

# Rapid Generation of Reports on Post-Seismic Events with gmProcess: A Case Study for A Dense Accelerometric Network In Veneto (NE Italy)

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## THE PROJECT

A project funded by the Regione del Veneto under the European program POR FESR 2014-2020 with claim «a safer Region»

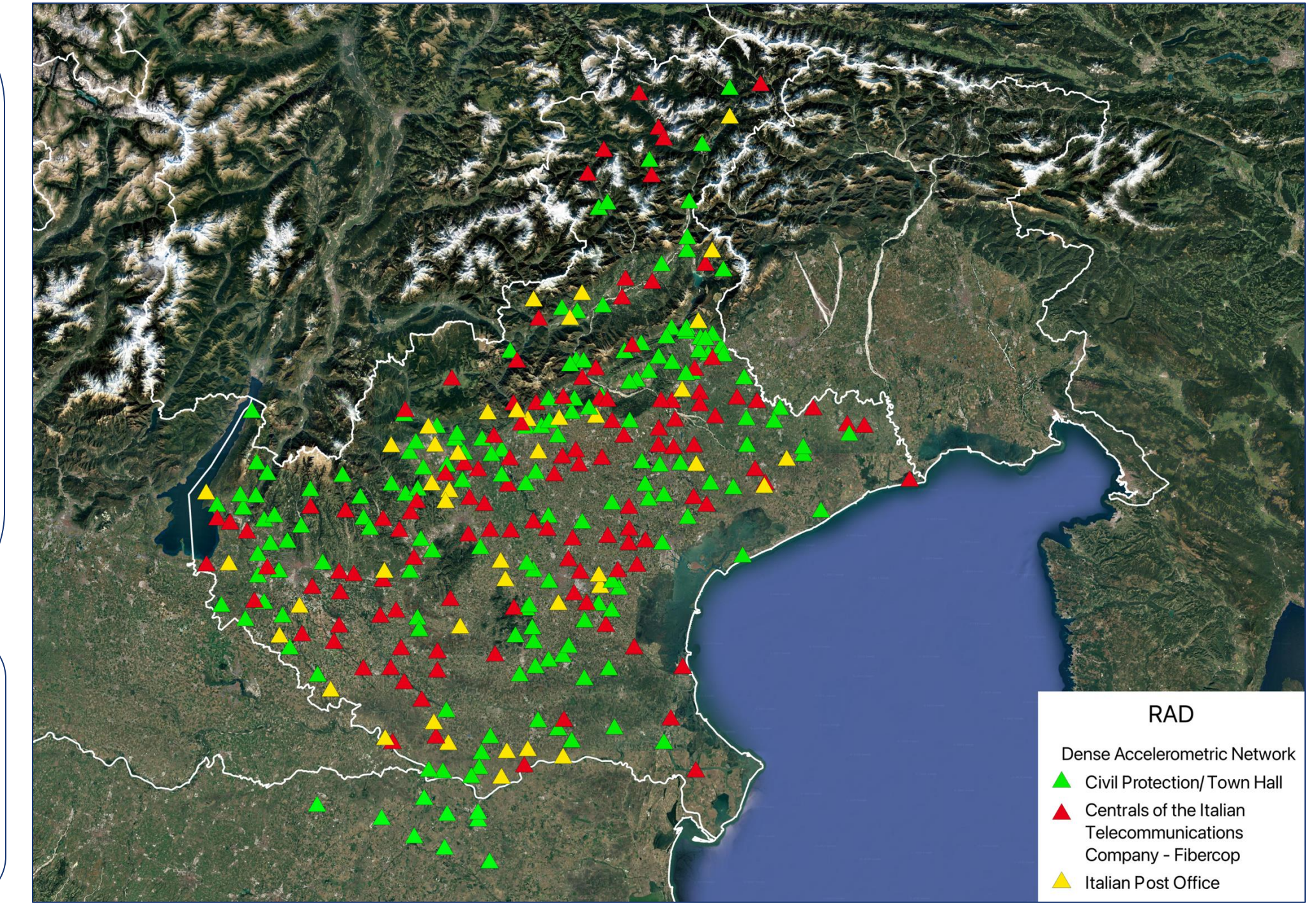
In 2020, the Regione del Veneto entrusted the OGS with the building of a dense accelerometric network of more than 300 stations in order to better support the rapid response to earthquakes with measures of ground shaking and near real-time damage estimates.



## THE Urban ACCELEROMETRIC NETWORK

The accelerometric network (Urban – Urb Accelerometric Network in Veneto), was set up in 2022 (Bragato et al., 2023; 2025). It includes 344 accelerometers at the base of 318 buildings (26 with additional sensors near the top, for characterizing their dynamic response).

- 318 buildings;
- 305 municipalities (54% of Veneto);
- 156 installations at Civil Protection Volunteers (129), municipalities (26), and schools (1);
- 120 installations at the Centrals of the Italian Telecommunications Company (TIM);
- 42 installations at the Italian Post Office;
- in 26 sites, installation of an accelerometer at the top of the building.



## A HIGH-PERFORMANCE, COST EFFECTIVE ACCELEROGRAPH

The accelerometers adopted for the project (ADEL ASX2000) is based on three high-quality MEMS sensors with a full scale of ± 2 g and an actual sensitivity (i.e. outside electronic noise) of about 0.1 mg, useful for recording earthquake over magnitude 2 in the near field. The device has extensive capabilities for local recording as well as transmission over LTE/4G connections.

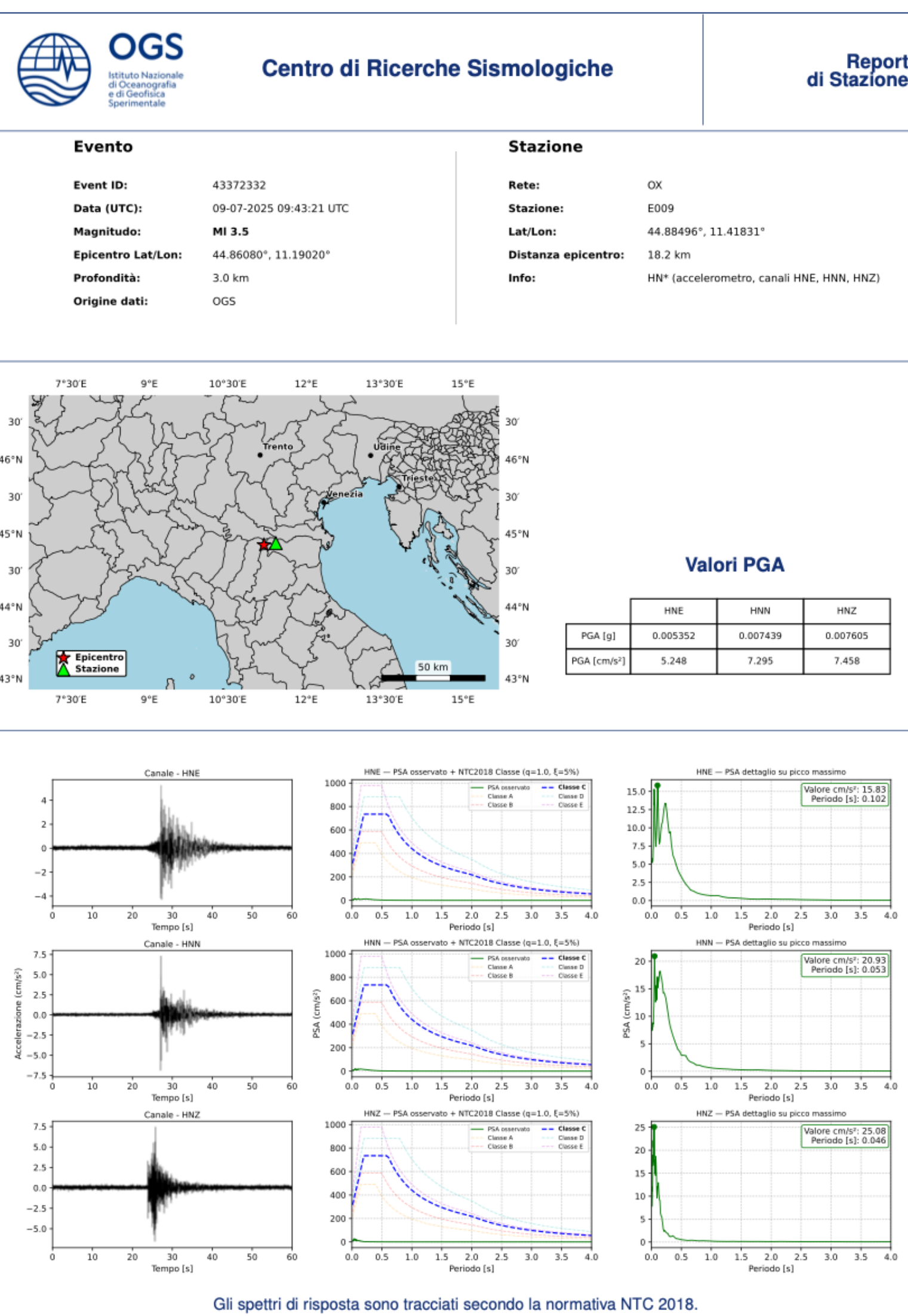
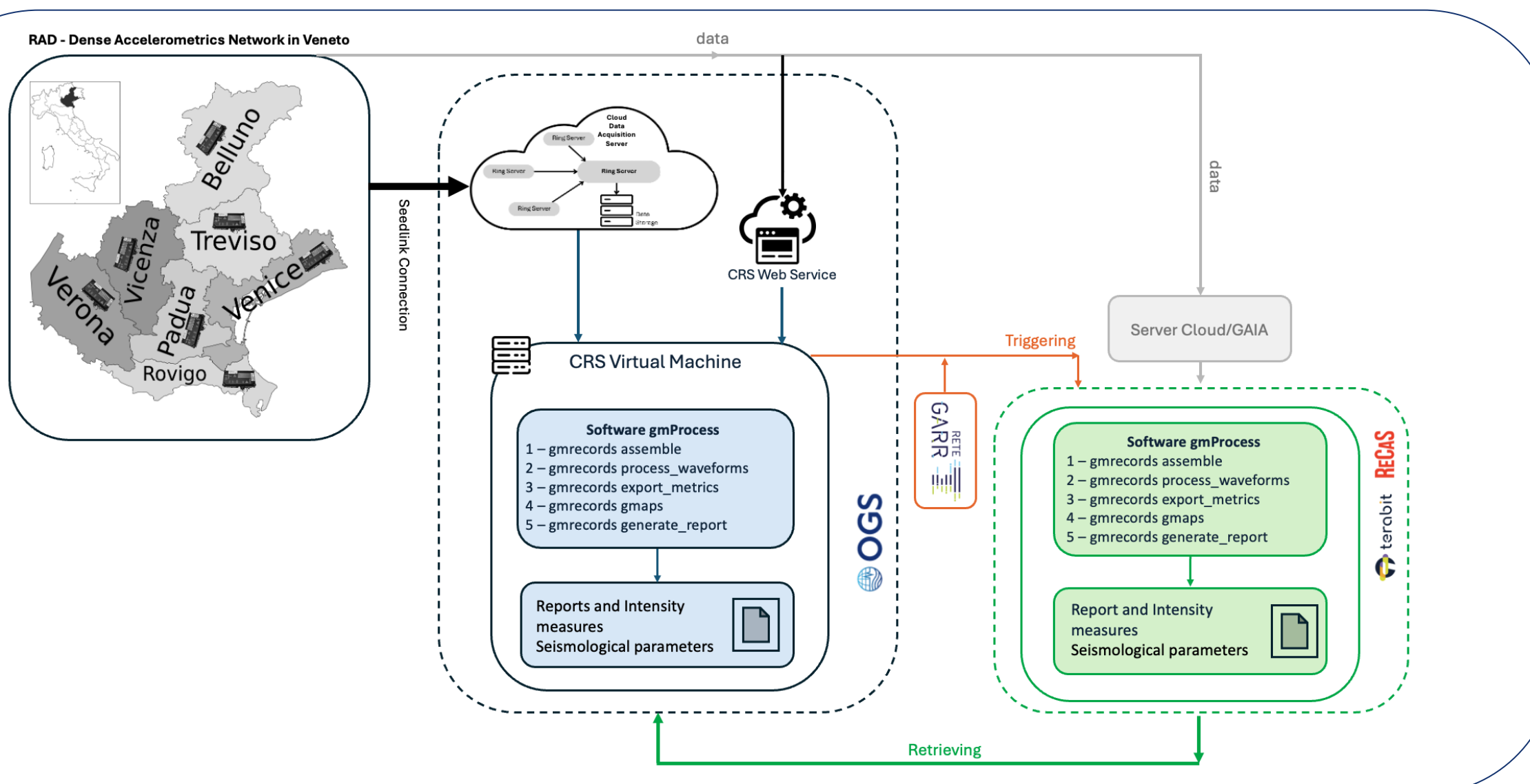
## THE ROLE OF gmProcess IN THE VENETO ACCELEROMETRIC NETWORK (RAD)

The gmProcess (Thomson et al. 2024), an open-source software developed by the United States Geological Survey (USGS), is used within the Veneto accelerometer network for the automatic processing of ground motion data recorded during an earthquake. This tool allows for the analysis of waveforms from accelerometric sensors, converting raw data into useful information. Thanks to the combination of a dense accelerometric network and the gmProcess software, the main objective is to generate a REPORT for each station immediately after a seismic event, determining key parameters such as Peak Ground Acceleration (PGA), shake maps, and other engineering metrics.

The gmprocess codebase, released under the open-source Unlicense, has been extensively adapted to meet the operational needs of the CRS seismic networks, including the Veneto Accelerometric Network (RAD) (Capotosti et al., 2025). Several commands and internal modules have been restructured to integrate seamlessly into the automated workflow for data acquisition and processing.

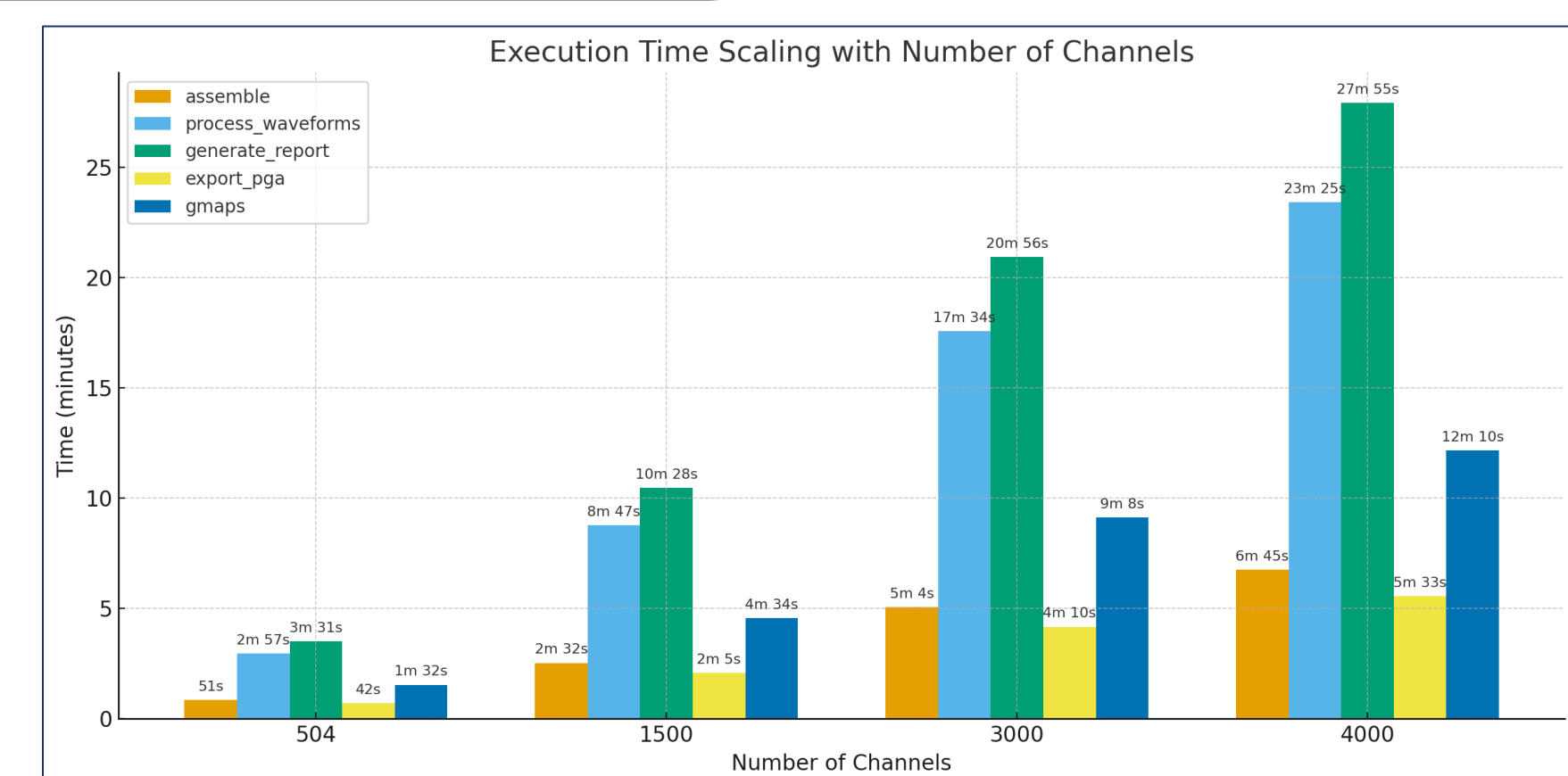
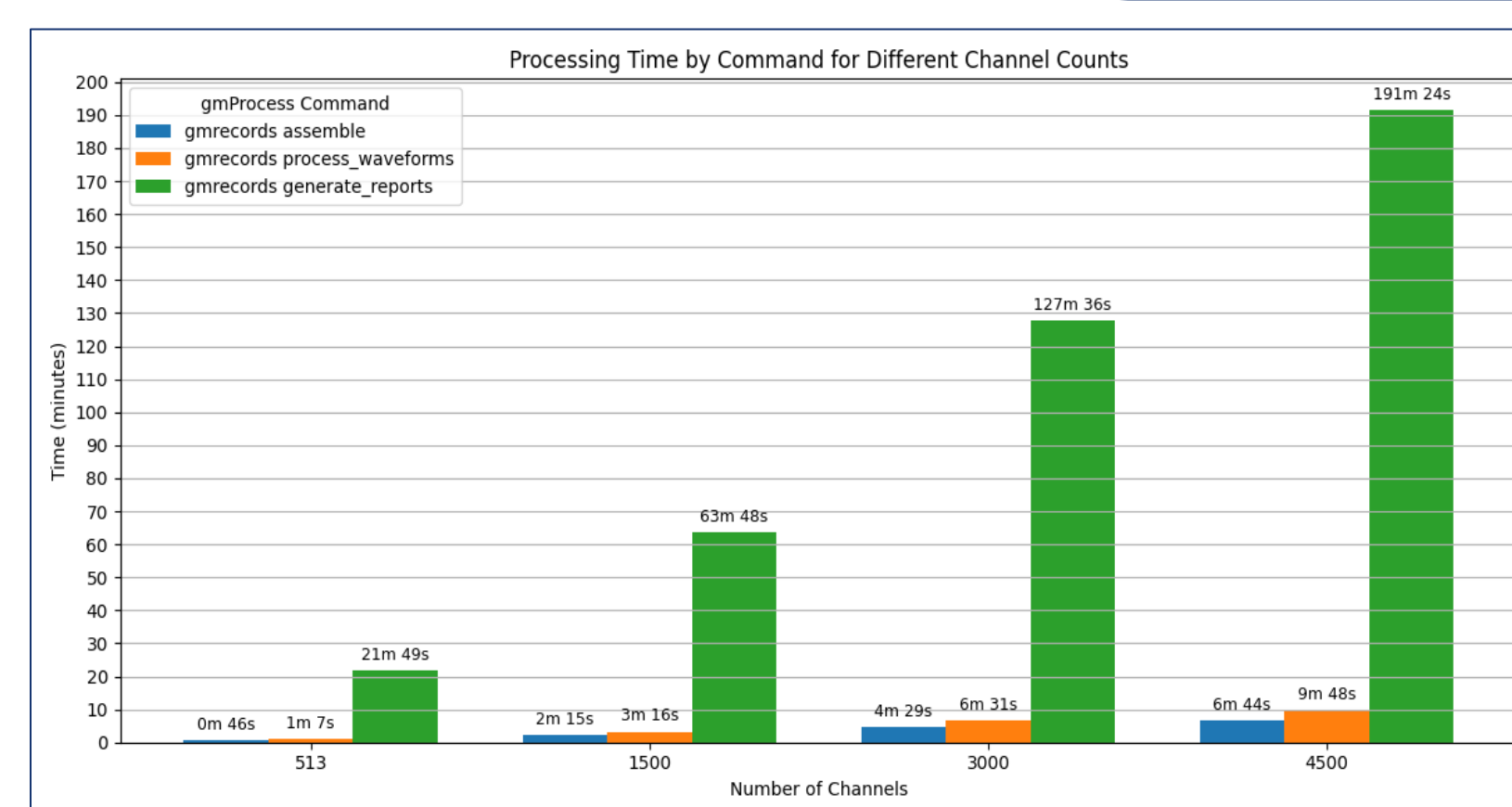
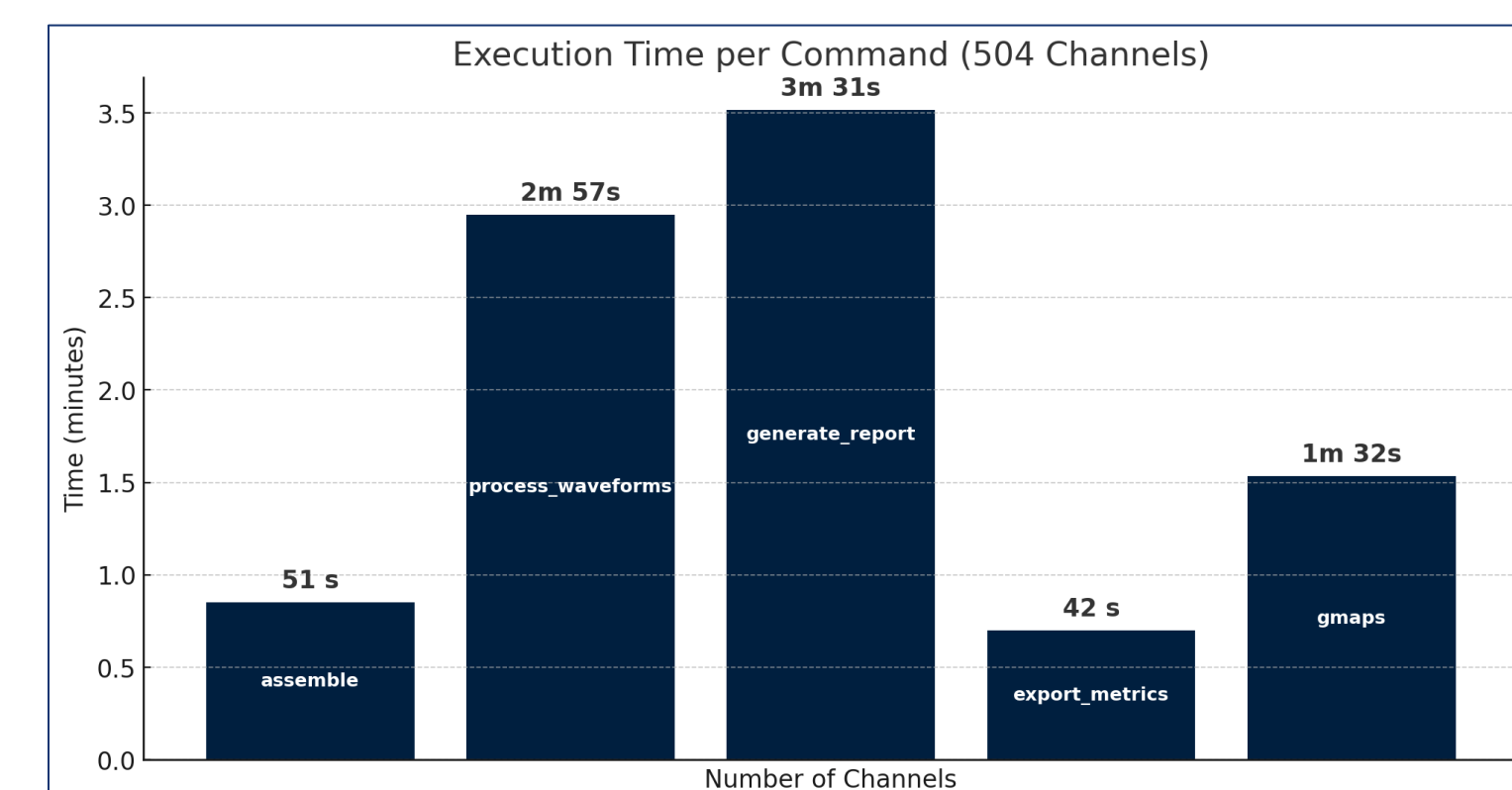
New code blocks have been introduced, and many existing components have been thoroughly refactored. In particular, summary\_plots.py has been rewritten to generate station-specific reports containing waveforms, PSA spectra, and PGA values, using a layout optimised for automated production. A dedicated gmprocess subcommand now produces both station-level and network-wide maps, while the former export\_metrics module has become export\_pga, providing PGA values directly compatible with ShakeMap.

The NTC 2018 seismic code has been incorporated into summary\_plots.py, enabling the computation of design spectra for soil classes A–E and allowing direct comparison between observed and normative spectra. This integration ensures that the generated products are suitable for engineering use as well as operational monitoring.



Several components originally designed for serial execution have been rewritten to support true parallel processing. The parallelized modules dynamically adjust computational load and CPU usage according to the volume of waveform data, ensuring scalable performance, significantly reducing processing times, and improving overall efficiency in both real-time and near-real-time workflows.

Adding new processing steps for full station reports such as maps, PGA tables, and synthetic figures would normally increase computation time. However, extensive code optimization and parallelization of the most demanding modules (process\_waveforms, generate\_report, export\_pga, generate\_gmaps) reduced the total execution time for 504 channels to less than half that of the original serial workflow.



The left-hand plot shows the execution time of the original gmrecords workflow, which included only a few commands (assemble, process\_waveforms, generate\_reports) and operated almost entirely in serial mode. Consequently, processing time increased rapidly with the number of channels, exceeding 190 minutes for 4500 channels and clearly revealing the scalability limits of the initial implementation.

In contrast, the right-hand plot illustrates the performance of the optimised and parallelised workflow. In this upgraded version, the processing has been expanded to include additional subcommands such as export\_pga and generate\_gmaps while enabling true parallel execution of the most computationally demanding modules. Despite the greater number of operations, scaling with channel count is significantly improved: execution times grow much more gradually, and each command remains computationally affordable even at high channel volumes.

## CONCLUSIONS

The large volume of waveforms to process and the need to produce results in near real time make high-performance computing (HPC) infrastructure essential. Integration of the HPC resources provided by TerABIT enables full exploitation of the optimized gmProcess workflow, which includes fully parallelised modules and new subcommands for automatic generation of station maps and summary reports. The automatic per-station reports, now fully operational, are planned for integration across multiple seismic and accelerometric networks and will be provided to Civil Protection as a rapid post-earthquake documentation tool. This approach, combining a dense accelerometric network, an optimized open-source software workflow, and advanced HPC resources, represents an efficient and replicable model for modern seismic monitoring.

## REFERENCES

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