December 20, 2022 Ferndale Earthquake: Coseismic Displacements, Finite-fault Model, Changes in Seismic Velocity, and Slow-moving Landslide Response

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The Mw 6.4 Ferndale Earthquake on December 20, 2022 was felt widely across Northern California. The earthquake occurred at 18 km depth on a steeply dipping fault striking southwest to northeast, likely in the downgoing Gorda Slab (the southern sub-plate of the Juan de Fuca plate). The largest aftershock in the sequence was magnitude 5.4 on January 1, 2023, 40 km southeast of the epicenter at a depth of 30 km. The Ferndale event occurred on the anniversary of a magnitude 6.2 earthquake that occurred 20 km to the southwest on December 20, 2021.

We present coseismic deformation measurements from Sentinel-1 and ALOS-2 Interferometric Synthetic Aperture Radar (InSAR) and high-rate GNSS, which indicate a maximum surface displacement of more than 20 mm near the GNSS station P161. We simultaneously invert seismic and geodetic observations to constrain a finite-fault model and find peak slip of 1.5 m, occurring over a depth range of approximately 16 to 24 km with a predominantly unilateral rupture of approximately 18 km to the NE. Using ambient noise seismology, we observe a marked drop (~0.6%) in seismic velocity (dv/v) at a nearby seismic station, following the 2022 Mw 6.4 mainshock.

Slow-moving landslides in Northern California experienced forcing from both earthquake shaking and increased precipitation. The nearest slow-moving landslide was 4.75 km from the epicenter, experienced shaking of Modified Mercalli Intensity (MMI) 7.2, and received nearly 800 mm rain in the subsequent month. We analyze slow-moving landslides with InSAR time series to look for changes in behavior from either the 2021 or 2022 ruptures. For both the landslide and seismic velocity analysis, the timing of the extreme rainfall events makes teasing apart earthquake and hydrological effects challenging.

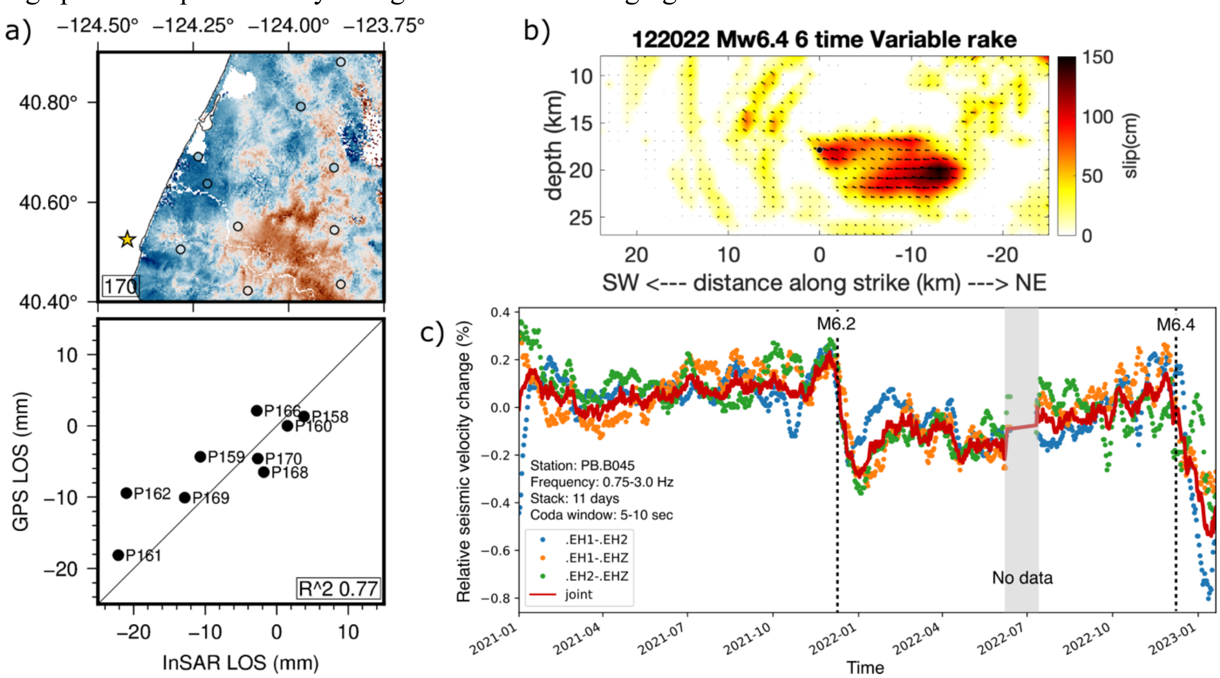

Figure 1. a) coseismic displacement measured by ALOS-2 (top) compared with GNSS displacements (bottom) b) finite-fault model and c) time history of relative seismic velocity changed inferred from a single-station cross-component analysis with PB.B045 borehole seismic data.