Source rupture imaging using regional strong motion records

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The dynamic rupture of large earthquakes generates complex radiation with a large frequency range. The radiation complexity is induced by the fault geometry and the properties of the fault interface. For large earthquakes (Mw > 7.5), teleseismic methods are used to study the rupture process at different frequency scales. For low frequency (LF) signals (50s -- 5s), inversion methods using kinematic models are well-established to determine the space-time distribution of the fault slip. On the contrary, for high frequency (HF) signals (1Hz -- 5Hz), even though models are more difficult to simulate, we can identify emission zones by the back projection method.

Large band spectral models of seismic sources are mainly kinematic. The slip distribution along the fault interface is modelled as a spatial and temporal stochastic process. At the fault scale, there is an effective rupture front propagation; and at small scale, we adjust the process to produce a spectrum which is consistent with the known seismic radiation. One of these models is the k-square model which superimposes a large number of asperities to produce one over k square final slip spectrum. The size of the asperities follows a power law distribution, they break with the rupture front passage and have a rising time proportional to their dimension.

Here, we want to improve the detail level of the HF images by using a regional network instead of a teleseismic one. The goal is to make our understanding of the rupture process better and to well-identify the link between HF radiation and the variability of strong ground motion. However, at regional scale, the heterogeneity of the crust implies a difference between the signals emitted along the fault from the point of view of one station; and the network aperture leads to a deformation of the phase shape of the Green function between stations. That is why there is not phase coherence anymore between two records. Therefore, by using characteristic functions (envelopes, kurtosis or Green functions), we want to extract the consistent information that lasts in the signal.

To do that, a known kinematic rupture, which is able to produce a correct HF radiation, is generated using a stochastic process. The different features of the rupture control the different frequency components of the source. We try to recover those features by back projection and have to deal with station distribution dependency or ghost signals.

References:

C. Satriano, V. Dionicio, H. Miyake, N. Uchida, J.-P. Vilotte and P. Bernard (2015)
Structural and thermal control of seismic activity and megathrust rupture dynamics in subduction zones: Lessons from the Mw 9.0, 2011 Tohoku earthquake
Earth and Planetary Science Letters,
doi: 10.1016/j.epsl.2014.06.037

J. A. Ruiz, D. Baumont, P. Bernard and C. Berge-Thierry (2011)
Modelling directivity of strong ground motion with a fractal, k^{-2}, kinematic source model
Geophysical Journal International,

doi: 10.1111/j.1365-246X.2011.05000.x

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