Distributed Dynamic Strain Sensing (DDSS) and Volcano-Seismology

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Objectives

- Use of multi-parametric dataset from Mt. Etna (seismometers, infrasound and fiber optics) to understand non-linear processes in the ground.
- Analyze and attempt to model the behavior of rock response.
- Aid from laboratory observations to improve time dependent assessments of natural hazards related to material failure and ground response.







Setup & Observations

- Channel spacing of 2 m.
- Sampling rate of 1kHz.
- Gauge length of 10 m.





Diaz-Meza et al., 2023













Strain-rate Correction (Engineered)









Diaz-Meza et al., 2023







Diaz-Meza et al., 2023

Stacking Standard Fibers

Diaz-Meza et al., 2023

Conclusions

- We compared stacked standard fibers with engineered fiber at Etna volcano to understand the DDSS instrumentation.
- Avoid saturation. Dynamic range depends on the sampling frequency and the gauge length. We can increase dynamic range, but we decrease sensitivity.

$$\dot{\epsilon}_{xx} = counts \cdot \left[\frac{116 \cdot 10^{-9} (\text{m/rad}) \cdot f_s(\text{Hz})}{L_G(\text{m}) \cdot No.}\right]$$

- We can correct strain-rate saturation for low noise datasets.
- We reduced noise up to 20% by stacking fibers.
- Continue to assess the non-linearity from corrected or discarded signals.

Diaz-Meza et al. 2023, "On the comparison of records from Standard and Engineered fiber optic cables at Etna volcano (Italy)", Sensors, MDPI, In press.

Strain Transfer

- Glass index and ground coupling discarded.
- Structure between Standard and Engineered cable is different.

$$\begin{array}{l} \text{Average} \\ \text{strain-transfer} \end{array} \quad \overline{\alpha} = 1 - \frac{\sinh(\beta \frac{L}{2})}{\beta \frac{L}{2} \cosh(\beta \frac{L}{2})} \\ \text{Shear lag} \\ \text{parameter} \end{array} \quad \beta^2 = \frac{2}{r_g^2 E_g \left\{ \sum_{i=1}^n \frac{1}{G_i} \ln(\frac{r_i}{r_{i-1}}) \right\}} \end{array}$$

From Li et al., 2006, and Reinsch et al., 2017

Modified from Currenti et al., 2021

- PDN Observatory (2.1 km from Mt. Etna.)
- High activity.
- 0.1 100 Hz.
- Non-consolidated scoria (2-3 cm particle size).
- 26 Broad-band and 12 Infrasound stations (200 Hz).

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Diaz-Meza et al., 2023

