ground water

Editorial/

More Data Required

by Keith J. Halford[1]

In the history of hydrogeology, understanding has been limited alternately by analytical tools and by field measurements. Theis' solution was an early analytical tool that shifted the onus of hydrogeologic investigations from developing methods of analysis to collecting and interpreting data. More aquifer tests were conducted and more transmissivities were estimated at field scale in response to the Theis solution. Data assimilation and interpretation again became limited by analytical tools until the advent of numerical methods and affordable computers. Hydrologic investigations ceased to be limited by analytical tools more than 10 years ago as numerical models and cheap, powerful computers proliferated.

Measurement and data limitations currently constrain hydrogeologic understanding even as model complexity increases. Recently, many such increases in model complexity resulted from coupling models to avoid poorly defined boundary conditions that result when separate models are used to simulate individual hydrologic processes. Nevertheless, even when the flux across the former boundaries of the individual models is simulated and consistent, the relation between this simulated flux and reality frequently remains unknown. The magnitude of this problem can be illustrated by considering recent experience with a coupled surface water and ground water model. This example is cited out of familiarity, not because data deficiencies are more egregious for this problem than any other.

For several investigations in Florida, rainfall runoff, surface water routing, and ground water flow models have been shackled together with the intent of improving ground water recharge estimates in humid environments. A coupled model does have the virtue that ground water recharge is a simulated term instead of a poorly defined, spatially distributed fudge factor (an ad hoc parameter that produces a desired result). Calibration is simplified because simulated discharges can be compared directly to measured discharges without attempting to identify surface runoff and ground water discharge components.

Unfortunately, ground water recharge estimates are not likely to improve just because models are coupled. Water still must be partitioned among evapotranspiration, surface runoff, and recharge, regardless of simulation approach. This partitioning is governed by more than a dozen spatially distributed fudge factors in a model that couples rainfall runoff, surface water routing, and ground water flow. Many of these fudge factors, such as canopy interception and macropore storage, are purely empirical factors. Empirical fudges are reasonable, but must be estimated from field measurements.

We cannot know if coupling models is useful and our empirical fudges are adequate unless we have pertinent measurements for comparison with simulated results. Water level measurements and stream discharges are good to have, but are not very helpful for estimating how water is partitioned into evapotranspiration, surface runoff, and recharge. Field-scale measurements of evapotranspiration, soil-moisture content, and hydraulic properties are necessary for meaningful comparisons with simulated quantities.

Model utility also changes as grids are refined and as simulated processes become less generalized. For example, evapotranspiration from ground water frequently is simulated as a linear function of water table depth below land surface. This simple process model has worked in regional flow models with grids of more than 100 m on a side where land surface might have varied more than 10 m between cells. A simple process model might cease to be sufficient at a field scale where evapotranspiration from individual stands of vegetation becomes significant relative to model cell size. Again, one needs pertinent measurements to assess the appropriateness of simulated processes, such as evapotranspiration from ground water.

Hydrogeologic understanding is limited currently by field measurements, not by a lack of models. Increasing model complexity likely will be beneficial, but only if commensurate data are collected to constrain these models. Differences between simulation and measurement that were heretofore assumed to be negligible may be revealed to be significant as additional measurements are collected. Significant differences between simulation and measurement can identify flawed assumptions, which is critical for improving our analytical tools and conceptual models. Relevant, additional data are more likely to dispel ignorance, rather than further simulation.

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