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Relative seismic velocity variations correlate with deformation at Kīlauea volcano

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Seismic noise interferometry allows the continuous and real-time measurement of relative seismic velocity through a volcanic edifice. Because seismic velocity is sensitive to the pressurization state of the system, this method is an exciting new monitoring tool at active volcanoes. Despite the potential of this tool, no studies have yet comprehensively compared velocity to other geophysical observables on a short-term time scale at a volcano over a significant length of time. We use volcanic tremor ($\sim$0.3 to 1.0 Hz) at Kīlauea as a passive source for interferometry to measure relative velocity changes with time. By cross-correlating the vertical component of day-long seismic records between $\sim$230 station pairs, we extract coherent and temporally consistent coda wave signals with time lags of up to 120 s. Our resulting time series of relative velocity shows a remarkable correlation between relative velocity and the radial tilt record measured at Kīlauea summit, consistently correlating on a time scale of days to weeks for almost the entire study period (June 2011 to November 2015). As the summit continually deforms in deflation-inflation events, the velocity decreases and increases, respectively. Modeling of strain at Kīlauea suggests that, during inflation of the shallow magma reservoir (1 to 2 km below the surface), most of the edifice is dominated by compression—hence closing cracks and producing faster velocities—and vice versa. The excellent correlation between relative velocity and deformation in this study provides an opportunity to understand better the mechanisms causing seismic velocity changes at volcanoes, and therefore realize the potential of passive interferometry as a monitoring tool.