European Geosciences Union
General Assembly 2020

EXTREMELY LOW FREQUENCY DETECTION OF ELECTRICAL DISCHARGES AT MINAMIDAKE CRATER (SAKURAJIMA VOLCANO, JAPAN)

Caron E.J. Vossen, Corrado Cimarelli, Alec Bennett, André Geisler, Damien Gaudin, Daisuke Miki, Masato Iguchi, Donald B. Dingwell

Check out the abstract at https://doi.org/10.5194/egusphere-egu2020-5298
Contact: caronvossen@gmail.com

How is volcanic lightning generated?

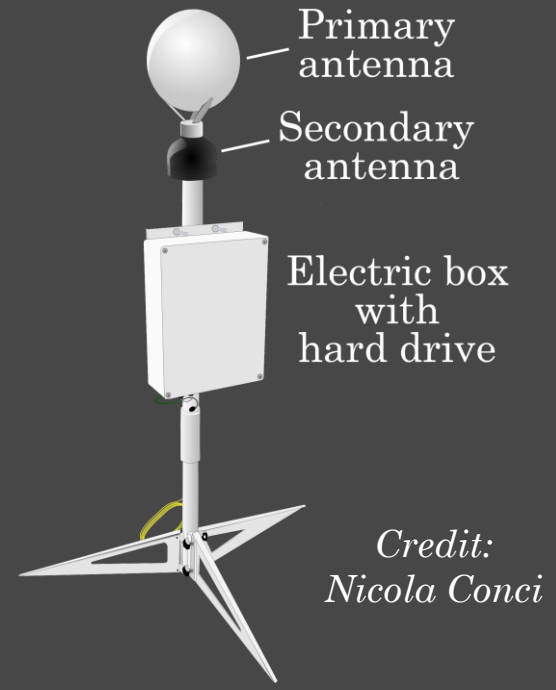
- Plume electrification is caused by charge separation as a result of:
  - Fracto-electrification (emission of charged species from freshly fractured surfaces)
  - Tribo-electrification (electron transfer through the collision of ash particles)
  - Ice nucleation/riming
  - Natural radioactivity

- If the breakdown voltage is exceeded, this will result in an electrical discharge.

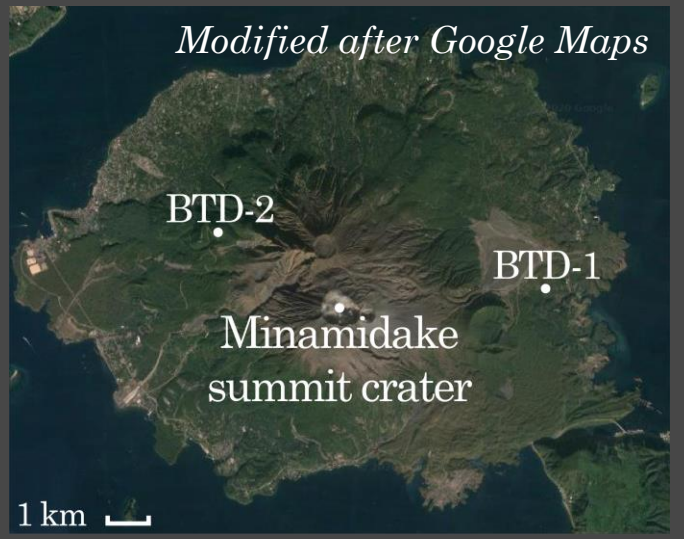
Credit: Martin Rietze and Hernando Rivera

Biral Thunderstorm Detector (BTD)

- Two prototypes of the BTD were installed at 3-4 km distance from Minamidake crater at Sakurajima volcano, Japan.
- Detects the change in electrostatic field, which is caused by charge neutralisation.
- Extremely low frequency range: 1-45 Hz
- Sample rate: 100 Hz



Credit: Nicola Conci



5 May, 2020

C. Vossen

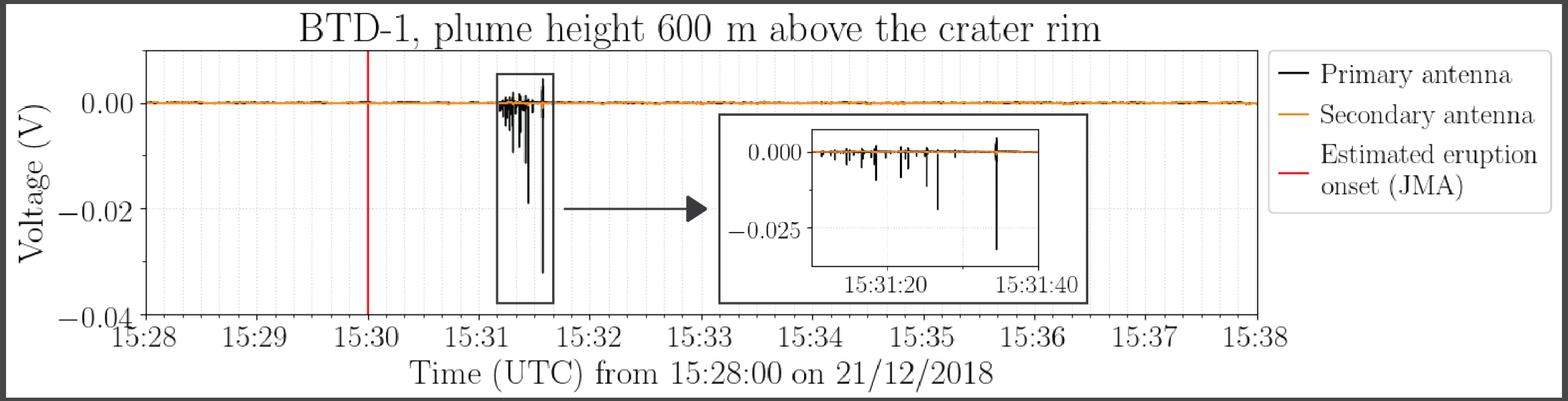
Data processing and analysis

- BTDs recorded between July 2018 – January 2020.

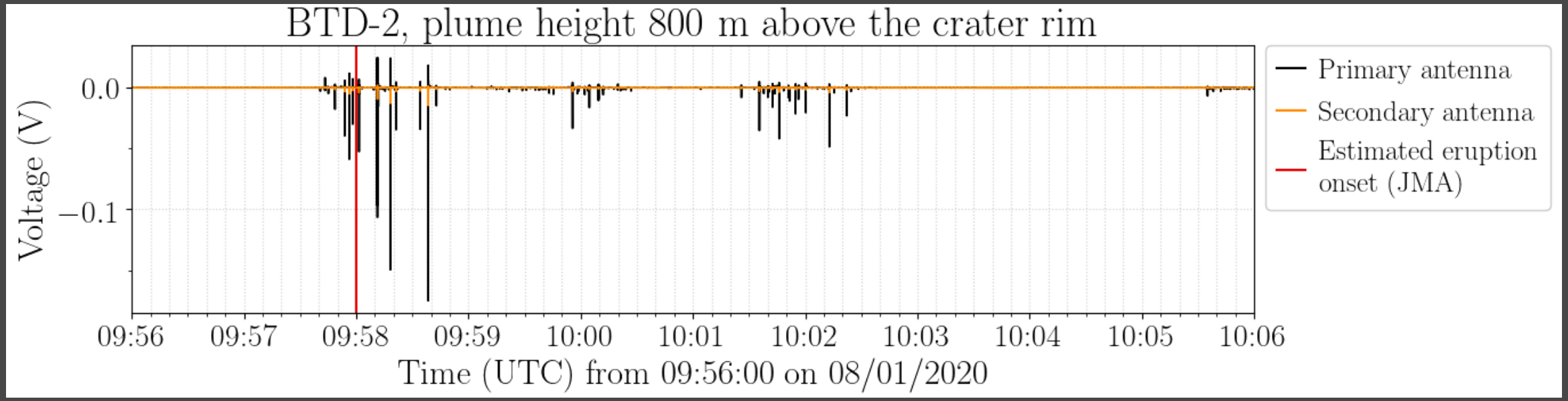
- Eruption database based on observations from the Japan Meteorological Agency (JMA) and Tokyo VAAC. The JMA gives an *estimated* time of the eruption onset (to the minute precise).

- Flash detection algorithm suitable for volcanic lightning.

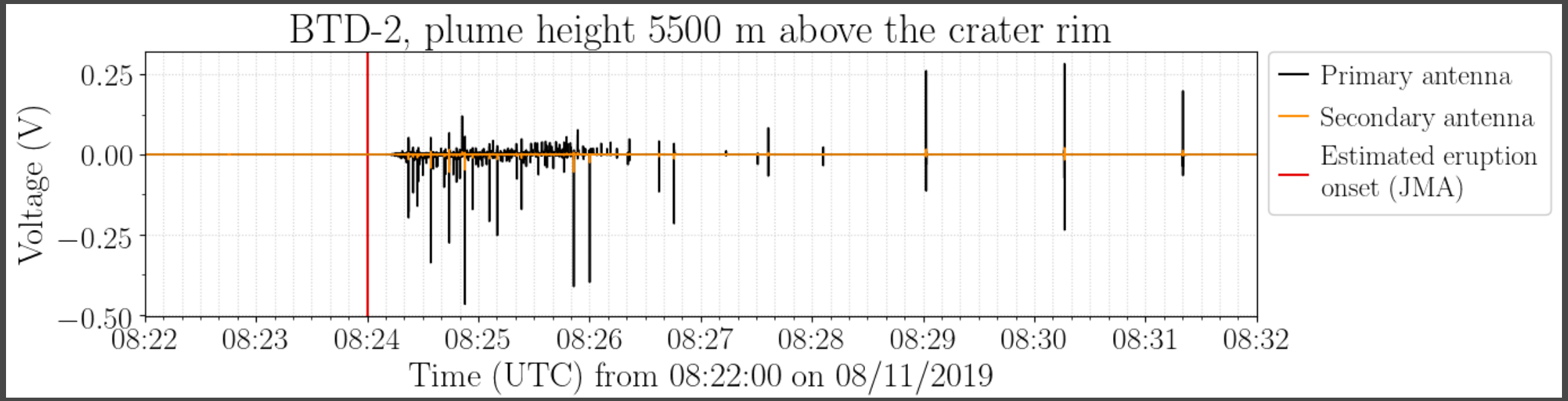
- Compare to data from the World Wide Lightning Location Network (WWLLN): Global Volcanic Lightning Monitor and Earth Networks Total Lightning Network (ENTLN).



- One vertical line equals one discharge.
- Primary antenna is the most important, because it is the most sensitive.
- Electrical discharges detected in relatively small explosive eruption.
- Ash plume did not reach the 0°C isotherm, so no ice nucleation.
- Eruption was not detected by ENTLN and WWLLN.



- Electrical discharges started 20s before the *estimated* eruption onset given by the JMA.
- Several pulses were detected by the BTD, but were not reported by the JMA.
- Ash plume reached just above the 0°C isotherm. Ice nucleation is possible as a charge separation mechanism, but unlikely on these relatively short time scales.
- Eruption was not detected by ENTLN and WWLLN.



- Biggest eruption at Sakurajima in 2019.
- Ash plume reached the -20°C isotherm. Ice nucleation likely played an important role as a charge separation mechanism.
- >800 discharges detected by BTD.
- Only 1-2 discharges detected by ENTLN and WWLLN.

Conclusions

- Electrical discharges mark the inception of the explosion more precisely.
- Electrical discharges can indicate a new pulse.
- Most eruptions did not reach freezing levels, indicating that ice nucleation did not play a (important) role as charge separation mechanism during those eruptions.
- The eruptions at Sakurajima volcano between July 2018 and January 2020 had plume heights ranging between 100 and 5500 meter above the crater rim.
- The BTDs detected electrical activity in 50% of the eruptions, regardless of plume height.
- ENTLN and WWLLN detected less than 1% of the eruptions.

Acknowledgements

Scientific support:
Matthias Hort and Joachim Bülow

Earth Networks Total Lightning Network data:
Jeff L. Lapierre and Michael Stock

World Wide Lightning Location Network: Global Volcanic Lightning Monitor
University of Washington, Seattle, Washington, United States

Funded by DFG Deutsche Forschungsgemeinschaft German Research Foundation