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Sequential, Joint, and Coupled Inversion: from the State of the Practice toward Improved Hydrogeophysical Assessment

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The use of geophysics in hydrologic investigations has been expanding rapidly over the past decade. In general, these applications can be divided into two categories: hydrogeologic mapping and hydrologic monitoring. The former application focuses on improving the coverage and resolution of subsurface properties or states. These applications, which can draw directly on advances made during the long history of applications of geophysics to mineral and oil exploration, represent an obvious and immediate benefit of geophysics to hydrology. As with exploration geophysics, these applications seek to identify spatial patterns of geophysical parameters and then to map them to hydrologic properties or states. This can be achieved through direct calibration and/or geostatistical approaches. We refer to this standard approach (collect geophysical data, construct images of geophysical properties, convert to hydrologic property distributions) as sequential hydrogeophysical analysis. Recent work has considered the simultaneous use of multiple geophysical (and hydrologic) measurements to improve both the geophysical images and the conversion to hydrologic property distributions. We refer to simultaneous interpretation of multiple data types as joint inversion. In principle, sequential and joint inverse approaches can be applied to hydrogeologic mapping and hydrologic monitoring. However, typical applications to time-lapse monitoring have been based on the formation of a series of subsurface images at a series of time. These images can be interpreted independently or simultaneously, using temporal relaxation approaches. Very few investigators have attempted to use hydrologic physical process models to interpret time lapse geophysical data. We present a

very simple example that shows the potential power of this approach, which we refer to as coupled hydrogeophyiscal inversion.