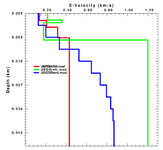
Joint Inversion of Surface-Wave Dispersion and First-Arrival Times for the Determination of Shallow P- and S-Velocity Structure

J. Chang, R. B. Herrmann and D. J. Crossley, Saint Louis University

Objective

Many techniques are used to estimate shallow S-wave velocity structure for engineering purposes. Surface wave techniques use data from active and passive experiments to obtain phase velocities. Among these are MASW and Remi. Active source experiments also provide first arrival time information that can be used to constraining structure. Often different data sets yield different structures – especially for surface wave techniques



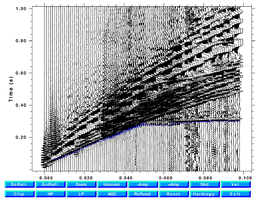
This effort investigates the feasibility of inverting P-wave first arrivals and Rayleigh-wave phase velocities obtained using a vertical hammer source and vertical geophones and SH-wave first arrivals and Love-wave dispersion obtained using horizontal hammer sourced and horizontal geophones.

Data Sets

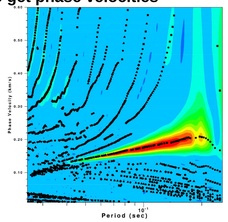
Acquired in 2005 with support from USGS Grant 05HQGR0046. The effort used a 24-channel Geometrics StrataView seismograph with 4.5 Hz vertical and horizontal geophones. Trace separation of 1 meter was obtained by a 3 meter geophone spacing and source offsets of 0, 1 and 2 meters The sites studies were in metropolitan St. Louis. A hammer source is used.

Data Processing

- The Computer Programs in Seismology package was used for all data analysis. (The new programs written are not yet part of the distribution).
- seg2tosac – convert SEG2 to sac (J. Mejia)
- gsac – Use *refr* command for arrival time picks.



- do_pom to get phase velocities



- Invert data sets using
  - surf96 – invert dispersion curves
  - ttinv96 – invert first arrival data (NEW)
  - shallow96 – joing inversion of first-arrivals and dispersion
  - All inversion routines use linearized least-squares inversion which many controls.

Discussion

- The joint inversion of P- and SH-wave first arrival times has been attempted using linearized least-squares inversion
- A perfect fit to all data sets was not obtained. However we have not determined the criteria for an acceptable fit.
  - The question of what constitutes and adequate inversion has not been addressed.
  - Should the criteria be a stable estimate of the site response?
- The forward modeling codes are fast enough that a Monte Carlo inversion can be attempted, one which may provide a suite of candidate models that will capture the true lack of knowledge at depth
- The next step will be to document all codes, write a tutorial and provide simple directions for robust inversion.

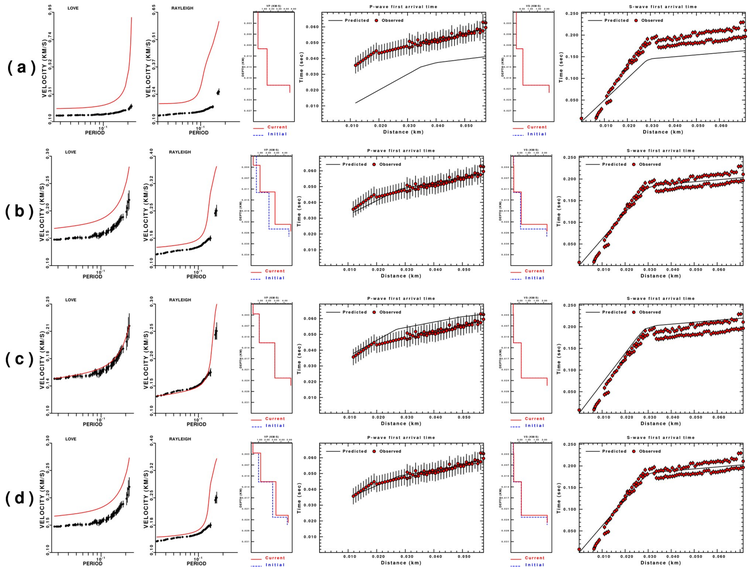
Free Open Documented Software

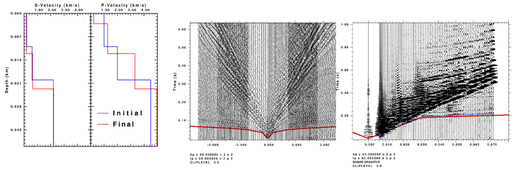
Computer Programs in Seismology (137 programs) Tutorials, Documentation, Q&A

http://www.eas.slu.edu/Earthquake_Center/CPS/CPS330.html

Bellefontaine Park West
38.7411N 90.2706W

- Initial model fit (a)
  - Emphasize travel time fit
  - Alternate inversion for layer thickness and velocity
  - Emphasize dispersion
- Split top layer
  - Fix halfspace velocities
  - Fit travel times (b)
- Surf96
  - Fit dispersion (c)
- Shallow96
  - Improve simultaneous fit (d)



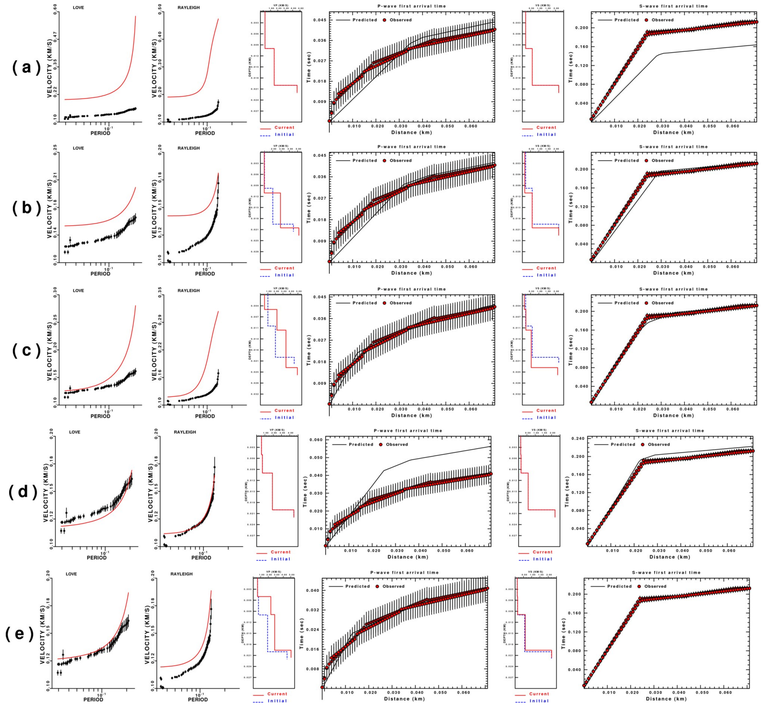


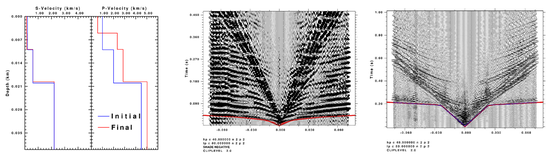
Discussion

- Cannot fit both data sets
- P and S ratios differ for first two layers – above/below water table?
- Differences will not affect site amplification much

Bellefontaine Park
38.6802N 90.2304W

- Dispersion and travel time of initial model and observed data.(a)
- Joint inversion based on initial model. Emphasize travel time fit.Alternative inversion for layer thickness and velocity. Emphasize dispersion fit. (b)
- Split the top layer of initial model to two layers. Same processing as previous step (c)
- Single surface wave dispersion inversion (SURF96) results. Based on the initial model. Fix the P velocity during surface wave dispersion (d)
- Joint inversion using SURF96 output model as input model. Same weighting for travel time and dispersion inversion. Alternae inversion for layer thickness and velocity. Based on current fit, change layer weighting, focused on shallow layer, deep layer didn't change(e)





Adequate fit!