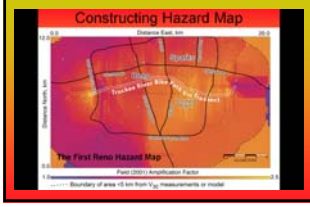
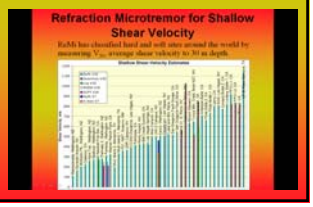
Geop480: Lectures (19)

Engineering Seismology-2

The Refraction Microtremor (ReMi) Method

Previous Lecture: REMI





Outline

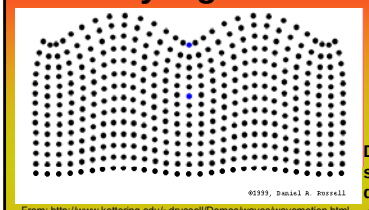
- ❑Remi
- ❑Equipment
- ❑Data Acquisition
- ❑Remi Method
- ❑Case Works

Equipment Needed

- Multi-channel seismograph
  - *12 or 24 channels*
  - *capable of recording at least 4 seconds of data per channel at 1-2 ms sampling intervals*
- Vertical P-wave geophones & sufficiently long cable for desired depth of investigation
  - *Measure Rayleigh wave dispersion*
- Ambient or induced surface wave energy
  - *noisy site (urban traffic, airport, construction, mining)*
  - *Jogging, driving vehicle along array, striking a hammer etc*
- Laptop / PC with SeisOpt® ReMi™ software for analysis
  - *Takes 2 to 3 hours for data acquisition and analysis*

A courtesy of Dr. Satish Pullammanappallil

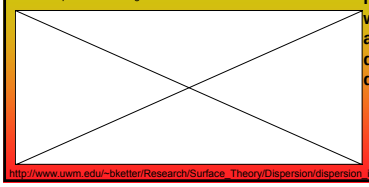
Rayleigh Wave Dispersion



From: http://www.kettering.edu/~drussell/Demos/waves/wavemotion.html

What is dispersion?

Dispersion is the apparent surface-wave velocity that depends on the period and reflects the velocity variation with depth. Dispersion appears on a seismogram as different periods arriving at different times.



http://www.uwm.edu/~bketter/Research/Surface_Theory/Dispersion/dispersion_index.html

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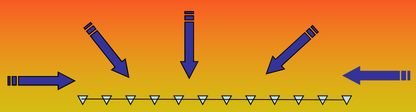
ReMi Data Acquisition



Linear array of vertical P-wave geophones recording ambient noise

ReMi @ Phoenix Airport and ReMi inside a house (courtesy Mike Rucker, AMEC)

A courtesy from Dr. Satish Pullammanappallil

ReMI for Shallow Shear Velocity

Low-frequencies, 1-20 Hz, so bad geophone plants still work.

From: 2005 Presentation of Dr.J.Louie

ReMI for Shallow Shear Velocity

Fieldwork is quick and simple; best results

From: 2005 Presentation of Dr.J.Louie

ReMI for Shallow Shear Velocity

Fieldwork is quick and simple; best results

From: 2005 Presentation of Dr.J.Louie

VUW, Optim LLC

ReMI for Shallow Shear Velocity

Fieldwork is quick and simple; best results in cities.

From: 2005 Presentation of Dr.J.Louie

Initial funding from SCEC, UNR, VUW, Optim LLC

REMI SURVEY: KFUPM

Here is what students are applying several actions as walking, running and jumping to generate adequate energy for a record of ground motion, which is required for REFRACTION MICROTREMOR (REMI).

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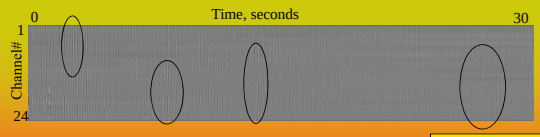
ReMi Method

•Acquire 10, 30 seconds microtremor data at 2ms sampling along a linear array.
•Array length depends on depth of investigation. Crooked line geometry can be handled. Thorson and Claerbout, 1985

Step 1: p-τ transformation

$$A(p=p0+dp\ \ \tau=kdt) = \Sigma A(x=jdx\ \ t=idt=\tau+px)$$



McMechan and Yedlin, 1981

Transforming data from the T-X domain into p-τ domain where p is the ray parameter or slowness, p=Δt/ Δx=1/V, and τ=t- p x

pp.60, Gadallah and Fisher, 2005

A courtesy of Dr. Satish Pullammanappallil

ReMi Method

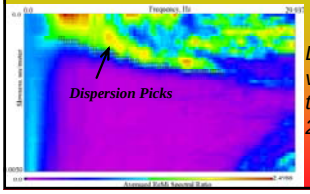
Step 2: Fourier transformation

$$F_A(p\ f=mdf) = \Sigma A(p\ \tau=kdt)e^{i2\pi m\ df\ kdt}$$

Step 3: Velocity Spectral Analysis : Power spectrum Louie, 2001

$$S_A(p,f) = F_A^*(p,f)\ F_A(p,f)$$

$$S_A(|p|,f) = [S_A(p,f)]_{p>=0} + [S_A(-p,f)]_{p<0} :\ \ S_{total}(|p|,f) = \Sigma S_{An}(p,f)]$$

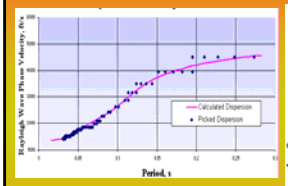


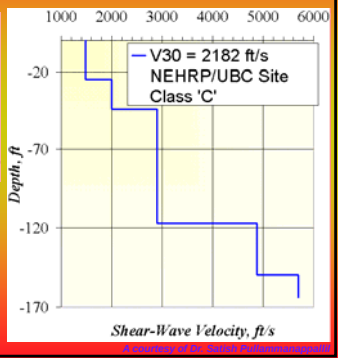
Lower limit of the apparent phase velocities can be recognized as the true phase velocities (Louie, 2001)

A courtesy of Dr. Satish Pullammanappallil

ReMi Method

Step 4: Interactive Forward Velocity Modeling





- *Avoids ambiguities associated with inversion, while providing the user with ability to include constraints while modeling*

A courtesy of Dr. Satish Pullammanappallil

ReMI Method: Advantages

- Data acquisition and analysis takes about three hours
- No physical restrictions beyond required line deployment space, minimal permitting
  - *Data can be acquired along roads, in buildings & at active construction sites*
- No specialized recording equipment required
  - *Standard refraction seismograph & refraction P-wave geophones*
- No artificial seismic source
  - *Uses ambient noise: "Quiet" site not required*
- Can be used offshore as effectively as on-shore

A courtesy of Dr. Satish Pullammanappallil

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