Tsunami Forecasting in the Salish Sea Using Machine Learning

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Bottom line:

An ocean bottom pressure sensor in the Strait of Juan de Fuca,

or other direct observation of tsunami entering the Strait,

could be very useful for creating accurate tsunami warnings in the Salish Sea.

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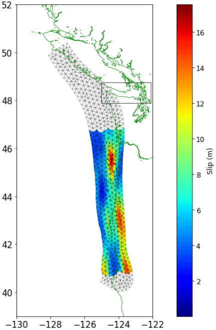
Why?

Regardless of source (CSZ or distant), the wave entering the Strait is generally a plane wave and almost entirely determines tsunami in the Salish Sea.

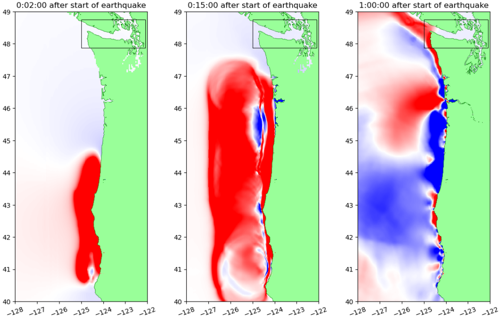
Tsunami can take several hours to propagate from Strait to some communities, so time for useful warnings.

“Random” CSZ earthquake #1127 (of 1300)

Fault Slip

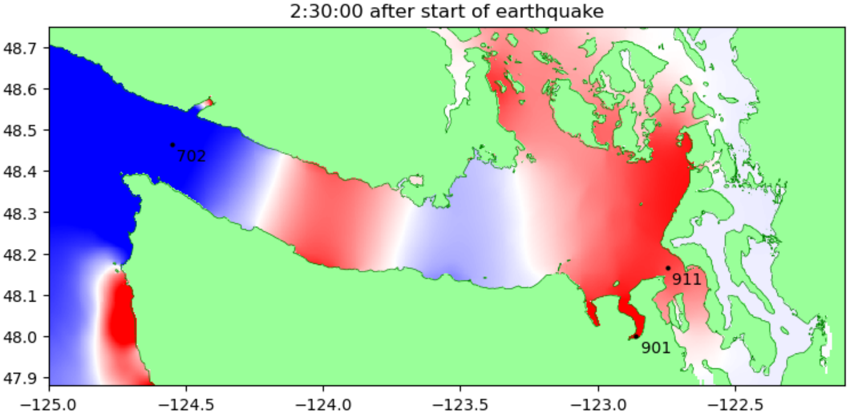


Tsunami simulation

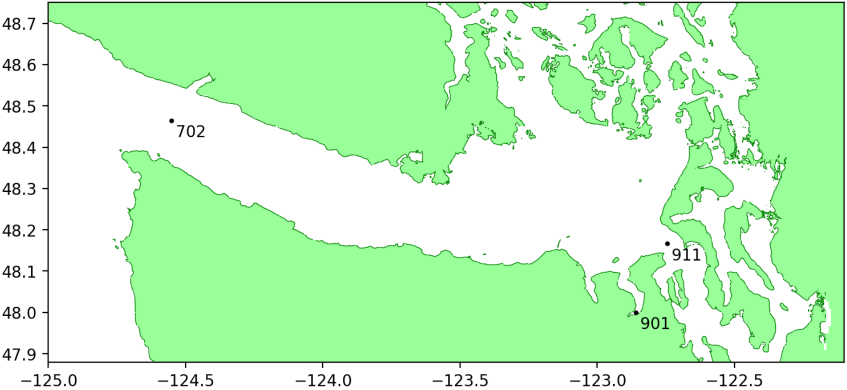


Fakequakes generated using github.com/dmelgarm/MudPy
Tsunami simulation using geoclaw.org

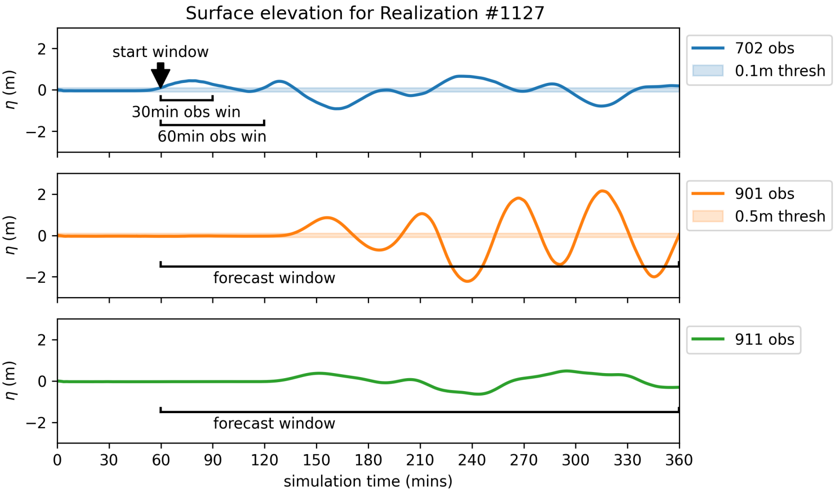
CSZ earthquake #1127 in Salish Sea



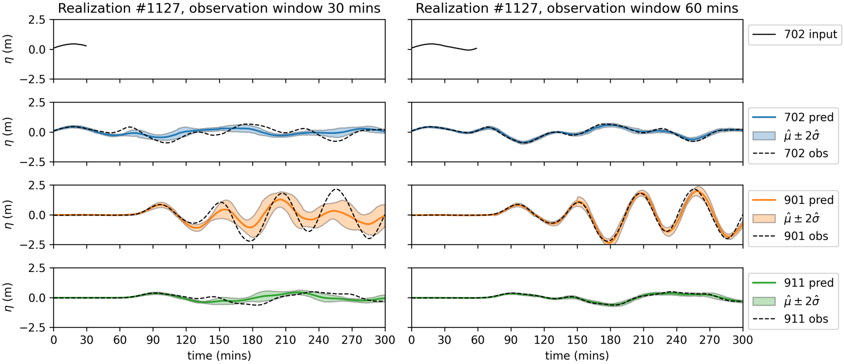
Synthetic Gauges in Strait of Juan de Fuca



Synthetic time series for #1127 (of 1300)



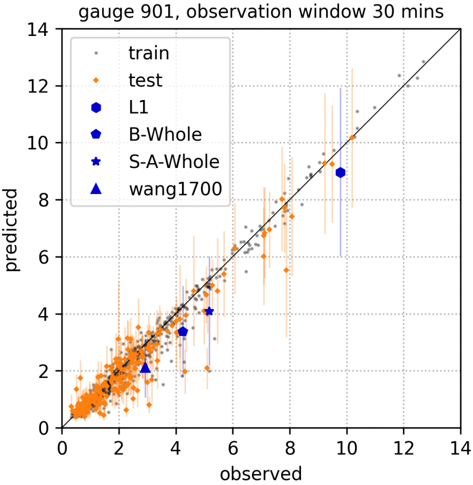
Time series forecasts for #1127 (of 1300)



Using Deterministic AutoEncoder (DAE)
with random initial parameters (also tried VAE)

Using PyTorch software, **pytorch.org**

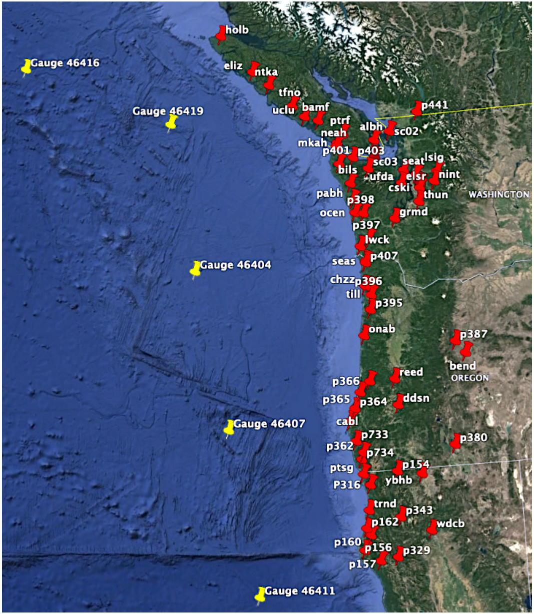
Also tried feature extraction (`tsfresh`) + SVM (`scikit-learn`).



1300 events were split into training set (80%) and test set (20%)

C.M. Liu, D. Rim, R. Baraldi, RJL, *Pure and Applied Geophysics* 2021.

https://doi.org/10.1007/s00024-021-02841-9

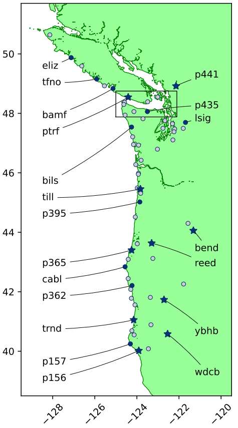


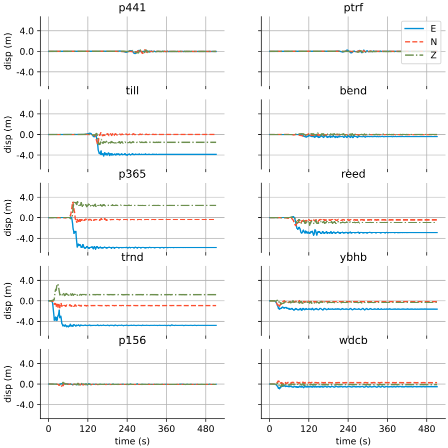
Using geodetic data instead of tsunami obs.

Red pins:
62 GNSS stations used in ML model

Yellow pins:
DART buoys

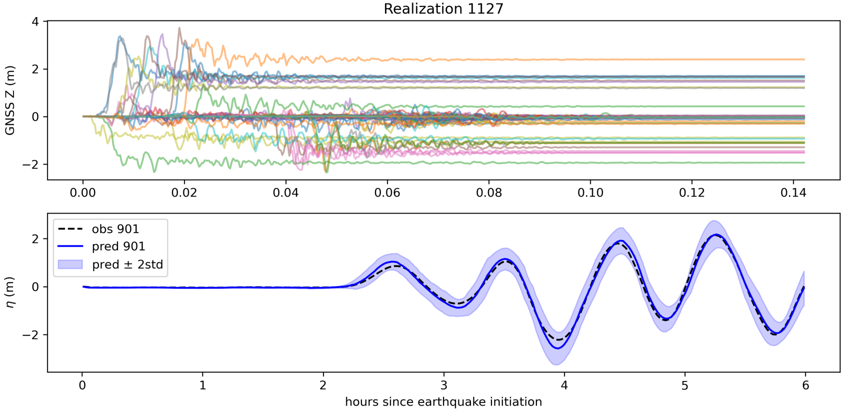
GNSS data for #1127





Forecasting Gauge 901 from GNSS observations

Using 62 GNSS sites, synthetic z-component (fakequakes)
Sampled at 1 Hz for 512 seconds (8.5 min)



D. Rim, R. Baraldi, C.M. Liu, RJL, and K. Terada Geophysical Research Letters (2022), DOI 10.1029/2022GL099511

GNSS data vs. direct tsunami observation

Advantages of using GNSS:

- 100's of GNSS stations already in place,
- Already transmitting data to Tsunami Warning Centers,
- All data available by end of shaking (< 10 minutes)

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