Title: Geophysical inversion and Machine Learning methods for solving inverse problems

Tutor: Ester Piegari

Research program

The geophysical exploration conventionally calls for an inversion procedure of the observed parameters, which requires an estimate of the intrinsic characteristics of the investigated volumes by numerically solving the fundamental equations underlying the physical processes. Through inversion a model of the subsurface is thus obtained in which, however, a residual ambiguity persists due to the non-uniqueness of the solution. To overcome the limitations related to the use of individual geophysical techniques, an integrated approach is usually applied, employing different geophysical techniques. The final result often consists only of a qualitative assessment of zones within the cross sections of the inverted models that are similar in terms of shape, position and magnitude of the anomalies.

In recent decades, Machine Learning (ML) techniques have introduced significant innovations in terms of programming techniques, processing and interpretation of experimental datasets. ML algorithms can provide solutions to inverse problems with the advantage of being implemented without the use of the fundamental equations. Furthermore, ML techniques are naturally predisposed to data integration, since they usually work in a multi-parameter space. However, they are sensitive to the amount of training data and to the choice of relevant parameters, which are essential for retrieving reliable models.

Proposal for a PhD position

The Department of Earth, Environmental, and Resources Sciences at the University of Naples, Federico II invites applications for one PhD position in Earth Sciences. The PhD research project is aimed at: i) the development and application of ML algorithms for solving inverse problems, with the aim of providing less ambiguous and more quantitative reconstructions of the parameters of direct use for geological modeling, ii) the analysis of similarities and differences between traditional geophysical inversion methods and ML approaches in solving inverse problems.

The project will involve the development and/or usage of numerical codes to model and analyze geophysical data. Resources relating to high performance computing projects funded by CINECA will be used for activities related to the PhD project. The candidate is expected to have a solid background in geophysics and statistics. Basic concepts of programming languages and basic knowledge of MATLAB and/or Python is highly desirable.