Role of Remote Sensing and GIS in Disaster Management

Unit 5

Remote Sensing

"Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it.

This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information."

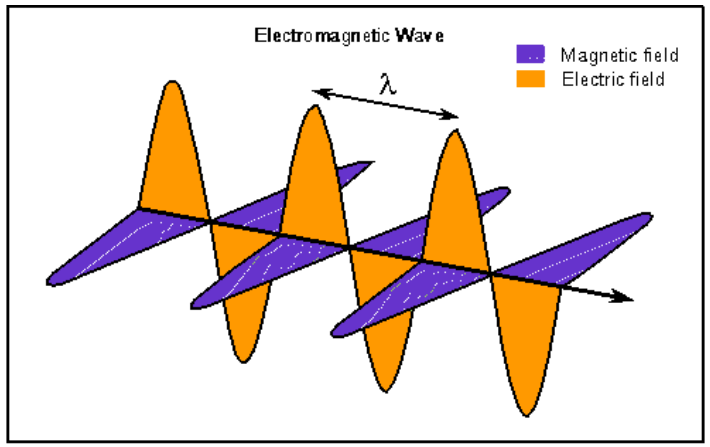
Electro Magnetic Spectrum

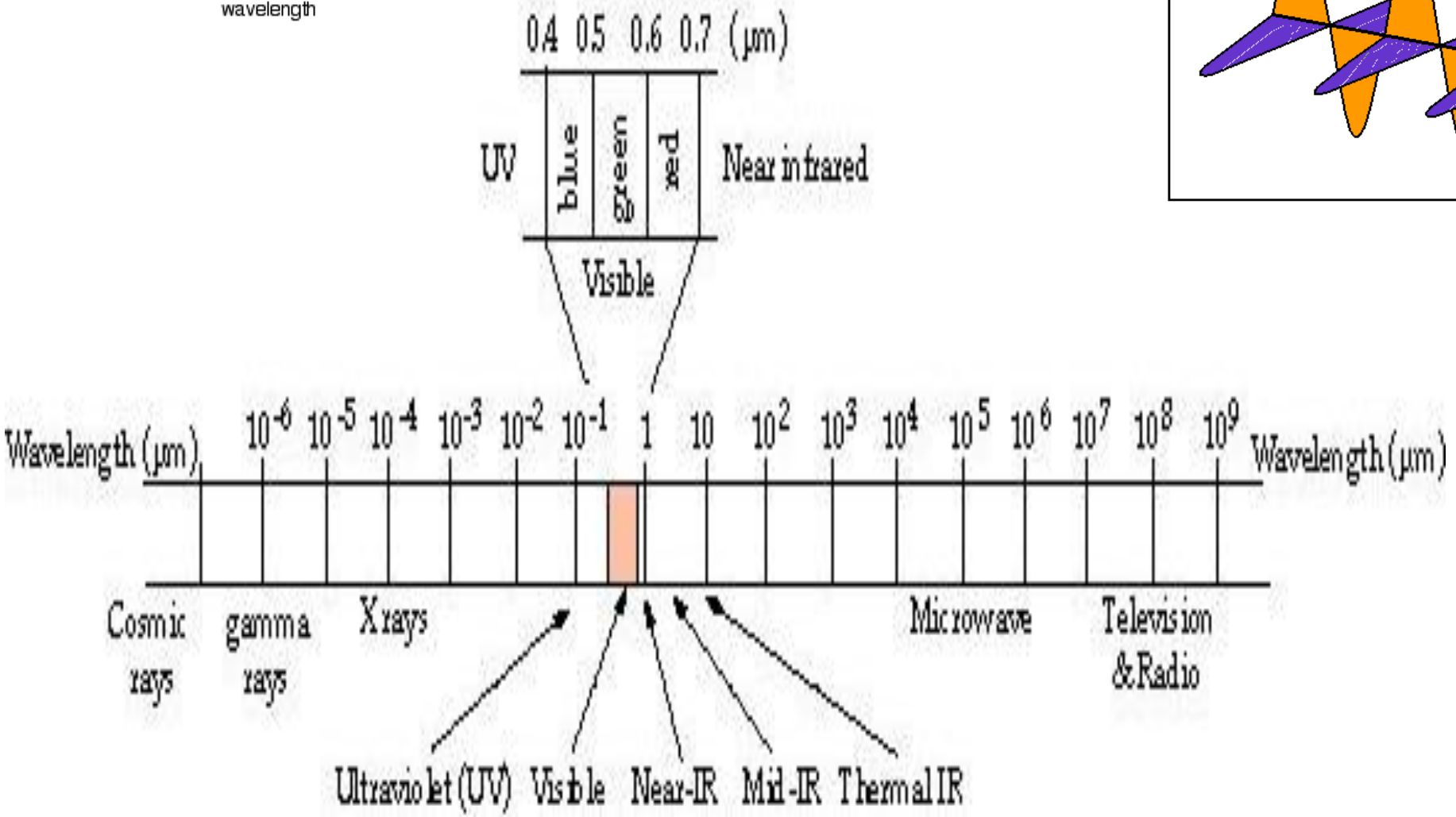
speed of light

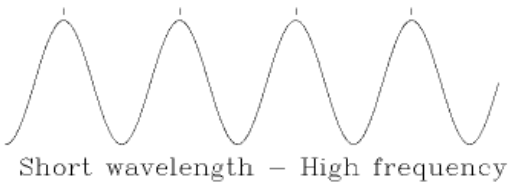
frequency
(Greek letter, nu)

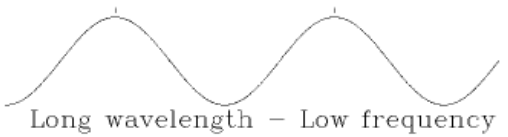
$$c = \lambda \nu$$

wavelength



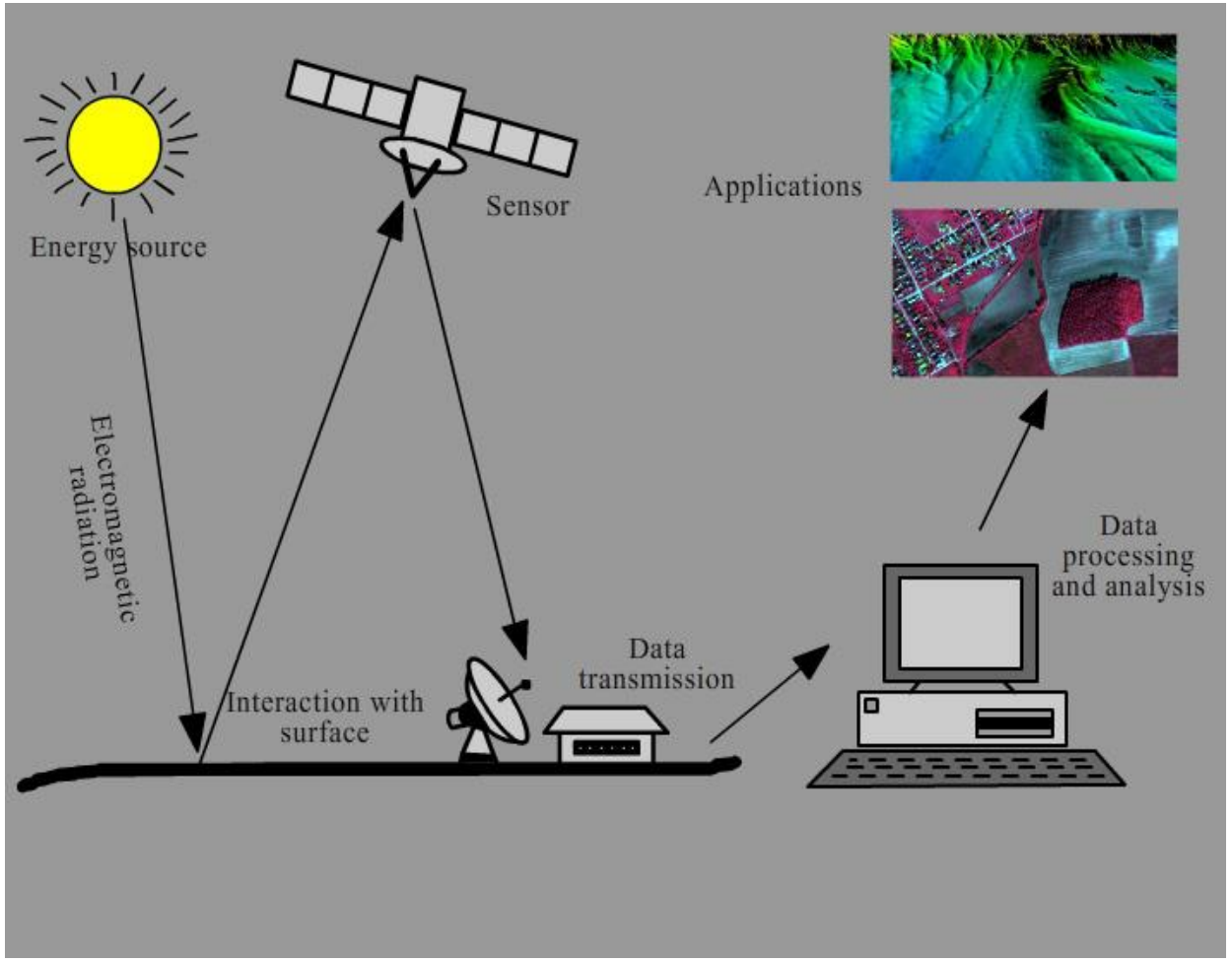




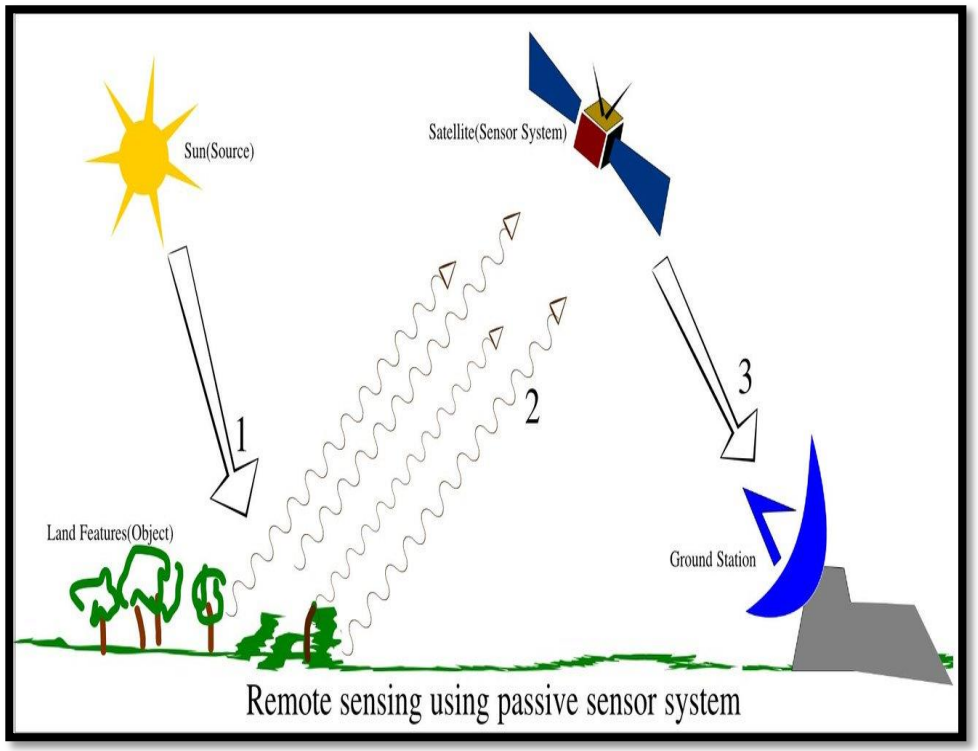


Elements or Components of Remote Sensing

1. Energy Source or Illumination (A)
2. Radiation and the Atmosphere (B)
3. Interaction with the Target (C)
4. Recording of Energy by the Sensor (D)
5. Transmission, Reception, and Processing (E)
6. Interpretation and Analysis (F)
7. Application (G)

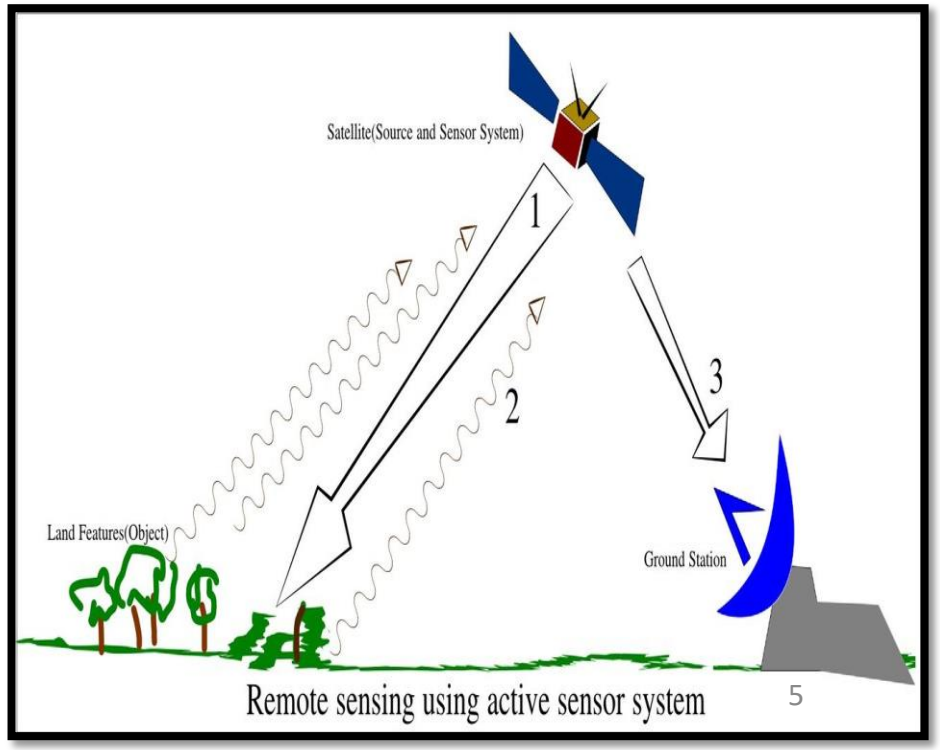


Types of Sensing



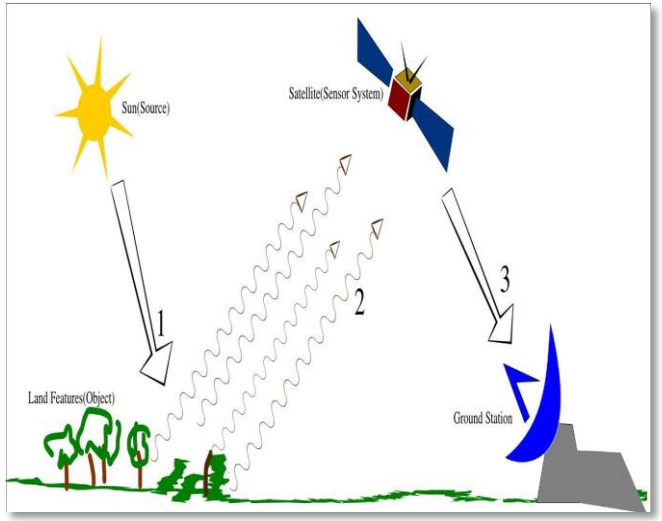
1. Passive sensing is a collection of energy that is reflected or emitted from the surface of the earth

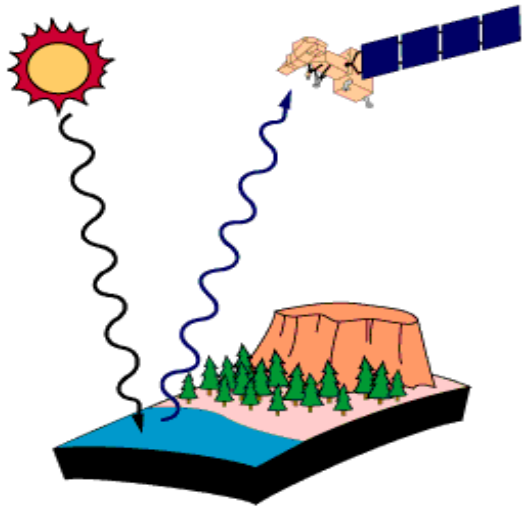
2. Active sensing system sends the energy towards the object then measure and detect the radiation that is reflected or backscattered from the object

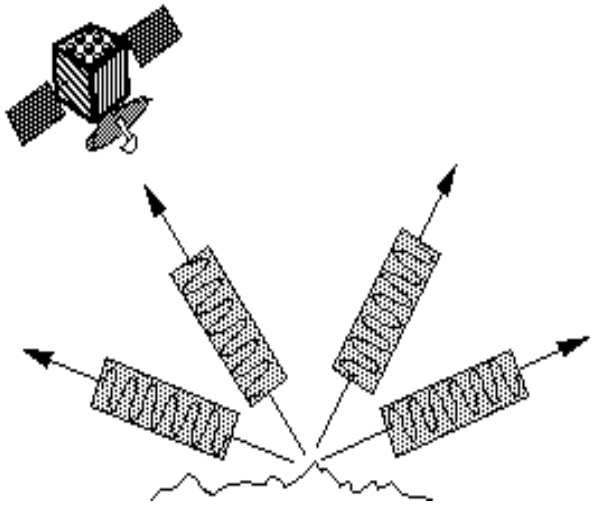


Remote Sensing observables

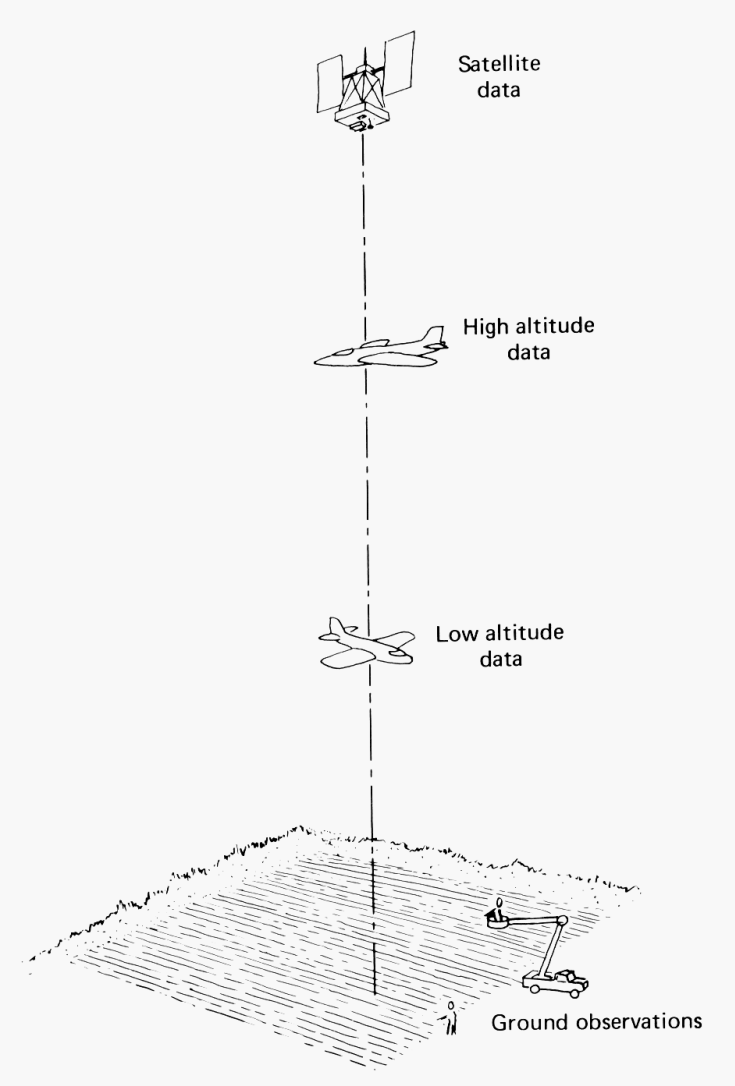
- Synoptic scale observation is done by sensing and recording **reflected, emitted and scattered energy** and processing, analyzing, and applying that information."







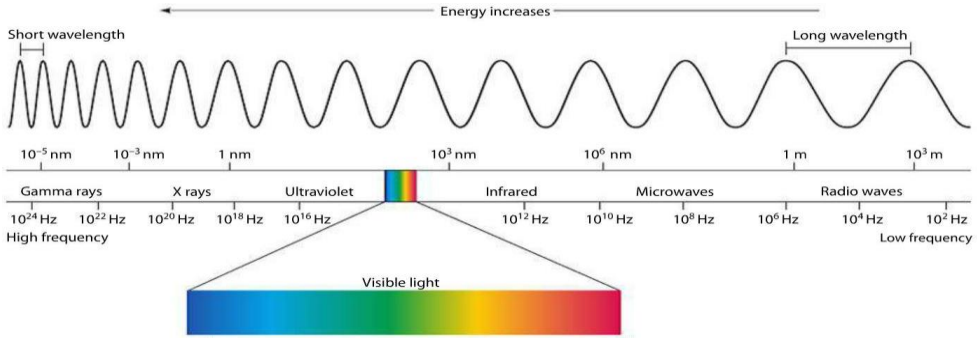
Platforms



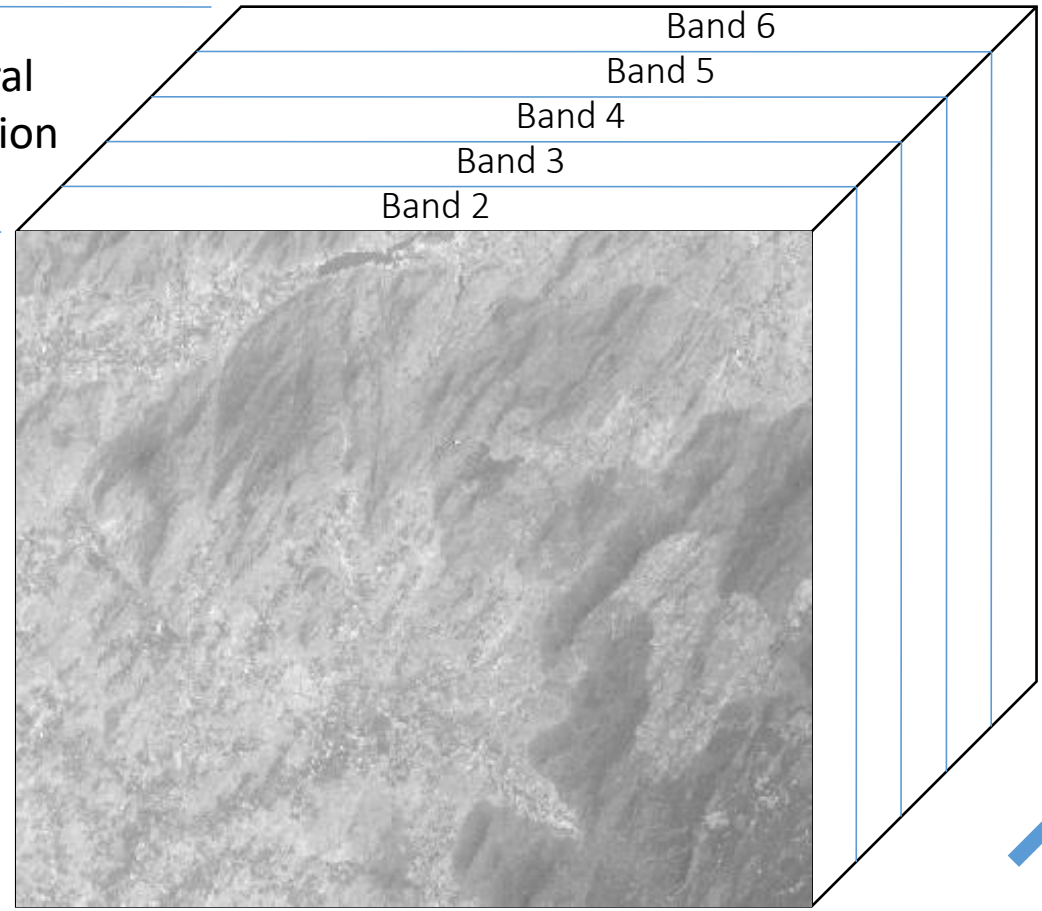
Platforms are:

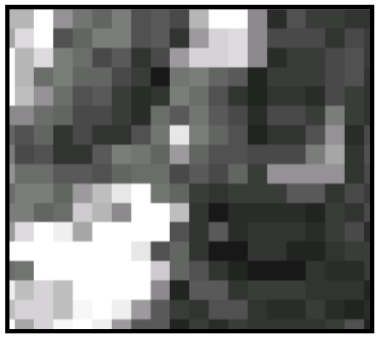
- Ground based
- Airborne
- Spaceborne

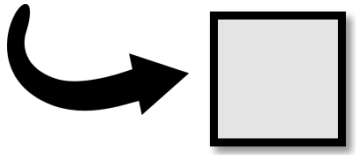
Sensing from 1 meter to 36,000 km height



Spectral Resolution

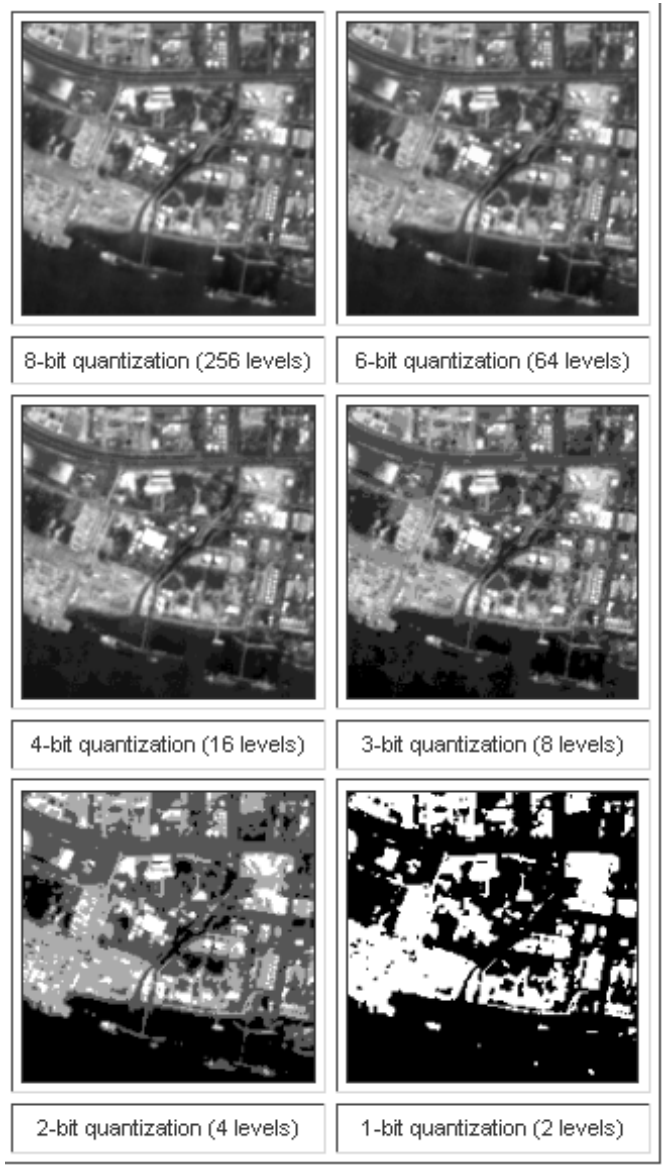






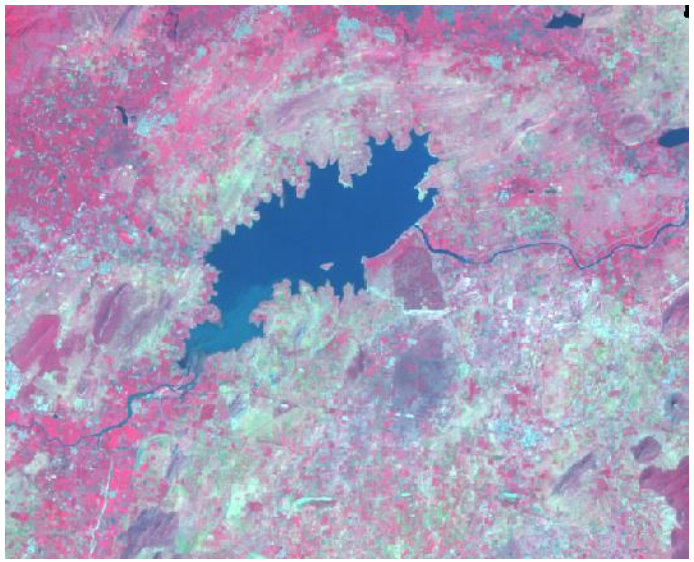
Spatial Resolution

Radiometric Resolution



Temporal Resolution

Year of Acquisition - 2000

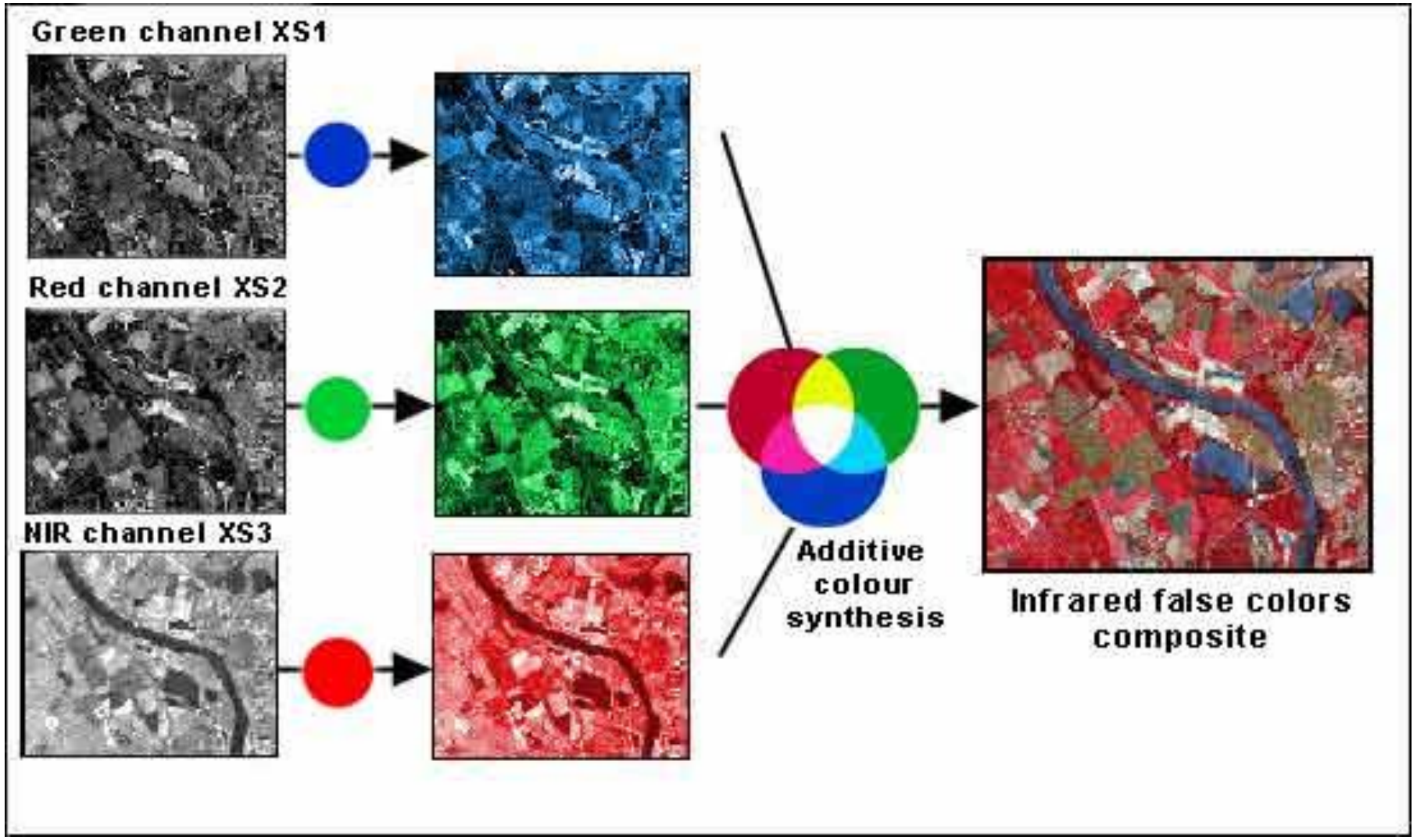


Year of Acquisition - 2005

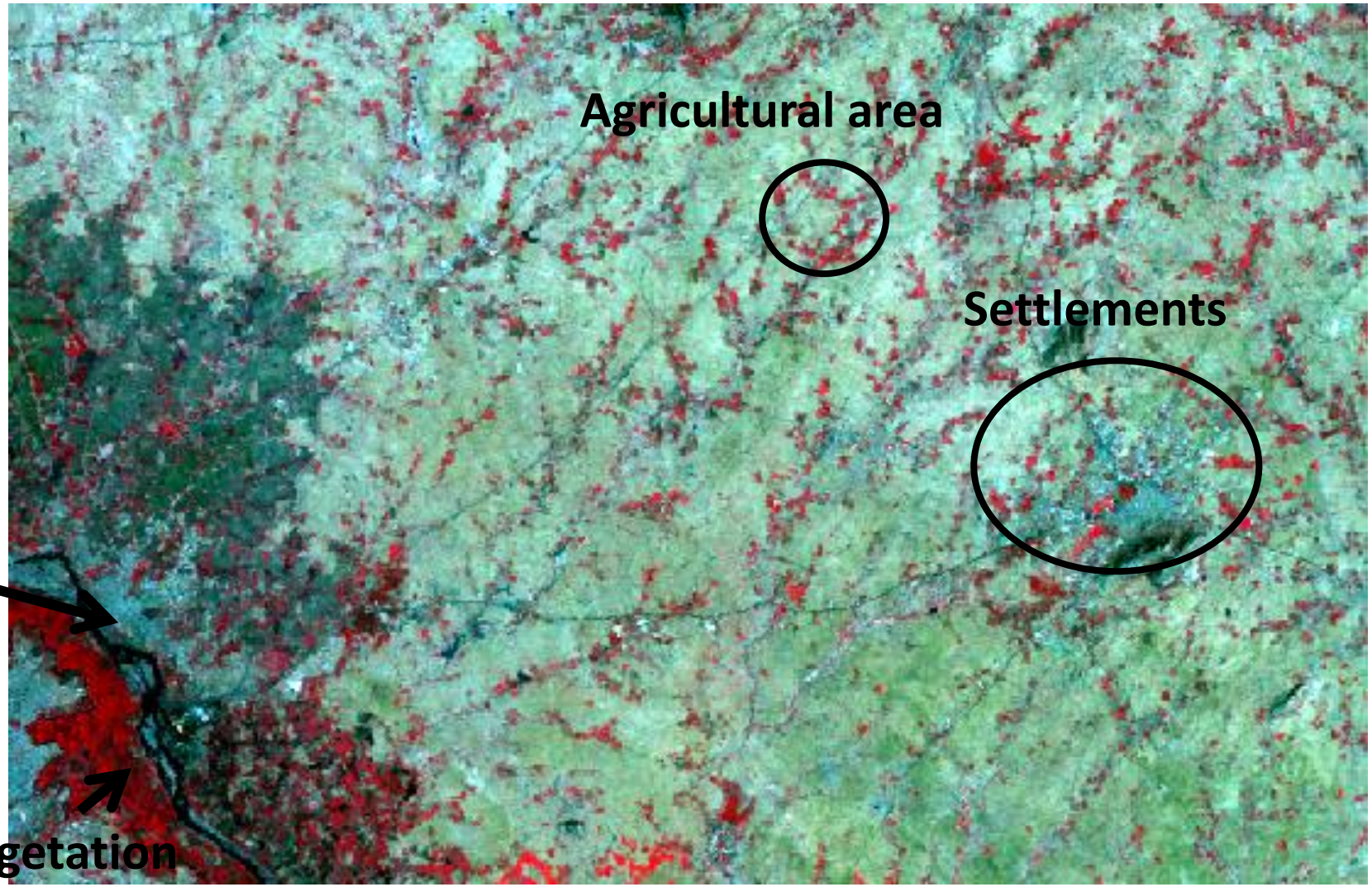
Sensor-platform characteristics

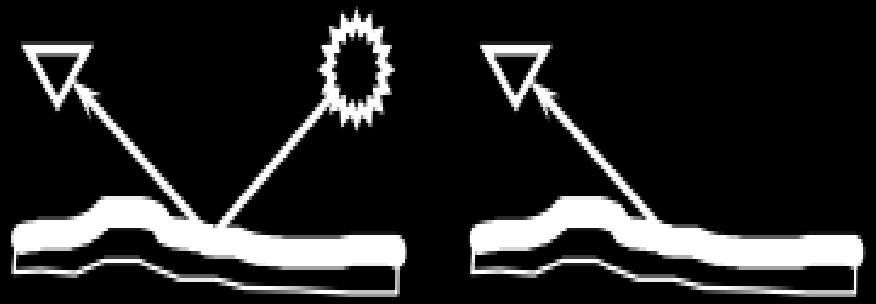
- **Spatial Resolution** - Spatial Resolution of the sensor and refers to the size of the smallest possible feature that can be detected .
- **Spectral Resolution** - It refers to the EMR wavelengths to which remote sensing system is sensitive.
- **Radiometric Resolution** – Radiometric resolution is the smallest difference in the radiant energy that can be detected by the sensor. (Quantitation Level)
- **Temporal Resolution** – Time frequency of data collection.

FCC (False Color Composite)

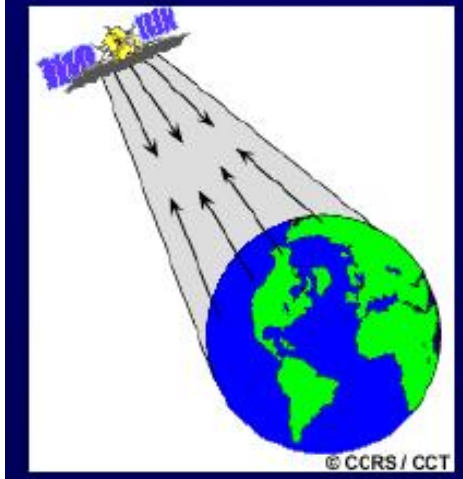


FCC (False Color Composite)

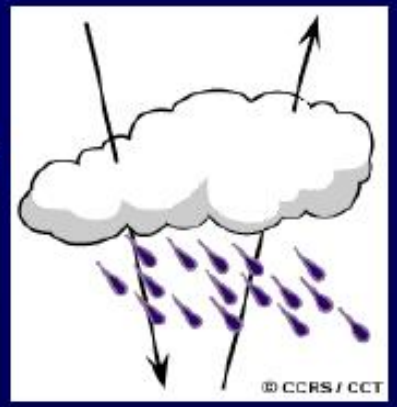


Sensor	Optical Sensor System		Antenna System
Wavelength Region	Visible – Reflective IR	Thermal Infrared	Microwave
			
Source	Sun	Object	Transmitted by Remote sensing System
Object	Reflectance	Thermal radiation (temperature, emissivity)	Backscattering coefficient
Electro-magnetic Spectrum	Visible – Reflective infrared	Thermal infrared	Microwave

Microwave Remote Sensing



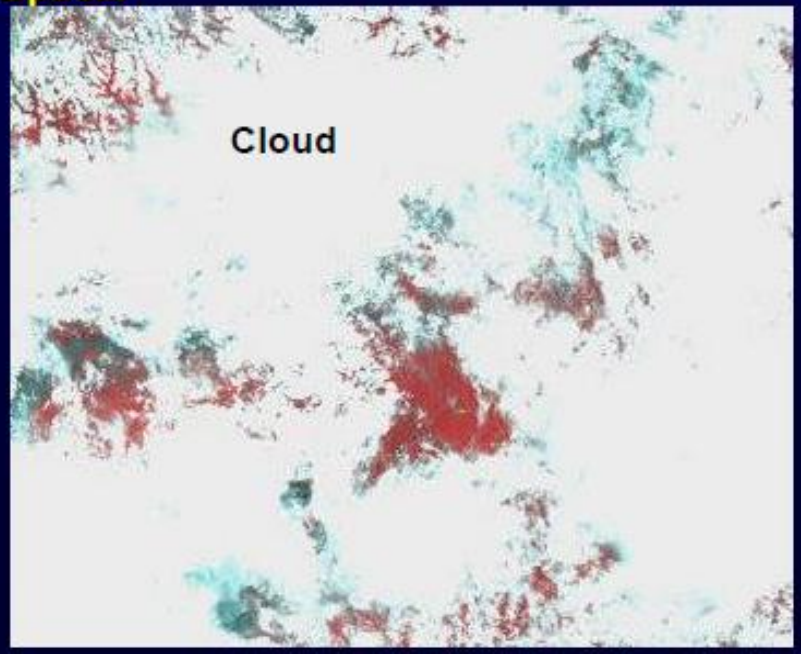
Active microwave sensors provide their own energy source for illumination.



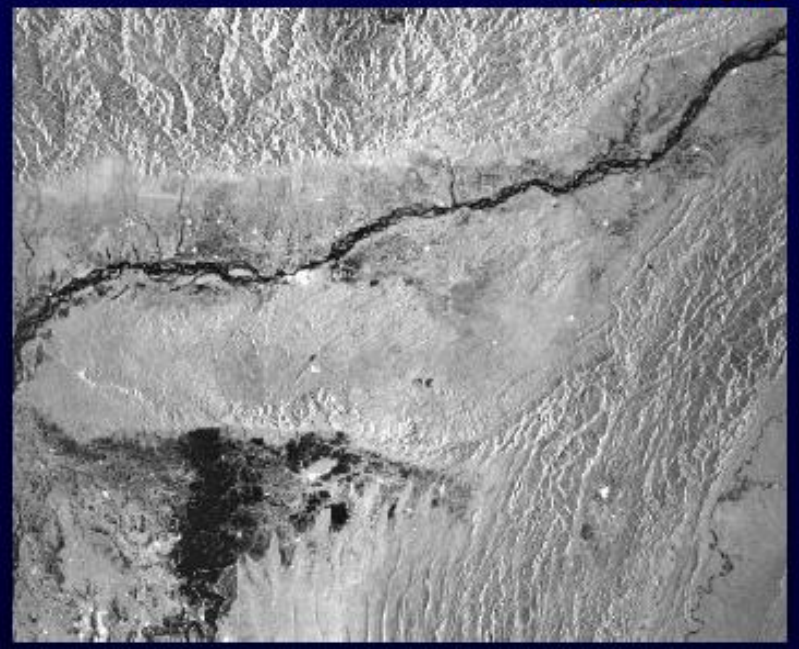
Cloud Cover is a major problem in many optical remote sensing applications

Microwave radiation can penetrate through Clouds

Optical

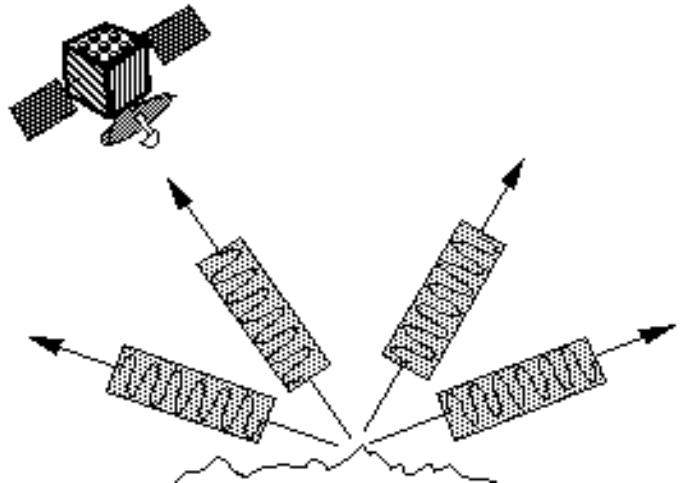


Microwave

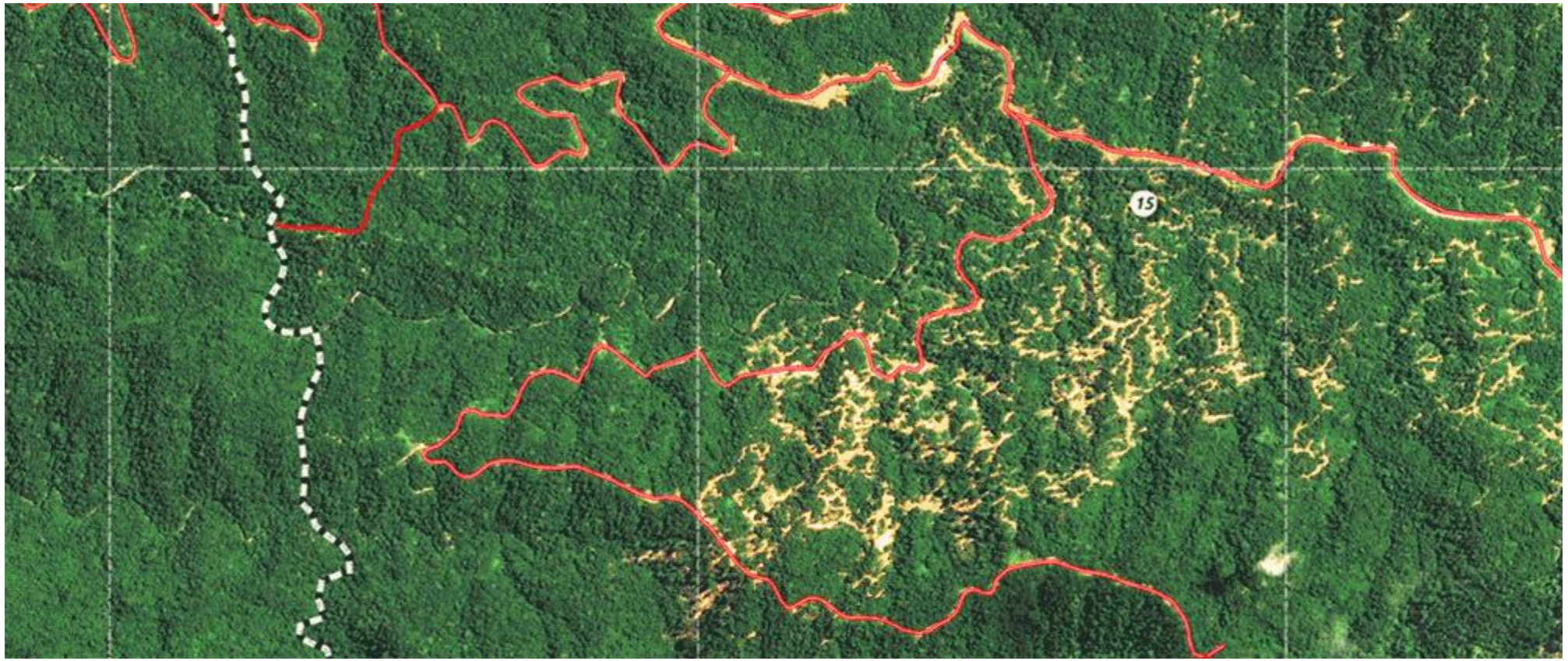


Microwave Remote Sensing

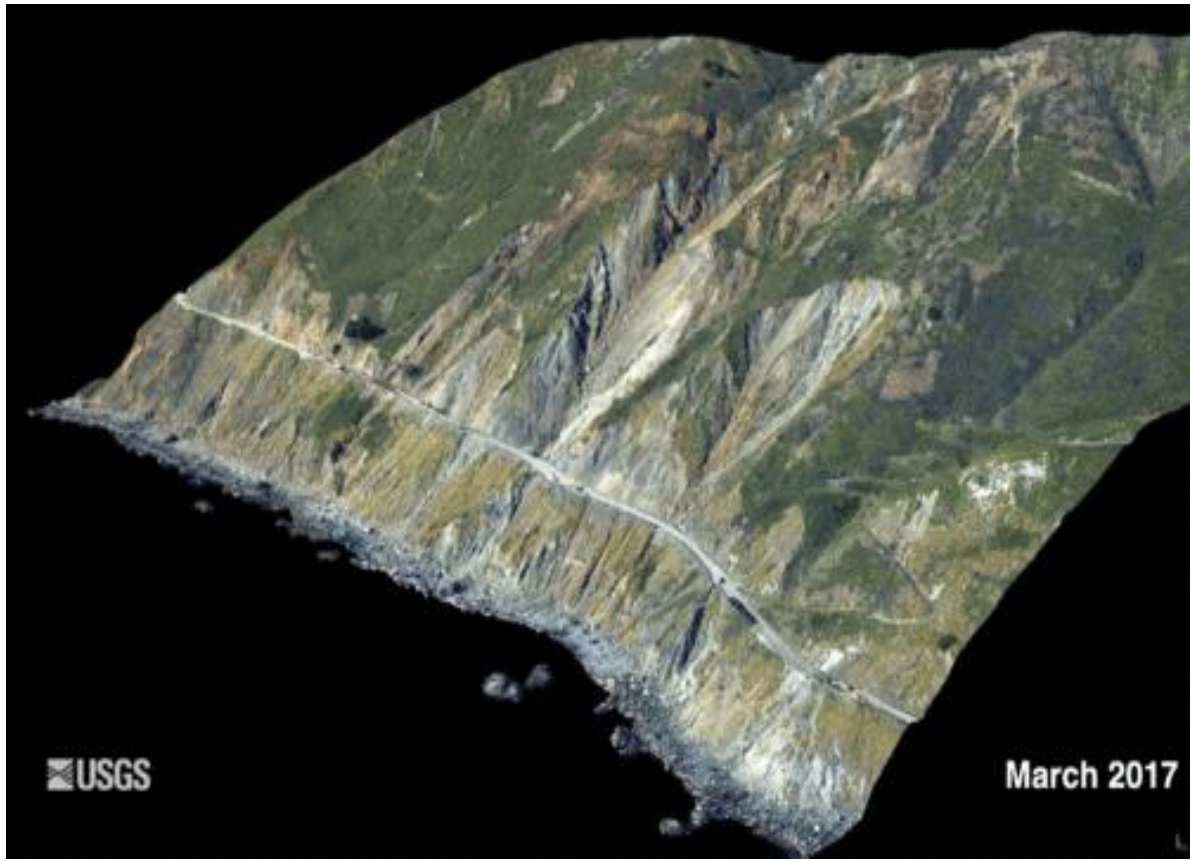
- Radar is an active remote sensing system because it provides its own source of energy. The system “illuminates” the terrain with longer electromagnetic energy, detects the backscattering energy returning from the terrain (called radar turn), and then records it as an image.



Classified SPOT satellite image is showing forest degradation over timer

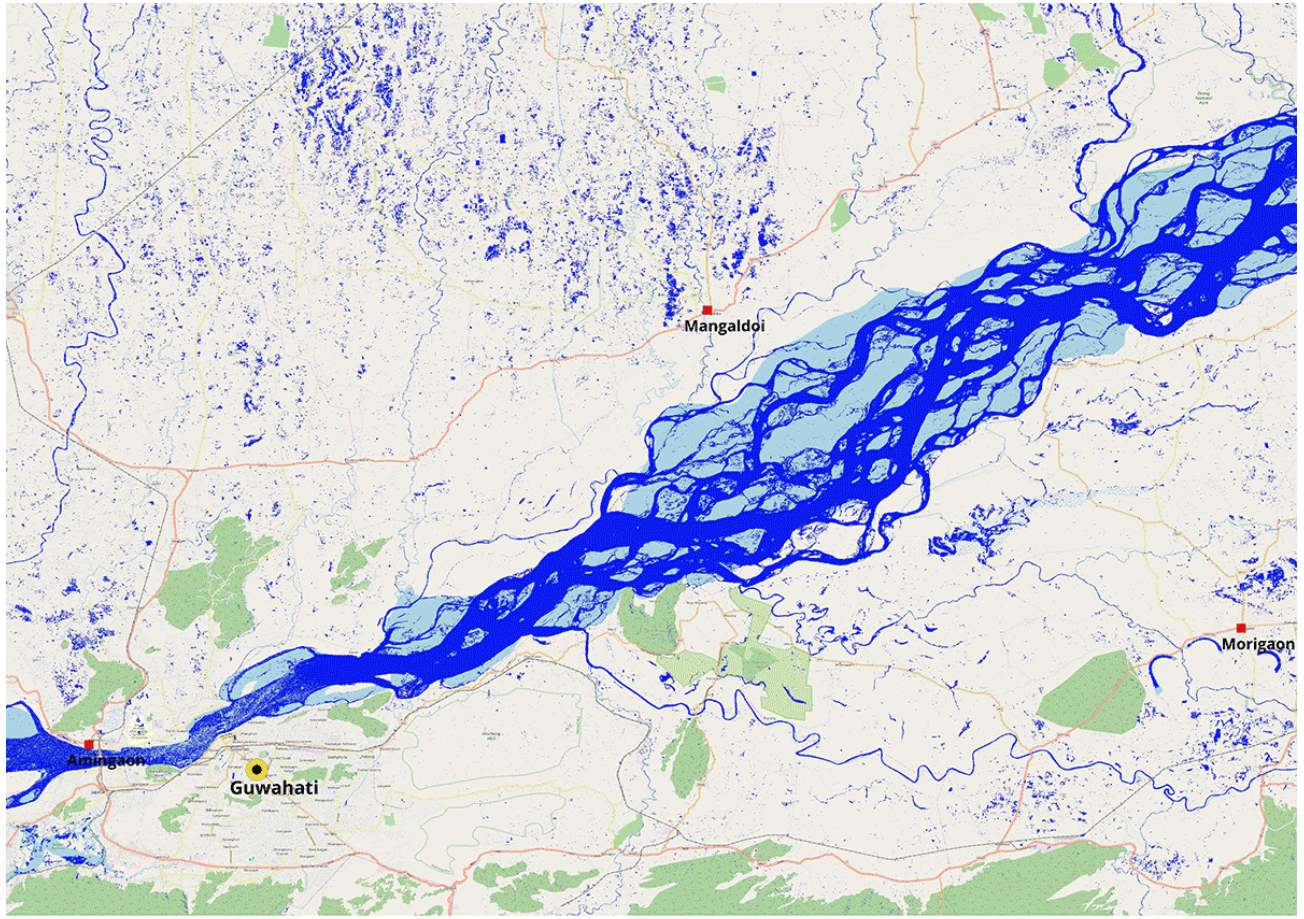


Landslide- Remote Sensing based Simulation



- It is expected that in future the Very High Resolution (VHR) imagery, such as from IKONOS-2, might be used successfully for landslide inventory.
- Multispectral imagery – vegetation, lithology and land use.
- Stereo SPOT imagery is used in geomorphological mapping, or terrain classification.
- Digital elevation models can be derived from SPOT or IRS images, or using airborne or spaceborne **InSAR** techniques.
- In the phase of disaster preparedness use could be made of the following techniques for the monitoring of landslide movements: ground measurements, photogrammetry, GPS, **Radar interferometry**.

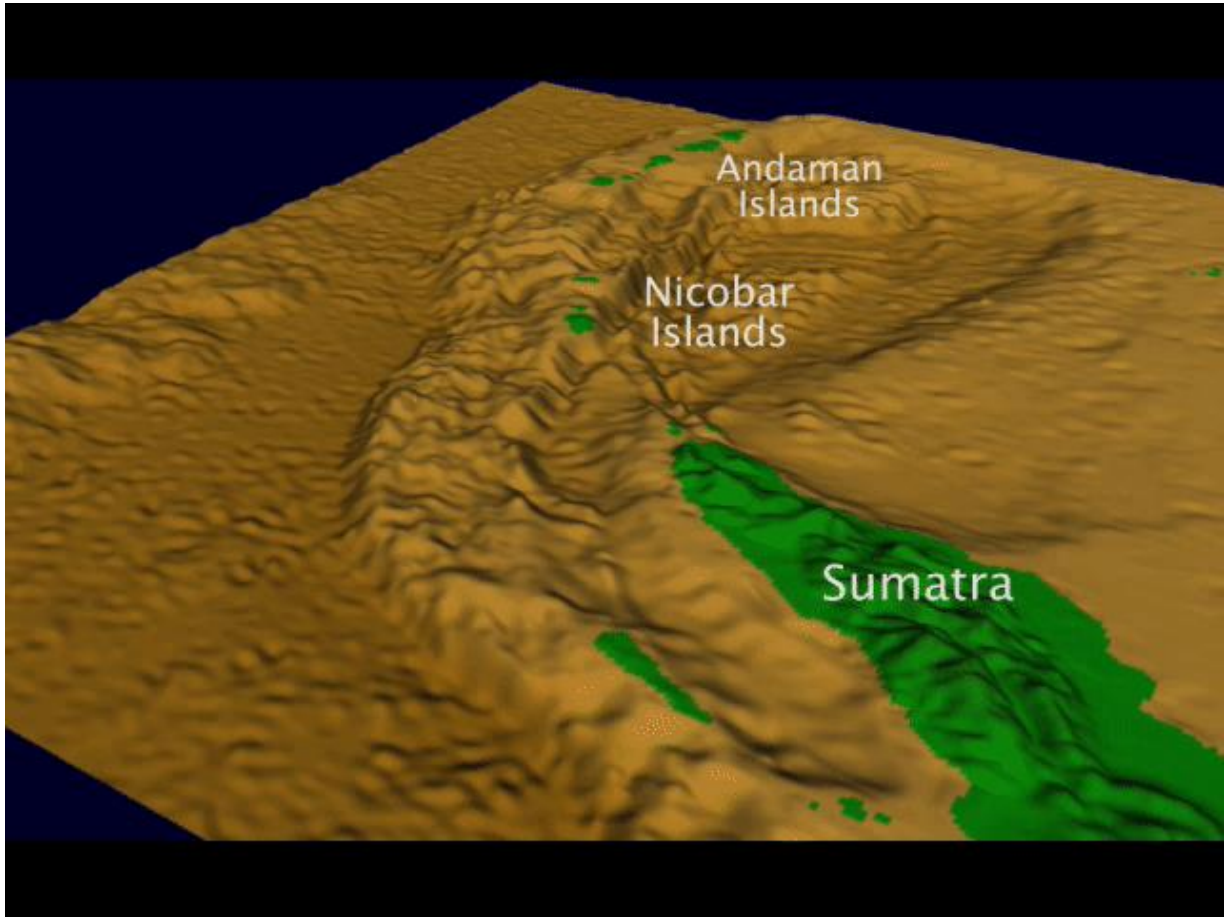
Flood – Remote Sensing Simulation



Recent time RADAR - - Sentinel-1 – considered to be effective

- Earth observation satellites are also used extensively in the phases of preparedness/warning and response/monitoring.
- The use of optical sensors for flood mapping is seriously limited by the extensive cloud cover.
- **Synthetic Aperture Radar (SAR)** from **ERS** and **RADARSAT** have been proven very useful for mapping flood inundation areas, due to their all weather capability.
- In India, ERS -SAR has been used successfully in flood monitoring since 1993, and Radarsat since 1998.
- Colour composites are generated using SAR data during floods and pre-flood SAR images.

Earthquake - Sumatra-Andaman earthquake seafloor movement



In earthquake hazard mapping two different approaches are to be distinguished, each with a characteristic order of magnitude of map scale

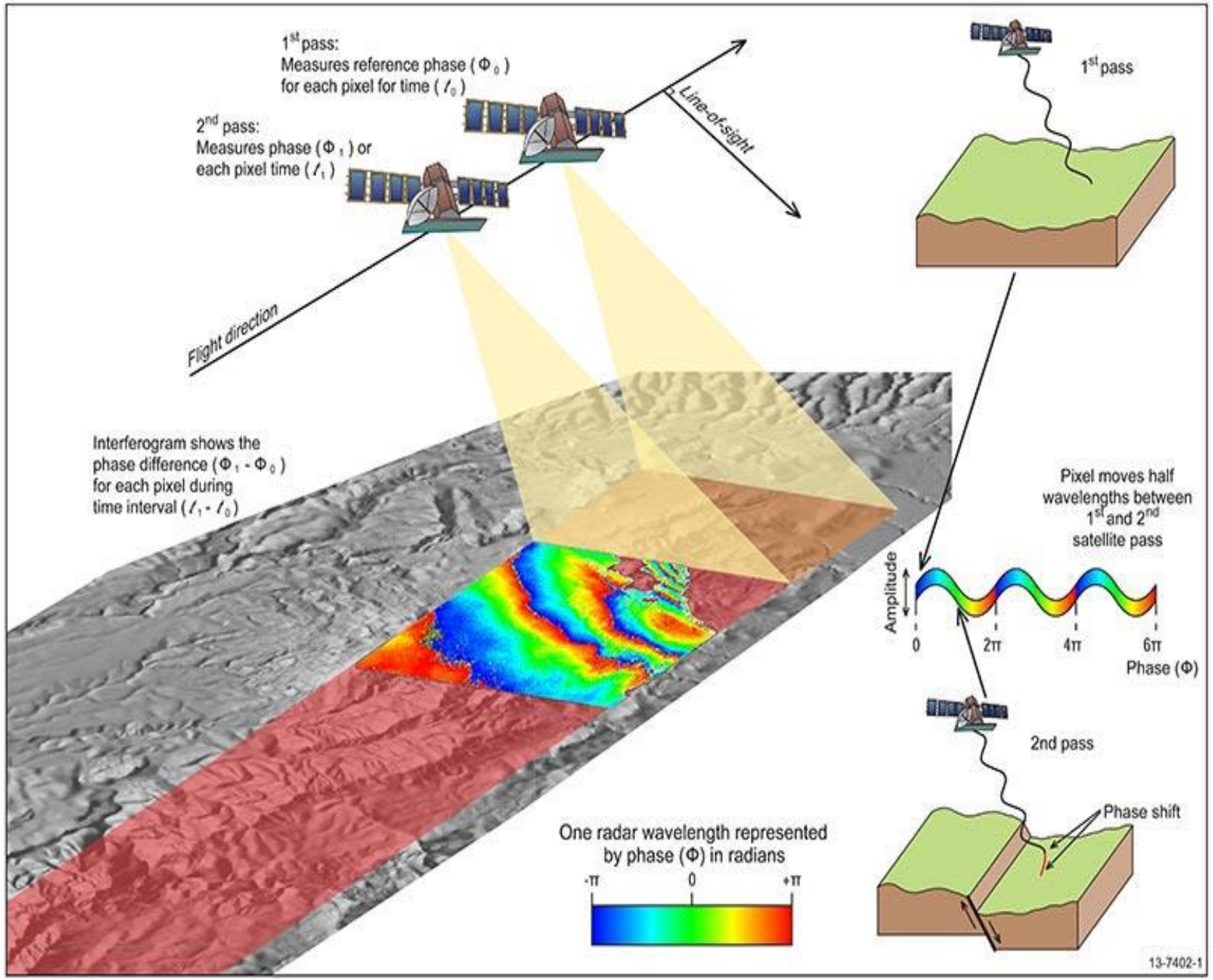
- small scale (regional) seismic macro zonation at scales 1:5,000,000 to 1:50,000 (Disaster Prevention- Remote Sensing).
- large scale (local) seismic micro zonation at scales of 1:50-25,000 to 1:10,000 (Disaster Management- accelerometers, geotechnical mapping, groundwater modelling, and topographic modelling)

Earthquake – Assisting Sensors

- Satellite Laser Ranging (SLR) and Very Long Base Baseline Interferometry (VLBI) have been used for the monitoring of crustal movement near active faults.
- Global Positioning System (GPS) - fault displacements
- An increasingly popular remote sensing application is the mapping of earthquake deformation fields using SAR interferometry (InSAR).
- In the phase of disaster relief, satellite remote sensing can at the moment only play a role in the identification of large associated features (such as landslides), which can be mapped by medium detailed imagery (SPOT, IRS etc.).
- Structural damage - Very High Resolution (VHR) mission, IKONOS-2, Quickbird.

(a) September 30, 2003

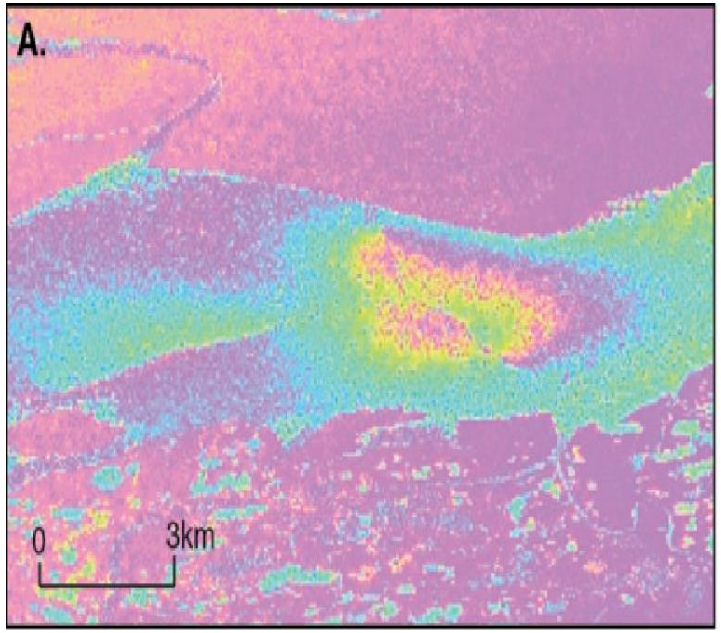
(b) January 3, 2004

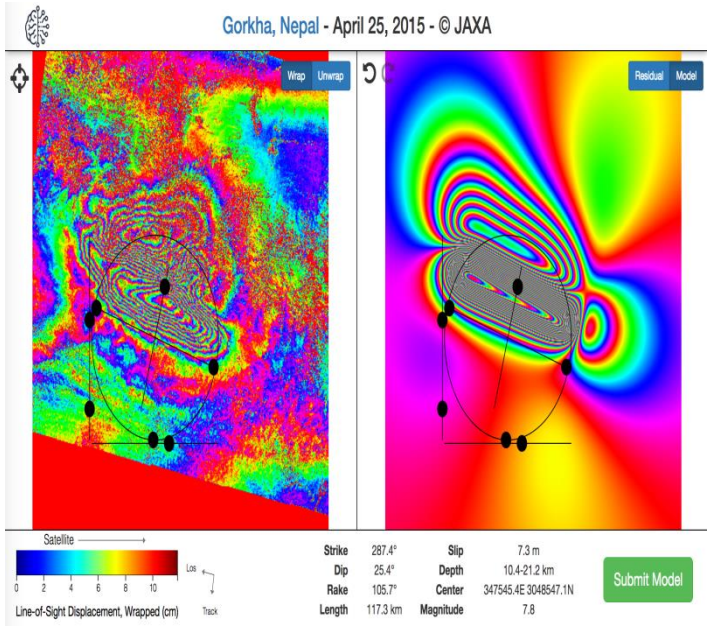


- Interferometry is the method of using two SAR images, taken with a time delay and/or cross-track parallax, to infer height or motion information of the Earth's surface.
- The time delay and phase difference of the two images are processes to obtain height and motion information

DEM - Interferometry

- Large Area Topographic Modelling
- Earthquake Engineering
- Hydrological Modelling
- Gravity Modelling





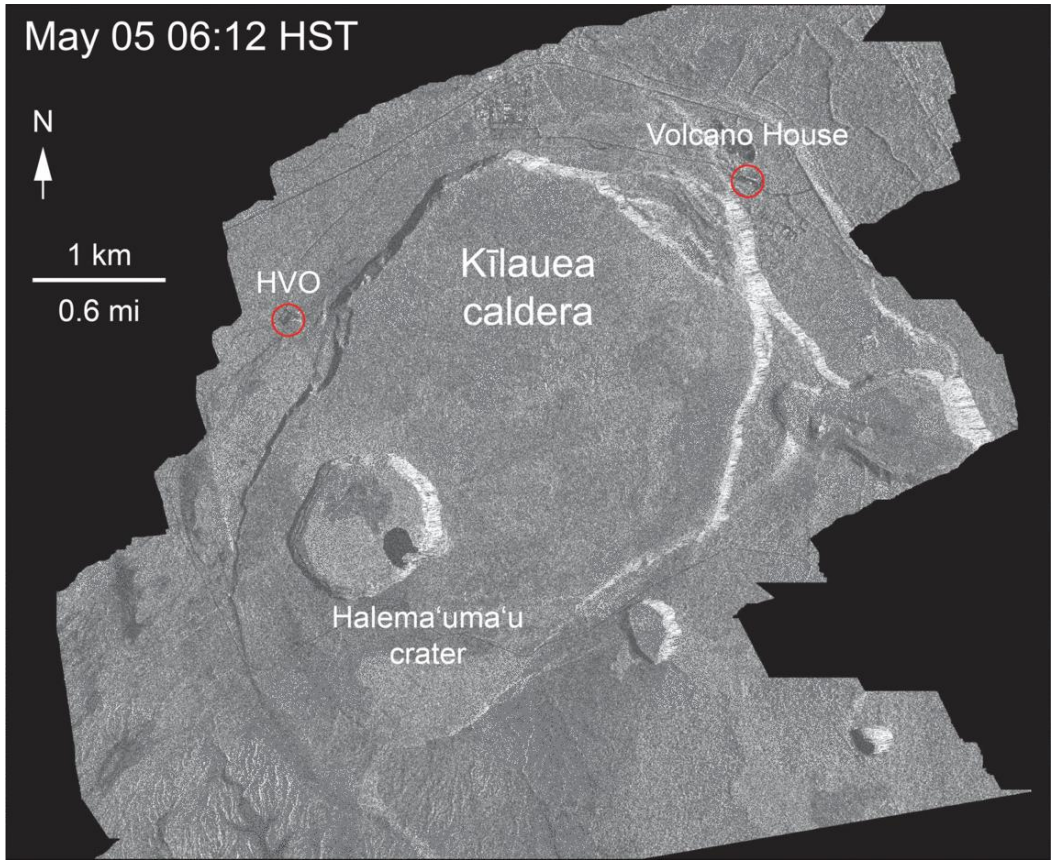
VOLCANIC ERUPTIONS

- Satellite remote sensing has become operational in some of the phases of volcanic disaster management, specifically in the monitoring of ash clouds.
- The major applications of remote sensing in volcanic hazard assessment are:

1) monitoring volcanic activity & detecting volcanic eruptions

2) identification of potentially dangerous volcanoes, especially in remote areas

3) mapping volcanic landforms and deposits



Synthetic Aperture Radar (SAR) sensors can provide valuable data which describes the **topography**. Measurement of ground deformation may eventually be achieved using **SAR inteferometry**.

What to be done?

- Distinguish between various data collection methodologies.
- Understand the pros and cons of different data sources.
- Select the right data set to answer your questions efficiently.

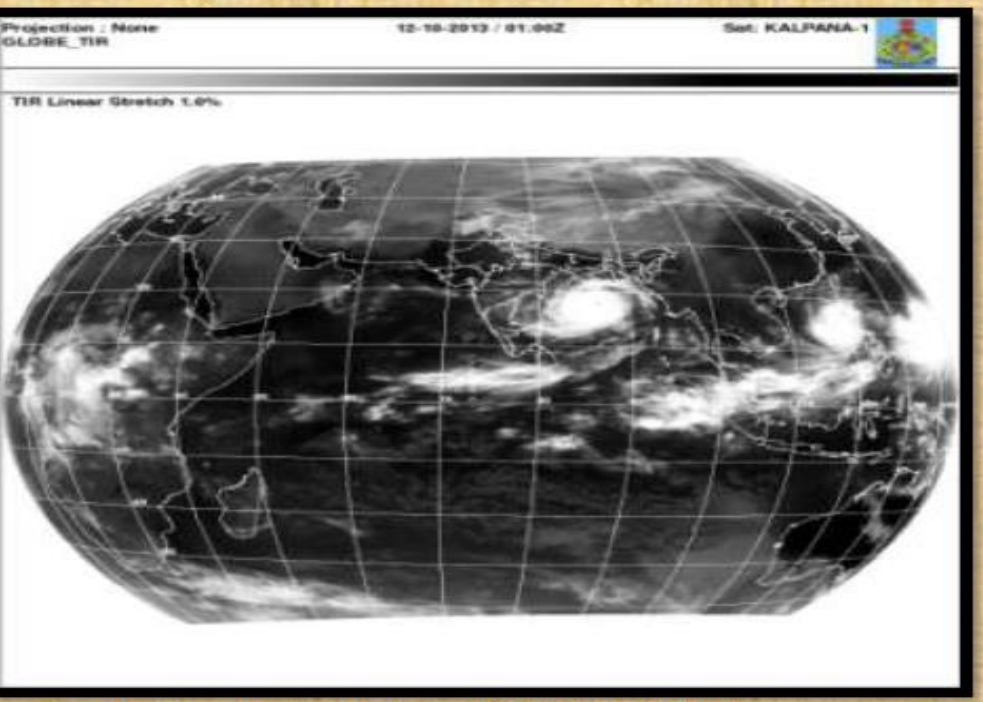
Microwave Remote Sensing Technologies

- Scatterometry – Cyclones
- Polarimetry – Drought, Flood
- Interferometry – Landslide, Volconic Eruption

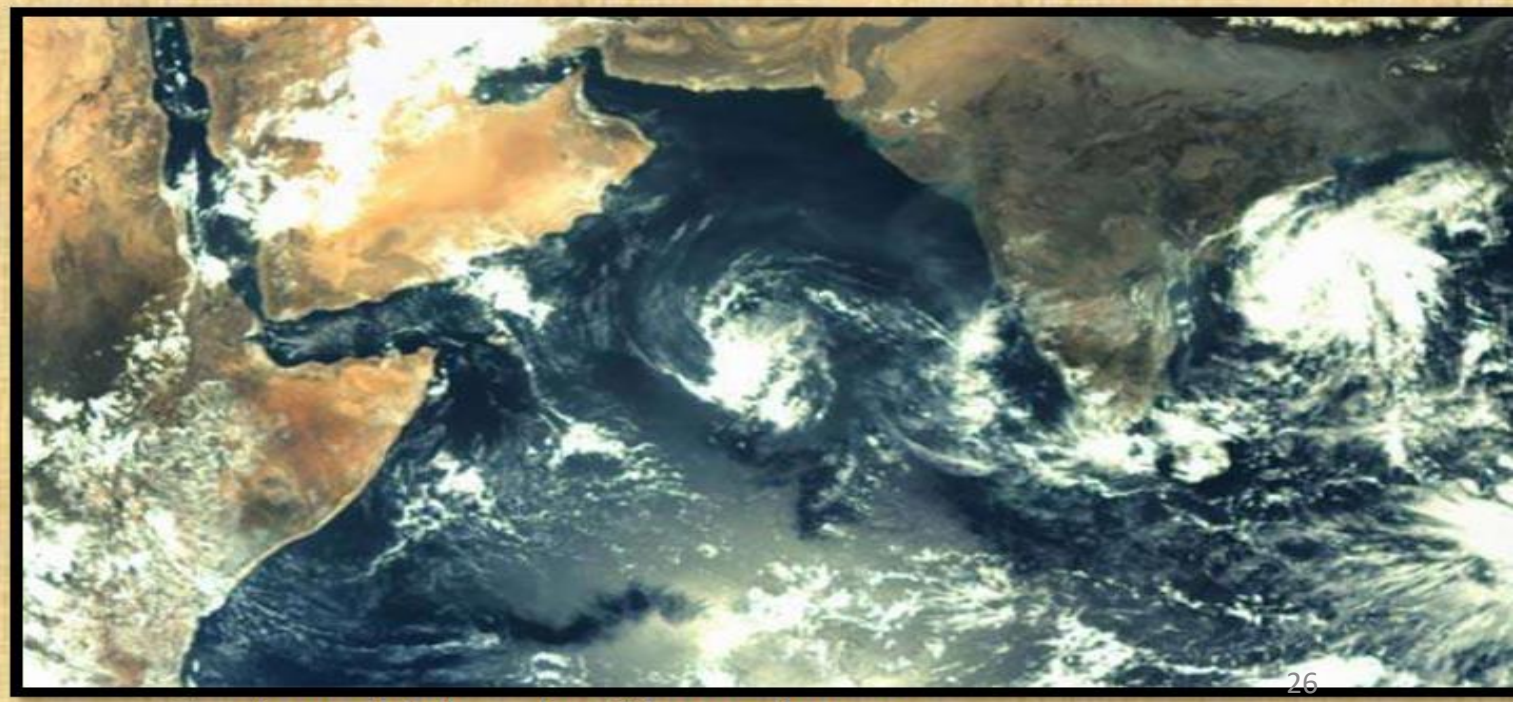
ROLE OF REMOTE SENSING: *IN* CYCLONE:

MITIGATION	PREPAREDNESS	RESCUE	RECOVERY	SATELLITES USED:
Risk modelling; vulnerability analysis.	Early warning; long-range climate modelling	Identifying escape routes; crisis mapping; impact assessment; cyclone monitoring; storm surge predictions.	Damage assessment; spatial planning.	KALPANA-1; INSAT-3A; QuikScat radar; Meteosat **SCATSAT-1**

Example:



Cyclone Lehar by KALPANA 1

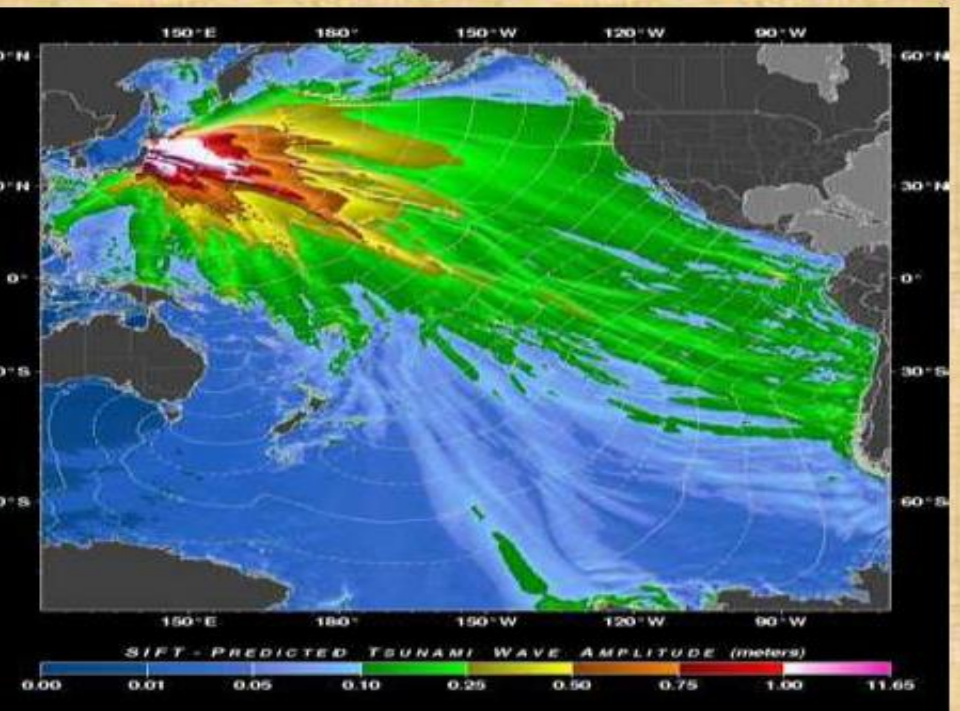


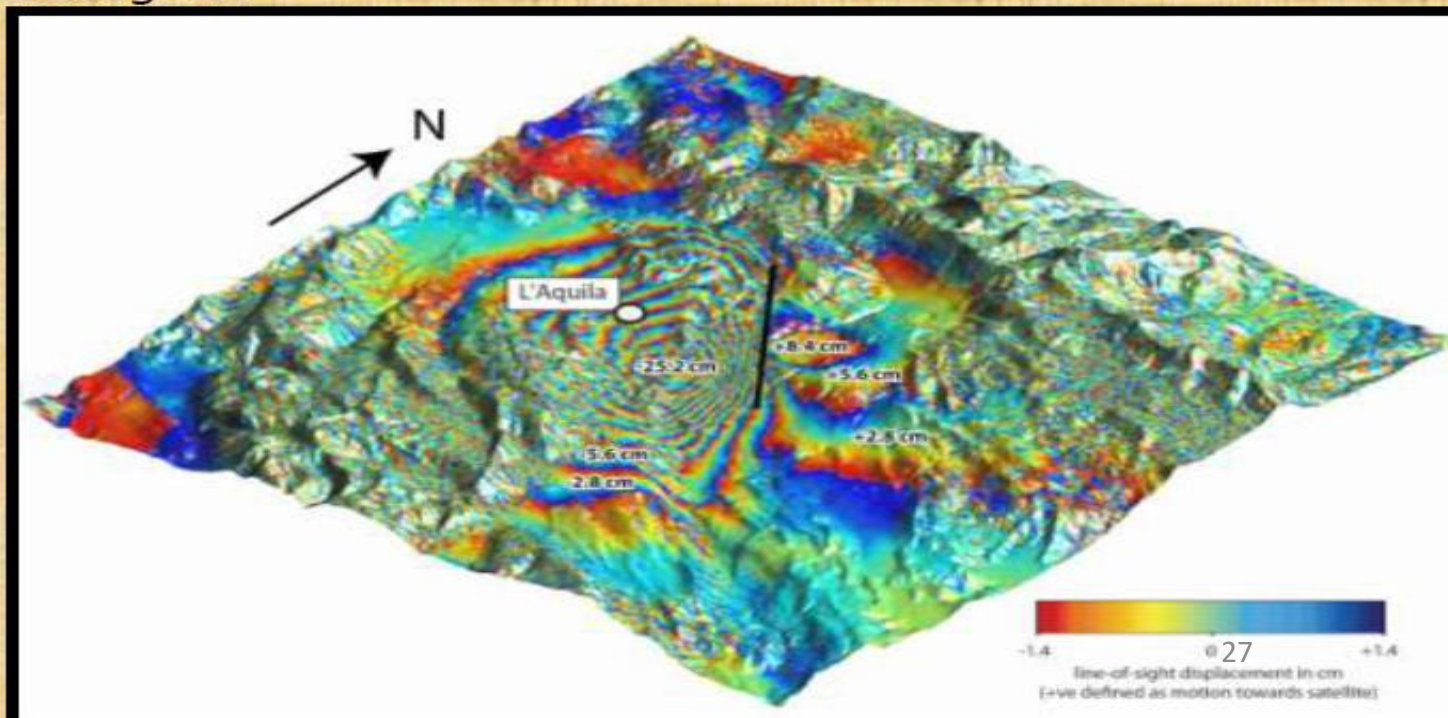
Cyclone Helen by Mangalayan

ROLE OF REMOTE SENSING: IN EARTHQUAKES:

MITIGATION	PREPAREDNESS	RESCUE	RECOVERY	SATELLITES USED
Building stock assessment; hazard mapping.	Measuring strain accumulation.	Planning routes for search and rescue; damage assessment; evacuation planning; deformation mapping.	Damage assessment; identifying sites for rehabilitation.	PALSAR; IKONOS 2; InSAR; SPOT; IRS

The **World Agency of Planetary Monitoring and Earthquake Risk Reduction** (WAPMERR) uses remote sensing to improve knowledge of building stocks — for example the number and height of buildings. High resolution imagery can also help hazard mapping to guide building codes and disaster preparedness strategies.





ROLE OF REMOTE SENSING: *IN* *FLOODS:*

MITIGATION	PREPAREDNESS	RESCUE	RECOVERY	SATELLITES USED
Mapping flood-prone areas; delineating flood-plains; land-use mapping.	Flood detection; early warning; rainfall mapping.	Flood mapping; evacuation planning; damage assessment.	Damage assessment; spatial planning.	Tropical Rainfall Monitoring Mission; AMSR-E; KALPANA I;

Sentinel Asia — a team of 51 organisations from 18 countries — delivers remote sensing data via the Internet as easy-to-interpret information for both early warning and flood damage assessment across Asia.
It uses the **Dartmouth Flood Observatory's** (DFO's) River Watch flood detection and measurement system, based on AMSR-E data, to map flood hazards and warn disaster managers and residents in flood-prone areas when rivers are likely to burst their banks.

Flood In Uttarakhand

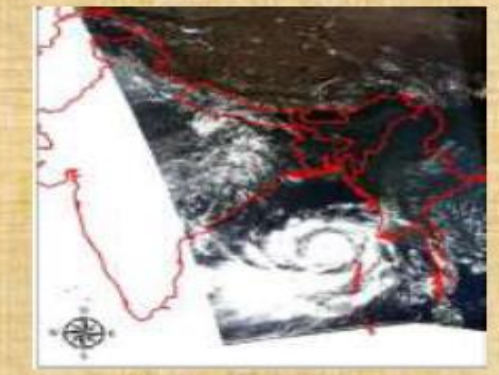
Flood In Assam

ROLE OF REMOTE SENSING: *IN OTHER DISASTERS:*

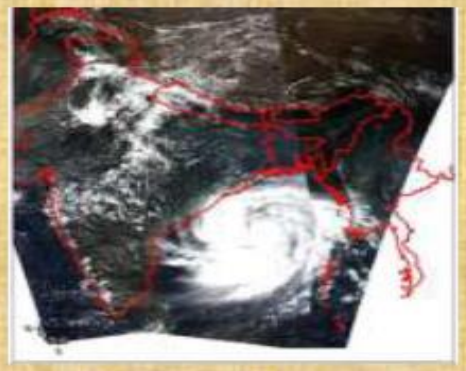
DISASTER	MITIGATION	PREPAREDNESS	RECOVERY	RESCUE	SATELLITES USED
DROUGHT	Risk modelling; vulnerability analysis; land and water management planning.	Weather forecasting; vegetation monitoring; crop water requirement mapping; early warning.	Monitoring vegetation; damage assessment.	Informing drought mitigation.	FEWS NET; AVHRR; MODIS; SPOT
VOLCANO	Risk modelling; hazard mapping; digital elevation models.	Emissions monitoring; thermal alerts.	Mapping lava flows; evacuation planning.	Damage assessment; spatial planning.	MODIS and AVHRR; Hyperion
FIRE	Mapping fire-prone areas; monitoring fuel load; risk modelling.	Fire detection; predicting spread/direction of fire; early warning.	Coordinating fire fighting efforts.	Damage assessment.	MODIS; SERVIR; Sentinel Asia; AFIS
LANDSLIDE	Risk modelling; hazard mapping; digital elevation models.	Monitoring rainfall and slope stability.	Mapping affected areas;	Damage assessment; spatial planning; suggesting management practices.	PALSAR; IKONOS 2; InSAR; SPOT; IRS

CASE STUDY :
USE OF REMOTE SENSING & GIS in PHAILIN CYCLONE

8th October



10th October



11th October

12th October

7th October, 2013: Indian Meteorological Department received information from KALPANA I, OCEANSAT and INSAT 3A Doppler radars deployed at vulnerable places, with over-lap, sensors in the sea and through the ships, about a cyclone forming in the gulf between Andaman Nicobar and Thailand named PHAILIN (Thai for "Sapphire").

8th October, 2013: IMD confirmed cyclone formation and predicted it as "severe cyclone" and its effects would be felt from Kalingapatnam in Andhra Pradesh to Paradeep in Odisha, and that it would probably first strikethe port of Gopalpur in Ganjam district at about 5 pm on 12 October. The wind speed could touch 200(km/h).

10th October, 2013: IMD prediction of a severe cyclone was converted to a "very severe cyclonic storm" with wind speeds up to 220 kmph. the US Navy's Joint Typhoon Warning Centre predicted it would have wind speeds up to 315 km/h.

12th October, 2013: The "very severe" cyclonic storm had its landfall at Gopalpur port at about 9 pm with a wind speed of 200 km/h.

CASE STUDY :
USE OF REMOTE SENSING & GIS in PHAILIN CYCLONE

MITIGATION	PREPAREDNESS	RESPONSE	RECOVERY
  GIS: Risk modelling; vulnerability analysis; Strengthening EWS; Disaster Response Infrastructures; Disaster Drills	Early Warning System; Constant updates from ISRO, IMD and USNJTWC etc.; Distribution of Satellite Phones , VHF and HAMRADIO to DMs, BDO's, Sarpanch etc.; Mass Evacuation on the basis of cyclone's path over the state.	 Google Crisis Map; Google People Finder; ODRAF & NDRF Deployment;	Relief Operations coordinated by Navy & Air Force; Disaster Assessment; Logistics Coordinated by Centrally Operated Units; Spatial planning;

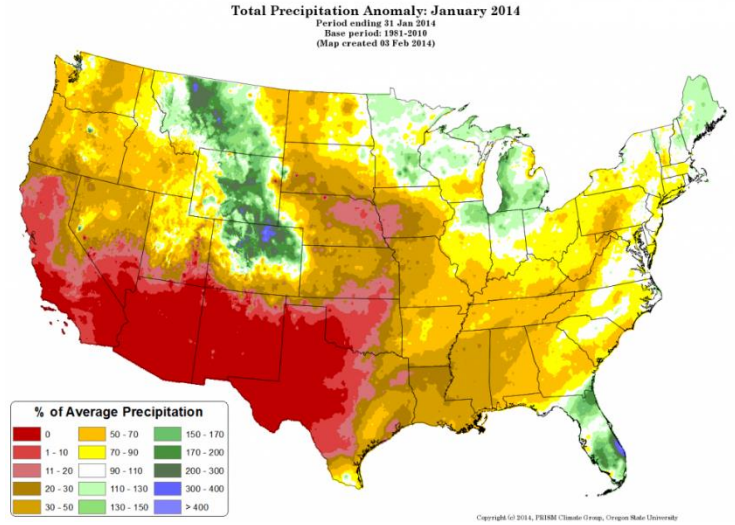
GIS – Geographical information System

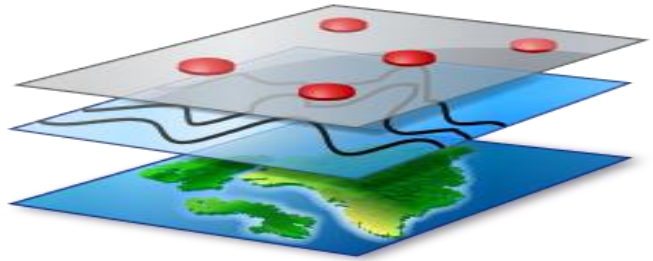
- GEO:- Earth.
- Geography:- Study of earth and where things are.
- Information:- For capturing, managing, analyzing and understanding information.
- System:- A set of Software , hardware and Data.

GIS is capable to collect, map, analyze and model the Vector and Raster data

Spatial Data?

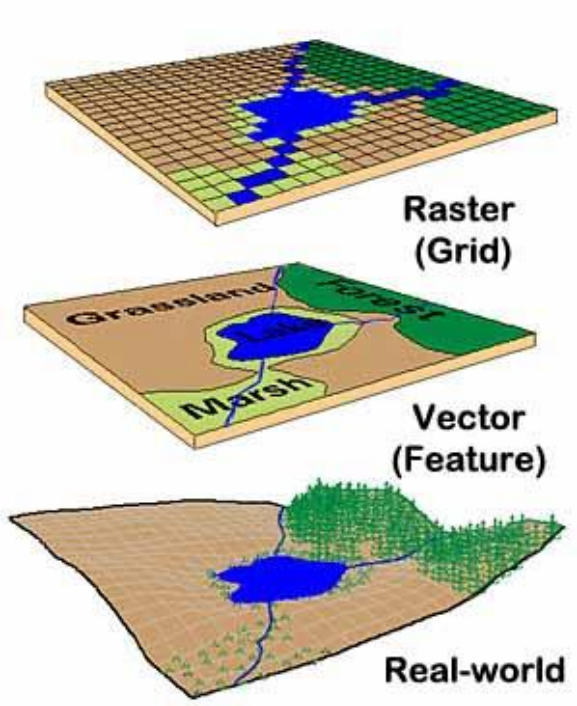
- Spatial data are data with a geographic component, such as maps, aerial photography, satellite imagery, GPS data, rainfall data, borehole data etc.
- Many of these data will have a different projection and co-ordinate system, and need to be brought to a common map-basis, in order to superimpose them.





Spatial and Non-spatial Products of GIS

- **Vector Data** - Spaghetti model – represented by point, line and polygon.
- **Raster Data** – composed of pixels.
- **DEM (Digital Elevation Model) is a raster product (satellite data product) used to extract the slope and aspect map of the surface- useful in forest fire and landslide applications.**
- Attribute data (Non-spatial data)



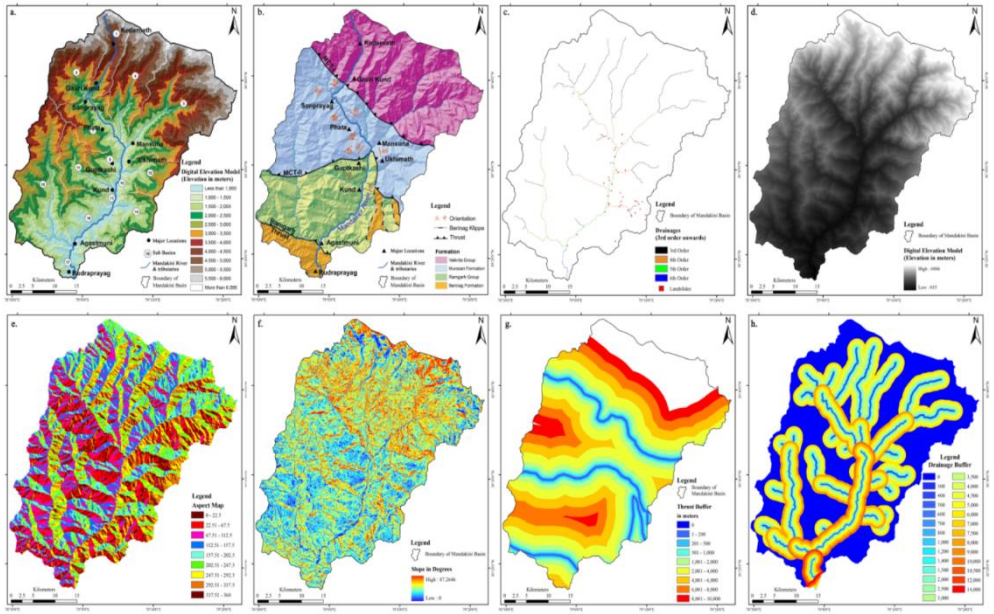
Attributes of aepoint

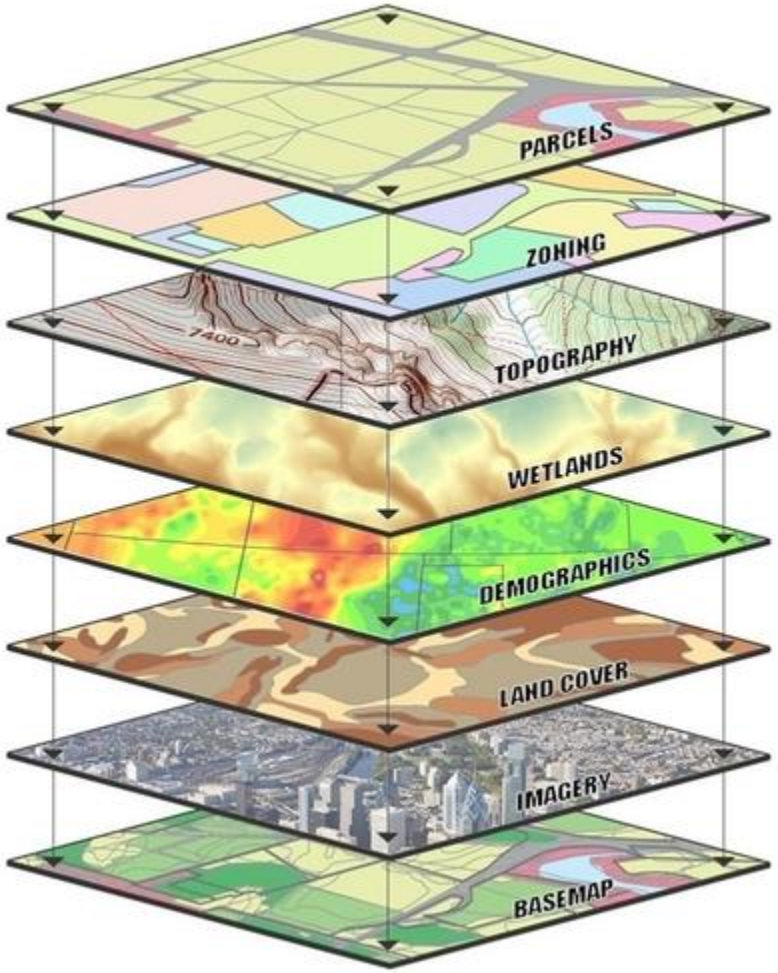
AEPOINT_	AEPOINT_ID	AEPTTYPE	AEPTNAME
1	8574	1	POWELL RIVER
2	8361	4	COMOX
3	8607	4	TEXADA
4	8420	4	PRINCETON
5	8399	4	PITT MEADOWS
6	8368	4	VANCOUVER INTL
7	8677	1	CHILLIWACK
8	8539	1	BOUNDARY BAY
9	8419	1	NANAIMO
10	8430	3	ABBOTSFORD
11	12404	1	BELLINGHAM INTL
12	8417	4	VICTORIA
13	12475	4	ROCHE HARBOR
14	11631	1	FRIDAY HARBOR

Record: 1 Show: All Selected Records (0 out of 66 Selected.)

GIS (Geographical Information System)

- Geographic Information System (GIS) is a computer based application of technology involving spatial and attributes information to act as a decision support tool. It keeps information in different layers and generates various combinations pertaining to the requirement of the decision making.





GIS (Geographical Information System)

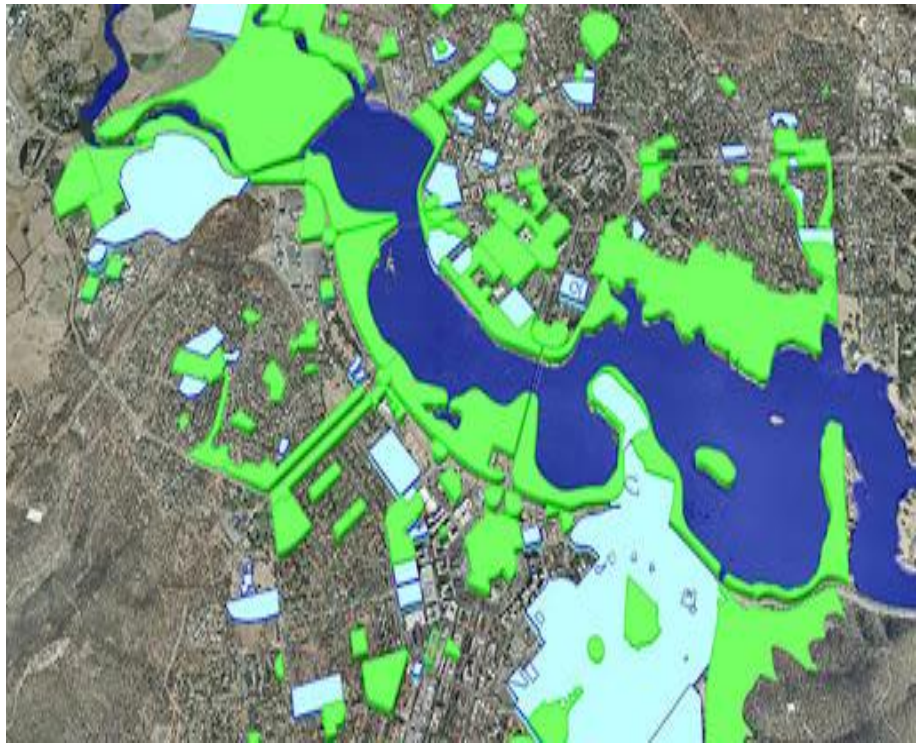
- The data required for disaster management is coming from different scientific disciplines, and should be integrated.
- Data integration is one of the strongest points of GIS. In general the following types of data are required:
  - ❖ Data on the disastrous phenomena (e.g. landslides, floods, earthquakes), their location, frequency, magnitude etc.
  - ❖ Data on the environment in which the disastrous events might take place: topography, geology, geo-morphology, soils, hydrology, land use, vegetation etc.
  - ❖ Data on the elements that might be destroyed if the event takes place: infrastructure, settlements , population, socio-economic data etc.
  - ❖ Data on the emergency relief resources, such as hospitals, fire brigades, police stations, warehouses etc.

Application of GIS in Disaster Management

- Identification of cyclone shelters location.
- Use in Automated Weather Stations (AWS)
- Preparation of the district vulnerability maps.
- Strengthening of embankment.
- Repair of roads.
- Identification of weak points in the embankments.
- Preparing the base map indicating location.

Application in Flood

- Remote sensing data for flood management should always be integrated with other data in a GIS. Especially on the local scale a large number of hydrological and hydraulic factors need to be integrated.
- One of the most important aspects in which GIS can contribute is the generation of detailed topographic information using high precision Digital Elevation Models, derived from geodetic surveys, aerial photography, SPOT, LiDAR (Light detection And Ranging) or SAR.
- These data are used in two and three dimensional finite element models for the prediction of floods in river channels and floodplains.



ArcGIS : The Complete Enterprise GIS

esri India

- Arc GIS is a complete GIS system for authoring, serving and using geographic information.
- It is an integrated collection of GIS software products for building and deploying a complete GIS wherever it is needed – on desktops, servers or custom applications, over the web or in the field

Role of GIS in Disaster Management Cycle

esri India

For Decision making - require information like

Where …? Incident exact location, Critical Infrastructure

Where is … ? Nearest Hospital, Fire Station …

Where do I … ? Safety storage siting …

What are …? Sensitive & Vulnerable Areas…

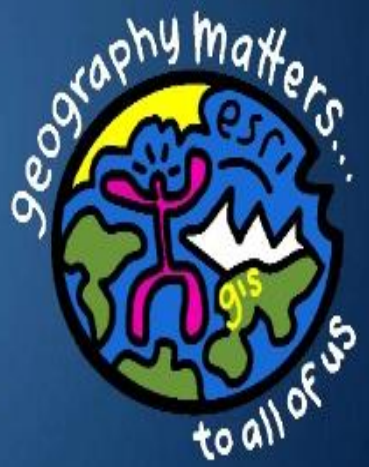
What if…? Facility provided…

Which … ? Optimum Route …

How many…? People are affected by floods …

How does…? Sustainable development …

What has changed …? Deforestation, Disasters, …



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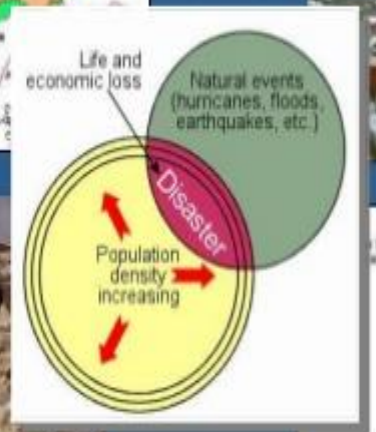
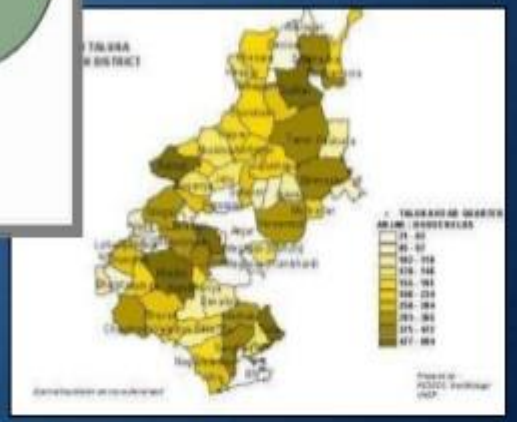
All Disasters Are Spatial In Nature …





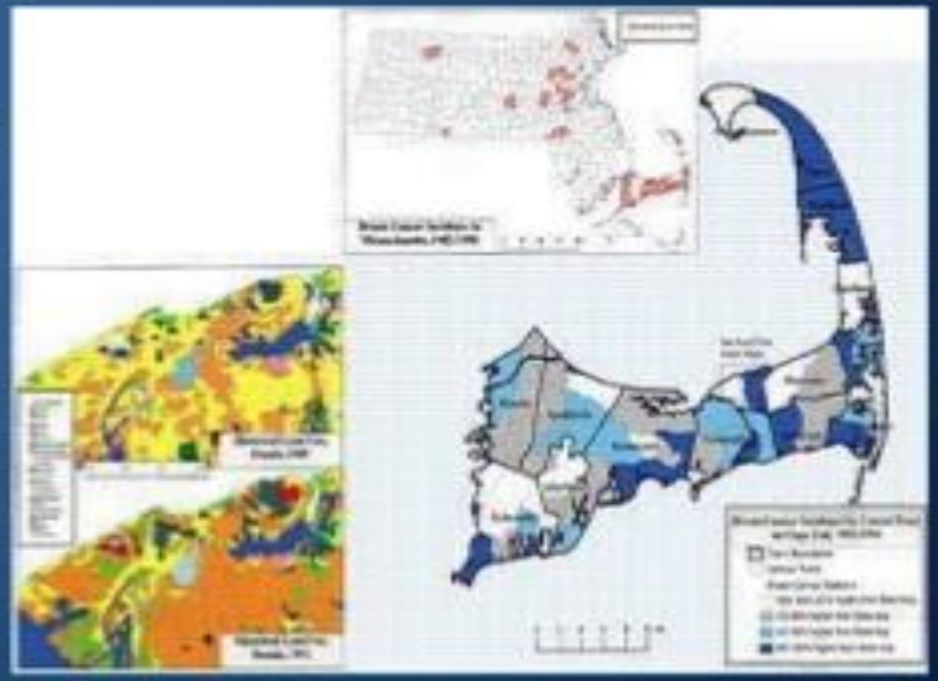
…lets try how best can we manage them !

Why GIS ?

- **Integrate** many different types of data
  - Spatial data + Non-spatial data (statistical, texts,..)

- With GIS we can easily:
  - Draw maps and visualize spatial distributions
  - Edit and alter existing data
  - **Map where things are?**
  - Map Quantities & Densities
  - Accurately measure distances and areas
  - Simulate scenario's for better planning

& much more



Using GIS for Emergency Management

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The Geographic Approach

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How GIS can be leveraged for Disaster Management

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GIS is the most complete information system for analyzing, modeling, and displaying community vulnerability

GIS aids in quickly establishing full situational awareness by linking people, processes, and information together using geography. It provides the map interface into getting a handle on an emergency and nimbly adjusting to change.

Accurate cataloging of GIS data and services, combined with your organization's existing investments, gives you an edge for turning raw data into useful information.

Getting accurate information from field operations back to the command center can be a difficult challenge. Mobile GIS gives you the advantage.

Where are My Assets

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Aeronautical
Retail
Land Records
Coastal Protection & Marine
Defense
Education
Parks & Recreation
Agriculture
Port Security
Hospital
Museum
Rescue
Economic Development
Telecommunication
Electric/Gas
Government
Banking
Security
Facility Management
Tourism
Refuse Collection
Lighting
Landscape Planning
Public Works
Sign Inventory

Field enablement

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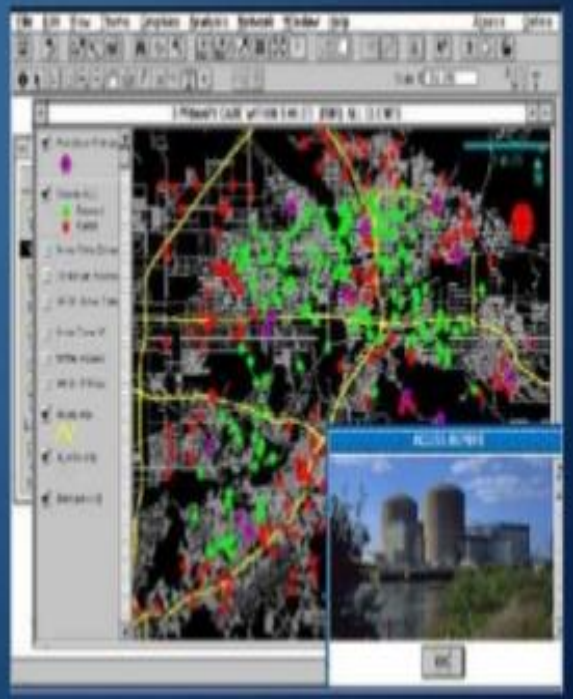
- Collect and Use Information Remotely
- Coordinate and Prioritize Response
- Optimize Operational Efficiency

Improving work in remote environments

Response and Recovery

Where? Who? How Long?

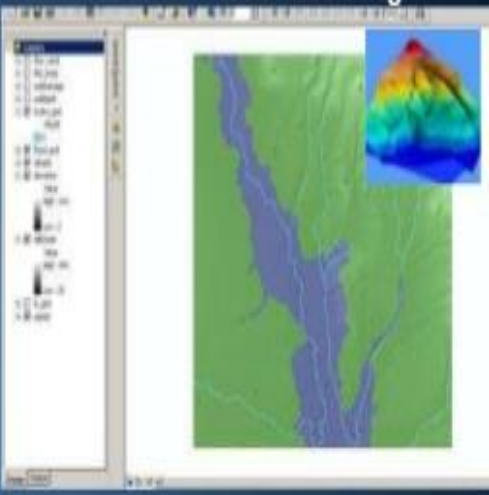
- GIS helps in creating Common Operational View
- GIS uses include:
  - *Mass Evacuation*
  - *Emergency Vehicle Dispatch and Tracking*
  - *System Restoration Monitoring*
  - *Damage Assessment*
  - *Infra availability assessment*



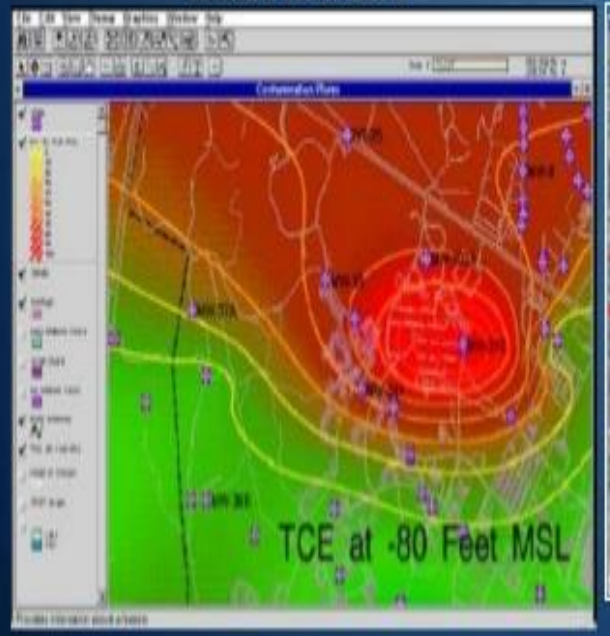
Assessment and Preparedness

- GIS uses include:
  - *Emergency Management Planning*
  - *Modeling Events*
  - *Mapping Critical Asset Locations Infrastructure Inventory*
  - Placement scenarios for motion detectors or cameras

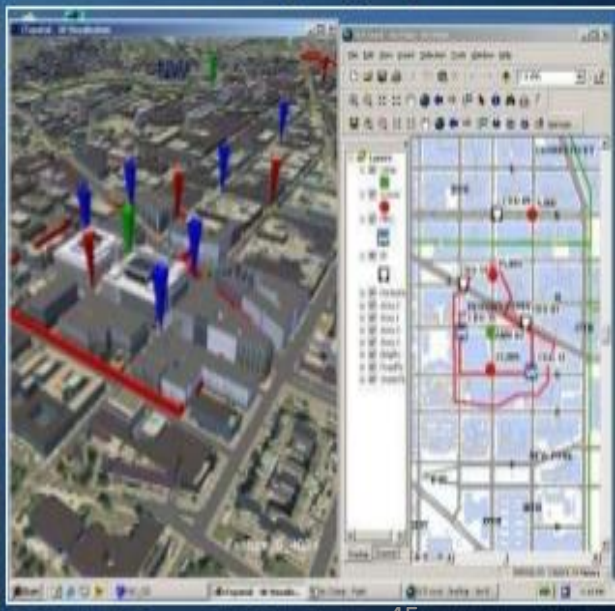
Flood Modeling



Motion Detection



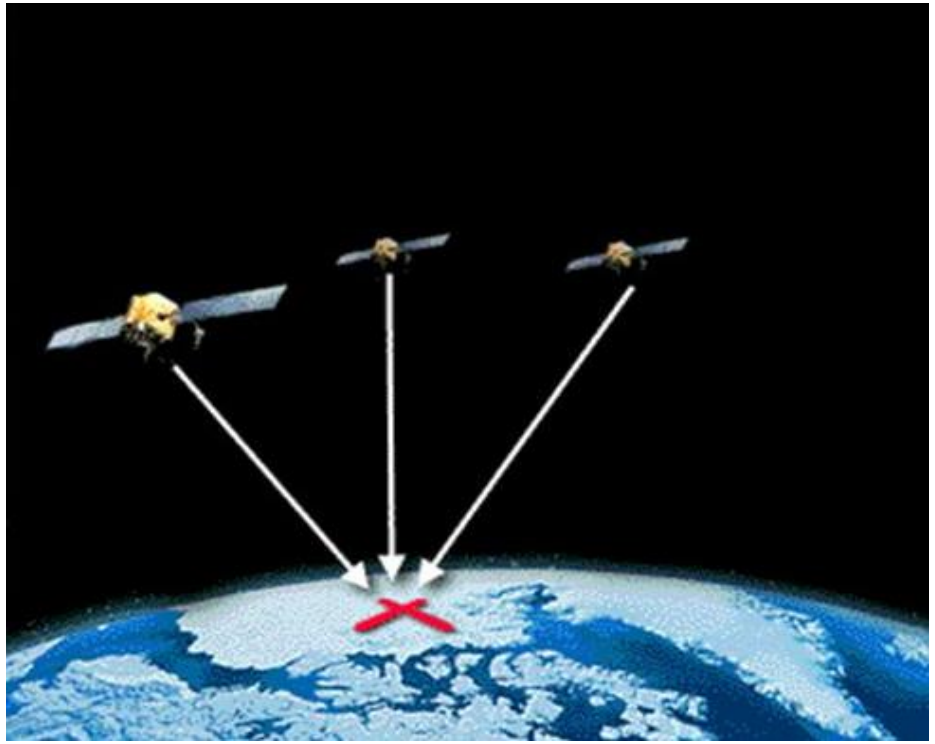
Planning/Mapping Critical Infra



Building a common operating environment

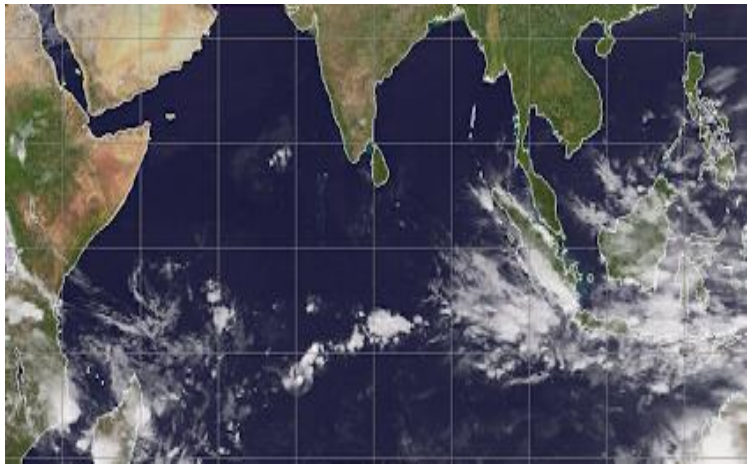
GPS in emergency management

Satellite based positioning– 3D positioning (Latitude, longitude & Altitude or x, y & z)



SATELLITE-BASED RADIO NAVIGATION SYSTEM

- WORLD-WIDE COVERAGE
- ALL WEATHER OPERATION
- CONTINUOUS SIGNAL

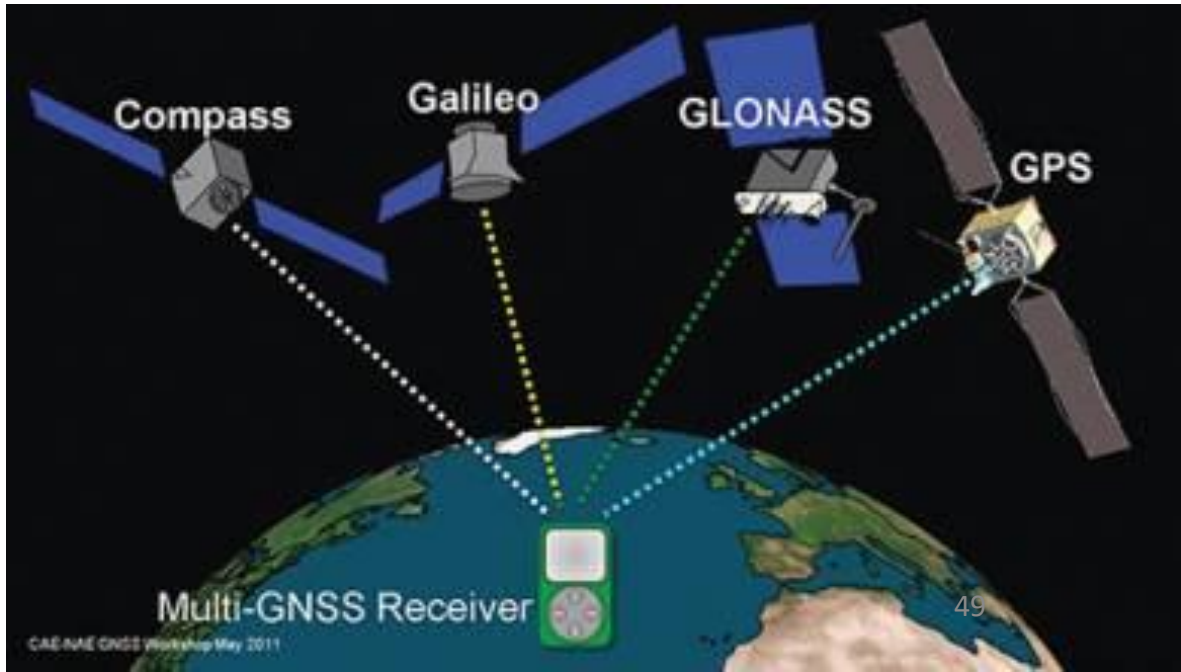


- *NAVIGATION*
- *POSITIONING*
- *PRECISE TIME*

Global Navigation Satellite System (GNSS)

- Satellite based navigation system that provide **autonomous geospatial positioning** with Global coverage.
- **GNSS** is a network of satellites that continuously **transmit coded information** to identify the locations on the earth by measuring the distance from the satellites.

- GNSS involves **satellites, ground stations** and **user equipment.**

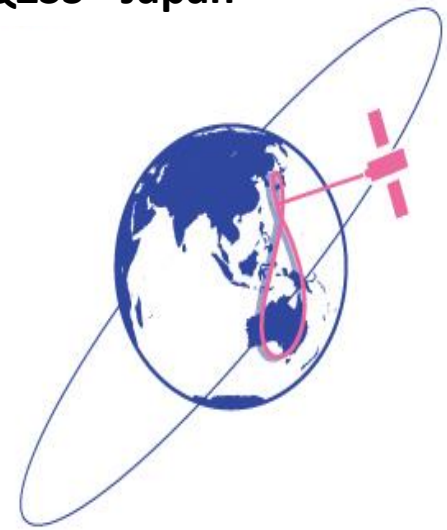


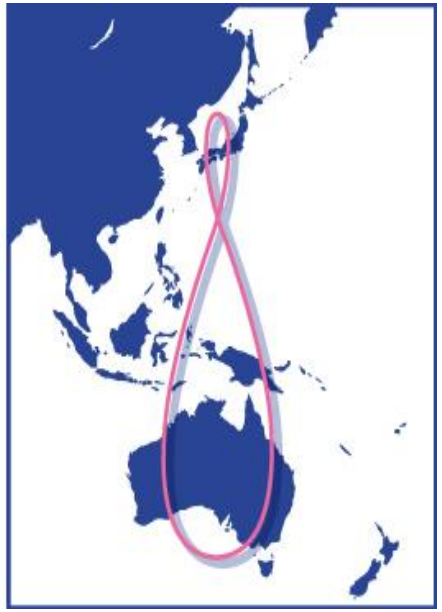
Galileo
EU/ESA

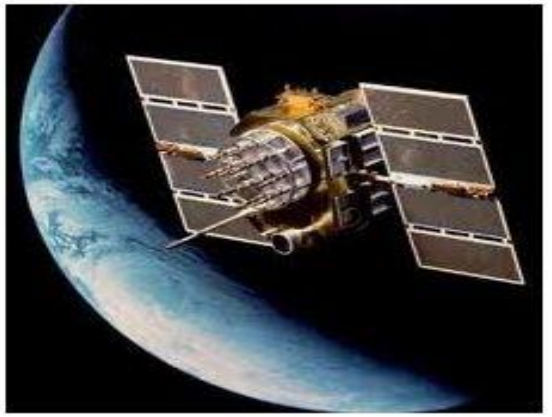
GPS
USA

GLONASS
Russia

QZSS - Japan







Compass
China

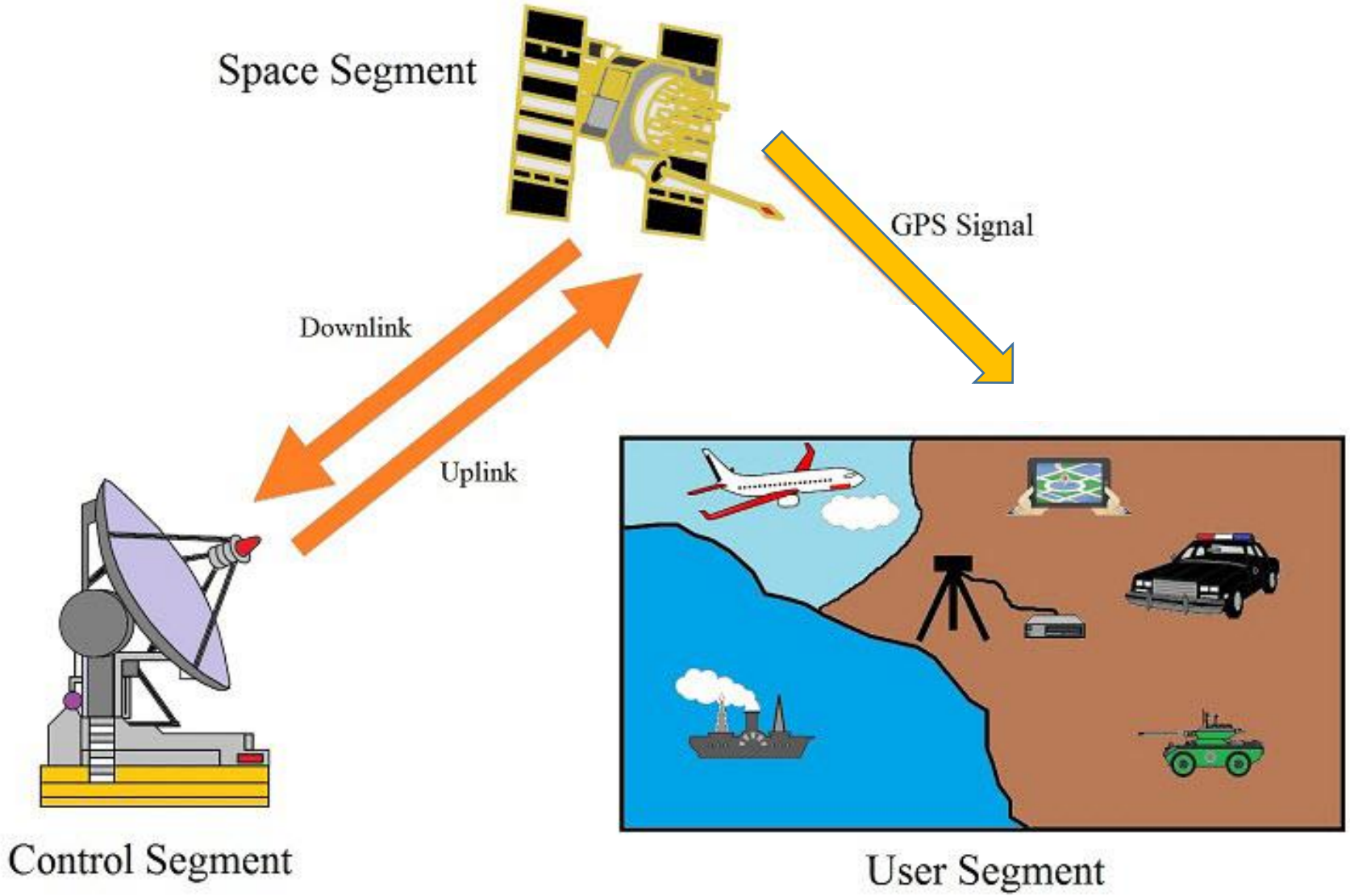
Design Objectives of GPS

- **Suitable for different platforms**: aircraft, ship, land-based and space (missiles and satellites),
- **Real-time positioning, velocity and time determination** capability to an appropriate accuracy,
- Single global geodetic datum (reference system) (**WGS 84**) for defining position,
- **Differential accuracy standards**: highest accuracy to be restricted to a certain class of authorized users,
- **Resistant to jamming** (intentional and unintentional),
- **Redundancy provisions** to ensure the survivability of the system,
- **Passive positioning system** that does not require the transmission of signals from the user to the satellite(s),
- Ability to provide the **service to an unlimited number of users** and **world-wide coverage**
- **Low cost, low power, therefore highly complex satellite segment**,

Global Positioning System

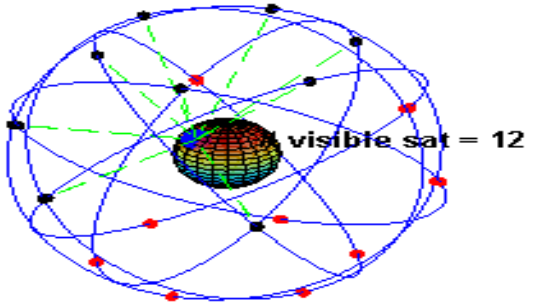
- GPS is a type of Global Navigation Satellite Systems.
- A very precise positioning system.
- Developed and maintained by the US Department of Defense(DOD).
- Satellite Based
  - 24 satellite in 6 constallations
  - 20,200 km high orbit.

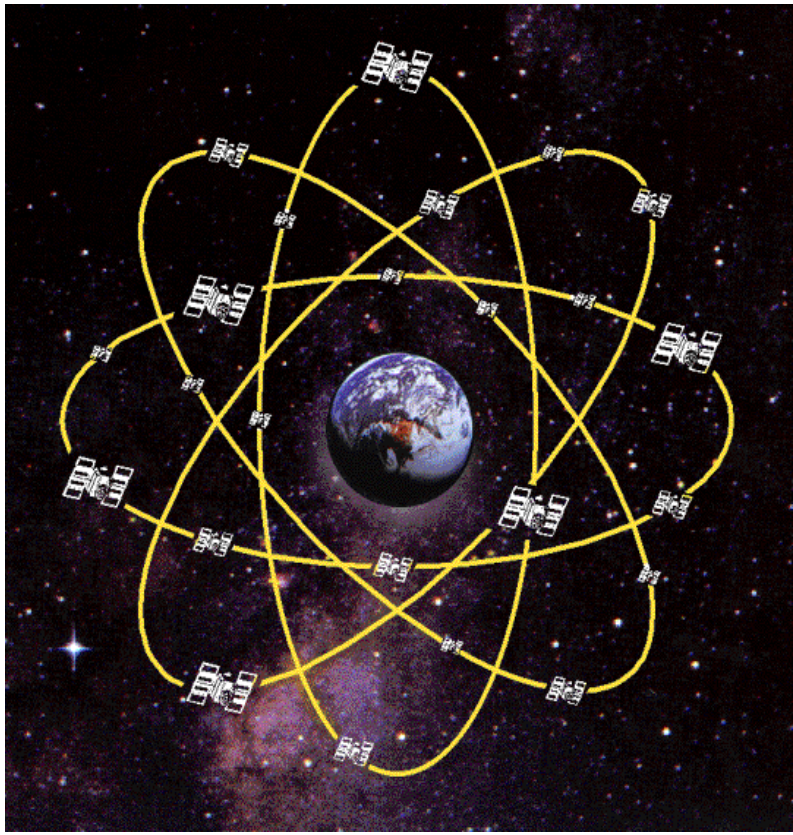
Functional Segments of GPS



Space Segment

- Higher altitudes are made to have larger area coverage.
- **At least 4 of the satellites are visible above the horizon** to GPS receivers on the ground at any time.





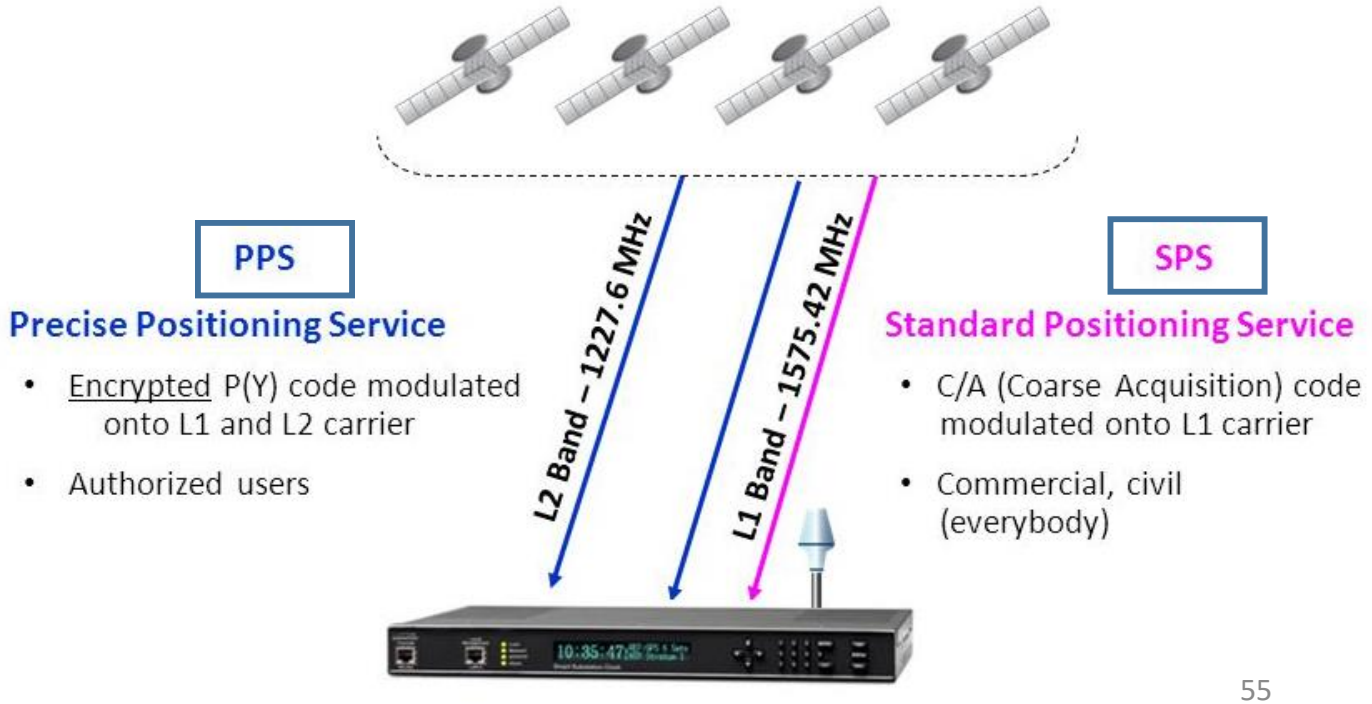
GPS Nominal Constellation
24 Satellites in 6 Orbital Planes
4 Satellites in each Plane
20,200 km Altitudes, 55 Degree Inclination

- **Satellites travel** at a speed of **3870 m/s**, which allows them to complete one revolution every **12h**. The satellites are **Geostationary** as well as **non-geostationary**. There are **12 satellites** on either side of the hemisphere at any time. Very high accurate **Atomic clocks** are used in **Satellites.**

Space Segment

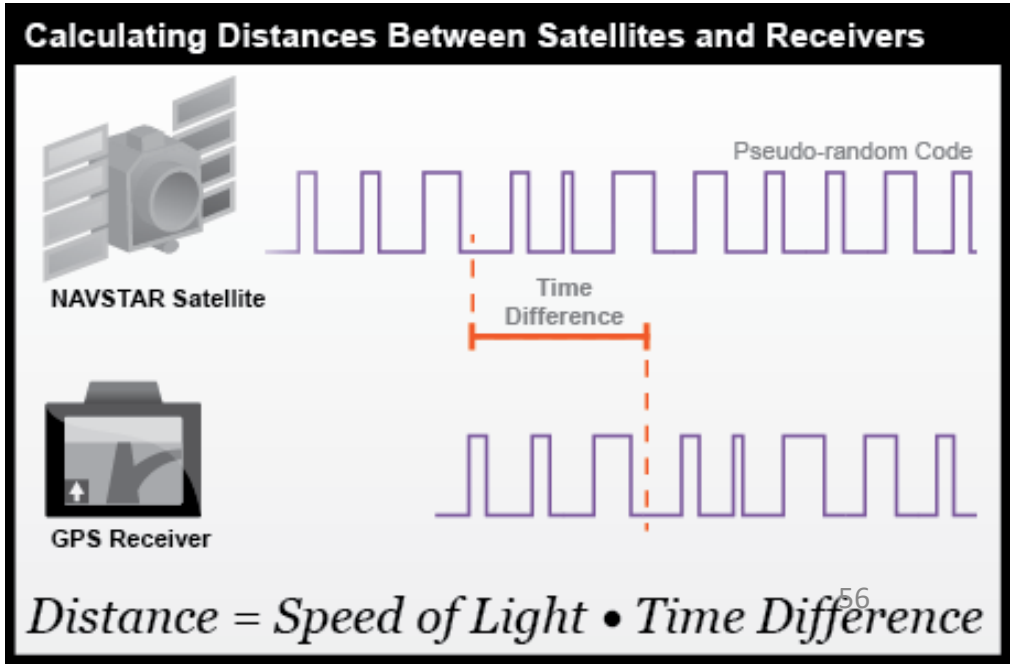
- **Main Functions of a GPS Satellites are**

1. It **receives** and **stores** data and other **corrections from the control segment.**
2. It maintains a very **precise time**.
3. It transmits the coded signals to user receivers through two Frequencies **L1 and L2.**



Space Segment

- Each satellite contains **at least 3 high precision Atomic clocks** which constantly transmits radio signals using its own identification code.
- These signals travels in the ‘Line of Sight’.
- Each signals contains ***pseudorandom codes (***which contain the information about the **time** and **orbital path** of the satellite***)*** through which the signal-travel time is calculated.



Control Segment (Ground Segment)

- It controls the GPS Satellites by tracking and providing them with correct **orbital and clock information**.

- Monitoring Stations are also called **Operational Control Segment (OCS)** monitor Station.
- 10 other National Geospatial Agency (NGA) stations are also deployed since 2005.

Main functions of the Control Segment

- **Monitor** the satellites.
- Estimate the **on-board clock state** and define the corresponding parameters to be broadcast.
- **Define the orbit** of each **satellite** to predict the ephemeris with almanac.
- **Determine the location and altitude** of the satellite in order to determine the parameters to be sent for **correcting** their orbits.
- **Uploading** the derived **clock correction** parameters, **ephemeris, almanac, and orbit correction** commands to the satellites.

User Segment

- Ground-based devices read and interpret the radio signals from several of the NAVSTAR satellites at once.
- Geographic position is determined using the time it takes signals from the satellites to reach the GPS receiver.
- Calculations result in varying degrees of accuracy that depend on:
  - Quality of the receiver
  - User operation of the receiver (e.g., skill of user and receiver settings)
  - Atmospheric conditions
  - Local conditions (i.e., objects that block or reflect the signals)
  - Current status of system

BASED ON FREQUENCIES

***Single frequency Receivers**

***Dual Frequency Receivers**

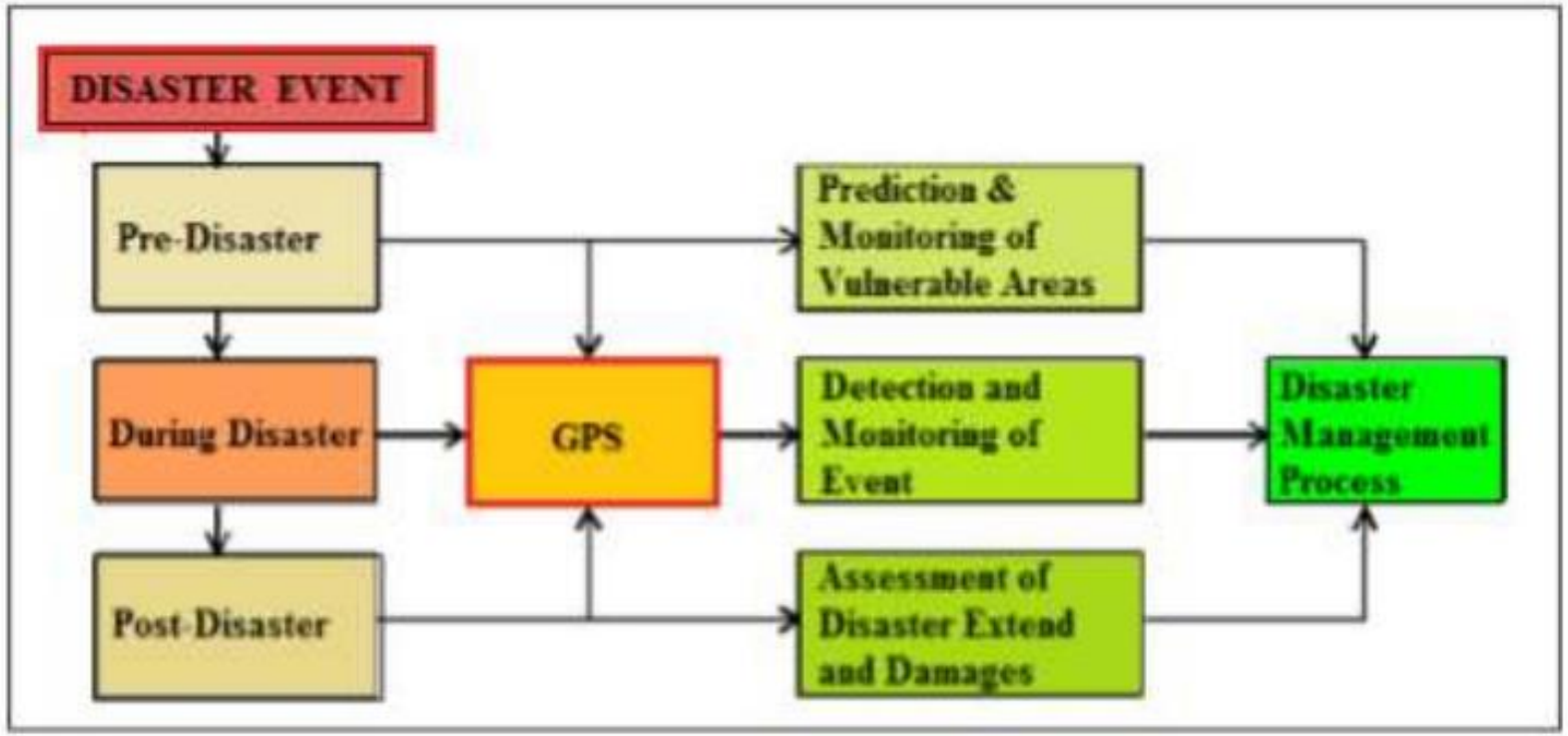
Application of GPS

- Location
- Navigation
- Tracking
- Mapping
- Timing

Applications of GPS in Disaster Management.

- GPS APPLICATION IN DISASTER EVENT.
- Landslide Study Using GPS Technologies
- GPS Application in Landslide Monitoring
- Application of GPS in Earth Quake
- GPS Application in Forest fire management
- Application of GPS in Flood Management

Applications of GPS in Disaster Management(contd.).



Characteristics of GPS

- Free
- Precise
- Reliable
- All weather
- Anytime & anywhere.
- Unlimited user capacity.

NATIONAL INSTITUTE OF HYDROLOGY, INDIA

UNIT 5

Introduction

- NIH - Working in the area of hydrology and water resources.
- It was founded on 16 December, 1978 as an autonomous body under the Ministry of Irrigation (now renamed as Ministry of Water Resources, River Development & Ganga Rejuvenation), Government of India at Roorkee.
- The research activities of the Institute are being carried out in six scientific divisions at the headquarters at Roorkee, two Centres for Flood Management Studies at Guwahati and Patna and four Regional Centres at Belagavi, Jammu, Kakinada and Bhopal.
- The Institute's research and other technical activities are monitored and guided by the Technical Advisory Committee, Working Group (for headquarter) and Regional Coordination Committees (for Regional Centres and Centres for Flood Management Studies).

Objectives

- To undertake, aid, promote and coordinate systematic and scientific work in all aspects of hydrology.
- To cooperate and collaborate with other national and international organizations in the field of hydrology
- To establish and maintain a research and reference library in pursuance of the objectives of the Society and equip the same with books, reviews, magazines and other relevant publications.

R & D Activities

- Climate change on water resources
- Integrated water resources management
- Groundwater modelling and management
- Flood and drought management
- Regional hydrology
- Hydrology of extremes
- Reservoir/lake sedimentation
- Watershed hydrology
- Water quality assessment in specific areas.

SCIENTIFIC DIVISIONS AT ROORKEE

- *Environmental Hydrology*
- *Ground Water Hydrology*
- *Hydrological Investigations*
- *Surface Water Hydrology*
- *Water Resources Systems*
- *Research Management and Outreach Division (RMOD)*

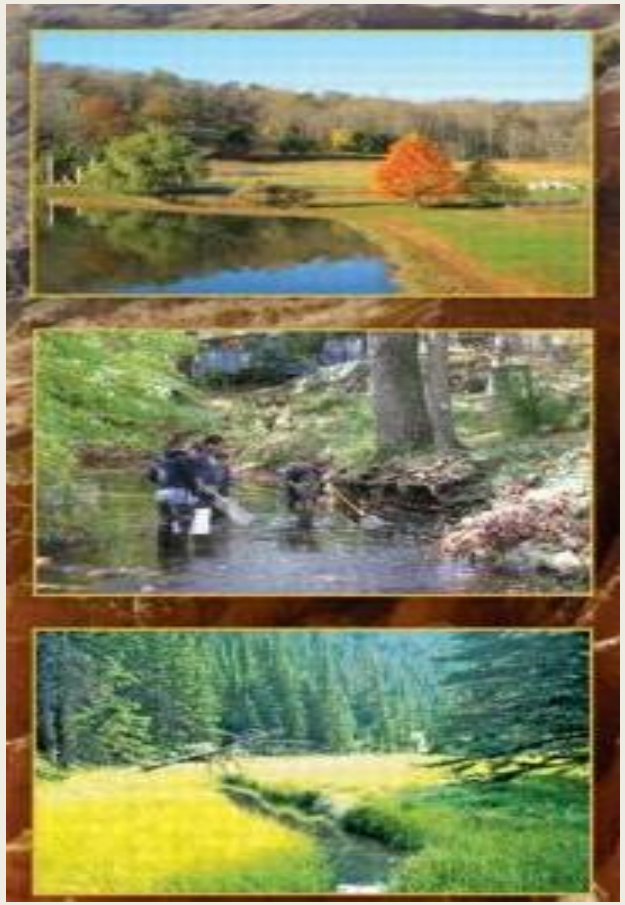
Environmental Hydrology

- All research is aimed at improving understanding of how the quality and quantity of water are affected by the natural environment and the anthropogenic activities.
- The laboratory is fully capable to identify and quantify physical, chemical and bacteriological parameters in various water bodies like rivers, lakes, reservoirs, wells, aquifers, canals etc.
- The laboratory has facilities and capabilities to determine various water quality constituents including major and minor ions, trace elements, pesticides, hydrocarbons and other organic compounds and bacteriological parameters.

Environmental Hydrology

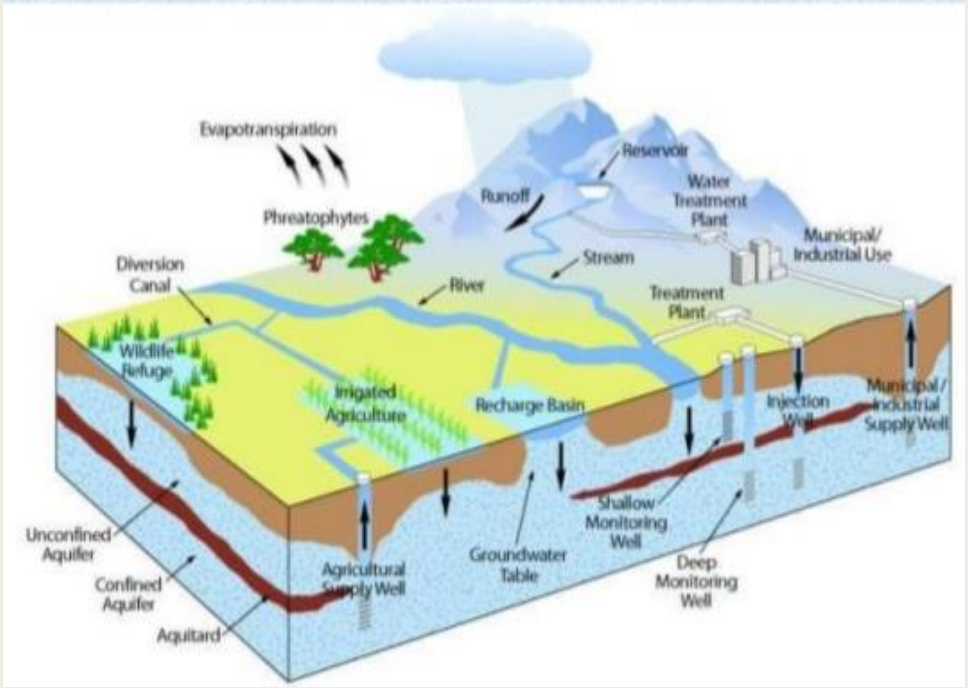
The thrust areas of research in the division include

- Environmental monitoring including natural contaminants,
- Point and non-point source pollution
- Adsorption kinetics and water sediment systems,
- Transport and sedimentation of pollutants,
- Contaminant transport modelling,
- Metal speciation/fractionation,
- Groundwater quality and aquifer contamination,
- Low cost treatment/remediation technologies,
- Water quality and human health,
- Environmental modelling, water quality and climate change, geo-microbial pollution, lake ecosystems and river bank filtration for sustainable water supply.



Ground Water Hydrology

- Vision - Providing efficient and effective methodologies and technologies for sustainable groundwater resources development and management.
- The division has two technical services facilities: “Soil Water Laboratory” and “Centre of Excellence for Advanced Groundwater Research” which is comprised of two units – “Numerical Groundwater Modeling Unit” and “Indo-German Competence Centre for Riverbank Filtration”.
- All these facilities are well equipped with advanced tools, and instrumentation



Thrust areas of Ground Water Hydrology

- Groundwater storage and resource estimation
- Groundwater modelling and management
- Coastal aquifer dynamics
- Surface water and groundwater interaction
- Hard-rock and karst hydrology
- Managed aquifer recharge for groundwater augmentation
- River-aquifer interactions for bank filtration and baseflow sustainability
- Re-use of treated effluents for managed aquifer recharge (MAR)
- Contaminants mobilization in groundwater system
- Threat of emerging contaminants in groundwater
- Groundwater protection against contaminants, and impact of environmental changes on groundwater resources

Hydrological Investigations

- Hydrological Investigations division conducts field and laboratory based hydrological studies for sustainability of water resources using advanced isotope techniques, geophysical and hydrological techniques.
- The division also has two state-of-art laboratories attached to it, namely,

(i) Nuclear Hydrology laboratory and

(ii) Hydrological Instrumentation laboratory.

Surface Water Hydrology – Thrust areas

- water availability analysis
- flow duration curve analysis and environmental flow requirement
- flood estimation,
- flood routing
- hydrological modelling,
- structural and non-structural measures of flood management,
- snow and glacier melt monitoring and modeling,
- urban hydrology,
- watershed management studies,
- socio-economic aspects of flood disasters,
- drought mitigation and management,
- impact of climate change on water resources.

Surface Water Hydrology

- Concerns - large spatial and temporal variability in availability of water and mismatch with demands
- Concerns - water stress in large parts of our country is rising and triggered (population, irrigation needs, industrialization, urbanization and climate change)
- Concerns - lack of accessible databases on hydrology and related sectors

Vision - to develop and apply methodologies for analysis of reservoirs, river basin planning, operation of irrigation systems, snow glacier studies and watershed problems; and applications of advanced tools such as remote sensing, GIS, ANN and DSS etc. in solving water resources problems.

Research Management and Outreach Division (RMOD)

- Vision - an effective dissemination of scientific output of the Institute so as to improve scientific delivery and outreach of the Institute for the benefit of various stakeholders.

REGIONAL CENTRES

- 2 Centers for Flood Management Studies (CFMS) and 4 Regional Centres.

1. *Centre for Flood Management Studies, Guwahati*
2. *Centre for Flood Management Studies, Patna*

1. *Hard Rock Regional Centre, Belagavi*
2. *Western Himalayan Regional Centre, Jammu*
3. *Deltaic Regional Centre, Kakinada*
4. *Central India Hydrology Regional Centre, Bhopal*

METEOROLOGICAL LABORATORY

UNIT 5

Indian Meteorological Department

- For Weather Information and Forecasts
- Early Warning System

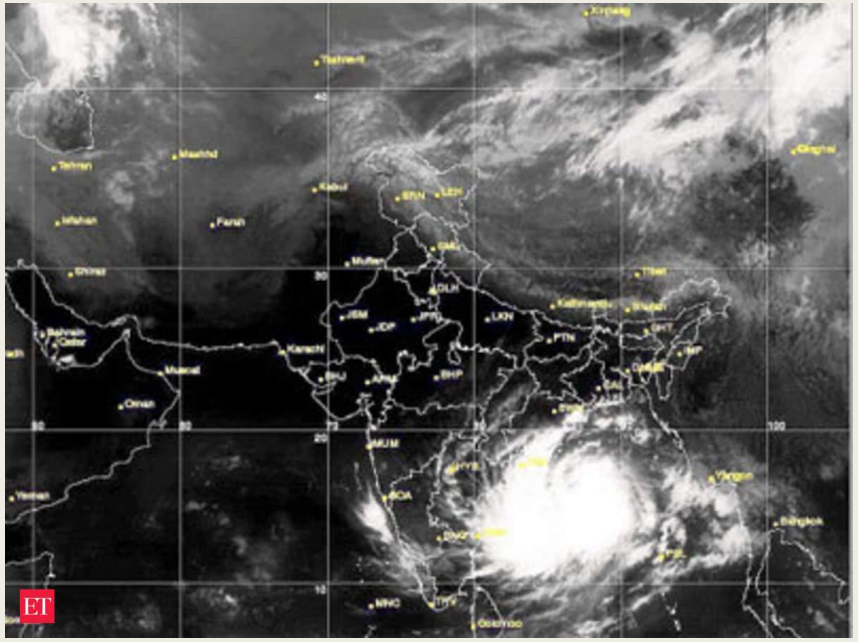
History of Meteorological Services in India

- **In the year 1875**, the Government of India established the India Meteorological Department, bringing all meteorological work in the country under a central authority.
- Mr. H. F. Blanford was appointed Meteorological Reporter to the Government of India.
- The first Director General of Observatories was Sir John Eliot who was appointed in May 1889 at Calcutta headquarters.
- The headquarters of IMD established in Calcutta, later shifted to Shimla, then to Poona (now Pune) and finally to New Delhi.



History of Meteorological Services in India

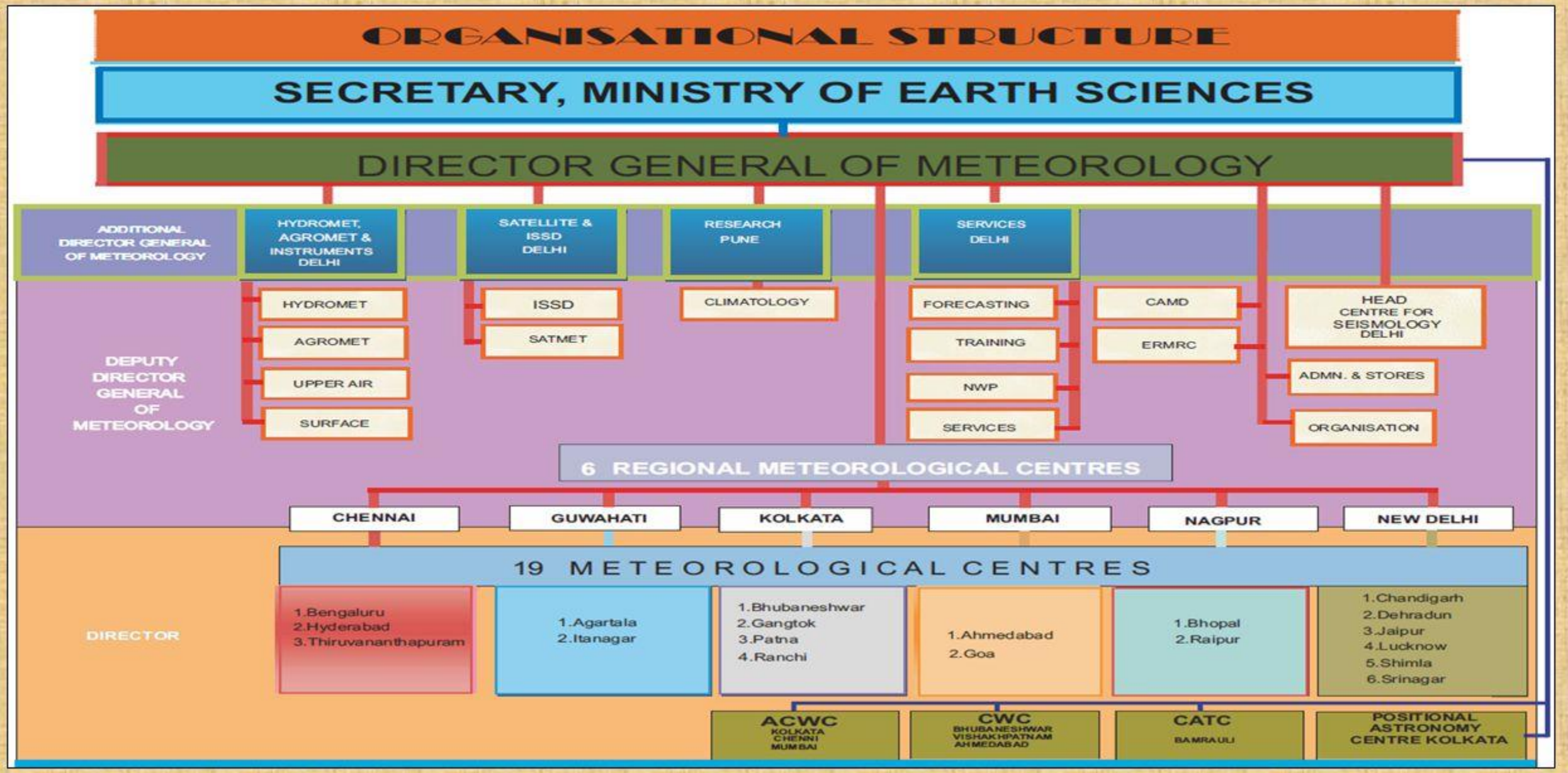
- From a modest beginning in 1875, IMD has progressively expanded its infrastructure for meteorological observations, communications, forecasting and weather services and it has achieved a parallel scientific growth.
- India was the first developing country in the world to have its own geostationary satellite, INSAT, for continuous weather monitoring of this part of the globe and particularly for cyclone warning.



Objectives of IMD

- To take meteorological observations and to provide current and forecast meteorological information for optimum operation of weather-sensitive activities like agriculture, irrigation, shipping, aviation, offshore oil explorations, etc.
- To warn against severe weather phenomena like tropical cyclones, Nor'westers, duststorms, heavy rains and snow, cold and heat waves, etc., which cause destruction of life and property.
- To provide meteorological statistics required for agriculture, water resource management, industries, oil exploration and other nation-building activities.
- To conduct and promote research in meteorology and allied disciplines.
- To detect and locate earthquakes and to evaluate seismicity in different parts of the country for development projects.

Organizational structure of IMD



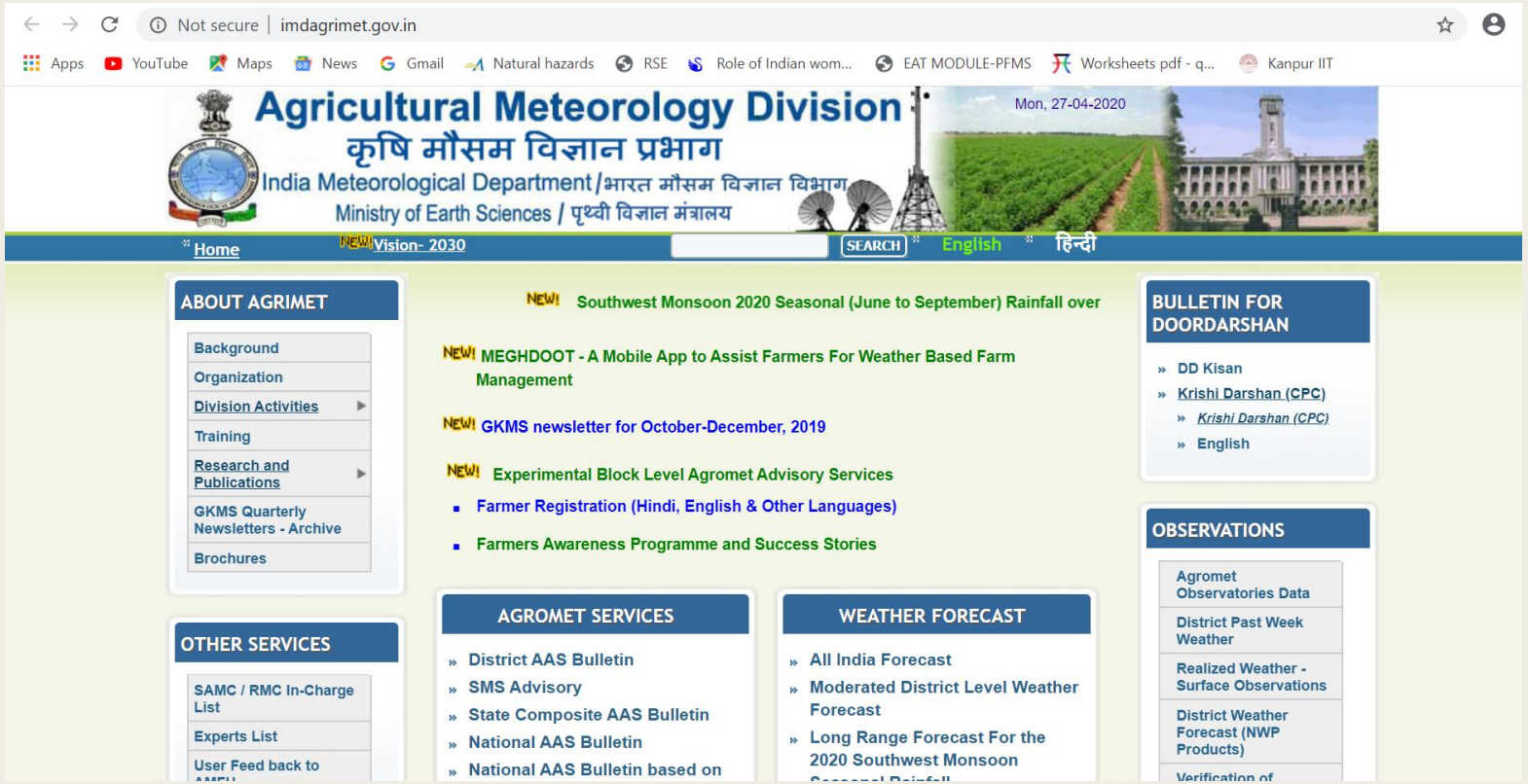
Services

- **Hydrometeorological Services in IMD** - Hydromet Division of IMD caters the information on various rainfall products through its **'Customised Rainfall Information System (CRIS)**', in form of reports and maps on the CRIS portal.

    1. **Flood Meteorological Unit** - During the flood season, FMOs provide valuable meteorological support to the Central Water Commission for issuing flood warnings
    2. **Flood Meteorological Service** - Rainfall forecast products in pictorial and tabular form which are useful for issuance of Quantitative Precipitation Forecasts (QPF's).
    3. **Rainfall Monitoring** - The real-time monitoring and statistical analysis of district wise daily rainfall is one of the important functions of the Hydro meteorological Division of IMD at New Delhi
    4. **Hydrology Project** - Aims at enhancing the physical infrastructure of hydrometeorological activities and data processing and management systems resulting in an enhancement of rainfall data quantity and quality.

Services

- **Meteorological Services for Agriculture in India** - set up in 1932 under the umbrella of India Meteorological Department (IMD) at Pune with the objective to minimize the impact of adverse weather on crops and to make use of favorable weather to boost agricultural production.

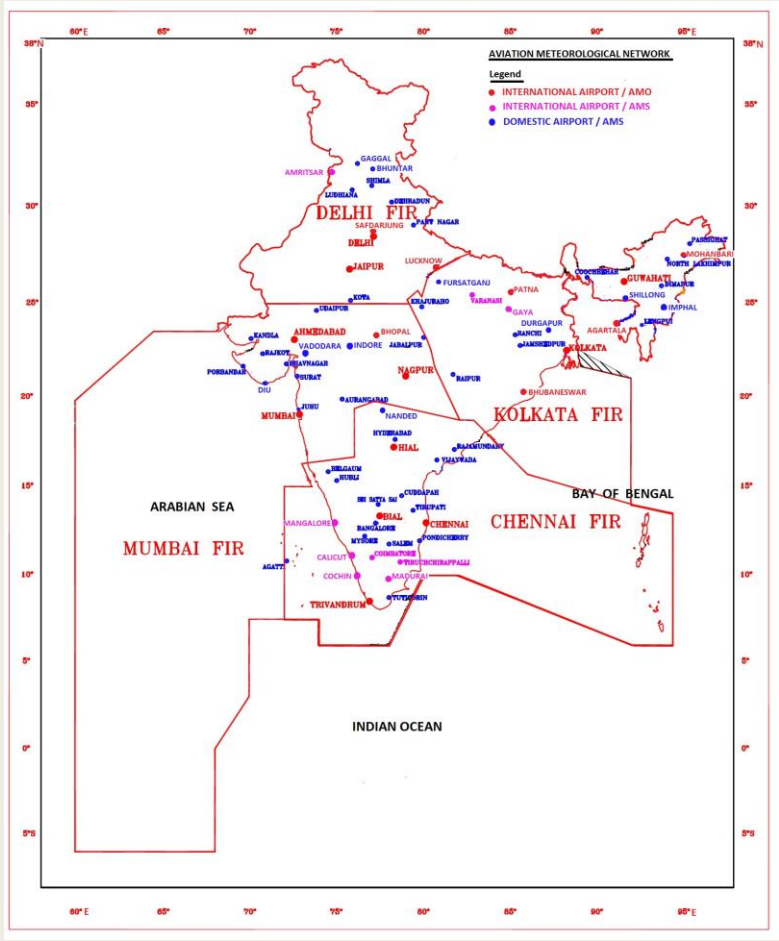


Dedicated Website for Agrometeorological Service of IMD

Services

- **Meteorological Services for Civil Aviation in India**

1. These services are provided through 18 Aerodrome Meteorological Offices (AMO) and 54 Aeronautical Meteorological Stations (AMS) located at various national and international airports of the country.
2. Meteorological Training Institute (MTI), Pune takes care of the training requirements of the Aeronautical Meteorological Personnel.
3. The installation and maintenance of Airport Meteorological Instruments are done by the Surface Meteorological Division at Pune.



SATMET Services

- INSAT is one of the largest domestic communication satellite systems in Asia-Pacific region with nine operational communication satellites placed in Geo-stationary orbit.
- It is a joint venture of the Department of Space, Department of Telecommunications, India Meteorological Department, All India Radio and Doordarshan.
- The first successful INSAT-1B satellite data receiving and processing system was established in 1983 in IMD.
- INSAT -1, INSAT -2, INSAT 2E. (1 km resolution)
- A dedicated meteorological satellite, Kalpana-1 was launched on 12th September, 2002 carrying VHRR payload.
- Multipurpose INSAT-3A satellite was launched on 10th April, 2003 carrying VHRR and CCD payloads along with communication transponders.

Current Status

- INSAT-3D & INSAT-3DR carrying 6 channel imager for imaging the earth in visible (0.55-0.75um),SWIR (1.55-1.70um) of resolution 1KmX1 Km, MIR (3.80-4.00um),TIR-1 (10.30-11.30um),TIR-2(11.50-12.50um) of resolution 4KmX4Km and WV (6.50-7.10um) of resolution 8KmX 8Km.
- INSAT-3D was launched on 26th July, 2013 and located at 82 degree east and INSAT-3DR was launched on 08th September 2016.
- The INSAT-3D and INSAT-3DR sounder scans are acquired on every 60 minutes for sector A (Indian land region) and every 90 minutes for sector B (Indian Ocean region) respectively, with inter-changing their scan areas between Sector A and B after every three-hour interval to get temperature and humidity profiles of these regions.
- In addition to these both satellites are having Data Relay Transponder (DRT) payloads which are being used to receive and transmit the data from Automatic Weather Stations (AWS)/ Automatic Rain Gauge (ARG) network of different institutions from all over India.

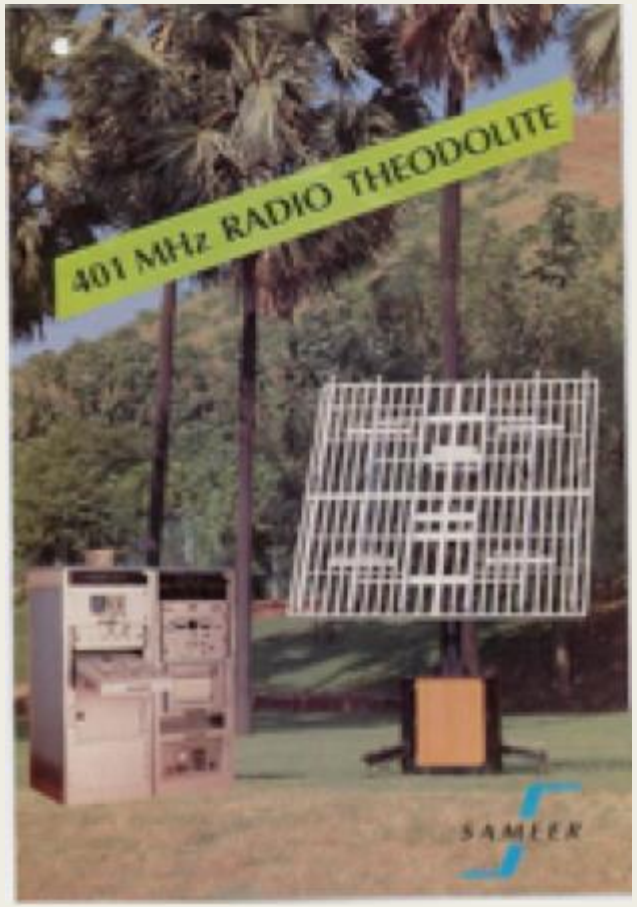
Service -IMD DWR Network

S No	DWR Station	State	Type of DWR
1	Agartala	Tripura	S - Band
2	Bhopal	Madhya Pradesh	S - Band
3	Bhuj	Gujarat	S - Band
4	Chennai	Tamil Nadu	S - Band
5	Cherrapunjee (ISRO)	Meghalaya	S - Band
6	Delhi (Palam)	Delhi	S - Band
7	Panaji	Goa	S - Band
8	Gopalpur	Odisha	S - Band
9	Hyderabad	Telangana	S - Band
10	Jaipur	Rajasthan	C - Band
11	Kolkata	West Bengal	S - Band
12	Kochi	Kerala	S - Band
13	Karaikal	Tamil Nadu	S - Band
14	Lucknow	Uttar Pradesh	S - Band
15	Machilipatnam	Andhra Pradesh	S - Band
16	Mohanbari	Assam	S - Band
17	Mumbai	Maharashtra	S - Band
18	Nagpur	Maharashtra	S - Band
19	New Delhi (Mausam Bhawan)	Delhi	C - Band
20	Paradip	Odisha	S - Band
21	Patiala	Punjab	S - Band
22	Patna	Bihar	S - Band
23	Srinagar	Jammu and Kashmir	X - Band
24	Thiruvananthapuram (ISRO)	Kerala	C - Band
25	Visakhapatnam	Andhra Pradesh	S - Band

Service- Surface Meteorological Instrumentation

- **Surface Instrument Division has the mandate :**
  1. To manufacture, calibrate, supply and maintain surface meteorological instruments at observatories of IMD.
  2. To supply and maintain Airport Meteorlogical Instruments for civil airports.
  3. To supply instruments to defence organisations.
  4. To maintain the network of Automatic Weather stations (AWS) and Automatic Raingauge stations (ARG) for near real time weather forecasting services of IMD.
  5. To impart trainings to operational staff of IMD for maintenance and upkeep of instruments.

Service: Upper Air Meteorological Instrumentation



Environmental monitoring and service

The main objective of GAW is to provide data and other information on the chemical composition and related physical characteristics of the atmosphere and their trends, required to improve understanding of the behavior of the atmosphere and its interactions with the oceans and the biosphere.

- Ozone Monitoring Network
- Precipitation and Particulate Matter Chemistry Monitoring
- Aerosol Monitoring Network
- Black Carbon Monitoring Network
- Multi-wavelength Integrating Nephelometer Network
- System for Air quality Forecasting And Research (SAFAR)

Service - Positional Astronomy

- Lunar phenomena for prediction of tides for Survey of India.
- Solar data for orienting large civil constructions projects, for laying electric transmission lines and for large public meetings.
- Position of the Sun for aligning antennas and radars for railways, communication, Air Force and for the atmospheric observations during expeditions (Antarctica).
- Pole star data for aligning radio transmitters for AIR. Times for rising, setting of the Sun & Moon and Moon's phases for defence, judiciary, crime detection agencies and scientific researchers.
- Local circumstances of eclipses for a large number of researchers/ amateur astronomers.
- Advance intimation on dates of festivals for Govt. holiday declaration, tourist promotion abroad and for use of Panchang Makers.

Department Websites

1 भा. मौ. वि. वि. - राजभाषा पटल
2 O/o ADGM(R), Pune
3 Upper Air Instrument Division, New Delhi
4 Surface Instrument Division, Pune
5 Agriculture Meteorology Division, Pune
6 Meteorological Training Institute, Pune
7 Regional Specialized Meteorological Centre
8 Regional Meteorological Centre, Chennai
9 Regional Meteorological Centre, Guwahati
10 Regional Meteorological Centre, Kolkata
11 Regional Meteorological Centre, Mumbai
12 Regional Meteorological Centre, Nagpur
13 Regional Meteorological Centre, New Delhi
14 Positional Astronomy Centre, Kolkata
15 Meteorological Watch Office, Kolkata
16 Cyclone Warning Centre Visakhapatnam
17 Meteorological Centre Ahmedabad
18 Meteorological Centre Agartala
19 Meteorological Centre Bhubaneshwar
20 Meteorological Centre Bengaluru
22 Meteorological Centre Chandigarh
23 Meteorological Centre Gangtok
24 Meteorological Centre Goa
25 Meteorological Centre Hyderabad
28 Meteorological Centre Patna
29 Meteorological Centre Ranchi
30 Meteorological Centre Raipur
31 Meteorological Centre Shimla
32 Meteorological Centre Srinagar
33 Meteorological Centre Thiruvananthapuram
34 Meteorological Centre Dehradun
35 Data Supply Portal
36 National Center for Seismology
37 Education and Training Portal - IMD

National Centre for Seismology

Ministry of Earth Sciences, Government of India

Unit 5

Background

- The first seismological observatory of the country was established at Alipore (Calcutta) on 1 December, 1898.
- The strong earthquakes, necessitated the need for national seismological network.
- Early 1960s marked a very important land mark in the history of seismic monitoring, when the WWSSN (World Wide Standardized Seismic Network) stations started functioning globally.

Mission and Vision

- **Mission**

To work towards creating a seismic resilient society

- **Vision**

Understanding the earthquake source processes and their effects through earthquake monitoring and seismological research for the cause of earthquake-safe society.

Need

- The National Center for Seismology (NCS) has been set up by bringing together all Seismology related activities of IMD (including those of EREC) under one umbrella.
- On creation of the NCS, all the ongoing activities and projects of IMD related to Seismology shall continue to be operated / implemented through the NCS.
- In addition, specific R&D activities will also be undertaken by NCS, using the data sets generated by various seismic and GPS networks.

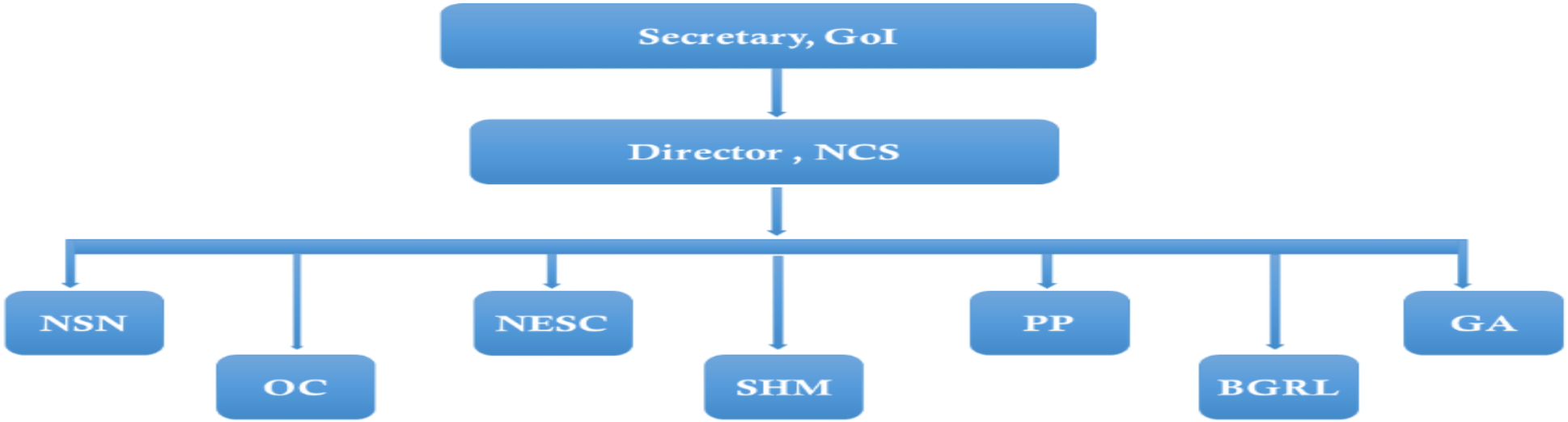
National Centre for Seismology

- National Center for Seismology (NCS) is the nodal agency for monitoring of earthquake activity in our country.
- NCS maintains National Seismological Network of **115 stations.**
- NCS monitors earthquake activity all across the country through its 24x7.
- NCS also monitors earthquake swarm and aftershock through deploying temporary observatory close to the affected region.

National Centre for Seismology

- Apart from earthquake monitoring, NCS is also actively involved in the **Seismic Hazard Microzonation and seismological research**.
- The major activities currently being pursued by the NCS are:
  - ✓ Earthquake monitoring on 24X7 basis
  - ✓ Operation and maintenance of national seismological network comprising of 115 Stations
  - ✓ Maintenance of Seismological data centre and information services.
  - ✓ Seismic hazard microzonation related studies
  - ✓ Aftershock/Earthquake swarm monitoring/survey
  - ✓ Understanding of Earthquake processes
  - ✓ Public outreach

Organization Structure



NSN : National Seismological Network
OC : Operational Centre (24x7 round the clock monitoring)
SHM : Seismic Hazard Microzonation
PP : Program and Planning
GA : General Administration
NESC : North East Seismological Centre (erstwhile C S O) Shillong
BGRL : Borehole Geophysical Research Laboratory Karad

Services & Activities

- Earthquake monitoring on 24x7 basis through National Seismological Network (NSN) of 115 stations is the prime activity of the center. Dedicated team maintains NSN to make available the real time data for real time monitoring of earthquake activity all across the country.
- Central Seismological Observatory (CSO) Shillong established in 1902 as second observatory in India; maintains a 20 station network of northeast India a part of 115 station national network.
- Center also deploy temporary network as and when required for monitoring of swarm or aftershock activity nearest to affected region of the country.

Services & Activities - SHM

- Besides earthquake monitoring NCS is engaged in Seismic Hazard Microzonation (SHM) studies of populous urban centers.
- Seismic Hazard Microzonation' is a process of classifying a region into zones of relatively similar exposure to various earthquake-related effects and has emerged as a major tool towards our efforts for preparedness and mitigation of losses due to earthquakes.
- NCS has completed microzonation of Delhi region on 1:10,000 scale and played a key role in various studies relating to the seismic microzonation of other cities, such as, Jabalpur and Guwahati.
- Currently microzonation studies of Chennai, Coimbatore, Bhubaneshwar and Mangalore are in progress.

Services & Activities – Geological Activity

- Borehole Geophysics Research Laboratory (BGRL), Karad is engaged in scientific deep drilling in Koyna-Warna region for directly measuring the in-situ physical properties of rocks, pore-fluid pressure, hydrological parameters, temperature and other parameters of an intra-plate, active fault zone in the near-field of earthquakes – before, during and after their occurrence.

Services & Activities – Data dissemination

- NCS provides earthquake data and seismicity reports of specific regions to various user agencies.
- Seismological information is provided to different agencies dealing with relief and rehabilitation measures.
- Data also prepared from raster scanning and vector digitization of seismic analog charts.

Services & Activities - Training

- NCS organizes awareness programs in Seismology and allied subjects at various levels to station operators and scientists.
- Officers of center also deliver lectures on various Seismology related topics.
- Familiarization training on various operational activities related to earthquake monitoring is also imparted to trainees from various organizations.

Services & Activities - INSURANCE CLAIMS

- A “**certificate on earthquake occurrence”** is issued to the **concerned insurance company only** on payment basis for settling damage claims after seeking approval of competent authority of the department.

Services & Activities - Technical Reports

- Brief technical reports on Seismicity / earthquake data, in respect of different places / sites for setting up of various projects like hydroelectric, thermal power, Refineries, high rise buildings, railway bridges, community centers and other critical structures of importance, is supplied to the concerned authorities of central / state governments, public undertakings, multinational & private companies etc.
- Such reports / data are supplied on payment basis after seeking approval of competent authority of the department.

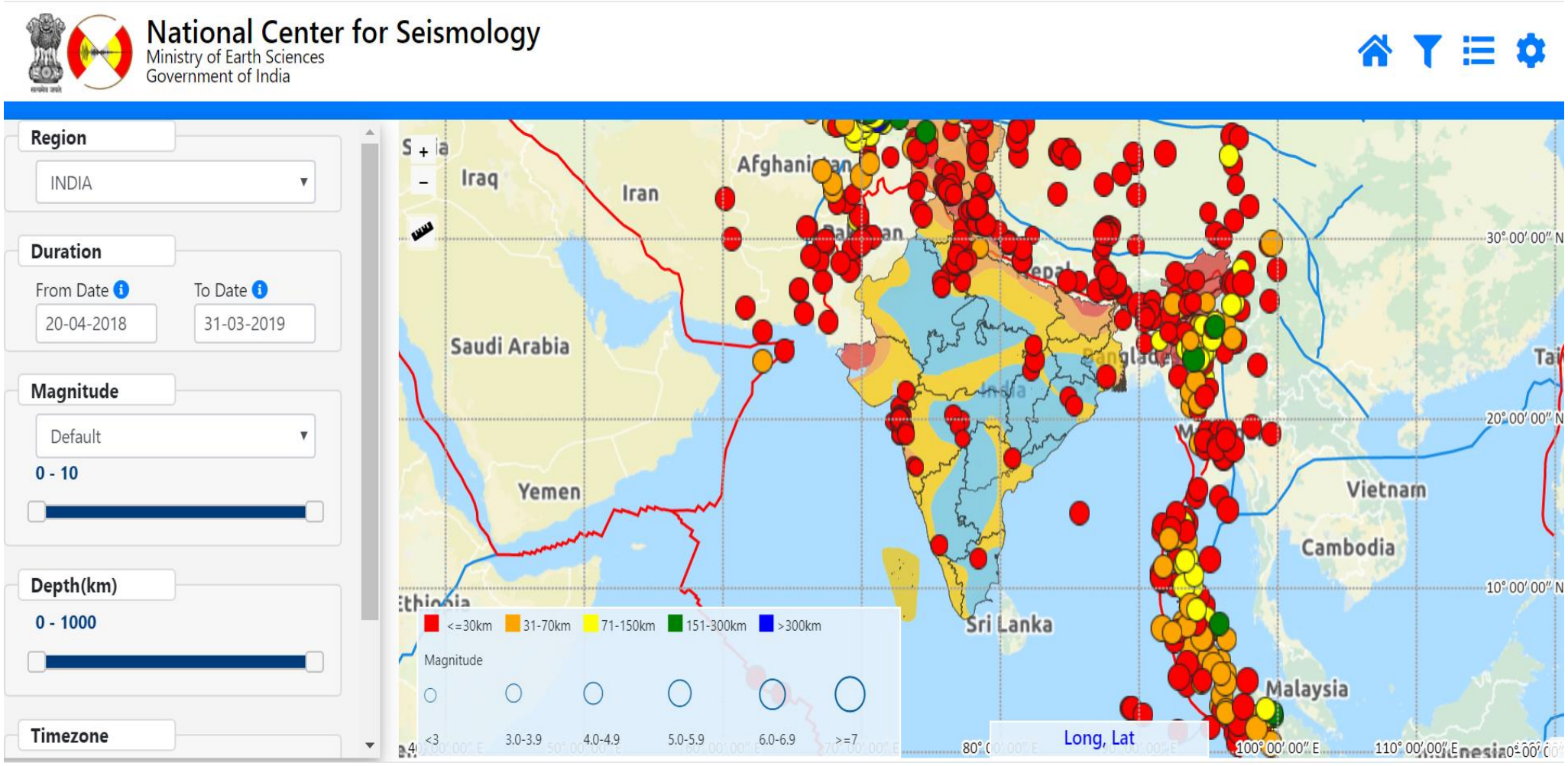
Archive Data

- Earthquake Catalogue
- Historical Seismograms
- Seismological Bulletins

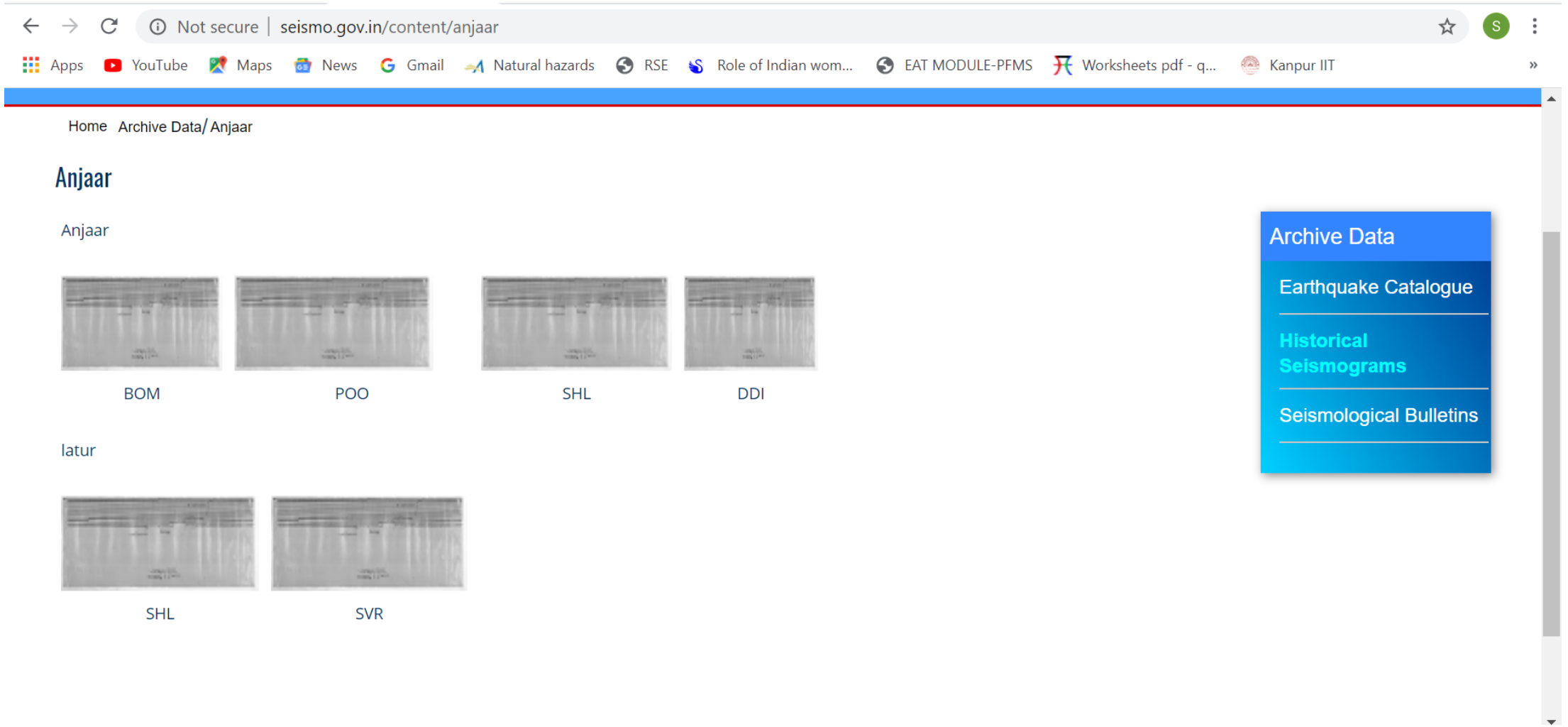
Earthquake Safety

- Do’s and Don’s
- MMI Scale
- Seismology Glossary

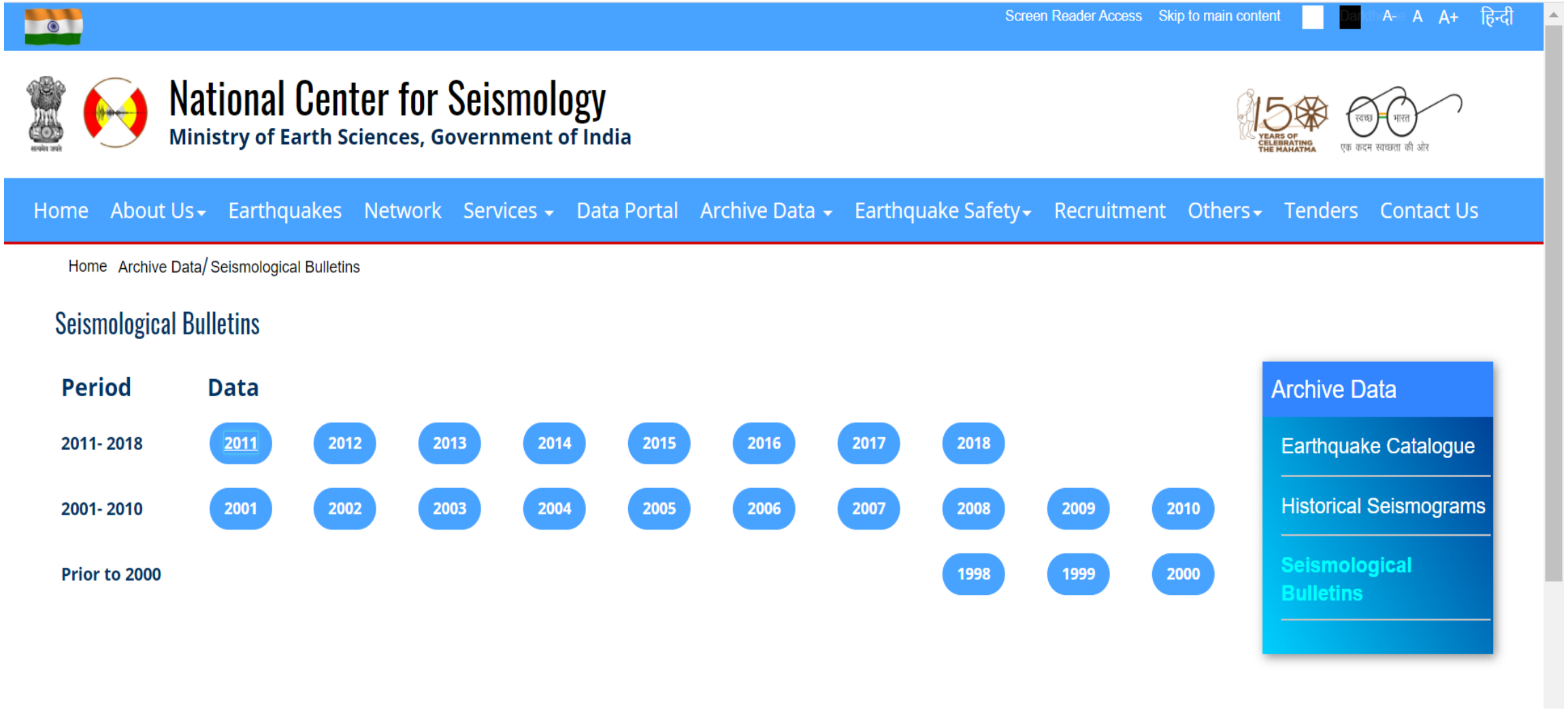
Earthquake Catalogue



Historical Seismograms



Seismological Bulletins



Do’s and Don’s

Before an Earthquake

During an Earthquake

After an Earthquake

MMI Scale

- 1 – Instrumental
- 2 - Feeble
- 3 - Slight
- 4 - Moderate
- 5 – Rather Strong
- 6 - Strong
- 7 – Very Strong
- 8 - Destructive
- 9 - Ruinous
- 10 - Disastrous
- 11 – Very Disastrous
- 12 - Catastrophic

1. Instrumental

2. Feeble

3. Slight

4. Moderate

5. Rather Strong

6. Strong

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11. Very Disastrous

12. Catastrophic

Seismology Glossary

Seismology Glossary

Active fault

A fault that has moved in historic (e.g., past 10,000 years) or recent geological past (e.g., past 500,000 years).

Aftershock

An earthquake that follows a large magnitude earthquake called, "main shock" and originates in or around the rupture zone of the main shock. Generally, major earthquakes are followed by a number of aftershocks, which show a decreasing trend in magnitude and frequency with time.

Amplitude

The maximum height of a wave crest or depth of a trough on a seismogram, used to estimate the strength of the earthquake.

Array

An ordered arrangement of seismometers or geophones, the data of which is fed to a central receiving station for recording and processing.

Arrival / Arrival Time

Arrival is the appearance of a wave, representing seismic energy, on a seismic record. The time at which a particular

Earthquake Safety
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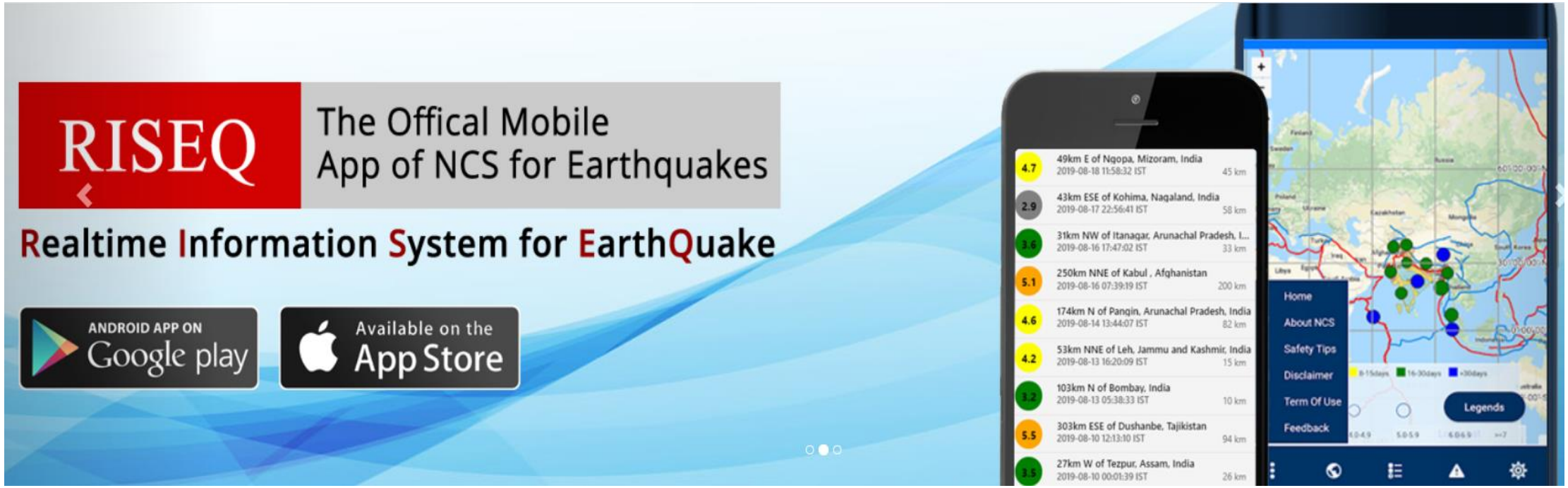
Other Services

- Mobile App



https://seismo.gov.in/