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Modelling the hillslope storage-discharge dynamics under changing climate

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Water availability at the river basin-scale is largely influenced by the water storage-discharge dynamics of the constituting hillslopes. These hillslopes partition the precipitation input into different fluxes of evapotranspiration, surface and subsurface runoffs, and soil moisture storage components in the vadose zone and saturated (groundwater) zone. Hence, for the river basin-scale climate change impact assessment on the subsurface flow, it is essential to understand the subsurface storage-discharge dynamics at the hillslope-scale. However, unavailability of information on the aquifer hydraulic properties at the suitable scale, hillslope topography, inadequacy of the existing models to include hillslope geomorphology, such as, the convergence and divergence of the hillslope plan-form geometry, are the major limitations for such studies. To address these issues, in this study, a low dimensional hillslope-scale model, viz., the hillslope storage Boussinesq (hsB) model is applied to a sub-catchment of the Baitarani River in eastern India having tropical monsoon-type climate. The one-dimensional (1-D) hsB model accounts for the three dimensional (3-D) flow domain by incorporating the hillslope plan-form geometry and profile shape; and hence, is as effective as a 3-D model. The calibrated set up is used for modelling the hillslope storage-discharge dynamics under different climate change trajectories, forecasted by the Intergovernmental Panel on Climate Change (IPCC), called as RCPs (representative concentration pathways) of 4.5, 6.0 and 8.5. The model is forced with the downscaled RCP data. The results reveal that the non-monsoon (dry season) subsurface discharge is more affected by the RCP scenarios in comparison to that during the monsoon (wet) season. Similarly, the vadose zone storage, which is the principal source of moisture for the perennial trees, is found to be fluctuating. This study provides a detailed understanding on how the climate change scenarios could impact on the baseflow dynamics of the study area under limited data-availability conditions with a future scope of upscaling the model for real-world ungauged river basins.

Keywords: climate change impact, subsurface storage-discharge, baseflow, hillslope-storage Boussinesq model