Daily monitoring of low-frequency earthquake activity

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Winter 2020 Incubator project

Low-frequency earthquakes (LFEs)

- Small magnitude (M $\sim$ 1)
- Dominant frequency low (1-10 Hz) compared with that of ordinary tiny earthquakes (up to 20 Hz)
- Source located on the plate boundary
- Grouped into families of events, with all the earthquakes of a given family originating from the same small patch on the plate interface
- Recurrence more or less episodic in a bursty manner

What we do now

- Download seismic data for a given period of time
- Analyze data and find time of occurrence of LFEs
- Create a catalog of LFEs for a given period of time and publish it

What we aim to do

- Low-frequency earthquake occur and are recorded by permanent seismic stations every day
- On a daily basis:
  - Download seismic data from the day before
  - Analyze data and find low frequency earthquakes
  - Update the catalog

First step: Python package

catalog

- Specific Python scripts for downloading data and finding LFEs
- Directory with templates for two LFE families

utils

General Python scripts for stacking and cross-correlation

data

- File with list of LFE families
- File with list of seismic stations
- Directory with instrument response from seismic stations

lfelib

- Specific Python scripts for downloading data and finding LFEs
- `utils` : General Python scripts for stacking and cross-correlation

tests

examples

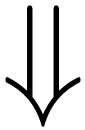
Templates, instrument responses, list of LFE families and seismic stations

.github/workflows

- environment.yml
- pyproject.toml

Second step: Command line

```
> python
>>>  get_all_responses('stations_permanent.txt')
>>>  find_LFEs('families_permanent.txt', \
    'stations_permanent.txt', 'templates', \
    (2020, 3, 7, 0, 0, 0), (2020, 3, 8, 0, 0, 0), 10.0, \
    60.0, (1.5, 9.0), 1.0, 0.05, 10, 10.0, 'MAD', 8.0)
```



```
getresp -s stations_permanent.txt

lfeall -ff families_permanent.txt -s stations_permanent.txt
-t templates -t0 $year1 $month1 $day1 0 0 0
-tf $year2 $month2 $day2 0 0 0 -td 10.0 -d 60.0
-f 1.5 9.0 -f0 1.0 -dt 0.05 -n 10 -w 10.0 -tr MAD -tv 8.0
```

Third step: GitHub workflow

```
name: CronJob
on:
  schedule:
    - cron: '0 0 * * *'
jobs:
  cronjob:
    runs-on: ubuntu-18.04
    steps:
      - name: Checkout Repo
        uses: actions/checkout@v2
      - name: Set up Python 3.7
        uses: actions/setup-python@v1
        with:
          python-version: 3.7
      - name: Install lfelib from PyPi
        run: |
          python --version
          pip install --extra-index-url https://test.pypi.org/simple/ lfelib
      - name: Run Analysis
        run: |
          ./myscript
```

Fourth step: Improving memory space and computing time

Memory space

Store instrument response into data directory

Memory space

Download instrument response before looking for LFEs

Computing time

Loop on LFE families
    Loop on seismic stations
        Download seismic data
    Analyze seismic data
    Delete seismic data

Computing time

Loop on seismic stations
    Download seismic data
Loop on LFE families
    Analyze seismic data
Delete seismic data

Fifth step: Saving results

To be completed

Future improvements

- Increase computing time by parallelization of the Python scripts
- GitHub CronJob offers a limited computing time $\rightarrow$ To analyze more data, we may use Amazon Lambda instead