Plans for and progress of "Validation of Strong Ground Motion Simulations of two Historical New Zealand Subduction Zone Earthquakes on the SCEC BBP"

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Presentation Outline

1. Background: SCEC BBP
2. Extension of BBP to subduction eqks
   - *sister project – SCEC funded*
3. Validation of two historical New Zealand subduction zone earthquakes
   - *this project*

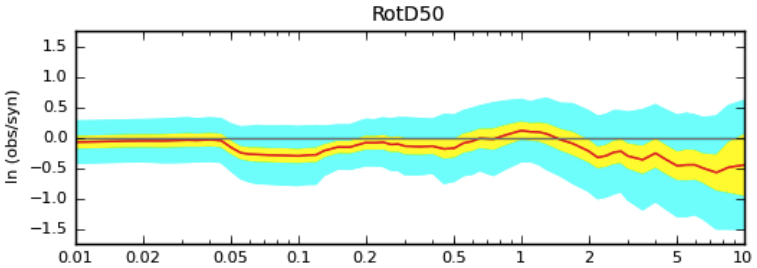
(1) Background: SCEC BBP

- The Southern California Earthquake Center (SCEC) Broadband Platform (BBP) is an open-source software distribution that contains physics-based ground-motion models capable of calculating broadband earthquake ground motions. (Maechling et al., 2015)
- The BBP contains software tools for evaluating ground-motion models and comparing simulation results to observed ground-motion recordings and against GMPEs (Maechling et al., 2015)
- Several years of software development have resulted in a mature computational platform that is now reliable and scalable enough for engineering-oriented validation exercises (Dreger et al., 2015)
- The simulation method with which we at AECOM are closely involved is Graves & Pitarka (aka GP)

(1) Background: SCEC BBP

For all BBP Simulations:

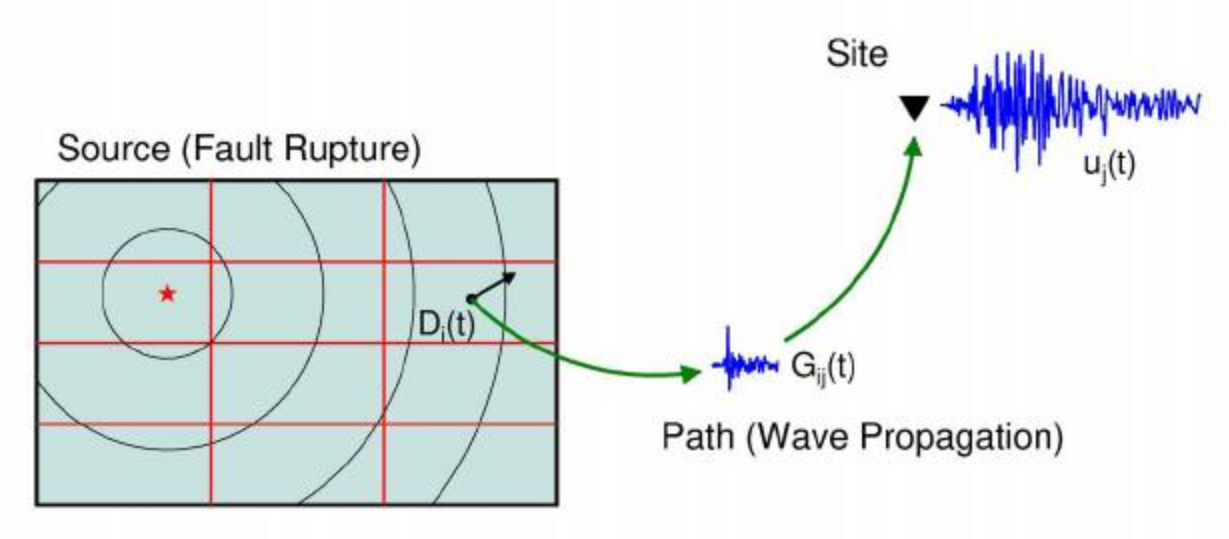
- Inputs:
  - Source descripton file (Magnitude, dimensions, avg rake, dip, fault location, hypocenter location, etc)
  - Region (determines velocity model, pre-computed GFs, and some region dependent parameters i.e. kappa, Q)
  - Site file (lists lat/lon of stations for which seismograms are calculated)
- Outputs:
  - Acceleration, velocity, and displacement time series
  - 5% damped response spectra (RotD50)
  - For validation events: Goodness of Fit (natural log of residuals vs period)



(1) Background: SCEC BBP

GP Simulations:

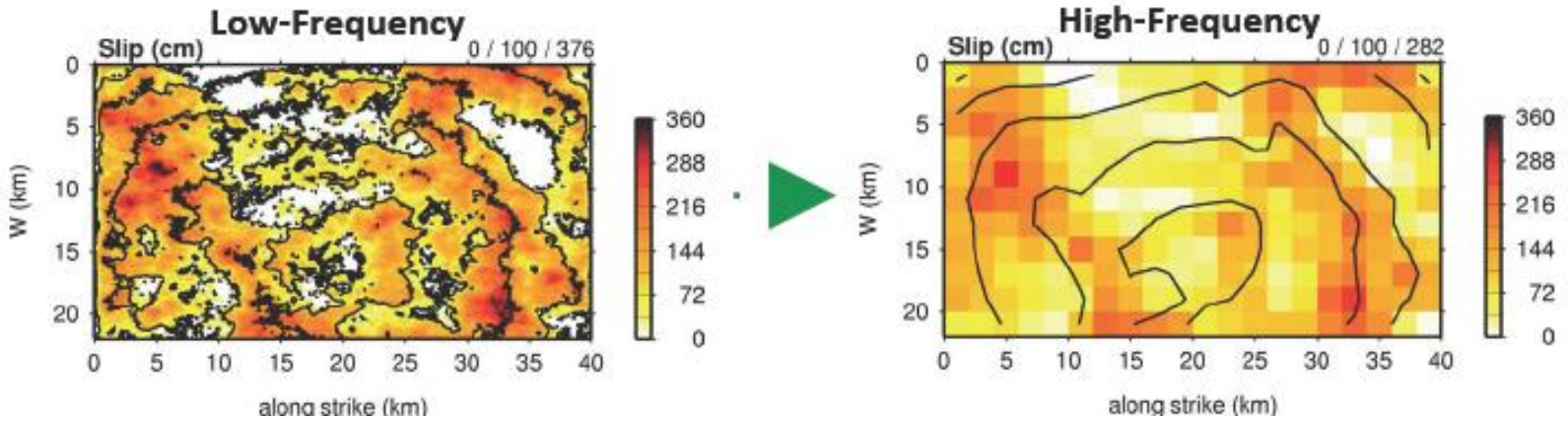
- Low Frequencies (comprehensive theoretical)
  - Source: kinematic representation of heterogenous rupture on a finite fault
  - Wave propagation: plane-layered (1D) structure, theoretical Green's functions pre-computed using f-k method, region dependent Vel and Q



(1) Background: SCEC BBP

GP Simulations:

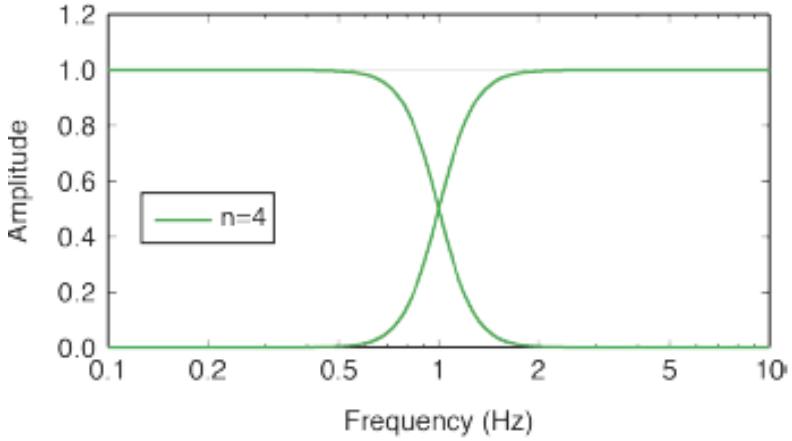
- High Frequencies (simplified theoretical)
  - Downsampled kinematic rupture to 1-2 km grid
  - Each subfault radiates an w^2 spectrum with stochastic phase
  - Uses simplified ray path GFs, include travel time and impedance effects.

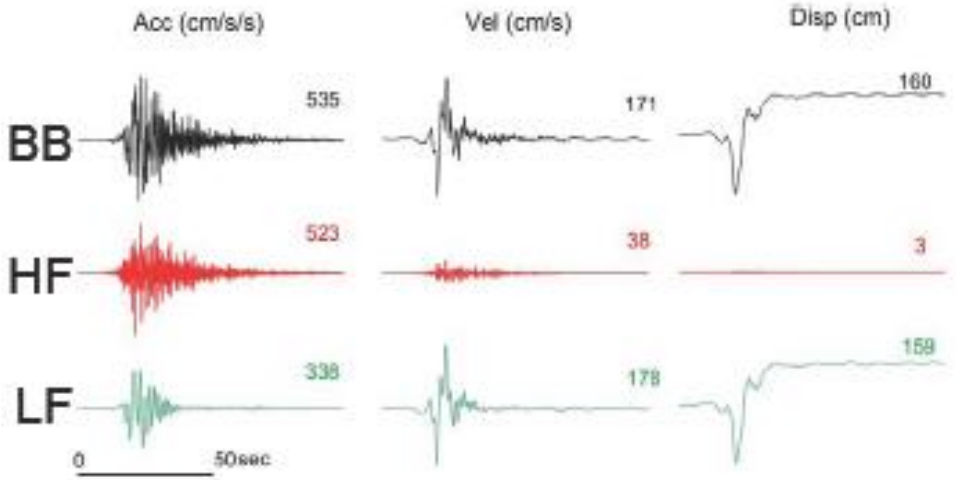


(1) Background: SCEC BBP

GP Simulations:

- Optional Site Amplification
  - Non-linear amplification factors based on Vs30
- Match Filtering





(2) Extension of BBP to Subduction

- At present, the BBP has been used to model and validate only shallow crustal earthquakes, but the PI's have submitted a proposal to SCEC to extend the applicability of the BBP to subduction earthquakes using the Mw 9.0 2011 Tohoku earthquake as a test case

Simplified Work Plan:

1. Select velocity model
2. Generate low frequency GFs; add them to the BBP
3. Adapt the GP rupture generator to subduction eqks (source scaling relations for subduction earthquakes; Skarlatoudis et al., 2015)
4. Adapt the GP simulation method for subduction eqks
5. Perform Simulations
6. Validation & Assessment

(3) Validation of two historical NZ subduction zone earthquakes

- The key objective of this proposal is to use the SCEC BBP to perform validations of broadband strong motion simulations of two historical New Zealand subduction zone earthquakes:
  - 15 July 2009 **M**7.57 Fiordland (Puysegur subduction zone at the southwestern end of the South Island)
  - 1931 **M**7.8 Hawkes Bay earthquake (which occurred within the accretionary prism of the Hikurangi subduction zone).
- This project will develop the capability for other users to perform broadband strong motion simulations of New Zealand subduction earthquakes and to validate these simulations against recorded ground motions where available.

(3) Validation of two historical NZ subduction zone earthquakes

Simplified Work Plan:

1. Select velocity models
   - We will seek models that have been constrained by shear wave information
2. Generate low frequency GFs; add them to the BBP
3. Adapt the GP rupture generator to subduction eqks
   - We expect this work will be done in the SCEC Project, if funded
4. Adapt the GP simulation method for subduction eqks
   - We expect this work will be done in the SCEC Project, if funded
5. Develop Planar Fault geometry models
   - We will develop planar fault models for each of the two events based on published information (Fry et al., 2010; Hull, 1990).

(3) Validation of two historical NZ subduction zone earthquakes

Simplified Work Plan, cont:

6. Prepare recordings
   - We will calculate the response spectra of the recorded ground motions of the 2009 Fiordland event and correct them for site response.
   - We plan to explore the site amplification factors of Boore et at. (2014), and check them for consistency with the understanding of amplification effects that has been gained from the Canterbury earthquake sequence (e.g. Bradley, 2013).
   - We will convert the observed intensities of the 1931 Hawkes Bay event to approximate peak velocities and correct them for site response.
   - Alternatively, we may not correct the recordings for site response, but may perform site corrections to the simulations. This step TBD.
7. Generate Rupture Models & Perform Simulations
8. Validation & Assessment
   - RotD50 Goodness of Fit