

# **Remote sensing application in geomorphology**



- ◆ As the title of the article indicates, the subject matter consists of two disciplines, remote sensing and geomorphology.
- ◆ Remote sensing which is, primarily based on principles of physics, is the science and art of acquiring information about an object or phenomena without physically coming in contact with it.
- ◆ Geomorphology is the science of study of the landforms of the earth.



- ◆ Remote sensing observations from aerial and space platforms which are currently in operation provide a synoptic view of terrain features in images which are interpreted by thematic specialists to understand and extract information of specific interest from the images.
- ◆ Formal training is required for interpretation to understand the significance of image elements contained in the image in addition to formal education in the theme speciality.
- ◆ Geomorphological mapping from satellite and aerial images for example, needs a thorough knowledge of the subject geomorphology, i.e., how certain natural and manmade processes lead to landforms.



- ◆ Since the most satellites data are essentially recorded in digital form without a stereoscopic coverage, generated images are two- dimensional.
- ◆ Geomorphological analysis of surface forms of the earth is a direct form of interpretation from space images.
- ◆ Aerial photos with required forward overlap usually provide the third dimension of height, which adds to the precision of interpretation including morphometry.



- ◆ Geomorphology as a science developed much later than geology although several aspects of geomorphology are embedded in geological processes.
- ◆ Geomorphology deals with the genesis of relief forms of the surface of the earth's crust.
- ◆ Certain natural processes are responsible for the forms of the surface of the earth.
- ◆ A thorough understanding of various processes leading to landforms is necessary to understand the environment in which we live.



- ◆ Remote sensing is an effective tool in this understanding, as aerospace images contain integrated information of all that is on the ground, the landform, the ecology, the resources contained in the area and the impact of human actions on the natural landscape.
- ◆ The dynamism with which changes occur in the landscape is brought out effectively by repeated coverage of images of the same area at different times.
- ◆ Images convey many things even to the untrained eye and for a professional it conveys much more including many features until now unknown or unseen on the ground.



# Geomorphology - basic concepts

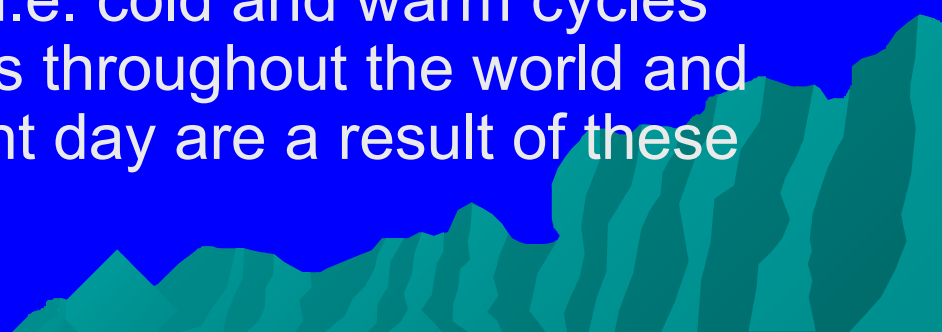
- ◆ The earth's surface forms are primarily due to hypogene or endogenous processes, which include diastrophism, leading to geologic structure, tectonic activity and volcanism leading to volcanic landforms.
- ◆ These forms are modified by epigene or exogenous processes, which include erosion and depositional activities of water, wind and ice.
- ◆ Other activities include weathering, mass wasting or movement of material by gravitational action, land-ocean interaction resulting in landforms due to waves, currents, tides and tsunamis.



- ◆ Climate is another important factor, which has relevance in shaping of the earth's surface because the processes that act upon the surface material are different in different climatic zones (Van Westen 1994).
- ◆ For example, limestone forms hills in a dry climate whereas in wet climate, it forms Karst topography with sink holes, caves and caverns predominating because of its susceptibility to solution activity.
- ◆ Similarly, granite stands out as hard rock in nontropical areas whereas in the tropics it undergoes deep chemical weathering and becomes a soft rock.
- ◆ It is also understood that climate has strong influence on vegetation which in turn has relationship with landforms.





- ◆ Landforms and plant ecology thus form a sound combination; a change in plant ecology may have significance in change in landform and vice-versa, although human influence on vegetation may disturb the relationship.
  - ◆ Time is another important factor that may preserve or destroy the natural landform, because it controls the stage in the sequence of processes leading to forms.
  - ◆ At any given time, the more recent processes and the resultant forms dominate the landscape.
  - ◆ The Pleistocene to Holocene glacial cycles with intervening interglacial periods i.e. cold and warm cycles have modified the surface forms throughout the world and many of the forms of the present day are a result of these cycles.
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# Geomorphological mapping

- ◆ The first geomorphological map prepared in 1914 but the main demand for the maps came from planners and agronomists after World War II.
- ◆ However, a formal mapping system was designed only during 1950s. Many systems were developed by European countries like France, Poland and Russia.
- ◆ The International Geographical Union's Sub-commission on geomorphological mapping was set up in 1960 to standardize legends for mapping.



- ◆ However, specific consensus was arrived at a modified legend.
- ◆ A geomorphological map must give information about morphology (appearance), morphometry (dimensions and slope values), morphogen (origin/genesis) and morphochronology (the age) of each form.
- ◆ Representation of these details is an involved and complicated matter on a single map.



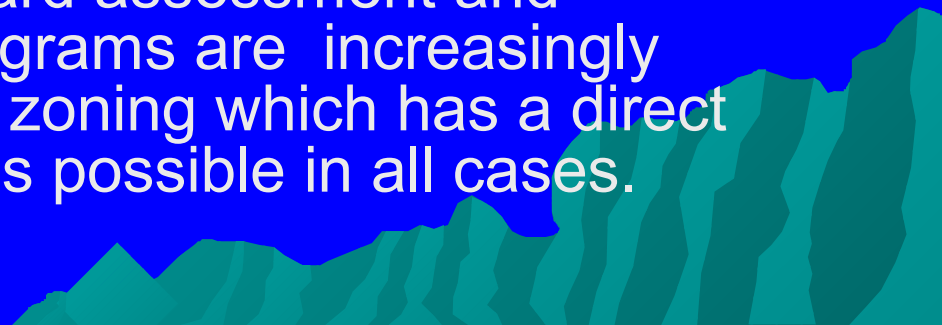
- ◆ The most comprehensive geomorphological survey method is the one evolved by ITC (Verstappen 1977) which resulted in three different kinds of maps: Analytical geomorphological map, synthetic geomorphological map and pragmatic (applied) geomorphological map. Analytical geomorphological maps are applicable for mapping at all scales and serve as a basis for applied geomorphological mapping.
- ◆ The informations contained in these maps include



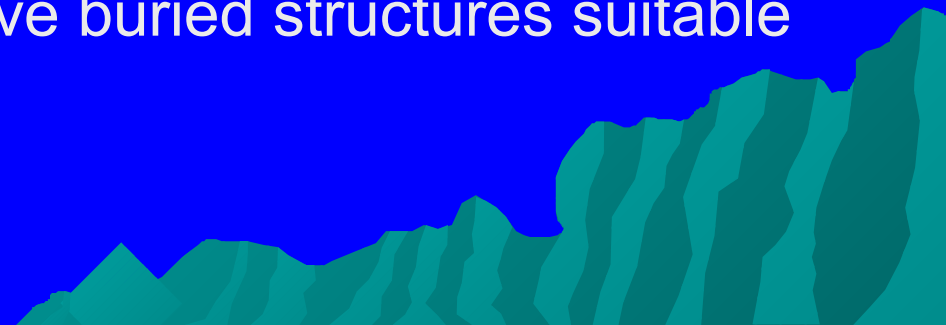
- a. morphogenesis i.e. the terminology should indicate the process/ gneisses (e.g. alluvial fan, piedmont);
- b. morphostructure/lithology. Usually the underlying bedrock and structure will have a profound influence on the landform (e.g. structural hill, granitic residual hill etc.);
- c. morphometry i.e. quantitative information about relief e.g. height of terrace, slope angle etc;
- d. morphochronology i.e. different ages of landforms whenever such information is available.




- ◆ Synthetic geomorphological maps contain, in addition to four levels of terrain mapping units, also contain additional environmental information required of every terrain mapping unit gathered subsequently on the basis of number of site observations in every unit.
- ◆ These observations include, for example, soils, hydrology, vegetation/ land use/ landcover and topography. These data are presented in tables or use of GIS can be made to indicate each theme as a spatial layer.
- ◆ Pragmatic or applied geomorphological maps can be derived from analytical and synthetic maps.
- ◆ Maps related to natural hazard assessment and developed for mitigation programs are increasingly becoming useful, as hazard zoning which has a direct bearing on geomorphology is possible in all cases.



- ◆ Maps on flood hazard zoning, mountain hazard zoning, drought hazard zoning, earthquake hazard zoning, volcanic hazard zoning, cyclone hazard zoning are some typical examples of pragmatic geomorphological maps (Verstappen 1977).
- ◆ Other applied geomorphological mapping examples include maps for mineral and hydrocarbon exploration , which contains geomorphic anomalies indicative of suitable subsurface structures.
- ◆ For example, incipient radial drainage or compressed meanders may indicate active buried structures suitable for mineral/ hydrocarbons.



- ◆ Similarly high recharge zones (piedmont), disappearing drainage lines and discharge zones indicated by sudden appearance of vegetation throw light on ground water exploration.
  - ◆ Anomalously displaced terraces and alluvial fans (Rao 1977, 1978), indicative of neotectonic activity changing river courses leading to anomalous lakes and study of Paleodrainages, indicative of climatic and tectonic activities all have immensely benefited in understanding the phenomena through the knowledge of geomorphology.
  - ◆ Traditionally geomorphological mapping has been in practice ever since aerial photos became available
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- ◆ Landforms have been the direct object of interpretation of aerial photos and these are interpreted in terms of other themes like geology, soils etc.
- ◆ Inductive and deductive reasoning is resorted to for interpretation of soils, for example, as pedological information is not directly seen and it has to be extracted from terrain feature like landforms, geology, vegetation, drainage etc.




# Remote sensing application

- ◆ Remote sensing as described earlier is sensing from a distance. The electro magnetic energy after interacting with matter can be recorded by a sensor and the recorded data can be seen as an image or photo depending upon the sensor.
- ◆ The electromagnetic spectrum is a continuum of energy that ranges from meter to nanometers in wavelength and travels at the speed of light.
- ◆ The spectrum has several windows through which reflected or emitted radiation is recorded in sensors (Sabins 1997).
- ◆ Among the sensors are aerial cameras, which employ a film for recording in visible (B&W and color) and near infrared band.

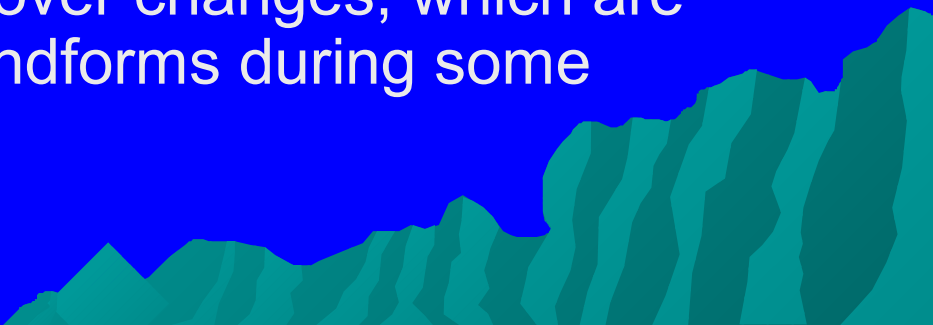
- ◆ Data from visible, near infrared and other optical windows are recorded by multispectral scanners. Thermal scanner records thermal (emitted) radiation.
- ◆ Active microwave sensors (SLAR or SAR) record data from microwave region of spectrum and have the advantage of recording day and night as well as through clouds.
- ◆ Thus technologically it is possible to record terrain information by various sensors.




# Advantages of remote sensing


- ◆ Remote sensing satellites by virtue of their orbiting in a sun synchronous orbit and crossing the equator at the same local time, capture the images of the terrain with the same illumination and provide repetitive coverages i.e. satellites revisit the same site at regular intervals of time which varies depending upon the orbit height, inclination etc.
  - ◆ The following are specific advantages of satellite images for deriving information on ground features, some of which are dynamically changing, like land use.
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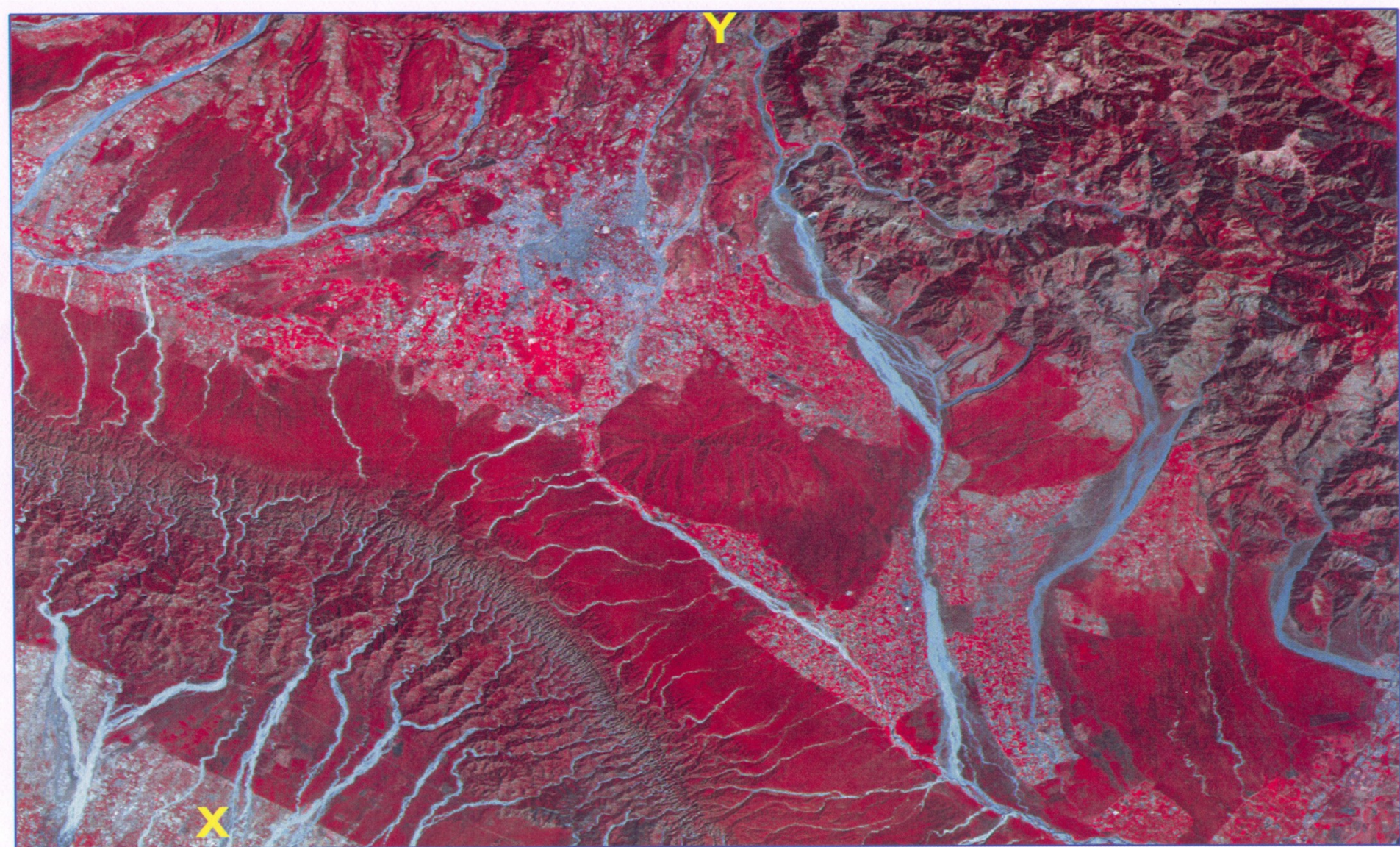
## Multi temporal capability

- ◆ Indian Remote Sensing satellite (IRS) at a height of about 800 km, revisits every 22 days the same site; any change occurring between two successive visits becomes evident in the image.
  - ◆ While no change occurs in major landforms in the short period, the changes brought about by disasters like floods, cyclones, landslides change in river courses, erosion of the river banks etc., can be automatically detected.
  - ◆ Additionally, landuse/ land cover changes, which are dynamic, highlight certain landforms during some seasons of the year.
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# Multi spectral capability

- ◆ Most remote sensing satellites have sensors, which record, not only in visible band but also in NIR, SWIR and MIR bands apart from thermal band in selected satellites.
  - ◆ Microwave recording requires special effort and usually such satellite are exclusive. The advantage in multispectral capability is that certain bands or a combination of bands provide better contrast for image interpretation than other bands.
  - ◆ The interpreter has to be knowledgeable to choose a particular sensor data depending upon the specific application.
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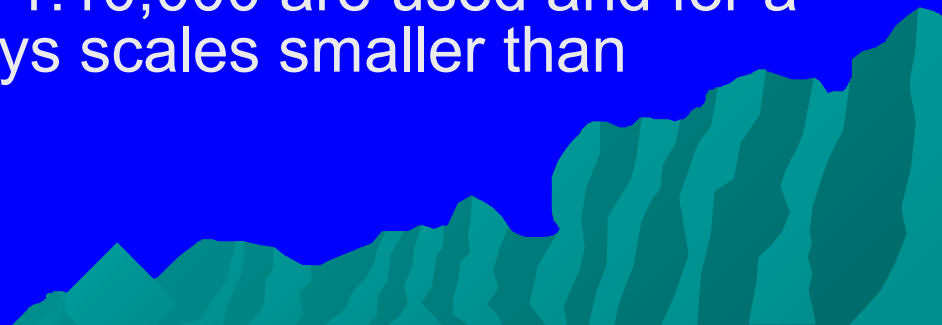
- ◆ While digital analysis is faster and appropriate in identification and delineation of crops and land use where each land use/land cover may have unique signature, landforms can be best interpreted on the basis of analysis of basic elements of interpretation outlined earlier namely tone, texture, size, shape, relief, drainage, slope, land use and association of features.
  - ◆ Four phases of image interpretation namely: (i) detection, (ii) recognition and identification, (iii) analysis and (iv) classification of observable features in terms of landform and genesis.
  - ◆ A good reference level in the subject plus a formal training in interpretation are essential to derive maximum information from image.
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Satellite data showing Doon Valley and surroundings.

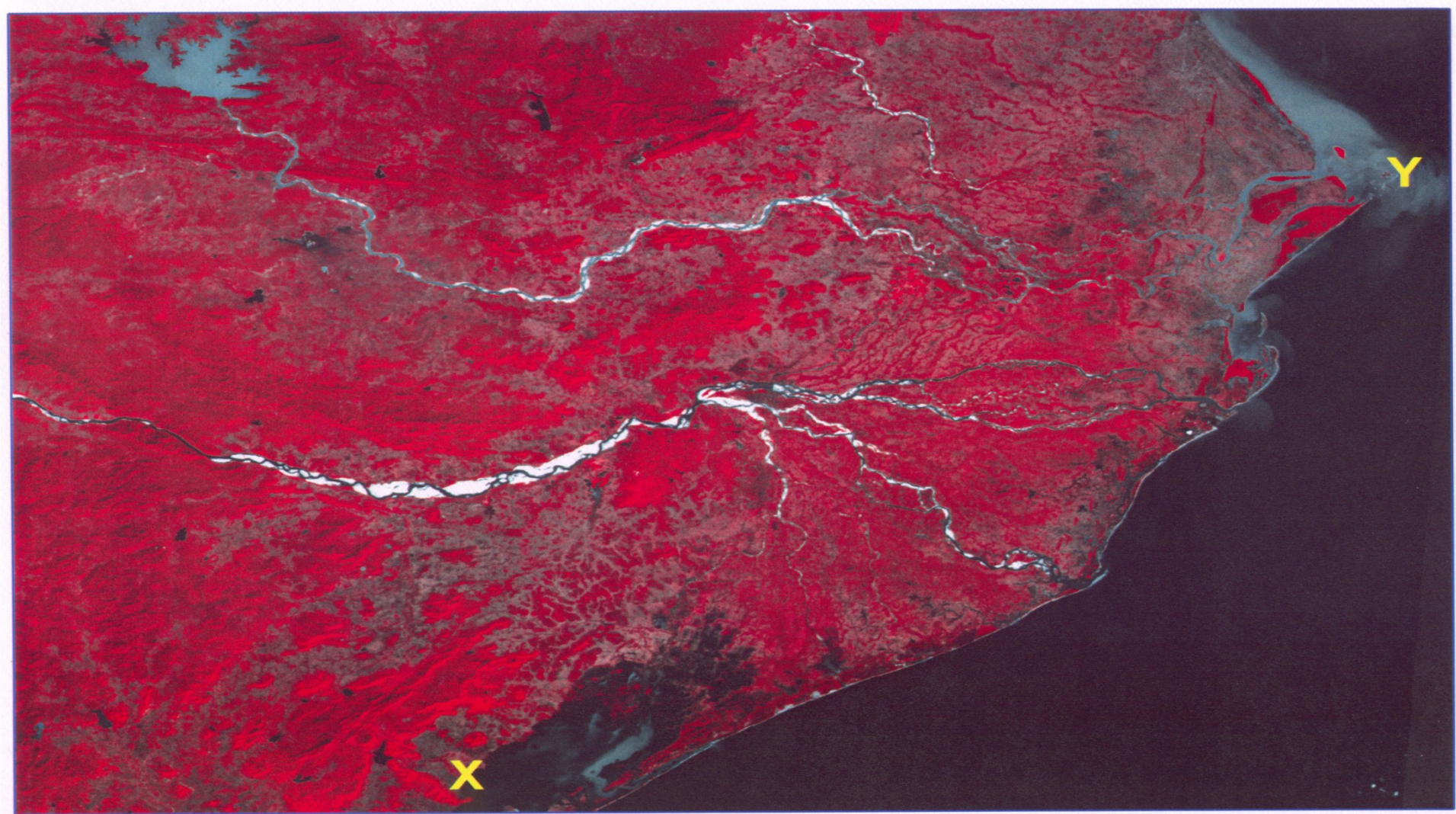


- ◆ Aerial photos have been historically used to capture ground features. Largely used in the beginning after World War II for geological mapping, it was soon realized that geomorphological understanding of terrain features is so direct from aerial photos.
- ◆ Several techniques of interpretation of aerial photos were developed. The basic elements which help in image interpretation are shape, size, tone, texture, slope/relief, drainage and association of features.
- ◆ These are related to the scale of aerial photos. The scales of commonly used aerial photos vary from 1:10,000 to 1:50,000 although for very large scale mapping, scales larger than 1:10,000 are used and for a quick reconnaissance surveys scales smaller than 1:50,000 are used.



- ◆ The advantage of aerial photo is that they provide stereoscopic view, enabling the interpreter to understand the genesis of landform in addition to amenability to measurement of slopes, heights etc.
  - ◆ Although black & white aerial photos are used in majority of cases, infrared, color, thermal and radar images from aerial platform are also used for specific purposes.
  - ◆ However, the mechanism of acquisition, storage, retrieval of images and their interpretation, is different for each type of image
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- ◆ Interpretation of remotely sensed images from space platforms for geomorphological understanding is rather direct as the main object of interpretation is landform itself, which manifests itself in its form.
  - ◆ Deduction is required unlike in other themes although for understanding the processes it may be employed usefully.
  - ◆ The synoptic view of a large area in a single view enables understanding of interrelationship of various terrain features.
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Satellite data showing Mahanadi Brahmani delta system and surrounding coastal landforms.

The End

