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

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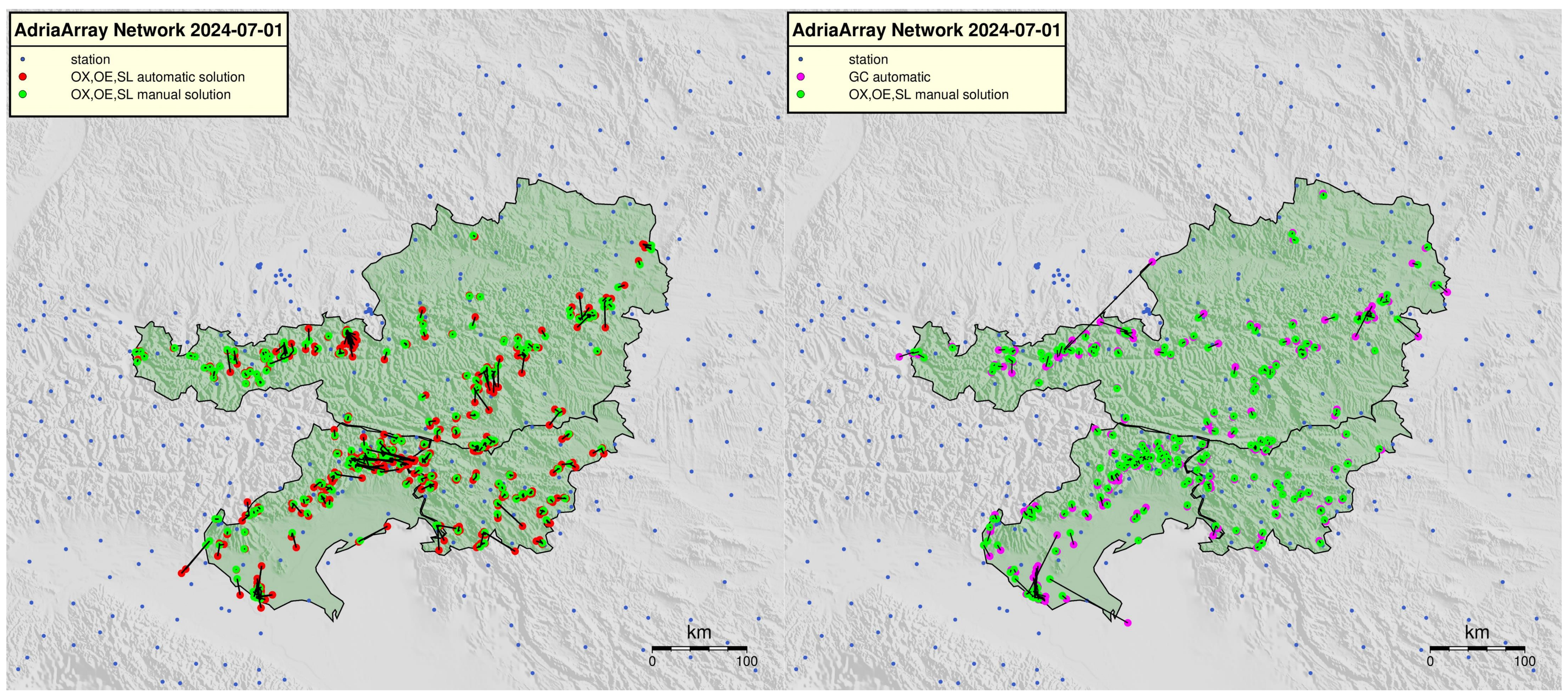
INTRODUCTION. The Italian National Institute of Oceanography and Applied Geophysics (OGS), Geosphere Austria (GA), and the Slovenian Environment Agency (ARSO) monitor seismicity in north-east Italy, Austria, and Slovenia, collaborating with civil protection authorities. In 2014, they founded the Central and Eastern Europe Earthquake Research Network (CE³RN) to coordinate cross-border monitoring, enhance research, and support civil protection. In 2022, the AdriaArray experiment launched to map the Adriatic plate with a dense seismic network. OGS, GA, and ARSO provide existing data, with OGS deploying additional stations in Austria and north-east Italy, improving earthquake location regionally, including Slovenia. The GOAT-CASE experiment quantifies this improvement by relocating earthquakes and comparing results, with detection shared among partners. 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 left) 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 0.5 m. 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 100 sps sampling, internal/removable storage, and real-time transmission via a SeedLink server. Its GPS/GALILEO-synced clock ensures <10 ms 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.

DATA ANALYSIS. The GOAT-CASE experiment leverages new AdriaArray seismic stations to virtually extend the networks of OGS, Geosphere Austria, and ARSO, with the best-performing sites potentially maintained post-project. The partners have long exchanged real-time seismic data using a relatively homogeneous Antelope-based system, which simplifies processing and enables reliable waveform and parameter sharing via routines like orb2orb. Challenges include configuring detectors and associators for temporary stations with higher noise, managing metadata discrepancies, and addressing inconsistencies across servers and naming conventions. The experiment also allows partners to refine workflows, eliminate redundancies, and implement new routines. The main goal is to demonstrate improved seismic bulletins with the additional AdriaArray stations by reprocessing three years of data and evaluating quality indicators such as azimuth gap and fault ellipse size.

RESULTS. Figure right on the left compares automatic and manual earthquake locations from GA, OGS and ARSO for events with local magnitude M > 1.5 during the first 2 years of the experiment. Figure right on the right compares GOAT-CASE automatic locations with the manual locations from the 3 institutes for the same period and magnitude threshold. Seismic stations used in the experiment are shown in blue; manual reference locations in green; automatic locations in red; and GOAT-CASE locations in pink. Automatic and GOAT-CASE locations are connected to their corresponding manual locations. It shows that the GOAT-CASE experiment performed very well. Aside from a few outliers, GOAT-CASE locations are generally closer to the manual references than those from individual institutes, as reflected by smaller median distances.



Although the average GOAT-CASE distance is larger than that of Geosphere automatic locations, this is mainly due to a single large mislocation in western Austria. Only events associated with manual locations are shown, so the event sets in the Figure differ slightly. The distributions of differences between automatic and manual locations for the three institutes and for GOAT-CASE show that most automatic real-time locations differ from the reference by several kilometres, a pattern also seen for GOAT-CASE but with fewer outliers, likely due to the larger number of phase picks used. Most GOAT-CASE locations are within 10 km of the reference; larger errors (10–15 km) cluster mainly in southwest OGS territory, western Austria near Innsbruck, and eastern Austria near Vienna, with a maximum error exceeding 130 km.

CONCLUSIONS. The GOAT-CASE experiment proved to be very helpful in finding problems and highlighting differences in our routine seismic monitoring. For example, ARSO in Slovenia showed a lower magnitude threshold in its earthquake catalogues. Further on, the localization of events outside the GC area needs to be better tuned (better selection of stations, better tuning the grids, etc.). The GC experiment was performed on archive data for the first two years, while some tests clearly indicated that running it in near real time would significantly reduce the workload. Geosphere Austria is routinely collecting locations in real time from other agencies, like INGV, ARSO and USGS: this improves its location capabilities and reliability. Exploiting the GOAT-CASE experiment, it seems appropriate that OGS and ARSO follow this procedure, at least for the earthquakes in the GOAT-CASE area.

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