

SCEC Activities Related to Engineering Applications

Thomas H. Jordan

Director, Southern California Earthquake Center

SSI Workshop, 29 Jan 2015

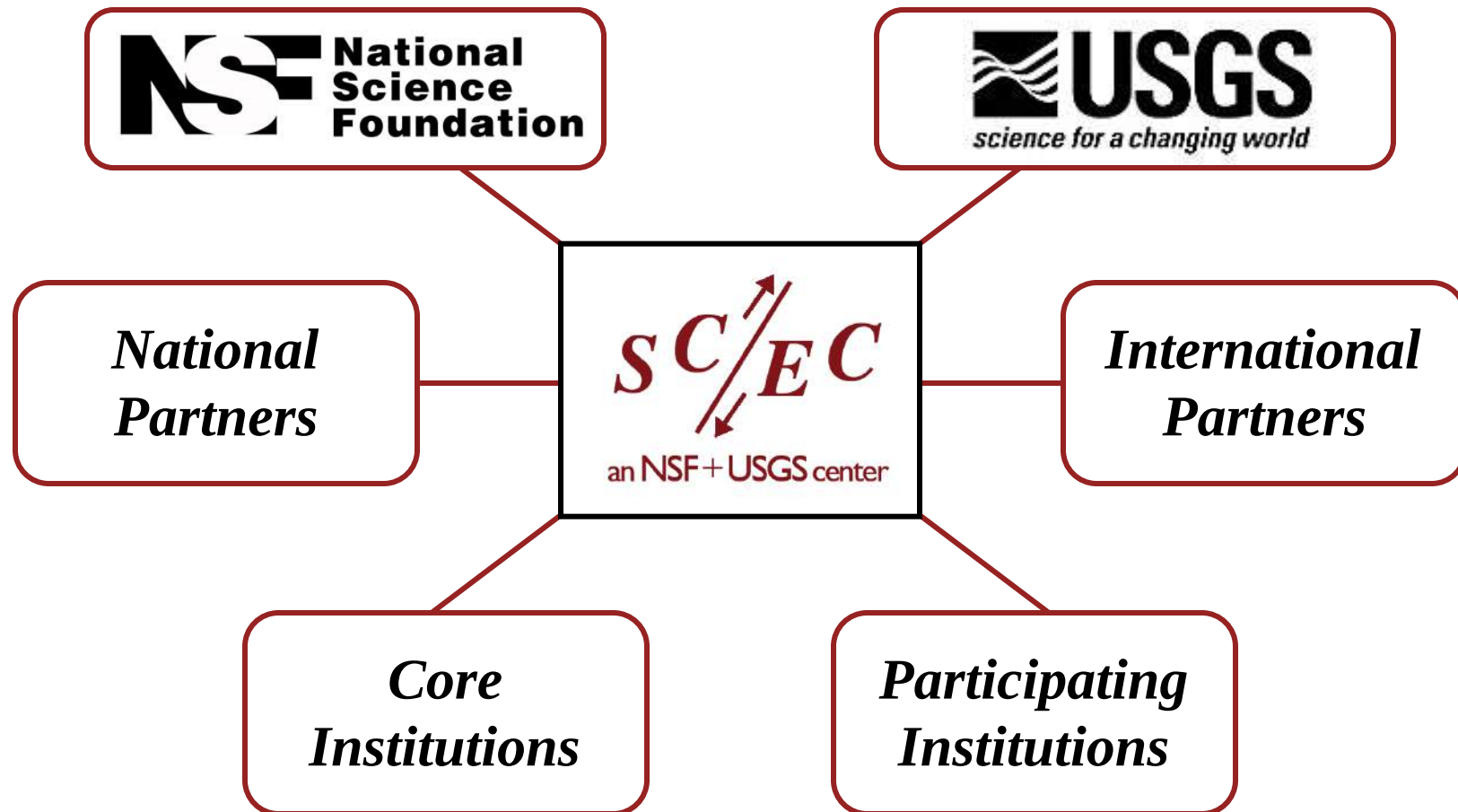


an NSF+USGS center

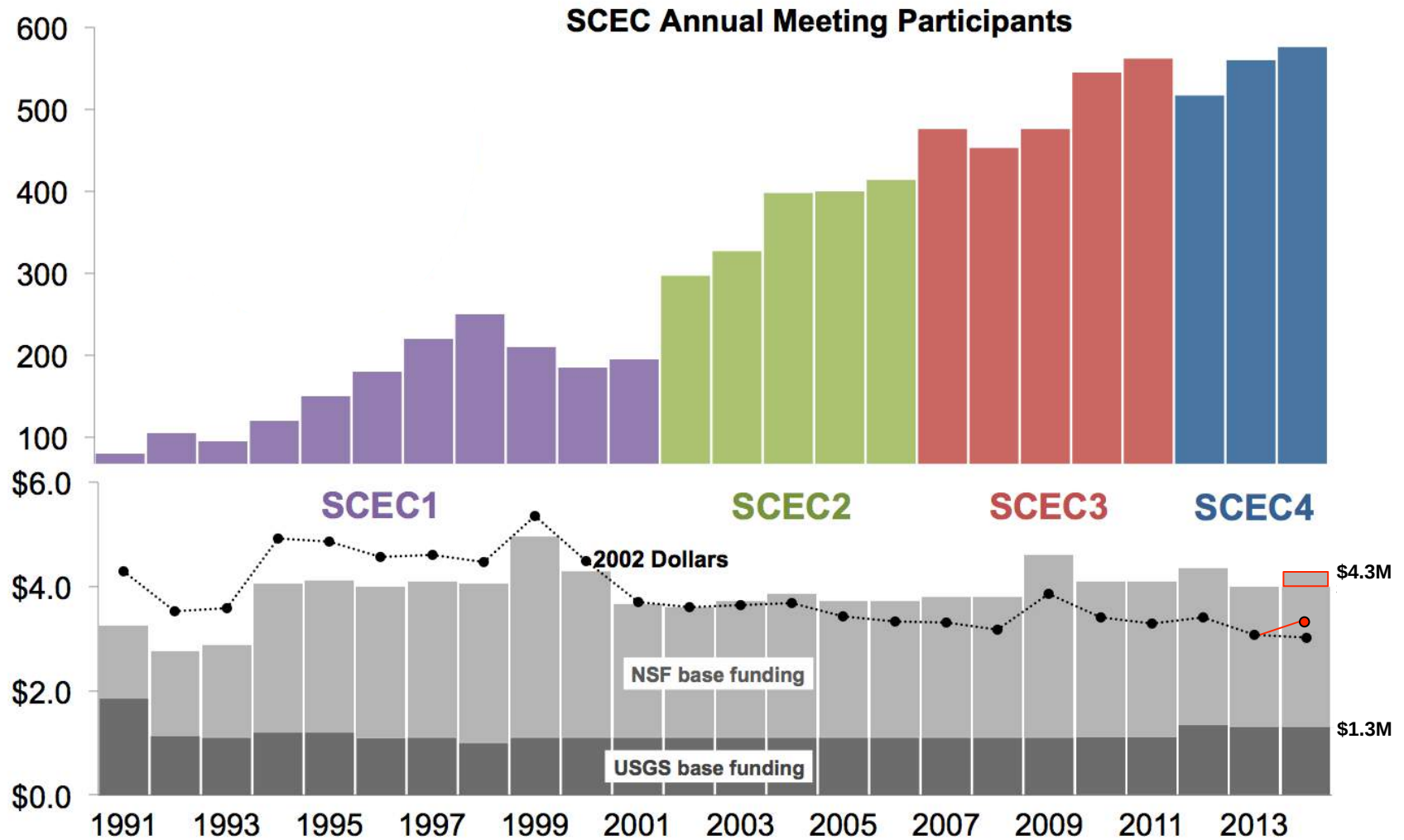
Topics

- **SCEC program in earthquake system science**
- **Ground motion simulation**
- **Validation activities**

The SCEC Partnership



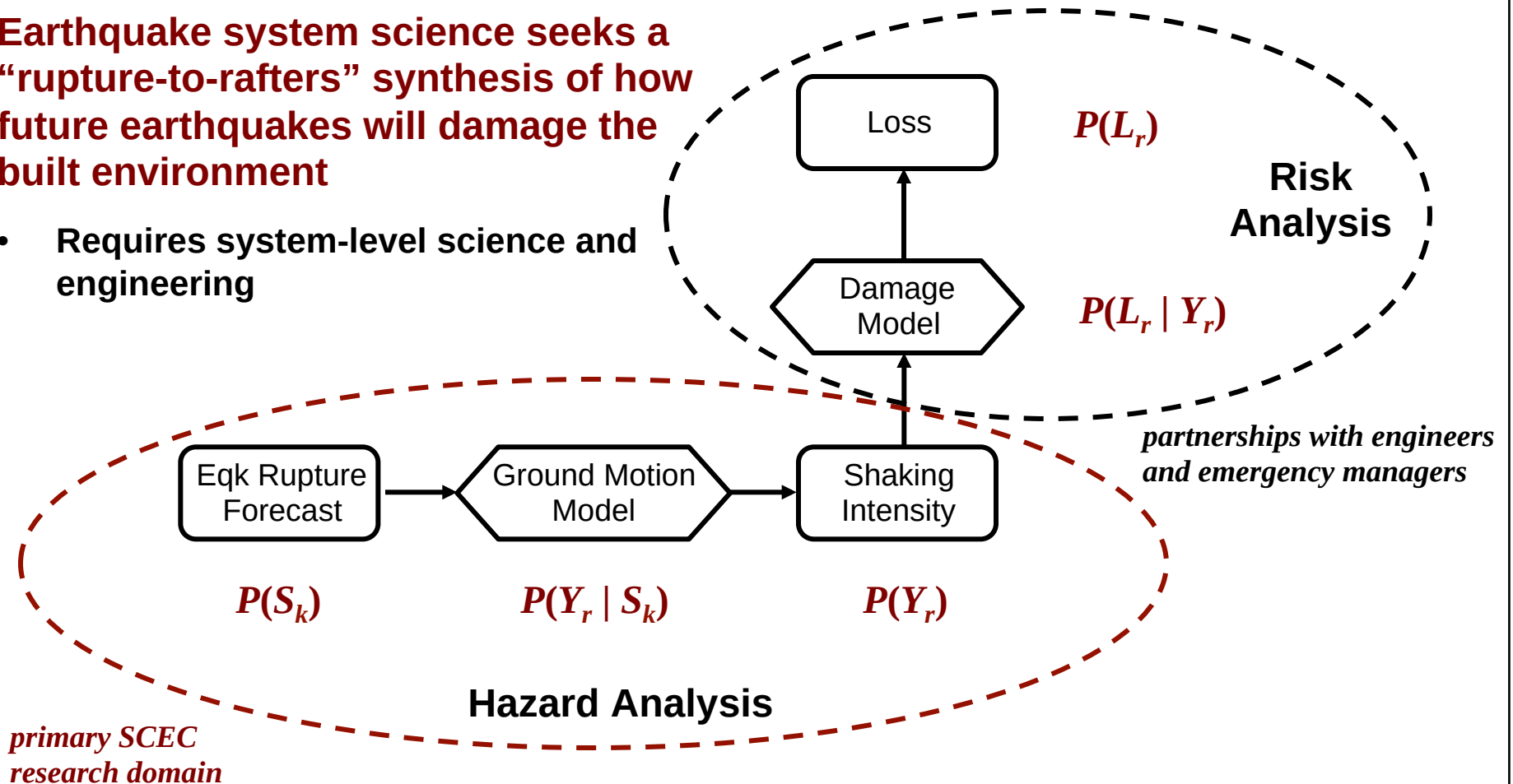
SCEC Base Program



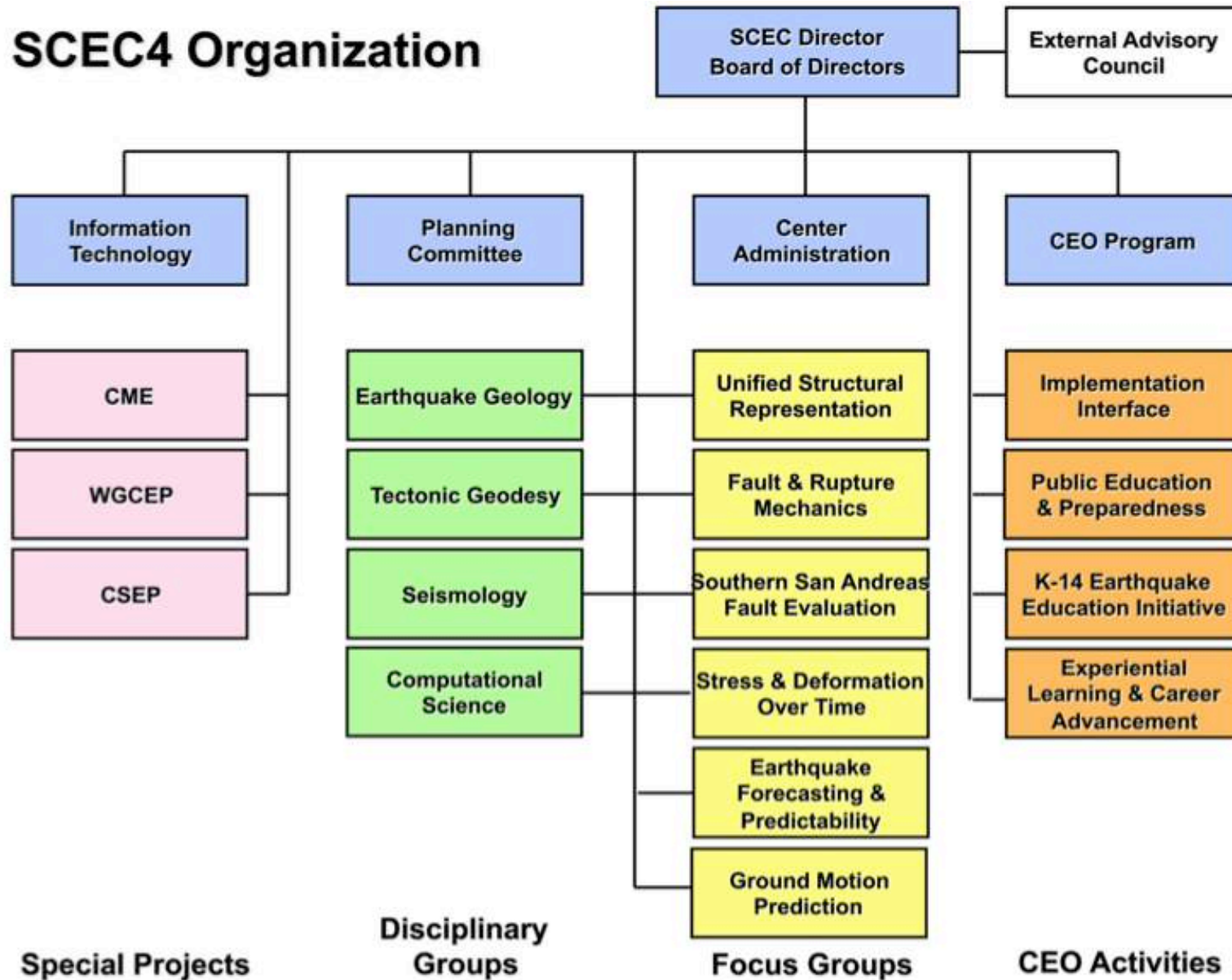
SCEC Program in Earthquake System Science

Earthquake system science seeks a “rupture-to-rafters” synthesis of how future earthquakes will damage the built environment

- Requires system-level science and engineering



SCEC4 Organization



Science Working Groups & Planning Committee

Disciplinary Committee



Seismology
Egill Hauksson*
Elizabeth Cochran



Tectonic Geodesy
Jessica Murray*
Dave Sandwell



EQ Geology
Mike Oksin
Whitney Behr



Computational Science
Yifeng Cui*
Eric Dunham

Interdisciplinary Focus Groups



USR
John Shaw*
Brad Aagaard



SoSAFE
Kate Scharer*
Ramon Arrowsmith



EFP
Jeanne Hardebeck*
Ilya Zaliapin



EEII
Jack Baker*
Jacobo Bielak



FARM
Greg Hirth*
Pablo Ampuero



SDOT
Kaj Johnson**
Thorsten Becker



GMP
Kim Olsen*
Christine Goulet

Special Projects



CME
Phil Maechling*



CSEP
Max Werner*
Danijel Schorlemmer



WGCEP
Ned Field*

Technical Activity Groups



Code Verification
Ruth Harris



GMSV
Nico Luco
Sanaz Rezaeian



SIV
Martin Mai



EQ Simulators
Terry Tullis



Transient Detection
Rowena Lohman

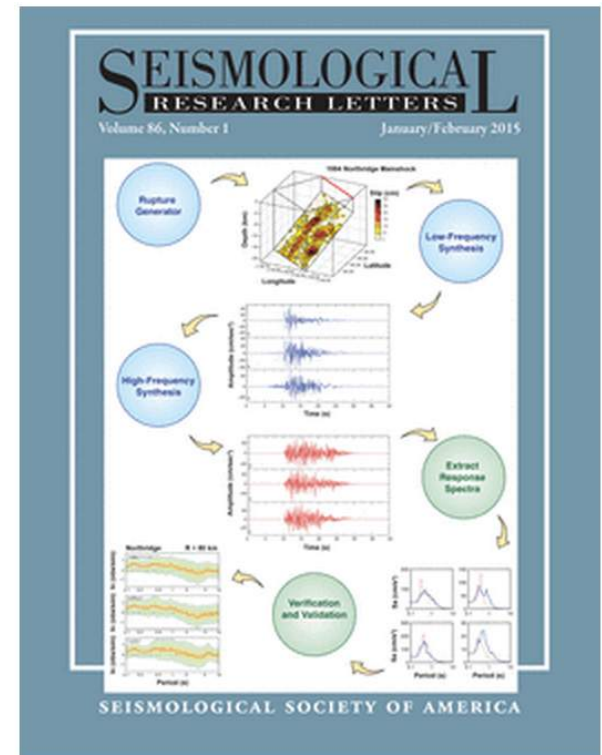


**SCEC Co-Director
& PC Chair**
Greg Beroza

SCEC Special Projects

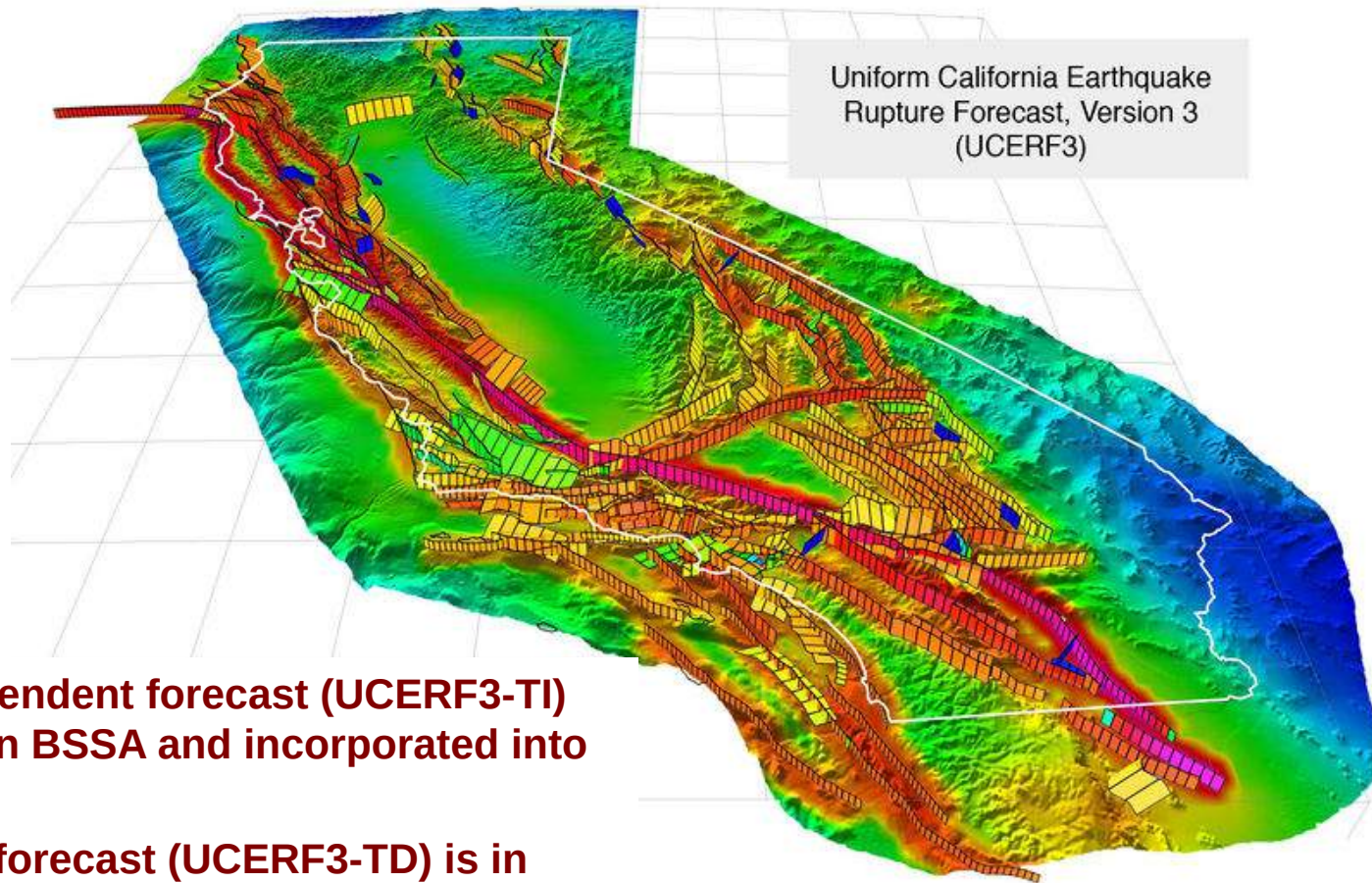
- **Uniform California Earthquake Rupture Forecast (UCERF3) by WGCEP**
- **Collaboratory for the Study of Earthquake Predictability (CSEP)**
- **Community Modeling Environment (CME)**
 - **Broadband platform**
 - **CyberShake platform**
 - **F3DT platform**
 - **High-F platform**

*SRL Special Focus on
the BBP, Jan 2015*



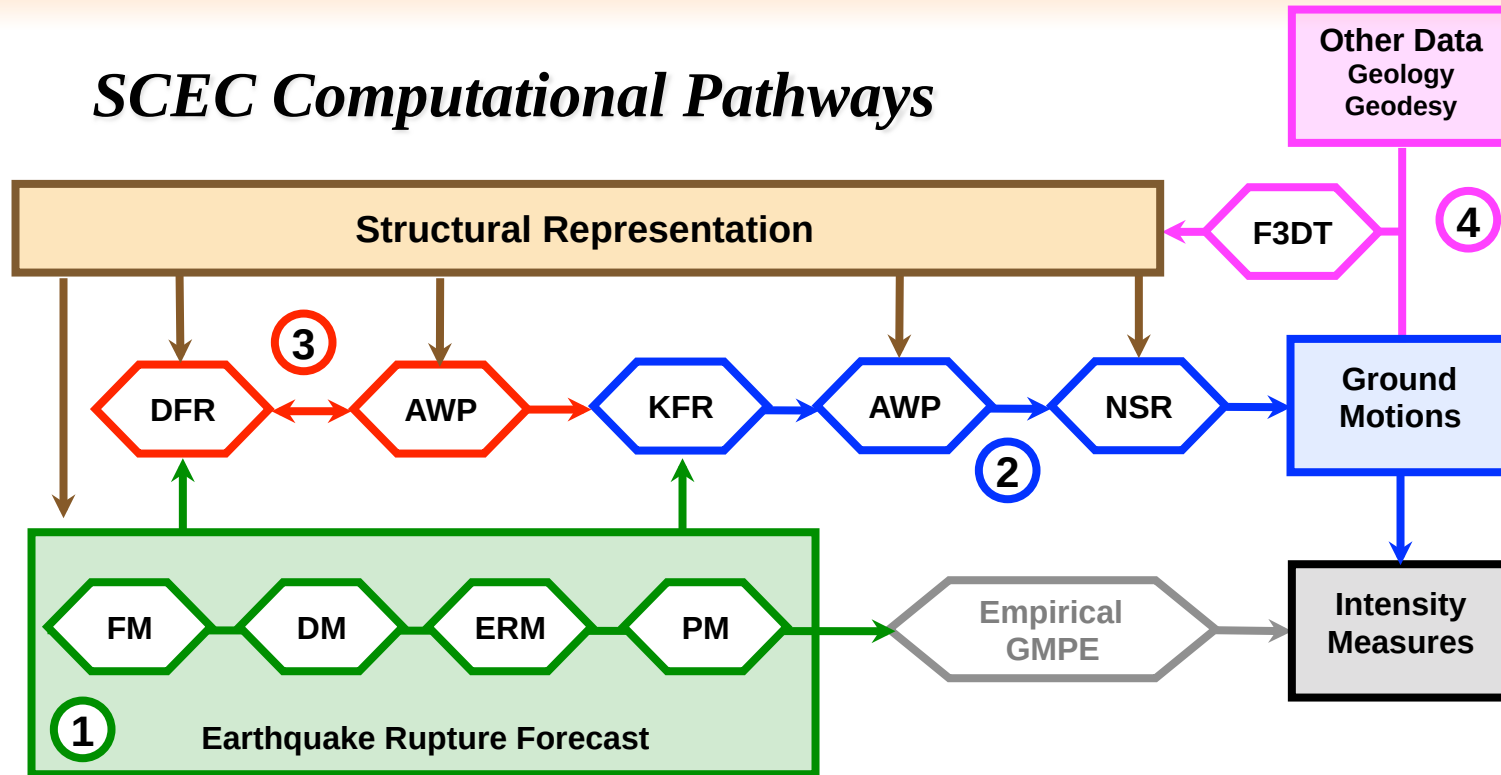
Working Group on California Earthquake Probabilities (2013)

Uniform California Earthquake Rupture Forecast (UCERF3)

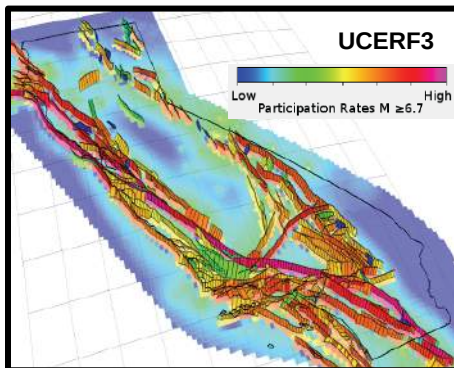


- Time-independent forecast (UCERF3-TI) published in BSSA and incorporated into NSHMP
- Long-term forecast (UCERF3-TD) is in press at BSSA
- Short-term component (UCERF3-ETAS) is still under alpha-testing

SCEC Computational Pathways

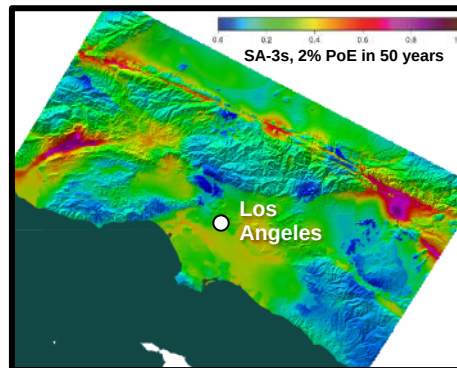


TACC Stampede



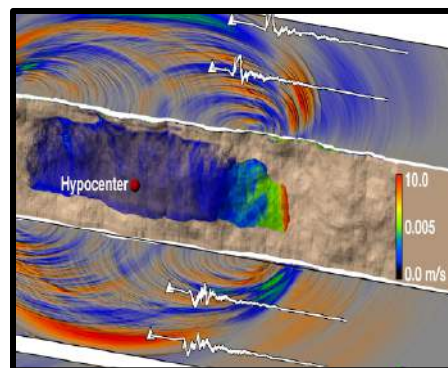
① Uniform California Earthquake Rupture Forecast (UCERF3)

NCSA Blue Waters



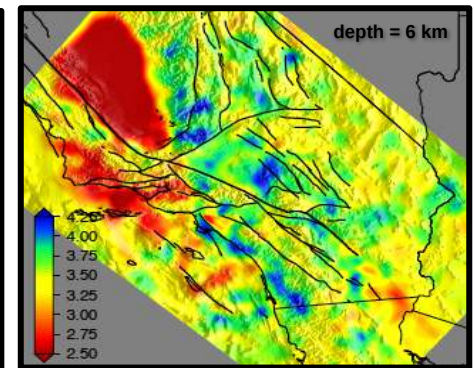
② CyberShake 14.2 seismic hazard model for LA region

OLCF Titan



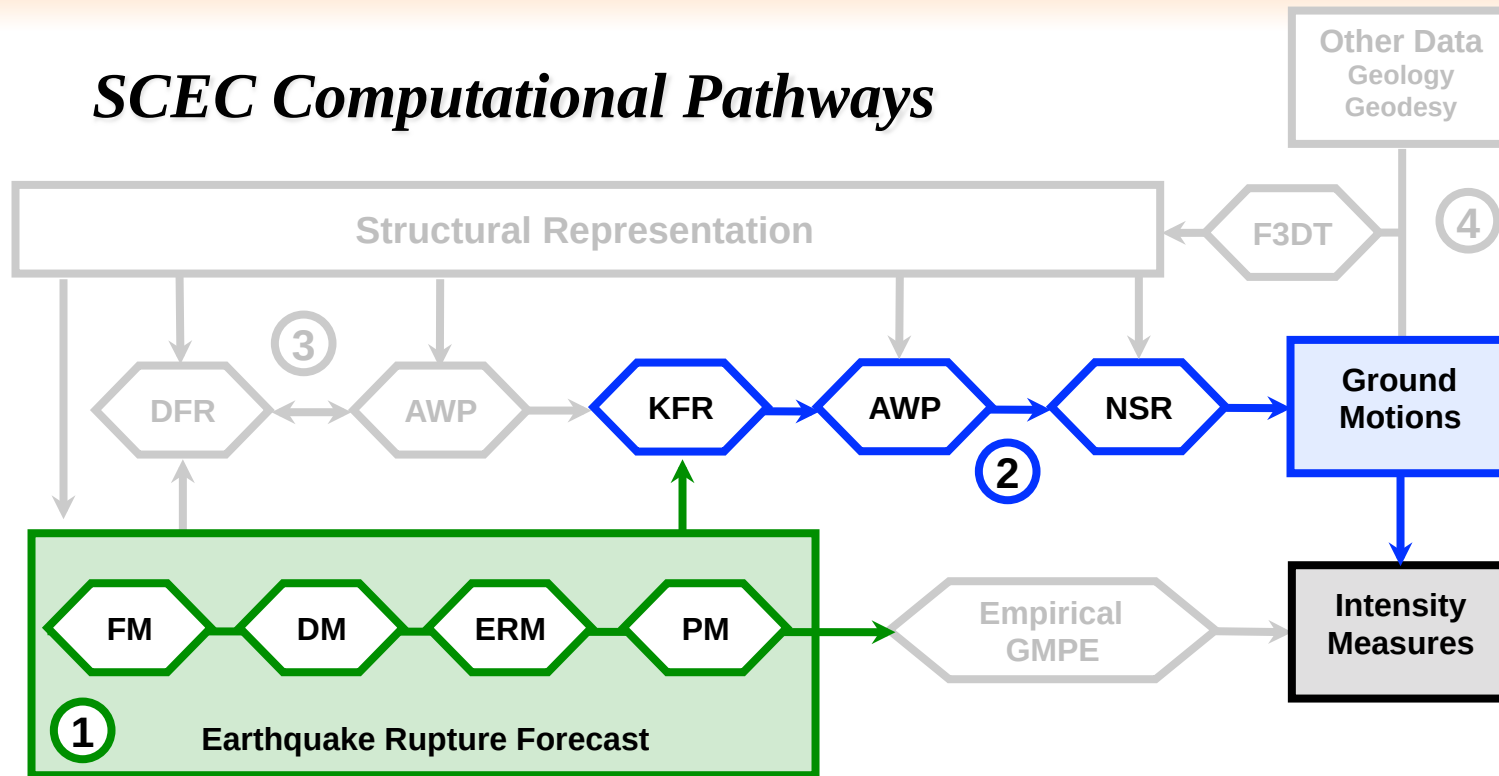
③ Dynamic rupture model of fractal roughness on SAF

ALCF Mira

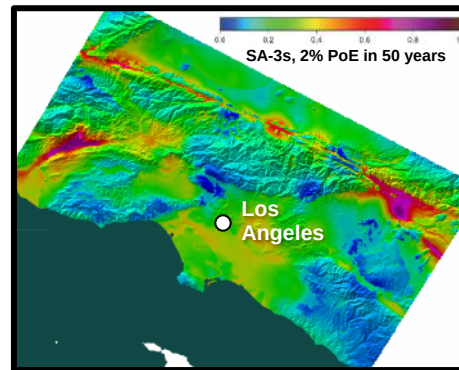


④ Full-3D tomographic model CVM-S4.26 of S. California

SCEC Computational Pathways



NCSA Blue Waters

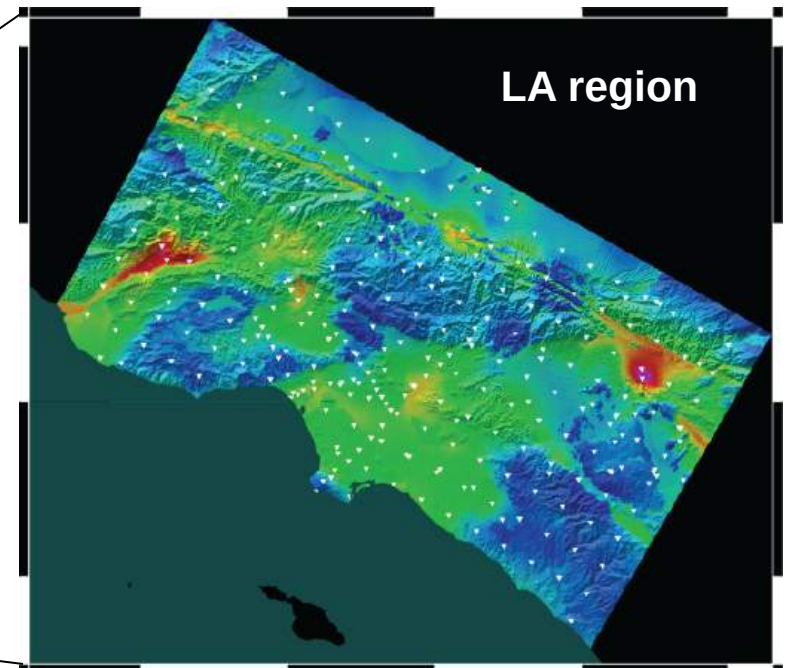
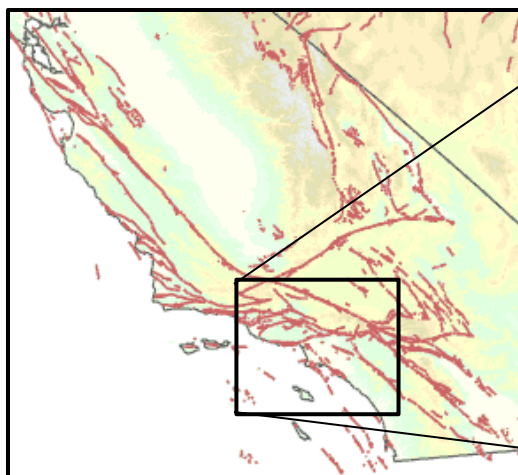


② CyberShake 14.2 seismic hazard model for LA region

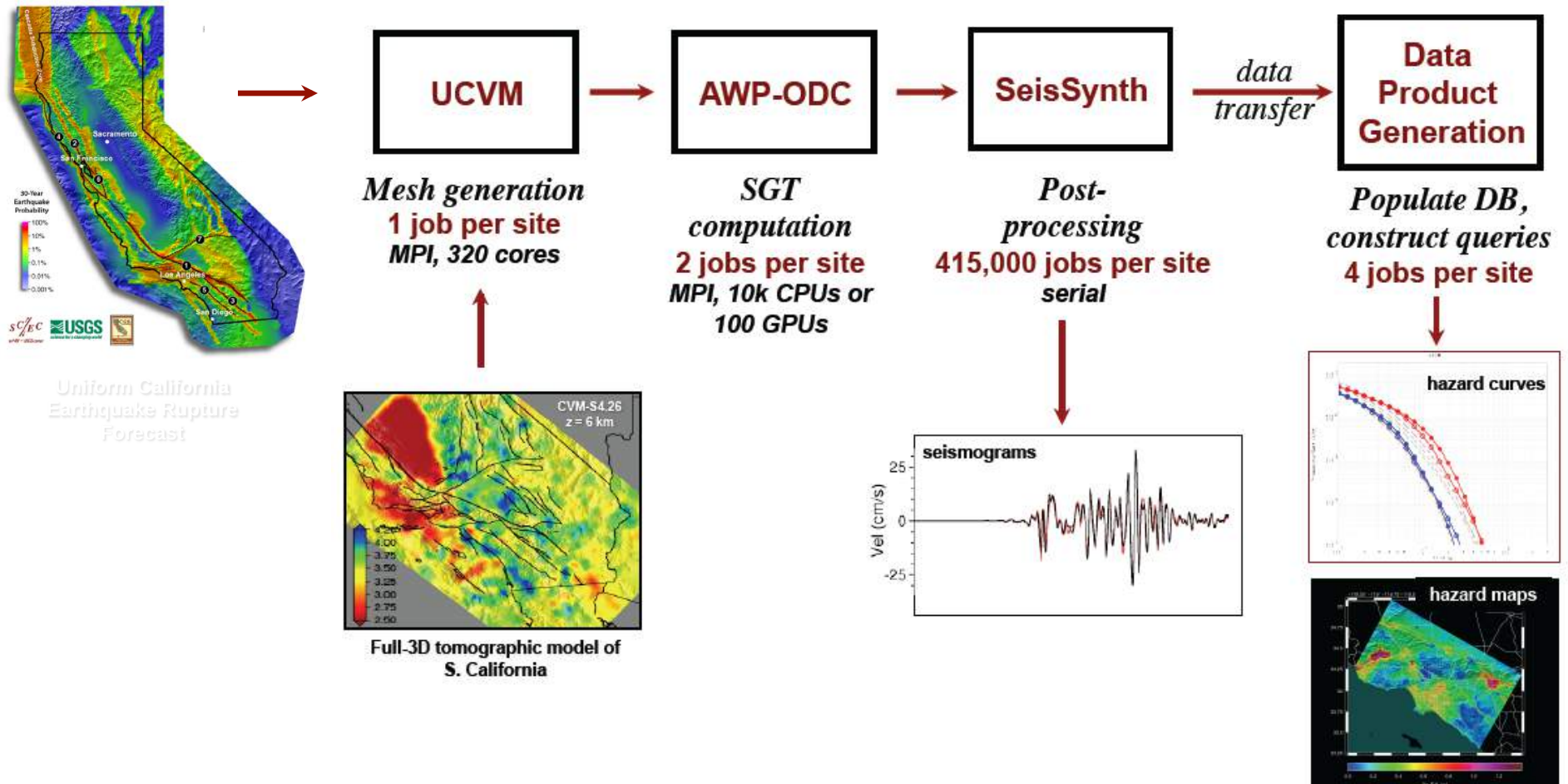
KFR = Kinematic Fault Rupture
 AWP = Anelastic Wave Propagation
 NSR = Nonlinear Site Response
 DFR = Dynamic Fault Rupture
 F3DT = Full-3D Tomography

CyberShake Hazard Model

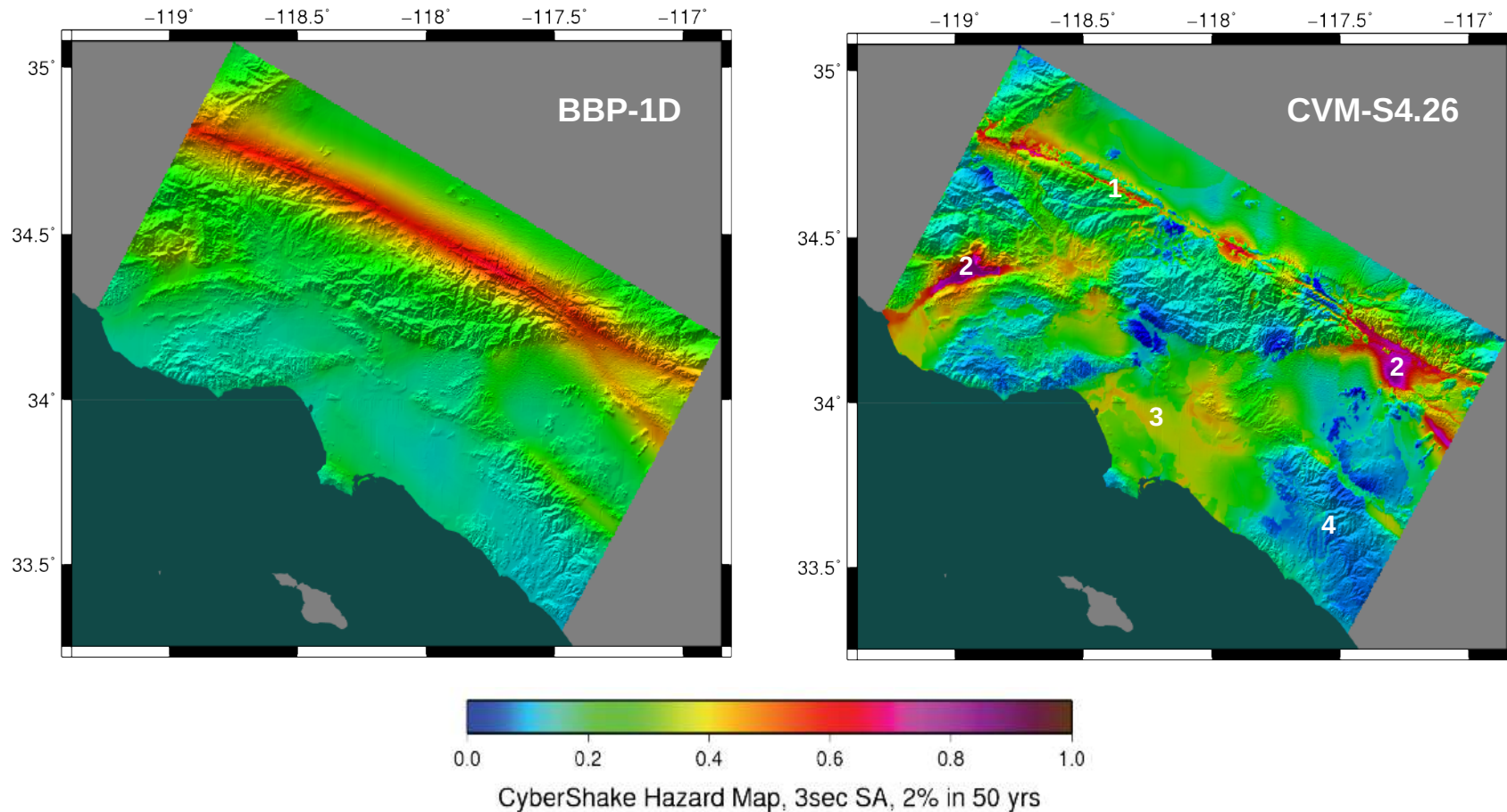
- **3D crustal model:**
 - CVM-S4.26
- **Sites:**
 - 283 sites in the greater Los Angeles region
- **Ruptures:**
 - All UCERF2 ruptures within 200 km of site (~14,900)
- **Rupture variations:**
 - ~415,000 per site using Graves-Pitarka pseudo-dynamic rupture model
- **Seismograms:**
 - ~235 million per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



Coupling of Computational Pathways in the CyberShake Workflow

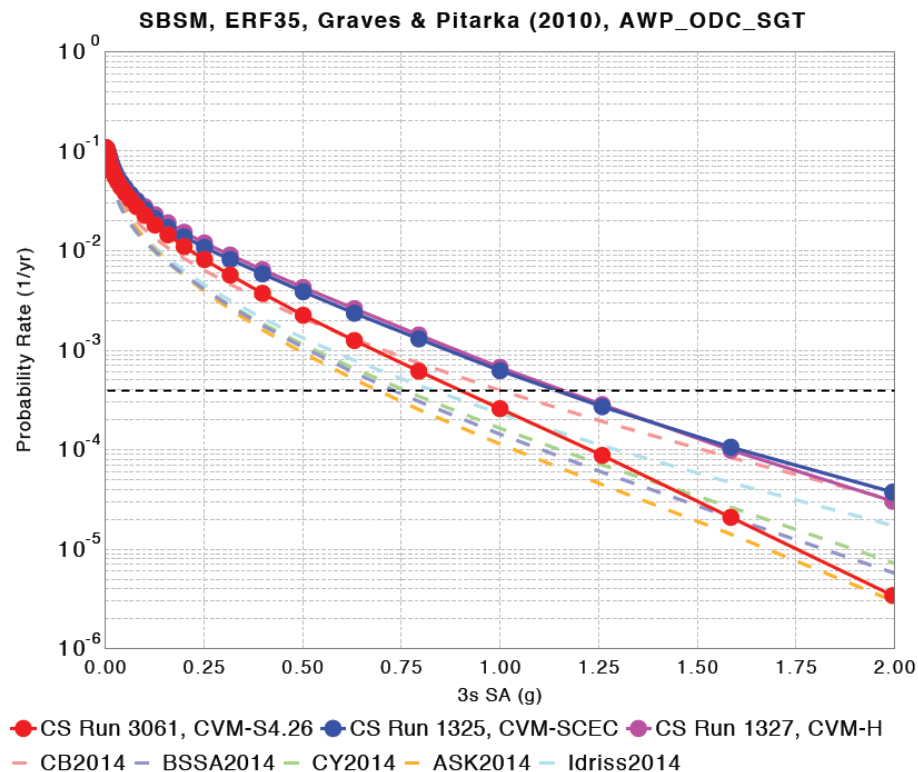
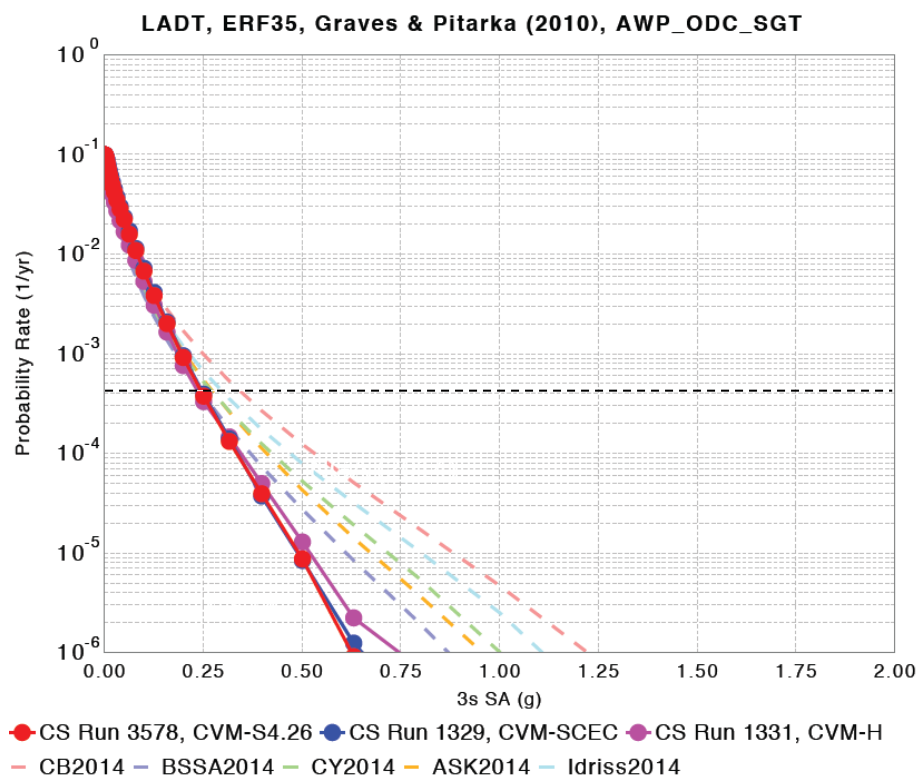


Comparison of 1D and 3D CyberShake Models for the Los Angeles Region

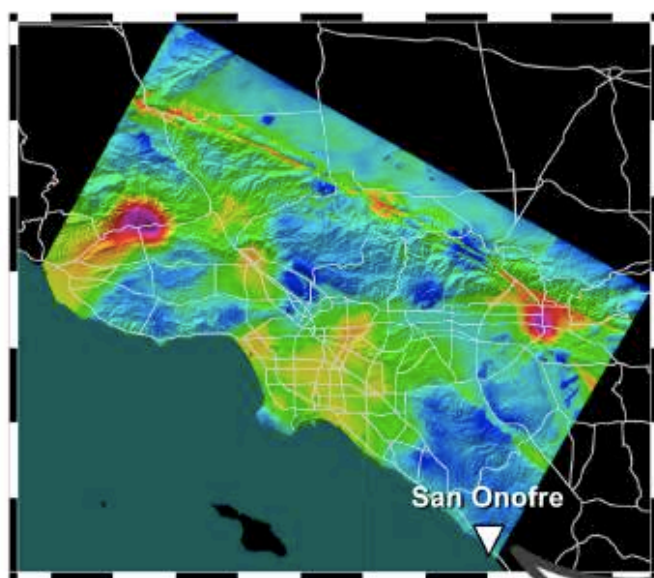


1. lower near-fault intensities due to 3D scattering
2. much higher intensities in near-fault basins
3. higher intensities in the Los Angeles basins
4. lower intensities in hard-rock areas

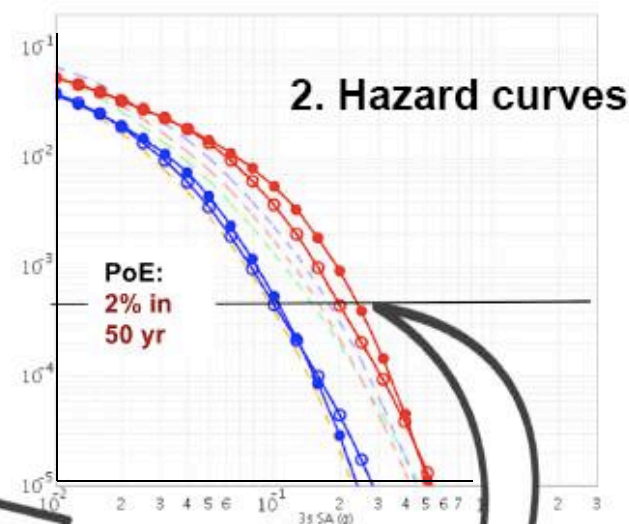
NGA(2014)-CyberShake Hazard Curve Comparisons



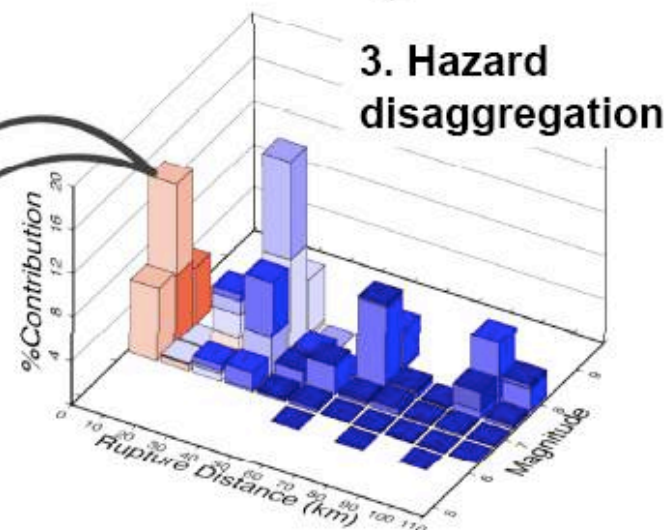
CyberShake Data Products



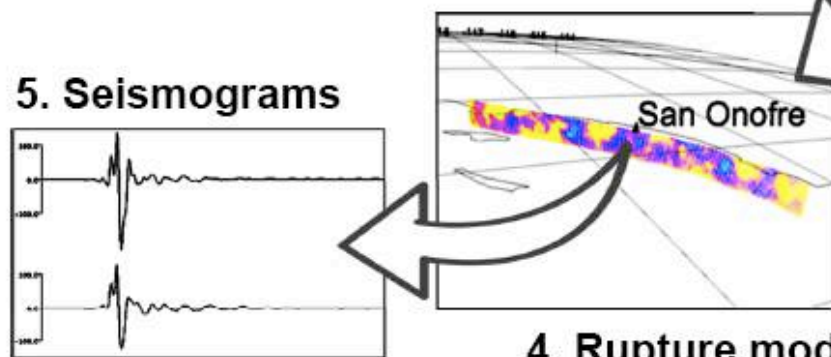
1. Hazard map



2. Hazard curves



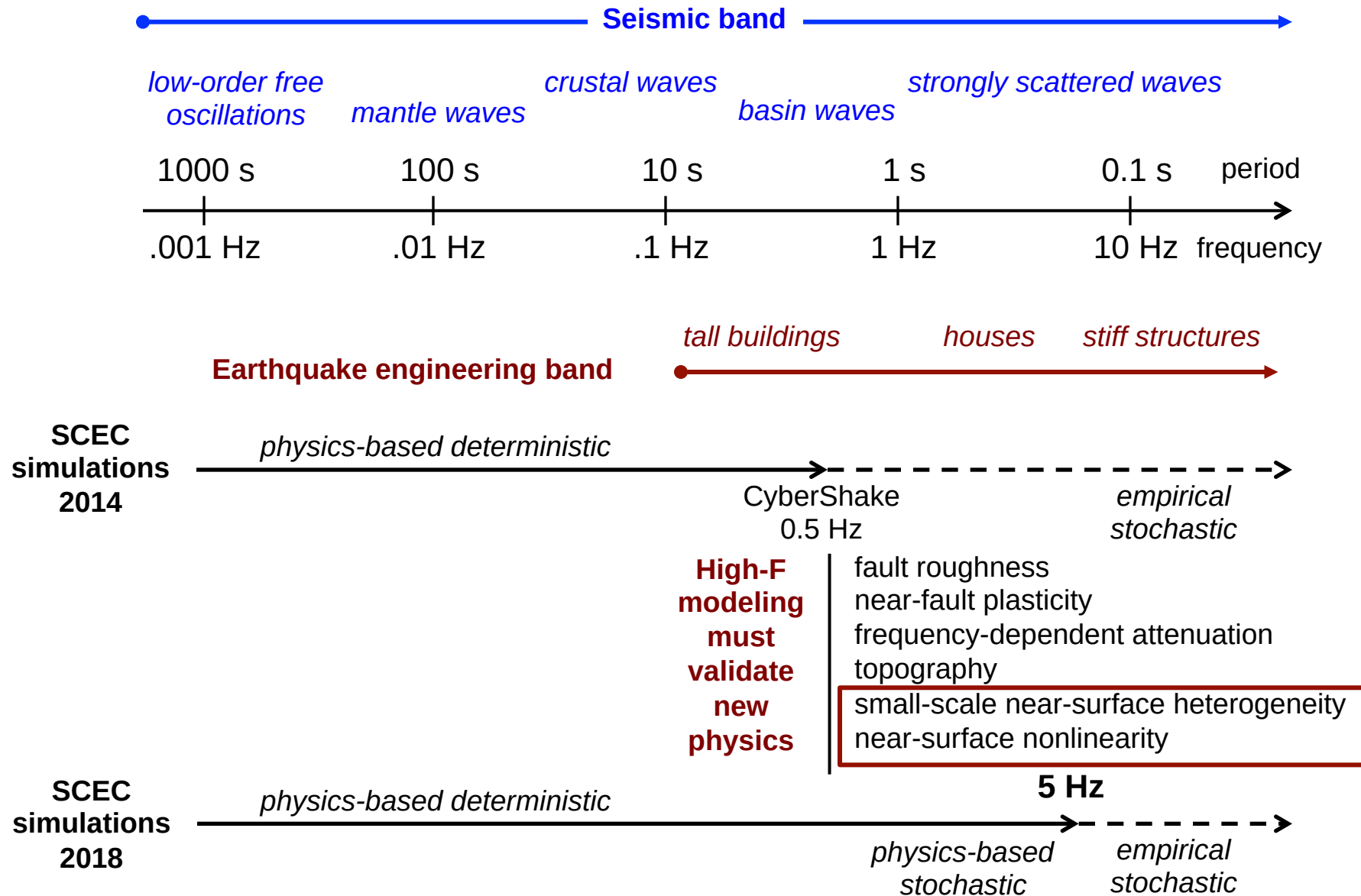
3. Hazard disaggregation



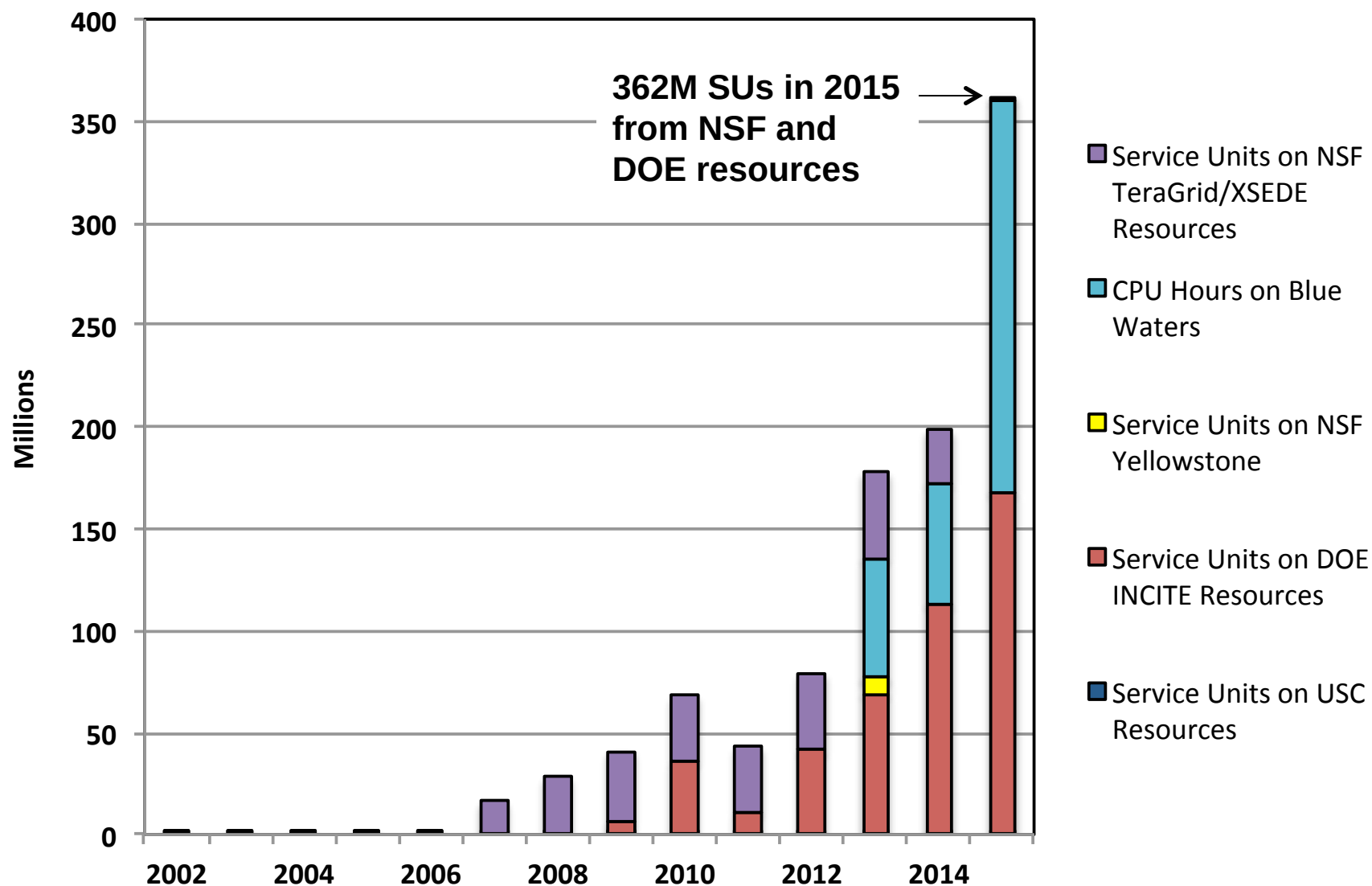
4. Rupture model

5. Seismograms

Push to Higher Seismic Frequencies



SCEC use of HPC resources is growing rapidly...



Ground Motion Simulation Validation

Two basic points:

- ***Practical application of simulation methods requires application-specific validation***
- ***Application-specific validation gauntlets must be designed collaboratively by earthquake scientists and engineers, including practicing engineers***

Ground Motion Simulation Validation

- **Coordinated through SCEC's Earthquake Engineering Implementation Interface (EII)**
 - SCEC focus group, represented on the Planning Committee
 - Co-leaders: Jack Baker and Jacobo Bielak
- **Main activities:**
 - High-frequency (High-F) project validation
 - Broadband platform (BBP) validation
 - Ground Motion Simulation Validation technical activity group (GMSV TAG)
 - Committee on the Utilization of Ground Motion Simulations (Utilization Committee)

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 - Historical recordings of moderate magnitude events; e.g., 1994 Northridge (M6.7), 2007 Chino Hills (M5.5), 2014 La Habra (M5.1)
 - Comparison with GMPEs
 - Example: Taborda & Bielak (BSSA, 2013)
 - Broadband platform (BBP) validation
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 - **Broadband platform (BBP) validation**
 - **Part A: Comparison mean simulated PSA RotD50 with data from 12 earthquakes in California, Japan, and eastern North America at distances < 200 km**
 - **Part B: Comparison the simulated PSA RotD50 with the mean 2008 NGA GMPE estimates for moderate-magnitude earthquakes (Mw 5.5–6.6) at intermediate distances (20 and 50 km)**
 - **Results: 8 papers in SRL, Jan-Feb 2015 issue**
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- Main activities:
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 - **Ground Motion Simulation Validation technical activity group (GMSV-TAG)**
 - **Goal: develop and implement, via collaboration between ground motion modelers and engineering users, validation gauntlets for engineering applications**
 - **Metrics: elastic and inelastic spectral accelerations/displacements, nonlinear building response, duration-sensitive geotechnical systems**
 - **Co-leaders: Nicolas Luco and Sanaz Rezaeian**
 - Committee on the Utilization of Ground Motion Simulations (Utilization Committee)

Ground Motion Simulation Validation

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 - **Committee on the Utilization of Ground Motion Simulations (Utilization Committee)**
 - **Develop long-period response spectral acceleration maps for Los Angeles region for inclusion in NEHRP and ASCE 7 Seismic Provisions and in Los Angeles City Building Code**
 - **C.B. Crouse (chair), N. Abrahamson, J. Anderson, R. Bachman, J. Baker, J. Bielak, A. Frankel, R. Graves, R. Hamburger, C. Haselton, J. Hooper, M. Hudson, C. Kircher, M. Lew, N. Luco, F. Naeim, P. Somerville**

End