Machine-learned, Earthquake Signal Classification of GNSS High Rate Velocities

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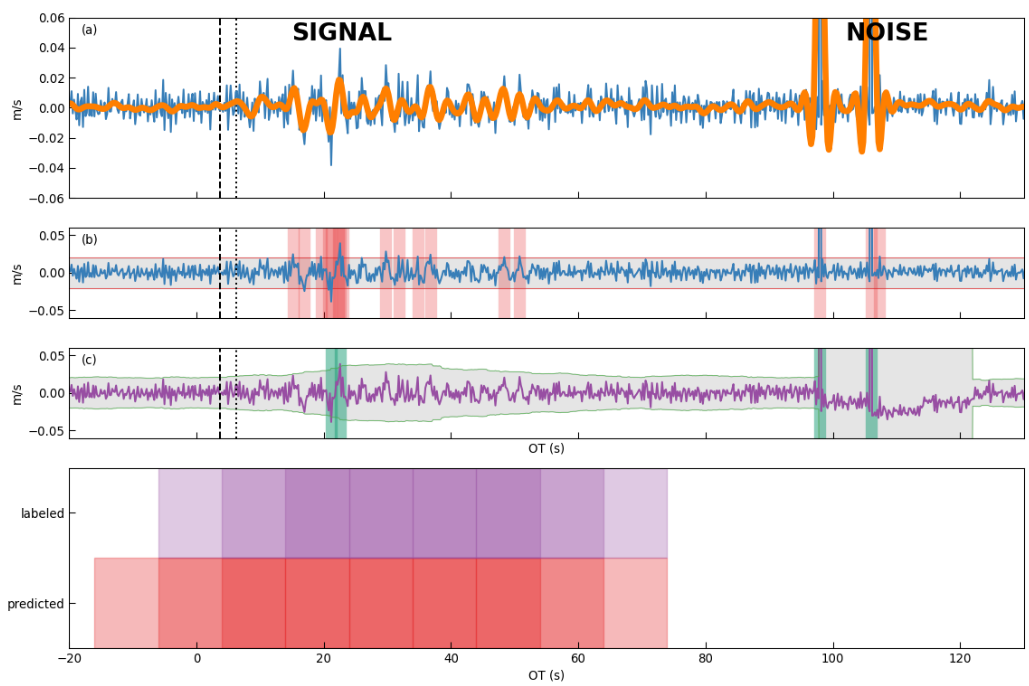
Data-driven approaches for identifying geophysical signals have proven beneficial in high dimensional environments where physics based, model-driven methods fall short. GNSS offers a source of unsaturated ground motion observations. These observations are critical to ground motion forecasting and rapid seismic hazard assessment and alerting. When sourced from GNSS, these signals are superposed onto hardware-, location- and time-dependent noise signatures influenced by the earth's atmosphere, low-cost or spacebourne oscillators and complex radio frequency environments. Eschewing physics-based models for a data-driven approach in this context is a step forward in autonomous signal discrimination. We report on results of training a random forest classifier on GNSS time differenced carrier phase velocity waveforms. We employed nested cross validation of a GNSS velocity catalog generated from the 77 events (Mw4.9-8.2) concurrent with available 5Hz GNSS observables in the NSF GAGE geodetic archive. We then quantified the benefits of data augmentation of transferred signal catalogs. Such expanded training sets improve the classifier's generalization and enable deeper learning models of relatively limited datasets.



(a.) An example of adjacent signal (M5.4 at 21 km) and noise disturbance within 5Hz GNSS velocities, with (b.) illustrating a common threshold detection approach with alerts in red, (c.) a modified STA/LTA with alerts in green, and (d.) a random forest classifier trained on separate events with predicted alerts in red and labels in purple.