Production and release of molecular bromine and chlorine from the Arctic coastal snowpack – Supporting Information

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This supporting information section includes 9 pages and 4 figures.

Experimental

Snow Collection and Measurements

Snow samples for ion chromatography analysis were collected in polyethylene bags using a polypropylene scoop. Before sampling the scoop was rinsed with methanol (ACS grade) and air dried. The sampler wore disposable gloves and remained downwind of the sampling site. The samples were maintained between -10 °C and -40 °C until they were melted for analysis; melted snow was analyzed within 24 h of melting. Melted snow samples (0.5 mL) were loaded into sterile single-use syringes and passed through a 0.2 µm filter. Cations were measured on a Dionex ICS-1100 system with an ultralow pressure trace cation concentrator column (TCC-ULP1, Dionex), a CG12A guard column (Dionex), and an CS12A analytical column (Dionex); methanesulfonic acid (20mM) was used as an eluent. Anions were measured on a Dionex ICS-2100 system with an ultralow pressure trace anion concentrator column (UTAC-ULP1, Dionex), a AG18 guard column (Dionex), and an AS18 analytical column (Dionex); a potassium hydroxide gradient generated by an EGC III KOH system was used as an eluent. Both the ICS-1100 and ICS 2100 systems use heated conductivity cells (DS6, Dionex) for detection.

Roughness Length Measurement

The roughness length z_0 employed in the calculation of eddy diffusivities was derived from sonic anemometer measurements made from 6 March to 15 April 2009 at a site near Utqiaġvik, AK (71.32388°N, 156.66266ºW).[1] Four sonic anemometers were mounted on a 10 m tower on booms facing the prevailing wind direction (60 degrees from true north). Data from the anemometer at 1.8 m above the snowpack (model CSAT3, Campbell Scientific Inc., Logan, UT, USA) were collected at 10 Hz on the three Cartesian wind components (u,v,w) and sonic temperature (θ_v). z_0

was calculated from data during conditions of near neutral stratification (|z/L| < 0.1) from the logarithmic wind profile equation:

$$U(z) = \frac{kz}{u_*}\ln(\frac{z}{z_0}) \quad \text{(S1)}$$

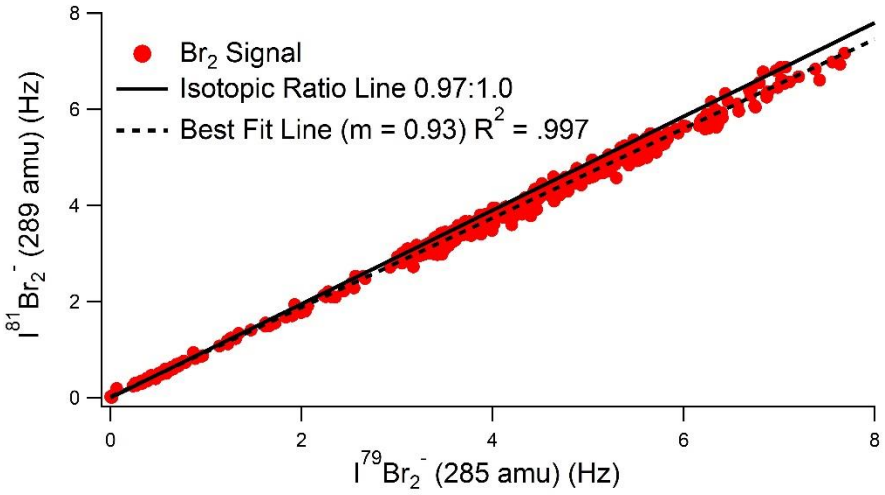
where U(z) is the wind speed at height z=1.8m, u_* is the friction velocity, defined as:

$$u_* = [(\overline{u'w'})^2 + (\overline{v'w'})^2]^{\frac{1}{4}} \quad \text{(S2)}$$

The Obukhov Length is defined as:

$$L = -\frac{u_*^3/k}{\frac{g}{\overline{\theta_v}}(\overline{w'\theta_v'})} \quad \text{(S3)}$$

The logarithmically averaged z_0 was 0.00019 ± 0.00001 m (standard error, n=1062).



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47 **Figure S1.** Isotopic ratio plot for Br_2 signals measured during an in-snowpack experiment on

48 February 11, 2014.

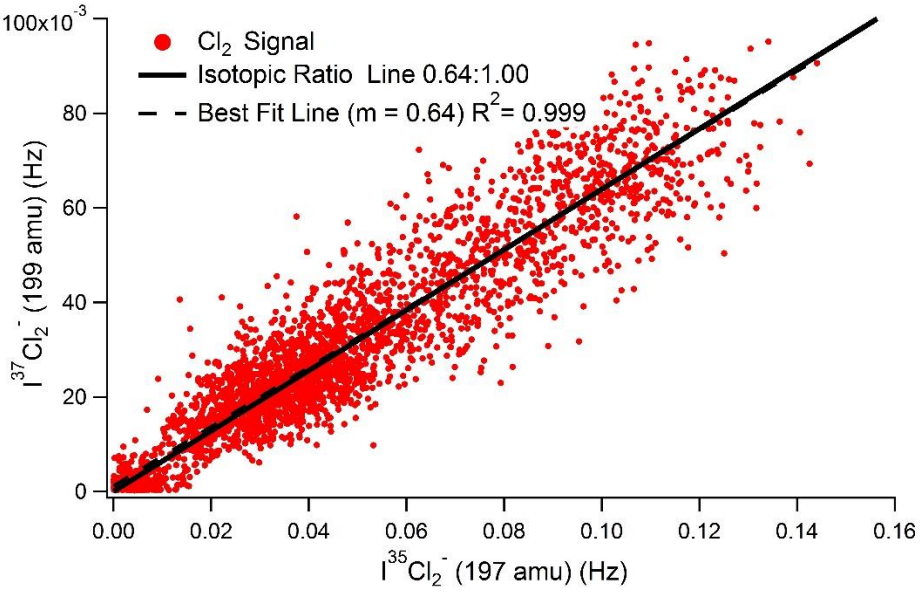

Figure S2. Isotopic ratio plot for Cl_2 signals measured during an in-snowpack experiment on February 11, 2014.

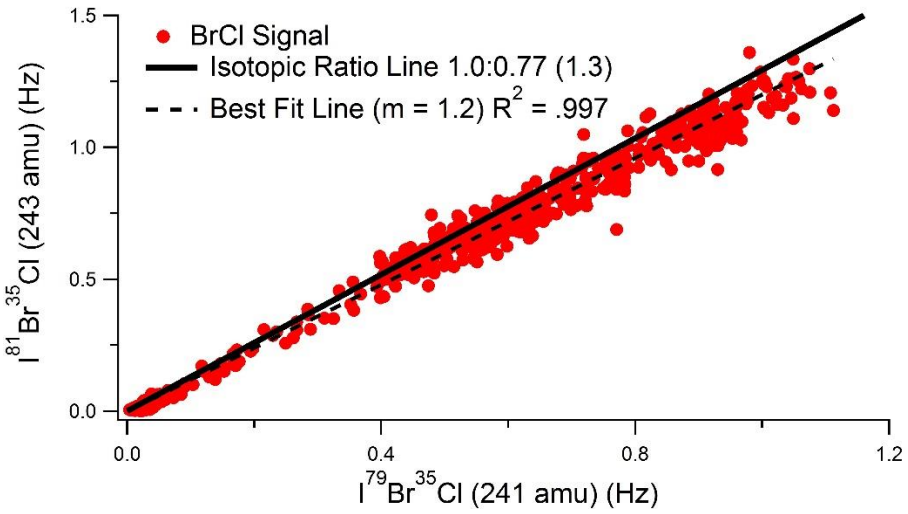

Figure S3. Isotopic ratio plot for BrCl signals during an in-snowpack experiment on February 11, 2014.

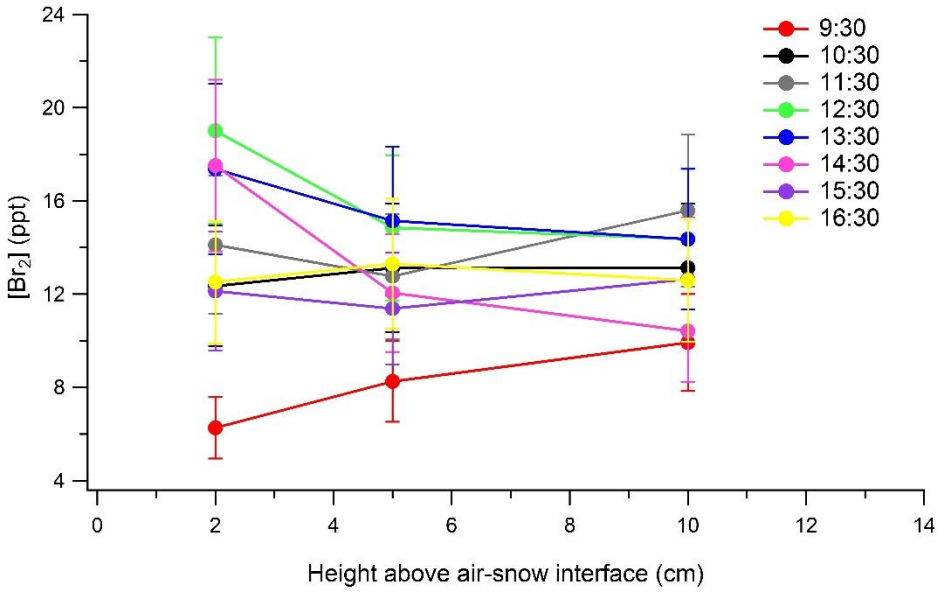

Figure S4. Br_2 vertical profile measurements on February 14, 2014 with the time (AKST) denoting the start of the vertical profile conducted at the height closest to the snow surface.

Table S1. Melted surface snow pH and inorganic ion concentrations during 2014 measurements near Utqiaġvik, Alaska**.**

Date	**pH**	**Cl^- (µM)**	**SO_4^- (µM)**	**Br^- (µM)**	**NO_3^- (µM)**	**Na^+ (µM)**	**K^+ (µM)**	**Mg^{2+} (µM)**	**Ca^{2+} (µM)**
Feb. 5, 2014	5.32± 0.01	574± 5	14.± 5	0.41± 0.08	7.22± 0.06	374± 2	15.8± 0.1	75.3± 0.7	16.6± 0.7
Feb. 23, 2014	5.46± 0.05	385± 1	14.1± 0.7	0.19± 0.03	8.6± 0.3	286± 22	9.7± 0.5	36.± 1	10.1± 0.8
Feb. 28, 2014	5.83± 0.08	378± 3	12.0± 0.8	0.24± 0.08	10.4± 0.3	279± 35	11.± 2	34.± 4	12.± 1

References

1. Boylan, P.; Helmig, D.; Staebler, R.; Turnipseed, A.; Fairall, C. W.; Neff, W., Boundary layer dynamics during the Ocean-Atmosphere-Sea Ice-Snow (OASIS) 2009 experiment at Barrow, AK. *J. Geophys. Res.* **2014,** *119*, 2261-2278.