

## **Characteristics of Helicopter-Generated and Volcano-Related Seismic Tremor Signals**

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In volcanic environments it is crucial to distinguish between man-made seismic signals and signals created by the volcano. We compare volcanic, seismic signals with helicopter generated, seismic signals recorded in the last 2.5 years in Iceland. In both cases a long-lasting, emergent seismic signal, that can be referred to as seismic tremor, was generated.

In the case of a helicopter, the rotating blades generate pressure pulses that travel through the air and excite Rayleigh waves at up to 40 km distance depending on wind speed, wind direction and topographic features. The longest helicopter related seismic signal we recorded was at the order of 40 minutes long. The tremor usually has a fundamental frequency of more than 10 Hz and overtones at integers of the fundamental frequency. Changes in distance lead to either increases or decreases of the frequency due to the Doppler Effect and are strongest for small source-receiver distances. The volcanic tremor signal was recorded during the Bardarbunga eruption at Holuhraun in 2014/15. For volcano-related seismic signals it is usually more difficult to determine the source process that generated the tremor. The pre-eruptive tremor persists for 2 weeks, while the co-eruptive tremor lasted for 6 months. We observed no frequency changes, most energy between 1 and 2 Hz and no or very little energy above 5 Hz.

We compare the different characteristics of helicopter-related and volcano-related seismic signals and discuss how they can be distinguished. In addition we discuss how we can determine if a frequency change is related to a moving source or change in repeat time or a change in the geometry of the resonating body.