A SOURCE SPECTRUM WITH A DOUBLE-CORNER FREQUENCY AND ITS PHYSICAL IMPLICATIONS FOR THE EARTHQUAKE SOURCE

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We introduce a self-similar, double-corner-frequency (DCF) source spectrum, which in conjunction with a stochastic ground-motion model, can reasonably reproduce the peak ground acceleration (PGA) and peak ground velocity (PGV) of the NGA West-2 data set for magnitudes 3.3 to 7.7. Its displacement spectrum amplitude is constant for frequencies less than f_{c1}, decays as f^{-1} between f_{c1} and f_{c2}, and f^{-2} for frequencies larger than f_{c2}. The two corner frequencies f_{c1} and f_{c2} scale with magnitude (M) as: (1) $\log(f_{c1}(M)) = 1.754 - 0.5M$ and (2) $\log(f_{c2}(M)) = 3.250 - 0.5M$. The apparent single corner frequency (f_c^A) of the classic ω^{-2} model, defined as $f_c^A = \sqrt{f_{c1} f_{c2}}$, satisfies (3) $\log(f_c^A(M)) = 2.502 - 0.5M$. We find that relation (1) is consistent with the known self-similar scaling relations of the rupture duration (τ_d), if τ_d relates with f_{c1} as $\tau_d = 1/((\pi f_{c1}))$. The relation (3) is tightly associated with the constant "stress parameter", previously noticed in strong motion community. We find that simultaneously satisfying long- and short-period seismic observations requires $f_c^A \approx 1.78/\tau_d$, rather than $((0.6\ or\ 1.0))/\tau_d$ used in prior analyses. The DCF predicted radiated energy and apparent stress agree with global estimates of these parameters. Such an empirical model explains why the average stress drop from seismological studies is different from the stress parameter used to estimate PGA and PGV. The physical explanation of the high corner frequency f_{c2}, which is a consequence of relations (1) and (3), is not clear yet. Its inferred characteristic time is much smaller than rupture duration of asperities; f_{c2} may be related with the average rise time $\overline{T}_r = 0.8/f_{c2}$ on the fault inferred from the slip models; or f_{c2} might be associated with the average peak time of the fault slip on asperities.