Application of the total and scattered field decomposition and perfectly-matched layers to improve the accuracy in electromagnetic modelling

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SUMMARY

Inhomogeneous Dirichlet boundary conditions are routinely applied in 2D magnetotelluric forward modelling. However, the finite size of the modelling domain results in false reflections of the anomalous field at the boundaries, because the prescribed boundary fields are normal fields. Hence, the anomalous field is not accounted for, and the solution accuracy may be significantly reduced. To eliminate such false reflections, we introduce the *total and scattered field decomposition* (TSFD) to geophysical modelling. This makes it possible to apply fully absorbing boundary conditions to the scattered (often anomalous) field, and we apply perfectly-matched layers. In the TSFD, the modelling domain is split into two regions: in the total-field region, encompassing receiver sites and geological targets, the unknowns are total-field values, and in the scattered-field region, consisting of boundary regions, the unknowns are scattered-field values. At the TSFD interface, that separates these regions, the incident plane-wave field is impressed as a source. At the outer boundaries of the scattered field region, perfectly-matched layers attenuate the outward propagating scattered field to zero. We develop TSFD setups for two types of models. The *horizontal TSFD* divides the domain along a horizontal TSFD interface in air, with perfectly-matched layers at the top and Dirichlet boundary conditions at the other boundaries. It is designed for models with different layerings at the left and right boundaries. In such cases the total field at the top boundary cannot be correctly computed, which always leads to reflections using standard Dirichlet boundary conditions. The horizontal TSFD solution is shown to be significantly more accurate. The *surrounding TSFD* is designed for horizontally layered background models. Here, the scattered field region comprises all boundaries, which can be placed closer to the area of interest without diminishing solution accuracy by using perfectly-matched layers. This results in significantly diminished computational problem size.

Keywords: total and scattered field decomposition, perfectly-matched layers, finite-element modelling, computational accuracy