Submission code: W89R6W074P

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Determination of Magnetic Anomalies for a 3-D Magnetized Body Embedded in a Magnetic Half-Space

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Introduction

Magnetic anomaly modeling is essential for characterizing subsurface bodies, particularly in contexts where direct methods are required for geophysical interpretation. This work proposes a theoretical formulation to determine the magnetic anomalies produced by a three-dimensional magnetized body embedded in a medium with distinct magnetic properties (i.e., a magnetic half-space). The model assumes a constant external magnetic field and employs orthogonal coordinates adapted to the body's geometry to simplify Laplace's equation. Specifically, bipolar and bispherical coordinates are explored as efficient approximations for cylindrical and spherical bodies, respectively.

Method and/or Theory

The methodology of this work generalizes the two-dimensional model proposed by Sampaio (1982) into three dimensions, using the magnetic field **B** as the theoretical basis. The boundary conditions ensure the continuity of the scalar magnetic potential and the normal components of the magnetic field across the interfaces of the physical model. The general solution is obtained numerically by determining the coefficients of a linear system, whose resolution enables the characterization of the anomalous magnetic field.

The transition to bispherical coordinates extends the methodology to three-dimensional problems while preserving the harmonic structure of the equations and rigorously applying boundary conditions. This approach guarantees a consistent mathematical formulation suitable for modeling magnetic anomalies generated by magnetized spherical bodies. Theoretical validation is performed through numerical simulations, which demonstrate the efficiency and robustness of the proposed method.

Results and Conclusions

The results show that, even with geometric simplifications, the model accurately reproduces anomalies generated by subsurface bodies with uniform magnetization. The proposed methodology proves promising for identifying magnetic permeability contrasts in diverse geological environments. It can be applied to mineral exploration, geotechnical investigations, and environmental or archaeological studies.