# Land observation Satellites

lecture 5

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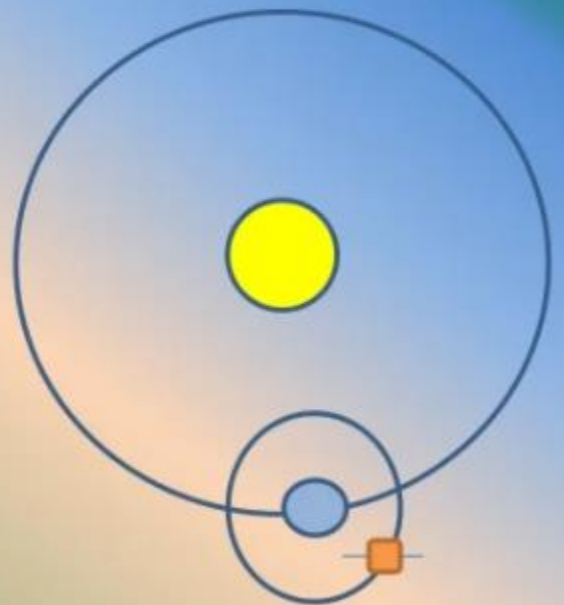
# Outlines

- Satellite (Definition)
- Satellite orbits
- Orbits classification
- Passive and active remote sensing

# Satellites

A satellite is an object put into orbit around the earth or any other planet in order to relay communication signals or transmit scientific data.



# Why use Satellites to Study the Earth?

- Consistent, routine, global measurements
- Overview of information on the hemispheric, regional, national, and local scales – the “big picture”
- Provide information in areas where there are no ground-based measurements
- Advance warning of impending environmental events and disasters
- Visual appeal: a picture is worth a thousand words

# Satellite Images

## Advantages

- Covers large areas
- Cost effective
- Time efficient
- Multi-temporal
- Multi-sensor
- Multi-spectral
- Overcomes inaccessibility
- Faster extraction of GIS-ready data

## Disadvantages

- Needs ground verification
- Doesn't offer details
- Not the best tool for small areas
- Needs expert system to extract data

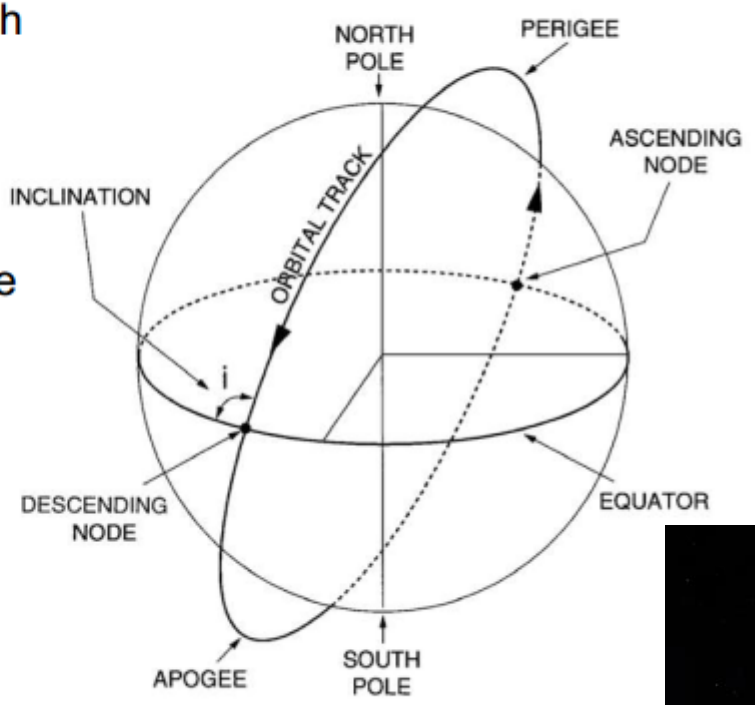
# General notes

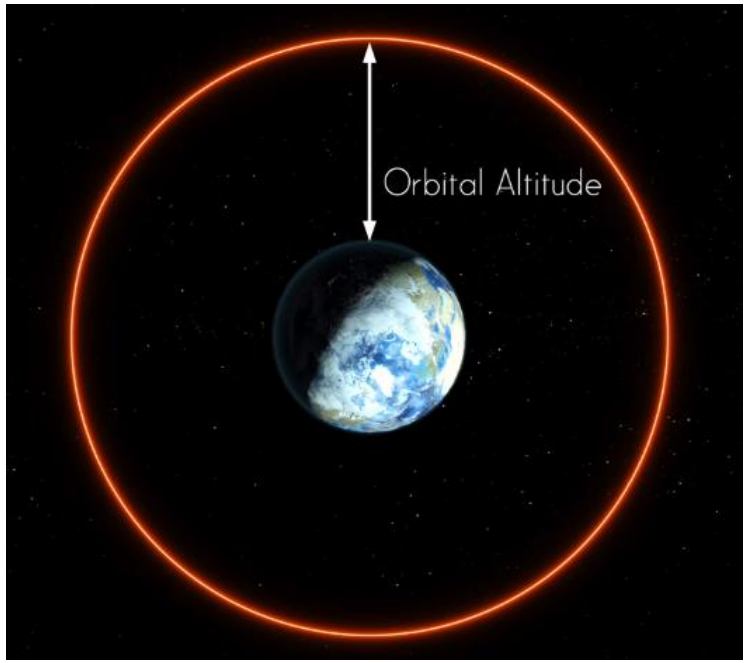
- ✓ The path followed by a satellite is referred to as its orbit.
- ✓ An object in orbit is called a satellite.
- ✓ Satellite orbits are matched to the capability and objective of the sensor(s) they carry.
- ✓ Orbit selection can vary in terms of altitude and their orientation and rotation relative to the Earth.

# Satellite orbits

**Satellites are placed into orbits tailored to match the objectives of each satellite mission and the capabilities of the sensors they carry.**

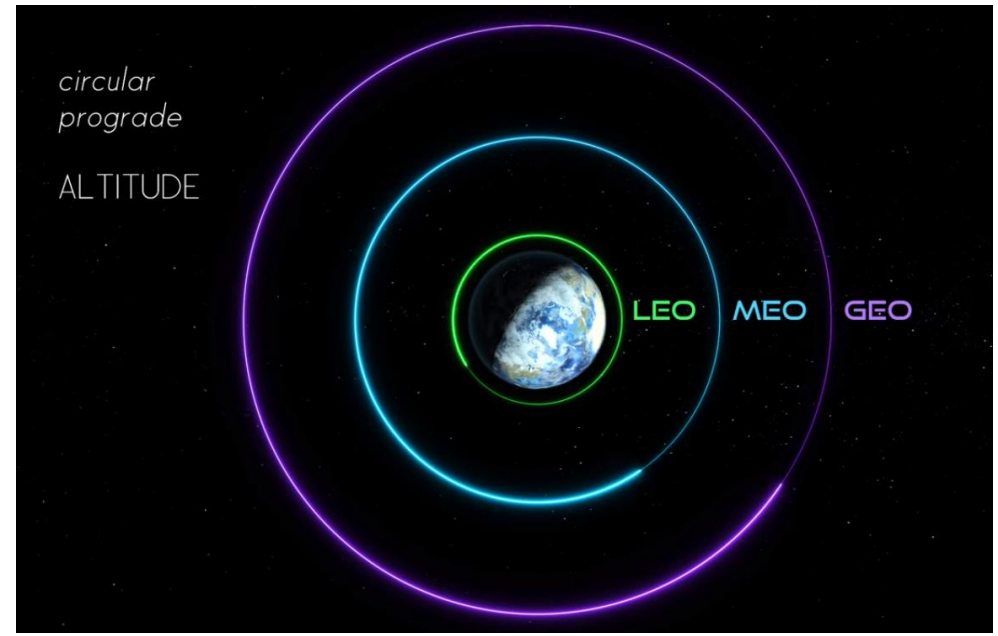
**Apogee (A)**: point farthest from the Earth
**Perigee (P)**: point closest to the Earth
**Ascending node (AN)**: point where the satellite crosses the equator moving south to north
**Descending node (DN)**: point where the satellite crosses the equator passing north to south
**Inclination (i)**: the angle between the Earth's axis at the North Pole and a line drawn perpendicular to the plane of the satellite orbit, viewed such that the satellite follows a counterclockwise trajectory



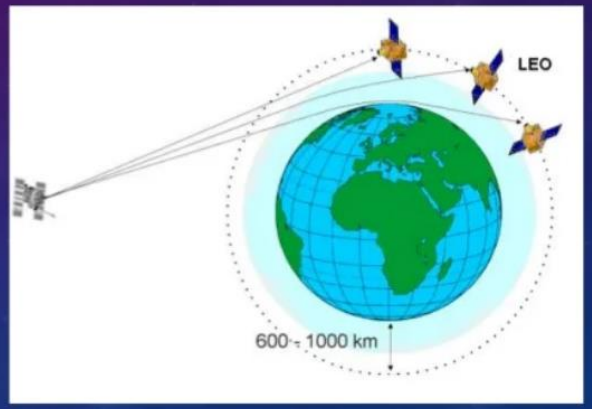

# ➢ TYPES OF ORBITS

- ❑ Low-Earth-Orbit (LEOs)
- ❑ Medium-Earth-Orbit (MEOs)
- ❑ Geostationary ORBIT(GEOs)



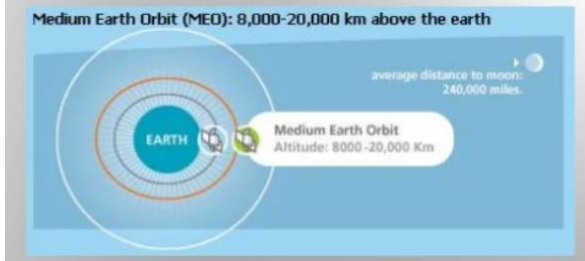
## LOW-EARTH-ORBIT (LEO)

- Altitude (600-1000 KM)
- satellite gives it a better signal strength




- Advantages:
  - Reduces transmission delay
- Disadvantages:
  - Smaller coverage area.
  - Shorter life span (5-8 yrs.)

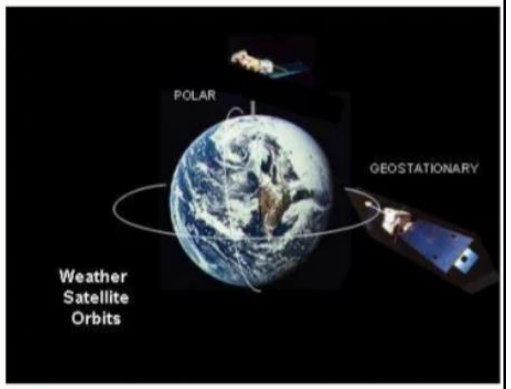
## MIDDLE-EARTH-ORBIT (MEO)

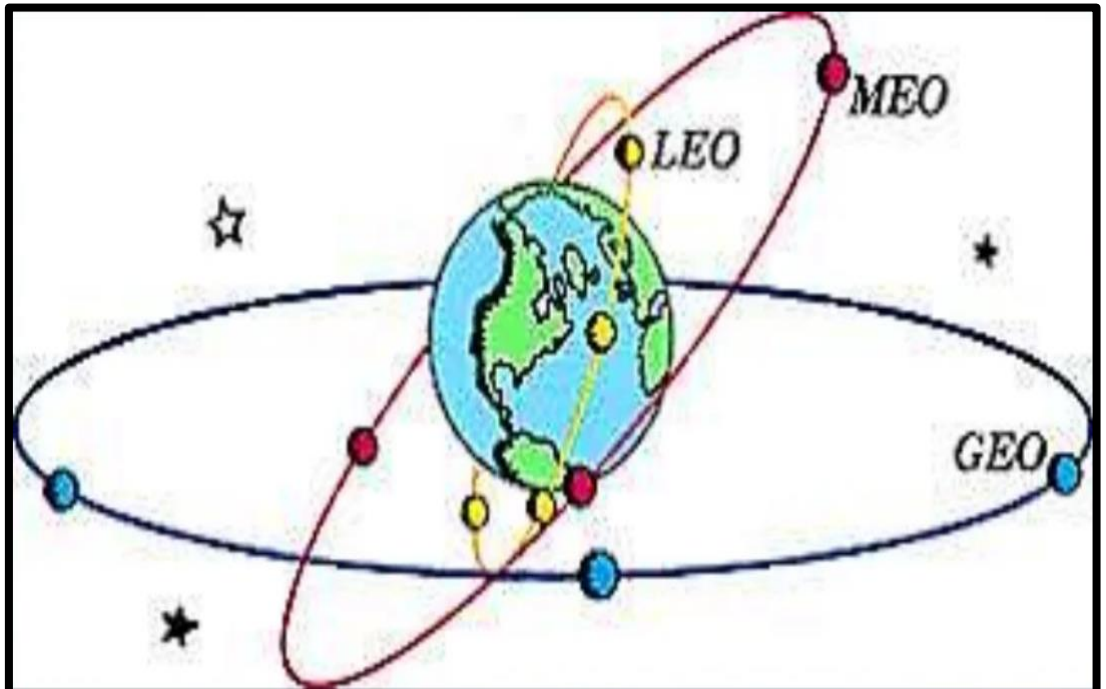



- MEOs orbits between the altitudes of 8,000 – 20,000 km above the earth.
- **MEO satellites have a larger coverage.**
- These orbits are primarily reserved for communications satellites that cover the North and South Pole.
- MEOs are placed in an elliptical (oval-shaped) orbit.

## Geostationary-Earth-Orbit (GEO)

- From the ground level the satellite appears fixed.
- GEO satellites have a 24 hour view of a particular area.
- Coverage to 40% of area Of planet by this satellite



## Low Earth Orbit (LEO)

- LEO satellites are much closer to the earth than GEO satellites, ranging from 600 to 1000 km above the surface.

- LEO satellites don't stay in fixed position relative to the surface, and are only visible for 15 to 20 minutes each pass.

LEO

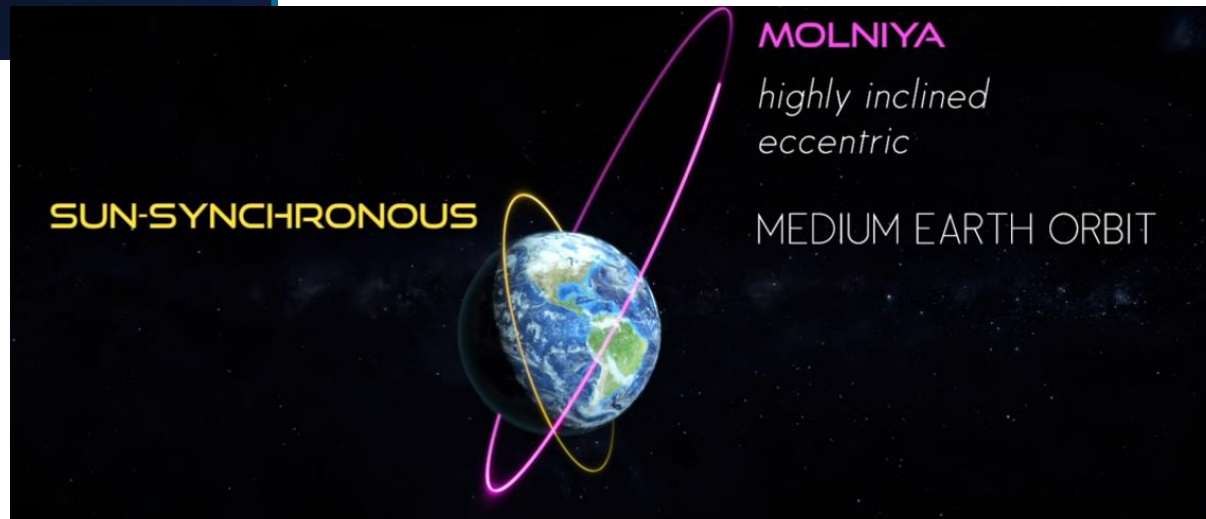
- Advantages
  - A LEO satellite's proximity to earth compared to a GEO satellite gives it a better signal strength and less of a time delay, which makes it better for point to point communication.
  - A LEO satellite's smaller area of coverage

# LEO [redacted]

- Disadvantages
  - A network of LEO satellites is needed, which can be costly
  - LEO satellites have to compensate for Doppler shifts cause by their relative movement.

# Medium Earth Orbit (MEO)

- A MEO satellite is in orbit somewhere between 8,000 km and 20,000 km above the earth's surface.
- MEO satellites are similar to LEO satellites in functionality.
- MEO satellites are visible for much longer periods of time than LEO satellites, usually between 2 to 8 hours.
- MEO satellites have a larger coverage area than LEO satellites.



# MEO

## Advantage

- A MEO satellite's longer duration of visibility and wider footprint means fewer satellites are needed in a MEO network than a LEO network.

## Disadvantage

- A MEO satellite's distance gives it a longer time delay and weaker signal than a LEO satellite, though not as bad as a GEO satellite.

## Geostationary Earth Orbit (GEO)

- These satellites are in orbit 35,863 km above the earth's surface along the equator.

- Objects in Geostationary orbit revolve around the earth at the same speed as the earth rotates. This means GEO satellites remain in the same position relative to the surface of earth.

# GEO

## Advantages

- A GEO satellite's distance from earth gives it a large coverage area, almost a fourth of the earth's surface.
- GEO satellites have a 24 hour view of a particular area.
- These factors make it ideal for satellite broadcast and other multipoint applications.

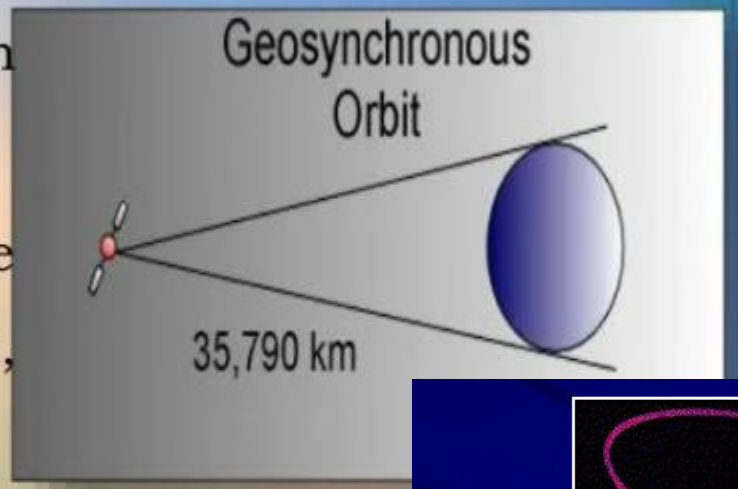
# GEO

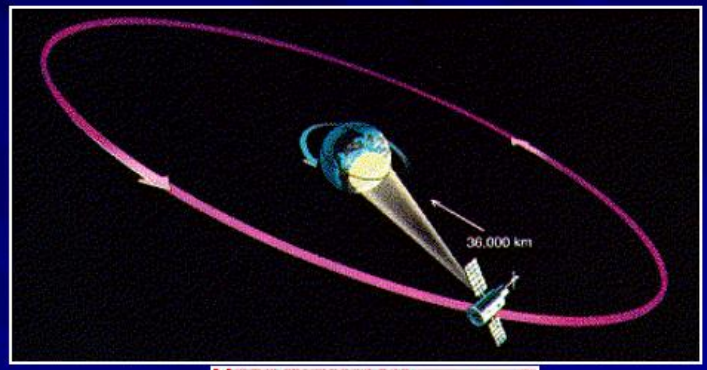
## Disadvantages

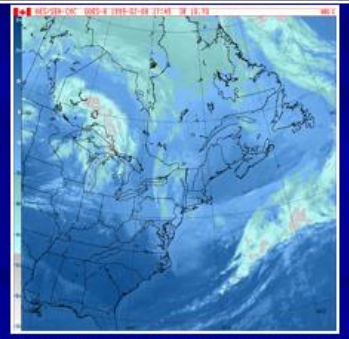
- A GEO satellite's distance also cause it to have both a comparatively weak signal and a time delay in the signal, which is bad for point to point communication.
- GEO satellites, centered above the equator, have difficulty broadcasting signals to near polar regions

## Geo Synchronous Orbits

- It is also known as geostationary orbits, satellites in these orbits circle the Earth at the same rate as the Earth spins.
- These satellites are used to study large scale phenomenon such as hurricanes, or cyclones.
- These orbits are also used for communication satellites.
- The other disadvantage is that these satellites have trouble monitoring activities near the poles.



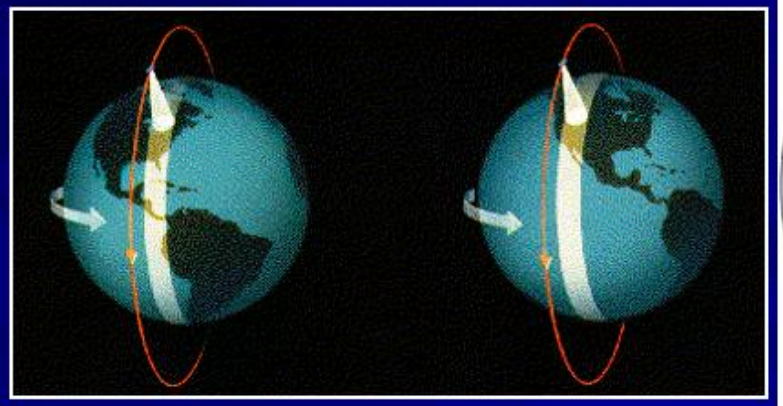
- geostationary orbiting satellites are those that remain stationary relative to a point on the surface of the earth i.e. communications and meteorological satellites `

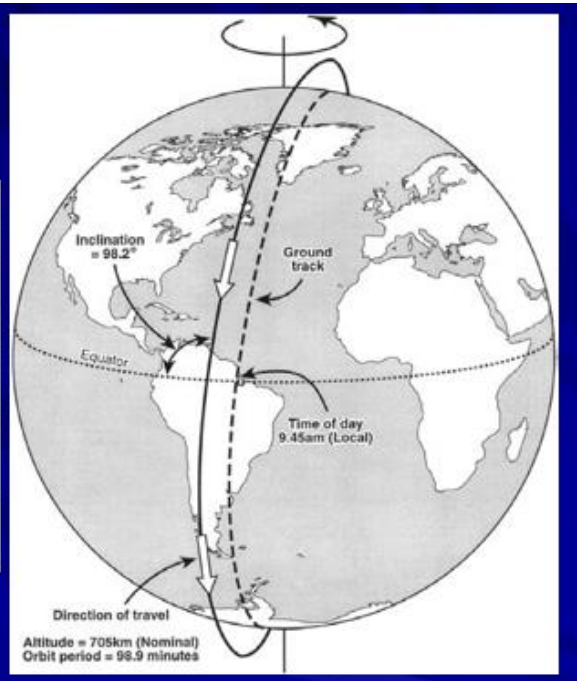
# Sun Synchronous Satellite

- ✓ Those satellites that moves around the earth and always gets its power source from the sun.
- ✓ Located approx. 750 km above the surface of the earth
- ✓ Landsat, Quick bird etc.

Uses:

- ✓ Military purposes
- ✓ Remote Sensing





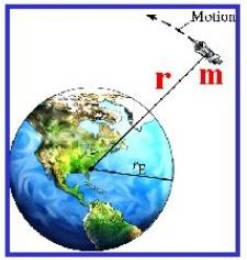

- currently there are 2777 satellites orbiting the earth (US – 878)
- multi-purpose: scientific defense communications global positioning system (GPS)
- polar-orbiting satellites are those in which the position of the satellite's orbital plane is kept constant relative to the sun. i.e. Landsat satellite series

# Geostationary Orbits (GEO)

If a satellite is moved to an orbit enough out from Earth then the period of this orbit can be selected to match the rotation of the Earth. This synchronization means that for an observer at a fixed location on Earth, a satellite in a geosynchronous orbit returns to exactly the same place in the sky at exactly the same time each day. The special case of a geosynchronous orbit that is circular and directly above the equator is called a geostationary orbit (GEO). A GEO has an orbital eccentricity of zero. A satellite in that orbit, at that chosen distance from Earth in the equatorial plane, moving in a counter-clockwise sense, moves around the Earth exactly the same speed as the Earth rotates. The satellite then stays fixed in the same place above the Earth in a geostationary orbit (see above calculating its altitude). This allows the satellites to observe and collect information continuously over specific areas. From the ground, a geostationary object appears motionless in the sky.

## Example: Geosynchronous Satellite

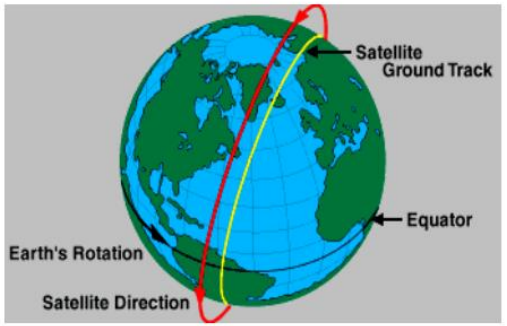
- A **geosynchronous satellite** is one that stays above the same point on the Earth, which is possible only if it is above a point on the equator.
- Such satellites are used for TV & radio transmission, for weather forecasting, as communication relays.




Earth, mass $M_E$

## Landsat – Orbit

- Sun synchronous, near polar
- ~ 705 km altitude
- 9:42 am equator crossing



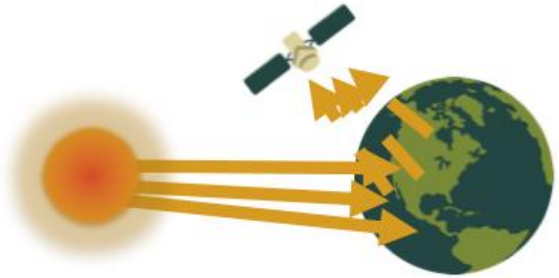

**Sunsynchronous orbits:** Many of the LEO near-polar satellite orbits (700 to 1000 km) are also sun-synchronous such that they cover each area of the world at a constant local time of day called local sun time. At any given latitude, the position of the sun in the sky as the satellite passes overhead will be the same within the same season. This ensures consistent illumination conditions when acquiring images in a specific season over successive years, or over a particular area over a series of days. This is an important factor for monitoring changes between images or for mosaicking adjacent images together, as they do not have to be corrected for different illumination conditions.

# Passive and Active Remote Sensing (Passive and Active sensors)

**Active Sensors:** Active Remote sensors create their own electromagnetic energy that is transmitted from the sensor towards the terrain, interacts with the terrain producing a backscatter of energy and is recorded by the remote sensor's receiver.

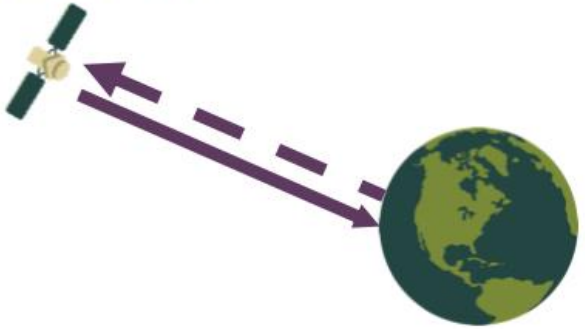
**Passive Sensors:** Passive sensor detects the naturally emitted microwave energy within its field of view.

## Passive Sensors

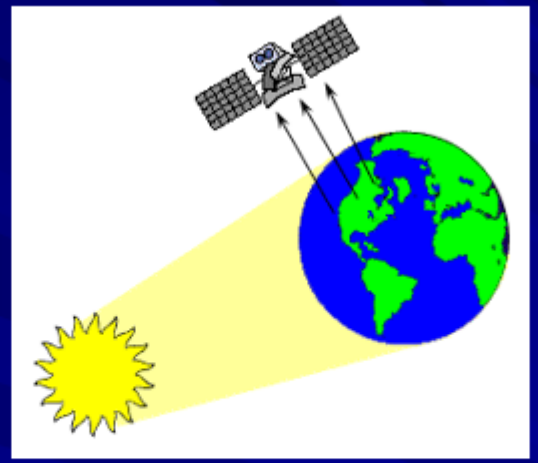


- Detect only what is emitted from the landscape, or reflected from another source (e.g., light reflected from the sun)
- Examples: (**MODIS, MISR, OMI, VIIRS**)

## Active Sensors

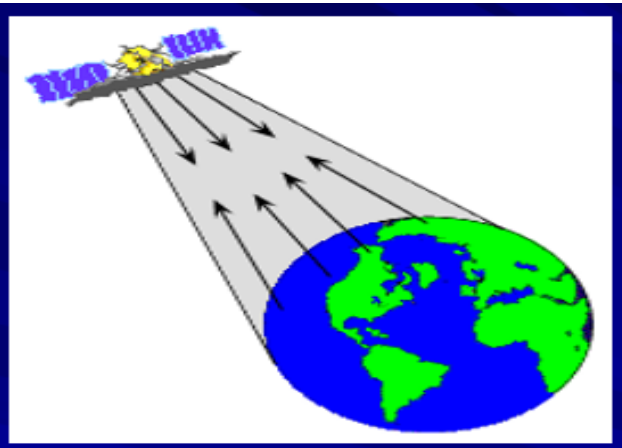


- Instruments emit their own signal and the sensor measures what is reflected back (e.g. sonar and radar)
- Example: **CALIPSO**



Passive Remote Sensing

- measure natural radiation emitted by target or/and radiation energy from other sources reflected from the target
- examples: passive microwave radiometers, LandSat, SPOT

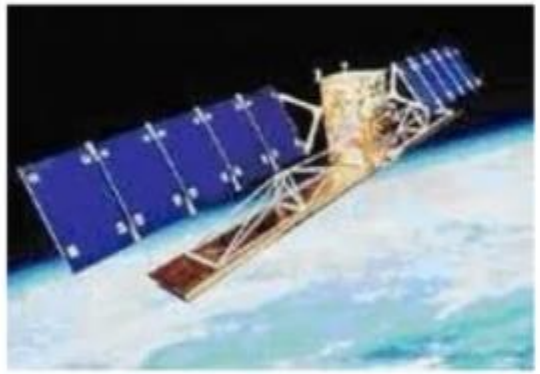


Active Remote Sensing

- transmit their own signal and measure the energy that is reflected or scattered back from the target
- advantages: ability to "see" regardless of time of day or season; use wavelengths not part of solar spectrum; better control of the way target is illuminated

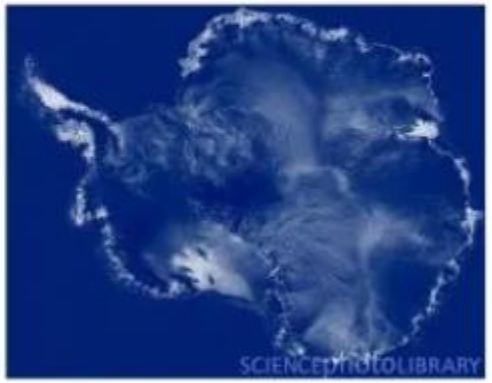
# Examples for Active sensors

**RADARSAT-1:** Is an advanced Earth observation satellite project developed by the Canadian Space Agency (CSA) on 4th Nov 1995 to monitor environmental change & to support resource sustainability.



RADARSAT Satellite

A 3D view of flight path & data shown over Radarsat(600x404)



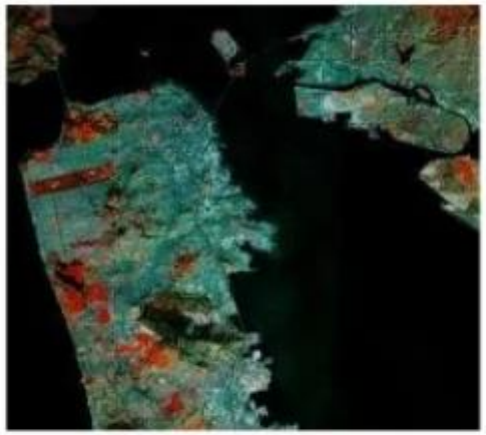

Radarsat image of Antarctica (3424x2848)

# Examples for Passive Sensors

1) SPOT-1: It was launched on 22nd Feb, 1986 with 10 panchromatic & 20 meter multispectral picture resolution capability.


SPOT Satellite image of

Kong(530x523)



Spot satellite image of San Francisco

& the East Bay(800x717)


SPOT satellite

Hong-

# Difference between Active & Passive Sensors

- Active sensors provides their own energy source for illumination.
- Active sensors are able to obtain measurements anytime (Day & Night).
- Passive sensors can only be used to detect energy when the naturally occurring energy is available.
- Passive Sensors can obtain measurements only in the Day time.

# References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