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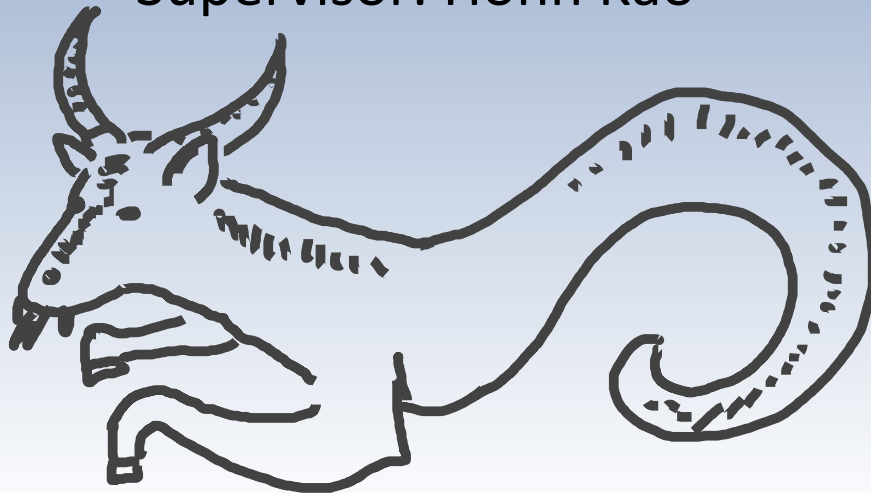
University of Victoria

Antelope-Python Integration for Observational Seismology

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Outline

- SeaJade (Seafloor Earthquake Array Japan-Canada Cascadia Experiment)
- Python Integration and Flow
- Python Scripts
  - Converted phase depth calculator
  - Waveform extractor
  - Focal mechanism candidate finder
 - Cross-correlation package
  - MTfit package

SeaJade

- Two phase project designed to study the offshore component of the northern Cascadia subduction zone.

- Phase 1 consisted of 33 functioning short-period ocean-bottom seismometers (OBS), deployed over a 3 month period during 2010.

- Phase 2 consisted of 35 OBS (one floated away during the experiment), also short-period, and 8 land-stations deployed in the Nootka sound region. The deployment lasted for nine months during 2014.
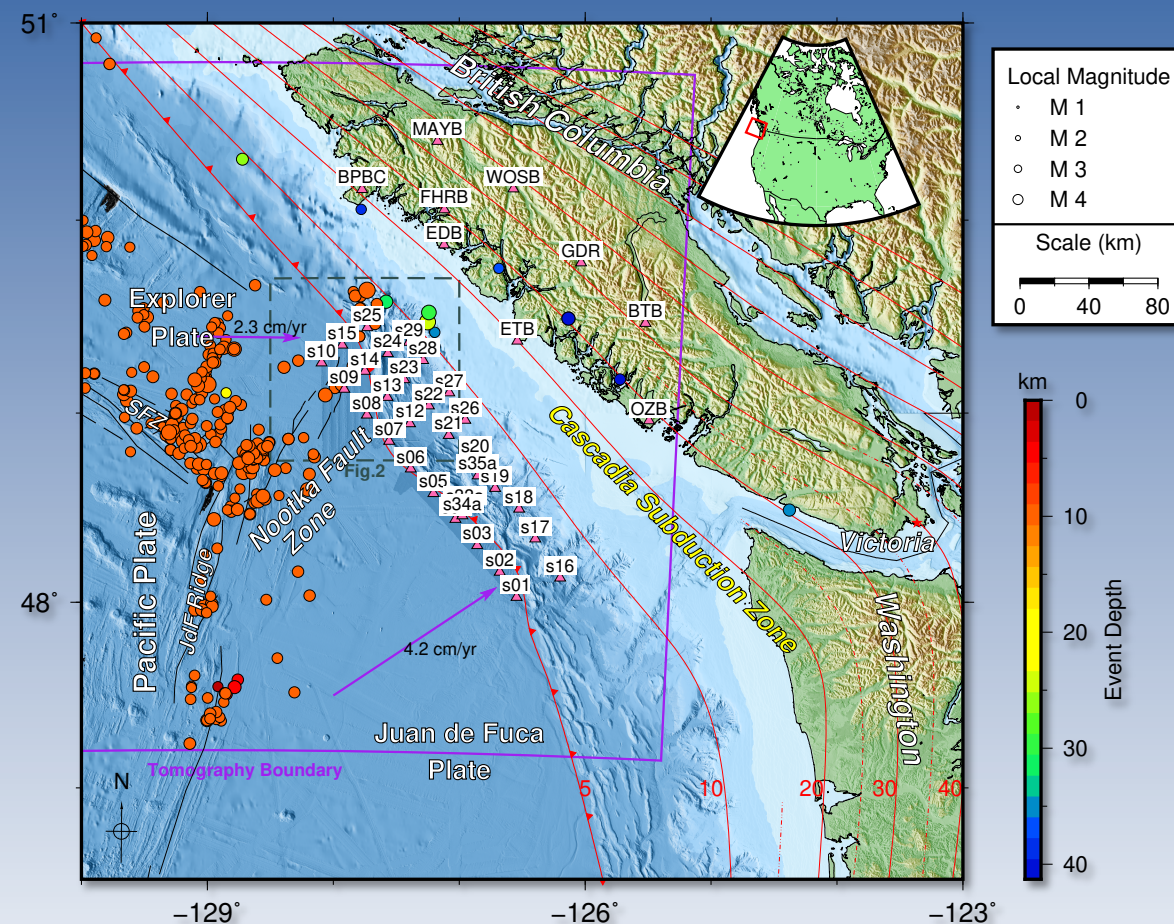

Region of Study

SeaJade

- My research has focused on event location, double-differential relocation, seismic tomography, focal mechanisms, and converted-phase depth calculations.

- Initial analysis was performed with the Antelope suite, which was then processed for further review with Python, HASH, Mtfit, HypoDD, and TomoDD.
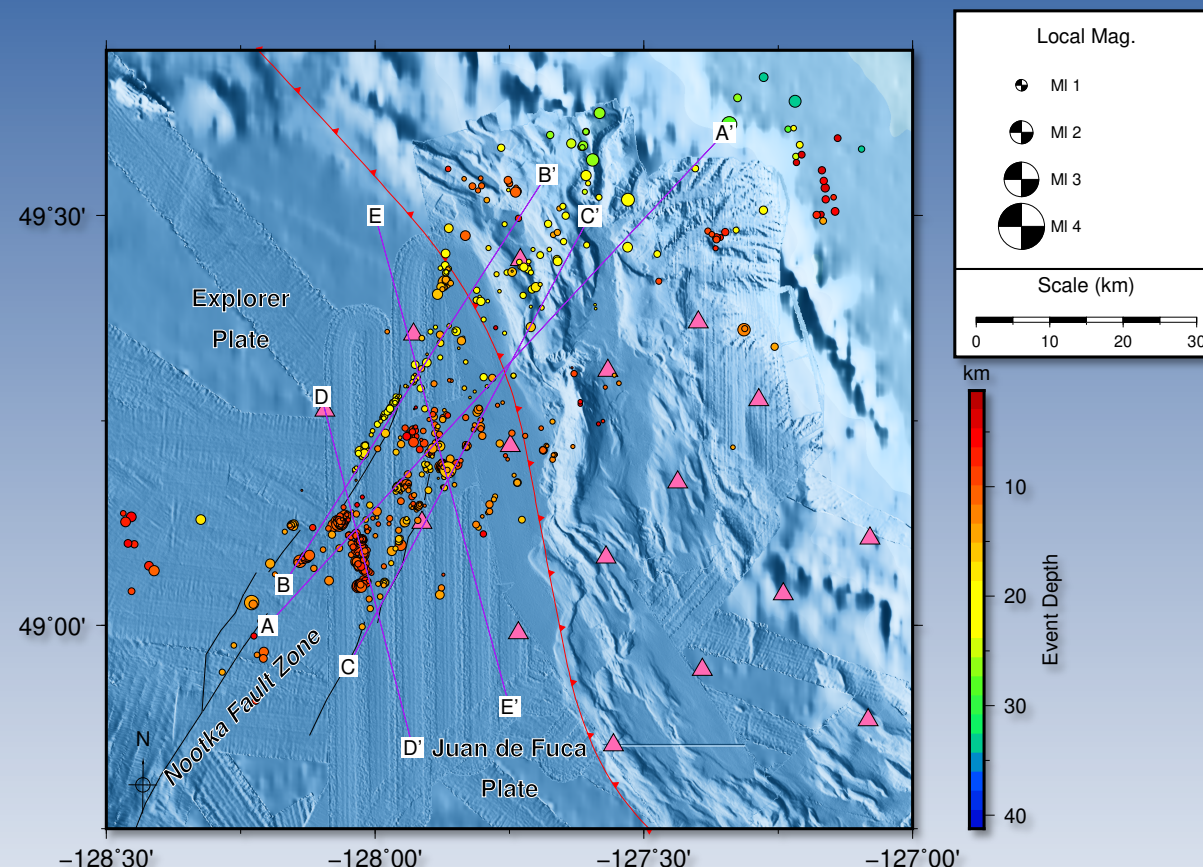
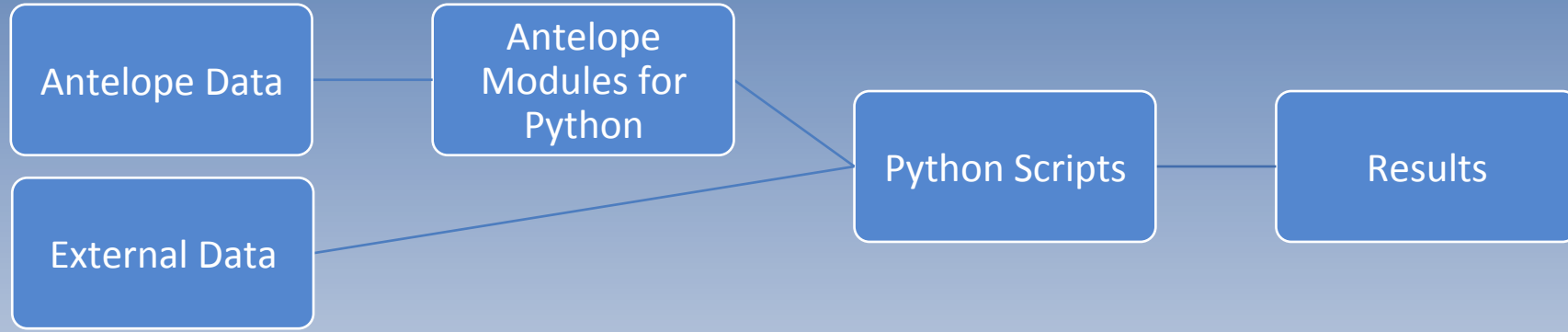SeaJade I Events and Stations

SeaJade

- For SeaJade II:
  - Utilized dbdetect for detecting P phases.
  - dbshear (Zachary Ross) for detecting S phases
  - dbgrassoc for initial locations
  - dbloc2 for event review, phase adjustment, and picking additional phases.
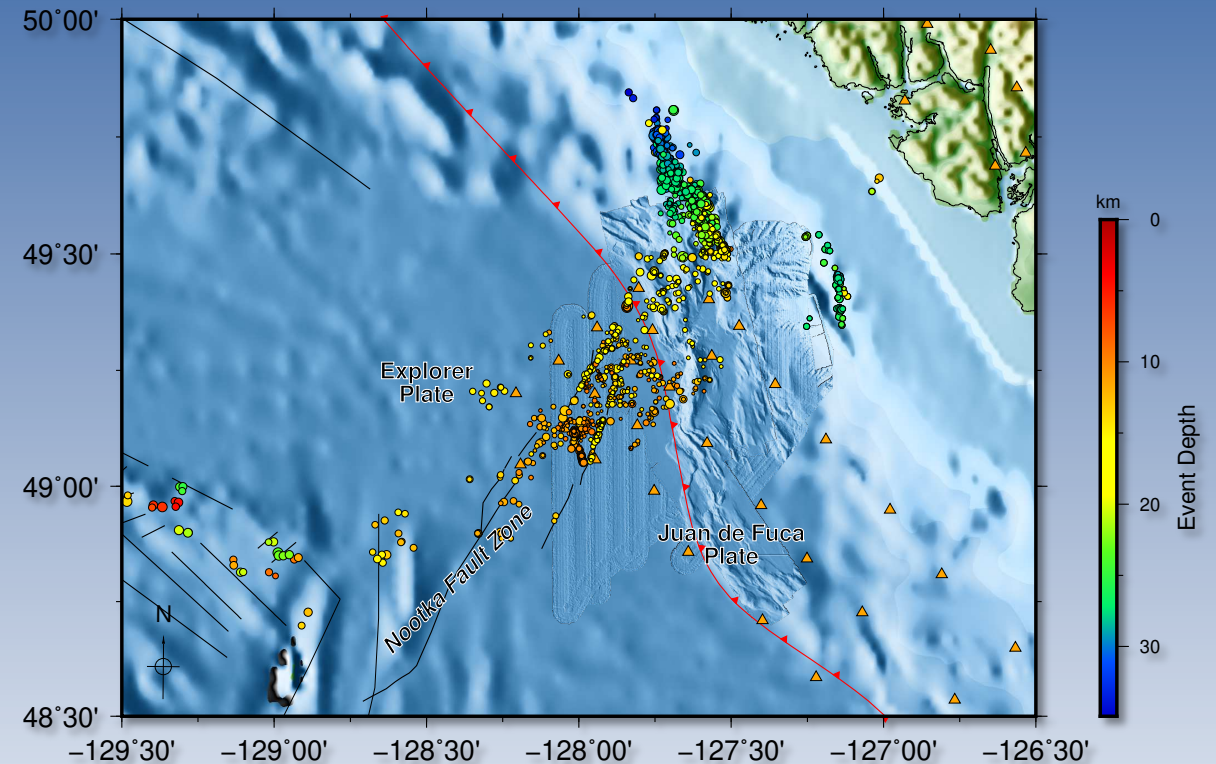
SeaJade II Events and Stations

Python Integration and Flow

Antelope Data

Antelope Modules for Python

External Data

Python Scripts

Results

Python Scripts

- Converted phase depth calculator
- Waveform extractor
- Focal mechanism candidate finder
- Cross-correlation package
- MTfit package

Python Scripts

- Converted phase depth calculator:
  - Finds converted phases (sP, pS, etc.).
  - Searches prior to their arrival time for event origin times.
  - Back-calculates the origin time for phase conversion and **calculates depth**.
  - Can be used with a base 1-D velocity model or a 1-D velocity model derived from the 3-D velocity model nodes.
  - Depends on the assumption that the event occurred nearly directly below the station where the converted phase(s) were observed.
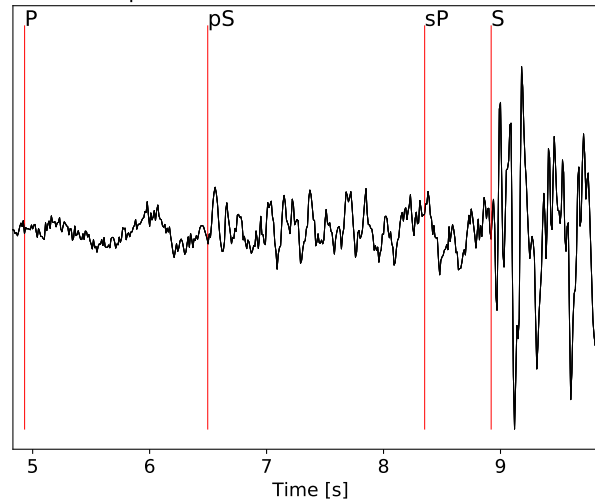
Python Scripts

- Waveform extractor:
    - **Extracts segments of waveform data into Obspy objects**.
    - Specific orid, station, and channel must be chosen.
    - The time window before and after the origin time can be adjusted.
    - Displays phases that occur within the time windows.
    - Gives the user control over graphics and the plots are easily written to any format.
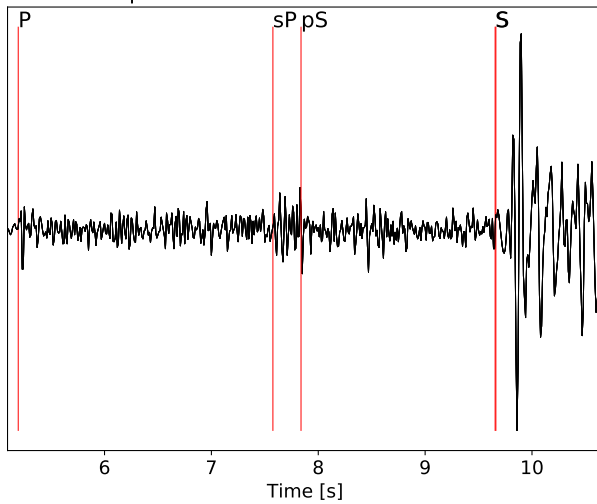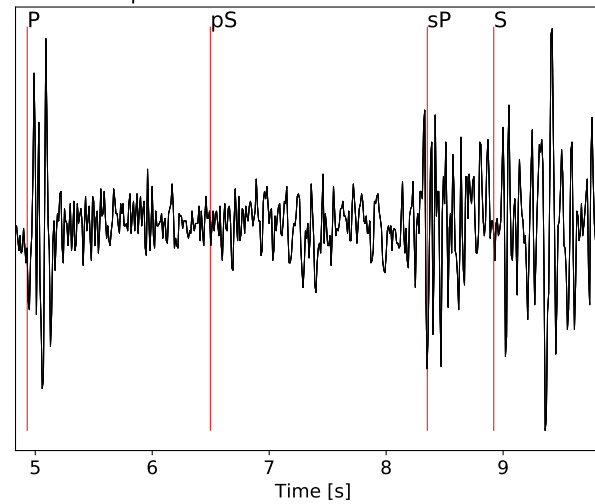
N component at Station s15 from Event No. 2
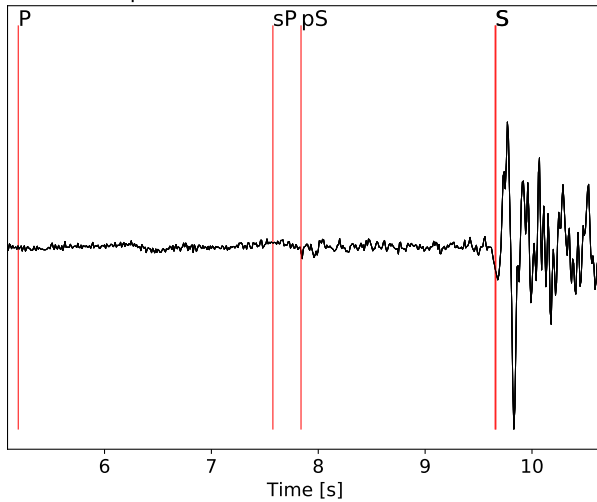
N component at Station s09 from Event No. 43

Z component at Station s15 from Event No. 2

Z component at Station s09 from Event No. 43

Example waveforms collected with the waveform extractor script.

Python Scripts

- Focal mechanism candidate finder:
  - Used to create a **candidate list of events** that could be used **to calculate focal mechanisms**.
  - Batch process.
  - Counts the number of P-phases associated with each event.
  - Any events higher than a given threshold (default: 8) are written to a text file.
  - Improves workflow, eliminating the need to identify first motions for every arrival.
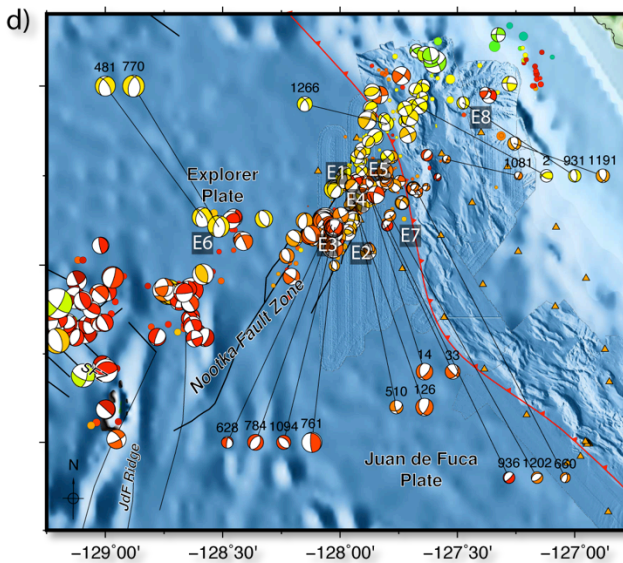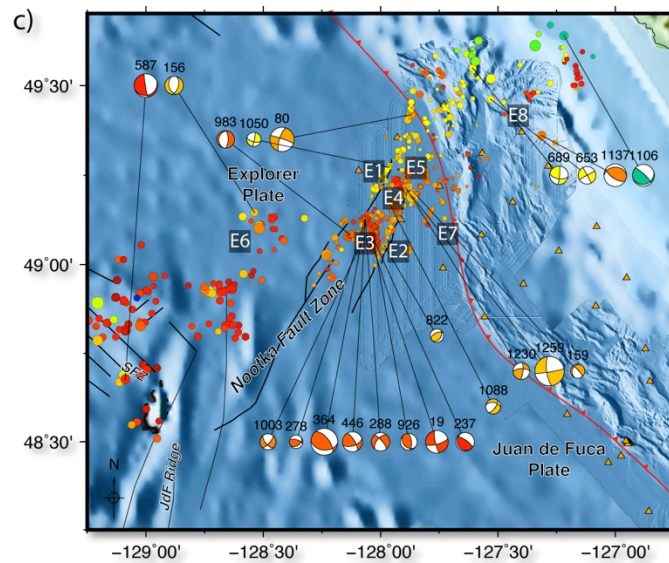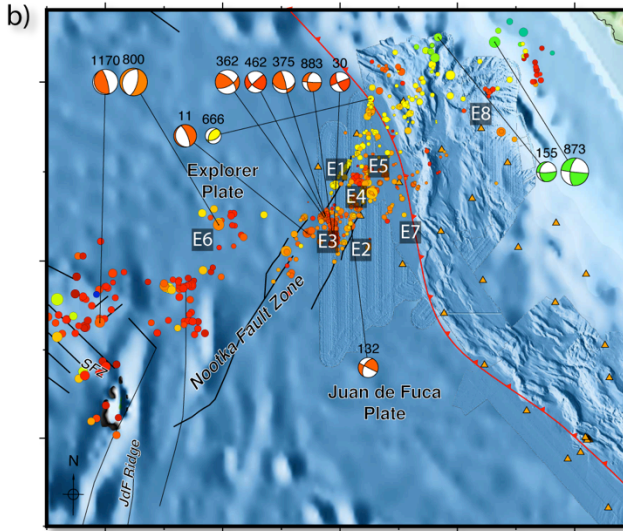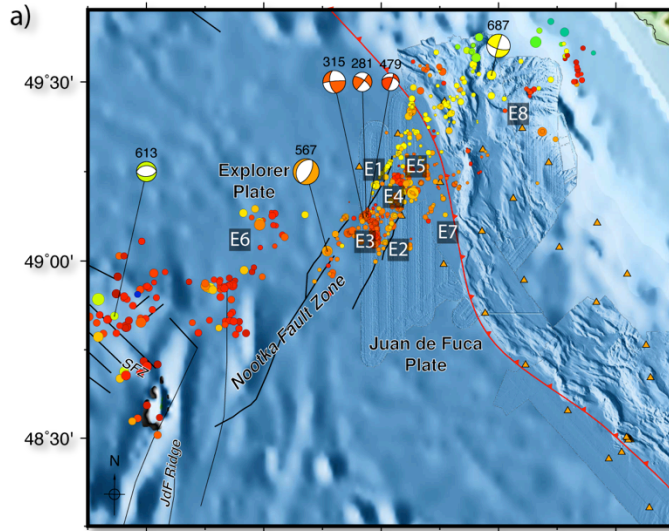
Focal mechanism solutions for events from SeaJade I. The earthquakes best suited for focal mechanism inversions were chosen with the focal mechanism candidate finder script.
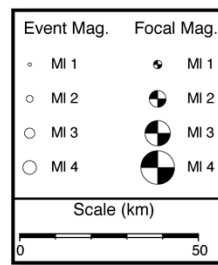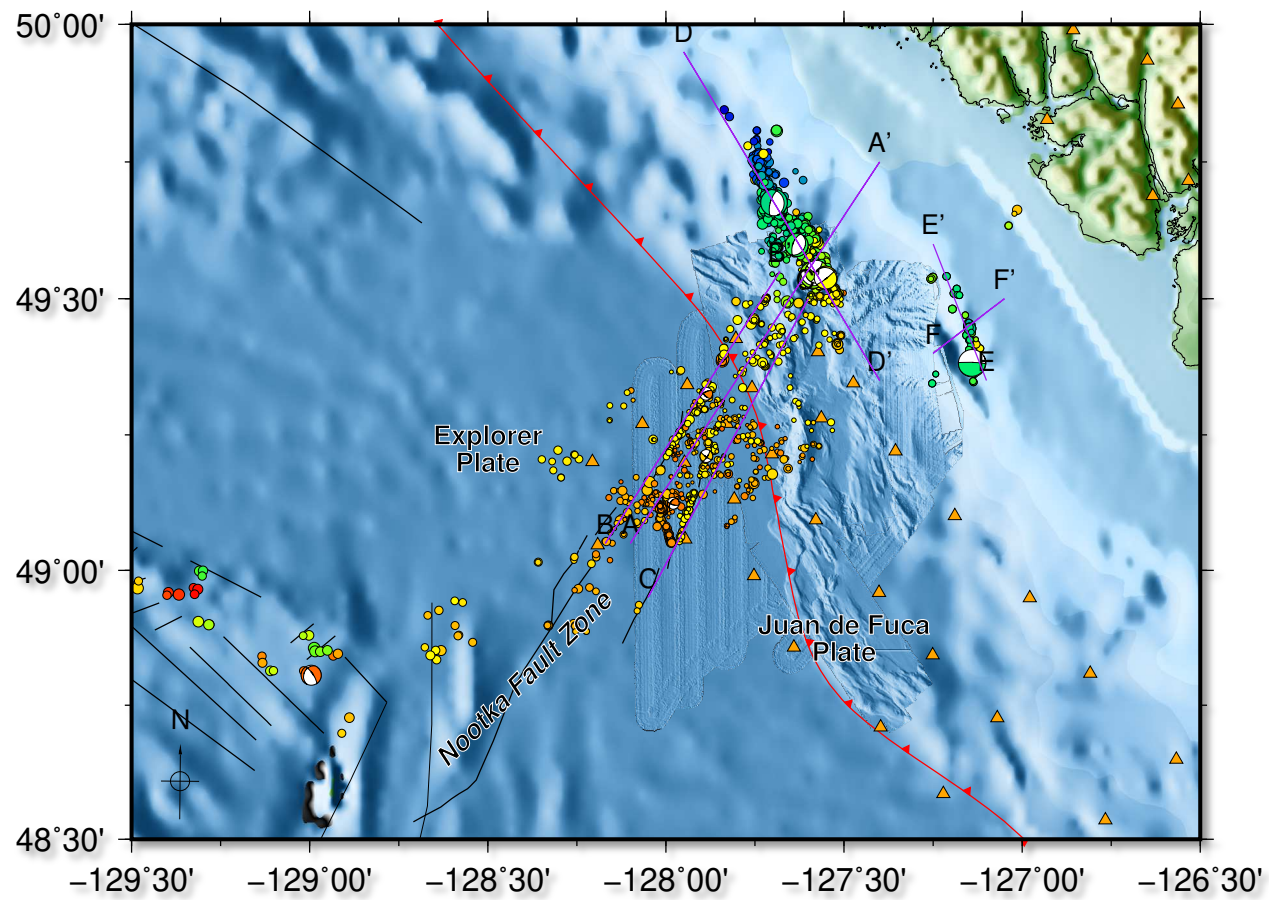
Python Scripts

- Cross-correlation package:
  - Derived from the cross-correlation package within the GISMO suite for Matlab by Celso Reyes
  - Advantage: open source and free of dependency on Matlab versions.
  - Three primary scripts:
    - dd_make_scp: **creates a list of stations, channels, and phases**, and the number of phases associated with each combination.
    - dd_multiprocess: reads in the scp list and the Antelope database. **Performs cross-correlations** for each station-channel-phase combination and writes the resultant data to numpy files. Uses multi-core processing for faster calculations.
    - dd_collate: **collates the travel-time differences and squared coherency** between event pairs for each station-channel-phase combination for HypoDD/TomoDD input.
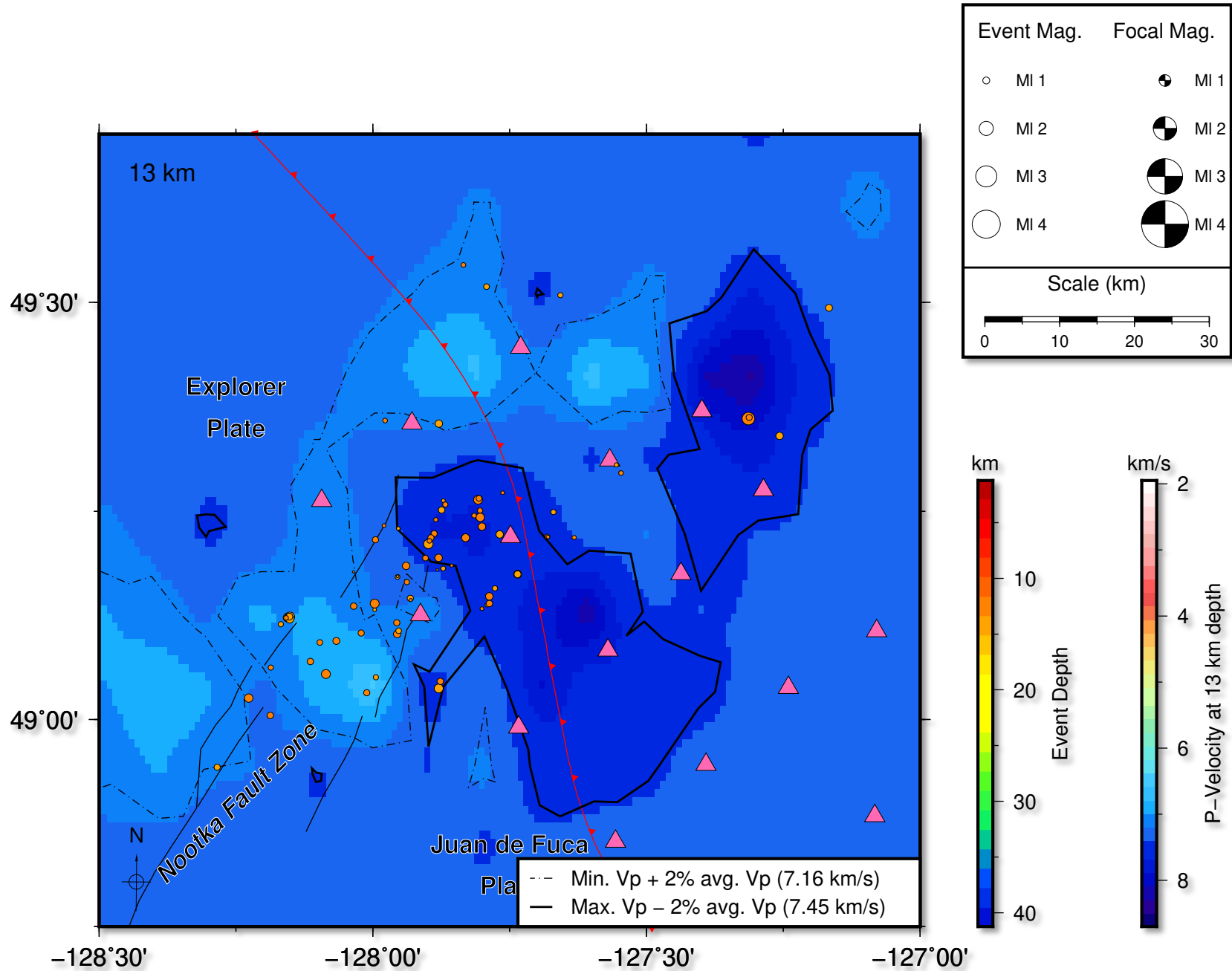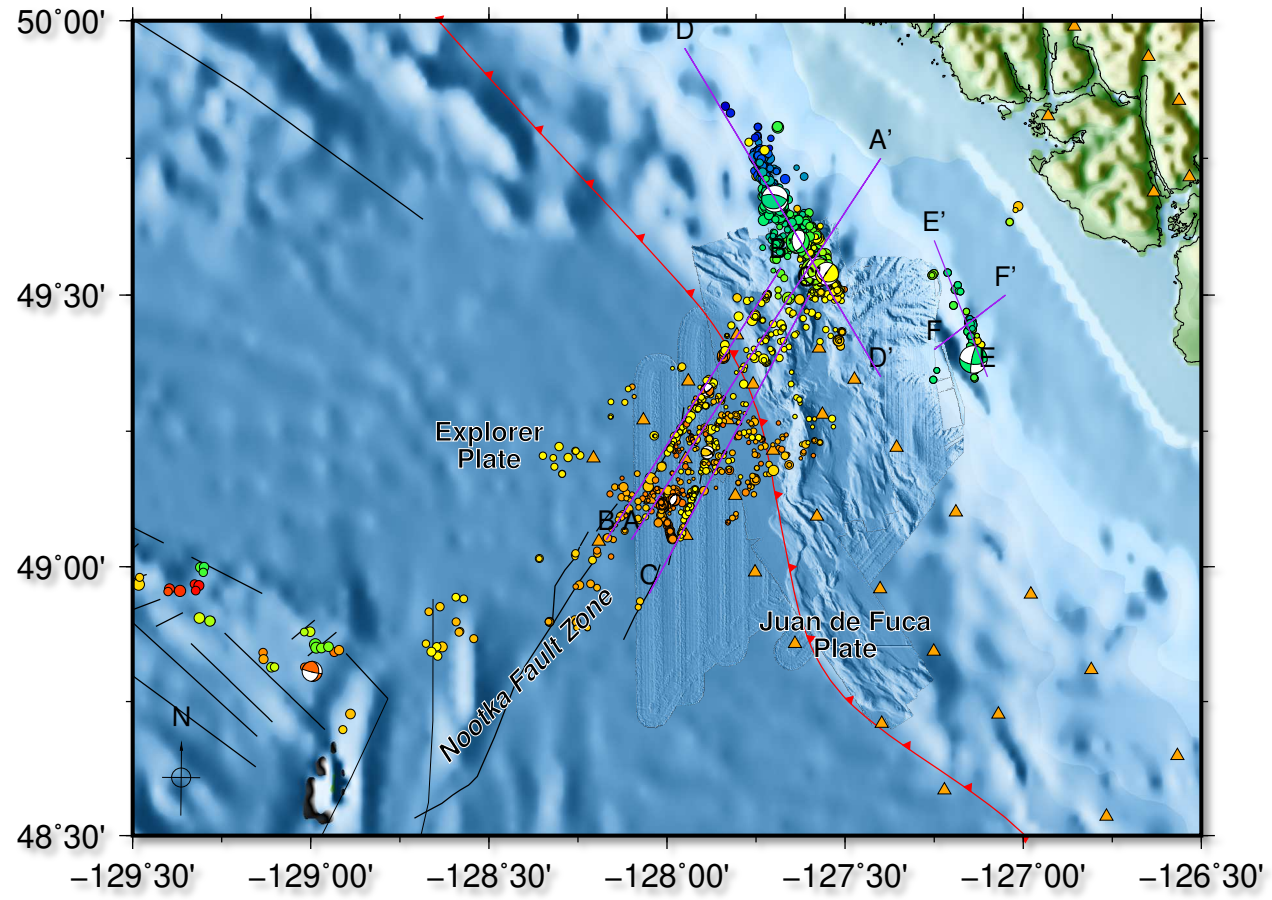
Tomography and relocation results from SeaJade I using TomoDD. Cross-correlations used for inversions were derived from the Python cross-correlation package.

Python Scripts

- MTfit package:
  - MTfit is a recently developed Python module that can calculate **moment tensor solutions for small earthquakes** using non-linear inversions (David J. Pugh).
  - The input format is very particular; it is a Python dictionary.
  - My script extracts the relevant data from Antelope (first motions and waveform amplitudes) and HypoDD (relocations and source information) and combines them to form the Python dictionaries used for MTfit.
  - MTfit is called across a cluster, processing dozens of events at the same time.
  - Results are written to GMT compatible files.

HASH

MTfit