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Rill and inter-rill erosion for two-dimensional overland flow: laboratory experiments on a soil flume

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Overland flow generation on a hillslope can be seen as a two-dimensional (2-D) process. In many studies the hillslope is represented as a plane surface with a certain longitudinal slope, and 1D models (e.g. kinematic wave theory) are used to simulate the overland flow generation process. However, most hillslopes also have a transversal slope and, in order to correctly represent overland flow and the associated transport process, a 2-D model for overland flow needs to be developed. Laboratory experiments can be a useful tool to test the performance of such a model.

The work described here aimed to provide experimental data so that a model able to simulate 2-D overland flow could be built. The goal of this experimental study was to assess the rill and inter-rill two dimensional overland flows and sediment loss.

Three experiments were carried out at the Laboratório de Hidráulica, Recursos Hídricos e Ambiente (LHRHA) of the University of Coimbra, Portugal. The basic experimental set-up consisted of a soil flume and a rainfall simulator. The soil flume was made out of a square box, 2m $\times$ 2m, adjustable to two different slopes, one in x-direction and the other in y-direction. The box was filled with an erodible soil (12% clay, 10% silt, 26% fine sand, 52% coarse sand). The soil was prepared by achieving a bulk density of 1565 kg/m^3 (original bulk density). The rainfall simulator was made of three nozzles at a distance of 0.5 m and was able to deliver a simulated rainfall with a constant intensity of 3.53 mm/min. The overland flow velocity was assessed, using a high resolution video-camera (dye was applied to the flume surface and 4 photographs were taken every 0.7 sec).

Three surface slopes were tested: i_x=10% and i_y=1%, i_x=10% and i_y=20%, and i_x=2% and i_y=20%, with an initial smooth soil surface and constant rainfall intensity during each experiment. Each experiment consisted of a sequence of several rainfall events with rainfall durations of less than 30 minutes. Runoff discharge and sediment loss were measured, in particular, the inter-rill overland flow in the two directionsQ_x, Q_y, rill flowQ_r(as soon as a rill appeared) and sediment losses q_x, q_y, q_r.

These data can also be used to check and compare different 2-D numerical schemes. In forthcoming experimental studies we intend to collect data with other experimental conditions, namely: different soils, different slopes, and wind-driven rains with different intensities.