

The SCEC Ground Motion Simulation Validation (GMSV) Technical Activity Group (TAG)

2016 Southern California Earthquake Center (SCEC) Annual Meeting – International Workshop on GMSV

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“... to develop and implement, via collaboration between ground motion modelers and engineering users, testing/rating methodologies for simulated ground motions to be used in engineering applications.”

Early Years of the GMSV TAG

- Proposed by Tom Jordan during 2010 Annual Meeting and mentioned in 2011 SCEC Collaboration Plan (RfP).
- No consensus on testing/rating methodologies, so ...
- convened 2011 Planning Workshop for recommendations, ...
- requested recommended proposals in 2012-Present Collaboration Plans, and ...
- convened Coordination Workshops (2012-2013) and Web Conferences (2013-Present).

2012-2014 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)

2016 Southern California Earthquake Center (SCEC) Annual Meeting – International Workshop on GMSV

Burks & Baker (2014), BSSA

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

Lynne S. Burks* and Jack W. Baker

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](http://www.stanford.edu/~bakerjw/e-supp/Burks_Baker_(2013)_Metrics,_BSSA-esupp.html)>

Rezaeian et al & Zareian (2015), *BSSA*

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.

2016 Southern California Earthquake Center (SCEC) Annual Meeting – International Workshop on GMSV

Afshari & Stewart (2016), *Eq. Spectra*

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 GMSV TAG Project

Title: Implementation of GMSV Gauntlets on the SCEC Broadband Platform

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

Tasks:

1. Selection of ground motion parameters with corresponding empirical ground motion models
2. Implementation & verification
3. Development of simulated-vs.-recorded and simulated-vs.-modeled comparison figures
4. Dissemination workshop with modelers

2015 GMSV TAG Project

Broadband v16.5.0 Release Notes

Broadband v16.5.0

This full release of the Broadband Platform includes several new features and bug fixes. Here is what is new in this release:

- Trac #298: Define evaluation criteria for comparing BBP Releases
- Trac #302: Fix matplotlib deprecation warnings for versions 1.3 and greater
- Trac #303: Integrate RMG rupture generator module into BBP Platform
- Trac #304: Update GP rupture generator code to version 5.0
- Trac #305: Update BBToolbox to version 1.6
- Trac #309: Update GP Rupture Generator to version 5.0.1
- Trac #310: Update GP site response module to version 2014
- Trac #312: Fix compilation warnings for various codes in the GP method
- Trac #313: Modify cluster scripts to use sceec-00 filesystem
- Trac #314: Include parameters from RZZ2015 into BBP workflows
- Trac #315: Include parameters from AS2016 in the BBP Workflows
- Trac #318: Add PyProj version to software_status file
- Trac #325: Respect module fails to run for observed seismograms
- Trac #326: Add Anderson GOF to Broadband Platform
- Trac #328: Update LABasin, Mojave and NoCal GFs
- Trac #329: Add RotD100/RotD50 ratio metric to BBP

Time evolution of intensity, frequency, & bandwidth (Rezaeian et al, 2015)

Duration (Afshari & Stewart, 2016)

Max±Median Horizontal Spectral Acceleration (Burks & Baker, 2014)

Anderson Goodness-of-Fit (2004)

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2016 GMSV TAG Project

Title: Demonstrations of the Efficacy of the
BBP Validation Gauntlets for Building
Response Analysis Simulations
(a.k.a., Validation of Validation Gauntlets)

Co-PIs: Luco & Rezaeian (USGS), Deierlein &
Bijelic (Stanford), Zareian (UC-Irvine), Lin
(Marquette), Silva & Maechling (SCEC)

Tasks: See Deierlein workshop presentation.

Other 2015-2016 GMSV TAG Projects

GMSV

Southern California Earthquake Center (University of Southern California) [US] https://collaborate.scec.org/gmsv/Main_Page#Current_Projects

Current Projects [\[edit\]](#)

- 2016 - Demonstrations of the Efficacy of the BBP Validation Gauntlets for Building Response Analysis Simulations [\[i\]](#) (N. Luco & S. Rezaeian, USGS; G. Deierlein & N. Bijelic, Stanford; F. Zareian, UC Irvine; T. Lin, Marquette; F. Silva & P. Maechling, SCEC)
- 2016 - International Workshop on Ground Motion Simulation Validation [\[i\]](#) (S. Rezaeian & N. Luco, USGS; B. Bradley, U-Canterbury; I. Iervolino, Naples Federico II)
- 2016 - Quantification of acceptable ranges of GMSV Gauntlets for validation of simulated ground motion for engineering practice (F. Zareian, UC-Irvine)
- 2016 - A Vs30-based site response module for modifying ground motion time-series on reference site conditions (D. Asimaki, Caltech)
- 2016 - Modeling and implementation of a stochastic geotechnical layer for physics-based ground motion simulations (D. Asimaki, Caltech; R. Taborda, U-Memphis; A. Yong, USGS)
- 2016 - Incorporation of Local Site Effects in Broadband Simulations of Ground Motions: Case Study of the Wildlife Liquefaction Array in Southern California (R. Motamed, UN-Reno; J. Anderson, UN-Reno)
- 2016 - Broadband ground motion simulations for the Canterbury earthquakes with nonlinear effective-stress modelling of surficial soils (B. Bradley, U-Canterbury)
- 2016 - Surface Topography Effects in Three-Dimensional Physics-Based Deterministic Ground Motion Simulations in Southern California (J. Bielak, CMU; R. Taborda, U-Memphis; D. Restrepo, EAFIT)
- 2016 - Next Generation SDSU BBP Module Validation (K. Olsen, SDSU)
- 2016 - An Examination of the Correlations Between Different Goodness-of-Fit Metrics Based on a Large Dataset of Ground Motion Simulation Validations (R. Taborda, U-Memphis)
- 2016 - Inter-Period Correlations of SCEC Broadband Platform Fourier Amplitudes and Response Spectra (J. Bayless, AECOM; A. Skarlatoudis, AECOM; P. Somerville, AECOM; F. Silva, SCEC)

Past Projects (& SCEC Reports) [\[edit\]](#)

- 2015 - Implementation of Ground Motion Simulation Validation (GMSV) Gauntlets on the Broadband Platform [\[i\]](#) (N. Luco & S. Rezaeian, USGS; C. Goulet, PEER; A. Skarlatoudis & J. Bayless, AECOM; F. Silva & P. Maechling, SCEC)
- 2015 - Utilization and validation of CyberShake ground motions for the nonlinear performance-assessment of tall buildings [\[i\]](#) (G. Deierlein, Stanford; T. Lin, Marquette)
- 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)
- 2015 - Toward a Framework for Ground Motion Simulation Validation using Attenuation Relationships. Part 1: Calibration Between NGA-West2 Predictions, Physics-Based Synthetics, and Data [\[i\]](#) (R. Taborda, Memphis)
- 2015 - Implementation and validation of the newly developed rupture model generator at SCEC broadband platform [\[i\]](#) (S.G. Song, KIGAM; L. Dalguer, swissnuclear)
- 2015 - Near source broadband ground-motion modelling of the Canterbury aftershocks and implications for assessing engineering metrics [\[i\]](#) (C. Holden & A. Kaiser, GNS)
- 2015 - Broadband ground motion simulations for the Canterbury earthquakes with nonlinear effective-stress modelling of surficial soil [\[i\]](#) (B. Bradley, Canterbury)
- 2012-15 - Validation of simulated ground motions relative to seismic geotechnical engineering demand parameters [\[i\]](#) (J. Stewart, UCLA)
- 2015 - Impact of Uncertainty in Magnitude-Area Scaling Relations on BBP Broadband Simulations [\[i\]](#) (A. Skarlatoudis, J. Bayless, & P. Somerville, URS; P. Maechling, SCEC)
- 2015 - Realistic velocity, Q, and scattering models consistent with high frequencies of strong ground motions in California modeled using the composite source model [\[i\]](#) (J. Anderson, UNR)
- 2015 - Including Scattering in the UCSB Broadband Modeling Method [\[i\]](#) (R. Archuleta, UCSB)

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Other GMSV-Related SCEC Groups

- Whereas GMSV TAG is primarily focused on validation for use in response history analysis of structural and geotechnical systems, ...
- Broadband Platform (BBP) group is primarily focused on simulation and validation for use in developing ground motion models for median spectral acceleration, and ...
- Utilization of Ground Motion Simulations (UGMS) committee is primarily focused on use of CyberShake simulations in developing hazard maps for building codes.

Broadband Platform (BBP) Group

Green = Also on GMSV list

- Christine Goulet
- Kim Olsen
- Fabio Silva
- Jorge Crempien
- Ralph J Archuleta
- Nicolas Luco
- Doug Dreger
- Karen Assatourians
- Julian Lozos
- Robert Graves
- Paul Somerville
- Mehrdad Hosseini
- Steve Day
- John Anderson
- Andreas Skarlatoudis
- Gail Atkinson
- R Takedatsu
- Jeff Bayless
- Philip Maechling
- Song Seok Goo
- Arben Pitarka
- Sanaz Rezaeian
- Brendon Bradley
- Tom Jordan
- Tran Huynh

UGMS Committee

Green = Also on GMSV list

- Norm Abrahamson
- John Anderson
- Bob Bachman
- Jack Baker
- Jacobo Bielak
- C.B. Crouse
- Art Frankel
- Rob Graves
- Ron Hamburger
- Curt Haselton
- John Hooper
- Marty Hudson
- Charlie Kircher
- Marshall Lew
- Nicolas Luco
- Farzad Naeim
- Paul Somerville

Questions for SCEC5 GMSV TAG

- Continue a mix of collaborative and coordinated projects?
- Pursue external (to SCEC) funding, like previous “SEISM” funding for Baker, Zareian, Stewart and/or BBP Validation Study funding for ground motion modelers?
- Continue separation of overlapping GMSV-related SCEC groups?