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Observation and identification of normal modes of the earth using the PBO strainmeter network

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The M9.0 Tohoku megathrust earthquake of March 2011 was one of the largest earthquakes ever recorded and the largest historical earthquake to ever strike Japan. Although the offshore location of the earthquake minimized the damage incurred from direct shaking, the event excited large-amplitude free oscillations of Earth that are observable on long-period seismic instruments and can be used help constrain the deep structure of the planet.

During the weeks following the Tohoku earthquake, we recorded long-period oscillatory strain signals on the Plate Boundary Observatory (PBO) network of 74 borehole strainmeters in the western United States. PBO strainmeters are sensitive to signals from 100Hz to 0.000001Hz, overlapping the lower-frequency range of broadband seismometers where the normal modes of Earth's free oscillations can be observed. Analyzing the spectral content of the PBO signals, we show that they are consistent with the expected signal due to normal mode oscillations, and we show how the spectrum varies temporally and spatially over the north-south extent of the PBO network and between stations in closely-grouped station arrays. We also compare these results to nearby broadband seismometers and show the limitations of coastal strainmeters for normal-mode studies, where contamination by tsunamigenic ocean loading obscures key portions of the spectral band. We believe that these results show that strainmeters can serve as an important new source of data for normal-mode seismology, augmenting and extending the capabilities of the current global broadband seismometer network.