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# Long-period Ground Motions from Past and Virtual Megathrust Earthquakes along the Nankai Trough, Japan

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Long-period ground motions from large ($M_w$ > 7.0) subduction-zone earthquakes are a real threat for large-scale human-made structures. The Nankai subduction zone, Japan, is expected to host a major megathrust earthquake in the near future and has therefore been instrumented with offshore and onshore permanent seismic networks (Fig. 1).

We use the ambient seismic field continuously recorded at these stations to simulate the long-period (4-10 s) ground motions from past and future potential offshore earthquakes. First, we compute impulse response functions between an ocean bottom seismometer of the DONET network (e.g., the KMD14 station), which is located offshore on the accretionary wedge, and 60 onshore Hi-net stations using seismic interferometry by deconvolution (Fig. 2; *Viens et al., 2017*). As this technique only preserves the relative amplitude information of the impulse response functions, we calibrate the amplitude with a moderate event which occurred within the fault plane of the 2004 $M_w$ 7.2 Off the Kii peninsula earthquake. After calibration, the impulse response functions are used together with a uniform stress drop source model to simulate the long-period ground motions of the $M_w$ 7.2 event (Fig. 1).

The simulated waveforms reproduce relatively well the recorded waveforms of the $M_w$ 7.2 event in terms of phase and amplitude (Fig. 3). Moreover, the residuals of the 5% damped spectral acceleration computed from the horizontal and vertical components of the observed and simulated waveforms exhibit almost no bias and acceptable uncertainties. We also compare the observed spectral acceleration values of the $M_w$ 7.2 event to those from the subduction-zone BC Hydro ground motion model (*Abrahamson et al., 2016*) and find that our simulations perform better than the model.

We also simulate the long-period ground motions of a hypothetical $M_w$ 8.0 subduction earthquake that could occur along the Nankai Trough. For this event, our simulations generally exhibit stronger long-period ground motions than those predicted by the BC Hydro ground motion model. This study suggests that the ambient seismic field recorded by the ever-increasing number of ocean bottom seismometers can be used to simulate the long-period ground motions from large-to-megathrust offshore earthquakes.

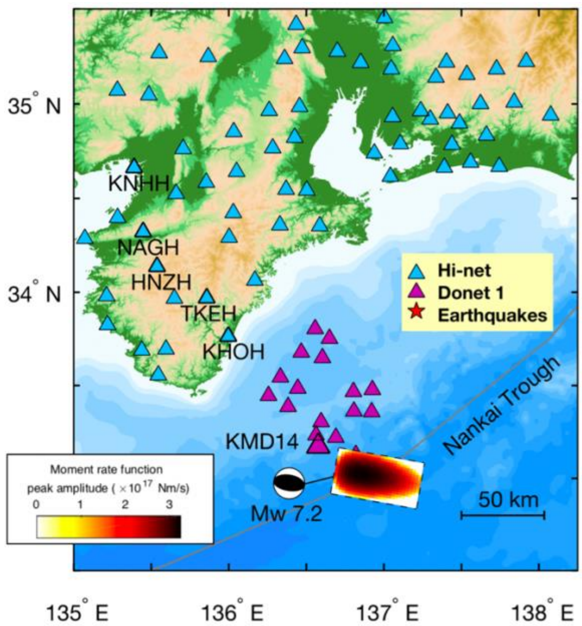


Fig. 1: Topographic map of the Kii peninsula region and the Nankai subduction zone including the Hi-net and DONET 1 stations (triangles) and the fault plane

of the 2004 $M_w$ 7.2 event projected at the surface (rectangle). The colored area inside the fault plane represents the peak amplitude of the moment-rate function at each subfault. The virtual source is the KMD14 station and the name of 5 Hi-net stations for which the results are presented in Fig. 3 are also indicated.

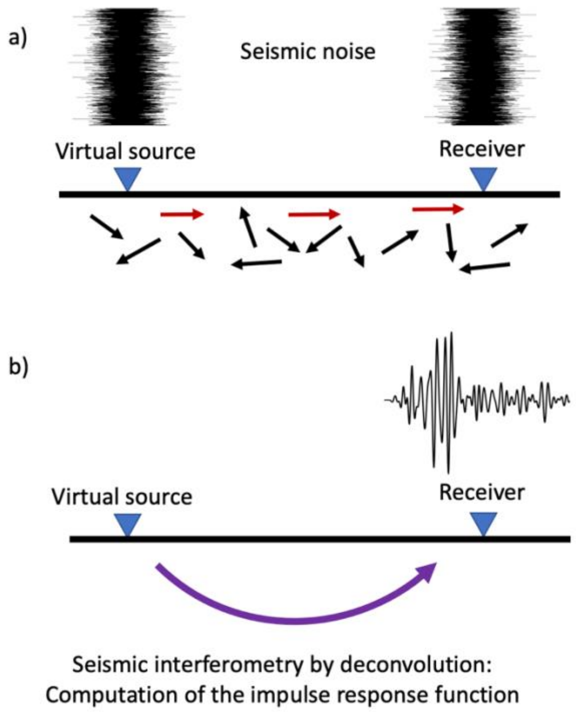


Fig. 2: (a) Recorded ambient seismic noise at the virtual source and receiver stations. The recorded ambient seismic noise contains coherent information that propagates between the two sensors (red arrows). (b) Computation of the impulse response function from the coherent information of the ambient seismic noise recorded at the two seismic stations using seismic interferometry by deconvolution.


**References:**

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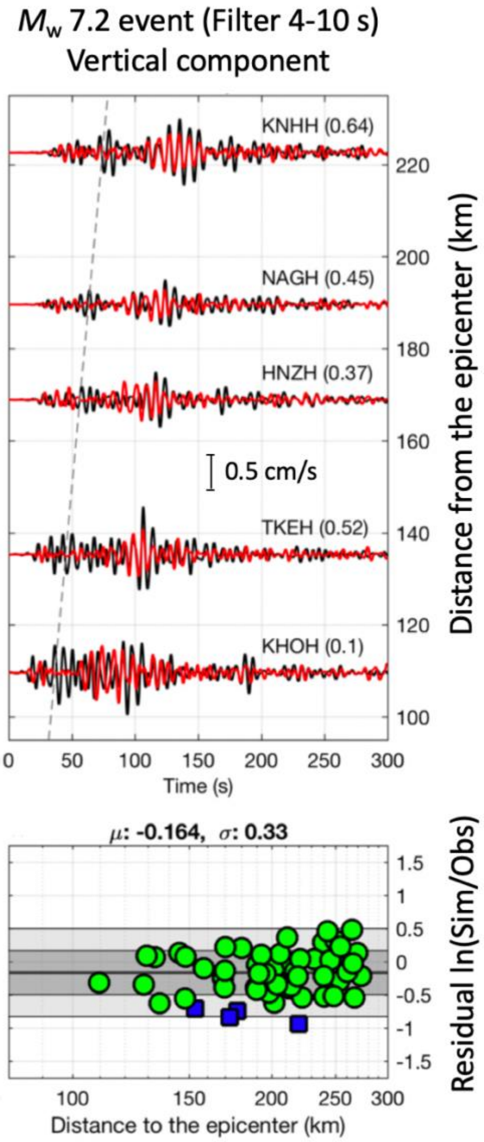


Fig. 3: Simulated (red) and observed (black) waveforms for the vertical component for 5 stations located towards Osaka City in the 4 to 10 s period range. For each station, the correlation coefficient between the waveforms is indicated. The dashed line represents the 3 km/s moveout. Long-period PGV residuals as a function of the distance from the epicenter. The green circles indicate that the ratio between the simulated and observed PGVs are within a factor of 2 and the blue squares represent values larger than a factor of 2 but within a factor of 3. The black thick line is the mean of the data. The 1 and 2 standard deviations to the mean are shown by the dark gray and light gray areas, respectively. The mean of the residual ($\mu$) and the standard deviation to the mean ($\sigma$) values are also shown.