Introduction to Remote Sensing and GIS

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III SEM: Laws of Remote Sensing and Geospatial Data

WHAT IS REMOTE SENSING ?

Science of making inferences about objects/targets from measurements made without actual physical contact with them. More commonly remote sensing is associated with identification of earth features by detecting and recording electro-magnetic (EM) radiation reflected or emitted from earth's surface and atmosphere

ACTIVE REMOTE SENSING

PASSIVE REMOTE SENSING

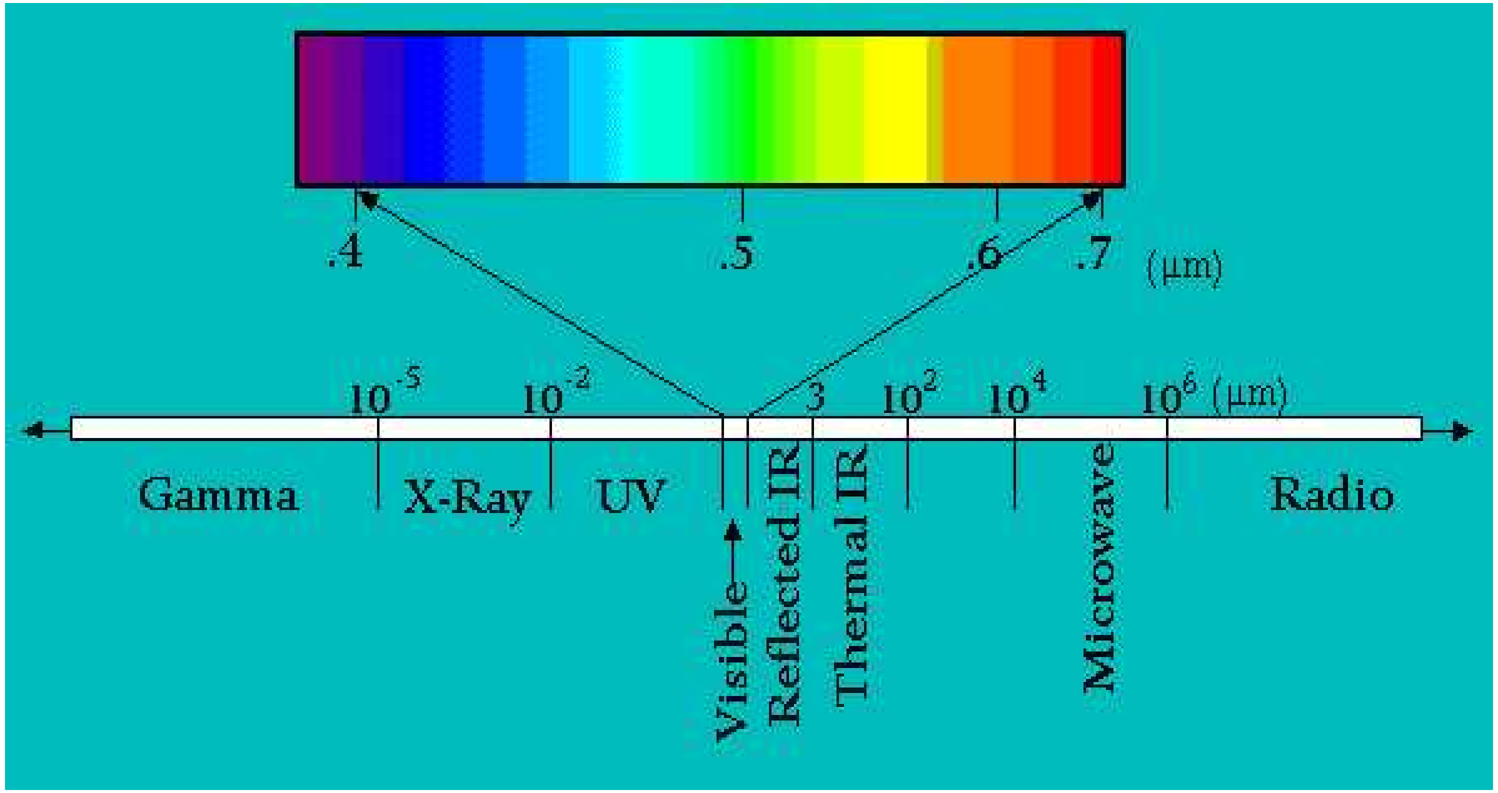
Process in Remote Sensing from Space (Passive)

A. Sun is the Energy Source
B. Radiation from Sun transmitted through earth's atmosphere
C. Solar Radiation interacts with Target on earth (Reflection/scattering/ emission (in a different wavelength)
D. Recording of Energy by Sensor mounted on platform like satellite
E. Transmission of data to reception terminal on earth &processing
F. Interpretation of data along with ground truth and analysis
G. Applications

REMOTE SENSING ADVANTAGES

- SYNOPTIC COVERAGE
- REPEATED OBSERVATION
- MULTI SPECTRAL IMAGING
- INFORMATION IN SPATIAL DOMAIN
- STEREO COVERAGE
- TIMELY AND ECONOMIC
- GLOBAL TO LOCAL APPLICATIONS

ELECTRO MAGNETIC SPECTRUM



OPTICAL REMOTE SENSING	**: 0.4 – 3.0 µ meters**
MICROWAVE REMOTE SENSING	**: L, C, X, Ku, Ka bands**
THERMAL REMOTE SENSING	**: 8 – 15 µ meters**

Microwaves

P Band 0.3 to 1 GHz (100 cm)
L Band 1-2 GHz
S band 2-4 GHz
C band 4-8 GHz
X band 8-12.5 GHz
Ku band 12.5 – 18 GHz
K band 18 – 26.5 GHz
Ka band 26.5 – 40 GHz (1.1 cm)

Optical Sensors

Optical Sensors operate in the visible part of the electromagnetic spectrum, measuring electromagnetic radiation emitted by the sun and reflected by land and ocean surface.

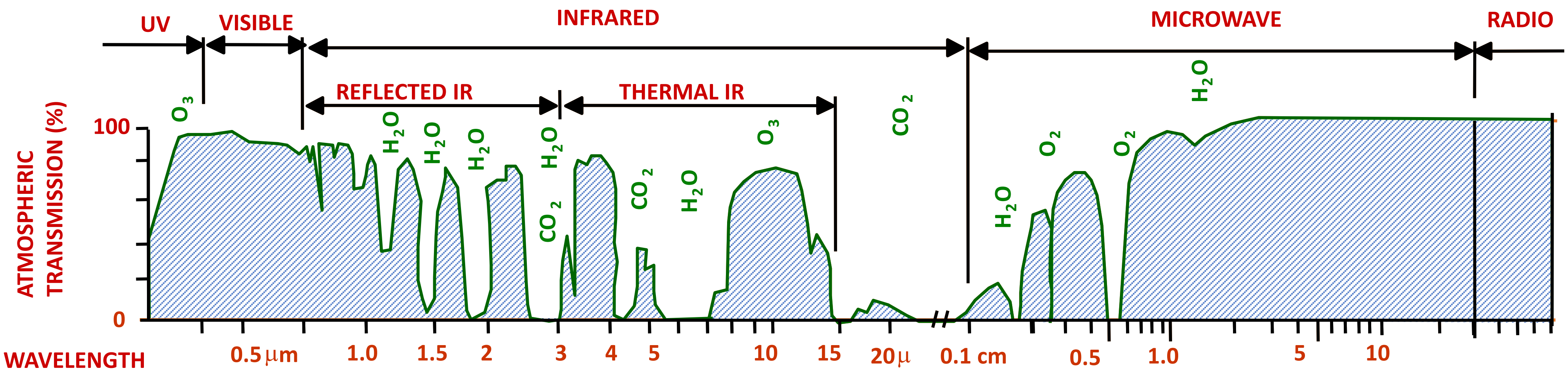
ATMOSPHERIC WINDOWS FOR EARTH OBSERVATIONS

Atmosphere practically transparent in visible EM region, whereas opaque in other regions. Remote sensing utilizes the transparent regions known as windows to avoid the effects of absorption of radiation.

0.38 - 0.78 Microns (visible)

0.72 - 3.00 Microns (middle IR, near IR)

8.00 - 14.00 Microns (thermal IR)



EFFECT OF ATMOSPHERE

The following compounds of the atmosphere change its transmittance:

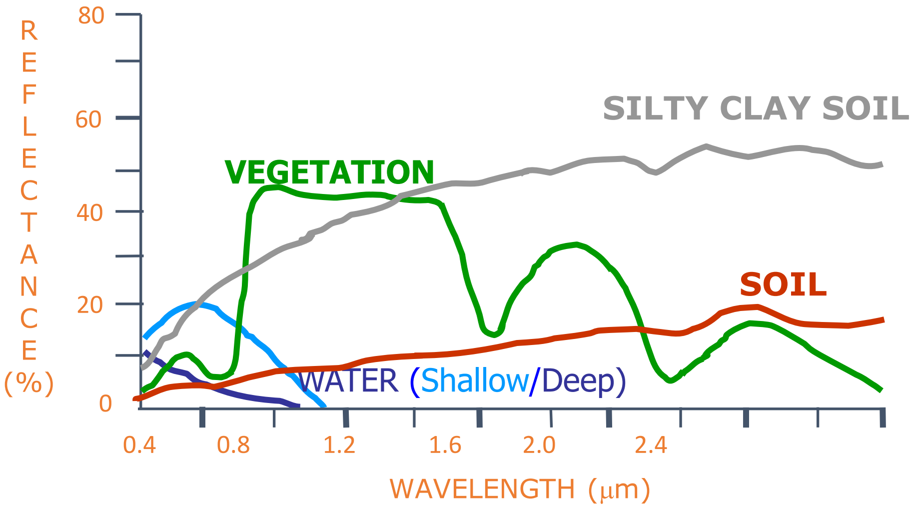
- **Gas molecules themselves**
- **Water vapor**
- **Aerosols**
- **Suspended particles of dust**
- **Water droplets in the form of clouds**

Rayleigh Scattering: when much small particles comparable to wavelength size interact with the light (radiation) in upper regions of atmosphere. Shorter wavelengths scatter more. Ex: Blue sky

Mie Scattering: when particles are of comparable size to wavelength (dust, pollen, smoke), higher wavelength scatter more. Ex: morning sky's grazing light, reddish sky.

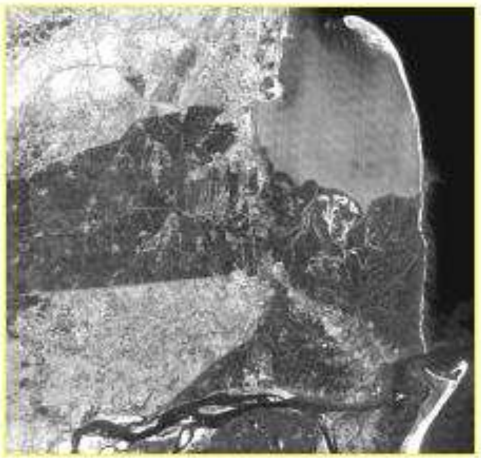
Absorption in atmosphere: Carbon dioxide, water vapor, Ozone absorb at specific wavelength ranges. Carbon dioxide absorbs Longwave emissions from earth and warms up (green house effect). Ozone absorbs UV radiation from Sun and protects earth life.

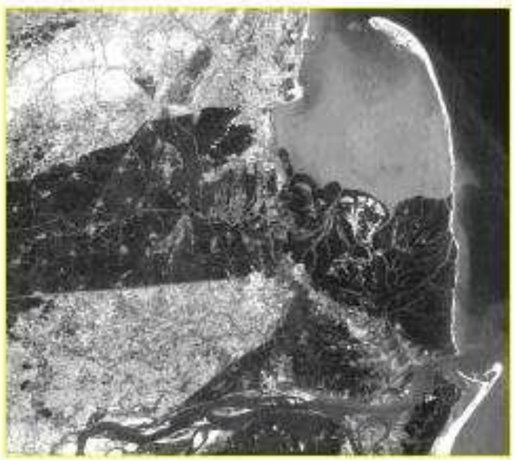
MULTI SPECTRAL REMOTE SENSING

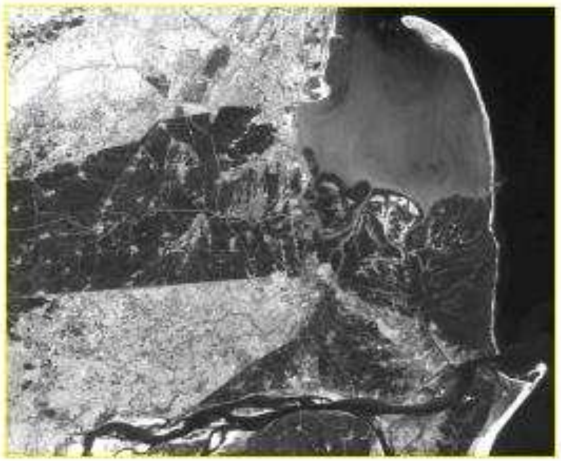


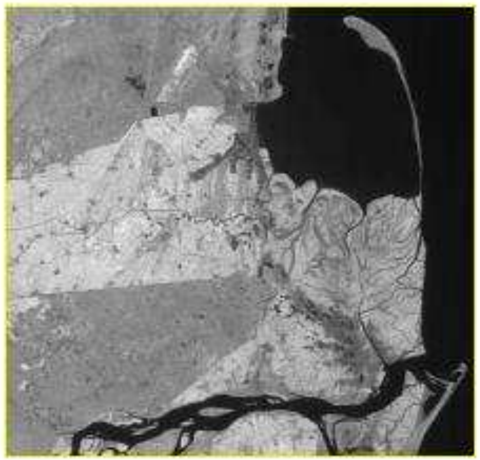
Incident EM energy interacts with the 'Target' and the resultant scattered wave contains the 'Finger print' of the target, in terms of its unique 'signature'. Reflected or emitted electromagnetic energy from earth surface is observed in different wavelengths (bands) of the spectrum to understand the target signature.

GREEN BAND (0.5-0.6 μm)	RED BAND (0.6-0.7 μm)	NEAR IR (0.7-0.9 μm)	SHORTWAVE IR (1.5-2.5 μm)









Selection of Spectral Bands

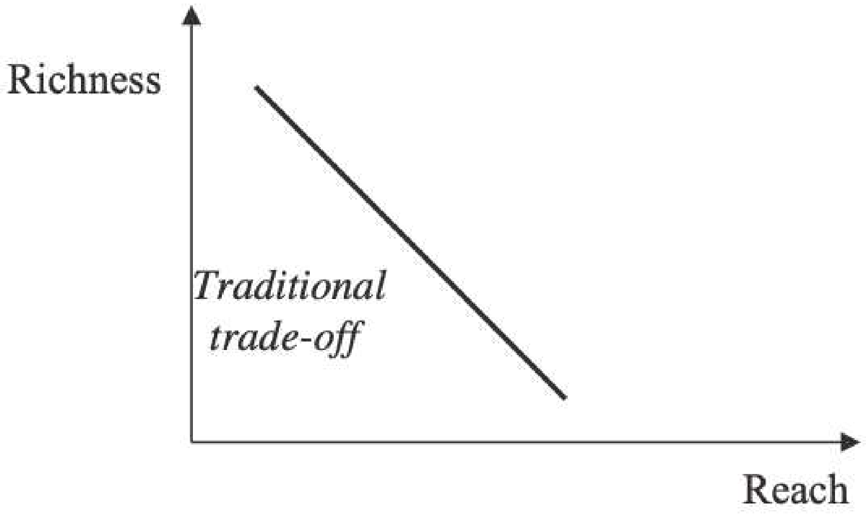
Spectral range (µm)	Major Application
0.45 – 0.52 (B1)	Sensitivity to Chlorophyll ; coastal water mapping soil/vegetation discrimination, forest mapping
0.52 – 0.59 (B2)	Green reflectance from healthy vegetation
0.62 – 0.69 (B3)	Sensitivity to chlorophyll ; water type discrimination ; plant species identification
0.76 – 0.90 (B4)	Water body delineation ; vegetation vigour and biomass determination
1.55 – 1.75 (B5)	Water stress in vegetation, snow / cloud differentiation ; drought monitoring
2.08 – 2.35	Discrimination of minerals and Rock types, identification of hydrothermal alterations in rocks
10.4 – 12.5	Surface temperature mapping incl. SST

Useful Microwave channels

Frequency (GHz)	Application
1.4	Sea salinity, soil moisture
2.7	- do –
6.7 – 7.1	Ocean surface Temp.
10.6	Rain, snow, Ice
18.7	Water vapour
21	Liquid water content
36.5	Rain, snow, water vapour
50.3	O_2 Temperature profiling
86 – 92	Clouds, oil spills, ice, snow
183	H_2O, moisture profiles, N_2O
200 – 209	H_2O,O_3,N_2O

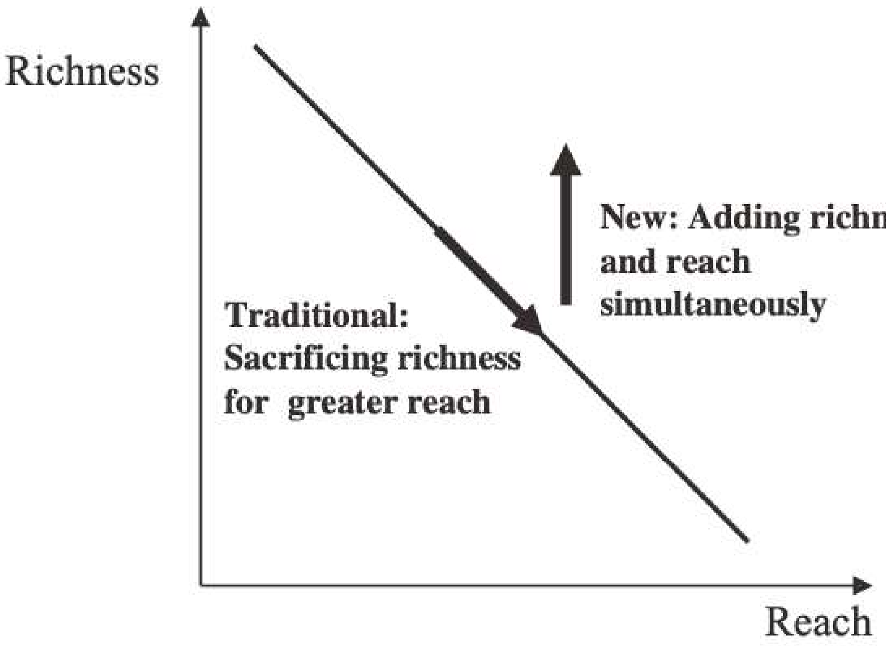
Reach/ Richness trade-off of Remote sensing data

The Trade-off between Richness and Reach

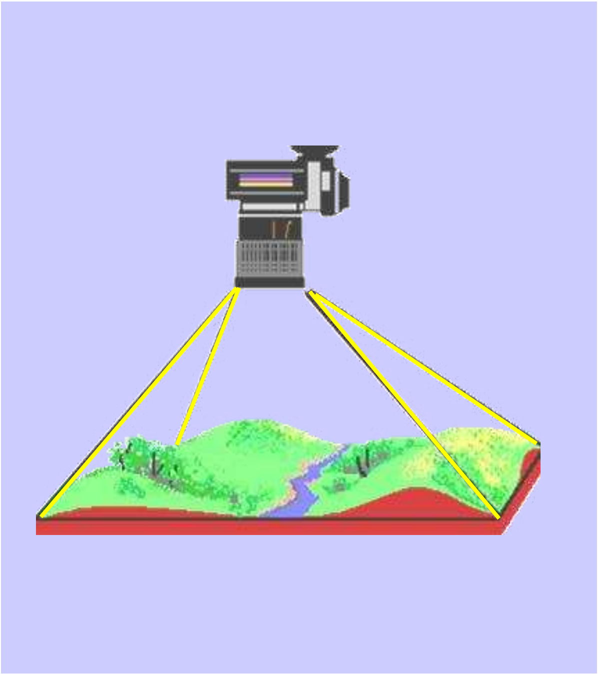


Source: P. B. Evans and T. S. Wurster, "Strategy and the New Economics of Information," Harward Business Review, Sept.-Oct. 1997, p. 74.

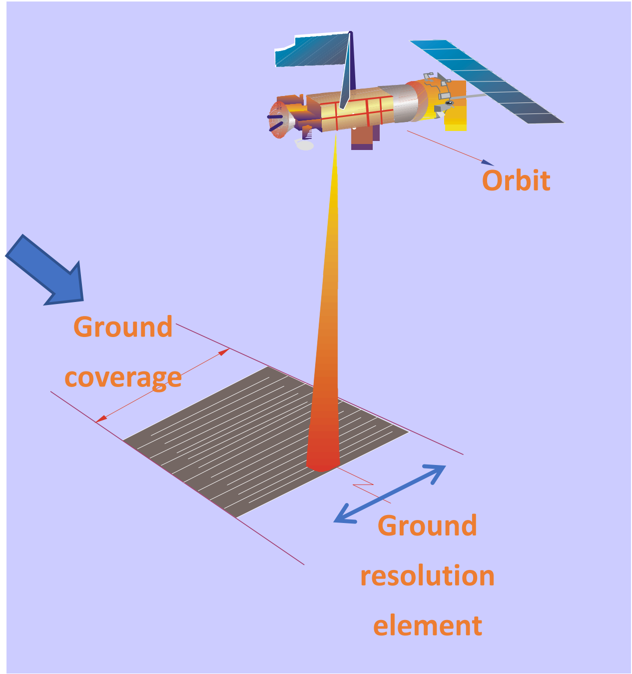
Remote sensing can produce change the traditional relationship between the Reach and Richness



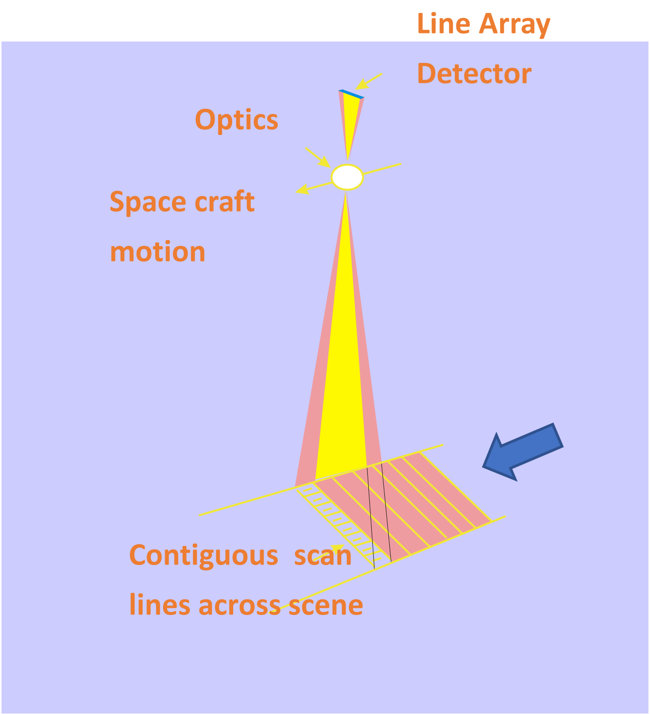
IMAGING SENSORS – TYPES OF SCANNING



AREA ARRAY



WHISK BROOM



PUSH BROOM

Push-broom Scanners using Charge Coupled Devices offer advantages like longer dwelling time (more signal), no moving parts (high reliability) and high geometric fidelity

Trade-offs among optics, altitude and detector size

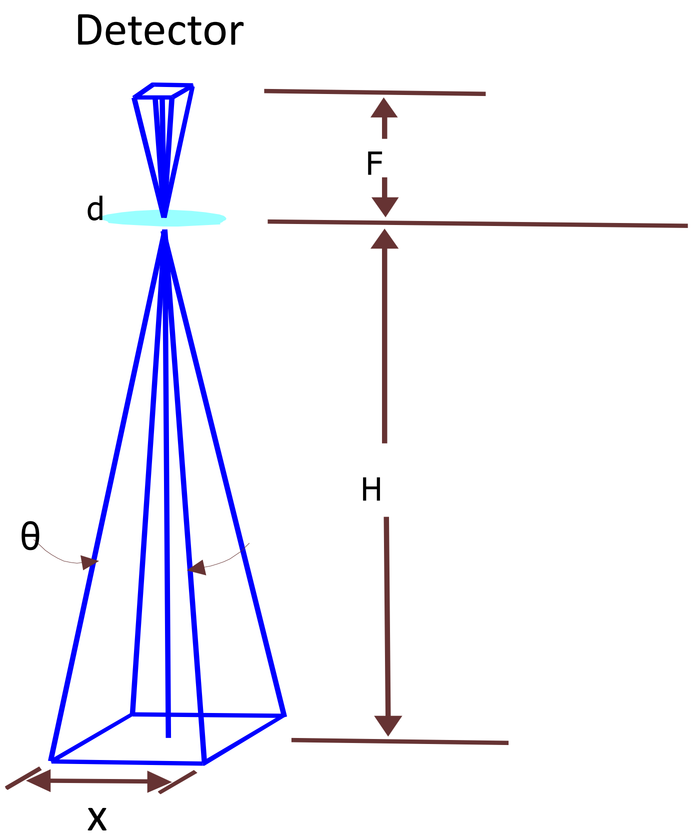
- IGFOV is governed by the relation, $d / F = x / H$

(IGFOV= Instantaneous ground field of view, H= altitude, x= IGFOV or pixel size, d= aperture of the optics, F= focal length)

- IGFOV (x) = $2 \times \text{Tan}\theta/2 \times H$

- f/no = F / Aperture diameter

  Smaller the f/no , Higher will be the Signal to Noise Ratio



Irradiance at image plane is inversely proportional to square of f/no.

Larger focal number—slow optics (light gathering capacity is low)

Passive microwave radiometers

Passive microwave radiometers operate at electromagnetic wavelengths 1.5–300 mm (i. e., the frequency 1–200 GHz).

Their advantage is the
• comparatively long wavelength, which is not sensitive to scattering by the atmosphere or aerosols, haze, dust, or small water particles in clouds

• the microwave sensors are all-weather devices.

• This advantage is countered by the fact that thermal emission is very weak at these longer wavelengths.

• To overcome noise levels a large field of view must be received; that results in low spatial resolution (25–150 km).

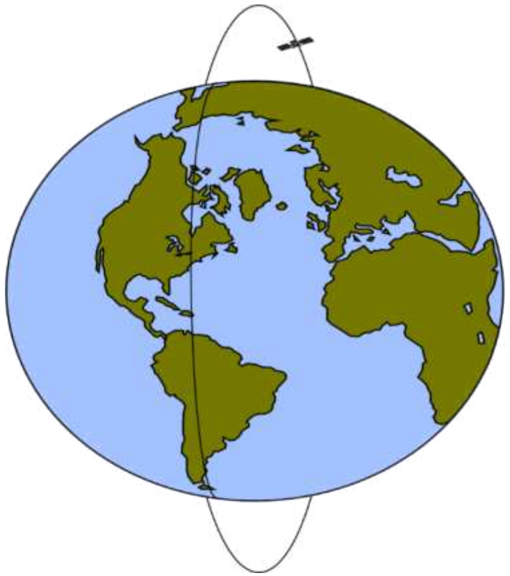
The emissivity of the sea at microwave frequencies varies with the dielectric properties of sea water (including salinity) and the surface roughness.

DATA RECEPTION AND PRE-PROCESSING

- Geometric Corrections
  - Earth rotation
  - Earth curvature
  - Platform attitude
  - Sensor alignments
- Radiometric Corrections
  - Sensor detector response variation
  - Non-uniform illumination

ORBITS

- Orbit height, swath width, resolution and life time trade-offs
- Repetition of path/ revisit consideration



- SUN SYNCRONOUS POLAR ORBITS
  - Sub-recurrent orbit
  - Combined repeat cycle

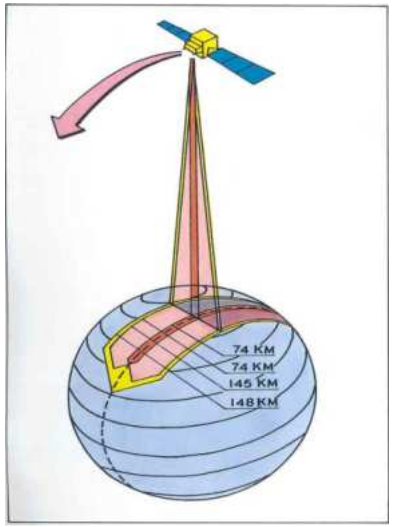
  Landsat 7 & 8 together….8 day repeat cycle

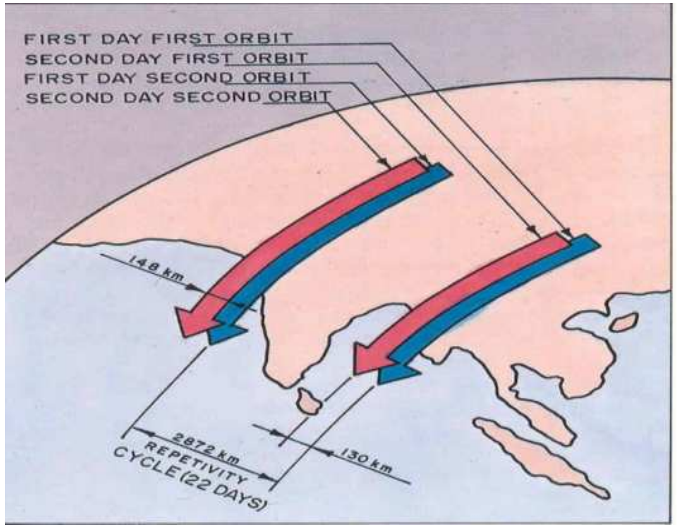
  Sentinel 2A and 2B together … 5 day revisit

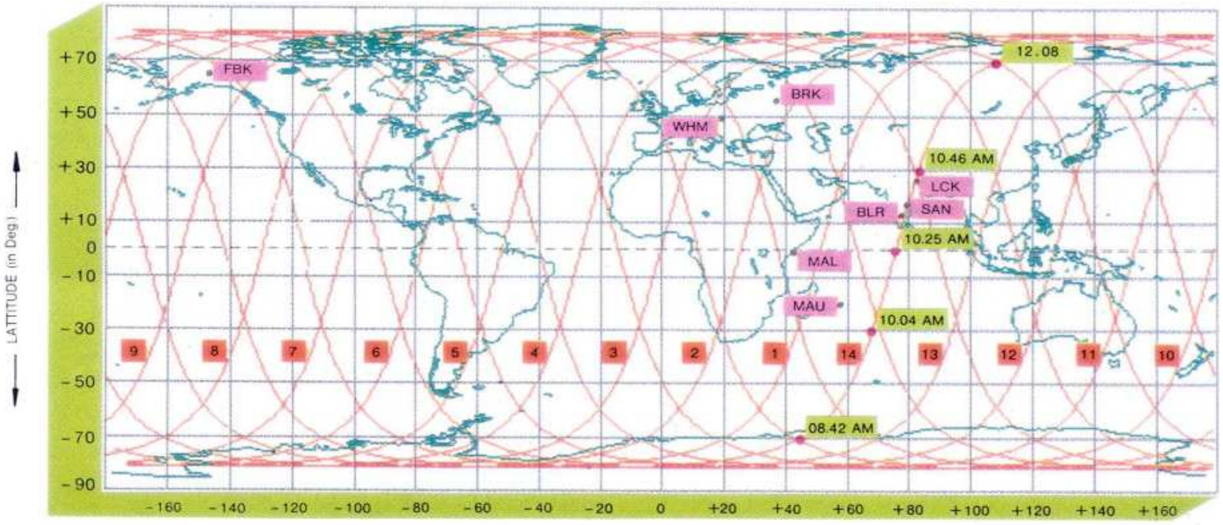
- GEOSTATIONARY EARTH ORBIT
  - Altitude 35, 786 km

- Constellations
- Formation flights

DATA COLLECTION – COVERAGE PATTERN





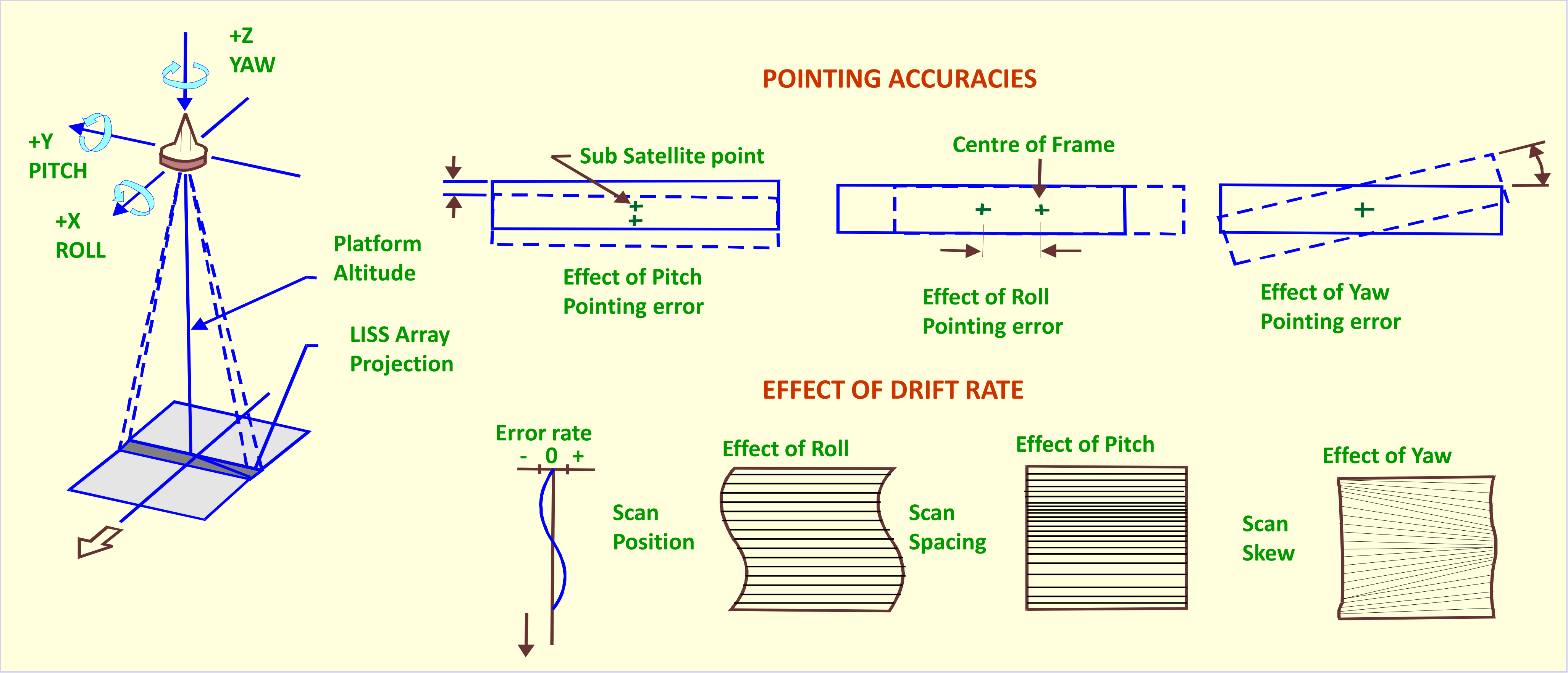


GROUND TRACE FOR IRS SATELLITES

- **Multi-spectral imaging**
  - to identify / discriminate targets
- **Multi-date imaging**
  - to monitor temporal changes
- **Multi-directional imaging**
  - to obtain bidirectional/ polarisation signatures
- **Multi-station imaging**
  - global coverage

SPACECRAFT ATTITUDE EFFECT ON IMAGERY

- Pointing accuracy affects location accuracy
- Angular velocities (drift rates) distorts image and affects pixel registration
- Jitter affects the resolution



Johnson’s criteria of interpretation

- Detection - an object is present: 2 +1/-0.5 pixels
- Orientation - symmetrical, asymmetric, horizontal or vertical: 2.8 +0.8/-0.4 pixels
- Recognition - the type object can be discerned, a person vs. a car: 8 +1.6/-0.4 pixels
- Identification - a specific object can be discerned, a woman vs. a man, the specific car: 12.8 +3.2/-2.8 pixels

  These measurements give a 50% probability of an observer discriminating an object to the specified level.

CONCEPT OF RESOLUTION

Quality of information derived from RS images strongly influenced by spatial, spectral, radiometric & temporal resolutions as well as by angular & polarimetric signatures

- **Spatial Resolution**

  instrument resolving power needed to spatially discriminate the smallest object

- **Spectral Resolution**

  encompasses the width of bands used from the wavelengths of the EM spectrum.

- **Radiometric Resolution**

  quantify No. of discernible signal levels in a band, {sensor's ability to discriminate radiance differences (NE$\Delta\rho$)}

- **Temporal Resolution**

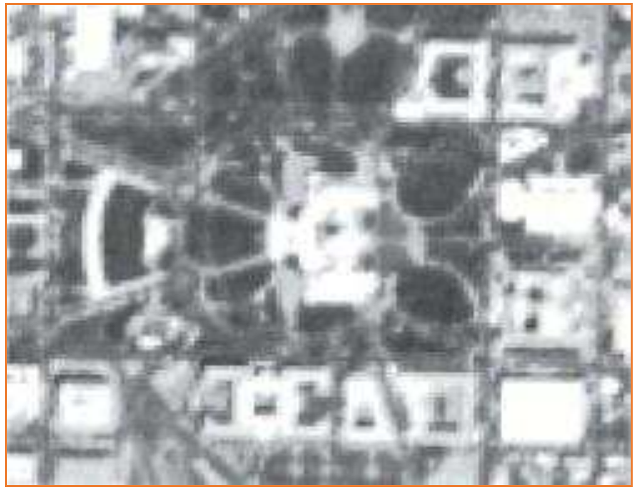
  time interval between imaging collections over the same geographic location

SPATIAL RESOLUTION - DISCRIMINABILTY

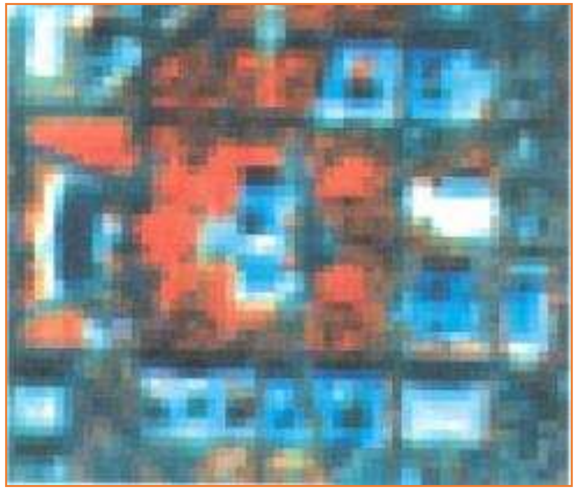
Ikonos Pan - 1 m GSD

Ikonos Colour - 4 m GSD

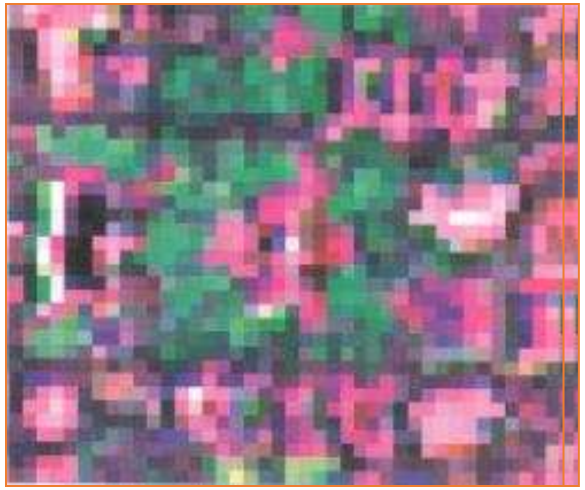
IRS-1C Pan – 5.8 m GSD



SPOT Pan - 10 m GSD

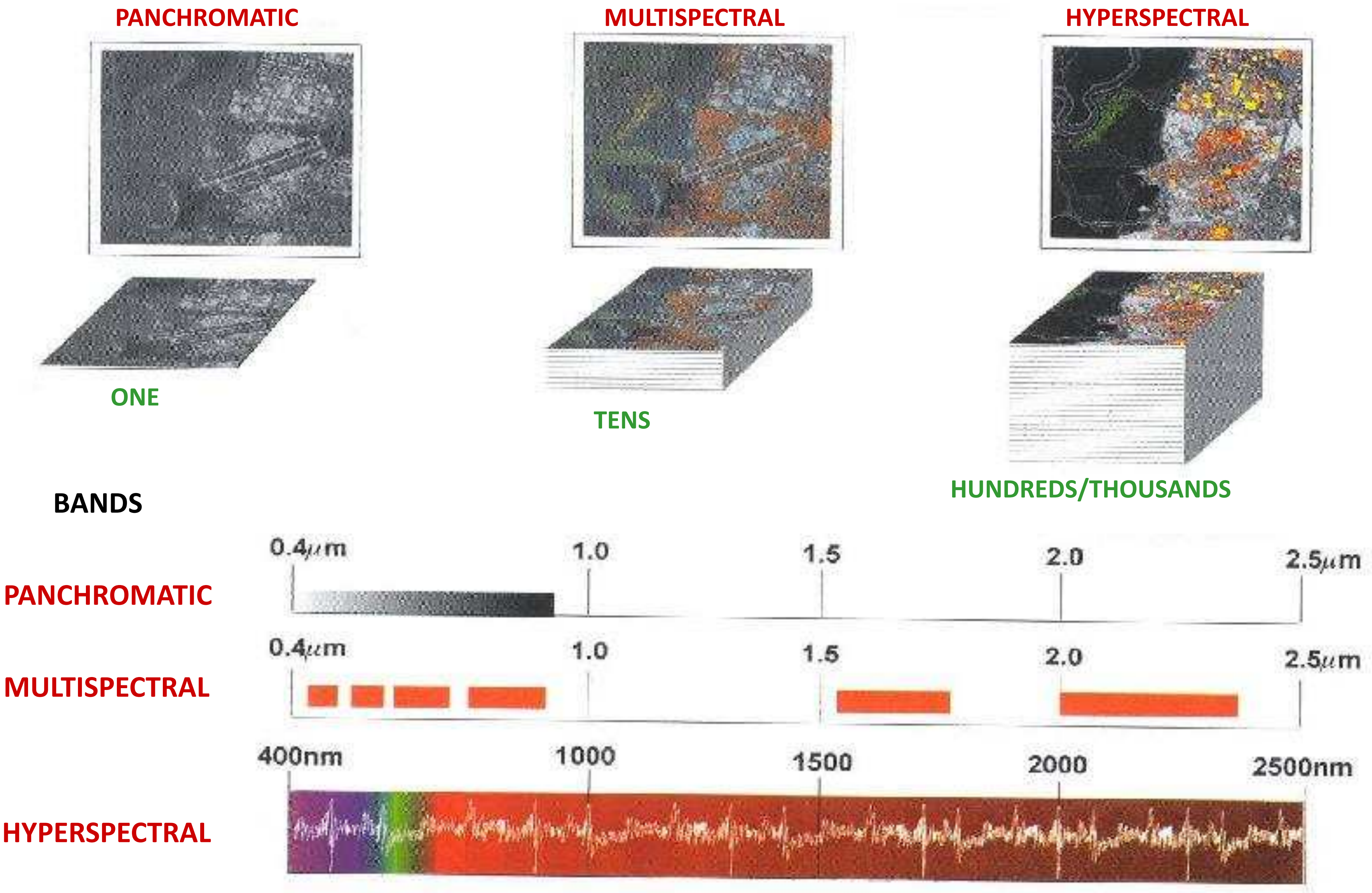


SPOT XS - 20 m GSD



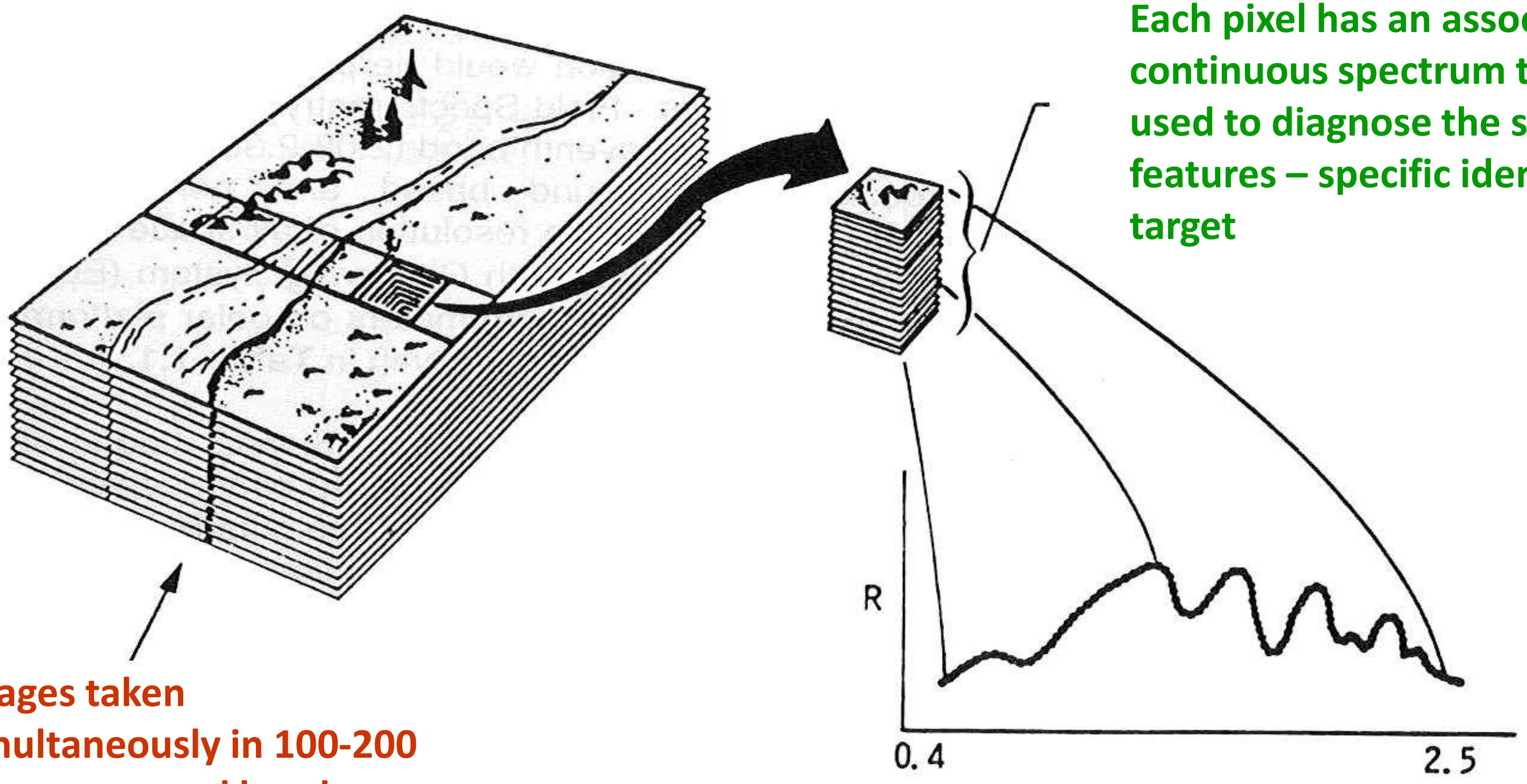
LANDSAT TM - 30 m GSD

SPECTRAL RESOLUTION CONCEPTS



HYPERSPECTRAL IMAGING –
'CAT SCANNING' FROM SPACE

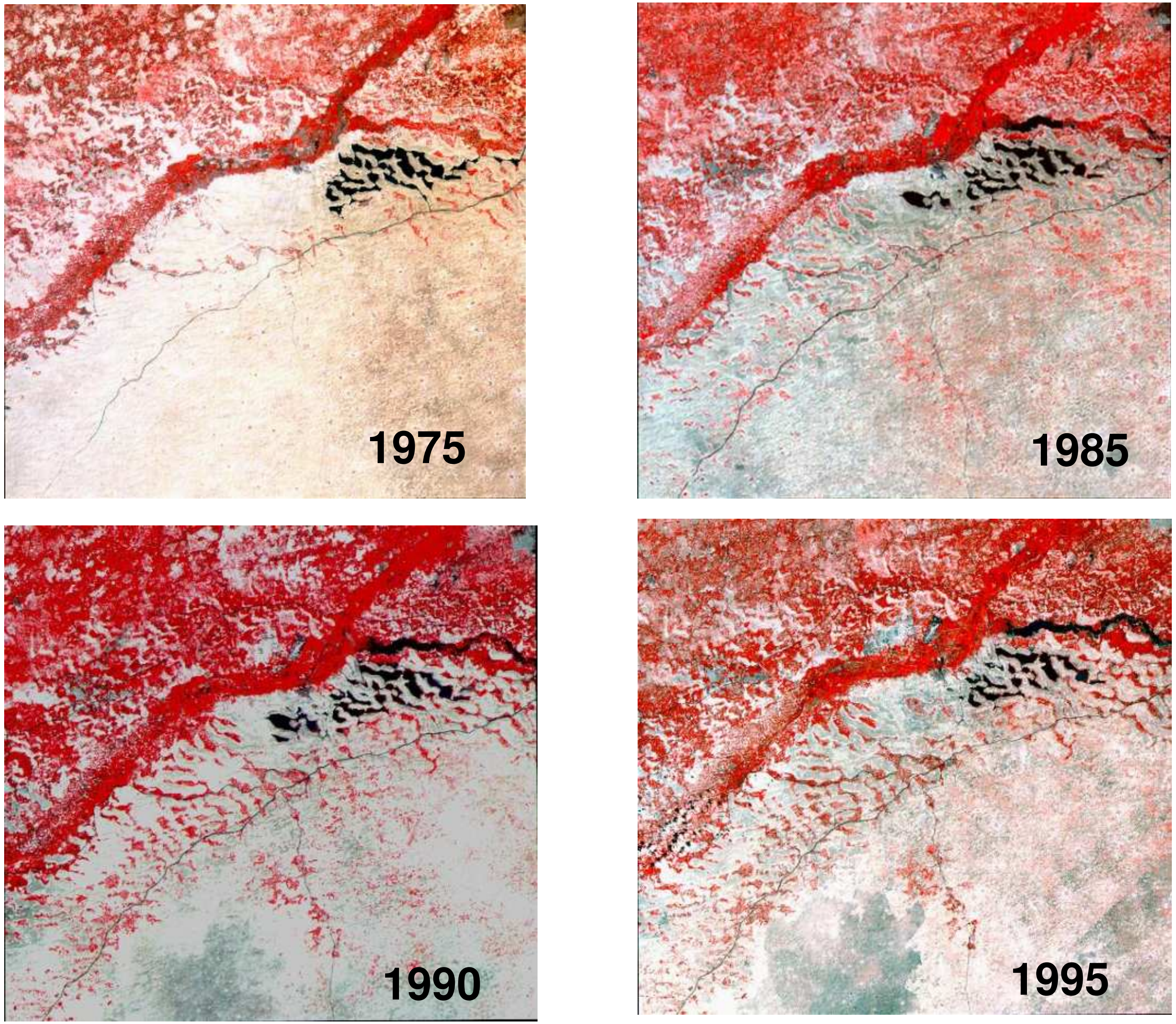
Each pixel has an associated, continuous spectrum that can be used to diagnose the subtle features – specific identity to a target



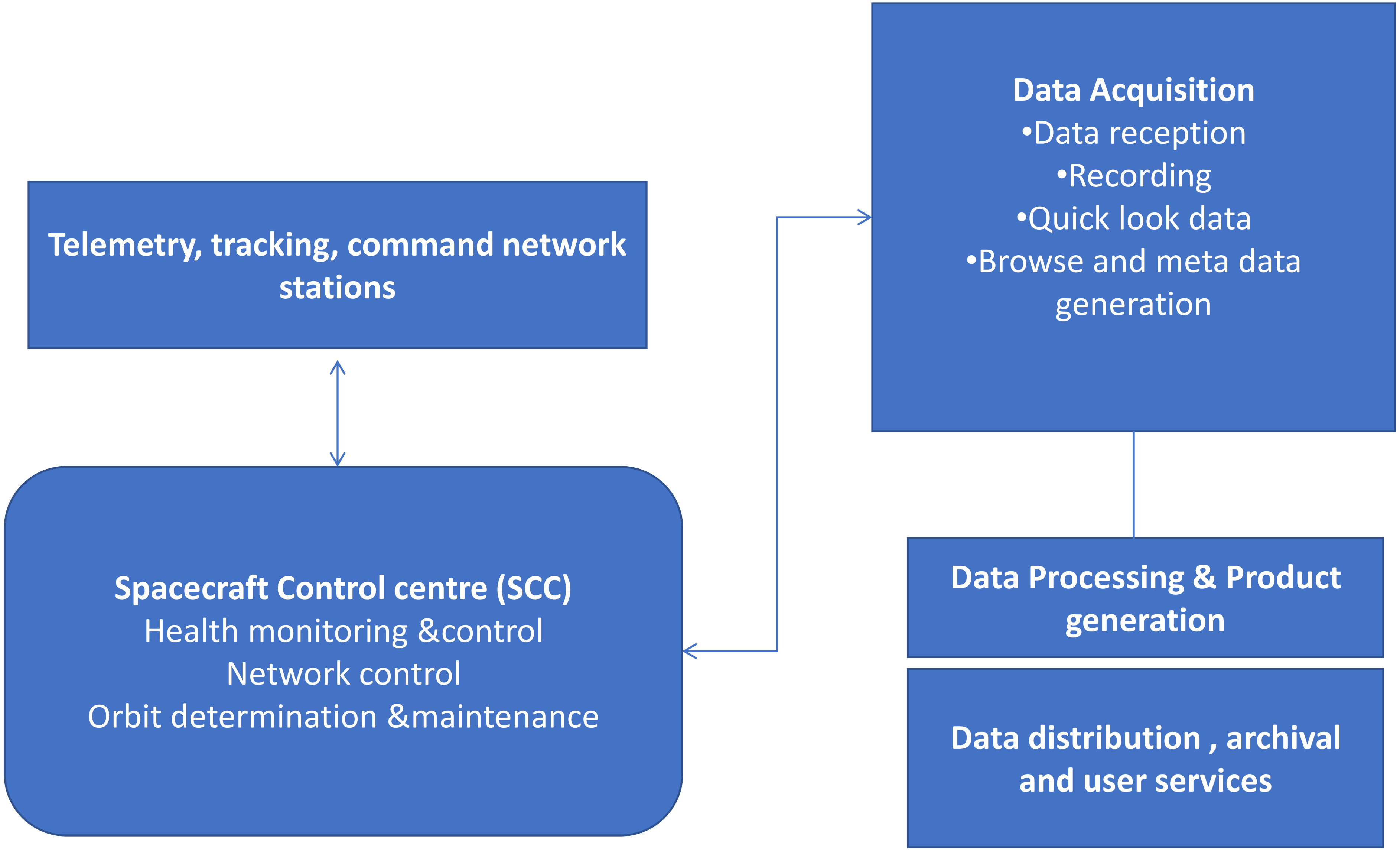
Wavelength, μm

Images taken simultaneously in 100-200 narrow spectral bands, inherently registered

MULTI –TEMPORAL COVERAGE



Typical ground station functions



- Radiometric errors - causes

Radiometric errors are introduced due to sensor characteristics, intervening atmosphere, noise introduced during signal generation, transmission/reception

- Geometric errors

Earth rotation, earth shape, sensor focal plane detector geometry, mis-registration of bands, off axis viewing distortions, altitude/ velocity variations causing scale changes, attitude variation induced distortions, measurement errors etc..

Data Products

1. **Standard**
2. **Special (example merged products)**

Level 0 Uncorrected (raw data)
Level 1 Radiometrically corrected and geometrically corrected only for earth rotation (browse product)
Level 2 Both Radiometrically and geometrically corrected
Level 3 Special processing like precision processing using GCPs, merging, enhancement, ortho image using DEM (digital elevation model) etc after level 2 corrections

Format

Data arrangement

Band Sequential (BSQ) : Band 1 data file, Band 2 data file , … etc
(within each band line by line and each line contains pixels in order)

Band interleaved by line (BIL) : All bands in single file and sequence of Line 1 (Band1)
Line1 (Band2) Line 1 (Band3) , then line 2 (B1, B2, B3) etc

Band interleaved Pixel (single file)
Line1 (First Pixels of all bands, second pixels of all bands.. Etc)
Then sequence of Line 2 pixels in the same way …. etc

Super structure file format: Volume directory file, Leader file, Image file, Trailer file, Null volume directory file

Special processing

1.Contrast enhancement .. Linear and non linear stretching
In the image for each band, each pixel has unique reflectance (Digital Number DN)
Example DN values in an image ranging 25 to 150 is stretched to 0 to 250
Value 25 becomes 0
Value 150 becomes 250
Value 75 becomes (75-25)x 250/125

2**. Colour coded enhancement** Ranges of gray level values in black & white image are assigned colour codes

3. Spatial Filtering- Process of modifying the gray value of a pixel on the basis of gray values of neighboring pixels. Filtering can be done for high frequency or low frequency spatial content. High frequency is rapid change in DN values in relatively smaller number of pixels. Low pass filter smoothes high frequencies. High pass filter highlights contrasts.

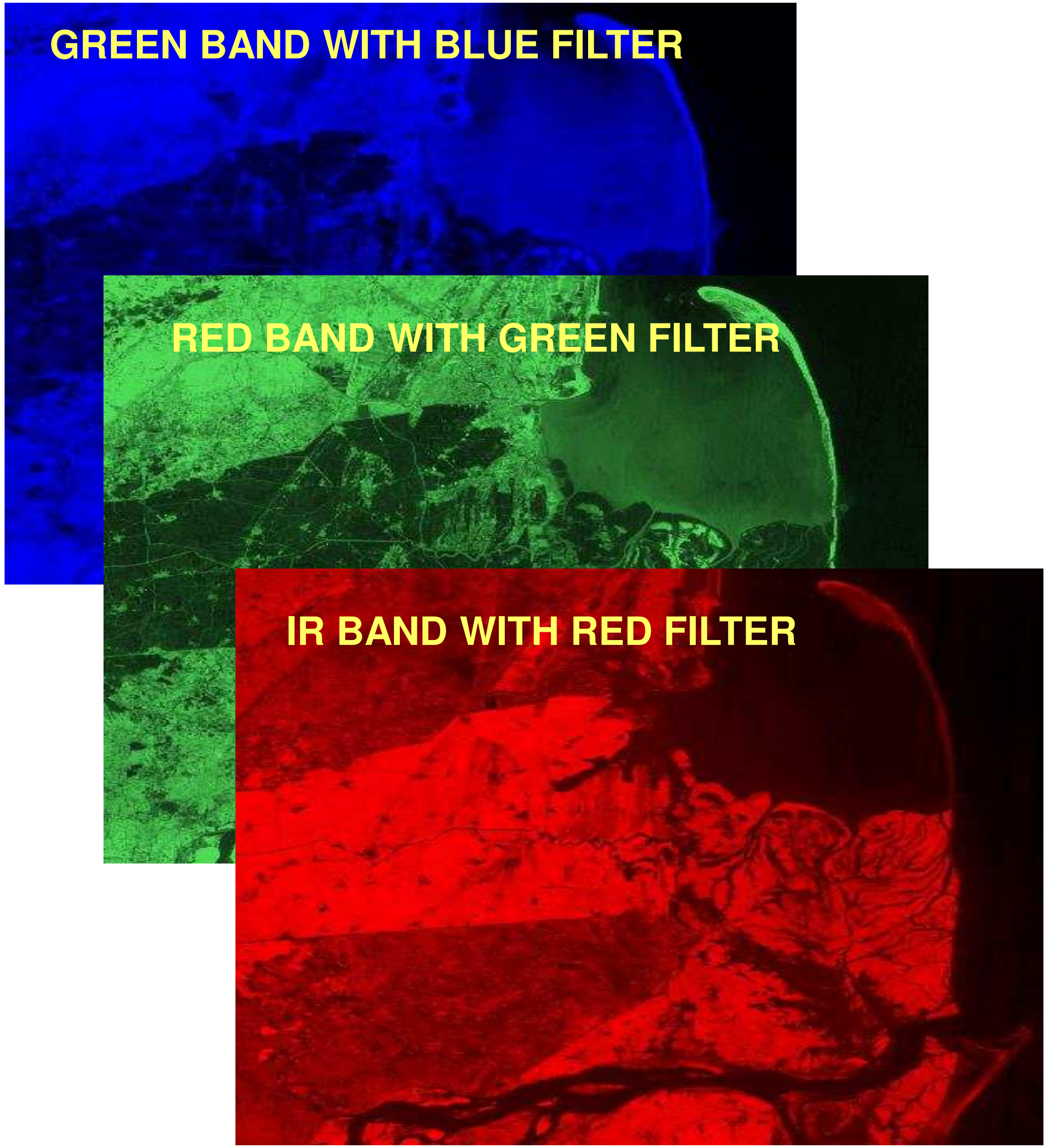
Image transforms

From images of two or three bands or two or three different time periods, create a new transformed image, whose pixels represent the ratio of the differences in pixel radiances of original images. Ratios of multiple bands can eliminate gain or bias errors. They can bring out features not discernible in original images

Principal Component transforms

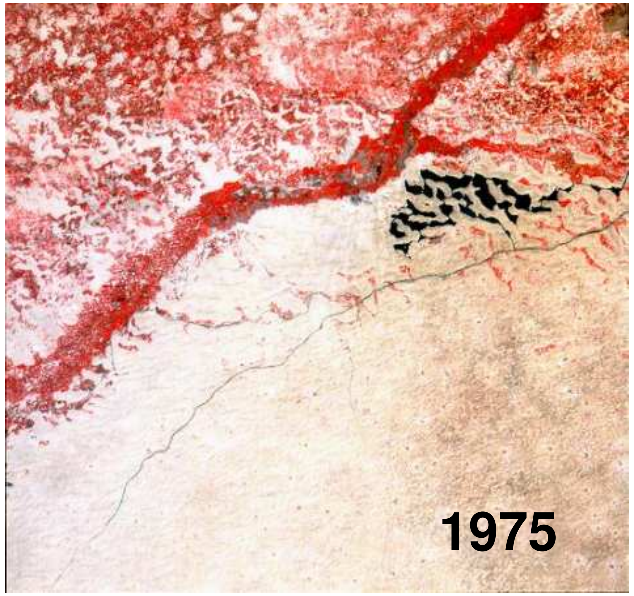
Multi spectral images often exhibit high correlation between spectral bands. When two data sets are perfectly correlated, then same information content in one set is available in the other set and hence second data set is redundant. Thus if there are n correlated spectral bands, PC transformation tries to reduce such redundancy in multi spectral data sets

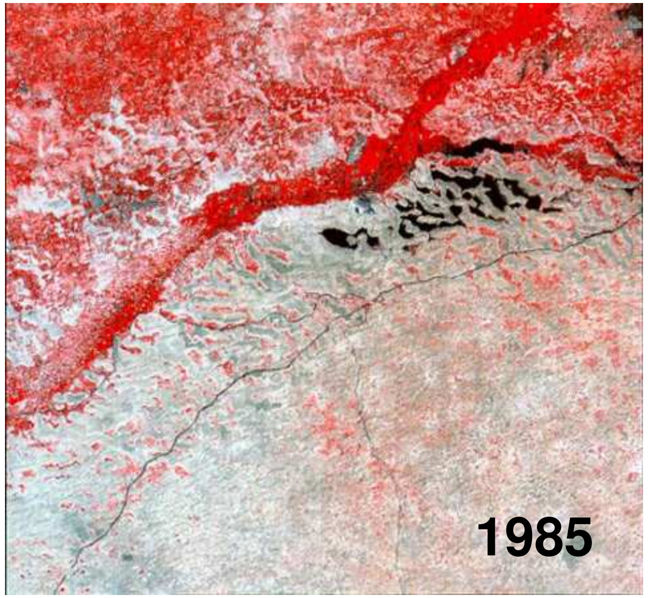
GENERATION OF FALSE COLOUR COMPOSITE

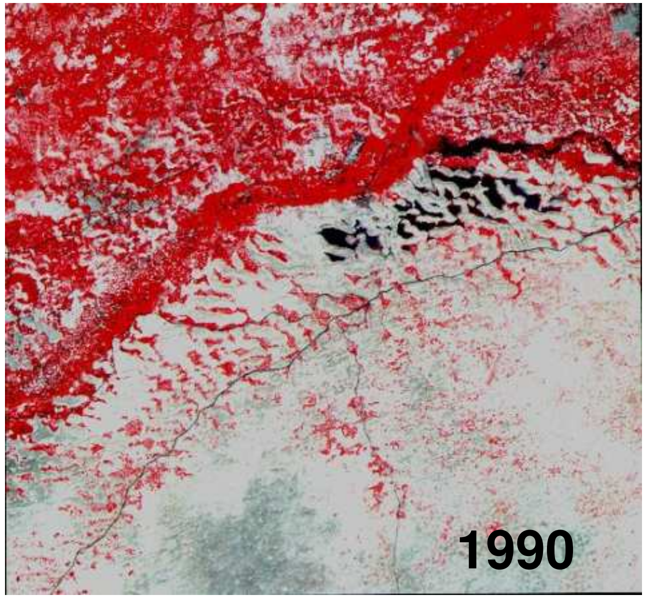


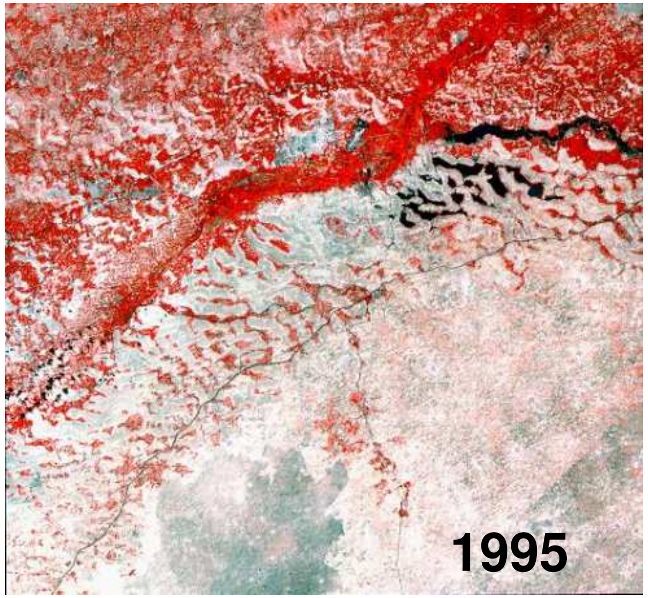
STANDARD FALSE COLOUR COMPOSITE

MULTI –TEMPORAL COVERAGE

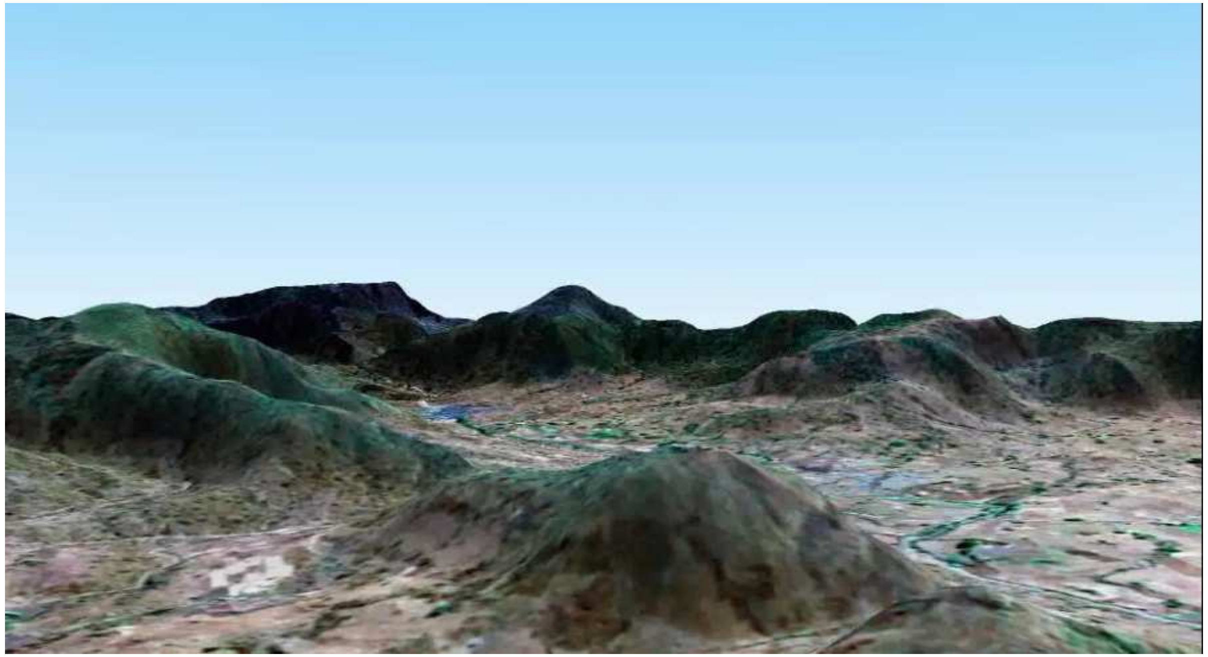




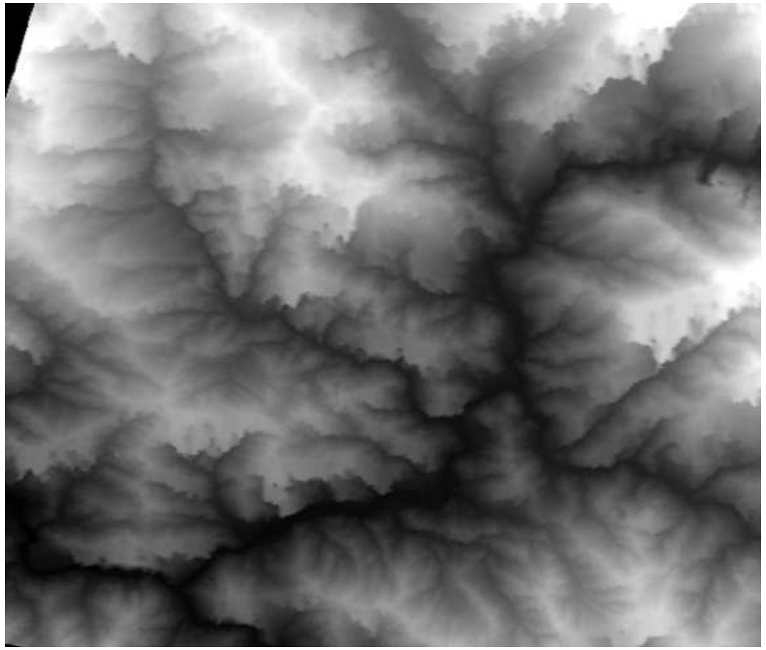


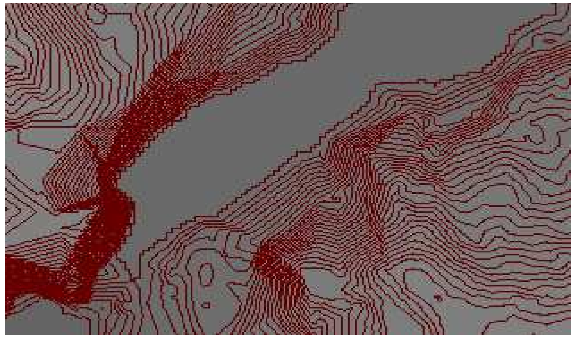


2.5m resolution stereo image from Cartosat-1- DEM draped.



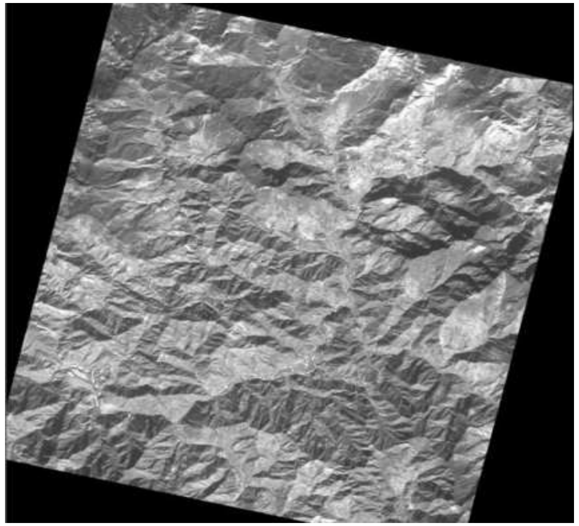
DEM





CONTOUR

ORTHO



Stereo imaging capability

NewSpace is Disruptive

- **NewSpace takes advantage of**:
  - Advances in micro and nanosatellites,
  - Using Commercially-Off-The-Shelf (COTS) components
  - Bulk production processes, and,
  - Often adopting constellation approach to orbital deployment – enhanced throughput
  - Aim at provisioning data or services at revolutionary costs and never before achieved revisits

New Space EO…

- Least dependence on governments for financing.

- Reconfiguration of value chain which legacy system find it difficult to adapt.

- Converging into other larger industry and business segments in Information Technology enabled services using the power of Cloud technology, Artificial Intelligence and Machine Learning.

- An ensemble of several innovations that give power to NewSpace.

- New space trend involves not only start-ups but also big web actors with substantial investment capacity.
- Aim to transforming space into a commodity, taking benefit from the convergence between Information technology and EO.
- For Earth observation markets, target is high resolution and high revisit.
- EO Data Buckets in Big Data domain in a significant manner

New Space EO system examples

No	Private EO Missions	Observations
1	Planet (US)	300 dove constellation; <20kgs each – 3m and 90 cms; Daily Earth coverage
2	Urthecast (US)	ISS based payloads; Deimos OptiSar (670/1400kg) combination; 1m SAR and optical data; Spot-scan coverage
3	Jilin (China)	60 satellites (~100-200kgs); 72cm imaging and UHD video; aims for all-weather data
4	Satellogic (Arg.)	~300 (when complete) smallsats (~35kgs); 1m XS and 2-hourly revisit
5	AstroDigital (US)	25+ smallsats (~10-20 kgs); 2.5m GSD; Daily coverage of Earth
6	NOVASAR (UK)	SAR satellites (~400kgs); SAR strip; 6m S-Band SAR small strips

Quantum leaps in onboard technologies

- Processor speeds up by million times in 40 years

- Storage capacity up from typical 10 GB (late 1990's) to 8 TB (2010)

- Solar power generators 100$/watt (1970) to 5 $/Watt (2010)---- Inflatable lightweight arrays

- Data transmission..X-band upto 1Gbps;
- With Adaptive Coding and Modulation… 1 TB per day;
- Higher bandwidth through use of 26 GHz band link;
- LEO-GEO- High Altitude Platform- Ground link using optical communications, upto 76 Tb per day possible.

Quantum leaps in onboard technologies

- Advent of Agile satellites for spot imaging

Example: Pleiades Agility for roll or pitch 60 degrees in 25 secs

- Improvement of specific energy densities from 40Wh/Kg (Ni Hydride) to >100 Wh/Kg (Lithium Ion)

- Synthetic Aperture Radar

From 8m resolution (RADARSAT,1995) to 1 m (TerraSAR-X, 2007) and even 25 cm resolution in *staring spot light* mode

Satellite's overall platform technologies

Legacy

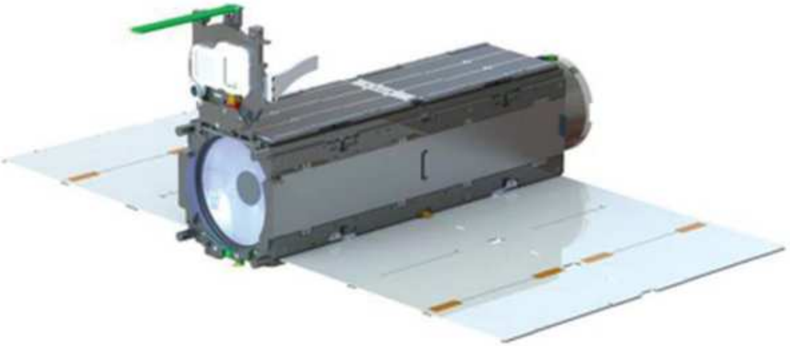
Landsat 8

image: usgs.gov

Mass 2071 Kg.
9 Visible+ 2 IR bands,
15m & 30m resolution
12 bit radiometry
Global coverage: 16 days
3.14 Tb onboard memory
Cost: 855 mi USD
Down link: 384 Mbps

NewSpace

Planet Lab's Dove



5Kg mass;
3-5m resolution, 3 bands;
29 MP CCD detector;
One Global image set per day with the full constellation deployed,
200Mbps data downlink

India's EO Programme- Sensor Epochs

IRS 1A (1988)	**CCD based 4-band MS camera (3 #), 72m & 36m resolution (LISS 1&2)**
INSAT 2A (1993)	Very High Resolution Radiometer (2.75 km Visible/11km thermal IR)
IRS- 1C (1995)	LISS-3 (23.6m), PAN CAMERA (<6m), WiFS (189m), SWIR band
Oceansat-1 (1999)	Ocean Color Monitor (8 band, 360m) Multi band Scanning Microwave Radiometer (MSMR)
TES (2001)	1 meter resolution , Step and stare imaging
INSAT 3A (2003) Resourcesat 1 (2003)	Improved VHRR (2 km VIS band /8 km W V /8km Ther. IR), CCD Camera LISS 4 (5 m MS) Advanced WiFs
Cartosat-1 (2005)	2.5m Fore & Aft cameras (In track stereo), Global DEM sets
Cartosat 2 (2007, 16)	Operational HR <1m resolution, HR colour, Step & Stare
Oceansat-2 (2009)	Ocean Colour Monitor (OCM), Scatterometer and ROSA payloads
Resourcesat 2 (2011)	LISS 4 (5m MS, 10 bit, 70km swath), AWiFS (12 bits), 200 GB Memory
Megha-tropiques (2011)	ISRO-CNES mission - MADRAS microwave radiometer, SAPHIR humidity profiler , SCARAB Radiation budget instrument
RISAT 1 (2012)	Synthetic Aperture Radar Payload
INSAT 3D (2013)	6 Channel Imager & 19 Channel Sounder
SARAL(2013)	: Ka band Altimeter

Indian High resolution systems

Parameter/ Sensor name	**TES**	**Carto sat-2, 2A, 2B**	**Cartosat-2C, 2D, 2E**		**Cartosat-3, 3A, 3B**		
	PAN	PAN	PAN	MX	PAN	MX	HySI
Spectral range(μ)	0.5 – 0.85	0.5 – 0.85	0.45 – 0.9	0.45 – 0.86	0.45 – 0.9	0.45 – 0.86	0.4 – 2.5
Channels	1	1	1	4	1	4	>200
Resolution (m)	1	0.8	0.65	2	0.25	1	12
Swath(km)	16	10	10	10	16	16	5
Quantization	7	10	11	11	11	11	11

Source: N N R M S B U L L E T I N - M A R C H 2 0 1 3

Developments in Microwave sensors

Day & Night, all weather imaging/ measurement

Multi-band passive microwave radiometers
Alti meters
Synthetic Aperture Radars
Scatterometers

Laser instruments

LiDARs
Terrain mappers

IMPACT OF “COTS “ APPROACH TO CAMERA

LISS III SENSOR
(RESOURCESAT)

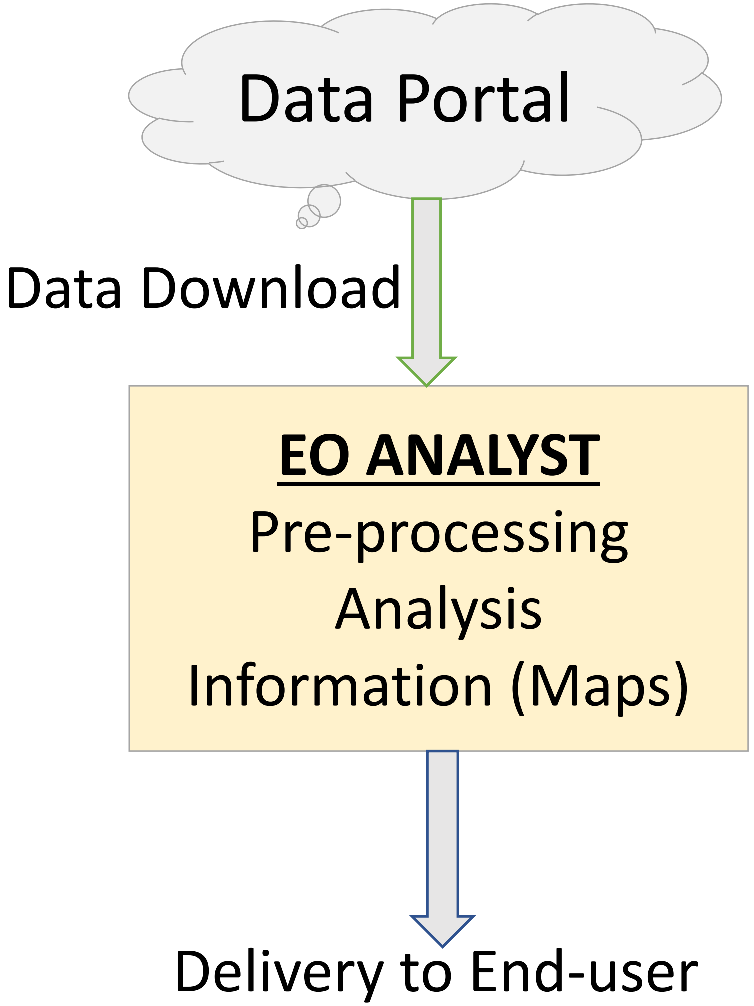
Medium Resolution
4 bands
23 meter spatial res.
70W power
140 km swath
106 Kg

CUBESAT Camera

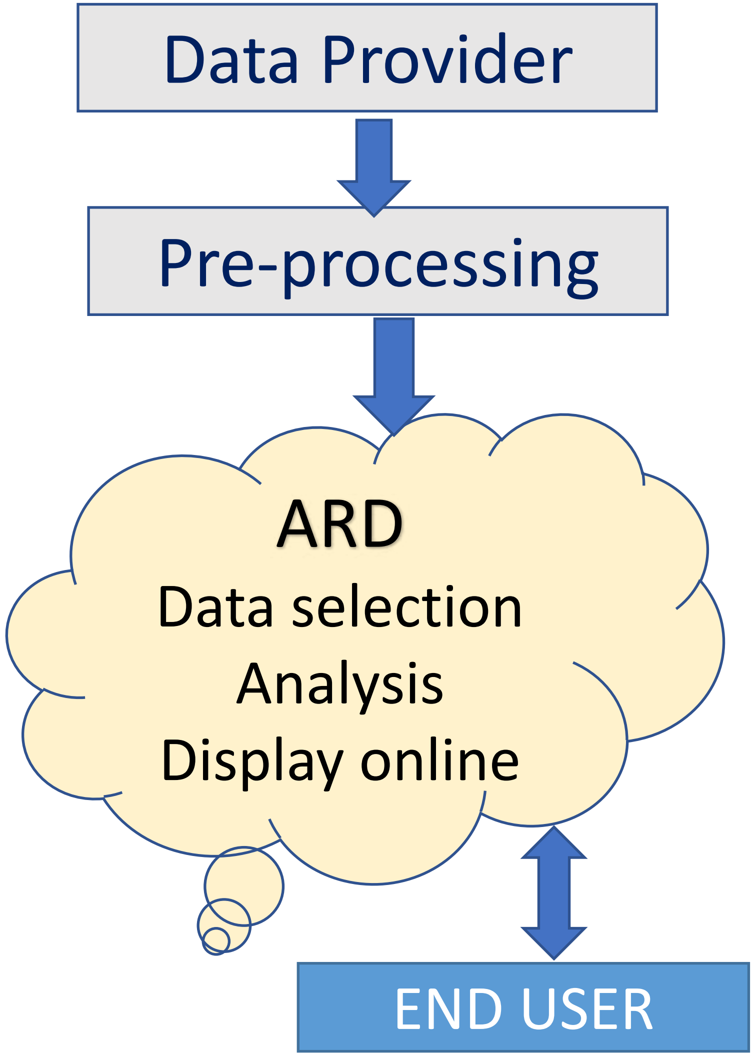
High resolution image & video
5m spatial resolution
3388 x 2712 pixel frame (9MP)
5.1 w power, 398 gram
Model: Imperx B 3412 DX
Mirror
Optics SY: 500mm f/6.3

Data access and Data Processing

LEGACY SYSTEMS



NEW DEVELOPMENT



Managed Ground Segments

- Availability of fully managed ground station as a service, as available through AWS ground stations

- facilitate users to undertake tasking, commanding, downlinking and processing of satellite data in cloud and distribute them.

- Integration of EO data into cloud based services such as AWS enables easy scaling of satellite operations by the user rapidly and cost effectively on the basis of the extent of usage.

Overview of portals for Big Earth data.

Download, Upload and processing online

Name	**Data Structure**	**Data availability**
Google Earth Engine	2D gridded raster bands	Satellite Imagery; Satellite-derived data products (Landsat, MODIS, Sentinel). Programming Env.(IDE)
Amazon Web Services	Image files	Satellite Imagery; Satellite-derived products (Landsat, Copernicus &MODIS, and DEMs)
Earth Server	Data cube	Satellite Imagery; Satellite-derived data products; Model outputs
EODC (water resource monitor)	Image files	Satellite Imagery; Satellite-derived products (EO/GIS users) (Copernicus)
Swiss Data Cube	Data cube	Satellite Imagery; Satellite-derived products
Digital Earth Australia	Data cube	Satellite Imagery
CODE-DE (Germany..)	Image files	Sentinel Imagery -Copernicus services

Data download portals

Name	Data Structure	Data Availability
NSIDC (Snow & Ice data)	Raster, Point, Vector data	In-situ data sets; Model Outputs; Satellite derived data products (soil moisture..)
EUMETSAT	Image Files	Satellite Imagery; Satellite derived data products
Earth Explorer (USGS)	Image files	Satellite Imagery; UAS Imagery, Data products, Digital Maps
Copernicus Open Access Hub	Image files	Satellite Imagery
PEPS (French)	Image files	Satellite Imagery, Copernicus ..

Download & upload

PANGEA (Environ. Science)	Raster, Point, Vector data	Model Outputs; Satellite derived data products

Other notable user resources

- NASA Sensor Web Suite – software tools for access, process and analysis of data
- For Landsat products—Earth explorer, GloVis and LandsatLook Viewer
- DIAS- Copernicus Data and Information Access Services

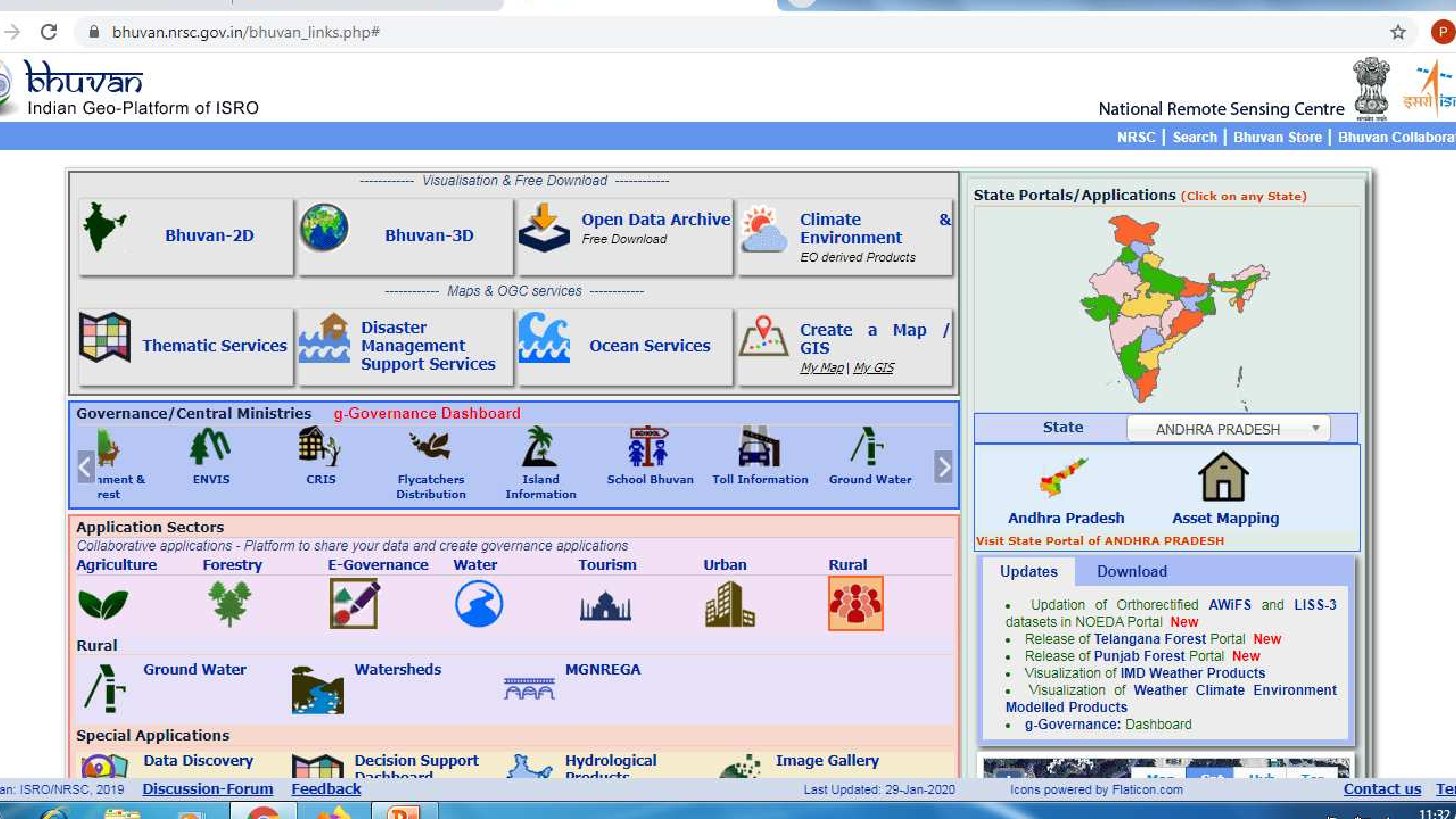
REFERENCE ON BIG EARTH DATA MANAGEMENT:

Martin Sudmanns, Dirk Tiede, Stefan Lang, Helena Bergstedt, Georg Trost, Hannah Augustin, Andrea Baraldi & Thomas Blaschke (2019): Big Earth data: disruptive changes in Earth observation data management and analysis?, International Journal of Digital Earth, DOI: 10.1080/17538947.2019.1585976--

Bhuvan Geo-portal

Geo spatial services

- IRS data hosting for visualisation (1m or coarser)
- Free down load of Resourcesat data (more than 2 year old)
- Satellite derived products
- Project / theme specific database information and visualisation
  - Natural Resource Census
  - Agriculture
  - Forestry & environment
  - Rural development
  - Water resources
  - Geo sciences
  - Urban & infrastructure
  - Ocean sciences and atmosphere
  - Disaster Management support
- Mobile applications


bhuvan.nrsc.gov.in/bhuvan_links.php#
bhuvan
Indian Geo-Platform of ISRO
National Remote Sensing Centre
NRSC | Search | Bhuvan Store | Bhuvan Collabora
Visualisation & Free Download
Bhuvan-2D
Bhuvan-3D
Open Data Archive
Free Download
Climate & Environment
EO derived Products
Maps & OGC services
Thematic Services
Disaster Management Support Services
Ocean Services
Create a Map / GIS
My Map | My GIS
Governance/Central Ministries
g-Governance Dashboard
nment & rest
ENVIS
CRIS
Flycatchers Distribution
Island Information
School Bhuvan
Toll Information
Ground Water
Application Sectors
Collaborative applications - Platform to share your data and create governance applications
Agriculture
Forestry
E-Governance
Water
Tourism
Urban
Rural
Rural
Ground Water
Watersheds
MGNREGA
Special Applications
Data Discovery
Decision Support Dashboard
Hydrological Products
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State
ANDHRA PRADESH
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Updation of Orthorectified AWiFS and LISS-3 datasets in NOEDA Portal New
Release of Telangana Forest Portal New
Release of Punjab Forest Portal New
Visualization of IMD Weather Products
Visualization of Weather Climate Environment Modelled Products
g-Governance: Dashboard
an: ISRO/NRSC, 2019
Discussion-Forum
Feedback
Last Updated: 29-Jan-2020
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APPLICATIONS DRIVERS

Monitoring Agriculture – crop areas, crop health and yield estimates, Advisories
Water resource mapping, ground water targeting, water pollution monitoring, fisheries information

Environmental impact assessments, and environment monitoring, weather observations, cyclone tracking, Forestry applications

Cartography and Mapping applications- digital elevation models, Asset mapping, and mobile assets tracking, Urban applications,
Land use and land cover changes
Information support for decentralised planning
Monitoring Disasters, warning and assessment of damages

Monitoring infringement of Laws – encroachments of forest lands, illegal mining, infringement of coastal zone regulations etc.

Visual interpretation keys

Tone (colour)
Texture
Shape
Size
Shadow
Pattern
Site
Height
Association

Supervised classification

In supervised classification, the analyst based on prior information on the spectral characteristics of these classes, trains the computer to generate boundaries in the feature space within which each class should lie

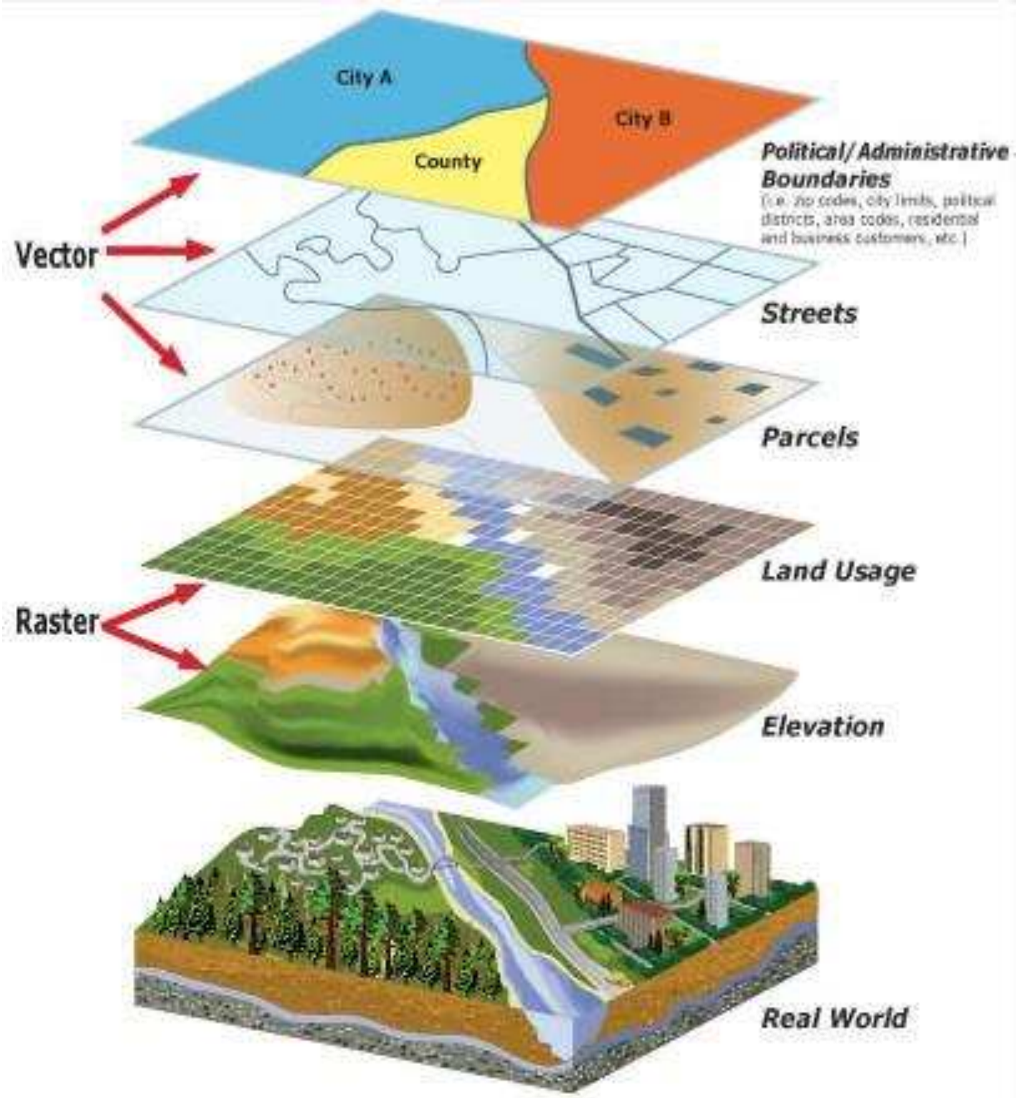
Geographical Information System (GIS)

Geographical Information System (GIS) is a system (of hardware /Software /data /applications/policies) that deals with spatially referenced and geographically tagged/linked data.

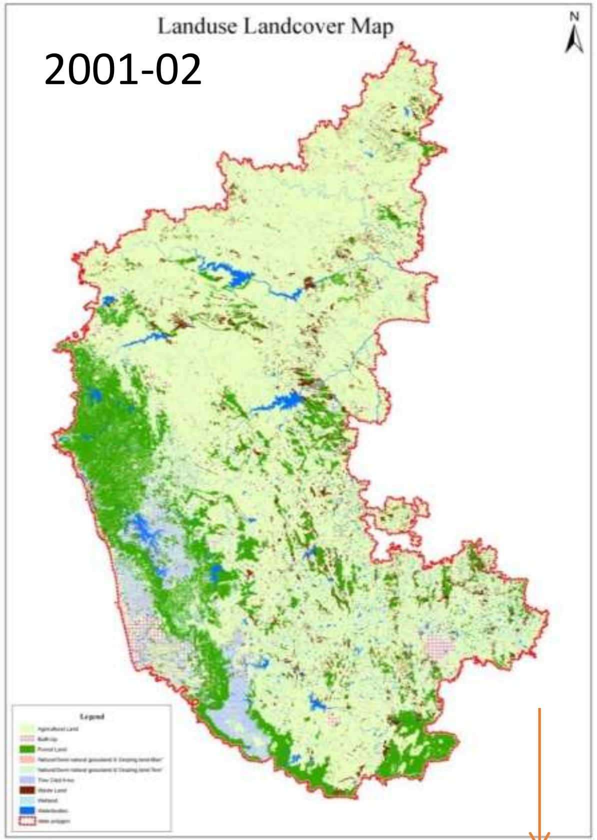
GIS allows analysis and integration of various map/image layers and geo-tagged tabular data to determine the spatial distribution, the relationship among various entities and the correlation of the variables in a geographic unit.

Further, the capability of GIS systems now allows creating map visualization of tabular data and making amenable the spatial or map representation of population data, migration data, consumer data, financial transactions, and beneficiary data and so on.

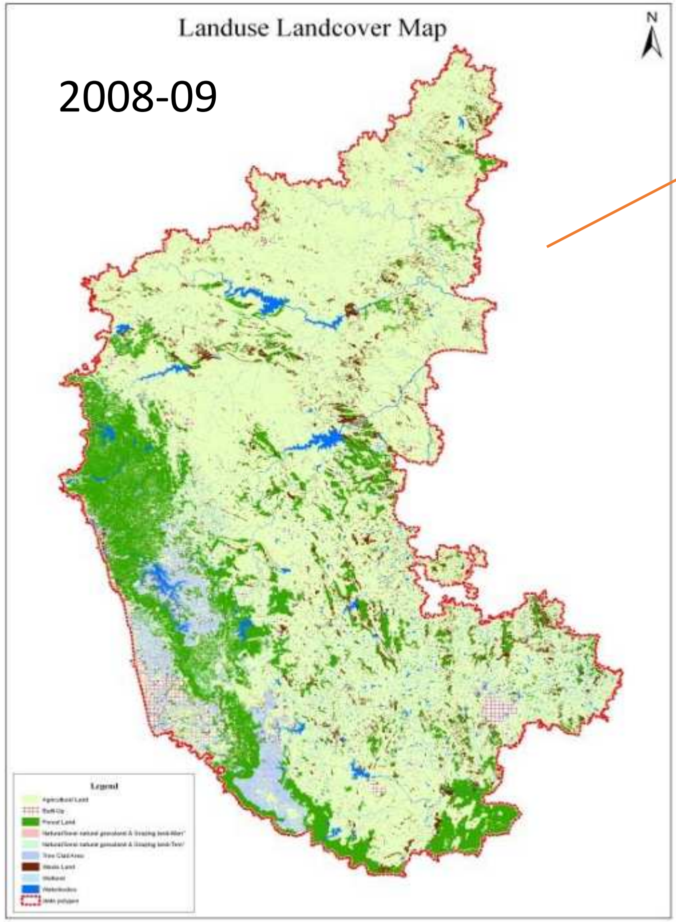
GIS components and concept



Example of GIS use: Land Use Status



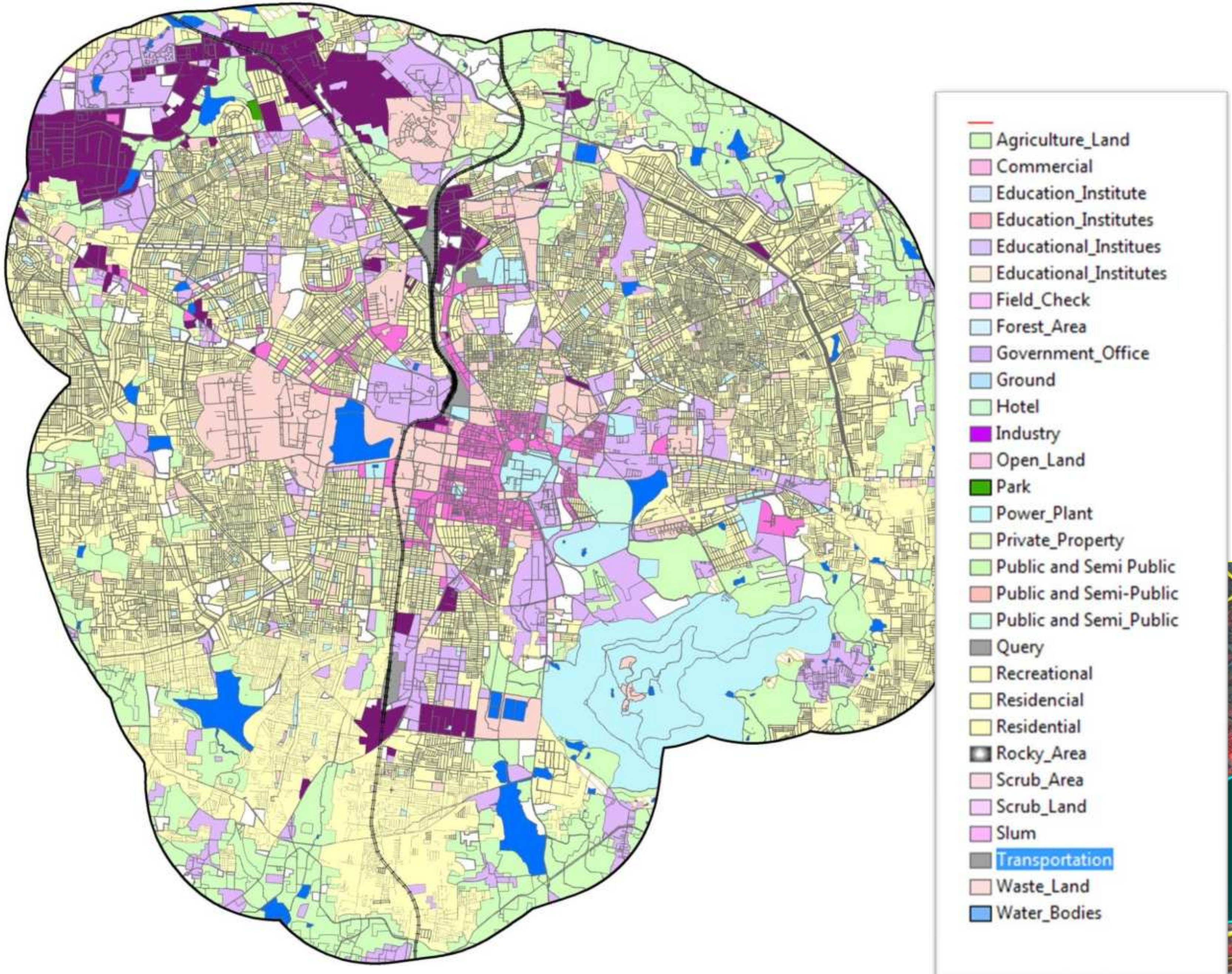
Agricultural land	130264.82
Built-up land	3480.32
Forest Cover	27391.95
Grassland / Grazing land	781.73
Others	10851.94
Wastelands	11831.66
Water Bodies	7154.62
Wetlands	35.84



Sl No	Description	Area in Sqkm
1	Agricultural Land	133191.42
2	Built-Up	5449.41
3	Forest Cover	29248.17
4	Natural/Semi natural grassland & Grazing land	636.55
5	Tree Clad Area	7413.86
6	Waste Land	8529.93
7	Waterbodies	7232.80
8	Wetland	86.12

Courtesy: K-GIS WORKSHOP-JANUARY 23, 2013

CITY-GIS FOR MASTER PLANNING



Courtesy KSRSAC
K-GIS WORKSHOP-
JANUARY 23, 2013

SATELLITE IMAGE FOR UPDATING

Spatial data quality

- Spatial data---data about positions, attributes and relationships in space
- Cartographer’s traditional approach– produce best possible accurate maps
- Advances in database and digital technologies- multiple sources, greater content, linkages and higher speeds and greater visualisation
- Multiplicity/ remoteness of players in creation and use of spatial data
- TWO ISSUES:
  - Quality information is essential for user – to choose the data set
  - Computer rendering shows high accuracies- need for data quality information included in the data set.

Spatial data quality

- Foundation step: Adoption of ISO9000 international standard (ISO 1987)
- Tenet: Give no more quality or less quality than the customer requires
- Specification of spatial data quality:

Definition of elements of spatial data quality

Specification of spatial data quality

Presenting known data quality in visualisations

Spatial Data Quality

Definition of spatial data quality- efforts in different parts of globe

- USA- National Committee on Digital Cartographic Data Standards(NCDCDS) - Draft 1987
- User to decide fitness for purpose of use
- Reporting data quality
  - Lineage,
  - positional accuracy,
  - attribute accuracy,
  - logical consistency, and
  - completeness.
- Europe- *Comite Europeen de Normalisation Technical committee 287 (CEN/TC287) 1992*
- *Commission on Sp. Data Quality of Intl. Cartographic Assoc.*
  - Addition of 2 more elements– Semantic and Temporal (1995)

Spatial Data Quality

- 1997 ISO's establishing TC211
  - CEN/TC287 work taken into account in the development of global ISO stds.
  - Continuity of ideas (US NIST, ICA and CEN/TC287)
- TC211 Working Group 3:
  - Item 13 --geographic information-quality
  - Item 14 – geographic information-quality evaluation
  - Item 15 – geographic information-meta data
  - Item 4 – geographic information-terminology
- ISO2001

ISO/TC211/WG3/NO13 quality principles

Quantitative elements

Thematic accuracy	Completeness	Logical Consistency	Positional accuracy
• Feature accuracy value • Classification accuracy • Misclassification	• Commission • Omission • User defined	• Domain consistency • Format Consistency • Topological consistency • Use defined	• Absolute or external accuracy • Gridded data positional accuracy • Positional stability • Relative Positional stability • Relative of internal accuracy • Shape fidelity • User defined

ISO/TC211/WG3/NO13 quality principles (continued)

NON QUANTITATIVE			
Temporal Accuracy	Lineage	Usage	Purpose
• Accuracy • Temporal consistency • Temporal validity • User defined	• History of data set from collection and acquisition through compilation and derivation to its current form	• Application description	• Intended use and rationale for creation of data set