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Comparing different approaches to parameterize sub-grid scale variability of topography

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Distributed macro-scale hydrological models and land surface models typically operate at resolutions of multiple square kilometers. Variability in soil, vegetation and topography, however, usually occurs at much smaller scales. For an accurate simulation of the water balance, this small-scale variability needs to be taken into account because it can influence the spatially averaged discharge and evapotranspiration. Because it cannot be resolved explicitly at these coarse model resolutions, it needs to be parameterized. Several approaches exist to do so. We compare three models that employ different approaches to a small, Alpine catchment, the Rietholzbach in Switzerland, measuring about 3.2 km2. The first model is the Variable Infiltration Capacity (VIC) model. It divides the grid cell into tiles based on vegetation type and elevation zone, and parameterizes small-scale variability of topography with an exponential function relating the infiltration capacity to the fraction of the grid cell that is saturated. The second model, TOPMODEL, employs a similarity index based on local slope and contributing area as they are derived from digital terrain information to derive a distribution of this so-called topographic index within a macro-scale grid cell or catchment. The third model is based on the hillslope-storage Boussinesq (hsB) model. The catchment is divided into individual hillslopes based on digital terrain information, and the hsB model is applied to each hillslope. Based on hillslope similarity parameters, individual hillslopes can then be grouped. Both TOPMODEL and hsB are coupled to an unsaturated zone model that solves the coupled water and energy balance. For TOPMODEL, effectively the TOPLATS land surface scheme is thus obtained. Spatially averaged evapotranspiration and streamflow as simulated by all models are compared with observations. In addition, the effect of aggregation will be investigated: for hsB the simulation of individual hillslopes will be compared with the simulation of classes of similar hillslopes. For TOPMODEL, the simulation of individual pixels (from a high-resolution DEM) is compared with the simulation of classes of pixels with similar topographic index and exposure.