Magnetotelluric response distortion over rugged topography

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Abstract
Topographic effects on magnetotelluric responses may be severe on rugged terrains.

Finite element simulation is a valuable tool to quantify this effect, due to its capability to match real morphologies. To do the estimate of the distortion, the AC/DC Module of COMSOL has been employed, using a model of homogeneous resistivity on which a DEM (Digital Elevation Model) of the Deep Freeze Range (Victoria Land, Antarctica) has been superimposed. Then, the MT responses at several surface sites have been computed.

Introduction

The first part of this study is devoted to model the MT responses in a rugged earth model. The chosen setting is representative of an EM acquisition in Antarctica, where the rugged topography (e.g. a height of 100 m) of the earth can strongly influence the MT response. The aim of this work has been to evaluate the amplitude of the correction needed to estimate the MT responses. To do this, a model of homogeneous resistivity on which a DEM of topographical elevation has been superimposed has been employed. This way, each single DEM element has been modeled as a different earth layer, and the complete earth model (containing both the electrical conductivity and the topography) has been fully modeled.

Physical settings

Magnetotelluric is the frequency range of MT responses, in which the magnetic fields are induced by conductive elements of a purely resistive earth. The frequency range of MT responses is limited by the depth of the earth conducting layers and by the skin depth of the magnetic field, which is inversely proportional to the frequency. The depth of the earth conducting layers is usually described in terms of the electrical depth of penetration, 

\[ \text{Electrical depth of penetration} = \sqrt{\frac{\rho}{\omega}} \]

where \( \rho \) is the Earth conductivity and \( \omega \) is the angular frequency. The electrical depth of penetration is a characteristic of the Earth's electrical properties and can be used to estimate the depth of the Earth's conductive layers.

Model and mesh sizing

The choice of the finite element mesh has been taken into account different and sometimes contrasting criteria, to retain the best approximation of the topographic effects, to preserve the accuracy of the MT responses, and to optimize the mesh size. The mesh size has been chosen to be comparable to the minimum skin depth at the frequency of interest. The mesh size has been chosen to be comparable to the minimum skin depth at the frequency of interest. The mesh size has been chosen to be comparable to the minimum skin depth at the frequency of interest.

Conclusions

The finite element method has been employed to simulate the MT responses in a rugged earth model. The results show that the topography can significantly affect the MT responses, and that the finite element method is a powerful tool to study these effects. The AMF technique has been used to estimate the apparent resistivity variations at different frequencies, and the results show that the apparent resistivity variations are consistent with the expected values. The results also show that the apparent resistivity variations are consistent with the expected values. The results also show that the apparent resistivity variations are consistent with the expected values.