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Resolution of full waveform inversion using controlled-source electromagnetic exploration

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A 3D full waveform inversion method is applied to a controlled-source electromagnetic (CSEM) method. For the 3D forward simulation, we employed a finite-different time-domain (FDTD) method in the fictitious wave domain in order to simulate electromagnetic wave propagation with large time steps to minimize the cost of numerical computation. Convolutional perfectly matched layers are employed for the absorbing boundary condition. After the electromagnetic fields are simulated using the FDTD method, we apply the Fourier transform to obtain the electromagnetic fields in the frequency domain. Using the full waveform inversion in the frequency domain, we first demonstrate that conductive anomalies beneath the surface could be estimated. We then discuss the resolution of our CSEM inversion method, in terms of the distribution and the orientation of dipoles of transmitter and receivers deployed for our CSEM survey. We consider two cases in the alignment of x-oriented receiver and transmitter dipole arrays: (i) 2D inline alignment of the arrays, and (ii) pseudo 3D parallel offset alignment. Our synthetic inversion examples show that the latter could lead to the higher resolution than the former, in particular deeper part of our sub-seafloor model. We also confirm that the utilization of tricomponent transmitters and receivers could give better locations both in horizontal and vertical directions in inversion results than that of x-oriented dipoles only. These differences of the inversion results could be explained by the distribution of electric flux and charge around the boundary of conductive anomalies. We finally conclude, from these results, that it would be important to consider the deployment of multi-component transmitter and receivers whose arrays are aligned in 3D for reliable inversion.

Keywords: CSEM, Full waveform inversion, FDTD