

A total of 81 bimolecular reactions were selected and they are given in Table 1. A total of 18 trimolecular reactions were selected and they are given in Table 2. The low and high pressure limits are combined as described in the 2003 JPL report available online at <http://jpldataeval.jpl.nasa.gov/download.html>. A total of 48 photolysis reactions were selected and they are given in Table 3. A total of 36 heterogeneous reactions were selected and they are given in Table 4.

## References

- [1] D.E. Anderson. The troposphere-stratosphere radiation-field at twilight - A spherical model. *Planet. Space Sci.*, 31(12):1517–1523, 1983.
- [2] G. Becker, J.U. Grooss, D.S. McKenna, and R. Muller. Stratospheric photolysis frequencies: Impact of an improved numerical solution of the radiative transfer equation. *J. Atmos. Chem.*, 37:217–229, 2000.
- [3] D.J. Lary and J.A. Pyle. Diffuse-radiation, twilight, and photochemistry: 1. *J. Atmos. Chem.*, 13(4):373–392, 1991.
- [4] D.J. Lary and J.A. Pyle. Diffuse-radiation, twilight, and photochemistry: 2. *J. Atmos. Chem.*, 13(4):393–406, 1991.
- [5] R.R. Meier, D.E. Anderson, and M. Nicolet. Radiation-field in the troposphere and stratosphere from 240-1000 nm. 1., General-analysis. *Planet. Space Sci.*, 30(9):923–933, 1982.
- [6] M. Nicolet, R.R. Meier, and D.E. Anderson. Radiation-field in the troposphere and stratosphere .2. Numerical-analysis. *Planet. Space Sci.*, 30(9):935–983, 1982.
- [7] W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery. *Numerical Recipes in Fortran - The Art of Scientific Computing*. Cambridge Univ. Press, New York, 2nd edition, 1992.
- [8] WMO. Scientific assessment of stratospheric ozone: 1985. Technical Report 16, Global Ozone Res. and Monitor. Proj., Geneva, Switzerland, 1986.

#	Reactants	Products	Rate coefficient
1	$O(^3P) + O_3$	$\longrightarrow 2 O_2$	$k_1^{bi} = 8.000 \times 10^{-12} e^{-\frac{2060.0}{T}}$
2	$OH + O_3$	$\longrightarrow HO_2 + O_2$	$k_2^{bi} = 1.700 \times 10^{-12} e^{-\frac{940.0}{T}}$
3	$HO_2 + O_3$	$\longrightarrow OH + 2 O_2$	$k_3^{bi} = 1.000 \times 10^{-14} e^{-\frac{490.0}{T}}$
4	$ClO + HO_2$	$\longrightarrow HOCl + O_2$	$k_4^{bi} = 2.700 \times 10^{-12} e^{-\frac{220.0}{T}}$
5	$Cl + H_2O_2$	$\longrightarrow HCl + HO_2$	$k_5^{bi} = 1.100 \times 10^{-11} e^{-\frac{980.0}{T}}$
6	$O(^1D) + N_2$	$\longrightarrow O(^3P) + N_2$	$k_6^{bi} = 1.800 \times 10^{-11} e^{-\frac{110.0}{T}}$
7	$O(^1D) + O_2$	$\longrightarrow O(^3P) + O_2$	$k_7^{bi} = 3.200 \times 10^{-11} e^{-\frac{70.00}{T}}$
8	$NO + O_3$	$\longrightarrow NO_2 + O_2$	$k_8^{bi} = 3.000 \times 10^{-12} e^{-\frac{1500.0}{T}}$
9	$NO_2 + O_3$	$\longrightarrow NO_3 + O_2$	$k_9^{bi} = 1.200 \times 10^{-13} e^{-\frac{2450.0}{T}}$
10	$H + O_3$	$\longrightarrow OH + O_2$	$k_{10}^{bi} = 1.400 \times 10^{-10} e^{-\frac{470.0}{T}}$
11	$OH + ClONO_2$	$\longrightarrow HOCl + NO_3$	$k_{11}^{bi} = 1.200 \times 10^{-12} e^{-\frac{330.0}{T}}$
12	$CH_4 + OH$	$\longrightarrow CH_3 + H_2O$	$k_{12}^{bi} = 2.450 \times 10^{-12} e^{-\frac{1775.0}{T}}$
13	$CH_3O_2 + NO$	$\longrightarrow CH_3O + NO_2$	$k_{13}^{bi} = 2.800 \times 10^{-12} e^{-\frac{300.0}{T}}$
14	$CH_3O + O_2$	$\longrightarrow HCHO + HO_2$	$k_{14}^{bi} = 3.900 \times 10^{-14} e^{-\frac{900.0}{T}}$
15	$HO_2 + HO_2$	$\longrightarrow H_2O_2 + O_2$	$k_{15}^{bi} = 2.300 \times 10^{-13} e^{-\frac{600.0}{T}}$
16	$N + O_2$	$\longrightarrow NO + O(^3P)$	$k_{16}^{bi} = 1.500 \times 10^{-11} e^{-\frac{3600.0}{T}}$
17	$HCHO + O(^3P)$	$\longrightarrow HCO + OH$	$k_{17}^{bi} = 3.400 \times 10^{-11} e^{-\frac{1600.0}{T}}$
18	$CH_3O_2 + HO_2$	$\longrightarrow CH_3OOH + O_2$	$k_{18}^{bi} = 4.100 \times 10^{-13} e^{-\frac{750.0}{T}}$
19	$Cl + H_2$	$\longrightarrow HCl + H$	$k_{19}^{bi} = 3.700 \times 10^{-11} e^{-\frac{2300.0}{T}}$
20	$Cl + O_3$	$\longrightarrow ClO + O_2$	$k_{20}^{bi} = 2.300 \times 10^{-11} e^{-\frac{200.0}{T}}$
21	$ClO + O(^3P)$	$\longrightarrow Cl + O_2$	$k_{21}^{bi} = 3.000 \times 10^{-11} e^{-\frac{70.00}{T}}$
22	$Cl + CH_4$	$\longrightarrow HCl + CH_3$	$k_{22}^{bi} = 9.600 \times 10^{-12} e^{-\frac{1360.0}{T}}$
23	$HCl + OH$	$\longrightarrow Cl + H_2O$	$k_{23}^{bi} = 2.600 \times 10^{-12} e^{-\frac{350.0}{T}}$
24	$ClO + NO$	$\longrightarrow Cl + NO_2$	$k_{24}^{bi} = 6.400 \times 10^{-12} e^{-\frac{290.0}{T}}$
25	$OH + H_2O_2$	$\longrightarrow H_2O + HO_2$	$k_{25}^{bi} = 2.900 \times 10^{-12} e^{-\frac{160.0}{T}}$
26	$H_2 + OH$	$\longrightarrow H_2O + H$	$k_{26}^{bi} = 5.500 \times 10^{-12} e^{-\frac{2000.0}{T}}$
27	$O(^3P) + H_2O_2$	$\longrightarrow OH + HO_2$	$k_{27}^{bi} = 1.400 \times 10^{-12} e^{-\frac{2000.0}{T}}$
28	$O(^3P) + ClONO_2$	$\longrightarrow ClO + NO_3$	$k_{28}^{bi} = 2.900 \times 10^{-12} e^{-\frac{800.0}{T}}$
29	$CO + OH$	$\longrightarrow CO_2 + H$	$k_{29}^{bi} = 1.500 \times 10^{-13}$
30	$HNO_3 + OH$	$\longrightarrow NO_3 + H_2O$	$k_{30}^{bi} = 2.410 \times 10^{-14} e^{-\frac{460.0}{T}}$
31	$NO + HO_2$	$\longrightarrow OH + NO_2$	$k_{31}^{bi} = 3.500 \times 10^{-12} e^{-\frac{250.0}{T}}$
32	$H_2O + O(^1D)$	$\longrightarrow OH + OH$	$k_{32}^{bi} = 2.200 \times 10^{-10}$
33	$OH + HO_2$	$\longrightarrow H_2O + O_2$	$k_{33}^{bi} = 4.800 \times 10^{-11} e^{-\frac{250.0}{T}}$
34	$OH + O(^3P)$	$\longrightarrow H + O_2$	$k_{34}^{bi} = 2.200 \times 10^{-11} e^{-\frac{120.0}{T}}$
35	$HO_2 + O(^3P)$	$\longrightarrow OH + O_2$	$k_{35}^{bi} = 3.000 \times 10^{-11} e^{-\frac{200.0}{T}}$
36	$NO_2 + O(^3P)$	$\longrightarrow NO + O_2$	$k_{36}^{bi} = 5.600 \times 10^{-12} e^{-\frac{180.0}{T}}$
37	$N_2O + O(^1D)$	$\longrightarrow 2 NO$	$k_{37}^{bi} = 6.700 \times 10^{-11}$
38	$N + NO$	$\longrightarrow N_2 + O(^3P)$	$k_{38}^{bi} = 2.100 \times 10^{-11} e^{-\frac{100.0}{T}}$
39	$H_2 + O(^1D)$	$\longrightarrow OH + H$	$k_{39}^{bi} = 1.100 \times 10^{-10}$

Table 1: Bimolecular reactions.

#	Reactants	Products	Rate coefficient
40	CH <sub>4</sub> + O( <sup>1</sup> D)	→ CH <sub>3</sub> + OH	k <sub>40</sub> <sup>bi</sup> = 1.250x10 <sup>-11</sup>
41	HCHO + OH	→ H <sub>2</sub> O + HCO	k <sub>41</sub> <sup>bi</sup> = 9.000x10 <sup>-12</sup>
42	HCO + O <sub>2</sub>	→ CO + HO <sub>2</sub>	k <sub>42</sub> <sup>bi</sup> = 5.200x10 <sup>-12</sup>
43	Cl + HO <sub>2</sub>	→ HCl + O <sub>2</sub>	k <sub>43</sub> <sup>bi</sup> = 1.800x10 <sup>-11</sup> e <sup><math>\frac{170.0}{T}</math></sup>
44	OH + HO <sub>2</sub> NO <sub>2</sub>	→ H <sub>2</sub> O + O <sub>2</sub> + NO <sub>2</sub>	k <sub>44</sub> <sup>bi</sup> = 1.300x10 <sup>-12</sup> e <sup><math>\frac{380.0}{T}</math></sup>
45	CH <sub>4</sub> + O( <sup>1</sup> D)	→ H <sub>2</sub> + HCHO	k <sub>45</sub> <sup>bi</sup> = 7.500x10 <sup>-12</sup>
46	OH + CH <sub>3</sub> OOH	→ H <sub>2</sub> O + CH <sub>3</sub> O <sub>2</sub>	k <sub>46</sub> <sup>bi</sup> = 3.800x10 <sup>-12</sup> e <sup><math>\frac{200.0}{T}</math></sup>
47	OH + OH	→ H <sub>2</sub> O + O( <sup>3</sup> P)	k <sub>47</sub> <sup>bi</sup> = 4.200x10 <sup>-12</sup> e <sup><math>-\frac{240.0}{T}</math></sup>
48	ClO + OH	→ Cl + HO <sub>2</sub>	k <sub>48</sub> <sup>bi</sup> = 7.400x10 <sup>-12</sup> e <sup><math>\frac{270.0}{T}</math></sup>
49	ClO + OH	→ HCl + O <sub>2</sub>	k <sub>49</sub> <sup>bi</sup> = 6.000x10 <sup>-13</sup> e <sup><math>\frac{230.0}{T}</math></sup>
50	HOCl + OH	→ H <sub>2</sub> O + ClO	k <sub>50</sub> <sup>bi</sup> = 3.000x10 <sup>-12</sup> e <sup><math>-\frac{500.0}{T}</math></sup>
51	Cl + HCHO	→ HCl + HCO	k <sub>51</sub> <sup>bi</sup> = 8.100x10 <sup>-11</sup> e <sup><math>-\frac{30.00}{T}</math></sup>
52	HO <sub>2</sub> + HO <sub>2</sub>	→ H <sub>2</sub> O <sub>2</sub> + O <sub>2</sub>	k <sub>52</sub> <sup>bi</sup> = 1.700x10 <sup>-33</sup> e <sup><math>\frac{1000.0}{T}</math></sup>
53	BrO + NO	→ Br + NO <sub>2</sub>	k <sub>53</sub> <sup>bi</sup> = 8.800x10 <sup>-12</sup> e <sup><math>\frac{260.0}{T}</math></sup>
54	Cl + HO <sub>2</sub>	→ OH + ClO	k <sub>54</sub> <sup>bi</sup> = 4.100x10 <sup>-11</sup> e <sup><math>-\frac{450.0}{T}</math></sup>
55	N + OH	→ NO + H	k <sub>55</sub> <sup>bi</sup> = 5.000x10 <sup>-11</sup>
56	Br + HCHO	→ HBr + HCO	k <sub>56</sub> <sup>bi</sup> = 1.700x10 <sup>-11</sup> e <sup><math>-\frac{800.0}{T}</math></sup>
57	H + HO <sub>2</sub>	→ H <sub>2</sub> + O <sub>2</sub>	k <sub>57</sub> <sup>bi</sup> = 6.500x10 <sup>-12</sup>
58	H + HO <sub>2</sub>	→ H <sub>2</sub> O + O( <sup>3</sup> P)	k <sub>58</sub> <sup>bi</sup> = 1.600x10 <sup>-12</sup>
59	H + HO <sub>2</sub>	→ OH + OH	k <sub>59</sub> <sup>bi</sup> = 7.300x10 <sup>-11</sup>
60	NO + NO <sub>3</sub>	→ NO <sub>2</sub> + NO <sub>2</sub>	k <sub>60</sub> <sup>bi</sup> = 1.500x10 <sup>-11</sup> e <sup><math>\frac{170.0}{T}</math></sup>
61	N <sub>2</sub> O + O( <sup>1</sup> D)	→ N <sub>2</sub> + O <sub>2</sub>	k <sub>61</sub> <sup>bi</sup> = 4.900x10 <sup>-11</sup>
62	N <sub>2</sub> O <sub>5</sub> + H <sub>2</sub> O	→ 2 HNO <sub>3</sub>	k <sub>62</sub> <sup>bi</sup> = 2.000x10 <sup>-21</sup>
63	O( <sup>1</sup> D) + CF <sub>2</sub> Cl <sub>2</sub>	→ ClO + Cl	k <sub>63</sub> <sup>bi</sup> = 1.400x10 <sup>-10</sup>
64	N + NO <sub>2</sub>	→ N <sub>2</sub> O + O( <sup>3</sup> P)	k <sub>64</sub> <sup>bi</sup> = 5.800x10 <sup>-12</sup> e <sup><math>\frac{220.0}{T}</math></sup>
65	Br + O <sub>3</sub>	→ BrO + O <sub>2</sub>	k <sub>65</sub> <sup>bi</sup> = 1.700x10 <sup>-11</sup> e <sup><math>-\frac{800.0}{T}</math></sup>
66	Br + HO <sub>2</sub>	→ HBr + O <sub>2</sub>	k <sub>66</sub> <sup>bi</sup> = 1.500x10 <sup>-11</sup> e <sup><math>-\frac{600.0}{T}</math></sup>
67	BrO + BrO	→ 2 Br + O <sub>2</sub>	k <sub>67</sub> <sup>bi</sup> = 1.500x10 <sup>-12</sup> e <sup><math>\frac{230.0}{T}</math></sup>
68	OH + HBr	→ H <sub>2</sub> O + Br	k <sub>68</sub> <sup>bi</sup> = 1.100x10 <sup>-11</sup>
69	CH <sub>3</sub> Br + OH	→ Br	k <sub>69</sub> <sup>bi</sup> = 2.350x10 <sup>-12</sup> e <sup><math>-\frac{1300.0}{T}</math></sup>
70	BrO + ClO	→ Br + OClO	k <sub>70</sub> <sup>bi</sup> = 9.500x10 <sup>-13</sup> e <sup><math>\frac{550.0}{T}</math></sup>
71	BrO + ClO	→ Br + ClOO	k <sub>71</sub> <sup>bi</sup> = 2.300x10 <sup>-12</sup> e <sup><math>\frac{260.0}{T}</math></sup>
72	BrO + ClO	→ BrCl + O <sub>2</sub>	k <sub>72</sub> <sup>bi</sup> = 4.100x10 <sup>-13</sup> e <sup><math>\frac{290.0}{T}</math></sup>
73	BrO + HO <sub>2</sub>	→ HOBr + O <sub>2</sub>	k <sub>73</sub> <sup>bi</sup> = 3.400x10 <sup>-12</sup> e <sup><math>\frac{540.0}{T}</math></sup>
74	BrO + O( <sup>3</sup> P)	→ Br + O <sub>2</sub>	k <sub>74</sub> <sup>bi</sup> = 1.900x10 <sup>-11</sup> e <sup><math>\frac{230.0}{T}</math></sup>
75	CH <sub>4</sub> + O( <sup>1</sup> D)	→ H + CH <sub>3</sub> O	k <sub>75</sub> <sup>bi</sup> = 3.000x10 <sup>-11</sup>
76	O( <sup>1</sup> D) + CH <sub>3</sub> Br	→ Br + CH <sub>3</sub> O	k <sub>76</sub> <sup>bi</sup> = 1.800x10 <sup>-10</sup>
77	O( <sup>1</sup> D) + O <sub>3</sub>	→ O <sub>2</sub> + O <sub>2</sub>	k <sub>77</sub> <sup>bi</sup> = 1.200x10 <sup>-10</sup>
78	O( <sup>1</sup> D) + O <sub>3</sub>	→ $\begin{array}{l} \text{O}_2 + \\ \text{O}(\text{}^3\text{P}) + \\ \text{O}(\text{}^3\text{P}) \end{array}$	k <sub>78</sub> <sup>bi</sup> = 1.200x10 <sup>-10</sup>
79	H + NO <sub>2</sub>	→ OH + NO	k <sub>79</sub> <sup>bi</sup> = 4.000x10 <sup>-10</sup>
80	BrO + CH <sub>3</sub> O <sub>2</sub>	→ O <sub>2</sub> + Br + CH <sub>3</sub> O	k <sub>80</sub> <sup>bi</sup> = 3.230x10 <sup>-11</sup> e <sup><math>-\frac{965.0}{T}</math></sup>
81	ClO + CH <sub>3</sub> O <sub>2</sub>	→ O <sub>2</sub> + Cl + CH <sub>3</sub> O	k <sub>81</sub> <sup>bi</sup> = 3.300x10 <sup>-12</sup> e <sup><math>-\frac{965.0}{T}</math></sup>

Table 1: (continued) Bimolecular reactions.

#	Reactants	Products	Rate coefficient
1	$O(^3P) + O_2 \xrightarrow{M}$	$O_3$	$k_1^o = [M] 6.000 \times 10^{-34} \frac{T}{300.0}^{2.400}$ $f_1^c = 0.6000$
2	$H + O_2 \xrightarrow{M}$	$HO_2$	$k_2^o = [M] 5.700 \times 10^{-32} \frac{T}{300.0}^{1.600}$ $k_2^\infty = 7.500 \times 10^{-11}$ $f_2^c = 0.6000$
3	$OH + OH \xrightarrow{M}$	$H_2O_2$	$k_3^o = [M] 6.900 \times 10^{-31} \frac{T}{300.0}^{1.000}$ $k_3^\infty = 2.600 \times 10^{-11}$ $f_3^c = 0.6000$
4	$OH + NO_2 \xrightarrow{M}$	$HNO_3$	$k_4^o = [M] 2.000 \times 10^{-30} \frac{T}{300.0}^{3.000}$ $k_4^\infty = 2.500 \times 10^{-11}$ $f_4^c = 0.6000$
5	$ClO + NO_2 \xrightarrow{M}$	$ClONO_2$	$k_5^o = [M] 1.800 \times 10^{-31} \frac{T}{300.0}^{3.400}$ $k_5^\infty = 1.500 \times 10^{-11} \frac{T}{300.0}^{1.900}$ $f_5^c = 0.6000$
6	$HO_2 + NO_2 \xrightarrow{M}$	$HO_2NO_2$	$k_6^o = [M] 1.800 \times 10^{-31} \frac{T}{300.0}^{3.200}$ $k_6^\infty = 4.700 \times 10^{-12} \frac{T}{300.0}^{1.400}$ $f_6^c = 0.6000$
7	$NO_2 + O(^3P) \xrightarrow{M}$	$NO_3$	$k_7^o = [M] 2.500 \times 10^{-31} \frac{T}{300.0}^{1.800}$ $k_7^\infty = 2.200 \times 10^{-11} \frac{T}{300.0}^{0.7000}$ $f_7^c = 0.6000$
8	$NO_2 + NO_3 \xrightarrow{M}$	$N_2O_5$	$k_8^o = [M] 2.000 \times 10^{-30} \frac{T}{300.0}^{4.400}$ $k_8^\infty = 1.400 \times 10^{-12} \frac{T}{300.0}^{0.7000}$ $f_8^c = 0.6000$
9	$CH_3 + O_2 \xrightarrow{M}$	$CH_3O_2$	$k_9^o = [M] 4.500 \times 10^{-31} \frac{T}{300.0}^{3.000}$ $k_9^\infty = 1.800 \times 10^{-12} \frac{T}{300.0}^{1.700}$ $f_9^c = 0.6000$
10	$NO + O(^3P) \xrightarrow{M}$	$NO_2$	$k_{10}^o = [M] 9.000 \times 10^{-31} \frac{T}{300.0}^{1.500}$ $k_{10}^\infty = 3.000 \times 10^{-11}$ $f_{10}^c = 0.6000$

Table 2: Trimolecular reactions.

#	Reactants	Products	Rate coefficient
11	$O(^1D) + N_2$	$\xrightarrow{M} N_2O$	$k_{11}^o = [M] 3.500 \times 10^{-37} \frac{T}{300.0}^{0.6000}$ $f_{11}^c = 0.6000$
12	$O(^3P) + O(^3P)$	$\xrightarrow{M} O_2$	$k_{12}^o = [M] 1.400 \times 10^{-33} \frac{T}{300.0}^{-408.0}$ $f_{12}^c = 0.6000$
13	$BrO + NO_2$	$\xrightarrow{M} BrONO_2$	$k_{13}^o = [M] 5.200 \times 10^{-31} \frac{T}{300.0}^{3.200}$ $k_{13}^\infty = 6.900 \times 10^{-12} \frac{T}{300.0}^{2.900}$ $f_{13}^c = 0.6000$
14	$ClO + ClO$	$\xrightarrow{M} Cl_2O_2$	$k_{14}^o = [M] 1.600 \times 10^{-32} \frac{T}{300.0}^{4.500}$ $k_{14}^\infty = 2.000 \times 10^{-12} \frac{T}{300.0}^{2.400}$ $f_{14}^c = 0.6000$
15	$CO + O(^3P)$	$\xrightarrow{M} CO_2$	$k_{15}^o = [M] 2.000 \times 10^{-37}$ $f_{15}^c = 0.6000$
16	$N_2O_5$	$\xrightarrow{M} NO_2 + M + NO_3$	$k_{16}^o = [M] 1.3000E - 03 \frac{T}{300.0}^{-3.500} e^{-\frac{1.1000E+04}{T}}$ $k_{16}^\infty = 9.700 \times 10^{14} \frac{T}{300.0}^{0.1000} e^{-\frac{1.1080E+04}{T}}$ $f_{16}^c = 0.3500$
17	$HO_2NO_2$	$\xrightarrow{M} HO_2 + M + NO_2$	$k_{17}^o = [M] 4.100 \times 10^{-5} e^{-\frac{1.0650E+04}{T}}$ $k_{17}^\infty = 4.800 \times 10^{15} e^{-\frac{1.1170E+04}{T}}$ $f_{17}^c = 0.6000$
18	$Cl_2O_2$	$\xrightarrow{M} ClO + ClO$	$k_{18}^o = [M] 1.000 \times 10^{-6} e^{-\frac{8000}{T}}$ $k_{18}^\infty = 4.800 \times 10^{15} e^{-\frac{8820}{T}}$ $f_{18}^c = 0.6000$

Table 2: (continued) Trimolecular reactions.

#	Reactants	Products
1	$\text{Br}_2 + h\nu$	$\text{Br} + \text{Br}$
2	$\text{BrCl} + h\nu$	$\text{Cl} + \text{Br}$
3	$\text{BrO} + h\nu$	$\text{O}(^3\text{P}) + \text{Br}$
4	$\text{BrO} + h\nu$	$\text{Br} + \text{O}(^1\text{D})$
5	$\text{BrONO} + h\nu$	$\text{Br} + \text{NO}_2$
6	$\text{BrONO}_2 + h\nu$	$\text{NO}_2 + \text{BrO}$
7	$\text{BrONO}_2 + h\nu$	$\text{Br} + \text{NO}_3$
8	$\text{CF}_2\text{Cl}_2 + h\nu$	$\text{Cl} + \text{Cl}$
9	$\text{CH}_3\text{Br} + h\nu$	$\text{Br} + \text{CH}_3$
10	$\text{CH}_4 + h\nu$	$\text{H} + \text{CH}_3$
11	$\text{CO}_2 + h\nu$	$\text{O}(^3\text{P}) + \text{CO}$
12	$\text{CO}_2 + h\nu$	$\text{CO} + \text{O}(^1\text{D})$
13	$\text{Cl}_2 + h\nu$	$\text{Cl} + \text{Cl}$
14	$\text{Cl}_2\text{O}_2 + h\nu$	$\text{Cl} + \text{ClOO}$
15	$\text{ClNO}_2 + h\nu$	$\text{Cl} + \text{NO}_2$
16	$\text{ClO} + h\nu$	$\text{O}(^3\text{P}) + \text{Cl}$
17	$\text{ClONO}_2 + h\nu$	$\text{Cl} + \text{NO}_3$
18	$\text{ClOO} + h\nu$	$\text{O}(^3\text{P}) + \text{ClO}$
19	$\text{H}_2\text{O} + h\nu$	$\text{H} + \text{H} + \text{O}(^3\text{P})$
20	$\text{H}_2\text{O} + h\nu$	$\text{H}_2 + \text{O}(^1\text{D})$
21	$\text{H}_2\text{O} + h\nu$	$\text{H} + \text{OH}$
22	$\text{H}_2\text{O}_2 + h\nu$	$\text{OH} + \text{OH}$
23	$\text{HCHO} + h\nu$	$\text{H}_2 + \text{CO}$
24	$\text{HCHO} + h\nu$	$\text{H} + \text{HCO}$
25	$\text{HCHO} + h\nu$	$\text{H} + \text{H} + \text{CO}$
26	$\text{HCl} + h\nu$	$\text{H} + \text{Cl}$
27	$\text{HO}_2 + h\nu$	$\text{O}(^3\text{P}) + \text{OH}$
28	$\text{HO}_2\text{NO}_2 + h\nu$	$\text{NO}_2 + \text{HO}_2$
29	$\text{HO}_2\text{NO}_2 + h\nu$	$\text{OH} + \text{NO}_3$
30	$\text{HOBr} + h\nu$	$\text{OH} + \text{Br}$
31	$\text{HOCl} + h\nu$	$\text{Cl} + \text{OH}$
32	$\text{HNO}_3 + h\nu$	$\text{OH} + \text{NO}_2$
33	$\text{CH}_3\text{OOH} + h\nu$	$\text{OH} + \text{CH}_3\text{O}$
34	$\text{CH}_3\text{OOH} + h\nu$	$\text{O}(^3\text{P}) + \text{H} + \text{CH}_3\text{O}$
35	$\text{N}_2\text{O} + h\nu$	$\text{N}_2 + \text{O}(^1\text{D})$
36	$\text{N}_2\text{O}_5 + h\nu$	$\text{O}(^3\text{P}) + \text{NO} + \text{NO}_3$
37	$\text{N}_2\text{O}_5 + h\nu$	$\text{NO}_2 + \text{NO}_3$
38	$\text{NO} + h\nu$	$\text{O}(^3\text{P}) + \text{N}$
39	$\text{NO}_2 + h\nu$	$\text{NO} + \text{O}(^1\text{D})$

Table 3: photolysis reactions. A key part of the chemical model is the calculation of photolysis rates. In this study they are calculated using full spherical geometry and multiple scattering [1, 3, 4, 5, 6] corrected after [2]. The photolysis rate used for each time step is obtained by ten point Gaussian-Legendre integration of the photolysis rate over the time step [7]. The photolysis rates are looked up in a photolysis rate tabulation which is updated every day for each latitude band to ensure that the current ozone and temperature profiles are used to calculate the photolysis rates. A total of 203 wavelength intervals are used from 116.7 to 850 nm [8]. Daily solar irradiances are used for each of the 203 wavelength intervals. The surface albedo used for each latitude band is the median albedo observed by TOMS for that month.

#	Reactants	Products
40	$\text{NO}_2 + h\nu \longrightarrow$	$\text{O}({}^3\text{P}) + \text{NO}$
41	$\text{NO}_3 + h\nu \longrightarrow$	$\text{O}({}^3\text{P}) + \text{NO}_2$
42	$\text{NO}_3 + h\nu \longrightarrow$	$\text{O}_2 + \text{NO}$
43	$\text{O}_2 + h\nu \longrightarrow$	$\text{O}({}^3\text{P}) + \text{O}({}^1\text{D})$
44	$\text{O}_2 + h\nu \longrightarrow$	$\text{O}({}^3\text{P}) + \text{O}({}^3\text{P})$
45	$\text{O}_3 + h\nu \longrightarrow$	$\text{O}({}^3\text{P}) + \text{O}_2$
46	$\text{O}_3 + h\nu \longrightarrow$	$\text{O}_2 + \text{O}({}^1\text{D})$
47	$\text{OCIO} + h\nu \longrightarrow$	$\text{O}({}^3\text{P}) + \text{ClO}$
48	$\text{OCIO} + h\nu \longrightarrow$	$\text{ClO} + \text{O}({}^1\text{D})$

Table 3: (continued) photolysis reactions.

#	Reactants	Products	Reaction Probability
1	HCl + ClONO <sub>2</sub>	$\xrightarrow{SA}$ Cl <sub>2</sub> + HNO <sub>3</sub>	
2	HCl + ClONO <sub>2</sub>	$\xrightarrow{NAT}$ Cl <sub>2</sub> + HNO <sub>3</sub>	$\gamma = 0.3000$
3	HCl + ClONO <sub>2</sub>	$\xrightarrow{Ice}$ Cl <sub>2</sub> + HNO <sub>3</sub>	$\gamma = 0.3000$
4	H <sub>2</sub> O + ClONO <sub>2</sub>	$\xrightarrow{SA}$ HOCl + HNO <sub>3</sub>	
5	H <sub>2</sub> O + ClONO <sub>2</sub>	$\xrightarrow{NAT}$ HOCl + HNO <sub>3</sub>	$\gamma = 6.0000E - 03$
6	H <sub>2</sub> O + ClONO <sub>2</sub>	$\xrightarrow{Ice}$ HOCl + HNO <sub>3</sub>	$\gamma = 0.3000$
7	H <sub>2</sub> O + N <sub>2</sub> O <sub>5</sub>	$\xrightarrow{SA}$ HNO <sub>3</sub> + HNO <sub>3</sub>	$\gamma = 0.1000$
8	H <sub>2</sub> O + N <sub>2</sub> O <sub>5</sub>	$\xrightarrow{NAT}$ HNO <sub>3</sub> + HNO <sub>3</sub>	$\gamma = 6.000x10^{-4}$
9	H <sub>2</sub> O + N <sub>2</sub> O <sub>5</sub>	$\xrightarrow{Ice}$ HNO <sub>3</sub> + HNO <sub>3</sub>	$\gamma = 3.0000E - 02$
10	HCl + N <sub>2</sub> O <sub>5</sub>	$\xrightarrow{NAT}$ ClNO <sub>2</sub> + HNO <sub>3</sub>	$\gamma = 3.0000E - 03$
11	HCl + N <sub>2</sub> O <sub>5</sub>	$\xrightarrow{Ice}$ ClNO <sub>2</sub> + HNO <sub>3</sub>	$\gamma = 3.0000E - 02$
12	HCl + HOCl	$\xrightarrow{SA}$ Cl <sub>2</sub> + H <sub>2</sub> O	$\gamma = 0.1000$
13	HCl + HOCl	$\xrightarrow{NAT}$ Cl <sub>2</sub> + H <sub>2</sub> O	$\gamma = 0.1000$
14	HCl + HOCl	$\xrightarrow{Ice}$ Cl <sub>2</sub> + H <sub>2</sub> O	$\gamma = 0.3000$
15	HBr + HOBr	$\xrightarrow{SA}$ Br <sub>2</sub> + H <sub>2</sub> O	$\gamma = 6.0000E - 02$
16	HBr + HOBr	$\xrightarrow{NAT}$ Br <sub>2</sub> + H <sub>2</sub> O	$\gamma = 0.1200$
17	HBr + HOBr	$\xrightarrow{Ice}$ Br <sub>2</sub> + H <sub>2</sub> O	$\gamma = 0.1200$
18	HCl + HOBr	$\xrightarrow{SA}$ BrCl + H <sub>2</sub> O	$\gamma = 0.1000$
19	HCl + HOBr	$\xrightarrow{NAT}$ BrCl + H <sub>2</sub> O	$\gamma = 0.2500$
20	HCl + HOBr	$\xrightarrow{Ice}$ BrCl + H <sub>2</sub> O	$\gamma = 0.2500$
21	HBr + HOCl	$\xrightarrow{SA}$ BrCl + H <sub>2</sub> O	$\gamma = 0.1000$
22	HBr + HOCl	$\xrightarrow{NAT}$ BrCl + H <sub>2</sub> O	$\gamma = 0.1000$
23	HBr + HOCl	$\xrightarrow{Ice}$ BrCl + H <sub>2</sub> O	$\gamma = 0.3000$
24	HBr + ClONO <sub>2</sub>	$\xrightarrow{SA}$ BrCl + HNO <sub>3</sub>	
25	HBr + BrONO <sub>2</sub>	$\xrightarrow{NAT}$ Br <sub>2</sub> + HNO <sub>3</sub>	$\gamma = 0.3000$
26	HBr + BrONO <sub>2</sub>	$\xrightarrow{Ice}$ Br <sub>2</sub> + HNO <sub>3</sub>	$\gamma = 0.3000$
27	HCl + BrONO <sub>2</sub>	$\xrightarrow{SA}$ BrCl + HNO <sub>3</sub>	
28	HCl + BrONO <sub>2</sub>	$\xrightarrow{NAT}$ BrCl + HNO <sub>3</sub>	$\gamma = 0.3000$
29	HCl + BrONO <sub>2</sub>	$\xrightarrow{Ice}$ BrCl + HNO <sub>3</sub>	$\gamma = 0.3000$
30	HBr + ClONO <sub>2</sub>	$\xrightarrow{NAT}$ BrCl + HNO <sub>3</sub>	$\gamma = 0.3000$
31	HBr + ClONO <sub>2</sub>	$\xrightarrow{Ice}$ BrCl + HNO <sub>3</sub>	$\gamma = 0.3000$
32	H <sub>2</sub> O + BrONO <sub>2</sub>	$\xrightarrow{SA}$ HOBr + HNO <sub>3</sub>	$\gamma = 0.9000$
33	H <sub>2</sub> O + BrONO <sub>2</sub>	$\xrightarrow{NAT}$ HOBr + HNO <sub>3</sub>	$\gamma = 6.0000E - 03$
34	H <sub>2</sub> O + BrONO <sub>2</sub>	$\xrightarrow{Ice}$ HOBr + HNO <sub>3</sub>	$\gamma = 0.3000$
35	HBr + N <sub>2</sub> O <sub>5</sub>	$\xrightarrow{NAT}$ BrONO + HNO <sub>3</sub>	$\gamma = 5.0000E - 03$
36	HBr + N <sub>2</sub> O <sub>5</sub>	$\xrightarrow{Ice}$ BrONO + HNO <sub>3</sub>	$\gamma = 5.0000E - 03$

Table 4: Heterogeneous reactions. When no value is given for  $\gamma$  the temperature and any other relevant dependencies of  $\gamma$  are calculated in a subroutine.