

# GROUND MOTION PARAMETERS EXTRACTION WITH ANTELOPE AND PYTHON

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# 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

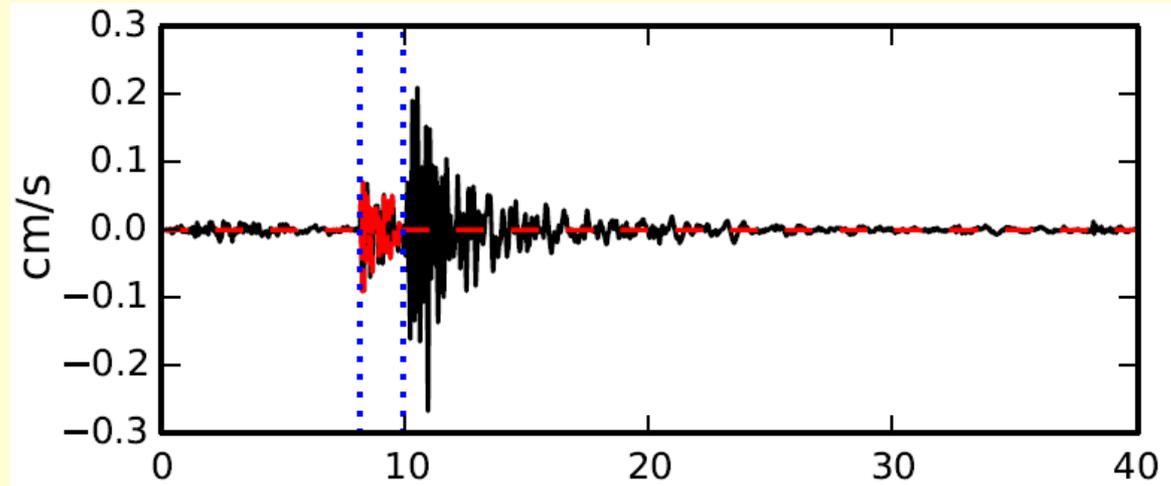
Housner intensity

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

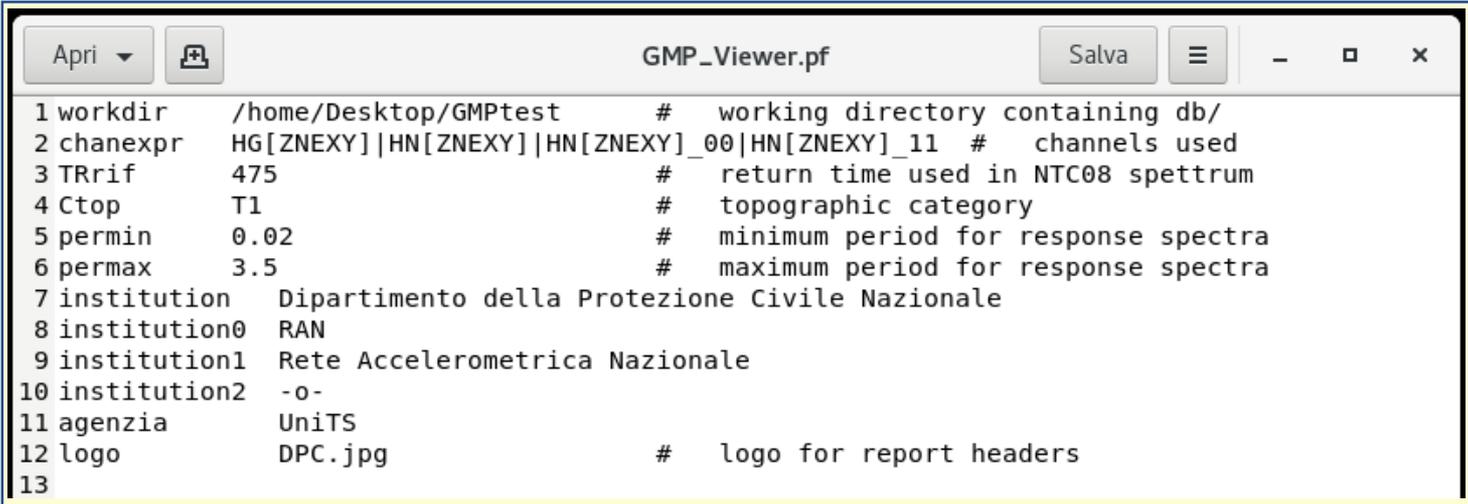
# A look at the code

```
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
```

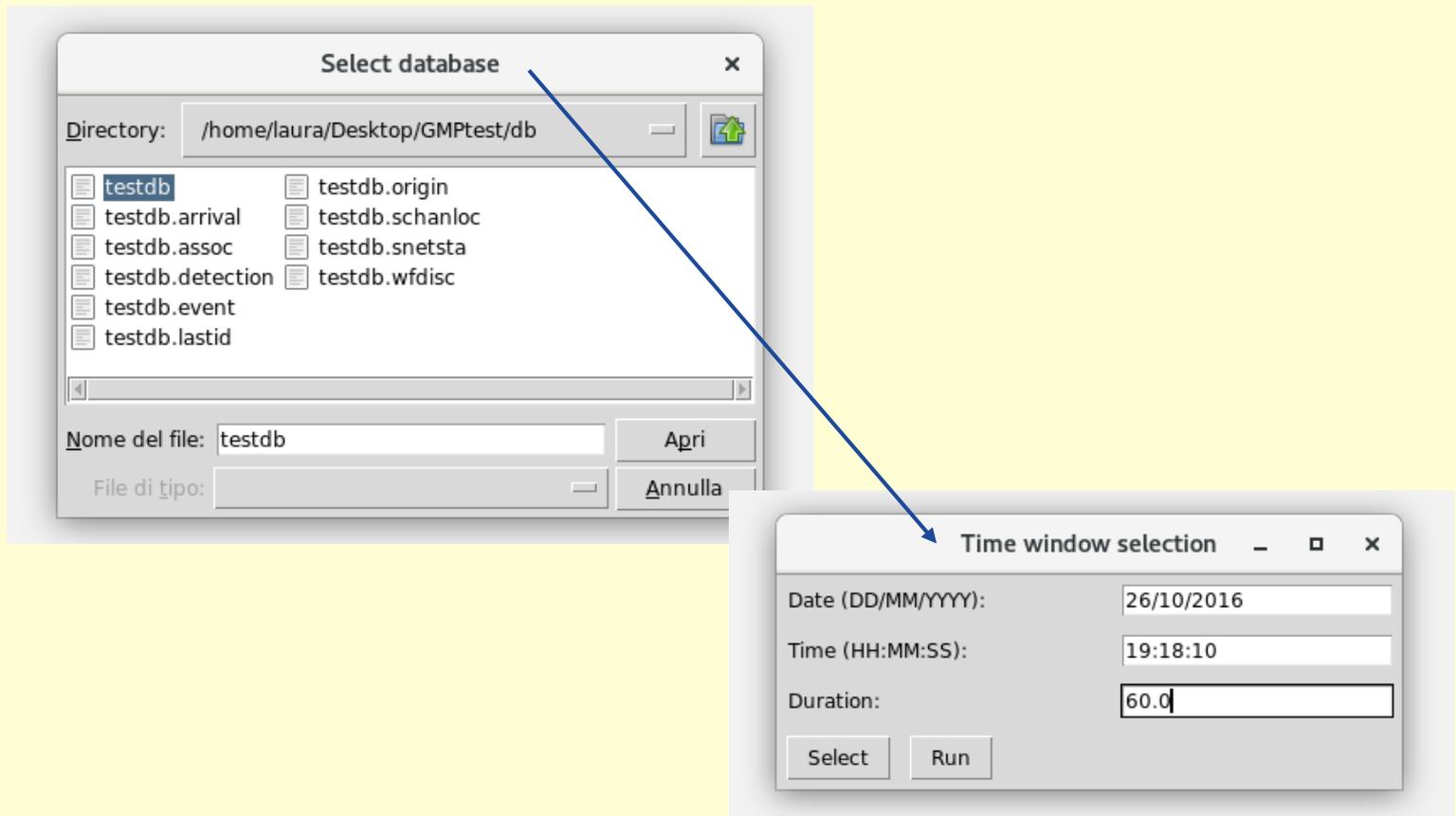


# Running the code

## Requirements:

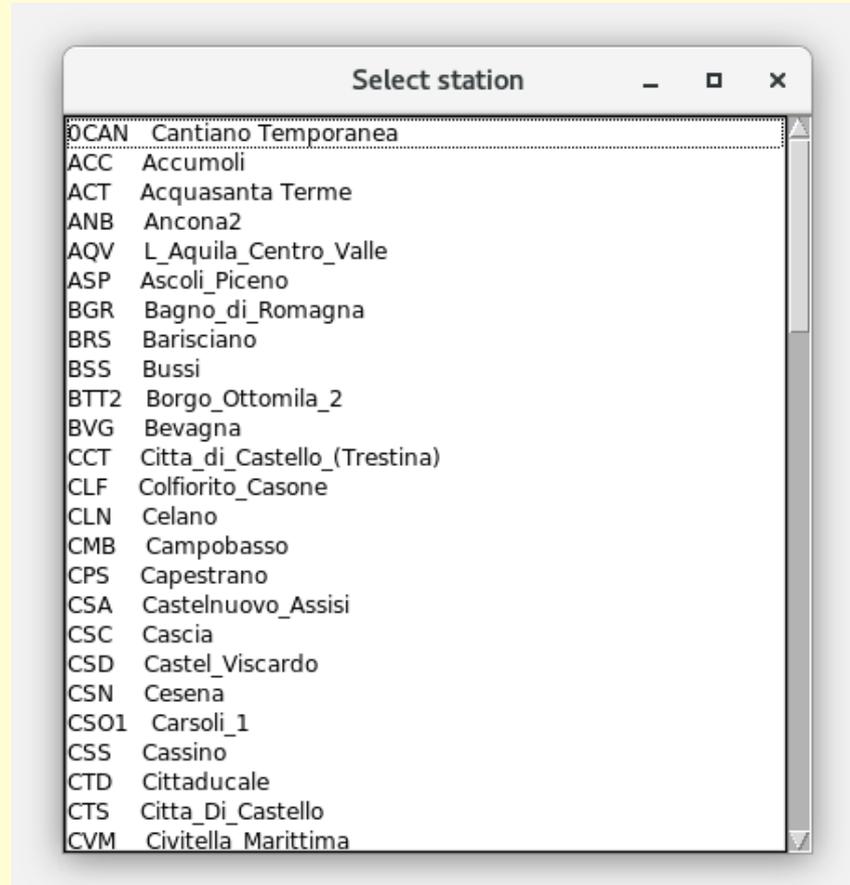
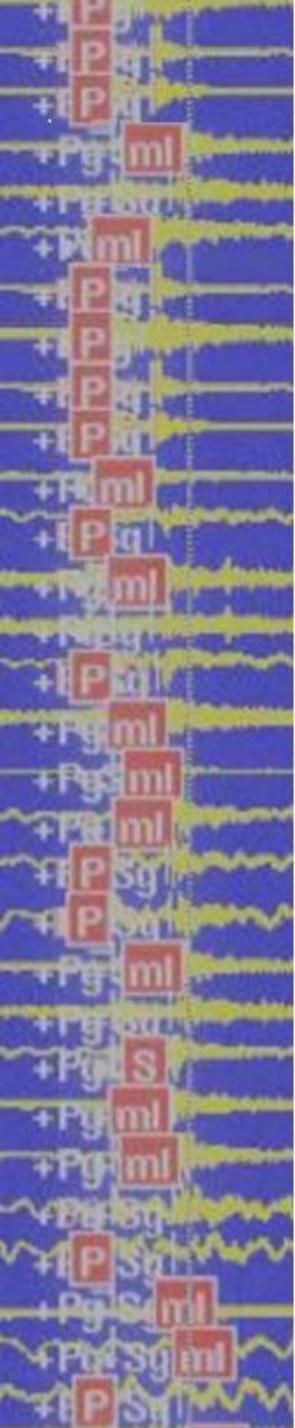
- Python: *obspy*, *matplotlib*, *numpy*, *scipy*, *time*, *Tkinter*, *tkFileDialog*, *contextlib*, *datetime*, *math*, *signal*, *PIL*
- Antelope
- An Antelope database with some tables already available (*sitechan*, *site*, *schanloc*, *wfdisc*); some are optional (*arrival*, *assoc*; *origin*, *event*;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

# Waveform selection (I)



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

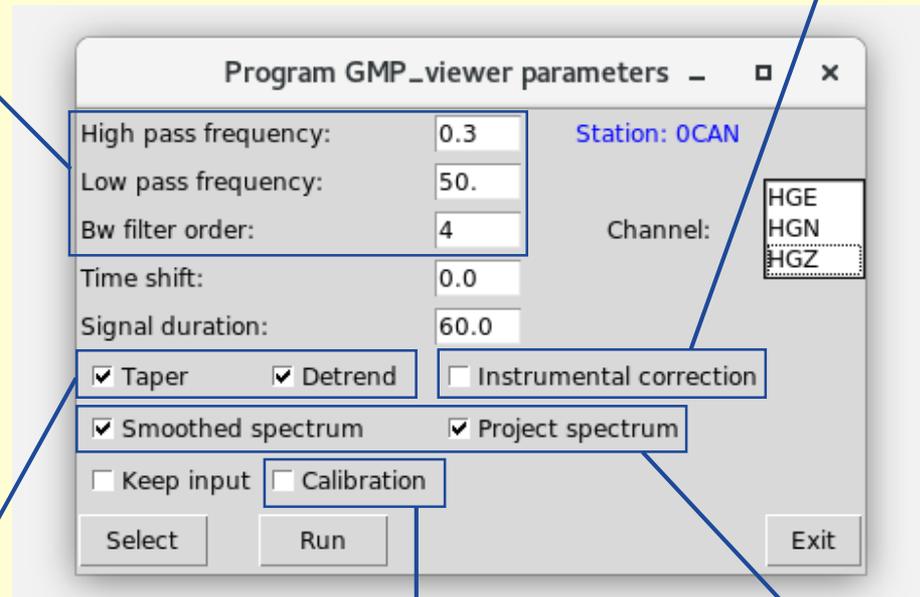
# Waveform selection (II)



# Waveform manipulation

Butterworth  
filter

instrumental correction



tapering &  
detrending

calibration

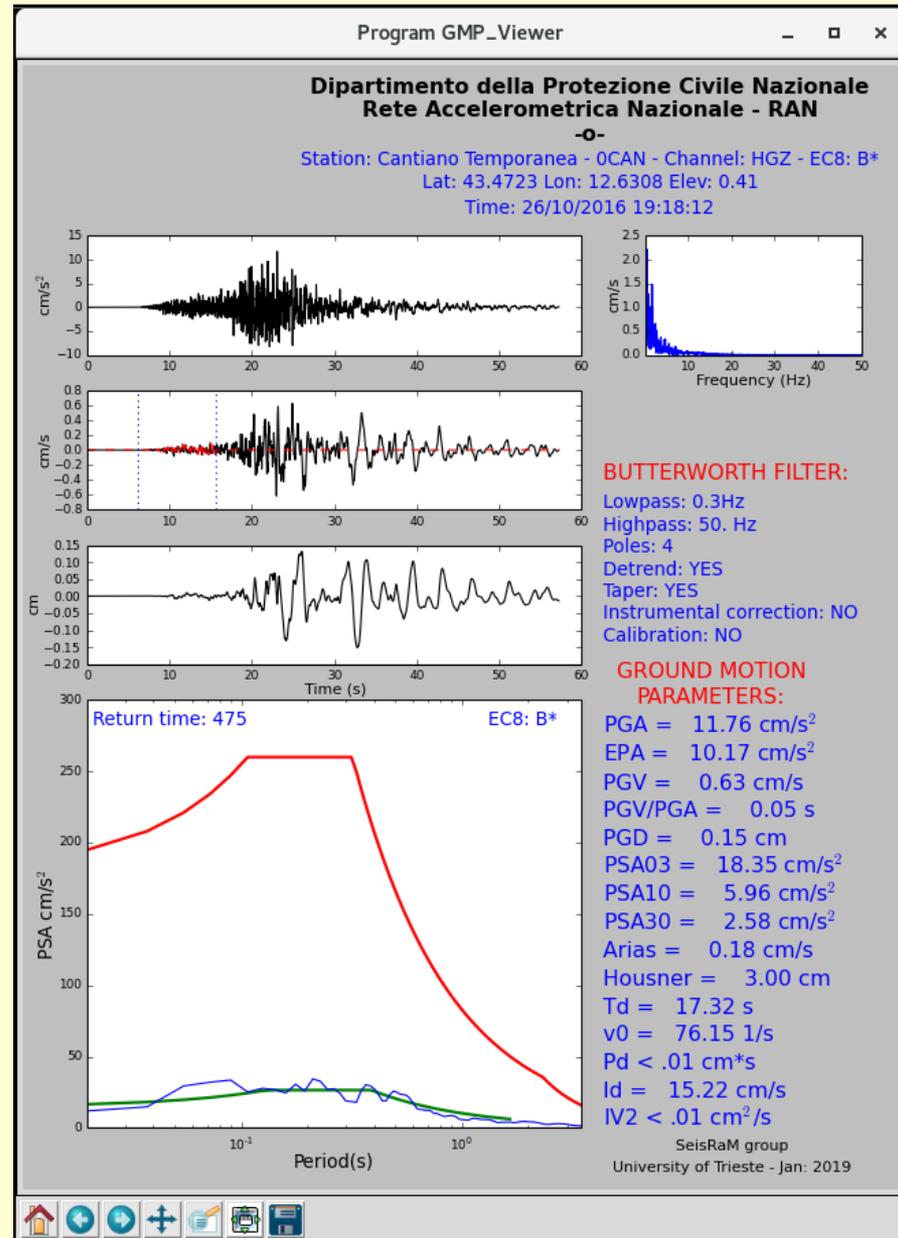
response  
spectra

# Output

txt + pdf →

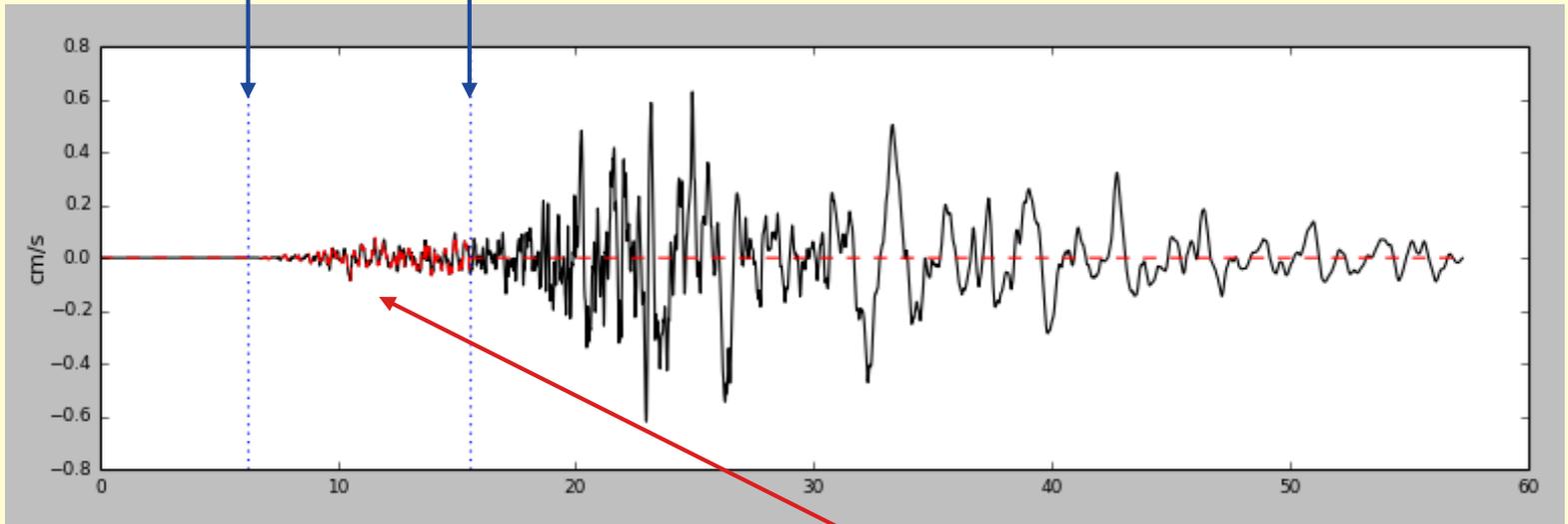


| 2016300_191810_0CAN_HGZ.txt |              |
|-----------------------------|--------------|
| 1 pga                       | 11.76        |
| 2 epa                       | 10.17        |
| 3 pgv                       | 0.63         |
| 4 pgv/pgs                   | 0.05         |
| 5 pgd                       | 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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1. Before you start
2. Preliminary steps
3. Running the code
4. Note on IV2 parameter

### Next topic

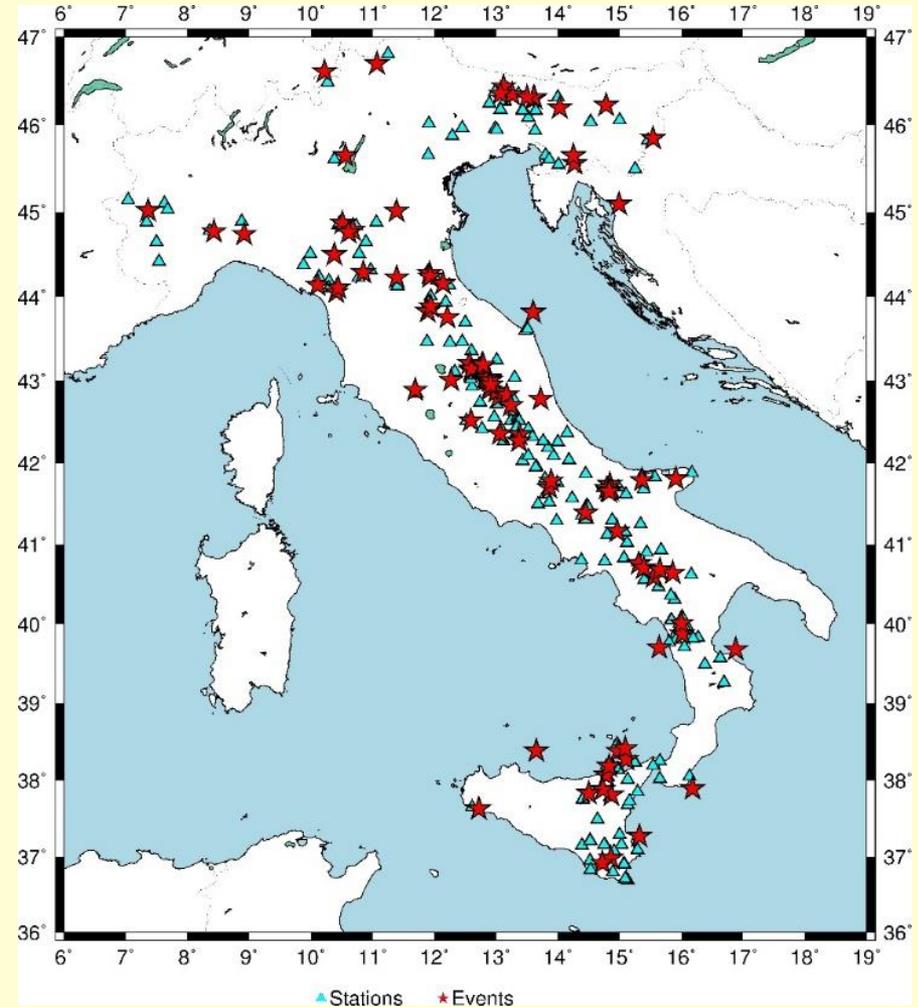
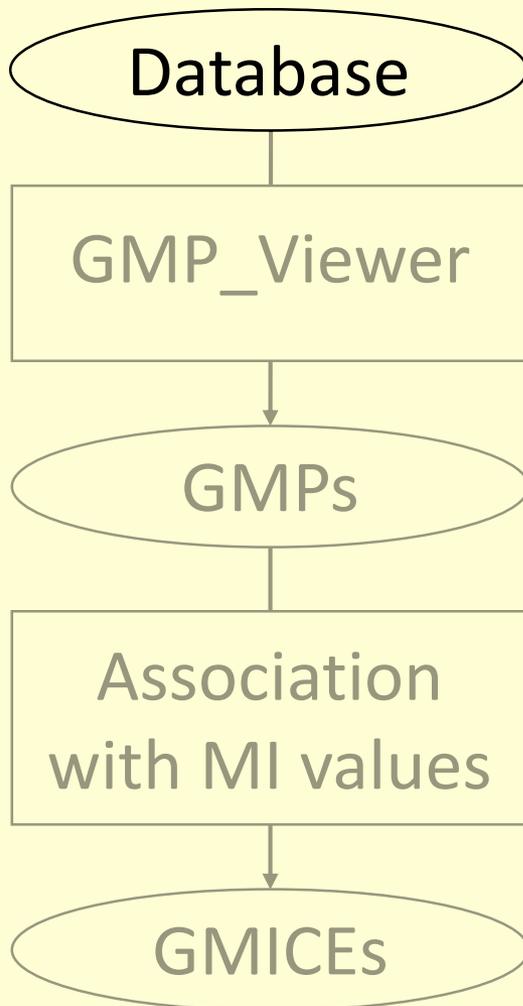
1. Before you start: An overview on the program

### This Page

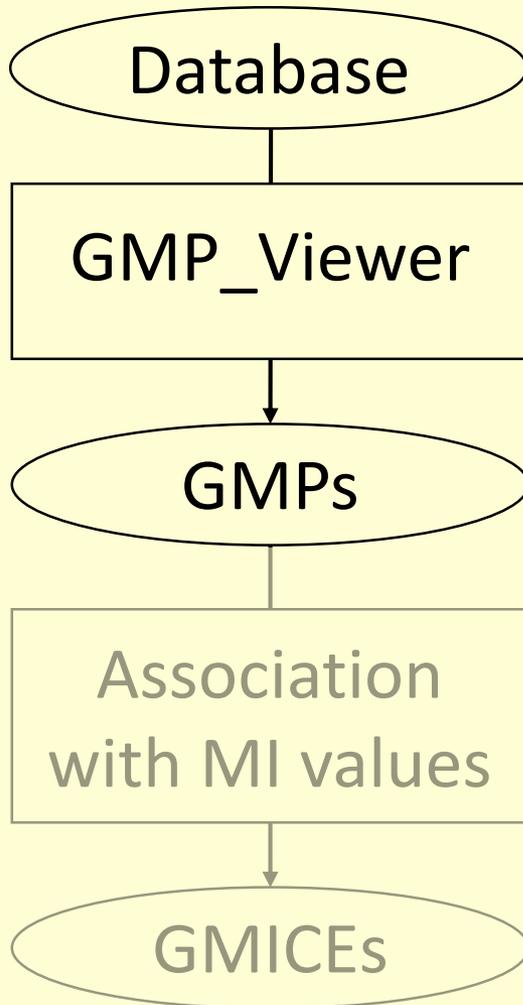
Show Source

### Quick search

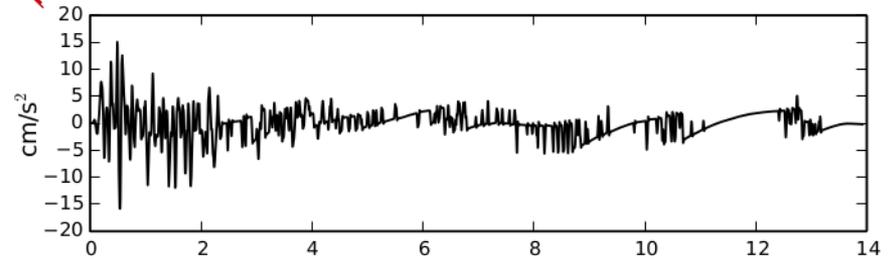
# Example of application: GMICEs



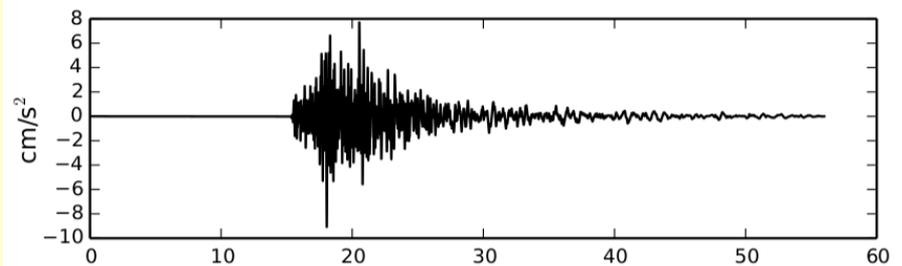
# Example of application: GMICEs



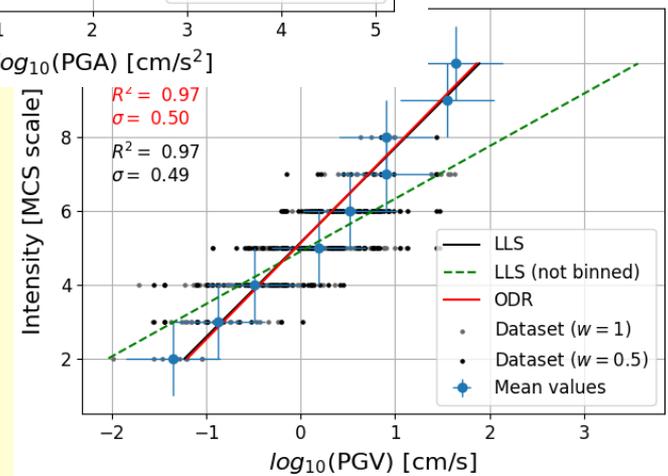
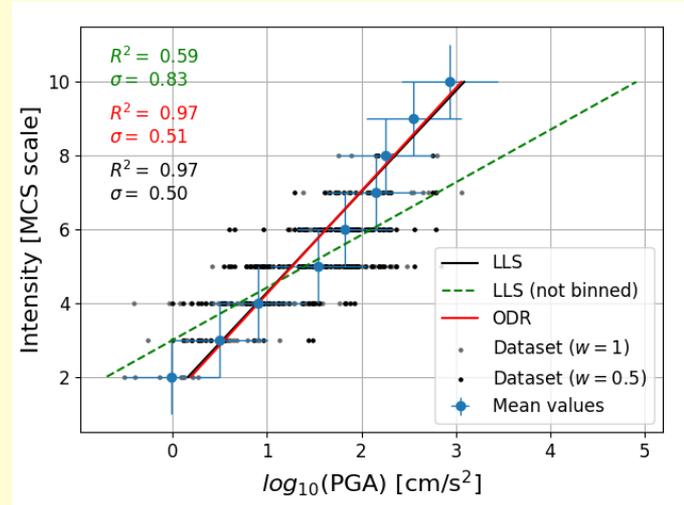
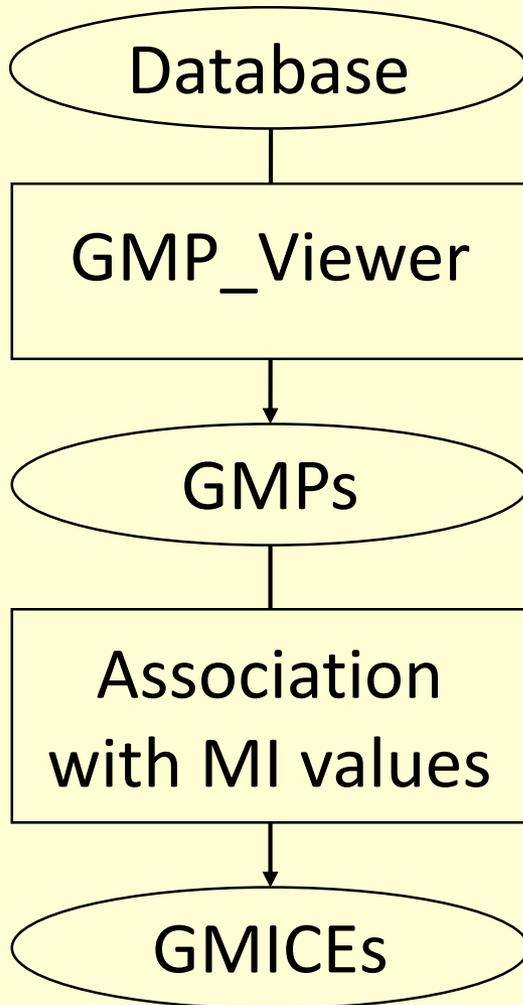
Station: Serravalle\_di\_Chienti - SER - Channel: HGE - EC8: n  
Lat: 43.0712 Lon: 12.9531 Elev: -999.0  
Time: 21/03/1998 16:45:09



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



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



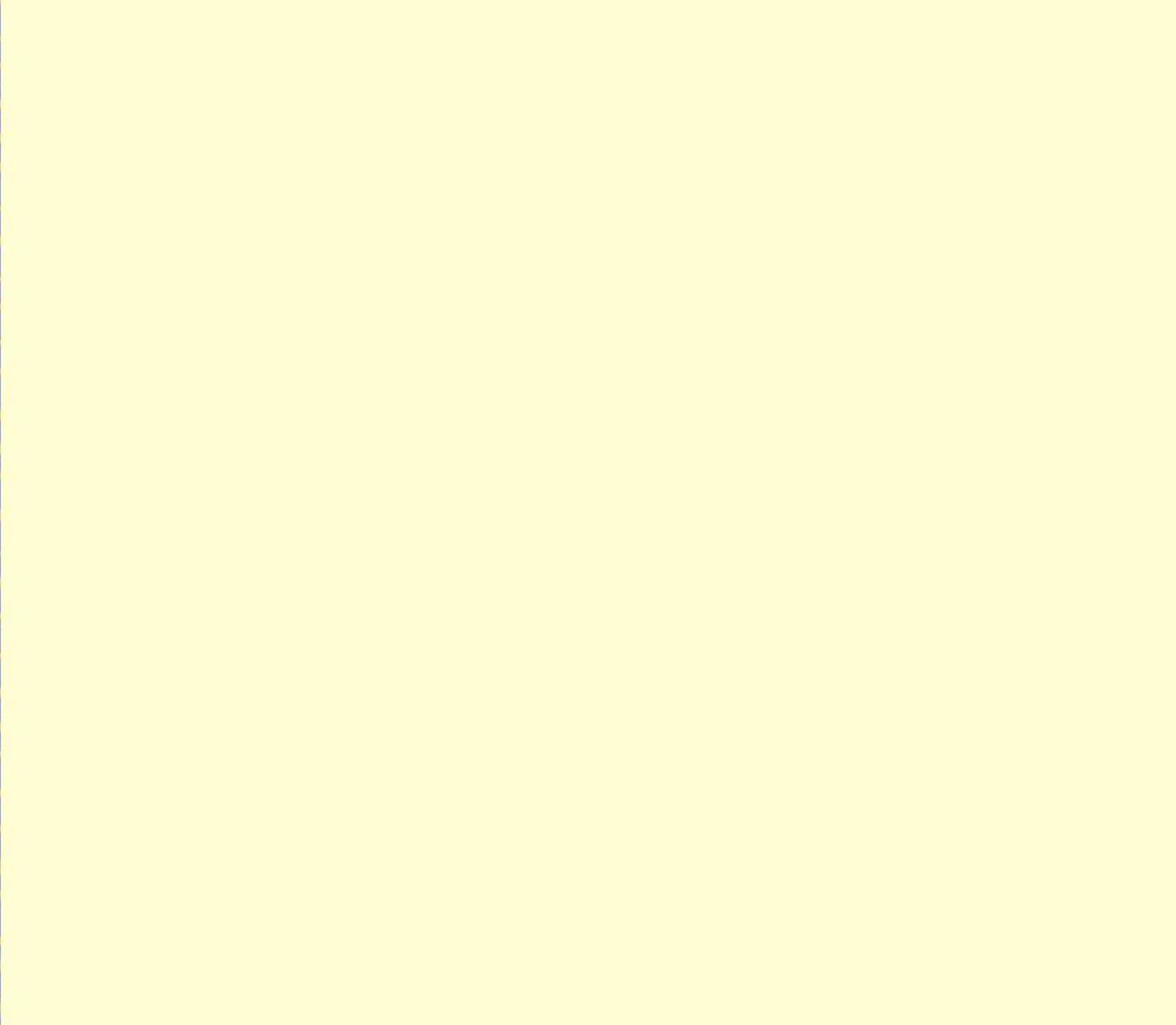
## Pros and cons

- 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
- ...



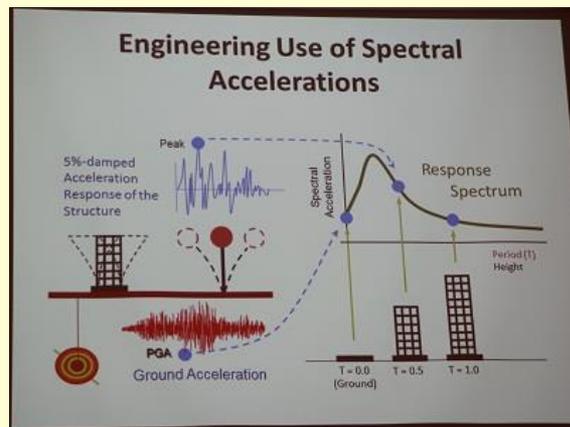
# Currently available GMPs

## EPA (Effective Peak Acceleration)

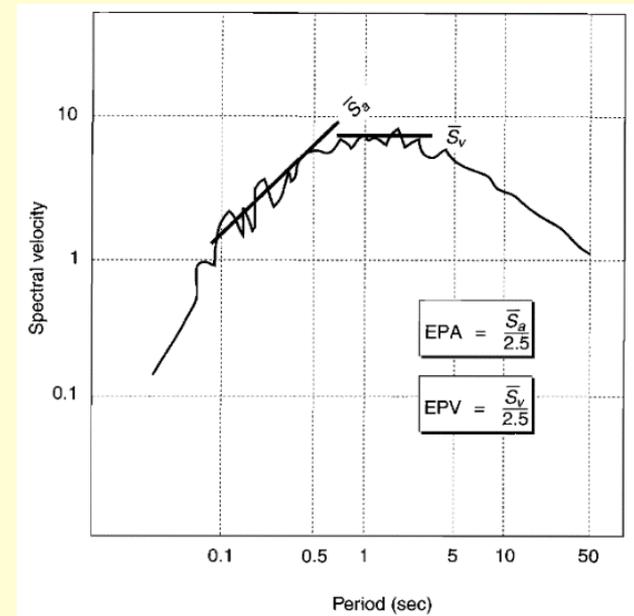
Average spectral acceleration over the period range 0.1 to 0.5 sec divided by 2.5 (the standard amplification factor for a 5% damping spectrum)

## 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 ( $\nu_0$ )

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) | $N_{SPT}$<br>(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](https://eurocodes.jrc.ec.europa.eu/doc/WS_335/S1_EC8-Lisbon_E%20CARVALHO.pdf)

# Eurocode 8 site classification

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|             |  | $v_{s,30}$ (m/s) | $N_{SPT}$<br>(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](https://eurocodes.jrc.ec.europa.eu/doc/WS_335/S1_EC8-Lisbon_E%20CARVALHO.pdf)

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|-------------|--|-----------------------|---------------------------|-------------|
|             |  | $v_{s,30}$ (m/s)      | $N_{SPT}$<br>(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<br>(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](https://eurocodes.jrc.ec.europa.eu/doc/WS_335/S1_EC8-Lisbon_E%20CARVALHO.pdf)

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

