Optimizing seafloor pressure sensor networks for the detection of slow slip earthquakes in Cascadia and beyond

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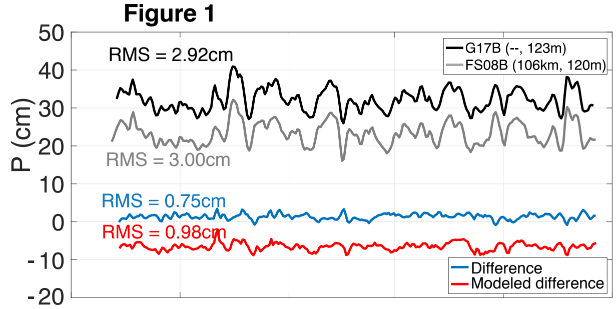
Figure 1



Offshore geodetic observations are essential for understanding the behavior of the shallowest segment of subduction zones, where land-based measurements have limited resolution. One such observation, seafloor pressure, has been used successfully in several subduction zones worldwide to detect and characterize slow slip earthquakes (SSEs) updip of and within the seismogenic zone; however, the resolution of these measurements is inhibited by the presence of large-amplitude oceanographic signals that mask expected deformation signals. We use seafloor pressure data from the 2011-2015 Cascadia Initiative experiment, along with models of oceanographic circulation and models of geophysical deformation, to show that oceanographic signals in Cascadia are largely coherent along isobaths and can be corrected for by differencing depth-matched pairs of pressure records. Under this method, noise in tidally filtered pressure data can be reduced from >3 cm water to <1 cm RMS between instruments separated by 100 km or more (Figure 1). This compares to an observed 1-6 cm peak vertical displacement from offshore SSEs in other settings. Synthetic pressure differences calculated from the oceanographic models produce comparable results and suggest a broader regional trend than is available in the limited observational data. We use a half-space fault model to calculate predicted seafloor displacements for a range of SSE scenarios, merging them with hindcast pressure time series from the oceanographic models to simulate observational records and assess detectability. These synthetic observations show that depth-matched differencing can reliably detect deformation signals at least as small as 1.5 cm (Figure 2). Our results suggest that future experiments should deploy sensors along lines of constant depth to maximize detectability. This approach needs to be evaluated for other subduction zones to determine whether it is widely applicable, as circulation patterns vary between regions. Additional offshore geodetic methods and their applications will also be discussed.

Figure 2