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EGU 2022

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Towards the characterization of slow slip deformation by means of deep learning

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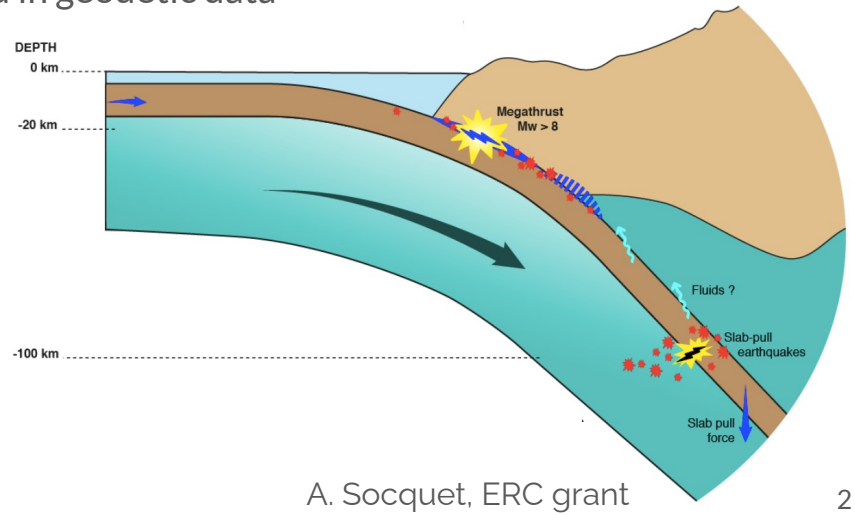
Introduction: motivation and interest of the work

Slow deformation ⟷ seismic rupture ?

Detection of small SSEs ⟶ understanding of the mechanics of active faults

Direct observation of slow slip ⟶ detection threshold in geodetic data

- more accurate equipment
- novel methods for systematic identification

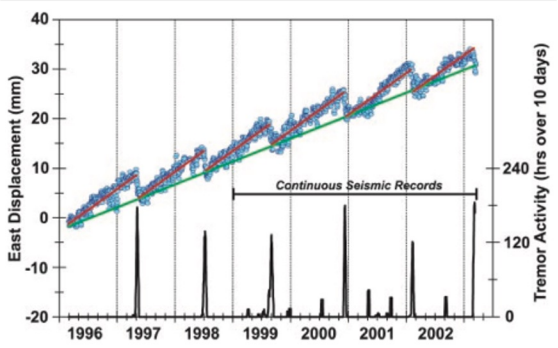


A. Socquet, ERC grant

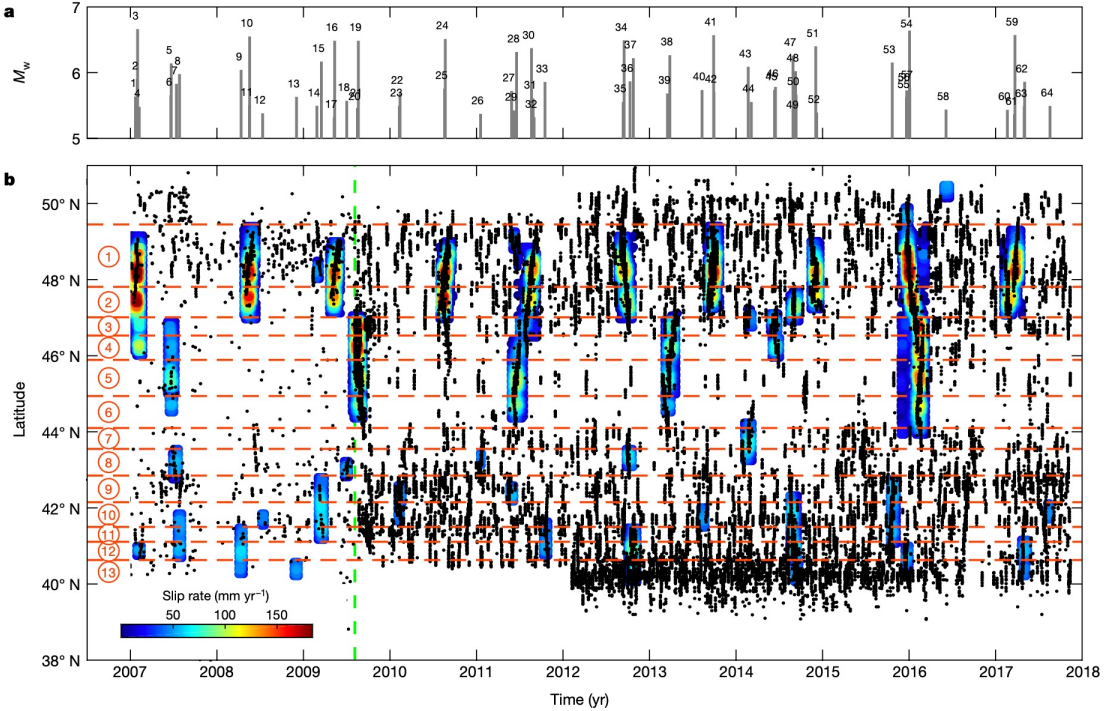
Introduction: motivation and interest of the work

Cascadia subduction zone

- Why is it a good target?



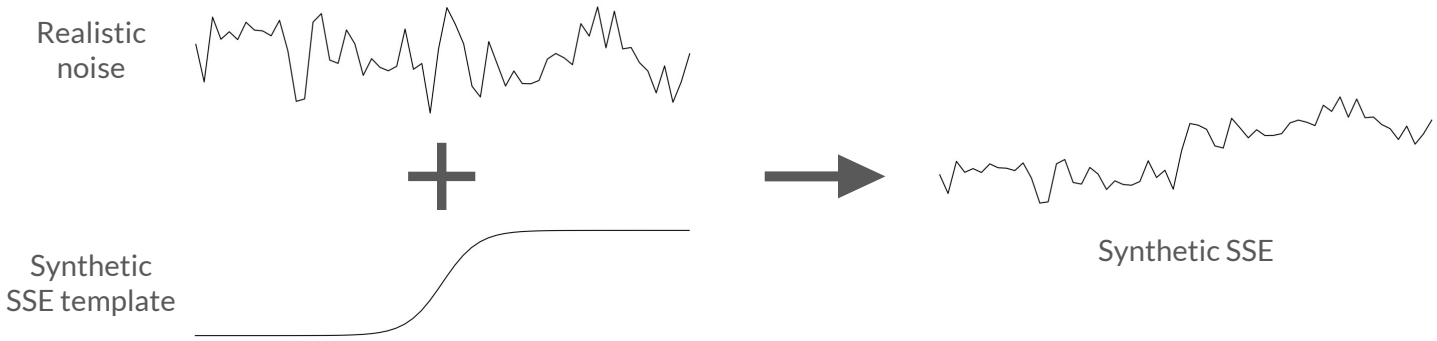
Rogers and Dragert, 2003

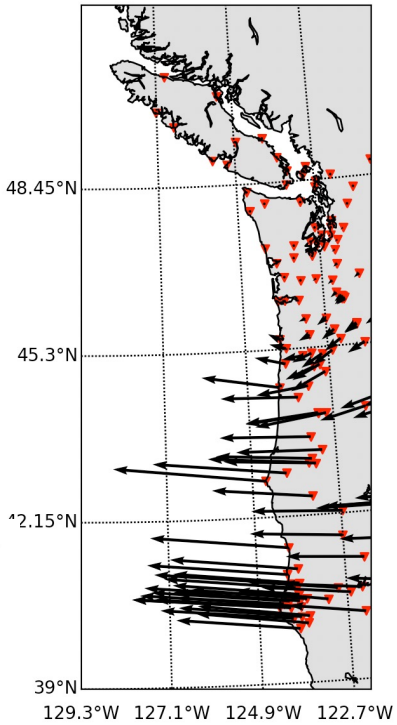


Michel et al., 2019

Data

- GNSS data from Nevada Geodetic Laboratory (NGL)
- Synthetic SSE signal → dislocation model (Okada, 1985) on the slab (slab2)
- Magnitude $M_w \sim \mathcal{U}(5.5, 7)$, depth $d \sim \mathcal{U}(4.5, 60)$ km

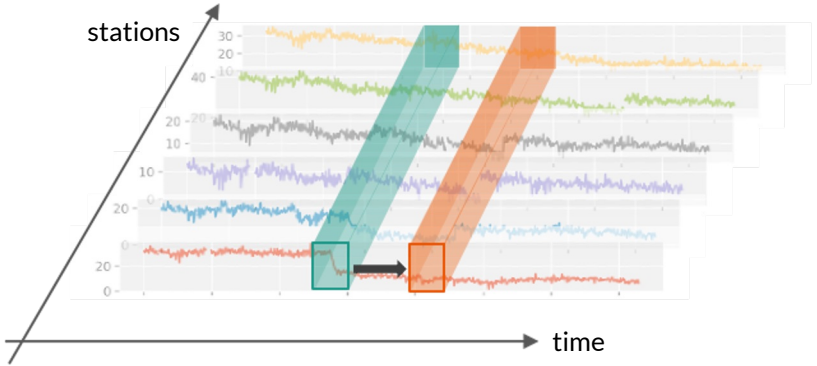




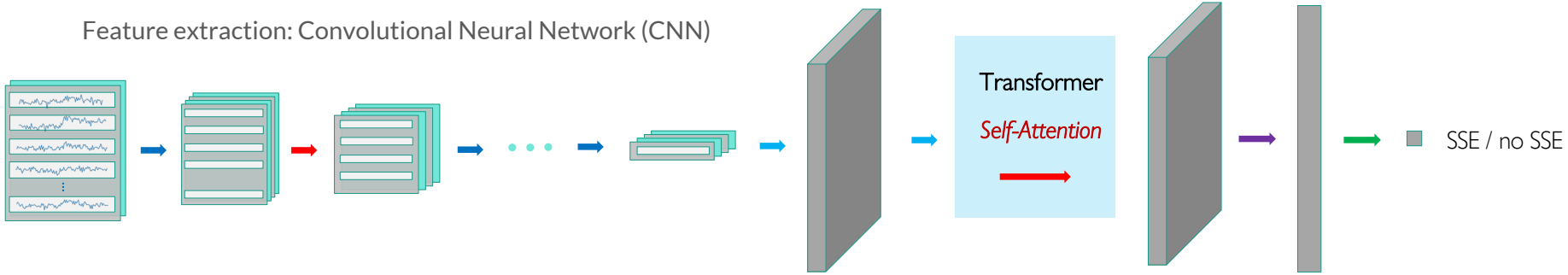
Example of synthetic dislocation

Deep learning method

- *Sliding window* approach
- Deep learning detector



Feature extraction: Convolutional Neural Network (CNN)

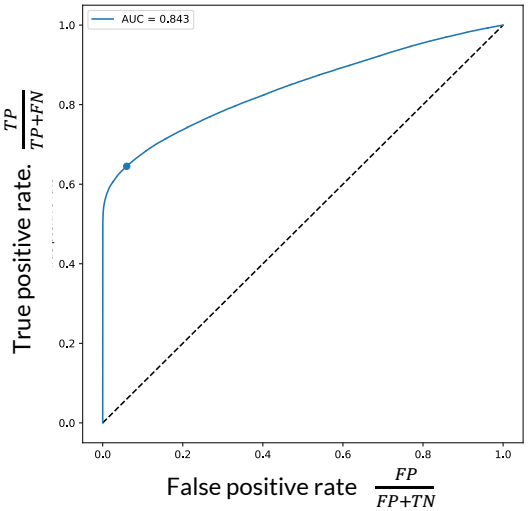


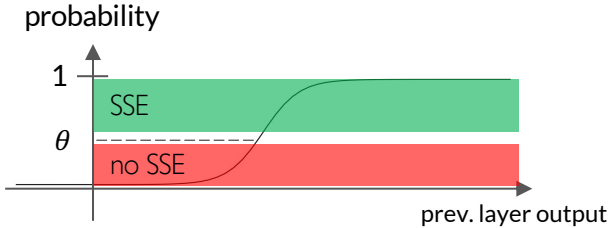
Data set (100K samples):

- 50% 'positive' cases [noise + SSE signal]
- 50% 'negative' cases [noise]

Results on synthetics

Receiver operating characteristic (ROC) curve

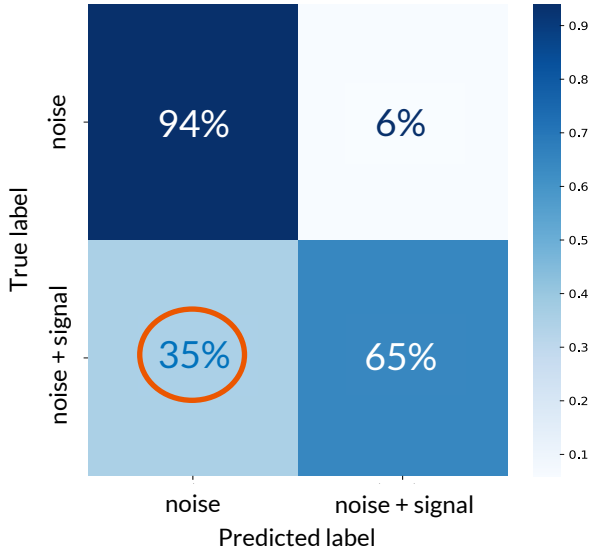




Detector output → can be interpreted as a probability

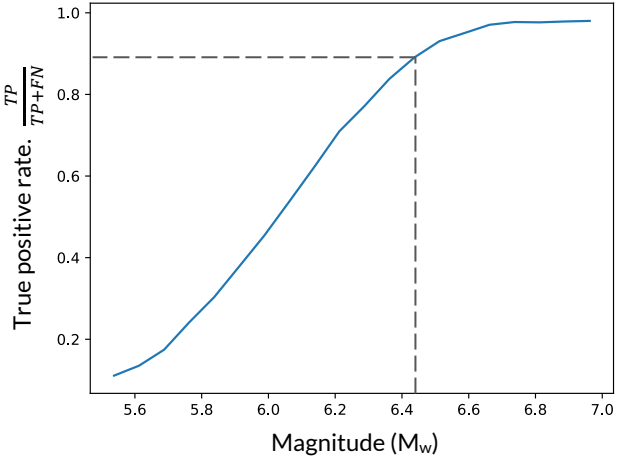
Detection → threshold θ on the probability → discretization

Confusion matrix (0.5 threshold)

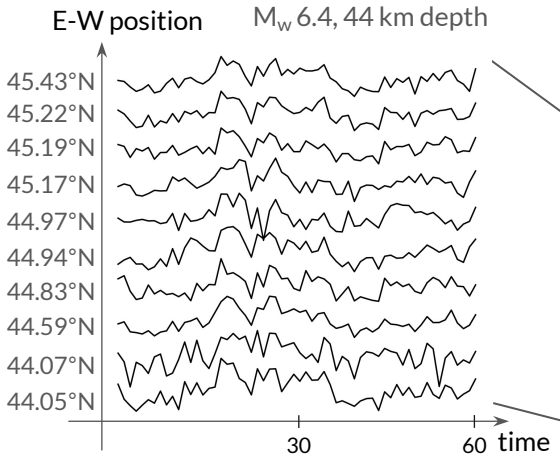


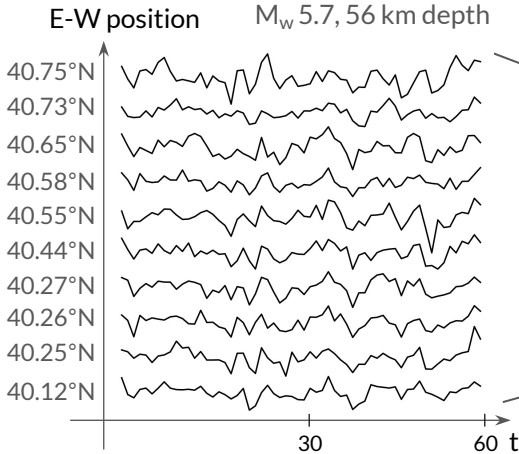
False negatives: information about the detection power

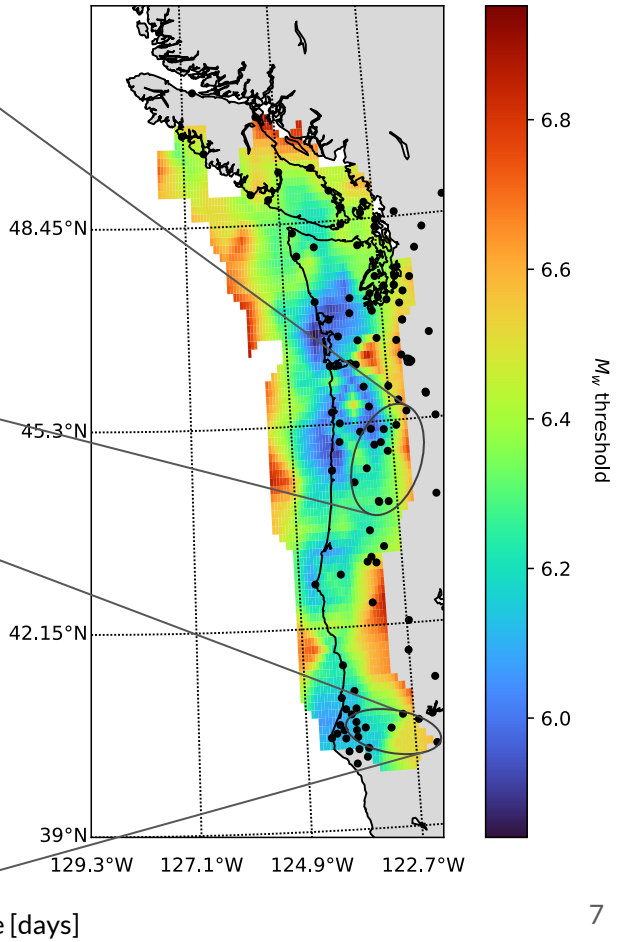
Sensitivity study



- Thrustful detections → 90% confidence
- Tradeoff between signal-to-noise ratio (SNR) and depth







Conclusions and perspectives

- Deep learning-based detector → promising results
- Detection ability depends on the location and the density of the GNSS network at first order

- Lowering the magnitude threshold → SNR limit?
- Improve the resemblance between synthetic and real data → test on real data