

Investigating the capability of time-domain electromagnetic surveys to infer aquifer properties in place of a monitoring well

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SCIENTIFIC GAP

Hydrogeologic investigations are often limited by our ability to quantify subsurface behaviors, but geophysical methods like time-domain electromagnetics (TDEM) have provided a means for imaging the subsurface extent of groundwater resources. Data collected from TDEM surveys has proven valuable for forming geologic models to serve as the basis for groundwater flow models and reducing the uncertainty of estimated aquifer properties. However, the sensitivity of TDEM to transient hydraulic changes during pumping test conditions has not been broadly studied. It is unclear whether the spatial sensitivity of TDEM during these conditions is sufficient to constrain aquifer properties with comparable reliability to conventional methods which require the use of point measurements at monitoring wells.

SCIENTIFIC & SOCIETAL VALUE

Evaluating the sensitivity of TDEM to transient groundwater flow processes has the potential to extend its role beyond imaging subsurface structure and into direct support of hydraulic parameter estimation. If the instrument response measurably reflects changes in subsurface conditions during pumping, TDEM data could be used to constrain aquifer properties rather than simply inform geologic models. A rapid, non-invasive method for obtaining this information would provide a practical way to reduce uncertainty in groundwater model parameterization, particularly in settings where monitoring well data are sparse. Because groundwater flow models are frequently used to inform water allocation decisions, drought planning, and long-term resource management, improving confidence in model inputs has broad societal relevance. Previous studies pairing TDEM with groundwater flow models through coupled hydrogeophysical inversion have demonstrated reductions in parameter uncertainty, but a clearer understanding of spatial sensitivity during transient conditions is needed to determine when and how these approaches are most reliable.

ANALYSIS PLAN

Using a forward modeling approach with the SimPEG Python framework, the response of the TDEM instrument will be simulated under changing subsurface conditions. These simulations will represent transient conditions during an unconfined aquifer pumping test by systematically altering electrical conductivity profiles. Results from these simulations will evaluate how the sensitivity of the instrument changes with depth and how variations in electrical conductivity translate into variations of the spatially averaged TDEM response. Forward model results will also be compared to data collected during an unconfined aquifer pumping test to examine differences between modeled and observed responses, but the majority of this work will focus on virtual pumping tests.

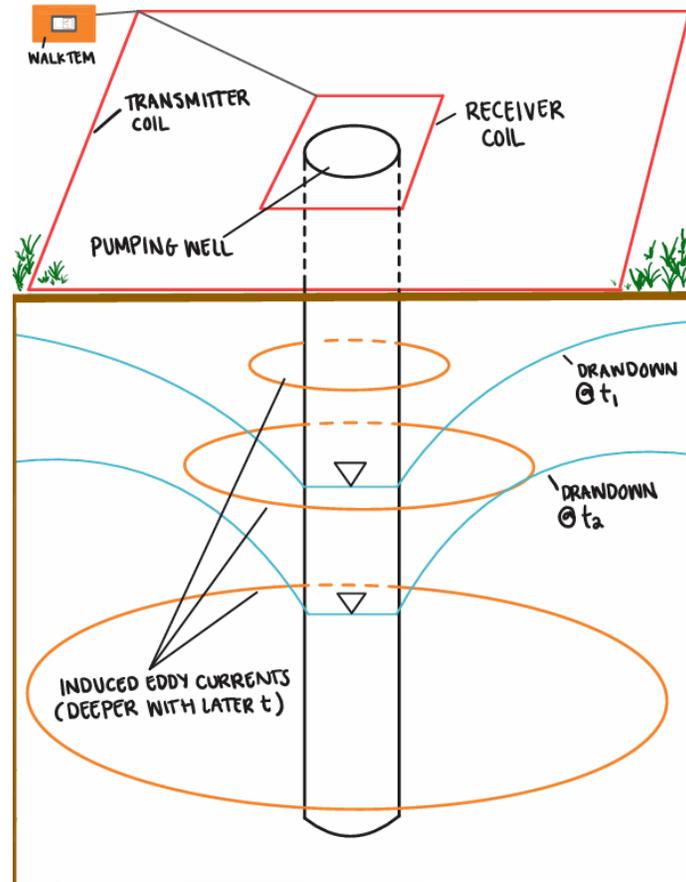


Figure 1. Conceptual image showing ground-based TDEM soundings over a pumping well.

TIMELINE AND MILESTONES:

March

- Begin perturbation analysis using SimPEG
- Present initial results and goals of interdisciplinary project at SAGEEP

April

- Investigate how changing loop geometries and hydrogeologic profiles affect modeled outputs
- Continue field work if appropriate site is found
- Begin writing up results in thesis format

May

- Create geologic model similar to field site at which joint TDEM survey and pumping test were conducted and compare simulated response to observed instrument response
- Continue writing draft

June

- Submit thesis draft to advisor, incorporate changes and any suggested data analysis

July

- Final thesis revisions and preparation of presentation materials