# ANÁLISIS GEOESPACIAL

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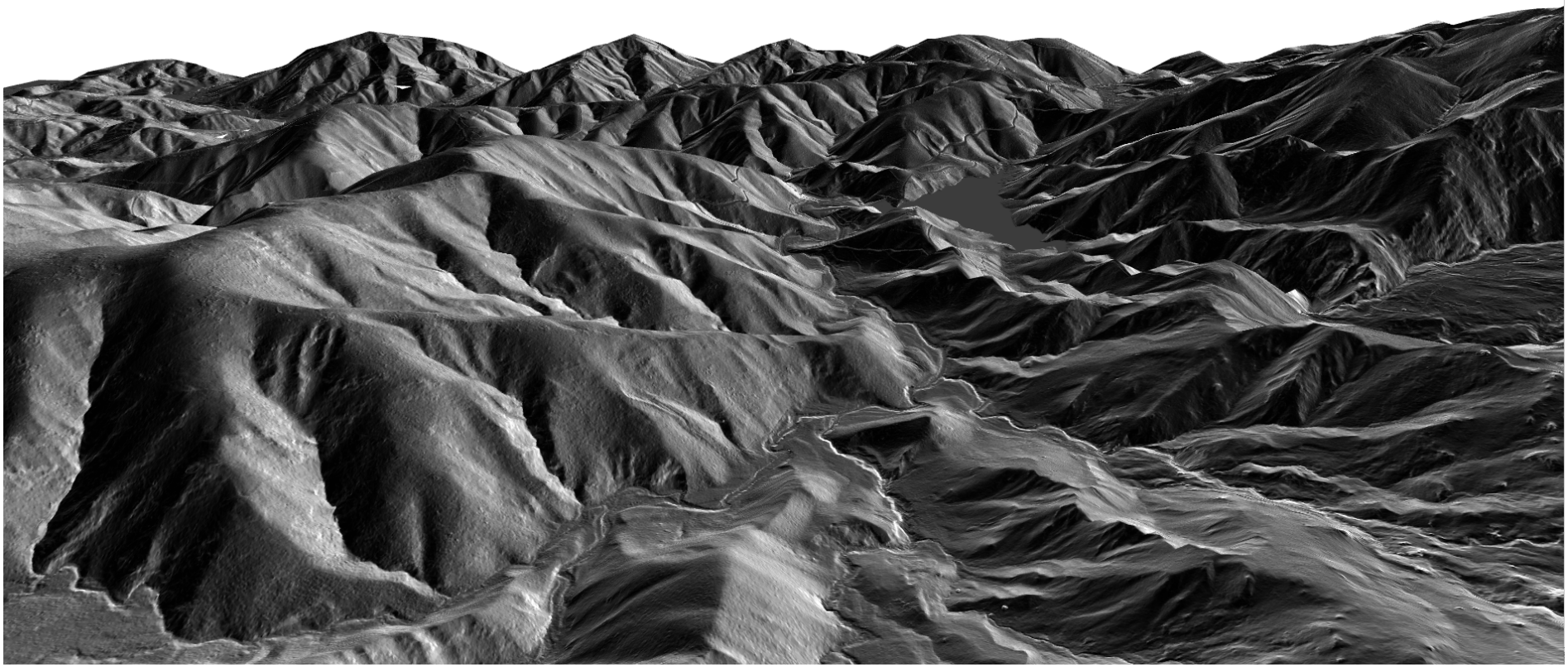
UNIVERSIDAD NACIONAL DE COLOMBIA
SEDE MEDELLÍN

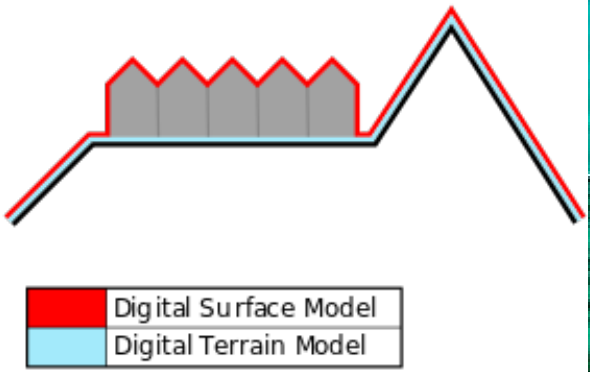
GEOHAZARDS
Semillero de Investigación

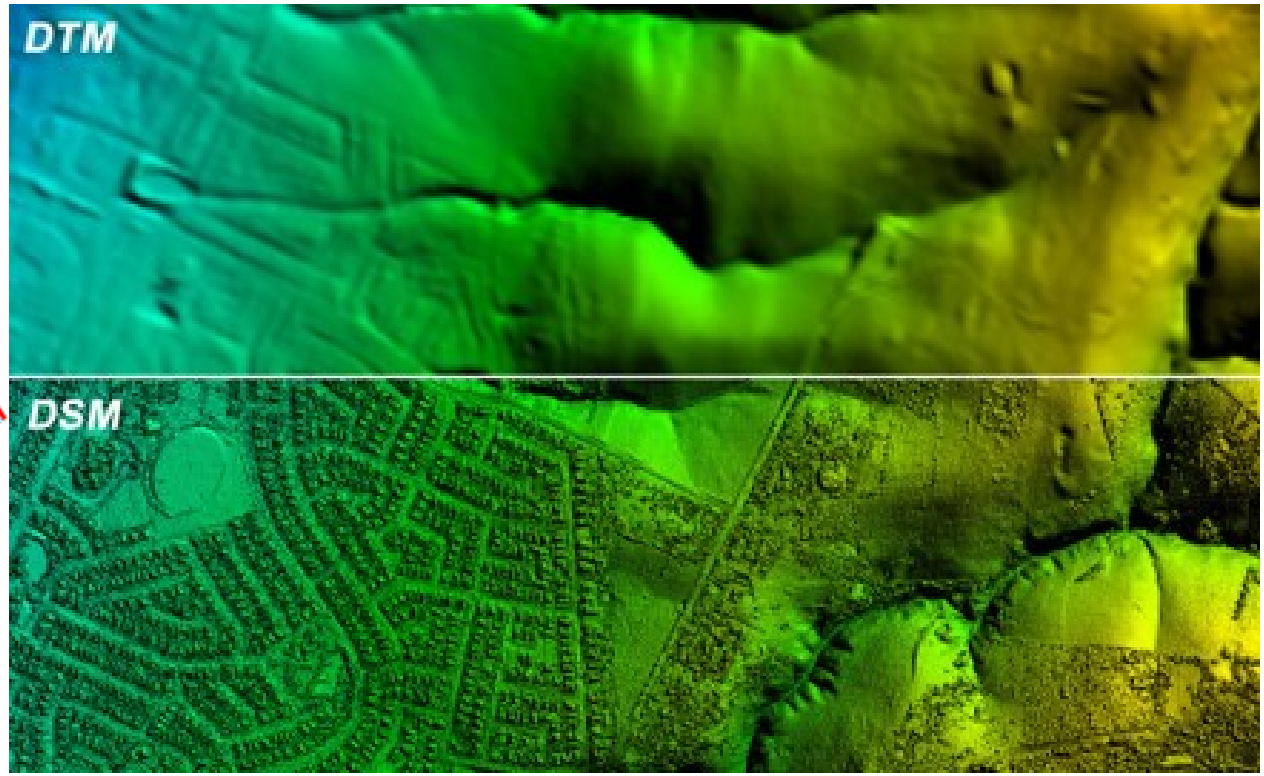
# Digital Elevation Models



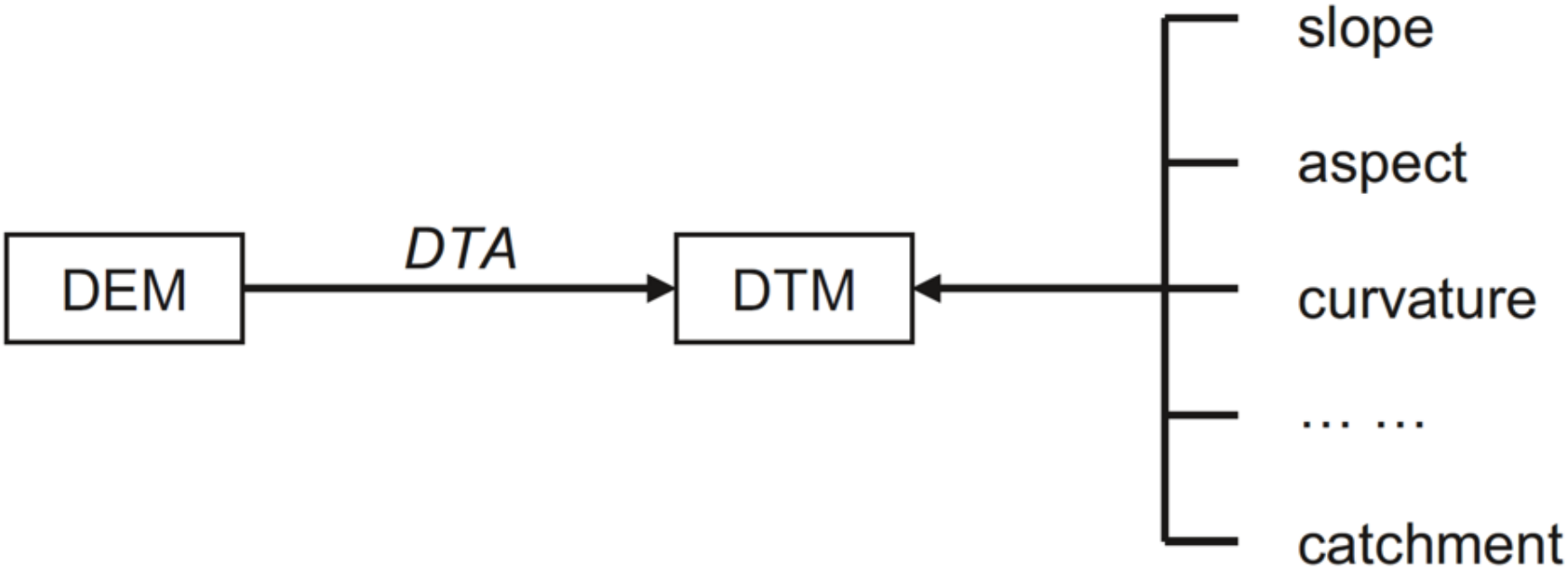
https://medium.com/on-location/from-points-to-pixels-creating-digital-elevation-models-from-open-topography-point-clouds

# DEM

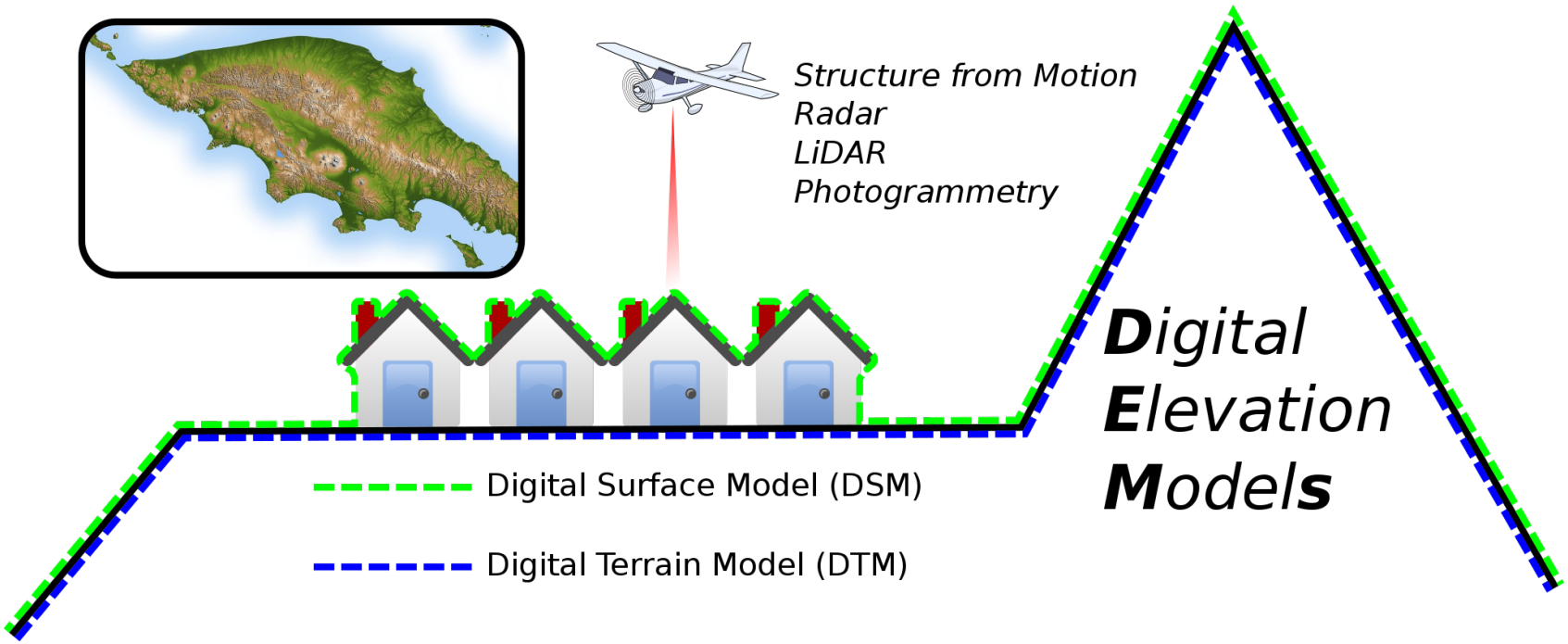


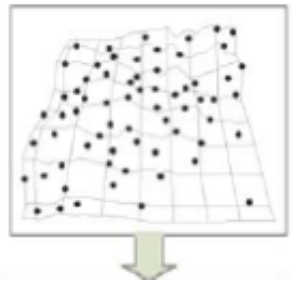
# DEM

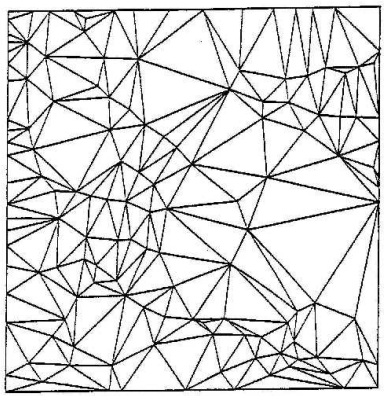


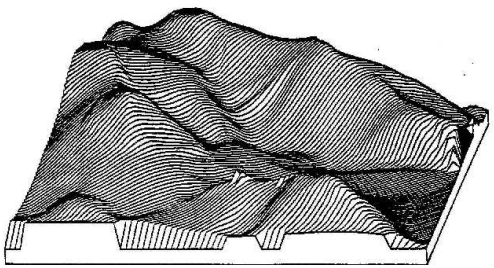
# Modelos Digitales de Elevación (DEM)

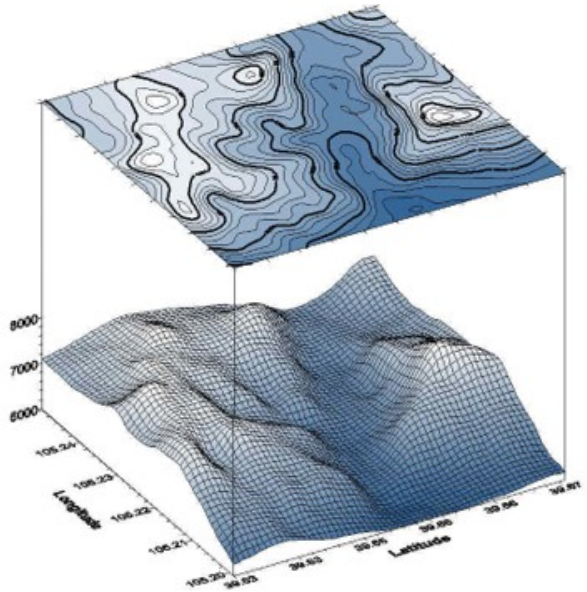


# DTM





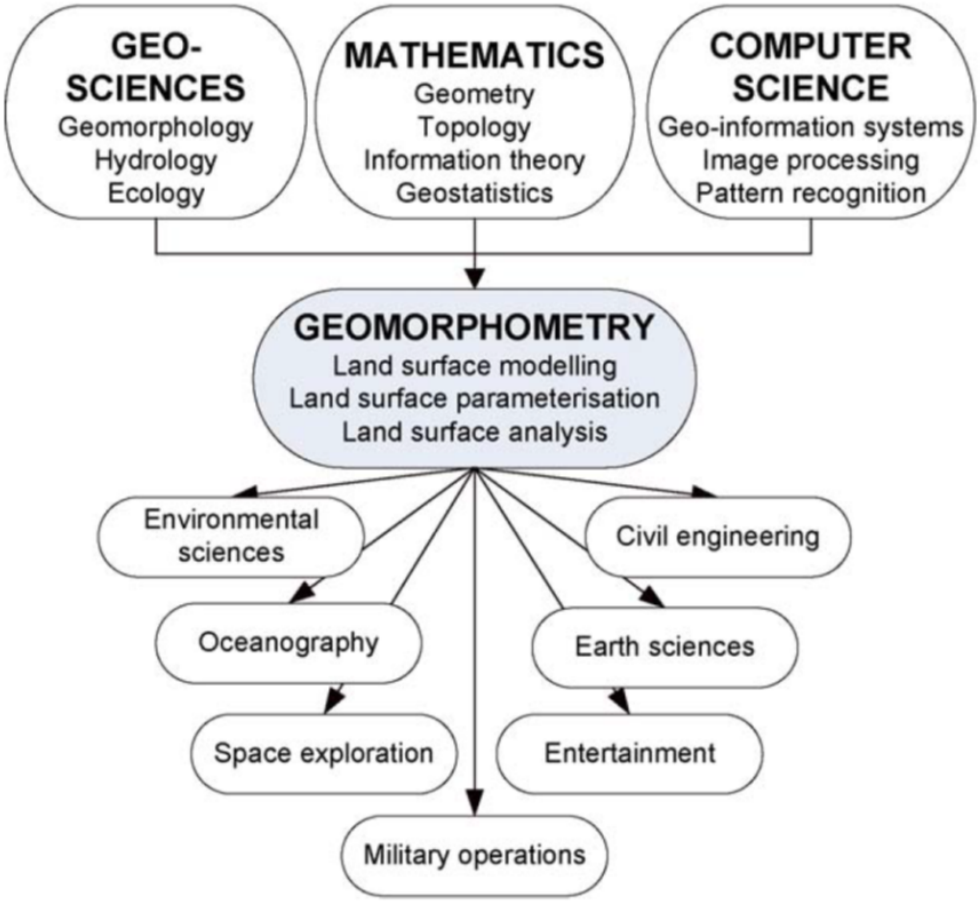





Southwest Corner of the
Morrison Quadrangle, Colorado


G R A N D E

# Geomorfometría



| Variable, notation, and unit | Definition and interpretation |
|---|---|
| Local morphometric variables | |
| *Form attributes* | |
| Minimal curvature, $k_{min}$, $m^{-1}$ | A curvature of a principal section with the lowest value of curvature at a given point of the topographic surface (Gauss, 1828). $k_{min} > 0$ corresponds to hills, while $k_{min} < 0$ relates to valleys (Section 2.2.4.5) |
| Maximal curvature, $k_{max}$, $m^{-1}$ | A curvature of a principal section with the highest value of curvature at a given point of the topographic surface (Gauss, 1828). $k_{max} > 0$ corresponds to ridges, while $k_{max} < 0$ relates to closed depressions (Section 2.2.4.5) |
| Mean curvature, $H$, $m^{-1}$ | A half-sum of curvatures of any two orthogonal normal sections at a given point of the topographic surface (Young, 1805). $H$ represents two accumulation mechanisms of gravity-driven substances—convergence and relative deceleration of flows—with equal weights (Sections 2.2.4.4) |
| Gaussian curvature, $K$, $m^{-2}$ | A product of maximal and minimal curvatures. According to *Teorema egregium*, $K$ retains values in each point of the topographic surface after its bending without breaking, stretching, and compressing (Gauss, 1828) (Section 2.2.4.6) |
| Unsphericity curvature, $M$, $m^{-1}$ | A half-difference of maximal and minimal curvatures (Shary, 1995). $M = 0$ on a sphere; $M$ values show the extent to which the shape of the topographic surface is nonspherical at a given point (Section 2.2.4.7) |

*Flow attributes*

| | |
|---|---|
| Slope gradient, $G$, degree | An angle between the tangential and horizontal planes at a given point of the topographic surface (Lehmann, 1799). Relates to the velocity of gravity-driven flows (Section 2.2.2) |
| Slope aspect, $A$, degree | An angle between the northern direction and the horizontal projection of the two-dimensional vector of gradient counted clockwise, from 0 to 360 degrees, at a given point of the topographic surface. A measure of the direction of gravity-driven flows (Section 2.2.3) |
| Horizontal curvature, $k_h$, $m^{-1}$ | A curvature of a normal section tangential to a contour line at a given point of the topographic surface (Krcho, 1983; Shary, 1991). A measure of flow convergence and divergence. Gravity-driven overland and intrasoil lateral flows are converged where $k_h < 0$, and they are diverged where $k_h > 0$ (Sections 2.2.4.2) |
| Vertical curvature, $k_v$, $m^{-1}$ | A curvature of a normal section having a common tangent line with a slope line at a given point of the topographic surface (Aandahl, 1948; Speight, 1974; Shary, 1991). A measure of relative deceleration and acceleration of gravity-driven flows. Overland and intrasoil lateral flows are decelerated where $k_v < 0$, and they are accelerated where $k_v > 0$ (Section 2.2.4.3) |

Nonlocal morphometric variables

| | |
|---|---|
| Catchment area, $CA$, $m^2$ | An area of a closed figure formed by a contour segment at a given point of the topographic surface and two flow lines coming from upslope to the contour segment ends (Speight, 1974). A measure of the contributing area (Section 2.3) |
| Dispersive area, $DA$, $m^2$ | An area of a closed figure formed by a contour segment at a given point of the topographic surface and two flow lines going down slope from the contour segment ends (Speight, 1974). A measure of a downslope area potentially exposed by flows passing through a given point (Section 2.3) |
| Specific catchment area, $SCA$, $m^2/m$ | A ratio of an area $CA$ to the length of a contour segment (Speight, 1974) (Section 2.3) |
| Specific dispersive area, $SDA$, $m^2/m$ | A ratio of an area $DA$ to the length of a contour segment (Speight, 1974) (Section 2.3) |

| Variable, notation, and unit | Definition and interpretation |
|---|---|
| **Solar morphometric variables** | |
| Reflectance, $R$ | A measure of the brightness of an illuminated surface (Horn, 1981) (Section 2.5.1) |
| Insolation, $I$, % | A measure of the topographic surface illumination by solar light flux (Shary et al., 2005) (Section 2.5.2) |
| **Combined morphometric variables** | |
| Topographic index, $TI$ | The logarithm of a ratio of $CA$ to tan $G$ at a given point of the topographic surface. A measure of the extent of flow accumulation (Beven and Kirkby, 1979) (Section 2.6) |
| Stream power index, $SI$ | The logarithm of a product of $CA$ and tan $G$ at a given point of the topographic surface. A measure of the potential flow erosion (Moore et al., 1991) (Section 2.6) |
| Shape index, $IS$ | A continual form of the discrete Gaussian classification of landforms. $IS>0$ relate to convex landforms, while $IS<0$ correspond to concave landforms. $\|IS\|=0.5,\ldots,1$ relates to elliptic surfaces, while $\|IS\|=0,\ldots,0.5$ relates to hyperbolic ones (Koenderink and van Doorn, 1992) (Section 2.7.1) |

# Pendiente

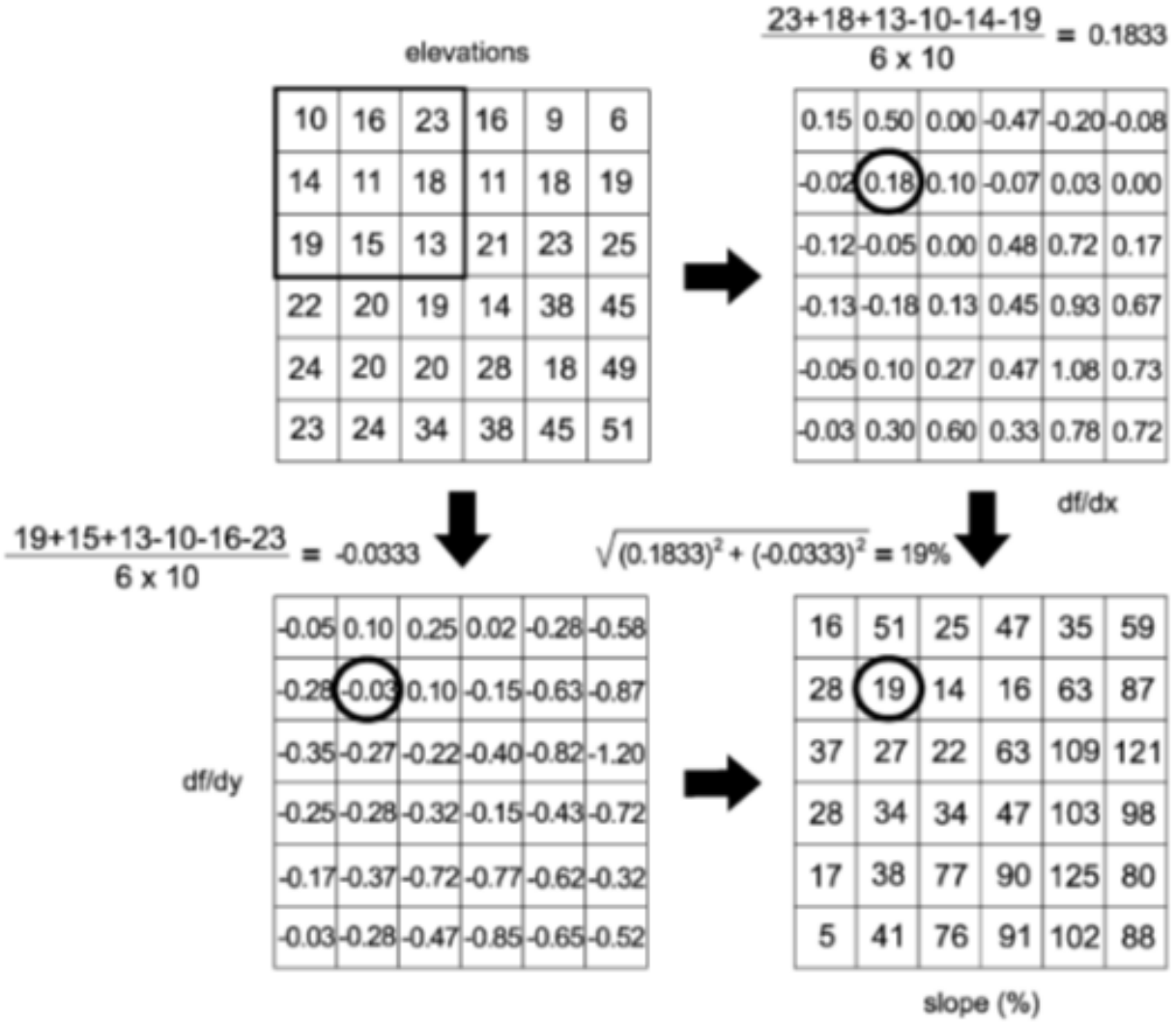



**FIGURE 5** Numerical example showing slope tangent (in %) extracted from a DEM using a $3 \times 3$

# Curvatura

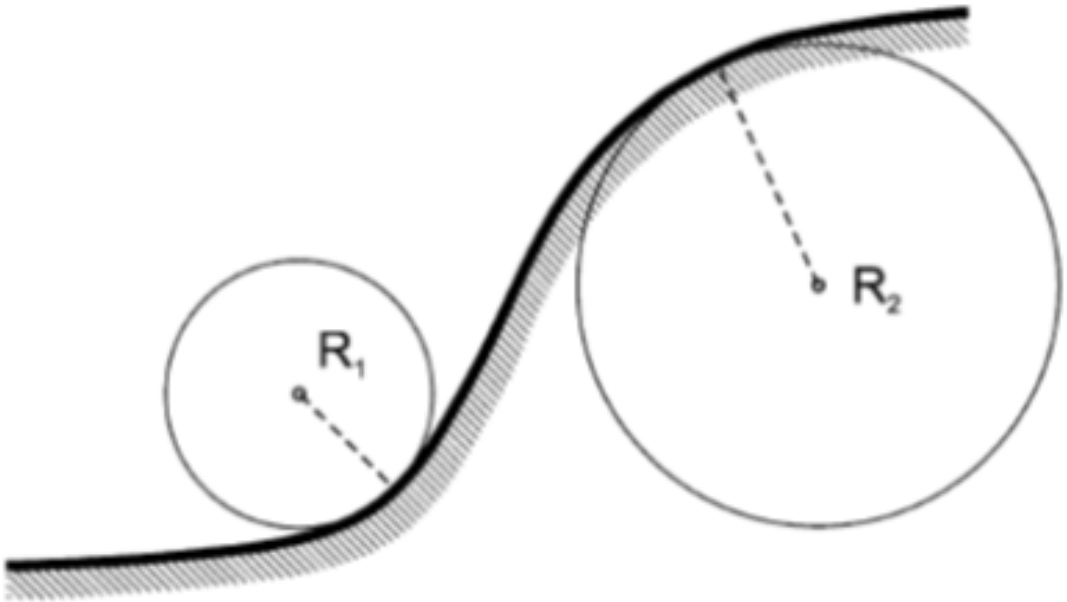
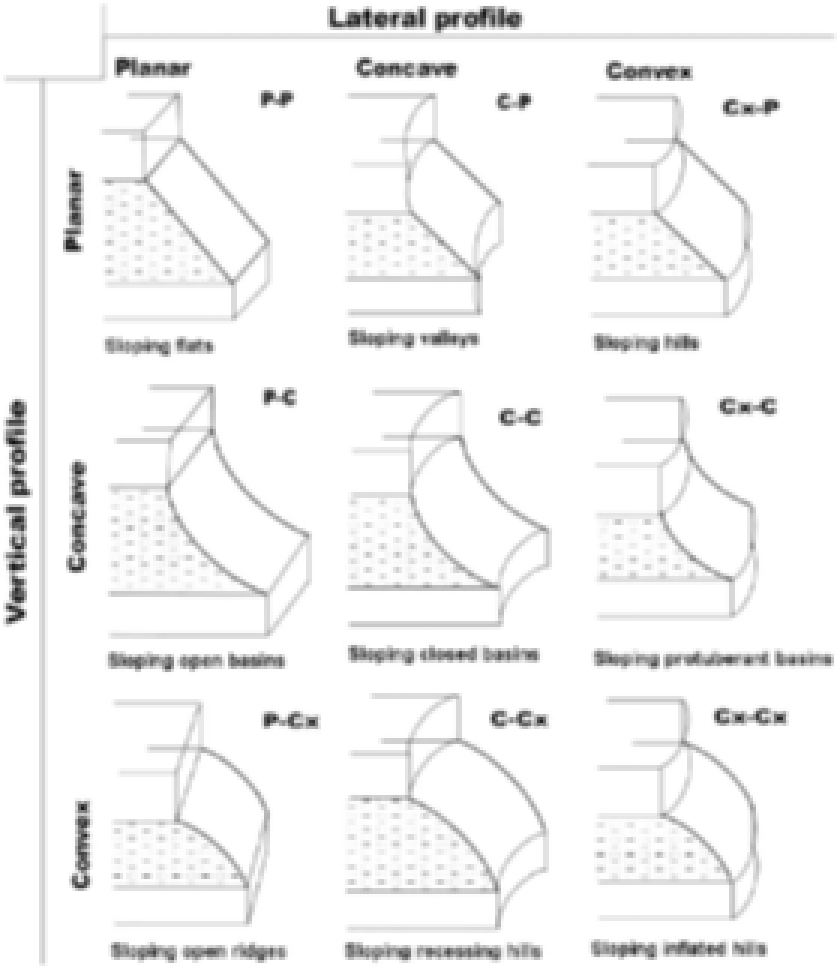
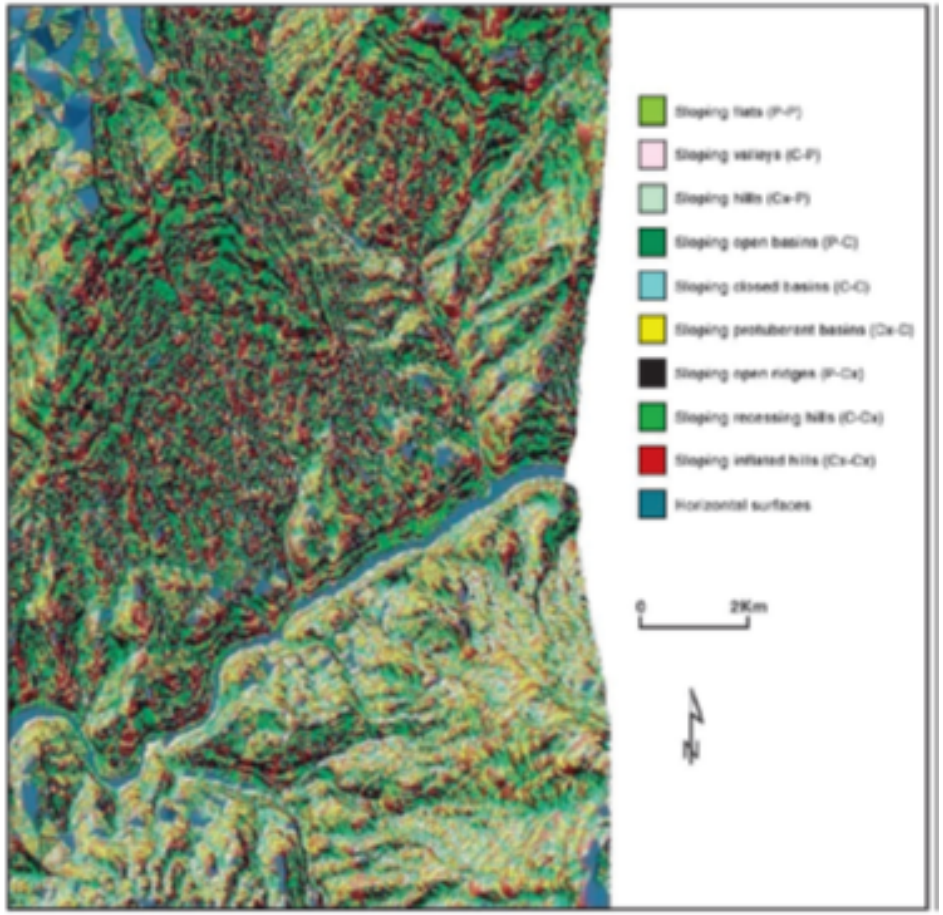
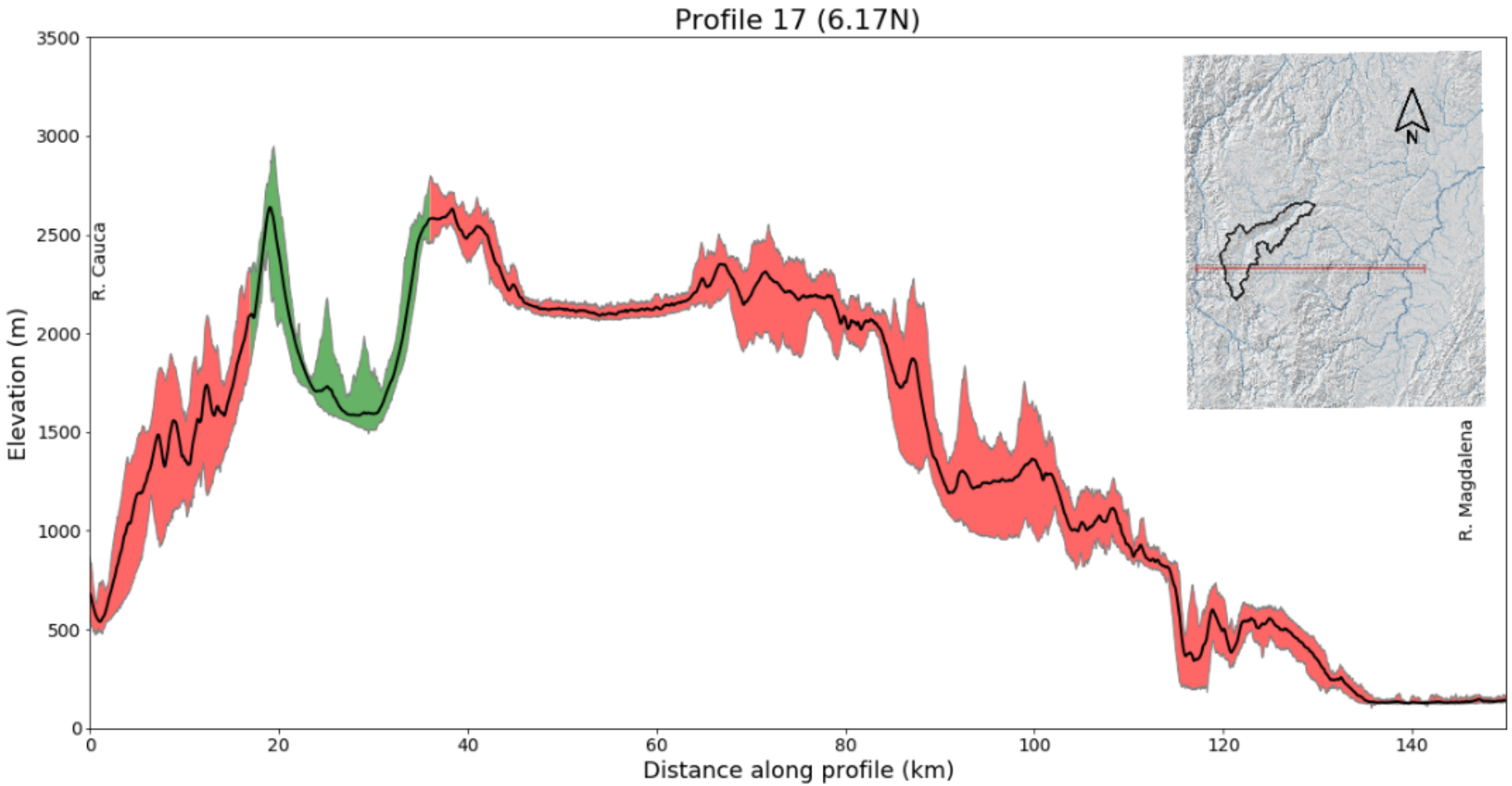



**FIGURE 5** Curvature $1/R$ of a plane curve is the inverse of the radius $R$ of a circle that is best fitted to this curve at a given point. It is agreed in Earth sciences that the sign of curvature is positive for a convex surface shape ($R_2 > 0$), and negative for a concave one ($R_1 < 0$).


Lateral profile
Planar
Concave
Convex
Vertical profile
Planar
Concave
Convex
P-P
C-P
Cx-P
P-C
C-C
Cx-C
P-Cx
C-Cx
Cx-Cx
Sloping flats
Sloping valleys
Sloping hills
Sloping open basins
Sloping closed basins
Sloping protuberant basins
Sloping open ridges
Sloping recessing hills
Sloping inflated hills

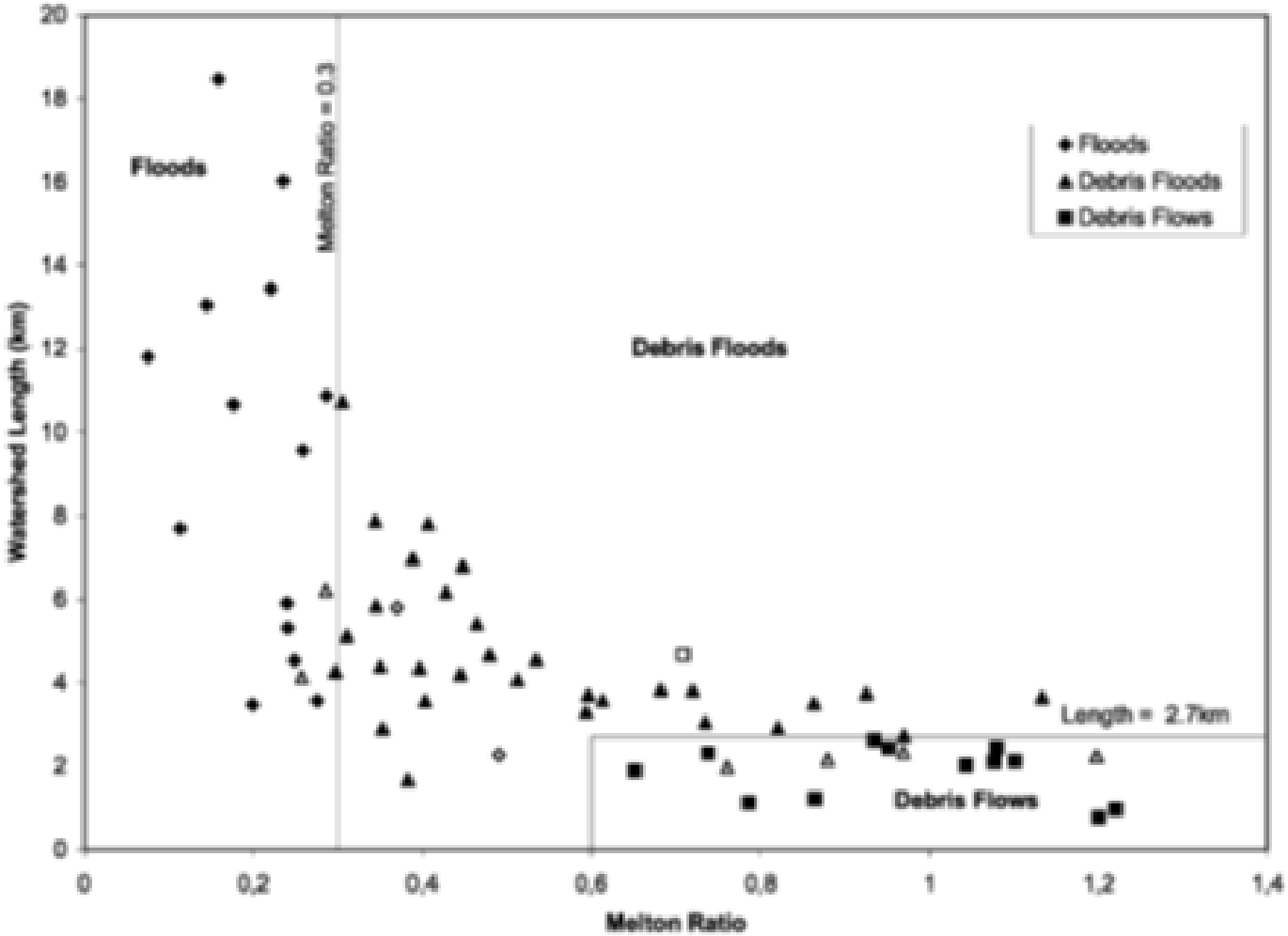

Sloping flats (P-P)
Sloping valleys (C-P)
Sloping hills (Cx-P)
Sloping open basins (P-C)
Sloping closed basins (C-C)
Sloping protuberant basins (Cx-C)
Sloping open ridges (P-Cx)
Sloping recessing hills (C-Cx)
Sloping inflated hills (Cx-Cx)
Horizontal surfaces
0
2Km

# Perfiles


Profile 17 (6.17N)
Elevation (m)
Distance along profile (km)
R. Cauca
R. Magdalena
N
0
500
1000
1500
2000
2500
3000
3500
0
20
40
60
80
100
120
140

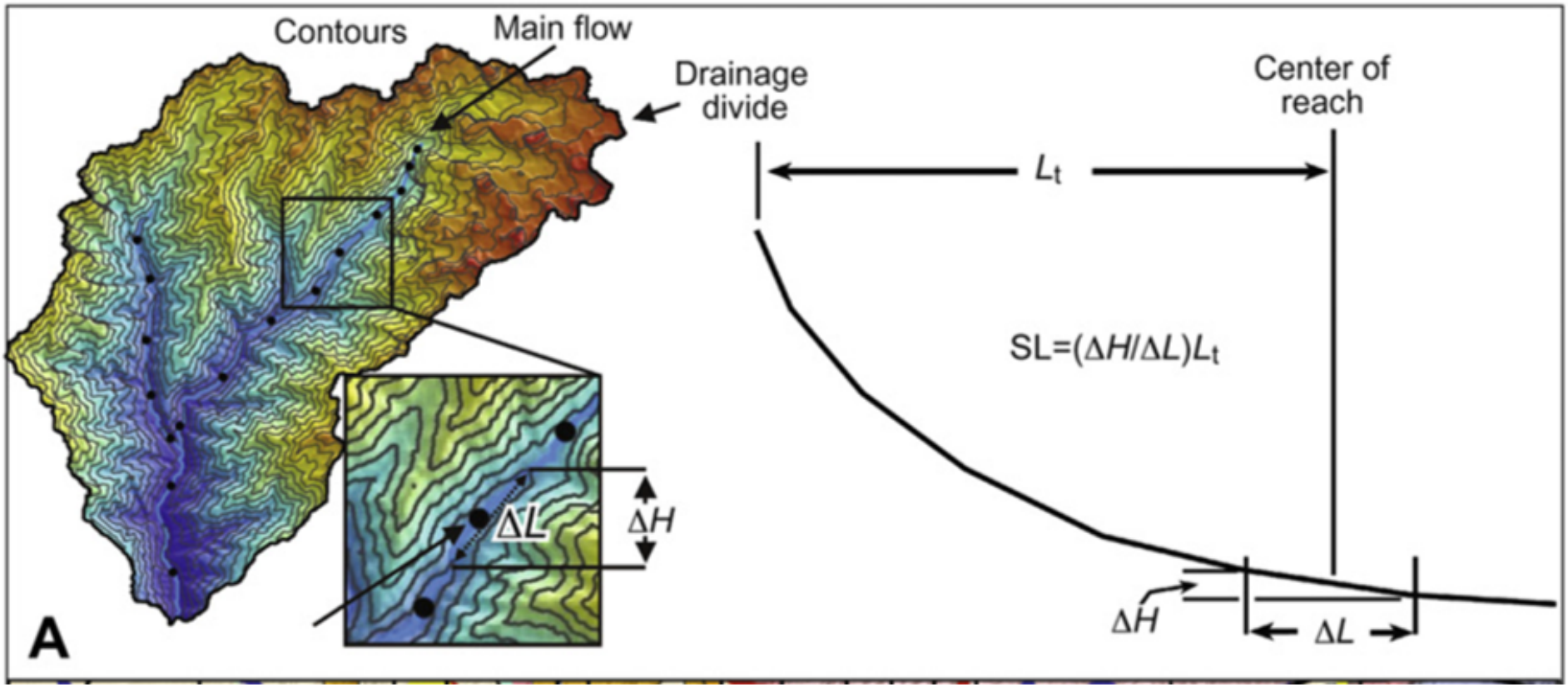
# Indices morfométricos

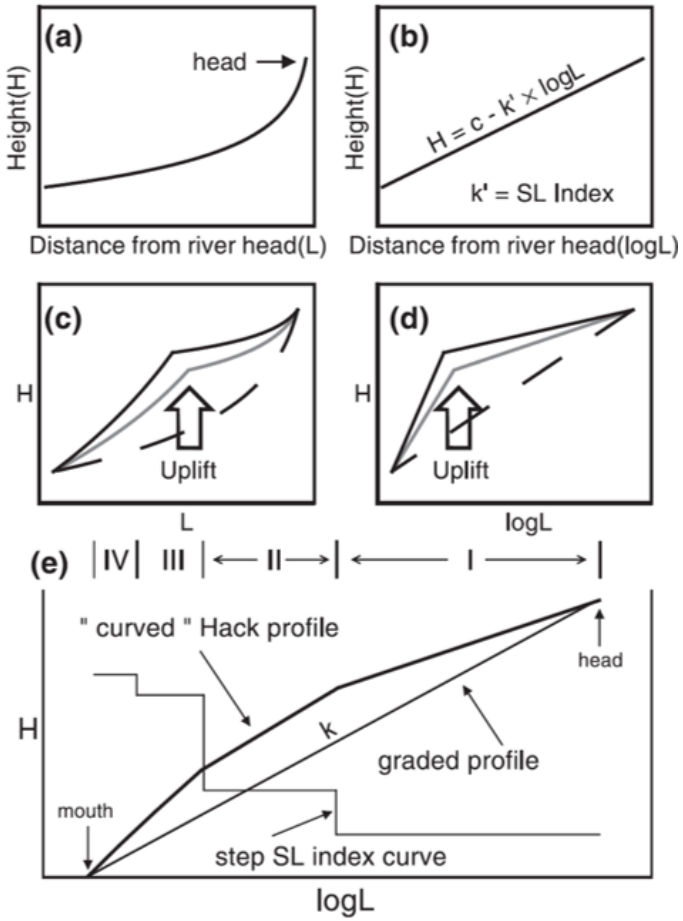
| Morphometric parameter | Name | Formula | Reference |
|---|---|---|---|
| **Drainage network** | | | |
| Stream order | $S_u$ | Hierarchical rank | (Strahler, 1952 ) |
| Stream Length | $L_u$ (km) | $L_{u=} L_1 + L_2 + \cdots + L_n$ | (Strahler 1964) |
| Stream Length Ratio | $L_{ur}$ | $L_{ur=} L_u / L_{u-1}$ | (Strahler, 1964) |
| Bifurcation Ratio | $R_b$ | $R_{b=} N_u / N_{u-1}$ | (Strahler, 1964) |
| Ro Coefficient | ρ | $\rho_= L_{ur} / R_b$ | (Horton 1945) |
| **Basin Geometry** | | | |
| Length of Basin | $L_b$ | | (Schumm 1956) |
| Area | A (Km) | | (Schumm 1956) |
| Perimeter | P (Km) | | (Schumm 1956) |
| Form Factor | $F_f$ | $F_f = A / {L_b}^2$ | (Horton 1932) |
| Texture Ratio | $R_t$ | $R_t = N_1 / P$ | (Schumm 1956) Smith 1950 |
| Circularity Ratio | $R_c$ | $R_c = 4\pi A / P^2$ | (Mueller 1968) |
| Melton Index | M | $M = \frac{H}{\sqrt{A}}$ | |
| **Drainage Texture Analysis** | | | |
| Drainage Density | $D_d$ | $D_d = L_u / A$ | (Horton 1932) |
| Infiltration Number | $I_f$ | $I_f = F_s * D_d$ | (Faniran 1968) |
| **Relief Characteristics** | | | |
| Relief | H | $H = Z - z$ | (Strahler, 1952) |
| Relief Ratio | $R_h$ | $R_h = H / L_b$ | (Schumm 1956) |
| Rudgeness Number | $R_n$ | $R_n = D_d * (\frac{H}{1000})$ | (Strahler 1964) |
| Mean Slope of the Basin | S (°) | | |



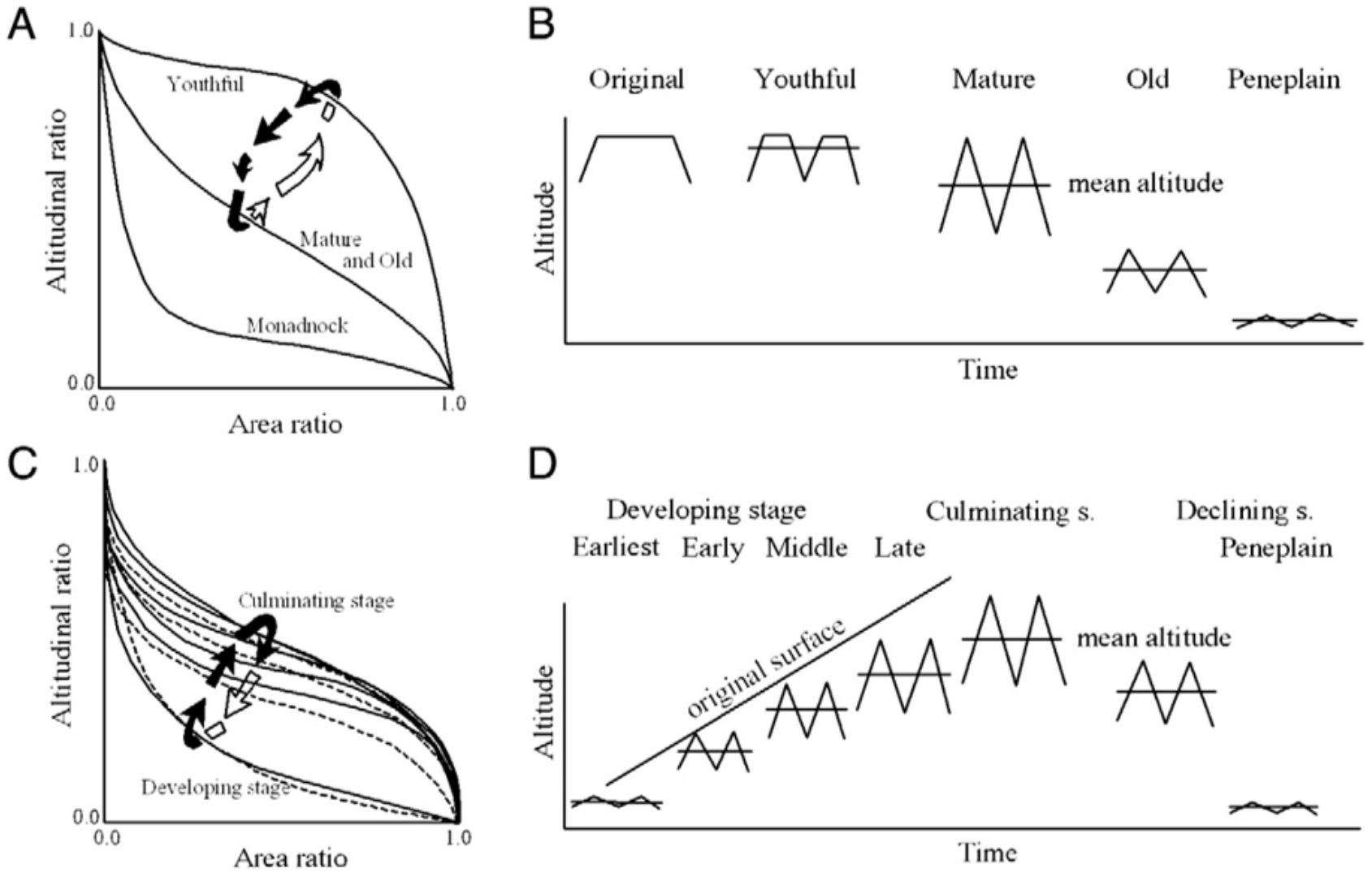

Fuente: Wilford et al. (2004)

# Perfiles longitudinales

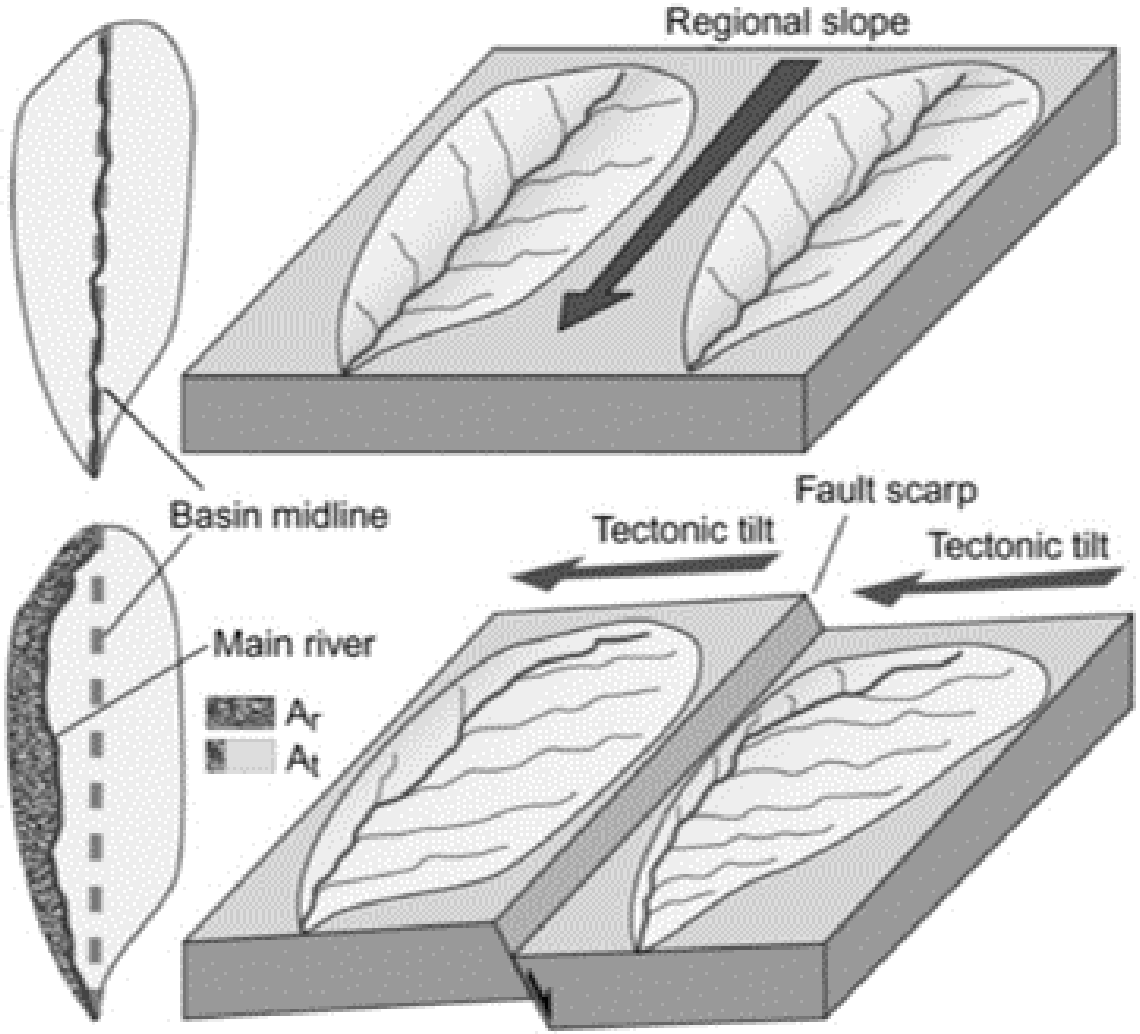


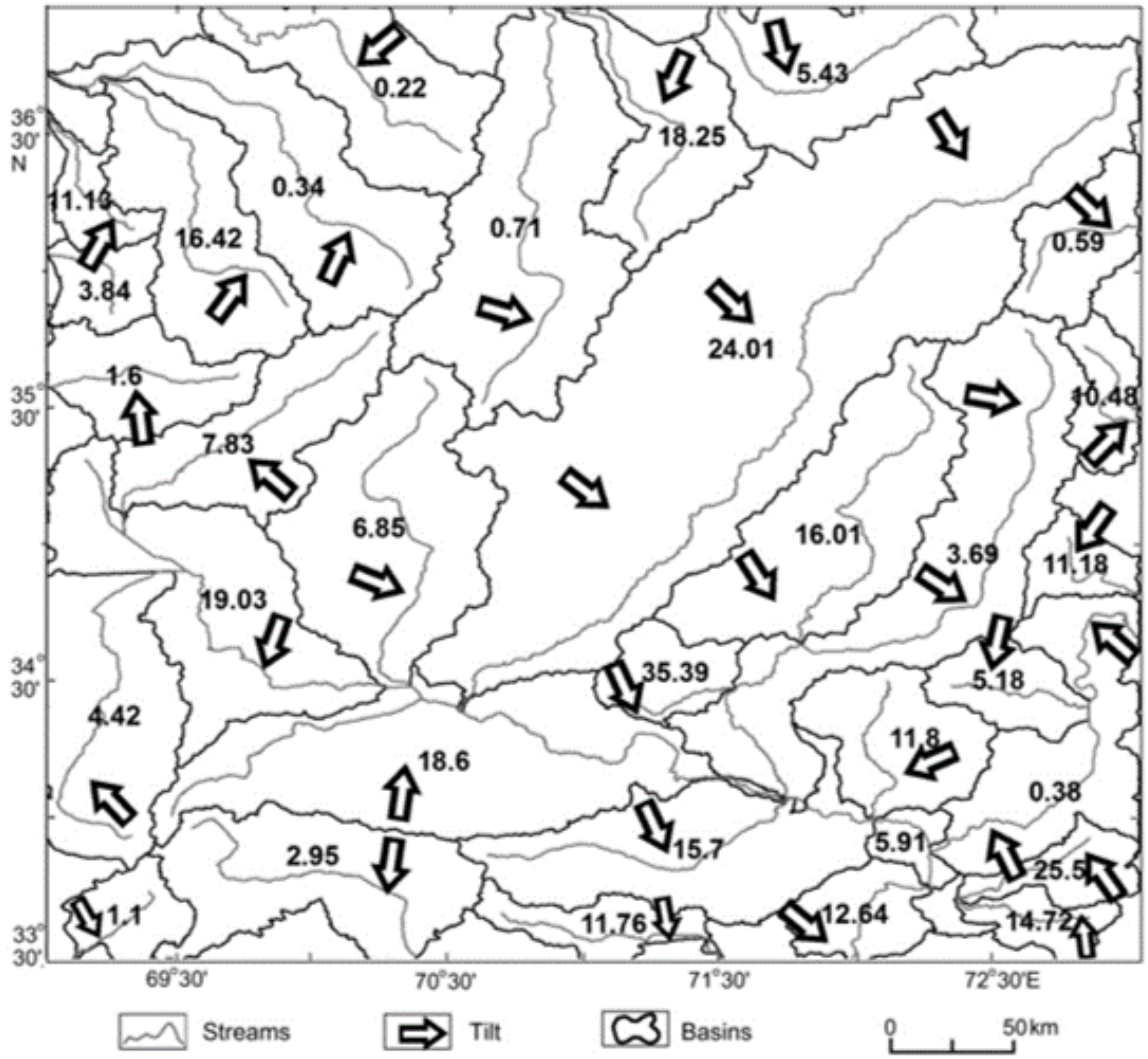

(a)
head
Height(H)
Distance from river head(L)
(b)
H = c - k' x logL
k' = SL Index
Height(H)
Distance from river head(logL)
(c)
H
Uplift
L
(d)
H
Uplift
logL
(e)
IV
III
II
I
" curved " Hack profile
head
H
k
graded profile
mouth
step SL index curve
logL

# Curva hipsométrica



# Indices tectónicos




0.22
5.43
18.25
11.13
0.34
16.42
0.71
0.59
3.84
24.01
1.6
10.48
7.83
6.85
16.01
3.69
11.18
19.03
35.39
5.18
4.42
11.8
18.6
0.38
2.95
15.7
5.91
25.5
1.1
11.76
12.64
14.72
36° 30' N
35° 30'
34° 30'
33° 30'
69°30'
70°30'
71°30'
72°30'E
Streams
Tilt
Basins
0
50 km

# Geomorfometría & Análisis Hidrológico