IAHS2017-135
IAHS Scientific Assembly 2017

Use of surface and groundwater data to build a multi-scale hydrologic model of a semi-arid, meso-scale catchment, the Baviaanskloof, South Africa

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This study demonstrates how observations of surface and sub-surface flows at various spatial and temporal scales were used to develop a hydrologic model of the Baviaanskloof, a mountainous, semi-arid, meso-scale, water supply catchment in South Africa's Eastern Cape. This catchment area feeds the Kouga Reservoir, a regionally important water source for urban centers and commercial agriculture. Hydrologic modelling of meso-scale catchment areas (100-10,000 km2) can assist catchment management by producing streamflow and groundwater predictions at scales relevant to managing major water supplies. Physically mechanistic and spatially discretized models are particularly useful in this regard because they allow for prediction of changes in water resources under different land management scenarios. However, the understanding of hydrologic processes that is used to construct mechanistic models is frequently sourced from observations made at the field plot or micro-catchment scale. This can present a challenge when modelling larger areas. Allowing multiple scales of process representation and spatial discretization in a catchment model structure is one way to incorporate the different scales of process understanding afforded by available data.

A network of observation points for rainfall, temperature, groundwater level, and surface water flow in the Baviaanskloof catchment has been monitored since 2012. This provided information about catchment processes at scales ranging from 200 m long hillslope and floodplain segments up to the entire 1,234 km2. Data were analysed for diagnostic patterns that gave insights about hydrologic connectivity across various scales. Two key results were that: a) the central valley alluvial aquifer is recharged by subsurface flows from surrounding mountain areas following multiple distinct pathways, both from interflow and a more temporally consistent bedrock aquifer contribution, and b) the direction of exchange between the alluvial aquifer and floodplain channel fluctuates regularly. The resulting levels of conceptual understanding of surface and subsurface flow in the Baviaanskloof catchment led to a multi-scale numeric model in which coarser process representation was used for the large mountainous areas and finer-scale representation for the floodplain areas and main river channel.