ANÁLISIS GEOESPACIAL

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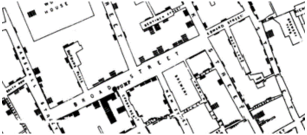
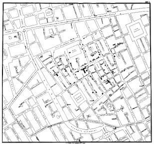
Sistemas de Información Geográfica

Elemento para analizar, presentar e interpretar datos espaciales

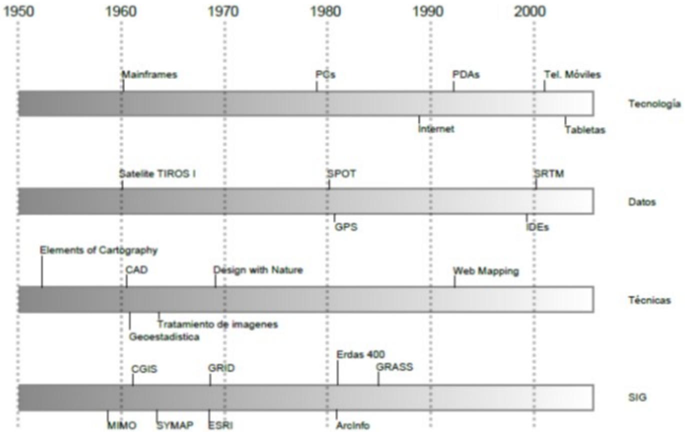
Evolución de GIS





In 1854 cholera hit the city of London, England. No one knew where the disease started. So, British physician *John Snow* started mapping the outbreak. But he also mapped out roads, property boundaries and water lines.

In 1968, *Roger Tomlinson* coined the term "GIS" in his paper "A Geographic Information System for Regional Planning". In 2014, Roger Tomlinson later passed away and will always be remembered as the *father of GIS*.


1950
1960
1970
1980
1990
2000
Mainframes
PCs
PDAs
Tel. Móviles
Tecnología
Internet
Tabletas
Satelite TIROS I
SPOT
SRTM
Datos
GPS
IDEs
Elements of Cartography
CAD
Design with Nature
Web Mapping
Técnicas
Tratamiento de imagenes
Geoestadistica
Erdas 400
CGIS
GRID
GRASS
SIG
MIMO
SYMAP
ESRI
ArcInfo

Componentes de un SIG

Data & Hardware & Software

2. HARDWARE: Hardware runs GIS software. It could be anything from powerful servers, mobile phones or a personal GIS workstation. The CPU is your workhorse and data processing is the name of the game. Dual monitors, extra storage and crisp graphic processing cards are must-haves too in GIS.

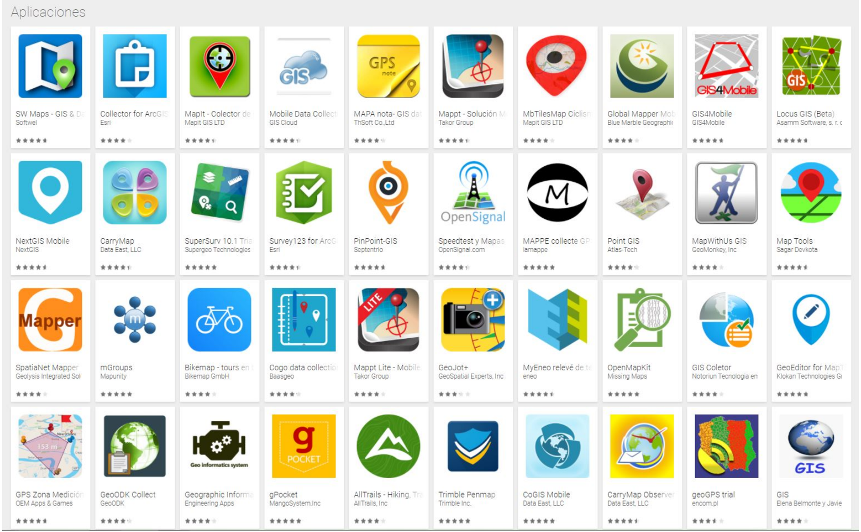
3. SOFTWARE: ArcGIS and QGIS are the leaders in GIS software. GIS software specialize in spatial analysis by using math in maps. It blends geography with modern technology to measure, quantify and understand our world.

Hardware


ArcGIS
Websites
Viewers
Desktops
Smartphones & tablets
Other mobile devices

Software

Software


Aplicaciones
SW Maps - GIS &
Softwel
Collector for ArcGIS
Esri
MapIt - Colector de
Mapit GIS LTD
Mobile Data Collect
GIS Cloud
MAPA nota- GIS dat
ThSoft Co.,Ltd
Mappt - Solución M
Takor Group
MbTilesMap Ciclism
Mapit GIS LTD
Global Mapper Mob
Blue Marble Geographic
GIS4Mobile
GIS4Mobile
Locus GIS (Beta)
Asamm Software, s. r. o
NextGIS Mobile
NextGIS
CarryMap
Data East, LLC
SuperSurv 10.1 Tria
Supergeo Technologies
Survey123 for ArcG
Esri
PinPoint-GIS
Septentrio
OpenSignal
Speedtest y Mapas
OpenSignal.com
MAPPE collecte GP
lamappe
Point GIS
Atlas-Tech
MapWithUs GIS
GeoMonkey, Inc
Map Tools
Sagar Devkota
Mapper
SpatiaNet Mapper
Geolysis Integrated Sol
mGroups
Mapunity
Bikemap - tours en
Bikemap GmbH
Cogo data collectio
Baasgeo
LITE
Mappt Lite - Mobile
Takor Group
GeoJot+
GeoSpatial Experts, Inc
MyEneo relevé de t
eneo
OpenMapKit
Missing Maps
GIS Coletor
Notoriun Tecnologia en
GeoEditor for MapT
Klokan Technologies Gi
153 m
GPS Zona Medición
OEM Apps & Games
GeoODK Collect
GeoODK
Geo informatics system
Geographic Informa
Engineering Apps
POCKET
gPocket
MangoSystem.Inc
AllTrails - Hiking, Tr
AllTrails, Inc
Trimble Penmap
Trimble Inc.
CoGIS Mobile
Data East, LLC
CarryMap Observer
Data East, LLC
geoGPS trial
encom.pl
GIS
GIS
Elena Belmonte y Javie

Componentes de un SIG

Data & Hardware & Software

The 3 main components of Geographic Information Systems are:

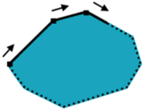
1. DATA: GIS stores location data as thematic layers. Each data set has an attribute table that stores information about the feature. The two main types of GIS data are raster and vector:

RASTER

Raster look like grids because they store data in rows and columns. They can be discrete or continuous. For example, we often represent land cover, temperature data and imagery as raster data.

VECTOR

Vectors are points, lines and polygons with vertices. For example, fire hydrants, contours and administrative boundaries are often vectors.



Geospatial Data

City	Latitude	Longitude
Seattle	47.5°	-122.3°
New York	40.7	-73.9°
Miami	25.8°	-80.2°
Los Angeles	33.9°	-118.2°

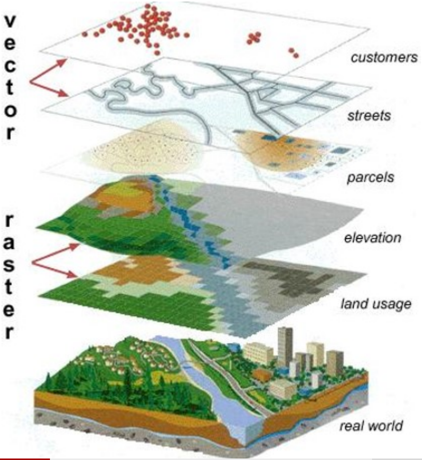
But when you add these positions on a map, it's like magic to the reader.

That's because maps make geographic information easier to understand.

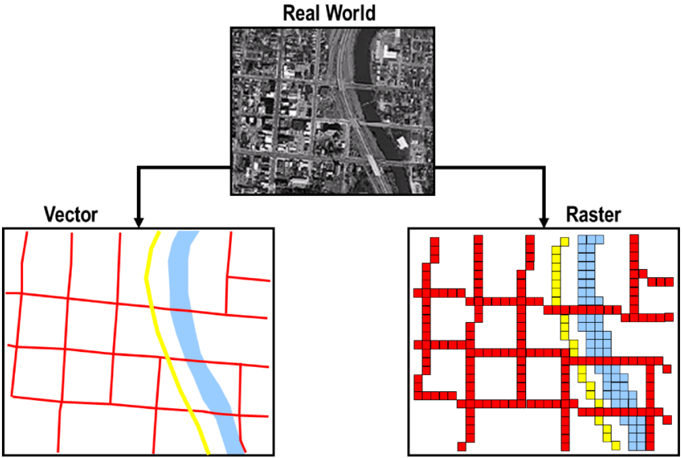
When you have geographic context, you don't only see where they are in a map. But you can:

Geospatial Data

Geospatial data is data about objects, events, or phenomena that have a location on the surface of the earth, including location information (usually coordinates on the earth), attribute information (the characteristics of the object, event, or phenomena concerned), and often also temporal information (the time or life span at which the location and attributes exist).



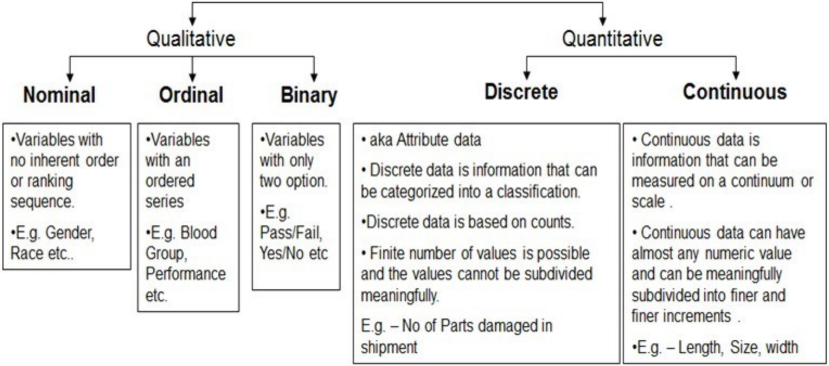
GIS Data Models



https://transportgeography.org/?page_id=6748

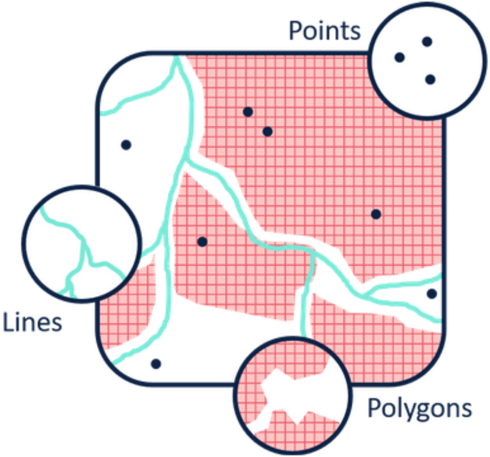

01
VECTOR
Vertices and paths as points, lines and polygons.
RASTER
Raster data is made up of pixels or grid cells.
02
03
DATABASES
Geographic databases store vectors and rasters.
WEB
Data built to serve and display geographic features over the internet.
04
05
MULTITEMPORAL
Multitemporal geodata has a component of location and time.

Data



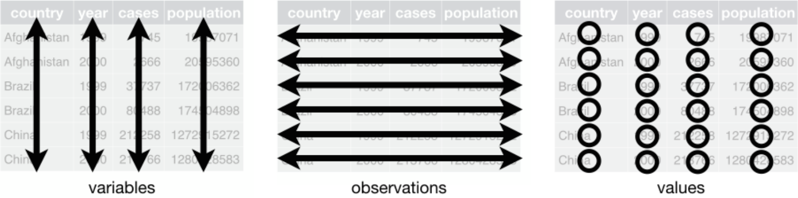
Qualitative
Quantitative
Nominal
Ordinal
Binary
Discrete
Continuous
•Variables with no inherent order or ranking sequence.
•E.g. Gender, Race etc..
•Variables with an ordered series
•E.g. Blood Group, Performance etc.
•Variables with only two option.
•E.g. Pass/Fail, Yes/No etc
• aka Attribute data
• Discrete data is information that can be categorized into a classification.
•Discrete data is based on counts.
• Finite number of values is possible and the values cannot be subdivided meaningfully.
E.g. – No of Parts damaged in shipment
• Continuous data is information that can be measured on a continuum or scale .
• Continuous data can have almost any numeric value and can be meaningfully subdivided into finer and finer increments .
•E.g. – Length, Size, width

Vector



https://datenlage.blog/2019/06/08/geospatial-data-1/

Vector

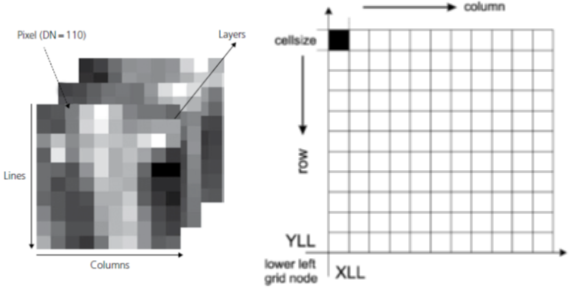


	Age	Gender	Weight	Height
Observation #1	**12**	**M**	**80** lbs	**55** in
Observation #2	**11**	**M**	**85** lbs	**58** in
Observation #3	**12**	**F**	**73** lbs	**52** in
Observation #4	**10**	**F**	**71** lbs	**49** in
.				
.				
.				
Observation #150				

Features

Target Variable

Raster

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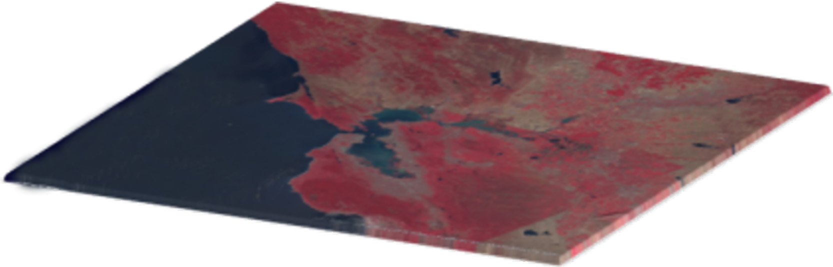
ncols 6
nrows 6
xllcorner 0
yllcorner 0
cellsize 10.00
nodata_value -32767
10 16 23 16 9 6
14 11 18 11 18 19
19 15 13 21 23 25
20 20 19 14 38 45
24 20 20 28 18 49
23 24 34 38 45 51
```

Wood, J. (2009). Geomorphometry - Concepts, Software, Applications. In Developments in Soil Science (Vol. 33). https://doi.org/10.1016/S0166-2481(08)00010-X

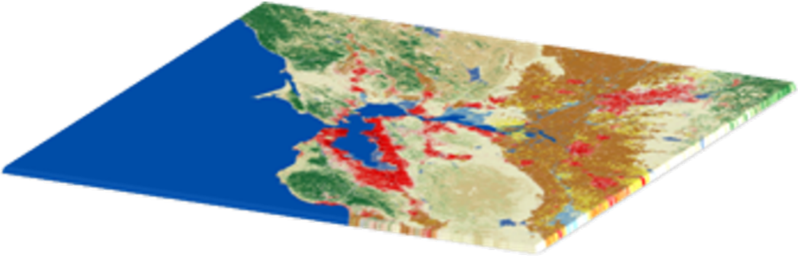
Raster Continuos

Continuous rasters (non-discrete) are grid cells with gradual changing data such as elevation, temperature or an aerial photograph. A continuous raster surface can be derived from a fixed registration point. For example, digital elevation models use sea level as a registration point. Each cell represents a value above or below sea level.



Raster Discretos

Discrete rasters have distinct themes or categories. For example, one grid cell represents a land cover class or a soil type.In a discrete raster land cover/use map, you can distinguish each thematic class. Each class can be discretely defined where it begins and ends. In other words, each land cover cell is definable and it fills the entire area of the cell.Discrete data usually consists of integers to represent classes.



Formatos

Extension	File Type	Description
Esri Shapefile	.SHP, .DBF, .SHX	The shapefile is BY FAR the most common geospatial file type you'll encounter. All commercial and open source accept shapefile as a GIS format. It's so ubiquitous that it's become the industry standard. But you'll need a complete set of three files that are mandatory to make up a shapefile. The three required files are: ▪ SHP is the feature geometry. ▪ SHX is the shape index position. ▪ DBF is the attribute data. You can optionally include these files but are not completely necessary. ▪ PRJ is the projection system metadata. ▪ XML is the associated metadata. ▪ SBN is the spatial index for optimizing queries. ▪ SBX optimizes loading times.

Vector

Geographic JavaScript Object Notation (GeoJSON)	.GEOJSON .JSON	The GeoJSON format is mostly for web-based mapping. GeoJSON stores coordinates as text in JavaScript Object Notation (JSON) form. This includes vector points, lines and polygons as well as tabular information. GeoJSON store objects within curly braces {} and in general have less markup overhead (compared to GML). GeoJSON has straightforward syntax that you can modify in any text editor. Webmaps browsers understand JavaScript so by default GeoJSON is a common web format. But JavaScript only understands binary objects. Fortunately, JavaScript can convert JSON to binary.
Geography Markup Language (GML)	.GML	GML allows for the use of geographic coordinates extension of XML. And eXtensible Markup Language (XML) is both human-readable and machine-readable. GML stores geographic entities (features) in the form of text. Similar to GeoJSON, GML can be updated in any text editor. Each feature has a list of properties, geometry (points, lines, curves, surfaces and polygons) and spatial reference system. There is generally more overhead when compare GML with GeoJSON. This is because GML results in more data for the same amount of information.

Vector

Google Keyhole Markup Language (KML/KMZ)	.KML .KMZ	KML stands for Keyhole Markup Language. This GIS format is XML-based and is primarily used for Google Earth. KML was developed by Keyhole Inc which was later acquired by Google. KMZ (KML-Zipped) replaced KML as being the default Google Earth geospatial format because it is a compressed version of the file. KML/KMZ became an international standard of the Open Geospatial Consortium in 2008. The longitude, latitude components (decimal degrees) are as defined by the World Geodetic System of 1984 (WGS84). The vertical component (altitude) is measured in meters from the WGS84 EGM96 Geoid vertical datum.
GPS eXchange Format (GPX)	.GPX	GPS Exchange format is an XML schema that describes waypoints, tracks and routes captured from a GPS receiver. Because GPX is an exchange format, you can openly transfer GPS data from one program to another based on its description properties. The minimum requirement for GPX are latitude and longitude coordinates. In addition, GPX files optionally stores location properties including time, elevation and geoid height as tags.

Raster

Extension	File Type	Description
ERDAS Imagine (IMG)	.IMG	ERDAS Imagine IMG files is a proprietary file format developed by Hexagon Geospatial. IMG files are commonly used for raster data to store single and multiple bands of satellite data. IMG files use a hierarchical format (HFA) that are optional to store basic information about the file. For example, this can include file information, ground control points and sensor type. Each raster layer as part of an IMG file contains information about its data values. For example, this includes projection, statistics, attributes, pyramids and whether or not it's a continuous or discrete type of raster.
American Standard Code for Information Interchange ASCII Grid	.ASC	ASCII uses a set of numbers (including floats) between 0 and 255 for information storage and processing. They also contain header information with a set of keywords. In their native form, ASCII text files store GIS data in a delimited format. This could be comma, space or tab-delimited format. Going from non-spatial to spatial data, you can run a conversion process tool like ASCII to raster.

Raster

GeoTIFF	.TIF .TIFF .OVR	The GeoTIFF has become an industry image standard file for GIS and satellite remote sensing applications. GeoTIFFs may be accompanied by other files: ▪ TFW is the world file that is required to give your raster geolocation. ▪ XML optionally accompany GeoTIFFs and are your metadata. ▪ AUX auxiliary files store projections and other information. ▪ OVR pyramid files improves performance for raster display.
IDRISI Raster	.RST .RDC	IDRISI assigns RST extensions to all raster layers. They consist of numeric grid c values as integers, real numbers, bytes and RGB24. The raster documentation file (RDC) is a companion text file for RST files. They assign the number of columns and rows to RST files. Further to this, they record t file type, coordinate system, reference units and positional error.

Raster

Envi RAW Raster	.BIL .BIP .BSQ	Band Interleaved files are a raster storage extension for single/multi-band aerial and satellite imagery. ▪ Band Interleaved for Line (BIL) stores pixel information based on rows for all bands in an image. ▪ Whereas Band interleaved by pixel (BIP) assigns pixel values for each band by rows. ▪ Finally, Band sequential format (BSQ) stores separate bands by rows. BIL files consist of a header file (HDR) that describes the number of columns, rows, bands, bit depth and layout in an image.
PCI Geomatics Database File (PCIDSK)	.PIX	PIX files are raster storage layers developed by PCI Geomatics. It's a flexible file type that stores all image and auxiliary data called "segments" in a self-contained file. For example, segments can include image channels, training site and histogram information. As a database file, PIX files can hold raster channels with varying bit depths. They can also store projections, attribute information, metadata and imagery/vectors.

Raster

ER Mapper Enhanced Compression Wavelet	.ECW	ECW is a compressed image format typically for aerial and satellite imagery. This GIS file type is known for its high compression ratios while still maintaining quality contrast in images. ECW format was developed by ER Mapper, but it's now owned by Hexagon Geospatial.
Joint Photographic Experts Group JPEG2000	.JP2	JPEG 2000 typically have a JP2 file extension. They are a wavelet compression with the latest JPG format giving an option for lossy or lossless compression. JPEG 2000 GIS formats require a world file which gives your raster geolocation. They are an optimal choice for background imagery because of its lossy compression. JPEG 2000 can achieve a compression ratio of 20:1 which is similar to MrSID format.

Raster

Autodesk Drawing	.DWF, .DWG, .DXF	Autodesk CAD (computer assisted drafting) file formats are designed for 2D and 3D designs. They generally contain elements such as edges, curves, annotation text in layers. DWG/DXF are vector files that use Cartesian coordinates. Every element plots XY points in a grid. ▪ DWF (Design Web Format) is more specific for view and use on the internet. ▪ DWG (DraWinG) is the native format and working version for AutoCAD containing metadata. ▪ Lastly, DXF (Drawing Exchange Format) stores drawing information as exact representations of the data. But the purpose of DXF was for data exchange between CAD programs.
Bentley Microsystems DGN File Format	.DGN	DGN or “Design” is the native format for Bentley Systems MicroStation. Similar to other CAD design formats, engineers and architects use it for construction design. DGN files consists of layers including annotation, points, polylines, polygons and multipath. They also contain style information (ColorIndex) and a spatial reference system.

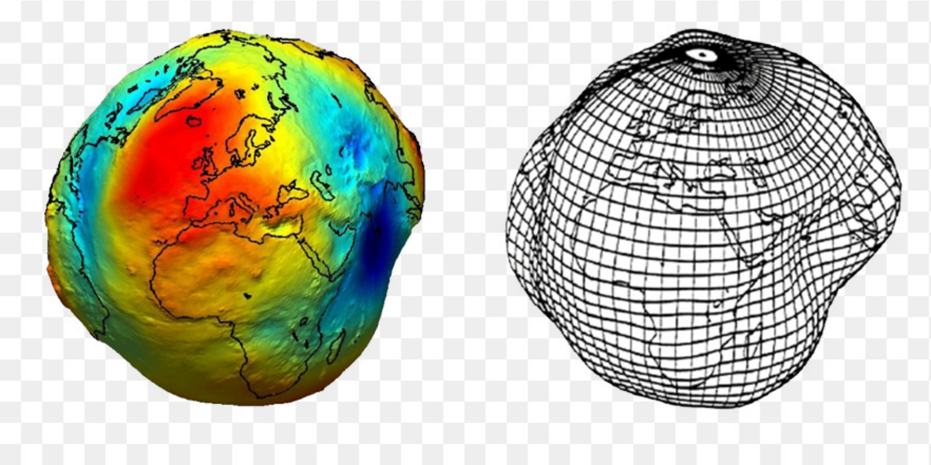
Raster

Point Cloud XYZ	.XYZ	XYZ files don't have specifications for storing point cloud data. The first 3 columns ger represent X, Y and Z coordinates. But there's no standard specification so it may incluc intensity values and other LiDAR values. They are in the ASCII point cloud group of file formats which includes TXT, ASC and PT Non-binary files like XYZ are advantageous because they can be opened and edited in editor.

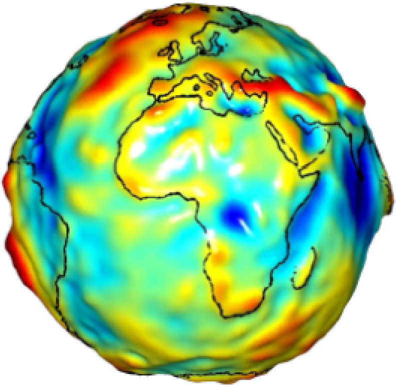
Raster

Extension	File Type	Description
Network Common Data Form (NetCDF)	.NC	NetCDF GIS format is an interface for array-oriented data for storing multi-dimensional variables. An example of a multi-dimension NetCDF could be temperature, precipitation or wind speed over time. It's commonly used for scientific data involved in the oceanic and atmospheric community as a GIS data storage format. The ArcGIS multidimensional toolbox and the QGIS NetCDF Browser both support NetCDF files.
Hierarchical Data Format	.HDF	HDF (Hierarchical Data Format) was designed by the National Center for Supercomputing Applications (NCSA) to manage extremely large and complex scientific data. It's a versatile data model with no limit on the number or size of data objects in the collection. ArcGIS is capable of reading HDF4 and HDF5 data. The free open source GDAL (command-line) tools supports the conversion of HDF files to GeoTIFF. The HDFView program allows users to view HDF files.

The Earth

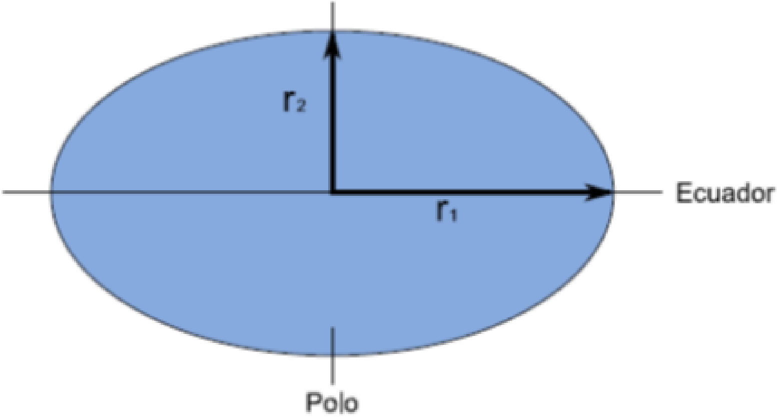


Geoide



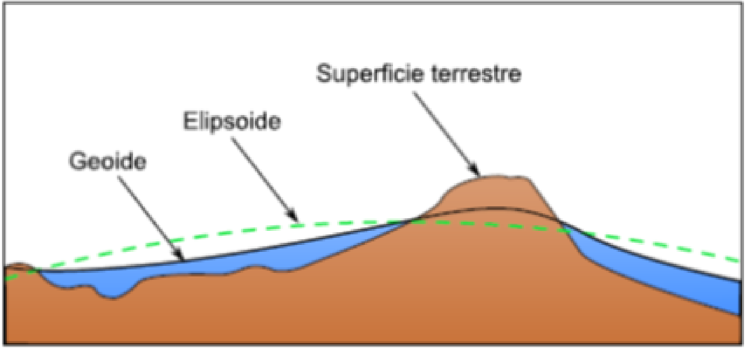
Elipsoide

WGS84

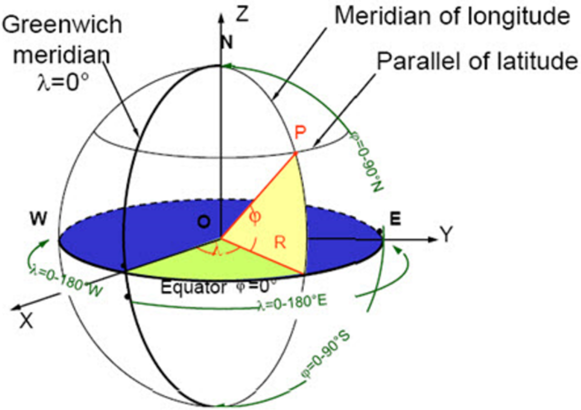


Elipsoide & Geoide

Datum geodésico



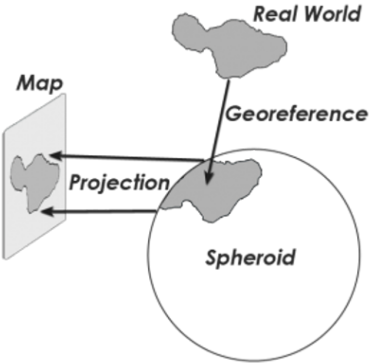
Coordenadas Geográficas



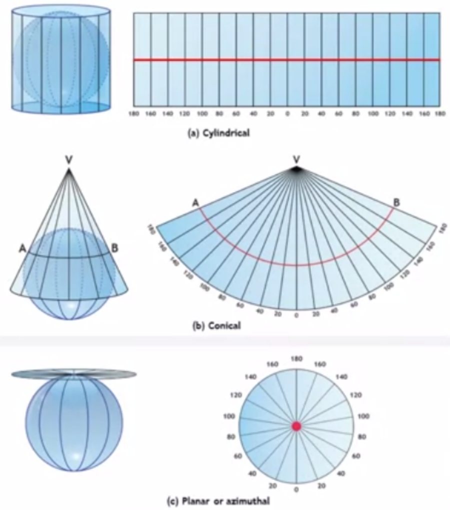
Proyección a Coordenadas Planas

You can't represent Earth's surface in two dimensions without distortion

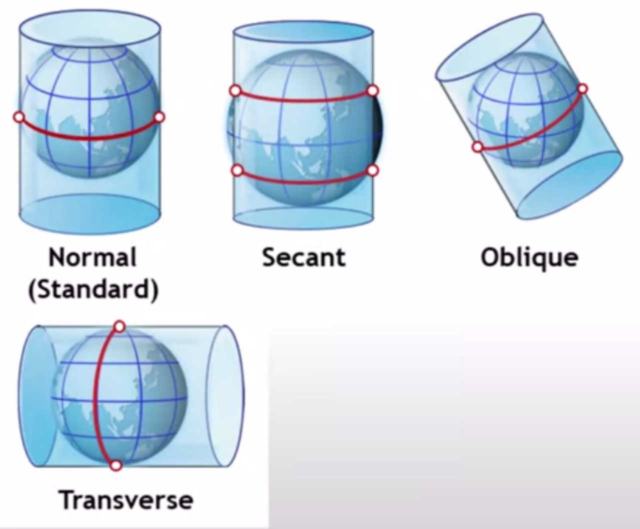
Similarly, a map projection is a method by which cartographers translates a sphere or globe into a two-dimensional representation. In other words, a map projection systematically renders a 3D ellipsoid (or spheroid) of Earth to a 2D map surface. Because you can't display 3D surfaces perfectly in two dimensions, distortions always occur. For example, map projections distort distance, direction, scale and area.



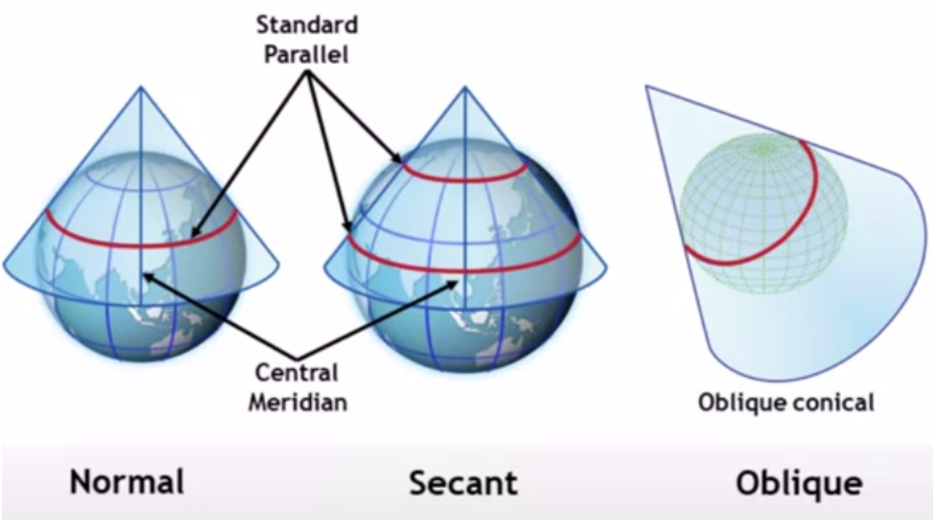
Proyección Cartográfica



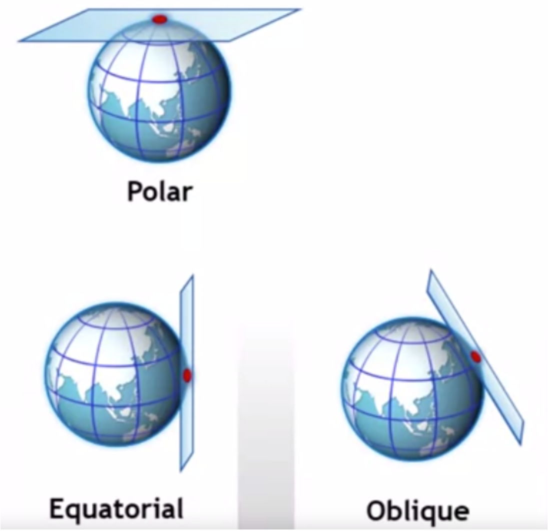
Proyección Cilíndrica



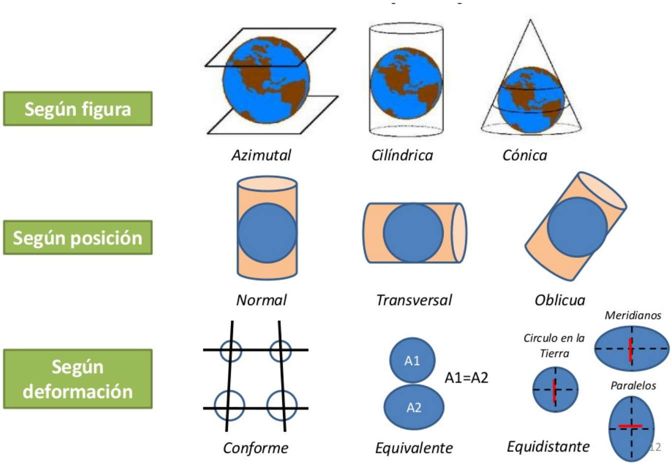
Proyección Cónica



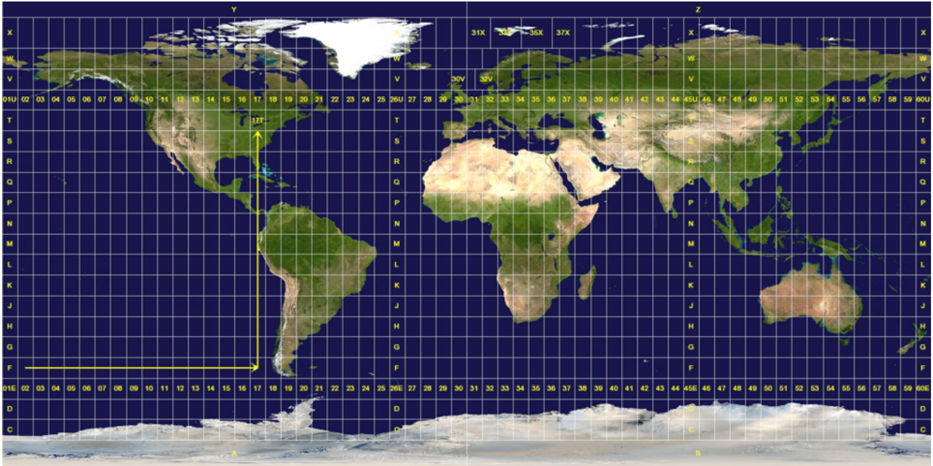
Proyección Planar



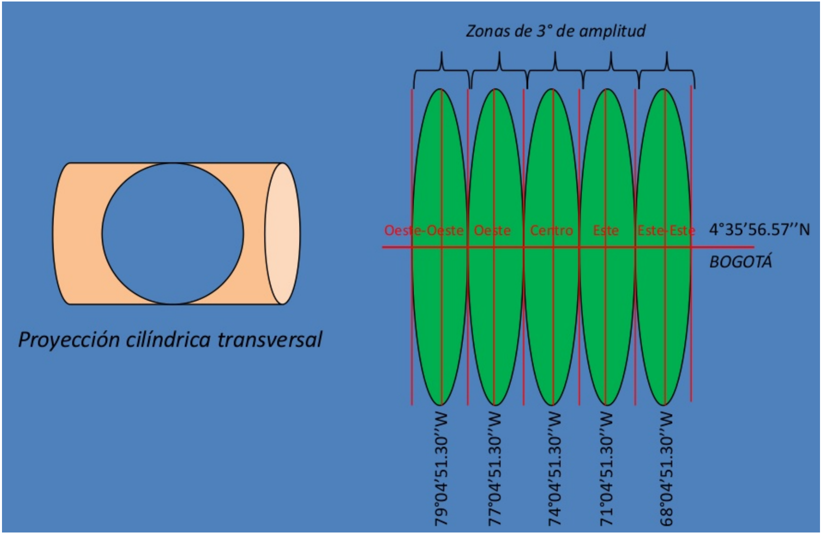
Proyección Cartográfica



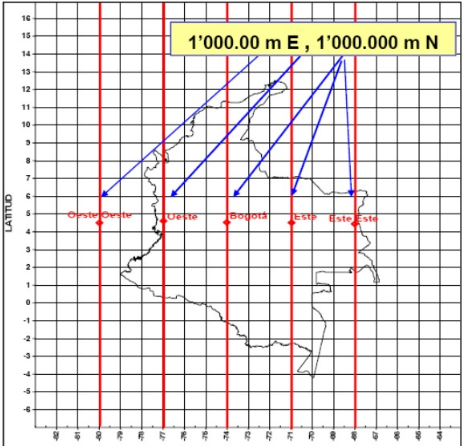
Universal Transversal Mercator (UTM)



Proyección Conforme de Gauss



Proyección Conforme de Gauss



Es importante tener presente que el hecho de migrar del dátum Bogotá al dátum MAGNA SIRGAS, implica cambiar el valor de las coordenadas geográficas de los puntos de origen.

Spatial Reference System Identifier (SRID)

Un SRID, Identificador de Referencia Espacial, es un identificador estándar único que hace referencia a un Sistema de Coordenadas concreto. Cada código, por tanto, se asocia de forma exclusiva a un Sistema de Coordenadas.


Home | Upload Your Own | List user-contributed references | List all references

Previous: EPSG:25829: ETRS89 / UTM zone 29N | Next: EPSG:25831: ETRS89 / UTM zone 31N

EPSG:25830

ETRS89 / UTM zone 30N (Google it)

- **WGS84 Bounds**: -6.0000, 34.7500, 0.0000, 62.3300
- **Projected Bounds**: 225370.7346, 3849419.9580, 774629.2654, 6914547.3835
- **Scope**: Large and medium scale topographic mapping and engineering survey.
- **Last Revised**: Oct. 19, 2000
- **Area**: Europe - 6°W to 0°W and ETRS89 by country

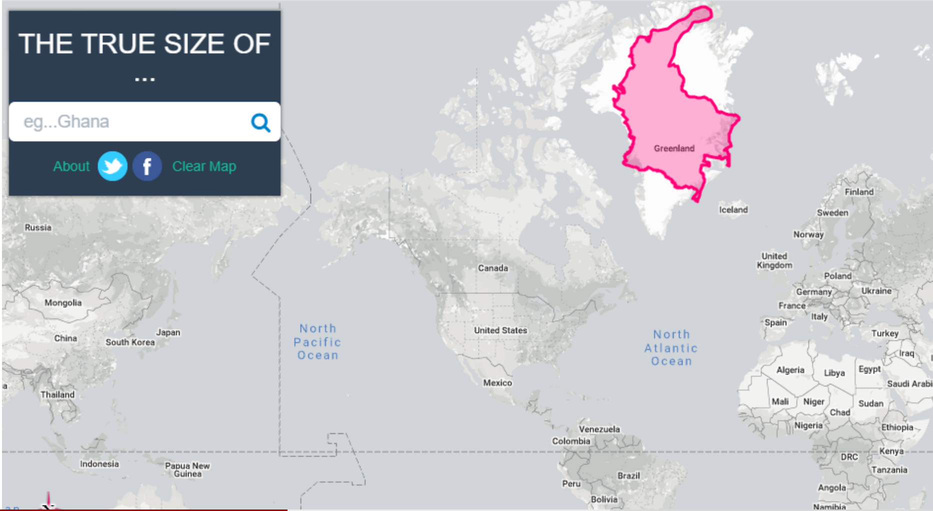
- Well Known Text as HTML
- Human-Readable OGC WKT
- Proj4
- OGC WKT
- JSON
- GML
- ESRI WKT
- .PRJ File
- USGS
- MapServer Mapfile | Python
- Mapnik XML | Python
- GeoServer
- PostGIS spatial_ref_sys INSERT statement
- Proj4js format

Input Coordinates: -3, 48.54 Output Coordinates: 500000, 5376321.814613

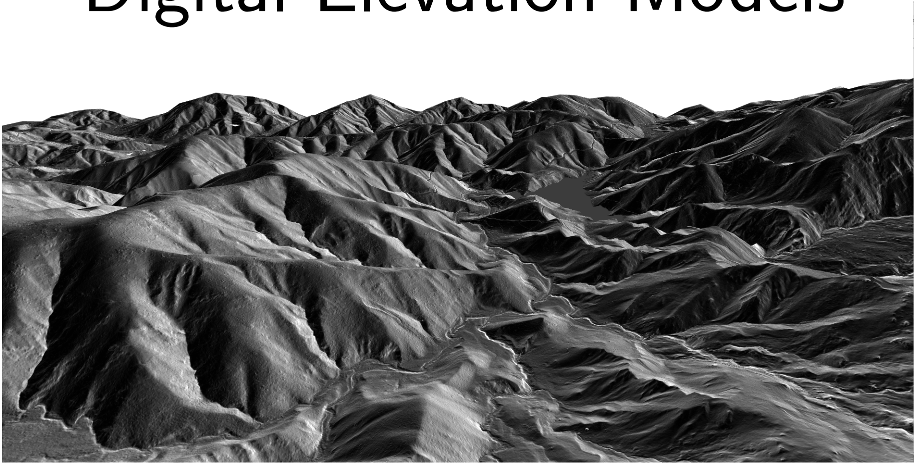
https://www.spatialreference.org/

The True Size of...

https://thetruesize.com

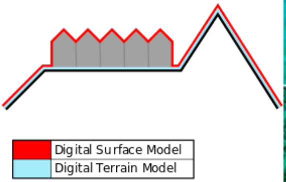


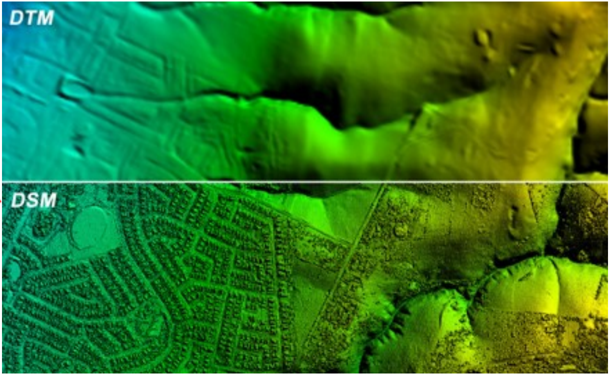
Digital Elevation Models



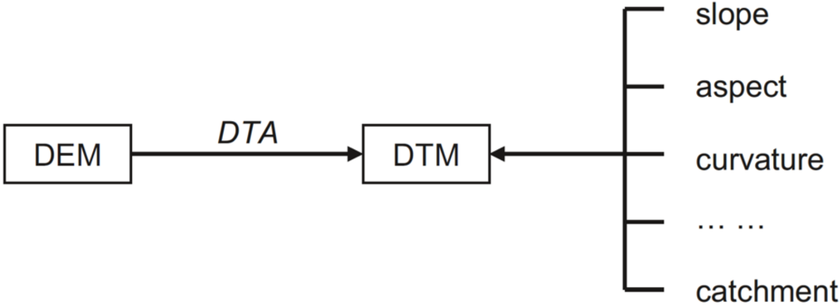
https://medium.com/on-location/from-points-to-pixels-creating-digital-elevation-models-from-open-topography-point-clouds

DEM

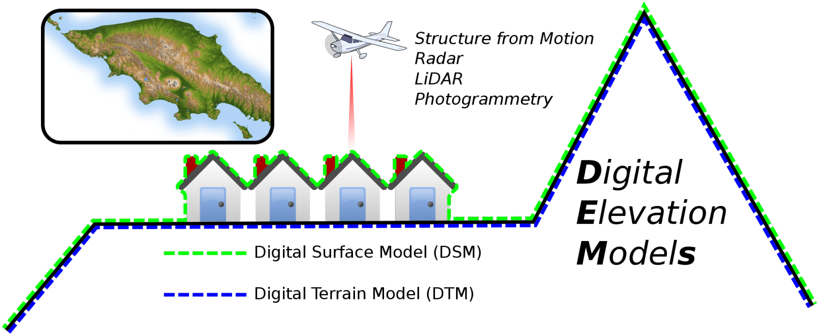




DEM

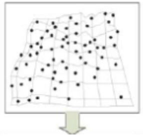


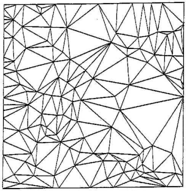
Modelos Digitales de Elevación (DEM)

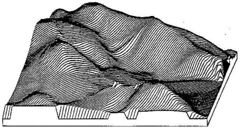


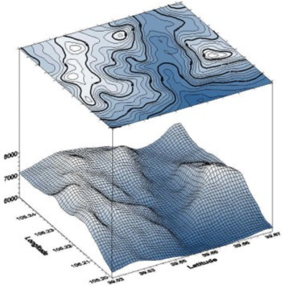
Arbeck / CC BY (https://creativecommons.org/licenses/by/4.0)

DTM





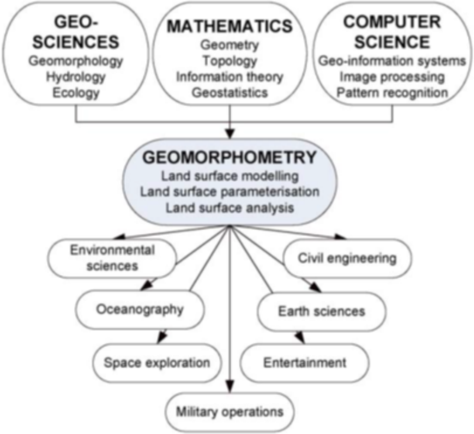




Southwest Corner of the
Morrison Quadrangle, Colorado


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

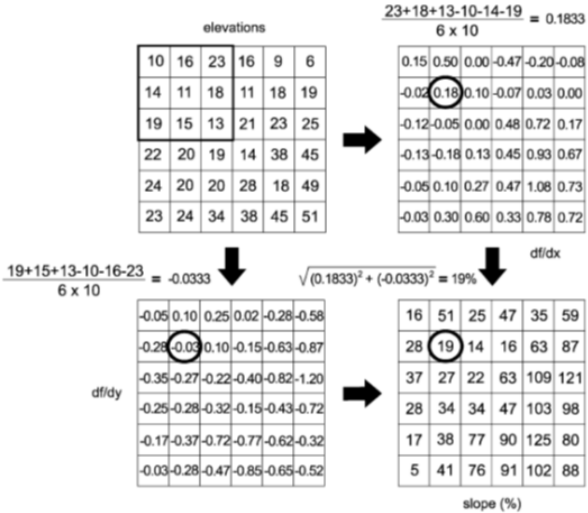


FIGURE 5 Numerical example showing slope tangent (in %) extracted from a DEM using a 3×3

Curvatura

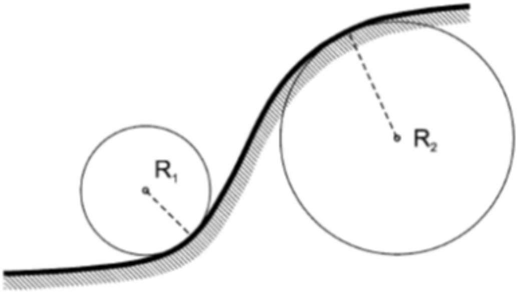
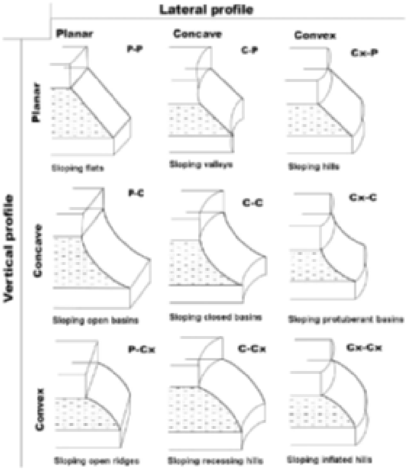
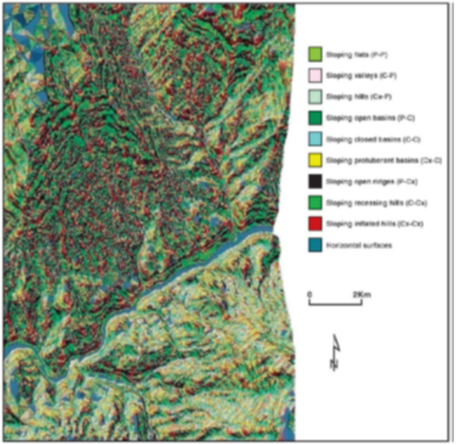
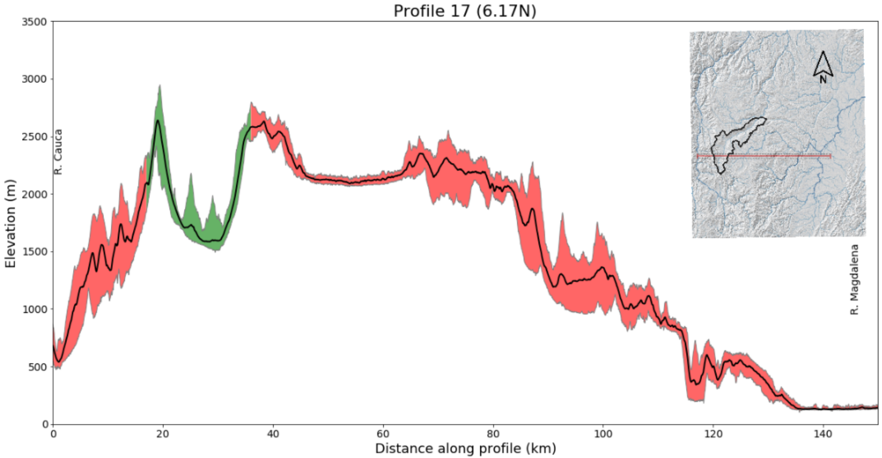


FIGURE 5 Curvature $1/R$ of a plane curve is the inverse of the radius R of a circle that is best fitted to this curve at a given point. It is agreed in Earth sciences that the sign of curvature is positive for a convex surface shape ($R_2 > 0$), and negative for a concave one ($R_1 < 0$).


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


Horizontal surfaces
0
2Km

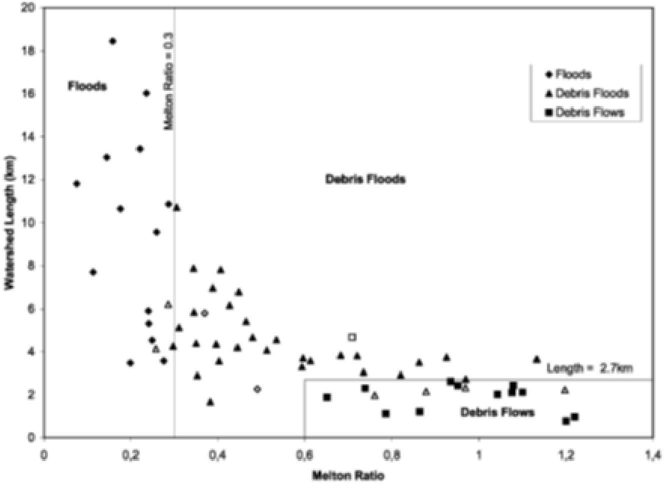
Perfiles



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

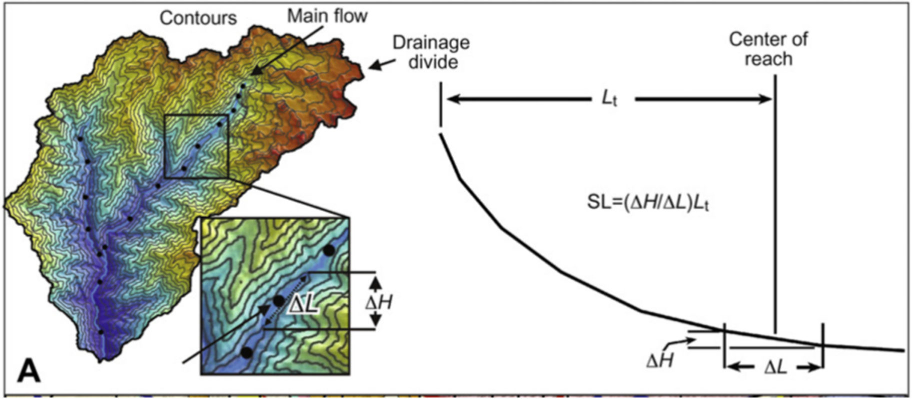
Indices morfométricos

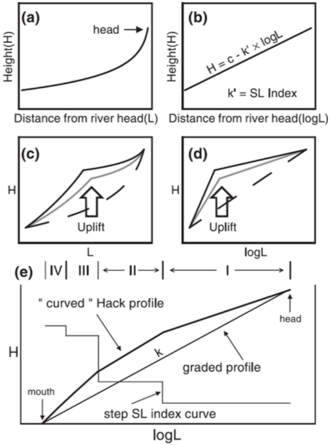
Morphometric parameter	Name	Formula	Reference
Drainage network			
Stream order	S_u	Hierarchical rank	(Strahler, 1952)
Stream Length	L_u (km)	$L_{u=} L_1 + L_2 + \cdots + L_n$	(Strahler 1964)
Stream Length Ratio	L_{ur}	$L_{ur=} L_u/L_{u-1}$	(Strahler, 1964)
Bifurcation Ratio	R_b	$R_{b=} N_u/N_{u-1}$	(Strahler, 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 (°)		



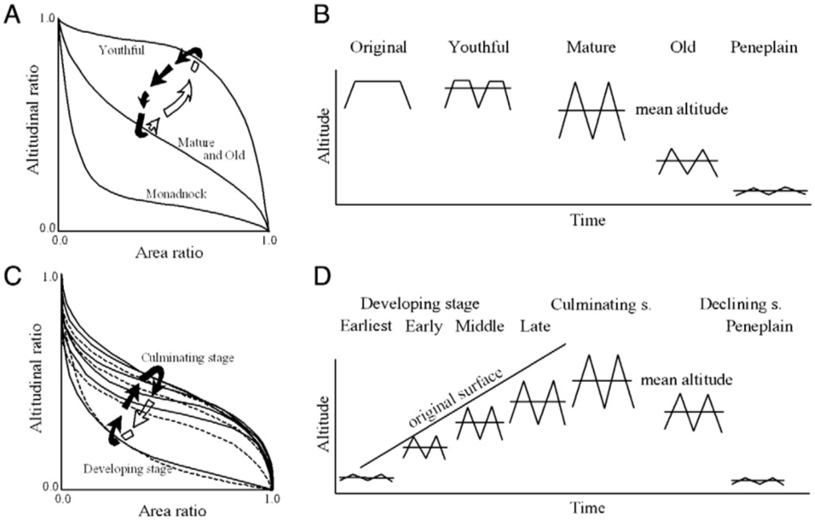
Fuente: Wilford et al. (2004)

Perfiles longitudinales

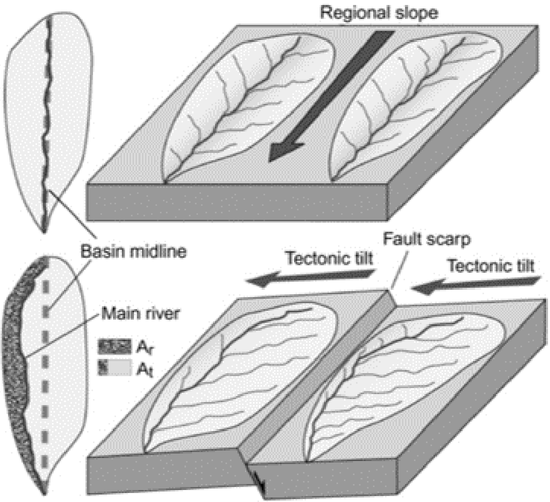


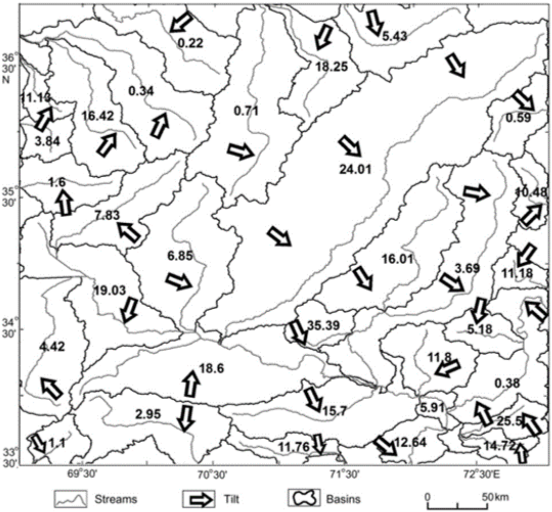

(a)
head
Height(H)
Distance from river head(L)
(b)
H = c - k' × logL
k' = SL Index
Height(H)
Distance from river head(logL)
(c)
H
Uplift
L
(d)
H
Uplift
logL
(e)
IV
III
II
I
" curved " Hack profile
head
H
k
graded profile
mouth
step SL index curve
logL

Curva hipsométrica



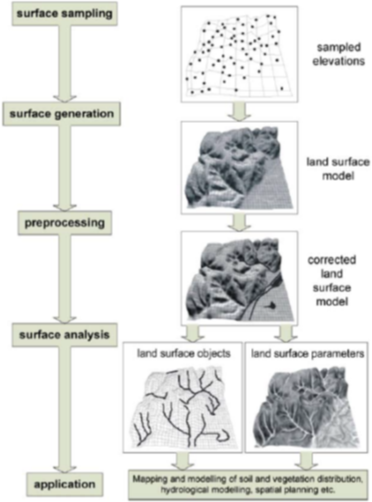
Indices tectónicos





0.22
5.43
18.25
36°30' N
11.16
16.42
0.34
0.71
0.59
3.84
24.01
1.6
10.48
35°30'
7.83
6.85
16.01
3.69
11.18
19.03
34°30'
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
33°30'
69°30'
70°30'
71°30'
72°30'E
Streams
Tilt
Basins
0
50km

Geomorfometría & Análisis Hidrológico



Tratamiento de imágenes de satélite

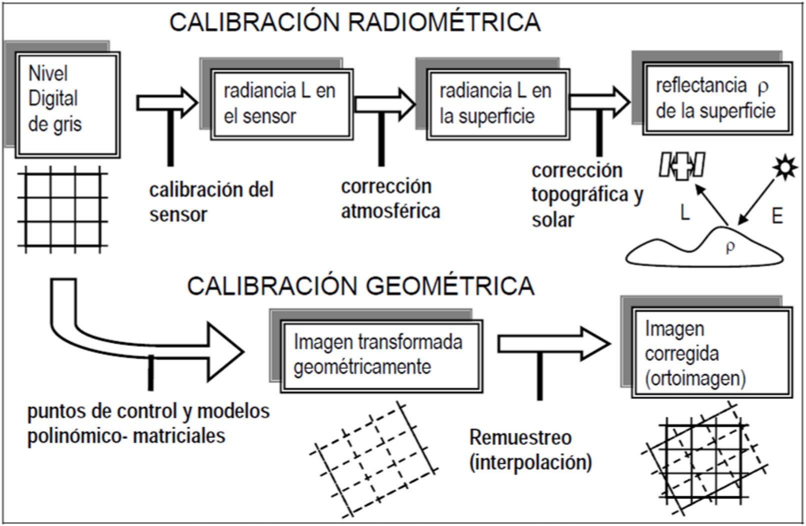
Existen una gran cantidad de procedimientos para el análisis de imágenes de satélite. En este curso nos concentraremos en 4 de ellas:

- Pro-procesamiento de imágenes
- Mejoramiento de imágenes
- Transformaciones de imágenes
- Clasificación de imágenes.

Single band	Multispectral
Radiometric correction	Algebraic operation with bands
Geometric correction	Vegetation indices (VI)
Image to image registration	Tasseled Cap
Histogram modification	Principal components analysis (PCA)
Digital filter	Classification

Cualquier imagen adquirida por un sensor remoto presenta una serie de alteraciones radiométricas y geométricas debidas a factores como:

Error	Cause	Type of distortion
Radiometric	Sensor	Radiometric calibration of the sensor Anomalies in the scansion (line striping effect)
	Geometry of the system	Effect of the Sun angle elevation Soil inclination (leaning)
	Atmosphere	Radiation absorption (subtractive) Atmospheric diffusion (additive)
Geometric	Acquisition system	Perspective deformation (asset variation, velocity and altitude) Panoramic distortion Distortion due to the opto-mechanical scan system oscillation
	Atmosphere	Atmospheric refraction
	Earth shape	Rotation, Earth curvature and orography


CALIBRACIÓN RADIOMÉTRICA
Nivel Digital de gris
radiancia L en el sensor
radiancia L en la superficie
reflectancia ρ de la superficie
calibración del sensor
corrección atmosférica
corrección topográfica y solar
L
E
ρ
CALIBRACIÓN GEOMÉTRICA
Imagen transformada geométricamente
Imagen corregida (ortoimagen)
puntos de control y modelos polinómico- matriciales
Remuestreo (interpolación)

Striping

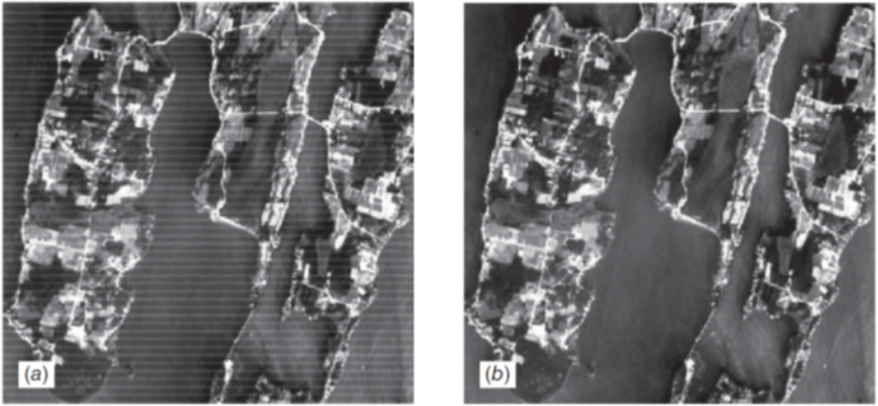


Figure 7.1 Destriping algorithm illustration: (*a*) original image manifesting striping with a six-line frequency; (*b*) restored image resulting from applying histogram algorithm. (Author-prepared figure.)

Line Drop

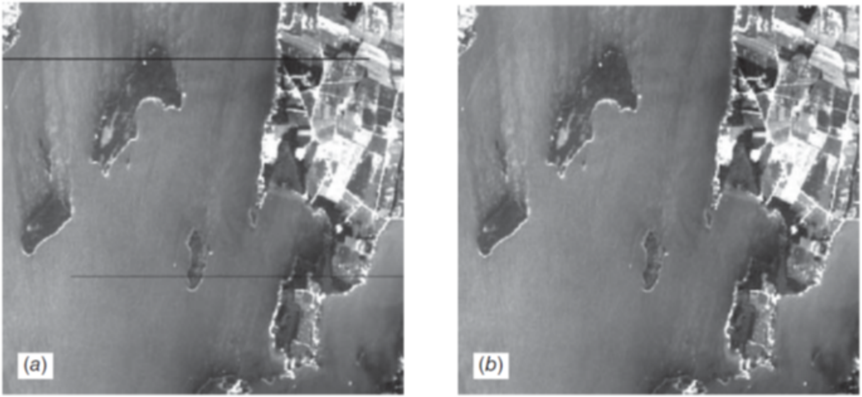


Figure 7.2 Line drop correction: (*a*) original image containing two line drops; (*b*) restored image resulting from averaging pixel values above and below defective line. (Author-prepared figure.)

Bit Error

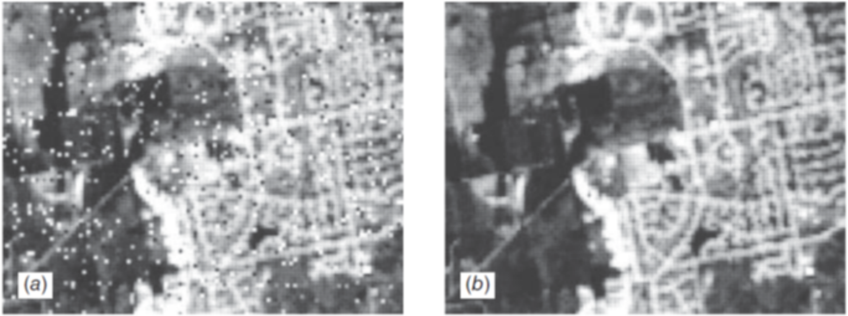
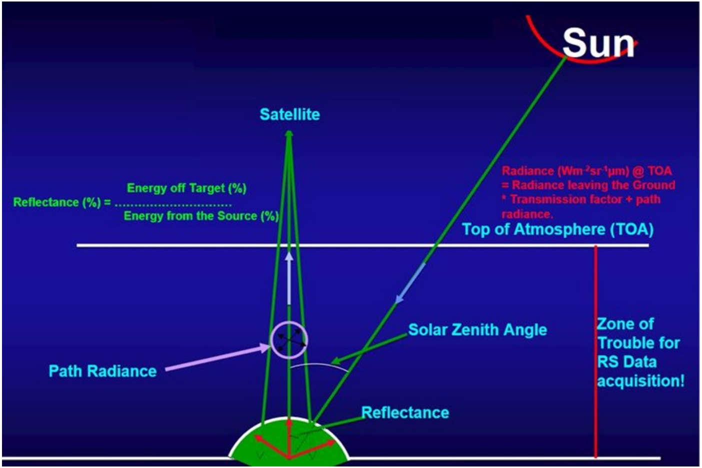
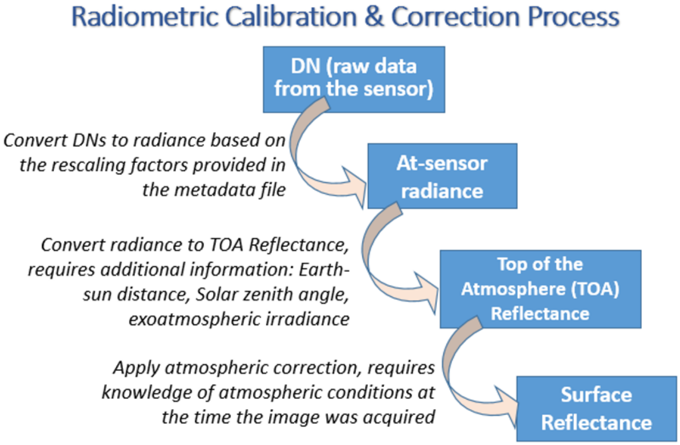


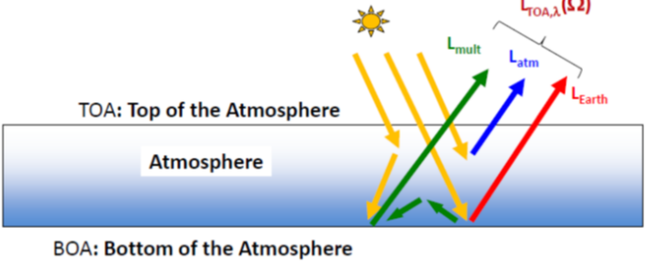
Figure 7.3 Result of applying noise reduction algorithm: (*a*) original image data with noise-induced "salt-and-pepper" appearance; (*b*) image resulting from application of noise reduction algorithm. (Author-prepared figure.)



Sun
Satellite
Radiance ($Wm^{-2}sr^{-1}\mu m$) @ TOA
= Radiance leaving the Ground
* Transmission factor + path
radiance.
Energy off Target (%)
Reflectance (%) = ...
Energy from the Source (%)
Top of Atmosphere (TOA)
Solar Zenith Angle
Zone of
Trouble for
RS Data
acquisition!
Path Radiance
Reflectance

Corrección & Calibración





$L_{TOA,\lambda}(\Omega)$ = "Radiance $L_{Earth,TOA,\lambda}(\Omega)$ due to scattering of sun flux by the Earth, only"

+

"Radiance $L_{atm,TOA,\lambda}(\Omega)$ due to scattering of sun flux by the Atmosphere, only

+

"Radiance $L_{mult,TOA,\lambda}(\Omega)$ due to scattering of sun flux by {Earth + Atmosphere}"

Conversión a Radiancia espectral TOA

$$L_\lambda = M_L * Q_{cal} + A_L$$

END_GROUP = MIN_MAX_PIXEL_VALUE
GROUP = RADIOMETRIC_RESCALING
RADIANCE_MULT_BAND_1 = 1.2517E-02
RADIANCE_MULT_BAND_2 = 1.2764E-02
RADIANCE_MULT_BAND_3 = 1.1687E-02
RADIANCE_MULT_BAND_4 = 9.8985E-03
RADIANCE_MULT_BAND_5 = 6.0065E-03
RADIANCE_MULT_BAND_6 = 1.5133E-03
RADIANCE_MULT_BAND_7 = 4.9229E-04

RADIANCE_ADD_BAND_1 = -62.58381
RADIANCE_ADD_BAND_2 = -63.81901
RADIANCE_ADD_BAND_3 = -58.43669
RADIANCE_ADD_BAND_4 = -49.49229
RADIANCE_ADD_BAND_5 = -30.03248
RADIANCE_ADD_BAND_6 = -7.56668
RADIANCE_ADD_BAND_7 = -2.46143
RADIANCE_ADD_BAND_8 = -55.74904

Donde:

*Lλ = Es el valor de radiancia espectral en el techo de la atmosfera (TOA) medida en valores de (Watts /m2 * srad * µm))*

ML = Banda – Es el factor multiplicativo de escalado especifico obtenido del metadato (RADIANCE_MULT_BAND_x, donde x es el número de la banda)

AL = Banda – Es el factor aditivo de escalado especifico obtenido del metadato (RADIANCE_ADD_BAND_x, donde x es el número de la banda)

Q cal = Producto estándar cuantificado y calibrado por valores de pixel (DN). Este valor se refiere a cada una de las bandas de la imagen.

Conversión a Reflectividad TOA

$$\rho_{\lambda}' = M_{\rho} * Q_{cal} + A_{\rho}$$

REFLECTANCE_MULT_BAND_1 = 2.0000E-05
REFLECTANCE_MULT_BAND_2 = 2.0000E-05
REFLECTANCE_MULT_BAND_3 = 2.0000E-05
REFLECTANCE_MULT_BAND_4 = 2.0000E-05
REFLECTANCE_MULT_BAND_5 = 2.0000E-05
REFLECTANCE_MULT_BAND_6 = 2.0000E-05
REFLECTANCE_MULT_BAND_7 = 2.0000E-05
REFLECTANCE_MULT_BAND_8 = 2.0000E-05
REFLECTANCE_MULT_BAND_9 = 2.0000E-05
REFLECTANCE_ADD_BAND_1 = -0.100000
REFLECTANCE_ADD_BAND_2 = -0.100000
REFLECTANCE_ADD_BAND_3 = -0.100000
REFLECTANCE_ADD_BAND_4 = -0.100000
REFLECTANCE_ADD_BAND_5 = -0.100000
REFLECTANCE_ADD_BAND_6 = -0.100000

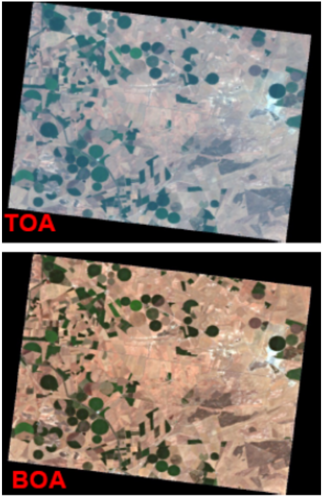
Donde:

Pλ` = Es el valor de reflectancia planetaria, sin corrección por ángulo solar. Note que Pλ` no contiene una corrección por el ángulo solar.

Mρ = Es el factor multiplicativo de escalado especifico por banda obtenido del metadato (REFLECTANCE_MULT_BAND_x, donde x es el numero de la banda).

Aρ = Es el factor aditivo de escalado especifico por banda obtenido del metadato (REFLECTANCE_ADD_BAND_x , donde x es el numero de la banda).

Q cal = Es el producto estándar cuantificado y calibrado para valores de pixel (DN). Este valor se refiere a cada una de las bandas de la imagen.



(Moreno, 2014)

Radiación Termal

La Temperatura cinética es la manifestación interna de la energía traslacional promedio de la moléculas que componen un cuerpo (temperatura cinética). Como consecuencia los objetos irradian energía en función de su temperatura (Temperatura radiante), adicionalmente esta temperatura sensada es de los primeros 50 cm, puede no ser representativa de todo el objeto.
Sin embargo debido a la diferencia de emisividad que tienen los objetos, un cuerpo puede tener la misma temperatura y aun así tener diferente radiancia. Solo los cuerpo negros presentan que la Trad = Tcin, para los demas cuerpos la temperatura radiante siempre es menor, ya que la emisividad es menor que 1.

TABLE 4.4 Kinetic versus Radiant Temperature for Four Typical Material Types

		Kinetic Temperature T_{kin}		Radiant Temperature $T_{rad} = \varepsilon^{1/4} T_{kin}$	
Object	Emissivity ε	K	°C	K	°C
Blackbody	1.00	300	27	300.0	27.0
Vegetation	0.98	300	27	298.5	25.5

Conversión a T de brillo

Las bandas del TIRS puede ser convertidas de radiancia espectral a temperatura de brillo en grados Kelvin usando la constante térmica suministrada en el archivo de metadatos:

$$T = \frac{K_2}{ln\left(\frac{K_1}{L_\lambda} + 1\right)}$$

```
GROUP = TIRS_THERMAL_CONSTANTS
    K1_CONSTANT_BAND_10 = 774.89
    K1_CONSTANT_BAND_11 = 480.89
    K2_CONSTANT_BAND_10 = 1321.08
    K2_CONSTANT_BAND_11 = 1201.14
  END_GROUP = TIRS_THERMAL_CONSTANTS
```

Donde:

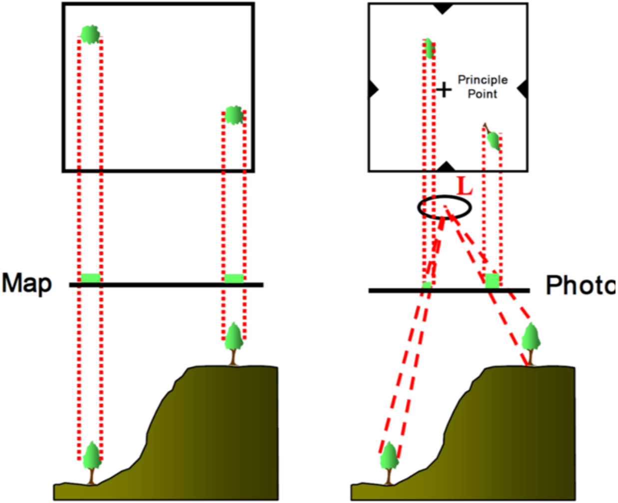
T = temperatura de brillo aparente en grados Kelvin

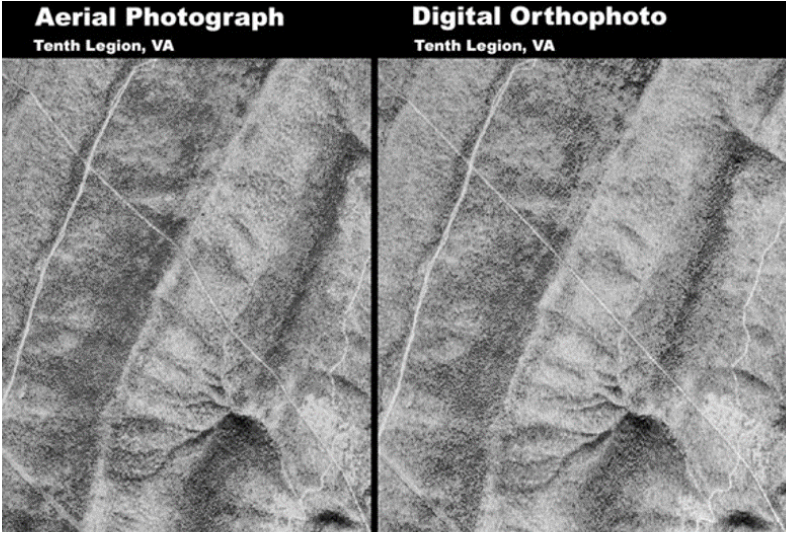
L = Radiancia espectral en el techo de la atmosfera TOA (watts/m2*srad*um)

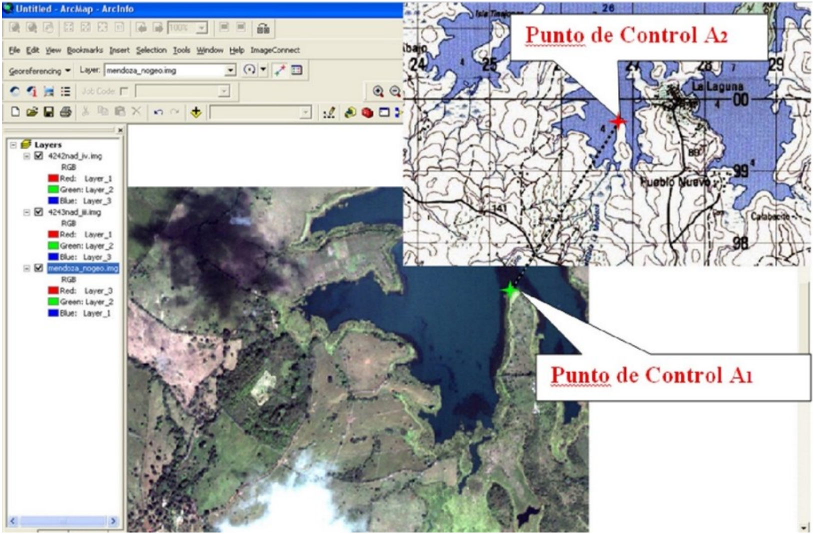
K1 = es la constante de conversión especifica para cada banda denominada en el metadato K1_CONSTANT_BAND_x, donde x es la banda 10 U 11.

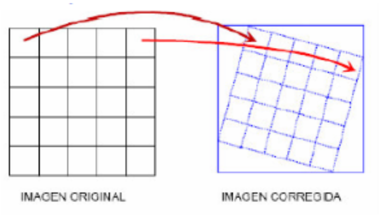
K2 = es la constante especifica para cada banda denominada en el metadato como K2_CONSTANT_BAND_x

Ortorectificación

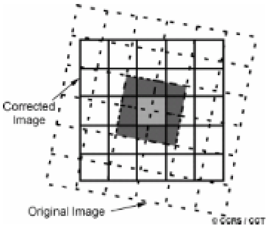



Aerial Photograph
Tenth Legion, VA
Digital Orthophoto
Tenth Legion, VA

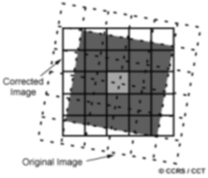

Untitled - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Tools Window Help ImageConnect
Georeferencing
Layer: mendoza_nogeo.img
Layers
4242nad_iv.img
RGB
Red: Layer_1
Green: Layer_2
Blue: Layer_3
4243nad_iii.img
RGB
Red: Layer_1
Green: Layer_2
Blue: Layer_3
mendoza_nogeo.img
RGB
Red: Layer_3
Green: Layer_2
Blue: Layer_1
Punto de Control A2
La Laguna
Pueblo Nuevo
Punto de Control A1



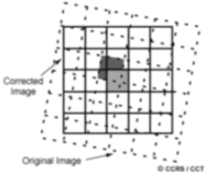
(a) Directa



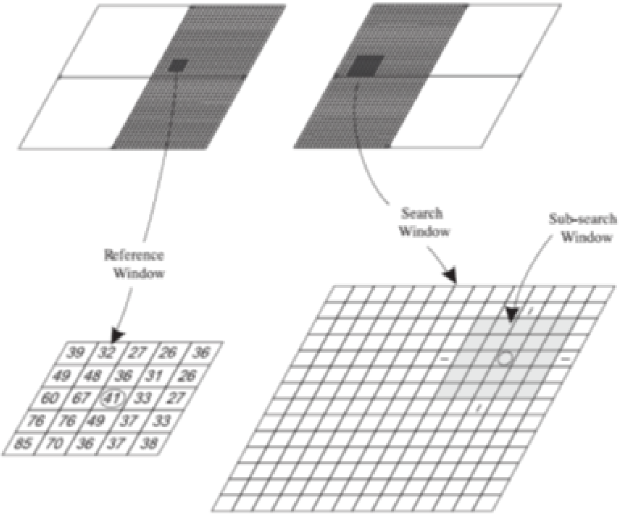
(b) Interpolación bilineal



(c) Interpolación cúbica



(d) Vecino mas Cercano


Reference Window
Search Window
Sub-search Window
39 32 27 26 36
49 48 36 31 26
60 67 41 33 27
76 76 49 37 33
85 70 36 37 38

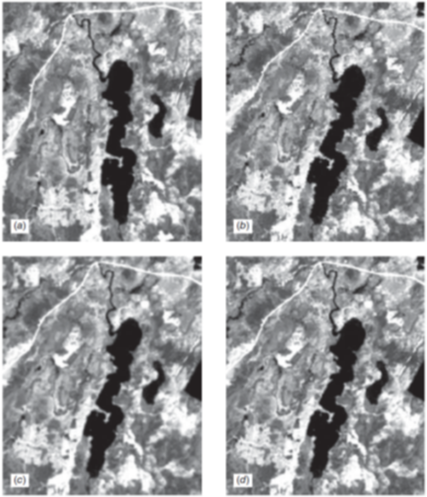
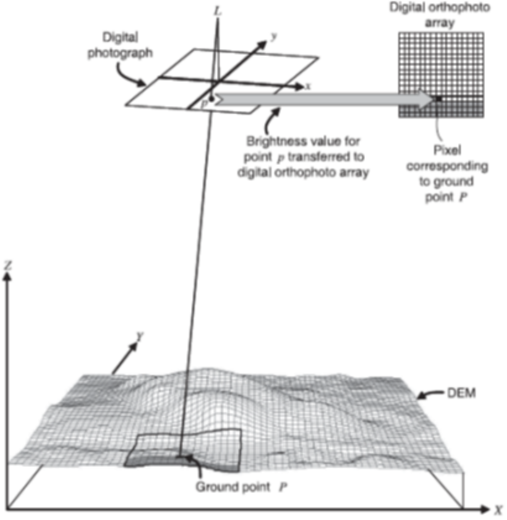
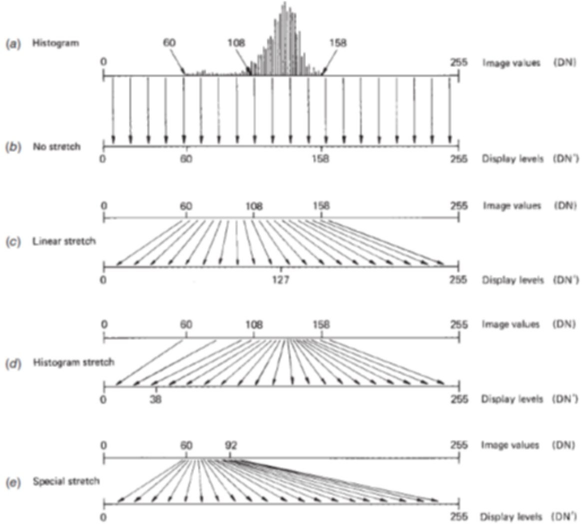


Figure 7.7 Resampling results: (a) original Landsat TM data; (b) nearest neighbor assignment; (c) bilinear interpolation; (d) cubic convolution. Scale 1:100,000. (Author-prepared figure.)

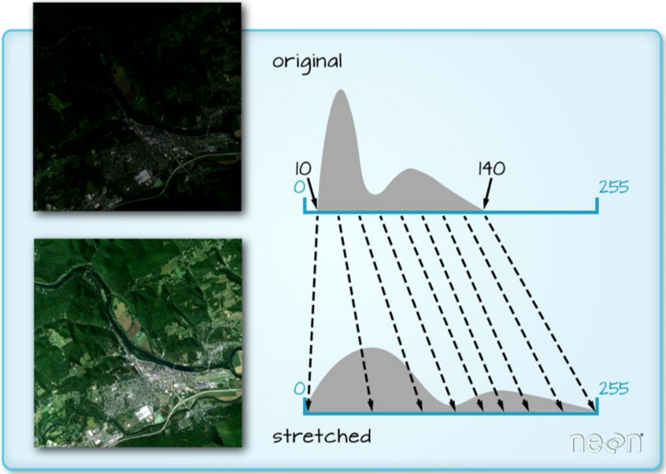

Digital orthophoto array
Digital photograph
L
y
x
p
Brightness value for point p transferred to digital orthophoto array
Pixel corresponding to ground point P
Z
Y
DEM
Ground point P
X

Mejoramiento de Imágenes



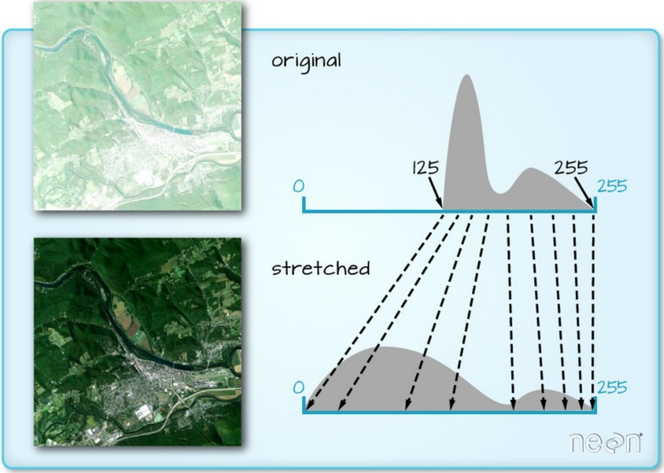
Ajustes del Histograma

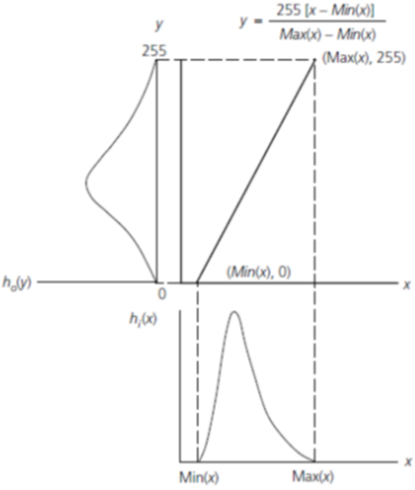
Strech



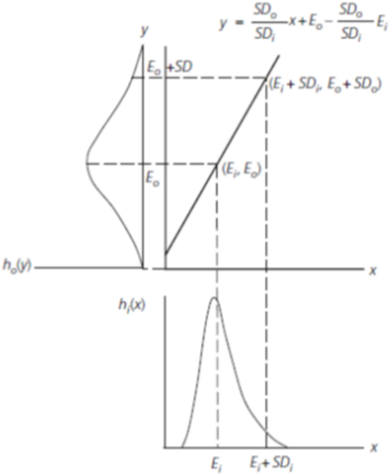
Ajustes del Histograma

Strech



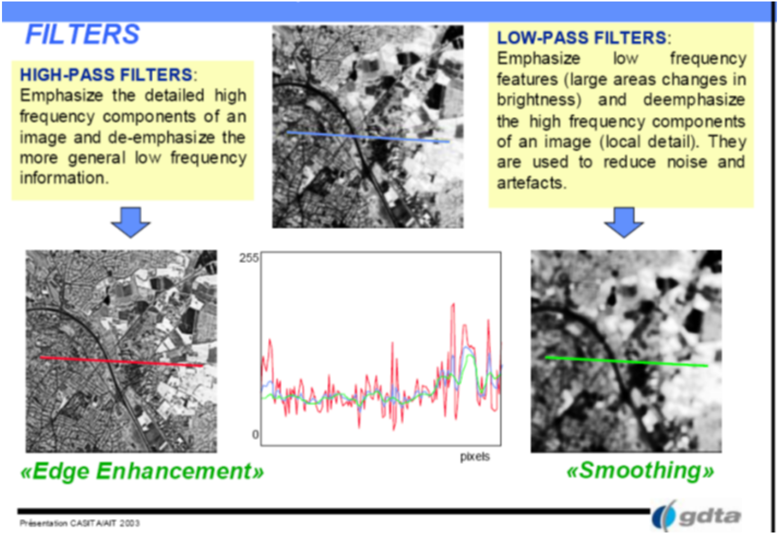


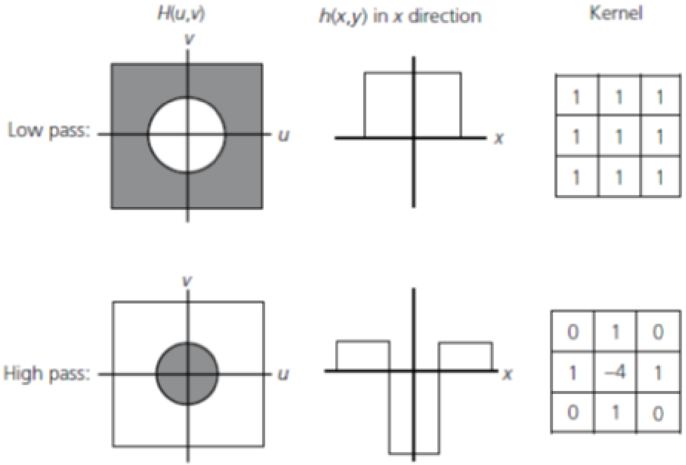
$y = \frac{255\,[x - Min(x)]}{Max(x) - Min(x)}$
y
255
(Max(x), 255)
(Min(x), 0)
$h_o(y)$
0
x
$h_i(x)$
x
Min(x)
Max(x)

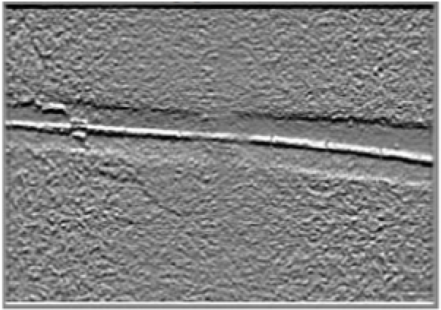


$y = \frac{SD_o}{SD_i}x + E_o - \frac{SD_o}{SD_i}E_i$
y
$E_o + SD$
$(E_i + SD_i, E_o + SD_o)$
(E_i, E_o)
E_o
$h_o(y)$
x
$h_i(x)$
x
E_i
$E_i + SD_i$

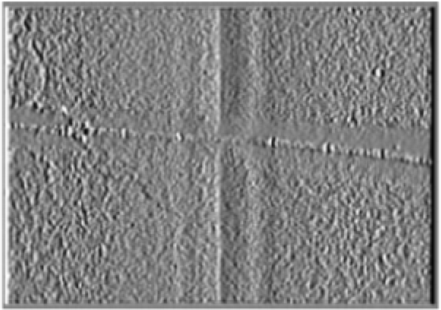
Filtros


FILTERS
HIGH-PASS FILTERS: Emphasize the detailed high frequency components of an image and de-emphasize the more general low frequency information.
LOW-PASS FILTERS: Emphasize low frequency features (large areas changes in brightness) and deemphasize the high frequency components of an image (local detail). They are used to reduce noise and artefacts.
255
0
pixels
«Edge Enhancement»
«Smoothing»
Présentation CASIT AIAIT 2003
gdta


H(u,v)
h(x,y) in x direction
Kernel
Low pass:
High pass:
v
u
x
1 1 1
1 1 1
1 1 1
0 1 0
1 –4 1
0 1 0



North edge enhancement



East edge enhancement

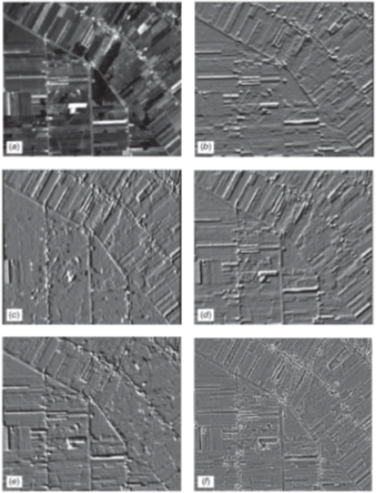
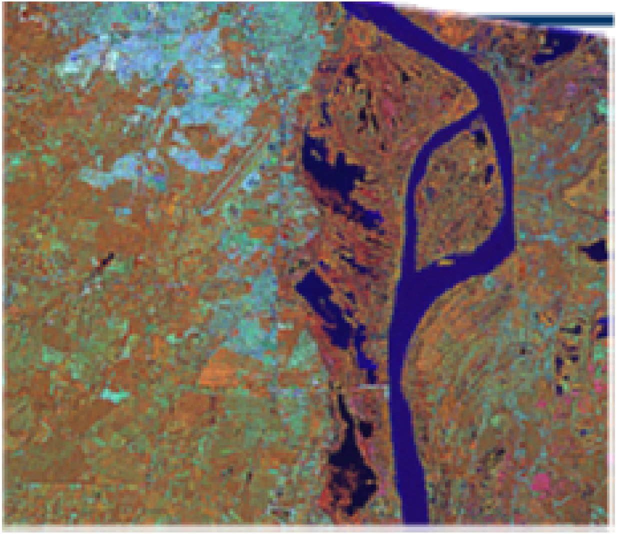
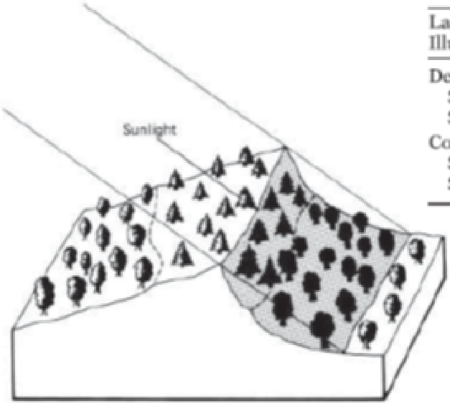


Figure 7.15 Edge enhancement through directional first differencing: (*a*) original image; (*b*) horizontal first difference; (*c*) vertical first difference; (*d*) right diagonal first difference; (*e*) left diagonal first difference; (*f*) Laplacian edge detector. (Author-prepared figure.)



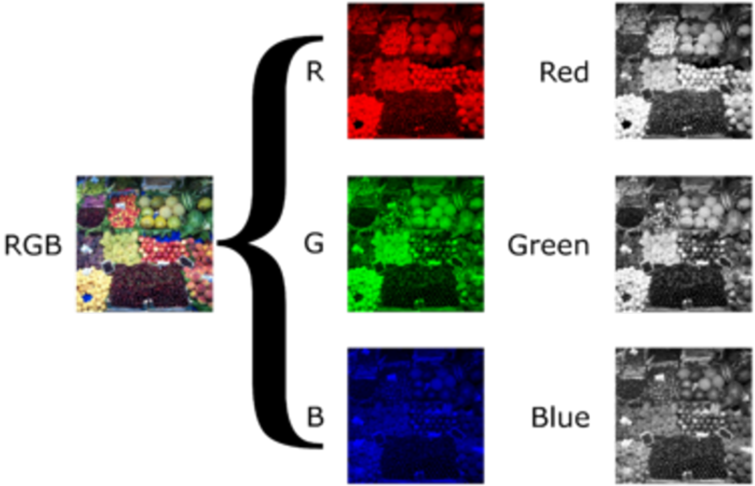
Cociente



Land Cover/ Illumination	Band A	Band B	Ratio (Band A/Band B)
	Digital Number		
Deciduous			
Sunlit	48	50	0.96
Shadow	18	19	0.95
Coniferous			
Sunlit	31	45	0.69
Shadow	11	16	0.69

Figure 7.20 Reduction of scene illumination effects through spectral ratioing. (Adapted from Sabins, 1997.)

Combinación de bandas

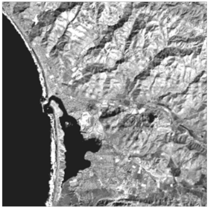


Morro Bay, California.

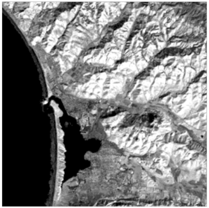
TM band 1

TM band 2

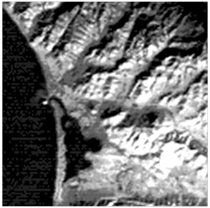
TM band 3



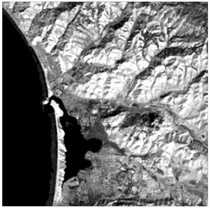
TM band 4



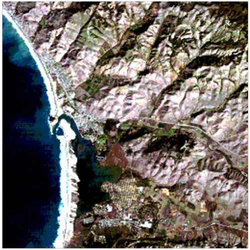
TM band 5



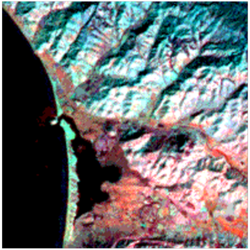
TM band 6



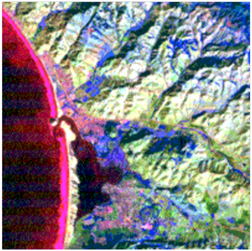
TM band 7



Morro Bay, California.



•TM Band 6 = red
•TM Band 7 = green
•TM Band 5 = blue



•TM Band 7 = green
•TM Band 4 = blue
•TM Band 1 = red

Combinación de bandas y cociente

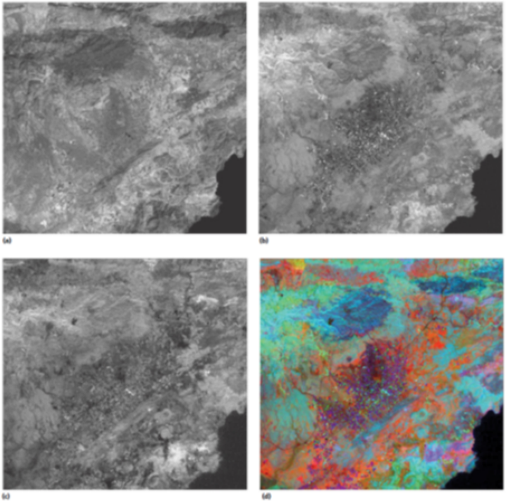
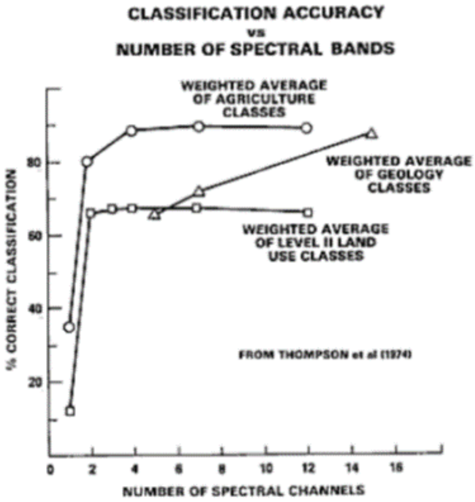


Fig. 3.4 Ratio images and ratio colour composite: (a) the ratio image of TM3/TM1; (b) the ratio image of TM4/TM3; (c) the ratio image of TM5/TM7; and (d) the ratio colour composite of TM5/TM7 in blue, TM4/TM3 in green and TM3/TM1 in red.


CLASSIFICATION ACCURACY
vs
NUMBER OF SPECTRAL BANDS
WEIGHTED AVERAGE OF AGRICULTURE CLASSES
WEIGHTED AVERAGE OF GEOLOGY CLASSES
WEIGHTED AVERAGE OF LEVEL II LAND USE CLASSES
FROM THOMPSON et al (1974)
% CORRECT CLASSIFICATION
20
40
60
80
0
2
4
6
8
10
12
14
16
NUMBER OF SPECTRAL CHANNELS

Transformación de imágenes

Componentes Principales

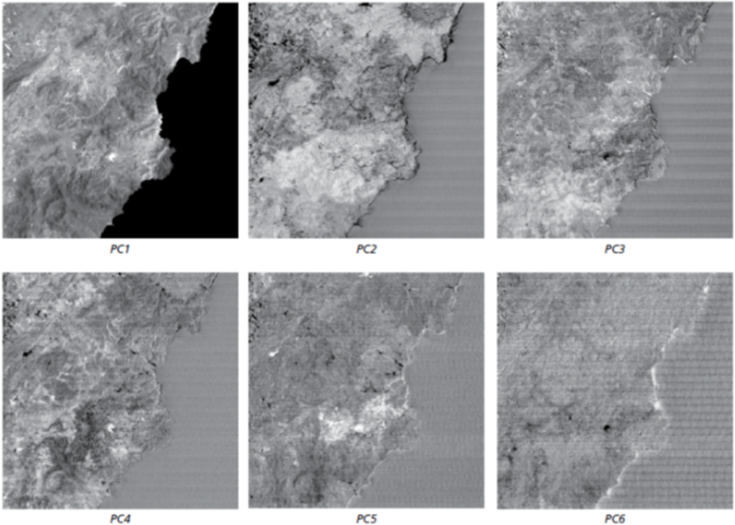


Table 7.2 The covariance matrix of bands 1–5, 7 of a TM sub-scene.

Covariance	TM1	TM2	TM3	TM4	TM5	TM7
TM1	232.202	196.203	305.763	348.550	677.117	345.508
TM2	196.203	178.980	284.415	335.185	660.570	335.997
TM3	305.763	284.415	460.022	545.336	1083.993	551.367
TM4	348.550	335.185	545.336	674.455	1347.927	678.275
TM5	677.117	660.570	1083.993	1347.927	2802.914	1402.409
TM7	345.508	335.997	551.367	678.275	1402.409	711.647

Table 7.3 The eigenvector matrix and eigenvalues of the covariance matrix of bands 1–5, 7 of a TM sub-scene.

Eigenvectors	*PC1*	*PC2*	*PC3*	*PC4*	*PC5*	*PC6*
TM1	0.190	−0.688	−0.515	−0.260	−0.320	−0.233
TM2	0.183	−0.362	0.032	0.050	0.136	0.902
TM3	0.298	−0.418	0.237	0.385	0.638	−0.354
TM4	0.366	−0.136	0.762	−0.330	−0.389	−0.079
TM5	0.751	0.433	−0.296	−0.318	0.242	0.013
TM7	0.378	0.122	−0.093	0.756	−0.511	0.011
Eigenvalues	4928.731	102.312	15.581	9.011	3.573	1.012
Information	97.4%	2.02%	0.31%	0.18%	0.07%	0.02%

Tasselled cap

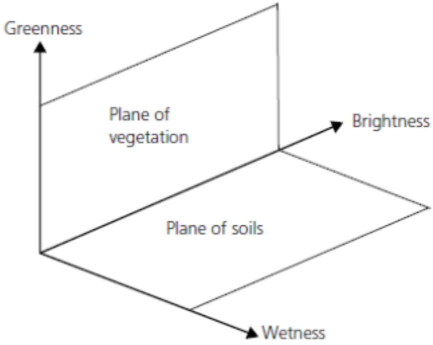
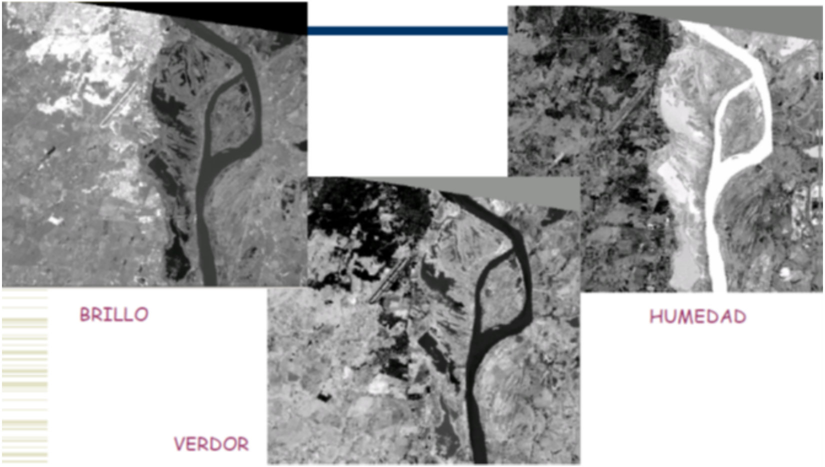


Fig. 7.5 The tasselled cap transformation coordinate system (Mather, 2004. Reproduced with permission of John Wiley & Sons.)

$$\begin{pmatrix} Brightness \\ Greenness \\ Wetness \end{pmatrix} = \begin{pmatrix} 0.3037 & 0.2793 & 0.4343 & 0.5585 & 0.5082 & 0.1863 \\ -0.2848 & -0.2435 & -0.5436 & 0.7243 & 0.0840 & -0.1800 \\ 0.1509 & 0.1793 & 0.3299 & 0.3406 & -0.7112 & -0.4572 \end{pmatrix} \begin{pmatrix} TM1 \\ TM2 \\ TM3 \\ TM4 \\ TM5 \end{pmatrix}$$


BRILLO
VERDOR
HUMEDAD

Transformación RGB - IHS

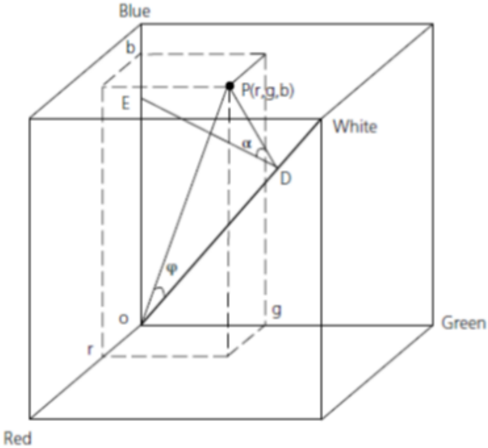
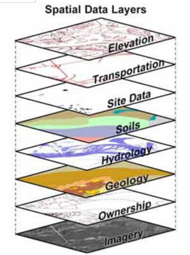
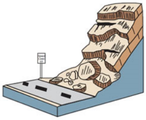


Fig. 5.1 The colour cube model for RGB-IHS transformation.

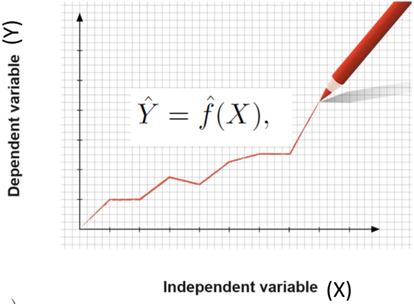


$$Y = f(X)$$

$\propto$



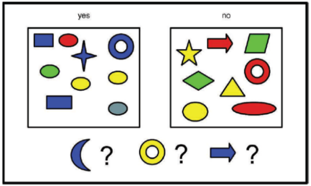
$$DependentVariable = f(IndependentVariables)$$



Realidad → **Datos**

$$Y = f(X)$$

$$\hat{Y} = \hat{f}(X),$$



(a)

D features (attributes)

N cases

Color	Shape	Size (cm)	Label
Blue	Square	10	1
Red	Ellipse	2.4	1
Red	Ellipse	20.7	0

(b)

To estimate unknown dependency between the input and output variables, from a set of past observations

$$OutputVariable = f(InputVariables)$$

Realidad → **Modelo basado en datos**

$$Y = f(X)$$

Efecto

Causas

Mecanismo

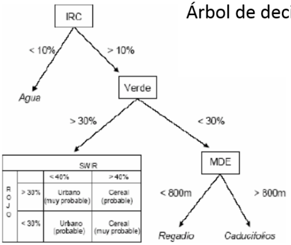
$$\hat{Y} = \hat{f}(X),$$

Label

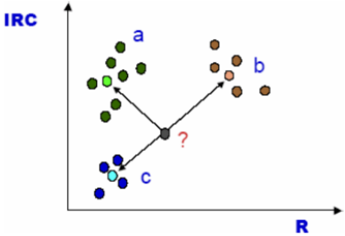
Features

Función objetivo

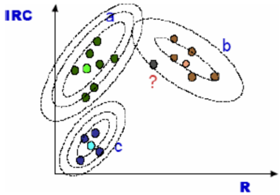
Árbol de decisión



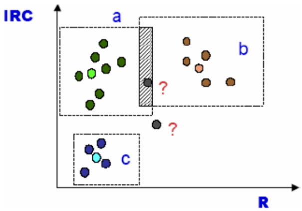
Mínima distancia

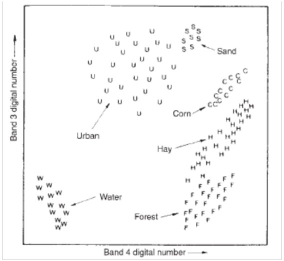


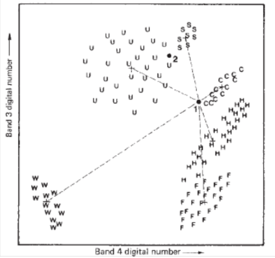
Máxima probabilidad

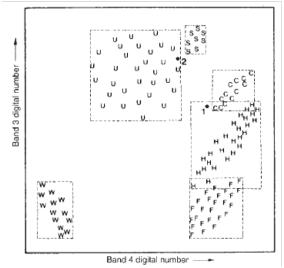


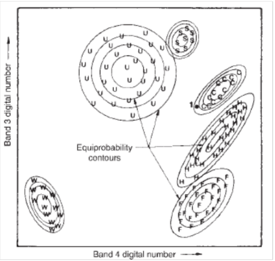
Paralelepípedos

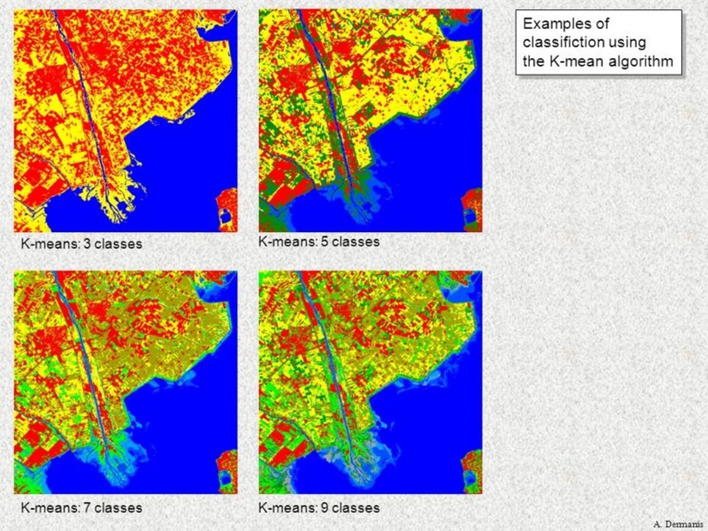


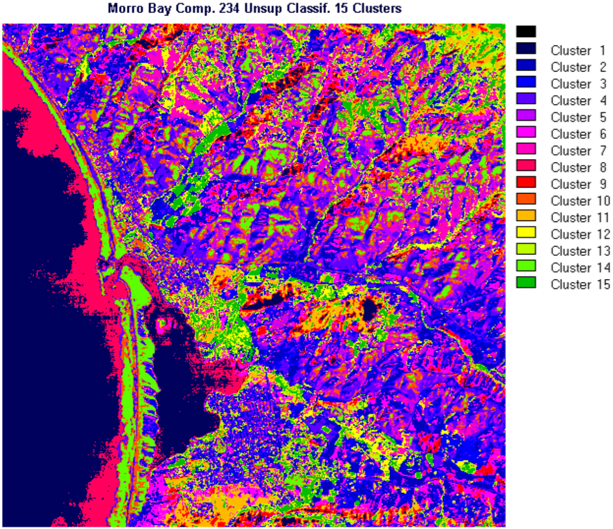

Band 3 digital number
Sand
Corn
Urban
Hay
Water
Forest
Band 4 digital number


Band 3 digital number
Band 4 digital number


Band 3 digital number
Band 4 digital number


Band 3 digital number
Equiprobability
contours
Band 4 digital number


K-means: 3 classes
K-means: 5 classes
K-means: 7 classes
K-means: 9 classes
Examples of classifiction using the K-mean algorithm
A. Dermanis


Morro Bay Comp. 234 Unsup Classif. 15 Clusters
Cluster 1
Cluster 2
Cluster 3
Cluster 4
Cluster 5
Cluster 6
Cluster 7
Cluster 8
Cluster 9
Cluster 10
Cluster 11
Cluster 12
Cluster 13
Cluster 14
Cluster 15

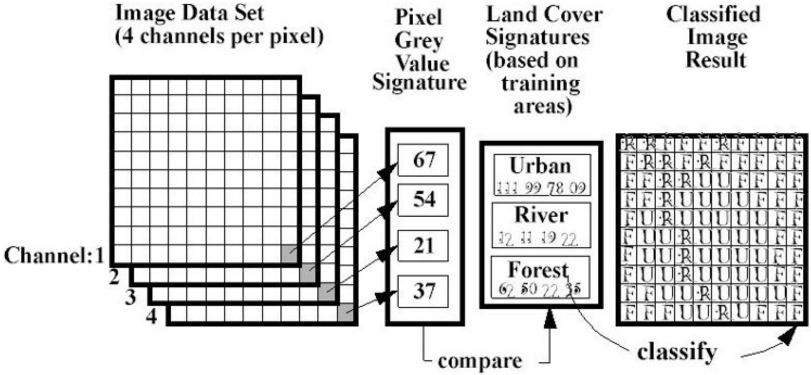
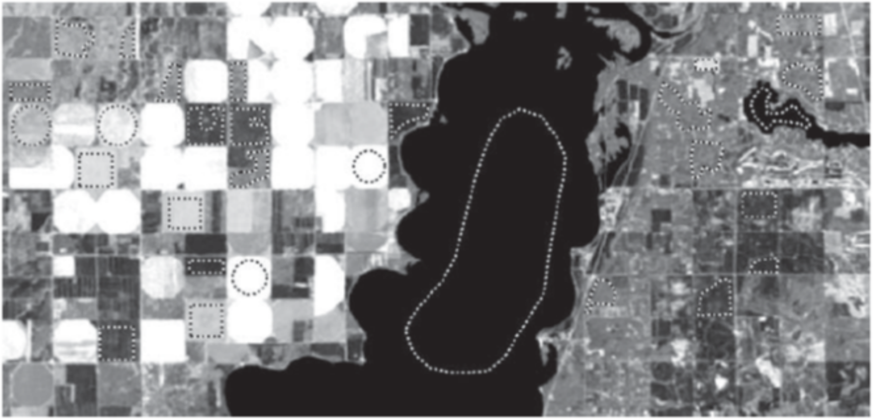
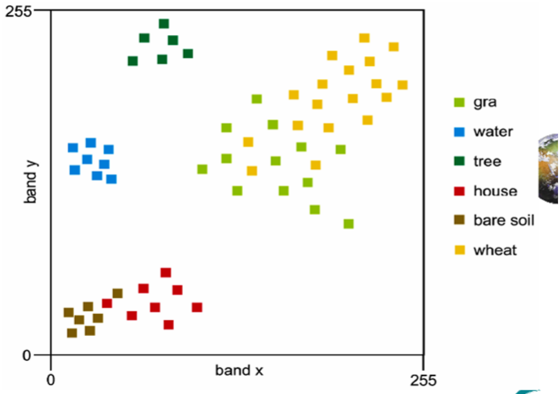


Image Data Set
(4 channels per pixel)
Channel: 1
2
3
4
Pixel Grey Value Signature
67
54
21
37
Land Cover Signatures (based on training areas)
Urban
111 99 78 09
River
12 11 19 22
Forest
62 50 22 35
Classified Image Result
compare
classify



Feature Space



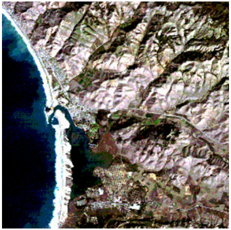
UNEP-ITC RS/GIS for Monitoring and Assessment of Iraqi Marshland, 6-10 Feb 2005

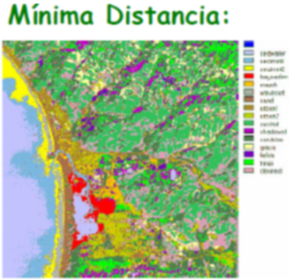
TABLE 7.1 **Portion of a Divergence Matrix Used to Evaluate Pairwise Training Class Spectral Separability**

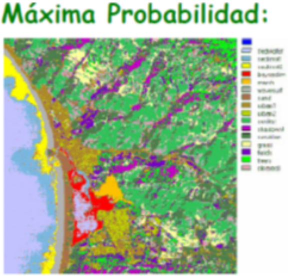
Spectral Class[a]	W1	W2	W3	C1	C2	C3	C4	H1	H2...
W1	0								
W2	1185	0							
W3	1410	680	0						
C1	1997	2000	1910	0					
C2	1953	1890	1874	860	0				
C3	1980	1953	1930	1340	1353	0			
C4	1992	1997	2000	1700	1810	1749	0		
H1	2000	1839	1911	1410	1123	860	1712	0	
H2	1995	1967	1935	1563	1602	1197	1621	721	0
⋮	⋮								

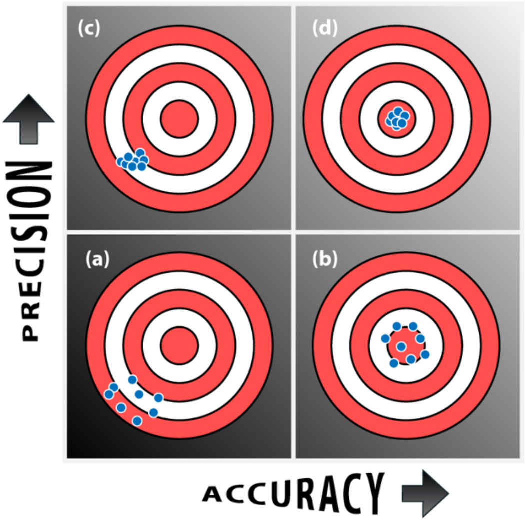
[a] W. water; C. corn; H. hay.

DTM

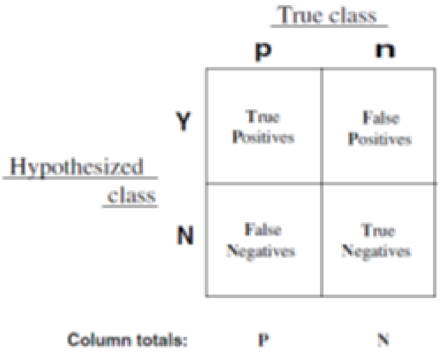







(c)
(d)
(a)
(b)
PRECISION
ACCURACY

Matriz de Confusión



Matriz de Contingencia

Accuracy + Error = 100%

TABLE 7.3 Error Matrix Resulting from Classifying Test Pixels

Error de Acción (inclusión) → FP
Error tipo II

Error de Omisión (exclusión) → FN
Error tipo I

	Reference Data[a]						
	W	S	F	U	C	H	Row Total
Classification data							
W	226	0	0	12	0	1	239
S	0	216	0	92	1	0	309
F	3	0	360	228	3	5	599
U	2	108	2	397	8	4	521
C	1	4	48	132	190	78	453
H	1	0	19	84	36	219	359
Column total	233	328	429	945	238	307	2480

De todas las que son cuantas acerté?

Producer's Accuracy

W = 226/233 = 97%
S = 216/328 = 66%
F = 360/429 = 84%
U = 397/945 = 42%
C = 190/238 = 80%
H = 219/307 = 71%

De todas las predije cuantas acerté?

User's Accuracy

W = 226/239 = 94%
S = 216/309 = 70%
F = 360/599 = 60%
U = 397/521 = 76%
C = 190/453 = 42%
H = 219/359 = 61%

Aunque el 97% de las clases de referencia W fueron correctamente identificadas como "W", solamente el 94% de las áreas identificadas como W en la clasificación fueron efectivamente W

Overall accuracy = (226 + 216 + 360 + 397 + 190 + 219)/2480 = 65%

[a] W, water; S, sand; F, forest; U, urban; C, corn; H, hay.

Coeficiente de Cohen Kappa

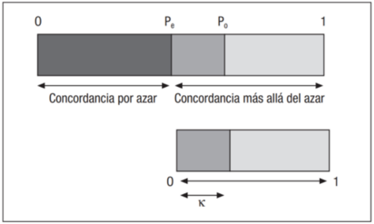


Tabla 3. Valoración del coeficiente kappa (Landis y Koch, 1977)[4]

Coeficiente kappa	Fuerza de la concordancia
0,00	Pobre *(Poor)*
0,01 - 0,20	Leve *(Slight)*
0,21 - 0,40	Aceptable *(Fair)*
0,41 - 0,60	Moderada *(Moderate)*
0,61 - 0,80	Considerable *(Substantial)*
0,81 - 1,00	Casi perfecta *(Almost perfect)*

Matriz de Contingencia

Tabla 1.

	Radiólogo A		
Radiólogo B	**Neumonía**	**No neumonía**	**Total**
Neumonía	4 a	6 b	r = a + b 10
No	c 10	d 80	s = c+ d 90
Total	14 t = a + c	u = b + d 86	N = a + b + c + d 100

	Reference Data[a]						
	W	S	F	U	C	H	Row Total
Classification data							
W	226	0	0	12	0	1	239
S	0	216	0	92	1	0	309
F	3	0	360	228	3	5	599
U	2	108	2	397	8	4	521
C	1	4	48	132	190	78	453
H	1	0	19	84	36	219	359
Column total	233	328	429	945	238	307	2480

Producer's Accuracy

W = 226/233 = 97%
S = 216/328 = 66%
F = 360/429 = 84%
U = 397/945 = 42%
C = 190/238 = 80%
H = 219/307 = 71%

User's Accuracy

W = 226/239 = 94%
S = 216/309 = 70%
F = 360/599 = 60%
U = 397/521 = 76%
C = 190/453 = 42%
H = 219/359 = 61%

Overall accuracy = (226 + 216 + 360 + 397 + 190 + 219)/2480 = 65%

[a] W, water; S, sand; F, forest; U, urban; C, corn; H, hay.

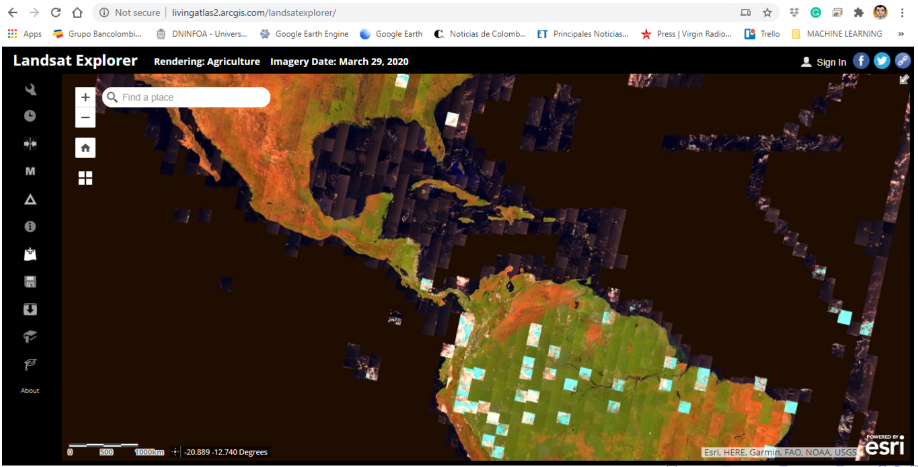
$$\sum_{i=1}^{r} x_{ii} = 226+216+360+397+190+219 = 1608$$

$$\sum_{i=1}^{r} (x_{i+} \cdot x_{+i}) = (239 \cdot 233) + (309 \cdot 328) + (599 \cdot 429) + (521 \cdot 945) + (453 \cdot 238) + (359 \cdot 307) = 1{,}124{,}382$$

$$\hat{k} = \frac{2480(1608) - 1{,}124{,}382}{(2480)^2 - 1{,}124{,}382} = 0.57$$

Software online

https://livingatlas2.arcgis.com/landsatexplorer/



Software online

https://www.arcgis.com/home/webmap/viewer.html