The Southern California Earthquake Center (SCEC) GMSV Technical Activity Group (TAG)

QuakeCoRE Monthly Webconference: Ground Motion Simulation Validation (GMSV)

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Outline

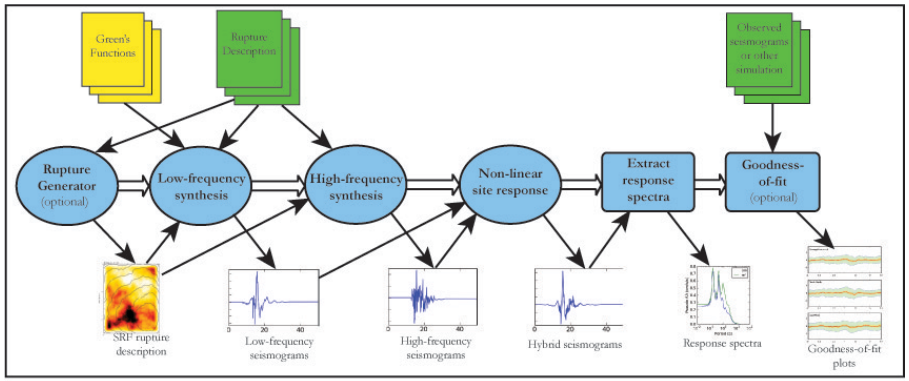
- Motivation – SCEC Ground Motion Simulation Efforts
- Objectives of SCEC GMSV TAG
- 2012-2014 Projects
- 2015 Project on “Implementation of GMSV Gauntlets …”
- 2016 SCEC GMSV TAG Activities (tentative)
- 2016 QuakeCoRE GMSV Coordination

SCEC Ground Motion Simulation Efforts

- Broadband Platform (BBP)

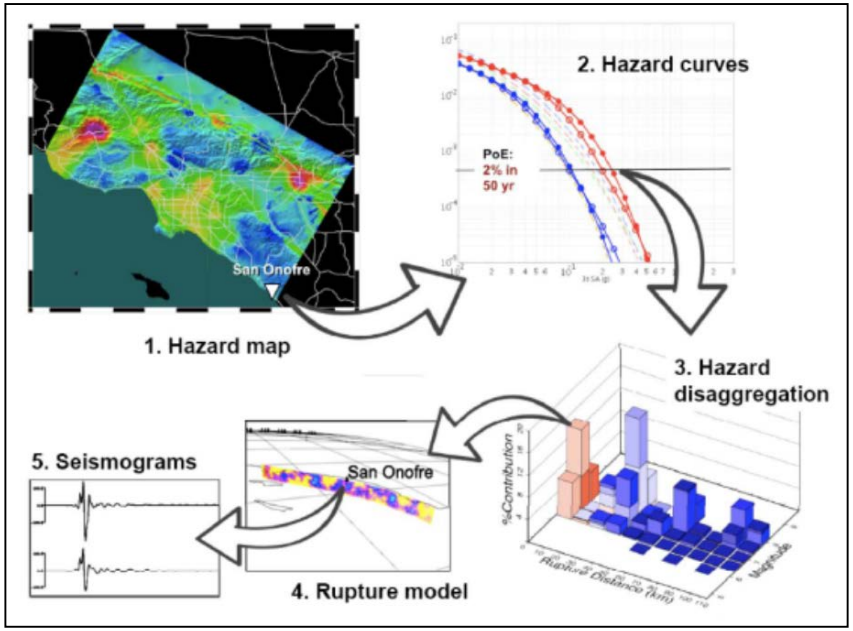
Software system for simulation of broadband (0-10 Hz) seismograms for historical & scenario earthquakes

Designed for use by both scientists & engineers



- Cybershake

3-D low-frequency wave propagation simulations for PSHA



SCEC GMSV TAG Objective

- Develop and implement testing/rating methodologies via collaboration between ground motion modelers and engineering users
- Focused on validation for use in “engineering applications,”

  such as …

  – development of Ground Motion Prediction Equations (GMPE’s), BPVP focused on elastic SDoF

  – Probabilistic Seismic Hazard Analysis (PSHA)

  – structural Nonlinear Response History Analysis (NRHA) of buildings

  – geotechnical Site Response Analysis (SRA)

SCEC GMSV TAG Objective

Not focused on …

- verification (comparison against theoretical predictions, as opposed to observations)
- comparisons of seismograms, as opposed to …
  - elastic response spectra
  - inelastic response spectra
  - response of geotechnical systems
  - multi-degree-of-freedom building response
  - other “engineering metrics”
- validation of individual simulated ground motions

2012-2014 SCEC GMSV TAG Projects

Main Page - GMSV Wiki

collaborate.scec.org/gmsv/Main_Page

Past Projects (& SCEC Reports)

- 2014 - "Use and validation of simulated earthquakes for the nonlinear performance-assessment of tall buildings considering spectral shape and duration" (G. Deierlein, Stanford; T. Lin, Marquette)
- 2014 - "Validation of simulated ground motions based on evolution of intensity and frequency content" (F. Zareian, UC-Irvine; S. Rezaeian, USGS)
- 2014 - "Methodology for validating median values and aleatory variability of broadband platform ground motion simulations" (J. Bayless, A. Skarlatoudis, & P. Somerville, URS)
- 2014 - "Empirical evaluation of the variance associated with multiple ruptures of a single fault" (J. Anderson, UNR)
- 2014 - "Proxy metrics for ground motion simulation validation: fling parameters" (J. Baker, Stanford)
- 2014 - "Near source broadband ground-motion modeling of the Canterbury aftershocks and implications for assessing engineering metrics" (C. Holden & M. Gerstenberger, GNS)
- 2014 - "Validating site response predictions in deterministic physics-based ground motion simulations (D. Asimaki, Georgia Tech; R. Taborda, Memphis)
- 2013-15 - Comparisons of nonlinear response of multi-degree-of-freedom building models to simulated and recorded ground motions (F. Zareian, UCI; I. Iervolino, Naples Federico II)
- 2013-15 - Validation of simulated ground motions relative to seismic geotechnical engineering demand parameters (J. Stewart, UCLA)
- 2014 - "Evaluation of attenuation models used in physics-based ground-motion earthquake simulation through validation with data and comparisons with NGA" (R. Taborda, Memphis)
- 2014 - "Broadband ground motion simulations for the Canterbury earthquakes with nonlinear effective-stress modeling of surficial soils" (B. Bradley, Canterbury)
- 2013-15 - Validation for engineering analysis using simple and robust ground motion parameters (J. Baker, Stanford)
- 2013 - "Validation of earthquake simulations and their effects on tall buildings considering spectral shape and duration" (G. Deierlein, Stanford; T. Lin, Marquette)
- 2013 - "Validation of simulated ground motions relative to seismic geotechnical engineering demand parameters" (J. Stewart, UCLA)
- 2013 - "Validation of ground motion simulations for seismic slope stability" (E. Rathje, UT Austin)
- 2013 - "Validating nonlinear site response prediction methodologies for SCEC broadband ground motion simulations" (D. Asimaki, GA Tech)
- 2013 - "Simulation and validation of long-period earthquake ground motion in the Kanto Basin in Japan" (J. Bielak, CMU)
- 2012 - "Validation of broadband ground-motion synthetics using earthquake engineering-relevant metrics" (K. Olsen, SDSU)
- 2012 - "US-Japan collaboration on strong ground motion prediction techniques" (P. Somerville / A. Pitarka / J. Bayless, URS)
- 2012 - Validation of elastic spectral correlation and inelastic spectra from ground motion simulations (J. Baker, Stanford)
- 2012 - "A framework for validation of ground motion simulations emphasizing predictive power and use of seismic effective stress analyses of soil deposits" (B. Bradley, Canterbury)
- 2012 - "PBR science for SCEC4: Validation of ground motion prediction and simulations" (G. Biasi, UNR)
- 2012 - "Behavior of multiple broadband ground motion simulation techniques for a suite of earthquake scenarios using multiple rupture model generators on the SCEC Broadband Platform" (J. Bayless / P. Somerville, URS)
- 2010 - "Non-linear structural simulations using SCEC simulated ground motions -- One-to-one comparisons" (C. Goulet, URS; C. Haselton, CSU-Chico; J. Bayless, URS)
- 2007 - Validation of ground motion simulations for engineering application (J. Baker, Stanford)

Related (but Separate) GMSV Efforts

Main Page - GMSV Wiki

collaborate.scec.org/gmsv/Main_Page#Related_Efforts

Related Efforts [edit]

- 2015 - A Working Group on Modeling and Integration of the Geotechnical Layer in SCEC Simulations (D. Asimaki, Caltech; J. Anderson, UNR; J. Stewart, UCLA; R. Taborda, Memphis)
- 2013-Present - "SCEC Utilization of Ground Motion Simulations Committee" (C.B. Crouse, URS)
- 2012-15 - "Software Environment for Integrated Seismic Modeling (SEISM) Project" (T. Jordan, SCEC / J. Bielak, CMU / Y. CUI, UCSD / K. Olsen, SDSU)
- 2012-15 - "SCEC Broadband Platform Validation Study" (SCEC login required) (T. Jordan / P. Maechling, SCEC; P. Somerville, URS; C. Goulet, PEER)

Past Projects (& SCEC Reports) [edit]

- 2014 - "Use and validation of simulated earthquakes for the nonlinear performance-assessment of tall buildings considering spectral shape and

Burks & Baker (2014)

Validation of ground motion simulations through simple proxies for the response of engineered systems

Lynne S. Burks* and Jack W. Baker

Bulletin of the Seismological Society of America, Vol. 104, No. 4, pp. 1930-1946, August 2014, doi: 10.1785/0120130276

Abstract

We propose a list of simple parameters that act as proxies for the response of more complicated engineered systems, and can therefore be studied to validate new methods of ground motion simulation for engineering applications. The primary list of parameters includes correlation of spectral acceleration across periods, ratio of maximum to median spectral acceleration across all horizontal orientations, and the ratio of inelastic to elastic displacement, all of which have reliable empirical models against which simulations can be compared. We also describe several secondary parameters, such as directivity pulse periods and structural collapse capacity, that do not have robust empirical models but are important for engineering analysis. We then demonstrate the application of these parameters to example simulations from the SCEC Broadband Platform validation exercise computed using a variety of methods, including stochastic finite fault (EXSIM), Graves-Pitarka hybrid broadband (GP), and composite source model (CSM). In general, each simulation method matches empirical models for some parameters and not others, indicating that engineers need to carefully validate all parameters relevant to their application before using ground motion simulations.

Online Material: Matlab functions to compute simple proxies and tables of ground motion recordings and simulations used for example calculation. <http://www.stanford.edu/~bakerjw/e-supp/Burks_Baker_(2013)_Metrics,_BSSA-esupp.html>

Rezaeian, Zhong, Hartzell & Zareian (2015)

Bulletin of the Seismological Society of America, Vol. 105, No. 6, pp. 3036-3049, December 2015, doi: 10.1785/0120140210

Validation of Simulated Earthquake Ground Motions Based on Evolution of Intensity and Frequency Content

by Sanaz Rezaeian, Peng Zhong, Stephen Hartzell, and Farzin Zareian

Abstract Simulated earthquake ground motions can be used in many recent engineering applications that require time series as input excitations. However, applicability and validation of simulations are subjects of debate in the seismological and engineering communities. We propose a validation methodology at the waveform level and directly based on characteristics that are expected to influence most structural and geotechnical response parameters. In particular, three time-dependent validation metrics are used to evaluate the evolving intensity, frequency, and bandwidth of a waveform. These validation metrics capture nonstationarities in intensity and frequency content of waveforms, making them ideal to address nonlinear response of structural systems. A two-component error vector is proposed to quantify the average and shape differences between these validation metrics for a simulated and recorded ground-motion pair. Because these metrics are directly related to the waveform characteristics, they provide easily interpretable feedback to seismologists for modifying their ground-motion simulation models. To further simplify the use and interpretation of these metrics for engineers, it is shown how six scalar key parameters, including duration, intensity, and predominant frequency, can be extracted from the validation metrics. The proposed validation methodology is a step forward in paving the road for utilization of simulated ground motions in engineering practice and is demonstrated using examples of recorded and simulated ground motions from the 1994 Northridge, California, earthquake.

Afshari & Stewart (2016)

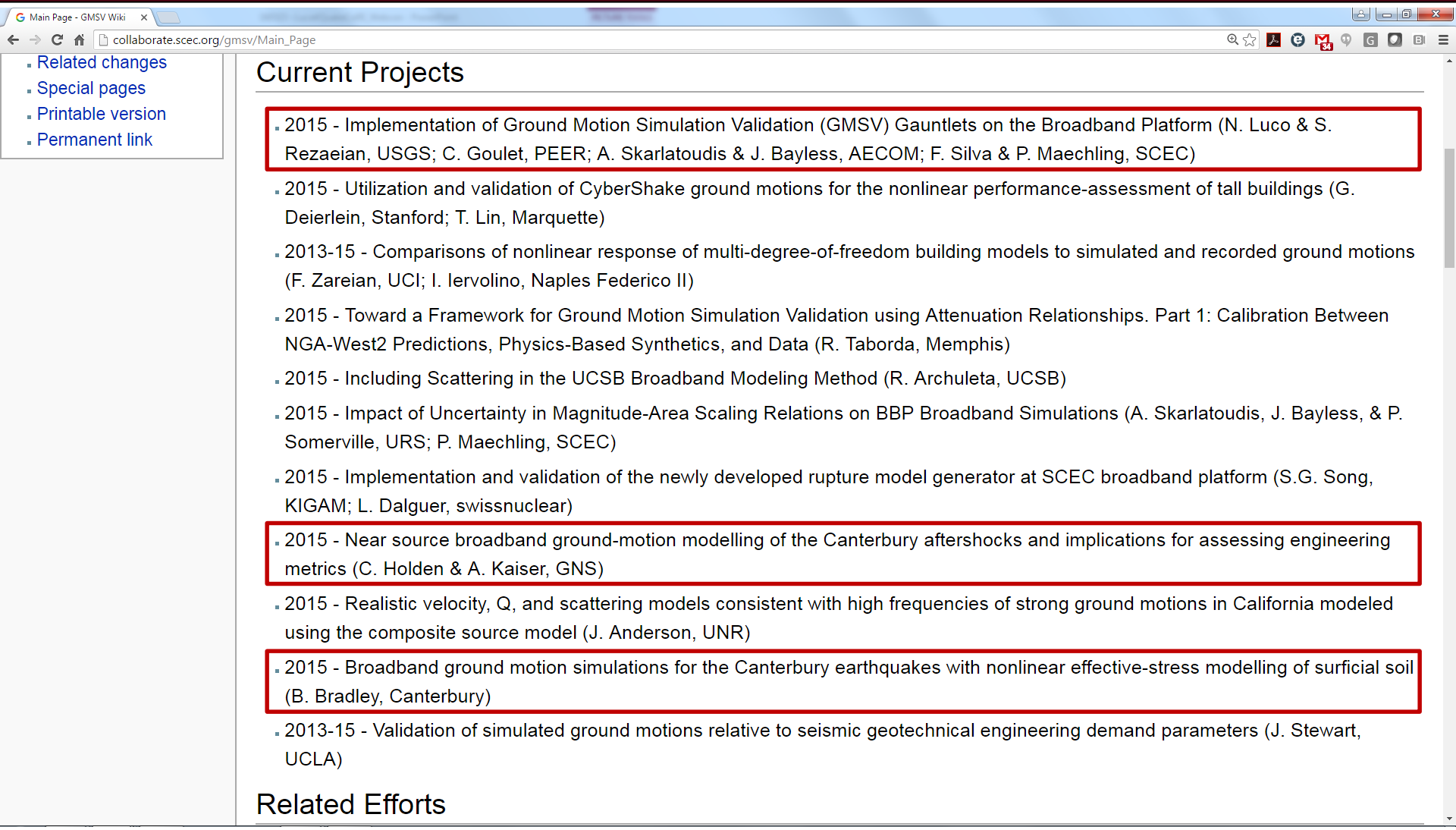
Earthquake Spectra, In Press, 2016, doi: http://dx.doi.org/10.1193/063015EQS106M

Physically Parameterized Prediction Equations for Significant Duration in Active Crustal Regions

Kioumars Afshari,[a] **S.M.EERI, and Jonathan P. Stewart** [b] **M.EERI**

We develop prediction equations for the median and standard deviation of the significant duration of earthquake ground motions from shallow crustal earthquakes in active tectonic regions. We consider significant duration parameters for 5-75%, 5-95%, and 20-80% of the normalized Arias intensity. The equations were derived from a global database with **M** 3.0-7.9 events. We find significant noise effects on duration parameters that compel us to exclude some records that had been used previously to develop models for amplitude parameters. Our equations include an **M**-dependent source duration term that also depends on focal mechanism. At small **M**, the data suggest approximately **M**-independent source durations that are close to 1 sec. The increase of source durations with **M** is slower over the range ~ 5 to 7.2-7.4 than for larger magnitudes. We adopt an additive path term with breaks in distance scaling at 10 and 50 km. We include site terms that increase duration for decreasing V_{S30} and increasing basin depth. Our aleatory variability model captures decreasing between- and within-event standard deviation terms with increasing **M**.

2015 SCEC GMSV TAG Projects



2015 “Implementation …” Project

Co-PIs: Luco & Rezaeian (USGS), Goulet (SCEC), Skarlatoudis & Bayless (AECOM), & Maechling & Silva (SCEC)

- Task 1 – **Selection of validation parameters**
- Task 2a – **Implementation & verification**
- Task 2b – **Development of validation evaluation criter**ia
- Task 3 – **Dissemination of results; begin feedback loop**

Selected GMSV Parameters

Selected validation **Parameters** for current implementation on the BBP:

Baker et al. Parameters:
B1. Ratio of inelastic to elastic displacement
B2. Correlation of spectral acceleration across periods
B3. Ratio of maximum to median response across orientations

Rezaeian et al. Time-Dependent Parameters (for visual inspection) :
Ra. Evolution of intensity & $[\epsilon_a, \nu_a]$
Rb. Evolution of predominant frequency & $[\epsilon_b, \nu_b]$
Rc. Evolution of bandwidth & $[\epsilon_c, \nu_c]$

Rezaeian et al. Scalar Parameters:
R1. I_a
R2. D_{5-95}
R3. I_a/D_{5-95}
R4. ω_{mid}
R5. ω'
R6. ζ

Stewart et al. Parameter (GMPE):
S1. Duration

Recent “Implementation …” Workshop

collaborate.scec.org/gmsv/2016_Implementation_of_GMSV_Gauntlets_on_the_Broadband_Platform_Workshop

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Workshop on Implementation of GMSV Gauntlets on the Broadband Platform

(Redirected from 2016 Implementation of GMSV Gauntlets on the Broadband Platform Workshop)

Organizers: Nico Luco, Christine Goulet, Andreas Skarlatoudis, Jeff Bayless, Phil Maechling, & Fabio Silva

Date: Monday, February 29, 2016 (10:00-16:00)

Location: SCEC Boardroom, University of Southern California, Los Angeles, CA

Participants: See below

Contents [hide]

Background & Objectives

One of the current projects of the SCEC Ground Motion Simulation Validation (GMSV) Technical Activity Group (TAG) is "Implementation of GMSV Gauntlets on the Broadband Platform." This multi-PI project is building on knowledge from previous SCEC GMSV projects to implement GMSV parameters beyond pseudo spectral acceleration (e.g., the ratio of maximum-direction to median spectral acceleration; see others in the first presentation posted at http://collaborate.scec.org/gmsv/SCEC_Project_15136_Meeting). The objectives of this workshop are to demonstrate use of the newly implemented parameters (and corresponding empirical prediction models) and to obtain feedback from developers and users of the Broadband Platform.

Recent “Implementation …” Workshop

collaborate.scec.org/gmsv/2016_Implementation_of_GMSV_Gauntlets_on_the_Broadband_Platform_Workshop

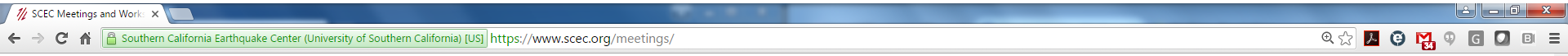
feedback from developers and users of the Broadband Platform.

Agenda

Presentation slides may be downloaded by clicking the title of the presentation. PLEASE NOTE: Files are the author’s property. They may contain unpublished or preliminary information and should only be used while viewing the talk.

10:00 - 10:05	Welcome and introductions	*C. Goulet for T. Jordan*
10:05 - 10:15	Overview of “Implementation …” Project	*N. Luco & F. Silva*
10:15 - 10:30	Baker *et al* spectral ground motion parameters	*J. Baker*
10:30 - 10:45	Example results from BBP	*C. Goulet*
10:45 - 11:15	Discussion (may be intertwined with presentations)	*All*
11:15 - 11:30	Rezaeian *et al* time-domain ground motion parameters	*S. Rezaeian*
11:30 - 11:45	Example results from BBP	*J. Bayless*
11:45 - 12:15	Discussion (may be intertwined with presentations)	*All*
12:15 - 12:55	*Lunch*	
12:55 - 13:10	Rezaeian *et al* scalar ground motion parameters	*S. Rezaeian*
13:10 - 13:25	Example results from BBP	*N. Luco*
13:25 - 13:55	Discussion (may be intertwined with presentations)	*All*

2016 SCEC GMSV TAG Workshops



SCEC-Funded Workshops

SCEC participants who wish to host a workshop may submit a proposal in response to the SCEC Science Collaboration Plan. We welcome workshop proposals that organizing collaborative research efforts for the five-year SCEC program (2012-2017). In particular, interactive workshops that engage more than one focus and/or disciplinary group are strongly encouraged. Below is a list of workshops funded for the current SCEC cycle.

Award	Workshop	Date	Location
16183	Community Rheology Model Workshop: Establishing a Geologic Framework, *Conveners: Michael Oskin, Elizabeth Hearn, Wayne Thatcher, and Whitney Behr*	TBD	Pomona, CA
16169	Organizational Meetings for the SCEC Utilization of Ground-Motion Simulations (UGMS) Committee, *Conveners: Tom Jordan (SCEC/USC) and C.B. Crouse (AECOM)*	TBD	Los Angeles, CA
16234	Workshop Proposal: Scientific Exploration of Induced SeisMicity and Stress (SEISMS), *Conveners: Heather Savage*	May 2016	Palisades, NY
16027	Ventura Special Fault Study Area Workshop, *Conveners: Scott Marshall, James Dolan, Thomas Rockwell, John Shaw*	TBD	Palm Springs, CA
16192	SoSAFE Workshop: Recent Successes and Future Challenges, *Conveners: Kate Scharer and Ramon Arrowsmith*	TBD	Palm Springs, CA
16288	Workshop on the Processes that Control the Strength of Faults and Dynamics of Earthquakes, *Conveners: John Platt, Whitney Behr, David Goldsby, and Christie Rowe*	TBD	Palm Springs, CA
16162	International Workshop on Ground Motion Simulation Validation, *Conveners: Sanaz Rezaeian, Nicolas Luco, and Brendon Bradley*	TBD	Palm Springs, CA
16110	Demonstrations of the Efficacy of the BBP Validation Gauntlets for Building Response Analysis Applications, *Conveners: Nicolas Luco, Sanaz Rezaeian, Gregory Deierlein, Farzin Zareian, Ting Lin, Fabio Silva, and Philip Maechling*	TBD	TBD

2016 QuakeCoRE GMSV Project

“Futher Coordination between QuakeCoRE and SCEC on Ground Motion Simulation Validation”

International travel costs for four U.S delegates to attend the 2016 QuakeCoRE Annual Meeting, to be shared with SCEC, if a parallel proposal to SCEC is funded, or with the USGS, to the extent possible. We also submitted a proposal to SCEC to hold an “International Workshop on GMSV” during the 2016 SCEC Annual Meeting (shortly after QuakeCoRE Annual Meeting) that QuakeCoRE representatives would be invited to participate in.