

# Data-Driven Discovery of Earth GeoDynamical Systems in the Pacific Northwest

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## Background

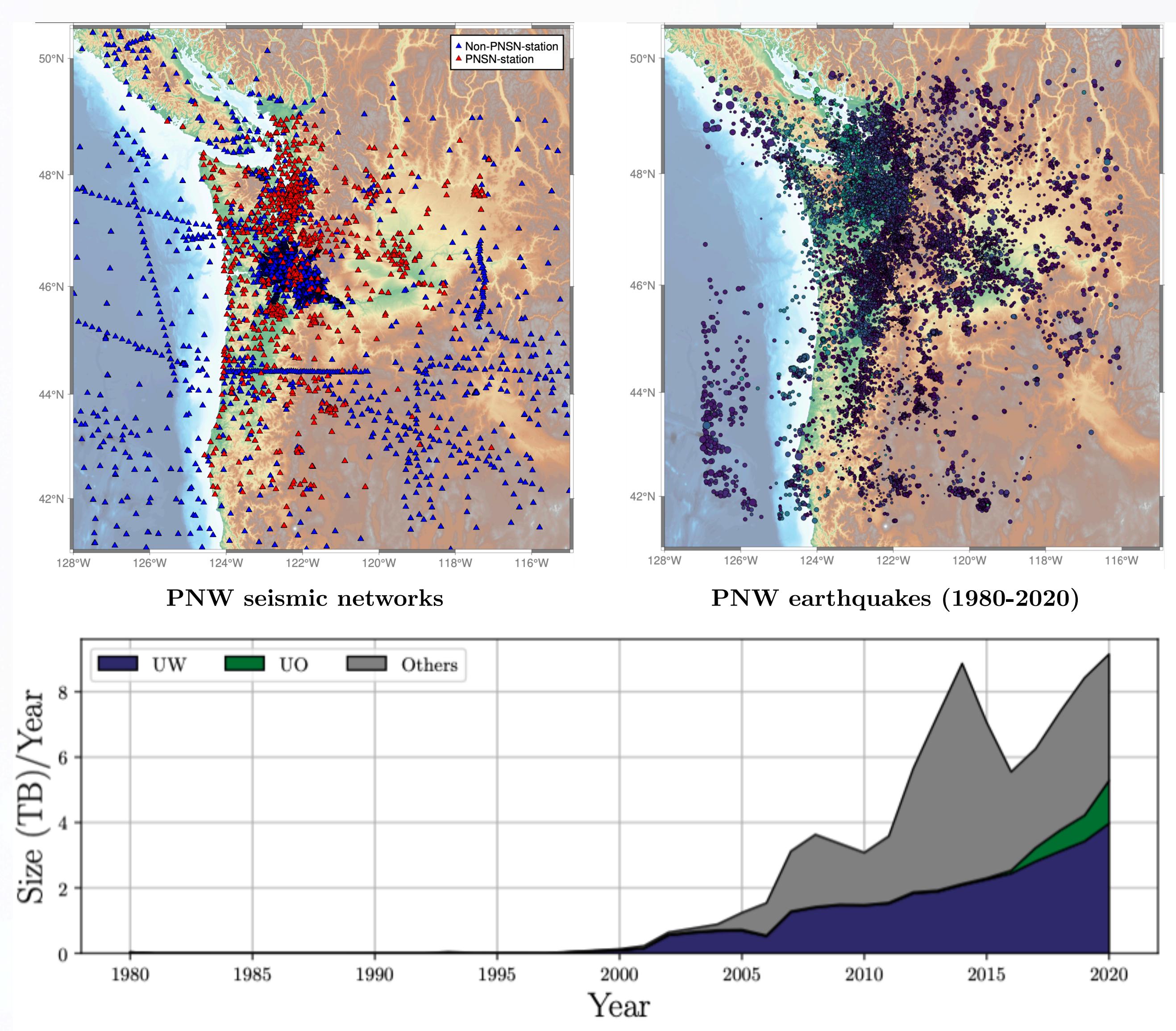
- The Pacific Northwest (PNW) is a particularly unique region in that it has a long record of seismicity (since the 1970s) and quite varied origins of crustal deformation, subduction-zone processes, volcanism, and surface processes.
- Earthquake catalogs gather important source characteristics of the past earthquakes. Seismologists rely heavily on accurate and comprehensive catalogs to do research like travel time tomography, full waveform inversion, seismic hazard characterization to establish active faults, and monitor seismicity to improve early earthquake warning. Manually processed catalogs usually are accurate, but impractical due to the time-intensive labor limits their completeness, especially as the seismic networks experience rapid growth.

## Data

- We downloaded all seismic recording available at Incorporated Research Institution for Seismology Data Management Center (IRIS DMC<sup>[5]</sup>), and focus on data of three-component seismometers sampled at 100Hz.
- Streams indexed with databases system for faster access (2x - 8x faster).
- Metadata of 60 temporary and permanent networks, and 100k earthquake events are stored in an XML format.

## Method

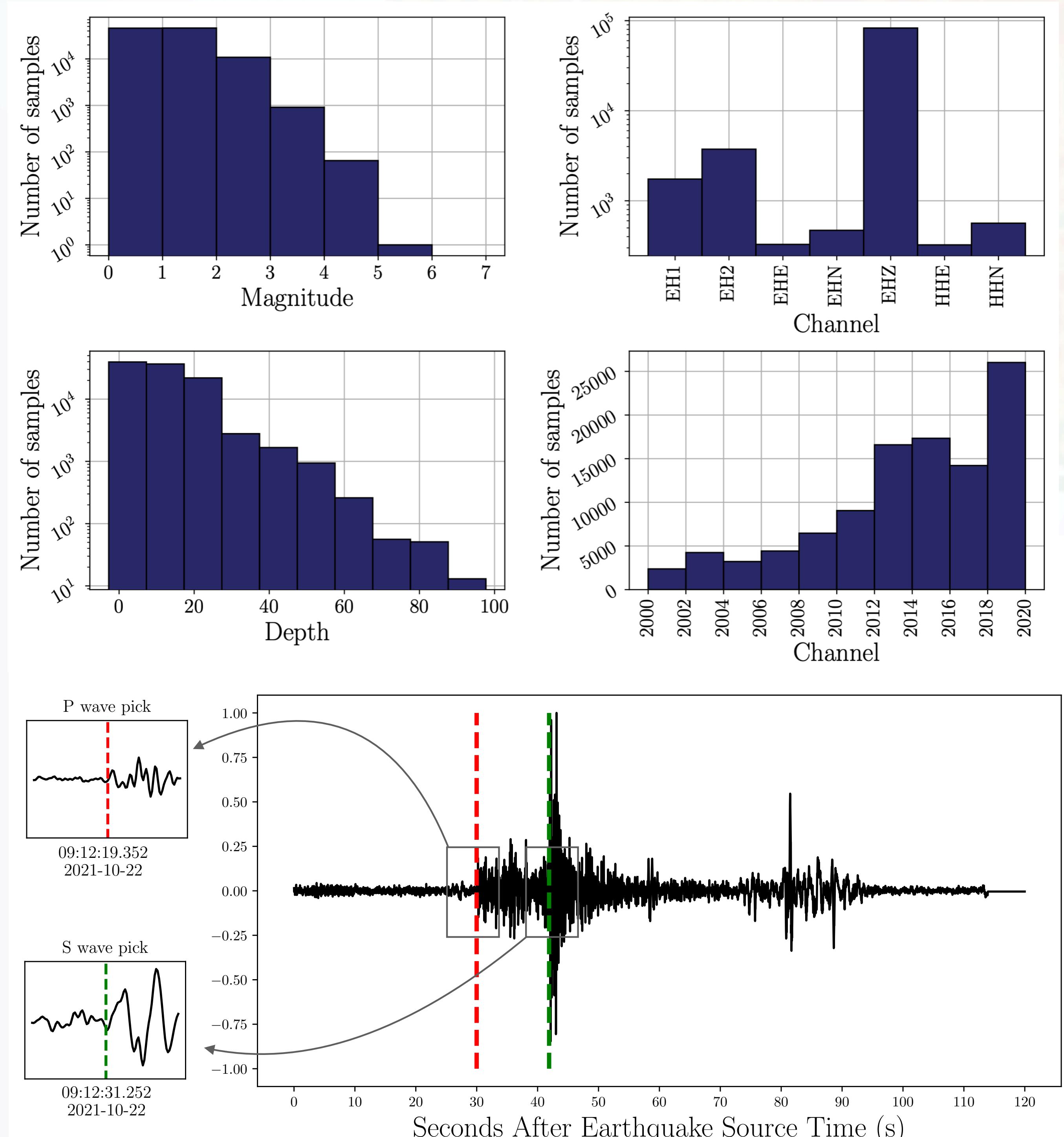
- Curate PNW dataset from 20 years of earthquake records from PNSN<sup>[4]</sup> network.
- Retrain Earthquake Transformer<sup>[2]</sup> model using PNW dataset. Workflow built with SeisBench<sup>[1]</sup> with the parameters pre-trained with global earthquake dataset STEAD<sup>[3]</sup>.
- Refine and improve data on existing earthquake catalog and windowed trace.
- Earthquake detection, phase picking, and event classification on continuous waveform of UW network.



PNW seismic data availability by year at IRIS DMC<sup>[5]</sup>. Total sizes are UW (34TB), UO (4TB), and Others (50TB).

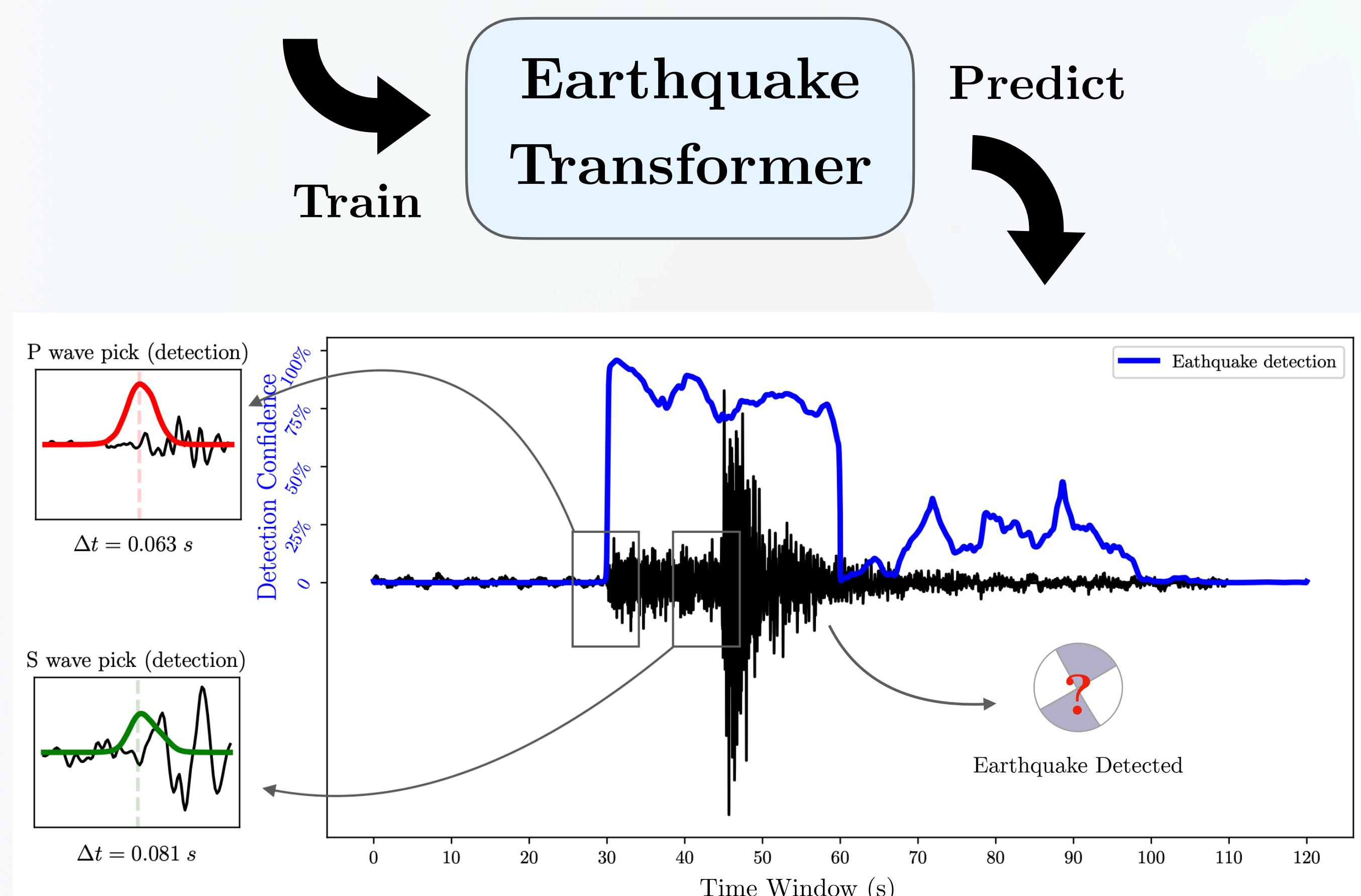
## PNW-ML dataset

- 103k waveforms with both P- and S-wave manual picks from EH?/HH?.
- Events in PNSN earthquake catalog between year 2000 and 2020.
- Ground motion record 50s before, and 100s after earthquake origin time.



Ground motion recorded at seismic stations when an earthquake happens.

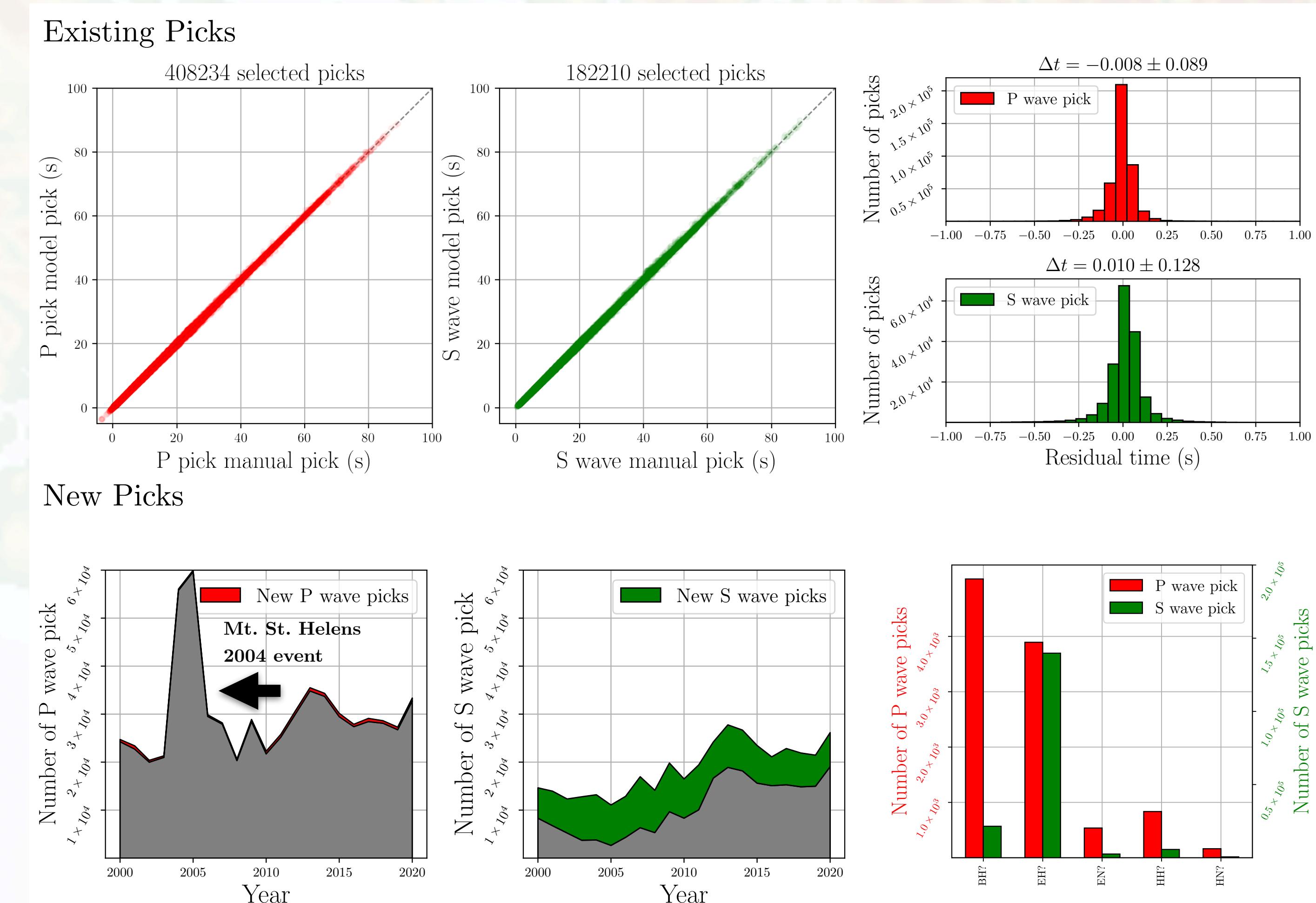
P waves are often more impulsive and easier to pick than S waves



## Results

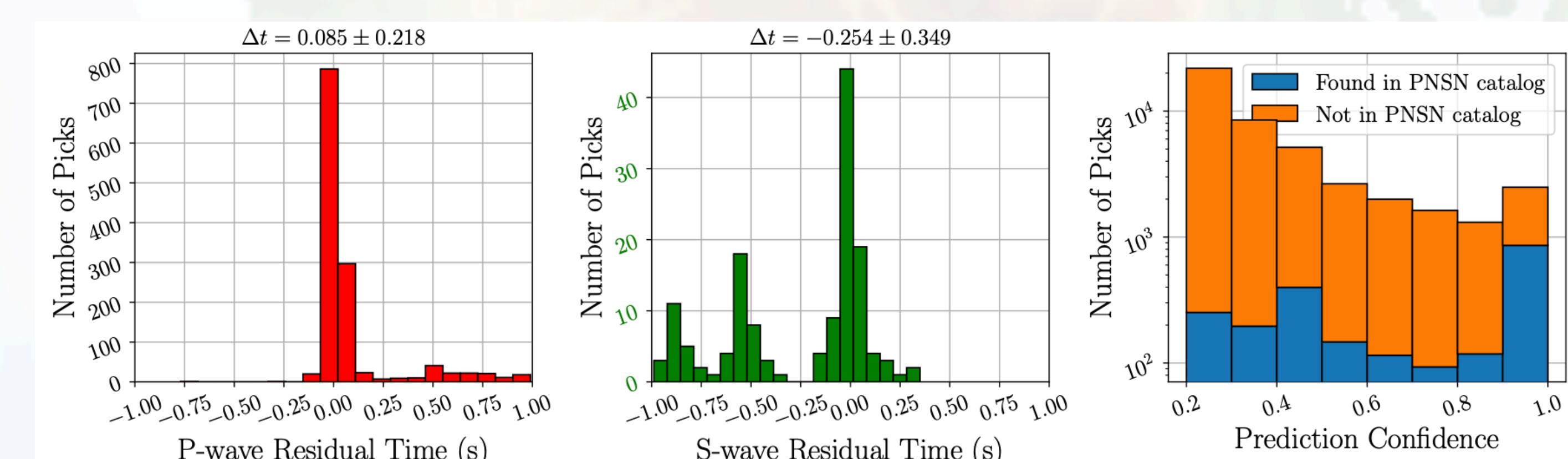
- It takes 11 hours of computation and 50 MB/s data streaming rate (from data server to computing server) to running our model on windowed data. 15 days expected for continuous data.
- Small bias (less than 1 data point for 100 Hz) and variant compared to manual picks for both P- and S-wave.
- Limited number of new P-wave picks found (not surprising). New S-wave picks concentrated in volcano stations, e.g., Mount St. Helens.

## Windowed data



## Continuous data (single station sample)

- 19 years (2002-2020) of continuous waveform from UW.WIW.EHZ. Prediction takes 2.5 hours of computation.
- 2339 over 2771 picks from PNSN are found with less than 1 second residual.



## Ongoing:

- Associate and check the quality of new P- and S-wave picks from both windowed and continuous stream.
- Apply the model to more PNW channels, stations and networks.
- Predict on off-shore seismic networks.

## Reference

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- Incorporated Research Institutions for Seismology Data Management Center: <https://ds.iris.edu/ds/nodes/dmc/>