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Broadening volcanic eruption forecasting using transfer machine learning

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Sudden steam-driven eruptions at tourist volcanoes were the cause of 63 deaths at Mt Ontake (Japan) in 2014, and 22 deaths at Whakaari (New Zealand) in 2019. Warning systems that can anticipate these eruptions could provide crucial hours for evacuation or sheltering but these require reliable forecasting. Recently, machine learning has been used to extract eruption precursors from observational data and train forecasting models. However, a weakness of this data-driven approach is its reliance on long observational records that span multiple eruptions. As many volcano datasets may only record one or no eruptions, there is a need to extend these techniques to data-poor locales.

Transfer machine learning is one approach for generalising lessons learned at data-rich volcanoes and applying them to data-poor ones. Here, we tackle two problems: (1) generalising time series features between seismic stations at Whakaari to address recording gaps, and (2) training a forecasting model for Mt Ruapehu augmented using data from Whakaari. This required that we standardise data records at different stations for direct comparisons, devise an interpolation scheme to fill in missing eruption data, and combine volcano-specific feature matrices prior to model training.

We trained a forecast model for Whakaari using tremor data from three eruptions recorded at one seismic station (WSRZ) and augmented by data from two other eruptions recorded at a second station (WIZ). First, the training data from both stations were standardised to a unit normal distribution in log space. Then, linear interpolation in feature space was used to infer missing eruption features at WSRZ. Under pseudo-prospective testing, the augmented model had similar forecasting skill to one trained using all five eruptions recorded at a single station (WIZ). However, extending this approach to Ruapehu, we saw reduced performance indicating that more work is needed in standardisation and feature selection.