Estimating the Depth to the Saturated Zone from Airborne Electromagnetic Data

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Effective groundwater management requires information about the large-scale hydrostratigraphy, such as can be provided by the airborne electromagnetic (AEM) method. To obtain a model of lithology from the model of resistivity, derived from the AEM data, requires a transform linking resistivity to lithology. One factor often not considered in the construction of the rock physics transform is the elevation of the top of the saturated zone (TSZ). The measured resistivity of a material is highly dependent on saturation state (e.g. Archie's law). In order to build and apply an accurate rock physics transform, we need to know the depth of the TSZ at the locations of the acquired AEM data, at the time of acquisition.

In this study we used two methods to estimate the TSZ, the first was developed during previous work in the San Joaquin Valley, where the change, with depth, in the width of the distribution of resistivity values was used to estimate the TSZ. An average depth to the TSZ of ~49 m was estimated with an RMS error of 10.6 m when compared to well-based measurements of water table elevation (WTE) that were made several weeks before the AEM data were acquired. This RMS error is roughly equal to the vertical resolution of the AEM method at the average depth of the TSZ.

The second method estimates the TSZ using targeted inversion of the AEM data close to validation wells. We worked with local partners to acquire well-based measurements of WTE at the time of the acquisition of ~800 line kilometers of AEM data in the Sacramento Valley. The measured depth to the water table ranged from ~4 to ~87 m, showing the large impact that saturation state would have on the derived lithology model if not accounted for in the rock physics transform. We evaluated both methods in the new study area using the WTE measurements; the resulting estimates of the TSZ will, in future work, inform the construction of the rock physics transform. Identifying the TSZ in AEM data allows us to obtain more accurate lithology models as the basis for groundwater management.