

## Seminario: Filtro Rápido de Coincidencias

### “Fast Matched Filter”

Posibles aplicaciones a microsismicidad

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Hugo S.

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Gracias a mis colegas:

P. Poli, L. Cabrera, D. Essing, A. Socquet, H. Tavera, E. Beaucé

*Seminario en el IGP, LabEx OSUG Project EFASAP*

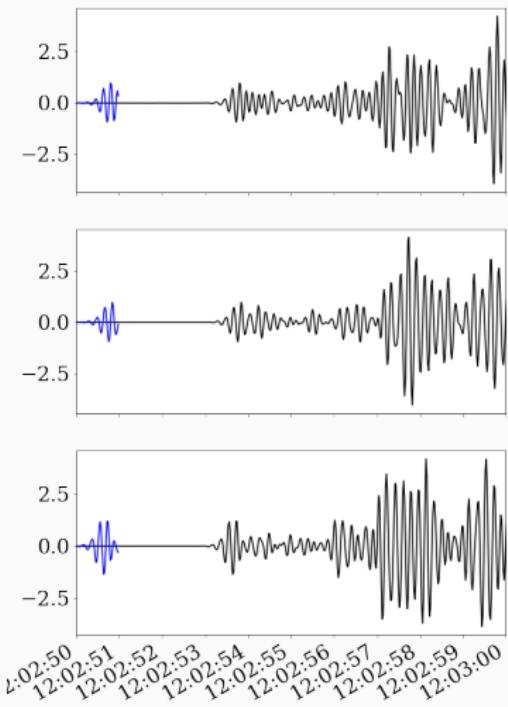
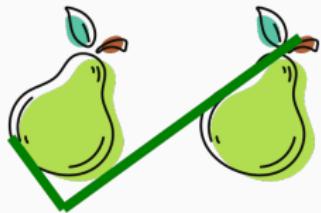
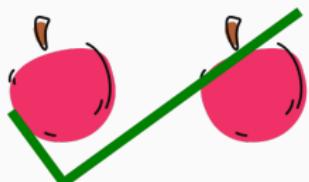
December 6, 2022

# Introducción

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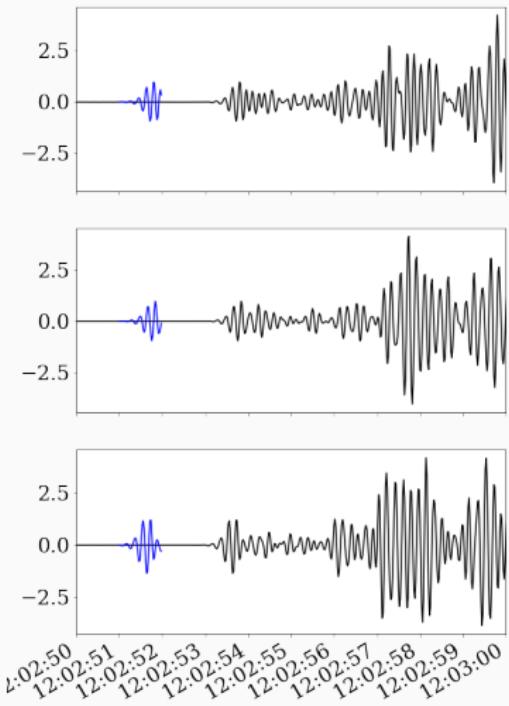
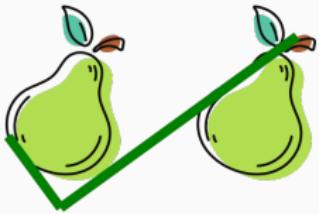
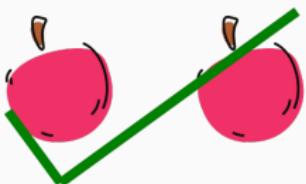
# Similitud, correlación

Manzanas con manzanas  
y peras con peras



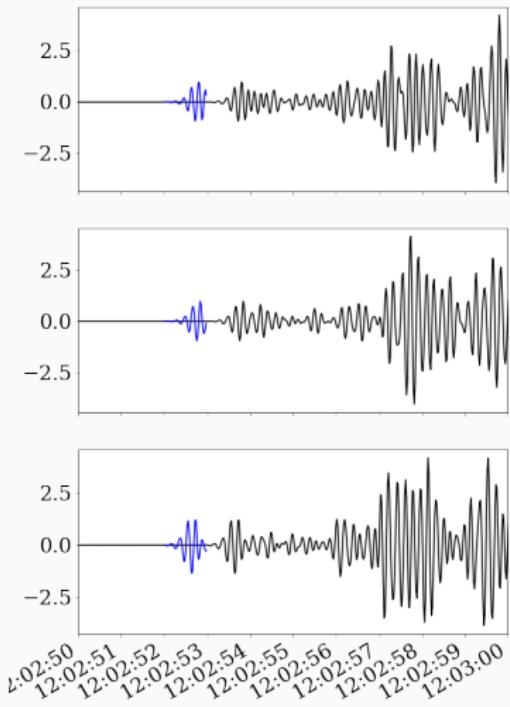
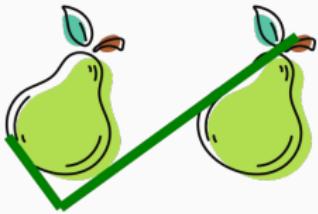
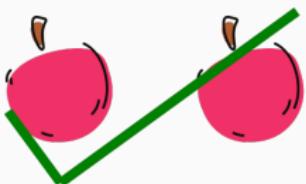
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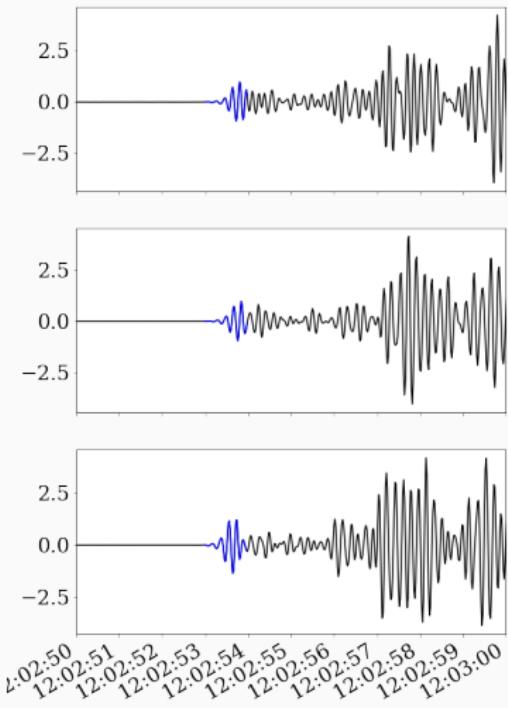
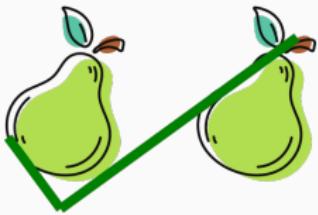
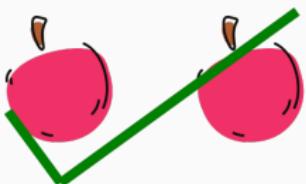
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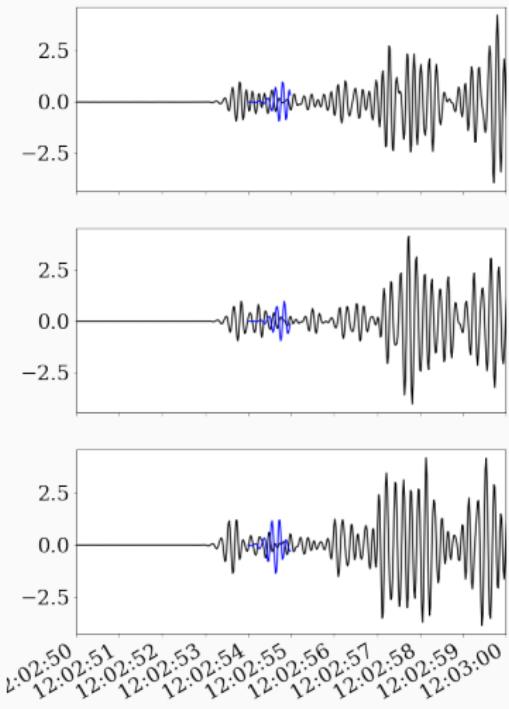
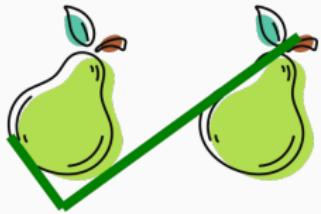
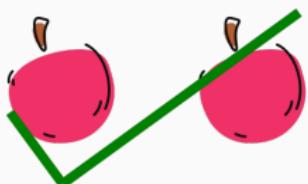
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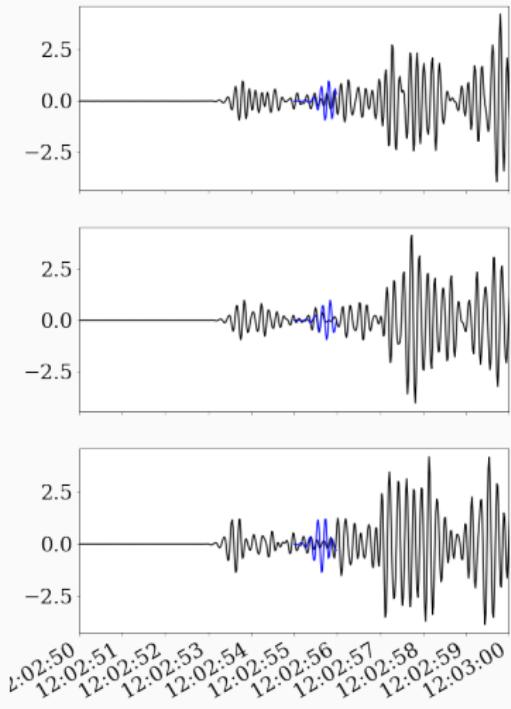
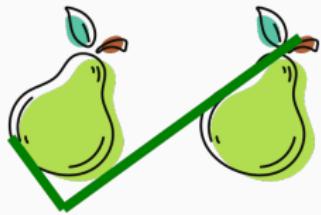
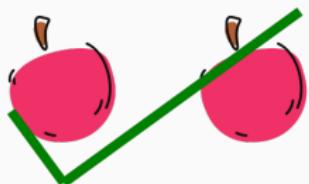
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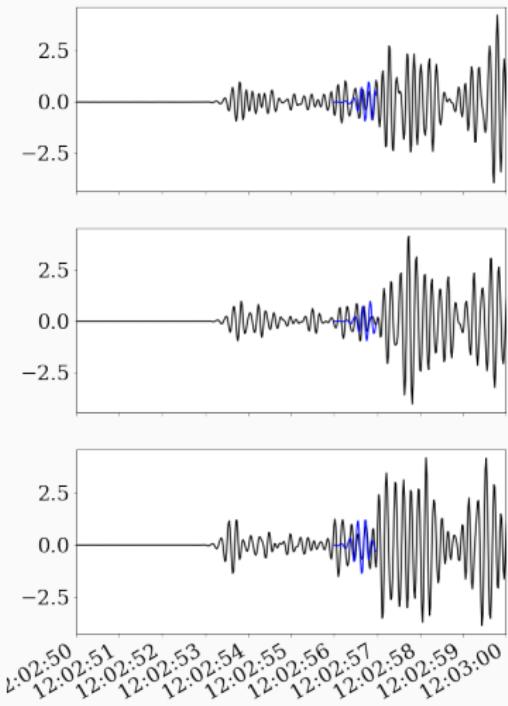
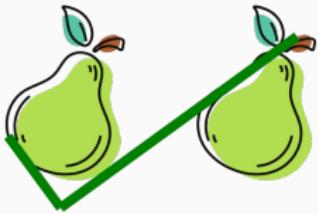
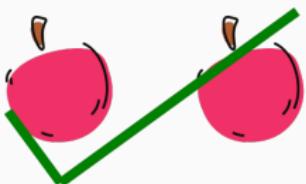
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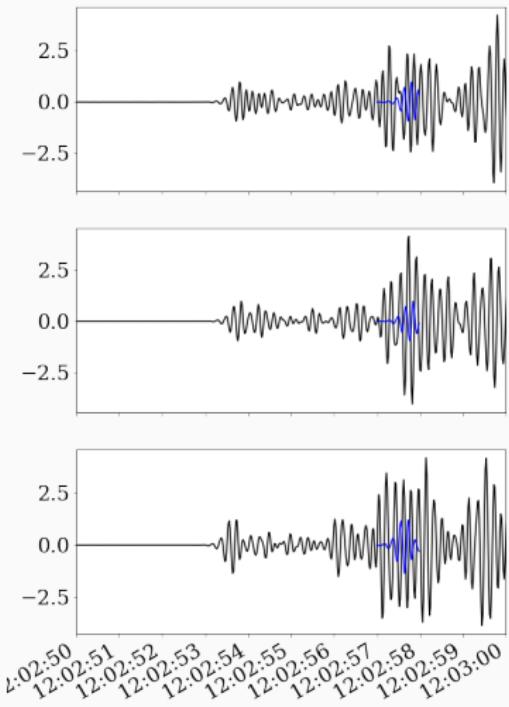
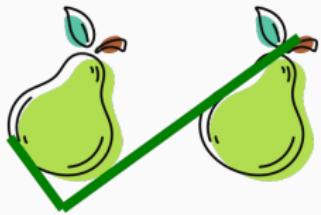
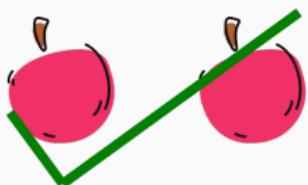
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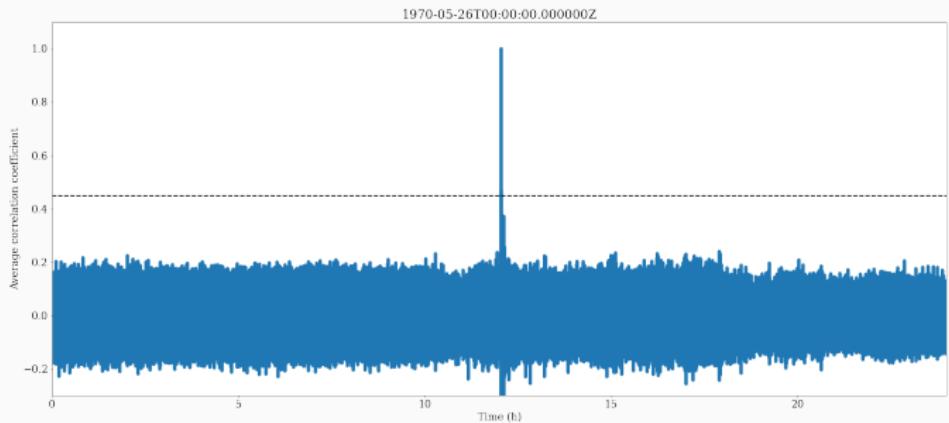


# Similitud, correlación

Manzanas con manzanas  
y peras con peras



# Similitud, correlación



## Instalación

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# Creación de ambiente de trabajo "fmf\_tuto"

```
Activities Terminal ▾ nov. 4 11:59 • sanchezh@ist-156-52: ~/Desktop/fmf
sanchezh@ist-156-52:~/Desktop/fmf$ conda create --name fmf_tuto --file FMF_tuto_Python_
packages.txt

Downloading and Extracting Packages
_libgcc_mutex-0.1      #####
ca-certificates-2019    #####
libgfortran-ng-7.3.0     #####
libstdcxx-ng-9.1.0       #####
pandoc-2.7.3            #####
libgcc-ng-9.1.0          #####
bzip2-1.0.8              #####
expat-2.2.5              #####
icu-64.2                 #####
jpeg-9c                  #####
libffi-3.2.1              #####
libiconv-1.15             #####
libopenblas-0.3.7         #####
libsodium-1.0.17          #####
libuuid-2.32.1            #####
ncurses-6.1                #####
openssl-1.1.1c            #####
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                                             100%
```

# Instalación de “ObsPy”

```
Activities Terminal ▾ nov. 4 12:01 · sanchezh@ist-156-52: ~/Desktop/fmf
sanchezh@ist-156-52: ~/Desktop/fmf$ conda activate fmf_tuto
(fmf_tuto) sanchezh@ist-156-52:~/Desktop/fmf$ pip install obspy
Collecting obspy
  Downloading https://files.pythonhosted.org/packages/4f/f8/cebf0acdfb8cd3a3c05937af73
212cf6f133b23357faced2951972cda83/obspy-1.3.1.tar.gz (16.9MB)
    |██████████| 16.9MB 5.0MB/s
Installing build dependencies ... done
Getting requirements to build wheel ... done
Installing backend dependencies ... done
Preparing wheel metadata ... done
Requirement already satisfied: requests in /home/sanchezh/anaconda3/envs/fmf_tuto/lib/p
ython3.7/site-packages (from obspy) (2.22.0)
Requirement already satisfied: sqlalchemy in /home/sanchezh/anaconda3/envs/fmf_tuto/lib/
/python3.7/site-packages (from obspy) (1.3.8)
Requirement already satisfied: lxml in /home/sanchezh/anaconda3/envs/fmf_tuto/lib/pytho
n3.7/site-packages (from obspy) (4.4.1)
Collecting matplotlib>=3.2.0 (from obspy)
  Downloading https://files.pythonhosted.org/packages/ad/62/7b662284352867a86acfb636761
ba351723fc3a235efd8397578d903413d/matplotlib-3.5.3-cp37-cp37m-manylinux_2_5_x86_64.many|
linux1 x86_64.whl (11.2MB)
    |██████████| 11.2MB 45.1MB/s
```

# Instalación de “ObsPy”

```
Activities Terminal ▾ nov. 4 12:01 · sanchezh@ist-156-52: ~/Desktop/fmf
sanchezh@ist-156-52: ~/Desktop/fmf          sanchezh@ist-oar: /data/cycle/sanchezh
Building wheels for collected packages: obspy
  Building wheel for obspy (PEP 517) ... done
    Created wheel for obspy: filename=obspy-1.3.1-cp37-cp37m-linux_x86_64.whl size=143776
72 sha256=92505f1e114853948b376b61c116181abb3b4552f2105b4eaf41e06e7dae4a99
    Stored in directory: /home/sanchezh/.cache/pip/wheels/ff/8f/e6/3e3aae47f0ea9ad1b70ecbae8a0fbfb6489e57c1bc1f467f9ff
Successfully built obspy
Building wheels for collected packages: pillow
  Building wheel for pillow (setup.py) ... done
    Created wheel for pillow: filename=Pillow-9.3.0-cp37-cp37m-linux_x86_64.whl size=1504
116 sha256=c53addc3e022195d936f9c71fc8267b036f89aff78794bc5feb7b6f68d25a9b9a
    Stored in directory: /home/sanchezh/.cache/pip/wheels/55/5a/ad/9f708fd6d1500e9ff680e1
7b1c2f436e8439477a5a226611c6
Successfully built pillow
Installing collected packages: pillow, fonttools, packaging, matplotlib, obspy
  Found existing installation: matplotlib 3.1.1
    Uninstalling matplotlib-3.1.1:
      Successfully uninstalled matplotlib-3.1.1
Successfully installed fonttools-4.38.0 matplotlib-3.5.3 obspy-1.3.1 packaging-21.3 pil
low-9.3.0
(fmf_tuto) sanchezh@ist-156-52:~/Desktop/fmf$
```

# Abrir "jupyter notebook"

```
Activities Terminal ▾ nov. 4 12:02 •
sanchezh@ist-156-52: ~/Desktop/fmf/tutorial
sanchezh@ist-156-52: ~/Desktop/fmf/tutorial  sanchezh@ist-oar: /data/cycle/sanchezh
Building wheel for obspy (PEP 517) ... done
Created wheel for obspy: filename=obspy-1.3.1-cp37-cp37m-linux_x86_64.whl size=143776
72 sha256=92505f1e114853948b376b61c116181abb3b4552f2105b4eaf41e06e7dae4a99
Stored in directory: /home/sanchezh/.cache/pip/wheels/ff/8f/e6/3e3aae47f0ea9ad1b70ecb
ae8a0fbfb6489e57c1bc1f467f9ff
Successfully built obspy
Building wheels for collected packages: pillow
Building wheel for pillow (setup.py) ... done
Created wheel for pillow: filename=Pillow-9.3.0-cp37-cp37m-linux_x86_64.whl size=1504
116 sha256=c53addc3e022195d936f9c71fc8267b036f89af78794bc5feb7b6f68d25a9b9a
Stored in directory: /home/sanchezh/.cache/pip/wheels/55/5a/ad/9f708fd6d1500e9ff680e1
7b1c2f436e8439477a5a226611c6
Successfully built pillow
Installing collected packages: pillow, fonttools, packaging, matplotlib, obspy
  Found existing installation: matplotlib 3.1.1
  Uninstalling matplotlib-3.1.1:
    Successfully uninstalled matplotlib-3.1.1
Successfully installed fonttools-4.38.0 matplotlib-3.5.3 obspy-1.3.1 packaging-21.3 pil
low-9.3.0
(fmftuto) sanchezh@ist-156-52:~/Desktop/fmf$ cd tutorial/
(fmftuto) sanchezh@ist-156-52:~/Desktop/fmf/tutorial$ jupyter notebook
```

## Ejemplo

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## The Imbricated Foreshock and Aftershock Activities of the Balsorano (Italy) $M_w$ 4.4 Normal Fault Earthquake and Implications for Earthquake Initiation

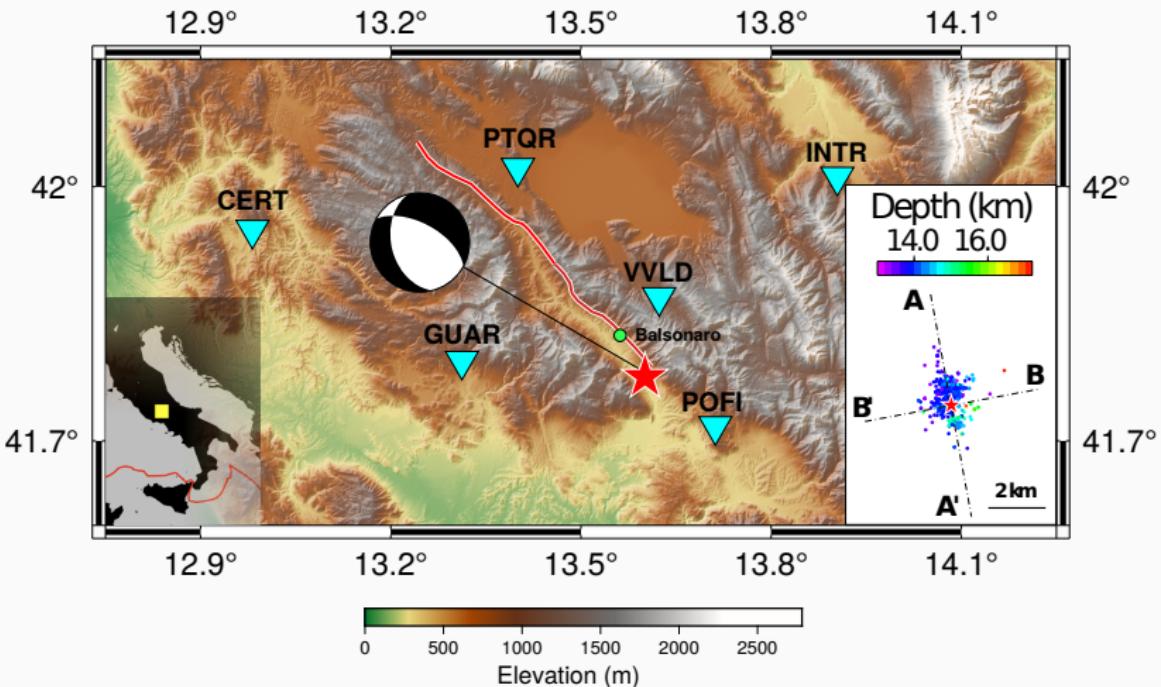
Hugo Sánchez-Reyes<sup>1</sup>, David Essing<sup>1</sup>, Eric Beauché<sup>2</sup>, and Piero Poli<sup>1</sup>

### Abstract

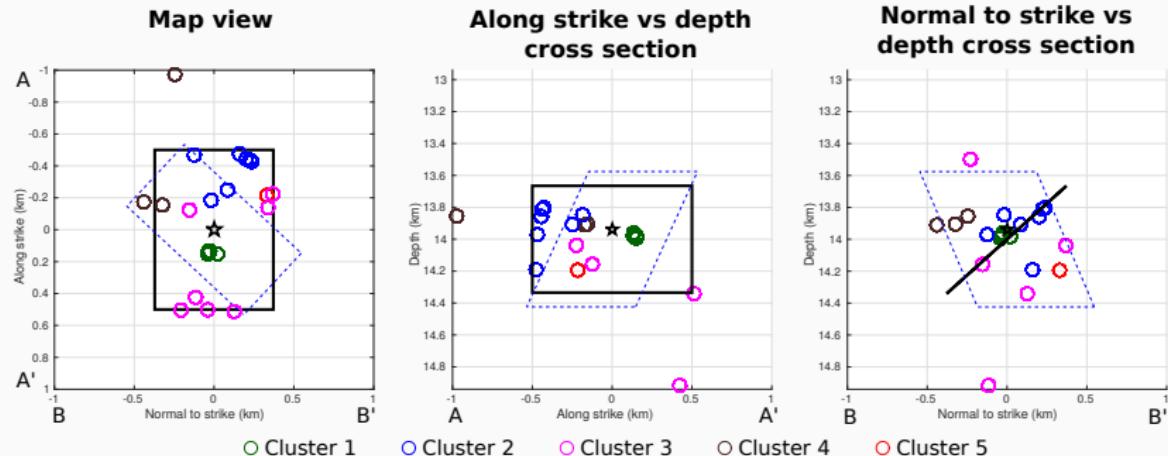
Foreshocks in the form of microseismicity are among the most powerful tools to study the physical processes that occur before main earthquakes. However, their detection and precise characterization is still sparse, especially for small-to-moderate-size earthquakes ( $M_w < 6$ ). We present here a detailed foreshock analysis for the 7 November 2019, Balsorano, Italy, normal fault earthquake ( $M_w$  4.4). To improve the detection of microseismicity before and after the mainshock, we use six three-component broadband receivers at distances of less than 75 km from the targeted seismicity, through template matching. To improve the understanding of the physical mechanism(s) behind the earthquake initiation process, as well as other accompanying phenomena, we also detail the spatiotemporal evolution of the sequence associated with this medium-sized earthquake, using waveform clustering and hypocenter relocation. Clear differences between foreshocks and aftershocks are revealed by this analysis. Moreover, five

Cite this article as: Sánchez-

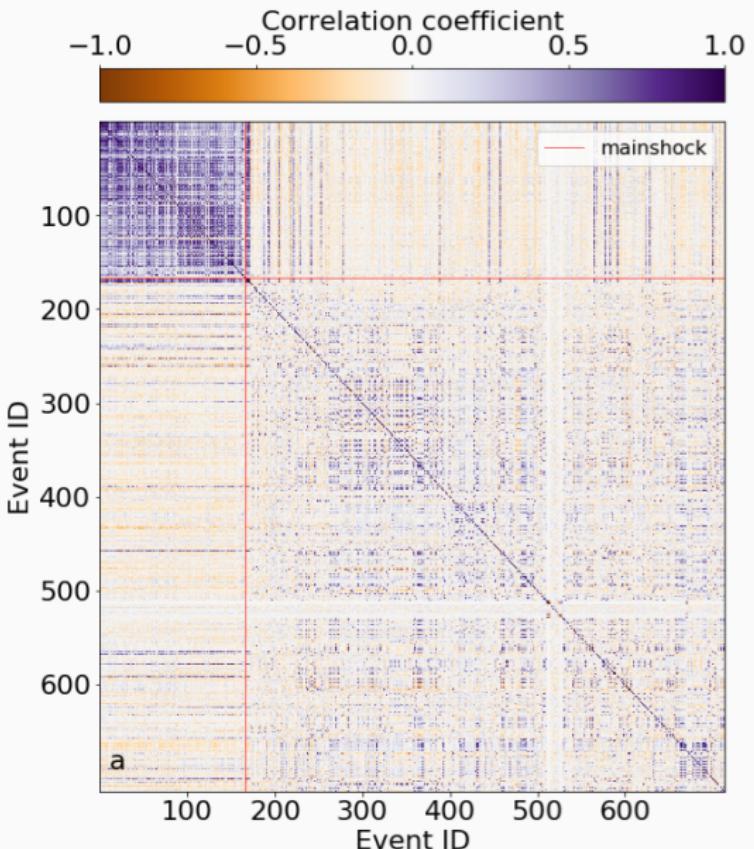
Secuencia sísmica del sismo 2019 Mw4 Balsorano, Italia



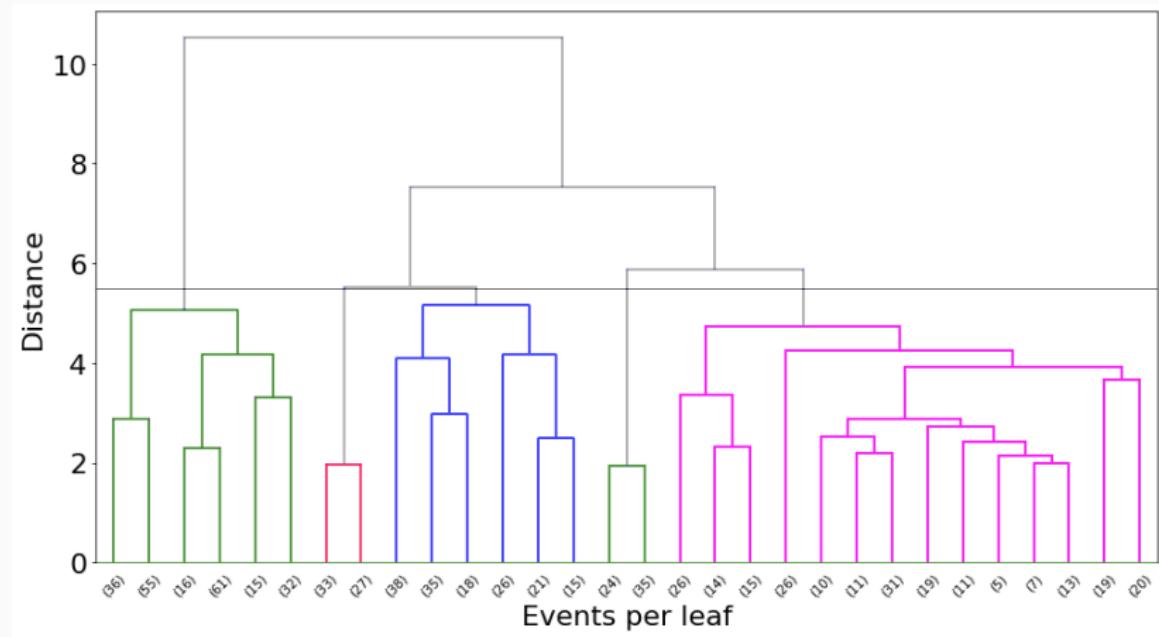
# Secuencia sísmica del sismo 2019 Mw4 Balsorano, Italia



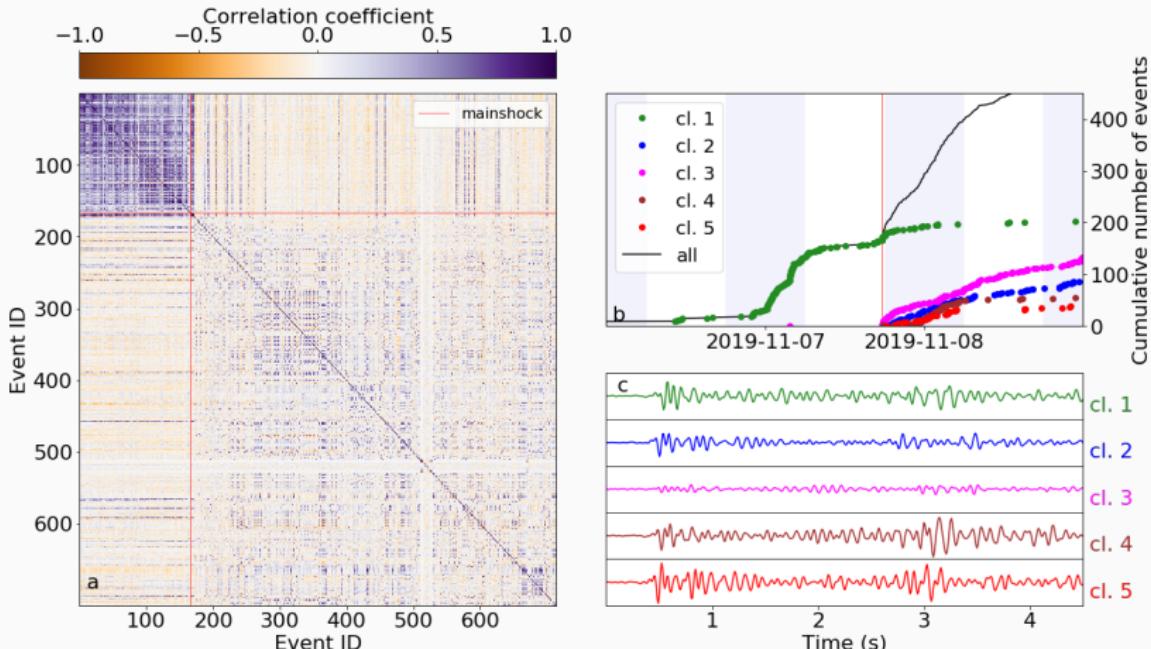
# Secuencia sísmica del sismo 2019 Mw4 Balsorano, Italia



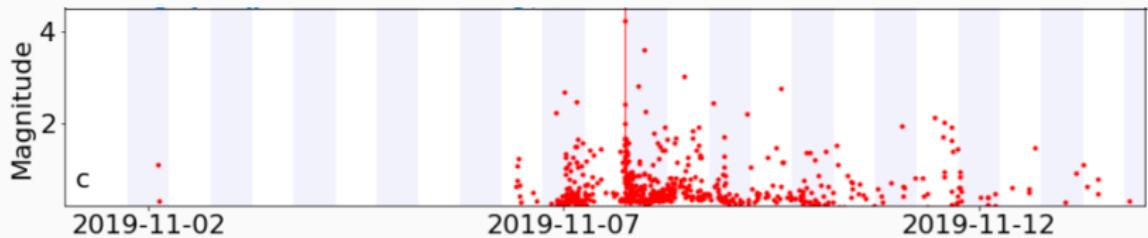
# Secuencia sísmica del sismo 2019 Mw4 Balsorano, Italia



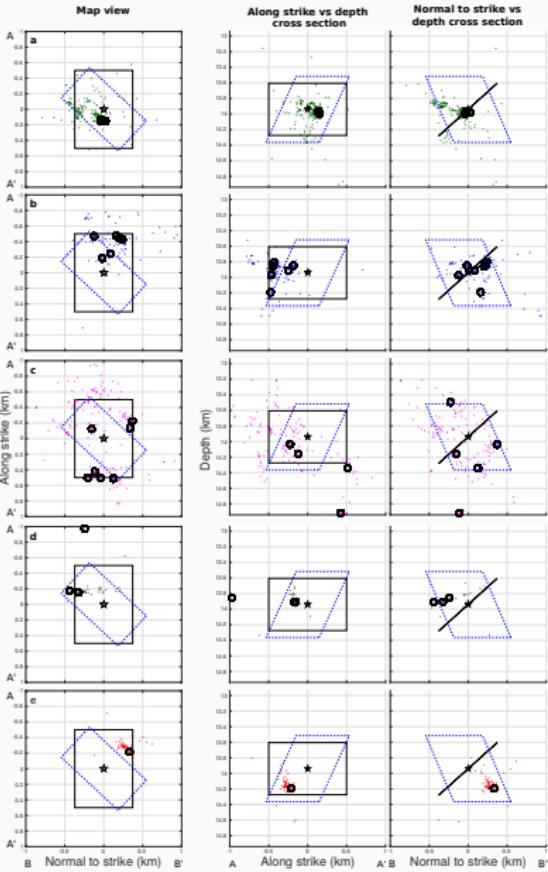
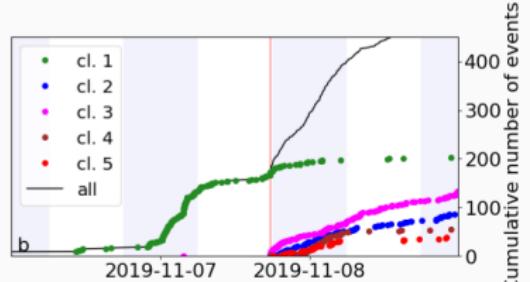
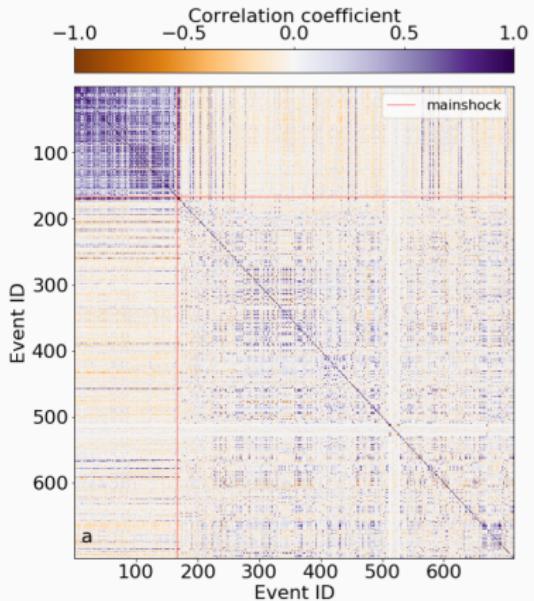
# Secuencia sísmica del sismo 2019 Mw4 Balsorano, Italia



# Secuencia sísmica del sismo 2019 Mw4 Balsorano, Italia



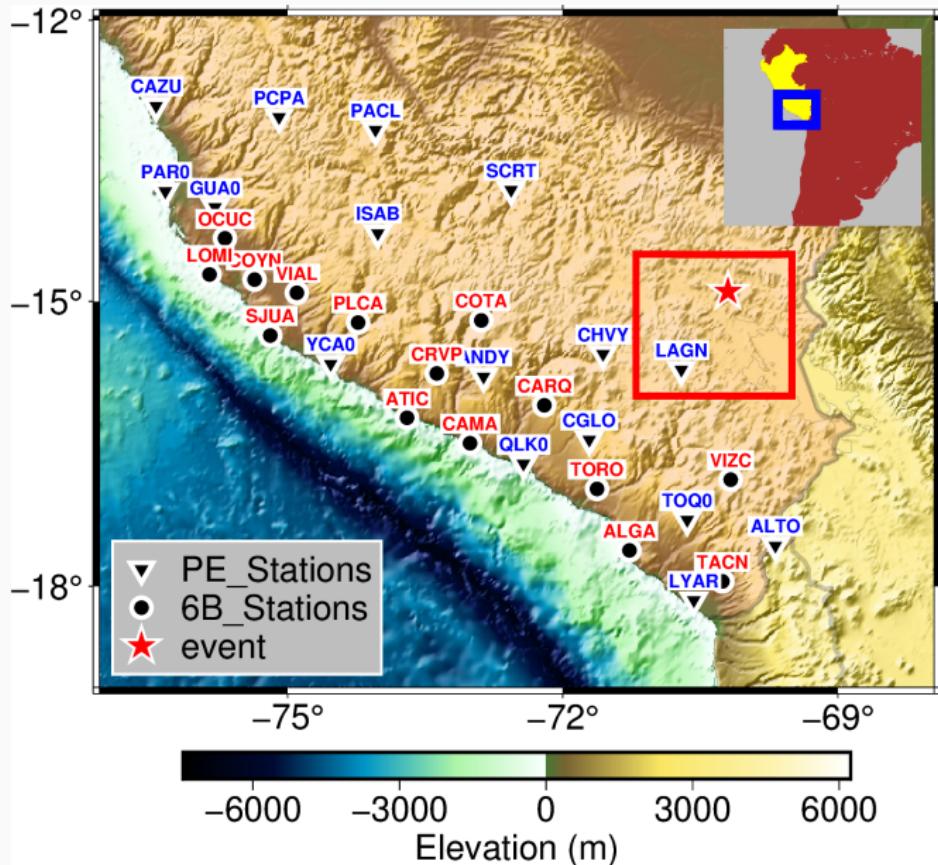
# Secuencia sísmica del sismo 2019 Mw4 Balsorano, Italia



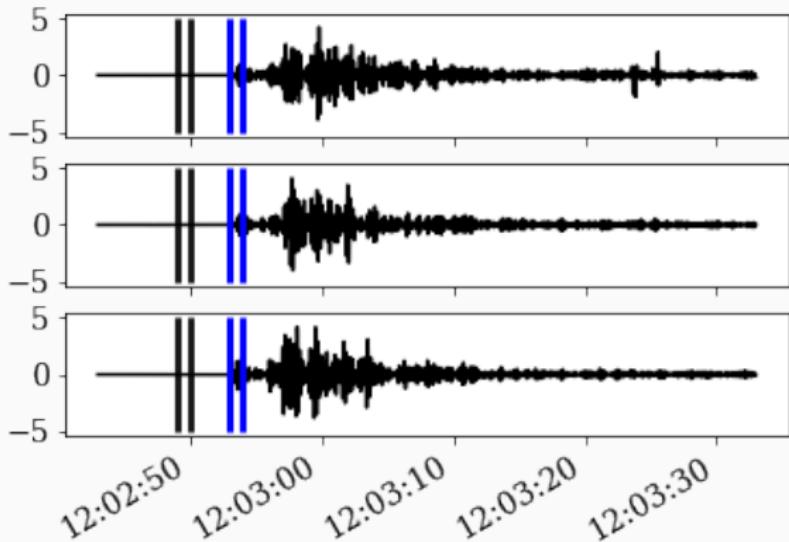
## Ejercicio

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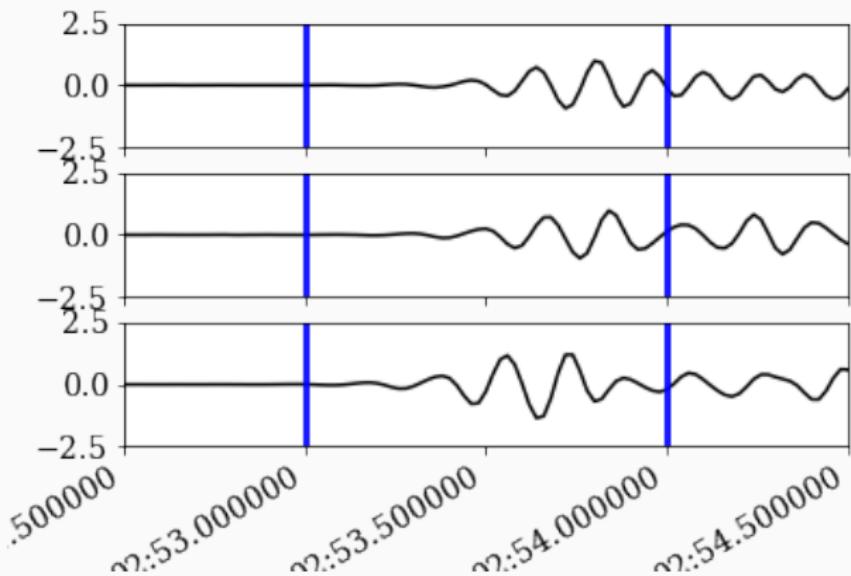
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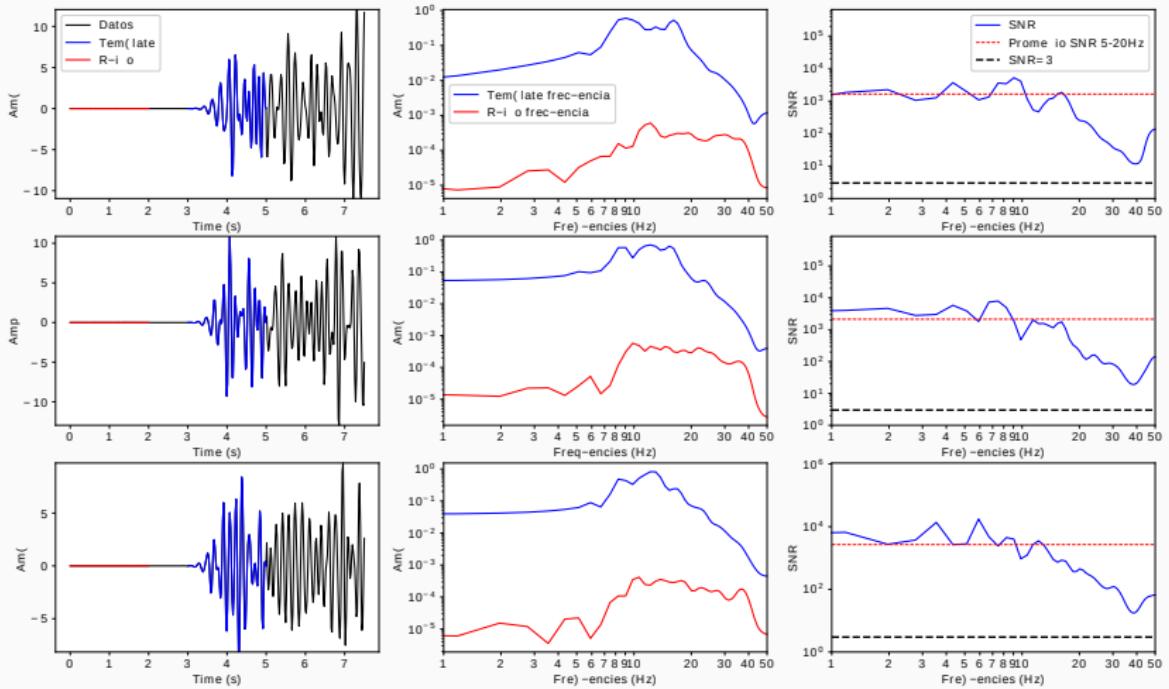
# Evento sísmico del 26 de Mayo del 2022, Mw7.2



# Evento sísmico del 26 de Mayo del 2022, Mw7.2

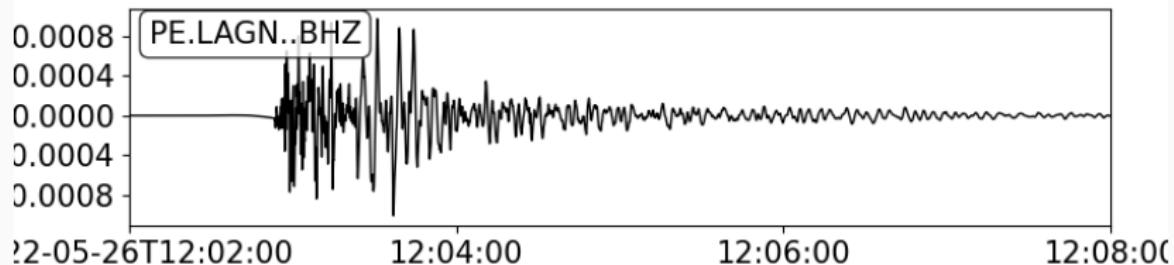


2022-05-26T12:02:23.000000Z CHVY



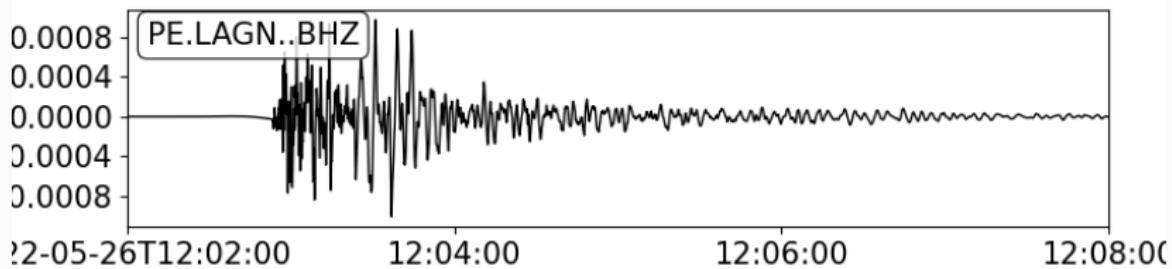
# Nuevas detecciones

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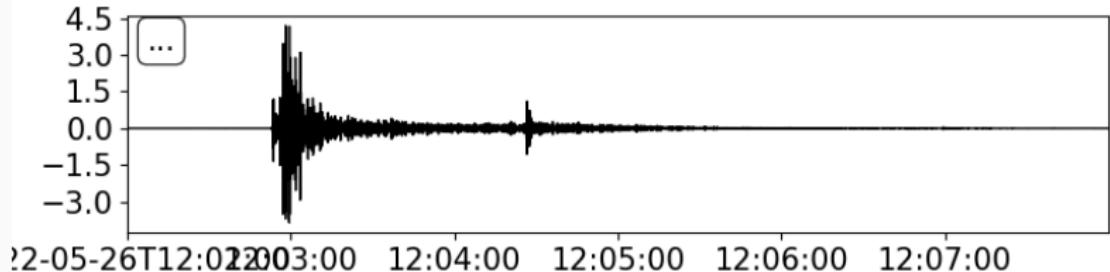


# Nuevas detecciones

2022-05-26T12:02:00 - 2022-05-26T12:08:00



2022-05-26T12:02:00 - 2022-05-26T12:07:59.98



# Nuevas detecciones

