Distribution of the macroseismic data points from the DBMI15 (Locati et al., 2022) recorded within NITRO as a function of the epicentral distance. Only reports associated with intensities greater than 6 (i.e. damage) and for which an instrumental location is available are reported. The black dashed line represents the national trend. The damaged area is usually limited to 50 km, with the exception of the 1976 Friuli event.

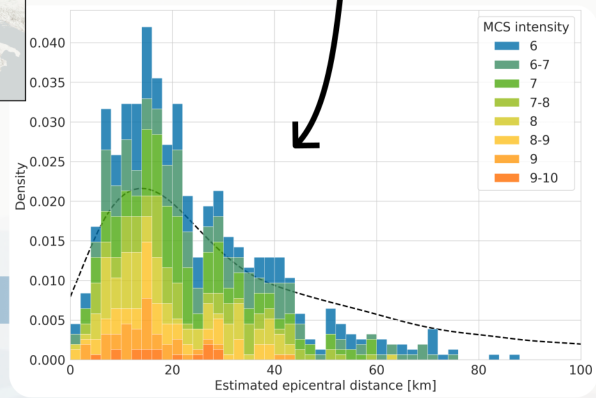
A Feasibility Study of Earthquake Early Warning at the NITRO Near-Fault

Simone Francesco Fornasari*, Giovanni Costa
University of Trieste, Department of Mathematics, Informatics, and Geosciences
*Corresponding author: simonefrancesco.fornasari@units.it

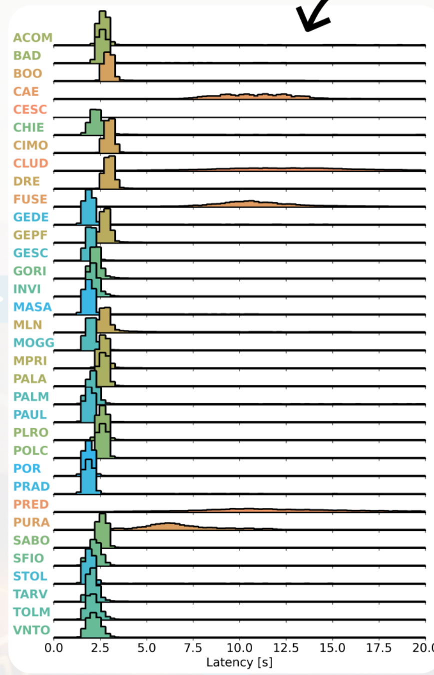
UNIVERSITÀ DEGLI STUDI DI TRIESTE

The Northeastern Italy Thrust Faults Observatory (NITRO) is a near-fault observatory (NFO), managed by the National Institute of Oceanography and Applied Geophysics and the University of Trieste, focused on multidisciplinary studies of the mechanisms governing seismicity and deformation along the Alpine thrust fault system that originated the 1976 M 6.4 Friuli earthquake.

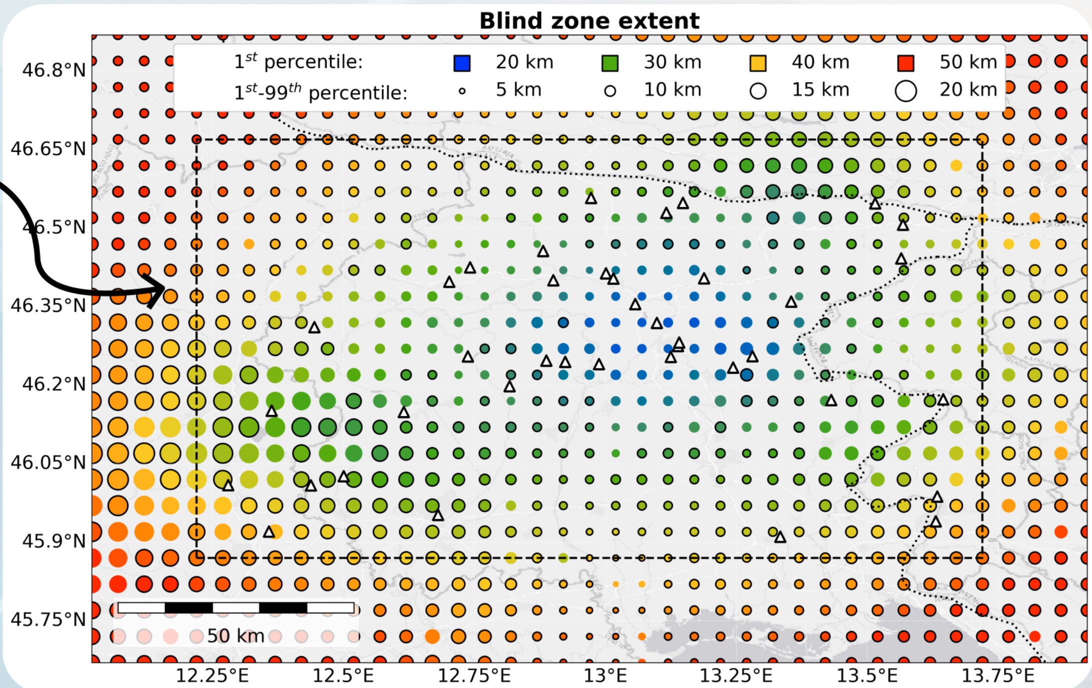
The effectiveness of earthquake early warning systems (EEWS) depends on multiple factors. This study evaluates the feasibility of EEWS at the Northeastern Italy Thrust Faults Observatory (NITRO). The assessment is based on extensive numerical simulations using the network-based algorithm PRESTo (Satriano et al., 2011) and complemented by offline replays of recorded events. System performance is quantified in terms of alert timeliness and blind zone extent under multiple configuration scenarios.



Distribution of the data transmission latency for the stations in NITRO's virtual network monitored for 6+ months.



Results of the numerical simulations in terms of extent of the blind zone. The color represents the 1st percentile (considered as the optimal condition) for an event at the specific epicentre. The size is proportional to the variation between 1st and 99th percentile (assumed as the worst case scenario).
A black outline shows the locations for which only synthetic events have been considered.
The white triangle represent the stations in NITRO's virtual network.

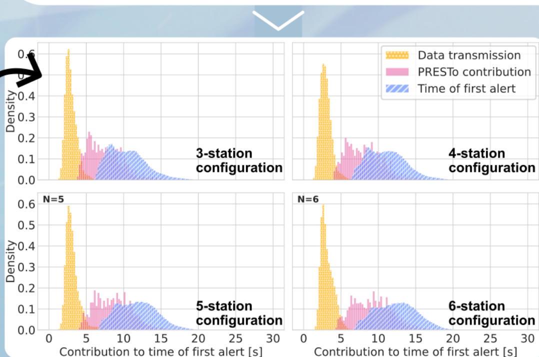


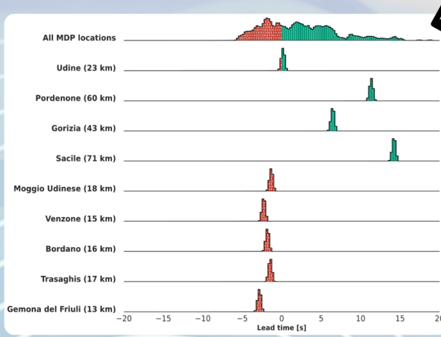
Each simulation considers one seismic source location (either from the focal mechanism catalog by Sugan et al., 2024 or using a synthetic source at the median depth for the region, i.e. 10km). All combinations are considered and the results are aggregated for 5km by 5km cells. The theoretical arrival times of the P- and S-waves are computed considering the velocity model by Imperatori et al. (2015).

Numerical simulations assessed the timeliness of alerts at NITRO.
Inputs incorporated six months of recorded station-specific transmission latencies and catalogue-based seismic sources (aggregated on a 5x5 km grid).
Theoretical arrival times were computed using a 1D velocity model with 0.2 s Gaussian noise added to simulate picking uncertainty.
Total alert time integrated theoretical arrivals, a 2 s magnitude estimation window, and a 1 s telemetry delay.
System performance was quantified across multiple configurations (3–6 stations) to assess lead times and the extent of blind zones.

The numerical simulations have been repeated considering the 1976 Friuli earthquake and assessing the lead time available at specific settlements (here ordered by their population). Only locations further away from the epicentre may have actionable lead times.

Contribution to the time of first alert for different configurations of PRESTo.
PRESTo contribution is assessed considering only the time needed to acquire the required data (i.e. without any transmission delay). The delay due to the data transmission is considered by comparing the time of first alert with and without transmission latencies.

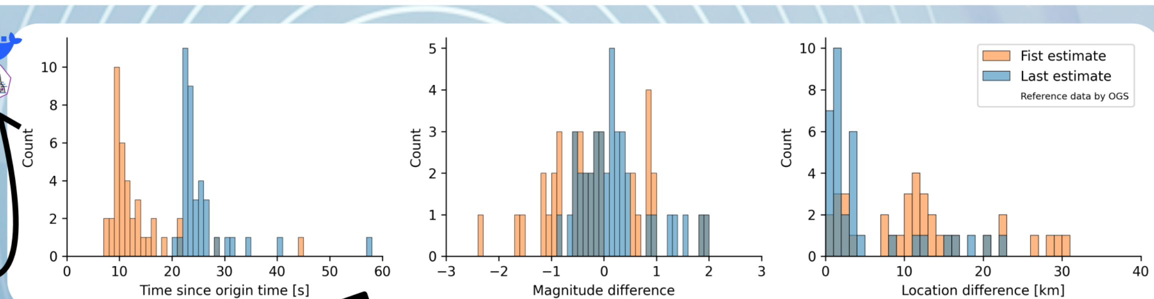




Given the current NITRO network layout, PRESTo alerts would have limited effectiveness.
About 50% of damaged sites are expected to fall within the blind zone in most scenarios.
Development of an alert dissemination infrastructure is required for effective operation.
The most effective way to improve system performance would be to include stations from currently excluded seismic networks already operational in the area.

Real -time testing

A containerized version of PRESTo is currently tested in real-time.
Since the beginning of 2026, it detected 40 events within NITRO and its surrounding area (with 3 false positive).



The software has been containerized to provide an easily reproducible working environment.

The results obtained running PRESTo on real-time data from NITRO are sent via a Telegram channel for testing and later compared to the manual revised location and magnitude by OGS.