CERIS Civil Engineering Research and Innovation for Sustainability

Inversion strategies for seismic surface waves and time domain electromagnetic data with application to geotechnical characterization examples

PhD student
Jeniffer Costa Barreto Viegas

PhD program
Architectural and Civil Engineering (IST, University of Lisbon and Università di Cagliari)

Supervisor
Giulio Vignoli (Università di Cagliari)

Co-supervisors
Jaime Santos (CERIS, IST, University of Lisbon) and Julien Guillemoteau (Postdam University)

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Summary

Geophysical methods are broadly used to map the subsurface. Their ability to investigate large areas in a short time and to reach significant depths with good resolution makes them suitable for a wide range of applications: from hydrological studies, mineral exploration, archaeological investigations to geotechnical characterization.

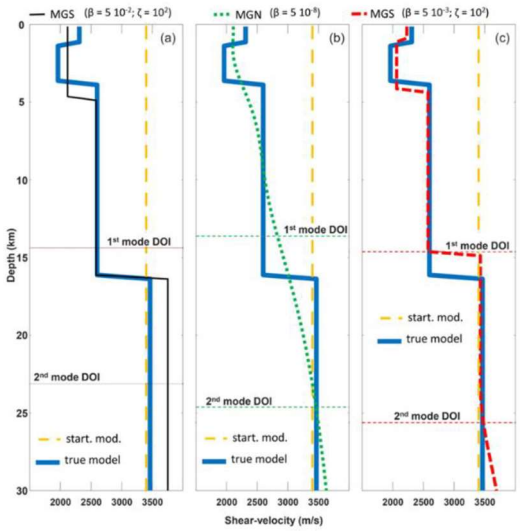
Unfortunately, most of the geophysical methods are ill-posed. Thus, to be able to effectively invert the geophysical data and get meaningful models of the subsurface a priori information needs to be included in the process. This is the basic idea behind the inversion theory. This thesis deals with the inversion of two types of geophysical measurements: the Seismic Surface Waves (SSW) data and the Time Domain Electromagnetic (TDEM) observations.

The present work consists of two parts: (1) The first one is about possible implementations of the minimum gradient support stabilizer into a SSW inversion routine and its extension to the laterally constrained case. By means of this novel approach, it is possible to tune the level of sparsity of the reconstructed velocity model, providing a solution with the desirable characteristics (smooth or sharp) in both directions (vertically and laterally). The capabilities of the proposed approach have been tested via applications on synthetic and measured data. (2) The second part of the thesis is about the joint interpretation of SSW and TDEM measurements for an improved geotechnical characterization of an area intended for construction. In this case, the SSW results, together with other ancillary data, are used as prior information for the subsequent inversion of TDEM measurements. In this respect, the SSW results have been translated into pieces of information to be used in the TDEM inversion via a petrophysical relationship.

This work is coherent with one of the goals of the United Nations Agenda 2030 for sustainable development [4], specifically, the item 11b, as geotechnical characterization is one of the essential components for the design of civil engineering works, ensuring the necessary safety and resilience to natural disasters and climate change. However, the field of application of the proposed approaches is very broad as they can also be used, e.g., for groundwater mapping, as well as for the evaluation of aquifer contamination. In this respect, the present work is also in line with items 6.1, 6.3 and 6.4 of the 2030 UN Agenda.

Keywords

Inversion, seismic surface waves, time domain electromagnetic, geotechnical characterization, regularization.



Comparison of the implemented stabilizer MGS against the commonly used stabilizer MGN.