Future of Space Remote Sensing and Applications

REMOTE SENSING TECHNOLOGY AND LAWS

PGD in GIS and RS Laws

NALSAR UNIVERSITY OF LAW, HYDERABAD

EARTH OBSERVATIONS FROM SPACE

- Valuable tool for…
- Understanding earth science and human interactions with earth system
- Modelling the behaviour
- Prediction of natural process

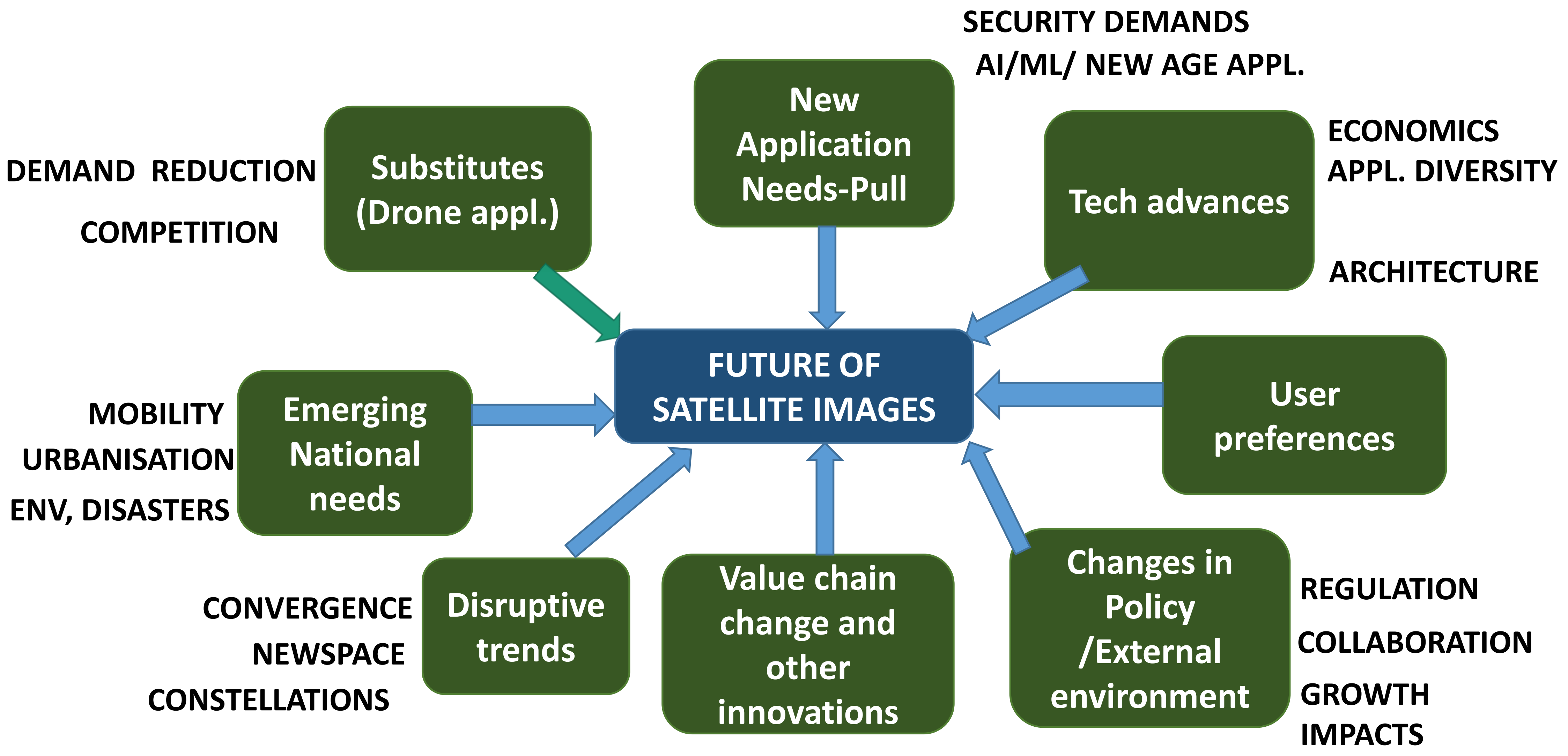
- Through…
- Non invasive observations
- Monitoring
- Change detection
- Measurement
- Identification
- Deriving knowledge

Image: NASA

History- some milestones

- 1960 Television Infrared Observation satellite (TIROS-1)
- ……….First satellite for earth observations
- 1972 ..Landsat-1 (Earth Resources Technology Satellite-1)
- ………..Multispectral Scanner & Return Beam Vidicon
- 1982 & 1984…. Landsats 4 & 5 .. Thematic Mapper (Photo diode/..
- 1986 …SPOT-1 (FRANCE), Multi- linear array devices
- 1988…. IRS-1A (INDIA), CCD based Linear Imaging Self Scanners
- 1991.. ALMAZ-1 (RUSSIA) Synthetic Aperture RADAR
- 1991….ERS-1 (European Space Agency) SAR, Altimeter, ATSR, 2384 Kg
- 1992… JERS-1 (Japan) L Band SAR payload, 18m Res.,1400Kg.
- 1995.. IRS-1C…Highest resolution (civilian) mission
- 1995…. RADARSAT-1 (Canada) . 8-100m resolution
- 2000….IKONOS (Space Imaging)…Private Commercial 1m mission

Future of Satellite Images – What factors drive it?



Is there some thing unique about satellite images?

- SYNOPTIC COVERAGE
- REPEATED OBSERVATION
- STEREO/ VIDEO COVERAGE
- MULTI SPECTRAL IMAGING/RADAR DATA
- INFORMATION IN SPATIAL DOMAIN
- CONSISTENT, SYSTEMATIC GLOBAL DATA SETS
- TIMELINESS AND ECONOMIC RATIONALE, LONG LIFE
- GLOBAL TO LOCAL APPLICATIONS

FREEDOM OF ACCESS TO SPACE

TRENDS

- 56 nations had acquired capacity for space based EO
- Over one decade in past, 700 EO satellites are in orbit
- Ownership shift towards private EO systems, who make available the very high resolution EO images in global markets
- Blurring boundaries between commercial imaging satellites and defence satellites
- Development of hybrid procurement schemes, combining proprietary missions and data buy framework contracts, partly triggered by the budgetary constraints of public customers.

TRENDS – Contd..

- EO data becoming mainstay for many Geographical Information Systems (GIS) applications

- Converging EO, GIS and Positioning technologies, leading to many innovative applications, with timely and user friendly access to services

- Emergence of NewSpace enterprises - mostly financed by private venture capital, with the promise of **mass market applications** and creation of new markets with **disruptive pricing models.**

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

How technologies are influencing changes?

Satellite Imaging- Capability determinants

ORBITS

PLATFORMS
- Weight and power
- Agility
- Pointing & Jitter
- Data throughput
- Memory
- Onboard intelligence
- Programmed - commanding

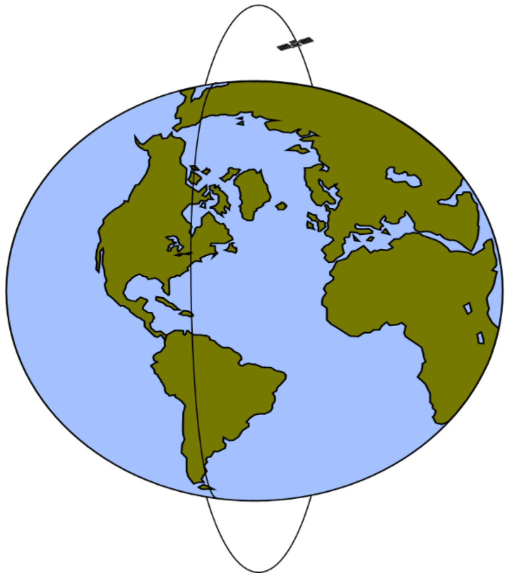
SENSORS
- Spatial resolution
- Spectral bands (V/IR/MW)
- spectral resolutions
- Temporal characteristics
- 2D/3D/Video

DATA RECEPTION
DATA PROCESSING
DATA/INFO DISSEMINATION

LIFE & RELIABILITY

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

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

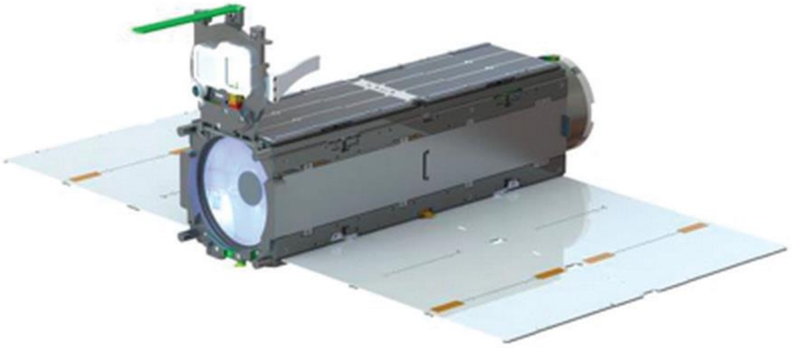
Landsat 8

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)

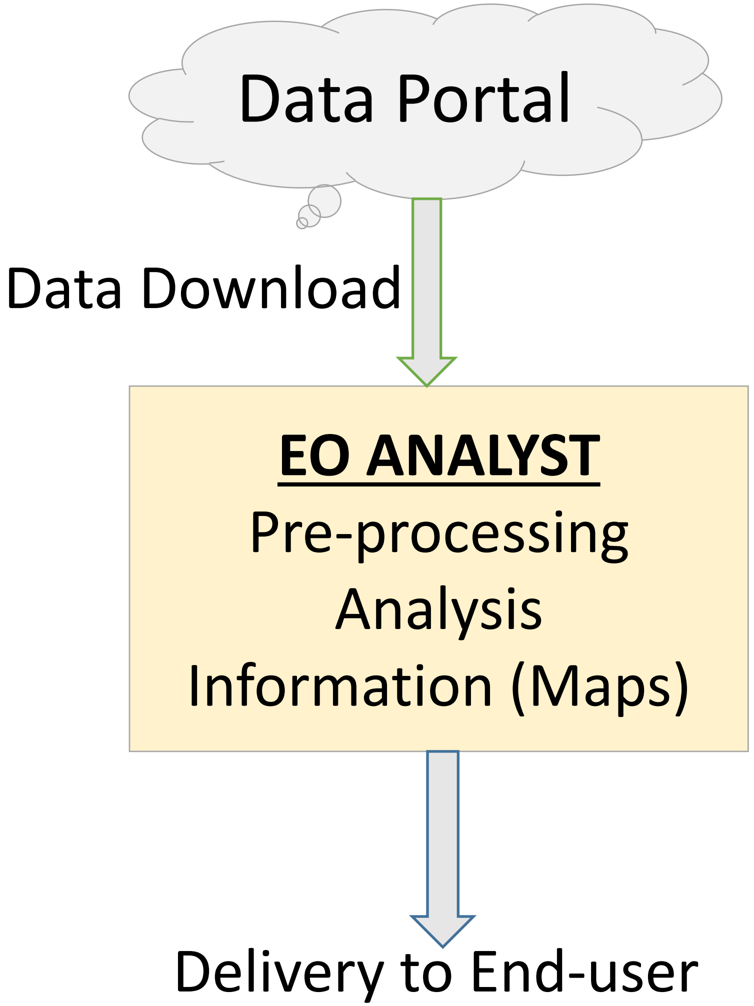
Medium Resolution
4 bands
23 meter spatial res.
70W power
140 km swath
106 Kg

CUBESAT Camera

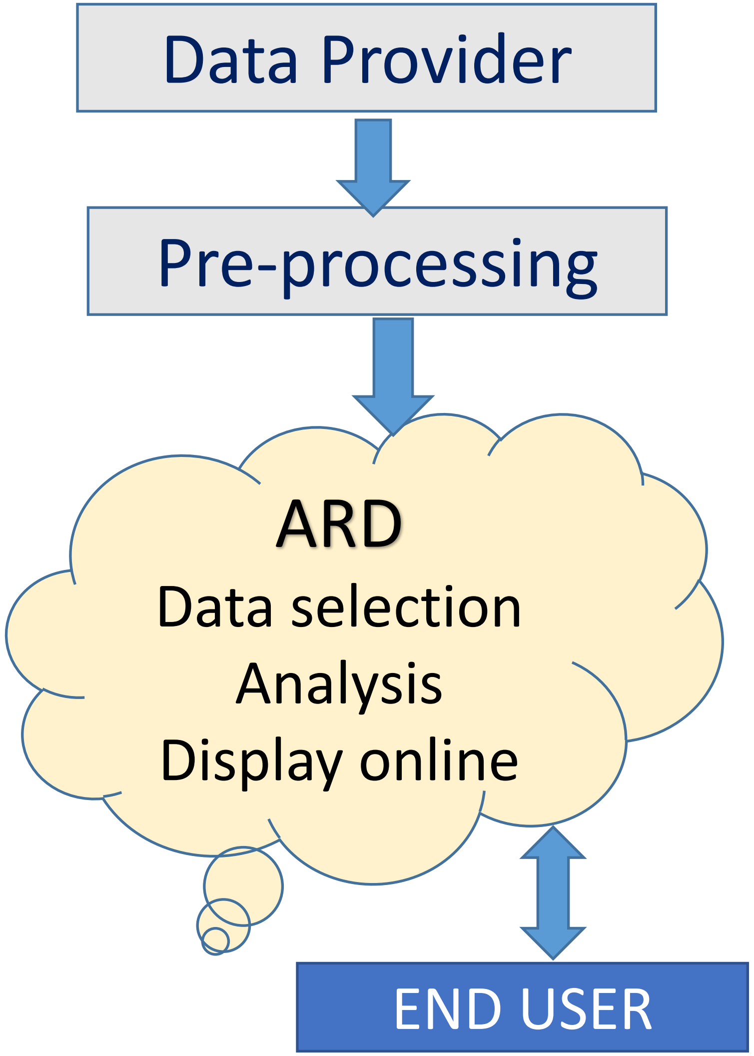
High resolution image & video
5m spatial resolution
3388 x 2712 pixel frame (9MP)
5.1 w power, 398 gram
Model: Imperx B 3412 DX
Mirror
Optics SY: 500mm f/6.3

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

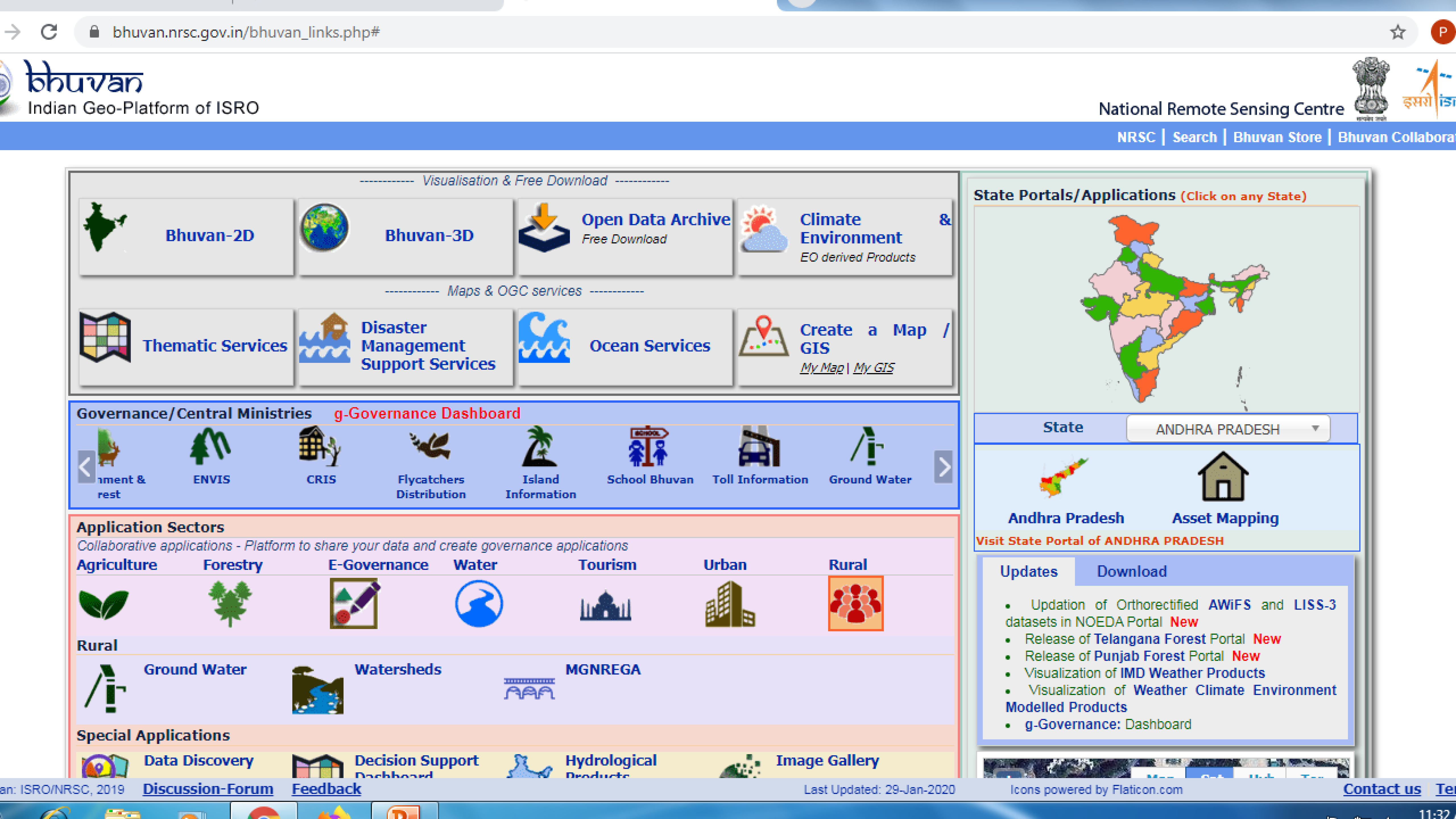
REFERENCE ON BIG EARTH DATA MANAGEMENT:

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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Indian Geo-Platform of ISRO
National Remote Sensing Centre
NRSC | Search | Bhuvan Store | Bhuvan Collabora
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Bhuvan-2D
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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
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an: ISRO/NRSC, 2019
Discussion-Forum
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Emerging India – New Paradigms

- INDIA …A VIBRANT, GROWING, KNOWLEDGABLE AND ASPIRATIONAL SOCIETY:
  - 1.35 B POPULATION – 70-80% LITERATE
  - > 40% YOUNG POPULATION
  - Aspiring to be 5 Trillion economy soon

Vastly New Approaches Needed

- 590 million in urban areas, 7400 km Metros/subways, 68 cities, >1million population, new skills and employment
- Vast changes in land use pattern, shrinking per capita agricultural land
- Climate change effects, changed precipitation, storm surges, agricultural yields.
- Water demand gap ~ 40%
- Evolving demands on national security

LAWS, POLICIES, PLANS …….. WILL PLAY AN INCREASING ROLE

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.

Market opportunities for EO in India

Needs

Education, Health, Mobility, Infrastructure development and Commercial services.

Demands for services

GIS based decision support systems, mobile multimedia, positioning and navigation services, disaster management support, rural connectivity and national security

National Missions

Digital India, Make in India, Smart City, Swach Bharat, National Education Mission and National Skill Mission programmes

Future data market potential IR 5 bi.
Value added market for info/solutions IR 60 bi

SATELLITE IMAGES & EO DATA – GLOBAL RELEVANCE

Satellite data/ observations playing key role in major international framework initiatives:

International Global Observing Strategy (IGOS)

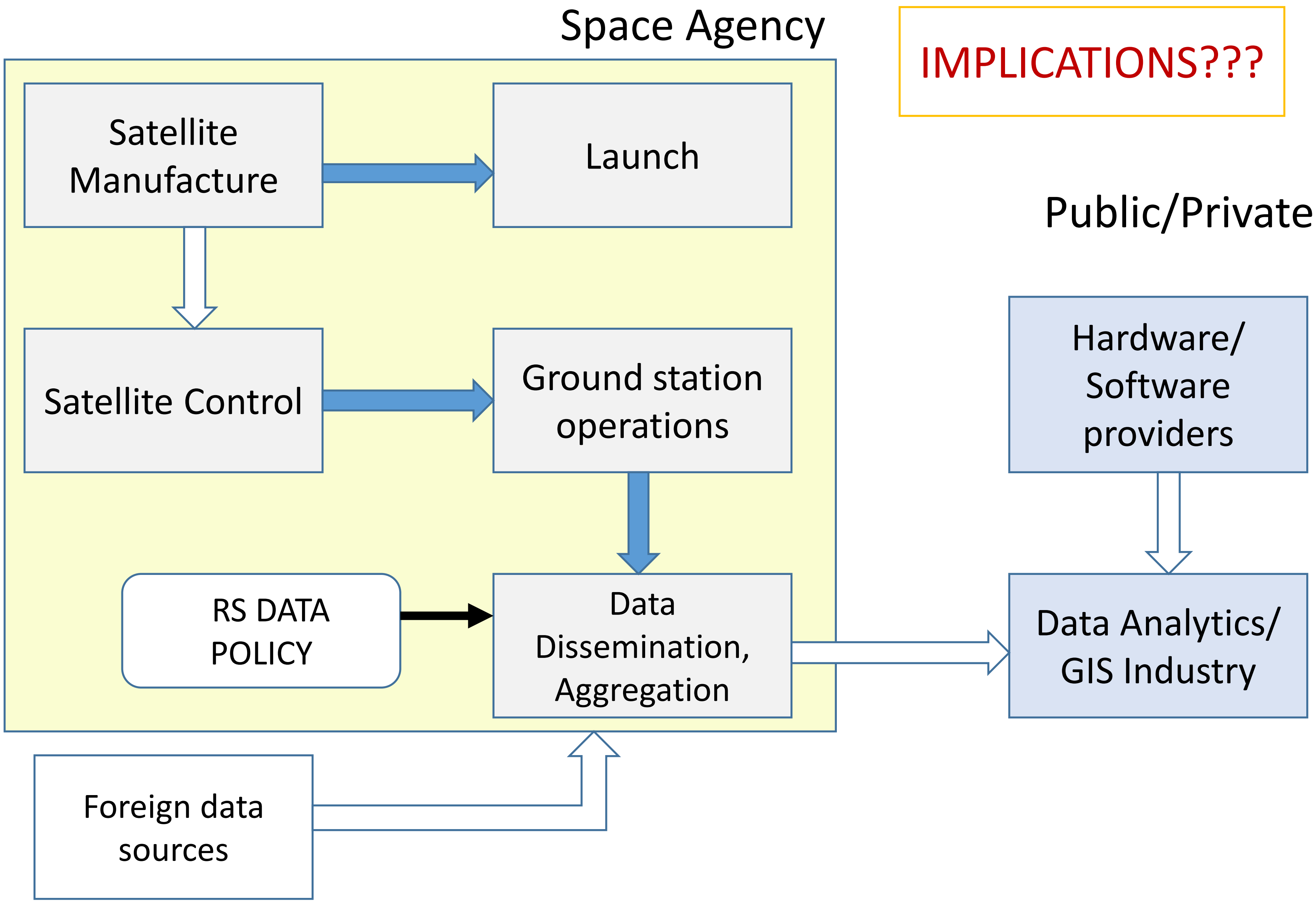
United Nations Sustainable Development Goals

Sendai framework for Disaster Reduction

Paris Agreement on Climate Change

New Urban Agenda

EO – organisational architecture in India



Future of Satellite images???

- Real-time on demand imaging service
- Information or service centric shifts
- Converging with main stream sectors
- Tackling societal issues important
- Commoditisation and ubiquity, wider use
- Growth of security demands

PART 2
Remote Sensing Applications

NALSAR

Atmospheric Applications of Remote Sensing

- Ozone monitoring
    - Montreal Protocol on Substances that Deplete the Ozone Layer.
- Monitoring gases, air pollutants, radiation, water vapor, and others
- LIDAR observations for trace gases up to the stratosphere
- Radar has been used for weather
- Weather forecasting and tracking trends
- Early warning

Weather Forecasting and Extreme Weather Events

- 4-km spatial resolution and 30-min temporal resolution
- GOES satellites of USA; METEOSAT of Europe and METEOR in Russia; INSAT/GSAT of India

Instruments for Coastal & ocean ecosystems

- Color scanners: used for ocean color mapping (chlorophyll and suspended sediments, diffused attenuation coefficients, etc.)
- • Multispectral data: used for water quality studies (chlorophyll a, suspended sol- ids, and turbidity) • Infrared radiometer data: used for sea surface temperature (SST) and currents mapping
- • Synthetic aperture radar: atmospheric gas regulation, soil formation, climate regulation etc.,
- • Hyperspectral data: used for water quality and pollution detection studies

Instruments……

- • Altimeter data: used for sea surface topography, currents, and surface roughness
- • Scatterometer data: used for amplitude of short surface waves (surface wind velocity and roughness)
- • Microwave radiometer data: used for microwave brightness temperature (salinity, surface temperature, and water vapor).
- • Optical sensors: Ocean color • Phytoplankton, Chlorophyll and other parameters • Total suspended sediment (TSS) and turbidity • Surface temperature • Ocean currents • Submerged aquatic vegetation (SAV) • Bathymetric data • Oil slicks and their spatial distributions • Coral reefs

Coastal & Ocean Applications

- Remote Sensing to Map Ocean Color, Phytoplankton, and Chlorophyll Concentration
- Phytoplankton biomass (indexed by chlorophyll concentrations), total suspended matter, and dissolved organic substances
- Nitrogen and phosphorus nutrients, and their main species including dissolved (nitrate, nitrite, ammonium, organic N, phosphate, organic P) and particulate (organic N, organic P) components

Ocean / Coastal apps

- Sea Surface Temperature and Circulation Patterns,
- Spatial Analysis of Submerged Aquatic Vegetation
- the difficulties inherent in interpreting reflectance values of water

Remote Sensing of Coastal Bathymetry

- In shallow coastal waters, remote sensing is being used to monitor benthic structure and classify bottom types mostly using radiometers, such as the SPOT-HRV
- LiDAR data integrated with global positioning systems (GPS) used for accurate topographic and bathymetric mapping, including shoreline positions. LiDAR surveys can produce a 10 cm vertical accuracy at spatial densities greater than one elevation measurement per square meter.

Remote Sensing of Coral Reefs

- One of the threats from oil spills from various oil rigs and oil transportation devices.
- 19% of the world's coral reefs are dead with another 15 % expected to die by 2025. Reefs are important as both fish habitats and buffers against high waves.
- Coral reefs are extremely vulnerable to changes in ocean temperature, pollution, and algal levels.
- RS maps indicate relative susceptibility to coral bleaching based on tidal currents and the generation of tidal mixing fronts

Achieving Sustainable Fisheries and Aquaculture Management

- Overfishing of the world's open and coastal regions has been a huge issue ecologically, as well as politically with impact on the global population of fish species
- Fishing fleets rely on GPS technologies to locate catches that are within reach and fuel costs.
- use of satellite sensors, such as the Advanced Very High Resolution Radiometer (AVHRR), Nimbus-7 coastal zone color scanner (CZCS), SeaWIFS, MODIS, and MERIS help augment stock assessment tools through phyto plankton mapping

GOOS

- Ocean Observing Networks:
  - The vastness of our oceans requires a global framework in collaborative data collection
- Global Ocean Observing System (GOOS)
  - The Global Ocean Observing System (GOOS) is a voluntary collaborative network of observations, where the components of the system are funded by national sources.
  - 77 countries contributing to tide gauge observations of sea level to about 10 countries involved in the resource-heavy global network using the platform of a research ship

Integrated national networks

- Australia's Integrated Marine Observing System (IMOS) to observe and manage marine resources addressing five major themes: multi-decadal ocean change, weather variability and weather extremes, major boundary currents and inter-basin flows, continental shelf processes, and ecosystem responses. Data is open for access.
- The European Marine Observation and Data Network (EMODnet) integrate existing, but fragmented and often inaccessible marine data
- The US Integrated Ocean Observing System (IOOS®) is a national–regional partnership created to ensure the sustained observation

Planetary and Extrasolar Observation

- NASA's "all-sky atlas" based on images of Wide-Field Infrared Survey Explorer (WISE) satellite
- NASA's Swift (i.e., the Swift Gamma-Ray Burst Mission) and Fermi (i.e., the Fermi Gamma-Ray Space Telescope) satellites
- the unmanned Mars Exploration Rovers Spirit and Opportunity, as well as the rover Curiosity, collecting data since 2012 as part of NASA's Mars Science Laboratory
- Ultimately, orbiting or fly-by spacecraft have collected remotely sensed data, in varying amounts, for all of the planets in our solar system and some of their moons, as well as asteroids and the Sun

Lunar Exploration

- Programs by diverse agencies/nations- NASA, ESA, China, Japan , India
- The Chandrayaan-1 spacecraft, had instruments from several nations. Moon Mineralogy Mapper, an imaging spectrometer collected data at visible and near-infrared wavelengths.
- Moon Mineralogy Mapper indicated the presence of very low levels of water over most of the lunar surface. Mini-SAR, estimates the water content of the Moon’s polar regions.

SUN

- 17 different NASA-sponsored or jointly sponsored spacecraft are collecting data on various aspects of the Sun–solar system connection.
- a better understanding of "space weather."
- In addition to solar flares and high-speed solar winds, the Sun periodically emits huge clouds, known as coronal mass ejections, which carry strong magnetic fields and energetic particles. These emissions cause geomagnetic storms that can disrupt power and communications systems on Earth as well as in orbiting spacecraft.
- Forecasting of above these occurrences. For example, the Solar Terrestrial Relations Observatory (STEREO) consisting of two satellites launched in 2006

Extra-solar Remote Sensing

- the Hubble Space Telescope is considered one of NASA's four "Great Observatories" along with the Compton Gamma Ray Observatory (1991– 2000), the Chandra X-ray Observatory (1999–current), and the Spitzer Space Tele- scope, an infrared observatory (2003–current).
- It carries a highly versatile instrument suite that is targeted at near-ultraviolet, visible, and near-infrared wavelengths (115–2500 nm) .
- Webb Space Telescope, will be capable of viewing infrared wavelengths
- The Hubble Space Telescope made breakthroughs, including the most accurate estimate yet of the age of the universe: 13.82 billion years.

Hubble's contributions..

- Discovery that the universe is expanding at an increasing speed, a still little-understood phenomenon known as "dark energy."
- evidence that supermassive black holes can be found at the centers of most galaxies, for example, NGC 4261. Mass of this black hole is estimated to be 1.2 billion times the mass of our Sun, but concentrated in an area roughly the size of our solar system

Exoplanets

- In 2008, the first visible-light images of an exoplanet, located roughly 25 light-years from Earth, captured with the Hubble Space Telescope’s Advanced Camera for Surveys.
- Exoplanets are planets orbiting stars other than our Sun;
- in 2007, Spitzer Space Telescope used to create the first-ever map of the surface temperature of the extrasolar planet: HD 189733b,

Exo planets

- The French Space Agency (Centre National D'études Spatiales), in conjunction with the ESA and other partners, launched the COnvection ROtation et Transits planétaires (CoRoT) space telescope & decommissioned in 2013.
- NASA launched the Kepler Space Telescope in 2009. Despite mechanical problems in 2014 that affected its targeting capabilities, the Kepler telescope continues detection of exoplanets, especially Earth-sized planets orbiting within the "habitable zone" (i.e., the zone likely to support life) of their parent stars.

Disaster Management Applications

- Constellations of satellites or a combination of different satellites operating under a coordinated framework
- Since 1960’s, RS is used to monitor patterns of flood, drought, coastal erosion, and volcanic activities.

Disaster Warning

- **Prevention**
- Risk assessment is a major operation for disaster prevention and satellite images are useful for hazard mapping, such as tectonic and flood plain maps.
- **Preparedness**
- Satellite images can assist in preparing for impending disasters, warning and prediction. Active microwave satellites are useful in facilitating flood warnings through the determination of wind velocities over the oceans. Furthermore, data on surface wind velocities may also help enhance capabilities in prediction of tropical cyclones.

Disaster Mitigation

- **Response**
- Images taken before and after the disasters are compared to identify damaged areas effectively. Satellite images combined with GPS data help identifying the exact location of the people in peril. Maps indicating locations of flooded areas provided critical assistance to search and rescue operations.

- Many international actors, including UN organizations, benefit from using satellite images for their relief efforts. Other examples include UNICEF, UNHCR, UNDP, WHO, and FAO - to name a few. Specifically, UNICEF has used IRS and Landsat imagery of areas exposed to earthquakes in order to plan special relief and assistance programs directed toward children in affected areas.

Disaster recovery

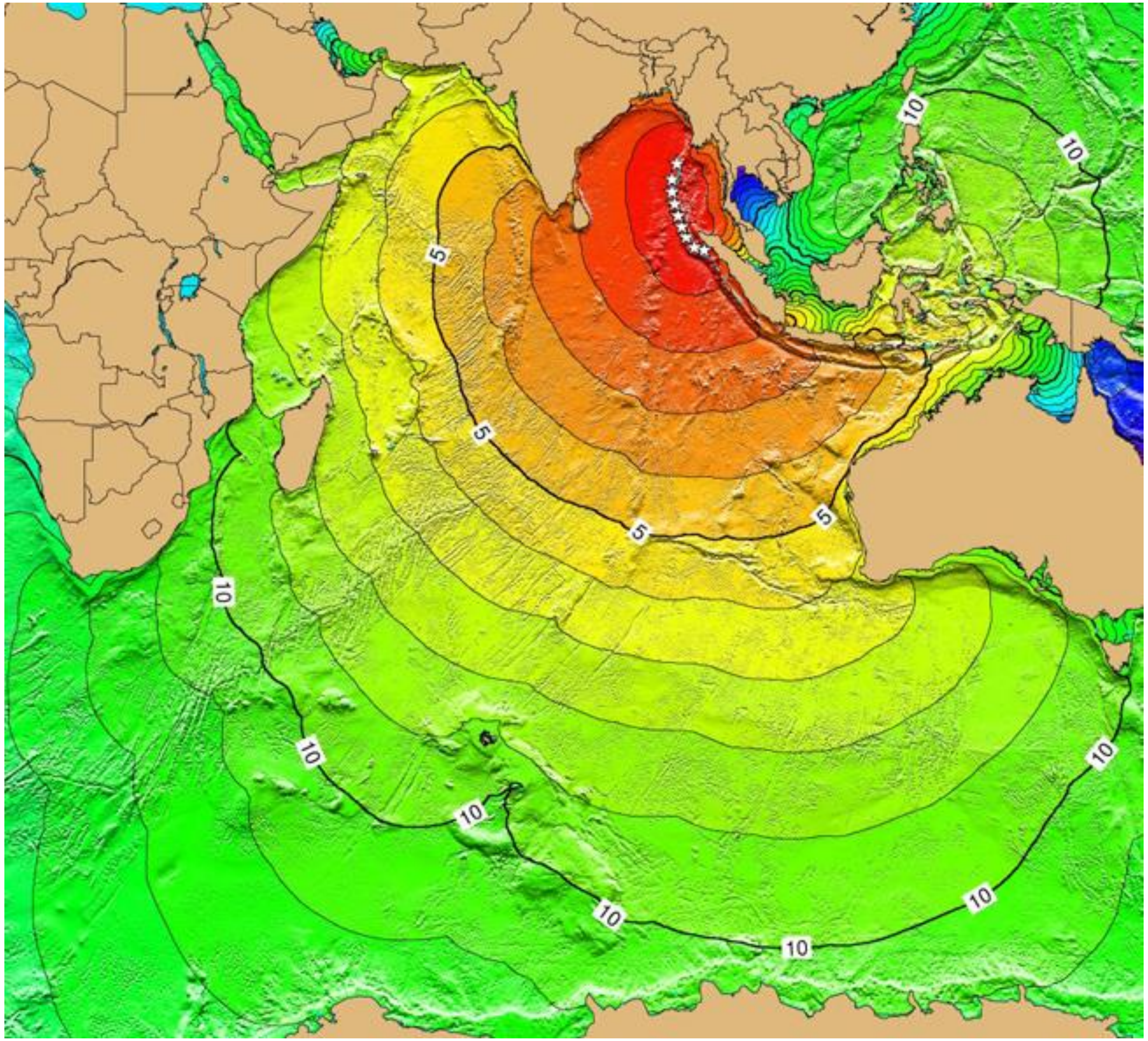
- **Recovery and Reconstruction**
- Satellite-derived information can be extensively used for the purpose of recovery and reconstruction by maps of affected populations and to facilitate effective planning for reconstruction activities such as rebuilding bridges and schools.

- Satellite data and derived information have been used for both national disaster management and to assist other countries. Some entities have voluntarily provided images free of charge in response to particular disasters, without adherence to specific programmes.

Prompt Response

- Insufficient international assistance and cooperation in different phases of general disaster management can be corrected with the use of satellite remote sensing, because assistance is achieved more easily through data provision and sharing, without much intrusion.
- International Charter on Major Disasters

Tsunami travel time map for the 2004 Indian Ocean tsunami



Source: NOAA
Official website

Case of Indian Ocean Tsunami

- Undersea earthquake of magnitude 9.3
- Occurred 150 km off the west coast of the northern Sumatra island in Indonesia
- Devastated the shores of : Indonesia, Sri Lanka, India, Thailand, the Maldives, Somalia, Myanmar, and Malaysia
- Resulted in the loss of more than 200,000 lives.
- No effective communications system to disseminate warnings
- No real-time monitoring of the tsunami – a major issue
- TOPEX/Poseidon and Jason-1’s passage
- Satellite images role: assessment and direction of aid efforts
- Activation of Disaster Management Charter

Exercise

Analyse the role of Space systems and how they were used, lessons, organizational aspects and legal issues connected with such disasters; what could be a durable solution to manage such natural disasters?

UN -SPIDER

- United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) as a UN Programme (since 2006)

- To "ensure that all countries and international and regional organizations have access to and develop the capacity to use all types of space-based information to support the full disaster management cycle."

- UN-SPIDER aims to coordinate space-based disaster management information – not just from remote sensing, but also derived from different space technologies such as GPS and telecommunications.

Thanking You

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