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Coseismic and postseismic velocity changes detected by Passive Image Interferometry: Comparison of five strong earthquakes (magnitudes 6.6 - 6.9) and one great earthquake (magnitude 9.0) in Japan

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We analyzed ambient seismic noise near five strong onshore crustal earthquakes in Japan as well as for the great Tohoku offshore earthquake. Green's functions were computed for station pairs (cross-correlations) as well as for different components of a single station (single-station cross-correlations) using a filter bank of five different bandpass filters between 0.125 Hz and 4 Hz. Noise correlations for different time periods were treated as repeated measurements and coda wave interferometry was applied to estimate coseismic as well as postseismic velocity changes. We used all possible component combinations and analyzed periods from a minimum of 3.5 years (Iwate region) up to 8.25 years (Niigata region). Generally, the single-station cross-correlation and station pair cross-correlation show similar results, but the single station method is more reliable for higher frequencies ($f > 0.5$ Hz), whereas the station pair method is more reliable for lower frequencies ($f < 0.5$ Hz). For all six earthquakes we found a similar behavior of the velocity change curve as a function of time. We observe coseismic velocity drops at the times of the respective earthquakes followed by postseismic recovery for all earthquakes. Additionally, most stations show a seasonal velocity variation. This seasonal variation was removed by a curve fitting and velocity changes of tectonic origin only were analyzed in our study. The postseismic velocity changes can be described by an exponential recovery model, where for all areas about half of the coseismic velocity drops recover on a time scale of the order of half a year. The other half of the coseismic velocity drops remain as a permanent change. The coseismic velocity drops are stronger at larger frequencies for all earthquakes. We assume that these changes are concentrated in the superficial layers but for some stations can also reach a few kilometers of depth. The coseismic velocity drops for the strong earthquakes (magnitudes 6.6 - 6.9) are concentrated near the respective rupture areas, whereas velocity changes caused by the Tohoku earthquake were even detected in Fukuoka prefecture at a distance of 1000 km from the epicenter. The reason for the observed coseismic and postseismic velocity changes is still unclear. We modeled the volumetric strain changes for the different earthquakes and showed that these changes cannot explain our observations, because the amplitudes of the coseismic velocity drops do not depend on the volumetric strain changes. Furthermore, we never observed coseismic velocity increases, although they are anticipated by the strain model in some areas. We also compared coseismic velocity drops to peak ground acceleration (PGA) and peak ground velocity (PGV) values recorded during the respective earthquakes by nearby strong motion instruments. We found that PGV values show a stronger correlation with the observations than PGA values. In general, the coseismic velocity drops increase with the PGV values. This observation supports the model of a coseismic destruction of material followed by a postseismic healing.