Seismic Eruption Catalog of Strokkur Geyser, Iceland

Eva P. S. Eibl[1,2] (eva.ps.eibl@hotmail.com), Sebastian Hainzl[2], Nele I. K. Vesely[1], Thomas R. Walter[2], Philippe Jousset[2], Gylfi P. Hersir[3], Torsten Dahm[2]

1: Institute of Geosciences, University of Potsdam, Karl-Liebknecht-Str. 24-25, 14476 Potsdam, Germany
2: GFZ German Research Centre for Geosciences, Telegrafenberg, 14473 Potsdam, Germany
3: ISOR, Reykjavik, Iceland

Time from 04:21:40 on 13 May 2018 (min)

1. Abstract

- We create a catalog of 73466 eruptions of Strokkur geyser, Iceland, from a 1 year seismic dataset.
- Eruptions are classified as single to sextuple eruptions.
- Single to sextuple eruptions are followed by a mean waiting time t_{after} of 3.7 to 16.4 min, respectively (linearly increasing).
- Single to sextuple eruptions are preceded by a mean waiting time t_{before} of 4 min.
- Waiting time after an eruption can be predicted, while future eruption type or amplitude cannot.

2. Field site and experiment
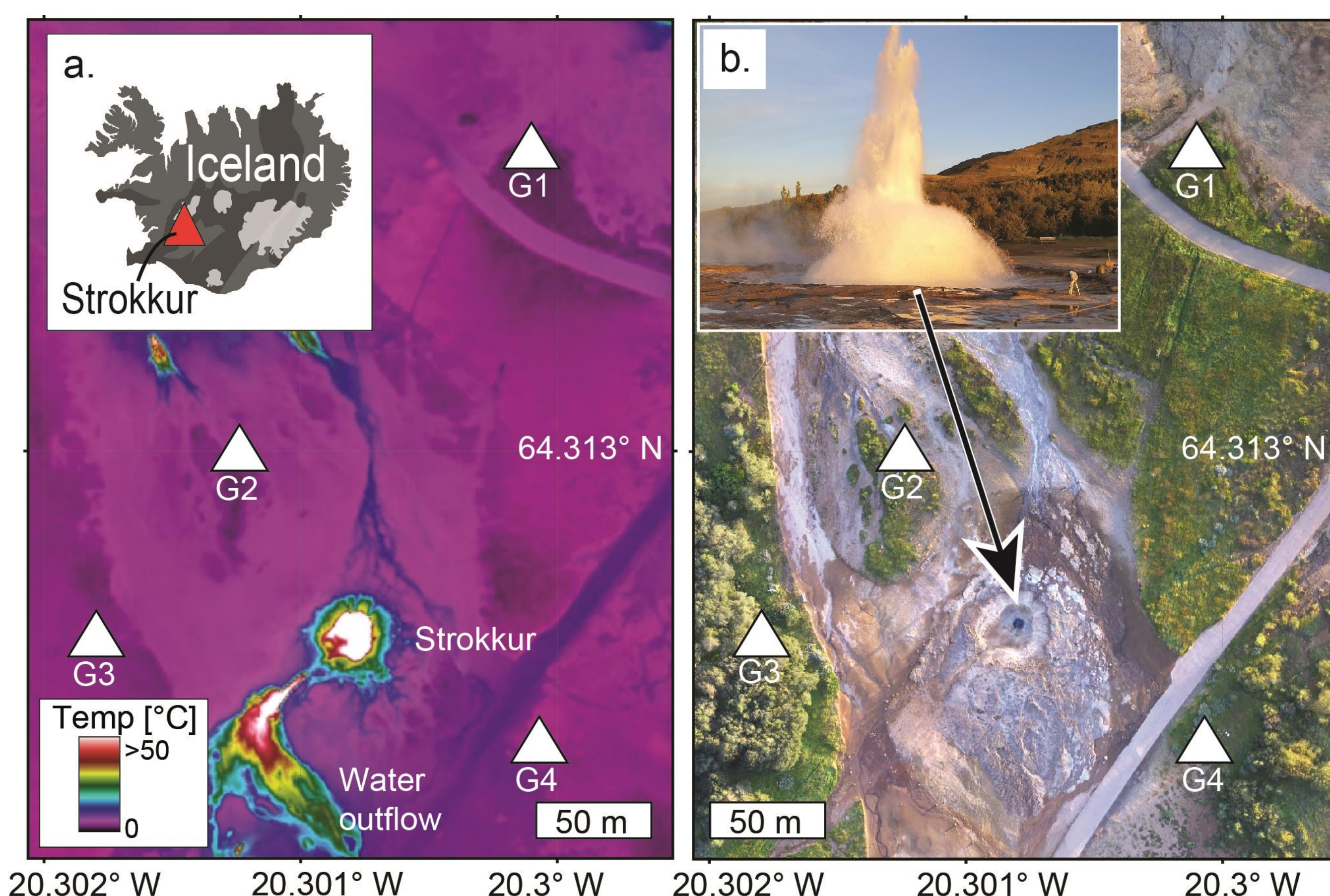
(a) Infrared aerial image of the geothermally active region around the geyser Strokkur showing the subaerial outflow channel to the southwest and the seismometer locations (white triangles). The inset shows the location in Iceland. (b) Aerial photo. The inset shows an eruption of Strokkur in progress.

3. Work flow
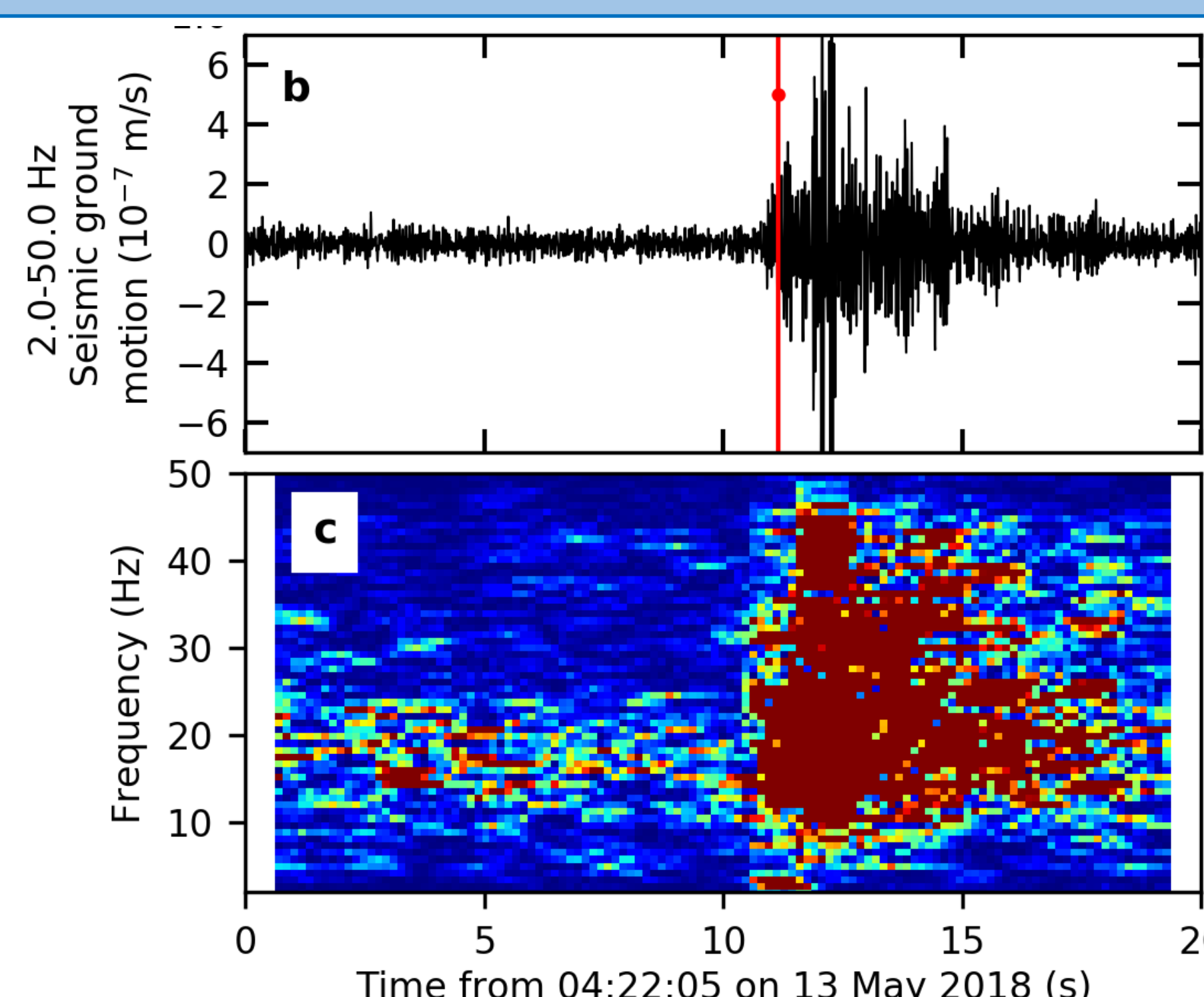
(b) Vertical seismogram of an eruption filtered 2-50 Hz. Picking time is marked with red dot & vertical line.
(c) Power spectral density spectrogram with a Fourier Transform window length of 1.28 s and 1.12 s overlap.

- Set marker at eruption (see 3)
- Calculate time between markers
- Classify eruptions as single to sextuple
- Distribution of times (see 4)
  - after a specific eruption type
  - before a specific eruption type
  - within a specific eruption type
- Statistics on (see 5)
  - times after a specific eruption type
  - times before a specific eruption type
  - times within a specific eruption type
  - seismic amplitude of eruptions
  - number of eruption
- Simulations (see 6)

4. Distribution of waiting time before & after single to sextuple eruptions

Example:

Let's assume the eruption sequence is:

single – 4 min – double – 6 min – single – 4 min – single – 4 min – triple – 9 min – – single – 4 min – double – 6 min

Looking at time AFTER an eruption this is sorted:
single: 4 min, 4 min, 4 min, 4 min
double: 6 min, 6 min
triple: 9 min
=> t_{after} is increasing

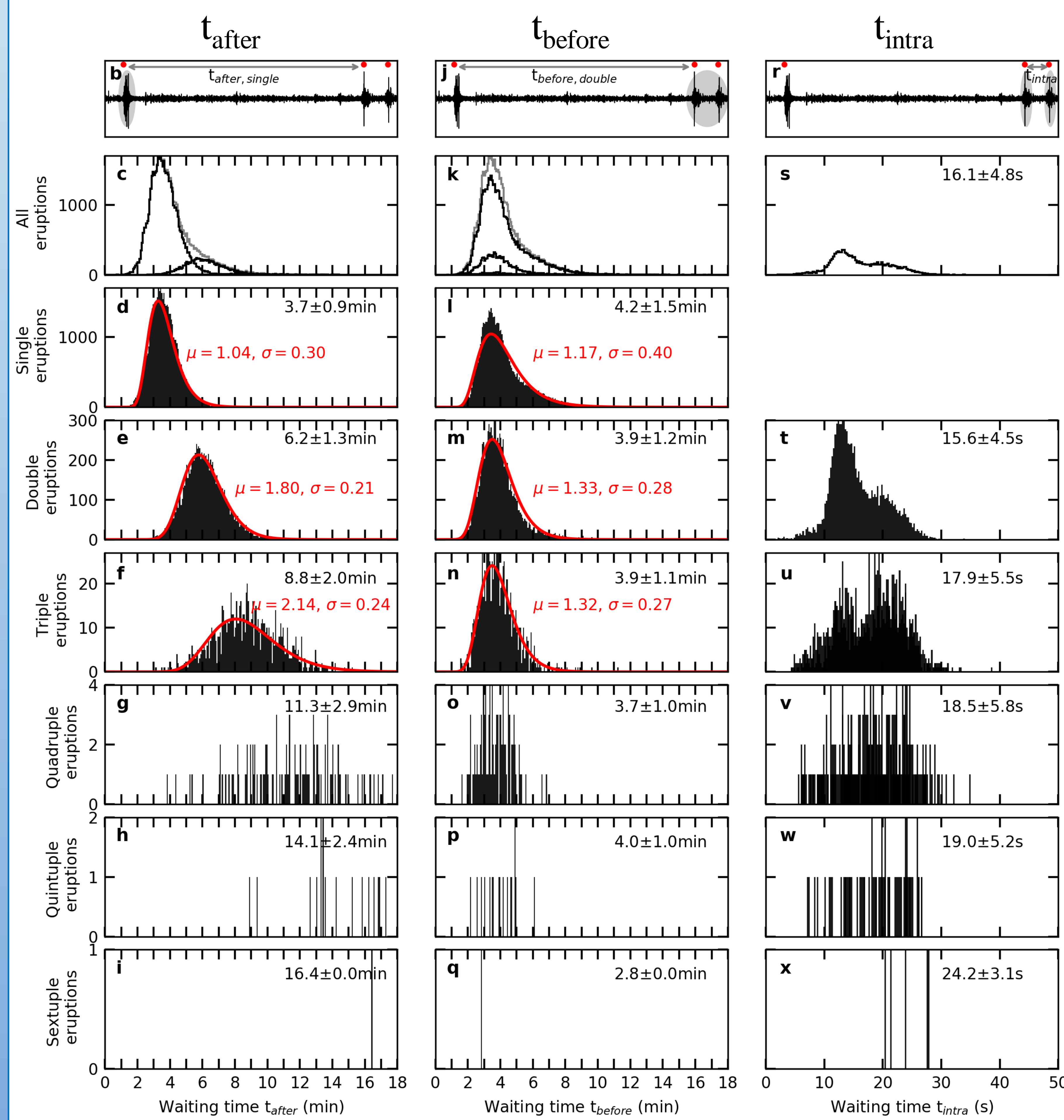Looking at time BEFORE an eruption this is sorted:
single: 6 min, 4 min, 9 min
double: 4 min, 4 min
triple: 4 min
=> no clear trend for t_{before}

Real data:

(b-i) t_{after} for each eruption type. Histograms: 4 s bins
(j-q) t_{before} for each eruption type. Histograms: 4 s bins
(r-x) t_{intra} for each eruption type. Histograms: 0.25 s bins

t_{after} increases from single (d) to sextuple eruptions (i).

t_{before} does not change significantly from single (l) to sextuple eruptions (q).

t_{intra} increases from double (t) to sextuple eruptions (x).

5. Mean Waiting Time & Amplitude Distribution
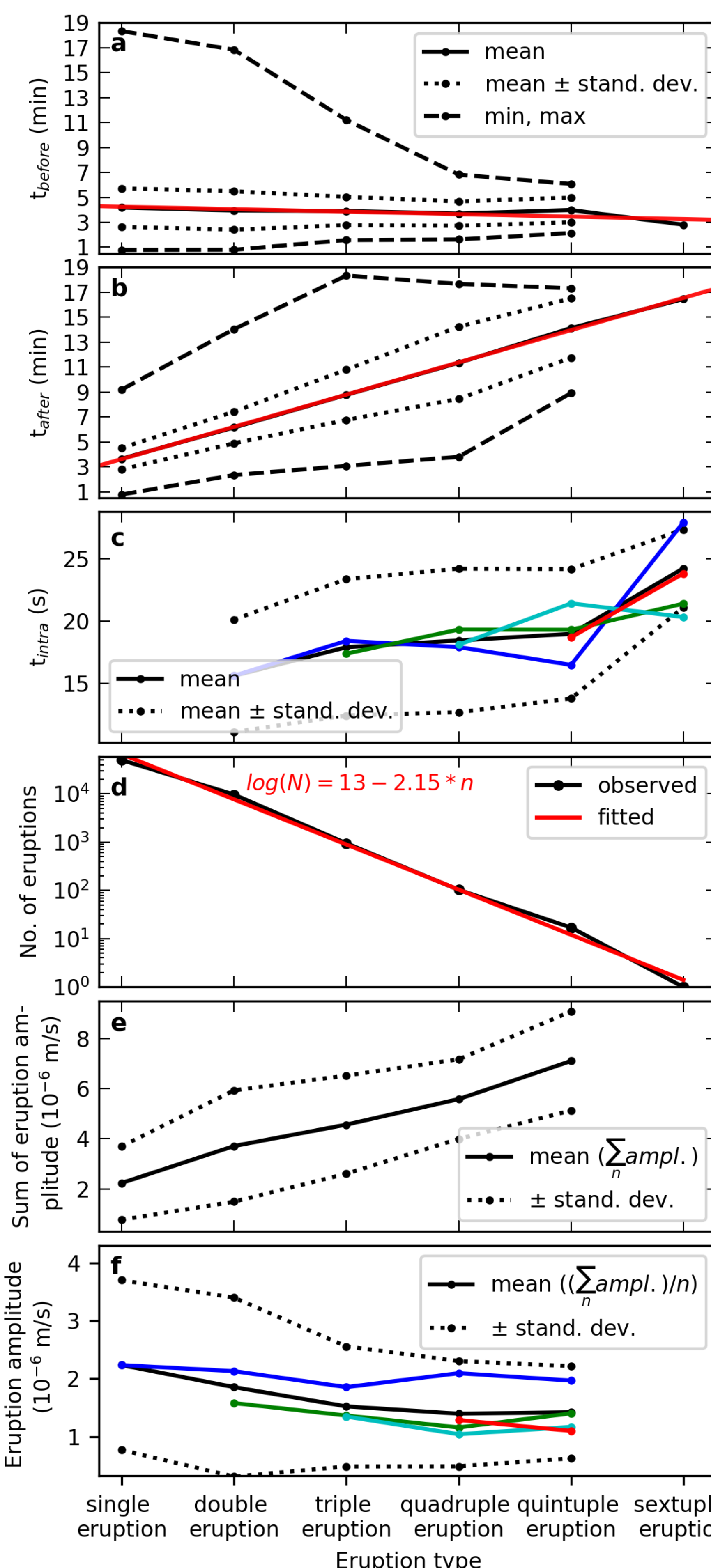
(a) t_{before} does not change significantly for different eruption types.

(b) t_{after} increases linearly from single to sextuple eruptions.

(c) t_{intra} increases from double to sextuple eruptions. Mean t_{intra} after first eruption (blue), second eruption (green), third eruption (cyan) and fourth eruption (red).

(d) Number of single to sextuple eruptions decreases exponentially.

(e) Sum of eruption amplitudes within single to sextuple eruptions at G4 increases.

(f) First events in a multi-tuple eruption are larger than the following events. However, first events are comparable in size. from single to sextuple eruptions.

6. Simulation

Model:

- Discharge (x) due to eruption proportional to number of bursts, sampled from log-normal distribution
- Reloading with constant recharging rate after fixed relaxation time
- Next eruption occurs when threshold is reached
- Consecutive bursts occur with constant probability
- Probability $p = \exp(-2.02)$

(g) Number of eruption types
(h) probability density function (PDF) of t_{after} with n = 1, 2, and 3 eruptions, where lines refer to the model result
(i) the mean ± one standard deviation of t_{after} for single to sextuple eruptions
The error bars in (g) and (h) refer to the standard deviation of the results for 100 simulations, while the bars in (i) refer to the standard deviation of the distribution of t_{after}

7. Reference:

https://tinyurl.com/mab6pen
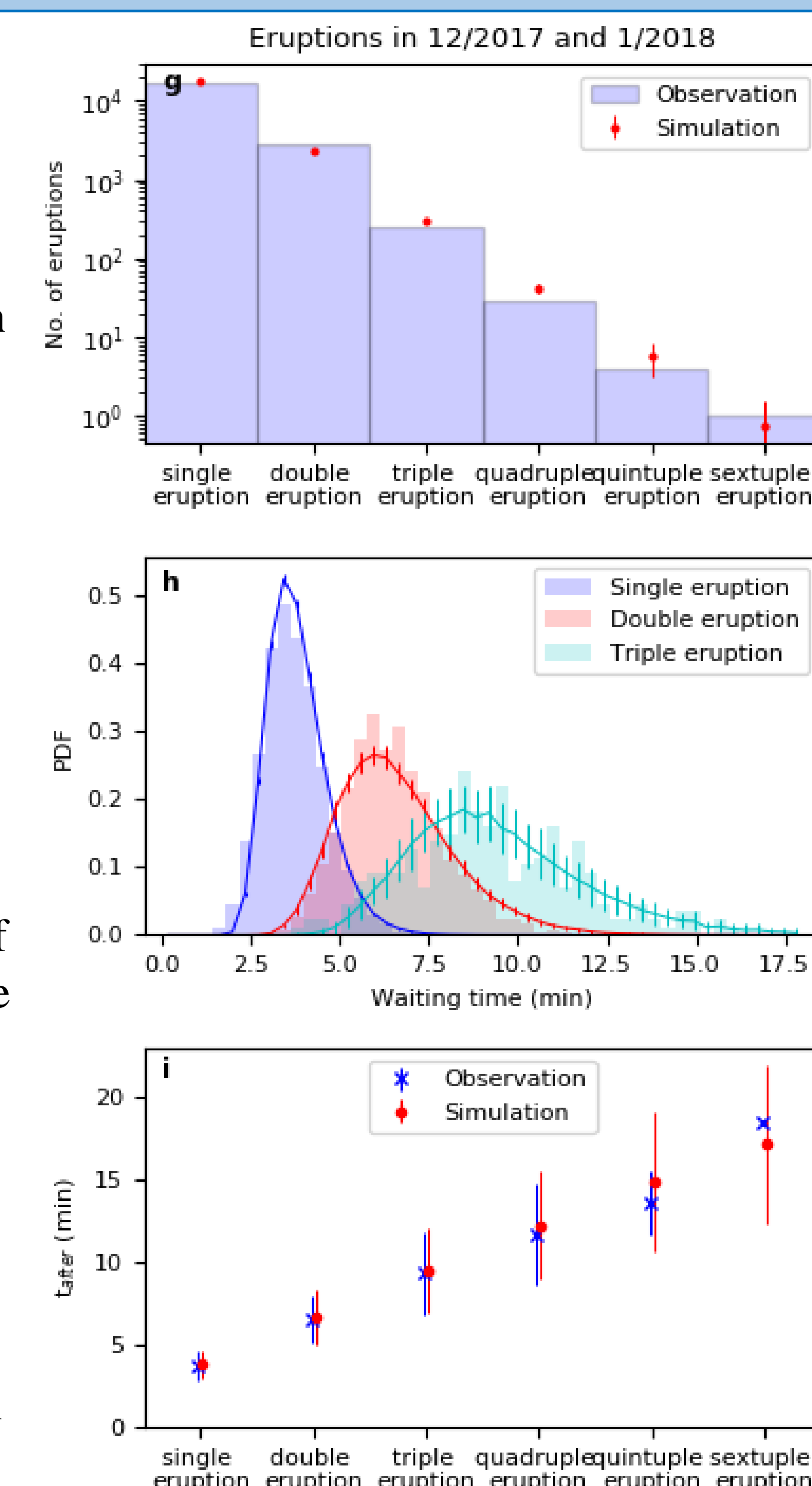
Eibl, E. P. S., Hainzl, S., Vesely, N. I. K., Walter, T. R., Jousset, P., Hersir, G. P., Dahm, T., (2020) Eruption Interval Monitoring at Strokkur Geyser, Iceland, *Geophysical Research Letters* 47, DOI: 10.1029/2019GL085266