Evaluation of uncertainty in capturing the spatial variability and magnitudes of extreme hydrological events for the uMngeni catchment, South Africa

Samuel Kusangaya[a,] Michele L. Warburton Toucher[a,] Emma Archer van Garderen[b]

[a] University of KwaZulu Natal, Centre for Water Resources Research, School of Agricultural, Earth and Environmental Sciences, Private Bag X01, Scottsville, Pietermaritzburg 3209, South Africa
[b] Council for Scientific and Industrial Research (CSIR), Natural Resources & the Environment Building 1, cnr Carlow & Rustenburg Roads, Melville, Johannesburg, South Africa

Abstract

Downscaled General Circulation Models (GCMs) output are used to forecast climate change and provide information used as input for hydrological modelling. Given that our understanding of climate change points towards an increasing frequency, timing and intensity of extreme hydrological events, there is therefore the need to assess the ability of downscaled GCMs to capture these extreme hydrological events. Extreme hydrological events play a significant role in regulating the structure and function of rivers and associated ecosystems. In this study, the Indicators of Hydrologic Alteration (IHA) method was adapted to assess the ability of simulated streamflow (using downscaled GCMs (dGCMs)) in capturing extreme river dynamics (high and low flows), as compared to streamflow simulated using historical climate data from 1960 to 2000. The ACRU hydrological model was used for simulating streamflow for the 13 water management units of the uMngeni Catchment, South Africa. Statistically downscaled climate models obtained from the Climate System Analysis Group at the University of Cape Town were used as input for the ACRU Model. Results indicated that, high flows and extreme high flows (one in ten year high flows/large flood events) were poorly represented both in terms of timing, frequency and magnitude. Simulated streamflow using dGCMs data also captures more low flows and extreme low flows (one in ten year lowest flows) than that captured in streamflow simulated using historical climate data. The overall conclusion was that although dGCMs output can reasonably be used to simulate overall streamflow, it performs poorly when simulating extreme high and low flows. Streamflow simulation from dGCMs must thus be used with caution in hydrological applications, particularly for design hydrology, as extreme high and low flows are still poorly represented. This, arguably calls for the further improvement of downscaling techniques in order to generate climate data more relevant and useful for hydrological applications such as in design hydrology. Nevertheless, the availability of downscaled climatic output provide the potential of exploring climate model uncertainties in different hydro climatic regions at local scales where forcing data is often less accessible but more accurate at finer spatial scales and with adequate spatial detail.