Remote sensing data - Status and Future

Rudi Gens
Alaska Satellite Facility –
Remote Sensing Support Center

Advanced Land Observing Satellite (ALOS)

Courtesy: JAXA

http://www.jaxa.jp/projects/sat/alos/index_e.html

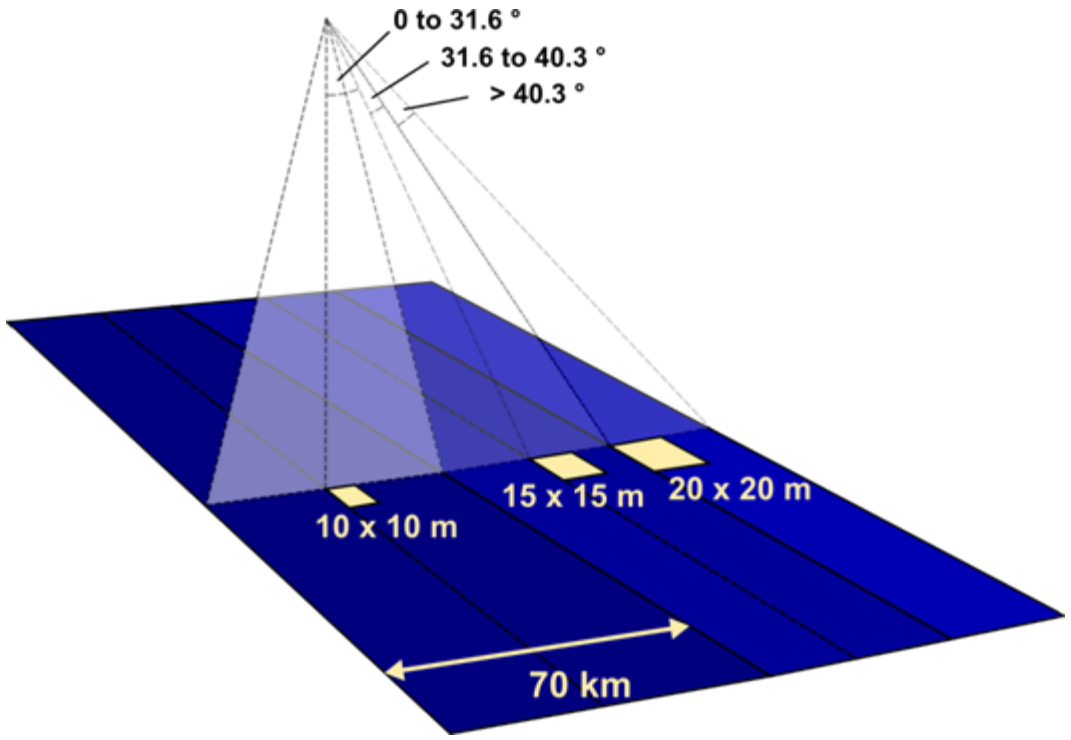
ALOS objectives

- high-resolution observation of the earth's surface to assist in the process of compiling very detailed maps of the Pacific rim region
- monitor disasters for environmental protection and for maintaining and developing earth observation technology
- launched on January 24, 2006

ALOS sensors

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

AVNIR-2



- ***Advanced Visible Near-Infrared Radiometer*** (AVNIR)
- at nadir at 10 m resolution and 70 km swath width
- off-nadir angle capability up to 44 degrees at reduced resolution (15-20 m)

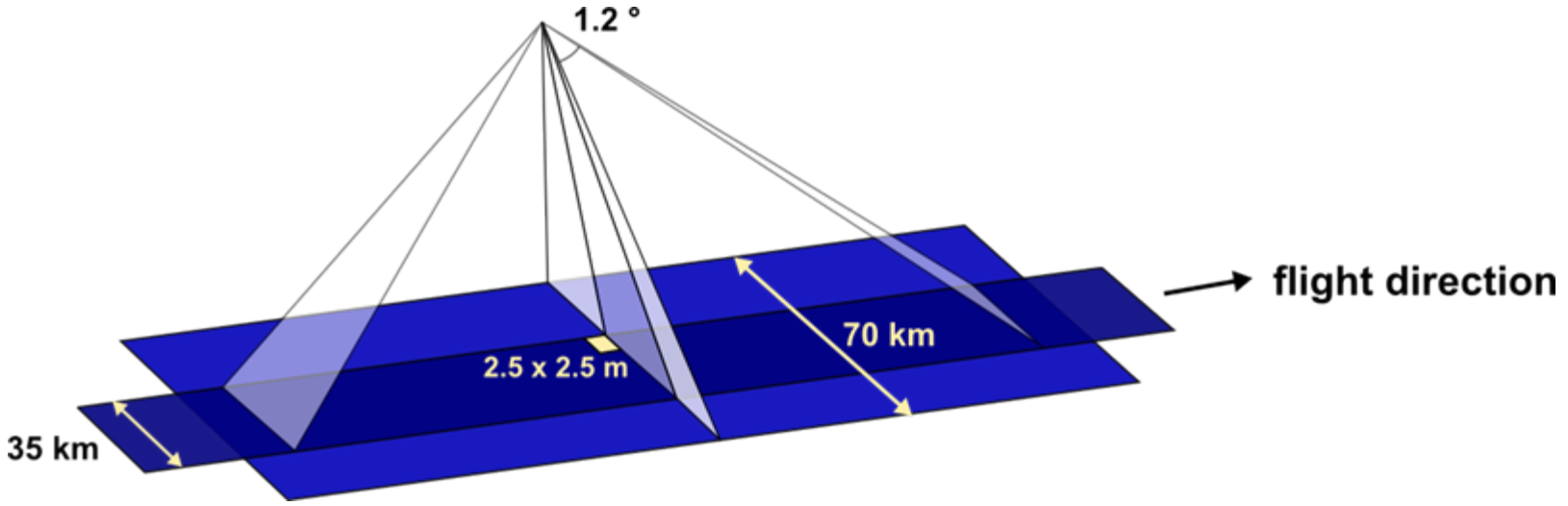
AVNIR-2

- four-band (visible-and near-infrared) radiometer with 10m resolution
- designed for observing land and coastal zones
- provides the basis for land coverage and land-use classification maps for monitoring regional environments
- cross-track pointing capability useful for quick response applications
  - disaster monitoring

AVNIR-2 characteristics

No. of Bands	4
Wavelength	1: 0.42-0.50 microns 2: 0.52-0.60 microns 3: 0.61-0.69 microns 4: 0.76-0.89 microns
Spatial Resolution	10 m (at NADIR)
Swath Width	70 km (at NADIR)
S/N	> 200
MTF	Band 1 ~ 3: >0.25 Band 4: >0.20
No. of Detectors	7000 / band
Pointing Angle	+ or −44˚
Bit Length	8 bits

PRISM



- Panchromatic Remote sensing Instrument ***for Stereo Mapping*** (PRISM) with 2.5 m resolution
- triple mode with 35 km swath width in flight direction
- nadir mode with 70 km swath width

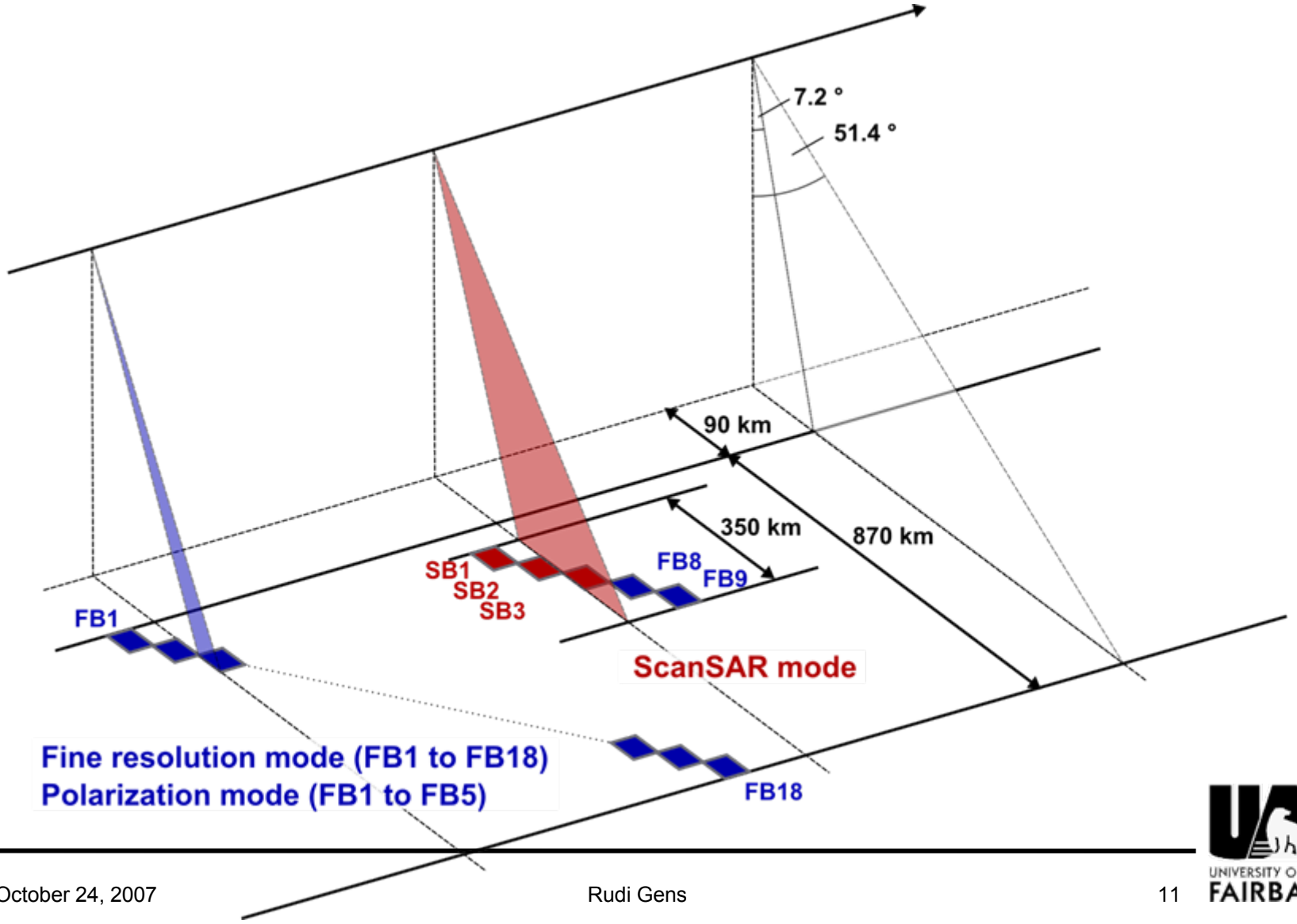
PRISM

- three panchromatic telescopes for forward, nadir, and backwards viewing
- stereoscopic views used to create highly accurate digital elevation models
- used to provide land coverage and land-use classification maps for monitoring regional environments

PRISM characteristics

No. of Bands	1 (Panchromatic)
Wavelength	0.52 ~ 0.77 micrometers
No. of Optics	3 (Nadir/Forward/Backward)
Base to Height Ratio	1.0 (Forward to Backward)
Spatial Resolution	2.5 m
Swath Width	35 km (Triplet mode) 70 km (Nadir only, wide swath mode)
S/N	>70
MTF	>0.2
No. of Detectors	28000/band (70- km swath w) 14000/band (35- km swath w)
Pointing Angle	-1.5 to +1.5 deg (triplet mode, cross track)
Bit Length	8 bits

PALSAR


7.2 °
51.4 °
90 km
350 km
870 km
SB1
SB2
SB3
FB8
FB9
FB1
ScanSAR mode
Fine resolution mode (FB1 to FB18)
Polarization mode (FB1 to FB5)
FB18

PALSAR

- L-band SAR with 10 m and 100 m resolutions
- capable of detailed, all-weather, day and night observations
- repeat-pass interferometry
- has a ScanSAR observation mode, with a swath (250 to 350 km) that is three to five times wider than conventional SAR images
- ScanSAR mode useful for
  - monitoring sea ice
  - monitoring rain forest extent

PALSAR characteristics

Mode	Fine		ScanSAR	Polarimetric
Center Frequency	1270 MHz (L-band)			
Chirp Bandwidth	28 MHz	14 MHz	14 MHz, 28 MHz	14 MHz
Polarization	HH	HH+HV	HH	HH+HV+VH+VV
Incident Angle	8 ~ 60 deg	8 ~ 60 deg	18 ~ 43 deg	8 ~ 60 deg
Range Resolution	7 ~ 44 m	14 ~ 88m	100m (multi look)	24 ~ 89m
Observation Swath	40 ~ 70 km	40 ~ 70 km	250 ~ 350 km	20 ~ 65 km
Bit Length	5 bits	5 bits	5 bits	3 or 5 bits
Data Rate	240 Mbps	240 Mbps	240 Mbps	240 Mbps

PALSAR – Calibrated modes

Product	Mode	Polarization	Available beams / incidence angle
PSR_FBS	Fine resolution mode single polarization	**HH** *(VV not calibrated)*	**21.5** or **34.3** or **41.5** degrees *(out of 18 possible beams ranging from 8 to 60 degrees)*
PSR_FBD	Fine resolution mode dual polarization	**HH&HV** *(VV&VH not calibrated)*	**41.5** degrees *(out of 18 possible beams ranging from 8 to 60 degrees)*
PSR_SL	ScanSAR burst mode 1 (14 MHz)	**HH** *(VV not calibrated)*	**5** scans *(out of 3 possible scans: 3/4/5)*
PSR_P	Polarimetry mode	**HH&HV&VV&VH**	**21.5** degrees *(out of 12 possible beams ranging from 8 to 30 degrees)*

PALSAR – Mode selection

- 21.5 degrees off-nadir has high sensitivity for oil-spill detection
- 34.3 degrees has similarity to the JERS-1 SAR
- 41.5 degrees reduces geometric distortion
- HH polarization is the mode reference
  - high penetration
  - similarity to JERS-1 SAR
- HH+HV shows good sensitivity to vegetation structure,
- quad-pol at 21.5 degrees is the baseline

European Remote Sensing (ERS-2)

Courtesy: ESA

http://www.esa.int/esaEO/SEMGWH2VQUD_index_0_m.htm

ERS-2 objectives

- follow-on mission to ERS-1
- launched in April 1995
- worked in tandem with ERS-1
  - excellent InSAR data sets acquired one day apart
- measure the ozone content of the atmosphere and monitor changes in vegetation cover

ERS-2 instrumentation

- Synthetic aperture radar
- Wind scatterometer
- Radar altimeter
- Along-track scanning radiometer
- Microwave sounder
- Global Ozone Monitoring Experiment (GOME)
- Precise Range and Range-Rate Equipment (PRARE)
- Retroreflector array

Environmental Satellite (Envisat-1)

Courtesy: ESA

http://envisat.esa.int/

Envisat-1 objectives

- launched in early 2002
- 5-year operational life
- monitoring and studying of the Earth's environment and climate changes
- management and monitoring of the Earth's resources, both renewable and non-renewable
- development of a better understanding of the structure and dynamics of the Earth's crust and interior

Envisat-1 sensors

- Michelson Interferometer for Passive Atmospheric Sounding (MIPAS)
- Global Ozone Monitoring by Occultation of Stars (GOMOS)
- SCanning Imaging Absorption spectrometer for AtMospheric CartograpHY (SCIAMACHY)
- MEdium Resolution Imaging Spectrometer (MERIS)
- Advanced Along Track Scanning Radiometer (AATSR)
- Advanced Synthetic Aperture Radar (ASAR)

Envisat-1 sensors

- Radar Altimeter 2 (RA-2)
- MicroWave Radiometer (MWV)
- Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS)
- RetroReflector Array (RRA)

TerraSAR-X

Source: www.astrium.eads.net

http://wwwserv2.go.t-systems-sfr.com/tsx/start_en.htm

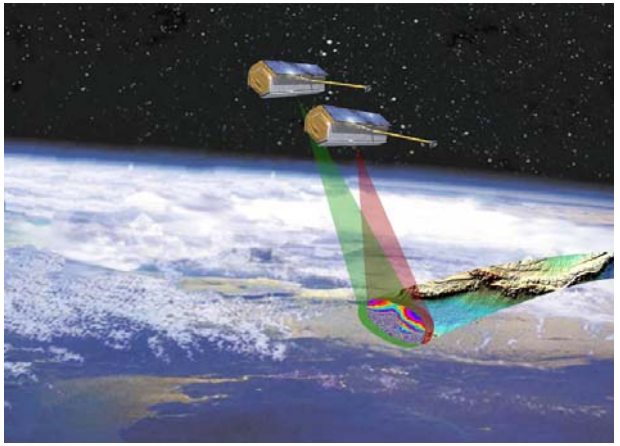
TerraSAR-X objectives

- launched June 2007
- provision of high-quality, multi-mode X-band SAR-data for scientific research and applications
- establishment of a commercial EO-market
- develop a sustainable EO-service business, based on TerraSAR-X derived information products

TerraSAR-X modes

- "Spotlight" mode with 10 x 10 km scenes at a resolution of 1-2 meters,
- "Stripmap"mode with 30 km wide strips at a resolution between 3 and 6 meters,
- "ScanSAR" mode with 100 km wide strips at a resolution of 16 meters.
- additionally TerraSAR-X supports the reception of interferometric radar data for the generation of digital elevation models

TanDEM-X



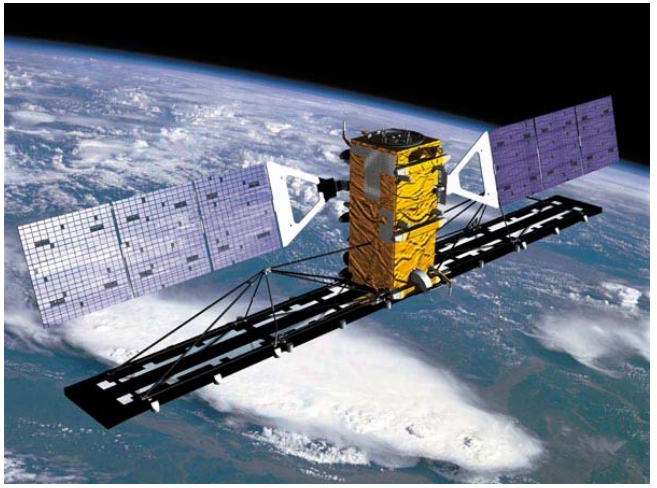
Source: www.astrium.eads.net

http://www.dlr.de/hr/en/desktopdefault.aspx/tabid-2317/3669_read-5488/

Tandem-X

- TanDEM-X (TerraSAR-X add-on for Digital Elevation Measurement) has the goal of generating a global Digital Elevation Model (DEM) with an unprecedented accuracy corresponding to the DTED-3 specifications
  - achieved by means of a second SAR satellite (TanDEM-X) flying in a tandem orbit configuration with TerraSAR-X

Radarsat-2



Source: www.space.gc.ca

http://www.radarsat2.info/

Radarsat-2 objectives

- launch scheduled December 2007
- follow-on to RADARSAT-1
- flexibility in selection of polarization
- left and right-looking imaging options
- highest resolution will be 3 m with 100 m positional accuracy

Radarsat-2 applications

- agricultural crop monitoring
- marine surveillance for ship and pollution detection
- terrestrial defence surveillance and target identification
- geological mapping
- land use mapping
- wetlands mapping
- topographic mapping
- sea ice mapping, iceberg detection, and ship routing

Ice, Cloud, and land Elevation Satellite (ICESat)

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

Courtesy: ICESat science team

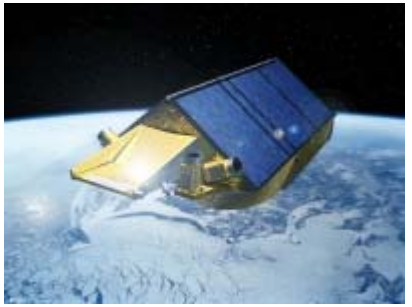
ICESat objectives

- primary objectives are to determine the mass balance of the polar ice sheets and their contributions to global sea level change
  - obtain essential data for prediction of future changes in ice volume and sea-level
- secondary objectives are to measure cloud heights and the vertical structure of clouds and aerosols in the atmosphere
  - map the topography of land surfaces
  - measure roughness, reflectivity, vegetation heights, snow-cover, and sea-ice surface characteristics

ICESat instrumentation

- Geoscience Laser Altimeter System (GLAS)
- Star-tracker attitude-determination system
- GPS receiver
- Retroreflector array

CryoSat-2



Courtesy: ESA

http://www.esa.int/esaLP/LPcryosat.html

CryoSat-2 objectives

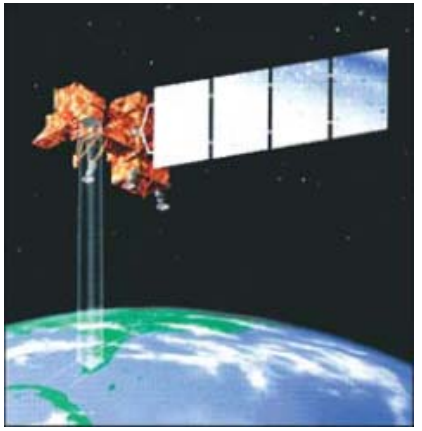
- intended to measure the secular trend in ice thickness for both the floating sea-ice and the ice-caps in both the northern and southern hemisphere
  - uses an advanced radar altimeter combined with precise orbit determination.
- launch in 2009
- CryoSat-1 satellite was lost due to a launch failure on October 8, 2005

CryoSat-2 instrumentation

- SAR/Inteferometric Radar Altimeter (SIRAL)
- DORIS receiver
- Retroreflector array
- Three star trackers

Landsat

http://landsat.usgs.gov/index.php



Courtesy: USGS

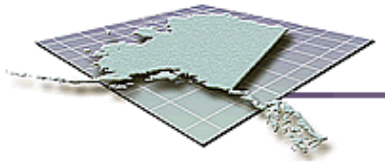
Landsat-5

- launched in March 1984
- on October 6, 2007, Landsat 5 experienced an issue with its onboard batteries, leading to concerns about power balance
- on September 1, 2007, Landsat 5 made its 125,000th orbit of the Earth

Landsat-7

- Landsat-6 launch October 1993 failed
- Landsat-7 launched April 1999
- on May 31, 2003 the Scan Line Corrector (SLC) in the ETM+ instrument failed
  - purpose of the SLC is to compensate for the forward motion (along-track) of the spacecraft so that the resulting scans are aligned parallel to each other
  - without the effects of the SLC, the instrument images the Earth in a "zig-zag" fashion, resulting in some areas that are imaged twice and others that are not imaged at all
  - net effect is that approximately one-fourth of the data in a Landsat 7 scene is missing when acquired without a functional SLC

Landsat data sources



GEOGRAPHIC INFORMATION NETWORK OF ALASKA

UNIVERSITY of ALASKA

• GINA Home • Get Data • Ground Station Ops • Projects •

• Site Search • Map Server • Learning Resources • Metadata Catalog • Partners and Sponsors •

Get Data

Current Alaska Images
Internet Map Server
Landsat Data
Metadata Catalog
Landsat 5 User Info
Global Topo Data
2006 MODIS Images
2005 MODIS Images
2004 MODIS Images
Alaska Data Links
National Data Links
Submit Your Data

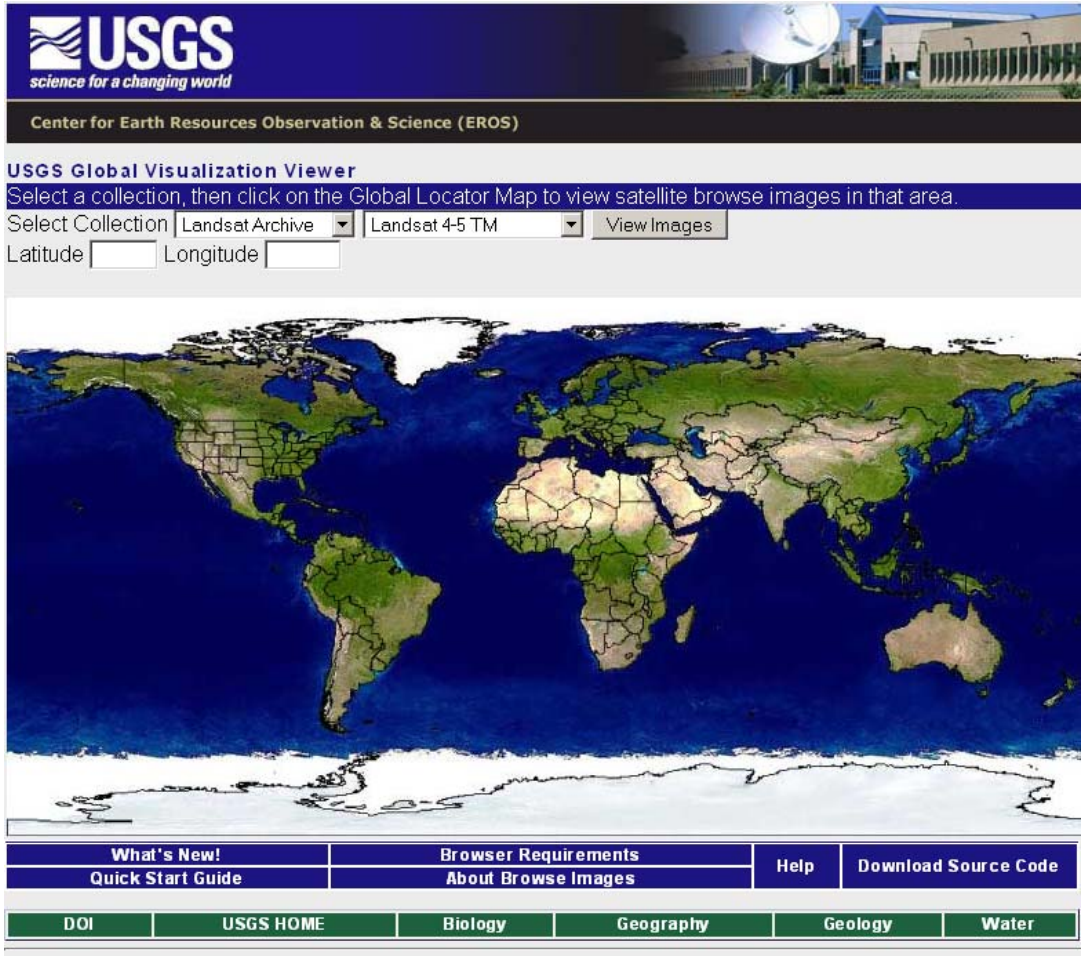
Landsat 5 Data - 2006 Alaska Coverage

Building on the successful 2005 program, Landsat 5 data for Alaska will be received again in 2006 through a joint program among UAF-GINA, USGS-EROS, and NOAA-NESDIS/FCDAS.

The USGS National Center for Earth Resources Observation Systems (EROS), NOAA/NESDIS Fairbanks Command & Data Acquisition Station (FCDAS), and UA Geographic Information Network of Alaska (GINA) have teamed up to provide Landsat 5 data for Alaska this summer. Landsat 5 is an Earth imaging satellite with many applications, including resource management, crisis response, and hazard monitoring. The Landsat program has gathered a continuous set of data since 1972, making it one of the most successful and widely used satellite remote sensing programs. More project background is available in the GINA news release. There is also additional information available for L5 data users.

http://www.gina.alaska.edu

Landsat data sources



http://glovis.usgs.gov

Landsat Data Continuity Mission (LDCM)

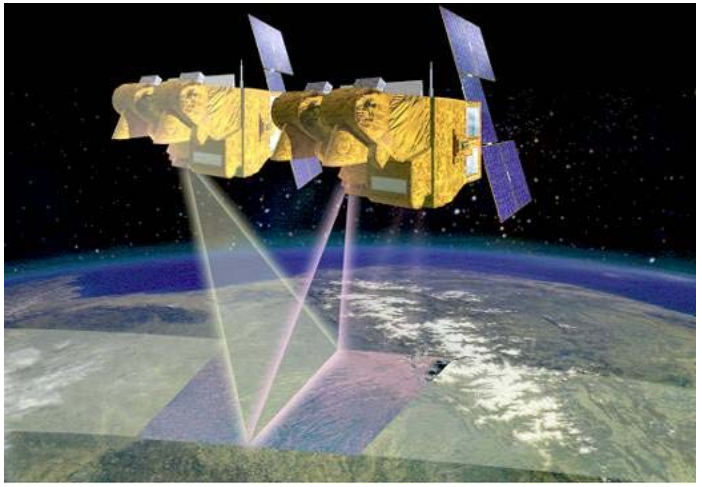
Source: isal.gsfc.nasa.gov

http://ldcm.usgs.gov/LDCMHome.php

LDCM objectives

- make Landsat-type data available at affordable cost
- data continuation for imaging the Earth's land environment at a resolution sufficient to record the impacts of human activties
- currently no thermal sensor planned
- launch scheduled 2011

SPOT-5



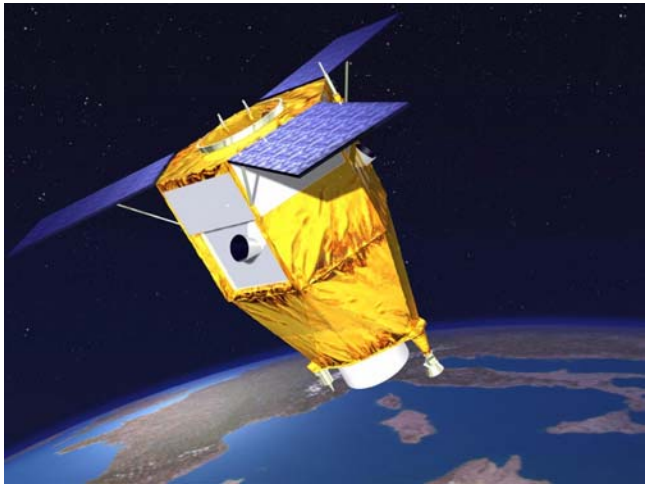
Source: spot5.cnes.fr

http://www.spotimage.fr/

SPOT-5

- SPOT program started 1986
- launched May 2002
- two high resolution geometrical (HRG) instruments
  - 2.5 to 5 m in panchromatic mode
  - 10 m in multispectral mode
- HRS imaging instrument operating in panchromatic mode
  - points forward and backward of the satellite
  - able to take stereopair images almost simultaneously to map relief

PLEIADES



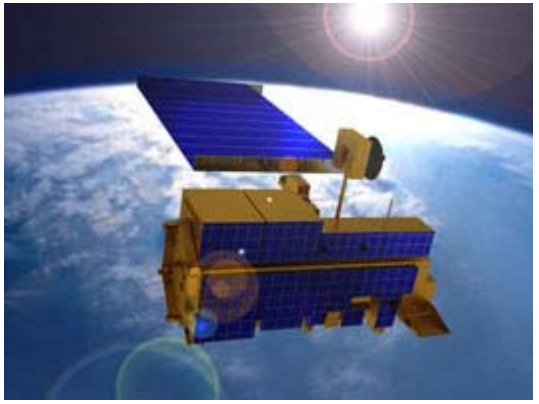
Courtesy: CNES

http://smsc.cnes.fr/PLEIADES/index.htm

PLEIADES program

- replace the SPOT satellites
- launch scheduled 2009
- high-resolution optical + near-infrared
  - 0.7 m panchromatic
  - 2.4 m multispectral
  - stereoscopic capabilities

Terra



Source: Wikipedia

http://terra.nasa.gov/

Terra objectives

- multi-national NASA scientific research satellite
- launched February 2000
- designed to monitor the state of Earth's environment and ongoing changes in its climate system

Terra instrumentation

- ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer)
- CERES (Clouds and the Earth's Radiant Energy System)
- MISR (Multi-angle Imaging SpectroRadiometer)
- MODIS (Moderate-resolution Imaging Spectroradiometer)
- MOPITT (Measurements of Pollution in the Troposphere)

Aqua

Source: Wikipedia

http://aqua.nasa.gov/

Aqua objectives

- multi-national NASA scientific research satellite in orbit around the Earth
- launched in May 2002
- studying the precipitation, evaporation, and cycling of water

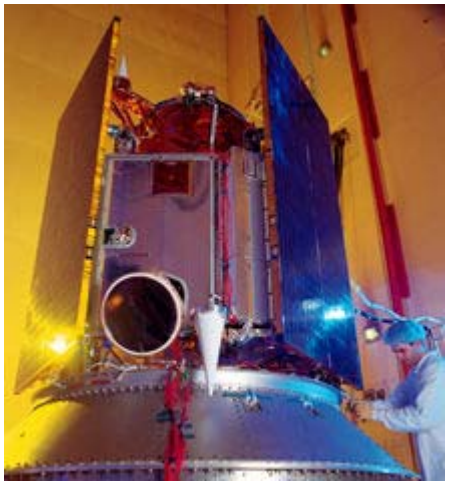
Aqua instrumentation

- AMSR-E - Advanced Microwave Scanning Radiometer-EOS - measures cloud properties, sea surface temperature, near-surface wind speed, radiative energy flux, surface water, ice and snow
- MODIS - Moderate Resolution Imaging Spectroradiometer, also measures cloud properties & radiative energy flux, also aerosol properties; land cover and land use change, fires and volcanos
- AMSU-A -Advanced Microwave Sounding Unit - measures atmospheric temperature and humidity

Aqua instrumentation

- AIRS - Atmospheric Infrared Sounder - measures atmospheric temperature and humidity, land and sea surface temperatures
- HSB - Humidity Sounder for Brazil - VHF band equipment measuring atmospheric humidity
- CERES - Clouds and the Earth's Radiant Energy System - measures radiative energy flux

IKONOS



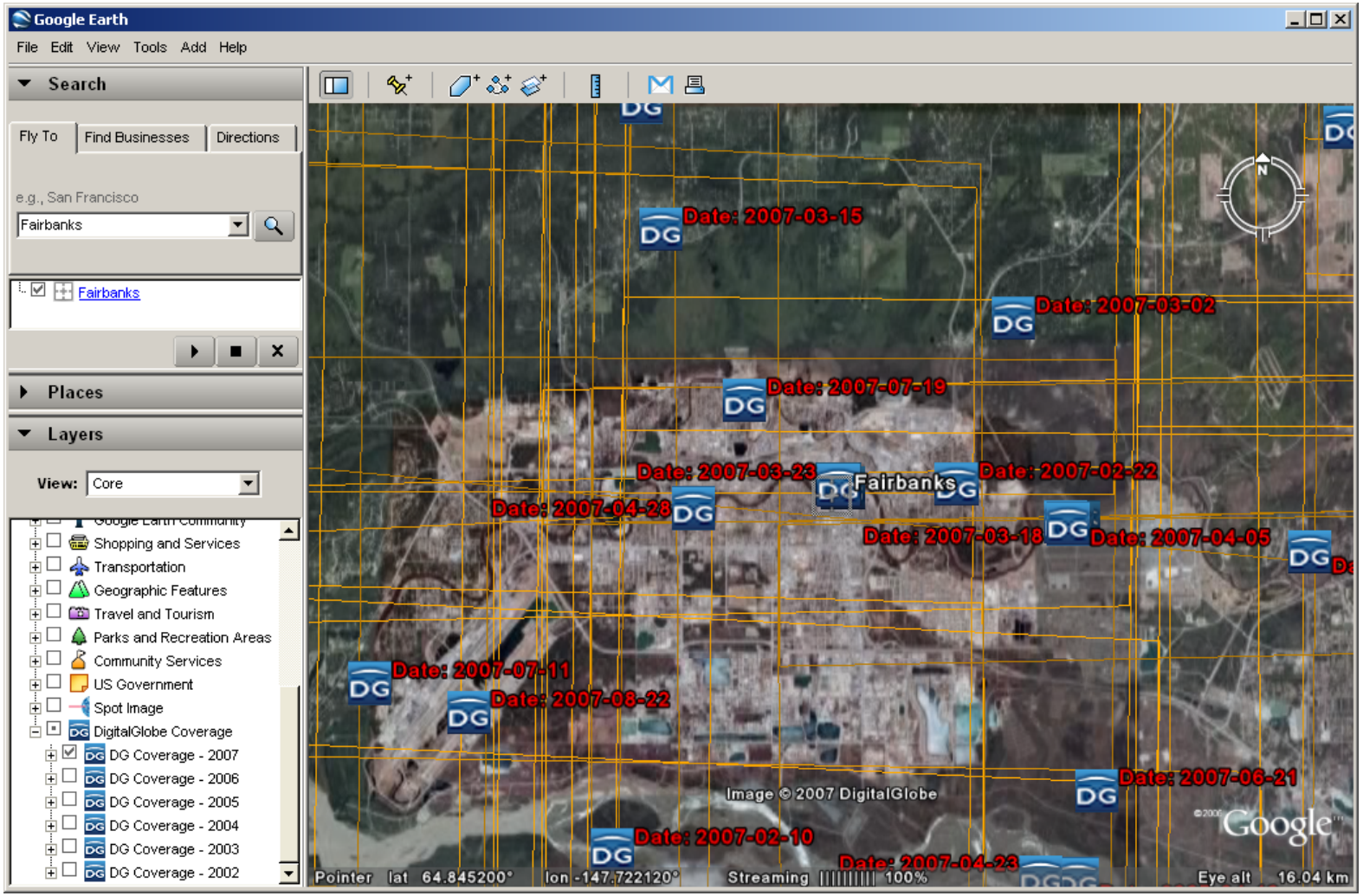
Source: Wikipedia

http://www.geoeye.com/products/imagery/ikonos/default.htm

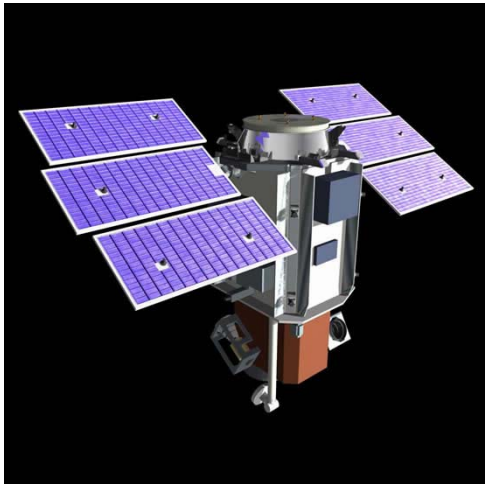
IKONOS

- launched in September 1999
- high-resolution optical data
  - 0.8 m panchromatic
  - 4-meter multispectral
  - 1-meter pan-sharpened
- applications range from national security and disaster assessment to urban planning and agricultural monitoring

IKONOS data in Google Earth



Quickbird



Source: www.sensor.com

http://www.digitalglobe.com/about/quickbird.html

Quickbird

- launched October 2001
- high-resolution optical data
  - 0.6 m panchromatic
  - 2.4 m multispectral

Indian Remote Sensing Satellite (IRS) program

Courtesy: Indian Space Research Organisation (ISRO)

http://www.isro.org

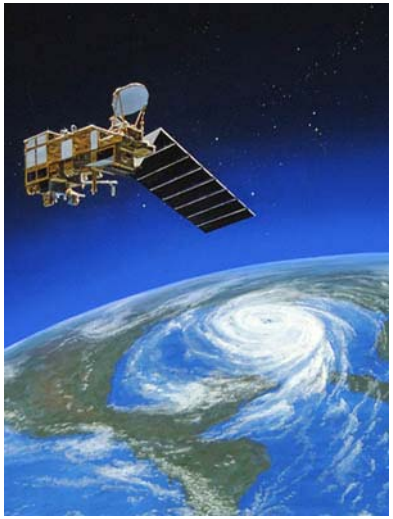
IRS program - Status

- Indian Remote Sensing Satellite (IRS) program established in 1988 (launch of IRS-1A)
- support the national economy in the areas of agriculture, water resources, forestry and ecology, geology, water sheds, marine fisheries and coastal management
- constellation of currently six satellites
  - Cartosat-1 (May 2005): 2.5 m panchromatic (stereo)
  - Cartosat-2 (January 2007): 0.8 m panchromatic

IRS program - Future

- RISAT (Radar Imaging Satellite)
  - synthetic aperture radar operating in C-band
  - planned for 2007/08
- Oceansat-2 (scheduled 2007/08)
  - envisaged to continue the service of OCEANSAT-1
  - will carry an Ocean Colour Monitor (OCM) and a Ku-band pencil beam scatterometer
- Resourcesat-2 (scheduled 2009/10)
  - imaging sensors similar to RESOURCESAT-1
  - payload electronics have been miniaturised to reduce the overall weight

NOAA Polar Operational Environmental Satellite System (NPOESS)



Courtesy: NOAA

http://www.ipo.noaa.gov/

NPOESS objectives

- satellite system used to monitor global environmental conditions, and collect and disseminate data related to
  - weather
  - atmosphere
  - oceans
  - land and near-space environment
- launched scheduled for 2013

NPOESS instrumentation

- VIIRS Visible/Infrared Imager/Radiometer Suite
- CMIS Conical Microwave Imager/Sounder
- CrIS Crosstrack Infrared Sounder
- OMPS Ozone Mapping and Profiler Suite
- SESS Space Environment Sensor Suite
- APS Aerosol Polarimeter Sensor
- ATMS Advanced Technology Microwave Sounder (currently under development by NASA)
- DCS Data Collection System
- ERBS Earth Radiation Budget Sensor

NPOESS instrumentation

- RADAR Altimeter
- SARSAT Search and Rescue Satellite Aided Tracking
- TSI Total Solar Irradiance Sensor
- ASCAT Advanced Scatterometer (ESA)
- Retroreflector array