

# Quantitative terrain analysis of Al Kalb river catchment

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## ABSTRACT

One of the quantitative terrain analysis methods is calculating the first and second elevation derivative, the curvature of a surface.

According to digital elevation models DEM of the Lebanese territory, we constructed curvature maps of Al Kalb river catchment and analyzed the spatial distribution of their morphometric variables.

In this study, we focused only on terrain second derivative, plan and profile curvature calculation, targeted at DEM of Shuttle Radar Topographic Mission (SRTM), processed and geospaialed in a series of GIS soft-ware.

A general statistics of the curvature done, to show the morphometric variability of Al Kalb catchment and to analyze its terrain structure.

## INTRODUCTION

Geographers are using elevation data to quantify the shape of the terrain. In this study, we focused on the cartographic representation and statistics values of variables computed from digital elevation models.

The study area situated at the North of the Lebanese capital Beirut inside the boundary of Al Kalb river catchment that occupied an area of 254 square kilometers beginning from the high mountains of Kfarzebiane arriving to the mouth of the catchment at the Sea between Dbayeh and Zouk Mosbeh.

The catchment characterized by its anisotropic morphological structure with a height amplitude of 2600 meters above the sea level.

Very known that with GIS and remote sensing fast evolution opened a new era in technologies especially in geographical modeling and analysis, what was very difficult to extract from topographic maps became very easy to do with Digital Elevation Models, as the case of our study that is laying on the calculation and the modeling of the terrain second derivative.

## MATERIALS AND METHODS

SRTM Elevation Data. The Space Shuttle Endeavour during an 11-day mission in February of 2000, known as "Shuttle Radar Topography Mission (SRTM)", obtained elevation data on a near-global scale (between 60°N and 56° S latitude) (Farr, 2009).

It produced digital topographic data on 3 arc-second grid which roughly translates to a 90-meter horizontal spatial resolution and an absolute horizontal and vertical accuracies are given as equal to 20 meters (circular error at 90% confidence) and 16 meters (linear error at 90% confidence).

The SRTM data of the study area given in geographic coordinates (using as horizontal datum the WGS84 ellipsoid). The SRTM grid values provided in terms of orthometric heights with respect to the geoid model computed from the EGM96 geopotential model.

Since SRTM data became widely available and free of charges, many studies utilized them for applications in topography (Falorni et al., 2005), geomorphology (Guth, 2003; Stock et al., 2002; Pogorelov and, Doumit 2008), vegetation cover studies (Kelldorfer et al., 2004), and urban studies (Gamba et al., 2002). SRTM data verification was perform using various altimetry data (Helm et al., 2002; Sun et al., 2003) and digital elevation models

(Jarvis et al., 2004; Muller, 2005; Smith and Sandwell, 2003).

Curvature of the Earth's surface could be describe using its inclination gradient directions: profile curvature measured in the direction of the gradient (in the Z plan), plan curvature (in the XY plan).

In this study we focused on the most common currently receptions curvature calculation, targeted at DEM (Digital Elevation Model). It should be noted that most morphometric variables (X, Y, Z) are calculated as partial derivatives .figure 1, show many morphologic parameters of the same river catchment (Al Kalb) with isosurface and hillshade.

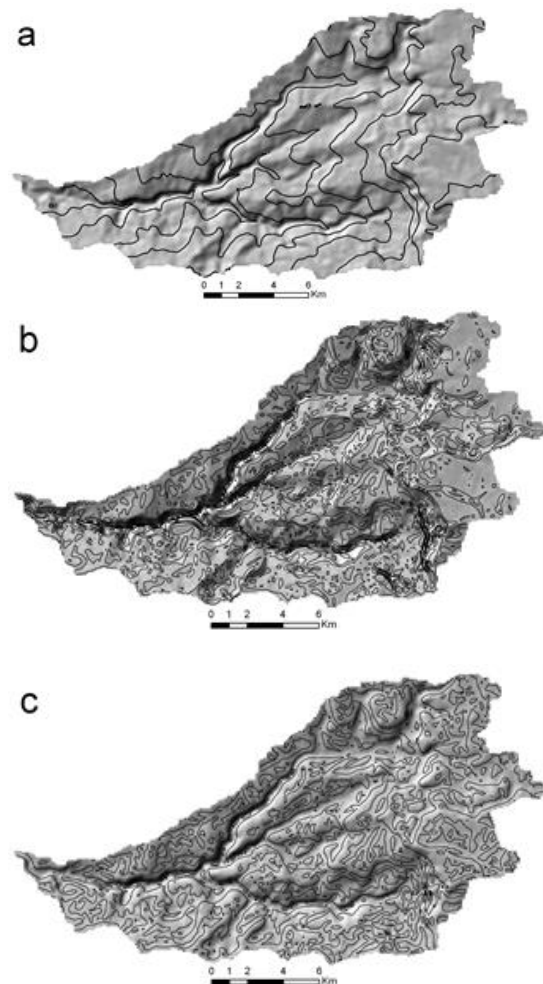


Figure 1: Morphologic parameters of the El Kaleb river watershed

**a** – Absolute elevation of the topographical surface (contour every 250 m)

**b** – Gradients of the topographic surface or first derivative of elevation (isolines every 100),

**c** – Profile curvature or second derivative of elevation (isolines every 0.5 in an interval of -1.27...+1.17)

The first derivatives characterize the slope of the catchment (fig. 1b) as isogradient. The second derivative (fig. 1c), show the gradient of the isogradient that indicate the convexity and concavity of the profile.

Methods of calculating basic morphometric variables (elevation, aspect slope and curva-ture) for a DEM, a 3 × 3 cells method is used (Zeuberger, Thorne, 1987).

The general principle of Zeuberger formulas is that they are applicable to calculate the morphometric variables at the local level, or, in other words, at the limit of spatial resolution of the DEM.

We construct maps of vertical and horizontal curvature of Al Kaleb catchment. As a digital databases used SRTM 3 (shuttle radar topographic mission), which has been transformed into a matrix (grid) with a resolution of approximately 85 m. Construction performed mainly in the programs of ArcGIS and SAGA (System for Automated Geoscientific Analyses).

## RESULTS AND DISCUSSION

The morphology of the catchment determines not only hydrologic functions of the river (speed, accumulation, erosion, etc.) but also a physical function (microclimates, soil, landscape, vegetation, etc.).

In general-morphometry, the positive curvature value is a convex surface and the negative one is concave.

Profile and plan convexity are useful in that they separate curvature out into two orthogonal components where the effects of gravitational process are either maximized (profile convexity) or minimized (plan convexity).

	Min	Max	$\sigma$	1 Quartile	Median	3 Quartile	S	E
Plan curvature $k_h$	-0.88	0.74	0.100	-0.05	0.005	0.06	-0.501	7.67
Profile curvature $k_v$	-1.27	1.17	0.131	-0.05	0.004	0.06	-1.005	9.73
curvature $k$	-1.91	1.46	0.191	-0.09	0.01	0.10	-0.515	6.53

Table 1: Statistical values of curvature in the Lebanese territory.

A general statistics of the curvature done, to show the morphometric variability of Al Kalb catchment. Table 1

Min and Max – minimum and maximum values ;  $\sigma$  – standard deviation,  $m$ ; S – skewness; E – kurtosis; 1 Quartile, median и 3 Quartile.

As shown in the table 1 the minimum values of all curvature parameters in Al Kaleb catchment are higher than the maximum values which means that the concave (pits and channels) are very deep.

This is understandable in connection with the representation of the hard Lebanese relief. All the skewness S values are negative, which means that the availability of right side asymmetry in the distribution of curvature. However, much more right side asymmetry expressed a profile curvature.

Profile curvature distribution was close to normal, which should be interpret as proportional representation in the convex and concave profile forms.

A high kurtosis coefficient (Table 1), indicating a high frequency of occurrence curvature and contrary, a very low frequency of extreme values of kh and kv.

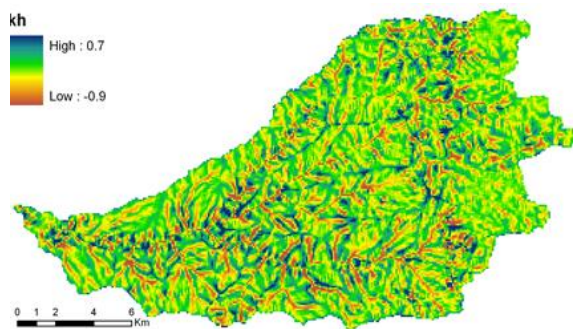


Figure 2: plan curvature of El Kalb river catchment

In figure 2 of the plan curvature kh the degradation of colors from the green to the dark blue indicate the value of concavity, beginning from the yellow color ending by the brown one indicate the concavity of the curvature, same for the profile curvature figure 4 the high positive value are convex and the negative are the concave one.

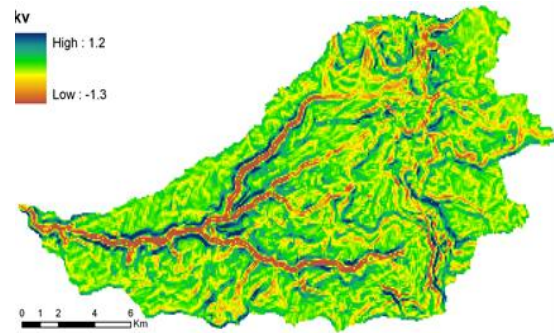


Figure 3: Profile curvature of El Kalb river catchment.

The horizontal curvature on the maps (Fig. 2) clearly identified break lines surface in the form of ridges, talwegs and distortions. The maps profile curvature (Figure 3), in accordance with the values kv visually identified morphologically and genetically homogeneous surface (watershed, slopes and valleys in all the diversity of its manifestations).

### CONCLUSION

Terrain shape is very important to geographical analysis. Many quantitative techniques are available for displaying and defining geomorphological data.

In our opinion, raster classification that represents a model of the surface curvature carries a great potential recognition of landforms, and other genetic characteristics. There is no doubt that such a model should better justify morphodynamic analysis and solution of topical tasks.

Curvature parameters in Al Kalb catchment. Figs. 2, 3), It must be noted that the maximum kh (0.7) and kv (1.2) are in the area of high elevations like mountains region .the minimum value of kh (-0.9) and kv (-1.3) situated in the saddles of high slope. GIS technology and digital elevation modeling, created a new environment for mor-phometric analysis. It is well know that the work under topographical maps caused significant distortions features in the use of contour lines. The prevailing tradition of contour lines, the solution to this problem is the use of DEM as primary materials in ex-tractions of geomorphologic parameters.

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