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3D Modeling for Frequency and Time-Domain Airborne EM Systems with Topography

Authors : C. Yin, B. Zhang, Y. Liu, J. Cai

Abstract : Airborne EM (AEM) is an effective geophysical exploration tool, especially suitable for ridged mountain areas. In these areas, topography will have serious effects on AEM system responses. However, until now little study has been reported on topographic effect on airborne EM systems. In this paper, an edge-based unstructured finite-element (FE) method is developed for 3D topographic modeling for both frequency and time-domain airborne EM systems. Starting from the frequency-domain Maxwell equations, a vector Helmholtz equation is derived to obtain a stable and accurate solution. Considering that the AEM transmitter and receiver are both located in the air, the scattered field method is used in our modeling. The Galerkin method is applied to discretize the Helmholtz equation for the final FE equations. Solving the FE equations, the frequency-domain AEM responses are obtained. To accelerate the calculation speed, the response of source in free-space is used as the primary field and the PARDISO direct solver is used to deal with the problem with multiple transmitting sources. After calculating the frequency-domain AEM responses, a Hankel's transform is applied to obtain the time-domain AEM responses. To check the accuracy of present algorithm and to analyze the characteristic of topographic effect on airborne EM systems, both the frequency- and time-domain AEM responses for 3 model groups are simulated: 1) a flat half-space model that has a semi-analytical solution of EM response; 2) a valley or hill earth model; 3) a valley or hill earth with an abnormal body embedded. Numerical experiments show that close to the node points of the topography, AEM responses demonstrate sharp changes. Special attentions need to be paid to the topographic effects when interpreting AEM survey data over rugged topographic areas. Besides, the profile of the AEM responses presents a mirror relation with the topographic earth surface. In comparison to the topographic effect that mainly occurs at the high-frequency end and early time channels, the EM responses of underground conductors mainly occur at low frequencies and later time channels. For the signal of the same time channel, the dB/dt field reflects the change of conductivity better than the B-field. The research of this paper will serve airborne EM in the identification and correction of the topographic effects.

Keywords : 3D, Airborne EM, forward modeling, topographic effect
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