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Assessing similarity in continuous seismic cross-correlation functions using hierarchical clustering

Alexander Yates[1,2], Corentin Caudron[1,2], Philippe Lesage[1], Aurélien Mordret[1], Thomas Lecocq[3], and Jean Soubestre[1,4]

[1]Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, IRD, Univ. Gustave Eiffel, ISTerre, 38000 Grenoble, France.
[2]Laboratoire G-Time, Department of Geosciences, Environment and Society, Université libre de Bruxelles, 1050 Bruxelles, Belgium
[3]Seismology and Gravimetry Department, Royal Observatory of Belgium, 1180 Uccle, Belgium
[4]Icelandic Meteorological Office, 150 Reykjavík, Iceland

Passive seismic interferometry has become a popular technique towards monitoring subsurface activities in a variety of settings. This includes active volcanoes and geothermal fields spanning a large range of temperatures (25C to 250C) in Belgium and Iceland. The method depends on the relative stability of background seismic sources in order to make repeatable measurements of subsurface properties. Such stability is typically assessed by examining the similarity of cross-correlation functions through time. Thus, techniques that can better assess the temporal similarity of cross-correlation functions may aid in discriminating between real subsurface processes and artificial changes related variable seismic sources.

In this work, we apply agglomerative hierarchical clustering to cross-correlation functions computed using seismic networks at volcanoes. These include Piton de la Fournaise volcano (La Réunion island) and Mt Ruapehu volcano (New Zealand). Clustering is then used to form groups of cross-correlation functions that share similar characteristics and also, unlike common similarity measures, the method does not require a defined reference period. At Piton de la Fournaise, we resolve distinct clusters that relate both to changes in the seismic source (volcanic tremor onset) and changes in the medium following volcanic eruptions. At Mt Ruapehu, we observe a consistency to cross-correlation functions computed in the frequency band of volcanic tremor, suggesting tremor could be useful as a repeatable seismic source.

Our results demonstrate the potential of hierarchical clustering as a similarity measure for cross-correlation functions, suggesting it could be a useful step towards recognizing structure, or complex patterns, in seismic interferometry datasets. This can benefit both decisions in processing and interpretations of observed subsurface changes.