model:

1: The halogen source molecules are parameterized to give realistic Cly and Bry.

2a-d: These species are not explicitly derived in CAM3.5. The time-dependent VMR lower boundary conditions for these species are added to surrogates with similar chemical lifetimes.

2e: CAM3.5 has a reduced NMHC mechanism for better representation of tropospheric chemistry.

3: The CCSRNIES model includes $CHBr_3$ with a constant surface mixing ratio of 1.8 pptv.

4a: For CMAM, photolysis of CO_2 is included (yielding CO + $O(^3P)$) though the concentration of CO_2 is globally constant.

5: CNRM-ACM also includes $ClNO_2$ species.

6*: E39CA uses parameterization of bromine-catalyzed ozone loss (Appendix in Stenke *et al*., 2009).

7*: Lumped into CFC-12 using weighting by amount of chlorine atoms.

8: GEOSCCM variables denoted by Y* are inferred from transported chemical families. CO_2, and H_2 are specified in the model.

8a: The surface boundary conditions of HCFC141b and HCFC142b are combined into one species defined as HCFC142b + 2*HCFC141b to account for total chlorine atoms involved.

8b: The surface boundary conditions of H-1211 and H-2402 are combined into one species defined as H-1211 + 2*H-2402 to account for the total bromine atoms involved.

9*: CFC-114 and CFC-115 are lumped into CFC-12 using weighting by number of chlorine atoms.

9a: Lumped into CH_3CCl_3 using weighting by number of chlorine atoms.

9b: Lumped into HCFC-22 using weighting by number of chlorine atoms.

9c: Lumped into CH_3Br using weighting by number of bromine atoms.

9d: Lumped into H-1301 using weighting by number of bromine atoms.

12: In the CCMVal SOCOL runs chlorine source gases were lumped in CFC-11 and CFC-12 (based on lifetimes) and bromine source gases lumped into CH_3Br.

13: NMHC chemistry is included in ULAQ with a limited number of species (6), using lumping technique.

15-17: In the CCMVal UMSLIMCAT and UMUKCA runs chlorine source gases were lumped in CFC-11 and CFC-12 (based on lifetimes) and bromine source gases lumped into CH_3Br.

18a-d: These species are not explicitly derived in WACCM. The time-dependent VMR lower boundary conditions for these species are added to surrogates with similar chemical lifetimes.

19: The PSS model also includes: $ClNO_2$, ClONO, ClOO, HOONO; $ClNO_2$ is produced by N_2O_5+HCl(het) & Cl+NO_2; ClONO is also produced by Cl+NO_2 and $ClONO_2$ photolysis; ClOO is produced by ClO+ClO; HOONO is produced by NO_2+OH. In this model, Cl_y, NO_y, and Br_y are specified, rather than being produced from the organic source gases and N_2O. C_2H_6 from tracer relations, with the focus on its production of HOx radicals and HCl, via reaction with OH and Cl, respectively.

Table 6S-2. Gas-phase Reactions in CCMs (1=AMTRAC3; 2=CAM3.5; 3=CCSRNIES; 4=CMAM; 5=CNRM-ACM; 6=E39CA; 7=EMAC; 8=GEOSCCM; 9=LMDZrepro; 10=MRI; 11=NIWA-SOCOL; 12=SOCOL; 13=ULAQ; 14=UMETRAC; 15=UMSLIMCAT; 16=UMUKCA-METO; 17=UMUKCA-UCAM; 18=WACCM; 19= PSS model).

#	Reactions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Oxygen Reactions																			
1	$O + O_2 + M$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
2	$O + O_3$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
3	$O + O + M$	N	N	J6	J6	N	N	N	J2	J6	J6	J6	J6	J6	N	J6	N	N	J6	J6
4	$O(^1D) + N_2$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
5	$O(^1D) + O_2$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
6	$O(^1D) + O_3$	N	J6	J6	J6	J6	J2	J2	J2	N	N	J6	J6	J6	N	J6	J6	I4	J6	J6
7	$O(^1D) + H_2O$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
8	$O(^1D) + N_2O$ (NO)	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	J2	J6	N
9	$O(^1D) + N_2O$ (N_2)	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	J2	J6	N
10	$O(^1D) + CH_4$ (tot)	J6	J6	J6	J6	J6	J2	J2	J2	J6	N	J6	J6	J6	J2	J6	J6	I4	J6	J6
11	$O(^1D) + H_2$	N	J6	J6	J6	J6	J2	J2	J2	N	J6	J6	J6	J6	N	J6	J6	I4	J6	J6
12	$O(^1D) + HCl$	N	J6	N	N	J6	N	N	N	N	N	J6	J6	N	N	N	J6	I4	J6	N
13	$O(^1D) + HBr$	N	N	J6	N	J6	N	N	N	J6	N	J6	J6	N	N	J6	J6	J2	J6	J6
14	$O(^1D) + CFC\text{-}11$	N	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	N	J6	J6	J2	J6	N
15	$O(^1D) + CFC\text{-}12$	N	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	N	J6	J6	J2	J6	N
16	$O(^1D) + CFC\text{-}113$	N	J6	J6	N	J6	N	N	J2	J6	N	J6	J6	J6	N	N	N	N	J6	N
17	$O(^1D) + CFC\text{-}114$	N	N	N	N	N	N	N	J2	N	N	J6	J6	J6	N	N	N	N	J6	N
18	$O(^1D) + CFC\text{-}115$	N	N	N	N	N	N	N	J2	N	N	J6	J6	J6	N	N	N	N	J6	N
19	$O(^1D) + HCFC22$	N	J6	J6	J6	J6	N	N	N	J6	N	J6	J6	J6	N	N	N	N	J6	N
20	$O(^1D) + HCFC\text{-}141b$	N	N	N	N	N	N	N	N	N	N	J6	J6	N	N	N	N	N	N	N
21	$O(^1D) + HCFC\text{-}142b$	N	N	N	N	N	N	N	N	N	N	J6	J6	N	N	N	N	N	N	N
22	$O(^1D) + CCl_4$	N	N	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	N	N	N	N	J6	N
23	$O(^1D) + CH_3Br$	N	N	J6	J6	J6	N	N	J2	J6	J6	J6	J6	J6	N	N	J6	J2	J6	N

#	Reactions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
24	$O(^1D) + H\text{-}1211$	N	N	J6	N	J6	N	N	J2	J6	J6	J6	J6	J6	N	N	N	N	J6	N
25	$O(^1D) + H\text{-}1301$	N	N	J6	N	J6	N	N	J2	J6	J6	J6	J6	J6	N	N	N	N	J6	N
26	$O(^1D) + H\text{-}1202$	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	Nitrogen Radicals																			
27	$H + NO_2$	N	N	N	J6	J6	N	N	J2	N	N	J6	J6	N	N	N	J6	J2	N	J6
28	$N + O_2$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	J2	J6	J6
29	$N + NO$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	J2	J6	N
30	$N + NO_2$	J6	N	N	N	J6	J2	J2	J2	J6	N	J6	J6	N	J2	N	J6	J2	J6	N
31	$N + O_3$	N	N	J6	N	J6	N	N	N	N	N	N	N	N	N	J6	N	N	N	N
32	$NO + O + M$	N	N	N	J6	J6	N	N	J2	N	N	J6	J6	N	J2	N	J6	J2	J6	J6
33	$NO + OH + M$ (HONO)	J6	N	N	N	N	J2	J2	N	J6	N	N	N	N	J2	N	N	N	N	J6
34	$NO + HO_2$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	J2	J6	J6
35	$NO + O_3$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
36	$NO_2 + O$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
37	$NO_2 + O + M$	N	N	N	N	J6	N	N	J2	N	N	J6	J6	N	N	N	J6	I4	J6	J6
38	$NO_2 + O_3$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
39	$NO_2 + NO_3 + M$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
40	$N_2O_5 + M$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
41	$NO_2 + OH + M$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
42	$NO_2 + HO_2 + M$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
43	$NO_3 + NO$	J6	J6	N	N	J6	J2	J2	J2	N	N	J6	J6	N	J2	J6	J6	I4	J6	J6
44	$NO_3 + O$	N	N	N	J6	N	N	N	N	N	N	J6	J6	N	N	J6	J6	I4	J6	J6
45	$NO_3 + OH$	N	N	N	N	J6	N	N	N	N	N	J6	J6	N	N	N	J6	J2	J6	J6
46	$NO_3 + HO_2$	N	J6	N	N	N	J2	J2	N	N	N	J6	J6	N	N	N	J6	I4	J6	J6
47	$HONO + OH$	J6	N	N	N	N	J2	J2	N	N	N	N	N	N	J2	N	N	N	N	J6
48	$HO_2NO_2 + OH$	N	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	J2	J6	J6
49	$HO_2NO_2 + M$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6

#	Reactions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
50	$HNO_3 + OH$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	a	I4	J6	J6
	Hydrogen Radicals																			
51	$H + O_2 + M$	J6	N	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	J2	J6	J6
52	$H + O_3$	J6	N	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
53	$H + HO_2$ (OH)	N	N	J6	J6	J6	J2	a	J2	J6	J6	J6	J6	J6	N	J6	J6	J2	J6	J6
54	$H + HO_2$ (H_2O)	N	N	J6	J6	J6	J2	a	J2	J6	J6	N	N	J6	N	J6	J6	J2	J6	J6
55	$H + HO_2$ (H_2)	N	N	J6	J6	J6	J2	a	J2	J6	J6	J6	J6	J6	N	J6	J6	J2	J6	J6
56	$OH + O$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
57	$OH + O_3$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
58	$OH + HO_2$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
59	OH + OH (tot)	J6	J6	J6	J6	J6	N	N	J2	J6	N	J6	J6	J6	J2	J6	J6	J2	J6	J6
60	$OH + OH + M$	J6	J6	N	J6	J6	N	N	J2	N	N	J6	J6	J6	J2	J6	J6	I4	J6	J6
61	$OH + H_2$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
62	$OH + H_2O_2$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
63	$HO_2 + O$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
64	$HO_2 + O_3$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
65	$HO_2 + HO_2$	J6	J6	J6	J6	J6	J2	b	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
66	$H_2O_2 + O$	N	N	N	J6	N	N	N	J2	N	N	J6	J6	N	N	N	J6	I4	J6	J6
	Chlorine Radicals																			
67	$Cl + O_3$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
68	$Cl + H_2$	N	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	N	J6	J6	I4	J6	J6
69	$Cl + H_2O_2$	N	J6	J6	J6	N	J2	J2	J2	N	N	J6	J6	N	N	J6	J6	I4	J6	J6
70	$Cl + HO_2$ (HCl)	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
71	$Cl + HO_2$ (ClO)	N	J6	J6	J6	J6	J2	J2	J2	N	N	J6	J6	J6	N	J6	J6	I4	J6	J6
72	$Cl + CH_2O$	J6	J6	J6	J6	J6	J2	J2	J2	J6	N	J6	J6	J6	J2	J6	J6	I4	J6	J6
73	$Cl + CH_4$	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
74	ClO + O	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6

#	Reactions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
75	ClO + OH (Cl)	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	J2	J6	J6
76	ClO + OH (HCl)	J6	J6	J6	J6	J6	J2	J2	J2	J6	N	J6	J6	J6	N	J6	J6	J2	J6	J6
77	ClO + HO_2	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
78	ClO + NO	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
79	ClO + NO_2 + M	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
80	ClO + ClO (Cl_2)	N	J6	J6	J6	J6	N	N	N	J6	N	J6	J6	J6	N	J6	J6	I4	J6	J6
81	ClO + ClO (ClOO)	J6	J6	N	N	a	N	N	N	N	N	N	N	J6	N	J6	J6	I4	J6	J6
82	ClO + ClO (OClO)	N	J6	J6	N	J6	N	N	N	N	N	N	N	J6	N	J6	J6	I4	J6	J6
83	ClO + ClO + M	N	J6	J6	J6	J6	J2	I5	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
84	OClO + O	N	N	J6	J6	N	N	N	N	N	J6	N	N	N	N	N	J6	I4	N	J6
85	OClO + NO	N	N	J6	J6	N	N	N	N	N	J6	N	N	N	N	N	J6	I4	N	J6
86	OClO + Cl	N	N	J6	J6	N	N	N	N	N	J6	N	N	N	N	N	J6	I4	N	J6
87	Cl_2O_2 + M	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
88	Cl_2O_2 + Cl	N	N	N	N	N	N	N	N	N	N	J6	J6	N	N	J6	J6	I4	N	J6
89	HCl + OH	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
90	HCl + O	N	J6	J6	J6	N	N	N	N	N	N	J6	J6	N	N	N	J6	J2	J6	J6
91	HOCl + O	N	N	J6	J6	J6	N	N	N	J6	J6	J6	J6	N	N	J6	J6	I4	J6	J6
92	HOCl + Cl	N	J6	J6	J6	J6	N	N	N	J6	N	J6	J6	N	N	J6	J6	J2	J6	J6
93	HOCl + OH	N	N	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	N	J6	J6	J2	J6	J6
94	$ClONO_2$ + O	J6	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	J2	J6	J6
95	$ClONO_2$ + OH	N	J6	N	N	N	N	N	J2	N	N	J6	J6	N	N	J6	J6	J2	J6	J6
96	$ClONO_2$ + Cl	N	J6	N	N	N	J2	J2	N	N	N	J6	J6	N	N	J6	J6	J2	J6	J6
	Bromine Radicals																			
97	Br + O_3	J6	J6	J6	J6	J6	*	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
98	Br + HO_2	J6	J6	J6	J6	J6	*	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
99	Br + CH_2O	J6	J6	J6	N	J6	*	J2	J2	J6	N	J6	J6	N	J2	J6	J6	J2	J6	J6
100	BrO + O	J6	J6	J6	J6	J6	*	J2	J2	J6	J6	J6	J6	J6	N	J6	J6	I4	J6	J6
101	BrO + OH	N	J6	J6	J6	J6	*	N	N	N	N	J6	J6	J6	N	J6	J6	I4	J6	J6

#	Reactions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
102	$BrO + HO_2$	J6	J6	J6	J6	J6	*	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	J2	J6	J6
103	$BrO + NO$	J6	J6	J6	J6	J6	*	J2	J2	J6	N	J6	J6	J6	J2	J6	J6	I4	J6	J6
104	$BrO + NO_2 + M$	J6	J6	J6	J6	J6	*	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
105	$BrO + ClO$ ($OClO$)	N	J6	J6	J6	J6	*	J2	J2	J6	J6	J6*	J6*	J6	N	J6	J6	I4	J6	J6
106	$BrO + ClO$ ($ClOO$)	J6	J6	J6	a	b	*	J2	J2	N	J6	J6*	J6*	J6	J2	J6	J6	I4	J6	J6
107	$BrO + ClO$ ($BrCl$)	J6	J6	J6	J6	J6	*	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
108	$BrO + BrO$	N	J6	J6	J6	J6	*	N	J2	N	N	J6	J6	J6	N	J6	J6	J2	J6	J6
109	$BrO+BrO \rightarrow Br_2 + O_2$	N	N	J6	N	c	*	N	N	J6	N	N	N	J6	N	N	N	N	N	J6
110	$Br_2 + OH$	N	N	N	N	N	*	N	N	N	N	N	N	N	N	N	N	N	N	J6
111	$HBr + O$	N	N	J6	N	N	*	N	N	N	N	J6	J6	J6	N	J6	J6	J2	J6	J6
112	$HBr + OH$	J6	J6	J6	J6	J6	*	J2	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
113	$HOBr + O$	J6	N	N	N	J6	*	J2	N	J6	N	J6	J6	J6	J2	J6	N	N	J6	J6
114	BrONO2 + O	N	N	N	N	N	*	N	N	J6	N	N	N	N	N	J6	N	N	J6	J6
	Organic Halogen Reactions																			
115	$CH_3Cl + Cl$	N	J6	N	J6	N	N	N	N	N	N	N	N	N	N	N	N	N	J6	N
116	$CH_3Cl + OH$	N	J6	J6	J6	J6	J2	J2	J2	J6	J6	J6	J6	J6	N	N	N	N	J6	N
117	$CH_3CCl_3 + OH$	N	J6	J6	J6	J6	J2	J2	J2	J6	N	J6	J6	J6	N	N	N	N	J6	N
118	HCFC22 + OH	N	J6	N	J6	J6	N	N	J2	J6	N	J6	J6	J6	N	N	N	N	J6	N
119	$CH_3Br + OH$	N	J6	J6	J6	J6	N	J2	J2	J6	N	J6	J6	J6	N	J6	J6	J2	J6	N
	CH_4 and Derivatives																			
120	$CH_4 + OH$	J6	J6	J6	J6	J6	J2	c	J2	J6	J6	J6	J6	J6	J2	J6	J6	I4	J6	J6
121	$CH_3O_2 + NO$	J6	J6	J6	J6	J6	J2	J2	J2	J6	N	J6	J6	J6	J2	J6	J6	I4	J6	J6
122	$CH_3O_2 + HO_2$	J6	J6	J6	J6	J6	J2	J2	J2	J6	N	J6	J6	J6	J2	J6	J6	I4	J6	J6
123	$CH_3O_2 + ClO$	N	N	J6	J6	J6	J2	J2	N	N	N	N	N	N	N	J6	J6	J2	N	J6
124	$CH_3O_2 + CH_3O_2$	J6	J6	J6	J6	J6	J2	J2	N	J6	N	J6	J6	J6	J2	J6	J6	J2	N	J6
125	$CH_3OOH + OH$	J6	J6	J6	J6	J6	J2	J2	J2	J6	N	J6	J6	J6	J2	J6	J6	I4	J6	J6
126	$CH_2O + NO_3$	N	J6	N	N	J6	J2	J2	N	N	N	J6	J6	N	J2	N	J6	I4	J6	J6

#	Reactions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
127	$CH_2O + OH$	J6	J6	J6	J6	J6	J2	d	J2	J6	N	J6	J6	J6	J2	J6	J6	I4	J6	J6
128	$CH_2O + O$	N	N	J6	J6	J6	N	N	J2	J6	N	J6	J6	J6	N	J6	J6	I4	J6	J6
128	$CO + OH + M (CO_2)$	J6	J6	N	J6	J6	J2	e	J2	J6	N	J6	J6	J6	J2	J6	I4	I4	J6	J6
129	$CO + OH + M (HOCO)$	N	N	N	b	J6	N	N	N	N	N	N	N	N	N	N	N	N	J6	J6
	C_2H_6 chemistry																			
130	C_2H_6+OH	N	N	N	N	N	N	c	N	N	N	N	N	J6	N	N	N	N	N	J6
131	C_2H_6+Cl	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	J6

Notes:

I4 = IUPAC, 2004.
I5 = IUPAC, 2005.
J2 = Chemical Kinetics and Photochemical Data for Use in Atmospheric Studies, Eval#14 (JPL-02).
J6 = Chemical Kinetics and Photochemical Data for Use in Atmospheric Studies, Eval#15 (JPL-06).
N = This reaction is not explicitly represented.

Notes specific to each model:

3: rxn#101: $BrO + OH \rightarrow Br + HO_2$ (98%), $\rightarrow HBr + O_2$ (2%) is assumed.
3: rxn#108: $BrO + BrO \rightarrow 2Br + O_2$ is assumed.
3: The CCSRNIES model includes the reactions $Cl + O_2 + M \rightarrow ClOO + M$, $OClO + OH \rightarrow HOCl + O_2$, $CHBr_3 + OH \rightarrow 3Br +$ products, and $CO + OH \rightarrow H + CO_2$.
4a: JPL-06 but forms $Cl + O_2$
4b: Both channels of $OH + CO$ included, but both yield $CO_2 + H$.
5: "a" produces OClO; "b" produces OClO; "c" produces 2xBr instead of Br_2.
6*: Uses parameterization of bromine-catalyzed ozone loss (Appendix in Stenke *et al.*, 2009).
7a: Hack *et al*. (1978), listed in JPL-02.
7b: Christensen *et al*. (2002), Kircher and Sander (1984).
7c: Atkinson (2003).
7d: Sivakumaran *et al*. (2003).

7e: McCabe *et al*. (2001).

12: The products of 105 and 106 are Cl + Br + O_2.

16a: The OH + HNO_3 reaction rate is amalgamated from JPL-06 and IUPAC (2002).

17: The IUPAC 2004 (I4) reference is used for many of the reactions; however, the rate constants were set in 2002 using the online version of IUPAC.

Table 6S-3. Photolytic Reactions in CCMs (1=AMTRAC3; 2=CAM3.5; 3=CCSRNIES; 4=CMAM; 5=CNRM-ACM; 6=E39CA; 7=EMAC; 8=GEOSCCM; 9=LMDZrepro; 10=MRI; 11=NIWA-SOCOL; 12=SOCOL; 13=ULAQ; 14=UMETRAC; 15=UMSLIMCAT; 16=UMUKCA-METO; 17=UMUKCA-UCAM; 18=WACCM; 19= PSS model).

#	Reaction	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	O_2 + hν (O^1D)	N	N	N	N	N	N	N	J2	N	N	La	La	N	N	N	J	J	J6	N
2	O_2 + hν (O^3P)	J6	J6	J6	J6	J6	a	a	J2	J6	J6	Af	Af	J6	Y	Mi	J	J	J6	J6
3	1.0 O_3 + hν (O^1D)	J6	J6	J0	J6	J6	b	b	J2	J6	J6	J0	J0	J6	Y	J2	J	J	J6	J6
4	O_3 + hν (O^3P)	J6	J6	J0	J6	J6	b	b	J2	J6	J6	J0	J0	J6	Y	J2	J	J	J6	J6
5	N_2O + hν	J6	J6	J6	J6	J6	J7	J7	J2	J6	J6	J2	J2	J6	Y	J0	J	J	J6	N
6	NO + hν	J6	Mi	Af	Mi	J6	c	c	J2	J6	J6	Ni	Ni	J6	Y	Mi	J	J	Mi	J6
7	NO_2 + hν	J6	J6	J2	J6	J6	J7	J7	J2	J6	J6	J2	J2	J6	Y	J0	J	J	J6	J6
8	N_2O_5 + hν (NO)	N	N	N	N	A	N	N	N	N	N	N	N	N	N	N	N	N	J6	N
9	N_2O_5 + hν (NO_2)	J6	J6	J2	J6	A	J7	J7	J2	J6	J6	J6	J6	J6	Y	J0	J	J	J6	J6
10	HONO + hν	J6	N	N	N	N	J7	J7	N	J6	N	N	N	N	Y	N	N	N	N	J6
11	HNO_3 + hν	J6	J6	J6	J6	J6	J7	J7	J2	J6	J6	J6	J6	J6	Y	J0	J	J	J6	J6
12	NO_3 + hν (NO)	J6	J6	J2	J6	J6	J7	J7	J2	J6	J6	J2	J2	J6	Y	J0	J	J	J6	J6
13	NO_3 + hν (NO_2)	J6	J6	J2	J6	J6	J7	J7	J2	J6	J6	J2	J2	J6	Y	J0	J	J	J6	J6
14	HO_2NO_2 + hν (NO_2)	J6	a	J2	J6	J6	d	d	J2	J6	J6	J6	J6	J6	Y	J0	J	J	a	J6
15	HO_2NO_2 + hν (NO_3)	N	a	J2	N	J6	N	N	N	N	N	N	N	N	N	N	J	J	a	J6
16	CH_3OOH + hν	J6	J6	J6	J6	J6	J7	J7	J2	J6	N	J6	J6	J6	Y	J0	J	J	J6	J6
17	CH_2O + hν (H)	J6	J6	J2	J6	J6	J7	J7	J2	J6	N	J2	J2	J6	Y	J0	J	J	J6	J6
18	CH_2O + hν (H_2)	J6	J6	J2	J6	J6	J7	J7	J2	J6	N	J2	J2	J6	Y	J0	J	J	J6	J6
19	H_2O + hν	J6	N	a	J	J6	J7	J7	J2	J6	J6	La	La	J6	Y	J	J	J	b	J6
20	HO_2 + hν	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	J6
21	H_2O_2 + hν	J6	J6	J6	J6	J6	J7	J7	J2	J6	J6	J2	J2	J6	Y	J0	J	J	J6	J6
22	Cl_2 + hν	Y	J6	J2	J6	J6	J7	J7	N	J6	J6	J6	J6	N	N	N	N	N	J6	J6
23	ClO + hν	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	J6	J6

24	$OClO + h\nu$	N	J6	J2	J6	J6	e	e	J2	J6	J6	N	N	N	N	J	J	J	J6	J6
25	$Cl_2O_2 + h\nu$	J6	b	J6	J6	J6	f	f	J2	J6	J6	J6	J6	a	Y	a	a	a	c	J6
26	$HOCl + h\nu$	J6	J6	J2	J6	J6	J7	J7	J2	J6	J6	J6	J6	J6	Y	J0	J	J	J6	J6
27	2.0 $HCl + h\nu$	J6	J6	J2	J6	J6	J7	J7	J2	J6	J6	J6	J6	J6	N	J0	J	J	J6	J6
28	$ClONO_2 + h\nu$ ClONO)	N	J6	J6	N	B	N	N	N	J6	N	N	N	N	N	N	N	N	J6	J6
29	$ClONO_2 + h\nu$ (NO_3)	J6	J6	J6	J6	J6	J7	J7	J2	J6	J6	J6	J6	J6	Y	J0	J	J	J6	J6
30	$BrCl + h\nu$	J6	J6	J6	J6	J6	N	J7	N	J6	J6	J6	J6	N	Y	J0	J	J	J6	J6
31	$BrO + h\nu$	J6	J6	J2	J6	J6	N	N	J2	J6	N	J6	J6	J6	Y	J0	J	J	J6	J6
32	$HOBr + h\nu$	J6	J6	J2	J6	J6	N	J2	J2	J6	J6	J6	J6	J6	Y	J0	J	J	J6	J6
33	$HBr + h\nu$	N	N	b	J6	N	N	N	N	N	N	N	N	N	N	N	N	N	N	J6
34	$Br_2 + h\nu$	N	N	J6	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	J6
35	$BrONO_2 + h\nu$ (NO_2)	N	J6	J2	N	N	N	N	J2	N	J6	J6	J6	N	N	N	J	J	J6	J6
36	$BrONO_2 + h\nu$ (NO_3)	J6	J6	J2	J6	J6	N	J7	N	J6	J6	J6	J6	J6	Y	J0	J	J	J6	J6
37	$CH_4 + h\nu$	J6	J	N	J	N	N	N	J2	J6	J6	La	La	N	N	J	J	J	J	J6
38	$CO_2 + h\nu$	N	N	N	J	J6	J7	J7	J2	J6	J6	La	La	J6	N	J	J	J	J	N
39	$CH_3Cl + h\nu$	N	J6	J0	J6	J6	J7	J7	J2	J6	J6	I5	I5	J6	N	N	N	N	J6	N
40	$CCl_4 + h\nu$	N	J6	J0	J6	J6	J7	J7	J2	J6	J6	I5	I5	J6	N	N	N	N	J6	N
41	$CH_3CCl_3 + h\nu$	N	J6	J0	J6	J6	J7	J7	J2	J6	N	I5	I5	J6	N	N	N	N	J6	N
42	CFC-11 + hν	N	J6	J0	J6	J6	J7	J7	J2	J6	J6	I5	I5	J6	N	J0	J	J	J6	N
43	CFC-12 + hν	N	J6	J0	J6	J6	J7	J7	J2	J6	J6	J2	J2	J6	N	J0	J	J	J6	N
44	CFC-113 + hν	N	J6	J0	N	J6	N	N	J2	J6	N	I5	I5	J6	N	N	N	N	J6	N
45	CFC-114 + hν	N	N	N	N	N	N	N	J2	N	N	I5	I5	J6	N	N	N	N	N	N
46	CFC-115 + hν	N	N	N	N	N	N	N	J2	N	N	I5	I5	J6	N	N	N	N	N	N
47	HCFC-22 + hν	N	J6	J6	J6	J6	N	N	J2	J6	N	I5	I5	J6	N	N	N	N	J6	N
48	HCFC-141b + hν	N	N	N	N	N	N	N	N	N	N	I5	I5	N	N	N	N	N	J6	N
49	HCFC-142b + hν	N	N	N	N	N	N	N	N	N	N	I5	I5	N	N	N	N	N	J6	N
50	$CH_3Br + h\nu$	N	J6	J0	J6	J6	N	J7	J2	J6	J6	I4	I4	J6	N	J0	J	J	J6	N
51	H-1202 + hν	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

52	H-1211 + hν	N	J6	J6	N	J6	N	J7	J2	J6	J6	I4	I4	J6	N	N	N	N	J6	N
53	H-1301 + hν	N	J6	J6	N	J6	N	J7	J2	J6	J6	J2	J2	J6	N	N	N	N	J6	N
54	H-2402 + hν	N	N	N	N	N	N	N	N	N	N	I4	I4	N	N	N	N	N	N	N

Notes:

J7 = Chemical Kinetics and Photochemical Data for Use in Atmospheric Studies, Eval#12 (JPL-97).
J0 = Chemical Kinetics and Photochemical Data for Use in Atmospheric Studies, Eval#13 (JPL-00).
J2 = Chemical Kinetics and Photochemical Data for Use in Atmospheric Studies, Eval#14 (JPL-02).
J6 = Chemical Kinetics and Photochemical Data for Use in Atmospheric Studies, Eval#15 (JPL-06).
I4 = IUPAC, 2004.
I5 = IUPAC, 2005.

J = Data taken from a variety of sources.
N = This reaction is not explicitly represented.

Notes specific to each model:

1: Cl_2 is photolysed, but lumped with Cl_2O_2.
2a: CAM3.5 does not include the near-IR photolysis of HO_2NO_2.
2b: JCl_2O_2 uses Burkholder *et al*., (1990) [with log-linear extrapolation to 450nm].
2Mi: On-line calculation of J_{NO} using parameterization of Minschwaner and Siskind (1993).

3Af: Allen and Frederick (1982).

3a: Equations (4.98) and (4.99) on p.157, Brasseur and Solomon (1986).

3b: Assumed to be the same values as those for J_{HCl}.

4Mi: On-line calculation of J_{NO} using parameterization of Minschwaner and Siskind (1993).

5a: Produces 2x NO_x according to JPL-06.

5b: Produces $ClO + NO_2$ according to JPL-06.

6a/7a: JPL-97 + Koppers and Murtagh (1996) + Chabrilla and Kockarts (1997).

6b/7b: JPL-97 + Talukdar *et al*. (1998).

6c/7c: Allen and Frederick (1982).

6d/7d: JPL-97 + Roehl *et al*. (2002).

6e/7e: Wahner et al. (1987).

6f/7f: JPL-97, j-value scaled by 1.4 (close to Burkholder *et al*. 1990). See PhotoComp. Some values marked with N can be calculated by the model but are not used.

11Af: Allen and Frederick (1982).

12Af: Allen and Frederick (1982).

12Ni: Nicolet (1979); Nicolet and Cieslik, (1980).

14: The code contains no information on when the rates were last updated, so only existence or not could be established.

15Mi: Minschwaner *et al*. (1993), Minschwaner and Siskind (1993);

15a: Burkholder et al., (1990) [with log-linear extrapolation to 450nm].

16-17: Photolysis in UMUKCA (both versions) is based on an earlier version of the SLIMCAT CTM but the cross sections have not been updated. Exceptions are the photolysis of HO_2NO_2, $ClONO_2$, and $BrONO_2$. Here the cross sections are unchanged but new information on branching ratios has been adopted. Also we have introduced a reaction $O_2 + hv \Rightarrow O(^1D) + O(^3P)$ with a branching ratio following JPL-06. The cross sections and quantum yields for oxygen photolysis follow WMO (1985).

18 For JO_2, the Ly-a and SRB is derived using Chabrillat and Kockarts (1997) and Kopper and Murtagh (1996), respectively.

18a: WACCM does not include the near-IR photolysis of JHO_2NO_2.

18b: JH_2O cross sections are taken from JPL-06, plus Lyman alpha photolysis.

18c: JCl_2O_2 uses Burkholder *et al*., (1990) [with log-linear extrapolation to 450nm].

18Mi: On-line calculation of J_{NO} using parameterization of Minschwaner and Siskind (1993).

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349 **Table 6S-4. Description of models in PhotoComp 2008.**

Label	Model	Method	Bins	Scattering code	SR Bands	Solar Irradiance and CS/QY comments	Low Sun	Cloud (P1c)	Aerosol(P 1b)
AMTR	AMTRAC	LUT from Groves & Tuck 1980	?	?	?	JPL 2002	Spherical solar rays, no refraction.		
CCSR	CCSRNIES	Inline RT	16 [200 – 690nm] + 2 [>690 nm], SR param for O2&NO	Two-stream, plane-parallel	O2: M93 NO: AF82	Sep86+Nov89 from L97	Spherical solar rays, no refraction.		Own aerosol scattering, same tau
EMAC	EMAC	Inline RT (v1.5)	7 [202-682 nm] + Ly-alpha + SR param.	Delta 2-stream (PIFM) + LUT	O_2: KM96 NO: AF82	JPL1997 + updates: $O(^1D)$, HNO4, acetone, OClO, HOBr, …	Extrapolation when SZA 88~94.5º (L03)	OD match PC08, LWC and scattering from EMAC	
GfJX	UCI Fast-JX (v6.2)	Standalone RT	18 [177.4 - 850nm], not contiguous.	8-stream, asymmetric Feautrier, plane-parallel	Redo SR ODFs in UCIr by BP02	JPL 2002, IUPAC 2005 + updates (O^1D, HNO_4, acetone, NO2(JPL O3 from AFGL/Molina. SUSIM solar fluxes (Mar 92+Nov 94)	Spherical solar rays, no refraction.	per PC08	per PC08
Gtbl	GEOSCCM	LUT (p,col-O_3,SZA, λ)	79 [176.215-652.5 nm] +Lyman-alpha	Matrix inversion, isotropic scattering	KM96	JPL 2002	Spherical solar rays with refraction		
LMDZ	LMDZRepro	LUT from TUV 4.1		LUT (p, col-O3, SZA, λ)	See TUV	See TUV 4.1	See TUV	?	?
NIWA	NIWA-SOCOL v2.0	LUT from Mezon CTM	73 total [120-750 nm] with Lyman-alpha	LUT (XO_2 & XO_3)	O_2 and NO: AF82	Mostly JPL 2006 + IUPAC. Solar: CCMVal2 see Lean 2005.	Spherical solar rays, no refraction	OD match PC08, LWC and scattering from S78	

SLIM	UMSLIMCAT	LUT(p,col-O3,SZA, T)	203 total [120-850 nm] with Lyman-alpha	Plane parallel isotropic multiple scattering.	O_2: M93 NO: MS93	JPL 2002. Solar: WMO (1985) for PhotoComp. Lean (2005) for CCMVal runs.	Spherical solar rays, no refraction.		
SOCL	SOCOL v2.0	Inline RT (Mezon CTM)	73 [120-750nm]	Delta-Eddington, plane-parallel	NO & O_2: AF82	Mostly JPL 2006 + IUPAC. Solar: CCMVal2 see Lean 2005.	Spherical solar rays, no refraction		
TUVM	NCAR TUV (v4.6)	Standalone RT	For campaign: fixed bins SR and 8 bins [208-735 nm], with **Lα**	4-stream discrete-ordinates, plane-parallel, St88.	KM96	mostly JPL06 Solar irradiance: SUSIM: λ < 150 nm Atlas 3: 150 ~ 400 nm Neckel and Labs 1984: > 400 nm	Spherical solar rays, no refraction	per PC08	per PC08
UCIJ	UCI Fast-JX (v6.5)	Standalone RT	18 [177.4 - 850nm], not contiguous	8-stream, asymmetric Feautrier, plane-parallel	Redo SR ODFs in UCIr by BP02	JPL 2002, IUPAC 2005 + updates (O^1D, HNO4, acetone, NO2(JPL O3 from AFGL/Molina. SUSIM solar fluxes (Mar 92+Nov 94)	Spherical solar rays, no refraction	per PC08	per PC08
UCIr	UCI ref J-code (2005)	Standalone RT	62 [202-850 nm] +83 ODFs [177-202 nm]	6-stream, symmetric Feautrier, plane-parallel	O_2 & NO ODFs derived from M93 & MS93	JPL 2002, IUPAC 2005, hi-res O3 + updates (O^1D, HNO4, acetone, NO2). SUSIM solar fluxes (Mar 92+Nov 94)	Spherical solar rays, no refraction		
WACC	WACCM	LUT [SZA , ALB, colO_3, temp, press]	100 total [120-750 nm] 33: [120-200 nm] 67: [200-750 nm] with Lα	4-stream discrete-ordinates, St98.	In line: O_2: KM96 NO: MS93	CS and QY: mostly JPL06 Solar irradiance model of Lean *et al*. (2005) interpolated to the 100 bins used in WACCM. A solar average file was used for the photocomp 2008.	Spherical solar rays, no refraction ; SZA ≤ 97º		

Abbreviations:

CS = Cross Sections; **QY**= Quantum yield; **SZA**: Solar zenith angle; **ALB** = surface albedo; **RT**=radiative transfer; **SR** = Schumann-Runge; **Lα** = Lyman-Alpha; **LUT:** Lookup Table, **λ:** wavelength

Abbr. References:

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SPARC CCMVal PhotoComp-2008 *(1 June 2008, MJP)*

GOALS. Evaluate how models calculate photolysis (and indirectly heating) rates in the stratosphere and troposphere with the incentive of locating errors or biases and identifying improved and practical methods. There are three basic parts to PhotoComp2008:

(1) Basic test of ***all*** J- values for high sun (SZA=15º), w/ & w/o additional scattering layers (stratiform clouds & stratospheric volcanic aerosols).

(2) Test of twilight, sphericity, and 24-hour averages (SZA = 84º - 96º).

(3) Test of wavelength integration w/o scattering (SZA = 15º).

There will be one standard atmosphere, whose primary definition will include air mass, ozone mass, and temperature in each layer. This atmosphere is typical of the tropics, ozone column = 260 DU. For efficiency, we will use this same atmosphere in all sections, even the low-sun, polar cases.

PARTICIPATION. This study is designed to aid development and testing of the photolysis and short-wave heating codes used in chemistry-transport models and coupled chemistry-climate models. This project is open: any research group can participate by running the experiments and reporting the results as specified below. We also encourage participation from groups (without CTMs or CCMs) who have participated in other model-measurement studies (e.g., IPMMI, POLARIS). Many CTM/CCMs will be using "the same" photolysis scheme (e.g., fast-TUV, fast-J) and think their participation redundant – this is false. The implementation of a standard scheme into any CTM/CCM will likely alter (intended or inadvertent) how the J-values are calculated: thus it is very important when you perform these tests that the photolysis module that is as close a possible to that embedded within the CTM/CCM and not the original, standalone version that you used to derive your inline model.

EXPERIMENTS.

Part 1 is a basic test of all J-values for high sun (SZA = 15º) over the ocean (albedo = 0.10, Lambertian). **Part 1a**: **Clear sky** (only Rayleigh scattering) and no aerosols. **Part 1b: Pinatubo aerosol** in the stratosphere (layer 10). **Part 1c: Stratus cloud** (layer 2). The primary atmosphere (Table 1a) is specified in terms of pressure layers, mean temperature, and column O_3 in each layer. Please do not include absorption by NO_2 or other species in calculating optical depths. For 1b and 1c we recommend that you use the specified optical properties in Table 1c, interpolating across the 5 specified wavelengths.

Part 2 tests the simulation of a spherical atmosphere and twilight conditions that are critical to the polar regions. Use the same atmosphere as Part 1 without clouds or aerosols. Assume equinox (solar declination = 0º) and a latitude of 84ºN. The surface SZA (not including refraction) varies from 84º (noon) to 96º (midnight). Report all J-values at noon, midnight, and the 24-hour average (integrating as you would in your CTM/CCM). With a spherical atmosphere, the local solar zenith angle changes with altitude and if refraction is included it will change the surface angle. Please note how you treat the solar ray path in your model description.

Part 3 tests the accuracy of wavelength binning in the critical region 290-400 nm that dominates tropospheric photolysis. Shut off all Rayleigh scattering and surface reflection (albedo = 0) giving effectively a simple Beer's Law calculation. Repeat the calculation in Part 1, but report only J-values for J-O3 (i.e., total), J-O3(1d) [$O_3 \Rightarrow O_2 + O(^1D)$], and J-NO2 [$NO_2 \Rightarrow NO + O$]. These are the two critical J-values for the troposphere, and they both have unusual structures in absorption cross section and quantum yields. The organizers will make these calculations using very high resolution (0.05 nm) cross sections and solar fluxes and for different options (e.g., JPL-06 vs. IUPAC cross sections) to provide a benchmark. NOTE that we will only use results below 20 km (L=1:11) for this comparison.

DIAGNOSTICS.

Model Documentation should include a brief outline of the methods and any references (limit: one page). Please include brief notes on: how you treat sphericity and refraction, the Schumann-Runge bands (J-O_2 and J-NO), Rayleigh scattering, multiple scattering, clouds and aerosols, seasonal changes in sun-earth distance, solar variability, and any specific parameterizations. Default cross sections are JPL-2006, please note if you are using alternate.

Report all J-values and all standard model layers since this is a check on all modeled J-values, not just the radiative transfer solution. See Appendix for data formatting. We are not specifying the day-of-the-year, so use solar fluxes for sun-earth distance = 1.0 au and average over the 11-yr solar cycle if possible. UCI's high-resolution solar spectrum used in these experiments is the average of two high and low SUSIM spectra (29 Mar 1992 and 11 Nov 1994), this is not meant to be the 11-yr average. It will be provided at 0.05 nm resolution, but we encourage you to use your own solar fluxes for the primary tests since changing solar fluxes will mostly likely require a complete re-averaging of all cross-sections (see Fast-J paper, Wild, Zhu, Prather, 2000). Please report in model documentation what you are using for the solar spectrum and how the solar cycle is represented in your submissions, and if possible submit it as a separate file so that it may be used to address differences later. (With different wavelength binning, this will not be trivial.) Reported photolysis rates should be calculated for the mass mid-point of each layer, this brings PhotoComp closer to current

CTM usage rather than the original grid-point formulation used in M&M. Results in the form of clearly labeled ascii text files should be sent to the organizers (see web posting for specific details).

DISCUSSION.

Implementation into a particular model's code will up to the participant. For example, at UCI we have two models that we will use in PhotoComp: a fast-JX model within the CTM that uses layers of uniform composition defined by mass (kg/m^2); and a stand-alone photochemical box model that defines altitude (in cm) as the vertical grid and uses number densities for air and ozone. For the latter, we have re-mapped the primary atmosphere (Table 1a) onto a grid-point structure (Table 1b) that has the same mid-layer properties as the layer mean value and the same columns of O_2 and O_3.

One question will be: What is the correct answer? In some cases we may be able to define a "best" answer based on obvious physics or convergence of some of the more resolved models, but in others we may not. Thus in all of our proposed experiments we will begin with a "standard model" result (not necessarily the best answer) from one of the models and then determine a best answer, if possible, after analysis of the results.

One approach to defining the correct answer would be to merge observed radiation fields or photolysis rates (e.g., IPMMI, POLARIS, see references below), but we feel this may be too difficult to match the exact observing conditions. One way to include the knowledge gained by these field studies is to ensure participation from some of the models (e.g., NCAR-TUV, APL).

We do not recommend reporting detailed actinic fluxes as a function of wavelength since everyone selects different ways of integrating over wavelength (e.g., bins) and trying to reconcile the different wavelength scales is not worthwhile. If major problems show up, then a subgroup of models can consider how to resolve the differences.

Another major issue with photolysis and heating rates is the treatment of clouds and cloud fraction. This is very important, but probably beyond the current PhotoComp. It would require a special workshop. We do include an option for a plane-parallel volcanic aerosol layer (aka Pinatubo) and a stratiform cloud.

APPENDIX

Standard Atmosphere & Other Specifications

Table 1a. PhotoComp 2008 standard atmosphere

L	edge p(hPa)	T	O3(mass/mass)	DU(**redundant)
1	1000.0	299.9	3.844E-08	2.4532
2^^	866.0	289.5	4.704E-08	4.8514
3	649.4	278.8	4.720E-08	3.6498
4	487.0	267.2	4.972E-08	2.8831
5	365.2	253.9	5.551E-08	2.4140
6	273.8	239.7	5.977E-08	1.9491
7	205.4	224.6	6.390E-08	1.5627
8	154.0	209.4	9.012E-08	1.6527
9	115.5	198.2	1.486E-07	2.0441
10**	86.60	195.8	3.885E-07	4.0065
11	64.94	203.1	1.533E-06	11.8582
12	48.70	209.9	3.790E-06	21.9783
13	36.52	215.5	6.849E-06	29.7855
14	27.38	220.1	1.034E-05	33.7361
15	20.54	224.5	1.326E-05	32.4219
16	15.40	228.9	1.577E-05	28.9124
17	11.55	233.3	1.653E-05	22.7293
18	8.660	237.8	1.670E-05	17.2239
19	6.494	242.6	1.578E-05	12.2053
20	4.870	248.3	1.363E-05	7.9054
21	3.652	254.1	1.236E-05	5.3734
22	2.738	259.5	9.733E-06	3.1740
23	2.054	262.9	8.158E-06	1.9951
24	1.540	265.1	6.721E-06	1.2325
25	1.155	266.9	5.511E-06	0.7578
26	0.8660	264.7	4.810E-06	0.4960
27	0.6494	261.8	4.009E-06	0.3100
28	0.4870	259.7	3.325E-06	0.1928
29	0.3652	254.3	2.820E-06	0.1226
30	0.2738	247.0	2.323E-06	0.0758
31	0.2054	239.4	1.909E-06	0.0467
32	0.1540	234.4	1.585E-06	0.0291
33	0.1155	232.7	1.335E-06	0.0184
34	0.08660	226.4	1.102E-06	0.0114

35	0.06494	216.4	8.927E-07	0.0069
36	0.04870	210.8	7.372E-07	0.0043
37	0.03652	208.0	6.168E-07	0.0027
38	0.02738	205.2	5.162E-07	0.0017
39	0.02054	202.4	4.317E-07	0.0011
40	0.01540	199.4	3.607E-07	0.00066
41	0.01155	197.6	3.032E-07	0.00042
42	0.00866			

above model top layer=41 @ 0.0866 hPa, assume uniform T & O3

42	0.00866	197.6	3.032E-07	0.00125
43	0.00000			

==========

^^ layer for stratiform cloud: OD (600 nm) = 20.0

** layer for Pinatubo sulfate aerosol: OD(600 nm) = 1.00

see Table 1c.

==========

Table 1b. Standard atmosphere shown mapped into grid points

==========

L	alt(km)	air(#/cm^3)	O3(#/cm^3)	T(K)
1	0.0	2.416E+19	5.611E+11	299.9
2	2.5	1.877E+19	5.335E+11	289.5
3	4.9	1.462E+19	4.169E+11	278.8
4	7.2	1.144E+19	3.436E+11	267.2
5	9.4	9.025E+18	3.027E+11	253.9
6	11.4	7.169E+18	2.589E+11	239.7
7	13.4	5.737E+18	2.215E+11	224.6
8	15.2	4.615E+18	2.513E+11	209.4
9	16.9	3.656E+18	3.283E+11	198.2
10	18.6	2.775E+18	6.514E+11	195.8
11	20.3	2.006E+18	1.858E+12	203.1
12	22.0	1.456E+18	3.334E+12	209.9
13	23.8	1.063E+18	4.399E+12	215.5
14	25.7	7.807E+17	4.879E+12	220.1
15	27.5	5.740E+17	4.598E+12	224.5
16	29.4	4.222E+17	4.022E+12	228.9
17	31.4	3.106E+17	3.102E+12	233.3
18	33.4	2.285E+17	2.306E+12	237.8
19	35.4	1.680E+17	1.602E+12	242.6

20	37.5	1.231E+17	1.014E+12	248.3
21	39.6	9.018E+16	6.732E+11	254.1
22	41.7	6.622E+16	3.894E+11	259.5
23	43.9	4.902E+16	2.416E+11	262.9
24	46.2	3.645E+16	1.480E+11	265.1
25	48.4	2.715E+16	9.039E+10	266.9
26	50.6	2.053E+16	5.966E+10	264.7
27	52.8	1.557E+16	3.771E+10	261.8
28	55.0	1.177E+16	2.364E+10	259.7
29	57.2	9.011E+15	1.535E+10	254.3
30	59.3	6.957E+15	9.766E+09	247.0
31	61.4	5.383E+15	6.210E+09	239.4
32	63.4	4.123E+15	3.949E+09	234.4
33	65.3	3.114E+15	2.512E+09	232.7
34	67.3	2.400E+15	1.597E+09	226.4
35	69.1	1.883E+15	1.016E+09	216.4
36	70.9	1.450E+15	6.458E+08	210.8
37	72.7	1.102E+15	4.107E+08	208.0
38	74.4	8.374E+14	2.612E+08	205.2
39	76.1	6.367E+14	1.661E+08	202.4
40	77.8	4.846E+14	1.056E+08	199.4
41	79.5	3.667E+14	6.717E+07	197.6

==========

above-top extend with 6.3-km scale-height for air & O3

columns:	air(#/cm^2)	O3(#/cm^2)
	2.129E+25	6.985E+18

==========

Table 1c. Scattering properties of Pinatubo and stratus layers

==========

Definitions:

W = wavelength (nm)

Q = scattering efficiency (average of cross-section / (pi * r**2))
typically Q ~ 2 for large clouds and large aerosols
fn of aerosol size distrib N(r), index of refraction, wavelength.

K = extinction (m2/g), the cross-sectional area per gram of material

```
          K(m2/g) = Q / [4/3 * Reff(micron) * Rho(g/cm3)]

      Reff = effective radius (microns)
             = Average[N(r) * r**3] / Average[N(r) * r**2]

      Rho = density of particles (g/cm3)

      n = index of refraction

      OD = optical depth (column) = column mass (g/m2) * K (m2/g)

      SSA = single scattering abledo

      LG(1:8) = coefficients of Legendre expansion of scattering phase fn.
           both polariztions are added.  By definition SLEG(1) = 1.
           Fast-JX uses these first 8 terms to define the scattering.

      g = asymmetry factor = LG(2) / 3.


Pinatubo:  OD = 1.0 in layer 10 (86.6 to 64.9 hPa)
============================================================
  Stratospheric aerosol composed of 75%-wt H2SO4.
  Rho  = 1.630
  n    = 1.514 + 0.000i  (200 nm)
         1.473 + 0.000i  (300 nm)
         1.459 + 0.000i  (400 nm)
         1.448 + 0.000i  (600 nm)
         1.435 + 0.000i  (999 nm)
  Log-normal distribution with R0 = 0.08 micron & sigma = 0.800
    **check that you are using the right log-normal by deriving Reff
  Reff = 0.386 micron

  K (600nm) = 2.610
  OD (@600nm) = 1.00 ==> aerosol = 1.00/K = 0.3832 g/m2

   W     Q     SSA  LG(2) LG(3) LG(4) LG(5) LG(6) LG(7) LG(8)
  200 2.5935 1.0000 2.092 2.914 2.880 3.295 3.185 3.430 3.379
  300 2.6669 1.0000 2.121 2.861 2.792 2.936 2.733 2.703 2.568
  400 2.5588 1.0000 2.144 2.813 2.711 2.695 2.425 2.257 2.069
```

600 2.1893 1.0000 2.149 2.713 2.547 2.362 2.018 1.740 1.499
999 1.4540 1.0000 2.118 2.537 2.277 1.951 1.555 1.229 0.972
(fast-JX v61 scatter #15)

Stratus: OD = 20.0 in layer 2 (866 to 649 hPa)

Pure water cloud
Rho = 1.000
n = 1.335 + 0.000i (assumed 200-999 nm)
Deirmendjian Cumulus C1 (Gamma, n(r) = a r**alpha exp[-b r**gamma])
mode radius Rc = 4 microns, alpha=6, b=3/2, gamma = 1
Reff = 6.00 micron

K (600nm) = 0.2668
OD (@600nm) = 20.0 ==> aerosol = 20.0/K = 75.0 g/m2

W	Q	SSA	LG(2)	LG(3)	LG(4)	LG(5)	LG(6)	LG(7)	LG(8)
200	2.0650	1.0000	2.610	3.998	4.771	5.450	6.196	6.829	7.721
300	2.0835	1.0000	2.596	3.973	4.725	5.406	6.129	6.751	7.607
400	2.1064	1.0000	2.571	3.936	4.660	5.345	6.056	6.670	7.492
600	2.1345	1.0000	2.557	3.902	4.596	5.263	5.923	6.507	7.267
999	2.1922	1.0000	2.499	3.799	4.418	5.081	5.667	6.213	6.851

(fast-JX v61 scatter #08)

Table 2. Standard diagnostics and file names

Ascii tables will be fine given small data sets.
Report J-values at the mid-point of Layers 1 through 40.
File names: PC08_{model name + version if need be}_{PhotoPart#}
Write format: J-title, J-value(1:41) '(a8,1x,41e9.2)'

File Examples:
PC08_UCIref_doc.txt (or .pdf or .doc if need formatting)
UCI old reference code, documentation
PC08_UCI-JX_doc.txt
UCI version of fast-JX, documentation
PC08_UCIref_P1a.txt

PC08_UClref_P1b.txt
PC08_UClref_P1c.txt
UCl-ref results for Part 1 clear, Pinatubo & stratus (see sample below)
PC08_UClref_P2n.txt
PC08_UClref_P2m.txt
PC08_UClref_P2a.txt
UCl-ref results for Part 2 noon, midnight and average
PC08_UClref_P3.txt
UCl-ref results for Part 3 (J-O3(1d) and J-NO2 only).

PC08_UClref_P1.txt
----------file: PC08_UClref_P1a.txt ----------
PhotoComp2008: UCl pratmo P1a '(a8,1x,41e9.2)' ** note that UClref does not calculate L=1(933) but at surface(1000)
pressure 933.** 750. 562. ..... .0237 .0178 .0133 .0100
J-NO 7.02E-31 6.85E-28 7.42E-25 ..... 4.71E-06 4.91E-06 5.10E-06 5.26E-06
J-O2 1.16E-23 6.49E-22 4.67E-20 ..... 4.80E-09 5.57E-09 6.45E-09 7.51E-09
J-O3 4.55E-04 5.09E-04 5.37E-04
J-O3(1D) 4.84E-05 7.00E-05 8.02E-05
J-H2COa 3.08E-05 4.43E-05 5.22E-05
.....
J-Acet-b 4.26E-07 3.94E-07 2.79E-07 .....
==========

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Table 3. Standard J-value names.
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Please use these abbreviations (if possible in the following order) so that J's can be sorted. For new J's please add with unique name. (available as PC08_J-labels.txt)

Note that for some J's, the branching ratios do not have different cross-sections associated with them and the branching ratios are fixed, hence we report only one J.

For many organics, the quantum yields are complex and have been incorporated into
these J's. If you do not calculate one of these, please keep that row in your table with zero or blank values.
==========
1 J-NO NO =N+O
2 J-O2 O2 =O+O
3 J-O3 O3 =O+O2 (total = both O(3P) and O(1D))*
4 J-O3(1d) O3 =O(1D)+O2
5 J-H2COa H2COa =H+HCO
6 J-H2COb H2COb =H2+CO

```
 7  J-H2O2    H2O2   =OH+OH
 8  J-CH3OOH  CH3OOH =CH3O+OH
 9  J-NO2     NO2    =NO+O
10  J-NO3     NO3    =NO+O2(11.4%) & NO2+O(88.6%)*
11  J-N2O5    N2O5   =NO2+NO3
12  J-HNO2    HONO   =OH+NO
13  J-HNO3    HNO3   =OH+NO2
14  J-HNO4    HO2NO2 =OH+NO3
15  J-ClNO3a  ClNO3a =Cl+NO3
16  J-ClNO3b  ClNO3b =ClO+NO2
17  J-Cl2     Cl2    =Cl+Cl
18  J-HOCl    HOCl   =OH+Cl
19  J-OClO    OClO   =O+ClO
20  J-Cl2O2   Cl2O2  =Cl+Cl+O2
21  J-ClO     ClO    =Cl+O
22  J-BrO     BrO    =Br+O
23  J-BrNO3   BrNO3  =Br+NO3(29%) & BrO+NO2(71%)*
24  J-HOBr    HOBr   =OH+Br
25  J-BrCl    BrCl   =Br+Cl
26  J-N2O     N2O    =N2+O
27  J-CFCl3   CFCl3  =...
28  J-CF2Cl2  CF2Cl2 =...
29  J-F113    CF2ClCFCl2=...
30  J-F114    CF2ClCF2Cl=...
31  J-F115    CF3CF2Cl=...
32  J-CCl4    CCl4   =...
33  J-CH3Cl   CH3Cl  =CH3+Cl
34  J-MeCCL3  CH3CCl3=...
35  J-CH2Cl2  CH2Cl2 =...
36  J-CHF2Cl  CHF2Cl =...
37  J-F123    CF3CHCl2=...
38  J-F141b   CH3CFCl2=...
39  J-F142b   CH3CF2Cl=...
40  J-CH3Br   CH3Br  =CH3+Br
41  J-H1211   CF2ClBr=...
42  J-H1301   CF3Br  =...
43  J-H2402   C2F4Br2=...
44  J-CH2Br2  CH2Br2 =...
45  J-CHBr3   CHBr3  =...
46  J-CH3I    CH3I   =CH3+I
```

```
  47  J-CF3I    CF3I   =CF3+I
  48  J-OCS     OCS    =CO+S
  49  J-PAN     CH3C(O)O2NO2 =CH3C(O)O2+NO2(60%) & CH3C(O)O+NO3(40%)*
  50  J-CH3NO3  CH3ONO2=CH3O+NO2
  51  J-ActAld  CH3CHO =CH3+HCO
  52  J-MeVK    CH3C(O)CH=CH2 =C3H6+CO(60%) & CH2=CHCO+CH3(40%)*
  53  J-MeAcr   CH2C(CH3)CHO =CH2=C(CH3)+HCO
  54  J-GlyAld  HOCH2CHO  =HOCH2+HCO
  55  J-MEKeto  CH3COC2H5 =CH3+C2H5CO(15%) & C2H5+CH3CO(85%)*
  56  J-EAld    C2H5CHO =C2H5+HCO
  57  J-MGlyxl  CH3COCHO =CH3CO+HCO
  58  J-Glyxla  (CHO)2 =HCO+HCO
  59  J-Glyxlb  (CHO)2 =H2+CO+CO
  61  J-Acet-a  C3H6O  =CH3CO+CH3
  62  J-Acet-b  C3H6O  =CH3+CH3+CO
=============================================================
* In preliminary comparisons, we have found it best to compare
the total O3 photolysis rate and the rate leading to O(1D),
skipping the O(3P) path.  When branching paths with % are
indicated in the table, they indicate the values derived for
fast-JX, please just report the total J-value.
```