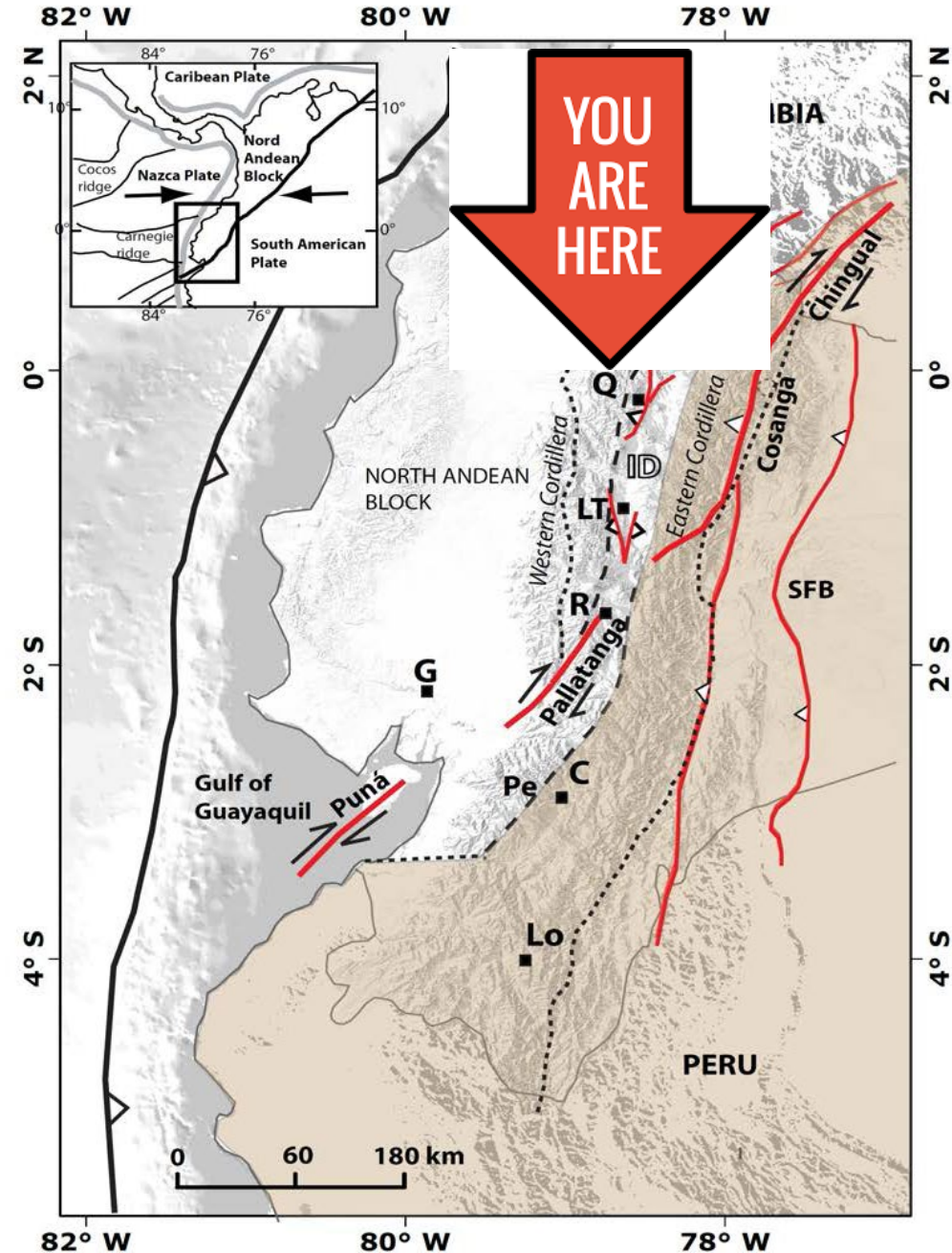


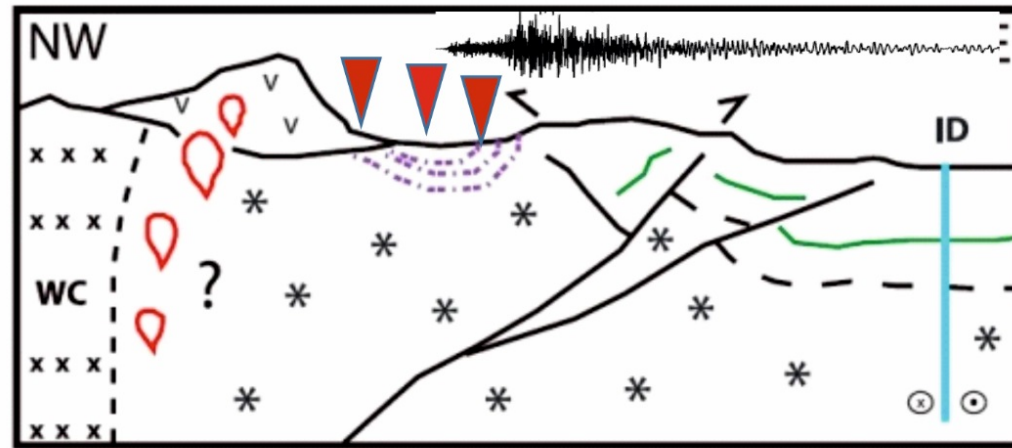
ARE SUBDUCTION EARTHQUAKES A THREAT FOR QUITO, CAPITAL OF ECUADOR, LOCATED ~170 KM FROM THE COAST ?

F. Courboulex,
D.A. Castro Cruz,
A. Laurendeau,
A. Alvarado , F. Bonilla, D. Mercerat, E. Bertrand



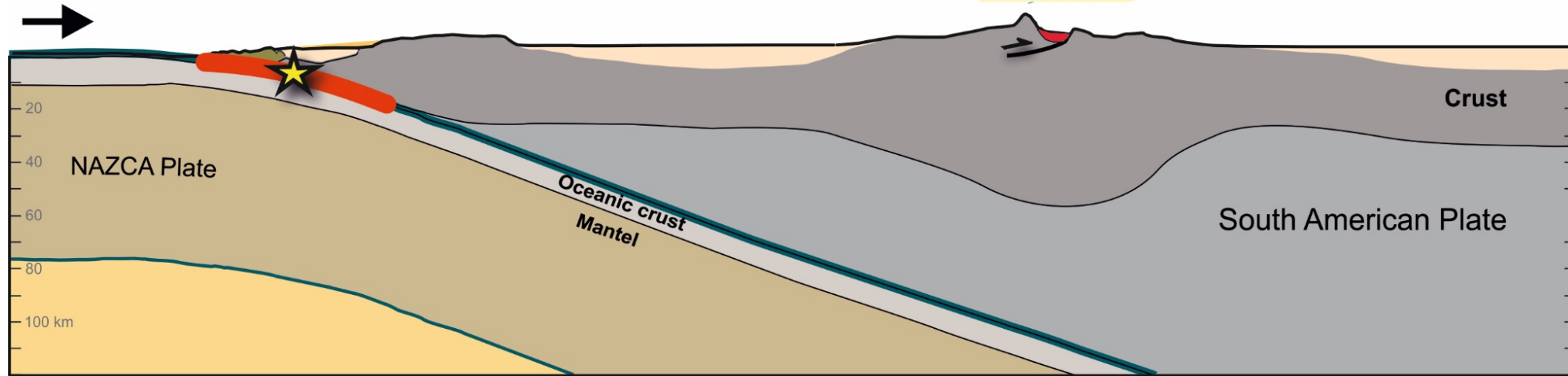
Alvarado et al, 2016

BASIN AMPLIFICATION ?



QUITO

~170 km

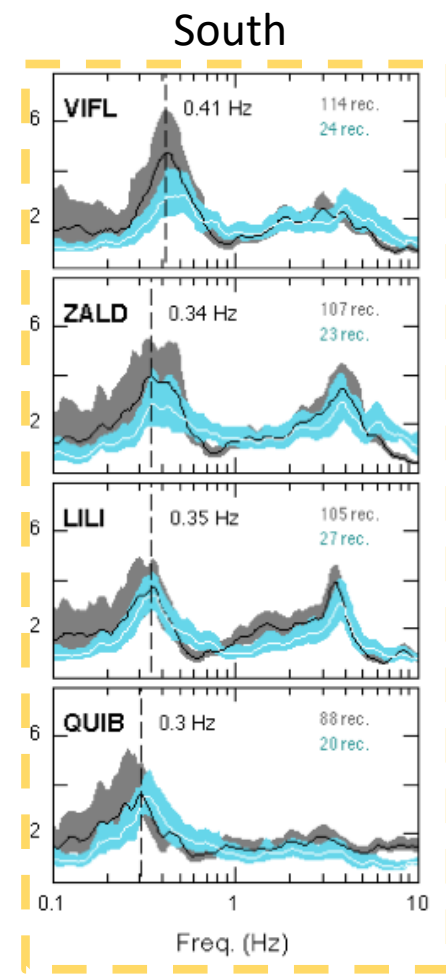
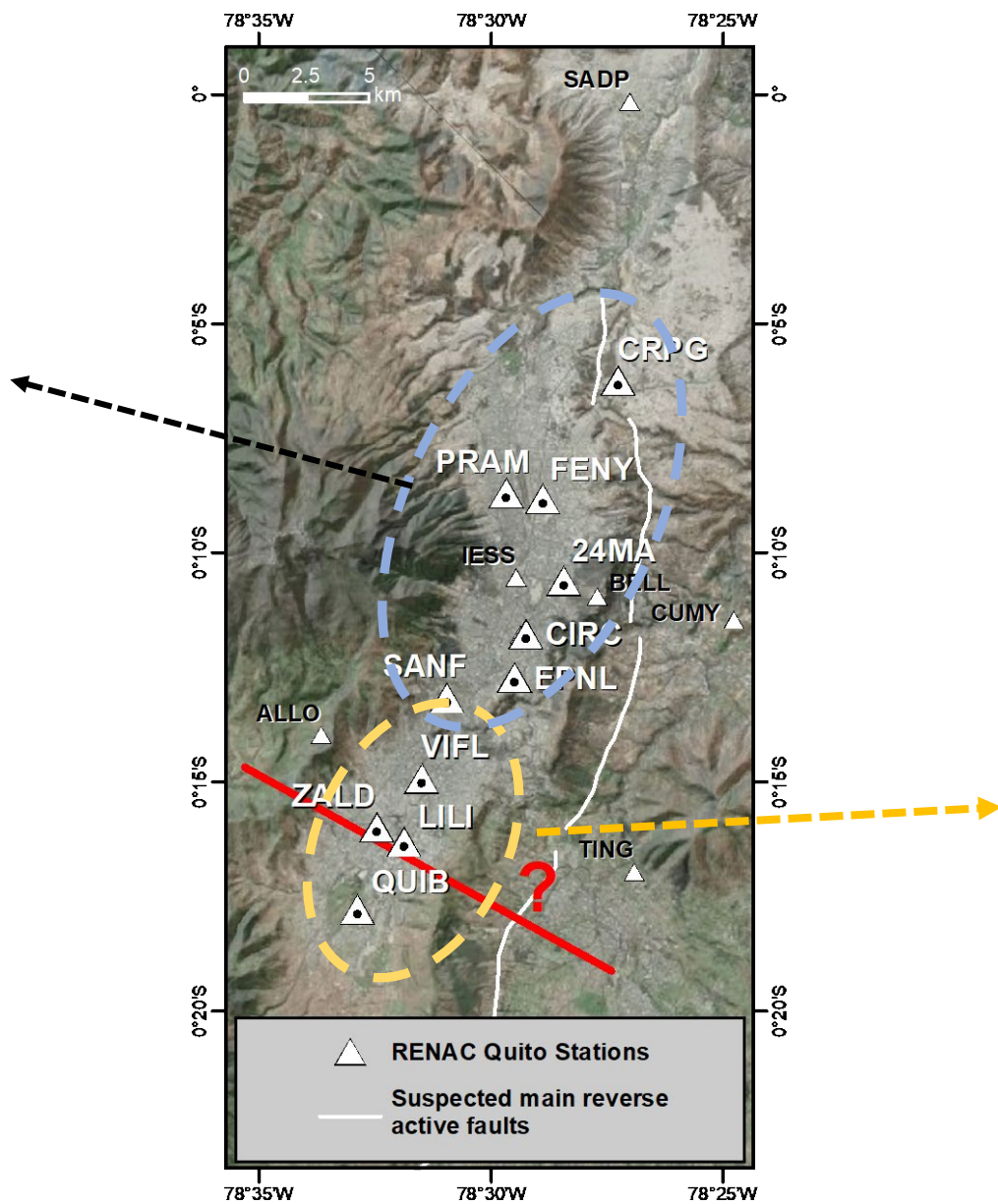
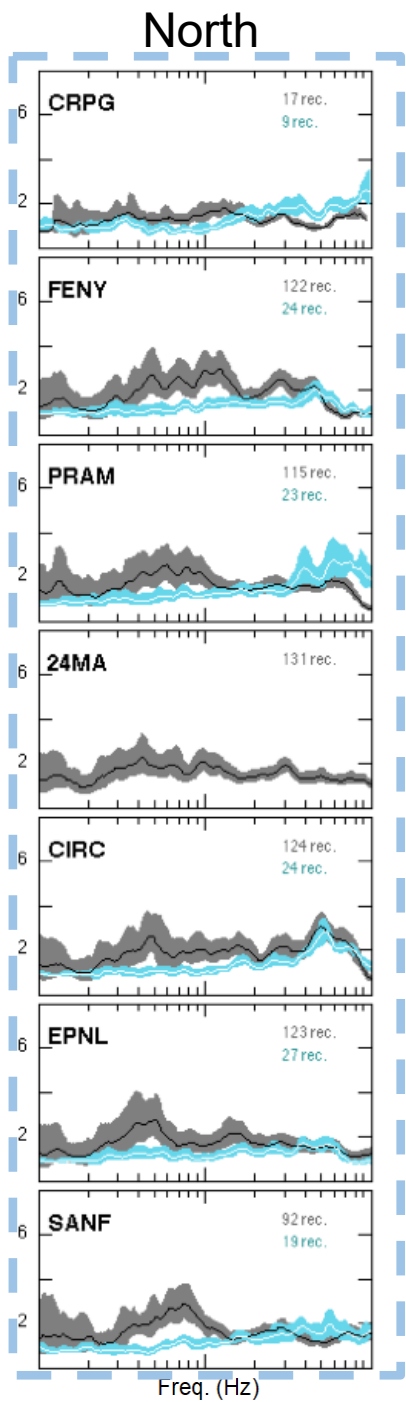


 Seismogenic interplate interface

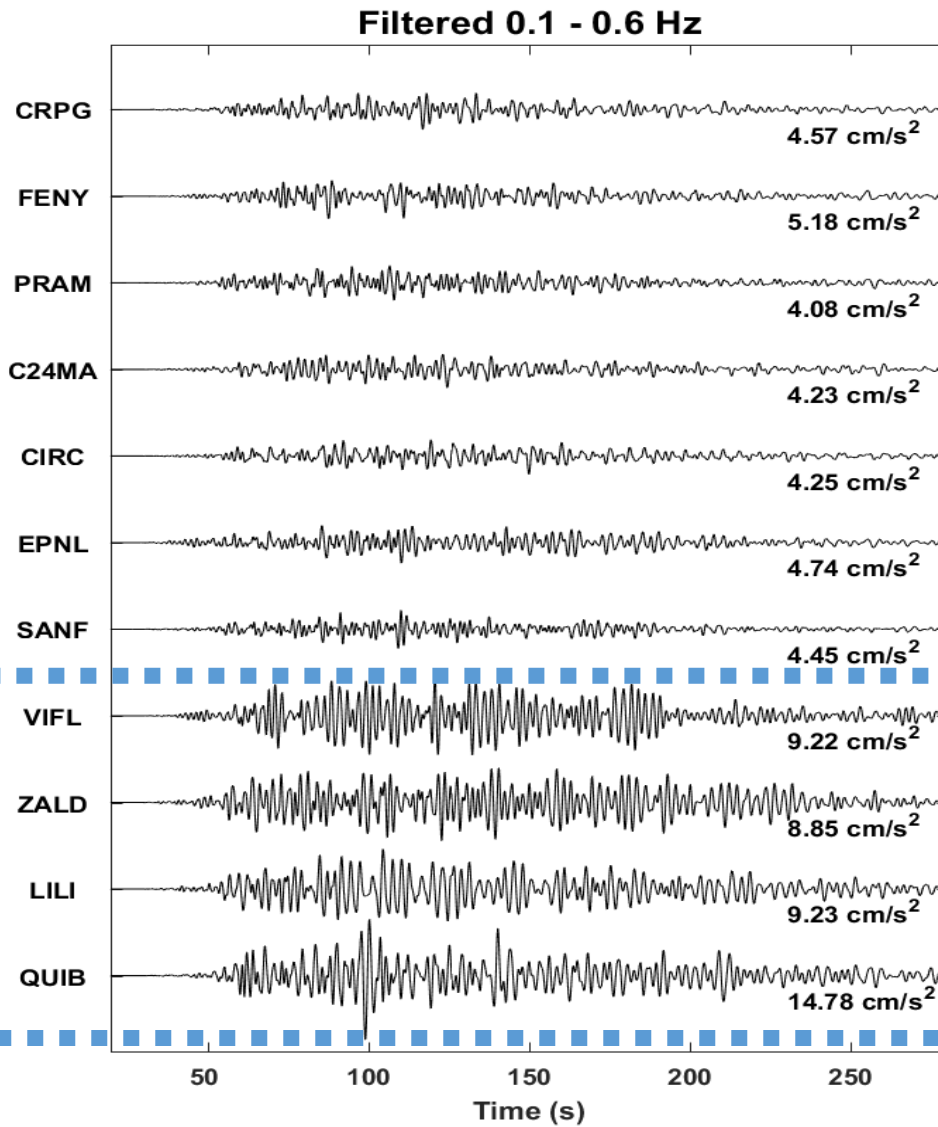
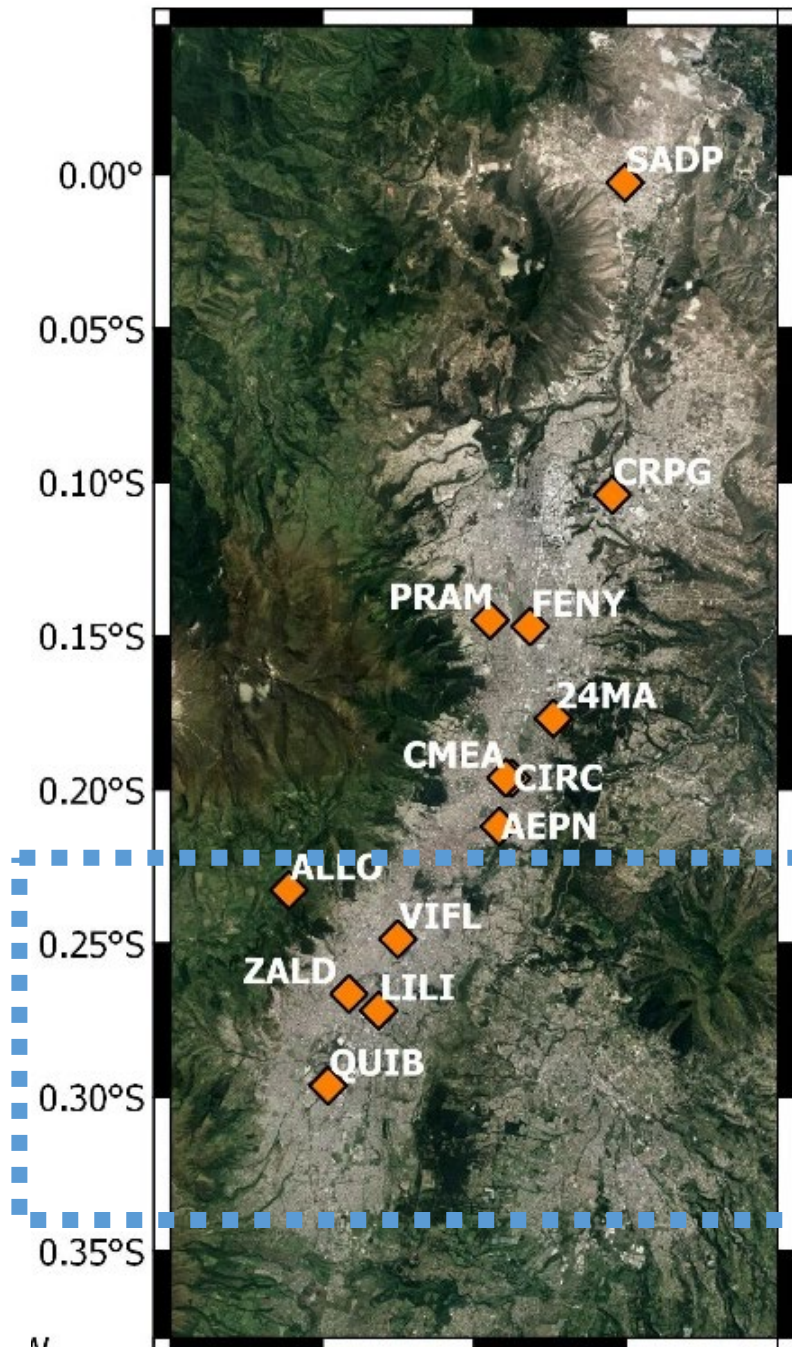


LOW FREQUENCY SEISMIC AMPLIFICATION IN THE QUITO BASIN (ECUADOR) REVEALED BY ACCELEROMETRIC RECORDINGS OF THE RENAC NETWORK

Laurendeau A., Courboux F., Bonilla L.F., Alfonso Naya V, Alvarado et al., BSSA (2017)



Data from Pedernales 2016 Eq (Mw 7.8) in Quito (170 km away)



South
of
Quito
Basin

ARE SUBDUCTION EARTHQUAKES A THREAT FOR QUITO?

The largest historical event : 1906 earthquake :

Magnitude 8.8 (Kanamori and Mc Nally, 1982) , Yamanaka et al (2017) $8.3 < M < 8.6$

→ **Almost no damage reported in Quito**

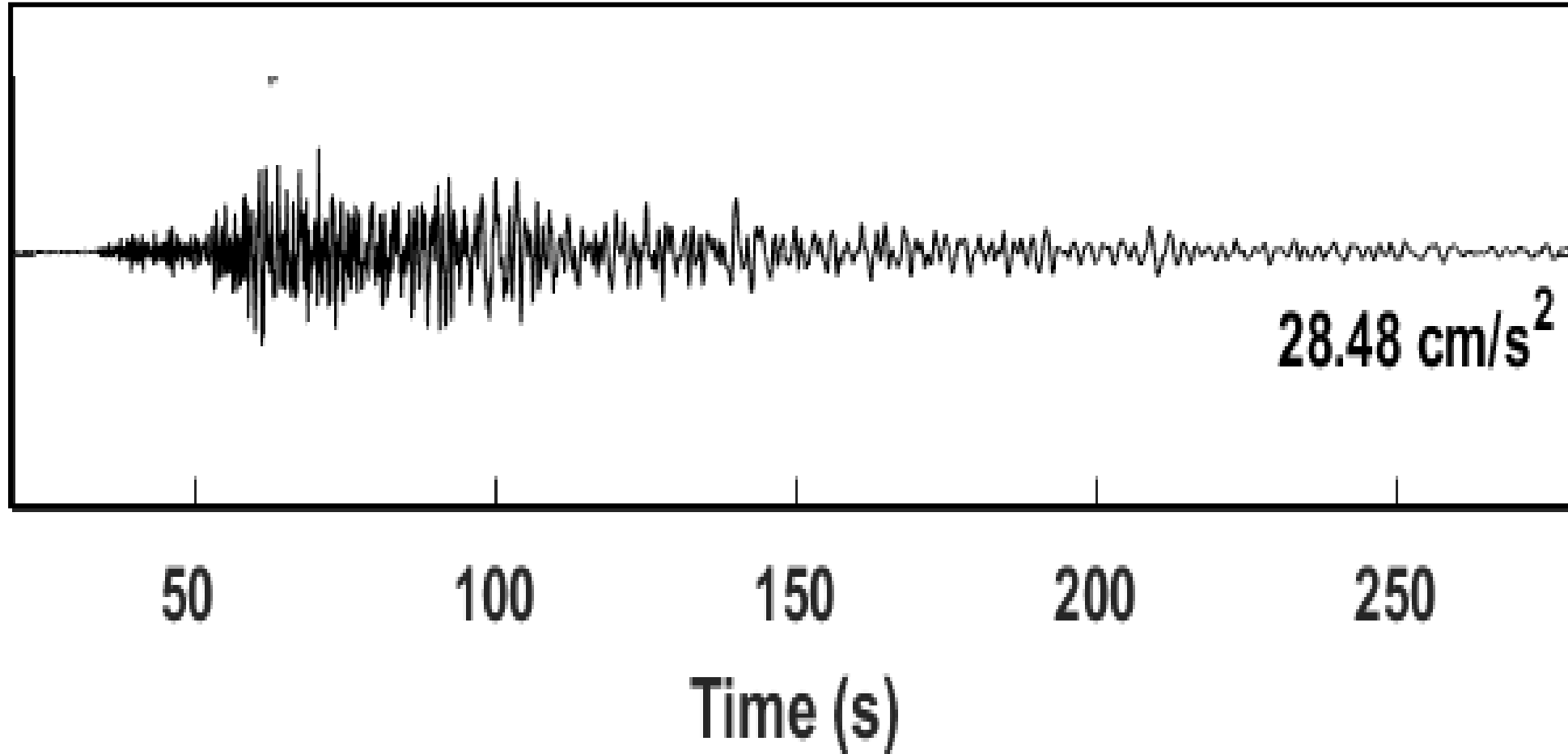
But :

- The main part of the slip occurred in the northern part of Ecuador
- The city of Quito was **much smaller than now**



→ Simulate the ground motions due to a large (M 8.5) earthquake in Quito with a focus on a realistic the variability of the results

Ground motions are due to : Source and wave propagation effects



Pedernales earthquake on QUIB station (RENAC network) in QUITO



Ground motions are due to : Source and wave propagation effects

Numerical Green's Function

The underground medium
must be well known

Empirical Green's Function



Ground motions are due to : Source and wave propagation effects

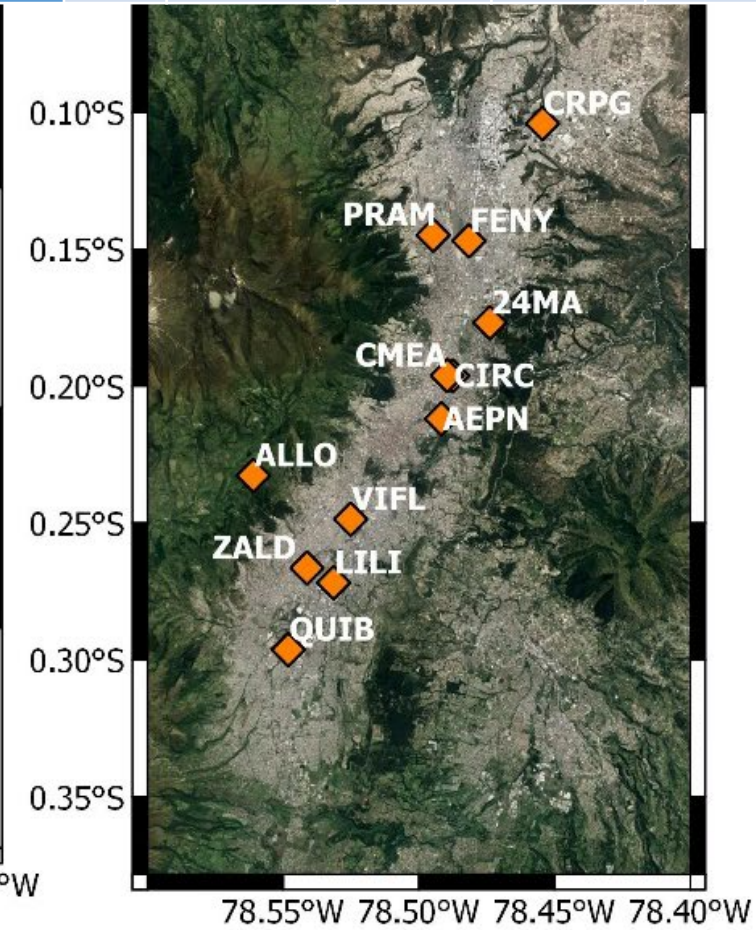
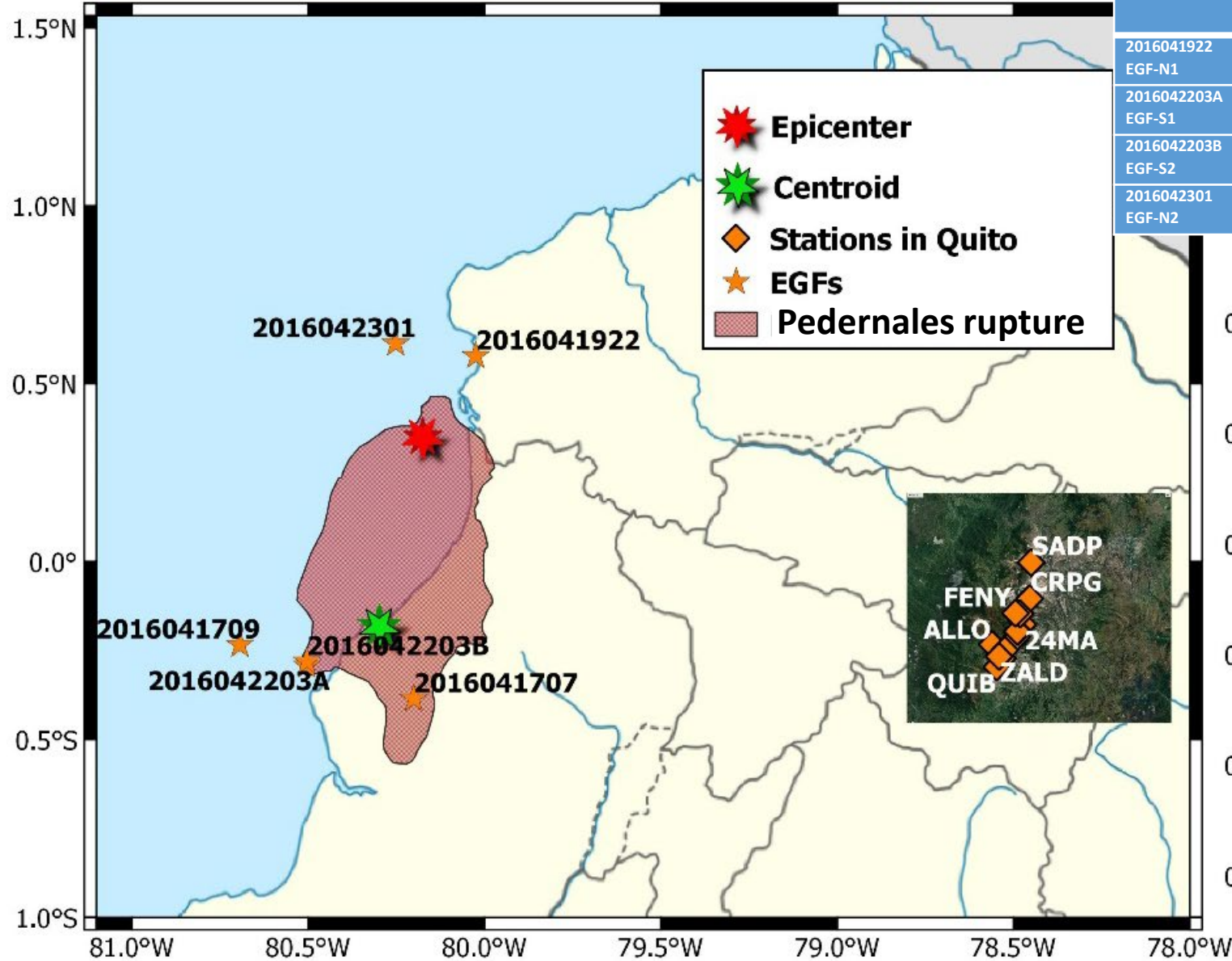
Numerical ~~Green's~~ Functions

Empirical Green's Functions

Small earthquakes Recordings

Advantage : realistic
consideration of site effects

Name	Mw	Origin time (UTC)		Location			Fc [Hz]
		Date	Hour	Latitude [°]	Longitude [°]	Depth [km]	
2016041922 EGF-N1	5.7	19/04/2016	22:22	0.578	-80.025	15.4	1.15E-01
2016042203A EGF-S1	6.0	22/04/2016	3:03	-0.292	-80.504	10.0	1.06E-01
2016042203B EGF-S2	5.9	22/04/2016	3:25	-0.281	-80.504	10.3	9.00E-02
2016042301 EGF-N2	5.7	23/04/2016	1:24	0.613	-80.252	10.0	1.10E-01



Pedernales rupture from Nocquet et al., (2016)

The regional path and site effects is constrained by the use of smaller events recordings as EGF



Ground motions are due to : Source and wave propagation effects

Complex models : a complete account for the rupture process (kinematic or dynamic).
Difficulties to constrain the input parameters → A huge variability of output ground motions

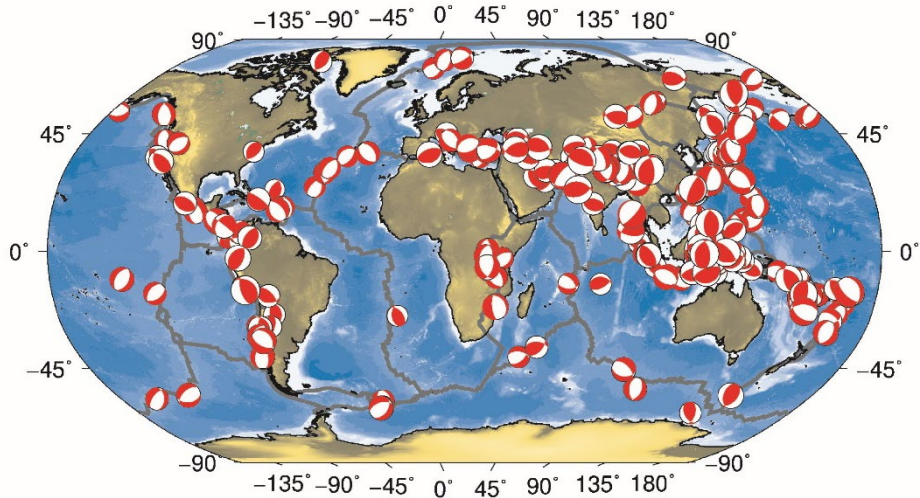
Simple model with a few number of parameter:

- Moment
- Location of the main slip zones
- Source time function duration (or static stress drop, V_r)

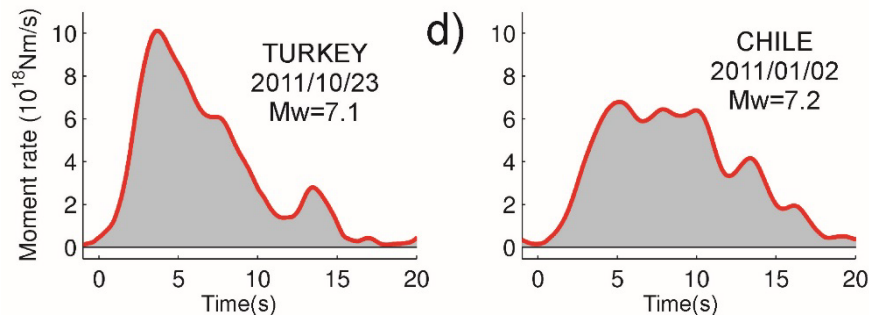
→ Robust constraints on the input parameters and their variability

→ Realistic variability of the results

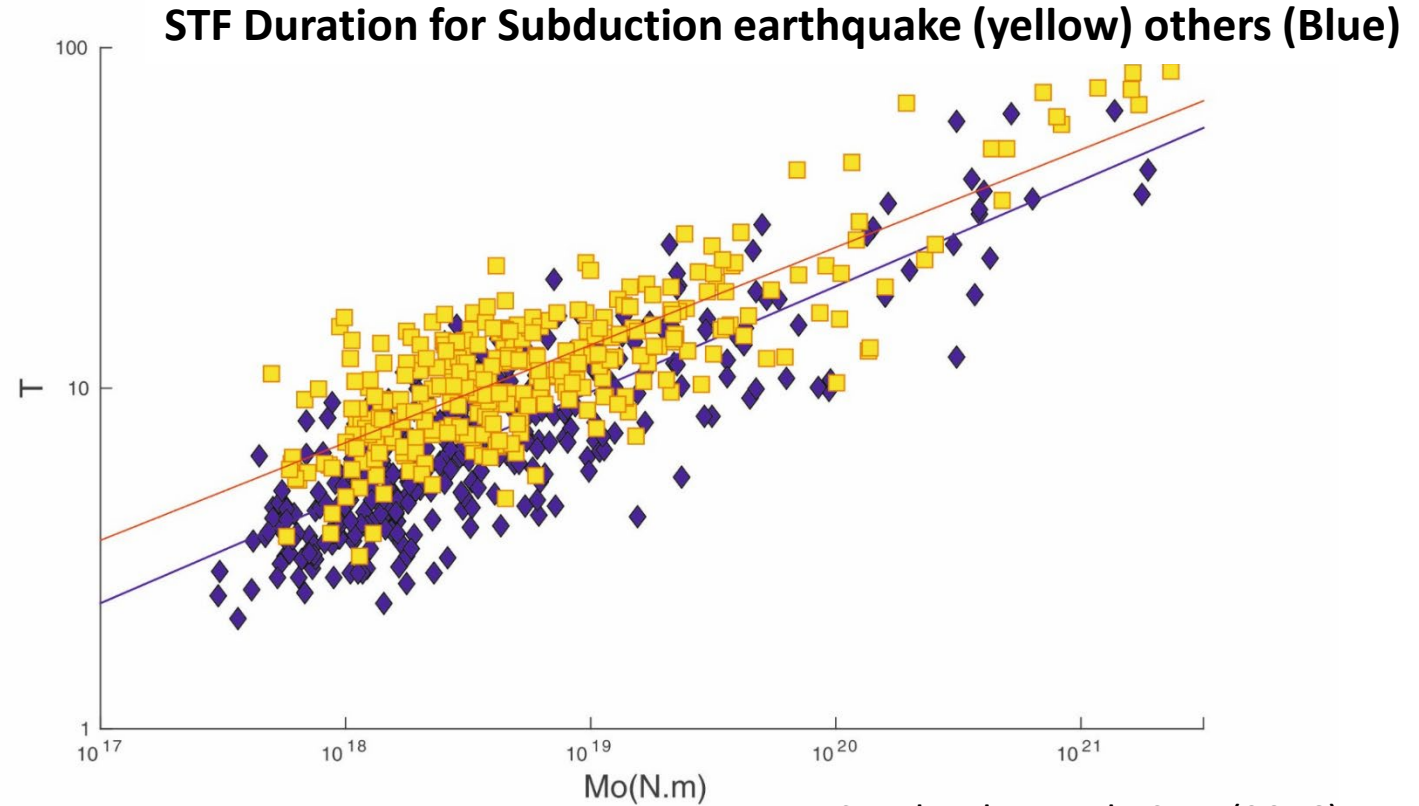
We constrain the STF duration (mean and variability) using the global SCARDEC database



1754 shallow earthquakes



Vallée (2013), Vallée and Douet (2016)
→ Chounet and Vallée (2018) ...



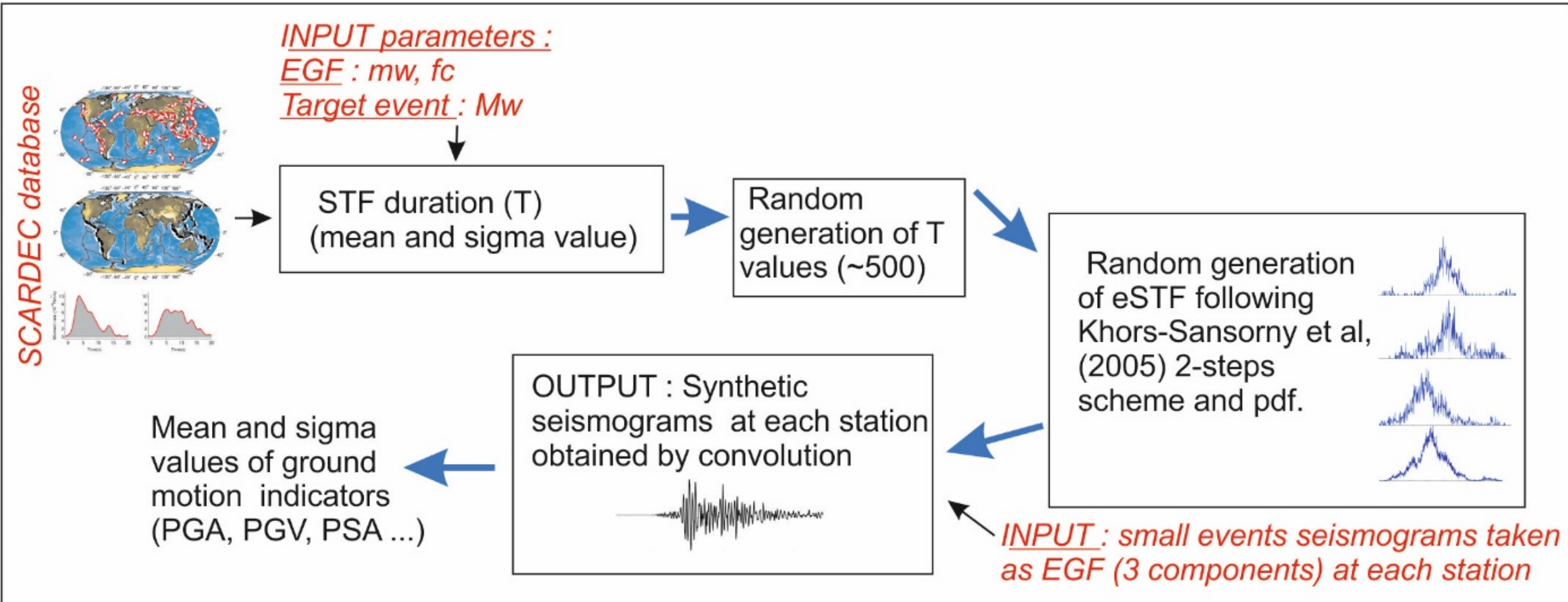
Courboux et al., SRL, (2016)

SUB: $\log(T) = 0.28 \log_{10}(M_o) - 4.32$

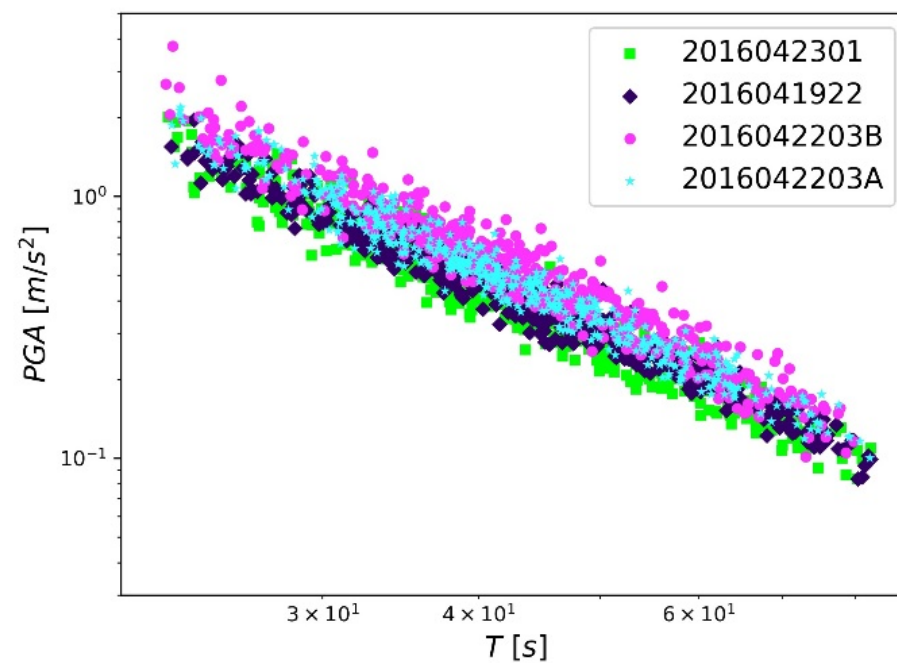
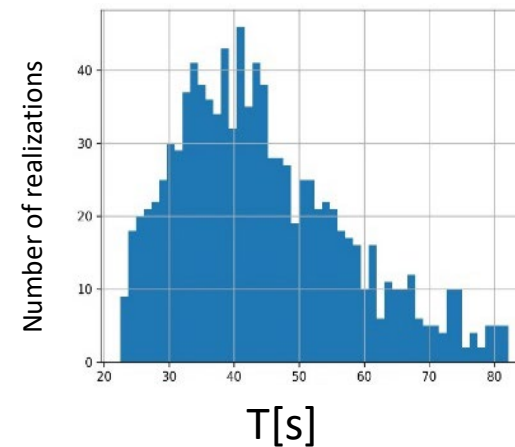
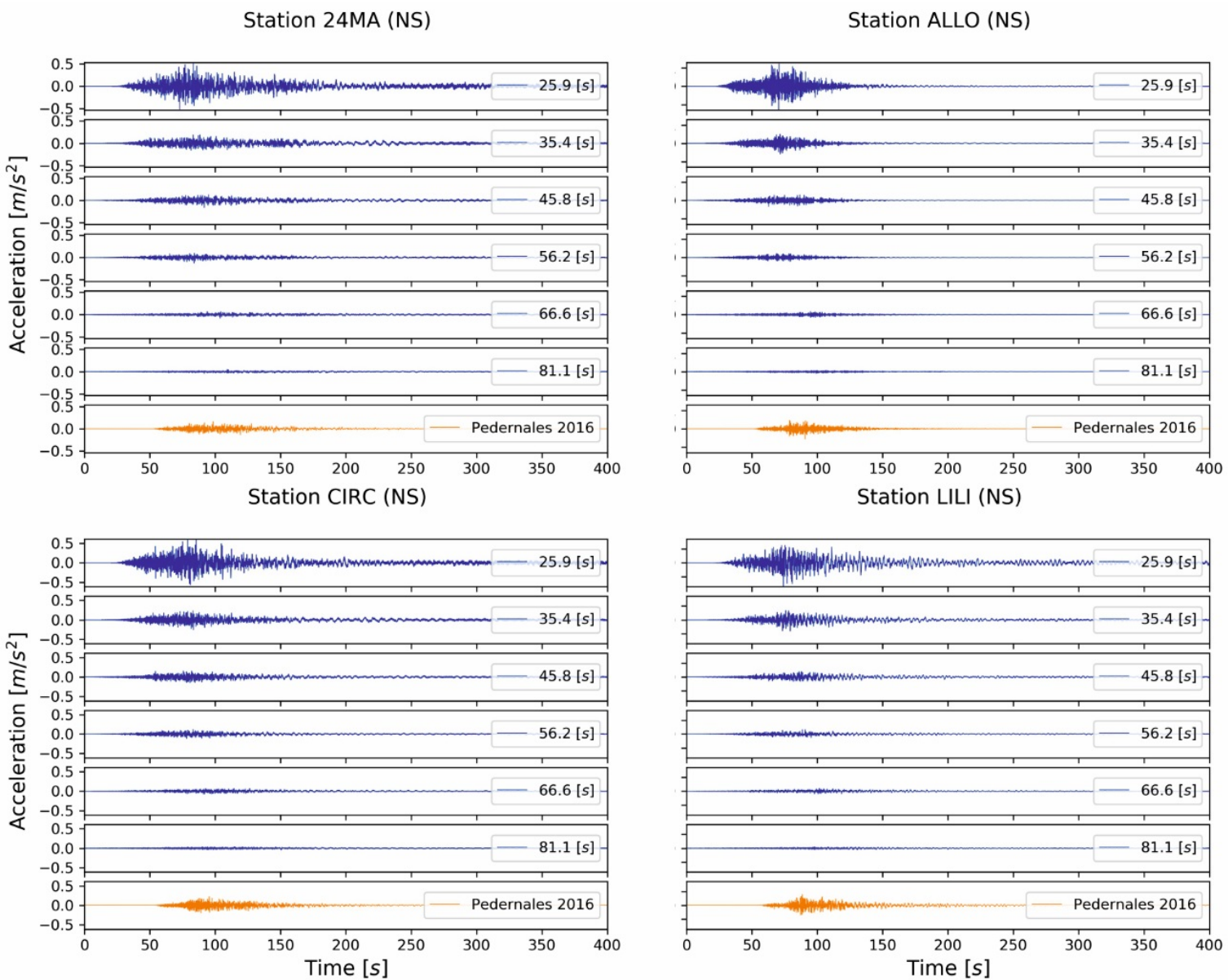
NOT-SUB: $\log(T) = 0.31 \log_{10}(M_o) - 4.90$

GROUND MOTION SIMULATION METHOD :

The source process (mean value and variability) is constrained by the global data base of source time function SCARDEC (Vallée et al, 2011, 2013; Vallée et Douet 2016, Chounet and Vallée, 2018)



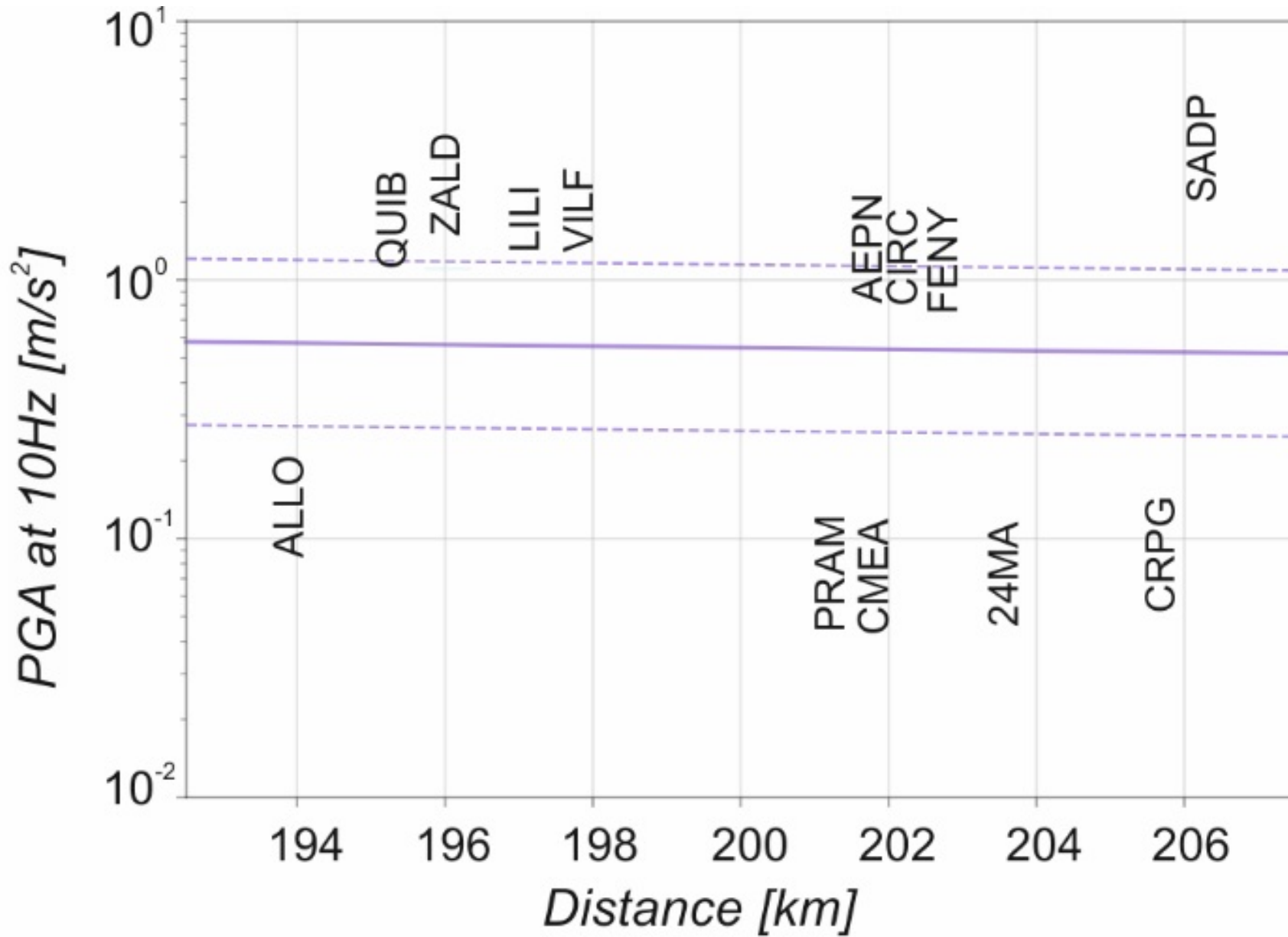
STEP 1 : VALIDATION ON THE PEDERNALES EARTHQUAKE



Simulations with EGF 22/04/2016 and different STF duration

PGA with the 4 EGF in function of the total STF duration

**SIMULATION OF A Mw 7.8
EARTHQUAKE**

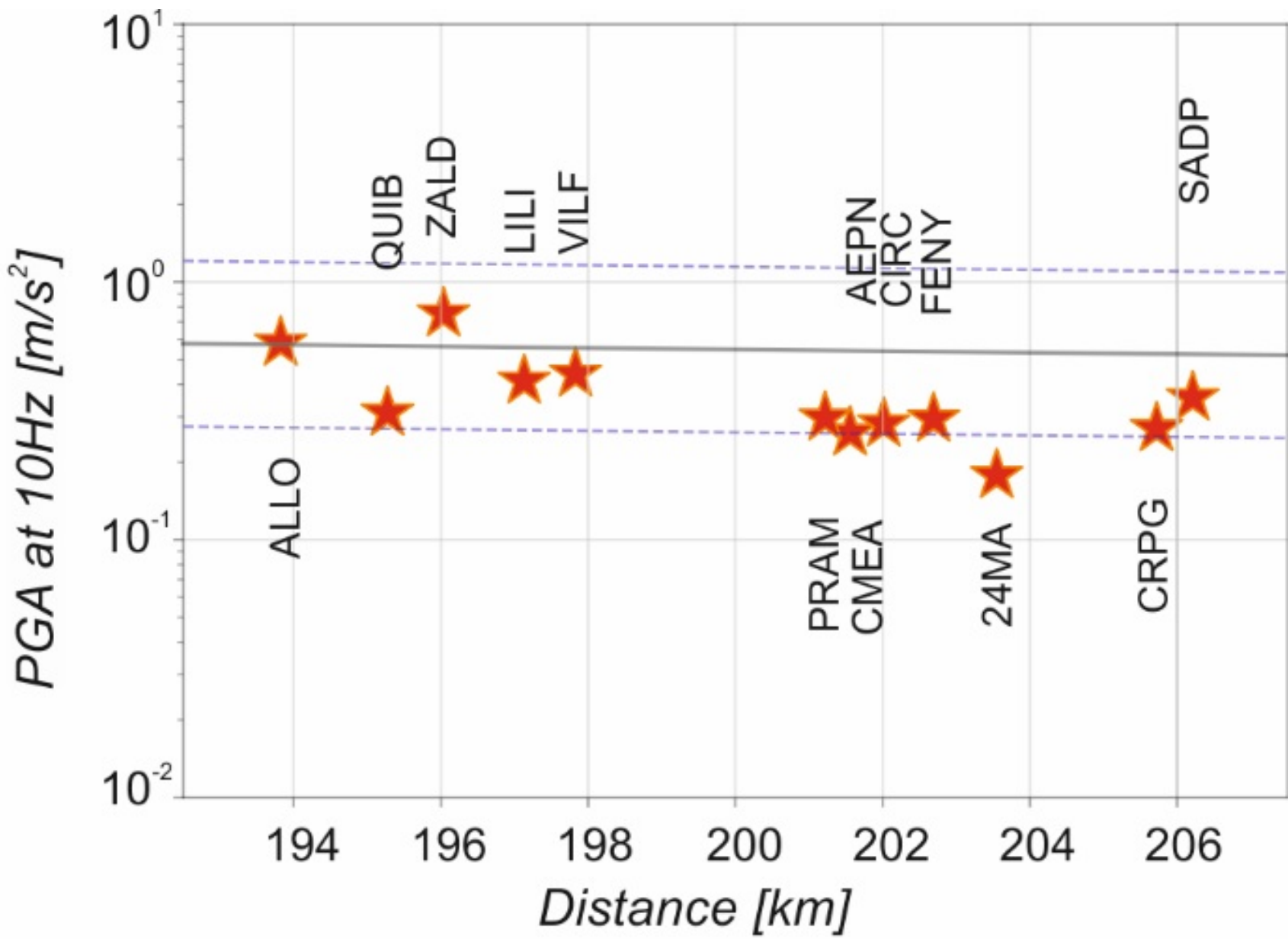


**For
HIGH FREQUENCIES
PGA (10HZ)**

--- GMPEs
(Abrahamson et al, 2016)

SIMULATION OF A Mw 7.8 EARTHQUAKE

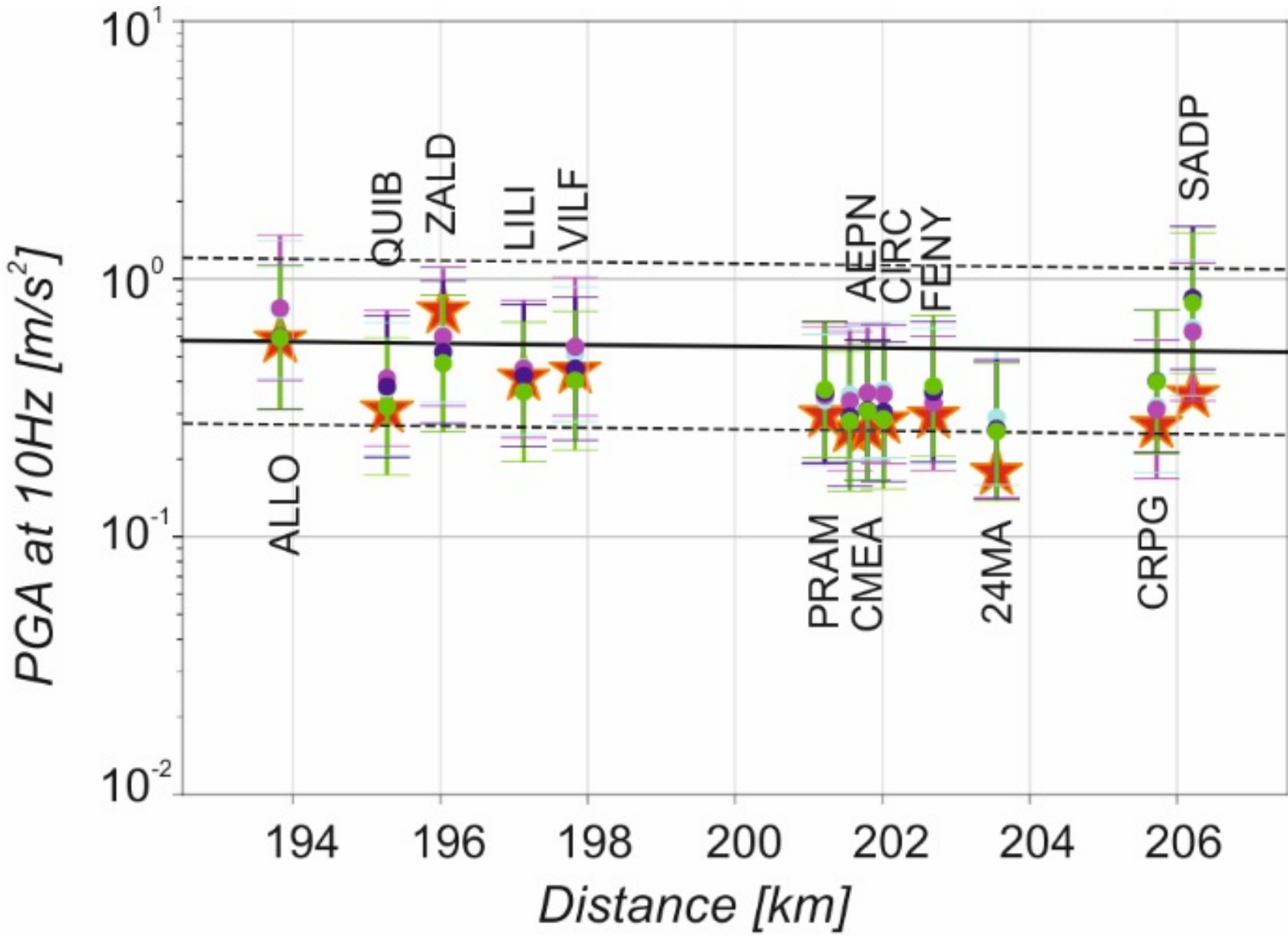
**For HIGH FREQUENCIES
PGA (10HZ)**



- GMPEs (Abrahamson et al, 2016)
- ★ Pedernales recordings

SIMULATION OF A Mw 7.8 EARTHQUAKE

**For HIGH FREQUENCIES
PGA (10HZ)**

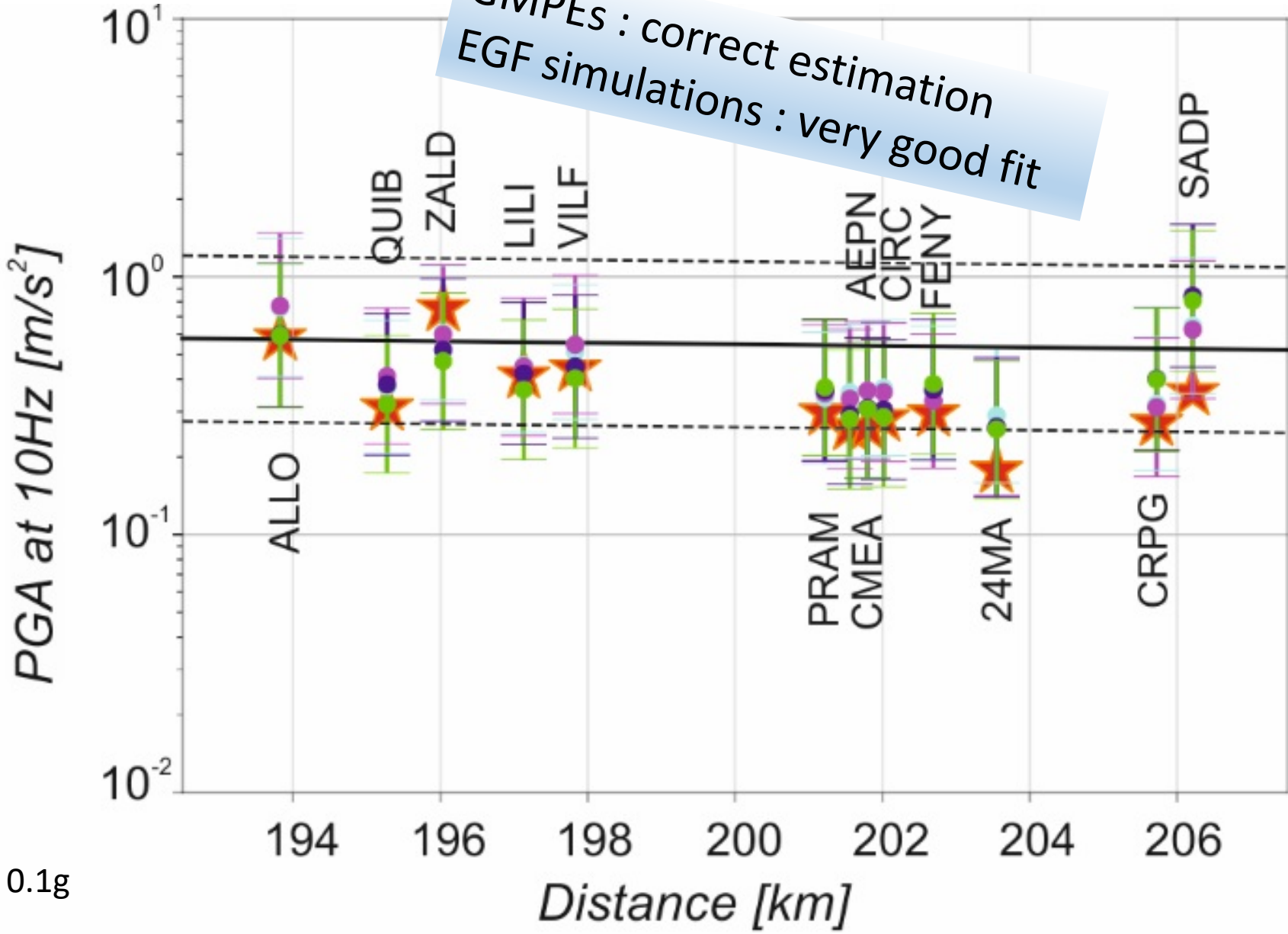


- GMPEs (Abrahamson et al, 2016)
- ★ Pedernales recordings
- Simu EGF 2016042203A
- Simu EGF 2016042203B
- Simu EGF 2016041922
- Simu EGF 2016042301

SIMULATION OF A Mw 7.8 EARTHQUAKE

GMPEs : correct estimation
EGF simulations : very good fit

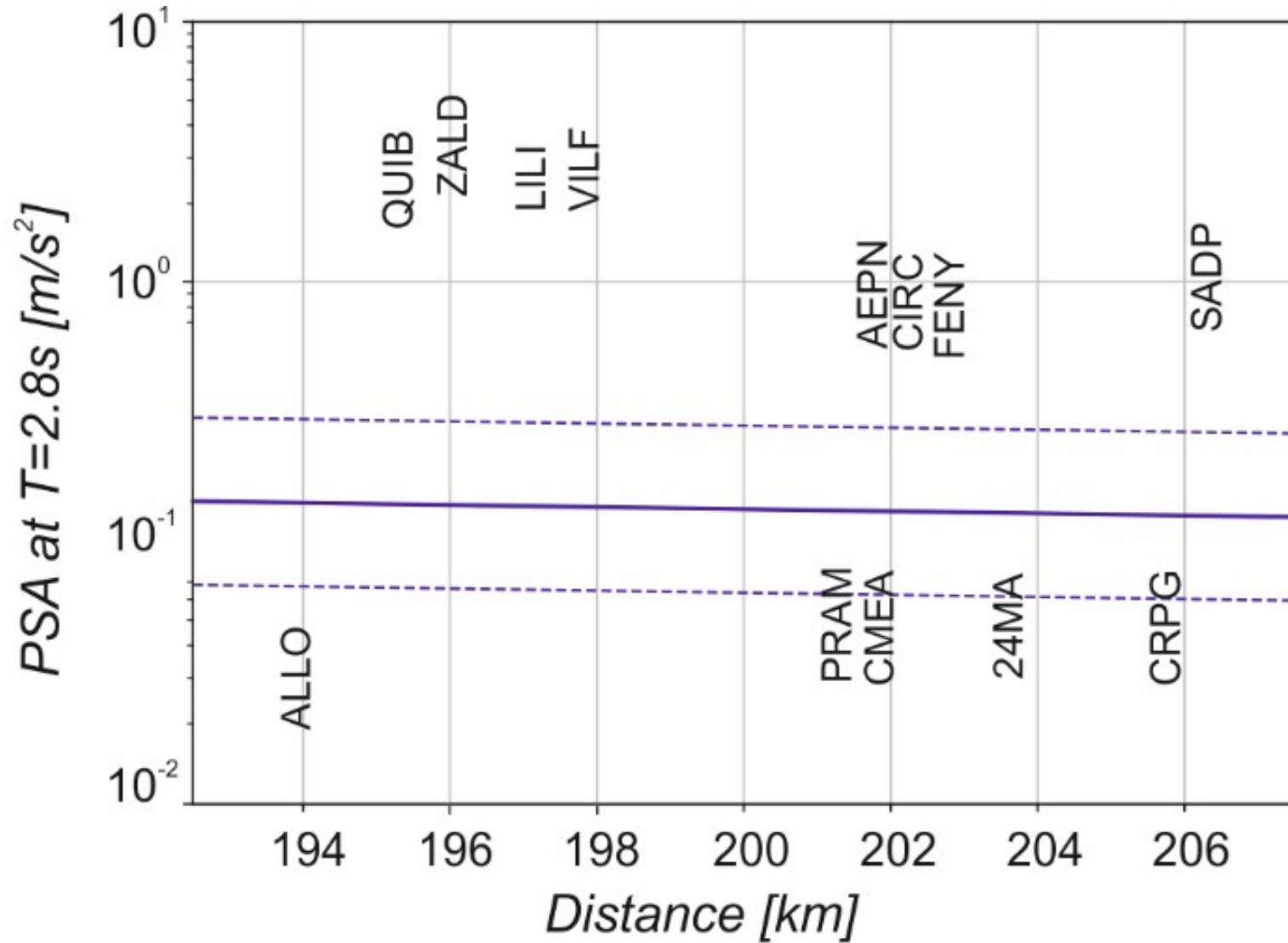
For
HIGH FREQUENCIES
PGA (10HZ)



PGA < 0.1g

- GMPEs (Abrahamson et al, 2016)
- ★ Pedernales recordings
- Simu EGF 2016042203A
- Simu EGF 2016042203B
- Simu EGF 2016041922
- Simu EGF 2016042301

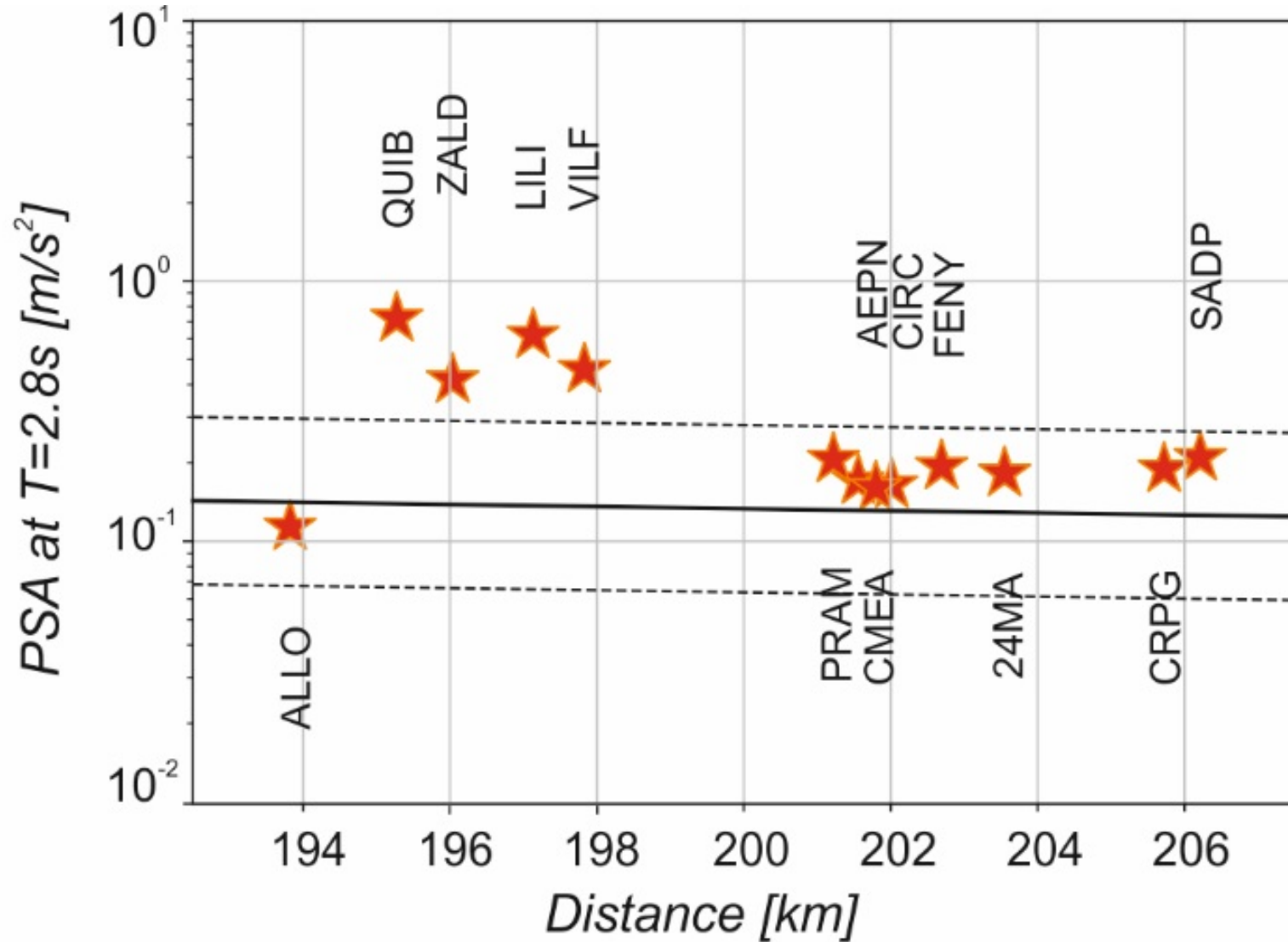
SIMULATION OF A Mw 7.8 EARTHQUAKE



For
Low FREQUENCIES
PSA at 0.35 Hz

--- GMPEs
(Abrahamson et al, 2016)

**SIMULATION OF A Mw 7.8
EARTHQUAKE**

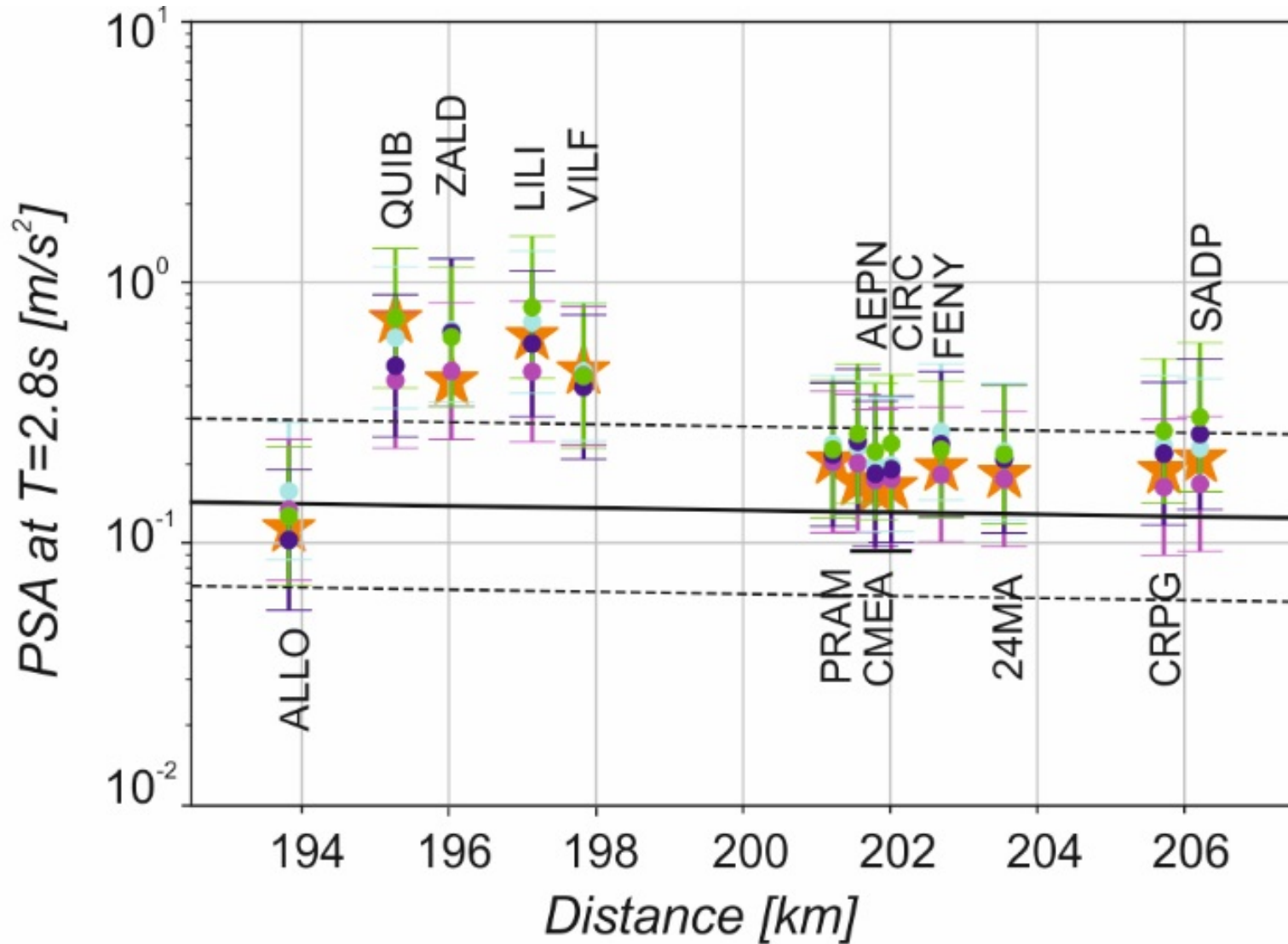


For
Low FREQUENCIES
PSA at 0.35 Hz

- GMPEs
(Abrahamson et al, 2016)
- ★ Pedernales recordings

SIMULATION OF A Mw 7.8 EARTHQUAKE

**For Low FREQUENCIES
PSA at 0.35 Hz**

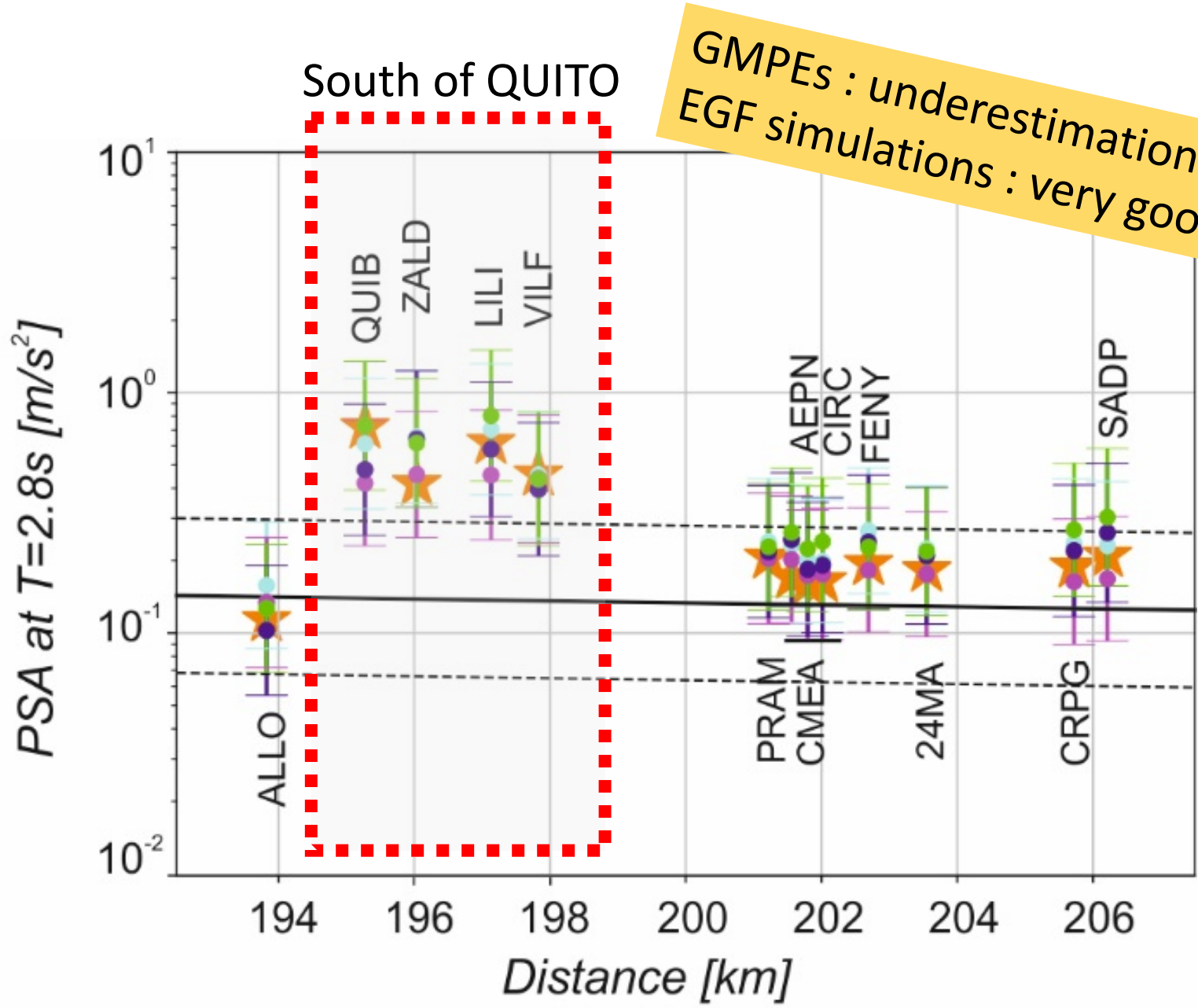


- GMPEs
(Abrahamson et al, 2016)
- ★ Pedernales recordings
- Simu EGF 2016042203A
- Simu EGF 2016042203B
- Simu EGF 2016041922
- Simu EGF 2016042301

SIMULATION OF A Mw 7.8 EARTHQUAKE

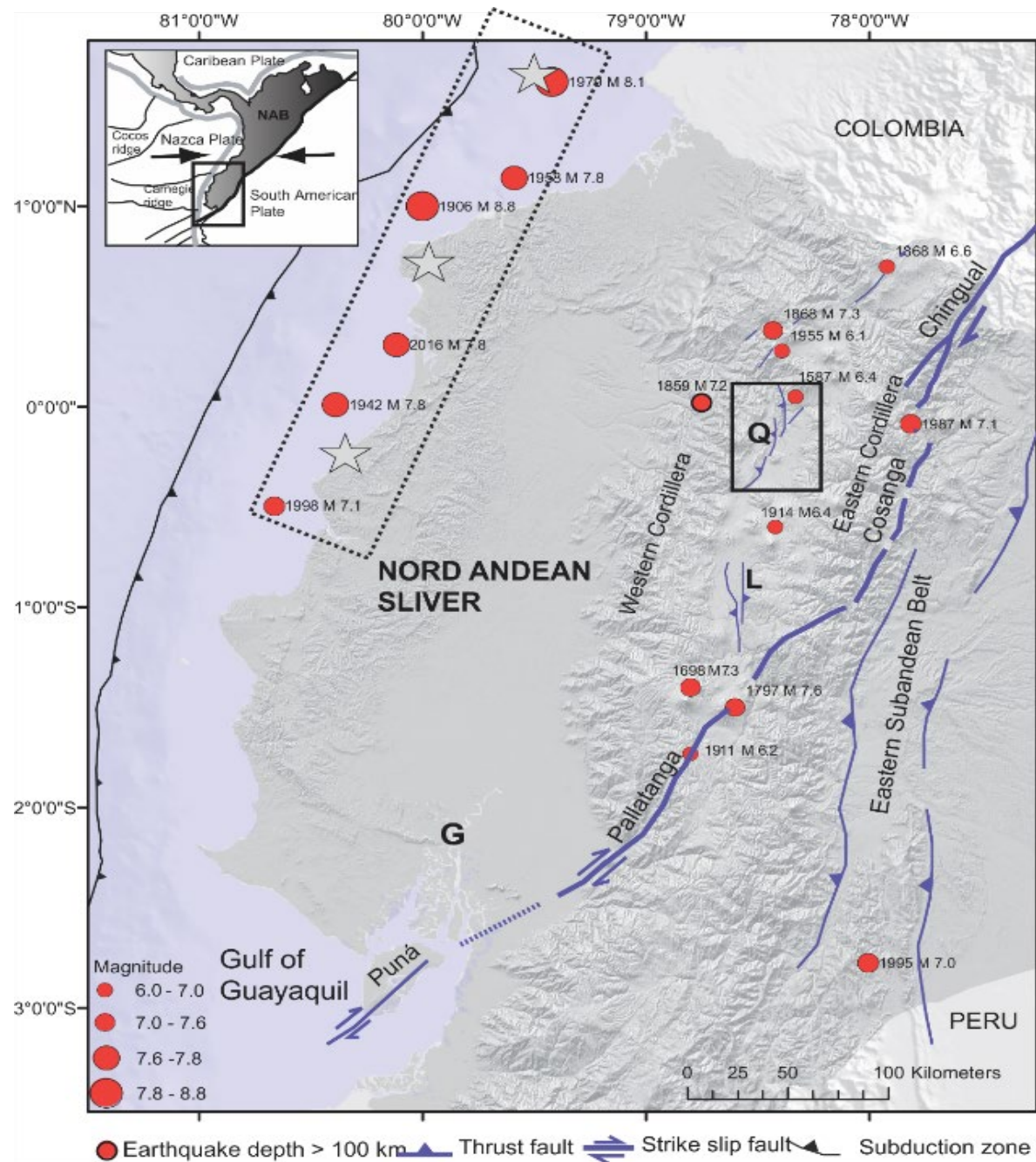
GMPEs : underestimation in the South
EGF simulations : very good fit

**For Low FREQUENCIES
PSA at 0.35 Hz**



- GMPEs (Abrahamson et al, 2016)
- ★ Pedernales recordings
- Simu EGF 2016042203A
- Simu EGF 2016042203B
- Simu EGF 2016041922
- Simu EGF 2016042301

STEP 2 : SIMULATION OF A Mw 8.5 EARTHQUAKE

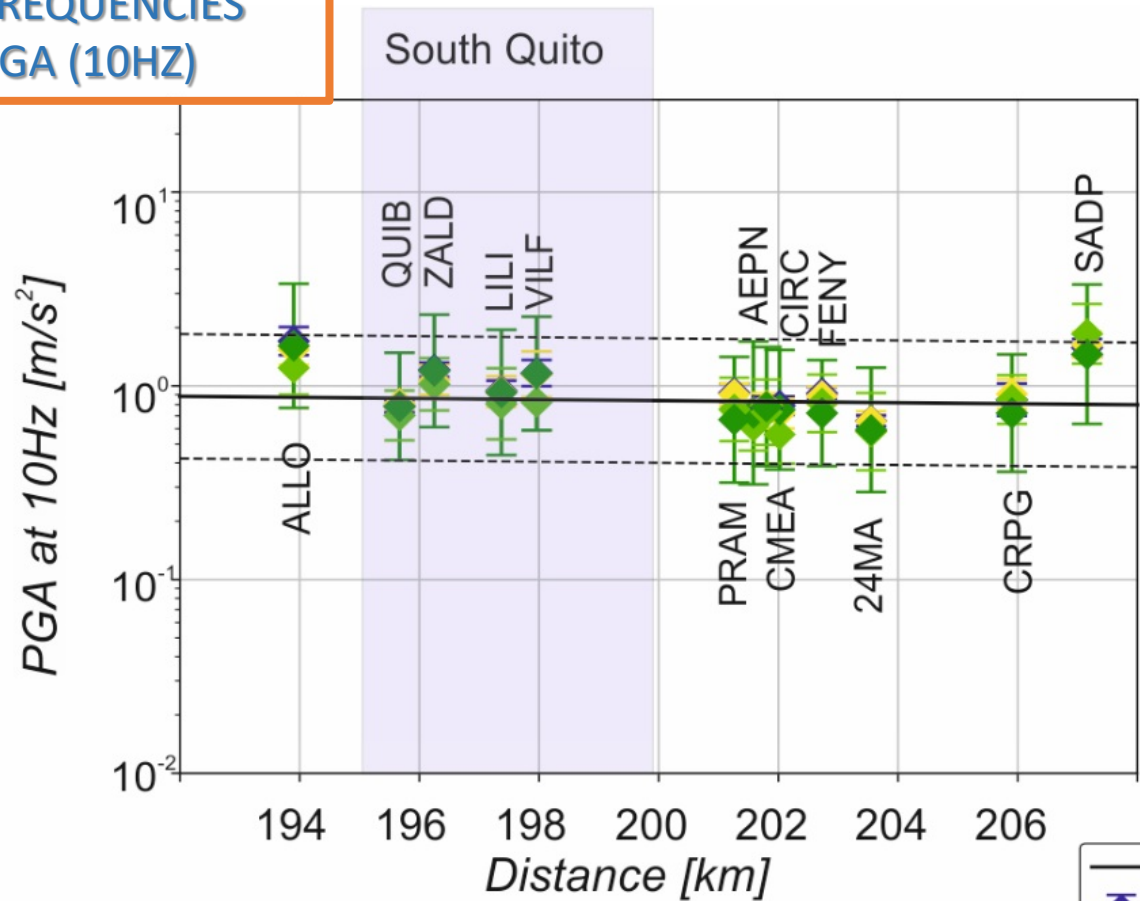


4 scenarios :

- 1 main patch at north
- 1 main patch at south
- 3 sub events (directivity toward the north)
- 3 sub events (directivity toward the south)

SIMULATION OF A MW 8.5 EARTHQUAKE

For HIGH FREQUENCIES
PGA (10HZ)

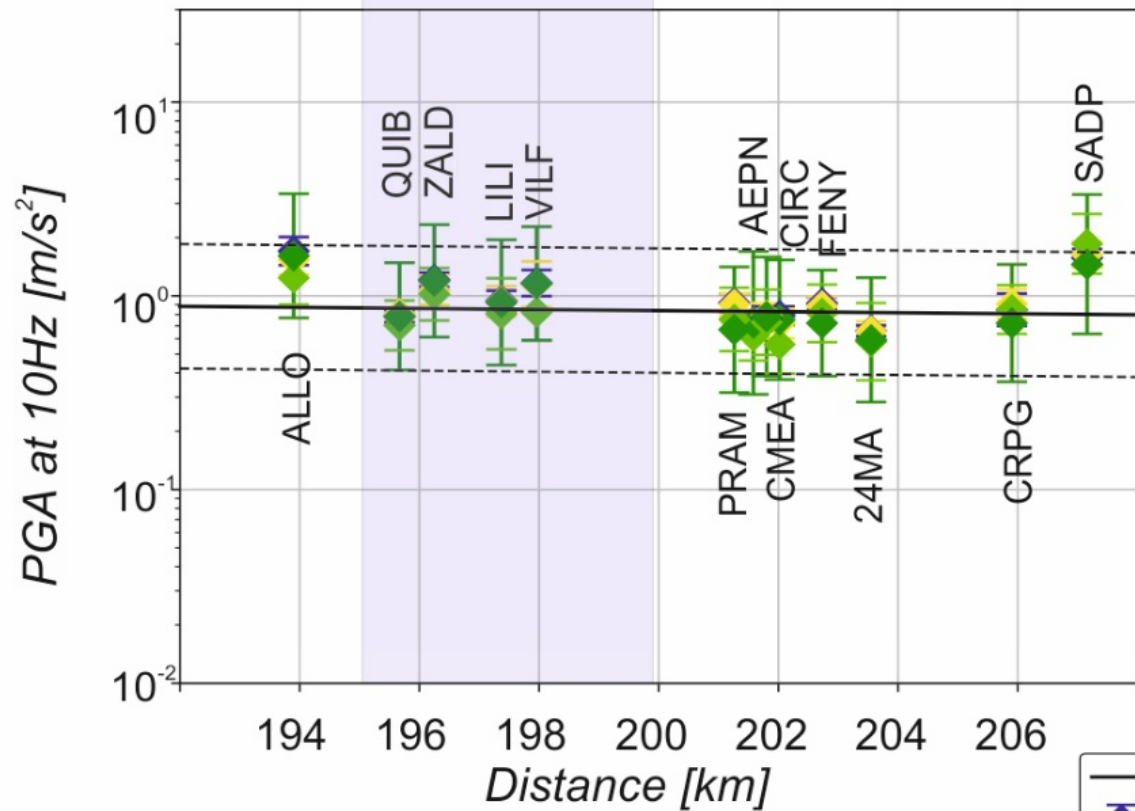


PGA max = 0.3 g

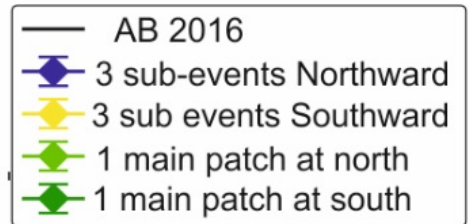
- AB 2016
- ◆ 3 sub-events Northward
- ◆ 3 sub events Southward
- ◆ 1 main patch at north
- ◆ 1 main patch at south

SIMULATION OF A MW 8.5 EARTHQUAKE

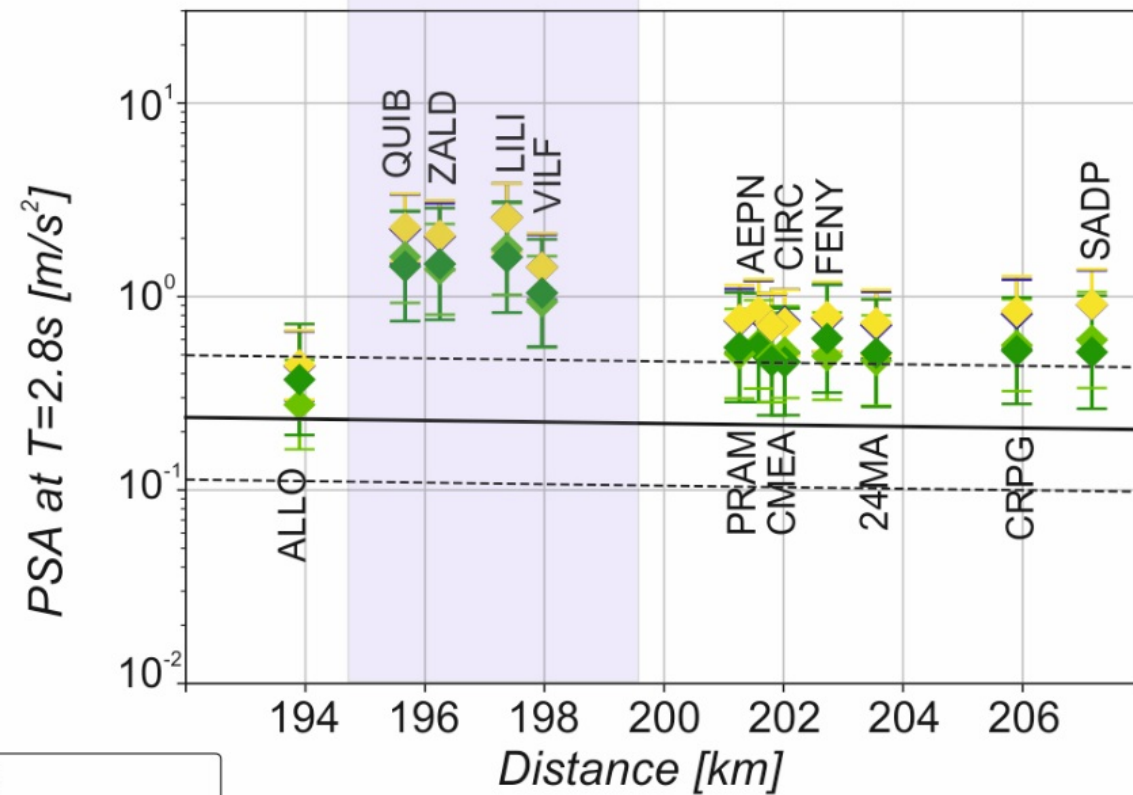
HIGH Frequency



PGA max = 0.3 g

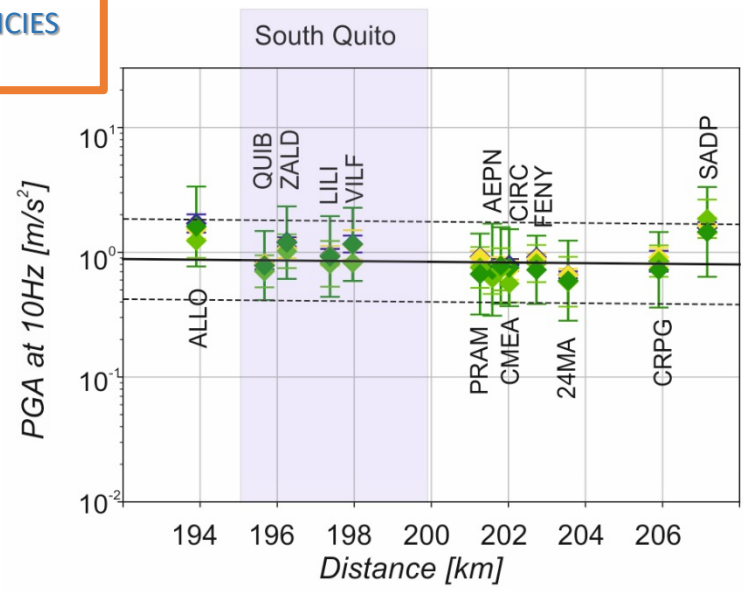


LOW Frequency

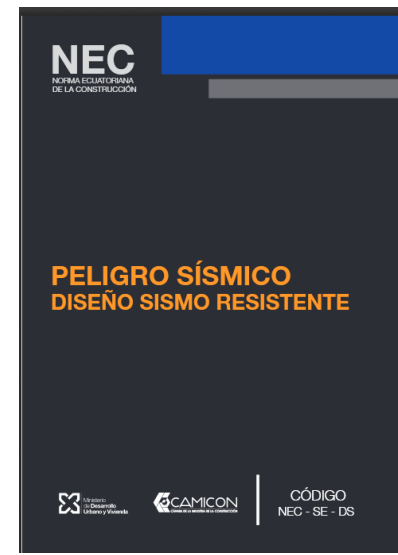
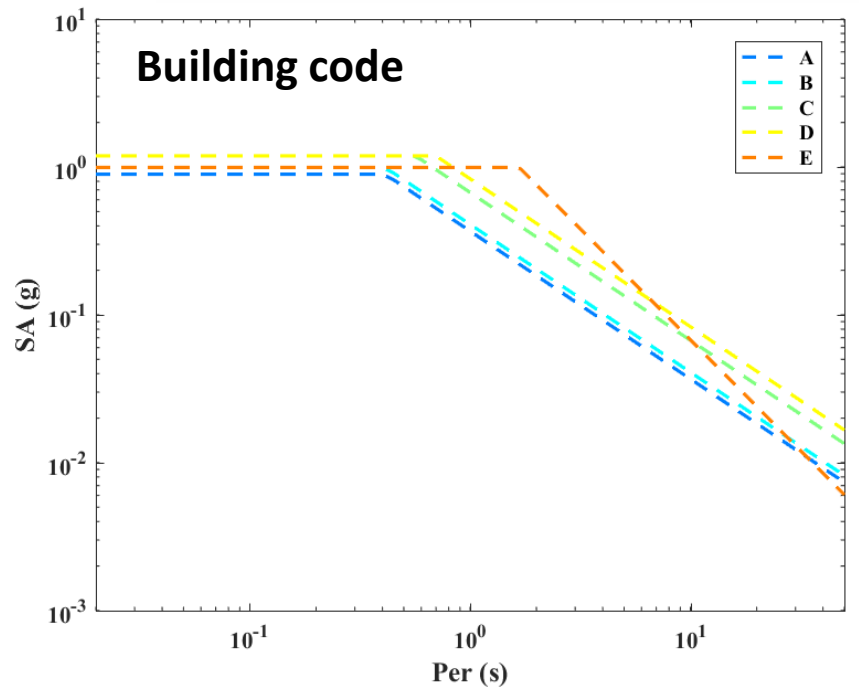
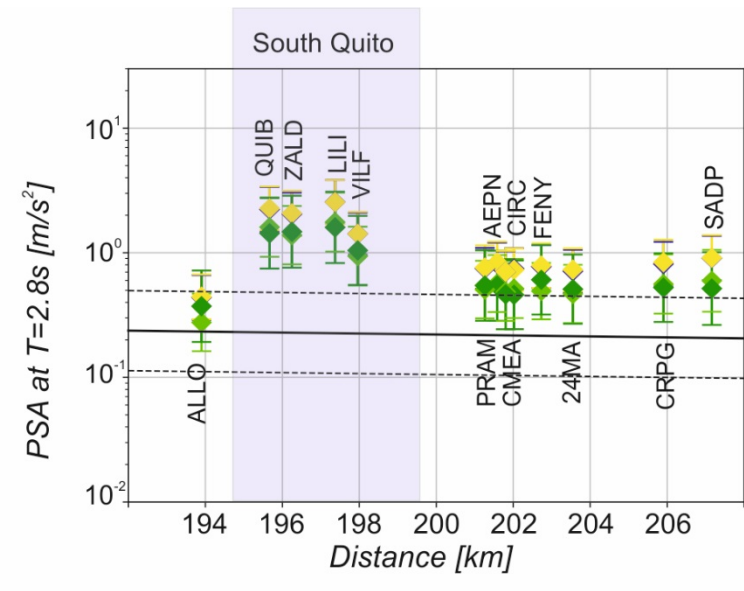


For
Low FREQUENCIES
PSA at 0.35 Hz

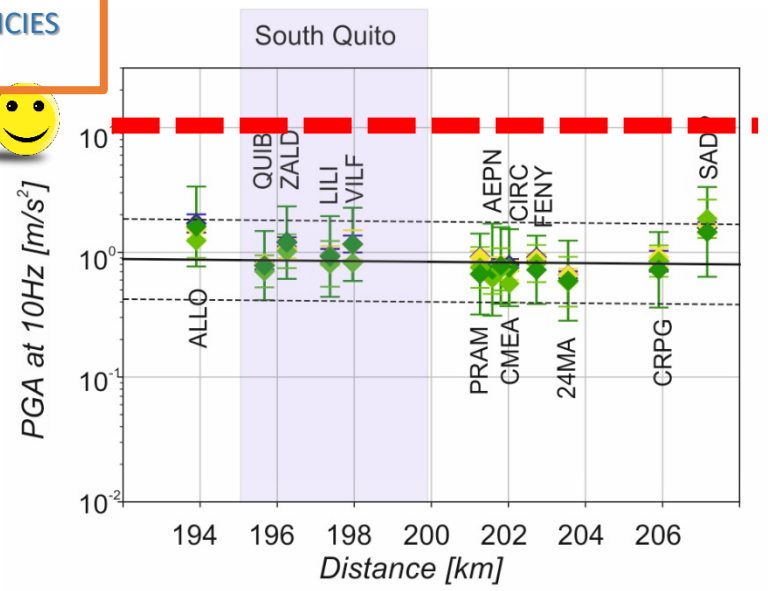
**HIGH FREQUENCIES
PGA (10Hz)**



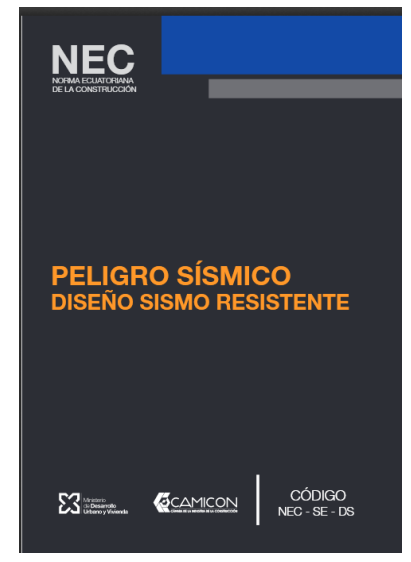
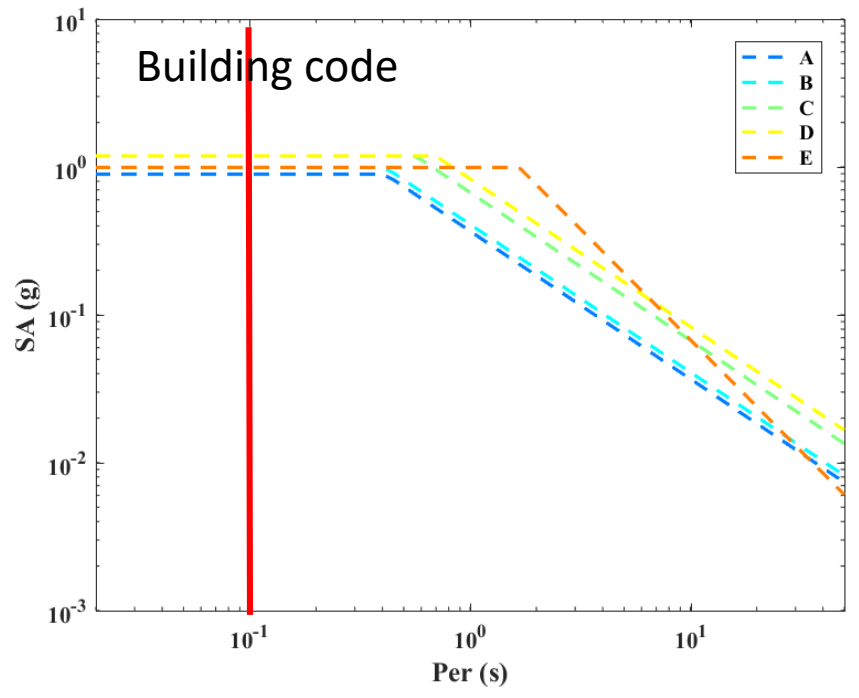
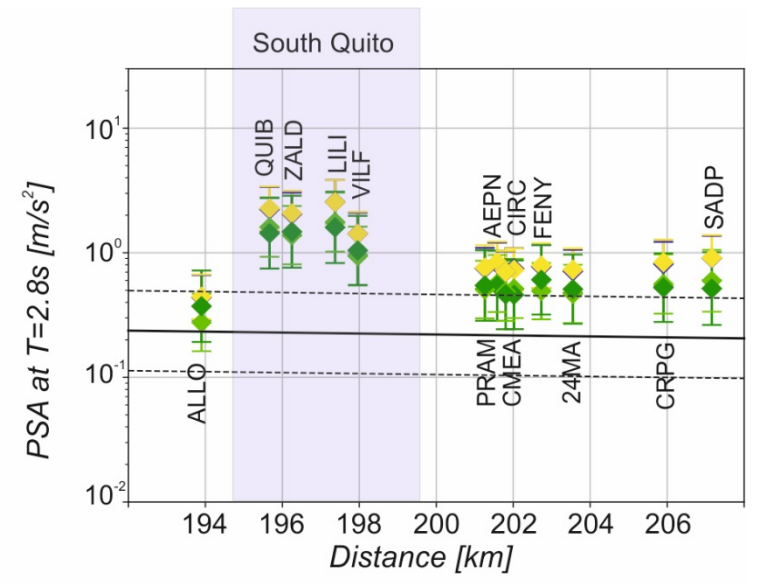
**Low FREQUENCIES
PSA at 0.35 Hz**



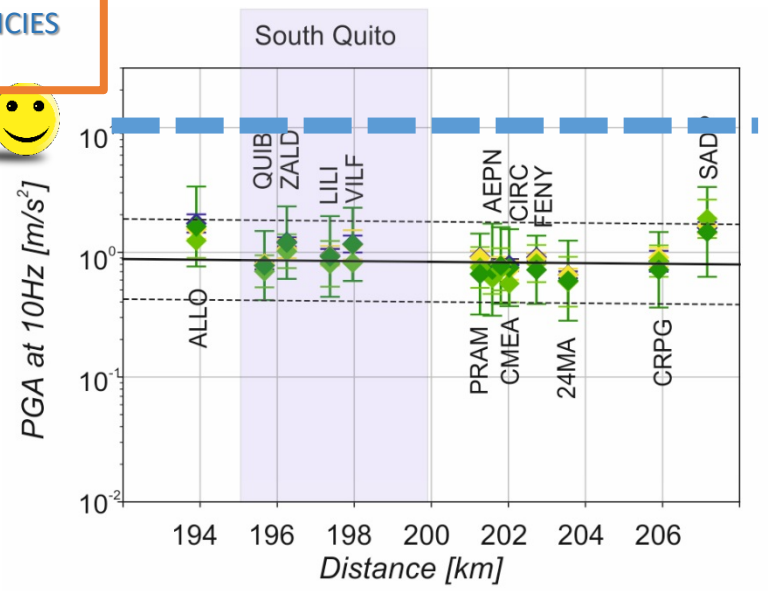
**HIGH FREQUENCIES
PGA (10Hz)**



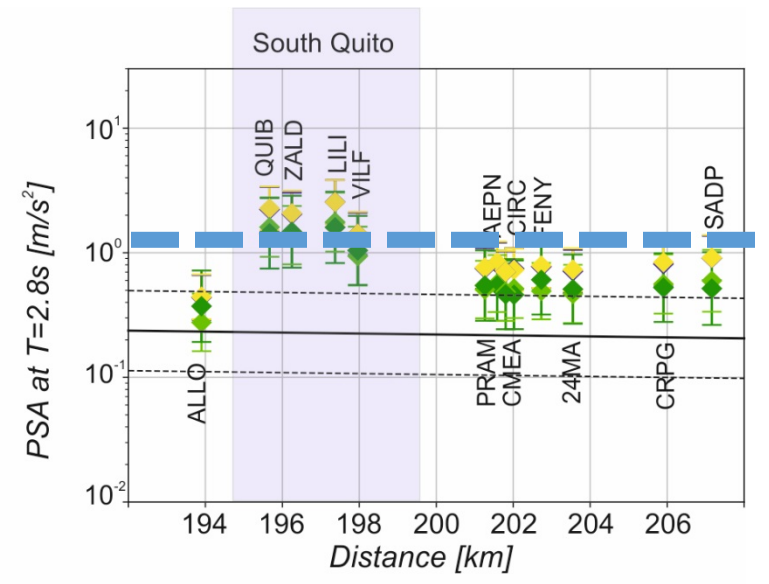
**Low FREQUENCIES
PSA at 0.35 Hz**



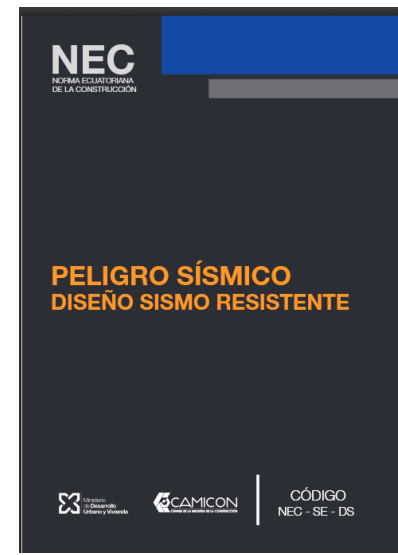
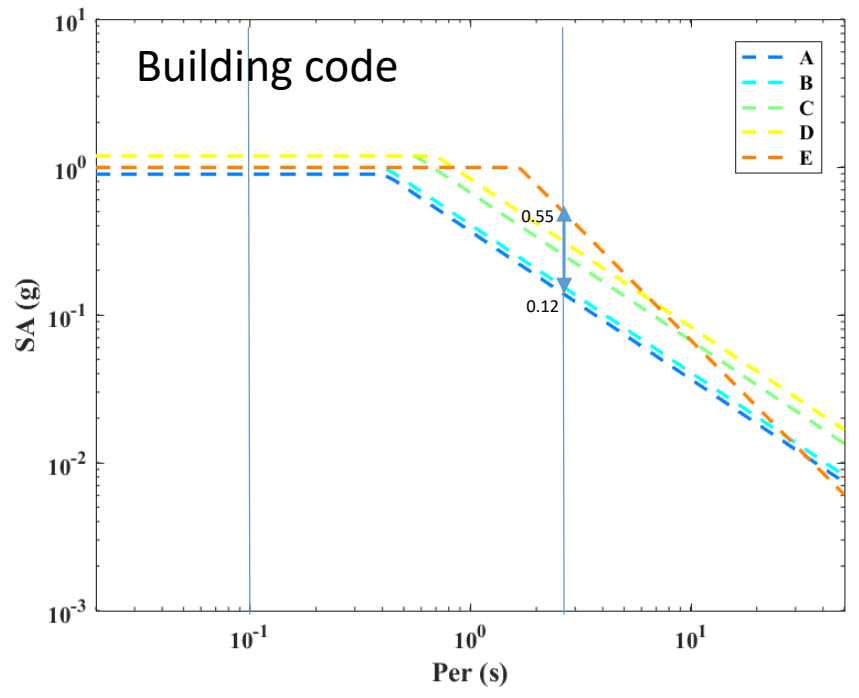
**HIGH FREQUENCIES
PGA (10Hz)**



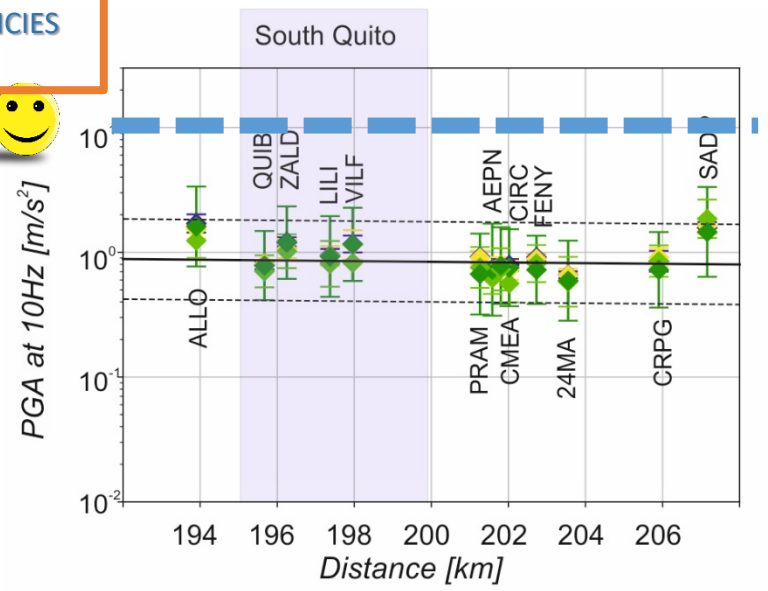
**Low FREQUENCIES
PSA at 0.35 Hz**



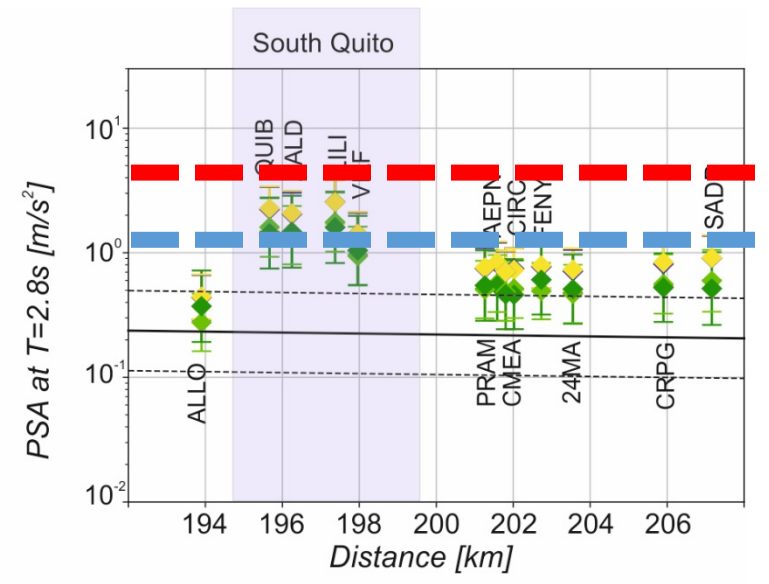
Soil type A,B 😞



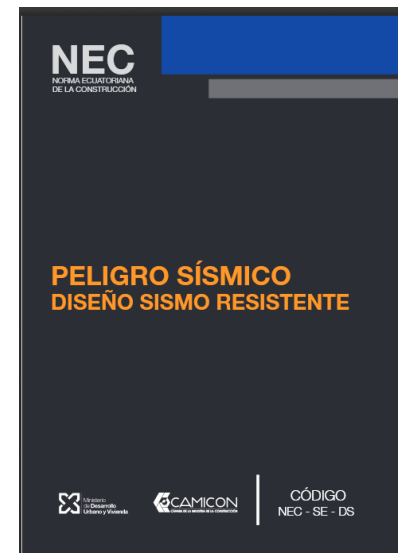
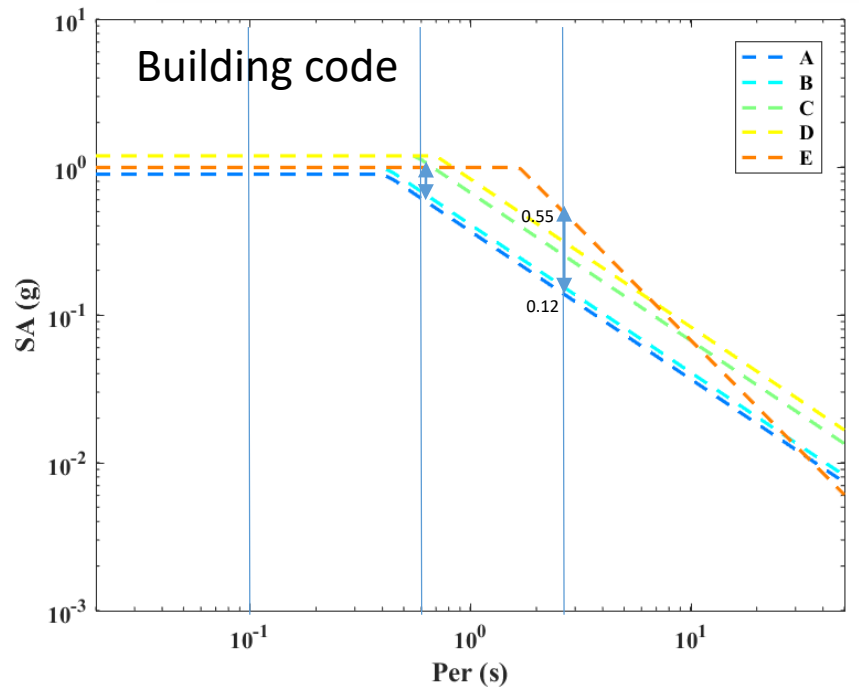
**HIGH FREQUENCIES
PGA (10Hz)**



**Low FREQUENCIES
PSA at 0.35 Hz**



Soil type E



Conclusion

**A future Mw 8.5 (or more) subduction event could generate damages in Quito,
especially in the southern part of the basin,
and for large buildings (20 floors and more) and large structures**

YOU
ARE
HERE

