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Rainfall-runoff-erosion modelling: Application of the ETC model to a small marly mountainous catchment, the Moulin (Draix, Alpes de Haute Provence, France).

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The ETC model is a conceptual spacialized model, working at the event scale with a rainfall-runoff component, followed by an erosion and transport component, taking into account the deposition, scouring and armoring processes. This model has been developed in Cemagref Grenoble since 1990 and was used both for research and applied study purposes for small mountainous catchments up to 50 or 100 km^2. It is a composed and evolutional model: for each elementary process (rainfall-runoff, rainfall-erosion, bed-load transport, etc...) different models are available or may be added.
The different components of the model are linked, some are working on the slopes, and some are working on the channels. On the slopes, rainfall-runoff component and rainfall-erosion component supply flow and sediments to the channel network. In the channels, the bed-load transport component refers to notions of maximum bedload transport capacity and initiation of sediment transport. It can take into account the armouring of the bed.
The basin is represented as a tree of slopes or sub-basins connected to channel reaches. For each unit the mean values of the characteristics are used as parameters. Therefore, each unit must be delimited in order to have physiographic features as homogeneous as possible. The spatial representation allows taking into account the variability of the features inside the whole basin. For example, geology, slope gradient and vegetation cover for the sub-basins, width, slope gradient and grain size distribution for the channels. The rainfall depth may be spatialized too. ETC makes the sum of the fluxes from upstream at each knot and applies the continuity equation to the water and sediment fluxes between the different units.
Several simple rainfall-runoff elementary models are available. In the channel the hydrograph is routed with a kinematic wave approximation or is translated without deformation according to the mean velocity. The rainfall erosion on the slope component can incorporate the results of existing slope processes models. When no model is adapted, the global ablation of each slope is empirically assessed for the considered flood. This global amount is distributed along the time proportionally to runoff at the outlet of the slope. In the channel the maximum transport capacity can be evaluated by different solid transport formulas adapted to steep slope reaches, for example formula given by Smart et Jaeggi (1983), Rickenmann (1990) and Lefort (1991).

The ETC model was used on the data sets from the Moulin catchment (0.089 km^2), one of the small basins of the Draix experimental site. This observatory, created in the period 1983-1984 aim principally at studying mountain erosion processes. The substratum of the basins is black marls, a very erodible ground. As a result, erosion processes and sediment transport are particularly high in that area. Four small watersheds, from 1000 m^2 to 1 km^2 are monitored for rainfall, runoff and solid transport.

Different levels of the spatial representation were tested for the Moulin basin, from a very detailed representation (77 slope units and 30 channel reaches) to a simplified representation (3 sub-basins and 3 reaches). In the complete version, the ability of ETC to model the seasonality of erosion and transport processes all around the year was verified. For most of the events (except for the small ones), the location of the deposition or scouring processes in the reaches was correctly described. In the simplified version, we need to adjust the slope of the reaches to a "functional slope" different of the "geometrical slope" in order to reproduce the sediment storing in the network. This appears as an additive parameter of the model.