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Pristine savannas: spatio-temporal variability in groundwater surface-water interactions in ephemeral drainages

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The knowledge of hydrological processes in ephemeral catchments of arid landscapes has been steadily growing in recent years, however few coupled groundwater surface-water studies of this nature have been conducted with the explicit link to savanna environments. It is important to understand these processes as savannas worldwide continue to experience rapid land-use changes, with an assumed significant impact on water resources availability.

The landscape of the Kruger National Park (KNP) in South Africa is characterised by mixed savanna woodland whose ecological variability is tightly coupled to the distribution of catena sequences, within approximately 20 000 km of ephemeral streams. This study supported the establishment of the KNP Supersites, initiated in 2011 to encourage integrated learning of savanna ecosystem patterns and processes on non-manipulated sites on both granite and basalt regions. In so doing the abiotic template of these sites commenced which included the quantification of groundwater-surface water interaction in low order catchments (1st to 3rd order systems) on these two diametrically opposing geologies existing in similar semi-arid settings.

This study presents quantification of hydrological connectivity in these ephemeral landscapes during two wet seasons between 2012-14, through observations: of multi-peizometer borehole networks; hydrometric data of the surface and vadose zones; hydrochemical tracer based studies; and surface energy balance remote sensing data to derive the status of surface-subsurface fluxes at various spatial scales (catena element, hillslope, stream and underlying aquifers).

In both settings clearly differentiated aquifers existed between deep hardrock and shallow weathered material, whilst groundwater hydraulic gradients followed the regional topography rather than that of the smaller scale low order catchments themselves. The 2nd order streams on both geologies where found to be significant conduits for groundwater recharge arising from abrupt geomorphic transitions to 3rd order systems. Typical groundwater recharge occurred following an Antedecent Precipitation Index (API) of 100 mm and 130 mm for the granites and basalts respectively. Typically runoff coefficients decreased with increasing catchment order on the granites for low intensity rainfall sequences, with an API below 50 mm, thereafter runoff coefficients increased with catchment order. Whereas on the basalts runoff coefficients increased with catchment order when the API was > 35 mm. Meanwhile flows were typically dominated by 70% and 90% event water contributions on the granites and basalts, respectively. On the basalts actual evapotranspiration was $\sim$200 mm less than on the granites, during the summer wet season, with the crest regions having the greatest actual evapotranspiration. This being marginally higher at lower orders, which is attributed to both lower topographic gradients and deeper soil moisture storage.

The findings are integrated in this paper to yield concise conceptual models of hydrogeological processes in these ephemeral catchment settings. Moreover, management implications are discussed in the context of land-use changes, inferred from observed impacts in comparable settings immediately adjacent to the KNP.