Simplified-physics high frequency ground-motion simulations using site-specific parameters

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1 Motivation

- Accurate estimation of high-frequency ground-motion is challenging due to poor understanding of physics behind their generation and propagation.
- Broadband simulations typically use simplified physics-based approach to compute high frequency (>1 Hz) ground-motions.
- Simplified physics-based technique employ same 1D S-wave/ P-wave velocity (Vs/Vp) and anelastic attenuation (Qs/Qp) profiles for all sites (generic case).
- Objective: Modify conventional simplified physics-based method to use site-specific information, build theoretical understanding and analyze improvements over generic approach.

2 Example of results for conceptual understanding

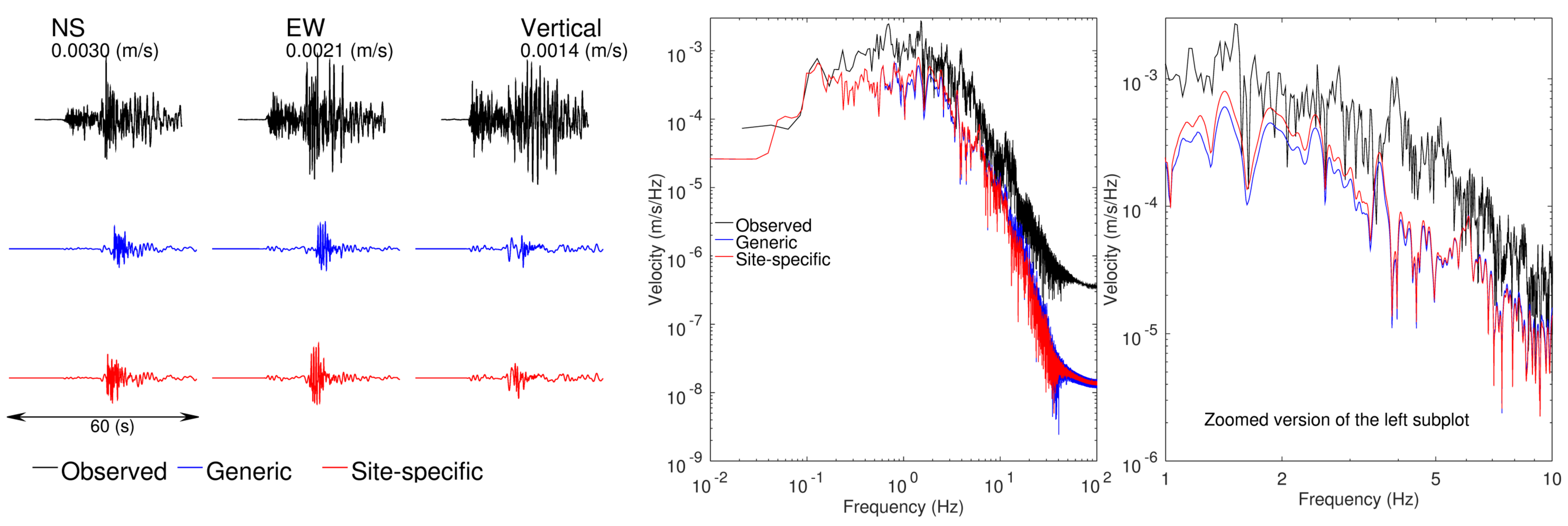


Figure 1: Waveform and Fourier spectra comparison.

- Comparing simulated ground motions from generic and site-specific approaches to recorded data due to April, 2011 (Mw 5.0) earthquake at CSHS site (which is 125 km from the source and is a 'rock' site).
- Simulations using generic approach show larger underprediction than site-specific method in predicting observations.

3 Concept of high-frequency computation method

- The Fourier Acceleration Spectrum (FAS) of ground-motion can be written as,

$$Y(M_0, R, f) = S(M_0, f)\, P(R, f)\, G(f) \quad (1)$$

where S, P and G represent source, path and site components of ground-motion. The site component is further subdivided into site-amplification A(f) and site-attenuation D(f).

- The ratio of FAS while using site-specific (SS) parameters in comparison to generic (Gen) approach,

$$Y_{SS2Gen} = \frac{Y_{SS}}{Y_{Gen}} = \frac{S}{S}\frac{P_{SS}}{P_{Gen}}\left[\frac{A_{SS}}{A_{Gen}}\;\frac{D}{D}\;\frac{CB14_{SS}}{CB14_{Gen}}\right] = P_{SS2Gen}\;A_{SS2Gen}\;CB14_{SS2Gen} \quad (2)$$

where CB14 represents the Campbell and Bozorgnia (2014) empirical model used to account for the near-surface non-linear soil effects.

4 Site-specific site-amplification A(f)

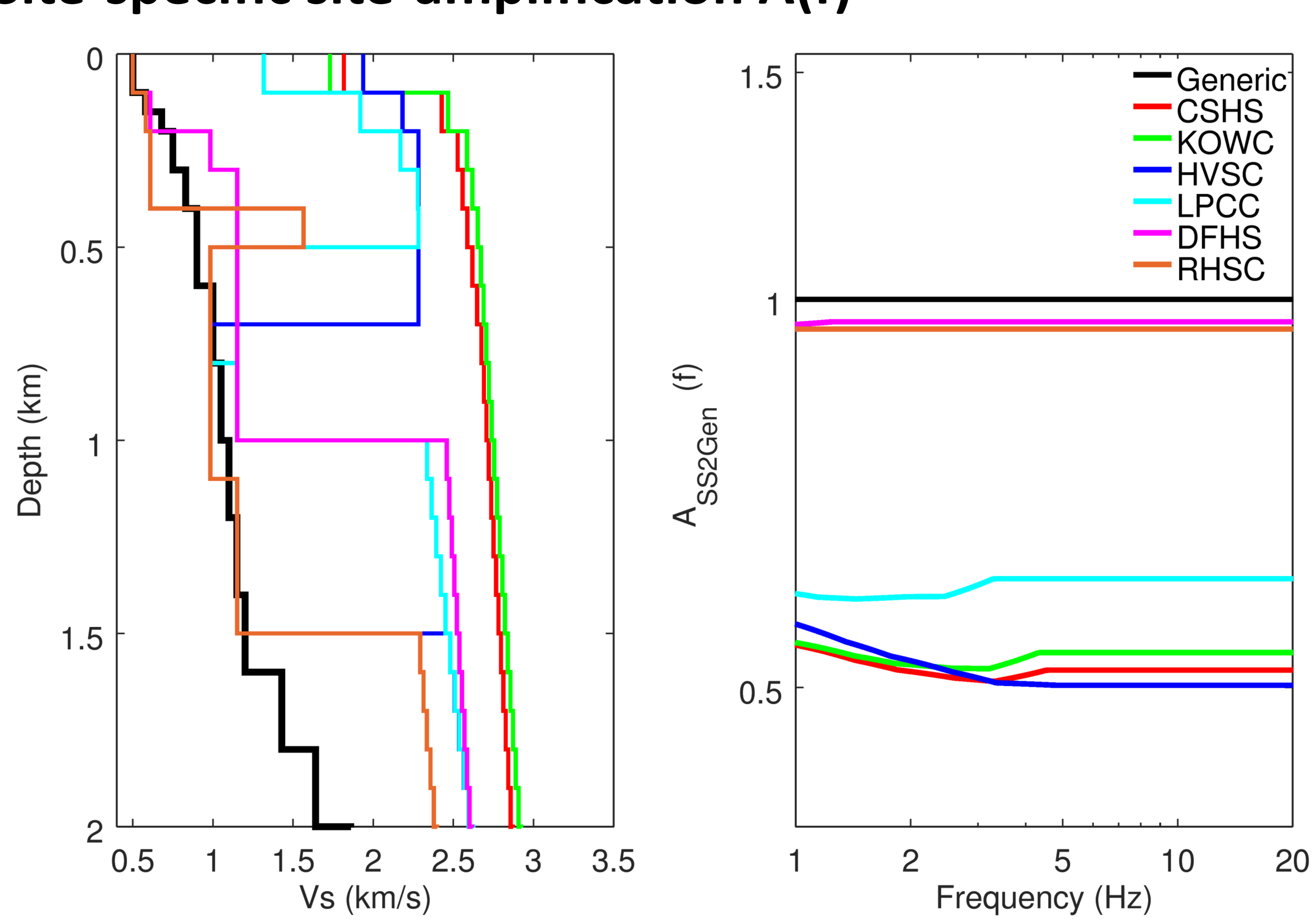


Figure 2: 1D Vs-profiles at six different sites and the ratio of site-amplification function calculated using site-specific Vs profile to generic Vs model.

- The site-amplification will be almost same for two soil sites (DFHS and RHSC) whereas ground-shaking at four rock sites will be lowered due to using site-specific Vs compared to generic Vs.

5 Site-specific path component P(R, f)

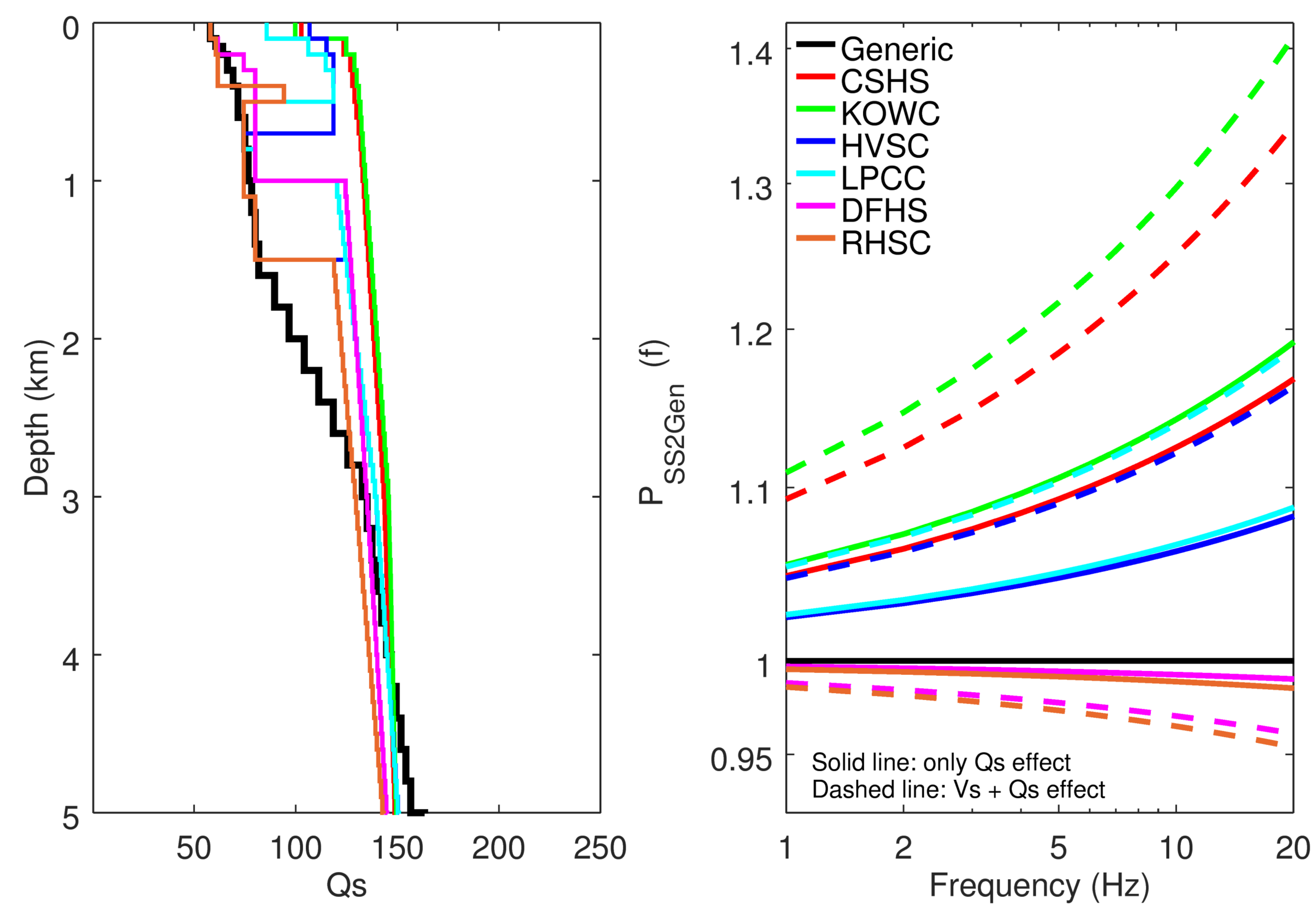


Figure 3: 1D Qs-profiles at six different sites and the ratio of path function; solid lines – only Qs effects; dashed lines – combined effect of Vs and Qs.

- Theoretically the ground-motion due to path effects at four rock sites will be higher from site-specific approach than generic case whereas for soil sites it remains almost comparable or slightly lower.

6 Site-specific Vs_{30}-based amplification CB14

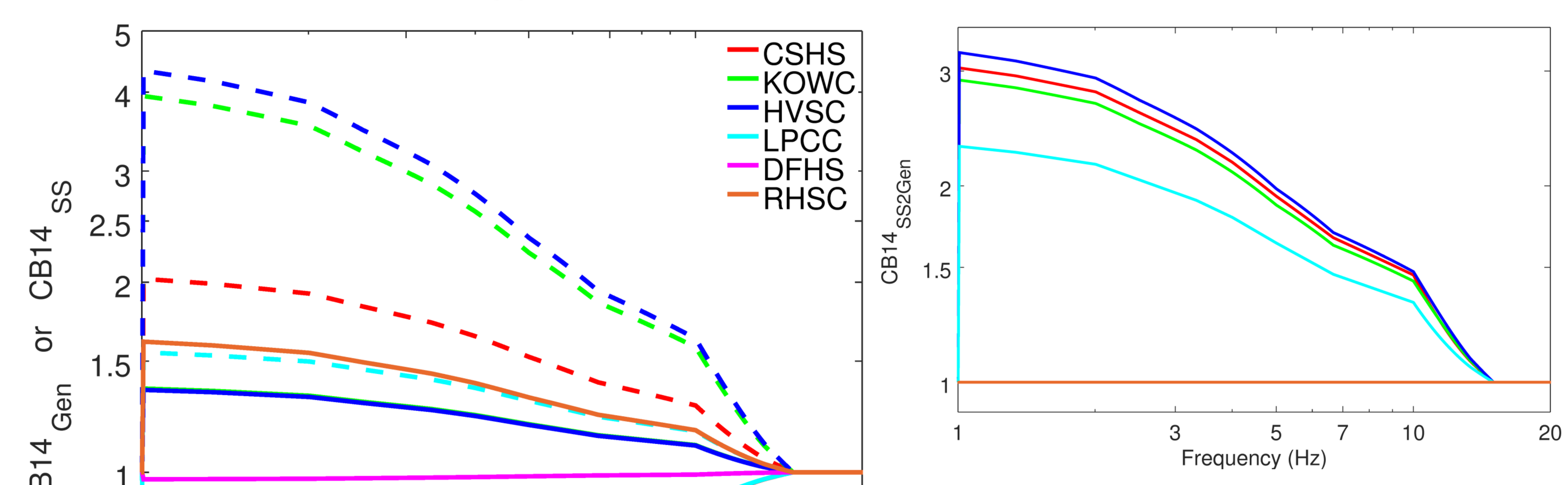


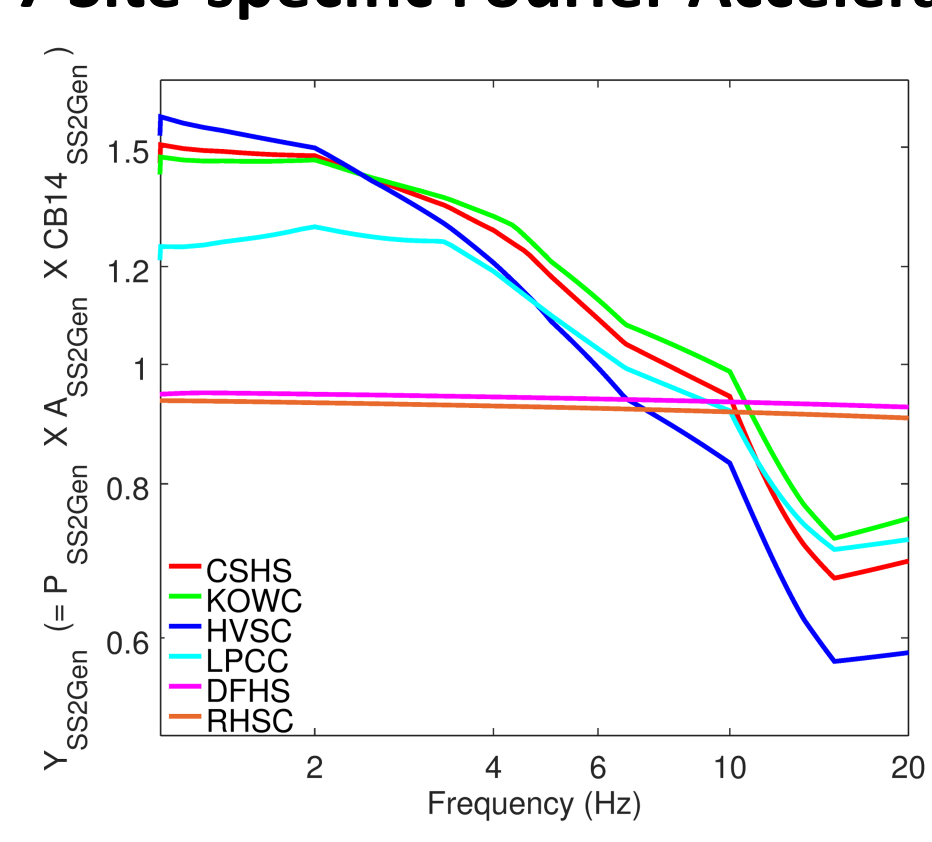
Table 1: Vs_{30} and Vs_{ref} at six sites used to calculate CB14 amplification.

Station Name	CSHS	KOWC	HVSC	LPCC	DFHS	RHSC
Vs_{30} (m/s)	800	350	352	792	515	286
$Vs_{ref\text{-}SS}$ (m/s)	1817	1730	1937	1317	500	500
$Vs_{ref\text{-}Gen}$ (m/s)	500	500	500	500	500	500

Figure 4: CB14 amplification calculated for six different sites using generic and site-specific soil conditions; and corresponding ratio of CB14 amplifications.

- The ground-motion at the four rock sites will be elevated for site-specific soil conditions compared to generic ones.

7 Site-specific Fourier Acceleration Spectrum FAS



- The FAS ratio at the four rock sites is greater than one for frequencies less than 6 Hz suggesting larger ground-motion from site-specific technique than generic approach.

Figure 5: The theoretical estimation of FAS ratio calculated using site-specific method to generic approach.

8 Conclusions

- We build theoretical understanding for computing high-frequency ground-motions using site-specific approach and our theoretical findings are in agreement with simulations (compare figures 5 and 1).
- The site-specific technique results in larger FAS (therefore, lower pSA residuals with respect to observed data) in comparison to generic approach (specially for rock sites).