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An approach to identify spatial and temporal variability in surface groundwater interactions

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Interactions between surface and groundwaters are complex and the underlying hydrogeological controls on their occurrence are poorly understood at the site, river-reach and catchment scale. The exceptions tend to be small, densely instrumented research locations where intensive monitoring data are available. There is a pressing need to investigate surface-groundwater interactions at multiple scales and provide methods which may be used for conceptualisation of both underlying processes and heterogeneity.

This paper identifies and analyses surface-groundwater interactions (SWGWI) occurring in a lowland permeable Chalk catchment in Dorset, UK, where groundwater dominates river flows (by around 80 to 90%) and spring sources control the transfer of groundwater to the surface water system.

We do this for multiple scales, first identifying the hydrogeological controls on individual spring sources, then considering the controls on streamflow accretion / depletion for river reaches, using spot flow gauging records, and then we use permanent flow gauging records to conceptualise the spatial and temporal heterogeneity in interactions at a catchment and sub-catchment scale.

At the site-scale, our results indicate the utility of a new Chalk lithostratigraphy in identifying the hydrogeological controls on individual spring sources aided by more detail in the mapping of lithology and geological structure, but this does not appear to infer a hydrostratigraphy.
At the river-reach scale, results suggest

(1) the majority of river flow volume is provided by perennial spring sources in particular locations;
(2) there are large numbers of headwater springs which flow intermittently and contribute relatively small volumes of water, but are crucial for maintaining streamflow during the summer;
(3) certain river reaches can be identified as predominant sources of groundwater, whilst others are predominant sinks, and these are a function of the underlying river valley lithology and geological structure.

At the sub-catchment to catchment scale, our method of analysing permanent streamflow gauging records (expressed as a depth of water per unit of surface water catchment area) enables the spatial and temporal heterogeneity of surface-groundwater interactions to be identified. Comparisons of observed hydrographs over several water years allows relative contribution of SWGWI to streamflow in different sub-catchments to be determined, and the temporal variability of these contributions and a cyclical component linked to the seasonal changes in groundwater catchment area.

These results provide a comprehensive description of the spatial and temporal heterogeneity in surface-groundwater interactions at multiple scales in the study catchment, and the methods are transferrable to other areas where data exist.