Different mechanisms of the pre- and co-eruptive tremor during the 2018 eruption at Sierra Negra volcano, Galapagos

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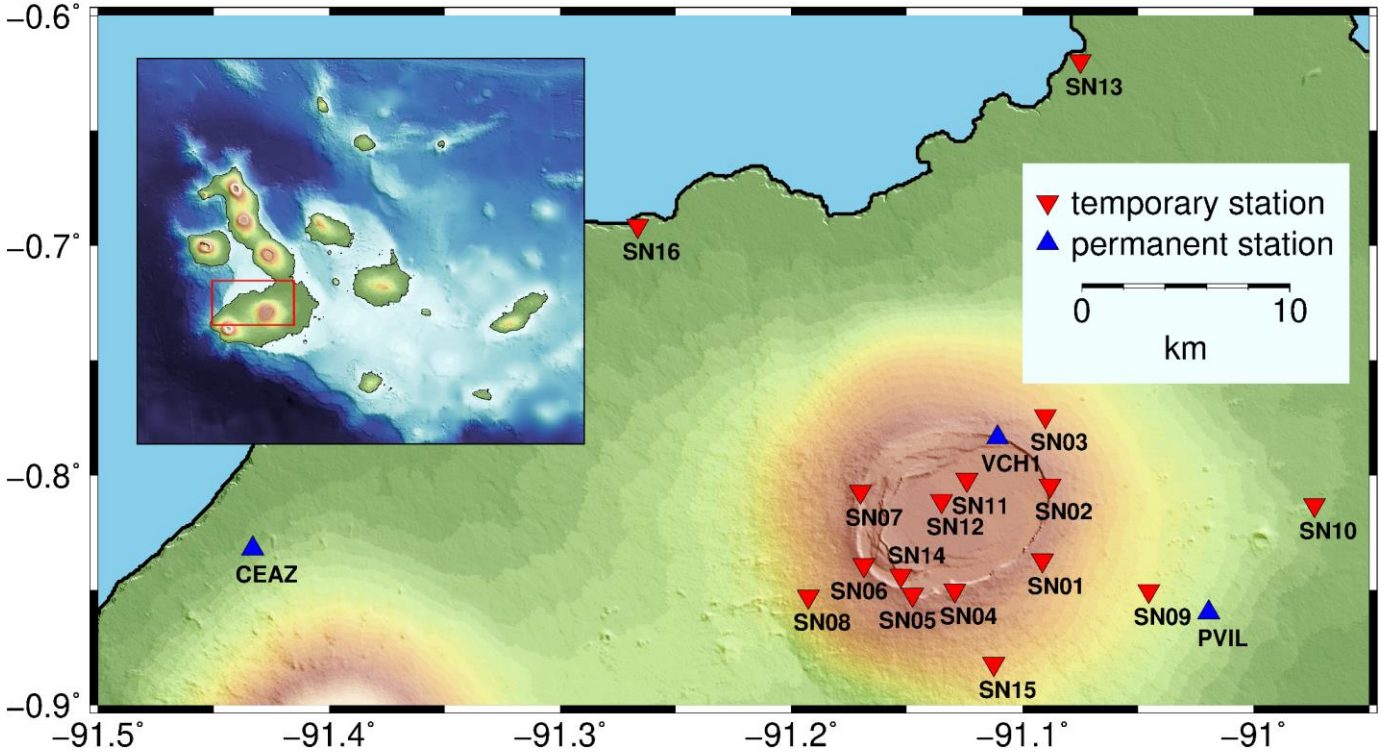
Summary

- We use tremor observed during the 2018 eruption at Sierra Negra volcano, Galapagos to demonstrate that **tremor occurs before and during an eruption can be associated with different mechanisms**.
- Spectral analysis indicates that the pre- and co-eruptive tremor have very different frequency characteristics.
- The pre-eruptive tremor stops when the co-eruptive phase starts.
- Location of the two tremor phases by a seismic amplitude ratio method suggests that the **pre-eruptive phase is generated by dike opening while the co-eruptive phase is associated with lava flow**.

The 2018 eruption at Sierra Negra volcano

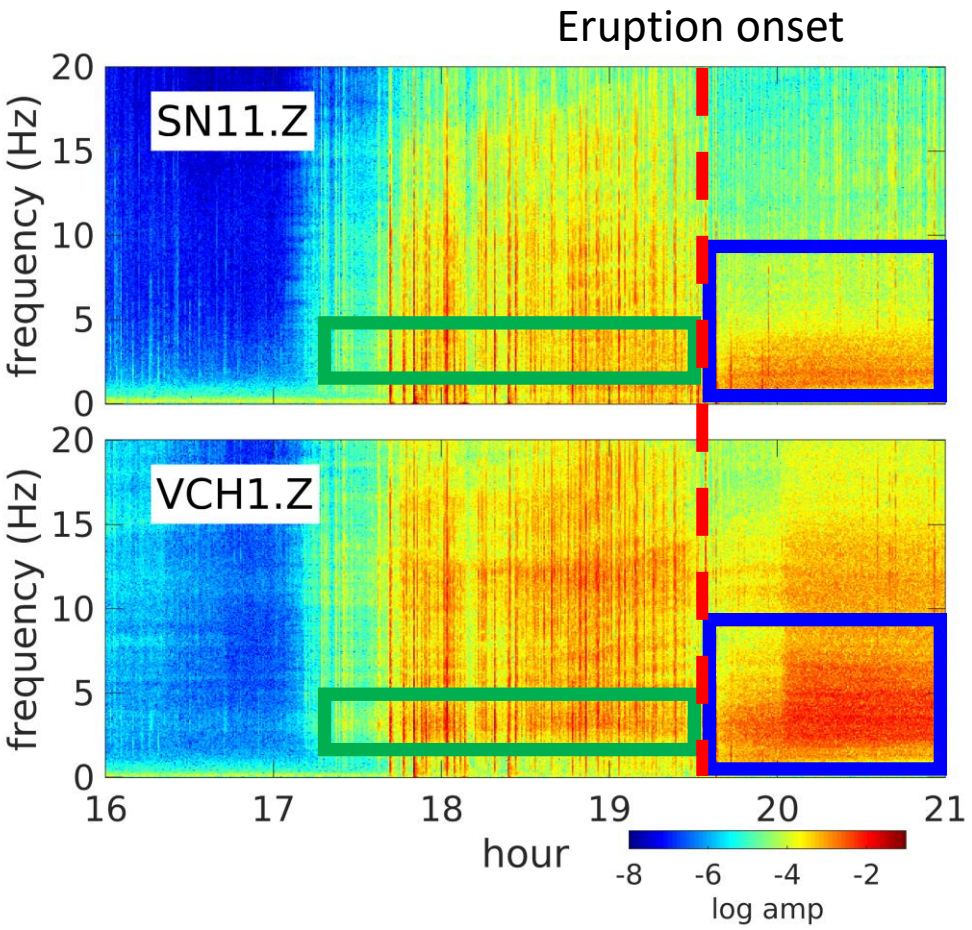
- Sierra Negra volcano is one of the most active volcanoes on the Galapagos Islands, ~ 1000 km west of continental Ecuador.



Two distinct tremor phases observed

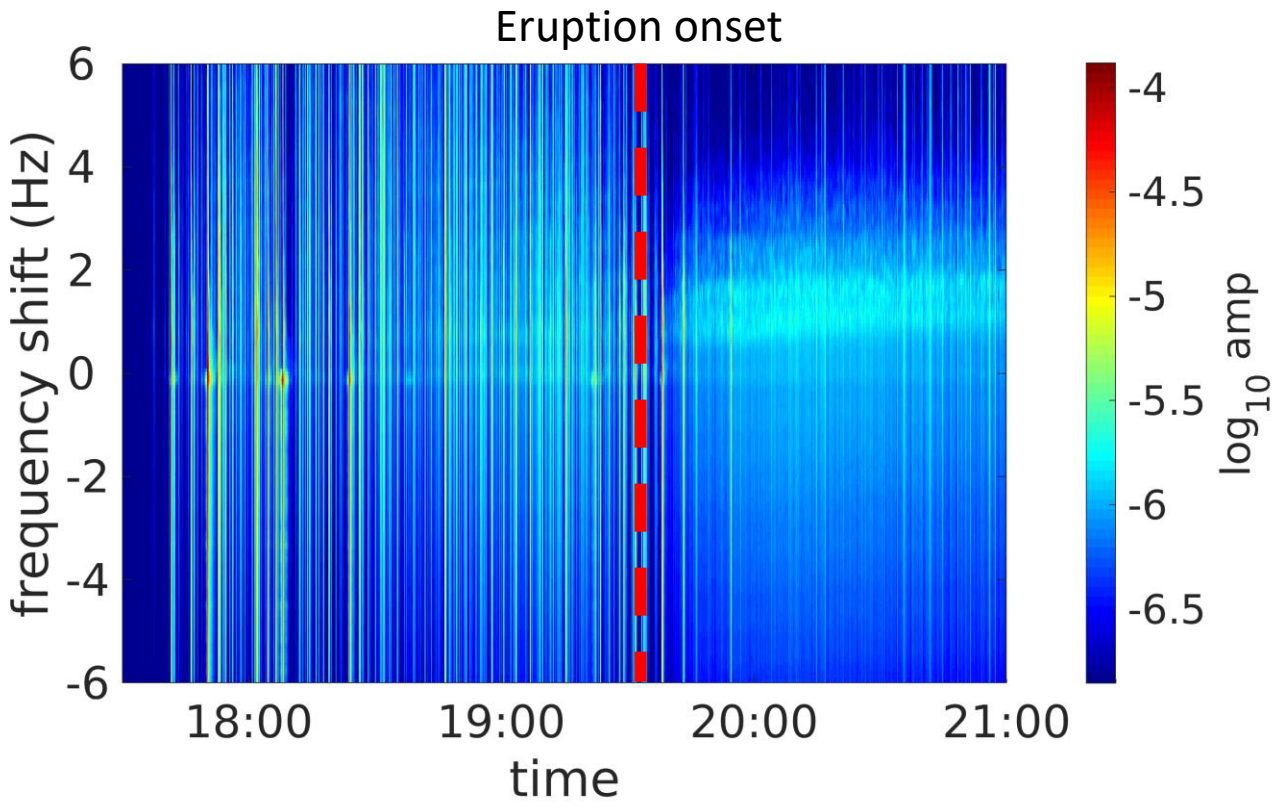
- Spectrograms of stations SN11 and VCH1 on the eruption day (26th June 2018) show two distinct phases of tremor.

- **Green**: pre-eruptive tremor (17:15 – 19:34) narrow frequency band
- **Blue**: co-eruptive tremor (from 19:34 onwards) wide frequency band
- **Red**: eruption onset time (~ 19:34)



Pre-eruptive phase ends when co-eruptive phase appears

- We study the temporal change in the tremor frequency content by cross correlating the amplitude spectrum of the pre-eruptive phase with the entire spectrogram (previous slide).



Pre-eruptive phase ends when co-eruptive phase appears

- High amplitude at zero frequency lag during pre-eruptive phase (17:15 – 19:34)

  → frequency contents unchanged during this period

- When co-eruptive phase starts, amplitude at zero frequency lag decreases sharply

  → frequencies presented in the pre-eruptive phase disappear

  → **pre-eruptive tremor stops when co-eruptive phase emerges**

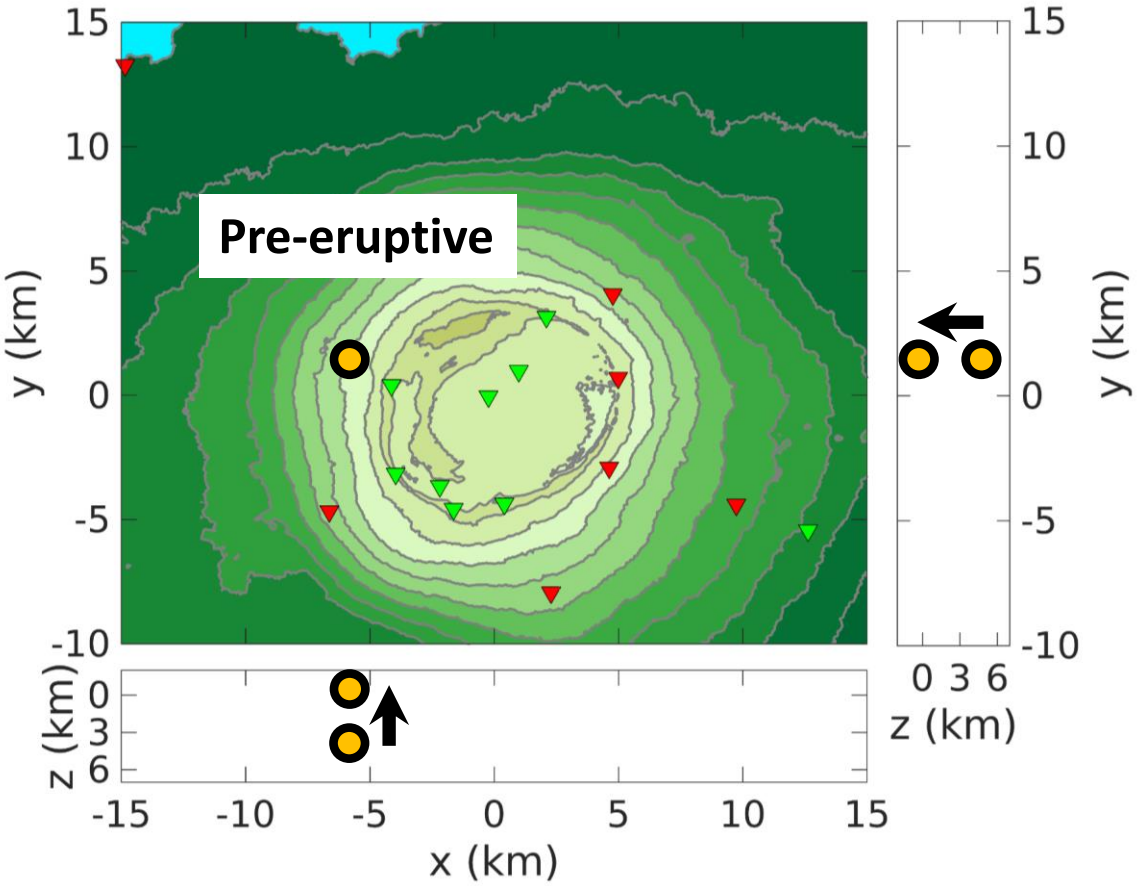
Locations of the two tremor phases

- To understand processes generating the two tremor phases, we locate the pre- and co-eruptive tremor signals.
- For location, we apply a seismic amplitude ratio method (e.g. Taisne et al., 2011, De Barros et al., 2013) which utilizes the ratios of seismogram amplitudes to invert for a location using a grid search approach.

Evolution of pre-eruptive tremor source

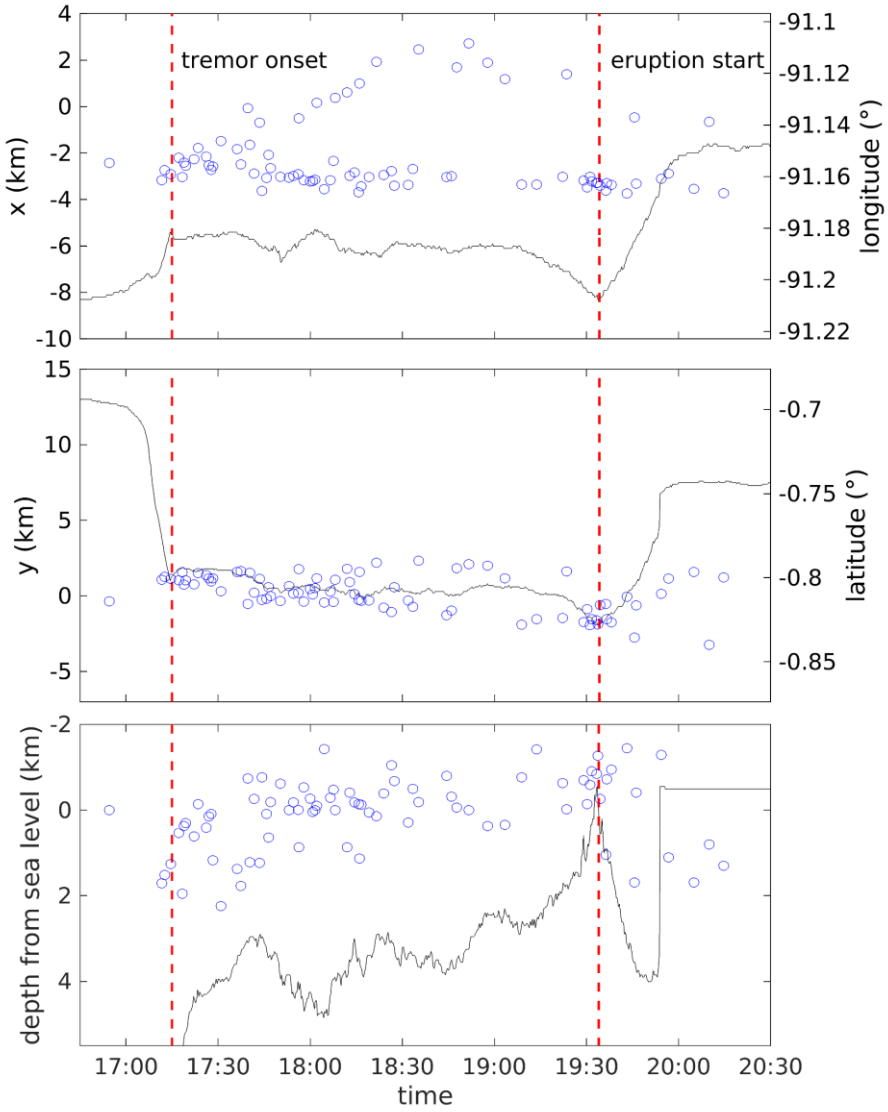
- The onset of the tremor (~ 17:15) locates to the west of the caldera. The lateral location is stable while the depth gradually reduces over the next 2 hours. Around 19:31, the tremor reaches the surface at a location close to an eruptive fissure.

Green triangles: stations used for the location



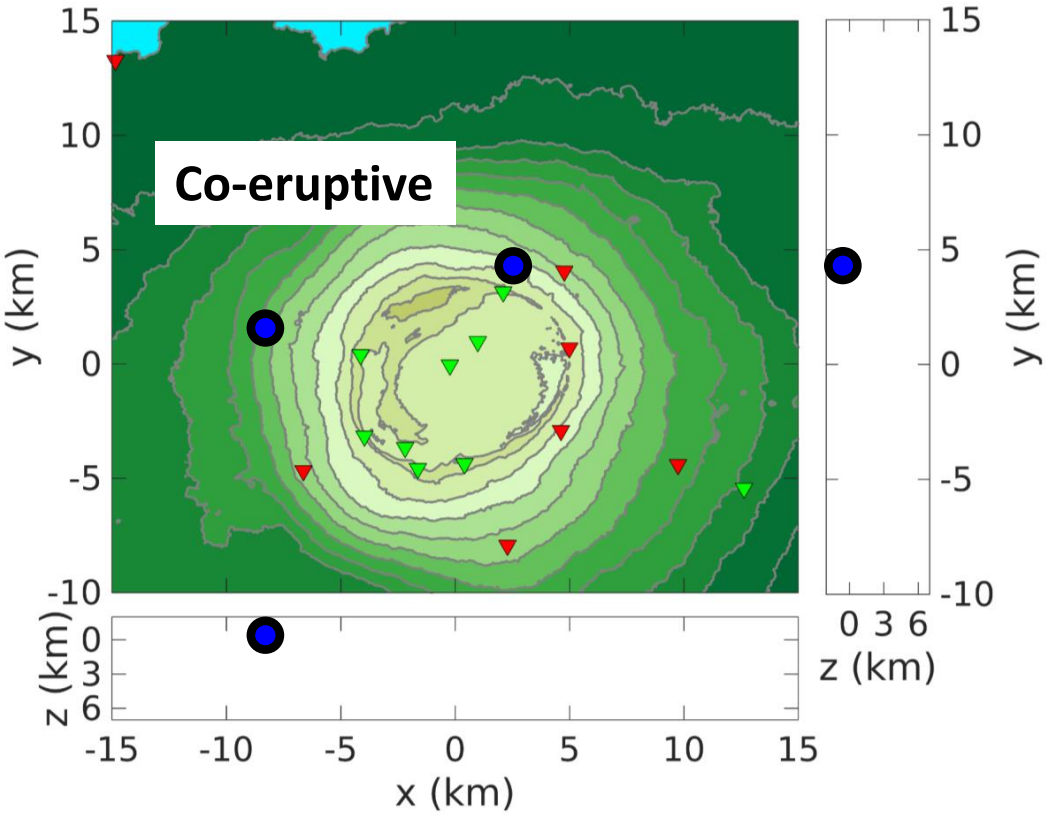
Tremor location vs time

- **Black solid lines**: tremor location as a function of time
- **Blue open circles**: earthquakes
- There is a rapid change in tremor source location from 19:34 (eruption onset) to 19:54.
- This may be due to the appearance of another source.



Evolution of co-eruptive tremor source

- Because of the appearance of a second source, we modify the seismic amplitude ratio method to locate two sources simultaneously.
- The two source locations are stable from the start of the co-eruptive phase.
- Both are located on the surface and close to the observed eruptive fissures.



Conclusions

Pre-eruptive phase ends when co-eruptive phase starts

Pre-eruptive source migrates in depth over time while co-eruptive source locates on the surface

The pre-eruptive phase is likely to be generated by dike opening while the co-eruptive phase is associated with lava flow

References

- Taisne, B. , Brenguier, F., Shapiro, N. M. & Ferrazzini, V. (2011). *Geophys. Res. Lett.*, 38, L04304. doi:10.1029/2010GL046068.
- De Barros, L., Bean, C. J., Zecevic, M., Brenguier, F. & Peltier, A. (2013). *Geophys. Res. Lett.*, 40, 4599-4603. doi: 10.1002/grl.50890.