REMOTE SENSING AND ITS APPLICATIONS IN GEOGRAPHY - 18MAG24E

(Syllabus,-UNIT – III: Satellite Remote Sensing: Satellite – Types, Orbits and Sensors – Resolution: types - aspects of LANDSAT, SPOT, IRS, IKONOS, QUIKBIRD and recent satellites – Marginal information and Interpretation – Applications of Microwave and Thermal Remote Sensing.)

Classification of satellites

Based on Orbit:-Sun synchronous-geostationary.

Based on number of bands:- panchromatic, Multi Spectral Remote sensing, Super Spectral Remote Sensing, Hyper Spectral Remote Sensing.

Based on Uses:- Communications satellites- Miniaturized satellites- Navigational satellites- Earth observation satellites- Astronomical satellites etc,…

Satellite Orbits

Remote sensing satellites use two types of orbits:
Geosynchronous (geostationary) satellites orbit 36,000 km over the equator and remain over a single spot. They always view the same region, and produce the movie "loops" seen on TV news. They cannot cover the high latitudes. They are used for weather forecasting, satellite TV, and communications. These satellites are not really stationary, but appear stationary when viewed from earth because their orbit at the same rate as the earth's daily rotation.

Polar orbiting satellites fly several hundred km over the earth's surface with a rotation period of about 110 minutes. They can cover most of the earth's surface except for regions immediately adjacent to the poles. They have an inclination which measures the angle at which they cross the equator and which determines how close they get to passing directly over the poles. They are also called sun synchronous satellites because they often try to maintain the same angle with respect to the sun and hence the illumination. The imaging satellites want some shadows, but not too many, so they generally time their orbits for mid morning collections, which can also minimize cloud formation. These satellites have characteristic orbital patterns, similar to those of the space shuttle or international space station (ISS). They will make about a dozen orbits every day, and at the equator each orbit will be about 3000 km apart. Almost all satellites used for remoted sensing and GIS work are polar orbiters.

Sensors

Remote sensing instruments are of two primary types:
Active sensors, provide their own source of energy to illuminate the objects they observe. An active sensor emits radiation in the direction of the target to be investigated. The sensor then detects and measures the radiation that is reflected or backscattered from the target.
Passive sensors, on the other hand, detect natural energy (radiation) that is emitted or reflected by the object or scene being observed. Reflected sunlight is the most common source of radiation measured by passive sensors.

Resolution

The resolution of remote sensed raster data can be characterized in several different ways. There are four primary types of "resolution" for rasters:

- Spatial
- Spectral
- Radiometric

- Temporal

It is nearly impossible to acquire imagery that has high spatial, spectral, radiometric and temporal resolution. This is known as Resolution Trade-off, as it is difficult and expensive to obtain imagery with extremely high resolution. Therefore it is necessary to identify which types of resolution are most important for a project.

Spatial resolution is the type of resolution most people are familiar with. Spatial resolution is usually reported as the length of one side of a single pixel. For example, Landsat 8 has 30 meter spatial resolution. In other words, an image with 30 meter spatial resolution means that a single pixel represents an area on the ground that is 30 meters across.

Spectral resolution refers to how many spectral “bands” an instrument records. Spectral resolution is also defined by how “wide” each band is or the range of wavelengths covered by a single band. Black and white photos contain only 1 band that covers the visible wavelengths, color (RGB) images contain 3 bands and Landsat 8 has a total of 11 bands. For example, MODIS (Moderate Resolution Imaging Spectroradiometer) has greater spectral resolution than Landsat 8 because it has 36 relatively narrow bands that cover wavelengths from 0.4 to 14 micrometers. Landsat 8, on the other hand, has a total of 11 bands that cover less wavelengths and each band is wider in terms of wavelength.

Radiometric resolution is how finely a satellite or sensor divides up the radiance it receives in each band. The greater the radiometric resolution the greater the range of intensities of radiation the sensor is able to distinguish and record. Radiometric resolution is typically expressed as the number of bits for each band. Traditionally 8-bit data was common in remote sensed data, newer sensors (like Landsat 8) have 16-bit data products. 8 bits = 28 = 256 levels (usually 0 to 255) 16 bits = 216 = 65,536 levels (0 to 65,535).

Temporal resolution :-Remote sensed data represents a snap shot in time. Temporal resolution is the time between two subsequent data acquisitions for an area. This is also known as the “return time” or "revisit time". The temporal resolution depends primarily on the platform, for example, satellites usually have set return times and while sensors mounted on aircraft or unmanned aircraft systems , have variable return times. For satellites, the return time depends on the orbital characteristics (low vs high orbit), the swath width and whether or not there is an ability to point the sensor. Landsat has a return time of approximately 16 days, while other sensors like MODIS have nearly daily return times.

Landsat

The Landsat program is the longest running enterprise for acquisition of satellite imagery of Earth. On July 23, 1972 the Earth Resources Technology Satellite was launched. This was eventually renamed to Landsat. The most recent, Landsat 7, was launched on April 15, 1999. The instruments on the Landsat satellites have acquired millions of images. The images, archived in the United States and at Landsat receiving stations around the world, are a unique resource for global change research and applications in agriculture, cartography, geology, forestry, regional planning, surveillance, education and national security. Landsat 7 data has eight spectral bands with spatial resolutions ranging from 15 to 60 meters; the temporal resolution is 16 days.

History

Hughes Santa Barbara Research Center initiated design and fabrication of the first three MSS Multispectral Scanners in the same year man landed on the moon, 1969. The first prototype MSS was completed within nine months by fall of 1970 when it was tested by scanning Half Dome at Yosemite National Park.

The program was called the Earth Resources Technology Satellites Program when it was initiated in 1966, but the name was changed to Landsat in 1975. In 1979, Presidential Directive 54 under President of the United States Jimmy Carter transferred Landsat operations from NASA to NOAA, recommended development of long term operational system with four additional satellites beyond Landsat 3, and recommended transition to private sector operation of Landsat. This occurred in 1985 when the Earth Observation Satellite Company (EOSAT), a partnership of Hughes Aircraft and RCA, was selected by NOAA to operate the Landsat system under a ten year contract. EOSAT operated Landsats 4 and 5, had exclusive rights to market Landsat data, and was to build Landsats 6 and 7.

In 1989, this transition had not been fully completed when NOAA's funding for the Landsat program was due to run out (NOAA had not requested any funding, and Congress had appropriated only six months of funding for the fiscal year) and NOAA directed that Landsats 4 and 5 be shut down. The head of the newly formed National Space Council, Vice President Dan Quayle, noted the situation and arranged emergency funding that allowed the program to continue with the data archives intact.

Again in 1990 and 1991, Congress provided only half of the year's funding to NOAA, requesting that agencies that used Landsat data provide the funding for the other six months of the upcoming year. In 1992, various efforts were made to procure funding for follow on Landsats and continued operations, but by the end of the year EOSAT ceased processing Landsat data. Landsat 6 was finally launched on October 5, 1993, but was lost in a launch failure. Processing of Landsat 4 and 5 data was resumed by EOSAT in 1994. NASA finally launched Landsat 7 on April 15, 1999.

The value of the Landsat program was recognized by Congress in October 1992 when it passed the Land Remote Sensing Policy Act (Public Law 102-555) authorizing the procurement of Landsat 7 and assuring the continued availability of Landsat digital data and images, at the lowest possible cost, to traditional and new users of the data.

Satellite chronology

- Landsat 1 (originally named Earth Resources Technology Satellite 1): launched July 23, 1972, terminated operations January 6, 1978
- Landsat 2: launched January 22, 1975, terminated January 22, 1981
- Landsat 3: launched March 5, 1978, terminated March 31, 1983
- Landsat 4: launched July 16, 1982, terminated 1993
- Landsat 5: launched March 1, 1984, still functioning. but severe problems since Nov. 2011
- Landsat 6: launched October 5, 1993, failed to reach orbit
- Landsat 7: launched April 15, 1999, still functioning, but with faulty scan line corrector (May 2003)

Future

The Landsat Data Continuity Mission (LDCM), scheduled to be launched February 2013, will be the next satellite in the Landsat series. It is being launched on an Atlas V 401 from Vandenberg Air Force Base by the Launch Services Program. It will continue to obtain valuable data and imagery to be used in agriculture, education, business, science, and government. The new satellite is being assembled in Arizona by Orbital Sciences Corporation.

SPOT

SPOT (Système Pour l’Observation de la Terre) (lit. "System for Earth Observation") is a high-resolution, optical imaging Earth observation satellite system operating from space. It is run by Spot Image based in Toulouse, France. It was initiated by the CNES (Centre national d'études spatiales — the French space agency) in the 1970s and was developed in association with the SSTC (Belgian scientific, technical and cultural services) and the Swedish National Space Board (SNSB). It has been designed to improve the knowledge and management of the Earth by exploring the Earth's resources, detecting and forecasting phenomena involving climatology and oceanography, and monitoring human activities and natural phenomena. The SPOT system includes a series of satellites and ground control resources for satellite control and programming, image production, and distribution. Earlier satellites were launched with the ESA rocket launcher Ariane 2, 3, and 4 while SPOT 6 was launched by the Indian PSLV.

The company SPOT Image is marketing the high-resolution images, which SPOT can take from every corner of the Earth.

- SPOT 1 launched February 22, 1986 with 10 panchromatic and 20 meter multispectral picture resolution capability. Withdrawn December 31, 1990.
- SPOT 2 launched January 22, 1990 and deorbited in July 2009.
- SPOT 3 launched September 26, 1993. Stopped functioning November 14, 1997
- SPOT 4 launched March 24, 1998
- SPOT 5 launched May 4, 2002 with 2.5 m, 5 m and 10 m capability
- SPOT 6 launched September 9, 2012

The SPOT orbit

The SPOT orbit is polar, circular, sun-synchronous, and phased. The inclination of the orbital plane combined with the rotation of the Earth around the polar axis allows the satellite to fly over any point on Earth within 26 days. The orbit has an altitude of 832 kilometers, an inclination of 98.7°, and completing 14 + 5/26 revolutions per day.

SPOT 1, 2, and 3

Since 1986 the SPOT family of satellites has been orbiting the Earth and has already taken more than 10 million high quality images. SPOT 1 was launched with Ariane 2 on February 22, 1986. Two days later, the 1800 kg SPOT 1 transmitted its first image with a spatial resolution of 10 or 20 meters. SPOT 2 joined SPOT 1 in orbit on January 22, 1990 and SPOT 3 followed on September 26, 1993.

The satellite loads were identical, each including two identical HRV (High Resolution Visible) imaging instruments that were able to operate in two modes, either simultaneously or individually. The two spectral modes are panchromatic and multispectral. The panchromatic band has a resolution of 10 meters, and the three multispectral bands (G,R,NIR) have resolutions of 20 metres. They have a scene size of 3600 km2 and a revisit interval of one to four days, depending on the latitude.

Because the orbit of SPOT 1 was lowered in 2003, it will gradually lose altitude and break up naturally in the atmosphere. Deorbitation of Spot 2 – in accordance with IADC (Inter-Agency Space Debris Coordination Committee)- commenced in mid-July 2009 for a period of two weeks, with a final burn on 29 July 2009. SPOT 3 is not working anymore either, due to problems with its stabilization system.

SPOT 5

SPOT 5 was launched on May 4, 2002 and has the goal to ensure continuity of services for customers and to improve the quality of data and images by anticipating changes in market requirements.

SPOT 5 has two high resolution geometrical (HRG) instruments that were deduced from the HRVIR of SPOT 4. They offer a higher resolution of 2.5 to 5 meters in panchromatic mode and 10 meters in multispectral mode (20 metre on short wave infrared 1.58 - 1.75 µm). SPOT 5 also features an HRS imaging instrument operating in panchromatic mode. HRS points forward and backward of the satellite. Thus, it is able to take stereopair images almost simultaneously to map relief.

SPOT 6 and SPOT 7

SPOT 6 was launched on September 9, 2012 while SPOT 7 proposed launch is in the year of 2013. They form a constellation of Earth-imaging satellites designed to provide continuity of high-resolution, wide-swath data up to 2023. EADS Astrium took the decision to build this constellation in 2009 on the basis of a perceived government need for this kind of data. Spot Image, a subsidiary of Astrium, is funding the satellites alone and owns the system (satellites and ground segments).

- Spectral bands, with simultaneous panchromatic and multispectral acquisitions:
- Panchromatic (450 – 745 nm)
- Blue (450 – 525 nm)
- Green (530 – 590 nm)
- Red (625 – 695 nm)
- Near-infrared (760 – 890 nm)
- Footprint: 60 km x 60 km

- Responsive satellite tasking, with 6 tasking plans per day, per satellite
- Capacity to acquire up to 3 million km2. Daily

Spot-6 was successfully launched by India's PSLV-C21 mission on 9th Sept. 2012 at 9:53 am (lift-off).

Indian Remote Sensing

Indian Remote Sensing satellites (IRS) are a series of Earth Observation satellites, built, launched and maintained by Indian Space Research Organisation. The IRS series provides many remote sensing services to India.

IRS System

Following the successful demonstration flights of Bhaskara-1 and Bhaskara-2 satellites launched in 1979 and 1981, respectively, India began to develop the indigenous Indian Remote Sensing (IRS) satellite program to support the national economy in the areas of agriculture, water resources, forestry and ecology, geology, water sheds, marine fisheries and coastal management.

Towards this end, India established the National Natural Resources Management System (NNRMS) for which the Department of Space (DOS) is the nodal agency, providing operational remote sensing data services. Data from the IRS satellites is received and disseminated by several countries all over the world. With the advent of high-resolution satellites new applications in the areas of urban sprawl, infrastructure planning and other large scale applications for mapping have been initiated.

The IRS system is the largest constellation of remote sensing satellites for civilian use in operation today in the world, with 12 operational satellites. All these are placed in polar sun-synchronous orbit and provide data in a variety of spatial, spectral and temporal resolutions.

IRS data applications

Data from Indian Remote Sensing satellites are used for various applications of resources survey and management under the National Natural Resources Management System (NNRMS). Following is the list of those applications:

- Preharvest crop area and production estimation of major crops.
- Drought monitoring and assessment based on vegetation condition.
- Flood risk zone mapping and flood damage assessment.
- Hydro-geomorphological maps for locating underground water resources for drilling well.
- Irrigation command area status monitoring
- Snow-melt run-off estimates for planning water use in down stream projects
- Land use and land cover mapping

- Urban planning
- Forest survey
- Wetland mapping
- Environmental impact analysis
- Mineral Prospecting
- Coastal studies
- Integrated Mission for Sustainable Development (initiated in 1992) for generating locale-specific prescriptions for integrated land and water resources development in 174 districts.

IRS launch

The initial versions are composed of the 1 (A,B,C,D). The later versions are named based on their area of application including OceanSat, CartoSat, ResourceSat. Some of the satellites have alternate designations based on the launch number and vehicle (P series for PSLV).

Serial	Satellite	Date of	Launch Vehicle	Status
1	IRS 1A	17 March	Vostok, USSR	Mission Completed
2	IRS 1B	29 August	Vostok, USSR	Mission Completed
3	IRS P1 (also IE)	20 September	PSLV-D1	Crashed, due to launch
4	IRS P2	15 October	PSLV-D2	Mission Completed
5	IRS 1C	28 December	Molniya, Russia	Mission Completed
6	IRS P3	21 March	PSLV-D3	Mission Completed
7	IRS 1D	29 September	PSLV-C1	Mission Completed
8	IRS P4 (Oceansat-1)	27 May 1999	PSLV-C2	Mission Completed
9	Technology Experiment	22 October	PSLV-C3	In Service
10	IRS P6 (Resourcesat-1)	17 October	PSLV-C5	In Service
11	IRS P5 (Cartosat 1)	5 May 2005	PSLV-C6	In Service
12	Cartosat 2 (IRS P7)	10 January	PSLV-C7	In Service
13	Cartosat 2A (IRS P?)	28 April 2008	PSLV-C9	In Service
14	IMS 1 (IRS P?)	28 April 2008	PSLV-C9	In Service
15	Oceansat-2	23 September	PSLV-C14	In Service
16	Cartosat-2B	12 July 2010	PSLV-C15	In Service
17	Resourcesat-2	20 April 2011	PSLV-C16	In Service
18	Megha-Tropiques	12 October	PSLV-C18	In Service
19	RISAT-1	26 April 2012	PSLV-C19	In Service

IKONOS SATELLITE

The IKONOS Satellite is a high-resolution satellite operated by GeoEye. Its capabilities include capturing a 3.2m multispectral, Near-Infrared (NIR)/0.82m panchromatic resolution at nadir. Its applications include both urban and rural mapping of natural resources and of natural disasters, tax mapping, agriculture and forestry analysis, mining, engineering, construction, and change detection. It can yield relevant data for nearly all aspects of environmental study. IKONOS images have also been procured by SIC for use in the media and motion picture industries, providing aerial views and satellite photos for many areas around the world. Its high resolution data makes an integral contribution to homeland security, coastal monitoring and facilitates 3D Terrain analysis.

Spatial resolution

- 0.8 m panchromatic (1-m PAN)
- 4-meter multispectral (4-m MS)
- 1-meter pan-sharpened (1-m PS)

Spectral Resolution

Band	1-m PAN	4-m MS & 1-m PS
1 (Blue)	0.45–0.90 µm	0.445–0.516 µm
2 (Green)	*	0.506–0.595 µm
3 (Red)	*	0.632–0.698 µm
4 (Near IR)	*	0.757–0.853 µm

Temporal resolution

The revisit rate for IKONOS is three to five days off-nadir and 144 days for true-nadir.

Radiometric resolution

The sensor collects data with an 11-bit (0–2047) sensitivity and are delivered in an unsigned 16-bit (0–65535) data format. From time-to-time the data are rescaled down to 8-bit (0–255) to decrease file size. When this occurs much of the sensitivity of the data needed by remote sensing scientists is lost.

Swath

11 km × 11 km (single scene)

QuickBird

high resolution optical products are available as part of the DigitalGlobe Standard Satellite Imagery products from the QuickBird, WorldView-1/-2/-3/-4, and GeoEye-1 satellites. All details about the data provision, data access conditions and quota assignment procedure are described into the Terms of Applicability available in Resources section.

In particular, QuickBird offers archive panchromatic products up to 0.60m GSD resolution and 4-Bands Multispectral products up to 2.4m GSD resolution.

DATA SET SPECIFICATIONS
Spatial coverage: 90 N, -90 S, -180 W, 180 E
Temporal coverage:2001-11-01 - 2015-03-31
Date of launch:2001-10-18
Operators:DigitalGlobe
Mission status:completed
Orbit height:450 km
Orbit type:Sun-synchronous
Swath width:16.5 km
Resolution:Very High Resolution - VHR (0 - 5m)
High Resolution - HR (5 - 20 m)
Wavelengths: VIS (0.40 - 0.75 µm), NIR (0.75 - 1.30 µm)

Applications of Microwave Remote Sensing.

- Flood mapping,
- Snow mapping,
- Oil Slicks Sea ice type,
- Crop classification,
- Forest biomass / timber estimation,
- Tree height Soil moisture mapping,
- Soil roughness mapping
- monitoring Wave height monitoring Crop yield,
- Crop stress
- Flood prediction
- Landslide prediction

Applications of Thermal Remote Sensing.

Applications:

- Surface temperature detection
- Camouflage detection
- Forest fire detection and fire risk mapping
- Evapotranspiration and drought monitoring
- Estimating air temperature
- Oil spill monitoring

- Water quality monitoring
- Volcanic activity monitoring
- Urban heat island analysis
- Military purpuses

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