Numerical Simulation of Groundwater Recharge and Discharge in Escarpment Retreat

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Abstract.
Escarpment retreat and the associated development of river basins are controlled by fluvial and hillslope denudation processes and, at large scales, isostatic uplift rates. Water drives the fluvial erosion processes, which depend on precipitation rates, soil moisture patterns, and groundwater movement. Groundwater is expected to be especially important to escarpment retreat if seepage faces occur on the escarpment edge. In this analysis, we investigate the role that groundwater movement plays in escarpment retreat using a modified landscape evolution model. In the model, precipitation is produced by a stochastic process that includes realistic temporal variation, and the precipitation is partitioned between surface runoff and groundwater using specified infiltration and recharge rates. Groundwater flow is described by a two-dimensional Dupuit equation for a homogeneous isotropic unconfined aquifer. The detachment-limited condition is assumed and the fluvial erosion is modeled as a power function of water discharge, which is composed of surface runoff and groundwater discharge. Two end-member cases are considered. In one case, the infiltration capacity is set to zero, so surface runoff is Hortonian and groundwater discharge is zero. In the other case, the infiltration capacity is large so that groundwater discharge is the primary source of flow in the channels. The numerical results show significant differences in the mode of escarpment retreat and the resulting river basin topography. These results indicate that infiltration capacity is an important control on escarpment retreat and river network development.