Geo-INQUIRE Transnational Access – Project Report

Geo-INQUIRE installation: PTHA – Probabilistic Tsunami Hazard Assessment (TA2-541-3)
Project title: Cross-Border Hazard Assessment: PTHA in Pilot Areas of Pakistan and Iran
Project acronym: CBHA
Project report ID: C1_TA2-541-3_3 (1st Call)
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Type of access: Transnational Access (HPC and Virtual Access)

Project report

The Makran Subduction Zone (MSZ), located offshore Pakistan and Iran along the northwestern Indian Ocean, is a potentially tsunamigenic subduction system capable of generating large earthquakes and damaging tsunamis. Despite relatively low instrumental seismicity, geological and geophysical evidence suggests that the MSZ may host earthquakes significantly larger than those observed historically. The 1945 Mw 8.1 Makran earthquake and tsunami demonstrated the regional tsunami hazard, while rapid coastal urbanization since then has considerably increased exposure, particularly in major port cities.

The Cross-Border Hazard Assessment (CBHA) project aims to develop a unified, high-resolution Probabilistic Tsunami Hazard Assessment (PTHA) for selected pilot areas along the coasts of Karachi (Pakistan) and Chabahar (Iran). The project is designed as a collaborative effort between Pakistani and Iranian institutions, using consistent seismic source models, numerical workflows, and high-performance computing resources provided through Geo-INQUIRE.

Before the Transnational Access period, the PI and team members were trained in the use of the Tsunami HySEA tsunami model and the associated ChEESE-CoE PTHA workflow, and gained hands-on experience in managing large-scale tsunami simulations on CINECA HPC systems during the visit and the translational access period. A nested-grid tsunami modeling framework was established, comprising a regional Arabian Sea grid and progressively finer nested grids down to ~30 m resolution in the coastal zones of Karachi and Chabahar. This configuration enables rigorous simulation of tsunami generation and

long-range propagation while resolving nearshore processes relevant to inundation and hazard mapping.

The seismic source model includes both predominant seismicity (PS) associated with the Makran subduction interface and background seismicity (BS) representing crustal and distributed sources. The PS sources extend the existing Makran PTHA source sets to include more variability by considering both variable and constant mu, while BS sources follow previously established regional models with updates reflecting the Arabian Sea and Persian Gulf focus of the study.

Large ensembles of tsunami scenarios were generated across a range of magnitude, with simulations executed in batch mode on GPU-enabled nodes. Extensive monitoring, job splitting, and re-submission strategies were applied to address workflow and hardware constraints inherent to large-scale HPC production runs.

At the time of reporting, grid preparation and workflow setup have been fully completed, and a substantial fraction of the PS simulations has been successfully executed. Remaining simulations, including completion of BS scenarios and targeted sensitivity tests (to tide levels), are ongoing. Post-processing activities to derive probabilistic hazard curves and spatial hazard metrics are planned to be executed in the coming few months.

The expected outcomes of the CBHA project include high-resolution probabilistic tsunami hazard maps and hazard curves for Karachi and Chabahar, suitable for informing tsunami early warning, evacuation planning, and disaster risk reduction strategies. The results will be disseminated through peer-reviewed publications, international conferences, and regional stakeholder engagement, including contributions to UNESCO-IOC initiatives and Geo-INQUIRE Virtual Access products.

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