

GROUND MOTION PARAMETERS EXTRACTION WITH ANTELOPE AND PYTHON

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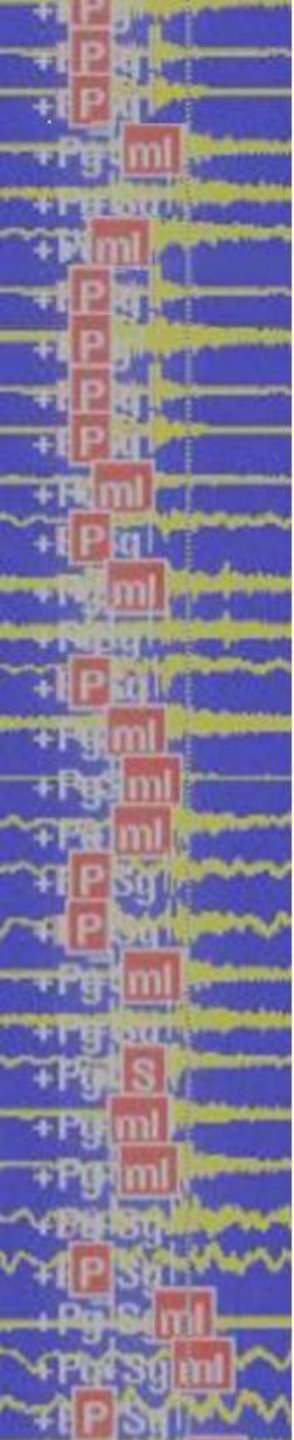
May 28th 2019

Taormina, Italy AUG



Why *GMP_Viewer*

Python script for Ground Motion Parameters (GMP) extraction from seismic waveforms in Antelope databases





GMP_Viewer main concept

- modularity: any new parameter calculation can be added
- control: high customization of signal processing for each individual trace
- clarity: synthetic graphical visualization of the results

Currently available GMPs

 PGA

 PGV

 PGD

 PGV/PGA

 duration

 PSA03


 PSA10


 PSA30

 zero crossings

 Saragoni factor

 Manfredi damage factor

 Arias intensity

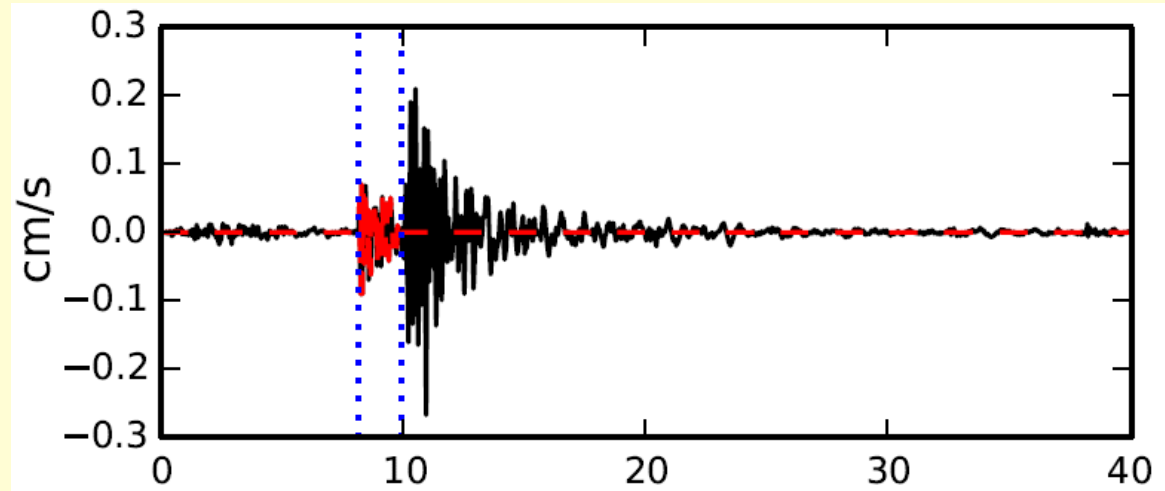
 Housner intensity

 EPA

 IV2

Currently available GMPs: IV2

$$IV2 = \int_t^{t+\Delta t} v_z^2(t) dt \quad \text{with} \quad t = t_P, \quad t + \Delta t = t_S$$



Kanamori, H., E. Hauksson, L. K. Hutton, and L. M. Jones (1993), Determination of earthquake energy release and ML using TERRAScope, *Bull. Seismol. Soc. Am.*, 83, 330–346

Picozzi, M., Bindi, D., Brondi, P., Di Giacomo, D., Parolai, S., and Zollo, A. (2017), Rapid determination of P wave-based energy magnitude: Insights on source parameter scaling of the 2016 Central Italy earthquake sequence, *Geophys. Res. Lett.*, 44, 4036–4045

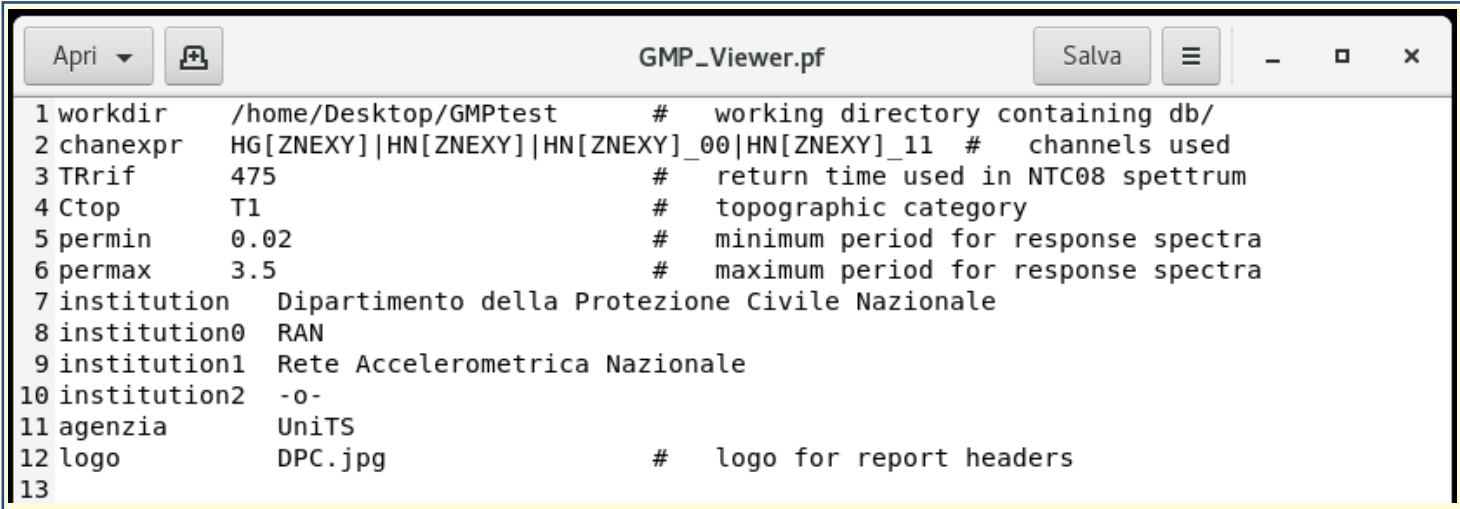
A look at the code

```
Apr 10 10:10:10 GMP_server.xpy ~/Scrivania Salva [Menu] [Close] [Maximize]
1 #!/opt/antelope/python2.7.8/bin/python
2
3 #-----
4 # Last modified 24/01/2019 by Laura
5 #
6 # This program calculates some main ground motion parameters on
7 # individual components taken from traces in a given antelope database.
8 # It currently calculates PGA, PGV, PGD, PGV/PGA, Arias, Housner, PSA
9 # at 0.3, 1.0 and 3.0 s, EPA, Td (duration), v0 (icounts/duration), Pd
10 # (Saragoni factor), Id (Manfredi damage factor) and IV2 (squared integral
11 # of vertical component of velocity on P waves signal; integration
12 # currently starts at the P pick, if present, or at the synthetic P
13 # arrival, and ends at the synthetic S arrival).
14 #
15 #-----
16
17 import os
18 import sys
19 import signal
20
21 signal.signal(signal.SIGINT, signal.SIG_DFL)
22 sys.path.append(os.environ['ANTELOPE'] + "/data/python")
23
24 import math
25 import numpy as np
26 import obspy
27 import antelope.stock as stock
28 import antelope.datascope as datascope
29 import antelope.sysinfo as sysinfo
```

Python ▾ Larg. tab.: 3 ▾ Rg 26, Col 13 ▾ INS

Running the code

> GMP_Viewer.xpy pf/GMP_Viewer.pf



```
1 workdir      /home/Desktop/GMPtest      # working directory containing db/
2 chanexpr     HG[ZNEXY]|HN[ZNEXY]|HN[ZNEXY]_00|HN[ZNEXY]_11 # channels used
3 TRrif        475                        # return time used in NTC08 spettrum
4 Ctop         T1                          # topographic category
5 permin       0.02                        # minimum period for response spectra
6 permax       3.5                         # maximum period for response spectra
7 institution   Dipartimento della Protezione Civile Nazionale
8 institution0  RAN
9 institution1  Rete Accelerometrica Nazionale
10 institution2 -o-
11 agenzia      UniTS
12 logo         DPC.jpg                    # logo for report headers
13
```

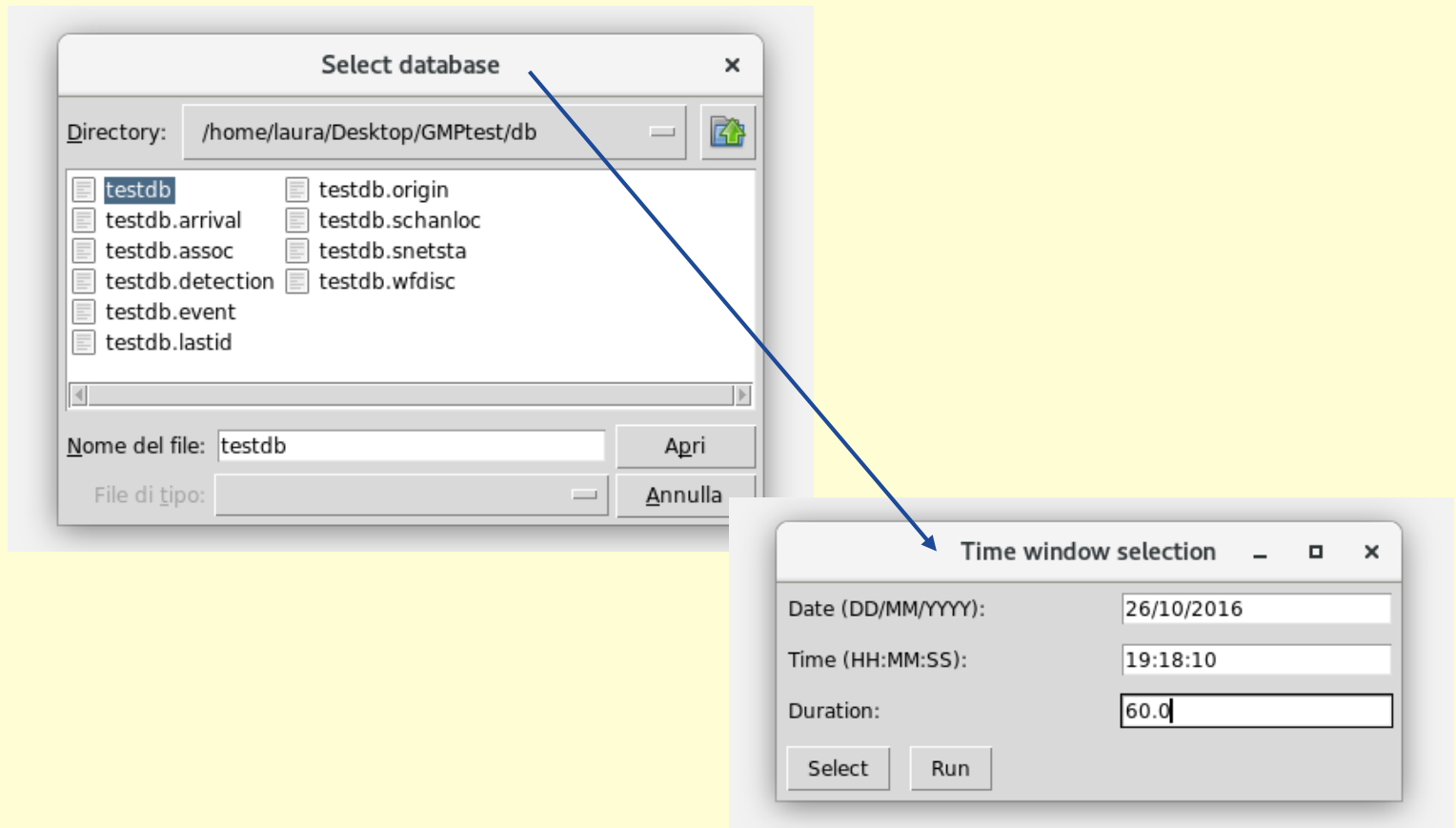


Running the code

Requirements:

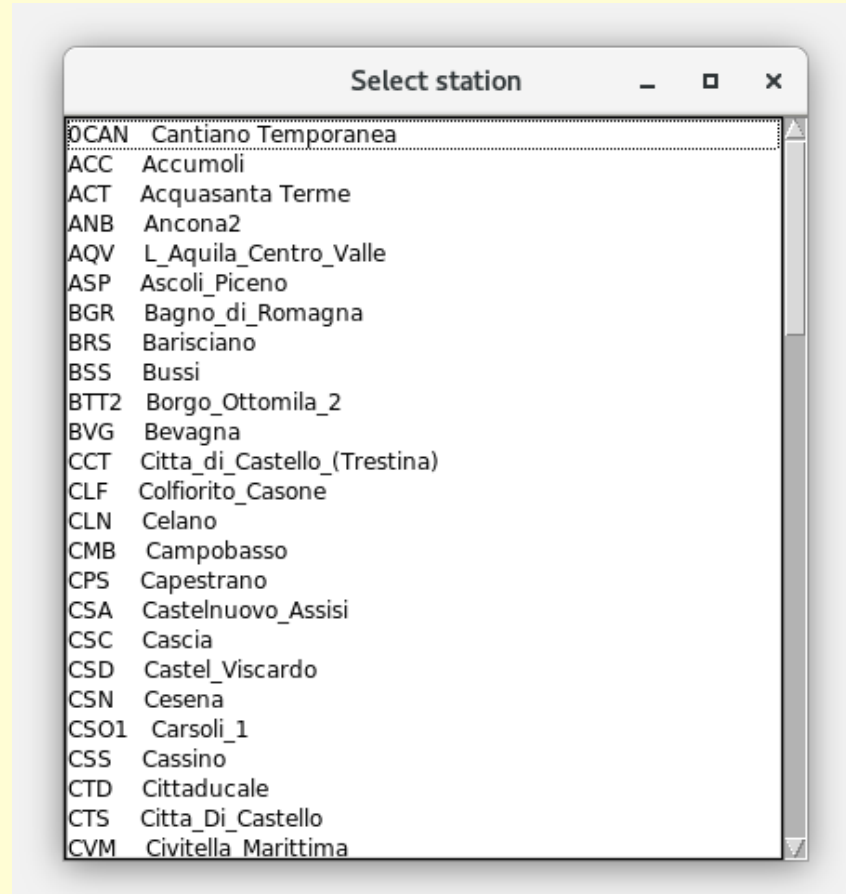
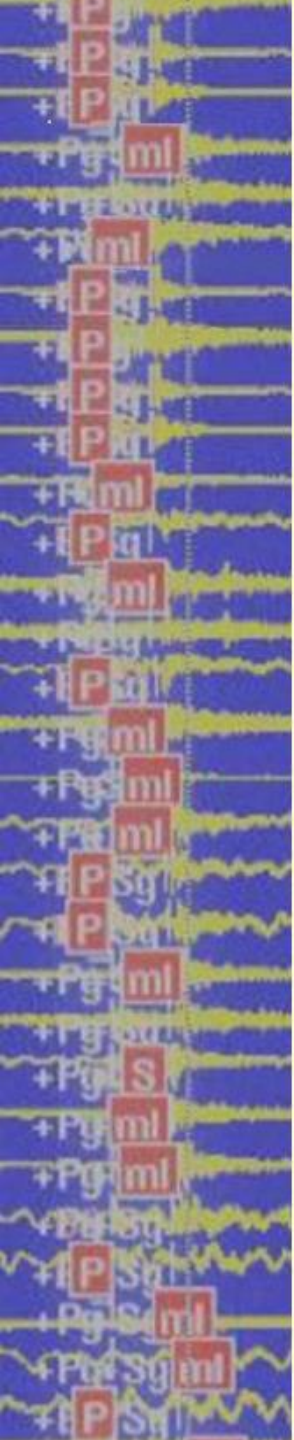
- Python: *obspy*, *matplotlib*, *numpy*, *scipy*, *time*, *Tkinter*, *tkFileDialog*, *contextlib*, *datetime*, *math*, *signal*, *PIL*
- Antelope
- An Antelope database with some tables already available (*sitechan*, *site*, *schanloc*, *wfdisc*); some are optional (*arrival*, *assoc*; *origin*, *event*; *calibration*; *stage*; *Geosite*, *Spetpar*)

Waveform selection (I)



E.g.: event of October 26th 2016, 19:18:06,
Central Italy sequence, $M_W = 5.9$

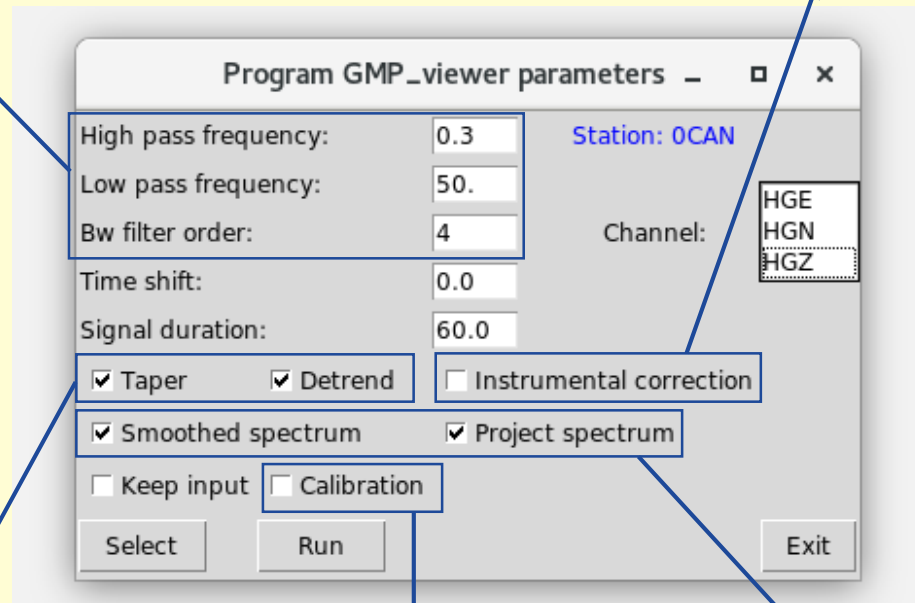
Waveform selection (II)



Waveform manipulation

Butterworth
filter

instrumental correction



tapering &
detrending

calibration

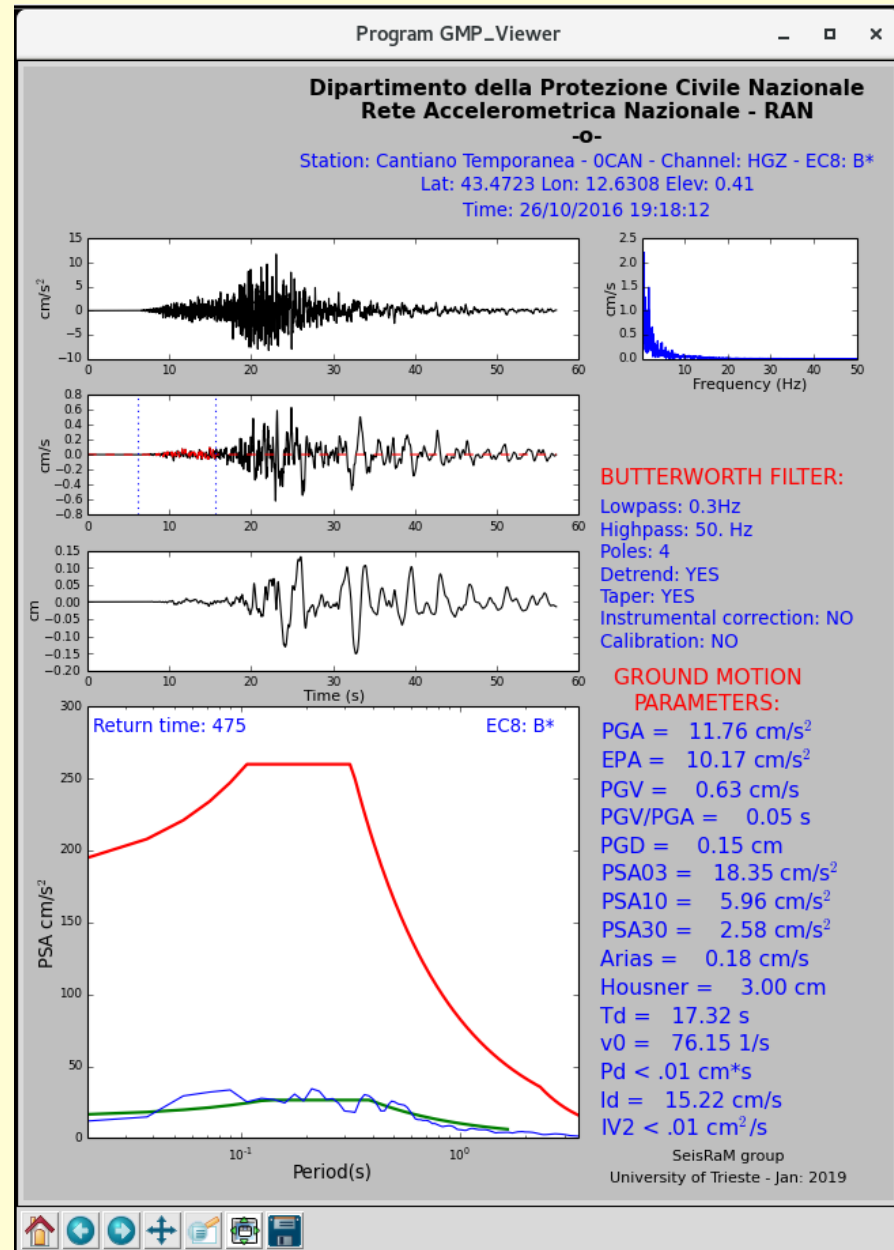
response
spectra

Output

txt + pdf →

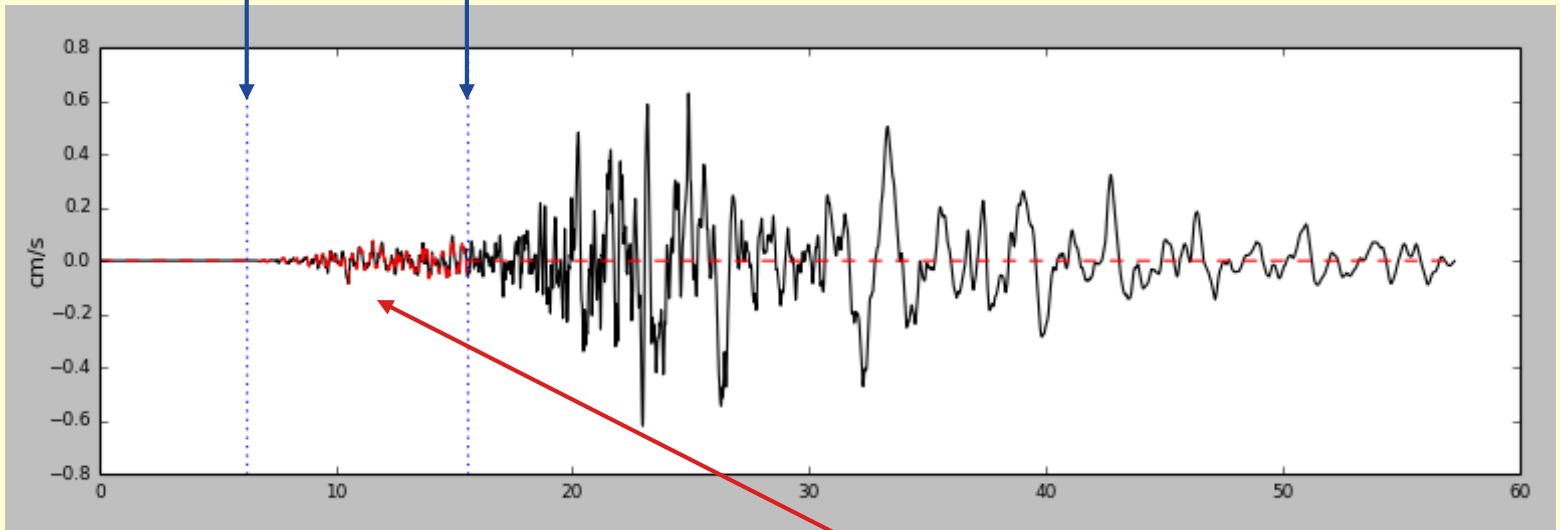


2016300_191810_0CAN_HGZ.txt	
1 pga	11.76
2 epa	10.17
3 pgv	0.63
4 pgv/pgs	0.05
5 pgd	0.15
6 psa03	18.35
7 psa10	5.96
8 psa30	2.58
9 arias	0.18
10 housner	3.00
11 Td	17.32
12 v0	76.15
13 Pd	< .01 cm*s
14 Id	15.22
15 IV2	< .01 cm^2/s



Output: IV2

Synthetic P and S picks



Trace used for integration

Documentation

Welcome to GMP_Viewer's short manual for ground motion parameters extraction! — GMP_Viewer_manual 0.0 documentation - Mozilla Firefox

file:///home/laura/Documents/GMPviewer_manual/_build/html/index.html

GMP_Viewer_manual 0.0 documentation » next | index

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2. Preliminary steps
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1. Before you start: An overview on the program

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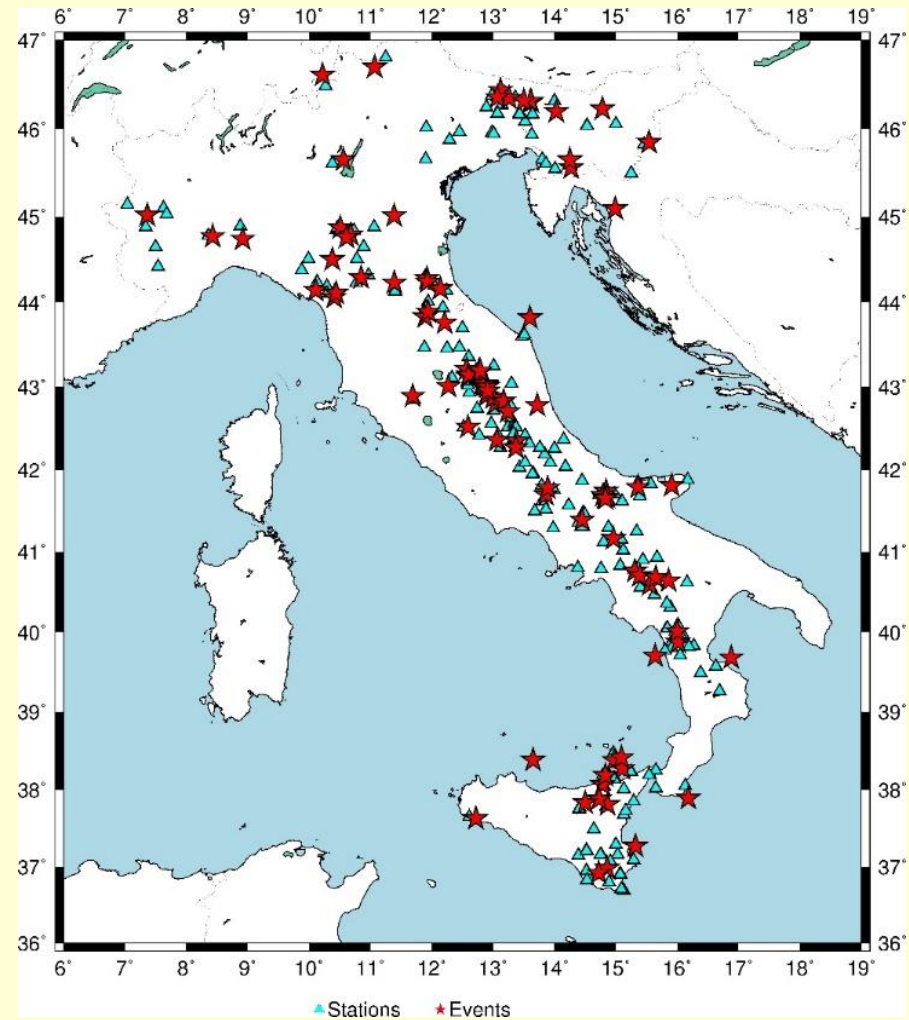
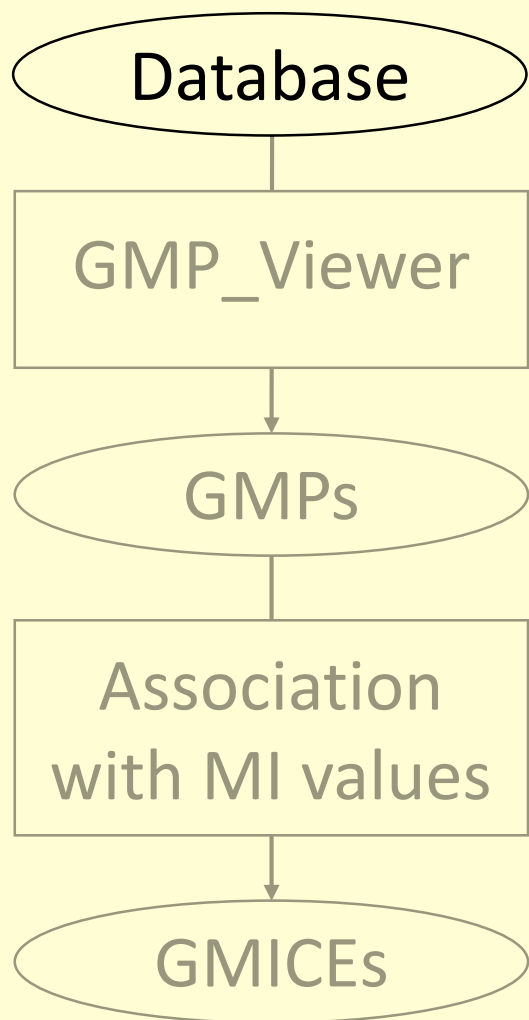
Show Source

Quick search

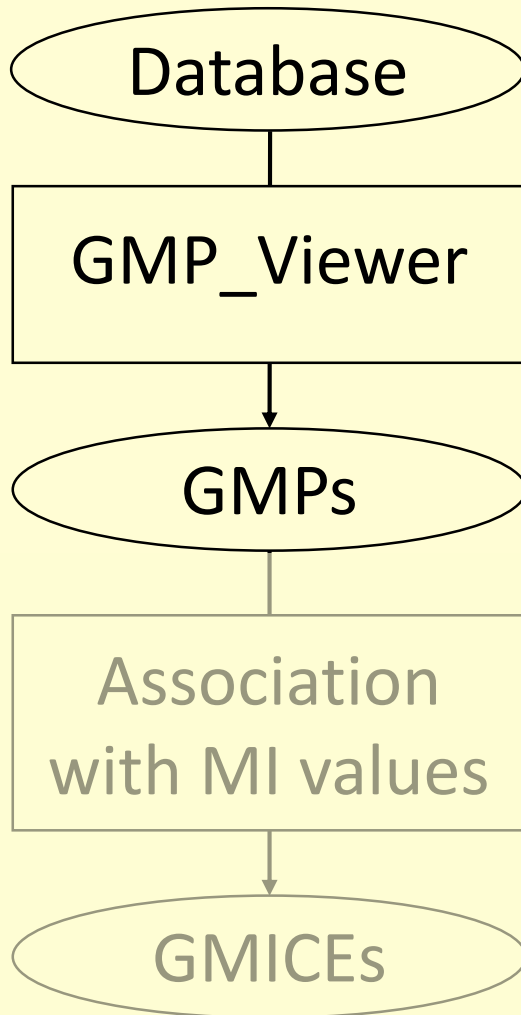
GMP_Viewer_manual 0.0 documentation »

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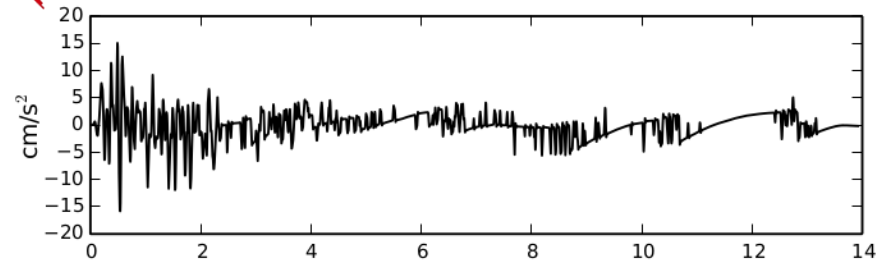
Example of application: GMICEs



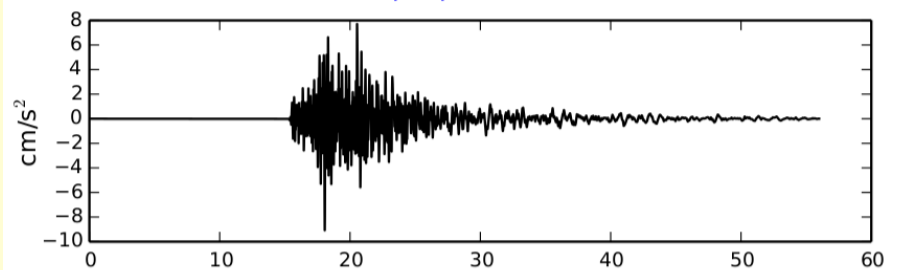
Example of application: GMICEs



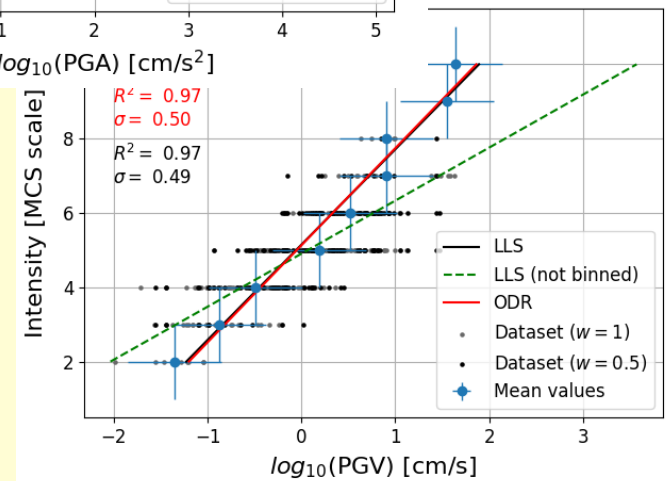
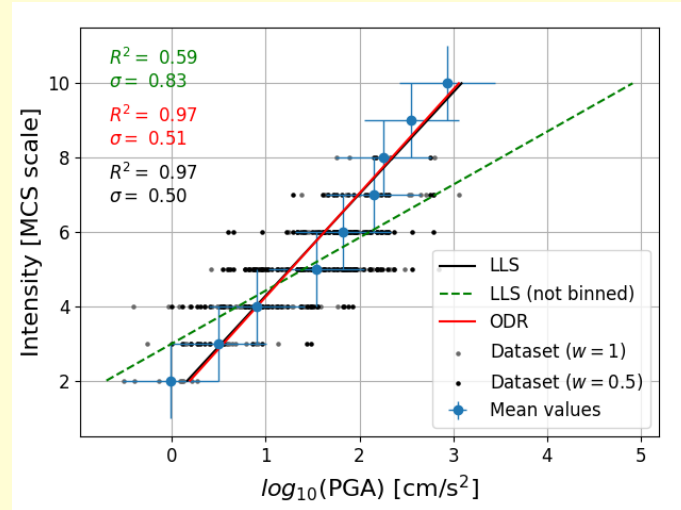
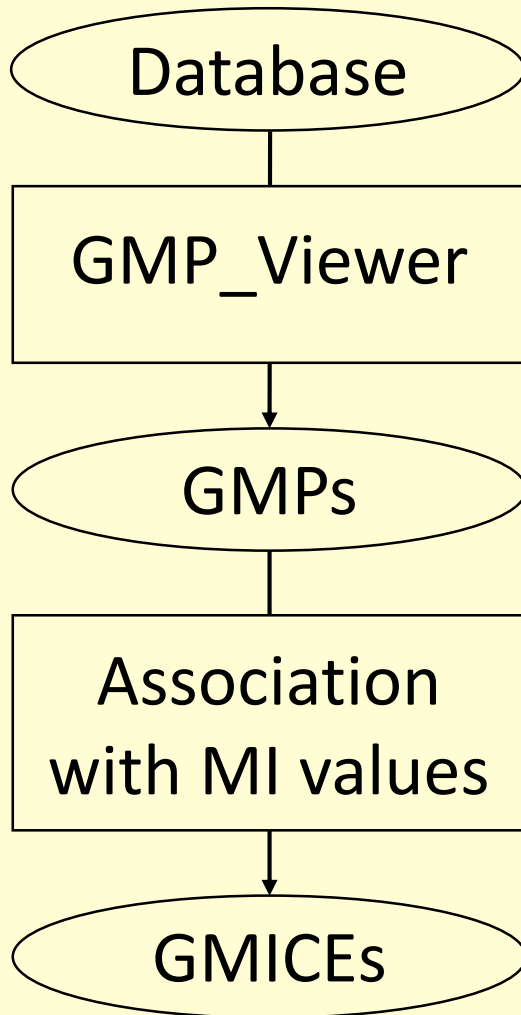
Station: Serravalle_di_Chienti - SER - Channel: HGE - EC8: n
Lat: 43.0712 Lon: 12.9531 Elev: -999.0
Time: 21/03/1998 16:45:09



Station: Norcia - NOR - Channel: HGE - EC8: C*
Lat: 42.7924 Lon: 13.0924 Elev: 0.661
Time: 29/11/1999 03:20:21



Example of application: GMICEs



$$I = a + b \log(\text{GMP})$$



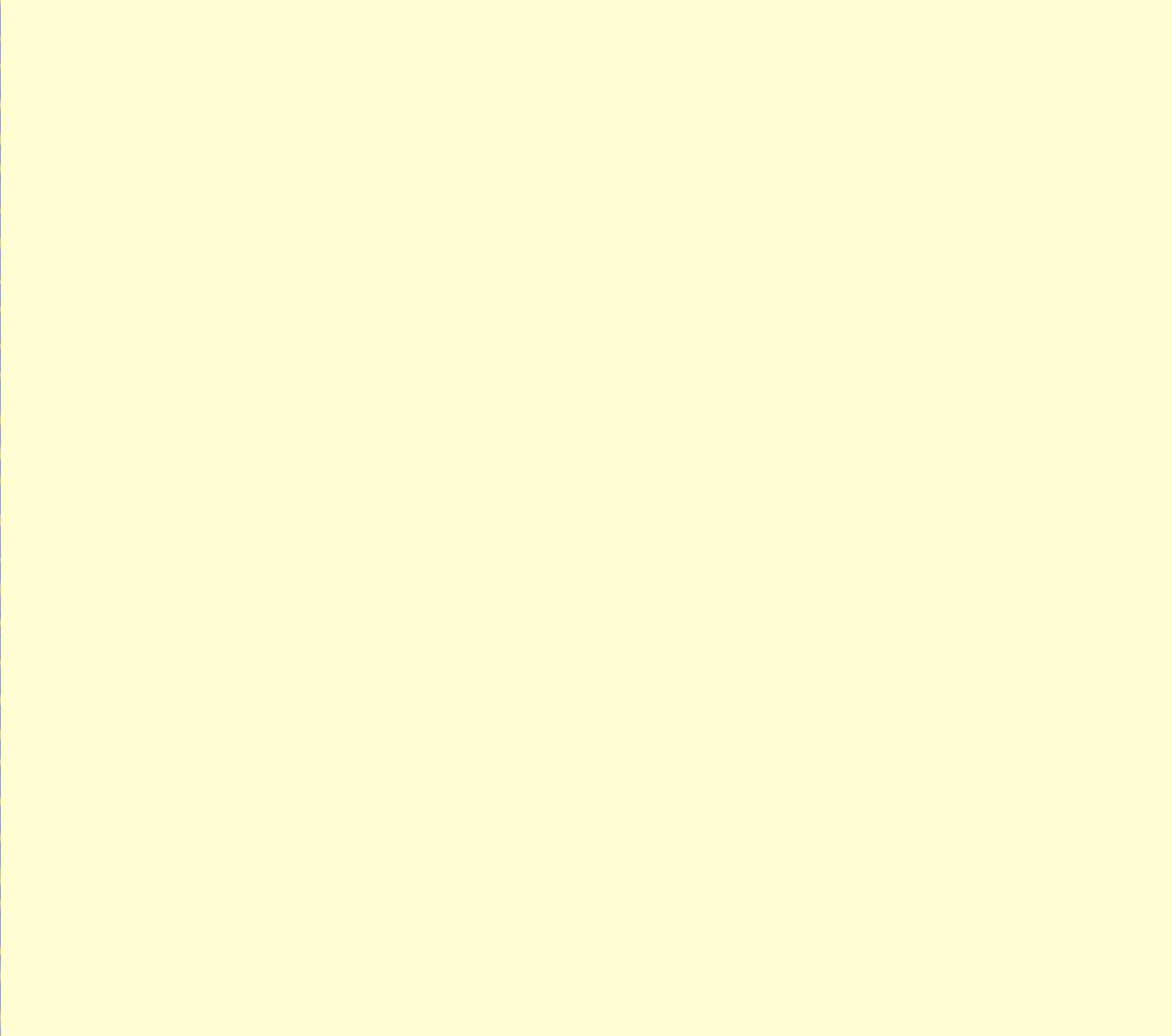
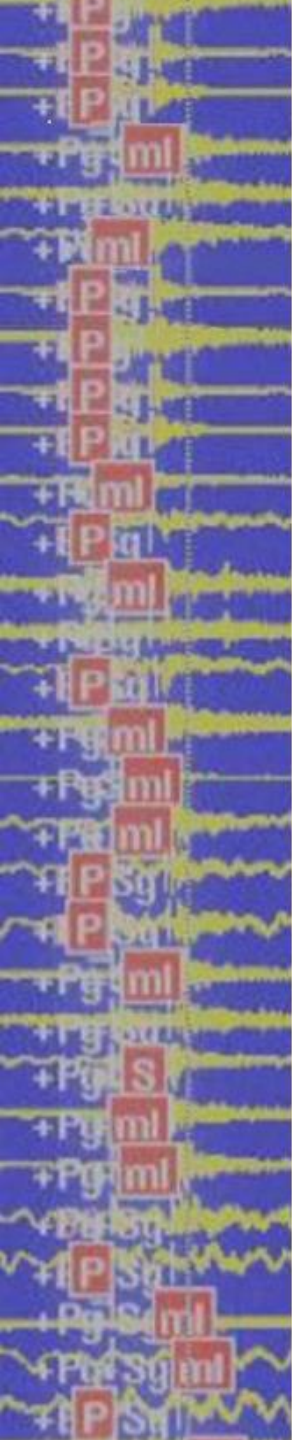
Pros and cons

- works on one trace at a time (can control the analysis parameters)
- works on one component at a time (need to manually select the absolute peak values)
- does not perform event detection or event information extraction
- useful for databases with known issues in the event detection
- ...



Future developments

- perform phase pickings
- analyse three components at the same time (no need to manually select the absolute peak values)
- implement the code as a python library
- ...



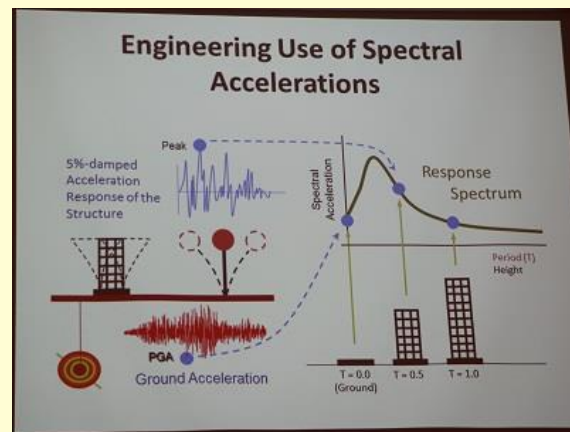
Currently available GMPs

EPA (Effective Peak Acceleration)

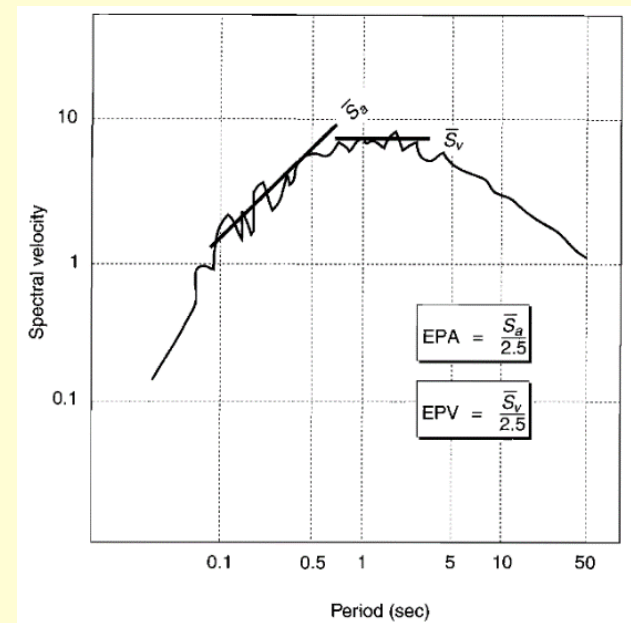
Average spectral acceleration over the period range 0.1 to 0.5 sec divided by 2.5 (the standard amplification factor for a 5% damping spectrum)

PSA03, PSA10, PSA30

5%-damped acceleration response of a SDOF oscillator at different periods



<https://www.seismology.az/en/news/274>



Kramer, Geotechnical Earthquake Engineering, 1996

Currently available GMPs

duration

Duration of the signal containing from 5% to 95% of the total energy

Arias intensity

$$I_A = \frac{\pi}{2g} \int_0^{T_d} a^2(t) dt$$

Housner intensity

$$I_H(\xi = 5\%) = \frac{\pi}{2g} \int_{0.1}^{2.5} PSV(T, \xi = 5\%) dT$$

Currently available GMPs

zero crossings (ν_0)

Number of zero crossings per second for the signal containing between 5% and 95% of the total energy

Saragoni factor

$$P_D = \frac{I_A}{\nu_0^2}$$

Manfredi damage factor

$$M_F = \frac{2g}{\pi} \frac{I_A}{PGA \times PGV}$$

Eurocode 8 site classification

Table 3.1: Ground types

Ground type	Description of stratigraphic profile	Parameters		
		$v_{s,30}$ (m/s)	N_{SPT} (blows/30cm)	c_u (kPa)
A	Rock or other rock-like geological formation, including at most 5 m of weaker material at the surface.	> 800	–	–
B	Deposits of very dense sand, gravel, or very stiff clay, at least several tens of metres in thickness, characterised by a gradual increase of mechanical properties with depth.	360 – 800	> 50	> 250

https://eurocodes.jrc.ec.europa.eu/doc/WS_335/S1_EC8-Lisbon_E%20CARVALHO.pdf

Eurocode 8 site classification

Table 3.1: Ground types

Ground type	Description of stratigraphic profile	Parameters		
		$v_{s,30}$ (m/s)	N_{SPT} (blows/30cm)	c_u (kPa)
C	Deep deposits of dense or medium-dense sand, gravel or stiff clay with thickness from several tens to many hundreds of metres.	180 – 360	15 - 50	70 - 250
D	Deposits of loose-to-medium cohesionless soil (with or without some soft cohesive layers), or of predominantly soft-to-firm cohesive soil.	< 180	< 15	< 70

https://eurocodes.jrc.ec.europa.eu/doc/WS_335/S1_EC8-Lisbon_E%20CARVALHO.pdf

Eurocode 8 site classification

Table 3.1: Ground types

Ground type	Description of stratigraphic profile	Parameters		
		$v_{s,30}$ (m/s)	N_{SPT} (blows/30cm)	c_u (kPa)
E	A soil profile consisting of a surface alluvium layer with v_s values of type C or D and thickness varying between about 5 m and 20 m, underlain by stiffer material with $v_s > 800$ m/s.			
S_1	Deposits consisting, or containing a layer at least 10 m thick, of soft clays/silts with a high plasticity index (PI > 40) and high water content	< 100 (indicative)	—	10 - 20
S_2	Deposits of liquefiable soils, of sensitive clays, or any other soil profile not included in types A – E or S_1			

https://eurocodes.jrc.ec.europa.eu/doc/WS_335/S1_EC8-Lisbon_E%20CARVALHO.pdf

$$I = a + b \log(GMP)$$

