ADVANCES IN THE APPLICATION OF SUBSURFACE TEMPERATURE PROFILES TO TRACE GROUNDWATER FLOW

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ABSTRACT
Quantifying groundwater fluxes to aquifers is a critical task required for sustainable groundwater resources management. Groundwater flow influences subsurface thermal regimes through advective heat transfer, and hydrogeologists have long exploited this knowledge by using temperature to trace groundwater flow. For example, rates of aquifer-river exchange can be inferred from the downward propagation of diel river temperature signals as revealed in multi-depth groundwater temperature-time series. Such approaches are restricted to the shallow subsurface and cannot be applied to yield basin-relevant groundwater fluxes. Alternatively, deeper vertical groundwater fluxes can be quantified through the analysis of temperature-depth profiles. Applications of temperature profile tracing techniques have been limited in research and practice; however, the relatively large spatial and temporal scales of these methods allow for broader applications in groundwater resources management.

Bredehoeft and Papadopulos (1965) derived a parsimonious, steady-state approach for estimating groundwater fluxes from the curvature of temperature profiles, but the steady-state assumption is often violated due to the downward migration of decadal climate warming signals. This research field has experienced a revival in the past five years with a number of new analytical and numerical techniques proposed that account for the influence of climate change and groundwater flow on groundwater temperature. These flexible techniques have been applied in diverse environments and produced recharge rates that are in general agreement with those indicated by other groundwater tracers. Given the uncertainties associated with all groundwater tracers, temperature profiles obtained from existing wells provide an inexpensive, but powerful, complement to other recharge estimation techniques. This study will highlight the history of using temperature profiles to trace groundwater recharge and provide a synthesis of recent methods and their international applications and potential limitations.