APPLICATIONS OF AN ORIGINAL METHOD FOR RUNOFF SIMULATION (*THE DIGITAL ISOCHRONES METHOD*)

DETERMINATION OF CRITICAL AREAS IN MOUNTAIN WATERSHEDS

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The **diversity and variability of life and environment** are well known. Particularly, the natural systems and their specific processes show an obvious **spatial variability** and certainly a time variation. The hydrological processes make no exception. Their complexity imposes the **system mathematical modeling** and **process simulation** as major research methods and as useful tools in the **decision making process** concerning the natural resources management. We consider that their **importance** will increase in the future, in the context of the human induced **environment modifications**, such as the largely debated **climate changes**, which will make inappropriate many management "golden rules" derived from past experience.

Modeling and simulation should be considered, in our opinion, two distinct notions. A **model** is a simplified representation of a complex system. A **simulation method** refers to a process taking place in the system represented by the model. The difference between the model and the simulation method is crystal-clear in the case of a **physical model** but this distinction should be made as well for the mathematical modeling and simulation, and this difference is also clearly outlined when using **GIS representations**.

The **mountain watersheds** are characterized by **large data sets** referring to geology, land forms, climatic conditions, soils, vegetation and certainly to the different land uses and their management scenarios. These data could be easily recorded in simple files (coordinates and local values) and represented as layers in a Geographic Information System (GIS). All these **thematic maps** could be then assembled in **a complex watershed model.** The complex watershed model (realized in an analytical raster GIS) is definitely **a mathematical model** but it differs from the classical ones by using functions synthetically defined through tables of values instead of analytical functions. These **synthetical functions**, f(x,y), are the matrices, the layers of the GIS raster representation. The GIS modules enabling cartographic and especially 3D-views lead to some similarities with the physical models, creating genuine **"virtual laboratories"** in our computers. The **watershed models**, comprise a large number of layers, of thematic maps referring to morphometry, cover etc. The core of these models is represented by the **digital elevation model** (DEM), a matrix with cell elevation values. In this way, the landforms could be accurately represented at “meso” (medium) level, but certainly, the geomorphological details (at micro scale) are stochastically distributed. The **accurate representation** of the geomorphology makes a great difference, because the **landforms are the backbone of the site**, enabling us to take account of: **soil properties spatial variation** (its depth, clay content etc. are obviously varying along a hillslope), the different **microclimatic conditions** (dependent of steepness, aspect, slope position -and also influenced by soil and cover peculiarities). These digital models are useful for **simulating a wide range of natural processes**, because a watershed represents a **geosystem**, a complex system integrating several related ecosystems, therefore a basic unit for **many geophysical and biological processes.**

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THE DIGITAL ISOCHRONES METHOD

In this paper, we are focusing on ***the digital "isochrones" method***, which is an original simulation procedure we have developed for simulating runoff hydrographs and estimating the peak discharges occurring in mountain watersheds. This simulation method is of a special type, that we call **“open box”** (as opposed to “black box” models), offering the user the possibility of replacing not only the coefficients (so called, calibration) but even the empirical relations (unavoidable for natural processes representation). The watersheds models are not only necessary for simulating the hydrological processes, there are **useful applications** in mountain climatology, in forest soils and site analysis, generally in **mountain and forest ecology**.
In hydrology, the catchment isochronous zones (that we simply name "isochrones") are defined as areas from which **runoff water** enters the **reference section** (usually located at the bottom end of the watershed) in the same time interval. For obtaining the isochrones images, which are specific to each storm event, we have to pass several stages. In order to assist the method application we have elaborated **original algorithms** for: special multi-criteria analysis for mapping important hydrological characteristics (runoff coefficients, curve numbers), surface runoff routing and water divides determination etc. The first step toward the digital isochrones map is represented by the **hillslope and channel velocities images**. Then a **lag time image** is obtained by adding the overland and stream flow travel times. A simple **reclassification** of this layer generates the **digital isochrones image**, as in the example shown in fig.1 (**a** and **b**), referring to an experimental catchment in Romanian Carpathians. Based on these isochrones images we developed several hydrograph simulation versions(fig.1-**c**), different regarding runoff formation and the way in which the time variability is accounted for.

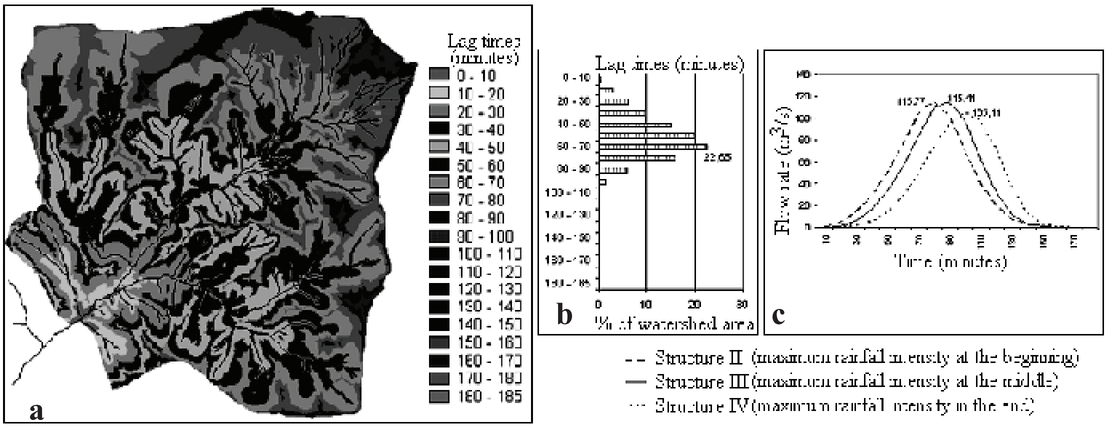

Fig.1: Digital isochrones image (a), for 10 minutes, with their area percentage (b) and a simulated hydrograph (c) with time variable rainfall (structure), retention and infiltration, during a hypothetical storm event of 90 mm in one hour (aprox. 100 years return period) in Bangaleasa Watershed (South-Eastern Carpathians - Romania)

CRITICAL AREAS DETERMINATION

By determining and mapping the **critical isochrones** (which have the major contribution to peak flow rate) it is possible to establish special management requirements and to impose for them certain **best management practices (BMP)**. Different areas from distanced parts of the catchment are linked within an isochronal zone. By analyzing the structure of these zones, as regards **cover type and quality** (forests density and age, pasture grazing load etc.), one could better observe the unbalanced situations (the threats) and to establish the adequate measures for ensuring the continuous and efficient hydrological protection, for preventing disasters.

Keywords: Mountain watersheds, GIS modeling, Runoff simulation, Critical areas, BMP