Bharathidasan University

Tiruchirappalli – 620 023, Tamil Nadu

6 Yr. Int. M.Tech. Geological Technology and Geoinformatics

Course Code : MTIGT1003   4 Credits

GIS BASED 3D VISUALIZATION IN GEOLOGICAL TECHNOLOGY

Unit-1:   Principles of 3D Visualization

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Course Objectives

- To learn the fundamentals of 3D visualization in GIS
- To study the possible methods of visualizing various Geological data
- To understand the ways and means of representing topographic relief in a 3 dimensional pattern
- To learn the methods of generating 3D images and interpretation of important geological structures using Geophysical data
- To learn the application of Geoinformatics in natural disaster mitigation.

MTIGT1003: GIS BASED 3D VISUALIZATION IN GEOLOGICAL TECHNOLOGY 4 Credits

Unit-1: Principles of 3D Visualization: Data Input (x, y, z) – Monoscopic and Stereoscopic 3D visualization; TIN – Vertical Exaggeration – DEM based visualization – Concepts of Shaded Relief mapping. **12 Hrs.**

Unit-2: 3D Visualisation of Topographic Data: Generation of x, y, z data – 3D visualization of topography – DEM based topographic analysis – shaded relief – applications. **12 Hrs.**

Unit-3: 3D Visualisation of Geophysical Data: X, Y, Z data from different sources – Generation of DEM, Different processed outputs of DEM, Shaded relief maps of Gravity, Magnetic and Resistivity data – Its applications. **16 Hrs.**

Unit-4: 3D Visualisation of Subsurface Lithology: Collection of borehole data – working out lithology and lithotop of various horizons – DEM of shaded relief of thickness of various formations, Depth of various formations and litho top of various formation – their interpretations. **12 Hrs.**

Unit-5: 3D Visualisation of Groundwater: Collection of water level and other aquifer variables (Transmissivity, Permeability, Storage co-efficient, etc.) – Generation of x, y, z – Generation of DEM and shaded relief of groundwater systems and interpretation. **12 Hrs.**

Unit:6. Current Contours: (Not for Final Exam only for Discussion): Step-by-step procedures for generation of high resolution DEM using CARTOSAT Stereo data; Derivation DEM products like Anaglyph and 3D Fence Diagram. Use of DEM for automated mapping of Geological Structures in GIS.

Course outcomes

After the successful completion of this course, the students are able to:

- Understand the concepts, develop GIS database and generate 3D visualized images of Geological and other terrain features
- Know the fundamentals pertaining to volume estimation, drainage mapping, watershed delineation, slope classification using 3D visualization techniques
- Learn the method of 3D visualization of topographic data
- Understand the method of visualization of Geophysical data and their application
- Learn the method 3D visualization of subsurface lithology and its applications
- Understand the method of 3D visualization of groundwater and its applications.

References

- Burrough, PA., Principles of Geographical Information Systems, Oxford University Press, 1997.
- DeMers, Michael N, Fundamentals of Geographic Information Systems, John Wiley and Sons, 1999.
- David J., Bringing Geographical Information Systems into Business, Second Edition Grimshaw, John Wiley and Sons, 1999.
- Christian, Serving Maps on the Internet: Geographic Information on the World Wide Web Harder, ESRI Press, 1998.
- Graeme F. Bonham-Carter, Geographic Information Systems for Geoscientists: Modelling with GIS, Pergamon Publications, 1994.
- Sabins, F.F.Jr., Remote Sensing Principles and Interpretation, Freeman, Sanfrancisco. 1978.
- Lillisand, T.M. and P.W. Kiefer, Remote Sensing and Image Interpretation, John Wiley & Sons, New York, 1986.

Unit-1: Principles of 3D Visualization

Unit-1: Principles of 3D Visualization: Data Input (x, y, z) – Monoscopic and Stereoscopic 3D visualization; TIN – Vertical Exaggeration – DEM based visualization – Concepts of Shaded Relief mapping. **12 Hrs.**

Monoscopic methods of Depth Perception

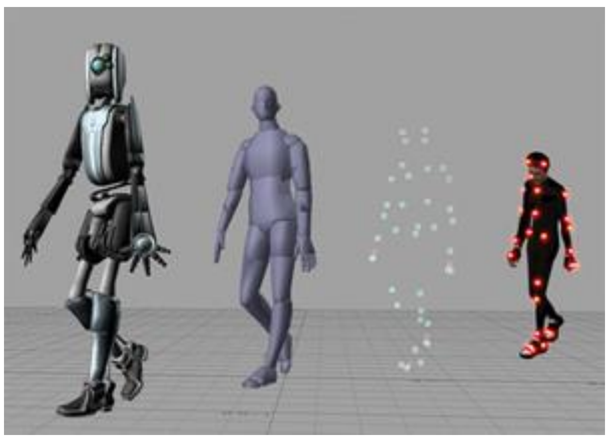
Distances to objects, or depth can be perceived monoscopically on the basis of

- **Relative sizes of objects**
- **Hiding of objects located at the backside**
- **Shadows of objects**
- **Brightness variation based on the shape of illuminated portion of objects**
- **Differences in focusing of the eye for viewing objects at varying distances and**
- **Parallax differences to objects at varying distances from view point for making continuous frames (stand-stills) to animate.**

3D (Monoscopic) Animations in 2D Platforms

In this .gif of a 2D Flash animation, each 'stick' of the figure is keyframed over time to create motion.

A ray-traced 3-D model of a jack inside a cube, and the jack alone below.



These are all one or the combination of the methods of 3D perception monoscopically. This Enables only rough impressions to be gained of distances to objects.

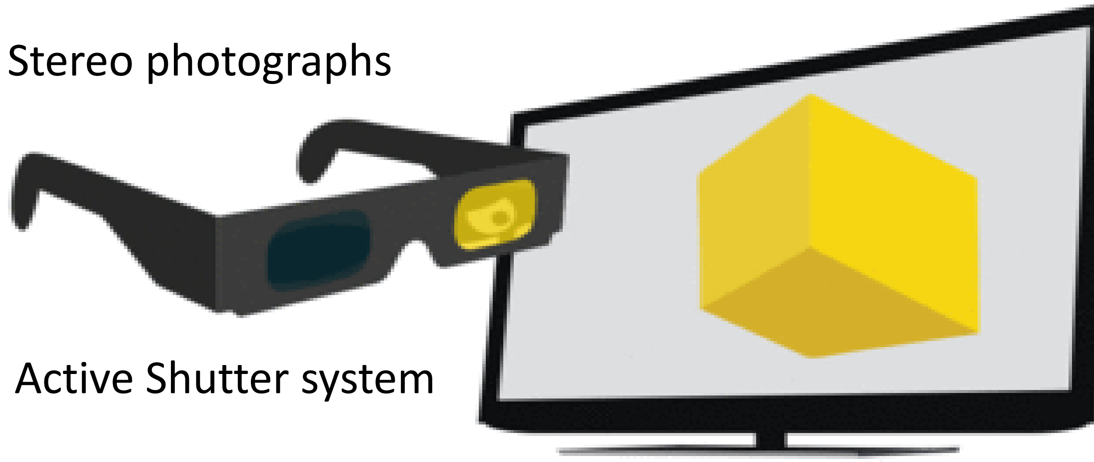
But, much greater degree of accuracy in depth perception and 3D measurements can be achieved by – STEREOSCOPIC VISION using PARALLAX differences to various features.

3D Stereoscopic Visualization in 2D Platforms

- Derive Stereomodels – Stereograms using stereoscopes / stereopsis or binocular vision
- Active - shutter systems
- Passsive
  - 3D Anaglyphs and Anaglyph glass
  - Polarization
  - Interference filter
  - ChromaDepth glass systems,
  - Pulfrich method
  - Over-under format ...

Stereo photographs

Polarized 3D system



Active Shutter system

Stereo Anaglyph image

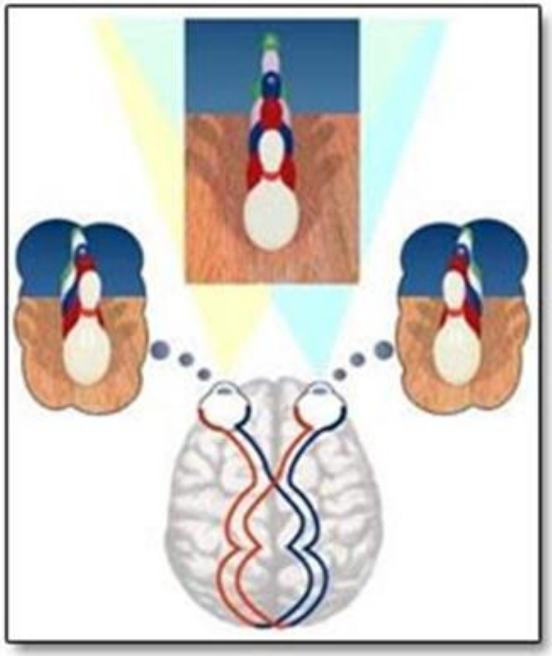
Stereo Anaglyph glass

ChromaDepth glass

Basic principles of 3D stereoscopic visualization

- For true perception of object's depth (like e.g. in the IMAX 3D cinema) it is necessary to visualize not only one 2D image, but at least two separated one for each human eye.
- The source image must be recorded by **multiple camera** or in the case of **Computer Graphics (CG)**, the view on the scene must be generated from multiple positions.
- In addition we must use technologies delivering the proper image just only to the proper eye.
- Only in this case the human brain is able to determine the full 3D depth of the scene.

Hence, 3D visualization of terrain / objects using the available spatial data can be developed using both Monoscopic and Stereoscopic methods.



DIGITAL ELEVATION MODELS

Definition

- Three dimensional representation of variation of relief over space using digital data is called as Digital Elevation Model

- Digital Terrain Model - Three dimensional representation of variation of terrain characteristics over space using digital data is called as Digital Terrain Model .

Need for Three Dimensional Models

i) For locating regional / local, artificial, synclinal, domal and basinal structures for resource modelling

ii) For understanding regional landscape architecture

iii)For geomorphic mapping and geo environmental planning

iv) Water reservoirs and dam / reservoir planning v) Mine planning, site selection of mine dumps and mine

vi) Reclamation

vii) Geohazards

i. Isostatic and fault movements
ii. Landslides ,earthquakes
iii. Mine pollution
iv. Flood zone mapping
v. Coastal erosion
vi. Salt water intrusion

Data Input - Data Sources for DEM

i) TOPOSHEETS

- Contour lines-Closed or open contour lines,
- Spot heights – Bench marks (BM), Triangulation Points (Δ), spot elevation in plains.

ii) AERIAL PHOTOGRAPHS

- Heights are measured from stereo models

iii) SPOT STEREO IMAGES

iv) ERS DATA DIRECTLY SUPPLY D T M IMAGERY

v) RADAR DATA

vi) LIDAR DATA

- 0.5 – 2m resolution, vertical accuracy of 15 cm

vii) GPS DATA

viii) BREAK LINES – represents sudden changes over the land surface -

e.g. Streams, shorelines, ridges, River / Tank / Dam Bunds, Rails at Railway stations, certain segments of Roads, Road Bunds ….

ix) AREA DATA – Water spread areas of tanks, lakes and reservoirs

Sampling Methods For D E M

- ➔ For example, using aerial photographs (stereo triplets) in stereo-plotters, the sampling can be done.
- ➔ In order to have correct relief and slope, different type of sampling is done.

Progressive Sampling

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.

Data Sampling methods

- **Photogrammetric Sampling**
  - **Selective Sampling**
    - Sample points are selected prior to or during sampling process
  - **Adaptive Sampling**
    - When redundant samples (carrying little information) need to be rejected during sampling
  - **Progressive Sampling**
    - When sampling and data analysis are carried out together, the results of the analysis dictating how the sampling should proceed

Modes of Sampling

- **Fully Manual sampling**
  - Human operator guides the stereoplotter – slow process and liable to error
- **Semi-automatic sampling**
  - The operator of the photogrammetric instruments (e.g. stereoplotter) is guided for taking accurate/correct samples without redundancy , with improved speeds – better than fully automated systems
- **Fully automated sampling**
  - Faster, but insufficiently accurate

Modes ...contd...

- **Purposive Sampling**
  - To digitize contour lines, form lines, profiles and morphological lines
- **Area Sampling**
  - Sampling based on altitude matrix using regular or irregular grid – random, stratified random grid.
- **Progressive Sampling**
  - as discussed previously, in a terrain having less variations in elevation, i.e., more gentle area then, only with few sample points.
  - On the contrary, if the terrain is highly undulating and large variations in height, then more samples are needed for correct representation of the terrain.

Procedure for Progressive sampling

- It involves series of successive steps / runs
- Begin with a coarse grid sampling
- Then proceed with increasing grid density, i.e., minimizing the grid size / double the grid density on each successive sampling run
- The points to be sampled are determined by a **computer analysis** of the data obtained on the preceding run

Computer analysis in progressive sampling

- Initially, a square patch of nine points on the coarsest grid is selected from the samples.
- The height values between each adjacent pair of points along the rows and columns are calculated.
- The differences are then calculated.
- These carry the information about the terrain curvature.
- If the estimated curvature exceeds a certain threshold, then it is desirable to increase the sampling density and sample points at the next level of grid density on the next run
- Suitable, if the area has no anomalous features in aerial photographs like, clouds, man-made objects (tall chimneys, etc.),
- Best for regular or semi-regular terrain with horizontal, slightly tilted or smoothly undulating surfaces.

Composite Sampling

- Suitable for moderately rough terrain with distinct morphological features with some anomalous areas.
- Abrupt steps in the terrain or the boundaries of natural or anomalous objects are first delineated by hand before sampling.

Selective Sampling

is opted for rough terrains with many abrupt changes.

Data registration and geocoding

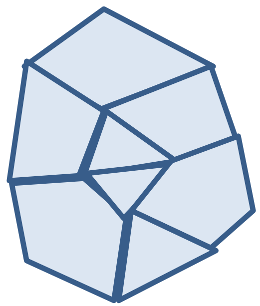
- Correct for distortions due to altitude variations, aircraft tilt, etc. – orthorectification
- Bring to a common coordinate system – for accurate scale – using projection systems
- For raster samples, this process is very time-consuming one

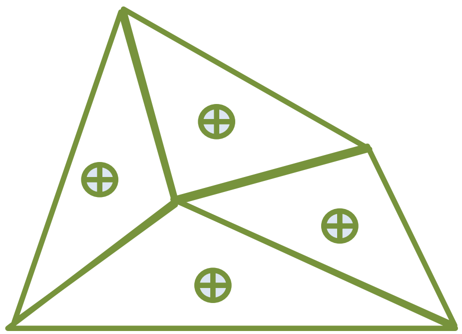
Methods of DTM Generation and Terrain 3D Representation

1. Mathematical Patch Methods

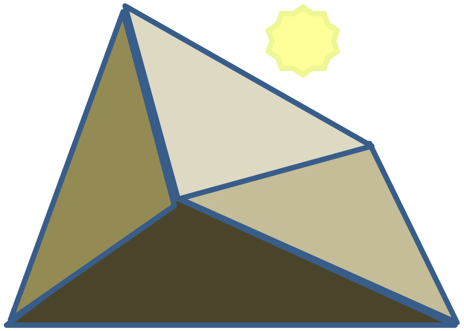
i) Split the complete surface into square cells or irregularly shaped **patches** of equal area and fit to a point of observation – Theissen method of spatial local interpolation.

ii) Use Mathematical functions to weld them, whenever needed, based on the facet-azimuth.





Methods of DEM Representation ...contd...



Methodology for Mathematical patch methods

- In local method, 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, by ensuring similar values along edges for the adjacent surface patches
- Weight functions are used to ensure matching along the edges of surface patches, though not always seem to be continuous in slope along borders
- Mathematical functions using piece / patch wise approximations of z-values for interpolating surfaces – useful in modeling complex surfaces in CAD systems

Methods of Representing DEMs... Contd...

2. Image methods

- Using point data
  - Regular – uniform density

    - Variable density
  - Irregular – triangulation

    - Proximal networks
  - Critical features – peaks, pits, passes, boundaries

- Using line data
  - Horizontal slices (contours)
  - Vertical slices (profiles)
  - Critical features – ridges, stream courses, shorelines, breaks in slope

Methodology for 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

iii) Develop D T M

➔ Grid size may vary for areas of complex relief and slope

➔ Data redundancy in areas of uniform slope

Point models … Methodology…contd…

- **Altitude matrices**

  - Common form: Altitude matrix or regular rectangular grid from stereo-plotter measurements or interpolated altitude matrix

  Useful for calculating contours, slope angles and aspects, hill shading and automatic basin delineation.

Disadvantages:

- Large amount of data redundancy in areas of uniform terrain
- Inability to adapt to areas of different relief complexity without changing the grid size
- Exaggerated emphasis along the axes of the grid for certain kinds of computation such as line of sight calculations

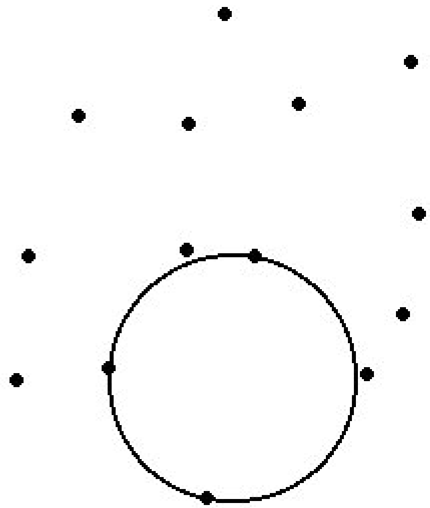
Line models … Methodology…contd…

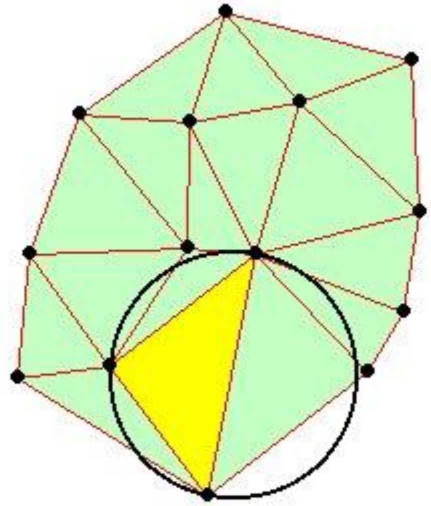
- Set of contour lines – hypsometric curves – produce poor quality DEMs
- Not suitable for computing slopes / shaded relief models
- So, they are converted to a point model – discrete altitude matrix
- During 1984, for altitude matrices the Contours are supplemented by drainage and ridge lines – **'The Graz Terrain Model'**
  - Grid map having appropriate cell size is overlaid on the digital image of contours, ridges and drainage lines
  - All cells lying on or immediately next to a contour lines are assigned the height value of that contour
  - All other cells are assigned a value of -1, using linear interpolation
    - along four search lines oriented N-S, E-W, NE-SW and NW-SE
    - by computing the local steepest slope for the window as a simple function of difference between the heights of cells that already have a height value assigned.

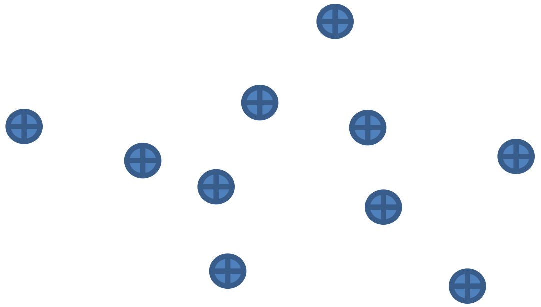
3. Triangulated Irregular Network (TIN)

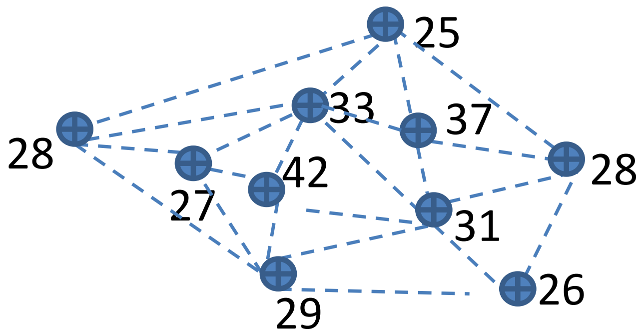
TIN is a vector-based representation of the physical land surface or sea bottom, made up of irregularly distributed nodes and lines with three-dimensional coordinates (*x*, *y*, and *z*) that are arranged in a network of non-overlapping triangles.

- ➔ Aerial triangulation
- ➔ Develop network
- ➔ Develop altitude matrices
- ➔ Treat each and every Δ as polygon in vector – Delaunay Triangulation
- ➔ Develop TIN – is also known as DTM.





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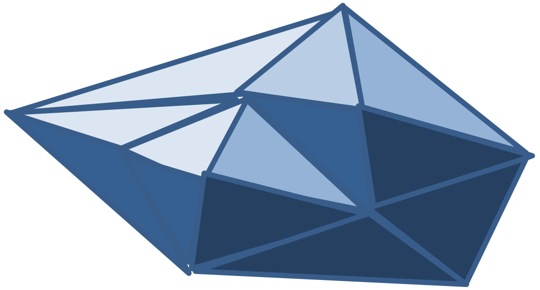


TIN …Contd…

- 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, known as **Mass Points**: well-chosen points located in places where accurate Lat., Long. & Elev. Values are known 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”**- important topological features can be digitized with required accuracy.

TIN Topology

- 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.
    - The triangle number
    - The numbers of each adjacent triangle
    - The three nodes defining the triangle
    - The x, y coordinates of each node
    - The surface z value of each node
    - The edge type of each triangle edge (hard or soft)

Geodetic elevation Model of Planetary Relief

- Alternative compact method for modelling planetary relief
- Based on recursive **Tesselation** (tiling) of a regular octahedron or icosahedron into equilateral triangular facets
- By Dutton during 1984
- It attempts to bring the whole of the Earth's surface into one system
- Horizontal coordinates are implicit in the hierarchy of nested triangles and only elevations are stored
- Entire terrain can be coded using less than one bit of data for each triangular facet.

Automated Landform delineation from DEMs

- Based on the topographical variations, Hills, Plateaux, Slopes, Foot hill features and Planar features can be easily mapped using DEM
- Programmes can be written to delineate these features of distinct type based on elevation difference and vectorize them.
- Smaller and plain geomorphological features need more exaggeration and
- Mapping of Planar features such as, Flood Plains, Oxbow lakes, Coastal Plains, can be automated by using additional morphological and associated feature details in conjunction with other data which can be incorporated like FCC wrapped DEM, etc.

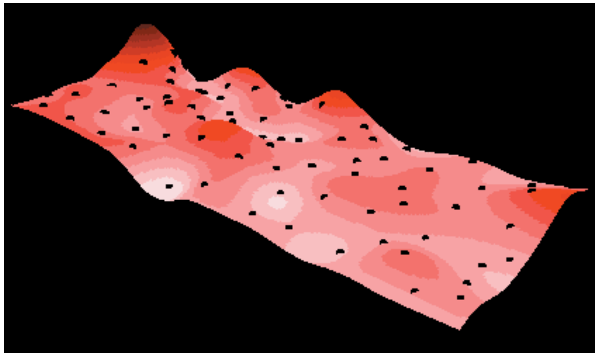
RASTER SURFACE MODELS

A surface is a continuous field of values that may vary over an infinite number of points

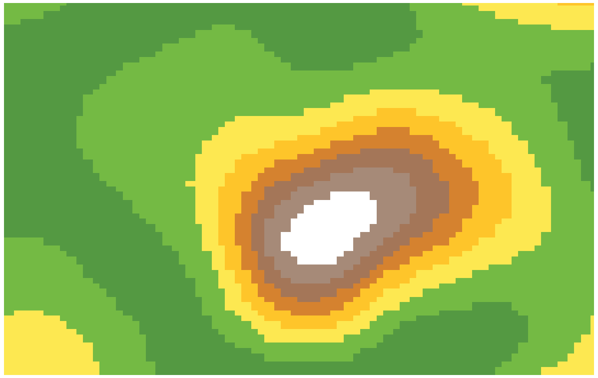
3D Analyst uses two types of surface models: **Rasters** and **TINs.**

Rasters represent a surface as a regular grid of locations with sampled or interpolated values.

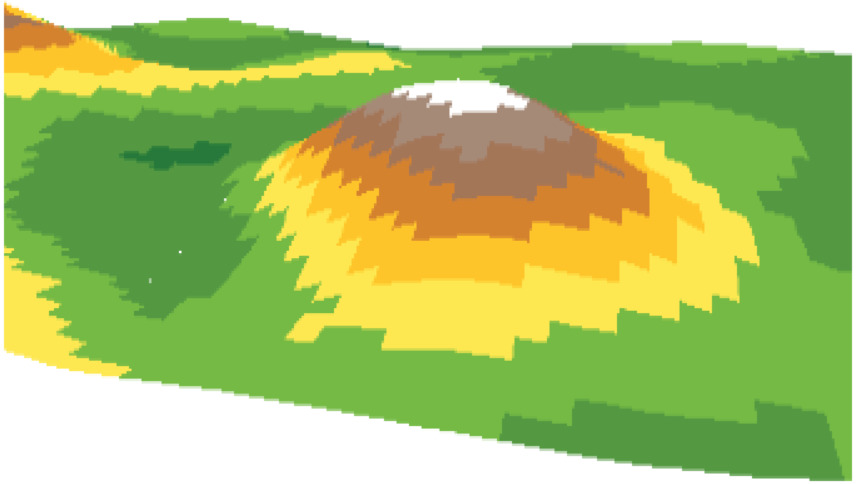
TINs represent a surface as a set of irregularly located points linked to form a network of triangles with z-values stored at the nodes



Surface model of chemical concentration across an area with points showing where the concentration was sampled

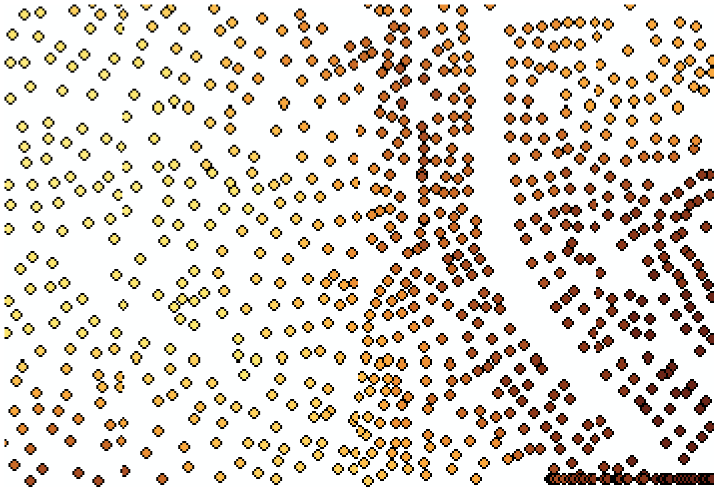


Grid in perspective view



CREATING TIN SURFACES FROM VECTOR DATA

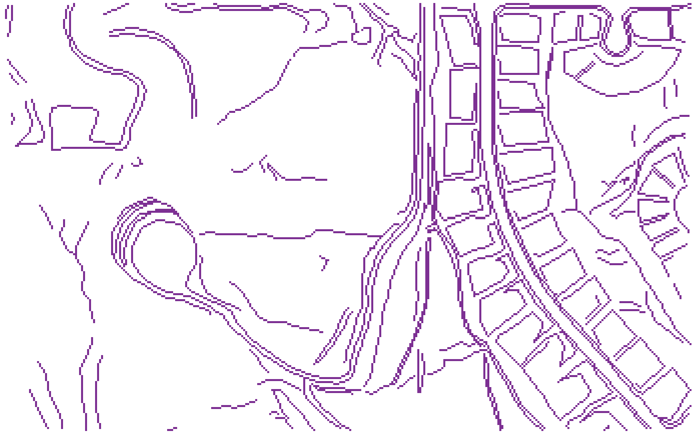
TINs are usually created from a combination of vector data sources. You can use point, line, and polygon features as input data for a TIN.

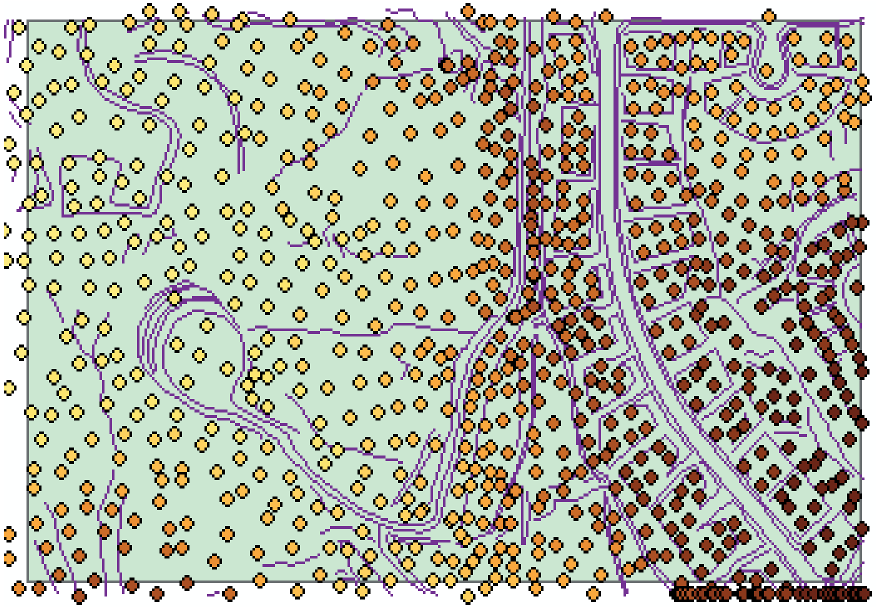


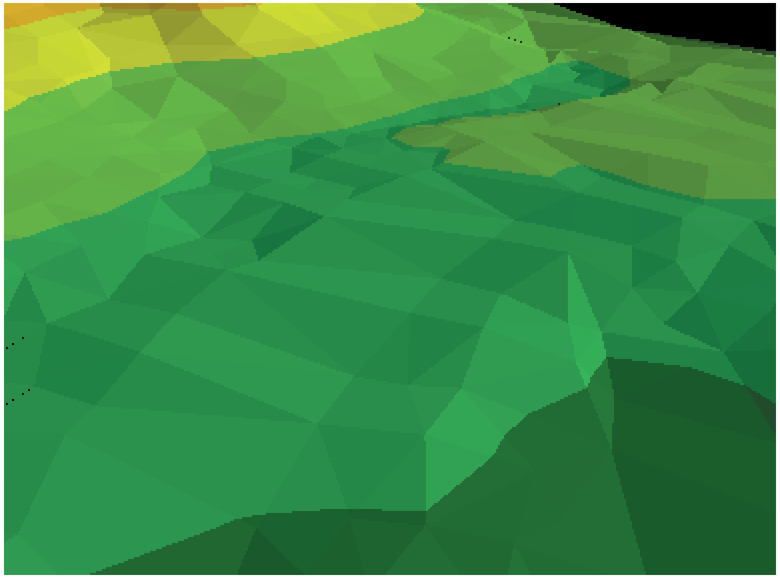
Mass points, categorized by height attribute

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

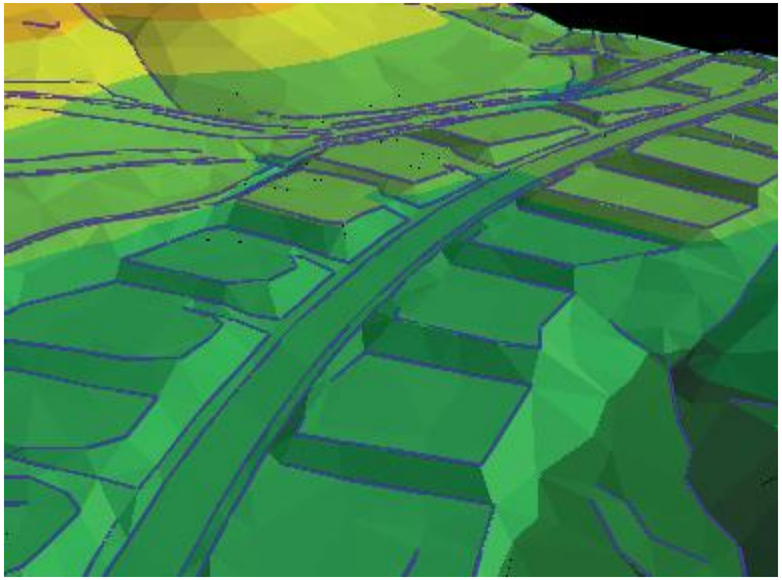




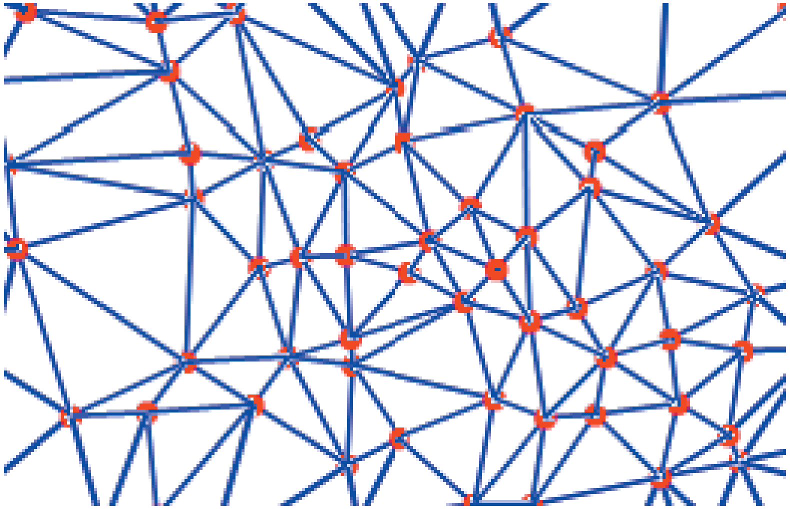


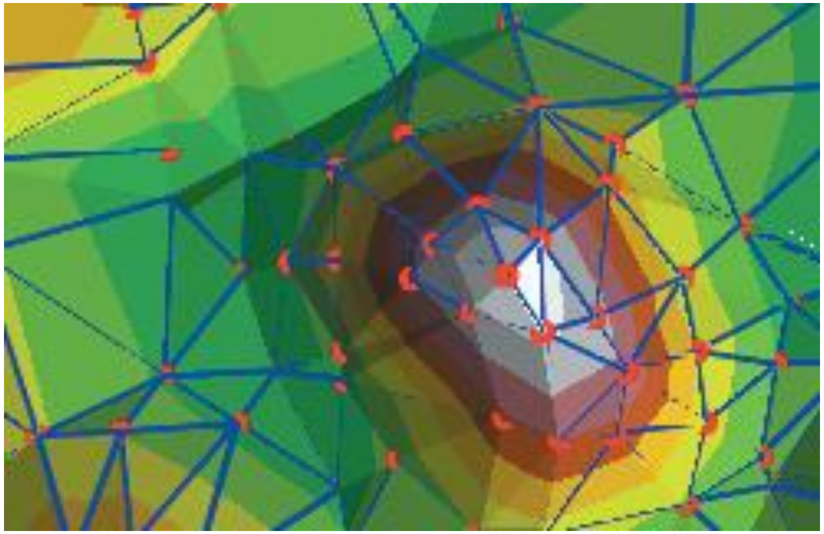
TIN created from mass points

TIN of the same area created from mass points and breaklines.

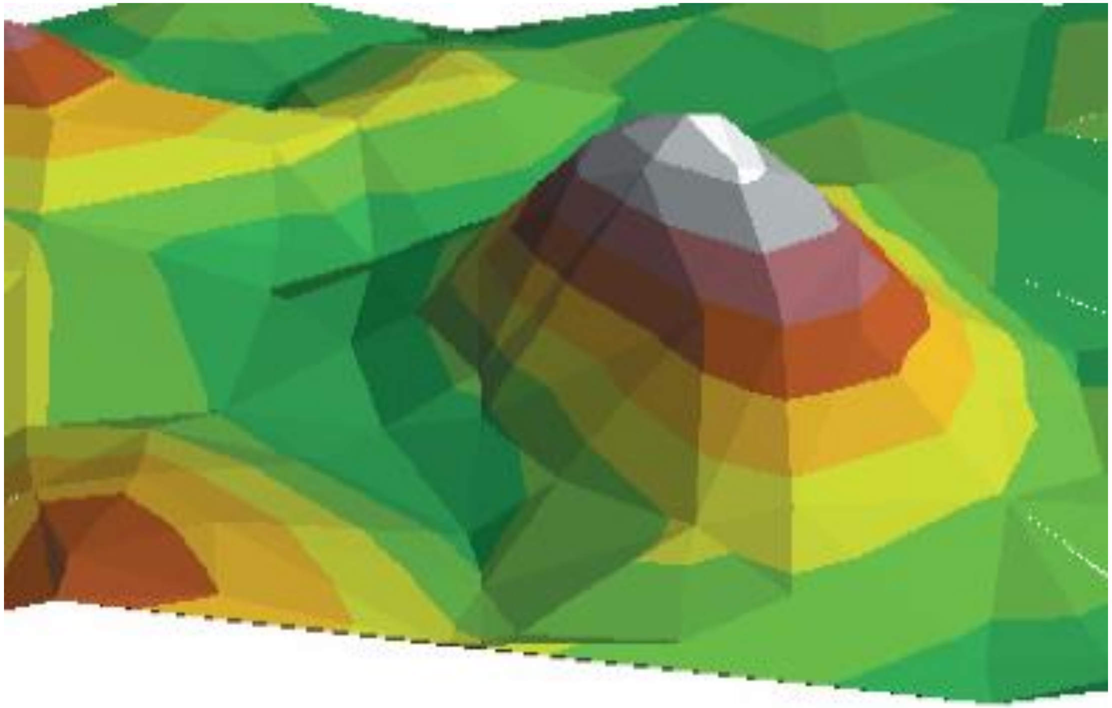


Nodes and edges of a TIN





TIN in perspective view



[3D Fly-thru]

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, a set of well 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 you extrude the wells 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 the vertical z units are feet and the horizontal x,y units are meters, it is necessary to use a z-factor of 0.3048 to convert the 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.

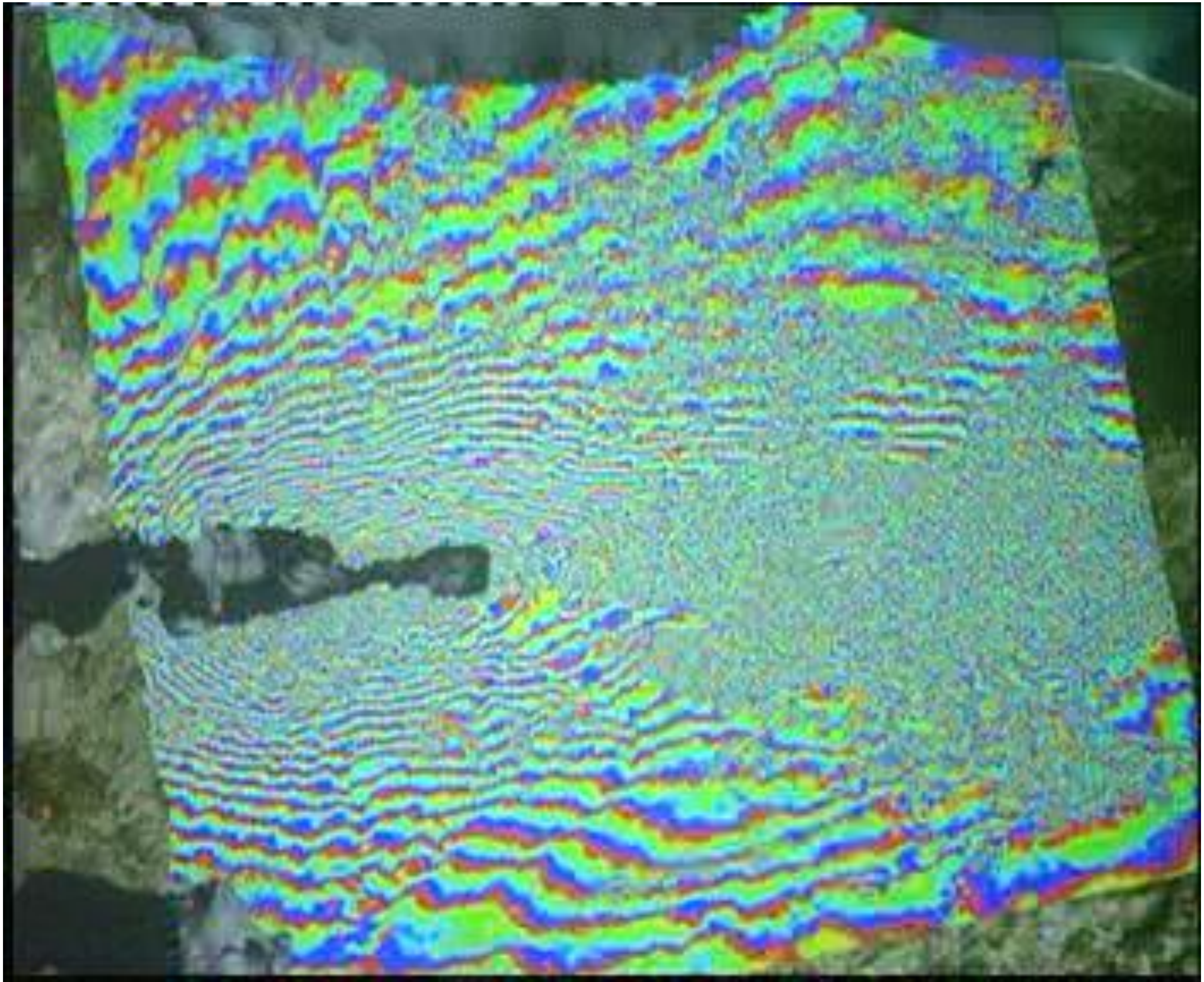
Z-factor ... contd...

If the x, y units are decimal degrees and the z units are meters, some appropriate z-factors for particular latitudes are:

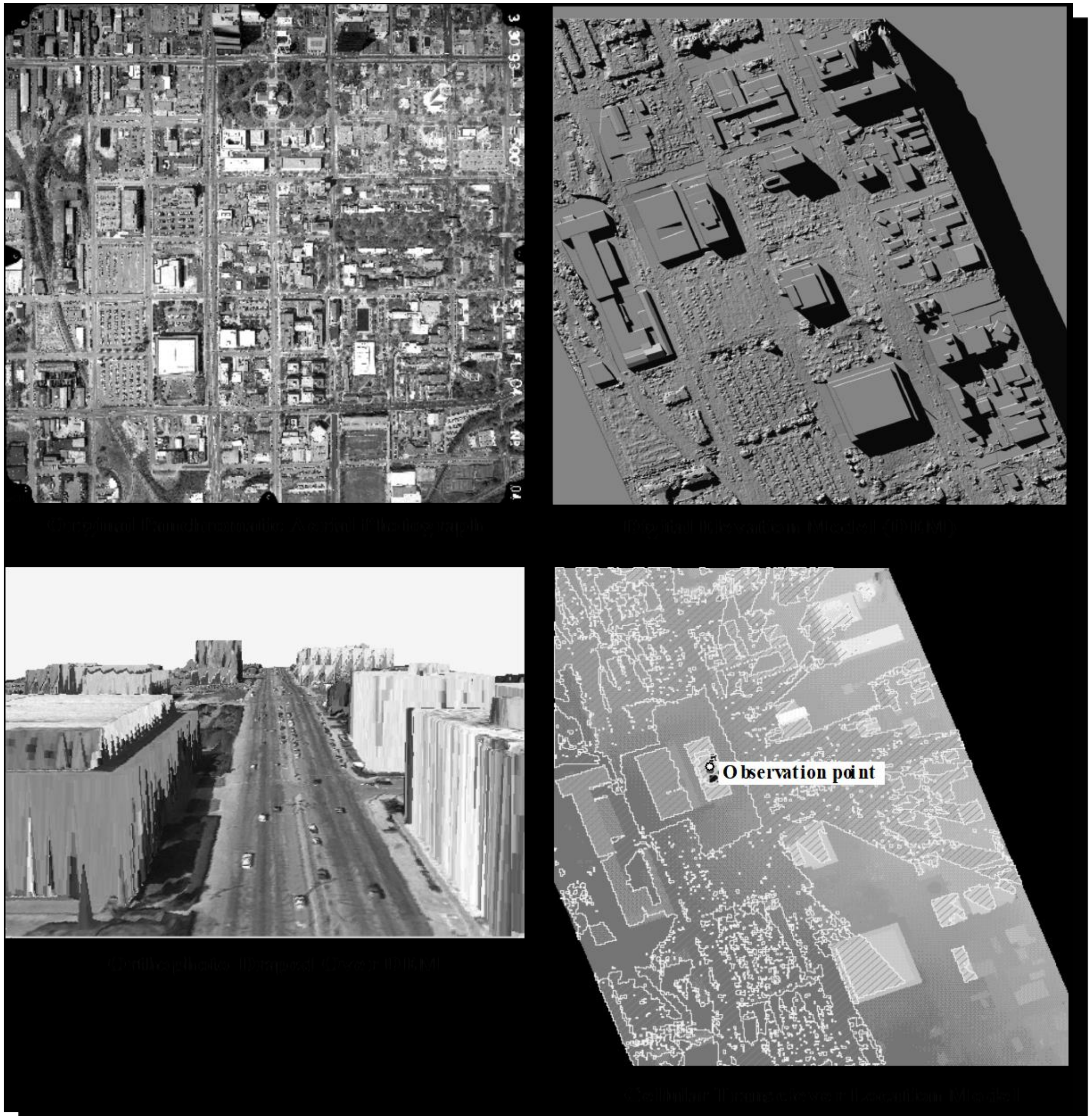
Latitude	Z-factor
0	0.00000898
10	0.00000912
20	0.00000956
30	0.00001036
40	0.00001171
50	0.00001395
60	0.00001792
70	0.00002619
80	0.00005156

It can be noted that as the range of latitude in the raster data increases, the more approximate the results will be.

Z-factor - used in 3D Animation for additional clarity in visualization



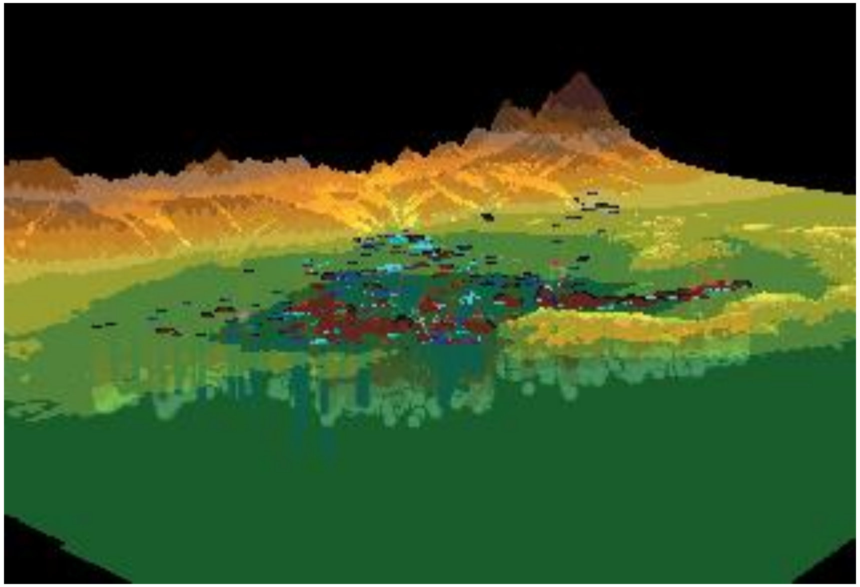
DEM BASED VISUALIZATION OF TERRAINS / SURFCES



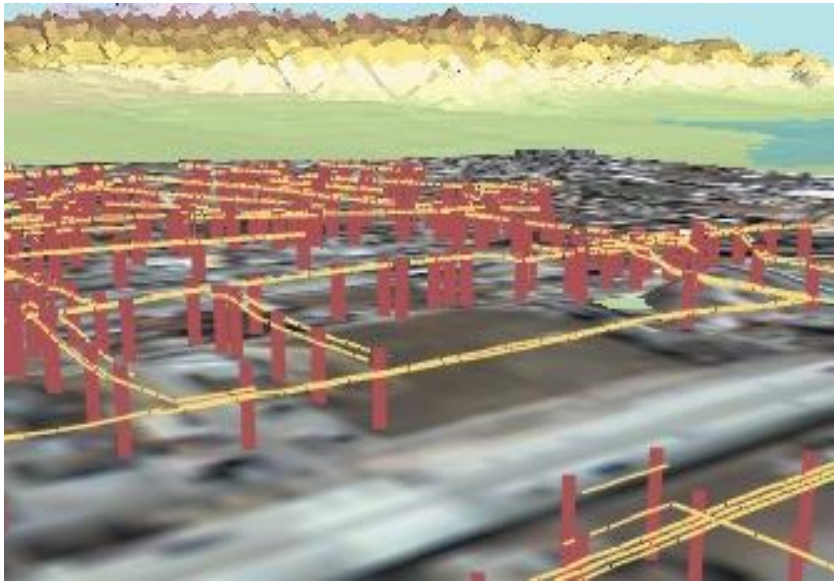
Digital Surface Model (DSM)

DIGITAL ELEVATION AND SURFCES COMBINED ...contd

3D view of raster and vector data

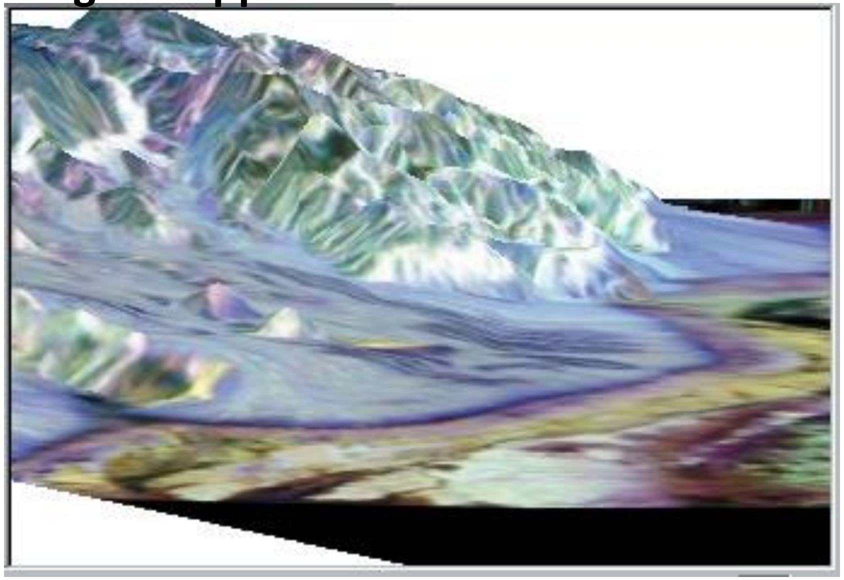


3D view of utility poles and power lines

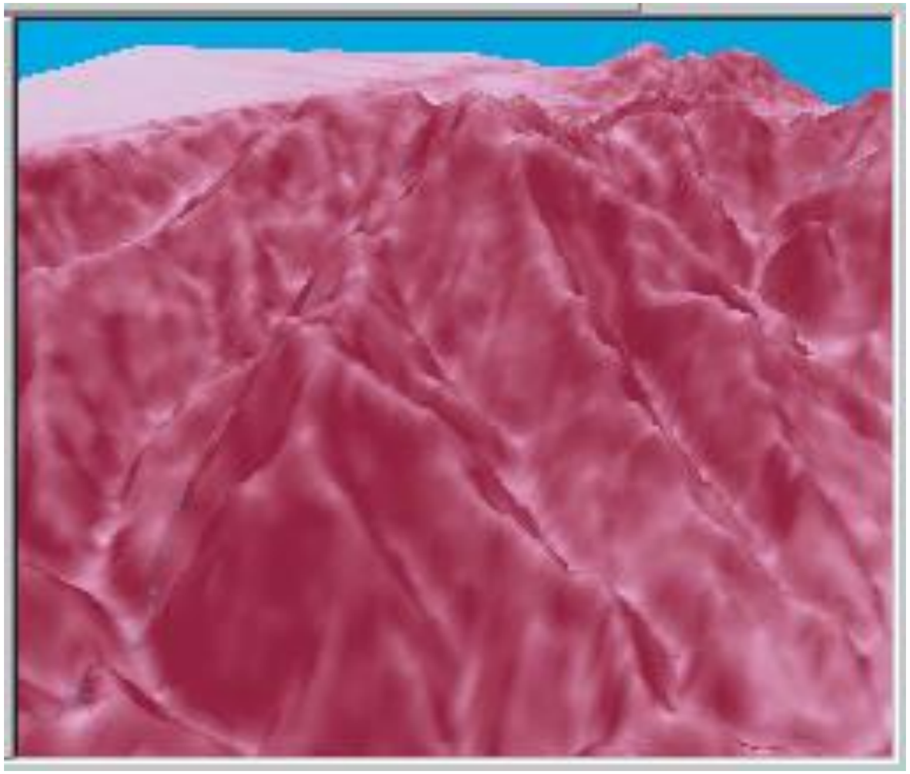


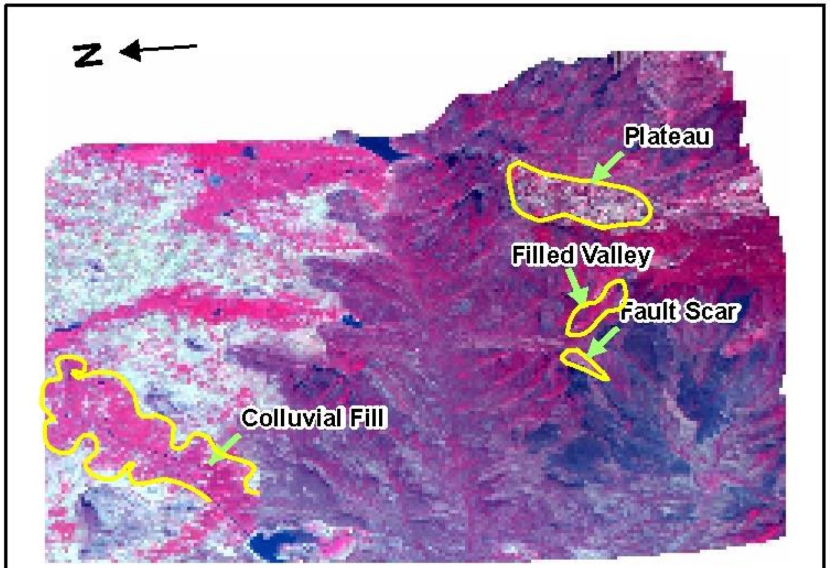
3Dimensional choropleth map -vector data

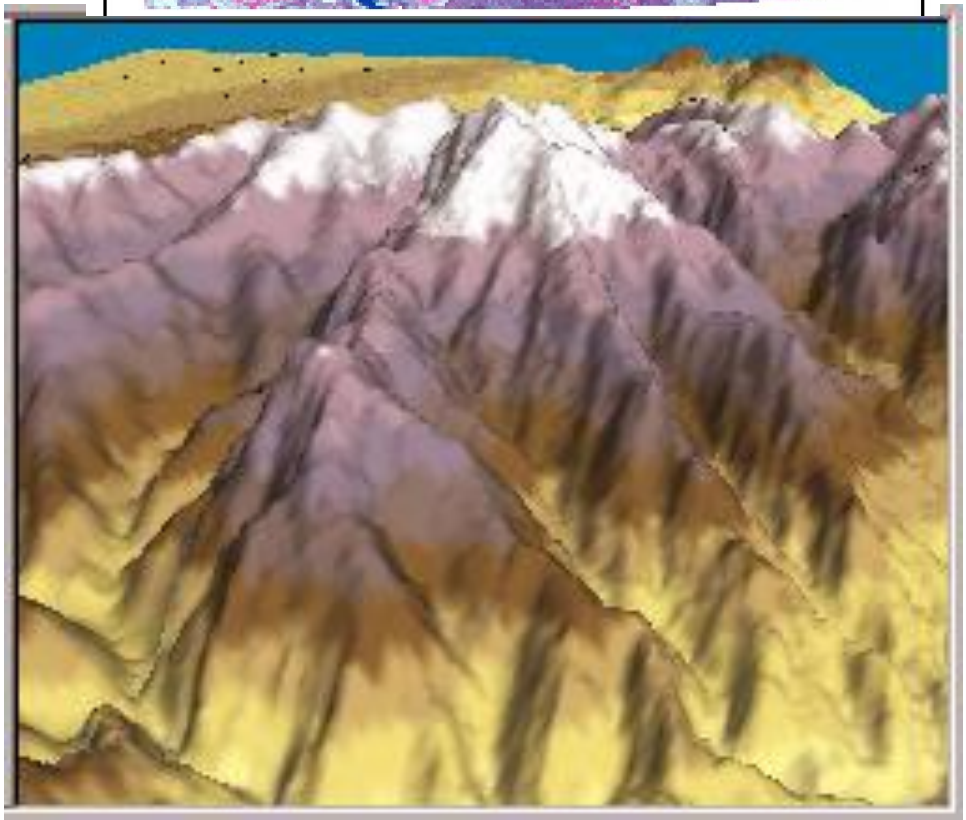
Image Wrapped DEM



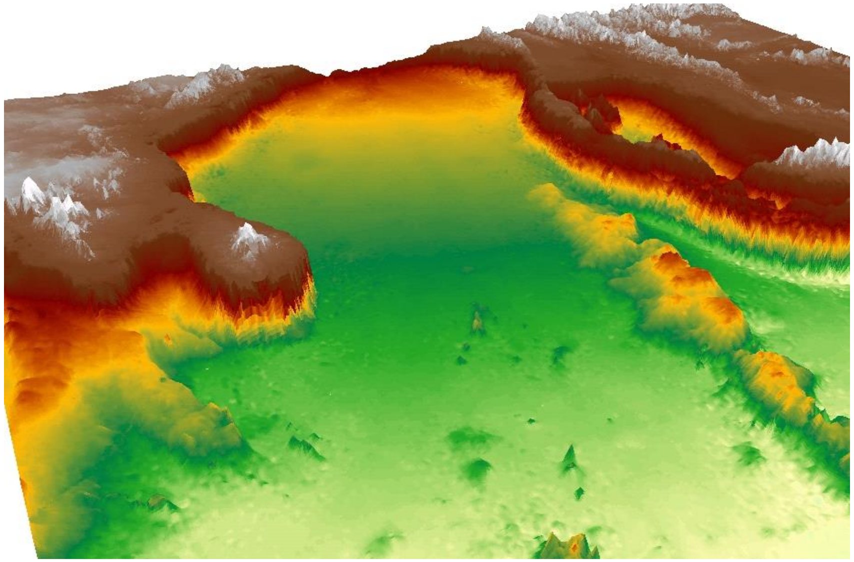
Understanding the shape of a surface

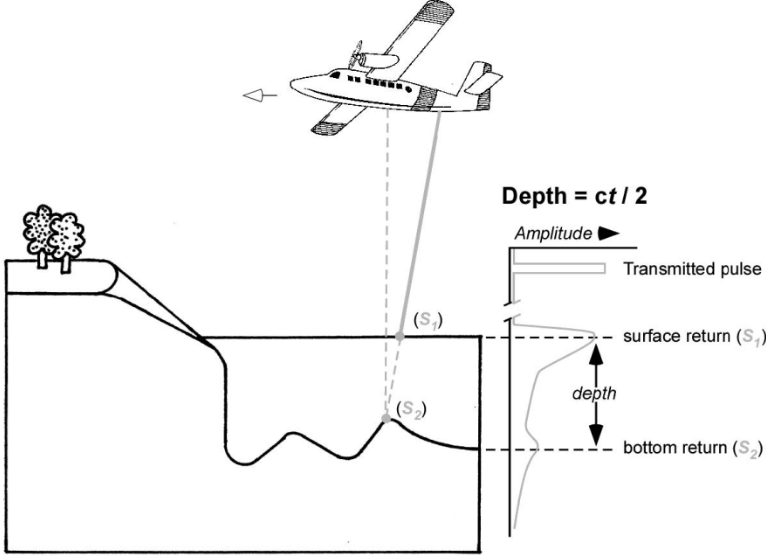


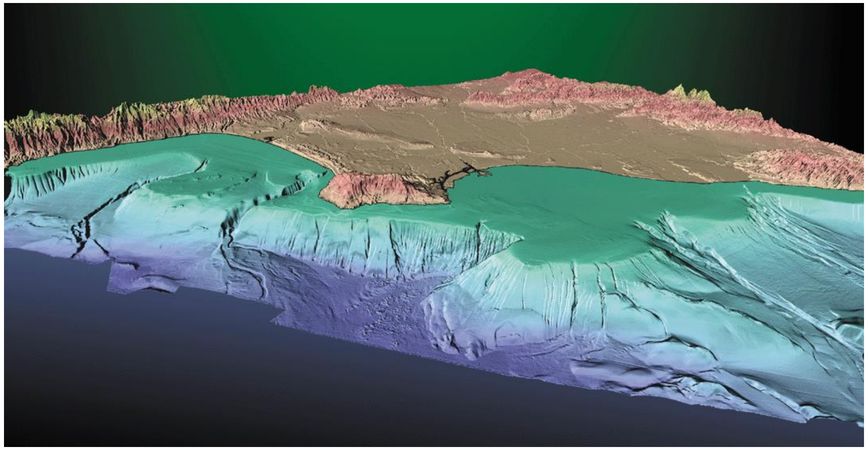




BATHYMETRY:



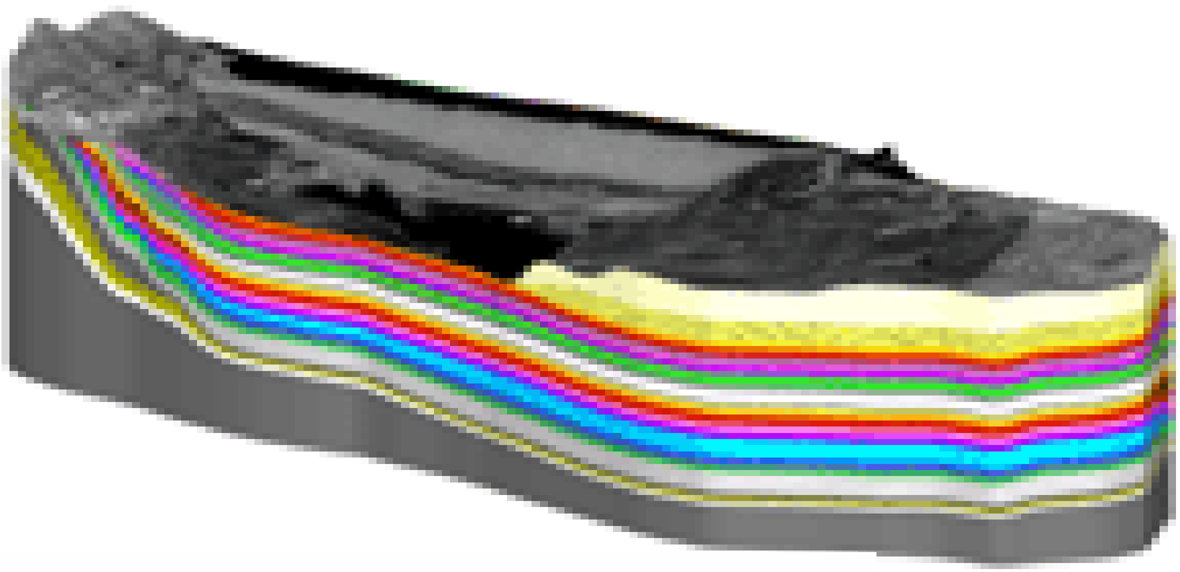


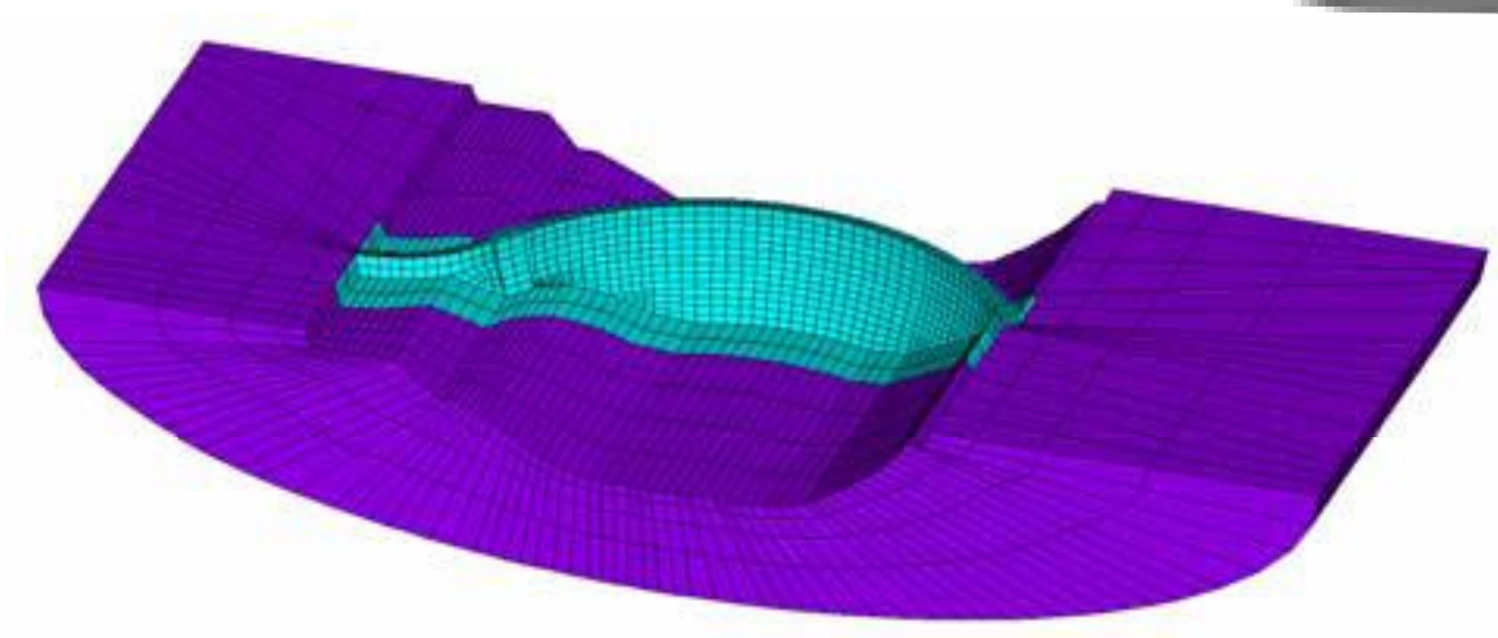


For any offshore structures including harbor development

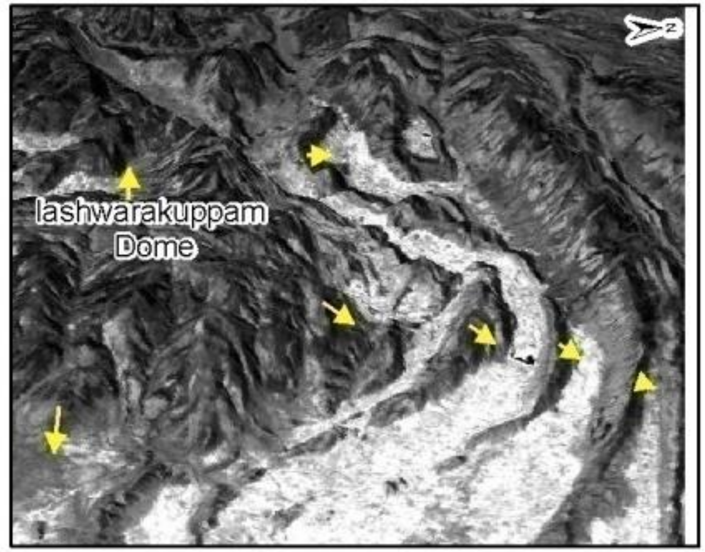
Pipeline etc.,

DIGITAL TERRAIN MODEL ...contd

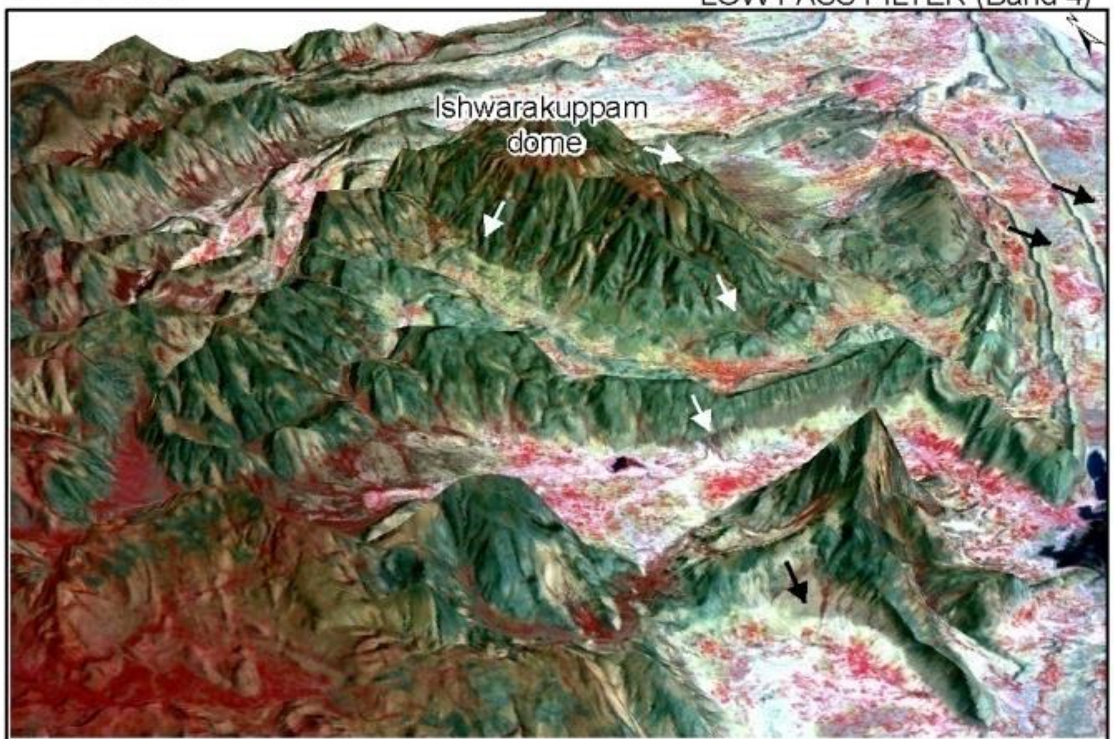




TM FCC data



LOW PASS FILTER (Band 4)



Products and Applications of DEM

- Block diagrams, profiles and horizons
- Volume estimation by numerical integration
- Contour maps
- Line of sight maps
- Maps of slope, convexity, concavity and aspect
- Shaded relief maps
- Drainage network and drainage basin delineation
- Drainage / stream orders, flow length, flow direction and accumulation,
- Fly-through models, etc.

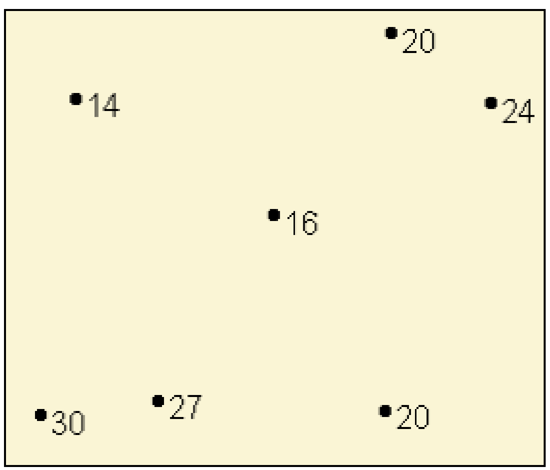
CREATING RASTER SURFACES FROM POINTS

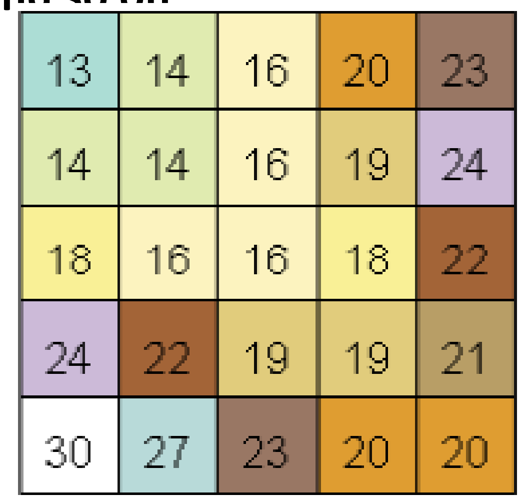
Surfaces of continuous data are usually generated from samples taken at points across the area

For example, the irregularly spaced weather stations in a region can be used to create raster surfaces of temperature or air pressure. The resulting surface is a regular grid of values.

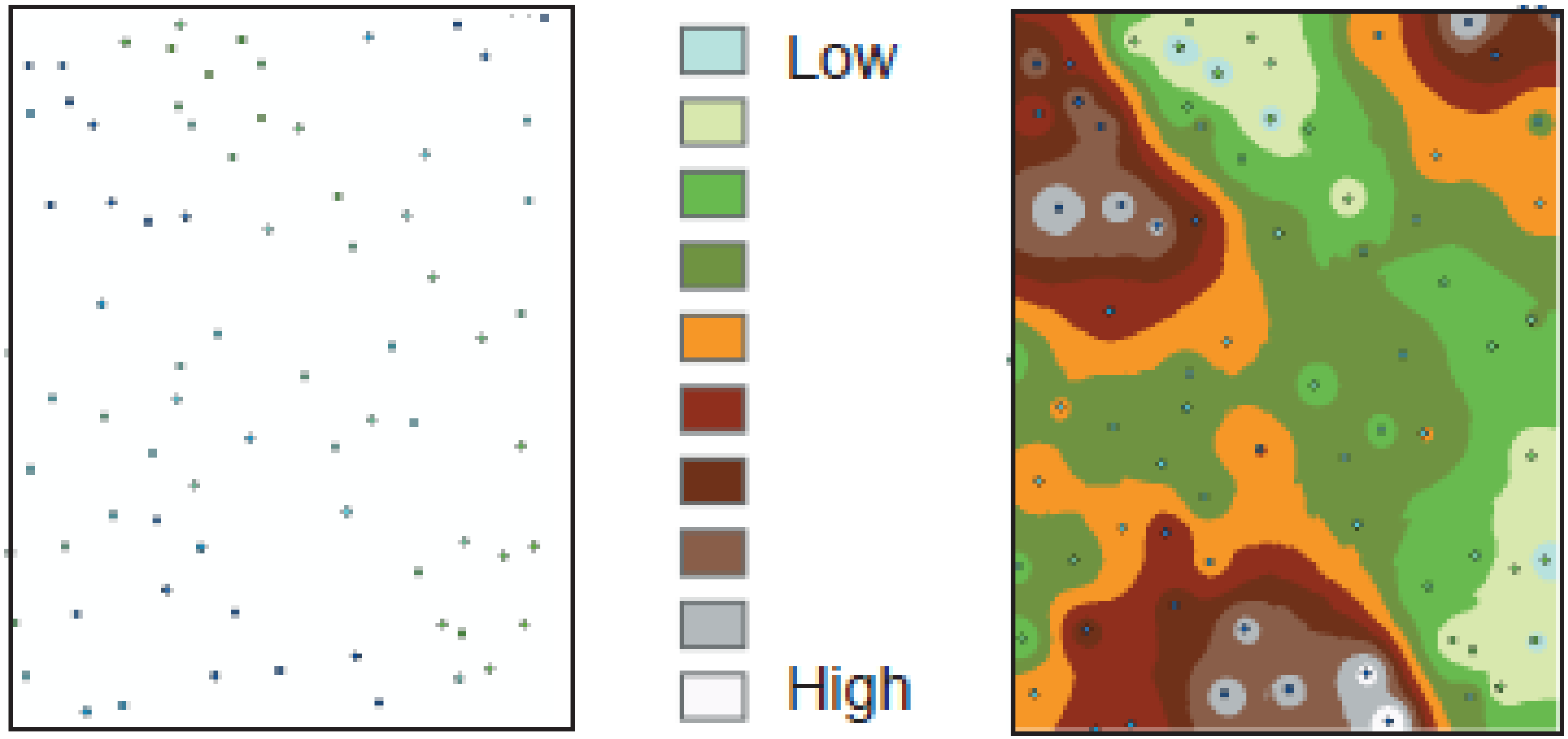
What is interpolation?

Interpolation predicts values for cells in a raster from a limited number of sample data points. It can be used to predict unknown values for any geographic point data: elevation, rainfall, chemical concentrations, noise levels, and so on.



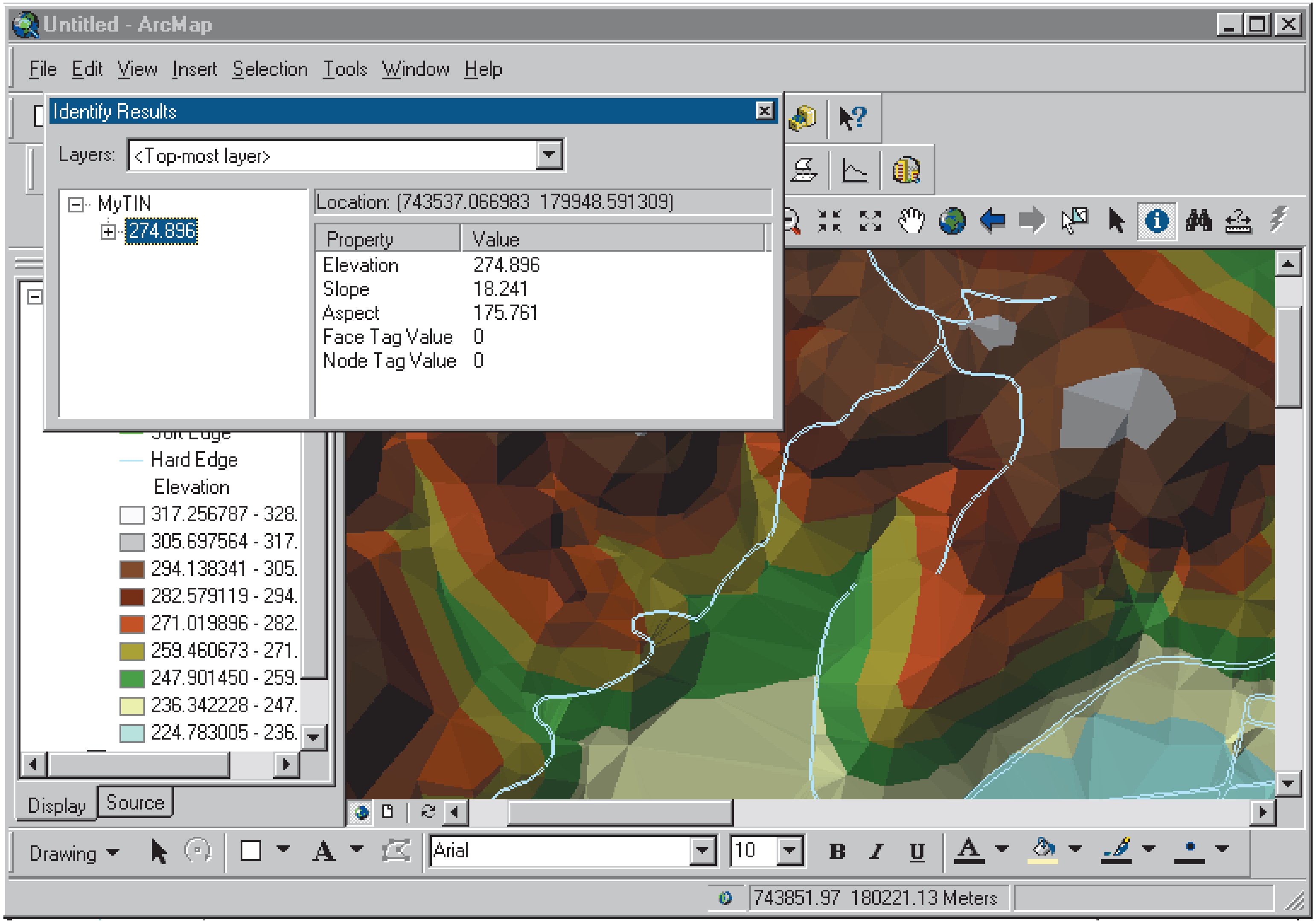


On the left is a point dataset of known values. On the right is a raster interpolated from these points. Unknown values are predicted with a mathematical formula that uses the values of nearby known points.

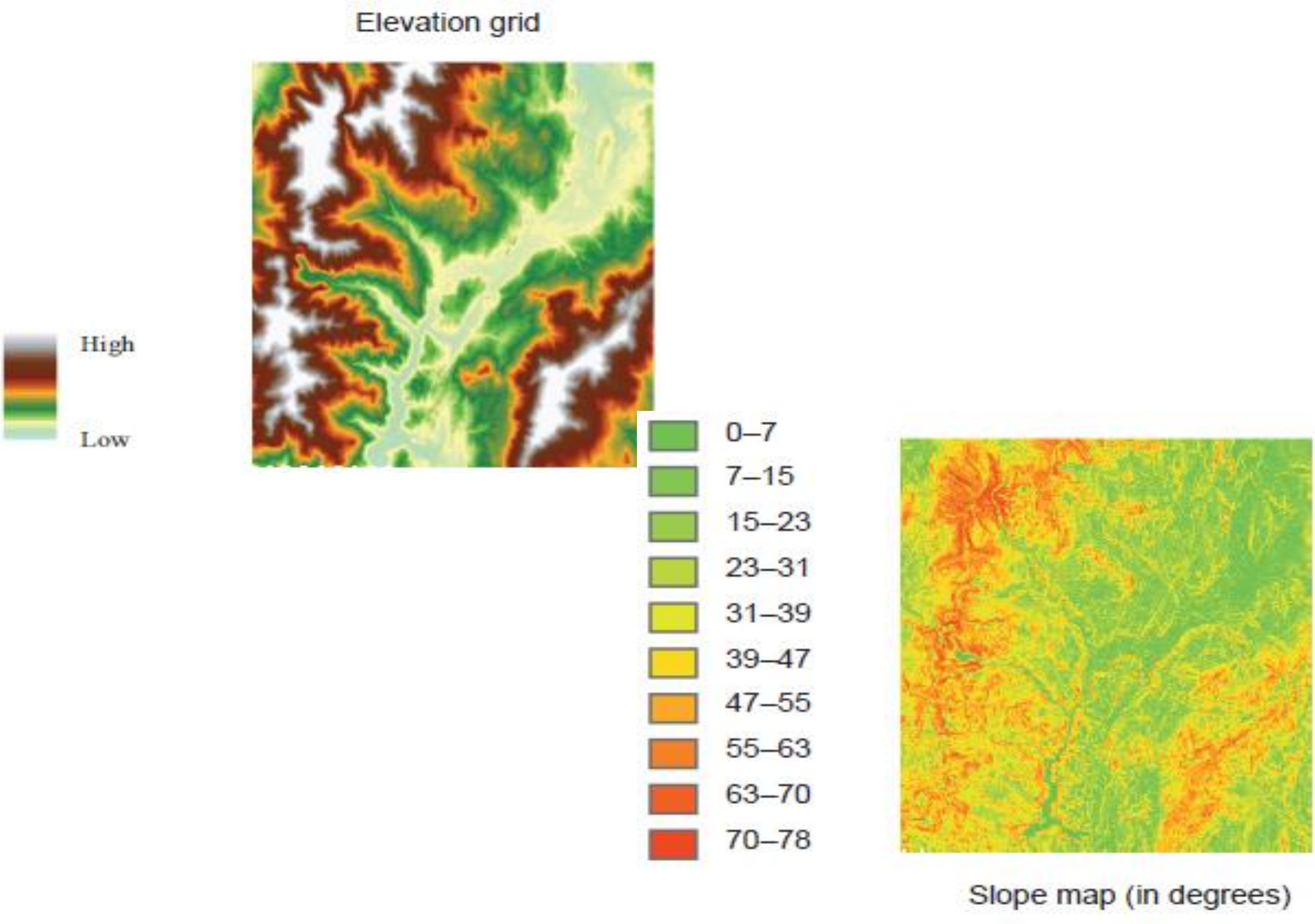


Low
High

Querying surface values

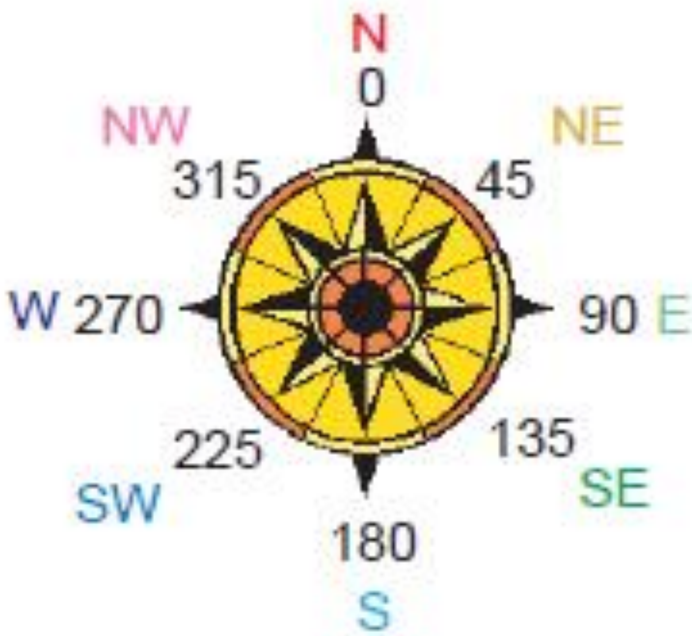


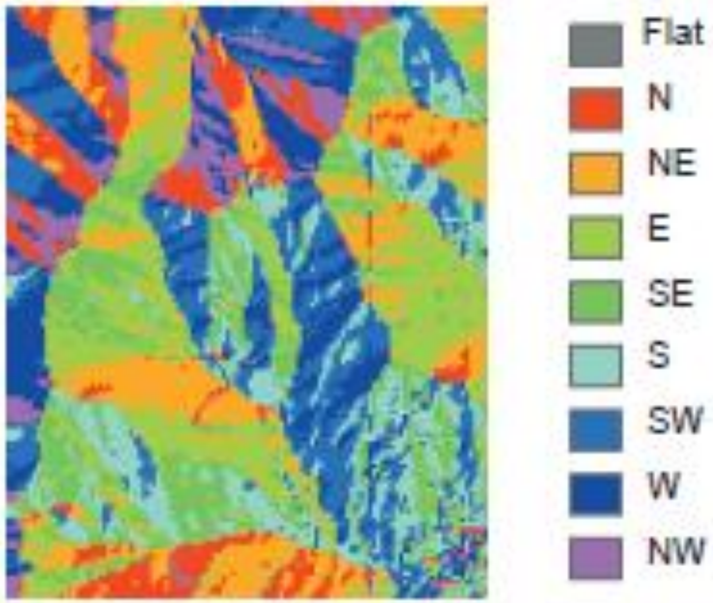
CALCULATING SLOPE



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, Convexities, Concavities?.....

- 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 **convexities** and **curvatures**) 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.**

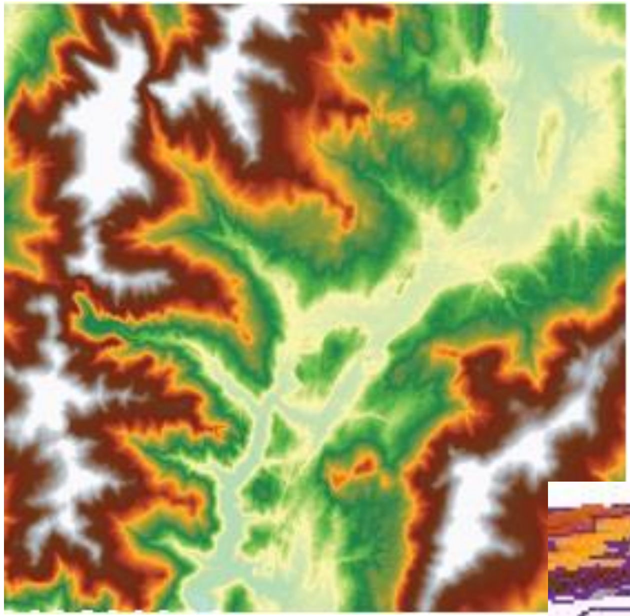
- **The slope percent is the traditional percent grade and is calculated with the formula 100*rise/run.**

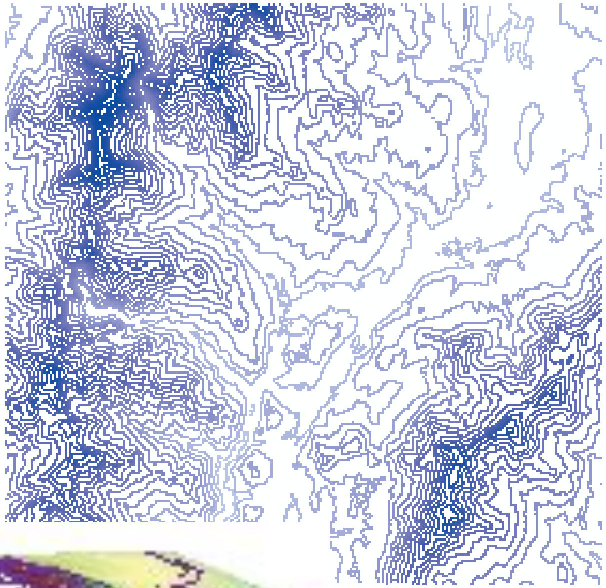
- **For example, a road that climbs 264 feet in a mile is a 5% grade (100*264/5280). To translate between slope in degrees and the percent, just form 100*tan(<slope in degrees>).**

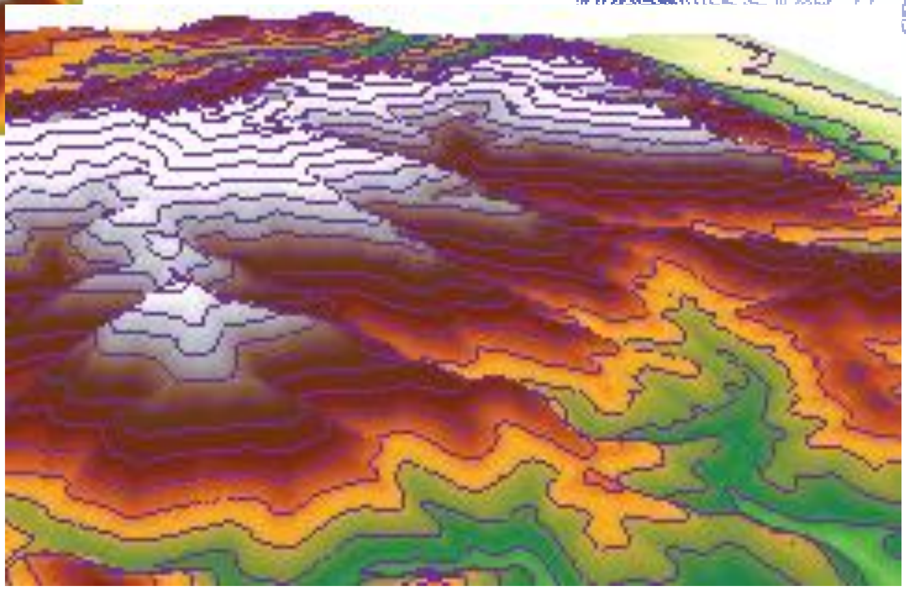
- For the convexity and curvature measures, convex surfaces are given positive values and concave surfaces are given negative values.
- The profile convexity (intersecting with the plane of the z-axis and aspect direction) measures the rate of change of the slope along the profile.
- The plan convexity (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

Contours are lines that connect points of equal value (such as elevation, temperature, precipitation, pollution, or atmospheric pressure).





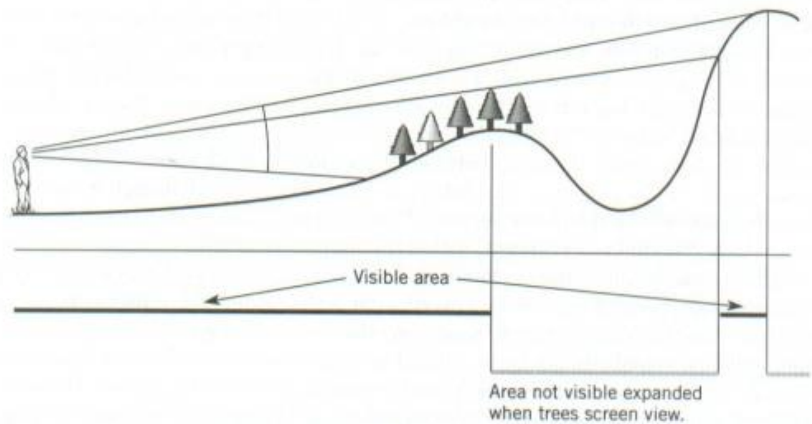


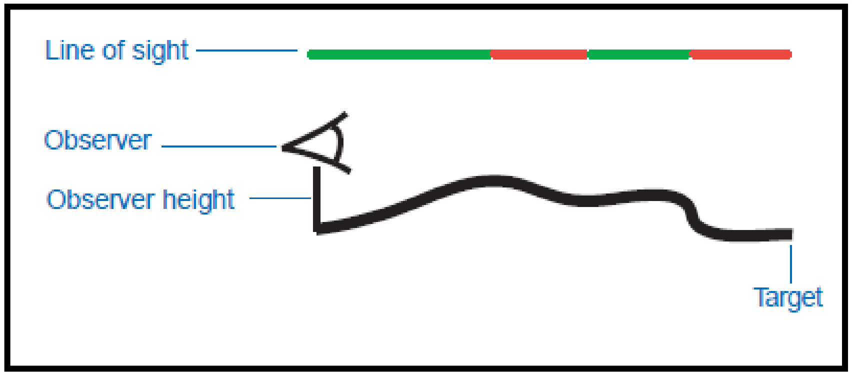
Analyzing visibility (line of sight)

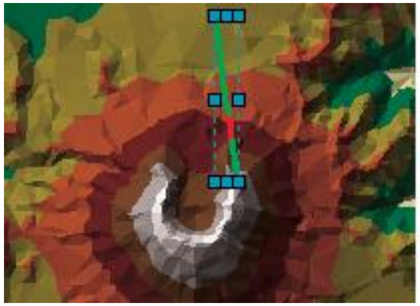
The shape of a terrain surface dramatically affects what parts of the surface someone standing at a given point can see.

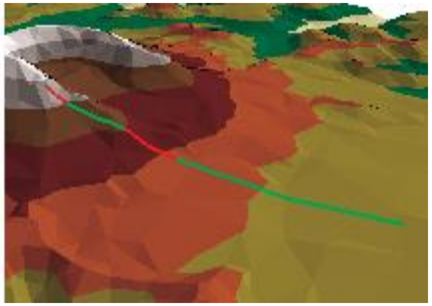
A *line of sight* is a line between two points that shows the parts of the surface along the line that are visible to or hidden from an observer

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 analysis / viewshed map is useful to know how visible the objects in the area and let us know about the visibility of area and the features therein from a particular location.

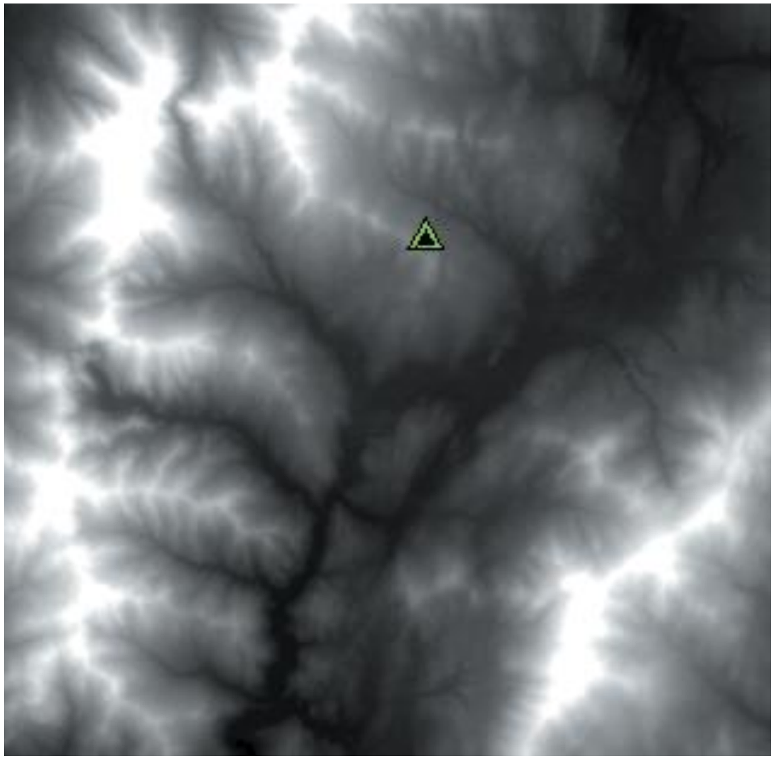
For example,

What will be the best location to place my advertisement board so that it can be visible from maximum places?

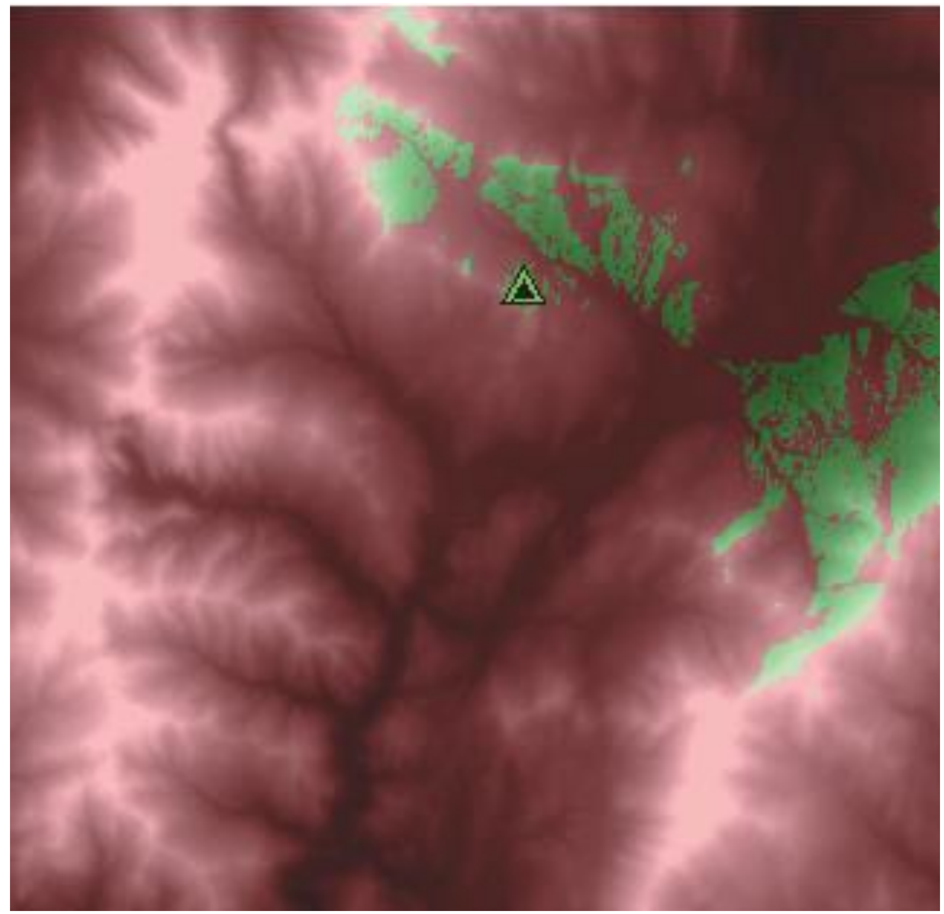
"What will be viewed from this road?

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

the observation point is marked as a green triangle.

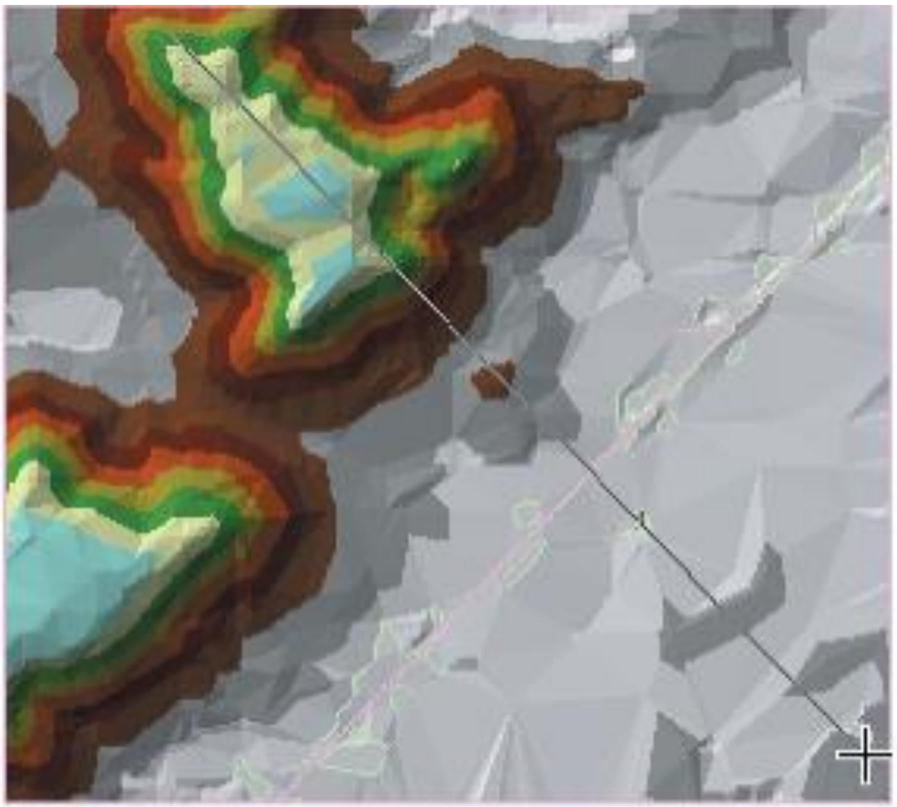


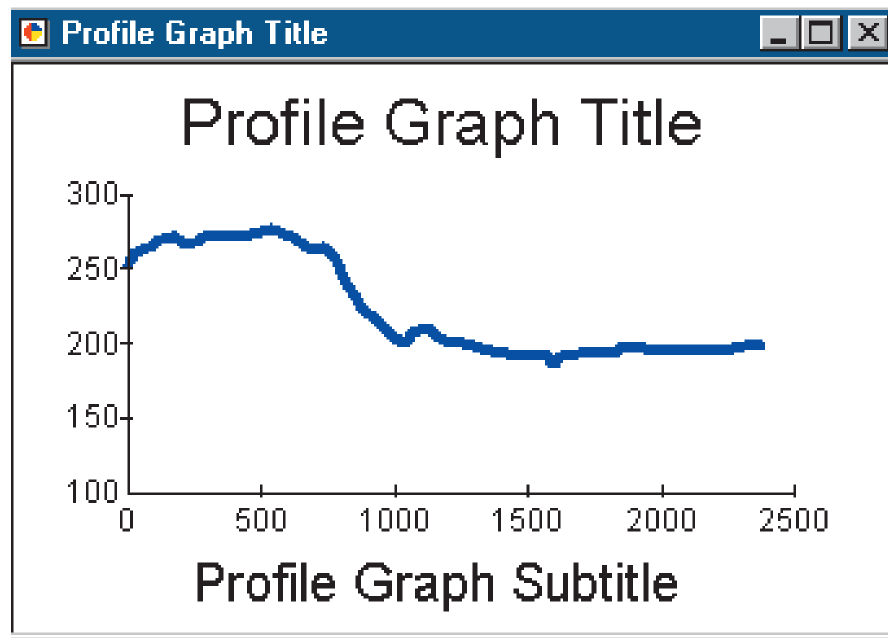
grid displays the height of the land (darker locations represent lower elevations), and the observation point is marked as a green triangle.



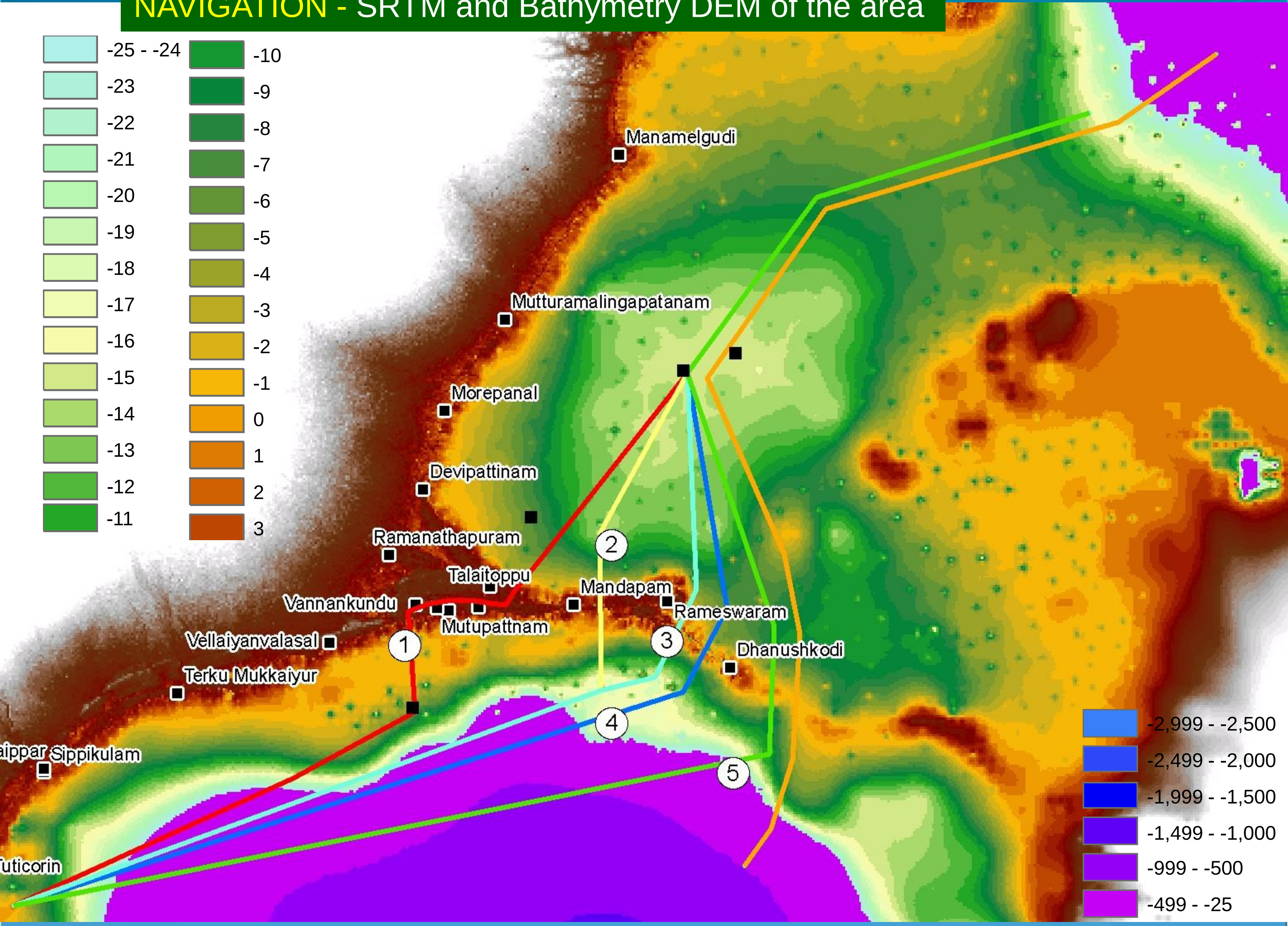
Determining height along a profile

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.

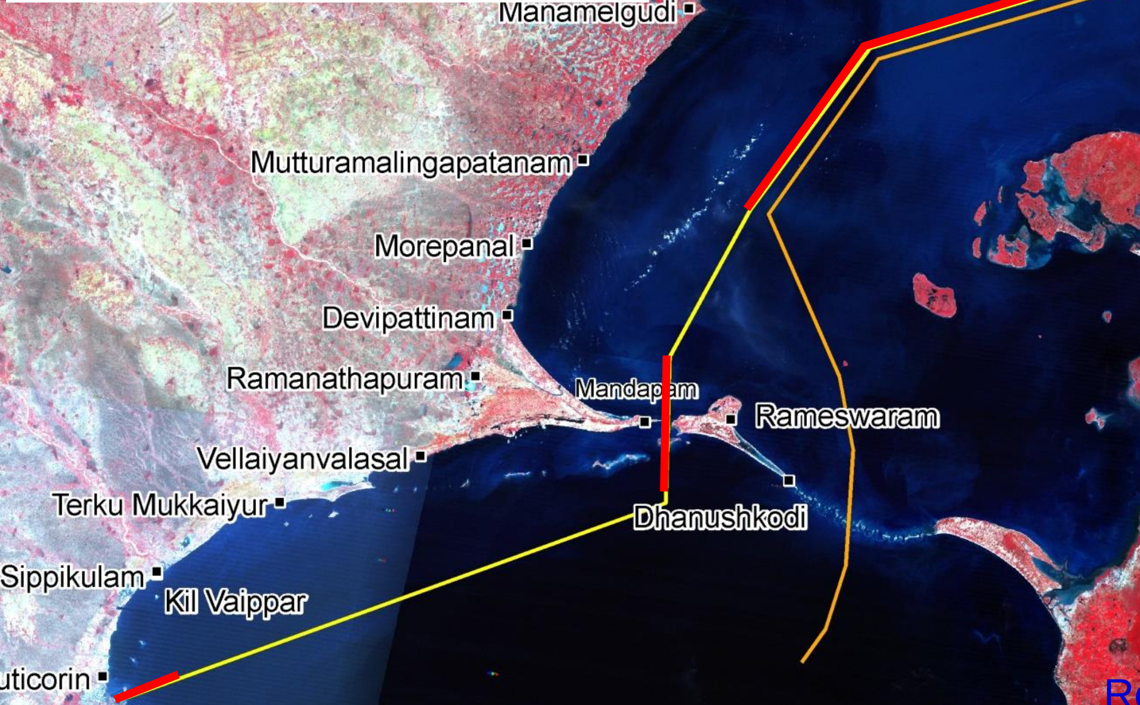




NAVIGATION - SRTM and Bathymetry DEM of the area



Route Alignment - 2

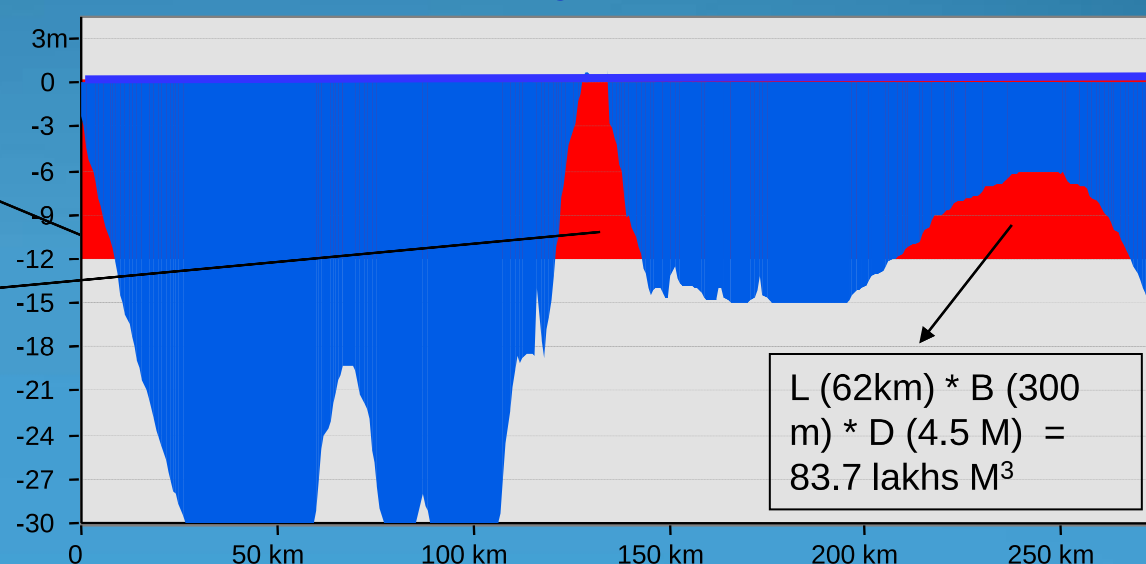


Sea Bottom (Blue)

Area in sea to be excavated (Red)

Land area to be excavated (Green)

Route Alignment - 2



L (9 km) * B (300 m) * D (4.5 M) = 21.5 lakhs M^3

L (21 km) * B (300 m) * D (7.2 M) = 45.36 lakhs M^3

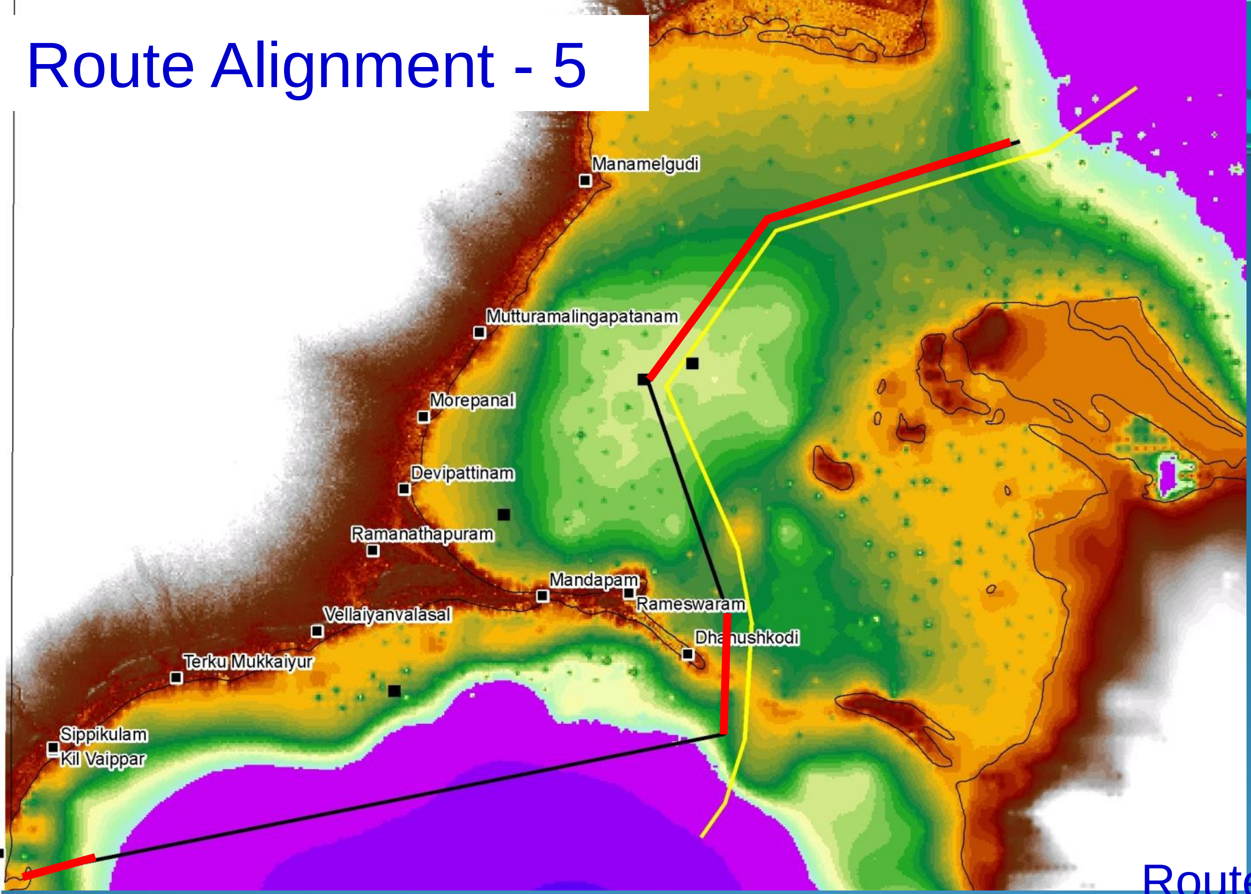
L (62km) * B (300 m) * D (4.5 M) = 83.7 lakhs M^3

L – Length to be excavated

B – Breadth to be excavated

D – Average excavating Depth

Route Alignment - 5



Sea Bottom (Blue)

Area in sea to be excavated (Red)

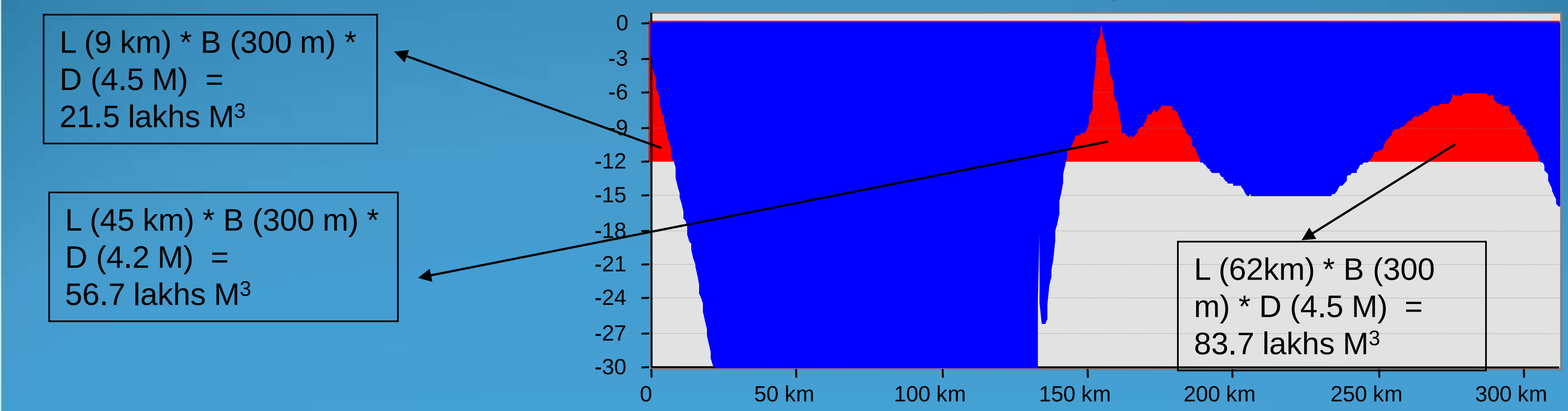
Land area to be excavated (Green)

L – Length to be excavated

B – Breadth to be excavated

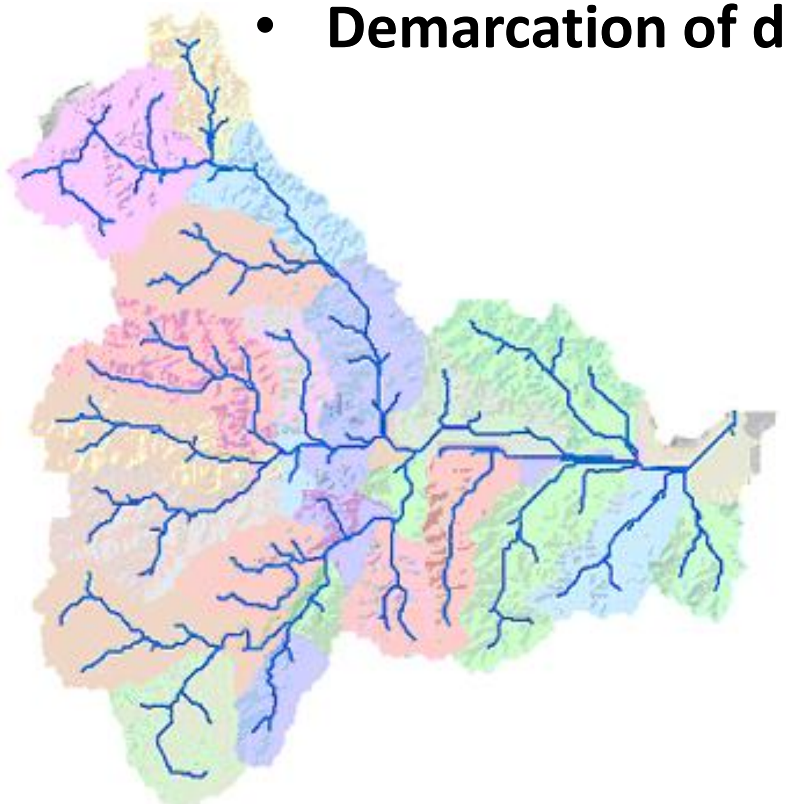
D – Average excavating Depth

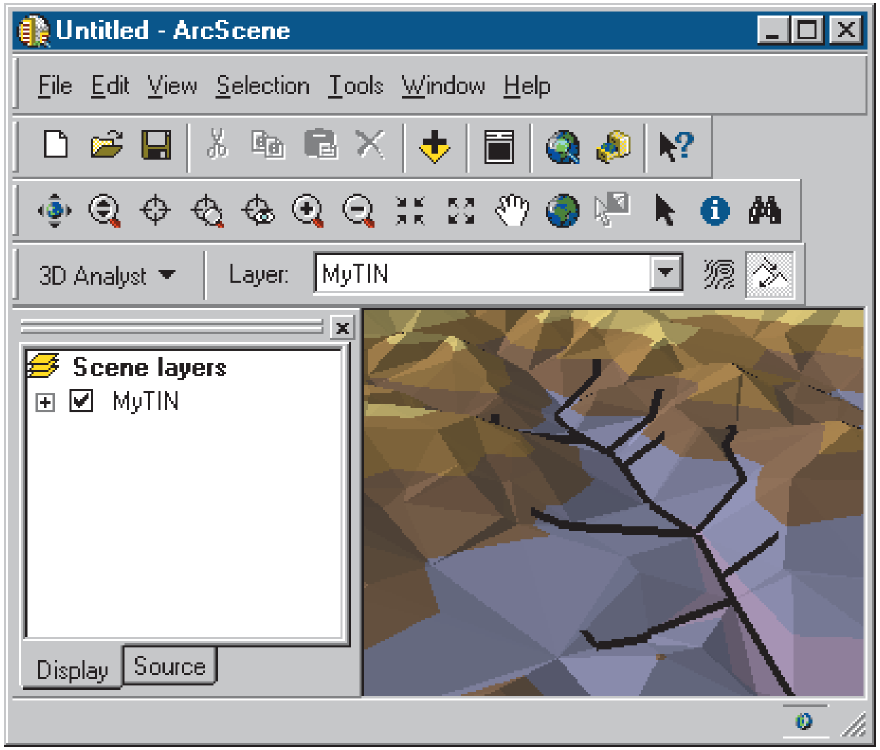
Route Alignment - 5



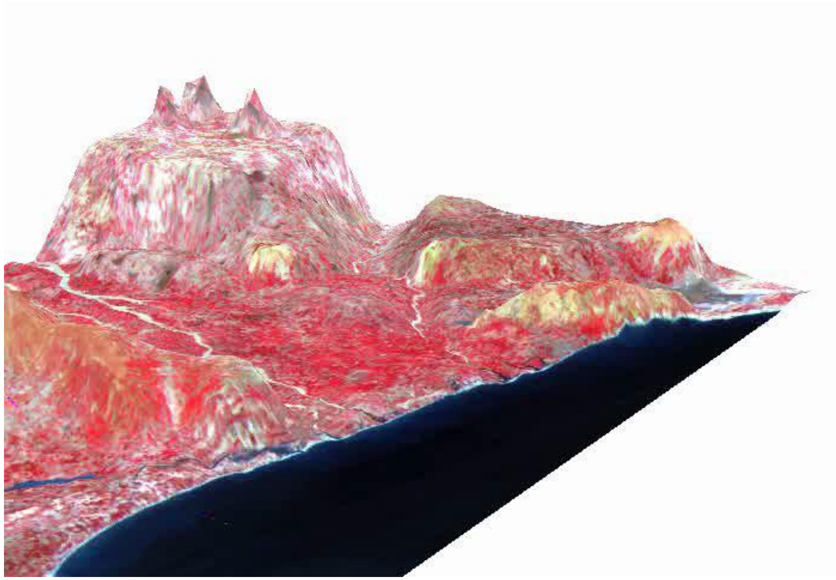
DRAINAGE ANALYSIS

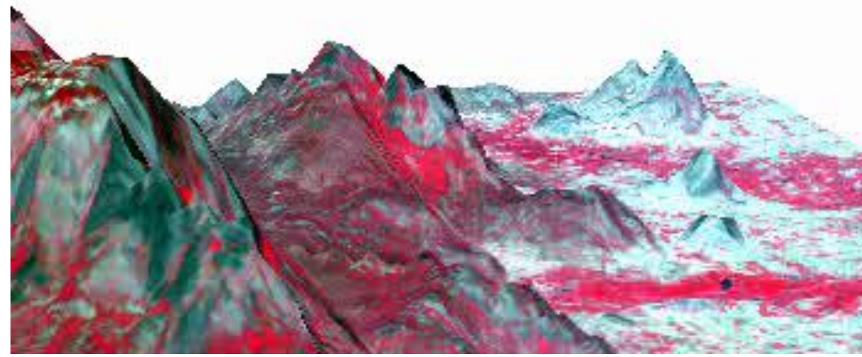
- **Delineation of Drainages,**
- **Stream order**
- **Flow Direction, Flow Accumulation**
- **Flow Length,**
- **Demarcation of drainage basins, etc.**

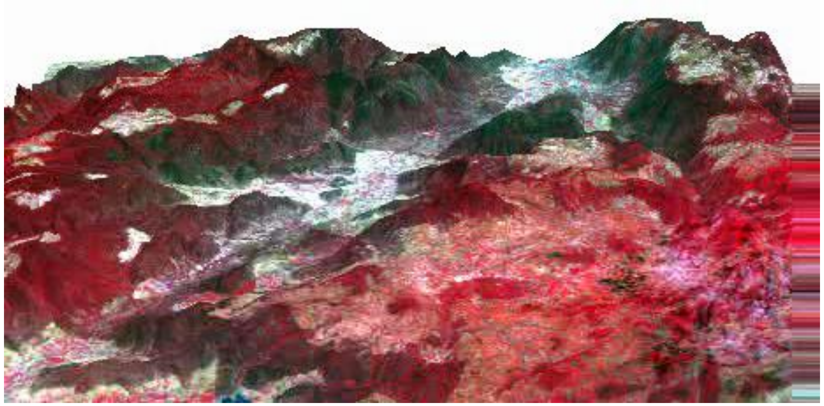


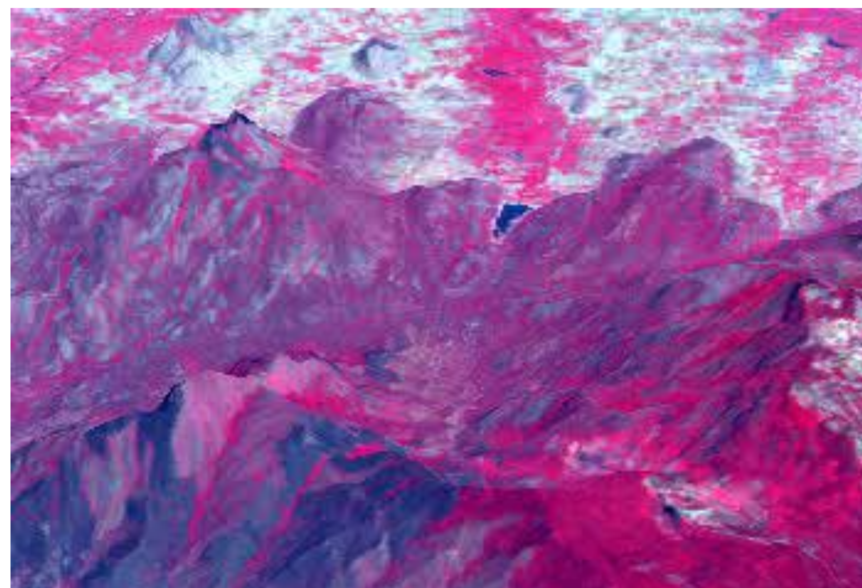


Fly-through Models





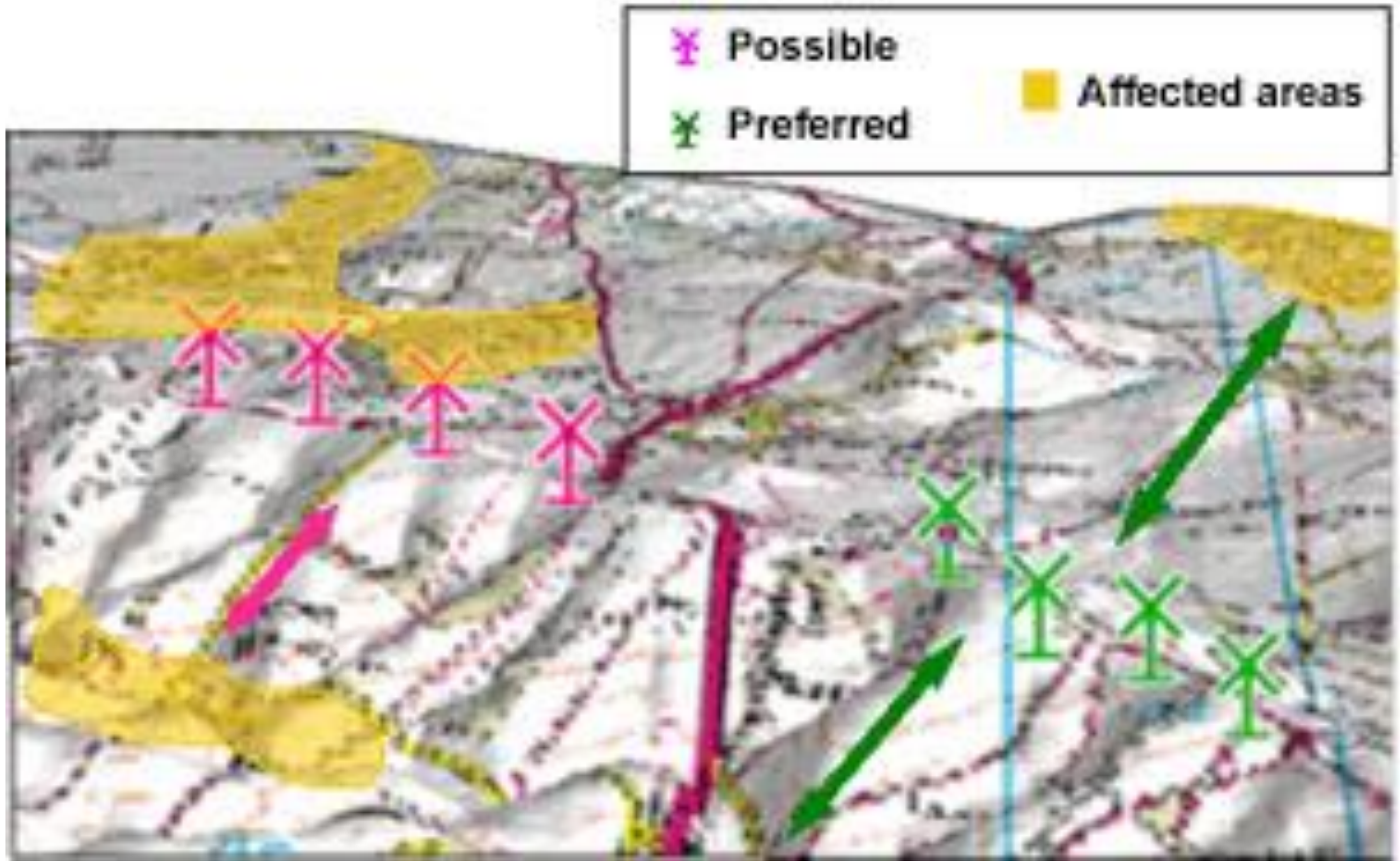




BACK

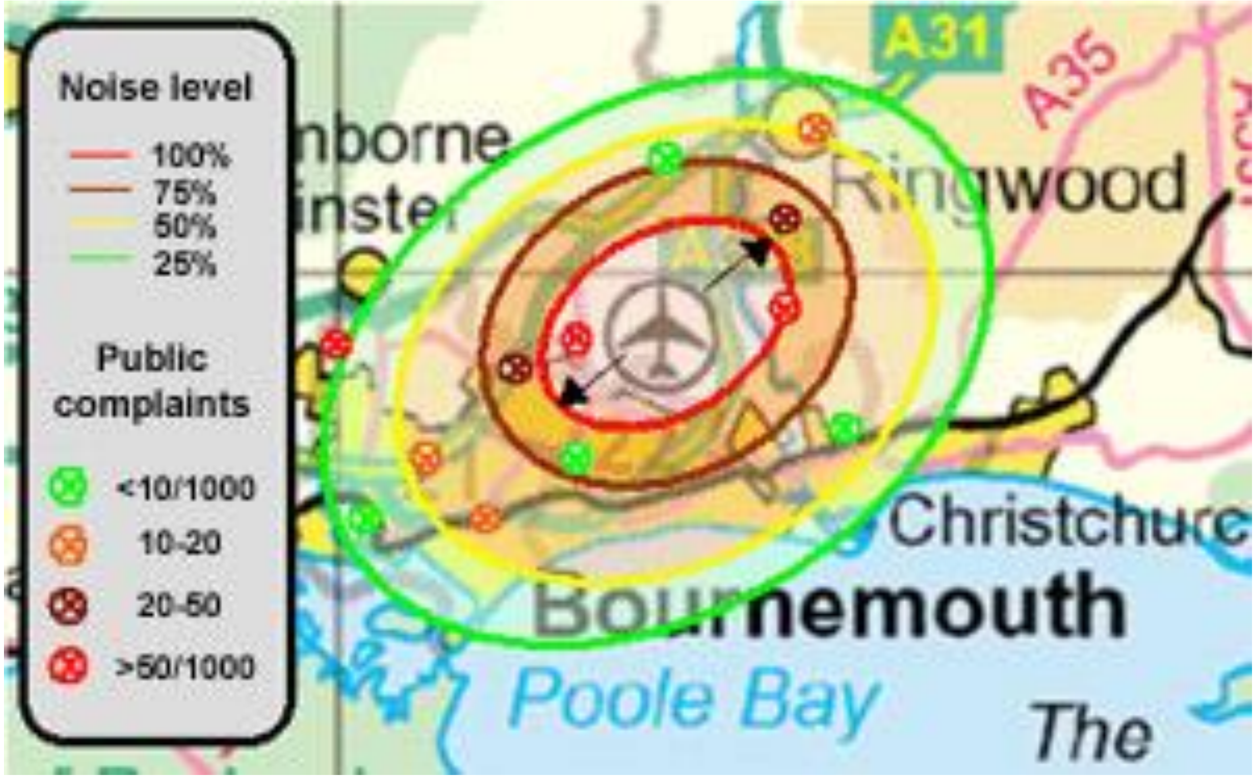
ENVIRONMENTAL IMPACT ANALYSIS

By building a 3-D model of a landscape it is possible to simulate the construction of a new feature which may have an impact on the natural beauty of an area. For example, planning a wind farm. By using accurate map data for the area, a realistic model can be created and viewed from all angles. This will help identify the location that the new wind farm will have the least impact upon.



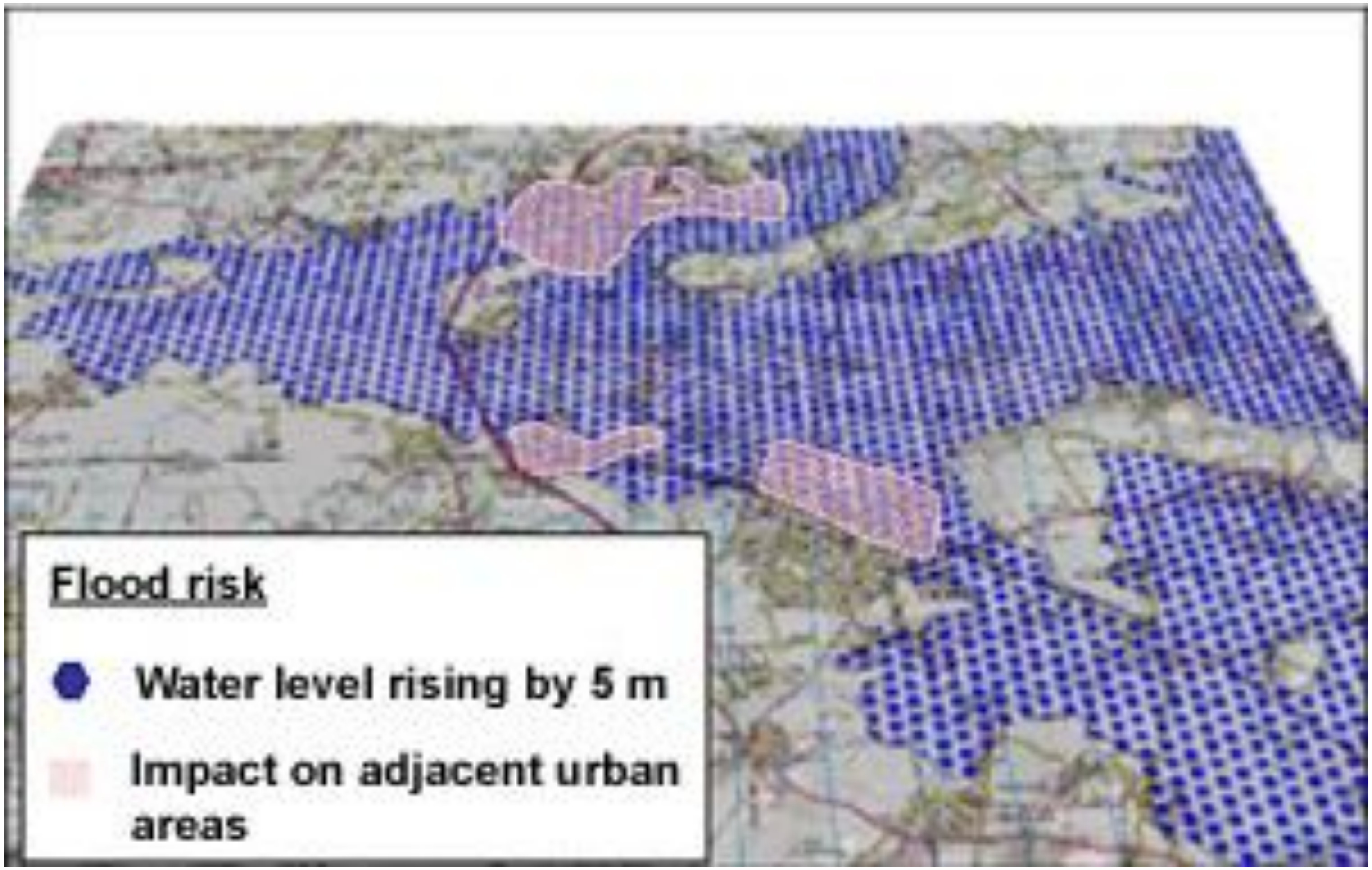
AIRPORT NOISE POLLUTION

Restrictions on the permissible levels of aircraft noise affect all busy airports. GIS can help monitor not only the noise itself but also complaints from nearby residents. The spread of sound from the airport can be mapped against the nearby built-up areas to identify how many houses are going to be affected by high noise levels. By logging the addresses of people who complain about noise, the airport can monitor the effectiveness of their noise control measures and whether or not the airlines are obeying guidelines.

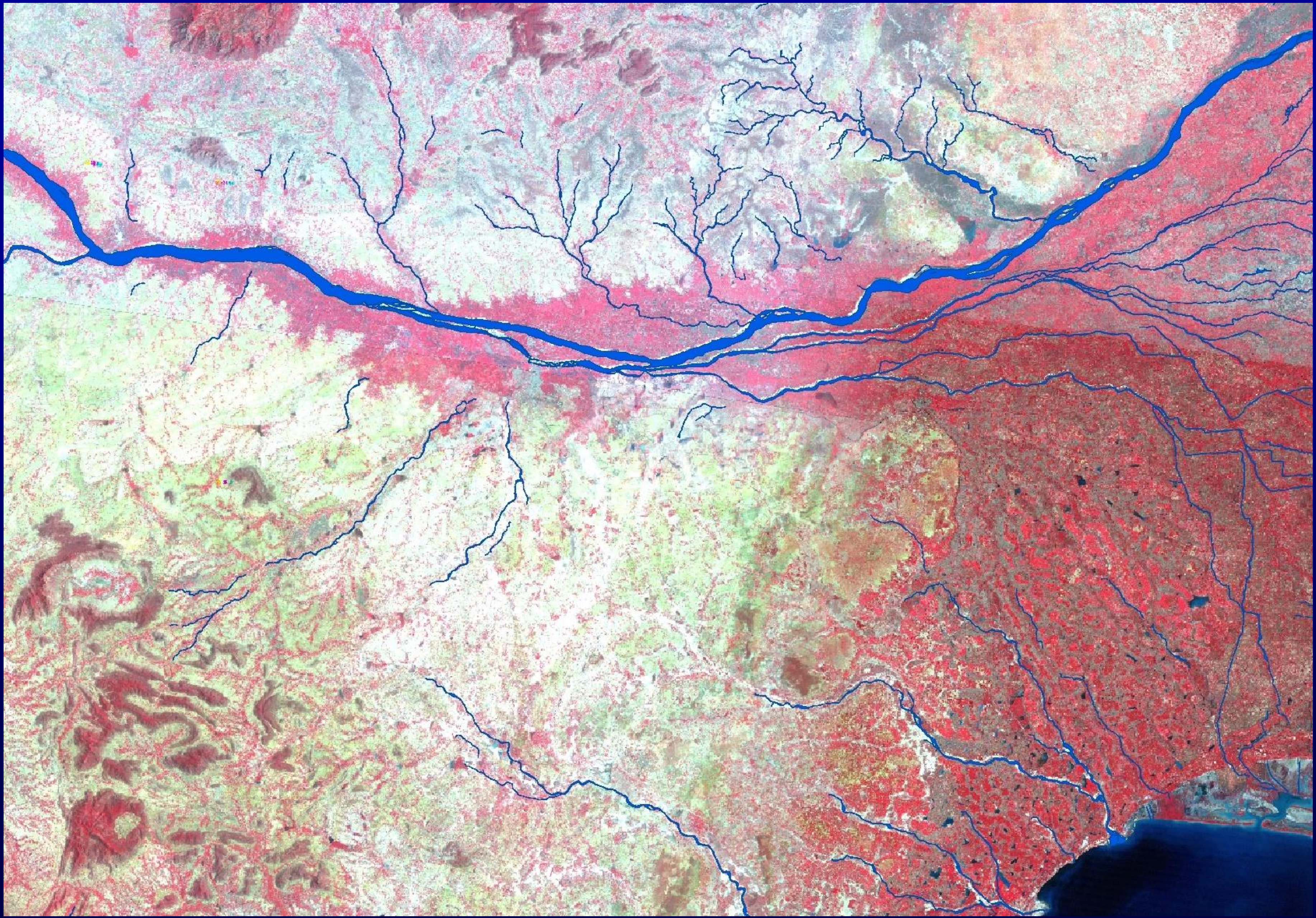


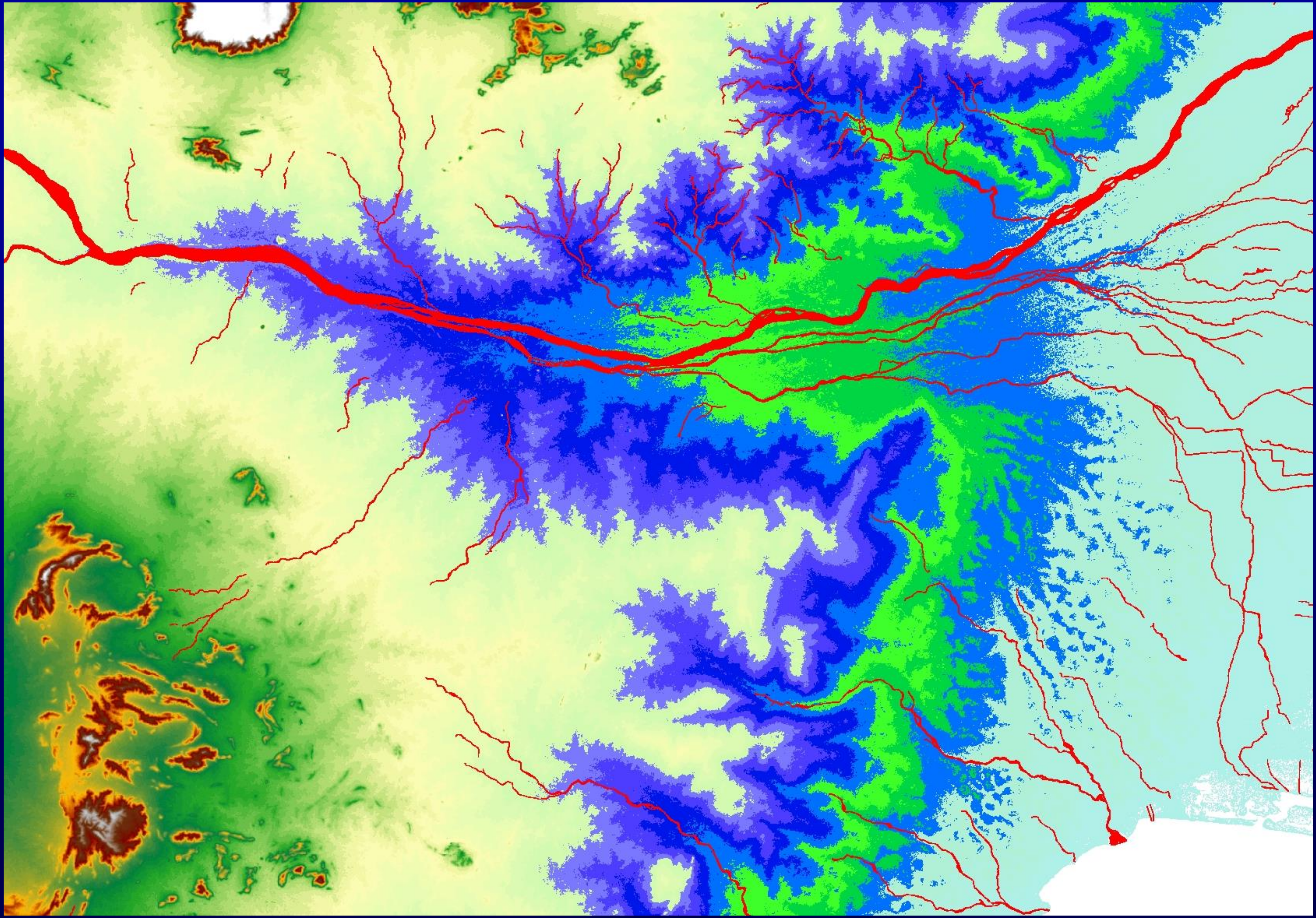
FLOOD RISK

Using 3-D height data and map data for river features it is possible to build a computer model of changing water levels; this can be used for predicting flood patterns and identifying areas in danger. By combining this model with address data, the likelihood of individual properties being flooded can be assessed. This is not just of environmental concern but of great value to insurance companies.

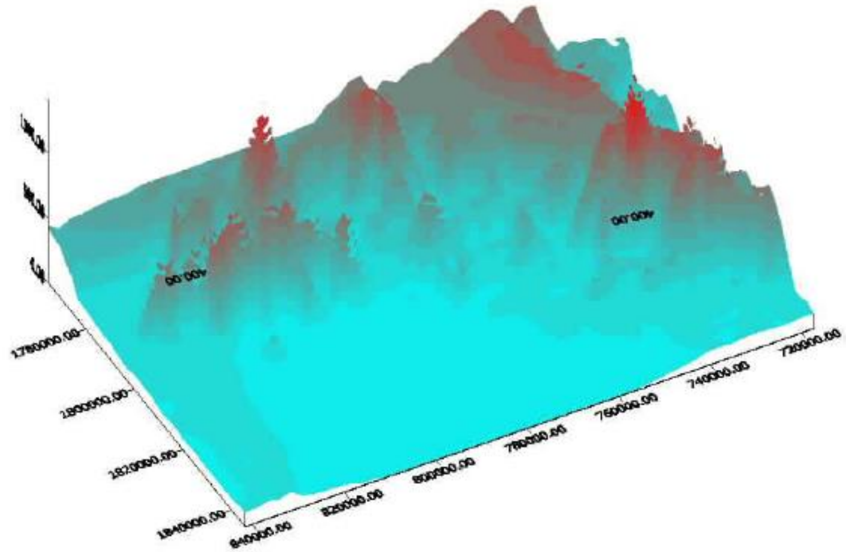


CAUVERY RIVER IN TRICHY – THANJAVUR PLAINS

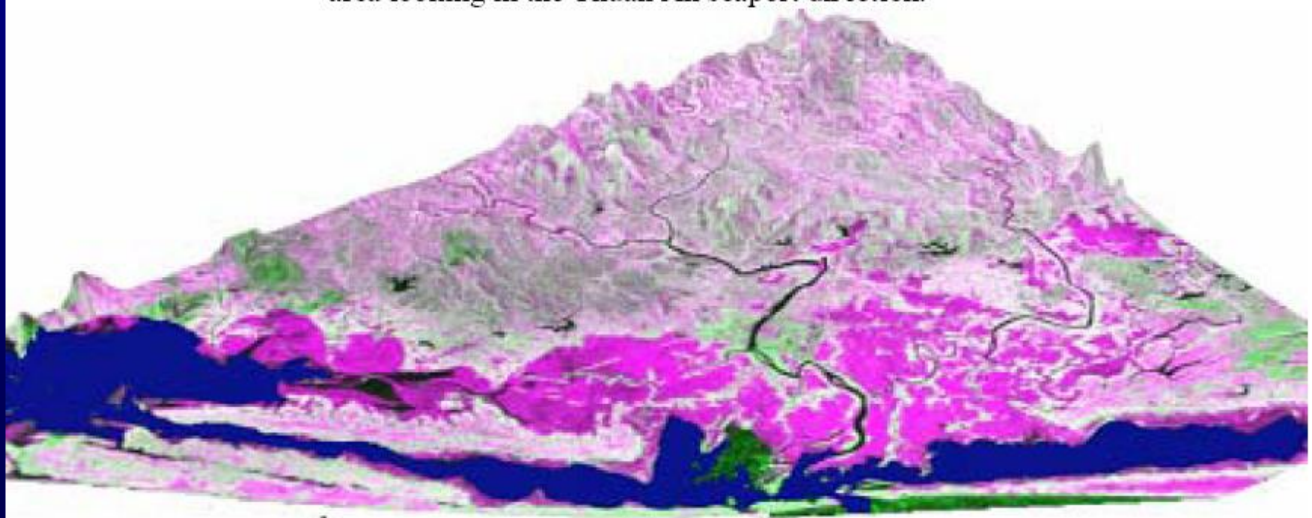




SRTM DATA vs FLOOD INUNDATION

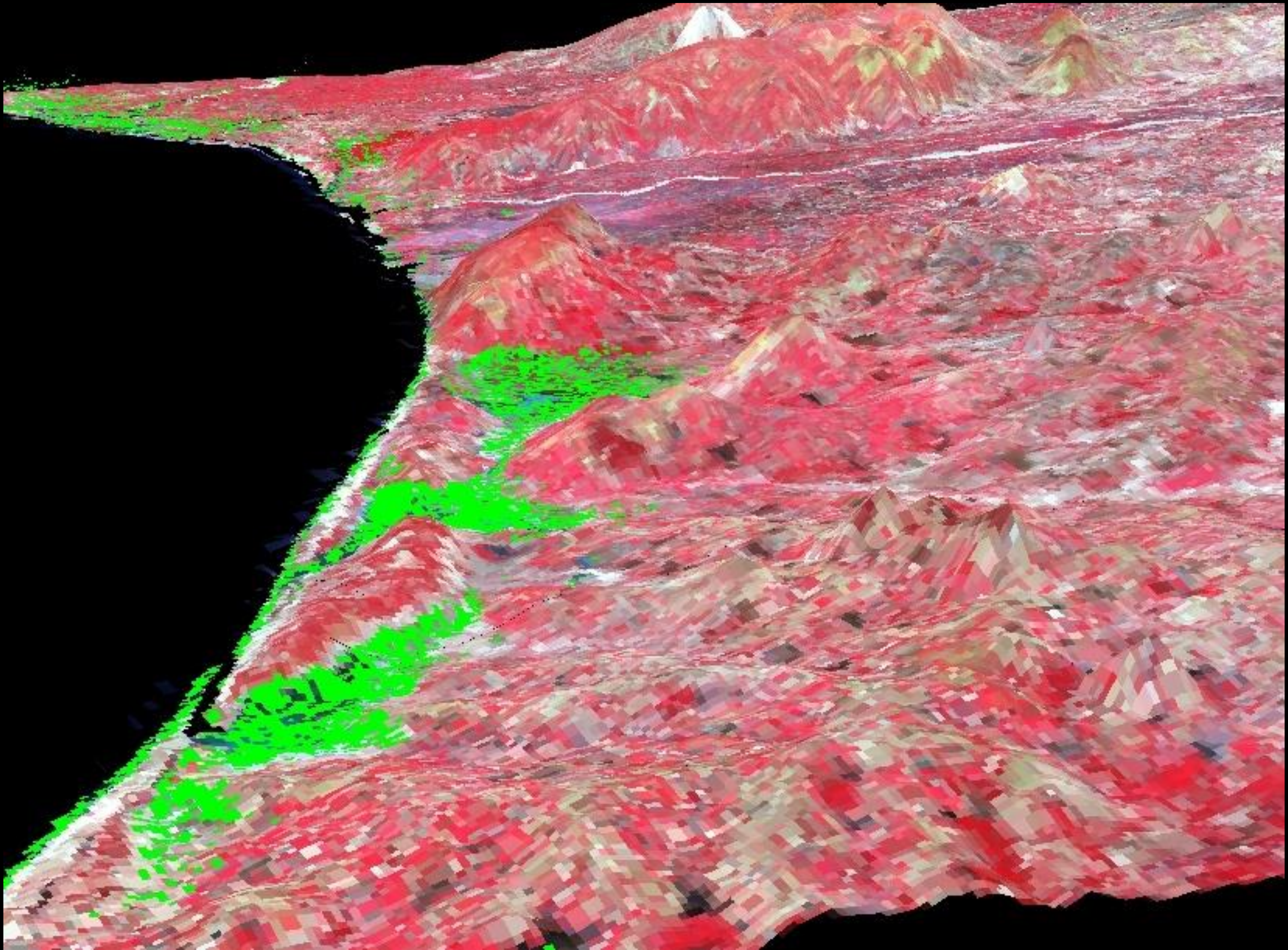


Picture 3: Three dimensional model of Thua Thien Hue area looking in the Thuan An seaport direction.

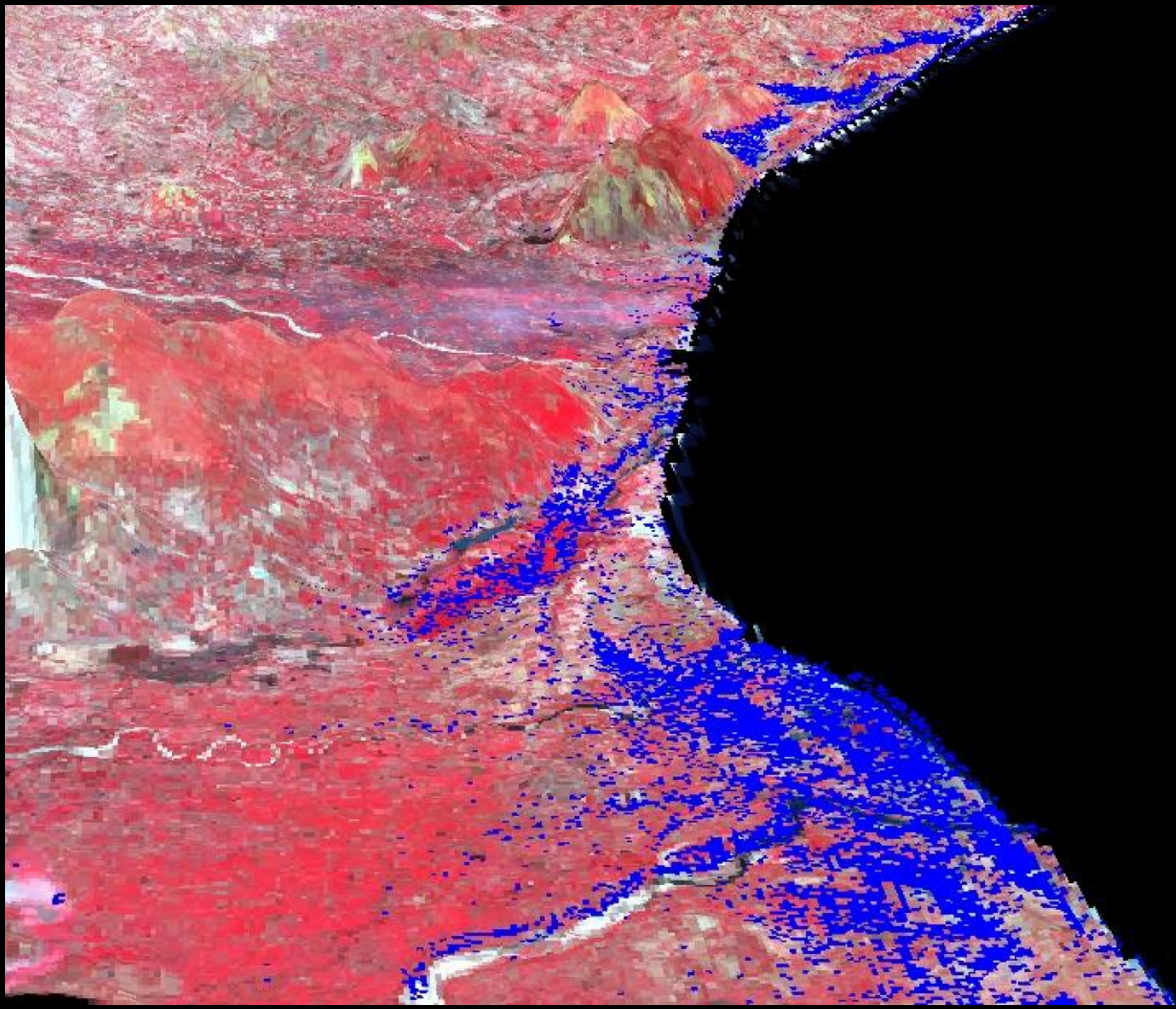


Picture 4: Three dimensional digital model covered by flooded area taken from RADASAT picture at the time of flood in Thua Thien Hue on November 6th 1999. The dark purple areas represent flooded areas.

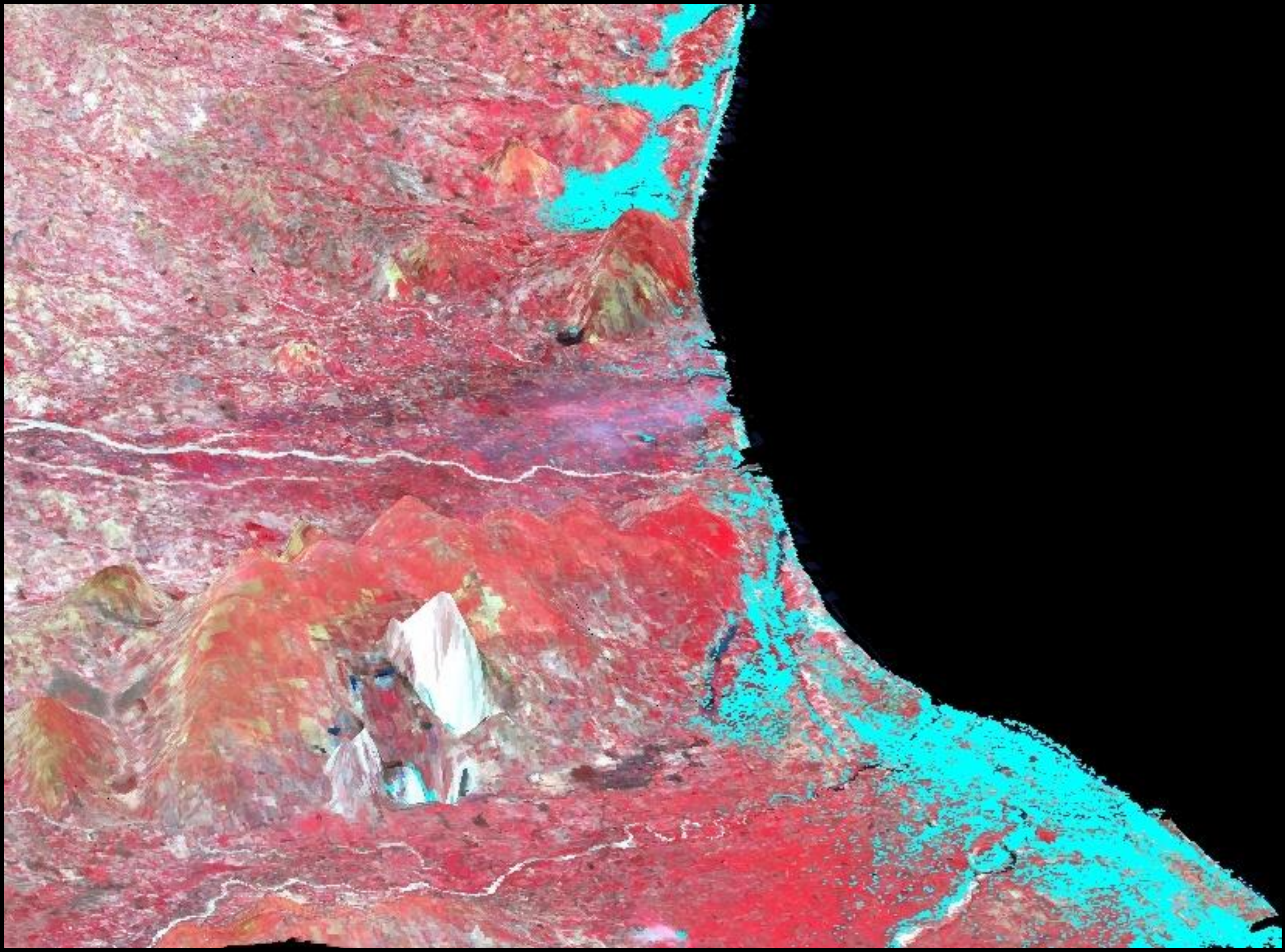
2M - SLR



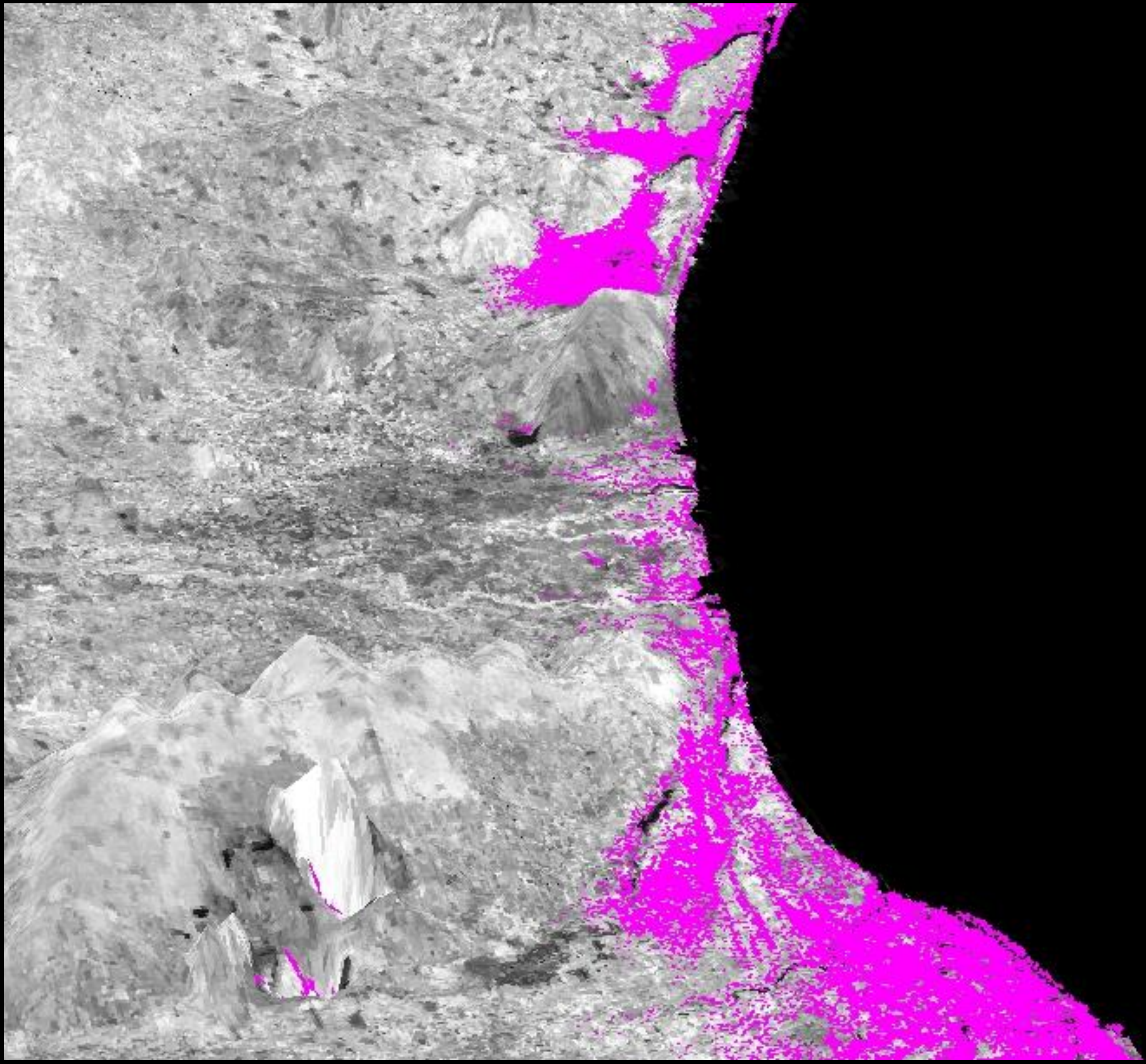
3M - SLR



4M - SLR



5M - SLR



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.

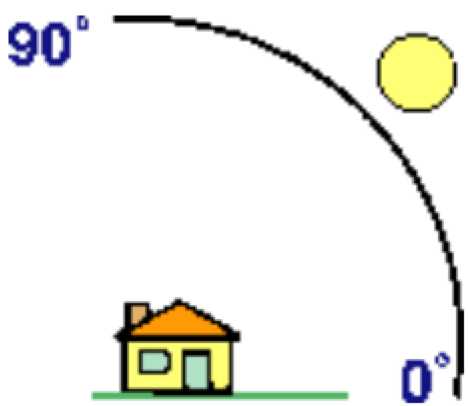
Optionally, a hillshade field can be written containing a brightness value for each triangle. Values range from zero to 255.

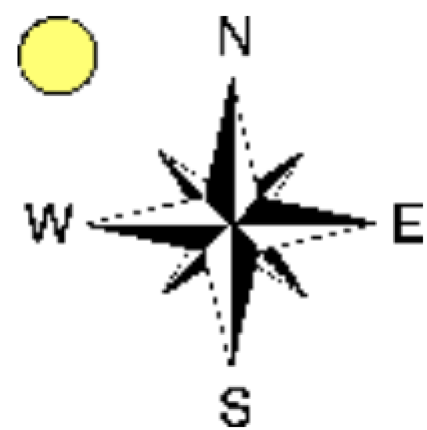
The brightness value is based on the relation between the plane defined by each triangle and a **light source**. The position of the light source defaults to the northwest, with an azimuth of 315 degrees (compass-based with 0 north, positive clockwise) and an altitude of 45.

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 and calculating the illumination values of each cell in relation to neighboring cells.

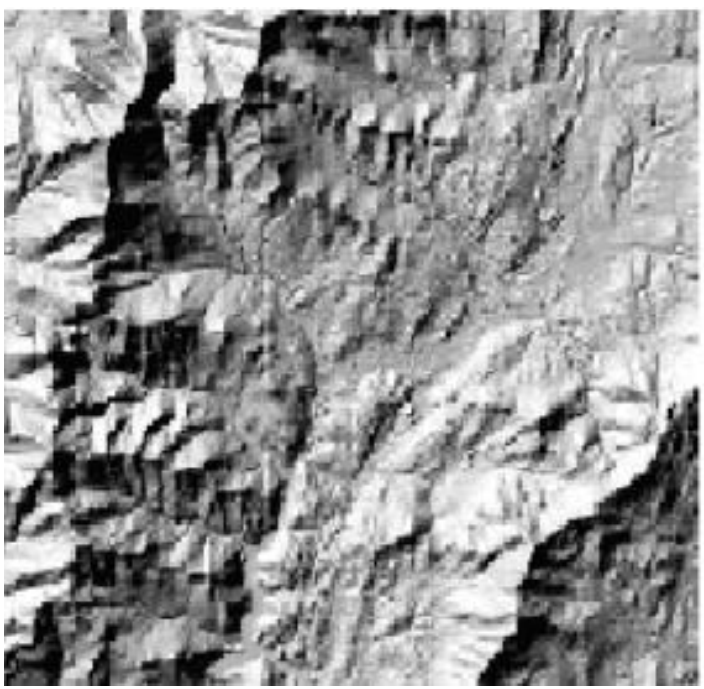
It can greatly enhance the visualization of a surface for analysis or graphical display, especially when using transparency.





By default, shadow and light are shades of gray associated with integers from 0 to 255 (increasing from black to white).
The azimuth 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).

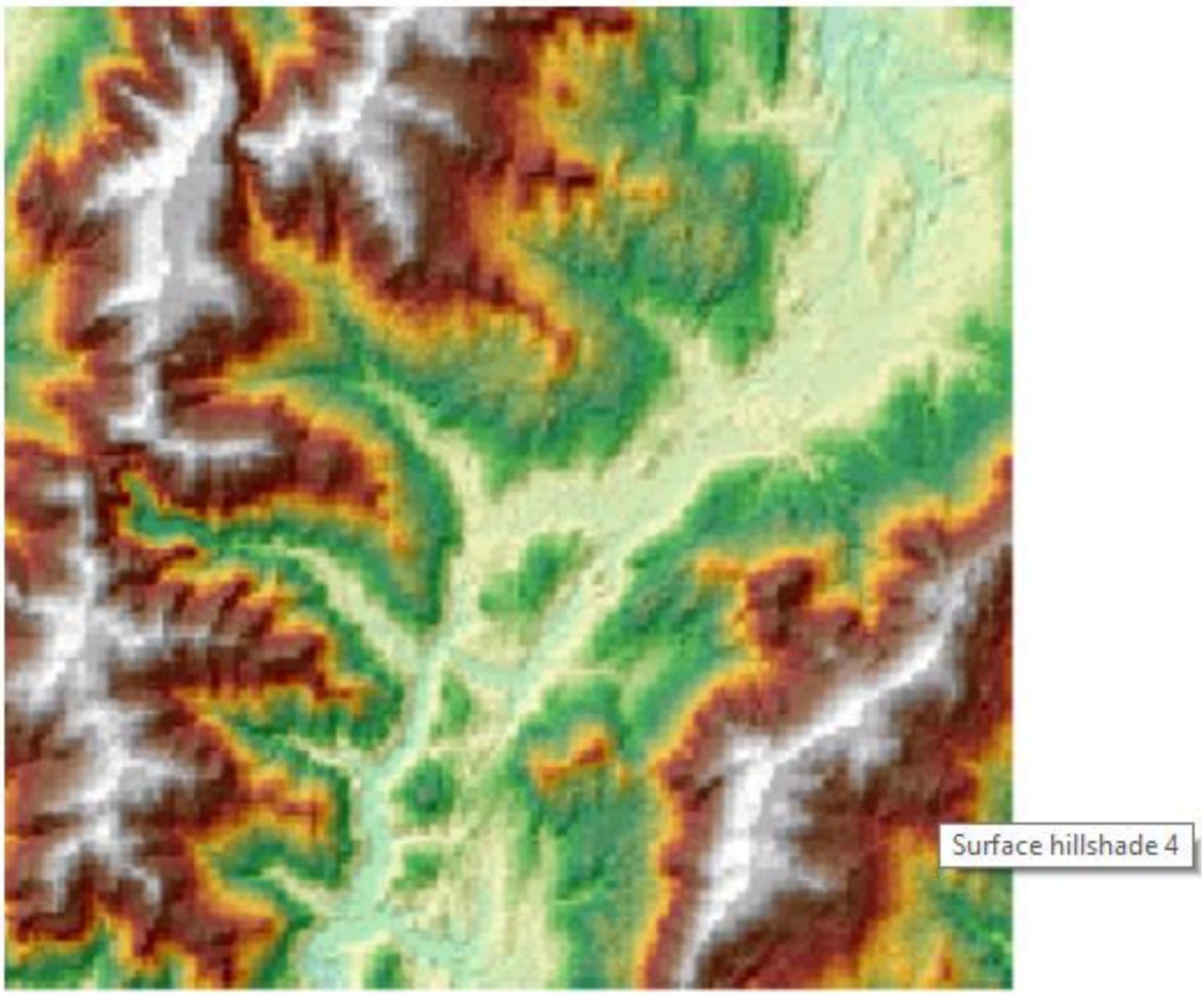
The altitude is the slope or angle of the illumination source above the horizon. The units are in degrees, from 0 (on the horizon) to 90 (overhead). The default is 45 degrees.



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.



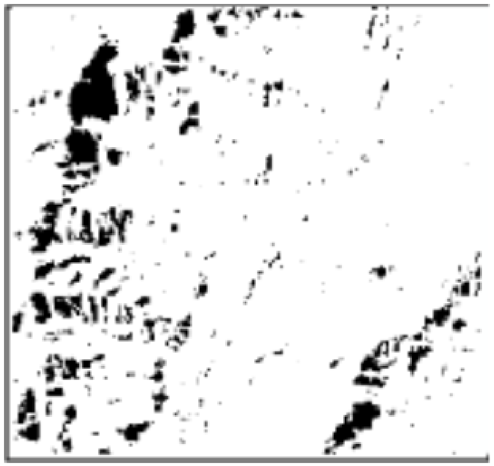
Other layers can also be added, such as roads, streams, or vegetation, to further increase the informational content in the display.

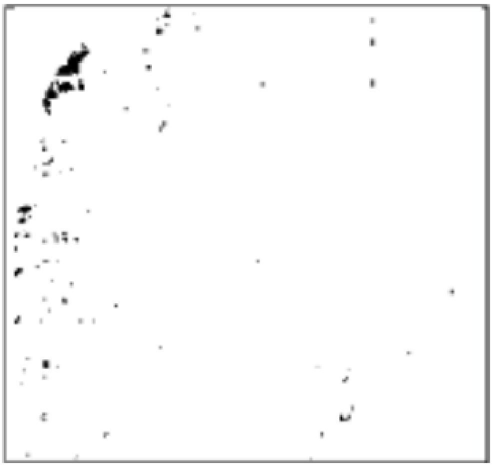
Use of Shaded Relief Map in Analysis

- 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.



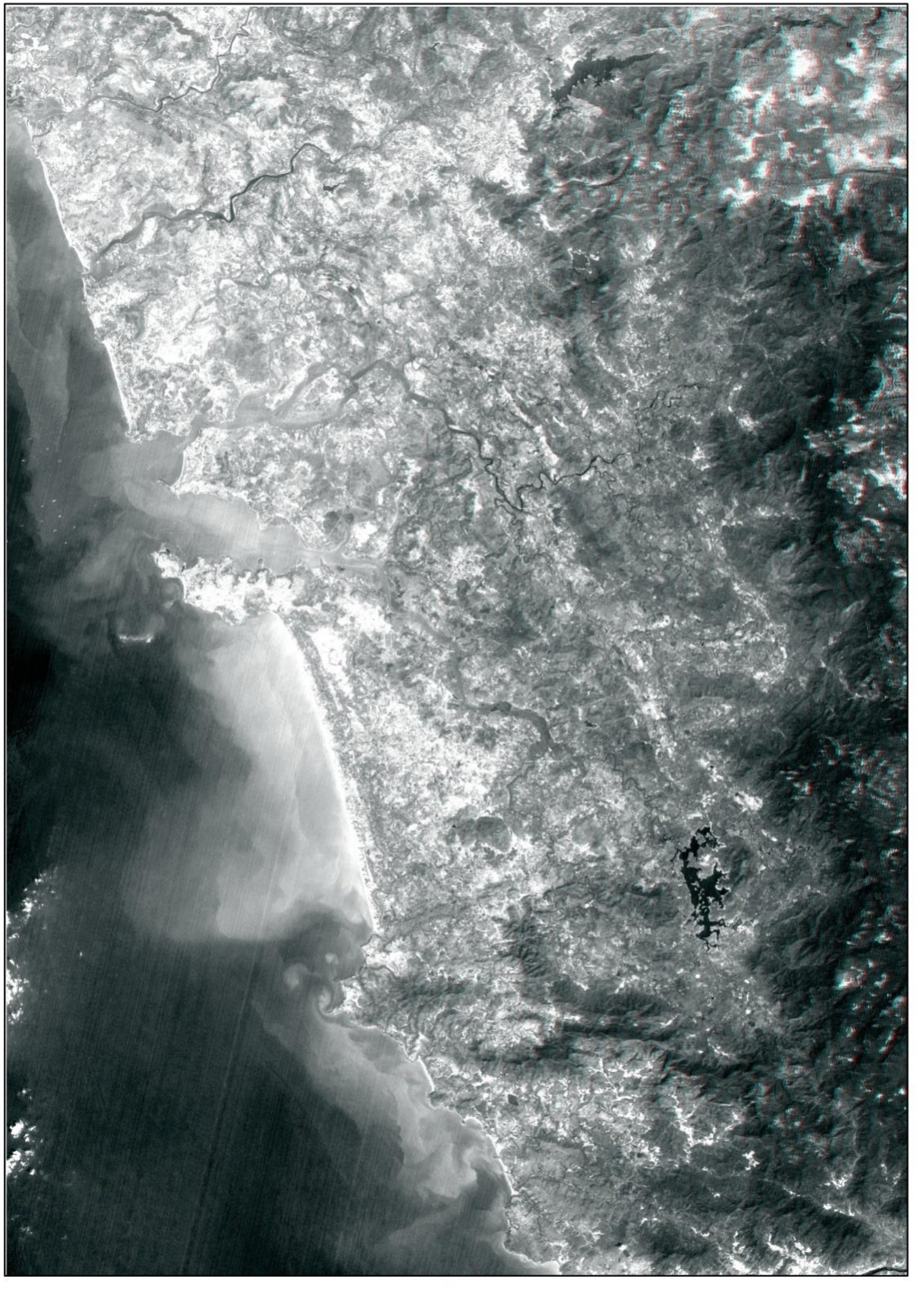


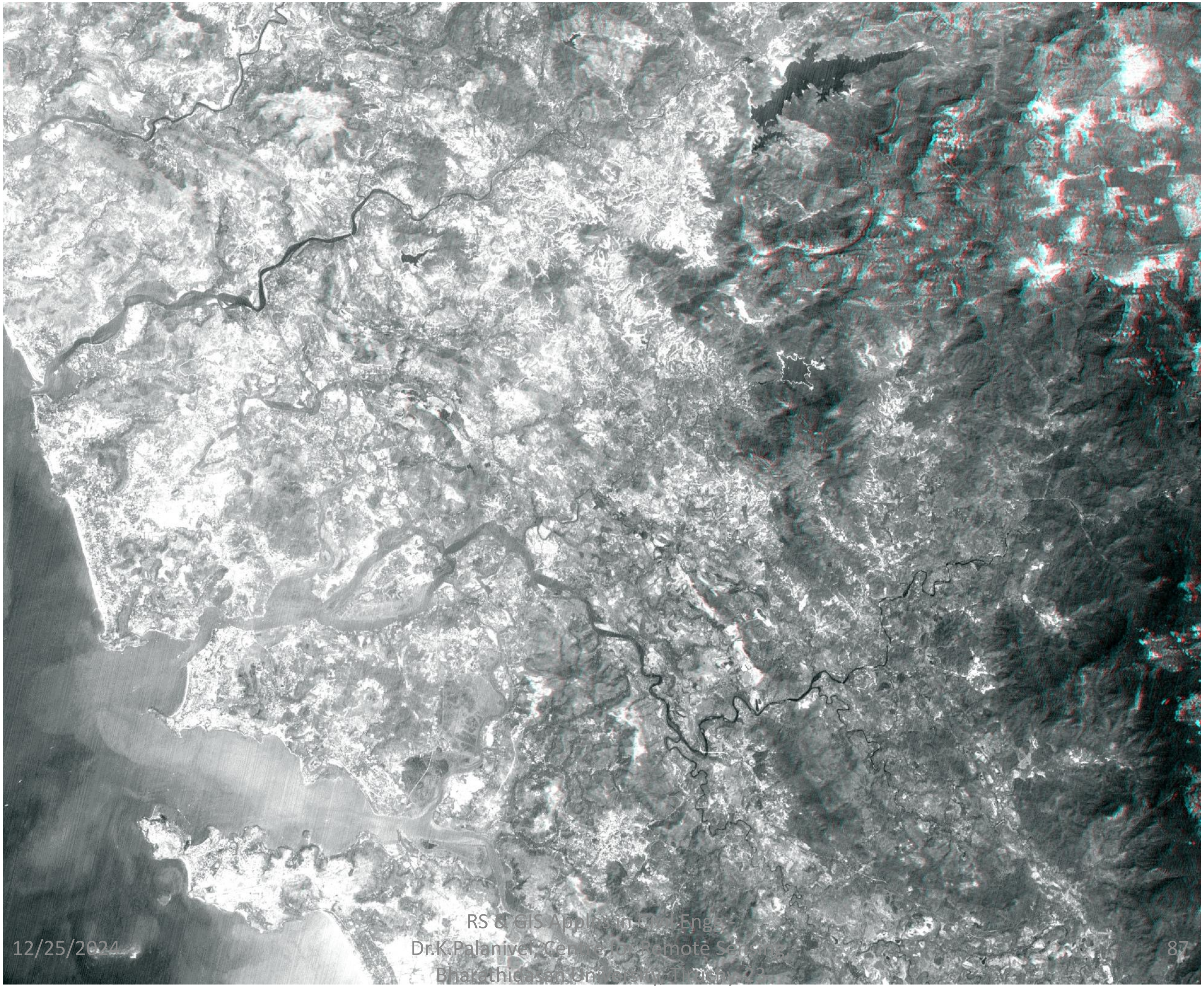
3D STEREOSCOPIC VISUALIZATION

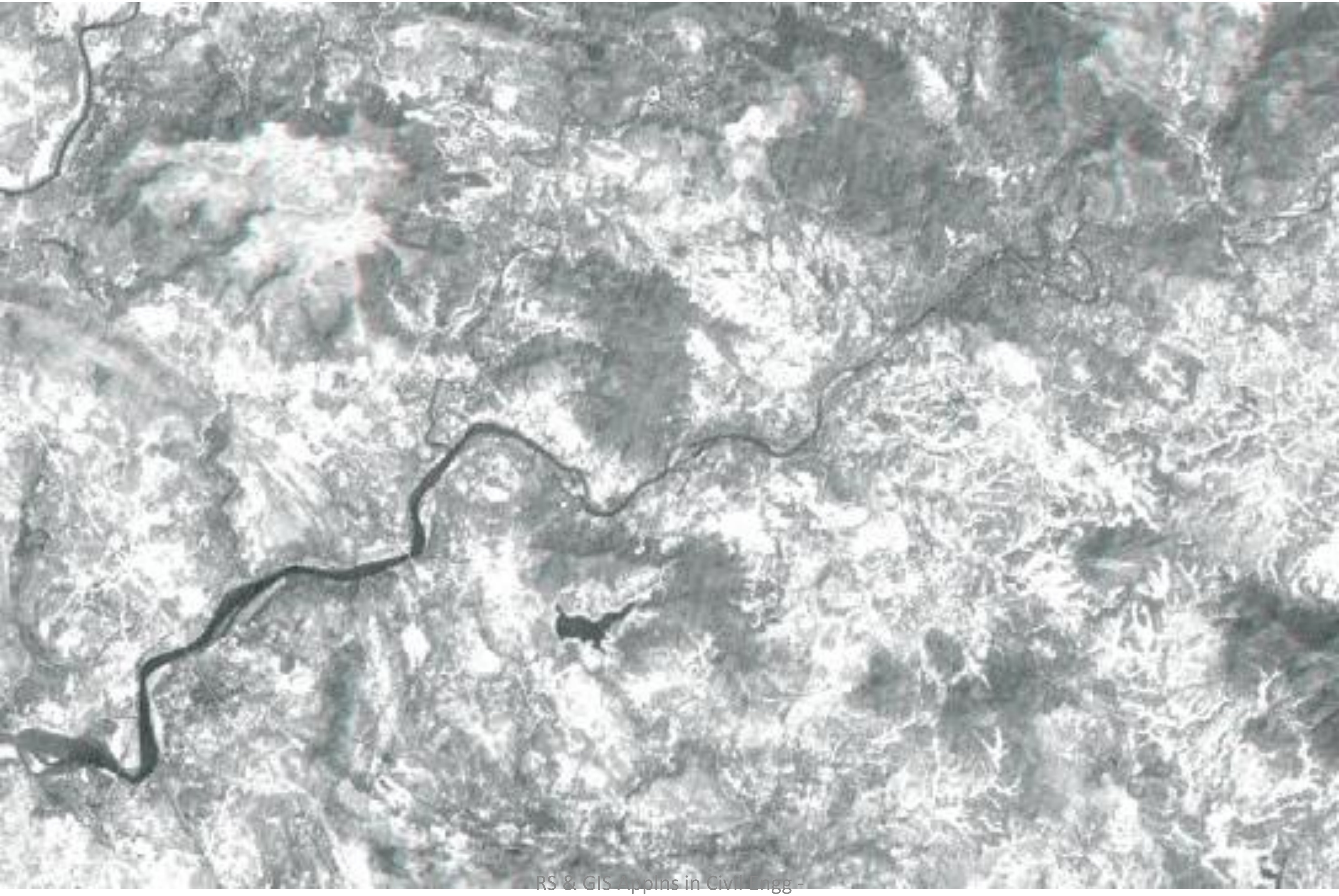
- **Digital Photogrammetric suites** – e.g., LPS
- **Data Sources - Spatial Stereo data** – e.g. CARTOSAT – Stereo data, Drone based data, LIDAR / LASER based cloud data
- **Derivative Stereo image product types** – Anaglyphs, Stereopairs…
- **Special Equipment Needed** – Anaglyph glass, Stereo enabled PC, Mouse and Glass viewer

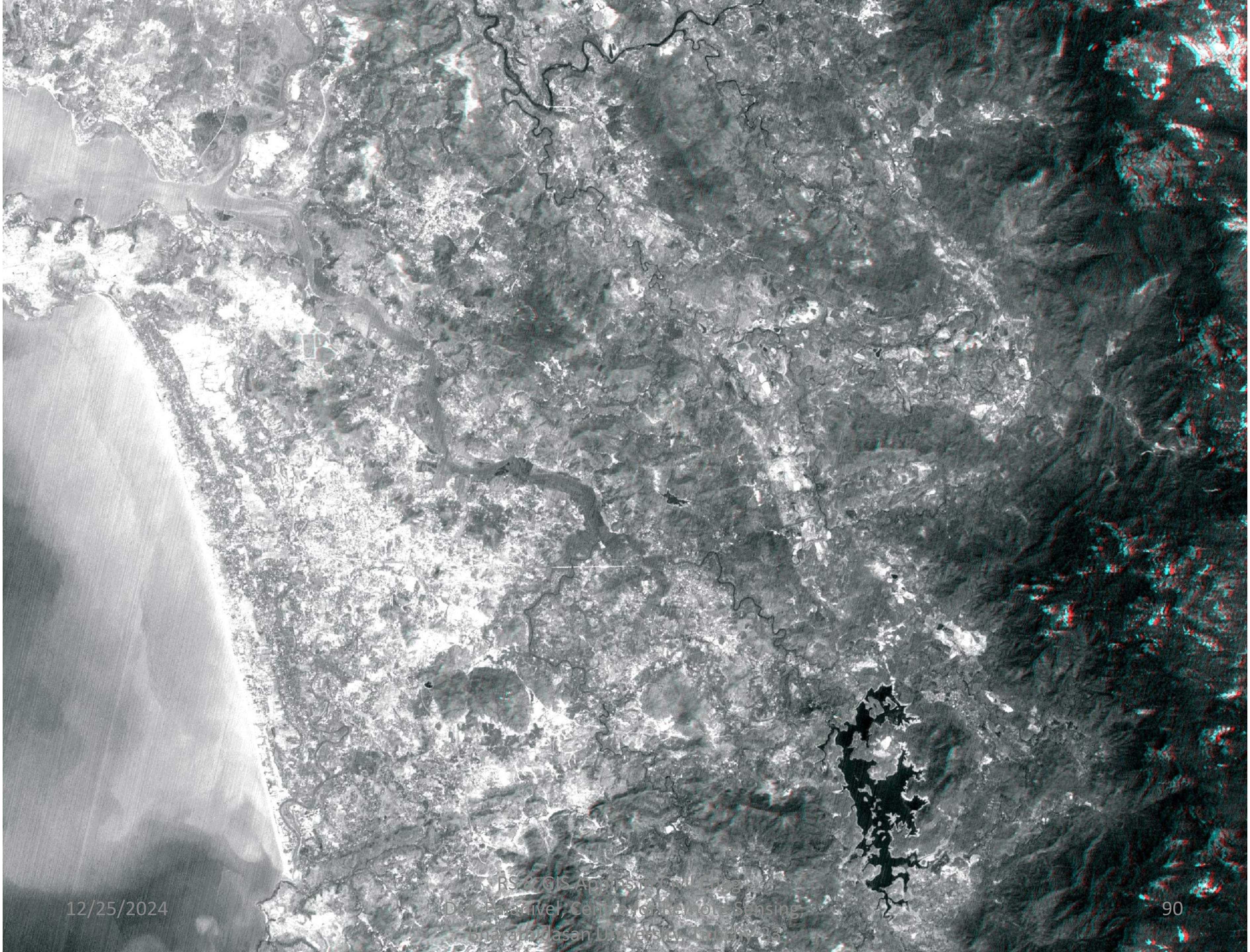
CARTOSAT Panchromatic ORTHO DATA wrapped high resolution Anaglyph image of GOA Area –

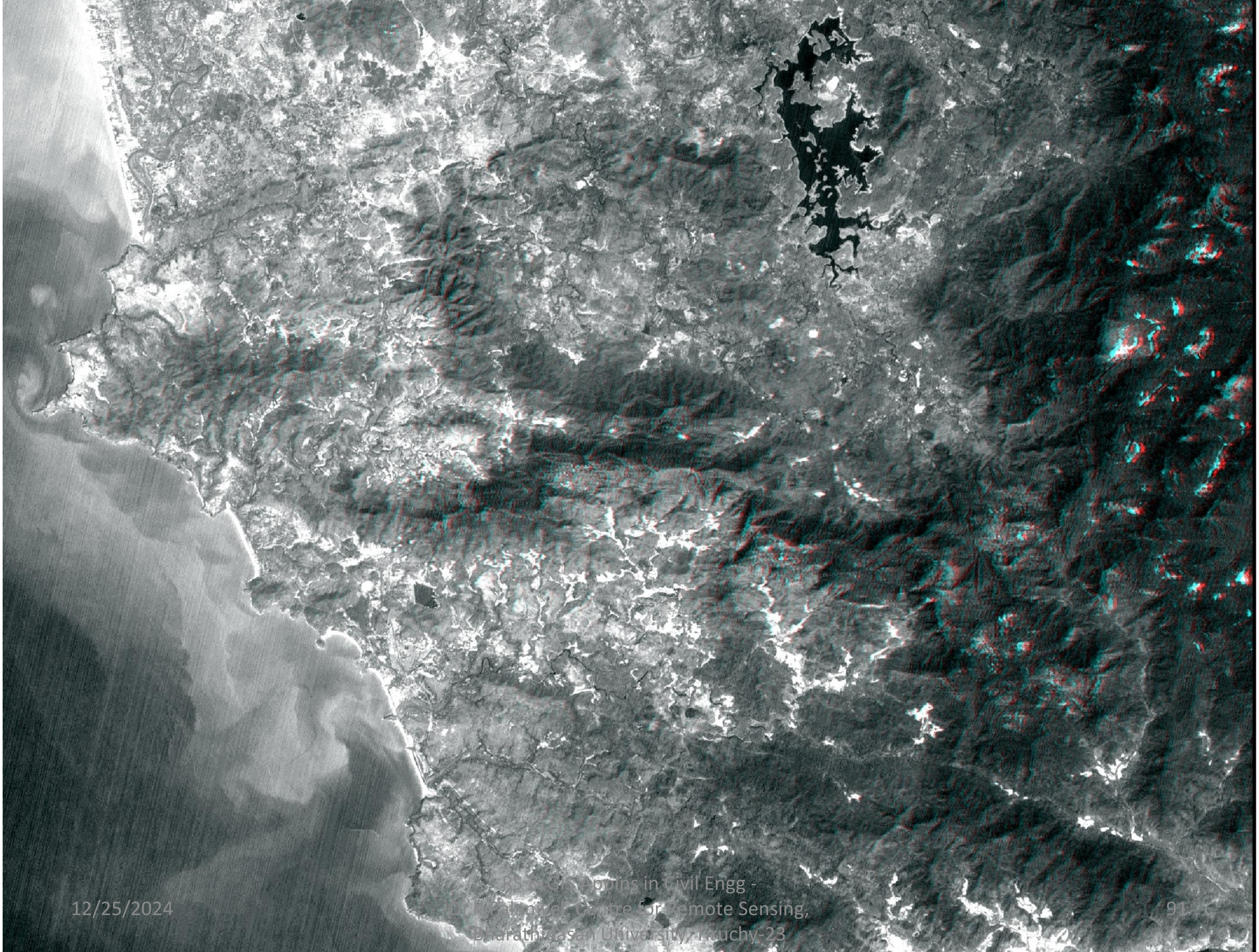
derived using CARTOSAT Stereo data through LPS (Leica Photogrammetric Suite) package

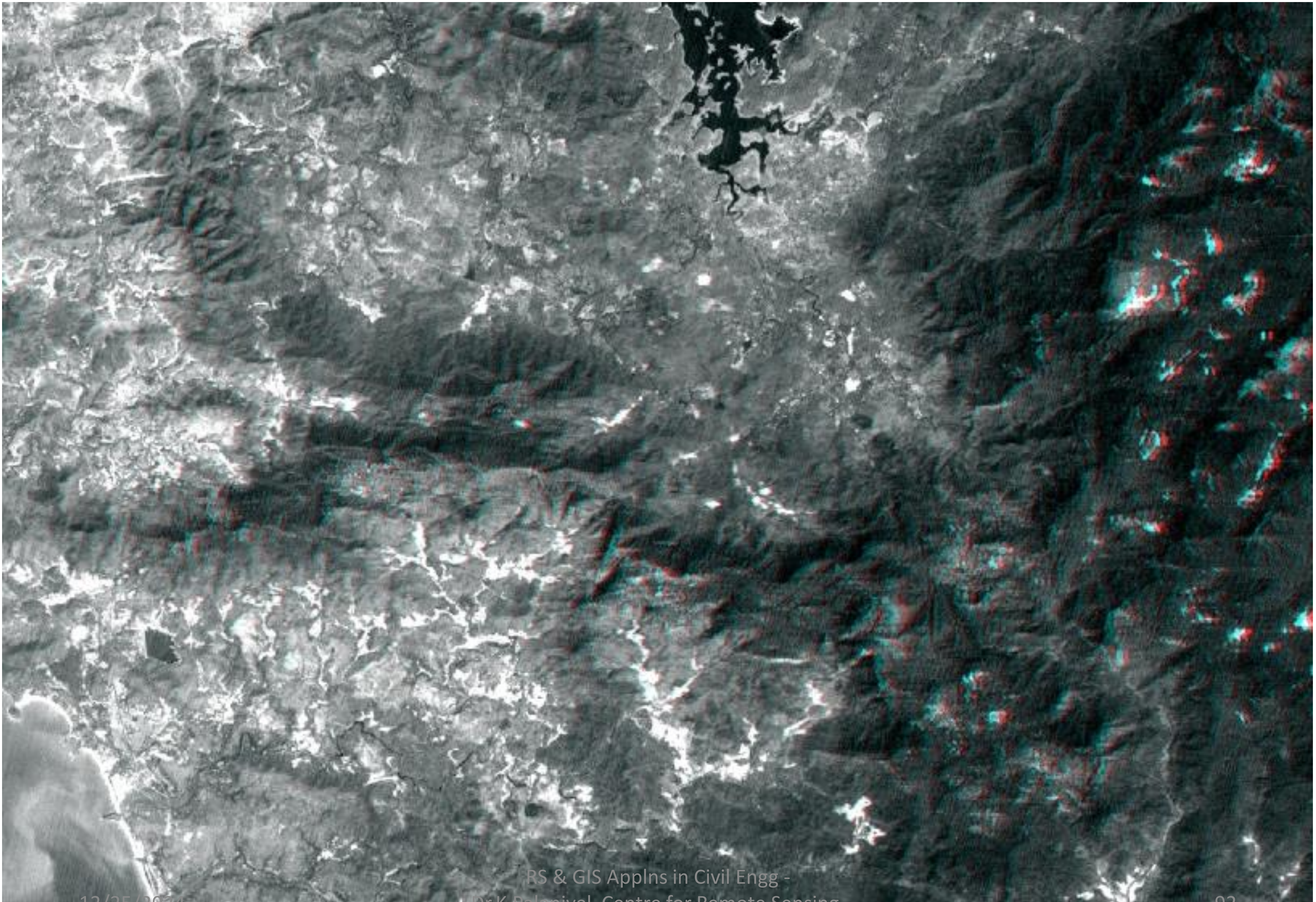






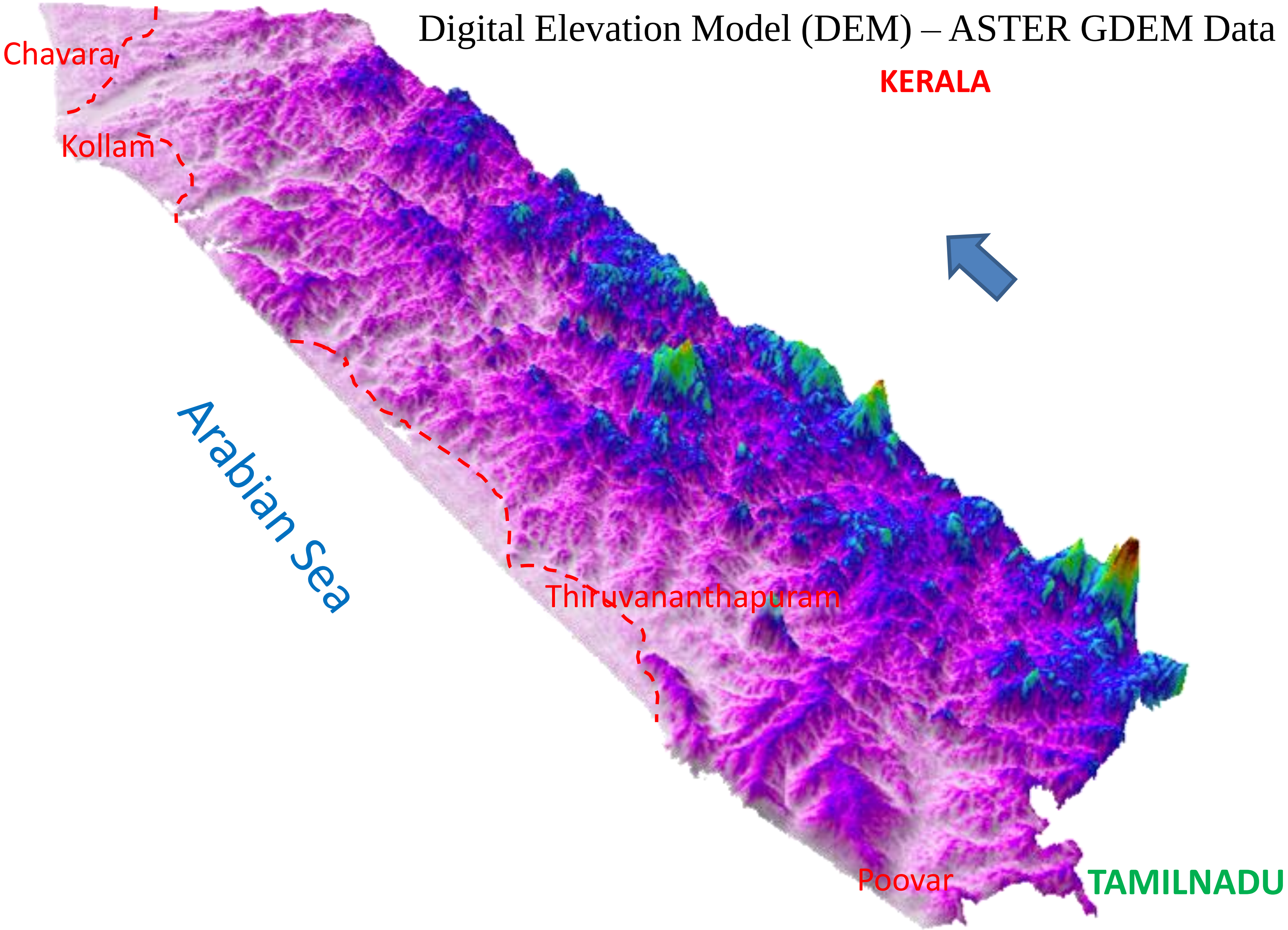




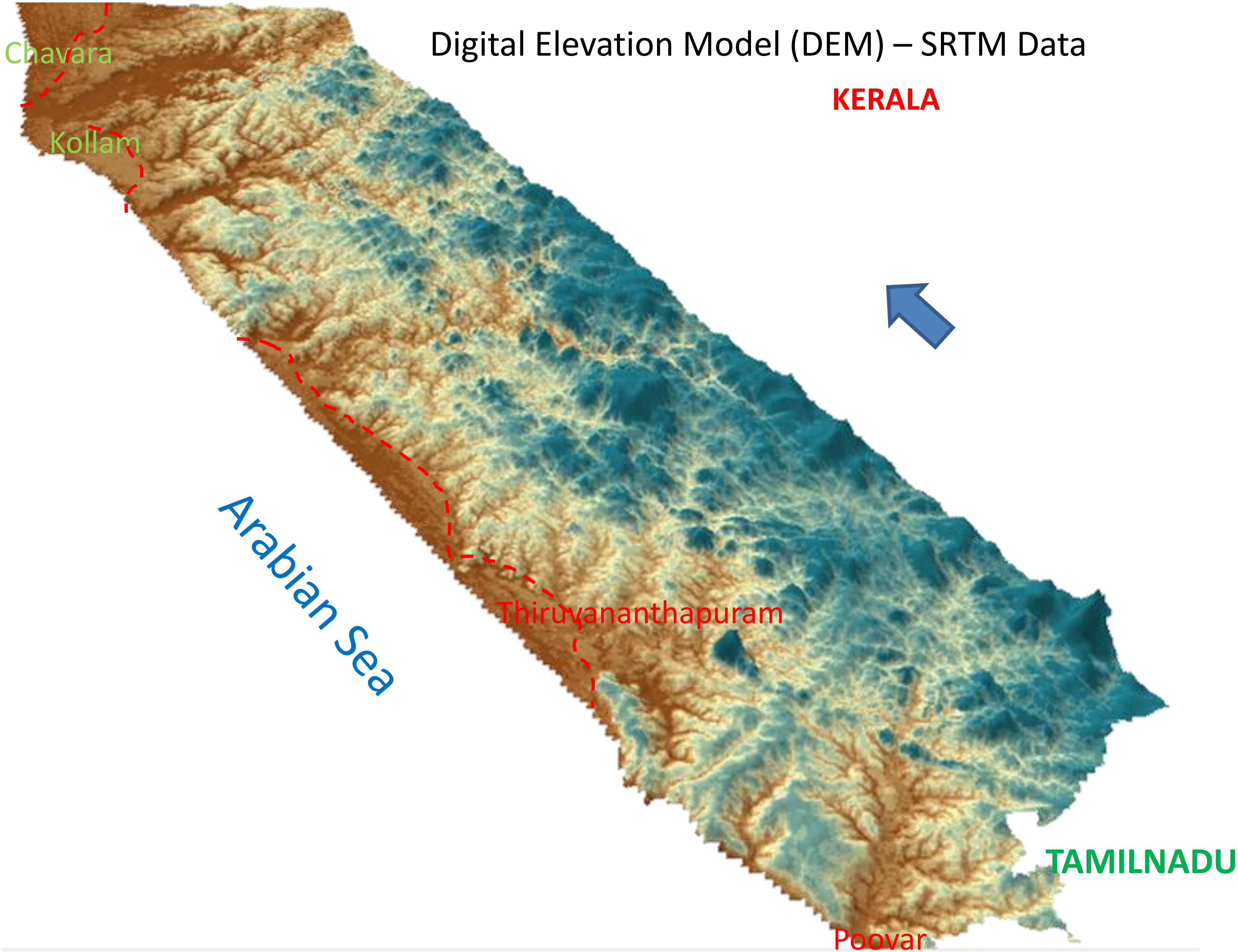


BACK

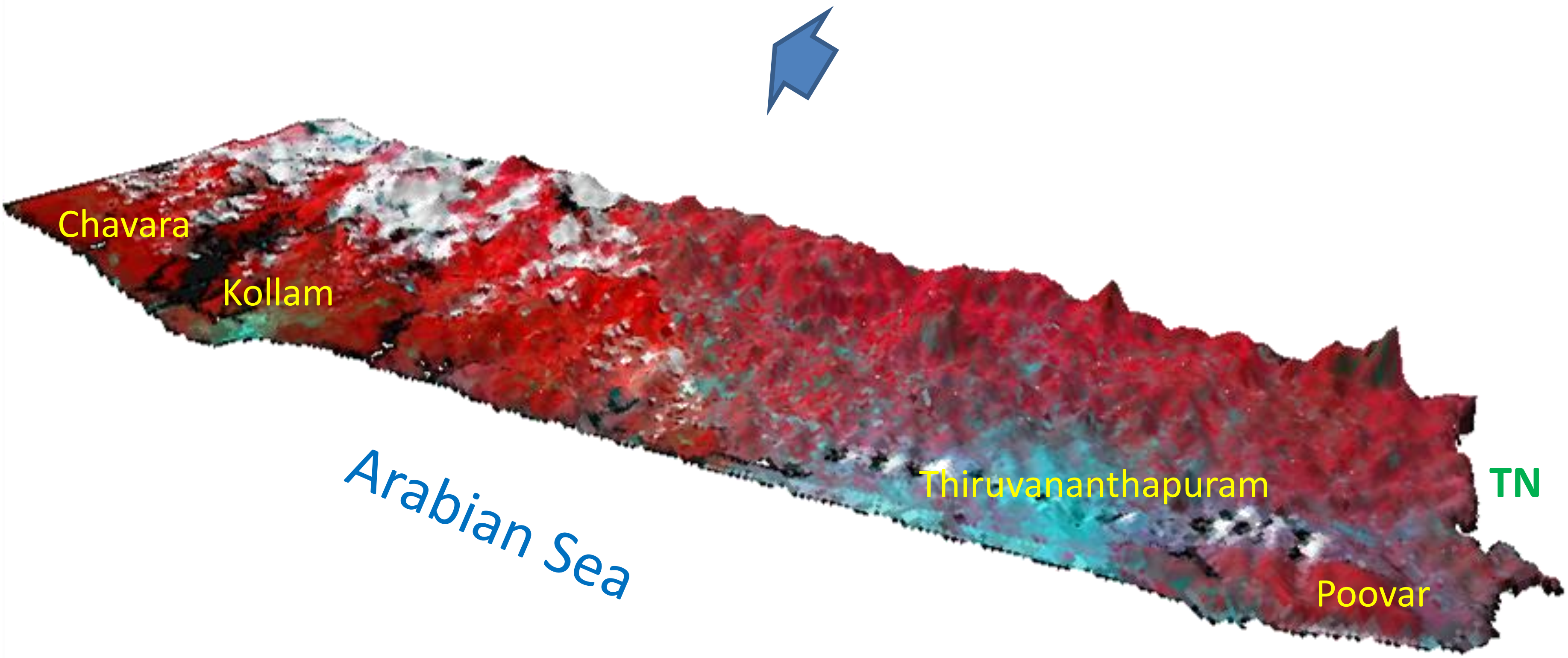
Digital Elevation Model (DEM) – ASTER GDEM Data



Digital Elevation Model (DEM) – SRTM Data



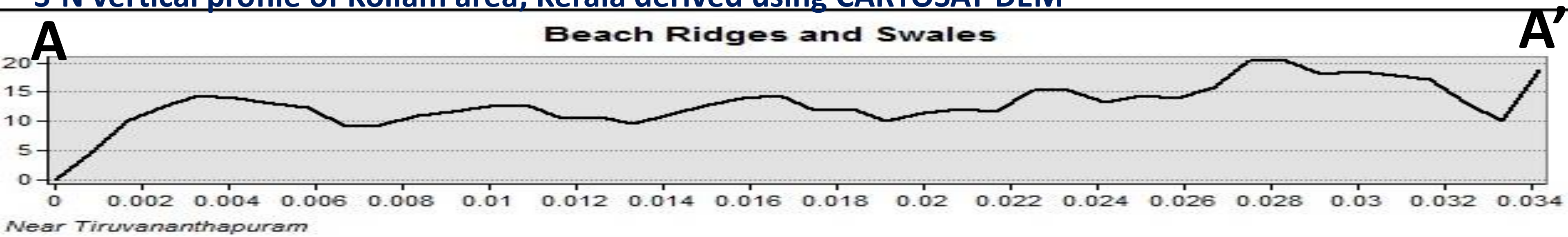
IRS P6 LISS-IV FCC IMAGE WRAPED ASTER GDEM (Global DEM), KERALA



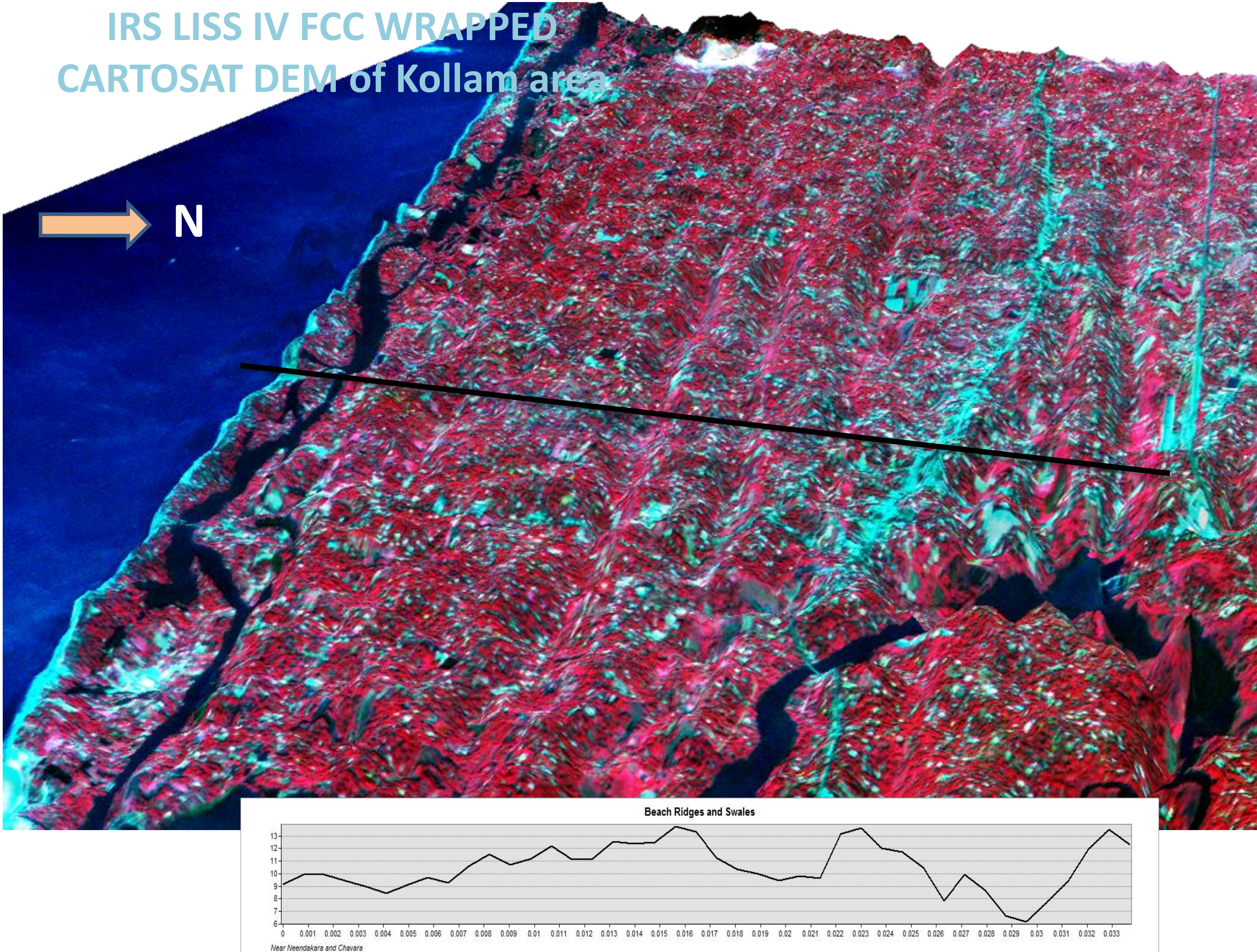
QuickBird TCC image & Geomorphic layer (showing Beach Ridge - transparent dull gray and Swale - open polys) wrapped CARTOSAT DEM, Kollam area, Kerala

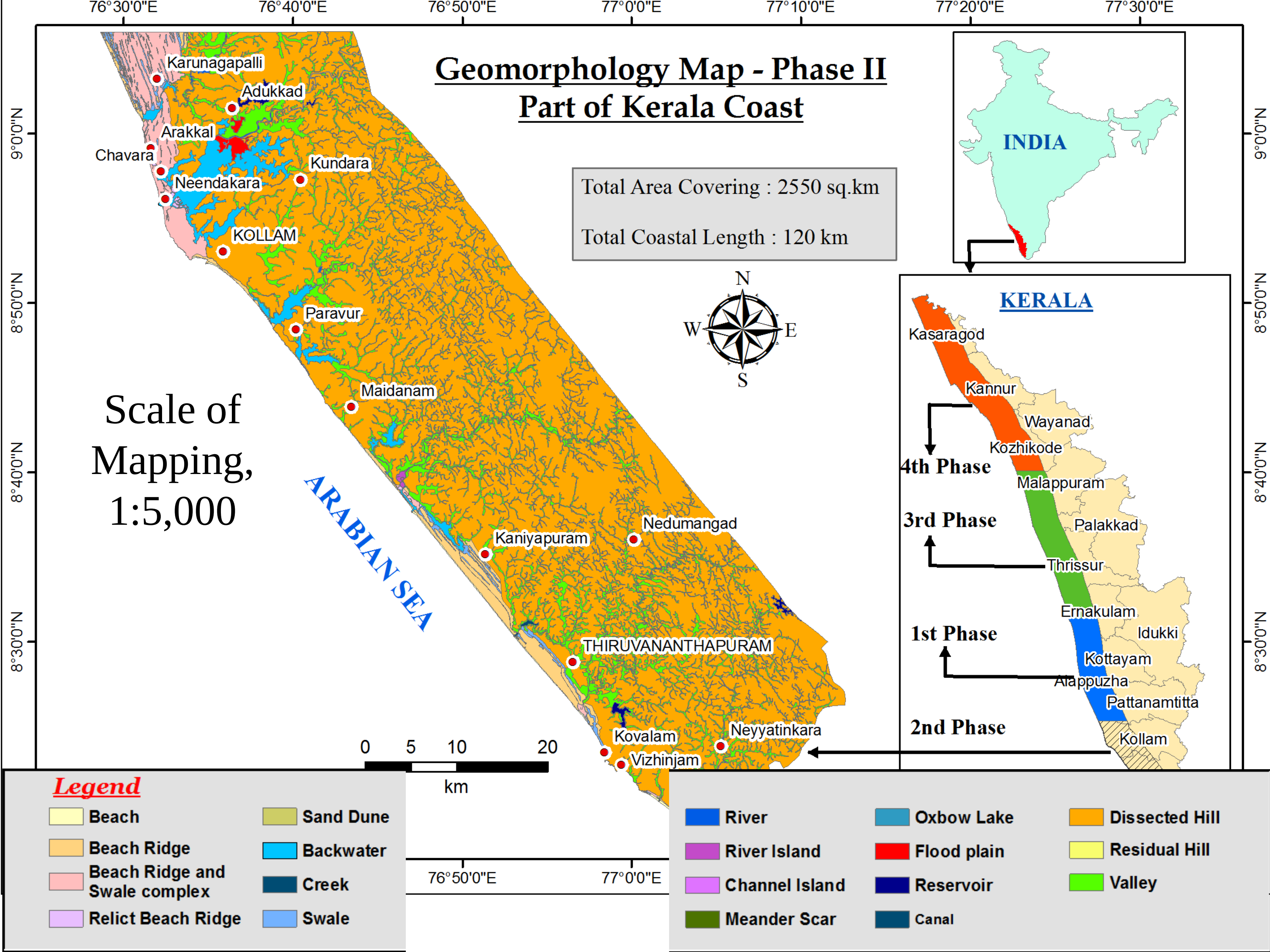
N

S-N vertical profile of Kollam area, Kerala derived using CARTOSAT DEM



IRS LISS IV FCC WRAPPED CARTOSAT DEM of Kollam area




Geomorphology Map - Phase II
Part of Kerala Coast
Total Area Covering : 2550 sq.km
Total Coastal Length : 120 km
Scale of Mapping, 1:5,000
N
S
E
W
INDIA
KERALA
Kasaragod
Kannur
Wayanad
Kozhikode
Malappuram
Palakkad
Thrissur
Ernakulam
Idukki
Kottayam
Alappuzha
Pattanamtitta
Kollam
4th Phase
3rd Phase
1st Phase
2nd Phase
Karunagapalli
Adukkad
Arakkal
Chavara
Neendakara
Kundara
KOLLAM
Paravur
Maidanam
ARABIAN SEA
Kaniyapuram
Nedumangad
THIRUVANANTHAPURAM
Kovalam
Vizhinjam
Neyyatinkara
0
5
10
20
km
76°30'0"E
76°40'0"E
76°50'0"E
77°0'0"E
77°10'0"E
77°20'0"E
77°30'0"E
9°0'0"N
8°50'0"N
8°40'0"N
8°30'0"N
Legend
Beach
Beach Ridge
Beach Ridge and Swale complex
Relict Beach Ridge
Sand Dune
Backwater
Creek
Swale
River
River Island
Channel Island
Meander Scar
Oxbow Lake
Flood plain
Reservoir
Canal
Dissected Hill
Residual Hill
Valley

Thank you