Introduction to Remote Sensing

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- **Current & Future satellite Systems**
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What is Remote Sensing?

"Remote" means far away. Remote sensing means sensing things from a distance. Of **our** five senses **we** use three as remote sensors when we:

a. watch a football game from the stands (sense of sight)
b. smell freshly baked bread in the oven (sense of smell)
c. hear a telephone ring (sense of hearing)

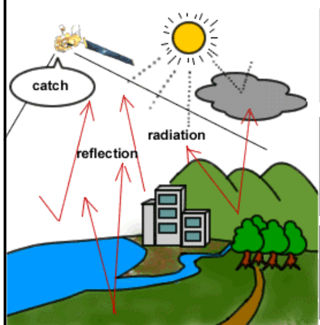
What are our other two senses and why aren't they used "remotely"?

What is Remote Sensing ?

"Remote Sensing is defined as the science and technology by which ***characteristics*** of objects of interest can be identified without direct contact"

Concept of Remote Sensing

Earth observation from space and air



Remote Sensing is a technology to observe objects' size, shape and character without direct contact with them.

The reflected or radiated electromagnetic (EM) waves are received by sensors aboard platform.

The characteristics of reflected or radiated EM waves depend on the type or condition of the objects.

By understanding characteristics of EM response and comparing observed information, we can know the size, shape and character of the objects.

Advantages of Satellite Observation

- **Enables to observe a broad area at a time**
- **Enables to observe the area for a long period**
  - **Repeat pass observation (Time series data, Change detection)**
- **Enables to know the condition without visiting the area**
- **Enables to know invisible information**
  - **Sensors for various electromagnetic spectrum (Infrared, microwave)**

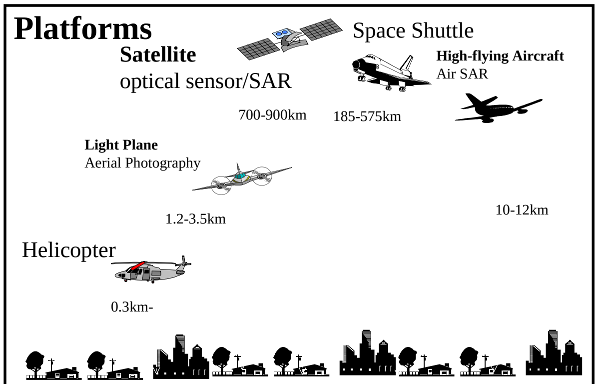
Brief History of Remote Sensing (1)

1826	The invention of photography
1850's	Photography from balloons
1873	Theory of electromagnetic energy by J. C. Maxwell
1909	Photography from airplanes
1910's	**World War I**: aerial reconnaissance
1920's	Development and applications of aerial photography and photogrammetry
1930's	Development of radar in Germany, USA, and UK
1940's	**World War II**: application of Infrared and microwave regions
1950's	Military Research and Development

Brief History of Remote Sensing (2)

1960's	**The satellite era**: Space race between USA and USSR.
1960	The first meteorological satellite (**TIROS-1**)
1960's	First use of term "**remote sensing**"
1960's	Skylab remote sensing observations from the space
1972	Launch of the first earth resource satellite (**Landsat-1**)
1970's	Rapid advances in digital image processing
1980's	**Landsat-4**: new generation of Landsat sensors
1986	Launch of French earth observation satellite (**SPOT-1**)
1980's	Development of hyperspectral sensors
1990's	Launch of earth resource satellites by national **space agencies** and **commercial companies**

Platforms



Sensors

Optical

- **Visible** — *Reflectance*
- **Near Infrared** — *Reflectance*
- **Thermal Infrared** — *Thermal Radiation*

Microwave

- **Passive** (Scatterometer) — *Microwave Radiation*
- **Active** (**SAR**, Altimeter) — *Backscatter*

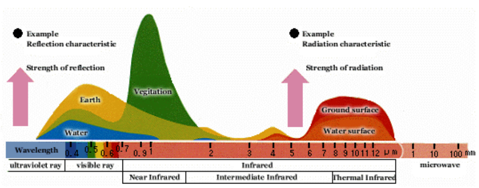
Laser

- **Active** — *Intensity, Time*

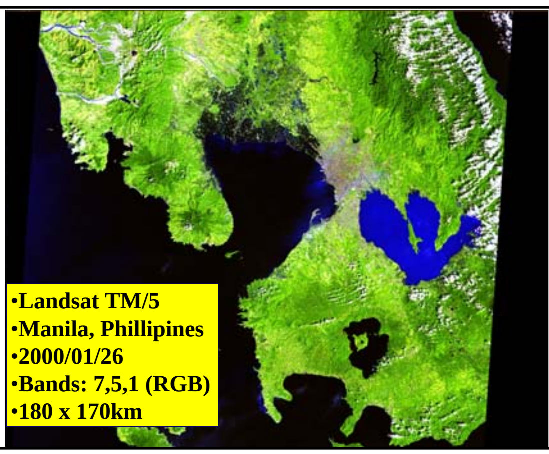
Sensors

Every material on earth shows its **own strength of reflection** in each wavelength when it is exposed to the EM waves

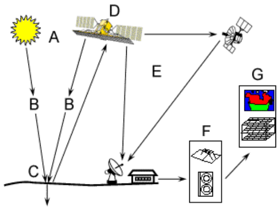
Sensors aboard a platform are capable to acquire the strength of reflection and radiation in each wavelength.



Strength of reflection and radiation of EM waves from plants, earth and water in each wavelength.



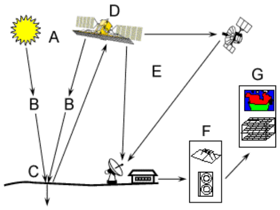
- **Landsat TM/5**
- **Manila, Phillipines**
- **2000/01/26**
- **Bands: 7,5,1 (RGB)**
- **180 x 170km**



Process of Remote Sensing (1)

Energy Source or Illumination (A) - the first requirement for remote sensing is to have an **energy source** which illuminates or provides electromagnetic energy to the target of interest.

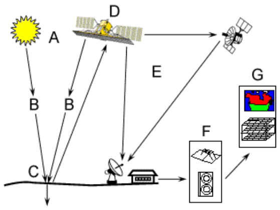
Radiation and the Atmosphere (B) - as the energy travels from its source to the target, it will come in contact with and **interact with the atmosphere** it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.



Process of Remote Sensing (2)

Interaction with the Target (C) - once the energy makes its way to the target through the atmosphere, it **interacts with the target** depending on the properties of both the target and the radiation.

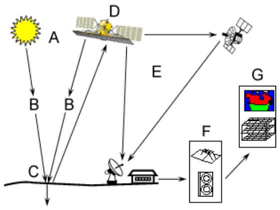
Recording of Energy by the Sensor (D) - after the energy has been scattered by, or emitted from the target, we require a **sensor** (remote - not in contact with the target) to **collect and record** the electromagnetic radiation.



Process of Remote Sensing (3)

Transmission, Reception, and Processing (E) - the energy recorded by the sensor has to be **transmitted**, often in electronic form, to **a receiving and processing station** where the data are processed into an image (hardcopy and/or digital).

Interpretation and Analysis (F) - the processed image is **interpreted**, visually and/or digitally or electronically, to extract information about the target which was illuminated.



Process of Remote Sensing (4)

Application (G) - the final element of the remote sensing process is achieved when we **apply the information** that we have been able to extract from the imagery about the target, in order to **better understand it**, **reveal some new information**, or **assist in solving a particular problem**.

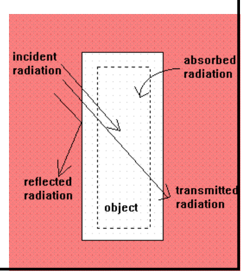
Transfer of Electromagnetic Energy

Conduction: Atomic or molecular collisions.

Convection: The physical movement of bodies of energetic material.

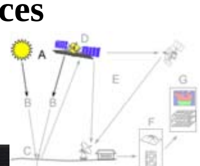
Radiation:

Transmission of **electromagnetic energy** through a medium or vacuum. ***<u>Observed by Remote Sensing</u>***



Energy Sources

- **Visible Light** is only **one form** of electromagnetic energy.
- Radio waves, heat, ultra-violet rays and X-rays are other familiar forms.
- All of this energy is inherently similar, and radiates in accordance with **basic wave theory**.



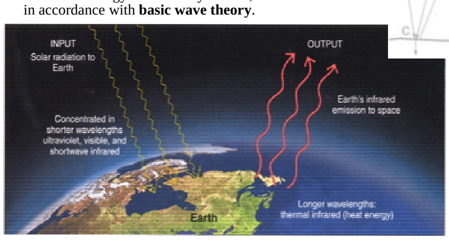
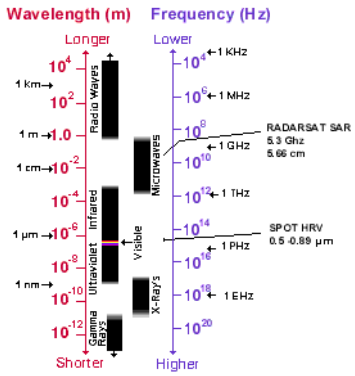


Figure 2-7 Earth's energy budget simplified.
Solar radiation is concentrated in shorter wavelengths. Earth emits longer wavelengths of infrared to the atmosphere and eventually to space.

Electromagnetic Spectrum



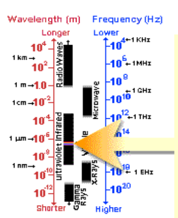
Visible Spectrum (1)

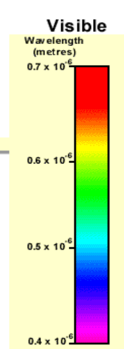
The light which our **eyes** - our "remote sensors" - can detect is part of **the visible spectrum**.

It is important to recognize **how small the visible portion** is relative to the rest of the spectrum.

There is a lot of radiation around us which is **invisible** to our eyes, but can be detected by other **remote sensing instruments** and used to our advantage.

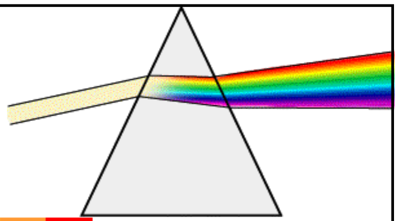
Visible Spectrum

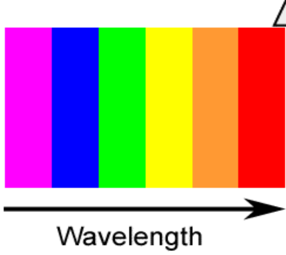




It is important to note that this is the only portion of the EM spectrum we can associate with **the concept of colours**.

Visible Spectrum





Violet: 400 - 0.446 µm
Blue: 446 - 0.500 µm
Green: 0.500 - 0.578 µm
Yellow: .578 - 0.592 µm
Orange: .592 - 0.620 µm
Red: 620 - 0.700 µm

Visible Spectrum (2)

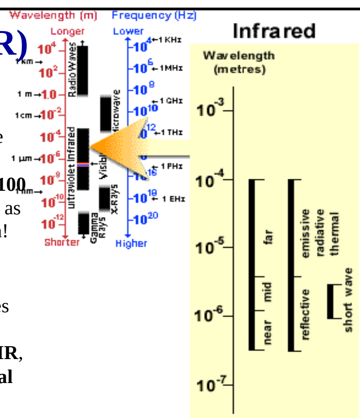
Blue, **green**, and **red** are the **primary colors** or wavelengths of the visible spectrum.

They are defined as such because no single primary color can be created from the other two, but **all other colors** can be formed by **combining blue, green, and red** in various proportions.

Although we see **sunlight** as a uniform or homogeneous color, it is actually **composed of various wavelengths** of radiation in primarily the **ultraviolet**, **visible** and **infrared** portions of the spectrum.

The **visible** portion of this radiation can be shown in its **component colors** when sunlight is **passed through a prism.**

Infrared (IR) Region



The IR Region covers the wavelength range from approximately **0.7 µm to 100 µm** - more than 100 times as wide as the visible portion!

The IR region can be divided into **two** categories based on their radiation properties - the **reflected IR**, and the **emitted** or **thermal IR**.

Reflected and Thermal IR

Radiation in **the reflected IR region** is **used for remote sensing** purposes in ways **very similar** to radiation in the **visible portion**. The reflected IR covers wavelengths from approximately 0.7 µm to 3.0 µm.

The thermal IR region is quite **different** than the visible and reflected IR portions, as this energy is essentially the **radiation that is emitted from the Earth's surface in the form of heat**. The thermal IR covers wavelengths from approximately 3.0 µm to 100 µm.

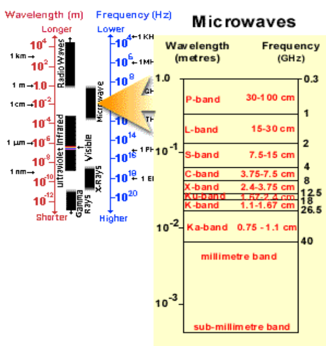
Microwave Region

The portion of the spectrum of more recent interest to **remote sensing** is the **microwave** region from about **1 mm to 1 m.**

This covers the **longest wavelengths** used for remote sensing.

The **shorter wavelengths** have properties **similar to the thermal infrared** region while the **longer wavelengths** approach the wavelengths **used for radio broadcasts**.

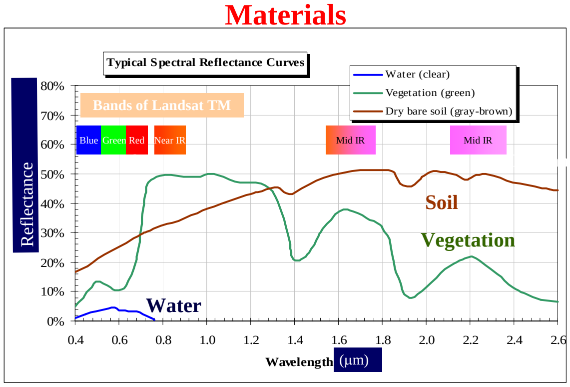
Microwave Region



Reflectance

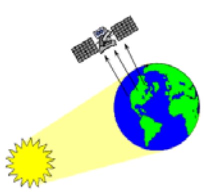
- The **proportions** of energy reflected, absorbed, and transmitted will depend on the **wavelength of the energy** and **the material and condition of the feature**.
- These features permit us to **distinguish different features** on an image.
- Even with a given feature type, the proportion of reflected, absorbed and transmitted energy will **vary at different wavelengths**.
- Different features may be distinguished **using more than one spectral range**.

Spectral Reflectance of Earth-Surface Materials

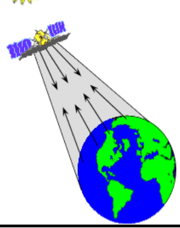


Passive and Active Remote sensing

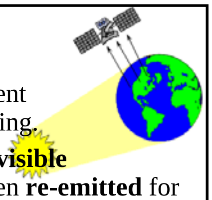
Passive Sensors: measure energy that is naturally available
(e.g. Optical sensors)



Active Sensors: provide their own energy source for illumination
(e.g. Synthetic Aperture Radar (SAR), Laser Scanner (LIDAR))

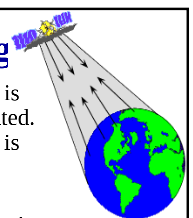


Passive Remote Sensing



- **The sun** provides a very convenient **source of energy** for remote sensing.
- The sun's energy is **reflected** for **visible** wavelengths, or **absorbed** and then **re-emitted** for **thermal IR** wavelengths
- **For all reflected energy**, this can only take place during the time **when the sun is illuminating the Earth**
- **Energy that is naturally emitted** (such as **thermal infrared**) can be **detected day or night**, as long as the amount of energy is large enough to be recorded.

Active Remote Sensing



- An **active** sensor **emits radiation** which is directed toward the target to be investigated. The **radiation reflected** from that target is detected and measured by the sensor.
- **Advantages** for active sensors:
  - the ability to obtain measurements **anytime**, regardless of the time of day, season or (weather),
  - **examine wavelengths** that are **not sufficiently provided by the sun** (e.g., microwaves),
  - to **better control** the way that a target is illuminated.
- However, active systems require the generation of a fairly **large amount of energy** to adequately illuminate targets.

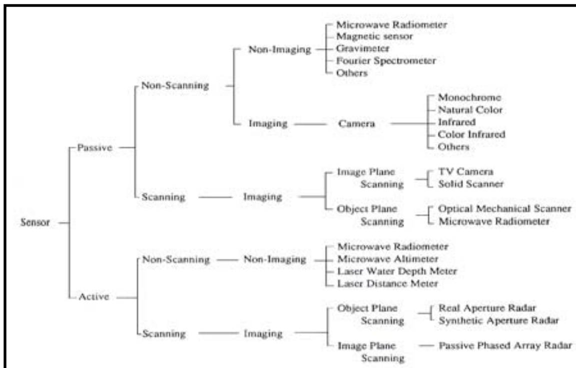


Figure 2.1.1 Classification of Sensor

Spatial Resolution and Pixel

Most remote sensing images are composed of a matrix of picture elements, or **pixels**, which are the **smallest units of an image**. Pixels are normally square and represent a certain area on an image.

It is important to **distinguish** between **pixel size** and **spatial resolution**. If a sensor has a spatial resolution of 20 m and an image from that sensor is displayed at full resolution, each pixel represents an area of 20m x 20m on the ground. In this case the pixel size and resolution are the same.

However, it is possible to **display** an image with **a pixel size different than the resolution**. Many posters of satellite images have their pixels averaged to represent larger areas, although the original spatial resolution of the sensor remains the same.

Spatial Resolution of Satellites

Images where only large features are visible are said to have **coarse or low resolution**.

In **fine or high resolution** images, small objects can be detected. **Military** sensors for example, are designed to view as much detail as possible, and therefore have very fine resolution.

Commercial satellites provide imagery with resolutions **varying** from a few metres to several kilometres.

Generally speaking, **the finer the resolution the less total ground area** can be seen.

Scale of Image/Map

The ratio of distance on an image or map, **to actual ground distance** is referred to as **scale**. If you had a map with a scale of 1:100,000, an object of 1cm length on the map would actually be an object 100,000cm (1km) long on the ground.

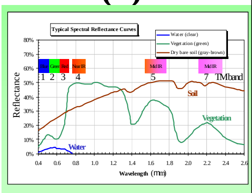
Maps or images with **small** "map-to-ground ratios" are referred to as **small scale** (e.g. 1:100,000), and those with **larger ratios** (e.g. 1:5,000) are called **large scale**.

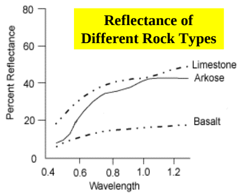
Spectral Resolution (1)

Different classes of features and details in an image can often be distinguished by comparing their responses over distinct wavelength ranges.

Broad classes, such as water and vegetation, can usually be separated **using very broad wavelength ranges** - the visible and near infrared .

Other **more specific classes**, such as different rock types, may not be easily distinguishable using these broad wavelength ranges and would require comparison **at much finer wavelength ranges** to separate them.



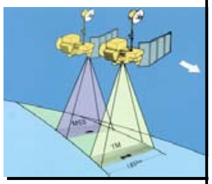


Spectral Resolution (2)

A sensor with **higher spectral resolution** is required for detailed distinction.

Spectral resolution describes the ability of a sensor to **define fine wavelength intervals**.

The **finer** the **spectral resolution**, the **narrower the wavelength range** for a particular channel or band.



Landsat/TM 5

Spectral Definition (μm) – Landsat/TM 5

Blue	Green	Red	Near IR	Mid IR	Mid IR	Far IR (thermal)
0.45-0.52	0.52-0.60	0.63-0.69	0.76-0.90	1.55-1.75	2.08-2.35	10.4-12.5
Band 1	**Band 2**	**Band 3**	**Band 4**	**Band 5**	**Band 7**	**Band 6**

Multi-spectral and Hyperspectral Sensors

Many remote sensing systems record energy over **several separate wavelength** ranges at various spectral resolutions. These are referred to as **multi-spectral sensors**.

Advanced multi-spectral sensors called **hyperspectral** sensors, detect **hundreds of very narrow spectral bands** throughout the **visible**, **near-IR**, and **mid-IR** portions of the EM spectrum.

Their very high spectral resolution facilitates **fine discrimination** between different targets based on their spectral response in each of the narrow bands.

Radiometric Resolution (1)

Every time an image is acquired on film or by a sensor, its **sensitivity to the magnitude of the EM energy** determines the **radiometric resolution**.

The radiometric resolution of an imaging system describes its **ability to discriminate** very **slight differences in energy**.

The **finer** the radiometric resolution of a sensor, the **more sensitive** it is to **detecting small differences** in reflected or emitted energy.

Radiometric Resolution (2)

Imagery data are represented by positive digital numbers which vary from 0 to (one less than) a **selected power of 2**. This range corresponds to the number of bits used for coding numbers **in binary format**.

Each bit records an exponent of power 2 (e.g. 1 bit = $2^1 = 2$). The maximum number of brightness levels available depends on the number of bits used in representing the energy recorded.

Thus, if a sensor used **8 bits** to record the data, there would be $\mathbf{2^8 = 256}$ **digital values** available, ranging from **0 to 255**.

Image data are generally displayed in a range of gray tones, with **black** representing a digital number of **0** and **white** representing the **maximum value** (for example, 255 in 8-bit data).

Comparison of 2-bit image with an 8-bit image

We can see that there is a large difference in the level of detail discernible depending on their **radiometric resolutions**.

2-bit image

8-bit image

Temporal Resolution (1)

In addition to **spatial**, **spectral**, and **radiometric** resolution, the concept of **temporal resolution** is also important to consider in a remote sensing system.

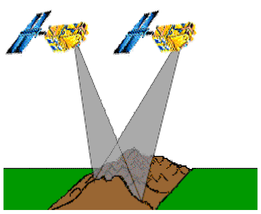
The revisit period of a satellite sensor is usually several days. Therefore the absolute temporal resolution of a remote sensing system to **image the exact same area** at the **same viewing angle** a second time is equal to this period.

But, because of some degree of **overlap** in the imaging **swaths** of adjacent orbits for most satellites and the **increase** in this **overlap** with **increasing latitude**, some areas of the Earth tend to be **re-imaged more frequently**.

Temporal Resolution (2)

Also, some satellite systems are able to **point their sensors to image the same area** between different satellite paths separated by periods from one to five days.

Thus, **the actual temporal resolution** of a sensor depends on a variety of factors, including the **satellite/sensor capabilities**, the **swath overlap**, and **latitude**.



Point their sensors to image the same area

Multi-temporal Imagery

The **time factor** in imaging is important when:

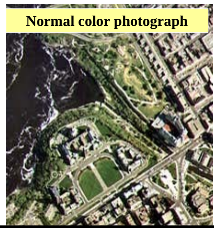
- Persistent clouds offer **limited clear views** of the Earth's surface (often in the tropics)
- **Short-lived phenomena** (floods, oil slicks, etc.) need to be imaged
- **Multi-temporal comparisons** are required (e.g. the spread of a forest disease from one year to the next)
- **The changing appearance of a feature over time** can be used to distinguish it from near-similar features (wheat / maize)

False Color and Normal color

In a **false color** photograph,

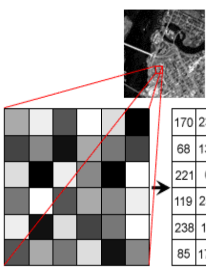
- targets with **high near-IR** reflectance appear **red**,
- those with a **high red** reflectance appear **green**,
- those with a **high green** reflectance appear **blue**.

thus giving us a "**false**" presentation of the targets relative to the color we normally perceive them to be.



Pixel and Digital Number

A photograph could also be represented and displayed in a **digital format** by subdividing the image into small equal-sized and shaped areas, called **picture elements** or **pixels**, and representing the brightness of each area with a numeric value or **digital number**.



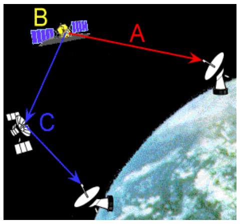
170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

Characteristics of Images (1)

- Electromagnetic energy may be detected either **photographically** or **electronically**. The **photographic process** uses chemical reactions on the surface of **light-sensitive film** to detect and record energy variations.
- It is important to distinguish between the terms **images** and **photographs** in remote sensing.
- An **image** refers to **any pictorial representation**, regardless of what wavelengths or remote sensing device has been used to detect and record the electromagnetic energy.
- A **photograph** refers specifically to images that have been detected as well as recorded on **photographic film**.

Data Reception, Transmission, and Processing

Data acquired from satellite platforms need to be **electronically transmitted to Earth**. There are **three** main options for transmitting data acquired by satellites to the surface.



- The data can be directly transmitted to Earth if a **Ground Receiving Station** (GRS) is in the line of sight of the satellite (A).
- If this is not the case, the data can be recorded on board the satellite (B) for transmission to a GRS at a later time.
- Data can also be relayed to the GRS through the **Tracking and Data Relay Satellite System** (TDRSS) (C), which consists of a series of communications satellites in **geosynchronous** orbit.

JERS-1 (1992-1998)

JERS-1 is an earth observation satellite to cover the global land area for national land survey, agriculture, forestry, fisheries, environment conservation, disaster mitigation and coastal surveillance, with emphasis on locating natural resources. It has following sensors

- Optical Sensor (OPS) 18x24m
- SAR (Synthetic Aperture Radar) 18m
- Swath width 75 km

ADEOS (1996-1997)

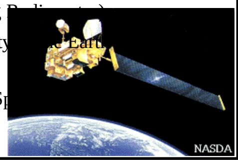
Advanced Earth Observation Satellite (ADEOS) is designed for earth observation with following sensors

- AVNIR (Advanced Visible Near Infrared Radiometer) Pan:8m Multi:16m
- OCTS (Ocean Color and Temperature Scanner) 700m
- POLDER (Polarization and Directionality of the Earth's reflectances)
- IMG (Interferometric Monitor for Greenhouse Gases)
- ILAS (Improved Limb Atmospheric Spectrometer)
- TOMS (Total Ozone Mapping Spectrometer)
- RIS (Retroreflector in Space)
- NSCAT (NASA Scatterometer)

ADEOS-II (2002)

ADEOS-II has been designed for global observation. Primary applications ADEOS data include monitoring global environmental changes such as maritime meteorological conditions, atmospheric ozone, and gases that promote global warming. Its sensors are

- GLI (Global Imager)
- AMSR (Advanced Microwave Scanning R
- POLDER (Polarization and Directionality Earth Reflectance)
- ILAS-II (Improved Limb Atmospheric Sp
- SEA WINDS

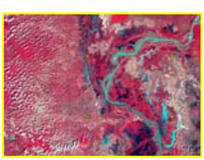


ALOS (2006)

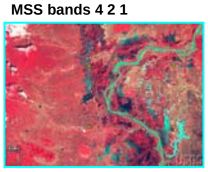
Advanced Land Observation Satellite (ALOS) has been designed for cartography, regional observation, disaster monitoring, and resource surveying.

- Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM)
- Advanced Visible and Near Infrared Radiometer (AVNIR)
- Phased Array type L-band Synthetic (PALSAR)

LANDSAT



3 January 1973, Landsat 1 MSS bands 4 2 1



14 December 1985, Landsat 5 MSS bands 4 2 1

A number of sensors have been on board the Landsat series of satellites, including the Return Beam Vidicon (RBV) camera systems, the MultiSpectral Scanner (MSS) systems, and the Thematic Mapper (TM)

Phnom Penh, Cambodia 1973, 1985

Phnom Penh (pronounced p-NOM PEN) is the capital city of Cambodia. These images show Phnom Penh, the Mekong River, and some irrigation works of the Khmer Rouge era. (Source information from USGS)

Landsat Thematic Mapper (TM)

Band No.	Wavelength Interval (um)	Spectral Response	Resolution (m)
1	0.45-0.52	Blue-Green	30
2	0.52-0.60	Green	30
3	0.63-0.69	Red	30
4	0.76-0.90	Near-IR	30
5	1.55-1.75	Mid-IR	30
6	10.40-12.50	Thermal-IR	120
7	2.08-2.35	Mid-IR	30

(TM) has been added to Landsats 4 (1982), 5 (1984), 6 (failed to attain orbit during launch and thus has never returned data) and 7 (1999).

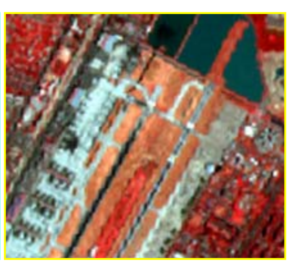
The SPOT satellites each have twin high resolution visible (HRV) imaging systems, which can be operated independently and simultaneously

SPOT

The image shows the temple complex of Angkor. The large bluish-black rectangle is the Western Baray (reservoir), part of Angkor's famous irrigation system. The large square to its east is Angkor Thom, a fortified city. The brown spot at the centre of the square is the Bayon, a monumental structure. To its south is the fabled temple of Angkor Wat, surrounded by a wide moat. Other temples and the Eastern Baray are located round the complex. The road running south from Angkor Wat goes to the nearby town of Siem Reap. The wide bluish strip to the south is the flooded lake of Tonlé Sap.

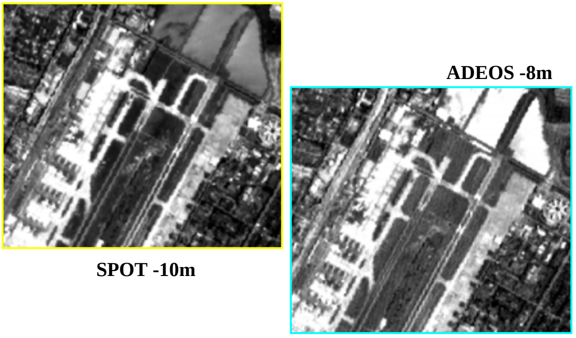
Comparison of Spatial Resolution

TM 30



ADEOS 16

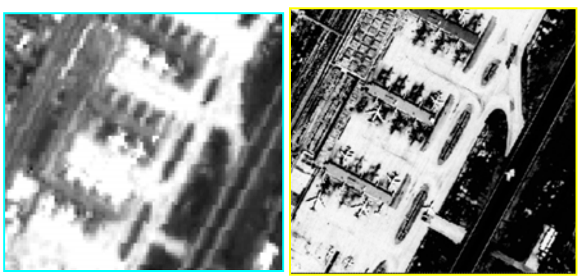
Comparison of Spatial Resolution



ADEOS -8m

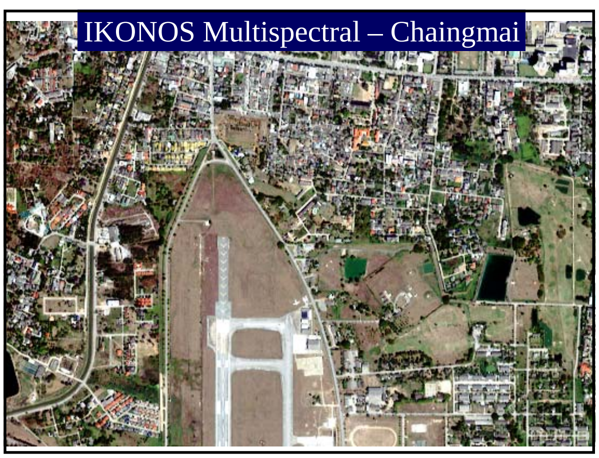
SPOT -10m

Comparison of Spatial Resolution



SPOT-10m

SPIN2-2m

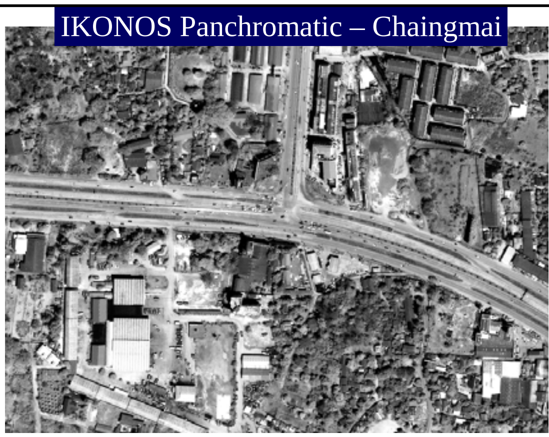


IKONOS – Chaingmai
Multispectral vs. Panchromatic

4 meter

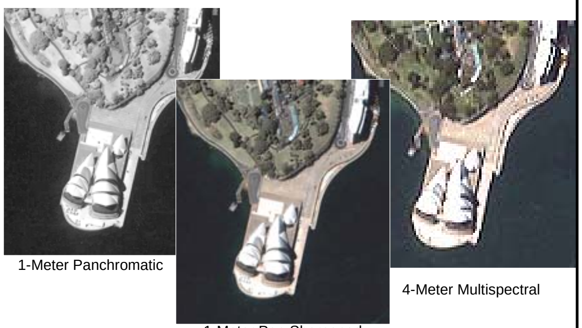
1 meter

IKONOS Panchromatic – Chaingmai



IKONOS Multispectral – Chaingmai

Pan-Sharpening



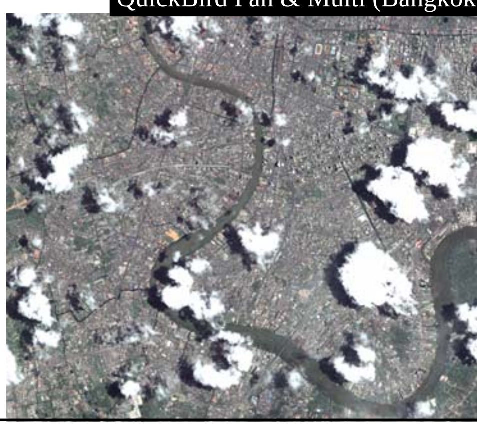
1-Meter Panchromatic

4-Meter Multispectral

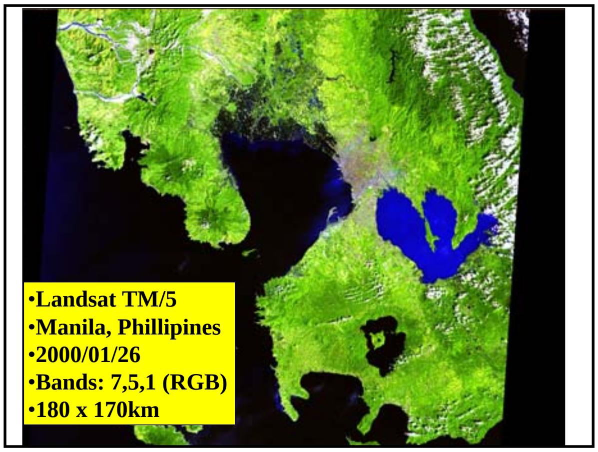
1-Meter Pan-Sharpened

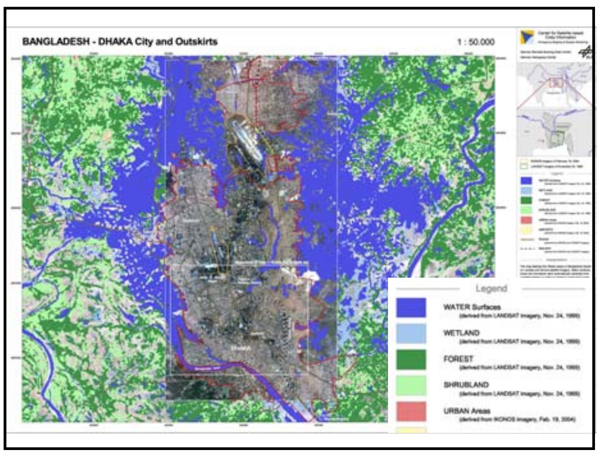
Space Imagine Product

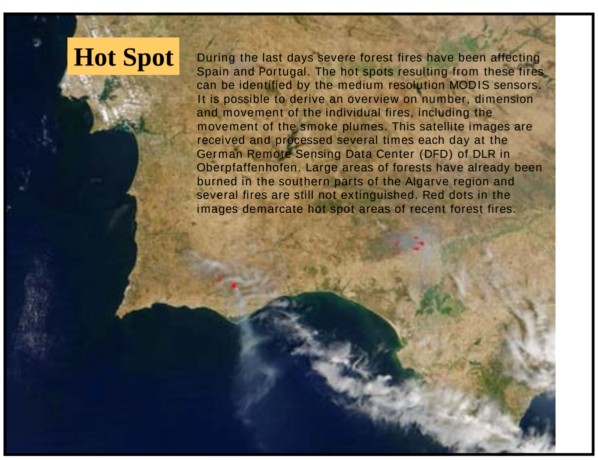
QuickBird Pan & Multi (Bangkok)



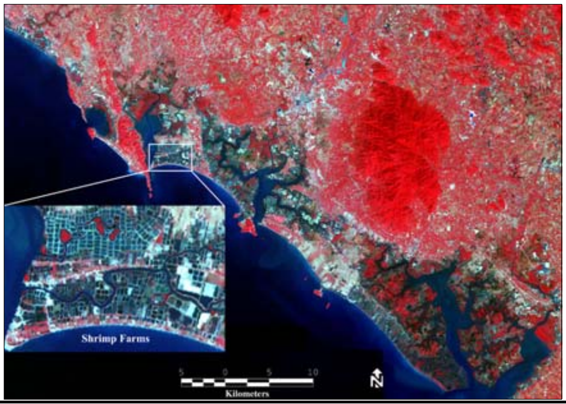
QuickBird Pan & Multi


•Landsat TM/5
•Manila, Phillipines
•2000/01/26
•Bands: 7,5,1 (RGB)
•180 x 170km

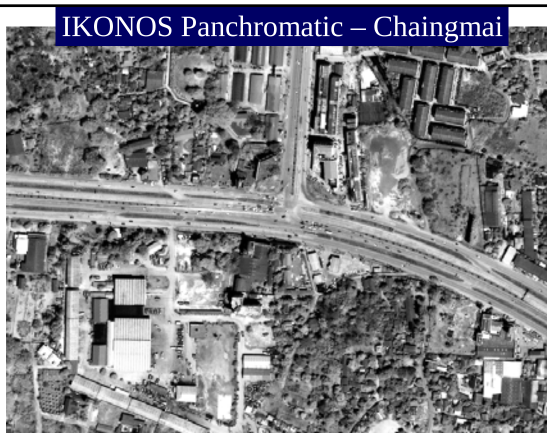

BANGLADESH - DHAKA City and Outskirts
1 : 50.000
Legend
WATER Surfaces
WETLAND
FOREST
SHRUBLAND
URBAN Areas

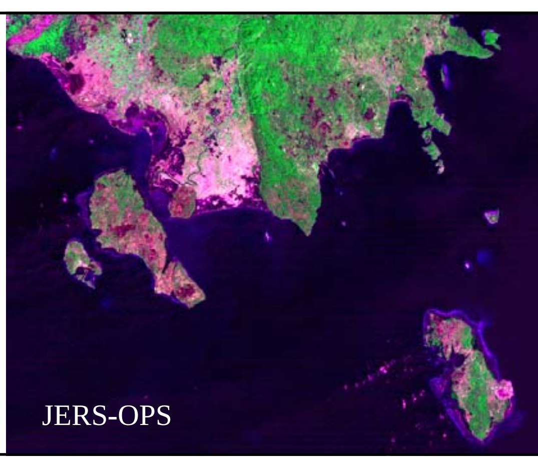

Hot Spot
During the last days severe forest fires have been affecting Spain and Portugal. The hot spots resulting from these fires can be identified by the medium resolution MODIS sensors. It is possible to derive an overview on number, dimension and movement of the individual fires, including the movement of the smoke plumes. This satellite images are received and processed several times each day at the German Remote Sensing Data Center (DFD) of DLR in Oberpfaffenhofen. Large areas of forests have already been burned in the southern parts of the Algarve region and several fires are still not extinguished. Red dots in the images demarcate hot spot areas of recent forest fires.

ADEOS False Color – NIR, Red, Green



IKONOS Panchromatic – Chaingmai

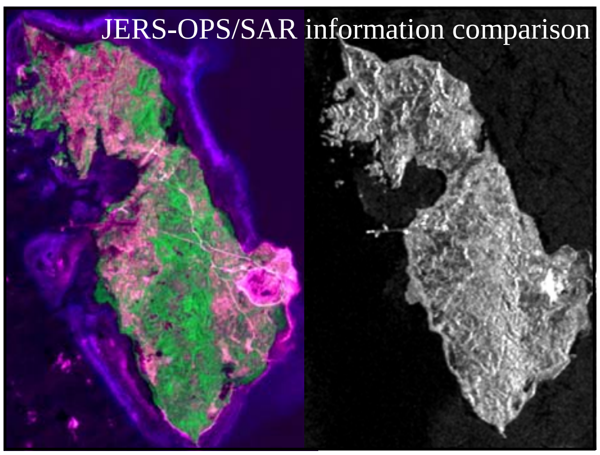




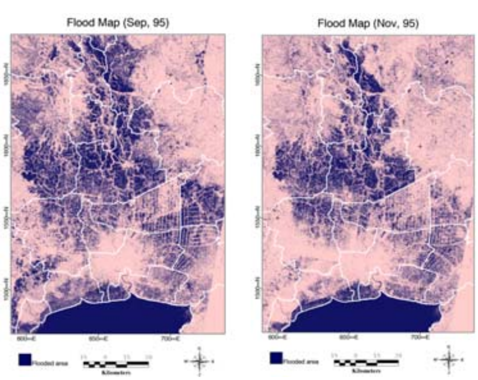
JERS-OPS

JER

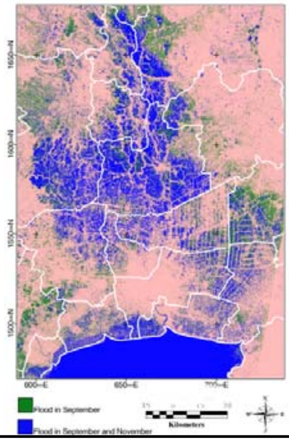
JERS-OPS/SAR information comparison



Open Flooded Area Maps (Sep & Nov)



Flood Movement



Bangladesh from MODIS

Description: This view of Bangladesh shows the confluence of the Padma (Ganges) and Jamuna Rivers before they empty into the Bay of Bengal. (Resolution: 625 meters; MODIS Data Type: MODIS-PFM; MODIS Band Combination: 1, 4, 3)

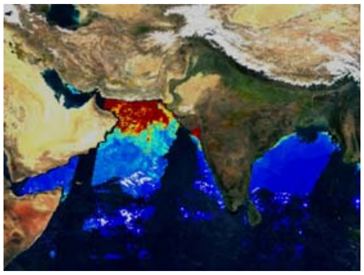
Jacques Descloitres, MODIS Land Science Team

Mouth of the Yellow River, China

A MODIS view of sediment emerging from the mouth of the Yellow River in China.

Credit:Jacques Descloitres, MODIS Land Group, 02-28-2000

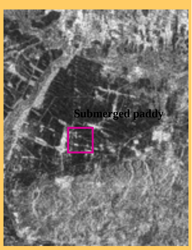
MODIS Chlorophyll from Indian Sub-continent



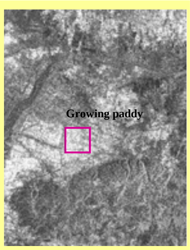
MODIS provides the unprecedented ability to measure chlorophyll fluorescence, which gives insight into the health of phytoplankton in the ocean. When phytoplankton are under stress, they no longer photosynthesize and begin to emit absorbed sunlight as fluorescence. In this image taken over the Arabian Sea, we see high concentrations of chlorophyll (red tones), indicating a denser concentration of the microscopic marine plant.

Credit: Scientific Visualization Studio, NASA Goddard Space Flight Center,
Satellite: Terra
Sensor: MODIS
Data Source: MODIS Ocean Group

Rice Growth Monitoring using RADAR Remote Sensing



Radar image in March 1997: showing YOUNG PADDY in dark color



Radar image in May 1997: showing GROWING STATE OF PADDY in bright color

ADEOS image of the same area in May 1997 : TCC showing GROWING STATE OF PADDY

Remote Sensing for Rice Yield Estimation in Indonesia

Heading

Planting

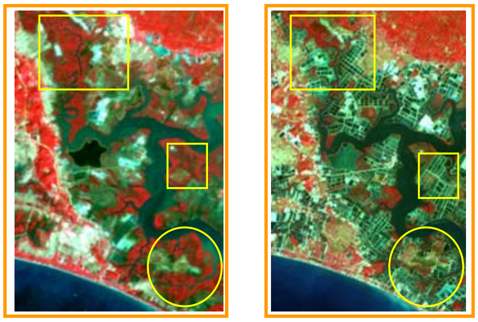
Ripening

Harvest

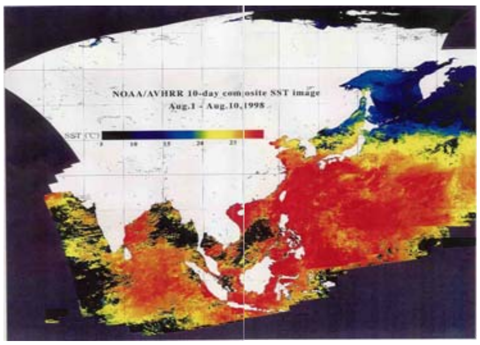
Rice main growth stages

Remote Sensing for Coastal Zone Management

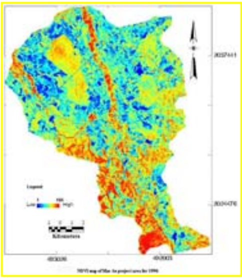
Shrimp Farm extension in Chantaburi(1987- 1995)



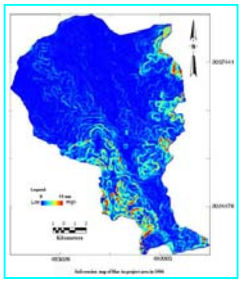
SST (Sea Surface Temperature) Composite Bangkok(AIT), Ulanbator, Tokyo, Kuroshima



Soil Erosion Monitoring

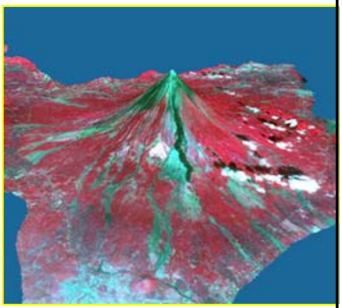


NDVI Map
(Normalized Differential Vegetation Index)



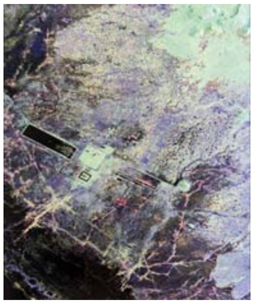
Soil Erosion Map

Mt. Mayon Volcano Comprehensive Disaster Prevention Master Plan



Archeology

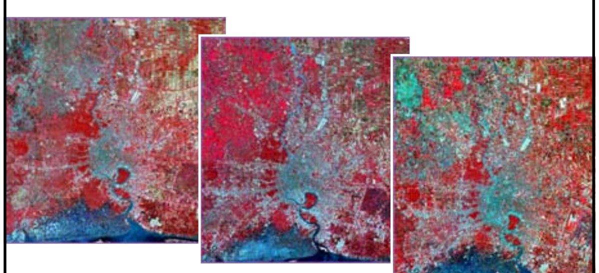
Angkor, Cambodia



Spaceborne Imaging Radar-C/X-band, Synthetic Aperture Radar (SIR-C/X-SAR)

Satellite Data Promotion Project (NASDA)

Transportation Network



Satellite	Sensor	Resolution	Scence Size	Cost
Landsat7 ETM+	Pan & Multispectral	15,30 & 60 metre	185km by 185km	900
IRS	Panchromatic	5 metre	70km by 70km	2500
IRS	Panchromatic	5 metre	23km by 70km	1100
IRS	Panchromatic	5 metre	23km by 23km	900
IRS	Multispectral	20 metre	140km by 140km	2500
IRS	Multispectral	20 metre	70km by 70km	1900
SPOT 4*	Panchromatic	10 metre	60km by 60km	1200
SPOT 4*	Multispectral	20 metre	60km by 60km	1200
SPOT 4	Panchromatic	10 metre	60km by 60km	1900
SPOT 4	Multispectral	20 metre	60km by 60km	1900
SPOT5	Panchromatic	2.5 metre	60km by 60km	6500
SPOT5	Panchromatic	5 metre	60km by 60km	3250
SPOT5	Multispectral	10 metre	60km by 60km	3250
RADARSAT	Fine Beam	8 metre	50 km by 50 km	5400
RADARSAT	Standard Beam	25 metre	100km by 100 km	4050
RADARSAT	Wide Beam	30 metre	150 km by 150km	4725
RADARSAT	ScanSAR Narrow	50 metre	300 km by 300 km	5400
RADARSAT	ScanSAR Wide	100 metre	500 km by 500 km	5400
RADARSAT	Extended High	25 metre	75 km by 75 km	4725
RADARSAT	Extended Low	35 metre	170 km by 170 km	4725
IKONOS	Pancromatic	1 metre	purchased by km^2	15
IKONOS	Multispectral	4 metre	purchased by km^2	15
IKONOS	Pan-Multi Fuse	1 metre	purchased by km^2	20
IKONOS	Pan-MULTI Bundle	1 & 4 metre	purchased by km^2	22
QuickBird	Panchromatic	0.61 metre	purchased by km^2	25
QuickBird	Multispectral	2.4 metre	purchased by km^2	30
QuickBird	Pan-MULTI Bundle	0.6 & 2.4 metre	12.5 km by 12.5 km	1500

Thank you

http://www.star.ait.ac.th
http://www.acrors.ait.ac.th
www.gac.ait.ac.th