Detection and characterization of seismic signals with dense arrays

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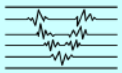
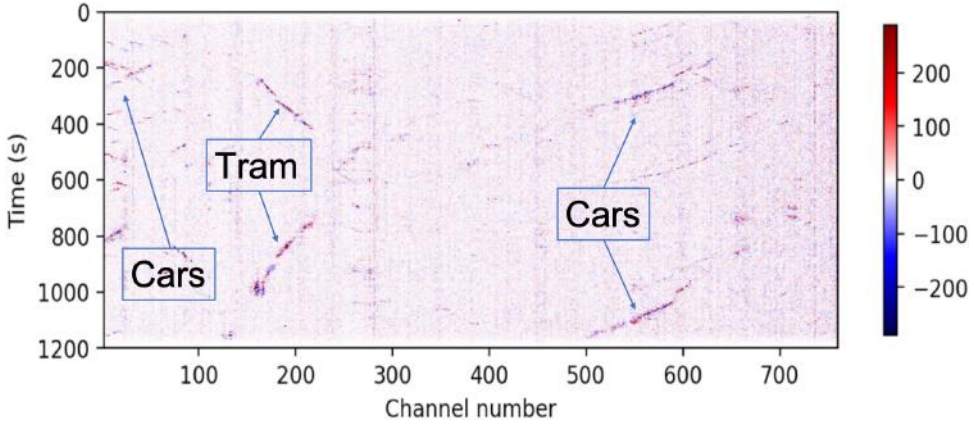
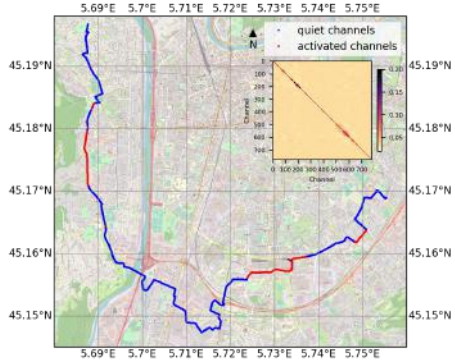
Funded by the European Union's Horizon 2020 research and innovation programme

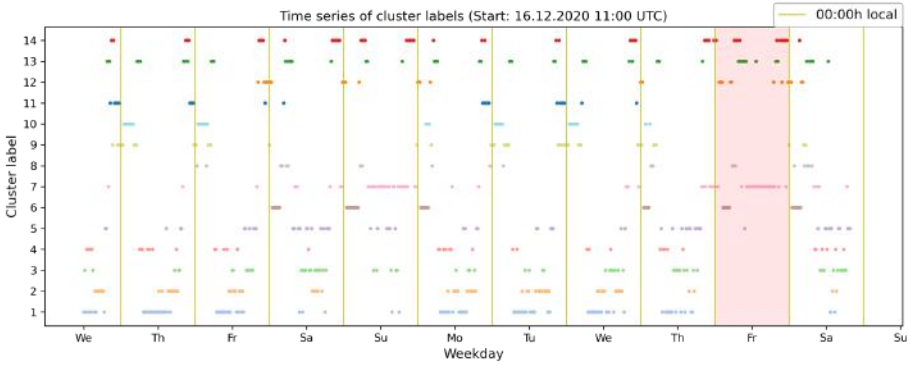


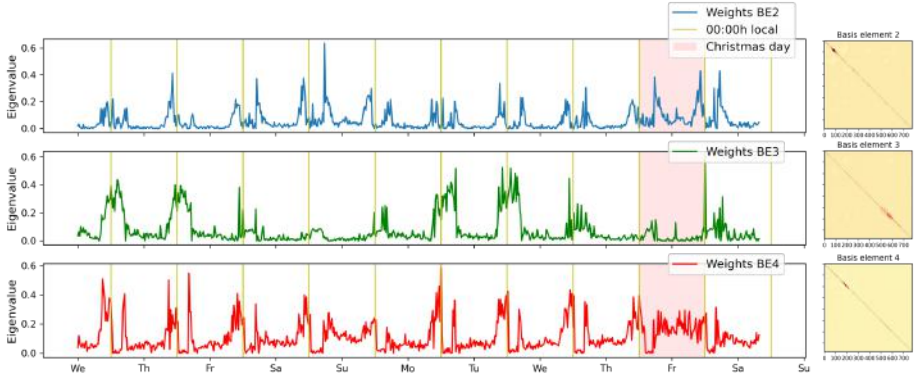
SPIN MONITORING A RESTLESS EARTH

Recap: Characterization of traffic

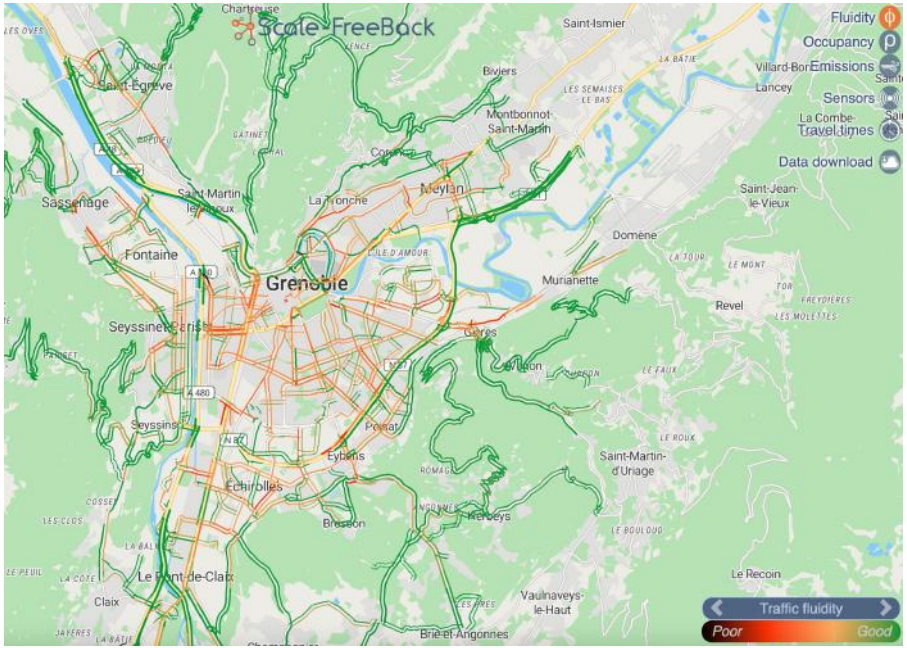


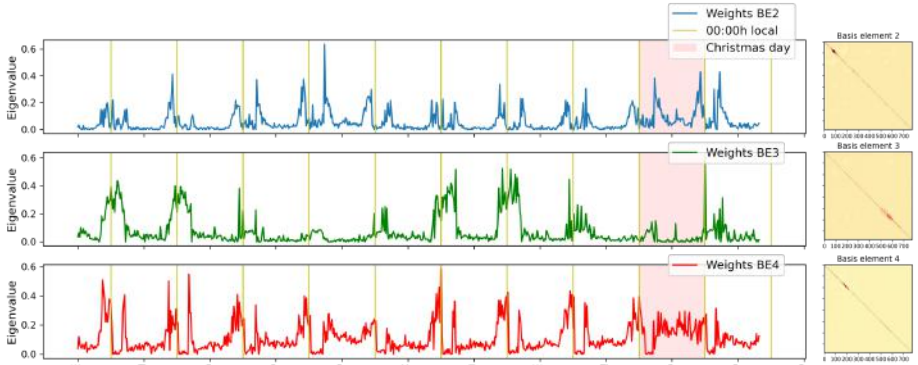






Recap: Characterization of traffic

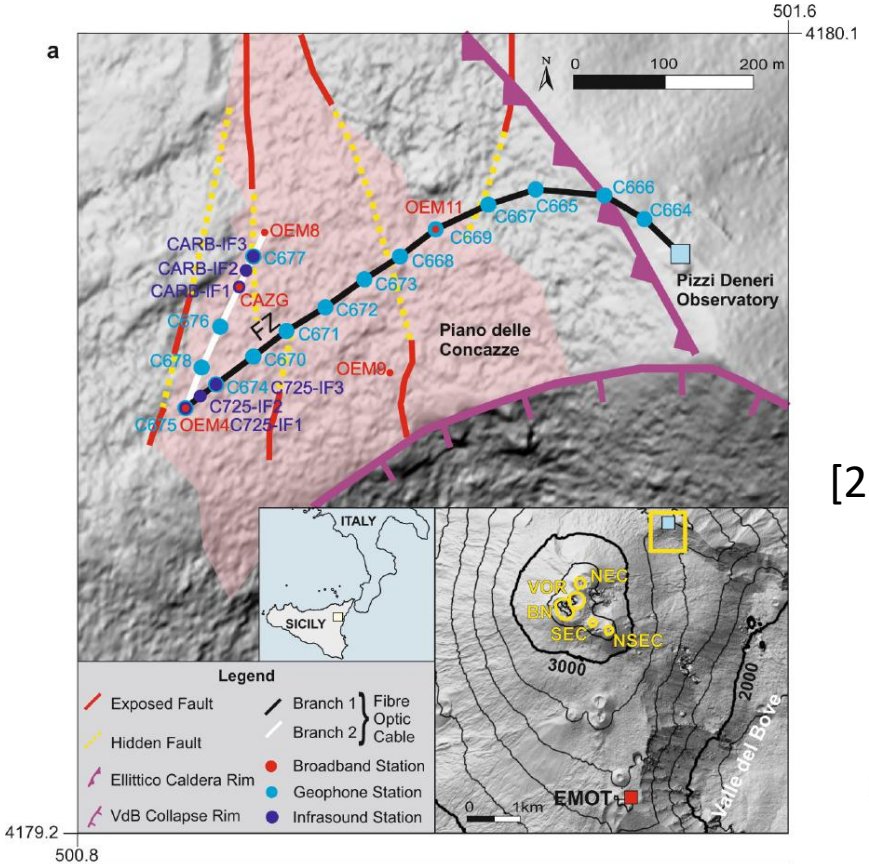




Grenoble Traffic Lab:

- Sensor data (Flow, speed, …)
- Computed data (Vehicle positions, predictions, emissions)

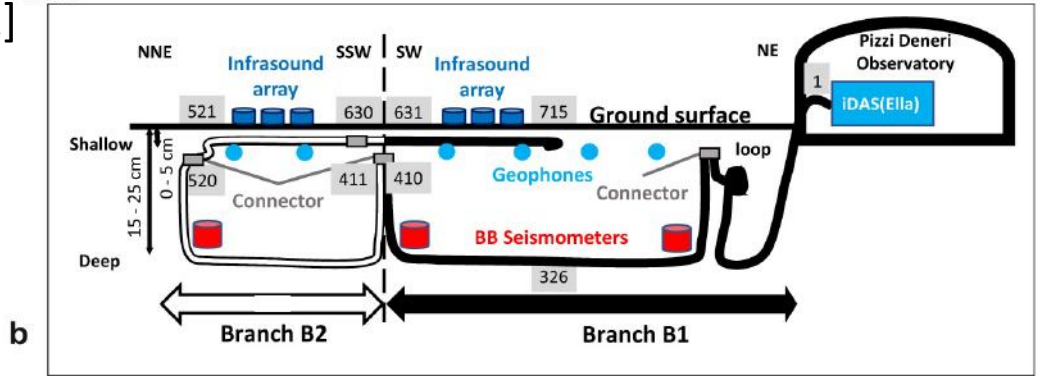
The 9N seismic network [1]



Temporary network (2018/08/30 – 2018/09/16)

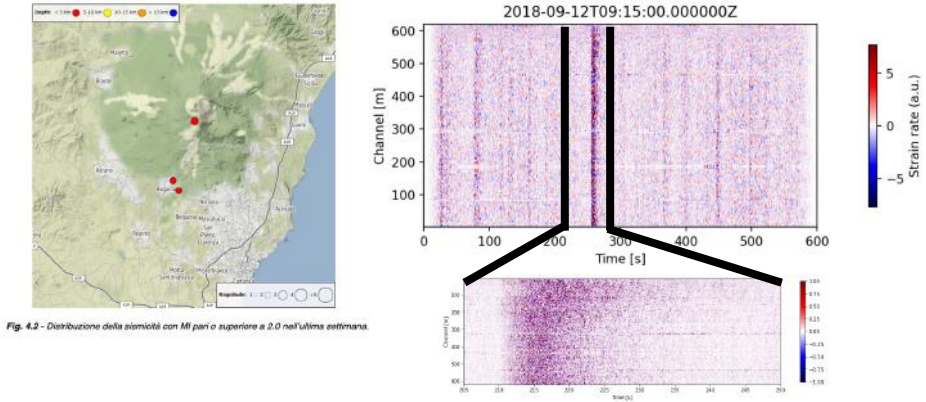
- 1.5 km long DAS cable (2 m channel spacing)
- 15 geophones
- 4 broadband seismometers
- 6 infrasound sensors

[2]

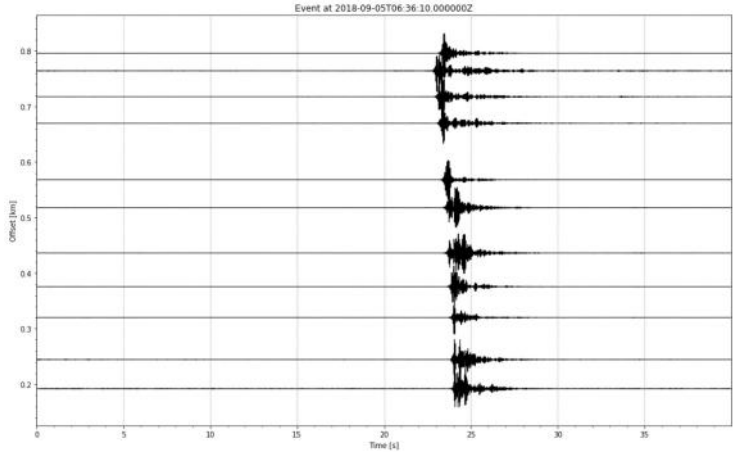


Mix of seismic signals

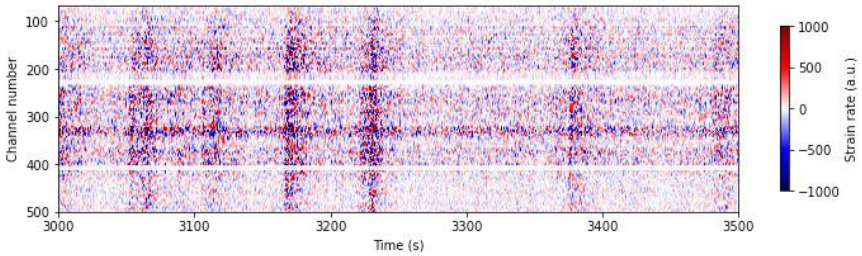
Volcano-tectonic earthquakes



Volcanic explosions



Transients in tremor



Anthropogenic signals (tourists, cars, …)
Environmental signals (thunderstorms, …)

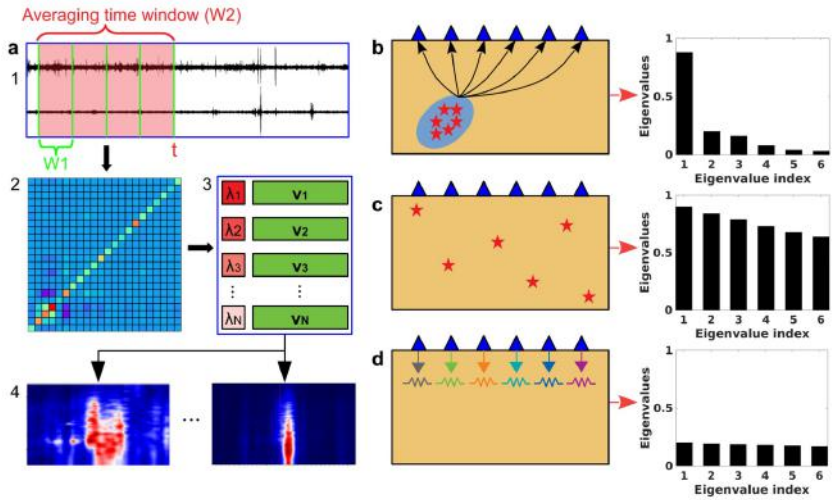
Detection methods

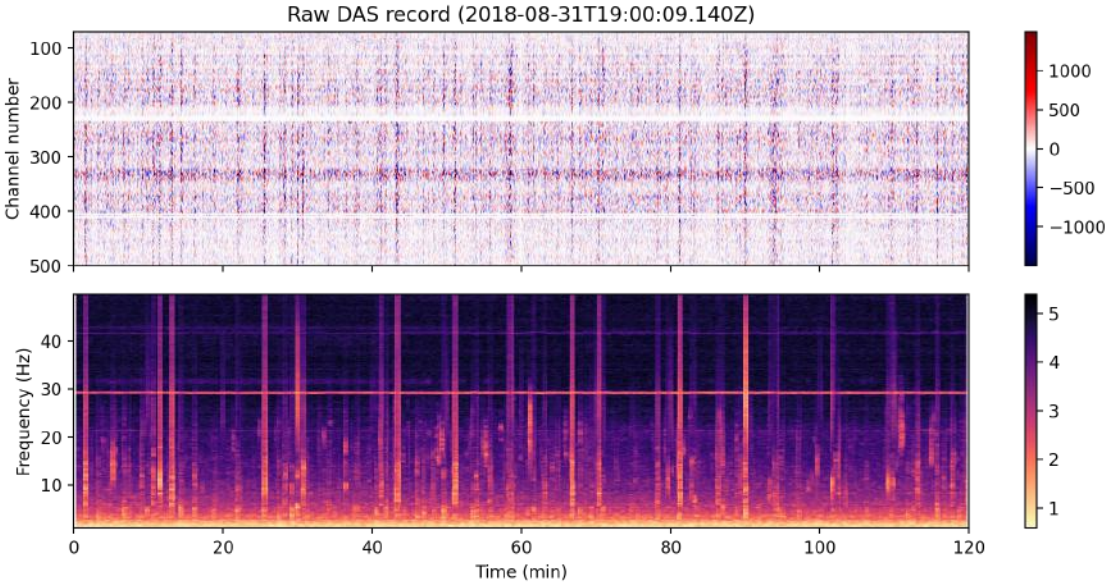
1. Spectral width of coherence matrix
2. First eigenvector of coherence matrix
    - Clustering of EVs
    - EV of known events as matched filter
3. Template matching (time domain)

→ Comparison of geophone and DAS data

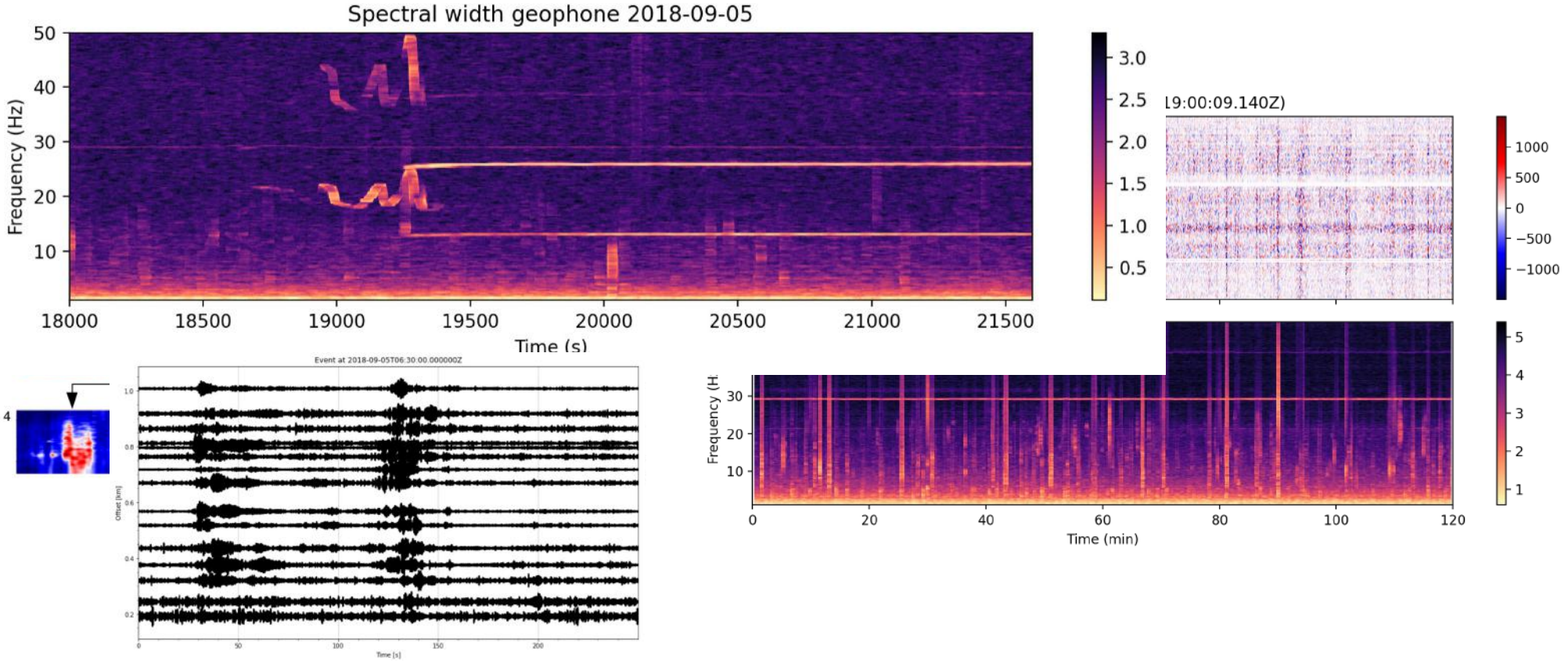
Spectral width of coherence matrix

[3]

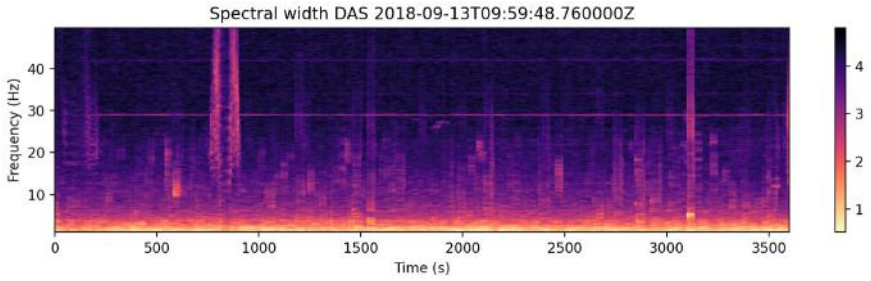


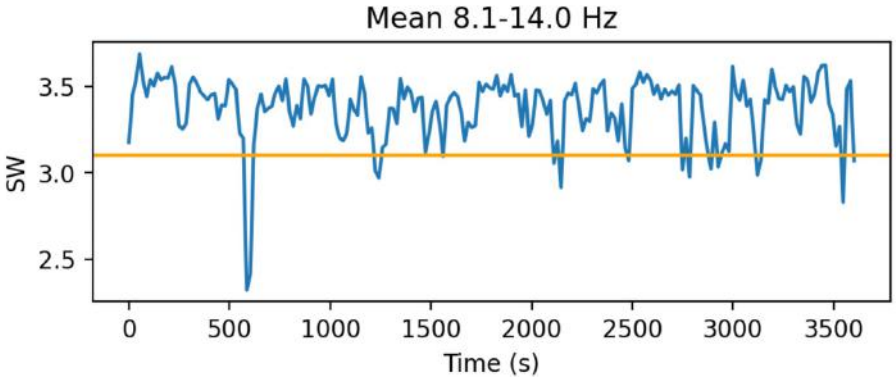


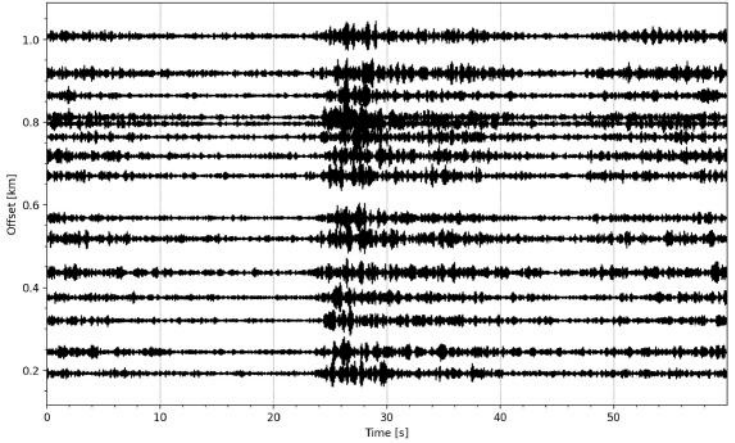
Spectral width of coherence matrix

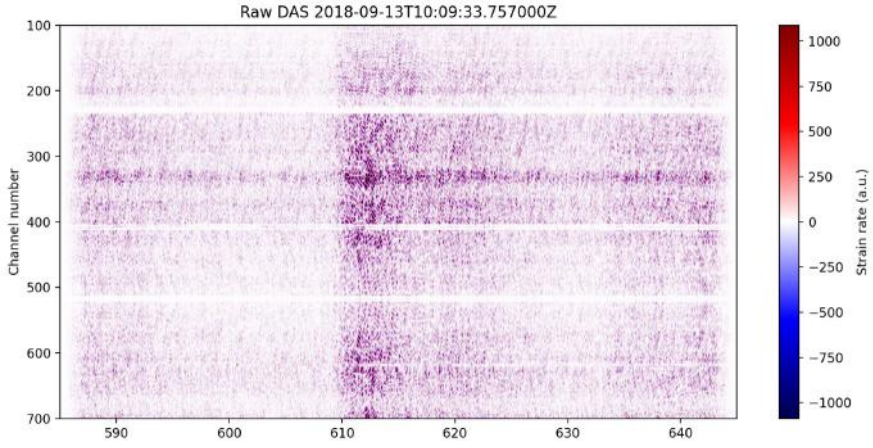


Detection based on spectral width

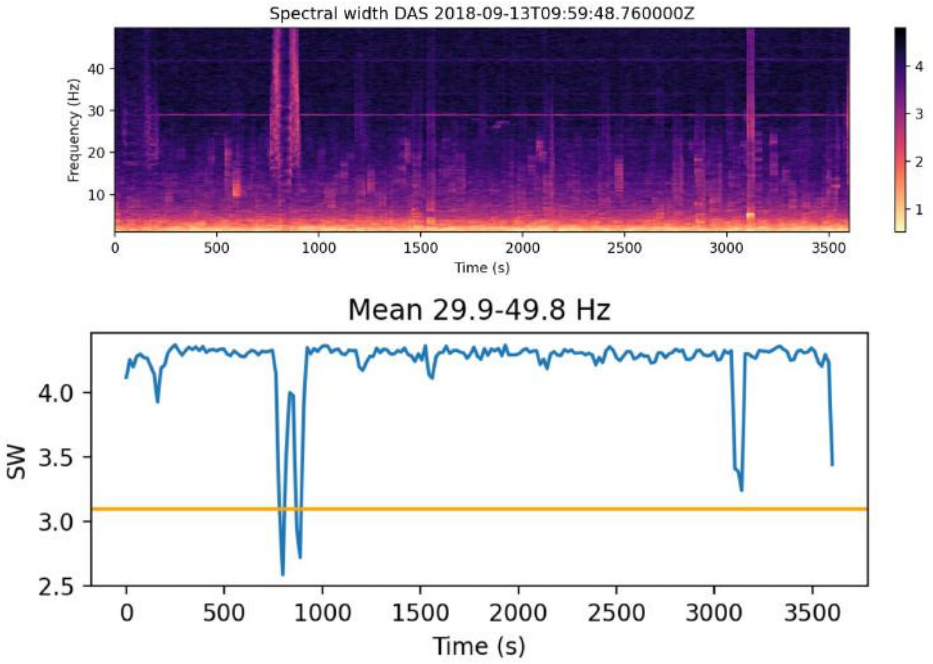


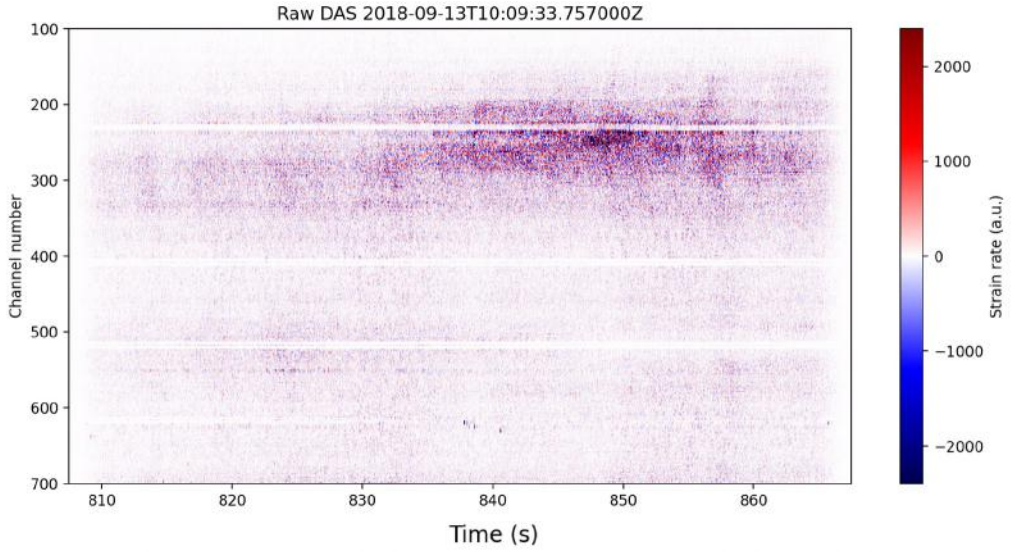


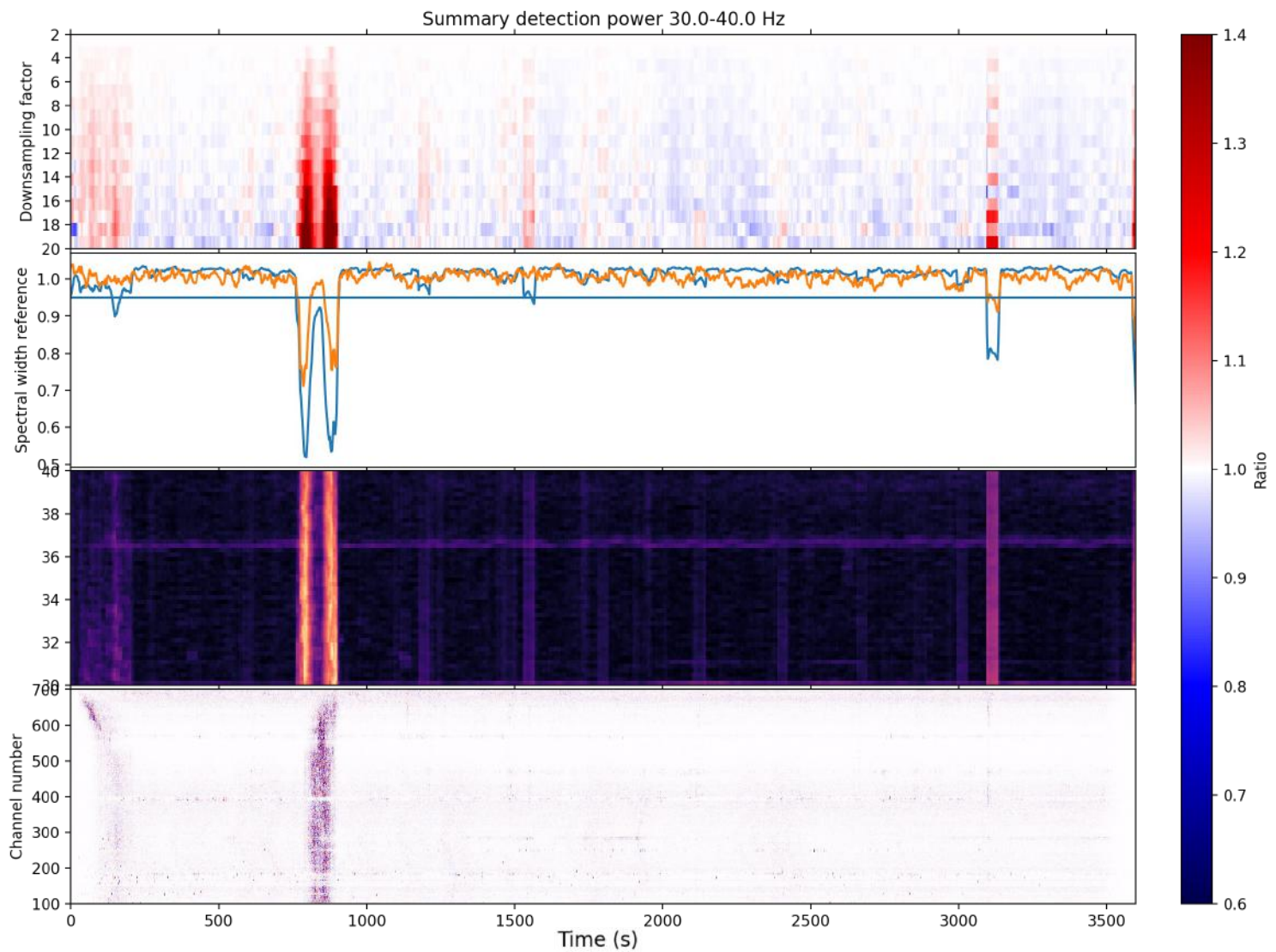




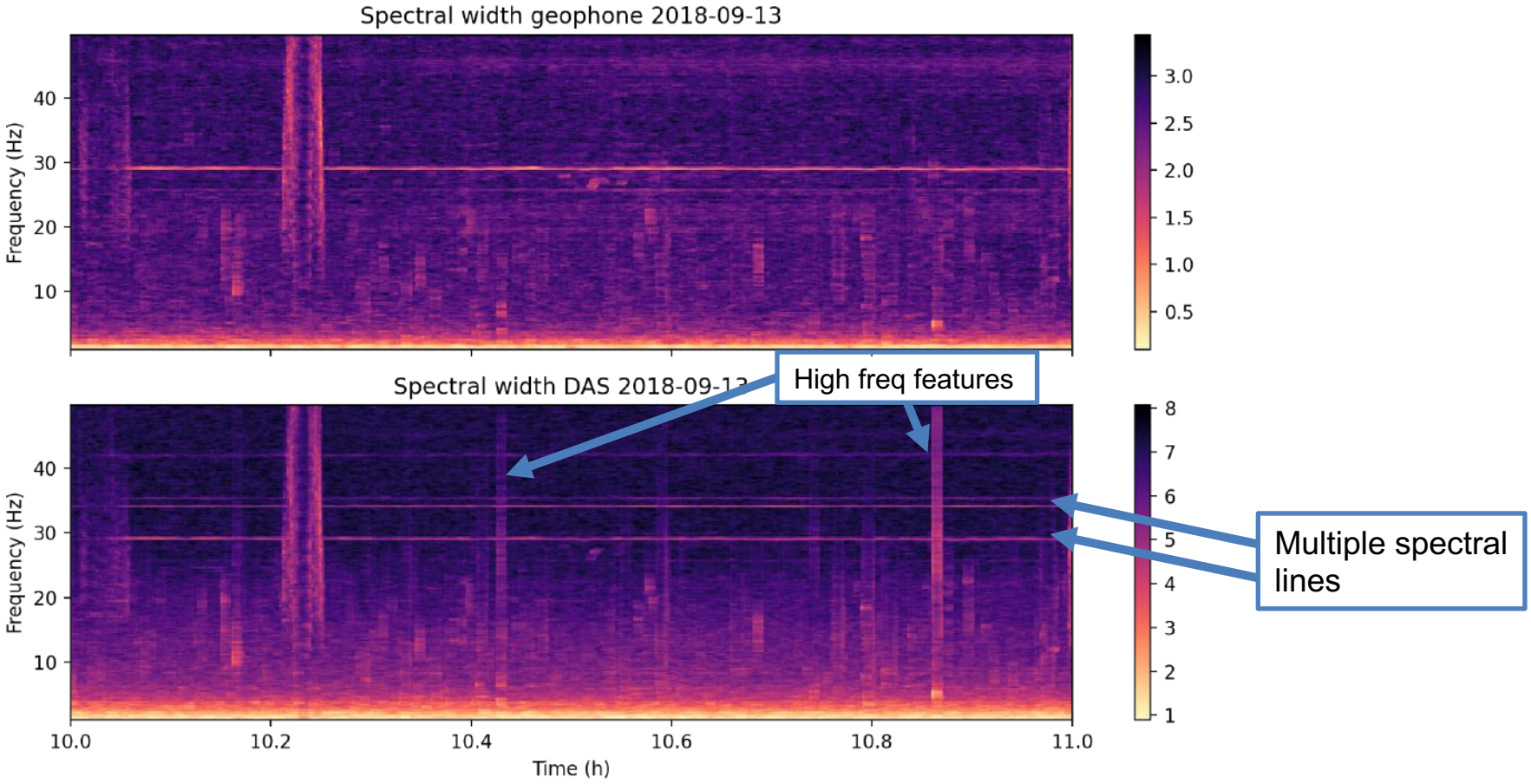
Detection based on spectral width





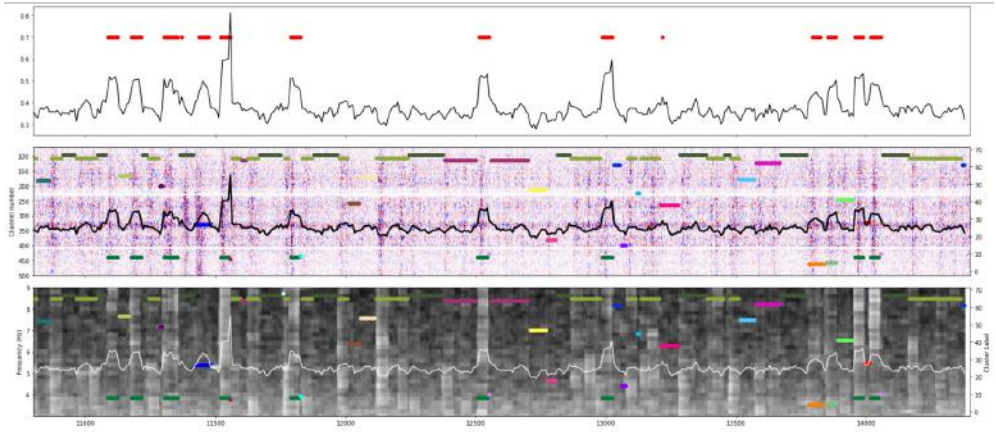

Summary detection power 30.0-40.0 Hz
Downsampling factor
Spectral width reference
Channel number
Time (s)
Ratio

SW differences geophone & DAS

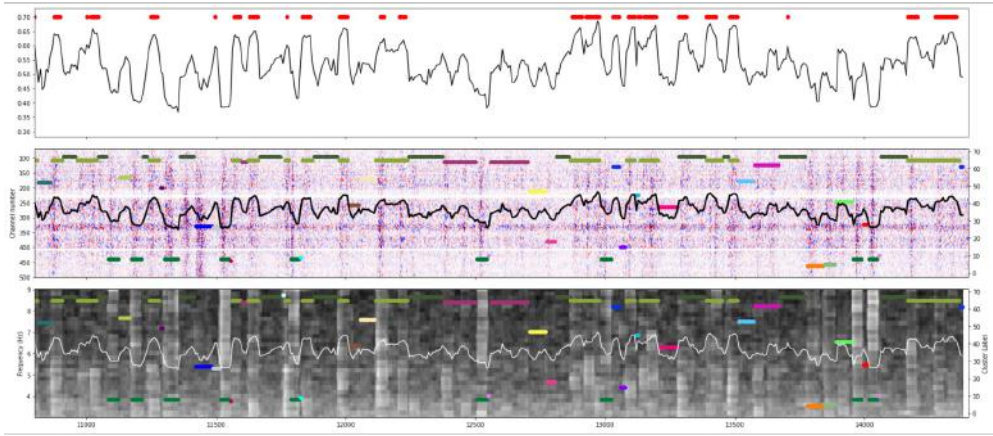


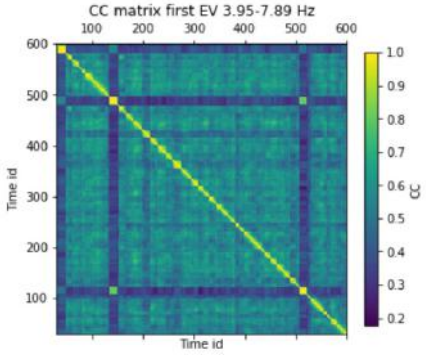
Clustering of first eigenvector

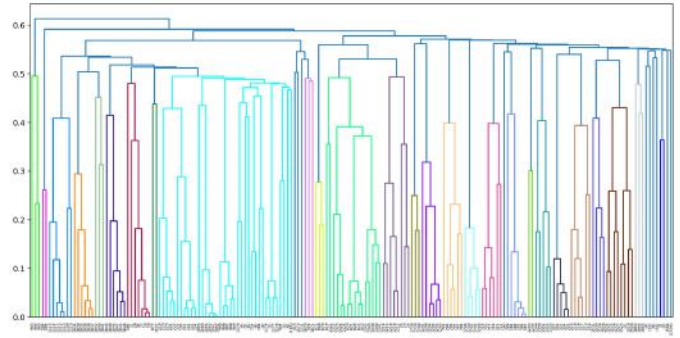
Matched filter for cluster 7



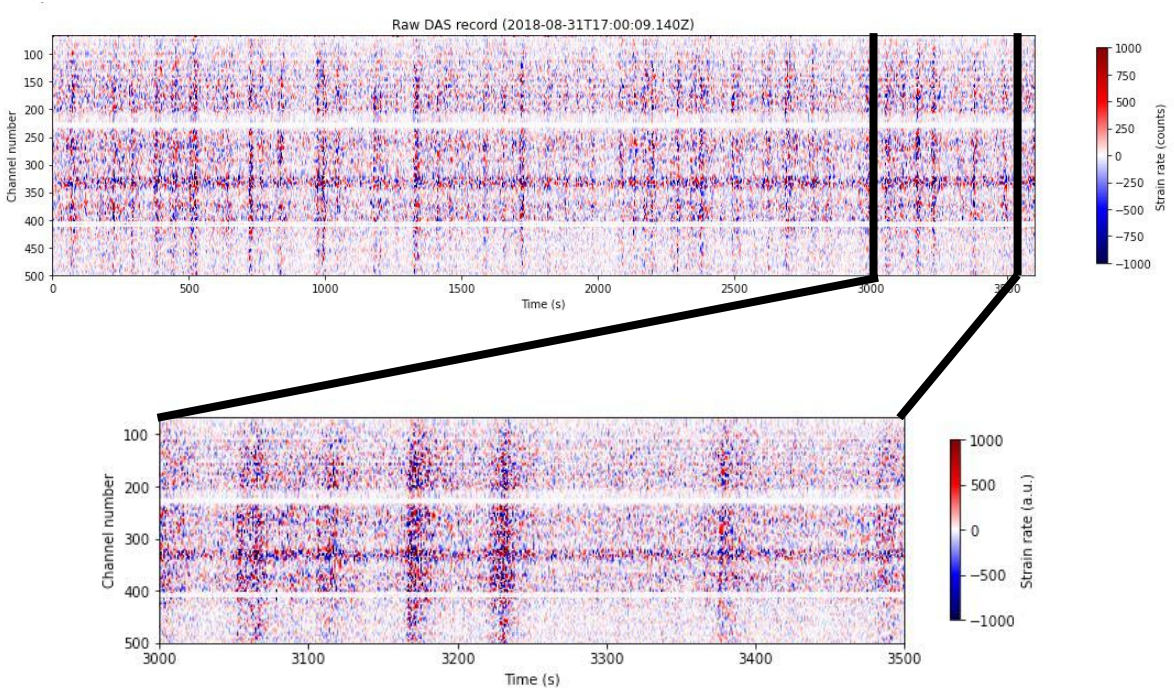
Matched filter for cluster 67



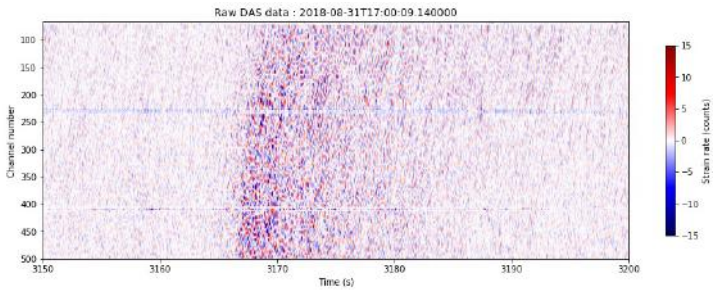


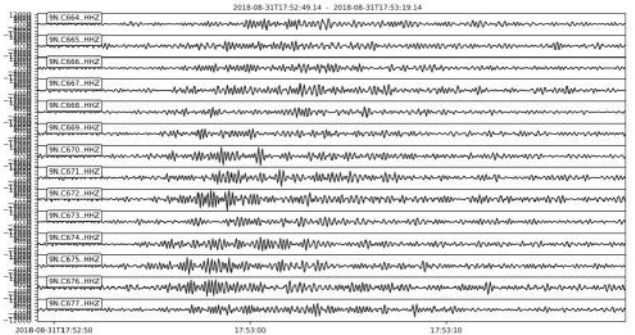


Template matching of degassing events

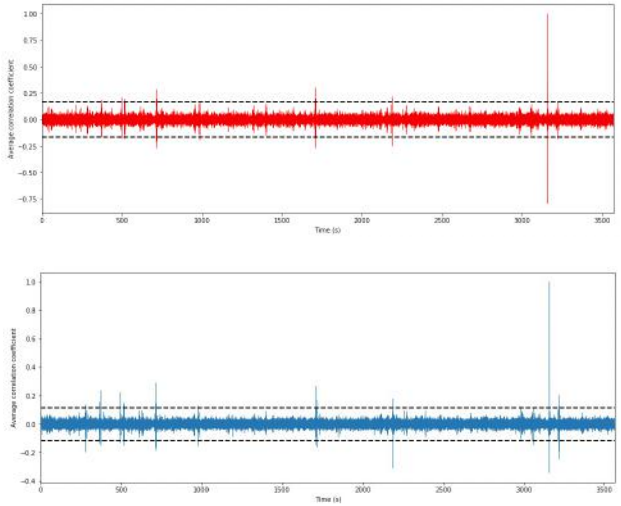


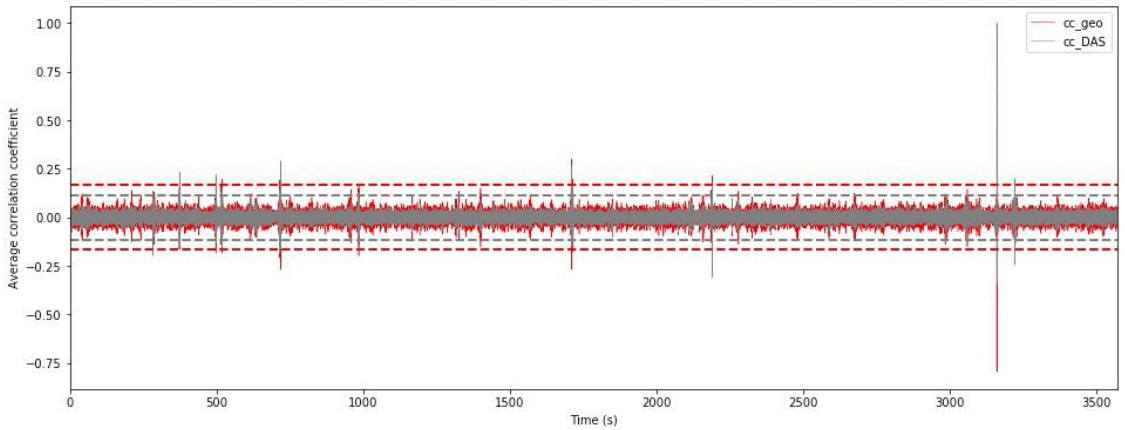
Templates





Comparison geophones & DAS





	Geophone	DAS
# Detections (10 MAD)	8	12
MAD	0.0167	0.0115
Max. CC	0.3016	0.2894
Ratio	18	25
# Channels	42 (14*3)	410

References

[1] Jousset, Philippe; Currenti, Gilda; Chalari, Athena; Tilmann, Frederik; Zuccarello, Luciano (2022): Fibre-optic distributed acoustic sensing, seismological and infrasonic data set from Etna, Italy. GFZ Data Services. Other/Seismic Network. doi:10.14470/4A7563971328.

[2] Jousset, P., Currenti, G., Schwarz, B. et al. Fibre optic distributed acoustic sensing of volcanic events. Nat Commun 13, 1753 (2022). https://doi.org/10.1038/s41467-022-29184-w

[3] "Detecting seismic activity with a covariance matrix analysis of data recorded on seismic arrays" by L. Seydoux, N.M. Shapiro, J. de Rosny, F. Brenguier, M. Landès; in Geophysical Journal International, 2016