Supplement to '3D simulations of tropospheric ozone depletion events using WRF-Chem'

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A Chemistry mechanism extensions

A.1 Gas phase halogen reactions added to the MOZART-4 mechanism

Table S1: Additional gas phase halogen reactions

# Reac.	Reaction	$k \left[(\text{molec. cm}^{-3})^{1-n} \text{s}^{-1} \right]$	Reference
1	$\text{O}_3 + \text{Br} \rightarrow \text{O}_2 + \text{BrO}$	$1.7 \times 10^{-11} \exp(-800/T)$	Atkinson et al. (2007)
2	$2\text{BrO} \rightarrow 2\text{Br} + \text{O}_2$	2.7×10^{-12}	Atkinson et al. (2007)
3	$2\text{BrO} \rightarrow \text{Br}_2 + \text{O}_2$	$2.9 \times 10^{-14} \exp(840/T)$	Atkinson et al. (2007)
4	$\text{BrO} + \text{HO}_2 \rightarrow \text{HOBr} + \text{O}_2$	$4.5 \times 10^{-12} \exp(500/T)$	Atkinson et al. (2007)
5	$\text{Br} + \text{HO}_2 \rightarrow \text{HBr} + \text{O}_2$	$7.7 \times 10^{-12} \exp(-450/T)$	Atkinson et al. (2007)
6	$\text{Br} + \text{CH}_2\text{O} \xrightarrow{\text{O}_2} \text{HBr} + \text{CO} + \text{HO}_2$	$7.7 \times 10^{-12} \exp(-580/T)$	Atkinson et al. (2007)
7	$\text{Br} + \text{C}_2\text{H}_2 \xrightarrow{3\text{O}_2} \text{Br} + 2\text{CO} + 2\text{HO}_2$	4.2×10^{-14}	Borken (1996)
8	$\text{Br} + \text{C}_2\text{H}_2 \xrightarrow{2\text{O}_2} \text{HBr} + 2\text{CO} + \text{HO}_2$	8.92×10^{-14}	Borken (1996)
9	$\text{Br} + \text{C}_2\text{H}_4\text{O} \xrightarrow{\text{O}_2} \text{HBr} + \text{CH}_3\text{CO}_3$	$1.8 \times 10^{-11} \exp(-460/T)$	Atkinson et al. (2007)
10	$\text{Br}_2 + \text{OH} \rightarrow \text{HOBr} + \text{Br}$	$2.0 \times 10^{-11} \exp(240/T)$	Atkinson et al. (2007)
11	$\text{HBr} + \text{OH} \rightarrow \text{Br} + \text{H}_2\text{O}$	$6.7 \times 10^{-12} \exp(155/T)$	Atkinson et al. (2007)
12	$\text{Br} + \text{C}_2\text{H}_4 \xrightarrow{3.5\text{O}_2} \text{Br} + 2\text{CO} + \text{H}_2\text{O} + 2\text{HO}_2$	2.53×10^{-13}	Barnes et al. (1993)
13	$\text{Br} + \text{C}_2\text{H}_4 \xrightarrow{2.5\text{O}_2} \text{HBr} + 2\text{CO} + \text{H}_2\text{O} + \text{HO}_2$	5.34×10^{-13}	Barnes et al. (1993)
14	$\text{BrO} + \text{CH}_3\text{O}_2 \rightarrow \text{HOBr} + \text{OH} + \text{HO}_2 + \text{CO}$	$2.4 \times 10^{-14} \exp(1617/T)$	Atkinson et al. (2007)
15	$\text{HOBr} + \text{O}(^3\text{P}) \rightarrow \text{BrO} + \text{O}_2$	$1.2 \times 10^{-10} \exp(-430/T)$	Nesbitt et al. (1995)
16	$\text{NO}_3 + \text{Br} \rightarrow \text{NO}_2 + \text{BrO}$	1.6×10^{-11}	Atkinson et al. (2007)
17	$\text{NO}_2 + \text{BrO} + \text{M} \rightarrow \text{BrONO}_2 + \text{M}$	$k_0 = 4.7 \times 10^{-31} (T/300)^{-3.1} [\text{N}_2]$	Atkinson et al. (2007)

# Reac.	Reaction	$k \left[(\text{molec. cm}^{-3})^{1-n} \text{s}^{-1} \right]$	Reference
		$k_{\infty} = 1.8 \times 10^{-11}$ $F_c = 0.4$	
18	$\text{NO} + \text{BrO} \rightarrow \text{NO}_2 + \text{Br}$	$8.7 \times 10^{-12} \exp(260/T)$	Atkinson et al. (2007)
19	$\text{HOCl} + \text{O}(^3\text{P}) \rightarrow \text{ClO} + \text{OH}$	1.7×10^{-13}	Atkinson et al. (2007)
20	$\text{ClO} + \text{O}(^3\text{P}) \rightarrow \text{Cl} + \text{O}_2$	$2.5 \times 10^{-11} \exp(110/T)$	Atkinson et al. (2007)
21	$\text{OCIO} + \text{O}(^3\text{P}) \rightarrow \text{ClO} + \text{O}_2$	$2.4 \times 10^{-12} \exp(-960/T)$	Atkinson et al. (2007)
22	$\text{ClONO}_2 + \text{O}(^3\text{P}) \rightarrow 0.5\text{ClO} +$ $0.5\text{NO}_3 + 0.5\text{OCIO} + 0.5\text{NO}_2$	$4.5 \times 10^{-12} \exp(-900/T)$	Atkinson et al. (2007)
23	$\text{Cl} + \text{HO}_2 \rightarrow \text{HCl} + \text{O}_2$	3.4×10^{-11}	Atkinson et al. (2007)
24	$\text{Cl} + \text{HO}_2 \rightarrow \text{ClO} + \text{OH}$	$6.3 \times 10^{-11} \exp(-570/T)$	Atkinson et al. (2007)
25	$\text{Cl} + \text{H}_2\text{O}_2 \rightarrow \text{HCl} + \text{HO}_2$	$1.1 \times 10^{-11} \exp(-980/T)$	Atkinson et al. (2007)
26	$\text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2$	$2.8 \times 10^{-11} \exp(-250/T)$	Atkinson et al. (2007)
27	$\text{Cl} + \text{HNO}_3 \rightarrow \text{HCl} + \text{NO}_3$	2.0×10^{-16}	Atkinson et al. (2007)
28	$\text{Cl} + \text{NO}_3 \rightarrow \text{ClO} + \text{NO}_2$	2.4×10^{-11}	Atkinson et al. (2007)
29	$\text{Cl} + \text{OCIO} \rightarrow 2\text{ClO}$	$3.2 \times 10^{-11} \exp(170/T)$	DeMore et al. (1997)
30	$\text{Cl} + \text{ClONO}_2 \rightarrow \text{Cl}_2 + \text{NO}_3$	$6.2 \times 10^{-12} \exp(145/T)$	Atkinson et al. (2007)
31	$\text{Cl}_2 + \text{OH} \rightarrow \text{Cl} + \text{HOCl}$	$3.6 \times 10^{-12} \exp(-1,200/T)$	Atkinson et al. (2007)
32	$\text{HCl} + \text{OH} \rightarrow \text{Cl} + \text{H}_2\text{O}$	$1.7 \times 10^{-12} \exp(-230/T)$	Atkinson et al. (2007)
33	$\text{HOCl} + \text{OH} \rightarrow \text{ClO} + \text{H}_2\text{O}$	5.0×10^{-13}	Atkinson et al. (2007)
34	$\text{ClO} + \text{OH} \rightarrow 0.94\text{Cl} +$ $0.94\text{HO}_2 + 0.06\text{HCl} + 0.06\text{O}_2$	$7.3 \times 10^{-12} \exp(300/T)$	Atkinson et al. (2007)
35	$\text{OCIO} + \text{OH} \rightarrow \text{HOCl} + \text{O}_2$	$1.4 \times 10^{-12} \exp(600/T)$	Atkinson et al. (2007)
36	$\text{ClONO}_2 + \text{OH} \rightarrow \text{HOCl} + \text{NO}_3$	$1.2 \times 10^{-12} \exp(-330/T)$	Atkinson et al. (2007)
37	$\text{HCl} + \text{NO}_3 \rightarrow \text{Cl} + \text{HNO}_3$	5.0×10^{-17}	Atkinson et al. (2007)
38	$\text{ClO} + \text{HO}_2 \rightarrow \text{HOCl} + \text{O}_2$	$2.2 \times 10^{-12} \exp(340/T)$	Atkinson et al. (2007)
39	$\text{ClO} + \text{O}_3 \rightarrow 0.06\text{OCIO} + 0.96\text{OCIO} + \text{O}_2$	1.6×10^{-17}	Atkinson et al. (2007)
40	$\text{ClO} + \text{NO} \rightarrow \text{Cl} + \text{NO}_2$	$6.2 \times 10^{-12} \exp(295/T)$	Atkinson et al. (2007)
41	$\text{ClO} + \text{NO}_2 + \text{M} \rightarrow \text{ClONO}_2 + \text{M}$	$k_0 = 1.6 \times 10^{-31} (T/300)^{-3.4} [\text{N}_2]$ $k_{\infty} = 7.0 \times 10^{-11}$ $F_c = 0.4$	Atkinson et al. (2007)
42	$\text{ClO} + \text{NO}_3 \rightarrow$ $0.74\text{ClOO} + 0.26\text{OCIO} + \text{NO}_2$	4.6×10^{-13}	Atkinson et al. (2007)
43	$2\text{ClO} \rightarrow \text{Cl}_2 + \text{O}_2$	$10^{-12} \exp(-1,590/T)$	Atkinson et al. (2007)

# Reac.	Reaction	$k \left[(\text{molec. cm}^{-3})^{1-n} \text{s}^{-1} \right]$	Reference
44	$2\text{ClO} \rightarrow \text{Cl} + \text{ClOO}$	$3.0 \times 10^{-11} \exp(-2,450/T)$	Atkinson et al. (2007)
45	$2\text{ClO} \rightarrow \text{Cl} + \text{OCIO}$	$3.5 \times 10^{-13} \exp(-1,370/T)$	Atkinson et al. (2007)
46	$2\text{ClO} + \text{M} \rightarrow \text{Cl}_2\text{O}_2 + \text{M}$	$k_0 = 2.0 \times 10^{-32} (T/300)^{-4.0} [\text{N}_2]$ $k_\infty = 10^{-11}$ $F_c = 0.45$	Atkinson et al. (2007)
47	$\text{Cl}_2\text{O}_2 + \text{M} \rightarrow 2\text{ClO} + \text{M}$	$k_0 = 3.7 \times 10^{-7} \times \exp(-7,690/T) [\text{N}_2]$ $k_\infty = 7.9 \times 10^{15} \exp(-8,820/T)$ $F_c = 0.45$	Atkinson et al. (2007)
48	$\text{OCIO} + \text{NO} \rightarrow \text{ClO} + \text{NO}_2$	$1.1 \times 10^{-13} \exp(350/T)$	Atkinson et al. (2007)
49	$\text{OCIO} + \text{Br} \rightarrow \text{ClO} + \text{BrO}$	$2.7 \times 10^{-11} \exp(-1,300/T)$	Atkinson et al. (2007)
50	$\text{Cl}_2\text{O}_2 + \text{Br} \rightarrow \text{BrCl} + \text{ClOO}$	$5.9 \times 10^{-12} \exp(-170/T)$	Atkinson et al. (2007)
51	$\text{BrO} + \text{ClO} \rightarrow \text{Br} + \text{OCIO}$	$1.6 \times 10^{-12} \exp(430/T)$	Atkinson et al. (2007)
52	$\text{BrO} + \text{ClO} \rightarrow \text{Br} + \text{ClOO}$	$2.9 \times 10^{-12} \exp(220/T)$	Atkinson et al. (2007)
53	$\text{BrO} + \text{ClO} \rightarrow \text{BrCl} + \text{O}_2$	$5.8 \times 10^{-13} \exp(170/T)$	Atkinson et al. (2007)
54	$\text{BrCl} + \text{Cl} \rightarrow \text{Br} + \text{Cl}_2$	1.45×10^{-11}	Sander et al. (1997)
55	$\text{Br}_2 + \text{Cl} \rightarrow \text{Br} + \text{BrCl}$	$2.3 \times 10^{-10} \exp(135/T)$	Sander et al. (1997)
56	$\text{Br} + \text{BrCl} \rightarrow \text{Br}_2 + \text{Cl}$	3.3×10^{-15}	Sander et al. (1997)
57	$\text{Br} + \text{Cl}_2 \rightarrow \text{BrCl} + \text{Cl}$	1.1×10^{-15}	Sander et al. (1997)
58	$\text{Cl} + \text{CH}_4 \xrightarrow{\text{O}_2} \text{HCl} + \text{CH}_3\text{O}_2$	6.6×10^{-12}	Atkinson et al. (2006)
59	$\text{Cl} + \text{C}_2\text{H}_6 \rightarrow \text{HCl} + \text{C}_2\text{H}_5$	$8.3 \times 10^{-11} \exp(-100/T)$	Atkinson et al. (2006)
60	$\text{Cl} + \text{C}_3\text{H}_8 \xrightarrow{2.5\text{O}_2}$ $\text{HCl} + \text{C}_2\text{H}_5\text{O}_2 + \text{H}_2\text{O} + \text{CO}_2$	1.4×10^{-10}	Atkinson et al. (2006)
61	$\text{Cl} + \text{CH}_2\text{O} \xrightarrow{\text{O}_2} \text{HCl} + \text{CO} + \text{HO}_2$	$8.1 \times 10^{-11} \exp(-34/T)$	Atkinson et al. (2006)
62	$\text{Cl} + \text{C}_2\text{H}_4\text{O} \xrightarrow{\text{O}_2} \text{HCl} + \text{CH}_3\text{CO}_3$	8.0×10^{-11}	Atkinson et al. (2006)
63	$\text{Cl} + \text{CH}_3\text{O}_2\text{H} \rightarrow \text{HCl} + \text{C}_2\text{H}_4\text{O} + \text{OH}$	5.9×10^{-11}	Atkinson et al. (2006)
64	$\text{Cl} + \text{C}_2\text{H}_5\text{O}_2\text{H} \rightarrow \text{HCl} + \text{C}_2\text{H}_5\text{O}_2$	5.7×10^{-11}	Atkinson et al. (2006)
65	$\text{Cl} + \text{C}_2\text{H}_2 \xrightarrow{3\text{O}_2} \text{Cl} + 2\text{CO} + 2\text{HO}_2$	2.0×10^{-11}	Borken (1996)
66	$\text{Cl} + \text{C}_2\text{H}_2 \xrightarrow{2\text{O}_2} \text{HCl} + 2\text{CO} + \text{HO}_2$	4.24×10^{-11}	Borken (1996)
67	$\text{Cl} + \text{C}_2\text{H}_4 \xrightarrow{3.5\text{O}_2} \text{Cl} + 2\text{CO} + \text{H}_2\text{O} + 2\text{HO}_2$	$k_0 = 1.26 \times 10^{-29} \times (T/300)^{-3.3} [\text{N}_2]$ $k_\infty = 6.0 \times 10^{-10}$ $F_c = 0.4$	Atkinson et al. (2006)
68	$\text{Cl} + \text{C}_2\text{H}_4 \xrightarrow{2.5\text{O}_2} \text{HCl} + 2\text{CO} + \text{H}_2\text{O} + \text{HO}_2$	$k_0 = 5.92 \times 10^{-30}$ $\times (T/300)^{-3.3} [\text{N}_2]$	Atkinson et al. (2006)

# Reac.	Reaction	$k \left[(\text{molec. cm}^{-3})^{1-n} \text{s}^{-1} \right]$	Reference
		$k_{\infty} = 6.0 \times 10^{-10}$ $F_c = 0.4$	
69	$\text{Cl} + \text{O}_2 + \text{M} \rightarrow \text{ClOO} + \text{M}$	$1.4 \times 10^{-33} (T/300)^{-3.9} [\text{N}_2]$ $+ 1.6 \times 10^{-33} (T/300)^{-2.9} [\text{O}_2]$	Atkinson et al. (2007)
70	$\text{ClOO} + \text{M} \rightarrow \text{Cl} + \text{O}_2 + \text{M}$	$2.8 \times 10^{-10} \exp(-1,820/T) [\text{N}_2]$	Atkinson et al. (2007)
71	$\text{Cl} + \text{ClOO} \rightarrow 0.95\text{Cl}_2 + 0.95\text{O}_2 + 0.1\text{ClO}$	2.42×10^{-10}	DeMore et al. (1997)
72	$\text{ClO} + \text{CH}_3\text{O}_2 \rightarrow \text{Cl} + \text{CH}_2\text{O} + \text{HO}_2$	$1.8 \times 10^{-12} \exp(-600/T)$	Atkinson et al. (2006)
73	$\text{HBr}_{\text{aq,m}} + \text{HOBr}_{\text{aq,m}} \rightarrow \text{Br}_2$	$1.6 \times 10^{-5} \text{mol}^{-1} \text{s}^{-1}$	Sander and Crutzen (1996)

A.2 Additional photolysis reactions

Table S2. Additional photolysis reactions. Also given is the corresponding New TUV photolysis rate variable (Madronich et al., 2002)

Reaction	Photolysis rate variable
$\text{Br}_2 \rightarrow 2\text{Br}$	$j(\text{Pj_br2})$
$\text{BrO} \rightarrow \text{Br} + \text{O}$	$j(\text{Pj_bro})$
$\text{HOBr} \rightarrow \text{Br} + \text{OH}$	$j(\text{Pj_hobr})$
$\text{BrNO}_2 \rightarrow \text{Br} + \text{NO}_2$	$j(\text{Pj_brno2})$
$\text{BrONO}_2 \rightarrow 0.85\text{Br} + 0.85\text{NO}_3 + 0.15\text{BrO} + 0.15\text{NO}_2$	$j(\text{Pj_brono2_a}) + j(\text{Pj_brono2_b})$
$\text{BrCl} \rightarrow \text{Br} + \text{Cl}$	$j(\text{Pj_brcl})$
$\text{Cl}_2 \rightarrow 2\text{Cl}$	$j(\text{Pj_cl2})$
$\text{HOCl} \rightarrow \text{Cl} + \text{OH}$	$j(\text{Pj_hocl})$
$\text{ClO} \rightarrow \text{Cl} + \text{O}$	$j(\text{Pj_clo})$
$\text{ClONO}_2 \rightarrow 0.85\text{Cl} + 0.85\text{NO}_3 + 0.15\text{ClO} + 0.15\text{NO}_2$	$j(\text{Pj_clono2_a}) + j(\text{Pj_clono2_b})$
$\text{OCIO} \rightarrow \text{ClO} + \text{O}$	$j(\text{Pj_oclo})$
$\text{ClOO} \rightarrow \text{ClO} + \text{O}$	$j(\text{Pj_cloo})$
$\text{CHBr}_3 \xrightarrow{\text{O}_2} 2\text{Br} + \text{HBr} + \text{CO}_2$	$j(\text{Pj_chbr3})$
$\text{HCOBr} \rightarrow \text{Br} + \text{HO}_2 + \text{CO}$	$3.55 \times 10^{-4} j(\text{Pj_no2})$
$\text{CBr}_2\text{O} \rightarrow 2\text{Br} + \text{CO}$	$5.66 \times 10^{-5} j(\text{Pj_no2})$

- 5 HCOBr and CBr₂O are not implemented in the New TUV mechanism and are instead scaled with the NO₂ photolysis rate. The scaling factor is taken from the ratio of 24 h average photolysis rates reported by Toyota et al. (2014).

Table S3. Heterogenous reactions and dry depositions occurring on the ice/snow surface

Reaction/Dry deposition	Accommodation coefficient δ [-]
$\text{HBr} \rightarrow$	0.06
$\text{HOBr} \rightarrow a \text{ Br}_2 + b \text{ BrCl}$	0.06
$\text{HCl} \rightarrow$	0.06
$\text{BrONO}_2 \rightarrow \text{HOBr} + \text{HNO}_3$	0.06
$\text{N}_2\text{O}_5 \rightarrow \text{BrNO}_2 + \text{HNO}_3$	0.09
$\text{O}_3 \rightarrow \alpha \text{ Br}_2$	-

Table S4. Additional reactions on aerosols

Transfer reaction	Molar mass [g]	Molar volume [l mol^{-1}]	γ [-]	T_γ [K]
$\text{HBr} \rightarrow \text{HBr}_{\text{aq},m}$	80.91	30	0.03	3940
$\text{HOBr} \rightarrow \text{HOBr}_{\text{aq},m}$	96.911	39.2	0.5	0
$\text{BrONO}_2 \rightarrow \text{HOBr}_{\text{aq},m} + \text{HNO}_3$	141.01	60.9	0.063	0

A.3 Additional depositions and emissions

For ozone, the Wesely dry deposition scheme (Wesely, 1989) for the surface resistance R_{sfc} already implemented in WRF-Chem is used. The other species listed in Table S3 have their surface resistance overwritten with the formula (Herrmann et al., 2019)

$$R_{\text{sfc}} = \frac{4}{v_{\text{th}} \delta}, \quad (\text{S1})$$

where v_{th} is the thermal velocity. As described in section 2.4, emission probability of Br_2 and BrCl due to HOBr deposition depend on the type of surface and deposition rate of HBr and its aerosol forms. The emission probability of Br_2 due to HOBr deposition is:

$$a = \begin{cases} 1 & \text{on FY ice} \\ \min \left(1, \frac{F_{\text{d}}(\text{HBr}) + \sum_{m=1}^4 F_{\text{d}}(\text{HBr}_{\text{aq},m})}{F_{\text{d}}(\text{HOBr})} \right) & \text{on MY ice or snow} \end{cases} \quad (\text{S2})$$

with $0 \leq a \leq 1$ and $F_{\text{d}} \geq 0$. The emission probability of BrCl due to HOBr deposition is given by

$$b = \begin{cases} 0 & \text{on FY ice or snow} \\ 1 - a & \text{on MY ice} \end{cases} \quad (\text{S3})$$

A.4 Additional reactions on aerosols

The temperature dependence of the accommodation coefficient is given by

$$\gamma(T) = \left\{ 1 + (1/\gamma(T_0) - 1) \exp \left[-T_\gamma \left(\frac{1}{T} - \frac{1}{T_0} \right) \right] \right\}^{-1}, \quad (\text{S4})$$

where $T_0 = 298.15$ K.

B Vertical distribution of grid cells

Table S5 shows the vertical distribution of grid cells in the present model for a grid cell over sea ice in the center of the domain.

WRF-Chem uses an η coordinate, which is an idealized hydrostatic pressure profile mapped to values between zero and one.

- One corresponds to the ground level and zero to around 50 hPa or 20 km height. It should be noted that the height shown in the table is only an approximate value, since height is temperature dependent due to η being the actual vertical coordinate used by WRF-Chem.

C In-situ measurements at Utqiagvik

Figure S1 shows ozone mixing ratios at Utqiagvik for simulations 1, 2, 3, 4, and 6 in comparison with in-situ observations.

30 D Tropospheric BrO VCDs for simulations 4 and 6

In this section, the BrO VCDs for simulations 1-4 and 6 following Figs. 10 and 11 in the main text are shown.

Table S5. Grid cell number and corresponding η at the lower boundary of the cell as well as pressure and height at the center of the grid cell.

Grid cell number	η [-]	pressure [hPa]	height [m]	Grid cell number	η [-]	pressure [Pa]	height [m]
1	1.000	99.810	14	33	0.763	76.535	1,967
2	0.996	99.430	41	34	0.743	74.445	2,169
3	0.992	99.050	68	35	0.719	71.975	2,415
4	0.988	98.670	96	36	0.691	69.220	2,698
5	0.984	98.290	124	37	0.661	65.800	3,064
6	0.980	97.910	152	38	0.619	61.192	3,585
7	0.976	97.530	181	39	0.564	56.110	4,199
8	0.972	97.150	209	40	0.512	51.360	4,818
9	0.968	96.770	238	41	0.464	46.990	5,430
10	0.964	96.390	267	42	0.420	42.905	6,044
11	0.960	95.962	299	43	0.378	39.057	6,668
12	0.955	95.487	336	44	0.339	35.495	7,291
13	0.950	95.012	372	45	0.303	32.170	7,923
14	0.945	94.537	409	46	0.269	29.082	8,566
15	0.940	94.015	450	47	0.238	26.280	9,210
16	0.934	93.445	495	48	0.210	23.762	9,854
17	0.928	92.874	540	49	0.185	21.482	10,507
18	0.922	92.257	589	50	0.162	19.440	11,159
19	0.915	91.592	643	51	0.142	17.587	11,816
20	0.908	90.927	697	52	0.123	15.877	12,488
21	0.901	90.215	755	53	0.106	14.357	13,149
22	0.893	89.455	818	54	0.091	12.980	13,813
23	0.885	88.647	885	55	0.077	11.745	14,469
24	0.876	87.792	957	56	0.065	10.605	15,140
25	0.867	86.890	1,033	57	0.053	9.560	15,819
26	0.857	85.940	1,114	58	0.043	8.657	16,468
27	0.847	84.942	1,201	59	0.034	7.850	17,109
28	0.836	83.850	1,296	60	0.026	7.090	17,778
29	0.824	82.662	1,401	61	0.018	6.425	18,421
39	0.811	81.380	1,516	62	0.012	5.855	19,031
31	0.797	79.955	1,646	63	0.006	5.285	19,704
32	0.781	78.340	1,796

Figure S1. Ozone mixing ratios at Utqiagvik and at Summit and BrO mixing ratio at Summit. Figures a-c share the legend.

Figure S2. BrO VCDs on selected days in the year 2009. Left: Satellite measurements. Center: Simulation 4 ($\beta = 2$, no bromide oxidation due to ozone). Right: Simulation 6 ($\beta = 1.5$, no nudging).

Figure S3. BrO VCDs in the year 2009 averaged over one month. Left: Satellite measurements. Center: Simulation 4 ($\beta = 2$, no bromide oxidation due to ozone). Right: Simulation 6 ($\beta = 1.5$, no nudging).

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