Perspectives on Time-Dependent Earthquake Forecasting

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CSEP Workshop

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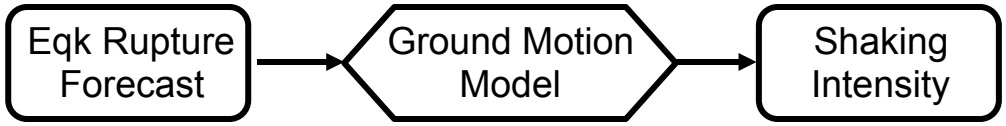
Operational Earthquake Forecasting

- **Goal of OEF is to inform the decisions that people and organizations must continually make to mitigate seismic risk and prepare for potentially destructive earthquakes on time scales from days to decades**
- **To fulfill this role, OEF must provide a complete description of the seismic hazard in concert with the long-term forecasts of PSHA**
  - **Requires time-dependent ground motion exceedance probabilities derived from short-term rupture probabilities**

Coupling CyberShake and UCERF3 to Forecast Time-Dependent Ground Motion Probabilities

- **Pre-computed CyberShake ground motion models are easily coupled to short-term forecasting models, such UCERF3-ETAS**
  - **Output is a time-dependent seismic hazard estimate**

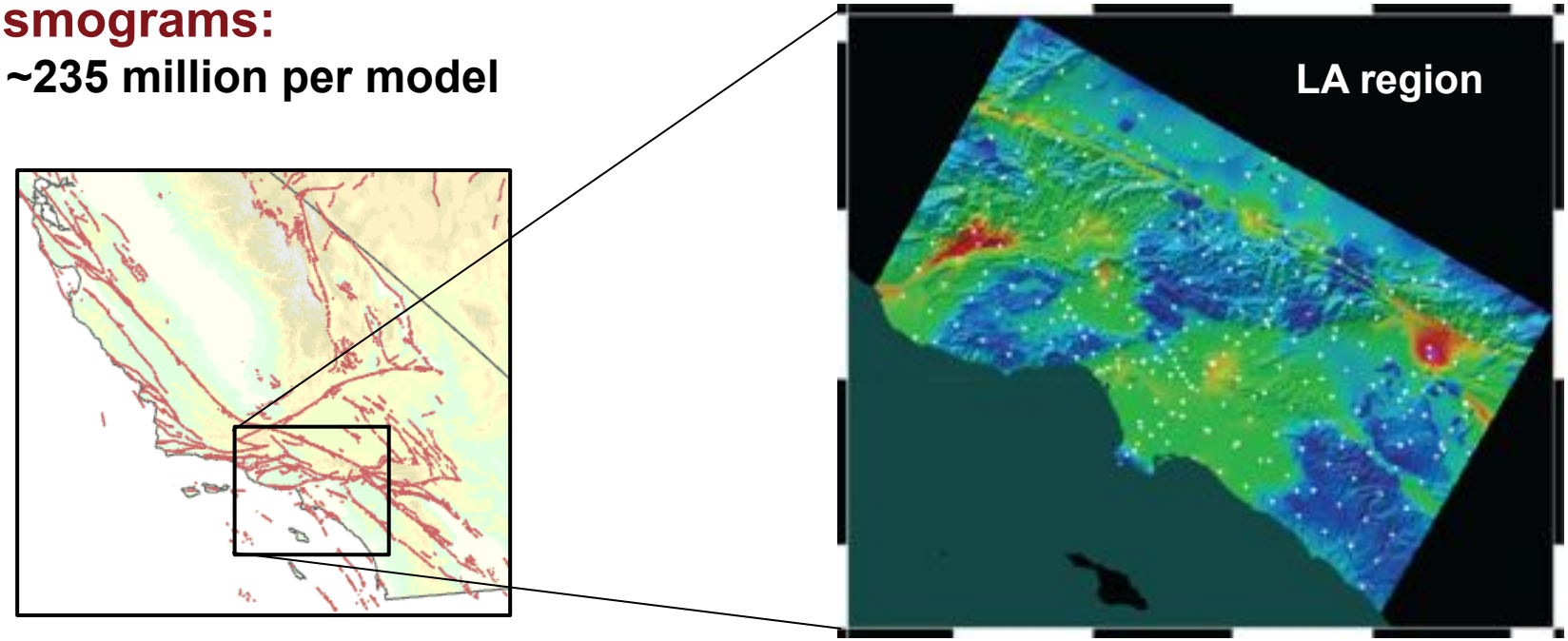


$P(S_k, T)$ $P(Y_n \mid S_k)$ $P(Y_k, T)$ T = forecast time

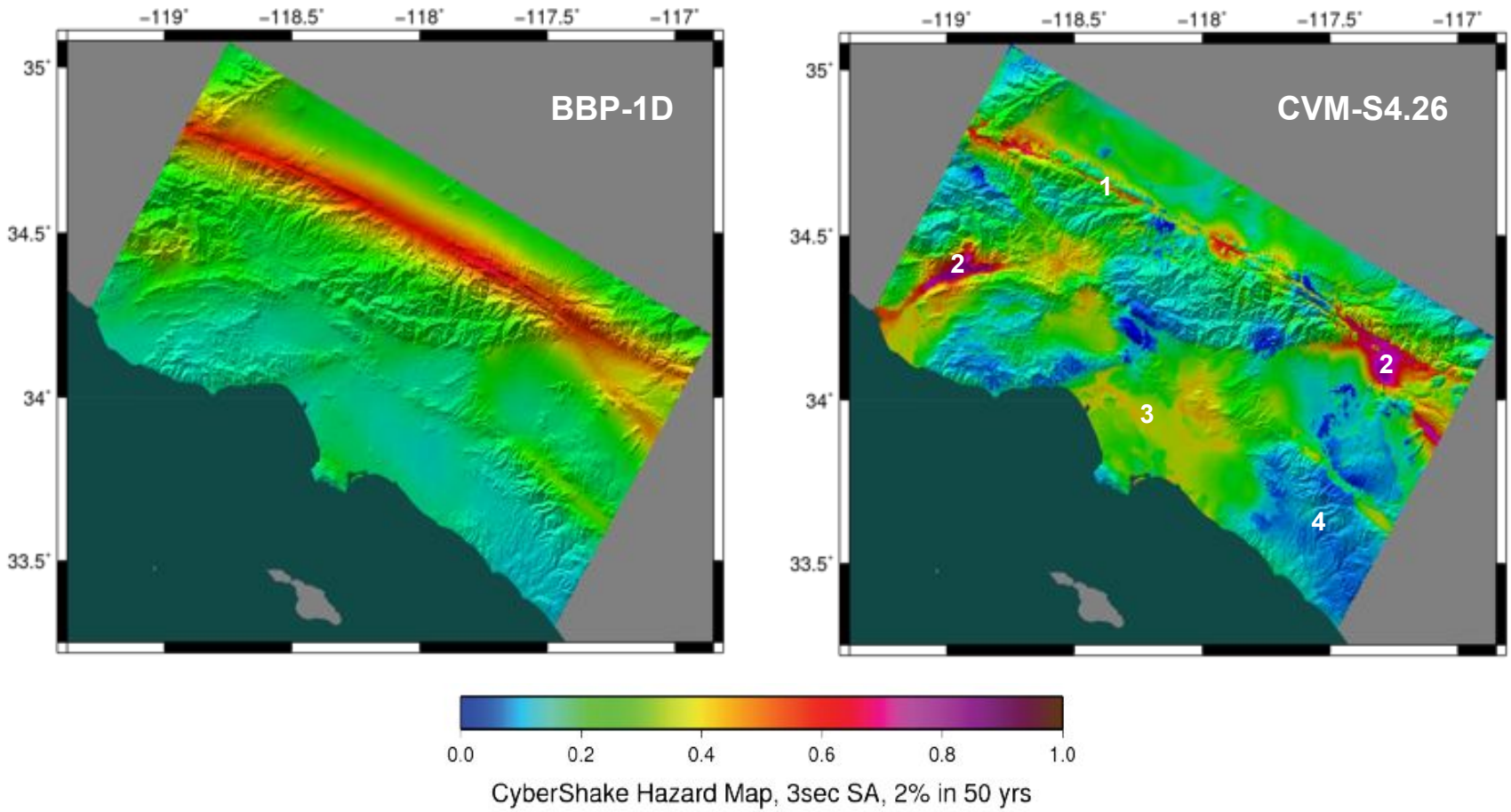
- **Short-term forecasting localizes epicenter probabilities**
  - **Coupled model achieves significant gains in ground motion probabilities through the forecasting of source directivity and directivity-basin coupling**

CyberShake Hazard Model

- **3D crustal model:**
  - CVM-S4.26
- **Sites:**
  - 283 sites in the greater Los Angeles region
- **Ruptures:**
  - All UCERF2 ruptures within 200 km of site (~14,900)
- **Rupture variations:**
  - ~415,000 per site using Graves-Pitarka pseudo-dynamic rupture model
- **Seismograms:**
  - ~235 million per model

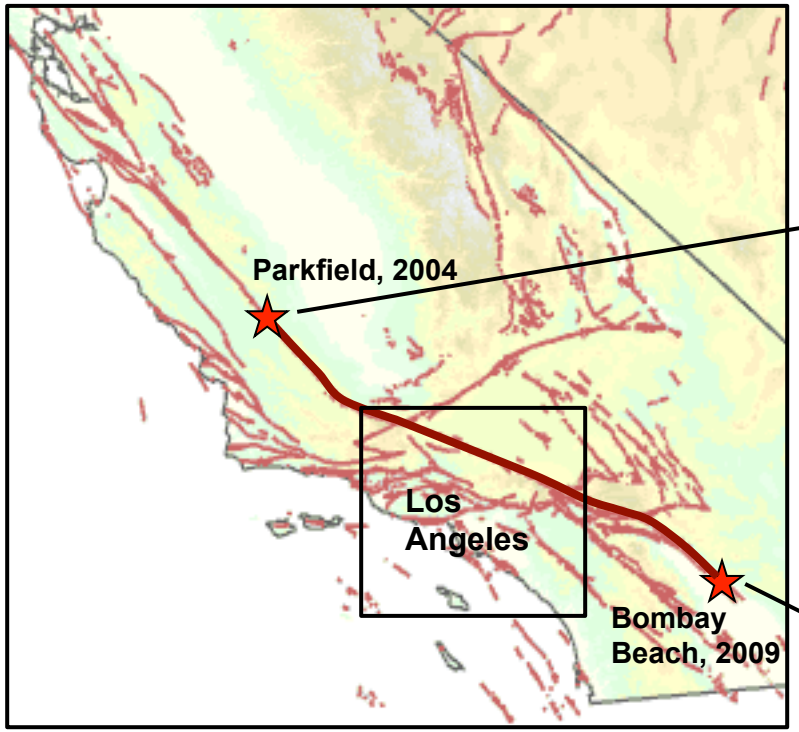


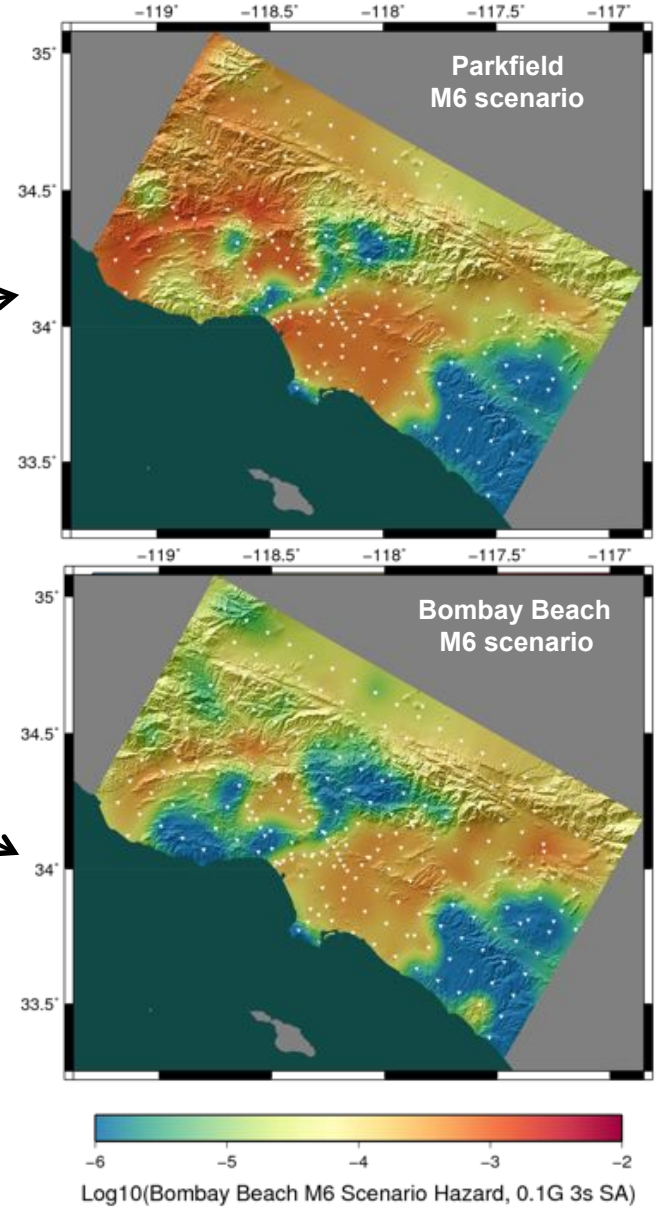
Comparison of 1D and 3D CyberShake Models for the Los Angeles Region



1. lower near-fault intensities due to 3D scattering
2. much higher intensities in near-fault basins
3. higher intensities in the Los Angeles basins
4. lower intensities in hard-rock areas

UCERF3-CyberShake Aftershock Forecast for M6 Scenarios





- Based on average of 40,000 UCERF3 simulations of aftershock sequences
- UCERF3 supra-seismogenic fault ruptures mapped onto UCERF2 ruptures in the CyberShake 14.2b model
- See poster #31 by Milner, Jordan & Field

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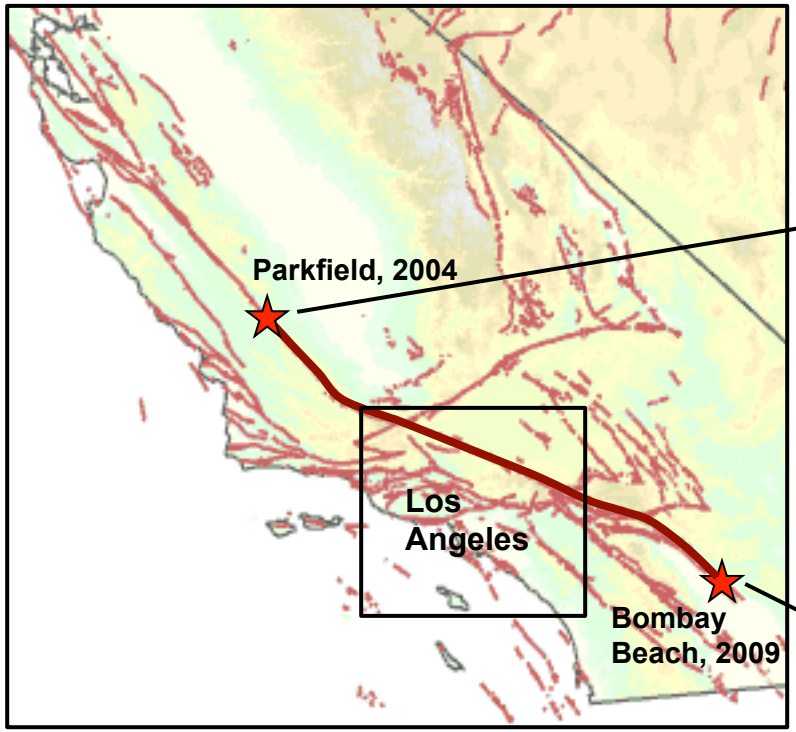

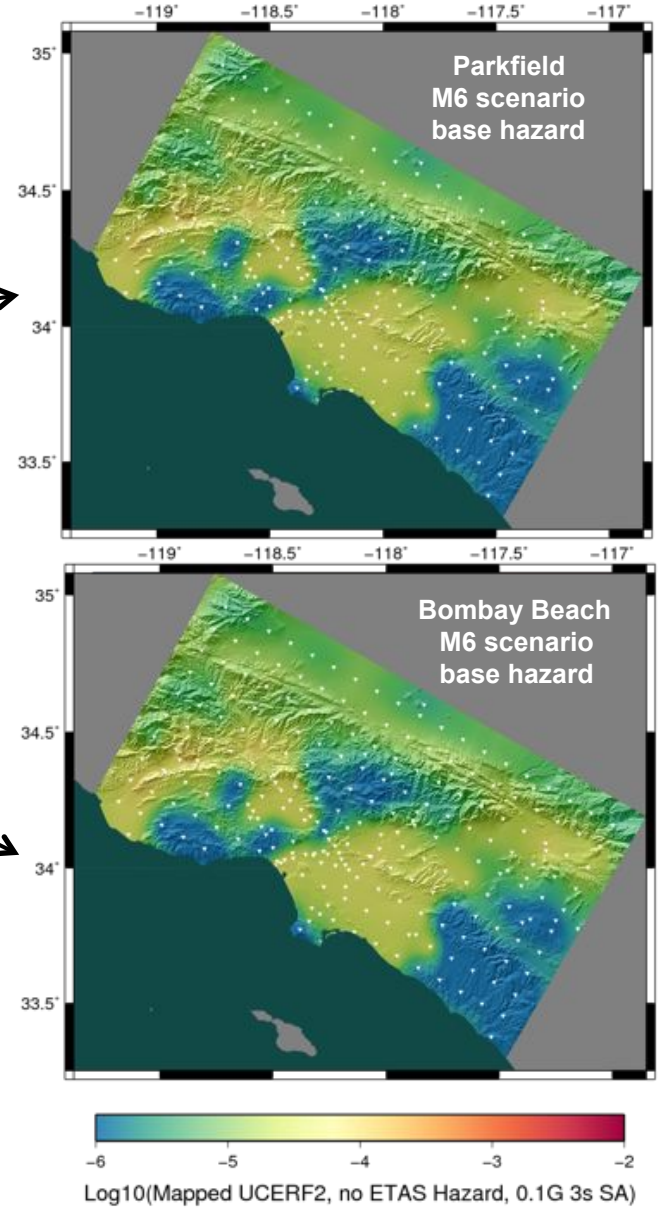

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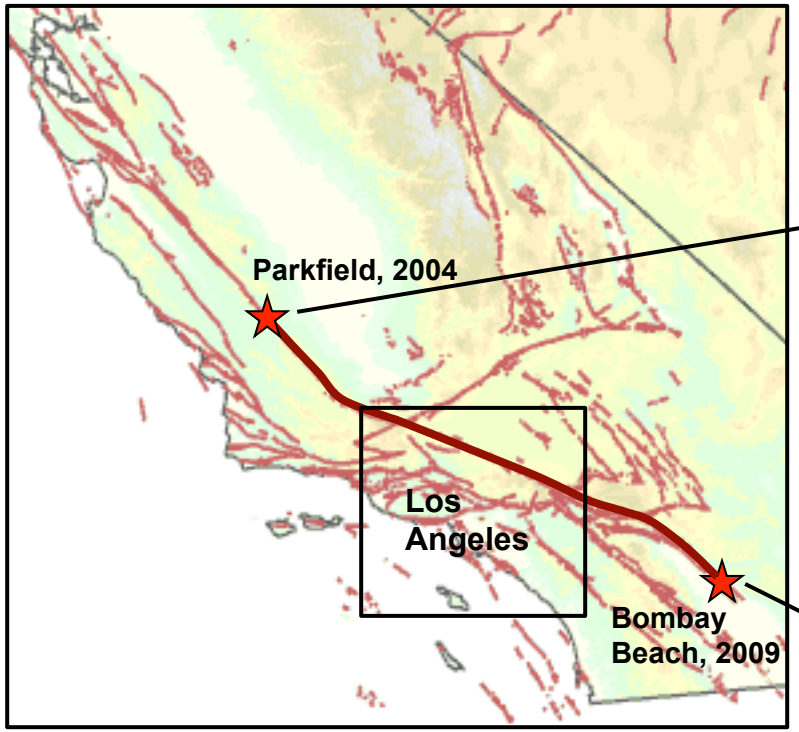

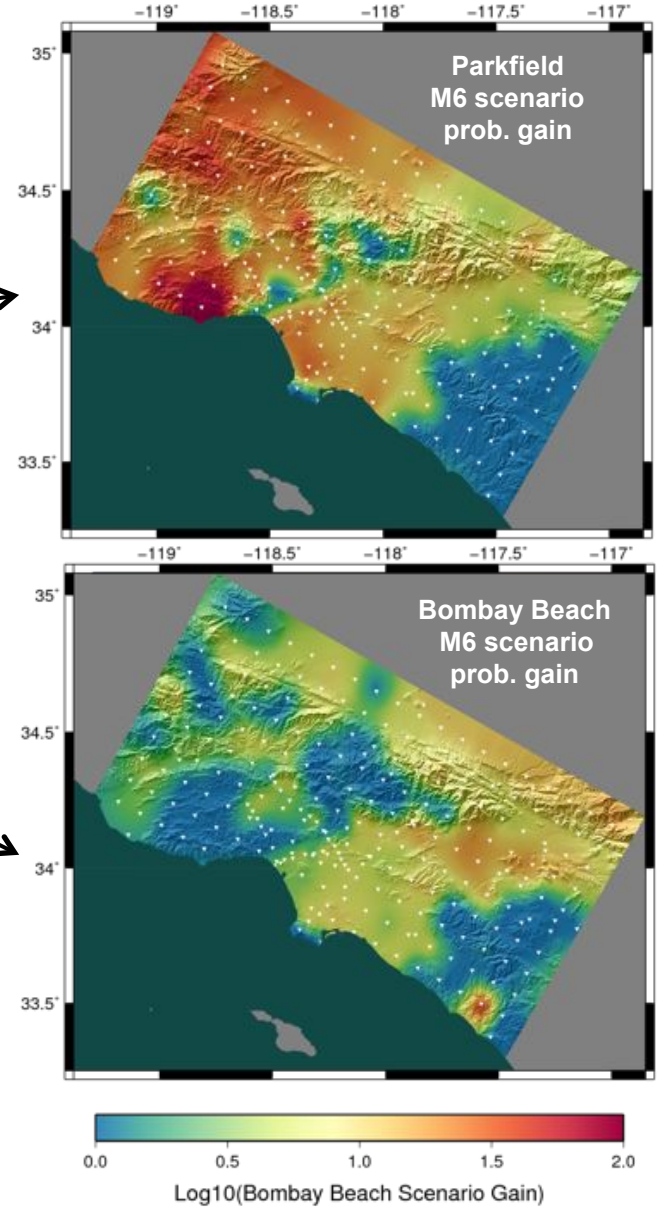

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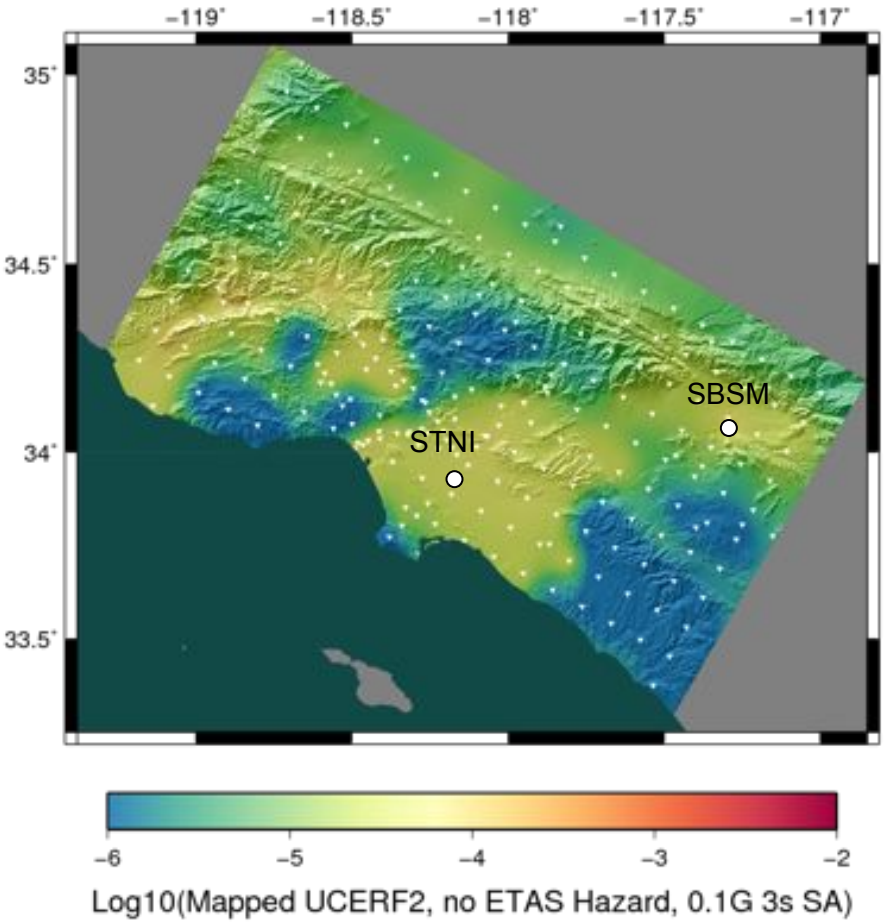
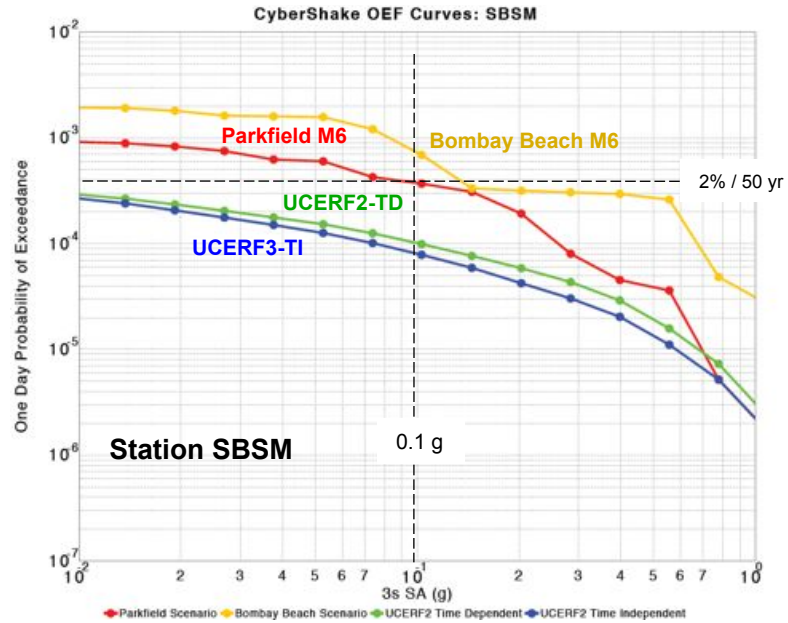
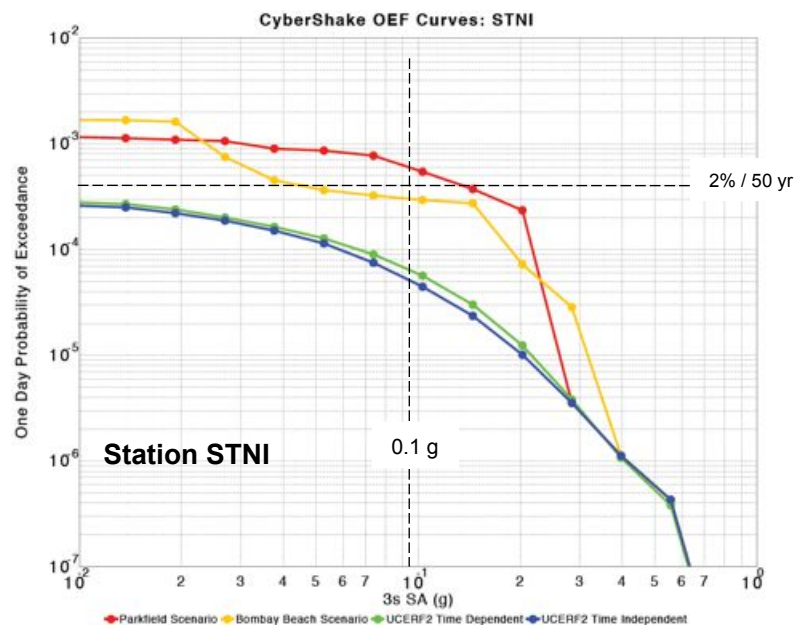
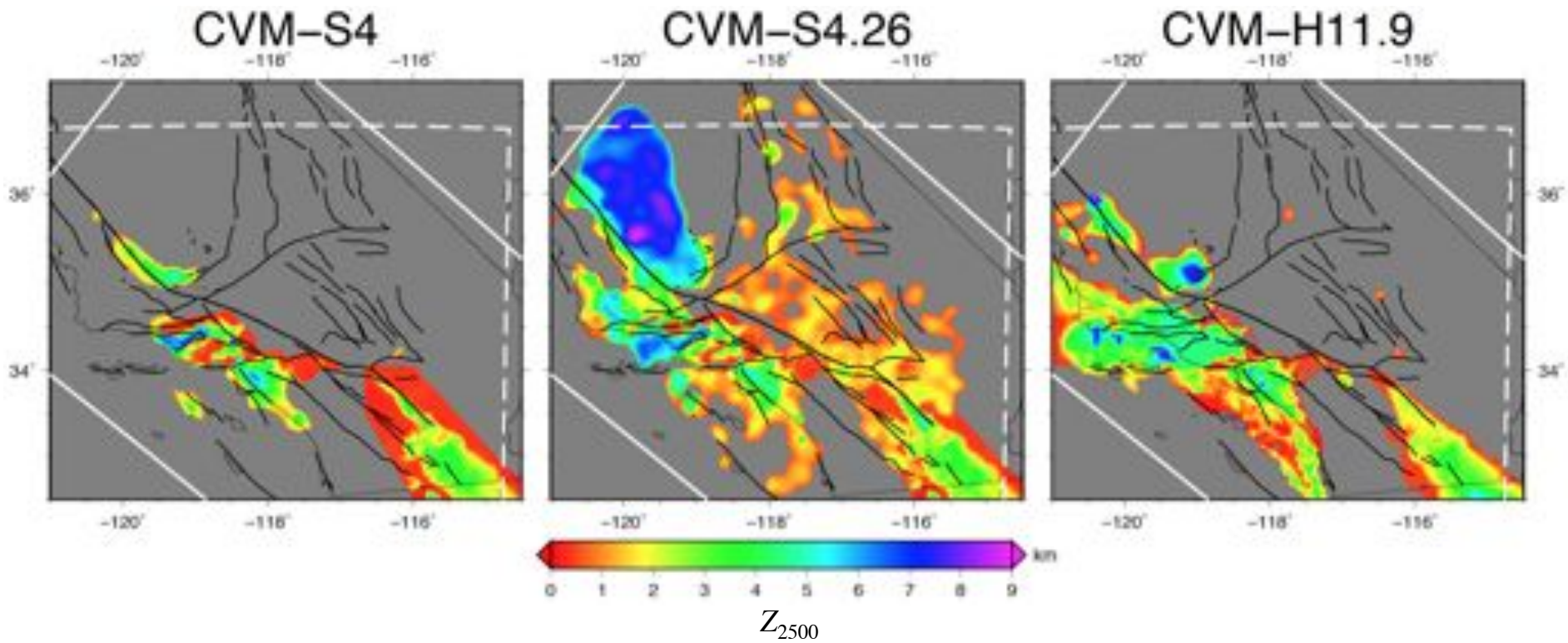
Hazard Curve Comparisons







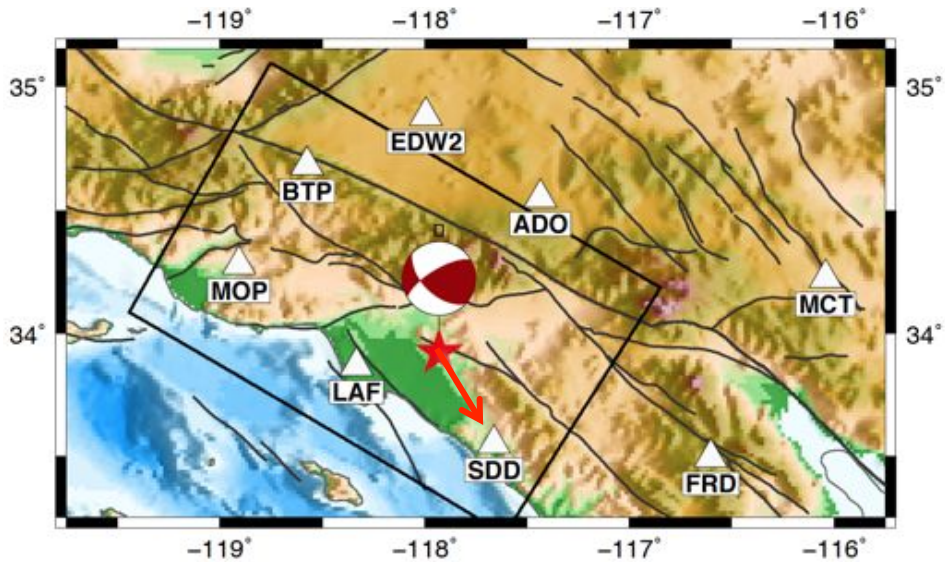
Basin Structures



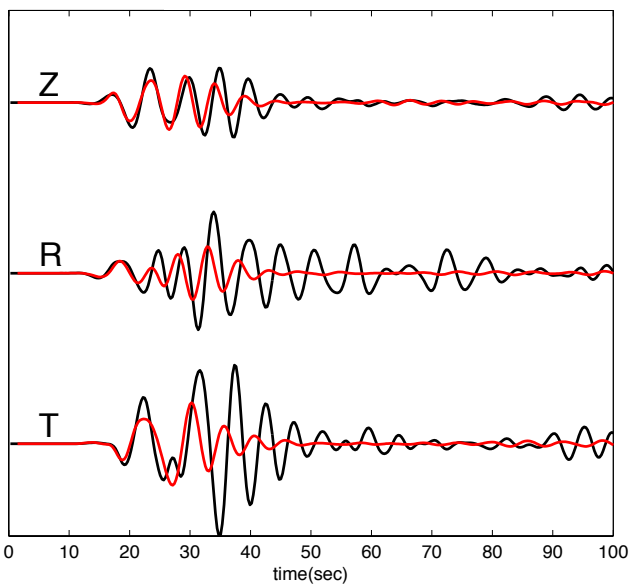
Z_{2500} : iso-velocity surfaces at $V_S = 2.5$ km/s

03/28/14 La Habra Earthquake (M5.1)

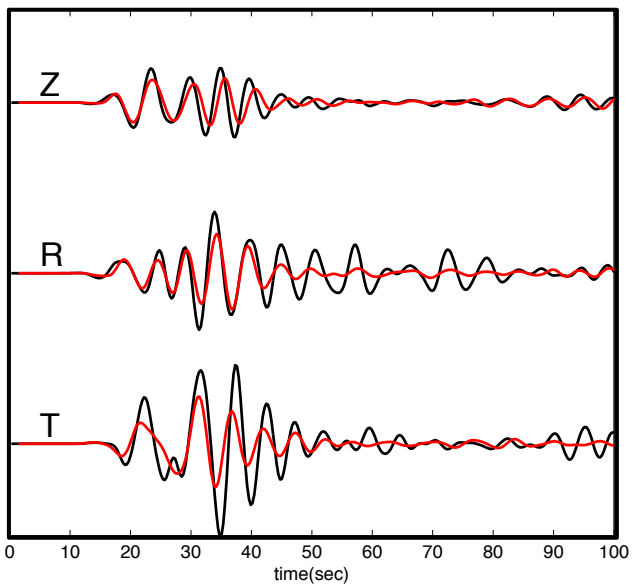
Station SDD
Observed in black
Synthetic in red



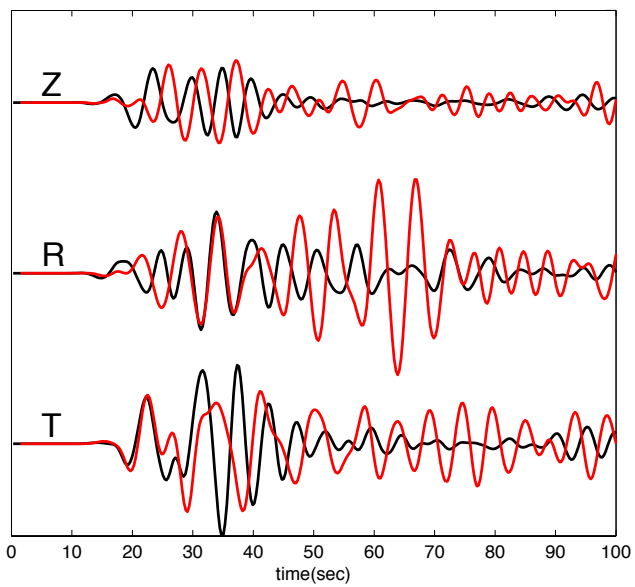
CS11: CVM-S4



CS14.2: CVM-S4.26

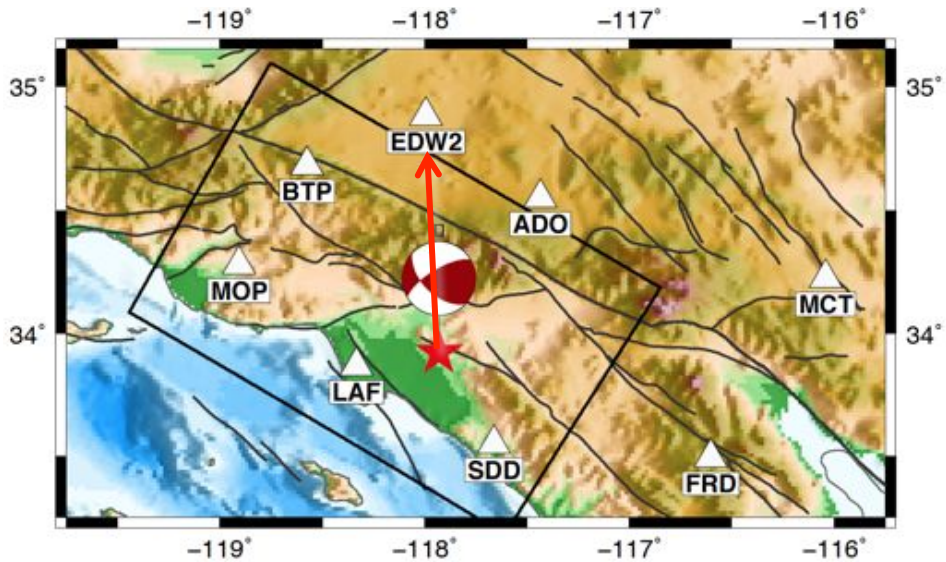


CS13.4: CVM-H11.9



03/28/14 La Habra Earthquake (M5.1)

Station EDW2
Observed in black
Synthetic in red



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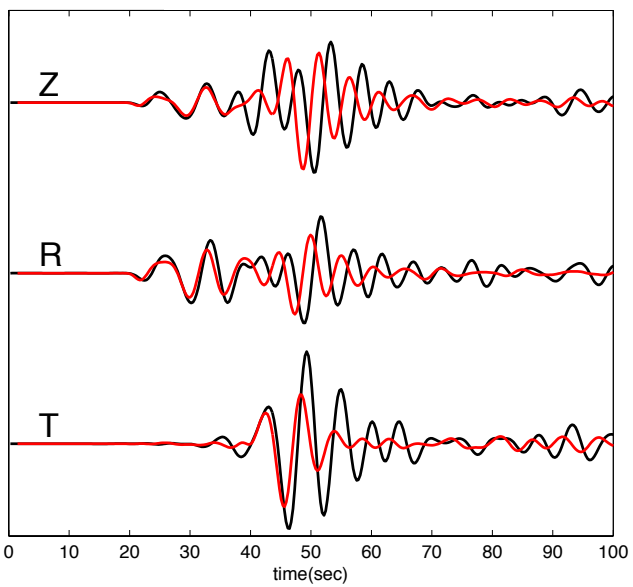

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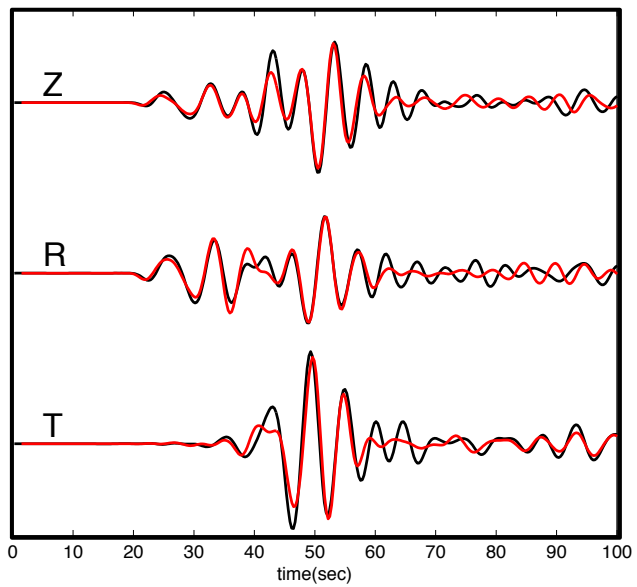

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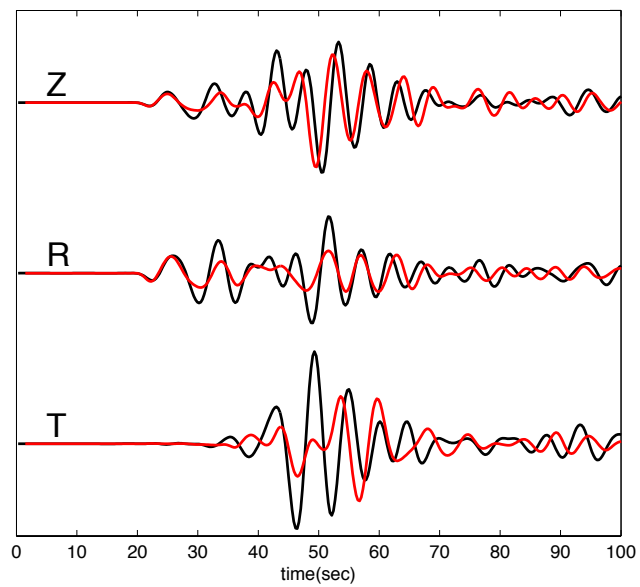

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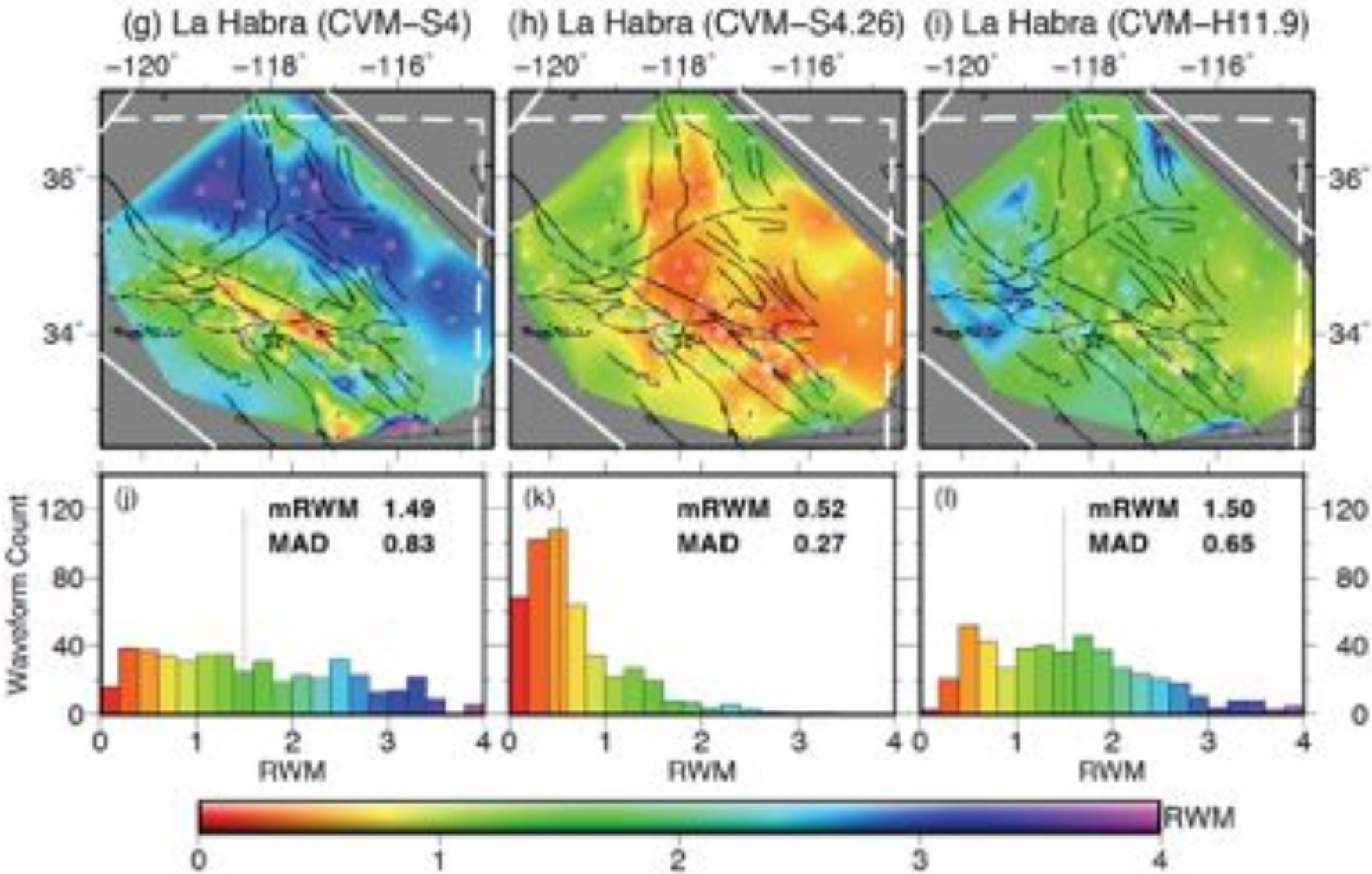

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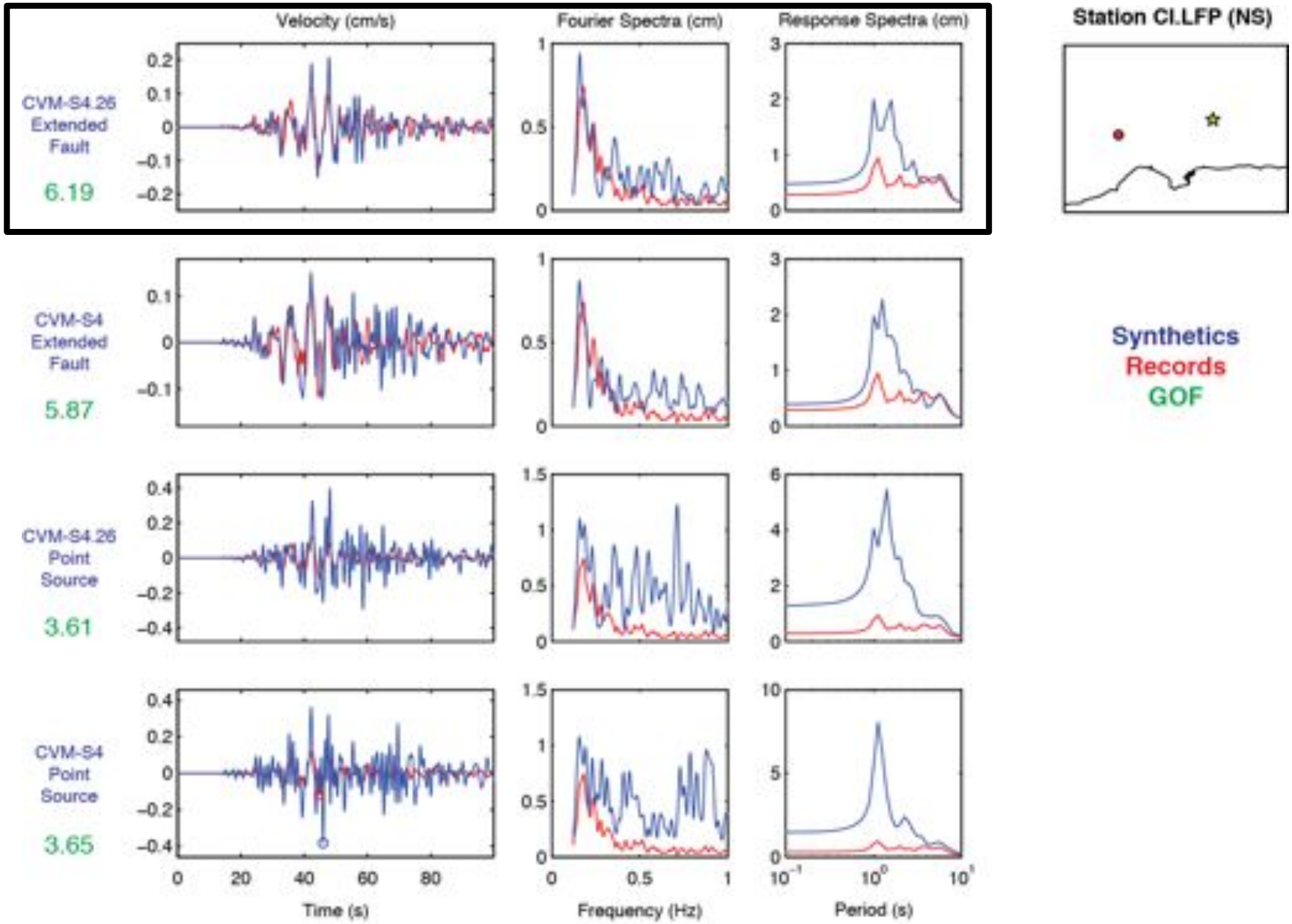

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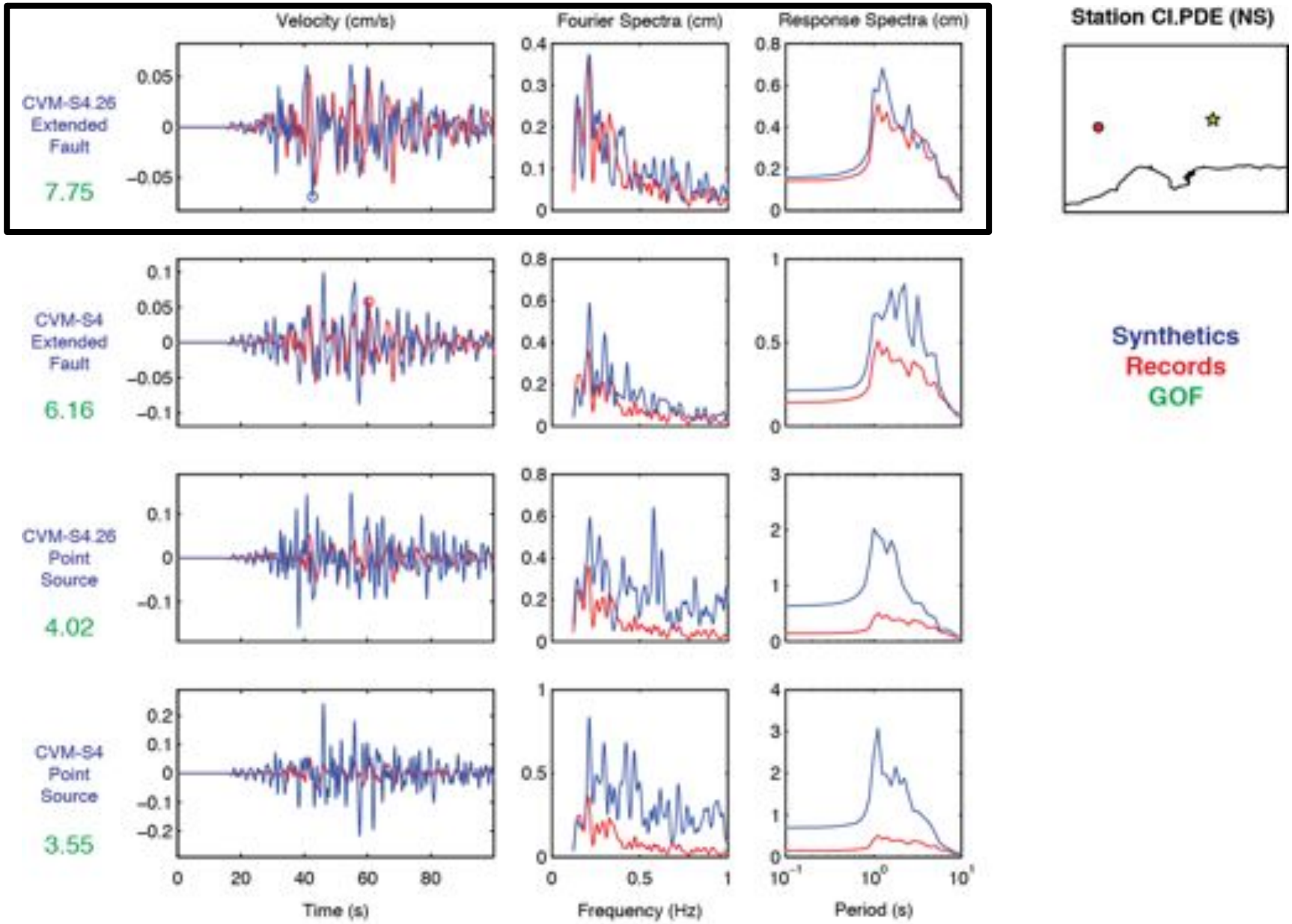

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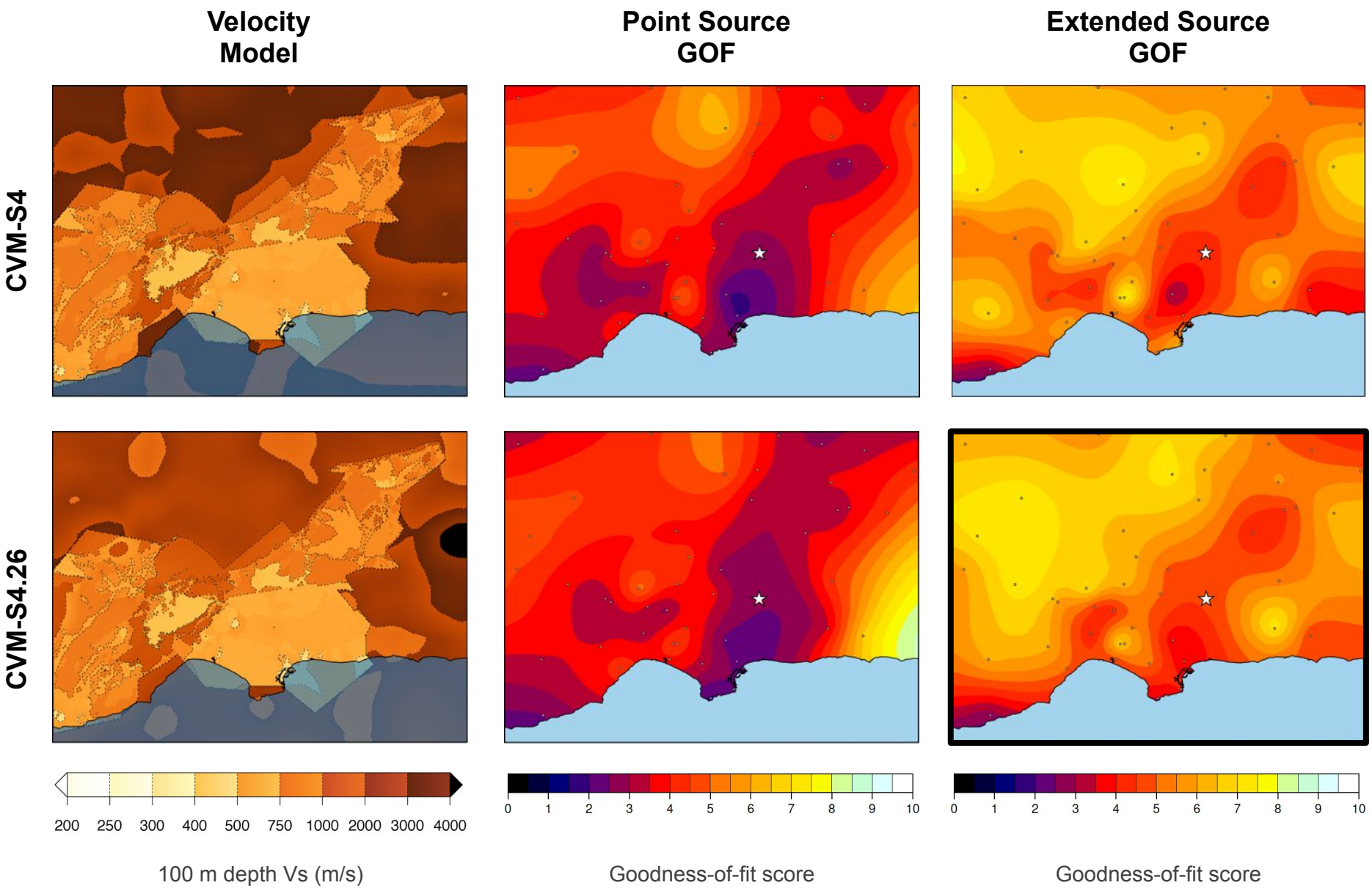


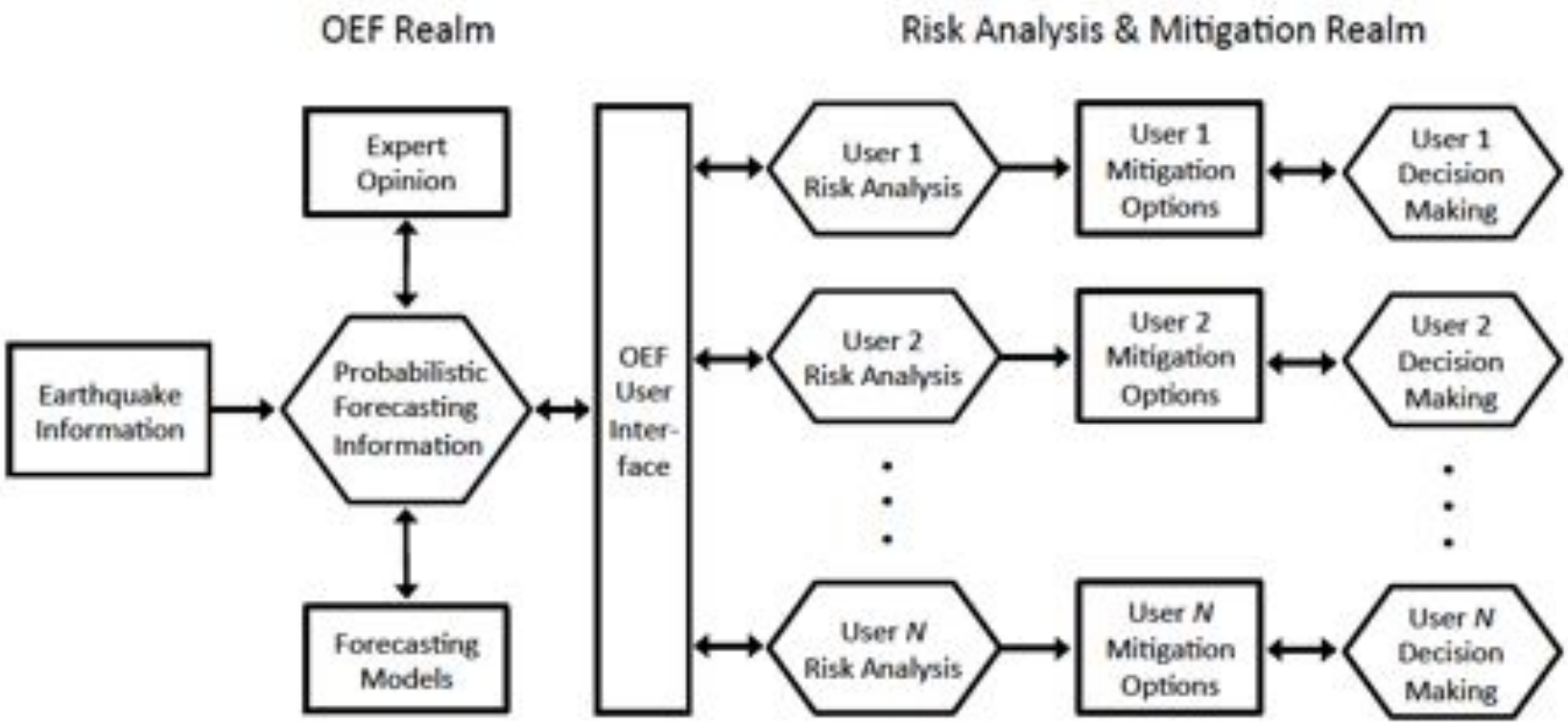
CyberShake Statewide Hazard Model

- **Extend CyberShake models to 1400 sites across California**
  - **Develop statewide Unified Community Velocity Model (UCVM)**
  - **Compute site response to 1 Hz deterministic, 10 Hz stochastic**
- **Couple time-dependent UCERF3 to CyberShake**
  - **Provide frequently updated time-dependent seismic hazard maps**
- **Extend CSEP to prospectively test ground motion forecasts against observations throughout California**

Statewide CyberShake

- Computational requirements for 1 Hz deterministic, 10 Hz stochastic:
  - Number of jobs: 23.2 billion
  - Storage: 2800 TB seismograms
  - Computer hours: 392 million

End


OEF Realm
Risk Analysis & Mitigation Realm
Expert Opinion
Earthquake Information
Probabilistic Forecasting Information
Forecasting Models
OEF User Inter-face
User 1 Risk Analysis
User 1 Mitigation Options
User 1 Decision Making
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