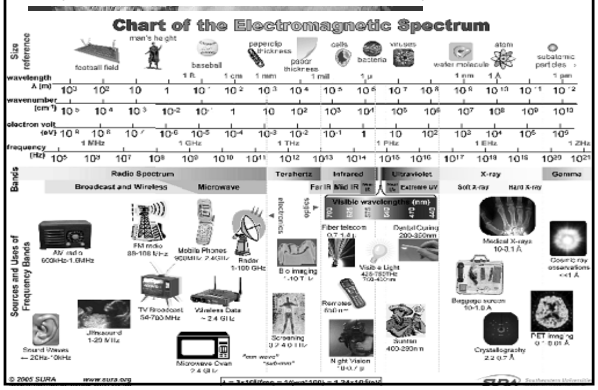
Remote Sensing- Continued (8b)

Satellites and their images

Satellite Sensors

Satellite	Sensor
NOAA	AVHRR
LANDSAT	MSS
LANDSAT	TM
SPOT	HRV(multispectral)
SPOT	HRV(panchromatic)
NIMBUS-7	CZCS
GOES	VISSR
TERRA	ASTER
TERRA	CERES
TERRA	MISR
TERRA	MODIS
TERRA	MOPITT

Different remote sensing instruments record different segments, or <u>bands</u>, of the electromagnetic spectrum.



Best bands per Category

Item	Category	Best Bands	Salient Characteristics
a.	Clear Water	7	Black tone in black and white and color.
b.	Silty Water	4,7	Dark in 7; bluish in color.
c.	Nonforested Coastal Wetlands	7	Dark gray tone between black water and light gray land; blocky pinks, reds, blues, blacks.
d.	Deciduous Forests	5,7	Very dark tone in 5, light in 7; dark red.
e.	Coniferous Forest	5,7	Mottled medium to dark gray in 7, very dark in 5; brownish-red and subdued tone in color,
f.	Defoliated Forest	5,7	Lighter tone in 5, darker in 7 and grayish to brownish-red in color, relative to normal vegetation.
g.	Mixed Forest	4,7	Combination of blotchy gray tones; mottled pinks, reds, and brownish-red.
h.	Grasslands (in growth)	5,7	Light tone in black and white; pinkish-red.
i.	Croplands and Pasture	5,7	Medium gray in 5, light in 7, pinkish to moderate red in color depending on growth stage.
j.	Moist Ground	7	Irregular darker gray tones (broad);darker colors.
k.	Soils-bare Rock-Fallow Fields	4,5,7	Depends on surface composition and extent of vegetative cover. If barren or exposed, may be brighter in 4 and 5 than in 7. Red soils and red rock in shades of yellow; gray soil and rock dark bluish; rock outcrops associated with large land forms and structure.
l.	Faults and Fractures	5,7	Linear (straight to curved), often discontinuous; interrupts topography; sometimes vegetated.
m.	Sand and Beaches	4,5	Bright in all bands; white, bluish, to light buff.
n.	Stripped Land-Pits and Quarries	4,5	Similar to beaches – usually not near large water bodies; often mottled, depending on reclamation.
o.	Urban Areas: Commercial Industrial	5,7	Usually light toned in 5, dark in 7, mottled bluish-gray with whitish and reddish specks.
p.	Urban Areas: Residential	5,7	Mottled gray, with street patterns visible; pinkish to reddish.
q.	Transportation	5,7	Linear patterns, dirt and concrete roads light, in 5; asphalt dark in 7.

Electro-Optical Scanners

- LANDSAT – Earth Resources Technology Satellite (ERTS)
- SPOT - Systeme Pour l'Observation de la Terre
- CZCS - Coastal Zone Color Scanner
- NOAA - Advanced Very High Resolution Radiometer (AVHRR)
- GOES - Geostationary Operational Env Satellites

LANDSAT Bands

Table 3.1 Wavelength Bands Used in Landsats 1 to 5. (Adapted From Lillesand and Kiefer 1987.)

Sensor	Missions	Band	Wavelengths in μm	Resolution 1-3	Resolution 4,5
MSS	1 to 5	4	0.5–0.6 (green)	79	82
		5	0.6–0.7 (red)	79	82
		6	0.7–0.8 (near-IR)	79	82
		7	0.8–1.1 (near-IR)	79	82
	3*	8	10.4–12.6 (thermal IR)	240	
TM	4,5	1	0.45–0.52 (blue)	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	10.4–12.5 (thermal IR)	120	
		7	2.08–2.35 (mid-IR)	30	

* Failed Shortly After Launch

LANDSAT 1,2&3

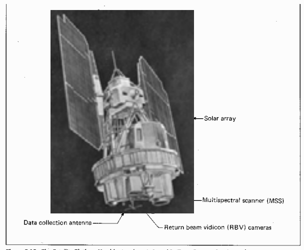


Figure 3.13 The Satellite Platform Used for Landsats 1, 2, and 3. (From Remote Sensing and Image Interpretation by Lillesand and Kiefer 1987, published by John Wiley and Sons.)

Multispectral Scanner System (MSS) instrument

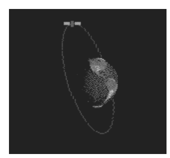
LANDSAT 4 & 5

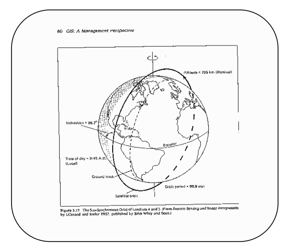
- Multispectral Scanner System (MSS)
- Thematic Mapper (TM).

LANDSAT 7

- Launch Date: April 15, 1999
- Status: operational despite Scan Line Corrector (SLC) failure May 31, 2003
- Sensors:ETM+
- Altitude: 705 km
- Inclination: 98.2°
- Orbit: polar, sun-synchronous
- Equatorial Crossing Time: nominally 10 AM (± 15 min.) local time (descending node)
- Period of Revolution : 99 minutes; ~14.5 orbits/day
- Repeat Coverage : 16 days

Sun-synchronous Orbit





- This orbit is a special case of the polar orbit. Like a polar orbit, the satellite travels from the north to the south poles as the Earth turns below it.
- In a sun-synchronous orbit, though, the satellite passes over the same part of the Earth at roughly the same local time each day.

Sun-synchronous Orbits

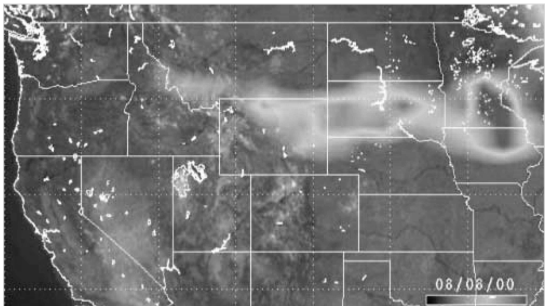
- Orbit that passes over the earth at the same local sun time.
- Return period every 18 days for LANDSAT 1,2&3 at 900km orbit.
- Return period every 16 days for LANDSAT 4&5 at 700km orbit.
- Return period every 16 days for LANDSAT 7 at 705km orbit.

Space Satellites that help Firefighters Monitor Raging Wildfires

- NASA's Total Ozone Mapping Spectrometer (TOMS).
- Sea-viewing Wide Field-of-view Sensor (SeaWiFS).
- National Oceanographic and Atmospheric Administration's (NOAA) Geostationary Operational Environmental Satellite 8 (GOES 8).
- Terra - MODIS, and MOPITT.

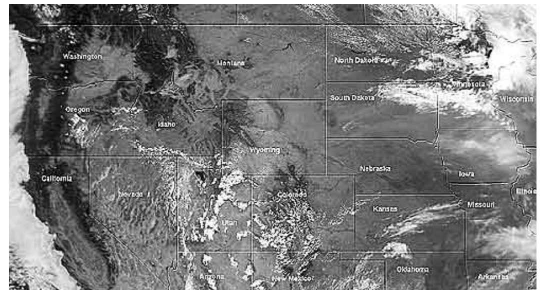
TOMS

distribution of smoke over the west and mid-west U.S.

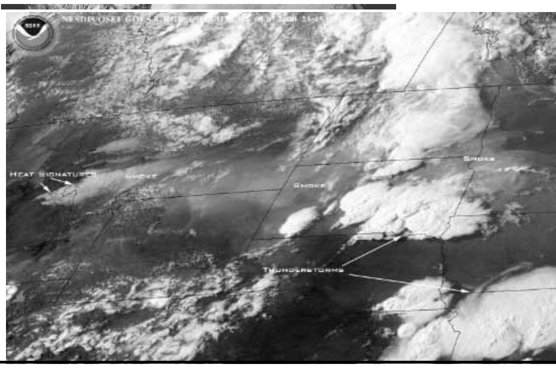


SeaWiFS

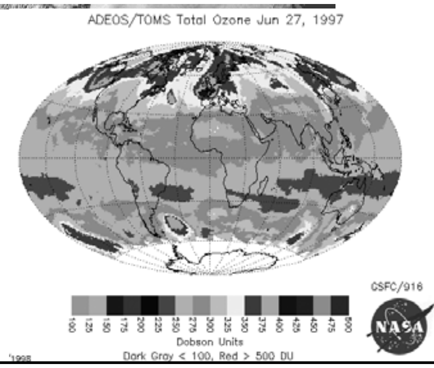
August 8, 2000. Smoke is seen as dark gray wisps; clouds are white and puffy.



A blanket of smoke (yellow) from the large fires burning in Idaho and western Montana extends across Montana and the Dakotas of western Minnesota.



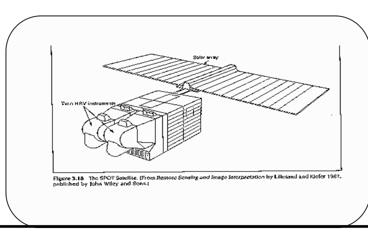
TOMS Measuring Ozone…



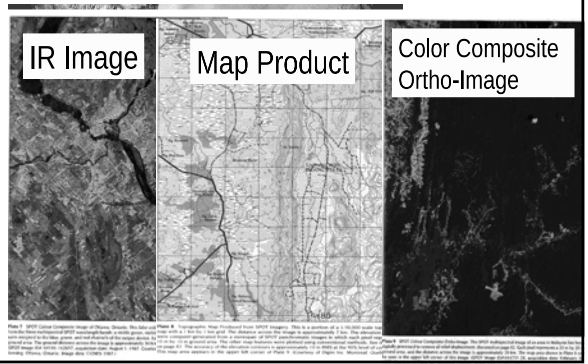
SPOT Satellite

Satellite Pour l'Observation de la Terre

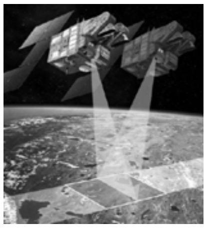
- high-resolution, optical imaging Earth observation satellite system.
- SPOT 5 launched May 4, 2002 with 2.5 m, 5 m and 10 m capability.



SPOT

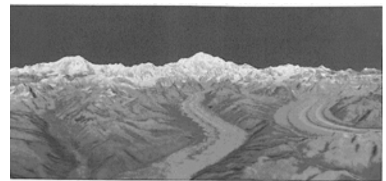


SPOT Stereoscopic Imaging



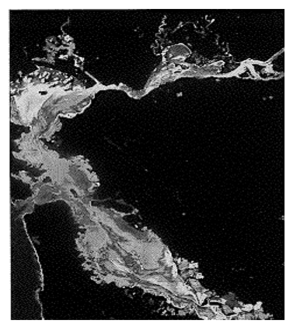
The stereo pairs are acquired in panchromatic (black and white) mode with a spatial resolution of 10 metres (along-track sampling of 5 metres) and a telescope viewing angle of ± 20°.

SPOT Stereoscopic Product



Thermal Infrared Imagery

Satellite Based Thermal channel (AVHRR)



NOAA –

Advanced Very High Resolution Radiometer (AVHRR)

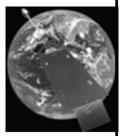
Table 3.3 Wavelength Bands Used in the AVHRR Sensor.

Channel	NOAA 6, 8, 10 in μm	NOAA 7, 9 in μm
1	0.58–0.68 (red)	0.58–0.68 (red)
2	0.72–1.10 (near-IR)	0.72–1.10 (near-IR)
3	3.55–3.93 (mid-IR)	3.55–3.93 (mid-IR)
4	10.5–11.5 (thermal IR)	10.5–11.5 (thermal IR)
5	(channel 4 repeated)	11.5–12.5 (thermal IR)

AVHRR

GOES

Geo-stationary Operational Environmental Satellite



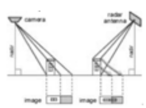
- Weather forecasting
- geo-stationary at 36,000 km

Active Scanners

Microwave - RADAR

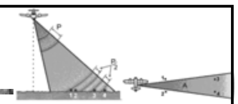
RAdio Detection And Ranging

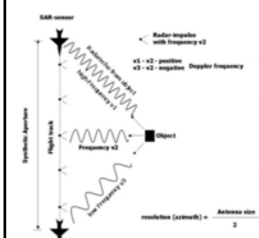
- SLAR - Side Looking Airborne Radar
- SAR - Synthetic Aperture Radar



- Cameras capture reflected visible wavelengths.
- Radar captures emitted microwave wavelengths that are bounced back to the antenna.

Radar





Radar resolution has two components; the "range" resolution and the "azimuth" resolution. These are determined by, among other factors, the width of the synthesized antenna (which is dictated by the pulse interval) and the wavelength.

Microwave Bands

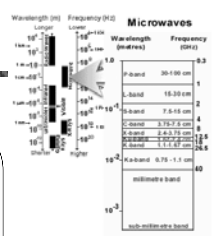
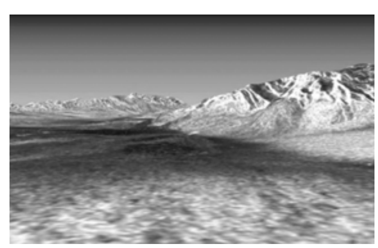


Table 3.4 Wavelength Bands Used in Microwave Remote Sensing.

Band Designation	Wavelength in cm
Ka	0.75 – 1.10
K	1.10 – 1.67
Ku	1.67 – 2.40
X	2.40 – 3.75
C	3.75 – 7.50
S	7.50 – 15.00
L	15.00 – 30.00
P	30.00 – 100.00

Radar – Shuttle Radar Topography Mission (SRTM)



National Elevation Dataset (NED)

Hyperspectral Imaging

- Now coming into its own as a powerful and versatile means for continuous sampling of broad intervals of the spectrum, is hyperspectral imaging.

Interval narrows to 10 nanometers

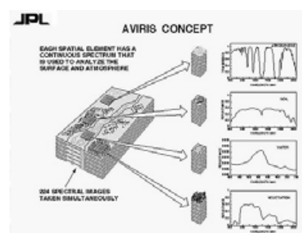
- In hyperspectral data, that interval narrows to 10 nanometers (1 micrometer [μm] contains 1000 nanometers [1 nm = 10-9m]).
- Thus, we can subdivide the interval between 0.38 and 2.55 μm into 217 intervals, each approximately 10 nanometers in width.

Hyperspectral Sensors

- The Jet Propulsion Lab (JPL) has produced two hyperspectral sensors, one known as AIS (Airborne Imaging Spectrometer), first flown in 1982, and the other known as AVIRIS (Airborne Visible/InfraRed Imaging Spectrometer), which continues to operate since 1987.
- AVIRIS consists of four spectrometers with a total of 224 individual CCD detectors (channels), each with a spectral resolution of 10 nanometers and a spatial resolution of 20 meters.

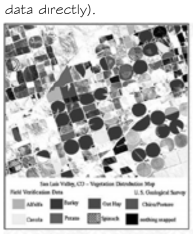
AVIRIS Platform

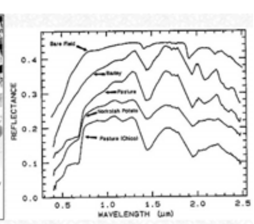
- From a high altitude aircraft platform such as NASA's ER-2 (a modified U-2), a typical swath width is 11 km.



AVIRIS data

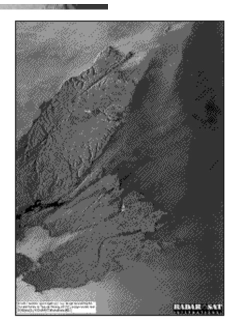
- Below is a hyperspectral image of some circular fields in the San Juan Valley of Colorado.
- The colored fields are identified as to vegetation or crop type as determined from ground data and from the spectral curves plotted beneath the image for the crops indicated (these curves were not obtained with a field spectrometer but from the AVIRIS data directly).





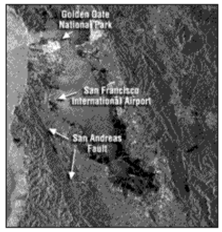
Radar and Thermal Systems

- Canadian Radarsat, ERS-1 and ERS-2 managed by the European Space Agency, and JERS-1 and JERS-2 under the aegis of the National Space Development Agency of Japan, NASDA.
- Image acquired by Radarsat, showing part of Cape Breton in Nova Scotia, and the surrounding waters.

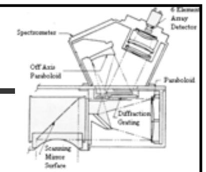


European Space Agency - Radar

- The European Space Agency, ESA, also has flown radar on its ERS-1 and ERS-2 satellites.
- Here is an image in black and white showing the San Francisco metropolitan area and the peninsula to its south, as well as Oakland, California, the East Bay, and beyond.



TIMS
(Thermal IR Multispectral Scanner)



- Thermal data, especially from the 8-14 μm region become more valuable in singling out (classifying) different materials when this spectral interval is subdivided into bands, giving multispectral capability.
- NASA's JPL has developed an airborne multiband instrument called TIMS (Thermal IR Multispectral Scanner) that is a prototype for a system eventually to be placed in space.

courtesy: Dr. J. Garvin

Earth Observing System (EOS) satellite Terra

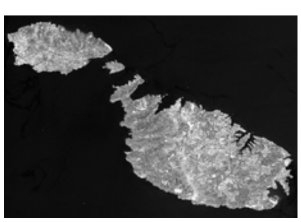
- Physically, the Terra spacecraft is roughly the size of a small school bus.
- It carries a payload of five state-of-the-art sensors that will study the interactions among the Earth's atmosphere, lands, oceans, life, and radiant energy (heat and light).
- Each sensor has unique design features that will enable Earth Observing System (EOS) scientists to meet a wide range of science objectives

TERRA Instruments

ASTER
CERES
MISR
MODIS
MOPITT

ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer)

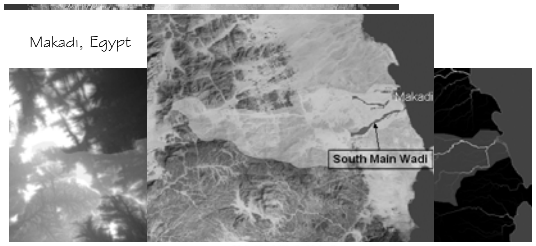
- ASTER consists of three different subsystems; the Visible and Near Infrared (VNIR), the Shortwave Infrared (SWIR), and the Thermal Infrared (TIR). To find out more about each module click on the item of interest.

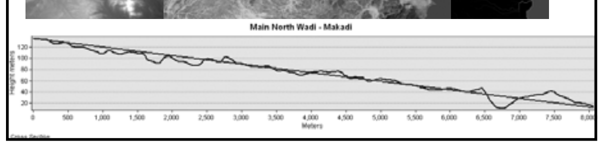


ASTER GDEM

distribution started on June 29, 2009

Makadi, Egypt

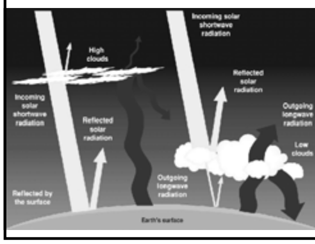


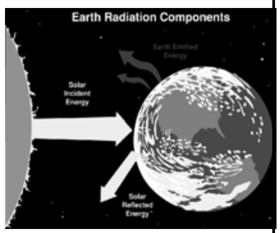


CERES - Clouds and the Earth's Radiant Energy System

- CERES instruments aboard Terra measure the Earth's total radiation budget and provide cloud property estimates that enable scientists to assess clouds' roles in radiative fluxes from the surface to the top of the atmosphere.

animation: http://terra.nasa.gov/About/CERES/ceres_swath.html

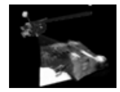




MISR - Multi-angle Imaging Spectro-Radiometer

MISR views the Earth with cameras pointed at nine different angles. One camera points toward nadir, and the others provide forward and aftward view angles, at the Earth's surface, of 26.1° , 45.6° , 60.0° , and 70.5° . As the instrument flies overhead, each region of the Earth's surface is successively imaged by all nine cameras in each of four wavelengths (blue, green, red, and near-infrared).

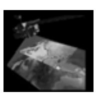
MISR is uniquely capable of observing cloud and aerosol plume structures in the atmosphere three-dimensionally, as well as measuring the relative heights and types of clouds. Its stereoscopic measurement abilities enable MISR to observe the amount of sunlight that is reflected at various angles. MISR will also help scientists trace smoke and aerosol plumes back to their sources.



Animation: http://terra.nasa.gov/About/MISR/misr_sci.html

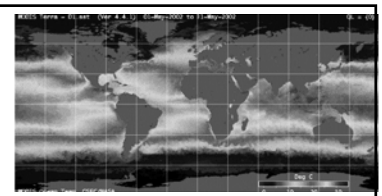
MODIS - Moderate-resolution Imaging Spectroradiometer

- With its sweeping 2,330-km-wide viewing swath, MODIS sees every point on our world every 1-2 days in 36 discrete spectral bands. Consequently, MODIS greatly improves upon the heritage of the NOAA Advanced Very High Resolution Radiometer (AVHRR) and tracks a wider array of the earth's vital signs than any other Terra sensor.
- MODIS sees changes in the Pacific phytoplankton populations that may signal the onset of the famous El Niño/La Niña climatic siblings well ahead of their arrival. In turn, by coupling its sea surface temperature and ocean color measurements,

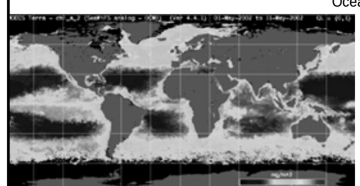


Land cover mapping at global scale

Animation: http://terra.nasa.gov/About/MODIS/modis_sci.html

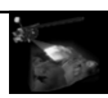


Ocean temperature from MODIS



Ocean color from MODIS

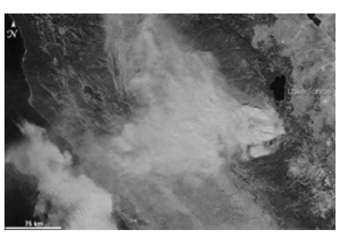
MOPITT - Measurements of Pollution in the Troposphere



- MOPITT is an instrument flying on NASA's EOS Terra spacecraft, measuring the global distributions of carbon monoxide (CO) and methane (CH_4) in the troposphere.

Fires in California

The combined smoke from the Freds and Power Fires in northern California southwest of Lake Tahoe was filling in the northern end of the Sacramento Valley on October 14, 2004. This image was captured by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite in the afternoon, when smoke had become so thick the actively burning areas of the fire that MODIS on the Terra satellite detected during its morning overpass could no longer be picked up.

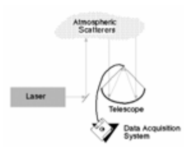


Detecting Clouds and Aerosols from Space

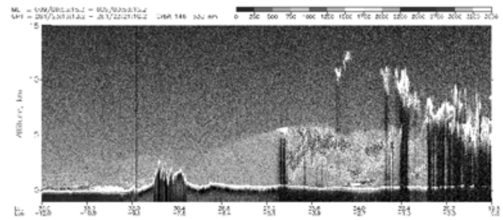
- LITE stands for LIdar Technology Experiment.
- LITE flew on shuttle mission STS-64 in September, 1994.

Lidar - Light Detection And Ranging (laser radar)

- A lidar also transmits and receives electromagnetic radiation, but at a high frequency. Lidars operate in the ultraviolet, visible and infrared region of the electromagnetic spectrum.



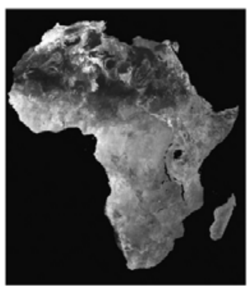
5 minutes of LITE observations over the Sahara on September 18, 1994



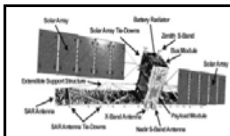
RADARSAT

Africa Mosaic

- This mosaic of Africa consists of approximately 1,600 scenes of Wide 2 images (south of the 10° S parallel) and ScanSAR Wide images (north of the 10° S parallel), which were acquired between 1997 and 2002.

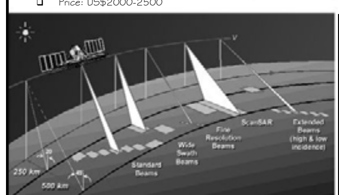


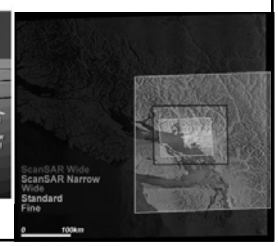
RADARSAT-1



Mode	Nominal Resolution (m)	No. of Positions / Beams	Swath Width (km)	Incidence Angles (degrees)
Fine	8	15	45	37 - 47
Standard	30	7	100	20 - 49
Wide	30	3	150	20 - 45
ScanSAR Narrow	50	2	300	20 - 49
ScanSAR Wide	100	2	500	20 - 49
Extended High	18 - 27	3	75	52 - 58
Extended Low	30	1	170	10 - 22

- Swath: 50 km to 500 km
- Revisit Time: 3 - 5 days
- Spatial Resolution: (10 -100) metres
- Price: US$2000-2500





From: Alan Forghani, C188 lecture 2006 www.radarsat.com

SAR Applications

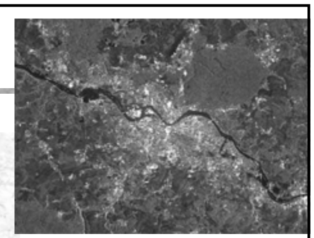
General Application	Advantage
Tropical / coastal studies	Radar penetrates cloud, fog and rain
Coastal / lakes studies	HH polarisation best for land/water discrimination
Discerning man-made features	These features strongly reflect radar energy
Assessment of soil and vegetation moisture content	Amount of SAR backscatter is related to this
Disaster studies (Volcanic eruptions, dust storms or flooding)	Radar penetrates dust and cloud
Remote area studies	Global coverage
Geology	Structural studies; exploration
Land use (including agriculture and forestry)	Mapping and change assessment

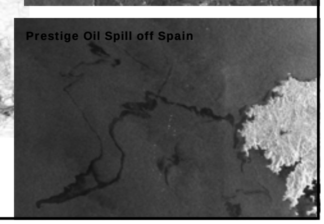
RADAR SAT-2

INNOVATIONS	BENEFITS
3-metre ultra-fine resolution	Highest-resolution commercially available SAR
Fully polarimetric imaging modes	Enhanced capabilities for various applications
Left- and right-looking capability	Faster revisit time 2,000 km accessibility swath Routine Antarctic mapping available
GPS receivers onboard	±60-metre real-time position information
10 ms delay between imaging modes	Faster mode changes
Yaw-steering for zero-doppler shift at beam centre	Facilitates image processing
Star-Trackers onboard	Easier to maintain satellite stability
Higher downlink power density	3-metre minimum size antenna on ground allowing station portability Lower "cost of entry" for new ground stations
Solid-state recorders for onboard image storage	Higher reliability Faster image access Simultaneous recording and downlink

From: Alan Forghani, C188 lecture 2006

Example of Applications





From: Alan Forghani, C188 lecture 2006

Airborne Laser Scanning

From: Aaron Smith, University of Idaho

ALS/LiDAR is an active remote sensing sensor that measures distance with reflected laser light.

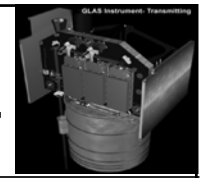
- Two basic families of lidar systems exist: waveform and discrete-return used in for a number of applications.
- 1st developed in 1960 by Hughes Aircraft inc.
- Modern computers and DGPS make it practical.
- Typically used in very accurate mapping of topography.
- New technologies and applications are currently being developed.
- Lidar points are used to create high resolution Digital Elevation Models (DEM)s.

From: Alan Forghani, C188 lecture 2006

LIDAR - GLAS

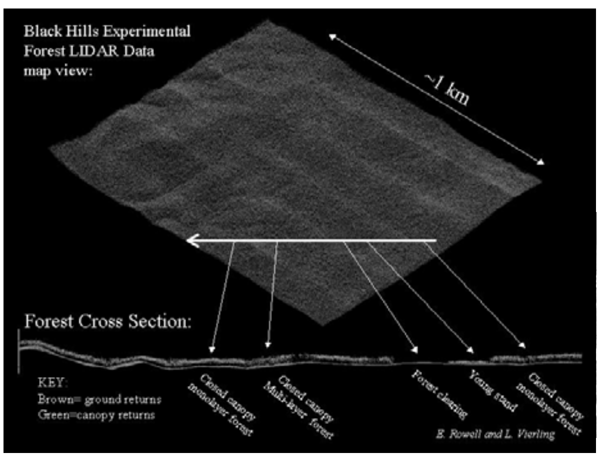
GLAS is Geoscience Laser Altimeter System on IceSAT launched Jan 12, 2003 for measuring

- ice sheet elevations
- changes in elevation through time
- height profiles of clouds and aerosols
- land elevations
- vegetation cover
- approximate sea-ice thickness.

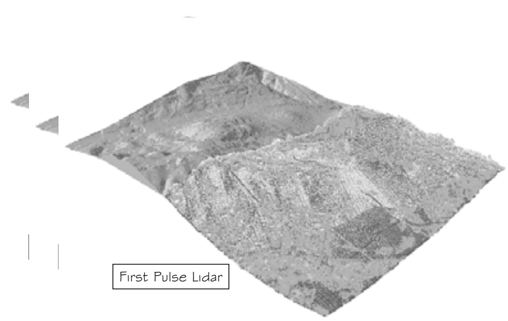


http://icesat.gsfc.nasa.gov/

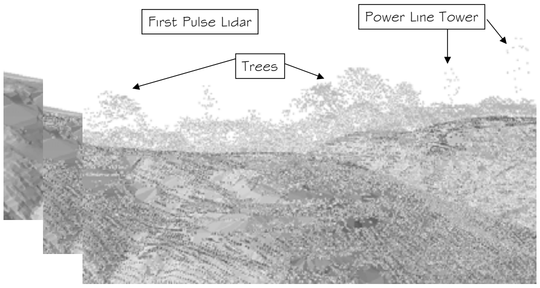
From: Alan Forghani, C188 lecture 2006



Contra Costa County – Lidar (4inch)



Contra Costa County – Lidar (4inch)



Contra Costa County – Remote Sensing

Ortho Photo

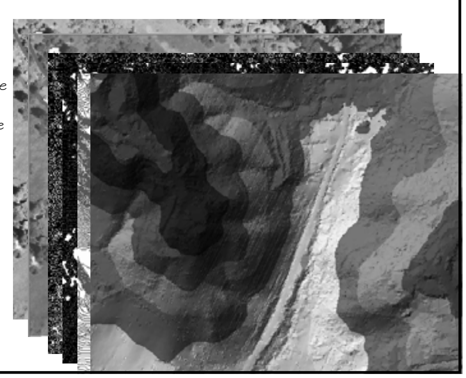
IR Photo

Lidar – First Pulse

Lidar – Last Pulse

Contours

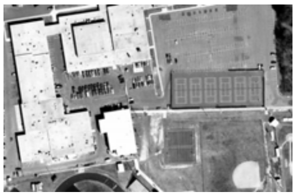
Terrain Model



Popular Contemporary Platforms & Sensors

Quickbird Imaging Satellite (October 18, 2001)

61-centimeter panchromatic image
(click on image for larger version)



2.44-meter multispectral image
Four bands: Blue, Green, Red, and Near-Infrared
(click on image for larger version)

Spatial and Spectral Resolution

Spatial and Spectral Resolution					
	Panchromatic	Multispectral			
Spectral Characteristics	Black & White	Blue	Green	Red	Near IR
	450 to 900-nm	450 to 520-nm	520 to 600-nm	630 to 690-nm	760 to 900-nm
Pixel Resolution[1]	61-cm to 72-cm (2 to 2.4-ft)	2.44 to 2.88-m (8 to 9.4-ft)			
Scene Dimensions	27,552 x 27,424 pixels	6,888 x 6,856 pixels			
Scene Size[2]	272-km^2 (nadir) to 435-km^2 (25° off-nadir) (105 to 168-mi^2)				
	16.5-km^2 (nadir) to 20.8-km^2 (25° off-nadir) 10.3 to 12.9-mi^2)				
Image Accuracy					
Positional Accuracy[3]	CE 90%		RMSE		
	23-meters (75-feet)		14-meters (46-feet)		
Processing					
Radiometric Corrections	Sensor Corrections		Resampling Options		
• Relative radiometric response between detectors • Non-responsive detector fill • Conversion to absolute radiometry	• Internal detector geometry • Optical distortion • Scan distortion • Any line-rate variations • Misregistration of the multispectral bands		• 4x4 cubic convolution • 2x2 bilinear • Nearest neighbor • 8-point sinc • MTF kernel		
Order Parameters					
Product Type	Panchromatic, multispectral or both				
Image Bits/Pixel	8 or 16 bits				
File Formats	TIFF 6.0, GeoTIFF 1.0, NITF 2.1 or NITF 2.0				

IKONOS

Resolution at Nadir (the point on the ground vertically beneath the sensor)
- 0.82 meters panchromatic;
- 3.2 meters multispectral

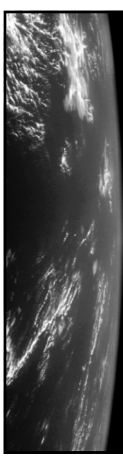
[redacted]

Landsat Continues

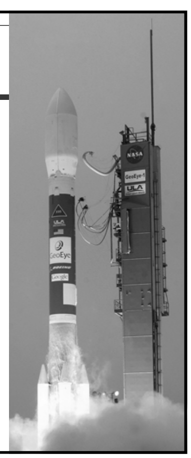
Landsat Data Continuity Mission (LDCM).

- The Landsat Data Continuity Mission (LDCM) is the future of Landsat satellites. It will continue to obtain valuable data and imagery to be used in agriculture, education, business, science, and government.

- The Landsat Program provides repetitive acquisition of high resolution multispectral data of the Earth's surface on a global basis. The data from the Landsat spacecraft constitute the longest record of the Earth's continental surfaces as seen from space. It is a record unmatched in quality, detail, coverage, and value.



New Satellite Sensors

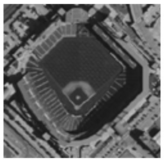


GeoEye-1 (launched 9/6/08)

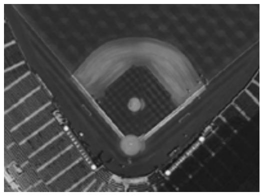
- The world's highest resolution and most-accurate commercial Earth-imaging satellite and is able to collect imagery with a ground resolution of 0.41 meters (about 16 inches) in black and white mode and 1.64 meters in color.
- By combining the multispectral and panchromatic imagery is able to produce color images at an unprecedented .41 meter resolution.
- Due to US Government licensing, commercial customers can only receive color imagery at half-meter resolution.

GeoEye-1 – Coors Field, Denver, Co
(simulated imagery)

1 meter resolution



0.5 meter resolution



NASA Plans Team of Mini-Satellites

- Weighing 44 pounds, and about the size of a solar-panel-clad birthday cake, they will be among the smallest -- and smartest -- satellites ever launched.
- The Constellation Trailblazer mission is preparing the way for this network of 22-pound (10 kilogram) satellites which is being planned for launch in 2010. Those 100 small orbiters will be launched as a single payload, and then deployed like flinging frisbees upon reaching orbit. NASA aims to build these satellites at a cost of $1 million each.

New Non-Satellite platforms

Other platforms and sensors and their images

Unmanned Aerial Vehicles (UAVs)

"Unmanned Aerial Vehicles (UAVs) and Imaging Systems For Real-Time Disaster Data Gathering"

ALTUS II with AIRDAS sensor

Vince Ambrosia

CA. State University – Monterey Bay / NASA-Ames

ALTUS II PLATFORM

ALTUS Specifications:

Wing Span: 55.3 ft.; Length: 23.6 ft.; Height: 9.8 ft.

Weights: Max GTOW: 2150 lb; Payload: 330 lb

Navigation: Litton LN-100G INS/P-Code GPS

Avionics: C-Band Line-Of-Sight RF; adaptable for OTH Operations; Remote Operations or autonomous

Performance:

Max Altitude: 65,000 Feet

Endurance: 8 Hours @ 60K ft.
18 Hours @ 30K ft.
24 Hours @ 25K ft.

Max Speed: 100 KIAS

Cruise / Loiter Speed: 65 KIAS

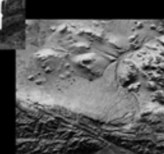
Range: ~1500 Mi. at 25K ft.

FiRE II

- ALTUS II performing in FAA NA
- High Altitude (20-55K ft)
- AIRDAS Payload / 500Kbs Telemetry
- Wildfire Condition
- Real-time scramble and data relay
- Geo-rectify and terrain fit using SRTM

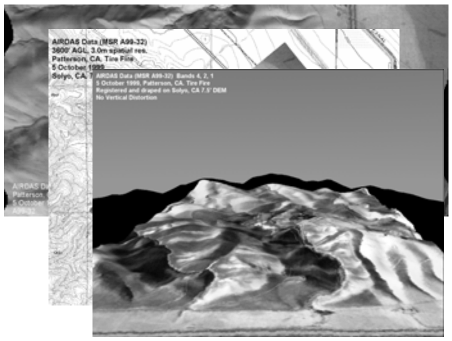
35 Mile Radius

50 Mile Radius



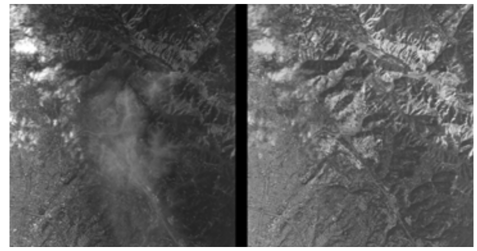
SRTM Data

Terrain Draping of Fire Data



Tactical Fire Imaging

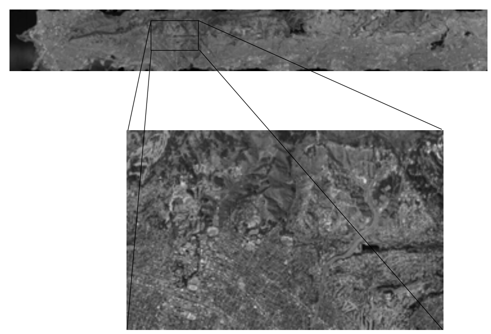
"Tunnel Fire" Oakland Hills



Visible Channel Composite | Thermal / IR Channel Composite

Oakland Hills Fire October 1991

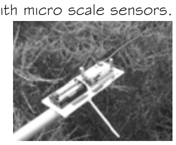
AIRDAS Data Collected Over Berkeley Hills, 15 May 2003



SMART DUST

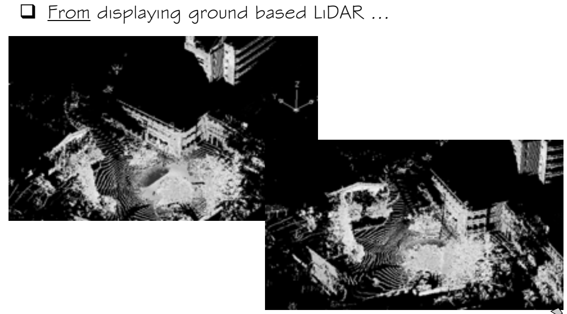
Autonomous sensing and communication in a cubic millimeter

"smart dust motes" = tiny, low-power radios outfitted with micro scale sensors.



The New-New Maps:

- <u>From</u> displaying ground based LiDAR ...



Welcome - SONY PS3 PlayStation

- Cell Broadband Engine Architecture
- PS3 to reach the petaFLOPS mark (thousand trillion floating point operations per second)
- Realistic Real time Rendered Terrain model

Some other Web sites for Remote Sensing

- http://rst.gsfc.nasa.gov/Front/tofc.html
- http://rst.gsfc.nasa.gov/Intro/Part2_6.html