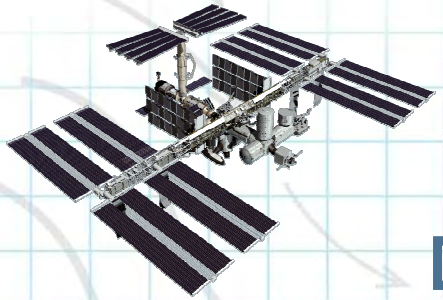
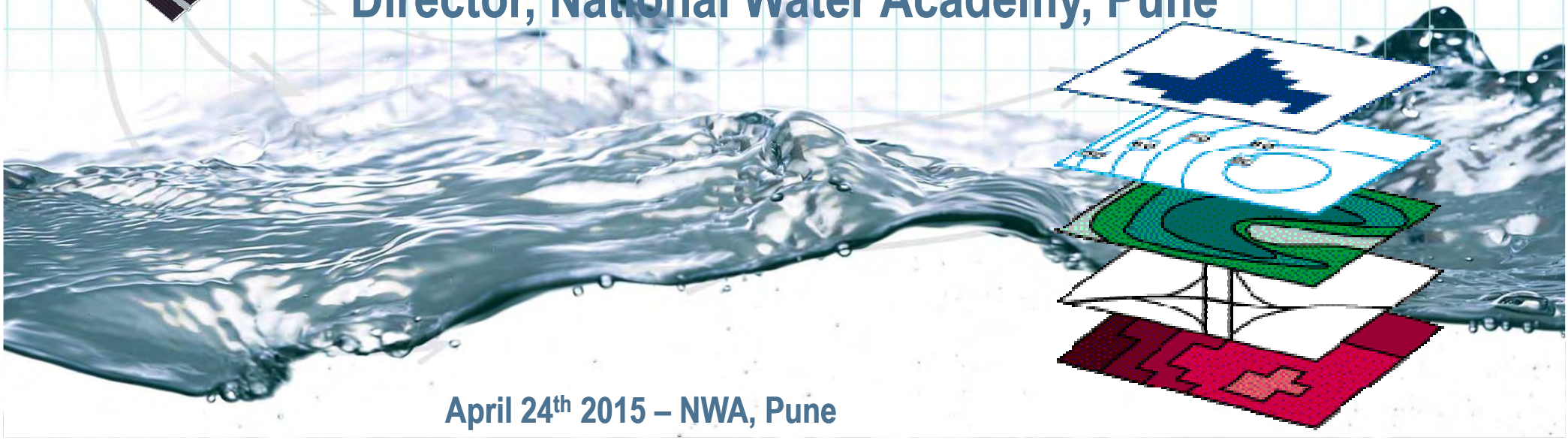
Training Programme for Officials of Royal Govt of Bhutan

Concepts of
Remote Sensing (RS) and Geographic Information System (GIS)

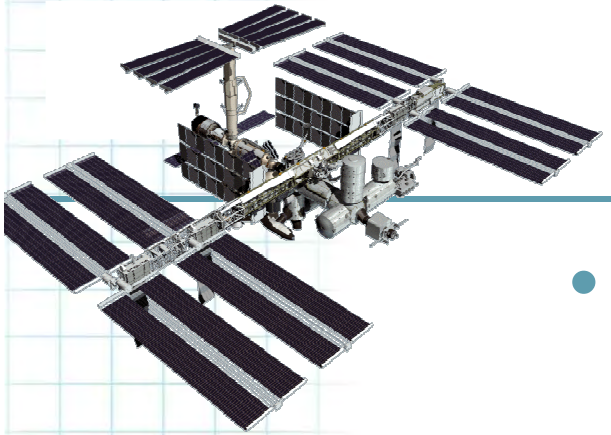


Sunil KUMAR

Director, National Water Academy, Pune

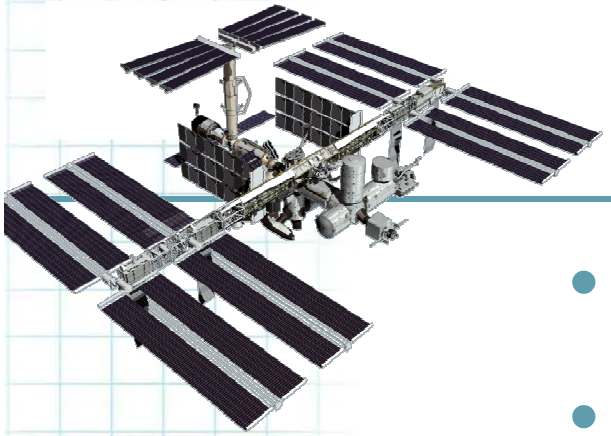


April 24th 2015 – NWA, Pune



What is Remote Sensing ?

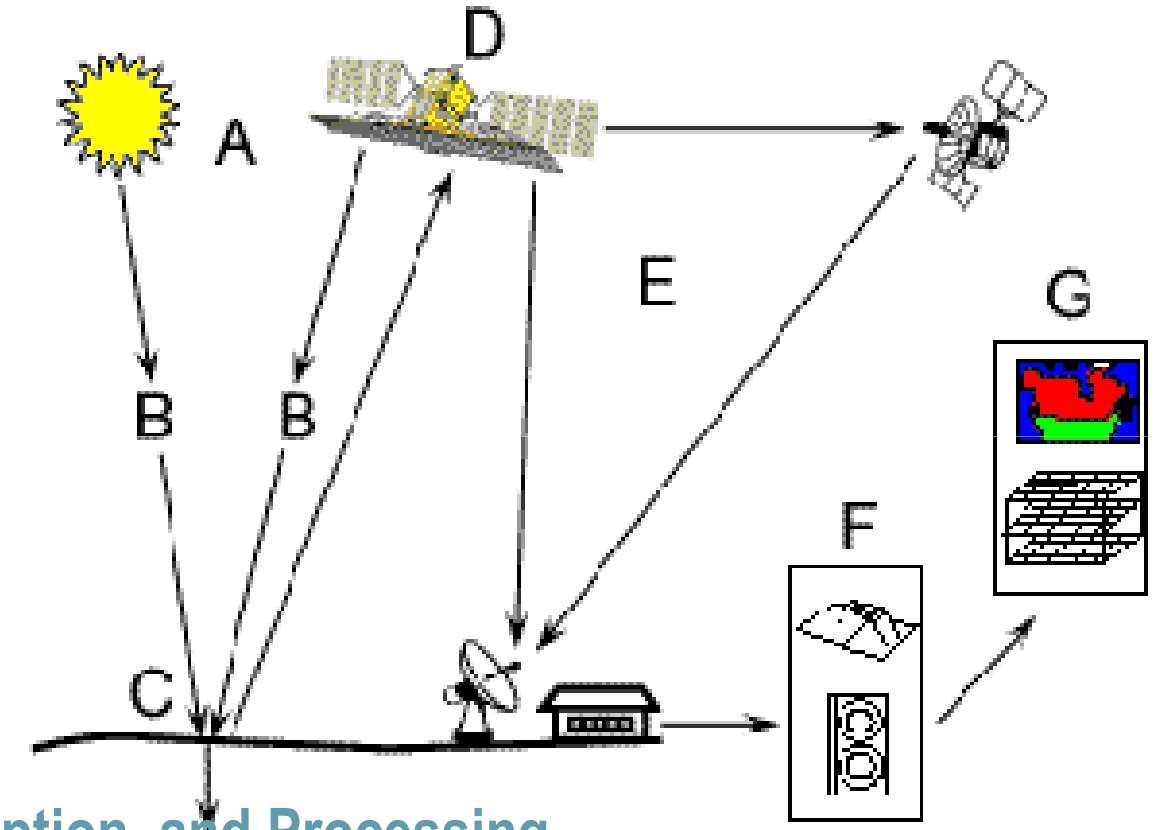
- Remote sensing is the science of acquiring information about the Earth's surface without actually being in contact with it.
- This is done by sensing and recording reflected or emitted energy and processing, analyzing and applying that information



Remote Sensing-Multidisciplinary

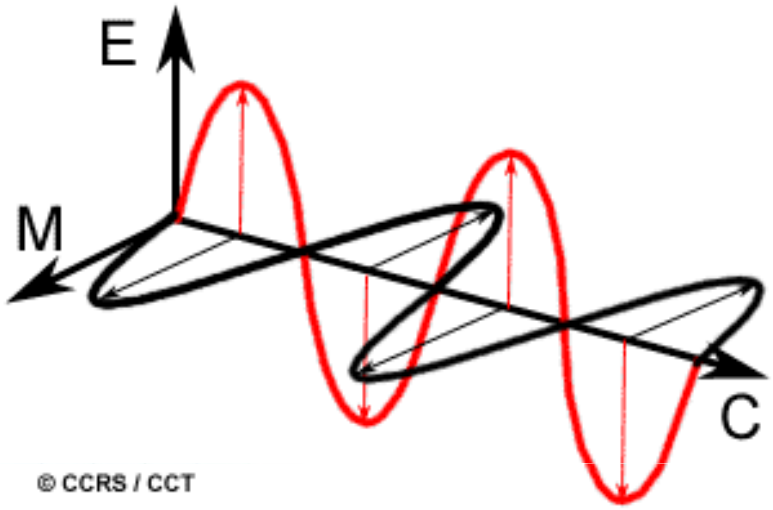
- Optics
- Spectroscopy
- Photography
- Computer
- Electronics
- Telecommunication
- Satellite

Principles of Remote Sensing



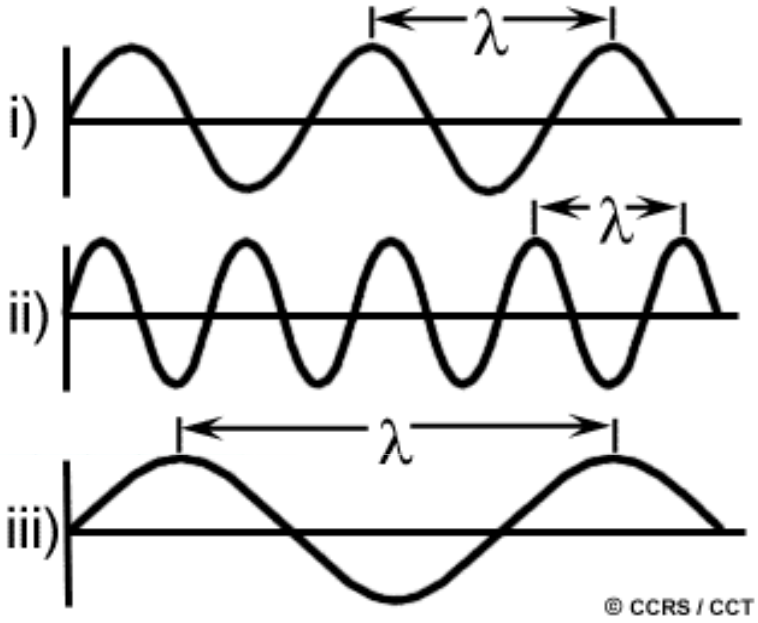
A - Energy Source
B - Atmosphere
C - Target
D - Sensor
E - Transmission, Reception, and Processing
F - Interpretation and Analysis
G - Application

Electromagnetic Radiation



- In 1886, Maxwell found that it might be possible to combine electric and magnetic fields, forming self sustaining waves;
- In 1888 Hertz further investigated the properties of Electromagnetic waves.

Wavelength & Frequency

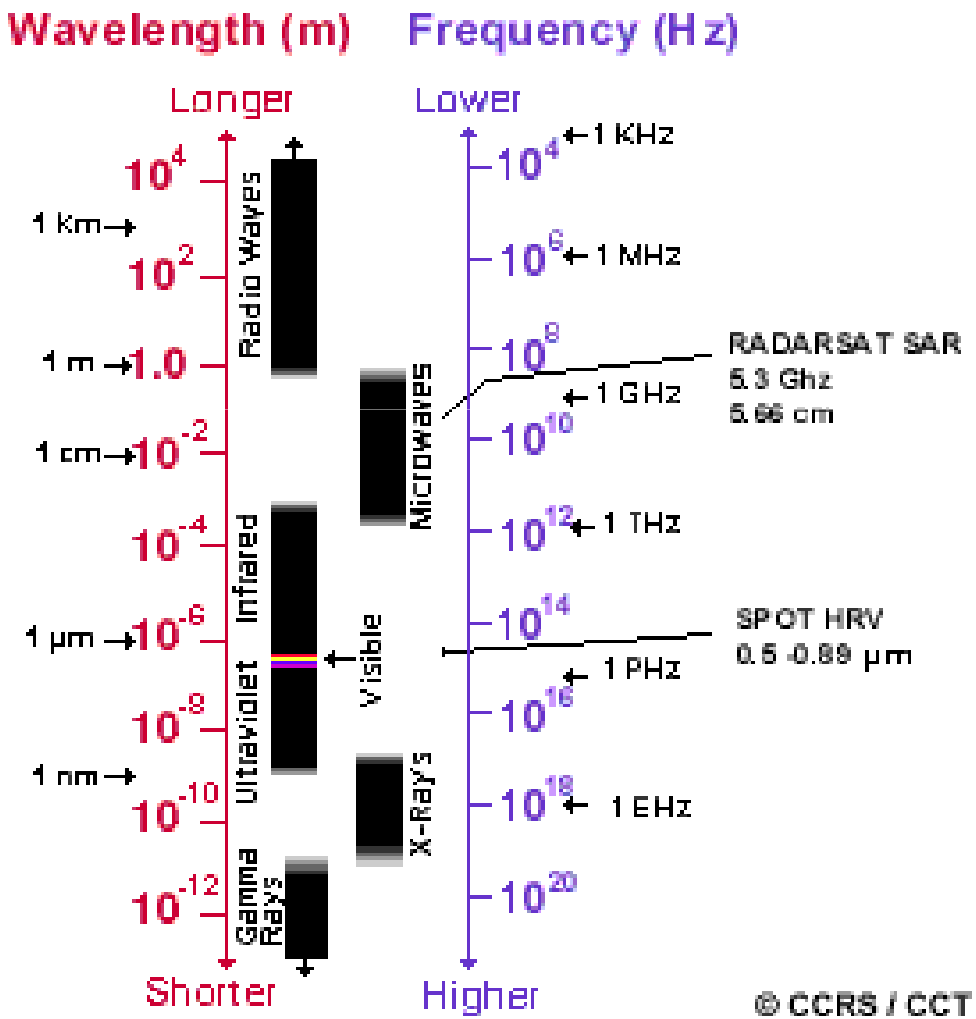


$c = \lambda v$

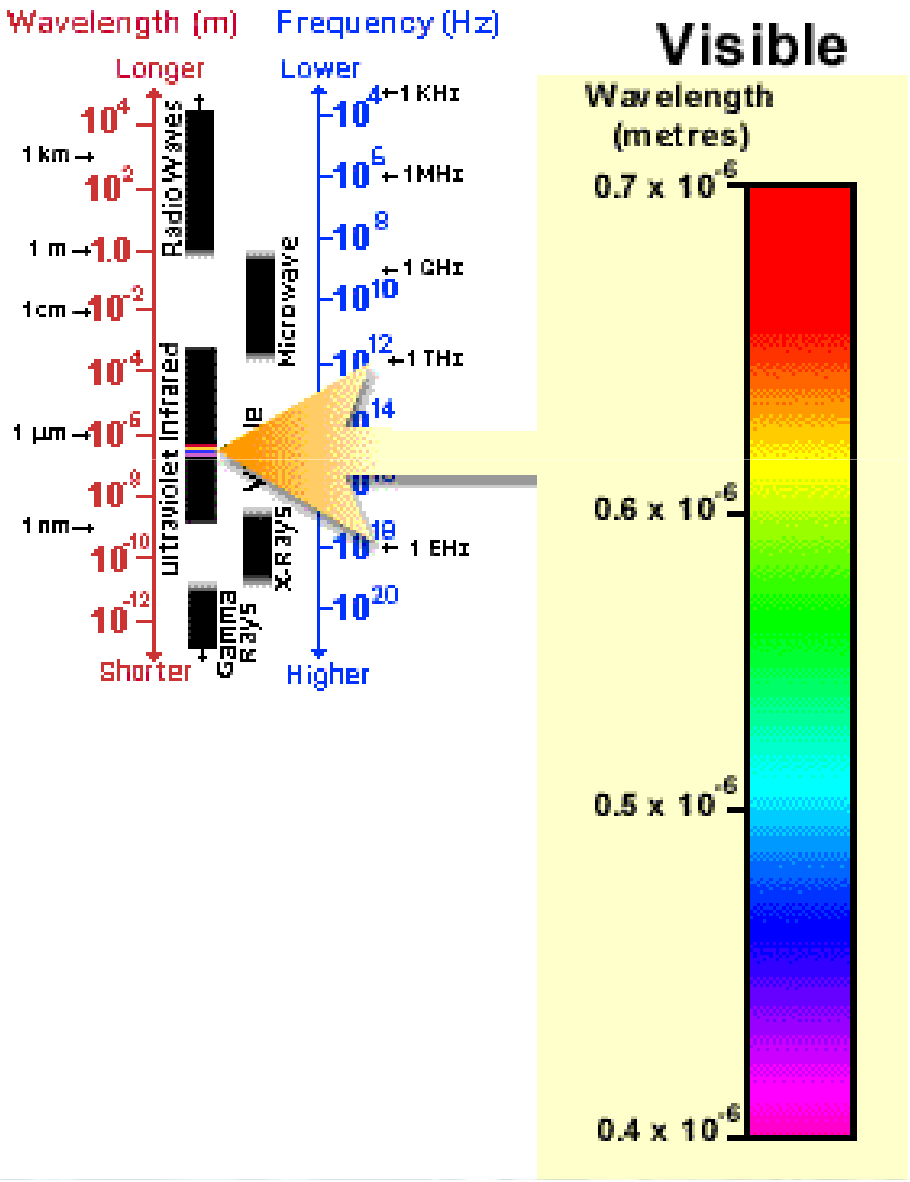
λ = wavelength (m)
v = frequency (cycles per second, Hz)
c = speed of light (3×10^8 m/s)

- Wavelength is the length of one wave cycle, which can be measured as the distance between successive wave crest
- Frequency is number of cycle of waves passing a fixed time per unit of time

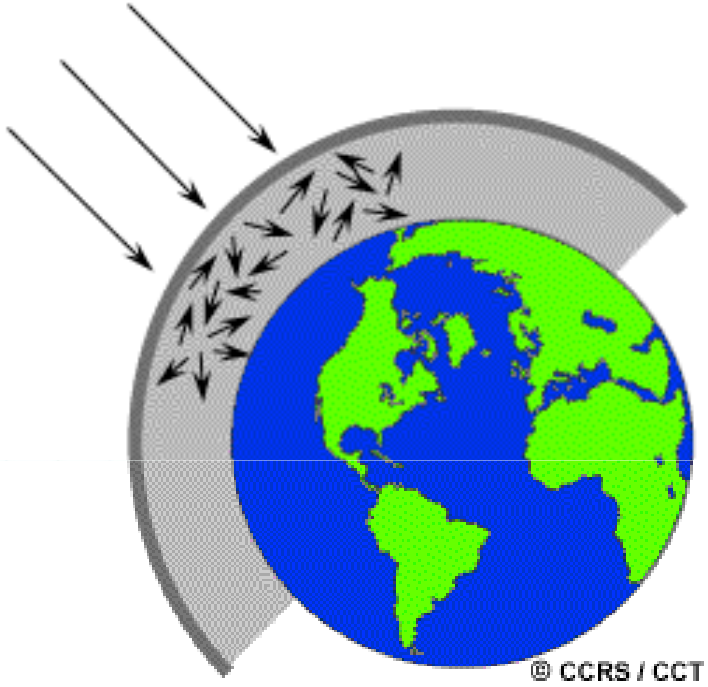
The Electromagnetic Spectrum



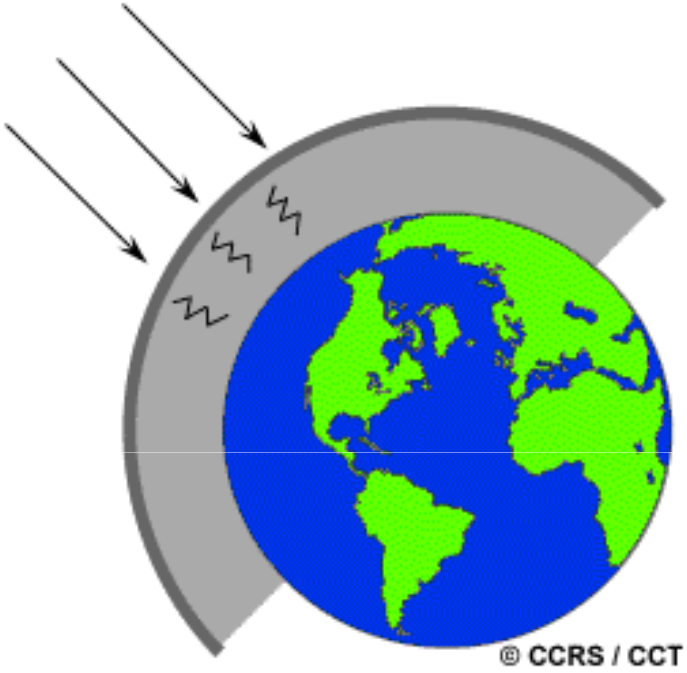
The Electromagnetic Spectrum



Interaction with the Atmosphere



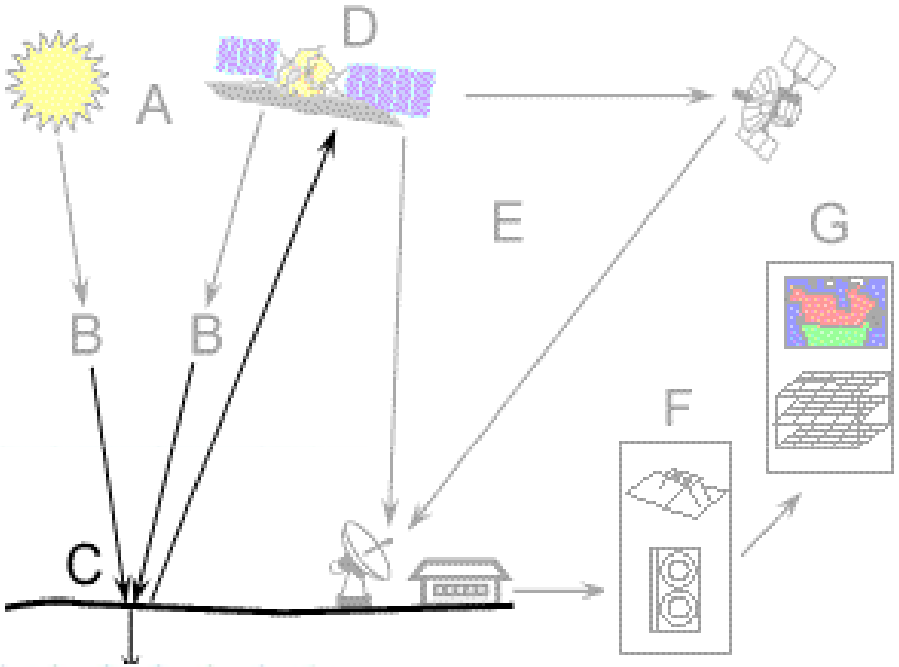
Scattering



Absorption

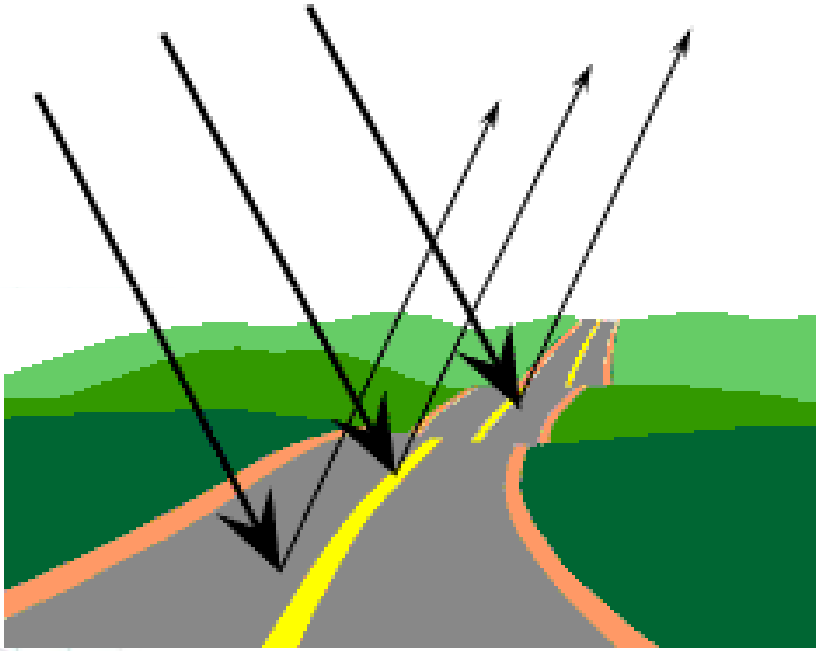
- UV Radiation – Ozone
- Infrared Radiation- Carbon dioxide
- Microwave Radiation – Water Vapour

Radiation – Target Interactions

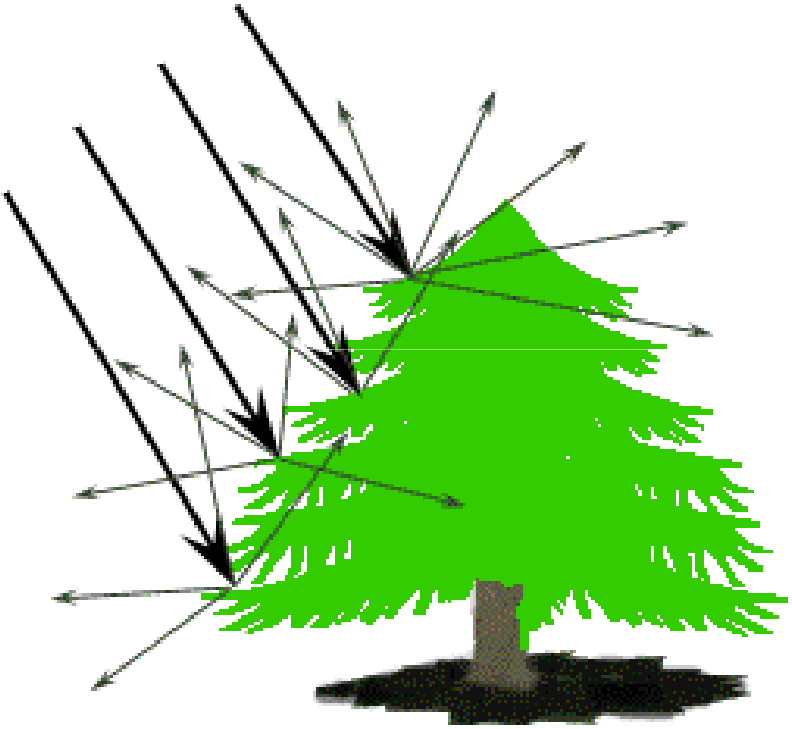


A-Absorption; T-Transmission, R-Reflection

Target Interactions-Reflections

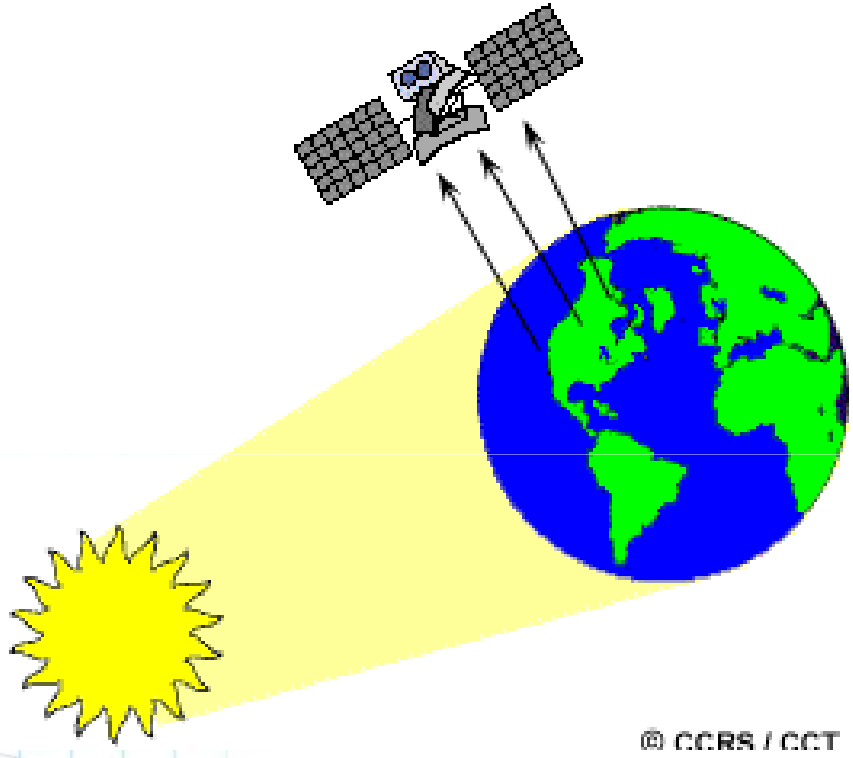


Specular Reflection

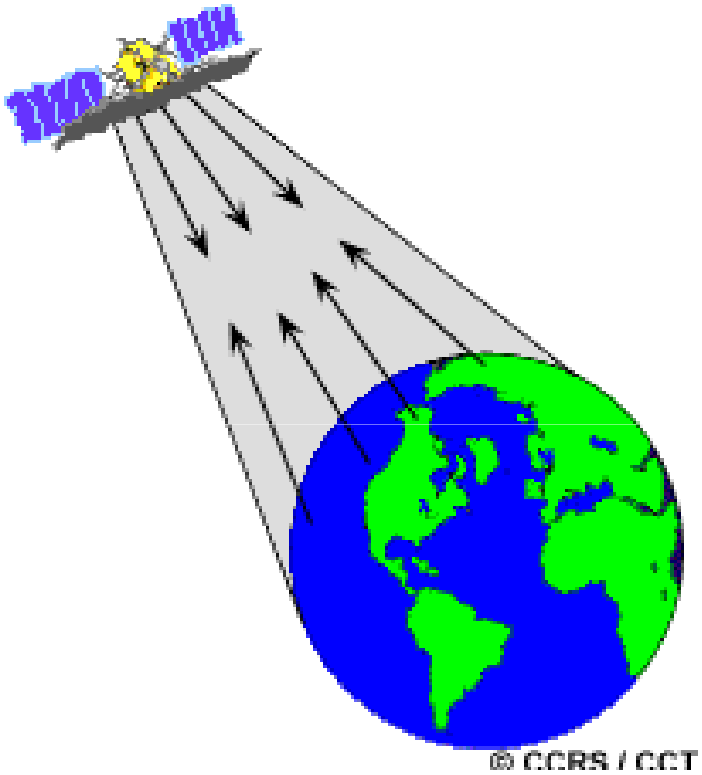


Diffuse Reflection

Sensors

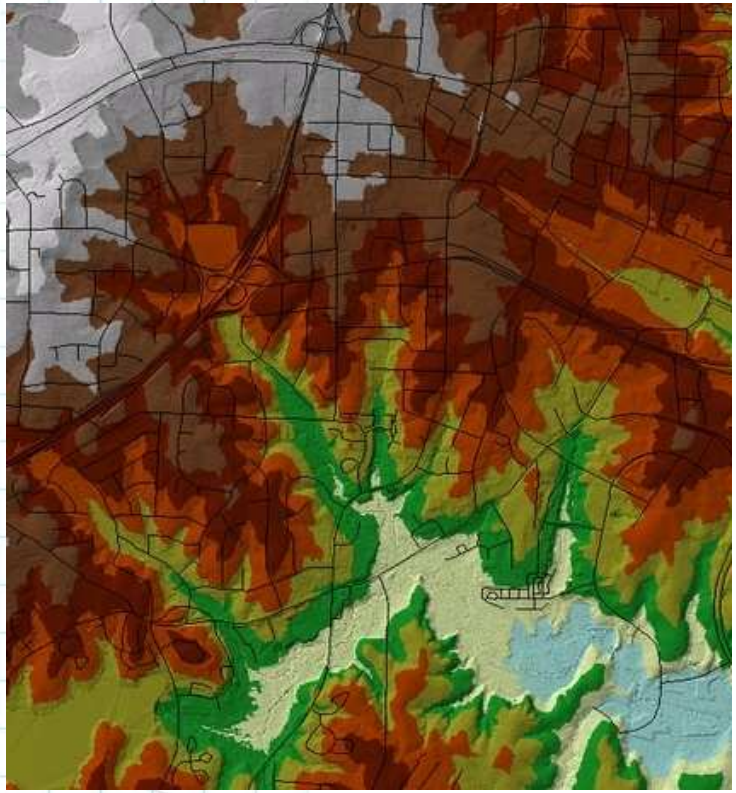


Passive Sensors



Active Sensors

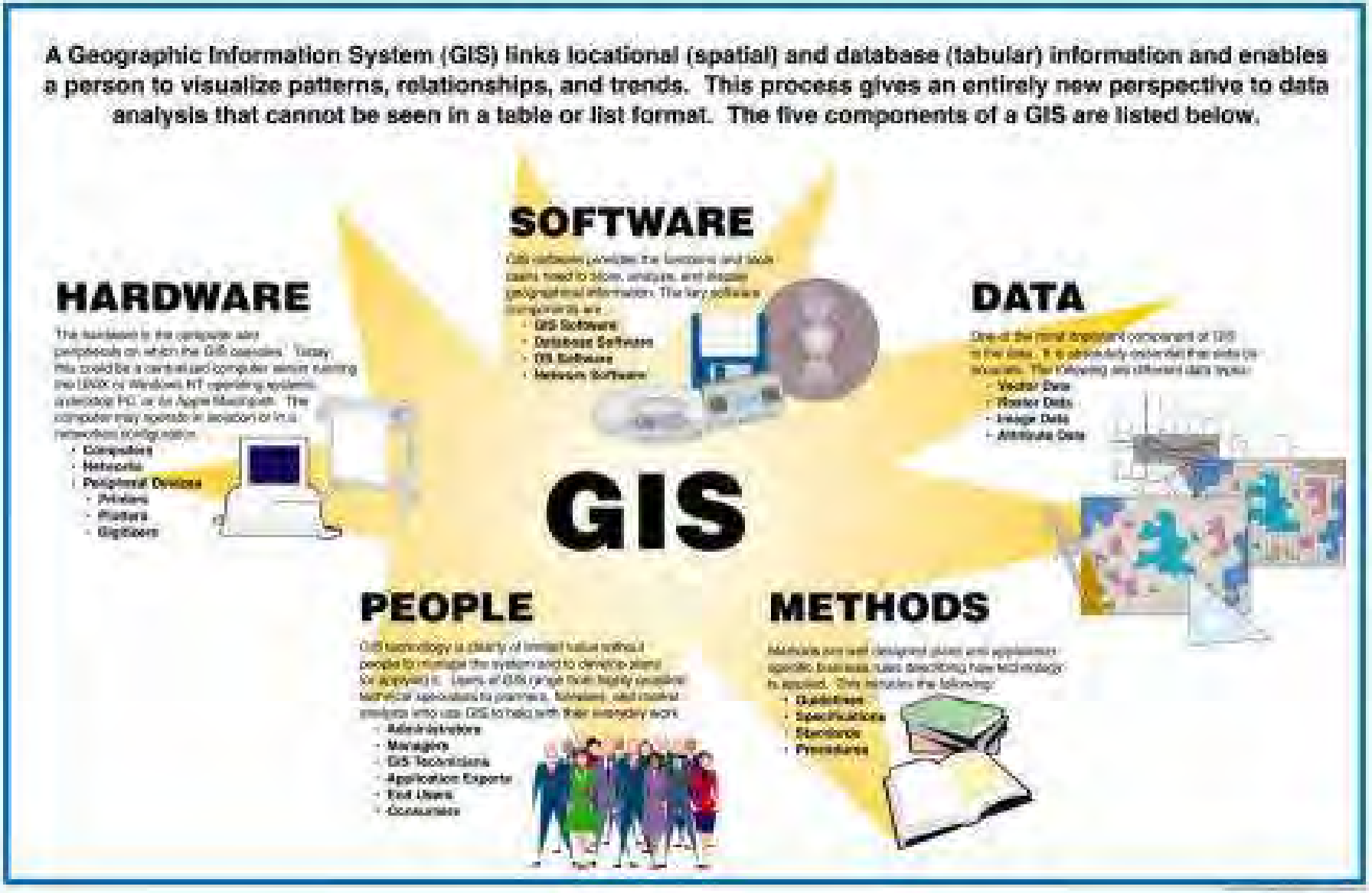
What is GIS ?



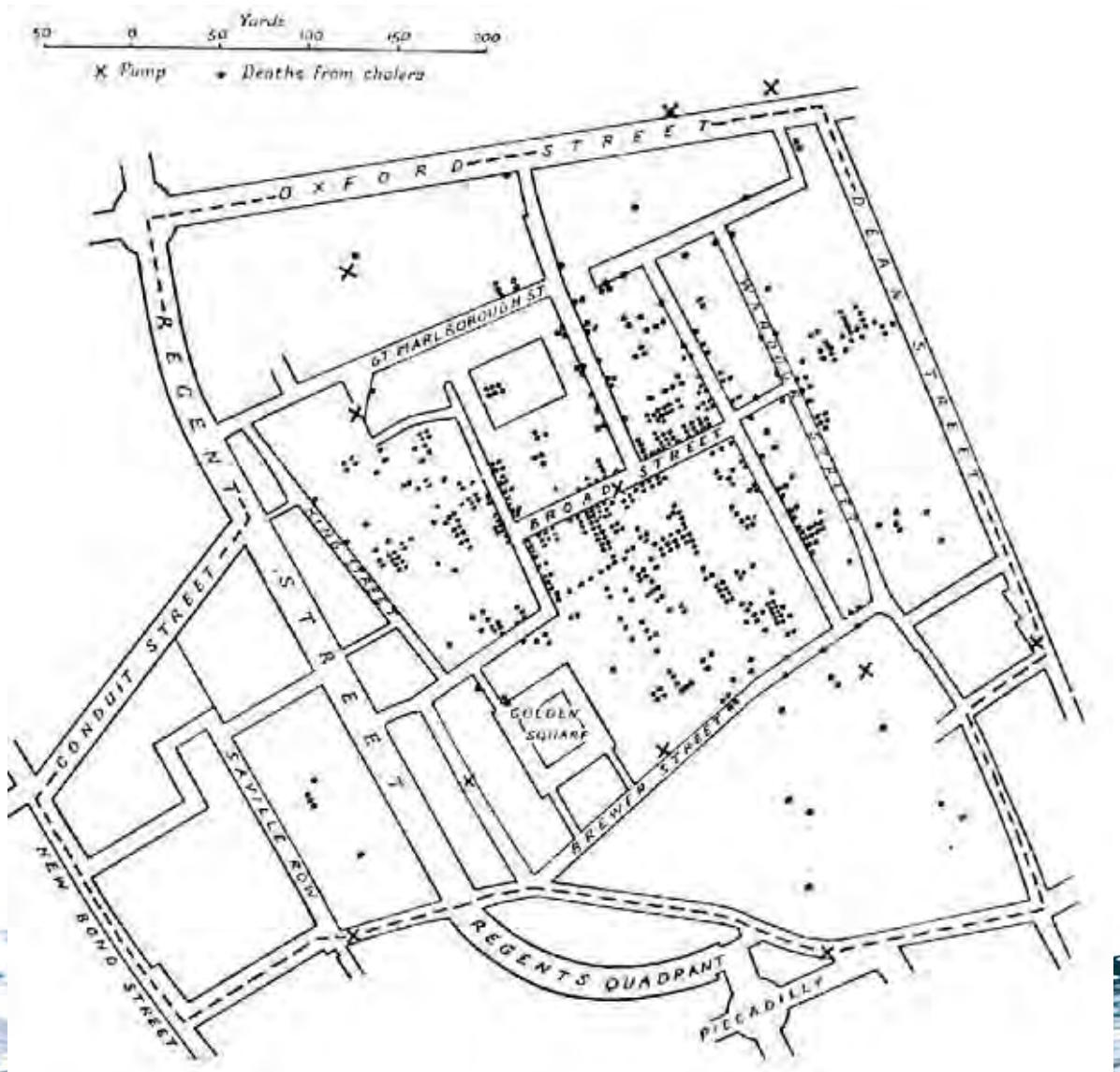
- GIS integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information
- GIS allows to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

Component of GIS

A Geographic Information System (GIS) links locational (spatial) and database (tabular) information and enables a person to visualize patterns, relationships, and trends. This process gives an entirely new perspective to data analysis that cannot be seen in a table or list format. The five components of a GIS are listed below.



GIS – History of Development



GIS – History of Development

- **1854 (John Show) : Cholera Outbreak in London;**
- **Early 20th Century: Photozincography for maps**
  - Concept of layers;
  - Originally drown on glass plates;
  - Later on thin plastic films;
  - Colour printing introduced;

  (Layer concept used in modern GIS)

GIS – History of Development

- **1960s: Development of Computer Hardware;**
  - 1960: First operational GIS in Ottawa, Canada
  - Department of Forestry and Rural Development.
  - Developed by **Dr. Roger Tomlinson** (Father of GIS)
  - Called Canada Geographic Information System (CGIS)
  - Used to store, analyze, and manipulate data collected for the Canada Land Inventory
  - Facilitated planning & management.

GIS – History of Development

- **1965-91:** Extensive Research at **Harvard Graduate School** of Design led to commercial development
- **1980s:** Environmental Systems Research Institute (ESRI), Computer Aided Resource Information System (CARIS), MapInfo, Earth Resource Data Analysis System (ERDAS) emerged as commercial vendors of GIS software.
- **1986:** Mapping Display and Analysis System (MIDAS), the **first desktop GIS product**, renamed in 1990 as **Mapinfo** as Microsoft windows based package.

GIS – Packages

Open Source GIS software

- **GRASS GIS –** Originally developed by the U.S. Army Corps of Engineers: a complete GIS.
- **ILWIS (Integrated Land and Water Information System) –** Integrates image, vector and thematic data.
- **MapWindow GIS –** Free desktop application and programming component
- **uDig –** API and source code (Java) available.

GIS – Packages

Commercial GIS software

- ArcGIS, ArcView, ArcSDE, ArcIMS, ArcWeb services and ArcGIS Server by ESRI;
- MapInfo by Pitney Bowes Software

Indigenous GIS Packages

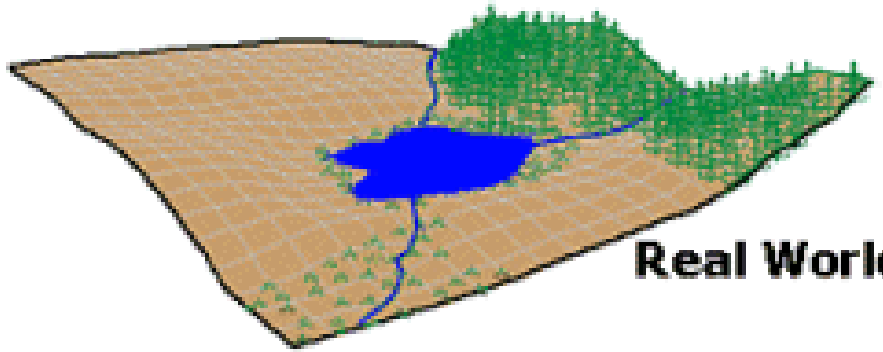
- ISROGIS

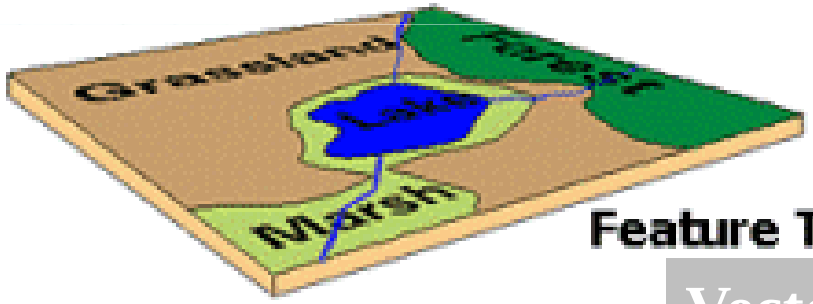
GIS – Map Features

- **Location:** Describes position of particular geographic feature on earth surface.
- **Attribute:** Describes characteristics of geographic feature such as type, name, area, length etc.

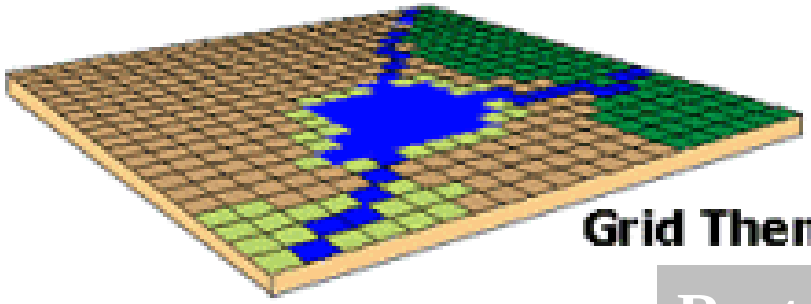
Name	FIPS	Pop90	Area	PopDn
Whatcom	53073	128	2170	59
Skagit	53057	80	1765	45
Clallam	53009	56	1779	32
Snohomish	53061	466	2102	222
Island	53029	60	231	261
Jefferson	53031	20	1773	11
Kitsap	53035	190	391	485
King	53033	1507	2164	696
Mason	53045	38	904	42
Grey Harbor	53027	64	1917	33
Pierce	53053	586	1651	355
Thurston	53067	161	698	231
Pacific	53049	19	945	20
Lewis	53041	59	2479	24

GIS – Data Model





Vector

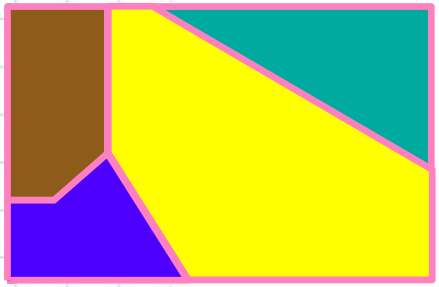


Raster

Attributes of Rain25used.txt

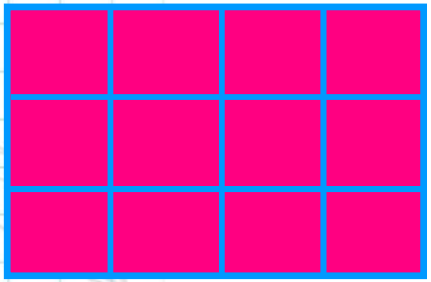
Shape*	rainfalls for site	Easting	Northing	Alt	Rain (mm)
Point	999	2411300	5901700	334	2592.200
Point	211302	2372144	5899615	4	2658.491
Point	211802	2416286	5898496	198	1833.954
Point	213810	2410022	5872000	183	2131.642
Point	214202	2361986	5858663	20	2551.988
Point	214301	2370172	5860685	12	3234.292
Point	214710	2405600	5862900	117	2424.000
Point	215102	2359367	5853050	11	2773.110
Point	215302	2375764	5855241	143	3394.845
Point	215401	2379943	5851617	75	3146.148
Point	215702	2406013	5848356	175	3068.048
Point	216401	2382989	5835007	116	5119.652
Point	216503	2392487	5838880	107	3696.638
Point	216510	2384400	5846800	90	2683.821
Point	217411	2379300	5826800	126	4308.232
Point	218910	2416759	5827584	1418	5025.104
Point	220201	2447921	5906255	380	1826.003
Point	223101	2442708	5874733	421	2236.851
Point	224001	2429123	5861627	368	2888.288

GIS – Data Model



Discrete Space:
Lumped models

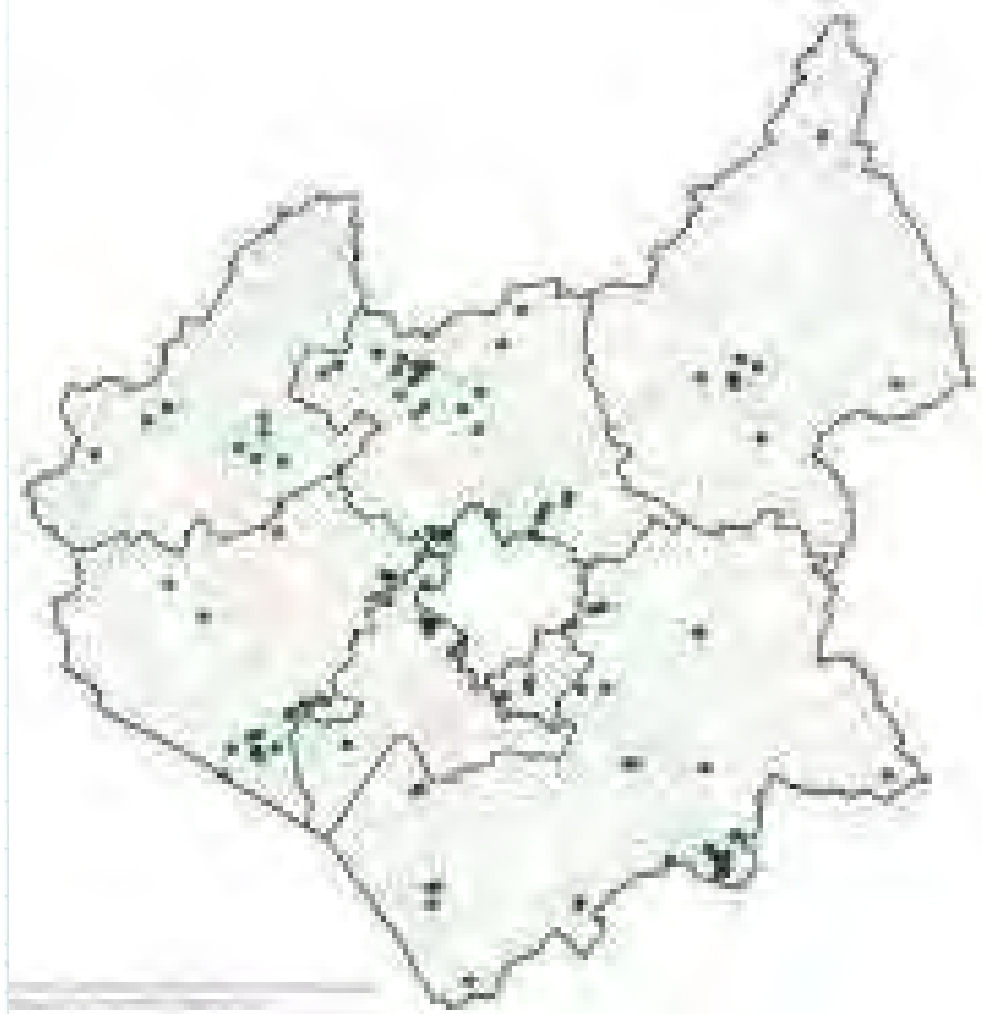
Feature/Vector data structures



Continuous Space:
Distributed models

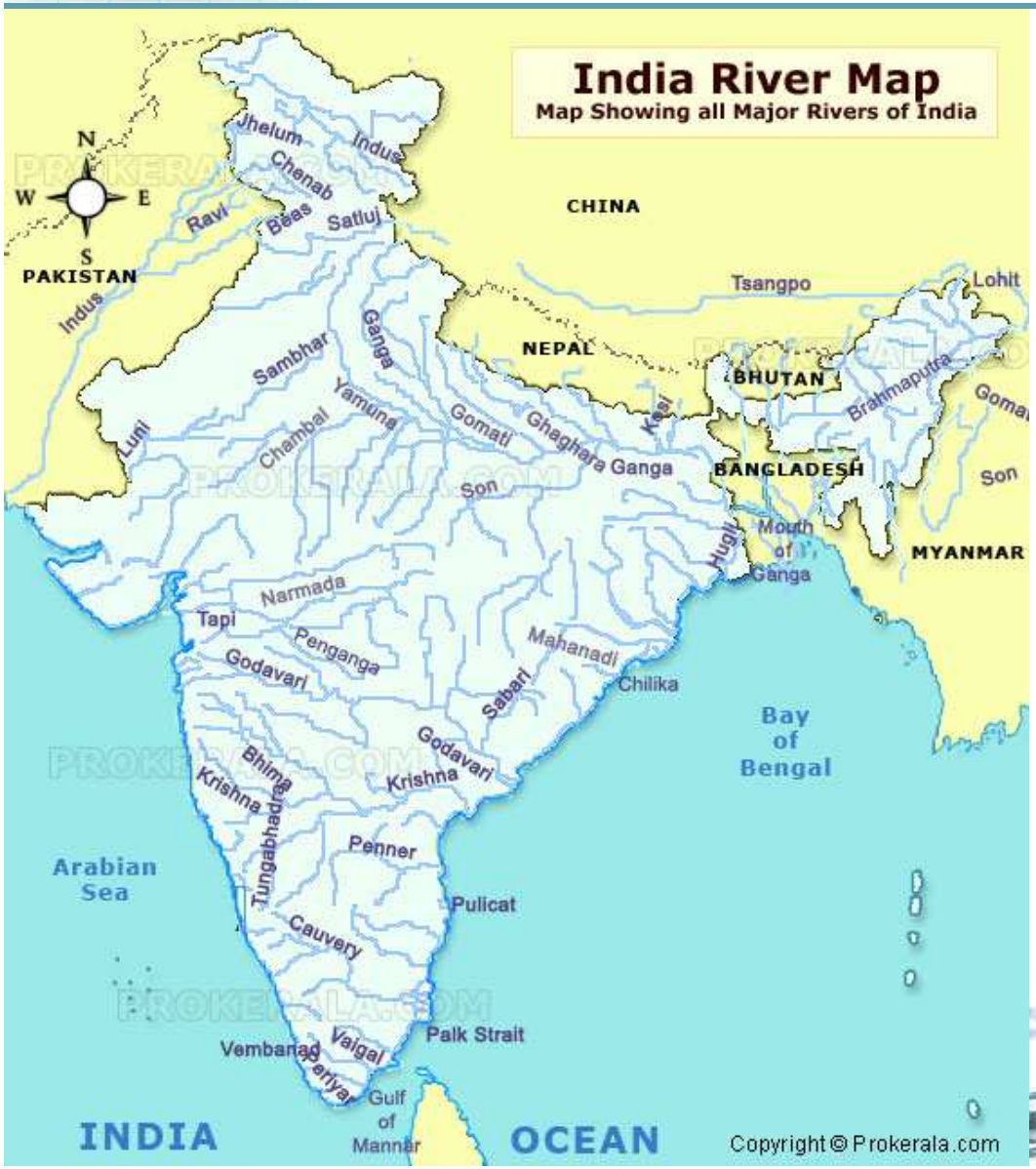
Raster/grid data structures

GIS – Map Features



Point Feature: Represents a single point location (eg. location of rain gauge, flow-gauge, manholes)

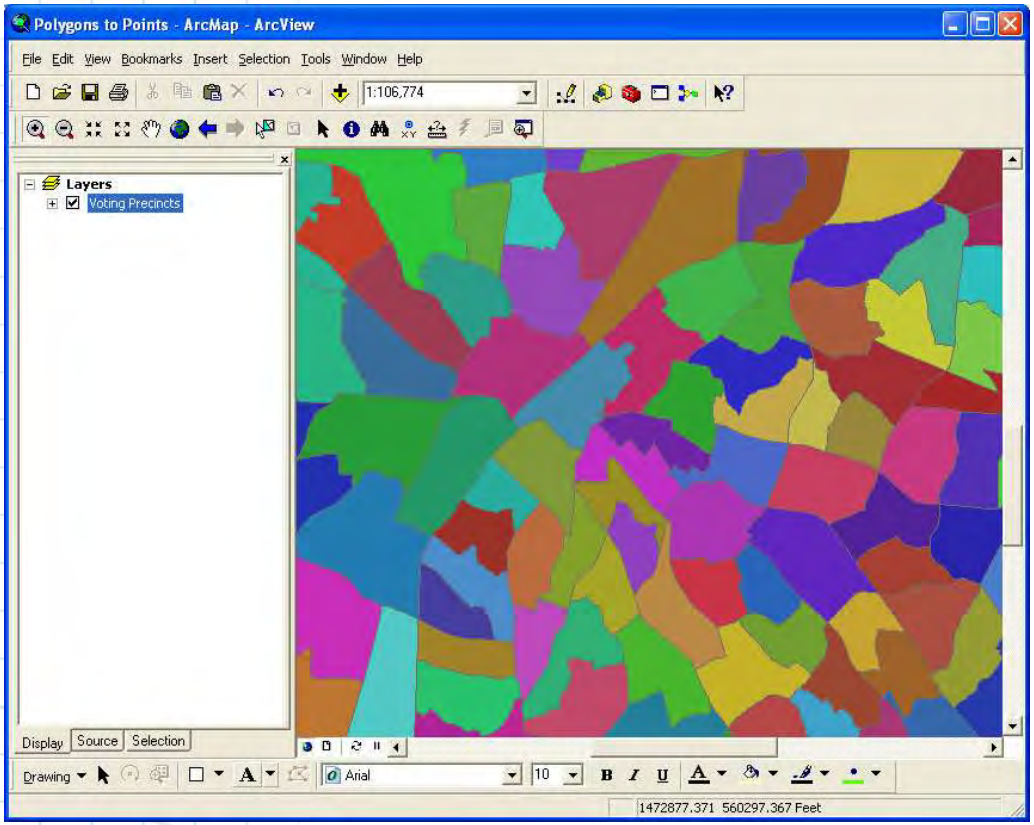
GIS – Map Features



Line Features: Lines are used to represent the shape and location of geographic objects, too narrow to depict as areas.

(eg. Streams, Rivers, Canals)

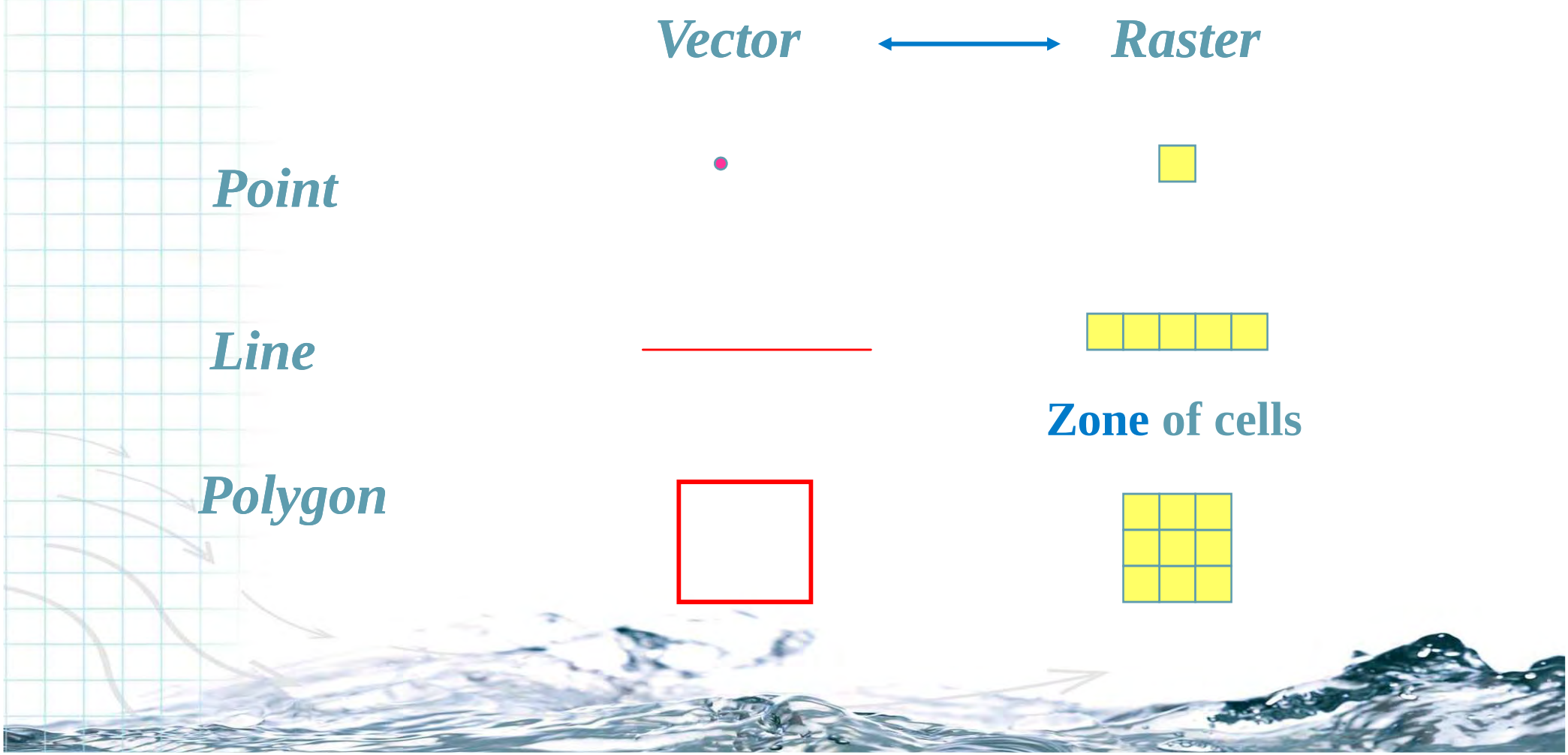
GIS – Map Features



Polygon Features: Polygon is used to represent a shape, set of connected, ordered coordinates forming an area

(eg. Watersheds, catchments, water bodies tc.)

GIS – Data Model



GIS – Data Model

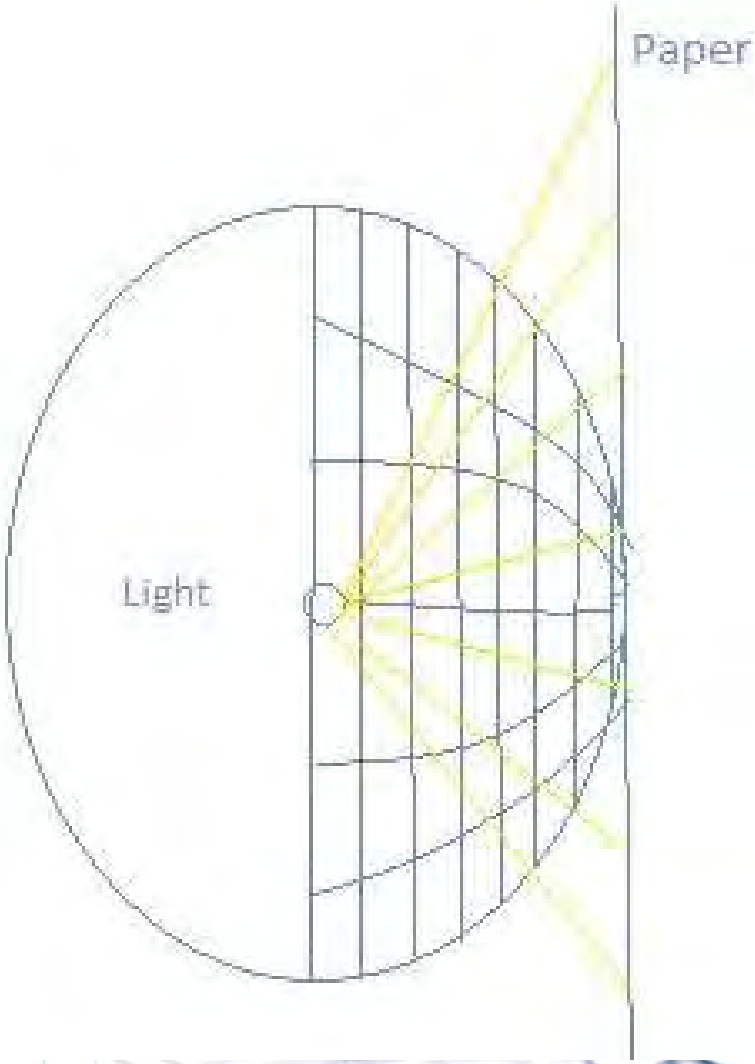
Vector Data Format

- Point, line, polygon, shape files

Raster Data Format

- Jpeg, tiff, gif, DEM

GIS – Map Projections

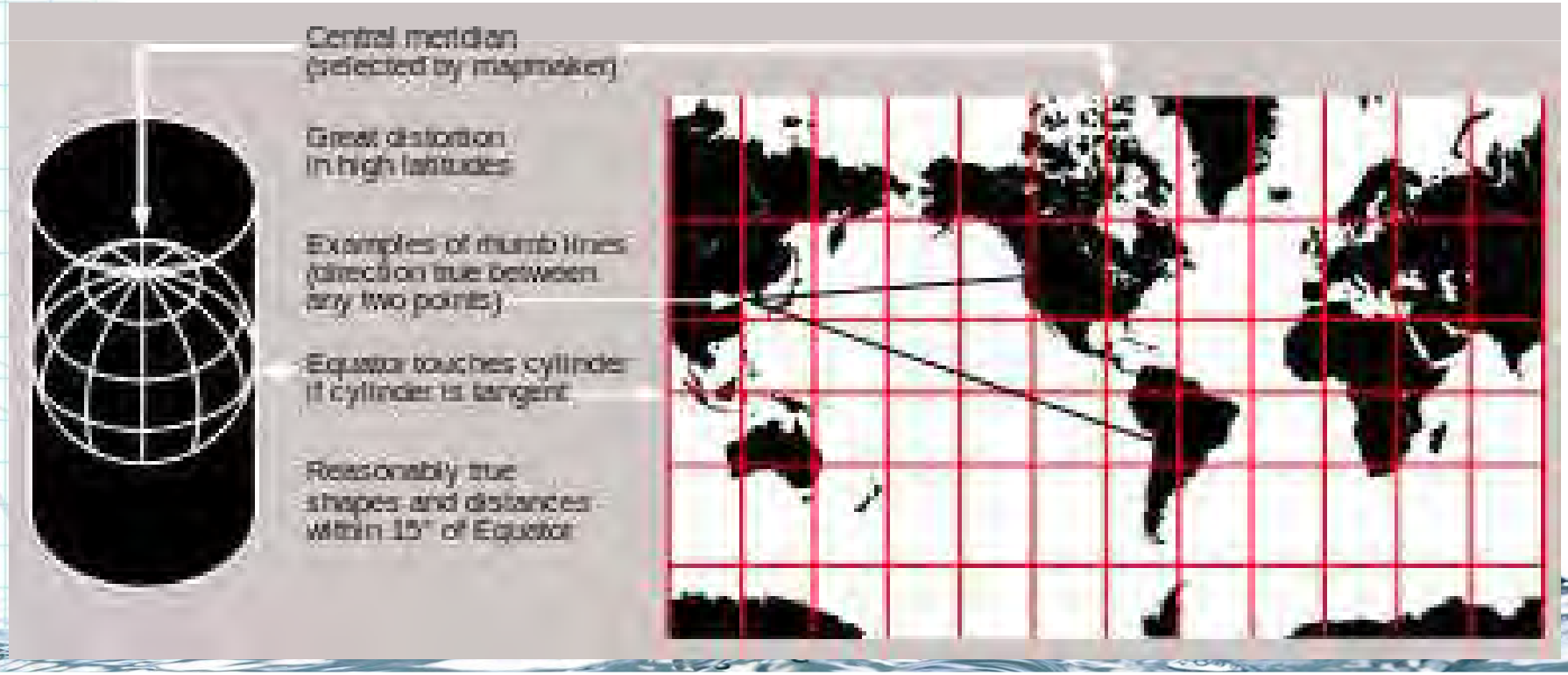


A map projection is a systematic transformation of the latitudes and longitudes of locations on the surface of earth into locations on a plane.

Planar representation of actual map features on the curved surface of the earth, all map projections necessarily distort some aspects.

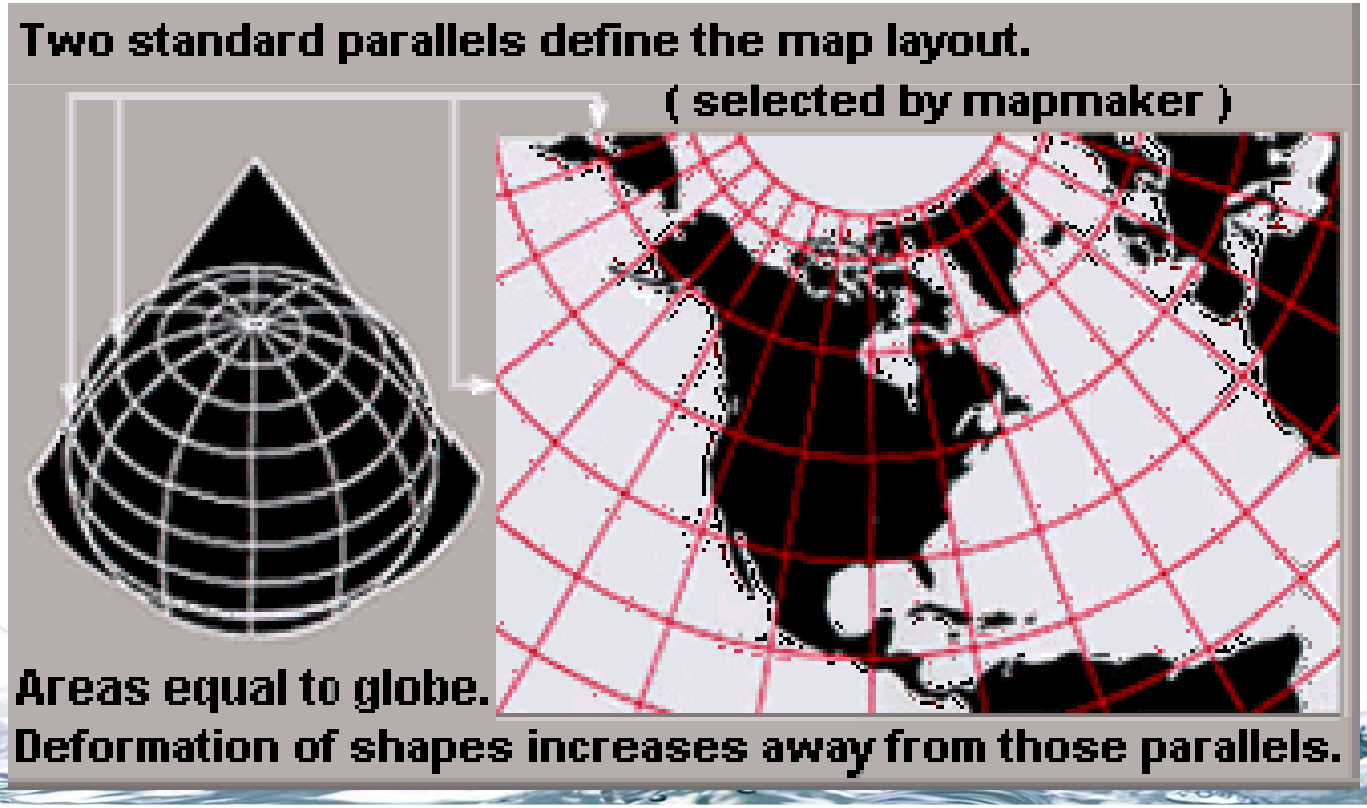
GIS – Map Projections

Cylindrical Projections: Meridians are mapped to equally spaced vertical lines and circles of latitude (parallels) are mapped to horizontal lines. Minimum distortion at equatorial region & maximum at poles)



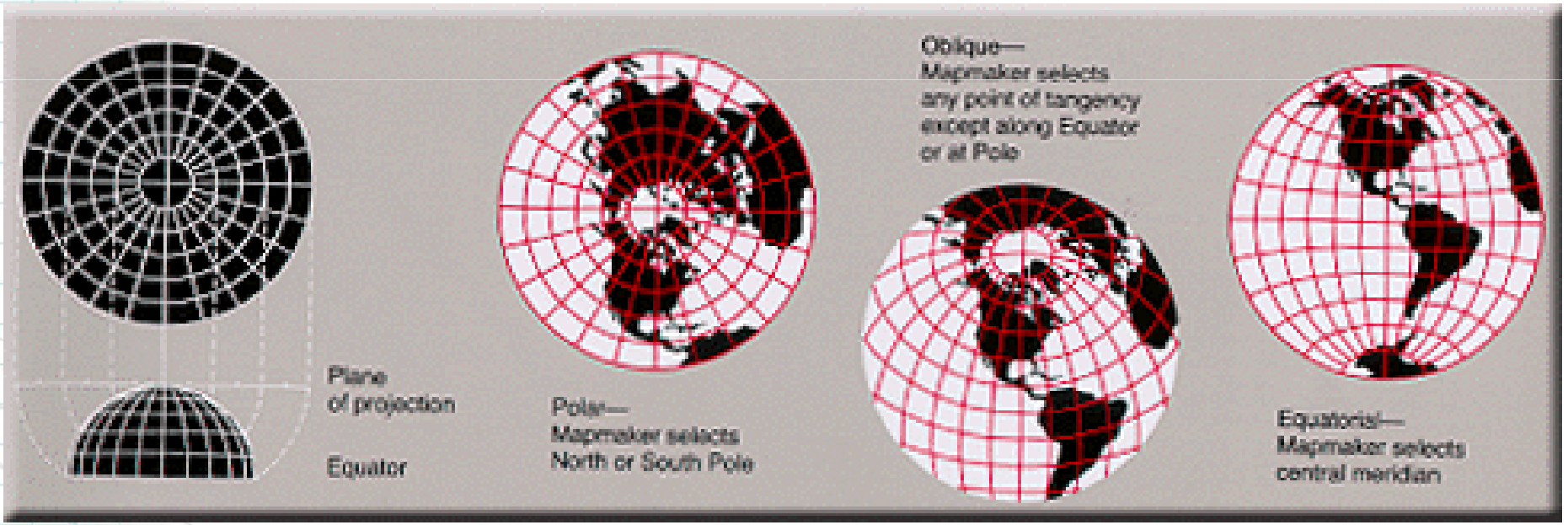
GIS – Map Projections

Conic Projections: meridians are mapped to equally spaced lines radiating out from the apex and circles of latitude (parallels) are mapped to circular arcs centered on the apex



GIS – Map Projections

Azimuthal Projections: Directions from a central point are preserved and therefore great circles through the central point are represented by straight lines on the map

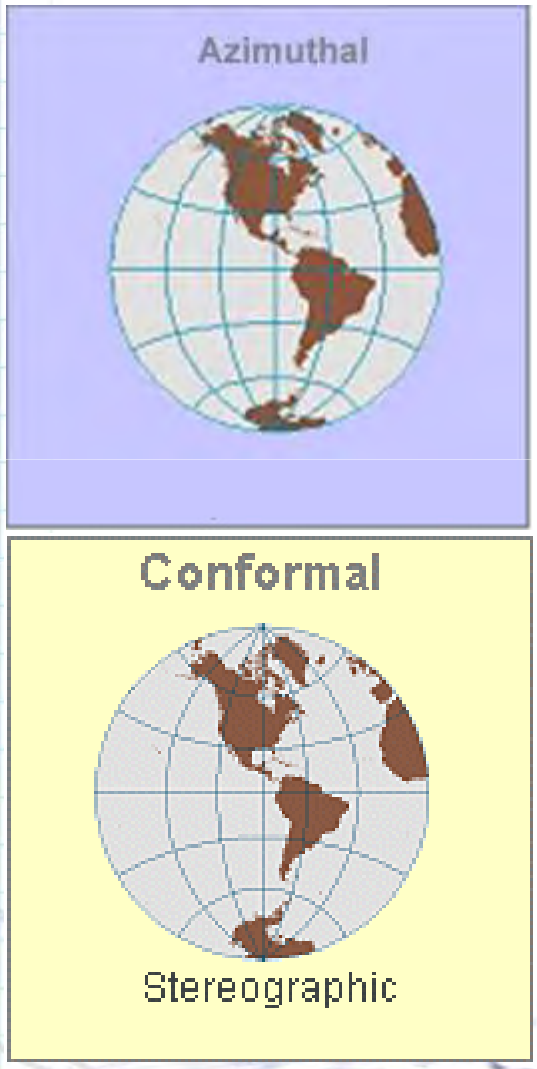


GIS – Map Projections

Metric Properties of Map:

- Area
- Shape
- Direction
- Distance

GIS – Map Projections



Preserving **direction** (Azimuthal), a trait possible only from one or two points to every other point

Preserving **shape** locally (conformal or orthomorphic)

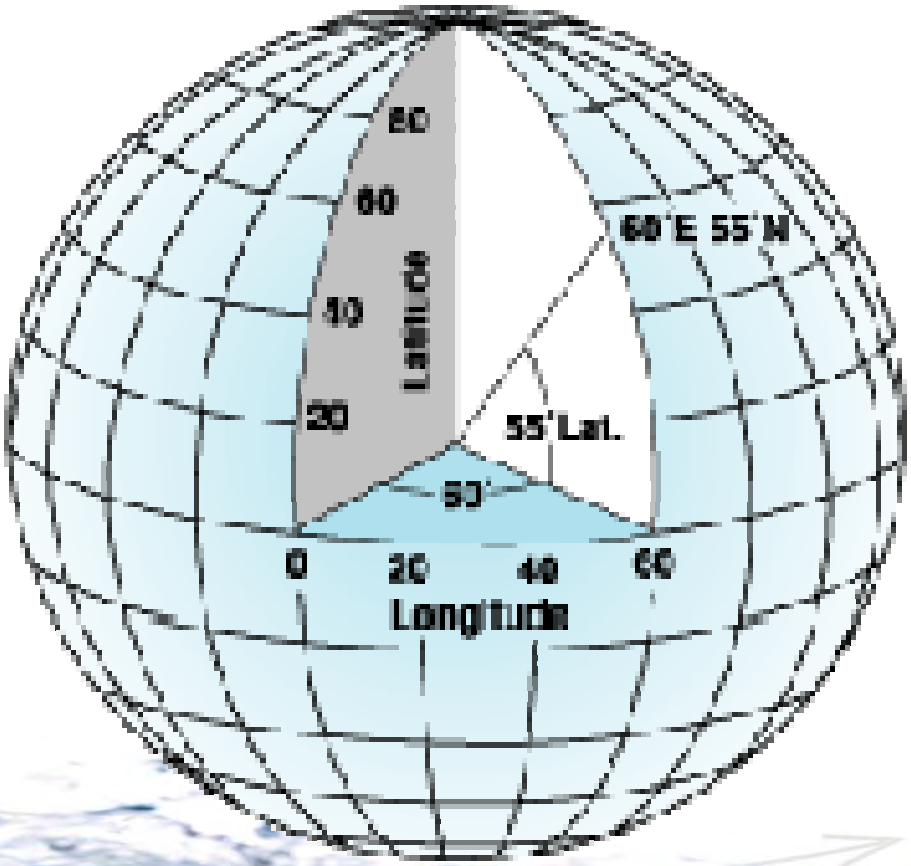
GIS – Map Projections

Preserving **area** (equal-area or equivalent or Authalic)

Preserving **distance** (equidistant), a trait possible only between one or two points and every other point

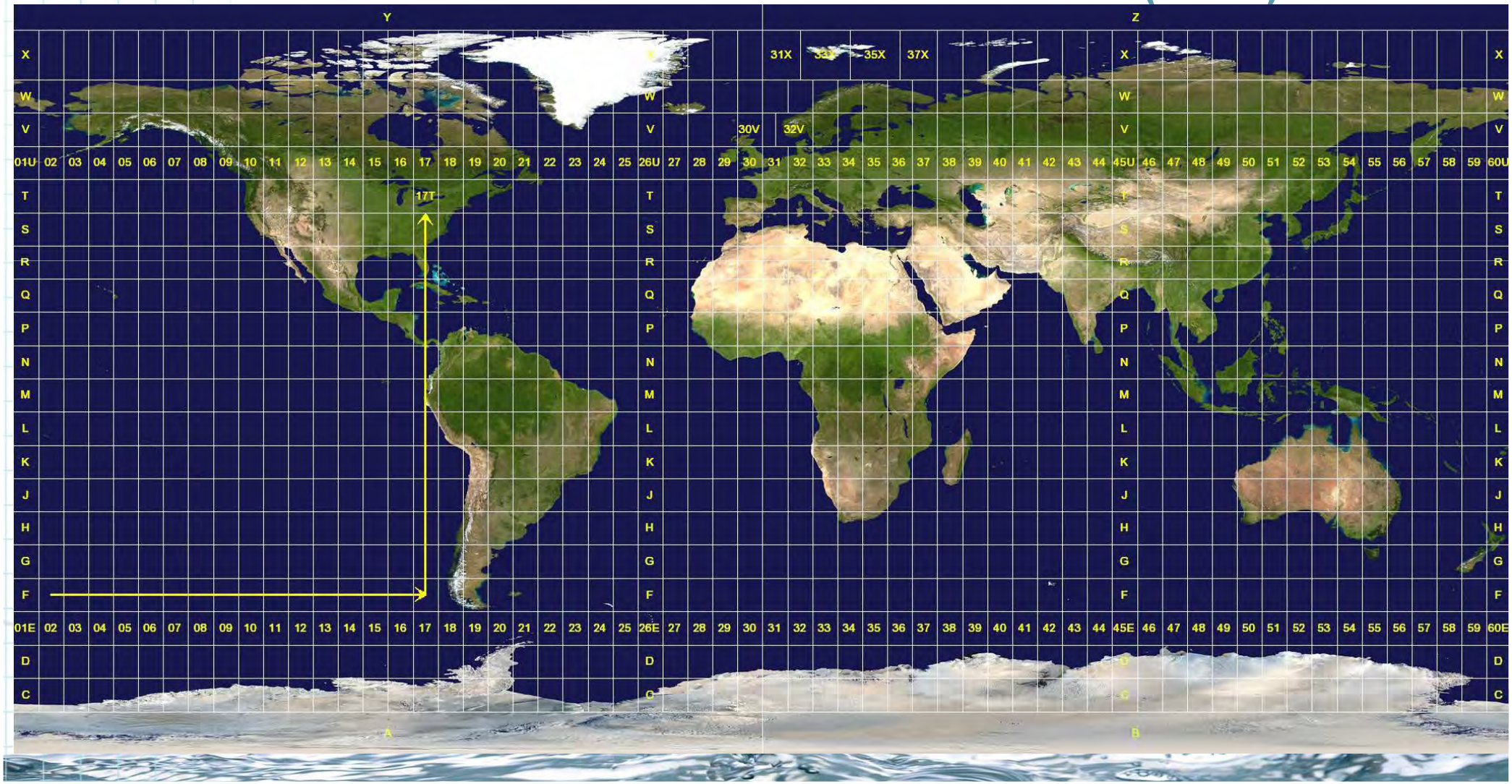
GIS Coordinate System

Geographic Coordinate Systems



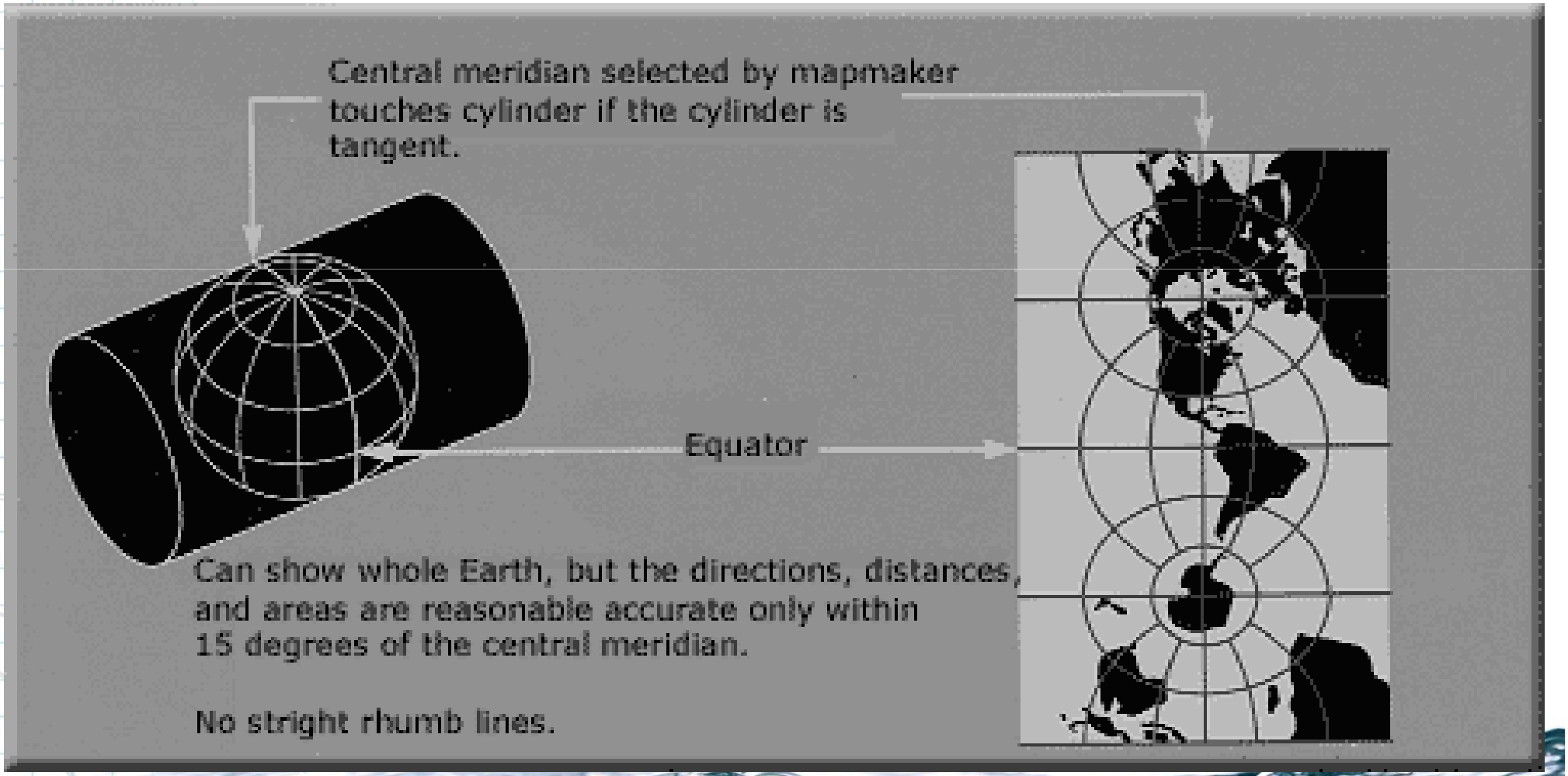
GIS Coordinate System

Universal Transverse Mercator (UTM)

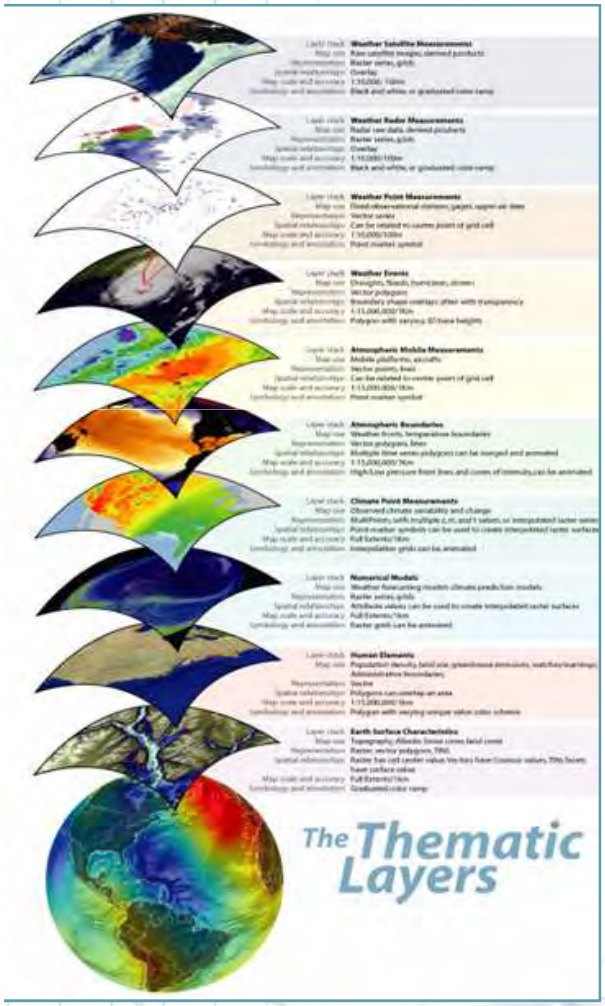


GIS Coordinate System

Transverse Mercator Projection

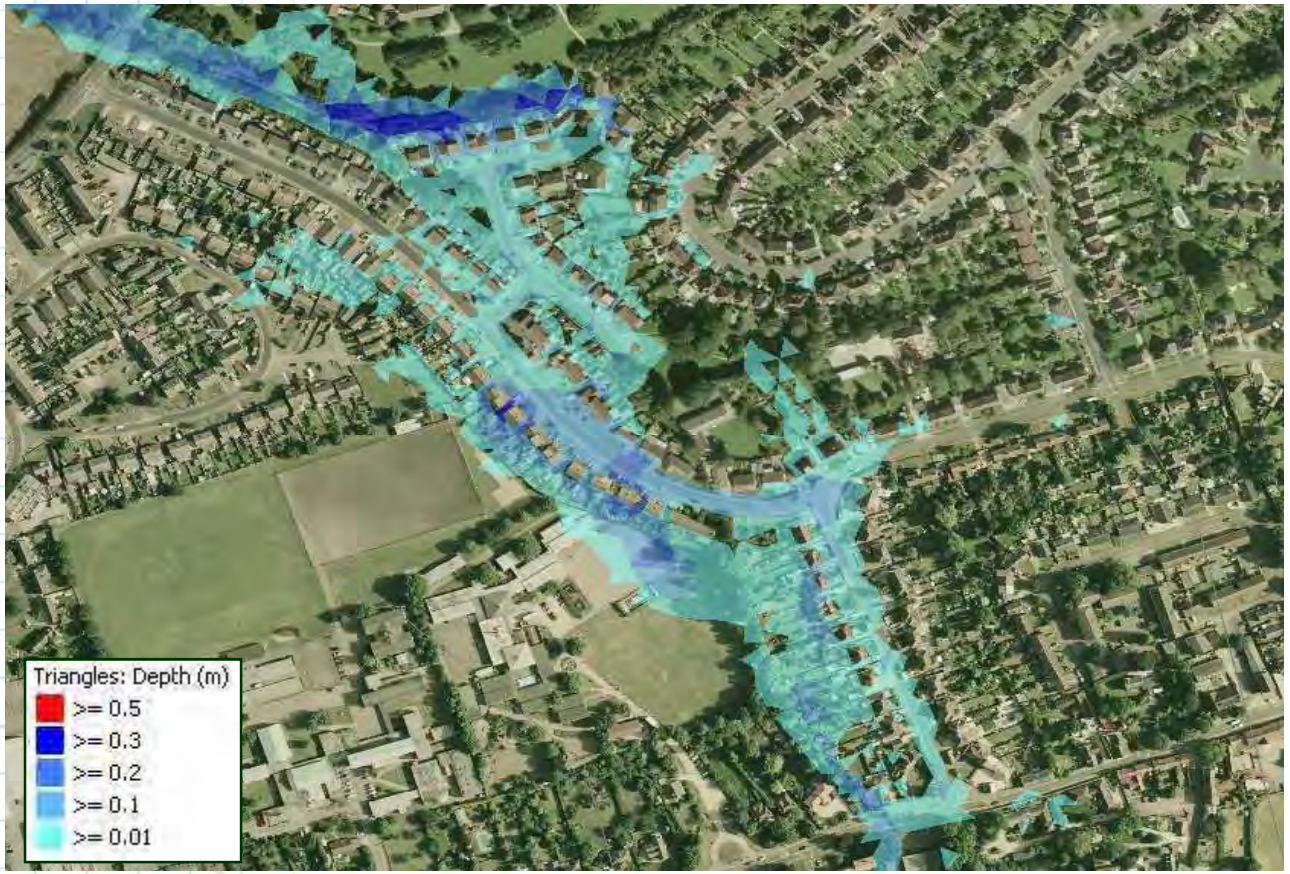


GIS Layers



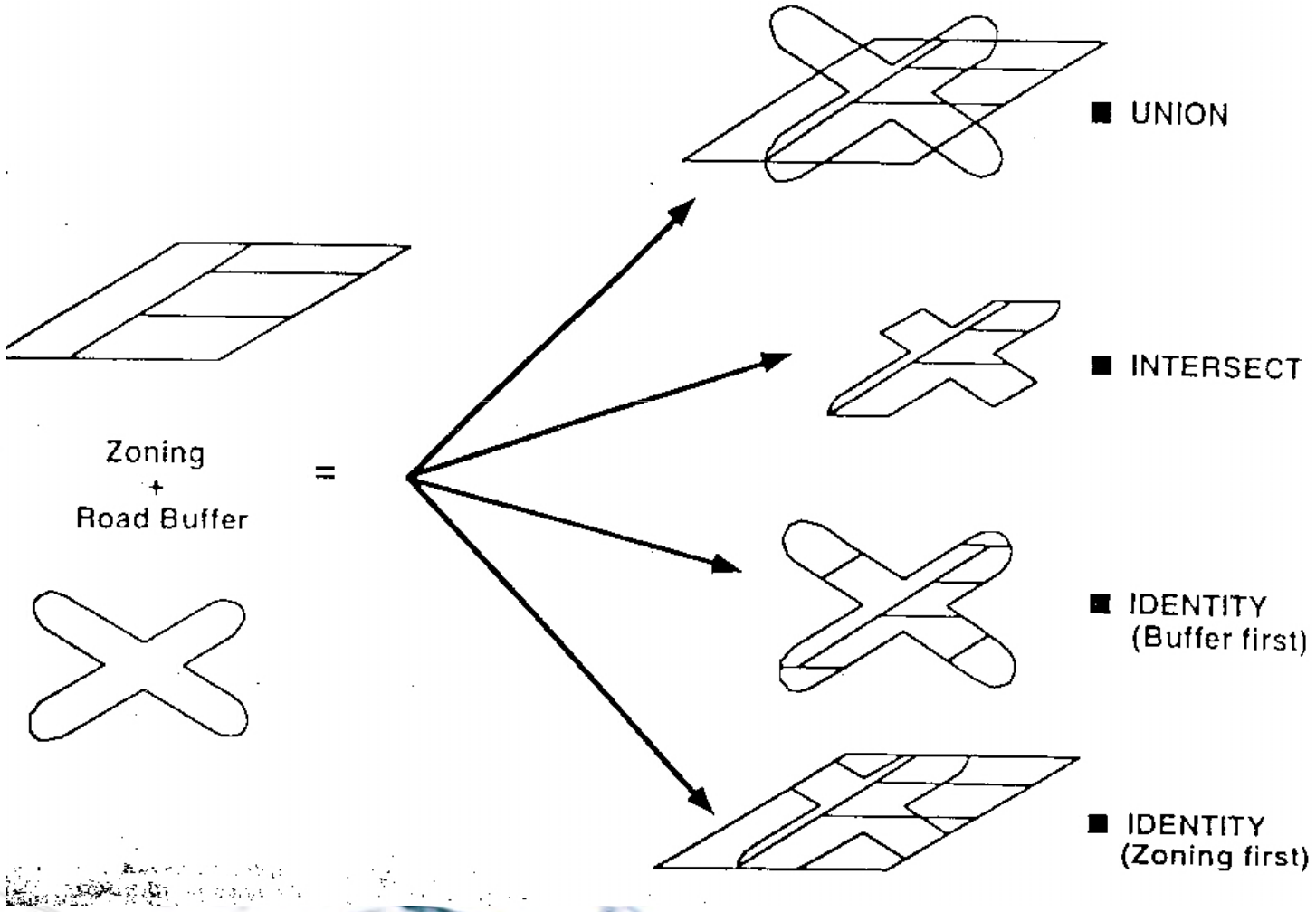
- GIS allows multiple layers of information to be displayed on a single map (eg. Landuse, soil type, Thiessen polygon).
- One of the main features of contemporary GIS
- Layers facilitates representation of real world.

Overlay Analysis



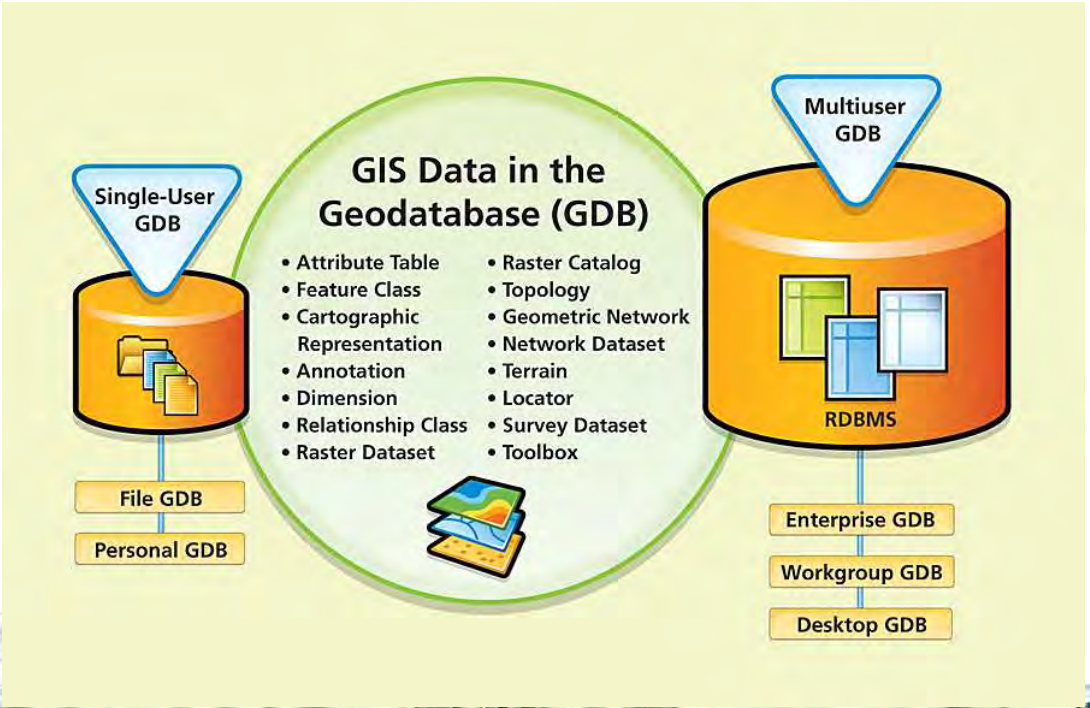
Superimposing two or more maps registered to a common coordinate system, to show relationships between features in the same study area.

Overlay Analysis



Geodatabase

The geodatabase is the common data storage and management framework which combines "geo" (spatial data) with "database" (data repository). Geodatabase associate data management capabilities to leverage spatial information.



Geodatabase

- Fully Relational Data Base Management System (RDBMS);
- Facilitates Relationships, Query, Report;
- In-built Attribute dataset, feature class;
- Provides flexibility to GIS environment.

GIS Data Collection

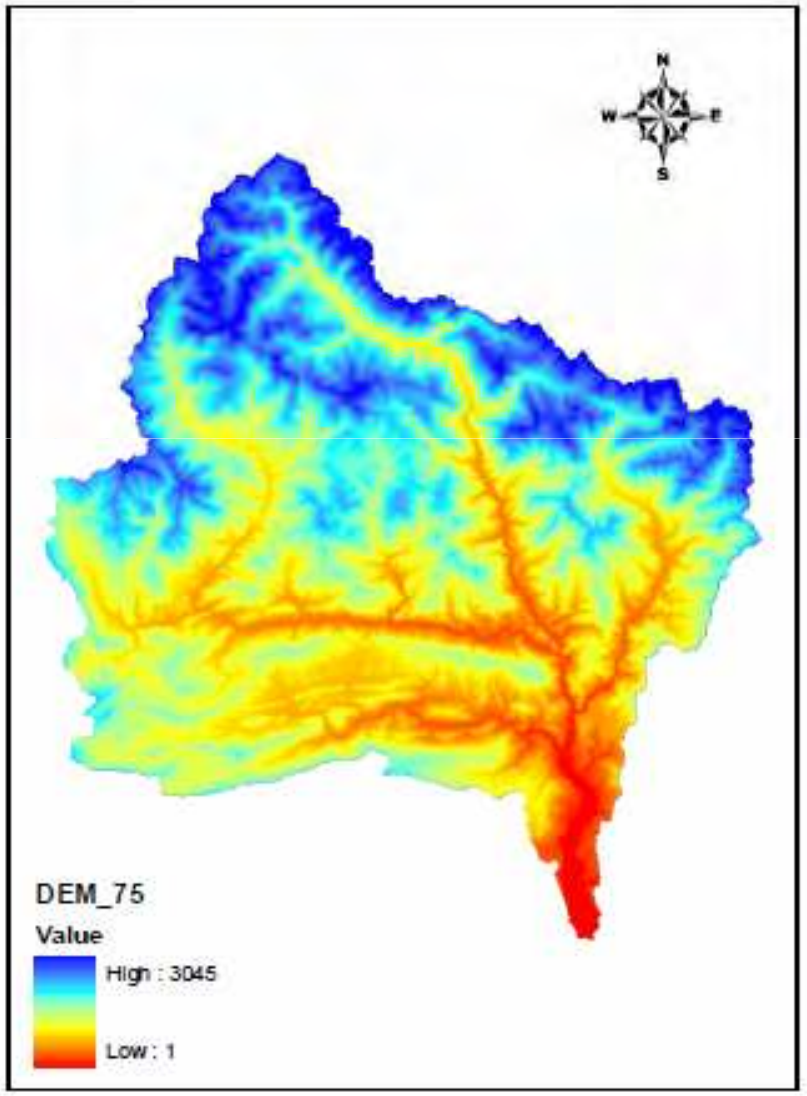
Primary Data: Collected directly from the field. Eg. Remote Sensing Data, Surveying Data, GPS, LiDAR.

Secondary Data: Collected from already published sources. Eg. Scanned maps, image, aerial photographs (raster).

GIS Applications

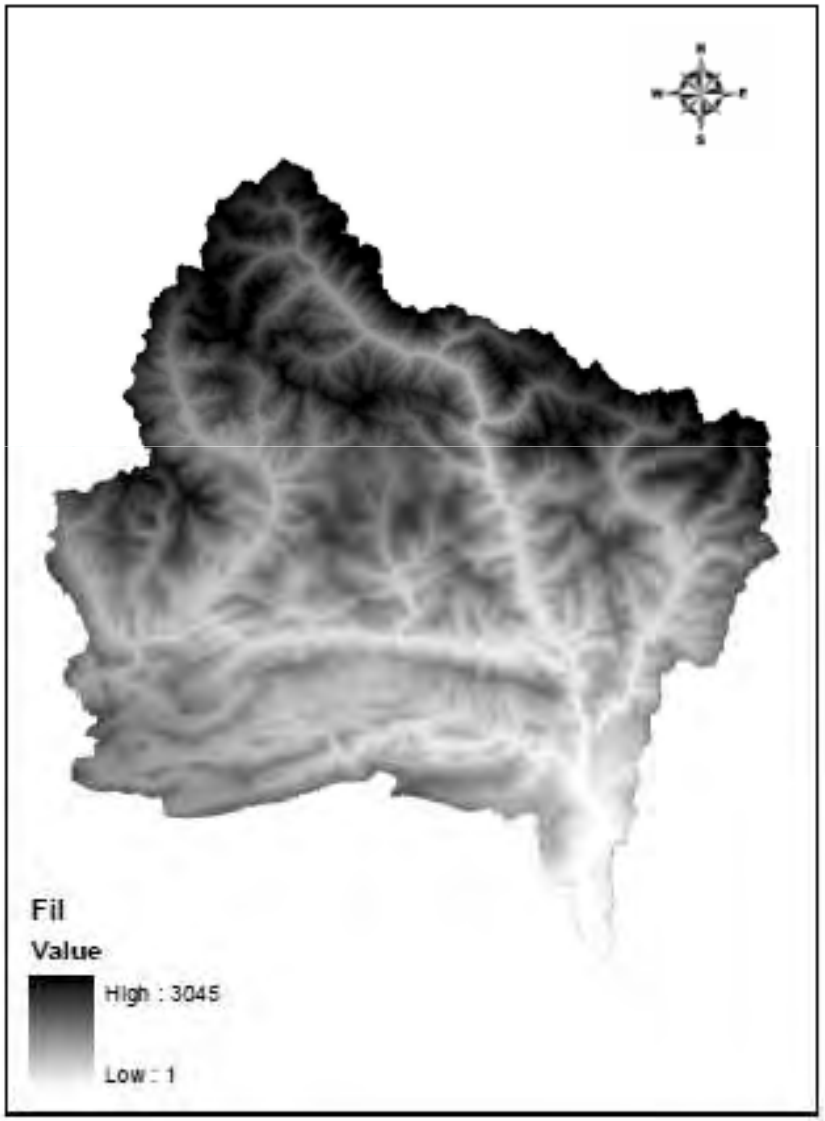
- Environmental assessment
- Forestry and wild life tracking
- Waste land development
- Water resources management
- Land use and thematic mapping
- Facility management
- Urban and town planning
- Defence
- Land Information Systems
- Business and retails

GIS Watershed Analysis



Digital Elevation Model (DEM): is a digital model or 3D representation of a terrain's surface — created from terrain elevation data.

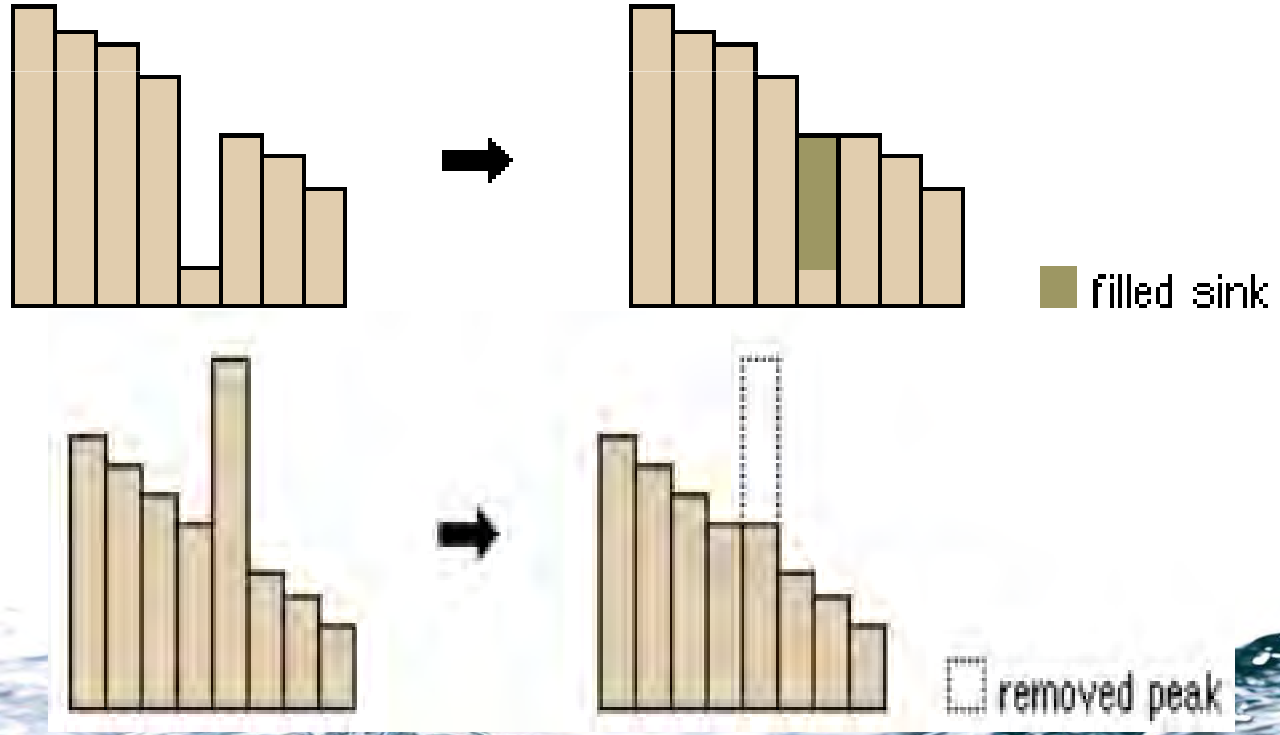
GIS Watershed Analysis



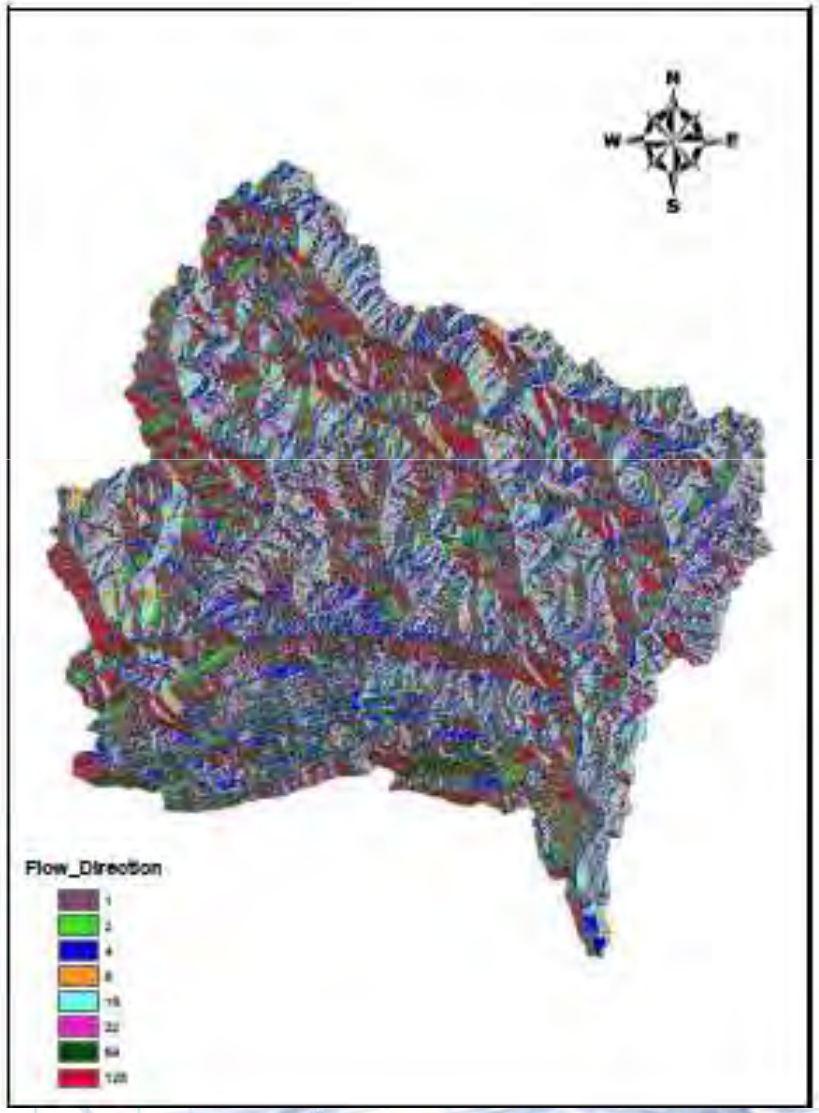
Fill Sinks: Sinks (and peaks) are often errors due to the resolution of the data or rounding of elevations to the nearest integer value.

GIS Watershed Calculations

Fill Sinks: Sinks should be filled to ensure proper delineation of basins and streams. If the sinks are not filled, a derived drainage network may be discontinuous.



GIS Watershed Analysis



Flow Direction:

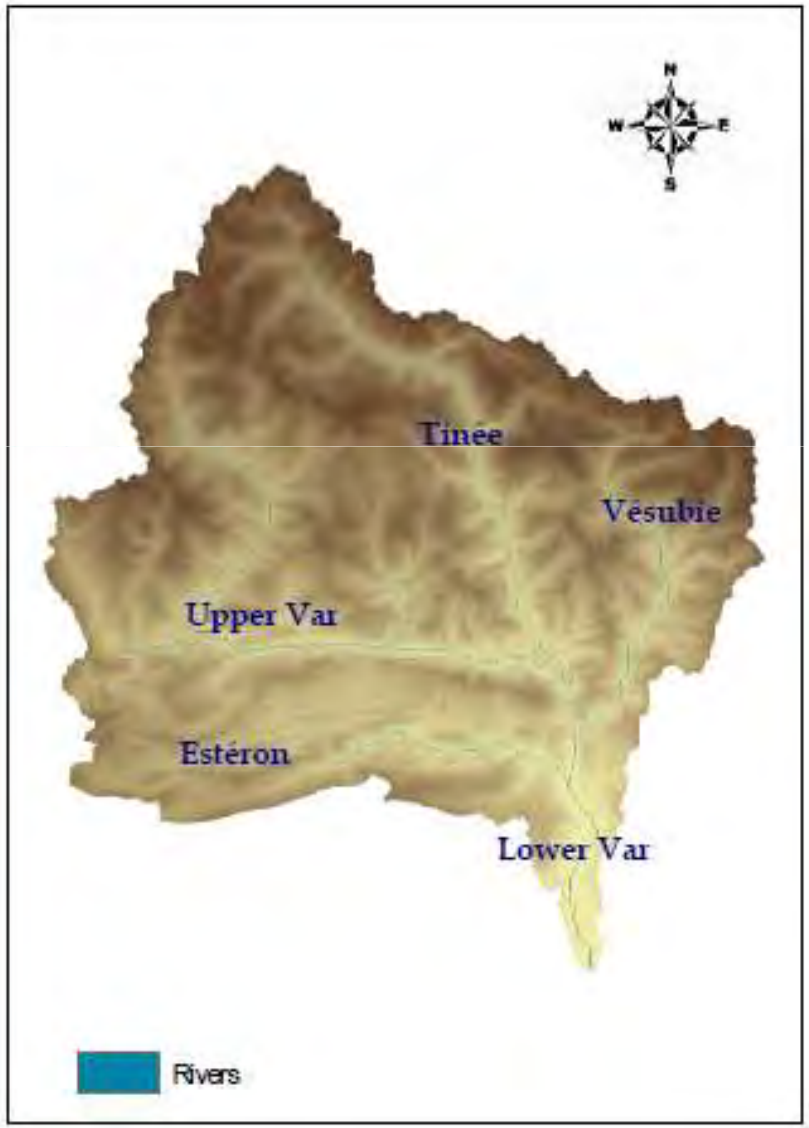
Flow direction tool permits to determine the flow behaviour depending on the height of the adjacent cells of a grid.

GIS Watershed Analysis

Flow Accumulation:

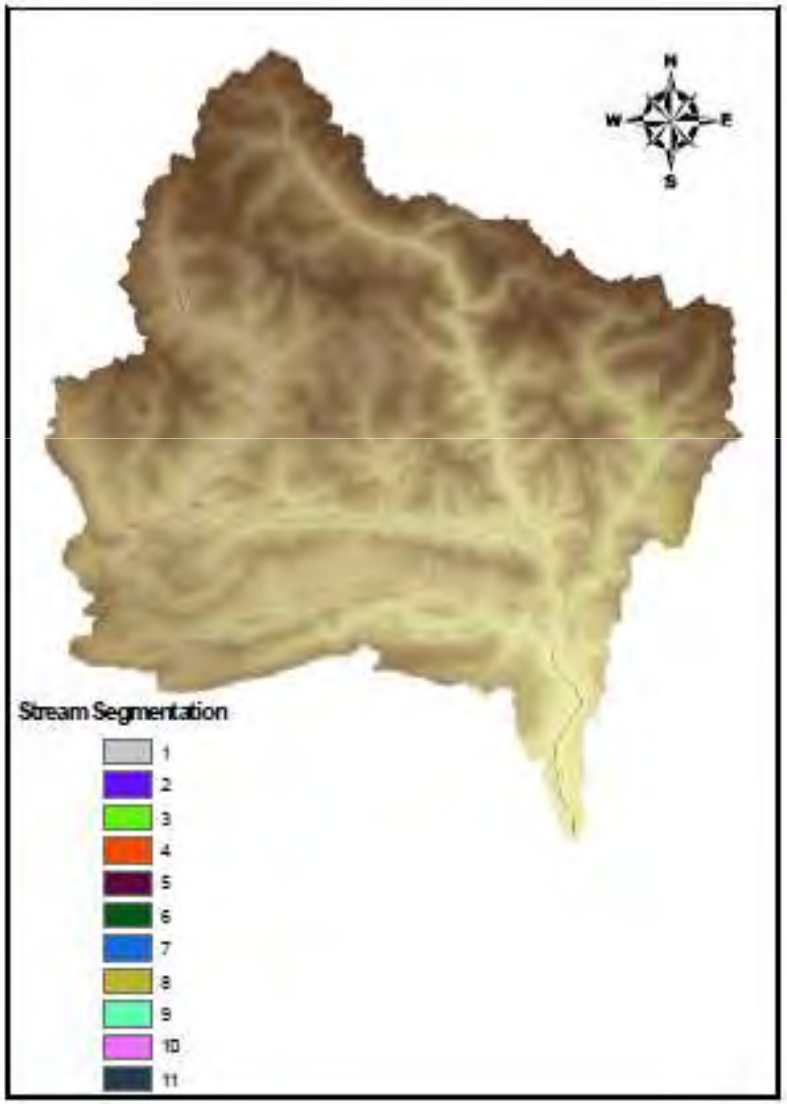
Calculates accumulated flow as the accumulated weight of all cells flowing into each downslope cell in the output raster.

GIS Watershed Analysis



Stream Definition: This generates a network with the main rivers. It assigns a value of 1 to the cells that contain a flow accumulation higher than a given threshold, while null value are provided to the cells with a lower accumulation flow.

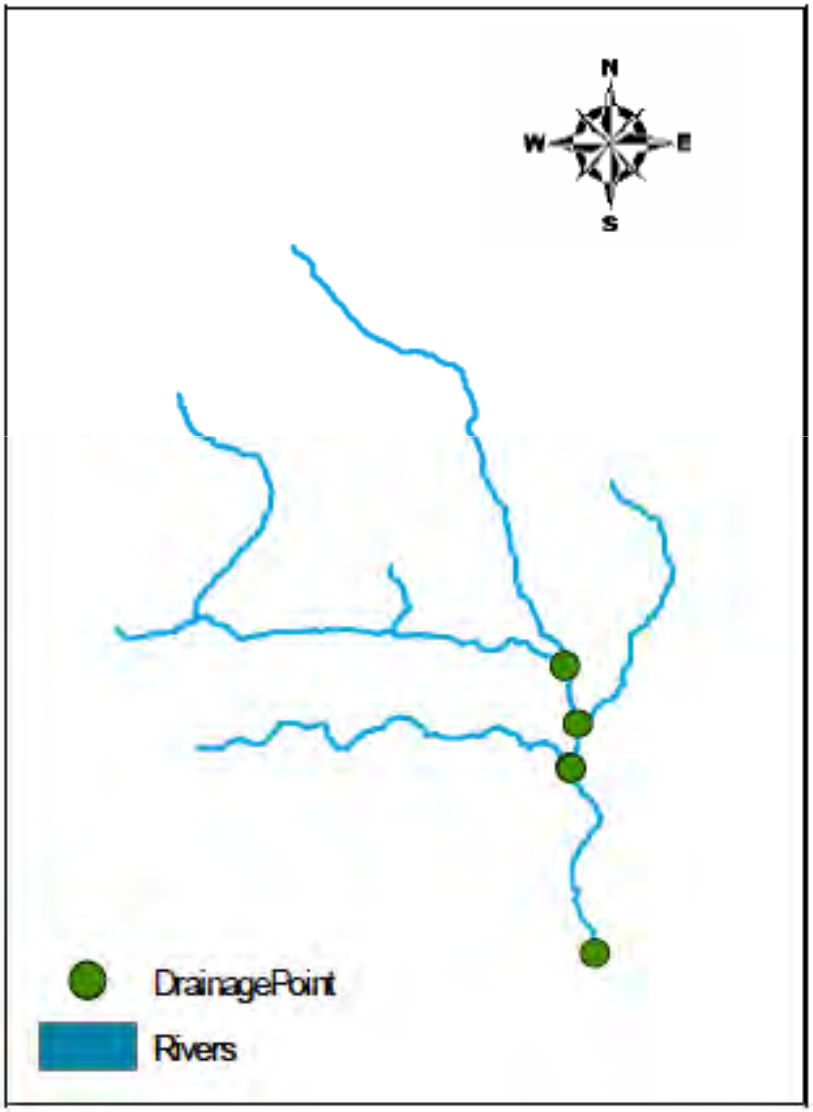
GIS Watershed Analysis



Stream Segmentation:

It creates a grid of stream segments, in such a way that all the cells with the same Grid Code compose one different segment

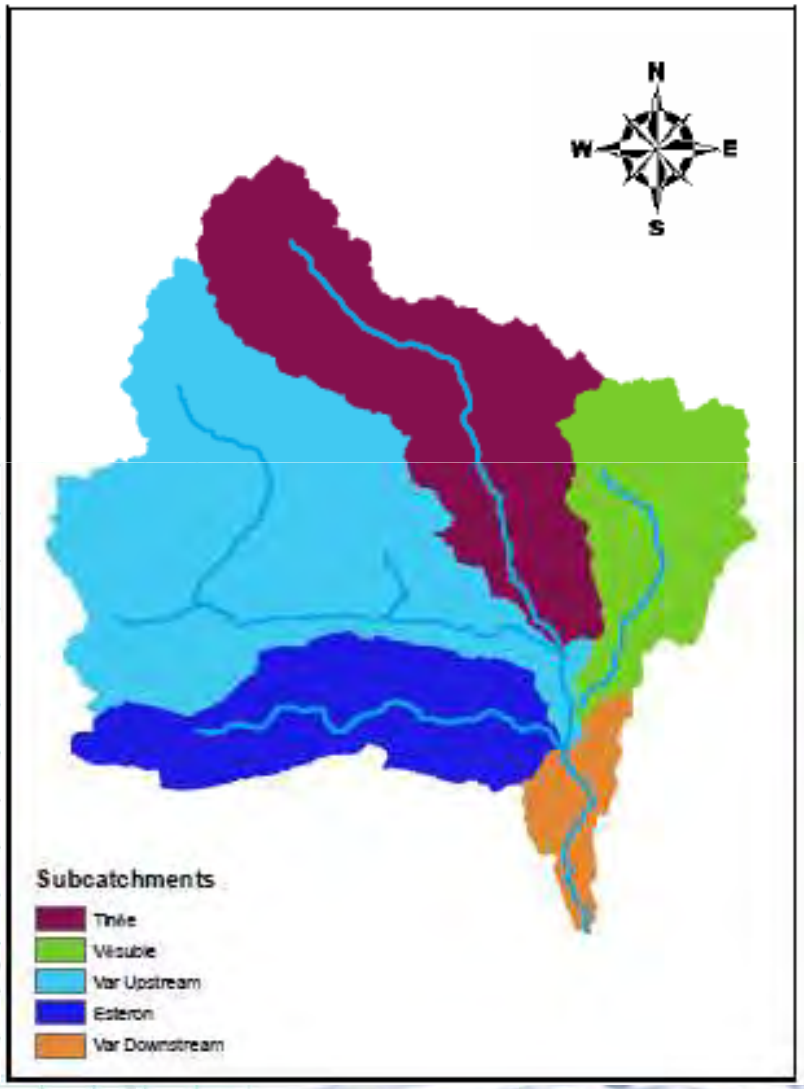
GIS Watershed Analysis



Drainage Point Location:

This function allows to identify drainage point at the most downstream point in the sub-catchments. This point contains the largest value in the flow accumulation grid.

GIS Watershed Analysis



Catchment Grid Delineation:

This function creates sub-catchment on the basis of drainage pour point & contributing area.

GIS Watershed Analysis

Subcatchment	Area (SqKM)	Longest path (km)	Mean Slope of the longest flowpath (%)	Lowest point (m asl)	Highest point (m asl)
Tinee	755.45	68.45	3.5%	257	2651
Upper Var	1091.43	83.74	3.2%	107	2805
Vesube	403.14	45.44	5.9%	140	2822
Esteron	459.43	59.96	2.8%	108	1800
Lower Var	162.97	36.65	3.7%	1	1341
Whole catchment	**2872.42**	**121.47**	**2.1%**	**1**	**2607**

MANY THANKS

Sunil KUMAR

April 24th 2015 – NWA, Pune