GEOMORFOLOGÍA

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UNIVERSIDAD NACIONAL DE COLOMBIA
SEDE MEDELLÍN

Geoformas

Los atributos son características usadas para la descripción, identificación y clasificación de las geoformas. De acuerdo con Tricart (1965) y Van Zuidam (1985) se usan los siguientes tipos de atributos en un mapa geomorfológico detallado:

Morfología: el relieve general

- Morfografía para describir la geometría y aspectos de las geoformas
- Morfométría para medir cuantitativamente las dimensiones de las geoformas

Morfogenéticos: para determinar el origen y la evolución de la geoformas

- Morfoestructura pasiva: la litología y estructuras relacionadas con proecesos denudacionales
- Morfoestructura dinámica: la dinámica endógena
- Morfodinámica: la dinámica exógena

Morfocronológicos: para circunscribir el contexto temporal en que se originaron las geoformas

- Datación relativa
- Datación absoluta

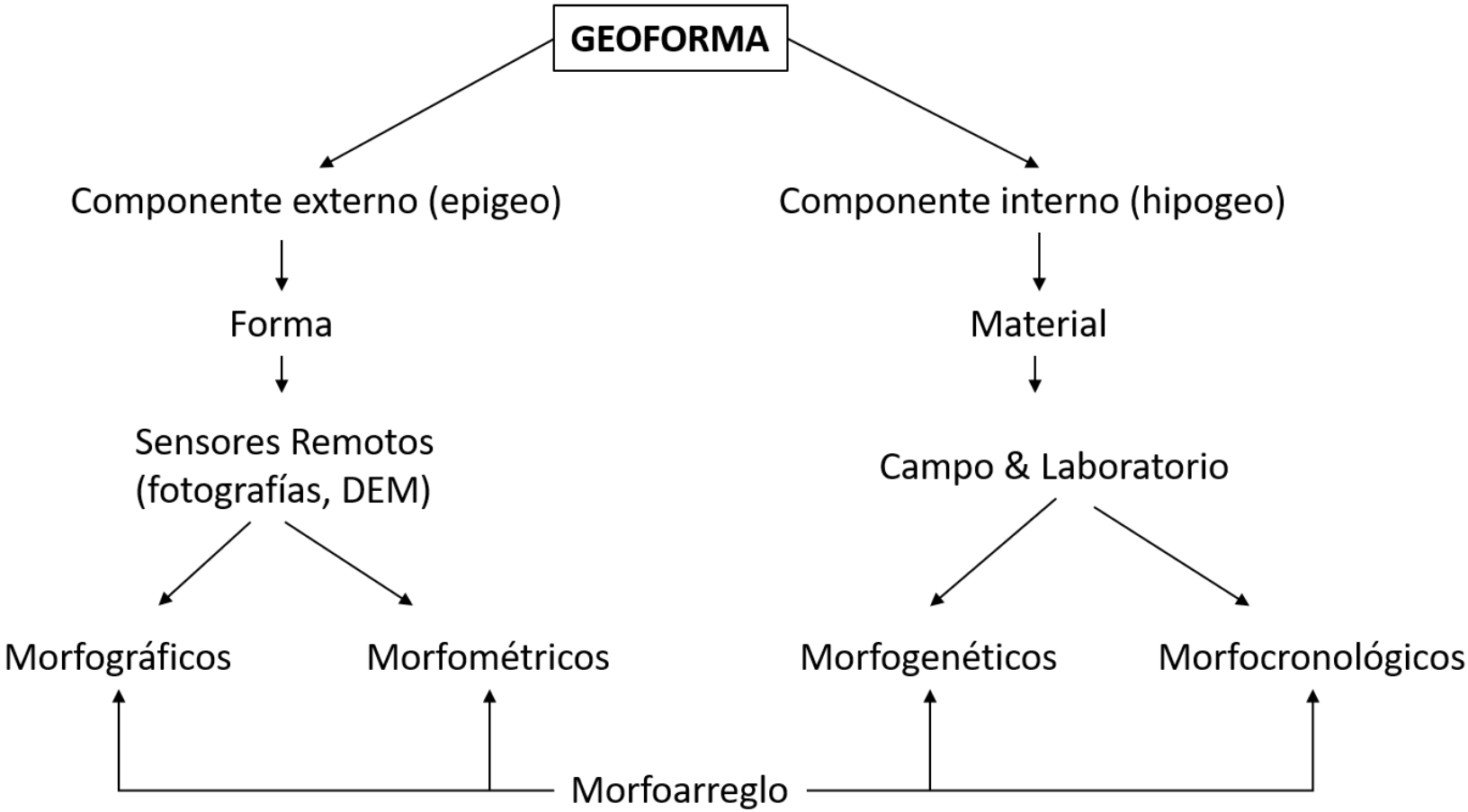
Morfoarreglo: el arreglo espacial y la interrelación de las diferentes geoformas y los procesos relacionados.

Fuente: Zinck (1988) & van Zuidam (1985)

Geoformas

Concepto genérico que designa todos los tipos de formas del relieve independiente de su origen, de su dimensión y de su nivel de abstracción.

Paisaje (Landscape)→agregado de **Geoformas** (Landform)→forma+proceso



Fuente: Zinck (1988)

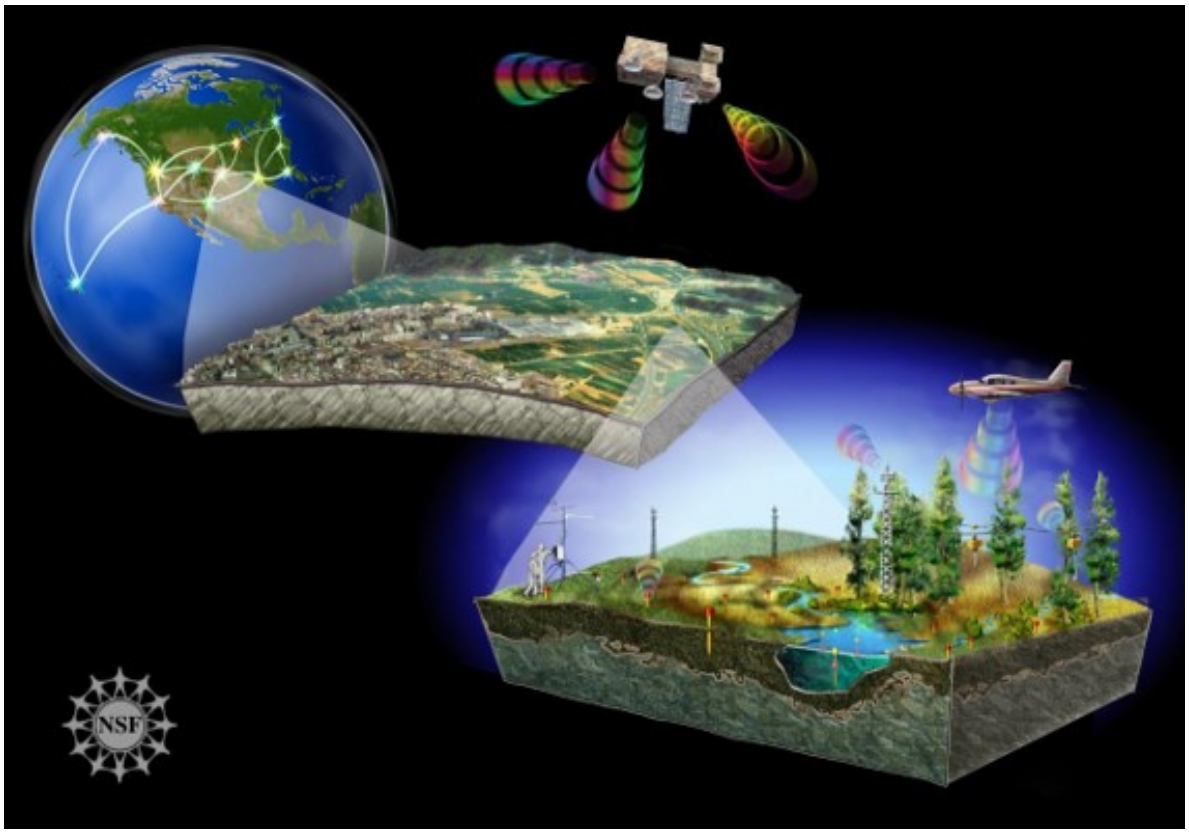
Atributos

Atributos	Paisaje	Relieve	Litología	F. terren
Morfométricos				
Altura relativa	+	+	-	o
Densidad de drenaje	+	+	-	-
Pendiente	+	+	-	+
Morfográficos				
Forma topográfica	+	o	-	-
Perfil topográfico	-	+	-	+
Exposición	-	+	-	+
Configuración	-	+	-	+
Diseño de los contornos	-	+	-	+
Patrón de drenaje	+	+	-	-
Condiciones circundantes	+	+	+	+
Morfogenéticos				
Granulometría	-	o	+	+
Estructura	-	-	+	+
Consistencia	-	-	+	+
Mineralogía	-	-	+	+
Morfoscopía	-	-	+	+
Morfocronológicos				
Grado de meteorización	-	-	+	+
Grado de desarrollo pedológico	-	-	o	+
Indices de lixiviación	-	-	o	+
Estado del complejo adsorbente	-	-	o	+
Mineralogía de arcillas	-	-	+	+

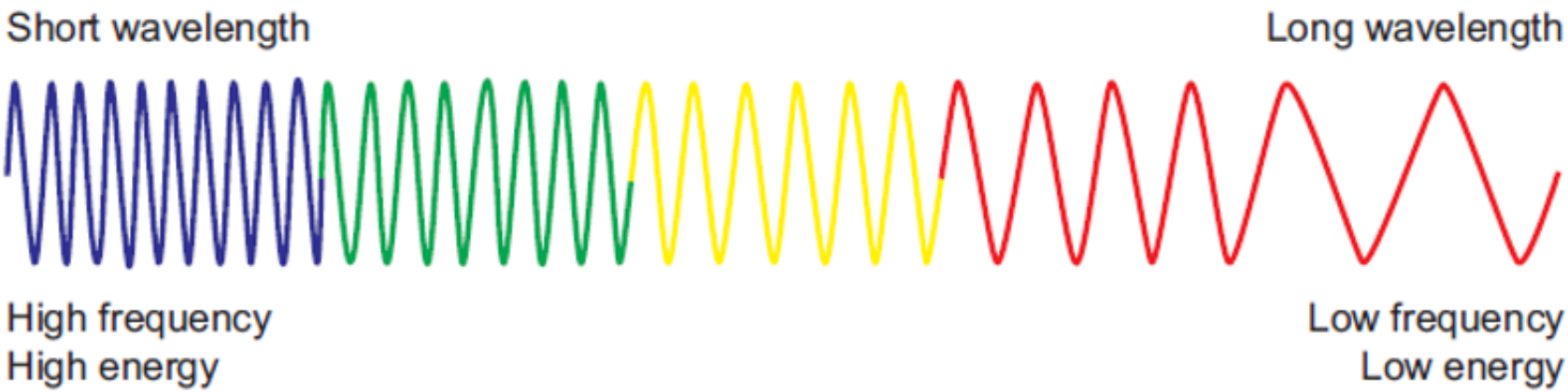
Fuente: Zinck (1988)

Sensores Remotos

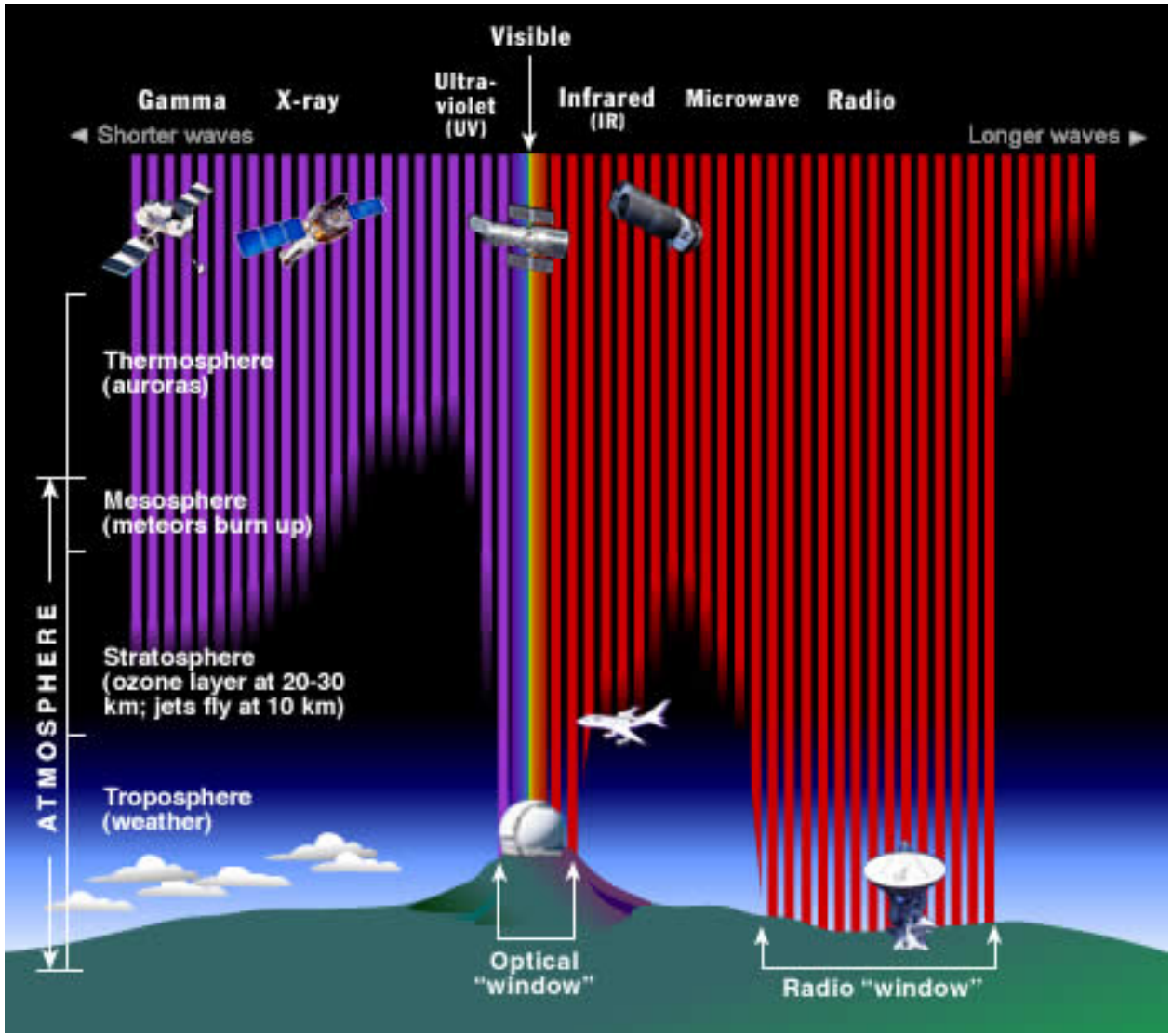
Los Sensores Remotos (teledetección) es el **arte, ciencia y tecnología** de observar un **objeto, escena o fenómeno** por técnicas basadas en instrumentos. El termino remoto se refiere a la observación realizada a una distancia **sin contacto físico** con el objeto de interés. Se puede utilizar herramientas de detección y despliegue en tiempo real o una herramienta que registra la energía, la cual es emitida o reflejada desde el objeto o la escena en observación. La energía puede ser luz u otra forma de **radiaciones electromagnética**, campos de fuerza o energía acústica. Fuente: ITC



Espectro Electromagnético

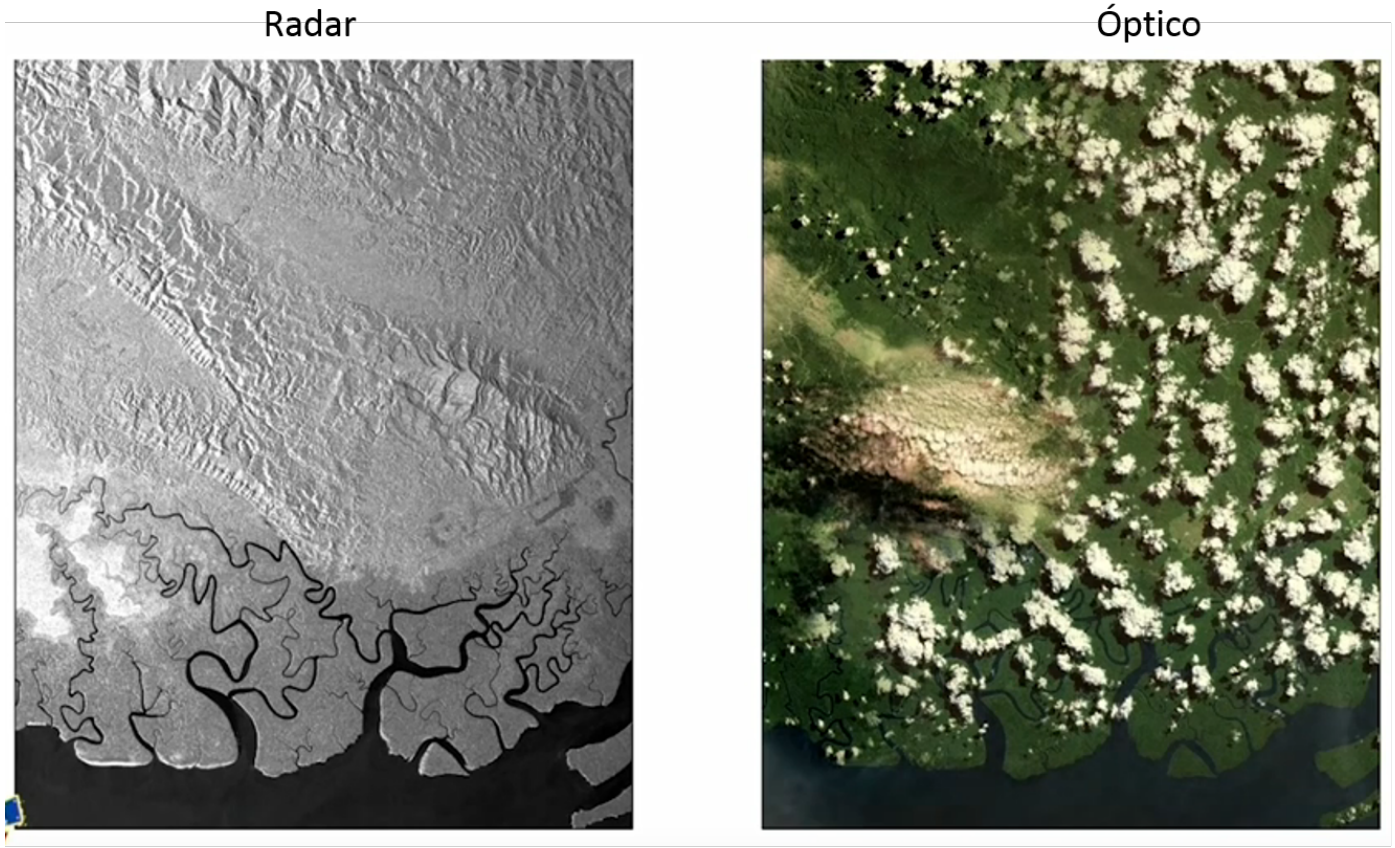


Ventanas Atmosféricas



Credit: NASA's Imagine the Universe

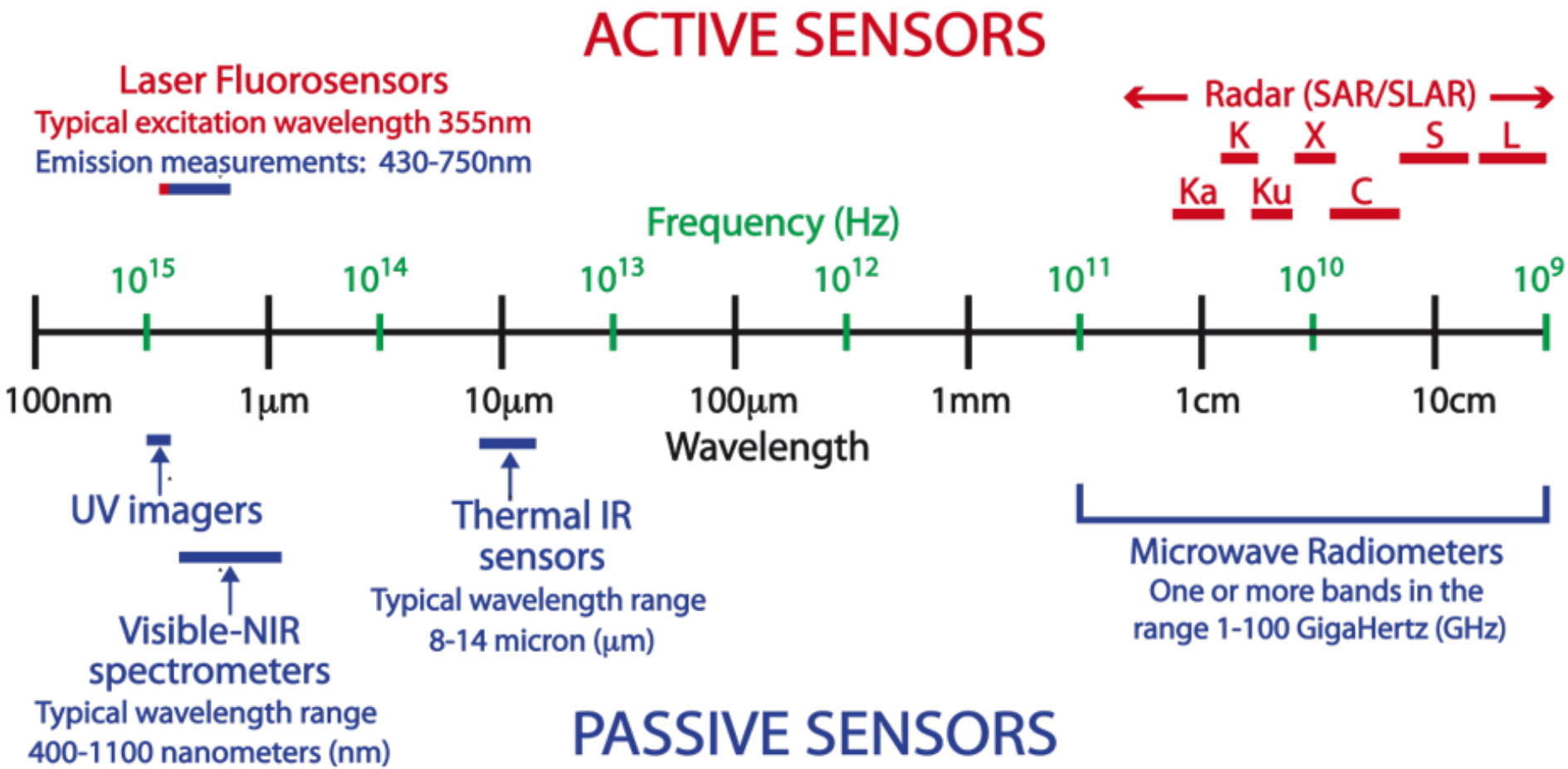
Radar vs Óptico



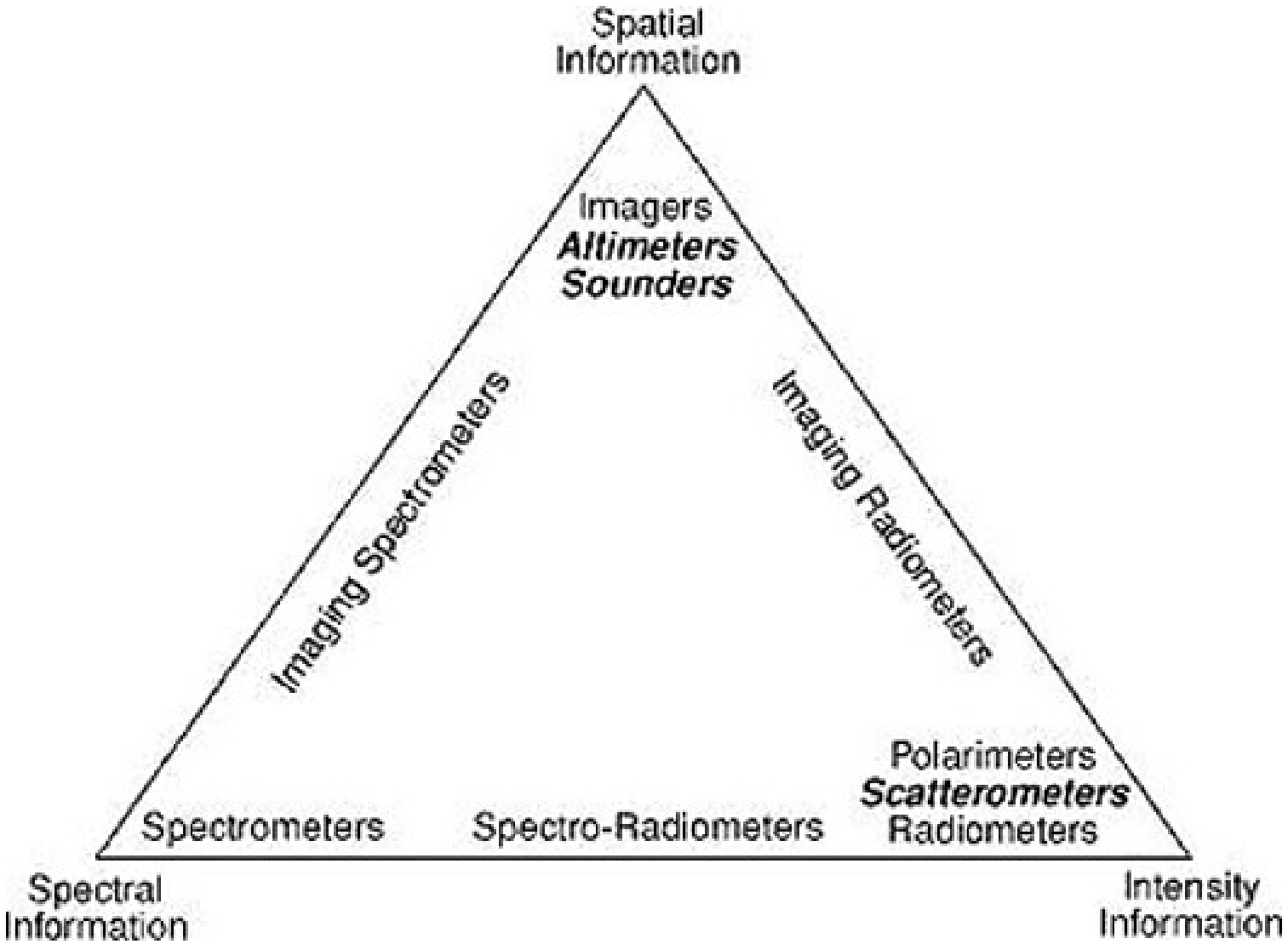
EAGE E-lecture: Satellite InSAR Data by Alessandro Ferretti

Credit: NASA's Imagine the Universe

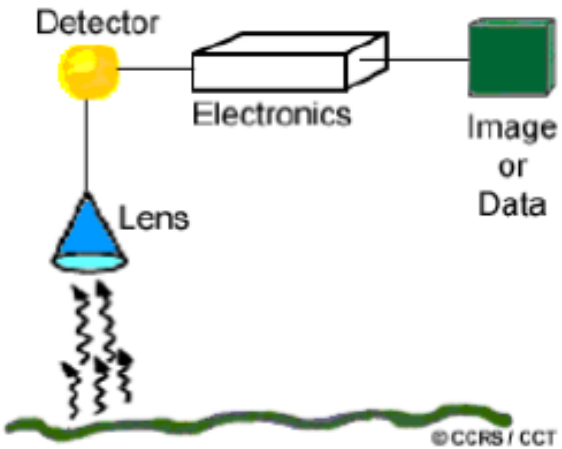
Sensores

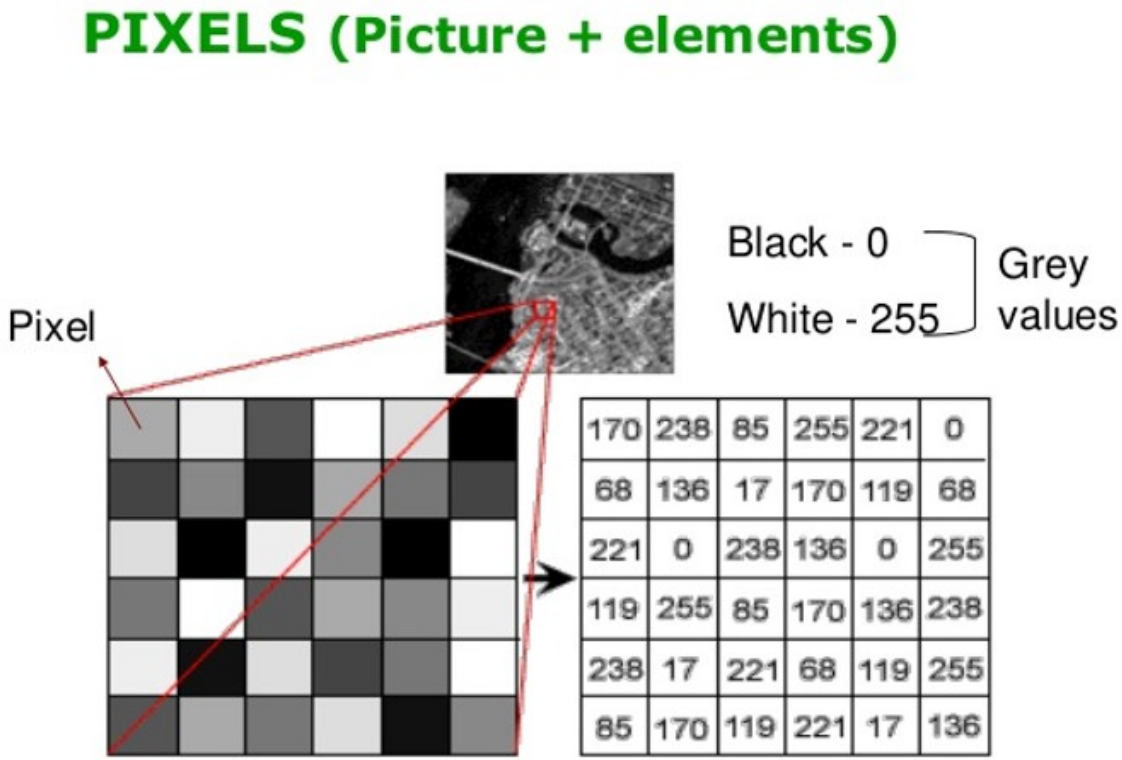

ACTIVE SENSORS
Laser Fluorosensors
Typical excitation wavelength 355nm
Emission measurements: 430-750nm
Radar (SAR/SLAR)
K
X
S
L
Ka
Ku
C
Frequency (Hz)
10^{15}
10^{14}
10^{13}
10^{12}
10^{11}
10^{10}
10^{9}
100nm
1μm
10μm
100μm
1mm
1cm
10cm
Wavelength
UV imagers
Visible-NIR spectrometers
Typical wavelength range
400-1100 nanometers (nm)
Thermal IR sensors
Typical wavelength range
8-14 micron (μm)
Microwave Radiometers
One or more bands in the range 1-100 GigaHertz (GHz)
PASSIVE SENSORS

Sensores

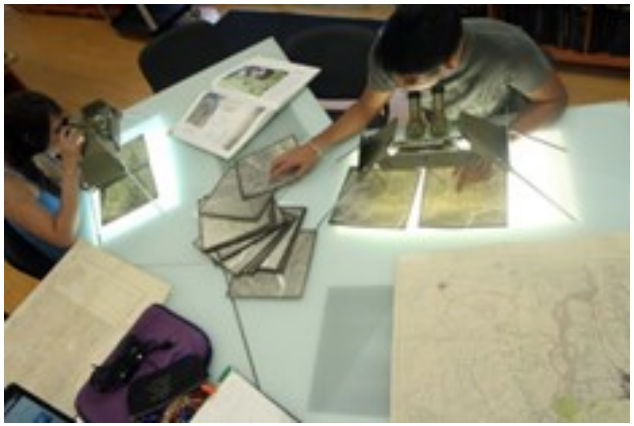

Spatial
Information
Imagers
Altimeters
Sounders
Imaging Spectrometers
Imaging Radiometers
Polarimeters
Scatterometers
Radiometers
Spectrometers
Spectro-Radiometers
Spectral
Information
Intensity
Information

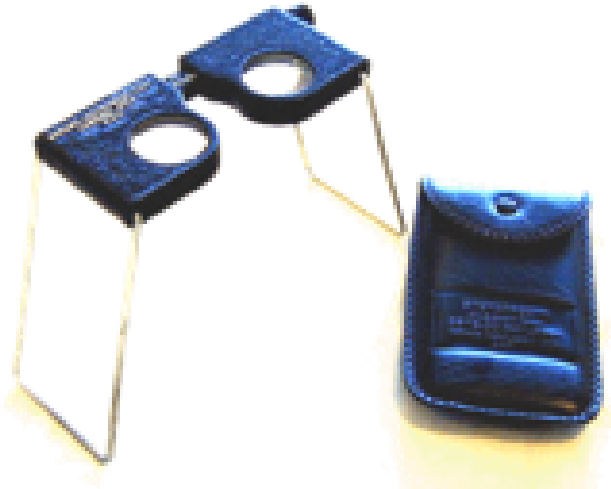
Detectores


Detector
Electronics
Image
or
Data
Lens
©CCRS / CCT

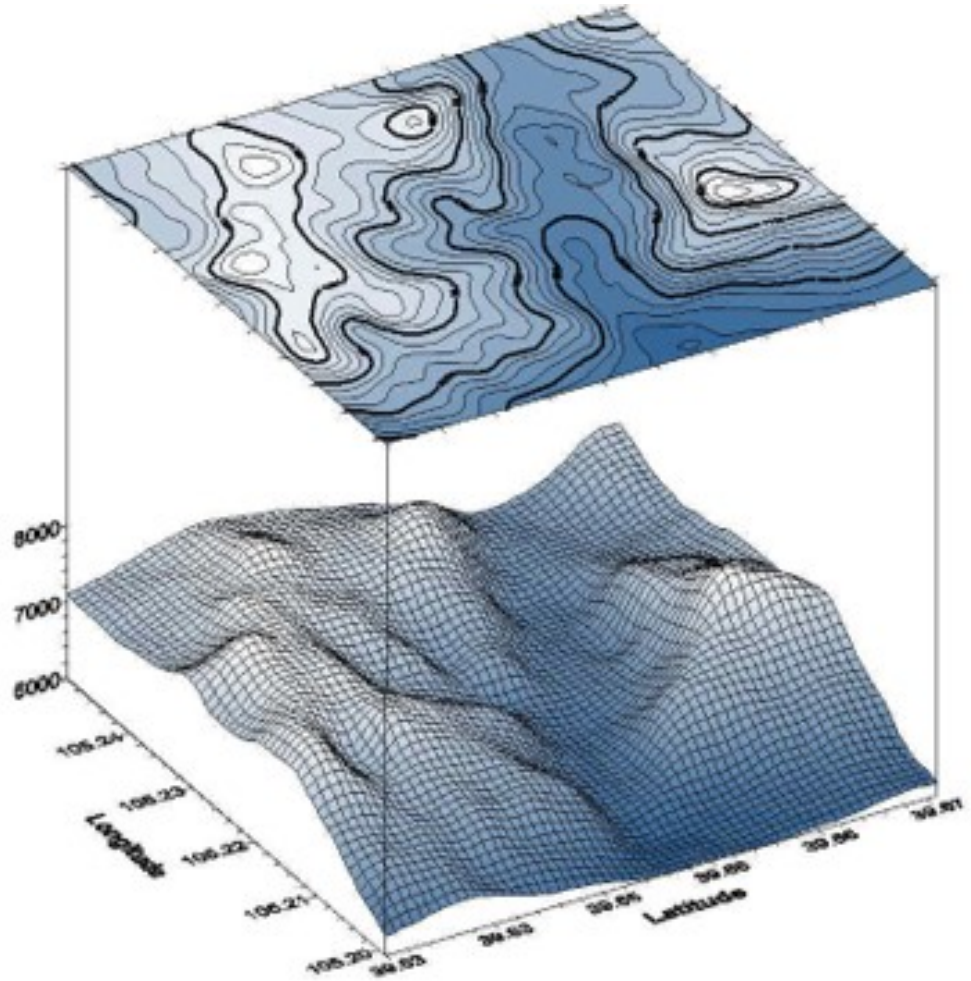

PIXELS (Picture + elements)
Pixel
Black - 0
White - 255
Grey
values
170 238 85 255 221 0
68 136 17 170 119 68
221 0 238 136 0 255
119 255 85 170 136 238
238 17 221 68 119 255
85 170 119 221 17 136

Estereoscopios





Sensores

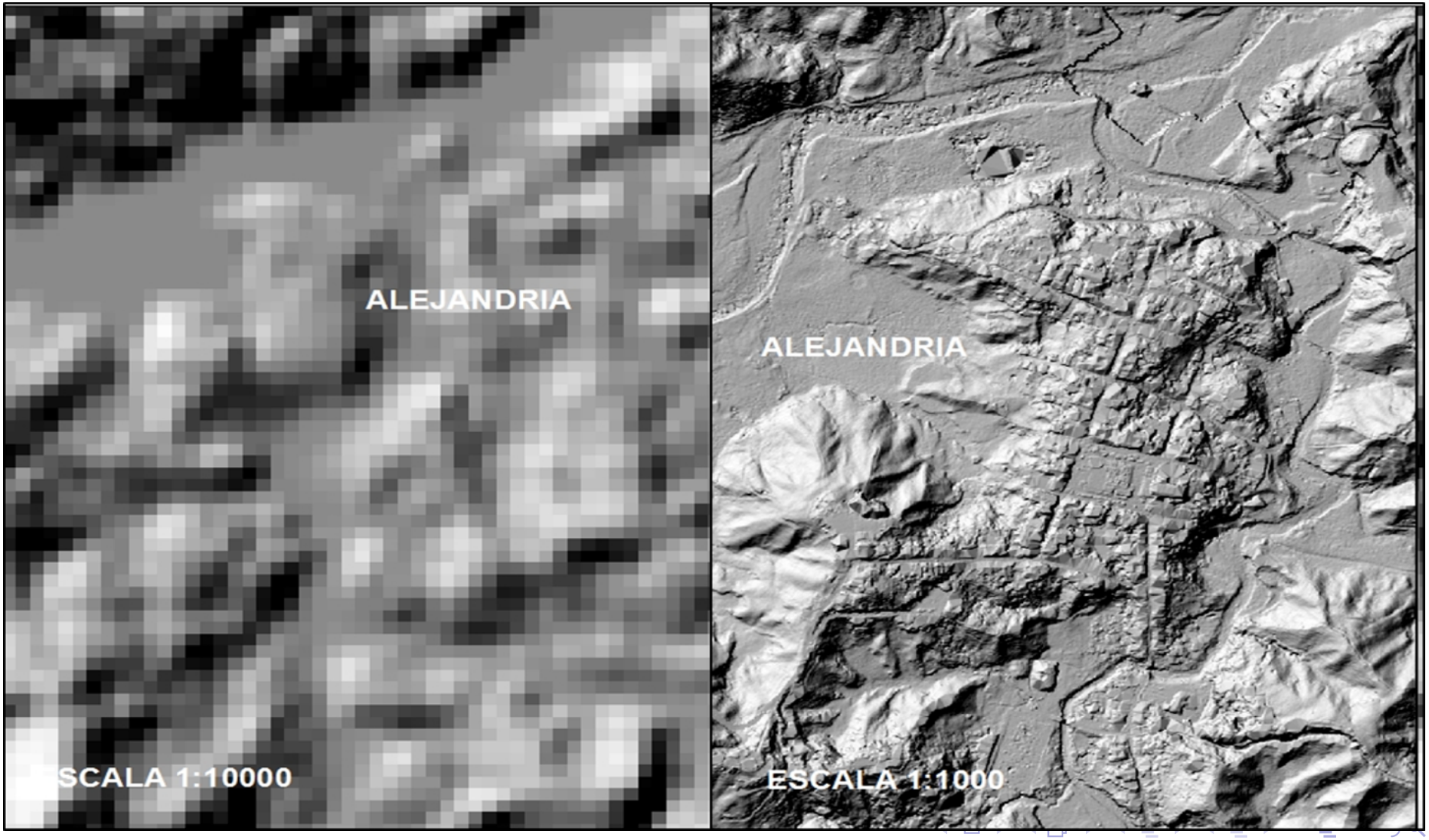


Southwest Corner of the Morrison Quadrangle, Colorado

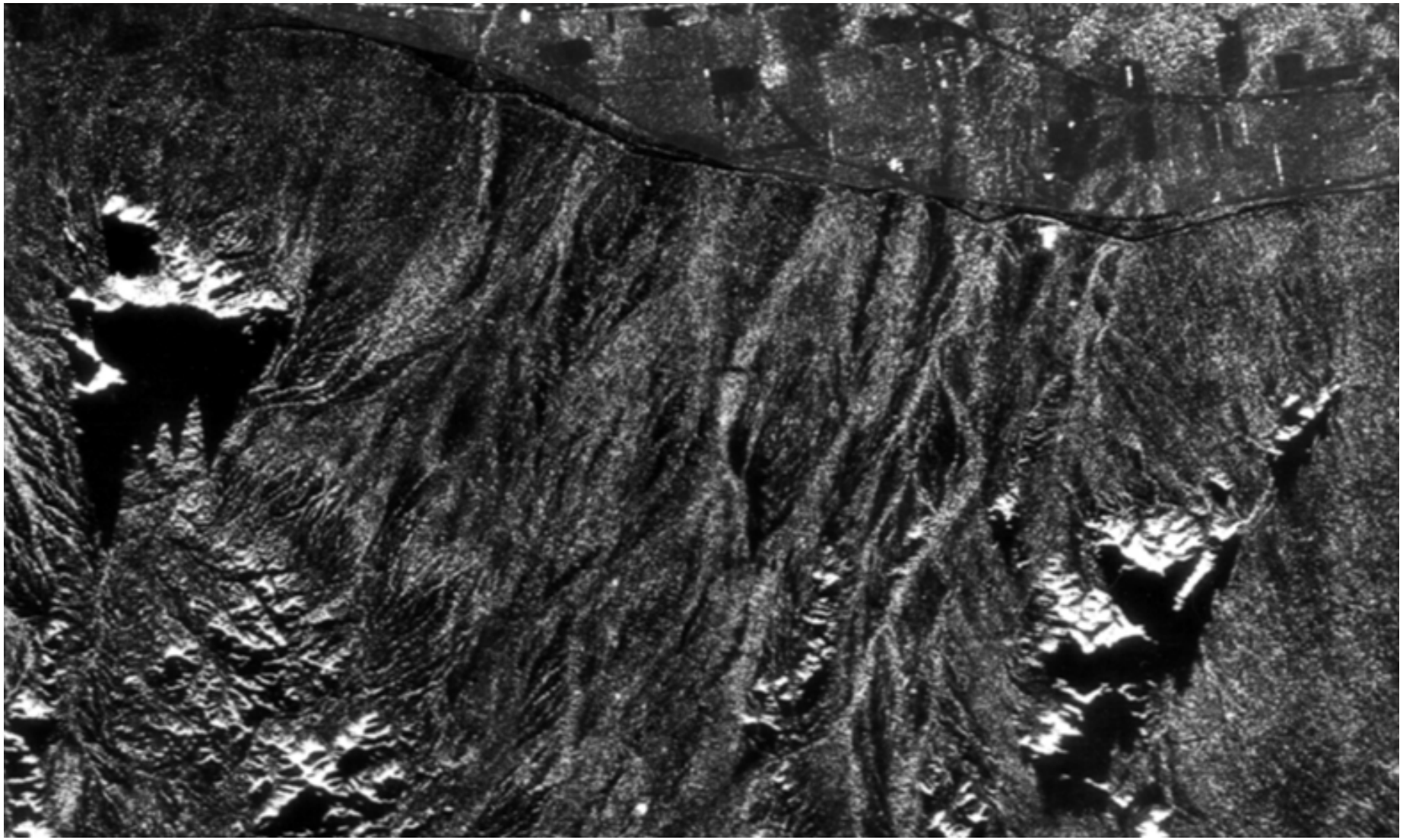
DEM

DEM

DEM



RADAR

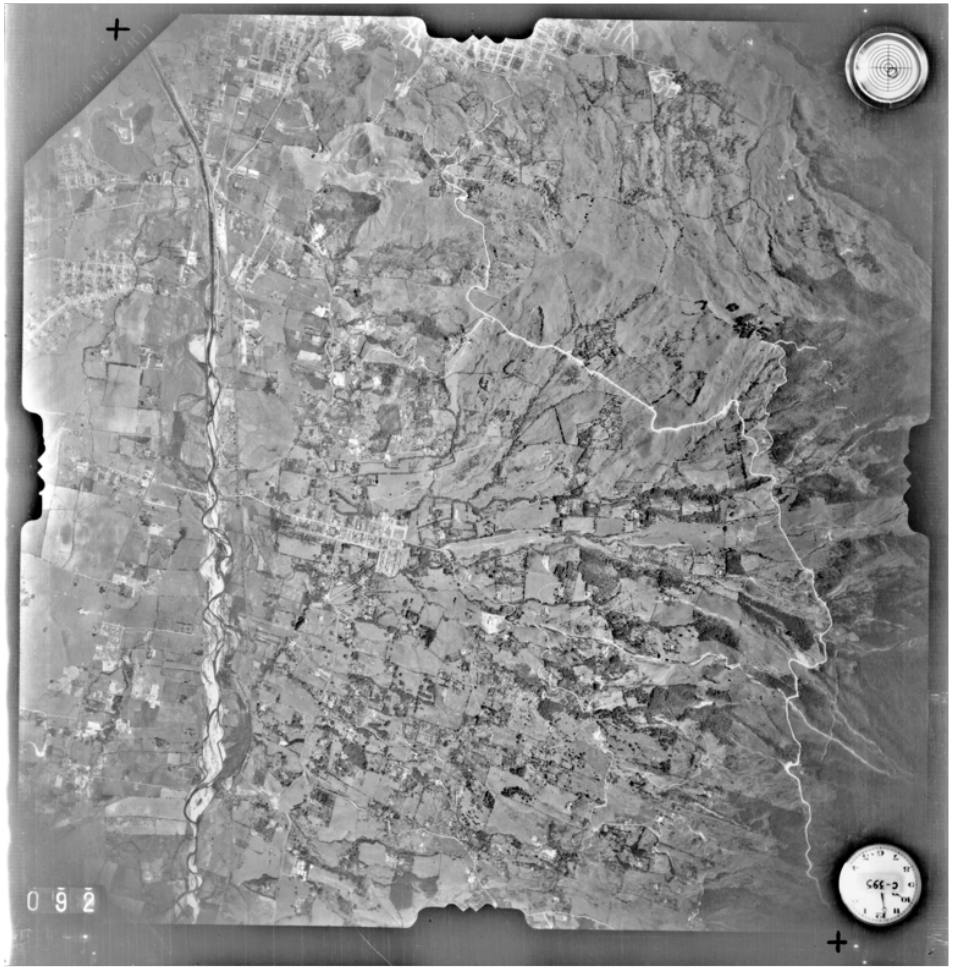


Imágenes del óptico

Imágenes del óptico

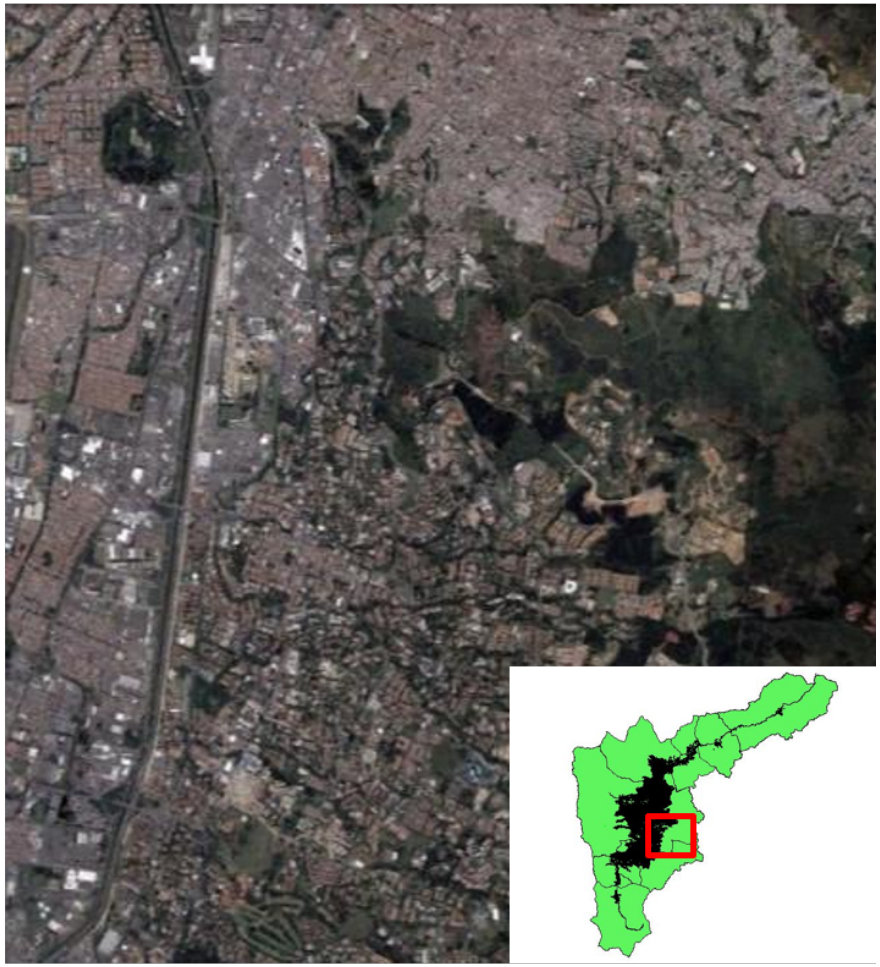
Imágenes del óptico

1943



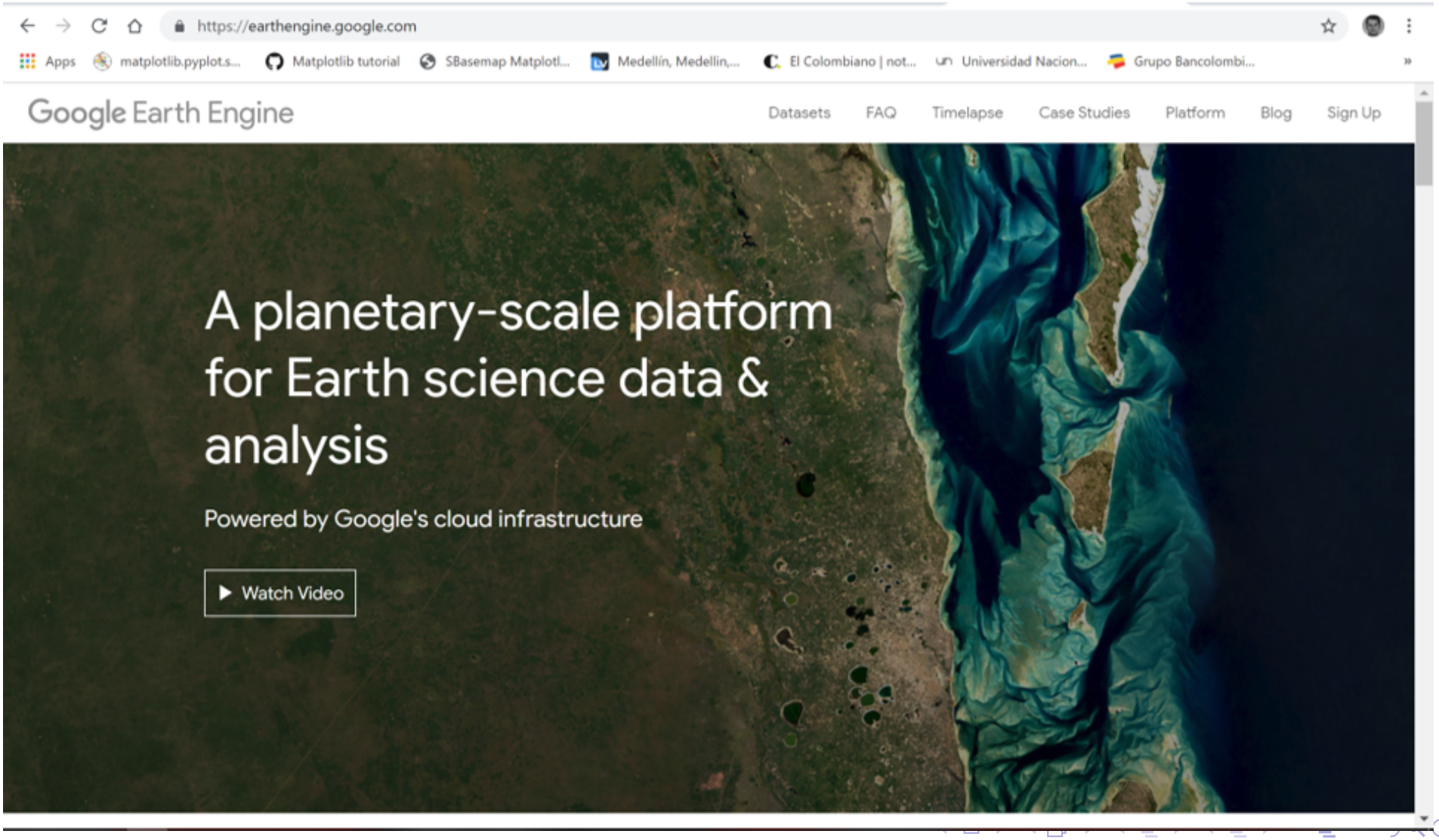
Fuente : Corantioquia

2018

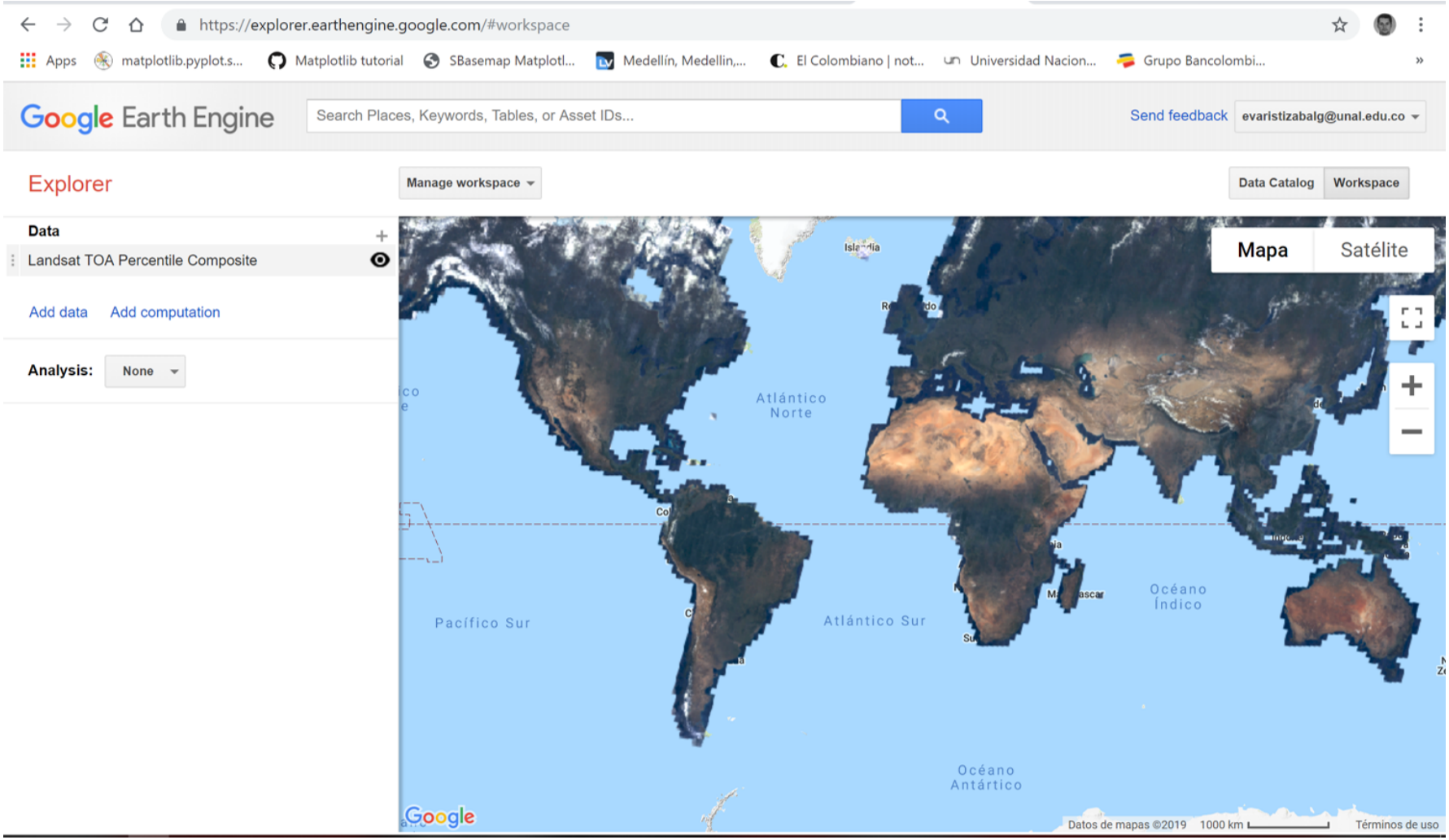


Tomado de Google

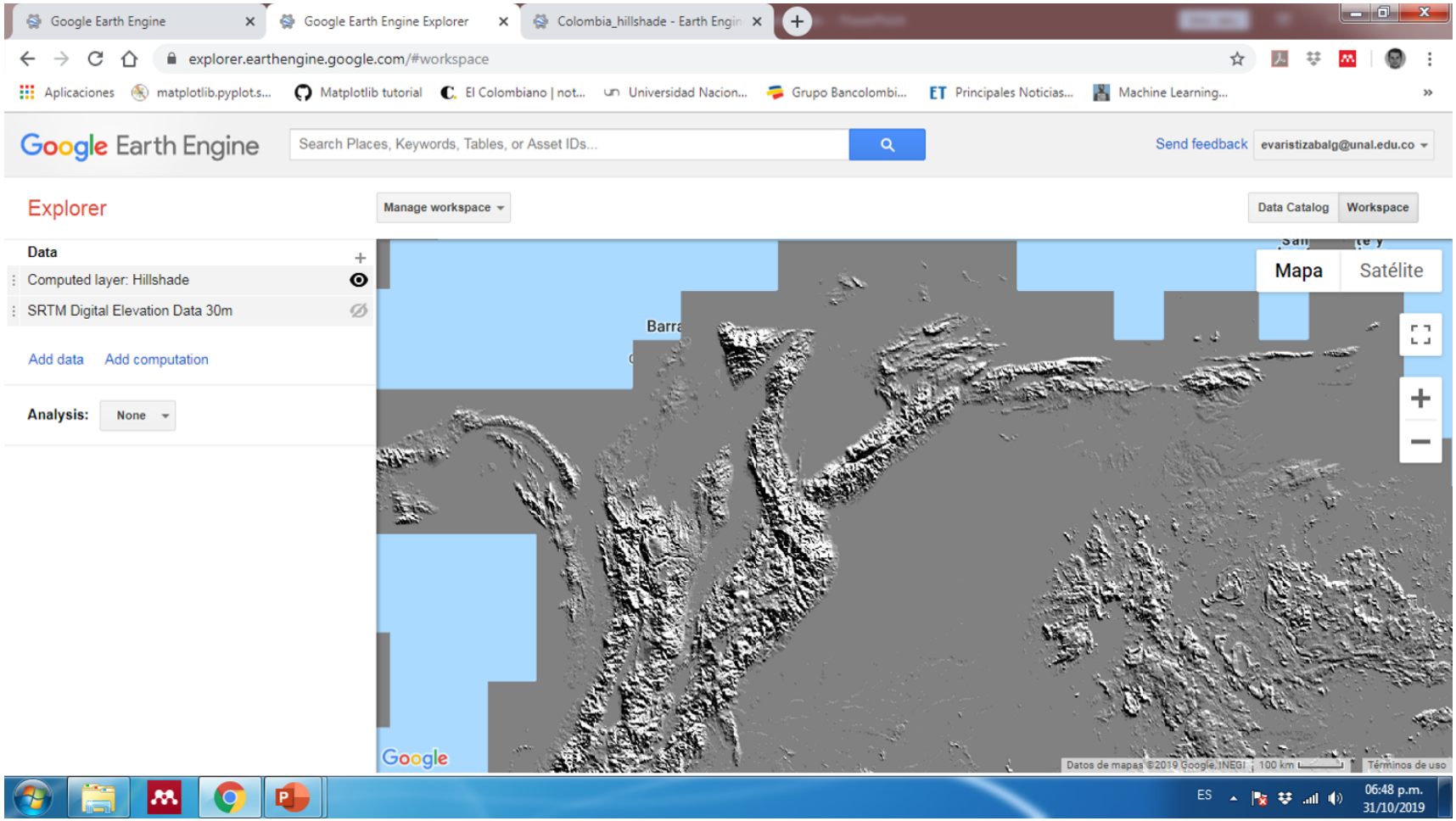
Imágenes disponibles



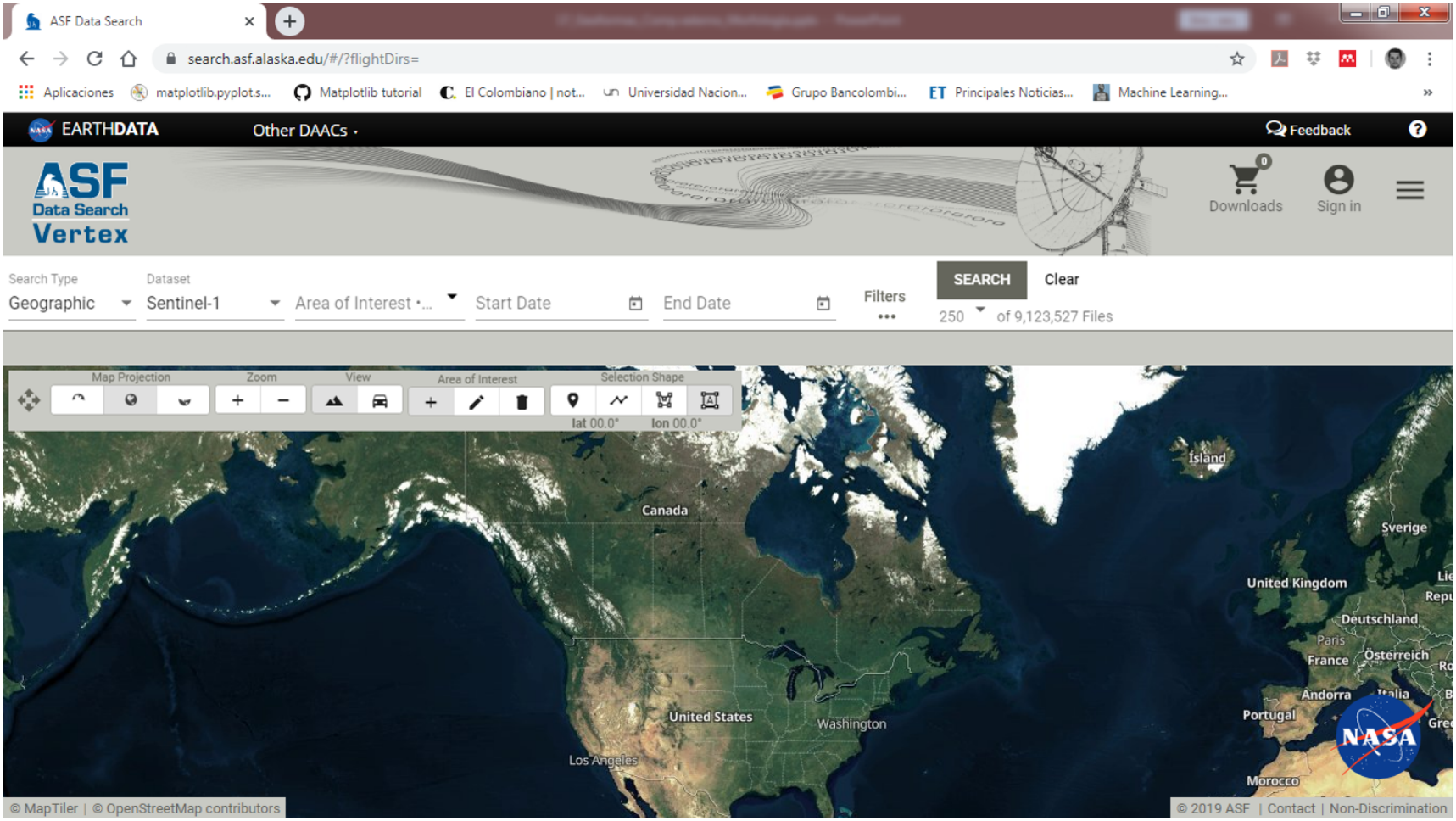
Imágenes disponibles



Imágenes disponibles

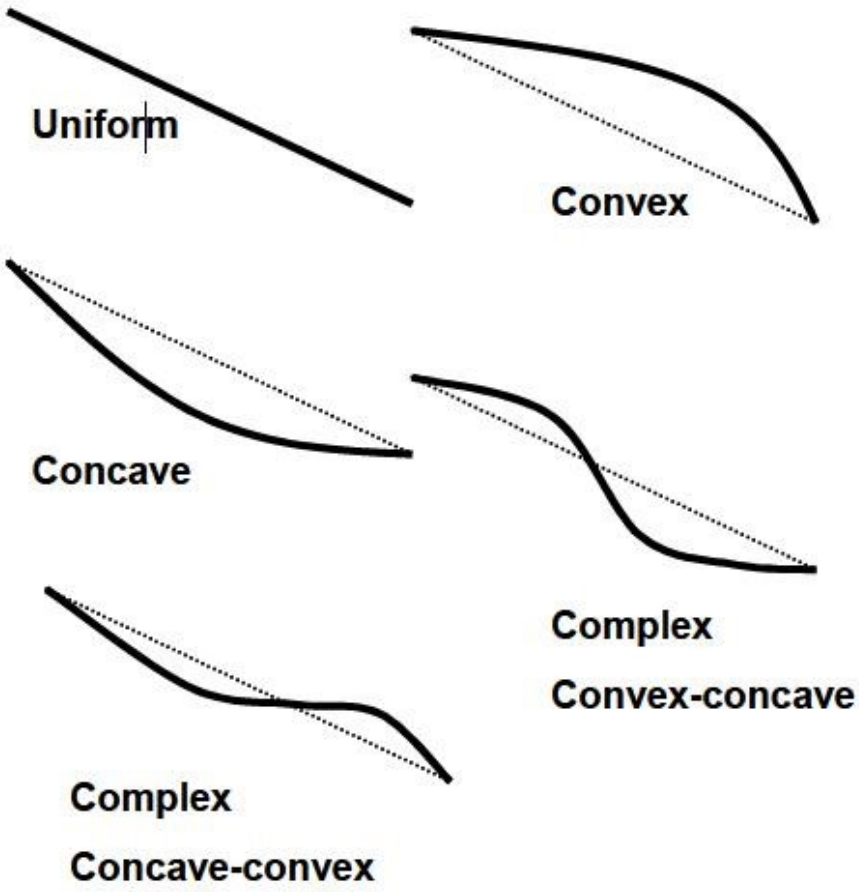


Imágenes disponibles

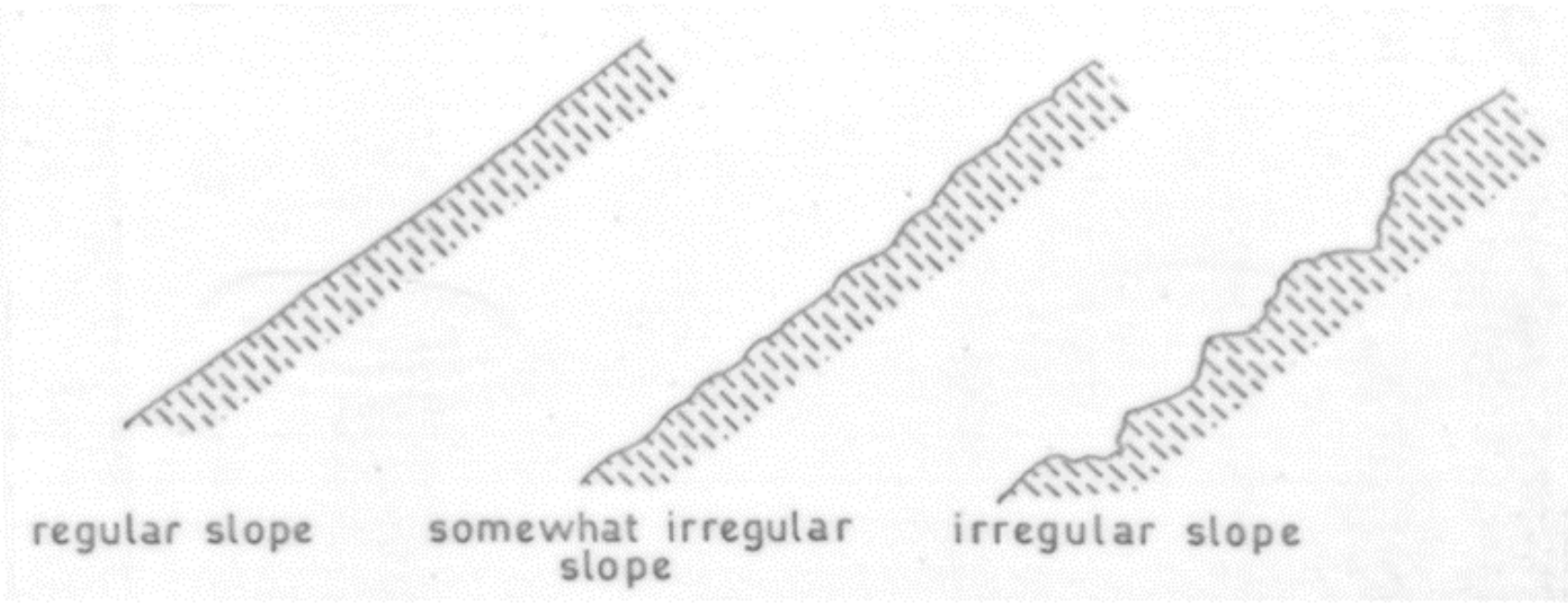


Imágenes disponibles

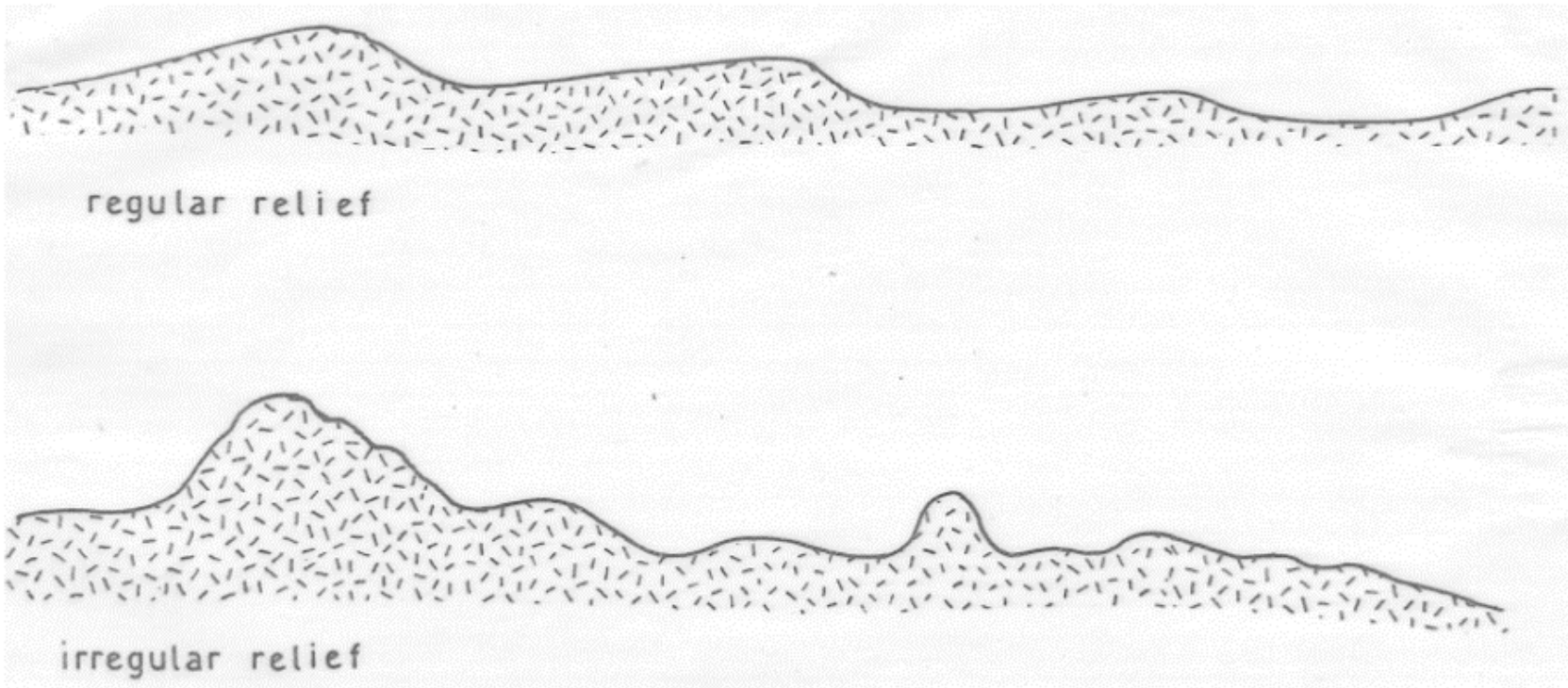
Morfografía



Morfografía



Morfografía



Morfografía

TIPO RELIEVE		
ID	TIPO	ELEVACION
	Montañoso	> 500 m
	Colina	201 - 499 m
	loma	50 - 200 m
	Montículos	0 - 49 m

Morfografía

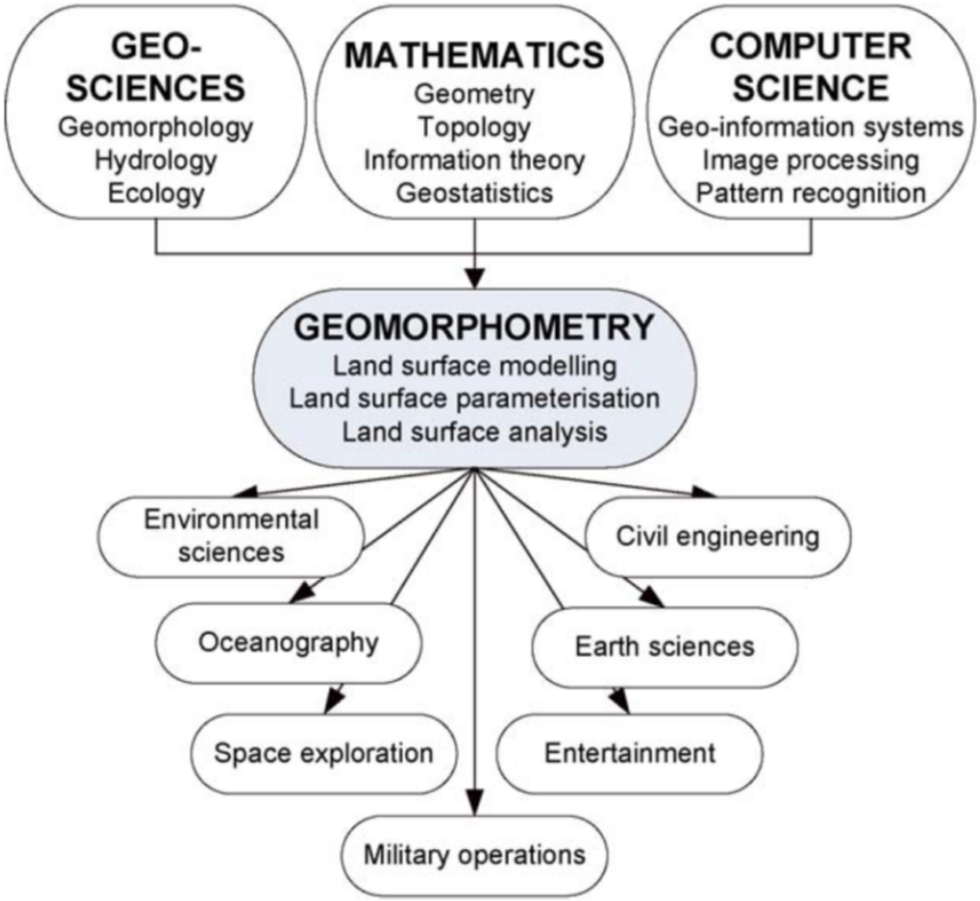
FORMA DE CRESTA		
ID	TIPO	CALIFICACION
	Aguda	
	Redondeada	
	Convexa amplia	
	Convexa Plana	
	Plana	
	Plana Disectada	

Morfografía

LONGITUD DE LADERA		
ID	LONGITUD	DESCRIPCION
	< 50 m	Muy Corta
	51 - 250 m	Corta
	251 - 500 m	Moderada
	501 - 1000 m	Larga
	1001 - 2500 m	Muy Larga
	> 2500 m	Extremadamente Larga

Geomorfometría

La medida y análisis de las características de geoformas que son aplicable a cualquier superficie continua. En general la Geomorfometría provee una base para la comparación cuantitativa de diferentes paisajes, y puede adaptar métodos de análisis de superficie por fuera de la geomorfología.



Geomorfometría

Variables morfométricas:
Una variable (atributo) morfométrica (topográfica) es un solo valor de una función bivariada que describe las propiedades de la superficie topográfica.

Existen 5 tipos principales de variables morfométricas:

- Variables locales
- Variables no locales
- Líneas estructurales
- Variables solares
- Variables combinadas

Variables morfométricas locales

Es un solo valor de una función bivariado que describe la geometría de la superficie topográfica en la vecindad de un punto dado de la superficie.

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 v a given point of the topographic surface (Gauss, 1 corresponds to hills, while $k_{min} < 0$ relates to valley
Maximal curvature, k_{max}, m^{-1}	A curvature of a principal section with the highest v a given point of the topographic surface (Gauss, 1 corresponds to ridges, while $k_{max} < 0$ relates to clos (Section 2.2.4.5)
Mean curvature, H, m^{-1}	A half-sum of curvatures of any two orthogonal n given point of the topographic surface (Young, 180 accumulation mechanisms of gravity-driven substa and relative deceleration of flows—with equal wei 2.2.4.4)
Gaussian curvature, K, m^{-2}	A product of maximal and minimal curvatures. Ac *egregium*, K retains values in each point of the topog

Variables morfométricas locales

Flow attributes

Slope gradient, G, degree	An angle between the tangential and horizontal of the topographic surface (Lehmann, 1799). Re gravity-driven flows (Section 2.2.2)
Slope aspect, A, degree	An angle between the northern direction and th of the two-dimensional vector of gradient count 360 degrees, at a given point of the topographic the direction of gravity-driven flows (Section 2
Horizontal curvature, k_h, m^{-1}	A curvature of a normal section tangential to a point of the topographic surface (Krcho, 1983; S of flow convergence and divergence. Gravity-d intrasoil lateral flows are converged where $k_h <$ diverged where $k_h > 0$ (Sections 2.2.4.2)
Vertical curvature,	A curvature of a normal section having a comn

Variables morfométricas no locales

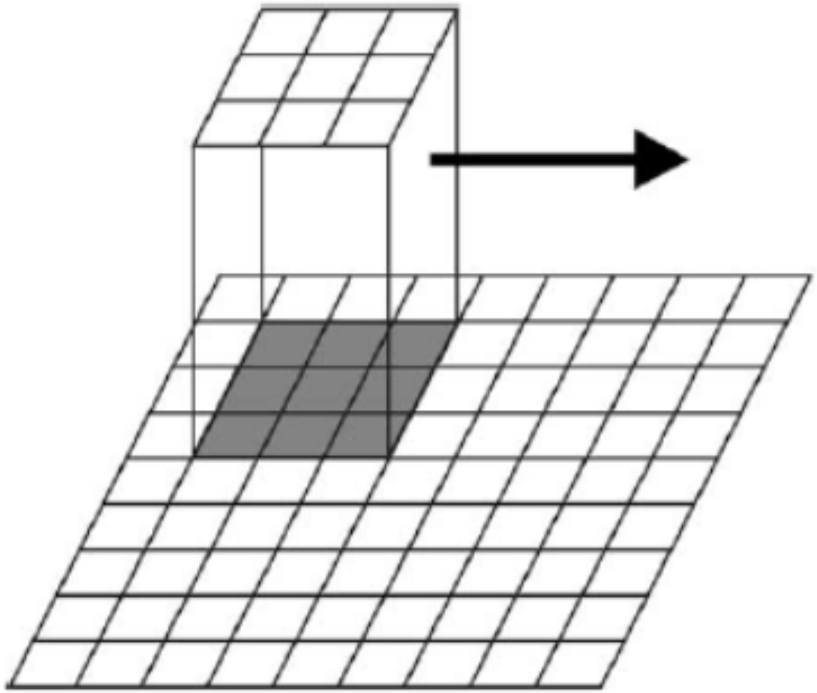
Nonlocal morphometric variables

Catchment area, *CA*, m^2	An area of a closed figure formed by a contour seg of the topographic surface and two flow lines cor the contour segment ends (Speight, 1974). A mea contributing area (Section 2.3)
Dispersive area, *DA*, m^2	An area of a closed figure formed by a contour seg of the topographic surface and two flow lines go the contour segment ends (Speight, 1974). A mea area potentially exposed by flows passing throu (Section 2.3)
Specific catchment	A ratio of an area *CA* to the length of a contour se

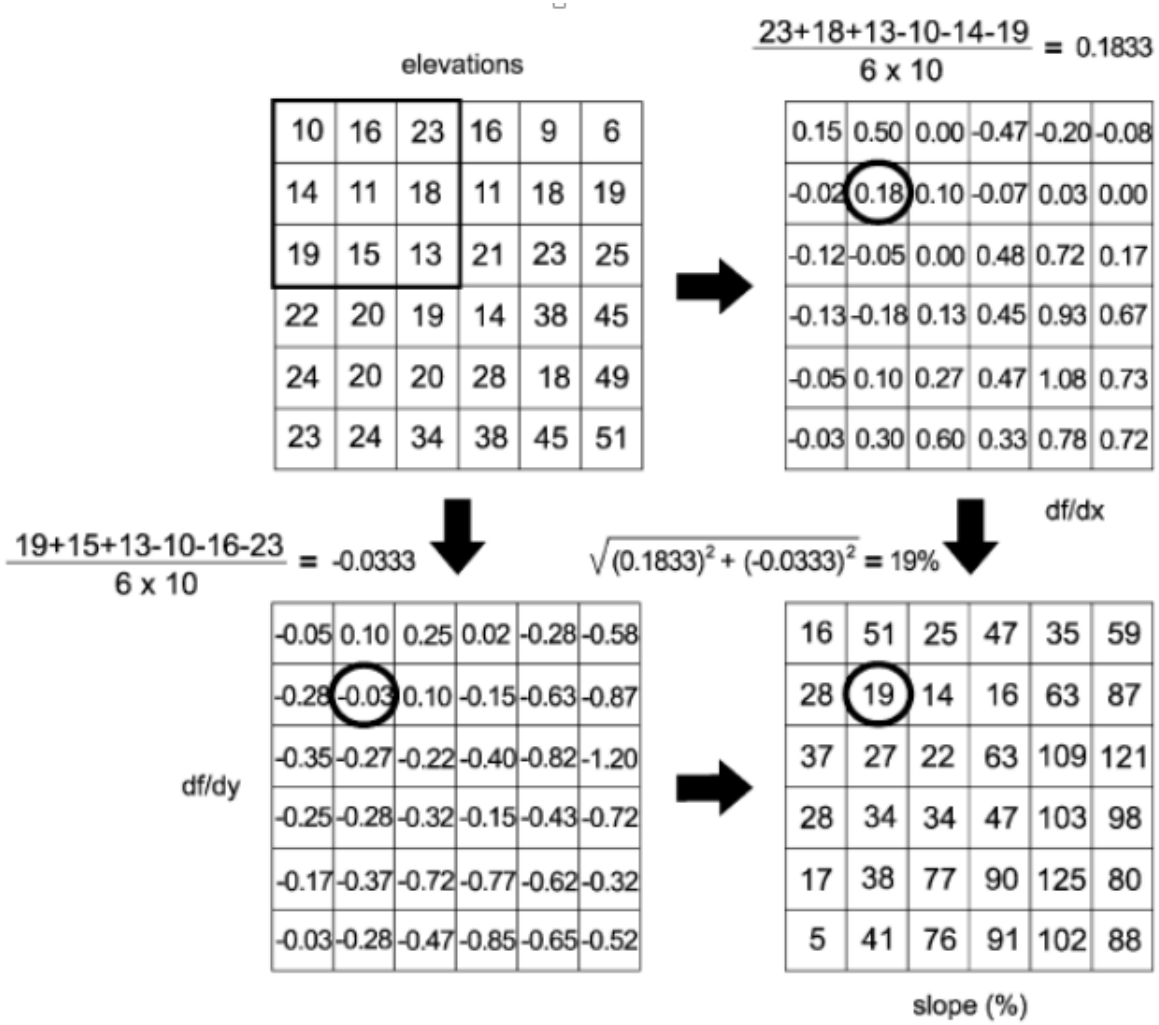
Variables morfométricas solares y combinadas

Variable, notation, and unit	Definition and interpretation
Solar morphometric variables	
Reflectance, *R*	A measure of the brightness of an illuminated s (Section 2.5.1)
Insolation, *I*, %	A measure of the topographic surface illuminati (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 give topographic surface. A measure of the extent of (Beven and Kirkby, 1979) (Section 2.6)
Stream power index, *SI*	The logarithm of a product of *CA* and tan *G* at a topographic surface. A measure of the potential et al., 1991) (Section 2.6)

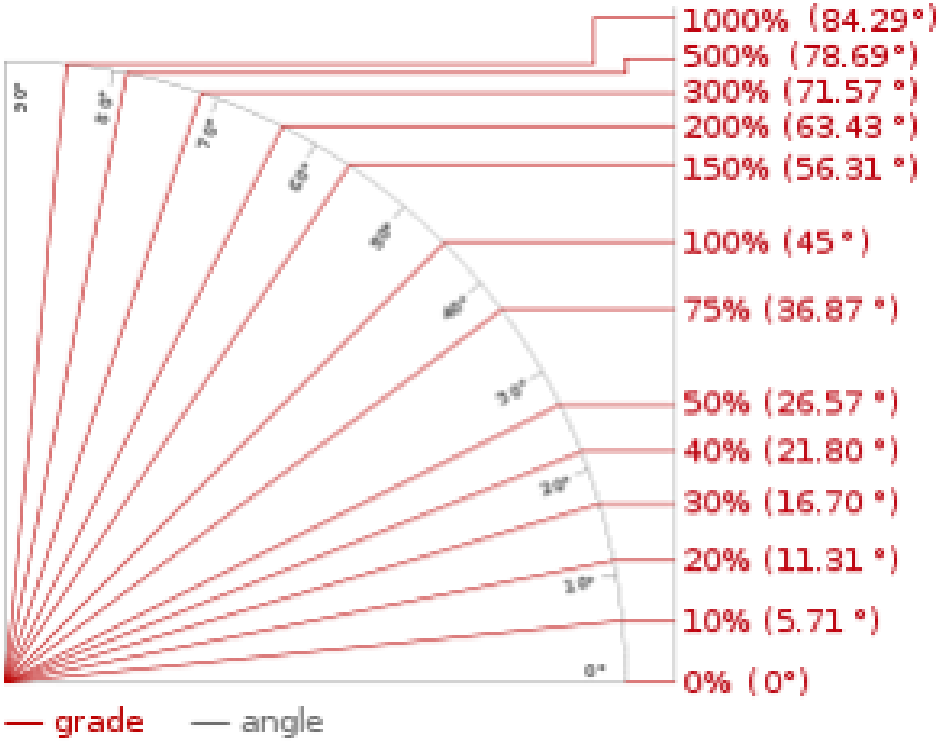
Pendiente

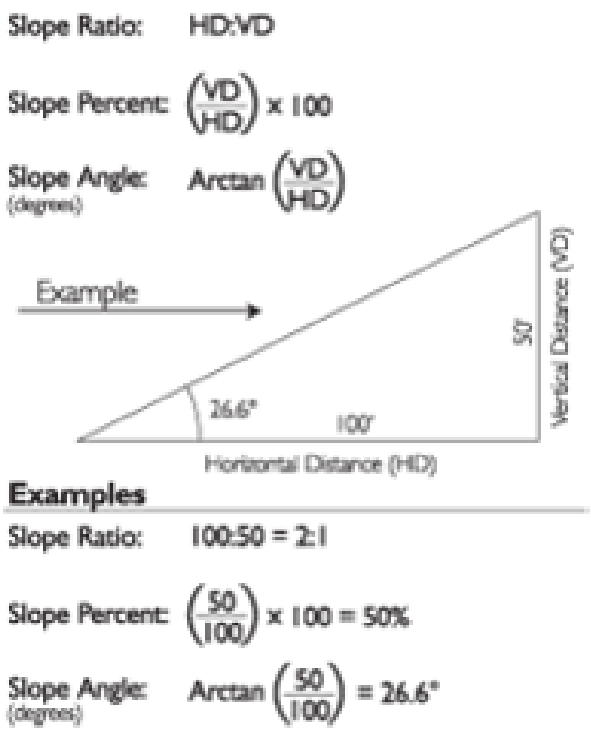


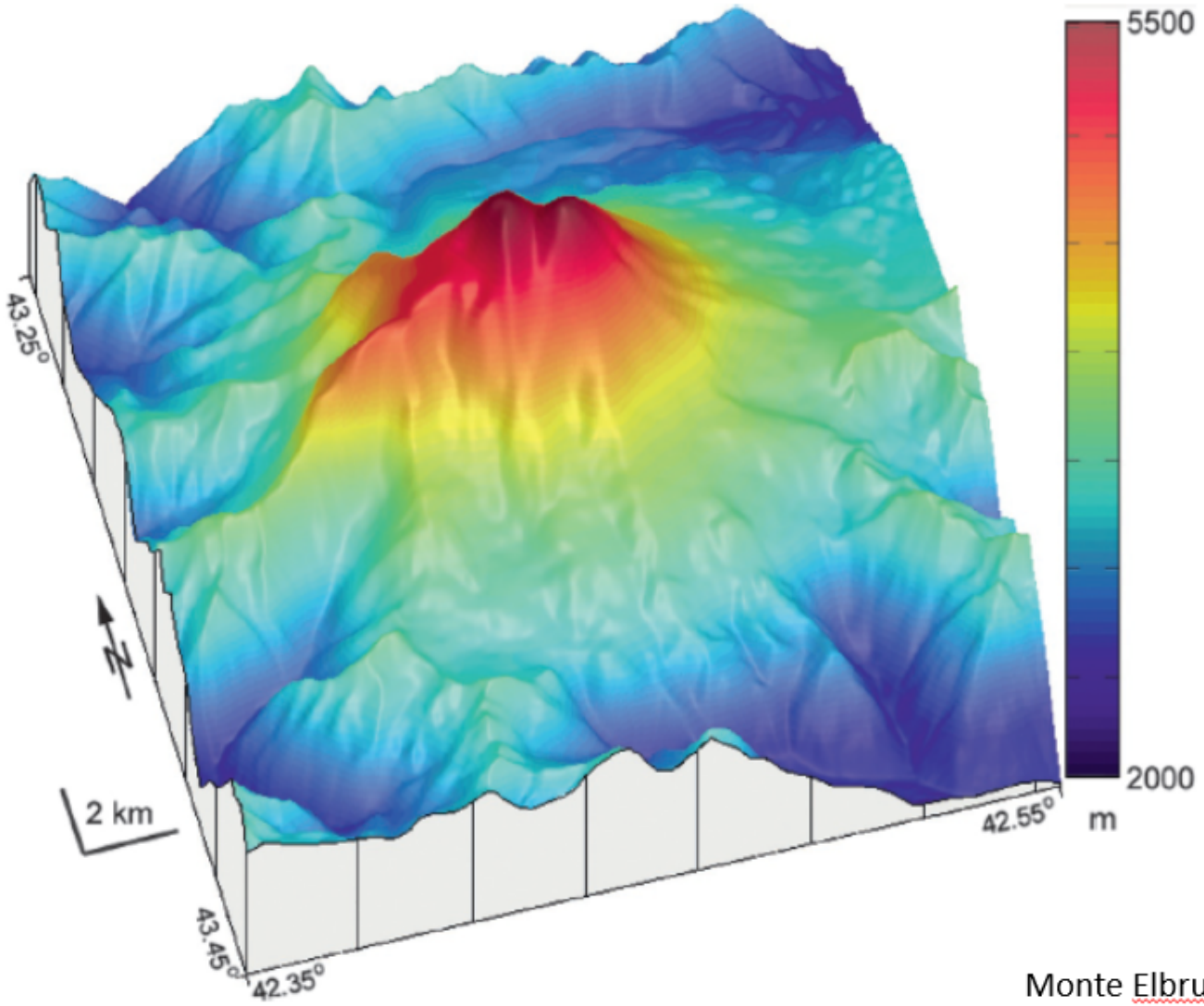
Pendiente


elevations
10 16 23 16 9 6
14 11 18 11 18 19
19 15 13 21 23 25
22 20 19 14 38 45
24 20 20 28 18 49
23 24 34 38 45 51
23+18+13-10-14-19 / 6 x 10 = 0.1833
0.15 0.50 0.00 -0.47 -0.20 -0.08
-0.02 0.18 0.10 -0.07 0.03 0.00
-0.12 -0.05 0.00 0.48 0.72 0.17
-0.13 -0.18 0.13 0.45 0.93 0.67
-0.05 0.10 0.27 0.47 1.08 0.73
-0.03 0.30 0.60 0.33 0.78 0.72
df/dx
19+15+13-10-16-23 / 6 x 10 = -0.0333
√(0.1833)² + (-0.0333)² = 19%
df/dy
-0.05 0.10 0.25 0.02 -0.28 -0.58
-0.28 -0.03 0.10 -0.15 -0.63 -0.87
-0.35 -0.27 -0.22 -0.40 -0.82 -1.20
-0.25 -0.28 -0.32 -0.15 -0.43 -0.72
-0.17 -0.37 -0.72 -0.77 -0.62 -0.32
-0.03 -0.28 -0.47 -0.85 -0.65 -0.52
16 51 25 47 35 59
28 19 14 16 63 87
37 27 22 63 109 121
28 34 34 47 103 98
17 38 77 90 125 80
5 41 76 91 102 88
slope (%)

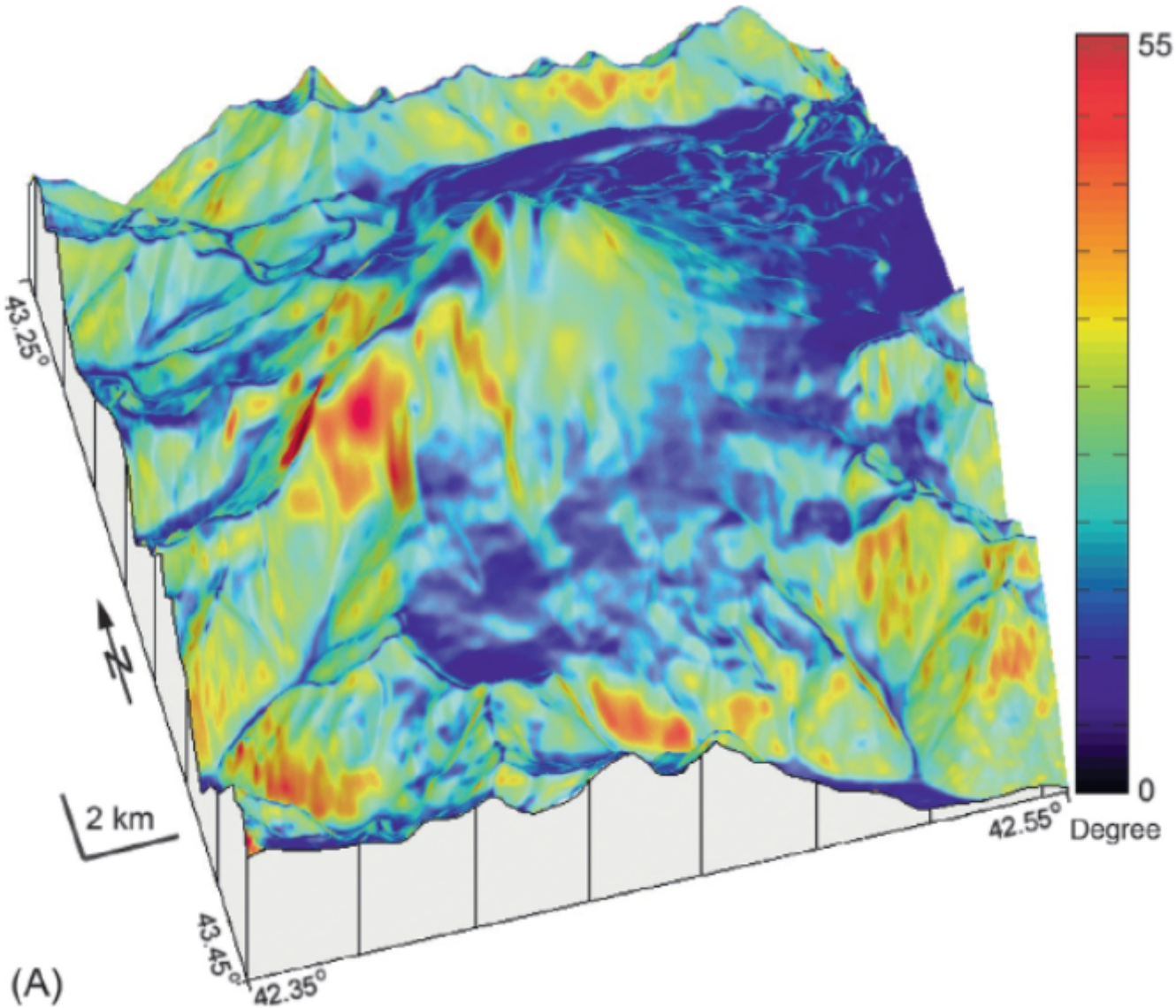
Pendiente

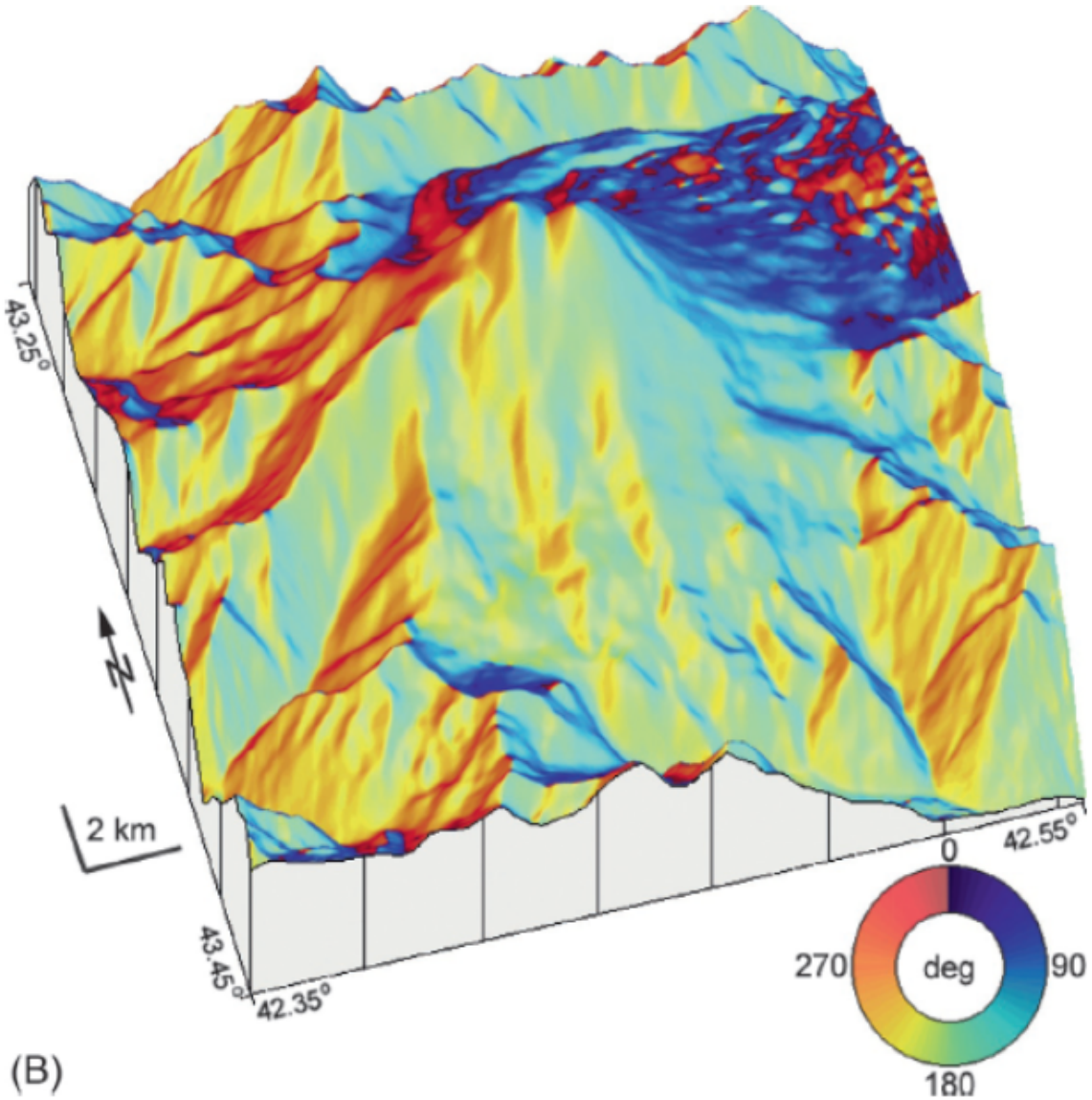

1000% (84.29°)
500% (78.69°)
300% (71.57 °)
200% (63.43 °)
150% (56.31 °)
100% (45 °)
75% (36.87 °)
50% (26.57 °)
40% (21.80 °)
30% (16.70 °)
20% (11.31 °)
10% (5.71 °)
0% (0°)
— grade
— angle

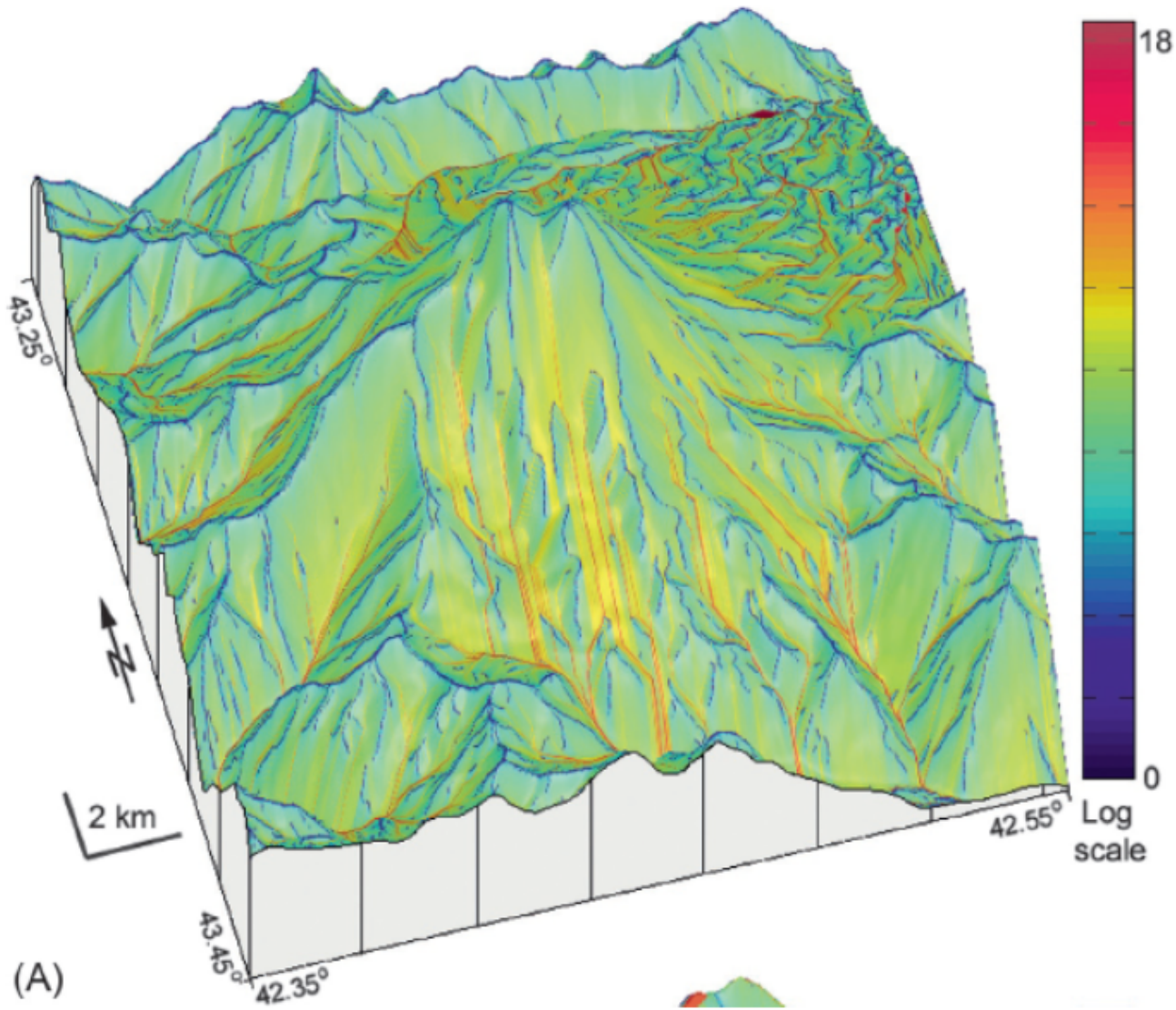

Slope Ratio: HD:VD
Slope Percent: (VD/HD) x 100
Slope Angle: Arctan (VD/HD)
(degrees)
Example
50'
26.6°
100'
Vertical Distance (VD)
Horizontal Distance (HD)
Examples
Slope Ratio: 100:50 = 2:1
Slope Percent: (50/100) x 100 = 50%
Slope Angle: Arctan (50/100) = 26.6°
(degrees)



Monte Elbrus


55
0
Degree
43.25°
43.45°
42.35°
42.55°
N
2 km
(A)


43.25°
N
2 km
43.45°
42.35°
0
42.55°
270
deg
90
180
(B)


18
0
Log
scale
43.25°
N
2 km
42.55°
43.45°
42.35°
(A)

Curvatura

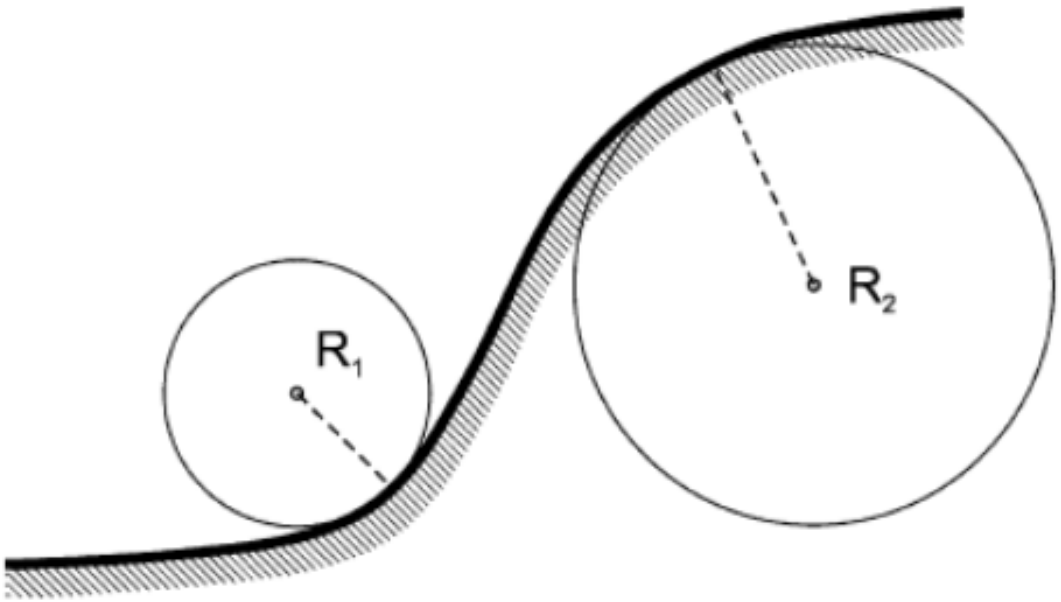
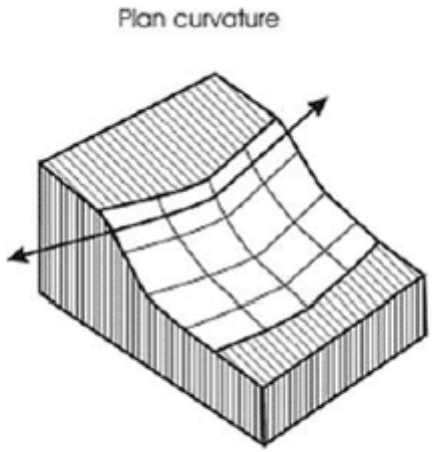


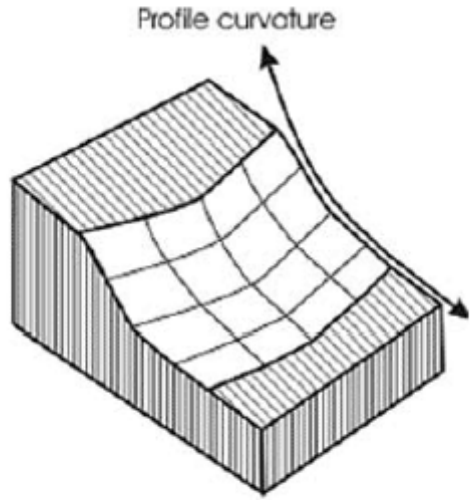
FIGURE 5 Curvature $1/R$ of a plane curve is the inverse of the radius R of a circle that is best fitted to this curve at a given point. It is agreed in Earth sciences that the sign of curvature is positive for a convex surface shape ($R_2 > 0$), and negative for a concave one ($R_1 < 0$).

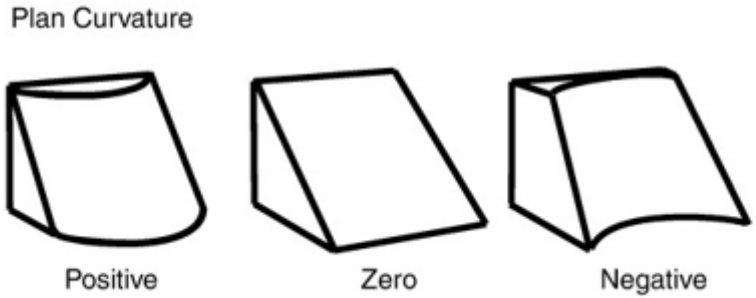
Curvatura

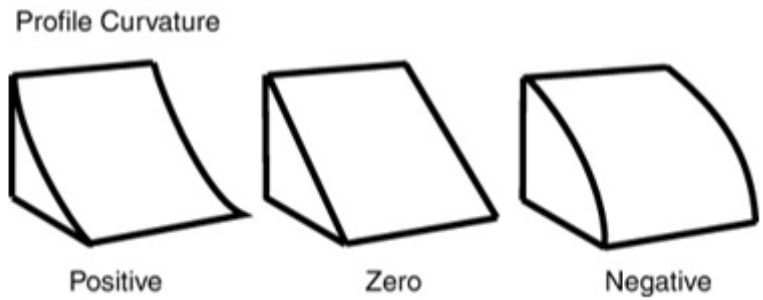
Curvatura plana
Convergencia del flujo (Kh < 0)
Divergencia del flujo (Kh > 0)

Curvatura vertical
Aceleración del flujo (Kv > 0)
Desacelera el flujo (Kv < 0)









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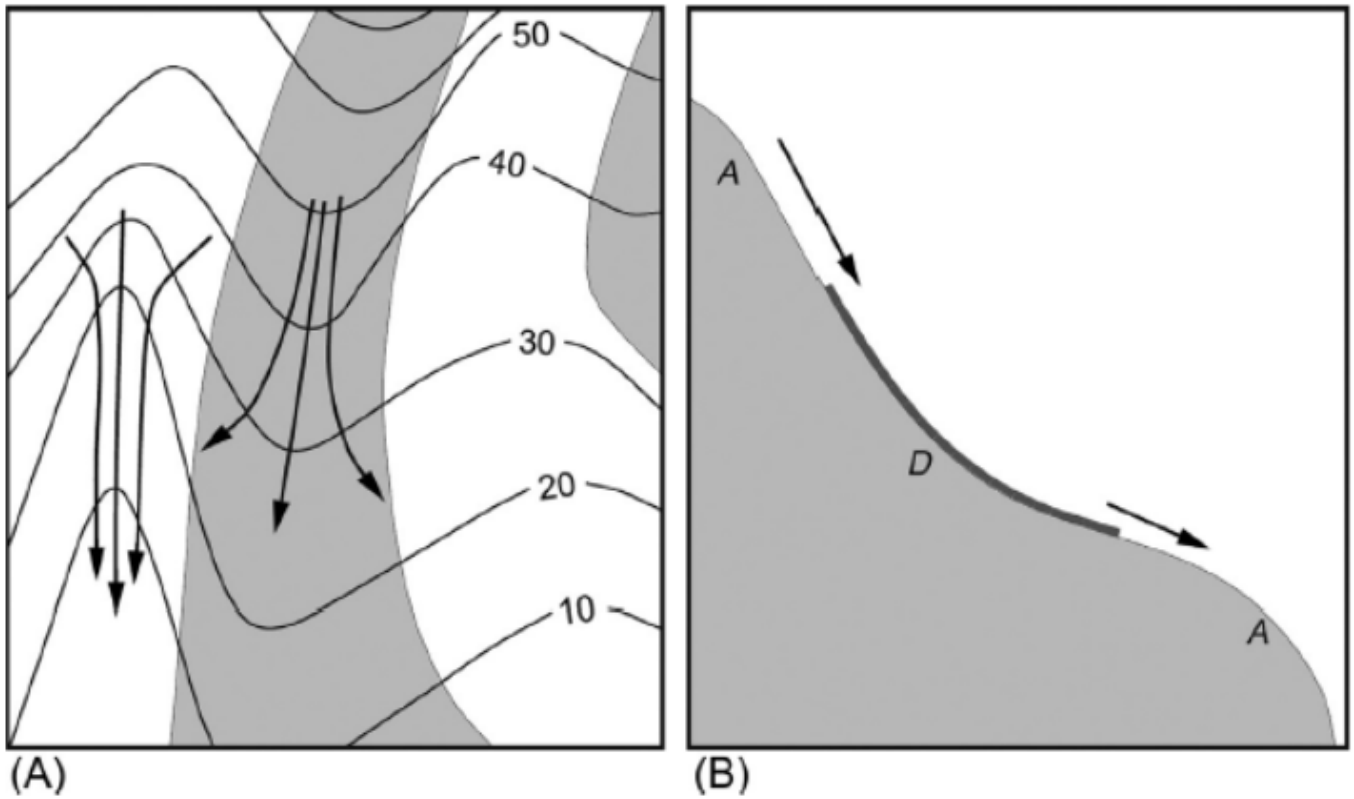
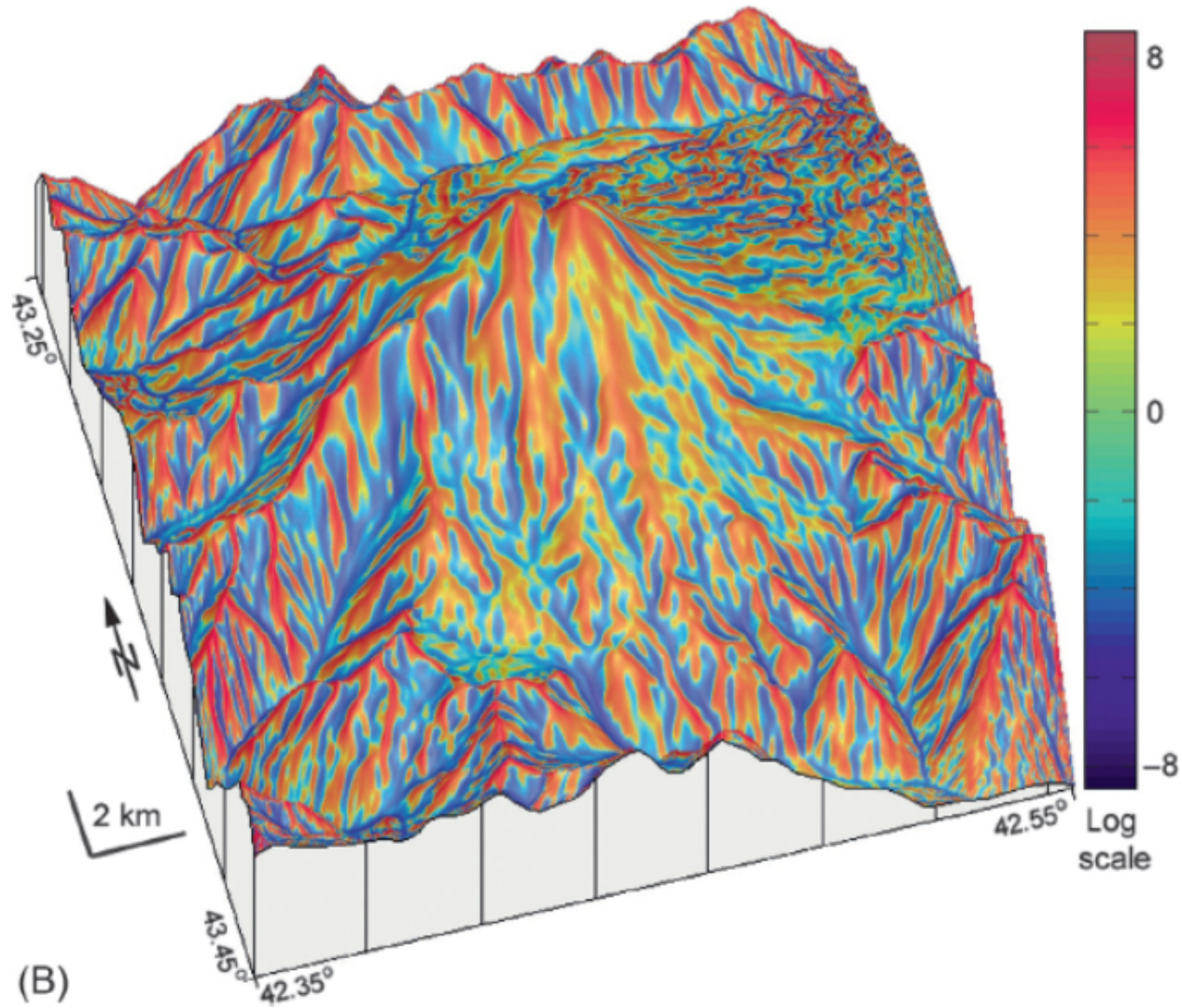
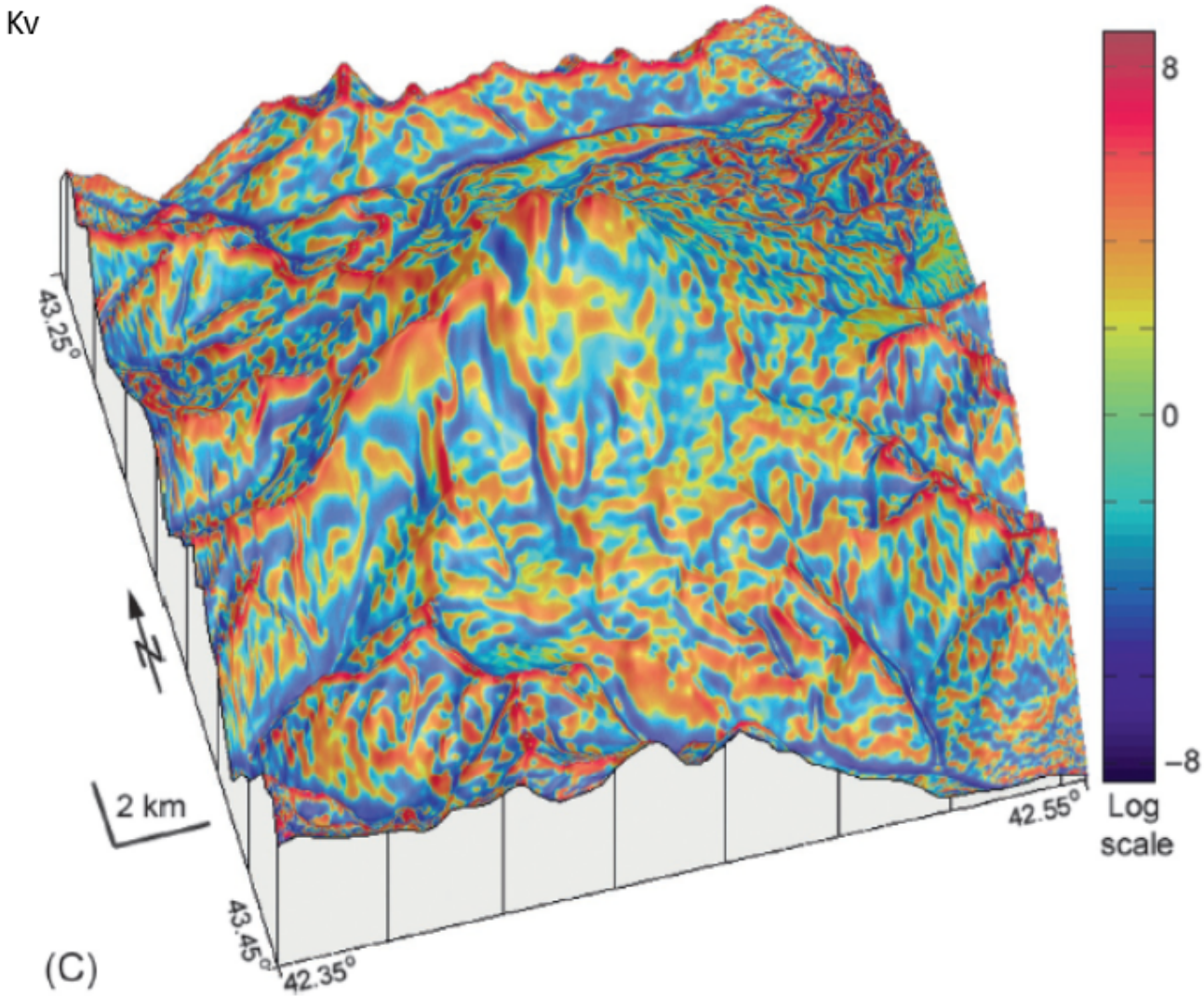


FIG. 2.8 Two accumulation mechanisms of gravity-driven flows: (A) Plan view. Flow convergence/divergence: flow lines converge where $k_h < 0$ (convergence areas, *white*) and diverge where $k_h > 0$ (divergence areas, *gray*). (B) Profile view. Flow relative deceleration/acceleration: flow decelerates where $k_v < 0$ (relative deceleration areas, *D*) and accelerates where $k_v > 0$ (relative acceleration areas, *A*). *Modified from Shary et al. (2002b), Fig. 4, reproduced with permission from Elsevier.*

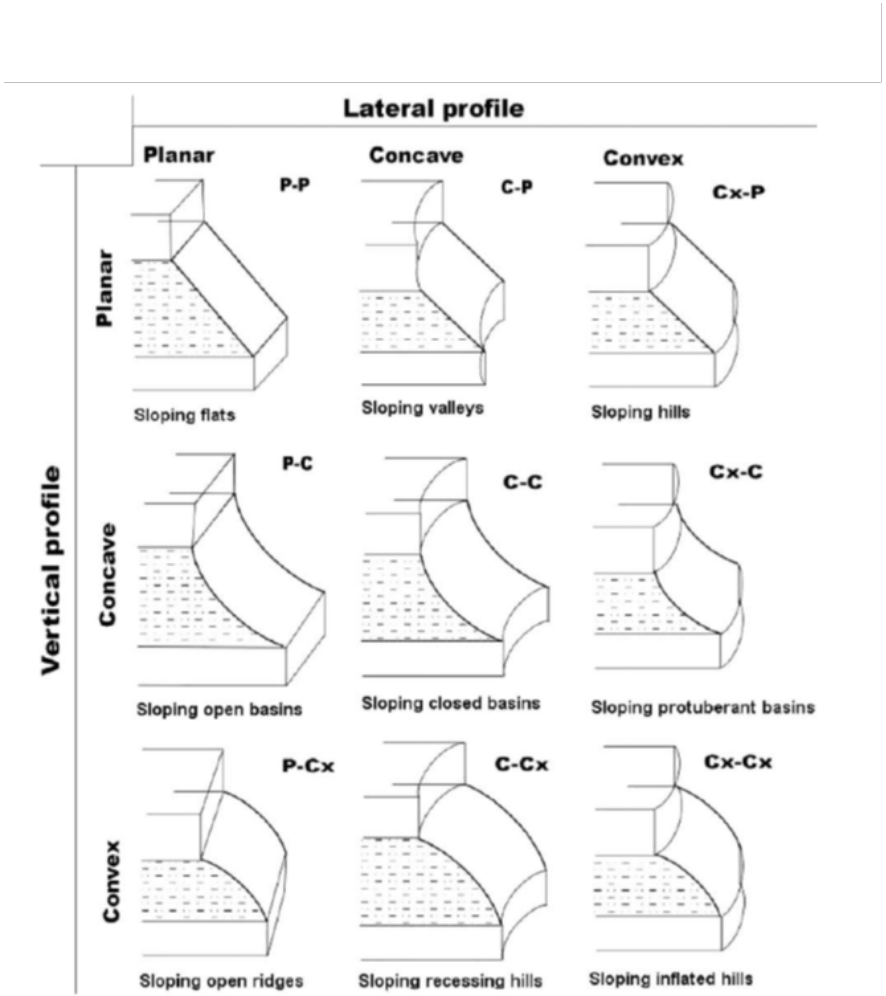
Curvatura Horizontal

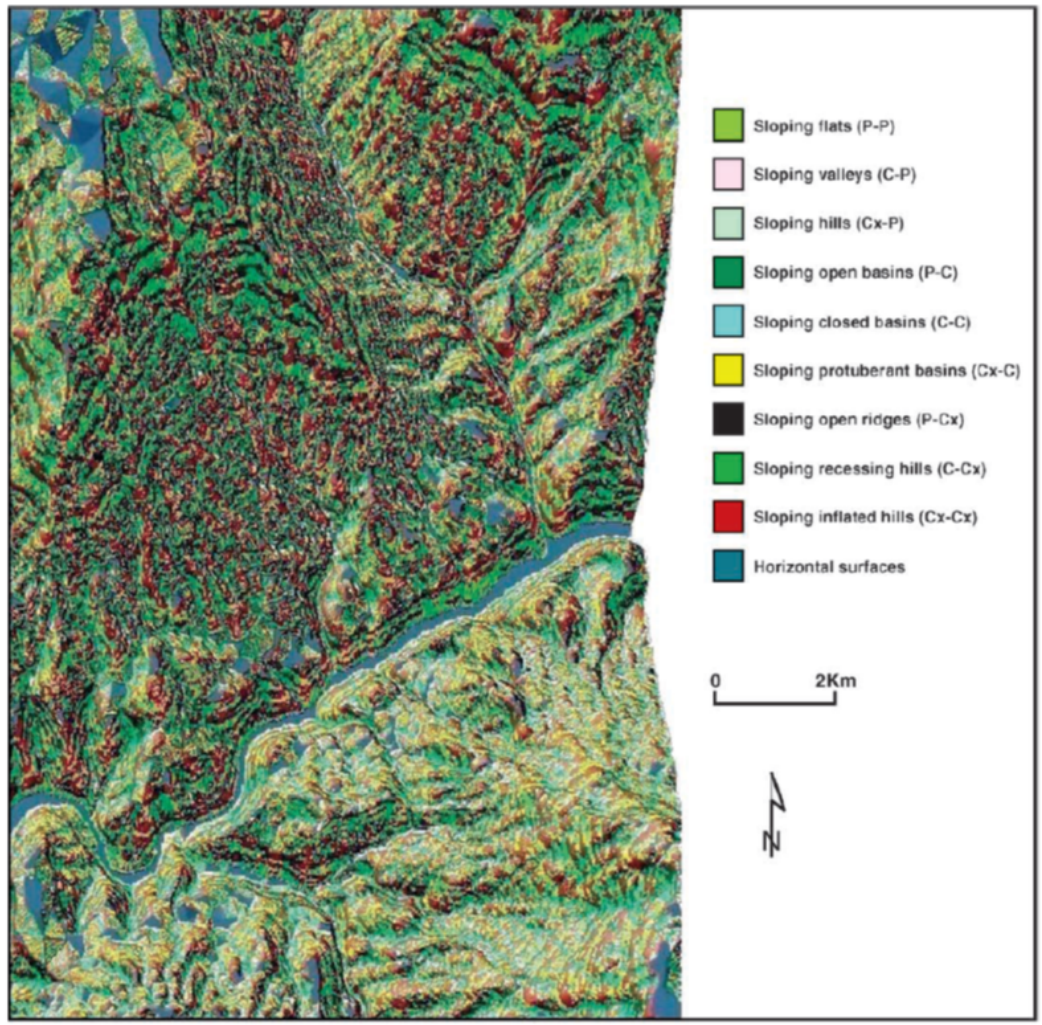


Curvatura Vertical



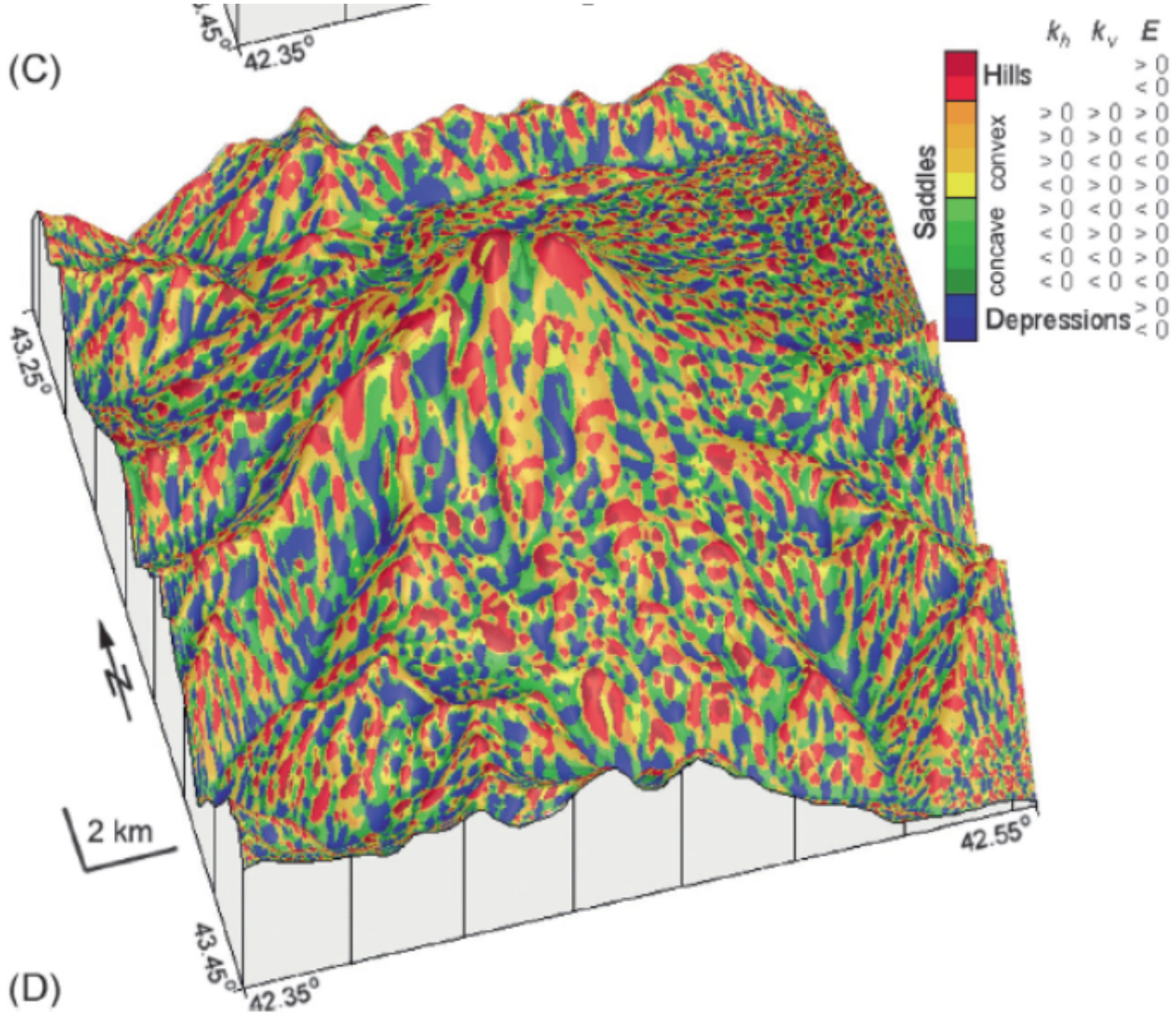
Curvatura



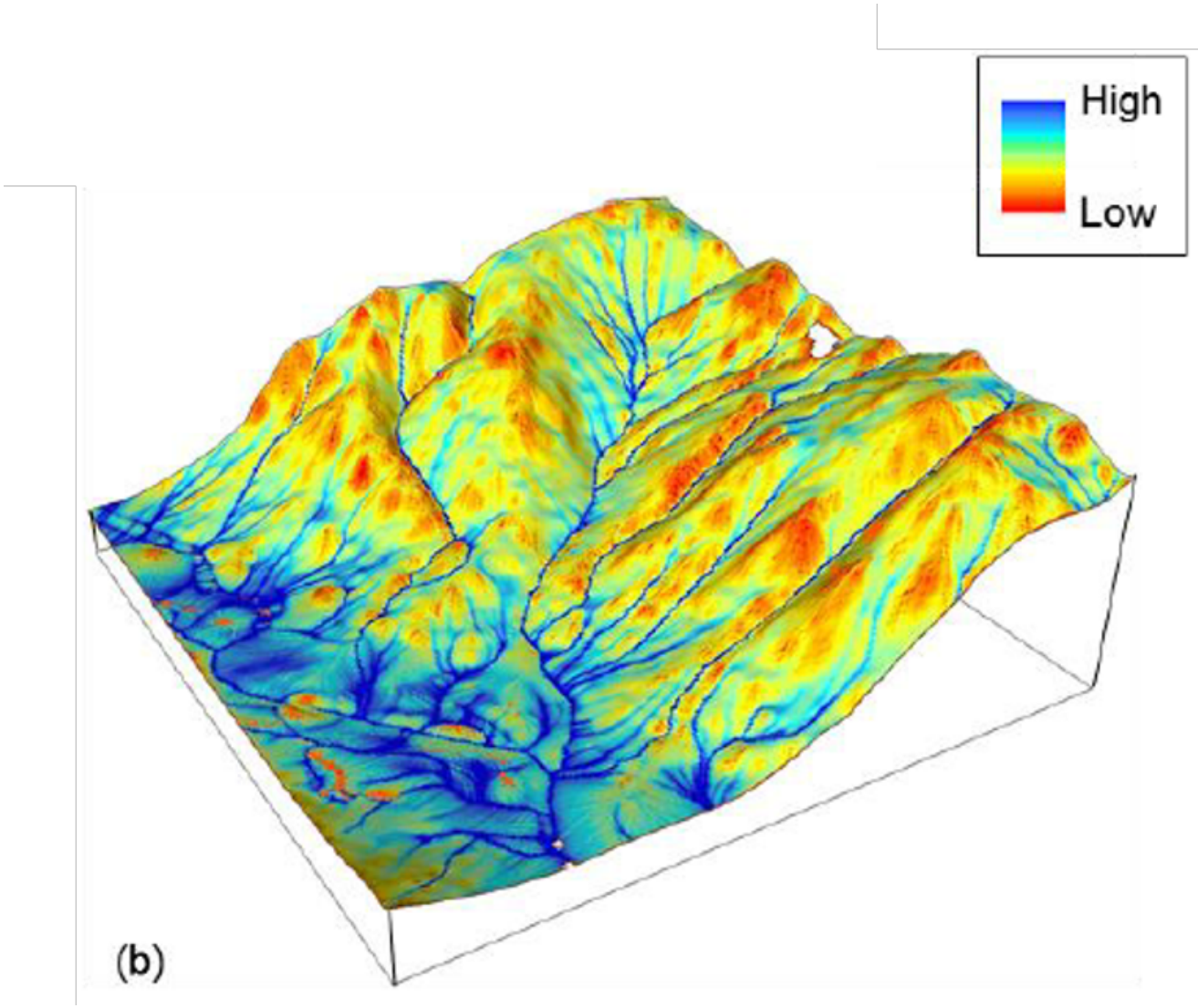


Ayalew & Yamagishi (2003) en la cuenca Blue Nile (Etiopía)

Geomorfometría para mapas geomorfológicos



Índice Topográfico de Humedad



Fuente: Gallay (2013)

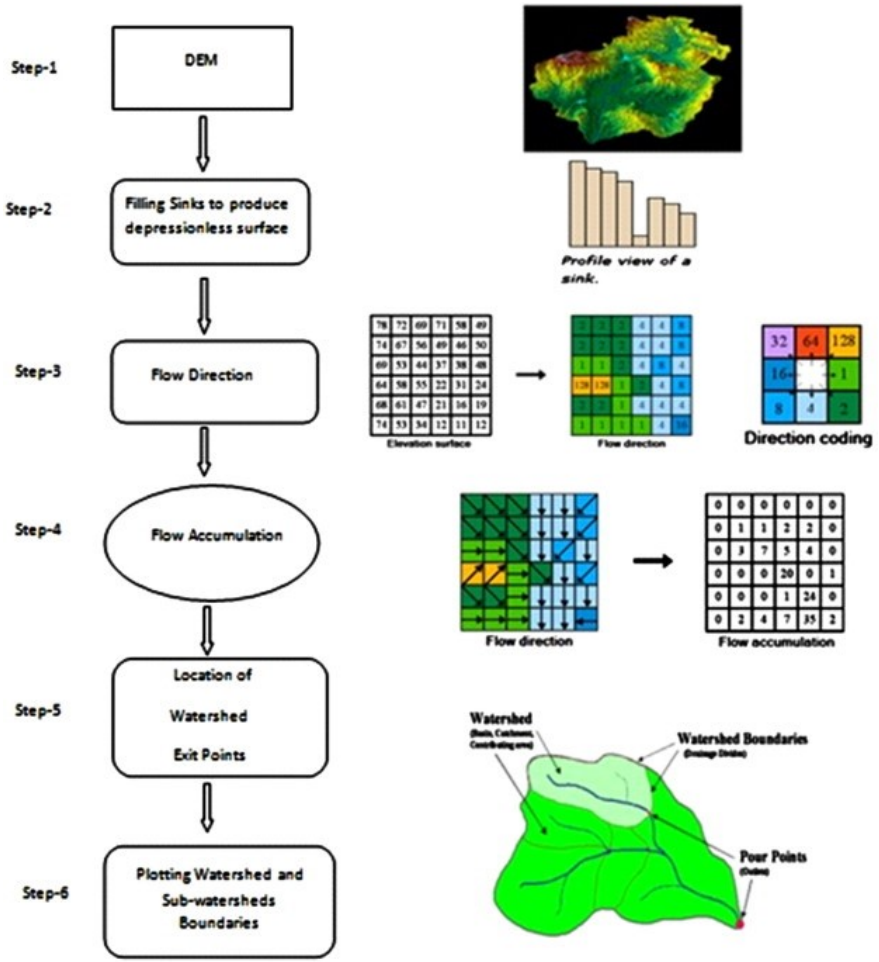
Parámetros morfométricos

No.	Parameter	Symbol/formula	References
Morphometric parameters			
A	Drainage network		
1	Stream order (u)	u	Strahler (1957, 1964)
2	Stream no. (N_u)	$N_u = N_1 + N_2 + \cdots + N_n$	Horton (1945)
3	Stream length (L_u)	$L_u = L_1 + L_2 + \cdots + L_n$	Strahler (1964)
4	Bifurcation ratio (R_b)	$R_b = N_u/N_u + 1$	Schumn (1956), Strahler (1964)
B	Basin geometry		
1	Basin length (km)	L_b = The longest in the basin in which are end being the mouth	Gregory and Walling (1973)
2	Basin width (km)	W_b = Largest horizontal distance between 2 points, nearly perpendicular to L_b	
3	Area (km)	A	Schumn (1956)
4	Perimeter (km)	P	Schumn (1956)
5	Form factor	$R_f = A/(L_b)^2$	Horton (1932)
6	Elongation ratio	$L_e = 2\sqrt{(A/\pi)}/L_b$	Schumn (1956)
7	Texture ratio	$T = N_1/P$	Schumn (1956)
8	Circulatory ratio	$R_c = 4\pi A/P^2$	Miller (1953)
C	Drainage texture analysis		
1	Stream frequency	$F_s = \sum N_u/A$	Horton (1932, 1945)
2	Drainage density (km/km^2)	$D_d = \sum L_u/A$	Horton (1932, 1945)
3	Constant channel maintenance (C)	$C = 1/D_d$	Schumn (1956)
4	Infiltration number	$I_f = D_d \times F_s$	Faniran (1968)
5	Length of overland flow (km)	$L_g = 1/(2D_d)$	Horton (1945)
D	Relief characterizes		
1	Basin relief (km)	$B_h = Z_x - Z_m$	Strahler (1952, 1957)
2	Relief (gradient) ratio or Basin slope (km)	$R_h = B_h/L_b$	Schumn (1956)
3	Ruggedness number	$R_n = B_h \times D_d$	Schumn (1956), Melton (1957), Strahler (1964)

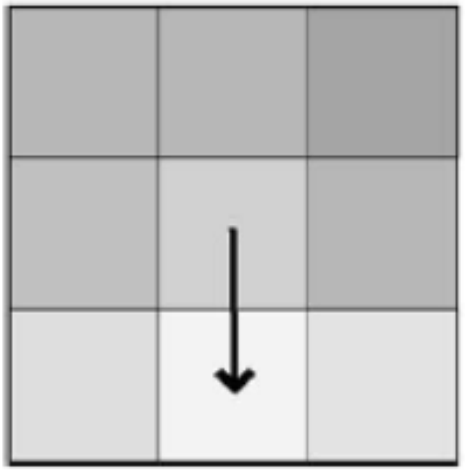
Parámetros morfométricos

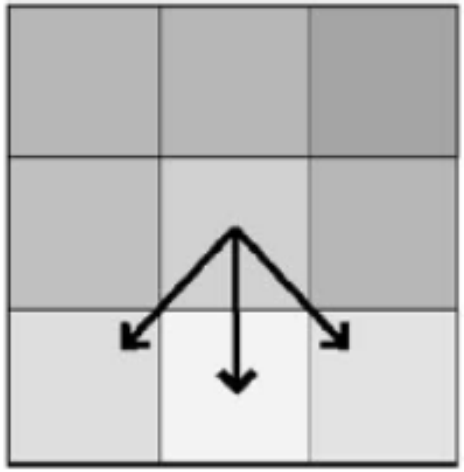
Attribute	Definition	Significance
Topographic wetness indices	$W_T = \ln\left(\frac{A_s}{T \tan \beta}\right)$	This equation assumes steady-state conditions and describes the spatial distribution and extent of zones of saturation (i.e., variable source areas) for runoff generation as a function of upslope contributing area, soil transmissivity, and slope gradient.
	$W = \ln\left(\frac{A_s}{\tan \beta}\right)$	This particular equation assumes steady-state conditions and uniform soil properties (i.e., transmissivity is constant throughout the catchment and equal to unity). This pair of equations predicts zones of saturation where A_s is large (typically in converging segments of landscapes), β is small (at base of concave slopes where slope gradient is reduced), and T_i is small (on shallow soils). These conditions are usually encountered along drainage paths and in zones of water concentration in landscapes.
	$W = \ln\left(\frac{A_e}{\tan \beta}\right)$	This quasi-dynamic index substitutes effective drainage area for upslope contributing area and thereby overcomes the limitations of the steady-state assumption used in the first pair of equations.
Stream-power indices	$\mathrm{SPI} = A_s \tan \beta$	Measure of erosive power of flowing water based on assumption that discharge (q) is proportional to specific catchment area (A_s). Predicts net erosion in areas of profile convexity and tangential concavity (flow acceleration and convergence zones) and net deposition in areas of profile concavity (zones of decreasing flow velocity).
	$\mathrm{LS} = (m+1)\left(\frac{A_s}{22.13}\right)^m \left(\frac{\sin \beta}{0.0896}\right)^n$	This sediment transport capacity index was derived from unit stream power theory and is equivalent to the length–slope factor in the Revised Universal Soil Loss Equation in certain circumstances. Another form of this equation is sometimes used to predict locations of net erosion and net deposition areas.
	$\mathrm{CTI} = A_s (\tan \beta)^2$	Variation of stream-power index sometimes used to predict the locations of headwaters of first-order streams (i.e., channel initiation).

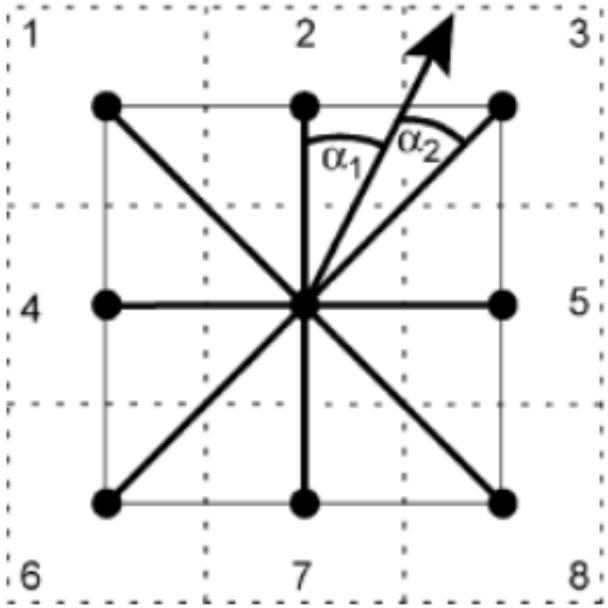
Procedimiento DEM corregido



Dirección del flujo







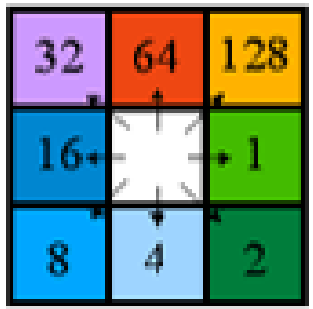
Dirección del flujo

78	72	69	71	58	49
74	67	56	49	46	50
69	53	44	37	38	48
64	58	55	22	31	24
68	61	47	21	16	19
74	53	34	12	11	12

Elevation surface

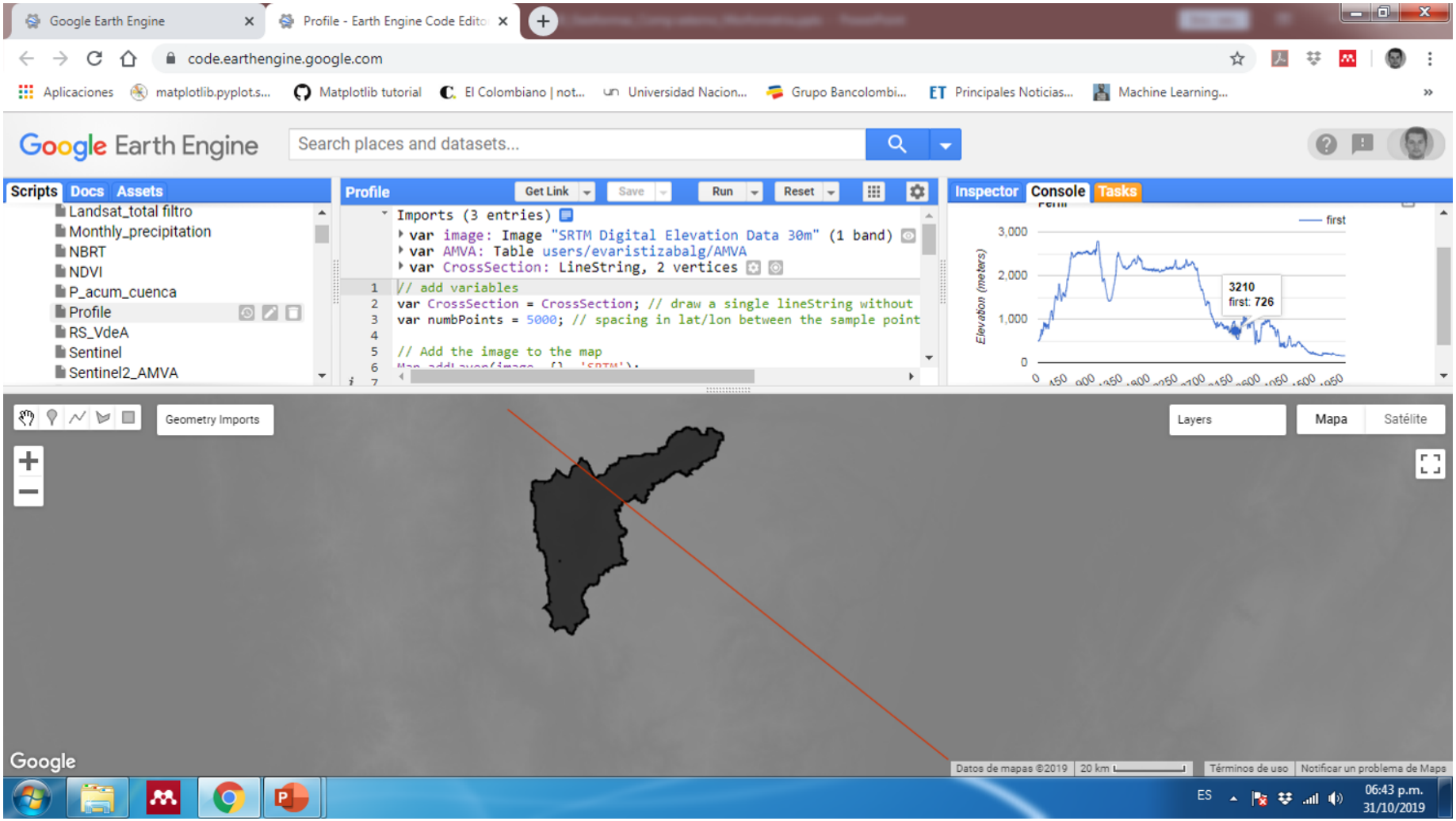
2	2	2	4	4	8
2	2	2	4	4	8
1	1	2	4	8	4
128	128	1	2	4	8
2	2	1	4	4	4
1	1	1	1	4	16

Flow direction



Direction coding

Perfiles


Google Earth Engine
Profile - Earth Engine Code Edito
code.earthengine.google.com
Aplicaciones
matplotlib.pyplot.s...
Matplotlib tutorial
El Colombiano | not...
Universidad Nacion...
Grupo Bancolombi...
Principales Noticias...
Machine Learning...
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Search places and datasets...
Scripts
Docs
Assets
Landsat_total filtro
Monthly_precipitation
NBRT
NDVI
P_acum_cuenca
Profile
RS_VdeA
Sentinel
Sentinel2_AMVA
Profile
Get Link
Save
Run
Reset
Imports (3 entries)
var image: Image "SRTM Digital Elevation Data 30m" (1 band)
var AMVA: Table users/evaristizabalg/AMVA
var CrossSection: LineString, 2 vertices
// add variables
var CrossSection = CrossSection; // draw a single lineString without
var numbPoints = 5000; // spacing in lat/lon between the sample point
// Add the image to the map
Inspector
Console
Tasks
first
3,000
2,000
1,000
0
Elevation (meters)
3210
first: 726
Geometry Imports
Layers
Mapa
Satélite
Google
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20 km
Términos de uso
Notificar un problema de Maps
ES
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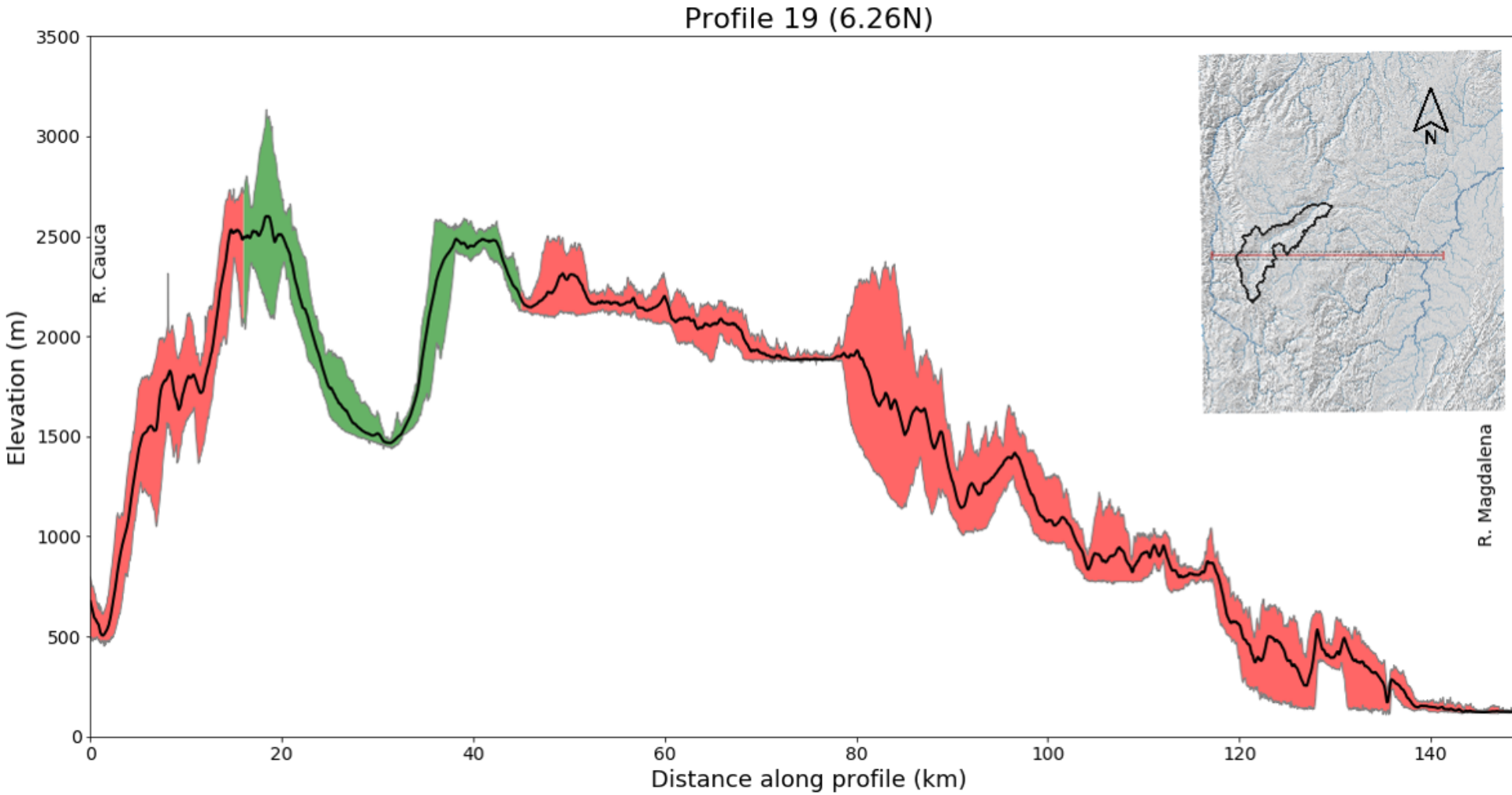
31/10/2019

Perfiles


Profile 19 (6.26N)
Elevation (m)
Distance along profile (km)
R. Cauca
R. Magdalena
N
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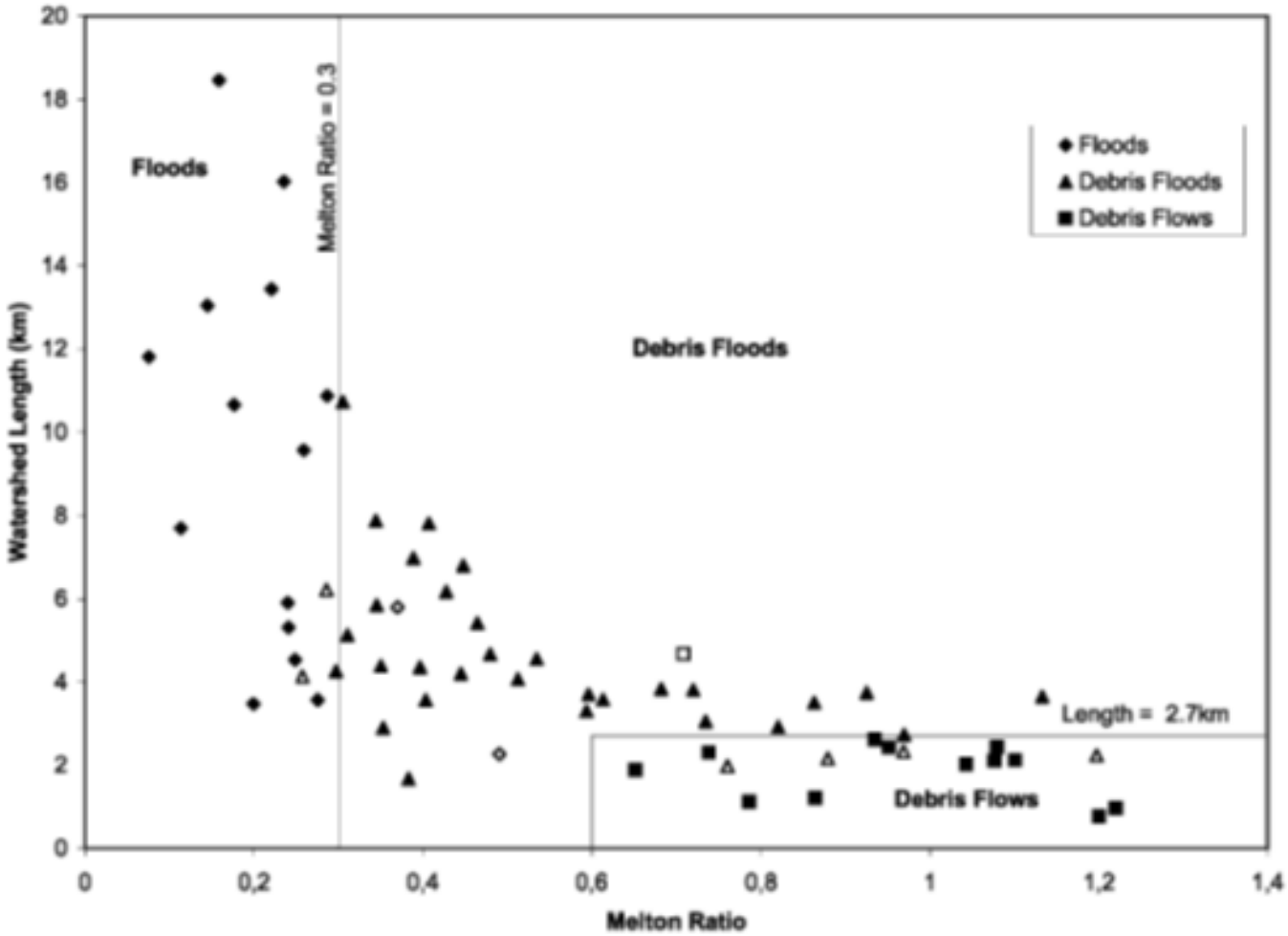
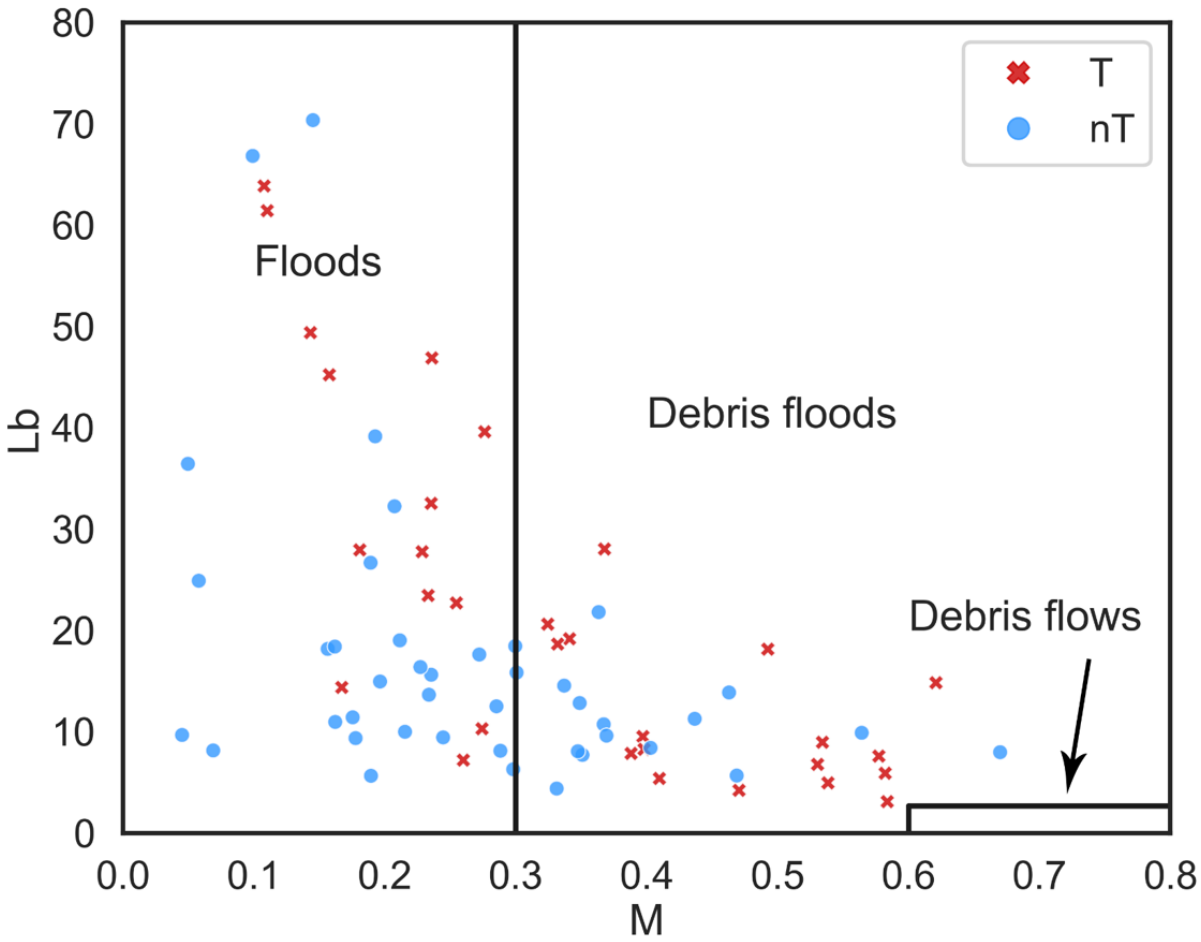
1000
1500
2000
2500
3000
3500
0
20
40
60
80
100
120
140

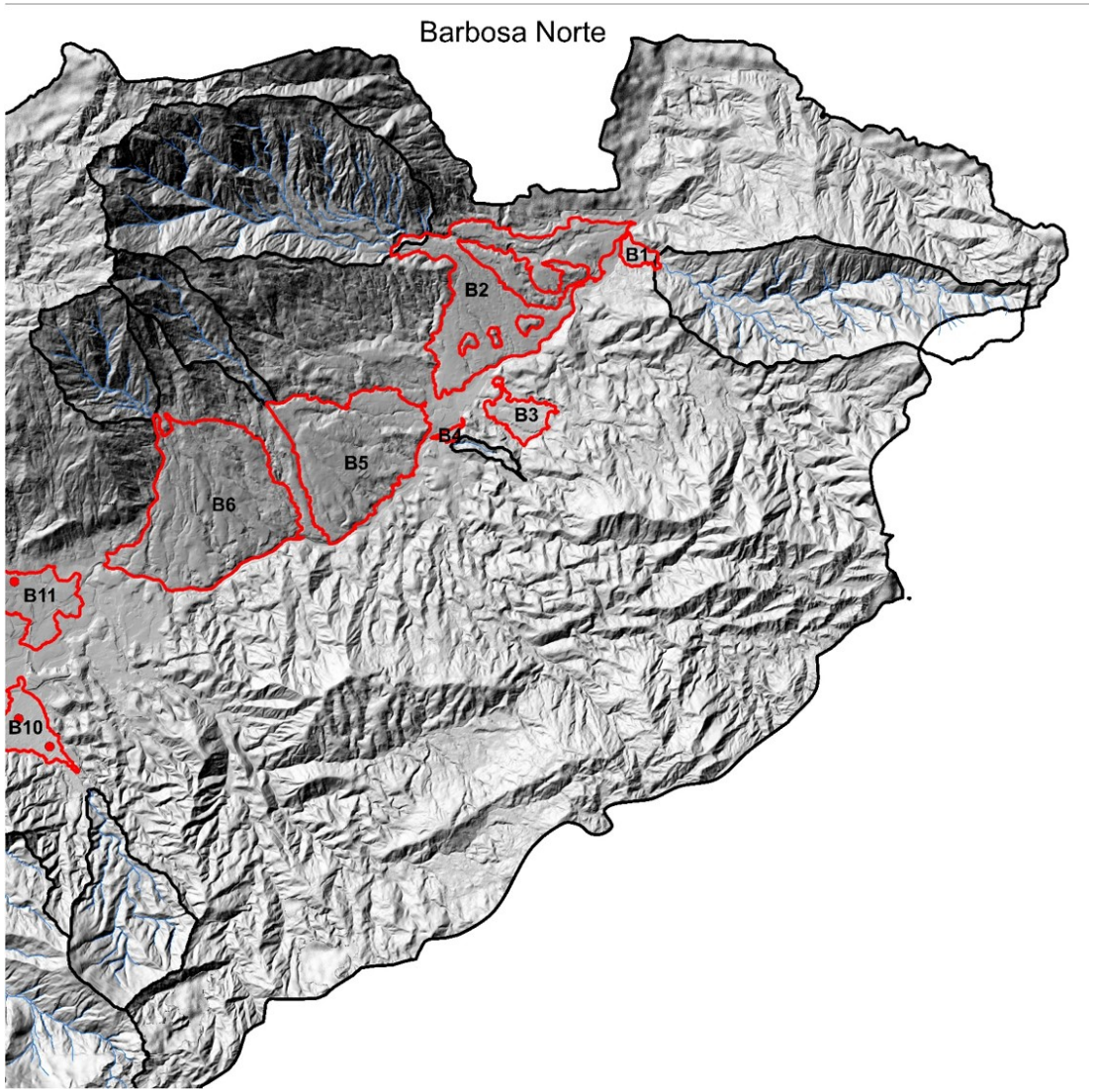
Índices Morfométricos



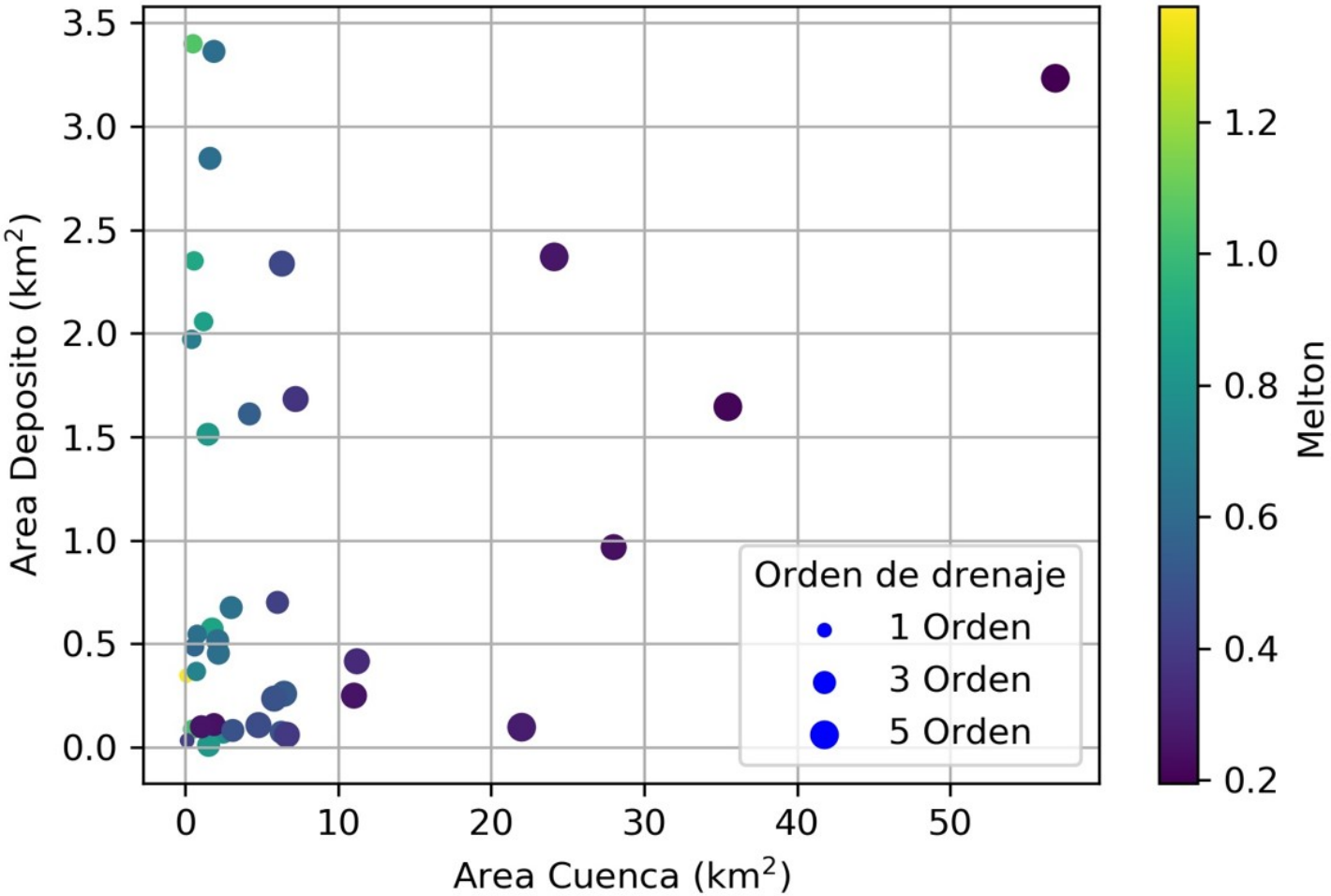
Índices Morfométricos



Abánicos en el Valle de Aburrá



Abánicos en el Valle de Aburrá



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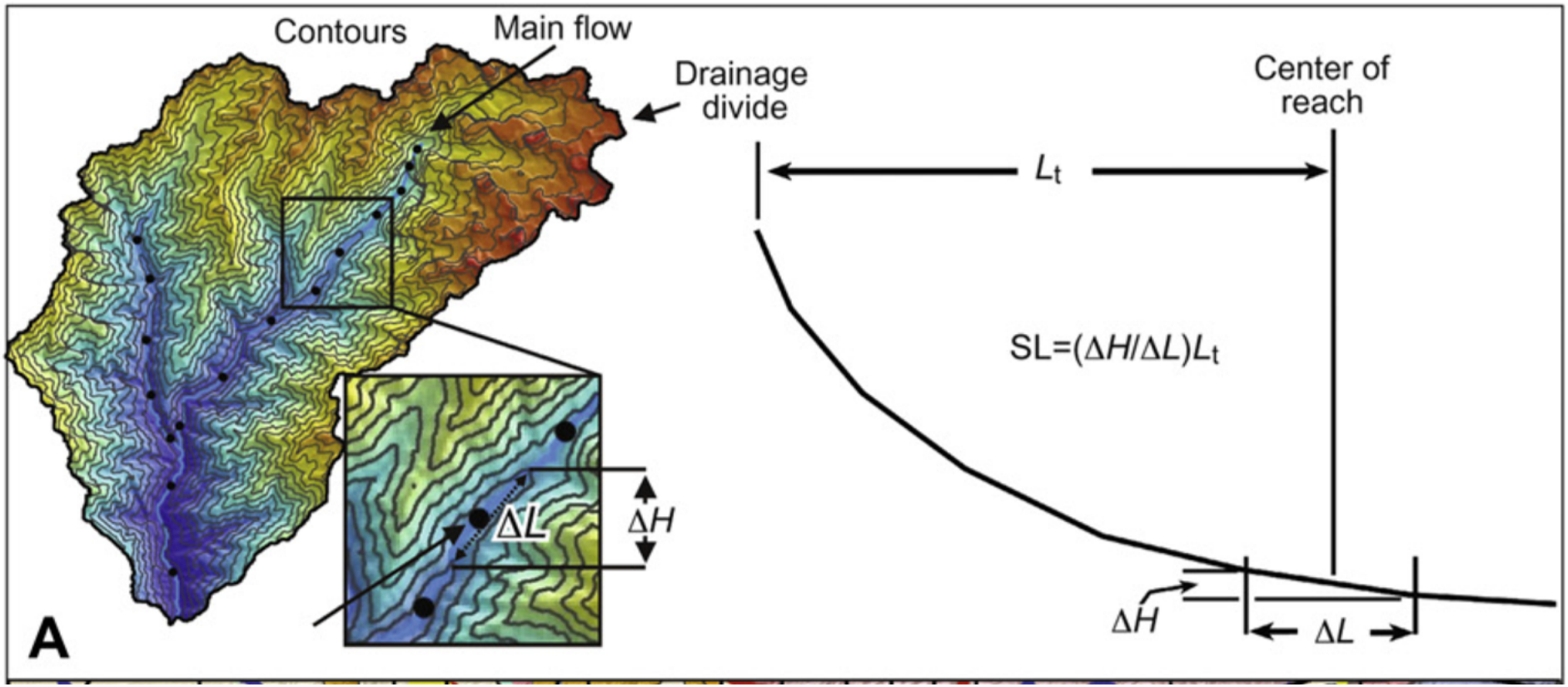

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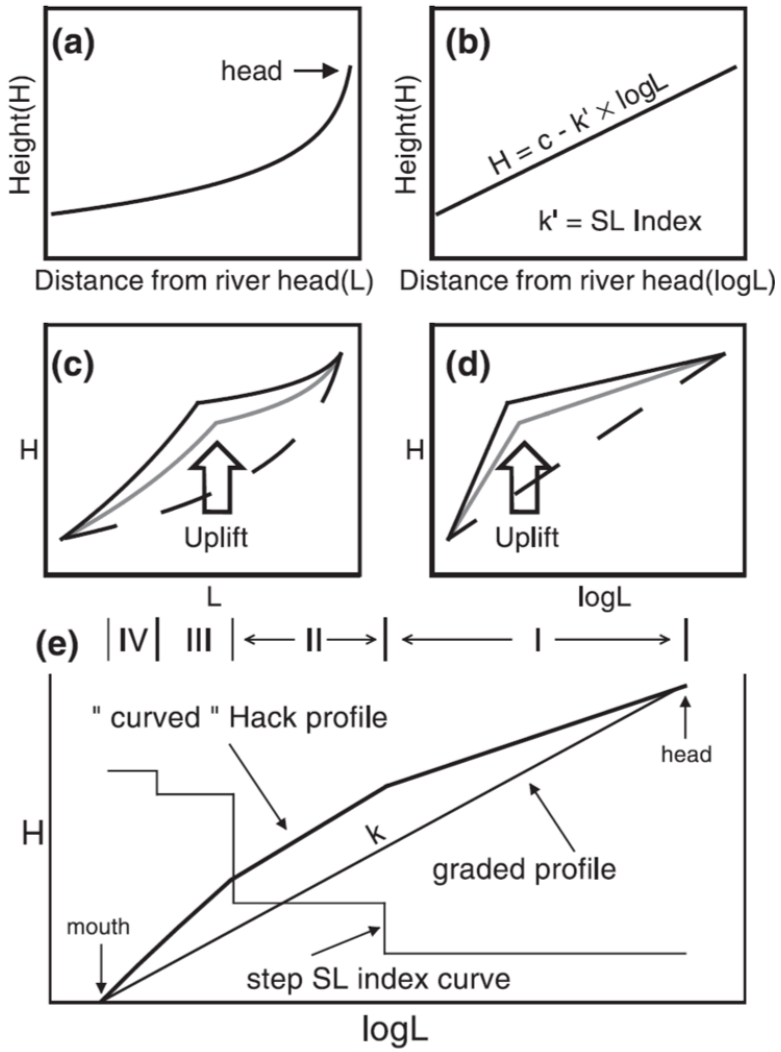

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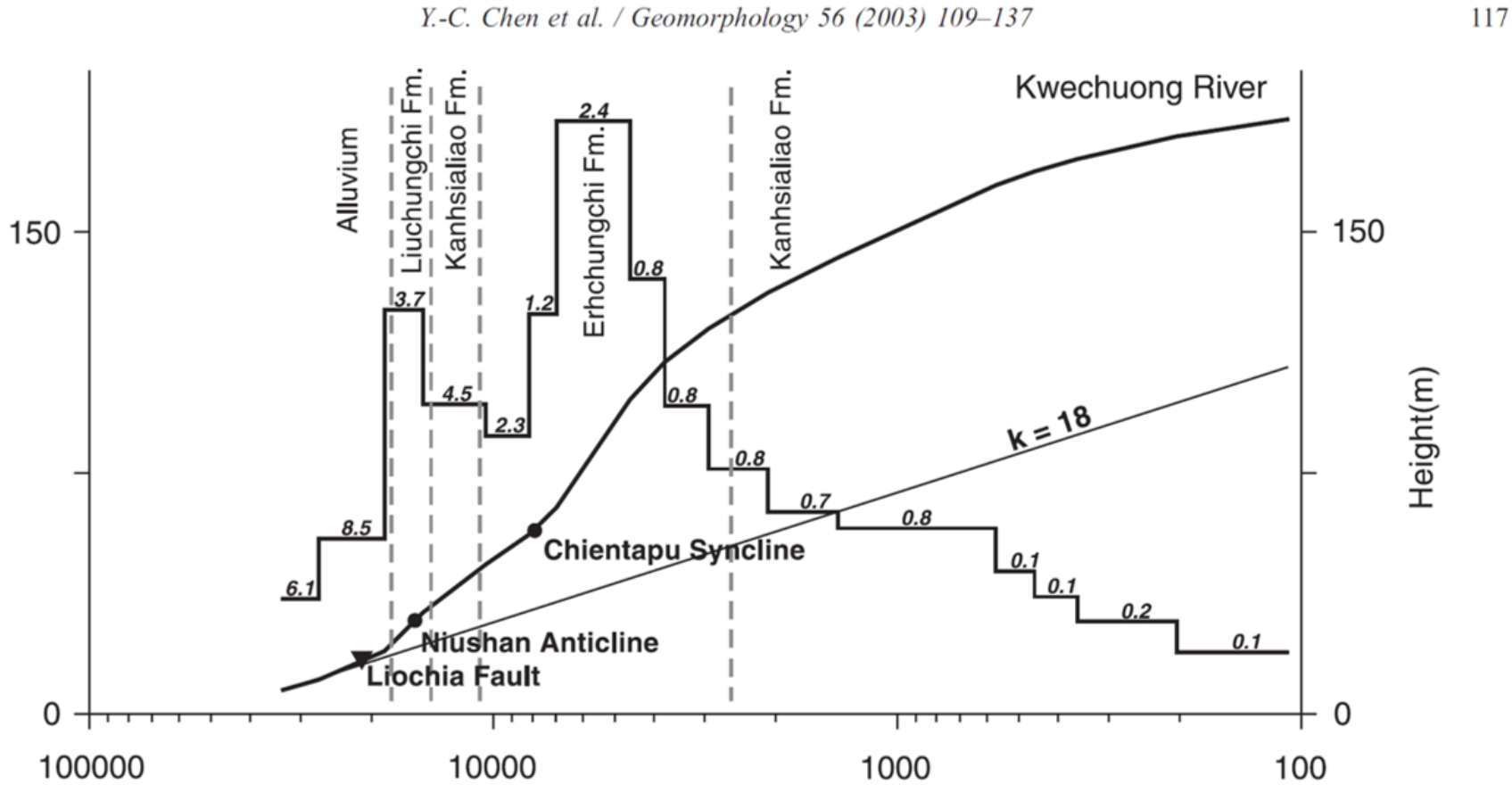


Fig. 5. Step curve of SL index and curved Hack profile of Kwechuong River, a tributary of Chishue River. Dashed lines are main lithological boundaries of the Pleistocene sequences. The profile starts at 100 m from the riverhead. Distance in kilometers for each segment is shown on the step.

Curva hipsométrica

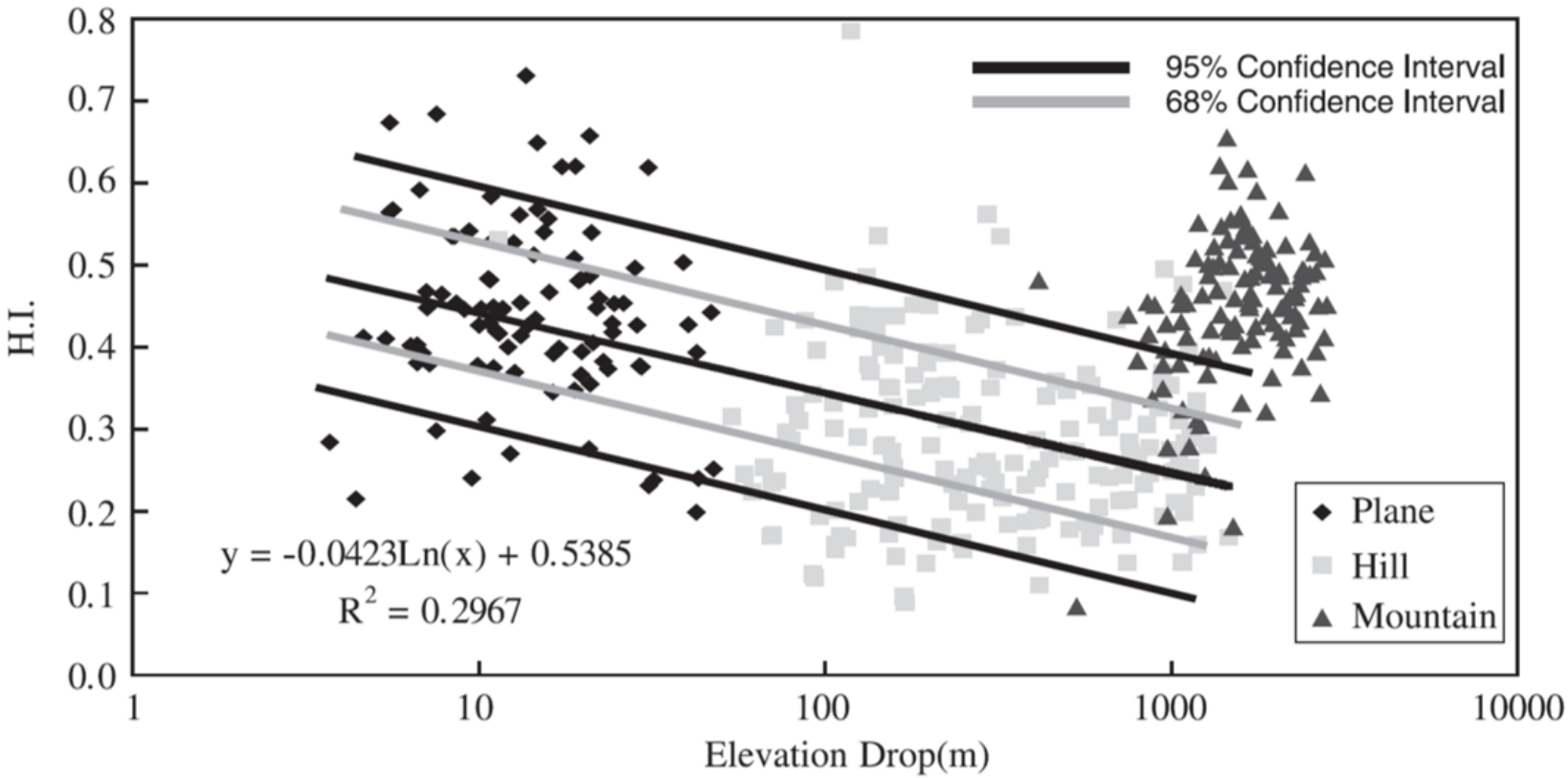
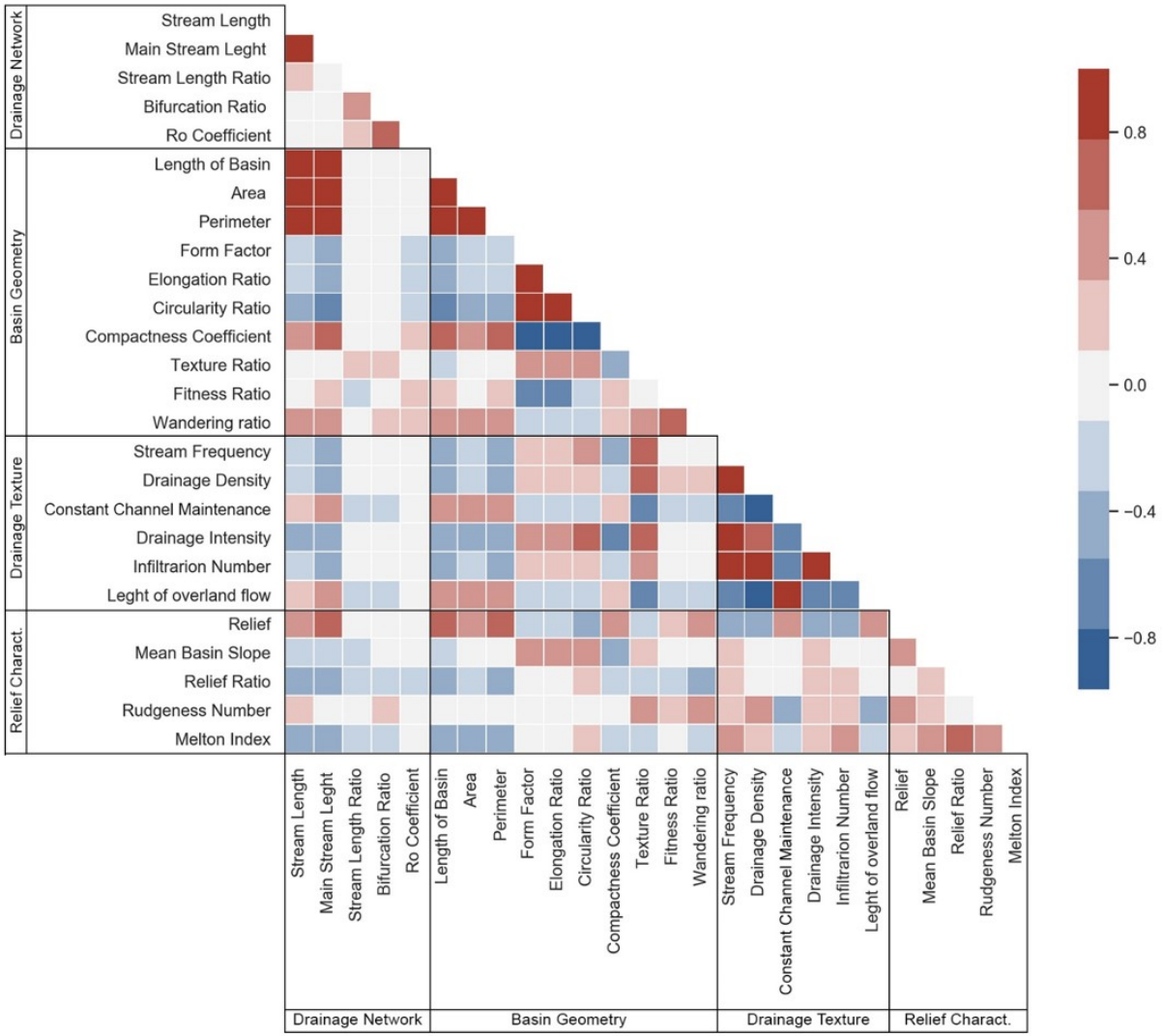
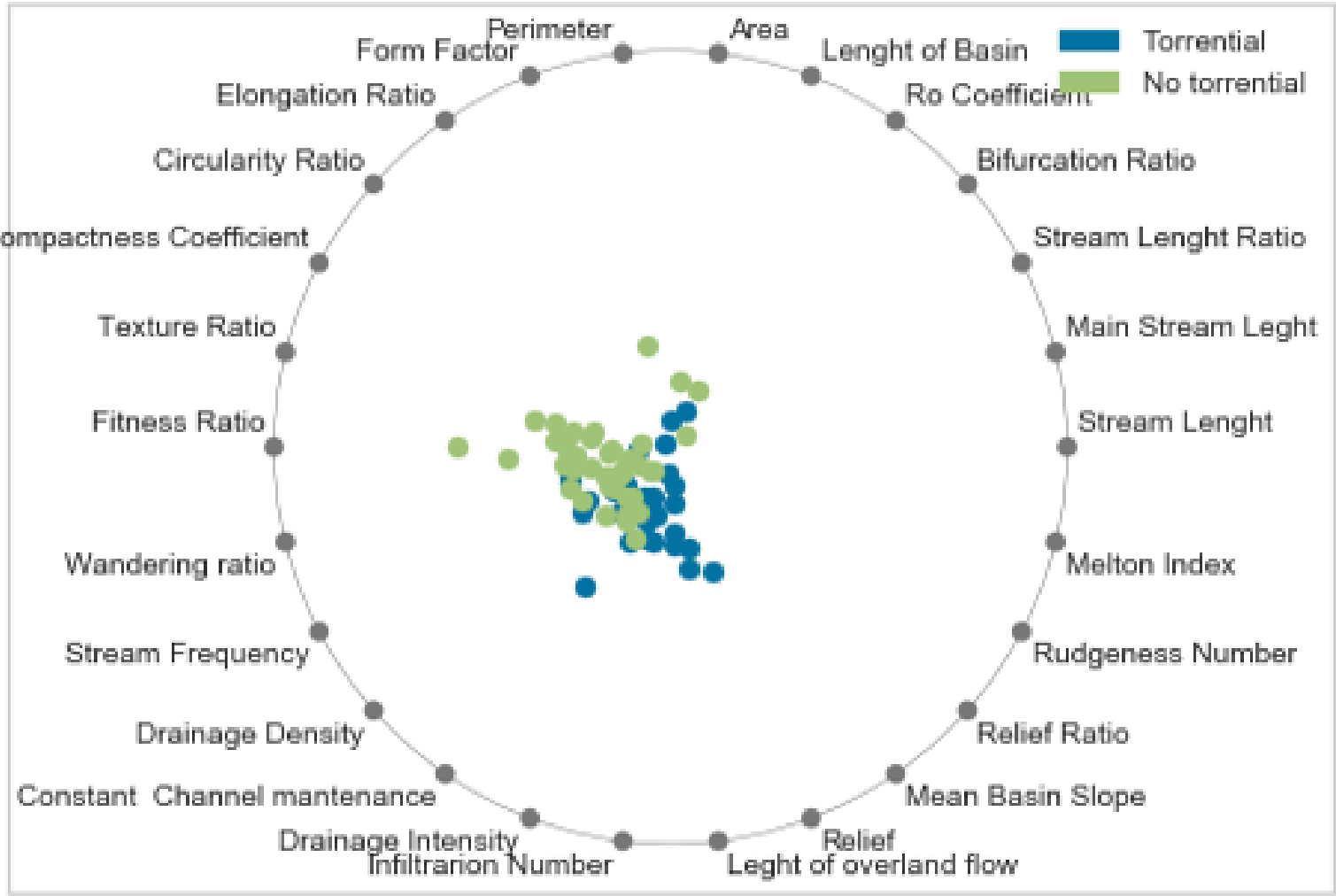


Fig. 14. Hypsometric integral vs. Basin Elevation Drop for drainage basins in the entire area studied. A regression line and its 68% and 95% confidence interval are shown. Average elevation of mountain-type subbasin >500 m; 500 m >hill-type >50 m, plain-type <50 m; basin relief o hill-type >50 m, plain-type <50 m. A threshold contributing area of 3 km^2 was applied.

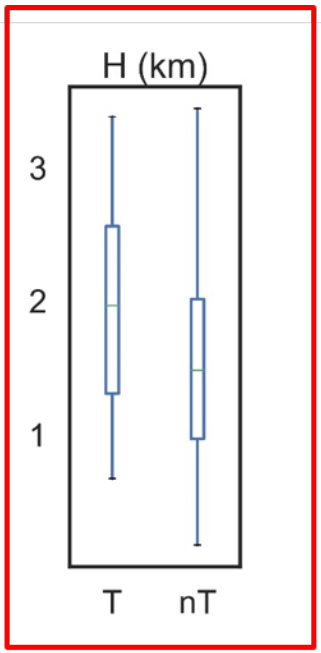
Correlación entre Índices Morfométricos

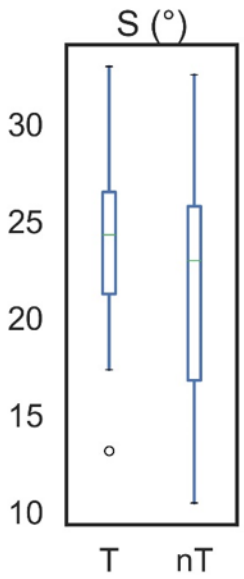


Índices Morfométricos



Índices Morfométricos





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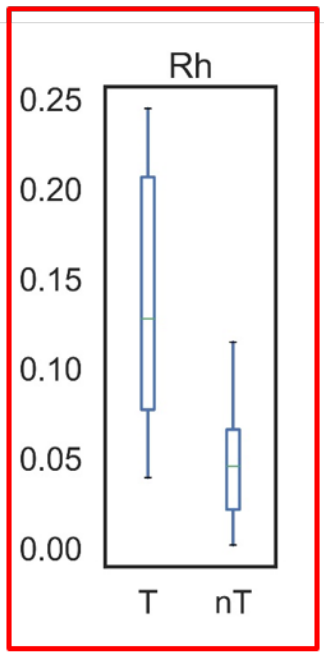

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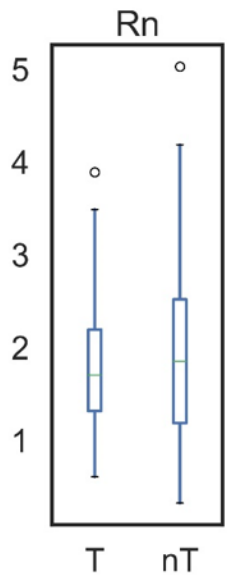
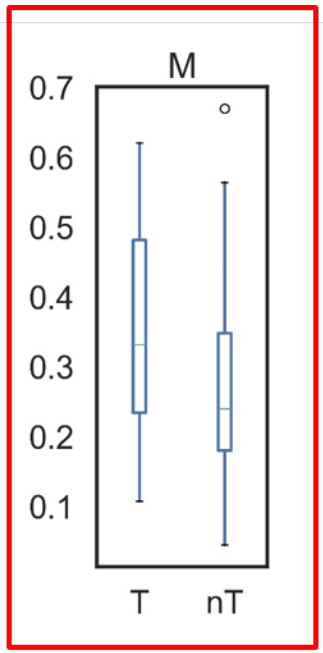
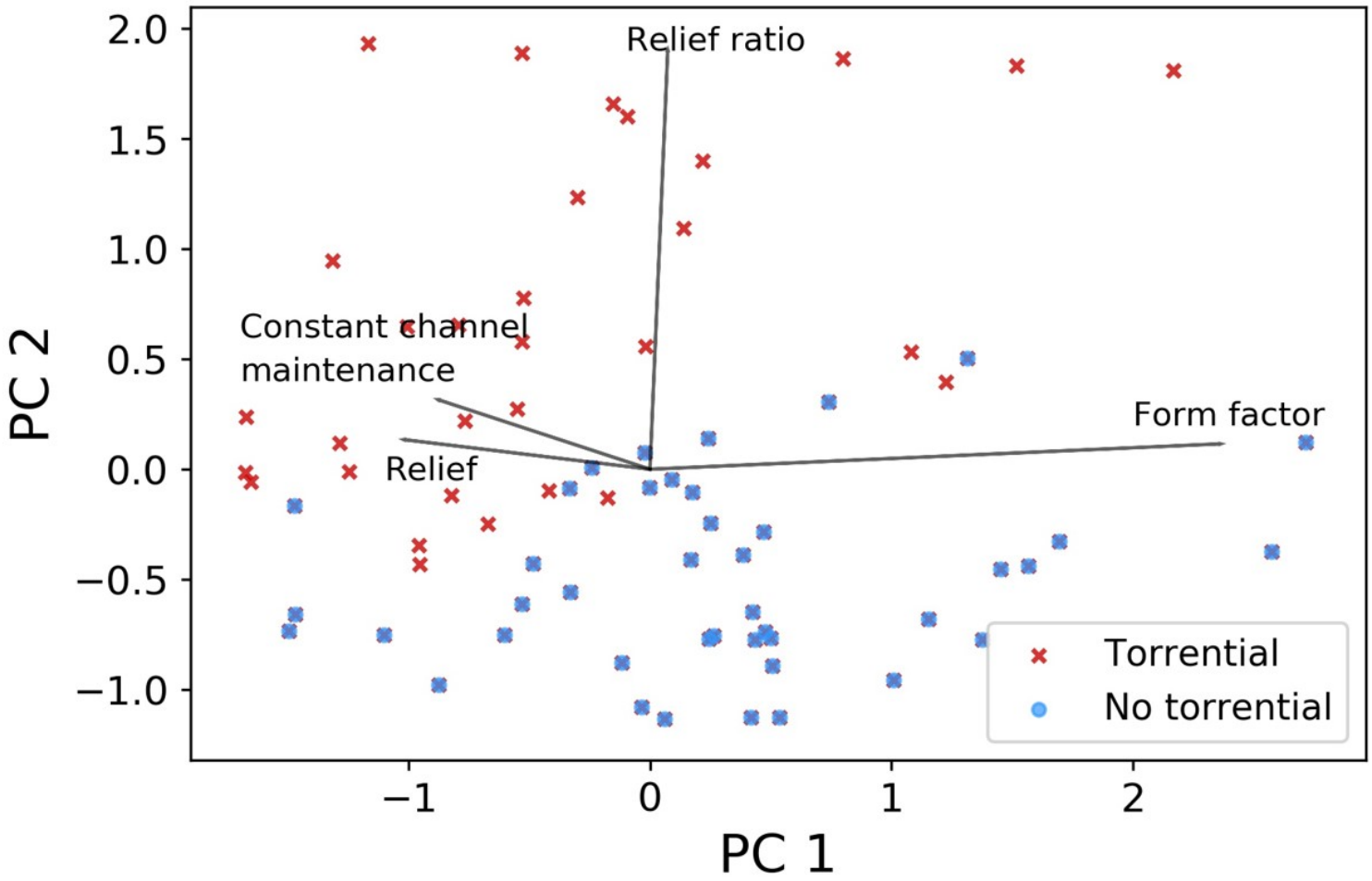


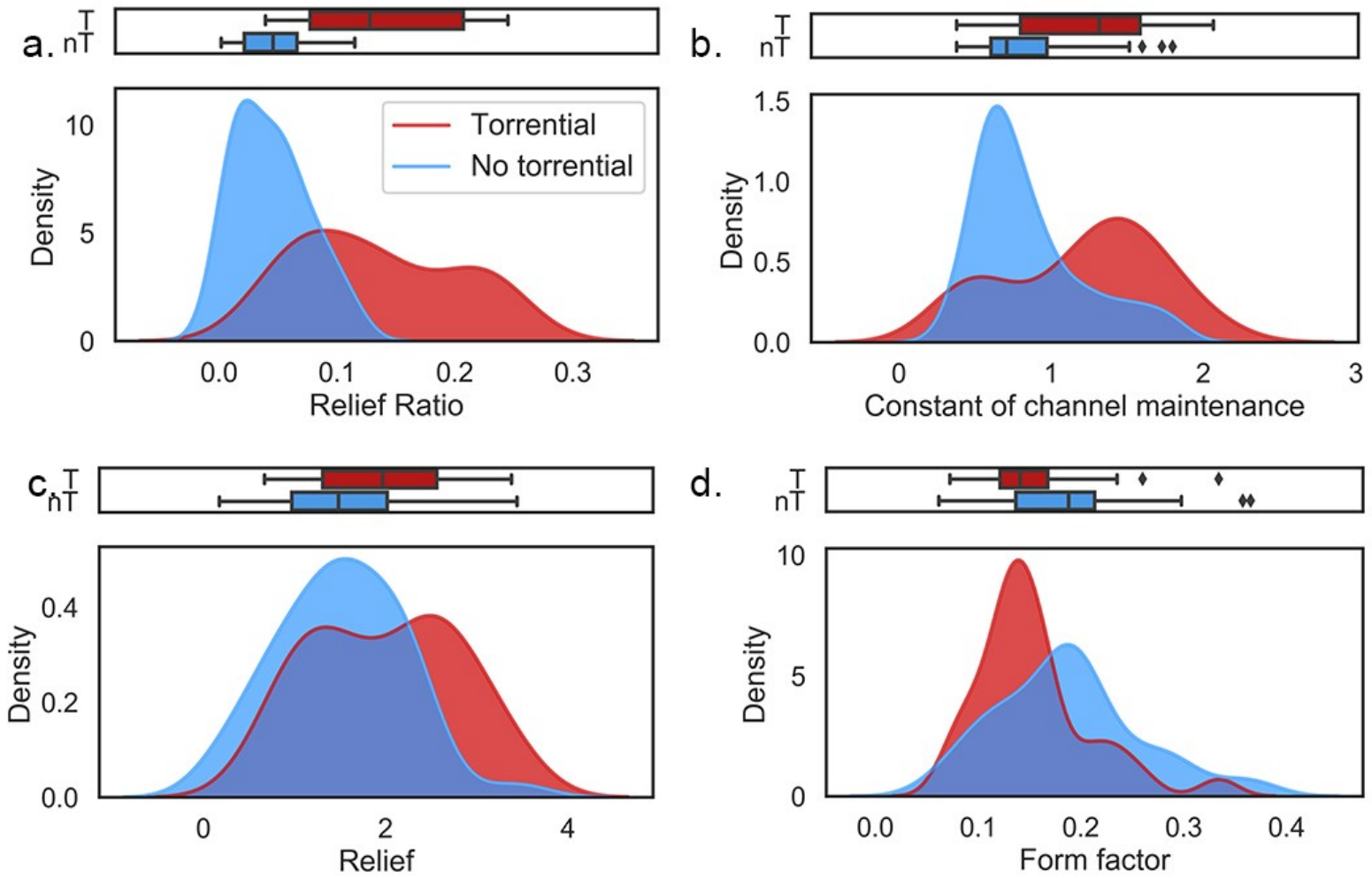


Índice de Melton

Índices Morfométricos



Índices Morfométricos



Índices Morfométricos