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Special section

3D forward modeling and inversion of electromagnetics and applications — Introduction

Xiangyun Hu[1], Qinghua Huang[2], Colin Farquharson[3], Evert Slob[4], and Klaus Spitzer[5]

Three-dimensional electromagnetic (EM) techniques are important and powerful tools for natural resources exploration (oil, minerals, geothermal, etc.) and geotechnical and environmental investigations because 3D imaging can provide detailed information about the subsurface. This special section is dedicated to 3D EM methods and their successful applications, aiming to present the current state of the art in theoretical developments and practical applications and to stimulate interest across a wide range of geophysicists.

This special section brings forward advances in theory, modeling, inversion, and innovative applications of 3D EM geophysics. A wide range of EM methods are presented that include airborne EM, magnetotellurics, land-based controlled-source EM (CSEM), marine CSEM, and borehole EM. The papers covering all of these methods in this special section address their recent advances in 3D forward modeling and inversion, as well as applications, such as in imaging oil fields and reservoir monitoring.

Schaller et al. quantify 3D inversion performance of a land-based CSEM survey carried out at the Schoonebeek oil field, Netherlands. Spatial variations in reservoir resistivity are visible in the measured data and inversion model by assuming good knowledge of the background resistivity distribution.

Zhou et al. propose a novel method for reservoir monitoring using borehole radars. Numerical simulations of 3D EM and fluid modeling suggest that borehole radars have the potential to improve oil recovery efficiency in a smart well production environment.

Kohnke et al. use the method of moments to calculate the electromagnetic response of steel casings with arbitrary geometry in a layered background conductivity model. The authors compare the results to Comsol finite-element models.

Varilsuha and Candansayar investigate different approaches in 3D magnetotelluric modeling. The authors recommend the use of the ungauged approach in inversion algorithms, which give faster forward solutions than the direct EM, Lorenz-gauged, Coulomb-gauged and axial-gauged approaches.

Lin et al. describe the 3D topographic effects on controlled-source audio frequency magnetotelluric data. The results indicate that all the electric field, magnetic field, apparent resistivity, and phase data are influenced by 3D topography, but to different extents.

Dunham et al. use a 3D finite-element forward solver to synthesize marine CSEM data from a complex model representing the Bay du Nord prospect offshore Newfoundland. The authors present the intricacies of model building, mesh construction, mesh optimization, marine CSEM data synthesizing, model updating, and data interpretation.

Belliveau and Haber develop a novel, efficient algorithm for solving the quasistatic time-domain Maxwell equations in the presence of dispersive media. The authors demonstrate, using synthetic examples, how this approach can be used to model induced polarization effects in grounded and inductive source electromagnetic surveys.

Zimmerling et al. consider Krylov model order reduction techniques for the full-wave and diffusive Maxwell equations. The authors discuss the construction and evaluation of causality- and passivity-preserving Krylov-based reduced-order models. The authors present numerical experiments that illustrate the performance of the proposed reduction techniques.

Zhang et al. create an adaptive method that can generate an effective mesh for time-domain 3D airborne EM full-wave modeling using the finite-element algorithm. Numerical experiments validate the efficiency and effectiveness of this method.

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[1]China University of Geosciences, Institute of Geophysics and Geomatics, Hubei Subsurface Multiscale Imaging Key Laboratory, Wuhan, China. E-mail: xyhu@cug.edu.cn.
[2]Peking University, School of Earth and Space Sciences, Department of Geophysics, Beijing, China. E-mail: huangq@pku.edu.cn.
[3]Memorial University of Newfoundland, Department of Earth Science, Canada. E-mail: cgfarquh@mun.ca.
[4]Delft University of Technology, Department of Geoscience and Engineering, Delft, The Netherlands. E-mail: e.c.slob@tudelft.nl.
[5]TU Bergakademie Freiberg, Institute of Geophysics and Geoscience Informatics, Freiberg, Germany. E-mail: klaus.spitzer@geophysik.tu-freiberg.de.