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Low-dimensional modelling of large-scale hillslope hydrology

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Lateral, topography driven, subsurface stormflow on the hillslope scale is a significant process governing the hydrology of most upland regions within the temperate climate zone. An efficient modelling scheme for this process is required for processed-based earth-system models where more empirical land surface models approaches are insufficient due to the lack of a direct relationship between physical parameters and model parameters, which is especially relevant when changes in these physical parameters are expected.

We present an efficient model for lateral stormflow that incorporates both the saturated and unsaturated zone. The model extends an earlier formulation by Blain and Milly (Adv. Wat. Res., 1991) that assumes local and successive hydrostatic equilibrium within the vertical. While their model eventually abandonned unsaturated zone store, we do include this and so create a local total storage–transmissivity relationship that is combined with the Boussinesq flux equation and a simple reduction-based evapotranspiration scheme.

Integrating over the hillslope width creates a 1 dimensional hillslope-scale model formulation that can be combined with statistics of hillslope planform shape and orientation to arrive at an efficient model scheme for (relatively) statistically homogeneous areas, such as physiographic units.

We present the model approach, make comparisons with alternative formulations (e.g. VIC, TOPLATS) and present initial results of the model applied to idealized and/or real topography.