Urban Seismology: Characteristics of Subduction Guided Waves in Taipei Using Formosa Array

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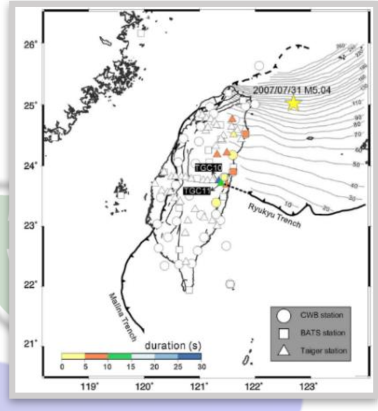
I. Introduction

Seismic events near subduction zones radiate complex wave field. In particular, low-frequency arrivals followed by large-amplitude, high-frequency signals with sustained coda are often observed at stations in the forearc, where the subducting plate acts as an efficient waveguide for the high frequency signals.

Previous study of subduction zone guided waves in Taiwan demonstrated that the higher frequency signal can be amplified by a factor of a few hundred with longer than 10 s shaking due to guiding effect, which provides important information for hazard mitigation planning.

Chen et al. (2013) used the spectral ratio for high-pass filtered with 5 Hz and low-pass filtered with 4 Hz as a standard to definite whether the stations have guiding effect or not. In this study, they found that the stations showing guided waves are concentrated in northeast Taiwan, as shown by longer-lasted high frequency energy. However, the stations are sparsely distributed especially in northern Taiwan. We want to examine the guiding effect more closely, using a dense array in Taipei area. That is Formosa Array.

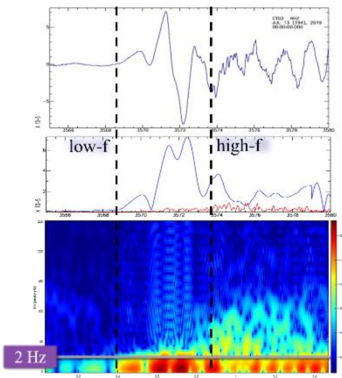


Chen et al. (2013)

II. Analysis

In the waveforms, the deeper event reveals stronger high-frequency energy and low-frequency first arrival with follow-up higher-frequency waves.

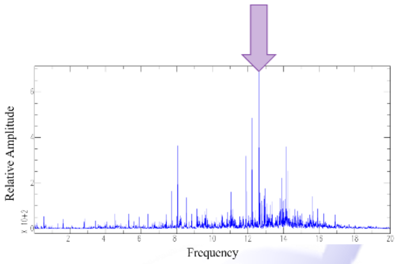
Small-scale heterogeneity in the plate may facilitate strong internal scattering to develop long high-f coda, leading to the later-arrived high-f energy. The earlier arrival of low-f energy can be also seen in the spectrogram. Also note that the high-f is enriched later in the coda. The clear separation between low- and high-f energy is 2 Hz, consistent with the low-pass and high-pass band chosen in the previous s

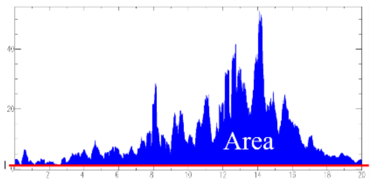


III. Quantification

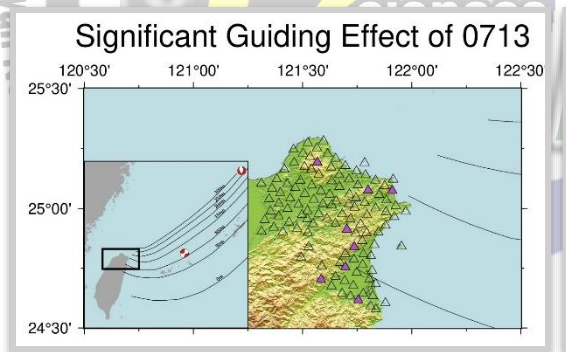
Using a large number of events close to Taiwan, Chen et al. (2013) used the spectral ratio of high-pass filtered wave and low-pass filtered wave to reflect guiding effect. However, due to limited data in this study, we have only a few deeper and large events to analyze. Therefore, we compute the spectral ratio between deeper and shallow events, to demonstrate the enrichment of high-frequency energy from deeper events.

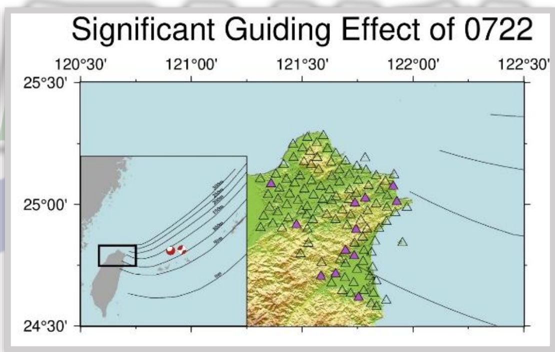
First is the max. value in the spectral ratio. This peak represents the frequency that makes the biggest difference between deeper and shallow events. The second is to obtain the area in the spectral ratio. It represents the relative energy between the intermediate-depth earthquakes and the shallow earthquake.





We ask for main frequency higher than 10 Hz and enrichment of high-f energy greater than 150. Combined criteria from the above measurements as "significant guiding effect." In these stations, the high-frequency energy is clearly seen for deeper events instead of shallow events.





IV. Conclusion

Using 140 stations densely distributed in Taipei metropolitan area, we studied guiding effect from focal depth over 100 km earthquakes occurred in the offshore area.

Comparing with shallow events, the guiding effect is evident by enrichment of over 4 Hz energy in the coda and low-frequency precursor followed by high-f coda.

We quantified the guiding effect by computing the peak and areal enrichment in spectral ratio between deeper and shallow event and further, identify the station showing significant guiding effect.

Significant guiding effect is found to concentrate in the Yilan and Keelung areas, showing longer-lasted over 10 Hz without clear amplification effect.

In Taipei city, it also shows some spots with guiding effect. This indicates that other than the low-frequency surface waves from far that leads to stronger shaking in high-rise building, the deeper event brings different effect on the building. The lower floor may be influenced by sustained high-frequency from deep, far away earthquakes.

V. Acknowledgement

Special thanks to the efforts by Cheng-Horng Lin, Min-Hung Shih, Ya-Chuan Lai who deployed the Formosa Array and shared the FA data for this project. We also appreciate the funding event resources provided by Dep. of Earth Sciences, National Taiwan Normal University, Taipei, Taiwan.

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