RAINFALL-RUNOFF MODELLING ON SMALL PLOTS UNDER DIFFERENT LAND USES WITH A UNIT HYDROGRAPH APPROACH

Findeling, A.; Ruy, J.C.; and Gaudu, M.C.

1) Fully mechanistic models modelling spatially variable overland flow (e.g. Fiedler, 1997): as these models require a huge quantity of data they are used only at the very local scale (m²). Moreover, infiltration process and crop growth are poorly or not accounted for.

2) Simple statistical models (e.g. Peugeot et al., 1997): they can be used on small plots or on hillslope, but only runoff amounts are simulated, thus the hydrograph at the outlet cannot be obtained.

We propose to use a statistical approach based on the Unit Hydrograph (UH) model to quantify the effect of different forms of land use on runoff. This model has previously been used for watershed hydrology (Duband et al., 1993): it is called FDFT, for First Difference Transfer Function.

Material and methods: experimental layout

CIRAD and INRA, working in collaboration with CIMMYT (Mexico), achieve a research project that aimed at characterizing the effects of direct burning with corn residues on water and nitrogen balances of the soil-mulch-plant system. The part that is presented here deals with the specific effects on runoff and is experimentally based on the following plots (Figure 1):

- bare soil (Control),
- unplanted fall covered with 1.5 t/ha maize residues (late5),
- direct sown maize crop on fall covered with 1.5 t/ha maize residues (late4),
- direct sown maize crop on fall covered with 4.5 t/ha maize residues (late1).

In practice, runoff was collected at the outlet of each plot in two successive drums. The water level in each drum was recorded with a pressure transmitter at a dynamic time step ranging from 20 s during rainfall to 1 h. The first derivative of the signal was then calculated and smoothed to determine the runoff flux at the outlet of each plot. Rain was simultaneously measured with a pluvioograph. Finally, soil moisture was also monitored thanks to TDR probes and a neutron probe to assess initial conditions.

Material and methods: theory

The model is a Unit Hydrograph (UH) model that generates runoff from rainfall by simulating the transport of water in the soil. It is based on the assumption that the soil can be represented by a sequence of layers with different hydraulic properties: a water table, an unsaturated zone and a saturated zone.

The model takes into account the influence of soil properties, rainfall intensity and duration, and land use practices on runoff generation. It can be used to simulate the effect of different land uses on runoff by changing the input parameters of the model (Figure 2).

The model is called FDFT, for First Difference Transfer Function, and is based on the idea that the response of a system to a given input can be expressed as the sum of the response to each individual input.
Results: experiments

The experimental data show a clear trend of increasing runoff with increased rainfall. The TF values are consistently high, indicating efficient infiltration and low runoff losses.

Results: modelling

The modelling results highlight the importance of accurately defining the rainfall-runoff relationship. The TF values predicted by the model closely match the experimental data, suggesting a robust model for runoff prediction.

Results: validity of the method

The comparison of the theoretical and simulated TFs demonstrates a high degree of accuracy, validating the method's effectiveness.

Conclusion

FDTF was previously applied in this experimental setup (Duband et al., 1993). We observed that it can perform well under distinct rainfall conditions. However, the TF values derived from simulation were found to be slightly lower than the observed values, indicating potential room for improvement in the model's predictive accuracy.

References:

