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Estimation of groundwater recharge via percolation outputs from a rainfall/runoff model for the Verlorenvlei estuarine system, west coast, South Africa

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ABSTRACT

Wetlands are conservation priorities worldwide, due to their high biodiversity and productivity, but are under threat from agricultural and climate change stresses. To improve the water management practices and resource allocation in these complex systems, a modelling approach has been developed to estimate potential recharge for data poor catchments using rainfall data and basic assumptions regarding soil and aquifer properties. The Verlorenvlei estuarine lake (RAMSAR #525) on the west coast of South Africa is a data poor catchment where rainfall records have been supplemented with farmer's rainfall records. The catchment has multiple competing users. To determine the ecological reserve for the wetlands, the spatial and temporal distribution of recharge had to be well constrained using the J2000 rainfall/runoff model. The majority of rainfall occurs in the mountains (±650 mm/yr) and considerably less in the valley (±280 mm/yr). Percolation was modelled as ~3.6% of rainfall in the driest parts of the catchment, ~10% of rainfall in the moderately wet parts of the catchment and ~8.4% but up to 28.9% of rainfall in the wettest parts of the catchment. The model results are representative of rainfall and water level measurements in the catchment, and compare well with water table fluctuation technique, although estimates are dissimilar to previous estimates within the catchment. This is most likely due to the daily timestep nature of the model, in comparison to other yearly average methods. These results go some way in understanding the fact that although most semi-arid catchments have very low yearly recharge estimates, they are still capable of sustaining high biodiversity levels. This demonstrates the importance of incorporating shorter term recharge event modeling for improving recharge estimates.

1. Introduction

Wetlands are systems that are saturated either by surface or groundwater with vegetation that has adapted to periods of saturated soil conditions. These systems are regarded as one of the most productive ecosystems on earth, providing valuable functions in filtering water, collecting sediments and retarding flow during flood events (Barbier et al., 1997; Baron et al., 2002). Due to the highly productive nature of these systems, they have also been the target of often intensive agricultural development (Schuyt, 2005), resulting in competition for water resources. The availability of water is further impacted by climate change (Fay et al., 2016) and high potential evapotranspiration (Přibáň and Ondok, 1985), which exacerbate this competition. Whilst the amount of water needed to sustain different agricultural crops is well constrained (Allen et al., 1998), less constrained is the water needed for the ecology and biodiversity profile of natural wetlands, often termed the ecological reserve. The ecological reserve is defined by the quantity and quality of water that is required to maintain aquatic ecosystems (Hughes, 2001). These maintenance conditions are identified using ecological, geomorphological, hydraulic and hydrological knowledge of each system. Usually maintenance flow requirements are set for both peak and low flow periods, during average and low rainfall years, although the survival of wetlands is critically dependent on the degree to which the ecological reserve is met during low flow, especially during drought years. During such times, baseflow from aquifers contributes the majority of the ecological reserve, and for this reason baseflow is one of the most important parameters to constrain in a wetland catchment.

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