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Developing hillslope-based catchment models: coupling Boussinesq and regional scale flow models

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The gaining recognition of hillslopes as fundamental building blocks in watershed hydrology makes them appealing for incorporation into larger scale river basin models. Hillslope processes are commonly simulated by means of the Boussinesq equation and are therefore applicable to single layer flow systems only. Two coupled models are presented to simulate both local hillslope scale and regional scale groundwater flow: 1) the hillslope-storage Boussinesq (hsB) model representing unconfined flow and a steady, analytic element model representing transient regional deep groundwater flow through a succession of steady state stress periods over many hydrological years, and 2) the hsB model and a newly developed analytical solution for 1D transient confined groundwater flow. Recharge zones are defined by means of irregular geometric domains, capturing the plan form geometry of the hillslopes. Lateral flows are calculated in inclined aquifers of homogeneous thickness. Tests are conducted on i) single hillslopes of varying inclination and plan form geometry and ii) a laboratory watershed, and heads and baseflows are compared to the results from a fully coupled 3D Richards equation model. Both approaches presented provide reasonable heads and fluxes for a range of hillslope properties in comparison to the benchmark model, and are promising approaches, applicable to a range of land surface models that lack a detailed description of subsurface flow. However the coupled hsB/1D-analytical model is numerically more stable and computationally more efficient than the coupled hsB/analytic element model.