Multispectral Remote Sensing Systems

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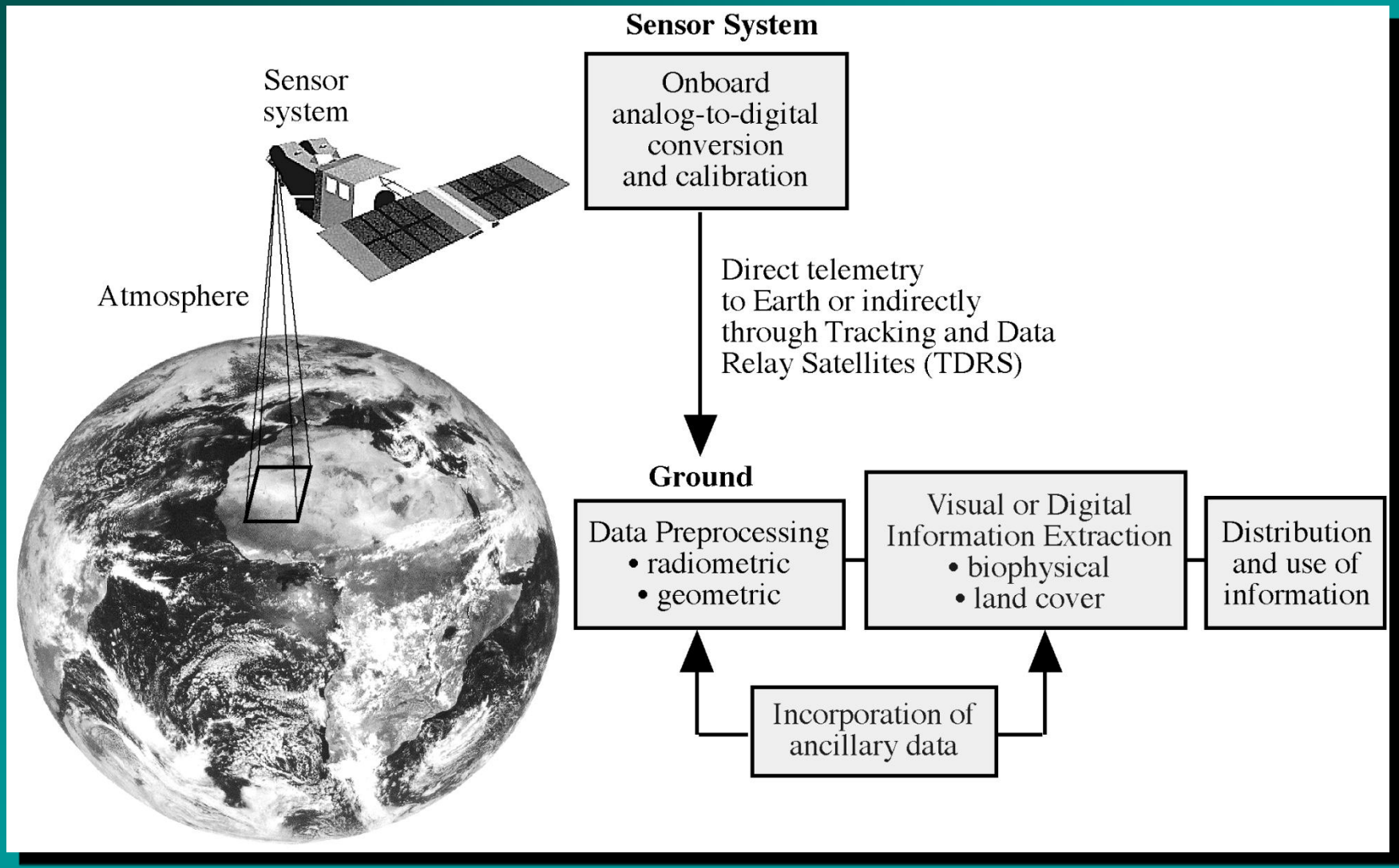
Overview



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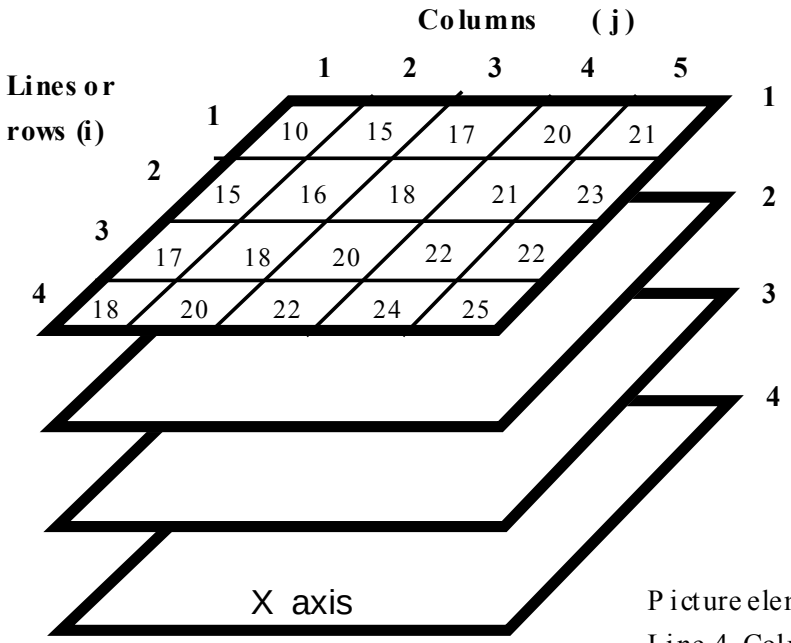
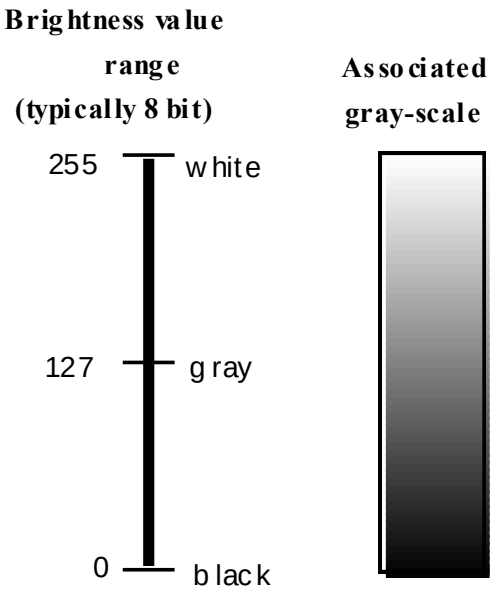
Remote Sensing Raster (Matrix) Data Format





Picture element (pixel) at location Line 4, Column 4, in Band 1 has a Brightness Value of 24, i.e., $BV_{4,4,1} = 24$.

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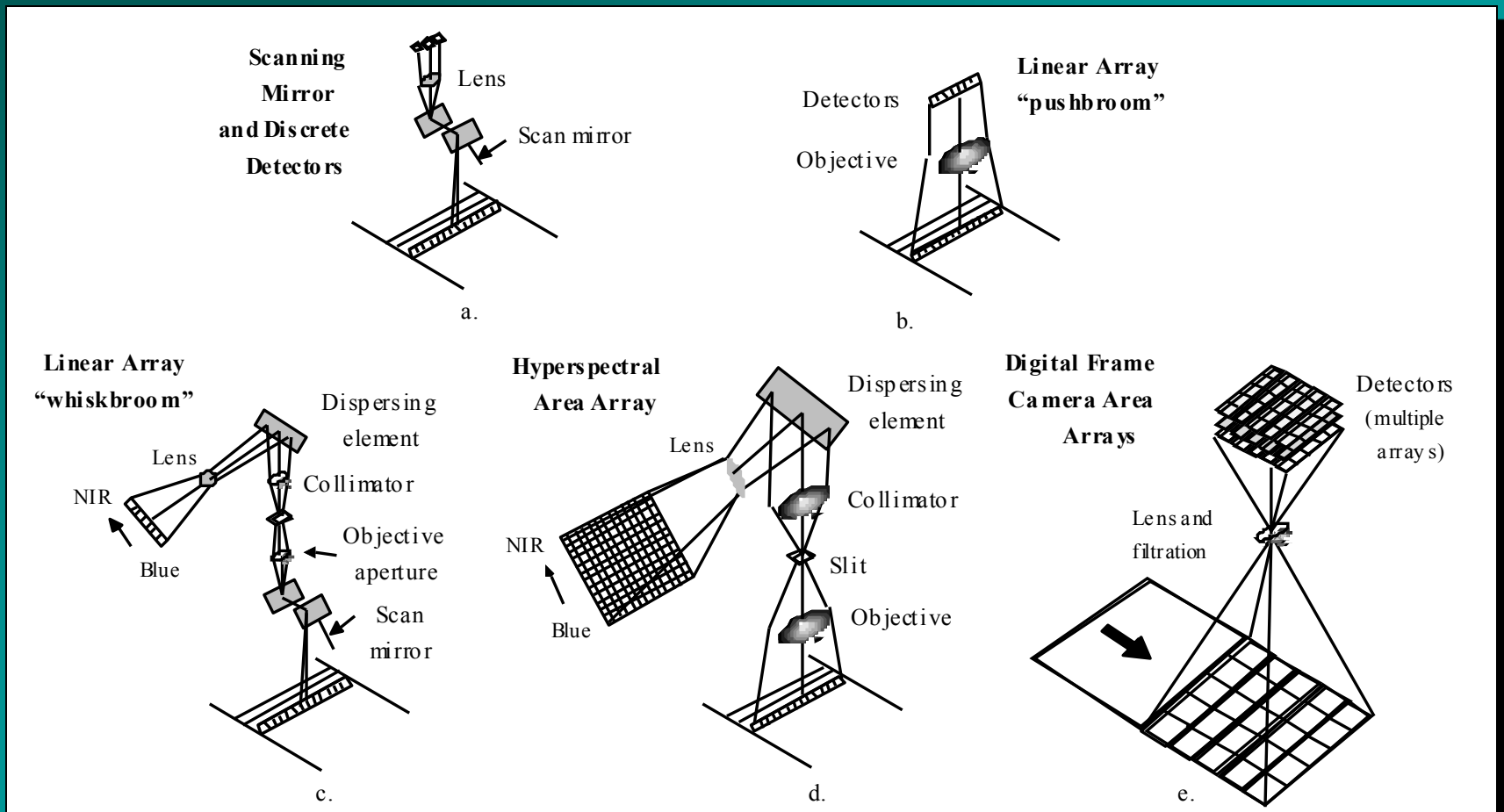
Types of Detector Configurations Used for Multispectral and Hyperspectral Remote Sensing



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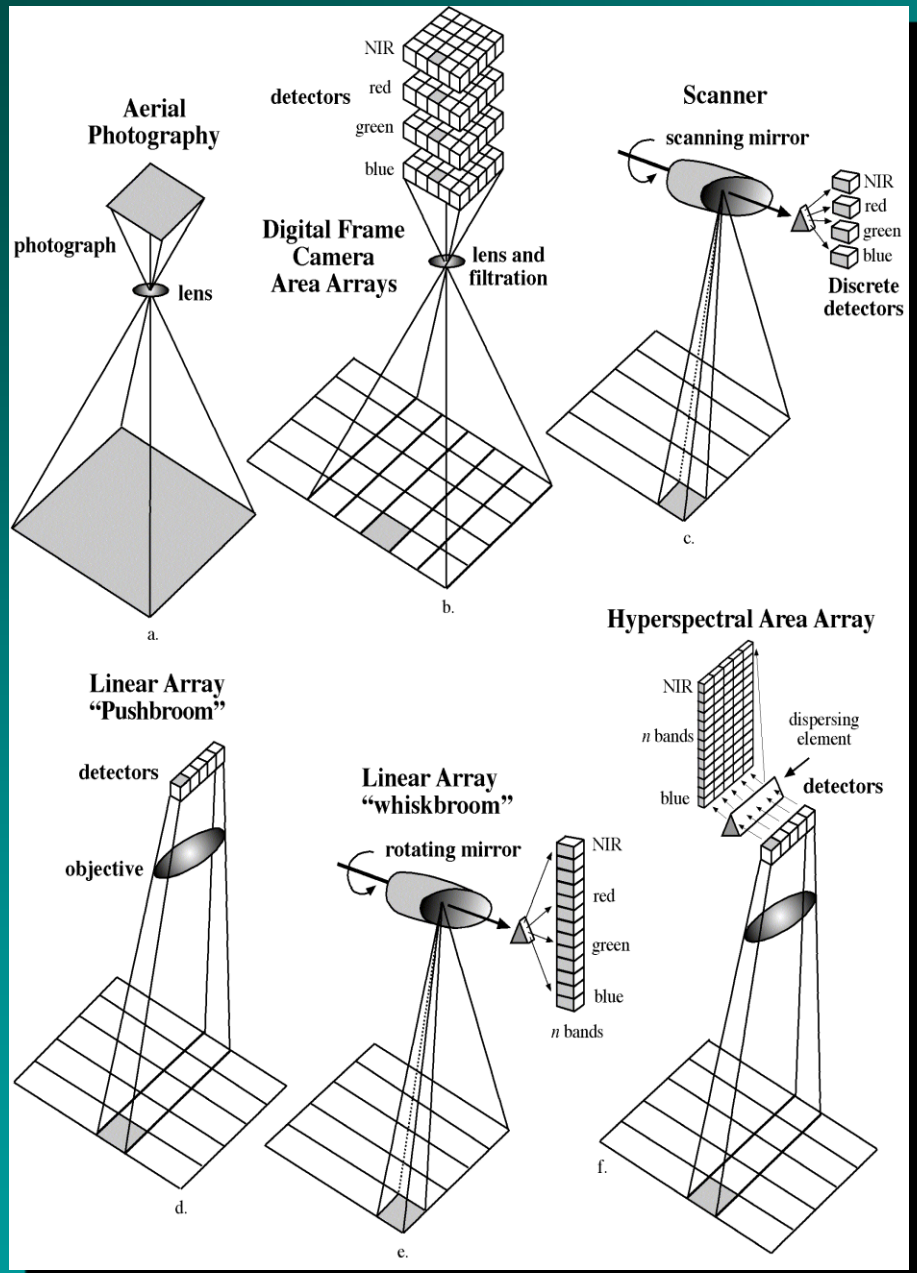
Detector Configurations Used for Panchromatic, Multispectral and Hyperspectral Remote Sensing



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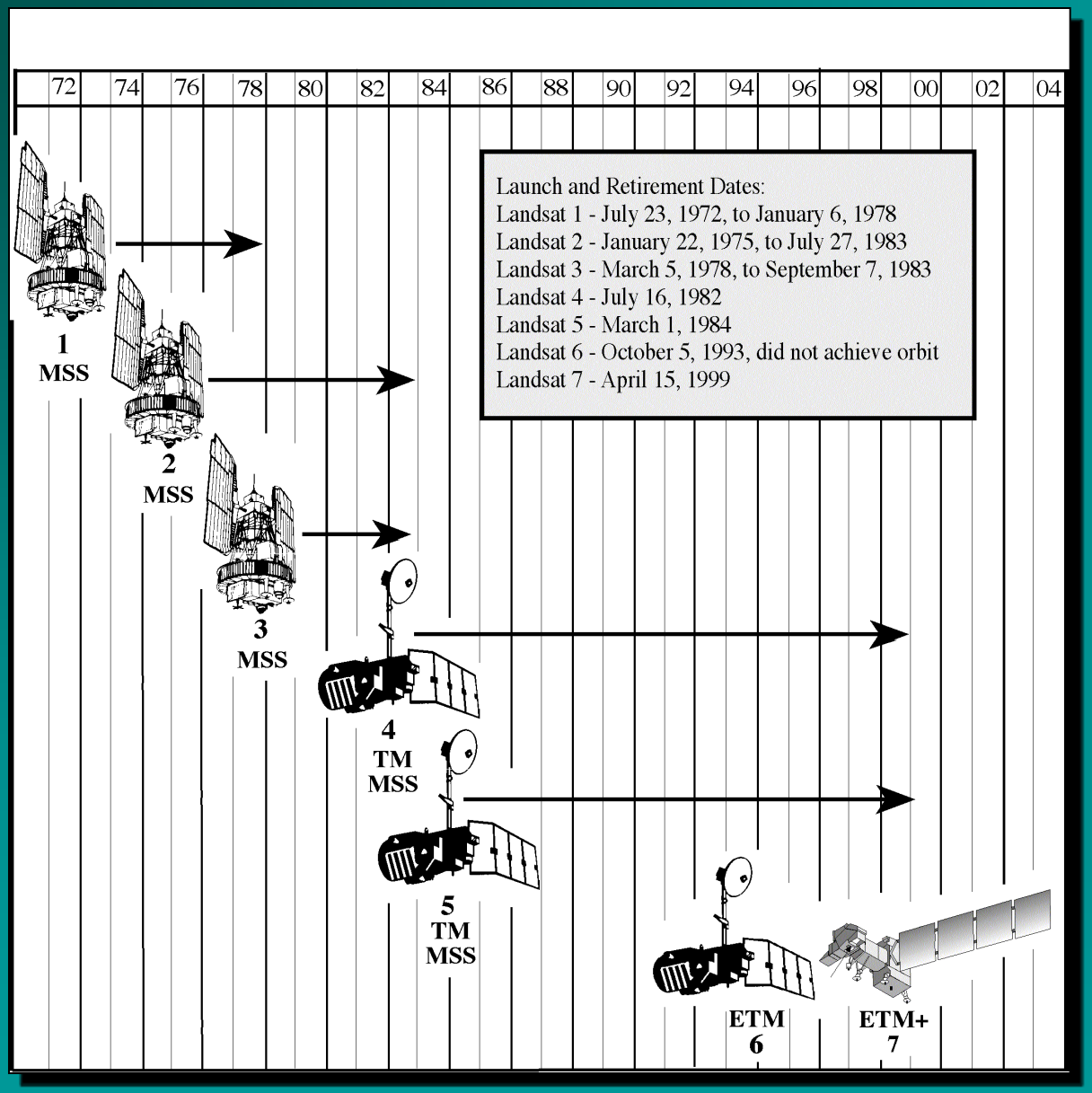
Chronological Launch and Retirement History of the Landsat Satellite Series



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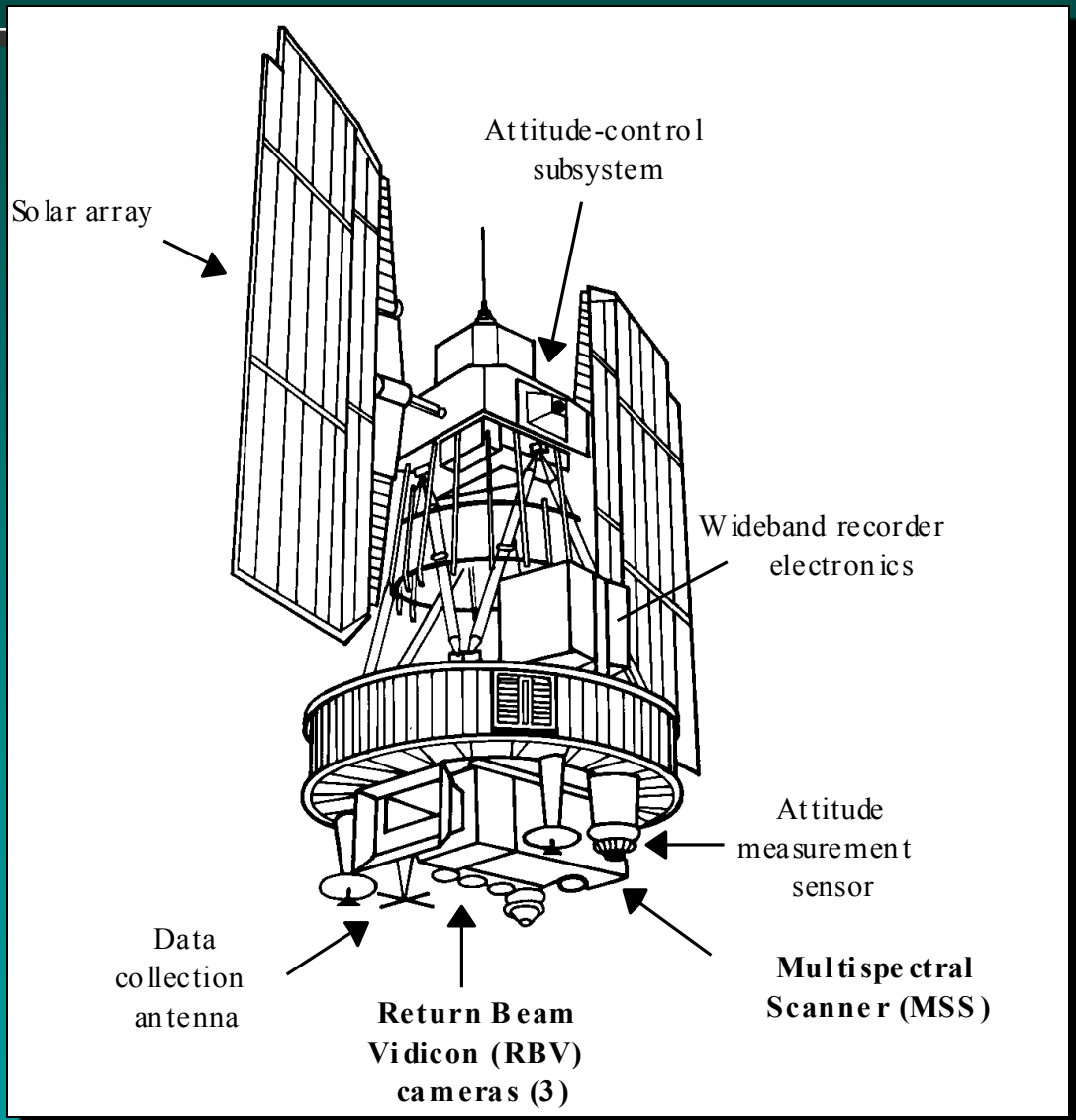
Landsat Multispectral Scanning System (MSS)



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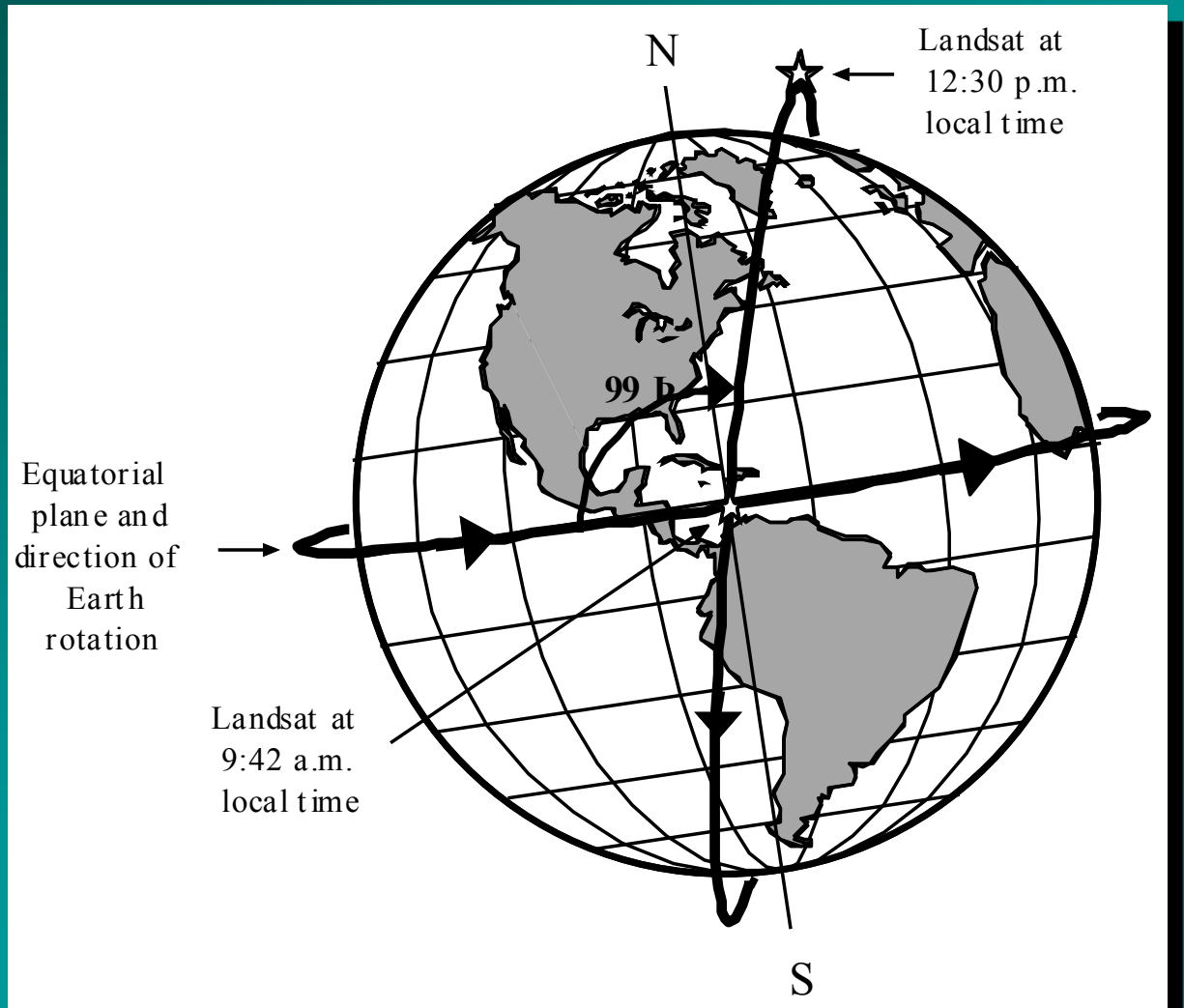
Inclination of the Landsat Orbit to Maintain A Sun-synchronous Orbit



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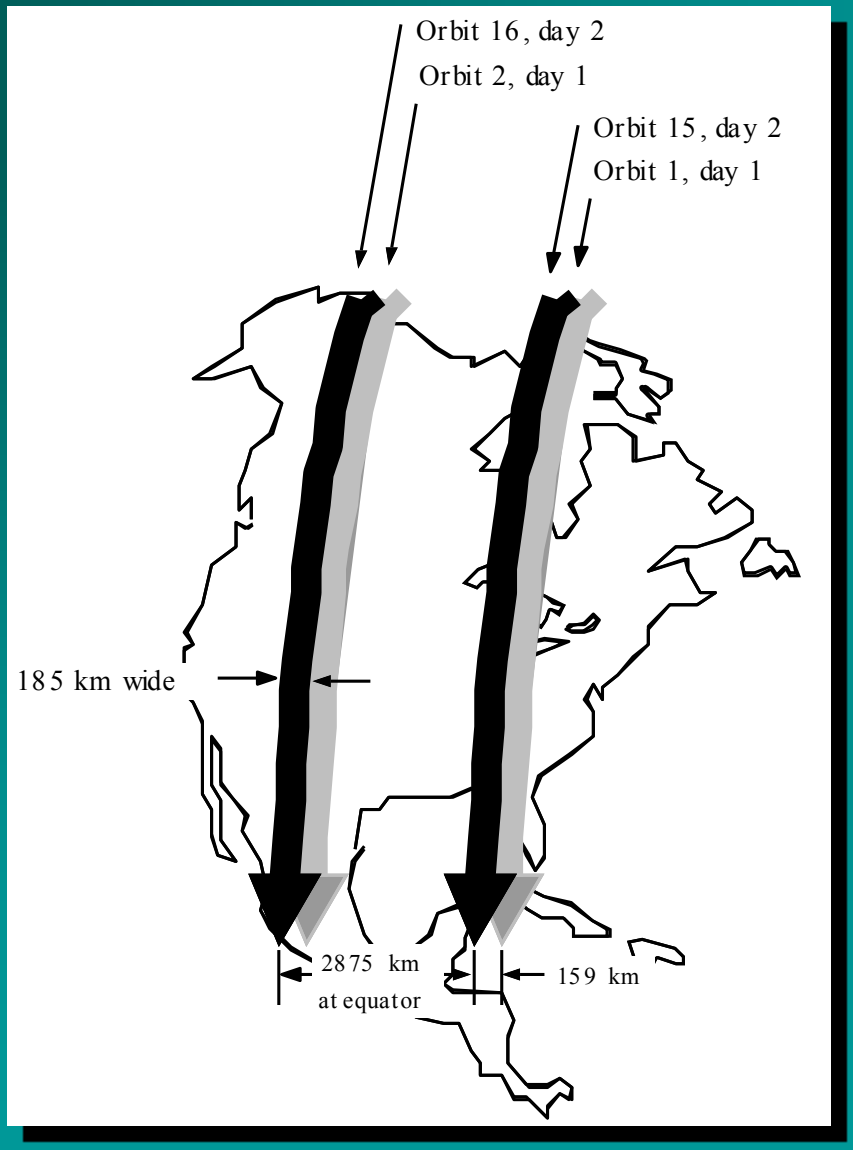
Landsat Multispectral Scanning System (MSS) Orbit



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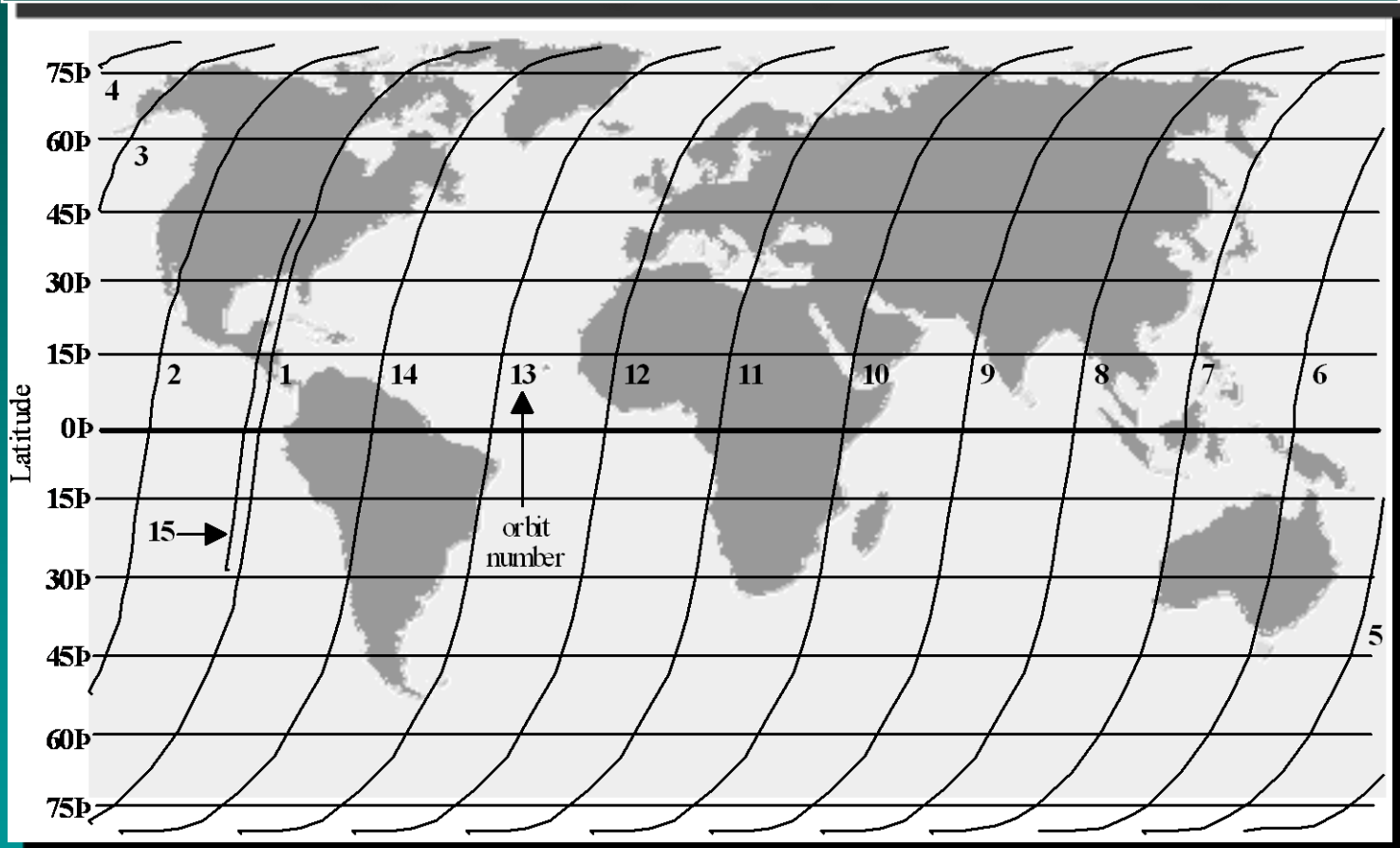
Orbit Tracks of Landsat 1, 2, or 3 During A Single Day of Coverage



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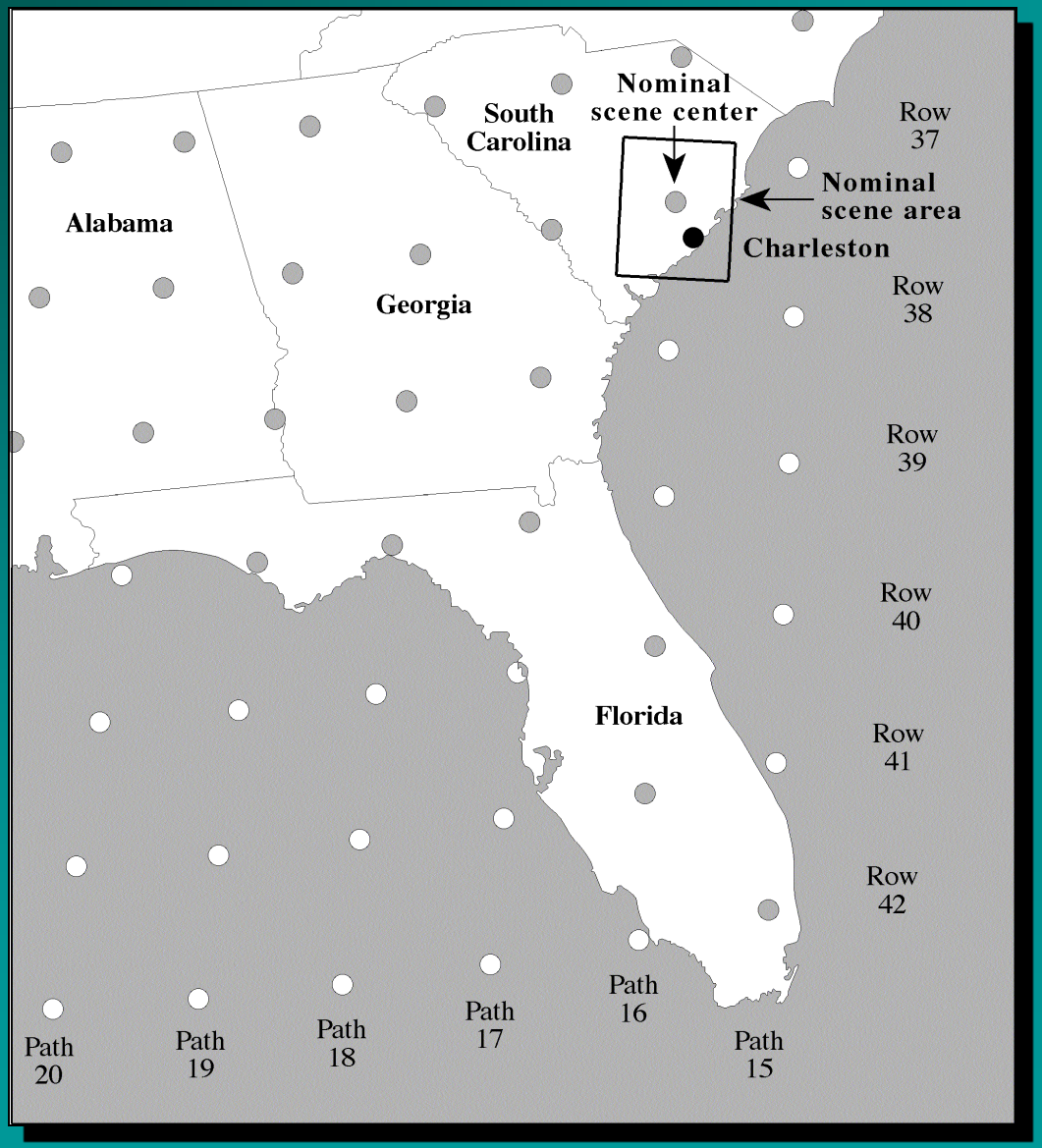
Landsat 4 and 5 Worldwide Reference System



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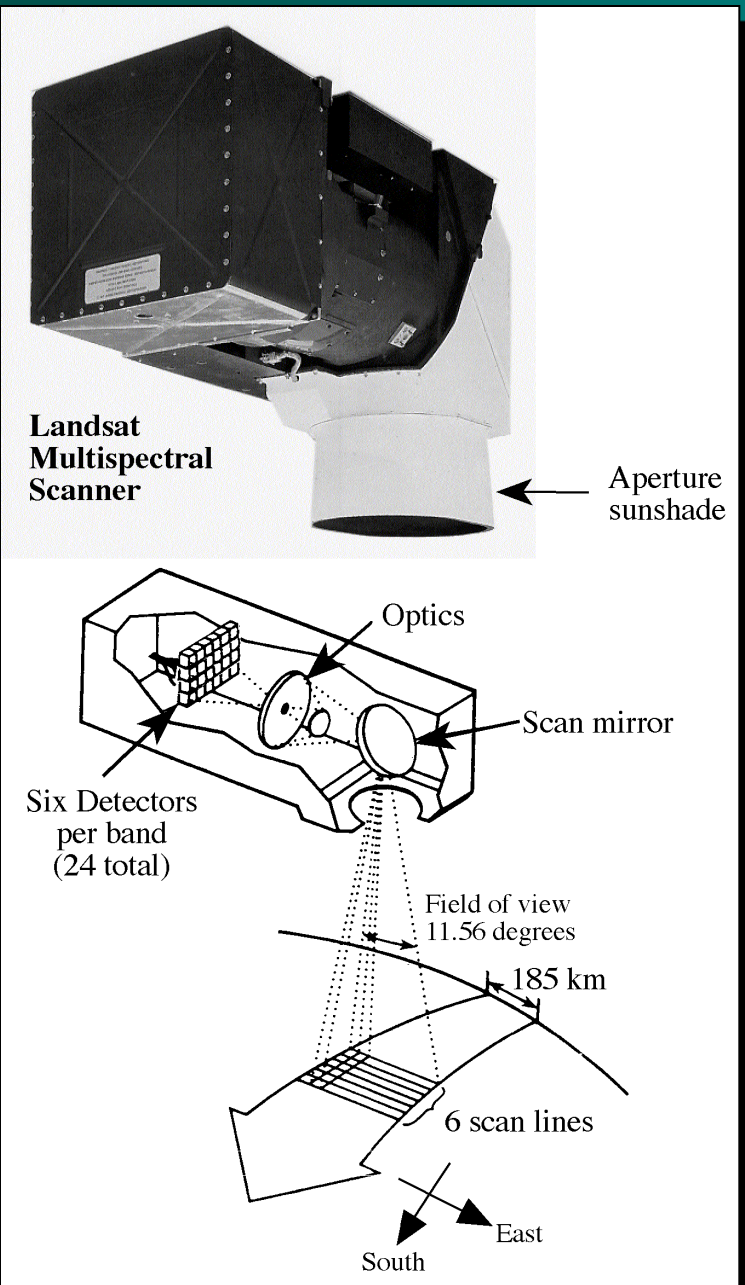
Components of the Landsat Multispectral Scanner (MSS) System on Landsat 1 Through 5



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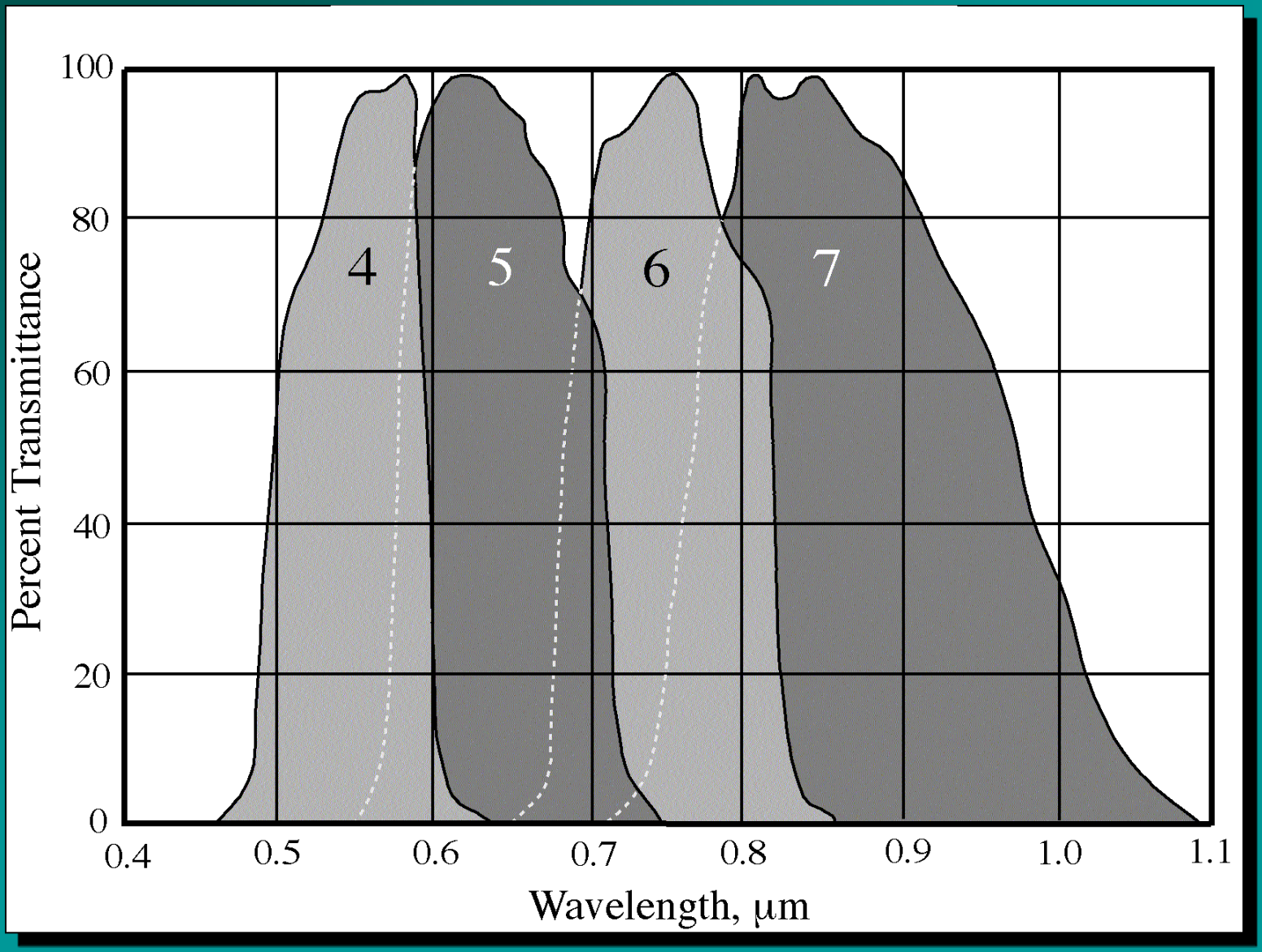
Landsat MSS Bandwidths



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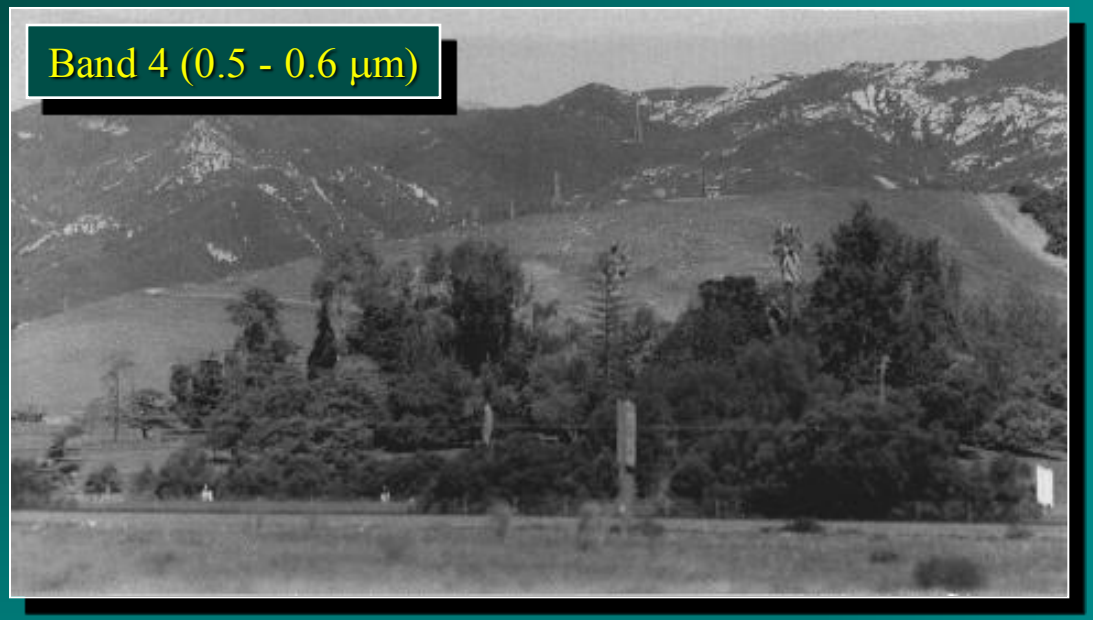

Terrestrial Images of Goleta, CA Obtained on March 4, 1972 Using the Landsat MSS

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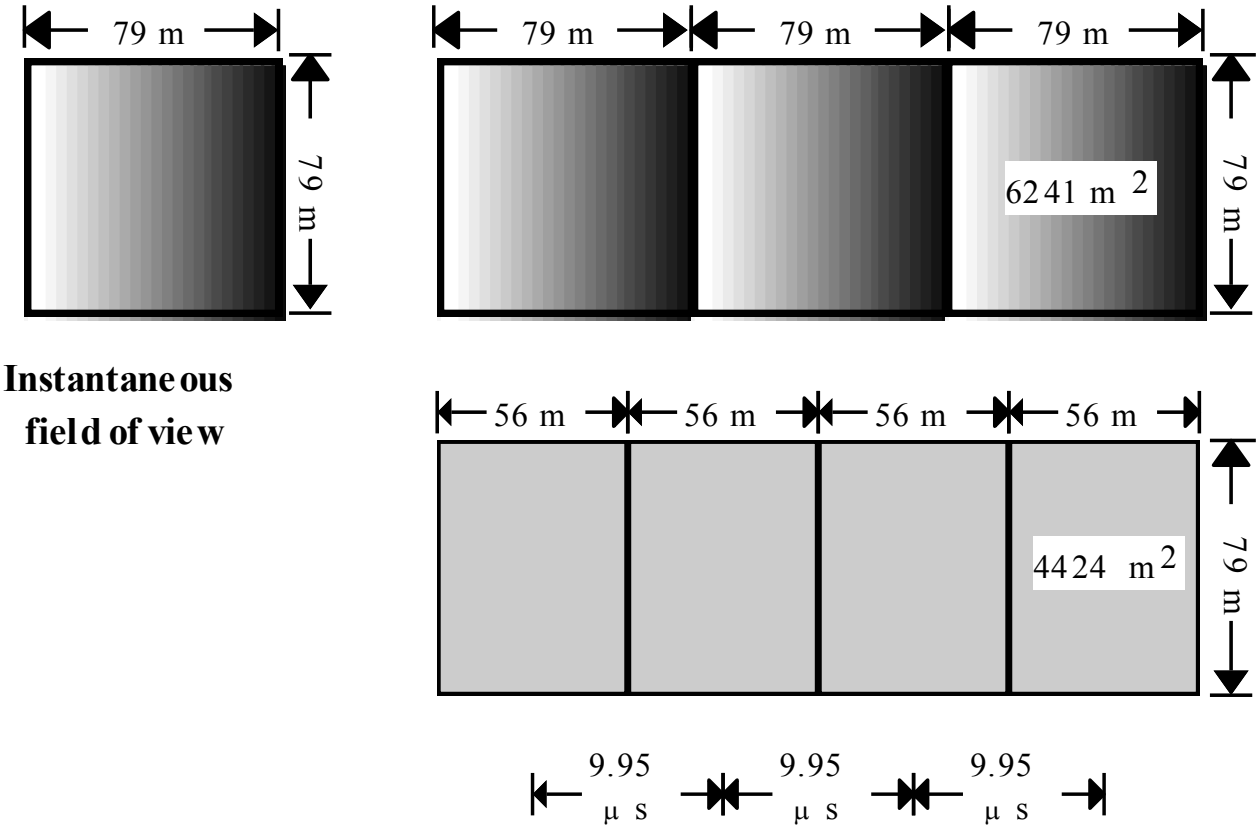
Relationship Between the Original 79 x 79 m IFOV of the Landsat MSS and the Rate at Which It Was Resampled (every 9.95 µs)



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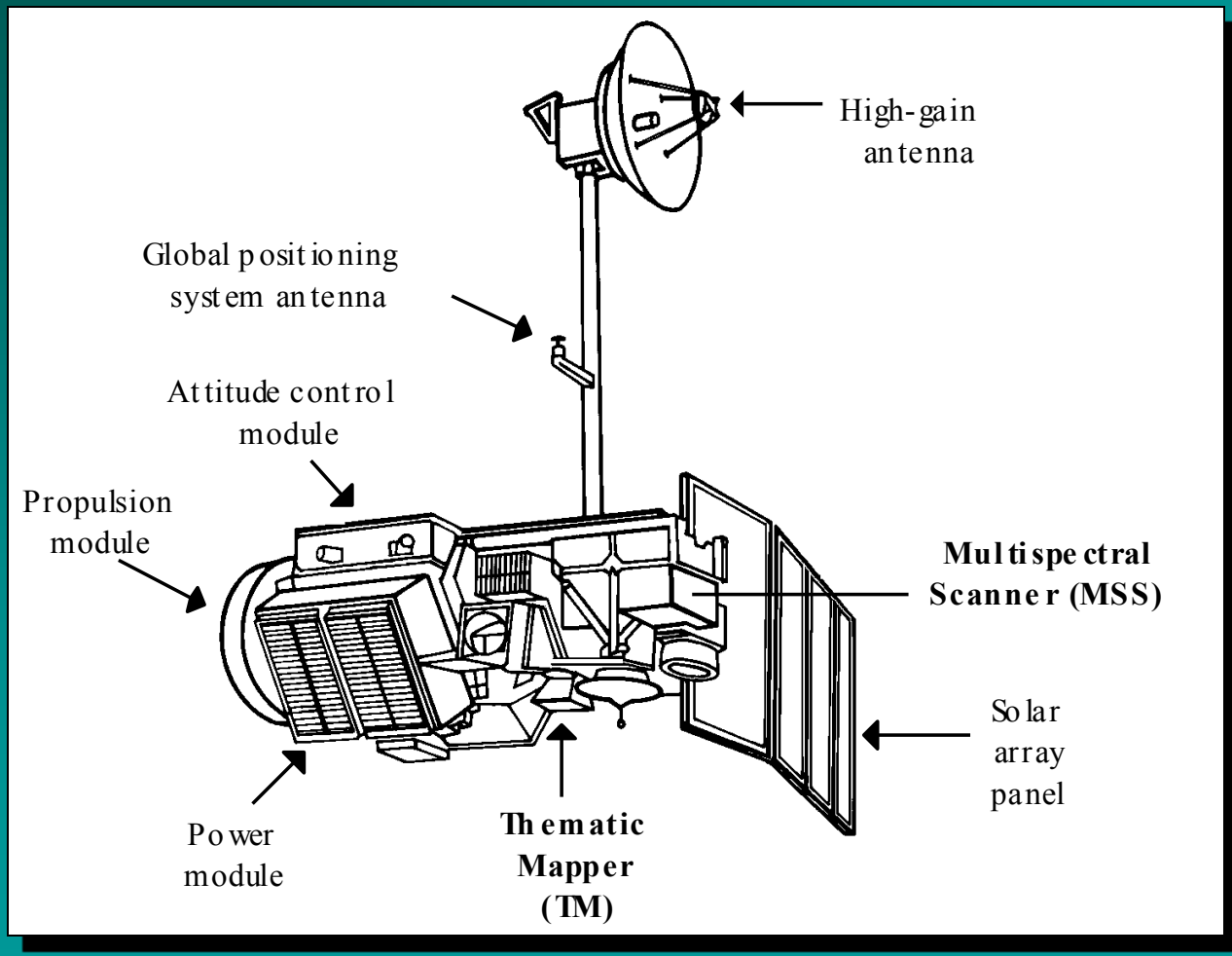
Landsat 4 and 5 Platform with Associated Sensor and Telecommunication Systems



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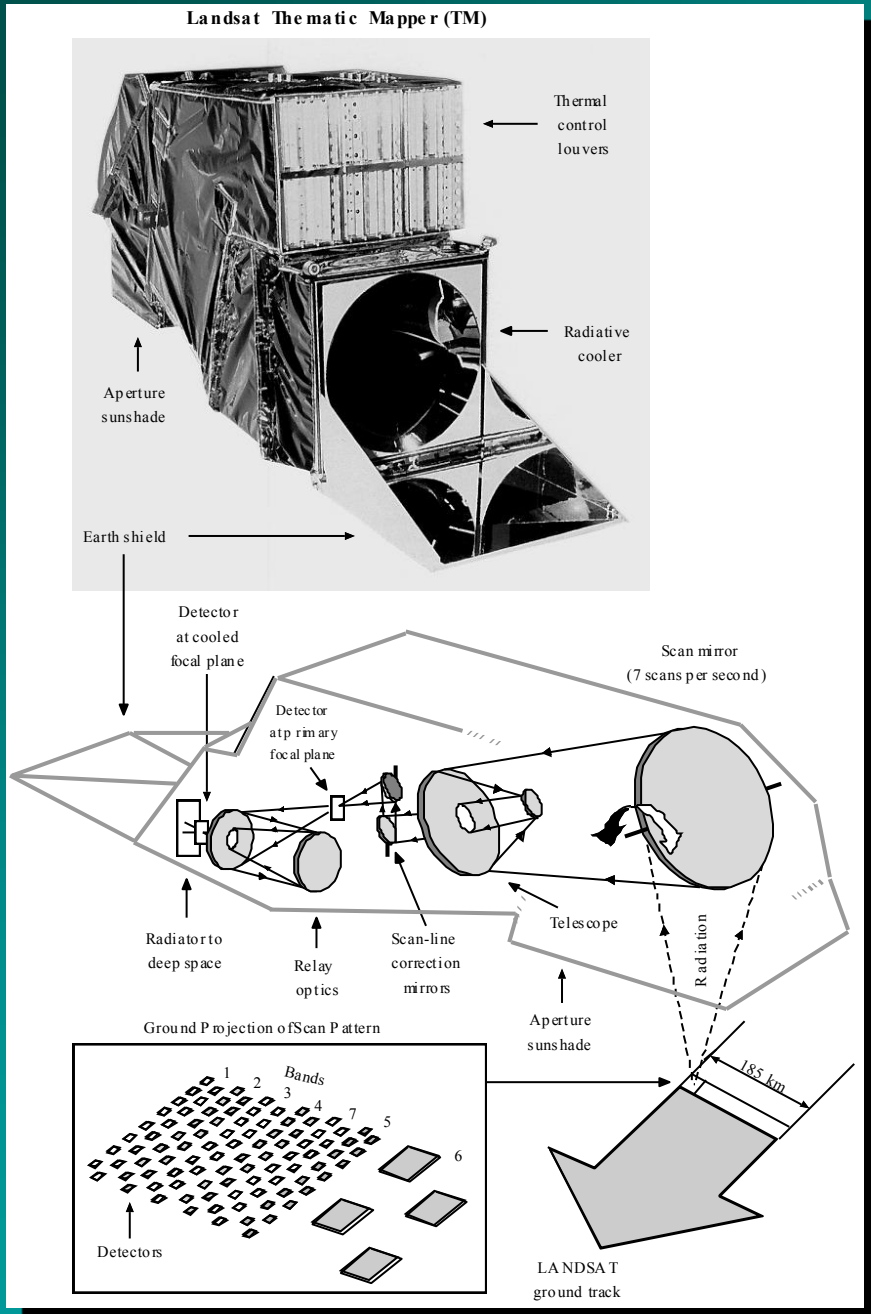
Components of the Landsat 4 and 5 Thematic Mapper



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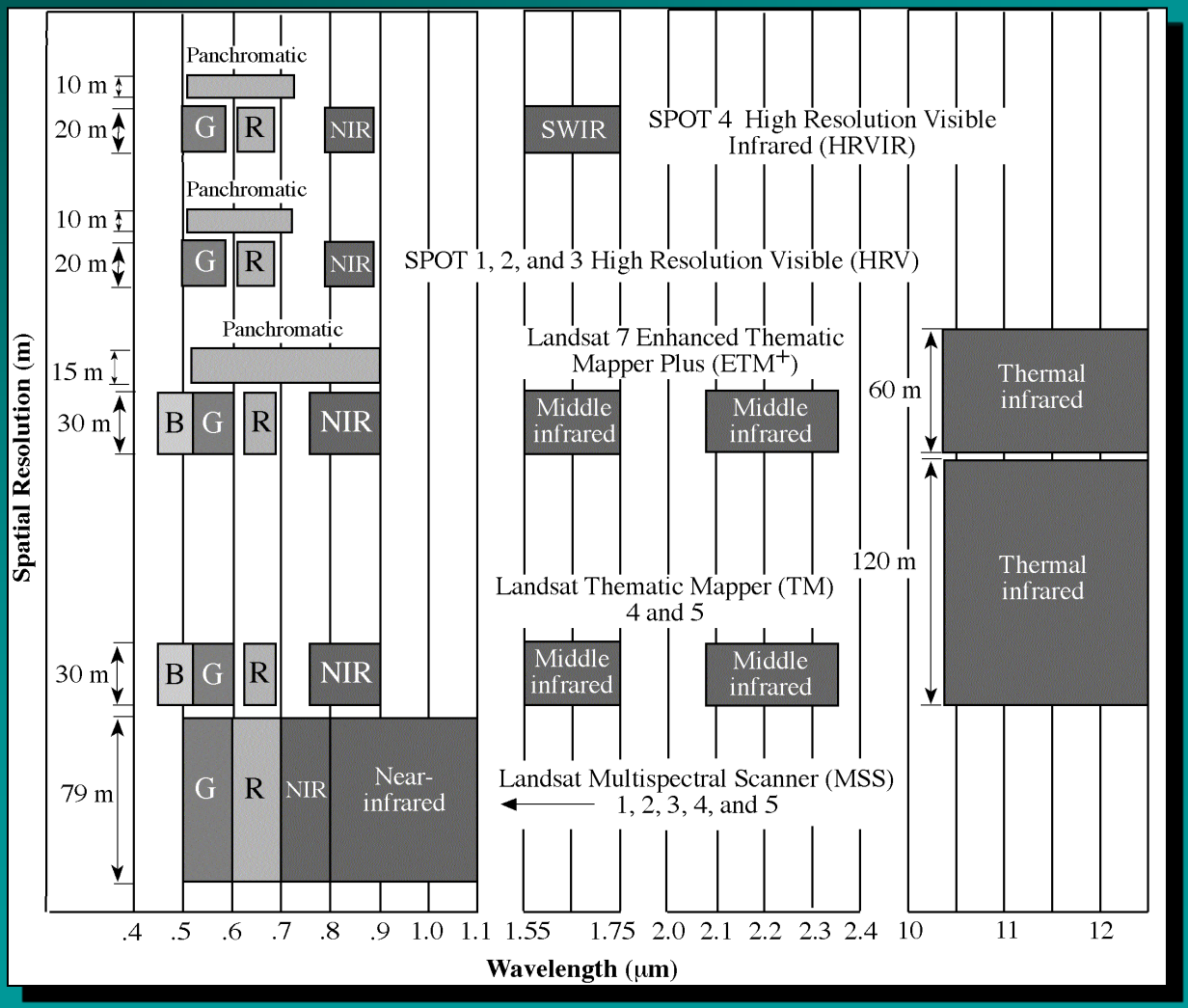
Spectral and Spatial Resolution of the Landsat Multispectral Scanner (MSS), Landsat 4 and 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), SPOT 1, 2, and 3 High Resolution Visible (HRV), and SPOT 4 High Resolution Visible Infrared (HRVIR) Sensor Systems



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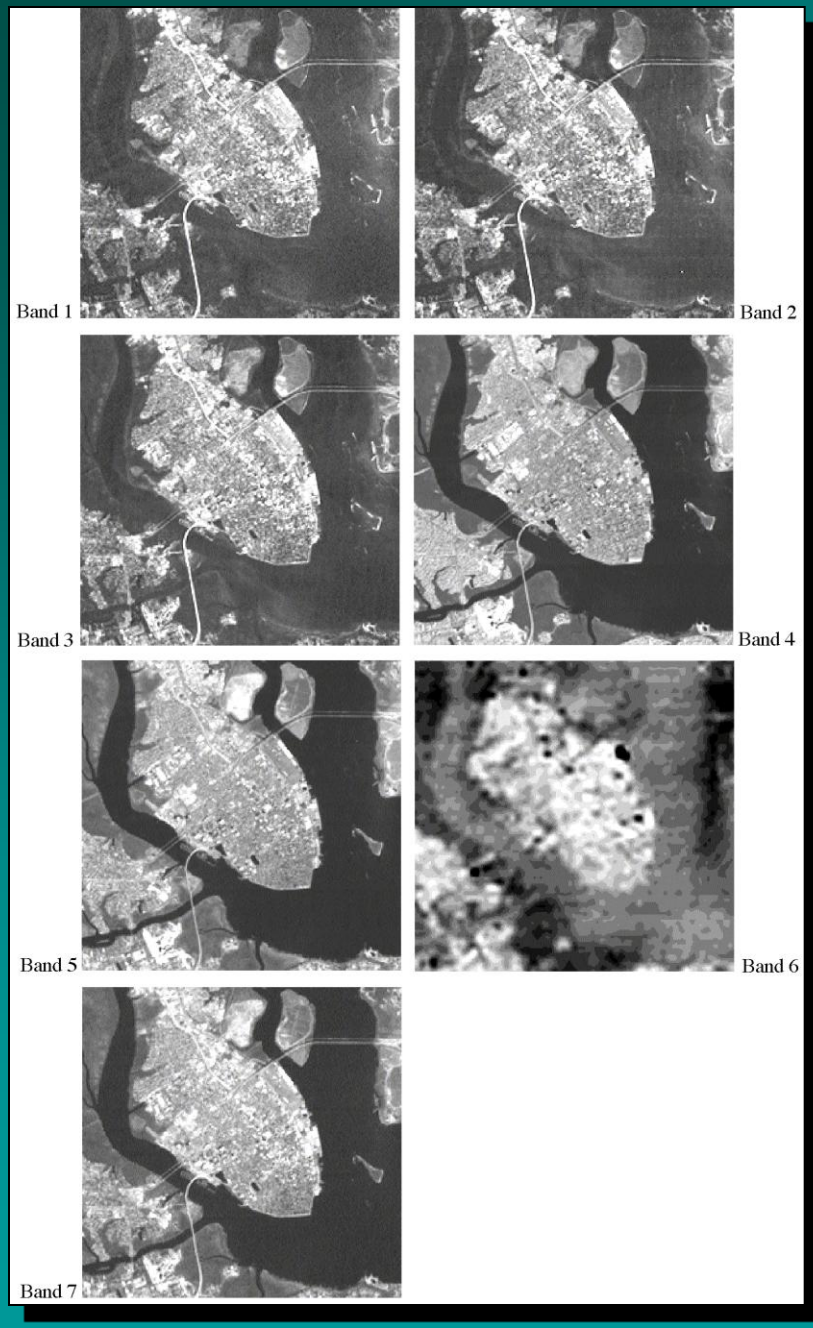

Seven Bands of Landsat Thematic Mapper Data of Charleston, SC, Obtained on February 3, 1994

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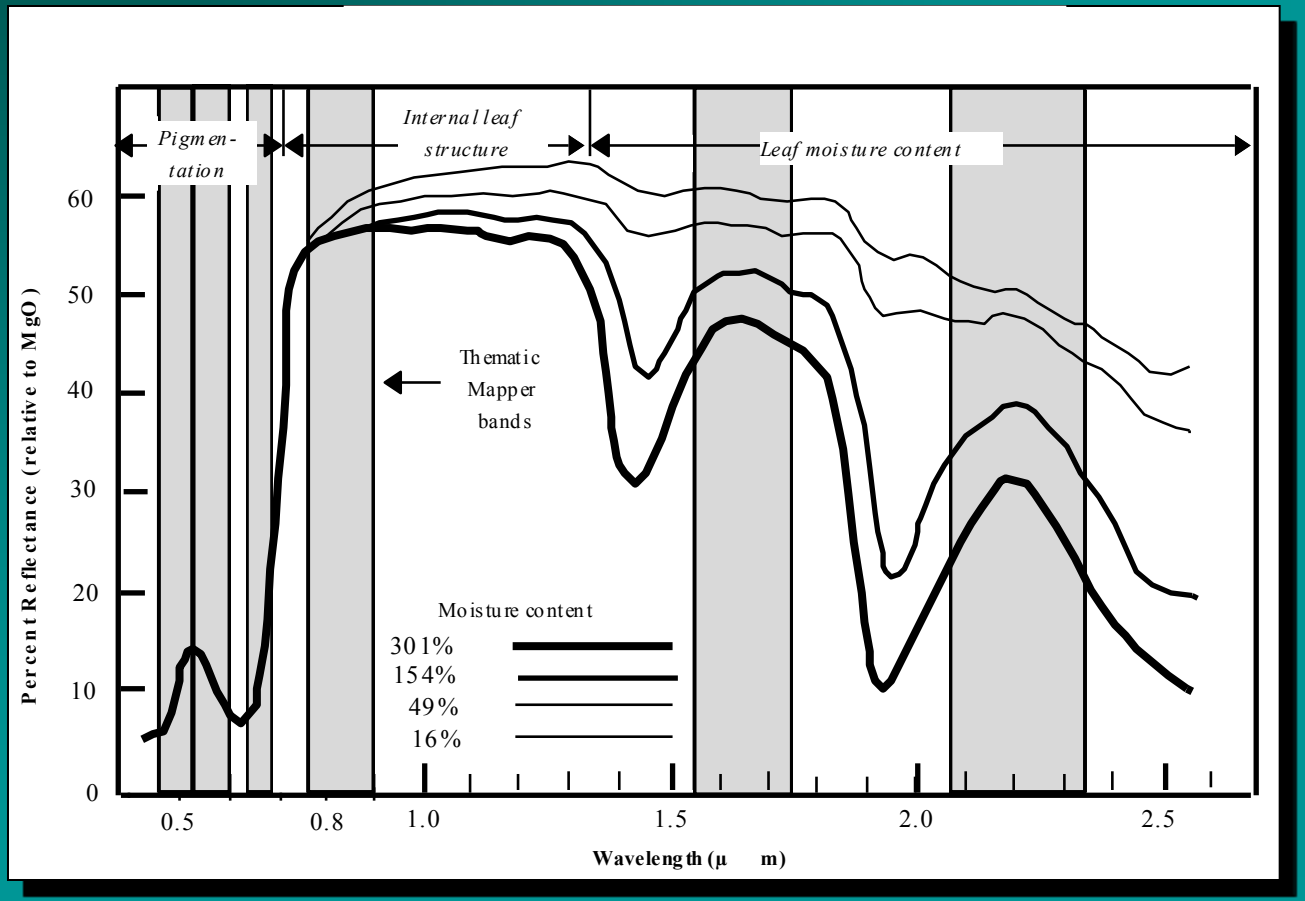
Reflectance of the Upper Surface of A Sycamore Leaf at Different Moisture Contents



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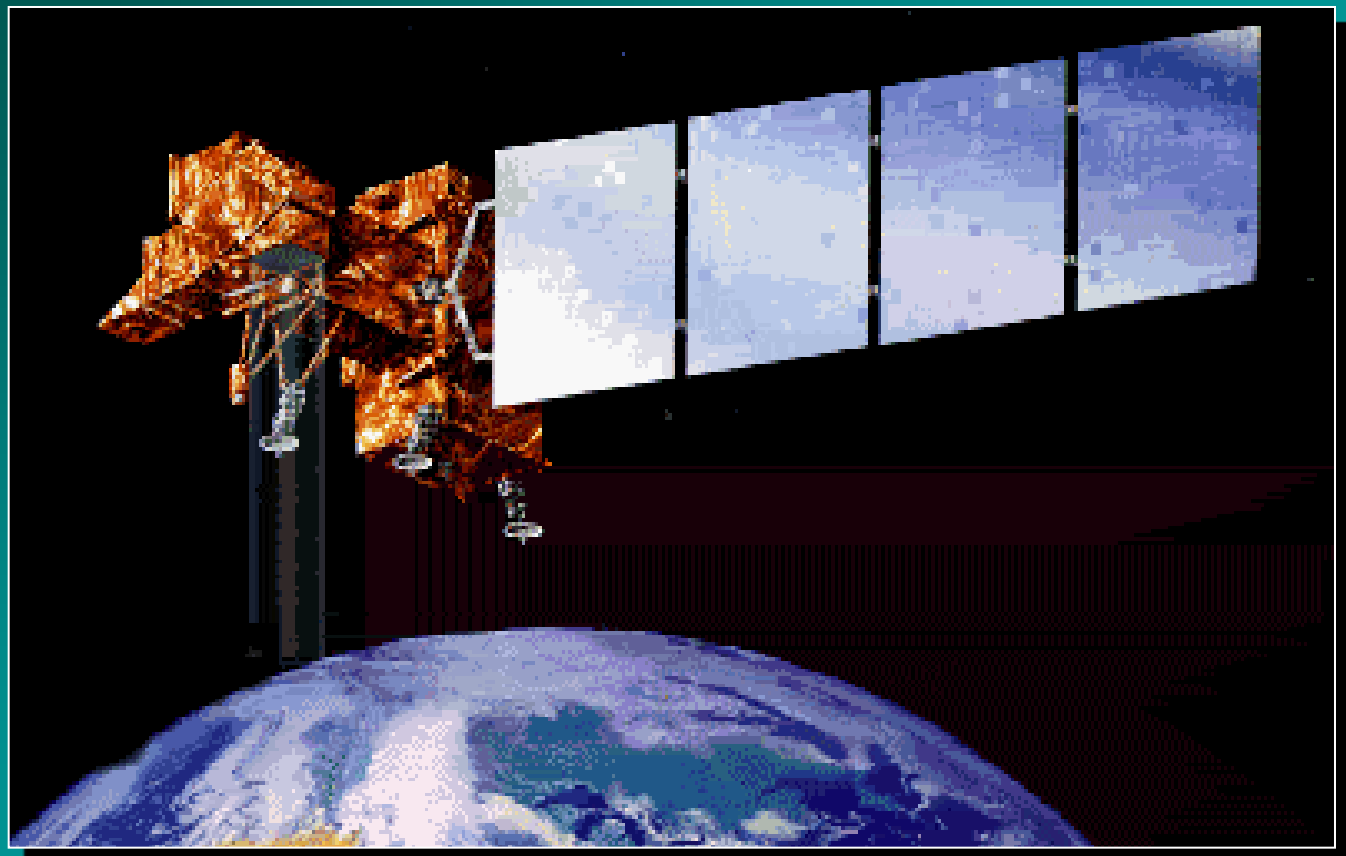
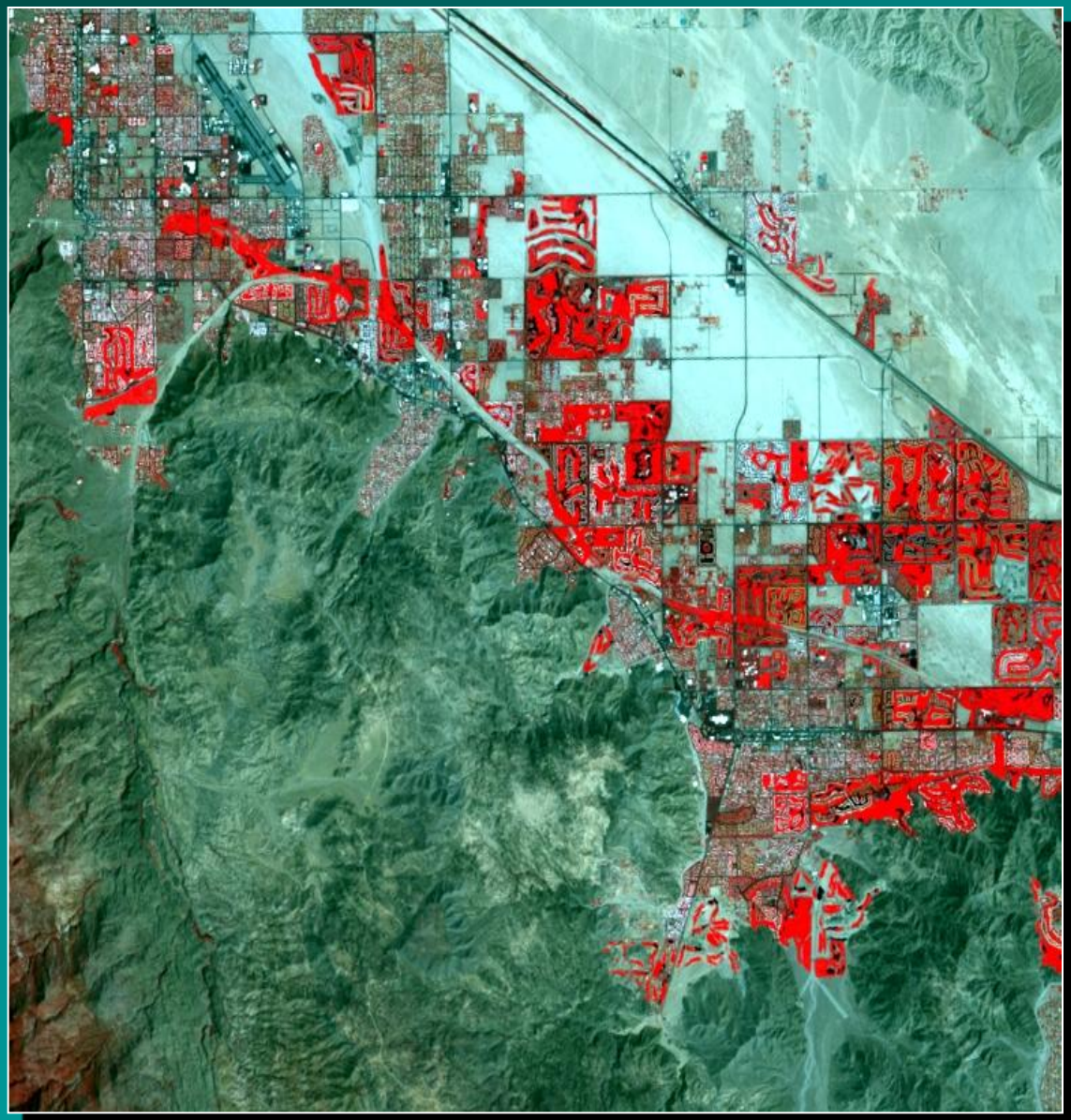
Landsat 7 Enhanced Thematic Mapper Plus

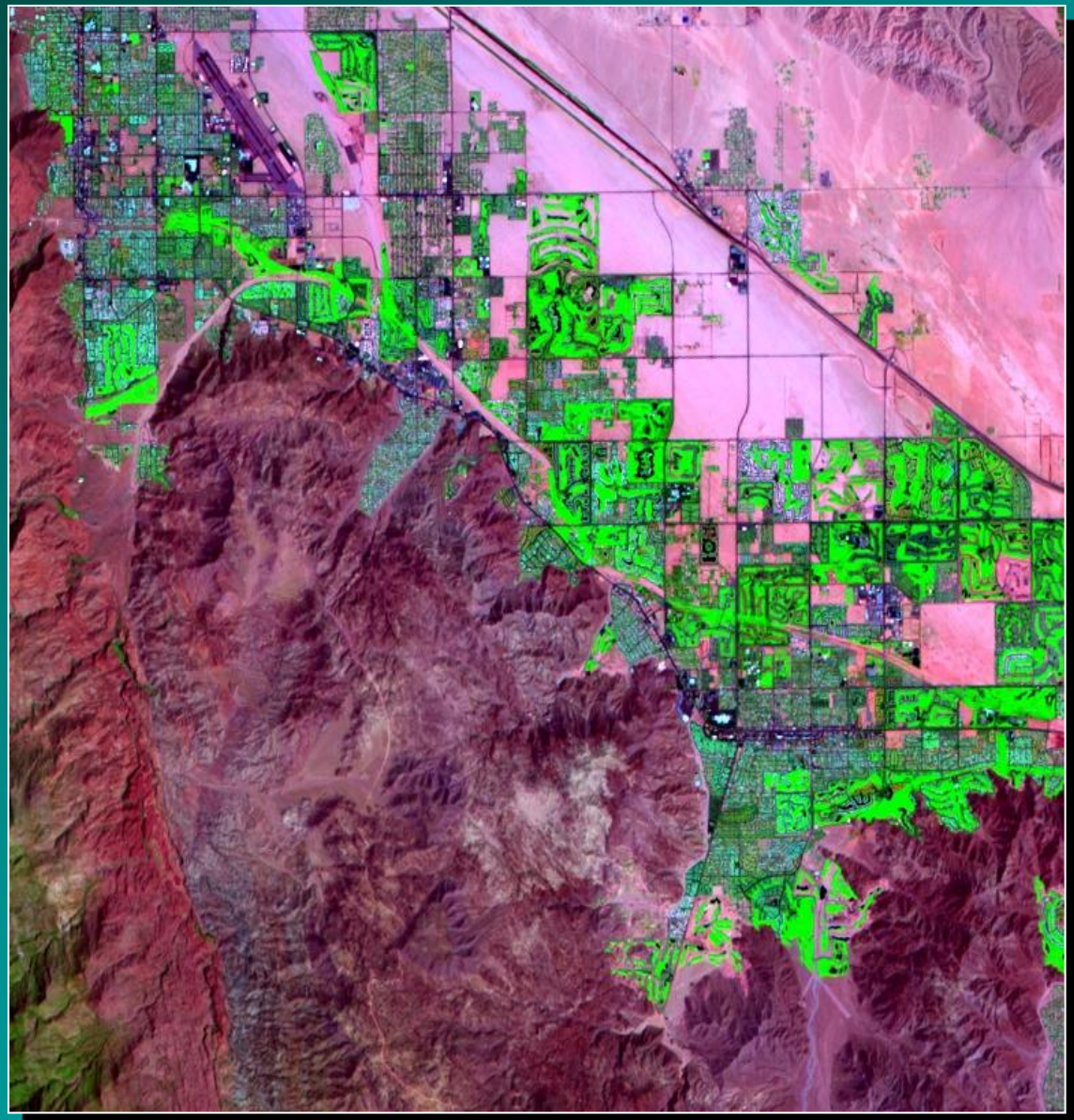


Jensen, 2000



Landsat 7 Image of
Palm Spring, CA
30 x 30 m
(bands 4,3,2 = RGB)

Jensen, 2000



Landsat 7 Image of
Palm Spring, CA
30 x 30 m
(bands 7,4,2 = RGB)

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First Landsat 7 ETM^{+} Image Obtained over Sioux Falls, SD on April 18, 1999

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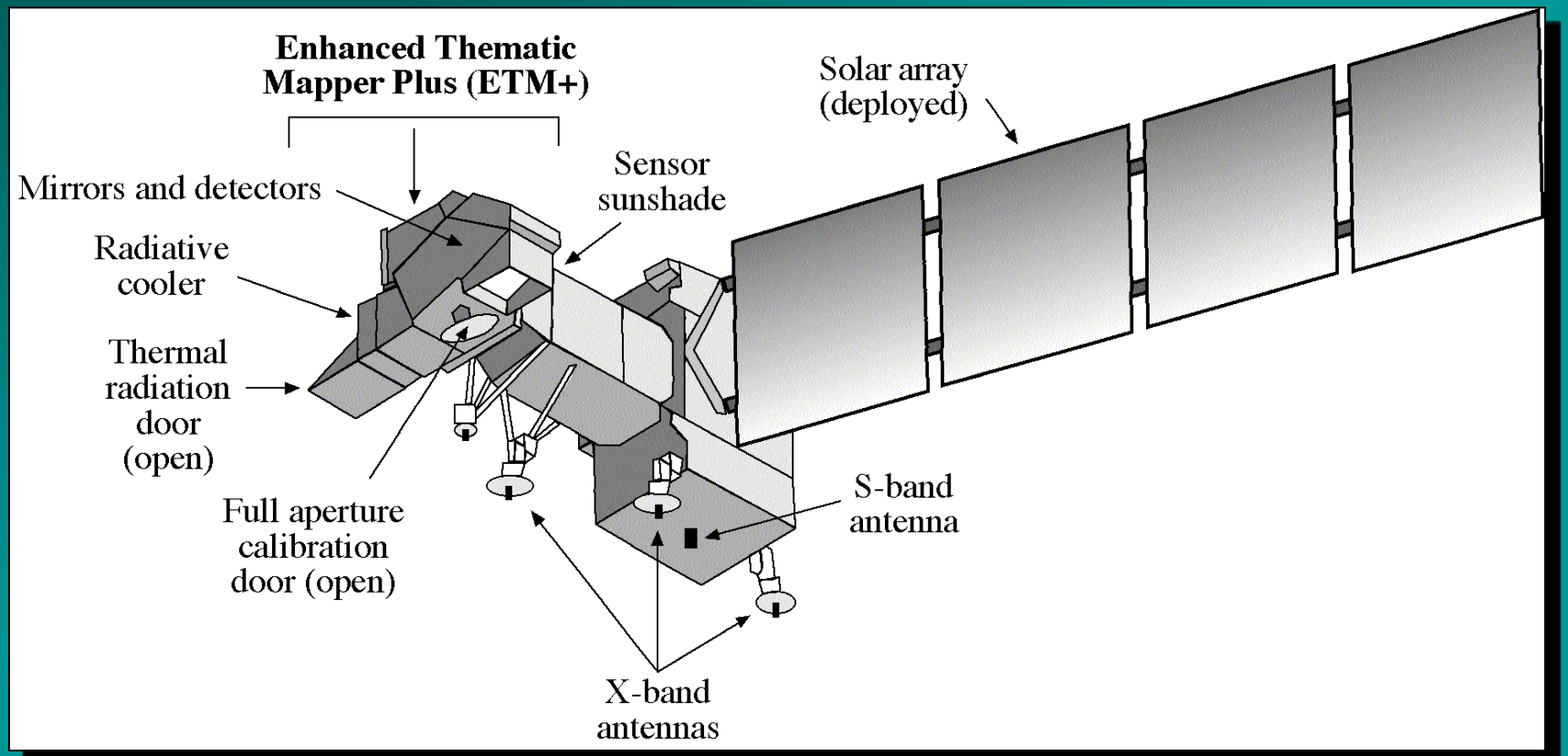
Schematic of the Landsat Enhanced Thematic Mapper Plus (ETM+)



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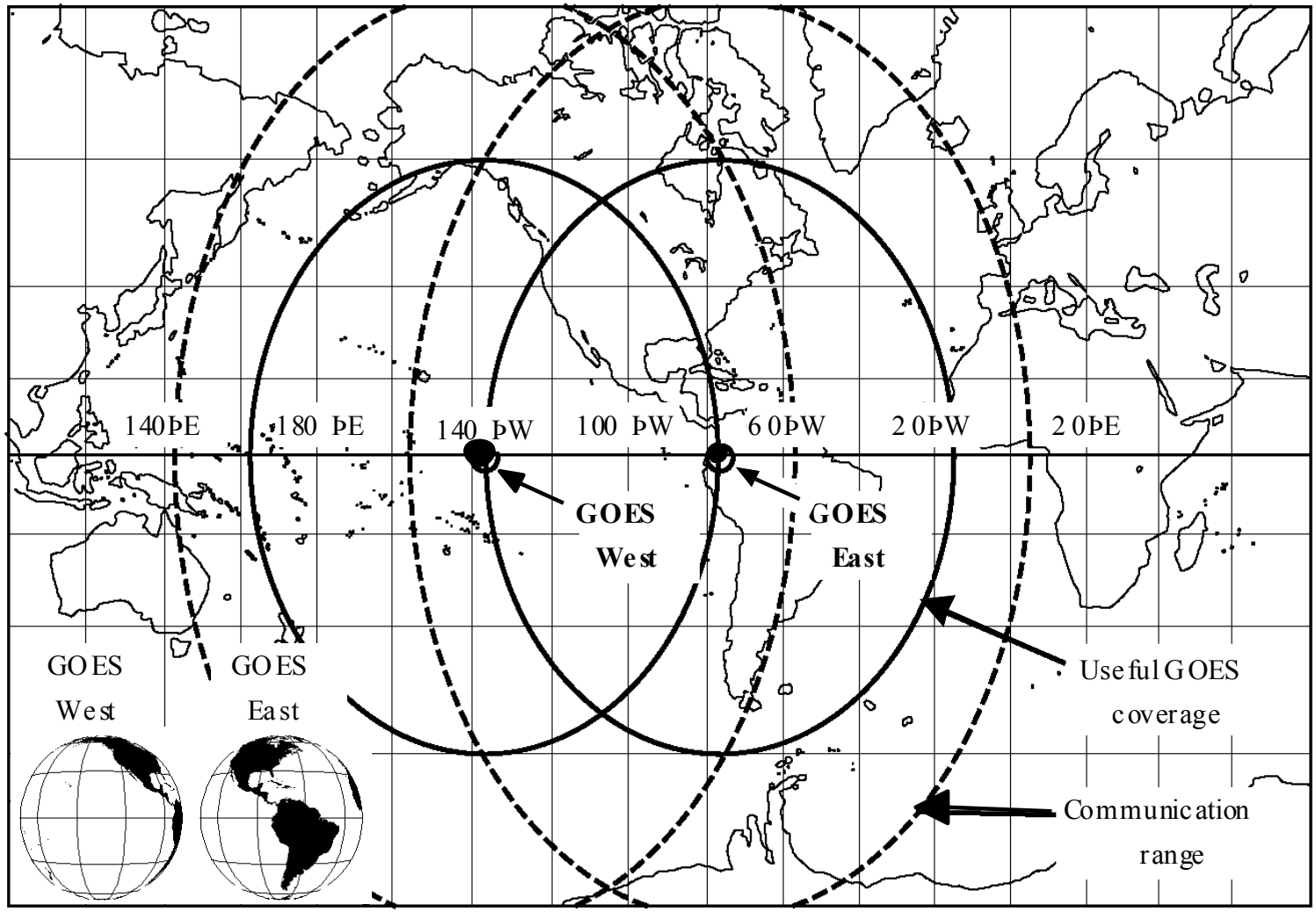
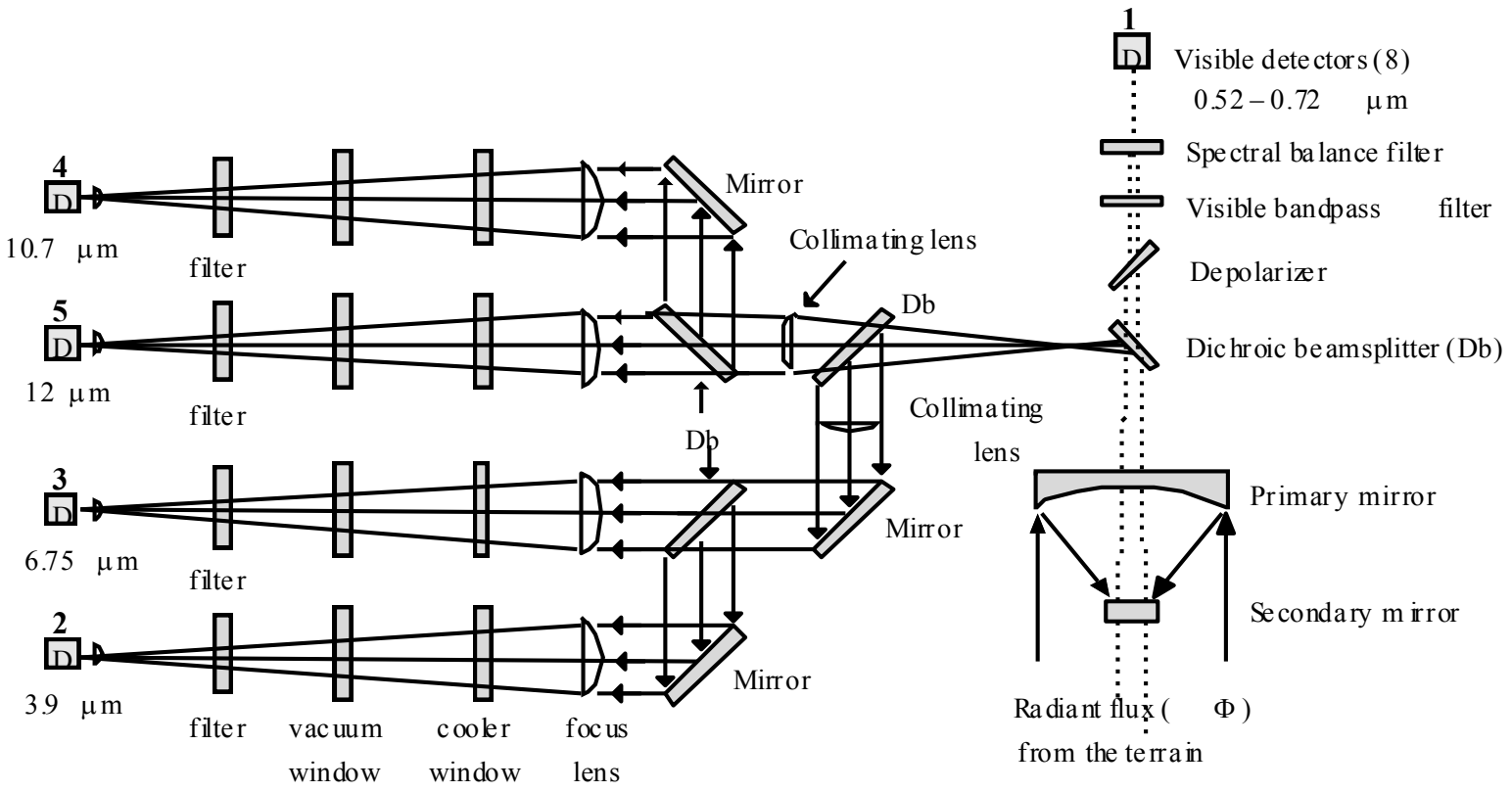
GOES East and West Coverage

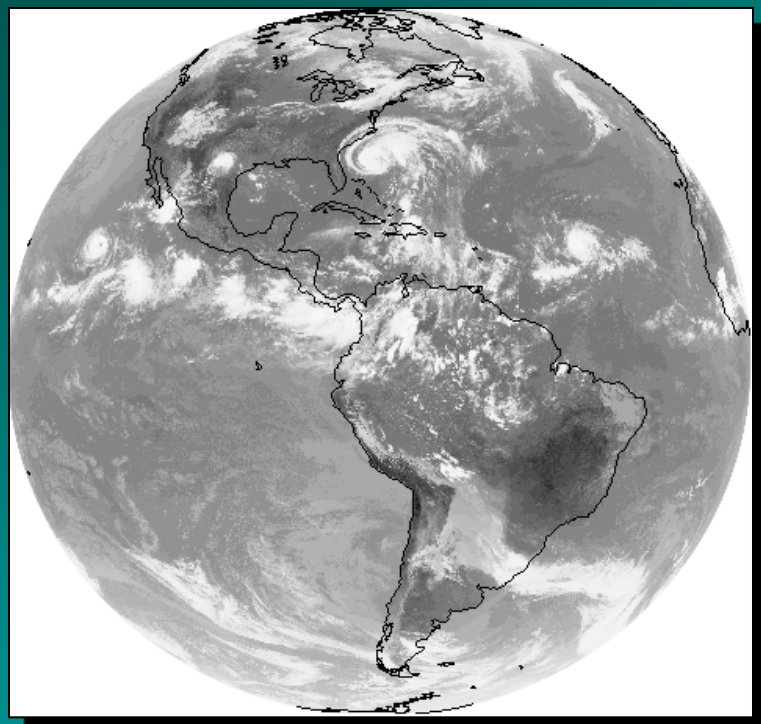


GOES Imager Optical Elements



Jensen, 2000

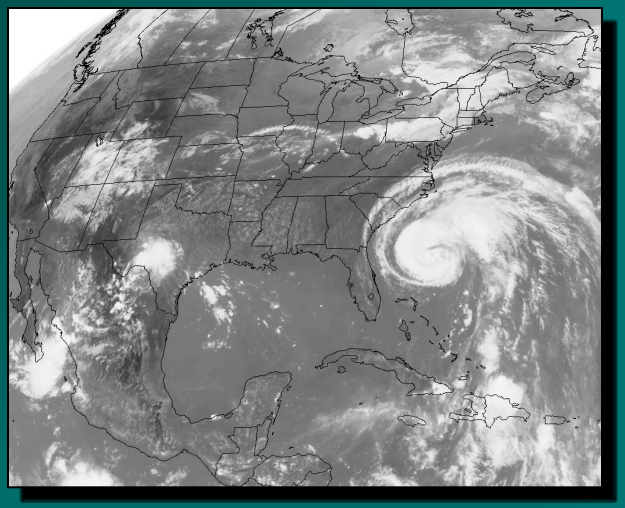
GOES East and West Coverage



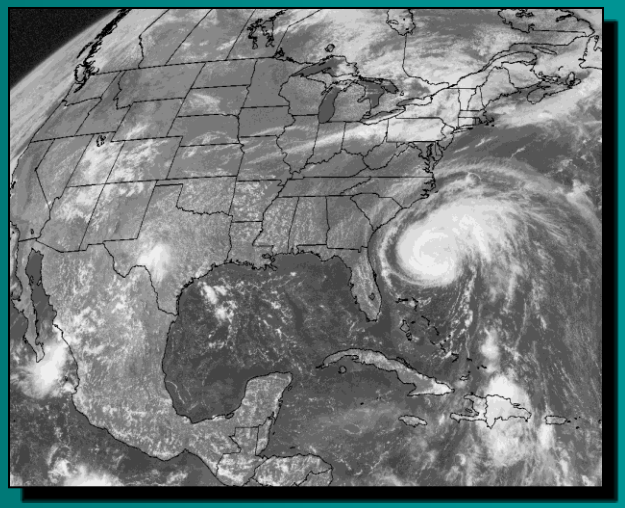
GOES East
Infrared
August 25, 1989

GOES East
Visible
August 25, 1989

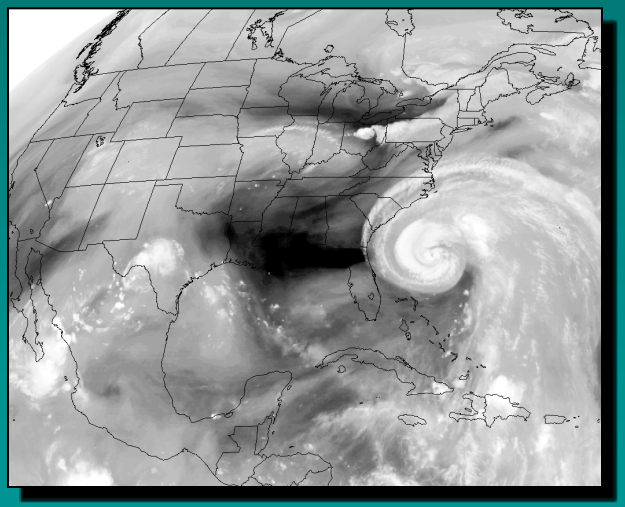
Jensen, 2000



GOES East Infrared



GOES East Visible

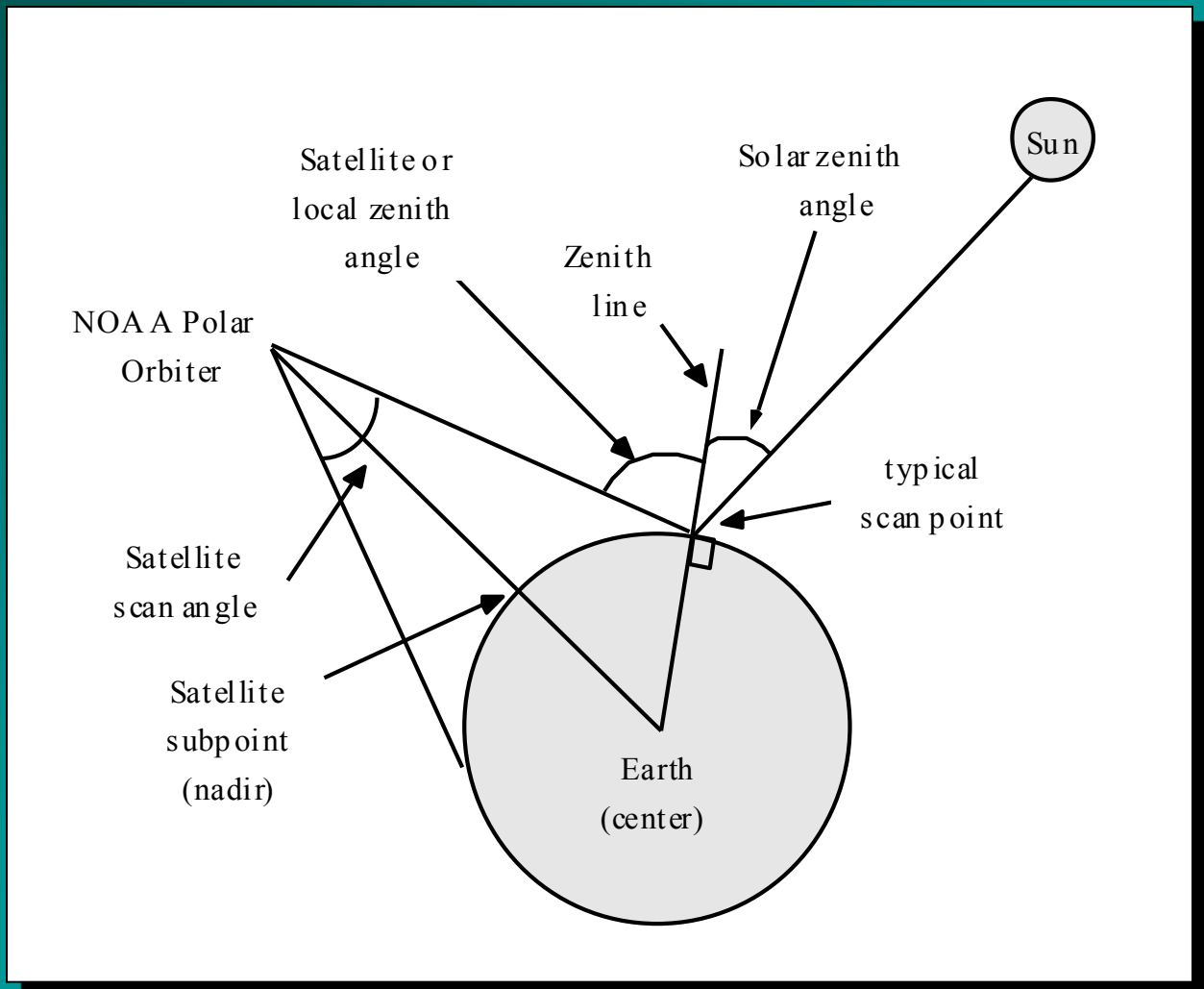


GOES East
Water Vapor

GOES East
August 25, 1989

Jensen, 2000

Advanced Very High Resolution Radiometer (AVHRR) Data Acquisition Characteristics



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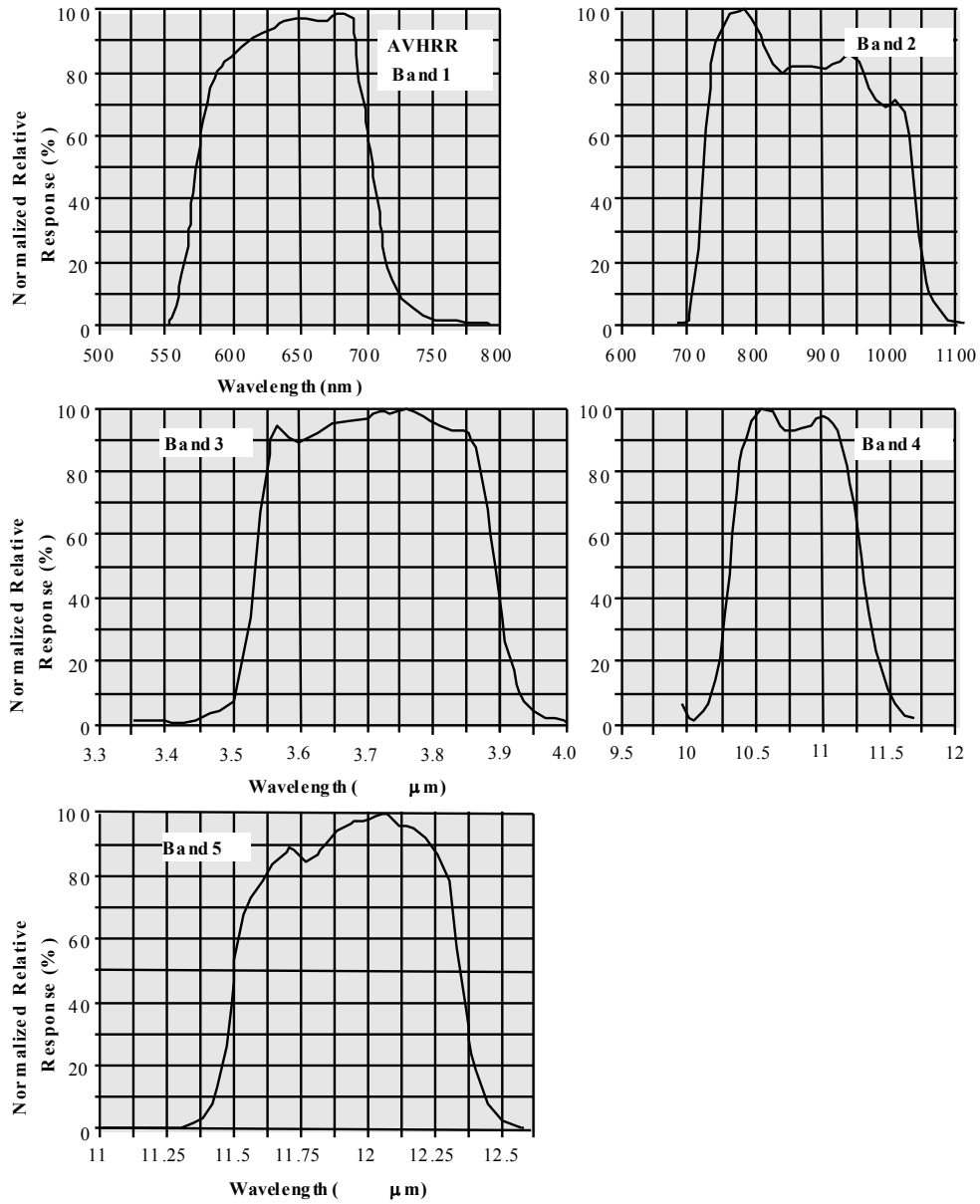
Advanced Very High Resolution Radiometer (AVHRR) Bandwidths



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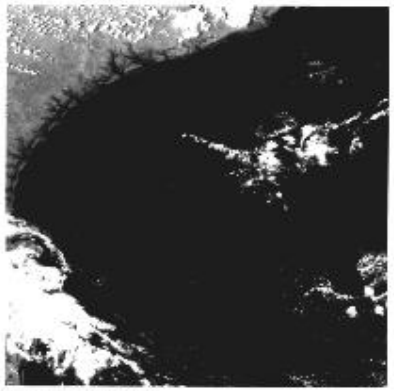
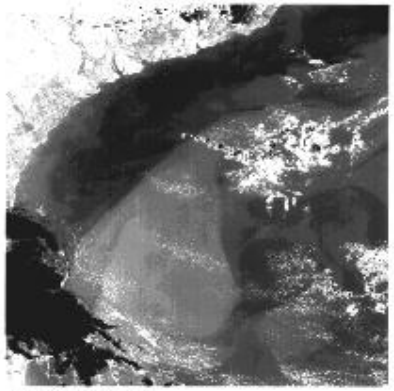
Advanced Very High Resolution Radiometer (AVHRR) Imagery

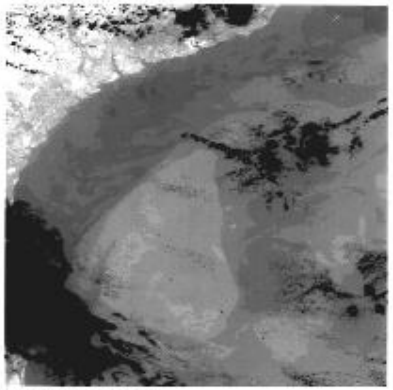
AVHRR Band 1



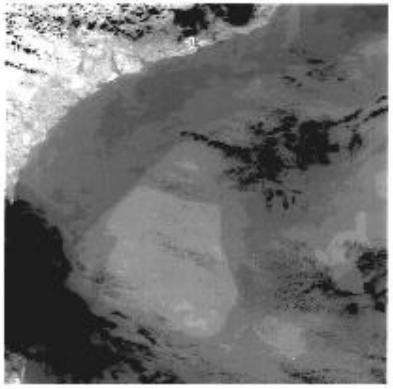
AVHRR Band 2



AVHRR Band 3



AVHRR Band 4



AVHRR Band 5

NOAA-11 AVHRR Data
of the South Carolina Coast
Obtained on May 13, 1993

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Advanced Very High Resolution Radiometer (AVHRR) Mosaic of the Conterminous United States

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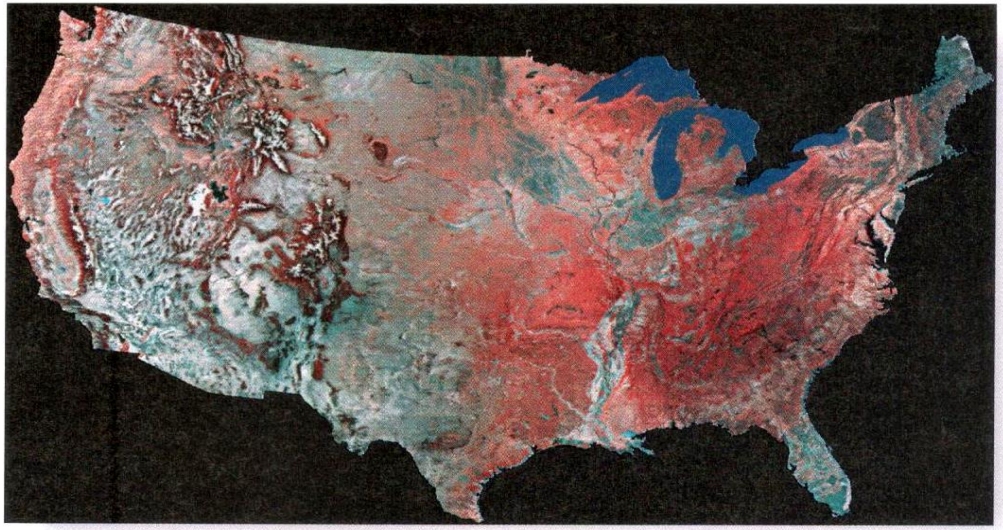
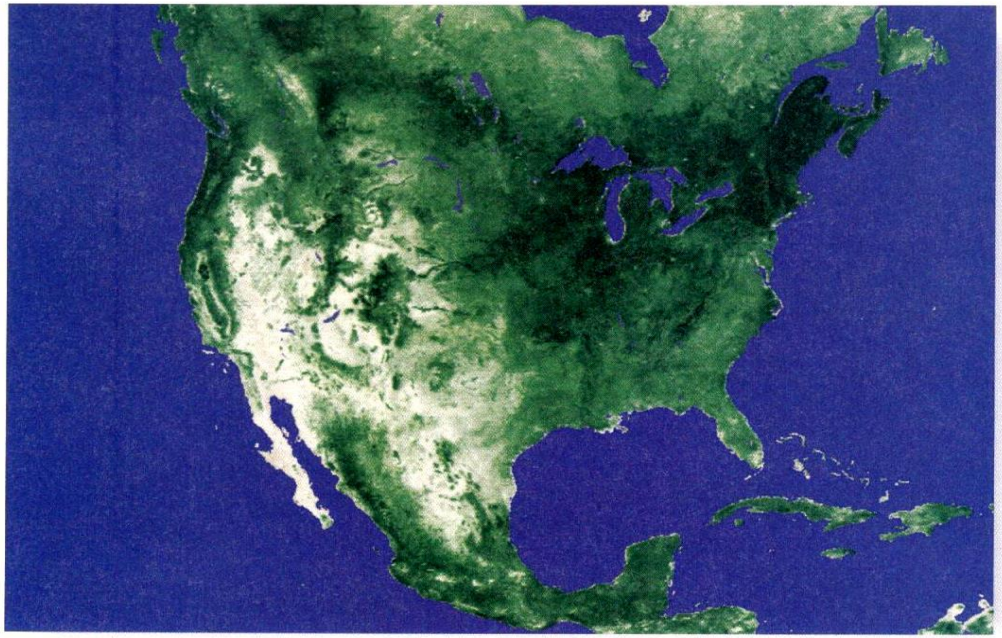
Advanced Very High Resolution Radiometer (AVHRR) Mosaic of the United States

a.



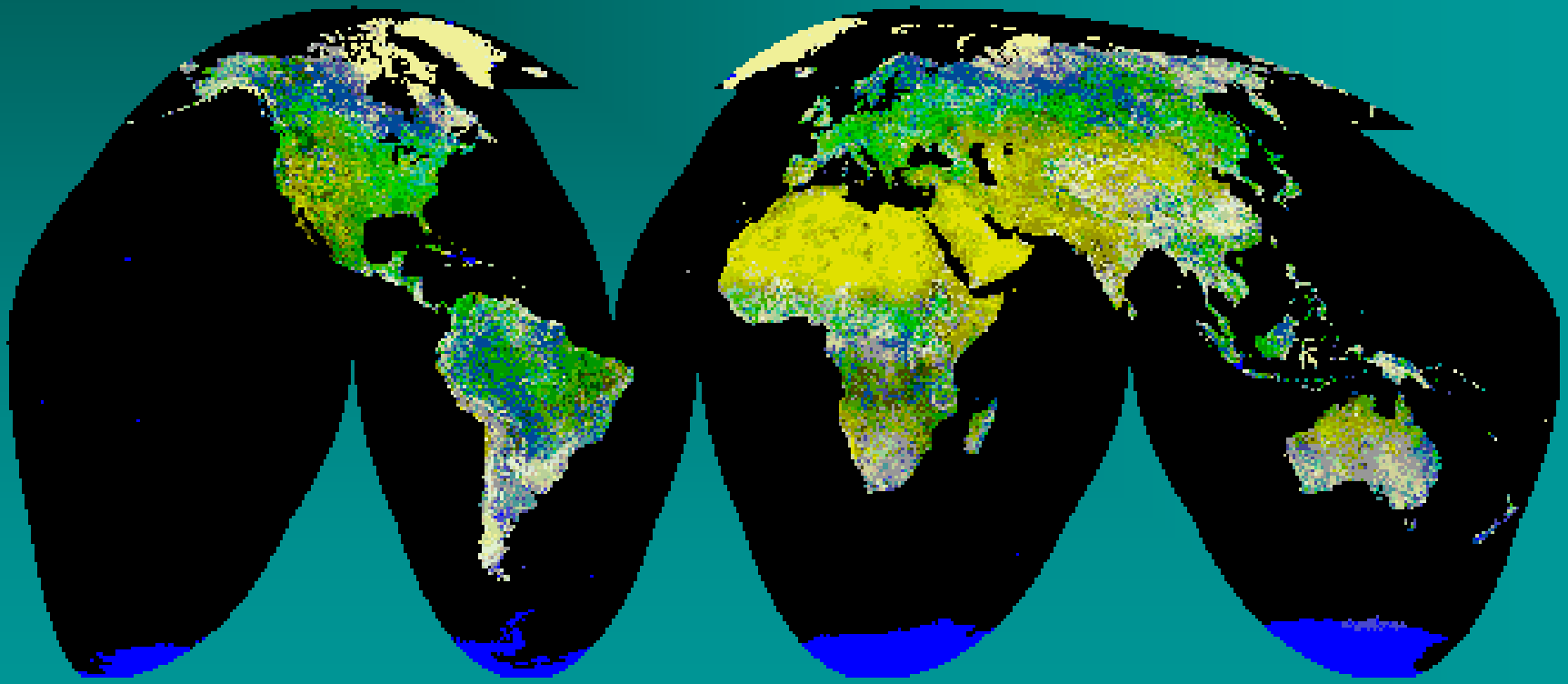
Average August AVHRR Normalized Difference Vegetation Index (NDVI) 1981 - 2000

b.



e 7-4 a) AVHRR mosaic of the conterminous United States derived from sixteen 1 × 1 km NOAA-8 and NOAA-9 A
obtained from May 24, 1984, to May 14, 1986, using channels 1 and 2 (image courtesy of NOAA and U.S. G
vey. b) Average August Normalized Difference Vegetation Index (NDVI) image of North America derived
imagery 1981 to 2000 (image courtesy of NASA Goddard Space Flight Center Scientific Visualization Stud

Global Normalized Difference Vegetation Index (NDVI) Image Produced Using Advanced Very High Resolution Radiometer (AVHRR) Imagery



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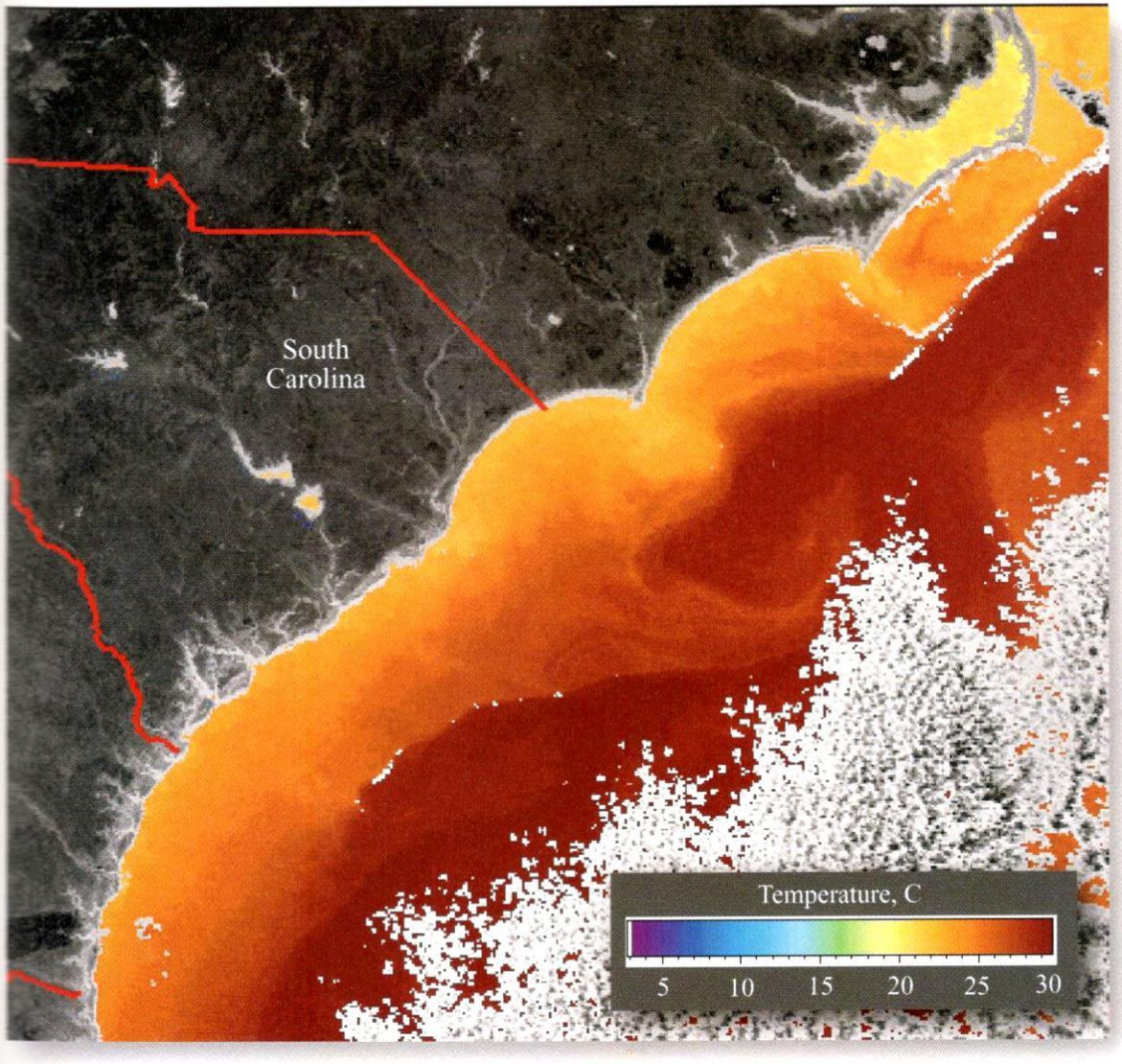
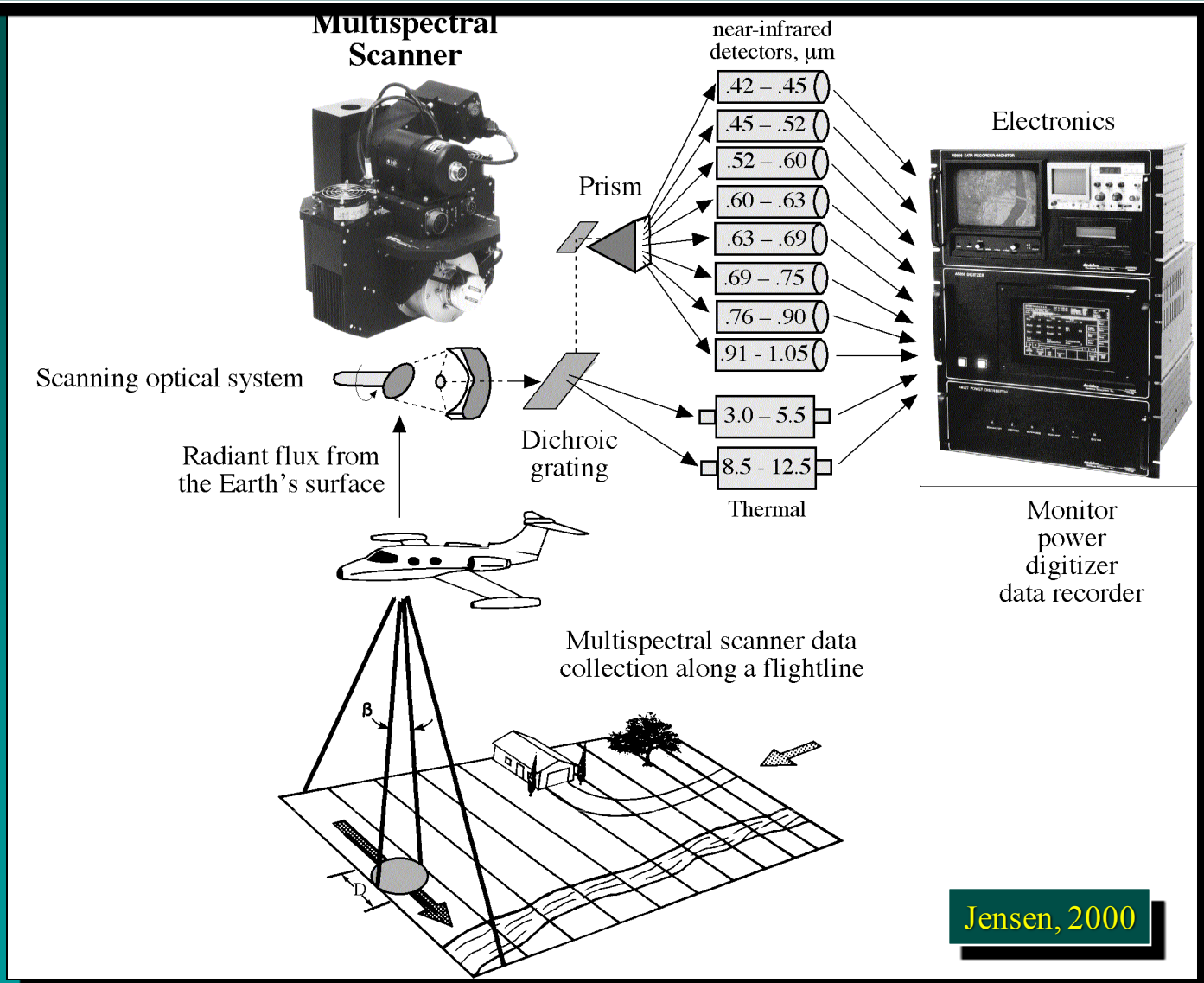
NOAA-16 Advanced Very High Resolution Radiometer (AVHRR) Imagery



Sea-surface temperature (SST) map derived from NOAA-16 AVHRR band 4 (10.3 - 11.3 μm) imagery obtained on October 16, 2003.

Color Plate 7-3 Sea-surface temperature (SST) map derived from NOAA-16 AVHRR thermal infrared imagery (courtesy of NOAA and the Ocean Remote Sensing Program at Johns Hopkins University; Gasparovic, 2003).

Characteristics of the Daedalus Airborne Multispectral Scanner (AMS)



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Near-infrared Band 6 (0.76 - 0.90 μm) Airborne Terrestrial Applications Sensor (ATLAS) Image of Sullivan's Island, SC Obtained October 15, 1998

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Sun City near Hilton Head, South Carolina

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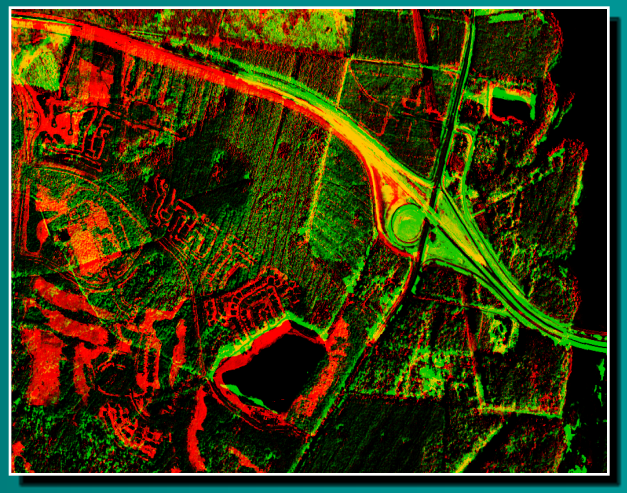
CAMS Band 6 (0.76 - 0.90 μm) data acquired on September 23, 1996 and scanned at 2.5 x 2.5 m

Sun City near Hilton Head, South Carolina

Scanned NAPP (0.70 - 0.90 µm) at
2.5 x 2.5 m (January 22, 1994)



Color composite
RGB = CAMS, NAPP, none

CAMS Band 6 (0.76 - 0.90 µm)
at 2.5 x 2.5 m (September 23, 1996)

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Pre-dawn Thermal Infrared Imagery of the Four Mile Creek Plume in the Savannah River near Augusta, Georgia

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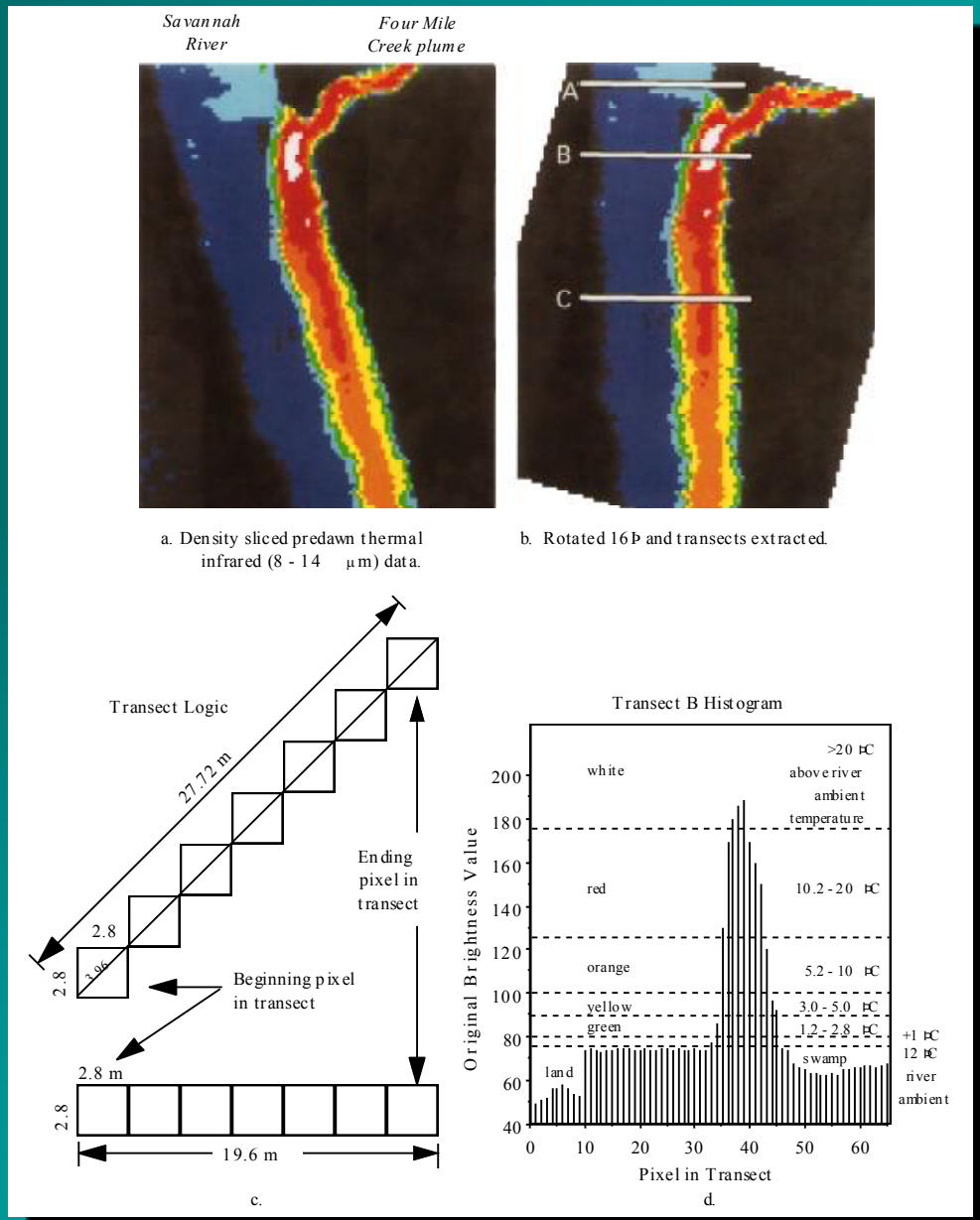
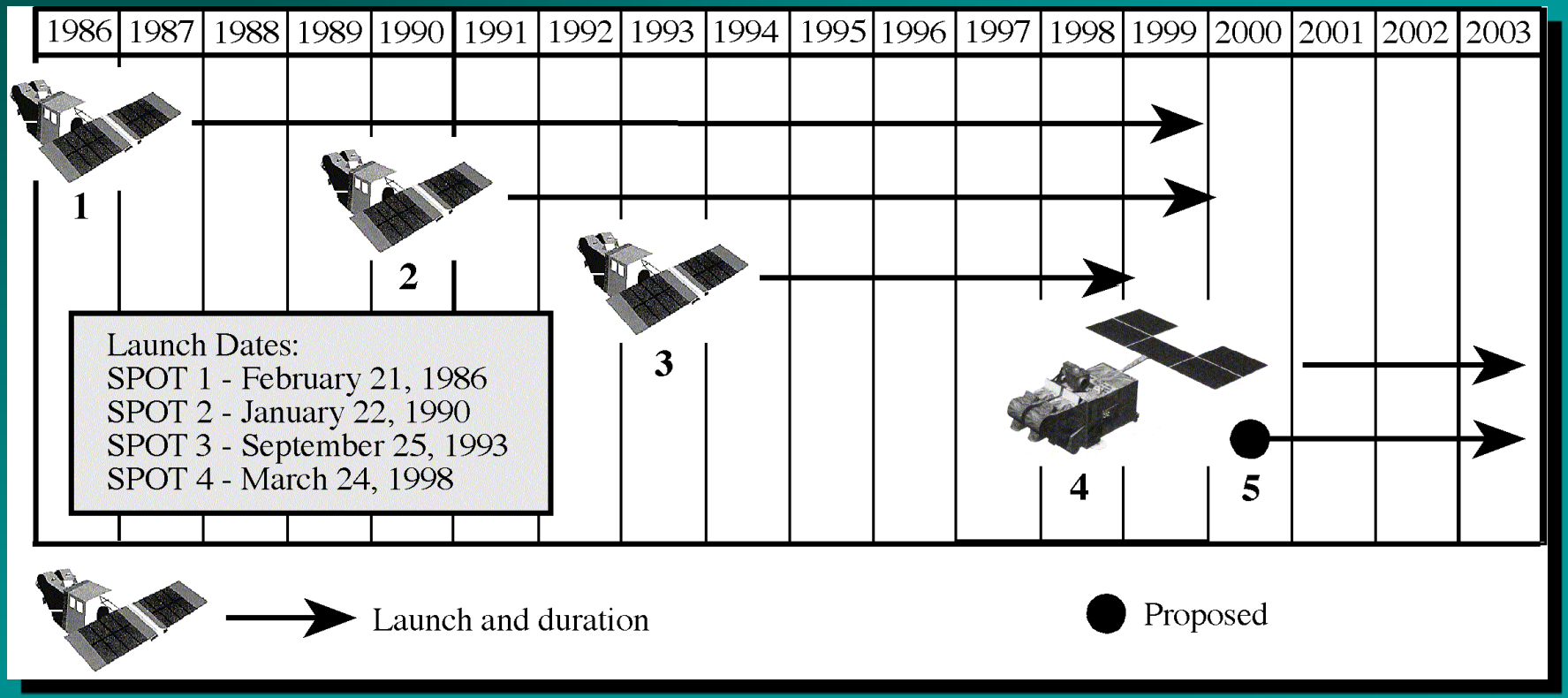


Chronological Launch History of the SPOT Satellites



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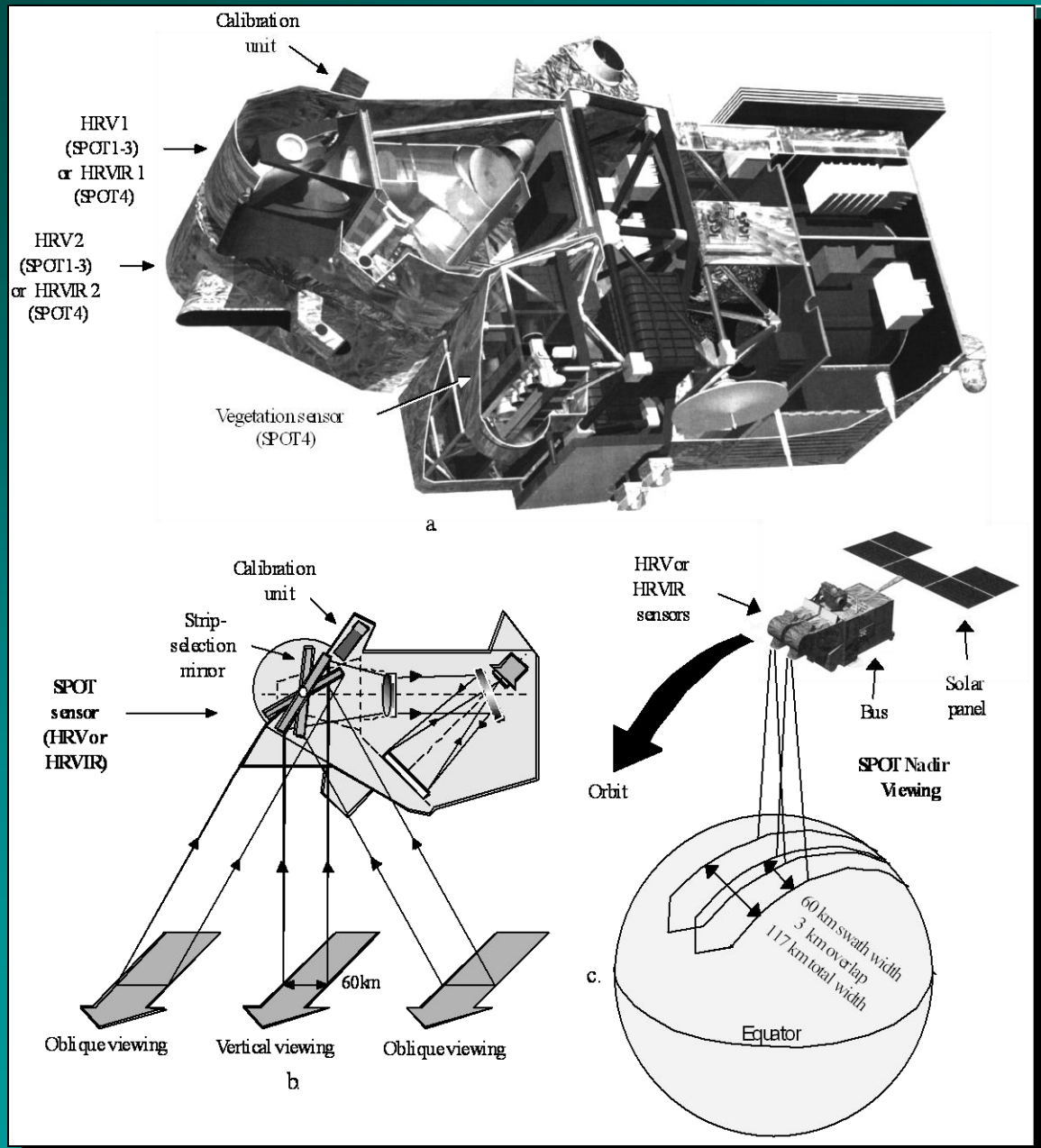
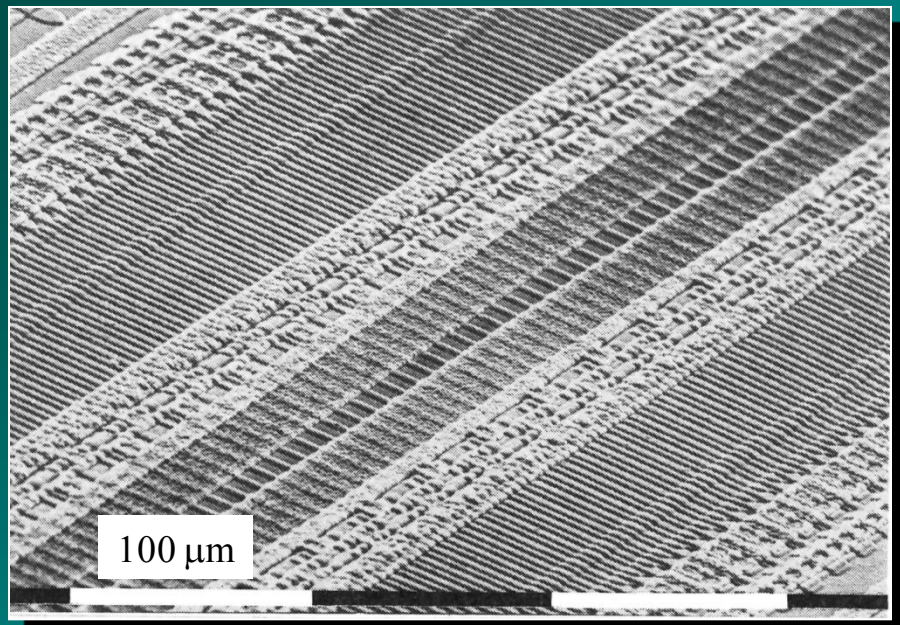
SPOT Satellite System Components

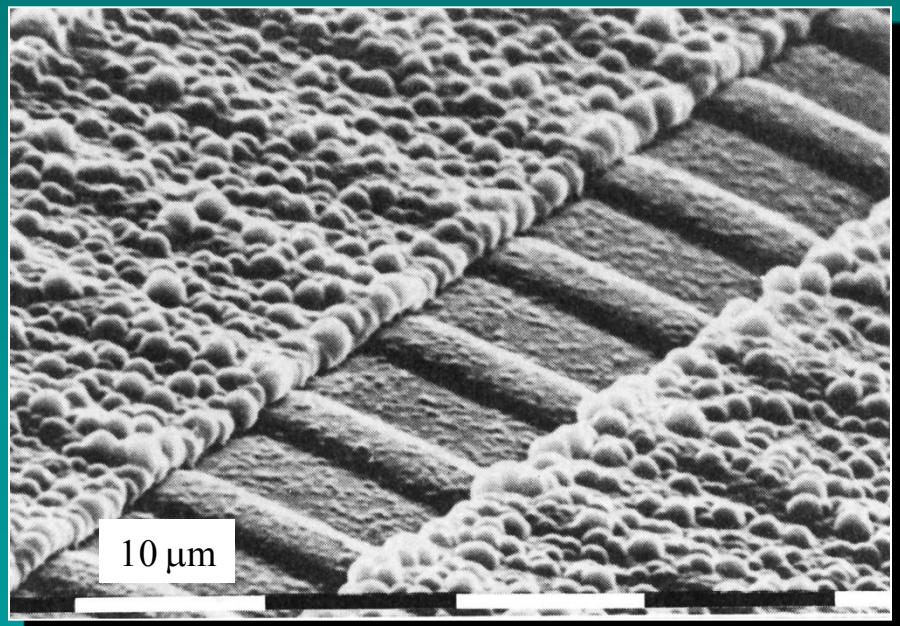


Courtesy of SPOT Image, Inc.

Jensen, 2000



Scanning Electron Microscope Image of the Front Surface of a CCD Linear Array Like that Used in the SPOT HRV Sensor Systems



Courtesy of SPOT Image, Inc.

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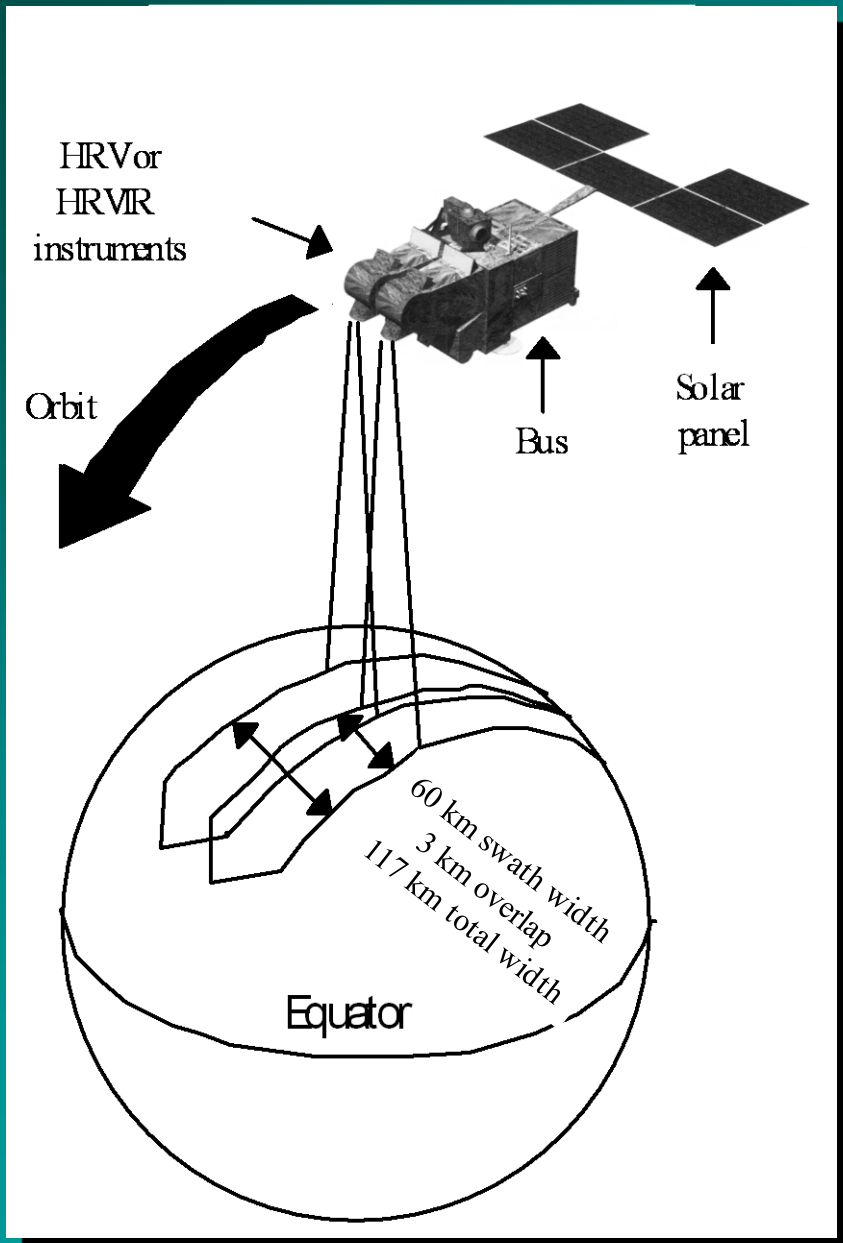
SPOT NADIR View



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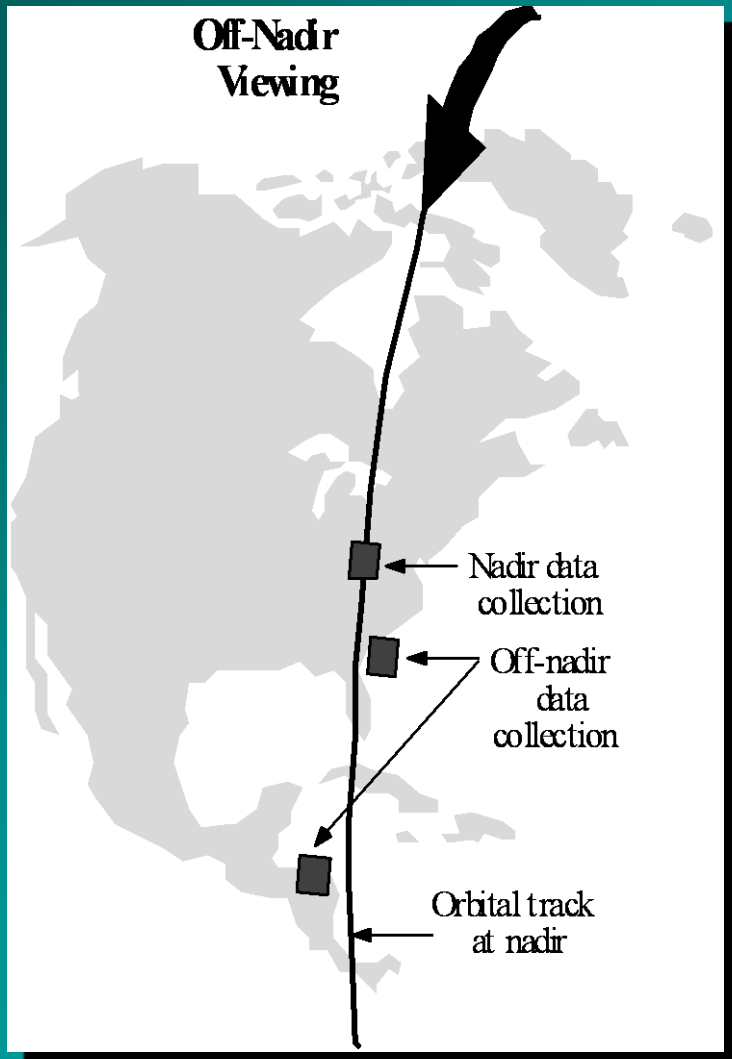
SPOT Off -NADIR View



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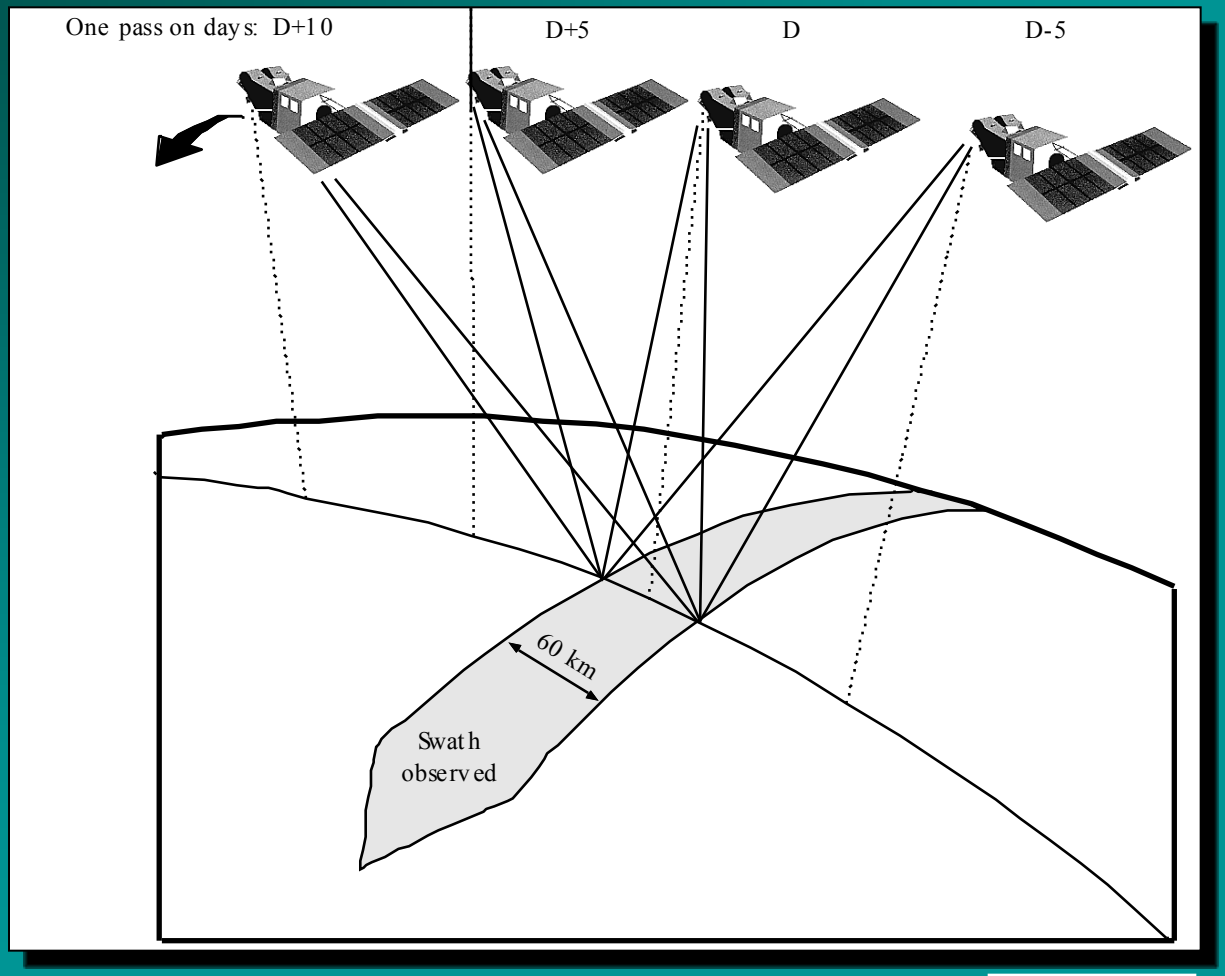
SPOT Off -NADIR Revisit Capabilities



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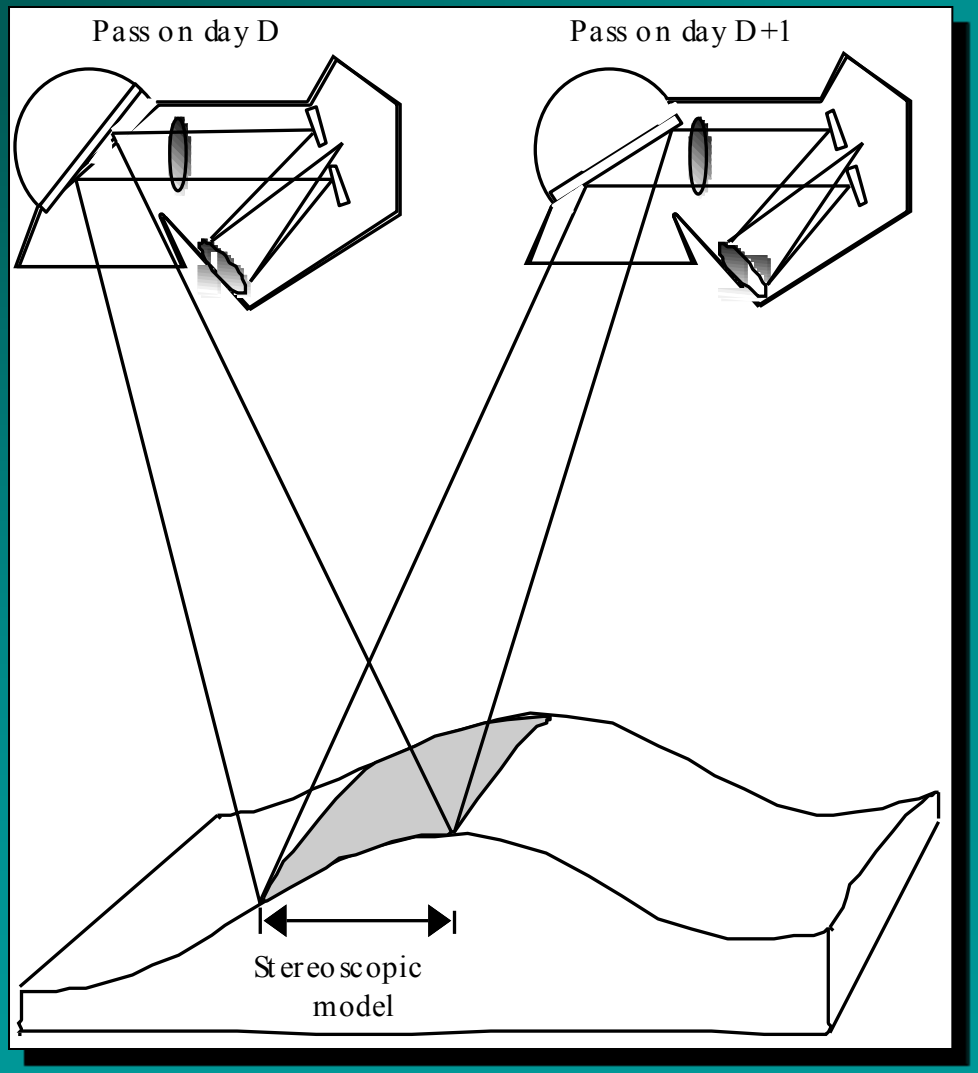
SPOT Stereoscopic Viewing Capabilities



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Comparison of the Detail of 30 x 30 m Landsat TM Band 3 Data and SPOT 10 x 10 m Panchromatic Data of Charleston, SC

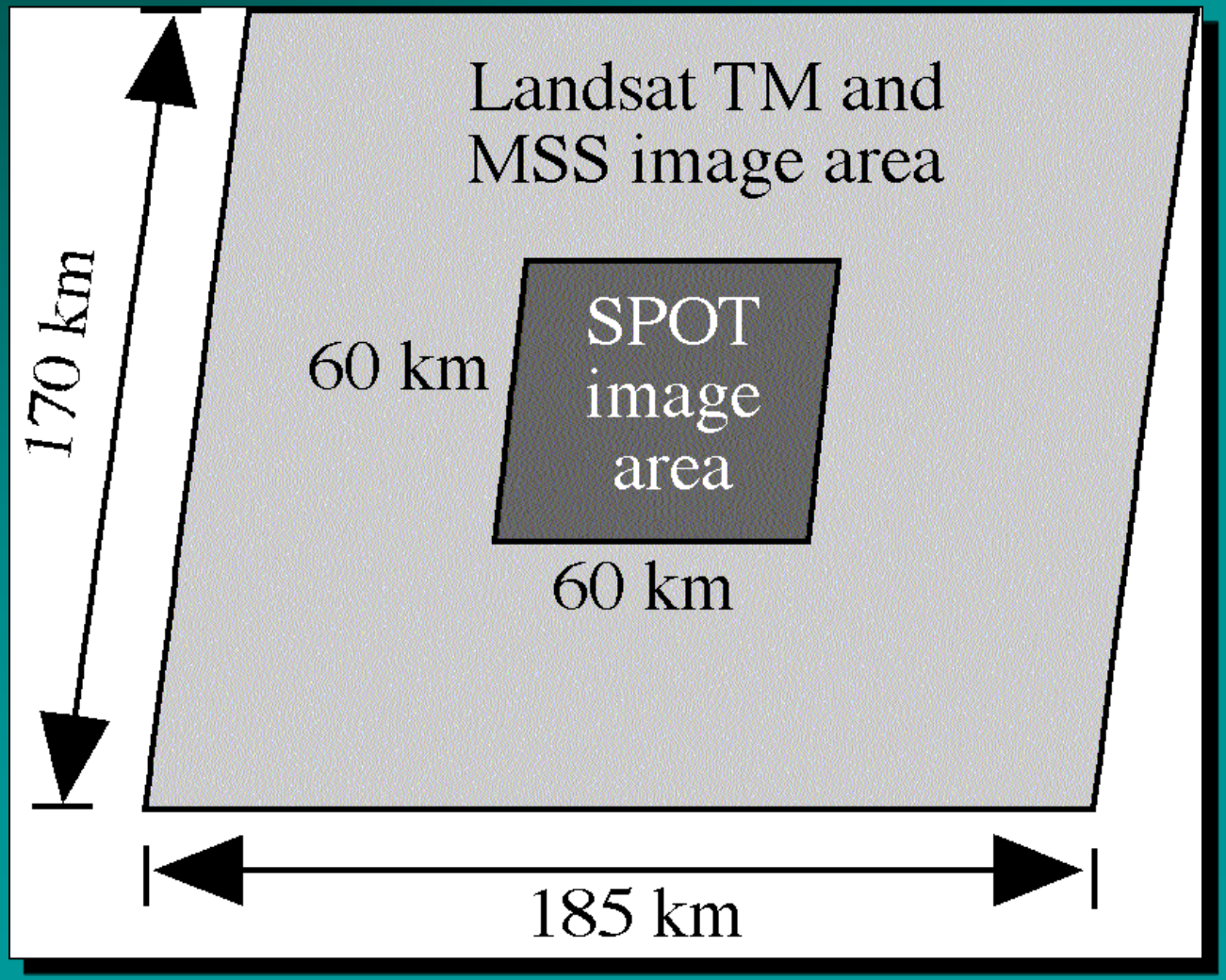
a. Landsat Thematic Mapper Band 3 (30 x 30 m) February 3, 1994

b. SPOT HRV Panchromatic Band (10 x 10 m) January 10, 1996

Courtesy of SPOT Image, Inc.

Jensen, 2000

Geographic Coverage of the SPOT HRV and Landsat Thematic Mapper Remote Sensing Systems



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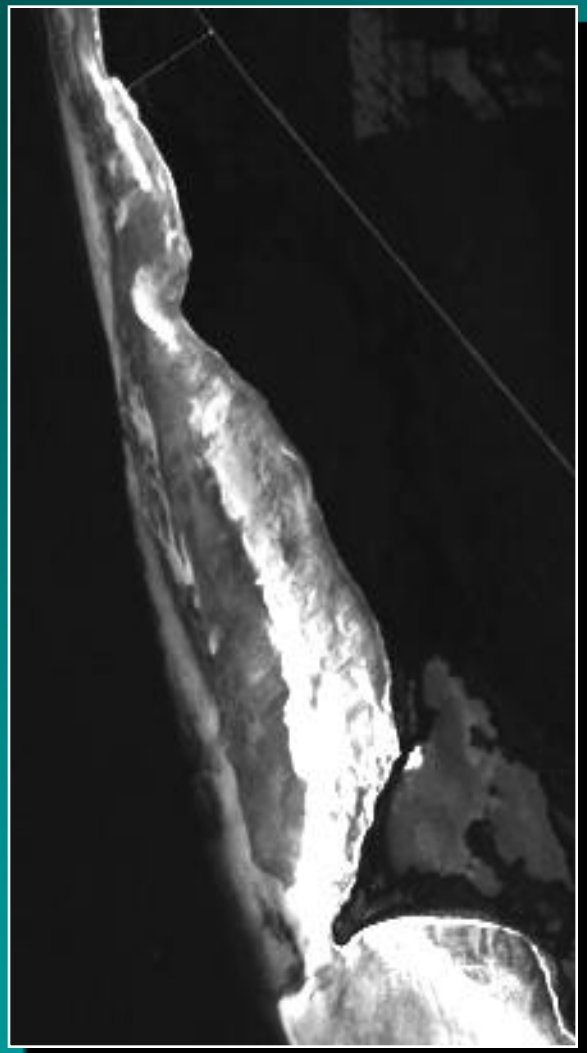
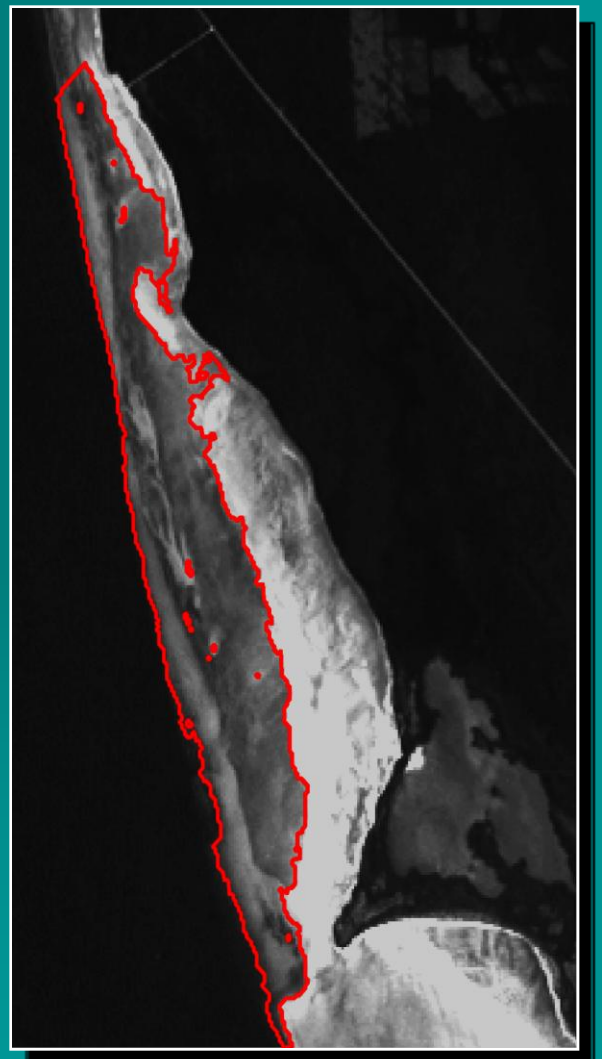
Columbia Reef on Cozumel Island, Mexico



Courtesy of
SPOT Image, Inc.

SPOT XS Band 1
(0.50 - 0.59 µm) April 19, 1988



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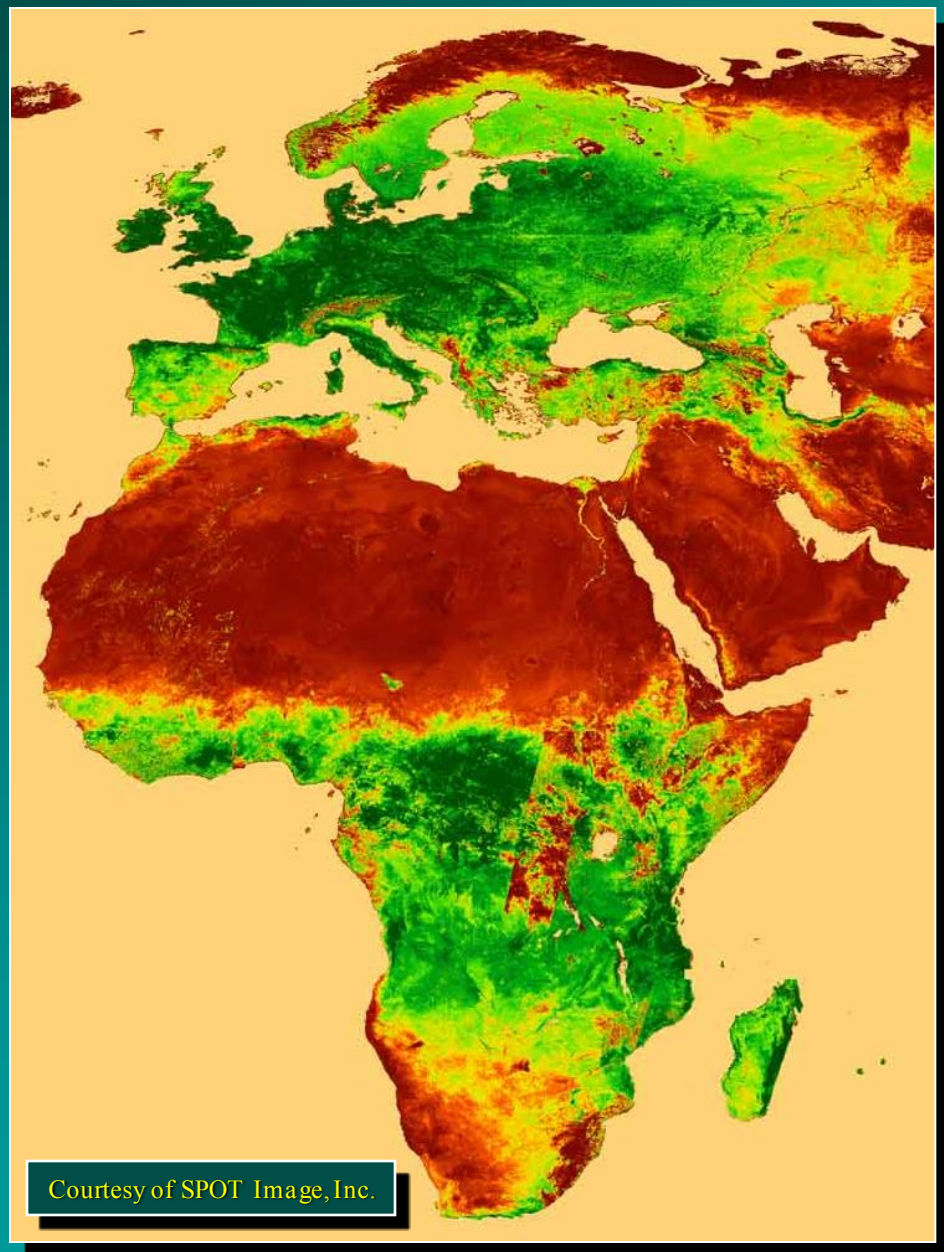
Perimeter = 80,880 ha
Area = 398 m^2



Portion of the First Global 10-day Synthesis Image Produced Using the SPOT Vegetation Sensor

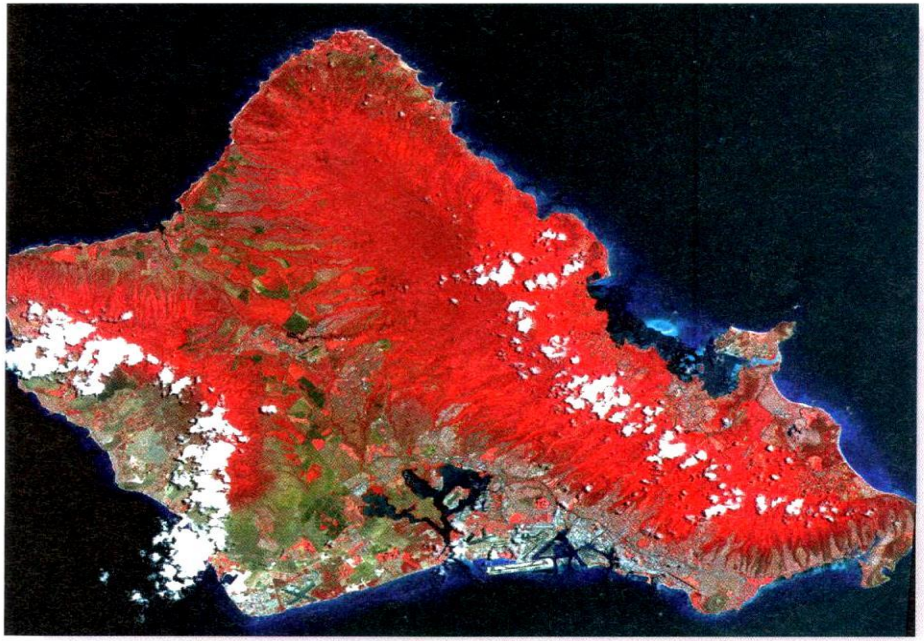
May 11-20, 1998

Jensen, 2000

Indian Remote Sensing Satellite (IRS-1D) Panchromatic Image of Downtown San Diego, CA at 5 x 5 m

Jensen, 2000

Terra ASTER Optical Imagery of Oahu, Hawaii

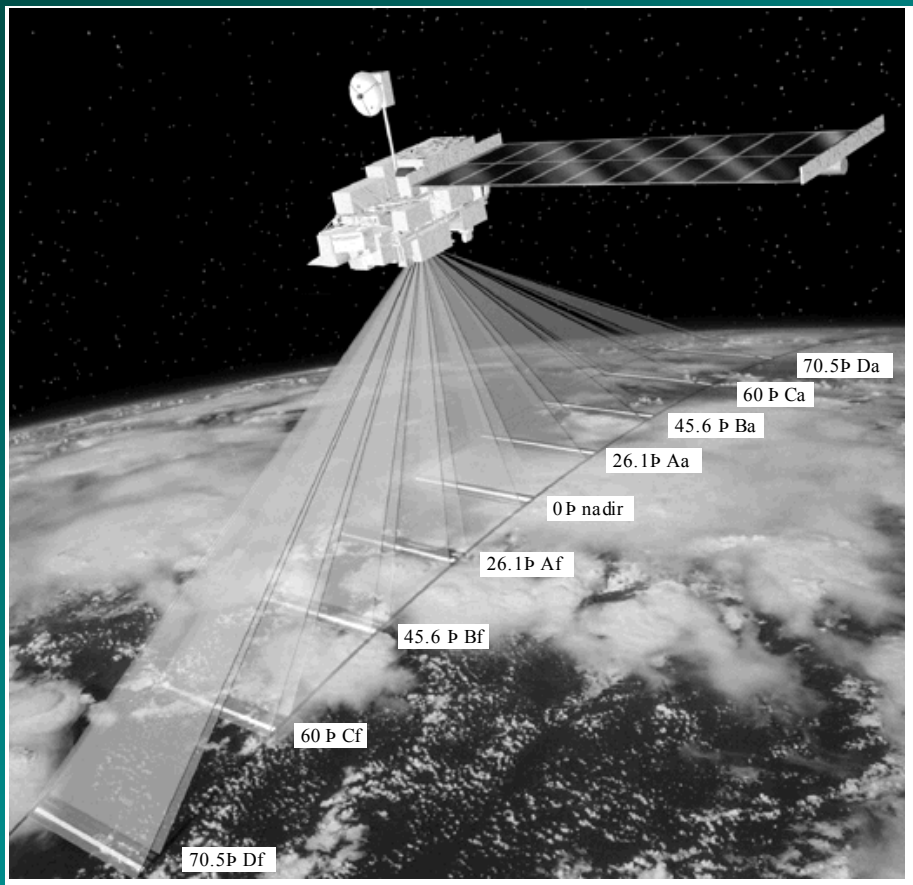


a. ASTER 15 x 15 m color composite obtained on June 3, 2000 (RGB = bands 3, 2, 1).

b. Enlargement centered on Pearl Harbor.

8 *Terra* ASTER imagery of Oahu, Hawaii (courtesy of NASA/GSFC/MITI/ERSADC/JAROS, U.S./Japan Team, and the California Institute of Technology).

Multi-angle Imaging Spectroradiometer (MISR) Onboard *Terra*



Sensors	Df	Cf	Bf	Af	An	Aa	Ba	Ca	Da
View angle	70.5Þ	60 Þ	45.6 Þ	26.1Þ	0Þ	26.1Þ	45.6 Þ	60 Þ	70.5Þ
425 – 467 nm									
543 – 571 nm									
660 – 682 nm									
846 – 886 nm									

275 x 275 m 1.1 x 1.1 km 275 m x 1.1 km

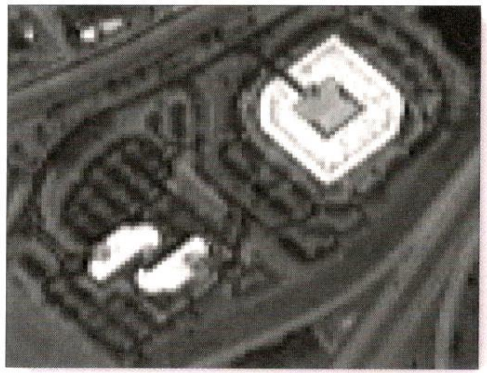
Jensen, 2000

IKONOS Panchromatic Images of Washington, DC

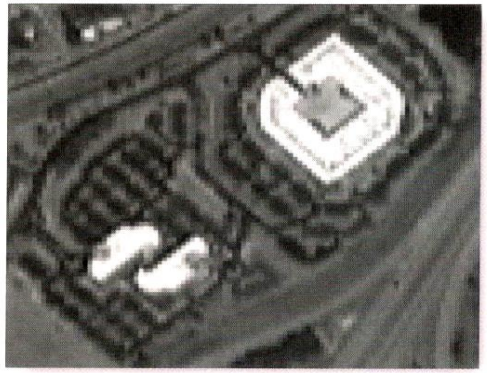
1 x 1 m spatial resolution

Jensen, 2000

IKONOS Multispectral and Panchromatic Imagery of Columbia, SC

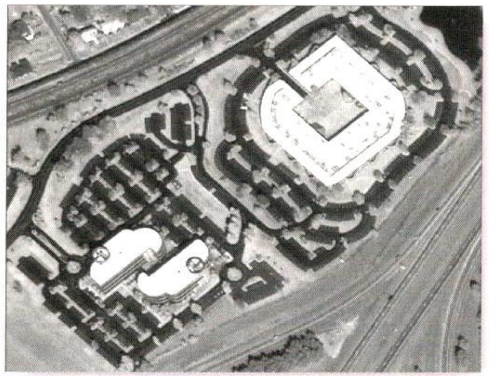


a. Band 2 (0.52 - 0.60 µm) 4 x 4 m.



b. Band 3 (0.63 - 0.69 µm) 4 x 4 m.

c. Band 4 (0.76 - 0.90 µm) 4 x 4 m.



d. Panchromatic band (0.45 - 0.90 µm) 1 x 1 m.

e. Color composite (RGB = bands 4, 3, 2).

f. Brovey merge of bands 4, 3, 2 and panchromatic.

7-9 IKONOS imagery of a business park in Columbia, SC. a–d) Individual 4 × 4 m multispectral bands and the 1 × chromatic band are displayed. e) Standard color composite of IKONOS bands 4, 3, and 2. f) Color composite multispectral (4 × 4 m) and panchromatic (1 × 1 m) data (images courtesy of GeoEye, Inc.).

IKONOS Panchromatic Stereopair of Columbia, SC Airport

Jensen, 2000

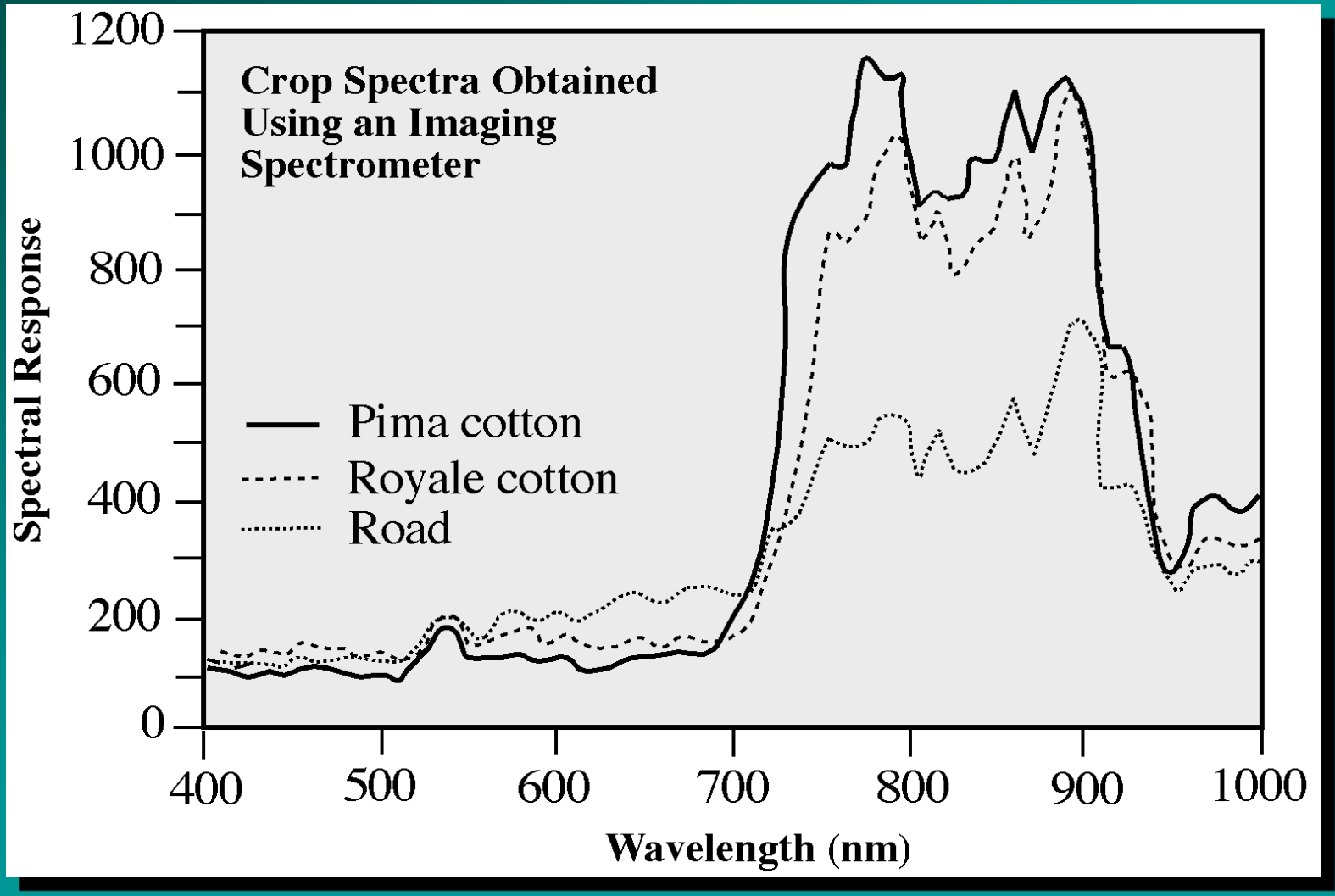
November 15, 2000

IKONOS Imagery of Columbia, SC Obtained on October 28, 2000

Panchromatic 1 x 1 m

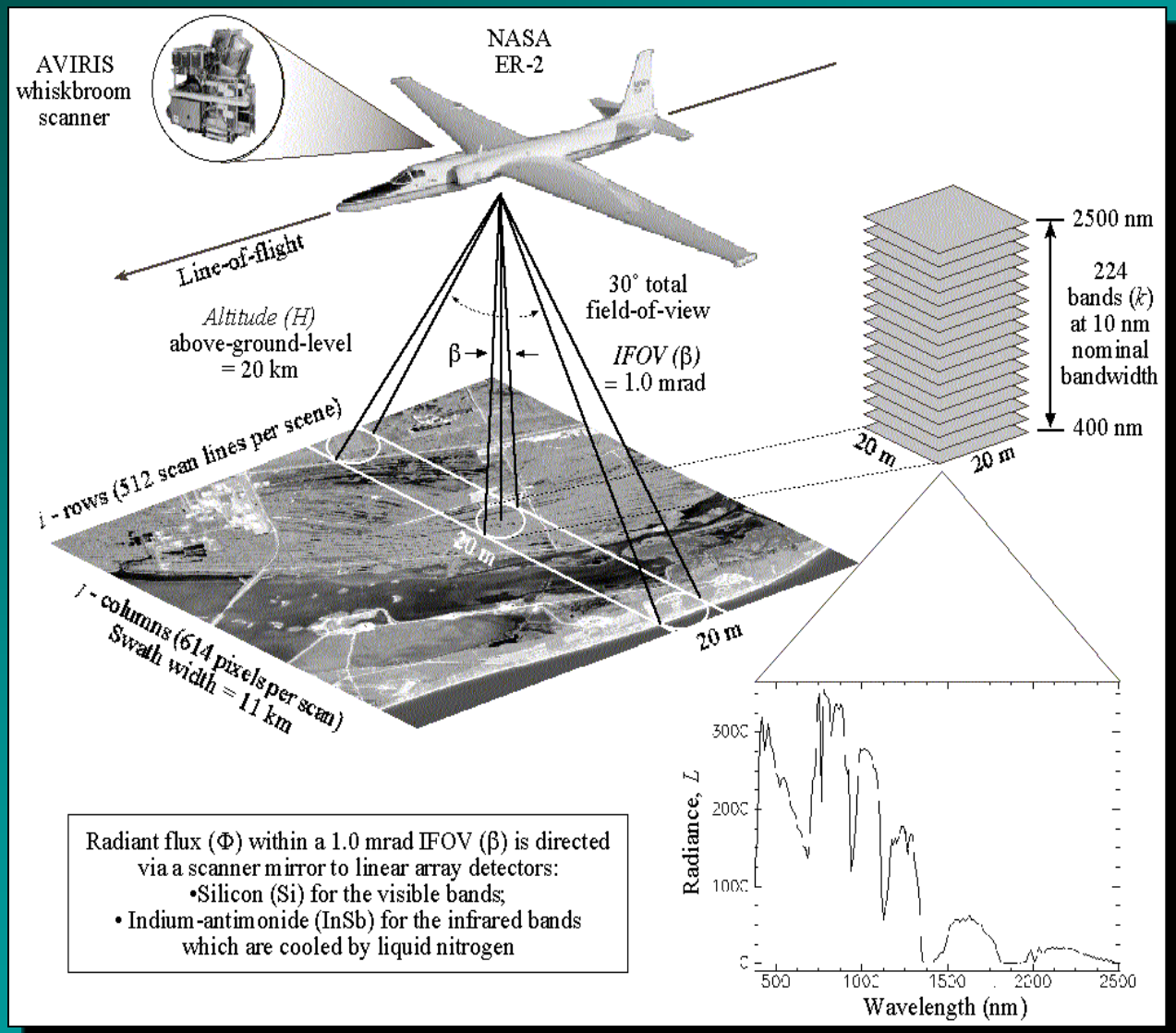
Pan-sharpened multispectral 4 x 4 m

Imaging Spectrometry



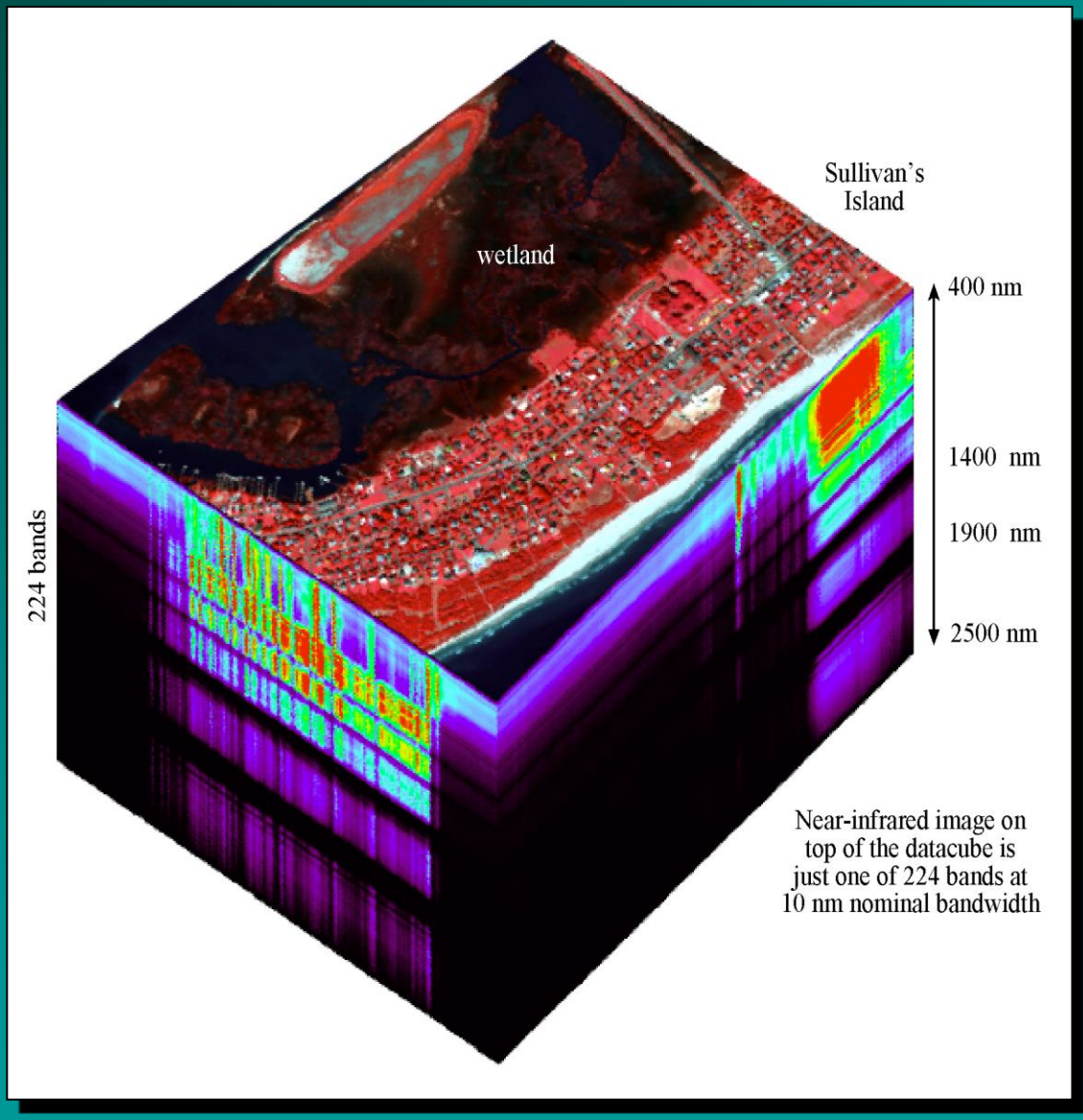
Jensen, 2000

NASA AVIRIS: Advanced Visible Infrared Imaging Spectrometer



Radiant flux (Φ) within a 1.0 mrad IFOV (β) is directed via a scanner mirror to linear array detectors:
- Silicon (Si) for the visible bands;
- Indium-antimonide (InSb) for the infrared bands which are cooled by liquid nitrogen

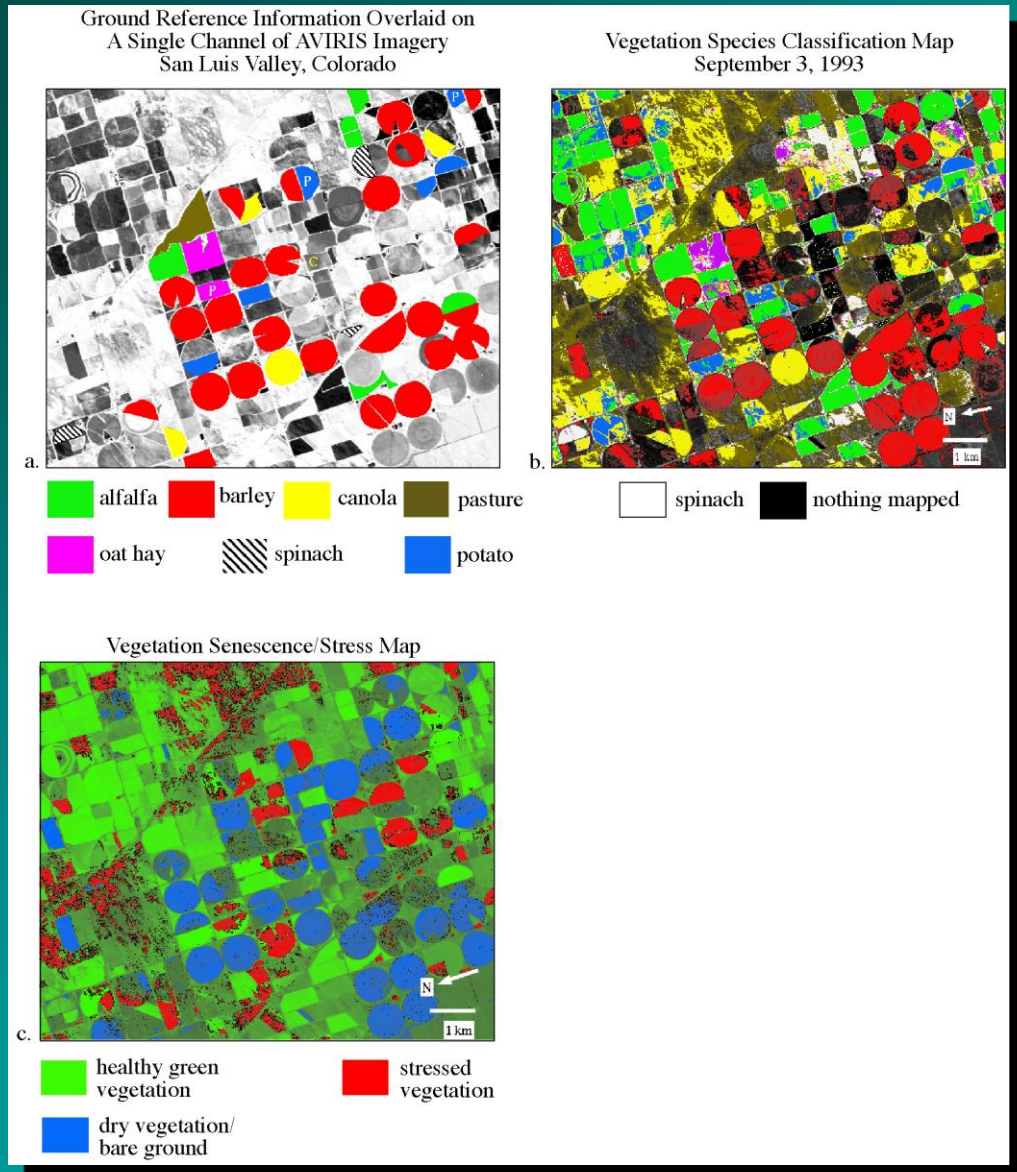
Jensen, 2000



Airborne Visible Infrared Imaging Spectrometer (AVIRIS) Datacube of Sullivan's Island Obtained on October 26, 1998

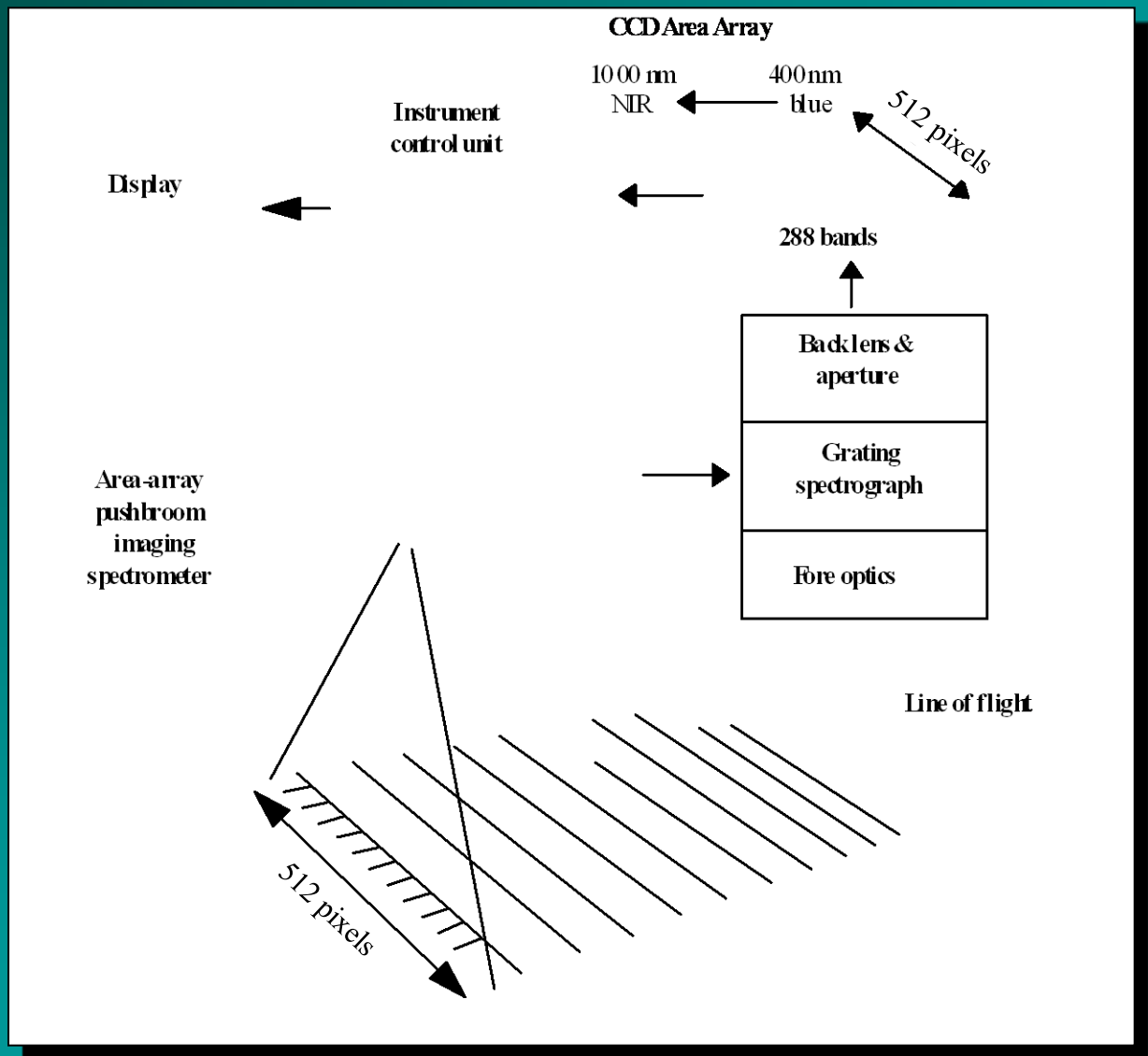
Jensen, 2000

Hyperspectral Crop Classification Using AVIRIS Data



Jensen, 2000

Area Array Pushbroom Imaging Spectrometer Concept

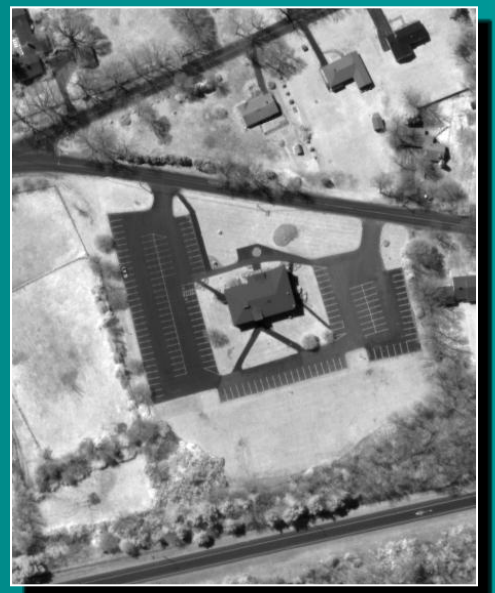


Jensen, 2000

Positive Systems, Inc., Imagery

Green

Red



Near-Infrared

System Components

Jensen, 2000

Emerge Spatial, Inc., Imagery

Green

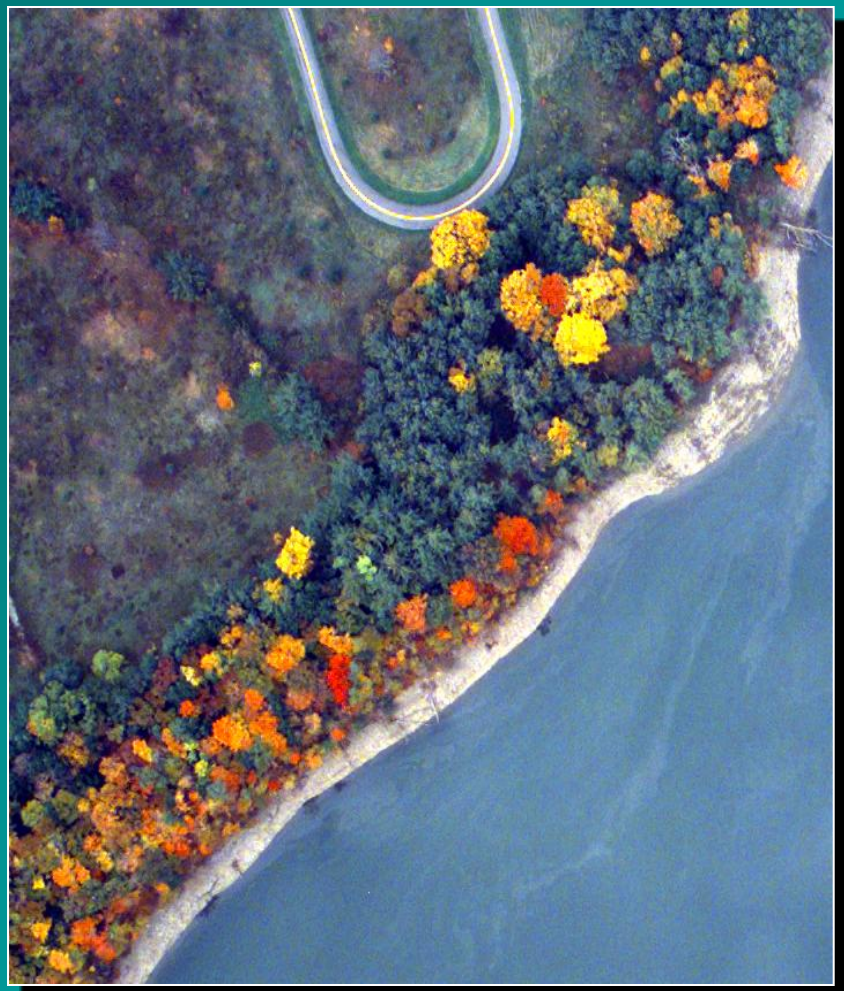
Red

Near-Infrared

Jensen, 2000

Litton Emerge Spatial, Inc., CIR image (RGB = NIR,R,G) of Dunkirk, NY, at 1 x 1 m obtained on December 12, 1998

Natural color image (RGB = RGB) of a N.Y. Power Authority lake at 1 x 1 ft obtained on October 13, 1997

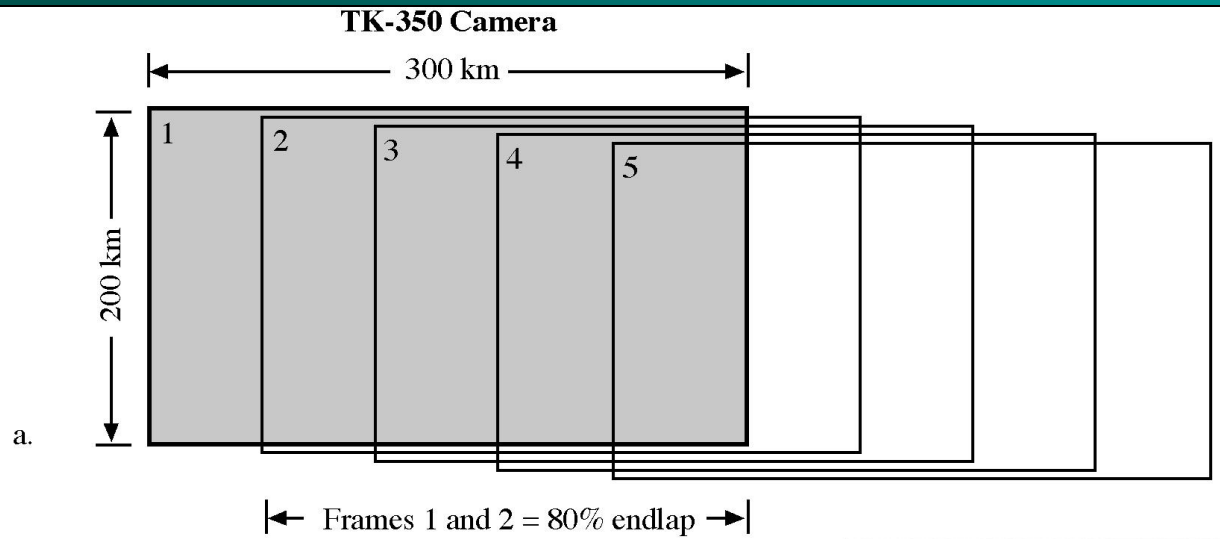


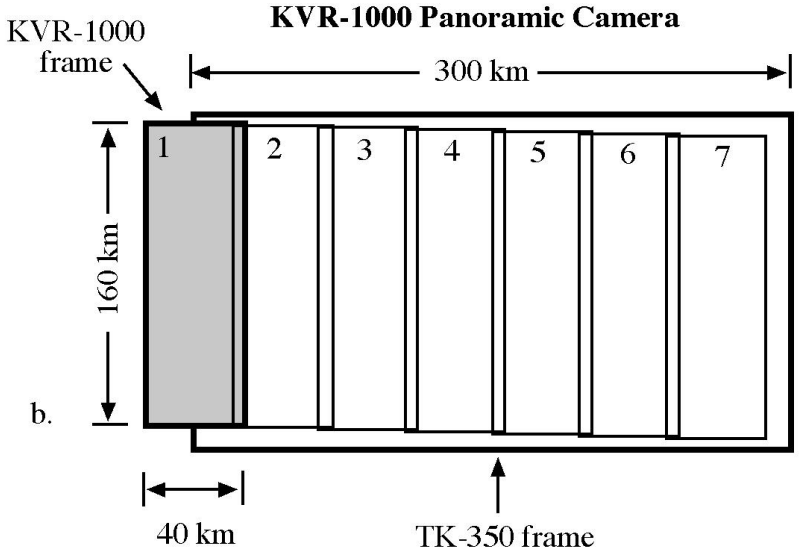
Jensen, 2000

Digital Frame Camera Imagery of Harbour Town, Hilton Head, SC

1 x 1 ft spatial resolution

SPIN-2





c. Portion of a digitized KVR-1000 image (2 x 2 m) of the Pentagon in Washington, DC.

Jensen, 2000

Earth Observing System - *Terra* Instruments

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 - Measurement of Pollution in the Troposphere

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Earth Observing System Measurements

Discipline	Measurement	EOS-AM Instruments
Atmosphere	Cloud Properties	MODIS, MISR, ASTER
	Radiative Energy Fluxes	CERES, MODIS, MISR
	Precipitation	
	Tropospheric Chemistry	MOPITT
	Stratospheric Chemistry	
	Aerosol Properties	MISR, MODIS
	Atmospheric Temperature	MODIS
	Atmospheric Humidity	MODIS
	Lightning	

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Earth Observing System Measurements

Discipline	Measurement	EOS-AM Instruments
Land	Land Cover/Land Use Change	MODIS, MISR, ASTER
	Vegetation Dynamics	MODIS, MISR, ASTER
	Surface Temperature	MODIS, ASTER
	Fire Occurrence	MODIS, ASTER
	Volcanic Effects	MODIS, MISR, ASTER
	Surface Wetness	

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Earth Observing System Measurements

Discipline	Measurement	EOS-AM Instruments
Ocean	Surface Temperature	MODIS
	Phytoplankton	MODIS, MISR
	Dissolved Organic Matter	MODIS, MISR
	Surface Wind Fields	
	Ocean Surface Topography	
Cryosphere	Land Ice Change	ASTER
	Sea Ice	MODIS, ASTER
	Snow Cover	MODIS, ASTER
Solar Radiation	Total Solar Radiation	
	Ultraviolet Spectral Irradiance	

Earth Observing System - *Terra* Instruments

MODIS - Moderate-resolution Imaging Spectroradiometer

Spectral Range	0.4 - 14.4 μm
Spectral Coverage	±55˚, 2330 km swath
Spatial Resolution	250 m (2 bands), 500 m (5 bands), 1000 m (29 bands)

ASTER - Advanced Spaceborne Thermal Emission and Reflection Radiometer

Spectral Range	VNIR 0.4 - 14.4 μm, SWIR 1.6 - 2.5 μm, TIR 8 - 12 μm
Spatial Resolution	15 m (VNIR : 3 bands)
	30 m (SWIR: 6 bands)
	90 m (TIR: 5 bands)

Jensen, 2000

Panchromatic 3 x 3-in Image of Popular Bluff, MO Obtained On February 15, 2000 at 5,000 ft AGL Using A Digital Array Panoramic Camera with 32,000 x 8,000 Detectors

Swath width
1.5 mi

Courtesy of Image America, Inc.

Jensen, 2000