



Physically based metrics to evaluate the hydraulic distance between the drainage network and a DEM cell

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The distance between the drainage network and a generic pixel of a DEM is an important indicator for different categories of geomorphologic and hydrologic processes, particularly as far as the analysis of susceptibility to flood is concerned (Tehrany, Pradhan, & Jebur, 2014).

On the DEM domain $D \subseteq \mathbb{R}^3$ and its subset given by the hydraulic network $N \subseteq D$, the distance is a function $d: N \times D \rightarrow \mathbb{R}$. The problem is far from uniquely determined, particularly in the field of flood susceptibility. In this specific case literature tends to consider two different distances, horizontal and vertical, given in theory by the projection of the actual distance on the two directions. Presently, the problem is effectively divided into substantially disconnected approaches.

Several authors, for the horizontal distance, use forms of Euclidean distance. Generally (Tehrany, Pradhan, & Jebur, 2014), (Tehrany, et al., 2017), (Lee, Kang, & Jeon, 2012), (Tehrany, Lee, Pradhan, Jebur, & Lee, 2014), (Khosravi, et al., 2018), (Rahmati, Pourghasemi, & Zeinivand, 2016) the distance is discretized in classes via buffers of progressively increasing size. The vertical distance, on the other hand, is determined as the absolute difference between the elevations. A different approach is taken from (Samela, et al., 2015), (Manfreda, et al., 2015), (Manfreda, Samela, Sole, & Fiorentino, 2014), (Samela, Troy, & Manfreda, 2017), who consider the flow distance, viz. the distance along the hydraulic path. This procedure firstly identifies for each point of DEM the nearest downstream element of the drainage network, and then calculates the difference between the corresponding elevations.

The flow distance well describes processes driven by gravity. Flood processes do not fall into these cases being governed by the hydraulic head difference between the river and the adjacent territory (the flow generally occurs with an adverse elevation gradient). Thus, the flooding will not follow classic direct runoff paths. For this, in order to quantify properly the distance (hereafter denominated "hydraulic distance") between the drainage network and a DEM cell, an original model is introduced in which a flood process is simulated with a simple 2D unsteady flow

parabolic model according to (Bates & De Roo, 2000) and implemented via a cellular automaton scheme. For each pixel of DEM, firstly we have determined the closest upstream pixel of the drainage network, and then the vertical distance as the difference of the two elevations.

The model allows to improve the flood susceptibility of the territory. Results, generated on a huge number of DEMs, are quite encouraging. Developments are in progress to decrease computational time and memory storage size.