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Seismic imaging and monitoring of the Piton de la Fournaise volcano from ambient seismic noise correlations

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Imaging the structure of volcanic edifices from the inversion of earthquake data is hampered by irregular distribution of hypocenters. To improve our knowledge of the Piton de la Fournaise basaltic volcano located at the La Reunion Island, we inverted surface waves reconstructed from cross-correlations of ambient seismic noise at different sensors. By using 18 months of ambient noise recorded by the 21 permanent stations ran by the Piton de la Fournaise Volcanological Observatory we could reconstruct Rayleigh waves with sufficient signal-to-noise ratio for 210 inter-station paths. We used the reconstructed waveforms to measure group velocity dispersion curves at periods between 1.5 and 4.5 s. The obtained measurements were inverted for two-dimensional group velocity maps and finally for a 3D Vs velocity model of the edifice from +2 to -1 km above sea level. Our results clearly show a high velocity body spatially located within the active 10 km width caldera. This anomaly is interpreted as a solidified magma body. Imaging these intrusive bodies is of particular interest because the magma path is usually believed to follow their geometry.

We further investigate the temporal variations of the reconstructed Green's functions associated to average seismic velocity perturbations within the volcanic edifice. We propose a robust method to measure travel time perturbations from the reconstructed Green's functions. Application of this method to 18 months of continuous seismic noise records allows us to detect clear decreases in seismic velocity preceding four eruptions of the Piton de la Fournaise volcano. These observed travel time anomalies

occurring a few weeks before the eruptions may be be interpreted as the opening of superficial cracks due to the inflation of the volcanic edifice. This new observation may prove useful for a more precise short term volcanic hazard assessment.