Lab 3: Observational seismology

October 28, 2026

Context. This lab focuses on the spectral analysis of seismic signals. You will learn how to compute and interpret the Fourier transform, and time-frequency analysis of seismic data, identify dominant frequencies, and understand how they relate to various wave propagation modes. The lab will also cover practical applications such as filtering in seismic data processing. You will work in the Jupyter notebook `observational_seismology.ipynb` (see the setup instructions on page 2).

Scientific objectives. Understand the principle of Fourier transform and its application to seismic signals. Learn the fundamentals of time-frequency analysis including uncertainty principle that trades-off time and frequency resolution. Understand what type of waves are visible in the time domain on three-component seismograms; observe their frequency content in the frequency domain; and identify their propagation modes (body waves, surface waves). Understand the waveform shapes depending on the source type (strike-slip, explosion, etc.) and the source-receiver distance. Filter to observe the dynamic of specific wave types in the time domain.

Technical objectives. We will primarily use the `obspy` library to download, read, process, and visualize seismic data. At the beginning of the lab, the instructor will provide a brief introduction to `obspy`, seismic data formats, and the principal seismic data centers. The computation of the Fourier transform will be performed using `numpy` and `scipy` libraries. We will also use `matplotlib` for plotting and visualizing the results. At several steps of the lab, you will be asked to infer the best parameters to use for the analysis (e.g., window length, filter type, etc.).

Expected outcomes. Overall, the goal is to identify an event of interest (earthquake, explosion, etc.) and analyze its seismic signal in both time and frequency domains to infer basic properties of the source and the wave propagation. For instance, identify the P and S wave arrivals, their frequency content, and how they relate to the source mechanism and distance. You will also be asked to filter the data to enhance specific wave types and observe them in the time domain.

Data. The data used in this lab will be downloaded from a data center such as IPGP or EarthScope (formerly IRIS). The instructor will provide the necessary information to access and download the data. You will work with three-component seismograms **of your choice** in standard formats such as MiniSEED.

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Setup instructions

Step 1: Connect to stella

1. Open a terminal on your local machine.
2. Log on to the stella head node: `ssh -XC myusername@stella` (use the password you defined for Lab 1).

Step 2: Create working directory on stella and copy lab material (first session only)

1. Navigate to the main directory you created for Lab 1, then create and enter a subdirectory for this lab:

```
cd ScientificComputing
mkdir Lab3_ObservationalSeismology
cd Lab3_ObservationalSeismology
```

2. Copy all necessary files:

```
cp -r /gpfs/users/themaster/scientific-computing-for-geophysical-problems/\
Lab3_ObservationalSeismology/* .
```

In a later session, do not repeat the `cp` command: it would replace your notebook with the empty one. Simply go back to your directory and resume.

Step 3: Access jupyter hub

1. Open Firefox on your local machine and navigate to: https://dante-jh/jupyter
2. Log in using your S-CAPAD/DANTE credentials (login + password).

Step 4: Configure environment

1. Select **Advanced Server Options** and set job duration to **4:00:00** (4 hours) and the memory to **4 GB** (instead of the default 2 GB). Make sure that the selected partition is the **jhcpu** partition.
2. If the **Custom** environment you created for Lab 1 still appears, select it and click the orange **Start** button. Otherwise, configure it again: choose **Custom**, Environment Name: `ScientificComputing`, path to jupyter env bin (**noting that there is no space in the path below**):

```
/gpfs/users/themaster/.conda/envs/scientific_computing/bin
```

then click **Add custom environment**, and the orange **Start** button.

Step 5: Open the notebook

1. Wait for server startup. Use the navigation bar to reach the `Lab3_ObservationalSeismology` directory, inside `ScientificComputing`.
2. Double-click `observational_seismology.ipynb` to start the notebook.

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