Bharathidasan University

Tiruchirappalli – 620 023, Tamil Nadu

M.Tech. Remote Sensing and GIS

Course : 24MTRS-05

GEOGRAPHIC INFORMATION SYSTEMS (GIS)

Unit-4 Surface Analysis, 3D Visualization and Network Modelling

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24MTRS-05: GEOGRAPHIC INFORMATION SYSTEM --- 4 credits

UNIT I **Basics of GIS** - Definition - Evolution of GIS - Geospatial, spatial and non-spatial data - Components of GIS - Computer Hardware, Software Modules and Organisational Context of GIS - Data Structure in GIS - Types of Data (Points, Lines and Polygons) - Data sources - Ground and remote sensing survey - Data Structures (Raster data structures and Vector data Structures) – Database Structures.. 12 Hrs.

UNIT II **GIS Data Input, Verification, Storage and Output** - Spatial Data Input Processes and Devices (Sources of data, - Different Types of Data Entry methods, viz., Manual input, Run length code, Digitization, Automated Scanning, etc. – Vector to Raster conversion - Raster to Vector conversion - Input devices) - Entry of non-spatial data – Linking of Spatial & Non-spatial data – Element generation - Geodatabase creation - Data Verification (Errors of different types) - Correction (Rubber Sheet Transformation, Bilinear interpolation, Cubic Convolution, etc.) - GIS capabilities for Data correction – Data output (Types of Output, GIS Capabilities for output, Output devices) - File formats for raster and vector. 14 Hrs.

UNIT III **Raster and vector data Interpolation and Analyses** - Raster data analysis: Local, neighbourhood and regional operations - Map algebra - Vector data analysis: Topological analysis, point-in-polygon, line-in-polygon, polygon-in-polygon - Proximity analysis: Buffering, Thiessen polygon - Non topological analysis: Attribute data retrieval and analysis – Concepts of SQL – ODBC - Basic Principles of Interpolation – Methods of Interpolation - Global Methods of Interpolation, Local Interpolation (Trend Surface Analysis) – Local Interpolation (Splines) - Optimal Interpolation (Kriging). 12 Hrs.

UNIT IV **Surface Analysis, 3D Visualization and Network Modelling** - Need for Three Dimensional Models - Methods of DEM & TIN - Products of DTM (Contour Maps, Shaded Relief Map, Maps Related to Slopes, Line Sight Maps, Drainage Analysis, Volume Estimation etc.) Usefulness of DEM/DTM. Overlay analysis, Capabilities (Point Operations, Regional Operations, Neighbourhood Operations) - Networking and Dynamic Segmentation – Applications, Minimum Distance Model, Maximum Covering Model (P-median model), Urban Transportation Planning Model. 14 Hrs.

UNIT V **Data Classification & Advanced GIS** - Principles – Types of Classification (Exogenous, Arbitrary, Idiographic & Serial) – Multivariate Analysis. Artificial Intelligence - Expert Systems - Object Oriented GIS - Web based GIS: Definition, merits - Architecture - Map server - Spatial data infrastructure - Spatial data standards - Free and open source - Proprietary GIS software. 12 Hrs.

UNIT VI **Current Contours – GIS - Case studies (Not for Final Exam; only for Discussion)** - Recent scientific and technological development, advancement, Industrial application and Job opportunities.

REFERENCES

1. Burrough, P.A 1986: Principles of Geographical information Systems for Land Resources Assessment, Clarandone Press, Oxford.
2. Avery, T.V,Interpretation of Aerial Photography Burgass, Publishing Company.
3. Gautham, N.C 1970: Urban Landuse Study Through Aerial Photo binterpretations Techniques, Pink Publishing House, Mathura.
4. American Society of Photogrammetry, 1983: Manual of Remote Sensing (2nd Edition), ASP Falls Church, Virginia.
5. Campbell, J 1984: introductory Cartography, Printers Hall Englewood Cliffs, N.J
6. Dent B.D 1985: Principles of Thematic Map Design, Addition - Wesley, Reading, Mass.
7. Freeman, H and GG.Pieroni 1980: Map Data Processing, Academic Press, New York.
8. Monmonier, M.A 1982: Computer Assisted Cartography - Principles and Prospects, Prentice Hall, Englewood Cliffs, NJ
9. Tomlinson, RF Calkins, HS and D.F.Marble 1976: Computer Handling of Geographic Data, UNESCO, Geneva.
10. Graeme F. & Bonham – Carter; Geographic information Systems for Geoscientists; Modelling with GIS, Pergamon.
11. Lo, C.P. and Yeung, Albert K.W., “Concepts and Techniques of Geographic Information Systems”, Pearson, 2016.

OBJECTIVE

To understand the fundamentals, data handling, analysis techniques, and advanced applications of Geographic Information Systems (GIS).

COURSE OUTCOMES

- The concepts of GIS, including data types, components, and data structures.
- Develop proficiency in GIS data input, verification, storage, and output processes.
- Gain knowledge in raster and vector data analysis, including interpolation methods and proximity analysis.
- Understand three-dimensional modeling, surface analysis, and network modeling techniques.
- Explore classification methods, AI integration, web-based GIS, and the use of open-source and proprietary GIS software.

Unit-IV

Surface Analysis, 3D Visualization and Network Modelling - Need for Three Dimensional Models - Methods of DEM & TIN - Products of DTM (Contour Maps, Shaded Relief Map, Maps Related to Slopes, Line Sight Maps, Drainage Analysis, Volume Estimation etc.) Usefulness of DEM/DTM. Overlay analysis, Capabilities (Point Operations, Regional Operations, Neighbourhood Operations) - Networking and Dynamic Segmentation – Applications, Minimum Distance Model, Maximum Covering Model (P-median model), Urban Transportation Planning Model. 14 Hrs.

DIGITAL ELEVATION MODELS

DEFINITION

- **DEM -** Three dimensional representation **of relief (elevation/topographic) variations** over space using digital data is called as **Digital Elevation Model.**

- **DTM -** Three dimensional representation of **attributes of landscapes** over space using digital data is called as **Digital Terrain Model.**

Digital Terrain / Elevation Models (DTM / DEM)

•The **Digital** Terrain Models (DTM) are the 3D perspective visualization of topographic / terrain features.

•These are created either through DEM (Digital Elevation Model) or TIN (Triangulated irregular networks).

•In GIS, DEMs are generated by fragmenting the area or theme into regular network of grids / pixels which have well defined x (longitude), y (latitude) and z (elevation or theme).

•So according to the elevations (altitude matrixes), the GIS create the 3D perspective image.

•When the attributes of landscapes (other than altitude) are visualized, these are called as Digital Terrain Models (DTM).

•Over these DEM or DTM, any type of theme can be overlaid and seen.

Need for Three Dimensional Models

- For locating regional / local artificial, synclinal, domal and basinal structures for resource modelling
- for understanding regional landscape architecture
- for geomorphic mapping and geo environmental planning
- water reservoirs and dam / petroliferous reservoir planning
- Volume estimation, work efficiency and time need calculations, etc.

- Mine planning, site selection of mine dumps and
- Mine reclamation
- Geohazards and Disaster Management
- i) Isostatic and fault movements
- ii) Landslides, Earthquakes
- iii) Mine pollution
- iv) Flood hazard zone mapping
- v) Coastal erosion / quantum of soil eroded
- vi) Salt water intrusion

DATA SOURCES FOR DEM

- i) Toposheets
  - Contour lines-Closed or open contour lines, mid/broken contours(shown with broken lines in SOI toposheets)
  - Spot heights – Bench marks (BM), Triangulation Points (Δ), spot elevation in plains.
- ii) Aerial Photographs
  - heights are measured from stereo models
- iii) Satellite stereo images – SPOT, CARTOSAT, …
- iv) RADAR DATA
- vi) LIDAR DATA
  - very high spatial resolution with a vertical accuracy of 15 cm
- vii) GPS DATA
- viii) Break lines
  - represents rapid changes in the land surface, e.g. Hill side Escarpments, Banks of Streams, -shorelines, -ridges, -roads …
- ix) Area data – water spread area of lakes and reservoirs.

Other Data sources for DEM

- Stereoscopic aerial photographs
  - DEM prepared using photogrammetric instruments
- Ground surveys – DGPS survey for higher accuracy
- SONAR (Sound Navigation and Ranging)
  - to understand Sea bed configuration
- **ERS** (European Remote sensing Satellite – ENVISAT Interferometry),
- **SRTM** (Shuttle Radar Topographic Mission),
- TERRA **ASTER** GDEM(Advanced Spaceborne Thermal Emission and Reflection Radiometer Global DEM),
- **GTOPO** (Global Topographic 30 Arc-Second DEM),
- **GLOBE** (Global Land One-km Base Elevation data),
- **ALOS** (Advanced Land Observing Satellite) ,
- **ETOPO** (Earth topography five minute grid) … are available for free download by the common users.

Data Sampling methods

- Photogrammetric Sampling
- Using aerial photographs in stereo-plotters the sampling is done
- In order to have correct relief and slope different type of sampling is done

1. Selective Sampling
    - Sample points are selected prior to or during sampling process
2. Adaptive Sampling
    - When redundant samples (carrying little information) need to be rejected during sampling

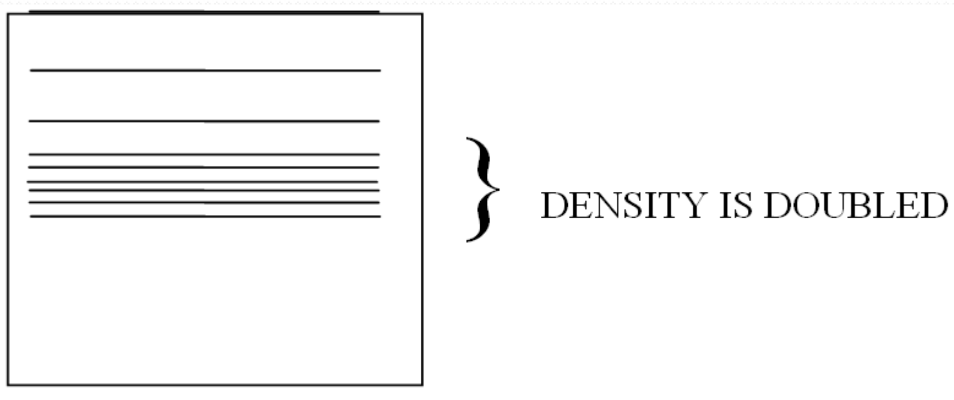
SAMPLING METHODS FOR D E M

3. **PROGRESSIVE SAMPLING**

- When sampling and data analysis are carried out together, the results of the analysis can dictate how the sampling should proceed. Steps involved are:

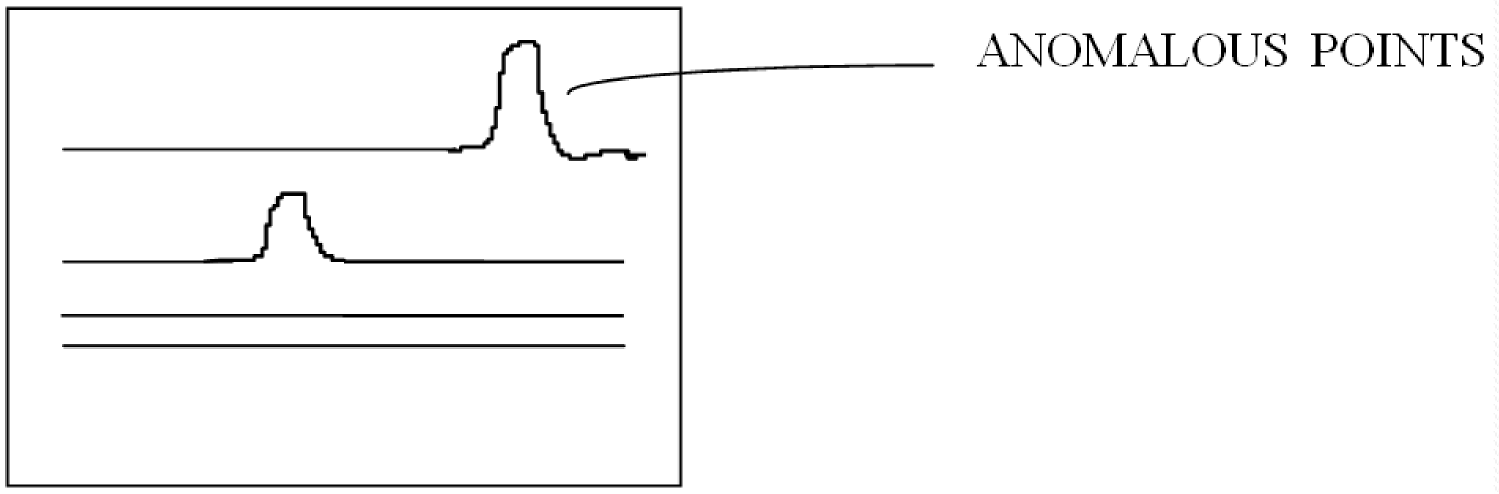
i) Series of successive runs are made first with coarser grid and then with successive finer grids

ii) This will be done automatically when the profiling proceeds



4. COMPOSITE SAMPLING

- Progressive sampling with removal of anomalous points – check for gaps and data dense areas-which is unnecessary there



Concepts of Monoscopic methods of Depth Perception

Distances to objects, or depth can be perceived monoscopically on the basis of

- Relative sizes of objects
- Hidden objects
- Shadows and
- Differences in focusing of the eye for viewing objects at varying distances with colour shades (bright at focus and dark in the other facets) and
- Sharp at focus & slightly blurring at others similarly.

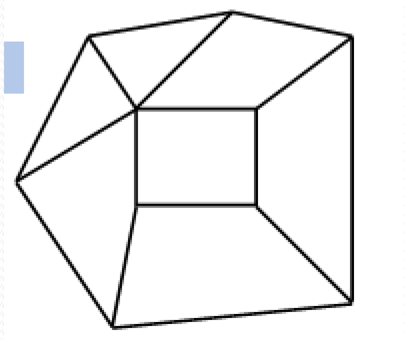
Concepts of Stereoscopic methods of Depth Perception

In combination of monoscopic parameters, the distances to objects, or depths can be perceived stereoscopically using **parallax differences** between same points / locations of objects seen in two or more images.

METHODS OF DTM GENERATION

- **MATHEMATICAL PATCH METHODS**

- Split the complete surface into square cells or irregularly shaped patches of equal area and fit to a point of observation
- Mathematical functions are used to weld them.



Methodology - Mathematical patches

Prepared on the basis of local method of spatial interpolation. The steps involved are:

- The surface area is split into square cells or irregularly shaped patches of roughly equal areas
- The surfaces are fitted to the point observations within the patch
- Weighting functions are used to ensure matching along the edges of surface patches, though not always seem to be continuous in slope along borders / break lines
- Mathematical functions using piecewise approximations for interpolating surfaces – useful in modeling complex surfaces in CAD systems - are adopted.

IMAGE METHODS

1. LINE METHODS

i) digitise the contours and add the attributes

ii) Identify the areas of equal inclination / increase/ decrease in values and make them as polygons and

iii) develop DTM

- ➔ output is too general

2. POINT METHODS

a) altitude matrices

i) develop grids

ii) identify the elevation of the grids from air photo using stereo plotters and develop altitude matrices and

iii) develop DTM

- ➔ grid size may vary for areas of complex relief and slope
- ➔ data redundancy in areas of uniform slope

3. Triangulated Irregular Network (TIN)

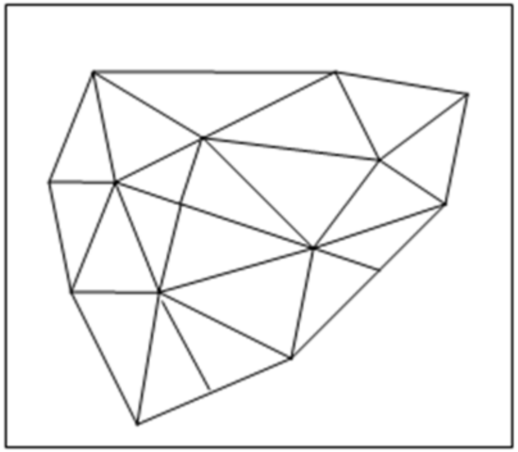
➔ Aerial triangulation - the process for determining the correct position and orientation of each surface in an area so they can be compiled into a triangles of equal slope / value

➔ develop network

➔ Develop altitude matrices

➔ Treat each and every Δ as polygon in vector

➔ Develop DTM



- Triangulation is done
- Elevations are identified
- DTM is prepared
- In tin each and every triangle is treated as "**<u>vector polygon</u>**"

TIN ...Contd...

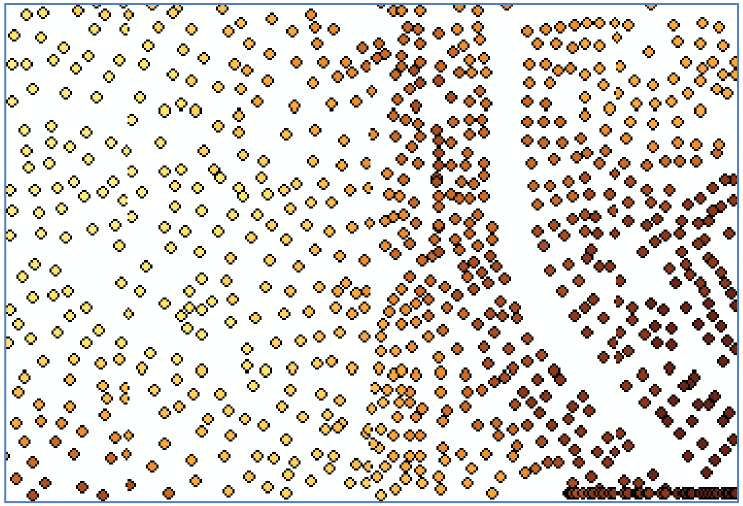
- Designed by Peuker and his co-workers – this avoids the redundancies of the altitude matrix
- More efficient for different types of computation (such as slope) than systems that are based only on digitized contours.
- This terrain model uses a sheet of continuous, connected triangular facets based on a Delaunay triangulation of irregularly spaced nodes or observation points.
- Unlike the Altitude Matrices, the TIN allows extra information to be gathered in areas of complex relief without the need for huge amounts of redundant data
- That is, a TIN is typically based on a Delaunay triangulation but its utility will be limited by the selection of input data points: well-chosen points will be located so as to capture significant changes in surface form, such as **topographical summits, breaks of slope, ridges, stream lines / valley floors, pits and cols.**
- These linearities can also be digitized as lines where topography is changing rapidly, called **“Break lines”**.
- After data capture along the above said important topological features – can be digitized with required accuracy.

TIN ….CONTD…….

- TIN – vector topological structure similar to the **fully topologically defined structure** for representing polygon networks
- With exception that it does not have to make provision for islands or holes
- Records the **nodes of the network** as primary database
- Topological relations are built into the database by **constructing pointers** from each node to each of its neighbouring nodes.
- The **neighbour list** is sorted clockwise around each node starting at north
- The world outside the area modeled by the TIN is represented by a **dummy node** on the reverse side of the topological sphere
- This dummy node assists with describing the topology of the border points and simplifies their processing
- The database consists of 3 sets of records: **Node list**, **Pointer list**, & **Trilist**
- In Node list – records identifying each node, coordinates, number of neighbouring nodes and the start location of the identifiers of these neighbouring nodes in the Pointer list
- Nodes on the edge of the area have a **dummy pointer** set to **-32000** to indicate that they border the outside the world.

CREATING TIN SURFACES FROM VECTOR DATA

TINs are usually created from a combination of vector data sources. You can use point, line, and polygon features as input data for a TIN.

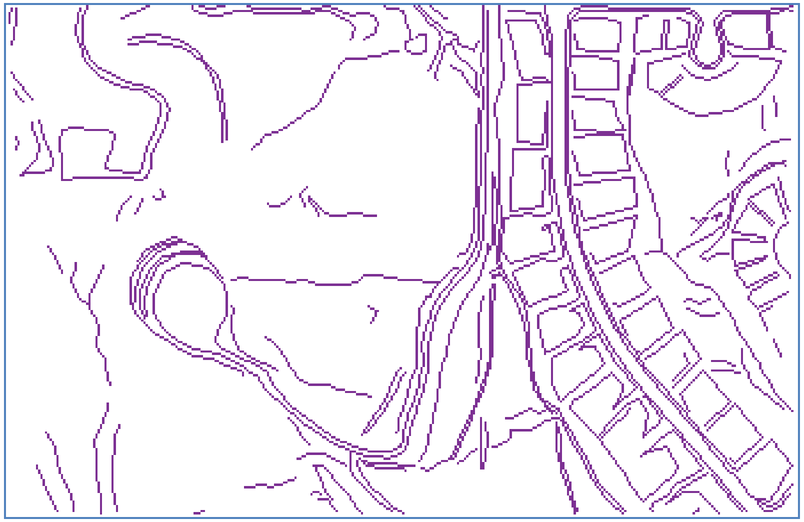


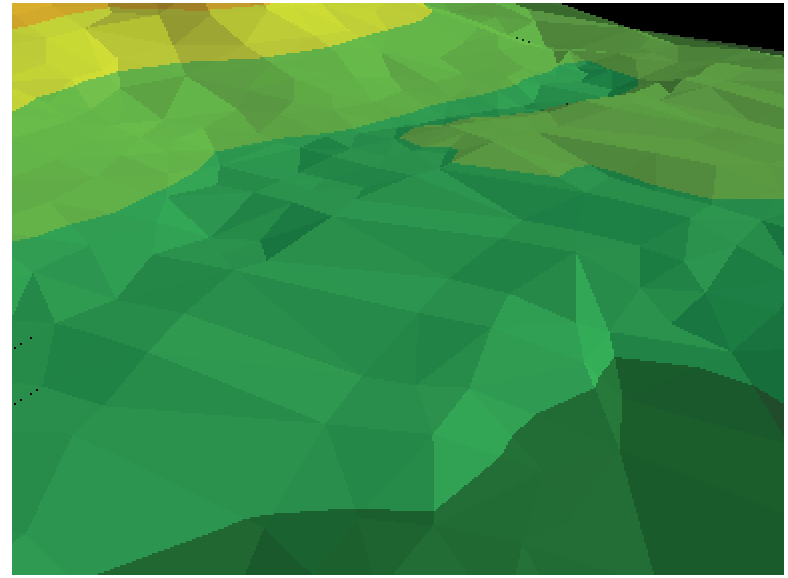
Mass points, are categorized by height attribute values.

Breaklines

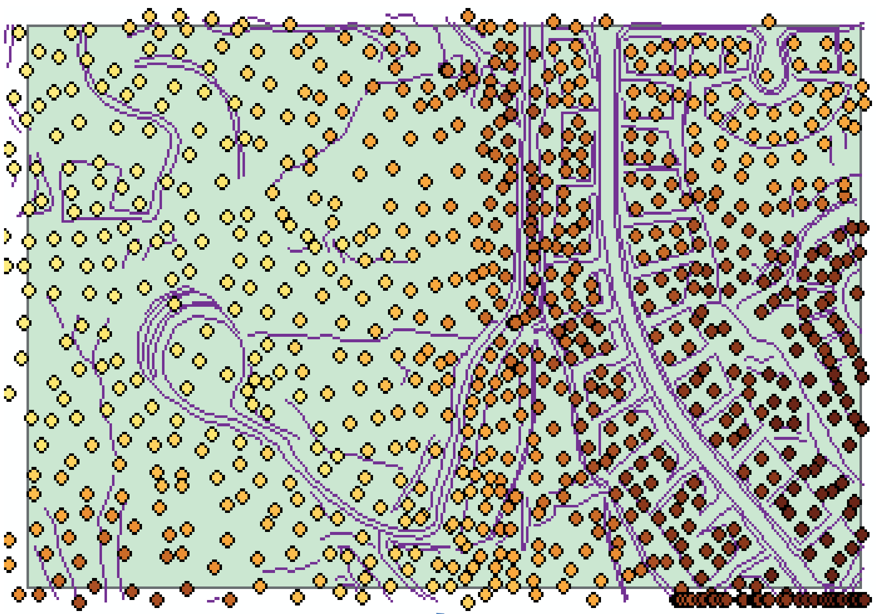
are lines with or without height measurements.

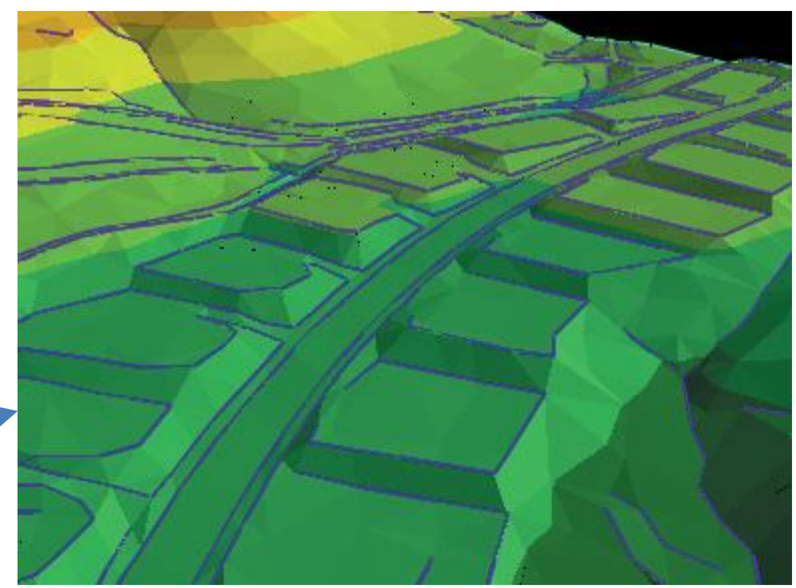
Breaklines typically represent either natural features such as ridgelines or streams or built features such as roadways.





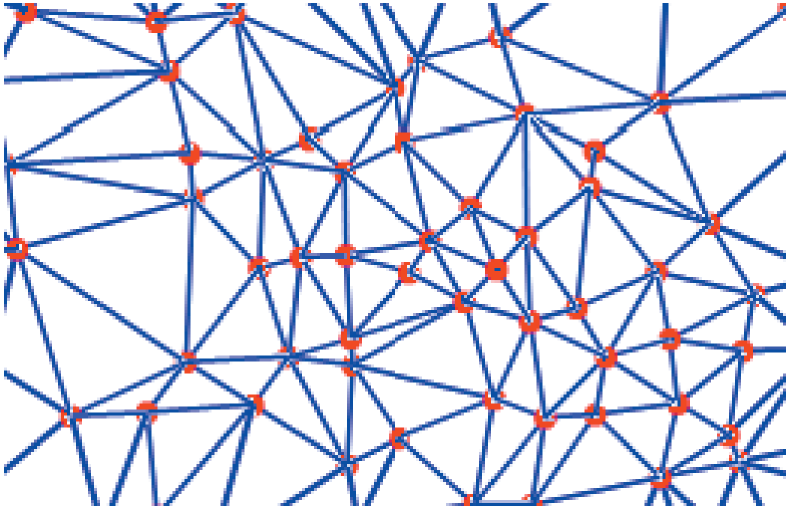
TIN created from mass points alone

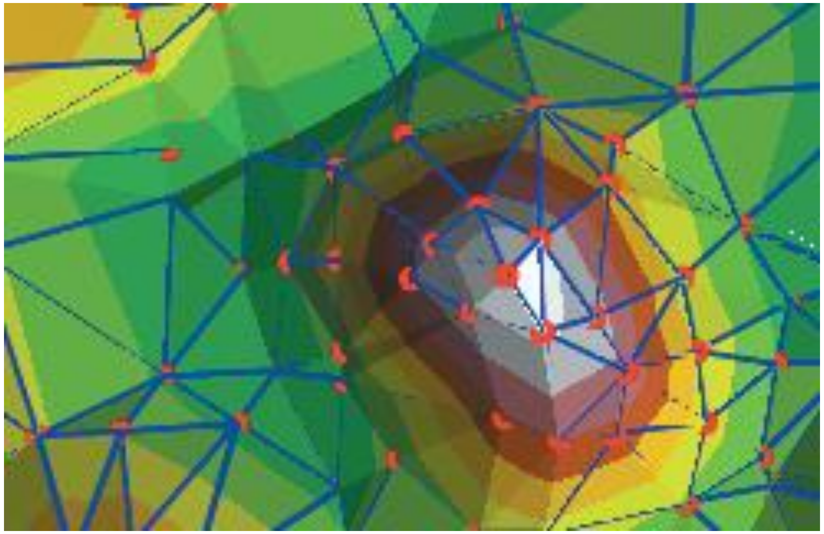




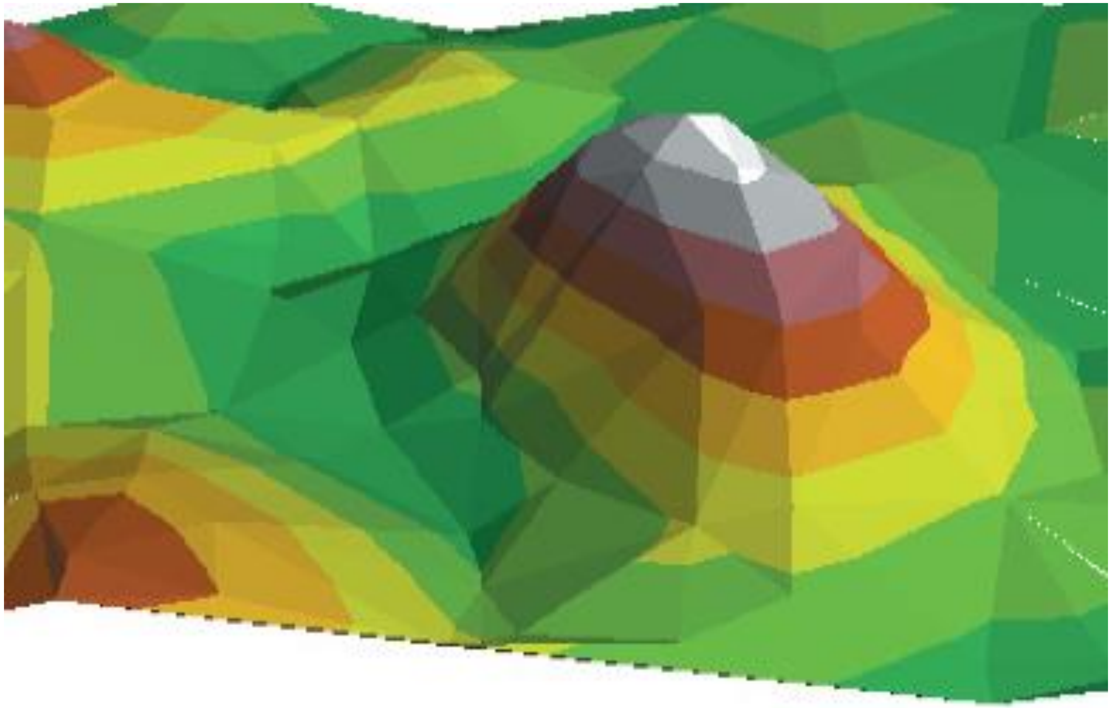
TIN of the same area created with more accuracy from the combination of both mass points and breaklines.

Nodes and edges of a TIN





TIN in perspective view



Vertical Exaggeration

Need for Vertical Exaggeration in 3D Visualization:

1. In spatial data, the z units are not always the x, y units of the coordinate system.

- For example, the **well** (dug / bore) features might be stored in UTM **meters** but have a **well depth** attribute in **feet**.
- To represent the wells correctly in 3D, the z-values must be converted to UTM meters.
- Otherwise, when the wells are seen in a 3D view, they will appear to be three times as deep as they really are.

2. In order to represent the flat topography / surface with enhanced elevation changes so as to highlight the subtle physical features that are there, vertical exaggeration is required.

Z-factor or Vertical Exaggeration Factor

The z-factor is a conversion factor that adjusts the units of measure for the vertical (or elevation) units when they are different from the horizontal coordinate (x,y) units of the input surface.

- It is the number of ground x,y units in one surface z unit. If the vertical units are not corrected to the horizontal units, the results of surface tools will not be correct.

- The z-values of the input surface are multiplied by the z-factor when calculating the output surface. If the x,y, and z units are all the same (in feet, for example), the z-factor is 1.

- This is the default value for the z-factor.

Z-factor … contd…

- For another example, if your vertical z units are feet and your horizontal x,y units are meters, you would use a z-factor of 0.3048 to convert your z units from feet to meters (1 foot = 0.3048 meter).
- The correct use of the z-factor is particularly important when the input raster is in a spherical coordinate system, such as decimal degrees.

- It is not uncommon to perceive the output from Hillshade to look peculiar if the input surface raster is not in a projected coordinate system.

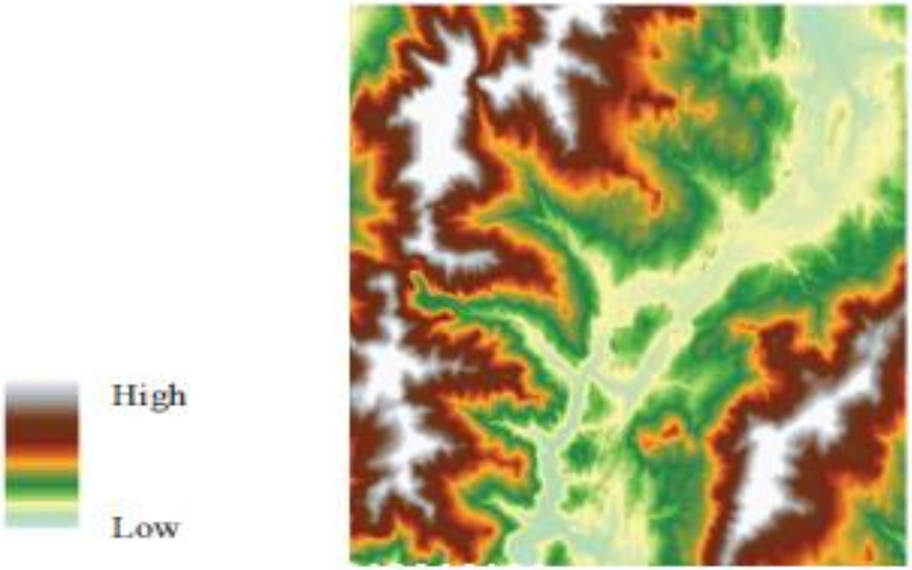
- This is due to the difference in measure between the horizontal ground units and the elevation z-units. Since the length of a degree of longitude changes with latitude, you will need to specify an appropriate z-factor for that latitude.

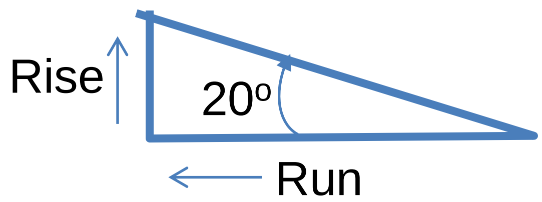
Products of DEM

1. Block diagrams, Profiles and Horizons
2. Anaglyphs
3. Volume estimation by numerical integration
4. Contour maps
5. Line of sight maps – Inter-visibility,
6. Maps of slope-radiance/degree, convexity, concavity and aspect
7. Shaded Relief Maps
8. Drainage Network and Drainage Basin / Watershed delineation
9. Drainage / Stream Orders, Flow length, Flow direction and Accumulation, etc.

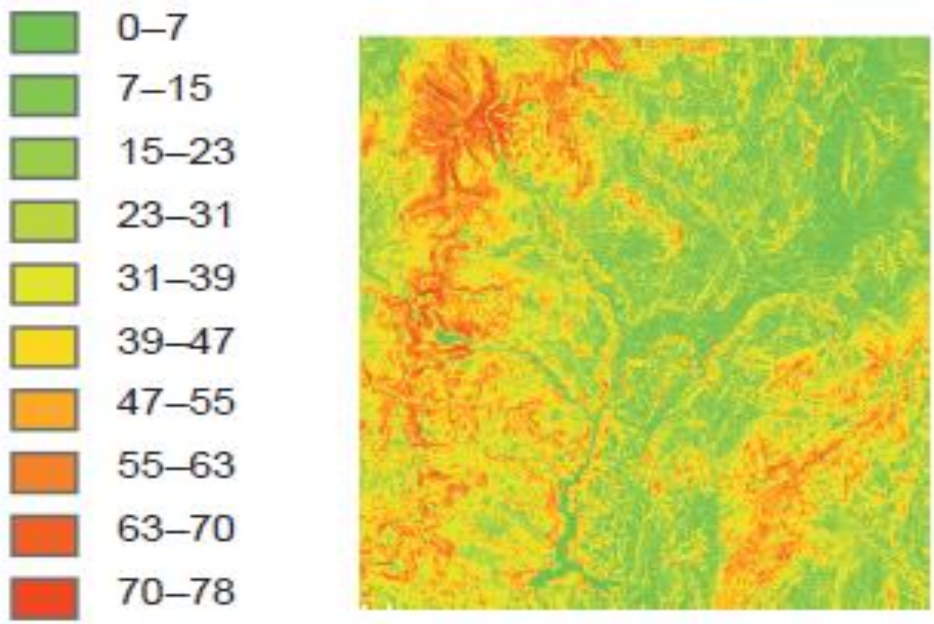
CALCULATING SLOPE

Elevation grid





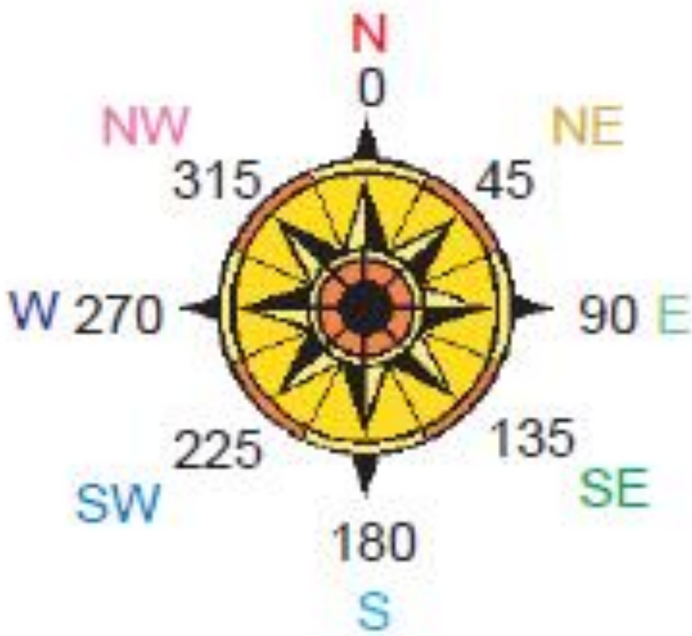
Slope in percent = 100 x (rise/run)

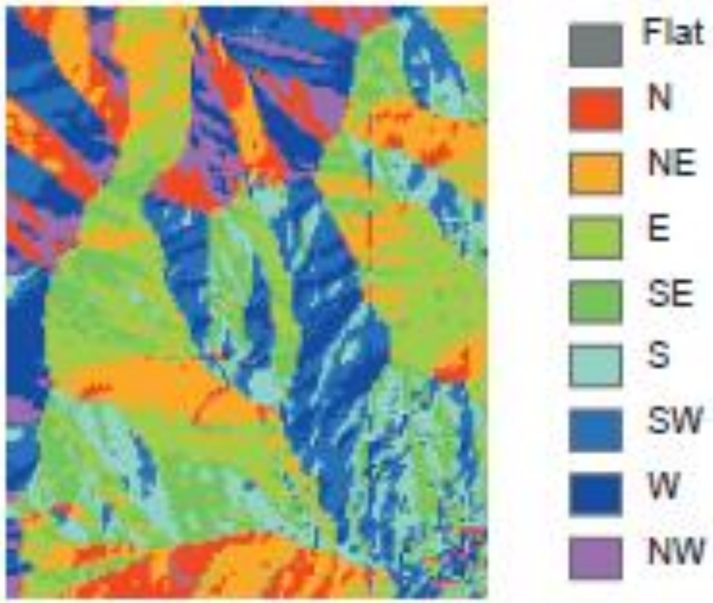


Slope map (in degrees)

CALCULATING ASPECT

Aspect is the direction that a slope faces





APPLICATION

Find all southerly slopes in a mountainous region to identify locations where the snow is likely to melt first, as part of a study to identify those residential locations that are likely to be hit by meltwater first.

Identify areas of flat land to find an area for a plane to land in case of emergency.

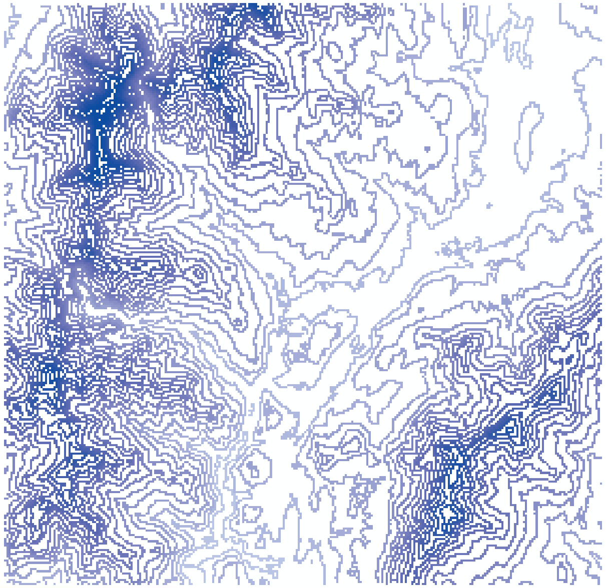
How to derive Slope, Aspect, geometry of slope?.....

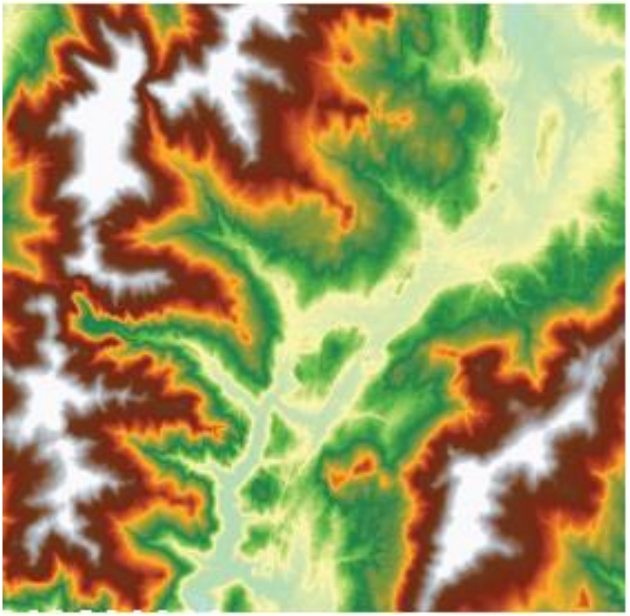
- All of the terrain / surface parameters (such as **slope** -the percentage or degree change in elevation over distance(degrees or percent), **aspect**-the direction (azimuth) that a surface faces, typically in degrees clockwise from North (0 degrees) and various slope geometries like **convexities** and **curvatures / plain / concavities**) are calculated by fitting a quadratic surface to the digital elevation data for the entered **kernel** size and taking the appropriate derivatives.
- The kernel size can be changed to extract multi-scale topographic information.
- **The slope degree is the convention of 0 degrees for a horizontal plane.**
- **The s/w measures the aspect angle with the convention of 0 degrees to the north (up) and angles increasing clockwise.**
- **The slope percent is the traditional percent grade and is calculated with the formula 100*rise/run.**
- **For example, a road that climbs 264 feet in a mile is a 5% grade (100*264/5280). To translate between slope in degrees and the percent just form 100*tan(<slope in degrees>).**

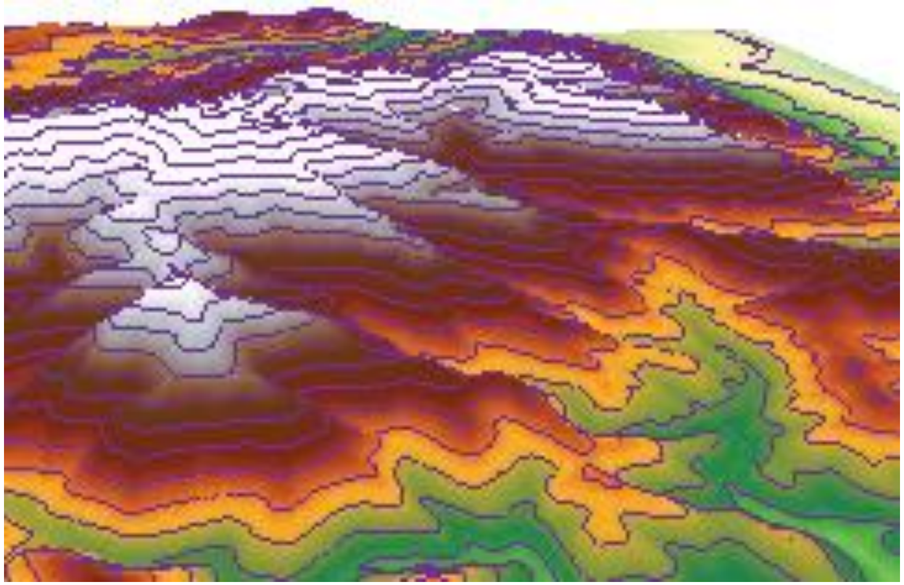
- For the convexity and curvature measures, convex surfaces are given positive values and concave surfaces are given negative values.
- The profile convexity (intersecting with the plane of the z-axis and aspect direction) measures the rate of change of the slope along the profile.
- The plan convexity (intersecting with the x,y plane) measures the rate of change of the aspect along the plan.
- These two surface curvature measures are in orthogonal directions with the profile convexity in the direction of maximum gravity effects and the plan convexity in the direction of minimum gravity effects.
- The longitudinal curvature (intersecting with the plane of the slope normal and aspect direction) and cross-sectional curvature (intersecting with the plane of the slope normal and perpendicular aspect direction) are also measures of the surface curvature orthogonally in the down slope and across slope directions, respectfully.
- The minimum and maximum overall surface curvatures can also be calculated.
- The programme also generates a root mean square (RMS) error image, which indicates how well the quadratic surface fits the actual digital elevation data.

Mapping contours and isolines

Contours are lines that connect points of equal elevation valuee
Isolines are the lines that connect points of equal values such as, temperature (isotherm), precipitation (isohyet), pollution (isopol), or atmospheric pressure (isobar)….





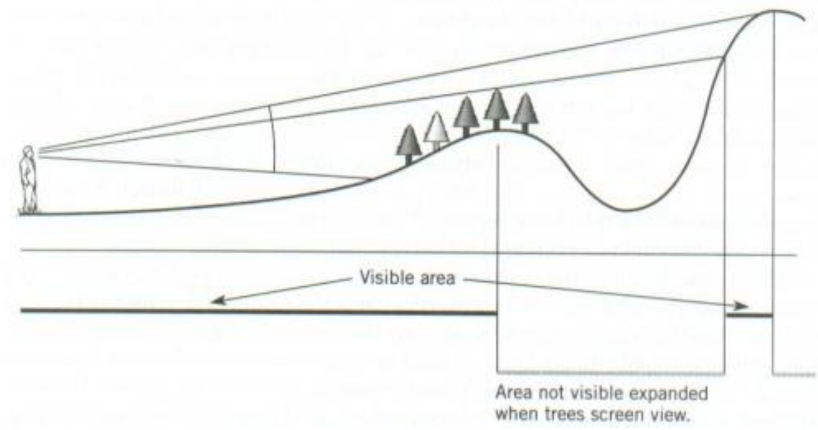


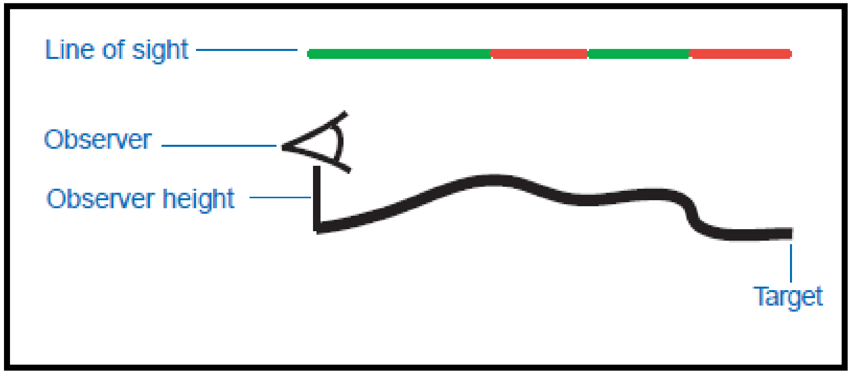
Analyzing visibility (line of sight)

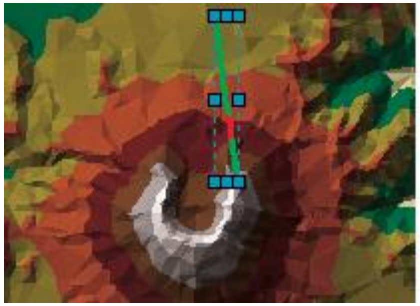
The shape of a terrain surface dramatically affects what parts of the surface someone standing at a given point can see.

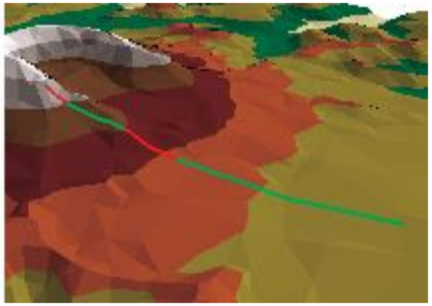
A *line of sight* is a line between two points that shows the parts of the surface along the line that are visible to or hidden from an observer

Application: real estate, the location of telecommunications towers, or the placement of military forces.









The visible segments are shown in green, and the hidden segments are shown in red.

What is the viewshed?

The viewshed identifies the cells in an input raster that can be seen from one or more observation points or lines

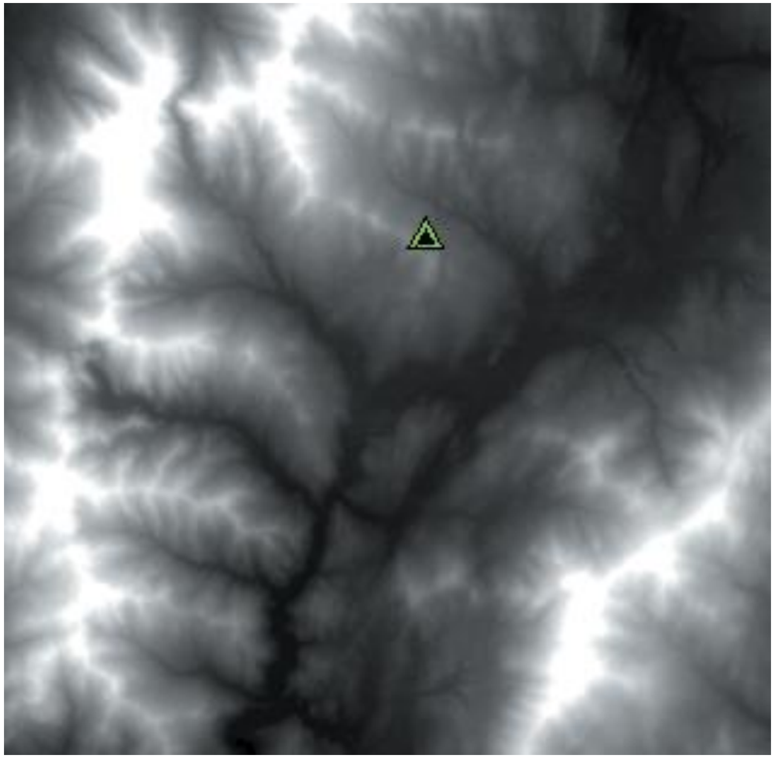
The viewshed is useful when you want to know how visible objects might be

For example, you may need to know "from which will be the best location to hold my advertisement board so that it can be visible from maximum places

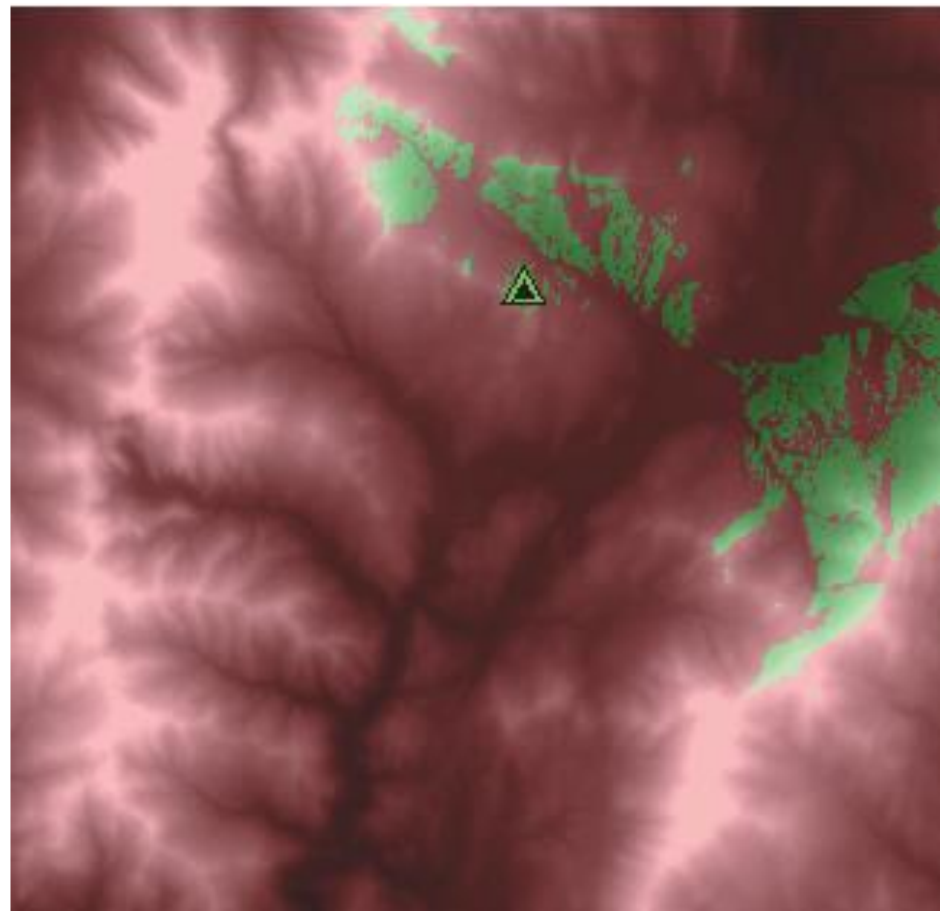
"What will the view from this road?

"Would this be a good place for a communications tower?"

the observation point is marked as a green triangle.

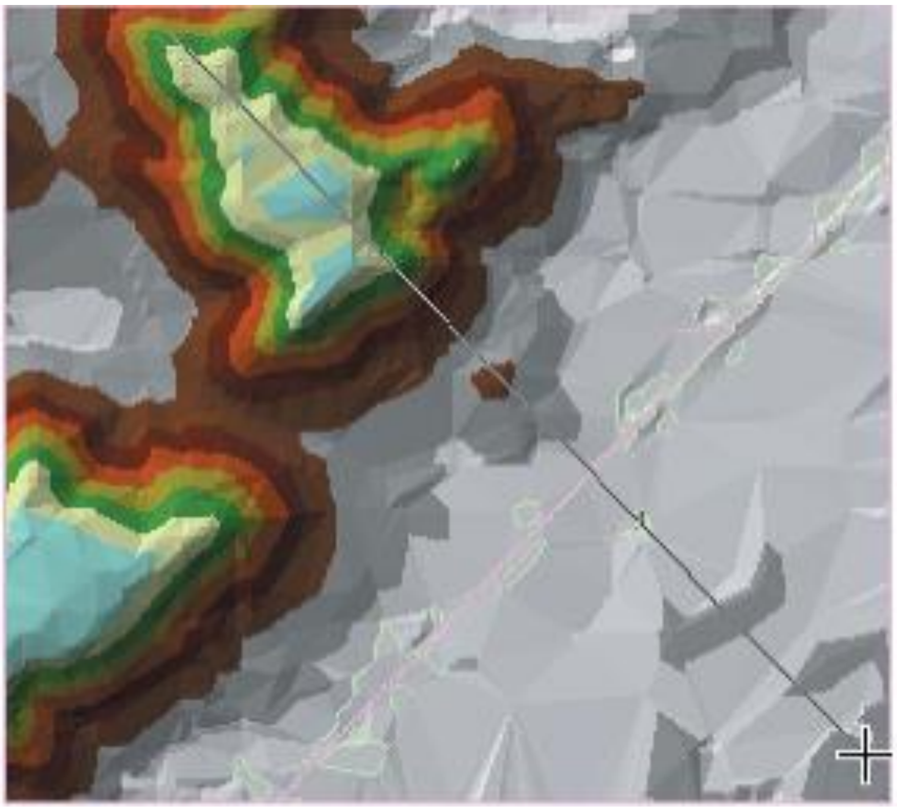


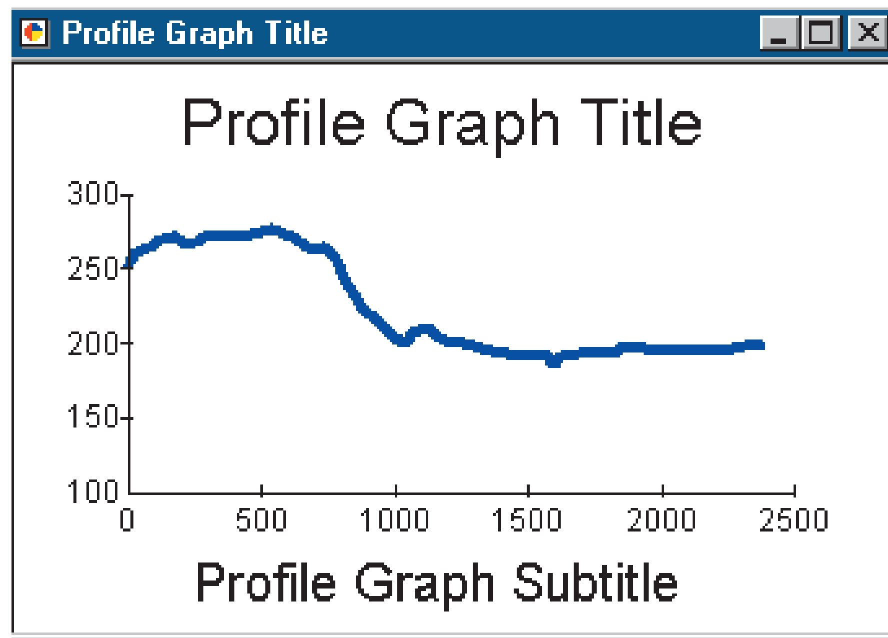
grid displays the height of the land (darker locations represent lower elevations), and the observation point is marked as a green triangle.



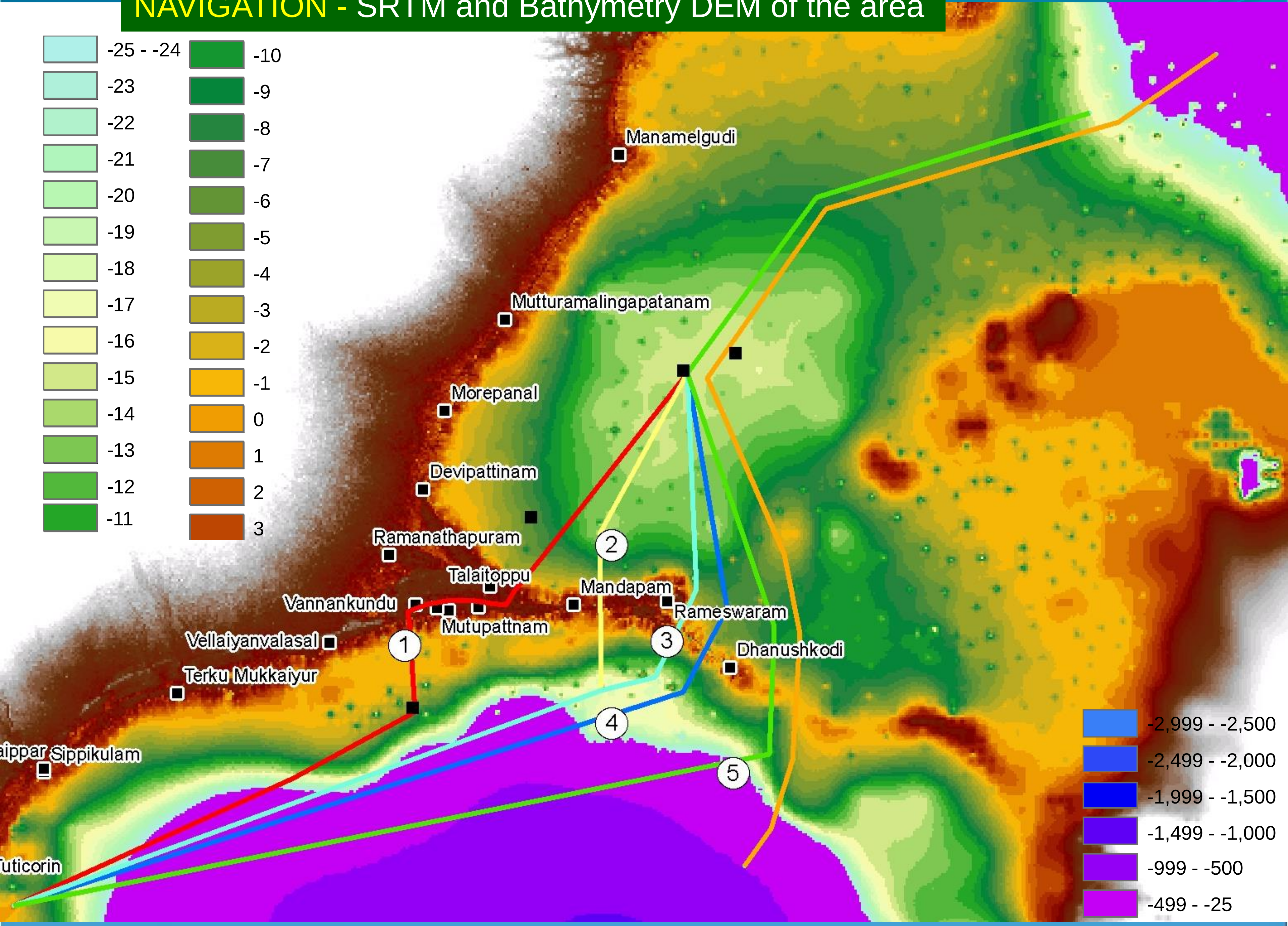
Determining height along a profile

Profiles show the change in elevation of a surface along a line. They can help you assess the difficulty of a trail or evaluate the feasibility of placing a rail line along a given route.

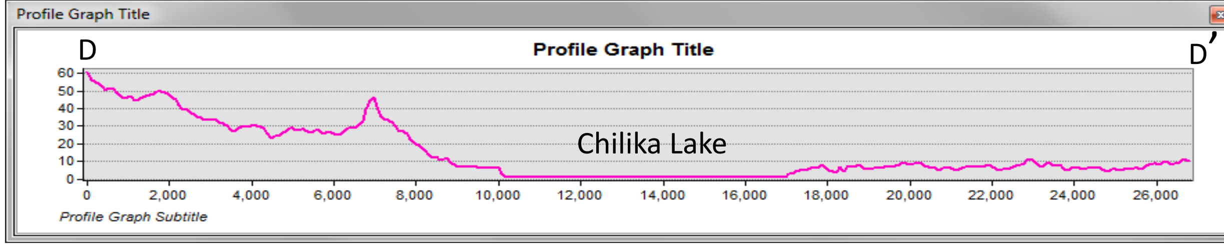


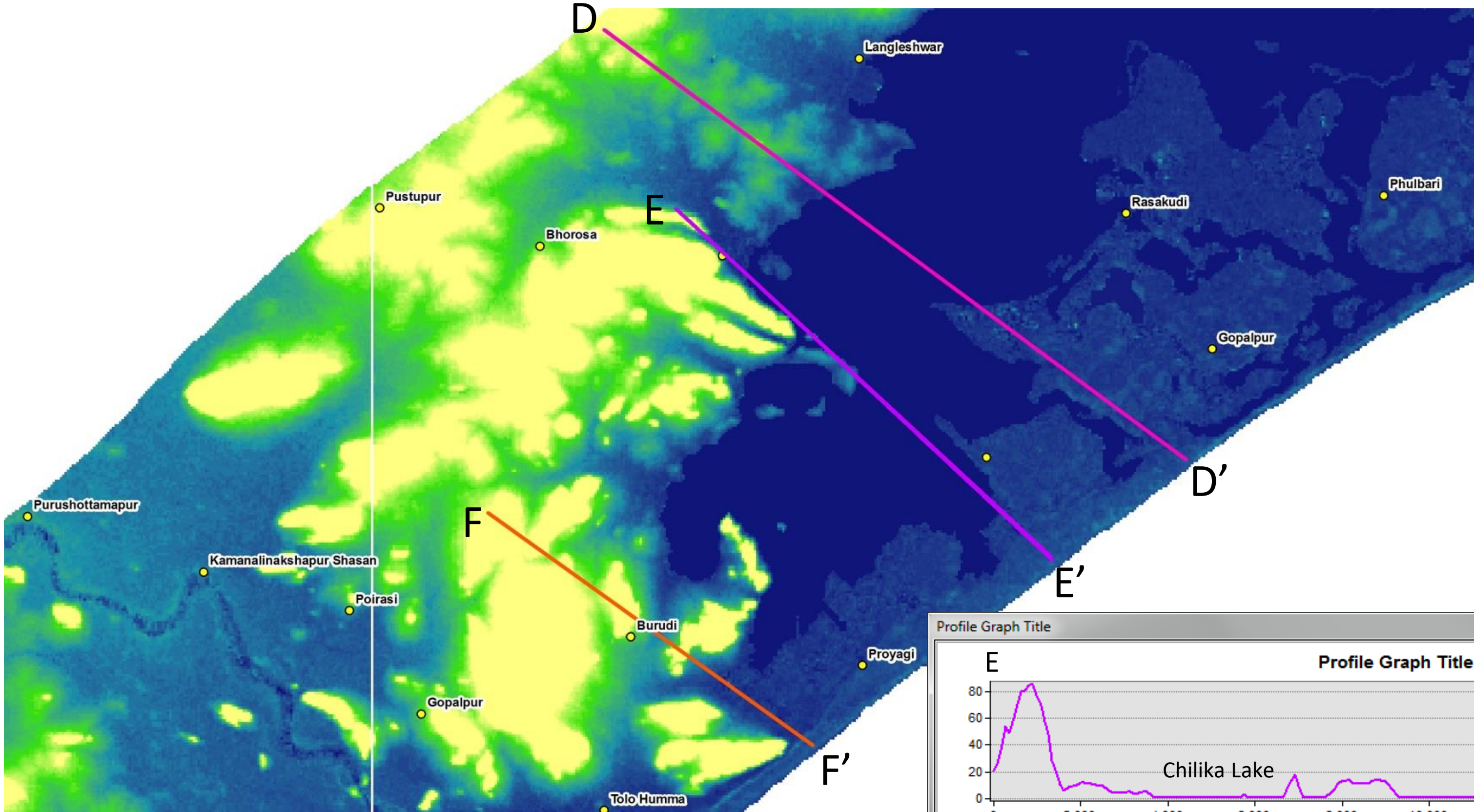


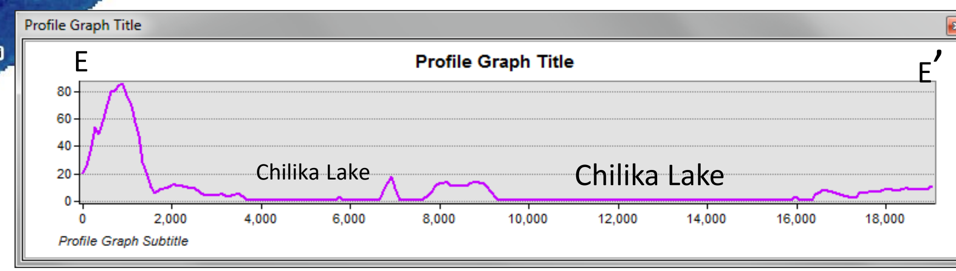
NAVIGATION - SRTM and Bathymetry DEM of the area

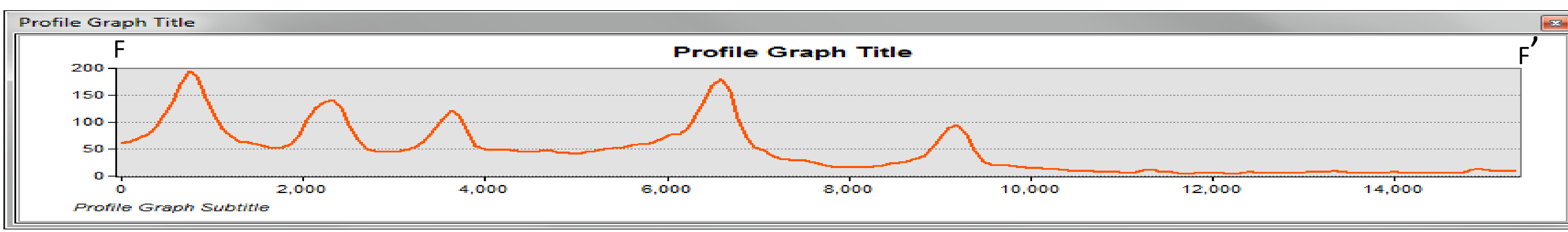


Vertical Profiles

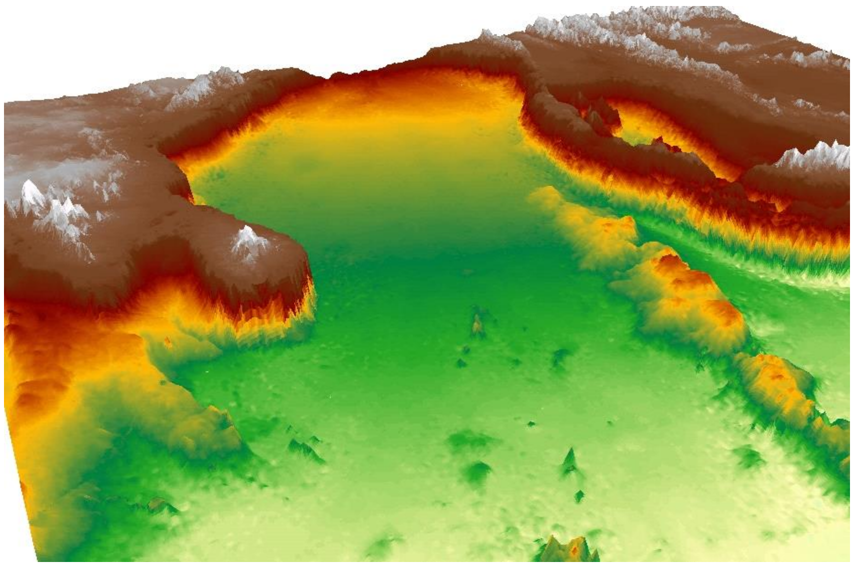


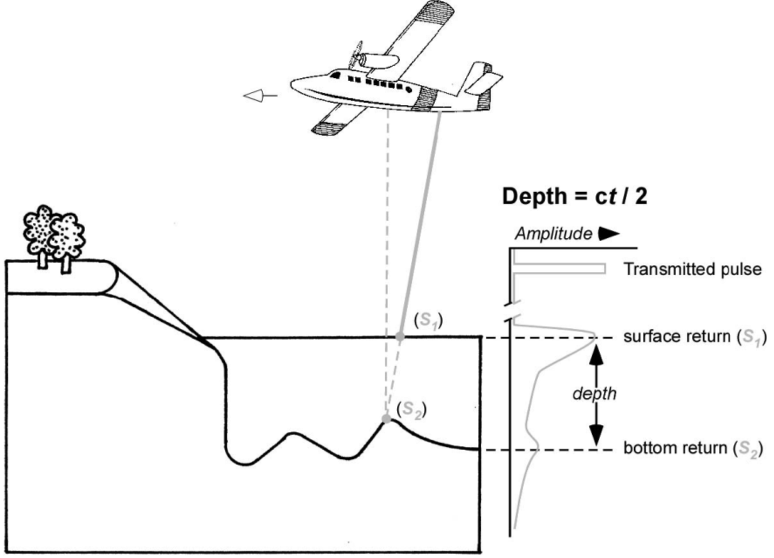


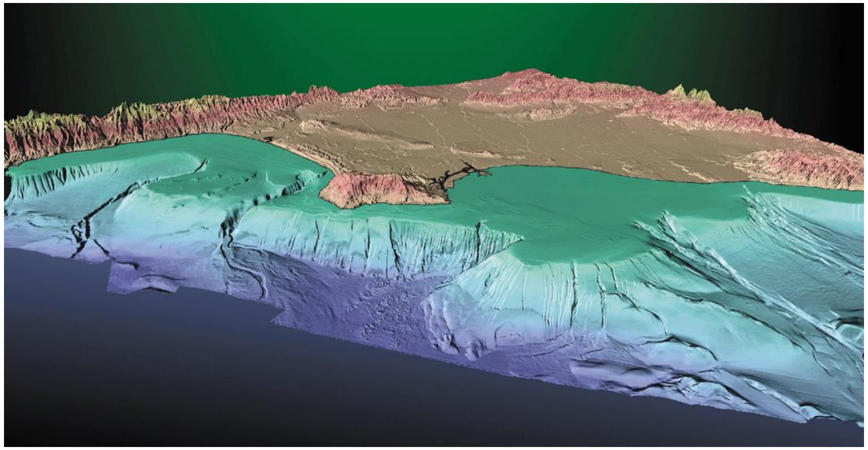




BATHYMETRY:



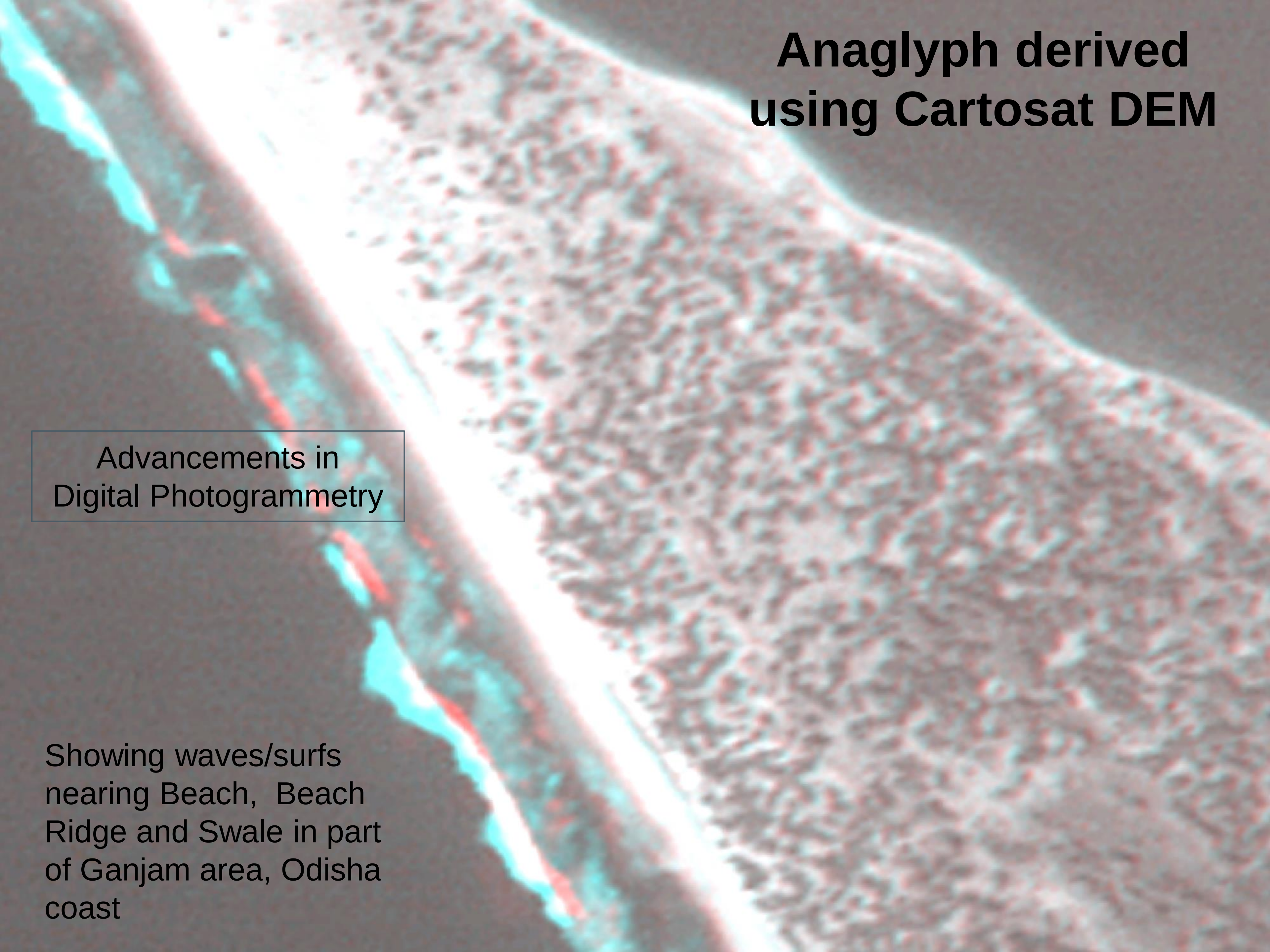




For any offshore structures including harbor development

Pipeline etc.,

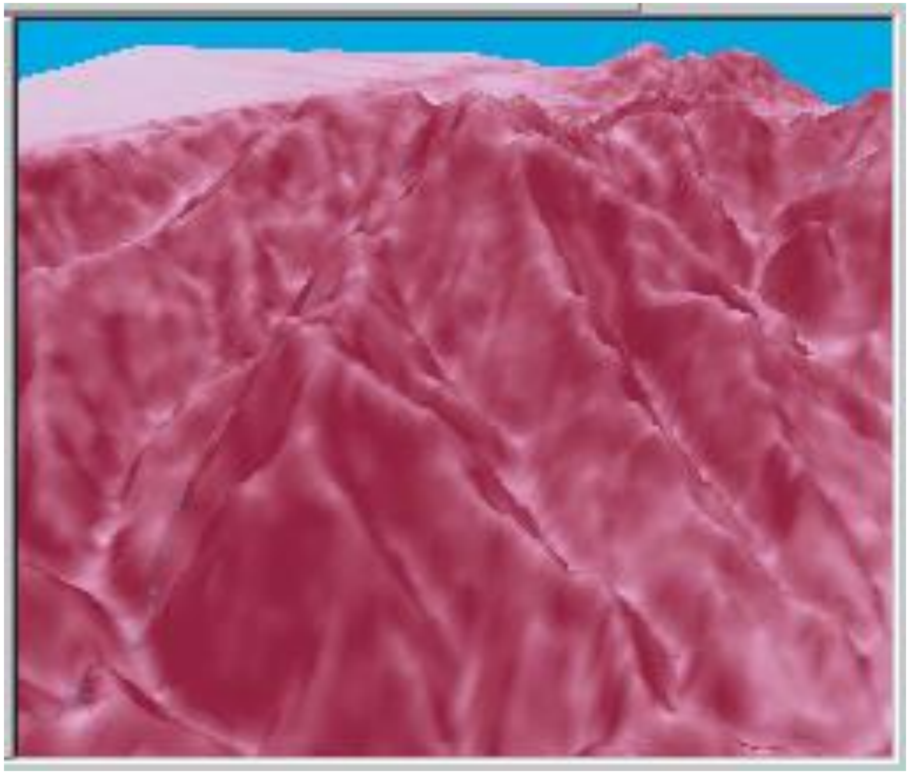
Anaglyph derived using Cartosat DEM

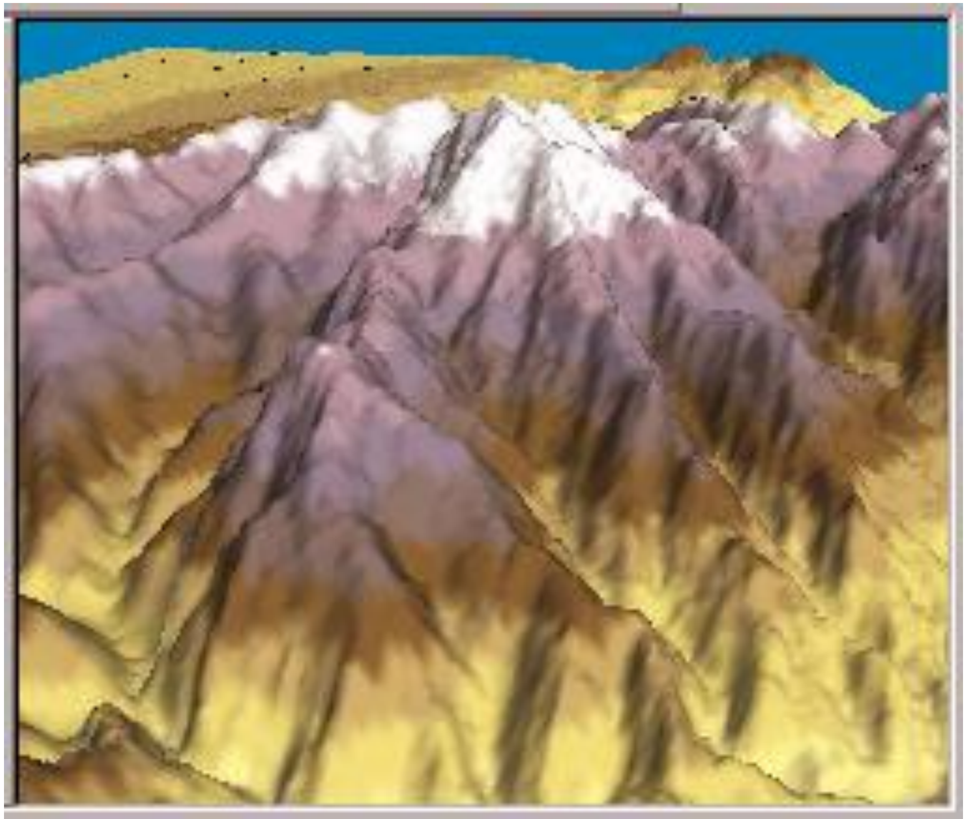


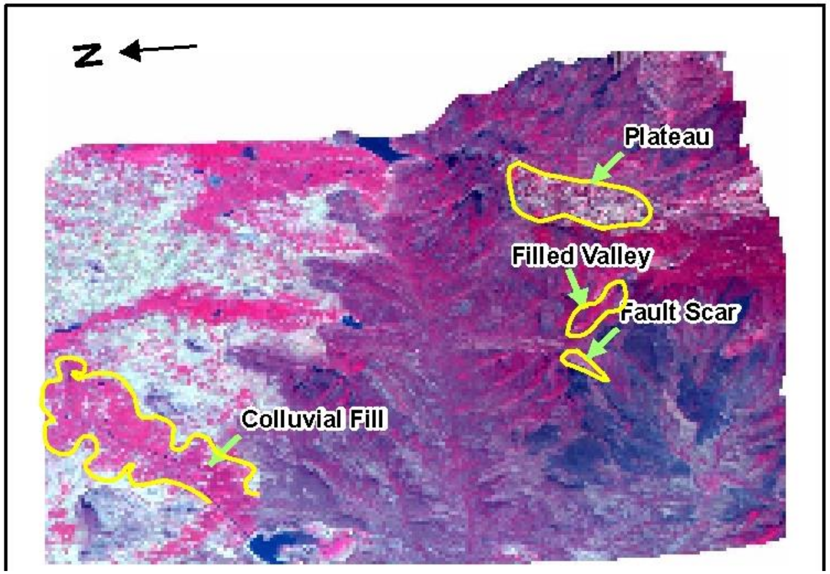
Advancements in Digital Photogrammetry

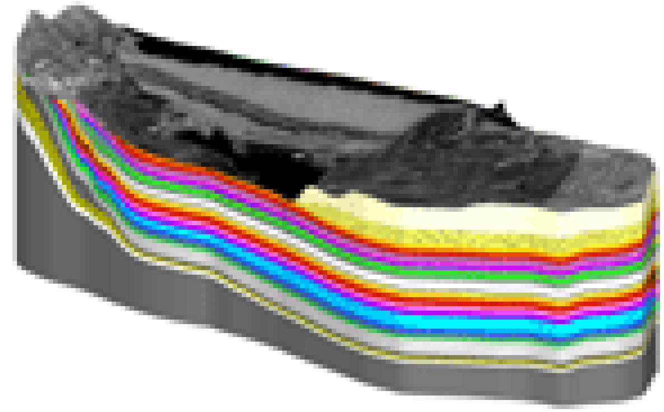
Showing waves/surfs nearing Beach, Beach Ridge and Swale in part of Ganjam area, Odisha coast

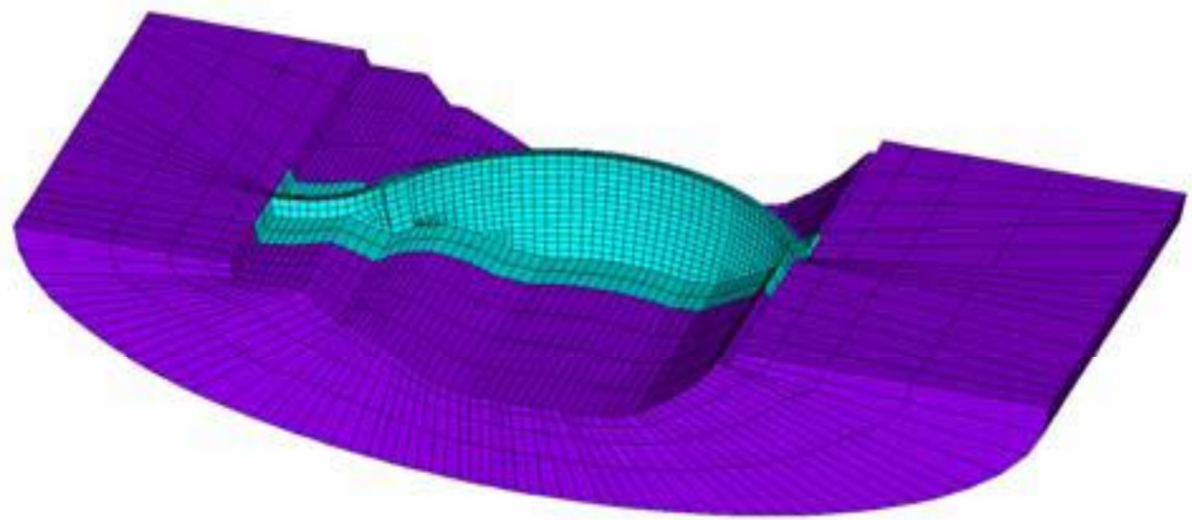
Understanding the shape of a surface



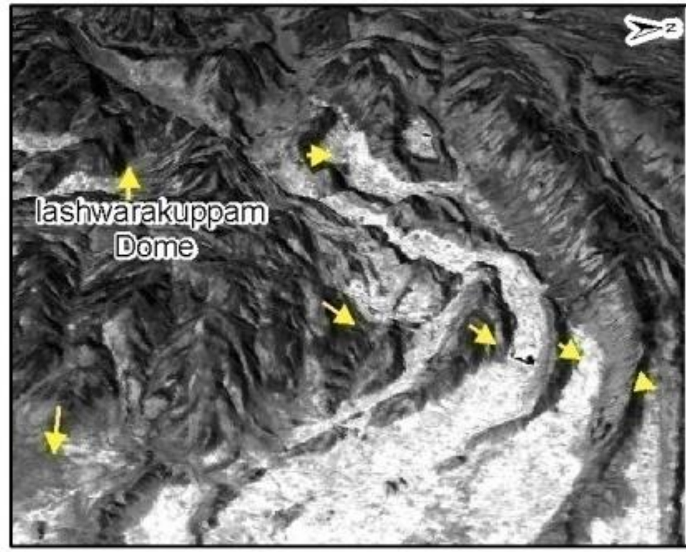



N
Plateau
Filled Valley
Fault Scar
Colluvial Fill

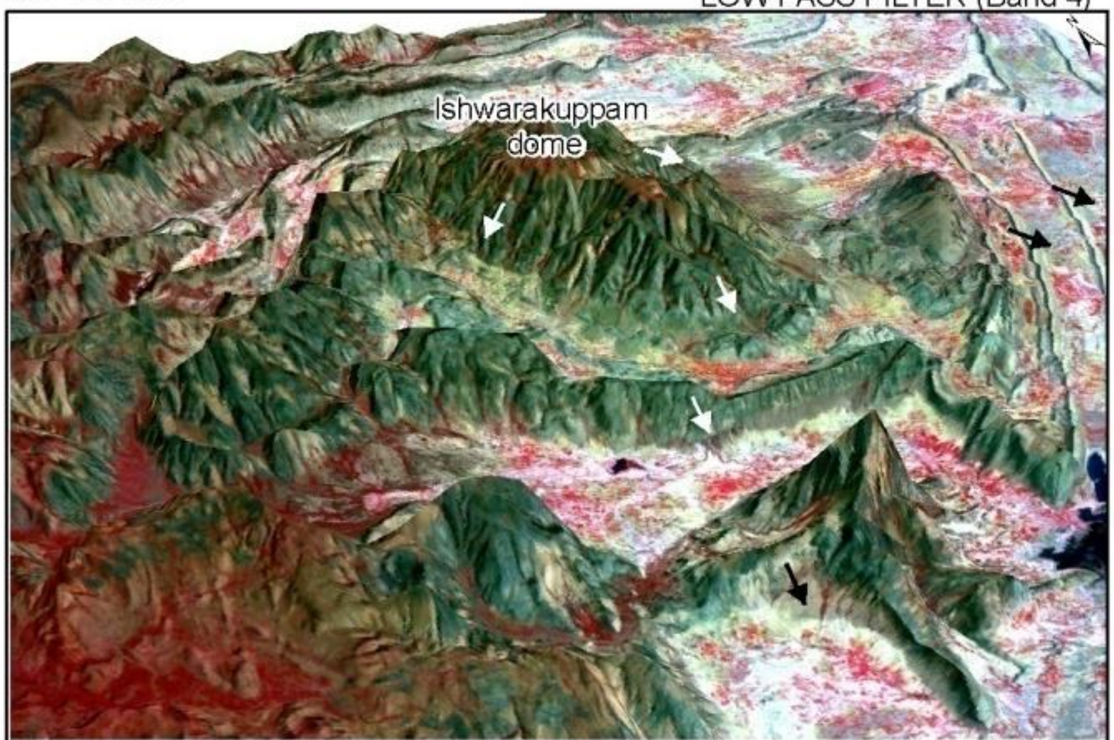




TM FCC data



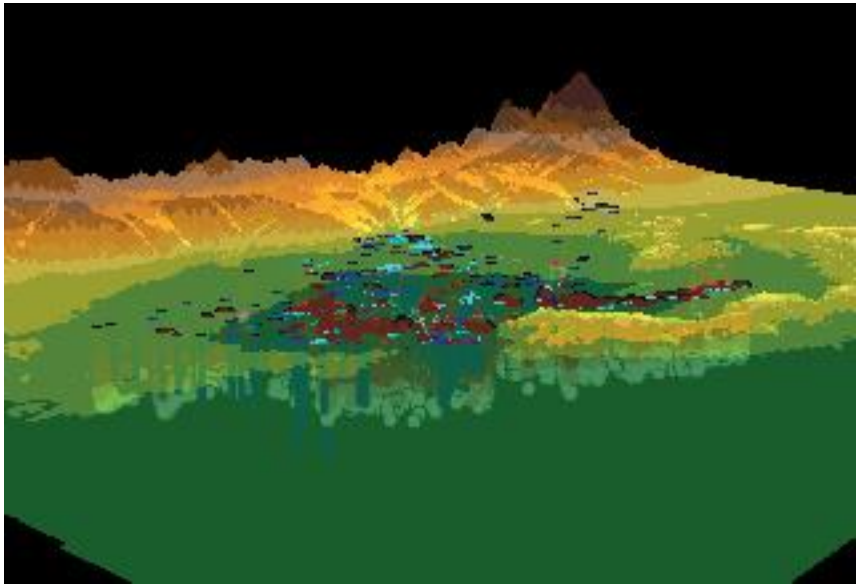
LOW PASS FILTER (Band 4)



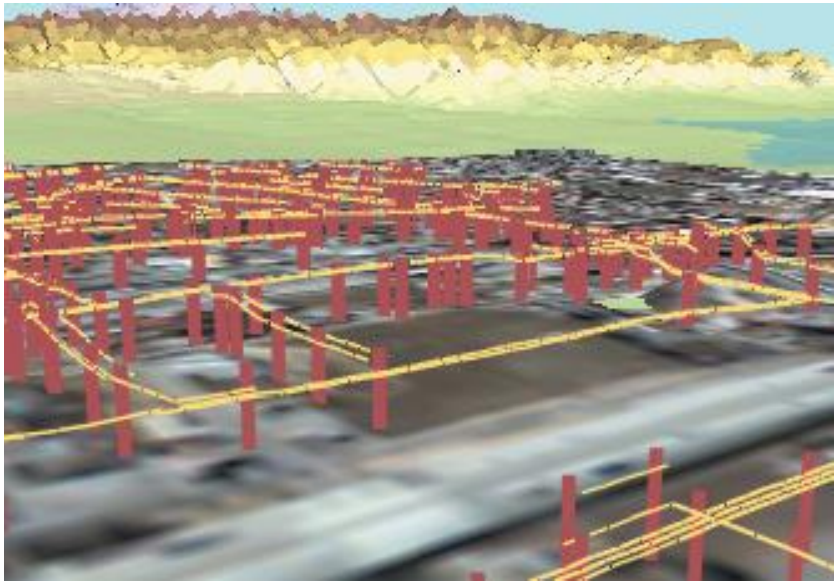
TM FCC data

DEM BASED VISUALIZATION OF TERRAINS / SURFCES

3D view of raster and vector data

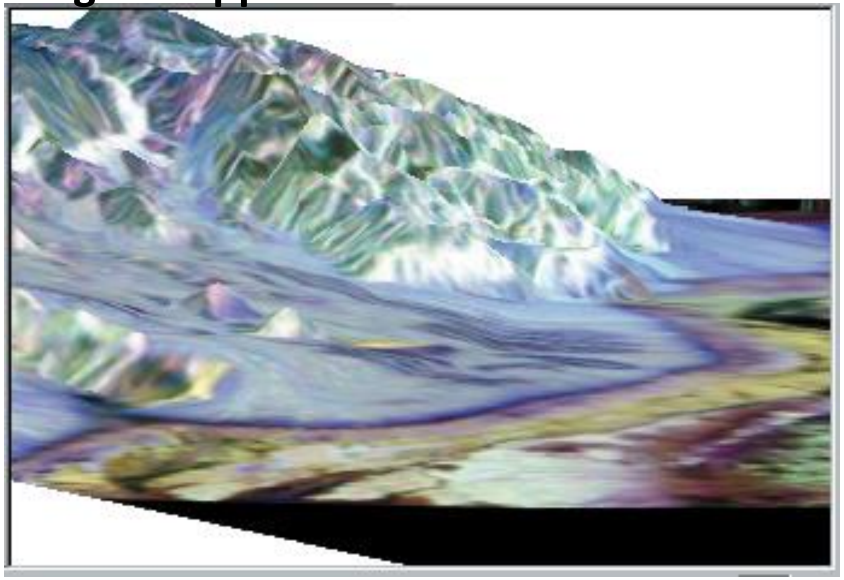


3D view of utility poles and power lines



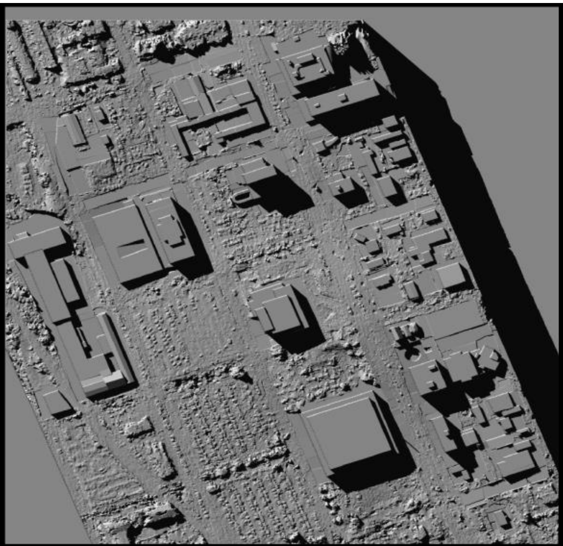
3Dimensional choropleth map -vector data

Image Wrapped DEM



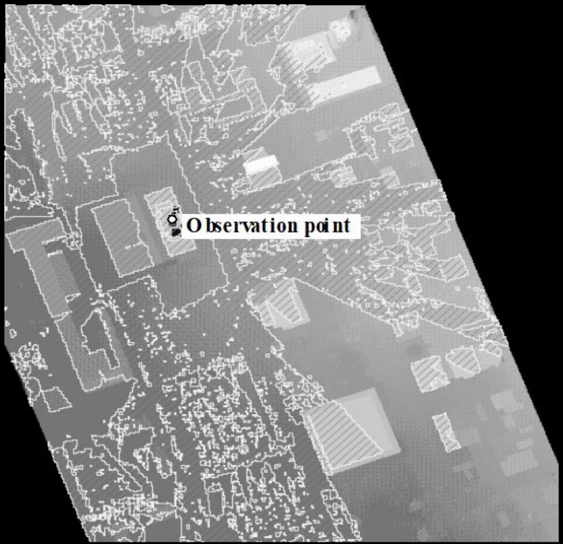
Digital Surface Model Creation

Original Panchromatic Aerial Photograph



Digital Elevation Model (DEM)

Orthophoto Draped Over DEM



Cellular Transceiver Location Model

Concepts of Shaded Relief mapping

Initially, to create shaded Relief map, slope and aspect are to be calculated based on the plane defined for each triangle.

Slope can be written in degrees by specifying degree and Aspect is always reported in degrees. Zero is north, and values increase clockwise like a compass. Flat triangles will be assigned an aspect value of -1.

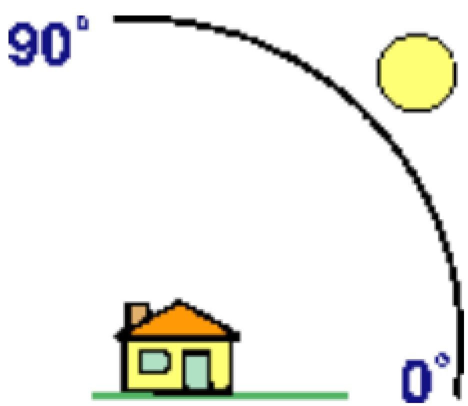
Optionally, a hillshade field can be written containing a brightness value for each triangle. Values range from zero to 255.

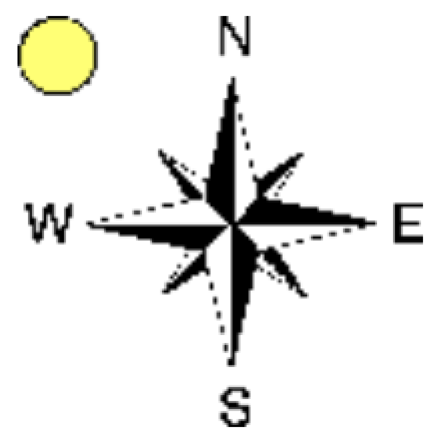
The brightness value is based on the relation between the plane defined by each triangle and a **light source**. The position of the light source defaults to the northwest, with an azimuth of 315 degrees (compass-based with 0 north, positive clockwise) and an altitude of 45.

For Hill shade, it is necessary to obtain the hypothetical illumination of a surface by determining illumination values for each cell in a raster.

It should be done by setting a position for a hypothetical light source **(Sun Elevation Angle)** and calculating the illumination values of each cell in relation to neighbouring cells.

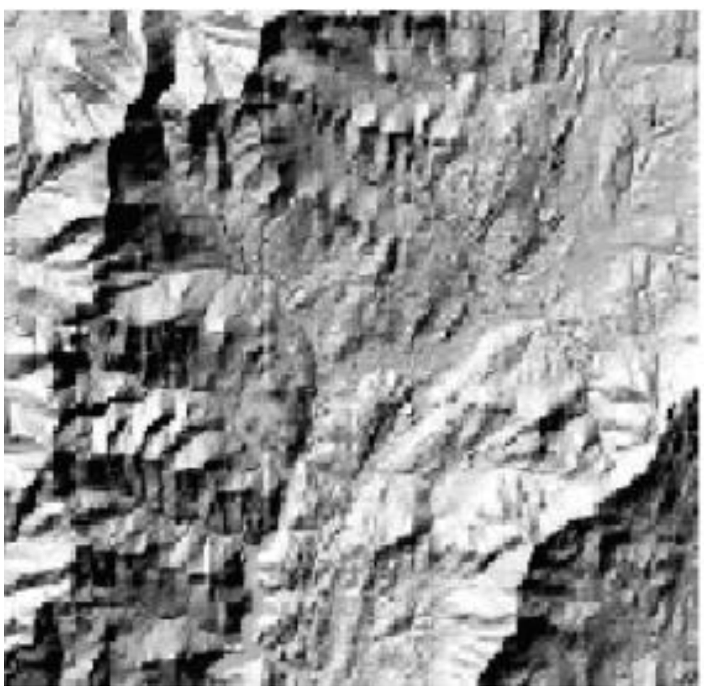
It can greatly enhance the visualization of a surface for analysis or graphical display, especially when using transparency.





By default, shadow and light are shades of gray associated with integers from 0 to 255 (increasing from black to white).
The **Sun azimuth Angle** is the angular direction of the sun, measured from north in clockwise degrees from 0 to 360. An azimuth of 90 is east. The default is 315 (NW).

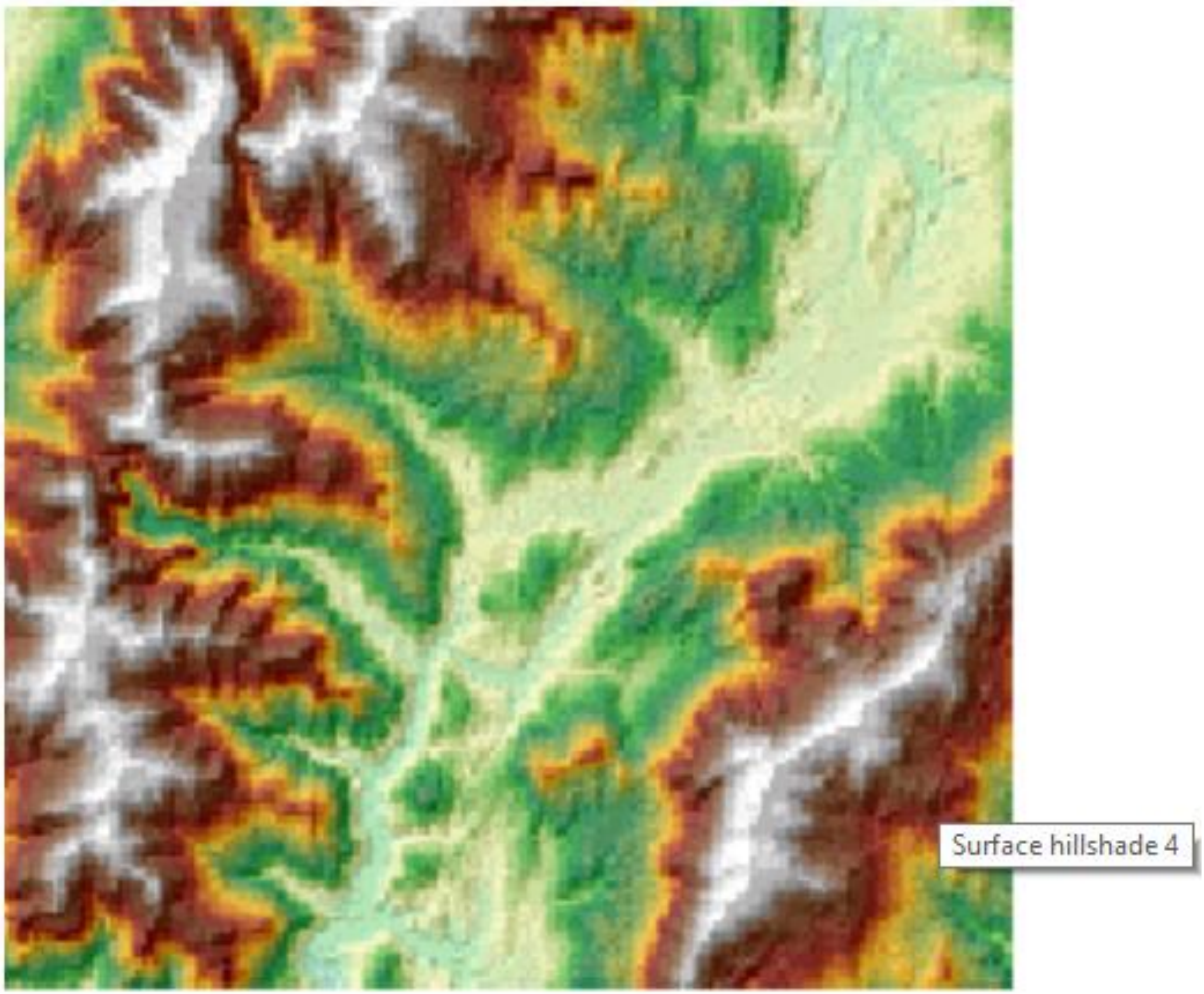
The altitude is the slope or angle of the illumination source above the horizon. The units are in degrees, from 0 (on the horizon) to 90 (overhead). The default is 45 degrees.



Shaded Relief Map with an azimuth of 315 and an altitude of 45 degrees

Use of Shaded Relief Map in Visualization/Display

By placing an elevation raster on top of a created hillshade and making the elevation raster transparent, it is possible to create realistic images of the landscape.

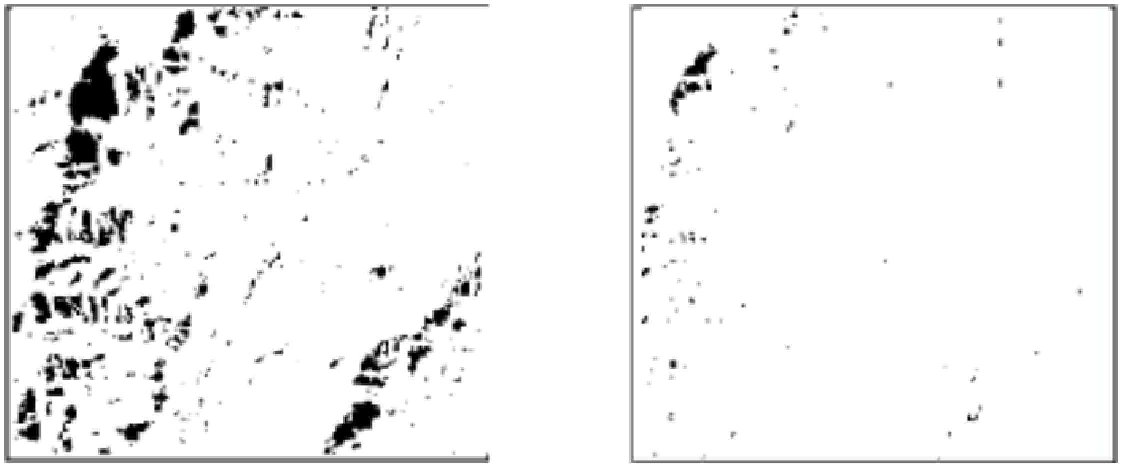


Other layers can also be added, such as roads, streams, or vegetation, to further increase the informational content in the display.

Use of Shaded Relief Map in Analysis

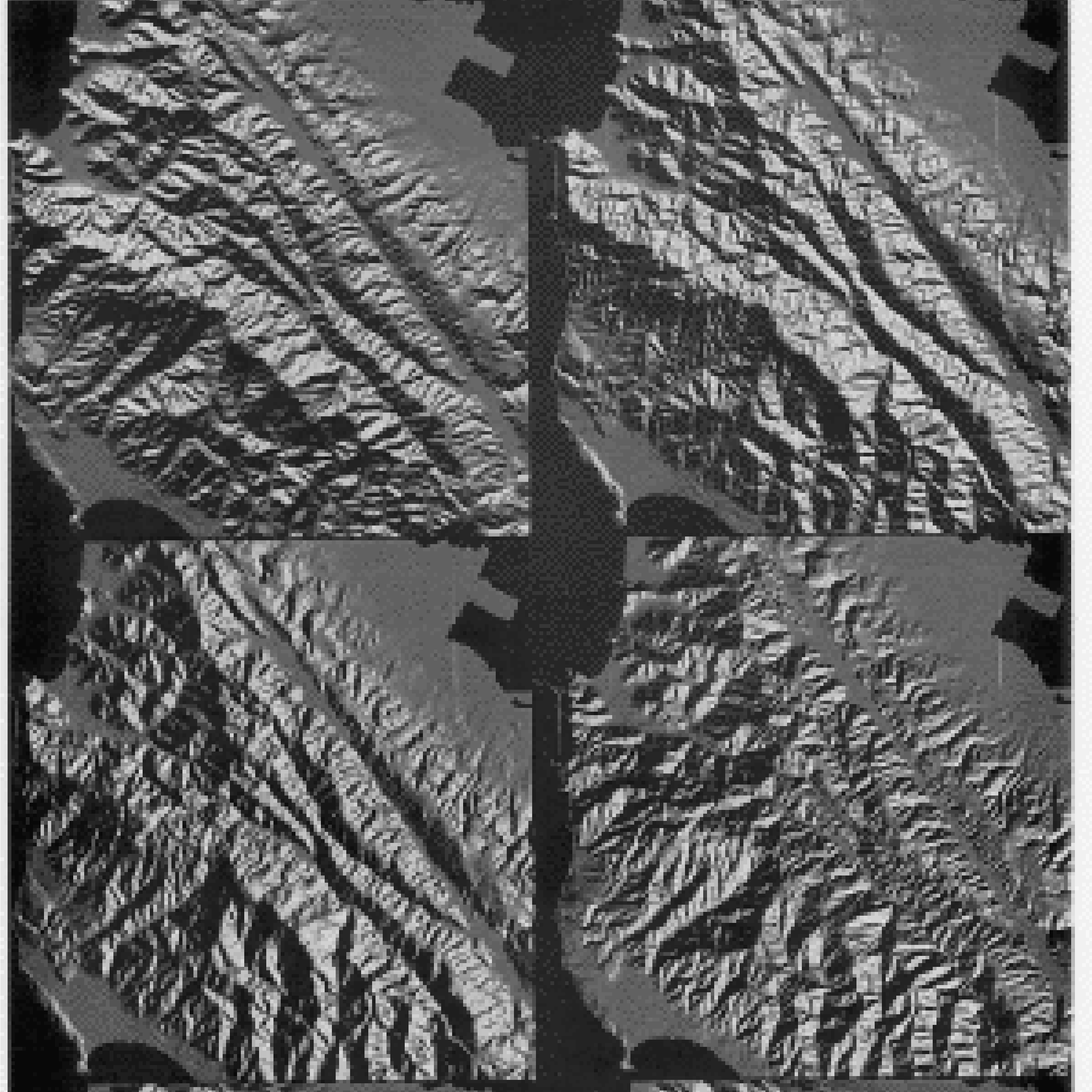
- By modeling shade (shadow), we can calculate the local illumination and whether the cell falls in a shadow or not at a particular time of day.
- Cells that are in the shadow of another cell are coded 0; all other cells are coded with integers from 1 to 255.
- All values greater than 1 to 1, can be reclassified producing a binary output raster.

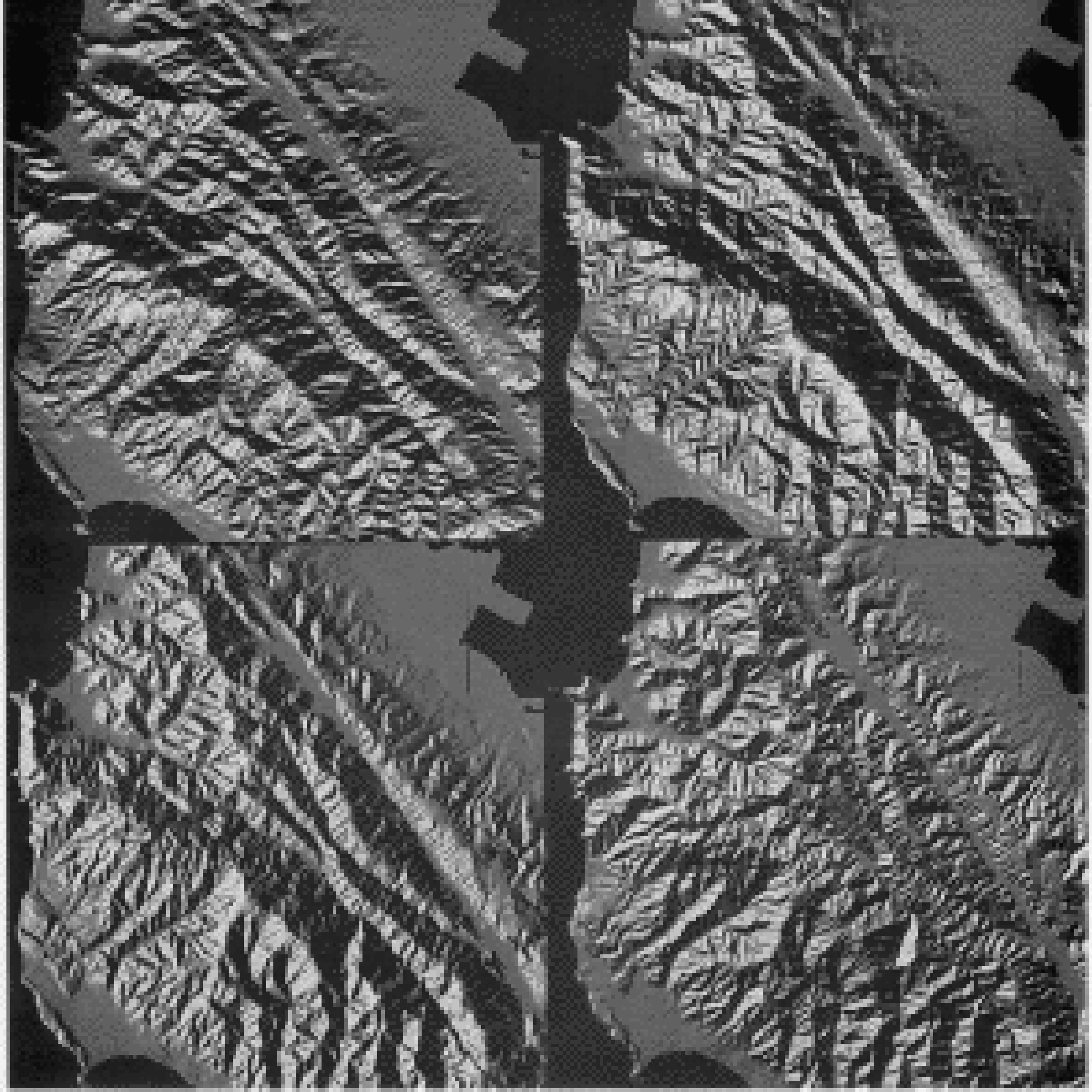
Fig. Black areas are in shadow



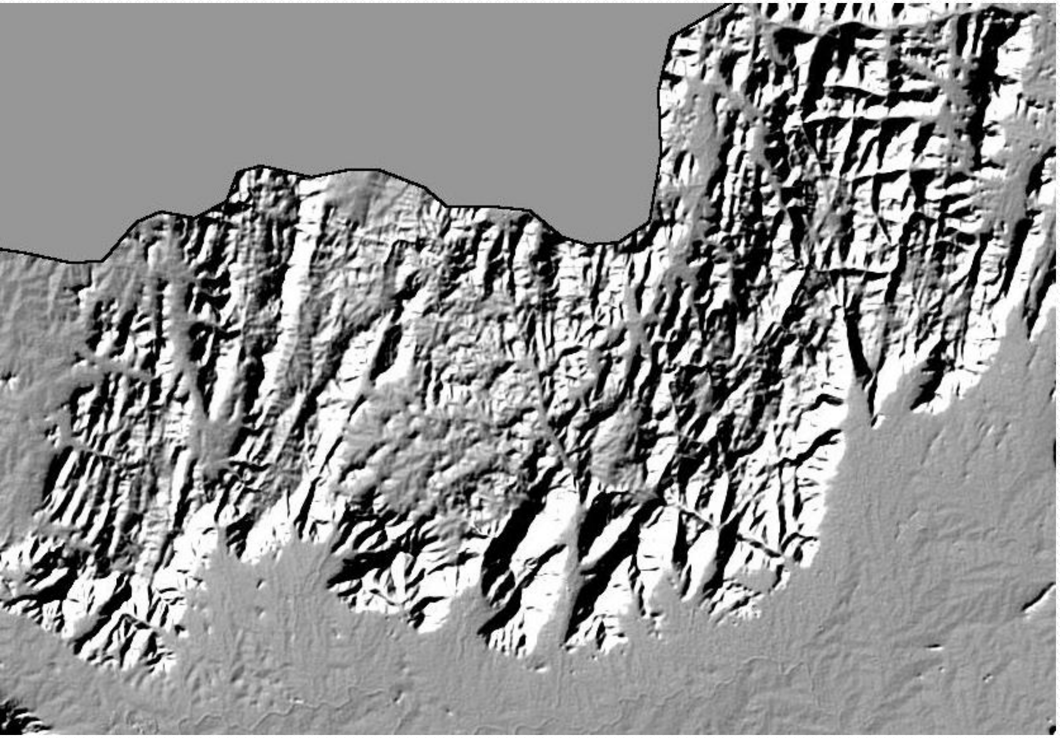
Azimuth is same in each image, but the sun angle (altitude) has been modified.

SRMs of San Andreas Fault zone in northern San Mateo County, California. With a Constant Sun Elevation Angle = 30º and Sun Azimuth Angles with an interval of 45º ; = 0º; 45º 90º ;135º; 180º; 225º; 270º

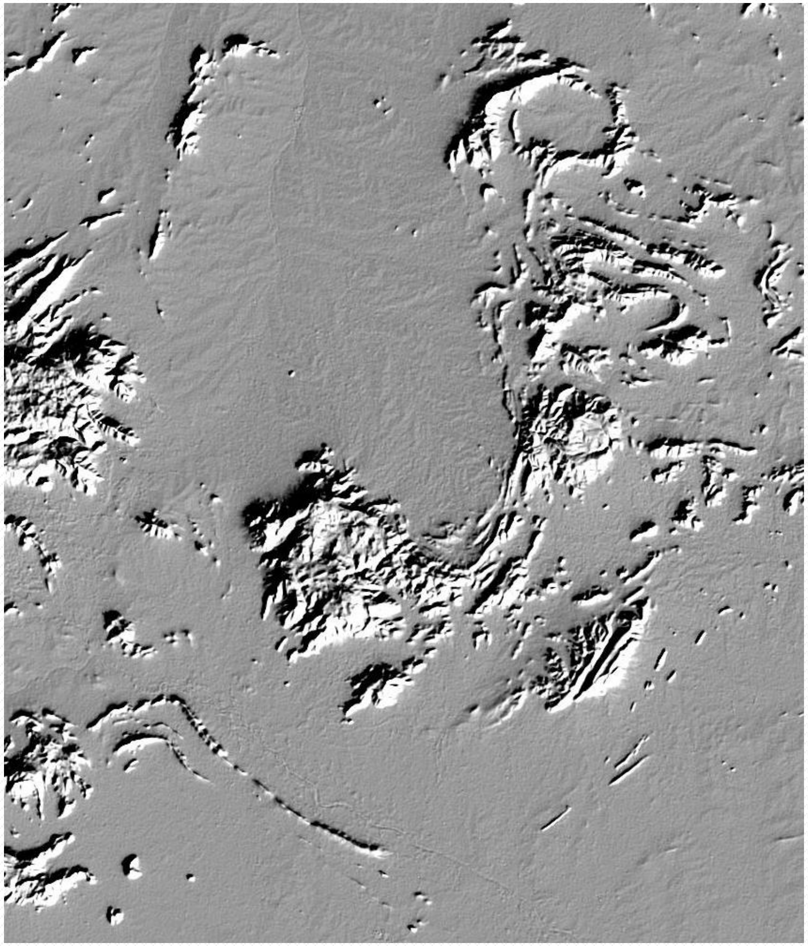




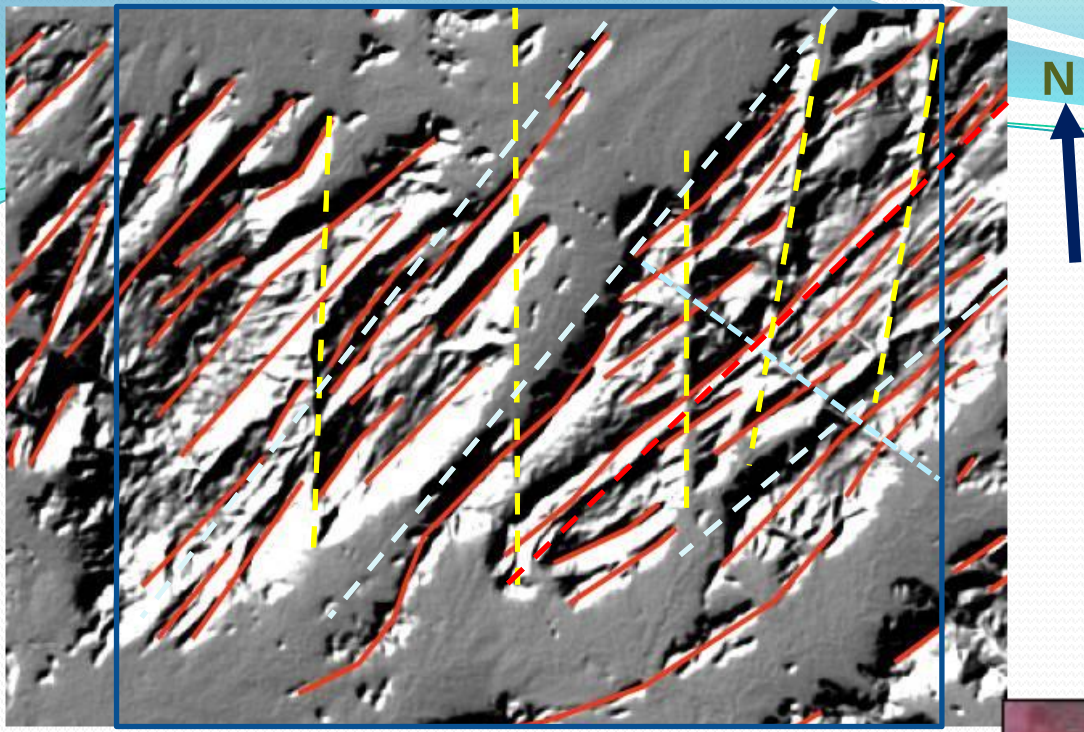
Shaded relief image showing Fractures in parts of Tamil Nadu



Shaded relief image showing Folds in parts of Tamil Nadu

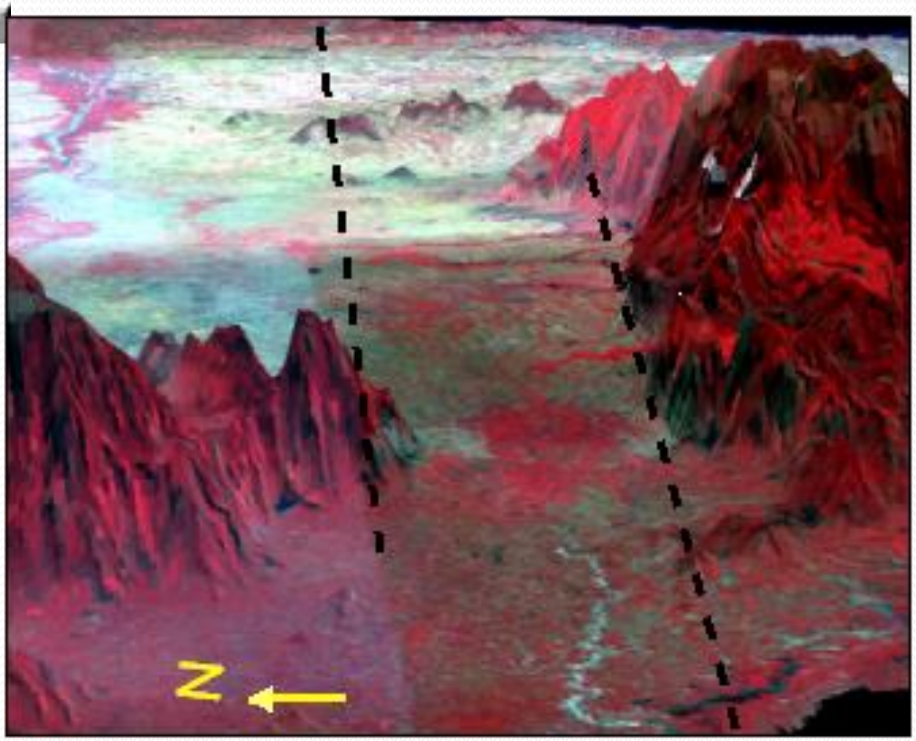


Mapping of Terrain Parameters



SRTM based shaded relief image shows the faults / fractures in Chitteri and Kalrayan hills

FCC wrapped over SRTM DEM shows the Palaghat Graben



Lineaments / Faults

Mapping of Folded structures – Fold Axes, Structural Trends

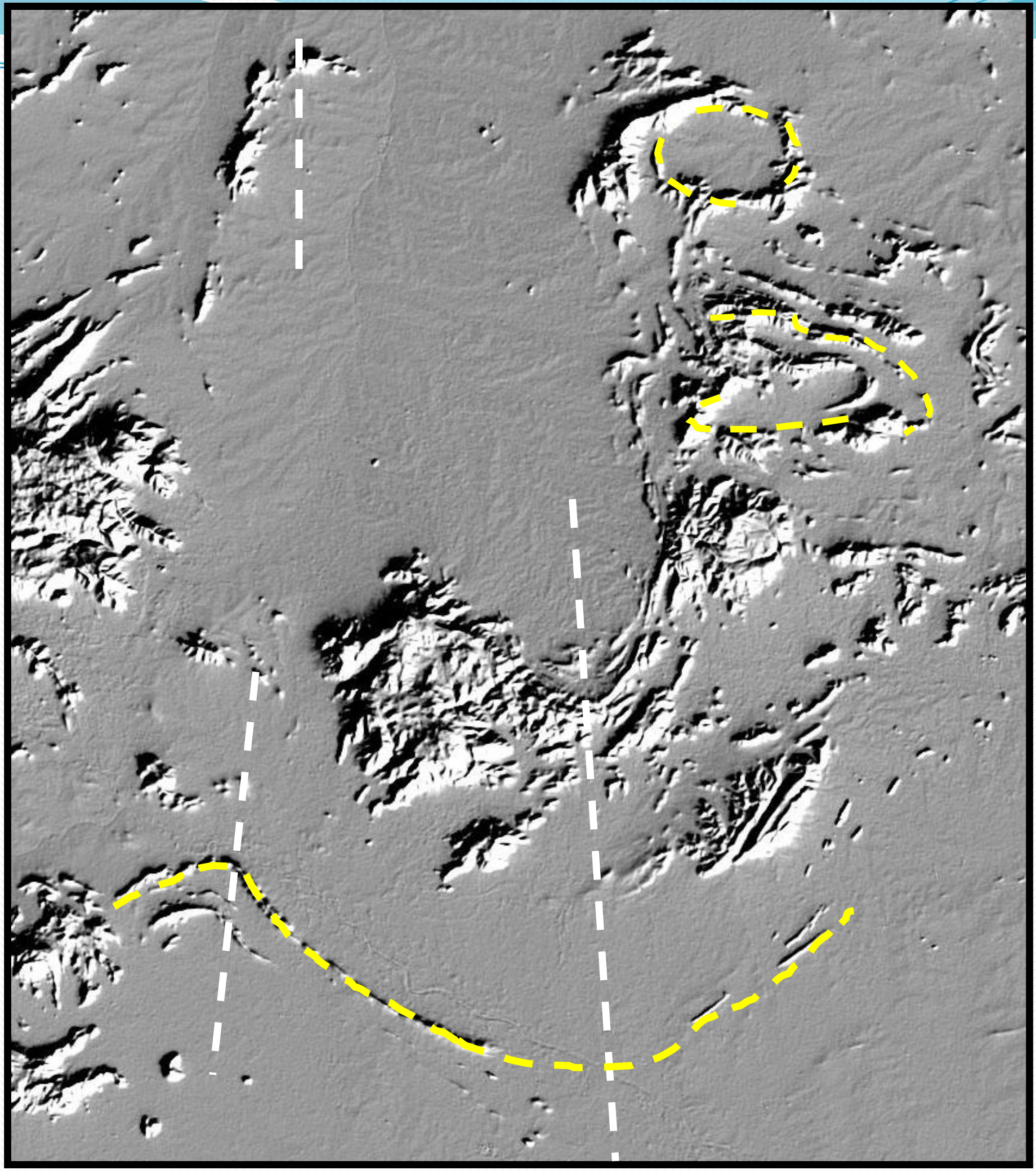
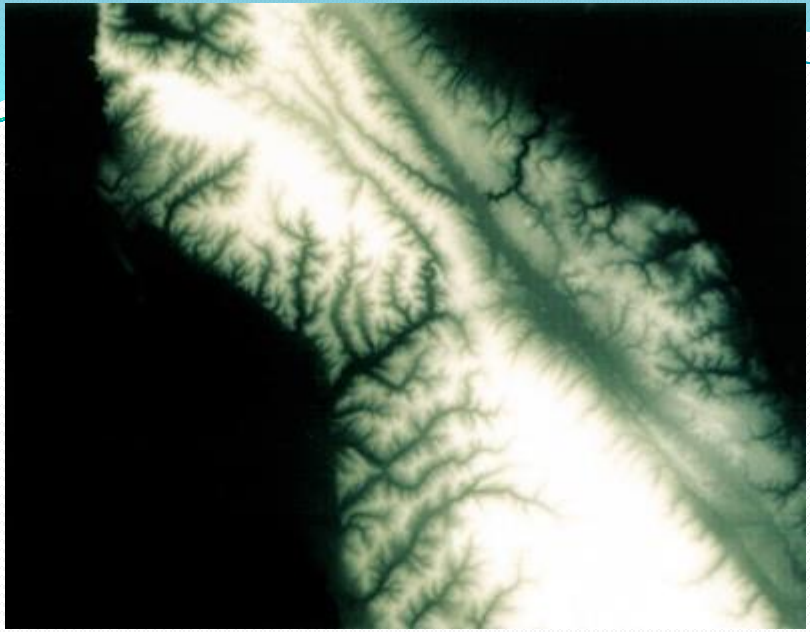
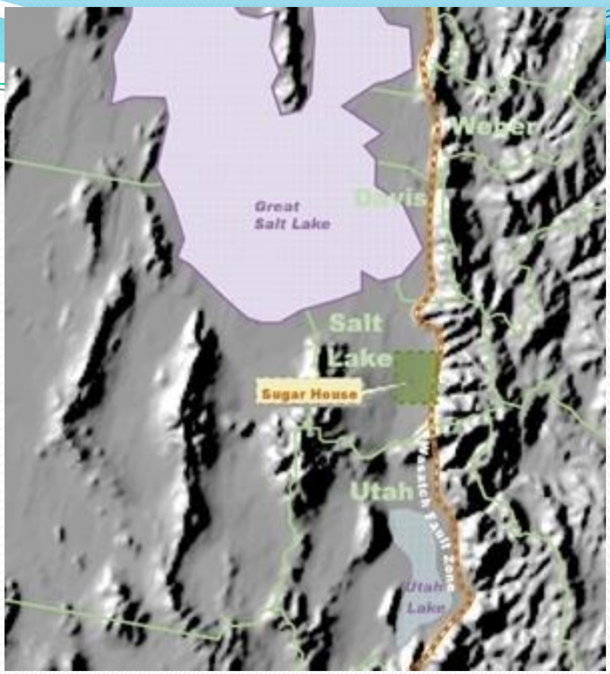


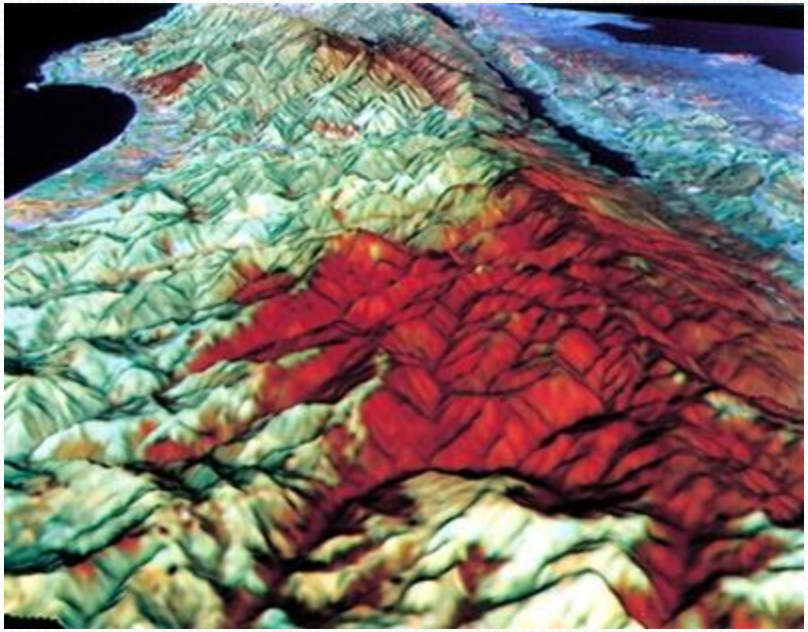
Fig.3 Mapping of Kadavur structure using SRTM based shaded relief image



DEM – 2D display using Black and White colour ramp



SHADED RELIEF MAP



SATELLITE FCC IMAGE WRAPPED OVER DEM

Analysis of Gravity data

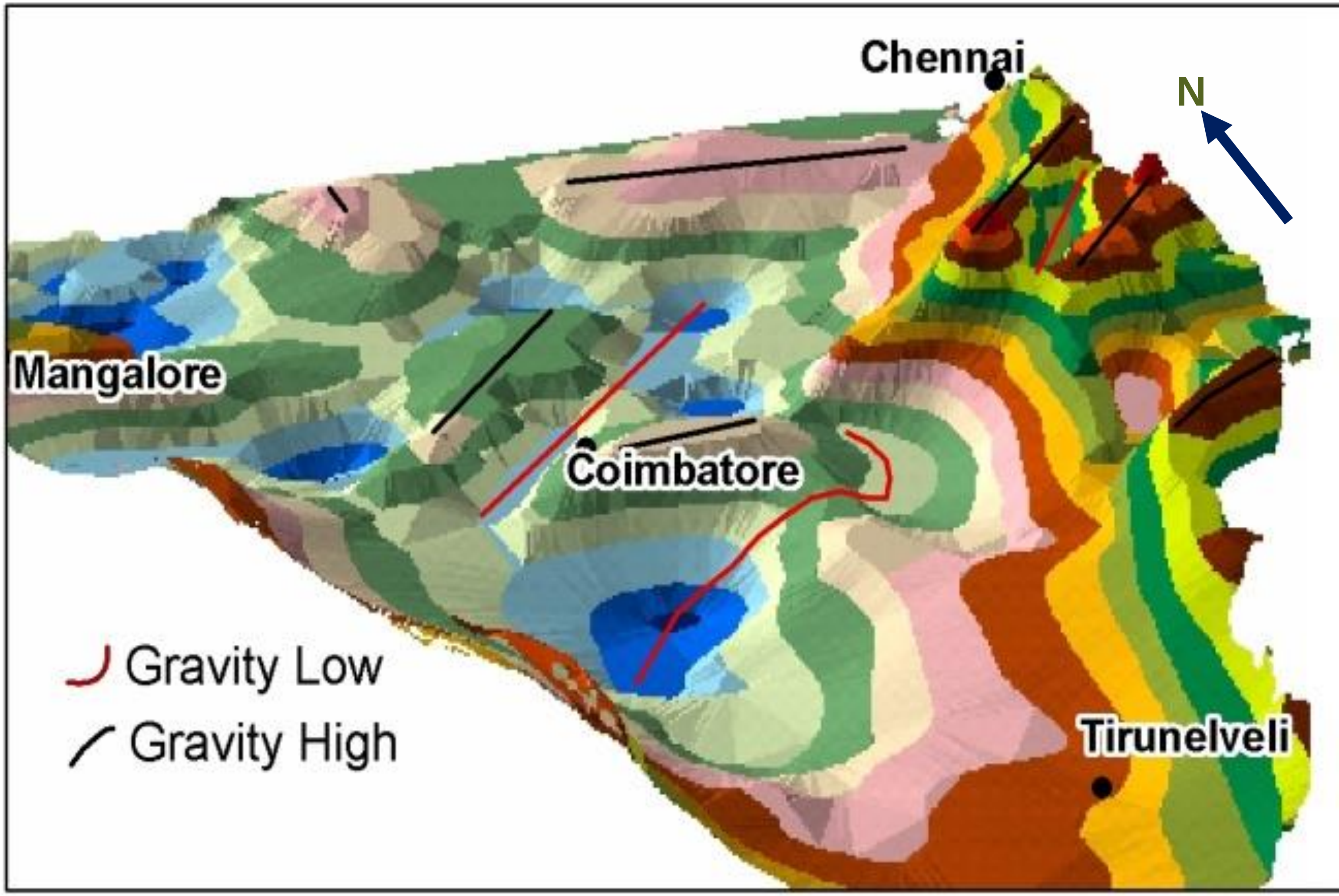


Fig. 5 3D GIS Image of Gravity Variation in South India

Analysis of Resistivity data

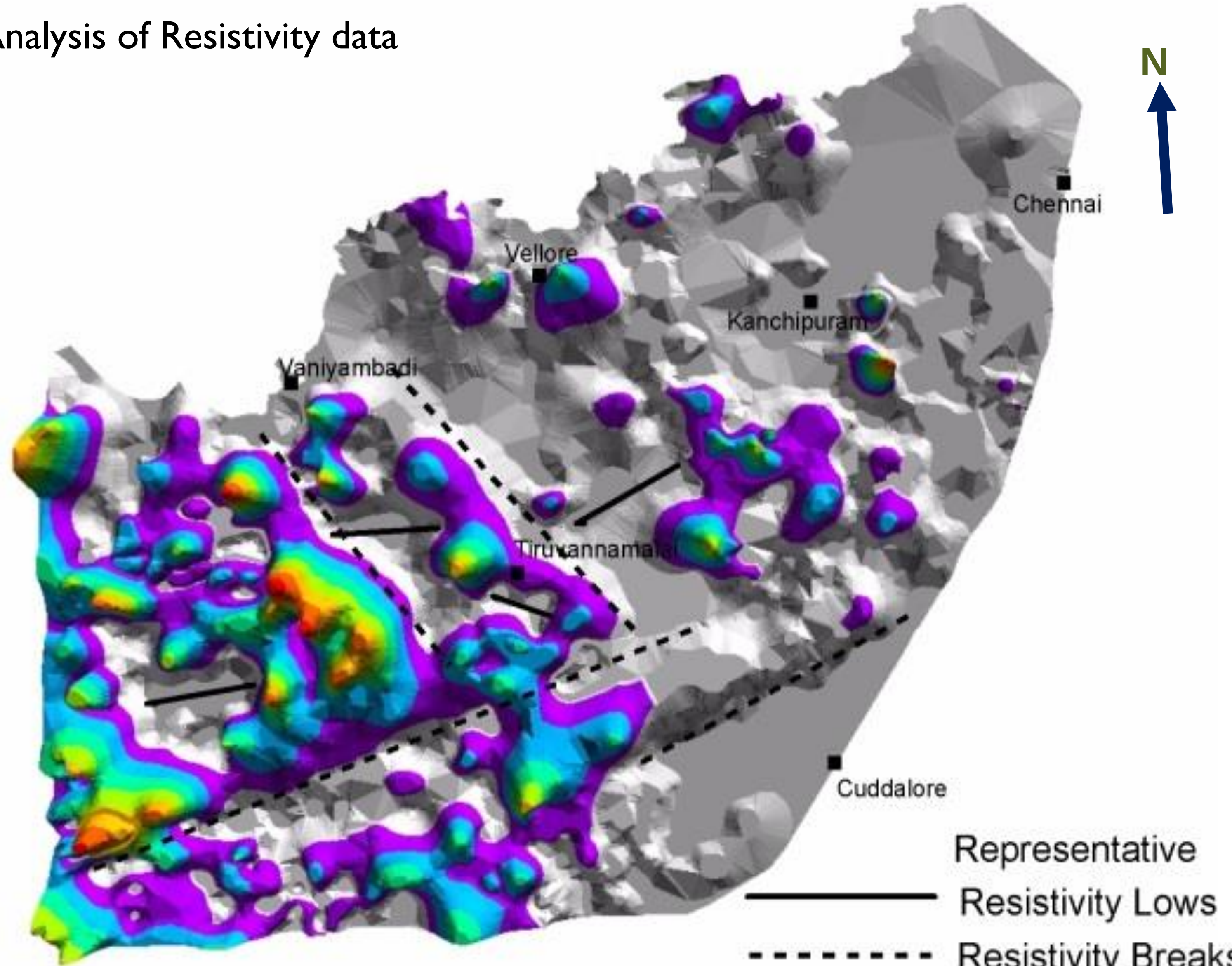


Fig. 6 Visualization of subsurface structures using resistivity data under 3D GIS environment

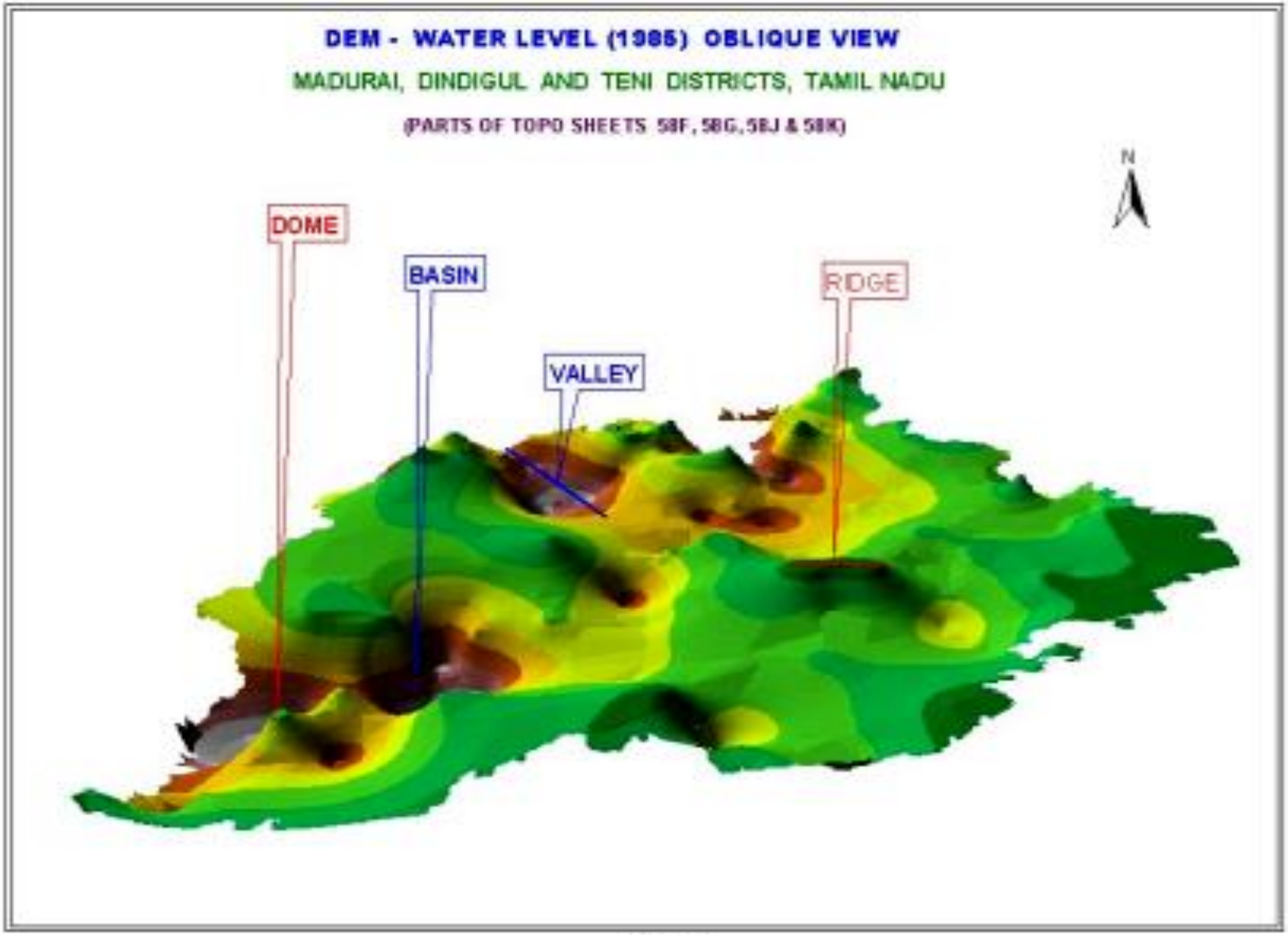
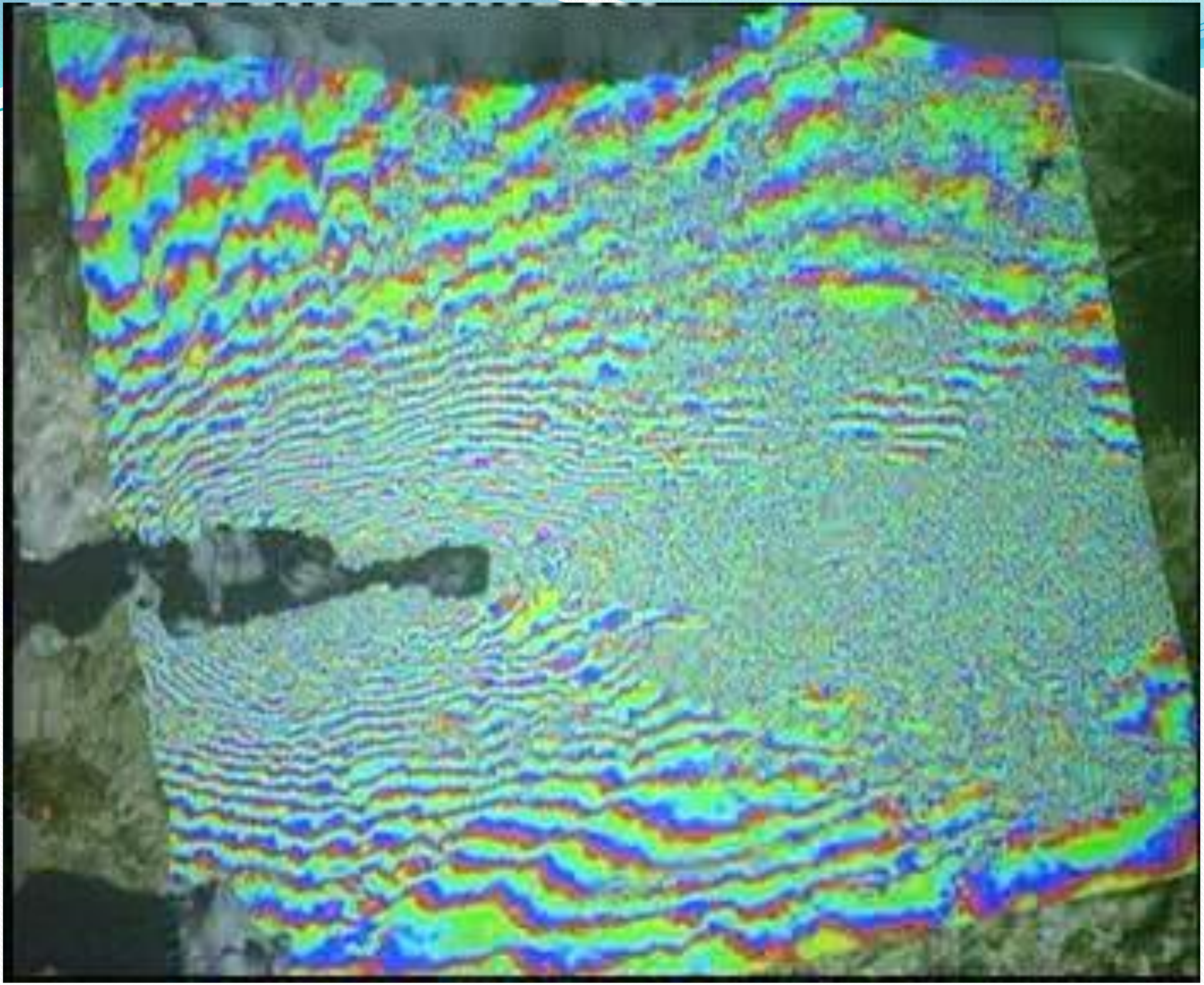
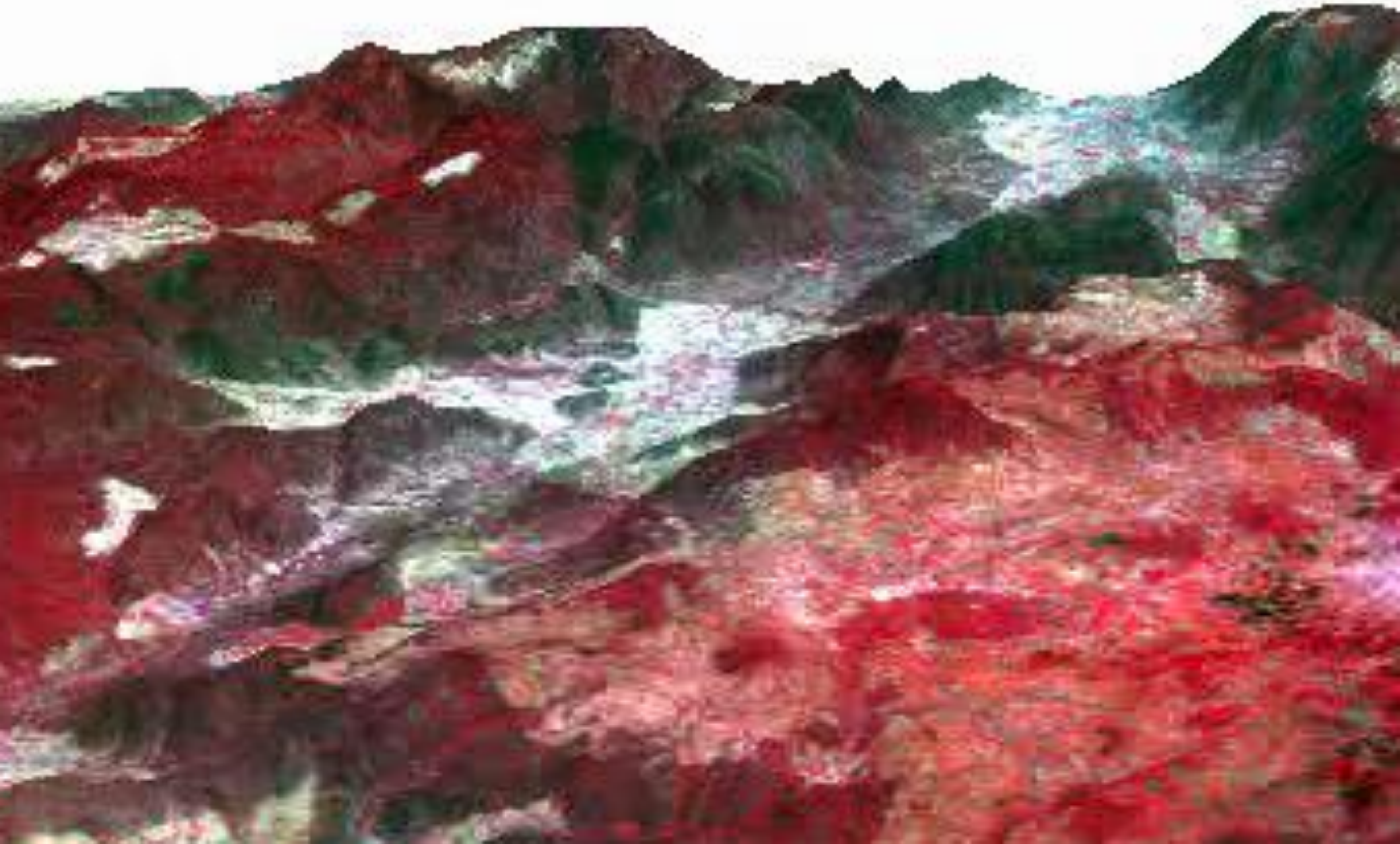


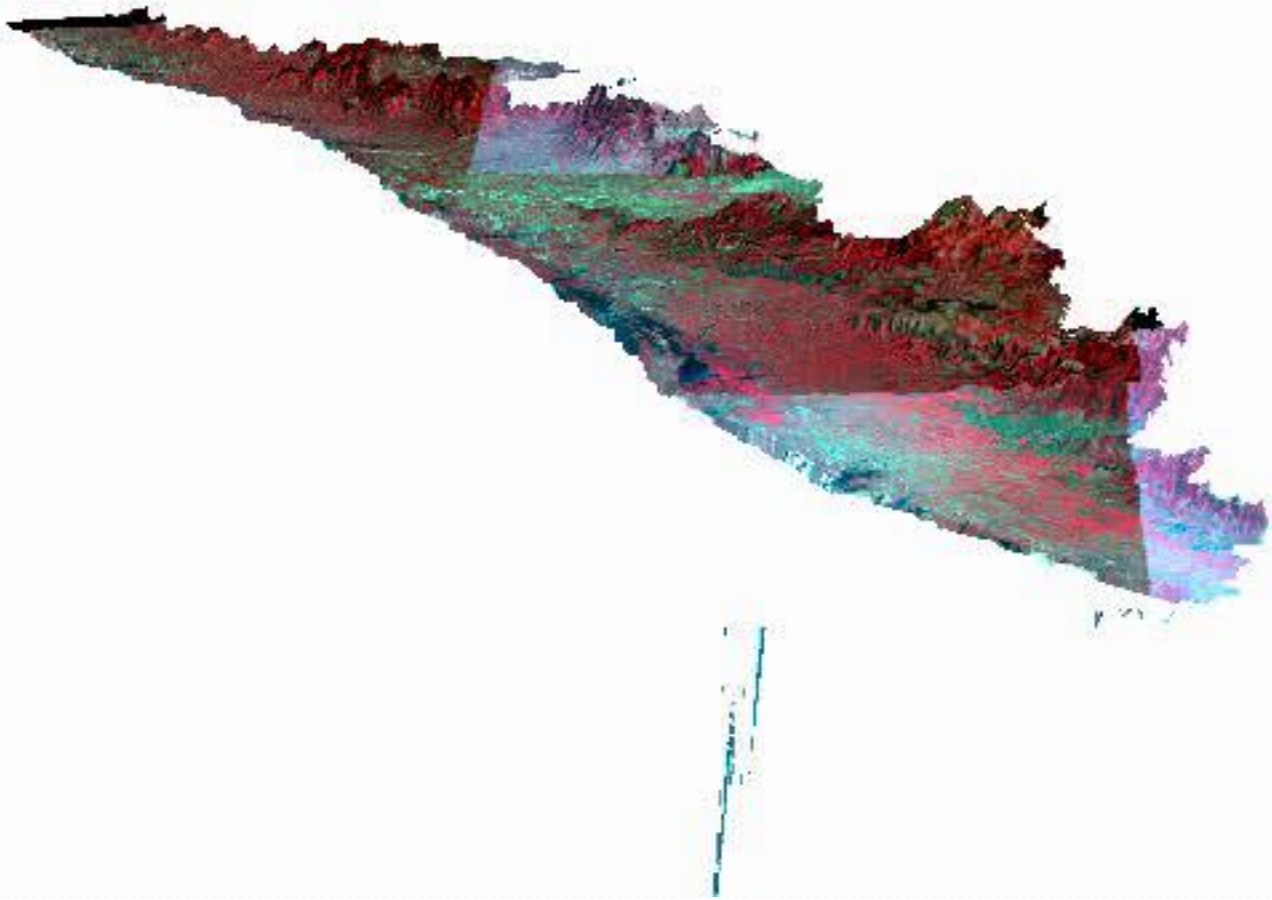
Fig. 7 3D Visualized GIS Image of Groundwater Levels for parts of Western Ghats, Tamil Nadu

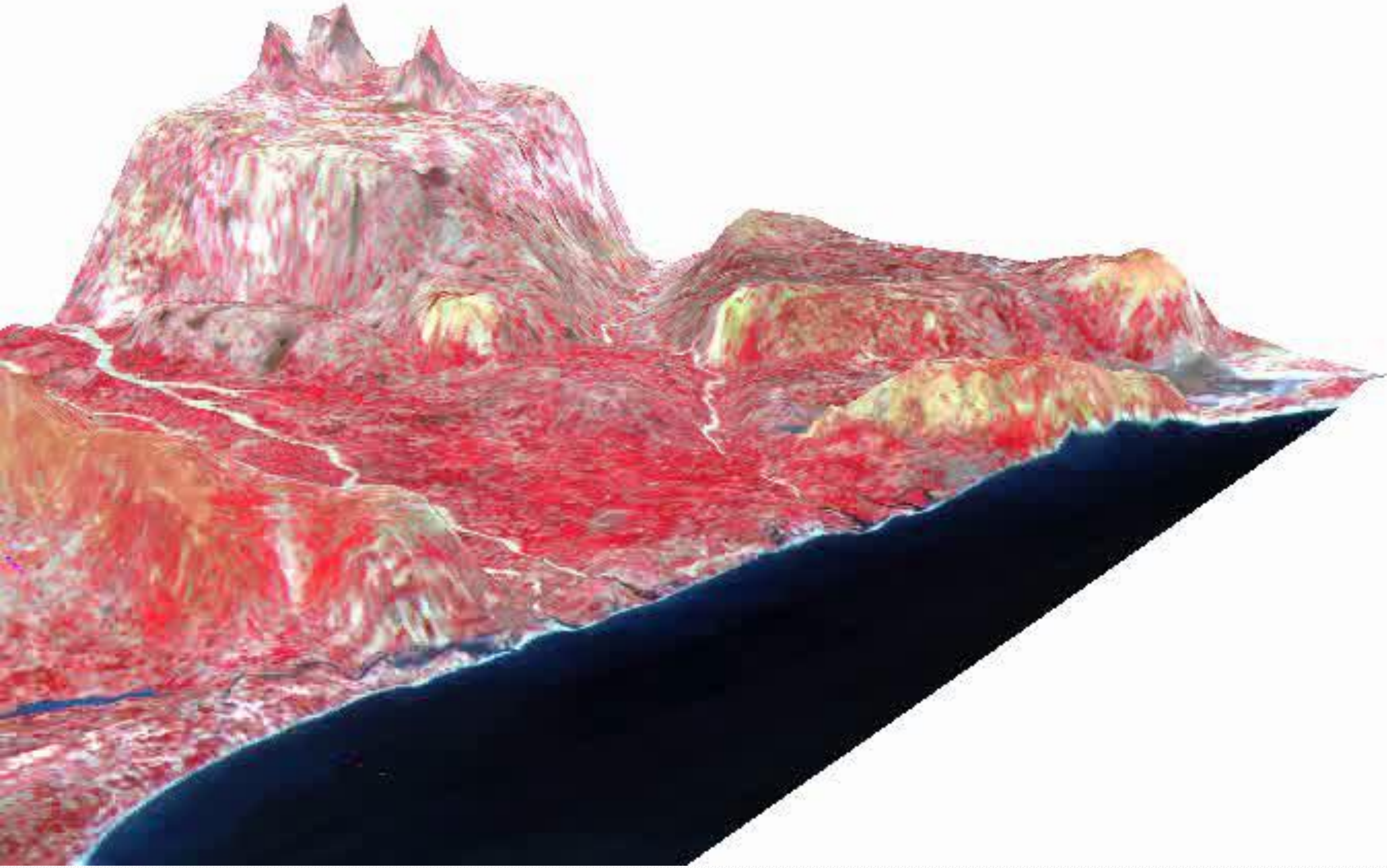


BACK

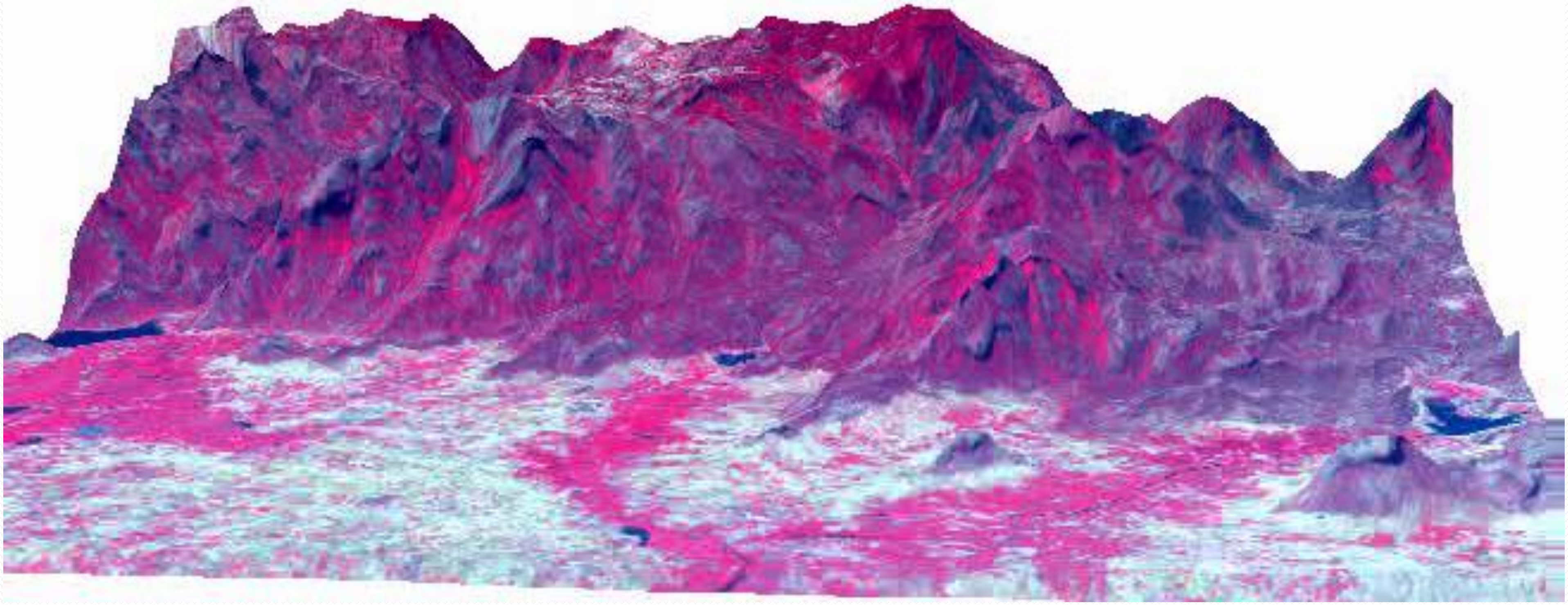


BACK



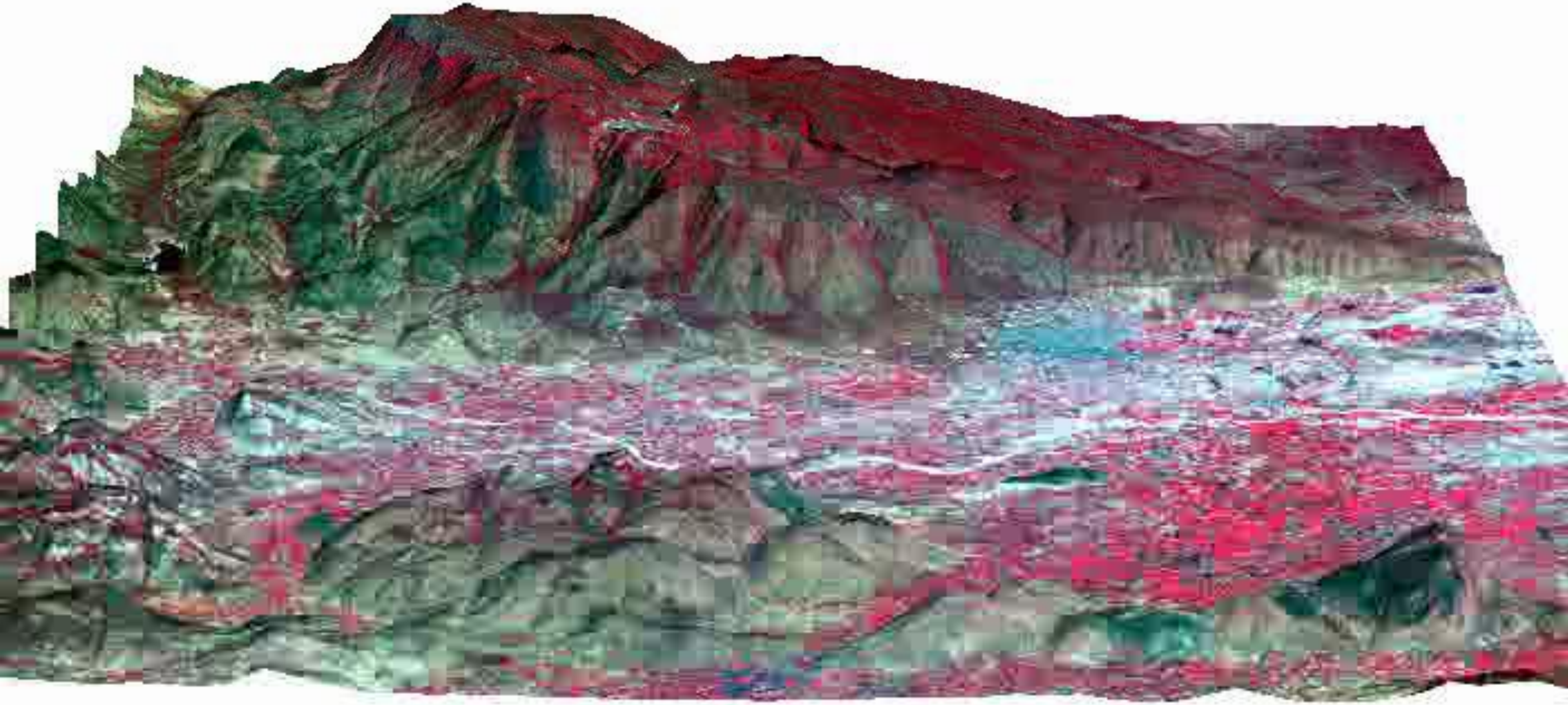


BACK



BACK

3D Flythru model of Tirumala Tirupathi region – Cuesta with Epiarchaen Unconformity and Swarnamuki river in front



Network Analysis / Model

- **Network** – Consists of connected linear features
    - E.g. Road, Railway, Bicycle paths, Streams & Shorelines.
- **Dynamic Segmentation**
    - A data model that is built upon lines of a network and allows the use of real-world co-ordinates with linear measures such as mileposts
    - To link linearly referenced data such as accidents & pavement conditions to geographically referenced road network
- For this, the networks need to be segmented and labelled by inserting nodes in proper locations
- For both **NW/DS** - Appropriate attributes are to be collected as per the real-world applications and entered in computer for 'Linking'.
    - For e.g., to use road network for Path Finding / Resource Distribution, etc., - we need the following attributes:

- Travel time
- Impedance at turn
- One-way streets
- Linear measures – to be added with arcs and nodes of the network – can be directly linked to road segments.

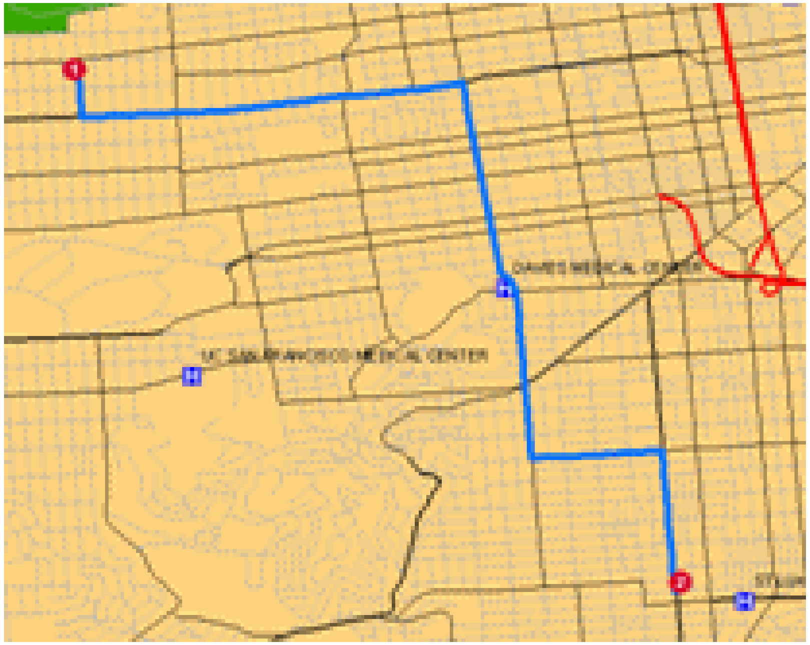
- 1. **Network** – is a line coverage, which is topology based and has the appropriate attributes for the flow of objects such as traffic.
  - Linear Feature + Attribute data, such as
    - Impedance values assigned to
      - network links – link impedance
      - Turns – turn impedance
    - One-way streets and
    - Overpasses and under passes.

Link impedance

- A link refers to a segment separated by two nodes in a road network

Link impedance is the cost or resistance or constraints of traversing a network link, which can be the time it takes to travel from one node to another.

NETWORK ANALYSIS



Route Identification

Involves, the direction of travel (turn) with link node attributes, connecting nodes to the destination, length of the line segments and impedances.

NETWORKS AND APPLICATIONS

Networks are simple. They are comprised of two fundamental components**,** ***edges*** *and* ***junctions.***

Edges are **streets, transmission lines, pipe** and **stream reaches.**

Junctions are **street intersections, fuses, switches, service taps,** and the **confluence of stream reaches.**

Edges connect at junctions.

Railroad schedules its trains to efficiently link with intermodal container trucks.

- A **parcel delivery service** optimizes its package delivery on a street system.

- An electric utility locates where **power outages** originate based on telephone calls received from affected customers.
- An environmental agency analyzes water samples collected from streams to trace **contaminant flow**.
- A regional transportation agency uses **traffic data** to plan **future highway construction**.
- A school district finds **optimum bus routes** to pick up children and deliver them to school.
- A driver uses a mapping system with a GPS receiver mounted in the car to find the **best way to get to a destination**.

THE GEOMETRIC NETWORK

A **geometric network** is a collection of features that comprise a connected system of ***edges*** *and* ***junctions.***

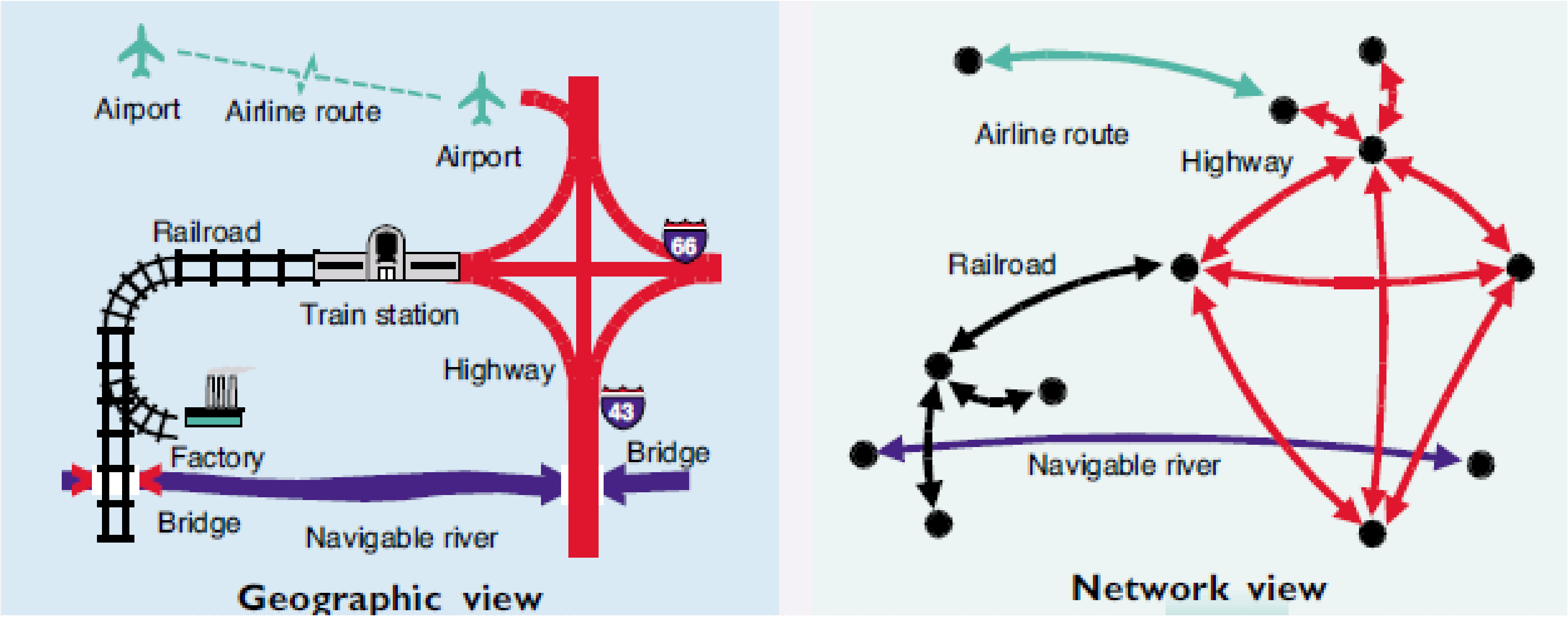
An ***edge*** *has* ***two junctions*** *and a junction* can be connected to any number of edges.

Network features: simple junction feature, complex junction feature, simple edge feature, or complex edge feature.

THE LOGICAL NETWORK

Like a geometric network, a **logical network** is a collection of connected **edges** and **junctions**.

The key difference is that a logical network does not have coordinate values.

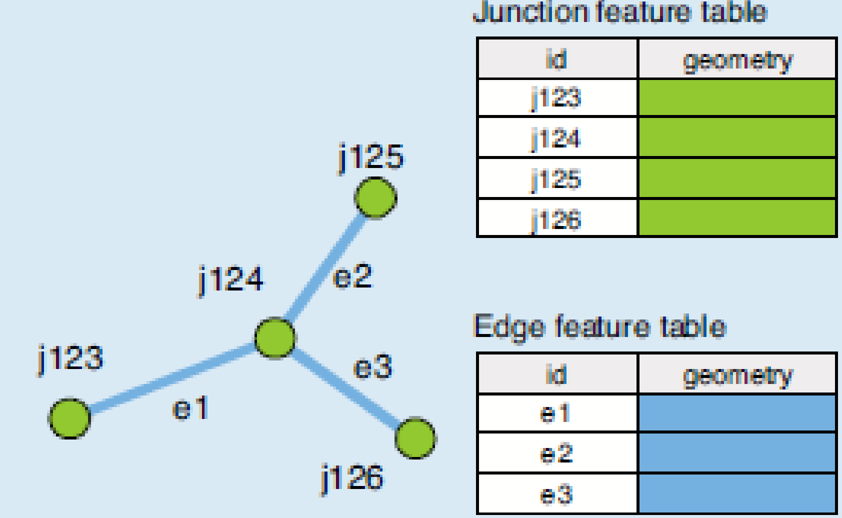

Airport
Airline route
Airport
Railroad
Train station
Highway
66
43
Factory
Bridge
Bridge
Navigable river
Geographic view
Airline route
Highway
Railroad
Navigable river
Network view

HOW FEATURES CONNECT

The center-piece of a logical network is the connectivity table, which describes how network elements are connected.

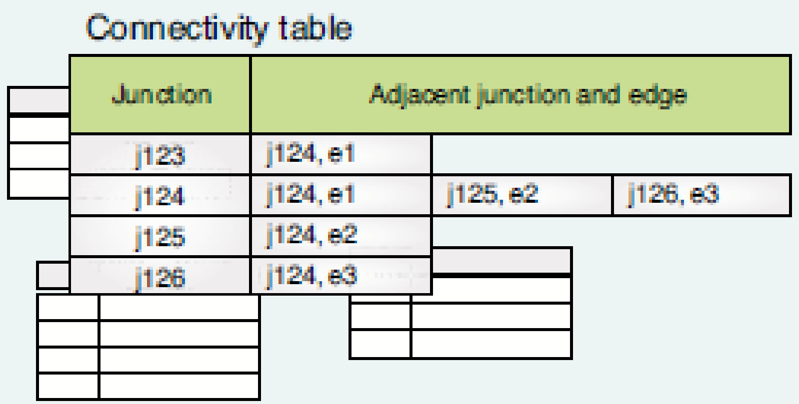
For every junction in the network, the connectivity table lists the adjacent junctions and edges — junctions at the other end of the connected edge.

Geometric network



A geometric network contains the features that participate in a network. Feature classes contain either edge features or junction features.

Logical network



A logical network contains the connectivity of the network. The connectivity table lists all the adjacent junctions to a given junction, along with the edge that connects them.

CONNECTIVITY RULES

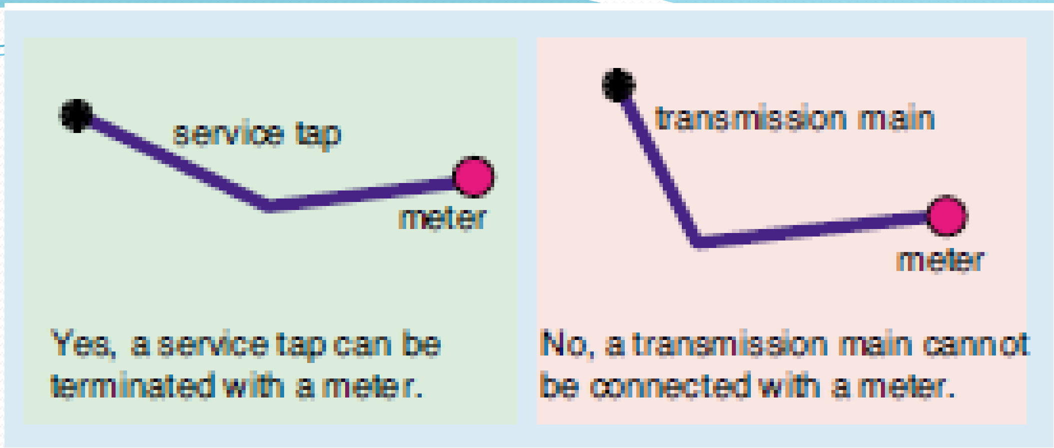
In most networks, not all edges can connect to all other junctions. Also, not all edges can connect to all other edges through a specified junction.

For example, a hydrant lateral in a water network can connect to a hydrant, but not to a service lateral.

Similarly, a 10-inch transmission main can only connect to an 8-inch transmission main through a reducer.

Edge–junction rule

This rule constrains which types of junctions can connect to a type of edge.

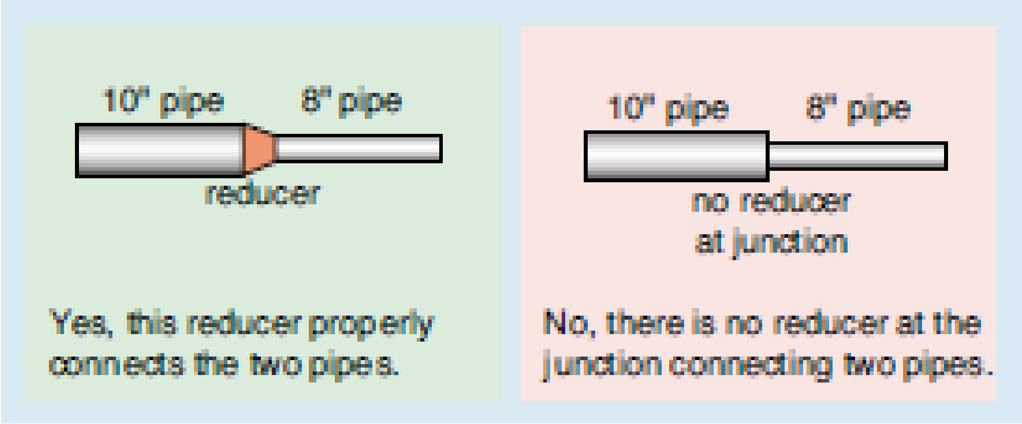


Meters can only connect to **low-voltage lines.**

Edge–edge rule

This rule establishes which combinations of edge types can connect through a given junction.

Two pipes of different diameters can be connected only through a properly sized **reducer**.

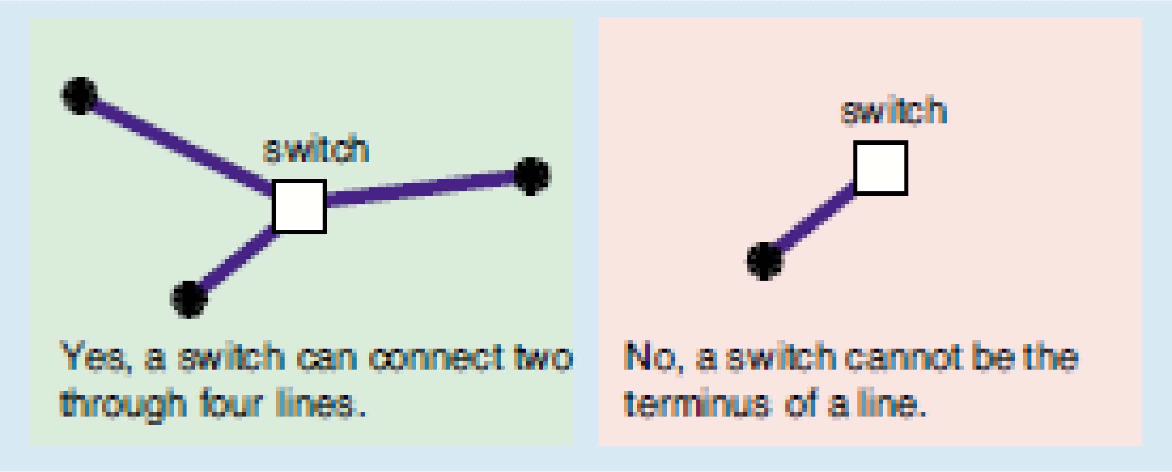


Edge–junction cardinality

This rule lets you restrict the count (cardinality) of edges that connect at a junction.

A certain type of switch might be designed to accept between two and four lines.

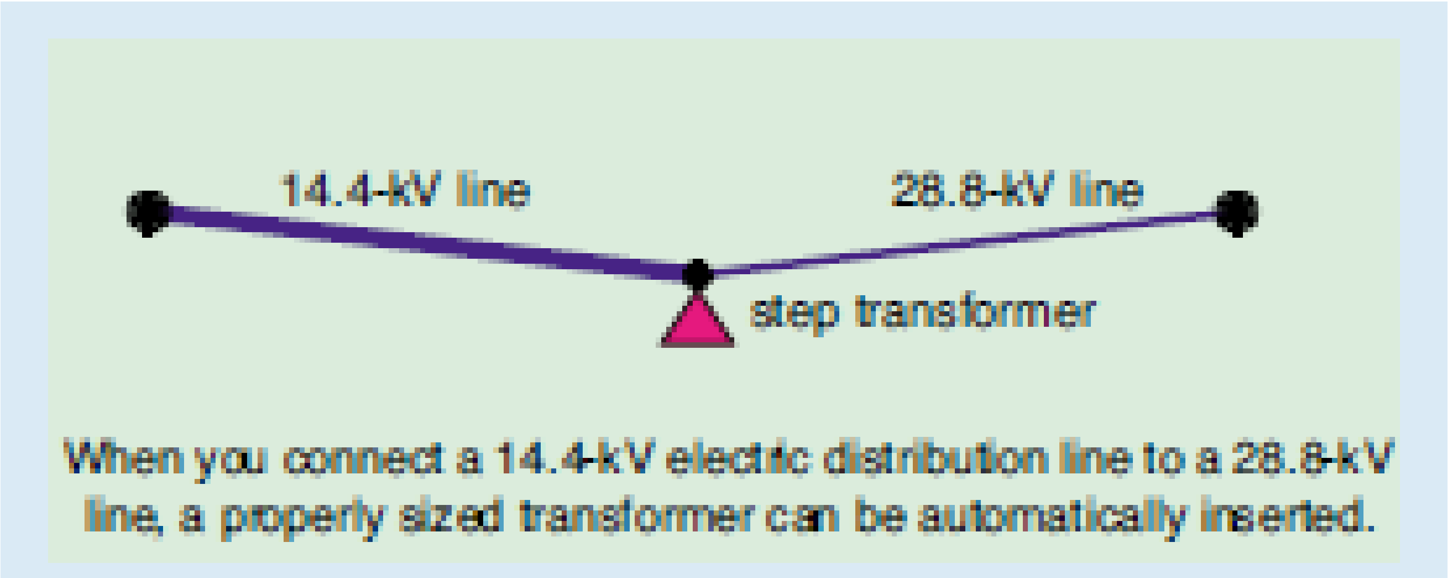
Precisely define the acceptable range of lines that can be connected at a junction.



Default junction type

When you connect one type of edge to another, you can specify a default junction type to be inserted.

When a 14.4-kV line is added to an end-junction of a 28.8-kV line, a step-down transformer with the correct electrical ratings is assigned to the junction



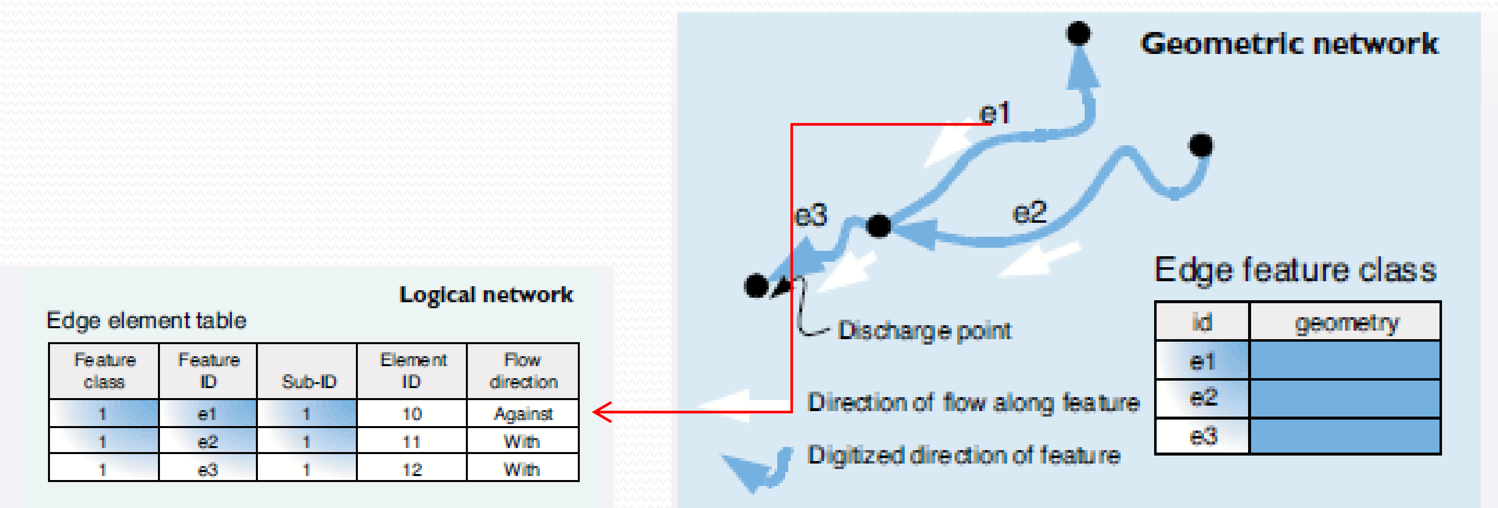
NETWORK FLOW

Networks are of two type: utility network and transportation network.

In a *transportation network*, depends on the need will be changed “will of their own.”

In a *utility network*, the commodity that flows through the network—water, electricity, oil—has no will of its own.

The network imposes flow direction by its configuration of sources, sinks, and switches



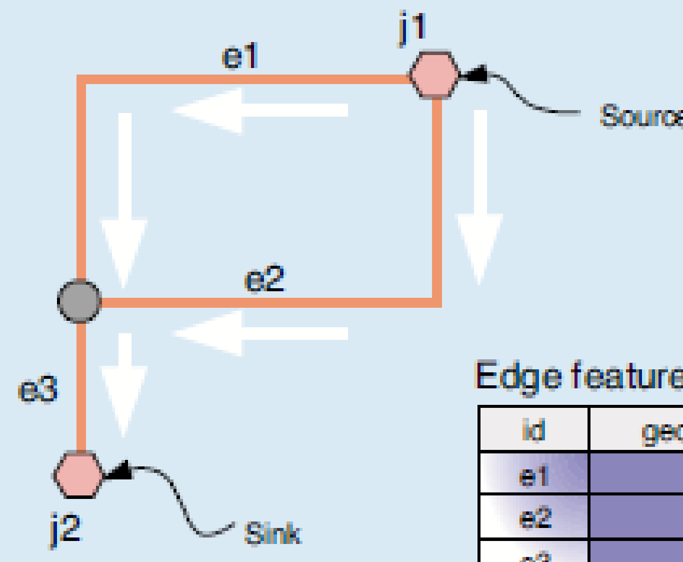
SOURCES AND SINKS

In a utility network, sources and sinks are used in determining flow direction.

Source is a junction from which a commodity flows, such as a well-head pump.

Sink is a junction where all commodity flow terminates, such as a wastewater treatment plant.

Geometric network



Edge feature class

id	geometry
e1	
e2	
e3	

Flow junctions feature class

id	Ancillary role	geometry
j1	Source	
j2	Sink	

Junction features can have an ancillary role of source, sink, or neither. The role is stored in an attribute of the feature class, which is accessed by the establish flow direction method.

DISABLED FEATURES

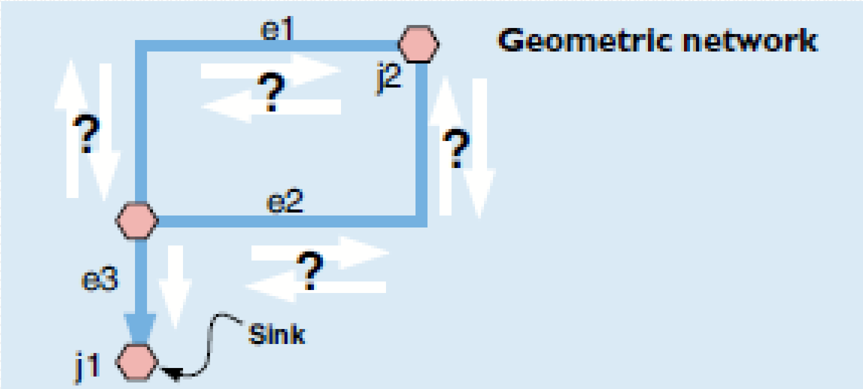
All features participating in a network have an enabled/disabled state.

Nothing flows into or out of the feature.

Disabled features are useful for representing open electrical switches or closed valves.

INDETERMINATE FLOW

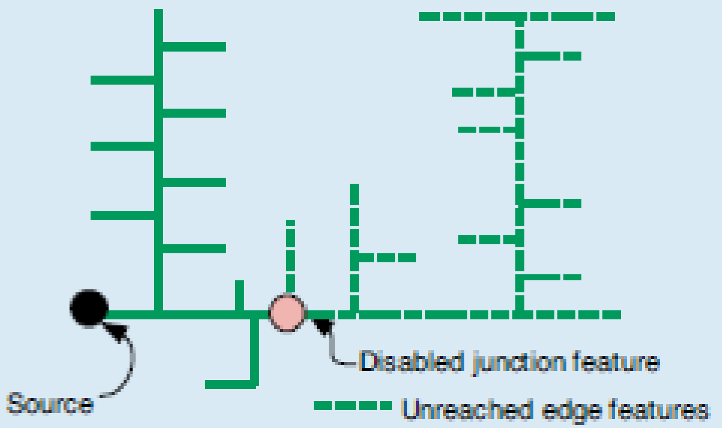
Indeterminate flow occurs when the established flow direction method cannot determine in which direction, commodities flow in a network.



It may not be possible to determine the direction of flow given a configuration of sources, sinks, and enabled features. In this example, it is impossible to determine the flow through edges e1 and e2 because they form a cycle. Changing junction j2 to a source would break the cycle.

UNINITIALIZED FLOW

When a flow is isolated because the edges are disconnected from the rest of the network (that has flow), flow is said to be uninitialized.



When establishing flow direction, edge features may be unreached because they are disconnected from the rest of the network. In this example, the unreached edges are disconnected because one of the junction features–a valve–is disabled.

Point operations in GIS analysis include:

Point Statistics

- calculates an output raster based on the values of input point features within a specified neighbourhood. The output raster value for each cell is a function of the input point features.

Point-in-Polygon

- A topological overlay procedure that determines if points are within polygons. Points are assigned the attributes of the polygons they fall within.
- In Geographic Information Systems (GIS), **regional operations** are a type of zonal operation that examines groups of cells that share a similar value or feature type.
- A region is a group of connected cells within a zone.
- The number of cells in a region can be unlimited.

- **Region Group**: This tool identifies unique connected regions of cells in an input raster.
- **Zonal Statistics**: This tool calculates statistics for each zone, such as the percentile, range, or standard deviation.
- Examine groups of cells that have similar features or values, such as land parcels, water bodies, or soil types.
- **Local operations:** Examine a single target cell. For example, a mathematical transformation to each cell in a raster can be applied to change the values.
- **Focal operations:** Examine the relationship between a target cell and its surrounding cells. A kernel, or window, defines the neighbourhood shape and dimension.
- **Global operations:** Examine the entire areal extent of the dataset.

Neighbourhood processing : An algorithm visits each cell in an input raster and calculates a statistic for the cells in the specified Neighbourhood shape around it.

- Eg. Buffer, interpolation and link analyses.

Minimum Distance Model

Euclidean distance

- This tool measures the distance from each cell to the nearest source in a straight line. Eg. to find the nearest hospital for an emergency flight or to plan a hiking trip.

Calculate Distance Band from Neighbour Count

- This tool evaluates minimum, average, and maximum distances for a specified number of Neighbours. It helps to determine an appropriate distance band value for analysis.

Distance Allocation

- This tool calculates the least accumulative cost distance to the nearest source, while accounting for surface distance and horizontal and vertical cost factors.
- Distance analysis is a fundamental part of most GIS applications.
- It can be used for a variety of tasks, including calculating distance, distance accumulation, and connecting locations.
- When calculating distance, it's important to consider factors that can alter the straight-line distance, such as barriers and surface distance.
- For example, a river, cliff, highway, or building can prevent you from traveling directly from one location to another.

Maximum Covering Model (P-median model)

- Finds the best locations for facilities to maximize the number of demand points covered with 3 aspects like, **Demand points** (within the critical distance of a facility), **Demand weights** (allocated to the nearest facility within the impedance cutoff of multiple facilities) and **Nodes** (weighted according to the demands generated at the nodes).
- The p-median model can be used in a GIS environment to solve problems such as **facility location, spatial analysis** and **transit facility allocation**:
- **Facility location**: The p-median model can be used to determine the location of facilities to minimize the average distance from the population to their nearest facility.
- **Spatial analysis**: The p-median model can be used for spatial analysis in a GIS environment.
- **Transit facility allocation**: The p-median model can be used to allocate transit facilities.

Urban Transportation Planning Model

- **Analyze traffic patterns:** GIS can help identify areas prone to congestion and analyze traffic patterns.
- **Plan routes:** GIS can help plan routes for public transportation.
- **Understand mobility patterns:** GIS can help understand why certain mobility patterns take place and how residents relate to the current infrastructure.
- **Improve land-use estimates:** GIS can help improve land-use estimates, which can lead to improved travel demand estimation.
- **Identify weaknesses:** GIS can help identify weaknesses in the manual overlay process.
- **Share data:** GIS can help streamline data sharing by enabling coordinated data exchange.


Thank you
For your kind cooperation
Patient listening & Learning GIS
Let us enjoy using GIS more efficiently & effectively…