Supplement of Atmos. Chem. Phys. Discuss., 15, 8329–8360, 2015
http://www.atmos-chem-phys-discuss.net/15/8329/2015/
doi:10.5194/acpd-15-8329-2015-supplement

Supplement of

The NO_x dependence of bromine chemistry in the Arctic atmospheric boundary layer

K. D. Custard et al.

Correspondence to: K. D. Custard (kdcustard@gmail.com)

Table S1. Gas-phase chemical reactions used in the model. All rate constants are calculated for a temperature of 248 K unless otherwise noted and are expressed in units of cm^3 $molecule^{-1}$ s^{-1}.

Reaction	Rate Constant	Reference
$O(^1D) + M \rightarrow O(^3P)$	3.34×10^{-11}	*Ravishankara et al.* [2002]
$O(^3P) + O_2 \rightarrow O_3$	2.12×10^{-14}	*Atkinson et al.* [2004]
$O(^1D) + H_2O \rightarrow 2OH$	2.2×10^{-10}	*Atkinson et al.* [2004]
$OH + O_3 \rightarrow HO_2$	3.84×10^{-14}	*Atkinson et al.* [2004]
$OH + HO_2 \rightarrow H_2O$	1.34×10^{-10}	*Atkinson e t al.* [2004]
$OH + H_2O_2 \rightarrow HO_2 + H_2O$	1.52×10^{-12}	*Atkinson et al.* [2004]
$OH + O(^3P) \rightarrow O_2$	3.74×10^{-11}	*Atkinson et al.* [2004]
$OH + OH \rightarrow H_2O + O(^3P)$	1.74×10^{-12}	*Atkinson et al.* [2004]
$OH + OH \rightarrow H_2O_2$	1.86×10^{-11}	*Atkinson et al.* [2004]
$OH + NO_3 \rightarrow HO_2 + NO_2$	2.0×10^{-11}	*Atkinson et al.* [2004]
$HO_2 + NO_3 \rightarrow HNO_3$	4.0×10^{-12}	*Atkinson et al.* [2004]
$HO_2 + O_3 \rightarrow OH + 2O_2$	1.39×10^{-15}	*Atkinson et al.* [2004]
$HO_2 + HO_2 \rightarrow H_2O_2 + O_2$	2.58×10^{-12}	*Atkinson et al.* [2004]
$NO + OH \rightarrow HONO$	3.49×10^{-11}	*Atkinson et al.* [2004]
$NO + HO_2 \rightarrow NO_2 + OH$	9.59×10^{-12}	*Atkinson et al.* [2004]
$NO + O_3 \rightarrow NO_2$	7.09×10^{-15}	*Sander et al.* [2006]
$NO + NO_3 \rightarrow NO_2 + NO_2$	2.98×10^{-11}	*Sander et al.* [2006]
$NO_2 + OH \rightarrow HNO_3$	1.2×10^{-10}	*Atkinson et al.* [2004]
$NO_2 + HO_2 \leftrightarrow HNO_4$	f: 8.6×10^{-12} r: 1.32×10^{-4}	*Atkinson et al.* [2004]
$NO_2 + O_3 \rightarrow NO_3$	6.15×10^{-18}	*Sander et al.* [2006]
$NO_2 + NO_3 \leftrightarrow N_2O_5$	f: 1.83×10^{-12} r: 3.76×10^{-5}	*Atkinson et al.* [2004]
$NO_2 + CH_3COOO \leftrightarrow PAN$	f: 1.4×10^{-11} r: 3.1×10^{-8}	*Atkinson et al.* [2004]
$NO_3 + NO_3 \rightarrow NO_2 + NO_2$	4.36×10^{-17}	*Sander et al.* [2006]
$N_2O_5 + H_2O \rightarrow HNO_3 + HNO_3$	2.6×10^{-22}	*Atkinson et al.* [2004]
$HONO + OH \rightarrow NO_2 + H_2O$	3.74×10^{-12}	*Sander et al.* [2006]
$HNO_3 + OH \rightarrow NO_3 + H_2O$	1.5×10^{-13}	*Atkinson et al.* [2004]
$HNO_4 + OH \rightarrow NO_2 + H_2O$	6.2×10^{-12}	*Atkinson et al.* [2004]
$CO + OH \rightarrow HO_2 + CO_2$	2.4×10^{-13}	*Atkinson et al.* [2004]
$CH_4 + OH \rightarrow CH_3OO + H_2O$	1.87×10^{-15}	*Sander et al.* [2006]
$C_2H_2 + OH \rightarrow C_2H_2OH$	7.8×10^{-13}	*Atkinson et al.* [2004]
$C_2H_6 + OH \rightarrow C_2H_5OO$	1.18×10^{-13}	*Lurmann et al.* [1986]
$C_2H_4 + OH \rightarrow C_2H_4OH$	1.02×10^{-11}	*hahtin et al.* [2003]
$C_3H_8 + OH \rightarrow nC_3H_7O_2$	1.56×10^{-13}	*Harris and Kerr* [1988]
$C_3H_8 + OH \rightarrow iC_3H_7O_2$	6.64×10^{-13}	*Harris and Kerr* [1988]
$C_3H_6 + OH \rightarrow C_3H_6OH$	3.63×10^{-11}	*Atkinson et al.* [2004]
$C_3H_6O + OH \rightarrow$ Products	2.51×10^{-11}	*Atkinson et al.* [2004]
$nC_3H_7O_2 + NO \rightarrow NO_2 + C_3H_6O + HO_2$	5.4×10^{-11}	*Eberhard et al.* [1996]
$iC_3H_7O_2 + NO \rightarrow NO_2 + CH_3COCH_3 + HO_2$	1.2×10^{-11}	*Eberhard and Howard* [1996]
$nC_4H_{10} + OH \rightarrow nC_4H_9OO$	1.64×10^{-12}	*Donahue et al.* [1998]
$iC_4H_{10} + OH \rightarrow CH_3COCH_3 + CH_3OO$	1.65×10^{-12}	*Donahue et al.* [1998]
$nC_4H_9OO + NO \rightarrow$ n-Butanal $+ NO_2 + HO_2$	5.4×10^{-11}	*Michalowski et al.* [2000]
$nC_4H_9OO + CH_3OO \rightarrow$ n-Butanal $+ HCHO + HO_2 + HO_2$	6.7×10^{-13}	*Michalowski et al.* [2000]
$nC_4H_9OO + CH_3OO \rightarrow$ n-Butanal $+ CH_3OH$	2.3×10^{-13}	*Michalowski et al.* [2000]
$nC_4H_9OO + CH_3OO \rightarrow nC_4H_9OH + HCHO$	2.3×10^{-13}	*Michalowski et al.* [2000]
$CH_3OH + OH \rightarrow CH_3O$	7.09×10^{-13}	*Atkinson et al.* [2004]
n-Butanal $+ OH \rightarrow$ Products	2.0×10^{-11}	*Michalowski et al.* [2000]
$CH_3OO + HO_2 \rightarrow CH_3OOH$	8.82×10^{-12}	*Atkinson et al.* [2004]
$C_2H_5OO + HO_2 \rightarrow C_2H_5OOH$	1.12×10^{-11}	*Atkinson et al.* [2004]
$CH_3COOO + HO_2 \rightarrow CH_3COOOH$	2.54×10^{-11}	*DeMore et al.* [1997]

58	$C_2H_5OOH + OH \rightarrow C_2H_5OO$	6.0×10^{-12}	*Atkinson et al.* [2004]
59	$CH_3OO + CH_3OO \rightarrow HCHO + HO_2$	3.64×10^{-13}	*Lurmann et al.* [1986]
60	$CH_3OOH + OH \rightarrow HCHO + H_2O + OH$	2.54×10^{-12}	*Sander and Crutzen* [1996]
61	$CH_3OOH + OH \rightarrow CH_3OO + H_2O$	6.01×10^{-12}	*Sander and Crutzen* [1996]
62	$CH_3OO + HO_2 \rightarrow CH_3OOH$	1.01×10^{-11}	*Atkinson et al.* [2004]
63	$CH_3OO + NO \rightarrow HCHO + HO_2 + NO_2$	8.76×10^{-12}	*Atkinson et al.* [2004]
64	$CH_3OO + NO_2 \rightarrow CH_3OONO_2$	9.63×10^{-12}	*DeMore et al.* [1997]
65	$CH_3OO + nC_3H_7O_2 \rightarrow HCHO + C_3H_6O + HO_2 + HO_2$	6.70×10^{-13}	*Lightfoot et al.* [1992]
66	$CH_3OO + nC_3H_7O_2 \rightarrow C_3H_6O + CH_3OH$	2.3×10^{-13}	*Lightfoot et al.* [1992]
67	$CH_3OO + nC_3H_7O_2 \rightarrow HCHO + nC_3H_7OH$	2.3×10^{-13}	*Lightfoot et al.* [1992]
68	$CH_3OO + iC_3H_7O_2 \rightarrow HCHO + CH_3COCH_3 + HO_2 + HO_2$	1.2×10^{-14}	*Lightfoot et al.* [1992]
69	$CH_3OO + iC_3H_7O_2 \rightarrow CH_3COCH_3 + CH_3OH$	4.1×10^{-15}	*Lightfoot et al.* [1992]
70	$CH_3OO + iC_3H_7O_2 \rightarrow HCHO + iC_3H_7OH$	4.1×10^{-15}	*Lightfoot et al.* [1992]
71	$CH_3OO + C_2H_5OO \rightarrow CH_3CHO + HCHO + HO_2 + HO_2$	2.0×10^{-13}	*Kirchner and Stockwell* [1996]
72	$CH_3OO + CH_3COOO \rightarrow HCHO + CH_3OO + HO_2$	1.58×10^{-11}	*Kirchner and Stockwell* [1996]
73	$C_2H_5OO + NO \rightarrow CH_3CHO + HO_2 + NO_2$	8.68×10^{-12}	*Lurmann et al.* [1986]
74	$C_2H_5OO + NO_2 \rightarrow C_2H_5OONO_2$	8.8×10^{-12}	*Atkinson et al.* [1997]
75	$C_2H_5OO + HO_2 \rightarrow C_2H_5OOH$	9.23×10^{-12}	*Atkinson et al.* [2004]
76	$C_2H_5OO + CH_3COOO \rightarrow CH_3CHO + CH_3COO + HO_2$	4.0×10^{-12}	*Michalowski et al.* [2000]
77	$iC_3H_7O_2 + HO_2 \rightarrow iPerox$	9.23×10^{-12}	*Michalowski et al.* [2000]
78	$nC_3H_7O_2 + HO_2 \rightarrow nPerox$	9.23×10^{-12}	*Michalowski et al.* [2000]
79	$HCHO + OH \rightarrow HO_2 + CO$	9.3×10^{-12}	*Atkinson et al.* [2004]
80	$HCHO + HO_2 \rightarrow HOCH_2O_2$	7.53×10^{-14}	*Sander et al.* [2006]
81	$HCHO + NO_3 \rightarrow HNO_3 + HO_2 + CO$	5.8×10^{-16}	*DeMore et al.* [1997]
82	$CH_3CHO + OH \rightarrow CH_3COOO + H_2O$	1.98×10^{-11}	*Atkinson et al.* [2004]
83	$CH_3CHO + NO_3 \rightarrow HNO_3 + CH_3COOO$	1.4×10^{-15}	*DeMore et al.* [1997]
84	$CH_3COCH_3 + OH \rightarrow H_2O + CH_3COCH_2$	1.37×10^{-13}	*Atkinson et al.* [2004]
85	$HOCH_2O_2 + NO \rightarrow HCOOH + HO_2 + NO_2$	8.68×10^{-12}	*Lurmann et al.* [1986]
86	$HOCH_2O_2 + HO_2 \rightarrow HCOOH + H_2O$	2.0×10^{-12}	*Lurmann et al.* [1986]
87	$HOCH_2O_2 + HOCH_2O_2 \rightarrow HCOOH + HCOOH + HO_2 + HO_2$	1.0×10^{-13}	*Lurmann et al.* [1986]
88	$HCOOH + OH \rightarrow HO_2 + H_2O + CO_2$	4.0×10^{-13}	*DeMore et al.* [1997]
89	$CH_3COOO + NO \rightarrow CH_3OO + NO_2 + CO_2$	2.4×10^{-11}	*Atkinson et al.* [2004]
90	$CH_3COOO + HO_2 \rightarrow CH_3COOH + O_3$	1.87×10^{-11}	*Kirchner and Stockwell* [1996]
91	$CH_3COOO + CH_3COOO \rightarrow CH_3COO + CH_3COO$	2.5×10^{-11}	*Kirchner and Stockwell* [1996]
92	$C_2H_5OONO_2 \rightarrow C_2H_5OO + NO_2$	3.2×10^{-3}	*Atkinson et al.* [1997]
93	$CH_3OONO_2 \rightarrow CH_3OO + NO_2$	3.4×10^{-3}	*Atkinson et al.* [1997]
94			
95	$Cl_2 + OH \rightarrow HOCl + Cl$	2.85×10^{-14}	*Atkinson et al.* [2004]
96	$Cl + O_3 \rightarrow ClO$	1.02×10^{-11}	*Atkinson et al.* [2004]
97	$Cl + H_2 \rightarrow HCl$	3.5×10^{-15}	*Atkinson et al.* [2004]
98	$Cl + HO_2 \rightarrow HCl$	3.57×10^{-11}	*Sander et al.* [2006]
99	$Cl + HO_2 \rightarrow ClO + OH$	6.68×10^{-12}	*Sander et al.* [2006]
100	$Cl + H_2O_2 \rightarrow HCl + HO_2$	2.11×10^{-13}	*Atkinson et al.* [2004]
101	$Cl + NO_3 \rightarrow ClO + NO_2$	2.4×10^{-11}	*Atkinson et al.* [2004]
102	$Cl + CH_4 \rightarrow HCl + CH_3OO$	3.99×10^{-14}	*Sander et al.* [2006]
103	$Cl + C_2H_6 \rightarrow HCl + C_2H_5OO$	5.36×10^{-11}	*Sander et al.* [2006]
104	$Cl + C_2H_4 \rightarrow HCl + C_2H_5OO$	1.0×10^{-10}	*Atkinson et al.* [2004]
105	$Cl + MEK \rightarrow HCl$	4.21×10^{-11}	*Atkinson et al.* [2004]
106	$Cl + C_2H_2 \rightarrow ClC_2CHO$	2.5×10^{-10}	*Atkinson et al.* [2004]
107	$Cl + C_3H_6 \rightarrow HCl + C_3H_6Cl$	2.7×10^{-10}	*Keil and Shepson* [2006]
108	$Cl + C_3H_8 \rightarrow HCl + iC_3H_7O_2$	1.65×10^{-10}	*DeMore et al.* [1997]
109	$Cl + C_3H_8 \rightarrow HCl + nC_3H_7O_2$	1.65×10^{-10}	*DeMore et al.* [1997]
110	$Cl + C_3H_6O \rightarrow HCl$	1.1×10^{-10}	*Wallington et al.* [1988]
111	$Cl + iC_4H_{10} \rightarrow HCl + C_4H_9$	1.3×10^{-10}	*Hooshiyar and Niki* [1995]
112	$Cl + nC_4H_{10} \rightarrow HCl + C_4H_9$	2.15×10^{-10}	*Tyndall et al.* [1997]
113	$Cl + n\text{-}Butanal \rightarrow HCl + Products$	1.1×10^{-10}	*Michalowski et al.* [2000]
114	$Cl + HCHO \rightarrow HCl + HO_2 + CO$	7.18×10^{-11}	*Sander et al.* [2006]

$Cl + CH_3CHO \rightarrow HCl + CH_3COOO$	8.08×10^{-11}	*Atkinson et al.* [2004]
$Cl + CH_3COCH_3 \rightarrow HCl + CH_3COCH_2$	1.39×10^{-12}	*Atkinson et al.* [2004]
$Cl + CH_3OOH \rightarrow CH_3OO + HCl$	2.36×10^{-11}	*Atkinson et al.* [2004]
$Cl + CH_3OOH \rightarrow CH_2OOH + HCl$	3.54×10^{-11}	*Atkinson et al.* [2004]
$Cl + CHBr3 \rightarrow HCl + Br + CBr2O$	2.9×10^{-13} (at 298 K)	*Kamboures et al.* [2002]
$Cl + OClO \rightarrow ClO + ClO$	6.35×10^{-11}	*Atkinson et al.* [2004]
$Cl + ClNO_3 \rightarrow Cl_2 + NO_3$	1.12×10^{-11}	*Sander et al.* [2006]
$Cl + PAN \rightarrow HCl + HCHO + NO_3$	1.0×10^{-14}	*Tsalkani et al.* [1988]
$Cl + HNO_3 \rightarrow HCl + NO_3$	1.0×10^{-16}	*Wine et al.* [1988]
$Cl + NO_2 \rightarrow ClNO_2$	1.43×10^{-12} (at 298 K)	*Ravishankara et al.* [1988]
$Cl + HBr \rightarrow HCl + Br$	4.48×10^{-12}	*Nicovich and Wine* [1990]
$ClO + O(^3\mathit{P}) \rightarrow Cl + O_2$	1.6×10^{-11}	*Atkinson et al.* [2004]
$ClO + OH \rightarrow Cl + HO_2$	2.45×10^{-11}	*Atkinson et al.* [2004]
$ClO + OH \rightarrow HCl$	2.37×10^{-13}	*Sander et al.* [2006]
$ClO + HO_2 \rightarrow HOCl$	8.67×10^{-12}	*Atkinson et al.* [2004]
$ClO + CH_3OO \rightarrow Cl + HCHO + HO_2$	2.08×10^{-12}	*Sander et al.* [2006]
$ClO + CH_3COOO \rightarrow Cl + CH_3OO + CO_2$	2.03×10^{-12}	*Michalowski et al.* [2000]
$ClO + NO \rightarrow Cl + NO_2$	2.04×10^{-11}	*Atkinson et al.* [2004]
$ClO + NO_2 \rightarrow ClNO_3$	7.1×10^{-12}	*Atkinson et al.* [2004]
$ClO + ClO \rightarrow Cl_2$	1.64×10^{-15}	*Atkinson et al.* [2004]
$ClO + ClO \rightarrow Cl + Cl$	1.54×10^{-15}	*Atkinson et al.* [2004]
$ClO + ClO \rightarrow Cl + OClO$	1.40×10^{-15}	*Atkinson et al.* [2004]
$OClO + OH \rightarrow HOCl$	1.13×10^{-11}	*Atkinson et al.* [2004]
$OClO + NO \rightarrow ClO + H_2O$	1.51×10^{-13}	*Atkinson et al.* [2004]
$HOCl + OH \rightarrow ClO + H_2O$	4.0×10^{-13}	*Sander et al.* [2006]
$HCl + OH \rightarrow Cl + H_2O$	6.84×10^{-13}	*Atkinson et al.* [2004]
$ClNO_3 + OH \rightarrow HOCl + NO_3$	3.17×10^{-13}	*Atkinson et al.* [2004]
$HOCl + O(^3\mathit{P}) \rightarrow ClO + OH$	1.7×10^{-13}	*Atkinson et al.* [2004]

$Br + O_3 \rightarrow BrO$	6.75×10^{-13}	*Atkinson et al.* [2004]
$Br_2 + OH \rightarrow HOBr$	5.0×10^{-11}	*Atkinson et al.* [2004]
$Br + HO_2 \rightarrow HBr$	1.25×10^{-12}	*Atkinson et al.* [2004]
$Br + C_2H_2 \rightarrow BrCH_2CHO$	3.7×10^{-14}	*Atkinson et al.* [2004]
$Br + C_2H_4 \rightarrow HBr + C_2H_5OO$	1.3×10^{-13}	*Atkinson et al.* [2004]
$Br + C_3H_6 \rightarrow HBr + C_3H_5$	1.60×10^{-12}	*Atkinson et al.* [2004]
$Br + HCHO \rightarrow HBr + CO + HO_2$	6.75×10^{-13}	*Sander et al.* [2006]
$Br + CH_3CHO \rightarrow HBr + CH_3COOO$	2.8×10^{-12}	*Atkinson et al.* [2004]
$Br + C_3H_6O \rightarrow HBr$	9.7×10^{-12}	*Wallington et al.* [1989]
$Br + nButanal \rightarrow HBr$	9.7×10^{-12}	*Michalowski et al.* [2000]
$Br + CH_3OOH \rightarrow HBr + CH_3OO$	4.03×10^{-15}	*Mallard et al.* [1993]
$Br + NO_2 \rightarrow BrNO_2$	6.3×10^{-12}	*Atkinson et al.* [2006]
$Br + NO_2 \leftrightarrow BrONO$	f: 6.3×10^{-12} r: 0.02	*Atkinson et al.* [2006] *Orlando and Burkholder* [2000]
$Br + BrNO_2 \rightarrow Br_2 + NO_2$	5.0×10^{-11}	*Orlando and Burkholder* [2000]
$Br + BrONO \rightarrow Br_2 + NO_2$	1.0×10^{-12}	*Orlando and Burkholder* [2000]
$Br + BrNO_3 \rightarrow Br_2 + NO_3$	4.9×10^{-11}	*Orlando and Tyndall* [1997]
$Br + OClO \rightarrow BrO + ClO$	1.43×10^{-13}	*Atkinson et al.* [2004]
$BrO + O(^3\mathit{P}) \rightarrow Br$	4.8×10^{-11}	*Atkinson et al.* [2004]
$BrO + OH \rightarrow Br + HO_2$	4.93×10^{-11}	*Atkinson et al.* [2004]
$BrO + HO_2 \rightarrow HOBr$	3.38×10^{-11}	*Atkinson et al.* [2004]
$BrO + CH_3OO \rightarrow HOBr + CH_2OO$	4.1×10^{-12}	*Aranda et al.* [1997]
$BrO + CH_3OO \rightarrow Br + HCHO + HO_2$	1.6×10^{-12}	*Aranda et al.* [1997]
$BrO + CH_3COOO \rightarrow Br + CH_3COO$	1.7×10^{-12}	*Michalowski et al.* [2000]
$BrO + C_3H_6O \rightarrow HOBr$	1.5×10^{-14}	*Michalowski et al.* [2000]
$BrO + NO \rightarrow Br + NO_2$	2.48×10^{-11}	*Atkinson et al.* [2004]
$BrO + NO_2 \rightarrow BrNO_3$	1.53×10^{-11}	*Atkinson et al.* [2004]
$BrO + BrO \rightarrow Br + Br$	2.82×10^{-12}	*Sander et al.* [2006]

$BrO + BrO \rightarrow Br_2$	9.3×10^{-13}	*Sander et al.* [2006]
$BrO + HBr \rightarrow HOBr + Br$	2.1×10^{-14}	*Hansen et al.* [1999]
$HBr + OH \rightarrow Br + H_2O$	1.26×10^{-11}	*Sander et al.* [2006]
$CH_3Br + OH \rightarrow H_2O + Br$	1.27×10^{-14}	*Atkinson et al.* [2004]
$CHBr_3 + OH \rightarrow H_2O + Br$	1.2×10^{-13}	*Atkinson et al.* [2004]
$Cl + BrCl \leftrightarrow Br + Cl_2$	f: 1.5×10^{-11} r: 1.1×10^{-15}	*Clyne and Cruse* [1972]
$Cl + Br_2 \leftrightarrow BrCl + Br$	f: 1.2×10^{-10} r: 3.3×10^{-1}	*Clyne and Cruse* [1972]
$BrO + ClO \rightarrow Br + Cl$	7.04×10^{-12}	*Atkinson et al.* [2004]
$BrO + ClO \rightarrow BrCl$	1.15×10^{-12}	*Atkinson et al.* [2004]
$BrO + ClO \rightarrow Br + OClO$	9.06×10^{-12}	*Atkinson et al.* [2004]
$HOBr + OH \rightarrow BrO + H_2O$	5.0×10^{-13}	*Kukui et al.* [1996]
$HOBr + Cl \rightarrow BrCl + OH$	8.0×10^{-11}	*Kukui et al.* [1996]
$HOBr + O(^3P) \rightarrow BrO + OH$	2.12×10^{-11}	*Atkinson et al.* [2004]

Table S2. Photochemical reactions. J_{max} values for 25 March are shown as an example. J coefficients are expressed in units of s^{-1}.

Reaction	**J_{max} 25 March**	**Lifetime**	**Source**
$O_3 + hv \rightarrow O_2 + O(^1D)$	3.9×10^{-6}	3.0 days	calculated from OASIS data
$NO_2 + hv \rightarrow NO + O(^3P)$	8.6×10^{-3}	1.9 min	calculated from OASIS data
$H_2O_2 + hv \rightarrow OH + OH$	3.4×10^{-6}	3.4 days	calculated from OASIS data
$NO_3 + hv \rightarrow NO + O_2$	4.5×10^{-2}	22 s	Michalowski et al. [2000]
$N_2O_5 + hv \rightarrow NO_2 + NO_3$	1.5×10^{-5}	18 h	calculated from OASIS data
$HONO + hv \rightarrow OH + NO$	1.8×10^{-3}	9.2 min	calculated from OASIS data
$HNO_3 + hv \rightarrow NO_2 + OH$	1.5×10^{-7}	79 days	calculated from OASIS data
$HNO_4 + hv \rightarrow NO_2 + HO_2$	7.3×10^{-7}	16 days	calculated from OASIS data
$HCHO + hv \rightarrow HO_2 + HO_2 + CO$	1.5×10^{-5}	19 h	calculated from OASIS data
$HCHO + hv \rightarrow CO + H_2$	3.1×10^{-5}	8.8 h	calculated from OASIS data
$CH_3CHO + hv \rightarrow CH_3OO + HO_2 + CO$	1.1×10^{-6}	11 days	calculated from OASIS data
$CH_3OOH + hv \rightarrow HCHO + HO_2 + OH$	3.2×10^{-6}	3.7 days	calculated from OASIS data
C3H6O +$hv \rightarrow$ HO2 + C2H5OO + CO	1.4×10^{-6}	8.3 days	calculated from OASIS data
$PAN + hv \rightarrow CH_3COOO + NO_2$	1.7×10^{-7}	66 days	calculated from OASIS data
$OClO + hv \rightarrow O(^3P) + ClO$	0.12	8.1 s	estimate from *Pöhler et al.* [2010]
$Cl_2 + hv \rightarrow Cl + Cl$	2.1×10^{-3}	8.1 min	calculated from OASIS data
$ClO + hv \rightarrow Cl + O(^3P)$	2.4×10^{-5}	11 h	calculated from OASIS data
$HOCl + hv \rightarrow OH + Cl$	1.4×10^{-4}	2 h	estimate from *Lehrer et al.* [2004]
$ClNO_3 + hv \rightarrow Cl + NO_3$	2.9×10^{-5}	9.5 h	calculated from OASIS data
$ClNO_3 + hv \rightarrow ClO + NO_2$	3.4×10^{-6}	3.4 days	calculated from OASIS data
$BrNO_3 + hv \rightarrow Br + NO_3$	2.1×10^{-4}	1.3 h	calculated from OASIS data
$BrNO_3 + hv \rightarrow BrO + NO_2$	1.2×10^{-3}	14.2 min	calculated from OASIS data
$BrO + hv \rightarrow Br + O(^3P)$	3.0×10^{-2}	33 s	calculated from OASIS data
$Br_2 + hv \rightarrow Br + Br$	4.4×10^{-2}	23 s	calculated from OASIS data
$HOBr + hv \rightarrow Br + OH$	2.3×10^{-3}	7.2 min	calculated from OASIS data
$BrNO_2 + hv \rightarrow Br + NO_2$	5.7×10^{-3}	2.9 min	estimate from *Scheffler et al.* [1997] & *Landgraf & Crutzen et al.* [1998]
$ClNO_2 + hv \rightarrow Cl + NO_2$	4.4×10^{-5}	6.3 h	estimate from *Ganske et al.* [1992]
$BrCl + hv \rightarrow Br + Cl$	1.26×10^{-2}	1.3 min	calculated from OASIS data

Table S3. Mass transfer reactions. All rate constants are expressed in units of s^{-1}.

Reaction	***k* (forward)**	***k* (reverse)**
Particles		
$HCl_{(g)} \rightarrow H^+_{(p)} + Cl^-_{(p)}$	2.58×10^{-3}	
$HBr_{(g)} \rightarrow H^+_{(p)} + Br^-_{(p)}$	1.80×10^{-3}	
$HOCl_{(g)} \rightarrow HOCl_{(p)}$	2.16×10^{-3}	
$HOBr_{(g)} \rightarrow HOBr_{(p)}$	1.26×10^{-3}	
$HOI_{(g)} \rightarrow HOI_{(p)}$	5.42×10^{-4}	
$OH_{(g)} \rightarrow OH_{(p)}$	3.26×10^{-5}	
$O_{3(g)} \leftrightarrow O_{3(p)}$	6.54×10^{-6}	8.76×10^{5}
$Cl_{2(g)} \leftrightarrow Cl_{2(p)}$	2.69×10^{-5}	2.96×10^{7}
$Br_{2(g)} \leftrightarrow Br_{2(p)}$	1.78×10^{-5}	2.97×10^{8}
$BrCl_{(g)} \leftrightarrow BrCl_{(p)}$	6.60×10^{-4}	1.91×10^{10}
$HNO_{3(g)} \rightarrow HNO_{3(p)}$	5.50×10^{-4}	
$N_2O_{5(g)} \rightarrow N_2O_{5(p)}$	1.08×10^{-4}	
$HONO_{(g)} \rightarrow HONO_{(p)}$	1.63×10^{-4}	
$PAN_{(g)} \rightarrow PAN_{(p)}$	2.05×10^{-5}	
$HNO_{4(g)} \rightarrow HNO_{4(p)}$	4.89×10^{-4}	
$ClNO_{2(g)} \rightarrow ClNO_{2(p)}$	1.26×10^{-3}	
$BrNO_{2(g)} \rightarrow BrNO_{2(p)}$	1.26×10^{-3}	
$ClNO_{3(g)} \rightarrow ClNO_{3(p)}$	1.26×10^{-3}	
$BrNO_{3(g)} \rightarrow BrNO_{3(p)}$	1.26×10^{-3}	
Snow		
$HBr_{(g)} \rightarrow H^+_{(s)} + Br^-_{(s)}$	1.67×10^{-5}	
$HCl_{(g)} \rightarrow H^+_{(s)} + Cl^-_{(s)}$	1.67×10^{-5}	
$HOBr_{(g)} \rightarrow HOBr_{(s)}$	1.67×10^{-5}	
$HOCl_{(g)} \rightarrow HOCl_{(s)}$	1.67×10^{-5}	
$OH_{(g)} \rightarrow OH_{(s)}$	1.67×10^{-6}	
$O_{3(g)} \rightarrow O_{3(s)}$	1.67×10^{-6}	
$Cl_{2(g)} \leftrightarrow Cl_{2(s)}$	8.0×10^{-6}	7.71×10^{-2}
$Br_{2(g)} \leftrightarrow Br_{2(s)}$	1.0×10^{-5}	7.71×10^{-2}
$BrCl_{(g)} \leftrightarrow BrCl_{(s)}$	1.25×10^{-5}	7.71×10^{-2}
$HNO_{3(g)} \rightarrow HNO_{3(s)}$	1.67×10^{-5}	
$N_2O_{5(g)} \rightarrow N_2O_{5(s)}$	1.67×10^{-5}	
$HONO_{(g)} \rightarrow HONO_{(s)}$	1.67×10^{-5}	
$PAN_{(g)} \rightarrow PAN_{(s)}$	1.67×10^{-5}	
$HNO_{4(g)} \rightarrow HNO_{4(s)}$	1.67×10^{-5}	
$ClNO_{2(g)} \rightarrow ClNO_{2(s)}$	1.67×10^{-4}	
$BrNO_{2(g)} \rightarrow BrNO_{2(s)}$	1.67×10^{-4}	
$ClNO_{3(g)} \rightarrow ClNO_{3(s)}$	1.67×10^{-4}	
$BrNO_{3(g)} \rightarrow BrNO_{3(s)}$	1.67×10^{-4}	

Table S4. Aqueous-phase reactions in the model. All aqueous reaction rate constants are converted to units consistent to the gas-phase reactions to be read by the modeling program.

* Third order rate constant, expressed in units of $cm^6 \cdot molecule^{-2} \cdot s^{-1}$

† second order rate constant, expressed in units of $cm^3 \cdot molecule^{-1} \cdot s^{-1}$

‡ first order rate constant, expressed in units of s^{-1}

Reaction	k (actual)	k (particle)	k (snow)	Reference
$Cl^- + HOBr + H^+ \rightarrow BrCl$ *	1.55×10^{-32}	5.17×10^{-21}	9.30×10^{-26}	(Wang et al., 1994)
$Br^- + HOCl + H^+ \rightarrow BrCl$ *	3.59×10^{-36}	1.2×10^{-24}	2.15×10^{-29}	(Sander et al., 1997)
$Br^- + HOBr + H^+ \rightarrow Br_2$ *	4.41×10^{-32}	1.47×10^{-20}	2.64×10^{-25}	(Beckwith et al., 1996)
$Cl^- + HOCl + H^+ \rightarrow Cl_2$ *	6.07×10^{-38}	2.02×10^{-26}	3.63×10^{-31}	(Wang and Margerum, 1994)
$BrCl + Cl^- \rightarrow BrCl_2^-$ †	1×10^{-11}	3.3	5.99×10^{-5}	(Michalowski et al., 2000)
$BrCl_2^- \rightarrow BrCl + Cl^-$ ‡	1.58×10^{9}	1.58×10^{9}	1.58×10^{9}	(Michalowski et al., 2000)
$BrCl + Br^- \rightarrow Br_2Cl^-$ †	1×10^{-11}	3.3	5.99×10^{-5}	(Michalowski et al., 2000)
$Br_2Cl^- \rightarrow BrCl + Br^-$ ‡	3.34×10^{5}	3.34×10^{5}	3.34×10^{5}	(Michalowski et al., 2000;Wang et al., 1994)
$Cl_2 + Br^- \rightarrow BrCl_2^-$ †	1.28×10^{-11}	4.27	7.66×10^{-5}	(Michalowski et al., 2000;Beckwith et al., 1996;Wang et al., 1994)
$BrCl_2^- \rightarrow Cl_2 + Br^-$ ‡	6.94×10^{2}	6.94×10^{2}	6.94×10^{2}	(Michalowski et al., 2000;Wang et al., 1994)
$O_3 + Br^- \rightarrow HOBr$ †	1.35×10^{-20}	4.5×10^{-9}	8.08×10^{-14}	(Michalowski et al., 2000)
$OH + Cl^- \rightarrow HOCl$ †	1.35×10^{-20}	4.5×10^{-9}	8.08×10^{-14}	assumed same as $O_3 + Br^-$
$N_2O_5 + Cl^- \rightarrow ClNO_2$ †	1.66×10^{-12}	5.5×10^{-1}	9.94×10^{-5}	assume diffusion limited
$ClNO_2 + H^+ + Cl^- \rightarrow Cl_2$ †	1.66×10^{-14}	5.5×10^{-3}	9.94×10^{-8}	estimated from (Roberts et al., 2008)
$N_2O_5 + Br^- \rightarrow BrNO_2$ †	1.66×10^{-12}	5.5×10^{-1}	9.94×10^{-5}	assume diffusion limited
$BrNO_2 + H^+ + Br^- \rightarrow Br_2$ †	7.31×10^{-17}	2.44×10^{-5}	4.38×10^{-10}	estimated from (Schweitzer et al., 1998)

Table S5. Summary of the ambient measurements from OASIS that were used to constrain the model and the instrumental method used. Constrained parameters were input into the model at 10 minute intervals.

Measured Species	Method	Method Reference
O_3 and NO_x	Chemiluminescence	*Ridley et al*. [1992]; *Ryerson et al.* [2000]; *Weinheimer et al*., [1998]
HONO	Long Path Absorption Photometer	*Villena et al.,* [2011]
CO	CO Monitor	
Cl_2 and Br_2	CIMS	*Liao et al*. [2011, 2012]
HCHO	Tunable Diode Laser Absorption Spectroscopy	*Fried et al.*, [2003]; *Lancaster et al.* [2000]
CH_3CHO, CH_3COCH_3, MEK, *n*-C_4H_{10}, *i*-C_4H_{10}	Online GC-MS	*Apel et al.* [2010]
C_2H_2, C_2H_4, C_2H_6, C_3H_8, C_3H_6, *n*-C_4H_{10}, *i*-C_4H_{10}	Canister samples, offline GC-MS	*Russo et al.* [2010]
Photolysis Frequencies	Spectral Actinic Flux Density	*Shetter and Muller et al.* [1999]

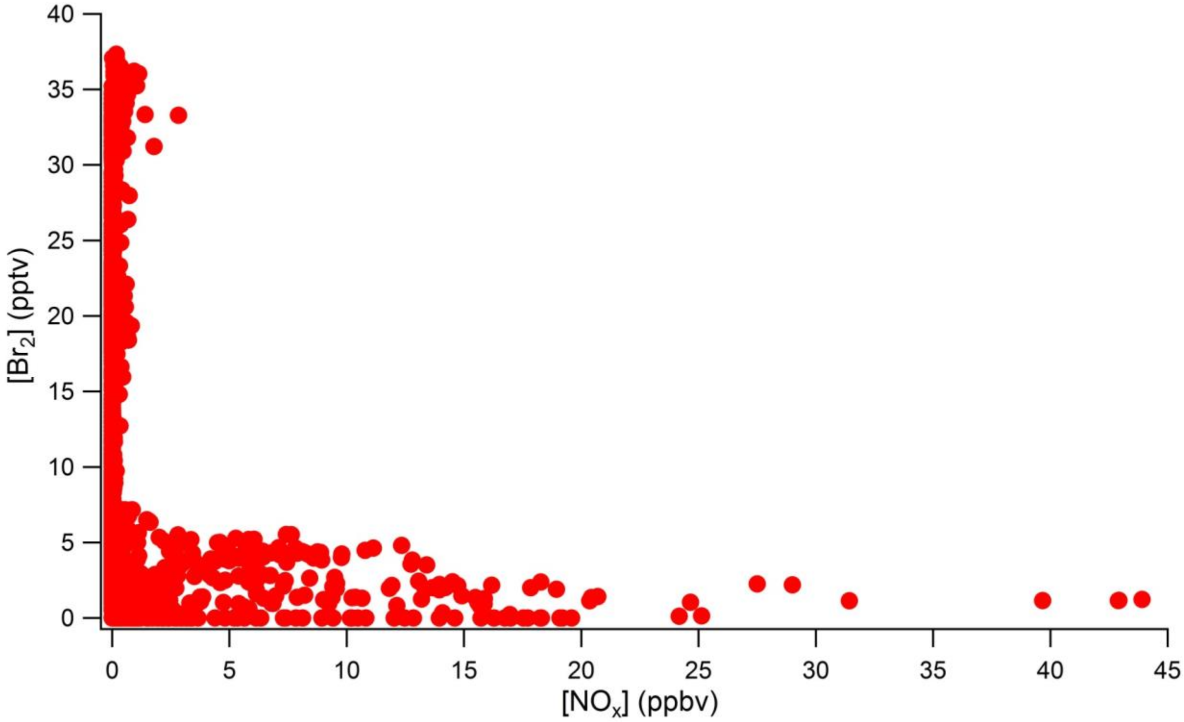

Figure S1. 5 minute averages of observed concentrations of Br_2 and NO_x from OASIS 2009. It should be noted that the Br_2 axis has pptv units and the NO_x axis has ppbv units.

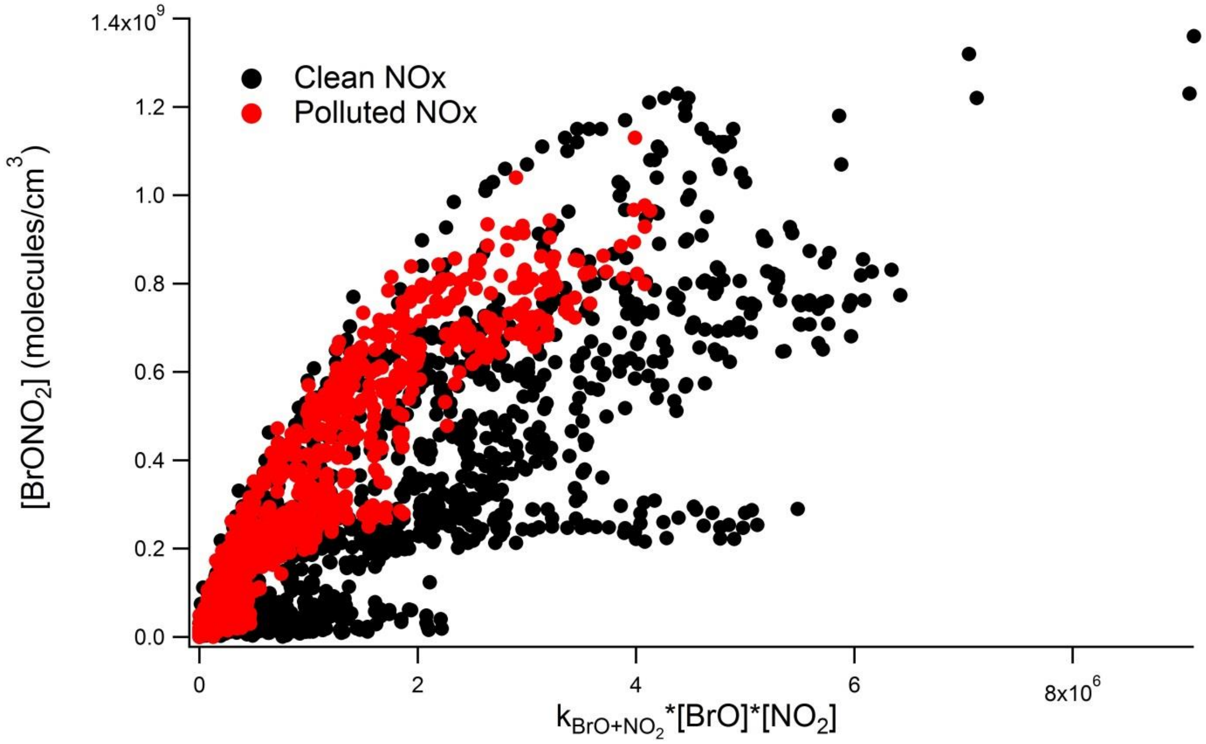

Figure S2. Simulated $BrONO_2$ mole ratio (low NO_x & high NO_x cases) plotted against the production rate of $BrONO_2$.

Apel, E. C., Emmons, L. K., Karl, T., Flocke, F., Hills, A. J., Madronich, S., Lee-Taylor, J., Fried, A., Weibring, P., Walega, J., Richter, D., Tie, X., Mauldin, L., Campos, T., Weinheimer, A., Knapp, D., Sive, B., Kleinman, L., Springston, S., Zaveri, R., Ortega, J., Voss, P., Blake, D., Baker, A., Warneke, C., Welsh-Bon, D., de Gouw, J., Zheng, J., Zhang, R., Rudolph, J., Junkermann, W., and Riemer, D. D.: Chemical evolution of volatile organic compounds in the outflow of the Mexico City Metropolitan area, Atmospheric Chemistry and Physics, 10, 2353-2375, 2010.

Aranda, A., LeBras, G., LaVerdet, G., and Poulet, G.: The BrO+Ch3O2 reaction: Kinetics and role in the atmospheric ozone budget, Geophysical Research Letters, 24, 2745-2748, 10.1029/97gl02686, 1997.

Atkinson, R., Baulch, D. L., Cox, R. A., Crowley, J. N., Hampson, R. F., Hynes, R. G., Jenkin, M. E., Rossi, M. J., and Troe, J.: Evaluated kinetic and photochemical data for atmospheric chemistry: Volume I - gas phase reactions of O-x, HOx, NOx and SOx species, Atmospheric Chemistry and Physics, 4, 1461-1738, 2004.

Beckwith, R. C., Wang, T. X., and Margerum, D. W.: Equilibrium and kinetics of bromine hydrolysis, Inorganic Chemistry, 35, 995-1000, 10.1021/ic950909w, 1996.

Clyne, M. A. A., and Cruse, H. W.: Atomic resonance fluorescence spectrometry for rate constants of rapid bimolecular reactions .1. Reactions O+NO2, Cl+ClNO,Br+CINO, Journal of the Chemical Society-Faraday Transactions Ii, 68, 1281-&, 10.1039/f29726801281, 1972.

DeMore, W. B., Sander, S., Golden, D., Hampson, R., Kurylo, M., Howard, C., Ravishankara, A., Kolb, C., Molina, M., and T, C. I. o.: Jet Propulsion Lab., Pasadena (1997), Chemical kinetics and photochemical data for use in stratospheric modeling, Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA 1997.

Donahue, N. M., Anderson, J. G., and Demerjian, K. L.: New rate constants for ten OH alkane reactions from 300 to 400 K: An assessment of accuracy, Journal of Physical Chemistry A, 102, 3121-3126, 10.1021/jp980532q, 1998.

Eberhard, J., and Howard, C. J.: Temperature-dependent kinetics studies of the reactions of C2H5O2 and n-C3H7O2 radicals with NO, International Journal of Chemical Kinetics, 28, 731-740, 10.1002/(sici)1097-4601(1996)28:10<731::aid-kin3>3.0.co;2-o, 1996.

Eberhard, J., Villalta, P. W., and Howard, C. J.: Reaction of isopropyl peroxy radicals with NO over the temperature range 201-401 K, Journal of Physical Chemistry, 100, 993-997, 10.1021/jp951824j, 1996.

Fried, A., Crawford, J., Olson, J., Walega, J., Potter, W., Wert, B., Jordan, C., Anderson, B., Shetter, R., Lefer, B., Blake, D., Blake, N., Meinardi, S., Heikes, B., O'Sullivan, D., Snow, J., Fuelberg, H., Kiley, C. M., Sandholm, S., Tan, D., Sachse, G., Singh, H., Faloona, I., Harward, C. N., and Carmichael, G. R.: Airborne tunable diode laser measurements of formaldehyde during TRACE-P: Distributions and box model comparisons, Journal of Geophysical Research-Atmospheres, 108, 23, 10.1029/2003jd003451, 2003.

Ganske, J. A., Berko, H. N., and Finlaysonpitts, B. J.: Absorption cross-section for gaseous ClNO2 and Cl2 at 298-K - potential organic oxidant source in the marine troposphere, Journal of Geophysical Research-Atmospheres, 97, 7651-7656, 1992.

Hansen, J. C., Li, Y. M., Li, Z. J., and Francisco, J. S.: On the mechanism of the BrO plus HBr reaction, Chemical Physics Letters, 314, 341-346, 10.1016/s0009-2614(99)01093-3, 1999.

Harris, S. J., and Kerr, J. A.: Relative rate measurements of some reactions of hydroxyl radicals with alkanes studied under atmospheric conditions, International Journal of Chemical Kinetics, 20, 939-955, 10.1002/kin.550201203, 1988.

Hooshiyar, P. A., and Niki, H.: Rate constants for the gas-phase reactions of Cl-atoms with C_2-C_8 alkanes at T=296 +/-2K, International Journal of Chemical Kinetics, 27, 1197-1206, 10.1002/kin.550271206, 1995.

Kamboures, M. A., Hansen, J. C., and Francisco, J. S.: A study of the kinetics and mechanisms involved in the atmospheric degradation of bromoform by atomic chlorine, Chemical Physics Letters, 353, 335-344, 10.1016/s0009-2614(01)01439-7, 2002.

Keil, A. D., and Shepson, P. B.: Chlorine and bromine atom ratios in the springtime Arctic troposphere as determined from measurements of halogenated volatile organic compounds, Journal of Geophysical Research-Atmospheres, 111, 11, 10.1029/2006jd007119, 2006.

Kirchner, F., and Stockwell, W. R.: Effect of peroxy radical reactions on the predicted concentrations of ozone, nitrogenous compounds, and radicals, Journal of Geophysical Research-Atmospheres, 101, 21007-21022, 10.1029/96jd01519, 1996.

Kukui, A., Kirchner, U., Benter, T., and Schindler, R. N.: A gaskinetic investigation of HOBr reactions with Cl(P-2), O(P-3) and OH((2)Pi). The reaction of BrCl with OH((2)Pi), Berichte Der Bunsen-Gesellschaft-Physical Chemistry Chemical Physics, 100, 455-461, 1996.

Lancaster, D. G., Fried, A., Wert, B., Henry, B., and Tittel, F. K.: Difference-frequency-based tunable absorption spectrometer for detection of atmospheric formaldehyde, Applied Optics, 39, 4436-4443, 10.1364/ao.39.004436, 2000.

Landgraf, J., and Crutzen, P. J.: An efficient method for online calculations of photolysis and heating rates, Journal of the Atmospheric Sciences, 55, 863-878, 10.1175/1520-0469(1998)055<0863:aemfoc>2.0.co;2, 1998.

Lehrer, E., Honninger, G., and Platt, U.: A one dimensional model study of the mechanism of halogen liberation and vertical transport in the polar troposphere, Atmospheric Chemistry and Physics, 4, 2427-2440, 2004.

Liao, J., Sihler, H., Huey, L., Neuman, J., Tanner, D., Friess, U., Platt, U., Flocke, F., Orlando, J., Shepson, P., Beine, H., Weinheimer, A., Sjostedt, S., Nowak, J., Knapp, D., Staebler, R., Zheng, W., Sander, R., Hall, S., and Ullmann, K.: A comparison of Arctic BrO measurements by chemical ionization mass spectrometry and long path-differential optical absorption spectroscopy, Journal of Geophysical Research-Atmospheres, 116, 10.1029/2010JD014788, 2011.

Liao, J., Huey, L., Tanner, D., Flocke, F., Orlando, J., Neuman, J., Nowak, J., Weinheimer, A., Hall, S., Smith, J., Fried, A., Staebler, R., Wang, Y., Koo, J., Cantrell, C., Weibring, P., Walega, J., Knapp, D., Shepson, P., and Stephens, C.: Observations of inorganic bromine (HOBr, BrO, and Br-2) speciation at Barrow, Alaska, in spring 2009, Journal of Geophysical Research-Atmospheres, 117, 10.1029/2011JD016641, 2012.

Lightfoot, P. D., Cox, R. A., Crowley, J. N., Destriau, M., Hayman, G. D., Jenkin, M. E., Moortgat, G. K., and Zabel, F.: Organic peroxy-radicals - kinetics, spectroscopy and tropospheric chemistry, Atmospheric Environment Part a-General Topics, 26, 1805-1961, 10.1016/0960-1686(92)90423-i, 1992.

Lurmann, F. W., Lloyd, A. C., and Atkinson, R.: A chemical mechanism for use in long-range transport acid deposition computer modeling, Journal of Geophysical Research-Atmospheres, 91, 905-936, 10.1029/JD091iD10p10905, 1986.

Mallard, W. G., Westley, F., Herron, J. T., Hampson, R. F., and Frizzel, D. H.: NIST Chemical Kinetics Database: Version 5.0 National Institute of Standards and Technology, Gaithersburg, MD. , 1993.

Michalowski, B., Francisco, J., Li, S., Barrie, L., Bottenheim, J., and Shepson, P.: A computer model study of multiphase chemistry in the Arctic boundary layer during polar sunrise, Journal of Geophysical Research-Atmospheres, 105, 15131-15145, 10.1029/2000JD900004, 2000.

Nicovich, J. M., and Wine, P. H.: Kinetics of the reactions of O(3P) and Cl(2P) with HBr and Br2, International Journal of Chemical Kinetics, 22, 379-397, 10.1002/kin.550220406, 1990.

Orlando, J. J., and Tyndall, G. S.: Rate coefficients for the thermal decomposition of BrONO2 and the heat of formation of BrONO2, Journal of Physical Chemistry, 100, 19398-19405, 10.1021/jp9620274, 1996.

Orlando, J. J., and Burkholder, J. B.: Identification of BrONO as the major product in the gas-phase reaction of Br with NO2, Journal of Physical Chemistry A, 104, 2048-2053, 10.1021/jp993713g, 2000.

Pohler, D., Vogel, L., Friess, U., and Platt, U.: Observation of halogen species in the Amundsen Gulf, Arctic, by active long-path differential optical absorption spectroscopy, Proceedings of the National Academy of Sciences of the United States of America, 107, 6582-6587, 10.1073/pnas.0912231107, 2010.

Ravishankara, A. R., Smith, G. J., and Davis, D. D.: A kinetics study of the reaction of Cl with NO_2, International Journal of Chemical Kinetics, 20, 811-814, 10.1002/kin.550201005, 1988.

Ravishankara, A. R., Dunlea, E. J., Blitz, M. A., Dillon, T. J., Heard, D. E., Pilling, M. J., Strekowski, R. S., Nicovich, J. M., and Wine, P. H.: Redetermination of the rate coefficient for the reaction of O(D-1) with N-2, Geophysical Research Letters, 29, 4, 10.1029/2002gl014850, 2002.

Ridley, B. A., Grahek, F. E., and Walega, J. G.: A small, high-sensitivity, medium-response ozone detector suitable for measurements from light aircraft, Journal of Atmospheric and Oceanic Technology, 9, 142-148, 10.1175/1520-0426(1992)009<0142:ashsmr>2.0.co;2, 1992.

Roberts, J. M., Osthoff, H. D., Brown, S. S., and Ravishankara, A. R.: N2O5 oxidizes chloride to Cl-2 in acidic atmospheric aerosol, Science, 321, 1059-1059, 10.1126/science.1158777, 2008.

Russo, R. S., Zhou, Y., White, M. L., Mao, H., Talbot, R., and Sive, B. C.: Multi-year (2004-2008) record of nonmethane hydrocarbons and halocarbons in New England: seasonal variations and regional sources, Atmospheric Chemistry and Physics, 10, 4909-4929, 10.5194/acp-10-4909-2010, 2010.

Ryerson, T. B., Williams, E. J., and Fehsenfeld, F. C.: An efficient photolysis system for fast-response NO2 measurements, Journal of Geophysical Research-Atmospheres, 105, 26447-26461, 10.1029/2000jd900389, 2000.

Sander, R., and Crutzen, P. J.: Model study indicating halogen activation and ozone destruction in polluted air masses transported to the sea, Journal of Geophysical Research-Atmospheres, 101, 9121-9138, 10.1029/95jd03793, 1996.

Sander, R., Vogt, R., Harris, G., and Crutzen, P.: Modeling the chemistry ozone, halogen compounds, and hydrocarbons in the arctic troposphere during spring, Tellus Series B-Chemical and Physical Meteorology, 49, 522-532, 10.1034/j.1600-0889.49.issue5.8.x, 1997.

Sander, S. P., Golden, D., Kurylo, M., Moortgat, G., Wine, P., Ravishankara, A., Kolb, C., Molina, M., Finlayson-Pitts, B., and Huie, R.: Chemical kinetics and photochemical data for use in atmospheric studies evaluation number 15 2006.

Scheffler, D., Grothe, H., Willner, H., Frenzel, A., and Zetzsch, C.: Properties of pure nitryl bromide. Thermal behavior, UV/Vs and FTIR spectra, and photoisomerization to trans-BrONO in an argon matrix, Inorganic Chemistry, 36, 335-338, 10.1021/ic9606946, 1997.

Schweitzer, F., Mirabel, P., and George, C.: Multiphase chemistry of N2O5, ClNO2, and BrNO2, Journal of Physical Chemistry A, 102, 3942-3952, 10.1021/jp980748s, 1998.

Shetter, R. E., and Muller, M.: Photolysis frequency measurements using actinic flux spectroradiometry during the PEM-Tropics mission: Instrumentation description and some results, Journal of Geophysical Research-Atmospheres, 104, 5647-5661, 10.1029/98jd01381, 1999.

Tsalkani, N., Mellouki, A., Poulet, G., Toupance, G., and Lebras, G.: Rate constants measurements for the reactions of OH and Cl with peroxyacetyl nitrate at 298 K, Journal of Atmospheric Chemistry, 7, 409-419, 10.1007/bf00058713, 1988.

Tyndall, G. S., Orlando, J. J., Wallington, T. J., Dill, M., and Kaiser, E. W.: Kinetics and mechanisms of the reactions of chlorine atoms with ethane, propane, and n-butane, International Journal of Chemical Kinetics, 29, 43-55, 1997.

Vakhtin, A. B., Murphy, J. E., and Leone, S. R.: Low-temperature kinetics of reactions of OH radical with ethene, propene, and 1-butene, Journal of Physical Chemistry A, 107, 10055-10062, 10.1021/jp030230a, 2003.

Villena, G., Wiesen, P., Cantrell, C., Flocke, F., Fried, A., Hall, S., Hornbrook, R., Knapp, D., Kosciuch, E., Mauldin, R., McGrath, J., Montzka, D., Richter, D., Ullmann, K., Walega, J., Weibring, P., Weinheimer, A., Staebler, R., Liao, J., Huey, L., and Kleffmann, J.: Nitrous acid

(HONO) during polar spring in Barrow, Alaska: A net source of OH radicals?, Journal of Geophysical Research-Atmospheres, 116, 10.1029/2011JD016643, 2011.

Wallington, T. J., Skewes, L. M., Siegl, W. O., Wu, C. H., and Japar, S. M.: Gas phase reaction of Cl atoms with a series of oxygenated organic species at 295 K, International Journal of Chemical Kinetics, 20, 867-875, 10.1002/kin.550201105, 1988.

Wallington, T. J., Skewes, L. M., Siegl, W. O., and Japar, S. M.: A relative rate study of the reaction of bromine atoms with a variety of organic compounds at 295 K, International Journal of Chemical Kinetics, 21, 1069-1076, 10.1002/kin.550211108, 1989.

Wang, T. X., Kelley, M. D., Cooper, J. N., Beckwith, R. C., and Margerum, D. W.: Equilibrium, Kinetic, and UV-Spectral Characteristics of Aqueous Bromine Chloride, Bromine, and Chlorine Species, Inorganic Chemistry, 33, 5872-5878, 10.1021/ic00103a040, 1994.

Wang, T. X., and Margerum, D. W.: Kinetics of Reversible Chlorine Hydrolysis: Temperature Dependence and General-Acid/Base-Assisted Mechanisms, Inorganic Chemistry, 33, 1050-1055, 10.1021/ic00084a014, 1994.

Weinheimer, A. J., Montzka, D. D., Campos, T. L., Walega, J. G., Ridley, B. A., Donnelly, S. G., Keim, E. R., Del Negro, L. A., Proffitt, M. H., Margitan, J. J., Boering, K. A., Andrews, A. E., Daube, B. C., Wofsy, S. C., Anderson, B. E., Collins, J. E., Sachse, G. W., Vay, S. A., Elkins, J. W., Wamsley, P. R., Atlas, E. L., Flocke, F., Schauffler, S., Webster, C. R., May, R. D., Loewenstein, M., Podolske, J. R., Bui, T. P., Chan, K. R., Bowen, S. W., Schoeberl, M. R., Lait, L. R., and Newman, P. A.: Comparison between DC-8 and ER-2 species measurements in the tropical middle troposphere: NO, NOy, O-3, CO2, CH4, and N2O, Journal of Geophysical Research-Atmospheres, 103, 22087-22096, 10.1029/98jd01421, 1998.

Wine, P. H., Wells, J. R., and Nicovich, J. M.: Kinetics of the reaction of F(2P) and Cl(2P) with HNO_3, Journal of Physical Chemistry, 92, 2223-2228, 10.1021/j100319a028, 1988.