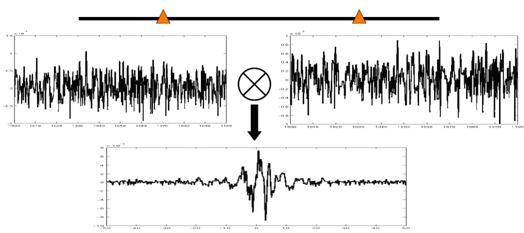
EAS 8803 - Obs. Seismology

Lec#22: Tutorial on Green's function retrieval from cross-correlations of ambient noise/coda waves

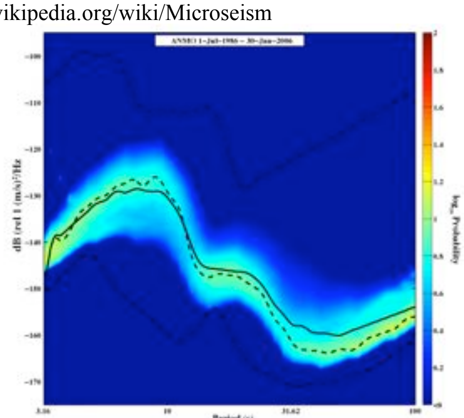
- Dr. Zhigang Peng, Spring 2011
- (with help from P. Zhao)

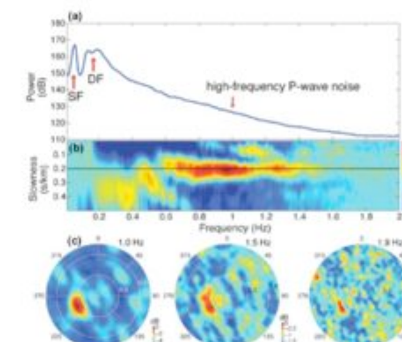


Outline

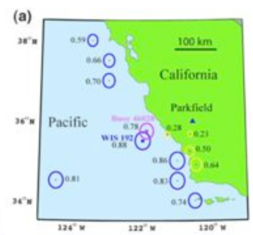
- Summary of recent topics
  - Using ambient noise to image the Earth's structures
  - Using ambient noise to monitor fault zone properties and volcanoes
  - Using earthquake coda waves as the source
- Steps to compute the Green's function
- Detailed examples of how to compute the Green's function from 1-day continuous recording

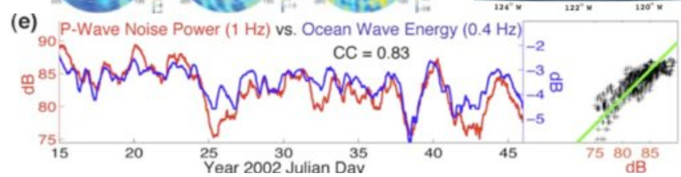
A microseism is defined as a faint earth tremor caused by natural phenomena, such as winds and ocean waves. It is a small and long-continuing oscillation of the ground.
http://en.wikipedia.org/wiki/Microseism

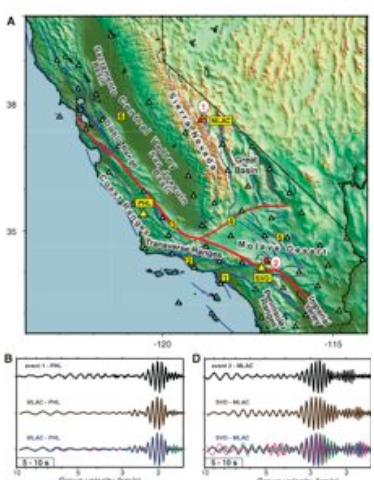




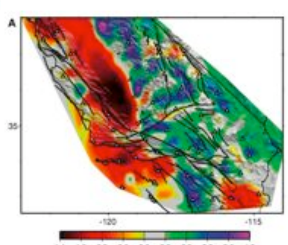
High-frequency P-wave noise correlates with the distant ocean winds (Zhang et al., GRL, 2009)





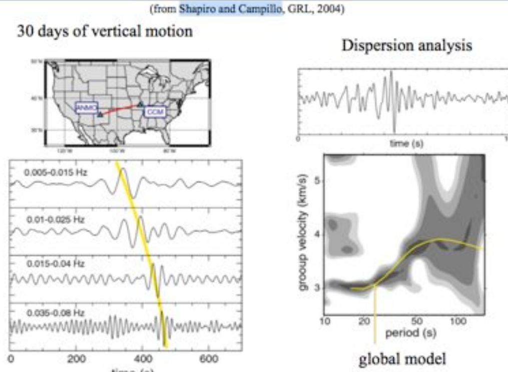


High-Resolution Surface-Wave Tomography from Ambient Seismic Noise (Shapiro et al., Science, 2005)



Cross-correlations of seismic noise: ANMO - CCM

(from Shapiro and Campillo, GRL, 2004)



http://www-lgit.obs.ujf-grenoble.fr/~campillo/Talk%202008/TALK.pdf

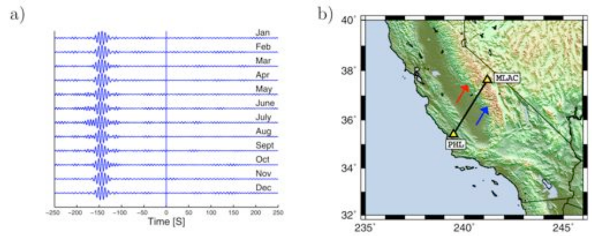


Figure 2. (a) Cross correlation between 5 and 10 s of 1 year (2002) of noise recorded on MLAC and

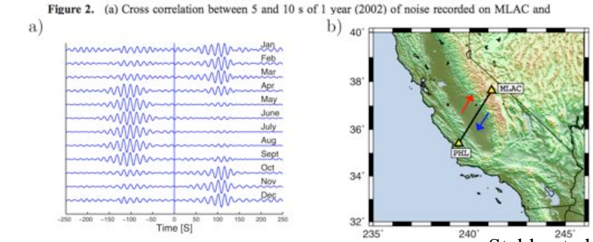
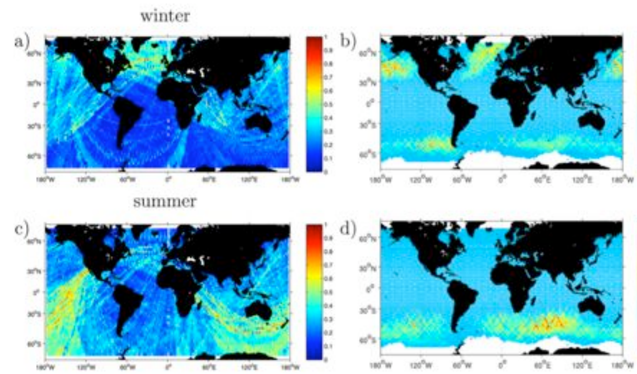


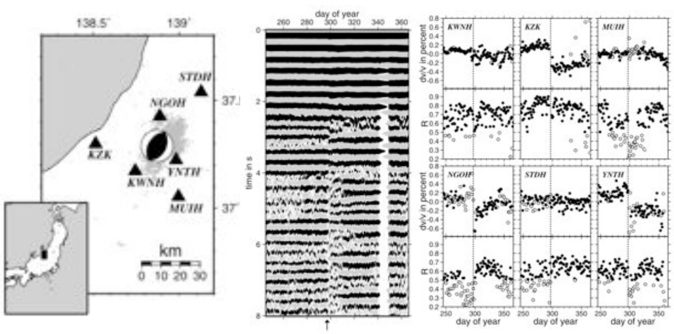
Figure 3. Same as Figure 2 but for the period range between 10 and 20 s.

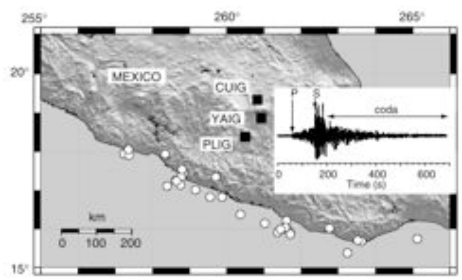
Stehly et al., JGR06

Conclusion: the secondary microseim (5-10 s) is generated by nonlinear interaction of the ocean with the coast. The primary microseism (10-20 s) is related to ocean wave activity in deep water (Stehly et al., JGR, 2006).



Fault zone monitoring with passive image interferometry (Wegler and Sens-Schonfelder, GJI, 2007 and Wegler et al., JGR, 2009) based on cross-correlation and/or auto-correlation of high-frequency background noise (2-8 Hz)





Long-range correlations in the diffuse seismic coda (Campillo and Paul, Science, 2003)

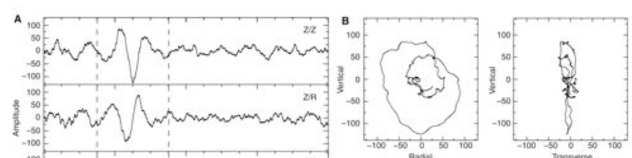


Fig. 2. (**A**) Stacked correlation functions computed from vertical-component records at station PLIG and vertical (Z), radial (R), and transverse (T) component records at station YAIG. Because the individual cross-correlations were normalized before the stack, the amplitudes are arbitrary. (**B**) Particle motion plots in the time window of the pulse (15 to 35 s).

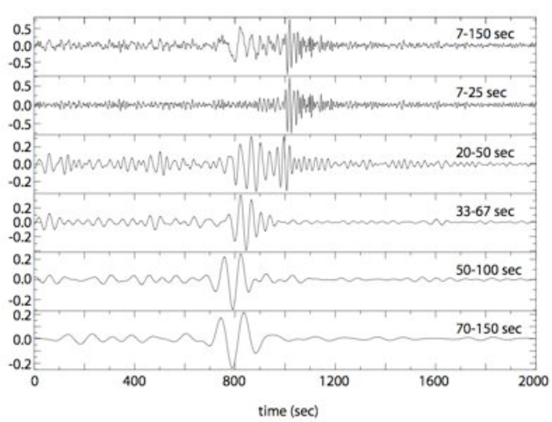
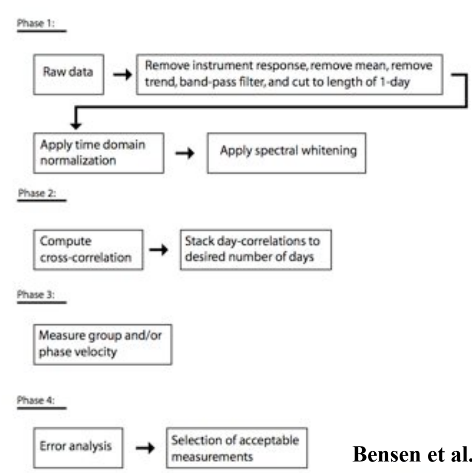


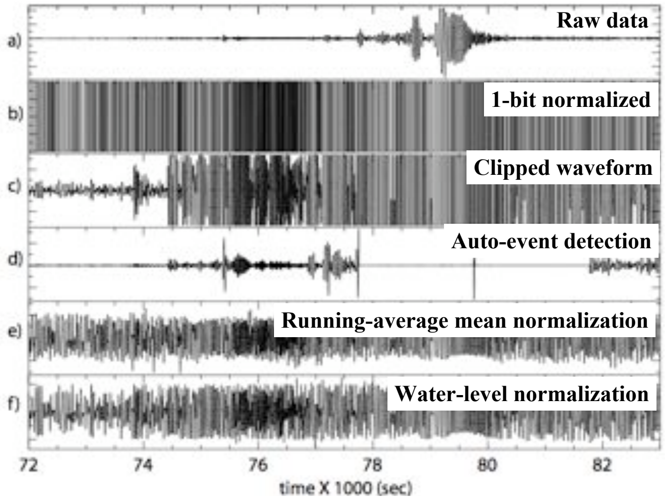
Figure 1. Example of a broad-band symmetric-component cross-correlation using 12-months of data from stations ANMO (Albuquerque, NM, USA) and HRV (Harvard, MA, USA). The broad-band signal (7–150 s passband) is shown at top and successively longer period passbands are presented lower in the figure. (The symmetric component is the average of the cross-correlation at positive and negative lags.)

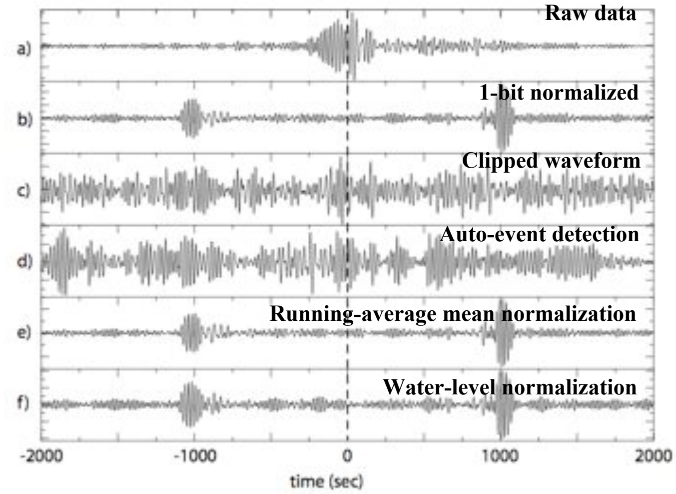
Bensen et al. (GJI, 2007)



Bensen et al. (GJI, 2007)

Figure 2. Schematic representation of the data processing scheme. Phase 1 (described in Section 2 of the paper) shows the steps involved in preparing single-station data prior to cross-correlation. Phase 2 (Section 3) outlines the cross-correlation procedure and stacking, Phase 3 (Section 4) includes dispersion measurement and Phase 4 (Section 5) is the error analysis and data selection process.





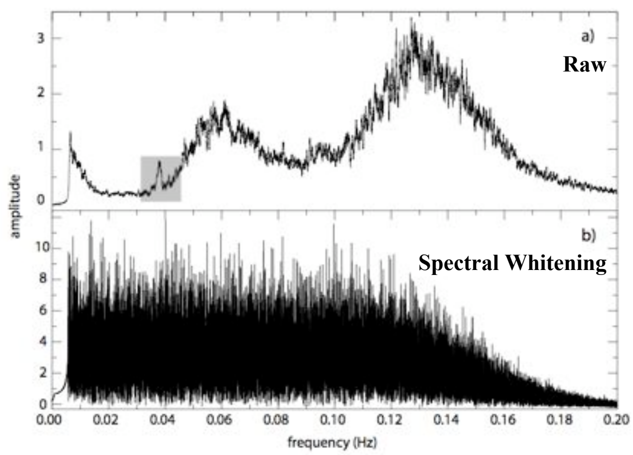
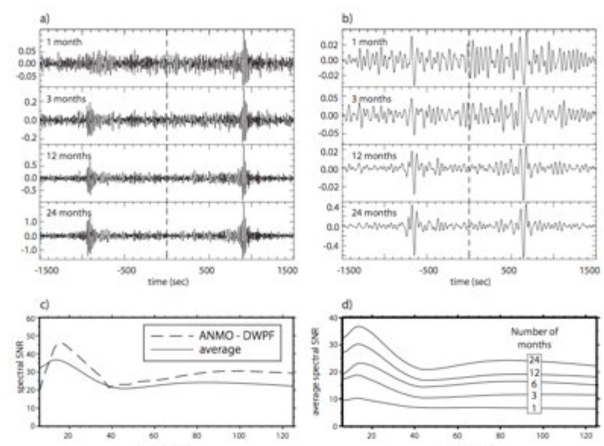


Figure 7. (a) Raw and (b) spectrally whitened amplitude spectra for 1 sample per second vertical component data at station HRV for July 5, 2004. The shaded box indicates the location of the 26 s period signal originating from the Gulf of Guinea. The taper seen at both ends of the spectra is largely attributable to a 7–150 s bandpass filter.

Increase of SNR based on stacking of the daily Green's function



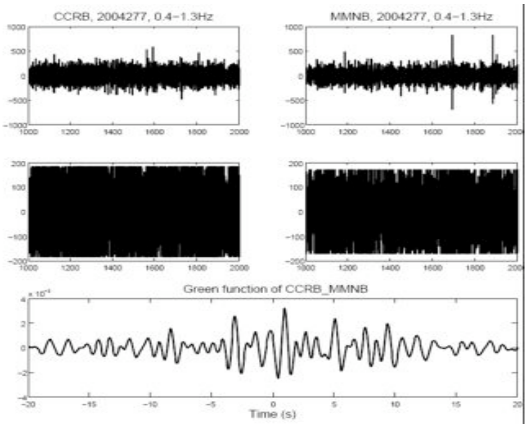
Procedure outlined in Zhao et al. (ES, 2010)

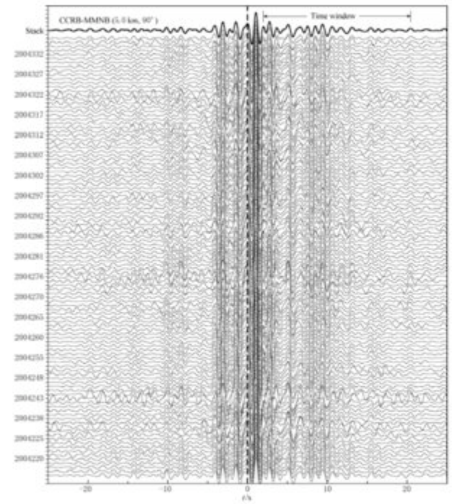
- Organize your data into daily range
- Pre-process the data
  - Remove the instrument response
  - Pre-filter the data into the desired frequency range
  - Compute the threshold for clipping data (to reduce the effects of large earthquakes or spurious noises) - median value of the standard deviation of the filtered daily records
  - Set the data above the threshold to be the threshold.

Cont: Procedure outlined in Zhao et al. (ES, 2010)

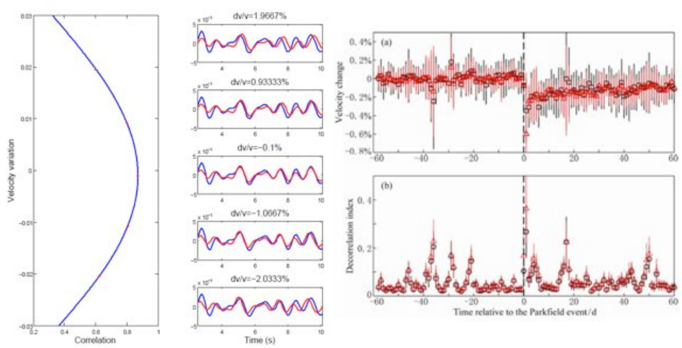
- Compute the Fast Fourier transform (FFT)
- Whiten the spectrum in the frequency domain
- Cross-correlate the whitened spectrum in the frequency domain
- Compute the inverse FFT back to the time domain to obtain the daily empirical Green's function (EGFs)

Data Procedures





Velocity Changes– stretch/compression method



[Wegler et al. JGR, 2009]

Time to run for the real examples (code written by pzhao)

http://geophysics.eas.gatech.edu/people/zpeng/Teaching/ObsSeis_2011/misc/Noise_Cross_Correlation_Example.tar.gz

Then extract it using
tar zxvf Noise_Cross_Correlation_Example.tar.gz

Then follow readme.txt in the directory
Noise_Cross_Correlation_Example