IMPROVED SCENARIO SHAKEMAPS USING 3D PHYSICS-BASED GROUND MOTION SIMULATIONS

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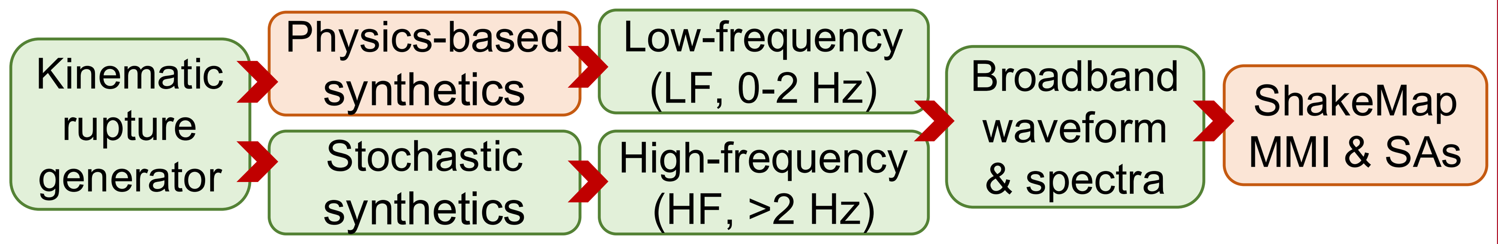
Objectives

► Generate and evaluate a hybrid 3D Broadband Platform (**BBP 3D**) for improved scenario ground motion simulation.

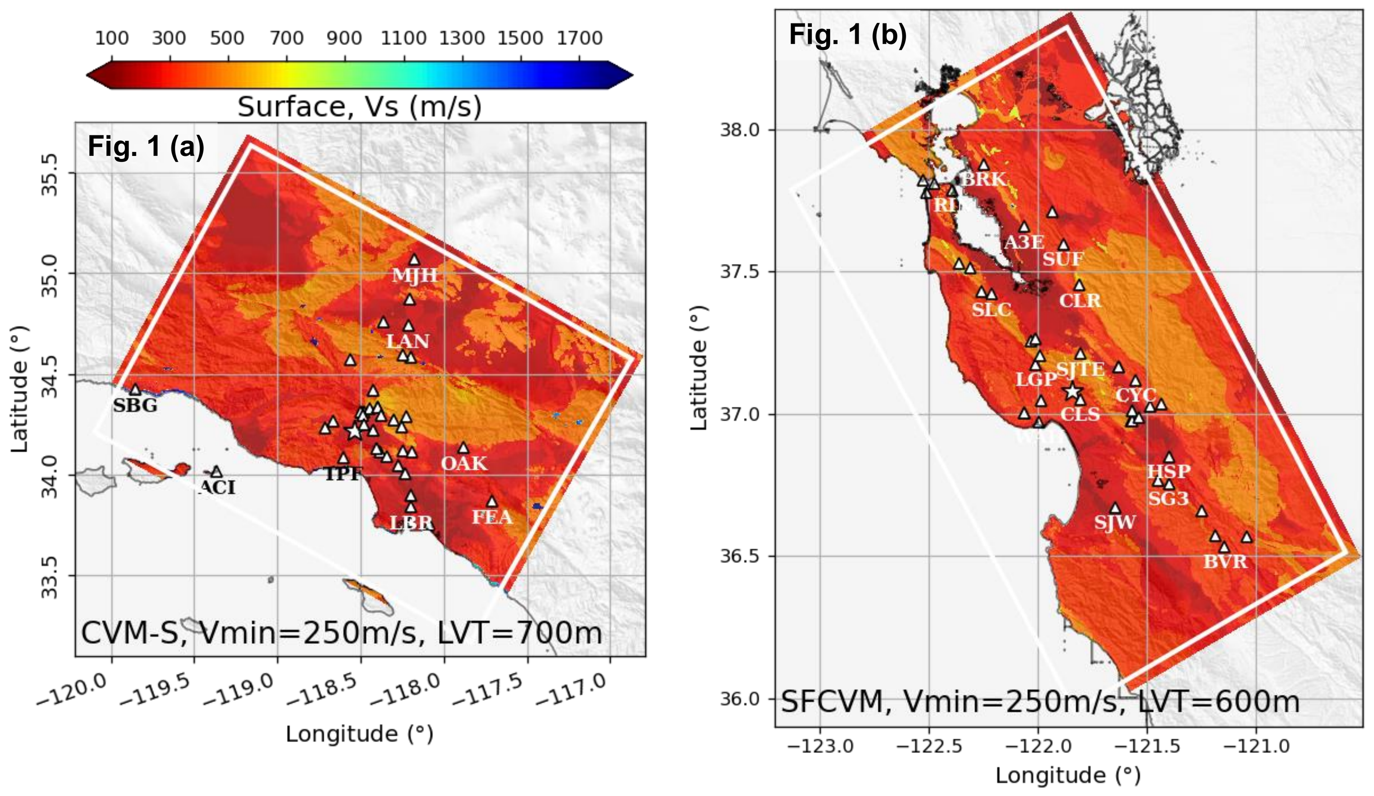
► Test the accuracy of scenario **ShakeMaps** generated by GMMs and the new BBP 3D.

Method: BBP 3D



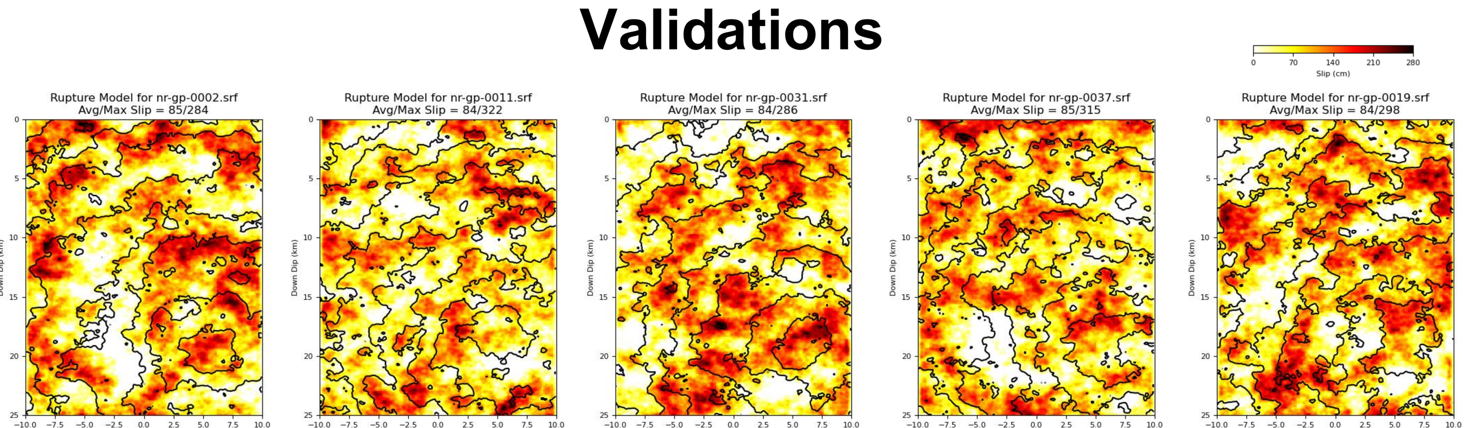
► From "**BBP 1D**" to "**BBP 3D**":

- 0-2 Hz LF physics-based synthetics calculated using **AWP-ODC** with curvilinear topography (O'Reilly et al., 2022), discontinuous mesh (Nie et al., 2017) and frequency-dependent attenuation (Withers et al., 2015).
- Use regional 3D models from SCEC **UCVM** (Small et al., 2017):
  - SFCVM v21.1 (Hirakawa et al., 2022) for northern CA, and
  - CVM-S4.26.M01 for central to southern CA.
- Include near-surface low-velocity taper (**LVT**, Ely et al., 2010).

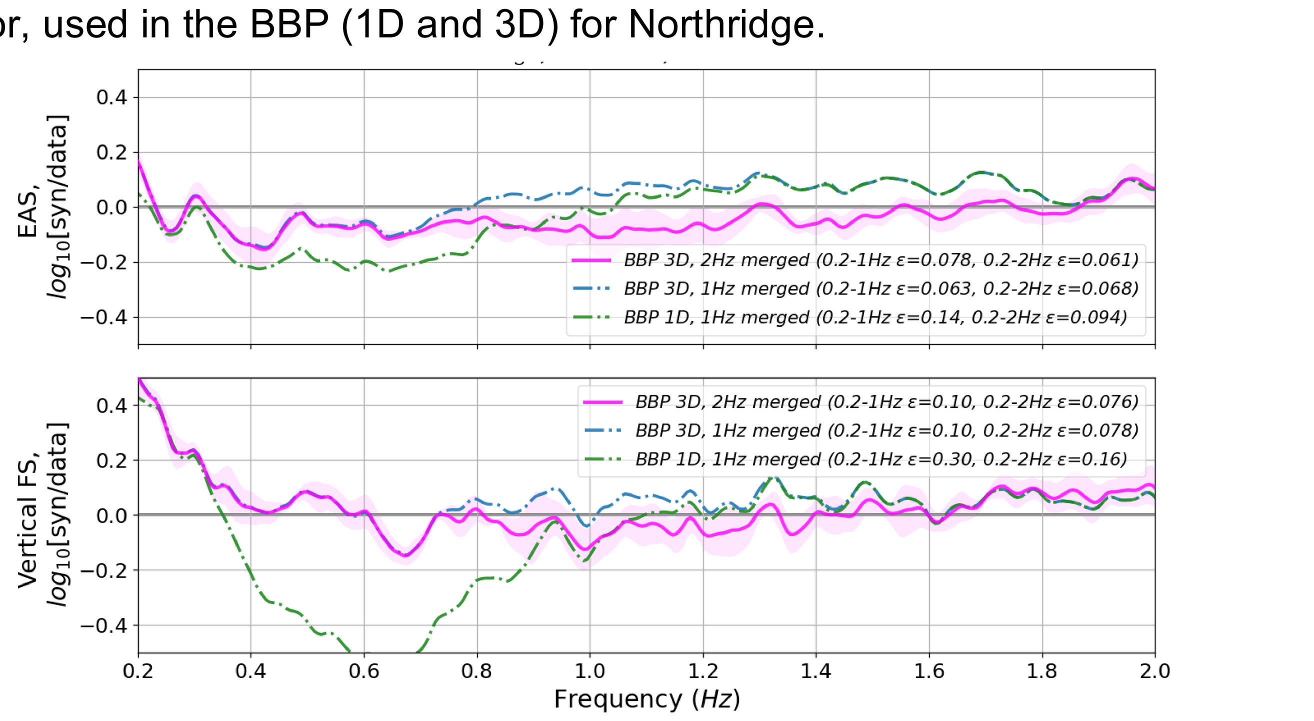


⇑ **Figure 1:** Simulation regions and surface Vs from UCVM 3D models: (a) CVM-S4.26.M01 for Southern CA, and (b) SFCVM v21.1 for Northern CA. Epicenters of validation events and ground motion stations are also on the map.

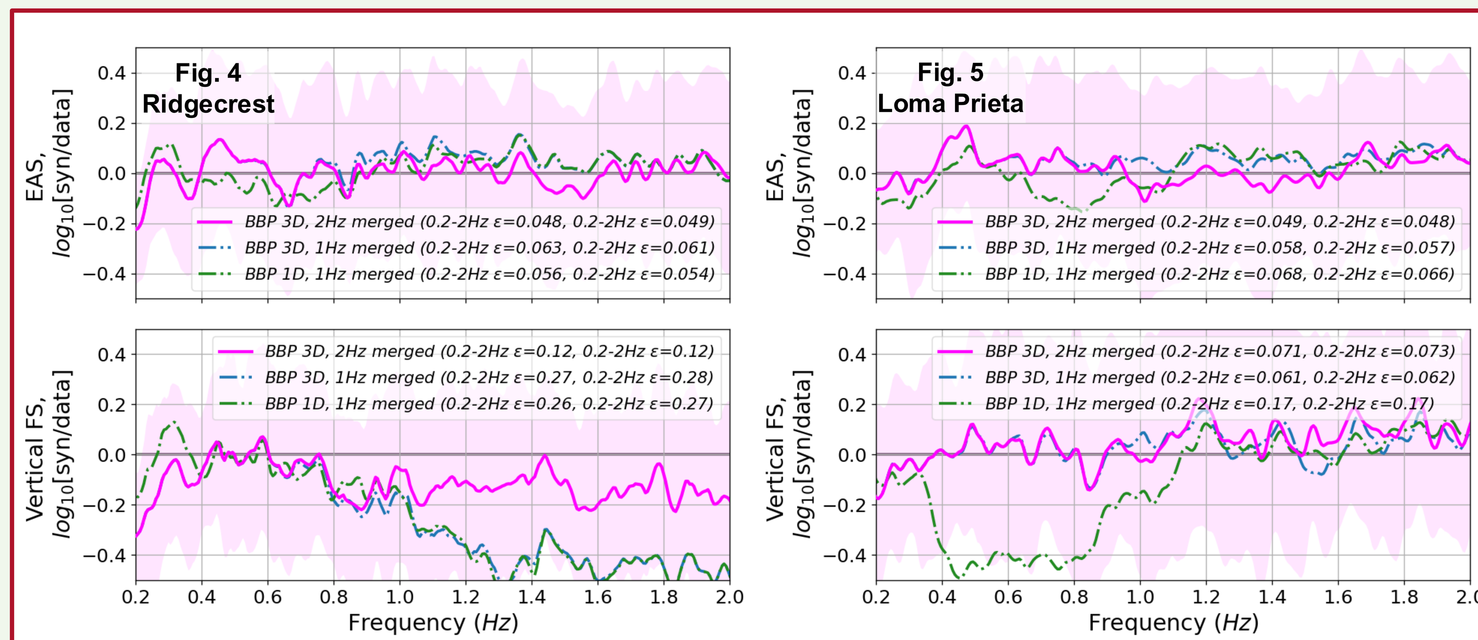
Validations



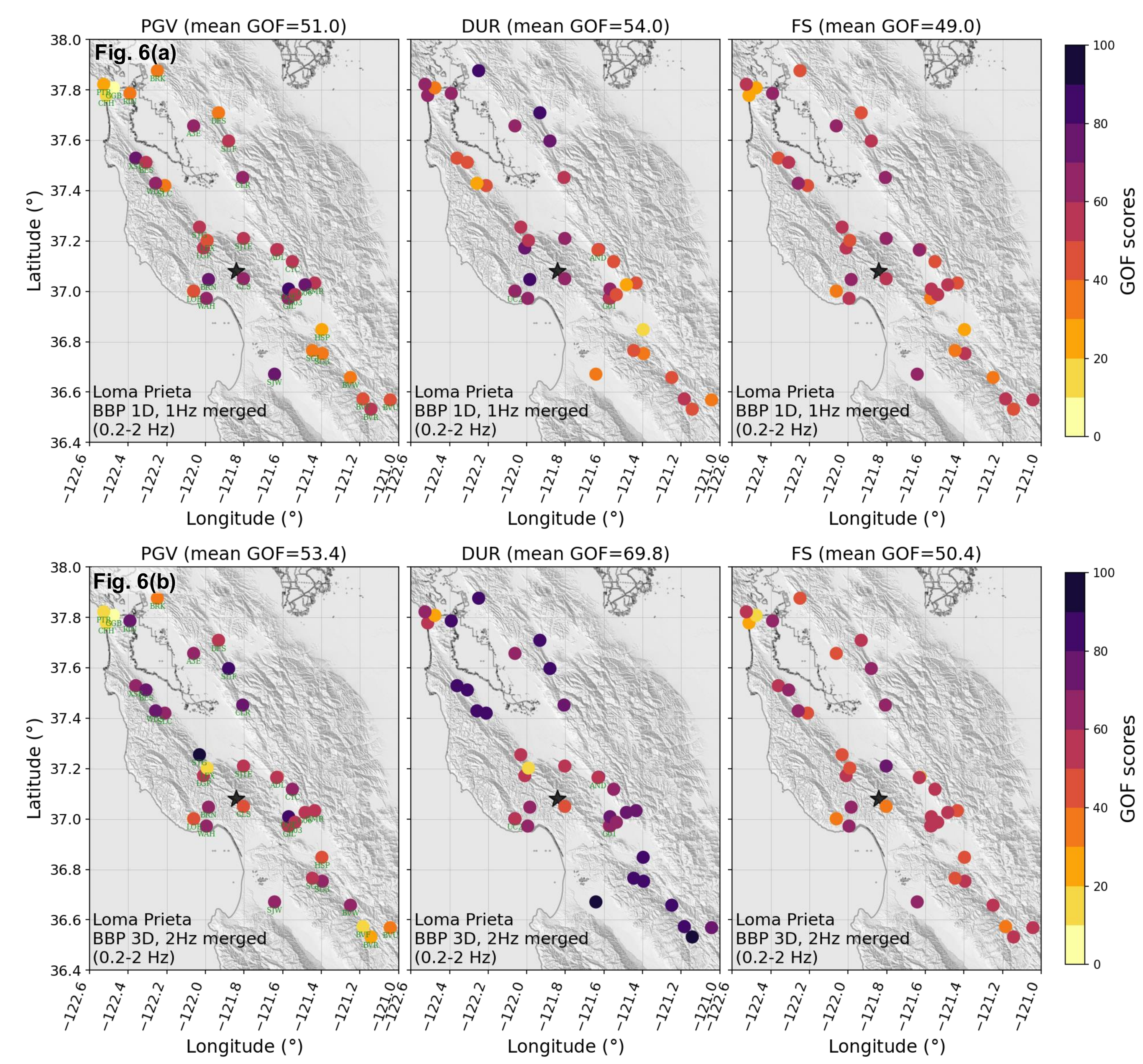
⇑ **Figure 2:** Slip and rupture time distributions of 5 finite-fault source realizations generated from the Graves-Pitarka (GP, Pitarka et al., 2021) kinematic rupture generator, used in the BBP (1D and 3D) for Northridge.



⇑ **Figure 3:** Effective amplitude spectral (EAS, horizontal) and vertical Fourier Spectral (FS) bias between synthetics and observations from the 1994 Northridge earthquake. Comparisons show BBP 1D and BBP 3D with merging frequencies at 1 Hz and 2 Hz, each with an averaged ensemble of simulations using 5 GP source realizations (Fig. 2). The numbers in parenthesis list the overall 0.2-2 Hz absolute bias. Note that the 2 Hz synthetics improve the bias by 35% compared to BBP 1D.



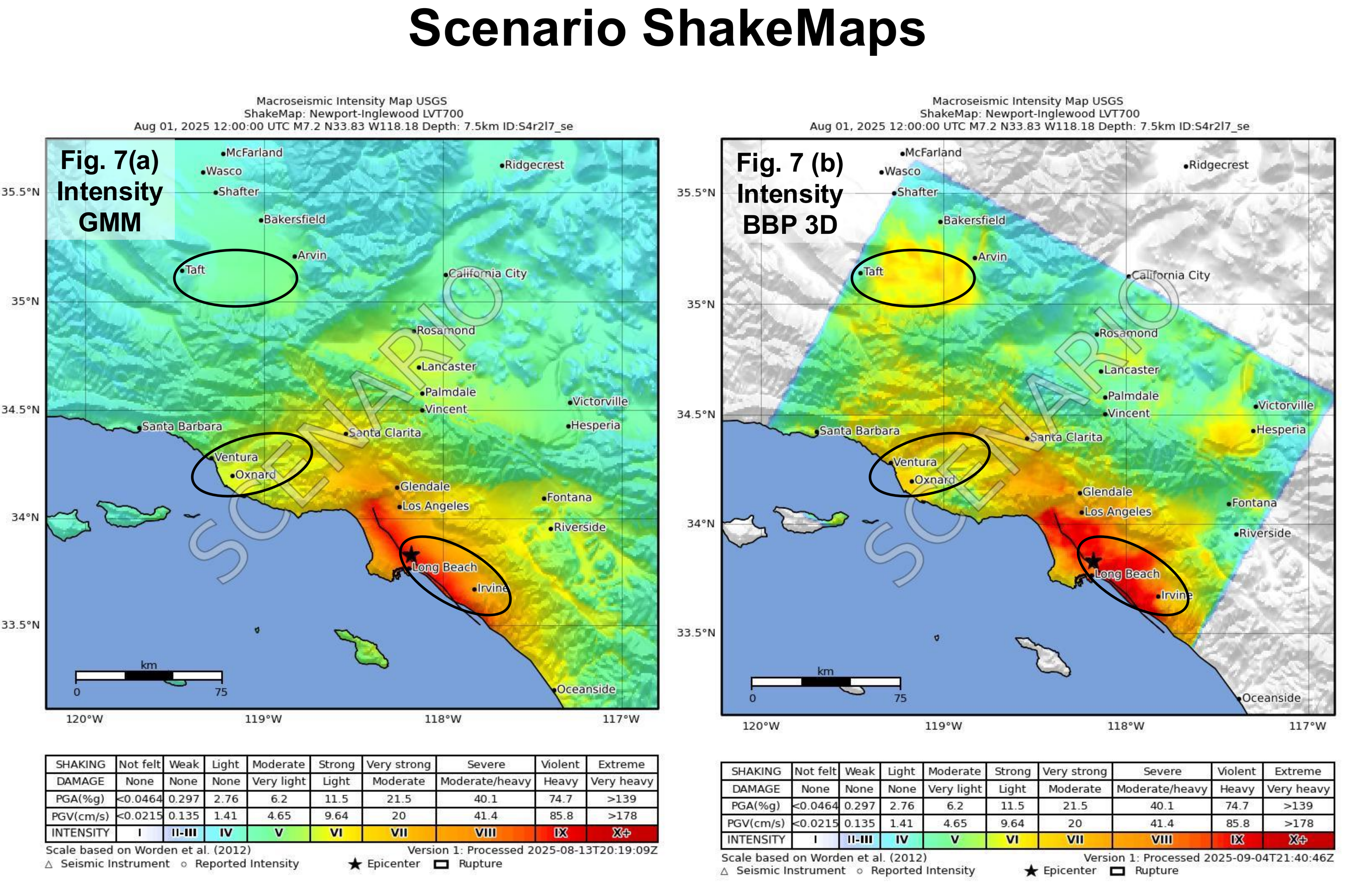
⇑ **Figure 4 & 5:** Same as Fig. 3, but for Ridgecrest and Loma Prieta, respectively.



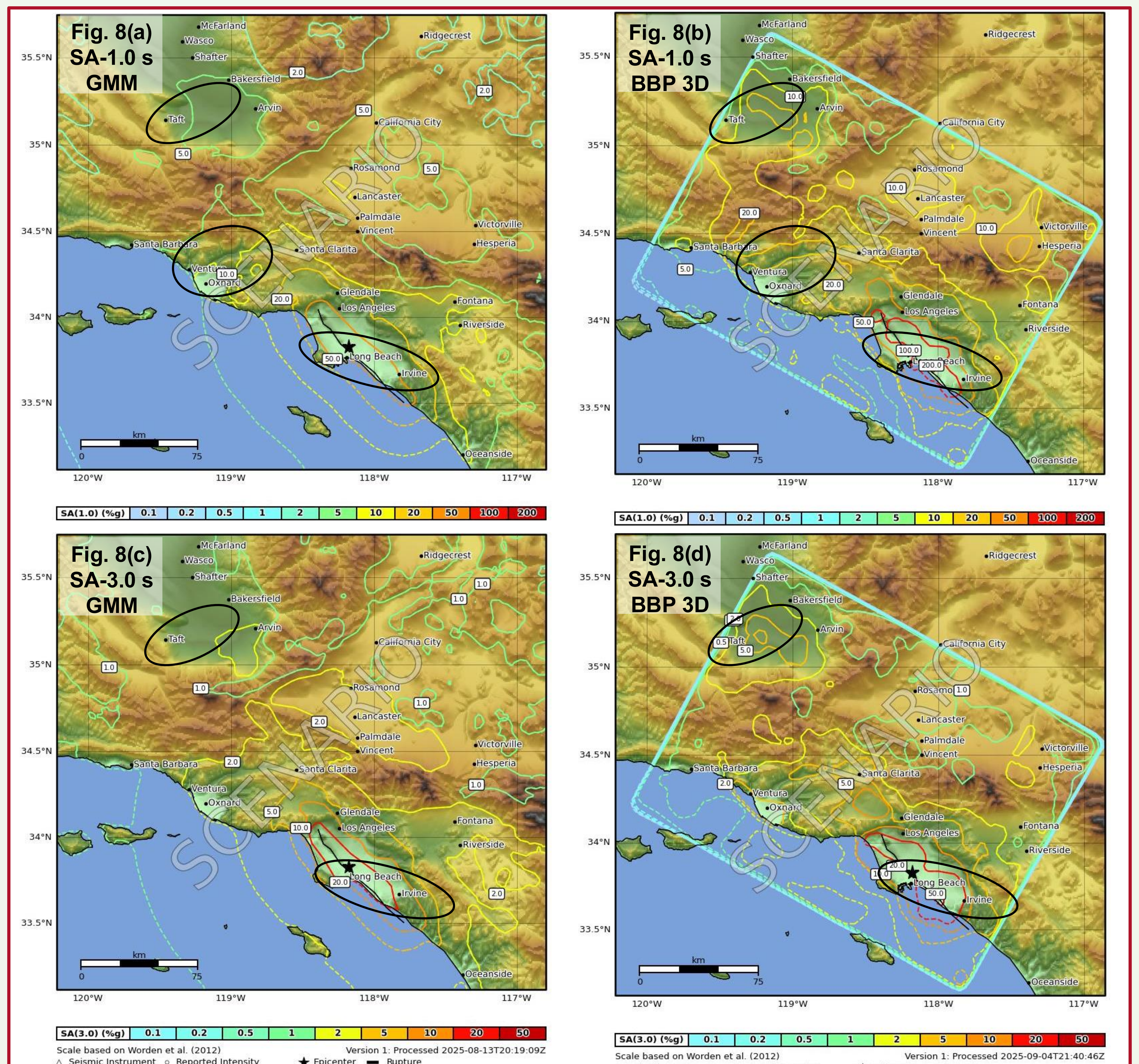
⇑ **Figure 6:** Combined GOF scores (100 means perfect fit) between observations and synthetics for the Loma Prieta validations, from (a) BBP 1D and (b) BBP 3D with merging frequency at 2 Hz. BBP 3D provides larger GOF for intensity measures PGV, Duration, and FAS compared to BBP 1D.

► The validations show that BBP 3D synthetics merged at 2 Hz improve FAS bias and GOF to data when compared with the BBP 1D, and it's a good candidate for scenario ground motion simulation.

Scenario ShakeMaps



⇑ **Figure 7**: Macroseismic intensity ShakeMaps based on (left) GMMs and (right) BBP 3D simulations for a M7.2 scenario earthquake on the Newport-Inglewood fault (black line). Note the higher intensities (VI+) in the BBP 3D versus GMM ShakeMap particularly in basin areas, as well as higher heterogeneity from source and topographic effects.



⇑ **Figure 8**: Spectral acceleration (SA-1.0s and SA-3.0s) ShakeMaps from (left) GMMs and (right) BBP 3D simulations. Note the higher intensities and heterogeneity in the BBP 3D.

Conclusions and Future Work

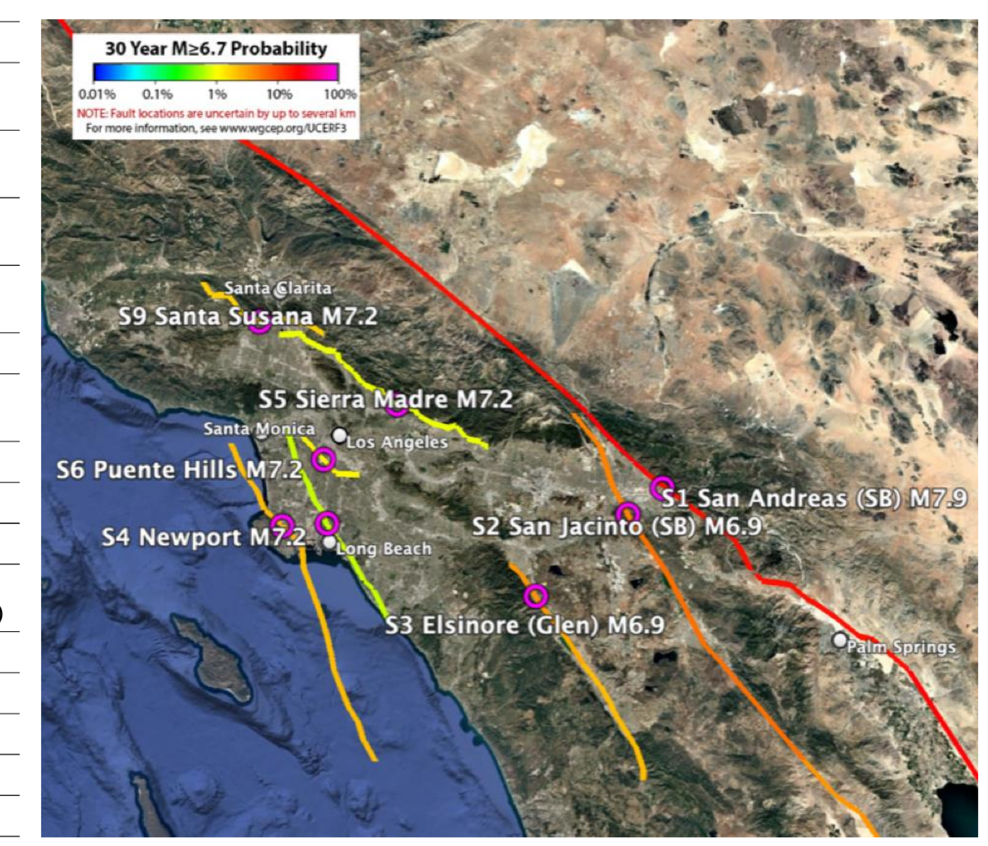
► We have developed a SCEC 3D Broadband Platform (BBP 3D).

► BBP 3D synthetics merged at 2 Hz improve FAS bias to data for Loma Prieta, Northridge and Ridgecrest by up to 35%.

► Scenario ShakeMaps based on the BBP 3D show promise of increased accuracy compared those based on GMMs.

► We plan to compare ShakeMaps based on GMMs and BBP 3D for 15 M6.7-7.9 scenario earthquakes across CA to assess the potential for increased accuracy of the maps.

#	M_w	Fault (section)
S1	7.9	S. San Andreas (San Bernardino Mt)
S2	6.9	San Jacinto (San Bernardino)
S3	6.9	Elsinore (Glen Ivy)
*S4	7.2	Newport-Inglewood (LA Basin)
*S5	7.2	Sierra Madre
*S6	7.2	Puente Hills (LA Basin)
S7	7.2	Palos Verdes
S8	7.2	Pitas Point (East)
S9	7.2	Santa Susana
N1	7.7	N. San Andreas (Peninsula-Loma Prieta)
N2	7.1	Hayward
N3	6.7	Rodgers Creek
N4	7.1	Calaveras
N5	7.0	Concord
N6	7.1	Maacama



⇑ **Figure 9 (right)**: Planned scenario earthquakes for ShakeMap evaluation. Colored lines depict the scenario fault traces from UCERF3 (Field et al., 2017).

References & Acknowledgements

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