GA-OGS-ARSO Transfrontier CE3RN AdriaArray Seismicity Experiment (GOAT-CASE) installations and results

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INTRODUCTION. The Italian National Institute of Oceanography and Applied Geophysics (OGS), GeoSphere Austria (GA), and the Slovenian Environment Agency (ARSO) monitor seismicity in north-east Italy, Austria, and Slovenia, collaborating with civil protection authorities. In 2014, they founded the Central and Eastern Europe Earthquake Research Network (CE3RN) to coordinate cross-border monitoring, enhance research, and support civil protection. In 2022, the AdriaArray experiment was initiated to image the Adriatic plate with a dense seismic network. Within this framework, OGS, GA, and ARSO contribute their permanent seismic stations data, while OGS additionally deploys temporary stations across Austria and north-eastern Italy, enhancing regional earthquake location capability, including for neighbouring Slovenia. The GOAT-CASE experiment quantifies this improvement by relocating earthquakes and comparing the corresponding solutions, with phase detection shared among the participating institutions. This poster presents the additional station deployments and compares seismic bulletins for the first two years of AdriaArray (01/07/2022–30/06/2024).

STATION DESIGN. A typical OGS seismic station for AdriaArray (Figure 1) consists of a Nanometrics Trillium Compact broadband seismometer (up to 120 sec) mounted on a marble base and thermally insulated with polystyrene. Indoor installations require only this setup, while outdoor stations are buried at least 0.5m. The Trillium Compact is compact, easy to level, and requires no mass-lock mechanism. Data are recorded via a Nanometrics Centaur 6-channel acquisition system, capable of 100sps sampling, internal/removable storage, and real-time transmission via a SeedLink server. Its GPS/GALILEO-synced clock ensures <10ms timing error. Real-time data are transmitted using Teltonika RUT955 industrial mobile routers over a VPN to handle dynamic IPs securely. Station electronics include overvoltage protection, power regulators, fuses, and a battery providing ~1 week of autonomous operation.

Figure 1. Components of an OGS seismic station for the AdriaArray project (a) the Nanometrics Centaur acquisition system; (b) the mobile internet router with switches; (c) both integrated in a closed metal cabinet; (d) the Nanometrics Trillium Compact 120 sec broadband seismometer, installed on a marble plate; (e) the sensor covered with plastic thermal insulation.

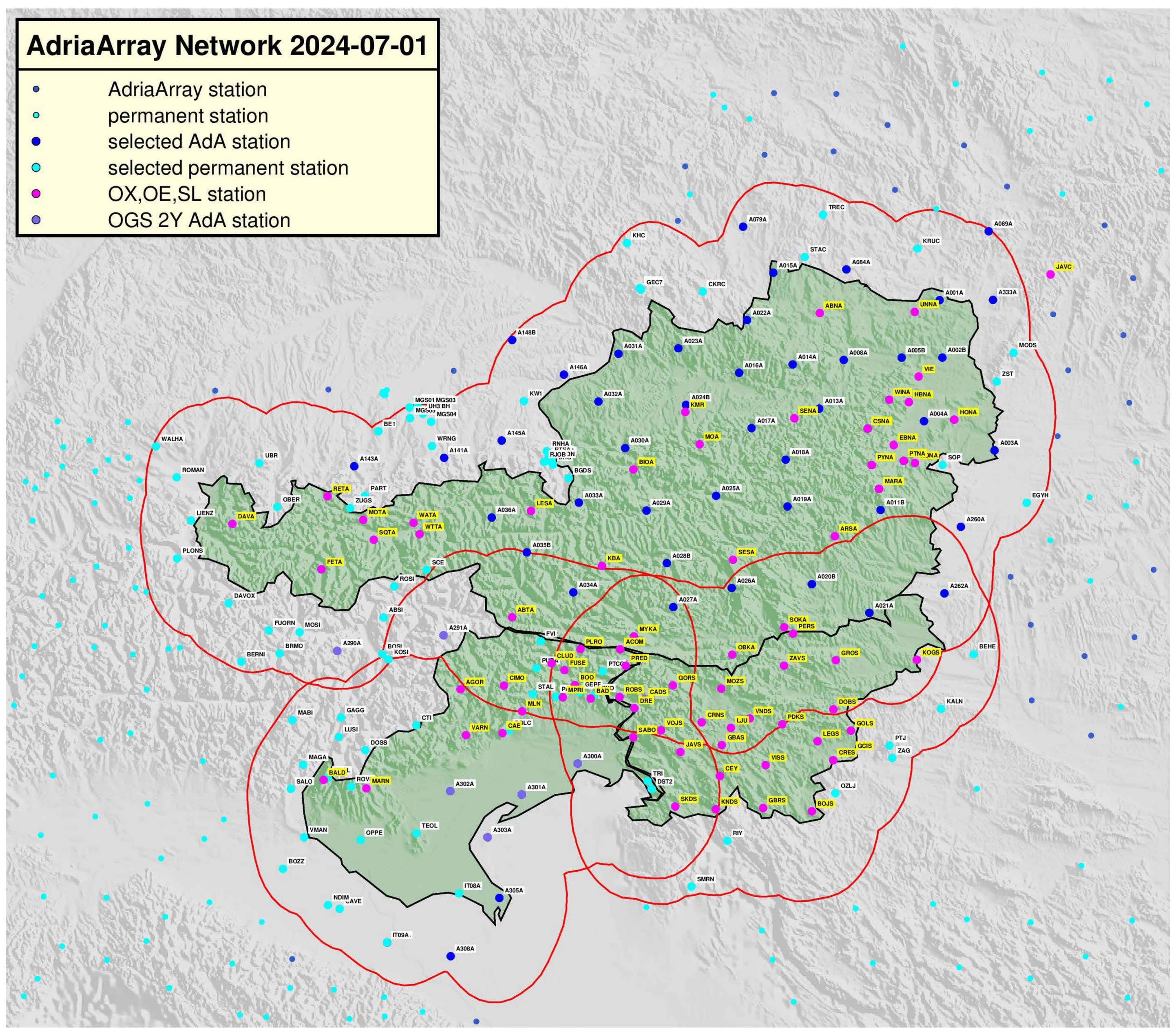

Figure 2. Map of the seismic stations used in the GOAT-CASE experiment: pink – permanent, light blue – additional permanent from other networks, dark blue – temporary additional AdriaArray stations, violet – OGS additional AdriaArray stations. The red lines define the area of the GOAT-CASE experiment, which is defined by the political borders plus the 50 km surrounding belt.

DATA ANALYSIS. The GOAT-CASE experiment leverages the new AdriaArray seismic stations to virtually extend the monitoring networks of OGS, Geosphere Austria, and ARSO (Figure 2), with the best-performing sites potentially retained after the project. The three partners have long exchanged real-time seismic data using a largely homogeneous Antelope-based system, which simplifies processing and ensures reliable waveform and parameter sharing through routines such as orb2orb. In the analysis, manual earthquake solutions are taken as reference and compared with automatic locations generated using Antelope phase picking and association: (a) using only the data of each individual institution, and (b) using the combined dataset of permanent stations and additional AdriaArray (AdA) stations. Challenges include configuring detectors and associators for temporary stations that often exhibit higher noise levels, handling metadata inconsistencies, and resolving discrepancies in server setups and naming conventions. The experiment further enables the partners to refine existing workflows, remove redundancies, and implement new processing routines. The main objective is to demonstrate improvements in seismic bulletins achieved through the inclusion of the additional AdriaArray stations by reprocessing the data and evaluating key quality indicators such as azimuthal gap and fault-ellipse dimensions.

RESULTS. Figure 3a compares automatic and manual earthquake locations from individual institutions for events with local magnitude M>1.5 during the first two years of the experiment. Figure 3b shows the same comparison for GOAT-CASE automatic and manual locations using the identical time period and magnitude threshold. Automatic real-time and GOAT-CASE locations are connected to their corresponding manual locations.

An overall improvement in locations derived from the joint dataset is clearly visible. Aside from a few outliers, the GOAT-CASE experiment exhibits the lowest median location error (2.24 km), in comparison with errors of 2.29 km for GA, 3.11 km for OGS, and 3.52 km for ARSO.

Only events associated with manual locations are shown; therefore, the event sets in Figure 3 differ slightly. Most GOAT-CASE locations fall within 10 km of the reference locations. Larger errors (10–15 km) occur primarily in southwestern OGS territory, western Austria near Innsbruck, and eastern Austria near Vienna, with a maximum error exceeding 130 km.

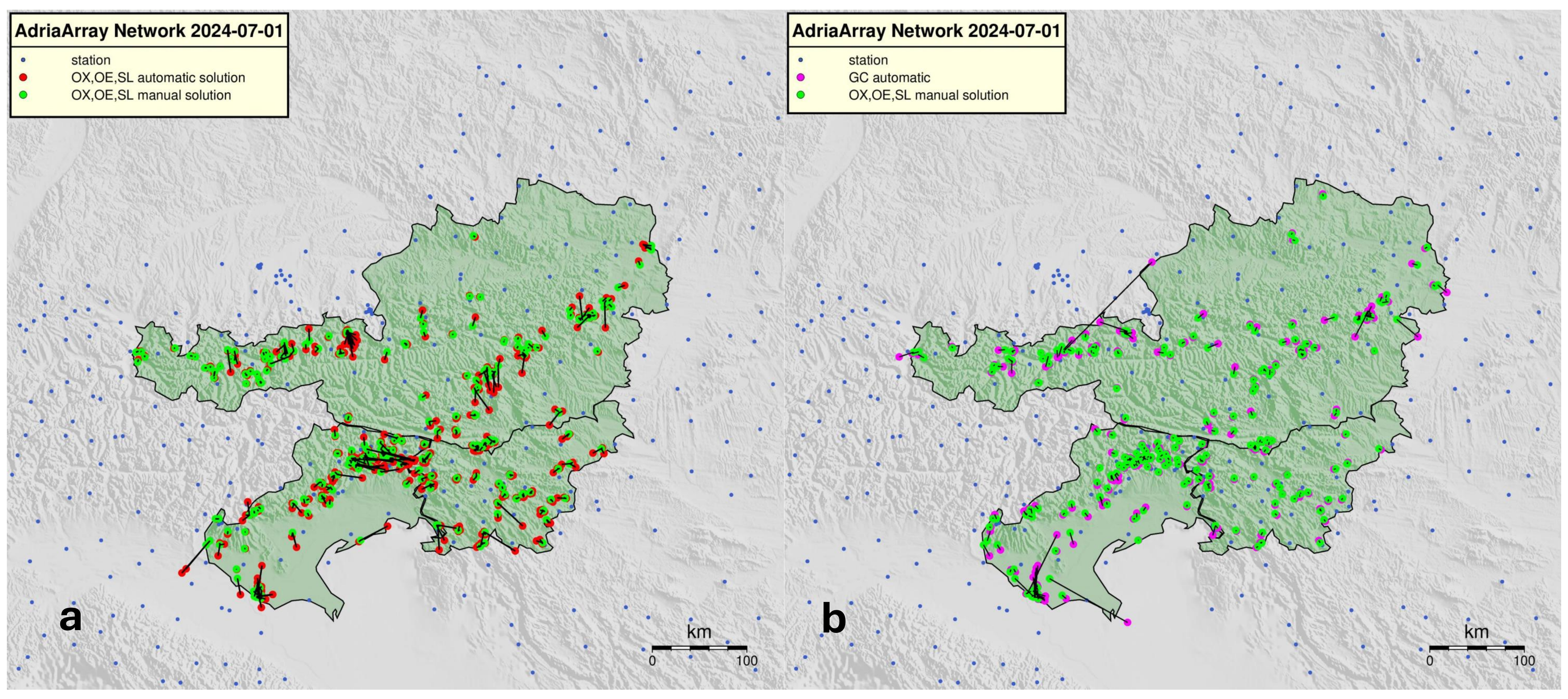

Figure 3. (a) For each individual institution, comparison between automatic real-time earthquake locations (red dots) and the institution's manual locations (green dots). (b) Comparison between GOAT-CASE earthquake locations (pink dots) and the manual locations of the individual institutions (green dots). Blue dots indicate permanent and temporary seismic stations.

CONCLUSIONS AND ACKNOWLEDGEMENTS. The GOAT-CASE experiment proved highly valuable for identifying issues and highlighting differences in routine seismic monitoring. While the analysis was carried out on archived data, several tests indicated that implementing the system in near–real time would substantially reduce operational workload.

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GeoSphere Austria
ARSO SEISMO Slovenian Environment Agency