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An improved time series approach for estimating groundwater recharge from groundwater level fluctuations

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Assuming that changes in groundwater level in an aquifer through time (t) are controlled by the balance of recharge (R) to, and net groundwater drainage (D) away from a given observation point, recharge may be calculated as follows: R = Sy.(Δh/Δt) + D where Sy is the specific yield. One of the main limitations of this method (often termed the water table fluctuation (WTF) method) is in accounting for the drainage term (D) robustly. An increasing lag and attenuation of the rainfall signal with increasing depth to water table is often observed. Thus, in shallow water table situations, R may be much larger than D during a recharge event and so the error in recharge estimation due to error in D may be negligible. However, where depth to the water table is greater and the water table varies more smoothly it becomes more important to account rigorously for D in order to minimise the error in estimating R.

An analytical solution to a linearised Boussinesq equation is extended to develop an expression for groundwater drainage for an ideal aquifer receiving a periodic recharge signal. It is shown that, for a wide range of values of aquifer diffusivity and for locations sufficiently far away from a drainage outlet, D is approximately equal to the average recharge in all but the smallest of catchments. Thus D can be related to the aquifer parameters using a relatively simple steady state solution of the governing equation.

An improved WTF technique for estimating groundwater recharge is presented using this result, extending the standard WTF technique by making it applicable, as long as aquifer properties for the area are relatively well known, in areas with smoothly varying water tables. The method is validated against numerical simulations and a case study from a catchment where recharge is 'known' a priori using other means.