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The use of lysimeters to assess the uncertainty of rainfall recharge model estimates, Canterbury, New Zealand

Paul White
GNS Science, Hydrogeology, Taupo, New Zealand (p.white@gns.cri.nz)

Models of groundwater recharge at the sub-regional scale, including rainfall recharge through the unsaturated zone, are important to the allocation of groundwater to users. SOILMOD/DRAIN is a soil moisture balance model that calculates RR (rainfall recharge) for this purpose. Model inputs include rainfall, PET and PAW (profile available water; which is an estimate of the total available water in the soil profile) and the model assumes runoff is zero which is reasonable over most of the Canterbury Plains. The model was used by Canterbury Regional Council to estimate rainfall recharge in between 1972 and 2003 and to develop groundwater allocation policies.

This paper summarises some characteristics of rainfall recharge measurements at four lysimeter sites (Christchurch Airport, Hororata, Lincoln and Winchmore; ground-level rainfall recorders operated at most of these sites) in the Canterbury area and models of these measurements. Some characteristics of the model were demonstrated by observations at the Lincoln lysimeter in the period spring 1999 and winter 2008 where RR averaged 100 mm/year. Seasonal average RR was largest in winter (79 mm) winter and much lower in spring and autumn (17 mm and 4mm, respectively); average RR in summer is 0 mm. In contrast, the distribution of rainfall was relatively even through the four seasons.

The sensitivity of model RR calculations to input parameters were assessed by varying each parameter by 5%. The sum of RR in the period was most sensitive to rainfall, then PET and least sensitive to PAW, as model RR varied by 15%, 5% and 4%, respectively. In addition, seasonal RR calculations were typically non-linear functions of PAW. For example, RR in summer and autumn was zero where PAW was greater than approximately 155 mm and 255mm, respectively. RR in winter was negatively correlated with PAW through a large range of PAW values; however, RR in spring was almost independent of PAW in the range 100 to 250 mm.

Model calibration demonstrates the value of rainfall recharge observations to the refined PAW estimates. For example, a model that was calibrated to observations at the Lincoln lysimeter estimated PAW as 140 – 180 mm, which was a narrower range of PAW than that estimated by the soil map (130 – 180 mm). PAW estimates at other sites derived by model calibration provided field estimates of PAW that demonstrated the variability of soil properties at local scales, e.g., PAW estimates at the Christchurch Airport site lysimeters were 90 to 100 mm and 60 to 64 mm, which are larger than PAW estimated by the soil map (15 to 50 mm).

Clearly, future models of rainfall recharge should consider the uncertainty in model inputs. Quantification of rainfall uncertainty is the first priority as model rainfall recharge is most sensitive to rainfall. Future research will be aided by a good distribution of rainfall recorders in most parts of Canterbury. In contrast, PET sites are sparsely distributed in the area and therefore this input variable may have large uncertainties.