SUPPLEMENTARY MATERIAL VOLCANICA

Supplementary Material 1 for: Spatial analysis of globally detected volcanic lightning from the June 2019 eruption of Raikoke volcano, Kuril Islands

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This Supplementary Material (Figure S1, Table S1, and Table S2) accompanies the article:

Smith, C. M., Van Eaton, A. R., Schneider, D. J., Mastin, L., Matoza, R. S., McKee, K. and Maher, S. (2022) "Spatial analysis of globally detected volcanic lightning from the June 2019 eruption of Raikoke volcano, Kuril Islands ", *Volcanica, 5*(2), pp. 385–395. doi: https://doi.org/10.30909/vol.05.02.385395.

Smith et al. [2022] should be cited if these data are used.

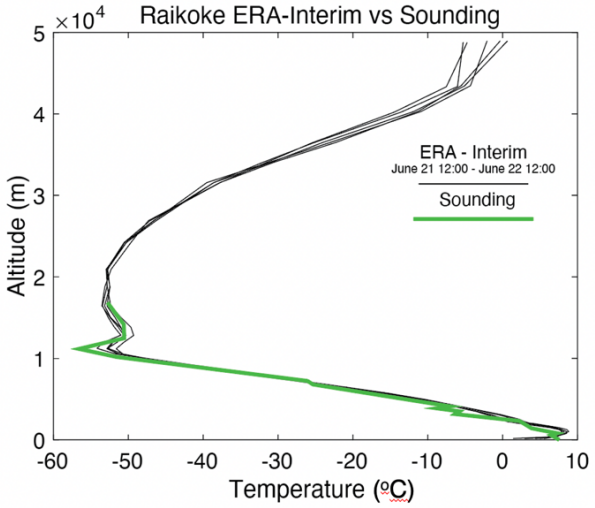

Figure S1: Comparison of atmospheric temperatures from the ERA-Interim reanalysis dataset interpolated over Raikoke volcano from 21–22 June 2019 and sounding measurements from Severo-Kurilsk at 00:00 UTC on 22 June 2019 (station number 32215, located ~340 km NE from Raikoke).

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Table S1: Observations and parameters from 1-D volcanic plume modeling using `Plumeria` for each of the eruptive pulses examined in this study. We did not model pulses 10 and 11. Other input parameters held constant for the plume modeling include a magma temperature of 1000 °C, magmatic water content of 2 wt.%, magma specific heat of 1000 J kg·K^{-1}, and (bubble-free) magma density of 2500 kg m^{-3}. We note that zero external water was added to the modeled plumes as a simplifying assumption.

Eruptive pulse #	Origin time of earliest infrasound signal*	First lightning stroke from GLD360	Min brightness temperature (°C)†	Max plume height, km asl‡	First signal	Time difference (mm:ss)
1	6/21/19 17:49:55	6/21/19 17:48:21	−44.9	9.5	lightning	01:34
2	6/21/19 18:49:10	6/21/19 18:48:04	−43.5	9.3	lightning	01:06
3	6/21/19 19:39:52	6/21/19 19:36:03	−48.5	10.1	lightning	03:49
4	6/21/19 20:34:07	6/21/19 20:46:13	−45.1	10.1	infrasound	12:06
5	6/21/19 21:08:25	6/21/19 21:12:15	−46.2	10.7	infrasound	03:50
6	6/21/19 21:54:40	6/21/19 22:00:58	−50.3	12.7	infrasound	06:18
7	6/21/19 22:28:58	6/21/19 22:28:56	−55.9	16.5	lightning	00:02
8	6/22/19 03:37:16	6/22/19 03:40:12	−51.0	13.0	infrasound	02:56
9	6/22/19 05:28:13	6/22/19 05:23:08	−50.9	12.4	lightning	05:05
10	6/22/19 06:54:25	6/22/19 06:53:47	−10.36	5.0	lightning	00:37
11	NA	6/22/19 09:52:45	−8.59	4.6	NA	NA

Eruptive pulse #	Low-level ash cloud visible?§	Modeled vent diameter (m)¶	Modeled exit velocity (m s^{-1})	Modeled height of ice formation (km asl)**	Number of lightning strokes in eruptive pulse
1	Yes	50	61	6.1	34
2	No	50	58	6.1	19
3	No	50	74	6.3	29
4	No	50	75	6.3	3
5	No	50	98	6.5	10
6	No	100	97	8.0	9
7	No	150	198	10.3	519
8	Yes	130	65	8.2	53
9	No	115	62	7.8	68
10	No	NA	NA	NA	7
11	No	NA	NA	NA	2

* Remote infrasound data from McKee et al. [2021] estimates the origin time of the signal from Raikoke volcano assuming constant celerity of 0.33 km s^{-1};
† Derived from the single coldest pixel within a bounding box in Himawari-8 channel 13 thermal Infrared brightness temperatures;
‡ Maximum plume height from each eruptive pulse estimated by matching the coldest temperature to a corresponding temperature in the atmospheric profile from ERA-Interim reanalysis interpolated over Raikoke volcano; asl = above sea level;
§ Evidence for low-level ash rising from ground-hugging pyroclastic density currents in Himawari-8 visible satellite images;
¶ Vent diameter (i.e. initial plume diameter) used as input to volcanic plume model runs using `Plumeria`;
** Height at which the plume initiates ice formation in `Plumeria` model runs.

Table S2: Volcanic lightning categories, shown as a proportion of the total strokes detected from the Raikoke eruption on 21–22 June 2019.

	Number	Percentage
total	753	100
positive IC	356	47
positive CG	82	11
negative IC	281	37
negative CG	34	5
total positive	438	58
total negative	315	42
total IC	637	85
total CG	116	15

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References

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