Microtremor measurements and seismic zonation in Peru

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■Status for a year after installation of new strong motion sensors in Lima

■Application of seismic interferometry to continuous recording data

■Results of analysis for earthquake data in Lima by Selene Quispe and microtremor data by Diana Calderon

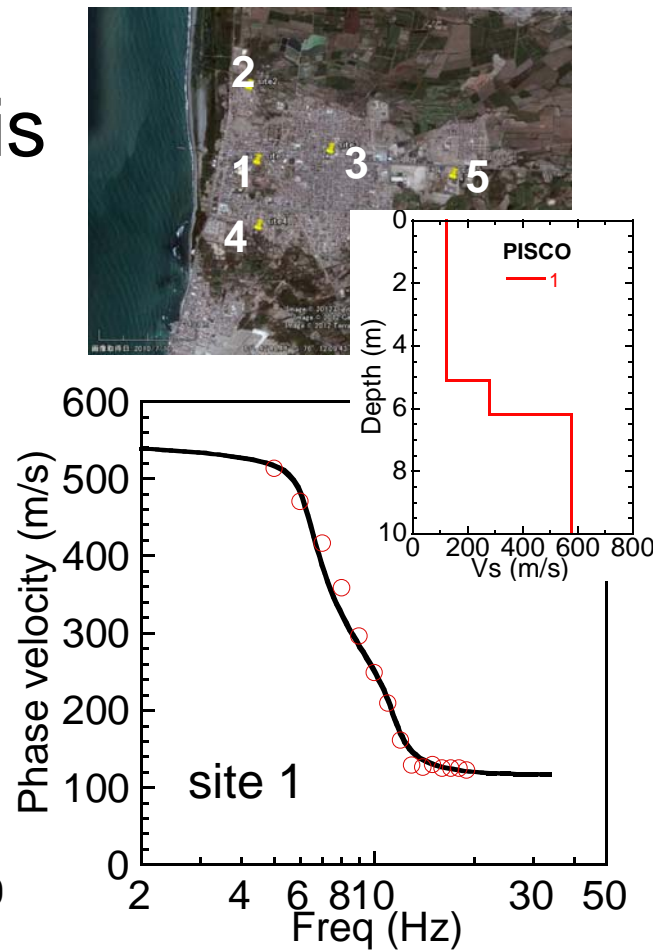# Microtremor exploration in Pisco
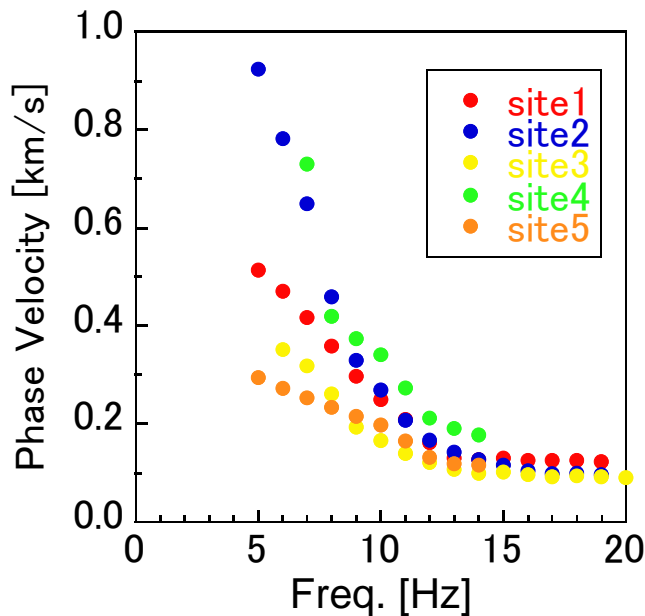

Jan 18-19, 2012
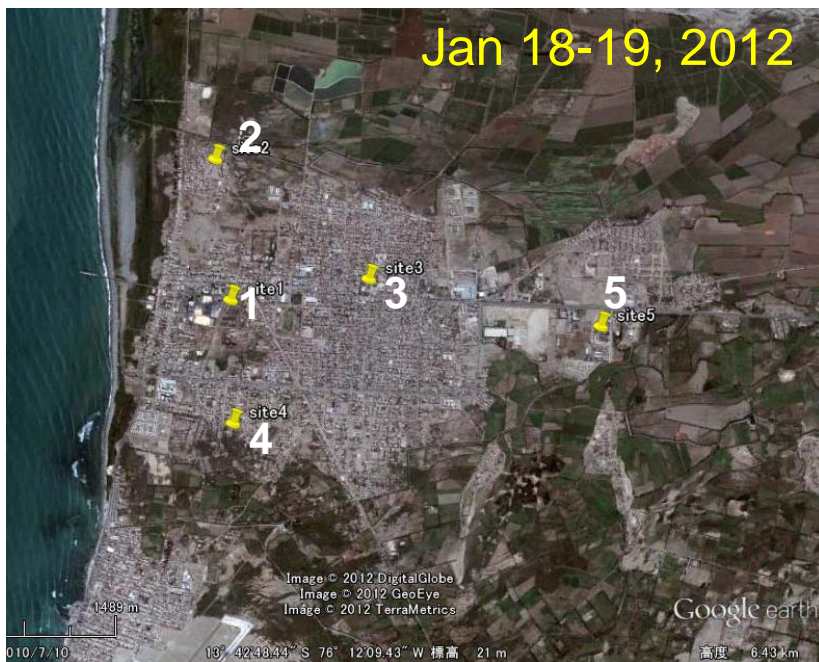
Triangular arrays with 4 sensors

Site	Length (m)
1	3,10,30
2	3,8,20,50
3	3,8,16
4	3,10,20
5	3,8,20

Microtremors obs in Pisco

Results of analysis of array data
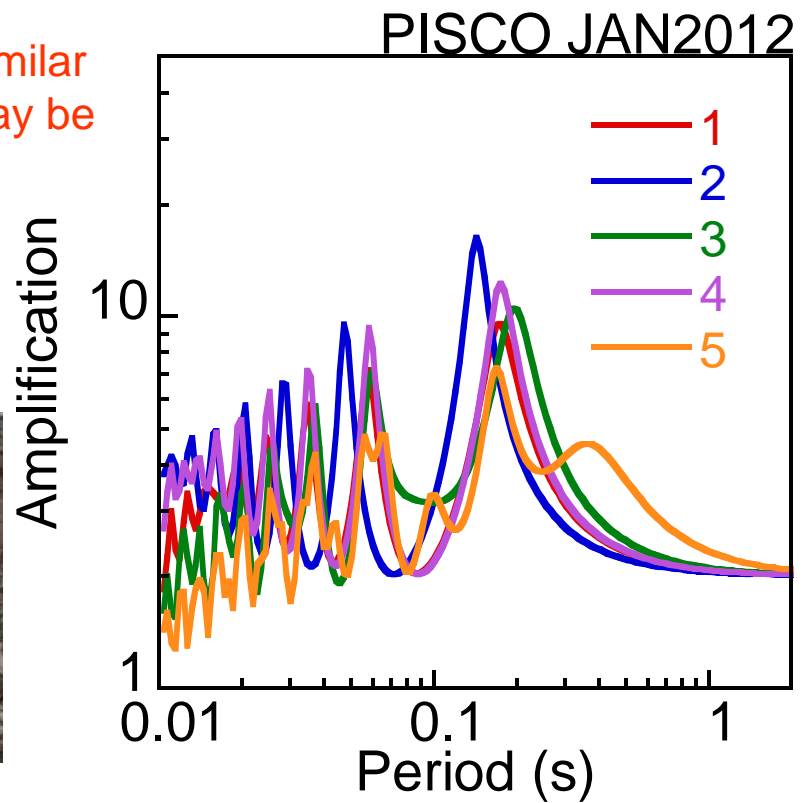

S-wave velocity profiles

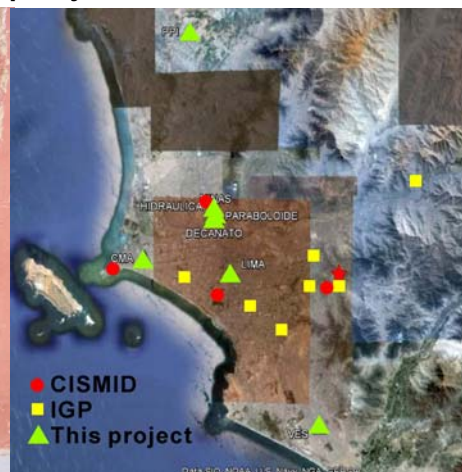| Site	AVs30	AVs10
1	345	191
2	455	225
3	309	164
4	439	208
5	228	160
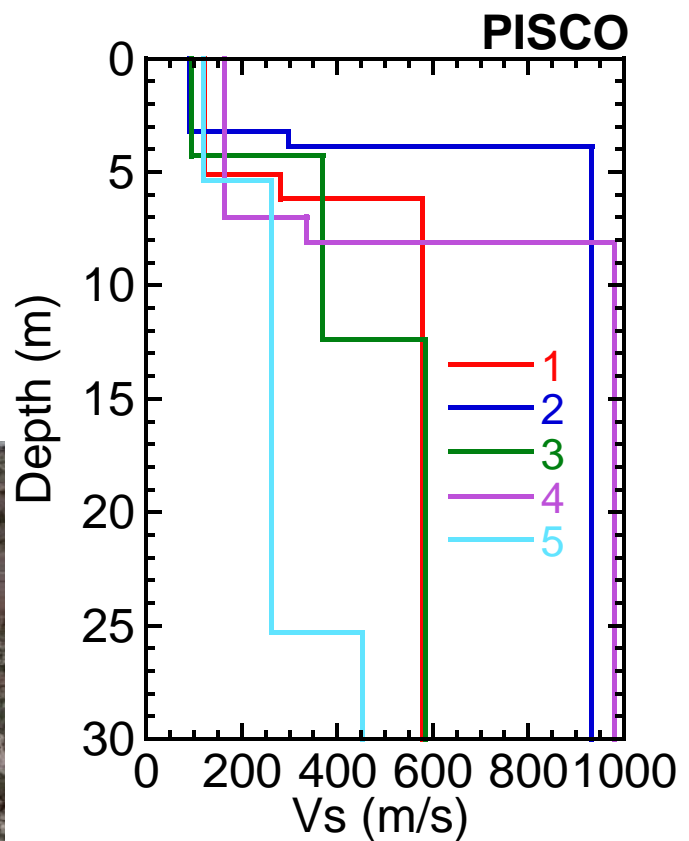
Site amplifications

Dominant periods are similar at all sites. The site 5 may be slightly difference.

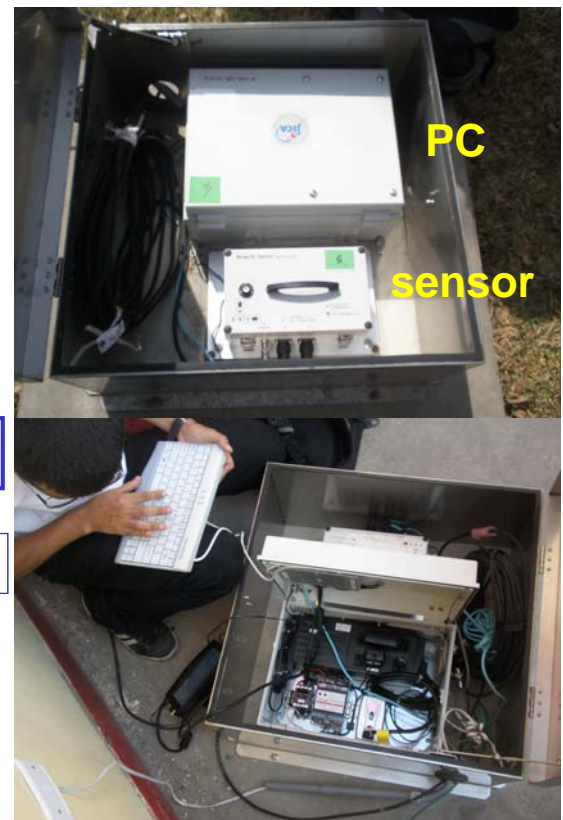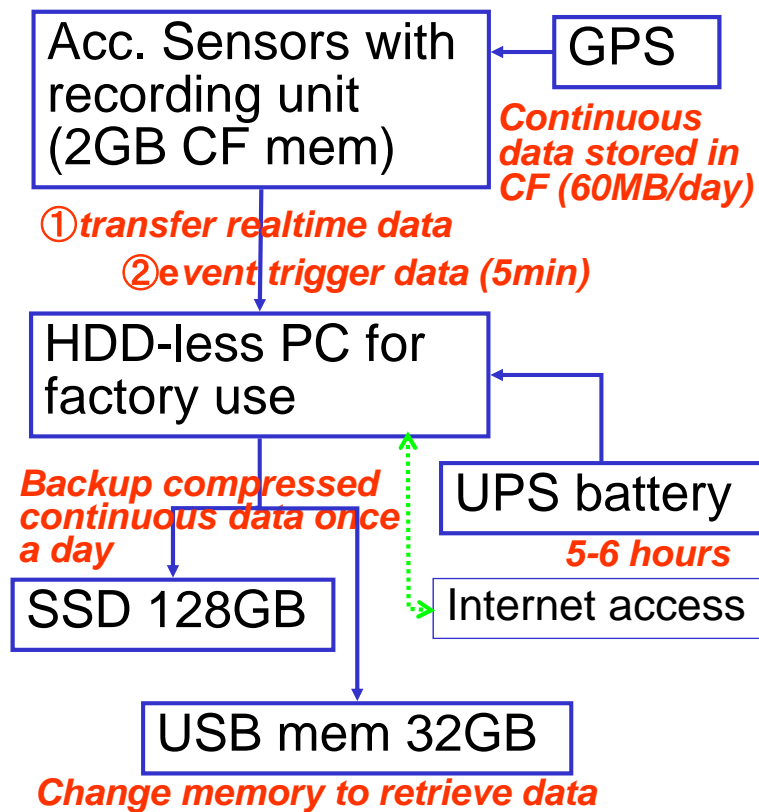PISCO JAN2012

Strong motion sites
10 strong motion instruments are prepared in the project

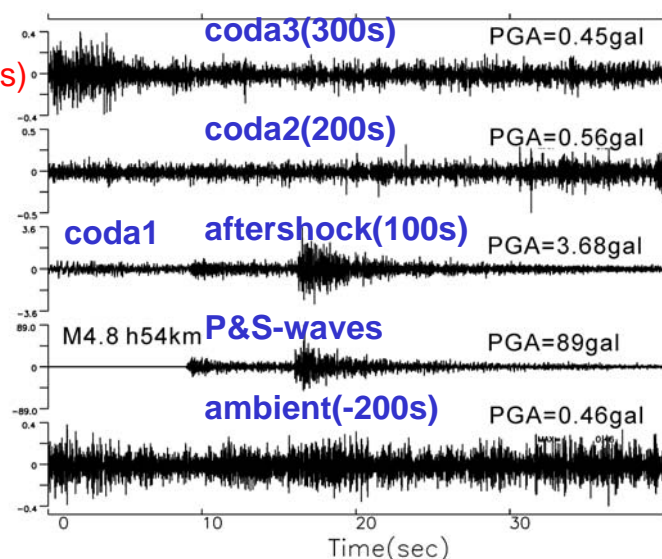Temperature of the instruments is very high under strong sunshine

New strong motion instruments
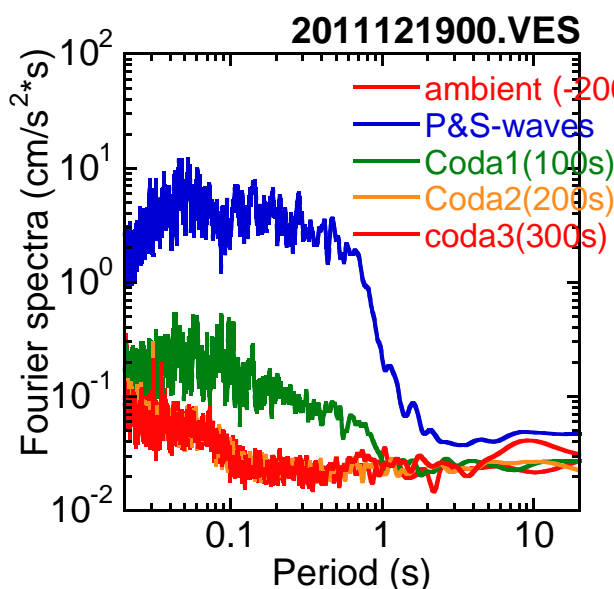
Acc. Sensors with recording unit (2GB CF mem)

GPS

Continuous data stored in CF (60MB/day)

①*transfer realtime data*
②*event trigger data (5min)*

HDD-less PC for factory use

Backup compressed continuous data once a day

UPS battery

5-6 hours

SSD 128GB

Internet access

USB mem 32GB

Change memory to retrieve data
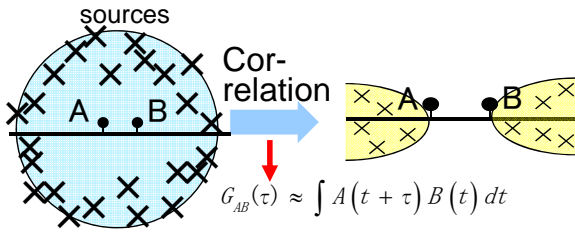
PC

sensor

Spectra at different levels

Continuous data provide records before and during event (M4.8, h54km), its aftershock and ambient noises are compared.

➡ Ambient noises are enough larger than instrumental noise levels to use the records as microtremor data
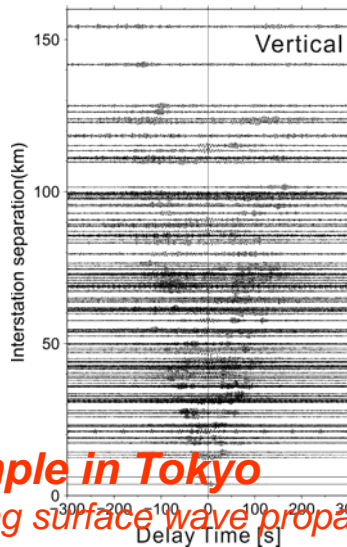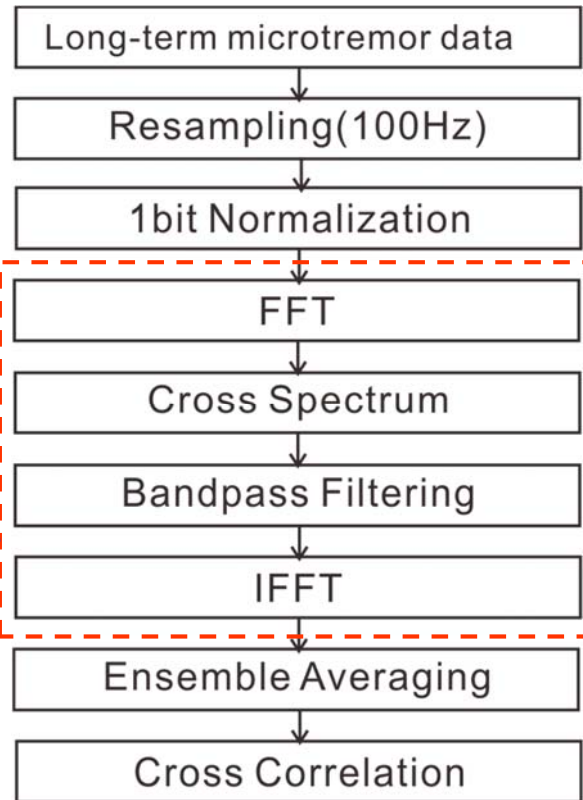
2011121900.VES

ambient (-200s)
P&S-waves
Coda1(100s)
Coda2(200s)
coda3(300s)

Fourier spectra (cm/s^2*s)

Period (s)

coda3(300s) PGA=0.45gal
coda2(200s) PGA=0.56gal
coda1 aftershock(100s) PGA=3.68gal
M4.8 h54km P&S-waves PGA=89gal
ambient(-200s) PGA=0.46gal

Time(sec)

Seismic interferometric analysis of continuous recording in Lima

sources
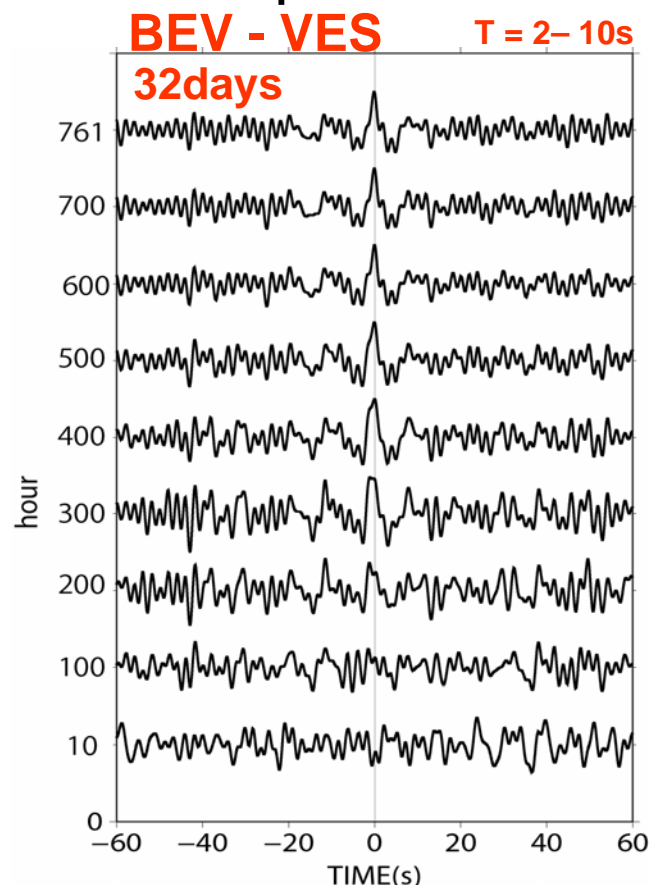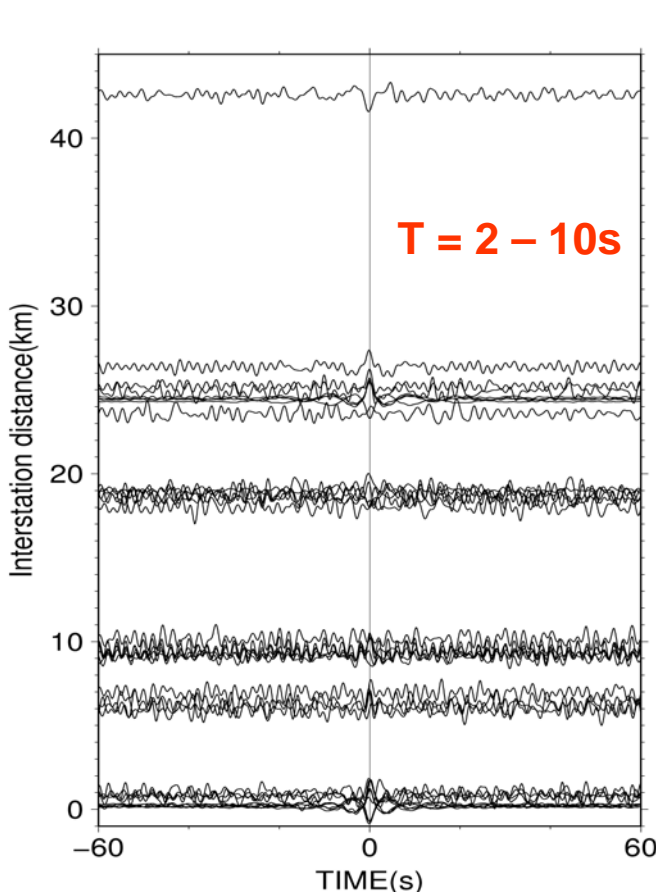
Cor-relation

$$G_{AB}(\tau) \approx \int A(t + \tau) B(t) \, dt$$

Contribution from sources in yellow zone remain with constructive interferences

Example in Tokyo
showing surface wave propagation

Long-term microtremor data

Resampling(100Hz)

1bit Normalization

FFT

Cross Spectrum

Bandpass Filtering

IFFT

Every one hour data

Ensemble Averaging

Cross Correlation

Correlation between all station pairs Lima

BEV - VES   T = 2– 10s

32days

T = 2 – 10s

Analysis of ground motion data for site amplifications by S. Quispe (CISMID)

Spectral separation technique was applied to the existing strong motion data before the project.
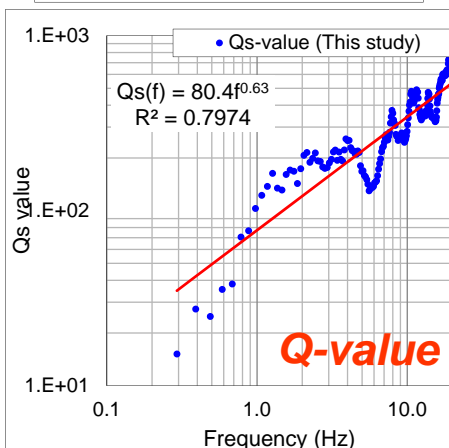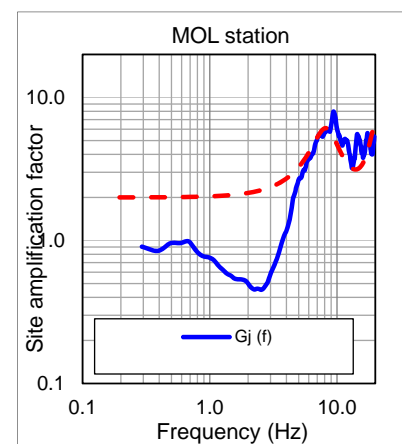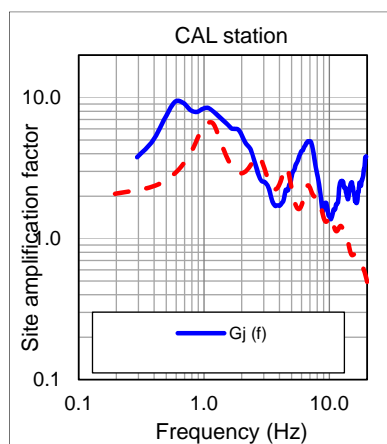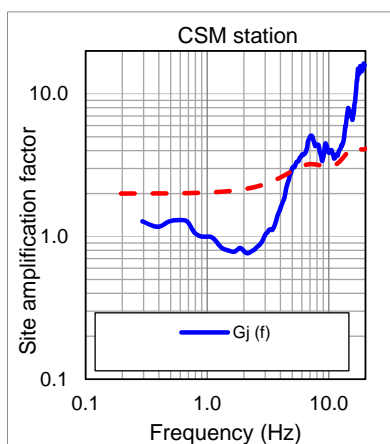30 records at 5 sites during 11 earthquakes were available for Lima area.

Only one record at CSM

CDLCIP as reference site
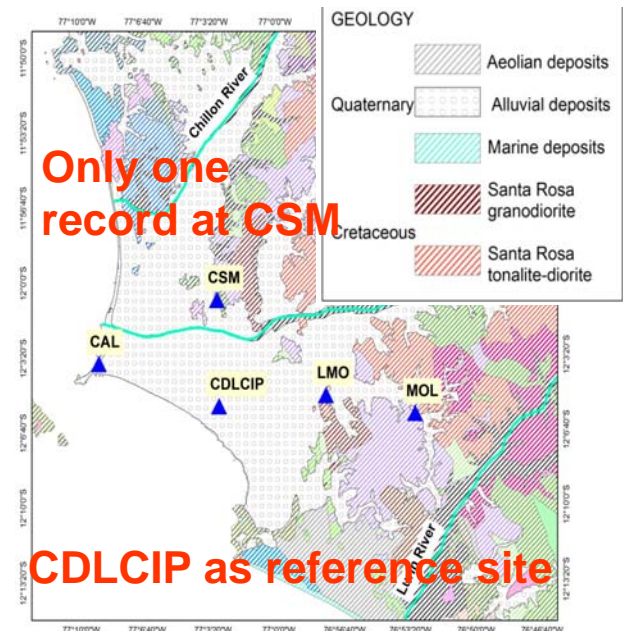
Source, Path and Site effects

reference Vs800m/s
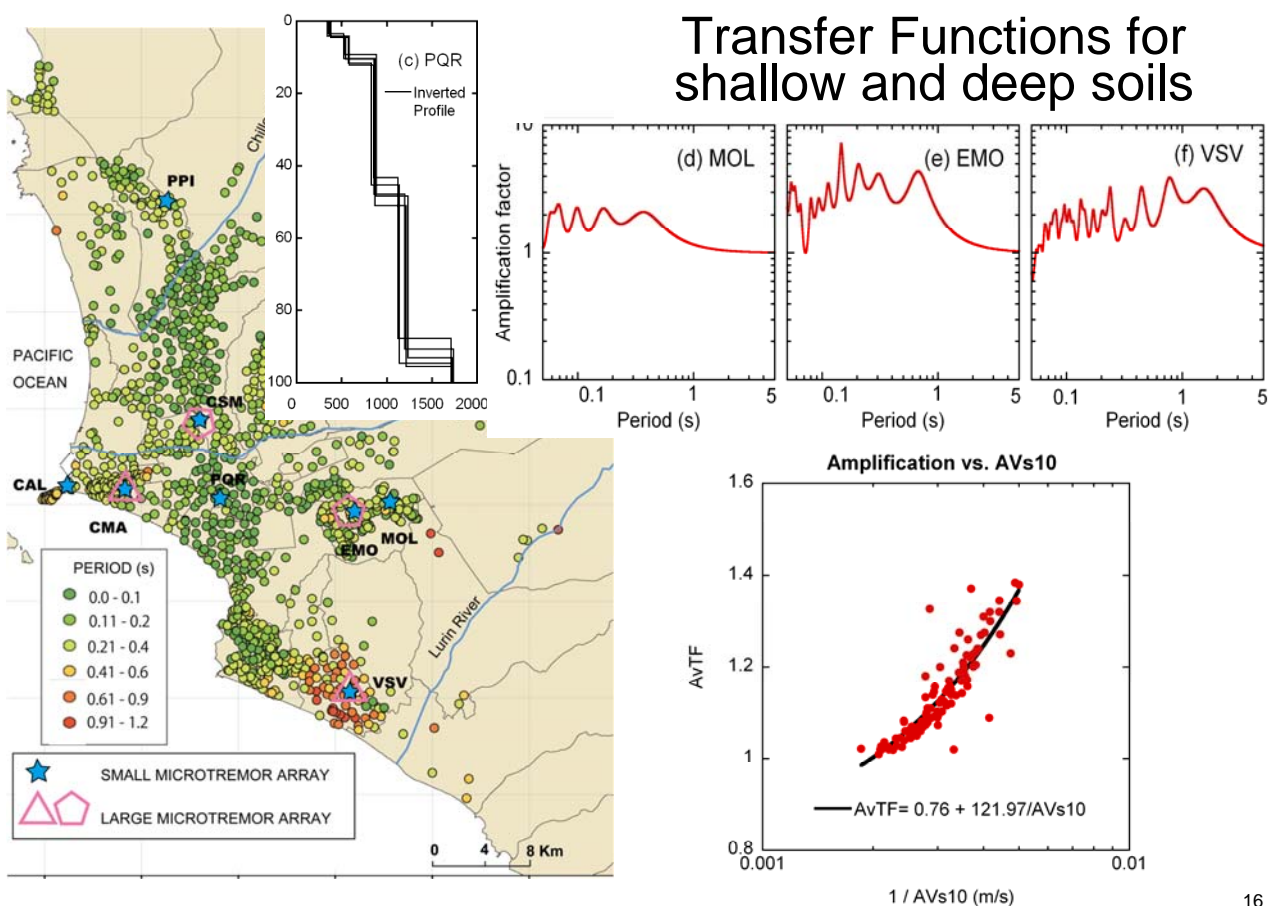

$Qs(f) = 80.4f^{0.63}$
$R^2 = 0.7974$

Q-value

Source
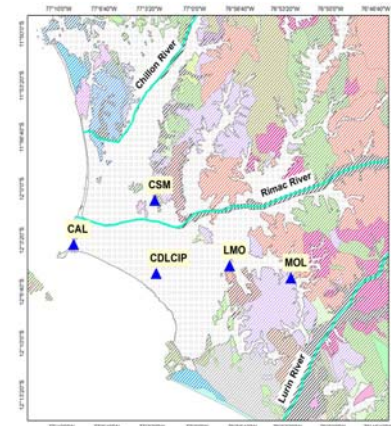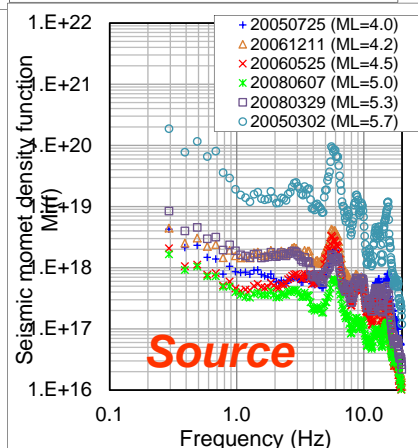
RESULTS FROM THE ARRAY MEASUREMENTS AND DEVELOPMENT OF THE AMPLIFICATION MAP

From PhD Thesis by D. Calderon
at Chiba Univ

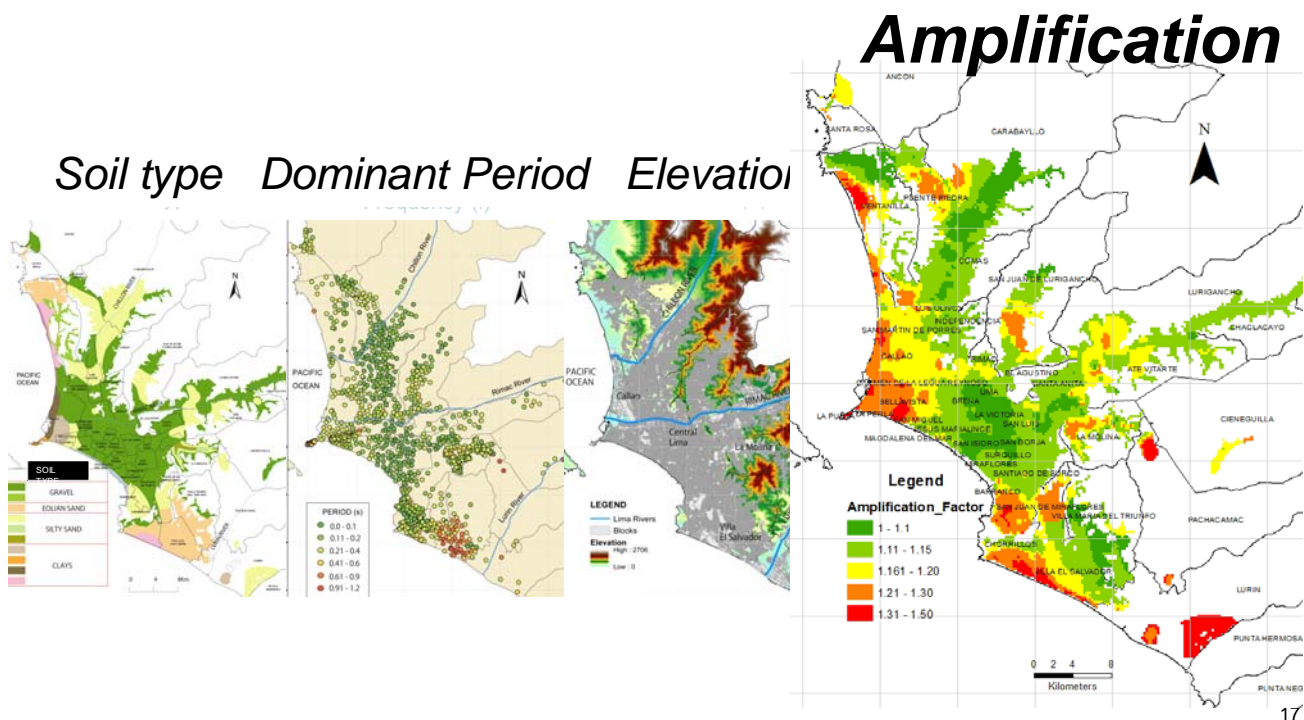Amplifications from microtremor array measurements

Transfer Functions for shallow and deep soils

Information available for empirical equation

AVS10=F(soil type, dominant freq, elevation)

Amplification (freq=1-20Hz) =G(AVS10)

Amplification

Soil type   Dominant Period   Elevation

Conclusions

- Vs-profiles were estimated at 5 sites in Pisco. Amplifications are the similar.

- Continuous records from strong motion observation were accumulated. Small troubles must be resolved for stable observation.

- Preliminary analysis using seismic interferometry shows difficulty to retrieve surface waves in Lima.

- Preliminary analysis of strong ground motion data around Lima was conducted to know source, path and site effects.

- Site amplification map was successfully constructed in entire Lima area.

- Strong motion simulation was conducted for scenario earthquake in Lima