Broadband Ground Motion Simulation Plans

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SCEC Ground Motion Simulation Validation Progress Workshop

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Outline

- Summary of participating simulation modules
- Selection of reference velocity and Q models
- Selection of reference source geometry (SRC)
- Generation of multiple rupture models (SRF)
- Running broadband simulations
- Goodness of fit based on best fitting rup model
- Goodness of fit based on average rupture model

Participating Simulation Modules

http://scec.usc.edu/scecpedia/Broadband_Platform_Meeting_-_7_March_2012

GREENS FUNCTION BASED MODELS

- SDSU – Olsen/Mai – operational
- UCSB – Archuleta et al – operational
- URS – Graves/Pitarka – operational

- Irikura/Miyake asperity source model – to be implemented
- Zeng/Anderson composite source model - to be implemented

NON-GREENS FUNCTION BASED MODULES

- Point source stochastic model – Boore - to be implemented
- Finite-fault stochastic model – Atkinson - to be implemented

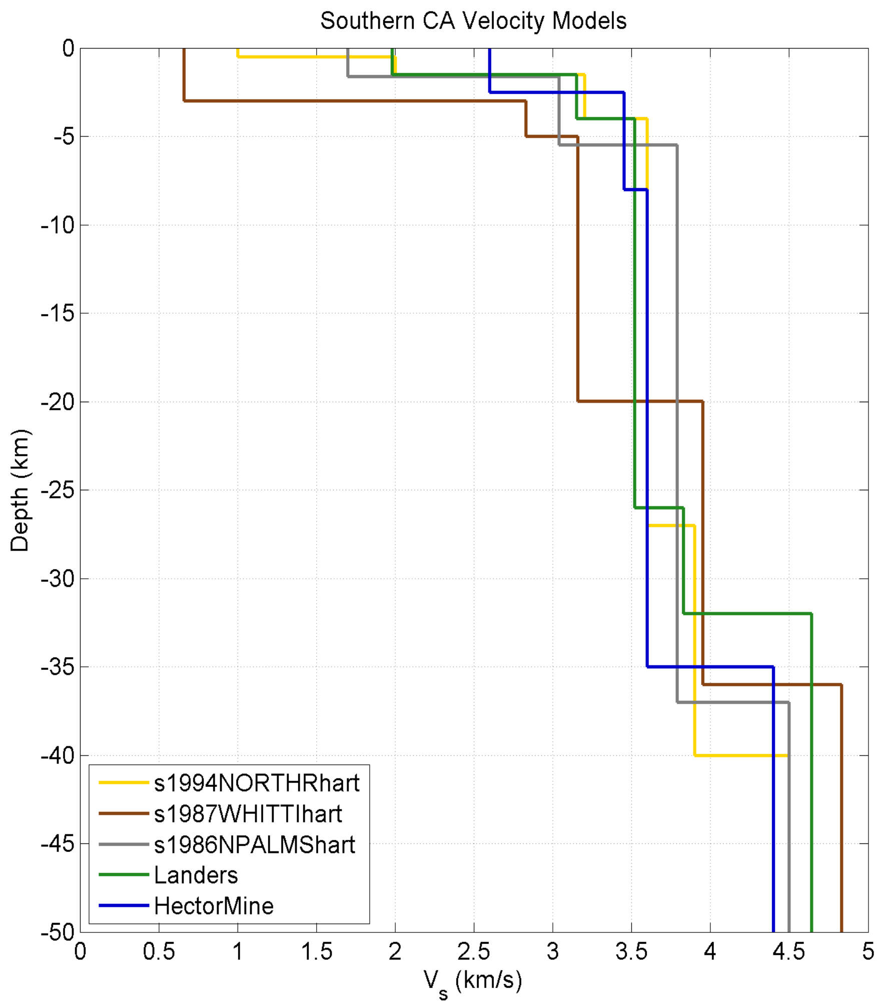
GMPE

- Empirical GMPE with event terms - to be implemented

Reference Velocity Models for Green's Function Calculations

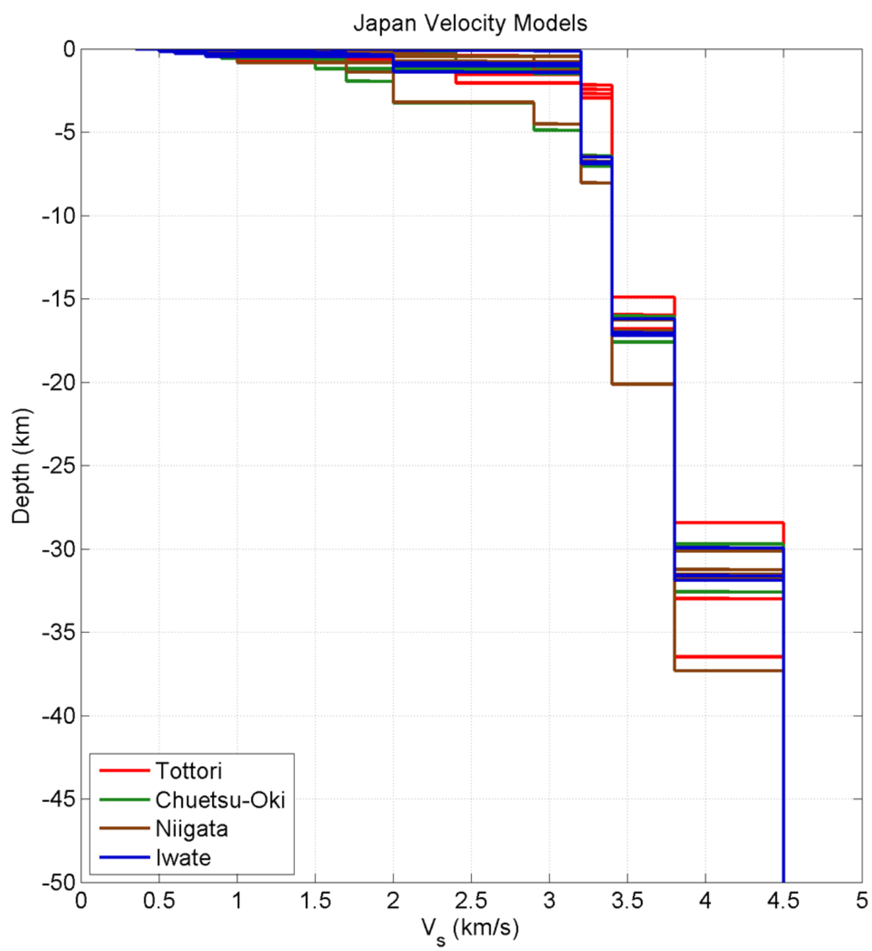
- Use regional velocity models for rock site conditions
- e.g. a southern California model
- e.g. a Japan model
- Use a standard shallow velocity profile with Vs30 = 863 m/s
- Data are corrections for basin conditions using Z1.0 in the C&Y 2008 GMPE

Southern California Velocity Models



Japan Velocity Models

from Koketsu 3D Model of Japan



Source Geometry (SRC file)

- MAGNITUDE = 6.9
- FAULT_LENGTH = 40.0
- DLEN = xxx
- FAULT_WIDTH = 17.5
- DWID = xxx
- DEPTH_TO_TOP = 3.85
- STRIKE = 128
- RAKE = 145
- DIP = 70
- LAT_TOP_CENTER = 37.0789
- LON_TOP_CENTER = -121.8410
- HYPO_ALONG_STK = 0.0
- HYPO_DOWN_DIP = 14.75
- DT = xxx
- SEED = xxx
- CORNER_FREQ = xxx
- SEISMIC MOMENT = xxx
- HYPO LAT = xxx
- HYPO LONG = xxx
- HYPO DEPTH = xxx

Selection of Reference SRC Models

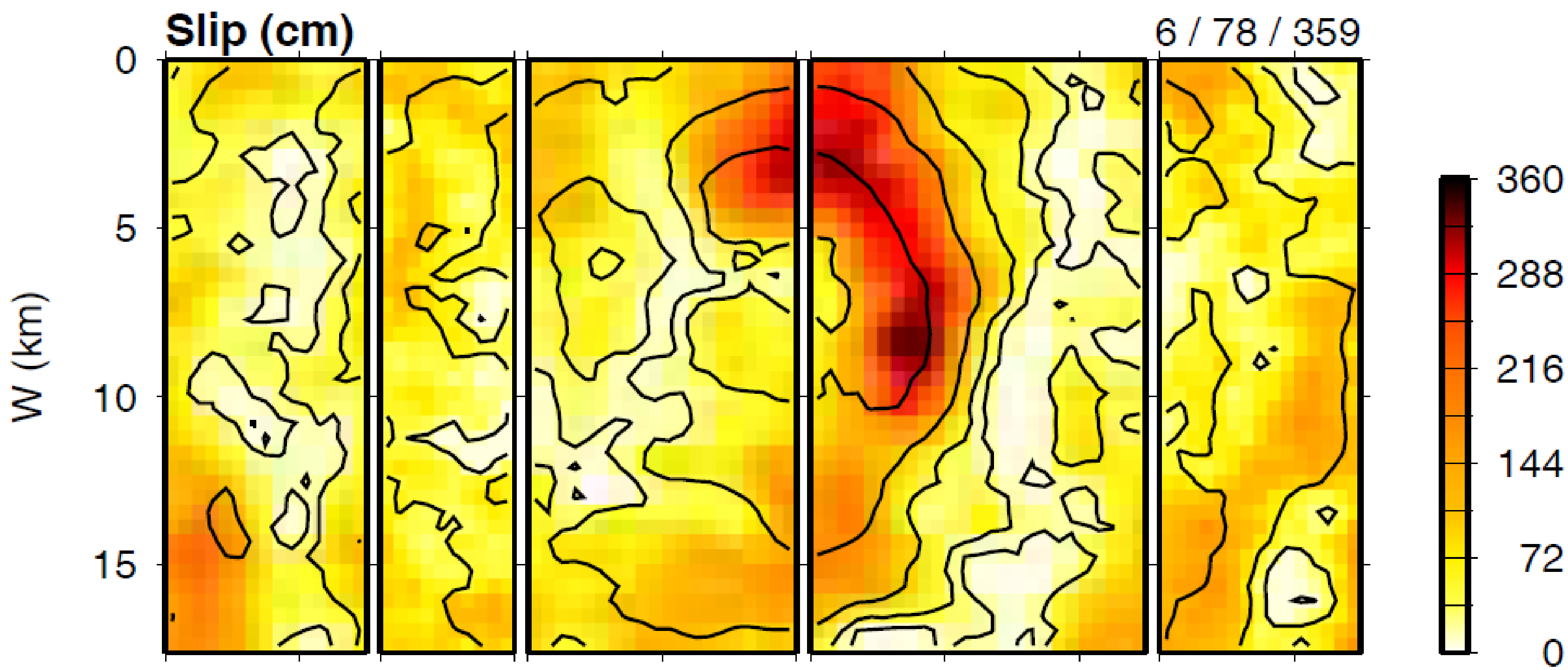
- Review alternative published rupture models (Mai website and newer sources)
- Retain significant multi-segment and branching characteristics, because one role of the simulations it to model these effects because they are hard to represent in GMPE's

Earthquake Event List

Eq Number	YEAR	REGION	EQ NAME	EQID	Multiple Fault Segments	Martin Mai Website	Author of Reference Model
1	2010	WUS	El Mayor Cucapah	280	yes	no	Wei et al., 2001
2	1994	WUS	Northridge	127	no	yes	Hartzell et al., 1996
3	1999	WUS	Hector Mine	158	yes	yes	Kaverina and Dreger, 2002
4	1992	WUS	Landers	125	yes	yes	Wald & Heaton, 1994
5	1987	WUS	Whittier Narrows	113	no	yes	Hartzell & Iida,1990
6	1992	WUS	Big Bear	126	no	no	Jones and Hough, 1995; NGA Event 126
7	2004	WUS	Parkfield	179	no	yes	Custodio et al., 2005
8	1989	WUS	Loma Prieta	118	no	yes	Wald et al., 1991
9	1986	WUS	North Palm Springs	101	no	yes	Hartzell, 1989
10	1983	WUS	Coalinga	76	no	no	NGA Event 76
11	2003	WUS	San Simeon	177	no	no	Ji et al., 2004
12	1988	CENA	Saguenay	CENA-5	no	yes	Hartzell et al., 1994
13	2005	CENA	Riviere-du-Loup	CENA-32	no	no	Herrmann
14	2011	CENA	Mineral, VA	CENA-88	no	no	Chapman, 2012
15	2000	JAPAN	Tottori	176	no	yes	Iwata & Sekiguchi, 2001
16	2007	JAPAN	Chuetsu-Oki	278	no	no	Aoi et al., 2008
17	2004	JAPAN	Niigata	180	no	no	Asano & Iwata, 2009
18	2008	JAPAN	Iwate	279	no	no	Yoshida et al., 2011
19	1999	TURKEY	Kocaeli	136	yes	yes	Sekiguchi & Iwata, 2002
20	1999	TAIWAN	Chi-Chi	137	yes	no	Ji et al., 2003
21	2009	ITALY	L' Aquila	274	no	no	Cirella et al., 2009
22	2011	NEW ZEALAND	Christchurch	346	yes	no	Beavan et al., 2012
23	2010	NEW ZEALAND	Darfield	281	yes	no	Beavan et al, 2012

Source Rupture Model (SRF file)

Tottori eq: Graves SRF from Iwata and Sekiguchi



Approaches to Rupture Modeling

- Randomly generate 50 SRF's from the SRC
- Perform simulations for each SRF
- Measure goodness of fit for each SRF

PATH 1

- Find the best fitting SRF
- Use its goodness of fit to represent modeling uncertainty
- Include uncertainty in SRF specification when forward modeling future scenarios

PATH 2

- Use the average goodness of fit of 50 SRF's to represent modeling uncertainty
- No need to include uncertainty in SRF specification when forward modeling future scenarios

Validations: Part A

- Compare simulations to observed ground motions
  - 20 shallow crustal earthquakes (M>6)
- Set up validation exercises for each earthquake
  - Path description
    - 1-D GF
  - Source description
    - Simple geometry and mechanism
    - Sets of alternative slip models
  - Site description
    - Locations
    - Site response factors – including non-linear factors
  - Observed ground motions
    - 5% damped response spectral values
    - Arias intensity
    - 5-75% Duration
- Compute bias (mean misfit) and standard deviation of misfit

Validations – Part B

- Compare to empirical GMPEs in range that is well constrained by data
  - M6-7
  - Distances 15-50 km
- Set up validation cases
  - M6.0, M6.5, M7.0
  - R 15, 20, 30, 40, 50 (multiple station locations along strike)
  - SS and RV (45 dip)
  - VS30=750 m/s
- For each case, run forward simulations for multiple realizations of the source model (e.g. 30-50) to give stable estimates of median and standard deviation
  - Compute bias (mean misfit) and standard deviation from simulations

SCEC Tasks

- New module development
- Validation Cases
  - Set up the validation exercises
    - Part A
    - Part B
- Conduct validation
  - Developers test and revise modules
- IT support for implementation for large suites of forward simulations
  - Does not cover costs for person to run simulations under QA
- Review forward simulation results
  - Workshop with module developers to understand the differences

Sponsor Objectives

- Broadband platform modules
  - Magnitudes: M6 – M8
  - Rupture Distances: 0-15 km
  - Mechanisms: Strike-slip, reverse, normal
  - Frequency Band: 0.1 to 30 Hz (can get by with 5-10 hz if it captures the peak in the acceleration response spectrum
  - Crustal structure: 1-D
- Validations
  - (A) test simulation methods for event-specific source models (optimized)
  - (B) test method for generating source models for future earthquakes
- Forward Simulations
  - Generate sets of ground motions for large suites of future earthquakes
  - Be able to conduct simulations under QA