The use of Earth observation data and geospatial technology to support decision-making in local municipality areas

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Why focus on a local municipality level

- A local municipality is an administrative unit that provides the general government of a specific population in a defined area
- In South Africa, local municipalities are responsible for managing and providing services such as water and sanitation, emergency, environmental regulatory, waste management, health services, land use management
- Implementation of strategies to address and respond to Climate Change; mitigation and adaptation
- Earth observation and geospatial technologies provide the capability to map and monitor human activity and the environment, key to achieving sustainable development.
- Different terms may be used for an administrative unit with similar functions depending on the country, however, the content of the training will still be relevant.

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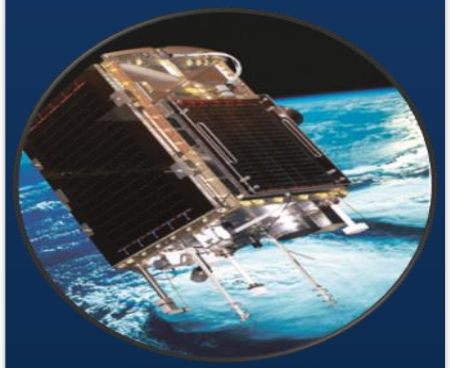
Act No. 36, 2008 SOUTH AFRICAN NATIONAL SPACE AGENCY ACT, 2008

To provide for the promotion and use of space and co-operation in space-related activities, foster research in space science, advance scientific engineering through human capital, support the creation of an environment conducive to industrial development in space technologies within the framework of national government policy, and for that purpose to establish the South African National Space Agency; to provide for the objects and functions of the South African National Space Agency and for the manner in which it must be managed and governed; and to provide for matters connected therewith.

Earth Observation directorate in Context

Space Programme



- Satellite development
- Industry development
- Technology development

Space Operations

- Launch support
- In-orbit testing
- Emergency support
- Carrier monitoring
- Hosting

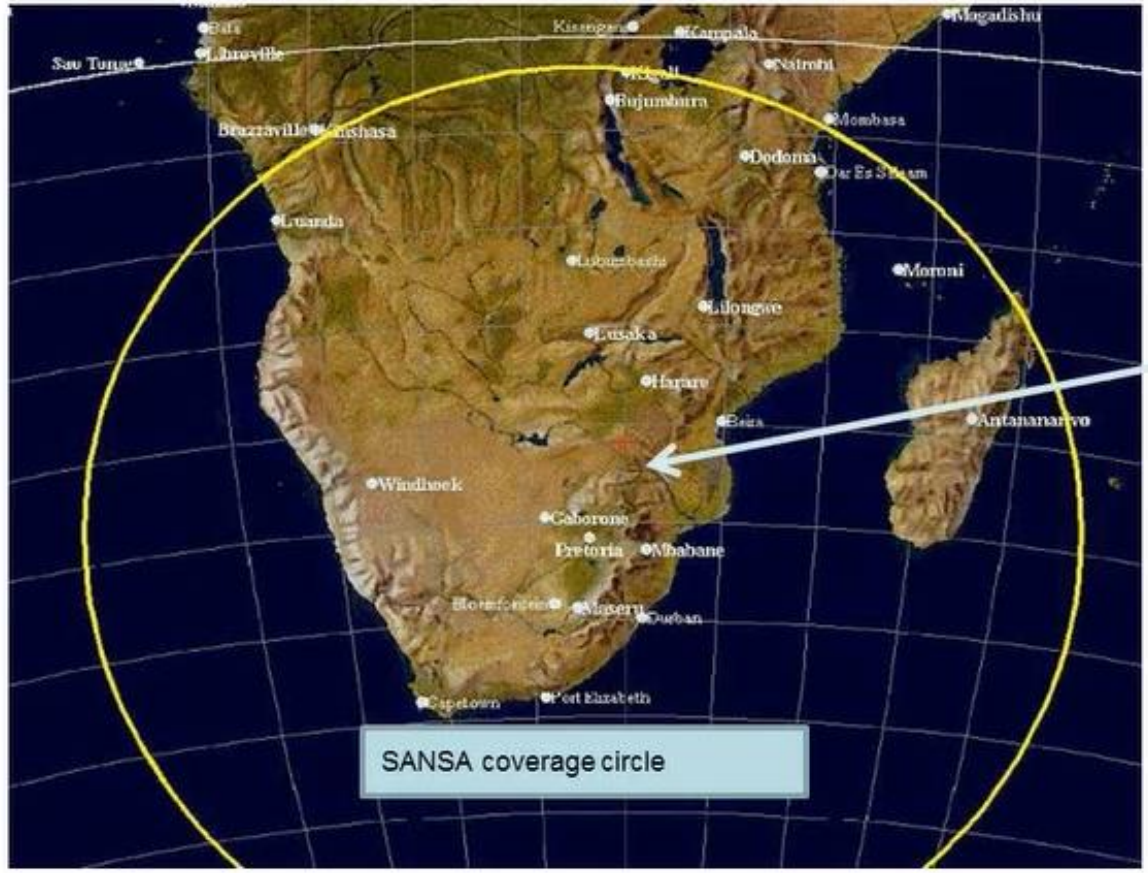
Space Science

- Geo-space observations
- Space physics
- Space weather
- EM technologies

Earth Observation

- Image acquisition, processing , archiving and dissemination
- Value-added services

SANSA Coverage Circle

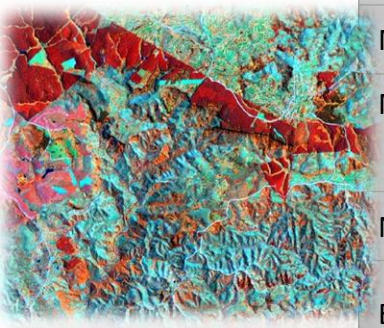


acquire, assimilate and disseminate space satellite imagery for any organ of state

Sources of Satellite Data for South Africa

Currently directly receiving
Landsat 8,9 CBERS 4A, 4B, SPOT 6,7 MODIS (Aqua and Terra

More in the EODC Archive



Sensor	Spatial Resolution	Coverage	Date of Acquisition
Landsat: MSS,TM, ETM, 7,8	15m-60m	Southern Africa	1972 - current day
SPOT 2, 4,5,6,7	1.5m-20m	Southern Africa	1994 - current day
CBERS 2B	20m	SADC except, Mauritius, DRC, Madagascar and Seychelles	2008 -2009
SAC-C	175m	SADC except, Mauritius, DRC, Madagascar and Seychelles	2008 - 2009
MISR	275m, 1.1km	Africa	2003 - current day
MODIS, AQUA & TERRA	250m,500m, 1km	Africa	2000 - current day
NOAA AVHRR	1.1km	Africa	1984 - current day
ERS-1	30m	Africa	1994 to 2009
MERIS	300m	Africa	2002 to 2010
SumbandilaSat	6.25m	Global	2000 to 2011

Acquisition of high spatial resolution satellite imagery

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Introduction to Remote Sensing and Geographic Information System

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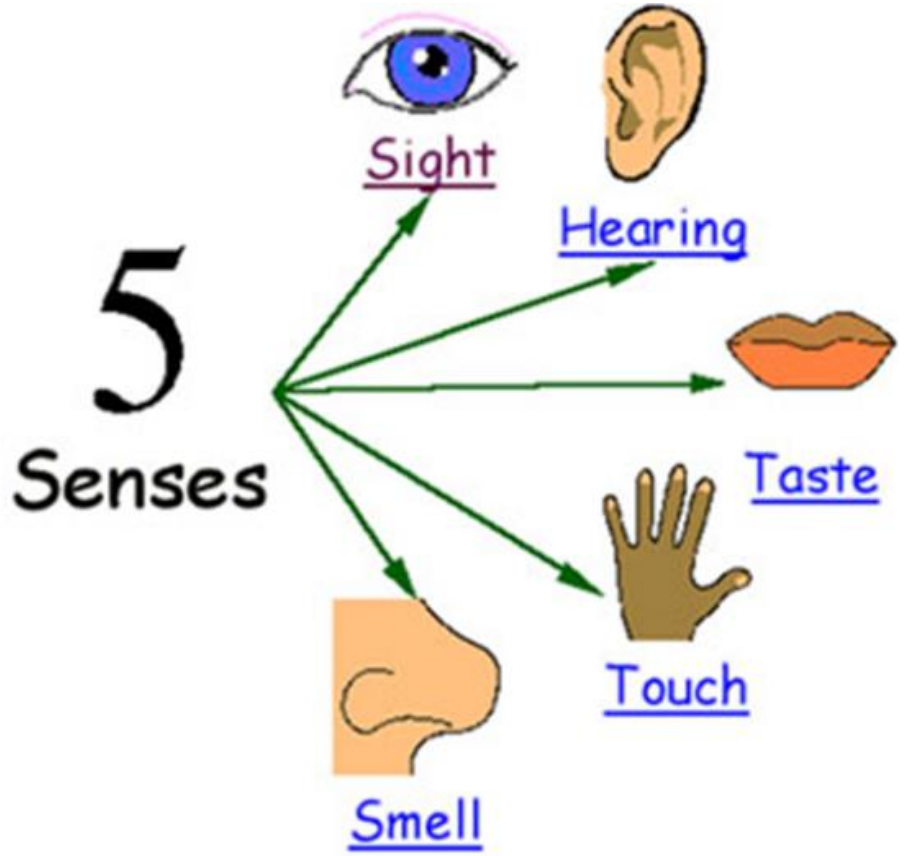
Remote Sensing

- Remote sensing is the science of acquiring information about an object without being in physical contact with it.
- The term is commonly used to refer to the acquisition of information on objects on Earth from a raised platform, such as an airplane or a satellites in space.

- The gathering of information at a distance

For earth observation

- “Remote sensing is the practice of deriving information about the earth’s land, water surfaces and atmosphere using images acquired from an overhead perspective, using electromagnetic radiation in one or more regions of the electromagnetic spectrum, reflected or emitted from the Earth’s surface” (Campbell & Wynne, 2011).



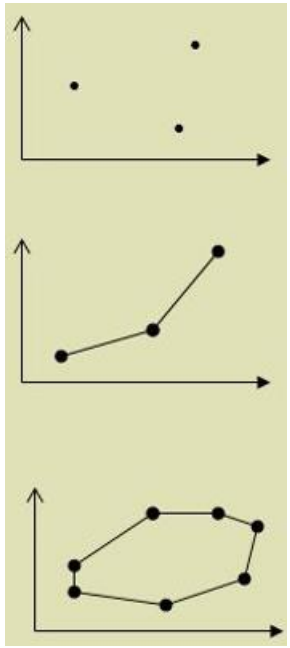
Geographical Information System (GIS)

- GIS is a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data.
- GIS is a system that deals with all types of geographically referenced (spatial) and non-referenced data (Aspatial).
- GIS uses advanced tools to explore spatial relationships, patterns and processes of demographics and economy

Vector and Raster Data

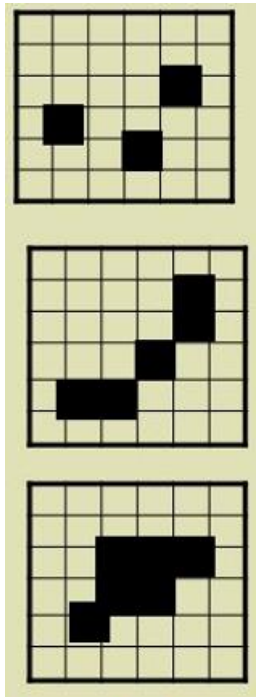
Vector

- Vector objects, Points, Lines, Polygon
- Identify locations on earth based on vector objects
- Information about feature is (are called “attributes”



Raster

- Uses cells to represent location on earth
- Data can be discrete/ continuous data



Remote sensing and GIS cont…

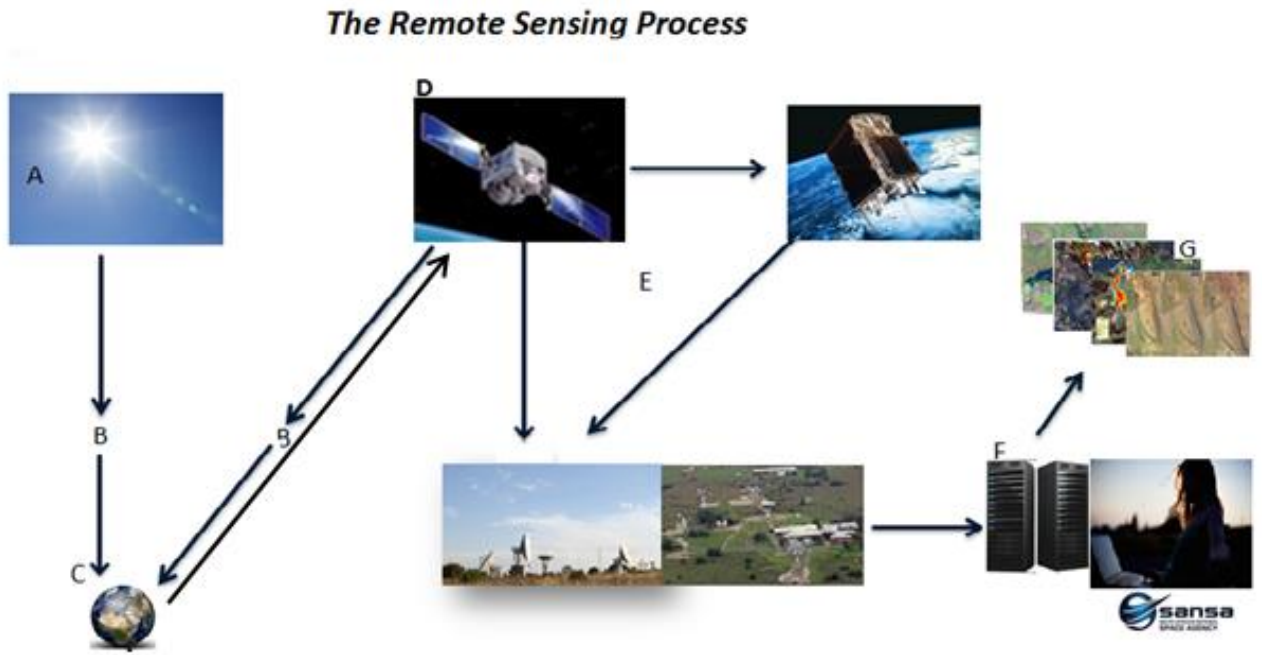
- Analysis of remote sensing data together with other geographical data are called geospatial data.
- GIS is used for the analysis of geospatial data with non-spatial data for to produce good quantitative and qualitative results to assist in informed decision-making.

- **Data Collection**, Digitizing, Survey, GPS etc.
- **Data Management**
- **Data Analysis**

WHAT ? WHEN? WHERE? WHY ? WHO?

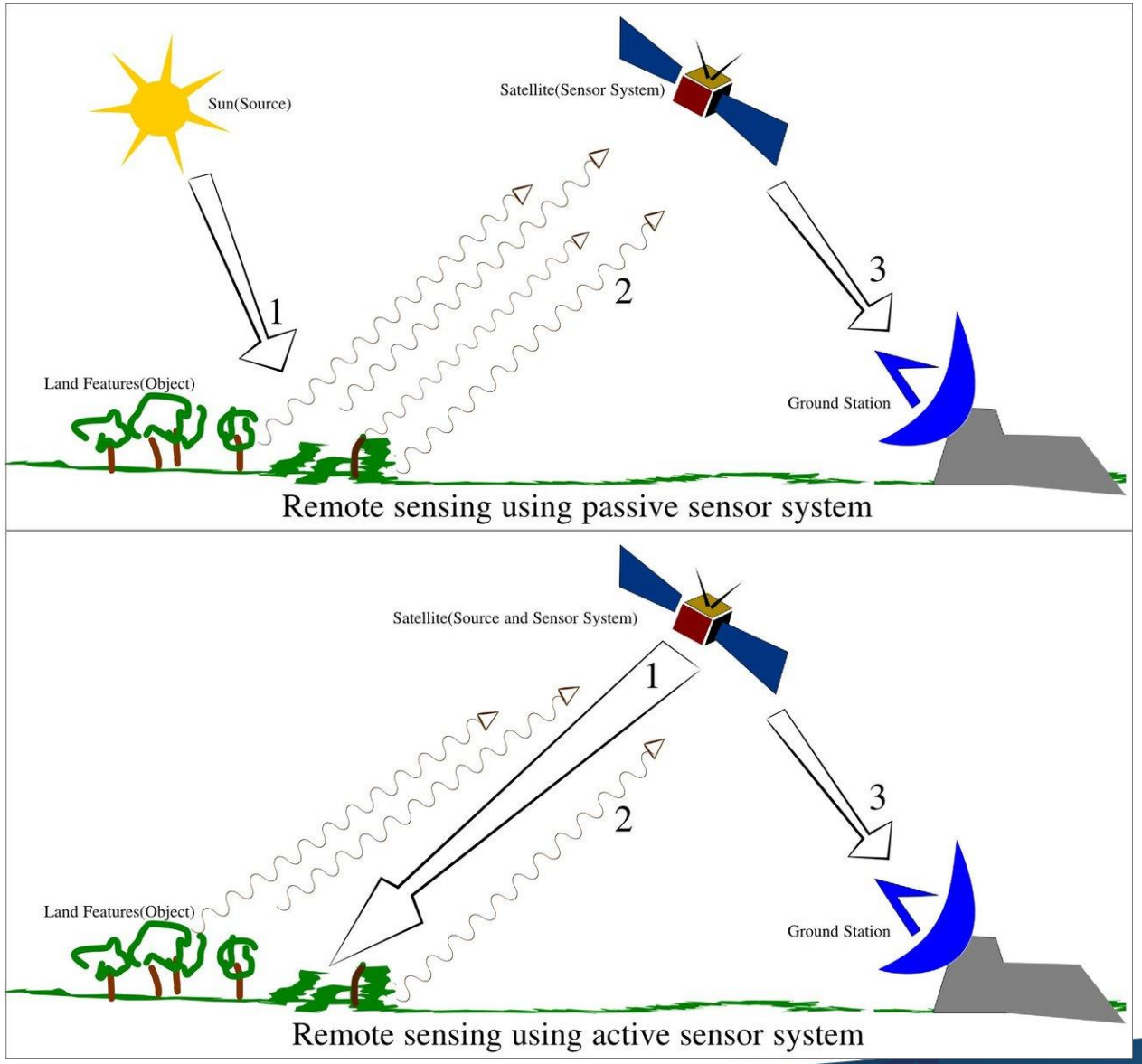
Image acquisition process

- A. Energy source
- B. Radiation
- C. Interaction with surface
- D. Satellite (recording energy)
- E. Transmission, reception & processing.
- F. Interpretation.
- G. Application



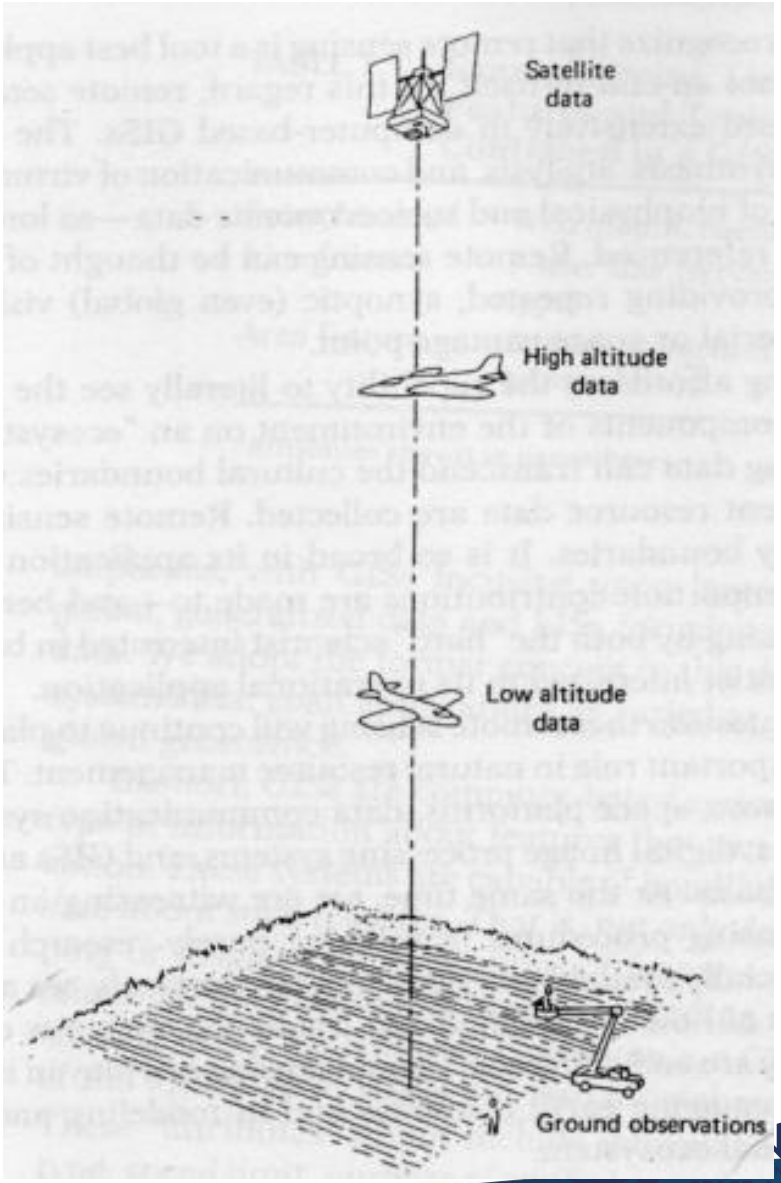
Energy Source

- Passive – Solar Radiation
  - Natural EMR from the Sun
  - External energy source
- Active – Microwave
  - Internal energy source

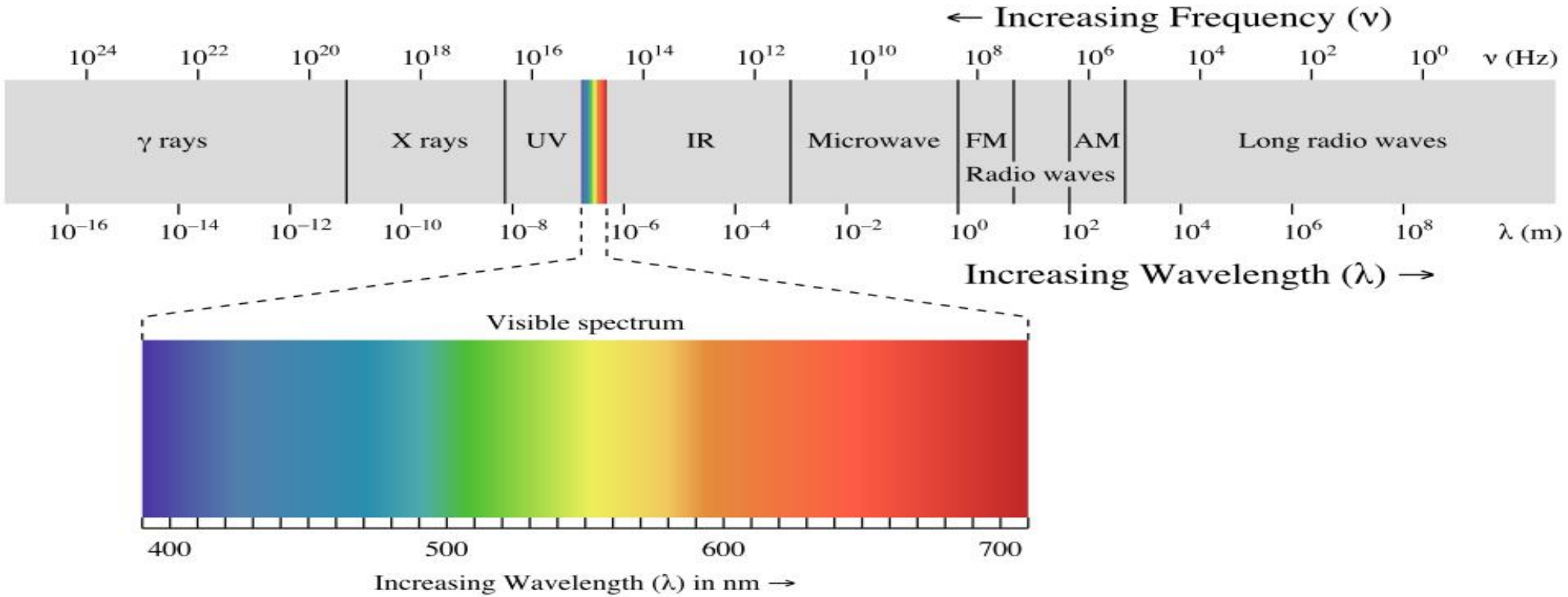


Platforms

- Platforms are the medium hosting the sensor.
- They are located at different altitude
- **Ground based**
  - Vehicles
  - Humans (hand held cameras, spectrometers).
- **Earth based**
  - UAV's
  - Fixed wing aircraft
- **Space based**
  - Satellites

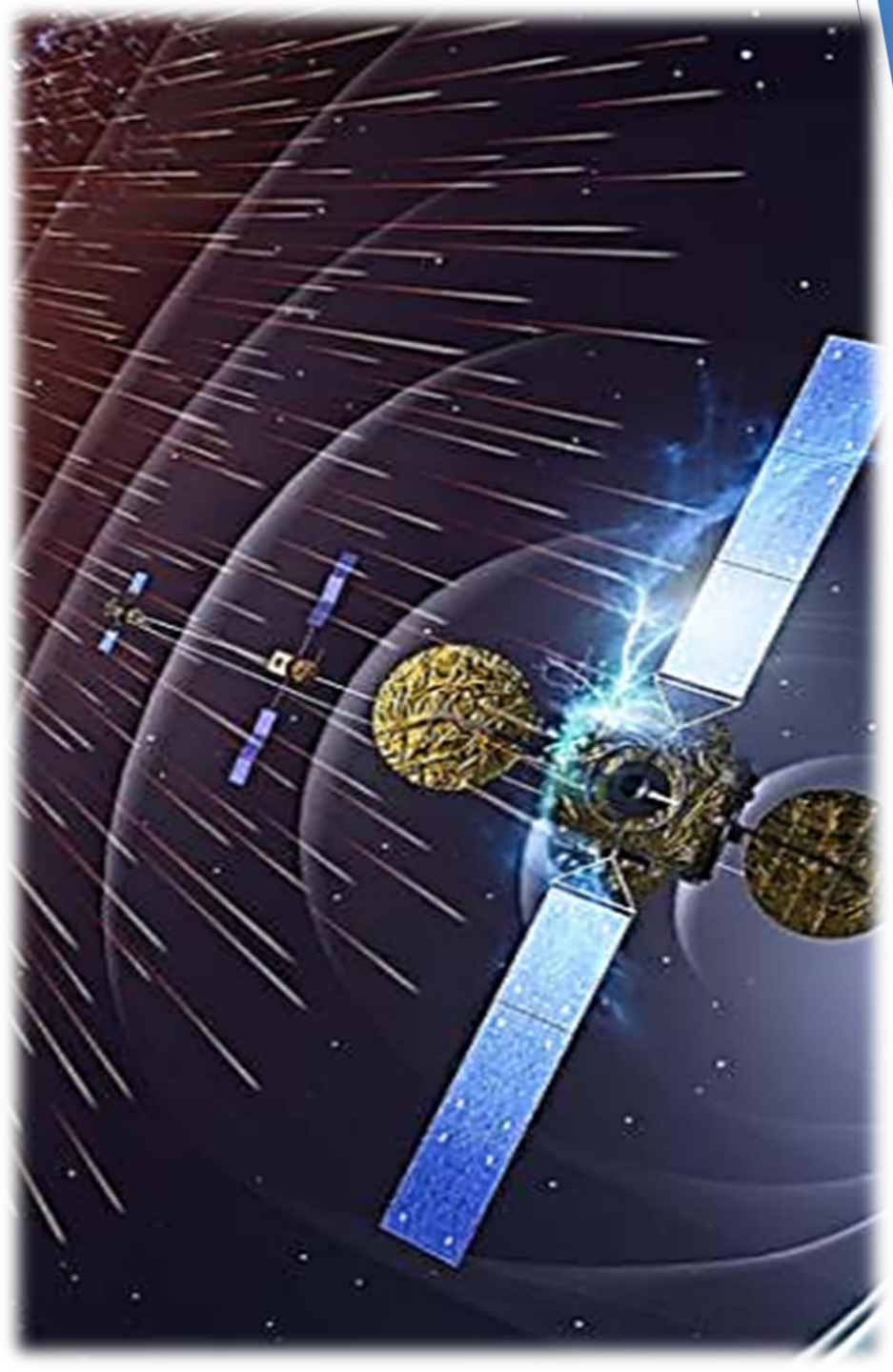


Remote sensing enabler: Radiation



Instrument lifetime

- RS instrument are expensive to build and operate
- Instruments design limited by lifetime
- When the satellite reaches the end of its life, data acquisition ceases



Resolutions

- Spatial Resolution
- Spectral Resolution
- Temporal Resolution
- Radiometric Resolution

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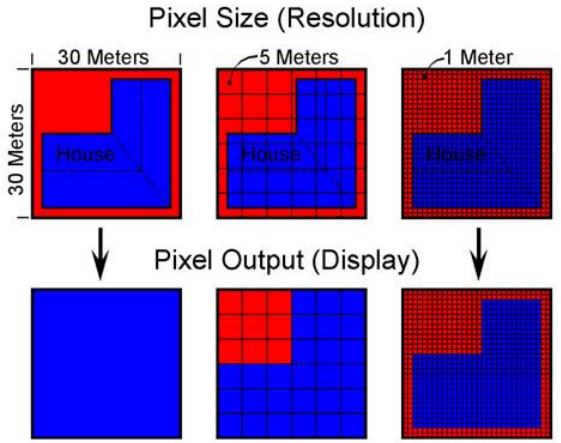
Spatial Resolution

- Specifies the pixel size of satellite images covering the earth surface
- Depends primarily on the IFOV
- Low/Coarse spatial resolution
- High/fine spatial resolution

High spatial resolution: 0.41 - 4 m

Low spatial resolution: 30 - > 1000 m



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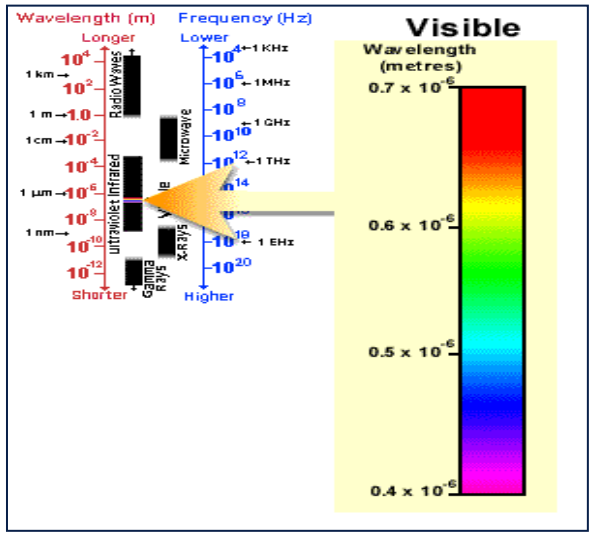
Spatial resolution

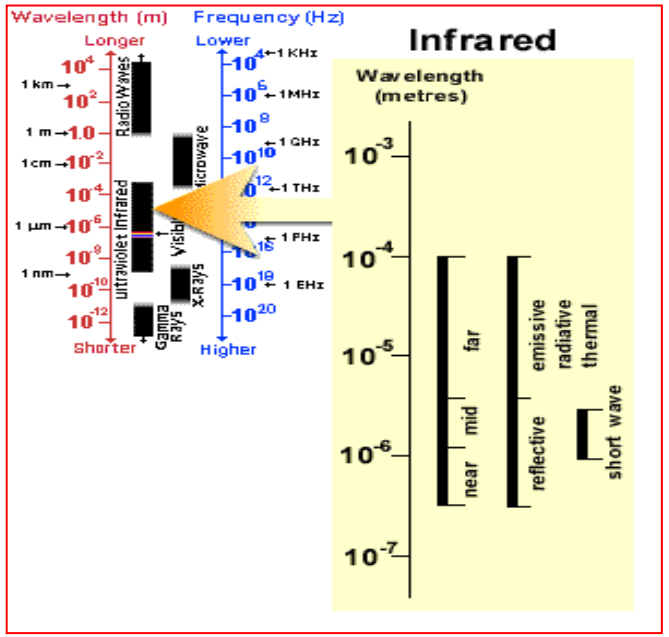
SPOT 6 Pan-sharpened imagery – 1.5m spatial resolution

Spectral resolution

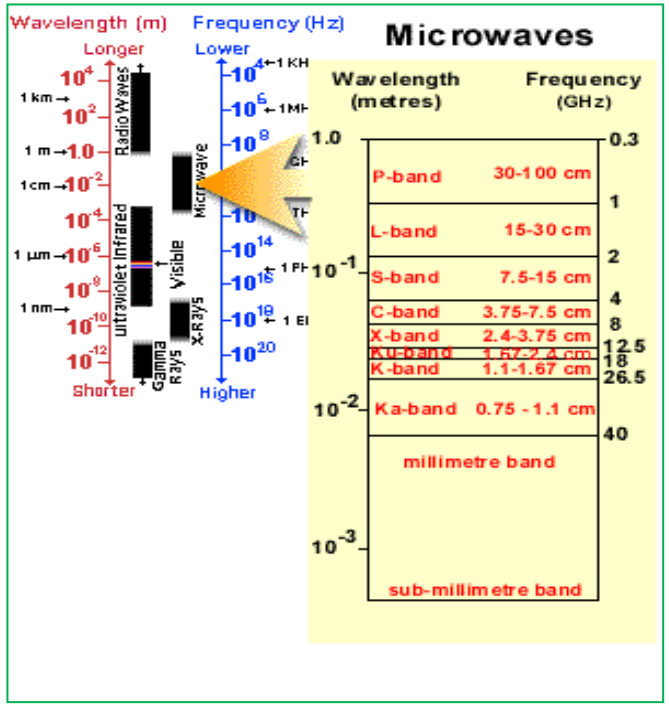
- The number of spectral bands
- electromagnetic spectrum regions



Visible spectrum
0.4-0.7 µm



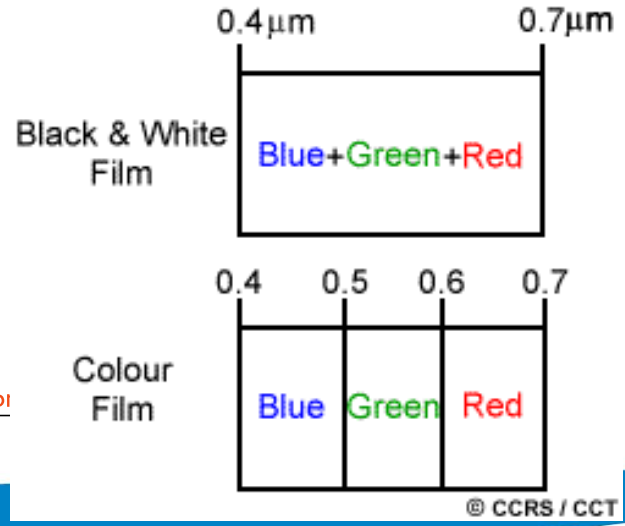
Infrared spectrum
NIR:0.7-2.5 µm
MIR: 2.5-25µm
FIR: 25-1000 µm

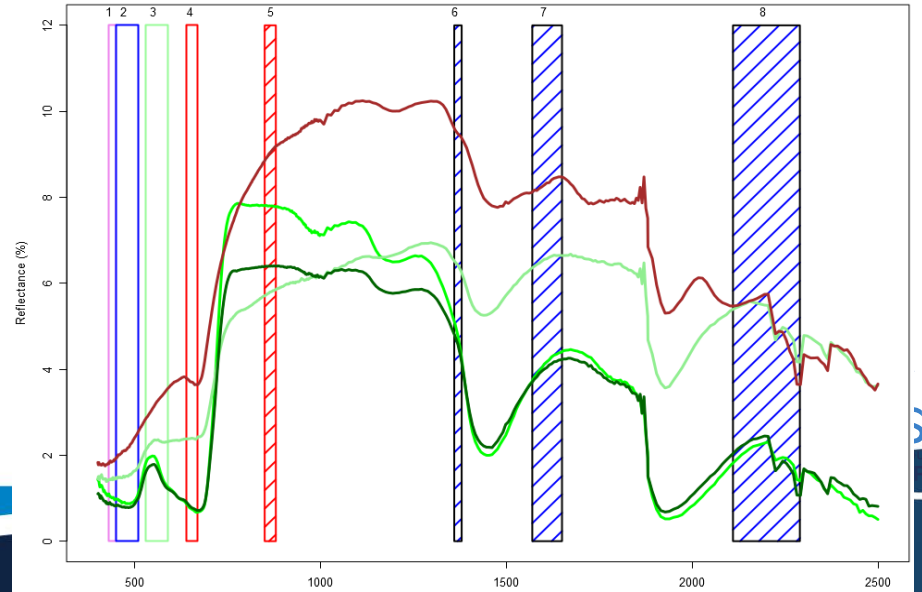


Microwave spectrum
1mm-1m

Spectral Resolution

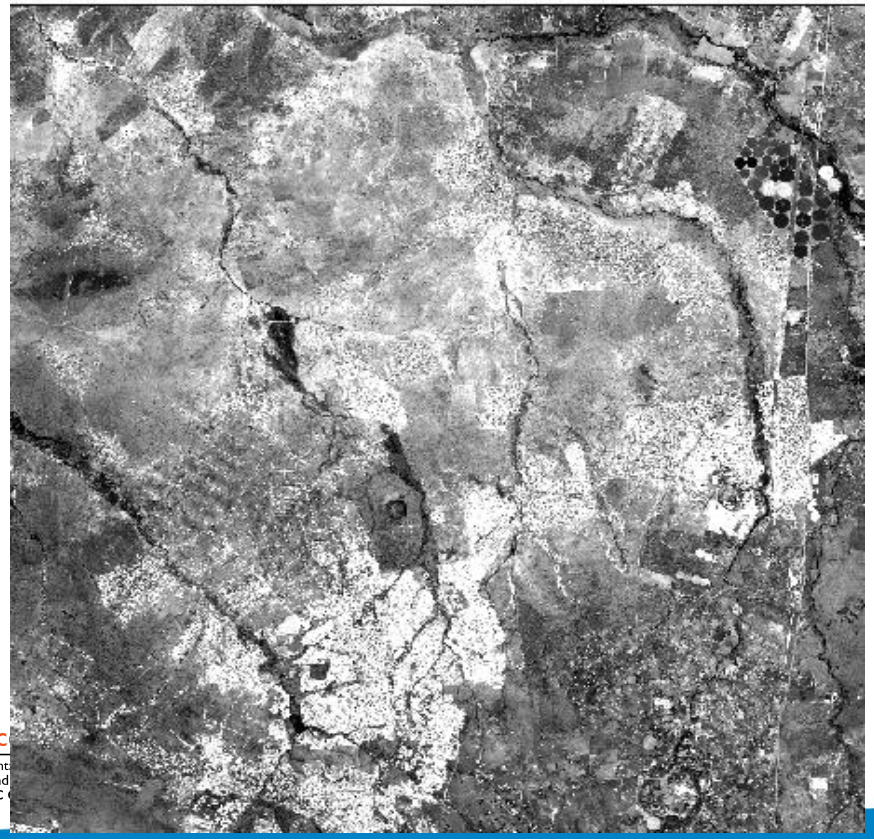
- Number of spectral bands in which sensor collects reflected radiance.
- Coarse: Panchromatic film records across entire visible portion of EMS.
- Medium: Multispectral sensors detect in several discrete broader bands.
  - Narrower bands = greater/finer spectral resolution
- High: Hyperspectral sensors, detect hundreds of narrow contiguous bands potentially throughout EMS
  - Finer spectral resolution facilitates discrimination between different targets





Spectral resolution

Panchromatic



Multispectral

SPOT 6 and 7

Panchromatic:	0.450-0.745 µm
B1 Blue:	0.450-0.520 µm
B2 Green:	0.530-0.590 µm
B3 Red:	0.625-0.695 µm
B4 Near Infrared:	0.760-0.890 µm

Spectral and Spatial resolution

	Spectral	Spatial
Band 1 - Coastal aerosol	0.43 - 0.45	30
Band 2 - Blue	0.45 - 0.51	30
Band 3 - Green	0.53 - 0.59	30
Band 4 - Red	0.64 - 0.67	30
Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
Band 6 - SWIR 1	1.57 - 1.65	30
Band 7 - SWIR 2	2.11 - 2.29	30
Band 8 - Panchromatic	0.50 - 0.68	15
Band 9 - Cirrus	1.36 - 1.38	30
Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100 * (30)
Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100 * (30)

Temporal Resolution

- Specifies revisit frequency of a satellite sensor for a specific location.
- High temporal resolution: < 24 hours - 3 days
- Medium temporal resolution: 4 - 16 days
- Low temporal resolution: > 16 days
- Temporal demands dependent on application:
  - Vegetation health – weekly/monthly
  - Land Temp – daily
  - Clouds - minutes

Radiometric Resolution

- Ability of a sensor to record levels of brightness linked to differences in energy (the grey scale range for each band)
- Particularly important in areas with high contrast targets (bright soil and water)
- Coarse: only a few BITS of data to detail a band – e.g. 1 Bit = 2 brightness values
- Medium: 8-bit = 255 brightness values
- High: 16-bit=65 536 brightness values

ADVANTAGES of satellite based remote sensing

- Large areal coverage (inaccessible areas)
- Resolutions spatial/spectral/radiometric/temporal
- Multi – sensors
- Multi –users
- Operational monitoring
- Multiple Applications
- See what the human eye cannot see

ADVANTAGES (Data democracy & costs)

- Relatively cheap compared to traditional methods of surveying.
- Many data providers have opted for data democracy.
  - Costs if any are limited to extraction and processing as costs of production and delivery
- Many are freely available to the scientific community

- Many more are commercial, but prices are becoming accessible

Applications

- Aerosol Properties
- Ambient Nitrogen Dioxide Concentration
- Ambient Ozone Concentration
- Ambient Particulate Matter (fine) Composition
- Ambient Particulate Matter Composition (coarse)
- Ambient Particulate Matter Concentration (coarse)
- Ambient Particulate Matter Concentration (fine)
- Ambient Sulphur Dioxide Concentration
- Ambient Volitile Organic Compounds
- Bathymetry
- Biodiversity
- Biomass
- Burned Area/Fires
- Carbon (stores, uptake, flux)
- Cloud Cover (cloud index)
- Cloud Parameters (Other)
- Cloud Water/Ice Amounts (3D Distribution)
- Column Nitrogen Dioxide Concentration
- Column Ozone Concentration
- Column Particulate Matter Concentration (coarse)
- Column Particulate Matter Concentration (fine)
- Column Sulphur Dioxide Concentration
- Contaminants/Pollutants (Inorganic/Organic)
- Cultivation
- Currents
- Curvature
- Deforestation
- Desertification
- Direct Normal Irradiation (DNI)
- Elevation
- Evaporation
- Evapotranspiration
- EVI
- Floods
- Forest Cover
- Forest Management Practices
- Forest Structure
- Fraction of Absorbed Photo synthetically Active Radiation (FAPAR)
- Fraction of Photo synthetically Active Radiation (fAPAR)
- Fuel Load/Characteristics
- Glacier/Ice Cap Elevation
- Glacier/Ice Sheet Depth
- Glacier/Ice Sheet Extent
- Global Horizontal Irradiation (GHI)
- Gross Primary Productivity
- Groundwater
- Lake/Reservoir Levels
- Land Cover
- Land Surface Temperature
- Land Use
- Leaf Area Index
- Net Primary Productivity (NPP)
- Non-Native Species
- Normalized Difference Vegetation Index (NDI)
- Nutrients (Phosphorous, Nitrogen, Potassium, Nitrates, Sulfates)
- Ocean Salinity
- Ocean Topography
- Photo synthetically Active Radiation (PAR)
- Population
- Pore Pressure
- Precipitation
- Rock Strength, Permeability, Spacing, orientation
- SAVI
- Sea Ice Cover

Skills requirement

- Theoretical knowledge
- Practicality and application skills
- Software competency

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Useful Links

- ESA Earth Remote Sensing Home Page: http://earth.esa.int/
- Canada Centre for Remote Sensing: http://www.ccrs.nrcan.gc.ca/
- The German Remote Sensing Data Center: http://www.dfd.dlr.de/
- The NASA/JPL Imaging Radar Home Page: http://southport.jpl.nasa.gov/
- Remote Sensing Platforms and Sensors: http://quercus.art.man.ac.uk/rs/sat_list.cfm
- UCT Dept. Electr. Eng.: http://www.rrsg.uct.ac.za/applications/applications.html
- ArcGIS resources:
- http://resources.arcgis.com/en/help/main/10.1/index.html#/Types_of_lidar/
- R.M. Hoff et al., The GAW Aerosol Lidar Observation Network (GALION), International Geoscience and Remote Sensing Symposium (IGARSS-08), Boston

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