High-Resolution Optical Satellites

High-resolution satellite data with a resolution of 5 to 10 meters in the panchromatic and 10 to 30 meters in the multi-spectral imaging mode may be suited to generate map products in the scale of 1: 50000 and 1: 100000. With an improved spatial resolution of 1 to 4 meters, as for instance IKONOS and Quickbird, satellite image data will also be applicable for mapping in scales of 1 : 25000 to 1 : 10000.

The high resolution makes it an excellent tool for creating and maintaining up-to-date thematic maps of even the most remote area of our planet.

High Resolution Optical Satellite Data:

2.5m - 30m spatial resolution by panchromatic or multispectral sensors or analogue camera systems such as:

Landsat ETM

SPOT PAN and MS

ASTER

IRS-1C/D (PAN and LISS)

Very High Resolution Optical Satellite Data:

0.6 m - 4m spatial resolution by panchromatic or multispectral sensors such as: IKONOS and Quickbird

Application Field
High-Resolution Optical RS

- **Natural Resource**
  - **Forestry**
  - **Agriculture (Crop Type, Growth Monitoring, Yield, Water Stress…)**
  - **Mineral Exploration (Mineral, Lineament Analysis)**
- **Environment**
  - **Land use/Land Cover**
  - **Costal Zone**
  - **Urban Environment (Urban expansion, Heat Island, Greeness, Urban land use)**
  - **Vegetation Mapping**
  - **Land Surface Process**
- **Disaster**
  - **Flood, Forest Fire, Earthquake, Oil Spil**
- **Topographic Information**
  - **DEM**

Advantage

- **High-Resolution**
  - **Easy for interpretation**
- **Good products line**
- **systematic**
- **High-Precision**
- **Good search/ordering system**
  - **Commercial Distributor**
- **Easy Handling**
  - **Common formats**
  - **Supported by various software**
  - **Good combination with 1/100,00 – 1/50,000 maps**
  - **Plenty of Application examples**
- **Improved resolution**
- **Multi-Spectral**

Limitation

- **Re-Visit Time**
  - **2 –18 days**
- **Cloud Cover**
  - **Project planning**
- **Spectral Information**
  - **Panchromatic to several bands only**
- **S/N**
  - **Normally 6-8 bits**
- **Geo-location**
  - **Distortion by topographic effect (edge, highmountains)**
  - **Off-Nadir Observation**
- **Coverage**
  - **Several 10km – 180km**
- **Cost**
  - **Usually not free**
  - **Sometimes expensive**
  - **Super-high reso: Expensive**
- **Satellite Geometry Model: sometimes not open**

Selection of RS Data

- Availability
  - Frequency
  - Cloud Cover
- Spatial Resolution
- Spectral Resolution
- Data Quality
  - S/N
  - Processing system
- Cost
  - Per Scene
  - Per sq.km
  - Mosaic
  - Time to obtain
- Confidence

LANDSAT

The program was first started by NASA in 1972

• Since 1984, satellite operation and data handling were managed by a commercial company EOSAT

• However, all data older than 2 years return to "public domain" and are distributed by the Earth Resource Observation System (EROS) Data Center, USGS, http://eros.usgs.gov/

• The first satellite in the series, LANDSAT-1 was launched on 23 July 1972.

LANDSAT Advantage

- Stable Quality: Good S/N
- Processing/Application Experience
- Huge Archive since 1972
- Big Coverage (180*180km)
  – Reduce mosaic cost
- Relatively Inexpensive
- Accessibility to technical information
  – Calculate Radiance, Reflectance, Temperature
  – Information Update: Anomaly
- Order from USGS: on-line, ftp or CD

Landsat Program – System Summary

System	Launch Date	End of service	Instru	Res. (m)	Altitude (km)	Revisit (days)	Data R. (mbps)
Landsat 1	7/27/72	1/6/78	RBV/MSS	80/80	917	18	15
Landsat 2	1/22/75	2/25/82	RBV/MSS	80/80	917	18	15
Landsat 3	3/5/78	3/31/83	RBV/MSS	30/80	917	18	15
Landsat 4	7/16/82		TM/MSS	30/80	705	16	85
Landsat 5	3/1/84		TM/MSS	30/80	705	16	85
Landsat 6	10/5/93	10/5/93	ETM	15 (pan) 30 (ms)	705	16	85
Landsat 7	4/15/99		ETM+	15 (pan) 30 (ms)	705	16	150

Instruments onboard Landsat satellites during the last 30 years

Enhanced Thematic Mapper Plus (ETM+): The ETM+ instrument currently flying on Landsat-7 is similar to the earlier TM, but adds an extra 15-meter resolution panchromatic band, and improved resolution for the thermal-infrared band (60-meters).

Thematic Mapper (TM): The TM was flown on Landsat-4 and Landsat-5. The TM is a cross-track scanner providing seven multispectral channels (3 visible, 1 near-infrared, 2 midinfrared, 1 thermal-infrared) at 30-meter resolution (120-meter resolution for the thermal-infrared band).

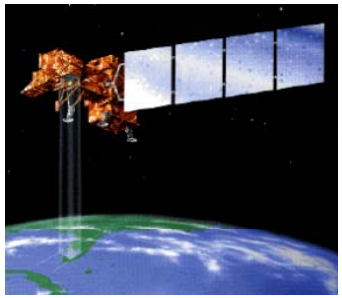
Instruments onboard Landsat satellites during the last 30 years

Multispectral Scanner (MSS): More successful than the RBV, the MSS was a cross-track (whiskbroom) scanner that acquired imagery in four channels (2 visible, 2 near-infrared) at 79-meter resolution. The MSS was included on Landsat-1 through Landsat-5.

Return-Beam Vidicon (RBV): Installed on the first three Landsat missions, the RBV was a multi-spectral video camera that did not achieve wide popularity.

Landsat 7 ETM+

•Launched April 15, 1999 on a DeltaII, from Vandenberg AFB, CA



•Carries Enhanced Thematic Mapper Plus (ETM+) designed to provide 15 meter resolution in the panchromatic band and 30 meters resolution in the multispectral bands.

•Added the Band 6 Low and High gain 60 meter thermal bands.

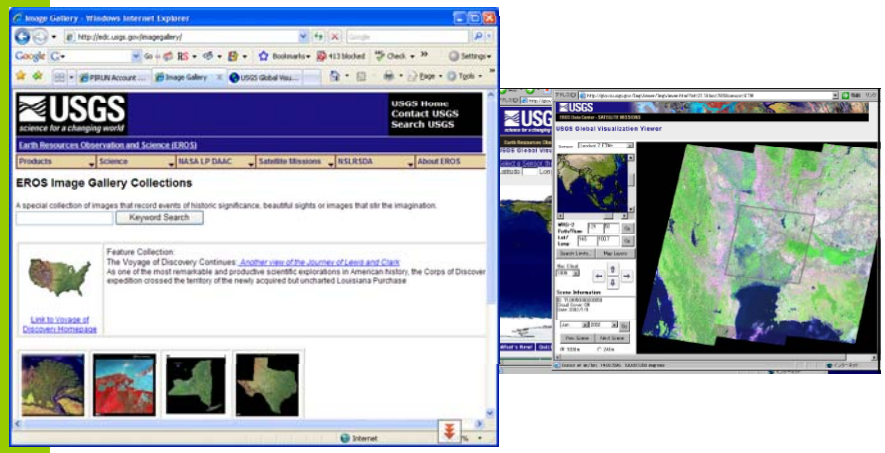
•Full Aperture Solar Calibrator(FASC)

•Partial Aperture Solar Calibrator (PASC)

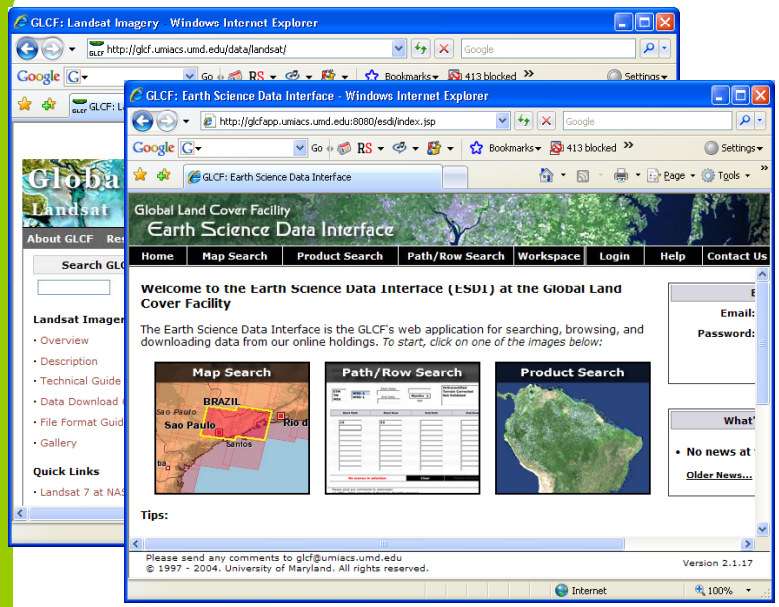
LANDSAT 7 ETM+ Spectral and Spatial Resolution

Band Number	Spectral Range (μm)	Ground Resolution (m)
1	0.45 to 0.52	30
2	0.53 to 0.61	30
3	0.63 to 0.69	30
4	0.78 to 0.90	30
5	1.55 to 1.75	30
6	(L/H) 10.4 to 12.5	60
7	2.09 to 2.35	30
pan	0.52 to 0.90	15

http://glovis.usgs.gov/ImgViewer/ImgViewer.html?lat=21.7&lon=78.5&sensor=ETM



http://edc.usgs.gov/imagegallery/



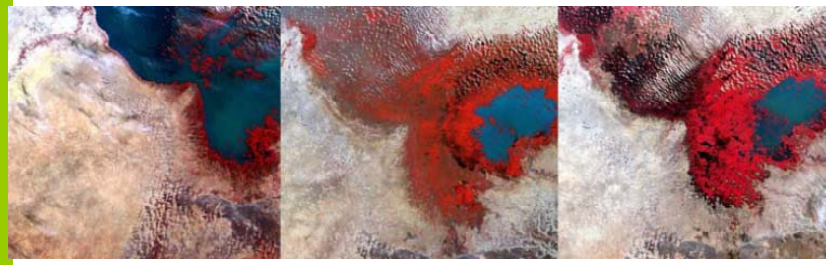
Applications of Landsat Data

Applications of Landsat data are quite diverse, including:

- agricultural monitoring (i.e., crop yield and acreage)
- land-cover/land-use change (i.e., forest cover)
- coastal resource monitoring (i.e., wetland health)
- mapping geologic resources and features
- environmental monitoring (i.e. water pollution)
- disaster management (flood and volcanic activity mapping)
- cartographic mapping and map updating

examples of Landsat 7 applications:
http://landsat.gsfc.nasa.gov/images/Landsat_Applications.html

Change Monitoring (Lake Chad, Africa)



The December 8th, 1972 image shows the lake level lower than the mid-1960s level. After the extended drought of the 1970s and mid-1980s, the lake shrunk to less than 3000 square kilometers, the light blue area at right-center in the October 1987 image. In the December 18th, 2002 Landsat 7 image, further changes are evident. Some of the changes include more enhanced exposure of dune features, increased wetland vegetation in the water and decreased wetland vegetation on the outside edges,

http://landsat.usgs.gov/gallery/detail/468/

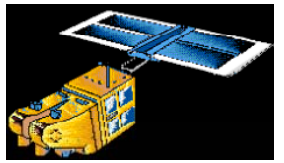
• Mapping Volcanic Deposits

Landsat data can produce maps of lava flows with pinpoint accuracy. With these maps researchers can study the evolution of individual eruptions while they are taking place.

Landsat 7 and Land-based views of two Guatamalan volcanoes

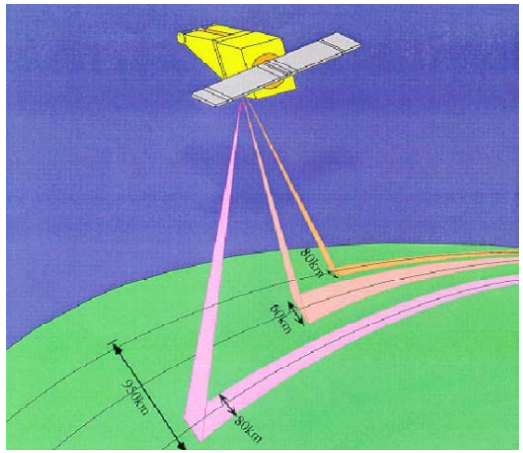
http://ltpwww.gsfc.nasa.gov/IAS/handbook/handbook_htmls/chapter14/htmls/volcanology.html/

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.

SPOT Satellite System



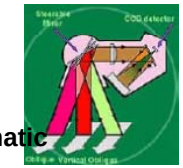
SPOT product spectral modes

SPOT products	SPOT satellites	Spectral mode	Bands	Ground pixel size
2.5 m colour	5	THR+HX	3	2.5 m
2.5 m B&W	5	THR	1	2.5 m
5 m colour	5	HM+HX	3	5 m
5 m B&W	5	HM	1	5 m
10 m colour	5	Hi	4	10 m
	4	M+Xi	4	10 m
10 m B&W	4	M	1	10 m
	1, 2, 3	P	1	10 m
20 m colour	4	Xi	4	20 m
	1, 2, 3	XS	3	20 m

SPOT satellite spectral bands and resolutions

Satellites	Spectral bands	Ground pixel size	Spectral range
Spot 5	Panchromatic B1: green B2: red B3: near infrared B4: short-wave infrared (SWIR)	2.5 m or 5 m 10 m 10 m 10 m 20 m	0.48 - 0.71 µm 0.50 - 0.59 µm 0.61 - 0.68 µm 0.78 - 0.89 µm 1.58 - 1.75 µm
Spot 4	Monospectral (panchromatic) B1: green B2: red B3: near infrared B4: short-wave infrared (SWIR)	10 m 20 m 20 m 20 m 20 m	0.61 - 0.68 µm 0.50 - 0.59 µm 0.61 - 0.68 µm 0.78 - 0.89 µm 1.58 - 1.75 µm
Spot 1 Spot 2 Spot 3	Panchromatic B1: green B2: red B3: near infrared	10 m 20 m 20 m 20 m	0.50 - 0.73 µm 0.50 - 0.59 µm 0.61 - 0.68 µm 0.78 - 0.89 µm

SPOT 4 imaging instruments



Multispectral Panchromatic

Spectral bands (mm)

0.50 - 0.59

0.61 - 0.68

0.79 - 0.89

1.58 - 1.75

0.61 - 0.68

Pixel size	**20 x 20 m**	**10 x 10 m**
Swath width (vertical viewing)		**60 km 60 km**
On board compression	**DPCM (3/4)**	**DPCM (3/4)**

Sample SPOT images

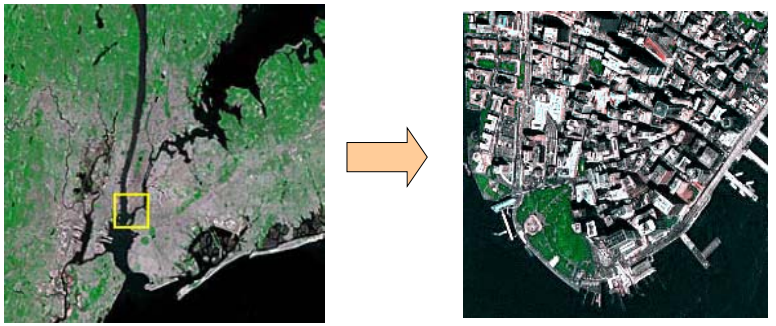
2.5-meter color image

full scene of 60 km x 60 km detail of scene extract

Toulouse, France

Sample SPOT images

5-meter color image

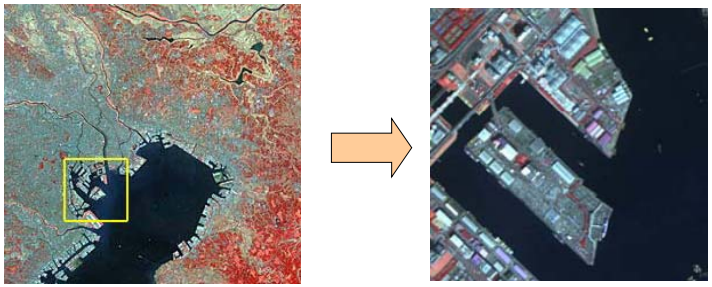


full scene of 60 km x 60 km detail of scene extract

New York, USA

Sample SPOT images

10-meter color image



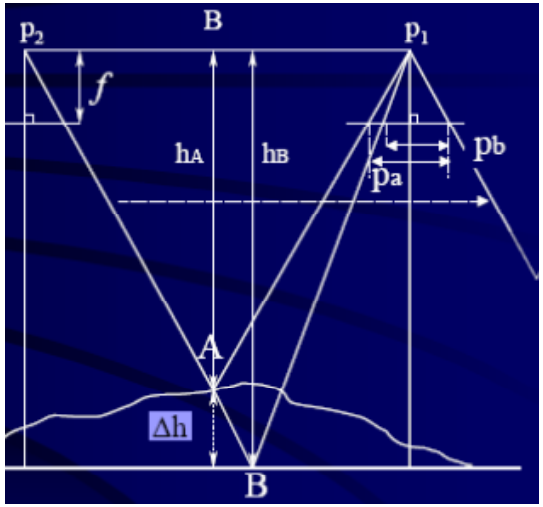
full scene of 60 km x 60 km detail of scene extract

Tokyo, Japan

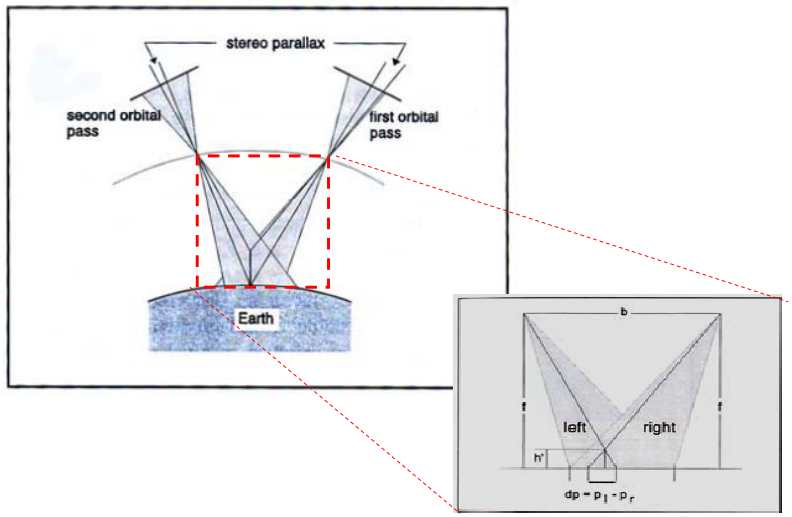
$$h = \frac{B \times f}{p}$$

$$\Delta h = h_B - h_A = B \times f \left(\frac{1}{p_b} - \frac{1}{p_a} \right)$$

p : parallax

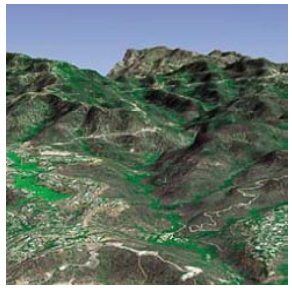


Relation between stereo parallax and object elevation

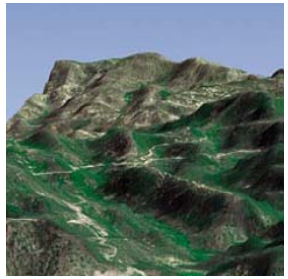


SPOT 3D Terrain Database
Sample Image in Kosovo
http://www.spot.com/home/proser/LISTVIEW/3d_terrain/3d_terrain.HTM

Sample SPOT images -3D



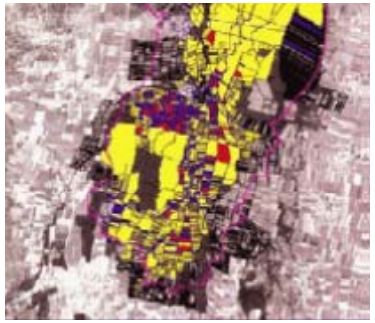
full scene



Zoom of screen

LA, USA

SPOT image Application



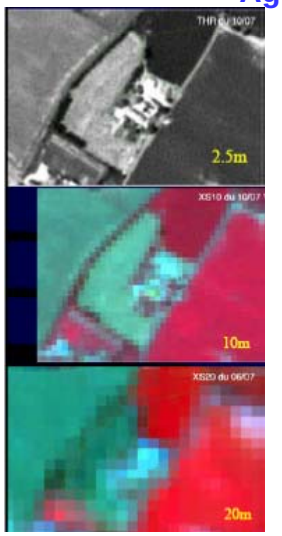
Flooding Example

Spot 5 2.5-meter B&W images, combined if necessary with aerial photography, are used for mapping the areas under study (to identify natural and man-made features) at a scale of 1:5,000. The data can be combined with cadastral maps for flood risk prevention planning.

flood zone
completely flooded parcels
partly flooded parcels

SPOT image Application

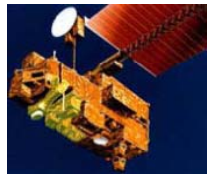
Agricultural Monitoring Example



Spot 5 2.5 and 5-meter black-andwhite imagery improves boundary detection and farmland area measurement, especially in the case of small parcels. In addition, the rich thematic content of Spot 5 color imagery makes it easier to describe the diversity of the areas observed and to identify the parcel content.

With 10 m colour (XS10), precise crop parcel boundaries,landuse within the parcel and hedges are more easily identified.

ASTER

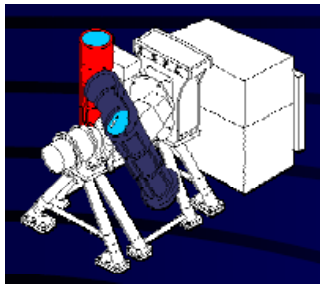


ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) is an imaging instrument that is flying on Terra, a satellite launched in December 1999 as part of NASA's Earth Observing System (EOS).

ASTER will be used to obtain detailed maps of land surface temperature, emissivity, reflectance and elevation. The EOS platforms are part of NASA's Earth Science Enterprise, whose goal is to obtain a better understanding of the interactions between the biosphere, hydrosphere, lithosphere and atmosphere.

ASTER Instrument

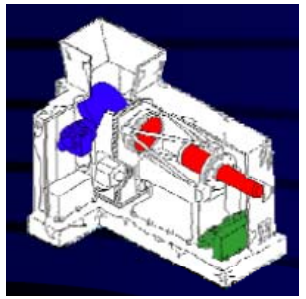
Nadir Looking Telescope - The VNIR subsystem nadir looking telescope is a reflecting-refracting improved Schmidt design. The focal plane of this telescope contains three 5000 silicon charge coupled detector line arrays. The nadir and backward looking telescope pair are used for same orbit stereo imaging and can be rotated as a unit +/- 24 degrees to provide extensive cross-track pointing capability



The VNIR subsystem produces by far the highest data rate of the three ASTER imaging subsystems. With all four bands operating (3 nadir and 1 backward) the data rate including image data, supplemental information and subsystem engineering data is 62 Mbps.

ASTER Instrument

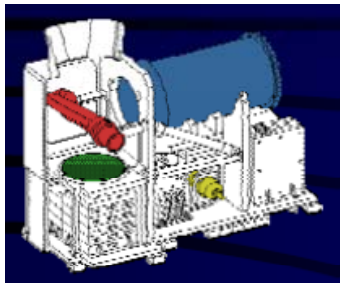
The SWIR subsystem operates in six spectral bands in the near-IR region through a single, nadir-pointing telescope that provides 30 m resolution. Cross-track pointing (±8.550) is accomplished by a pointing mirror. Because of the size of the detector/filter combination, the detectors must be widely spaced, causing a parallax error of about 0.5 pixels per 900 m of elevation. This error is correctable if elevation data, such as a DEM, are available.



Two on-board halogen lamps are used for calibration in a manner similar to that used for the VNIR subsystem, however, the pointing mirror must turn to see the calibration source. The maximum data rate is 23 Mbps.

ASTER Instrument

The **TIR subsystem** operates in five bands in the thermal infrared region using a single, fixed-position, nadir-looking telescope with a resolution of 90 m. Unlike the other instrument subsystems, it has a "whiskbroom" scanning mirror. Each band uses 10 detectors in a staggered array with optical bandpass filters over each detector element.



The scanning mirror functions both for scanning and cross-track pointing (to ±8.55 degrees). In the scanning mode, the mirror oscillates at about 7 Hz and, during oscillation, data are collected in one direction only.

ASTER Spectral Range

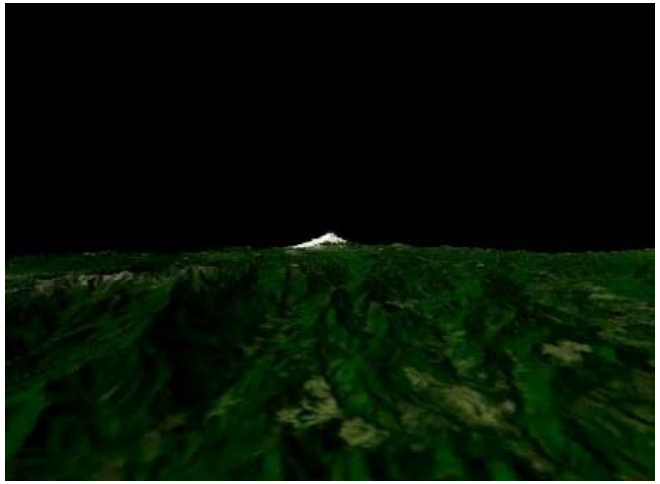
VNIR	SWIR	TIR
Band 1 0.52 - 0.60 µm Nadir looking	Band 4: 1.600 - 1.700 µm	Band 10: 8.125 - 8.475 µm
Band 2 0.63 - 0.69 µm Nadir looking	Band 5: 2.145 - 2.185 µm	Band 11: 8.475 - 8.825 µm
Band 3 0.76 - 0.86 µm Nadir looking	Band 6: 2.185 - 2.225 µm	Band 12: 8.925 - 9.275 µm
Band 3 0.76 - 0.86 µm Backward looking	Band 7: 2.235 - 2.285 µm	Band 13: 10.25 - 10.95 µm
	Band 8: 2.295 - 2.365 µm	Band 14: 10.95 - 11.65 µm
	Band 9: 2.360 - 2.430 µm	

ASTER Instrument Characteristics

Characteristic	VNIR	SWIR	TIR
Ground Resolution	15 m	30m	90m
Data Rate (Mbits/sec)	62	23	4.2
Cross-track Pointing (deg.)	±24	±8.55	±8.55
Cross-track Pointing (km)	±318	±116	±116
Swath Width (km)	60	60	60
Detector Type	Si	PtSi-Si	HgCdTe
Quantization (bits)	8	8	12

Sample product:

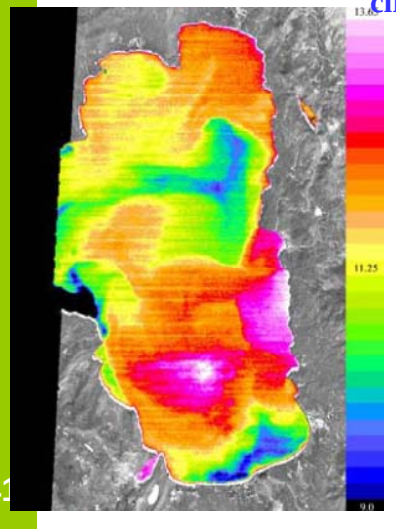
DTM from ASTER Data



Mt. Fuji, Japan, Flyby Animation

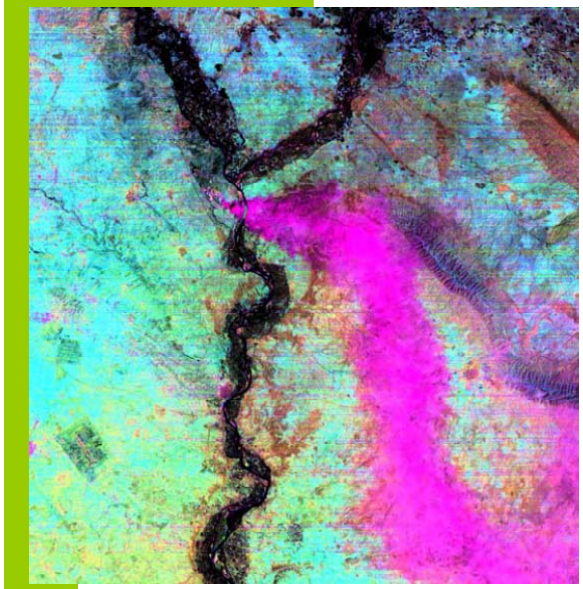
Sample application

Using ASTER to measure circulation in lakes



ASTER instrument also measures the radiation emitted in the thermal infrared part of the spectrum. These data can be used to measure the surface temperature and produce maps of lake surface temperature. Such maps are valuable for the understanding of a variety of processes in lakes, such as wind-induced upwelling events and surface water transport patterns.

The temperature images from ASTER can be used to map these nutrient pathways which help explain the distribution of organic matter and fine sediments around the lake.

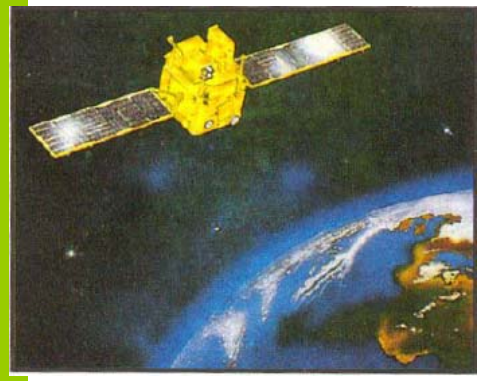


Iraq Sulfur Fire

A fire has been burning at an industrial sulfur plant in Iraq south of Mosul since June 25. It is producing a noxious cloud of sulfur-containing gases. ASTER's TIR bands highlight the presence of SO2 in purple. The ASTER image was acquired on July 14, 2003 and covers an area of 60 x 61 km.

http://asterweb.jpl.nasa.gov/

IRS
Indian Remote Sensing Satellites



The Indian Remote Sensing (IRS) satellites was operationalized with the commissioning of IRS-1A in March 1988. The first two satellites in the series, IRS-1A and 1B, have been the workhorse for generating resources information in a variety of application areas, such as, agriculture, forestry, geology and hydrology. The satellites, IRS-1A & 1B, were placed in a sun-synchronous orbit of 904 kms in such a way as to provide a combined repetitivity cycle of 11 days.

http://ceos.cnes.fr:8100/cdrom-97/ceos1/isro/eospro/irs1b.htm

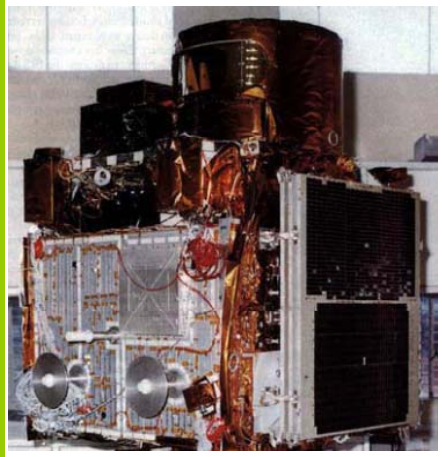
Presently Working Satellites

- IRS-1B, 1991
- IRS-P2, 1994
- IRS-1C, 1995
- IRS-P3, 1996
- IRS-1D, 1997
- IRS-P4, 1999 (Oceansat)

***Satellites System* (IRS-1D Satellite)**

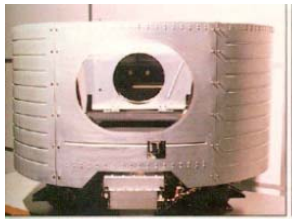
Resolution: 5.8 m in Panchromatic and 23.5 m in multispectral
Equatorial Crossing time: 10.40 A.M
Alitude : 737 Km(Perigee)/821 Km. (Apogee)
Repetivity : 24 days; (3 days revisit)
No. of Sensors : Three; 1) PAN, 2) LISS-III and 3) WiFS

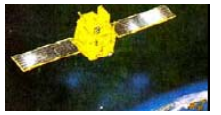
The IRS-1C satellite



IRS-1C data are currently being received at three ground stations: Shadnagar in India; Norman in Oakland and Neustrelitzl in Germany.

The Pan sensor on IRS-1C is the first commercial satellite imagery to break the 10 metre barrier and offer regular repeat coverage.





The IRS-1C satellite

Panchromatic Camera

LISS-III Sensor

Wide Field Sensor

WiFS will collect data in two spectral bands
Ground swath 810km spatial Resolution 188.3 m.

Imaging Sensor Characteristics (LISS-III Sensor)

Parameters	B2 B3 B4	B5
Spectral bands	0.59-0.59(green) 0.62-0.68(reg) 0.77-0.86(NIR)	1.55-1.70 (MID)
Resolution (m)	23.5 (for bands B2,B3,B4)	70.5 (for b5)
Swath (Kms)	141	148
Equi focal length (mm)	347.5	301.2
Number of grey levels	128 (7 bits)	128

Band 2 is centered around the first peak of the vegetation reflectance curve
Band 3 is centered around the chlorophyll absorption region of vegetation.
Band 4: The high reflectance plateau region of the vegetation reflectance is in this band.
Band 5: the middle infra-red region from 1.3-2.5 microns is sensitive to leaf water content.

Panchromatic Camera (PAN)

Parameters	Specifications (PAN)
Band (microns)	0.50 - 0.75
Resolution (m)	5.8
Effective focal lenght	980 mm
Coding	6 bits (64 grey levels)
Swath (km.) 1. Nadir 1. Off-nadir	70 91
Off-nadir viewing (deg)	+/-26 for obtaining stereoscopic data and 5 day revisit

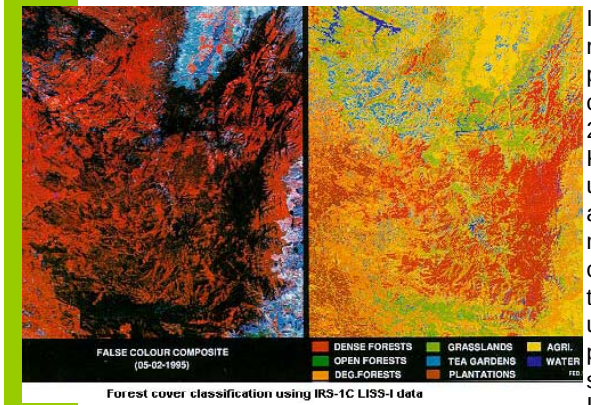
Wide Field Sensor (WiFS)

This sensor is most useful for vegetation studies. With larger swath (770 Km), high repetivity (5 days) and operation in two vegetation specific bands, the sensor provide vegetation index at regional level

Parameters	Specifications (PAN)
Spectral bands (microns)	B3 - 0.62-0.68 (red) B4 - 0.77-0.86 (near IR)
Resolution (m)	188
CCD devices	2048 elements
Swath (km.)	810 (5 days repetivity)
Equivalent focal length (mm)	56.4
No. of grey levels	128 (7 bits)
SNR	>128

http://www.fas.org/irp/imint/irs_tp.htm

Example: IRS-1C LISS-111 data for forest mapping



Forest cover classification using IRS-1C LISS-I data

IRS- I C with 23.5 m spatial resolution is expected to provide data outputs comparable to the scale of I : 25,000. A study area in North Kanara has been selected using 24 January 1996 data and was analyzed using maximum likelihood classification algorithm. The training areas are selected using the available aerial photographs and detailed stock maps for the region on I : 25,000 scale.

The classification accuracy and mapping accuracy have been found to be 85%. The analysis of LISS-III in the study area showed bamboo mixed forests and teak plantations besides dense and open forests

IKONOS

IKONOS Satellite

The launch on September 24, 1999 of Space Imaging's IKONOS commercial remote sensing satellite, including the deployment of its digital camera system designed and built by Kodak, marks the beginning of the longawaited era of one-meter resolution Earth imaging

The integrated imaging payload is enabling IKONOS to collect panchromatic (gray-scale) image data of Earth to one-meter resolution; and multi-spectral data (red, green, blue, and near infrared) to 4 meter resolution.

IKONOS Satellite

The imaging sensors are panchromatic and multi-spectral. This satellite has a polar, circular, sun-synchronous 681-km orbit and both sensors have a swath width of 11 km.

Band	Wavelength Region (μm)	Resolution (m)
1	0.45-0.52 (blue)	4
2	0.52-0.60 (green)	4
3	0.63-0.69 (red)	4
4	0.76-0.90 (near-IR)	4
PAN	0.45-0.90 (PAN)	1

Ikonos Data source: http://www.spaceimaging.com/

IKONOS Products

CARTERRA Geo
geometrically corrected to a pre-specified ellipsoid and map projection

CARTERRA Reference
orthorectified: 25m horizontal accuracy, useful for large area mapping to 1:50,000 scale, particularly international coverage, and GIS applications requiring low positional accuracy.

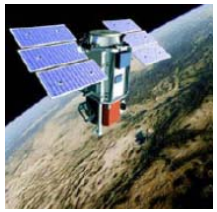
CARTERRA Pro
orthorectified: 10m horizontal accuracy, useful for city and local government, telecommunications and utilities customers, mapping to 1:12,000 scale.

CARTERRA Precision
orthorectified with ground control and DEM's; 4m horizontal accuracy, premium product ideal for urban mapping, cadastre mapping and GIS applications requiring high positional accuracy, mapping to 1:4,800 scale.

Ikonos Data source and prices:
http://www.spaceimaging.com/

Sample IKONOS Data Set of the Study area part (Sukumvit)

QuickBird Satellite



QuickBird was launched on 18 October 2001.This is currently the highest resolution commercial satellite data available.

QuickBird is now acquiring 61-centimeter (2-foot) resolution panchromatic (black and white) and 2.44-meter (8-foot) multispectral (color) imagery. At 61-centimeter resolution, buildings, roads, bridges and other detailed infrastructure become visible. The imagery will be used for a wide range of applications, focusing on the assessment and management of land, infrastructure, and natural resources.

QuickBird Satellite

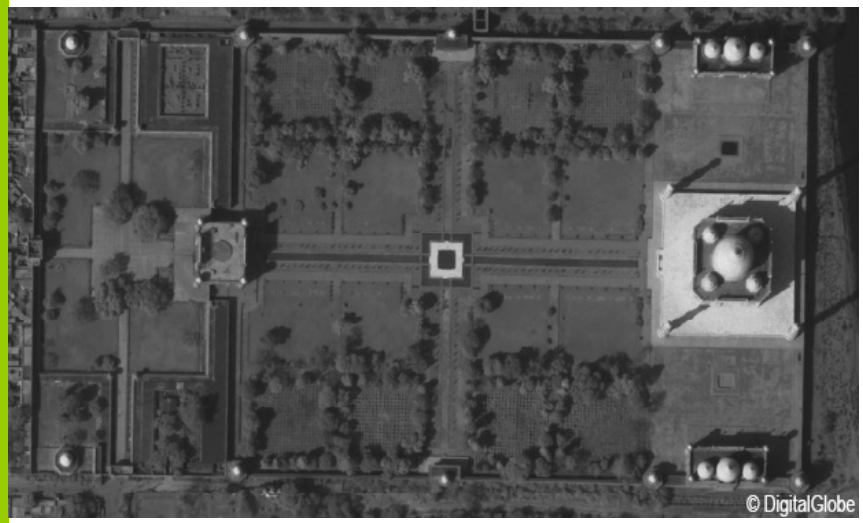
QuickBird collects an industry-leading 16.5-kilometer (10.3-mile) swath of imagery that enables greater collection of large areas.

A summary of the multi-spectral band information is given below.

	Band Width	Spatial Resolution
Band 1	0.45 - 0.52µm (blue)	2.44 - 2.88 meters
Band 2	0.52 - 0.60µm (green)	2.44 - 2.88 meters
Band 3	0.63 - 0.69µm (red)	2.44 - 2.88 meters
Band 4	0.76 - 0.90µm (near infra-red)	2.44 - 2.88 meters

This image is a 61-centimeter natural color pan-sharpened image of Singapore, collected by QuickBird on February 26, 2002. The focal point of this image is a subset of the Singapore Changi Airport.

This featured image is a 61-centimeter panchromatic image of the Taj Mahal of India, collected by QuickBird on February 15,2002



Earth Observing-1 (EO-1) satellite

The NASA Earth Observing-1 (EO-1) satellite was launched on November 21, 2000 as part of a one-year technology validation/demonstration mission. The original EO-1 mission was successfully completed in November 2001.

The EO-1 Extended Mission is chartered to collect and distribute Advanced Land Imager (ALI) multispectral and Hyperion hyperspectral products

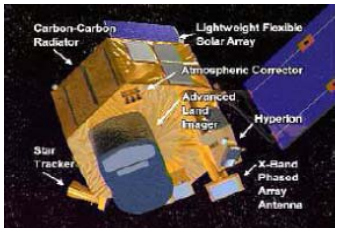
Advanced Land Imager (ALI)

The instrument operates in a pushbroom fashion, with a spatial resolution of 30 meters for the multispectral bands and 10 meters for the panchromatic band. The standard scene width is 37 kilometers. Standard scene length is 42 kilometers, with an optional increased scene length of 185 kilometers.

Earth Observing-1	Wavelength (micrometers)	Resolution (m)
Band 1	0.48-0.69	10
Band 2	0.433-0.453	30
Band 3	0.45-0.515	30
Band 4	0.525-0.605	30
Band 5	0.63-0.69	30
Band 6	0.775-0.805	30
Band 7	0.845-0.89	30
Band 8	1.2-1.3	30
Band 9	1.55-1.75	30
Band 10	2.08-2.35	30

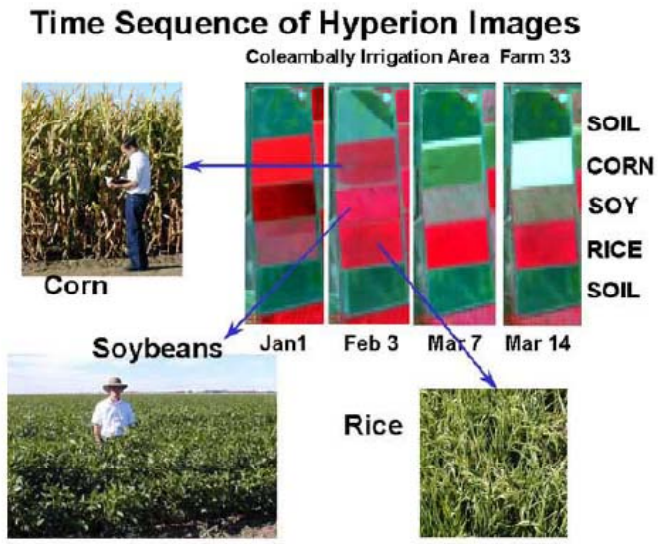
Earth Observing-1 (EO-1) satellite

Hyperion



Hyperion collects 220 unique spectral channels ranging from 0.357 to 2.576 micrometers with a 10-nm bandwidth. The instrument operates in a pushbroom fashion, with a spatial resolution of 30 meters for all bands. The standard scene width is 7.7 kilometers. Standard scene length is 42 kilometers, with an optional increased scene length of 185 kilometers.

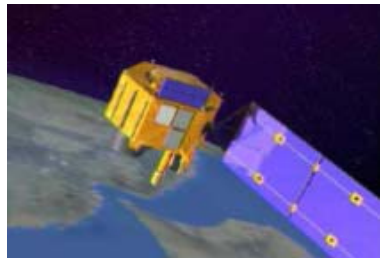
Hyperion: Agricultural application



ALI

Hyperion

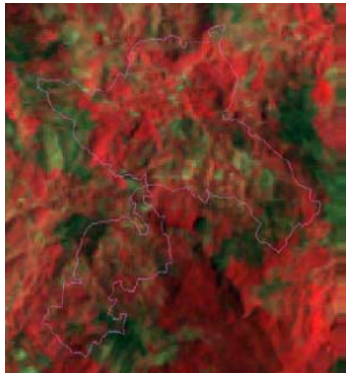
Earth Observing-1 (EO-1) satellite



For product description, prices, and order: visit the website

http://edc.usgs.gov/products/satellite/eo1.html#description

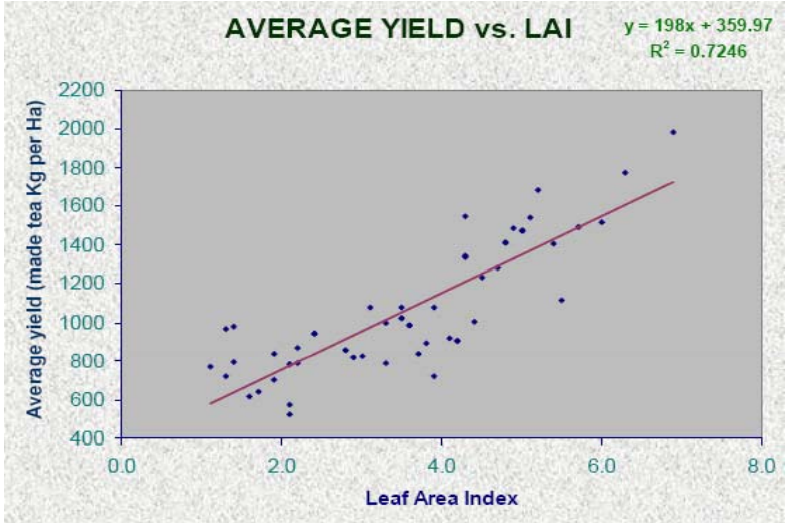
Remote Sensing and GIS for Estimating Tea Yield in Sri Lanka



Landsat-TM (06, March 1995)

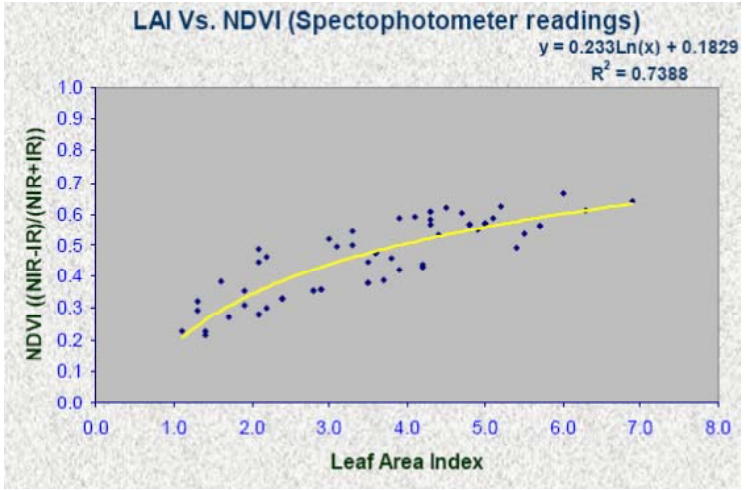
Results : Model Developments

•Correlation between LAI and Average annual Tea yield

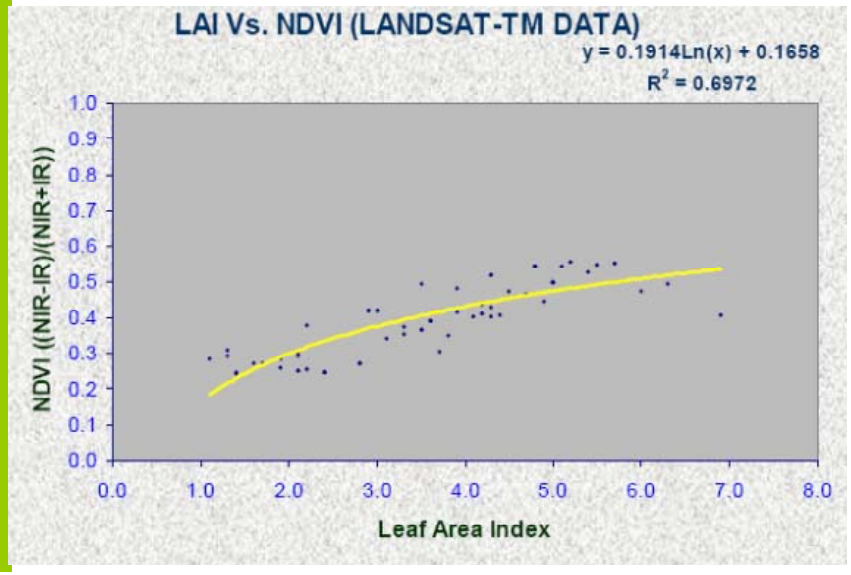


Results : Model Developments

•Develop a model to find the correlation between LAI and NDVI derived from spectrophotometer readings



Correlation between LAI and NDVI derived from LANDSAT-TM images



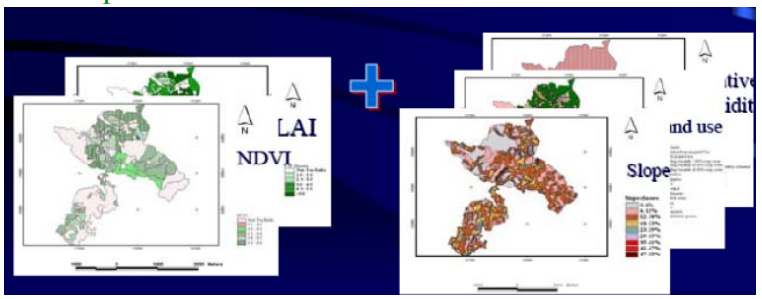
Model for estimating yield using LAI, topographic and meteorological variables

Considered parameters :

Yield, satellite image derived LAI,topographic and meteorological variables

Method :

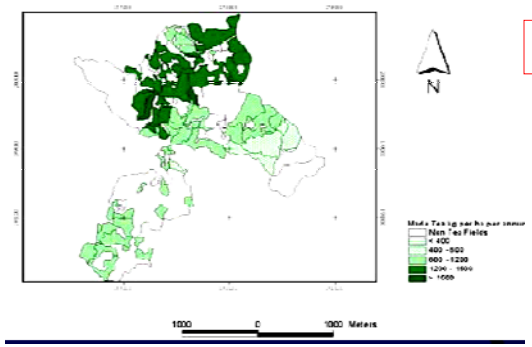
- assigning weights for each parameter
- the relationship between average yield and weight of each parameter



Tea yield Model

Yield = -603.923 +50.124wd – 23.5wr – 14.049wl + 65.845wi + 513.54wa +39.54wh + 65.695wf + 46.338we

Where;
wd = Soil depth weight; wr = Rockiness cover weight; wl = Landuse type weight
wi = LAI weight; wa = Age of tea plantation weight; wh = Relative humidity weight
wf = Rainfall weight; we = Elevation weight

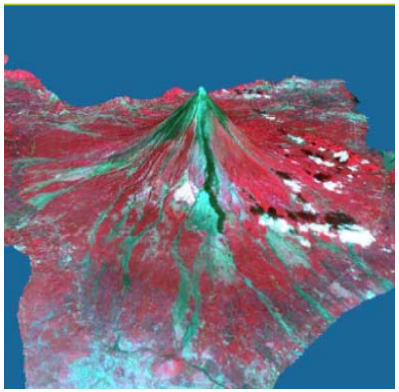


Accuracy = 95%

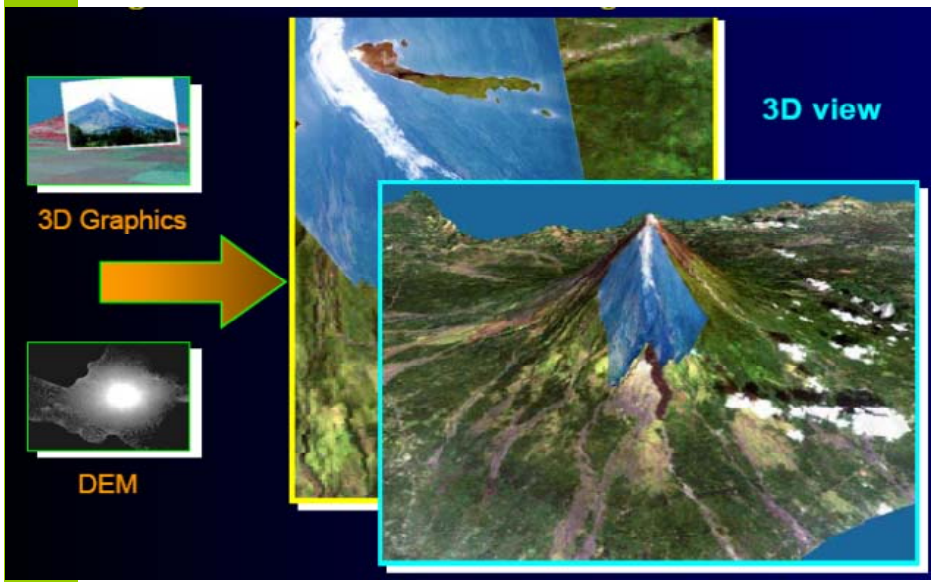
Predicted average yield map for year 2000 for Westhall estate: 2000 – 1084 kg made tea ha-1

Mt. Mayon Volcano Comprehensive Disaster Prevention Master Plan

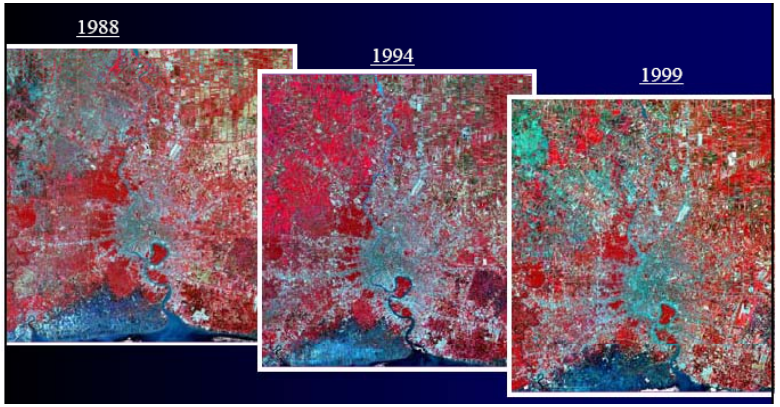
- GIS Data Development for Planner
- Historical River planform Change by lava, pyroclastic flow,lahar
- Sediment Production Estimation for river structure planning



Orthophoto from Ground Digital Camera Image
1st Image – 2min, 2nd and later image 3sec.



Bangkok Urban Area Expansion 1988 - 1999



78

Urban extent from 1988 to 1999 using classified Landsat TM

79

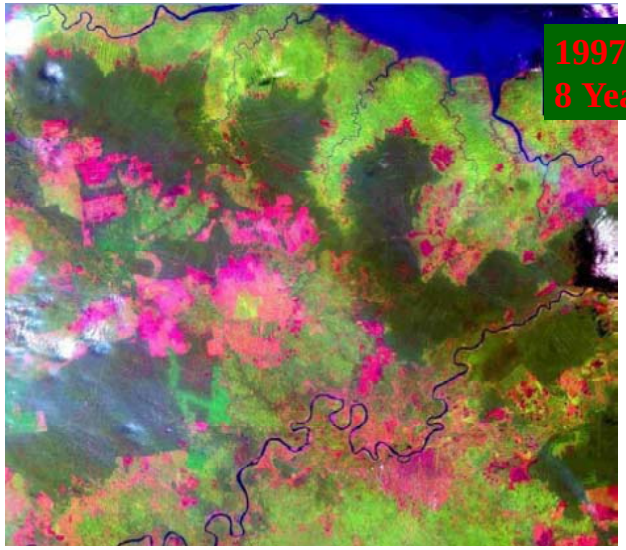
Historical TM image for the TREES test site 125/61 on Sumatra

The TM image from 9 June 89 is located in the Jambi province of Sumatra. The false colour composite (R /G/ B = 5/4/3 - sw-infrared / near infrared / red) displays forest cover and oil palm plantations in dark green.

http://www.gvm.sai.jrc.it/Forest/asia/rs_sources.htm

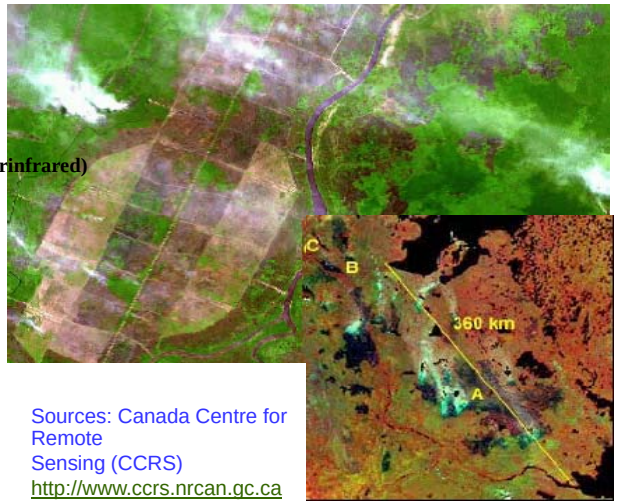
80

Recent TM image for the TREES test site 125/61 on Sumatra
The TM image from 18 August 97 shows new oil palm plantation areas, partly established by replacing old plantations, partly by conversion of forests.



Forest Fire Management and Assessment

•Remote sensing can be used to detect and monitor forest fires and the regrowth following a fire.
• Thermal data is best for detecting and mapping ongoing fires and remaining "hot-spots"
• Multispectral (optical and nearinfrared) data are preferred for observing stages of growth and phenology in a previous burnt area.
• Moderate spatial coverage, high to moderate resolution, and a low turnaround time are required for burn mapping.
• On the other hand, fire detection and monitoring requires a large spatial coverage, moderate resolution and a very quick turnaround to facilitate response.



Sources: Canada Centre for Remote Sensing (CCRS)
http://www.ccrs.nrcan.gc.ca

During the period of 4-16 July 2000, many fires were detected in Sumatra and Kalimantan of Indonesia.

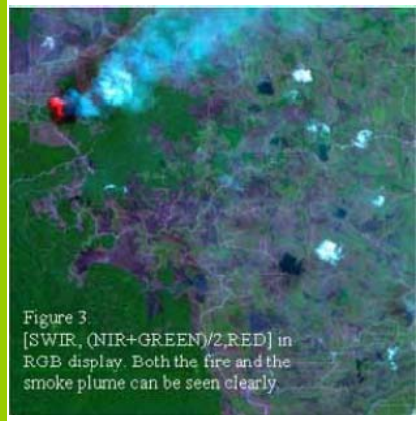


Figure 3
[SWIR, (NIR+GREEN)/2,RED] in RGB display. Both the fire and the smoke plume can be seen clearly.

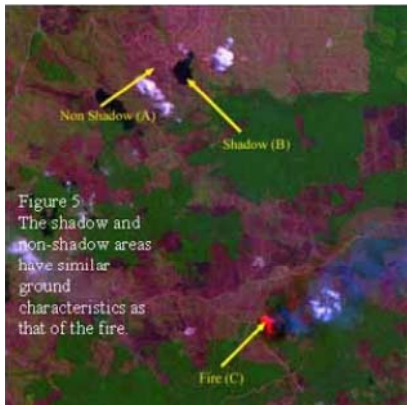
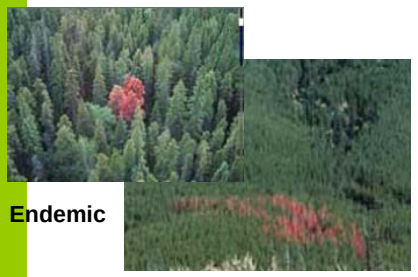


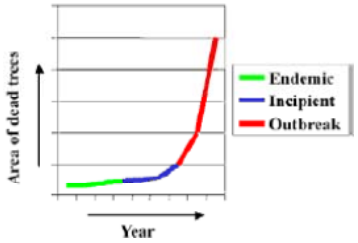
Figure 5
The shadow and non-shadow areas have similar ground characteristics as that of the fire.

Mountain Pine Beetle
Pacific Forestry Centre



Endemic

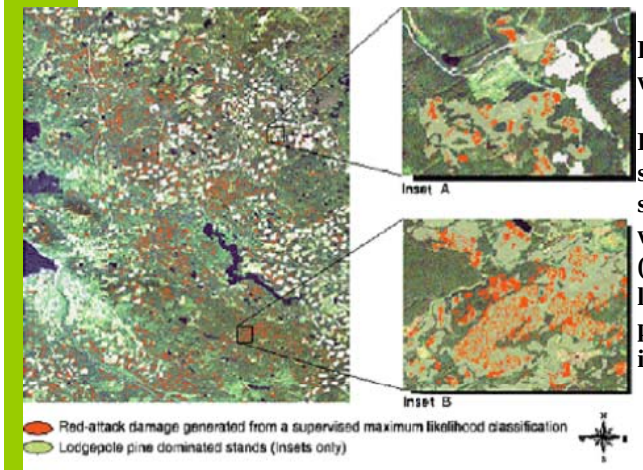
Incipient



Mountain Pine Beetle Redattack Forest Damage British Columbia, Canada

Outbreak

Mountain Pine Beetle Red-attack Forest Damage Classification Using Stratified Landsat TM Data in British Columbia, Canada



Red-attack damage class within stand polygons.

Polygons with several small patches represent stands in which beetles were relatively abundant (Inset A). Some relatively large homogeneous patches indicate high infestation areas (Inset B)

http://www.pfc.forestry.ca/entomology/mpb/detection/remote/background_e.html

Deforestation

Clearcutting in parts of the world has become a major problem and is the subject of much environmental concern, because of habitat destruction and biochemical threats to the atmosphere.

- **Multitemporal data provides for change detection analyses**
- **Images of earlier years are compared to recent scenes, to tangibly measure the differences in the sizes and extents**
- **As for many multi-temporal applications, a higher resolution image can be used to define the baseline, and coarser resolution images can be used to monitor changes to that baseline.**

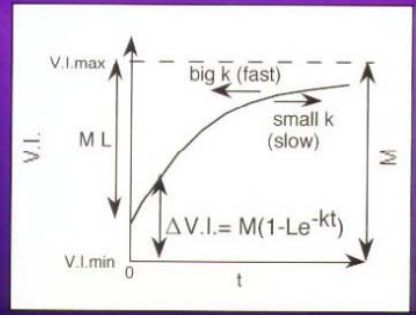
IKONOS image of the Copper Mountain area of the Colorado Rockies.

Degraded Forest in Asio Copper Mine Landsat-5 TM May 21, 1987

Growth Curve

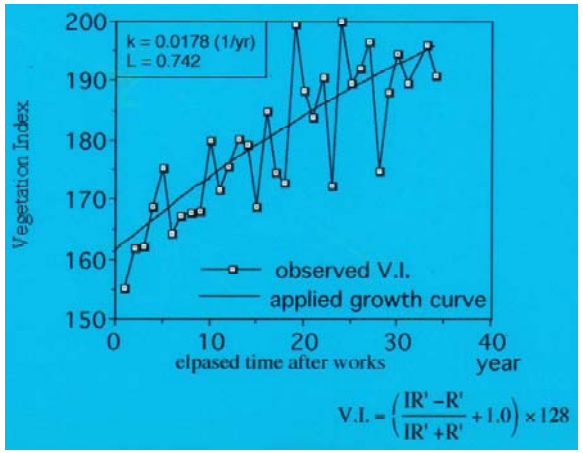
$$V.I. = V.I.min + M\,(1 - L\,e^{-kt})$$

M : V.I. fluctuation range
L : initial fall ratio of V.I.
k : restoration speed



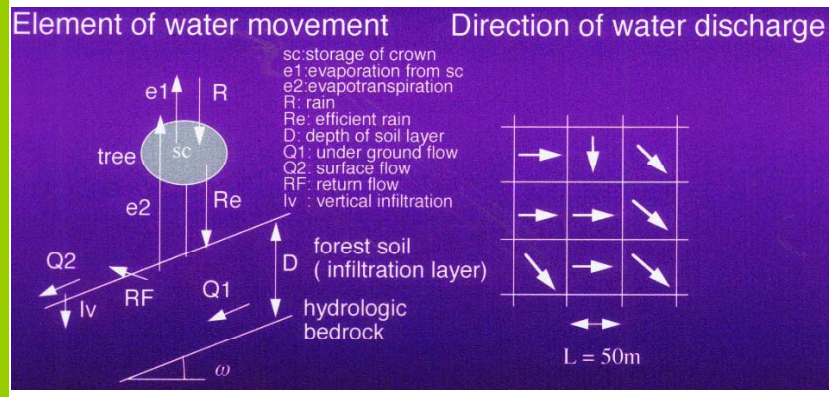
Mitsherlich's Growth Curve

Restoration Process



Restoration Process in the Work Area

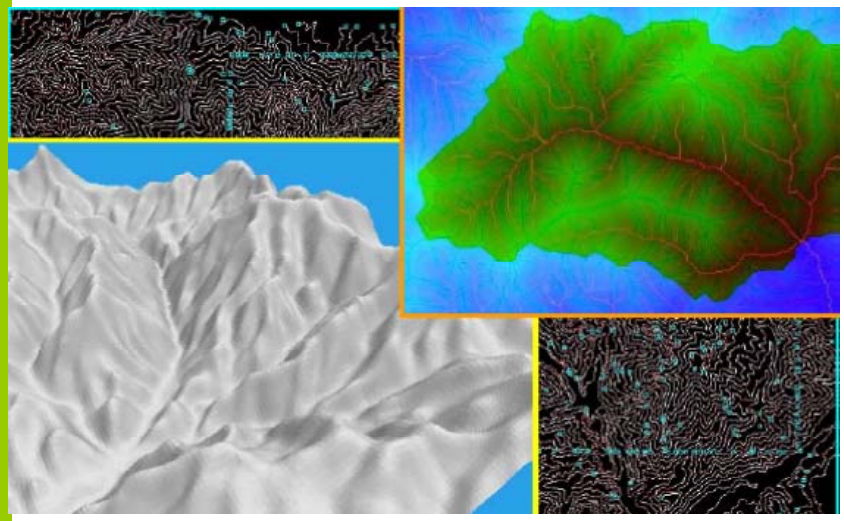
Water and Sediment Discharge Model



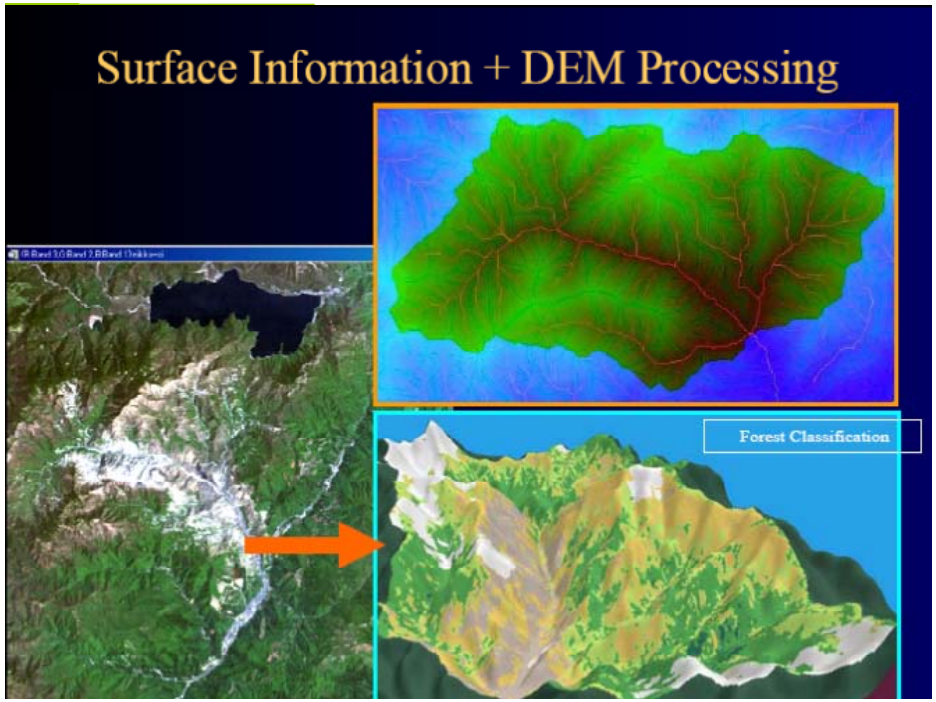
Water Discharge Model

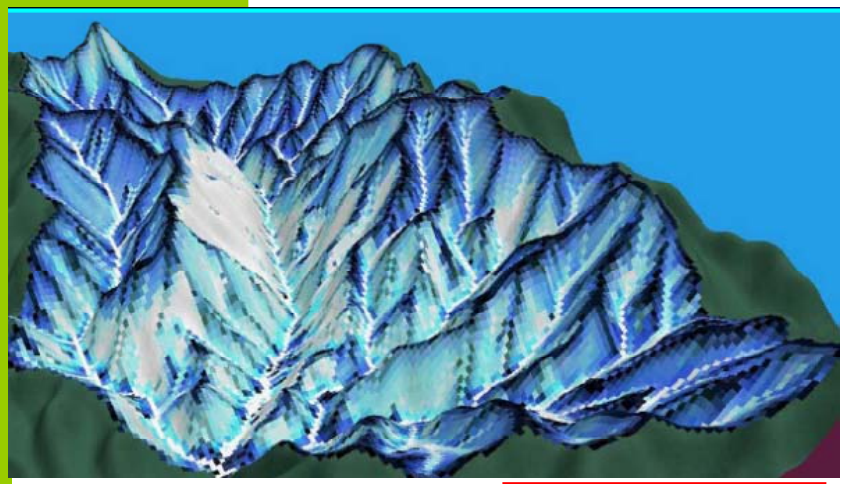
Contour Lines

Watershed



Digital Elevation Model





Ground Water

Saturation	
Red	12 hr
Green	18 hr
Blue	24 hr