OSCILLATORY HYDRAULIC TOMOGRAPHY: NUMERICAL STUDIES

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Hydraulic tomography (HT) consists of two key steps – firstly, collecting of a large quantity of data from a series of pumping tests and then, second, analyzing these data to estimate subsurface parameter variability. HT produces images of subsurface heterogeneity by analyzing a series of pumping tests in a tomographic fashion. While first suggested over 20 years ago, details of how HT is applied have changed greatly in recent years. Because of the simplicity of steady Poisson equation groundwater models, early synthetic HT studies focused on s teady state HT under confined conditions. The assumptions of these early models were restrictive, though, requiring in field practice that a series of long-term pumping tests that achieve steady drawdown conditions be performed. As modeling sophistication has matured, other methods for analyzing HT data allow analysis of transient (i.e., shorter duration) pumping tests using a variety of methods – including, amongst others, temporal moments fitting, "steady shape" fitting, and full transient data fitting.

Instead of traditional constant-rate pumping tests, we propose the use of transient, oscillatory signals as a stimulation strategy for hydraulic tomography, which we designate "oscillatory hydraulic tomography" (OHT). Such a stimulation strategy has several potential advantages for both practical application and inversion of the resulting data. For field experiments, oscillatory pumping does not require that any water be injected or extracted from an aquifer, which is advantageous at contaminated sites (where detailed characterization is most often of interest). Likewise, oscillatory pumping tests may result in practical time-savings, since several oscillatory pumping tests at different frequencies can be carried out at the same time and their responses deconvolved in the frequency domain. Numerically, the use of oscillatory pumping has several advantages in that it allows the use of steady-periodic numerical models for signal analysis, which are faster-running than comparable transient models.

We will discuss in our presentation several key aspects of developing OHT protocols, including:

- Practical testing strategies for both focused aquifer imaging and long-term aquifer monitoring
- Analytical techniques for designing test configurations and optimizing test design.
- Forward, adjoint, and inverse models for analyzing OHT data
- The sensitivity of steady-periodic signals at various frequencies to spatially distributed aquifer flow parameters (K, Ss,Sy)
- The resolution and uncertainty associated with subsurface images produced using OHT.

Our presentation will focus on several key numerical studies which will help to illuminate the range of applicability of the OHT technique. In addition, comparisons of OHT against more traditional hydraulic tomography surveys will be presented, focusing on both practical benefits and drawbacks of each strategy and their effectiveness in producing accurate spatially-distributed aquifer parameter estimates.