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Application of particle method to forward modeling of marine controlled-source electromagnetic survey

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A new marine controlled-source electromagnetic (MCSEM) forward simulation is presented in this study. The benefit of the method is the better treatment of complicated seafloor topography and/or buried structures than before. Here, we focused on the moving particle semi-implicit (MPS) method. In our method, the Maxwell ' s equations are discretized with particle arrangement without grid structure, which is usually used in finite-difference method (FDM). Each particle denotes the three components of electromagnetic fields at each particle. MPS method has some advantages over the other methods such as finite-element method (FEM), FDM, integral method (IE), etc. An obvious advantage of this approach is a numerical model that can flexibly form arbitrary topography shapes. Although FEM is sometimes employed to treat the topographic structure, especially for MCSEM, pre-process for creating grid or mesh structures require a time-consuming procedure especially in three-dimensional cases. A second advantage is that the three components of electric field and electric current as well as magnetic field and source are defined at the same location of every particle, while not at the same location in the case of Yee ' s grid.

We tested our three dimensional MCSEM forward simulation using the particle method and confirmed that the accuracy of the forward simulation with the simple tilted layered model would be improved. Our forward modeling results show the accuracy sufficient to discuss with the analytical results. The local and arbitrary refinement of particle is conducted to obtain more accurate result using the same model. The local refinement is applied only near the transmitter and receiver dipoles. The accuracy of MPS becomes higher in the local refinement than in the use of isodiametric particles. Our results suggest that the method using MPS with locally refined particles is useful for the forward simulation of electromagnetic field with arbitrary topography in the MCSEM modeling.

Keywords: Marine controlled-source electromagnetic, Forward simulation, Particle method