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Constraining the spatial and depth extent of deep-seated, slow-moving landslides using seismic noise interferometry

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Catastrophic failure of deep-seated landslides is one of the most disastrous hazards due to the deep-rooted sliding interface and a large bulk volume involved. Estimating their bulk volume in terms of the basal depth and monitoring their temporal states are crucial but challenging for geotechnical methods since the measurements are usually spatially limited due to expensive drilling cost and sometimes suffer difficulty in determining primary sliding interface when multiple shear zones are present or bore logs between different holes are inconsistent. Recent advances of the seismic noise interferometry (SNI) have provided a new means to monitor the subsurface medium in a non-invasive, continuous, and relatively inexpensive way. Utilizing a seismic network from the Lantai landslide monitoring project in the Ilan area, northern Taiwan, we demonstrated that the SNI is capable of constraining the spatial and depth extent of the deep-seated Lantai landslide. During a typhoon event, the seismic velocity of the landslide area was reduced in response to the heavy rainfall and an acceleration phase of surface movement. Through the dispersion characteristics of surface waves in the correlational coda we retrieved, a deep origin of the seismic velocity changes at the depths of 90-110 m is suggested and could represent the primary sliding interface of the Lantai landslide, consistent with the identified shear zones of 70-100 m in a nearby bore log. With that, we suggest that the SNI is a promising supplement to the current engineering- and geodesy-based methods for landslide monitoring and could be integrated with other measures to gain a better understanding of landslide susceptibility to external forcing and the sliding characteristics toward the failure.