



Finite-fault modeling, interpolation of Green's functions over the fault.

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Abstract

We model high frequency radiation of finite fault by combining the composite and kinematic models. The composite model makes up time histories of mainshock from time histories of subevents. The subevent size distribution is fractal. The time histories of subevents are computed either using point-source approximation or considering subevent as a finite-source. We introduce a technique of Green's function interpolation over fault, which enhances efficiency of calculations. Calculation is also performed for the 1999 Athens earthquake, for which we make comparison with observed data.

Synthetic tests

- Tune the interpolation method to get accurate Green's function usable both in kinematic and point-source modeling of subevents.
- Show an influence of finiteness of subevents.

Synthetic model

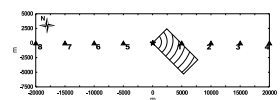


Figure 1: Receivers are depicted by triangles, bold solid rectangle represents surface projection of finite fault. Star denotes surface projection of nucleation point of finite-fault rupture, which is outlined by arcs.

Parameter	Value	Parameter	Value	Parameter	Value	Parameter	Value
Depth	13.5°	Length	1.5°	Width	0.5°	Strike	330°
Slip	0.2	Velocity	2.0	Acceleration	0.1	Duration	0.1
Length	1.5°	Width	0.5°	Strike	330°	Slip	0.2
Depth	13.5°	Length	1.5°	Width	0.5°	Strike	330°
Slip	0.2	Velocity	2.0	Acceleration	0.1	Duration	0.1

Table 1.2: Source parameters and crustal model.

Interpolation of Green's functions

To reduce expense of computation, we introduce interpolation of impulse responses (IR). The interpolation is carried out in frequency domain. Real and imaginary parts of impulse response spectra represent two independent 2D functions of position within fault surface for fixed frequency. We use 2D cubic splines to obtain value of IR spectra at any point of fault surface, from relatively coarse grid where the IR spectra are computed by DW method (Bouchon 1981). An example of such interpolation is plotted in Fig. 2.

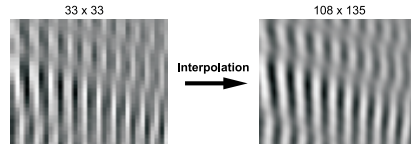


Figure 2: Real part of IR spectra over fault surface at 5 Hz, for receiver 8.

- Interpolation is tested on modeling the point-source (Brune's time function), where the exact solution can be obtained using DW directly, and also the finite-extent, Haskell-like source (homogeneous slip, radial rupture, constant rupture velocity, boxcar slip velocity function of constant width), see Fig. 3. Computations were made up to 5 Hz.

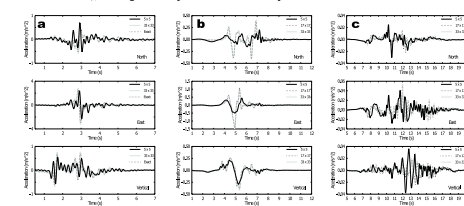


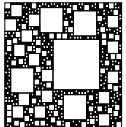
Figure 3: Acceleration time histories: a) point-source placed at upper left corner of fault and receiver 1, b) and c) Haskell-like finite-source with rupture outlined in Fig. 1, receiver 1 (towards rupture propagation) and receiver 8 (opposite direction). The numbers in legend determine the number of points in the coarse grid.

- We do not deduce any simple rule for determining fault sampling in kinematic modeling, neither for coarse nor for fine grid. We just claim that, in this model, the ratio fine/coarse grid sampling (in both directions) cannot be larger than about 4 for receivers placed toward rupture propagation and about 3 for receivers in opposite direction.

Composite modeling

The strong motion synthesis is performed according to Burjánek (2002) with following features:

- Composite model with Fractal Subevent Size Distribution - number of subevents with characteristic dimension greater than R is proportional to R^{-2} .
- Both amplitude and duration of slip are proportional to R .
- Subevents are distributed randomly over the entire fault.
- Subevents are triggered as the rupture front propagating over entire fault, with constant velocity, reaches prescribed point of subevent.
- For finite-source subevents, we study four alternative choices of such triggering points:



- A: Each subevent is rupturing radially from its center.
- B: Each subevent is rupturing radially from its point closest to the hypocentre.
- C: Each subevent is rupturing radially from its random point.
- D: No radial rupturing of each subevent! The rupture front on subevent follows the rupture front of entire fault.

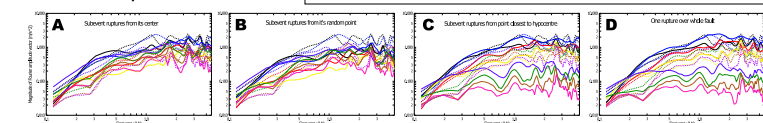


Figure 4: Fourier amplitude spectra for modulus of ground acceleration vector. Receivers are distinguished by colors, dashed and solid line denotes point-source subevents and finite-source subevents respectively. Average from 10 FSSD realizations is shown.

Partial result:

- A & B & point-source subevents, limited directivity at high freq. < preferable
- C & D strong directivity at high frequencies

Modeling of Athens 1999 earthquake

- 1D layered model was taken from Novotný et al. (2001).
- Focal mechanism was taken from Zahradník (2001).
- Source dimension is based on empirical relations of Somerville et al. (1999).
- Position of hypocentre within fault plane was taken from Plicka & Zahradník (2002).
- Calculations were made up to 5 Hz, for 10 FSSD realizations.
- Point-source subevents used.
- Position of largest subevent is fixed to model asperity found Tselenis & Zahradník (2000).
- The strong ground motion synthetics were compared with observed data, recorded by 11 strong motion seismographs deployed by NOA (8) and ITSAC (3), see Fig. 5.

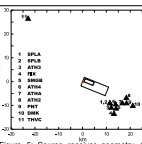
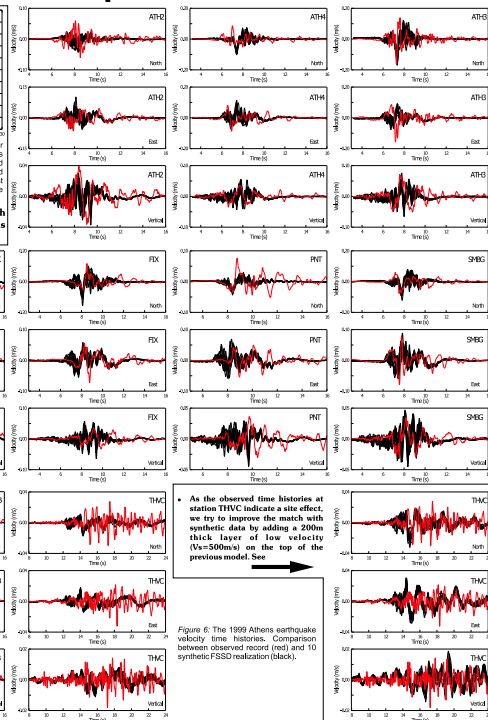


Figure 5: Source region geometry. Star denotes hypocentre, solid rectangle shows surface projection of the fault and bold solid rectangle outlines the largest subevent (fixed in calculation). Entire fault 11x6 km. Largest subevent: 4.4x3.2 km. Triangles denote the stations.



Conclusions

- Massive calculations are enabled by efficient Green's function interpolation
- Directivity study has indicated preference of point source approximation of subevents
- Modeling of strong ground motion in Athens has basically confirmed the source model previously obtained from independent regional studies of Tselenis & Zahradník (2000), Plicka & Zahradník (2002). The main feature of that source model is a single asperity, rupturing from its western corner.

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