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Temperature-depth profiles: An overlooked source of hydrogeological information

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Quantifying groundwater fluxes to and from deep aquifers or shallow sediment is a critical task faced by researchers from many environmental science disciplines including hydrology, hydrogeology, ecology, climatology and oceanography. Because these vertical subsurface flows are slow and typically diffuse, they cannot be measured directly and must rather be estimated using groundwater tracers. 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 time-series approaches are restricted to the shallow subsurface in zones of focused groundwater flow and cannot be applied to yield basin-average groundwater fluxes. Alternative methods that utilize temperature-depth profiles are applicable across a broader range of hydrologic environments, and point-in-time measurements can be quickly taken to cover larger spatial scales.

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 interactions among climate change, groundwater flow, and 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 provide an inexpensive, but underutilized, complement to other recharge estimation techniques. This talk will highlight the history of using temperature profiles to trace groundwater flux and provide a synthesis of recent methods and their international applications.