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OSSIM Training (Dia 1)

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Introducciones

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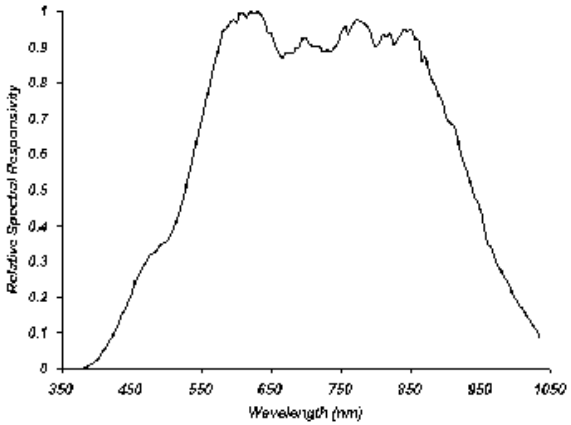
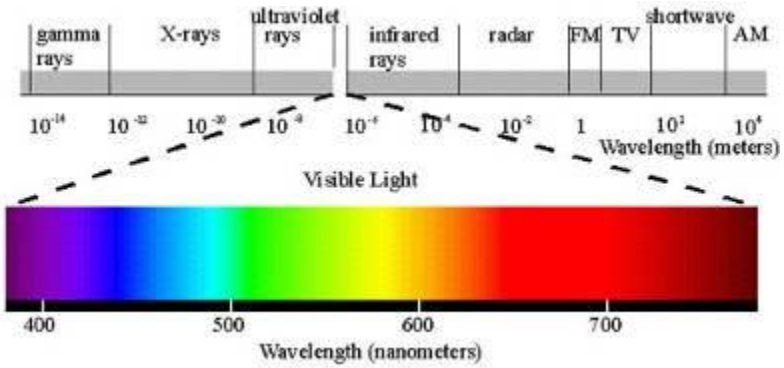
Satellite Imagery Overview

Panchromatic Imagery ("Pan")
Multi/Hyper-spectral (MSI/HSI)
Synthetic Aperture Radar (SAR)

Panchromatic Imagery Overview

Quickbird





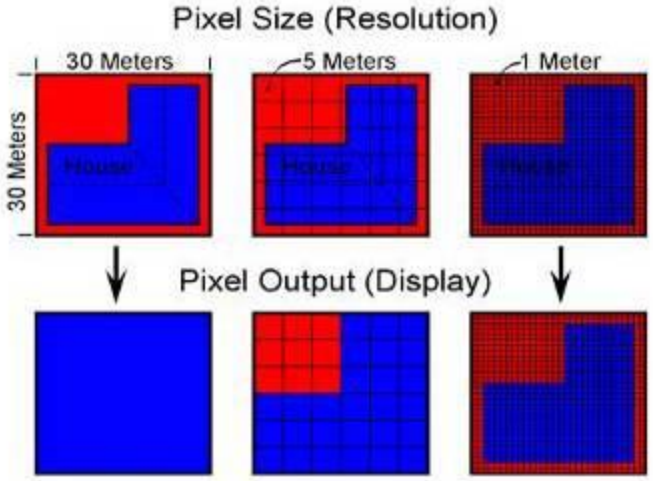
Electro-Optical (EO) "Panchromatic" Imagery

Black and White Imagery

(450-900nm)

How Good is that Image?
What is Resolution?

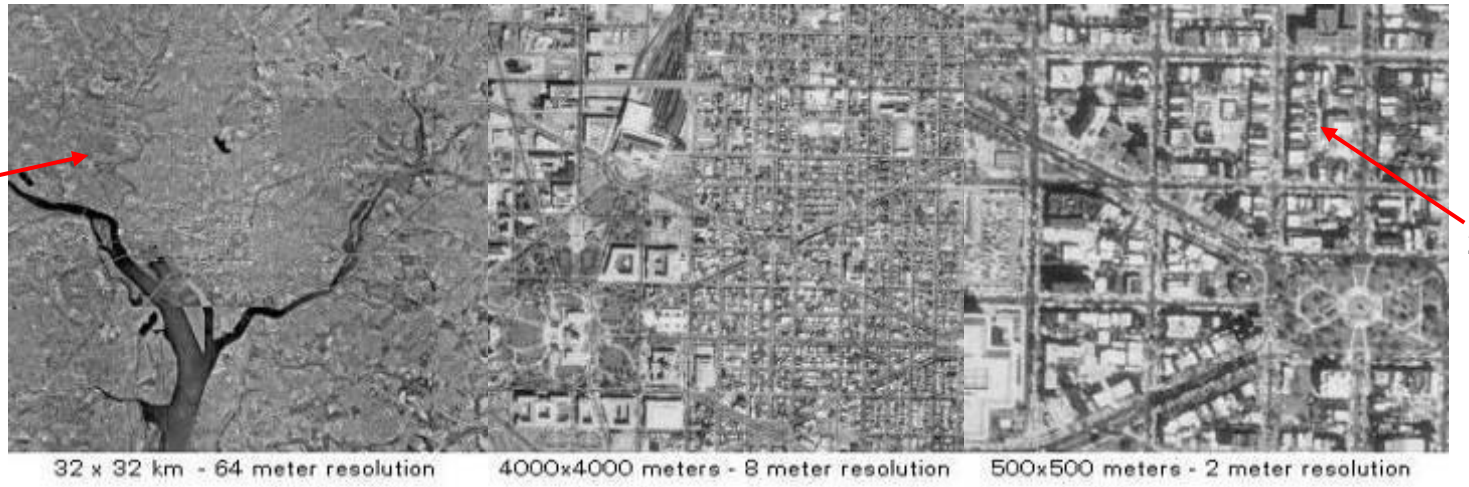
Image spatial resolution (often measured in Ground Sample Distance (GSD)) describes the detail an image holds. Higher resolution means more image detail.



"High resolution" / low GSD = good image quality

"Low/poor resolution" / high GSD = poor image quality

1 pixel = 64 meters



1 pixel = 2 meters

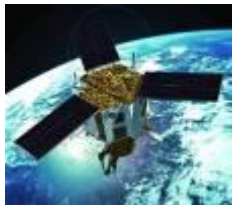
How Good is that Image?
Resolution / Swath and the Soda Straw Effect

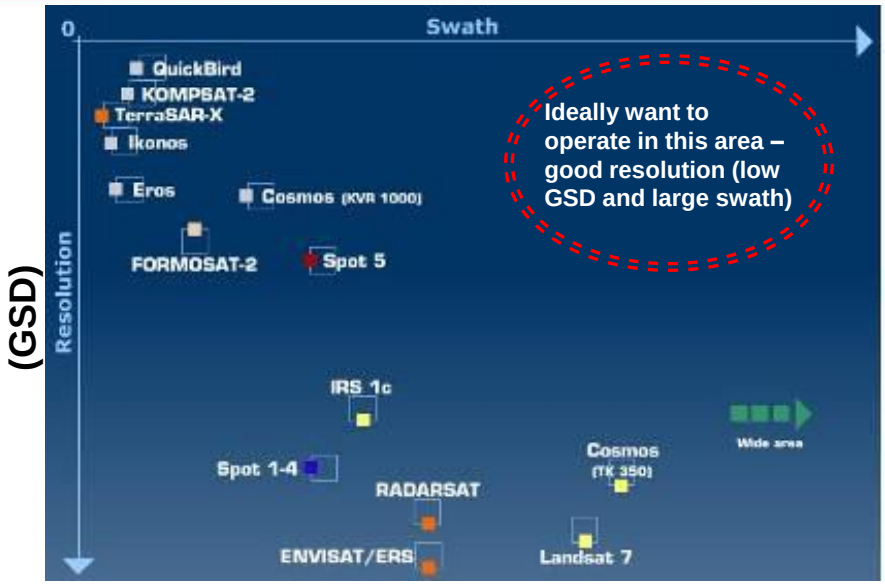
Quickbird
DigitalGlobe
61cm B&W

WorldView-1
DigitalGlobe
50cm B&W

FormoSat-2
Spot Image 2m B&W

Ikonos
GeoEye 1m B&W



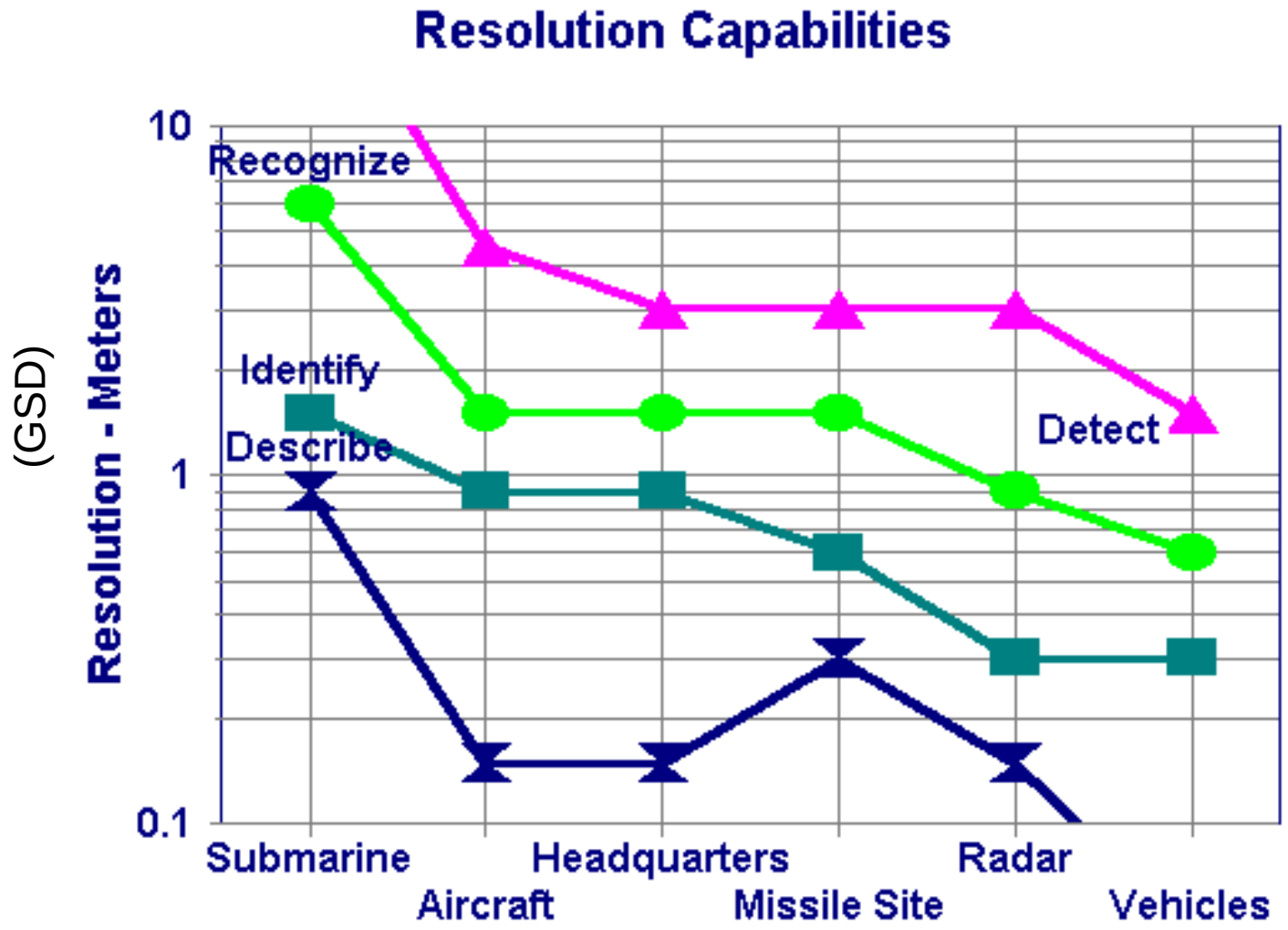


Tradeoff Between Swath Width and Resolution

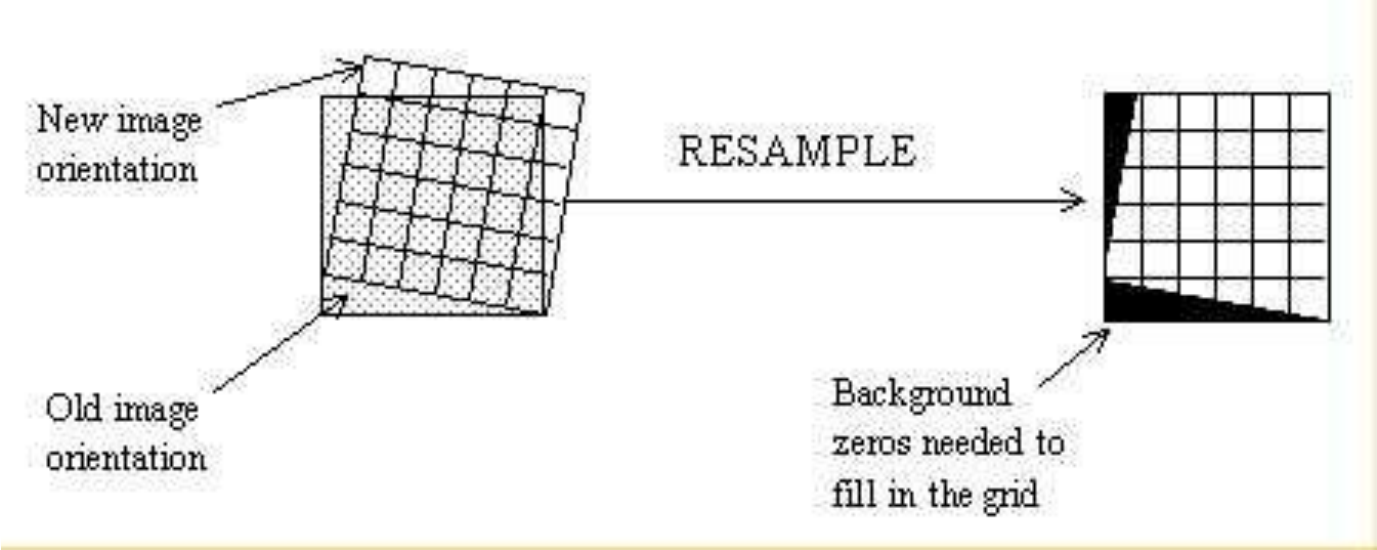
Soda Straw Effect – "It's Like Looking Through a Soda Straw"

Example SPOT and Quickbird Footprints

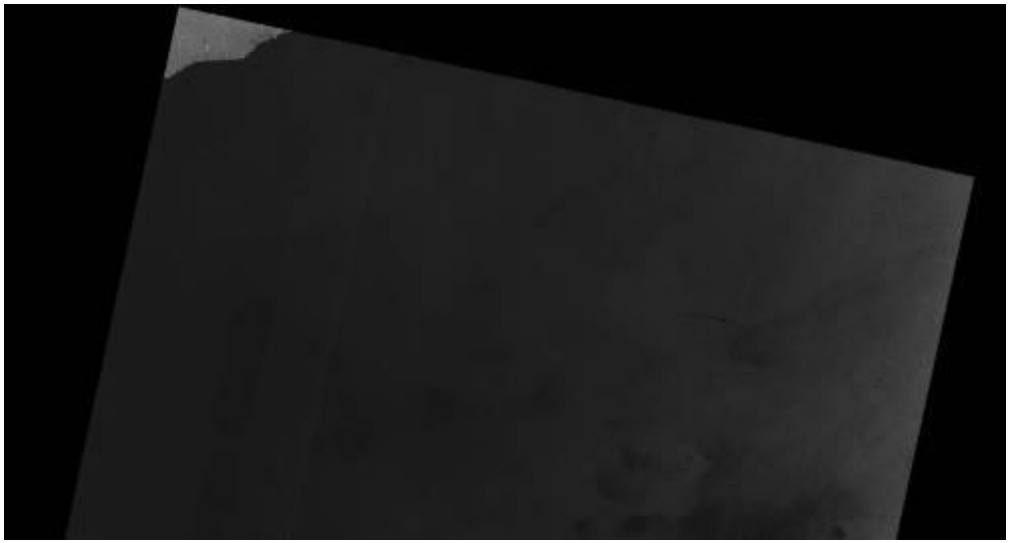
How Good is that Image?
More About Resolution



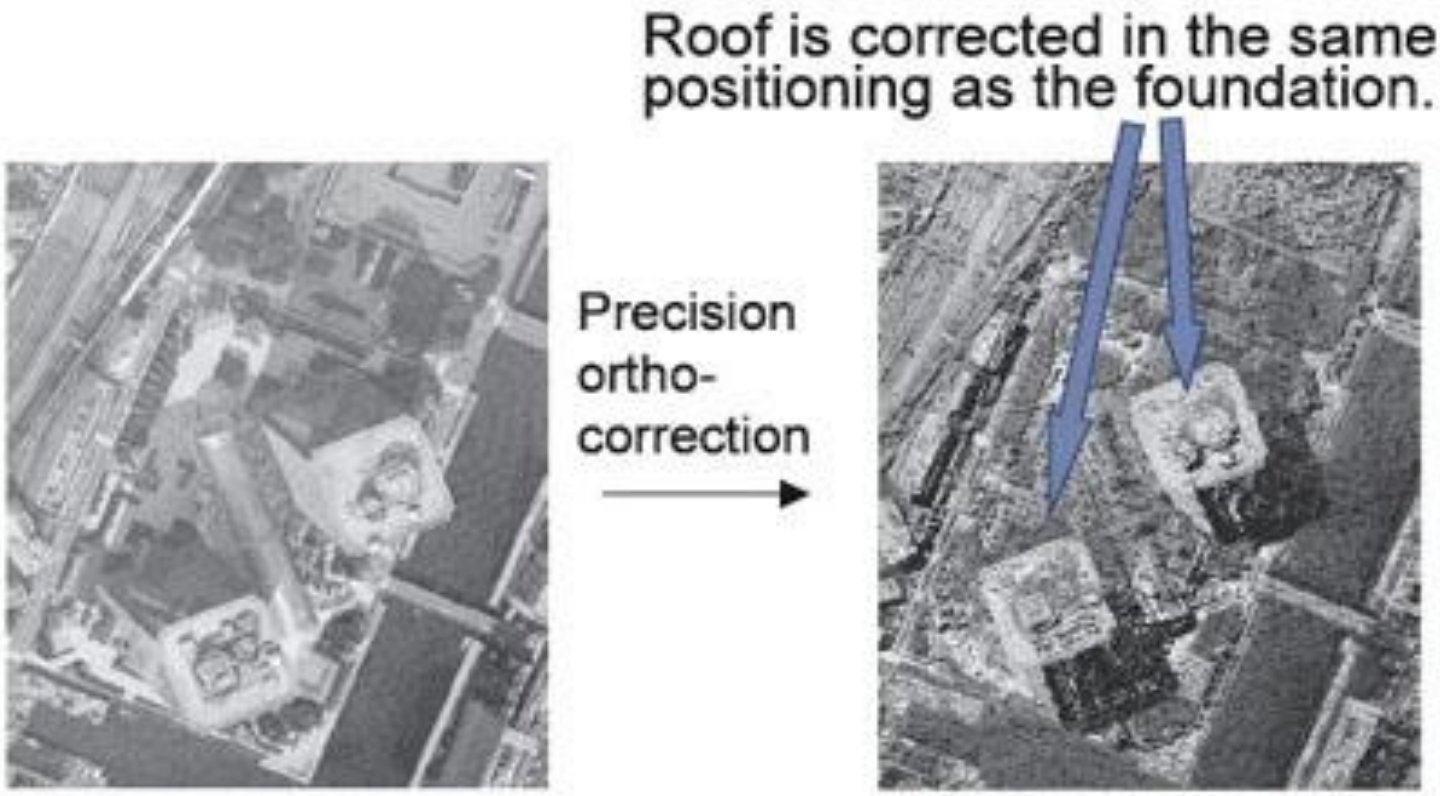
Post Processing the Image
What is Georectification? ("Map Projection")



Georectification is the conversion of the data to real-world coordinates (such as latitude and longitude). Often times we refer to "north is up". Georectifying imagery will orient the imagery such that north is at the top of the image.



Post Processing the Image
What is Orthorectification?



Orthorectification is a procedure that corrects geometric distortion and relief displacement. Variations in the terrain surface (ground relief or topography) and the perspective view of the camera lens cause these distortions. Orthorectification removes these distortions so the imagery accurately represents features on the ground in their true positions. This enables distances and objects to be measured with confidence.

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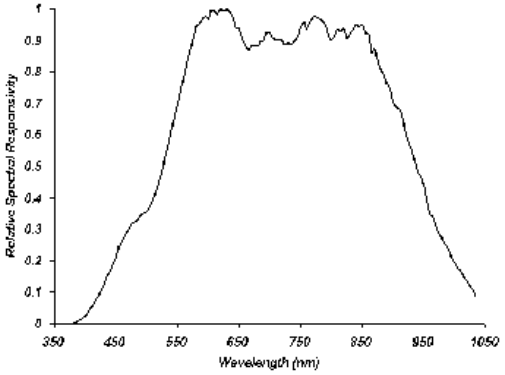
Importance of Orthorectification

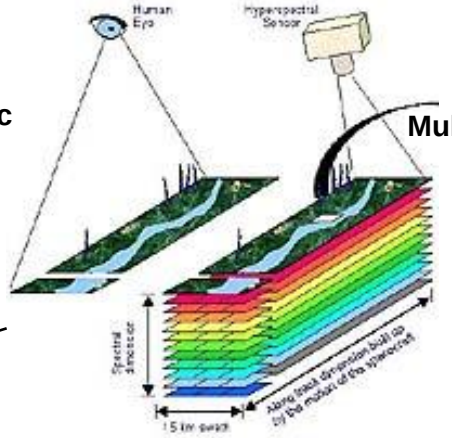
Quickbird Low Grazing Angle (Oblique) Panchromatic Image Of San Francisco

Multi/Hyper-spectral Imagery Overview

Quickbird



Panchromatic

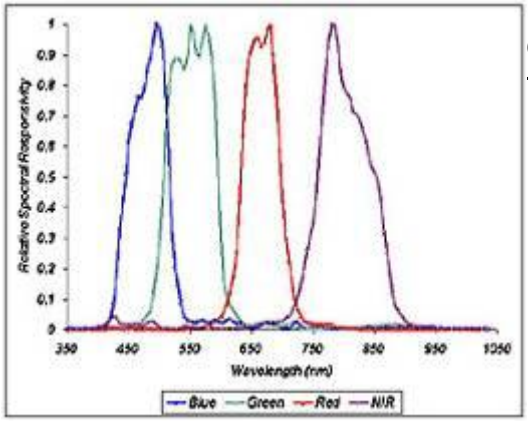


Multispectral

Panchromatic (Single Band) Black and White VERY High Resolution (Half Meter)

Good for visual representation

Where is the grass in this image?



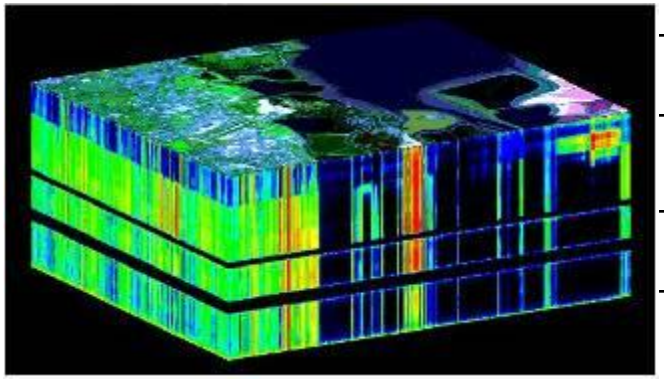
Here you can find the grass

Multispectral Color (Multiple Bands) High Resolution (Several Meters)

Good for scientific analysis

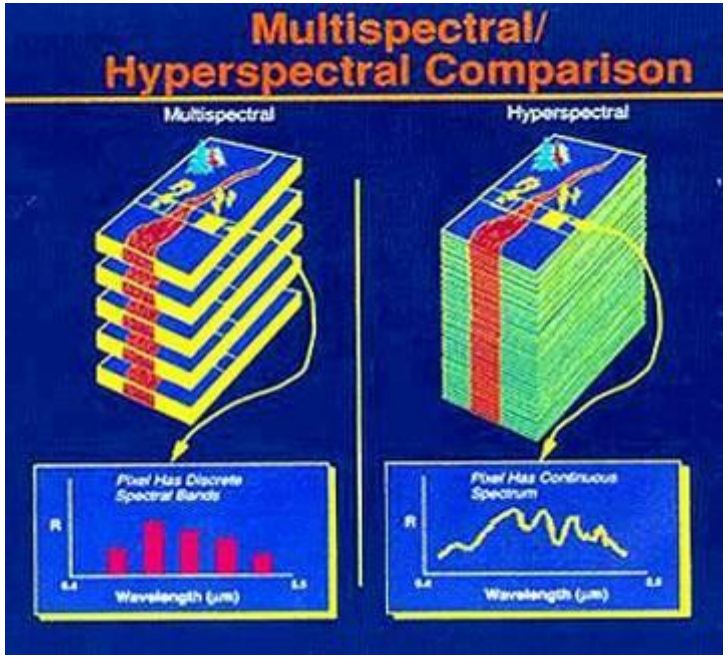
Multi/Hyper-spectral Imagery Overview

Multi/Hyper-spectral "Cube"



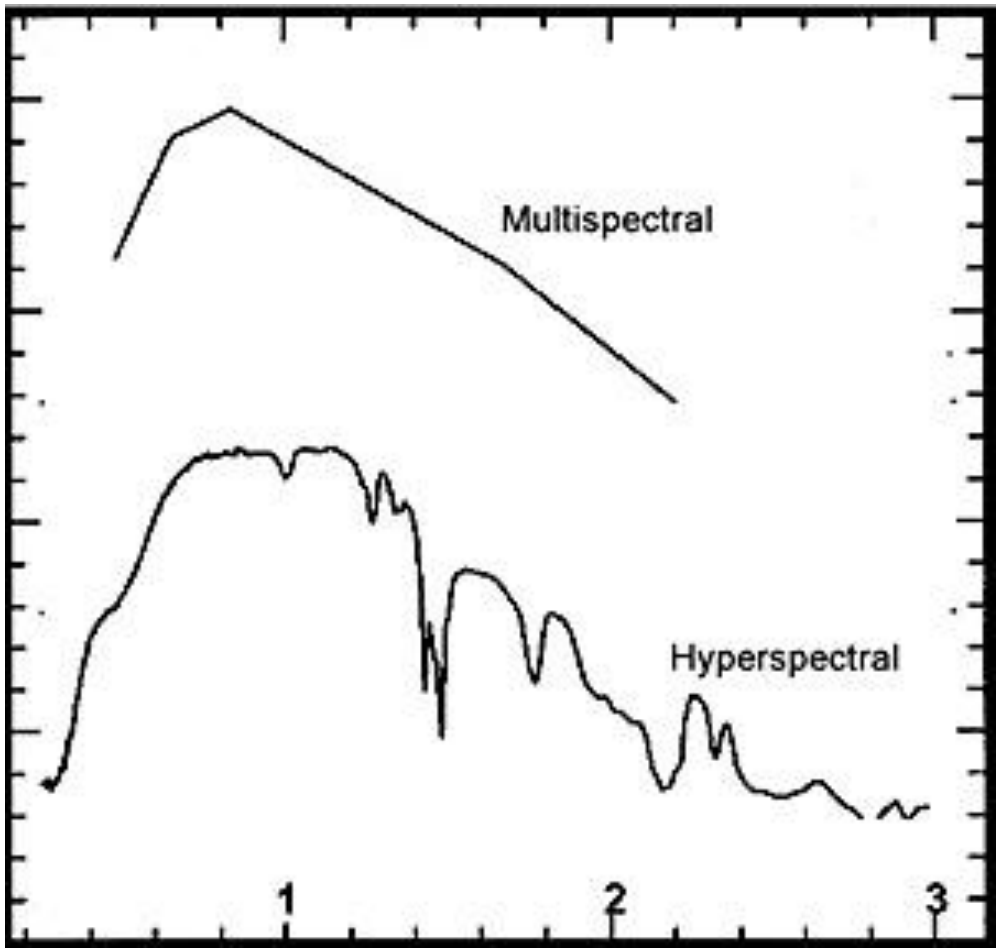
- Blue (450-520nm)
- Green (520-600nm)
- Red (630-690nm)
- Near Infrared (NIR) (760-900nm)

Four Images or "Bands"



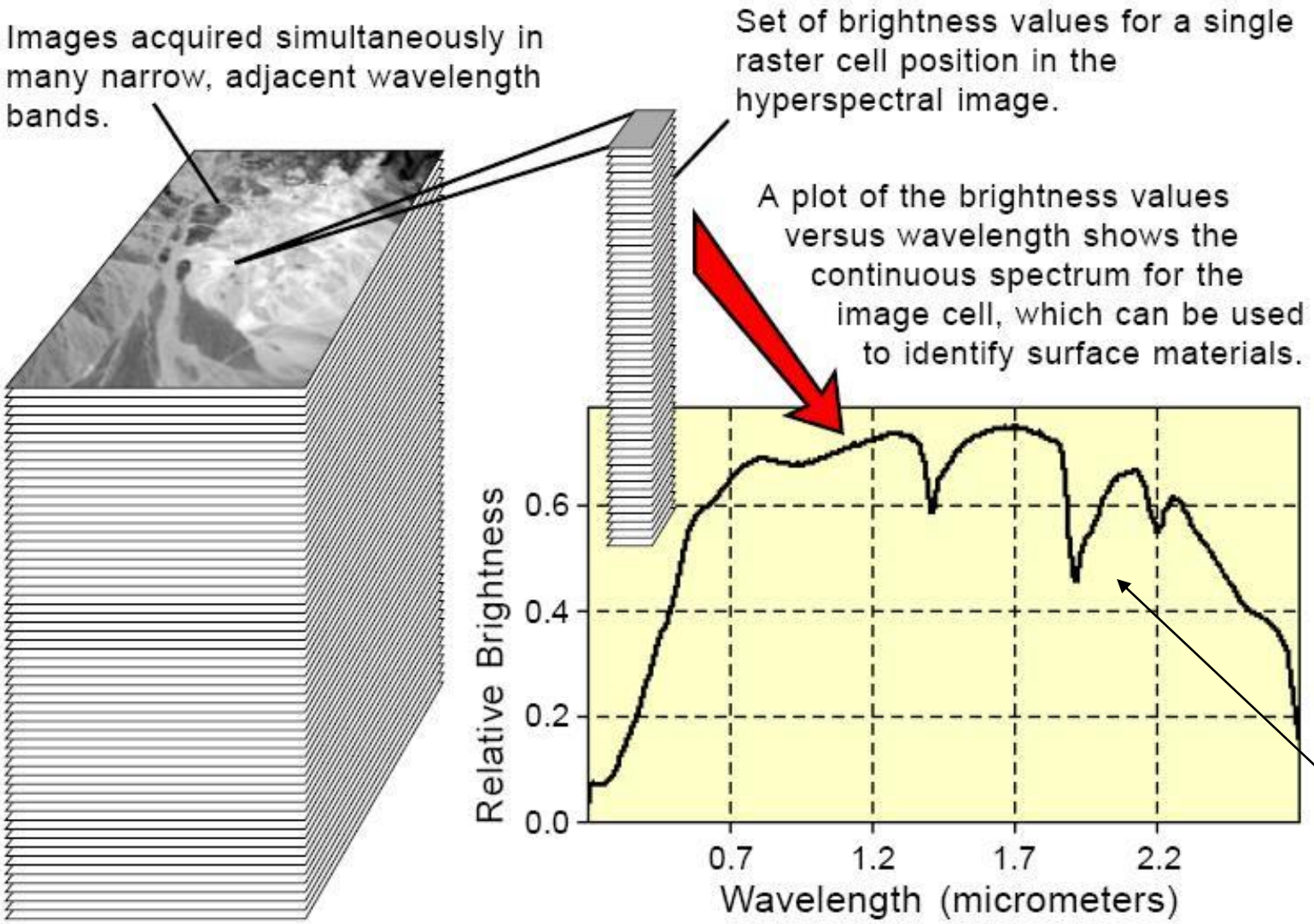
100s-1000s of Images or "Bands"

How Good is that Image?
Spectral Resolution



Multispectral vs. Hyperspectral Response of an Object

Spectral Analysis Overview



ID'ing this Spectral Response Helps Us ID this Object

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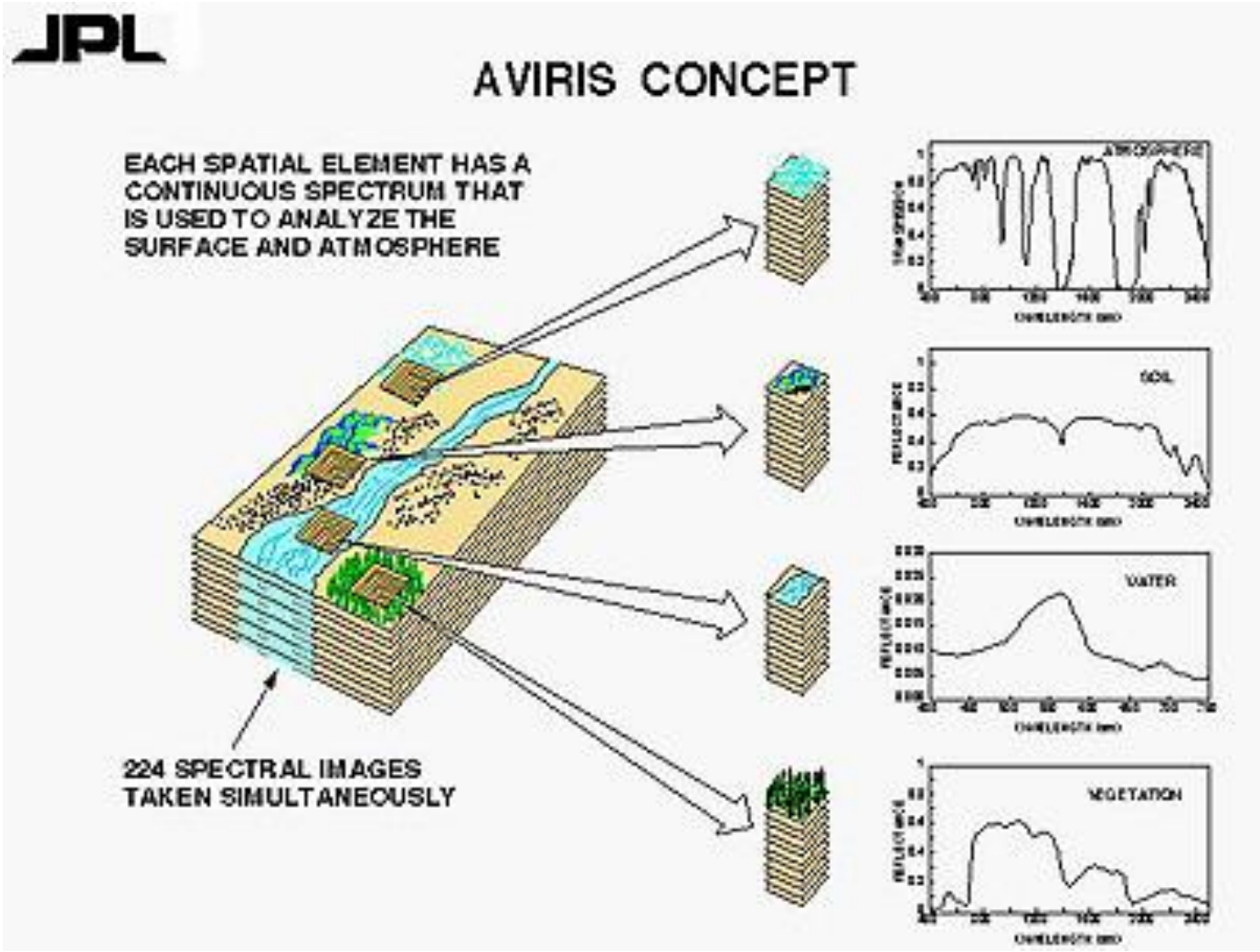
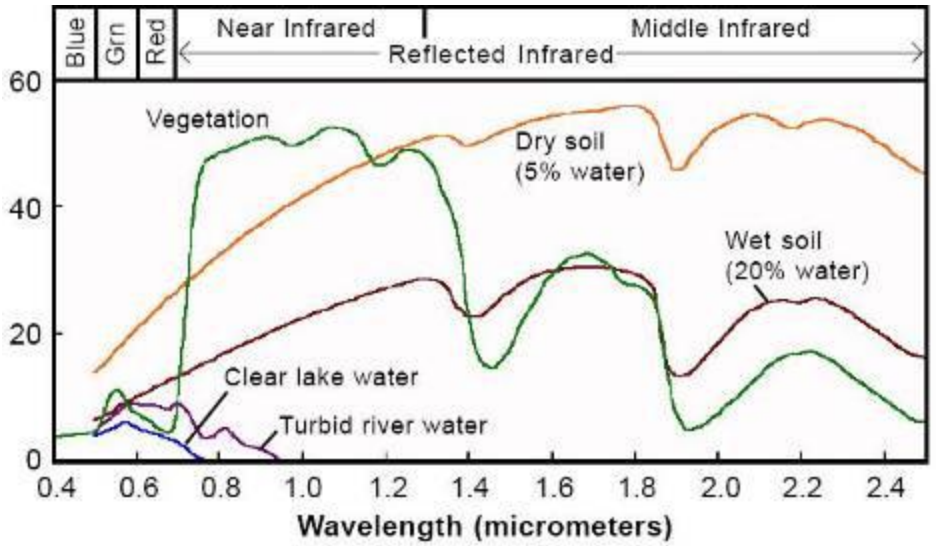
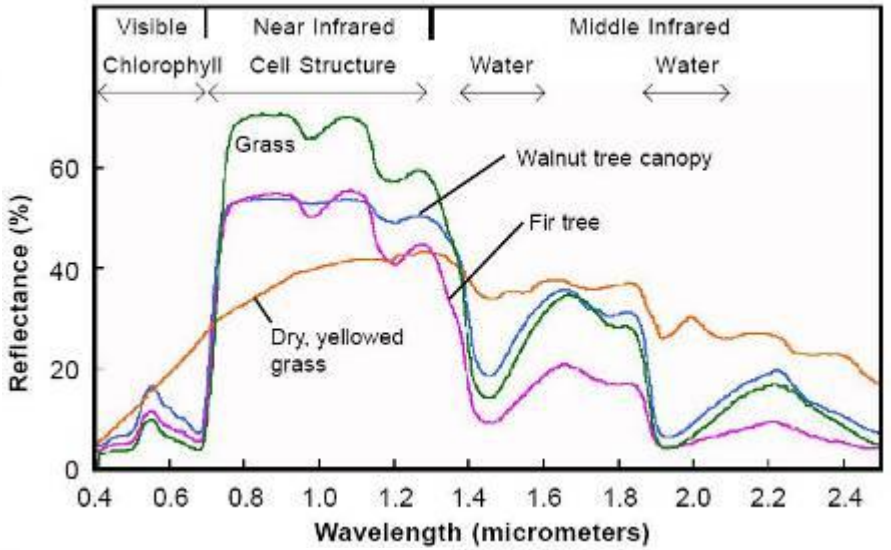
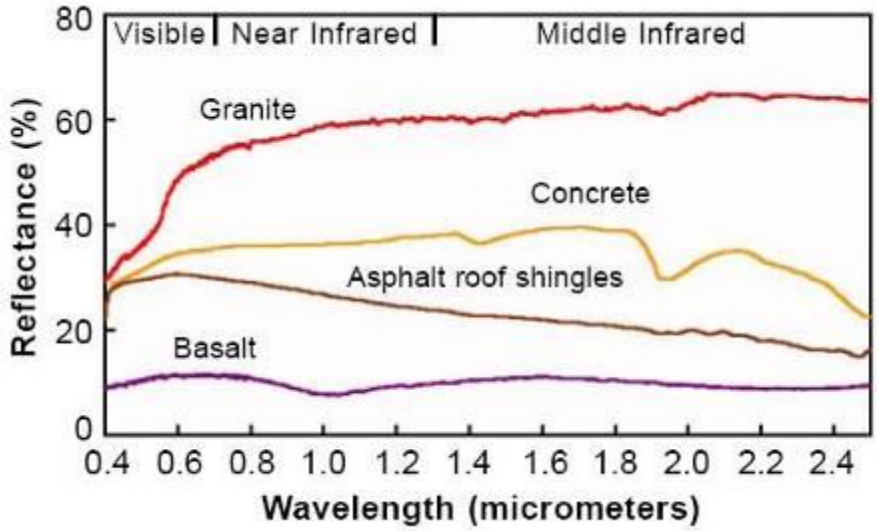
Spectral Analysis Overview



Post Processing the Image
Spectral Signature Libraries







Spectral Regions

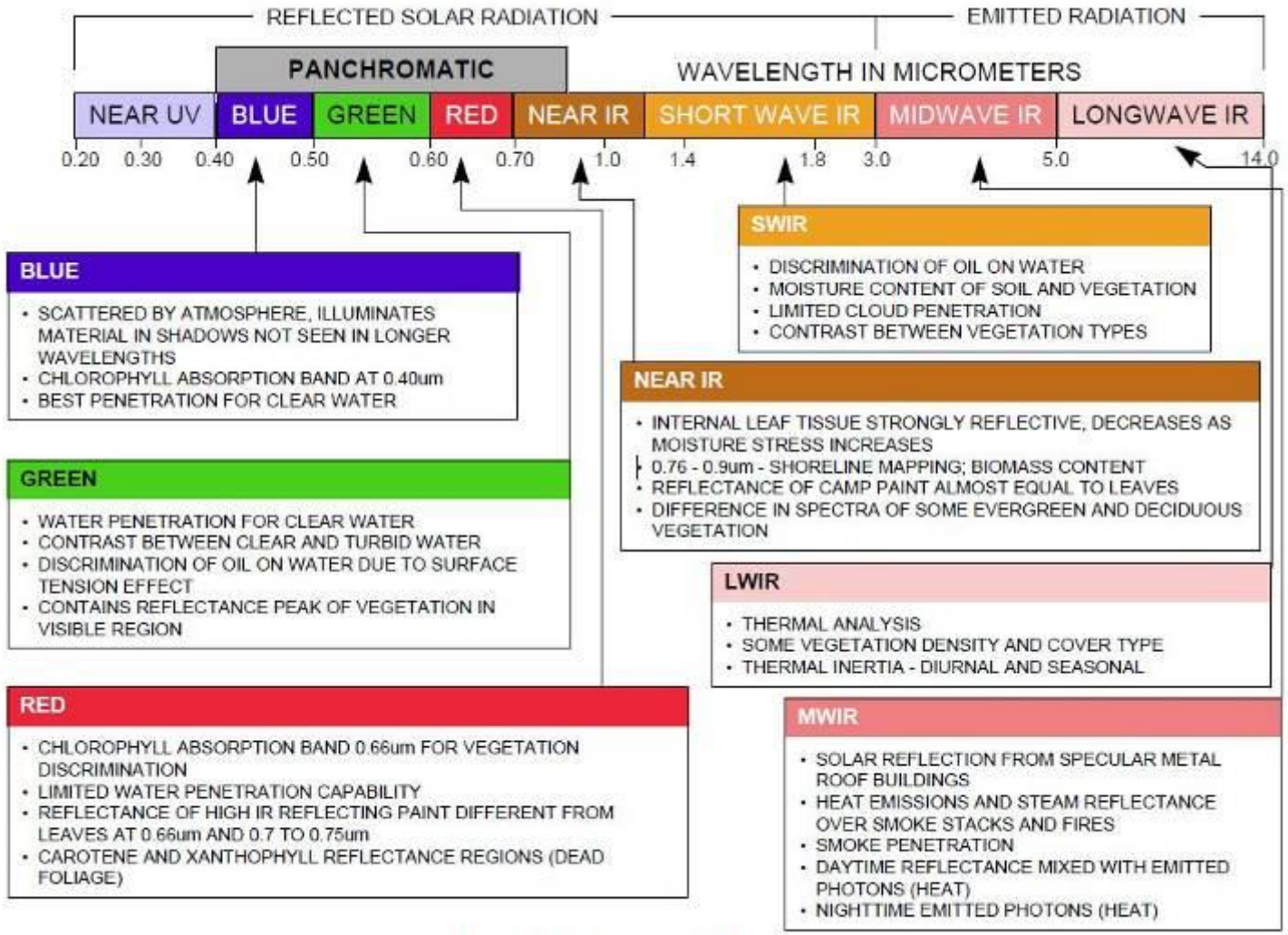
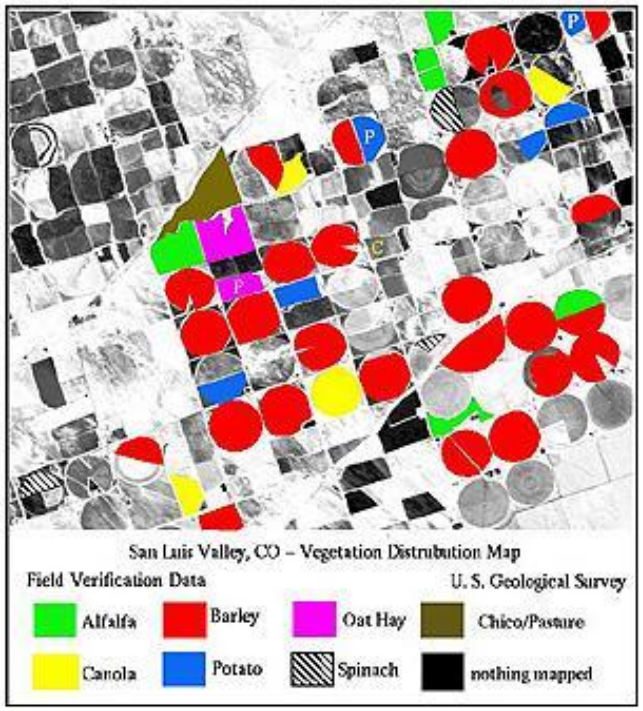
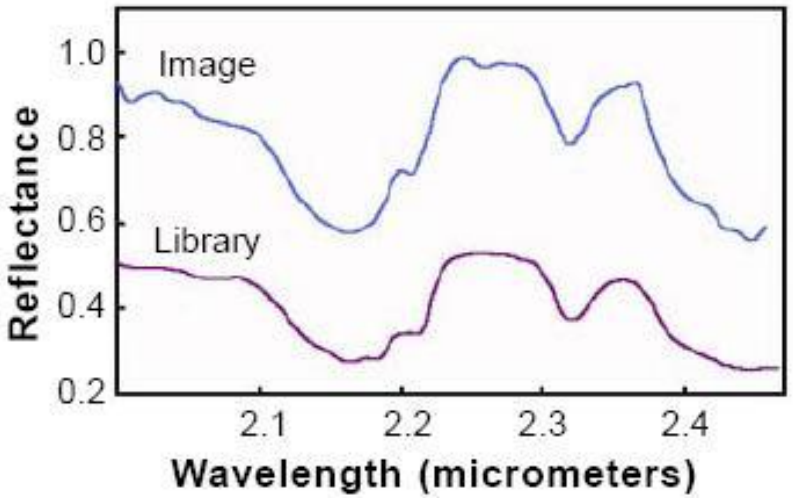


Fig. 12-7. Spectral Regions

Post Processing the Image
Spectral Signature Matching Techniques



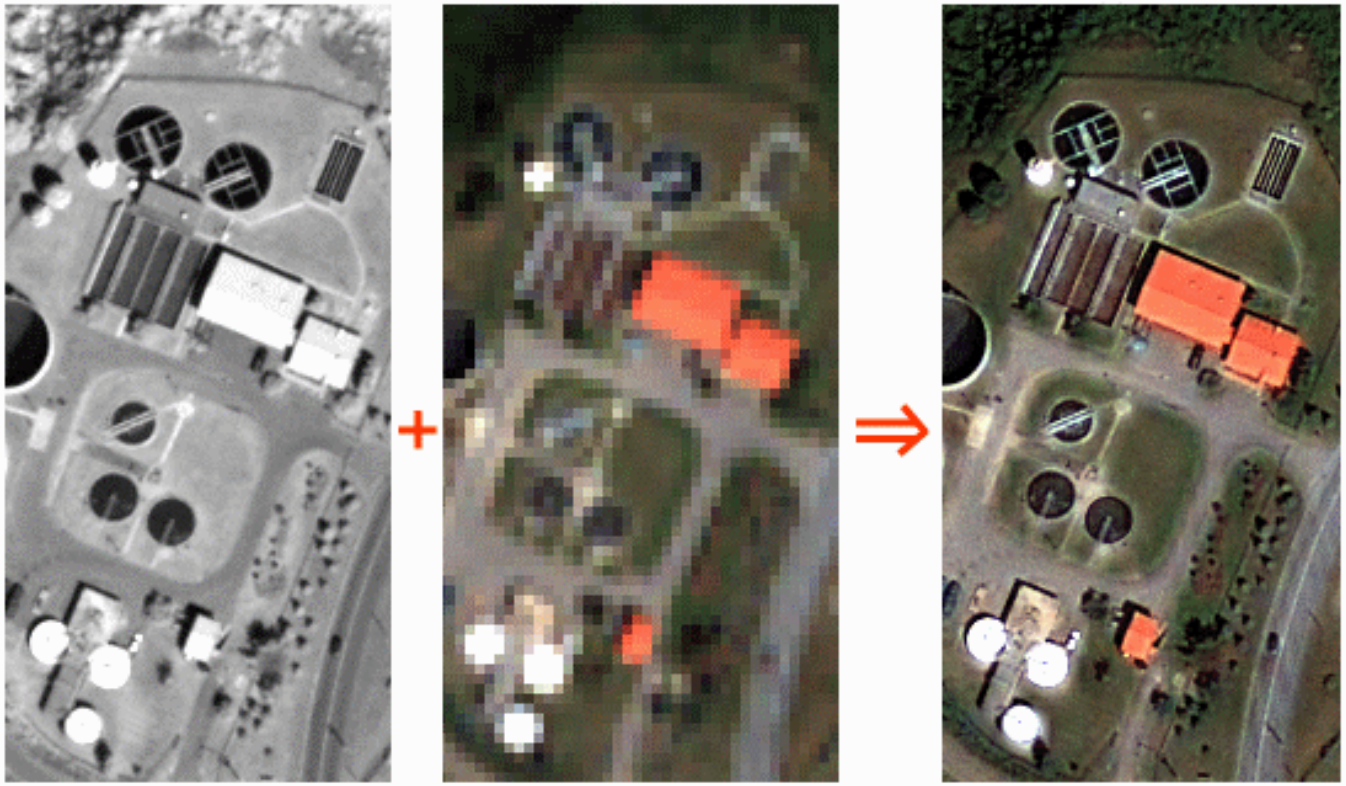


Detection and identification techniques such as:

- Anomaly Detection (RX)
- Matched Filtering
- Linear Unmixing

Post Processing the MSI Image

Pan Sharpening (this is what's on Google Earth!!)



Current Set of High Resolution MSI Imagers

Quickbird
DigitalGlobe
2.4m Color
4 bands

NEW!

WorldView-2
DigitalGlobe
1.84m Color
8 bands

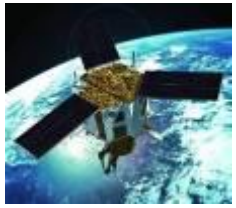
GeoEye-1
GeoEye
1.65m Color
4 bands

SPOT-4
SPOT Image
20m Color
4 bands

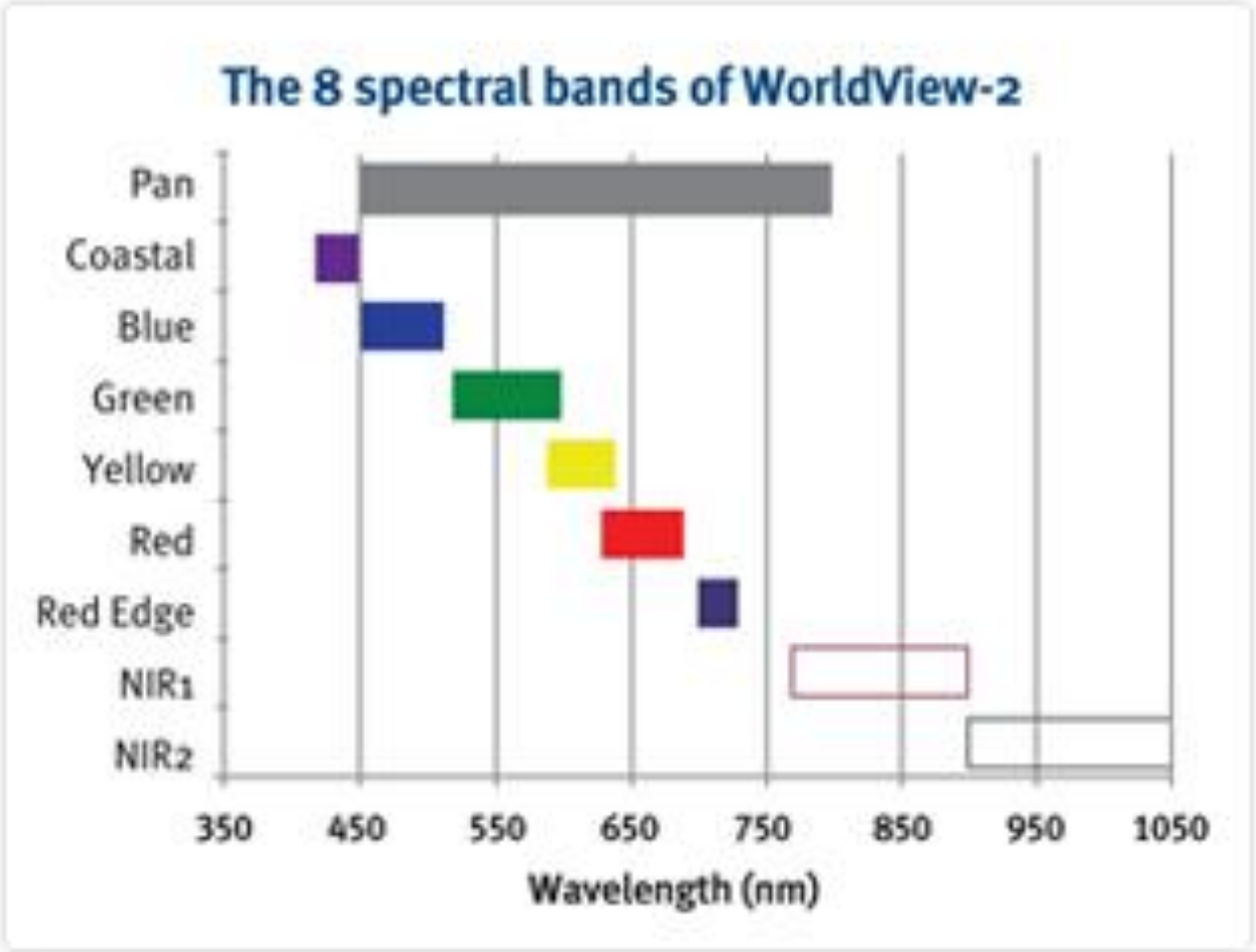
SPOT-5
SPOT Image
5m, 10m Color
4 bands

OrbView-3
GeoEye
1.65m Color
4 bands

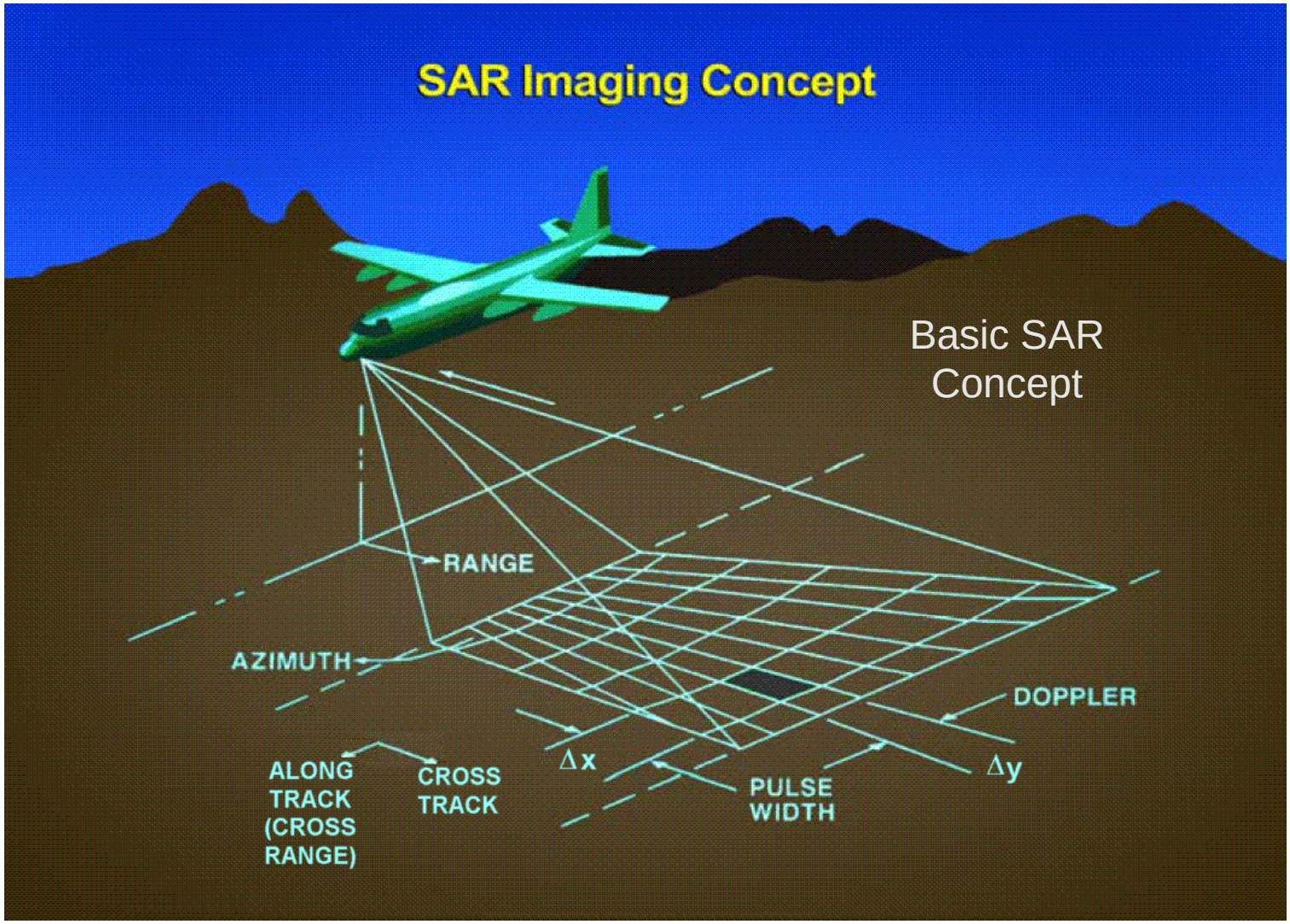
Ikonos
GeoEye
3.2m Color
4 bands



Current Set of High Resolution Imagers



Synthetic Aperture Radar (SAR) Geometry



What is SAR?

- SAR synthesizes a large antenna (aperture).
- Larger antennas → higher resolution
- SAR coherently sums multiple returns from scatterers as it sweeps across a viewing area

Example: How does a real-aperture radar compare to SAR?

f = 3 GHz (center frequency)
D = 10m (antenna size in azimuth dimension)
A = azimuth Resolution (m)

What is the *azimuth resolution* for ranges of 10km, 100km, and 1000km?

SAR: independent of range → **A = 5 m (for focused SAR)**

Real-Aperture Radar: 10km → A = 100m
1000km → A = 10km

Result: It would be *impossible* to image the Earth from space with a real-aperture radar!

What is SAR?

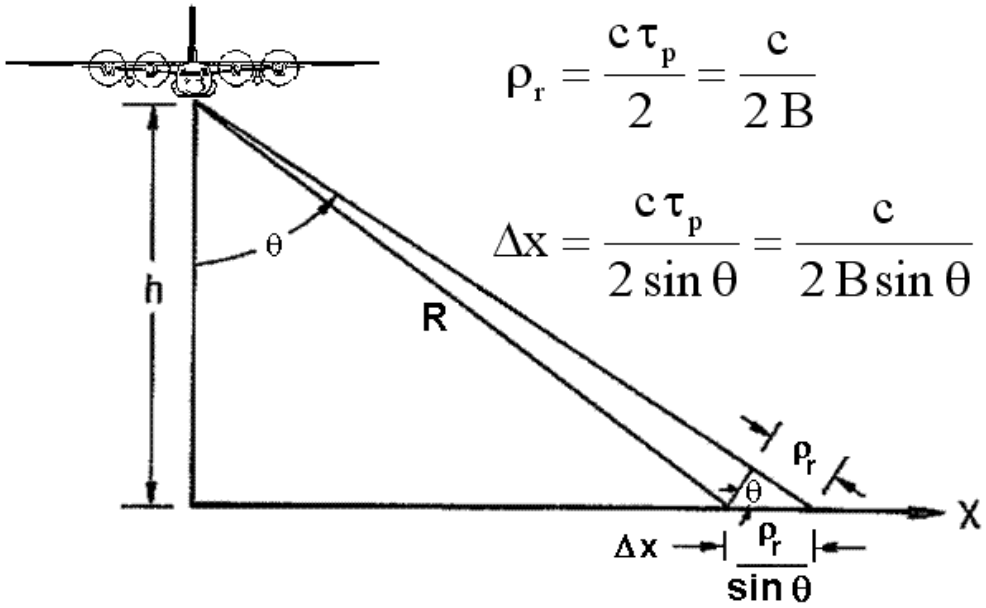
Shadows

Figure 5-10. Perceptual confusion in synthetic aperture radar (SAR) images – images obtained from the side appear like images obtained from overhead.

What is SAR?

Cross-Track Resolution: Δ**x**

- Larger angle θ → better cross-track resolution.
- Projection of range resolution ρ onto the ground plane.



$$\rho_r = \frac{c\tau_p}{2} = \frac{c}{2B}$$

$$\Delta x = \frac{c\tau_p}{2\sin\theta} = \frac{c}{2B\sin\theta}$$

Along-Track Resolution: Δ**y**

- Δy = L/2 (focused SAR), L = along-track antenna length
- $\Delta y = \sqrt{R\lambda/2}$ (unfocused SAR), R = range to target

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What is SAR?

Unfocused vs. Focused SAR

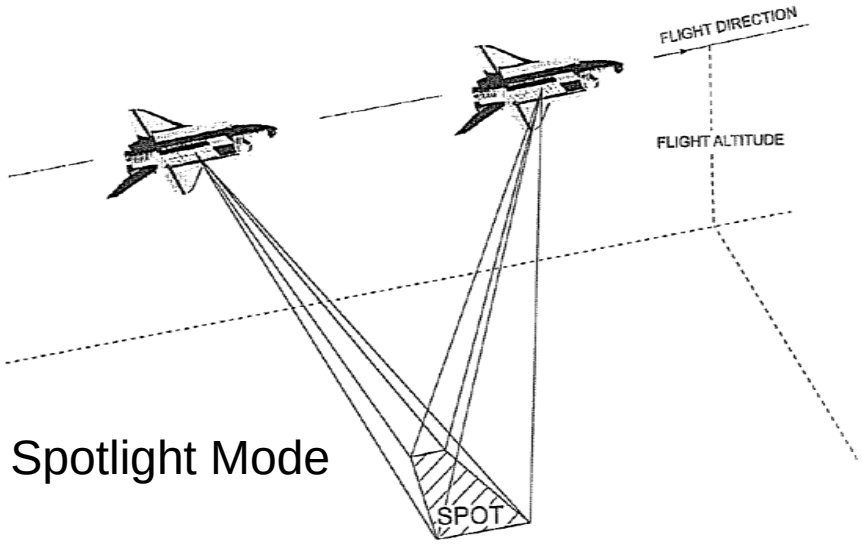
1. Unfocused SAR uses simpler signal processing algorithms at the cost of reduced along-track resolution.

2. Focused SAR performs *2D matched filtering* to obtain the highest resolution at the cost of more complicated signal processing.

What is SAR?

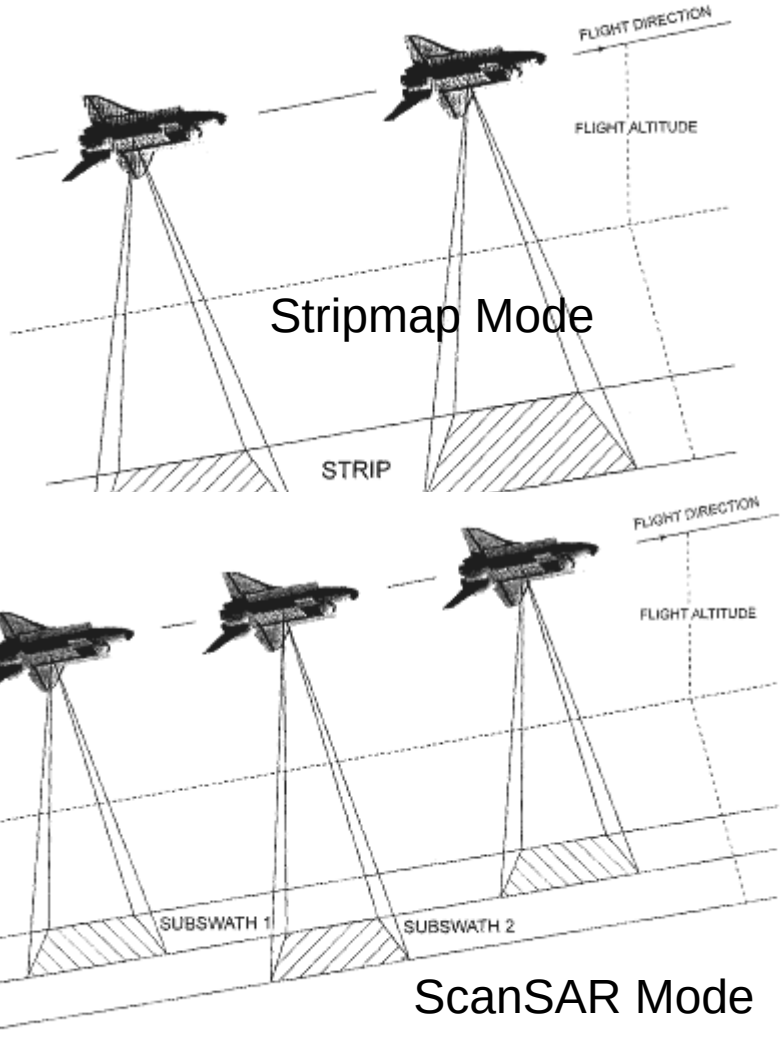
SAR Mode Examples

- SAR sensors use different modes to obtain different viewing areas and resolutions.



Spotlight Mode

FIGURE 14 Spot SAR operation mode.



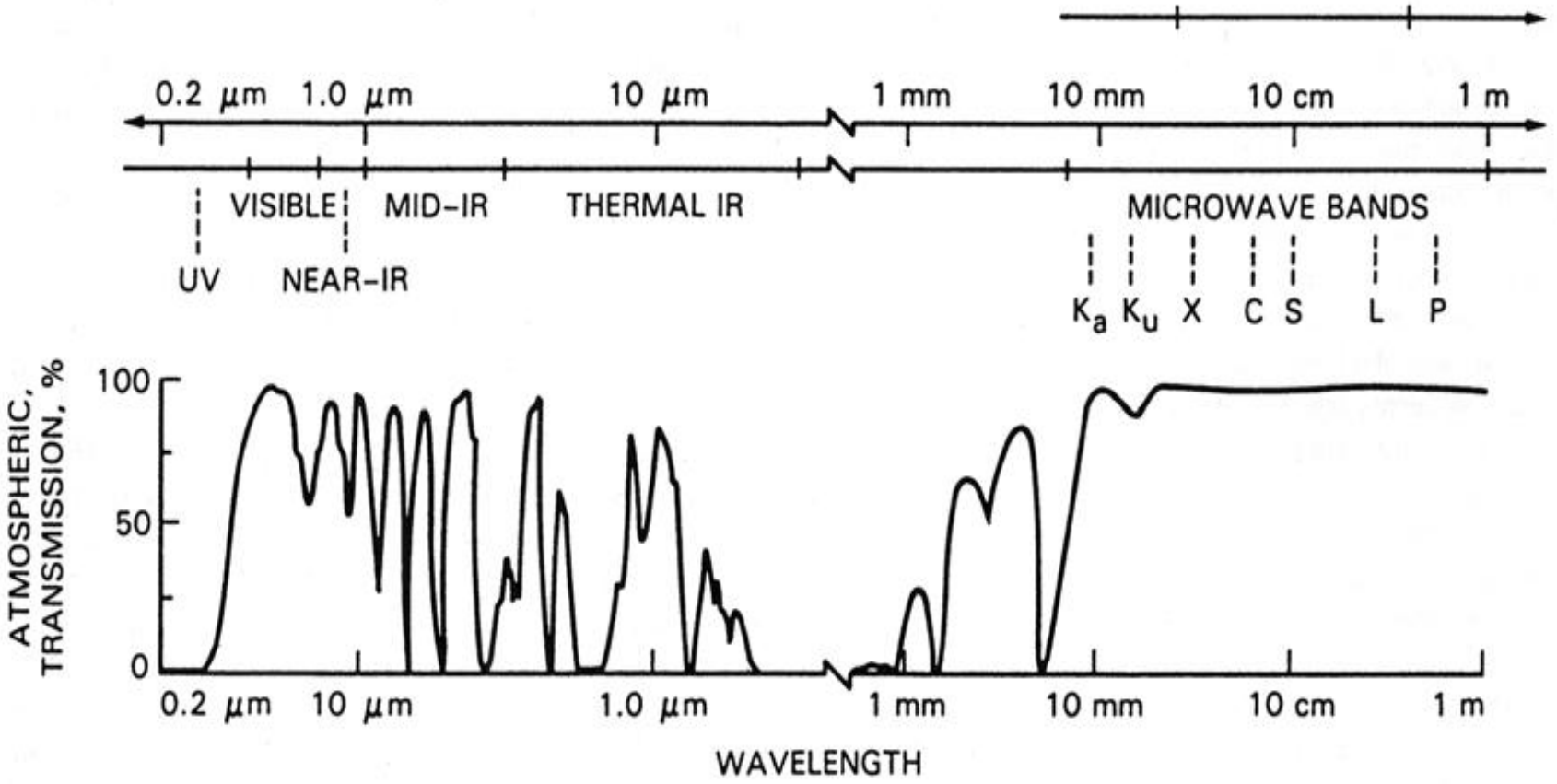
Stripmap Mode

ScanSAR Mode

FIGURE 13 Scan SAR operation mode; two-subswath case. Compared to real operations, azimuth swath dimension is significantly reduced to highlight stepping function.

Operating Frequencies of Some SAR Systems

SAR is an active source, all weather, day or night imaging system.



Atmospheric Transmission of Electromagnetic Waves in Spectral Areas of Visible Light and Different Radar Bands. (NASA 1989)

Some Satellite-Based SAR Sensors

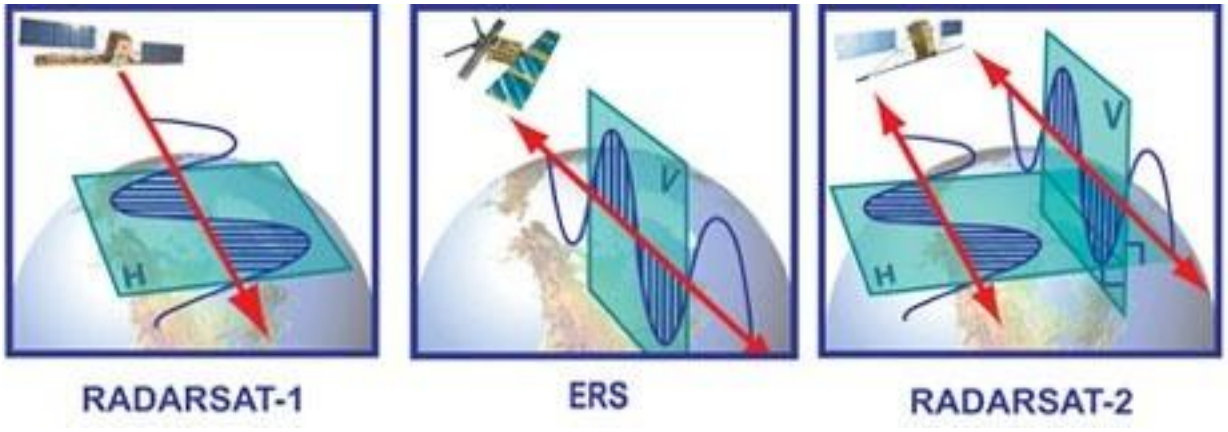
PALSAR
http://www.palsar.ersdac.or.jp/e/product/sample.html
TSX and RS
http://www.infoterra.de/tsx/freedata/start.php ftp://ftp.mda.ca/

Sensor Name	Year Launched	Resolution	Band
Lacrosse	1988	1 m	X
ERS-1	1991	26 m	C
J-ERS-1	1992	18 m	L
RADARSAT-1	1995	10 m	C
ENVISAT	2002	25 m	C
TerraSAR-X	2006	1 m	X
RADARSAT -2	2005	3 m	C
SAR-Lupe	2005	1 m	X
IGS-2b	2008	30 cm	X
COSMO Skymed	2008/2009	1 m	X
PALSAR	2006	10 m	L

Cross Polarized vs. Co-Polarized

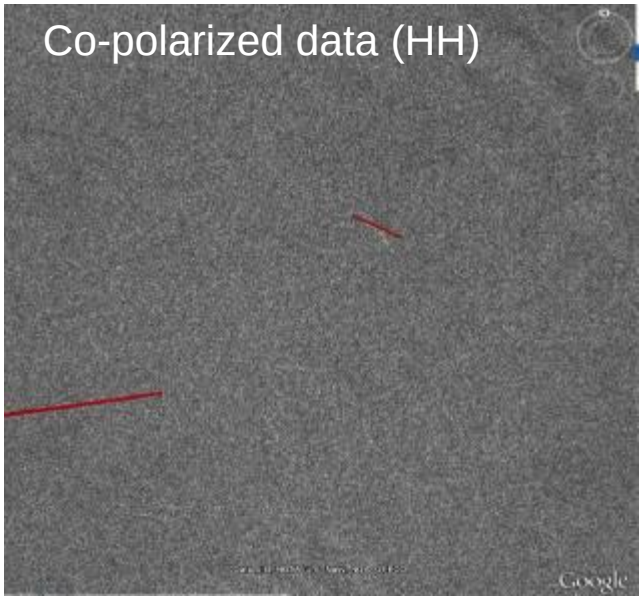
- In radar, energy is transmitted with either horizontal or vertical linear polarization, and similiarly received as either horizontal or vertically polarized energy.

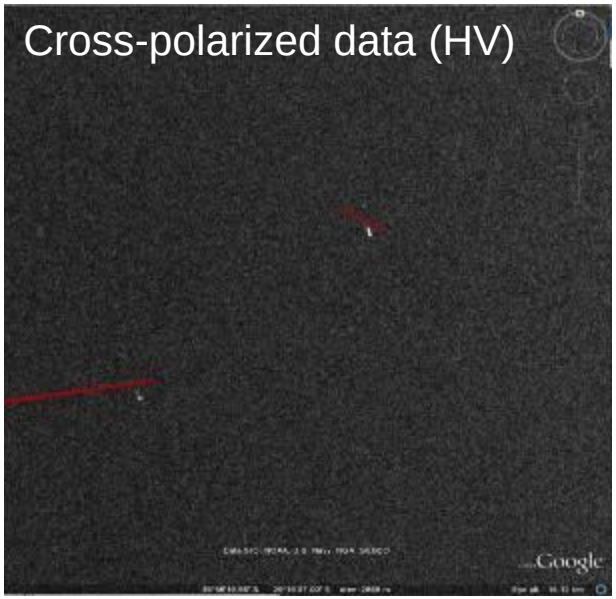
- RADARSAT-2 and TerraSAR-X are capable of transmitting both horizontally and vertically polarized energy simultaneous, and likewise receiving both horizontally and vertically polarized energy simultaneously, giving 4 possible polarization combinations:
  - -HH: transmit in H, receive in H
  - -HV: transmit in H, receive in V
  - -VV: transmit in V, receive in V
  - -VH: transmit in V, receive in H



Polarization (cont.)

Different polarizations are useful for different applications depending on many factors (imaging geometry, weather conditions, specific application, etc).

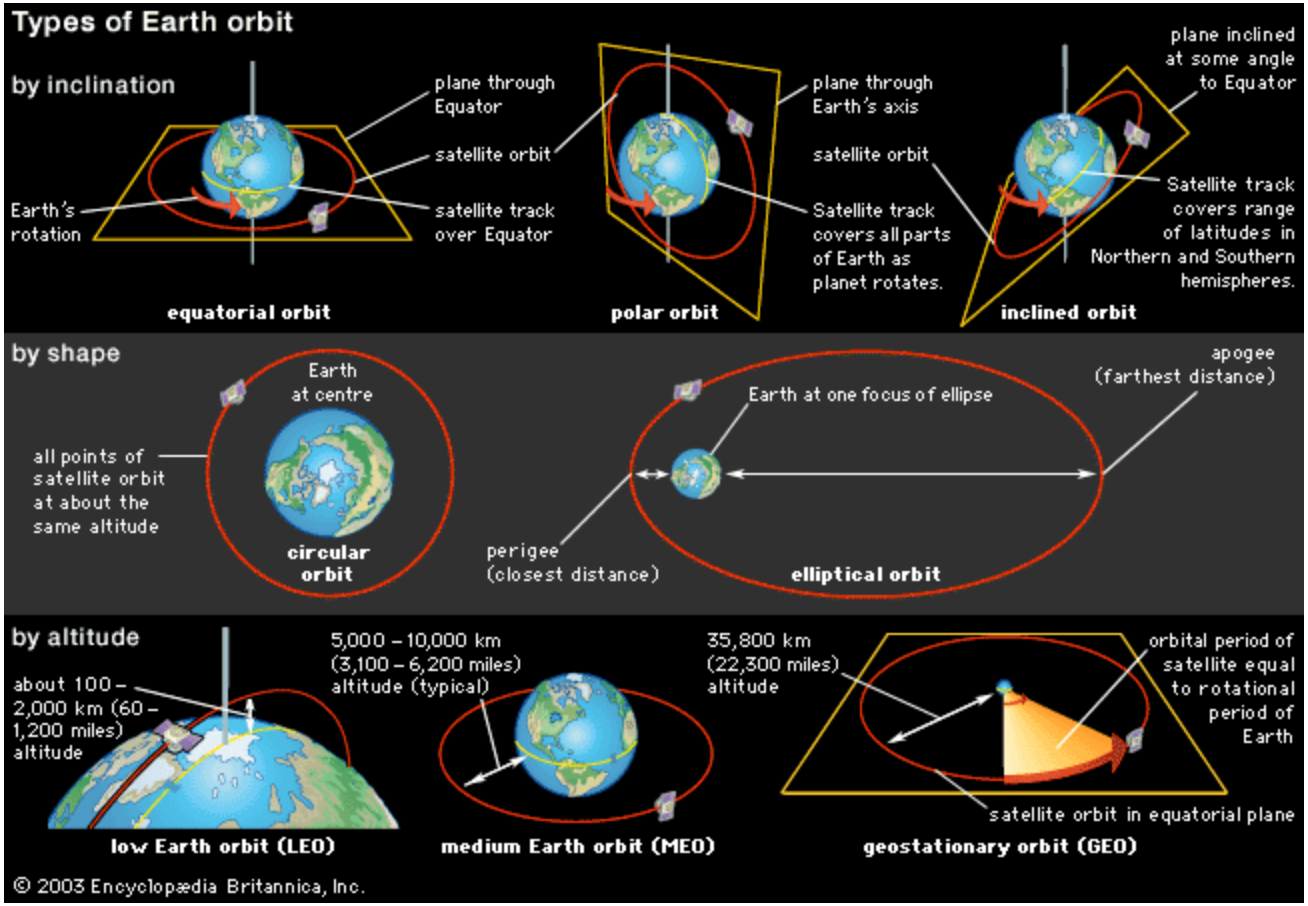




For ship detection at low incidence angles, cross-polarized SAR data provides higher signal to clutter ratio (SCR)

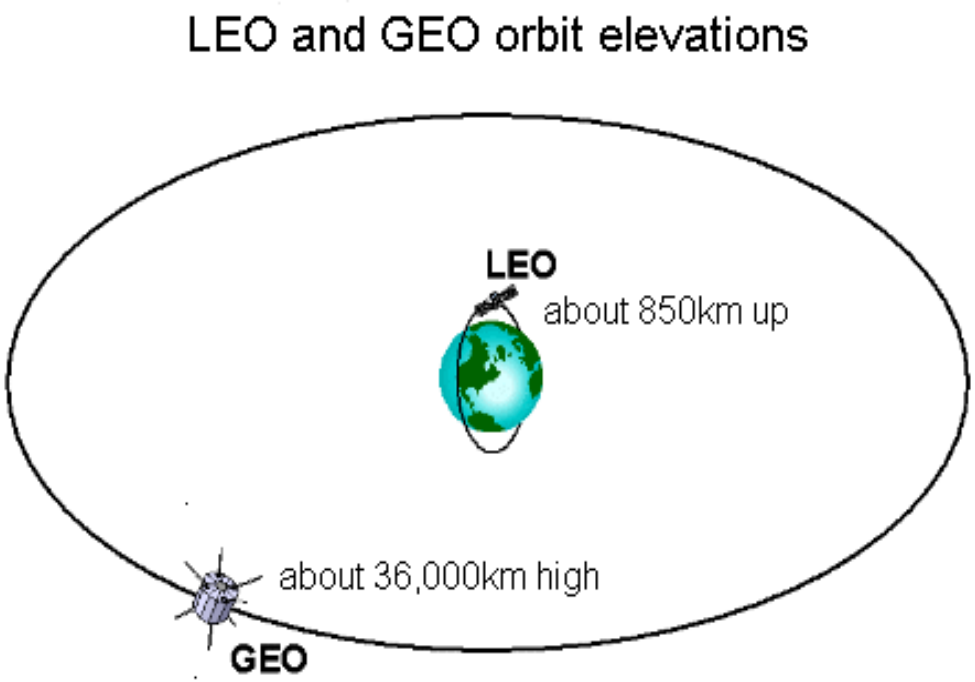
Types of Satellite Orbits

http://www.gearthblog.com/kmfiles/100brightestsatellites.kmz
http://orbitingfrog.com/files/google_earth_files/TrackAnySat.kmz



Orbits: GEO and LEO

The Quickbird imager is in a LEO orbit



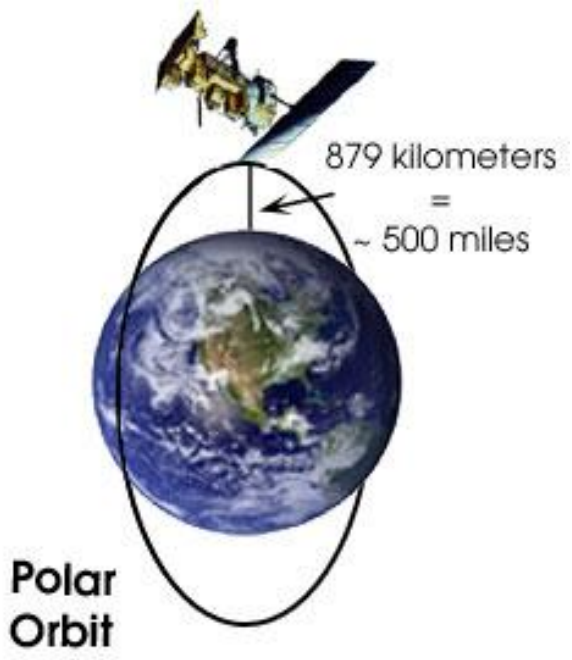
The GOES imager is in a GEO orbit

Geostationary Orbits

A geostationary (GEO=geosynchronous) orbit is one in which the satellite is always in the same position with respect to the rotating Earth. The satellite orbits at an elevation of approximately 35,790 km because that produces an orbital period (time for one orbit) equal to the period of rotation of the Earth (23 hrs, 56 mins, 4.09 secs). By orbiting at the same rate, in the same direction as Earth, the satellite appears stationary (synchronous with respect to the rotation of the Earth). Geostationary satellites provide a "big picture" view, enabling coverage of weather events. This is especially useful for monitoring severe local storms and tropical cyclones. Because a geostationary orbit must be in the same plane as the Earth's rotation, that is the equatorial plane, it provides distorted images of the polar regions with poor spatial resolution.

Orbits: Polar is a Type of LEO

The Terra and Aqua are in Polar orbits

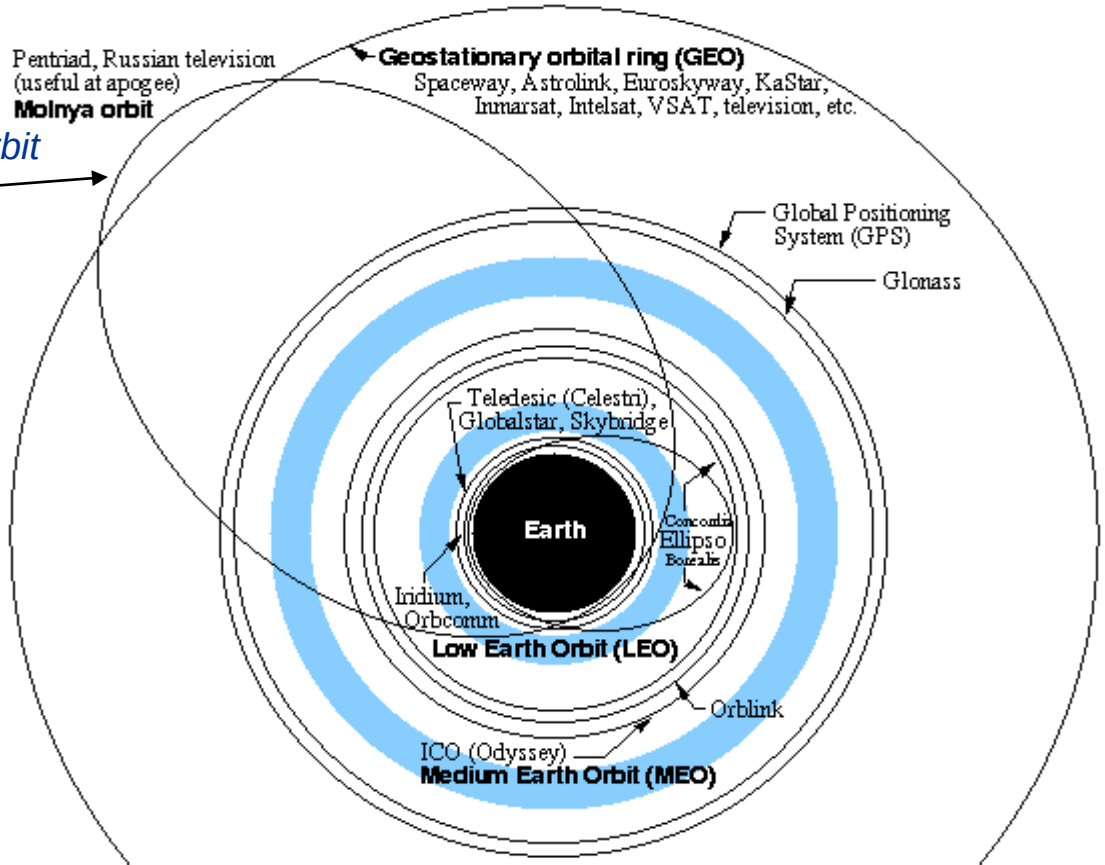


Polar Orbits

Polar-orbiting satellites provide a more global view of Earth, circling at near-polar inclination (the angle between the equatorial plane and the satellite orbital plane -- a true polar orbit has an inclination of 90 degrees). Orbiting at an altitude of 700 to 800 km, these satellites cover best the parts of the world most difficult to cover in situ (on site). For example, McMurdo, Antartica, can be seen on 11-12 of the 14 daily NOAA polar-orbiter passes. These satellites operate in a sun-synchronous orbit. The satellite passes the equator and each latitude at the same local solar time each day, meaning the satellite passes overhead at essentially the same solar time throughout all seasons of the year. This feature enables regular data collection at consistent times as well as long-term comparisons. The orbital plane of a sun-synchronous orbit must also rotate approximately one degree per day to keep pace with the Earth's surface.

Orbits: Other Orbits

This is a HEO orbit



Orbital altitudes for satellite constellations

peak radiation bands of the Van Allen belts (high–energy protons)

orbits are not shown at actual inclination; this is a guide to altitude only

from Lloyd's satellite constellations http://www.ee.surrey.ac.uk/Personal/L.Wood/constellations/

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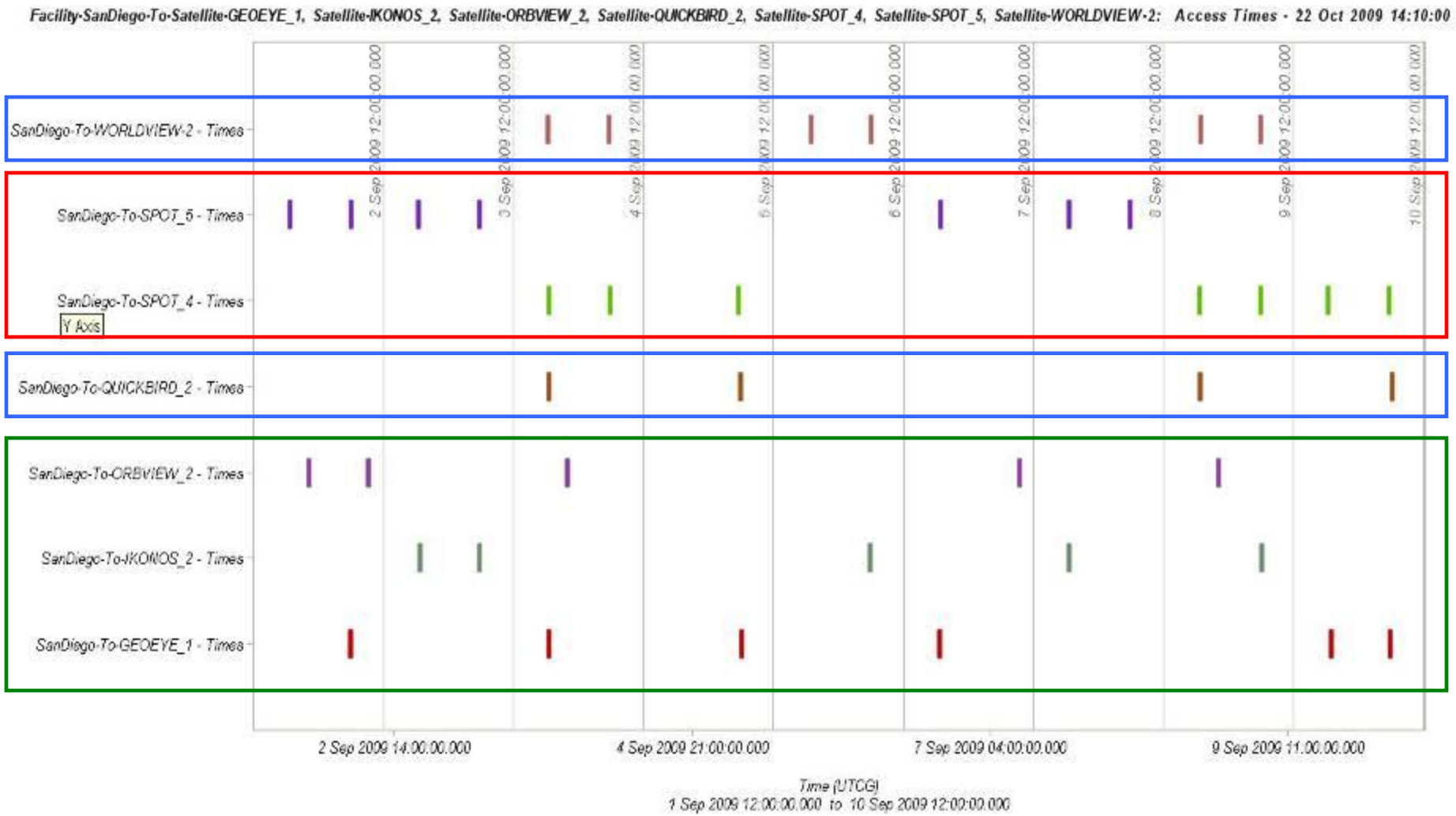
Revisit Rates

SPOT 4/5, Quickbird, Ikonos, GeoEye-1, WorldView-2, Orbview Imaging Opportunities



Importance of Bit Depth

Quickbird Imagery:	**11-bits**
SPOT Imagery:	**8-bits**
TerraSAR-X Imagery:	**16-bits or 32-bits**

8 bits has 256 values it can represent (2^8)

16 bits has 65K values it can represent

- Dynamic range is important for the detection of low contrast / dim objects in EO
- In spectral imagery applications, where spectral signatures play an important role, bit depth plays a key role in being able to detect and classify objects.
- Saturation of imagery may cause a large number of false detects if the object of interest and it's background are at approximately the same gray level. In EO and MS imagery, saturation can occur due to clouds, sand, or other highly reflective surfaces. This saturation results in lower signal to noise ratios between objects of interest and their background (ships against ocean).

SPAWAR Systems Center PACIFIC

Low Resolution Satellite Imagery Resources Overview

Imagery Resources (NASA)

Large Footprint, Low Resolution, Many Spectral Bands

Imagery Resources (NASA) Links

Hyperion/EO-1
http://edcsns17.cr.usgs.gov/EarthExplorer/
http://edcsns17.cr.usgs.gov/eo1/index.php
http://glovis.usgs.gov/

Real Time Satellite Data Animations:
http://www.cira.colostate.edu/RAMM/Rmsdsol/main.html
Animations, no archive, not downloadable

Space Science and Engineering Center:
http://www.ssec.wisc.edu/data/geo.html
Animations, not downloadable

NOAA Satellite Server: http://www.goes.noaa.gov/
Month Long Archive, can't download

Another NOAA Link: http://www.osdpd.noaa.gov/ml/imagery/index.html

Imagery Resources (NASA) Links

Warehouse Inventory Search Tool (WIST): https://wist.echo.nasa.gov/%7Ewist/api/imswelcome/
GEOS, Landsat, MODIS - "order" products from other sources like LAADS

USGS Global Visualization Viewer: http://glovis.usgs.gov/ (interactive search map like EQUIS)
Landsat, MODIS, Hyperion- downloadable from site

Level 1 and Atmosphere Archive and Distribution System (LAADS): http://ladsweb.nascom.nasa.gov/data/
MODIS

Landsat - Free Global Orthorectified Landsat Data: http://www.landsat.org/ortho/index.php
Landsat

OceanColor: http://oceancolor.gsfc.nasa.gov/ (main page)
Seawifs and other search choices (MODIS, CZCS, MERIS-Envisat) - http://oceancolor.gsfc.nasa.gov/cgi/browse.pl?sen=sw&typ=GAC

USGS National Map Seamless Server: http://seamless.usgs.gov/index.php
Download International Data - http://seamless.usgs.gov/website/seamless/viewer.htm?startbottom=-85.0&starttop=85.0&startleft=-179.5&startright=179.5&limitbottom=-85.0&limittop=85.0&limitleft=-179.5&limitright=179.5

USDA - US Data only http://datagateway.nrcs.usda.gov/NextPage.aspx?HitTab=1&Progress=0

NASA Visible Earth - http://visibleearth.nasa.gov/