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ACCIONES QUE CONTRIBUYEN A LA ESTIMACIÓN DEL PELIGRO SÍSMICO

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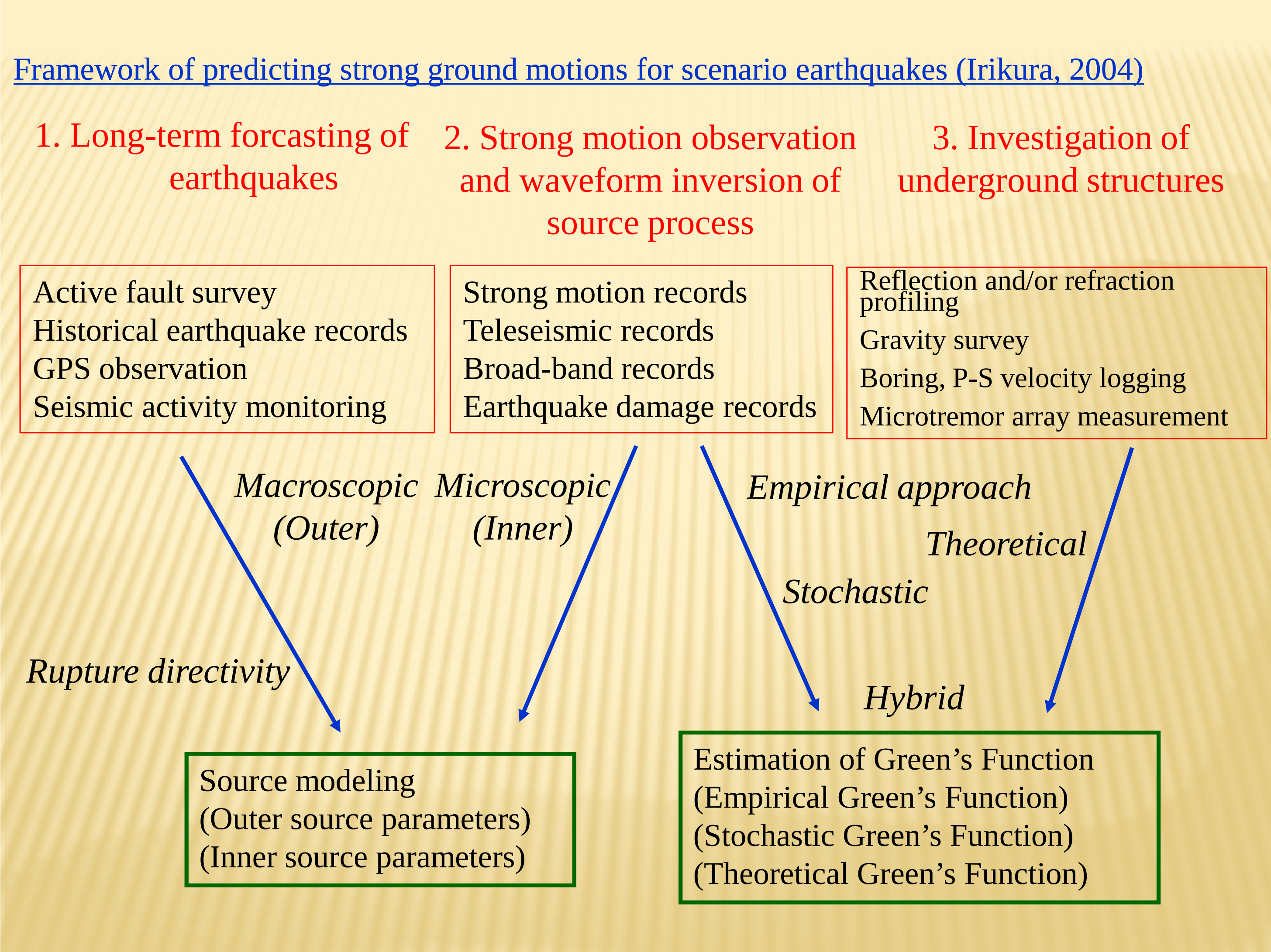
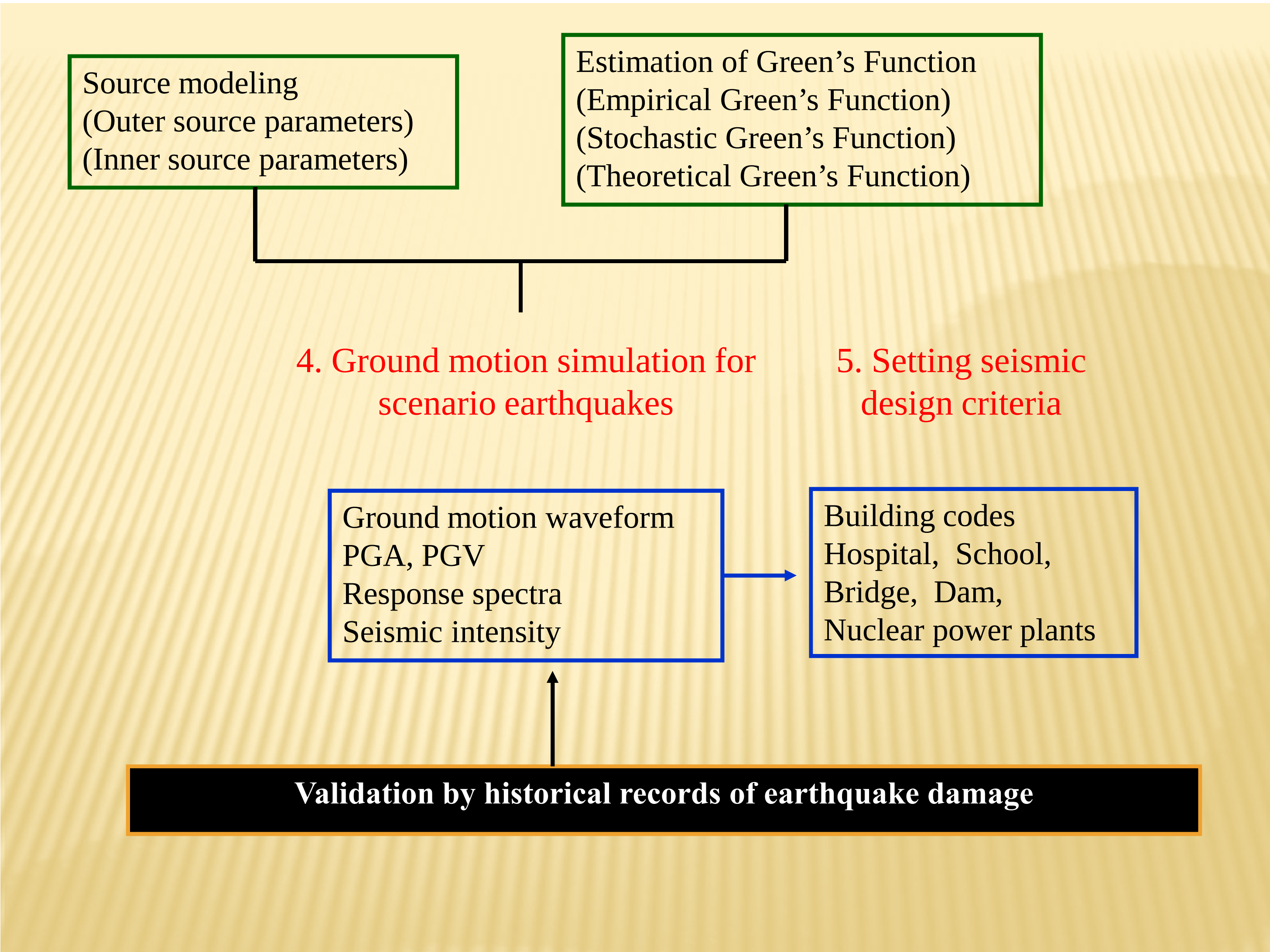
ACTIONS THAT CONTRIBUTE TO THE SEISMIC HAZARD ESTIMATION

- Probabilistic Approach
  - PGA Distribution espected for a given period of time
    - Definition of seismogenic Zones
    - Ground Motion Atenuation Relation
- Deterministic Approach
  - Waveforms from a specific earthquake scenario.
    - Details of Seismic Source (characterization)
    - Details of Path.
    - Details of Site Effect.


Framework of predicting strong ground motions for scenario earthquakes (Irikura, 2004)
1. Long-term forcasting of earthquakes
2. Strong motion observation and waveform inversion of source process
3. Investigation of underground structures
Active fault survey
Historical earthquake records
GPS observation
Seismic activity monitoring
Strong motion records
Teleseismic records
Broad-band records
Earthquake damage records
Reflection and/or refraction profiling
Gravity survey
Boring, P-S velocity logging
Microtremor array measurement
Macroscopic (Outer)
Microscopic (Inner)
Empirical approach
Theoretical
Stochastic
Rupture directivity
Hybrid
Source modeling
(Outer source parameters)
(Inner source parameters)
Estimation of Green's Function
(Empirical Green's Function)
(Stochastic Green's Function)
(Theoretical Green's Function)


Source modeling
(Outer source parameters)
(Inner source parameters)
Estimation of Green's Function
(Empirical Green's Function)
(Stochastic Green's Function)
(Theoretical Green's Function)
4. Ground motion simulation for scenario earthquakes
5. Setting seismic design criteria
Ground motion waveform
PGA, PGV
Response spectra
Seismic intensity
Building codes
Hospital, School,
Bridge, Dam,
Nuclear power plants
Validation by historical records of earthquake damage

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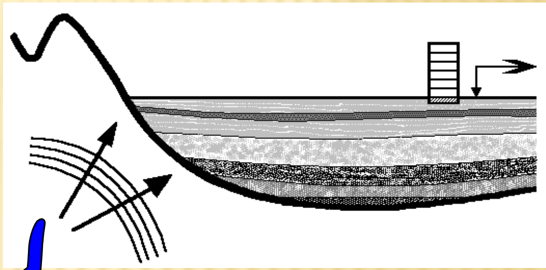
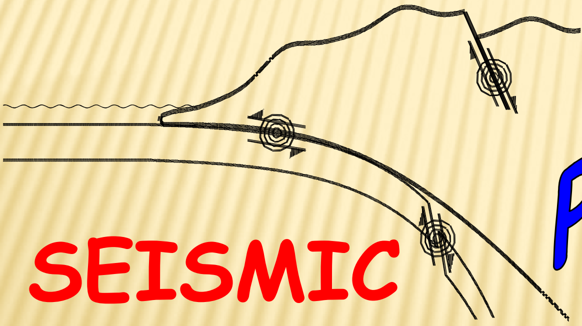
SITE EFFECTS



PATH



SEISMIC SOURCE

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EARTHQUAKE STRONG GROUND MOTIONS

- SEISMIC SOURCE CHARACTERIZATION
  INER and OUTER PARAMETERS
- SEISMIC WAVES PATH
  GMAR
  ATENUATION
- LOCAL GROUND CONDITIONS
  Site effects

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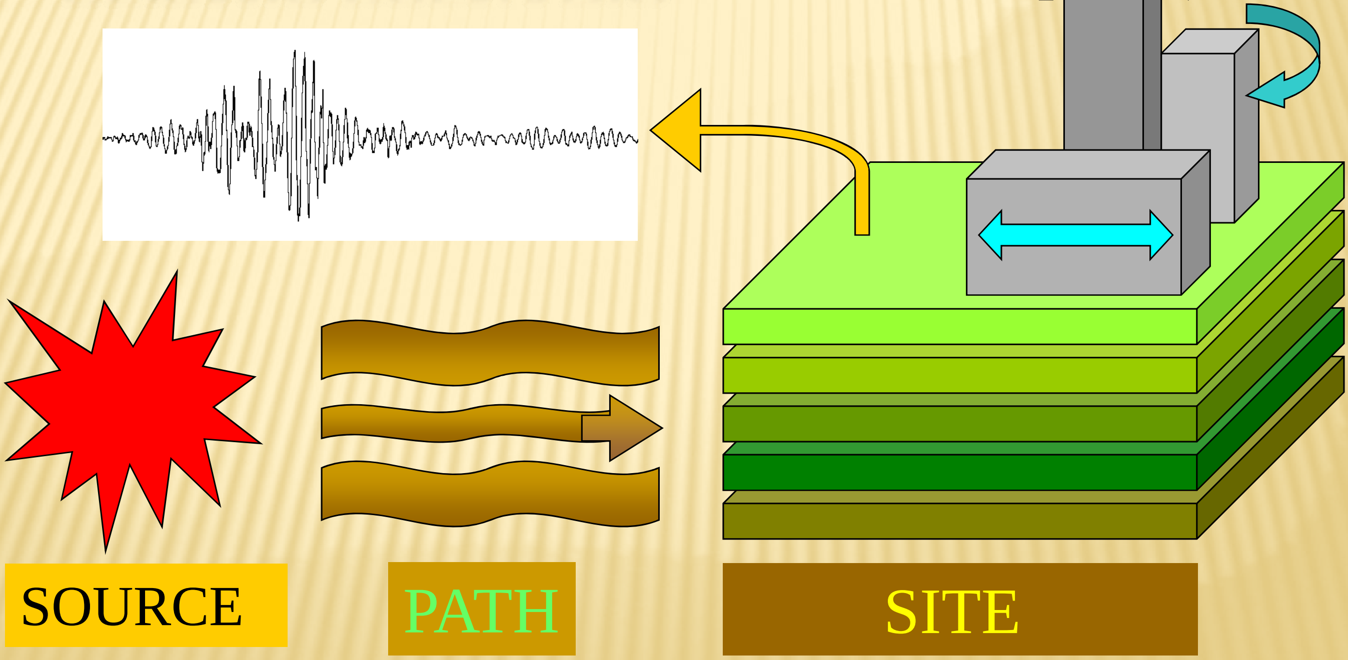
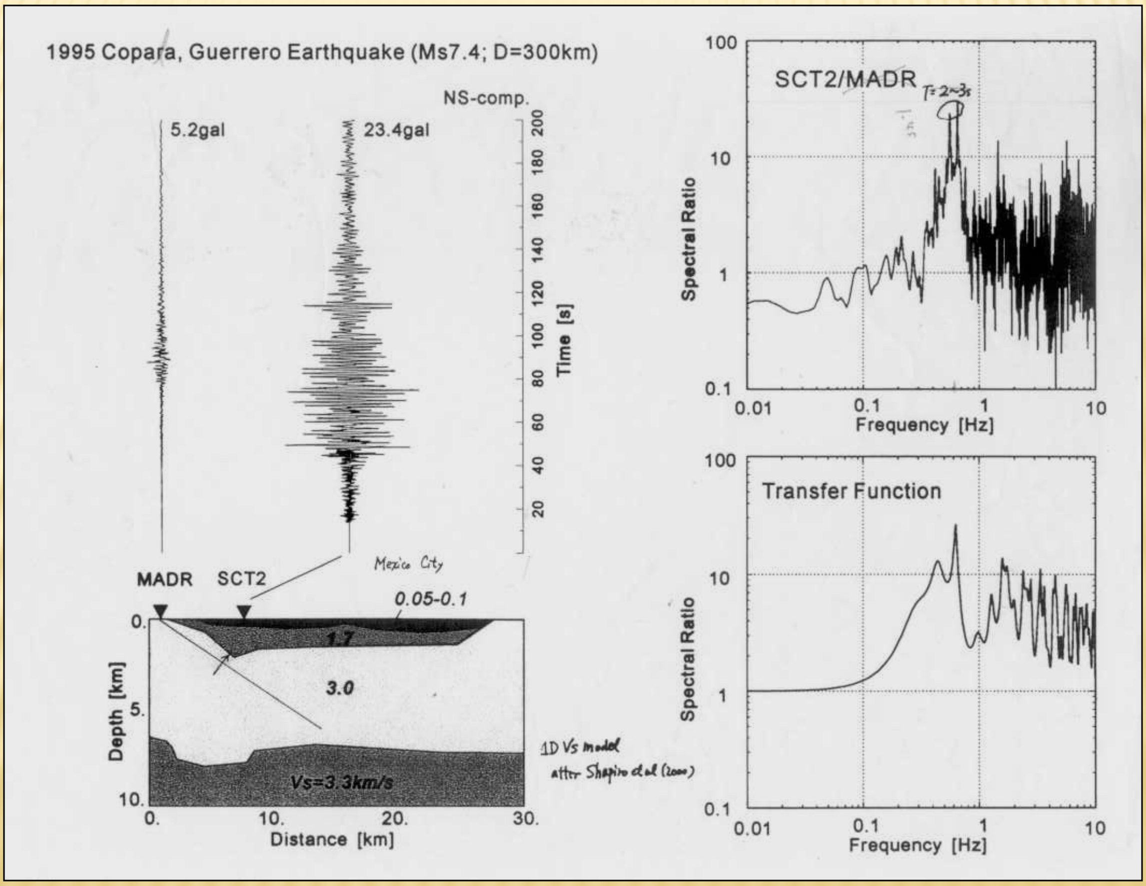
SEISMIC SCENARIO



SITE EFFECTS

HOW TO EVALUATE THE SITE EFFECTS?



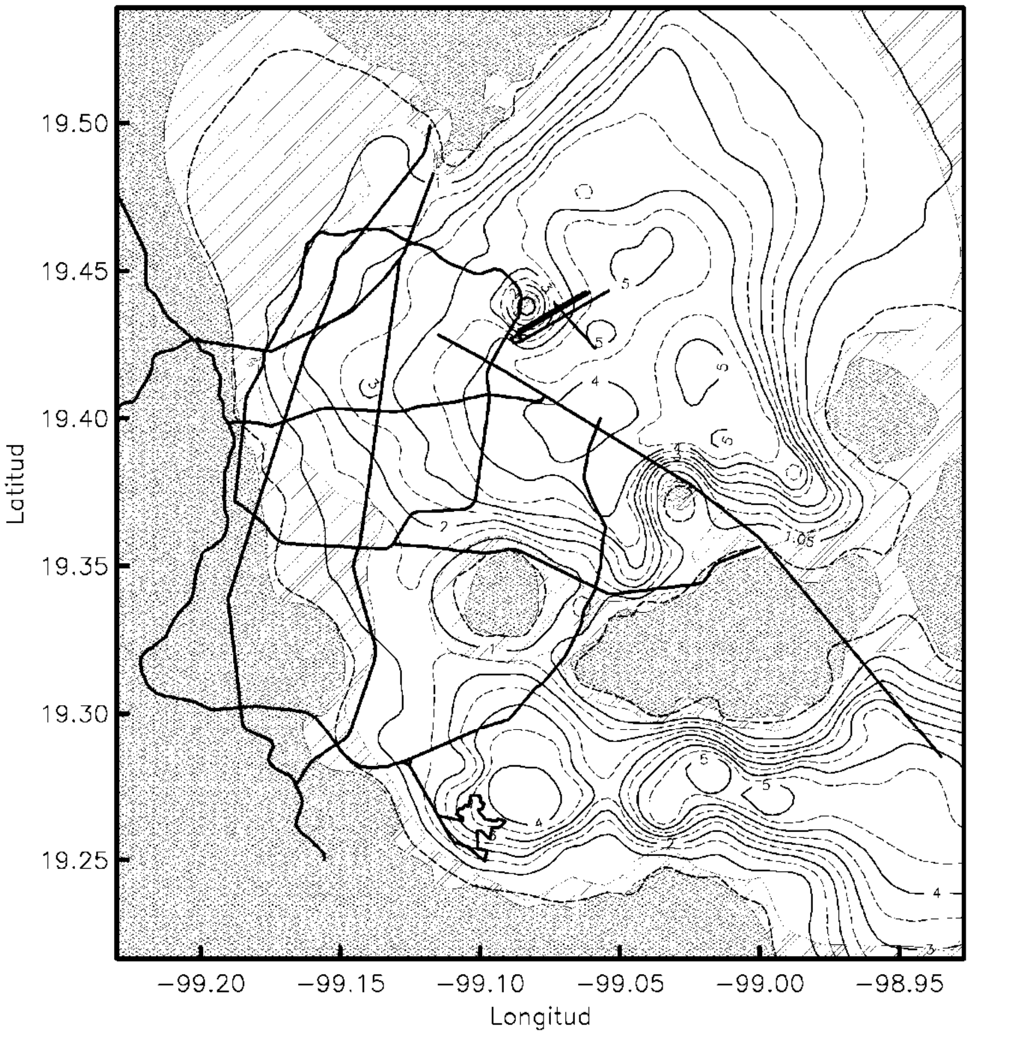
HOW TO EVALUATE THE SITE EFFECTS?

By Knowing the physical characteristics of the surfitial layers:

- Thickness
- P wave propagation velocity
- S wave propagation velocity
- Density
- Damping

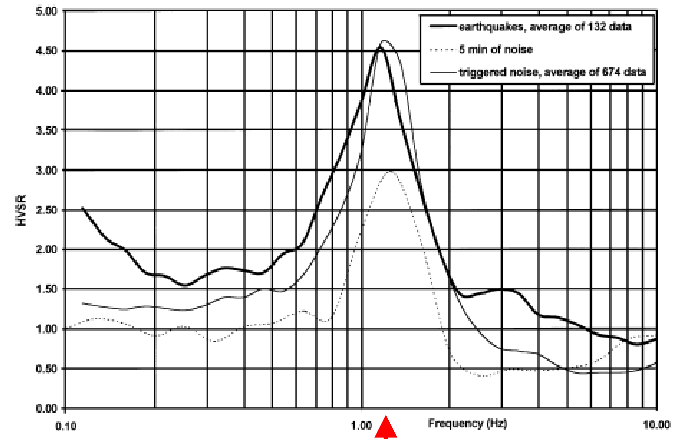
Exploration methods:

- Seismic Refraction
- Crosshole
- Downhole
- Refletion
- Methods that use microtremors
  - HVSR, ReMi, f-k, SPAC



Predominant Period

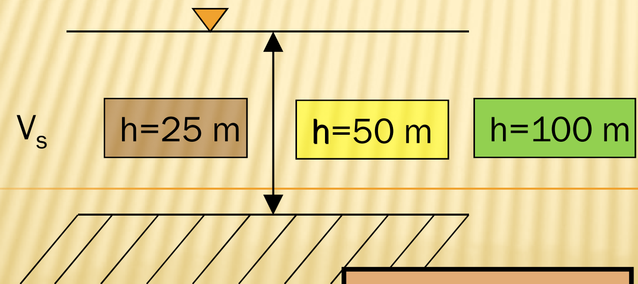
Uso "tradicional" de Microtremores



$$HVSR = \frac{Comp.Horiz.(f)}{Comp.Vert.(f)}$$

Figure 2. Average of HVSR calculated for 132 earthquakes (thick line), 674 triggered noise recordings (thin line), and a standard microtremor measurement (dotted line).

f=1.2 Hz



$$f = \frac{V_s}{4h}$$

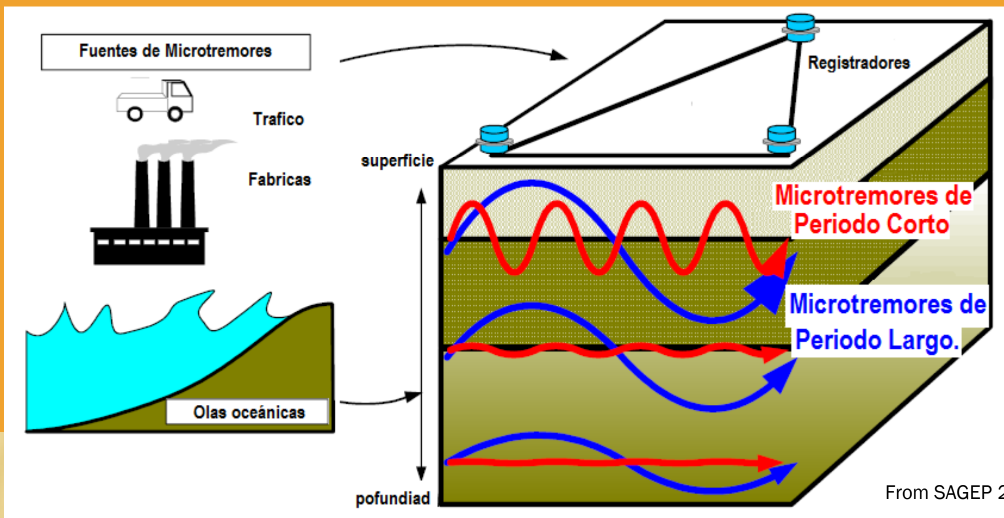
V_s=120 m/s

V_s=240 m/s

V_s=480 m/s

SPAC METHOD (SPATIAL AUTOCORRELATION METHOD)

- Propoused by Aki (1957).
- Microtremors in instrumental arrays.
- Rayleigh waves phase velocity dispersion curves estimation, through the spatial autocorrelation.
- Velocity structure   * At least 3 stations.



From SAGEP 2003 (corporation OYO).

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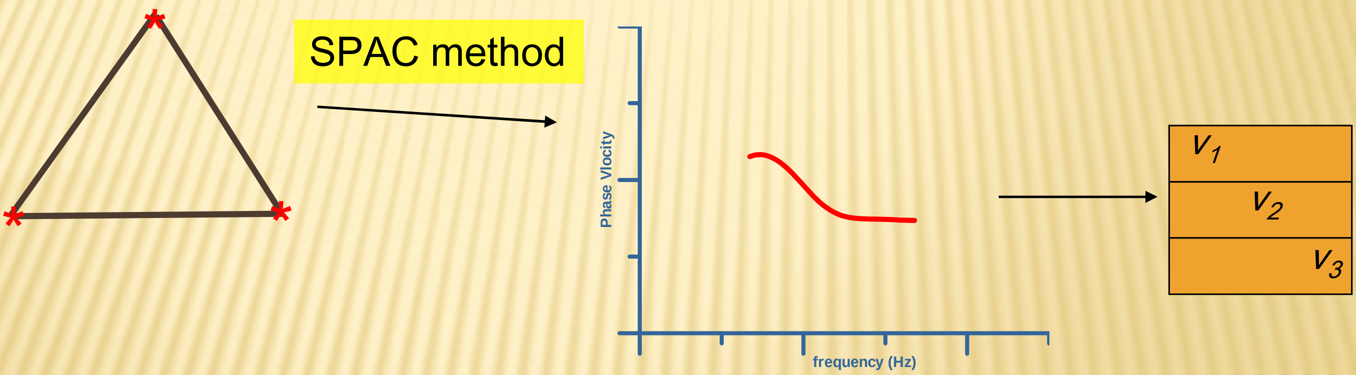
SPAC METHOD MICROTREMORS ARRAY OBSERVATION



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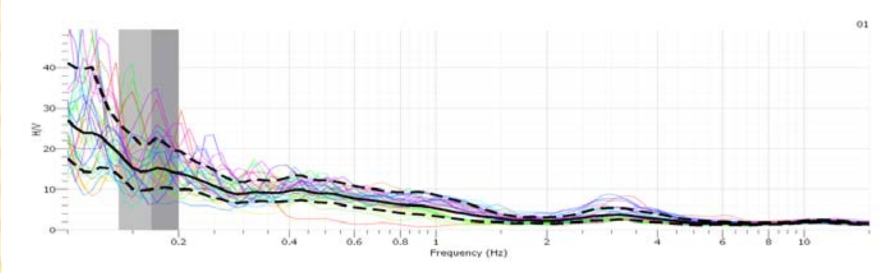
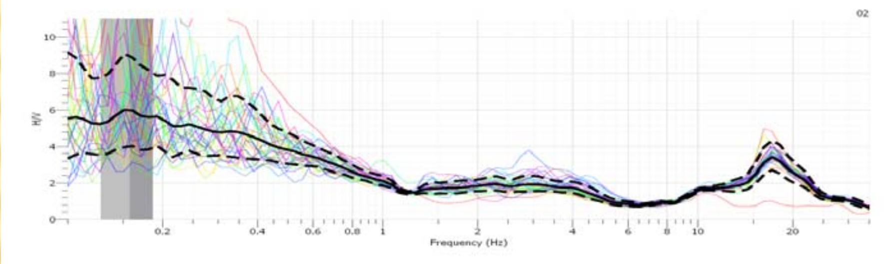
EXAMPLES OF MICROTREMOR ARRAY OBSERVATION USING TRIANGLES

H/V USING GURALP FOR THE LARGEST ARRAY

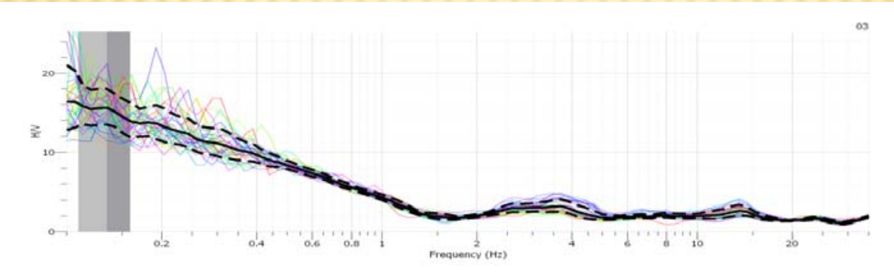


Estation 01

Fo=0.16
14 times H/V



Estation 02



Estation 03
Band pass filter 0.1-10 Hz

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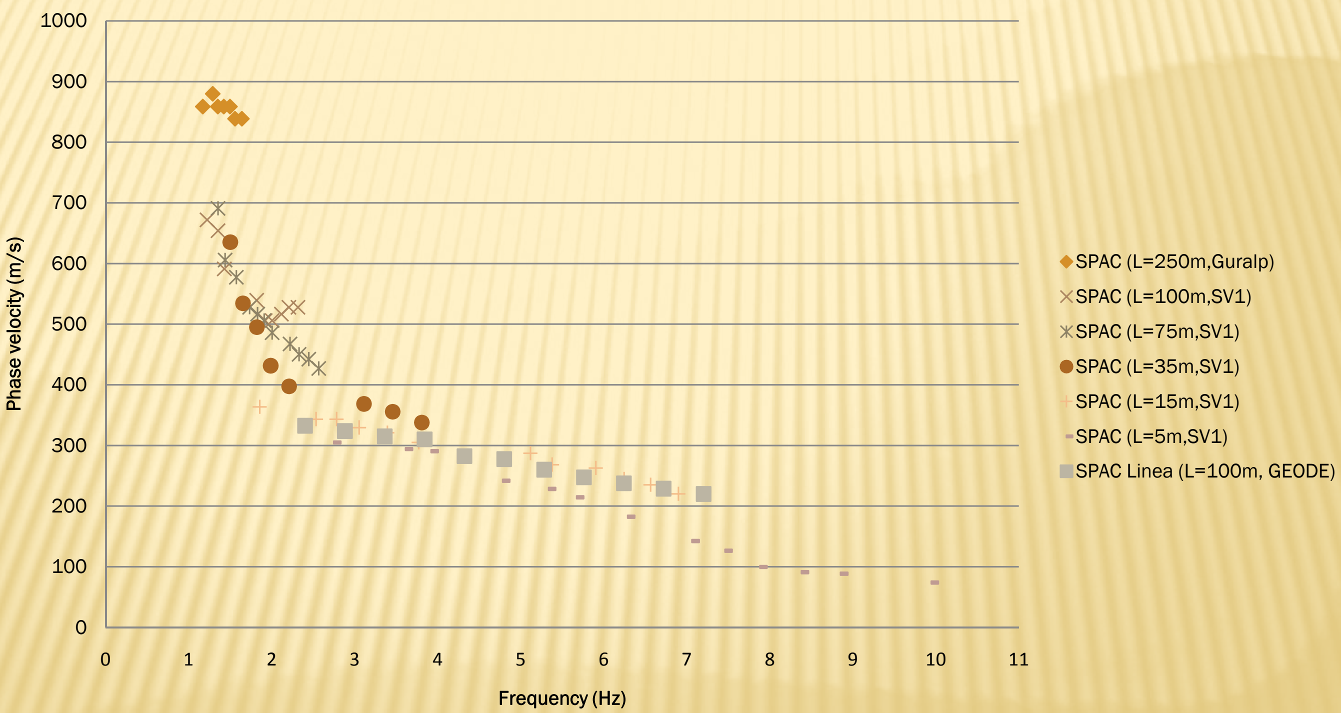
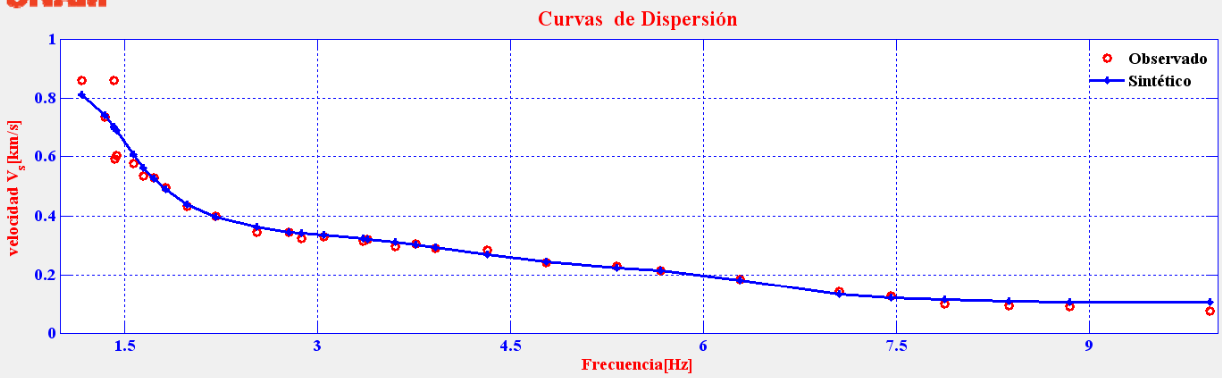
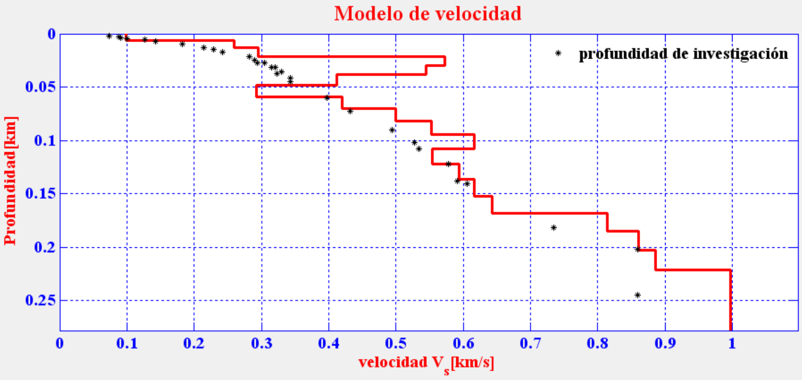
All the array sizes

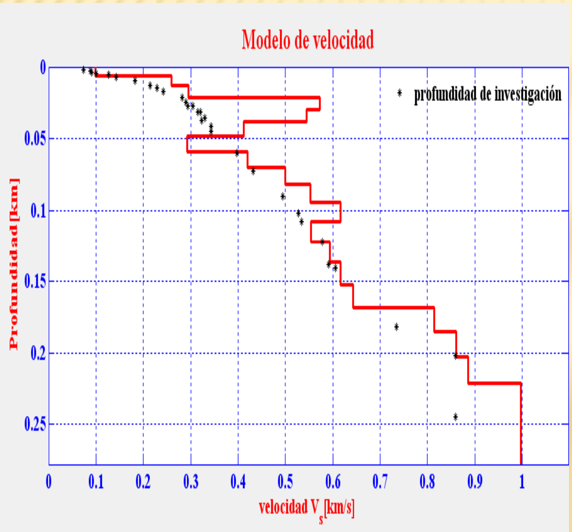


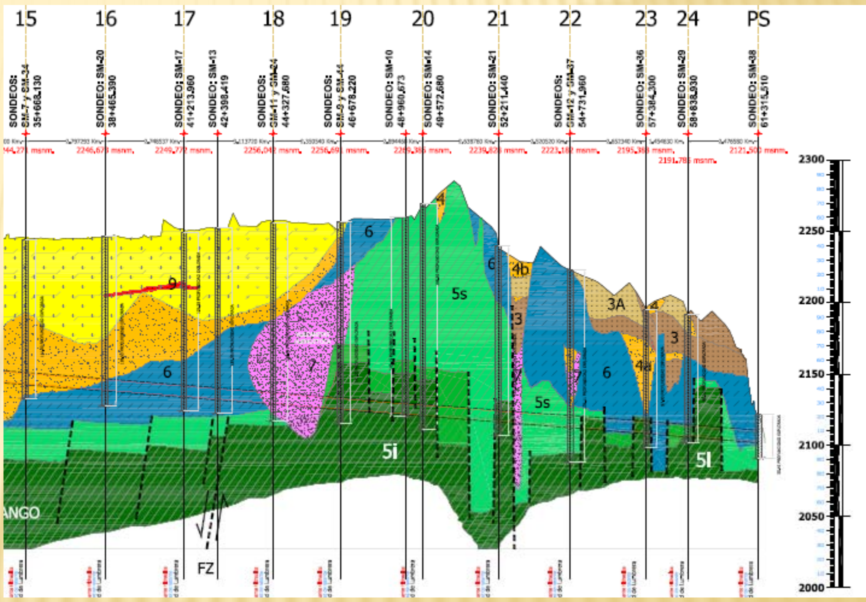




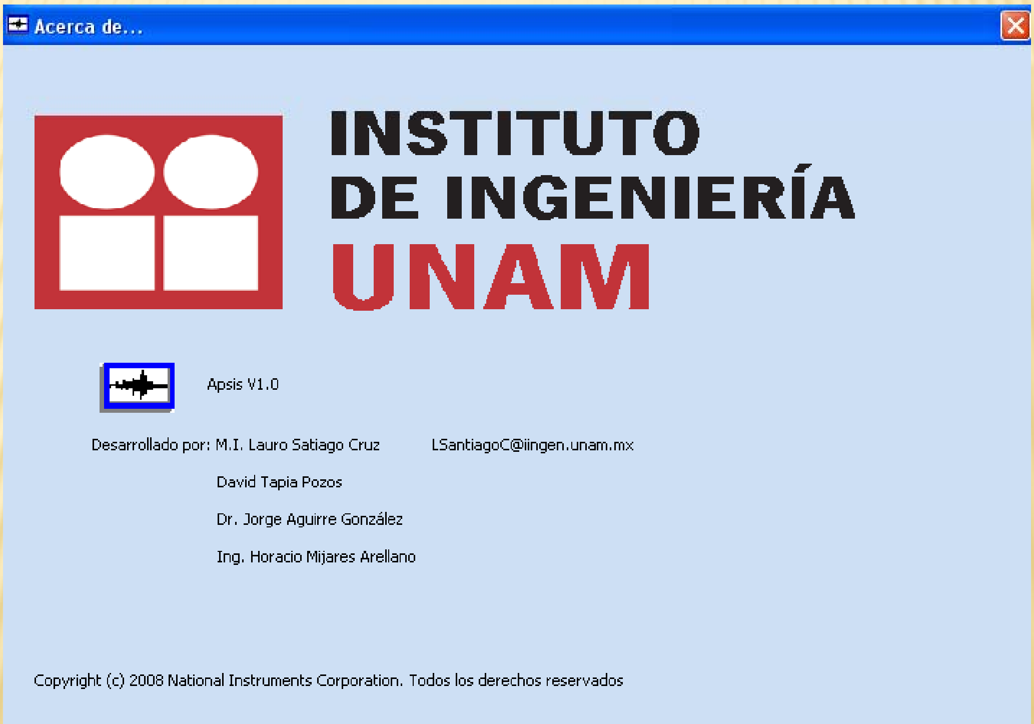
profundidad[km]	velocidad V_s[km/s]
0.000	0.099
0.006	0.099
0.013	0.259
0.021	0.296
0.029	0.572
0.039	0.544
0.048	0.412
0.059	0.293
0.070	0.420
0.082	0.500
0.095	0.553
0.108	0.616
0.122	0.553
0.137	0.594
0.152	0.617
0.168	0.642
0.185	0.814
0.203	0.860
0.221	0.886
0.278	0.998

COMPARISON WITH THE GEOLOGICAL MODEL

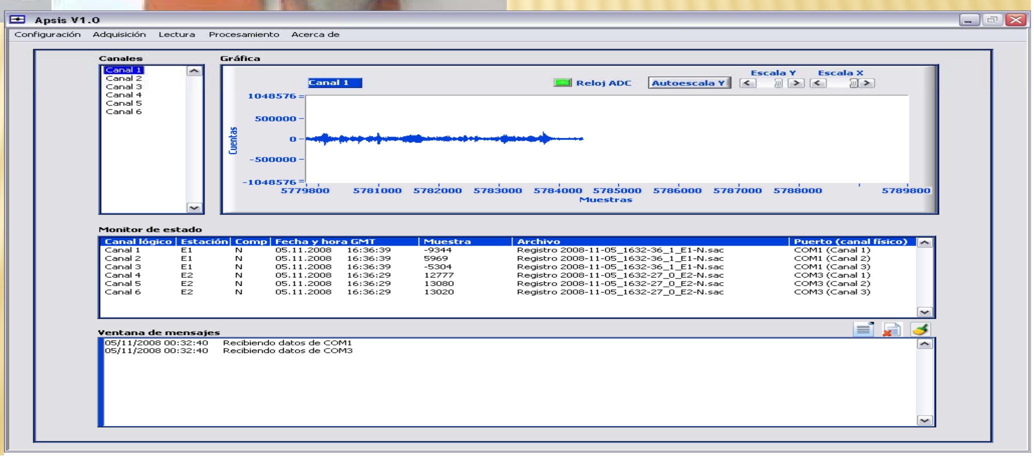




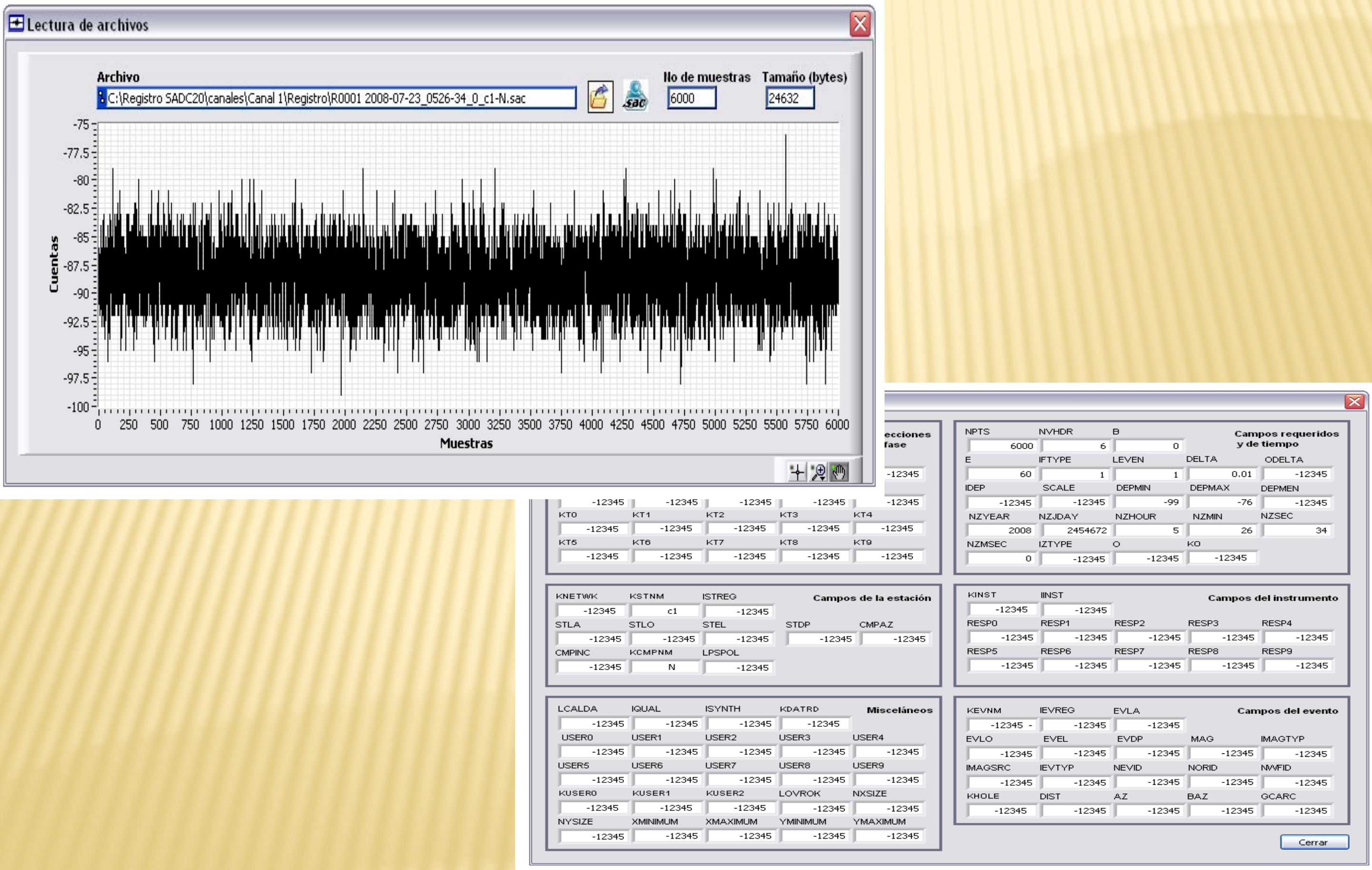
APSIS: FREE SOFTWARE



FUNCTION 1: CONTROL AND RECORDING OF MOTIONS USING THE SEISMIC UNIT SR04

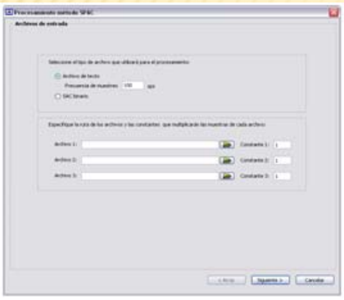


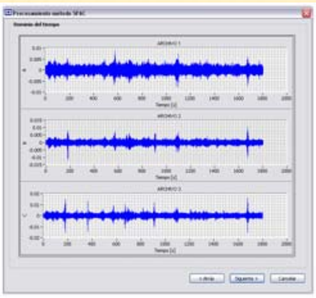
FUNCTION 2: *READING AND DEPLOYMENT OF A SAC FORMAT FILE*

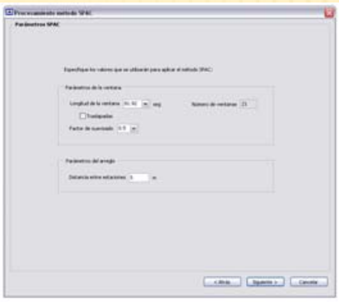


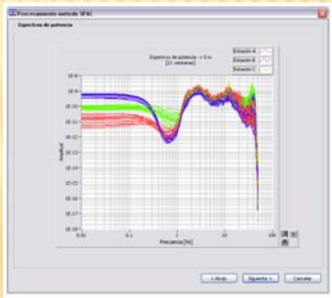
FUNCTION 3: SPAC METOD *PROCESSING*

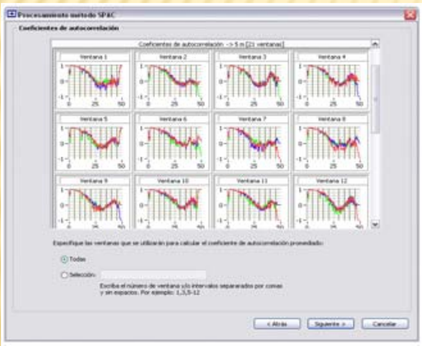
(EQUILATERAL TRIANGLE)

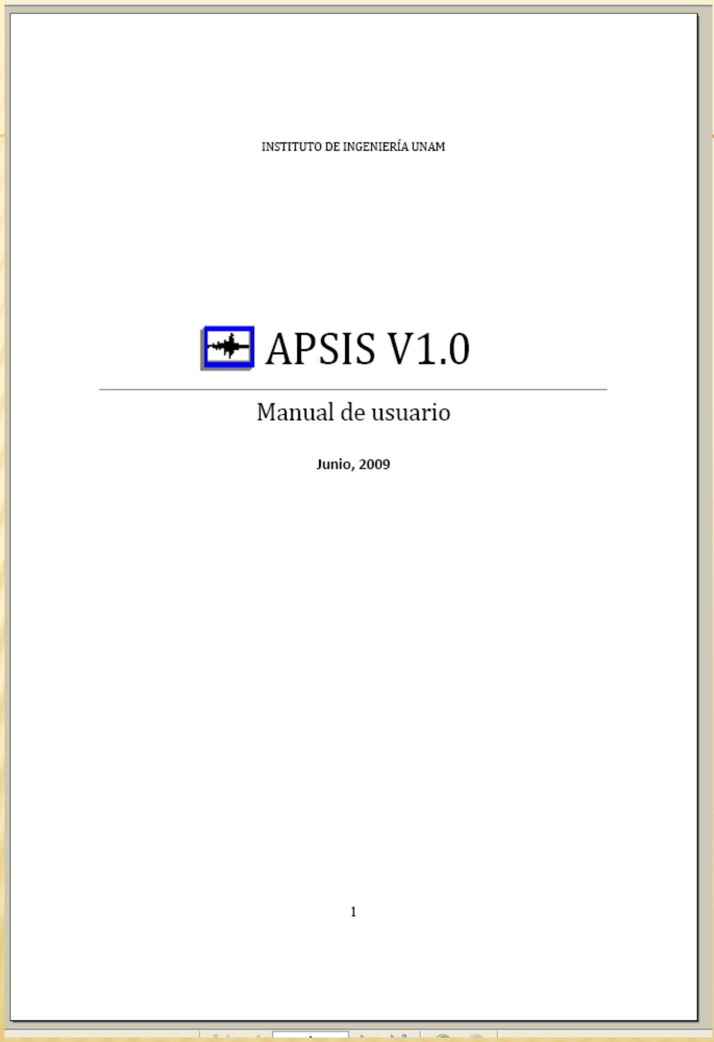












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APSIS V1.0

Manual de usuario

Junio, 2009

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USER MANUAL

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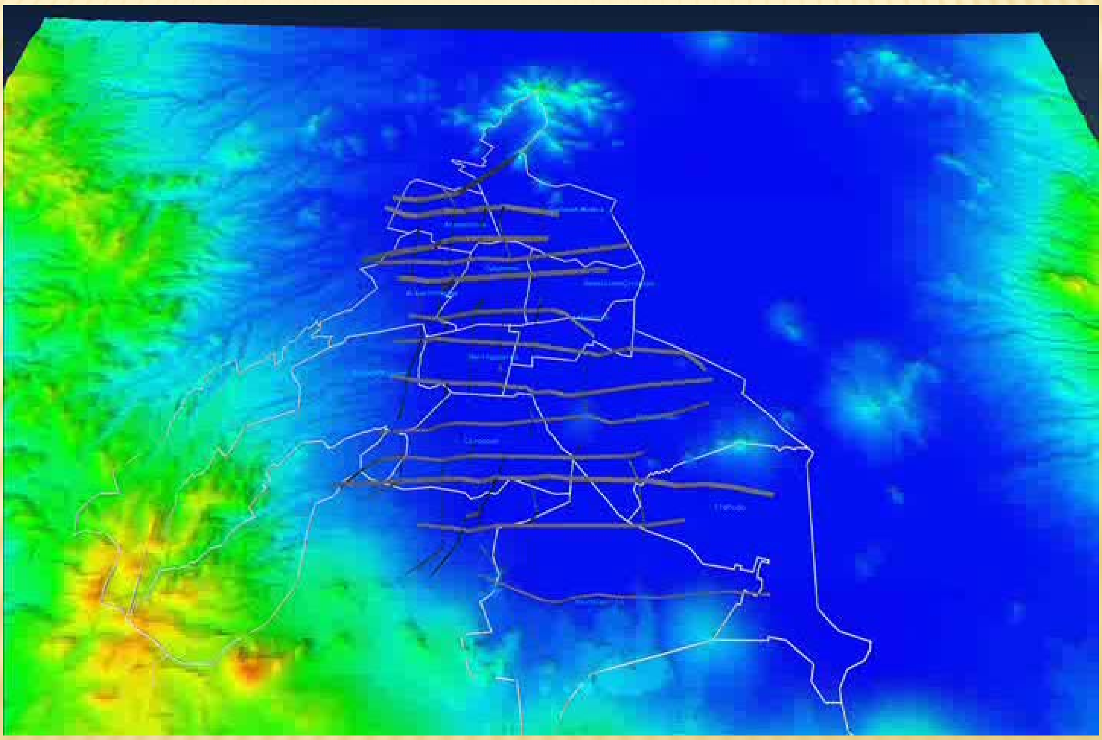
MEXICO CITY 3D MODEL



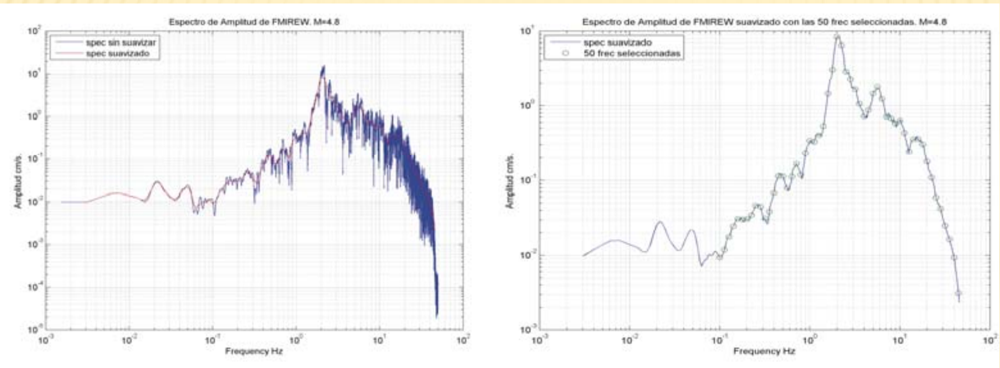
PATH

ATENUATION

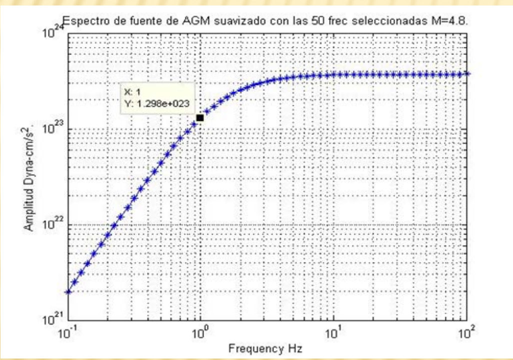
Temporary Michoacán Atenuation Network

Earthquakes Analyzed in This Study						
Event No	Date (d/m/y)	Latitude (°N)	Longitude (°W)	Depth (Km)	Mw	Mo (dyne-cm)
1	31/05//2007	18.66	-104.14	11	5.1	$5.62x10^{23}$
2	31/05//2008	18.2	-103.49	5	4.5	$7.08x10^{22}$
3	06/01/2007	18.72	-104.07	20	4.8	$2.00x10^{22}$
4	17/06/2007	18.22	-103.44	12	4.4	$5.01x10^{22}$
5	27/06/2007	18.75	-104.07	8	4.3	$3.55x10^{22}$
6	07/05/2007	18.19	-103.44	5	4.1	$1.78x10^{22}$
7	07/08/2007	18.16	-102.83	16	4.2	$2.51x10^{22}$

Data Analysis

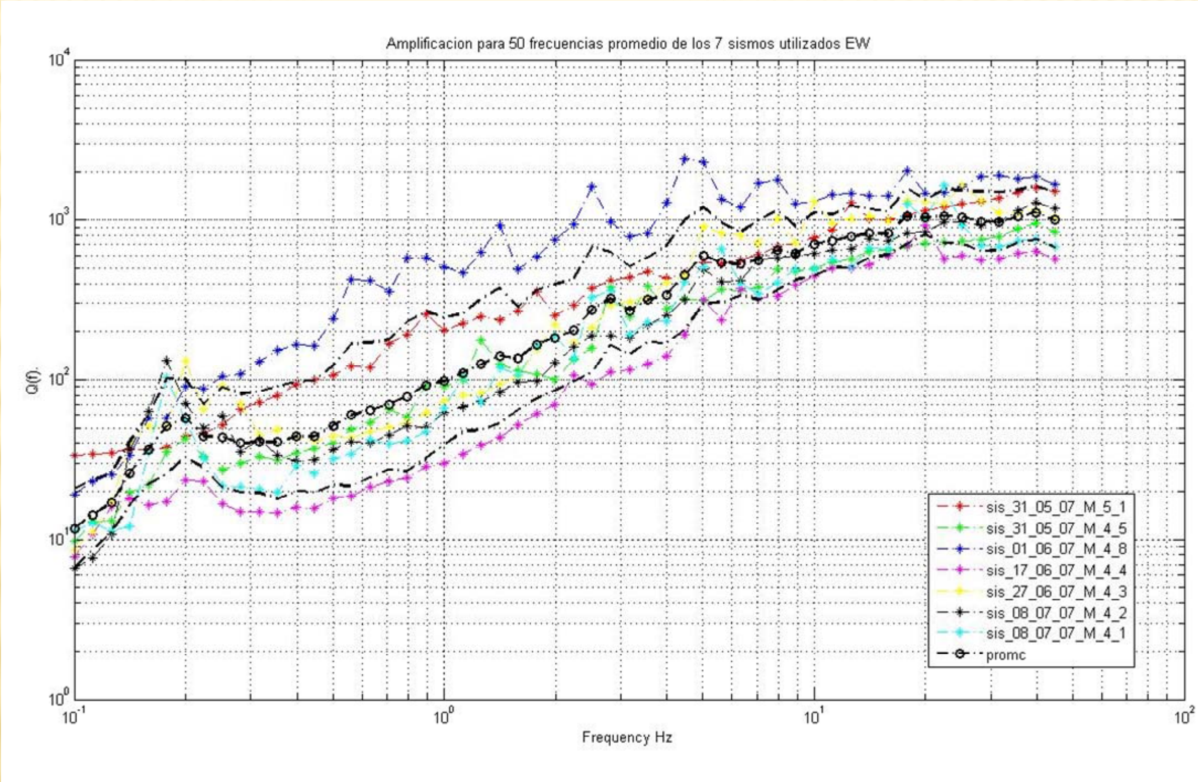


Resampling

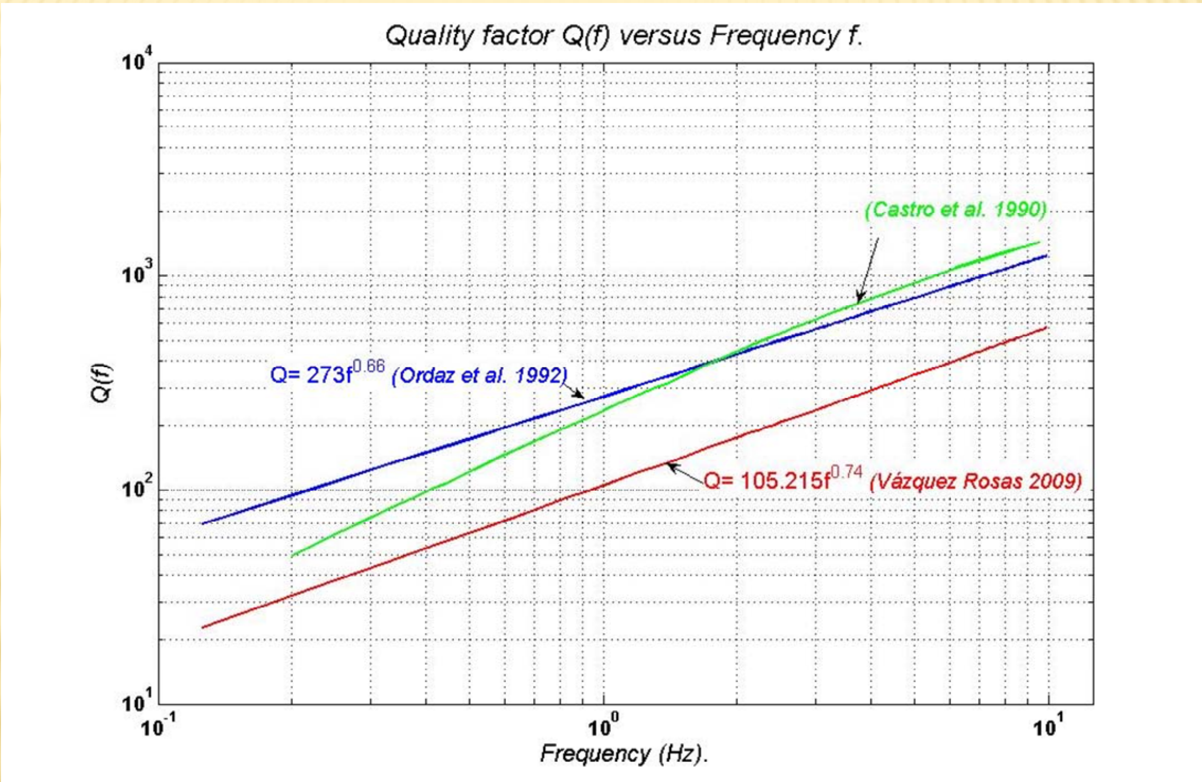


ω^2 source model remotion

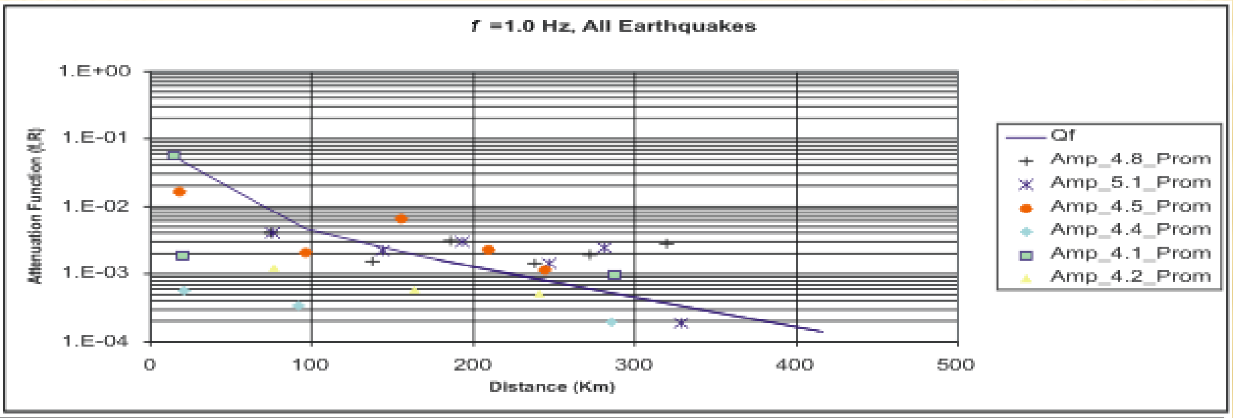
QUALITY FACTOR VS FREQUENCY

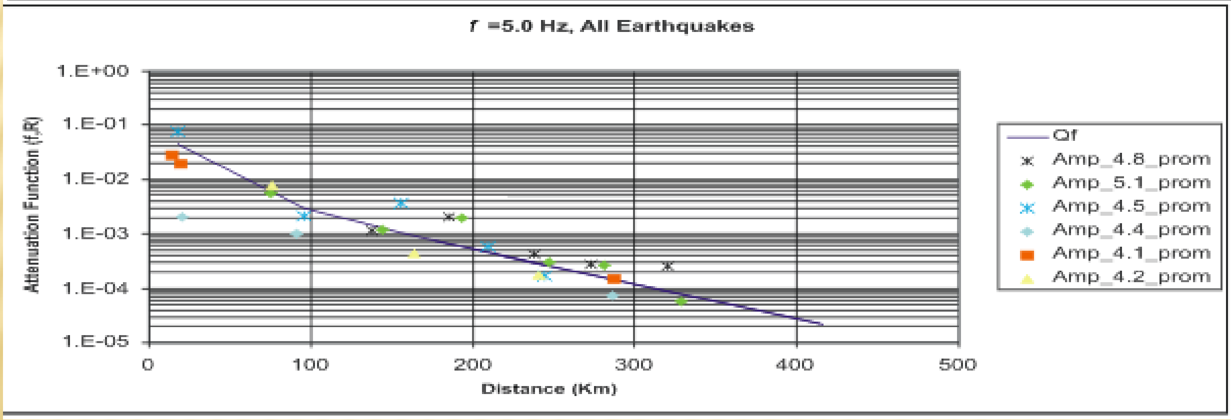


THIS WORK COMPARED WITH OTHERS

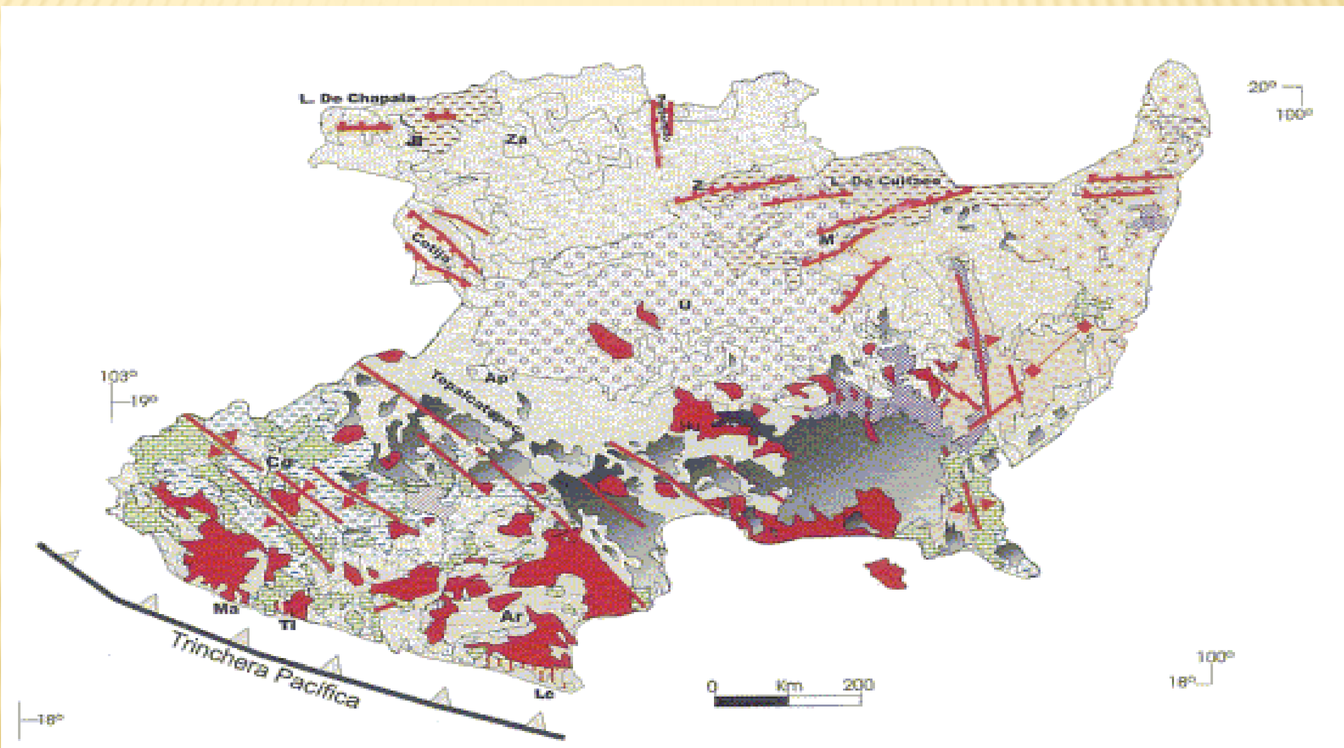


AMPLITUDE VS DISTANCE





REGIONAL GEOLOGY OF MICHOACAN STATE



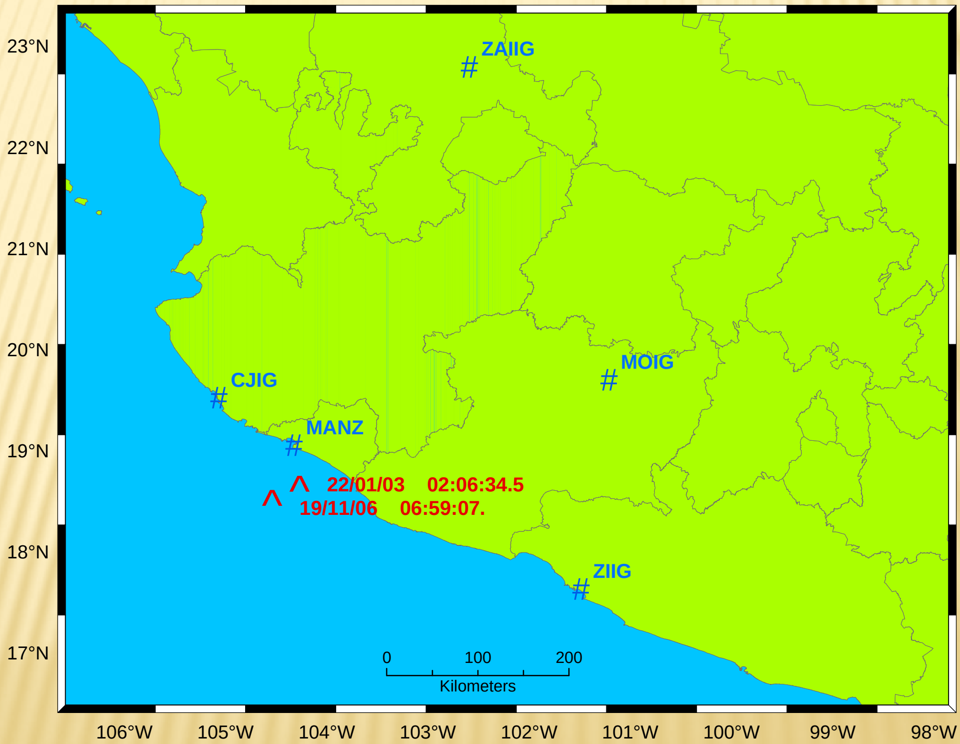
CONCLUSIONS

(ATENUATION)

- Temporary Network in Michoacán State
- Seven eathquakes used (4.1 < Mw < 5.1)
- Distances from about 20 to 320 Km
- $Q = 105 f^{0.74}$
- Smaller than previous relations for Guerrero
- Neo-volcanic trans-mexican belt
- Risky to extrapolate the atenuation relations

SOURCE

TECOMAN EARTHQUAKE
22/I/2003 Mw 7.5



EGF METHOD APLICATION

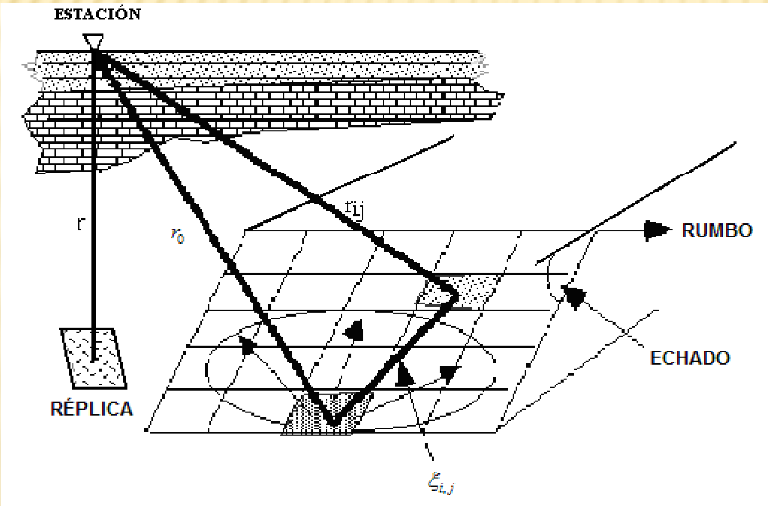
Small Shock
19 nov 2006
M_w. 5.6

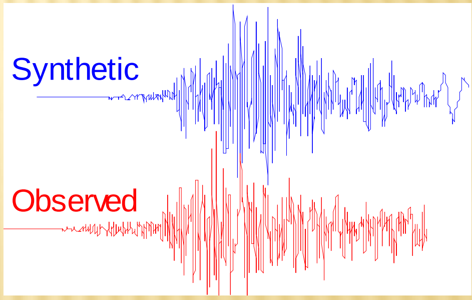
SOURCE MODEL

Mainshock
21 enero 2003
M_w. 7.6

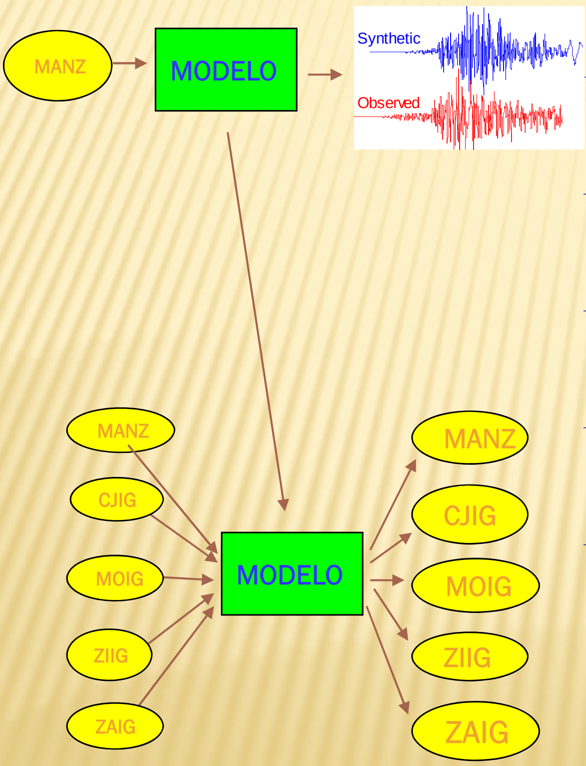
Empirical Green´s Function Method

$$A(t) = \sum_{i=1}^{Nx} \sum_{j=1}^{Nw} \left(\frac{r}{r_{ij}} \right) F(t - t_{ij}) * a(t).$$



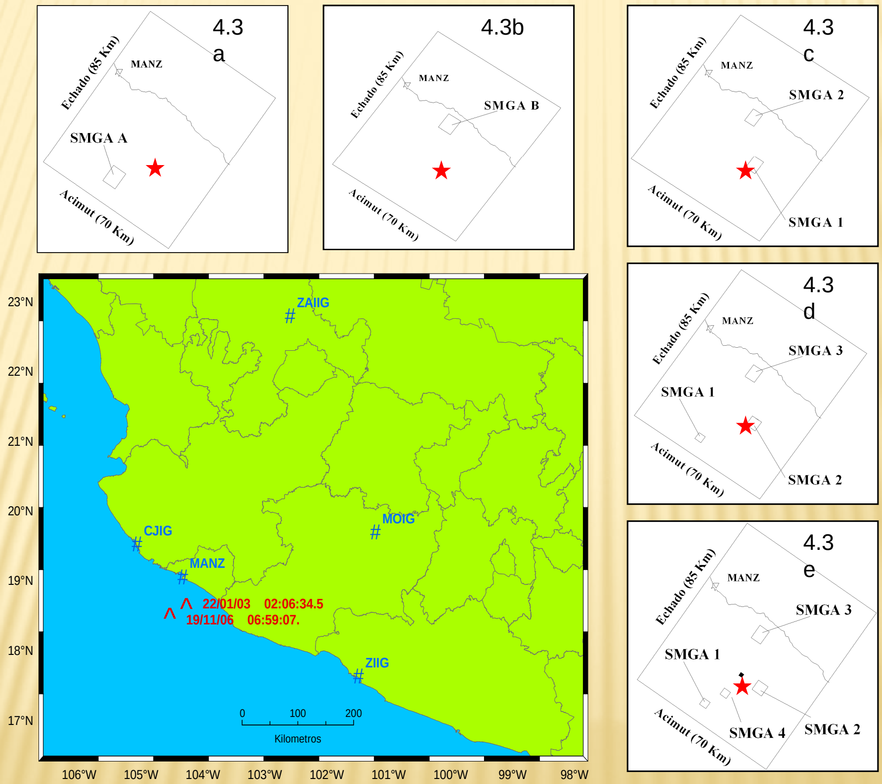


Model Validation

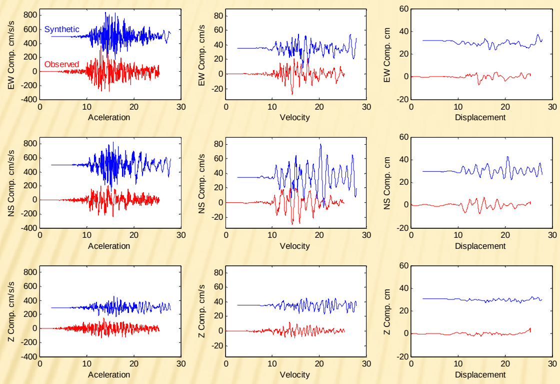


The five stations used to obtain the source model.

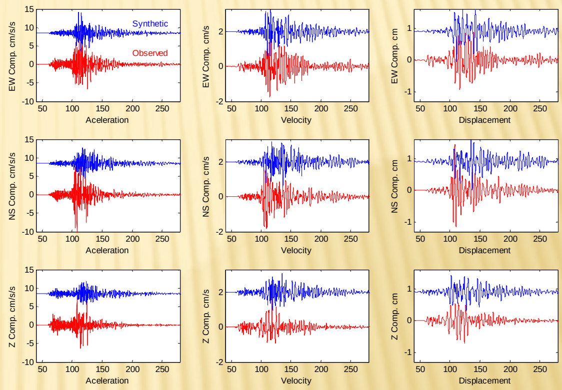
SOURCE CHARACTERIZATION USING EMPIRICAL GREEN´S FUNCTIONS METHOD



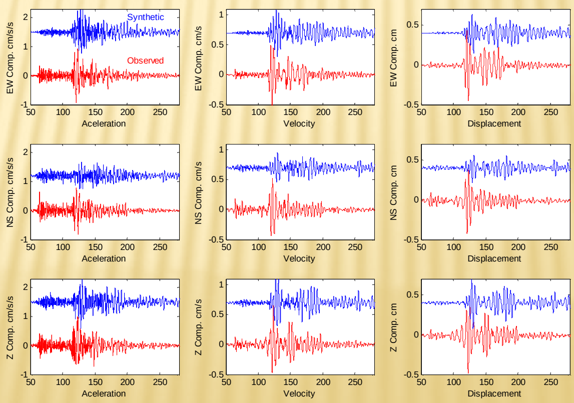
MANZ STATION



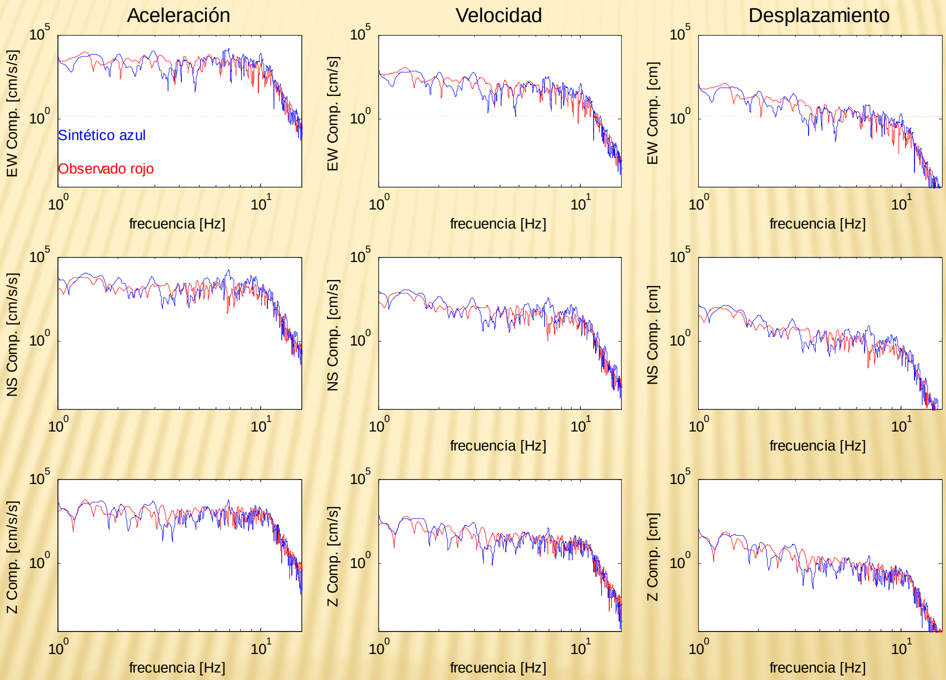
MOIG STATION



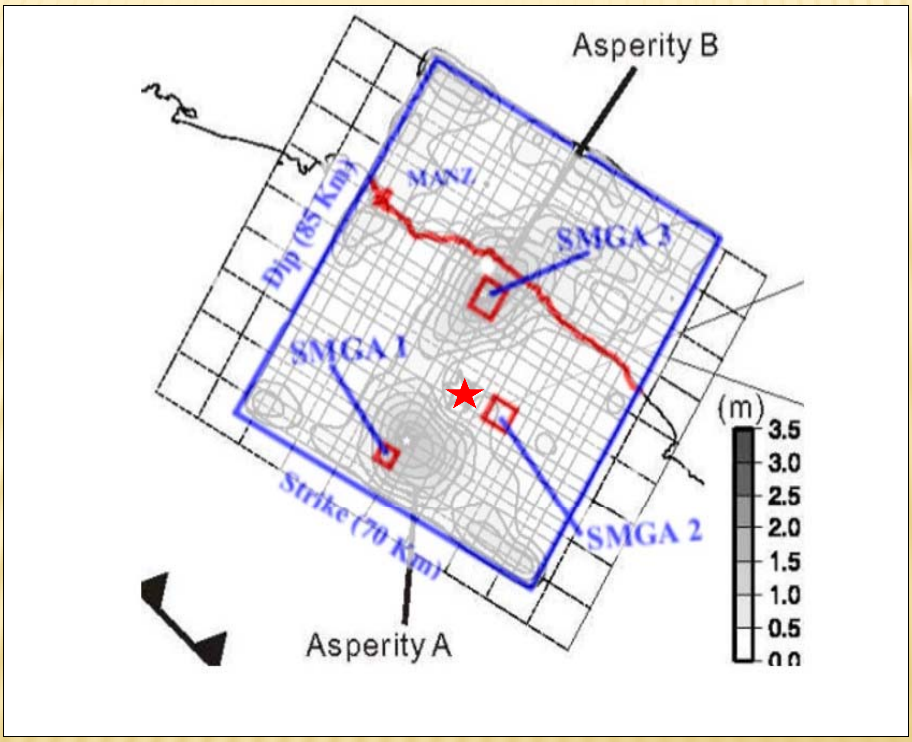
ZAIG STATION



FOURIER SPECTRA STATION MANZ (3 SMGA)
GREEN – SYNTETICS BLUE - OBSERVED

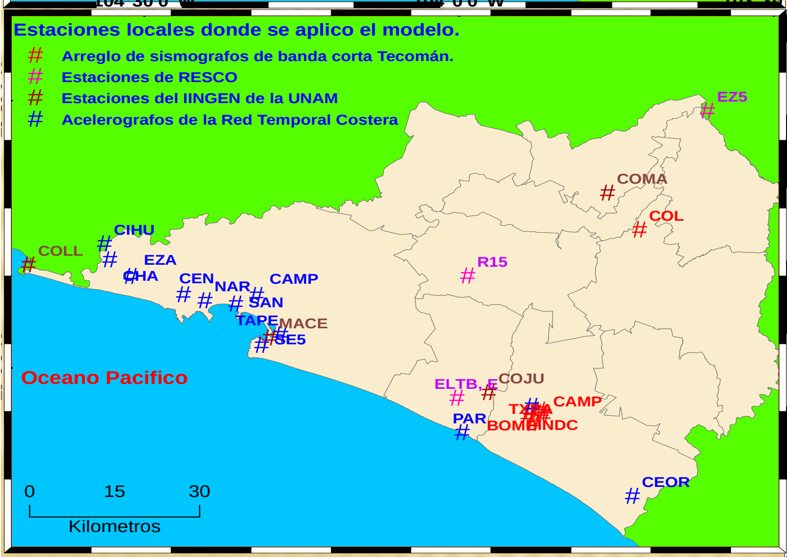


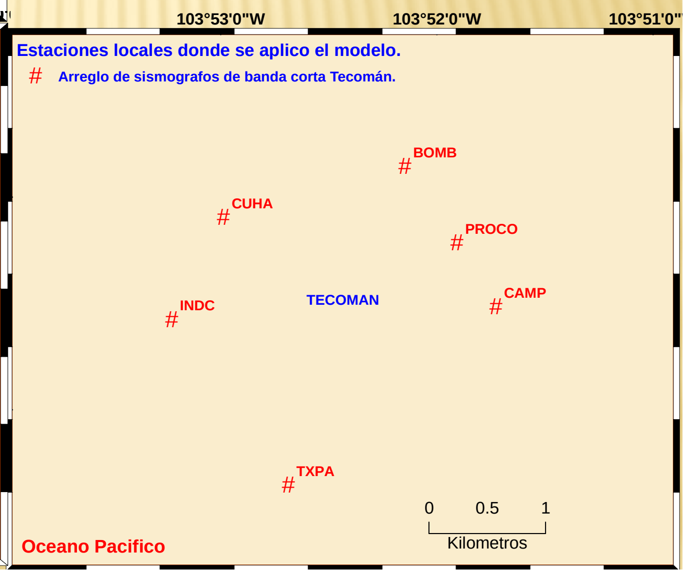
COMPARISON WITH THE DISLOCATION MODEL OBTAINED BY YAGI ET AL. (2004).



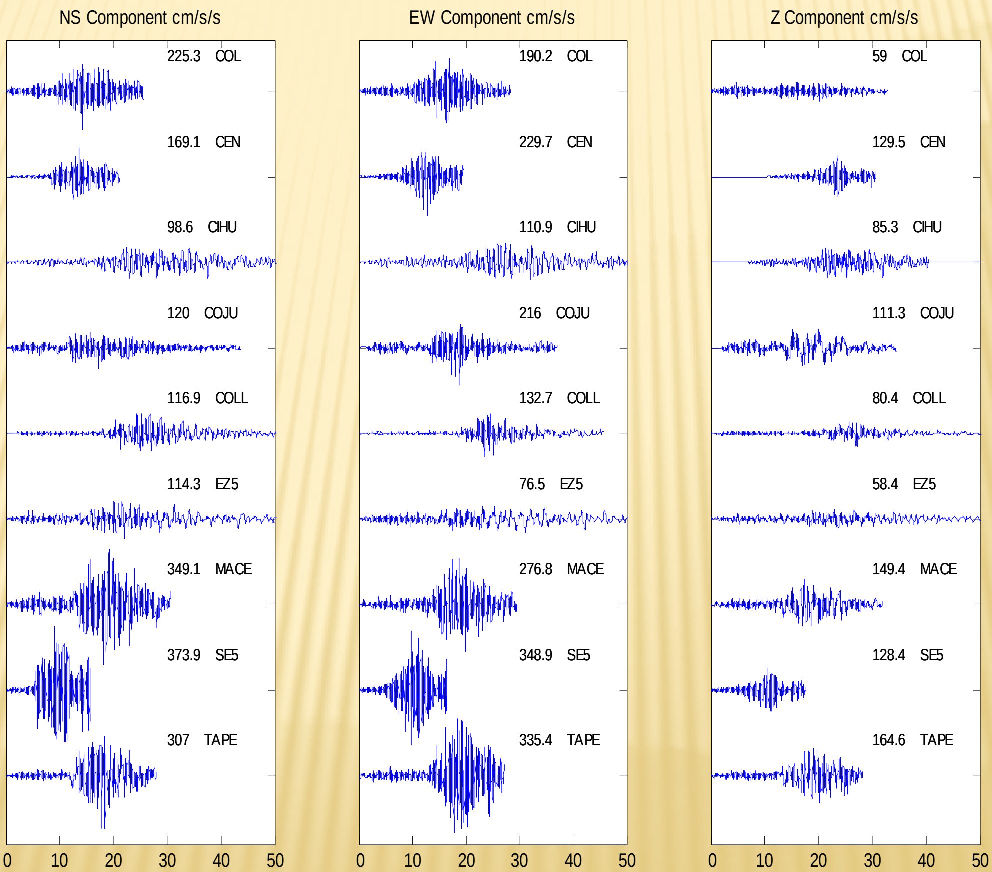
Stations where we simulate the mainshock using the source model

- 16 RTC y R Tecomán
- 2 RESCO
- 4 SSN
- 9 IINGEN

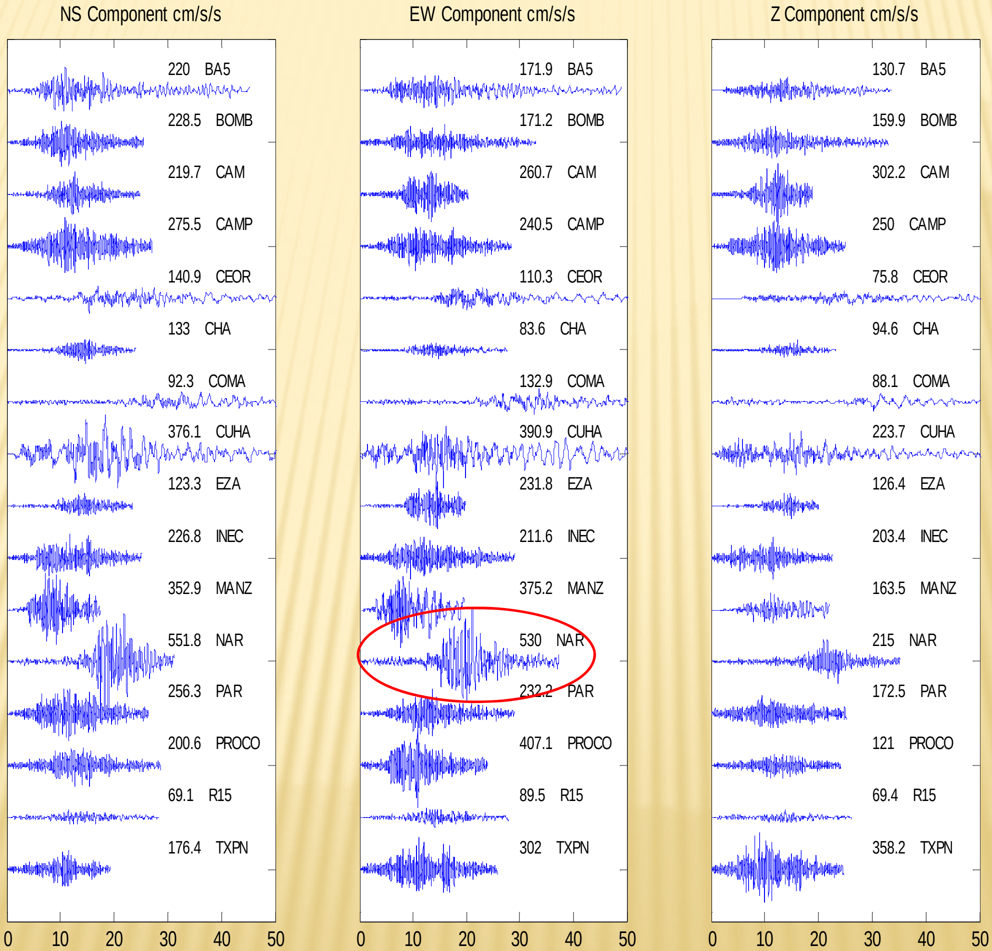




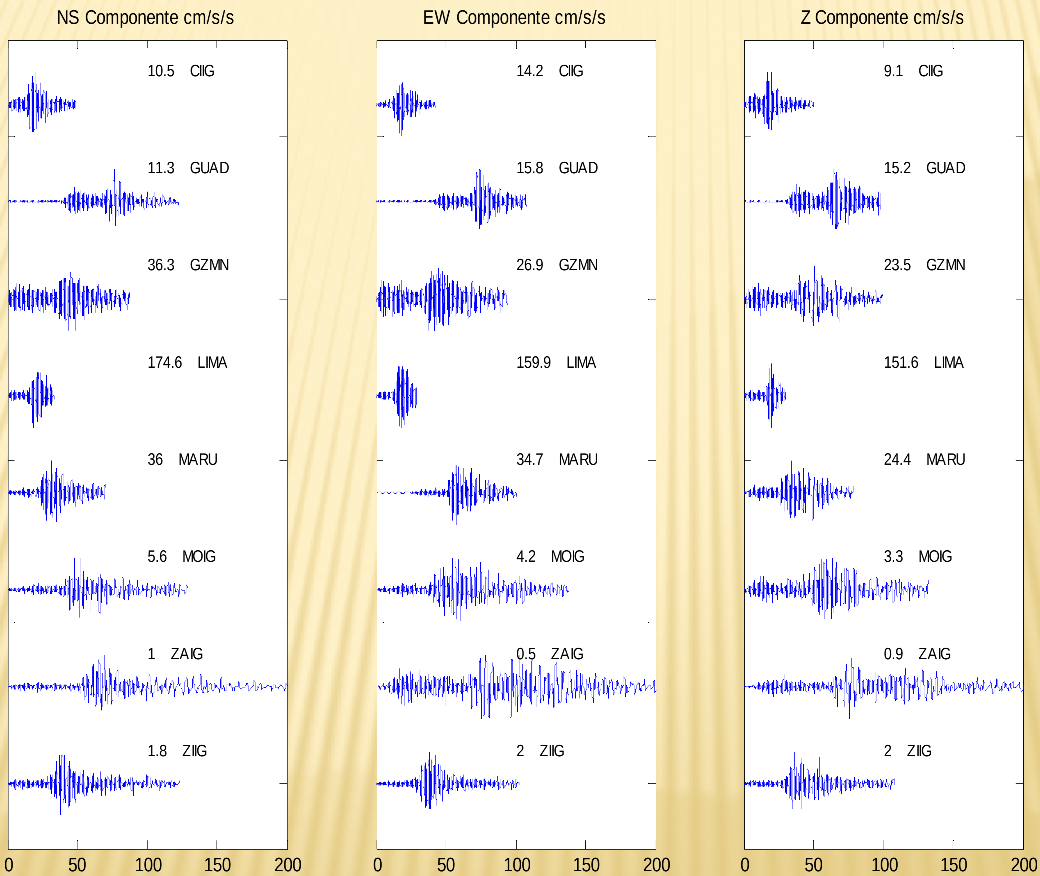
Simulations for stacions at rock site within the Colima State



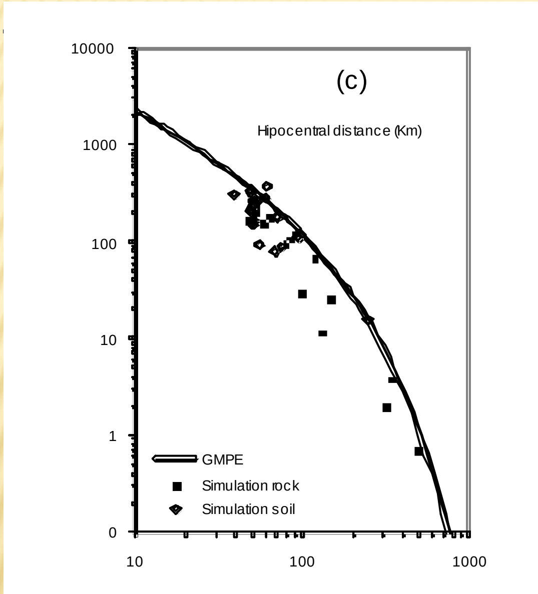
Simulation for stations soil within Colima State



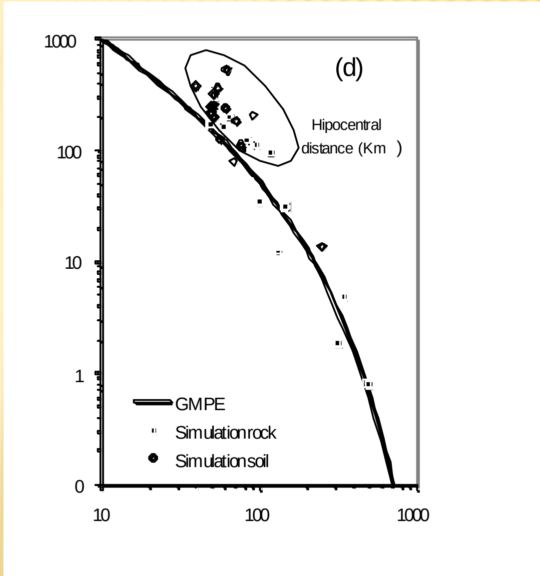
Simulation for stations outside of Colima



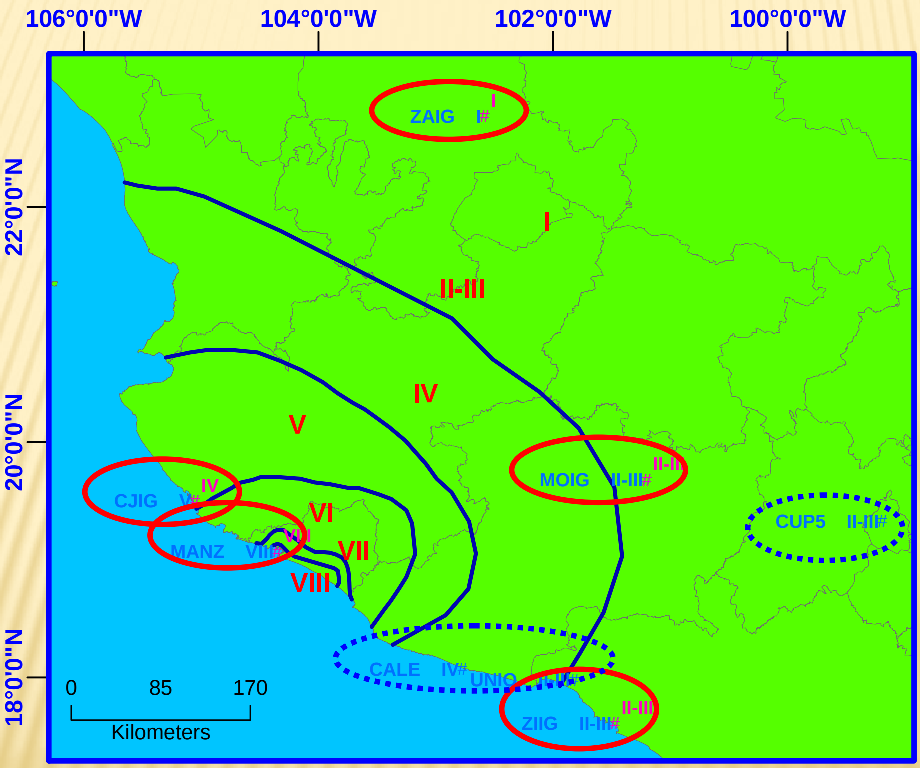
COMPARISON WITH TWO ATENUATION RELATIONS

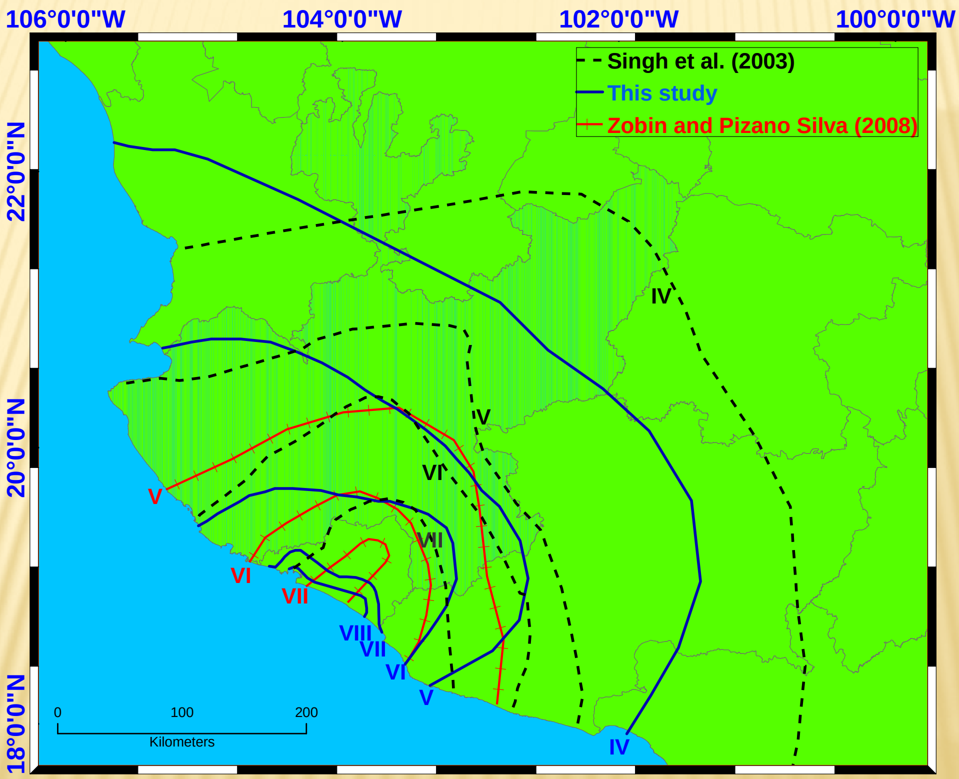


Ordaz *et al.*(1989)



Garcia *et al.* (2005)





CONCLUSIONS (SOURCE)

- Succesfull aplication of EGFM
- High frequency model that are of interest to earthquake engineering
- Waveform simulation at sites where there was no seismic station during the Tecomán earthquake.

Model aplication.

1. Acceleration, Velocity ,and displacement waveforms, Fourier spectra, PGA, I_{MM}.
2. We can aplied our knowledge od the seismic source for the modeling of future earthquakes.