

# PLATFORMS & SENSORS

Platform: the vehicle carrying the remote sensing device

Sensor: the remote sensing device recording wavelengths of energy

e.g. Aerial photography - the plane and the camera

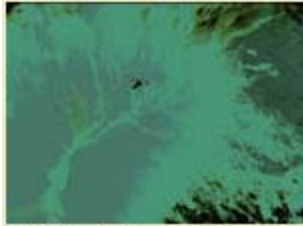
## **Satellite image example:**

Platform: Landsat (1, 5, 7 etc..)

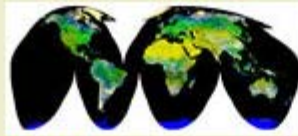
Sensor: Multispectral Sensor (MSS) or Thematic Mapper (TM)

# Selected satellite remote sensing systems

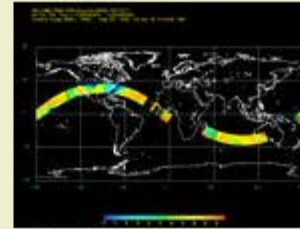
NASA Visible Earth: [long list](#)



**ASTER** (Advanced Spaceborne Thermal Emission and Reflection Radiometer)



**AVHRR** (Advanced Very High Resolution Radiometer)



**CERES** (Clouds and the Earth's Radiant Energy System)



**DMSP/OLS** (Defense Meteorological Satellite Program/Operational Linescan System)



**ETM+** (Enhanced Thematic Mapper Plus)



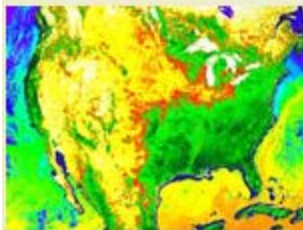
**IKONOS**



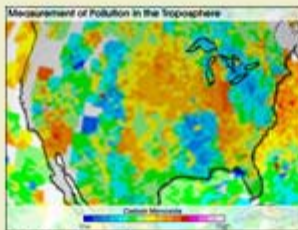
**IRS** (Indian Remote Sensing Satellite)



**MISR** (Multi-Angle Imaging Spectroradiometer)



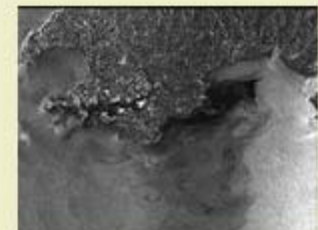
**MODIS** (Moderate-Resolution Imaging Spectroradiometer)



**MOPITT** (Measurements of Pollution in the Troposphere)



**QuickBird**



**SAR** (Synthetic Aperture Radar)

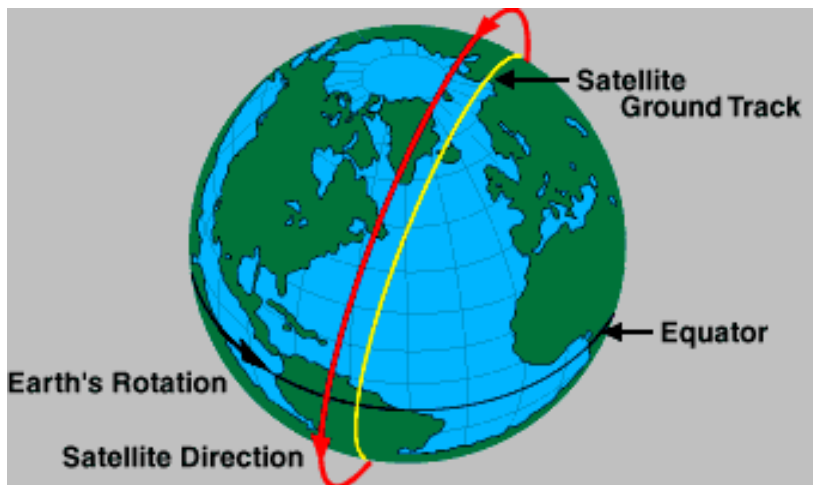
Wim Bakker's website <http://members.home.nl/wim.h.bakker>



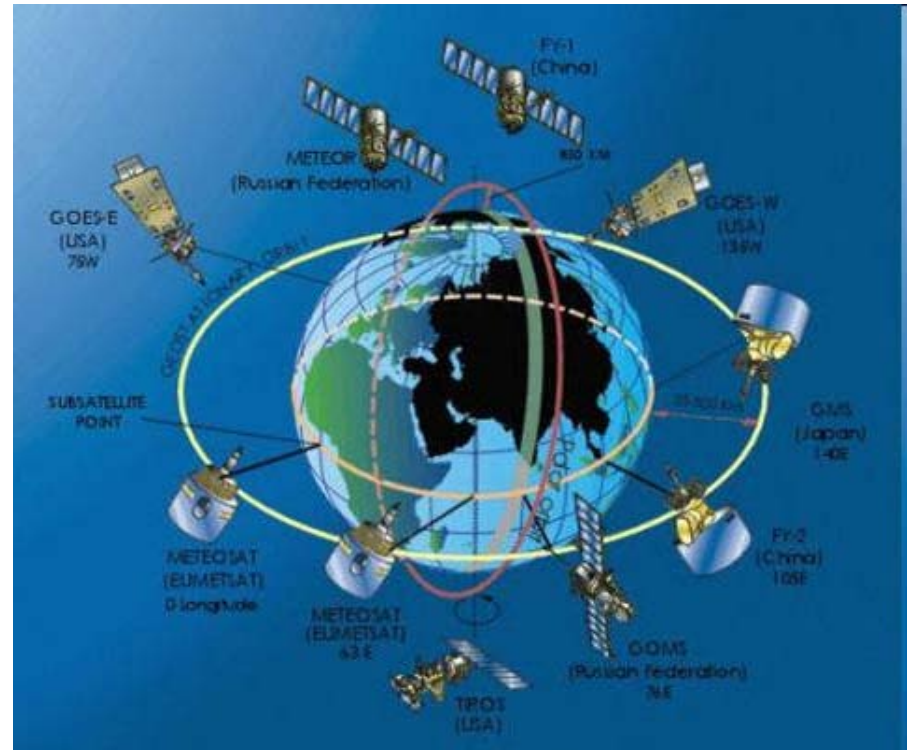
<http://earthobservatory.nasa.gov/IOTD/view.php?id=52174>



# 1. Satellite orbits



"Sun-synchronous"  
Land monitoring  
~ 700 km altitude

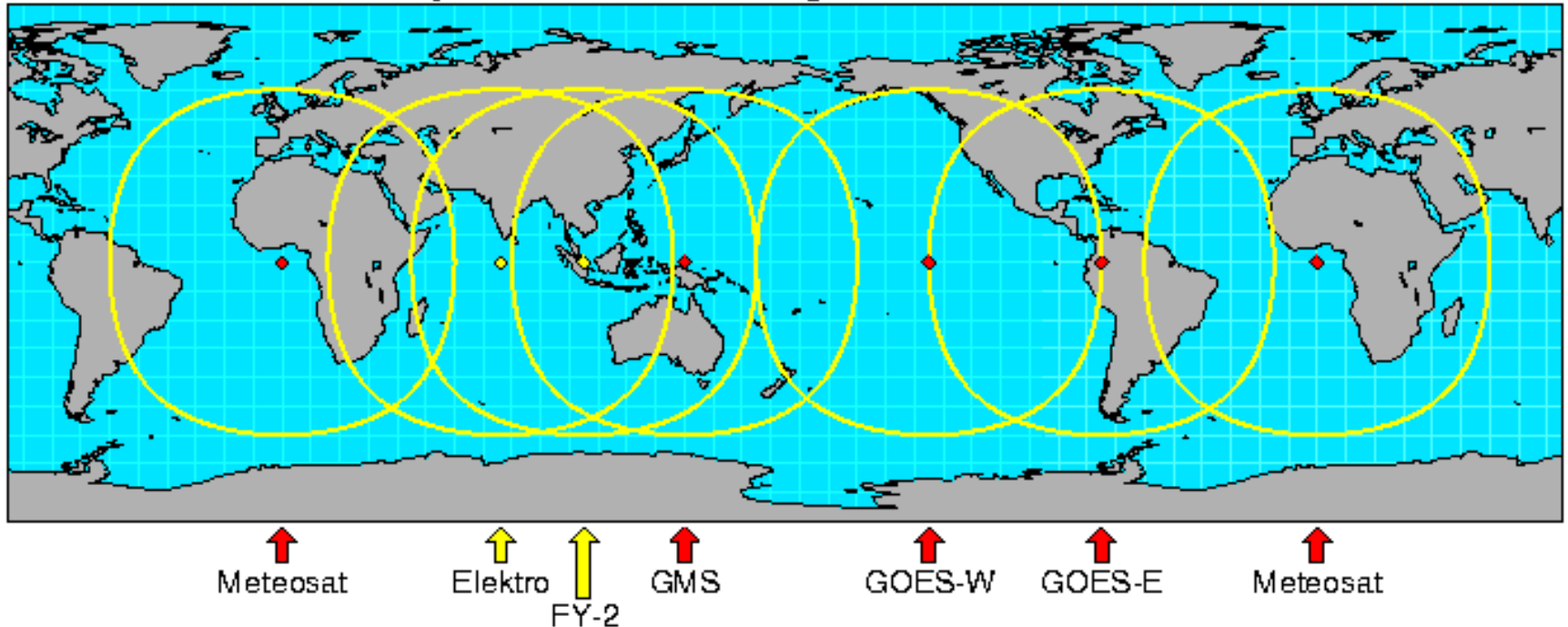


"Geostationary"  
Weather satellites  
~ 30,000 km altitude

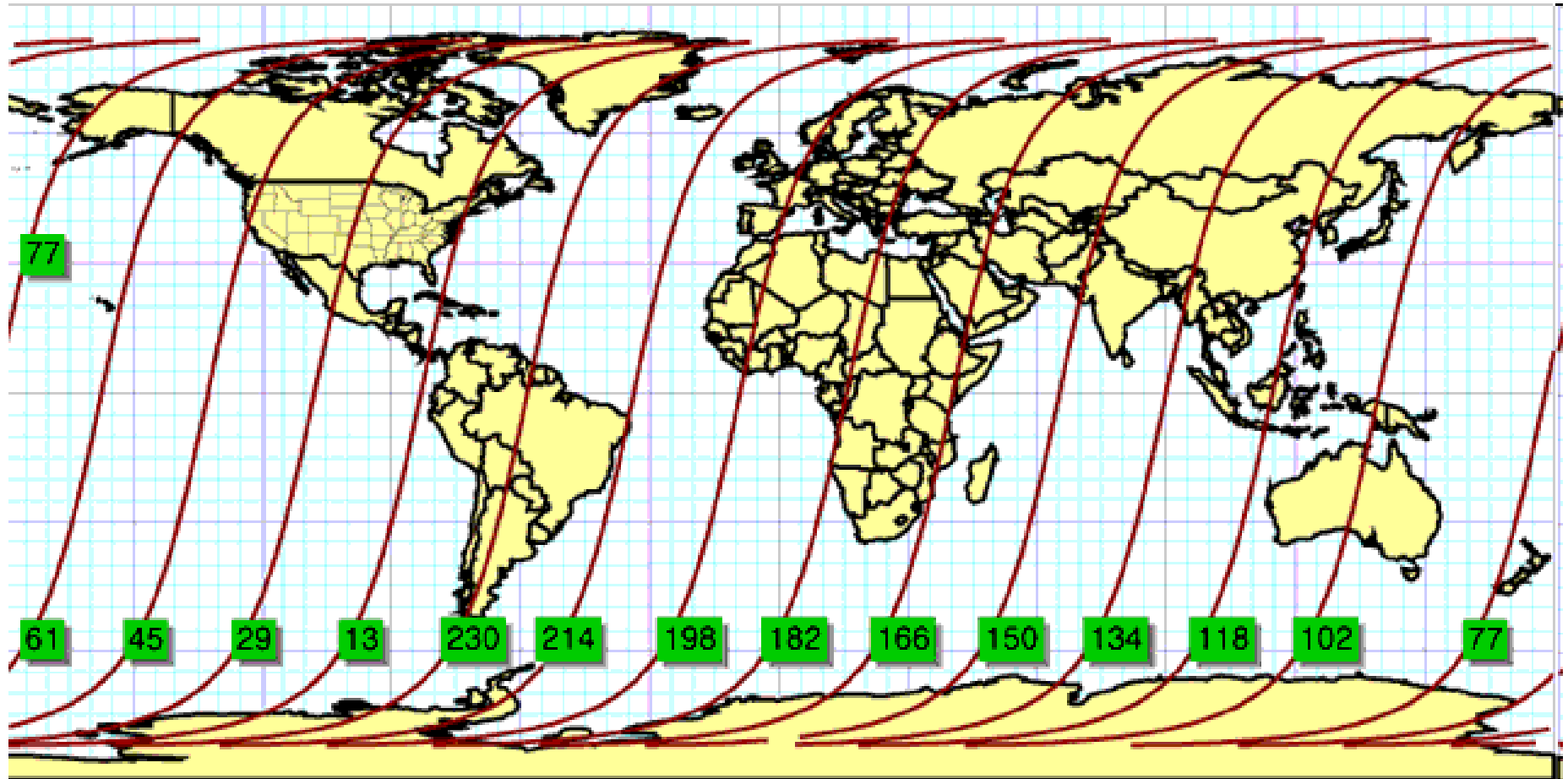
# Satellite orbits

**Geostationary / geosynchronous** : 36,000 km above the equator, stays vertically above the same spot, rotates with earth - weather images, e.g. GOES (Geostat. Operational Env. Satellite)

Global Geostationary Satellite Coverage



**Sun-synchronous satellites:** 700-900 km altitude, rotates at circa 81-82 degree angle to equator: captures imagery approx the same time each day (10am +/- 30 minutes) -



Landsat path: [earthnow](#)



# Sun-synchronous

Graphic: [http://ccrs.nrcan.gc.ca/resource/tutor/datarecept/c1p2\\_e.php](http://ccrs.nrcan.gc.ca/resource/tutor/datarecept/c1p2_e.php)

700-900 km altitude

rotates at  $\sim 81-82^\circ$  angle to the equator (near polar):

captures imagery the same time each day

(10.30am +/- 30 minutes) - for earth mapping

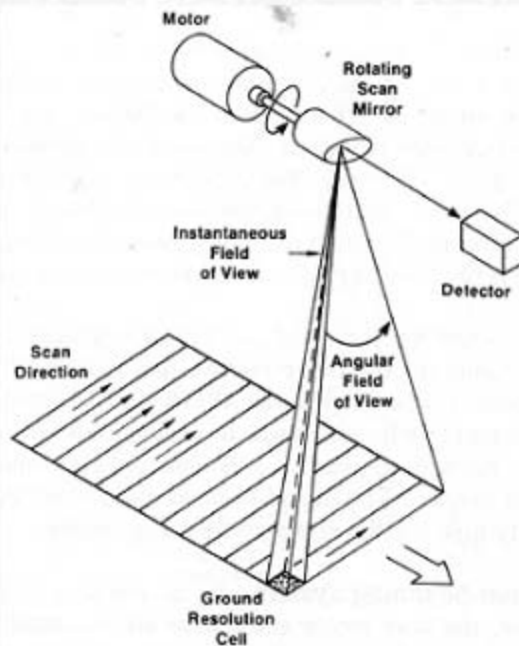
Orbit every 90-100 minutes produces similar daytime lighting

Geostationary satellites capture a (rectangular) scene,  
sun-synchronous satellites capture a continuous swath,  
... which is broken into rectangular scenes.

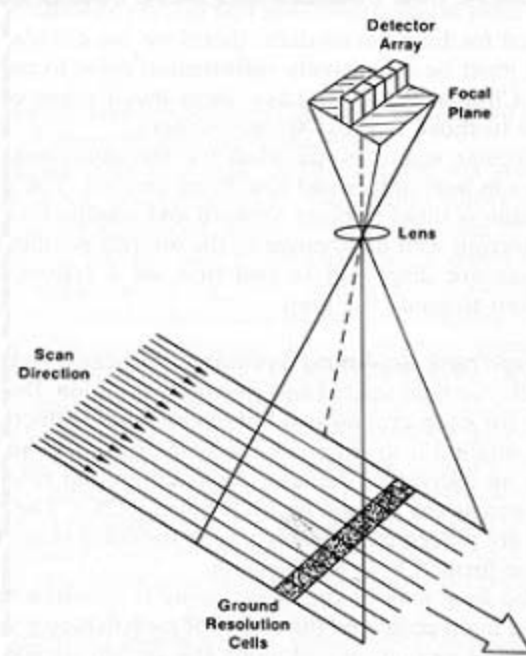
## 2. Scanner types

**Whiskbroom (mirror/ cross-track):** a small number of sensitive diodes for each band sweep perpendicular to the path or swath, centred directly under the platform, i.e. at 'nadir' e.g. LANDSAT MSS /TM

**Pushbroom (along-track):** an array of diodes (one for each column of pixels) is 'pointed' in a selected direction, nadir or off-nadir, on request, usually 0-30 degrees (max.), e.g. SPOT HRV



A. CROSS-TRACK SCANNER.



C. ALONG-TRACK SCANNER.



# 3. Sensor groups

Multi-spectral sensors record bands in multiple wavelengths:

Visible

Near IR

Mid IR

Thermal

Microwave

And at different spatial resolutions:

Low

Medium

High

Very high

Many satellites carry multiple sensors with different resolutions

Some sensors have more than one resolution

## 4. Low resolution

**Weather: GOES** (24 HOURS per day)

GOES 8: 75W longitude, GOES 9: 135W longitude

VNIR/TIR (5 bands), Visible: 1km,

Thermal: 4km, 10-bit data

<http://www.goes.noaa.gov>

# NOAA AVHRR (Advanced Very High Resolution Radiometer)

1.1km Red / NIR / TIR

1978-present (16 satellites to 2000)- global vegetation monitoring:  
data are freely downloadable

two run concurrently, one passing over in a.m., one in p.m.

2500 x 2500 pixels, 10 bit data

AVHRR/3 Channel Characteristics			
Channel Number	Resolution at Nadir	Wavelength (um)	Typical Use
1	1.09 km	0.58 - 0.68	Daytime cloud and surface mapping
2	1.09 km	0.725 - 1.00	Land-water boundaries
3A	1.09 km	1.58 - 1.64	Snow and ice detection
3B	1.09 km	3.55 - 3.93	Night cloud mapping, sea surface temperature
4	1.09 km	10.30 - 11.30	Night cloud mapping, sea surface temperature
5	1.09 km	11.50 - 12.50	Sea surface temperature

## 5. MEDIUM RESOLUTION (100m-500m)

**MODIS (MODerate resolution Imaging Spectroradiometer)**

Descending 10.30am on Terra, Ascending 1.30pm on Aqua

Red / NIR: 250metres (2 bands)

Blue/Green/NIR/MIR: 500 metres (4 bands)

VNIR/MIR/TIR: 1000 metres (29 bands)

Swath width: 2330km

<http://modis.gsfc.nasa.gov>

[MODIS Circumpolar mosaic](#) (and other images)



## 6. HIGH RESOLUTION 5-80m

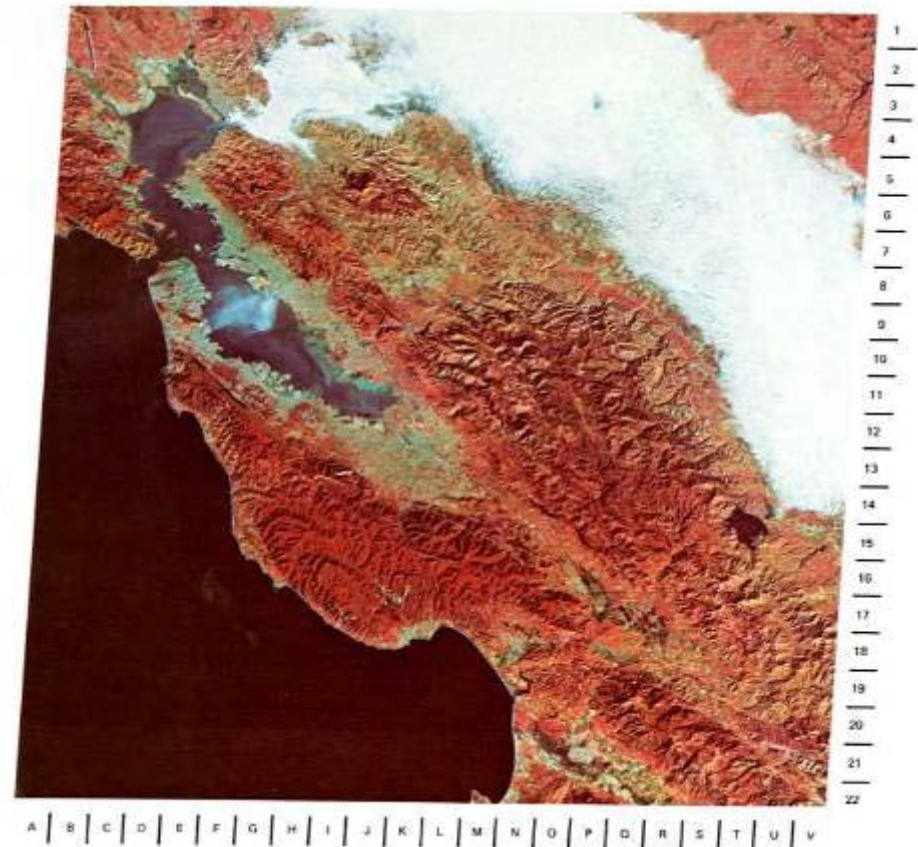
LANDSAT (U.S.) initially known as ERTS

1972 Landsat 1 Multi-Spectral Scanner (MSS: 80m)

1975 Landsat 2 until 1982

1978 Landsat 3 until 1983

Band	Spectral band	Resolution
4	0,5 - 0,6 $\mu\text{m}$	79 m x 82
5	0,6 - 0,7 $\mu\text{m}$	79 m x 82
6	0,7 - 0,8 $\mu\text{m}$	79 m x 82
7	0,8 - 1,1 $\mu\text{m}$	79 m x 82



# HIGH RESOLUTION

**LANDSAT (U.S.)** - the next generation

1982 Landsat 4 Thematic Mapper (TM: 30m) until 1987

1984 Landsat 5 TM ... still operational

*1993 Landsat 6 Enhanced TM: (ETM+) failed shortly after launch*

1999 Landsat 7 ETM+ ... malfunctioned April 2003

2005 Landsat imagery (ETM-2000) was used for Google Earth mosaic

*Overlap for Landsat sensors is 14% at equator, 45% at 50 degrees*

# Landsat TM bands

Band No.	Wavelength Interval ( $\mu\text{m}$ )	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

Landsat TM: [http://rst.gsfc.nasa.gov/Intro/Part2\\_20.html](http://rst.gsfc.nasa.gov/Intro/Part2_20.html)

**ETM+** (Landsat 7): add PAN 0.52-0.9 (Green->IR) band 15m, Thermal is 60m

# SPOT (France) High Resolution Visible (HRV) bands

SPOT 1-3: 1986, 1990, 1993

<b>Mode</b>	<b>Band</b>	<b>Spectral band</b>	<b>Resolution</b>
XS-multispectral	XS1	0,50 - 0,59 $\mu\text{m}$	20m x 20m
	XS2	0,61 - 0,68 $\mu\text{m}$	20m x 20m
	XS3	0,79 - 0,89 $\mu\text{m}$	20m x 20m
P-panchromatique	PAN	0,51 - 0,73 $\mu\text{m}$	10m x 10m

SPOT 4-5: 1998, 2002

<b>Mode</b>	<b>Band</b>	<b>Spectral band</b>	<b>Resolution</b>
Multispectral	B1	0,50 - 0,59 $\mu\text{m}$	20m x 20m
	B2	0,61 - 0,68 $\mu\text{m}$	20m x 20m
	B3	0,79 - 0,89 $\mu\text{m}$	20m x 20m
	MIR	1,58 - 1,75 $\mu\text{m}$	20m x 20m
M - monospectral	PAN	0,61 - 0,68 $\mu\text{m}$	10m x 10m

<http://eoedu.belspo.be/>



# SPOT (France)

Systeme Probatoire d'Observation de la Terre

1 - 5: 1986 - 2002

programmable, pushbroom -60km wide

Can be viewed on 7 different passes (at equator) to 11 at 45 degrees, hence may be revisited twice a week

SPOT 4: mid-IR added (1.53-1.75  $\mu$ m), also a 1km 'vegetation sensor'

PAN changes to .61-.68, but switched back for SPOT5 to match SPOT1-3

SPOT 5: PAN 2.5 or 5m, 10m multispectral (G / R / Near IR / mid IR)

<http://www.spot.com>

[\*SPOT receiving station at U. Lethbridge \(2005\)\*](#)

SPOT imagery (2005-2010) downloadable from [geobase.ca](http://geobase.ca)

## Summary table: Landsat TM versus SPOT HRV (1980s)

	<b>LANDSAT TM</b>	<b>SPOT HRV</b>
Launch	1982 / 1984	1986
Altitude	705 km	832 km
Attitude (polar)	8.2 degrees	8.7 degrees
Equatorial time	9.45 am	10.30 am
Swath width	185km	60km
Repeat coverage	16 days	26 days
Sensor	Thematic Mapper (TM)	High Resolution Visible (HRV)
Number of detectors	100	6000/3000
Advantages	#bands, swath size	higher resolution, #'looks'
Bands	7	1 + 3
Scanner type	Mirror (Whisk broom)	Pushbroom

# IRS (Indian Remote Sensing)

IRS 1B, 1C, 1D, 1E, 1F, 1G, 1H, 1I, 1J, 1K, 1L, 1M, 1N, 1O, 1P, 1Q, 1R, 1S, 1T, 1U, 1V, 1W, 1X, 1Y, 1Z ... Resourcesat / Cartosat 2011 (17)

LISS (Linear Imaging Self Scanner), 5.8m resolution in PAN

MS in Visible / Near-IR at 23.5m and shortwave IR (SWIR) at 70m;

also Wide Field Sensor (WiFS) Red/NIR, 190m

[wikipedia IRS](#) [IRS history](#)

# ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer)

on board Terra satellite (along with MODIS), 2000

Band 1-3 (15m): G/R/NIR

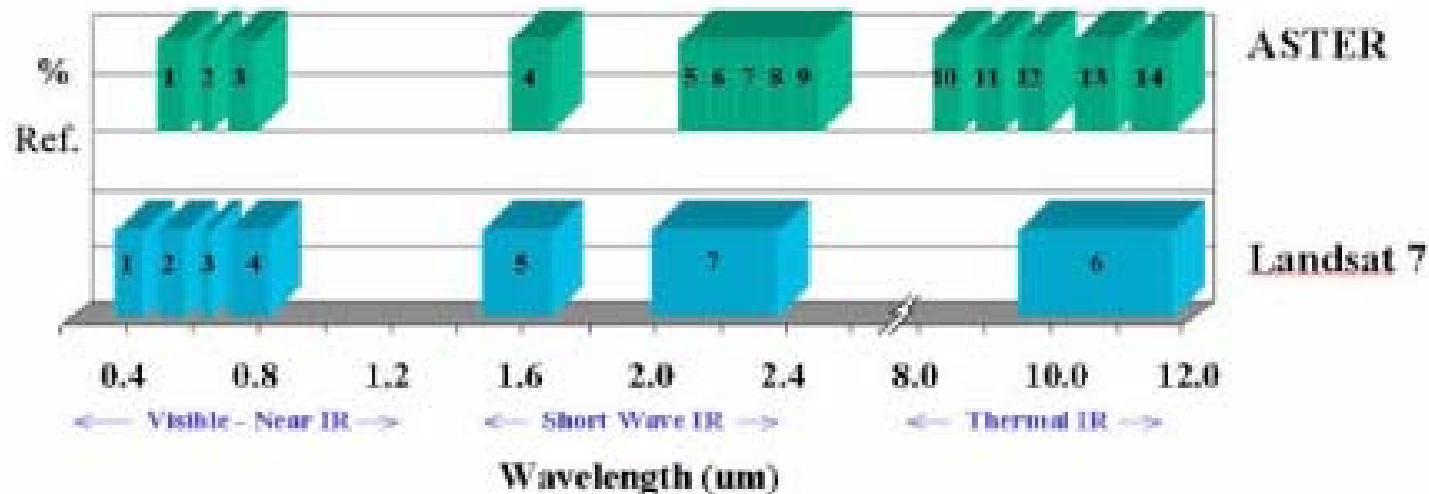
Bands 4-9 (30m) SWIR

Bands 10-14 (60m) TIR

swath width: 60km, associated DEM from backward looking band 3b

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

## ASTER bands compared to Landsat TM





## ASTER Bands

<u>Band</u>	<u>Label</u>	<u>Wavelength</u>	<u>Resolution</u>
B1	VNIR_Band1	0.52 - 0.60	15m
B2	VNIR_Band2	0.63 - 0.69	15m
B3	VNIR_Band3N	0.76 - 0.86	15m - Nadir view
B4	VNIR_Band3B	0.76 - 0.86	15m - Backward scan (used to create high resolution DEM)
B5	SWIR_Band4	1.60 - 1.70	30m
B6	SWIR_Band5	2.145 - 2.185	30m
B7	SWIR_Band6	2.185 - 2.225	30m
B8	SWIR_Band7	2.235 - 2.285	30m
B9	SWIR_Band8	2.295 - 2.365	30m
B10	SWIR_Band9	2.36 - 2.43	30m
B11	TIR_Band10	8.125 - 8.475	90m
B12	TIR_Band11	8.475 - 8.825	90m
B13	TIR_Band12	8.925 - 9.275	90m
B14	TIR_Band13	10.25 - 10.95	90m
B15	TIR_Band14	10.95 - 11.65	90m

ASTER: USA / Japan

# Advanced Land Imager (ALI)

"Landsat like"

onboard EO-1 satellite  
37km swath  
10 bands

Band	Wavelength( $\mu\text{m}$ )	Ground Sample Distance(m)
Pan	0.48 - 0.69	10
MS - 1'	0.433 - 0.453	30
MS - 1	0.45 - 0.515	30
MS - 2	0.525 - 0.605	30
MS - 3	0.63 - 0.69	30
MS - 4	0.775 - 0.805	30
MS - 4'	0.845 - 0.89	30
MS - 5'	1.2 - 1.3	30
MS - 5	1.55 - 1.75	30
MS - 7	2.08 - 2.35	30

<http://earthobservatory.nasa.gov/IOTD/view.php?id=40169>

<http://edcsns17.cr.usgs.gov/eo1/sensors/ali>

<http://glovis.usgs.gov> data download

Glaciers Flow into a Greenland Valley

Posted September 13, 2009



acquired August 29, 2009



download large image (3 MB, JPEG)

acquired August 29, 2009

## 7. Very high resolution 0.5- 5m (Corporate)

### 1. Ikonos (1999) (pushbroom)

11-bit data, 11km swath, up to 26° off nadir

Pan 1m (0.45-0.9) MS 4m (B/G/R/NIR)

Ikonos imagery of [UNBC and PG](#) (2002)

### 2. Quickbird 2001 (pushbroom)

11 bit data, 16.5 km swath, 460km altitude

Pan 61cm (2 feet) (0.445-0.90) MS 2.44m (8 feet) (B/G/R/NIR)

<http://www.digitalglobe.com> [image gallery](#)

### 3. EROS 2001 1.8 metres pan (ISRAEL) [EROS](#)

### 4. Worldview: 2007 0.5m pixels, 11 bit data [Worldview](#)

### 5. Geoeye: 2008 0.25m

<http://www.geoeye.com/CorpSite/gallery>

[GeoEye-1 on Google Earth](#)



## 7. Very high resolution 0.5- 5m (Corporate)

**Ikonos** (1999) Pan 1m MS 4m (B/G/R/NIR)

**Quickbird** (2001) Pan 61cm (2 feet) MS 2.44m (8 feet)

Pushbroom, 11-bit data, 11 / 16.5 km swath, 460km altitude, up to 26° off nadir

several others launched since .. e.g. *Geoeye* (Google, 2008)



Inauguration of Barack Obama as US President - Jan 20 2009 (*Geoeye*)