THE EFFECT OF MOVING STORM ACCELERATION ON RUNOFF HYDROGRAPHS

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Introduction

The large majority of runoff studies assume that storms are stationary. However, runoff hydrographs are strongly influenced by the characteristics and spatial variability of rainfall, which is frequently generated by moving storms. The effect of moving storms on the characteristics of runoff hydrographs has been known for many decades. Storm movement influence on the shape of the hydrograph and peak discharges depends on its direction, speed, length and pattern.

This study reports a preliminary assessment of this effect by numerically and experimentally modelling the dominant processes involved in the response of a plane surface (pervious or impervious) to accelerating or decelerating storms, aiming at relating the variable speed of moving storms to hydrograph characteristics.

Numerical simulation and experimental procedure

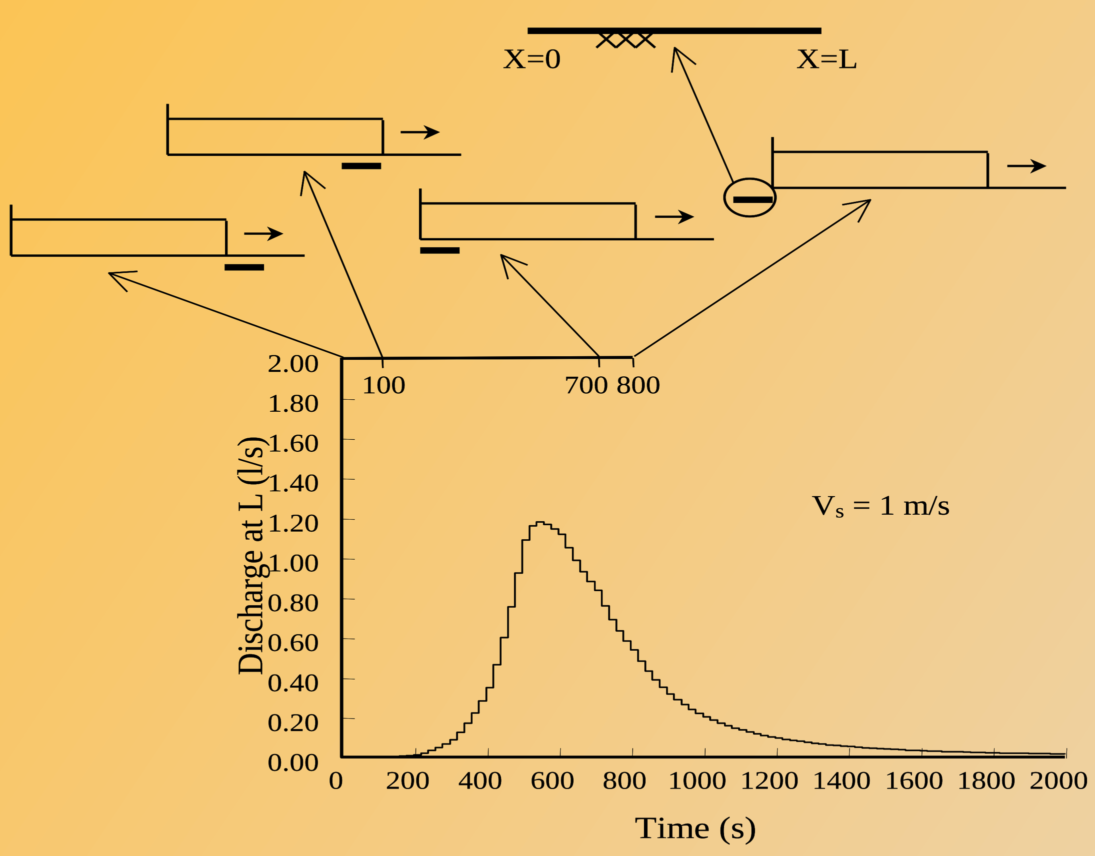

Figure 1 – Example of storm movement with milestones and respective runoff response.

Figure 2 – Rainfall simulator infrastructure.

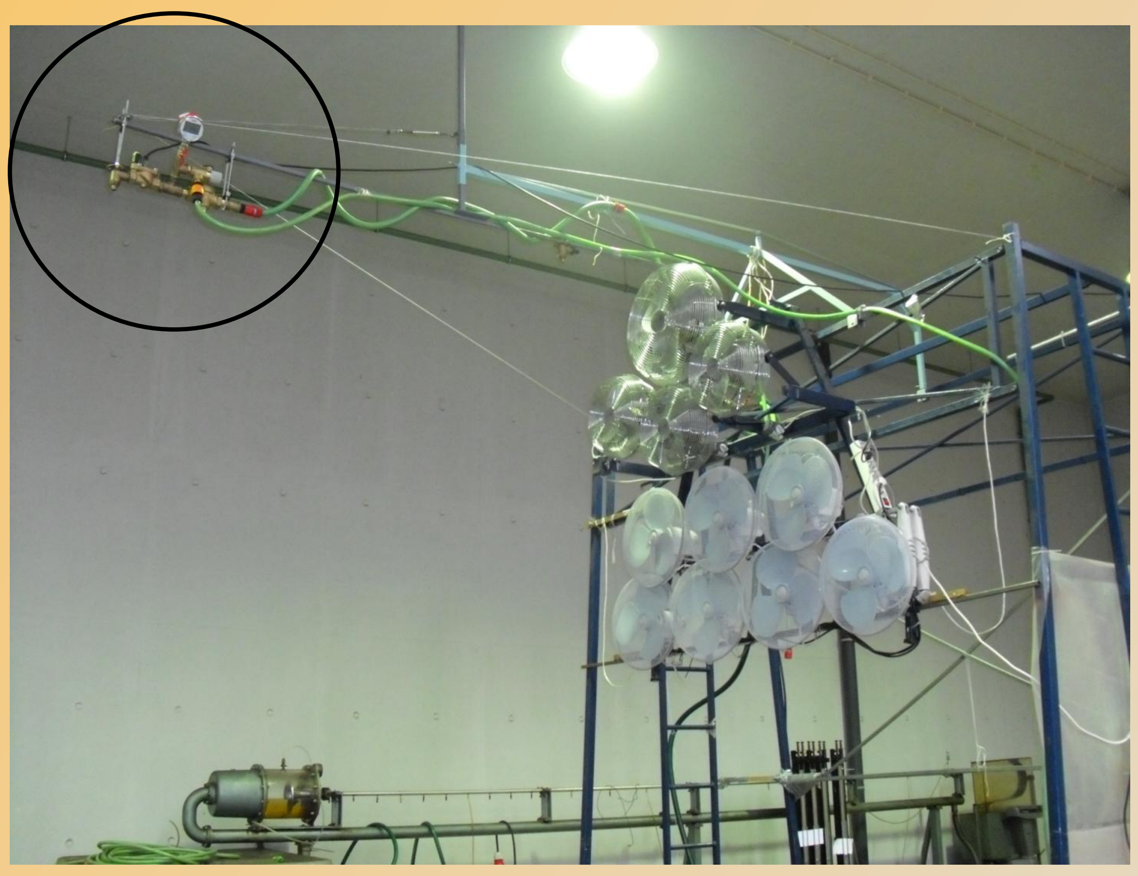

Figure 3 – Rainfall simulator superstructure.

Figure 4 – Flow control system.

To evaluate the hydrologic response of plane surfaces to storm movement, a fixed uniform rainstorm block pattern with variable speed was considered and maintained for the entire duration of the simulation as shown in Fig. 1.

The physical laboratory model used a flume and a rainfall sprinkler-type simulator installed on a structure that was electrically driven along a rail to simulate raincell movements and wind effect. The rainfall simulator comprised:

- a constant level reservoir;
- a pump;
- a system of hoses;
- a stand;
- two electric engines;
- an automatic control panel to control the speed at which the apparatus moved (the structure was electrically driven along a rail (Fig. 2) to simulate the raincell movement);
- a set of seven electric fans (to simulate the existence of wind) and a sprinkler (Fig. 3) with flow control and (constant) pressure gauge (Fig. 4) fixed on a connecting rod on the stand 2.0 m above the surface physical model.

Kinematic wave equations for planar flow, solved by the Lax-Wendroff method, were used in the numerical model. For both physical and numerical modelling, simulated storms were moved up and down the plane at non-uniform speed, over a range of acceleration levels, simulating one single dry-wet-dry cycle. One and two-dimensional numerical modelling was performed and the results were compared with observations.

Effect of storm acceleration

Taking into consideration the motion of a rectangular block storm over an impervious plane surface at a constant speed Vs, as represented in Fig. 5, the rainfall input at the surface, in time, is represented in Fig. 6. Top: constant speed, Vs; Middle: positive acceleration, a > 0; Bottom: negative acceleration, a < 0.

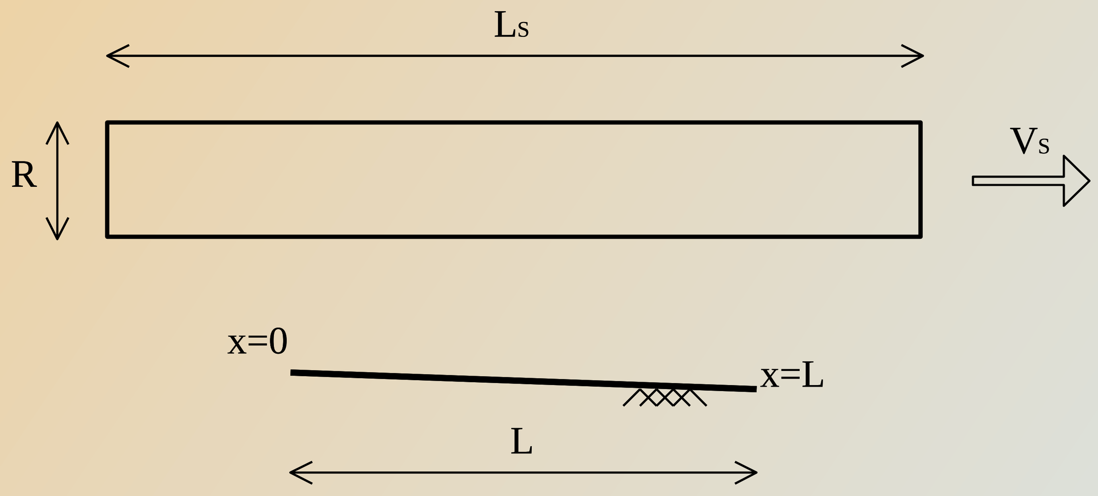

Figure 5 – Rectangular block rainstorm (uniform constant rainfall pattern with length Ls, moving across a plane).

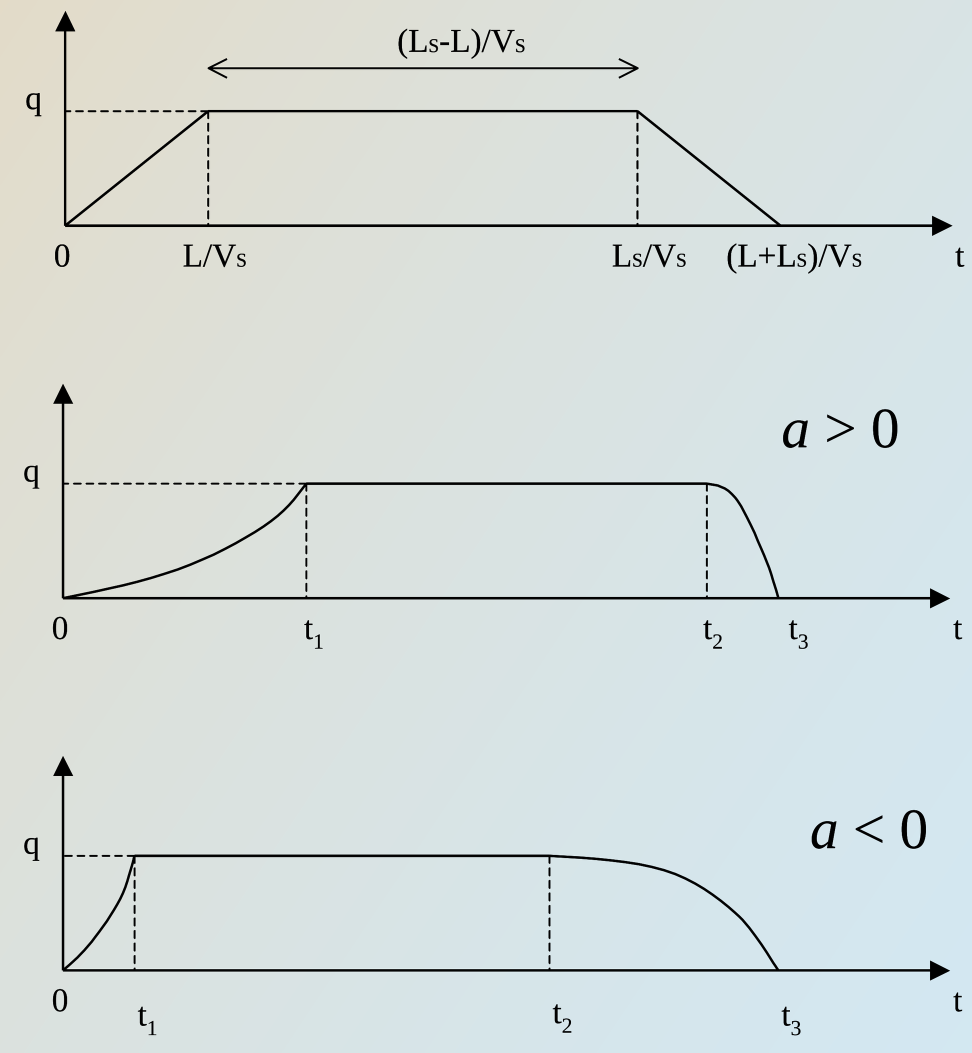

Figure 6 – Rainfall input for moving storms.

Figure 7 – RADAR image of raincell movement in the South of Portugal.

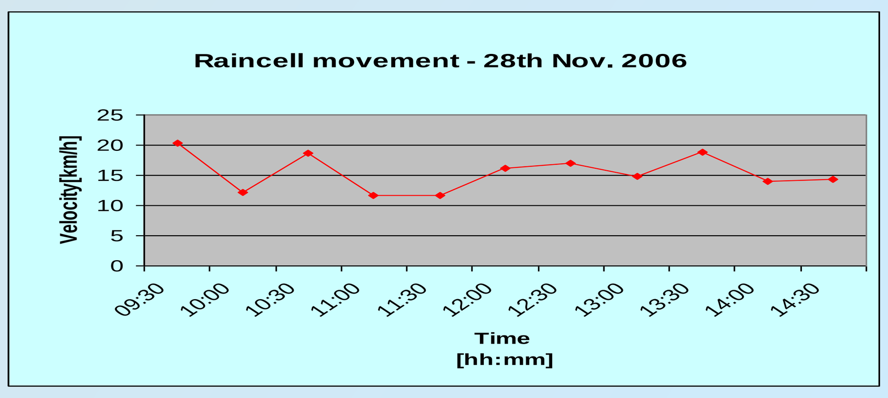

Figure 8 – Raincell velocity in the South of Portugal.

Final remark

Results indicate significant differences in hydrograph shapes for equivalent moving storms with different accelerations. For example, storms that enter the drainage basin at a higher speed (decelerating) have a short response time and hydrographs have high peaks.