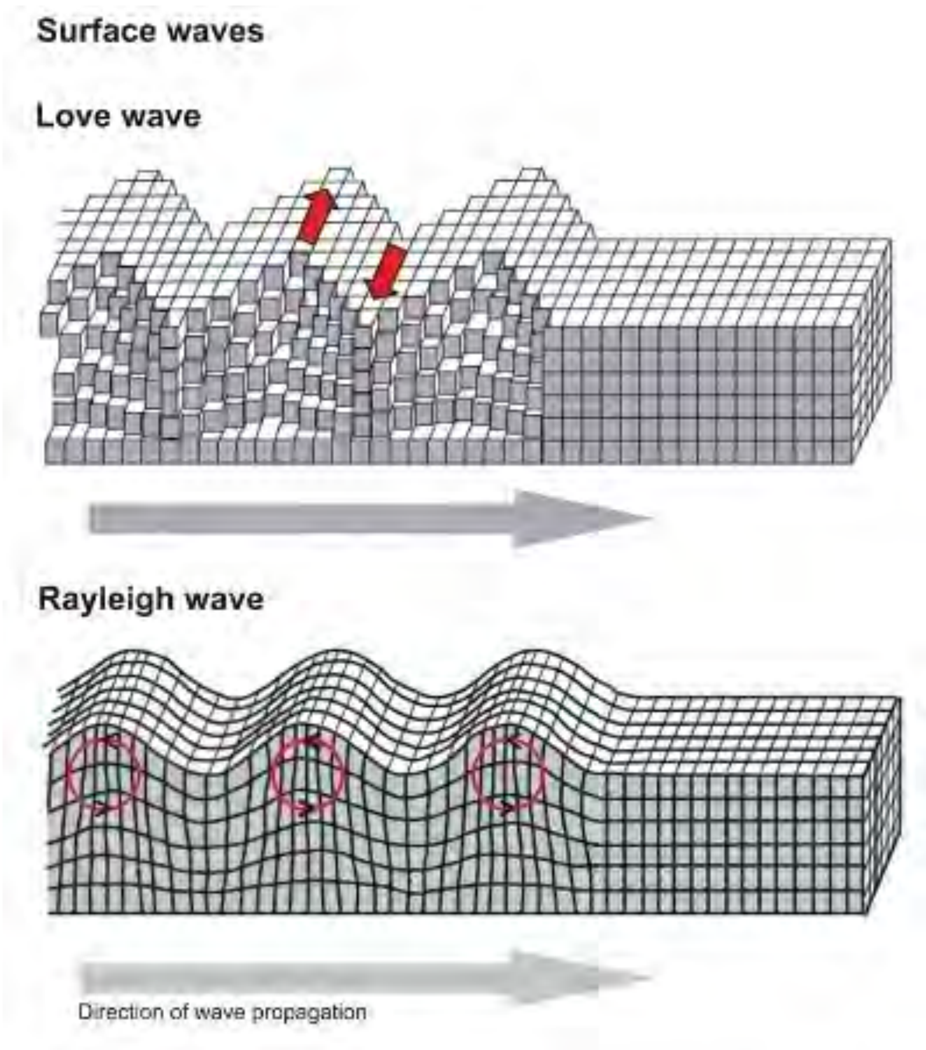
February 8, 2010

Surface wave tomography

E. Garnero, ASU
EarthScope Seminar Class

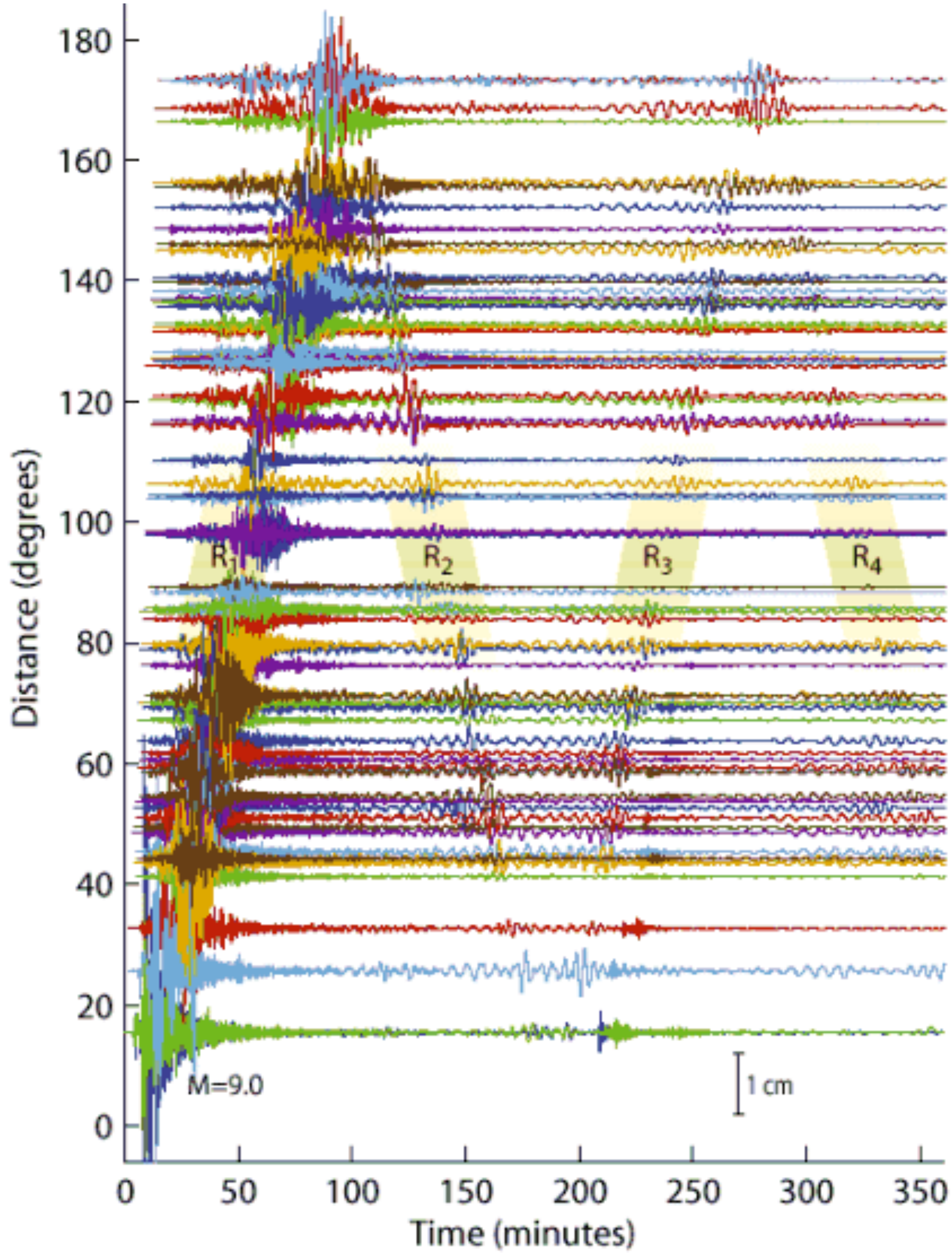
Slides from various sources, including a Canadian course.



Particle motion is perpendicular to great-circle plane (transverse). Love waves due to a wave guide effect from a low velocity layer (i.e., crust)

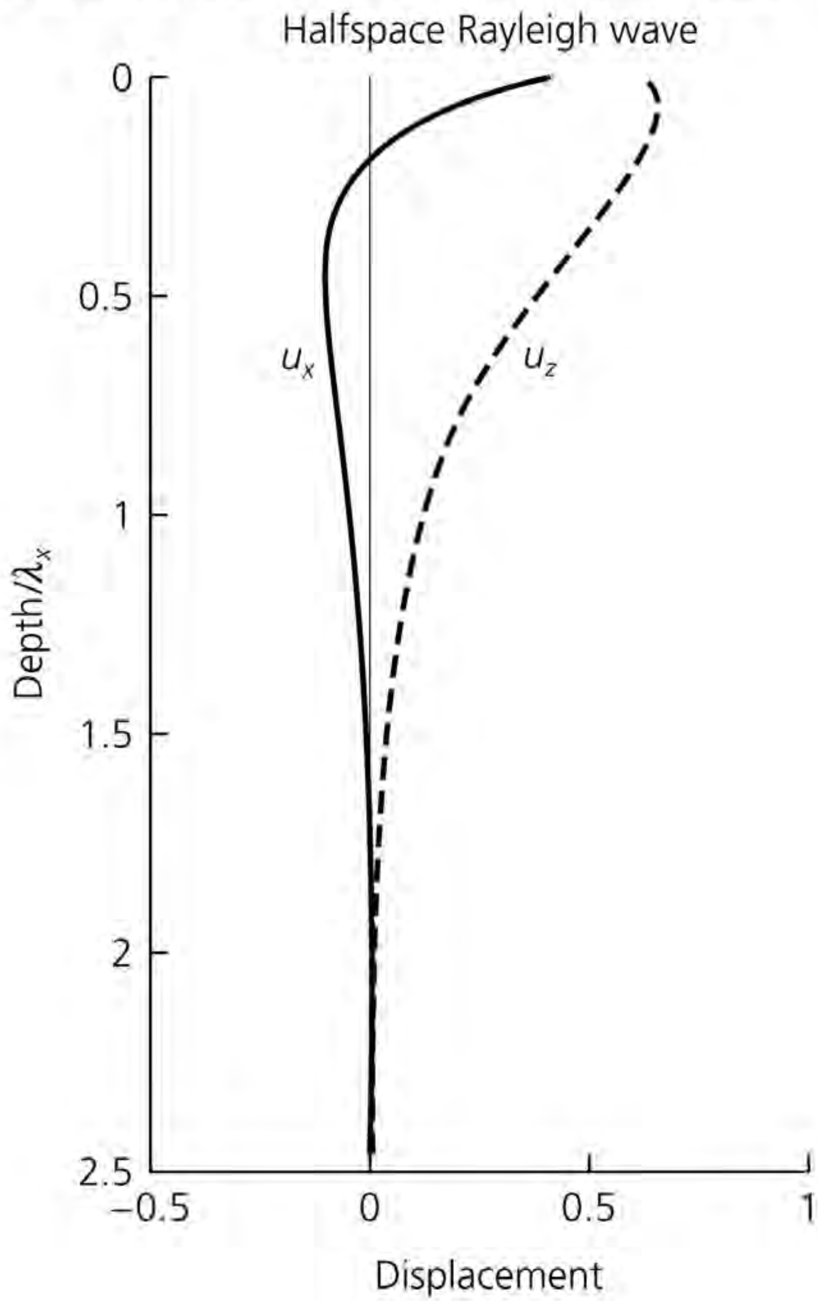
Retrograde elliptical particle motion in the great circle plane (radial-vertical plane), due to free surface.

Andaman-Sumatra Earthwuake, Dec 26, 2004

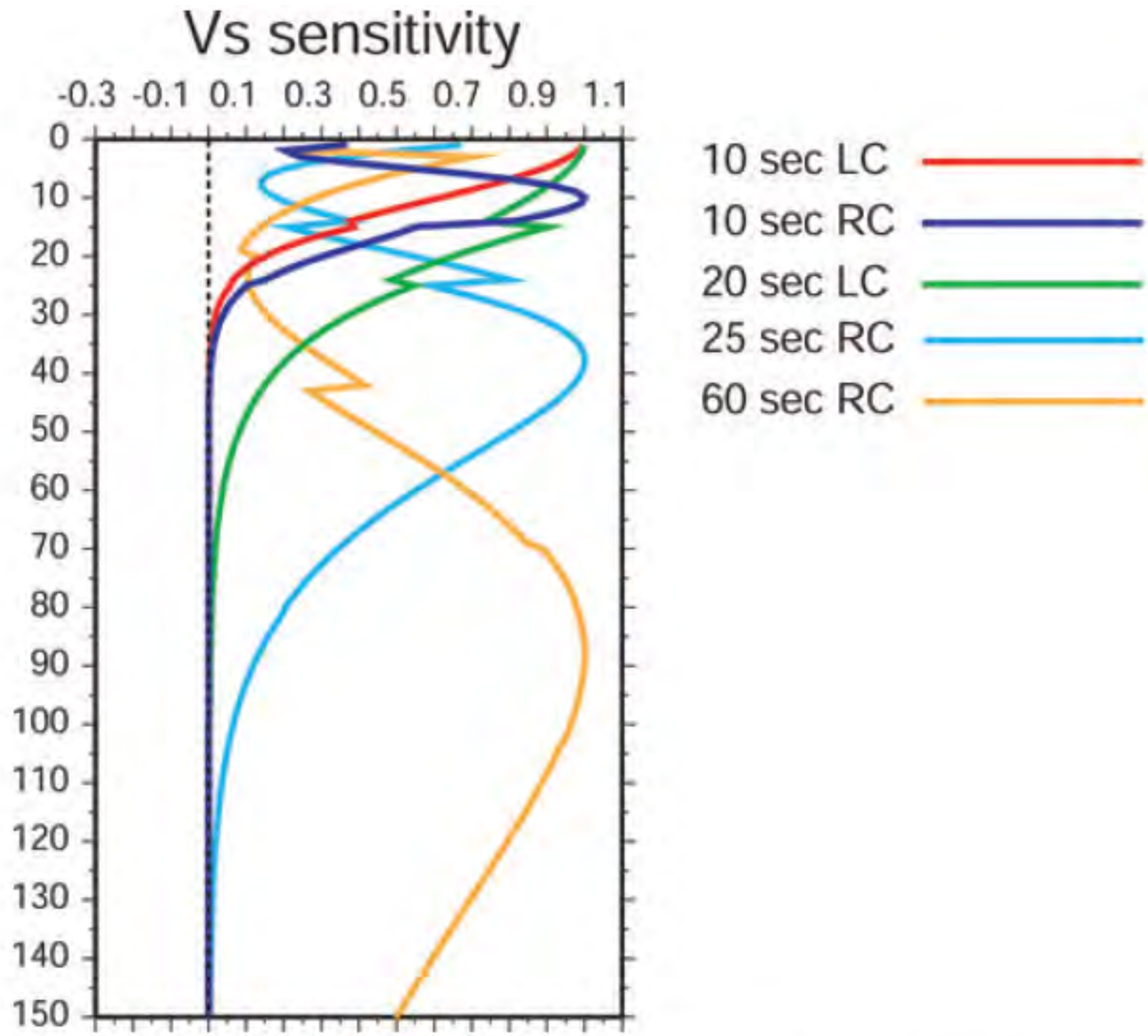


IRIS, R. Aster

Figure 2.7-5: Rayleigh wave displacements as a function of depth.



Stein & Wysession

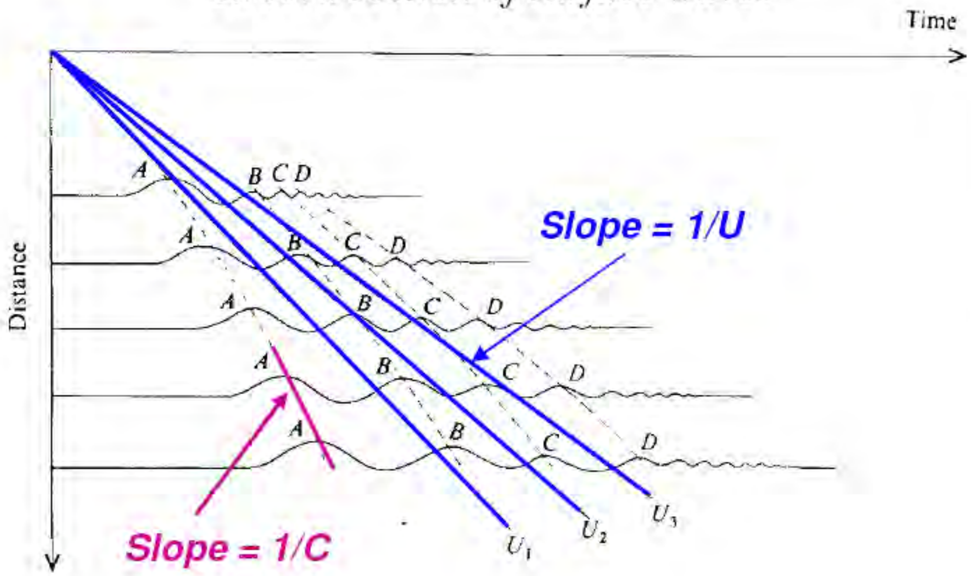


Sensitivity kernels for Rayleigh (labelled RC) and Love (labelled LC) wave phase speeds at a selection of periods.

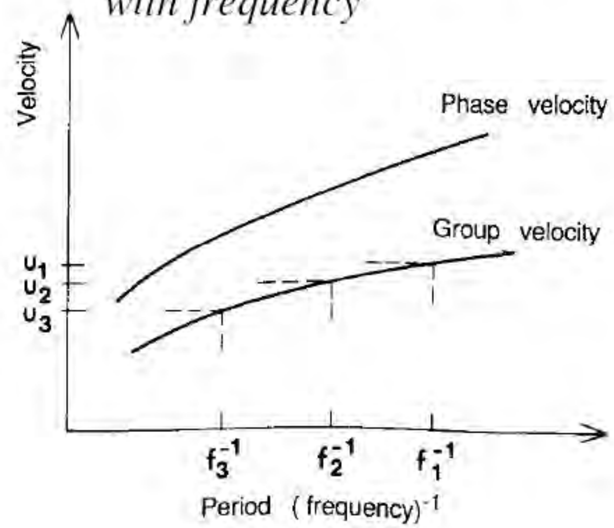
Benson et al. (2009)

Group and phase velocity

Record section of surface waves



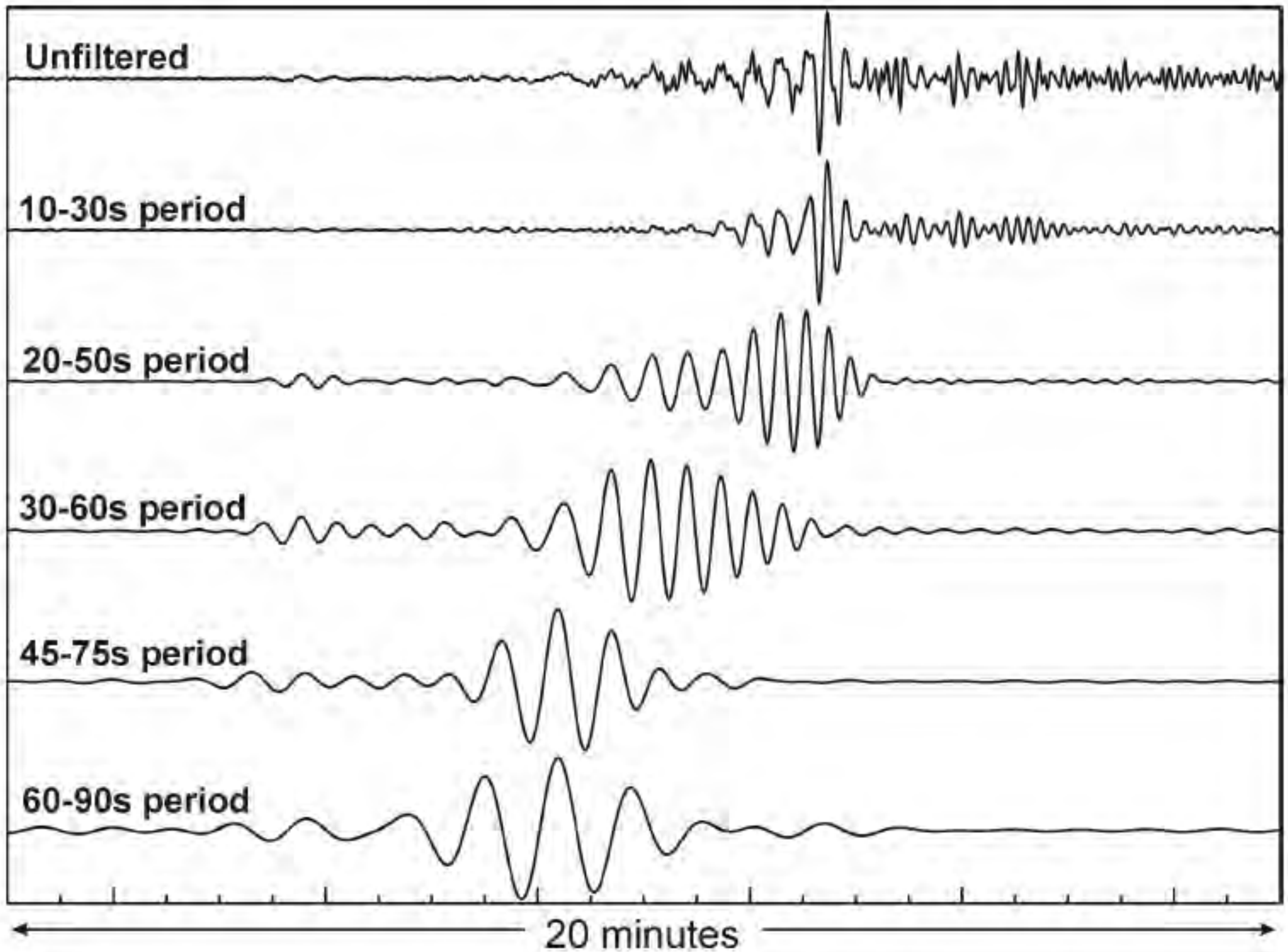
Dispersion curves – describe the variation in seismic velocity with frequency



Definitions:

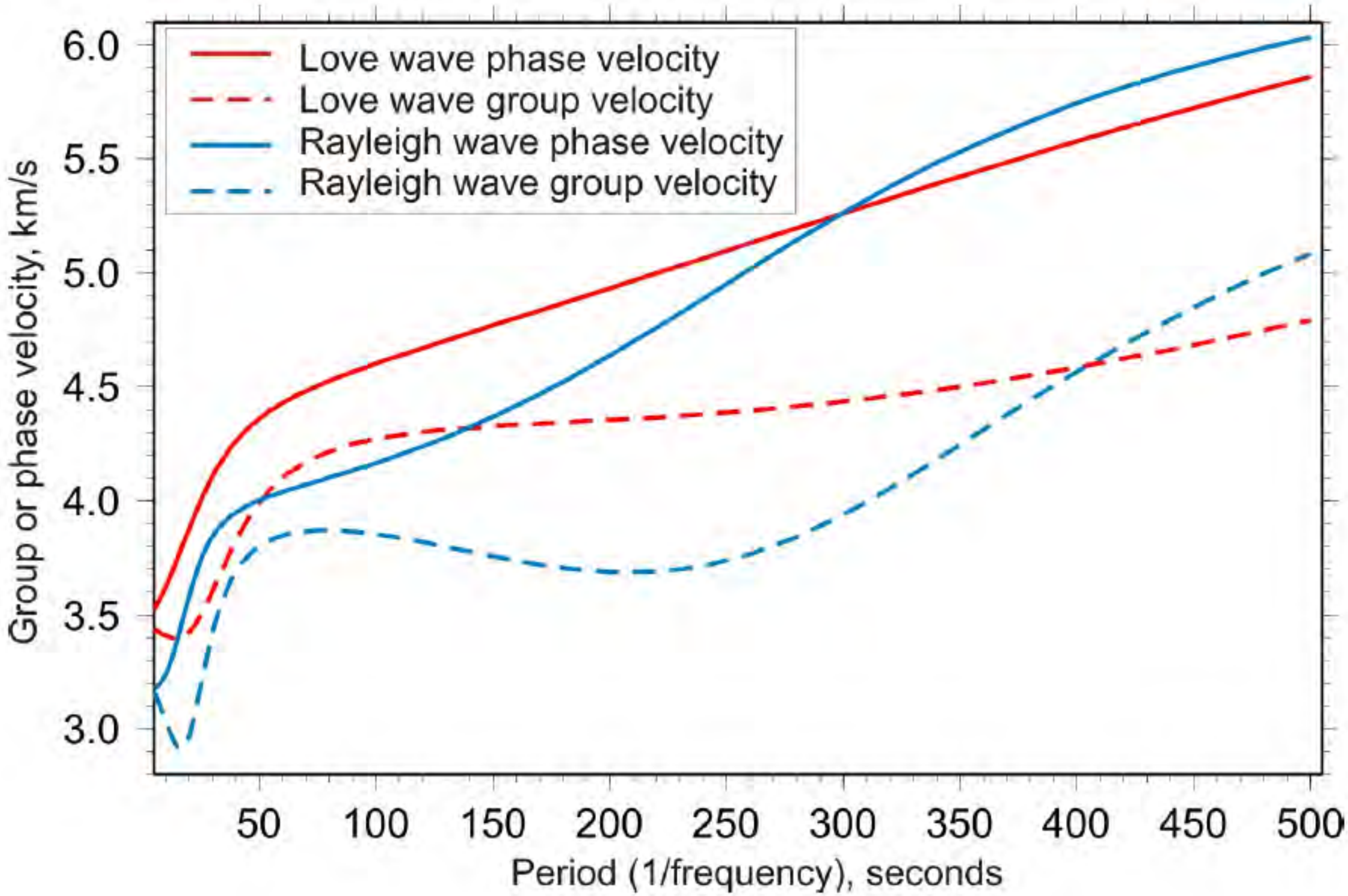
Group velocity (U) – velocity of a particular frequency in the wave packet
Can also be thought of as the velocity at which the wave packet (envelope) propagates.

Phase velocity (C) – velocity of a particular phase, e.g. peak or trough (Note that the frequency of a given phase changes with distance.)

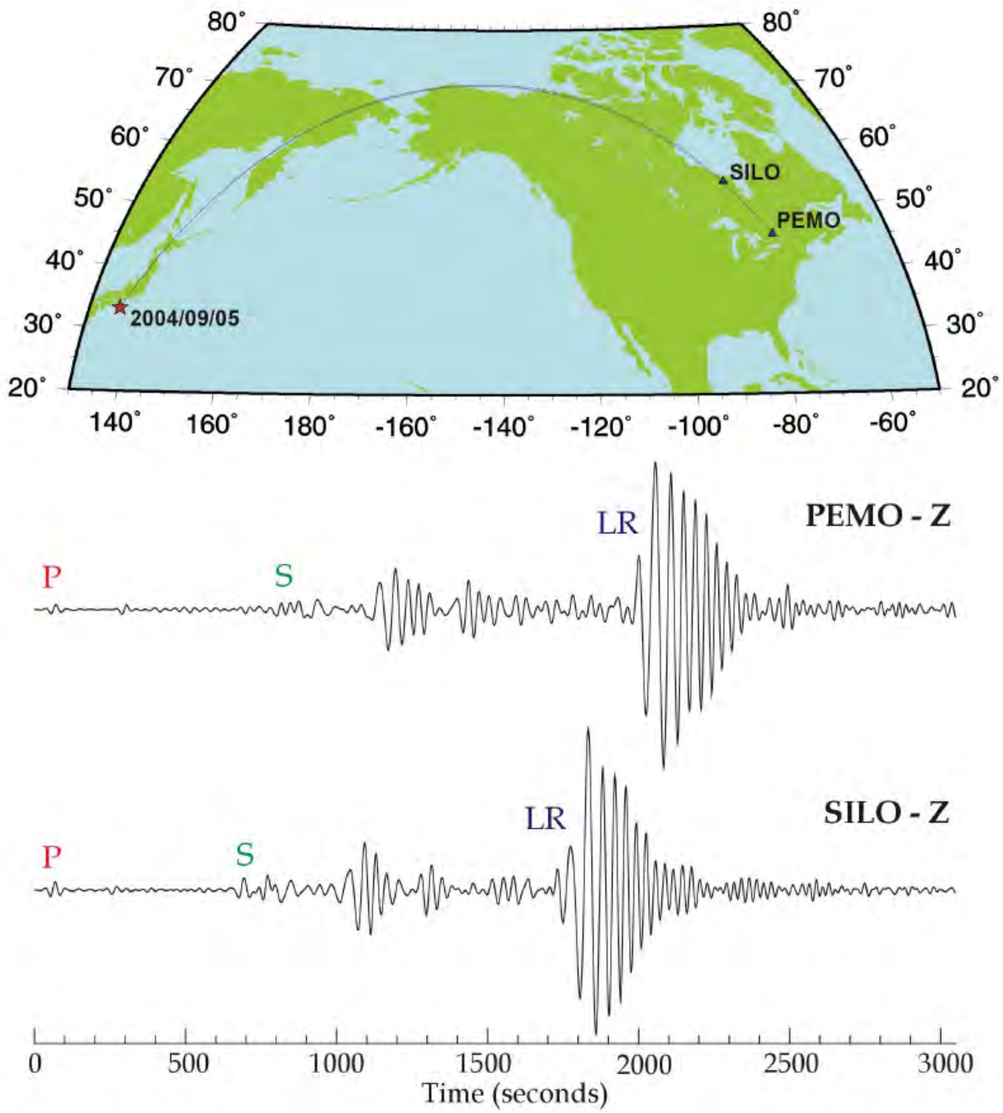


Earthquake near Vancouver Island, 2004, recorded by a seismograph station in southeast Ontario. Longer wave periods (lower frequencies) arrive earlier i.e. with higher group velocity.

Dispersion curves for ak135 global reference model



(computed for a crust/mantle model parameterised to 1100km depth)



Two-station measurements:

• Select two stations which lie on a common great-circle path from a teleseismic earthquake.

• Analyze seismograms together. Earthquake source function and effect of common path cancel out.

• Resulting dispersion relation is a measure of the average structure **between the stations**.

• This method is applied on regional scales in a tomographic inversion

TWO MAIN PAPERS TODAY

1.

Teleseismic surface wave tomography in the western U.S. using the Transportable Array component of USArray

Yingjie Yang,Michael H. Ritzwoller

GEOPHYSICAL RESEARCH LETTERS, VOL. 35, L04308, doi:10.1029/2007GL032278, 2008

2.

Surface wave tomography of the western United States from ambient seismic noise: Rayleigh wave group velocity maps

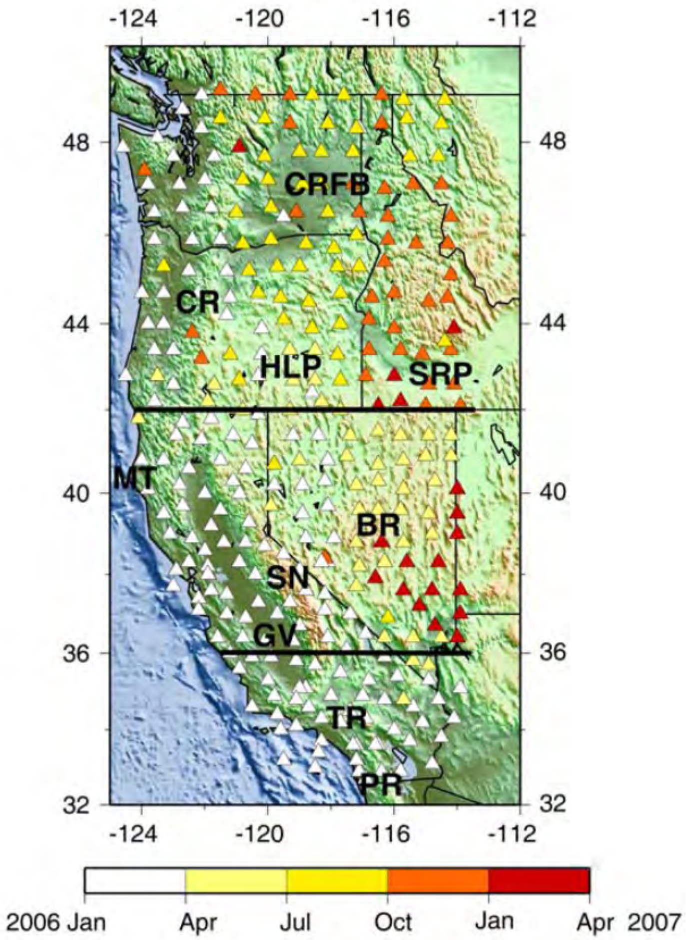
M. P. Moschetti, M. H. Ritzwoller, N. M. Shapiro

Geochem. Geophys. Geosyst., 8, Q08010,Volume 8, No. 8, August 2007

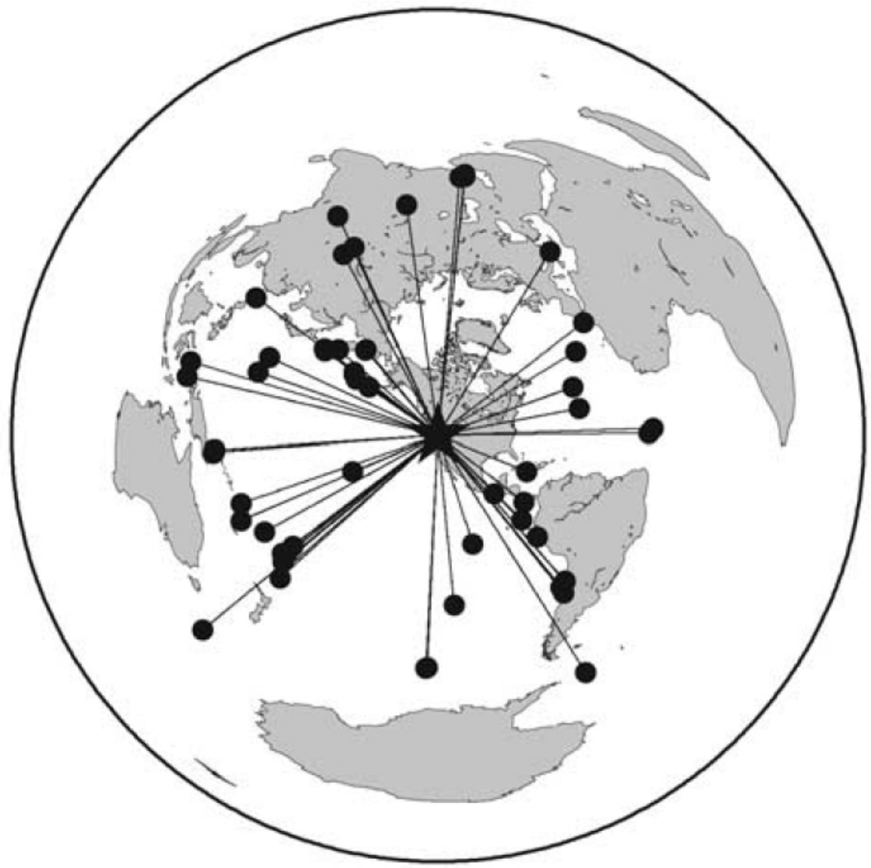
1. Teleseismic surface wave tomography in the western U.S. using the Transportable Array component of USArray

Yingjie Yang,Michael H. Ritzwoller, GRL, 2008

***Data**: fundamental mode Rayleigh waves*
@ T = 25, 33, 50, 66, 100 sec



Station network



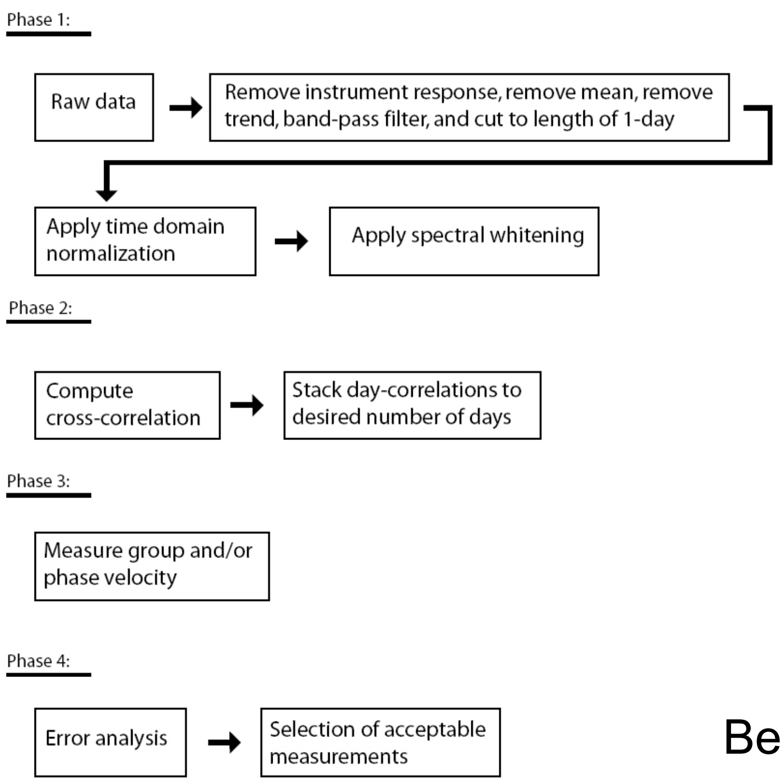
Earthquakes

2. Surface wave tomography of the western United States from ambient seismic noise: Rayleigh wave group velocity maps

M. P. Moschetti, M. H. Ritzwoller, N. M. Shapiro, G^3, 2007

Data/method: ambient noise surface wave tomography. Computation of Green's functions from cross-correlating noise records between every station-pair, 5-50 s period, dispersion of Rayleigh waves, group velocity @ 8, 16, 24, 30, 40 s periods

Data are stripped of EQs, despiked, demeaned, inst-deconvolved, etc., then long ' time periods are used in cross-correlations, then stacked, group/phase velocity Measured.



Benson et al (2007)

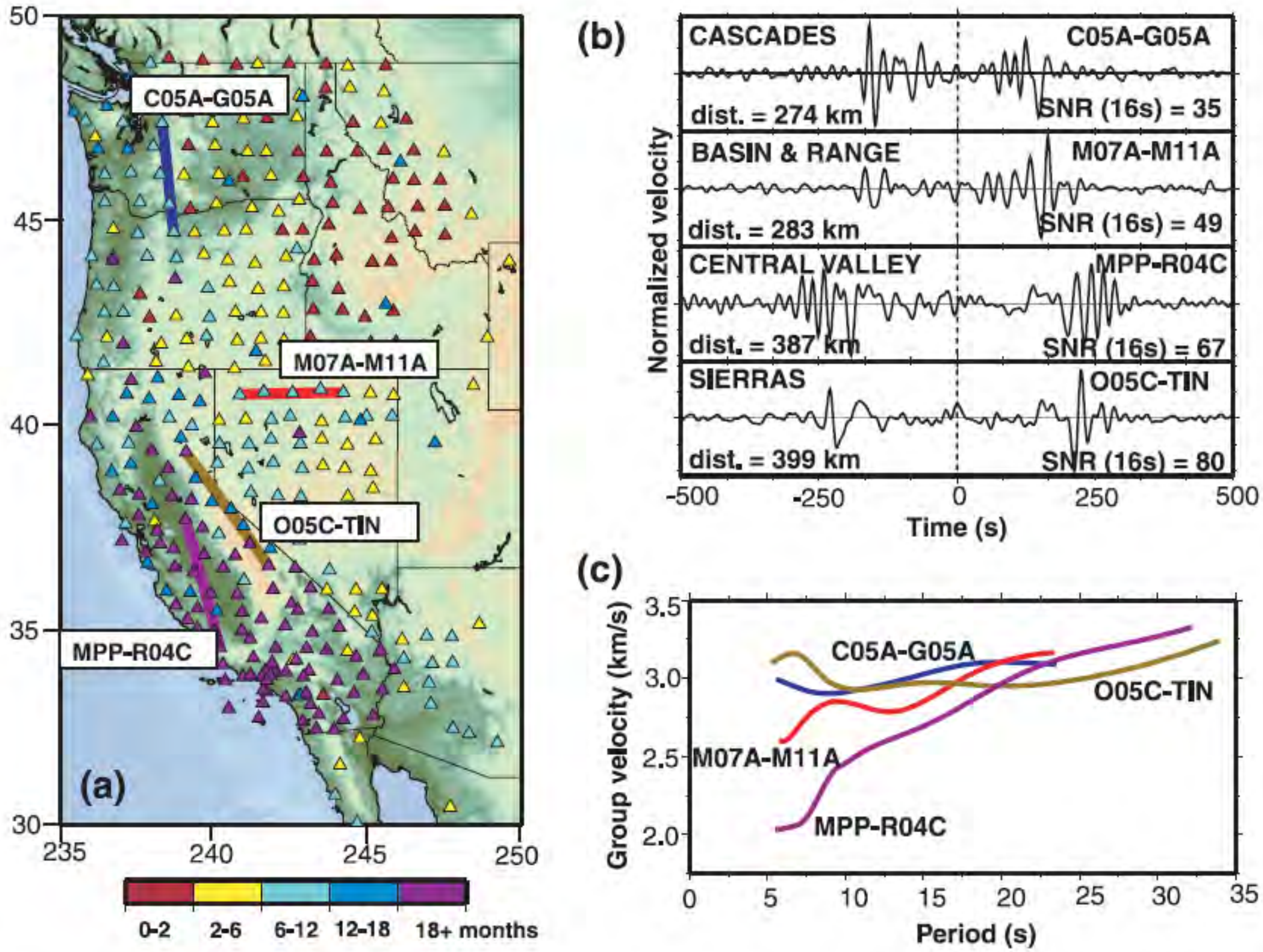


Figure 1. (a) Station locations used in this study, color coded by the time series length. Interstation paths for the measurements shown in Figures 1b and 1c are indicated. (b) Full, broadband cross-correlation waveforms from four receiver pairs. The waveforms result from time stacks of 3.4, 2.1, 17.5, and 13.6 months of data, respectively. (c) The dispersion curves are for the station-pairs labeled from the waveforms in Figure 1b.

Paper 2

Shapiro & Campillo (GRL 2004)

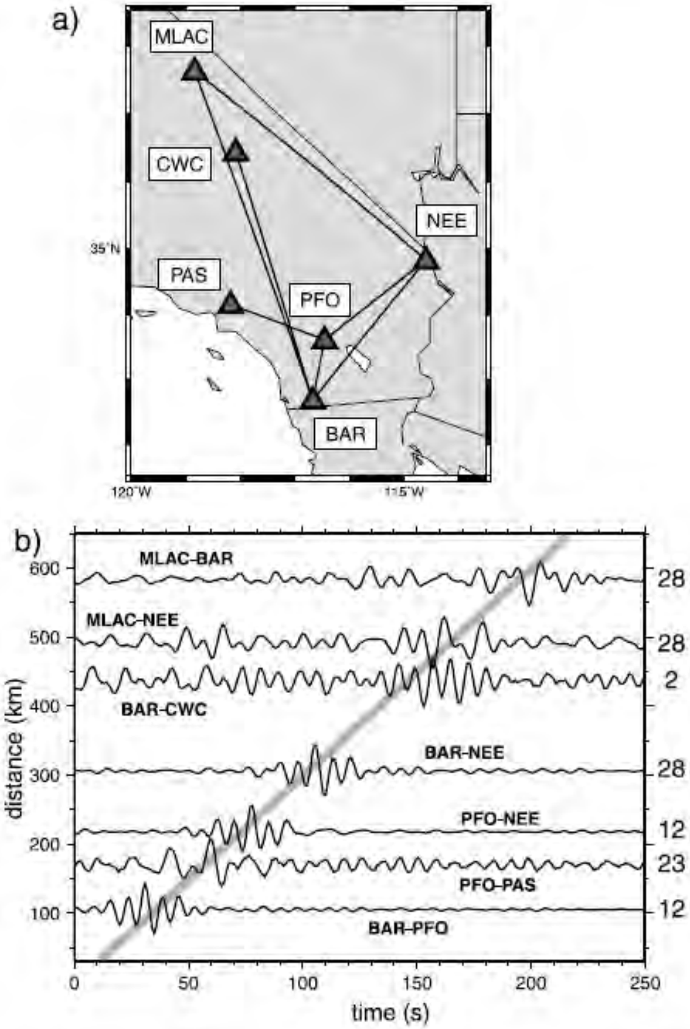


Figure 3. (a) Map showing six TERRAscope stations located in California. (b) Stacked cross-correlations of vertical-component short-period (5–30 s) computed from continuous records taken between 03/11/1996 and 04/09/1996. Gray line indicates times corresponding to velocity of 3 km/s. Total durations in days of the noise records available for each pair of stations is indicated on the right side of the plot.

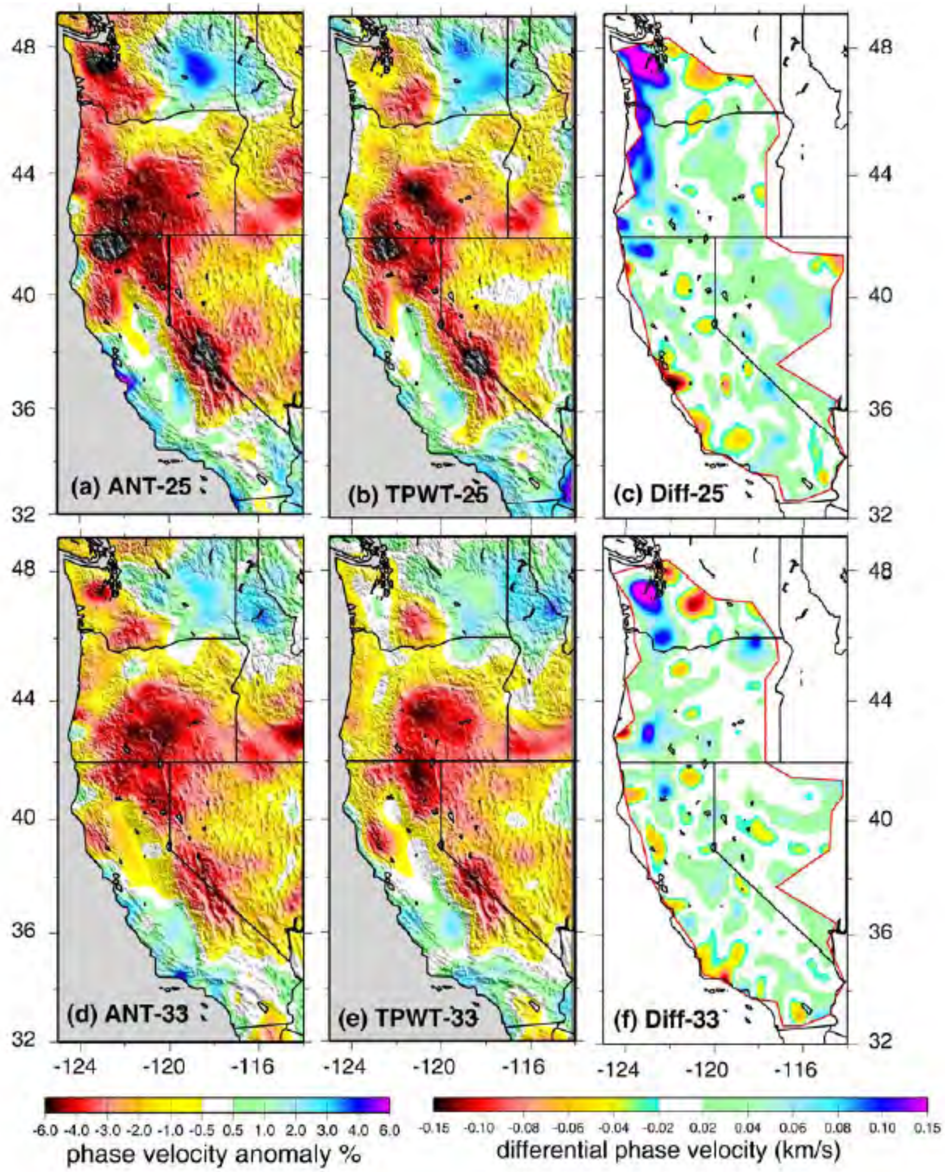


Figure 3. Rayleigh wave phase velocity maps from ambient noise tomography (ANT) compared with teleseismic two-plane wave tomography (TPWT). (a and b) ANT and TPWT at 25 s period, respectively. (d and e) ANT and TPWT at 33 s period, respectively. Anomalies are presented as the percent deviation from the average velocity across Southern California determined by *Yang and Forsyth* [2006a]. (c and f) Phase velocity differences between ANT and TPWT at 25 and 33 sec. The difference maps are clipped such that the red contour encompasses the region where seismic stations were deployed before September 15, 2006.

Paper 1

KEY POINTS

“noise” from a variety of sources produces diffuse traveling waves, which can be used to measure Rayleigh wave velocities, and hence Earth structure.

Care must be taken in some of the data processing steps (see Benson et al. 07)

ANT does not depend on earthquakes, and hence is not limited to EQ→station geometries, and thus can provide very important information for modeling crustal and uppermost mantle structure.

Coupled with traditional surface wave studies, Earth’s crust and uppermost mantle can be modeled with much greater resolution.