Real-Time 3D Inversion of Deep-Sensing Borehold Electromagnetic Measurements for Reactive Well Navigation Across Spatially Complex Rocks: Applications to Subsurface Water/Energy Production, CO_2 Sequestration, Hydrogen Storage, and Geothermal Systems

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Abstract: This project will develop efficient 3D inversion methods for interpretation of deep-sensing borehole electromagnetic measurements. The main application is for real-time, reactive subsurface well navigation to substantially improve the efficiency of energy projects such as water, hydrocarbon recovery, CO_2 sequestration, hydrogen storage, and geothermal heat conversion. Placing the well across optimal fluid storage/flow zones in the subsurface and designing the well trajectory for best fluid production/injection/containment practices is indisputably the most important factor for the success of all subsurface energy projects, potentially translating into billions of dollars of savings and considerable increases in recovery/storage factors.

Inversion-based 3D interpretation of deep-sensing borehole electromagnetic measurements will be achieved with efficient gradient-based methods implemented with low-order regularization and reduced-order modeling approaches. The inversion algorithms will be executed on massively parallel computers available at TACC and will also estimate the uncertainty of results for quantification of the effects of (a) non-uniqueness, and (b) instability due to inadequate and noisy measurements. The objective is to estimate 3D variations of anisotropic electrical resistivity (and their uncertainty) within a 50 m radius of the well trajectory in real time by processing tens of thousands of tri-axial and multi-frequency measurements acquired along several km-long well trajectories.