# Floodplain delineation using cluster analysis of geomorphometric variables and class spectral statistics

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*Abstract*—**Floodplain delineation it very important in geomorphology and hydrology. Nowadays DEMs are the most used representations of terrain and landforms. We present a method of morphological floodplain delineation from DEMs based on cluster analysis of geomorphometric variables and class spectral statistics. The method is easy to be implemented in most GIS packages and perform well on different scales and DEM sources. The precision of the delineation depends on the DEM resolution.**

## I. Introduction

Floodplain are morphologic sectors of a valley, flat area adjacent to the river [1], [2]. The extension of the floodplain can be hydrological argued, as the area which is flooded [1], but in a geomorphologic morphologic interpretation, the floodplain extent is limited by the valley walls [1].

Floodplain delineation is an important aspect for river geomorphology and hydrology. The range of methods for floodplain delineation varies from the use of relative altitude [3], water inundation modelling [4], hydraulic modelling [5] or object based image analysis [6]. The floodplain delineation criteria is either pure morphologic, or associated with hydraulic thresholds. In the present case we use a morphologic approach, and not a hydrologic one, by searching for the steep change between the floodplain and the valley wall.

Our approach is to use cluster analysis, for separating landform geomorphometric clusters, for different numbers of classes, and the spectral statistic of the classes, to find the areas where, irrespective of the number of classes, the clusters are stable.

## II. Data

### A. DEMs

DEM are used for the representation of terrain and landforms, becoming the de facto source for landform analysis. Some DEM data can be hydrological pre-processed in various settings [7], [8], while other has some influence of vegetation or man made features (the case of SAR DEMs).

### B. Study area

We have choose three study areas, and two DEMs. Entire Romania SRTM3-DEM at 90 m resolution, Iași county SRTM1-DEM resampled from 90 m to 30 m, and Bălțați-Sârca region 30 m DEM, interpolated using kriging from 1:25 000 topographic contours.

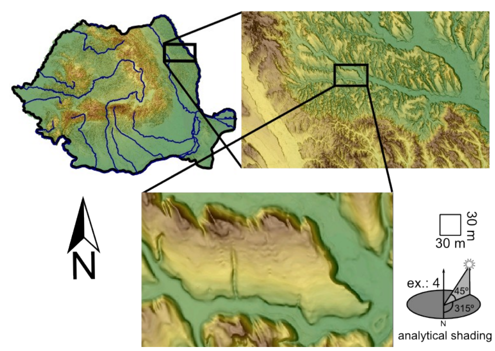


Fig. 1 Study areas

# III. METHODS

## A. Cluster analysis

We have used for the simplicity of the computation, a cluster analysis method implemented in SAGA GIS. This is the Hill climbing cluster algorithm [9]. The algorithm was applied for the three areas, with 5 step classes between 5 and 35 classes. The used geomorphometric variables were absolute altitude, range of altitude and the vector ruggedness measure [10] in 3x3 pixels kernel window.

## B. Class spectral statistics

For the assessment of cluster stability, we have used a spectral variation measure, implemented in SAGA GIS, after the idea of [11]. This measure is the distance in the feature space, to the centroid for all cells in a specified neighborhood (3x3 pixel kernel window).

# IV. RESULTS

## A. Discussions

Cluster analysis methods are widely used in landform classification based on DEMs [12], [13], [14]. The cluster analysis results are specific to the study area, but the results from different extents, and data sources, can show that the clusters are morphologically stable, reflecting real landform features, as others stated [15]. While the clusters are stable, their threshold limit can vary (Fig. 2). In the present case we use the spectral distance of this variation to find the areas which does not change the cluster centroid on big feature space distances. These areas are the flat or gentle sloping areas, in which the floodplain areas appears. The delineation of the floodplains will result from the tracing of the spectral distance spikes around the small values areas.

## B. Validation

Because reference data about the floodplain limit is not available, we have used cross-sections (Fig. 3) to test the validity of the method. The results (Fig. 4) show that in general the step altitude change of the valley wall bottom part is well depicted, giving spikes of big spectral distances, but there are areas where due to the gentle change, the method fail to find the change (the low terraces from the Fig. 4). This problem can be resolved in the delineation, by extrapolating the limits where the method apply.

Because of the DEM resolution, the floodplain can be depicted only for rivers with floodplain width bigger than 3 pixels.

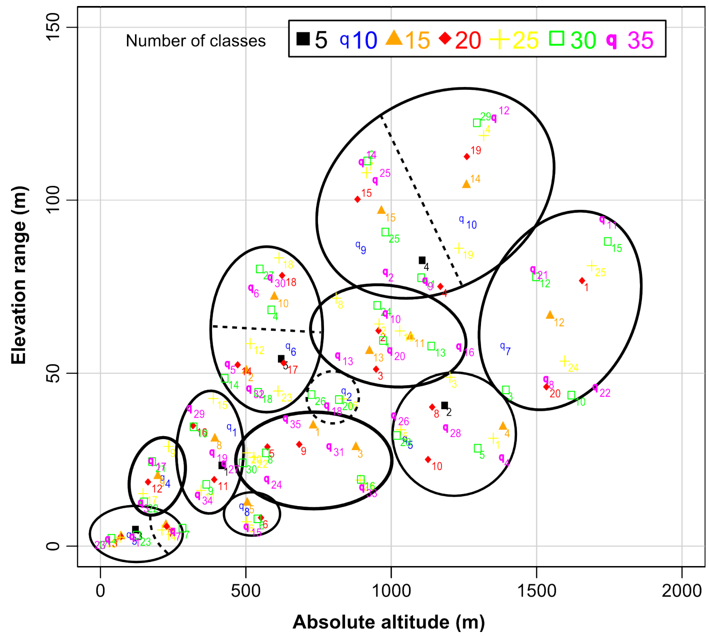


Fig. 2 Positions of the resulted clusters in a 2D feature space

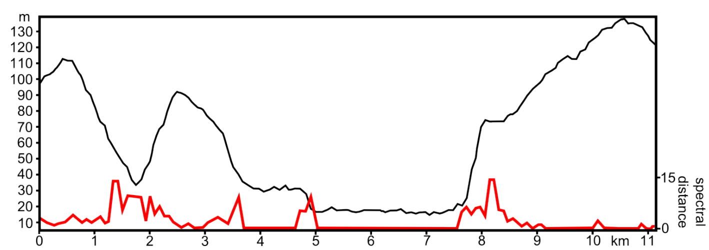


Fig. 3 Topographic cross-section on a typic floodplain site (same area from Fig. 4)

# V. CONCLUSIONS

In the technical problem of morphological floodplain delineation from DEMs, we use the results of a cluster analysis of geomorphometric variables and their class spectral statistics. The strong part of the method is that is easy to be implemented in most GIS packages. The partial validation show that the method perform well on different scales and DEM sources, but this must be further evaluated with truth data, other areas, and other elevation sources.

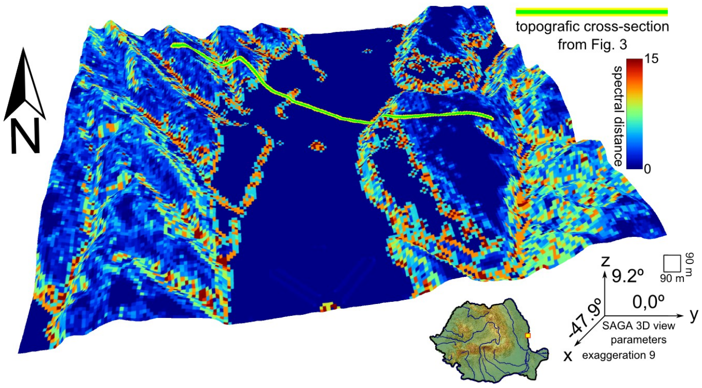


Fig. 4 Depiction of floodplain and lower terraces in Prut river valley

## References

[1] Charlton, R., 2008. “Fundamentals of fluvial geomorphology”, Routledge, 234 p.

[2] Dury, G.H., 1971. “Relation of morphometry to runoff frequency”, in “Introduction to fluvial processes”, ed. R.J. Chorley, Methuen & Co Ltd, p. 177-188.

[3] Hartvich, F and J. Jedlicka, 2008. “Progressive increase of inputs in floodplain delineation based on the DEM: application and evaluation of the model in the catchment of the Opava River”, Acta Universitatis Carolinae, Geographica, 1-2:87-104.

[4] Dodov, B.A., and E. Foufoula-Georgiou, 2006. “Floodplain morphometry extraction from a high-resolution digital elevation model: a simple algorithm for regional analysis studies” Geoscience and Remote Sensing Letters, IEEE, 3(3):410-413.

[5] Yang, J., R.D. Townsend and B. Daneshfar, 2006. “Applying the HEC-RAS model and GIS techniques in river network floodplain delineation”, Canadian Journal of Civil Engineering, 33(1):19-28.

[6] Alfaya, F.A.V.S., T.G. Florenzano, and C.C.F. Barbosa, 2012. “Mapping Amazon river floodplain reach with SRTM-DE using the hand descriptor and object based image analysis”, Proceedings of the 4th GEOBIA, May 7-9, 2012, Rio de Janeiro, Brazil, p. 137-140.

[7] Tate, E.C., D.R. Maidment, F. Olivera and D.J. Anderson, 2002. “Creating a terrain model for floodplain mapping”, Journal of Hydrologic Engineeriing, 7(2):100-108.

[8] Getirana, A.C.V., M-P Bonnnet, O.C. Rotunno Filho and W.J. Mansur, 2009. “Improving hydrological information acquisition from DEM processing in floodplains”, Hydrological Processes, 23:502-514.

[9] Rubin, J., 1965. “Optimal classification into groups: an approach for solving the taxonomy problem”, Journal of Theoretical Biology, 15(1):103-144.

[10] Sappington, J.M., K.M. Longshore, and D.B. Thoompson, 2007. “Quantifying landscape ruggedness for animal habitat analysis: a case study using bighorn sheep in the Mojave desert”, Journal of Wildlife Management, 71(5):1419-1426.

[11] Palmer, M.W., P.G. Earls, B.W. Hoagland, P.S. White and T. Wohlgemuth, 2002. “Quantitative tools for perfecting species lists” , Environmetrics, 13:121-137.

[12] Lagacherie, P., D.R. Cazemier, P.F.M. Van Gaans, and P.A. Burrough1, 997. “Fuzzy k-means clustering of fields in an elementary catchment and extrapolation to a larger area”, Geoderma, 77(2-4):197-216.

[13] Burrough, P.A., P.F.M. Van Gaans and R.A. MacMillan, 2000. “High-resolution landform classification using fuzzy k-means”, Fuzzy Sets and Systems, 113(1):37-52.

[14] Biosca, J.M., and J.L. Lerma, 2008. “Unsupervised robust planar segmentation of terrestrial laser scanner point clouds based on fuzzy clustering methods”, ISPRS Journal of Photogrammetry and Remote Sensing, 63(1):84-98.

[15] Vilalta, R., T.F. Stepinski and M. Achari, 2007. “An efficient approach to external cluster assessment with an application to martian topography”, Data Mining and Knowledge Discovery, 14(1):1-23.

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[18]