SCEC Multi-scale Community Velocity Model TAG

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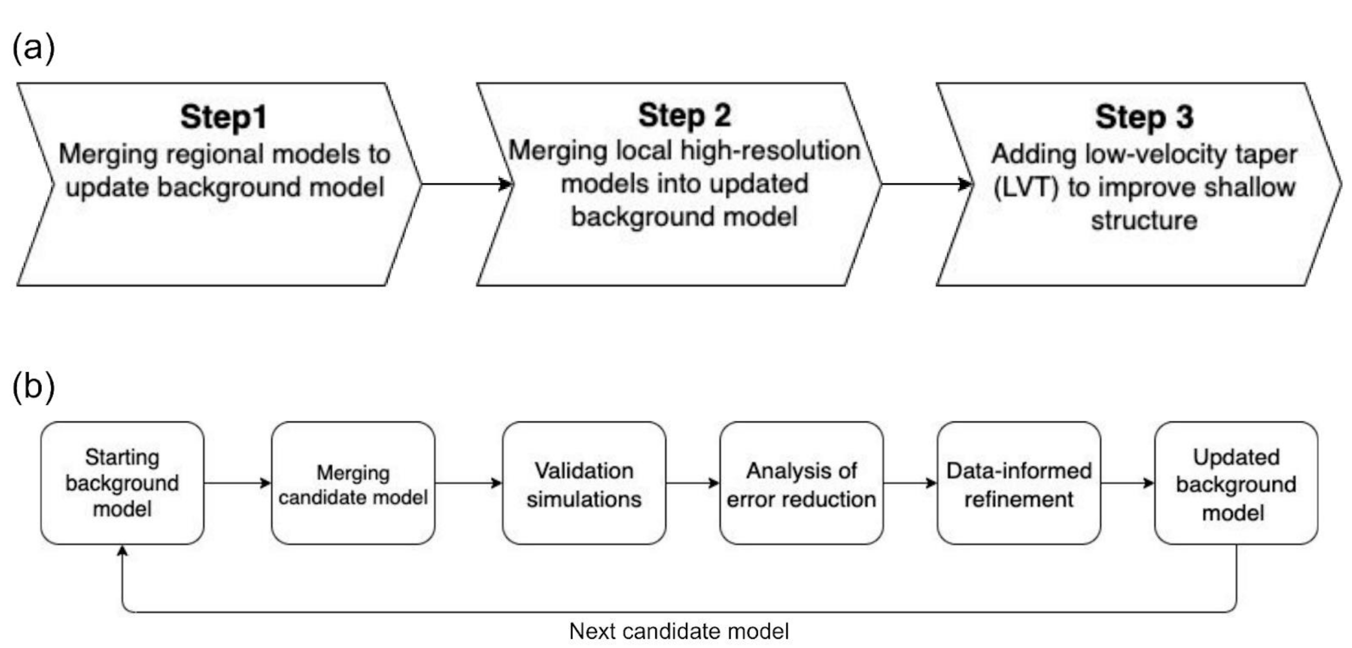
Background

The SCEC Multi-scale Community Velocity Model TAG is centered on the multi-scale P and S seismic velocity models of California and Western Nevada version 1 (MUSCAL) recently developed by Yeh, Ben-Zion and Olsen (2026). MUSCAL was generated by merging and validating nine regional and nine local high-resolution velocity models using 67 M_w4.0-4.8 events throughout California and Western Nevada. The model merging procedure retained only the parts of the models providing superior ground motion prediction efficacy from validation of simulated and recorded ground motions using a 'fitness' measure depending on both spectral and time-domain (envelope) metrics. Thus, MUSCAL by design leads to better ground motion prediction accuracy and decreased uncertainty in seismic hazard calculations as compared to the parent model components.

The TAG plans to advance MUSCAL by creating a SCEC workflow and code base for standardized and transparent validation and ingestion of local velocity models. The new workflow will be tested on a number of new available velocity models. We will create a map of the uncertainty of MUSCAL in terms of commonly used intensity measures, which is an important contribution to the uncertainty of the resulting ground motions. We will work toward improving the accuracy of MUSCAL for the San Francisco Bay region using a mix of simulation based and geophysical survey methods with particular emphasis on overlap zones between models, including the Livermore and Concord-Mt. Diablo portion of the East Bay. We will add new seismic data to the combined body-wave and surface-wave data set used by Guo et al. (2025) and explore the use of independent constraints on shallow structure from alternate seismic and non-seismic sources. Finally, we will explore ways to include more accurate anelastic attenuation information into MUSCAL.

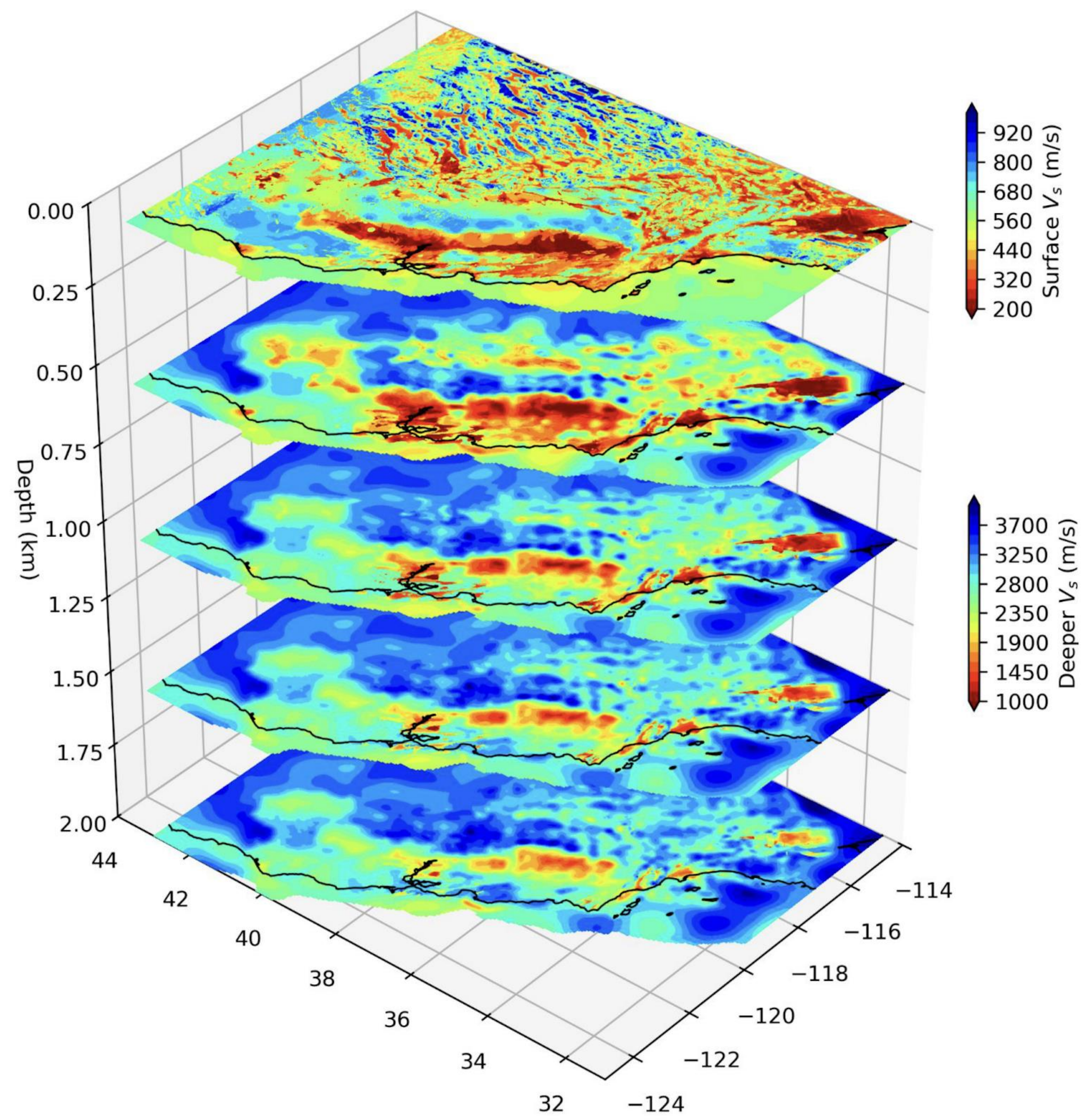
Please see **Poster 75** for more details on MUSCAL!

Framework for the development of MUSCAL



(a) Three-step strategic workflow designed to achieve a multi-scale model structure. (b) Standardized model incorporation procedure applied iteratively within the first two steps of the workflow. This loop ensures that every candidate model undergoes a rigorous cycle of merging, validation through ground-motion simulations, and data-informed refinement before final incorporation, if warranted by the validation.

Current MUSCAL Vs Structure



Three-dimensional view of the shear-wave speeds of the fully developed MUSCAL model from 0 km (surface) to 2 km depth. Note the different color scale used for the surface slice to accommodate the significantly lower wave speeds at the surface.

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Plans for SCEC CVM TAG – Year 1

New MUSCAL Cyberinfrastructure
We plan to develop a cyberinfrastructure that will allow user-friendly, standardized and transparent validation and ingestion into MUSCAL of parts of new local velocity models found to perform better than MUSCAL Version 1. The new workflow for updating MUSCAL will be tested for new high-resolution velocity models.

Uncertainty estimation
We plan to map the accuracy of MUSCAL, which, along with uncertainty in the source descriptions, control the uncertainty of the resulting ground motions. We plan to translate the validation results into quantitative mapping of the uncertainty of MUSCAL on commonly used intensity measures (e.g., SA, EAS, and FAS) and identify the parts of MUSCAL showing the largest uncertainties to guide future updates. We expect to estimate the uncertainty up to 0.5-1 Hz.

Scrutiny on overlap zones
MUSCAL is composed from an abundance of existing seismic velocity models across different spatial scales and different amounts of overlap. The integration of local multi-scale models into MUSCAL was obtained via a combination of traditional 'blending' approaches (e.g., Ajala and Persaud, 2021) and dictionary machine-learning (ML) methodology (Zhang and Ben-Zion, 2024).

We will use a mix of simulation-based and geophysical survey methods to evaluate models, rank them in terms of performance in areas where they overlap, and identify specific metrics and geographical areas where certain models perform better than others. Target locations include the Livermore basin and Concord-Mt. Diablo portion of the East Bay, where refinement may also draw on current geophysical studies in the Livermore basin (Lin and Taira) (led by **Hirakawa**), as well as the Sacramento San Joaquin River Delta, where the SFCVM is relatively poorly constrained, but some newer geological and geophysical models are available.

New Velocity Models
We furthermore plan to (1) add new seismic data to the combined body-wave and surface-wave data set used by Guo et al. (2025) and carry out a new inversion for P- and S-wave velocities, and (2) explore the use of independent constraints on shallow structure from other seismic and non-seismic sources (led by **Thurber**).

Plans for SCEC CVM TAG – Years 2-3

Three-year vision for proposed TAG includes the following:

- Refine the cyberinfrastructure for validating and ingesting new models into MUSCAL
- Determine areas in need of largest improvement In MUSCAL and reduce MUSCAL uncertainty estimates for ground motion predictions
- Identify areas with data gaps
- Identify and use non-seismic datasets in CVM development and validation
- Further optimize accuracy of merging local high-resolution and reference models by testing additional (e.g., ML) blending methods
- Validate new local models and ingest into MUSCAL as warranted
- Obtain more accurate estimates of anelastic attenuation in MUSCAL
- Explore depth dependent merging procedures