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Drainflow: a fully distributed integrated surface/subsurface flow model for drainage studies

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The scale of drainage studies may vary from high-resolution small scale investigations through to comprehensive catchment or regional-scale studies. This wide range of scales poses a significant challenge for the development of a suitable drainage model.
To meet this demand, a fully distributed surface/subsurface interactive flow model named henceforth Drainflow has been developed. Drainflow includes both the Saint Venant equations for surface flow components and the Richards equation for saturated and unsaturated zones. To develop the model, surface and subsurface flow modules are formulated separately, then each component is connected to the other parts. All modules simultaneously interact to calculate water level and discharge in tile drains, channel networks, and overland flow. In the subsurface domain, the model also yields soil moisture and water table elevation. A smoothed Heaviside function is introduced to give a continuous transition of the model between Dirichlet and Neumann boundary conditions for tile drains and surface/subsurface flow interface boundaries.
Compared to traditional drainage studies, Drainflow has the advantage of estimating the land surface recharge (LSR) directly from the partial differential Richards equation rather than via an analytical or empirical drainage method like the Green and Ampt equation.
To test the model's accuracy, comparisons are made between Drainflow and a range of surface/subsurface flow models for five published integrated surface and subsurface problems. The comparison indicates Drainflow has a reasonably good agreement with the other integrated models. Furthermore, it is shown that the smoothed Heaviside functions technique is a very effective method to overcome the non-linearity problem created from switching between dry and wet boundary conditions.
In addition, Drainflow was run for some drainage study examples and was found to be fairly flexible in terms of changing all or part of the model dimensions as required by problem complexity, scale, and data availability. Drainflow can be easily simplified dimensionally or methodologically to a less comprehensive and less complex model if required. This flexibility gives Drainflow the capacity to be modified to meet the specific requirements of the varying scale and boundary conditions often encountered in drainage studies.