SCEC Report: Proposal 17113

Physics-based scattering attenuation:
Calibrating the correlation structure of a stochastic model for the shallow sedimentary structure of the Los Angeles basin

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1 Data sources of shear wave velocity measurements

To calibrate a one-dimensional stochastic model (SVM) for the shallow sedimentary layers of the Los Angeles basin, we used four datasets of V_S profile measurements : (1) 178 profiles reported by *Yong et al.* (2013), (2) 277 profiles documented in *Boore* (2003), (3) 137 profiles collected by Chris Wills from the California Geological Survey (personal correspondence), and (4) 322 profiles measured by LeRoy Crandall and Associates (personal correspondence). The total number of profiles is 914. The first three datasets are publicly accessible, and the last dataset is proprietary. For simplicity, we henceforth refer to these four datasets as AY, DB, CW, and LC, respectively.

The V_S profiles in all four datasets are measured within California, concentrated mostly in Los Angeles and San Francisco areas, as shown in Figure 1. The histograms of V_{S30} values calculated from the profiles of each dataset are shown in Figure 2. The vast majority of sites have V_{S30} between 200 and 500 m/s, and outside this range, the measurements are relatively scarce.

The V_S profiles were measured using two families of site characterization techniques: the DB, CW, and LC profiles were measured using invasive methods (e.g., suspension logging, cross-hole and down-hole tests), and the AY profiles were measured using non-invasive methods (based on the inversion of surface wave dispersion curves, such as SASW, MASW, and/or ReMi). A number of previous studies (*Boore and Asten* 2008; *Boore and Brown* 1998; *Brown et al.* 2002; *Rix et al.* 2002; *Stephenson et al.* 2005) have shown that non-invasive shear-wave velocity profiling

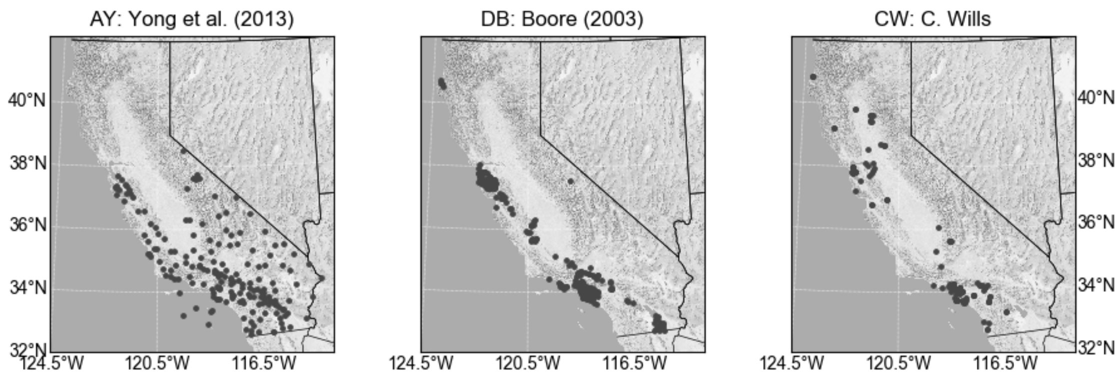

Figure 1: Locations of V_S profile measurements of three of the four datasets: AY (*Yong et al.*, 2013), DB (*Boore*, 2003), and CW (Chris Wills). Each dot on the map denotes the location of a V_S profile measurement. (The LC dataset is proprietary, so we do not show their locations here.)

techniques produced similar results as the invasive techniques. Thus in principle, the four datasets could have been merged directly for our subsequent analyses. Except for one discrepancy between the AY profiles and the DB+CW+LC profiles that can be traced back to the measurement techniques, which we documented in detail in *Shi and Asimaki* (2018), the four datasets can be merged into one.

2 Functional form and parameterization of SVM

The functional form of the parameterized profiles was selected to qualitatively match the velocity profile of typical sedimentary deposits:

$$V_S(z) = \begin{cases} V_{S0} & , 0 \leqslant z < z^* \\ V_{S0}\left(1 + k\left(z - z^*\right)\right)^{1/n} & , z > z^* \end{cases} \tag{1}$$

where z is depth in meters, and z^* is chosen as 2.5 m; V_{S0} is the shear wave velocity (m/s) from $z = 0$ to 2.5 m, and k and n are two dimensionless parameters: k is analogous to the "slope" of the curve which describes how fast V_S increases with z, and n controls the degree of curvature ($n = 1$ is a straight line, $n > 1$ is "convex",

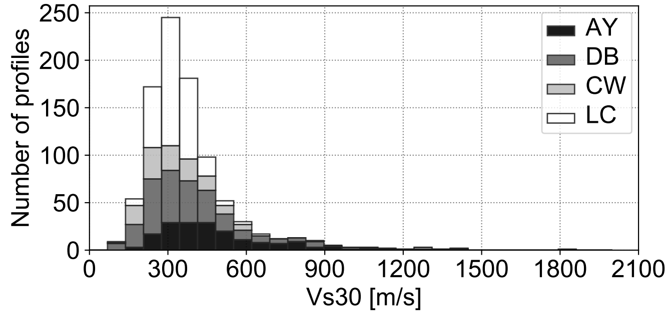

Figure 2: Histograms of V_{S30} values of the measured profiles. There is an abundance of measurement for V_{S30} between 200 and 500 m/s, and outside of this range, the measurements are relatively scarce.

and $n < 1$ is "concave"). And V_{S0}, k, and n can be correlated with V_{S30} as follows:

$$\begin{aligned} V_{S0} &= p_1 \left(V_{S30}\right)^2 + p_2 \left(V_{S30}\right) + p_3 \\ [h] \quad k &= \exp\left(r_1 \left(V_{S30}\right)^{r_2} + r_3\right) \\ n &= s_1 \exp\left(s_2 V_{S30}\right) + s_3 \exp\left(s_4 V_{S30}\right) \end{aligned} \tag{2}$$

Our curve fitting results produced the following parameter values: $p_1 = -2.1688 \times 10^{-4}$, $p_2 = 0.5182$, $p_3 = 69.452$, and $r_1 = -59.67$, $r_2 = -0.2722$, $r_3 = 11.132$, and $s_1 = 4.110$, $s_2 = -1.0521 \times 10^{-4}$, $s_3 = -10.827$, $s_4 = -7.6187 \times 10^{-3}$. Therefore, given a V_{S30} value, we can first use Eq (2) to calculate (V_{S30}, k, n), and then substitute them into Eq (1) to calculate an analytical V_S profile.

The details about the curve-fitting process have been documented in *Shi and Asimaki* (2018).

3 Example realizations in one- and two-dimensions

Shi and Asimaki (2018) also provided estimates of the uncertainties in the measured data. If these estimates are used as input to the randomization model proposed by *Toro* (1995), instead of the default value of the model, SVM produces randomized 1D V_S profiles as a function of V_S30. Figure 3 depicts three examples of smooth (background) and randomized V_S layered media.

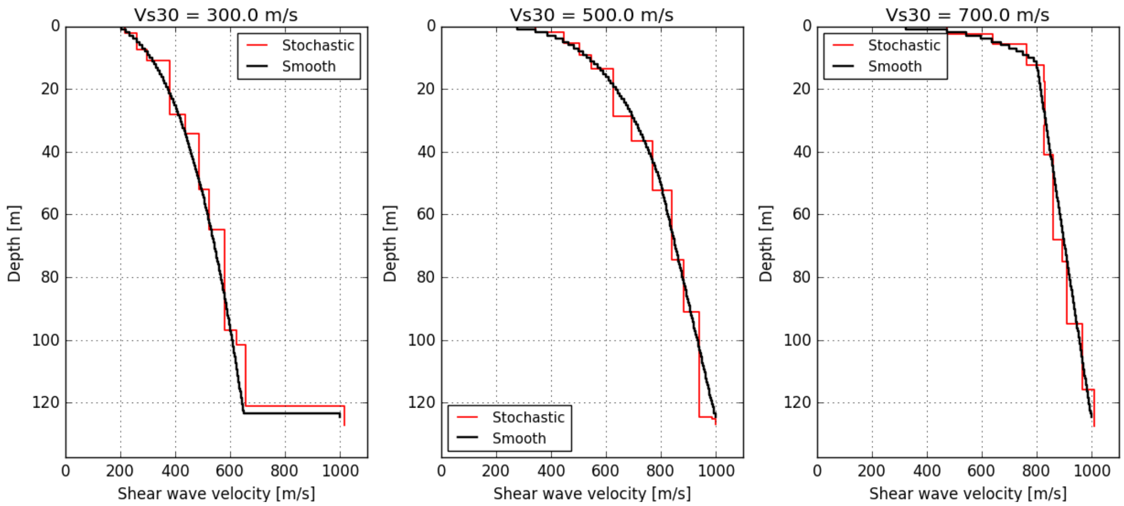

Figure 3: Smooth 1D V_S profiles generated by the SVM and stochastic 1D profiles generated using the model by *Toro* (1995).

We are currently extending the stochastic model to 3D by coupling the profile statistics with high resolution surface array inversions in Southern California. In the meanwhile, we implement the following rule of thumb to generate 2D V_S profiles within a cross section: we generate random realizations for every grid point based on the site specific V_{s30} but to avoid artificial large impedance contrasts, we impose constraints on the seed number increments of successive realizations. Results are shown in Figures 4 and 5, which show two example 2D cross sections in the Los Angeles basin. For each cross section, we compaee 2D profiles generated using CVM-S4.26.M01, CVM-S4.26.M01 modified by GTL model (*Ely et al.*, 2010), and CVM-S4.26.M01 modified by SVM. *Shi and Asimaki* (2018) have validated results for the one-dimensional model, while validation of the 3D model against recorded data is scheduled to take place when we compute realistic correlation structures in the horizontal directions (under development).

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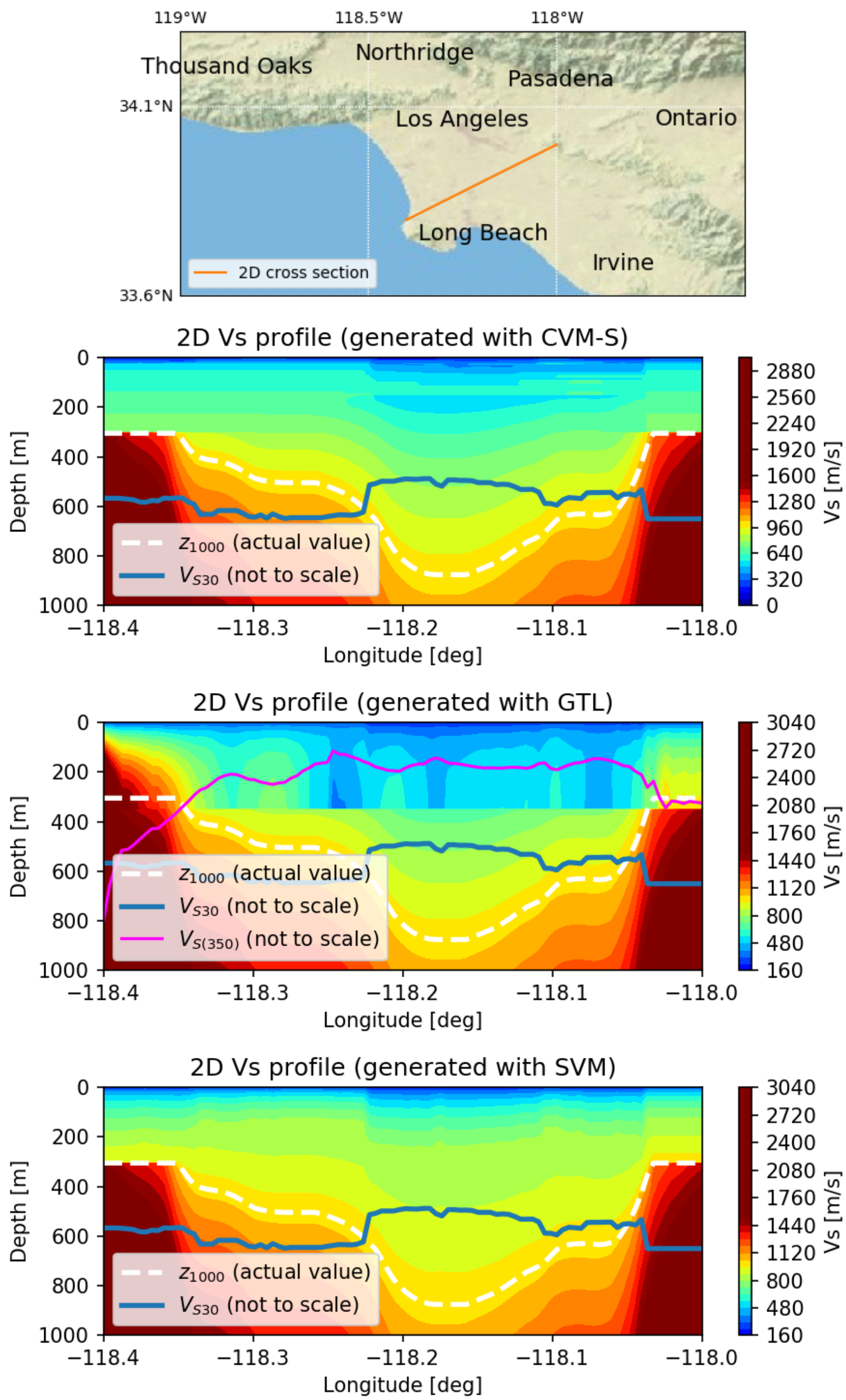

Figure 4: A 2D cross section in the Los Angeles basin and the 2D V_S profiles generated by CVM-S4.26.M01, CVM-S4.26.M01 + GTL, and CVM-S4.26.M01 + SVM

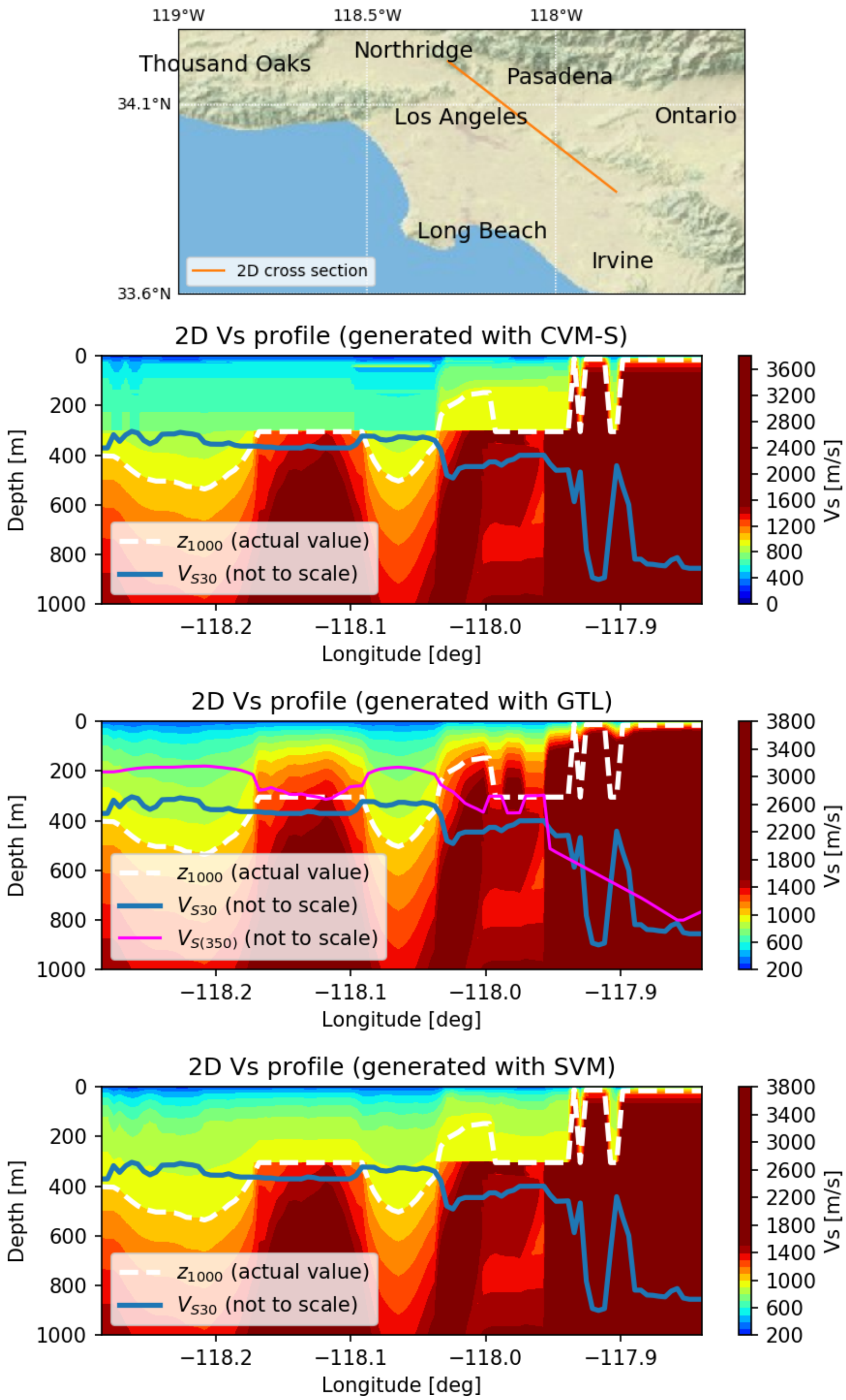

Figure 5: Another 2D cross section in the Los Angeles basin and the 2D V_S profiles generated by CVM-S4.26.M01, CVM-S4.26.M01 + GTL, and CVM-S4.26.M01 + SVM

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