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AN INTRODUCTION TO GEOGRAPHIC INFORMATION SYSTEMS (GIS)

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- Types of queries a GIS can answer
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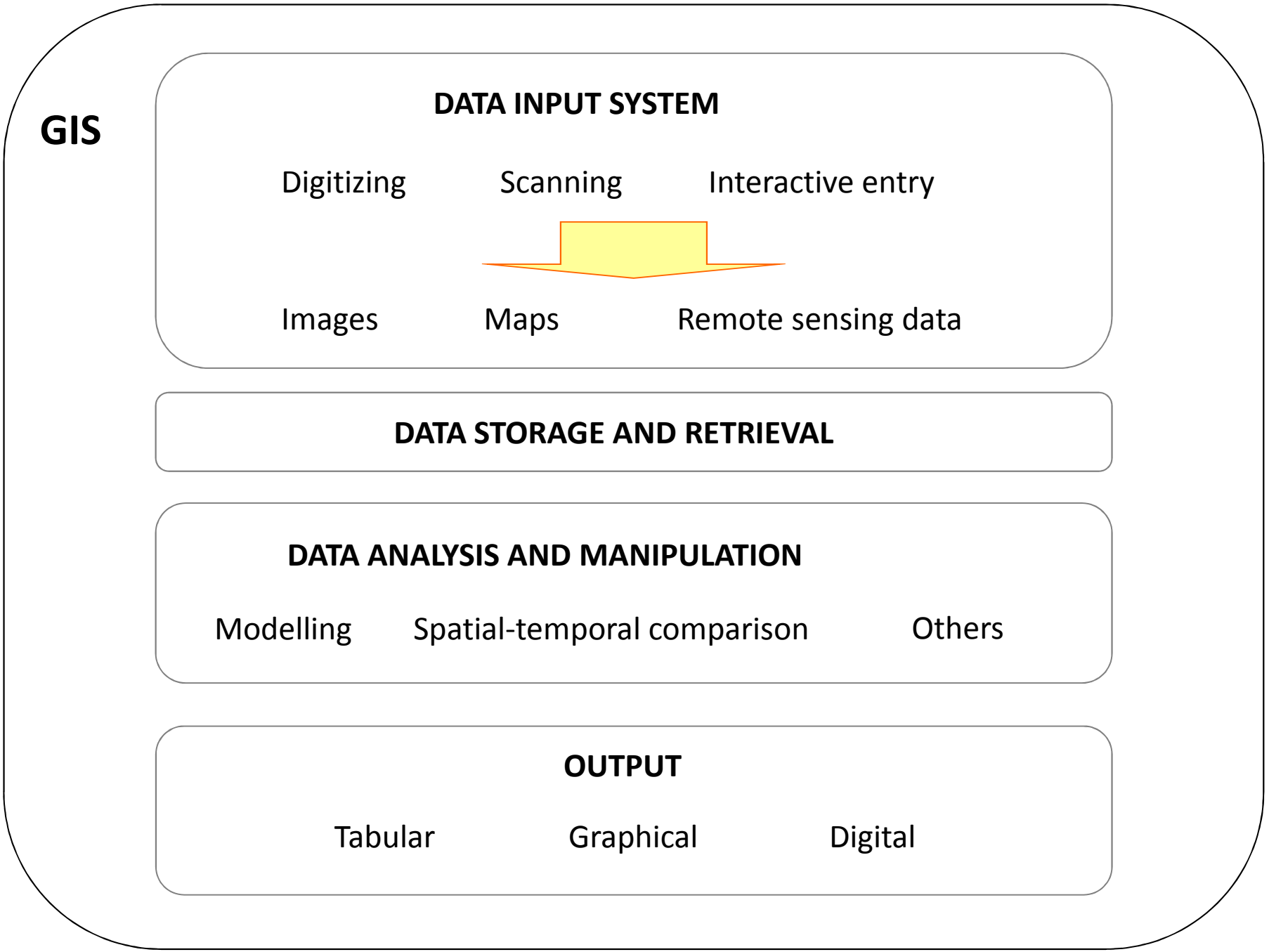
- Examples of software
- DIVA-GIS
- ArcGIS

What are GIS?

"GIS are integrated systems of computer hardware and software for the analysis and display of spatially distributed data"

Johnston (1998)


GIS
DATA INPUT SYSTEM
Digitizing
Scanning
Interactive entry
Images
Maps
Remote sensing data
DATA STORAGE AND RETRIEVAL
DATA ANALYSIS AND MANIPULATION
Modelling
Spatial-temporal comparison
Others
OUTPUT
Tabular
Graphical
Digital

Types of queries a GIS can answer

Location:

WHAT exists here - what is at a particular location?

"What type of land use is at 41.95N, -8.25W?"

Condition:

WHERE are specific conditions

"Where does it rain 3000 mm per year ?"

Trends:

WHAT HAS CHANGED (over time)

"How far has the population of a certain species receded in the past 20 years?"

Types of queries a GIS can answer

Patterns:

HOW are patterns related

"How does soil type influence the distribution of a particular species?"

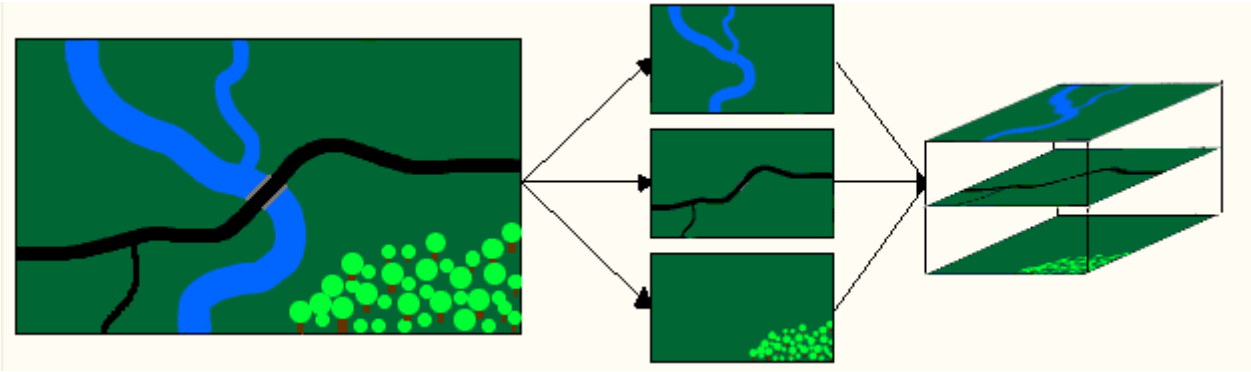
Modeling:

WHAT IF ..?

"What would happen to a certain habitat if the climate warmed by 2 degrees?"

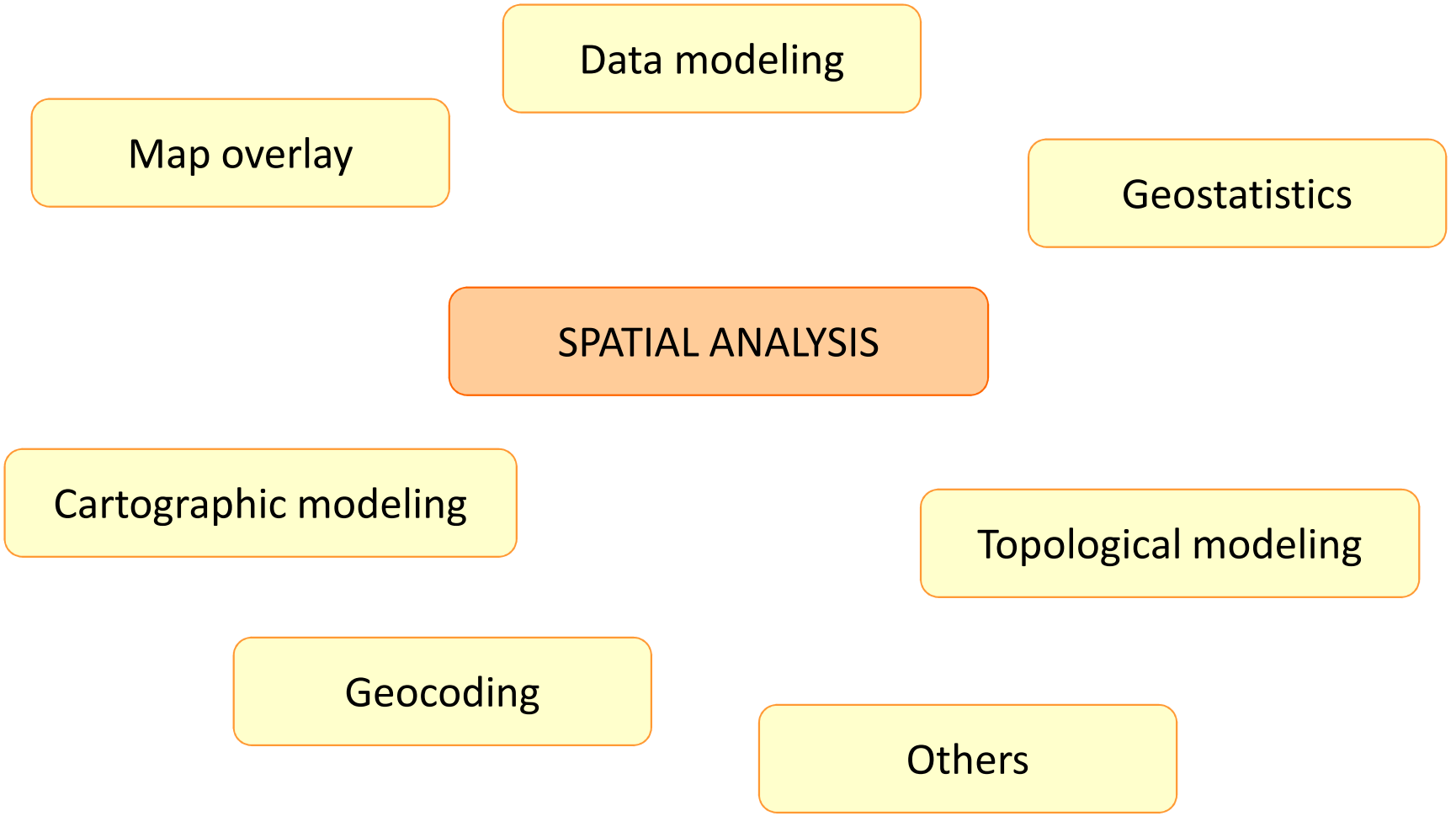
How does it work?

- Data are stored in layers of information
- Each layer = different types of information (soil type, rainfall, etc…)
- Layers combine to produce a map (when the spatial reference system is common)



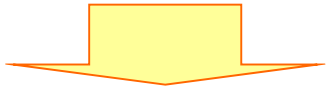
SPATIAL ANALYSIS

Spatial analysis



Spatial modeling...

All phenomena in our environment cannot be observed at one time



Create a simplified representation of reality - model

A model is a way of describing something that cannot be directly observed

Spatial features and attributes

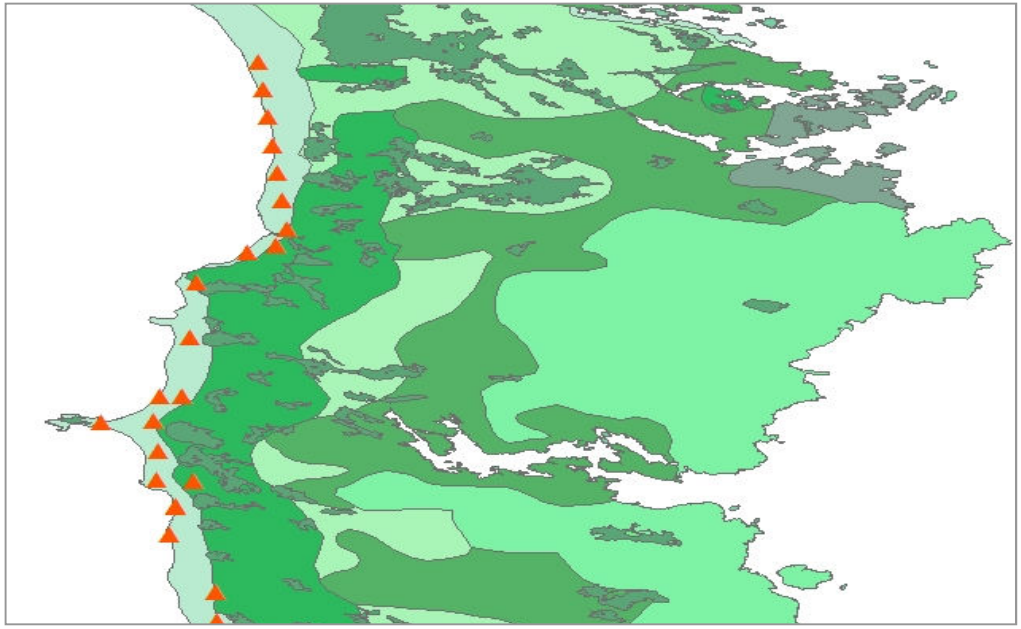
Two basic types of data are associated with GIS:

Spatial data: "where is it?“

Attribute data: "what is it ?"

Spatial features

- Stored as x and y coordinates (= 2 columns of data)
- Give information on the location and shape of features and between geographical features e.g. proximity



Attribute data

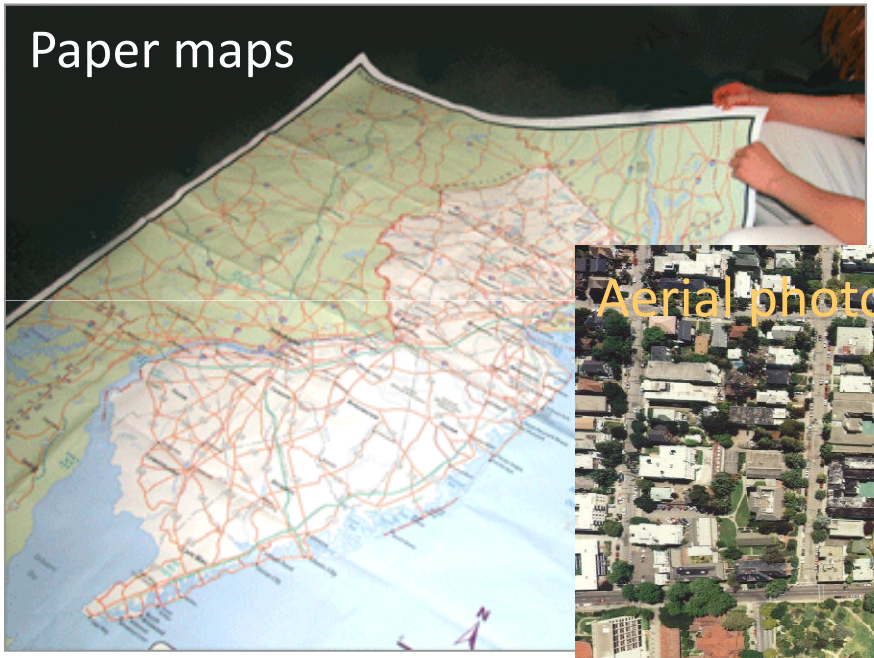
- Descriptors of spatial data (nature and qualities of features)
- Stored in tabular format (tables) and linked to the spatial data by a common identifier
- Numbers or text (e.g. 2, 3; marsh; high/low)

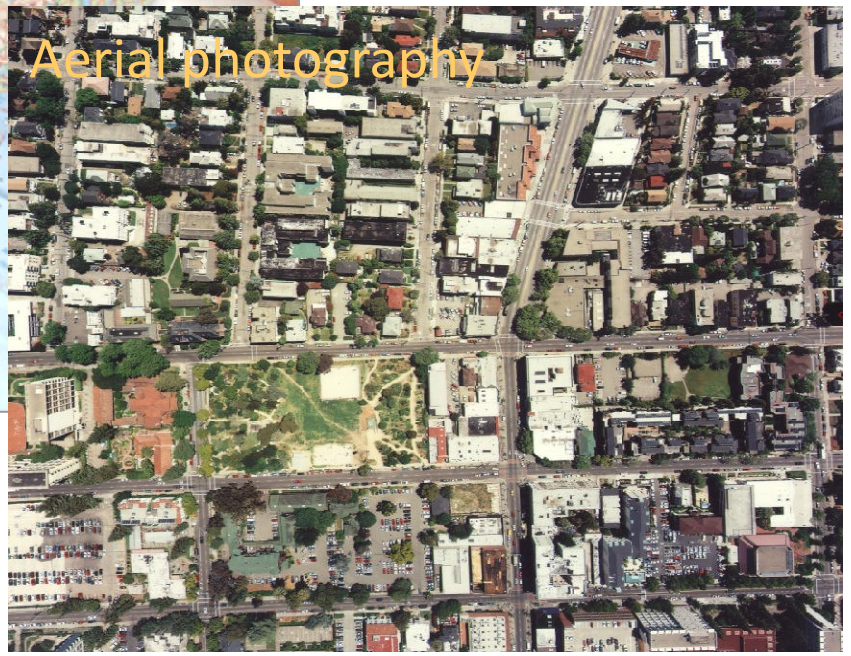
Attributes of land_form_Outer_Hebrides_islands

FID	Shape*	AREA	PERIMETER	LCA_SCOT_	LCA_SCOT_I	CODE	SHT_CODE	LANDSCAPE	LEVEL_1	LEVEL_2
0	Polygon	8819.747070	494.212622	1185	1184	ISLD	WIS	Coastal Island	Coastal Island	Coastal Island
1	Polygon	22890203.1437	42358.229173	1187	1186	WIS1	WIS	Crofting One	Crofting One	Island Linear Crofting
2	Polygon	5248.997070	314.700381	1203	1202	WIS1	WIS	Crofting One	Crofting One	Island Linear Crofting
3	Polygon	2295.115234	200.482909	1205	1204	ISLD	WIS	Coastal Island	Coastal Island	Coastal Island
4	Polygon	828131.582395	4059.597562	1237	1236	WIS6	WIS	Machair	Machair	Island Sand and Machair Coastal Landscapes
5	Polygon	18396.586914	749.106751	1285	1284	ISLD	WIS	Coastal Island	Coastal Island	Coastal Island
6	Polygon	632767399.631	602543.749142	1313	1312	WIS7	WIS	Boggy Moorland	Boggy Moorland	Island Peatlands
7	Polygon	3648608.95531	8150.393237	1363	1362	WIS1	WIS	Crofting One	Crofting One	Island Linear Crofting
8	Polygon	3679122.54738	9646.521312	1406	1405	WIS1	WIS	Crofting One	Crofting One	Island Linear Crofting
9	Polygon	79992	1095.583297	1425	1424	LOCH	WIS	Inland Loch	Inland Loch	Inland Loch
10	Polygon	59192	970.775339	1445	1444	LOCH	WIS	Inland Loch	Inland Loch	Inland Loch
11	Polygon	100039.5	2288.164079	1458	1457	LOCH	WIS	Inland Loch	Inland Loch	Inland Loch

Record: 1 Show: All Selected Records (0 out of 2595 Selected.) Options

Data representation formats

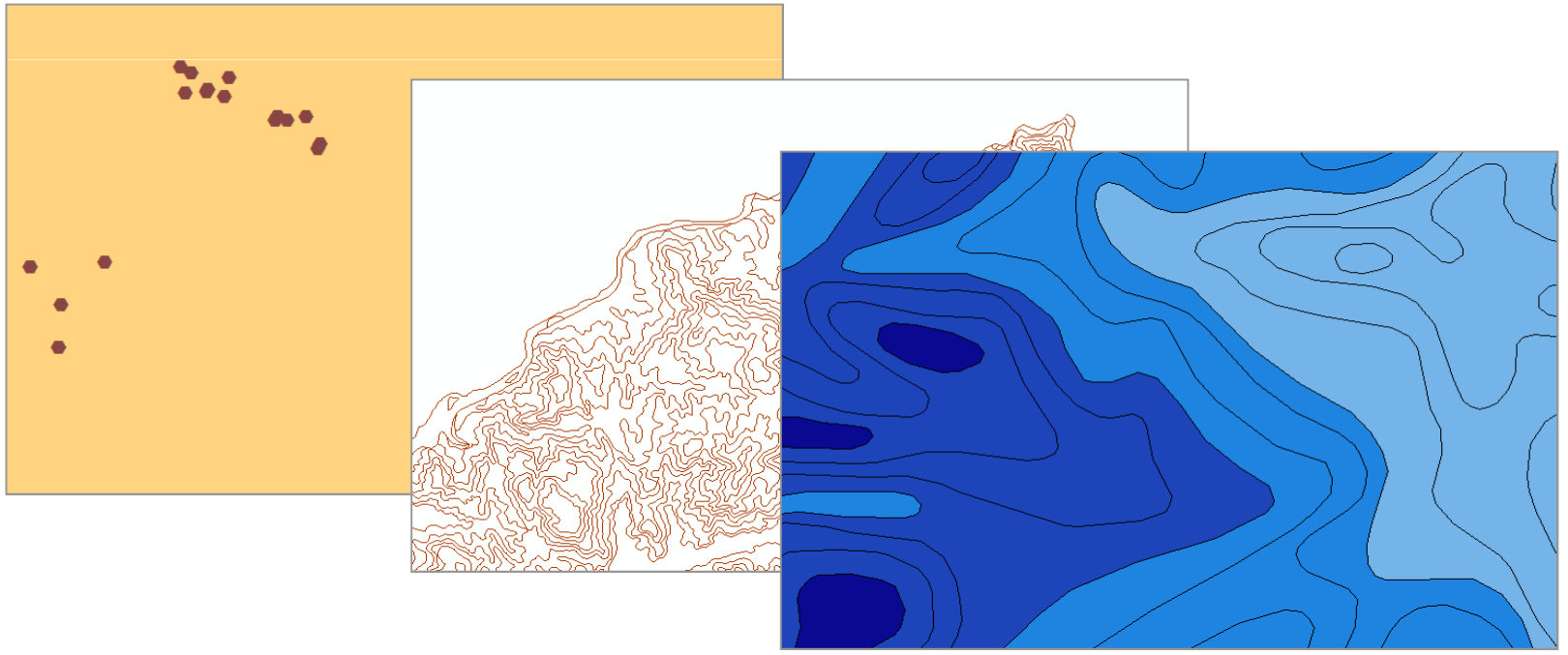




VECTOR FORMAT

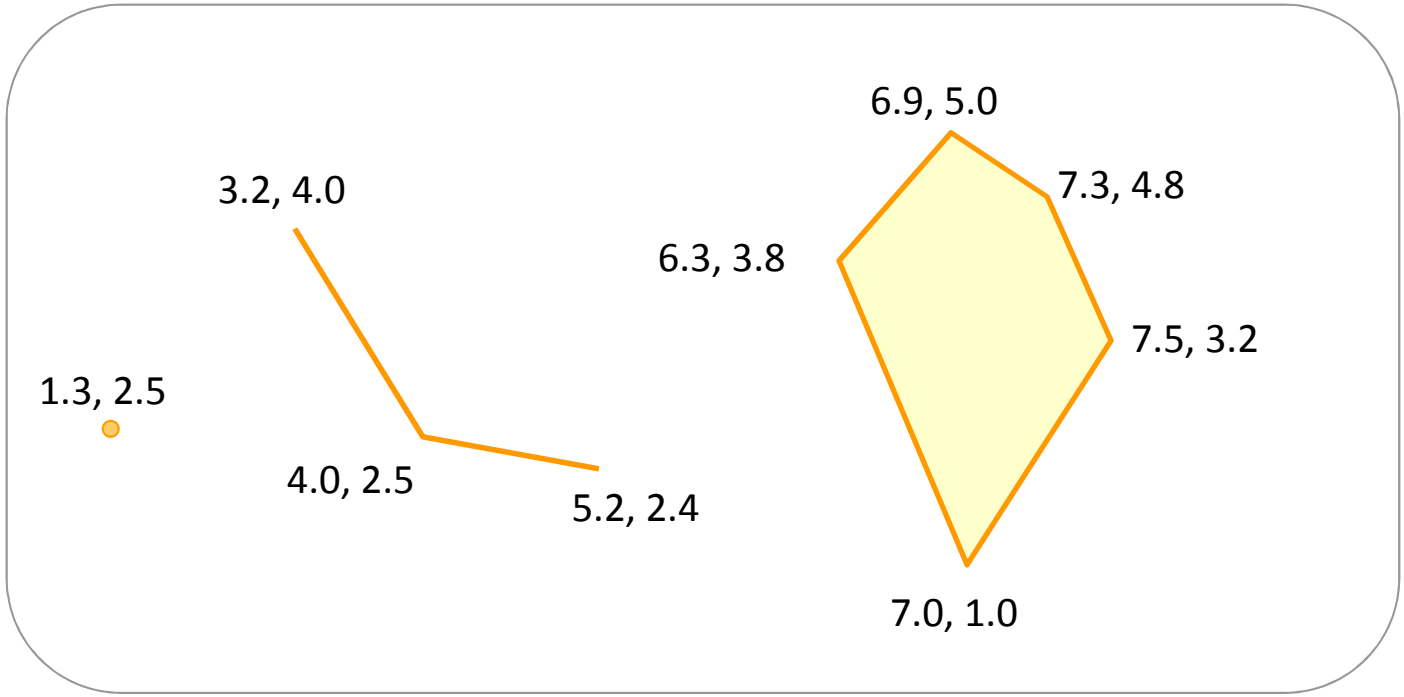
Data representation formats

VECTOR FILES: have x and y coordinates, portray features as points, lines and polygons

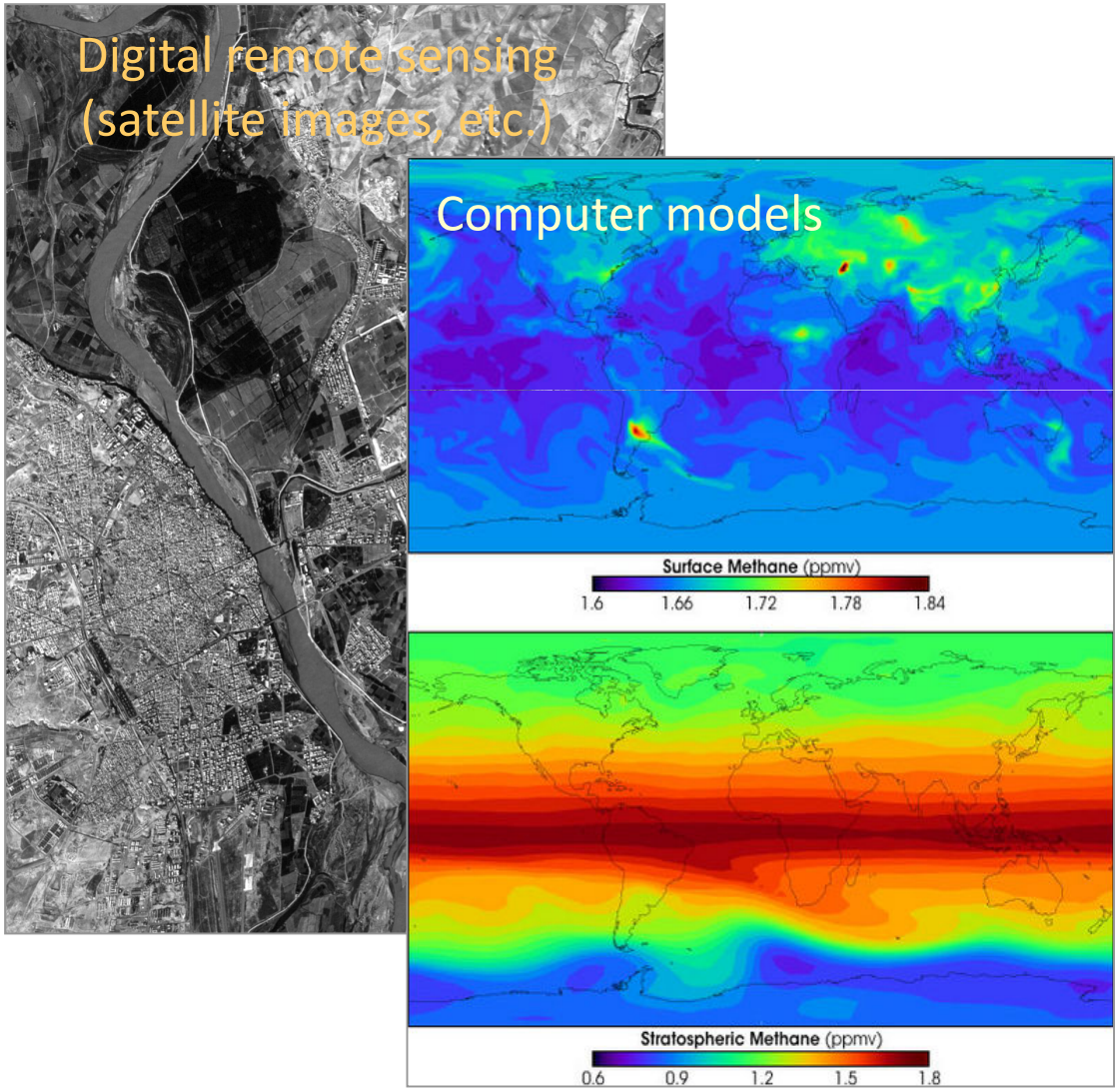


Data representation formats

VECTOR FILES



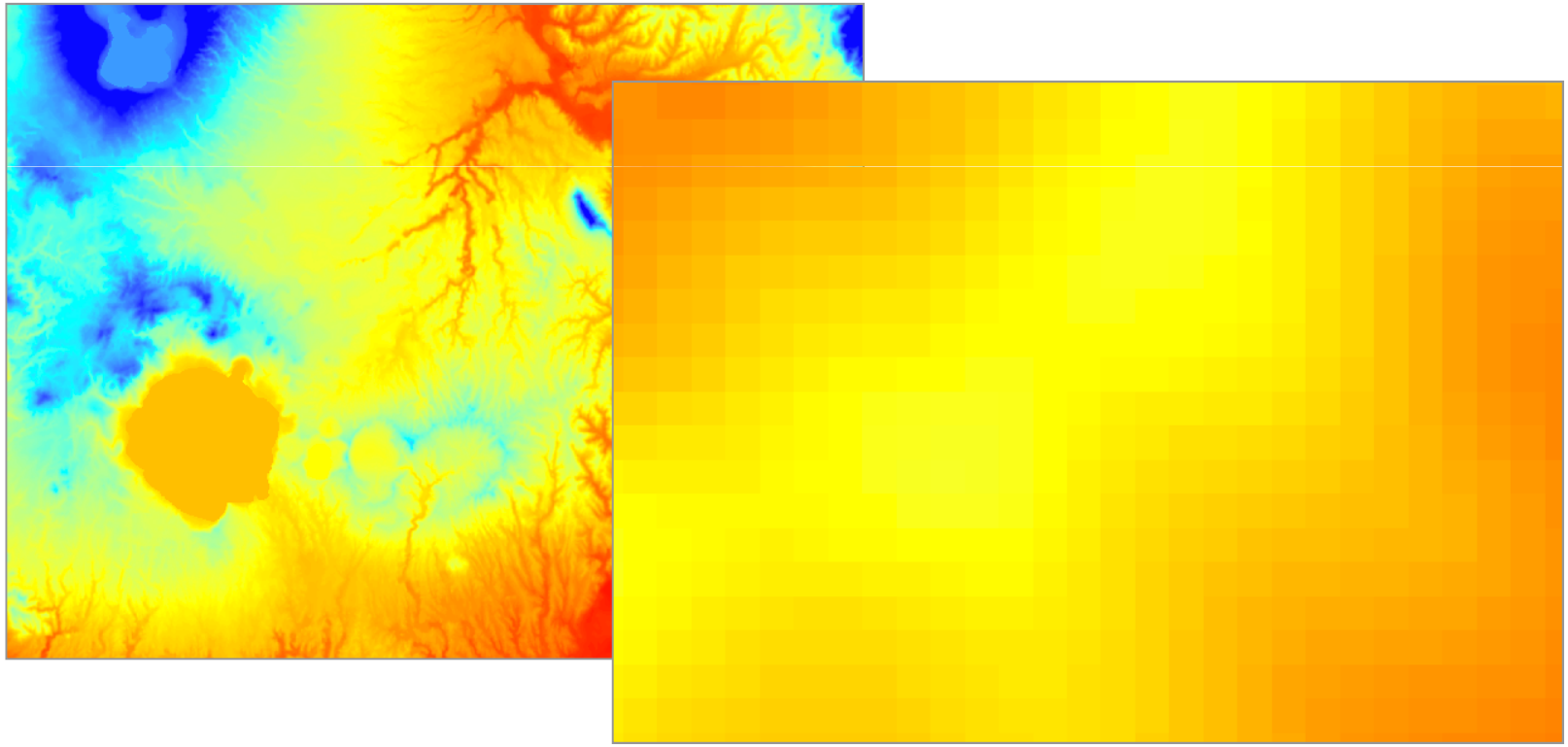
Data representation formats



RASTER FORMAT

Data representation formats

RASTER FILES: portray features as a matrix of grid cells, one value per grid square



Vector *versus* Raster

VECTOR

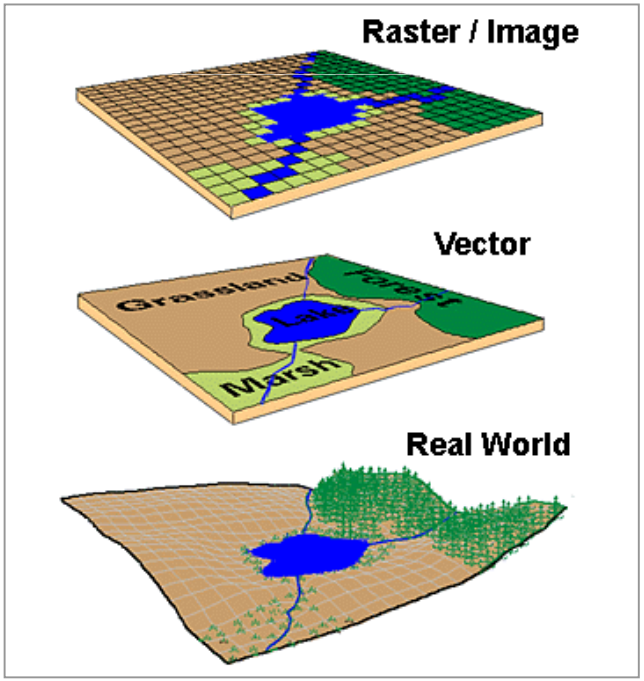
Advantages

- Compact data structure for homogenous areas
- Efficient encoding of topology
- Better suited for map output

Disadvantages

- More complex data structure
- Cannot store image data (continuously varying)

Example: shapefiles (consists of at least three files: .shp, .shx, .dbf), CAD files



RASTER

Advantages

- Simple data structure
- Overlay operations are straight forward
- High spatial variability is efficiently represented
- Only raster can easily store image data (e.g. photos)

Disadvantages

- Data structure is not compact
- Map output can appear 'blocky'

Example: .jpg, .tif (image), .geotiff (georeferenced)

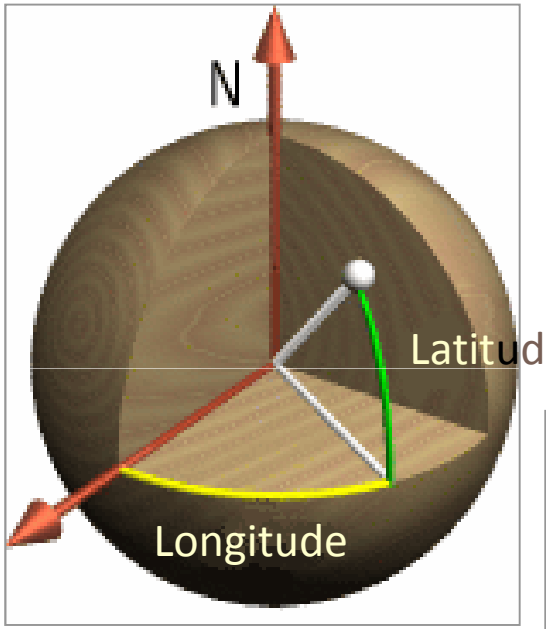
Coordinate systems

A reference system that uses a 3-dimensional spherical surface to determine locations on the Earth

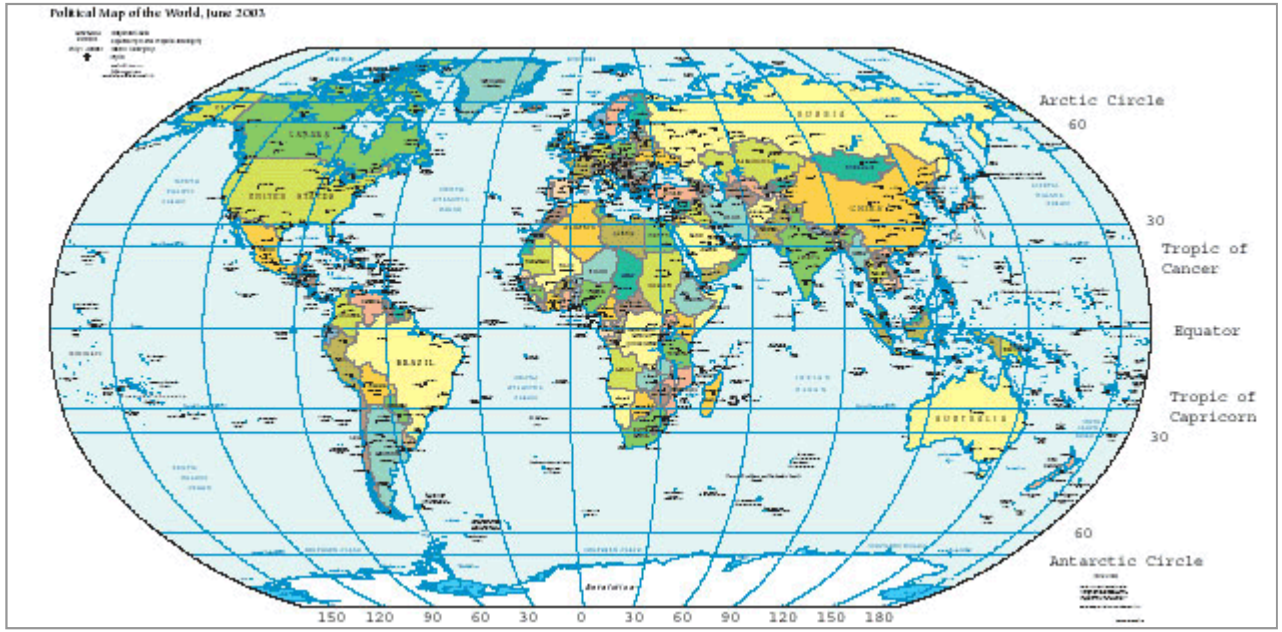
Geographic: uses latitude and longitude coordinates (only along the equator the distance represented by one degree of longitude approximate the distance represented by one degree of latitude)

Projected: uses a mathematical conversion to transform 3D latitude and longitude coordinates to a 2D surface

Geographic coordinate systems



Longitude (vertical lines)



Latitude (horizontal lines)

Map projections

A projection is a mathematical means of representing the 3-dimensional curved surface of the Earth to a 2-dimensional medium.

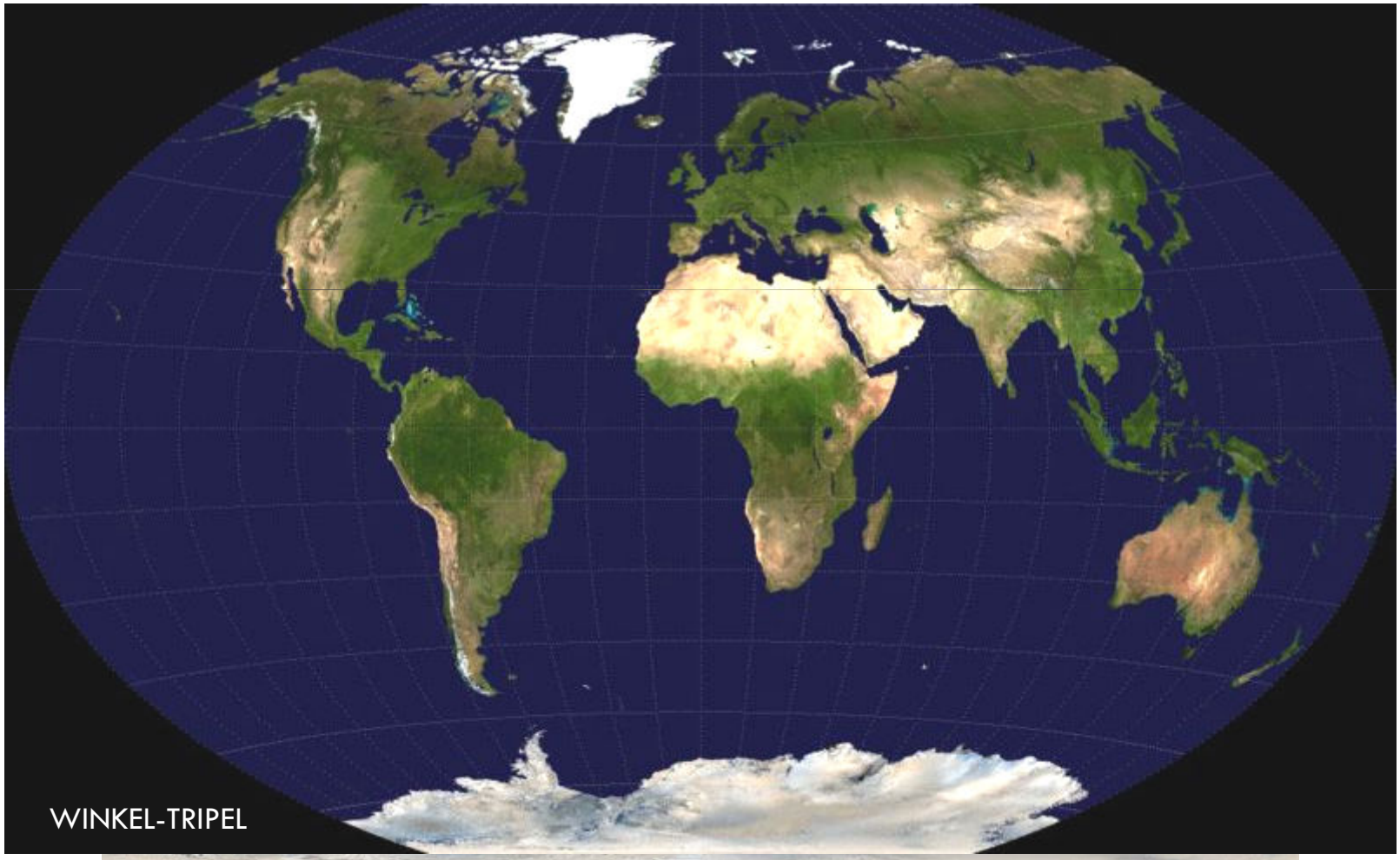
- Multiple types of projections which serve different purposes
- Designed to preserve different properties of the curved surface
- Any projection creates some degree of distortion (areas, distances, directions, combination of these)

Map projections

The type of projection depends on:

1. Whether the surface projected onto is conical, cylindrical, or planar
2. The orientation of the cone, cylinder, or plane relative to the globe
3. Whether the lines of contact are tangent or secant
4. Which particular underlying ellipsoidal model of the Earth's shape (called the *datum*) is used.

Map projections



What can be used for?

- Scientific research
- Resources management
- Sustainable development
- Conservation planning
- Environmental impact assessment
- Urban planning
- Cartography
- Route planning
- Public health
- Crime mapping
- National defence
- Transportation
- etc.

The use of GIS in conservation

- Measure habitat distribution
- Map and predict species distribution
- Speculate about why some certain species occur in a particular habitat and not elsewhere
- Study ecological processes (e.g determination of how micro-topography affects the flowering success of different species)
- Evaluate the impact of human constructions on rare plant populations

The use of GIS in conservation

- Ecogeographic survey (e.g. map species distribution, GAP analysis)
- Field exploration (e.g. development of field aids, information on the best time to undertake field work)
- Design, management and monitoring *in situ* genetic reserves (e.g. analysing species richness, frequency, distribution and abundance of endangered species)

The use of GIS in conservation

- Germplasm regeneration and evaluation (e.g. climate data and distribution maps for pests, diseases, pollinators, and taxa can be overlaid in order to identify potential sites for regeneration; to determine the suitability of different sites for the evaluation of specific traits)
- Use of genetic resources (e.g. help to improve the quality of the location data associated with collections; help to identify interesting germplasm and reveal the genetic structure of the material being held in Genebanks).

Before starting a project in GIS...

- Keep it simple: start with simple data and software
- Read documentation: good manuals and online help available
- Use existing data
- Plan ahead: a GIS requires multiple steps which should be formulated in advance
- Keep good records
- Check results: determine of the results obtained from a GIS procedure are logical before continuing
- Consult with experts.

Software – some examples

GENERAL

- ArcGIS
- ARC/INFO
- CARIS
- GENASYS
- IDRISI
- GEOMEDIA
- MAPINFO

GENETIC RESOURCES

- DIVA-GIS
- Flora Map

OTHERS:

- Biomapper

DIVA-GIS

- Designed to be used for spatial analysis of data associated with genetic resources collection and it can be used in developing strategies for future collecting and *in situ* activities
- Free from **http://www.diva-gis.org/**

DIVA-GIS

Spatial analysis:

- assign coordinates
- check for errors
- analyse point distribution and produce maps
- display the number of observations, the number of distinct classes of observations for an array of grid cells
- calculate statistics parameters for numerical variables

DIVA-GIS

Spatial analysis (cont.):

- calculate several diversity indices (Margalef, Mehhinick, Shannon, Simpson, Brillouin)
- predict potential species distribution given the climate of the locations where it was observed (BIOCLIM, DOMAIN)
- identify sets of grid cells that are complementary to each other (that captures a maximum amount of diversity in few cells as possible).

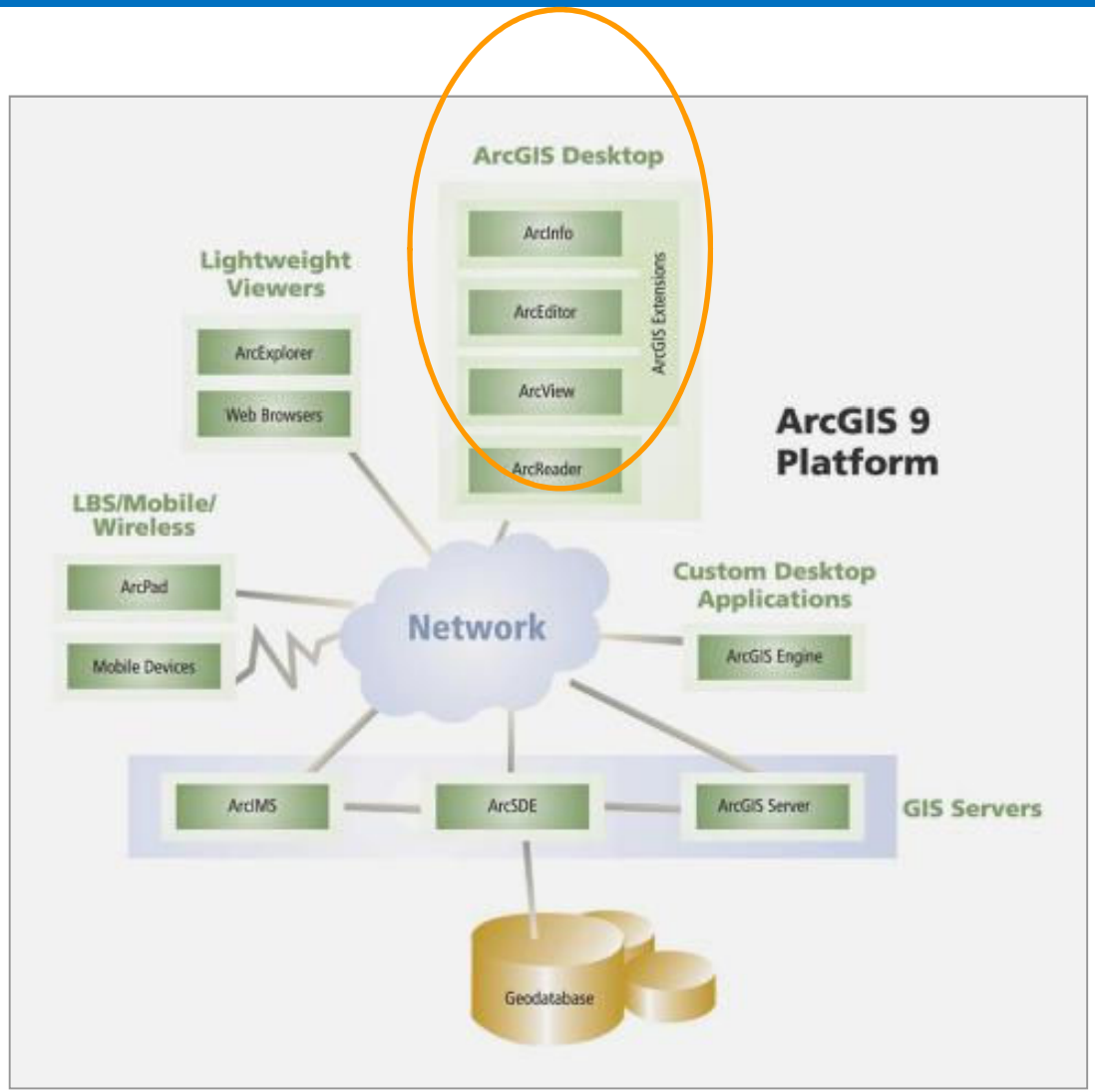
ArcGIS definition

"ArcGIS is a scalable system of software for geographic data for every organization from an individual to a globally distributed network of people"

Environmental Systems Research Institute (ESRI)

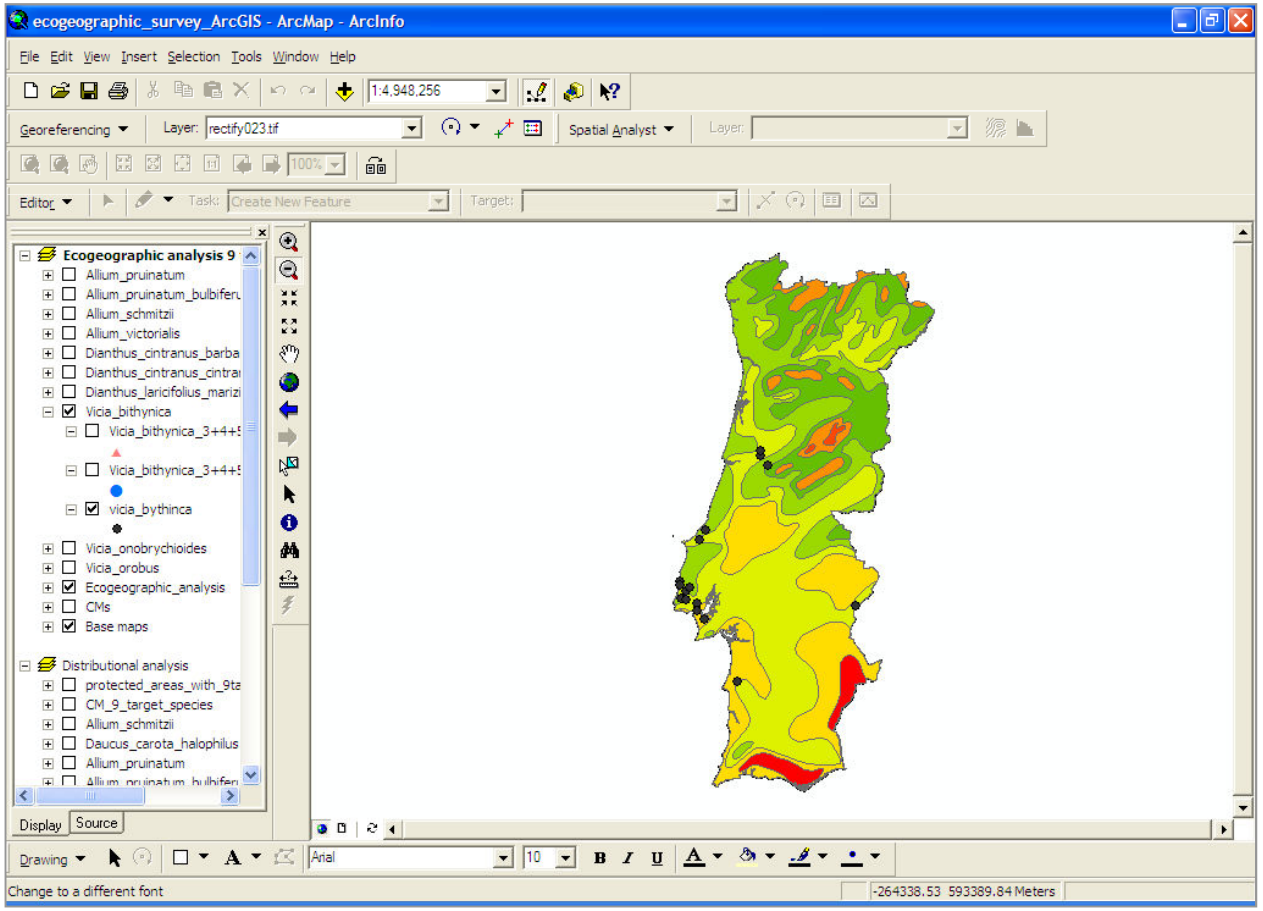
ArcGIS

- ArcCatalog
- ArcMap
- ArcToolbox



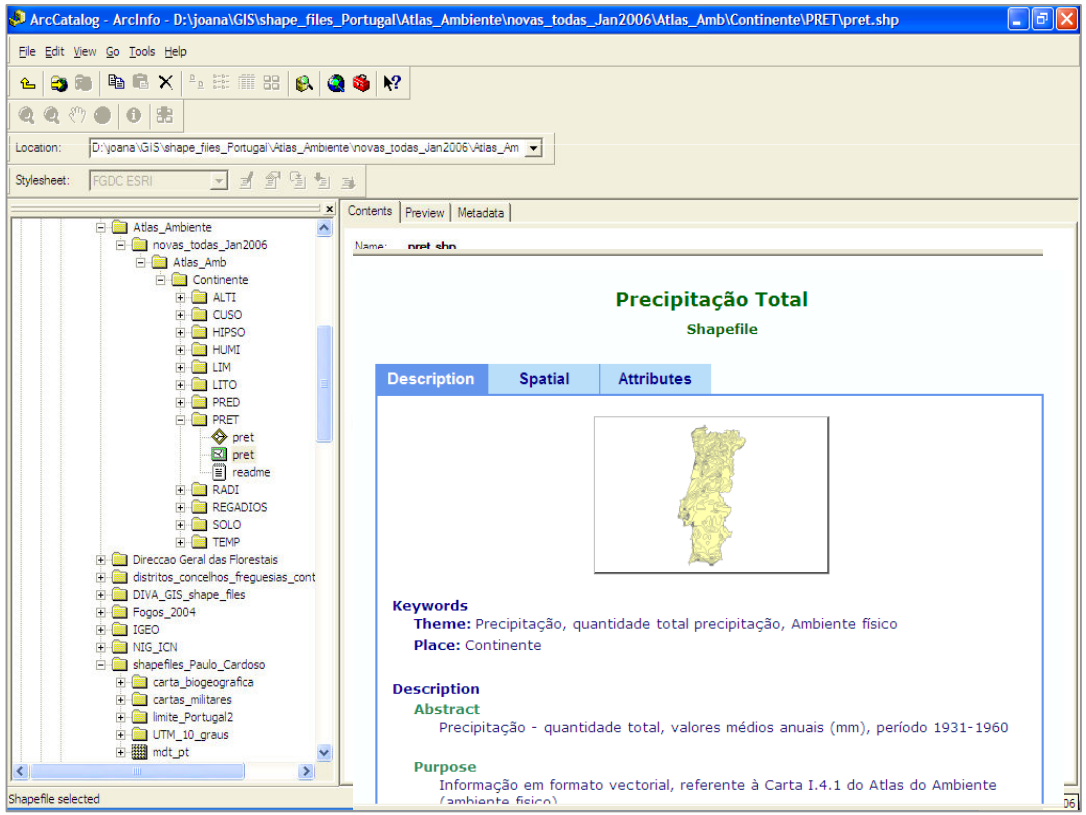
ArcMap

- Creates, displays, queries and edits maps
- Performs many spatial analysis tasks.

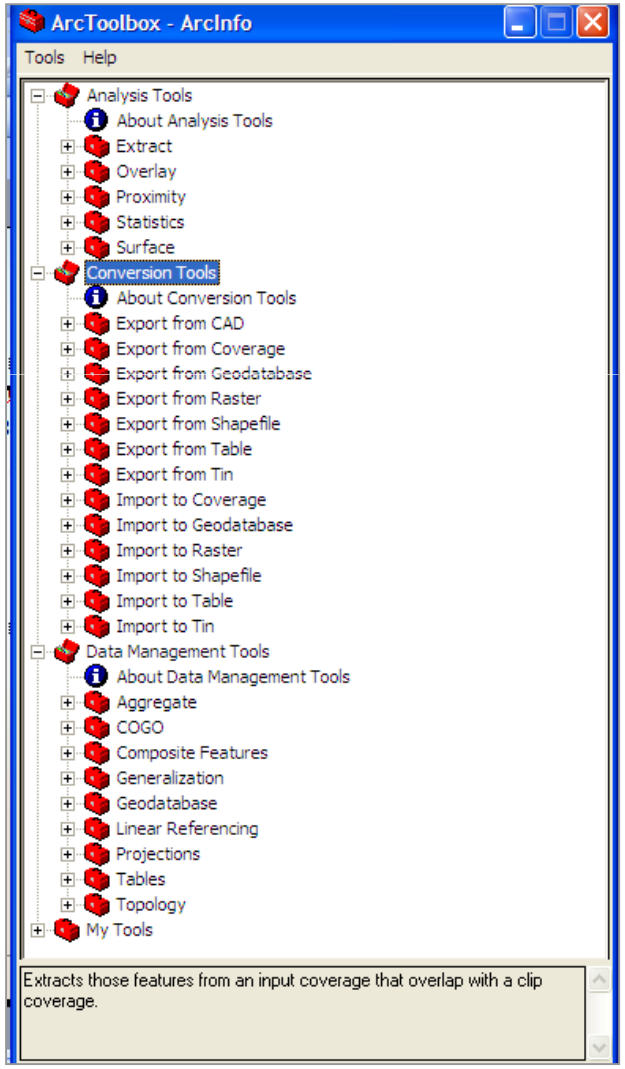


ArcCatalog

- Manages geographic data
- Data can be copied, moved, deleted, and viewed before it is added to the map
- Metadata can either be read or created
- New shapefiles can be created.



ArcToolbox



Geoprocessing operations:

- import/export
- format conversion
- statistics
- spatial and 3D analyst tools
- etc….

Extensions

- Spatial Analyst: advanced spatial modelling and analysis tools
- 3D Analyst: visualize and analyse surface data
- Network Analyst: network-based spatial analysis (e.g. routing, travel directions)
- Geostatistical Analyst: spatial data exploration and optimal surface generation
- And many more…

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