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

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How is volcanic lightning generated?

- Plume electrification is caused by charge separation as a result of:
  - Fracto-electrification (fragmentation of particles)
  - Tribo-electrification (collision of particles)
  - Ice nucleation/riming
  - Natural radioactivity

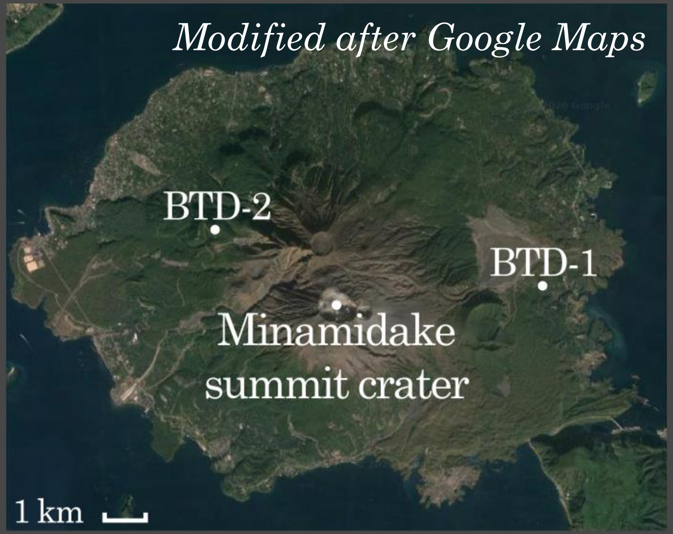
- If the breakdown voltage is exceeded, this will result in an electrical discharge.


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



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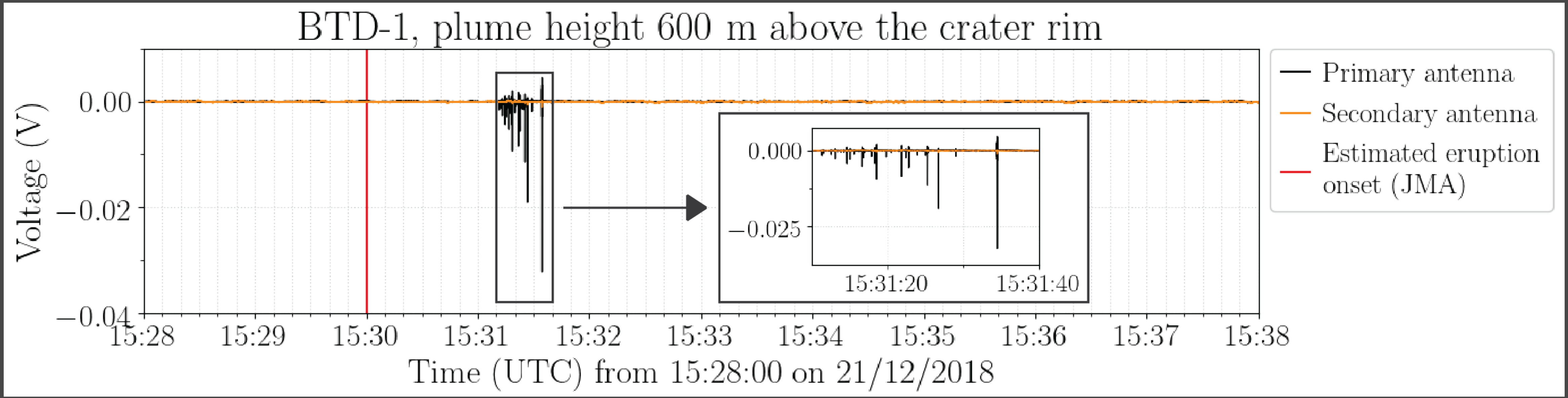
Data processing and analysis

- 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.

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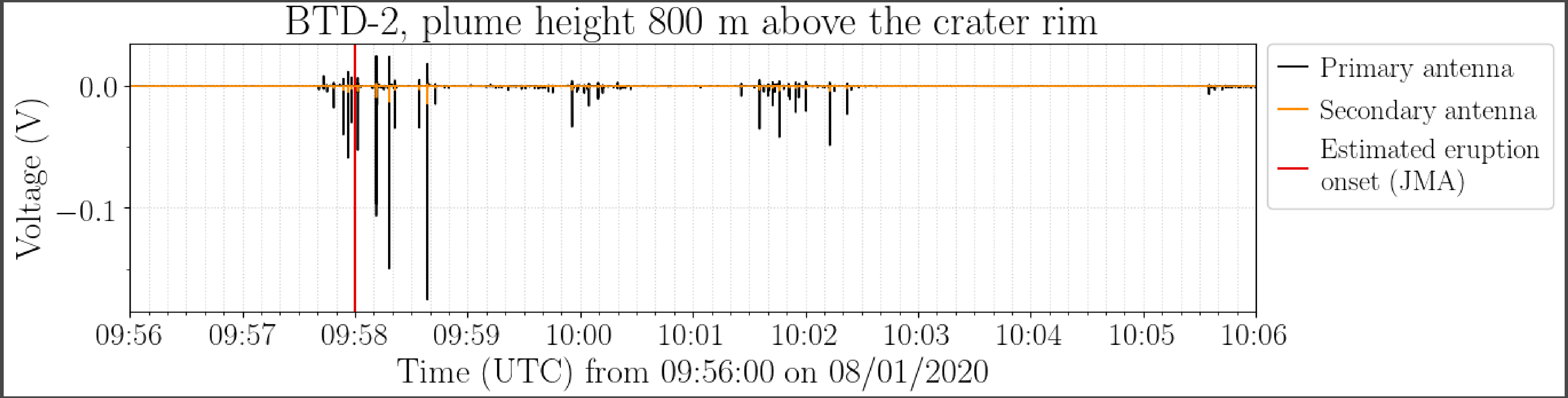
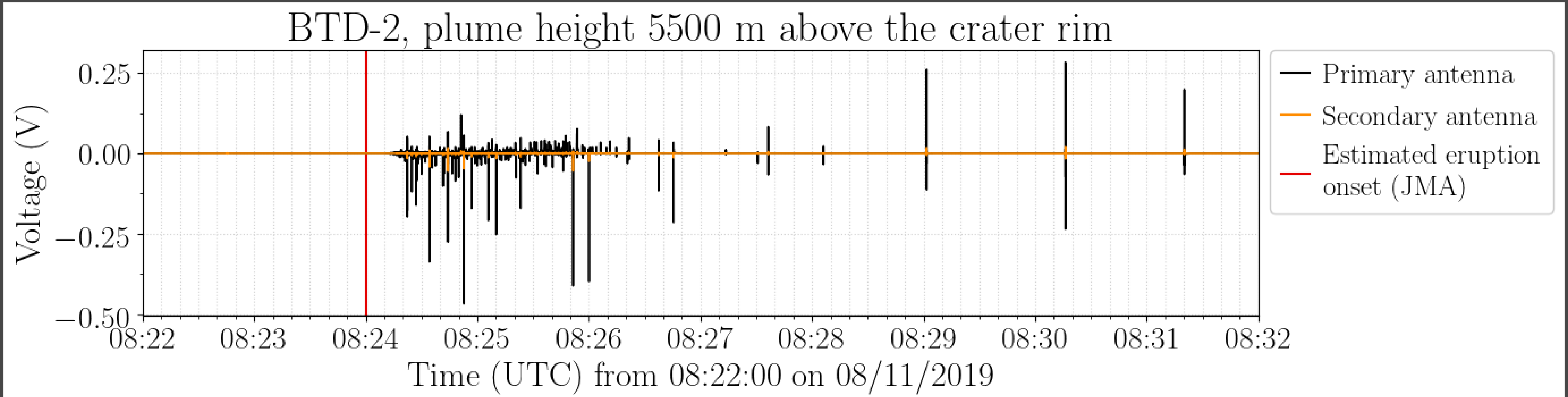


- Electrical discharges started 20s before the *estimated* eruption onset given by the JMA.
- Several pulses were detected by the BTD, but were not reported by the JMA.
- Ash plume reached just above the 0°C isotherm. Ice nucleation is possible as a charge separation mechanism, but unlikely on these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

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