

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»

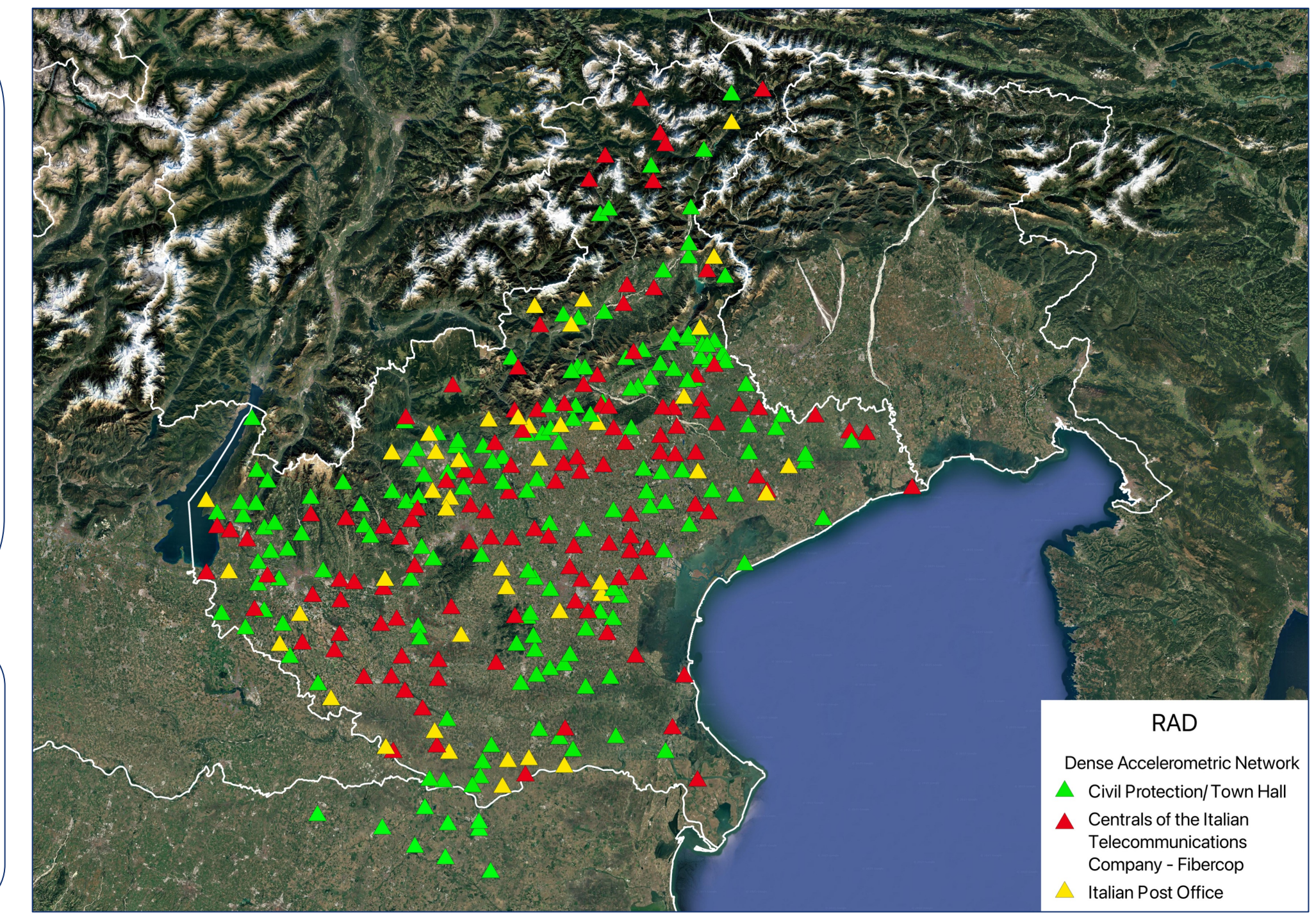


In 2020, the Regione del Veneto entrusted the OGS with the building of a dense accelerometric network of more than 300 stations in order to better support the rapid response to earthquakes with measures of ground shaking and near real-time damage estimates.

THE Urban ACCELEROMETRIC NETWORK

The accelerometric network (**Urban** - **Urban 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.

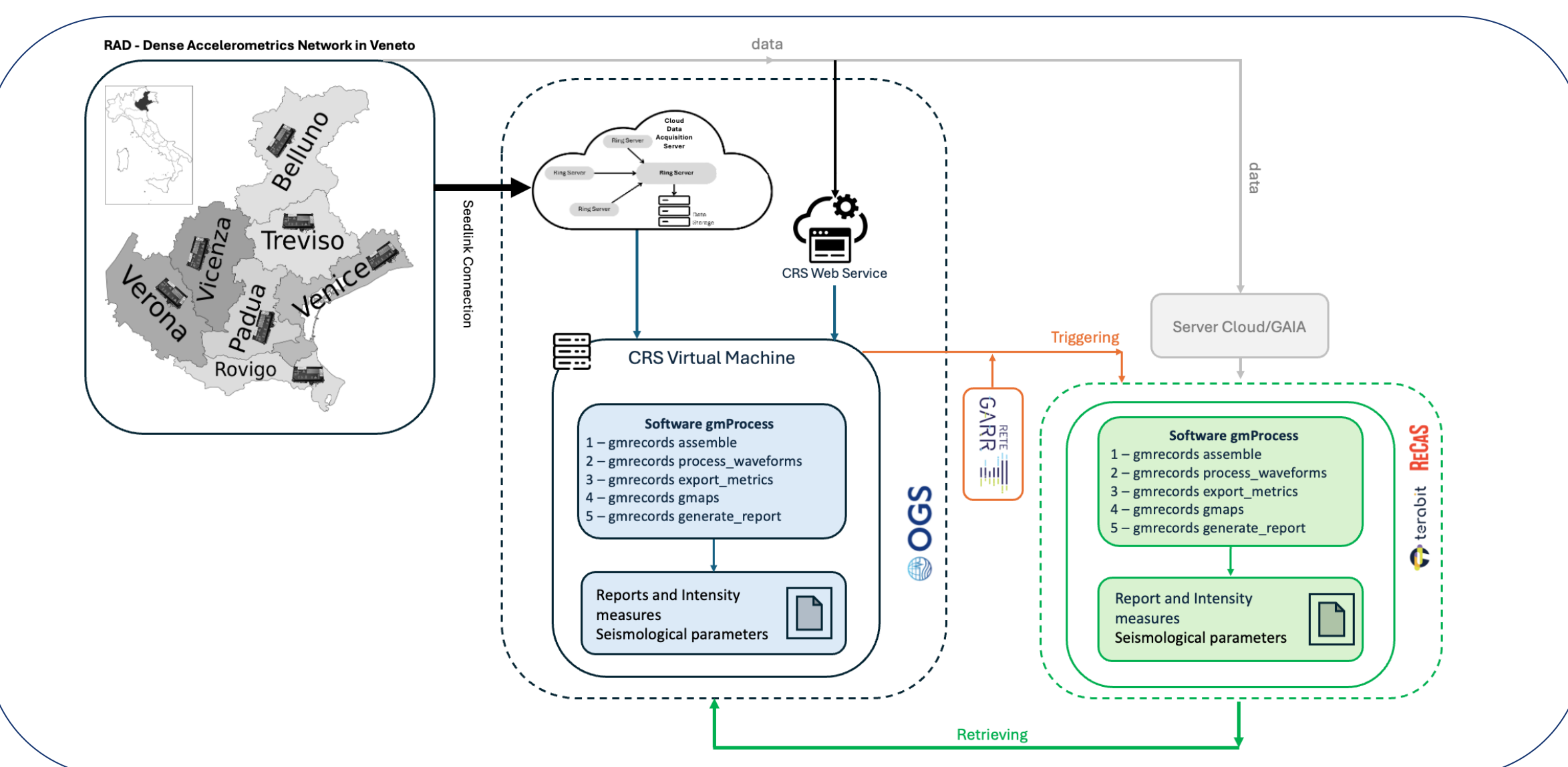


A HIGH-PERFORMANCE, COST EFFECTIVE ACCELEROGRAPH

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)

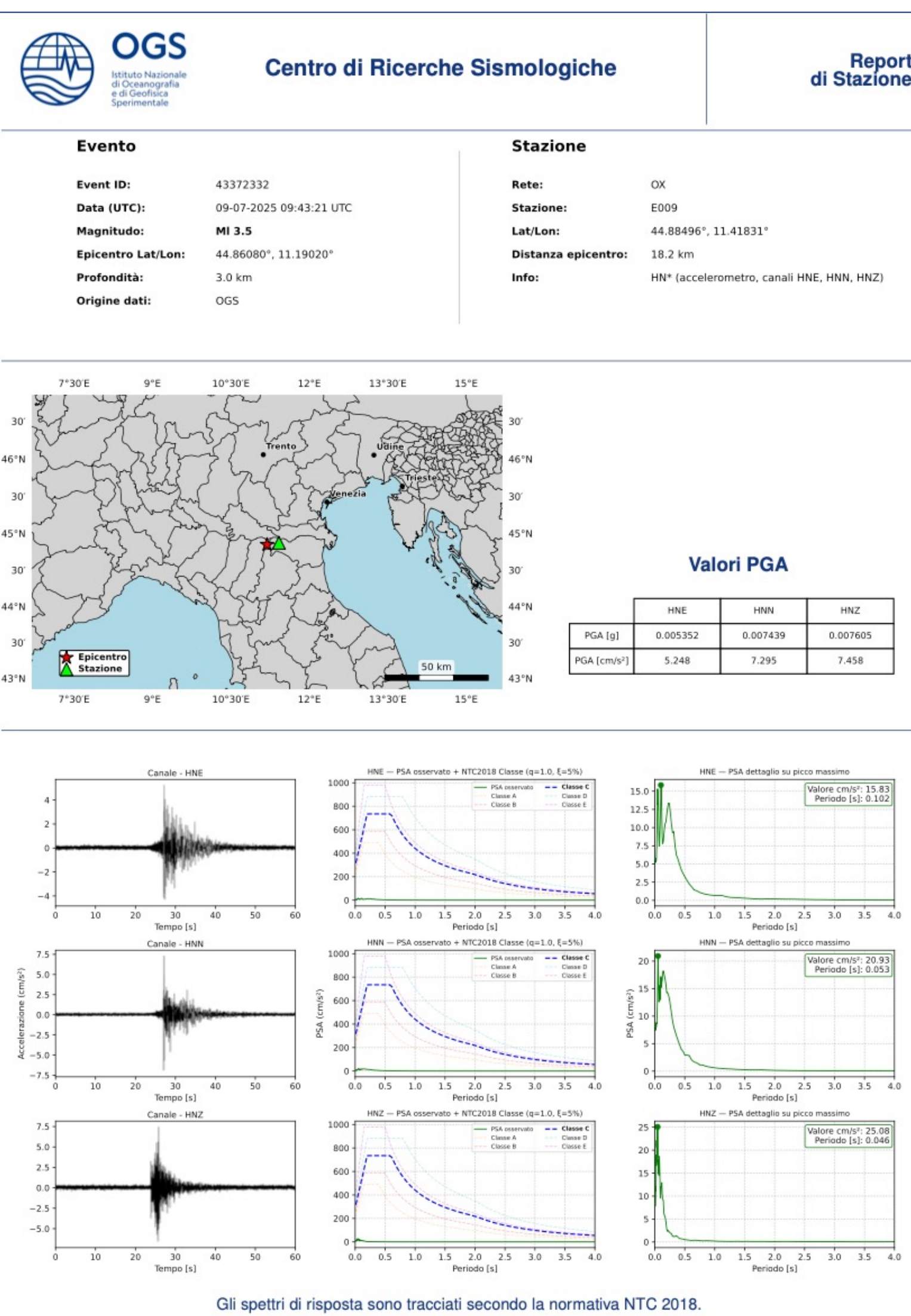
The **gmProcess** (Thomson et al. 2024), an **open-source** software developed by the United States Geological Survey (USGS), is used within the Veneto accelerometer network for the **automatic processing** of ground motion data recorded during an earthquake. This tool allows for the analysis of waveforms 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.

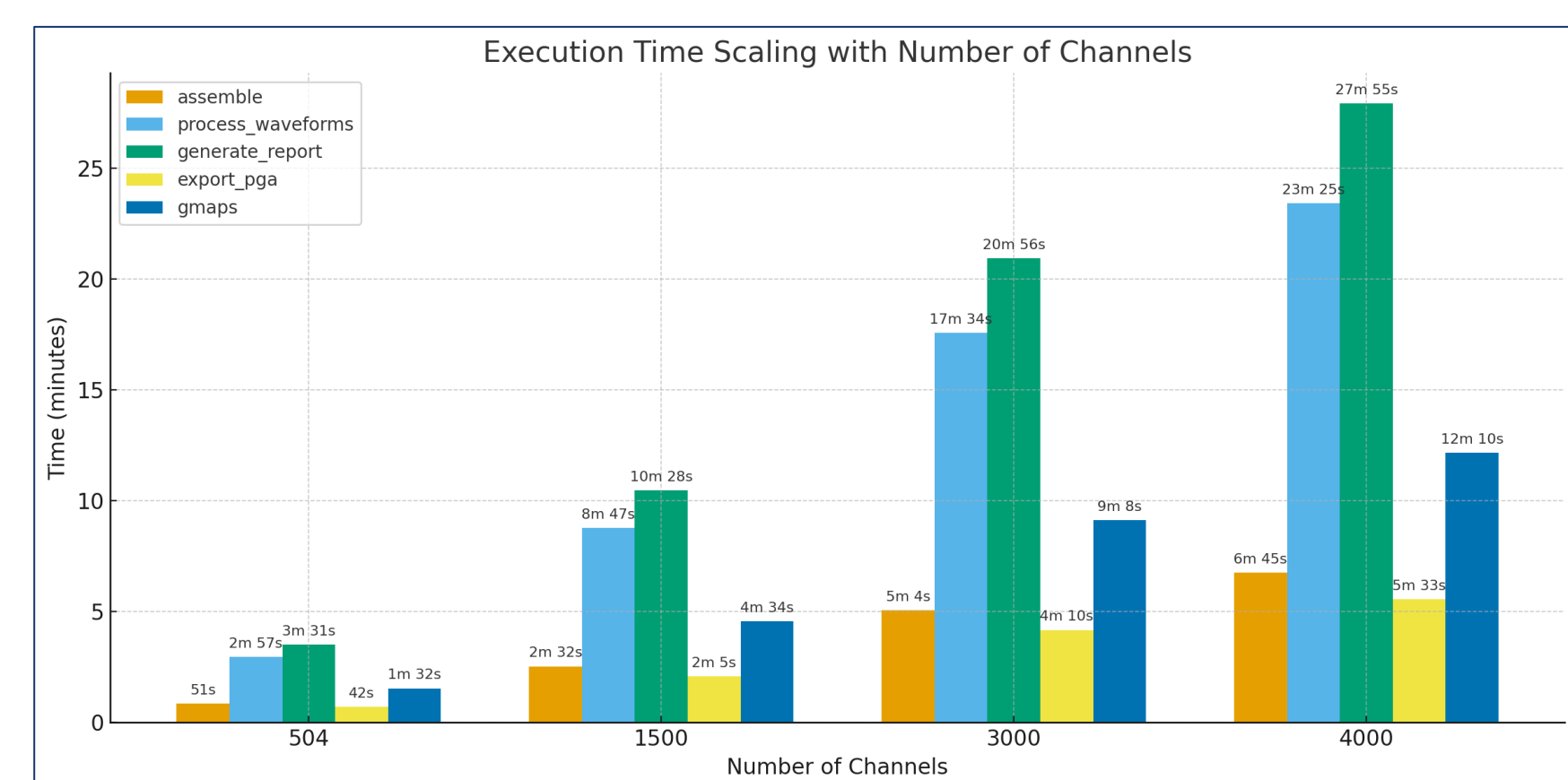
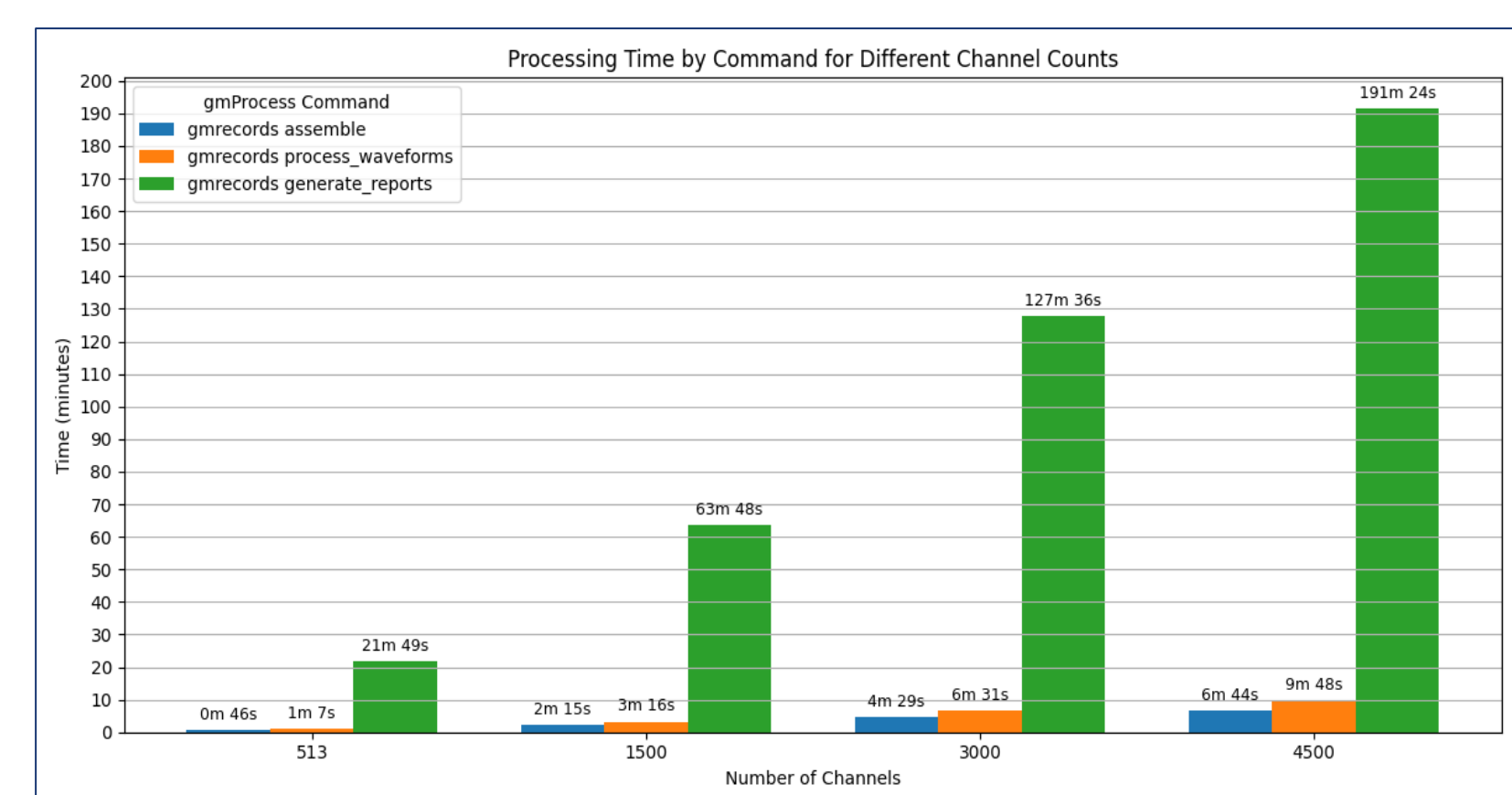
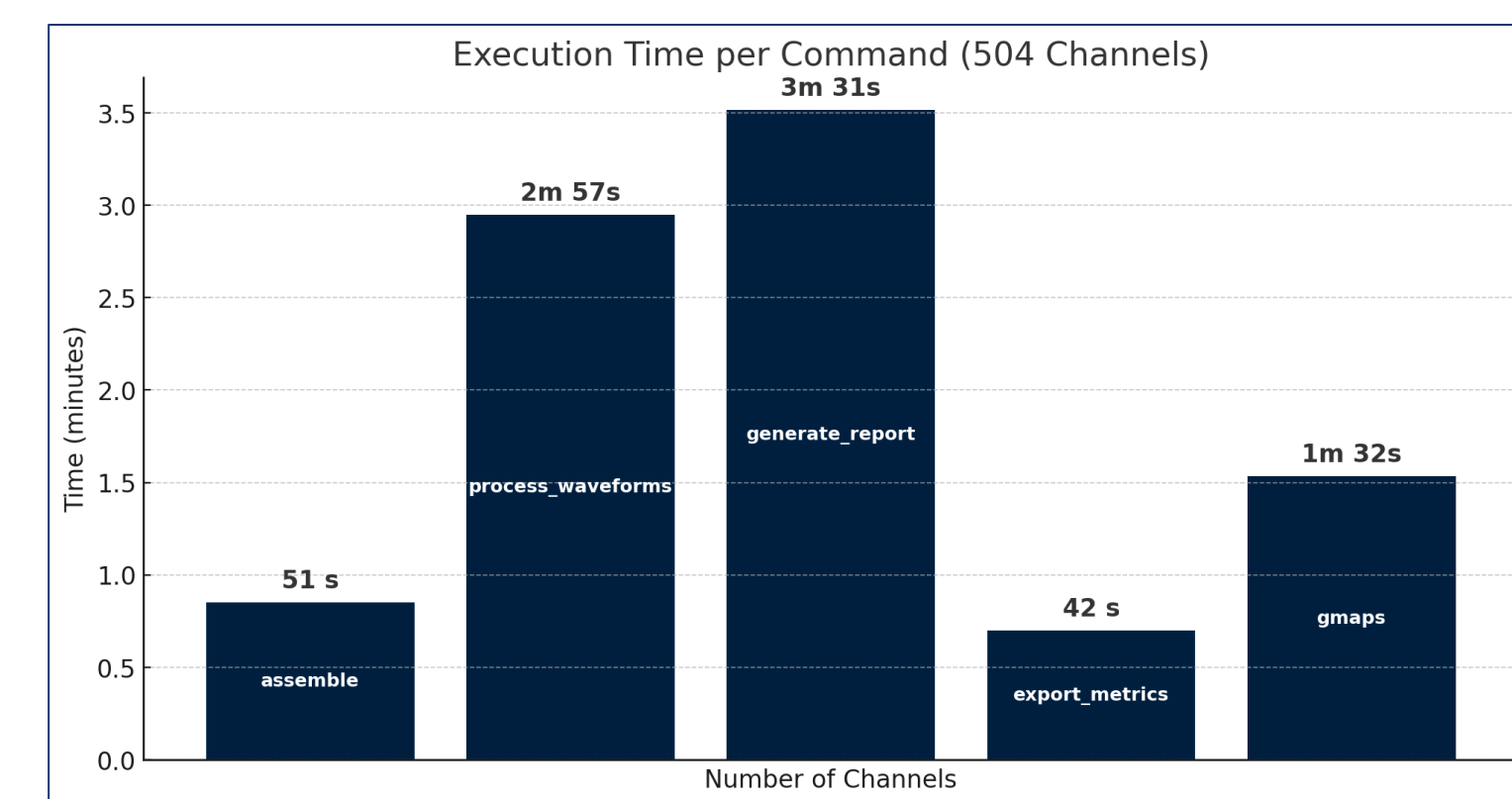
New code blocks have been introduced, and many existing components have been thoroughly refactored. In particular, **summary_plots.py** has been **rewritten** to **generate station-specific reports** containing **waveforms, PSA spectra, and PGA values**, using a layout optimised for automated production. 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.

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