Applied geophysics methodologies and the use of artificial intelligence to characterize marine and shallow terrestrial environments

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This project is dedicated to the memory of Dr Lorenzo Petronio, Lead Technologist at OGS and responsible for the geophysical infrastructures and fixed - term professor of applied geophysics at the University of Padua.

The idea for the project stems from the collaboration between the University of Padua and the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – OGS in the field of applied geophysics and aims to help close the knowledge gap in seismic oceanography.

The Open Science paradigm is recognised as a fundamental and indispensable principle for the advancement of knowledge and as a prerequisite for sustainable natural resource management policies based on shared and transparent scientific knowledge. Scientific communities, public stakeholders and the productive world need free, easy and rapid access to certified data and information. OGS has a leading position in open data, having developed many of the technologies used by several international initiatives to support web-based access and management of marine and geophysical data. OGS has an extensive archive of oceanographic and geophysical data collected as part of its own scientific campaigns and those of other institutions. By applying a FAIR approach and developing and applying internationally recognised standards, OGS is indeed a reference point for data accessibility at international level.

The OGS National Oceanographic Data Centre plays a crucial role in the collection, management and dissemination of marine data supporting a wide range of scientific and applied research disciplines. Part of these datasets are managed by the National Oceanographic Data Centre, which is responsible for the most comprehensive marine data repository in Italy. Furthermore, as a key player in the pan-European marine data infrastructure SeaDataNet, OGS plays a strategic role in harmonising and managing large and diverse datasets collected in the world’s seas and oceans. This data-driven approach is essential for tackling global challenges such as climate change, marine resource management and biodiversity conservation.

As Italy's official Italian National Oceanographic Data Center, recognised by UNESCO and integrated into the International Oceanographic Data Exchange (IODE) system, OGS ensures free access and dissemination of marine data to national and international scientific communities as well as to the civil and economic sectors. The database contains over 300,000 profiles of the water column, covering a wide range of physical and biogeochemical variables and providing important insights into the dynamics of the ocean. Clearly, facilitating the open exchange of high-quality oceanographic data will enhance interdisciplinary collaboration and the ability to understand and protect the marine environment.

On the other hand, the geophysical data available consist of more than 100,000 kilometres of seismic lines acquired in the Mediterranean and Black Seas and include all seismic data acquired by all research institutions in Antarctica (more than 350,000 kilometres of seismic lines).

Given this extensive and multidisciplinary data availability, this project aims to integrate the oceanographic and geophysical database using seismic data analysis and the artificial intelligence approach. The aim is to expand the information on the structure of the water column using

multidisciplinary data and to propose a method that can be used in the future to extract as much information as possible from the geophysical and oceanographic data that will be collected in the future.

Oceanographic data is the basis for seismic oceanography, a multidisciplinary approach that utilises geophysical techniques to study the structure of the water column. By integrating seismic analyses with traditional oceanographic measurements, researchers can gain a more detailed understanding of temperature gradients, water mass circulation and other dynamic processes that influence marine ecosystems and climate studies.

In detail, the project is divided into the following phases:

1. Evaluation of existing geophysical and oceanographic data required for the methodological tests;
2. Analysis of the seismic data with the main objective of identifying the reflections in the water column based on acoustic contrast using open source software (such as Seismic Unix);
3. Analysis of other geophysical data such as CHIRP, sub-bottom profiles, bathymetry, useful to characterise the water column and the seabed;
4. Reconstruction of seawater velocity using oceanographic data;
5. Integration of the results and identification of the best method to analyse the geophysical data for the characterisation of the seawater column;
6. Use of artificial intelligence to improve the results and reduce the time needed to characterise the seawater column on a large scale;
7. Based of best data availability, selection of the study area in the Mediterranean, Black Sea or Antarctic;
8. Application of the developed method for studies on ocean variability;
9. Investigate the possible application of the developed method to reconstruct the shallow properties of the subsurface on land by using geophysical data and direct measurements;
10. Identification of study areas on land and collection of available data for environmental studies, such as water resource;
11. If a lack of information is identified, a collection campaign using the OGS infrastructures could be proposed;
12. Development of an open source software for the application of the developed method.

This project will benefit from the participation in the “Partnership For Advances Computing in Euro” (PRACE), which provides access to high-performance computing. Furthermore, the available dataset could be integrated in the acquisition of new geophysical data by using the infrastructures acquired by OGS within the “Piano Nazionale di Ripresa e Resilienza” (PNRR) and available for marine and terrestrial geophysical campaigns.