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Time-domain Electromagnetic Exploration of Salt Islands: Three-dimensional Modelling and Field Results

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The time-domain electromagnetic method (TDEM) has been widely used in groundwater exploration and geological mapping applications. TDEM measures the subsurface electrical conductivity, which is strongly correlated with groundwater salinity. TDEM thus offers cheap and non-invasive ways to map saltwater intrusion and groundwater salinization. Typically, TDEM data is interpreted using 1D layered-earth models of the subsurface. However, most saltwater intrusion and groundwater salinization phenomena produce eminently three-dimensional anomalies. To fully exploit the information of TDEM data in this context, three-dimensional modeling of the TDEM response is required.

We present a finite-element solution for three-dimensional forward modeling of TDEM responses from arbitrary subsurface electrical conductivity distributions. As an application example, the groundwater salinization process on islands in the Okavango Delta is simulated using a variable-density flow and salinity transport model. The transport model outputs are subsequently converted to TDEM responses using the 3D TDEM forward code.

A field dataset of ground-based and airborne TDEM data from a selected Okavango Delta island is presented. The TDEM field data cannot be interpreted in terms of 1D layered-earth models, because of the strongly three-dimensional nature of the salinity anomaly under the island. A 3D interpretation of the field data allows detailed and consistent mapping of this anomaly.