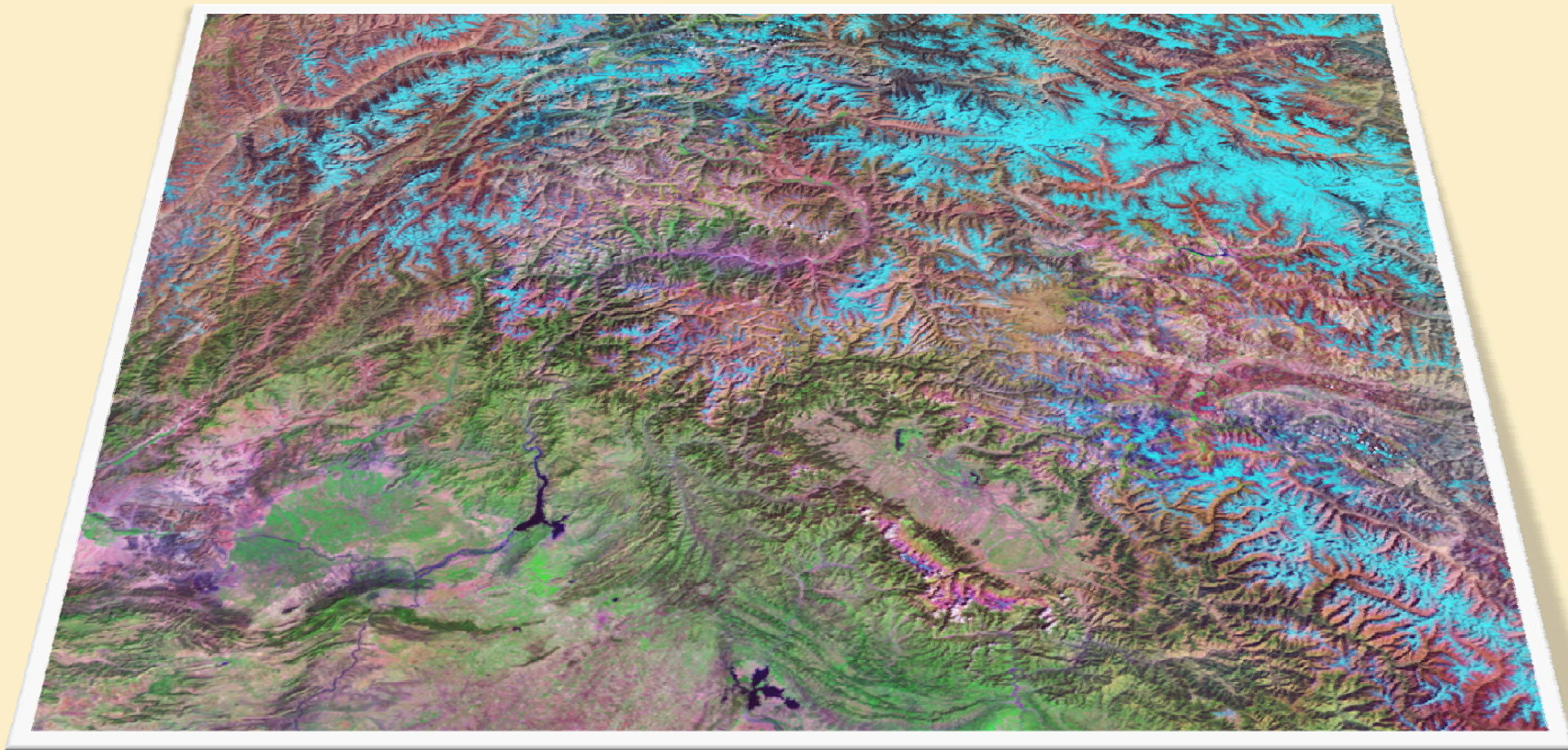


INTRODUCTION TO REMOTE SENSING



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University of Peshawar

WHAT IS REMOTE SENSING?

- ✗ *Remote sensing is the science of acquiring information about the Earth's surface without actually being in contact with it.*

REMOTE SENSING

is the science and art of acquiring information (spectral, spatial, temporal) about material objects, area, or phenomenon through the analysis of data acquired by a device from measurements made at a distance, without coming into physical contact with the objects, area, or phenomena under investigation.

HOW DOES REMOTE SENSING WORK?

- ✗ *Remote Sensing is performed by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information".*

REMOTE SENSING OVERVIEW

- ✗ Observation without direct contact.

PASSIVE REMOTE SENSING

makes use of sensors that detect the reflected or emitted electromagnetic radiation from natural sources.

ACTIVE REMOTE SENSING

makes use of sensors that detect reflected responses from objects that are irradiated from artificially-generated energy sources, such as radar.

WHAT IS EMR?

- ✗ Electromagnetic Radiation is a form of energy with the properties of a wave.

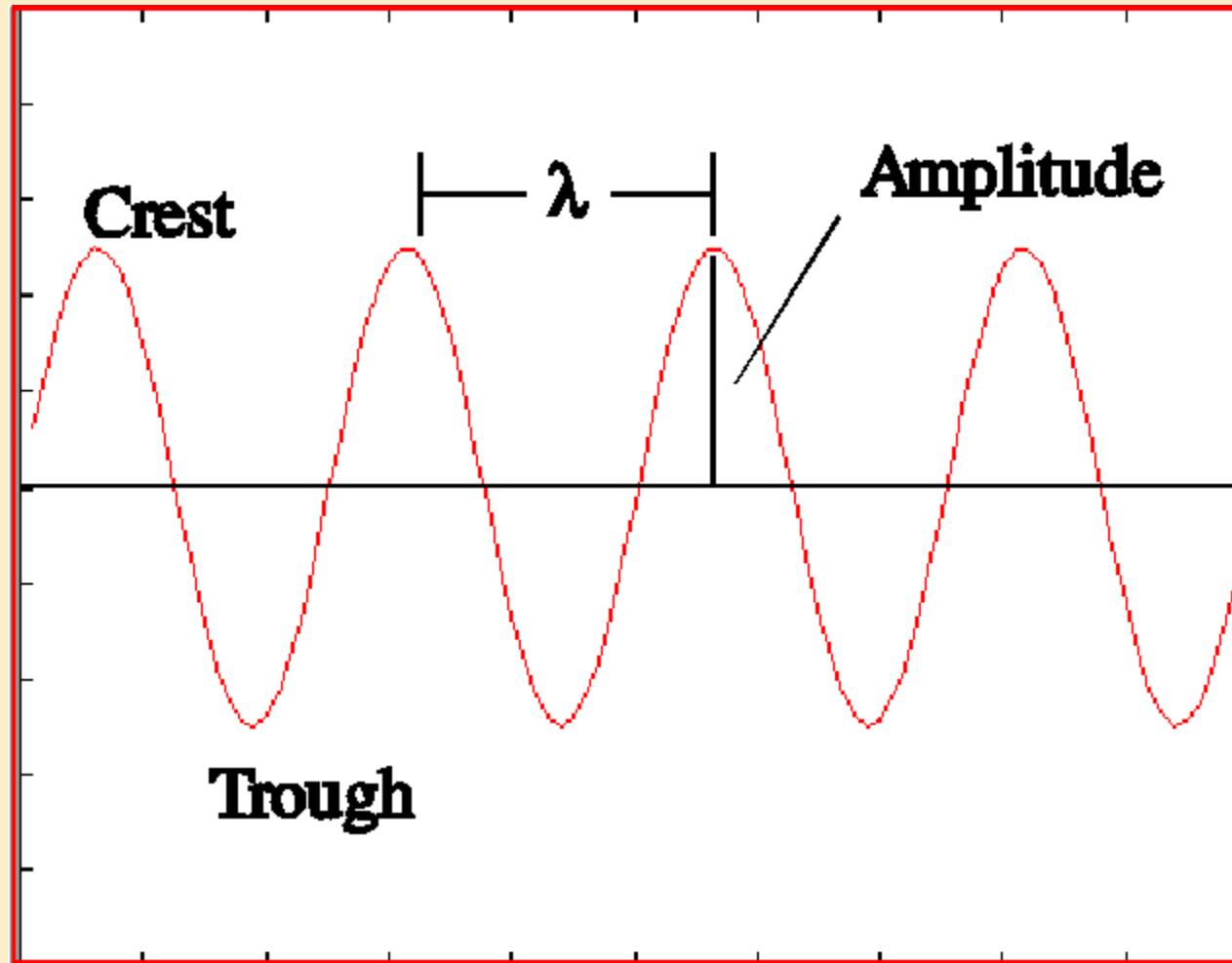
WHAT IS EMR?

- ✗ The waves propagate through time and space in a manner rather like water waves, but oscillate in all directions perpendicular to their direction of travel.

ELECTROMAGNETIC WAVES

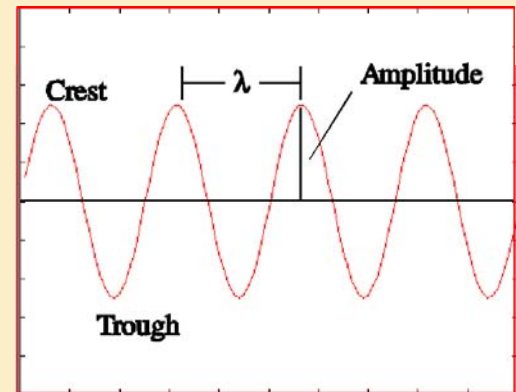
- ✗ A wave is characterized by two principal measures: wavelength and frequency:
- ✗ The *wavelength* (λ) is the distance in meters between successive crests of the waves.
- ✗ The *frequency* (ν) is the number of oscillations completed per second.

ELECTROMAGNETIC WAVES



TERMS

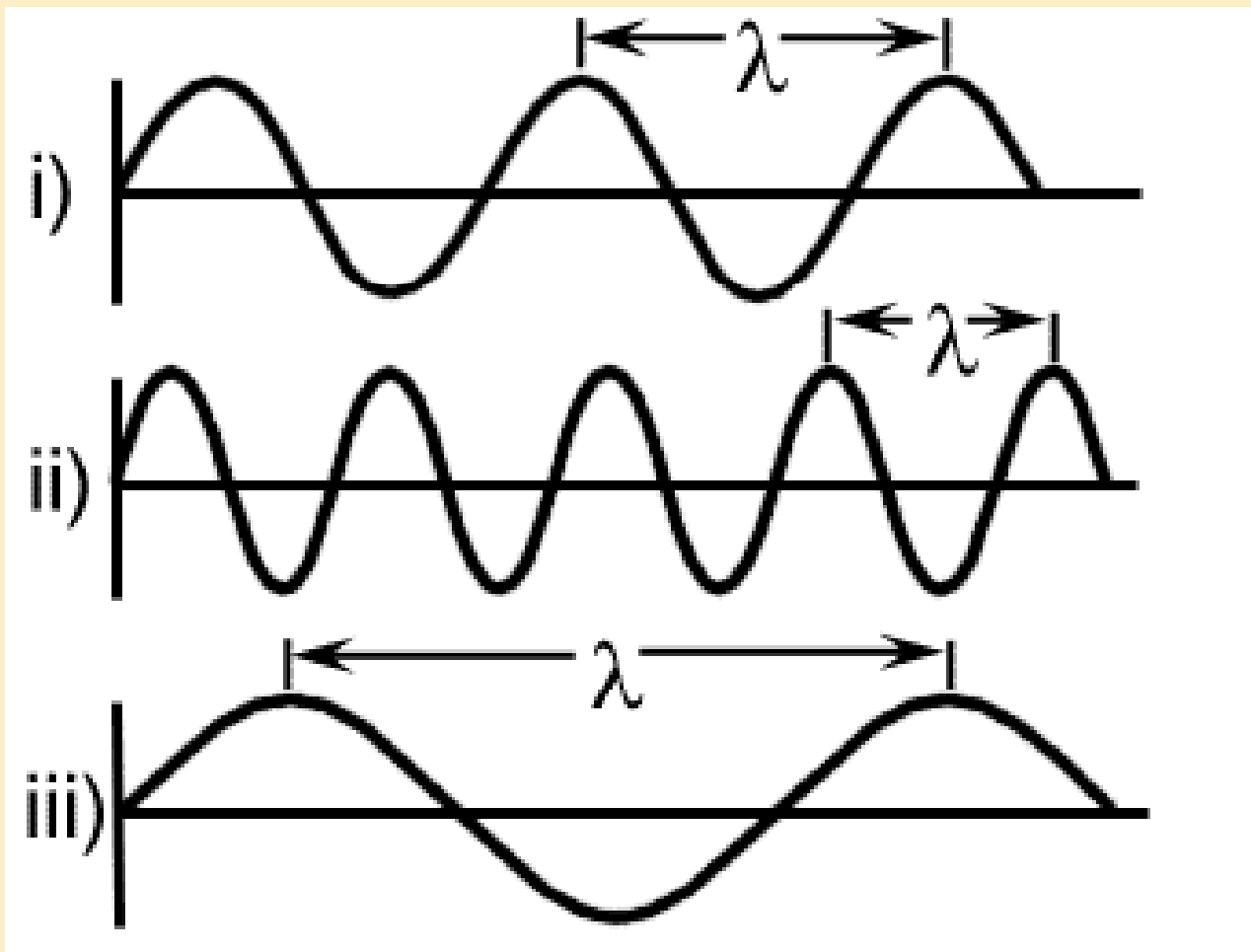
- Crest : The highest point of the wave.
- Trough : The lowest point of the wave.
- Amplitude : The height of the wave as measured between the trough and the crest.
- Wavelength : The distance between two identical points on the wave.
- Period : The time it takes for a wavelength to pass a stationary point.
- Frequency : The number of wavelengths that pass a point in a set period of time.



WAVELENGTH

- ✗ The wavelength (λ) is the distance in metres between successive crests of the waves.

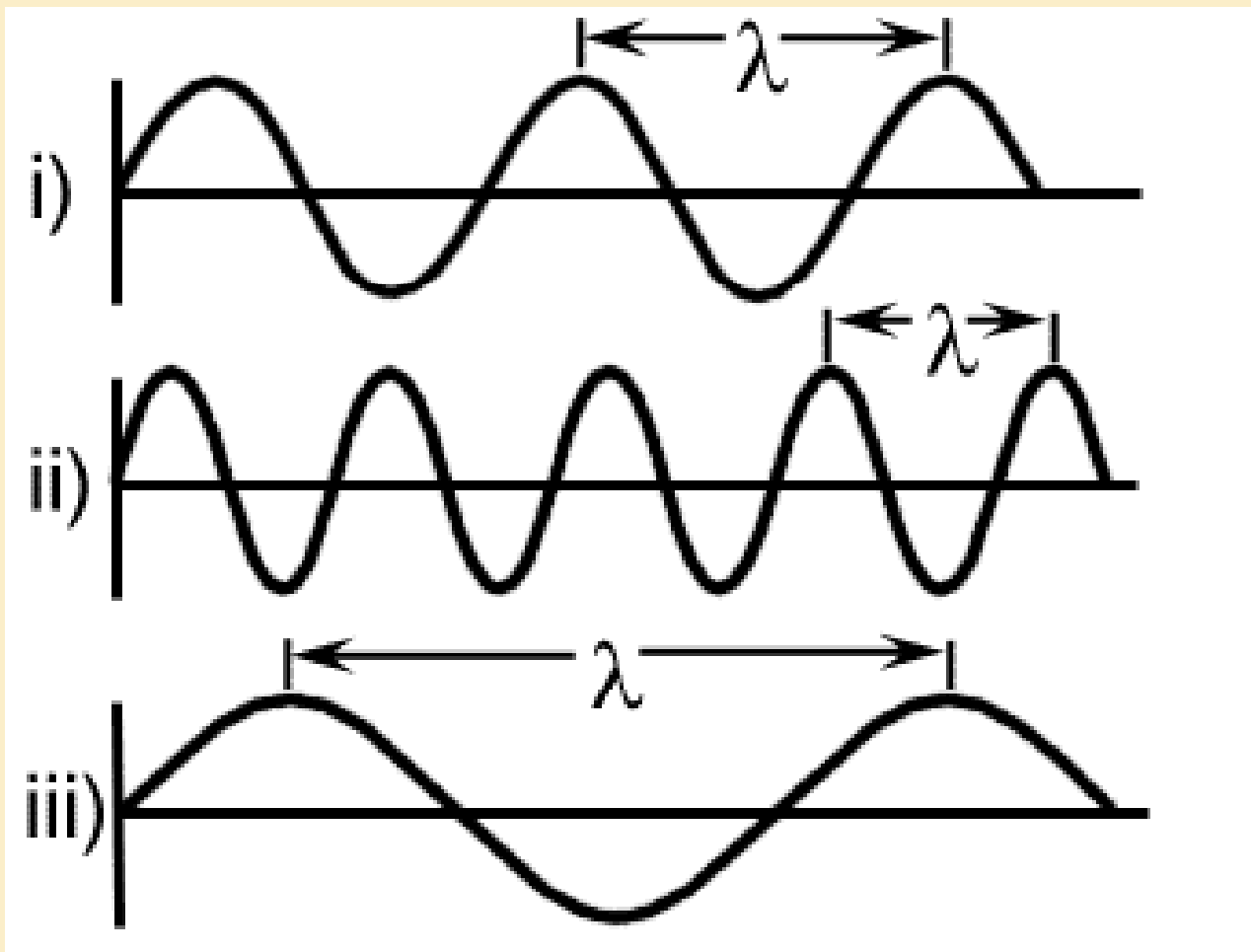
ELECTROMAGNETIC WAVES



FREQUENCY

- ✗ The frequency (ν) is the number of oscillations completed per second.

ELECTROMAGNETIC WAVES



WAVELENGTH AND FREQUENCY

- ✗ Wavelength and frequency are related by the following formula:

$$c = \lambda \nu$$

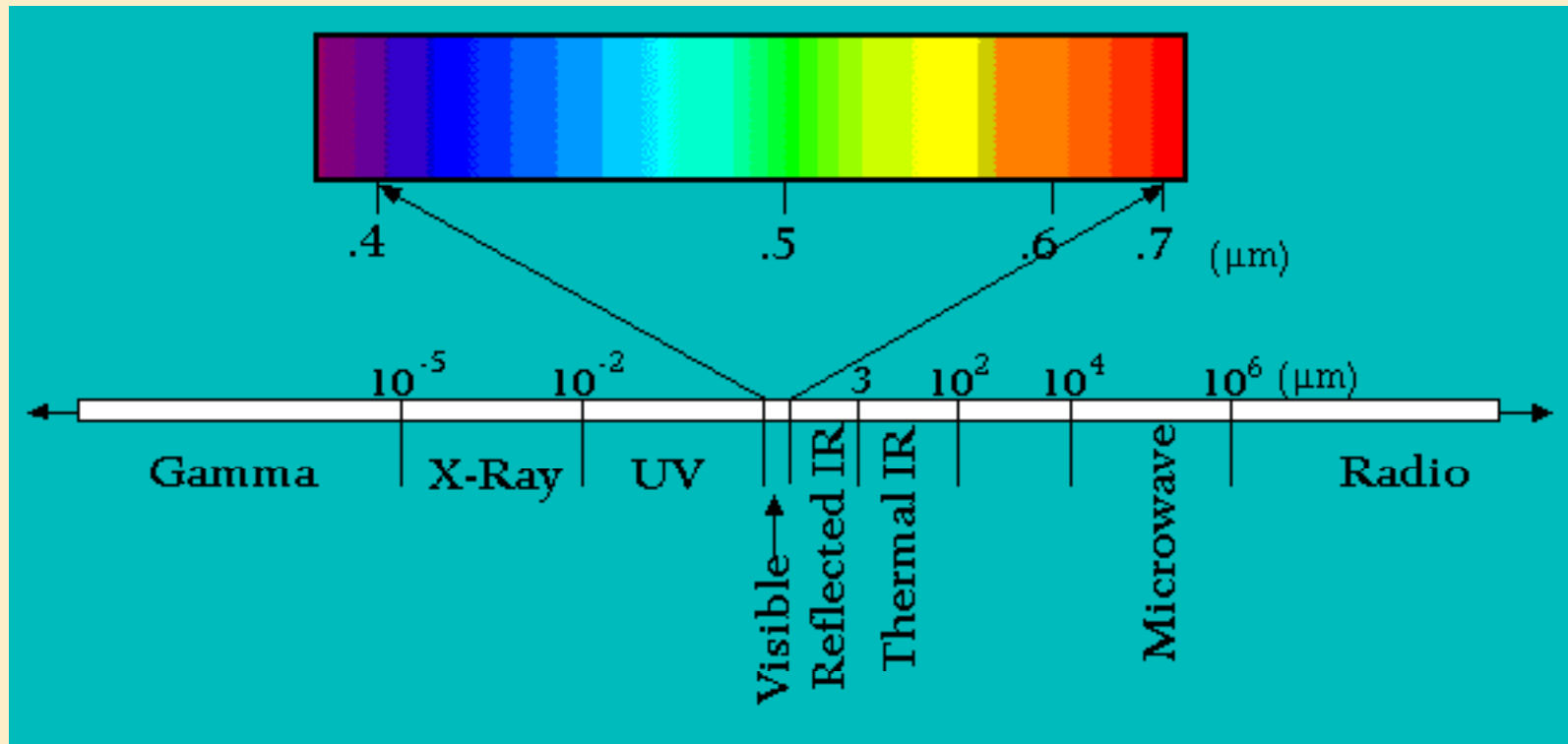
where:

λ = wavelength (m)

ν = frequency (cycles per second, Hz)

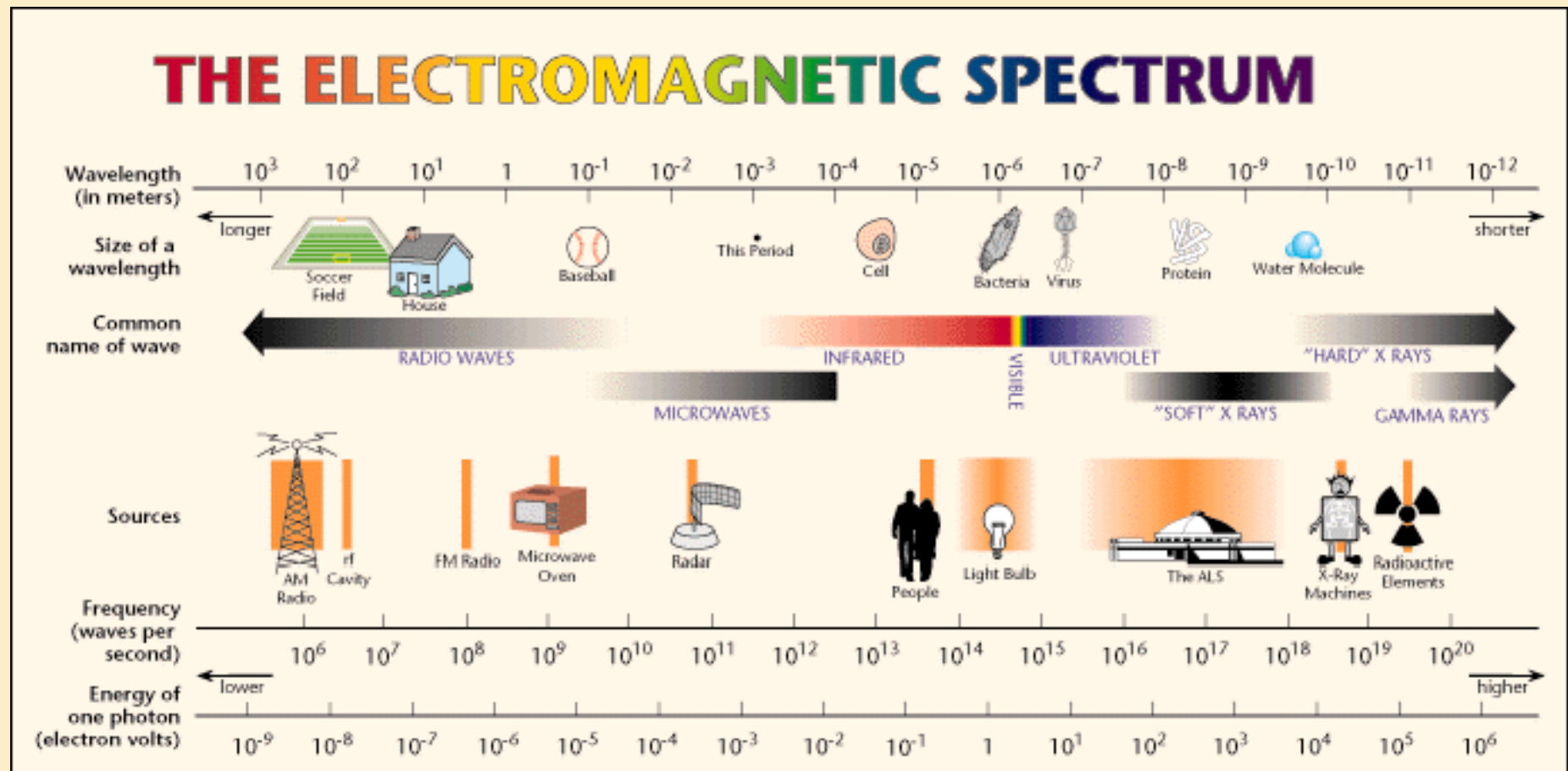
c = speed of light (3×10^8 m/s)

WHAT CAN SATELLITES SEE?



Satellite electromagnetic sensors let us “see” beyond the visible..

ELECTROMAGNETIC SPECTRUM



ELECTROMAGNETIC INTERACTIONS

- ✗ EMR that interacts with an object is called *incident radiation*

Electromagnetic energy is either,
reflected, transmitted, or absorbed
by the surface it strikes.

The Major Components Of Remote-sensing Technology

1. **ENERGY SOURCE** (*PASSIVE SYSTEM: sun, irradiance from earth's materials; ACTIVE SYSTEM: irradiance from artificially-generated energy sources such as radar*)
2. **PLATFORMS** (*Vehicle to carry the sensor*) (*truck, aircraft, space shuttle, satellite, etc.*)
3. **SENSORS** (*Device to detect electro-magnetic radiation*) (*camera, scanner, etc*)
4. **DETECTORS** (*To convert electro-magnetic radiation into recorded signals*) (*film, silicon detectors, etc*)
5. **PROCESSING** (*Handling signal data*) (*photographic, digital, etc*)
6. **INSTITUTIONALISATION** (*Organization for execution at all stages of remote-sensing technology: international and national organizations, centers, universities, etc*)

Platforms

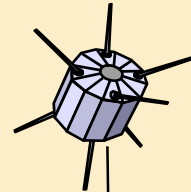
The vehicles or carriers for remote sensors are called the platforms. Typical examples of platforms are satellites and aircraft, but they can also include radio-controlled aeroplanes, balloons, kits for low altitude remote sensing, as well as ladder trucks or 'cherry pickers' for ground investigations. The key factor for the selection of a platform is the altitude that determines the ground resolution and which is also dependent on the instantaneous field of view (IFOV) of the sensor on board the platform.

Remote-Sensing Platforms

Orbit Elevation

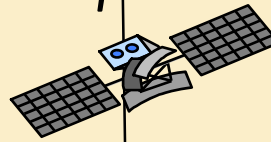
Platforms

36,000 km



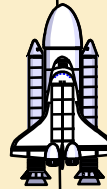
*GMS
(Geostationary Satellite)*

1,000km



*LANDSAT, MOS,
SPOT*

500km



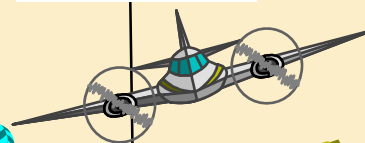
SPACE SHUTTLE

240 - 350 km



*HIGH ALTITUDE
JETPLANE*

10,000 - 12,000m



*LOW & MIDDLE
ALTITUDE
AIRPLANE*

1,200 - 3,500m



GROUND TRUTH



Platform Types And Observation Objects

Platform	Altitude	Observation
geostationary satellite	36,000km	fixed point observation
circular orbit satellite (earth observation)	500km - 1,000km	regular observation
space shuttle	240km - 350km	irregular observation space experiment
radio - sound	100m - 100km	various investigations (meteorological, etc)
high altitude jet-plane	10km -12km	reconnaissance wide area investigations
low or middle altitude plane	500m - 8,000m	various aero investigation surveys
helicopter	100m- 2,000m	various aero investigation surveys
radio-controlled plane	below 500m	various aero investigation surveys
hang-plane	50 - 500m	various aero investigation surveys
hang-balloon	800m -	various investigations
cable	10 - 40m	archaeological investigations
crane car	5 - 50m	close range surveys
ground measurement car	0 - 30m	ground truth

Sensors

As sensor or 'remote sensor' is a device to detect the electro-magnetic radiation reflected or emitted from an object. Cameras or scanners are examples of remote sensing-sensors.

Classification of Sensors

Passive

Non-scanning

Non-imaging

Microwave Radiometer

Magnetic Sensor

Gravimeter

Fourier Spectrometer

Other

Imaging

Camera

Monochrome

Natural color

Infrared

Other

Scanning

Imaging

Image Plane Scanning

TV Camera

Solid Scanner

Object Plane Scanning

Optical Mechanical Scanner

Microwave Radiometer

Continued Classification of Sensors

Active

Non-scanning

Non-imaging

Microwave Radiometer

Laser Water Depth meter

Laser Distance meter

Scanning

Imaging

Object Plane Scanning

Real Aperture Radar

Synthetic Aperture Radar

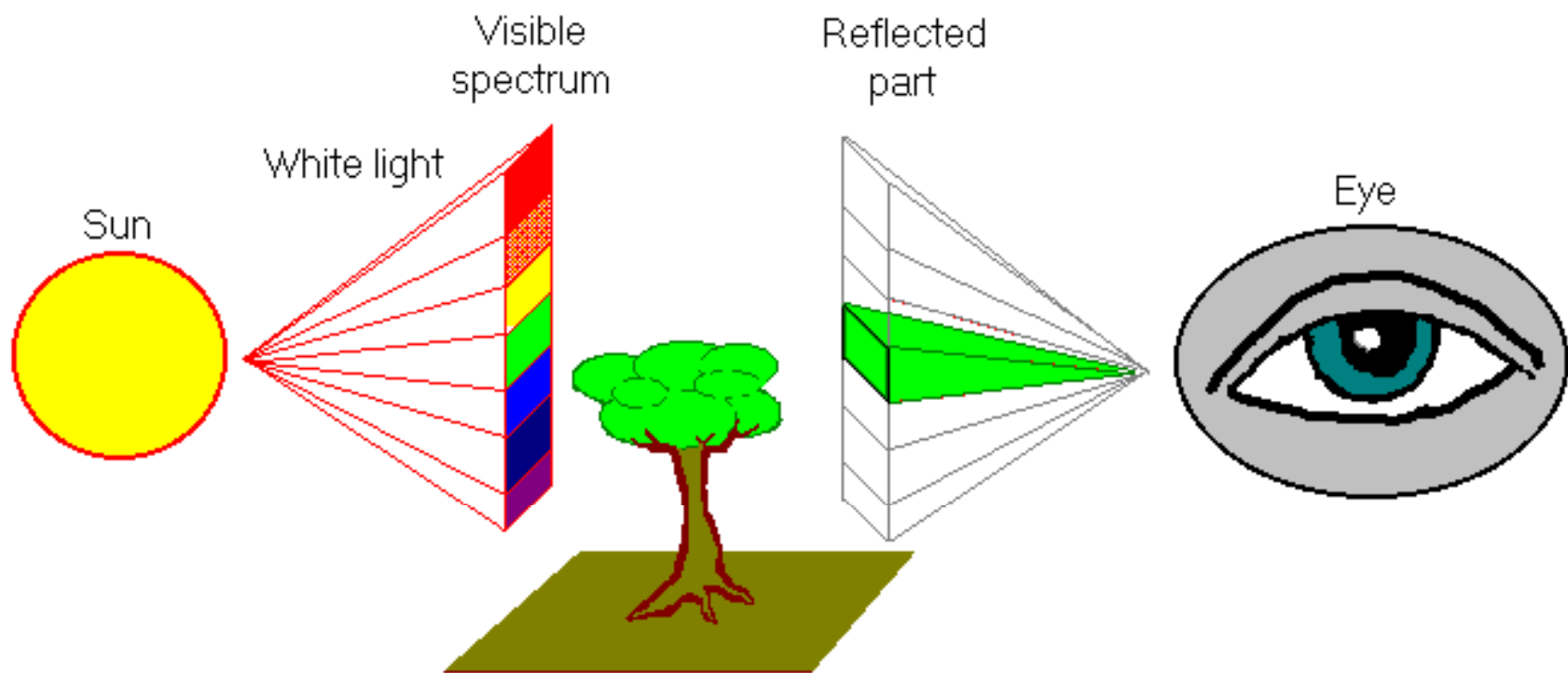
Image Plane Scanning

Passive Phased Array Radar

Table 5: Wavelength Band of Principle Sensor

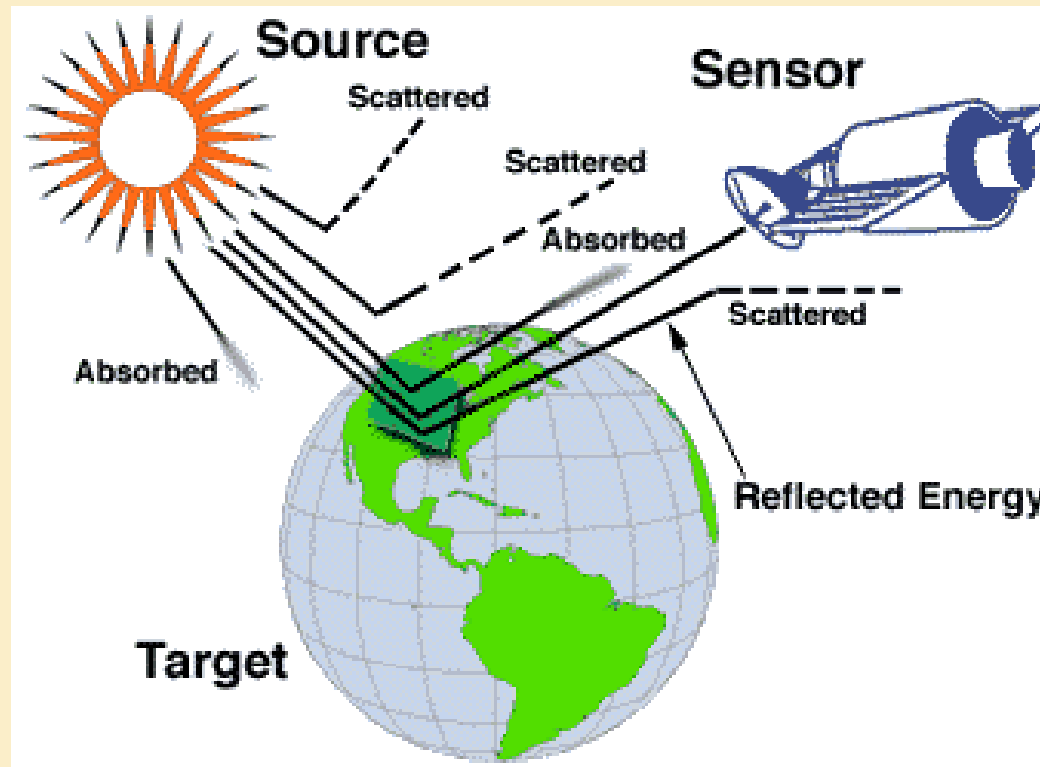
Wavelength (m)	U V	VISIBLE		INFRA-RED									RADIO
				Near S. W. Inter. Thrm. Far									
SENSOR	0.4	0.5	0.6	0.7	0.9	1.5	5.5	8.0	14	1000	1000	100000	
(CAMERAS:)													
monochrome film													
Color film													
IR film													
Color IR film													
SOLID SCANNER (SPORT HRV)													
(Thermal Video)													
TV CAMERA													
OPTICAL MECHANICAL SCANNER													
(Airborne MSS)													
(Landsat MSS)													
(Landsat TM)													
RADAR													
MICROWAVE RADIOMETER													

Reflection of colours



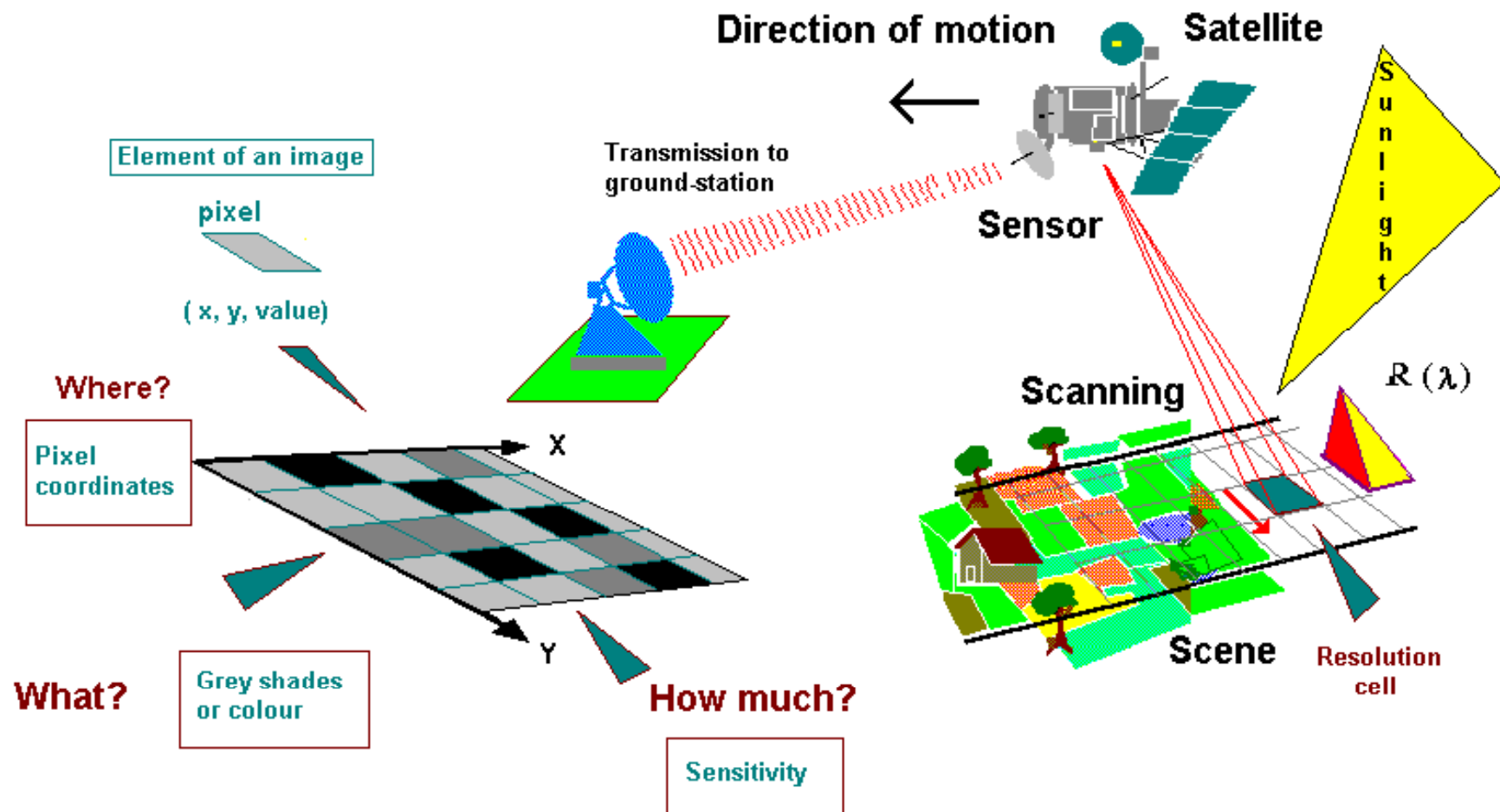
E.L.

HOW DO IMAGING SATELLITES WORK?

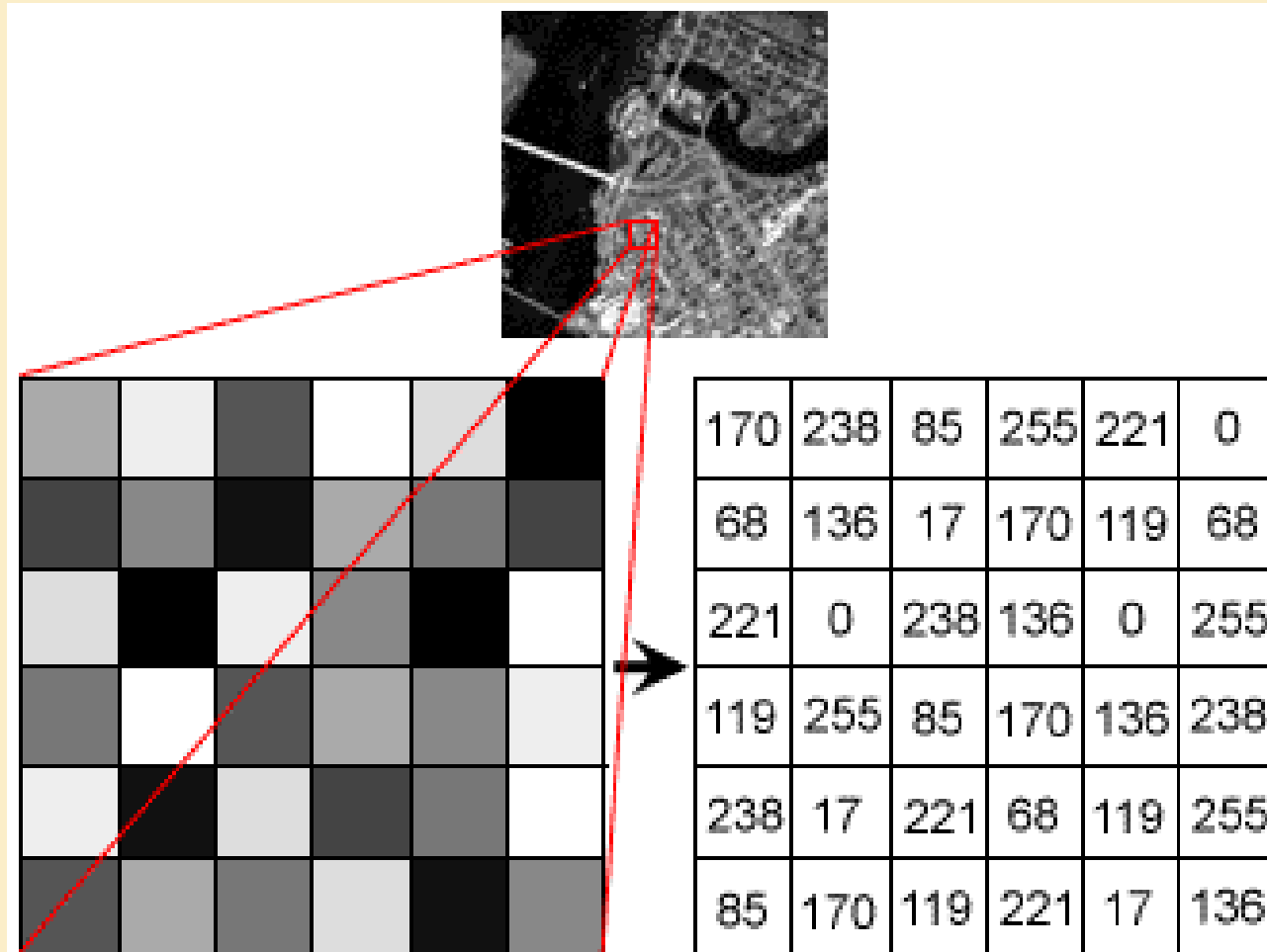


Satellite electromagnetic sensors “see” reflected and emitted radiation

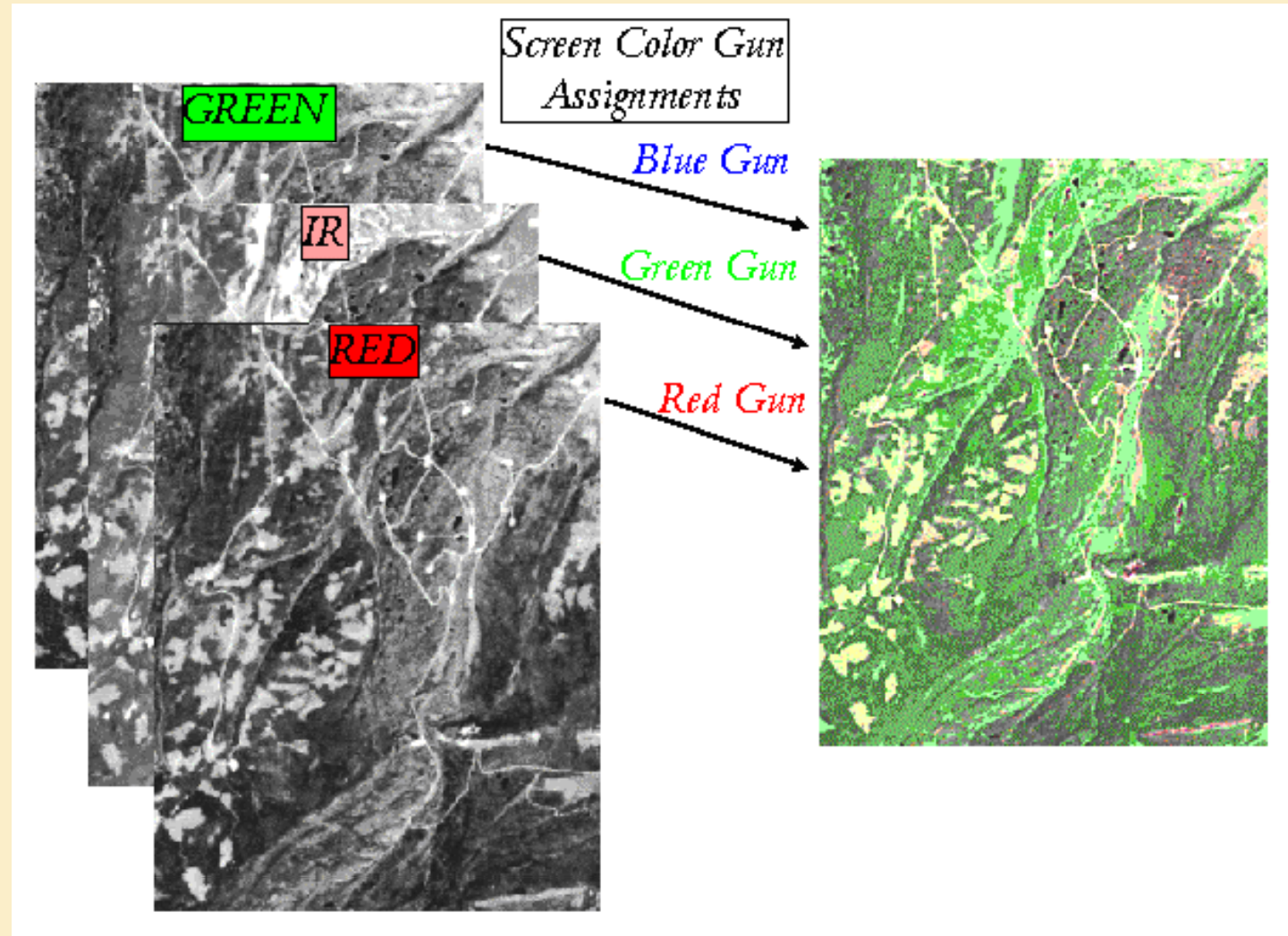
Acquisition and reproduction of remotely sensed images



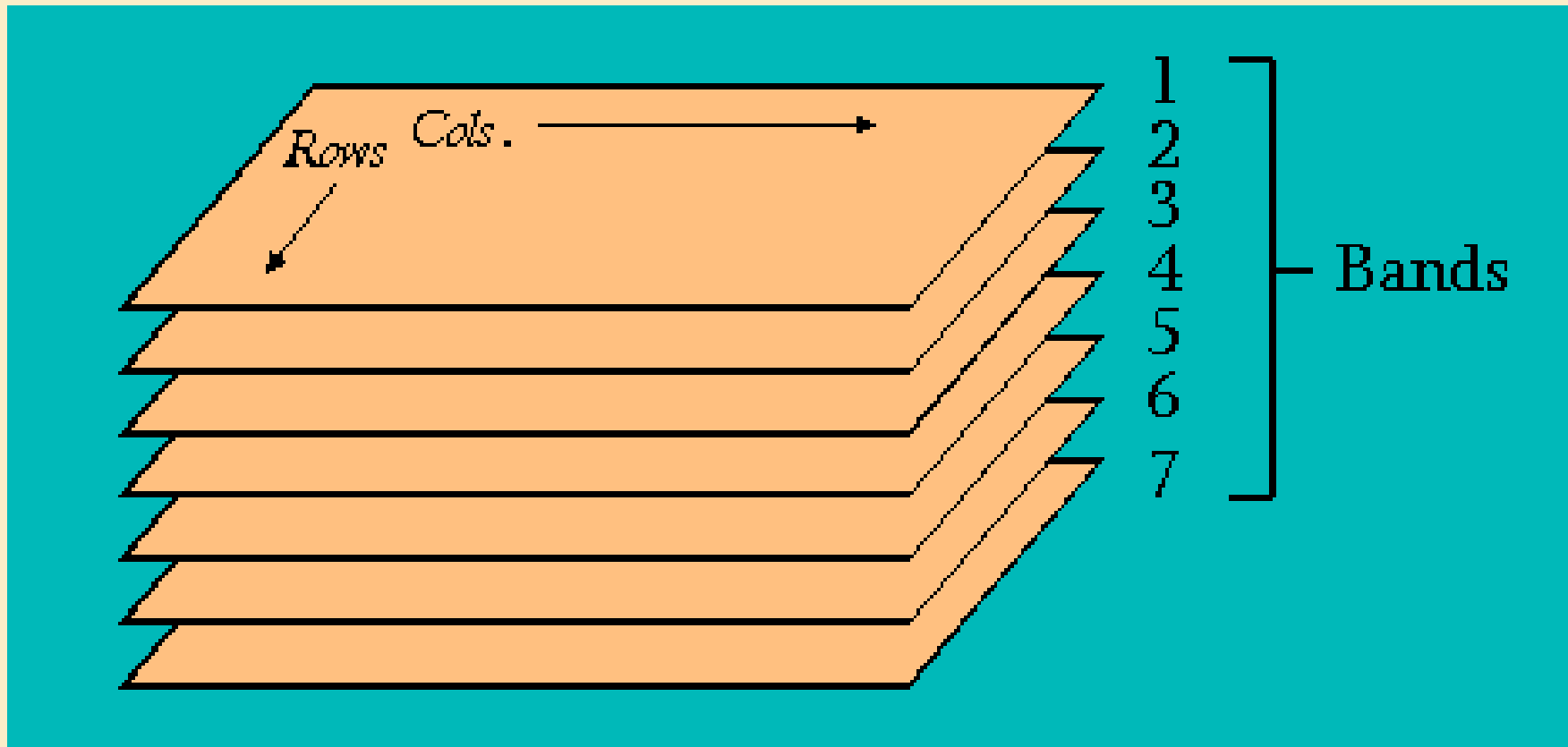
REMOTE SENSING IMAGES



COLOR COMPOSITE IMAGES



MULTISPECTRAL REMOTE SENSING IMAGES



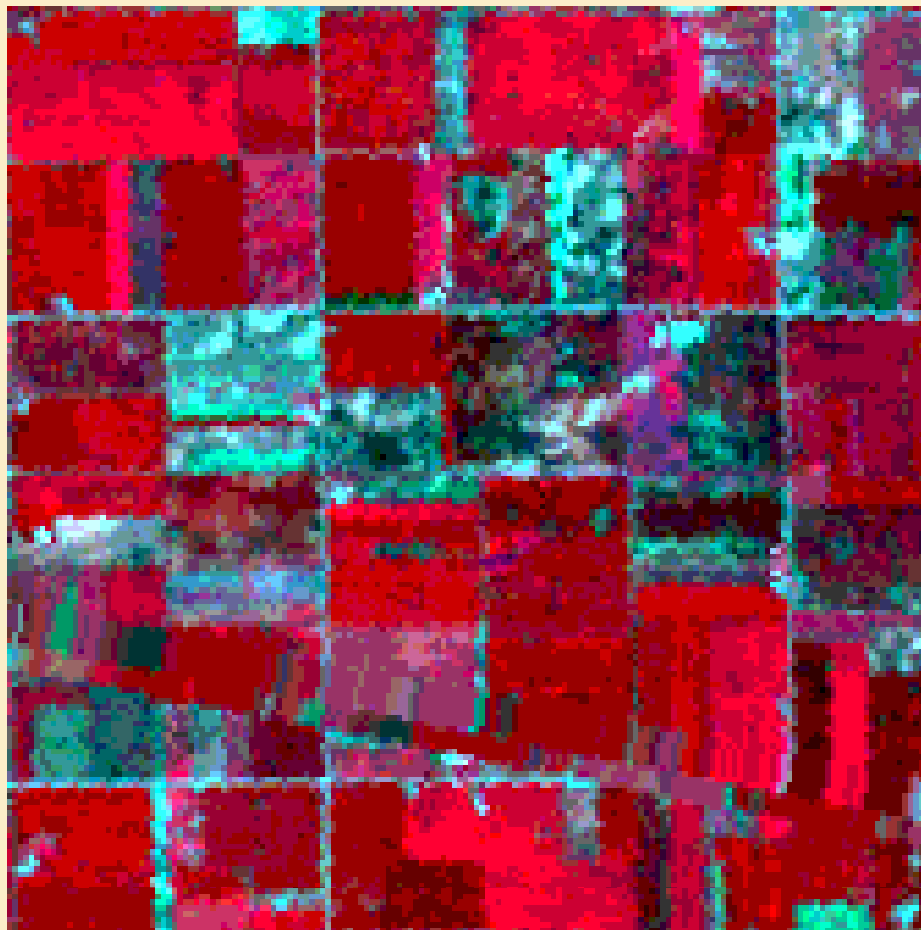
REMOTE SENSING APPLICATIONS

- Archaeology
- Agriculture
- Cartography
- Civil Engineering
- Climatology
- Coastal Studies
- Emergency Response
 - Forestry
 - Geology
 - Hazards
 - Land-Use
- Meteorology
- Natural Disasters
- Oceanography
- Water Resources

AGRICULTURAL APPLICATIONS

- crop type classification
- crop condition assessment
- crop yield estimation
- mapping of soil characteristics
- mapping of soil management practices
- compliance monitoring (farming practices)
- precision farming

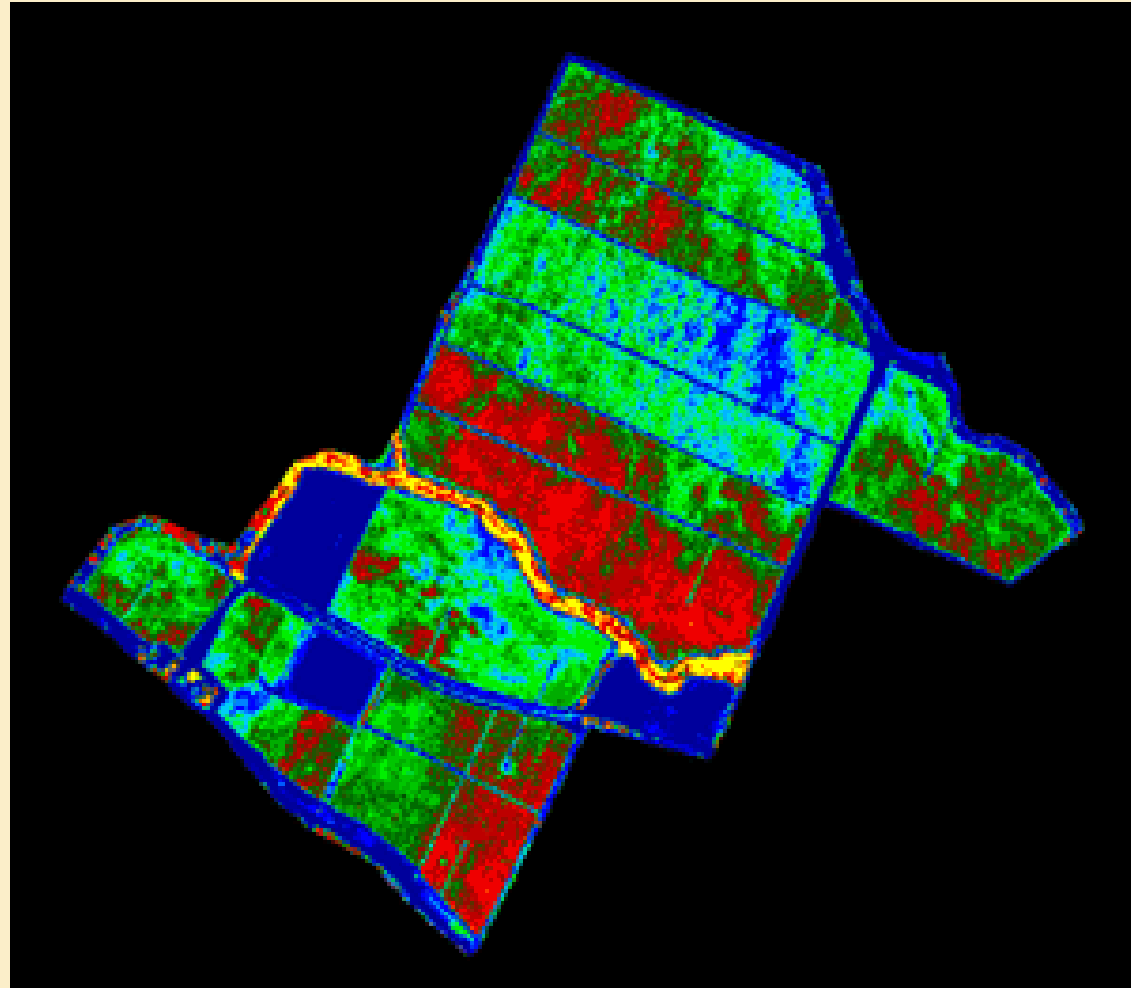
AGRICULTURAL EXAMPLE



CROPS MONITORING (TORNADO DAMAGE)



PRECISION AGRICULTURE



FORESTRY APPLICATIONS

- forest cover type discrimination
- clear cut mapping / regeneration assessment
- burn delineation
- infrastructure mapping / operations support
- forest inventory
- biomass estimation
- species inventory
- forest health and vigour

FOREST BURNS



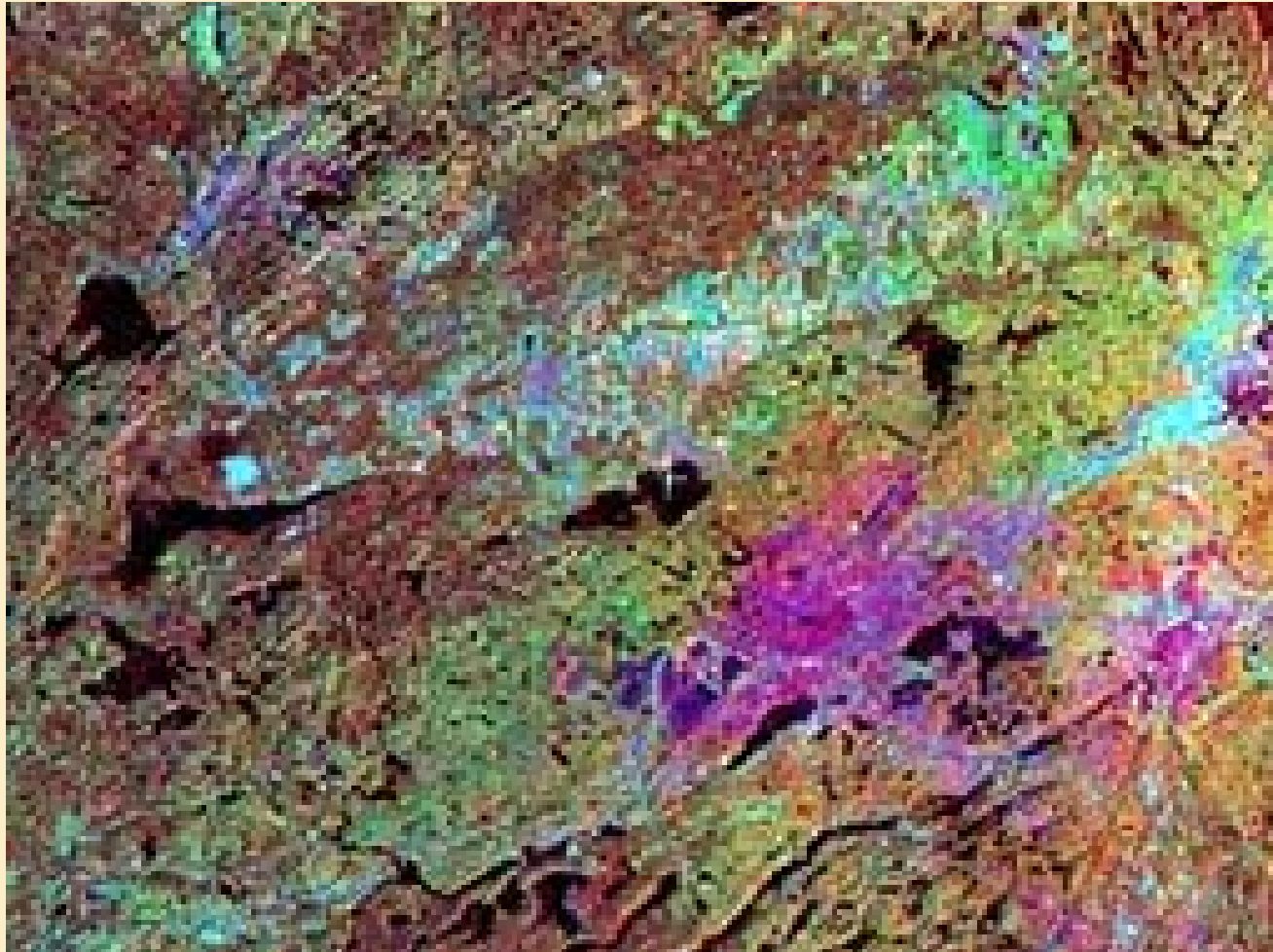
GEOLOGICAL APPLICATIONS

- surficial deposit / bedrock mapping
- lithological mapping
- structural mapping
- sand and gravel (aggregate) exploration/ exploitation
- mineral exploration
- hydrocarbon exploration
- environmental geology
- sedimentation mapping and monitoring
- geo-hazard mapping

STRUCTURAL MAPPING



GEOLOGICAL UNIT MAPPING



Dana Hilltop

*Large Lake
Karli Nulla*

*Small Lake
Tung Nulla*

IKONOS,



HYDROLOGICAL APPLICATIONS

- wetlands mapping and monitoring,
- soil moisture estimation,
- snow pack monitoring,
- measuring snow thickness,
- river and lake ice monitoring,
- flood mapping and monitoring,
- glacier dynamics monitoring
- drainage basin mapping and watershed modelling
- irrigation mapping



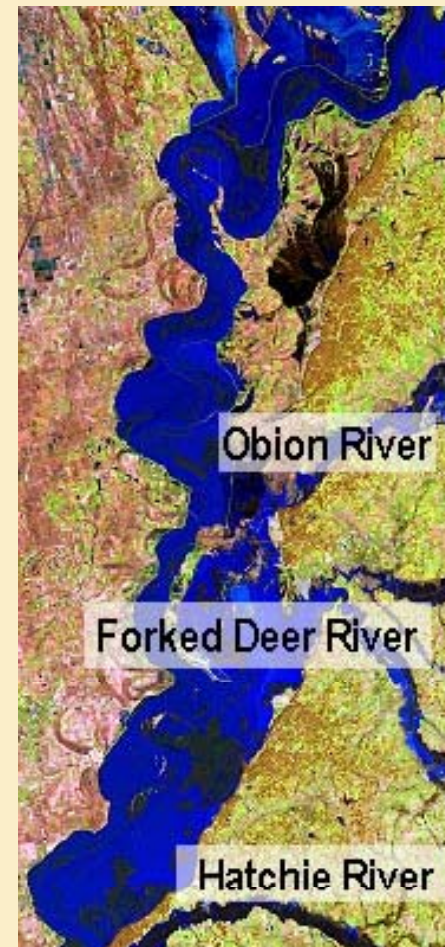
June 15, 2005



June 27, 2005

FLOODS AND DISASTER RESPONSE

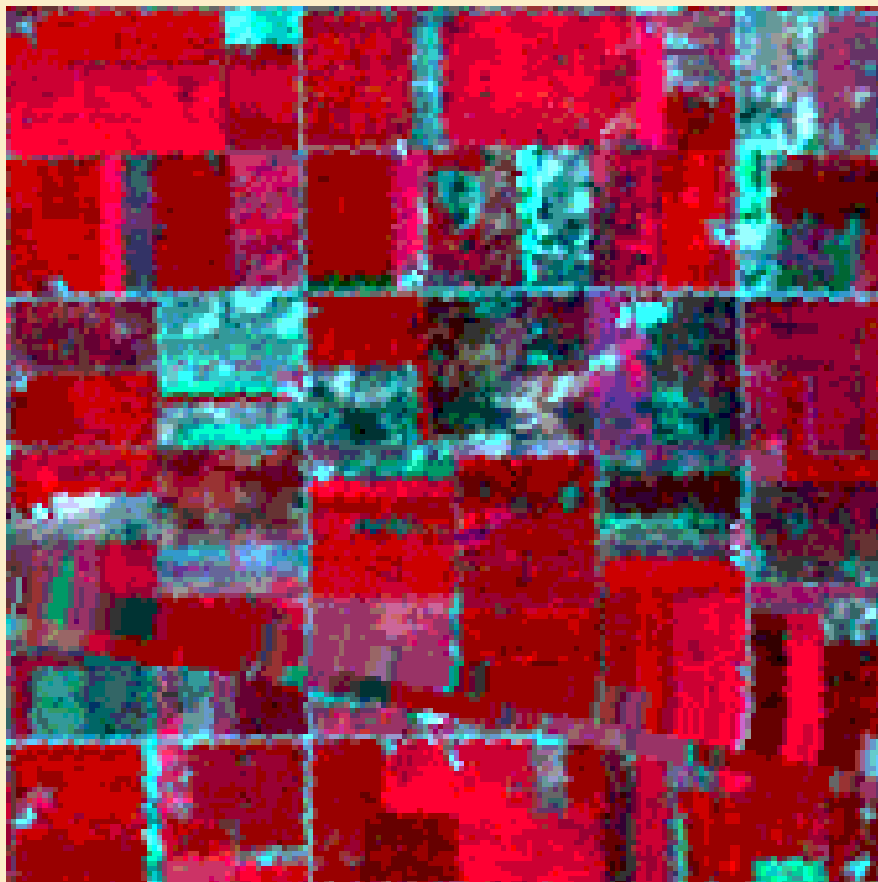
EXAMPLE



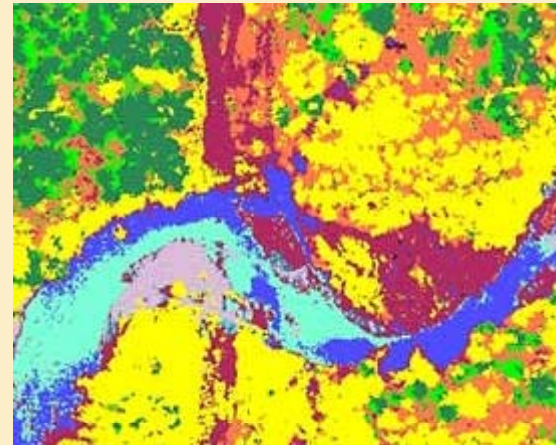
LAND-USE LAND-COVER APPLICATIONS

- natural resource management
- wildlife habitat protection
- urban expansion / encroachment
- damage delineation (tornadoes, flooding, volcanic, seismic, fire)
- legal boundaries for tax and property evaluation
- target detection - identification of landing strips, roads, clearings, bridges, land/water interface

LAND COVER CLASSIFICATION



SPECIES MAPPING



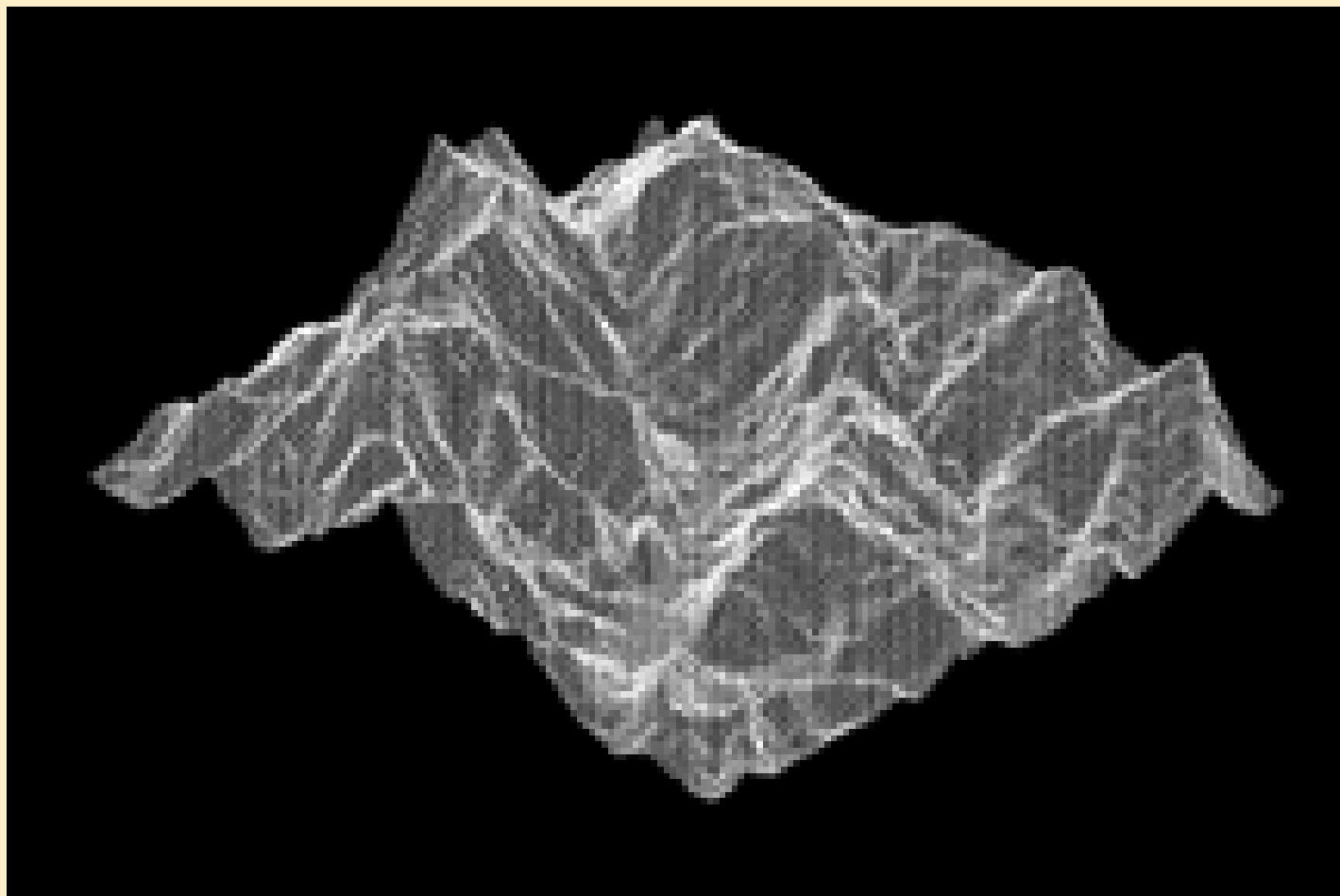
MAPPING APPLICATIONS

- planimetry
- Digital elevation models (DEM's)
- baseline thematic mapping
- Topographic mapping

PLANIMETRIC MAPPING



DIGITAL ELEVATION MODELS



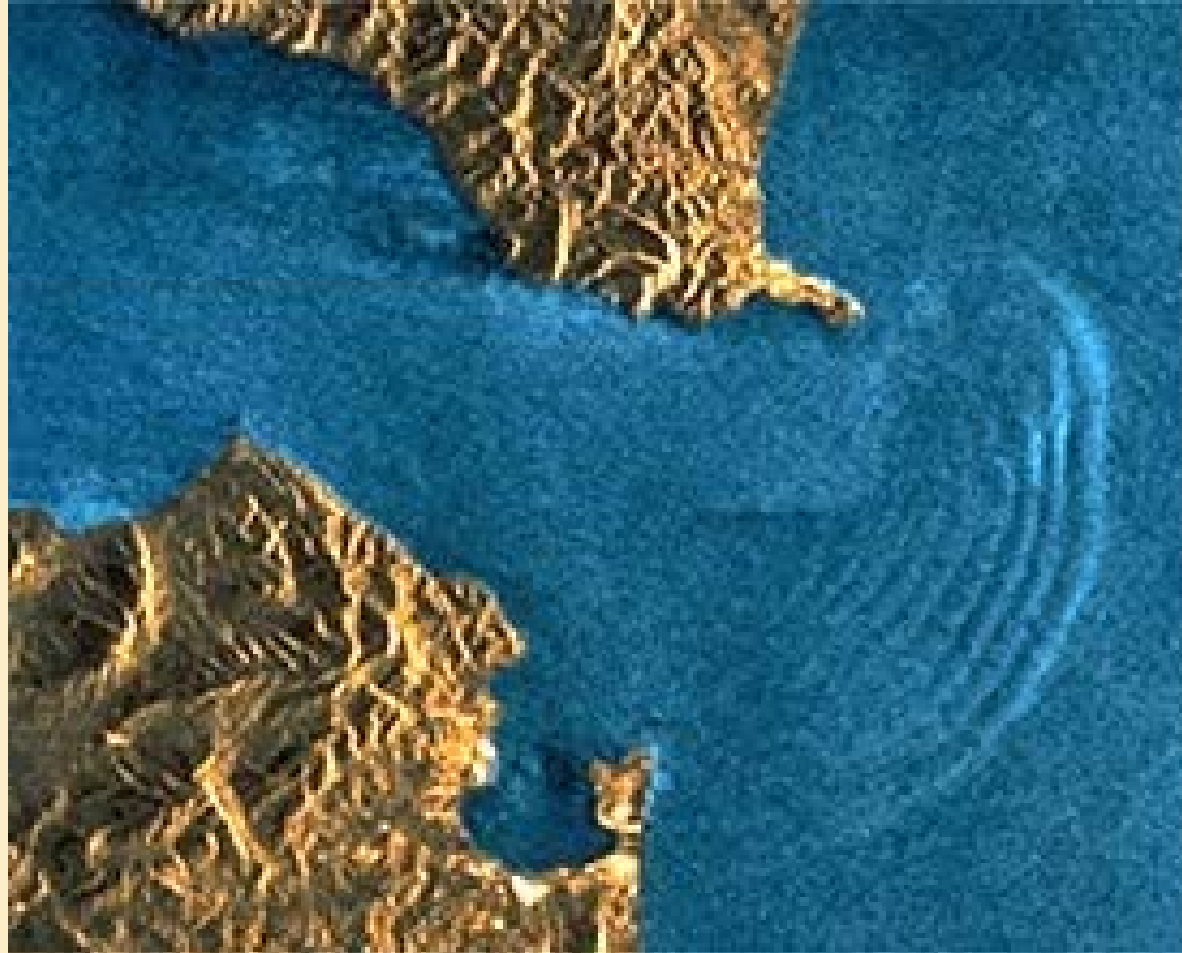
TOPOGRAPHIC MAPPING



OCEAN APPLICATIONS

- Ocean pattern identification:
- Storm forecasting
- Fish stock and marine mammal assessment
- Water temperature monitoring
- Water quality
- Ocean productivity, phytoplankton concentration and drift
- Mapping and predicting oilspill extent and drift
- Strategic support for oil spill emergency response decisions
- Shipping navigation routing
- Mapping shoreline features / beach dynamics
- Coastal vegetation mapping

INTERNAL WAVES



OIL SPILLS

