A hybrid ML-physical modelling approach for efficient approximation of tsunami waves at the coast for probabilistic tsunami hazard assessment

Naveen Ragu Ramalingam, Kendra Johnson, Marco Pagani, and Mario Martina
PhD Student at IUSS Pavia, Italy

IUSS Scuola Universitaria Superiore Pavia

GEM GLOBAL EARTHQUAKE MODEL working together to assess risk

EGU General Assembly 2022, Austria 23–27 May 2022

This presentation participates in OSPP

EGU

Outstanding Student & PhD candidate Presentation contest

A hybrid ML-physical modelling approach for efficient approximation of tsunami waves at the coast for probabilistic tsunami hazard assessment

Naveen Ragu Ramalingam, Kendra Johnson, Marco Pagani, and Mario Martina
PhD Student at IUSS Pavia, Italy

IUSS Scuola Universitaria Superiore Pavia

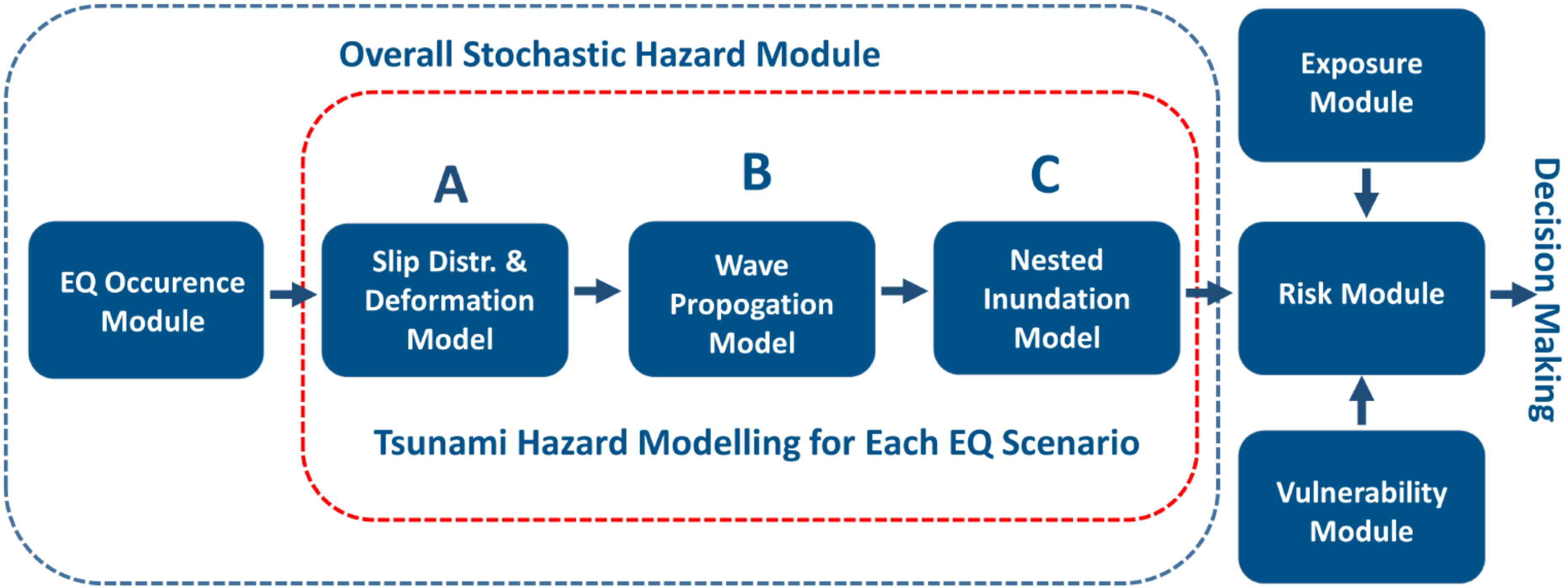
GEM GLOBAL EARTHQUAKE MODEL working together to assess risk

EGU General Assembly 2022, Austria 23–27 May 2022

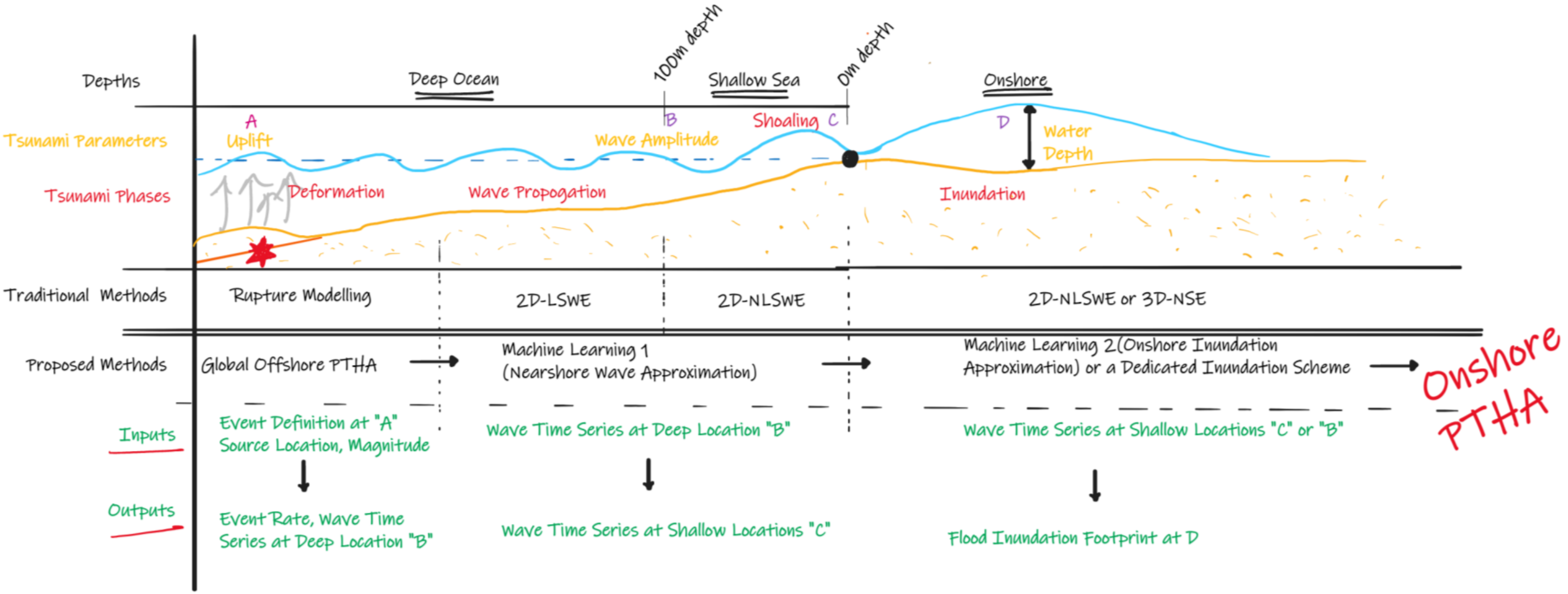
This presentation participates in OSPP

Outstanding Student & PhD candidate Presentation contest

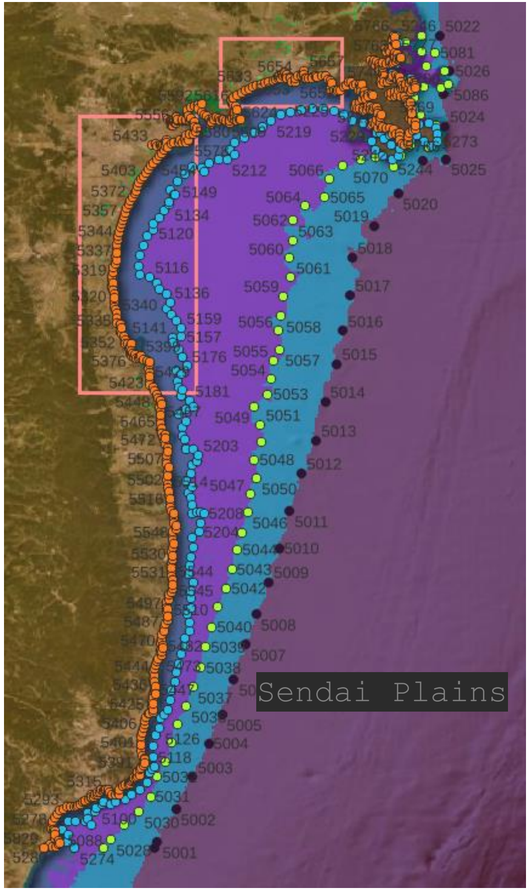
Workflow of probabilistic tsunami risk assessment(EQ sources)

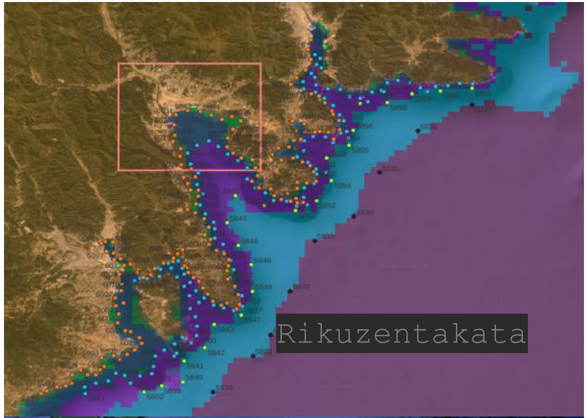


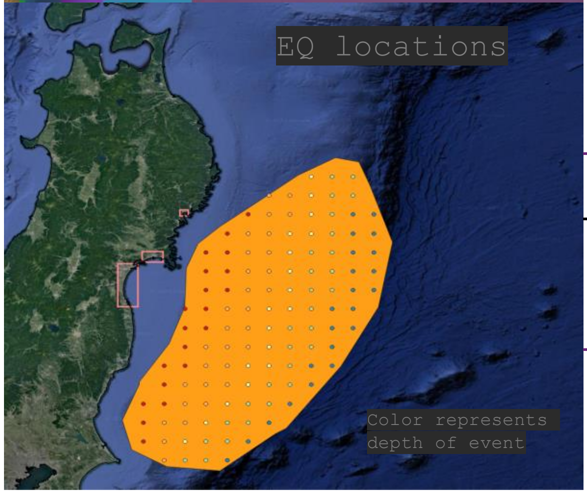
Hazard Module



Propagation/Inundation database





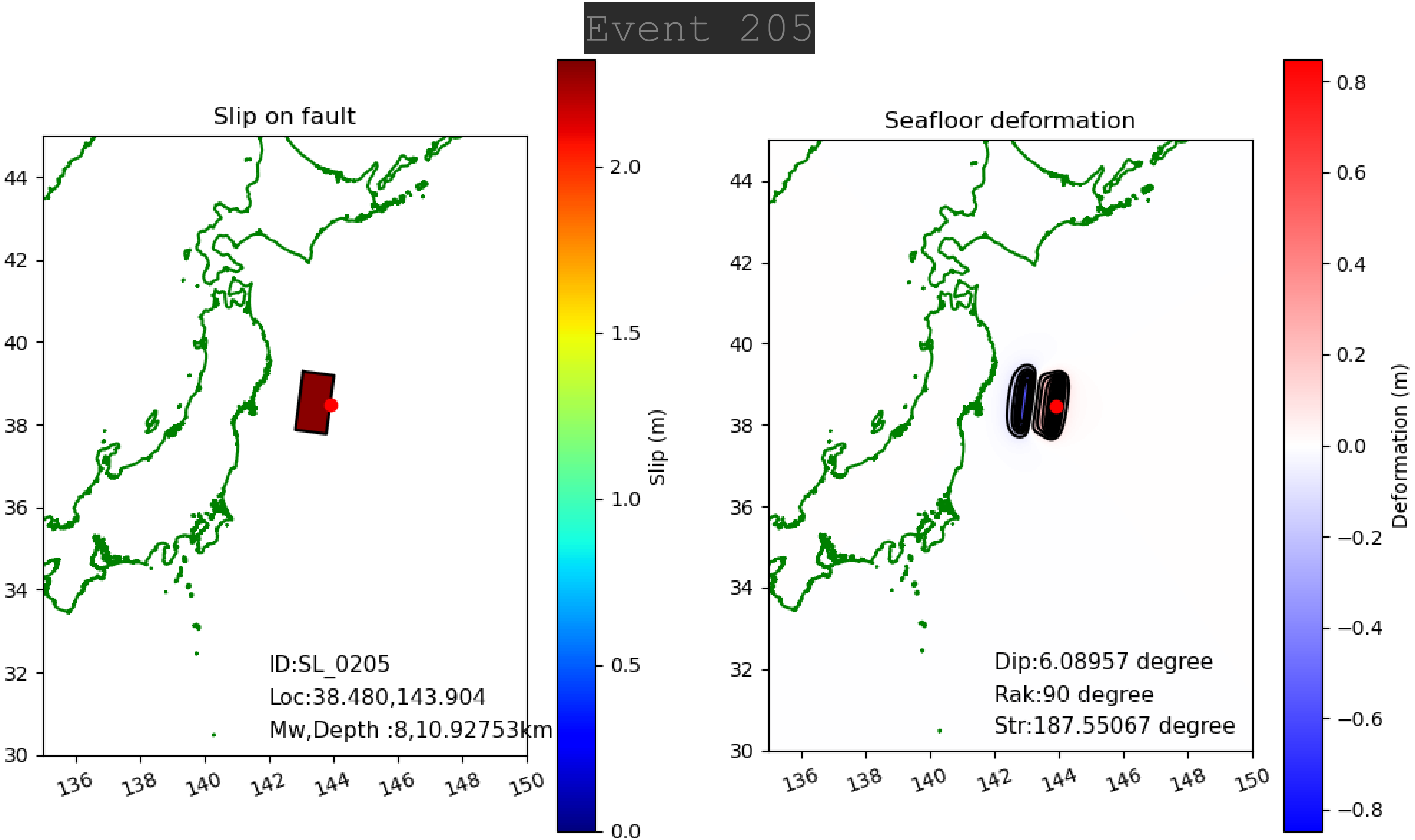


- 1133 locations for observing waveform at different depths (5,25,50 and 100m)
- 3 selected AOI selected to record the max flood depths highlighted by pink rectangles.
- 594 events of varying location and magnitude are simulated for 6 hours of duration
- Homogenous slip events for rectangular fault whose dimensions are scaled based on Mw(7.5, 8, 8.5, 9,9.5)
- Fault parameters(angles) defined using SLAB.2 data and deformation modelled using Okada solution

EQ Source Parameters

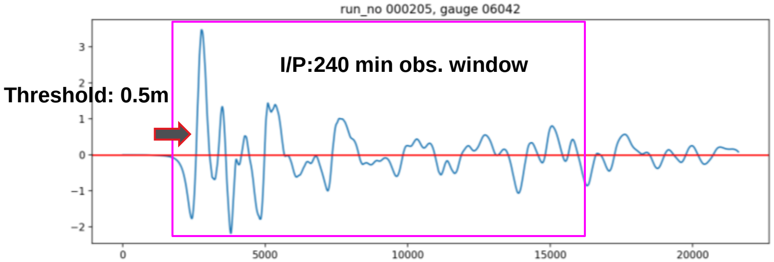
Range	Mw	Lat	Lon	Dep	Rak	Str	Dip
min	7.5	35.73	141.15	10.2	90	187.20	5.54
max	9.5	39.48	143.90	45.7	90	225.78	17.0

Preprocessing – Feature design

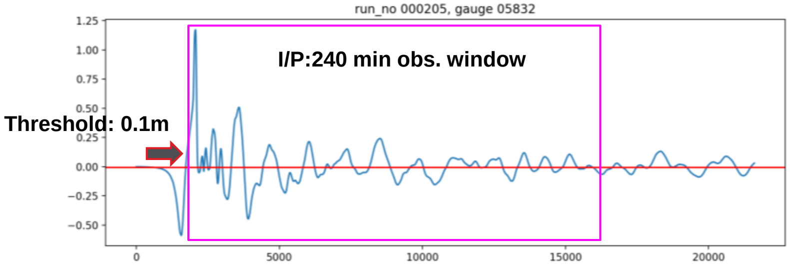


Preprocessing – Feature design

Event 205



Nearshore Gauge

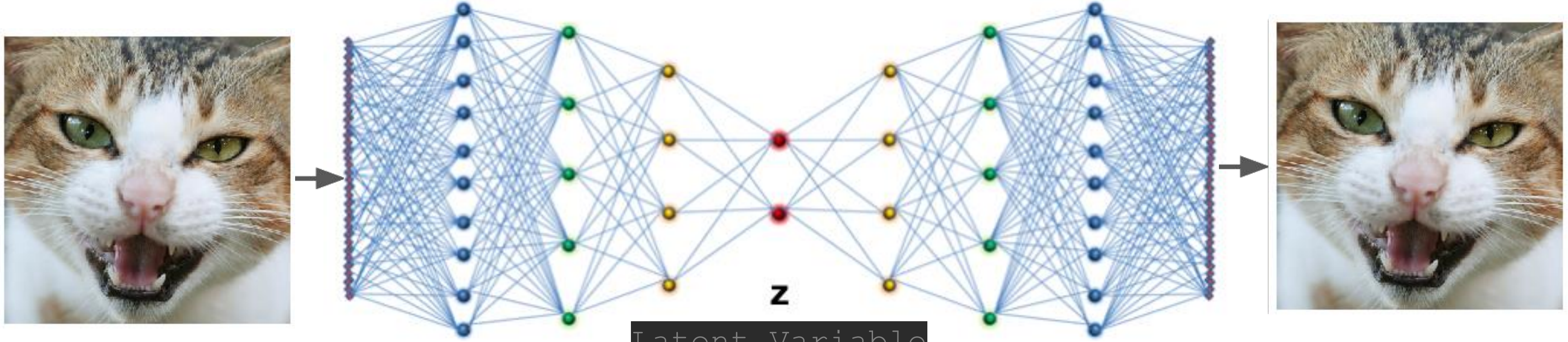


Offshore Gauge

Time to feed a ML model - VAE(variational autoencoder)

Encoder

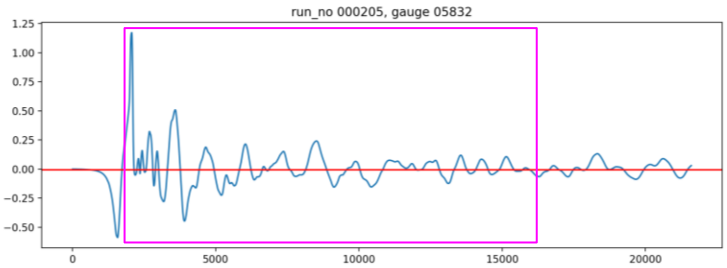
Decoder



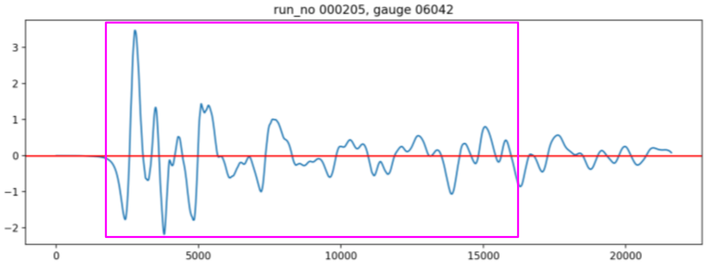
Latent Variable

Offshore Gauge

Nearshore Gauge

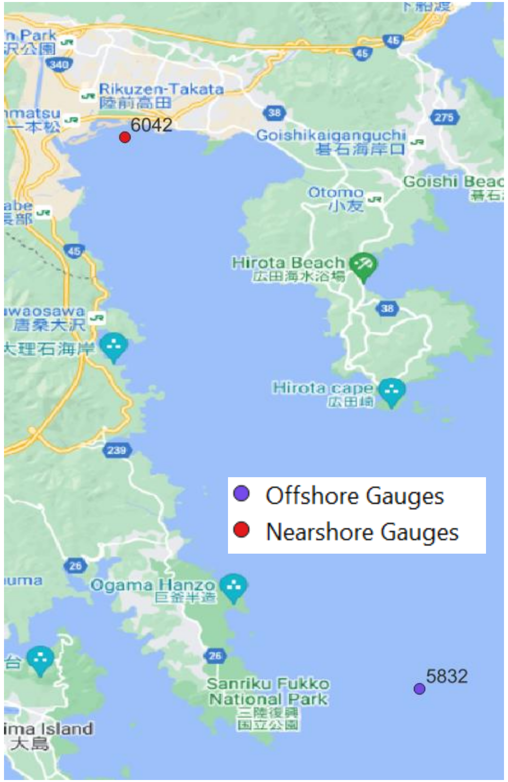


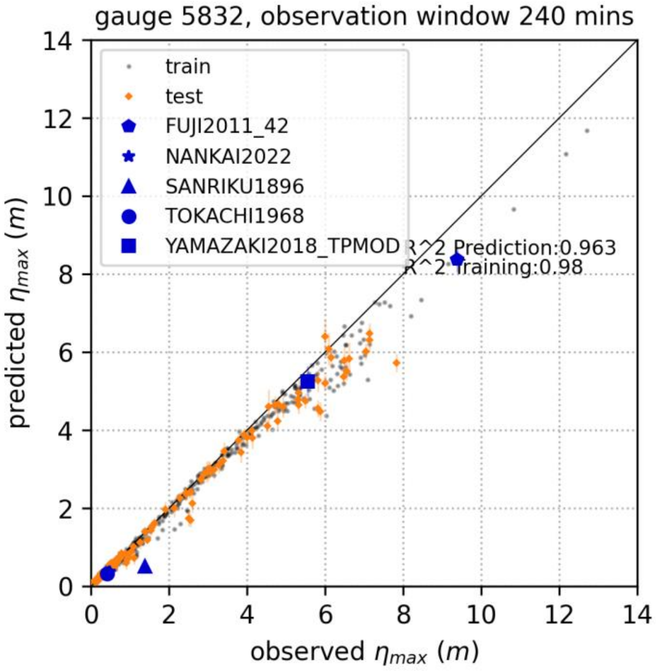
VAE Transformer



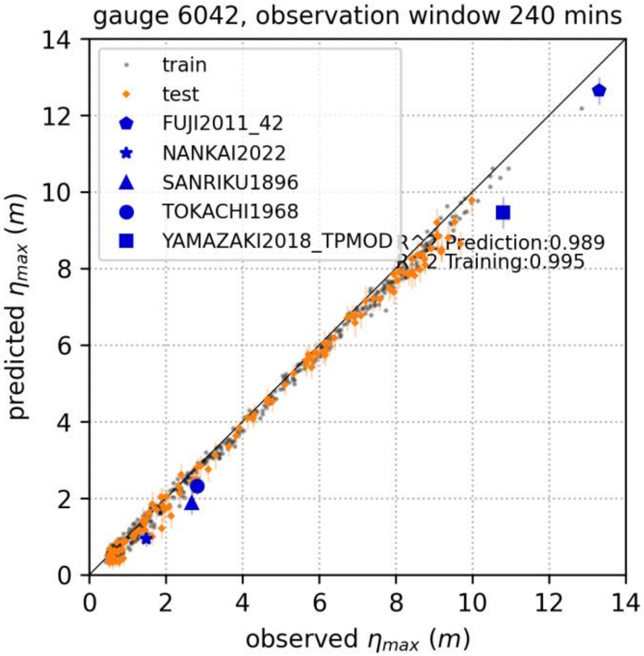
Liu et al 2021

But does it work? Testing at Rikuzentakata



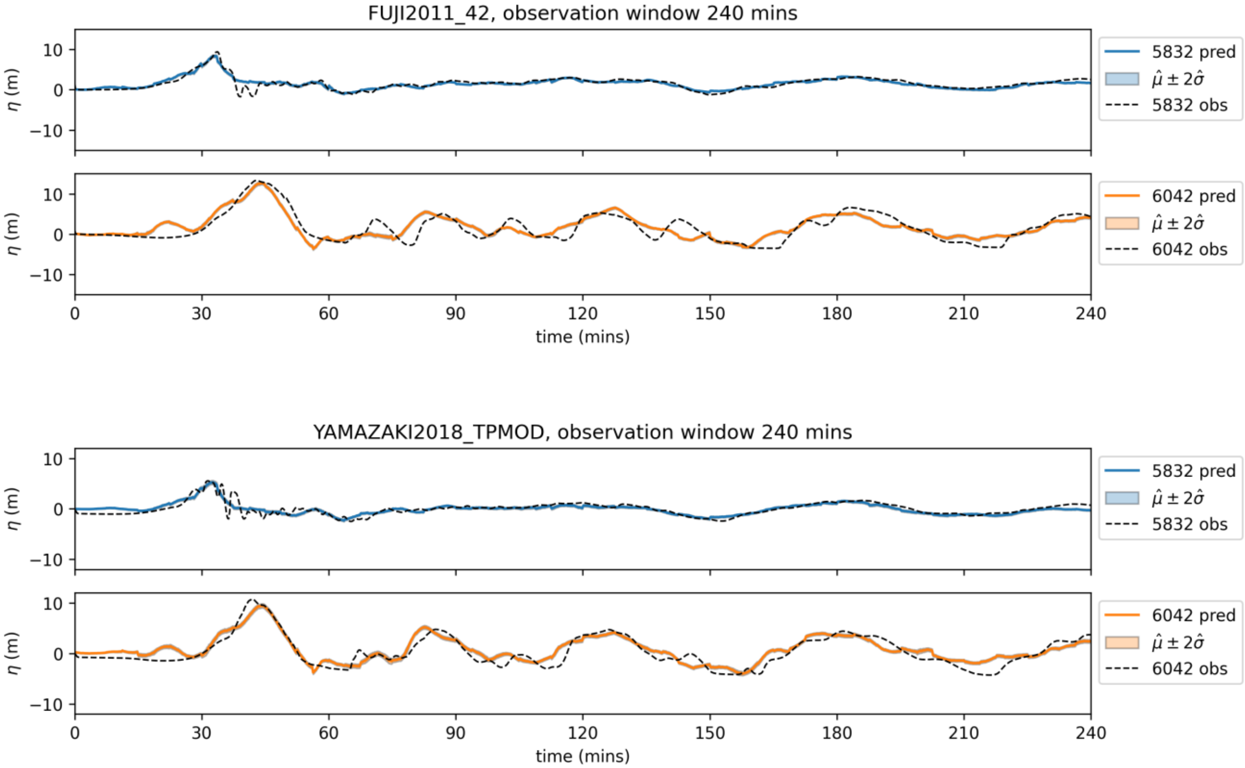


Offshore Gauge

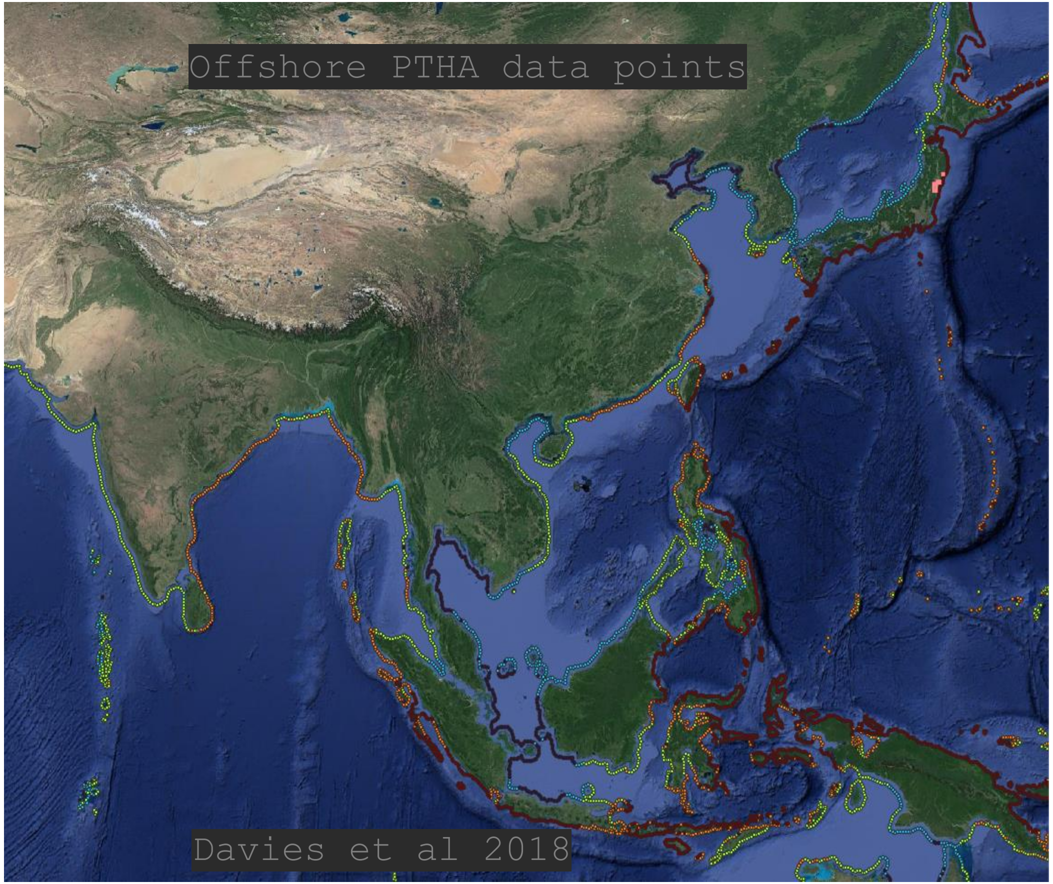


Nearshore Gauge

Tohoku 2011 event

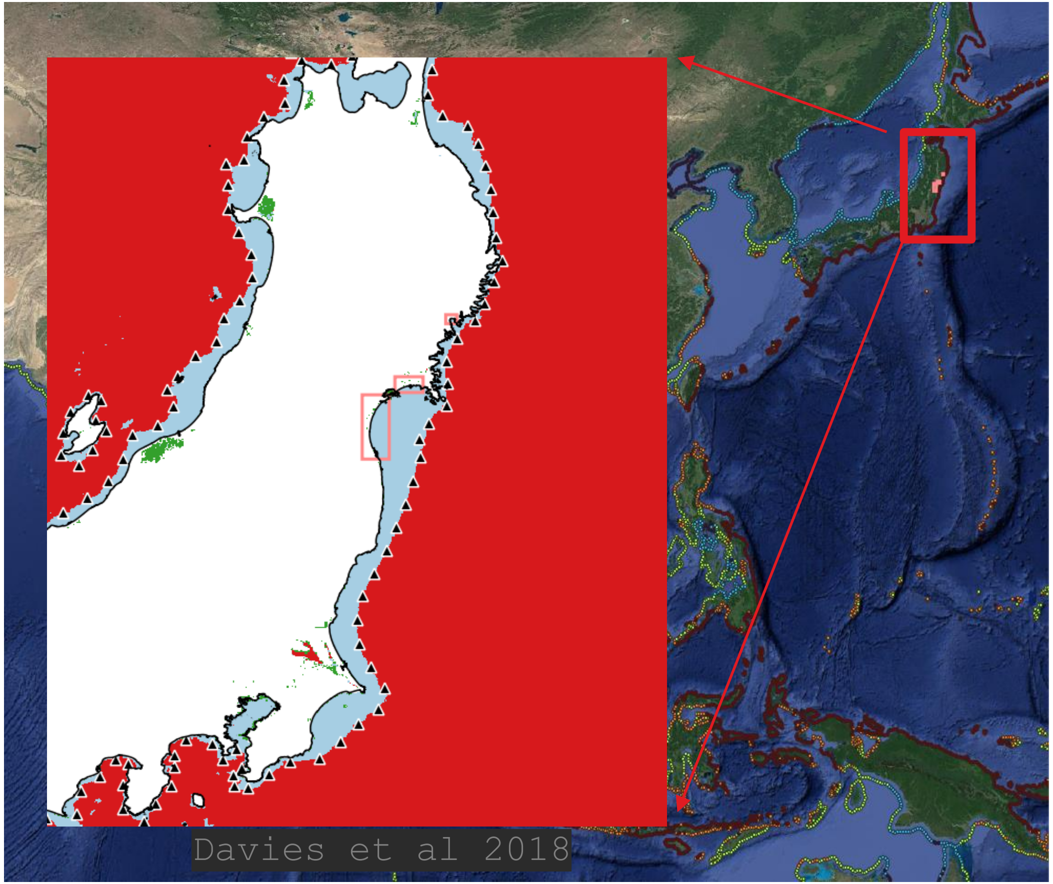


Challenges and Opportunities



- Sparse dataset(balance number of simulation vs accuracy of ML model)
- Fine tuning of ML and transferability – lots of hyperparameters, training configuration, model architecture
- Expand work to multi-input architecture, model inundation footprint directly
- Implement smart feature design and training(clustering, batch etc)
- Probabilistic wave or inundation database can be used as BC
- Link with available PTHA model which provides hazard offshore and convert them to hazard or risk onshore

Challenges and Opportunities



- Sparse dataset(balance number of simulation vs accuracy of ML model)
- Fine tuning of ML and transferability – lots of hyperparameters, training configuration, model architecture
- Expand work to multi-input architecture, model inundation footprint directly
- Implement smart feature design and training(clustering, batch learning)
- Probabilistic wave or inundation database can be used as BC
- Link with available PTHA model which provides hazard offshore and convert them to hazard or risk onshore

Thank you for your attention!

naveenraguramalingam@iusspavia.it

naveenragur.github.io

This presentation participates in OSPP

EGU

Outstanding Student & PhD candidate Presentation contest