Introduction to the SCEC Ground Motion Simulation Validation (GMSV) TAG

SCEC GMSV TAG Planning Workshop, August 24, 2018, USC, Los Angeles, CA

Sanaz Rezaeian
Co-Leader of the GMSV TAG, Research Structural Engineer
U.S. Geological Survey (USGS), Golden, CO

Jonathan Stewart (UCLA), Nicolas Luco (USGS), Christine Goulet (USC),
Gregory Deierlein (Stanford) & Farzin Zareian (UCI)

Workshop Agenda

09:30 - 10:00	**Welcome and Introductions** *(Sanaz Rezaeian)*
10:00 - 12:00	**GMSV Objectives and Path Forward for Ground Motion Characterization**
10:00 - 10:20	- Background: SCEC Broadband Platform Validation and Outcomes *(Christine Goulet)*
10:20 - 10:40	- Vision: Future Validation Needs for Hazard Characterization *(Yousef Bozorgnia)*
10:40 - 11:30	- Breakout Group Discussions *(All Attendees)*
11:30 - 12:00	- Summaries from Breakout Groups
12:00 - 13:00	*Lunch*
13:00 - 15:00	**GMSV Objectives and Path Forward for Engineering Applications**
13:00 - 13:20	- Background: Use of SCEC Seismogram Simulations for Building Response Analysis *(Nicolas Luco)*
13:20 - 13:40	- Background: New Zealand GMSV Guidelines for Engineers *(Sanaz Rezaeian)*
13:40 - 14:00	- Vision: What Engineers Need in Terms of Sample Simulations and Guidelines for Use of Simulations *(Gregory Deierlein)*
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14:30 - 15:00	- Summaries from Breakout Groups
15:00 - 16:00	**Summary and Conclusions** *(Jonathan Stewart)*
16:00	*Adjourn*

Workshop Participants

Conveners:

1. Sanaz Rezaeian (USGS)
2. Jonathan Stewart (UCLA)
3. Nicolas Luco (USGS)
4. Christine Goulet (SCEC/USC)
5. Gregory Deierlein (Stanford)
6. Farzin Zareian (UCI)

*not on the website!

Participants:

1. Rob Graves (USGS)
2. Kevin Milner (SCEC/USC)
3. John Vidale (SCEC)*
4. Yousef Bozorgnia (UCLA)
5. Katie Wooddell (PG&E)
6. Morgan Moschetti (USGS)
7. Ting Lin (Texas Tech)
8. Ali Sumer (OSHPD)
9. Jon Heintz (ATC)
10. Marty Hudson (AMEC)
11. Jongwon Lee (ARUP)
12. Anoosh Shamsabadi (HSRA)
13. Ertugrul Taciroglu (UCLA)
14. Cairo Briceno (Parsons)*
15. Steven McCabe (NIST)*
16. *Farid Ghahari (UCLA)*
17. *Edric Pauk (SCEC)*

Remote Participants:

- CB Crouse (AECOM)
- Albert Kottke (PG&E)
- Farzad Naeim (Naeim Assoc.)
- Josh Gebelein (Parsons)
- Pedro Arduino (UW)
- Domniki Asimaki (Caltech)
- Philip Caldwell (BSSC)

Discussion Sessions

Group 1:

1. Yousef Bozorgnia (UCLA)
2. Nicolas Luco (USGS)
3. Farzin Zareian (UCI)
4. Anoosh Shamsabadi (HSRA)
5. Jongwon Lee (ARUP)

Remote Group 1*:

- CB Crouse (AECOM)*
- Farzad Naeim (Naeim Assoc.)
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- Josh Gebelein (Parsons)
- Pedro Arduino (UW)
- Domniki Asimaki (Caltech)
- Philip Caldwell (BSSC)

Group 2:

1. Jonathan Stewart (UCLA)
2. Gregory Deierlein (Stanford)
3. Sanaz Rezaeian (USGS)
4. Kevin Milner (SCEC/USC)
5. John Vidale (SCEC)
6. Ting Lin (Texas Tech)
7. Jon Heintz (ATC)
8. Farid Ghahari (UCLA)

Group 3:

1. Christine Goulet (SCEC/USC)
2. Katie Wooddell (PG&E)
3. Morgan Moschetti (USGS)
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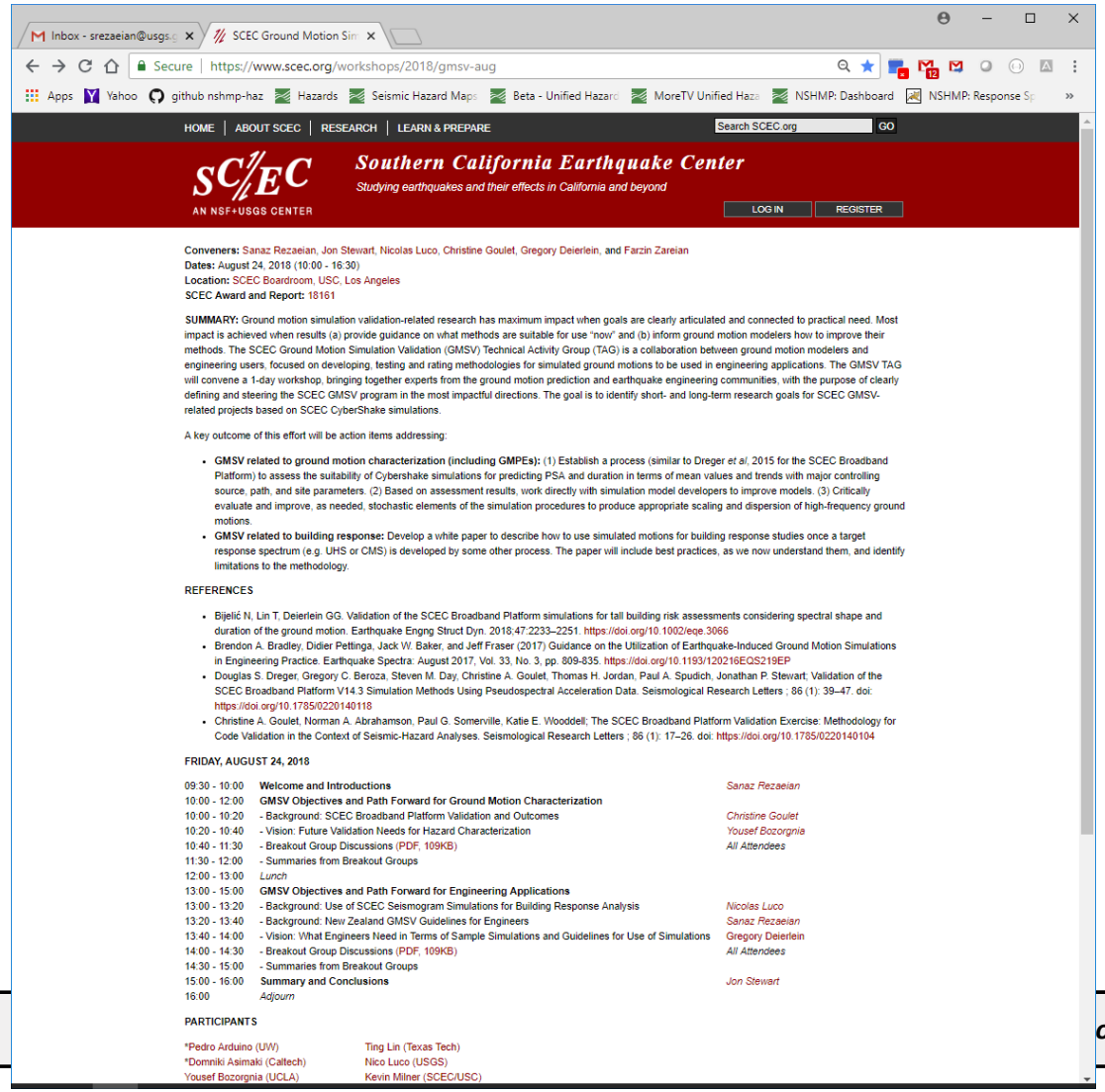
Workshop Website & Resources

https://www.scec.org/workshops/2018/gmsv-aug



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SCEC AN NSF+USGS CENTER

Southern California Earthquake Center

Studying earthquakes and their effects in California and beyond

LOG IN REGISTER

Conveners: Sanaz Rezaeian, Jon Stewart, Nicolas Luco, Christine Goulet, Gregory Deierlein, and Farzin Zareian
Dates: August 24, 2018 (10:00 - 16:30)
Location: SCEC Boardroom, USC, Los Angeles
SCEC Award and Report: 18161

SUMMARY: Ground motion simulation validation-related research has maximum impact when goals are clearly articulated and connected to practical need. Most impact is achieved when results (a) provide guidance on what methods are suitable for use "now" and (b) inform ground motion modelers how to improve their methods. The SCEC Ground Motion Simulation Validation (GMSV) Technical Activity Group (TAG) is a collaboration between ground motion modelers and engineering users, focused on developing, testing and rating methodologies for simulated ground motions to be used in engineering applications. The GMSV TAG will convene a 1-day workshop, bringing together experts from the ground motion prediction and earthquake engineering communities, with the purpose of clearly defining and steering the SCEC GMSV program in the most impactful directions. The goal is to identify short- and long-term research goals for SCEC GMSV-related projects based on SCEC CyberShake simulations.

A key outcome of this effort will be action items addressing:

- **GMSV related to ground motion characterization (including GMPEs):** (1) Establish a process (similar to Dreger *et al.* 2015 for the SCEC Broadband Platform) to assess the suitability of Cybershake simulations for predicting PSA and duration in terms of mean values and trends with major controlling source, path, and site parameters. (2) Based on assessment results, work directly with simulation model developers to improve models. (3) Critically evaluate and improve, as needed, stochastic elements of the simulation procedures to produce appropriate scaling and dispersion of high-frequency ground motions.
- **GMSV related to building response:** Develop a white paper to describe how to use simulated motions for building response studies once a target response spectrum (e.g. UHS or CMS) is developed by some other process. The paper will include best practices, as we now understand them, and identify limitations to the methodology.

REFERENCES

- Bijelić N, Lin T, Deierlein GG. Validation of the SCEC Broadband Platform simulations for tall building risk assessments considering spectral shape and duration of the ground motion. Earthquake Engng Struct Dyn. 2018;47:2233–2251. https://doi.org/10.1002/eqe.3066
- Brendon A. Bradley, Didier Pettinga, Jack W. Baker, and Jeff Fraser (2017) Guidance on the Utilization of Earthquake-Induced Ground Motion Simulations in Engineering Practice. Earthquake Spectra: August 2017, Vol. 33, No. 3, pp. 809-835. https://doi.org/10.1193/120216EQS219EP
- Douglas S. Dreger, Gregory C. Beroza, Steven M. Day, Christine A. Goulet, Thomas H. Jordan, Paul A. Spudich, Jonathan P. Stewart; Validation of the SCEC Broadband Platform V14.3 Simulation Methods Using Pseudospectral Acceleration Data. Seismological Research Letters ; 86 (1): 39–47. doi: https://doi.org/10.1785/0220140118
- Christine A. Goulet, Norman A. Abrahamson, Paul G. Somerville, Katie E. Wooddell; The SCEC Broadband Platform Validation Exercise: Methodology for Code Validation in the Context of Seismic-Hazard Analyses. Seismological Research Letters ; 86 (1): 17–26. doi: https://doi.org/10.1785/0220140104

FRIDAY, AUGUST 24, 2018

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PARTICIPANTS

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*Domniki Asimaki (Caltech)
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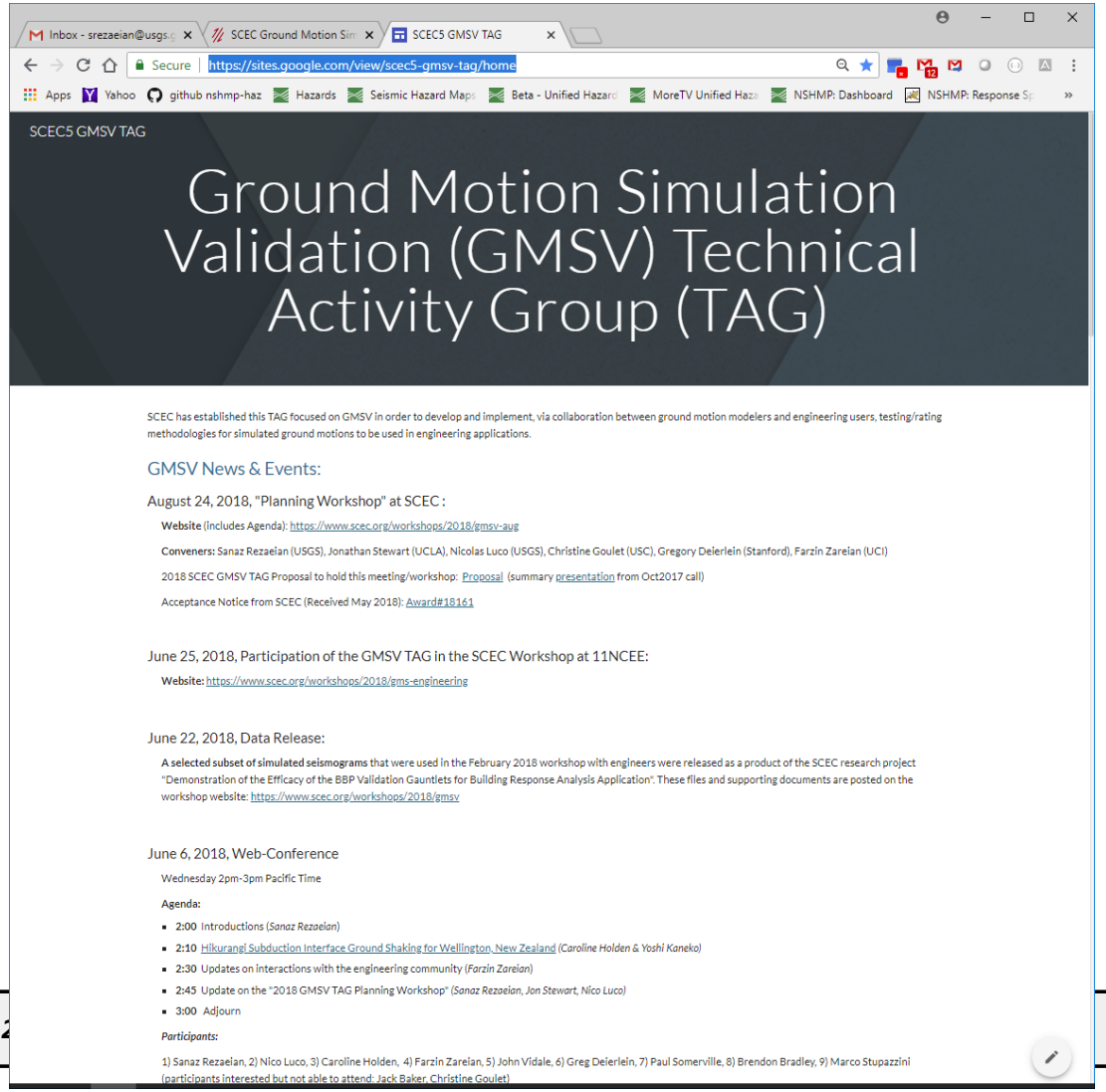
Nico Luco (USGS)
Kevin Milner (SCEC/USC)

https://sites.google.com/view/scec5-gmsv-tag/home



SCEC5 GMSV TAG

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

SCEC has established this TAG focused on GMSV in order 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.

GMSV News & Events:

August 24, 2018, "Planning Workshop" at SCEC :

Website (includes Agenda): https://www.scec.org/workshops/2018/gmsv-aug

Conveners: Sanaz Rezaeian (USGS), Jonathan Stewart (UCLA), Nicolas Luco (USGS), Christine Goulet (USC), Gregory Deierlein (Stanford), Farzin Zareian (UCI)

2018 SCEC GMSV TAG Proposal to hold this meeting/workshop: Proposal (summary presentation from Oct2017 call)

Acceptance Notice from SCEC (Received May 2018): Award#18161

June 25, 2018, Participation of the GMSV TAG in the SCEC Workshop at 11NCEE:

Website: https://www.scec.org/workshops/2018/gms-engineering

June 22, 2018, Data Release:

A selected subset of simulated seismograms that were used in the February 2018 workshop with engineers were released as a product of the SCEC research project "Demonstration of the Efficacy of the BBP Validation Gauntlets for Building Response Analysis Application". These files and supporting documents are posted on the workshop website: https://www.scec.org/workshops/2018/gmsv

June 6, 2018, Web-Conference

Wednesday 2pm-3pm Pacific Time

Agenda:

- **2:00** Introductions (*Sanaz Rezaeian*)
- **2:10** Hikurangi Subduction Interface Ground Shaking for Wellington, New Zealand (*Caroline Holden & Yoshi Kaneko*)
- **2:30** Updates on interactions with the engineering community (*Farzin Zareian*)
- **2:45** Update on the "2018 GMSV TAG Planning Workshop" (*Sanaz Rezaeian, Jon Stewart, Nico Luco*)
- **3:00** Adjourn

Participants:

1) Sanaz Rezaeian, 2) Nico Luco, 3) Caroline Holden, 4) Farzin Zareian, 5) John Vidale, 6) Greg Deierlein, 7) Paul Somerville, 8) Brendon Bradley, 9) Marco Stupazzini
(participants interested but not able to attend: Jack Baker, Christine Goulet)

Introduction to the SCEC Ground Motion Simulation Validation (GMSV) Technical Activity Group (TAG):

SCEC Seismogram Simulations

Current Differences	CyberShake	Broadband Platform
Purpose	PSHA	Scenarios
Methods	Graves & Pitarka	Several (7)
Crustal model	3-dimensional	1-dimensional
Frequency band	< ~1 Hz	0-100 Hz
Computer needed	Supercomputer	Personal computer
Validations	Relatively limited	Relatively extensive

Table from Nico Luco.

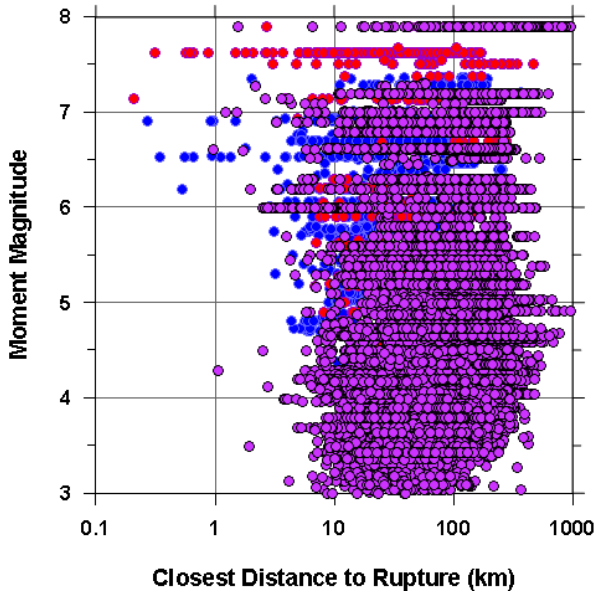
Motivation for Simulation & Validation

Simulated ground motions and their validations are needed when …

Missing or limited recorded data:

No data for large M at close distance

Few moderate M events



PEER NGA-West2 Database

Bozorgnia et al., 2014, Earthquake Spectra

Need site/region specific motions:

Represent local directivity effects, basin effect, etc. as opposed to using motions from other locations

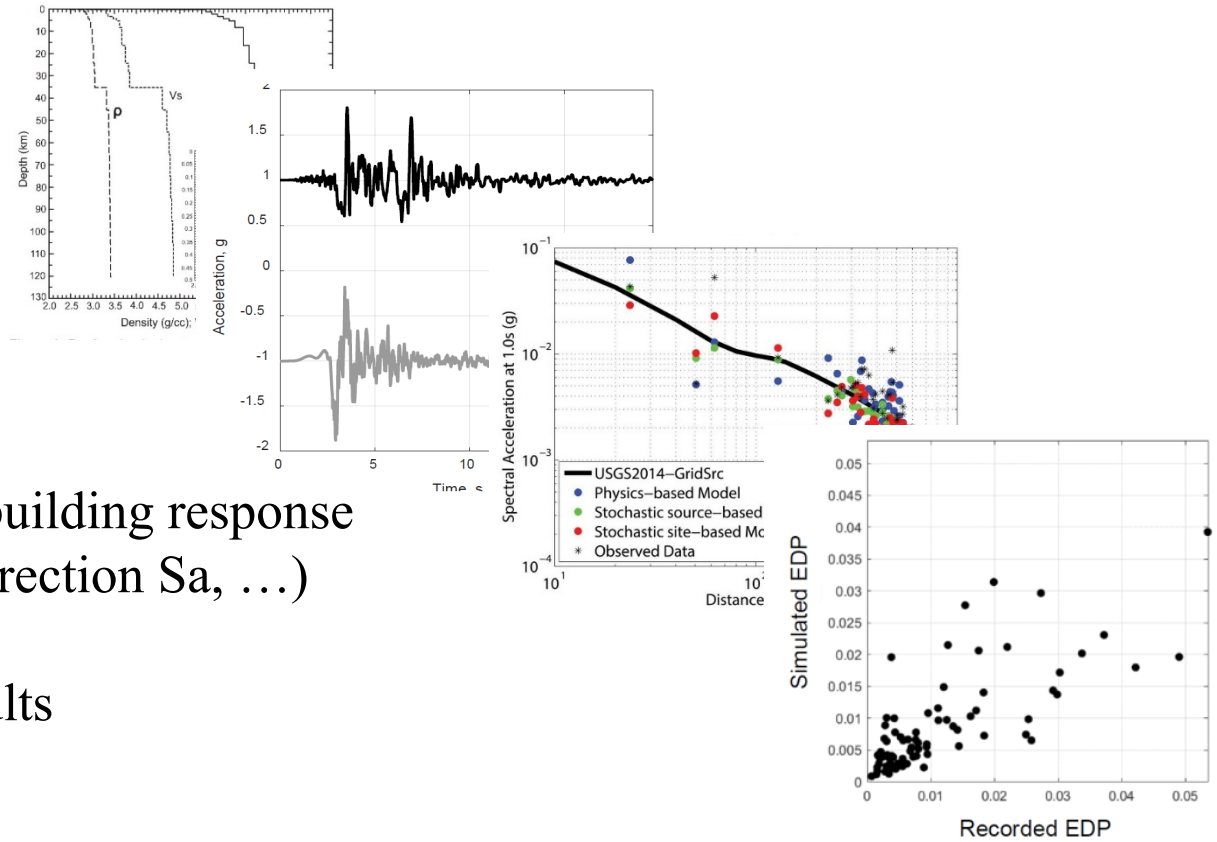
Earthquakes w/ M>6.0 since 1950

Usgs.gov

Validation of Simulations

Simulation methods can be validated by comparisons to *"data from past earthquakes"* or to *"empirical models"* based on such data (e.g., GMPEs). This can be done at various levels:

- Model Components (e.g., velocity model)
- Seismogram Waveforms
- Response Spectra (Sa)
- Simple proxies beyond Sa for building response (e.g., Duration, max/median-direction Sa, …)
- Building response analysis results



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- Model Components (e.g., velocity model)
- Seismogram Waveforms

Usually done by simulators

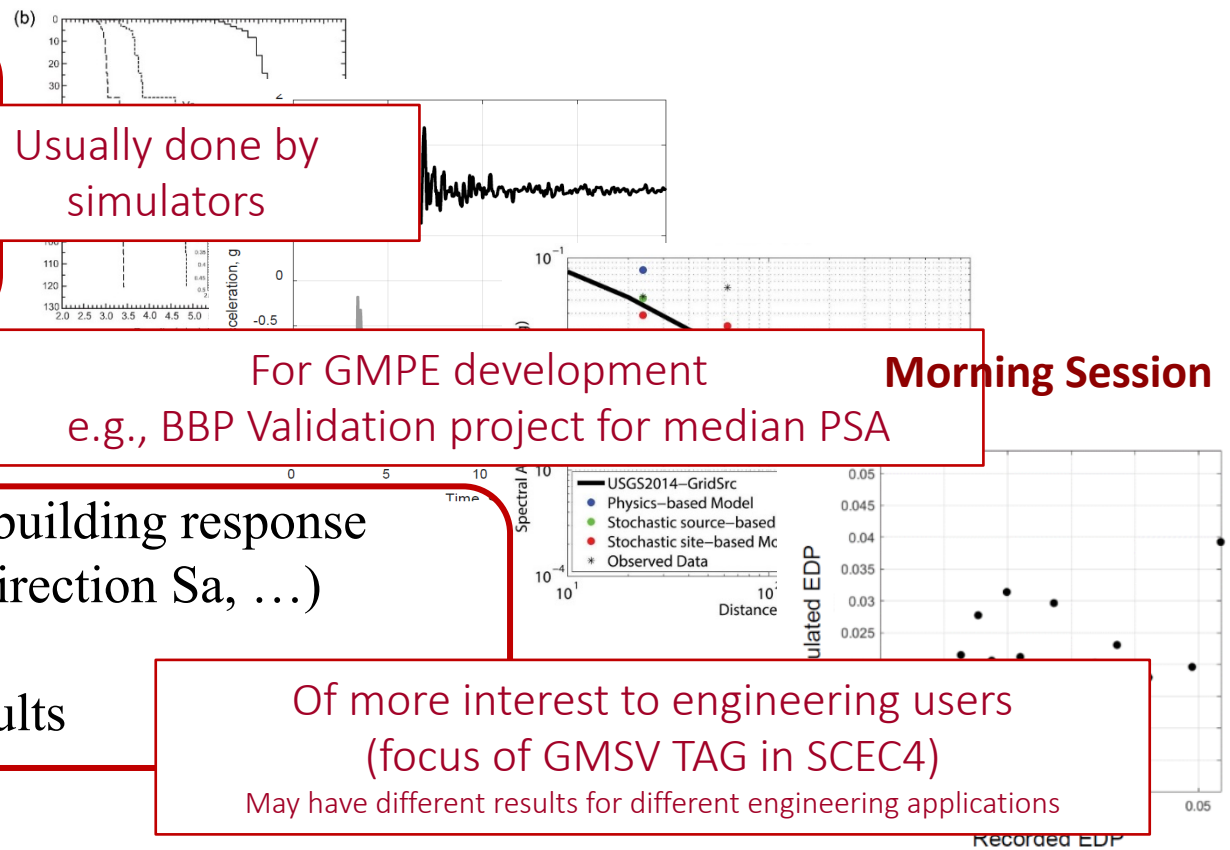
- Response Spectra (Sa)

For GMPE development
e.g., BBP Validation project for median PSA

Morning Session

- Simple proxies beyond Sa for building response (e.g., Duration, max/median-direction Sa, …)
- Building response analysis results

Of more interest to engineering users
(focus of GMSV TAG in SCEC4)
May have different results for different engineering applications



Increasingly application-specific

Afternoon Session

SCEC GMSV TAG History

Established in **2010**, led by Nico Luco (USGS), to develop and implement testing/rating methodologies for validation of simulation *methods* for *engineering applications*

- Collaboration between ground motion simulators and engineering users

- **2011-2014+:** Individual proposals focused on 3 broad engineering applications (coordinated under TAG)
  1. Validation based on SDOF / Simple Proxies
  2. Validation based on MDOF responses
  3. Validation based on geotechnical systems

		GMSV done for three kinds of responses:		
		SDoF / Simple Proxies	**MDoF**	**Geotech**
Testing Methods	**Historical Earthquakes**	Rezaeian et al. (2014)		Rathje et al. (2013)
	Empirical Models	Baker et al. (2013-15)		Stewart et al. (2013-15) Rathje et al. (2013)
	Similar Spectra		Zareian et al. (2013-15) Deierlein et al. (2014) Baker et al. (2013-15)	

Many more related projects (also outside SCEC) not listed here.

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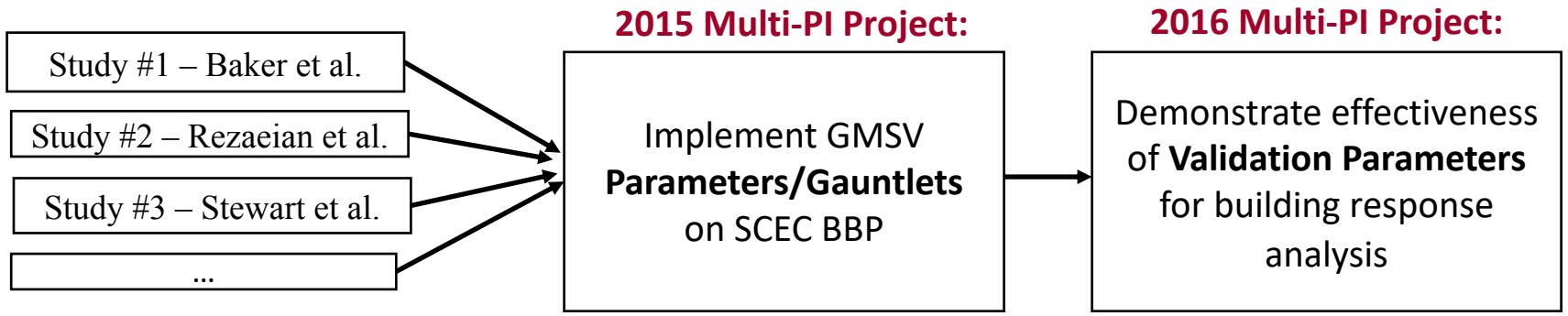

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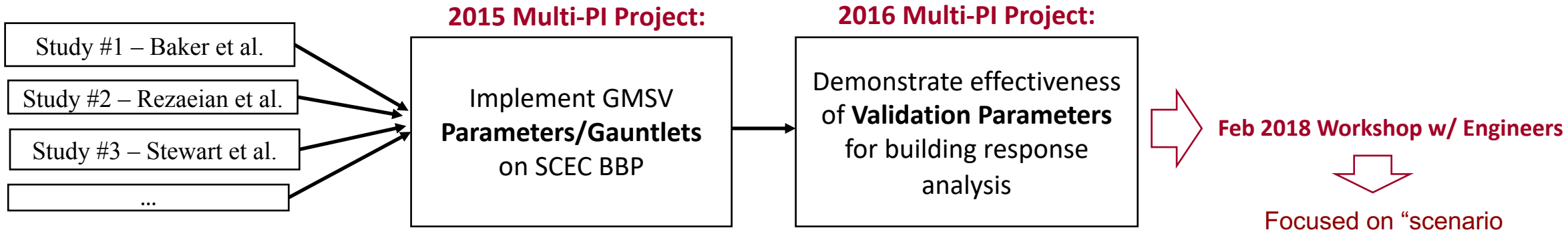

- **Nov 2017:** continuation of the TAG into SCEC5 (w/ 1st yr plan)

Today's Objective: Plans for the next 4 years?

Coordination with other groups

- SCEC Broadband Platform Validation Project (BPVP)
  - using BBP
  - Christine Goulet's presentation (2 background papers emailed to everyone)

- SCEC Utilization of Ground Motion Simulations (UGMS)
  - using CyberShake
  - chaired by CB Crouse

- International groups: New Zealand, Italy, …
  - 2016 workshop at SCEC annual meeting
  - a background paper emailed to everyone

- Interactions w/ USGS to implement simulations in PSHA
  - Morgan Moschetti's WG

Outcome & Future Direction

Outcome of SCEC 4 (2010-2016):

- Initiated a feedback loop with some model developers (through individual PI interactions)
- Implemented validation parameters/gauntlets on the SCEC BBP (through multi-PI projects)
- Generated scenario simulations for engineering users for large M events (through multi-PI projects)
- Achieved more confidence in using simulations for hazard (BPVP) and for structural analysis (Feb workshop)

Future Direction in SCEC 5 (the next 4 years and beyond):

- Consider validation related to both *"ground motion prediction"* and *"engineering applications"* within the same group
- Validation related to ground motion characterization:
  - Identify areas of bias in ground motion predictions from simulations (include standard deviations)
  - Improve simulation procedures (BBP & Cybershake) and support GMPE development
  - Spatial correlations of IMs for application to distributed infrastructure
- Validation related to engineering utilization:
  - More specific engineering applications similar to the Feb workshop?
  - Help engineers to gain confidence in utilizing simulations (PSHA, RHA, etc). Guidelines for engineers?

Today's Objectives

The objective of this workshop is to **define goals of the GMSV program(s) in SCEC**, and to **identify short- and long-term research** that is needed, which will build on past/current work.

- How should the TAG be organized/operate?
  - Ideas for SCEC RFP for individual PI proposals?
  - Multi-PI proposals to SCEC? (e.g., Cybershake validation project)
  - Multi-PI proposals to outside agencies? (e.g., BPVP)

- What should the specific outcome of this workshop be?
  - A report on what the current GMSV needs are?
  - A suite of action items?
  - Ideas for future research?

- What should future TAG projects focus on?
  - What simulations should the SCEC GMSV TAG validate?
  - What validation methodologies should the TAG use?
  - For what applications should the TAG validate the simulations?

  (refer to the discussion questions for details)

Discussion Questions

Morning Session:

GMSV in relation to ground motion characterization

1. Should we focus on validation of the current versions of simulations, or on tools for validation of current and future simulations?
2. What are the roles of Broadband Platform (BBP) versus Cybershake simulations moving forward?
3. Are high frequency components of ground motion needed as a product of physics-based simulations ($f > 1$-2 Hz)?
4. Are vertical ground motion simulations needed?
5. What aspects of ground motion prediction equations (GMPEs) are simulations best suited to resolve (e.g., large M scaling, basin effects, etc.)? What validation can be undertaken to provide confidence in simulations for these purposes?
6. How can uncertainties in the scaling relationships (e.g., GMPEs) be identified if there is an absence of observations?
7. How to get regionally appropriate simulations or validate them?

Discussion Questions

Afternoon Session:

GMSV in relation to engineering applications

1. Organization:
   a. Should the validations be done by SCEC-funded researchers, or a group of engineering users? Or some combination of both?
   b. What form of communication to the professional community will be most impactful in advancing practice in this area? (e.g., a white paper on utilization of simulations in engineering applications, a NEHRP Part 3 document, *see Bradley et al. 2017 EQS paper as an example*)
2. What frequency bandwidths are most relevant to what problems? Are verticals needed?
3. What would practicing engineers like to see from validations to have confidence in using simulated ground motions for derivations of fragility? For example:
   a. Motions scaled to a spectral shape should have a reasonable range of other parameters known to affect fragility (duration etc., *see Bijelic et al. 2018 paper as an example*)
   b. Motions should have realistic period-to-period correlations.
4. What are the research and development steps needed to get us to a point to provide this guidance?
5. What new topics should we pursue? For example:
   a. Validation parallel to what has been done for GMPEs, but for engineering demand parameters (EDPs)
   b. Validation for long period structures, site-specific analysis, or dams
   c. Validation for response of nonstructural components (i.e. floors spectra)

Notes: