

Satelitarne badania  
Ziemi i atmosfery

6

Wizualne i podczerwone techniki obrazujące (VIR)  
wysokiej rozdzielczości

# Obserwacje optyczne wysokiej rozdzielczości

Wysoka rozdzielczość detektorów optycznych pozwala na szczegółowe obrazowanie powierzchni Ziemi.

Na ogół są to obserwacje w modzie nadir z rozdzielczością poziomą od 100 m do 10 m i szerokości pasa obserwacji ok. 100 km.

Obecnie technologia pozwala na obserwacje z dokładnością poniżej metra w trzech wymiarach.

# Obserwacje optyczne wysokiej rozdzielczości

Obserwacje są wykonywane na dwa sposoby:

- panchromatycznie ( jedna barwa)
- wielo-widmowo (kilka barw jednocześnie)

Obserwacje dokonuje się:

w zakresie widzialnym

lub/i

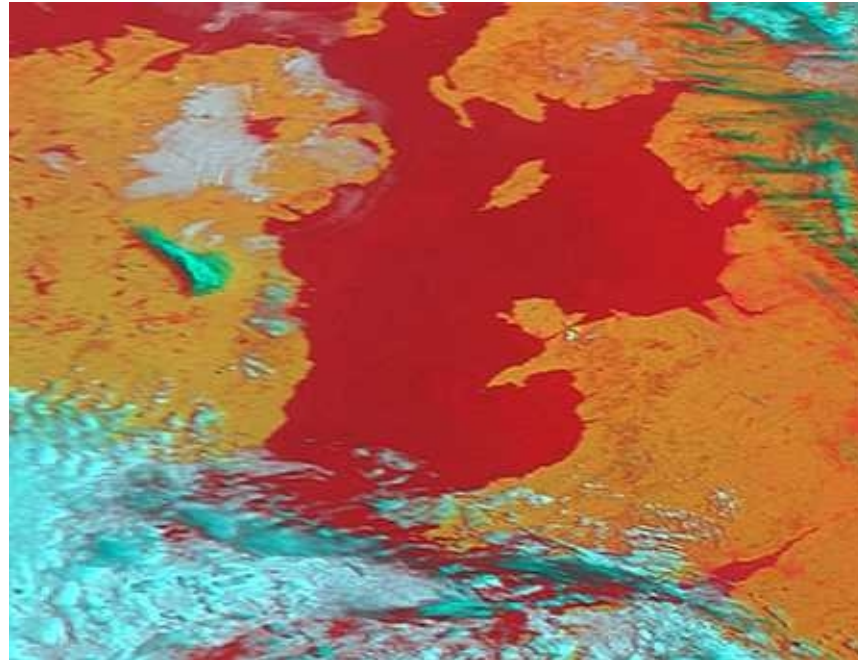
w zakresie podczerwieni



# Spatial resolution

NOAA

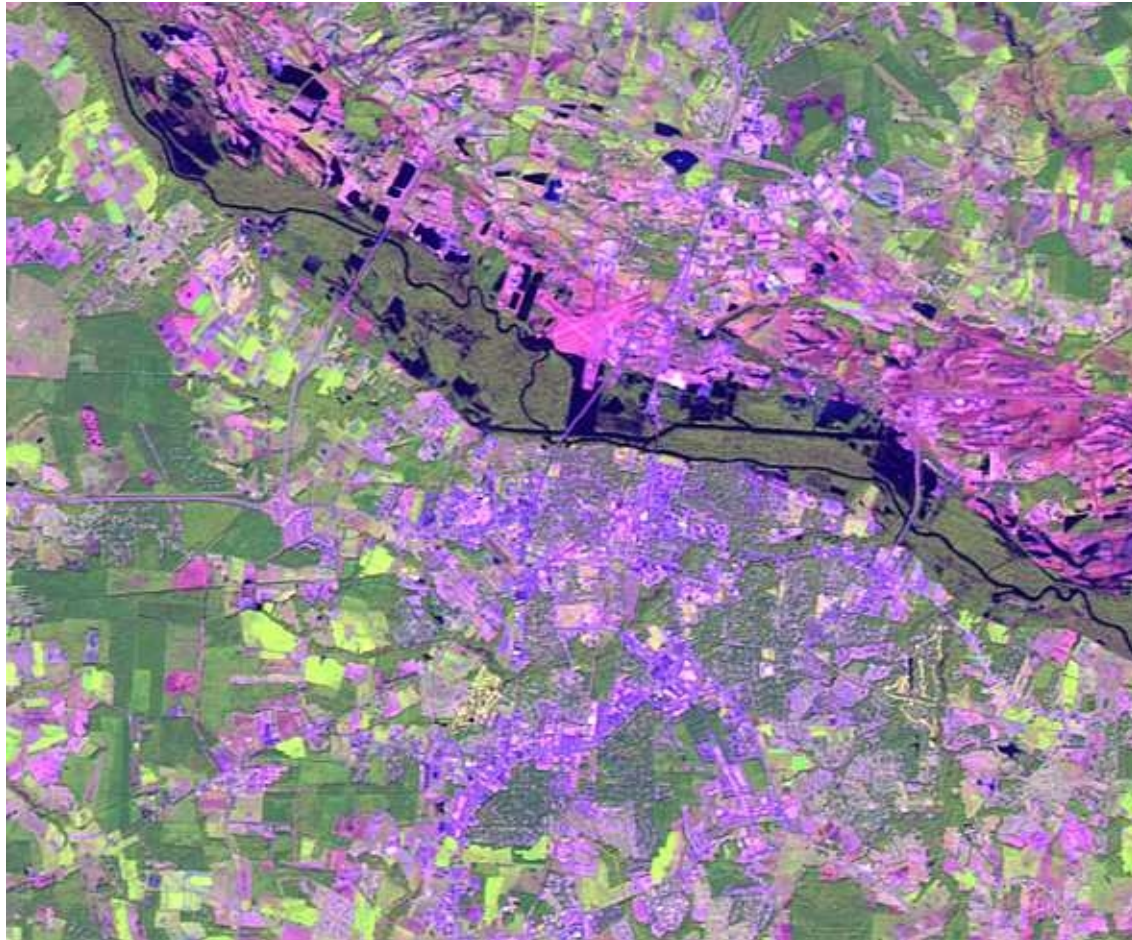
Advanced Very High Resolution Radiometer



Kanał angielski,  
przykład obserwacji radiometrycznych  
niskiej rozdzielczości.

# Spatial resolution

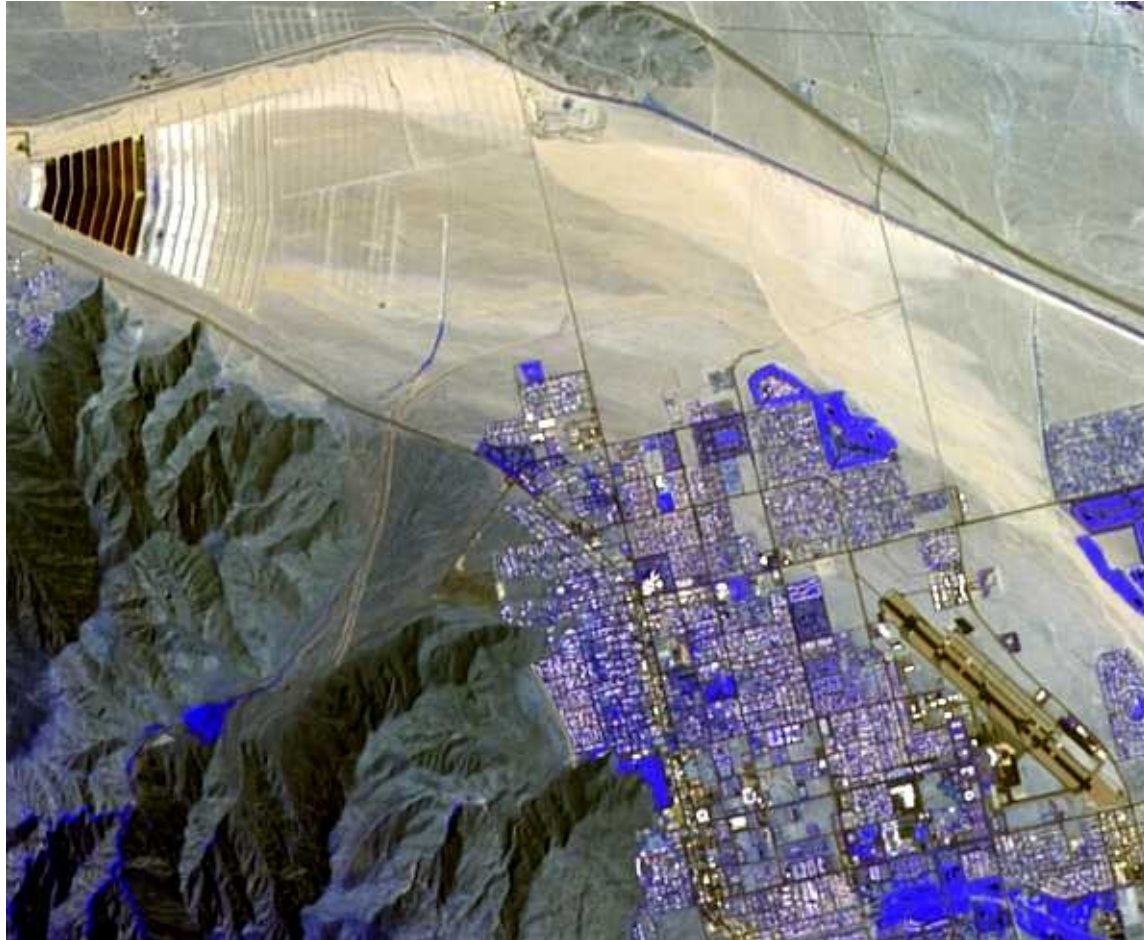
Landsat 4, Landsat 5  
Thematic Mapper (TM)



Greenville, NC

# Spatial resolution

SPOT 6, SPOT 7 (2014-)  
Satellite Pour l'Observation de la Terre

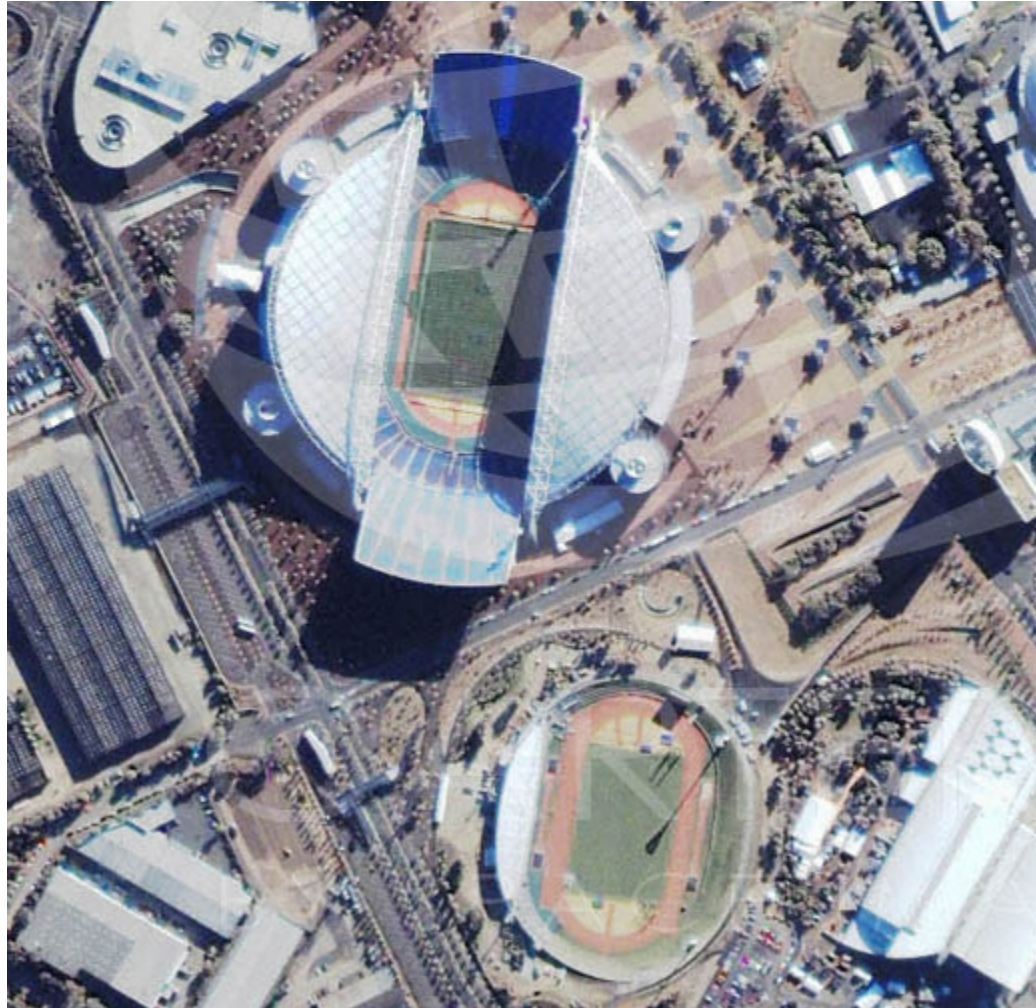


Palm Springs, CA

# Spatial resolution

IKONOS (1999-2015)

pierwszy komercyjny satelita oferujący zdjęcia o rozdzielczości 1m



Sydney Olympic Park



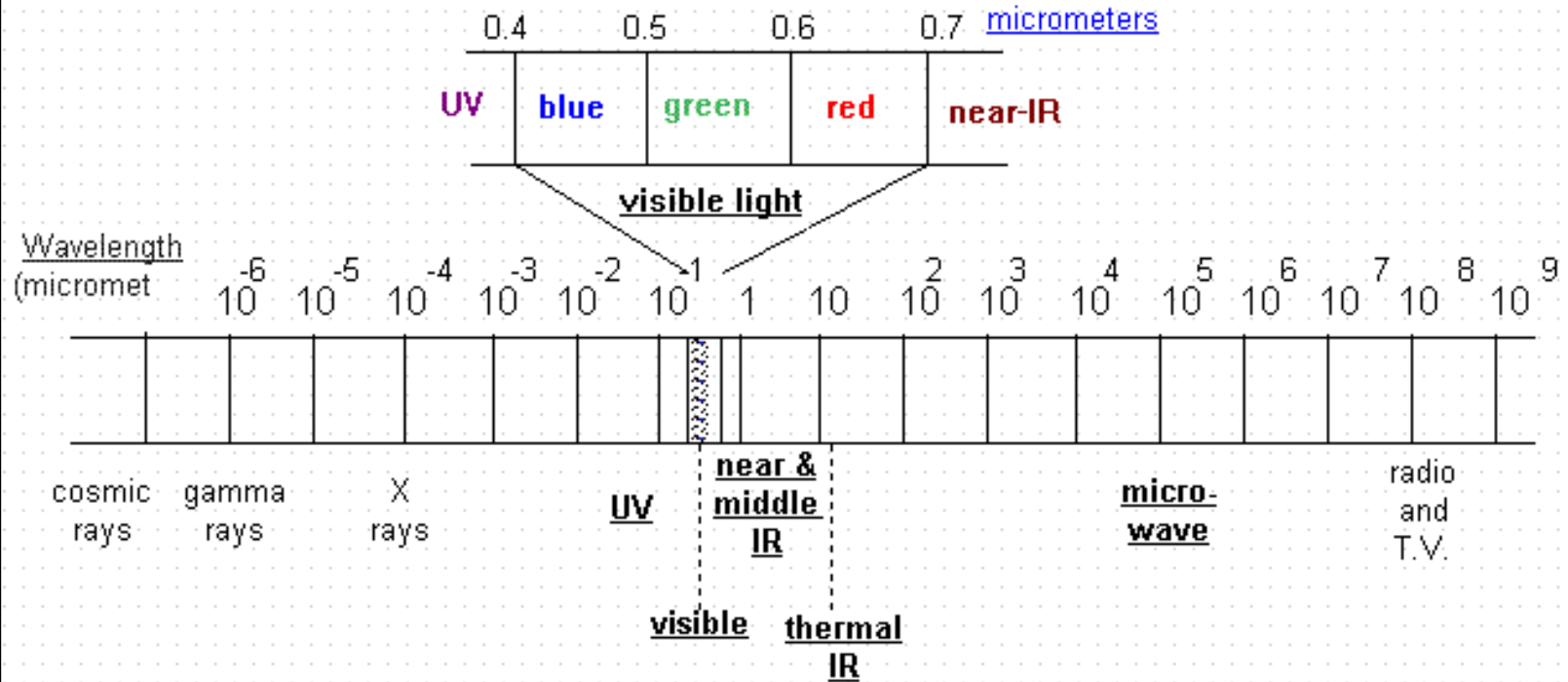
# Rozdzielczość czasowa

- Czas powrotu satelity nad to samo miejsce
  - Landsat - 16 dni
  - AVHRR - 1 dzień
  - IKONOS - 1 - 3 dni
  - SPOT - 26 dni

# Rozdzielczość widmowa

- ilość, rozmieszczenie i szerokość filtrów
- im wyższa rozdzielczość widmowa tym lepsza detekcja podstawowych cech widma (pasm absorpcyjnych),  
ale mniej światła na detektorze,  
co oznacza konieczność zwiększenie kolektora,  
zwiększenia czasu naświetlania (jeśli się da),  
lub najczęściej zmniejszenia rozdzielczości przestrzennej na Ziemi

# The Electromagnetic Spectrum



# Landsat spectral resolution

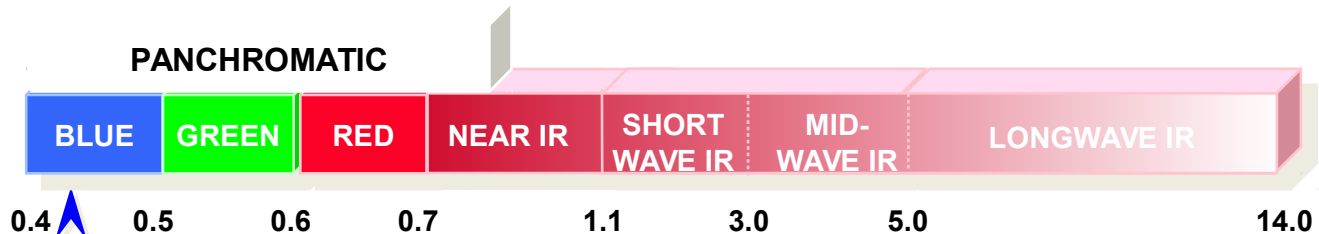


## Landsat TM:

	<b>Wavelength (in micrometers)</b>	<b>Description</b>
1	0.45 - 0.52	Blue-green
2	0.52 - 0.60	Green
3	0.63 - 0.69	Red
4	0.76 - 0.90	Near-IR
5	1.55 - 1.75	IR
6	10.4 - 12.5	Thermal
7	2.08 - 2.35	Mid-IR

# Spectral Regions – Landsat MSS

*BAND 1 (Visible Blue)*



0.4 - 0.5  $\mu\text{m}$

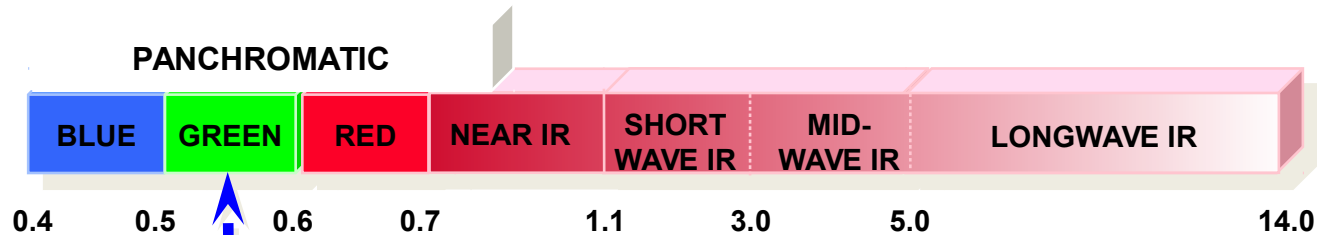
- Illuminates Materials in Shadows
- Water Penetration for Bathymetry
- Soil / Vegetation Differentiation
- Deciduous / Coniferous Differentiation

# Band 1



# Spectral Regions – Landsat MSS

## *BAND 2 (Visible Green)*



0.5 - 0.6 μm

- Water Penetration for Bathymetry
- Clear and Turbid Water Contrast
- Discrimination of Oil on Water
- Green Reflectance Peak of Healthy Vegetation

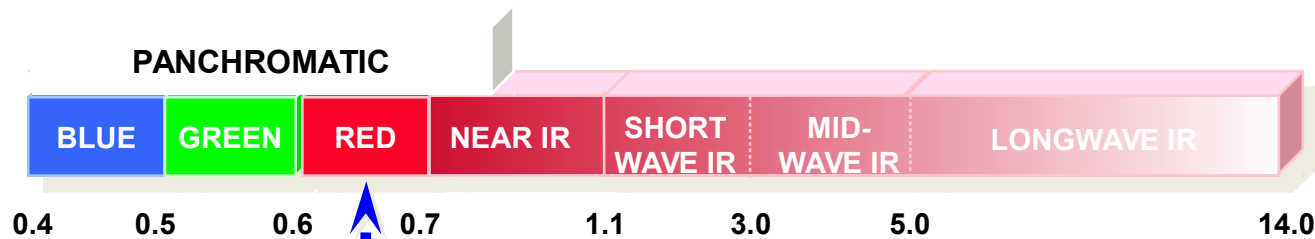
# Band 2





# Spectral Regions – Landsat MSS

*BAND 3 (Visible Red)*



0.6 - 0.7 μm

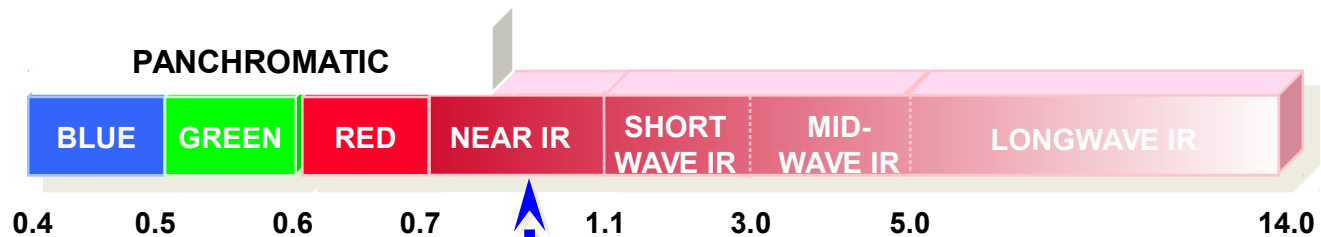
- Vegetation Differentiation
- Chlorophyll Absorption
- Limited Water Penetration for Bathymetry

# Band 3



# Spectral Regions – Landsat MSS

## *BAND 4 (Near Infrared)*



0.7 - 1.1  $\mu\text{m}$

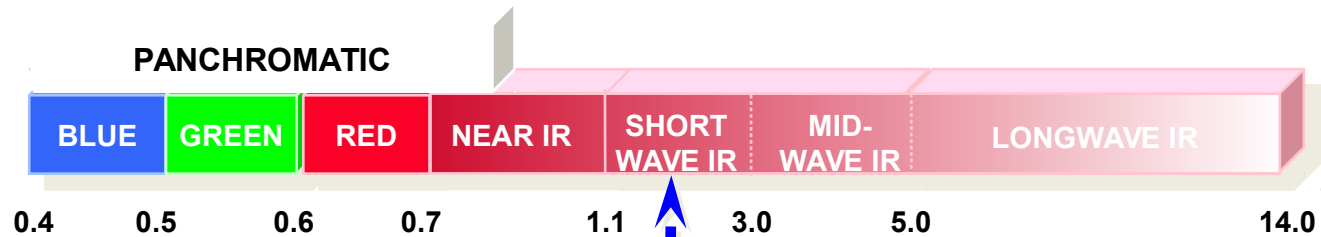
- Vegetation Analysis
- Shoreline Mapping
- Landcover Discrimination

# Band 4



# Spectral Regions – Landsat MSS

## *BAND 5 (Short-wave Infrared)*



1.1 - 3.0 μm

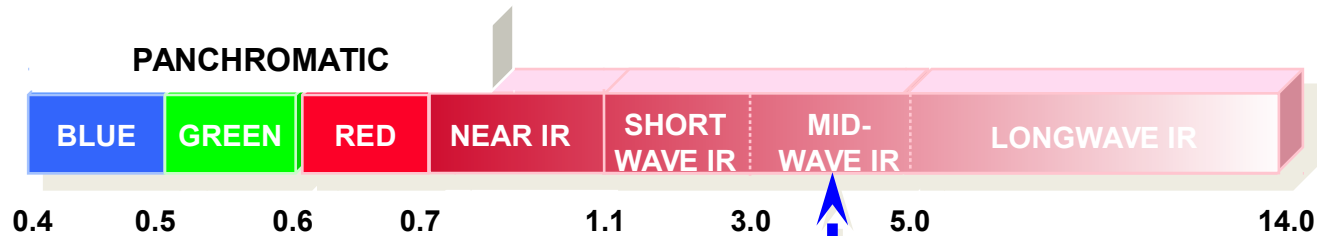
- Fire Mapping
- Discrimination of Oil on Water
- Moisture Content of Soil and Vegetation
- Snow / Cloud Differentiation
- Vegetation Analysis

# Band 5



# Spectral Regions – Landsat MSS

## *BAND 7 (Mid-wave Infrared)*



3.0 - 5.0μm

- Solar Reflectance From Specular Metal Roofs
- Smoke Penetration
- Daytime Reflectance Mixed With Emitted EM Radiation
- Nighttime Emitted EM Radiation

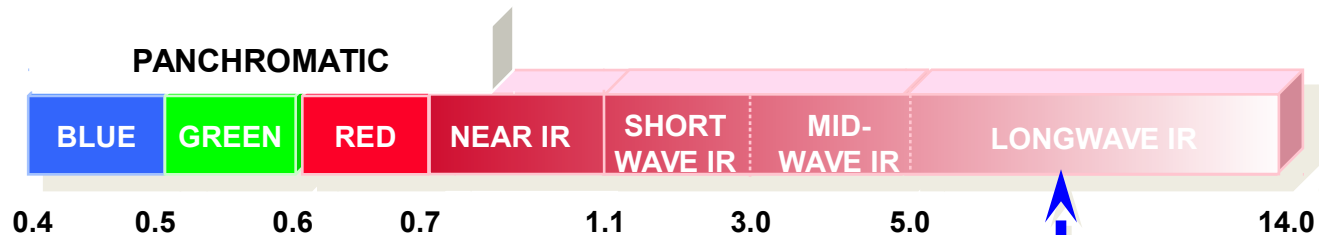
# Band 7





# Spectral Regions – Landsat MSS

## *BAND 6 (Long-wave Infrared)*



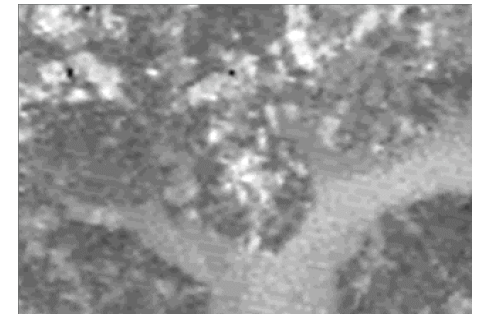
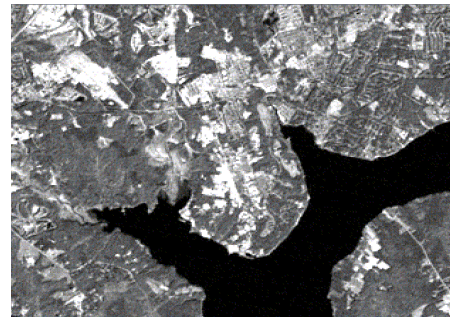
5.0 - 14.0 $\mu$ m

- Thermal Analysis
- Vegetation Density
- Urban Heat Islands

# Band 6

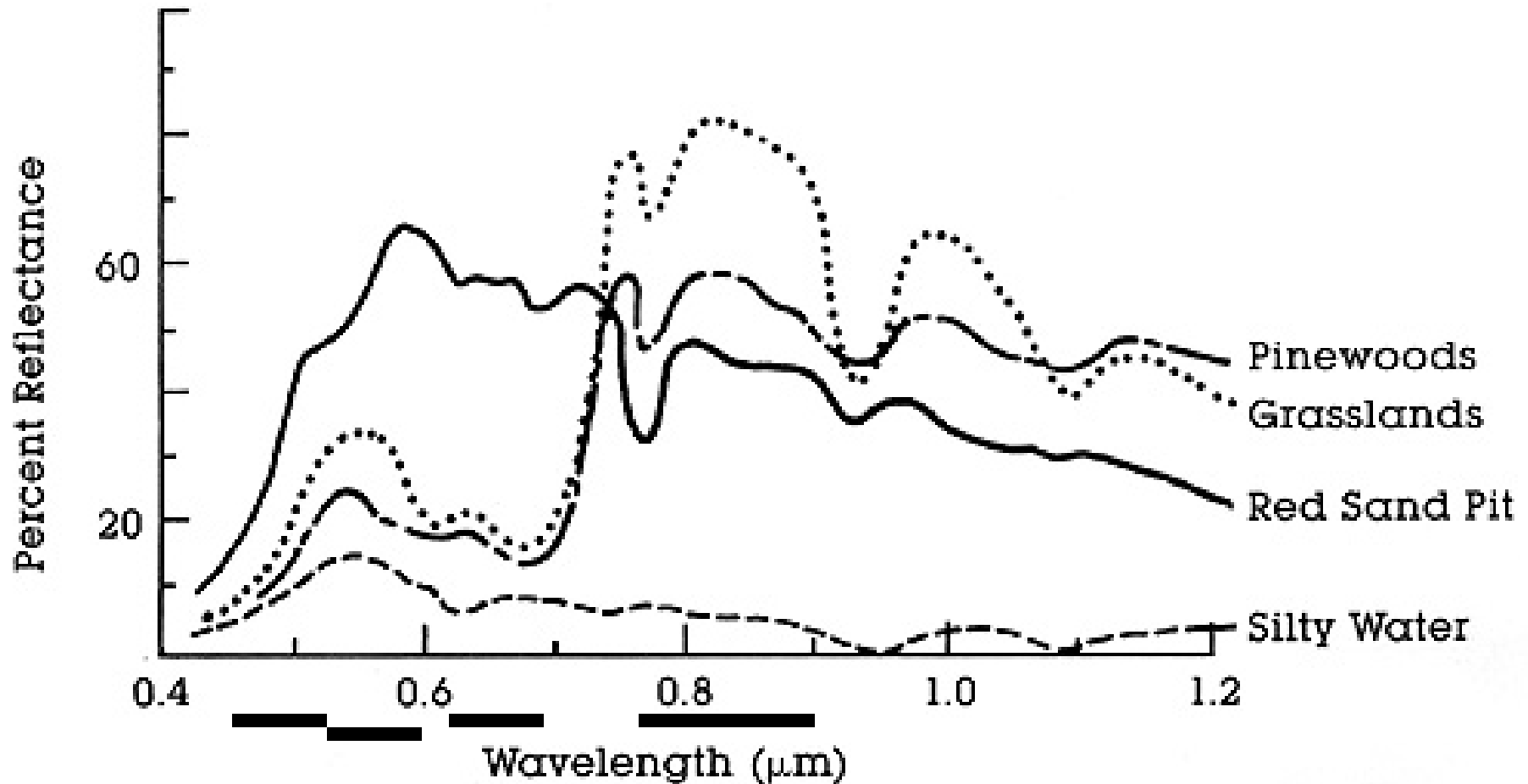


# Landsat Bands



# Spectral Resolution of Landsat TM

These bands provide a coarse summary of spectral signatures.



TM Band:

1

2

3

4

5

7

# Radiometric Resolution

---

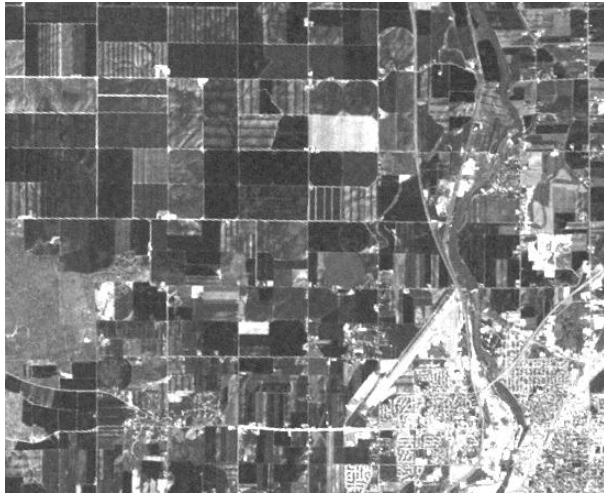
- Number of possible data values reported by the sensor
- Range is expressed as a power ( $2^n$ )
  - 8-bit resolution has  $2^8$  values, or 256 values  
Range is 0-255
  - 12-bit resolution has  $2^{16}$  values, or 65,536 values  
Range is 0-65535
- The value in each pixel is called the
  - **Digital Number (DN)**
  - **Brightness Value (BV)**

# Image Display

---

- Graphics display devices use three **color guns**
  - Red, Green, Blue
  - All colors can be formed from various combinations of these 3 colors (which is why they're used in computer/TV screens)
- The brightness values (BV) to be displayed will often have an 8-bit range
  - 0 to 255
- In remote sensing, we assign one band to each color gun to give color to the image

# Landsat Image of Idaho



Band 1



Band 2



Band 3



Band 4

# Landsat Image of Idaho



Band 5



Band 6



Band 7

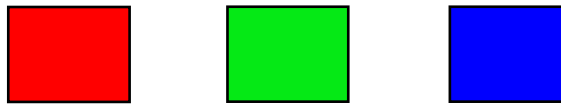


# Multispectral Imagery Display

Band Composite Output =



Color Guns =



Band Combination =

7 4 2

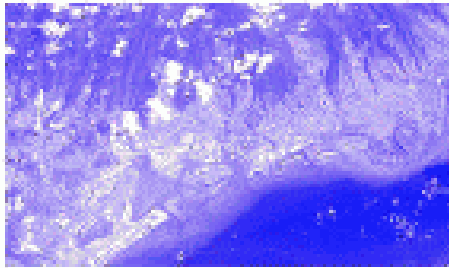


Landsat TM Band =

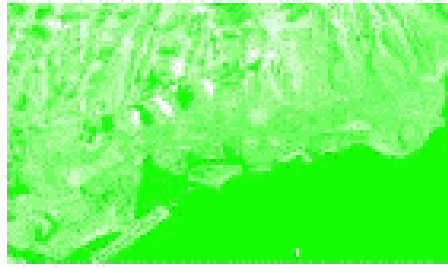
1 2 3 4 5 7 6

# Color Composite Image

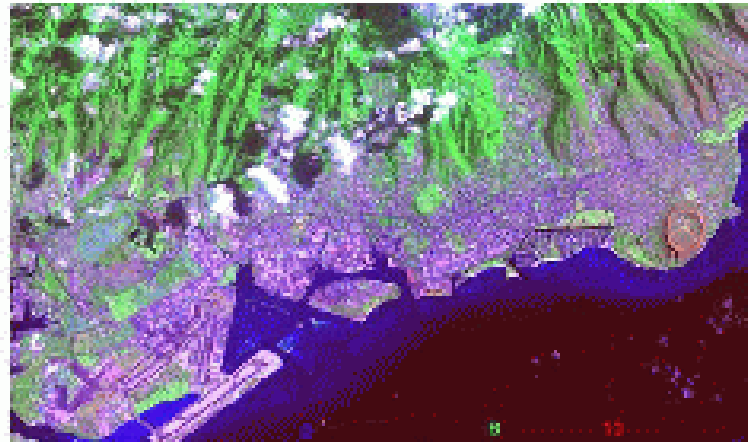
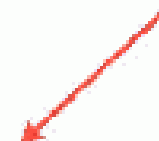
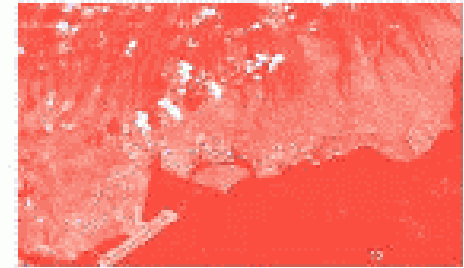
Band A  
Blue color gun



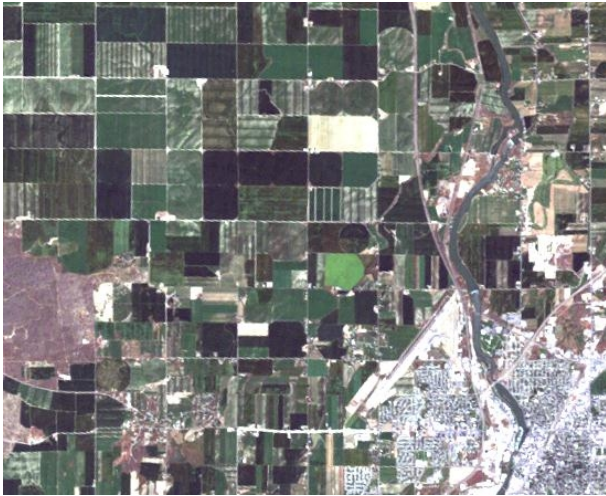
Band B  
Green color gun



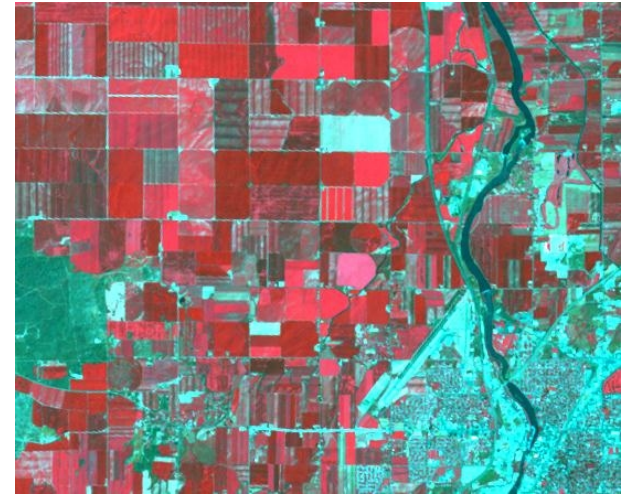
Band C  
Red color gun



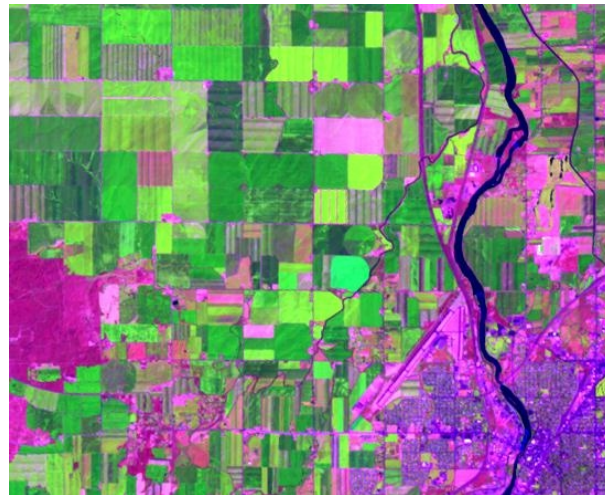
# Landsat TM Image of Idaho



321



432



543

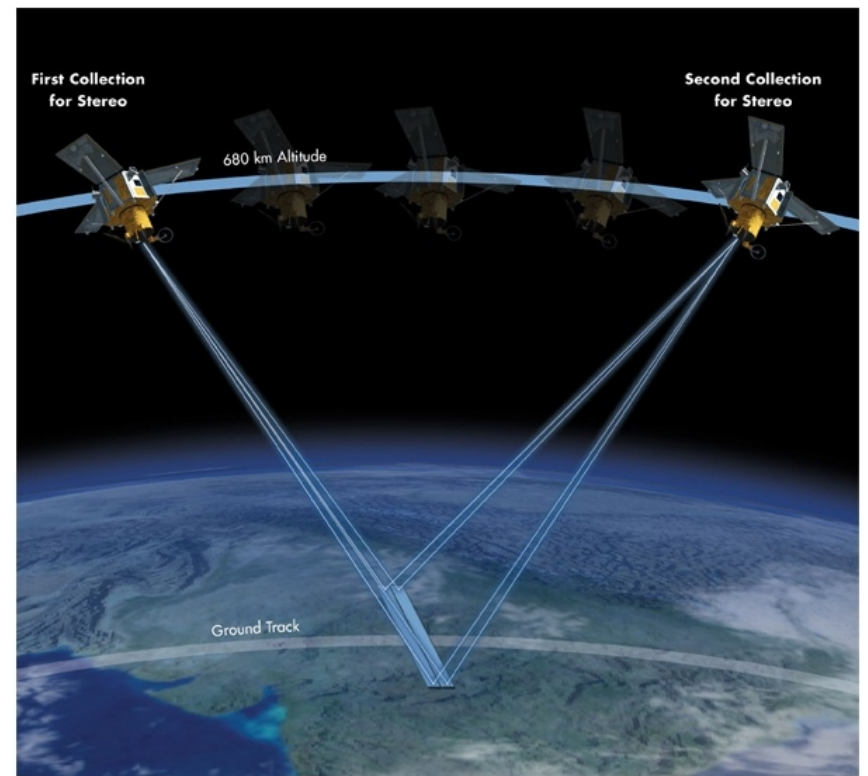
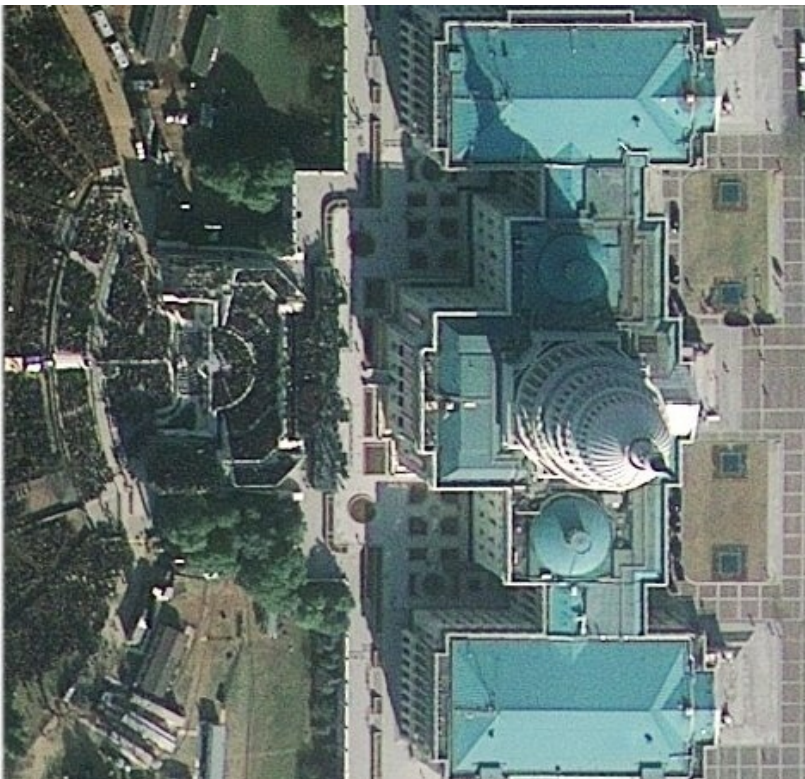
# Obserwacje optyczne wysokiej rozdzielczości

Dokładność obserwacji zależy od stanu atmosfery Ziemskiej,  
dlatego wykorzystuje się dobrą pogodę do wykonywania  
zdjęć o najlepszej rozdzielczości



# Obserwacje optyczne wysokiej rozdzielczości

Dodatkowe informacje można wydobyć wykorzystując obserwacje stereoskopowe.



<http://www.3dphoto.net/>

# Obserwacje optyczne wysokiej rozdzielczości

## Instrumenty

Current and planned Instruments	
AEISS	MSI
ALI	MSI (Sentinel-2)
ASTER	MSS (Roscosmos)
AVNIR-2	MSU-200
CCD	NigeriaSat Medium and High Resolution
CCD (HJ, HY)	PAN
Geoton-L1	PAN (BJ-1)
High Resolution Panchromatic Camera	PAN (Cartosat-1)
HiRI	PAN (Cartosat-2)
HRC	PAN (Cartosat-3)
HRG	PAN (GISTDA)
HRMS	PAN (IRS-1C/1D)
HRS	PAN CAMERA
HRTC	PAN+MS (RGB+NIR)
HRVIR	PRISM
LISS-III (IRS)	PSS
LISS-III (RESOURCESAT)	SLIM-6
LISS-IV	SLIM-6-22
MBEI	TES PAN
MSC	TOPSAT telescope



Landsat

SPOT

Sentinel-2

Number in series	7+1*	5**	starting with 2	
Launch	1972 to 1999*	1986 to 2002	<b>S2-A launch end 2013</b>	
Measurement principle	scanner	pushbroom	pushbroom	
Earth coverage	16	26	5	days
Swath	185	2 × 60	290	km
Multispectral bands	7(8*)	4+1 (panchromatic)	13	
Spatial sampling distance	30, 60	10, 20, (2.5)	10, 20, 60	m

\* LCDM mission targeted early 2013

\*\* SPOT-6 targeted end 2012



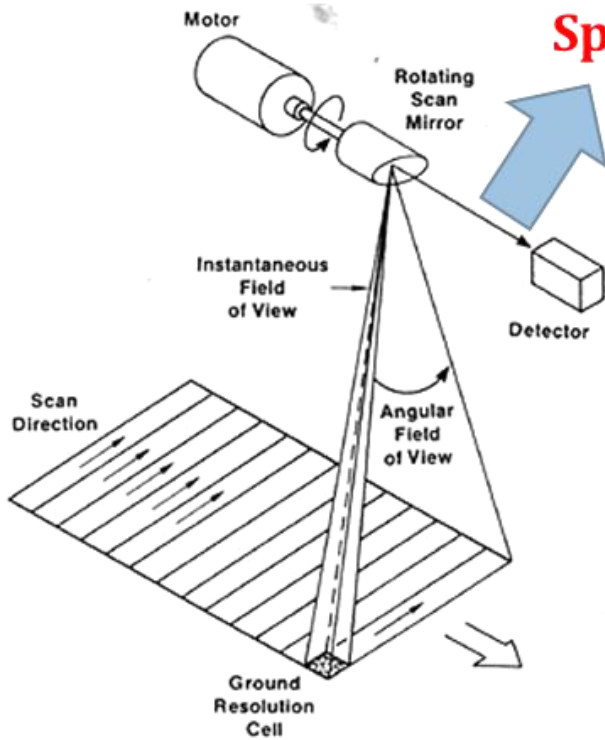
wiskbroom



pushbroom

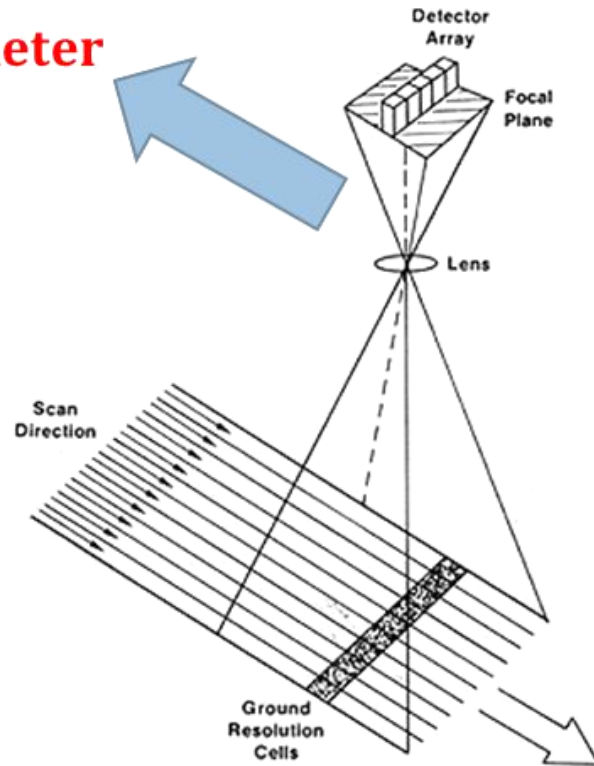


# Spectrometer



A. CROSS-TRACK SCANNER.

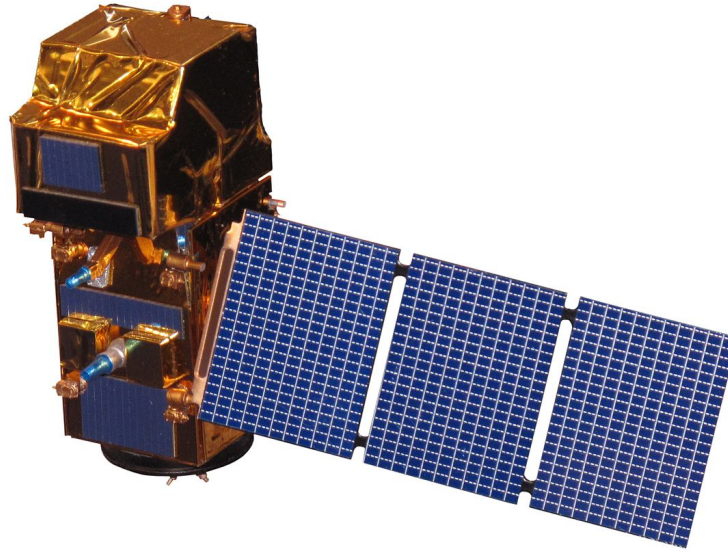
wiskbroom



C. ALONG-TRACK SCANNER.

pushbroom

## Sentinel-2



Docelowo 4 satelity: 2A, 2B, 2C, 2D

Start: 2A – 2015, 2B – 2017, 2C i 2D - 2021

Masa: 1.2 tony

Czas życia: 7.25 lat

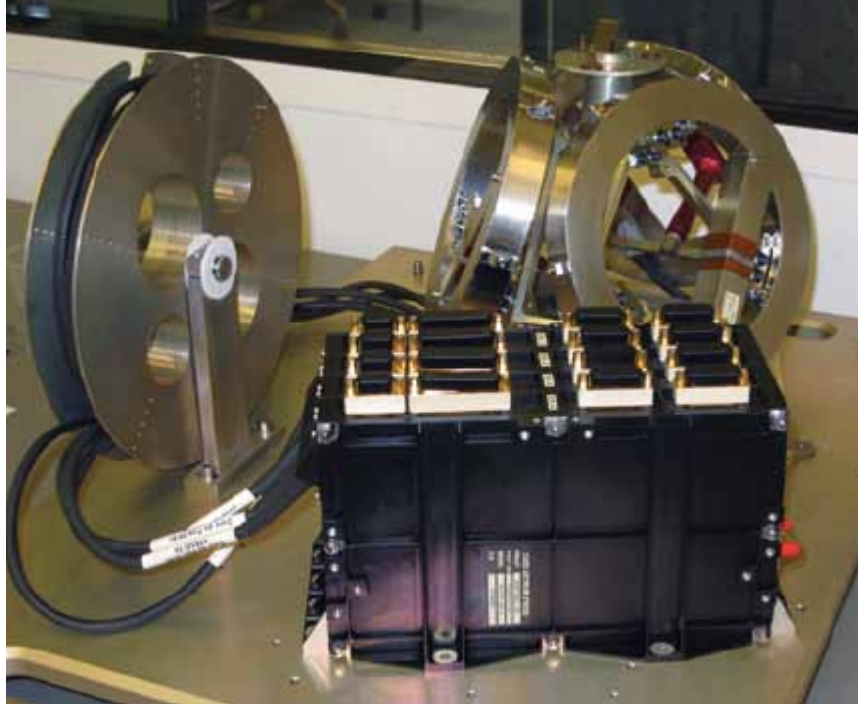
Zapas paliwa: 12 lat

Wymiary: odpowiednie dla małych rakiet typu Vega

Jeden instrument:

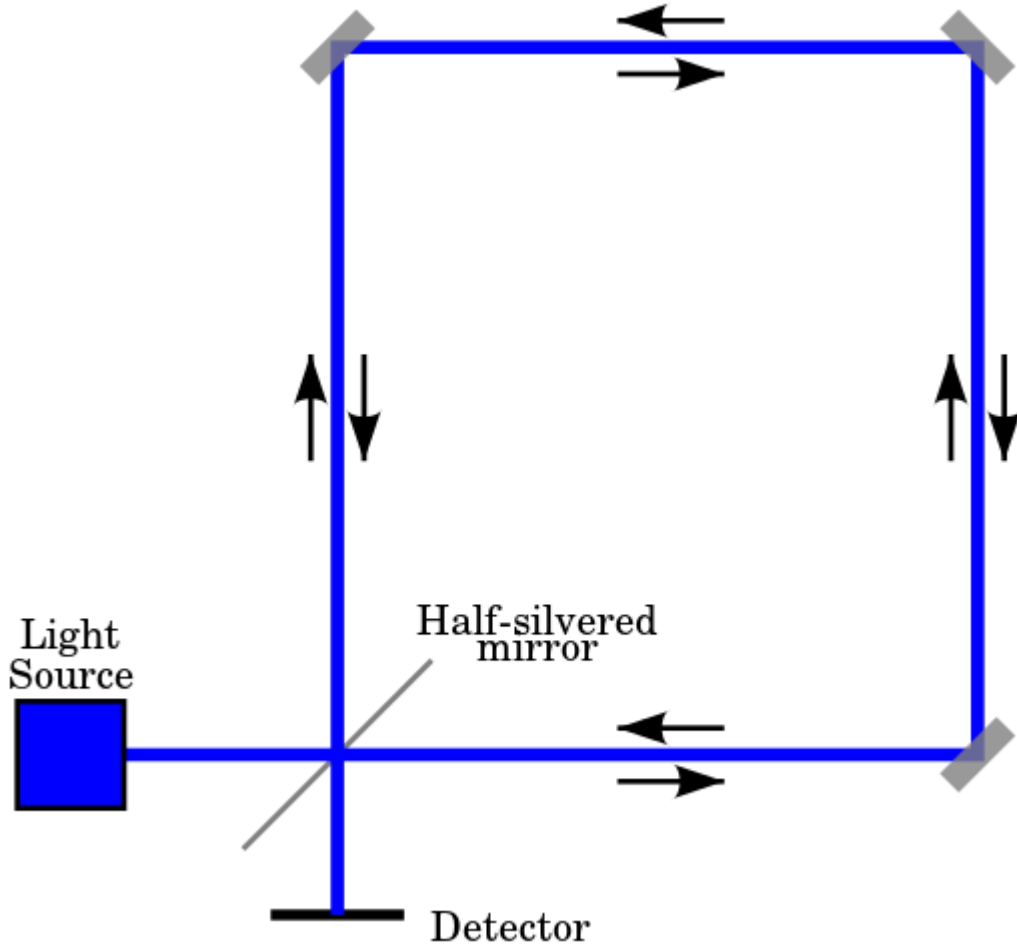
MSI – multi-spectral instrument

13 filtrów, 10-60m rozdzielczości

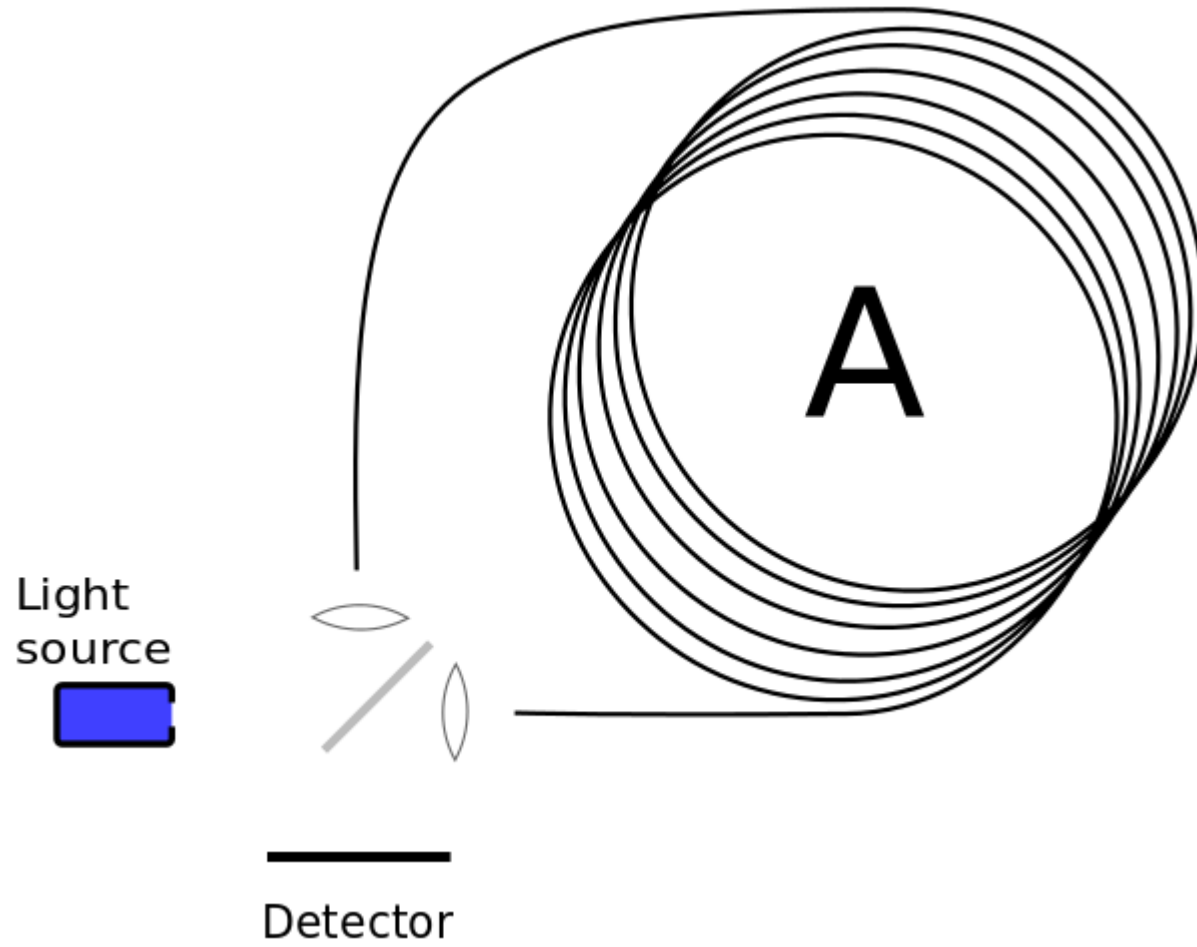


Stabilizacja: żyroskopy światłowodowe (u góry),  
4 koła reakcyjne, elektromagnesy (magnetic torque rods)

# Interferometr Sagnaca

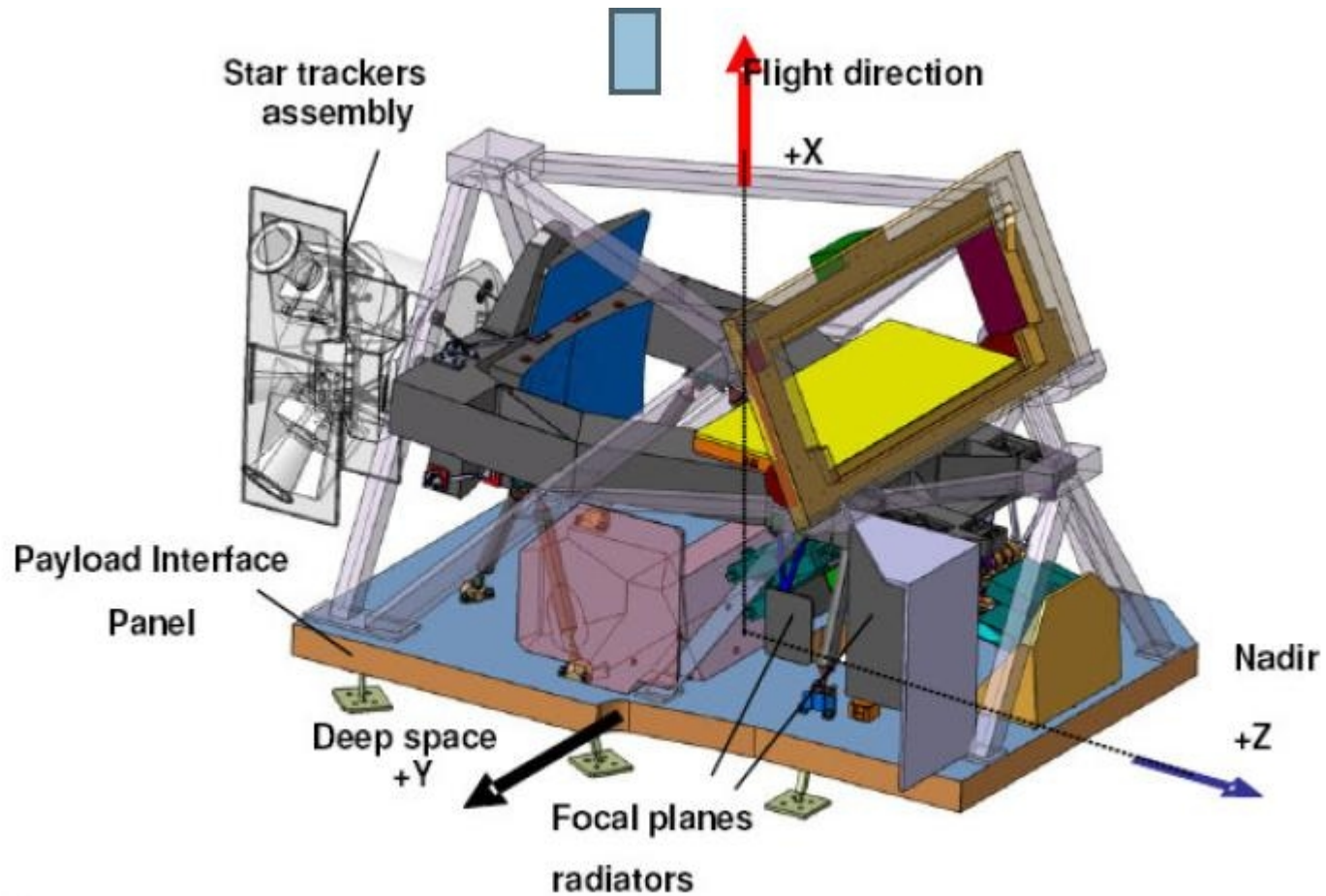


# Żyroskop światłowodowy



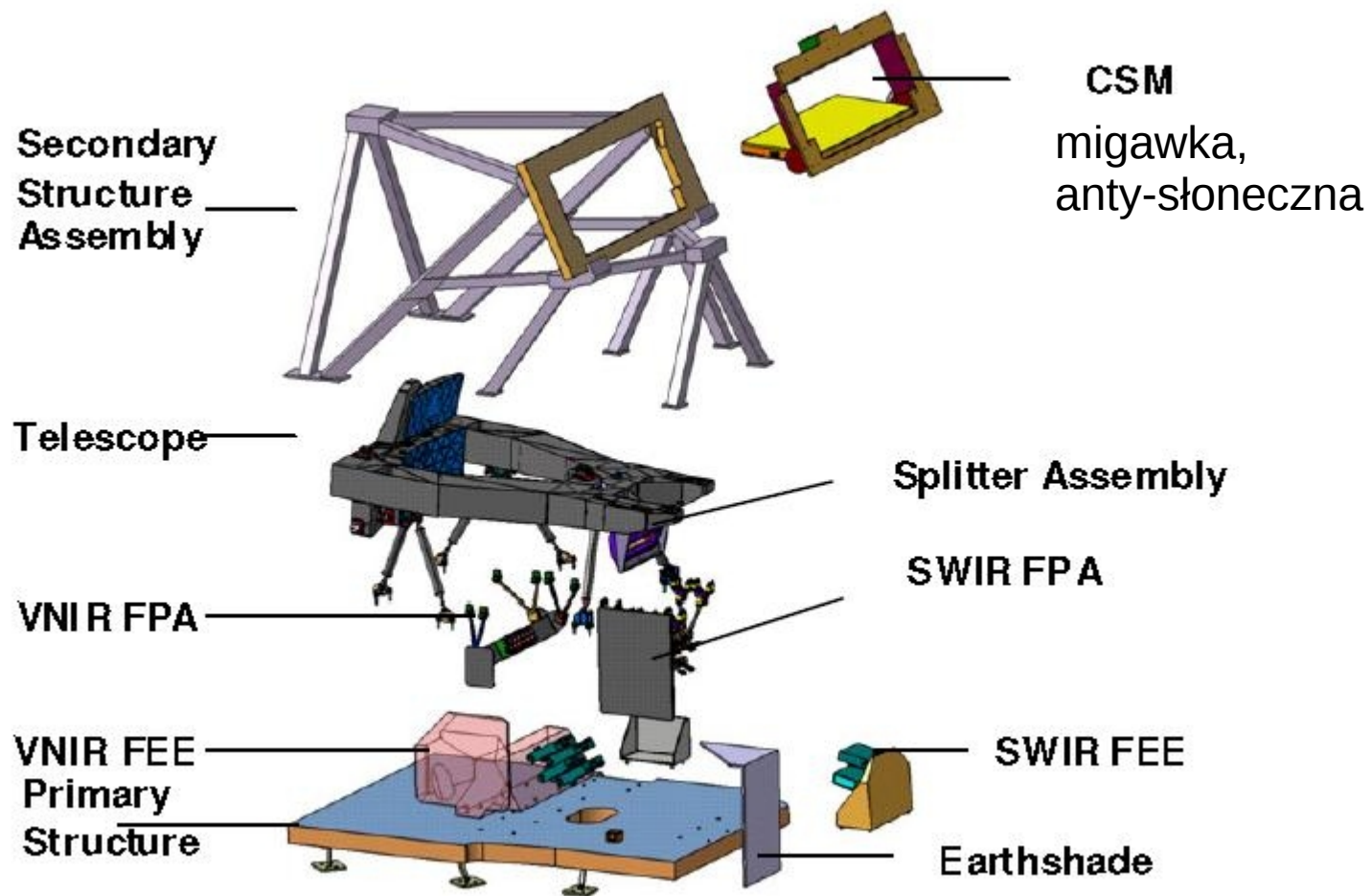
# Obserwacje optyczne wysokiej rozdzielczości

## Multi-Spectral Instrument (MSI) – Sentinel-2



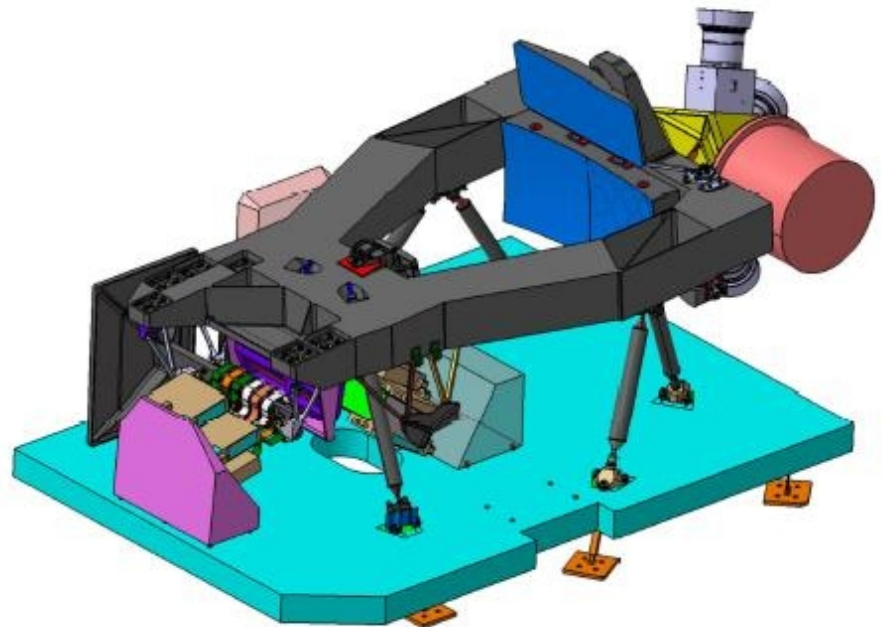
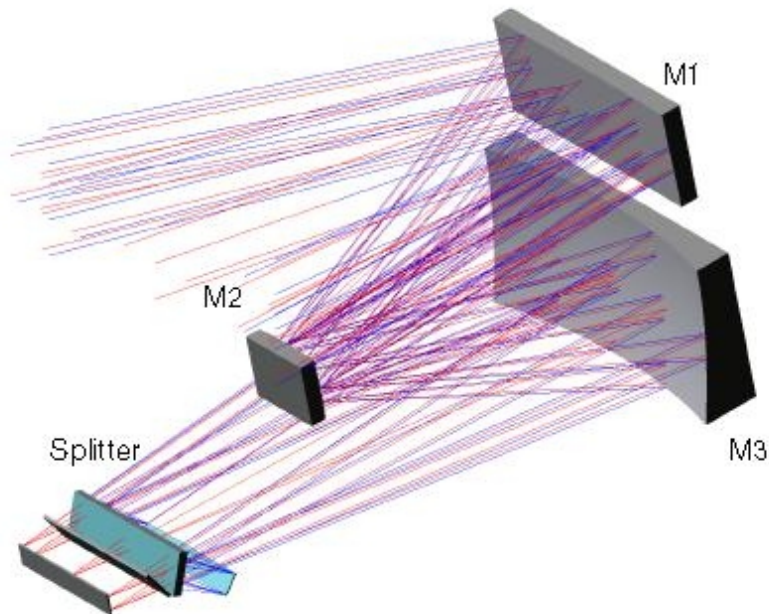
# Obserwacje optyczne wysokiej rozdzielczości

## Multi-Spectral Instrument (MSI)



# Obserwacje optyczne wysokiej rozdzielczości

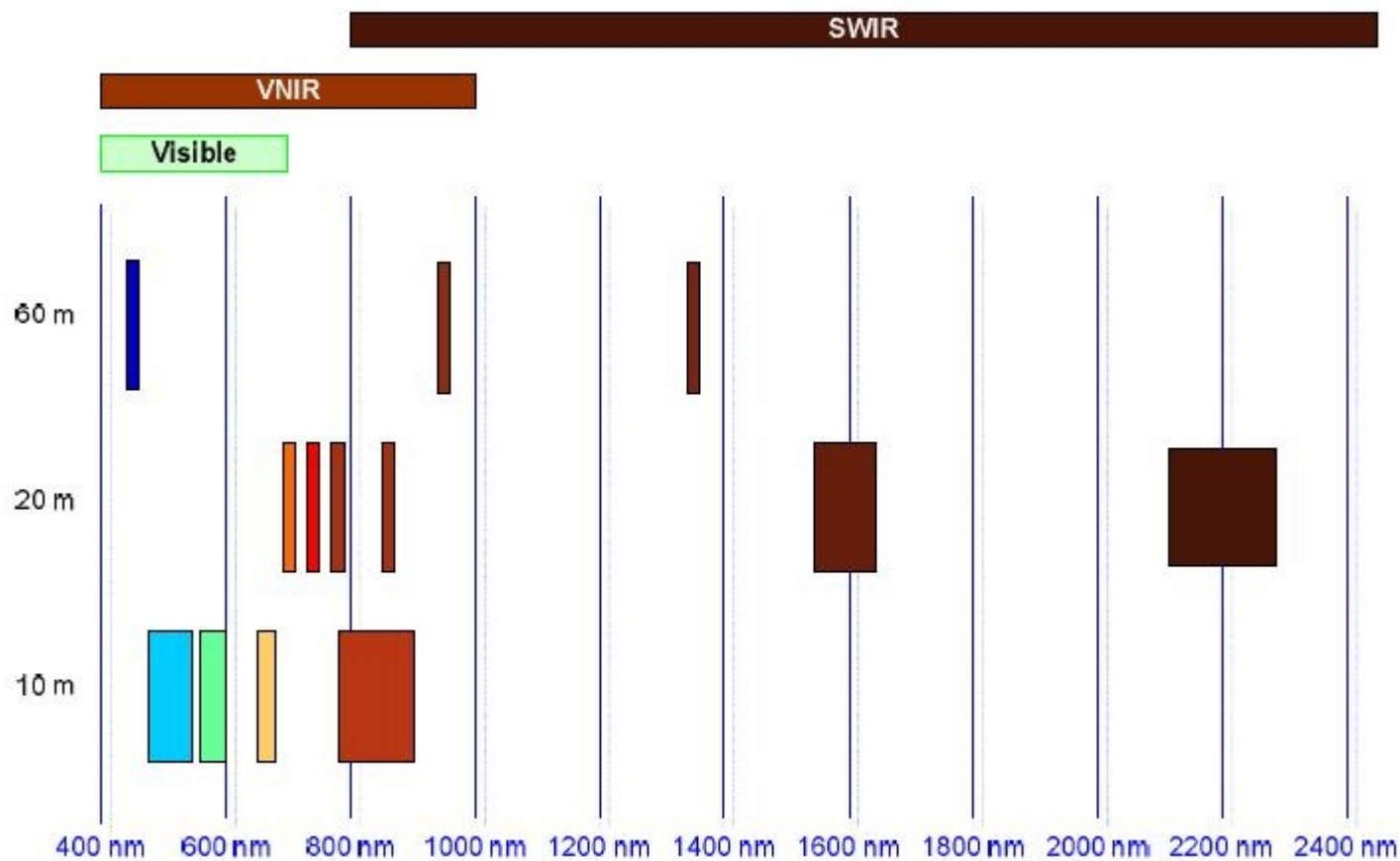
## Multi-Spectral Instrument (MSI)

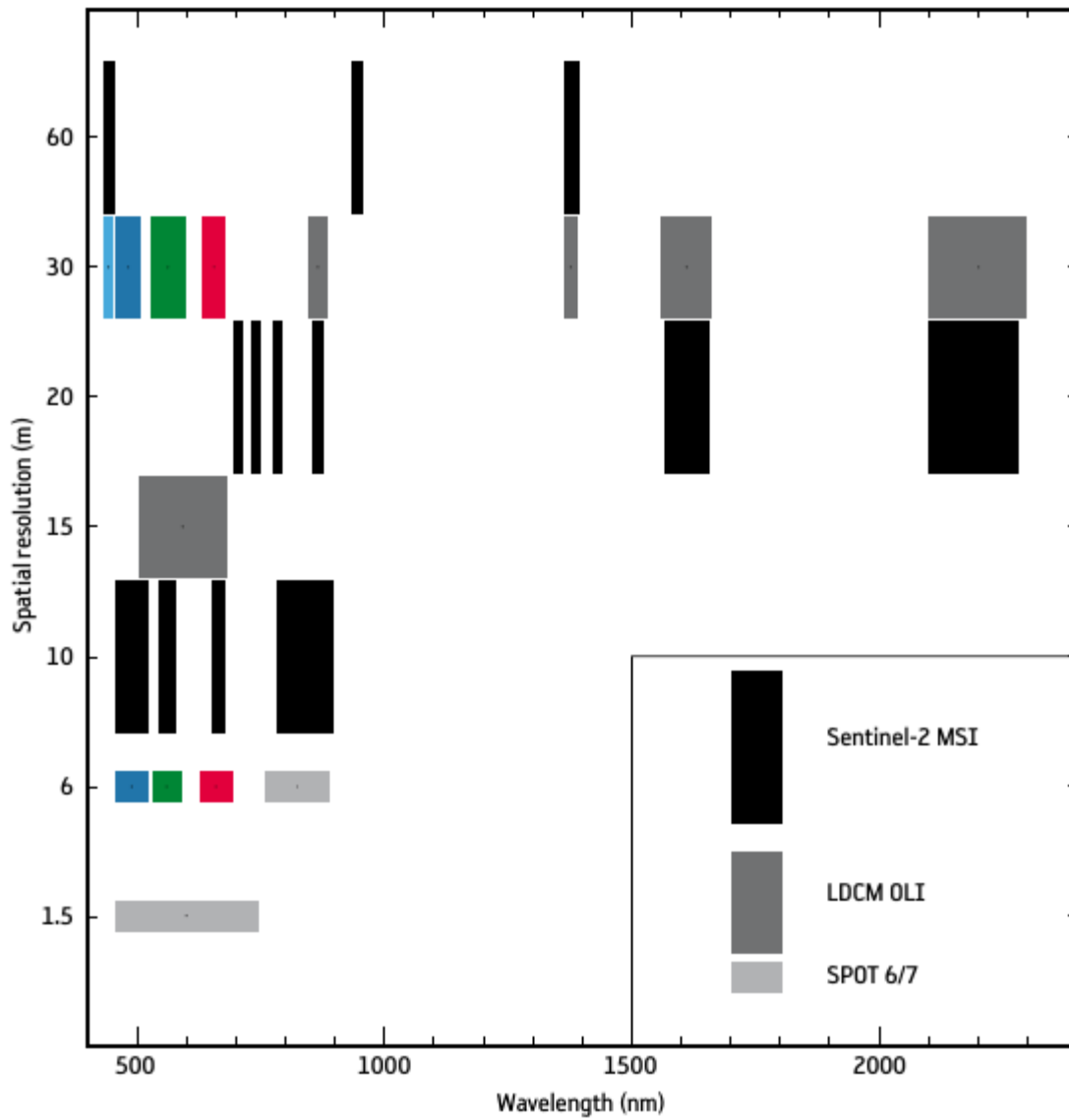




# Obserwacje optyczne wysokiej rozdzielczości

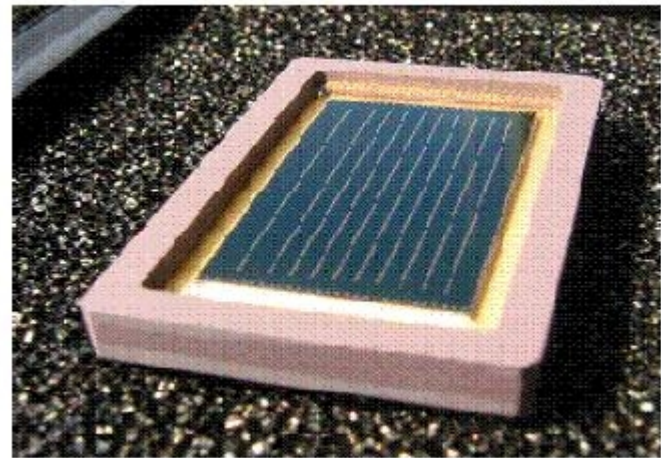
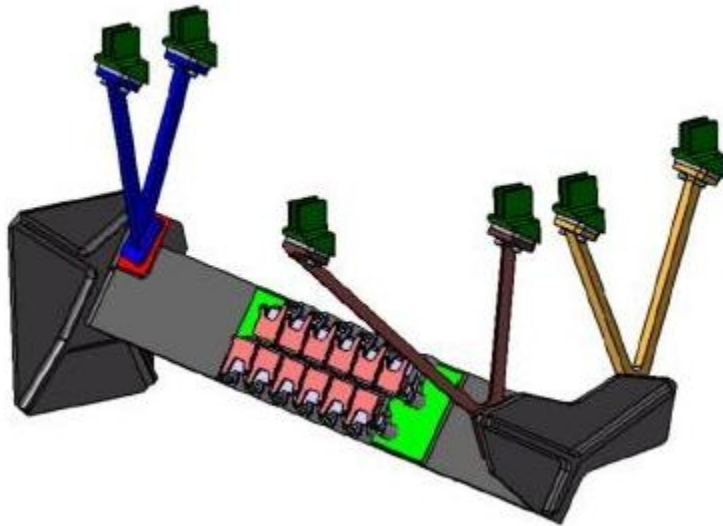
## Multi-Spectral Instrument (MSI)





# Obserwacje optyczne wysokiej rozdzielczości

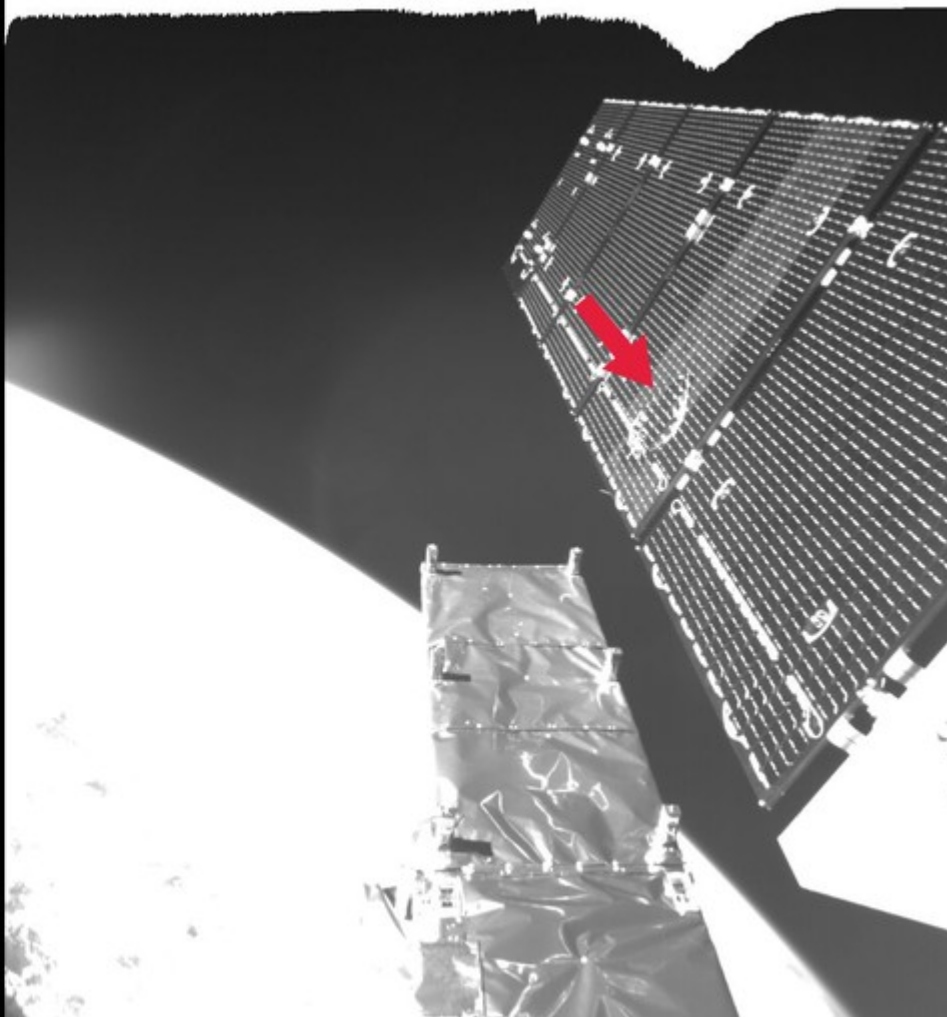
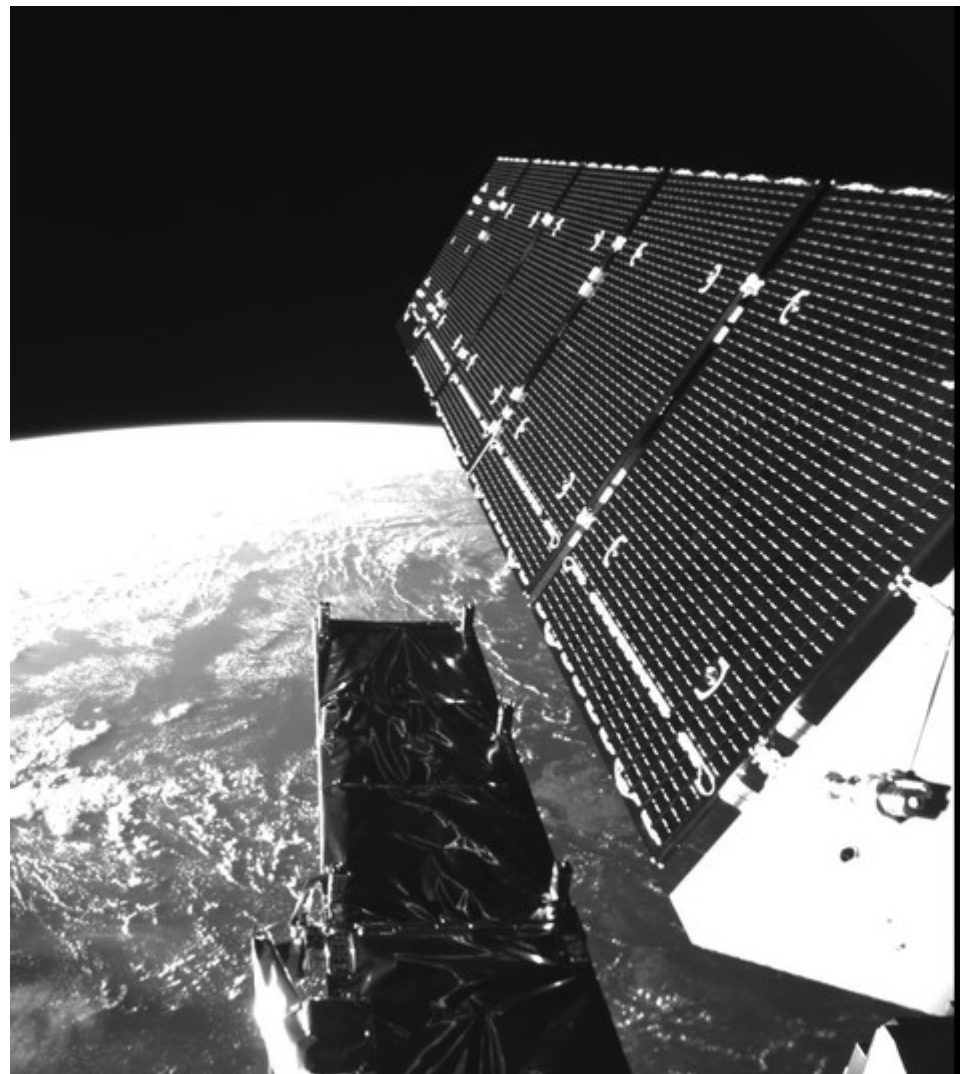
## Multi-Spectral imaging Instrument (MSI)



# Obserwacje optyczne wysokiej rozdzielczości

## Multi-Spectral imaging Instrument (MSI)

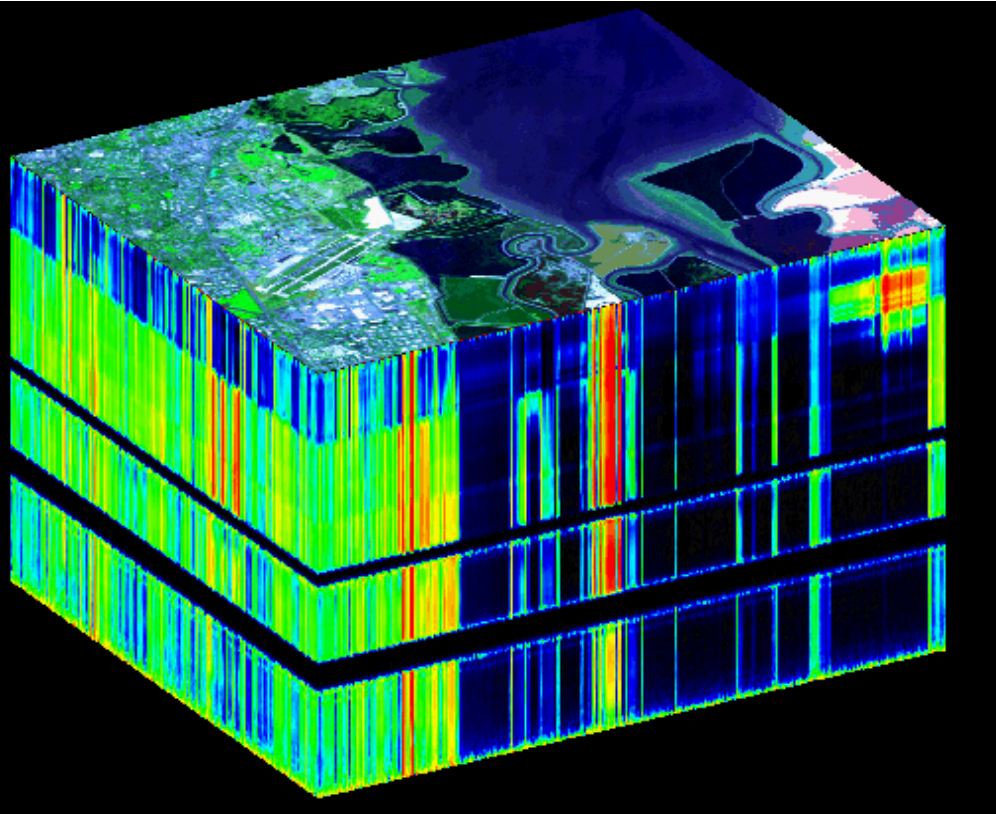




Sentinel-1 został uderzony przez śmieć kosmiczną.



# Hyperspectral Imaging Applications



**EOS 840 Course**

**Lecture Notes**

*Course Instructor:*

*Dr. Richard B. Gomez*

[rgomez@gmu.edu](mailto:rgomez@gmu.edu)

George Mason University  
School of Computational Sciences  
Center for Earth Observing and Space Research

# What is Hyperspectral Sensing?

- Sensor with hundreds of spectral channels with each channel covering a narrow and contiguous portion of the light spectrum
- Hyperspectral sensing allows the analyst to perform reflectance or fluorescence spectroscopy on each spatial element of the image scene

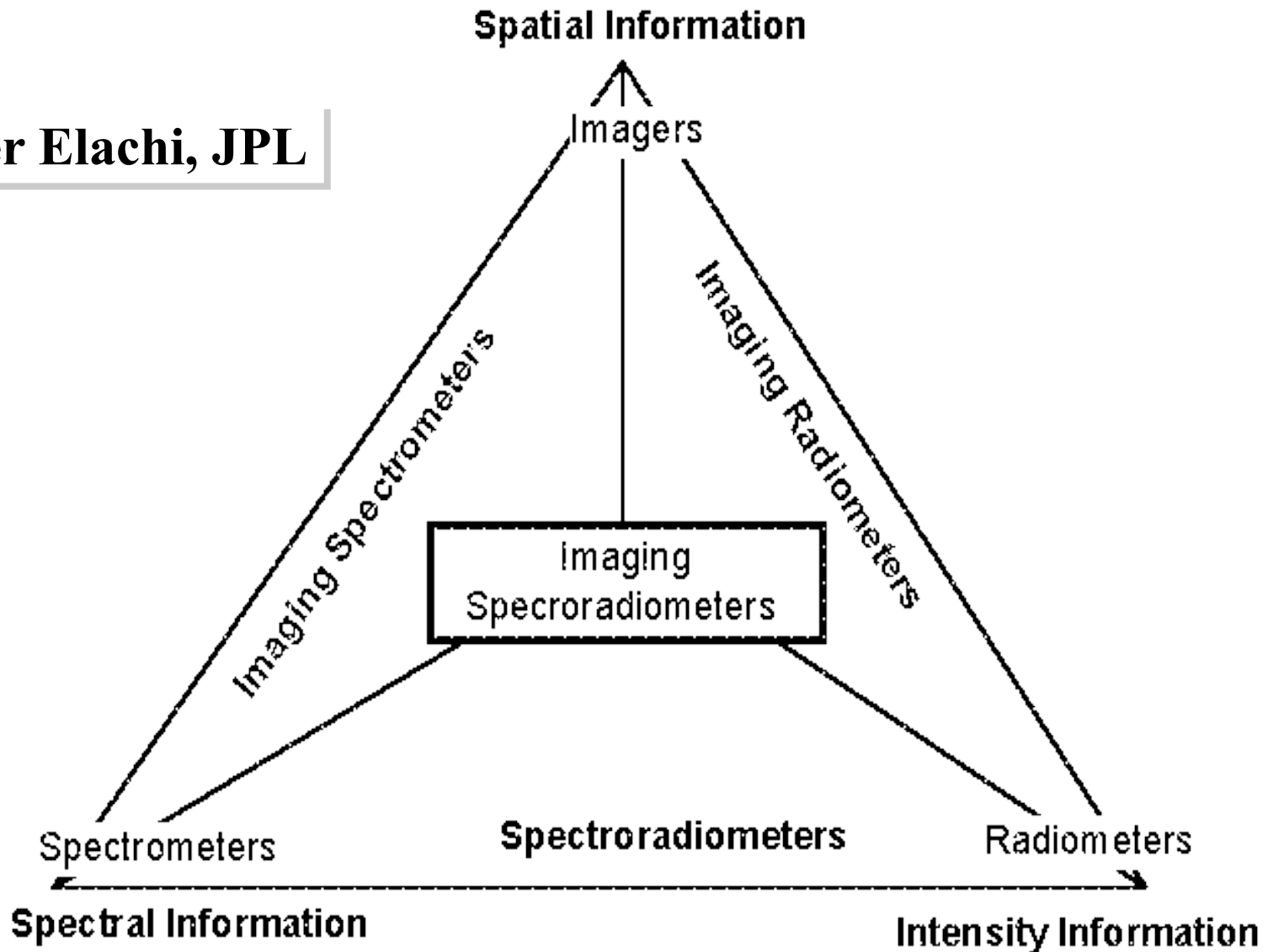


# Scientific Principles

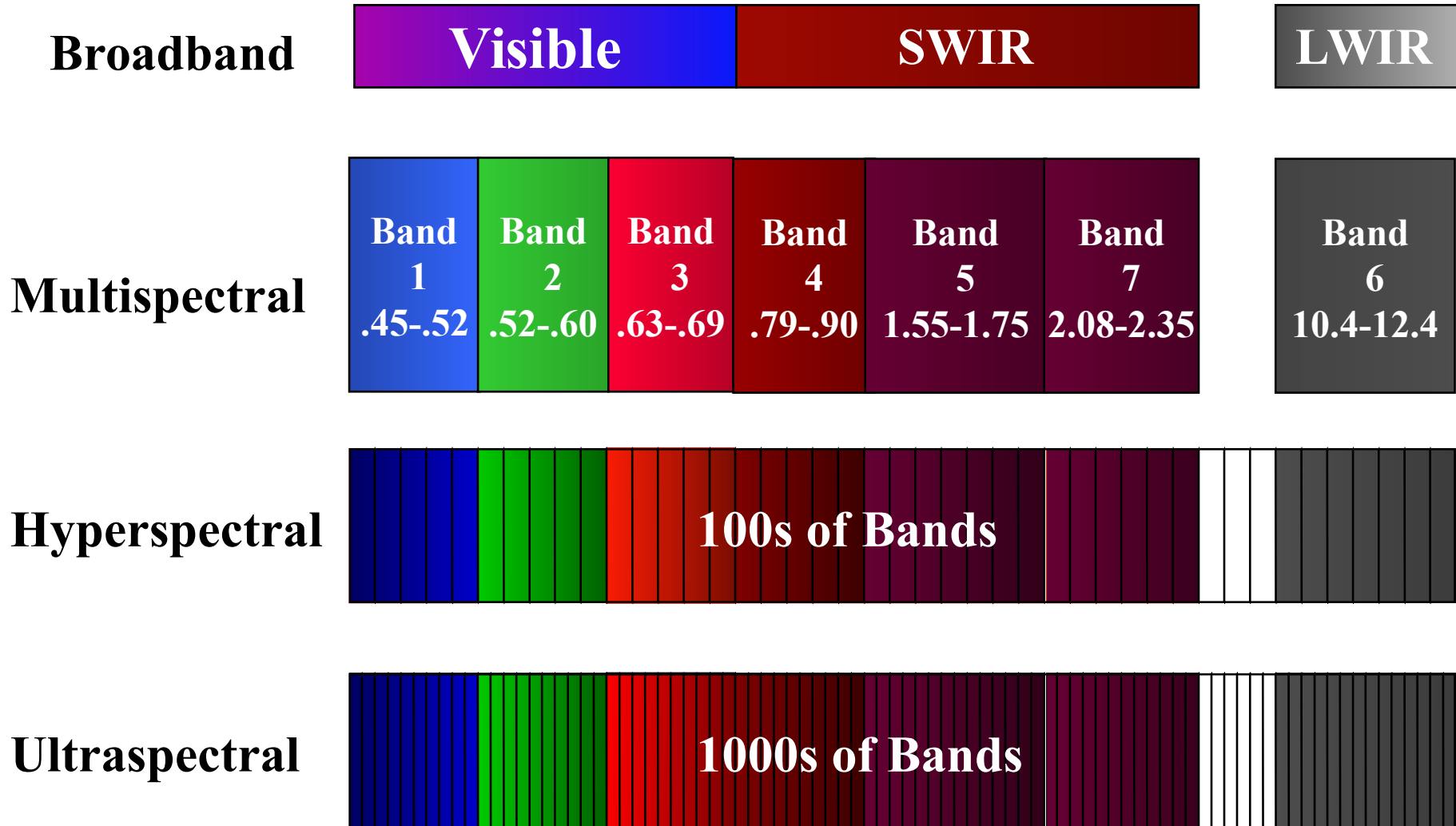
- Photons traveling through the Earth's atmosphere strike the surface and are either absorbed, transmitted, scattered and/or reflected
- Various materials absorb photons over specific wavelength intervals resulting in absorption features in reflectance spectra
- The location and shape of these unique absorption features provide information on the chemical composition of materials

# Hyperspectral Sensing Concept

After Elachi, JPL



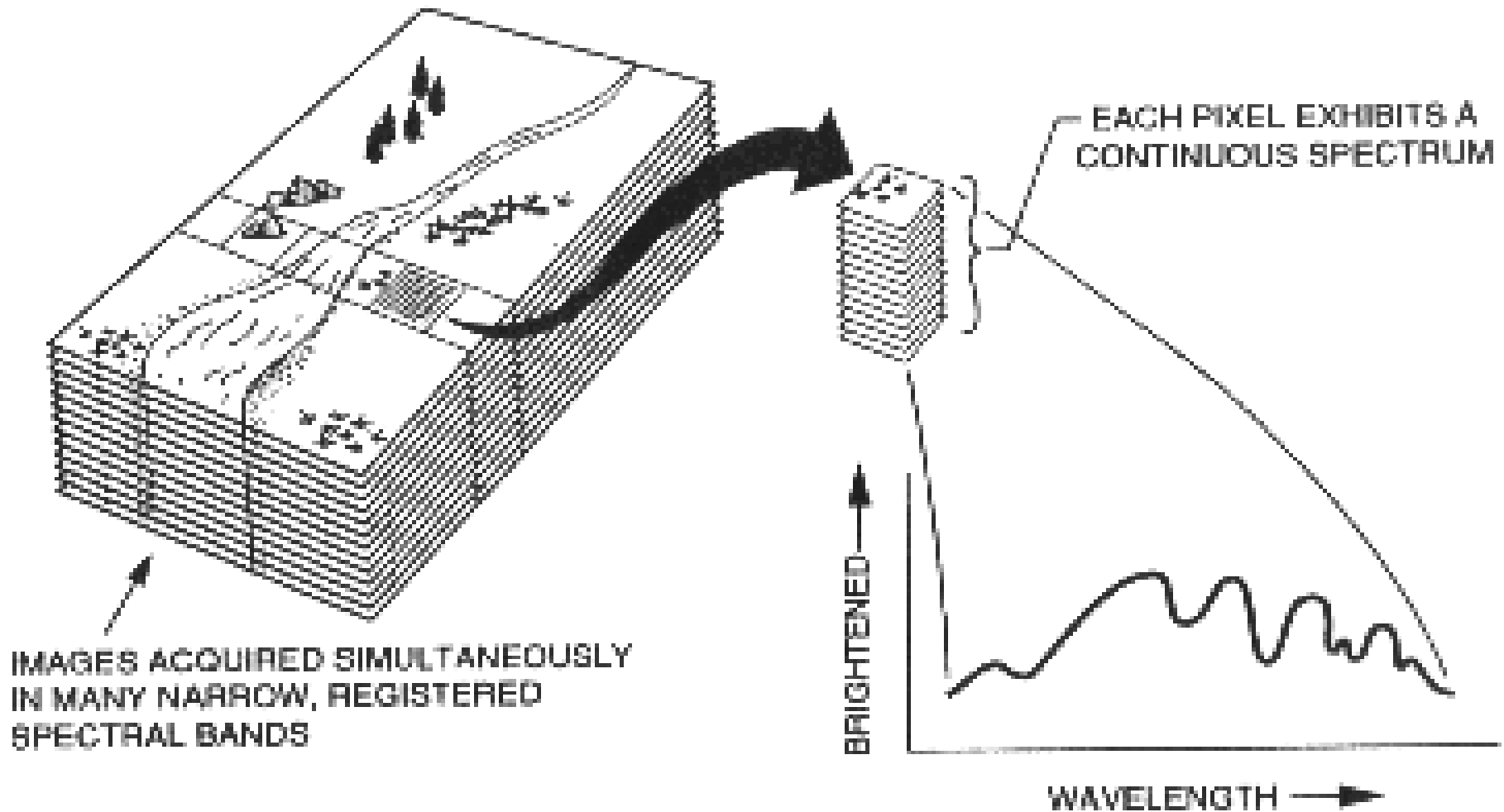
# Spectral Sensing



# Hyperspectral Sensing Concept (Cont.)

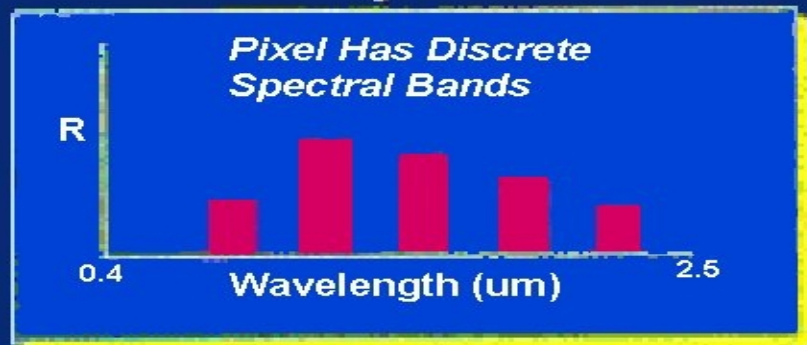
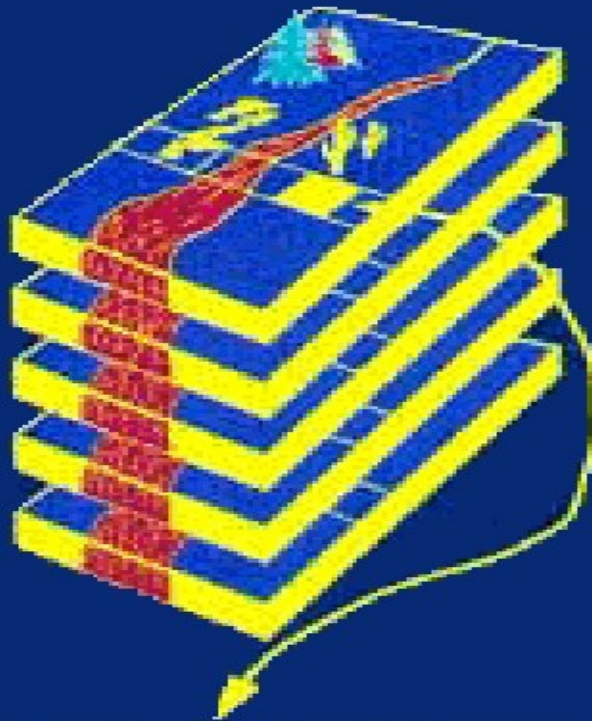
Courtesy of JPL

Hyperspectral Remote Sensing

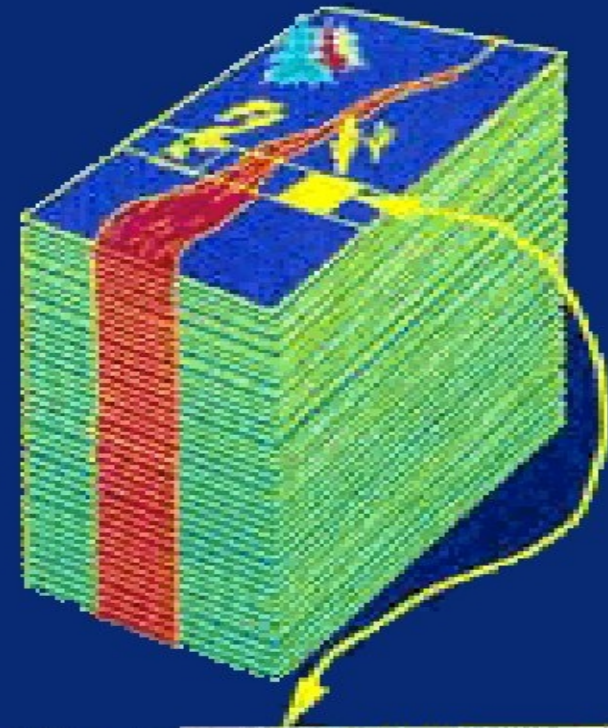


# Multispectral/ Hyperspectral Comparison

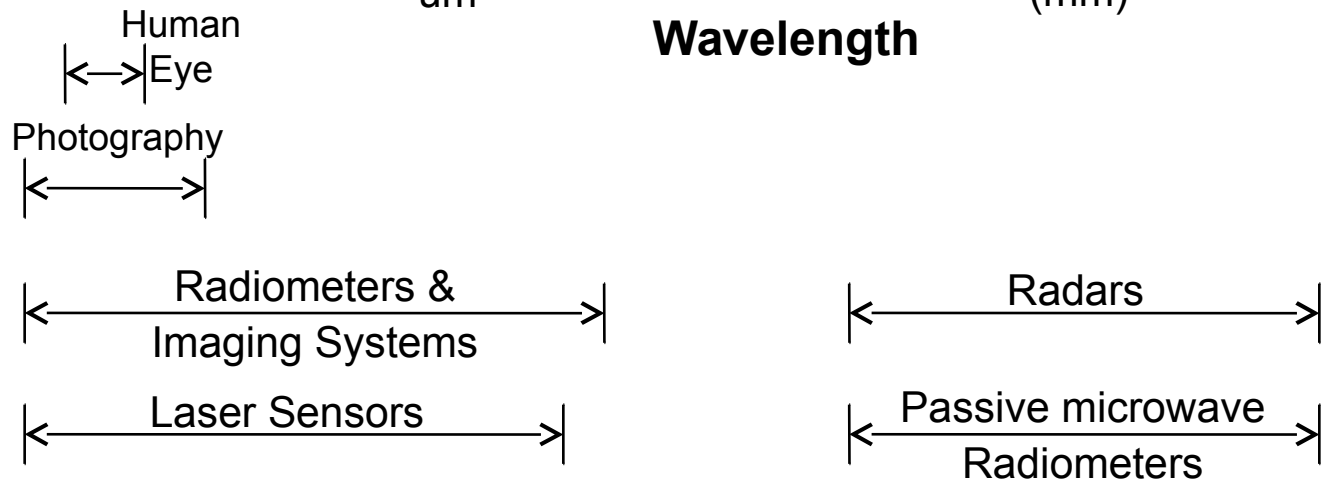
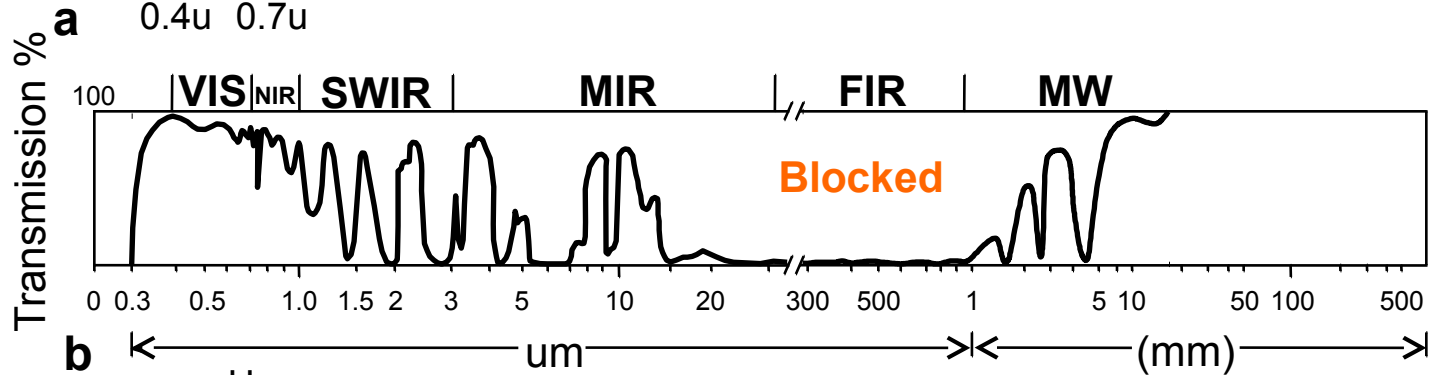
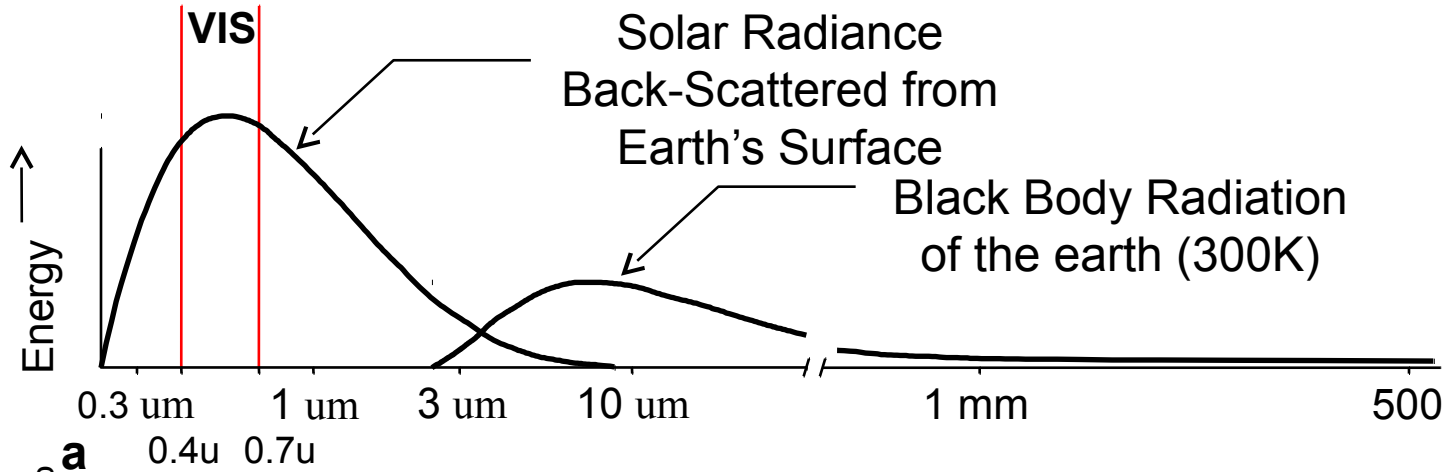
Multispectral



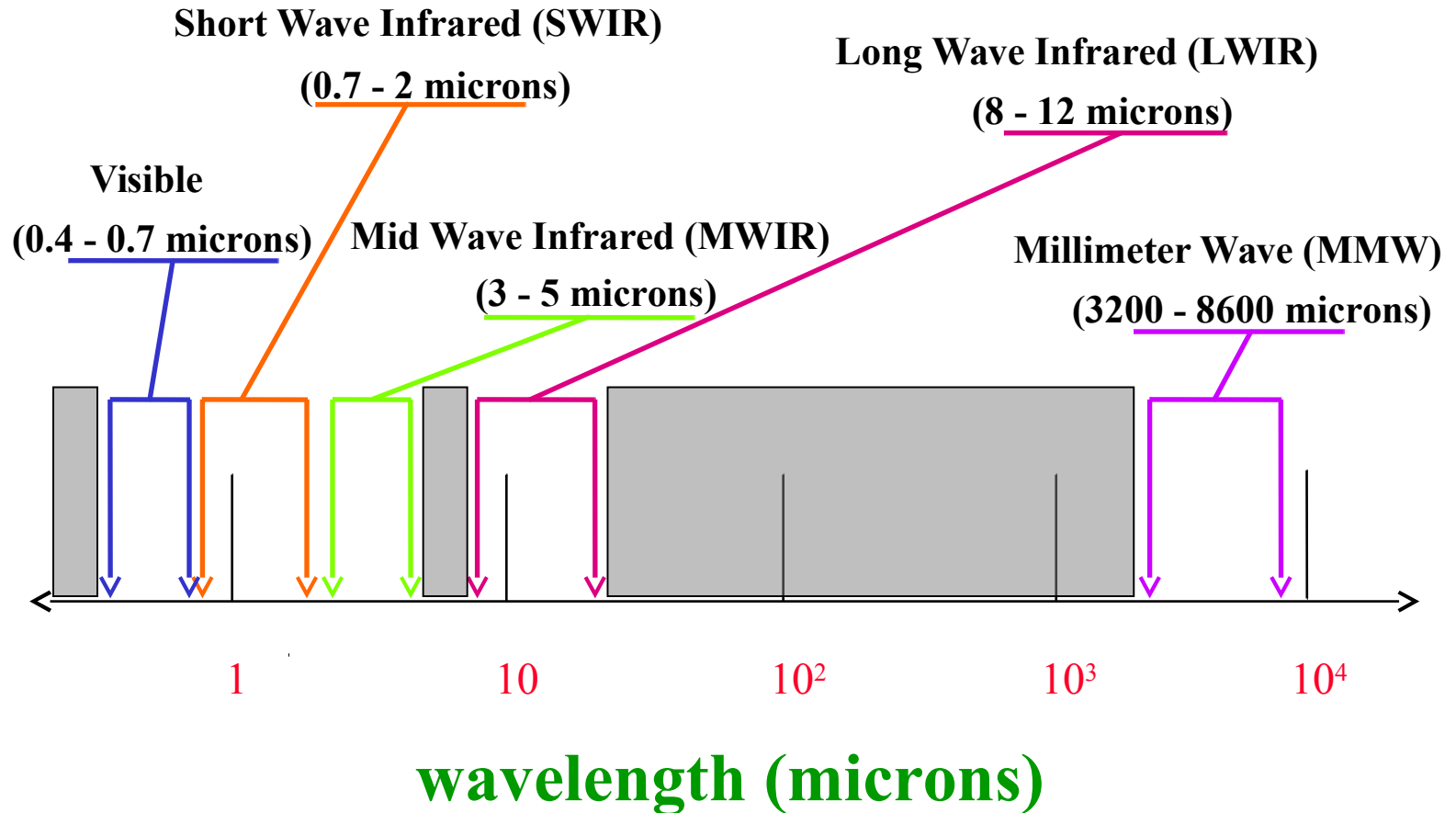
Hyperspectral



# Remote Sensing Electromagnetic Spectrum

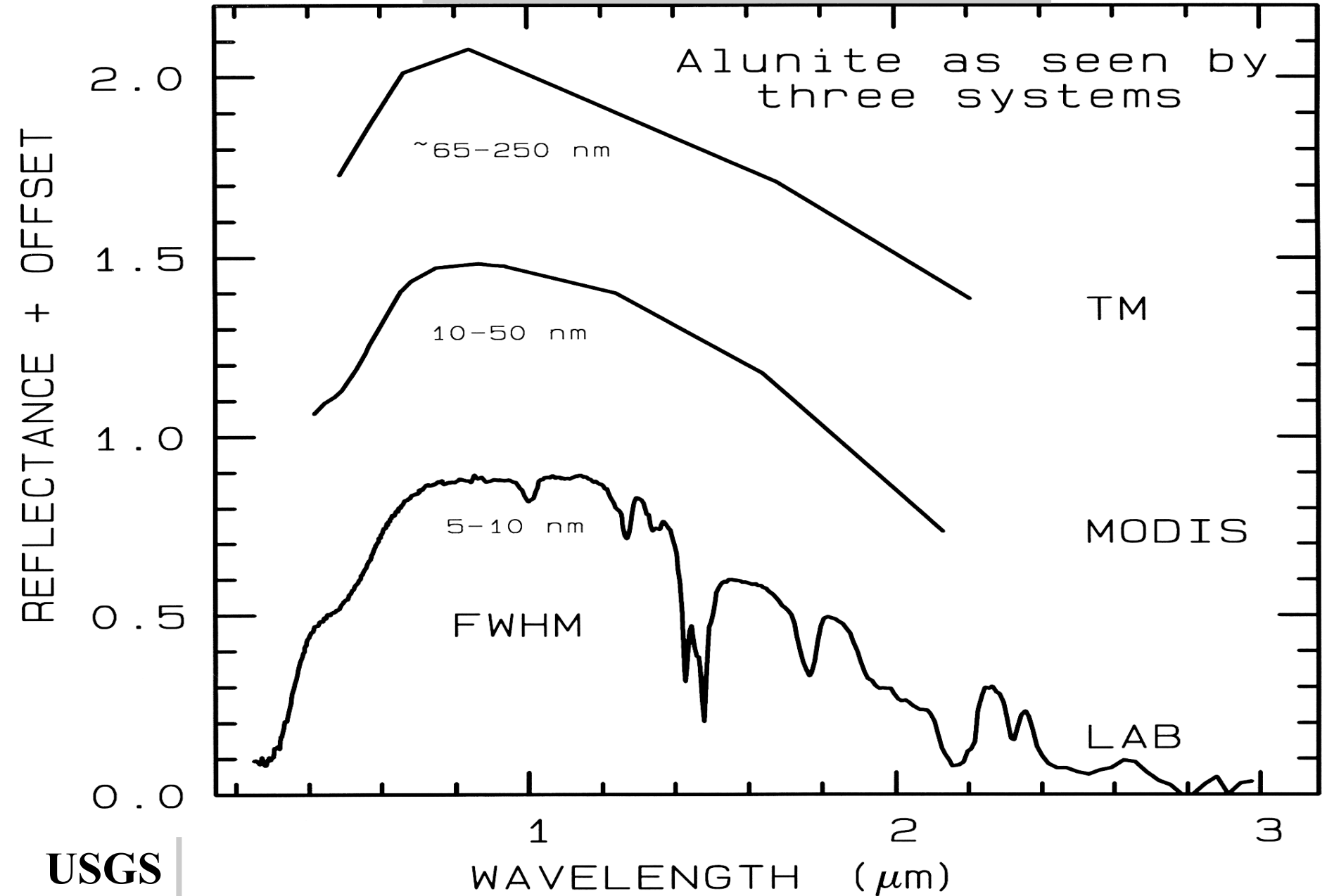


# Spectral Windows



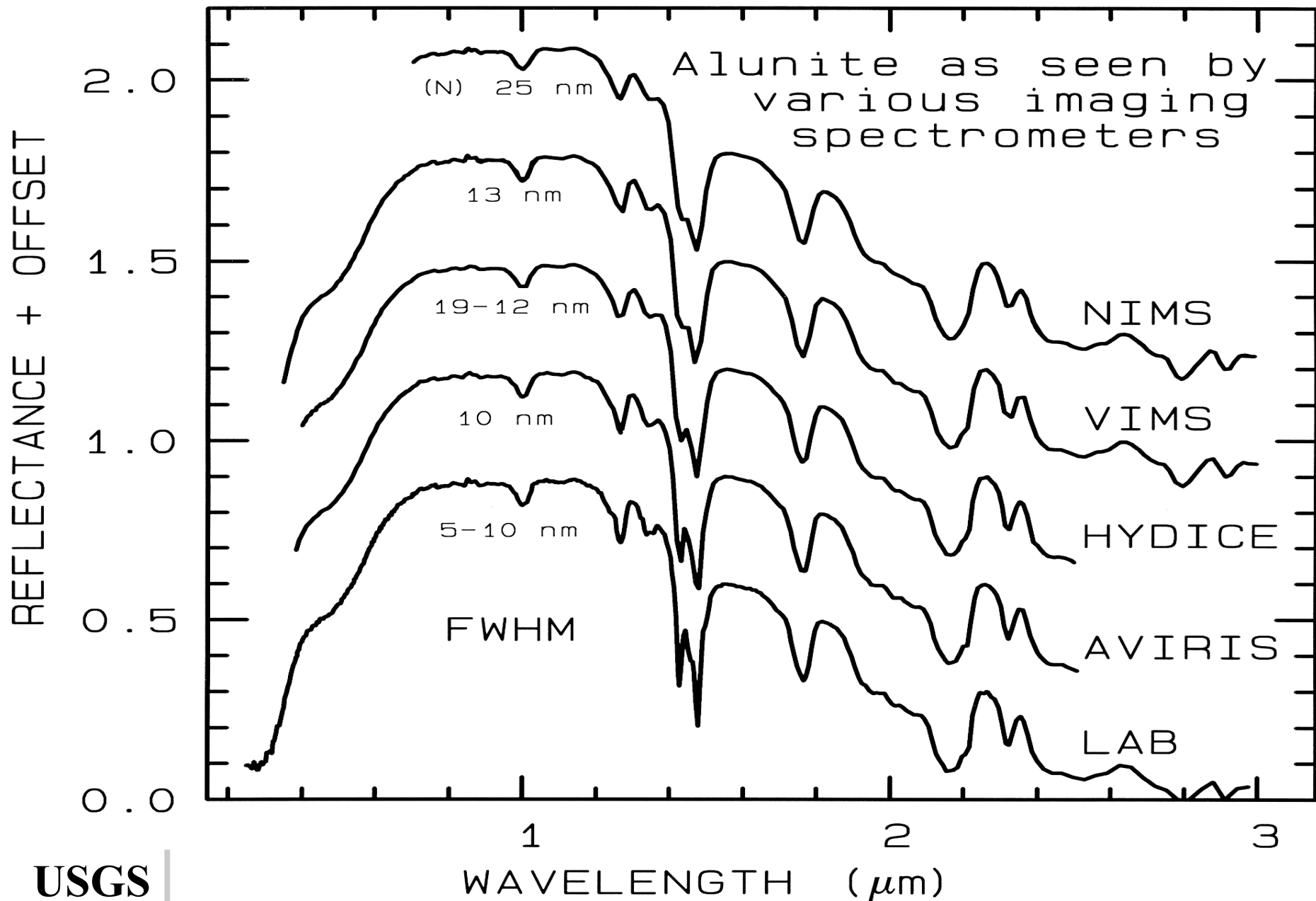
Photons falling between the “spectral windows” highlighted above are severely **attenuated** (either **absorbed**, **scattered**, or both) by the Earth’s atmosphere.

# Multispectral Imaging





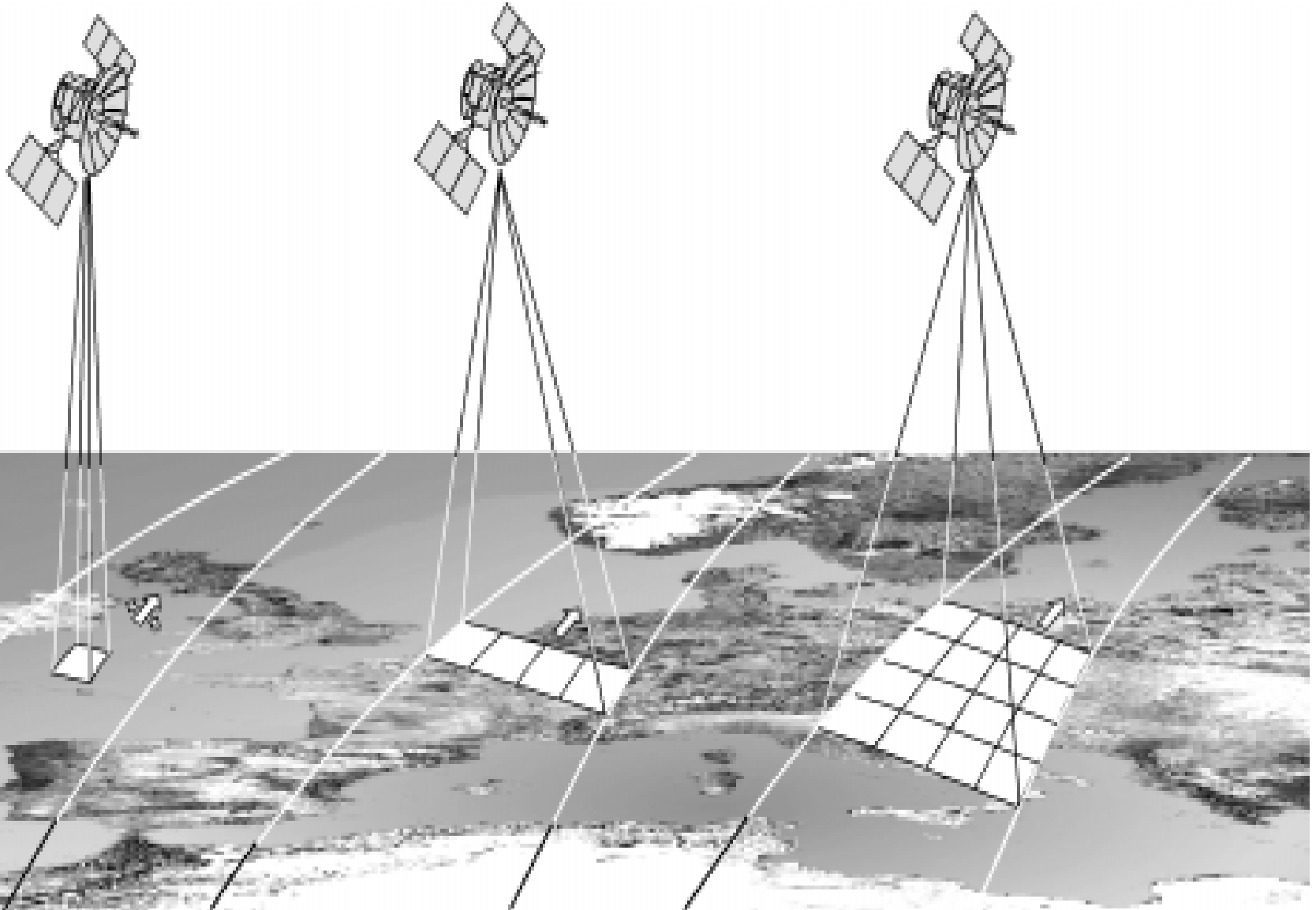
# Hyperspectral Imaging



# Classification of Sensors

- Image Acquisition Modes
  - Whiskbroom Imagers
  - Pushbroom Imagers
  - Staring Imagers
- Spectral Selection Modes
  - Dispersion Element (grating, prism)
  - Filter-Based Systems
    - Interference Filters
    - Acoustical-Optical Filters
    - Liquid Crystal Tunable Filters (LCTF)
  - Interferometer-Based Systems
    - Michelson Interferometer
    - Fourier Transform Interferometer System
- Other (e.g., Multi-order etalons)

# Image Acquisition Modes



Whiskbroom

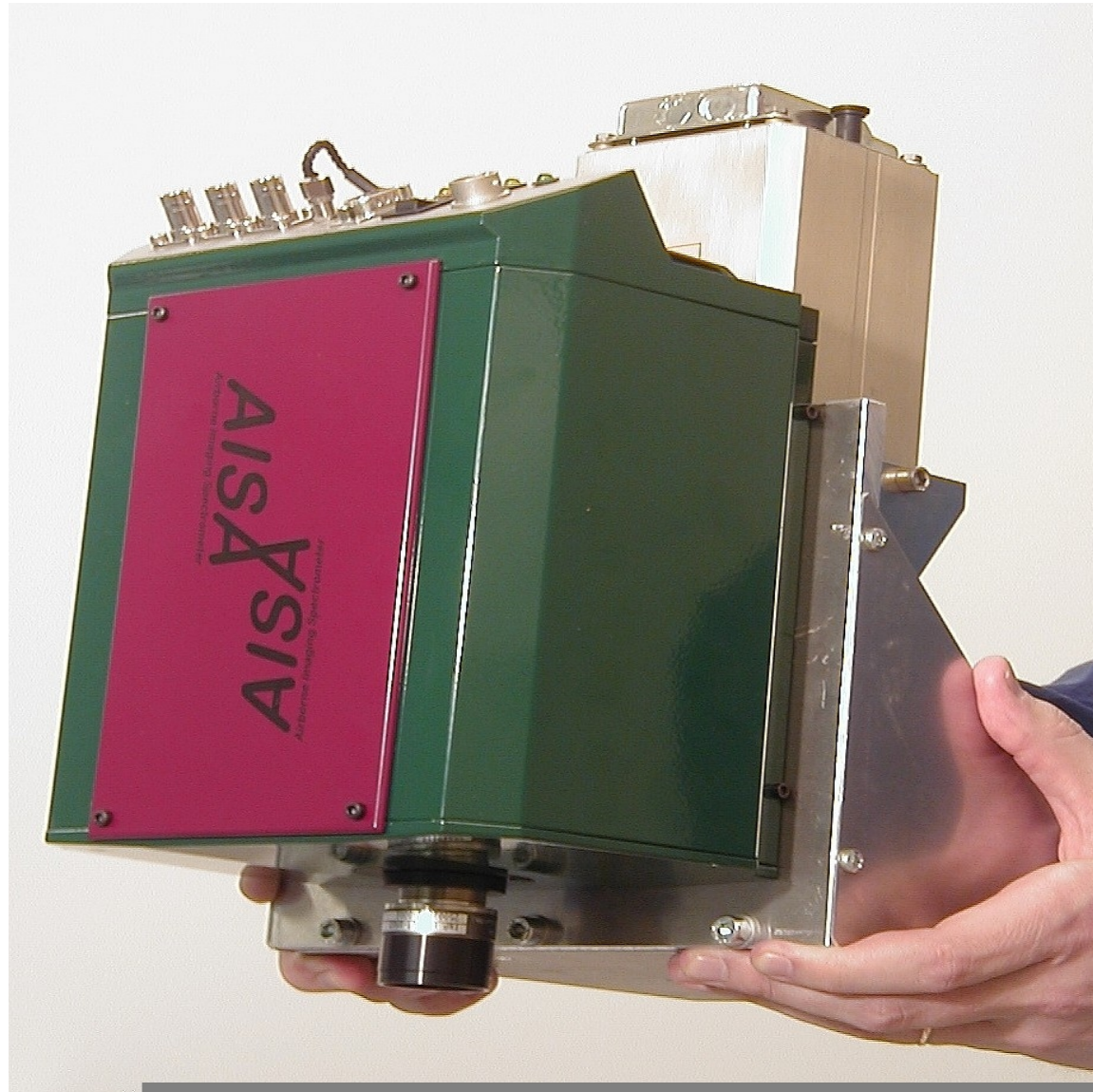
Pushbroom

Staring

# Airborne Hyperspectral Systems

- **1983 AIS, 10m pixels, 128 bands (0.8-2.4um) - retired**
  - **1986 GER 63, 10m pixels, 63 bands (0.43-2.5um)**
  - **1987 AVIRIS, 3, 20m pixels, 224 bands (0.40-2.45um)**
  - **1989 CASI, 10m pixels, 288 bands (0.4-0.9um)**
  - **1993 AISA, 286 bands (0.43-0.9 um)**
  - **1994 TRWIS III, 242 bands (0.45-2.5 μm)**
  - **1995 HYDICE, 210 bands (0.4-2.5 um)**
  - **1996 HyperCam, 256 bands (0.45-1.05 μm)**
  - **1997 PROBE-1, 128 bands (0.43-2.5um)**
  - **1998 HyMap, 126 bands (0.4-2.5 um)**
  - **1999 AURORA, 512 bands (0.4-0.9 um)**

# AISA Hyperspectral System

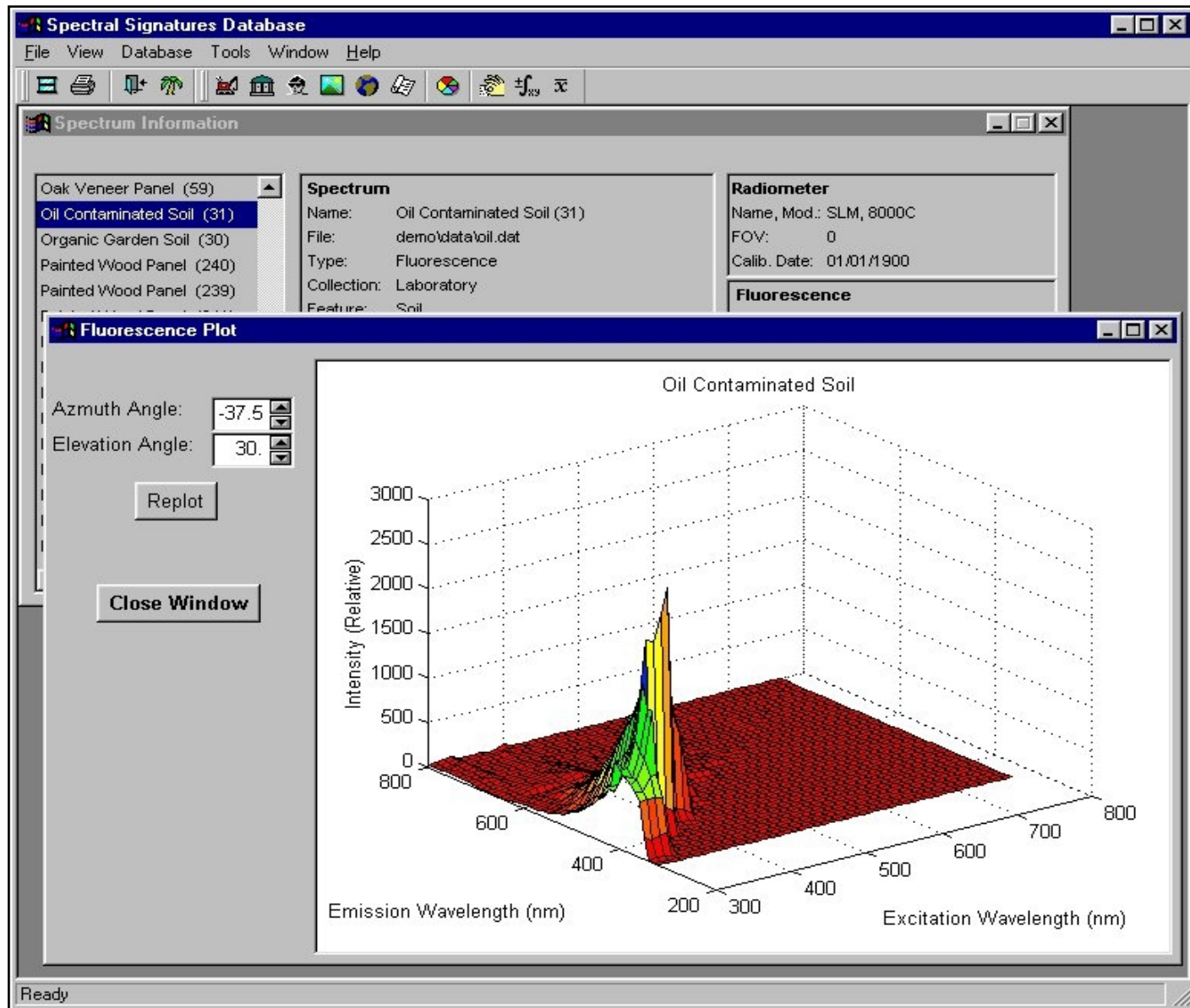


# Spaceborne Hyperspectral Systems Launched in 2000-2003

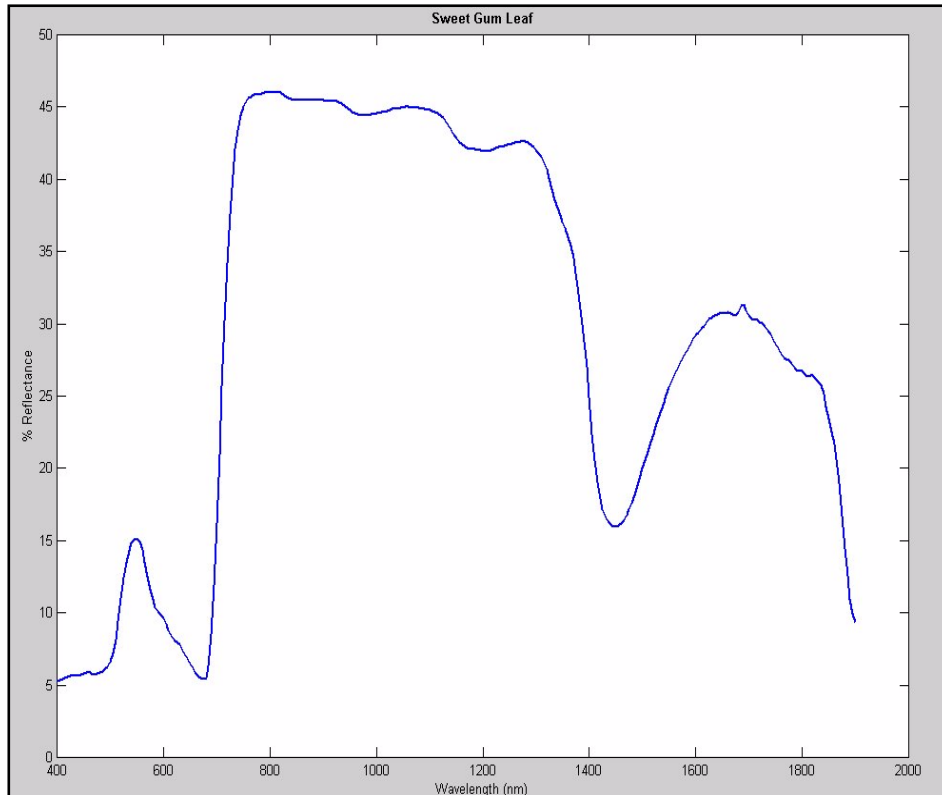
---

- Australian Resource Information and Environment Satellite (ARIES)  
(Launch date keeps changing)
- Naval EarthMap Observer (NEMO) Coastal Ocean Imaging Spectrometer (COIS) – Likely Program Terminated
- Orbview 4 (Warfighter 1)  
Launched: 21 September 2001 (Failed to Orbit)
- TRW Hyperion (EO-1)  
Launched: 21 November 2000
- AFRL MightySat II.1 (Sindri) - FTHSI  
Launched: 19 July 2000
- Compact High Resolution Imaging Spectrometer (CHRIS)  
Launched aboard ESA's PROBA satellite on 22 October 2001

# Laboratory Measurements



# Field Measurements



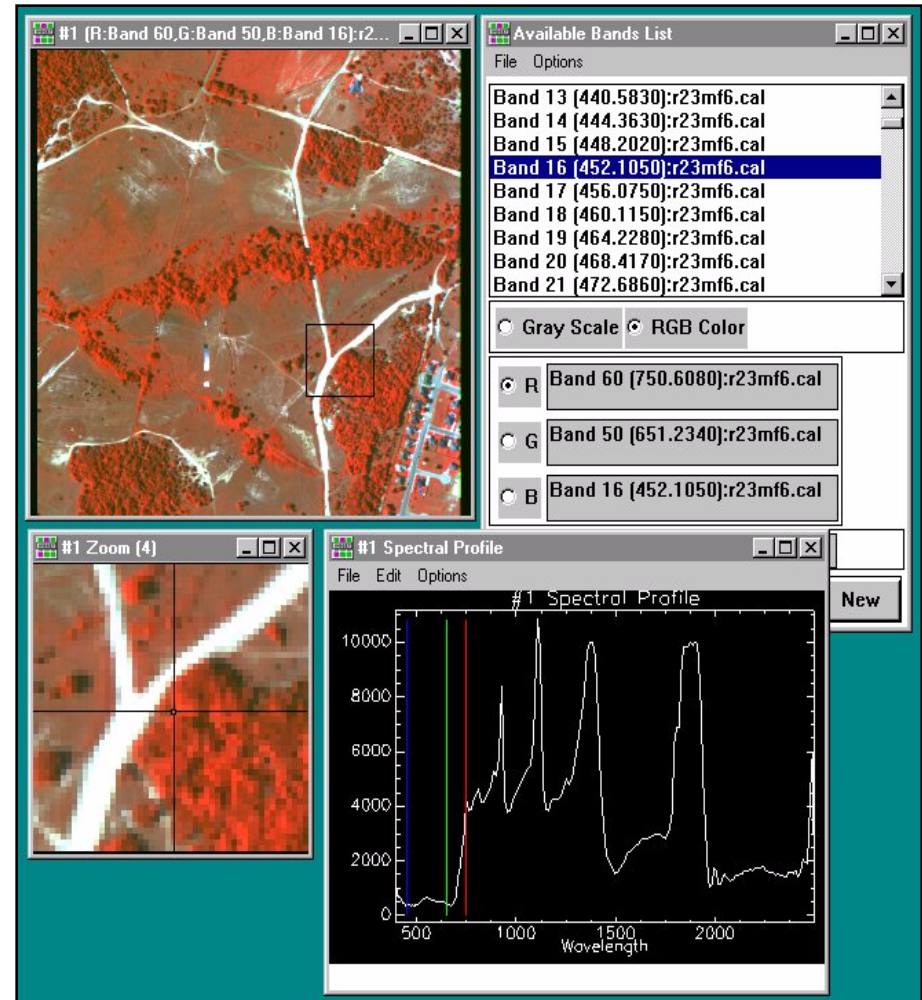
Sample field vegetation  
spectral measurement





# Image Measurements

- Reflectance spectrum of a live oak from Ft. Hood Texas
- Signature extracted from HYDICE imagery using ENVI software

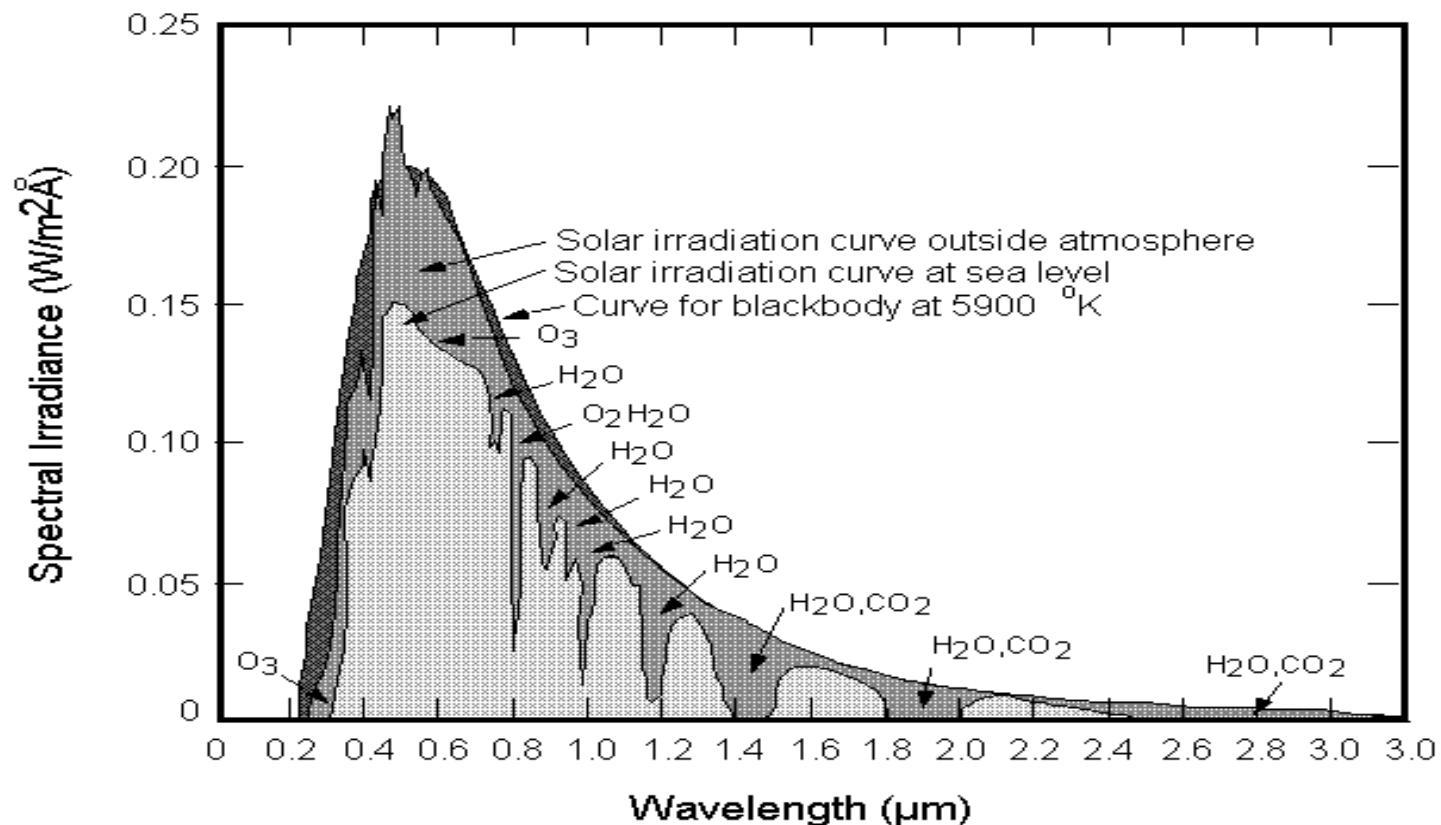


# Spectral Database Issues

- **Existing spectral libraries are in a wide variety of formats and need to be consolidated**
- **A spectral database is an essential tool on which to base future research**
- **A spectral database will be absolutely necessary to handle flood of future data**
- **A spectral database could be federated with other applicable databases (e.g., Imagery, DEMs, IFSAR, etc.)**

# Atmospheric Compensation

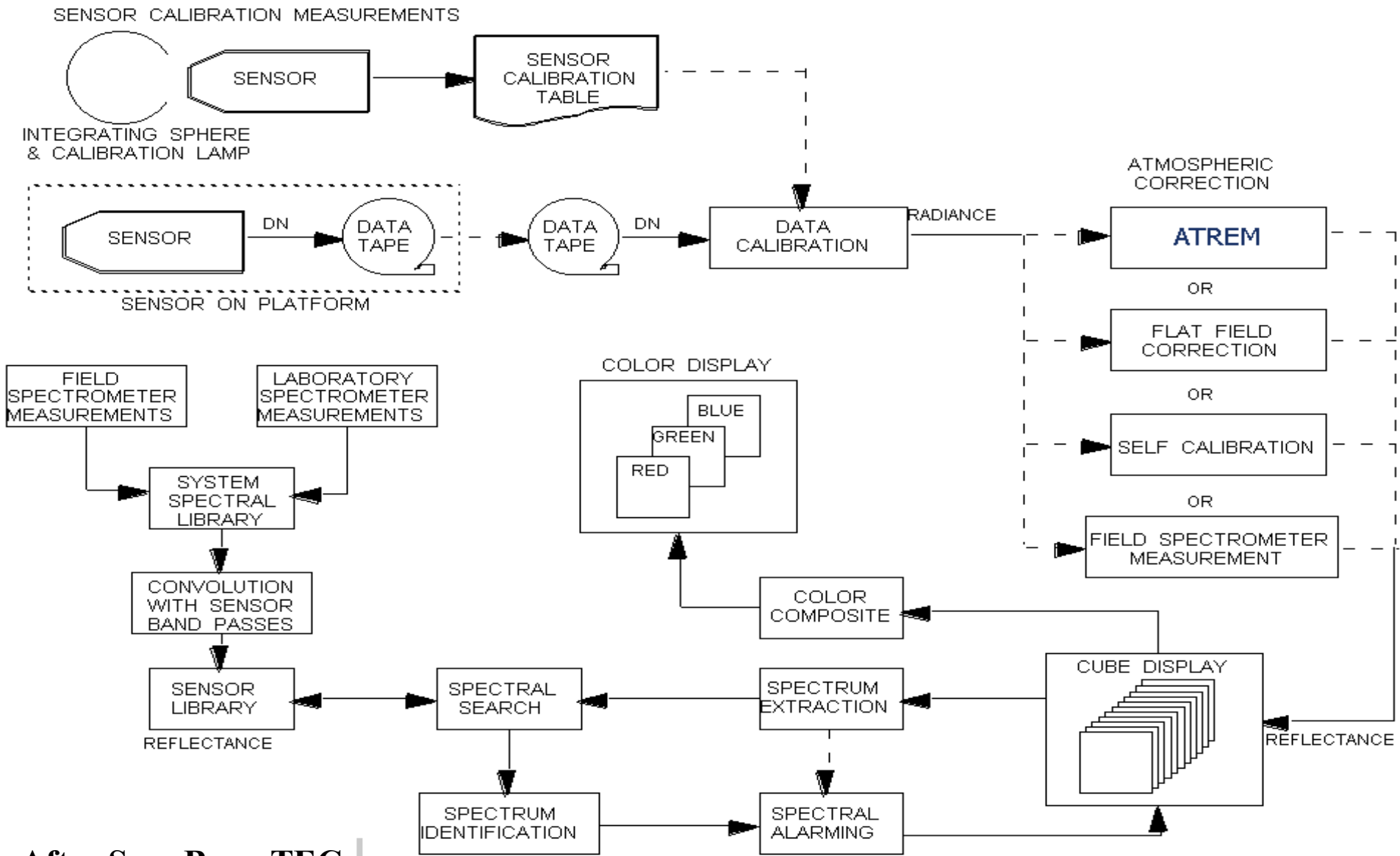
## Solar Spectrum with Atmospheric Absorptions



# Atmospheric Compensation (Cont.)

- Physics – based Models
  - Atmospheric REMoval (ATREM)
  - Atmospheric Correction Now (ACORN)
  - Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH)
  - FLAASH utilizes the Full MODTRAN-4
- Semi-Empirical Models
- Empirical Models

# Hyperspectral Data Processing



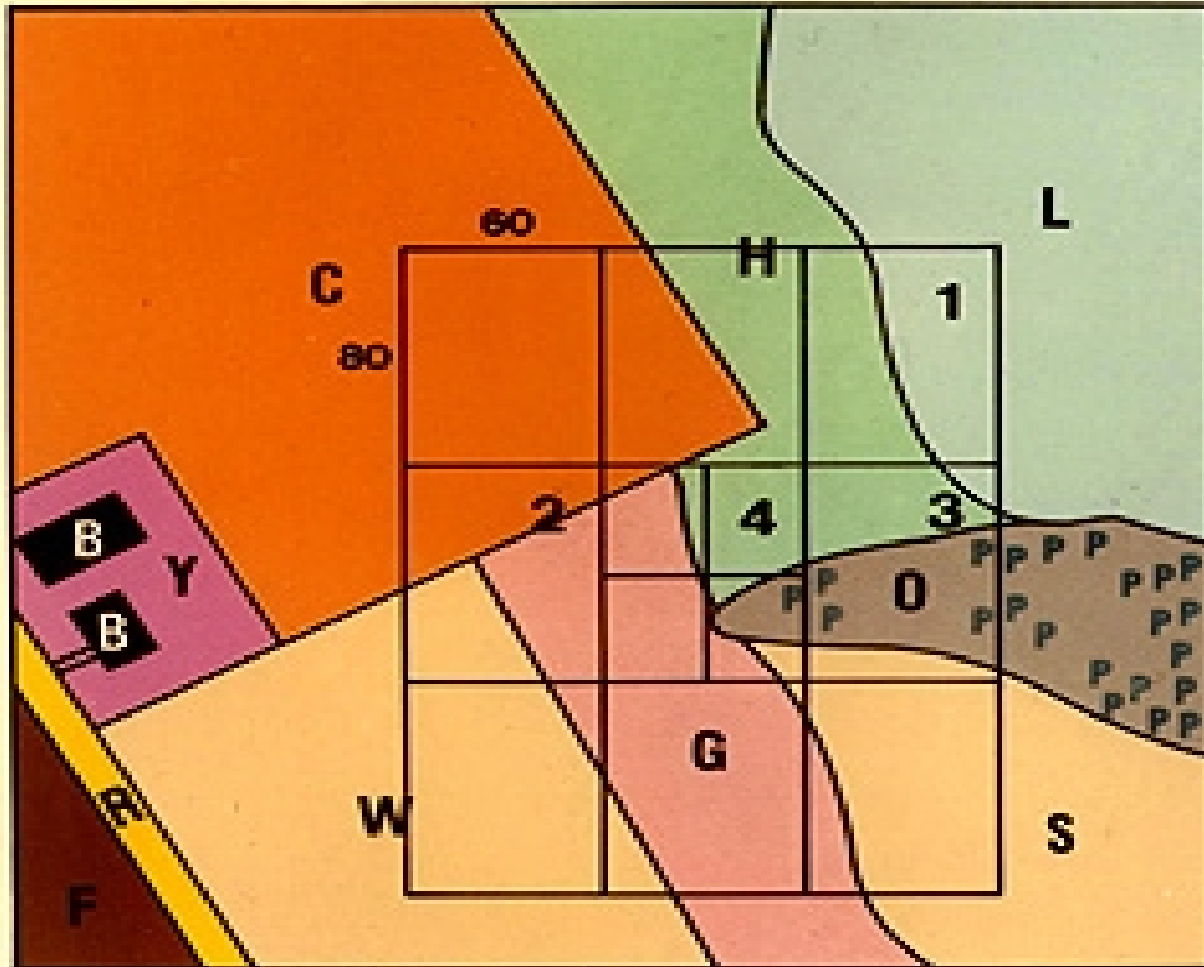
# Spectral Sensing Processing Systems

- Spectral Analysis Manager (SPAM) – JPL
- Integrated Software for Imaging Spectrometers (ISIS) – USGS Flagstaff
- Hyperspectral Image Processing System (HIPS) – U.S. Army TEC
- Spectral Image Processing System (SIPS) – University of Colorado, Boulder
- SPECtrum Processing Routines (SPECPR) – USGS Denver
- Optical Real-time Adaptive Spectral Identification System (ORASIS) – NRL
- DIMPLE 3.0 – RockWare, Inc.
- Imaging Spectrometer Data Analysis System (ISDAS) – CCRS in Canada
- PCI – PCI Remote Sensing Corporation
- Environment for Visualizing Images (ENVI) – Research Systems, Inc.
- Multispectral Image Data Analysis System (MultiSpec) – Purdue University
- HyperCube – U. S. Army TEC
- ProVIEW – Applied Coherent Technology, Inc.
- ERDAS IMAGINE – Commercial package
- Others

# Categories of Errors

- Data Acquisition Errors
- Data Processing Errors
- Scene-dependent Errors

# The Pixel Mixing Problem



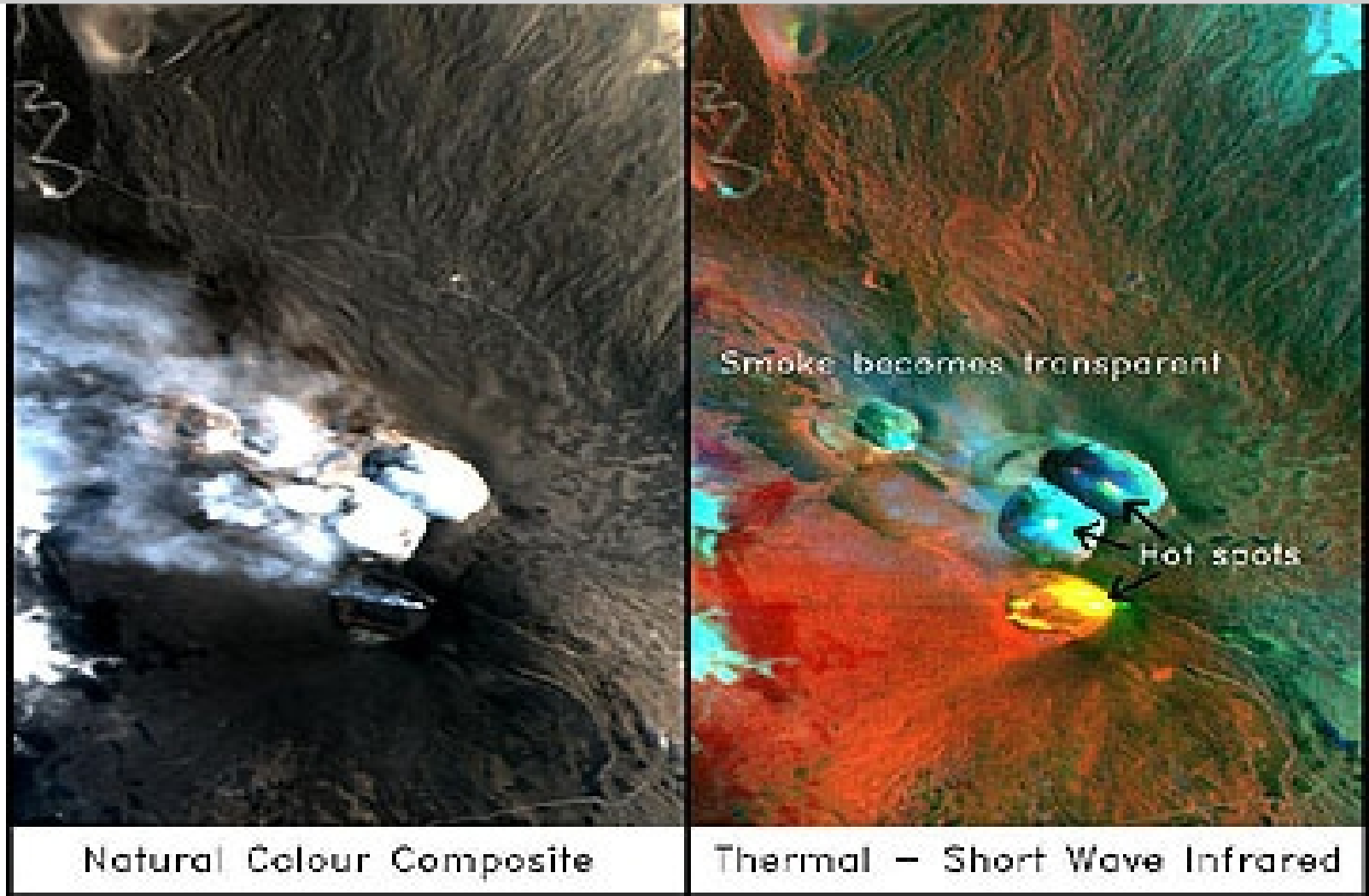
CATEGORY	BAND	
	5	7
L = LAKE	10	5
O = ROCK OUTCROP	30	45
H = HARDWOODS	30	55
P = PINEWOODS	15	30
G = GRASSLANDS	40	60
S = SHRUBBY MEADOWS	25	40
W = WHEAT	50	70
C = CORN	30	60
F = FALLOW FIELD	40	30
R = ROAD	70	40
B = BUILDING	40	10
Y = YARD	30	40



# Hyperspectral Sensing Applications

- **Material Identification**
- **Environmental (wetlands, land cover, hydrology, etc.)**
- **Health Care (food safety, medical diagnoses, etc.)**
- **Littoral Studies (bathymetry, water clarity, etc.)**
- **Trafficability Analysis**
- **Land Mine Detection**
- **Plume Analysis**
- **Camouflage, Concealment, Detection**
- **Biological and Chemical Detection**
- **Precision Agriculture/Farming**
- **Disaster Mitigation**
- **City Planning and Real Estate**
- **Law Enforcement**
- **Many Others**

# Digital Airborne Imaging Spectrometer (DAIS)



**Aerial oblique view made with DAIS.** Shows a natural color image on the left and a SWIR-thermal image on the right, of Mount Etna in Sicily, during one of its active periods. Smoke obscures some details of volcanic features in the natural image but not in the SWIR Thermal-IR rendition.

# Hyperspectral Imagery

**SPECTRAL SEARCH**

**Search From:**

**File Type:** Data Set | File | Library

**Library Type:** User | General

**Library Name:** Houses\_Library

**Spectrum Index:** 6

**Search Against:**

**File Type:** Data set

**Data Set:** houses.cal.10

**Subset:** 1-512:1-512:1-10:

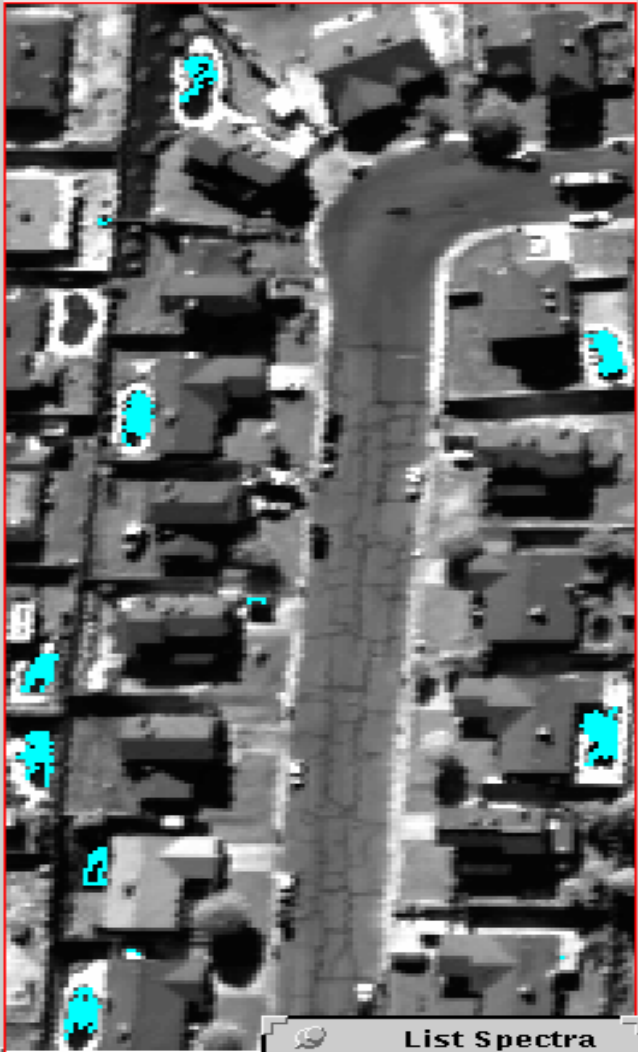
**Type of Search:**

Abs. Diff.	Der. Diff.	Rel. Diff.	H
(Abs. Diff)**2	(Def. Diff)**2	Euclidean	H

Number of Matches: 1

**DISPLAY 2D: EXPAND**

Select ▾ Factor: 2 3 4 5 6




**DISPLAY 2D: OVERLAY**

**Data set:** /data2/houses.isr/h1.w.ov

**Subset:** 1-512:1-512::

**Min:** .9 **Max:** 1.0

**Color selected:** cyan



Accept Reset

**List Spectra**

6 : Water

# U.S. Navy Plane in China

Real

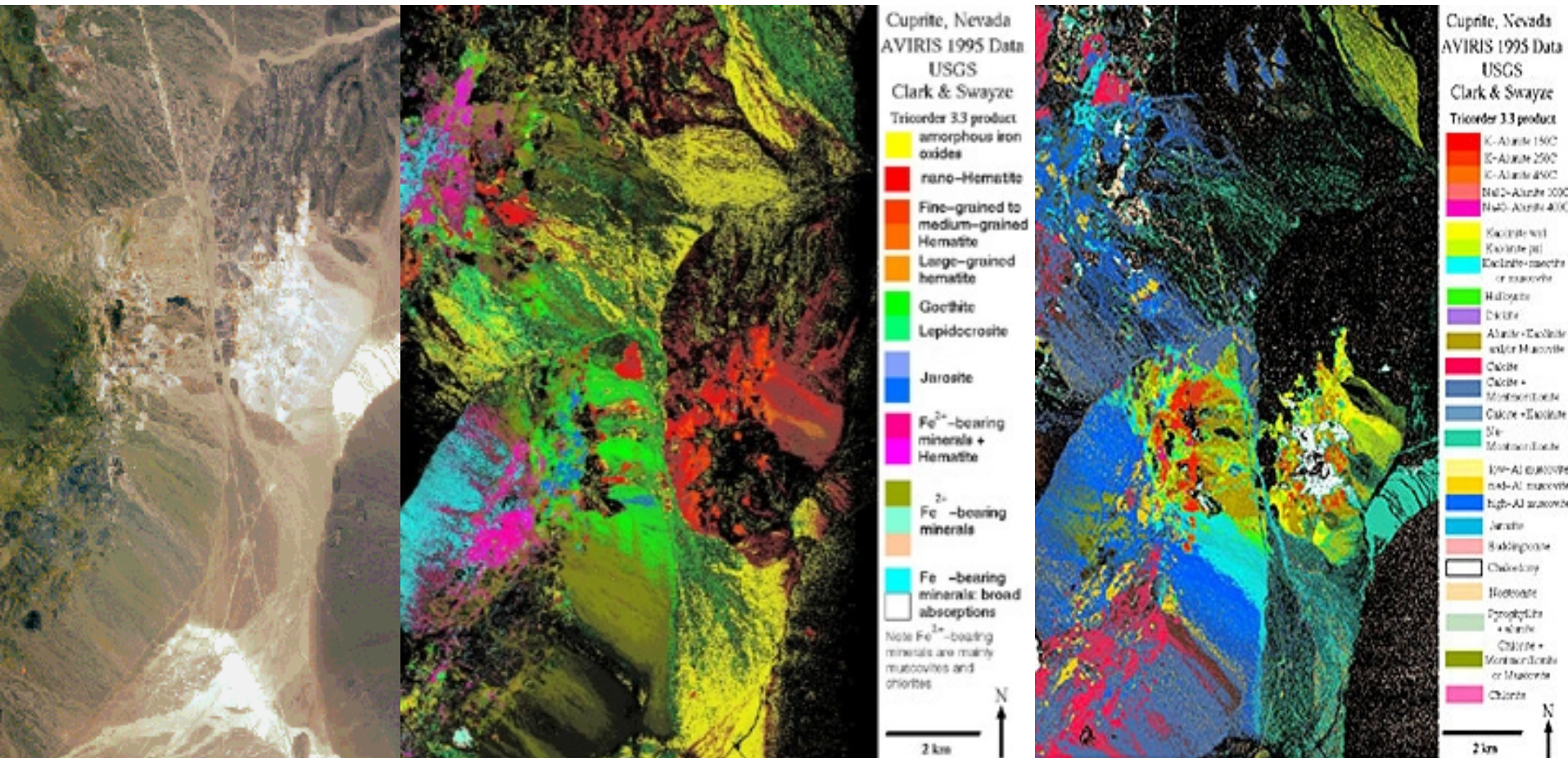
or

Fake?



(SPACEIMAGING.COM)

# Airborne Visual/Infra-Red Imaging Spectrometer (AVIRIS)



**NASA AVIRIS flights over Cuprite, Nevada.** The JPL and the Spectroscopy Group at the U.S. Geological Survey in Denver reduced and manipulated the data.

# Hyperspectral Data Fusion

**Low Resolution / High Spectral**



**High Resolution / Low Spectral**



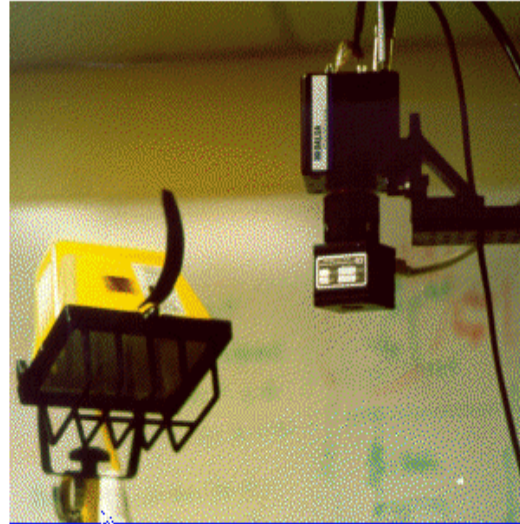
**High Resolution / High Spectral**

The fusion of higher spatial resolution panchromatic imagery with high spectral, low spatial resolution MSI or HSI resulting in a spectrally accurate, high spatial resolution image

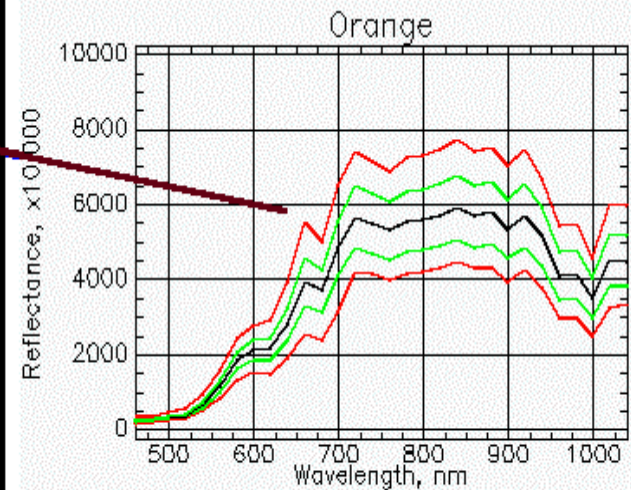
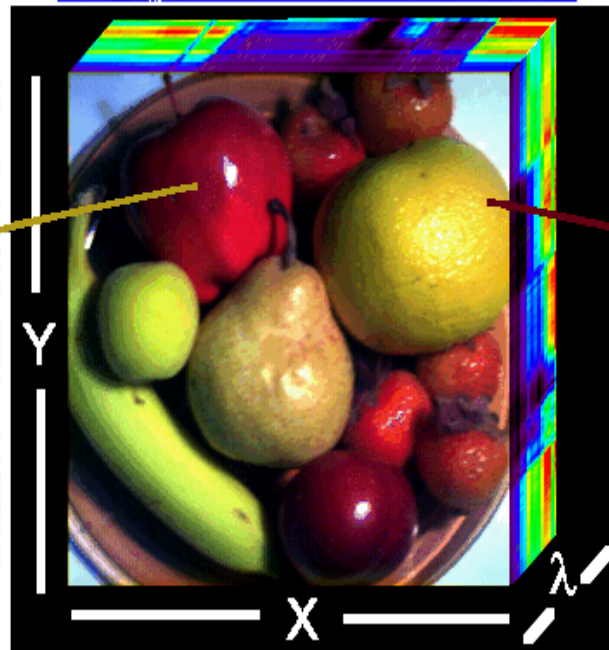
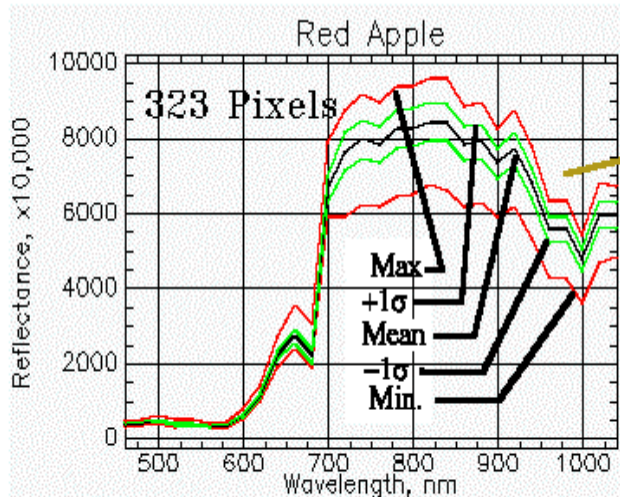
# Summary

- **Hyperspectral Imaging (HSI) is a Mature Technology**
- **Sensor and Data Fusion is the way to go**
- **Data Collection, Storage, and Usage Methods are Currently Inefficient**
  - **Crucial Data are Costly and Hard to Find**
  - **Need for Accessible, Up-to-Date, Relevant, Accurate, Timely, and User-Friendly Digital Spectral Information Library (Spectral Data Bank)**
- **Need Standards, Definitions, Policies, and Collaborations**
- **Emphasis Needs to be Placed in Training the Workforce**

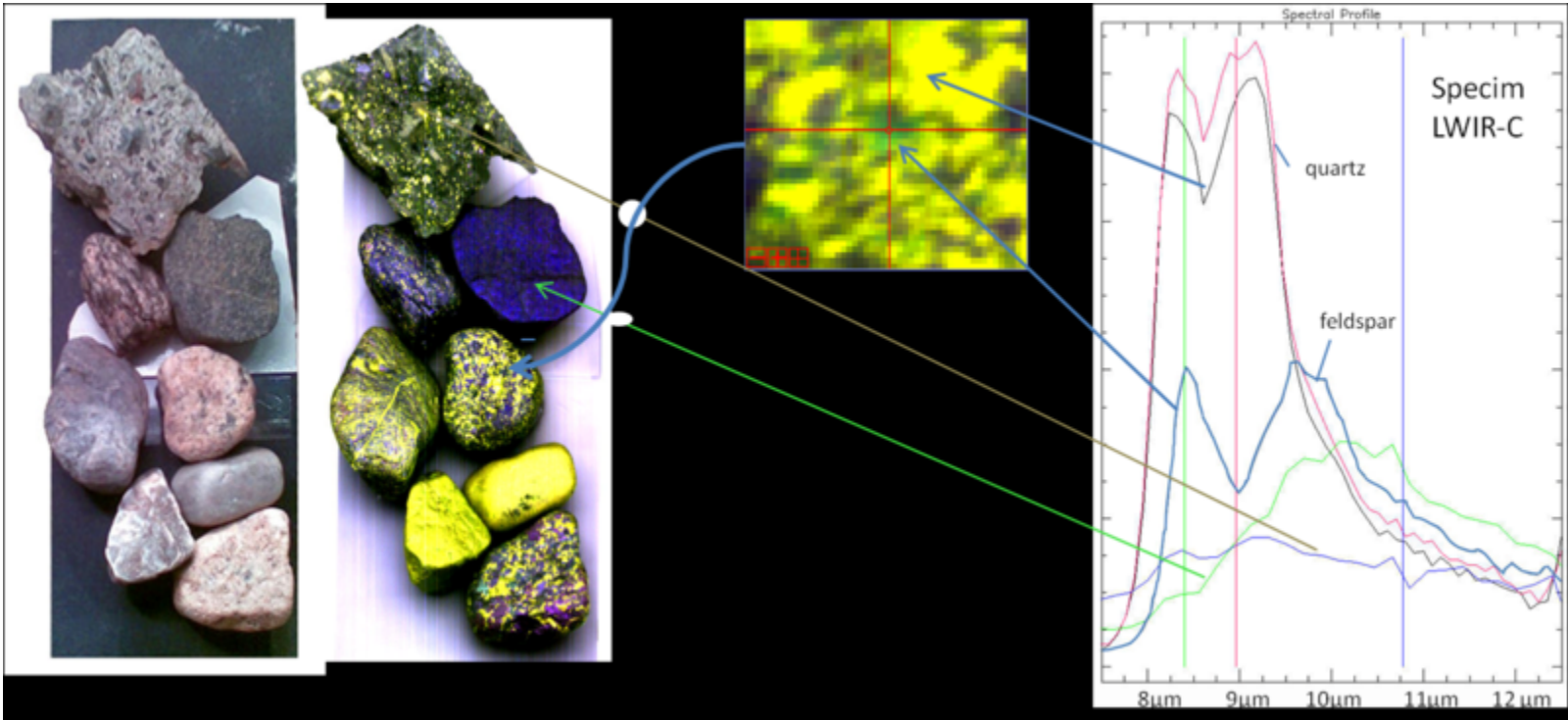
# Comparing Apples to Oranges



Opto-Knowledge  
Systems, Inc.







# Obserwacje optyczne wysokiej rozdzielczości spektralnej w zakresie IR i VIS

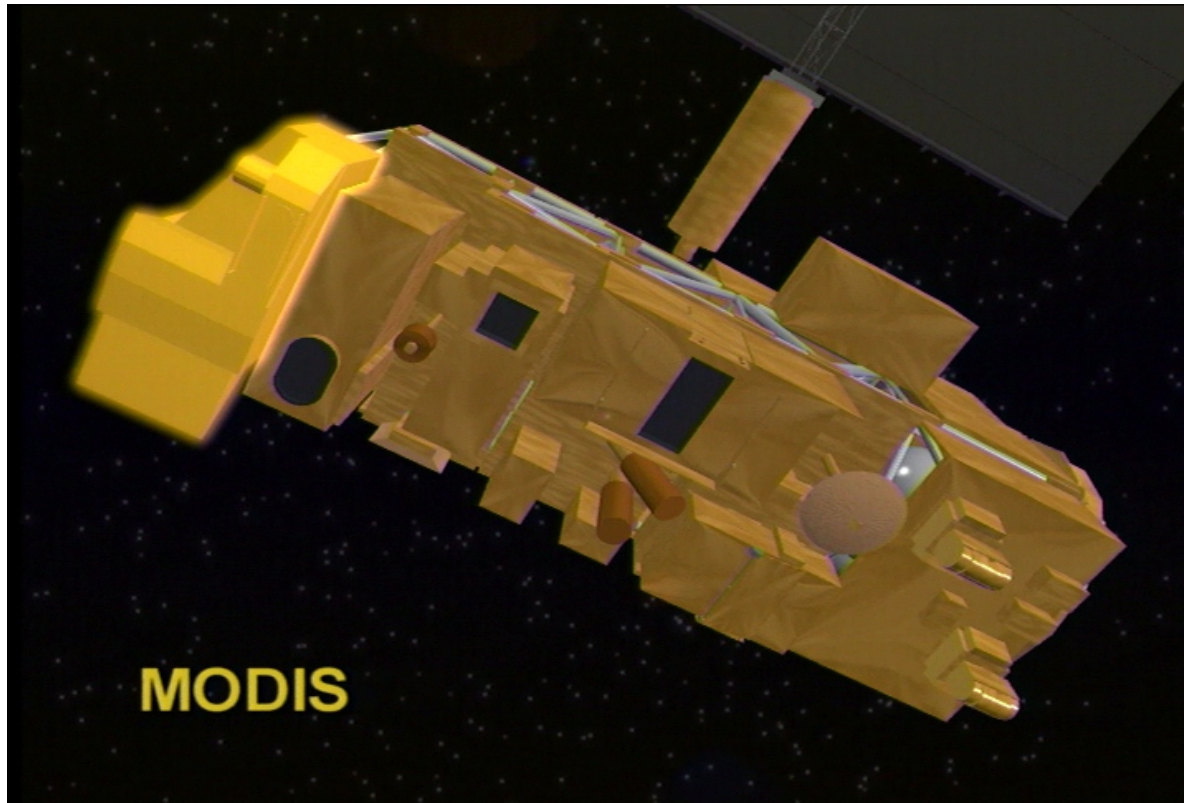
## Current and planned Instruments

AATSR	MSS
ABI	MSU-GS
ATSR-2	MSU-MR
AVHRR/3	Multi-spectral thermal infrared imager (HyspIRI)
AWiFS	MUX
CCD camera	MVIRI
CHRIS	MVIRS
CZI	MVISR (10 channels)
ETM+	MxT
FCI	NigeriaSat Medium Resolution
HSC	OBA
HSI (HJ-1A)	OLI
HSMS	OLS
HSS	Panchromatic High Sensitivity Camera
HSTC	PCW
HYC	PSA
Hyperion	RASAT VIS Multi-spectral
HySI (IMS-1)	RASAT VIS Panchromatic
HySI (TES-HYS)	RDSA
IIR	SEVIRI

Imager (INSAT)	Sumbandila Sat Imager
IMAGER/MTSAT-2	TANSO-CAI
IR (HJ-1B)	TIR (OCEANSAT-3)
IR Correlation Radiometer (GeoCape)	TIRS
ISR	TM
IVISSR (FY-2)	UV/Vis Near IR Wide Imaging Spectrometer (Geo-Cape)
JAMI/MTSAT-1R	VEGETATION
KMSS	VHRR
LEISA AC	VIIRS
MCSI	VIRR
MERIS	VIRS
METimage	Visible imaging spectrometer (HyspIRI)
MIREI	VSC
MMRS	WFC
MOC	WFI
MODIS	WFI-2
MS (GISTDA)	WiFS
MSI (BJ-1)	WS LISS-III
MSI (EarthCARE)	

# Obserwacje optyczne wysokiej rozdzielczości spektralnej w zakresie IR i VIS

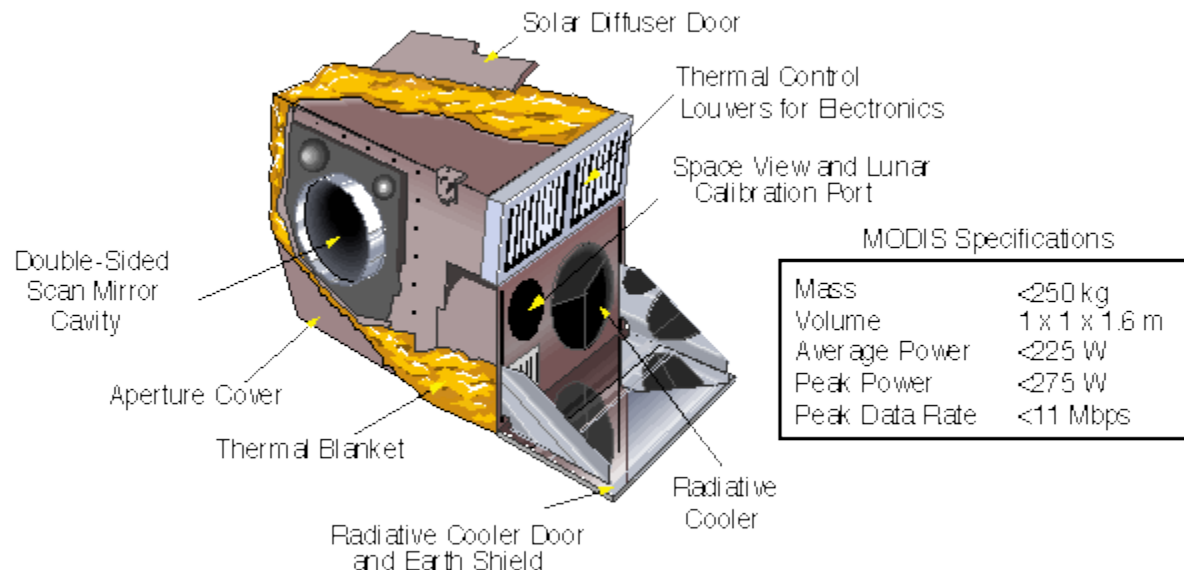
**MODerate resolution Imaging Spectroradiometer  
satelity: Terra, Aqua**



# Obserwacje optyczne wysokiej rozdzielczości spektralnej w zakresie IR i VIS

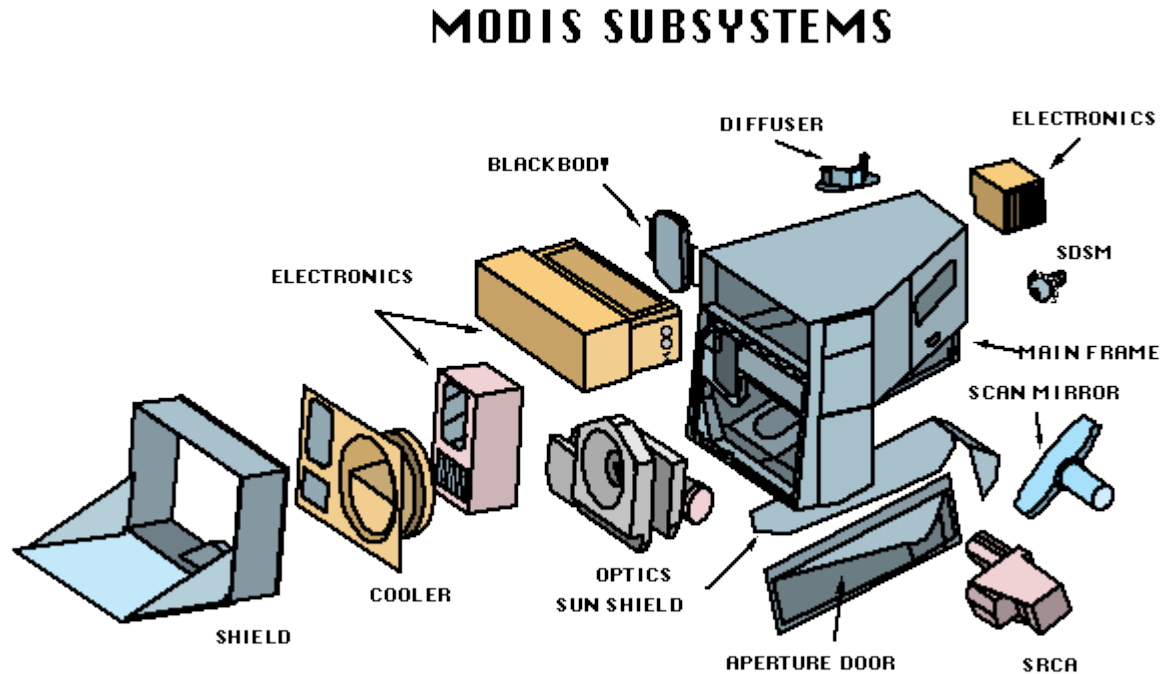
## MODerate resolution Imaging Spectroradiometer

MODIS External Cutaway



# Obserwacje optyczne wysokiej rozdzielczości spektralnej w zakresie IR i VIS

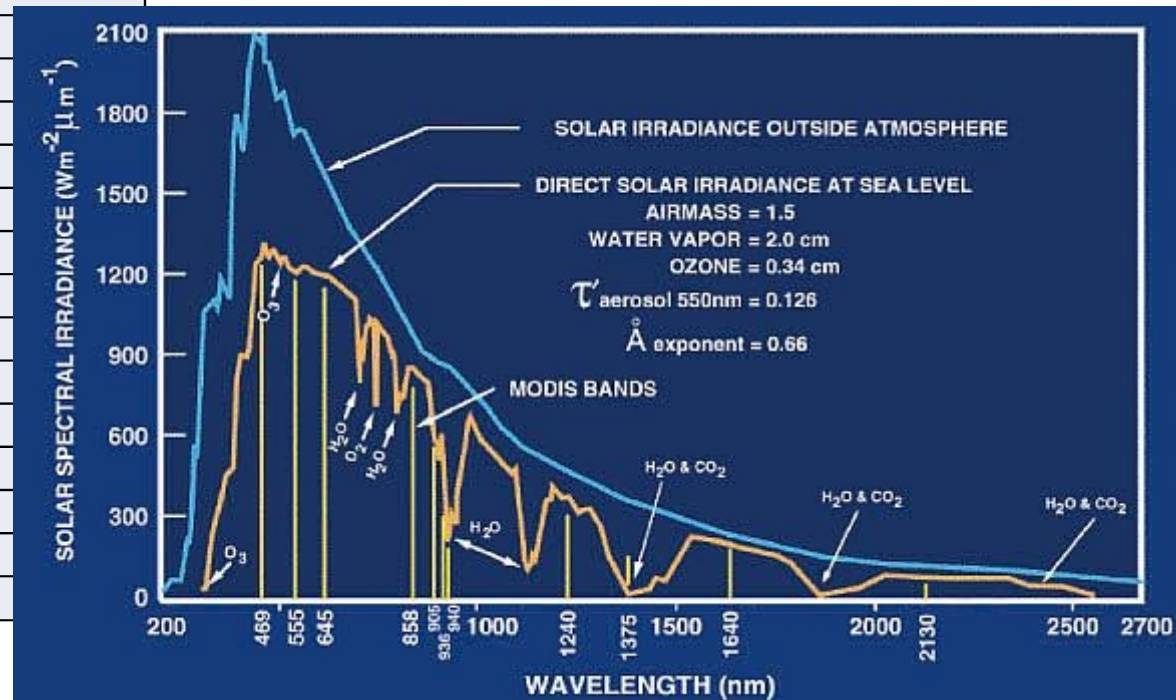
## MODerate resolution Imaging Spectroradiometer



# Obserwacje optyczne wysokiej rozdzielczości spektralnej w zakresie IR i VIS

## MODerate resolution Imaging Spectroradiometer

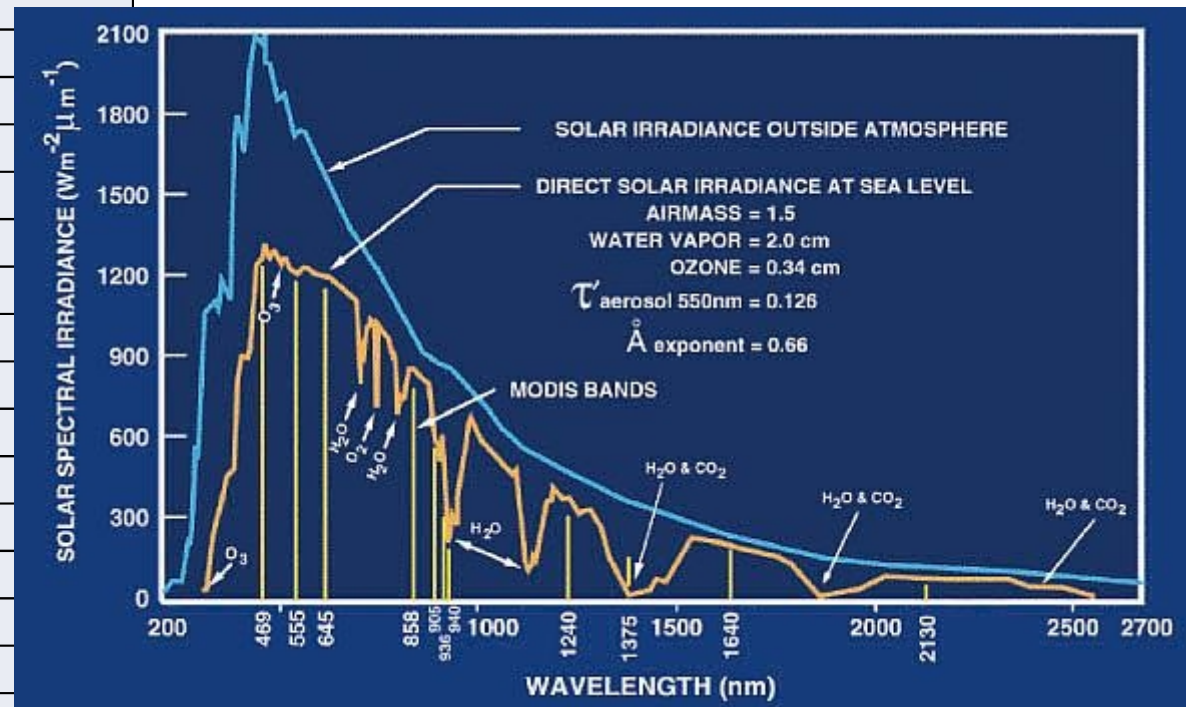
Pasma	Długość fali (mikrometr)	Rozdzielczość (metr)
1	0,62 - 0,67	250
2	0,841 - 0,876	250
3	0,459 - 0,479	500
4	0,545 - 0,565	500
5	1,23 - 1,25	500
6	1,628 - 1,652	500
7	2,105 - 2,155	500
8	0,405 - 0,42	1000
9	0,438 - 0,448	1000
10	0,483 - 0,493	1000
11	0,526 - 0,536	1000
12	0,546 - 0,556	1000
13	0,662 - 0,672	1000
14	0,673 - 0,683	1000
15	0,743 - 0,753	1000
16	0,862 - 0,877	1000
17	0,89 - 0,92	1000
18	0,931 - 0,941	1000



# Obserwacje optyczne wysokiej rozdzielczości spektralnej w zakresie IR i VIS

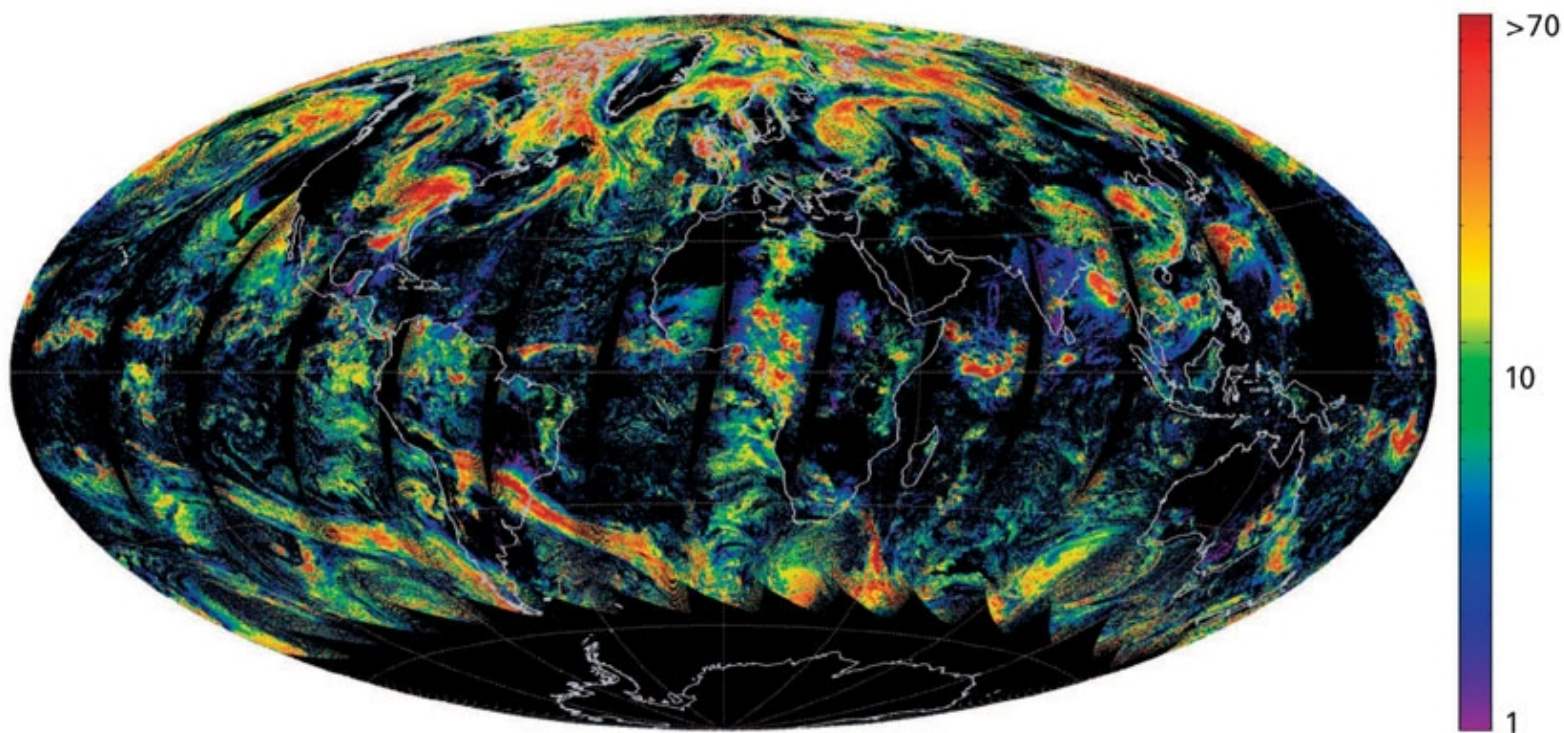
## MODerate resolution Imaging Spectroradiometer

19	0,915 - 0,965	1000
20	3,66 - 3,84	1000
21	3,929 - 3,989	1000
22	3,929 - 3,989	1000
23	4,02 - 4,08	1000
24	4,433 - 4,498	1000
25	4,482 - 4,549	1000
26	1,36 - 1,39	1000
27	6,535 - 6,895	1000
28	7,175 - 7,475	1000
29	8,4 - 8,7	1000
30	9,58 - 9,88	1000
31	10,78 - 11,28	1000
32	11,77 - 12,27	1000
33	13,185 - 13,485	1000
34	13,485 - 13,785	1000
35	13,785 - 14,085	1000
36	14,085 - 14,385	1000



# Obserwacje optyczne wysokiej rozdzielczości spektralnej w zakresie IR i VIS

## MODerate resolution Imaging Spectroradiometer

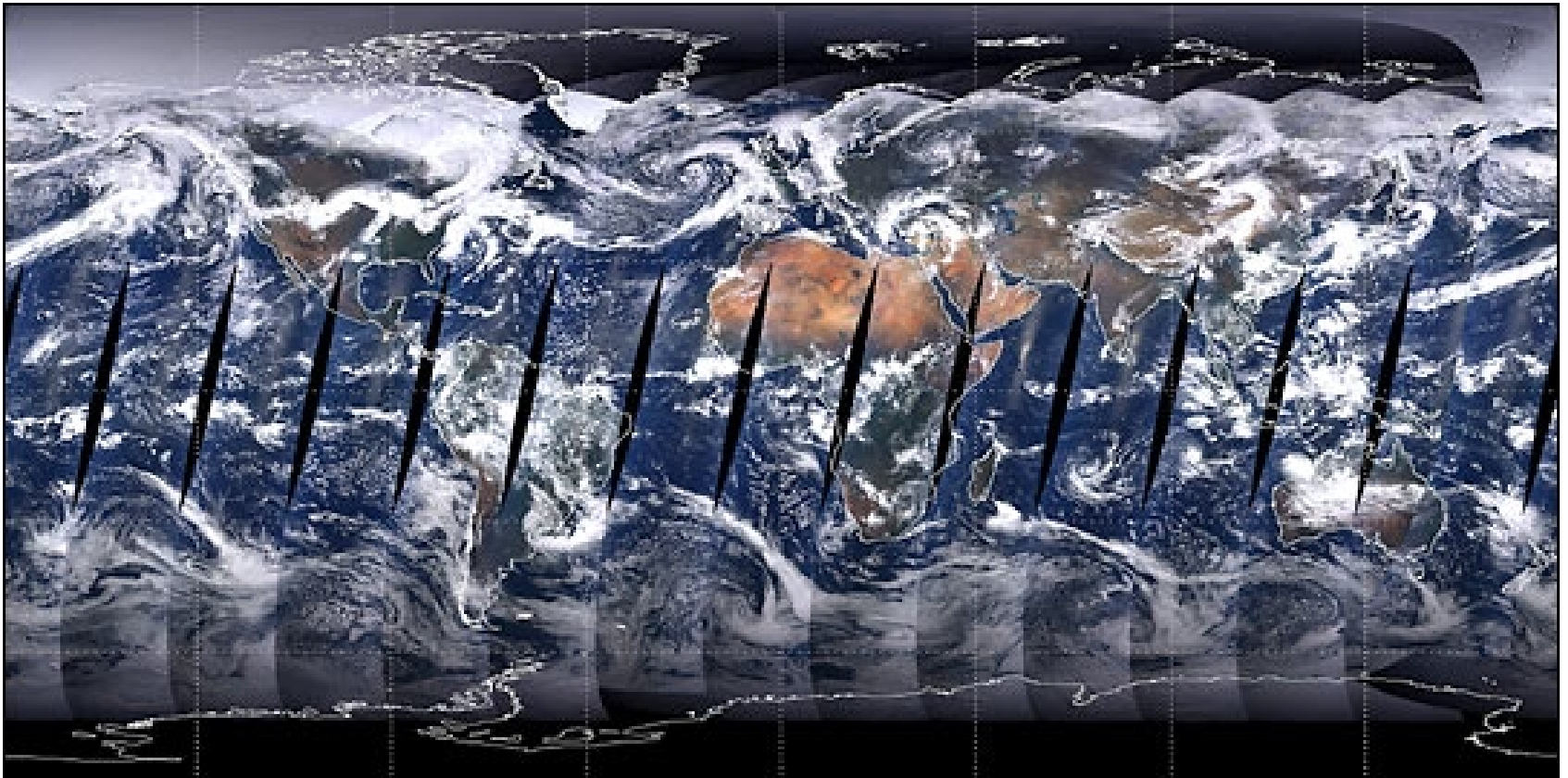


**Imaging aerosols.** MODIS/Terra technology allows scientists to map concentrations and dimensions of atmospheric aerosols in a variety of ways.



# Obserwacje optyczne wysokiej rozdzielczości spektralnej w zakresie IR i VIS

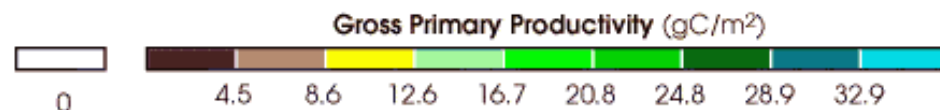
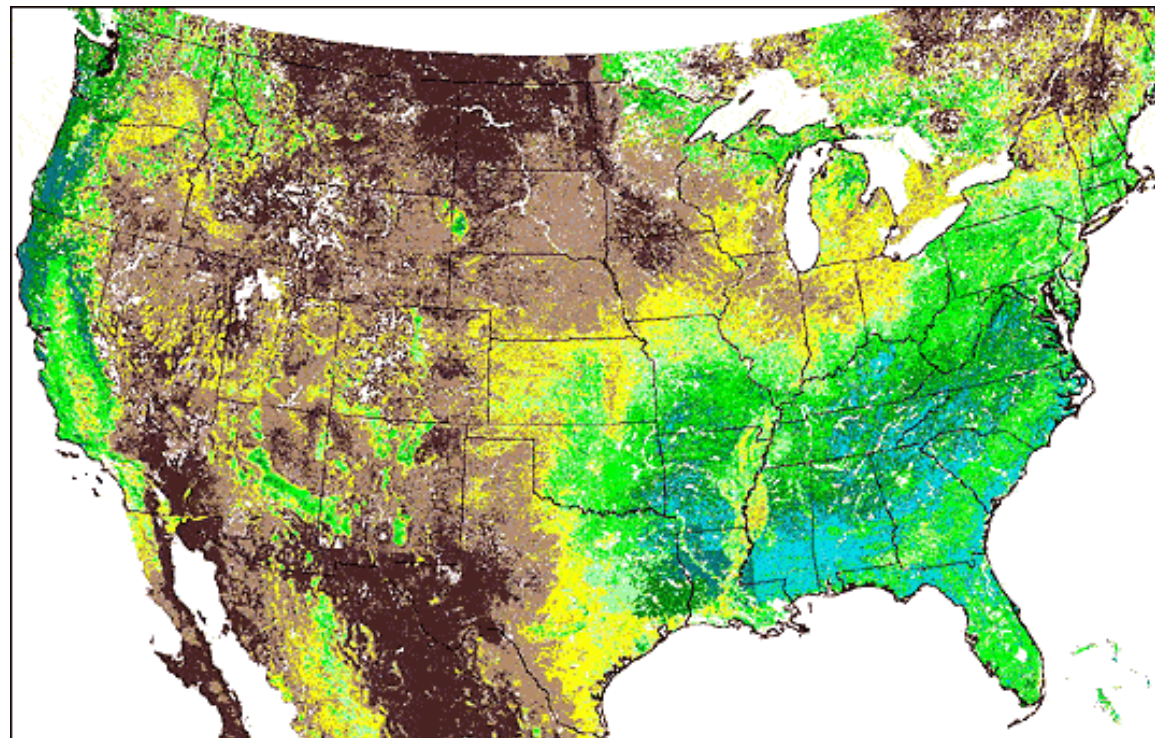
**MODerate resolution Imaging Spectroradiometer**



# Obserwacje optyczne wysokiej rozdzielczości spektralnej w zakresie IR i VIS

## MODerate resolution Imaging Spectroradiometer

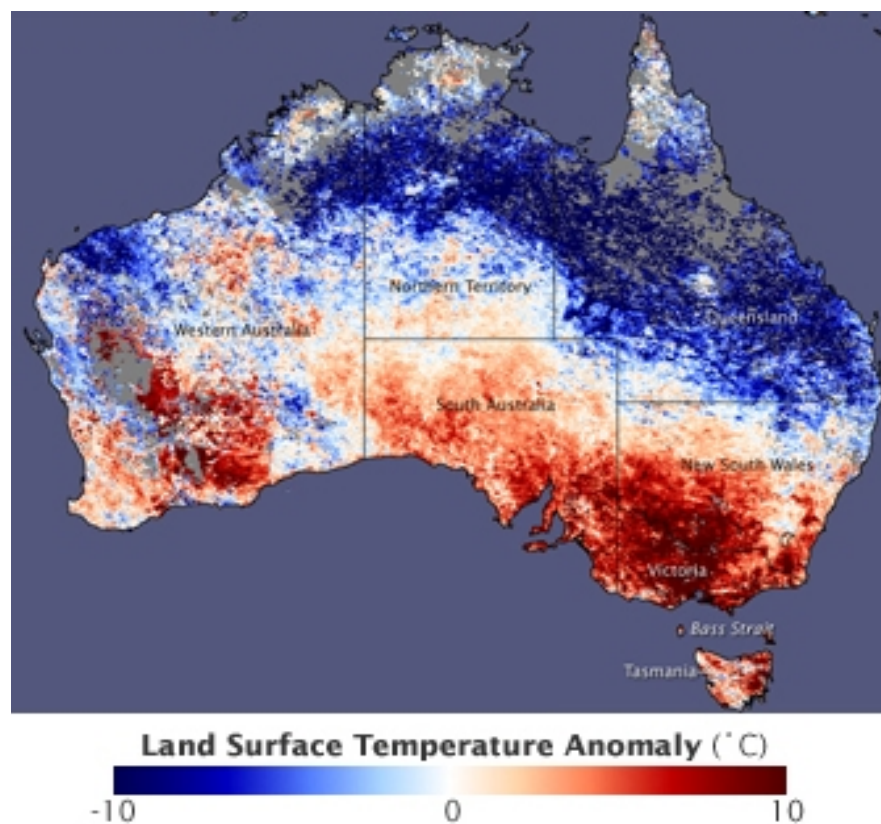
Wskaźnik produkcji pierwotnej biomasy



# Obserwacje optyczne wysokiej rozdzielczości spektralnej w zakresie IR i VIS

## MODerate resolution Imaging Spectroradiometer

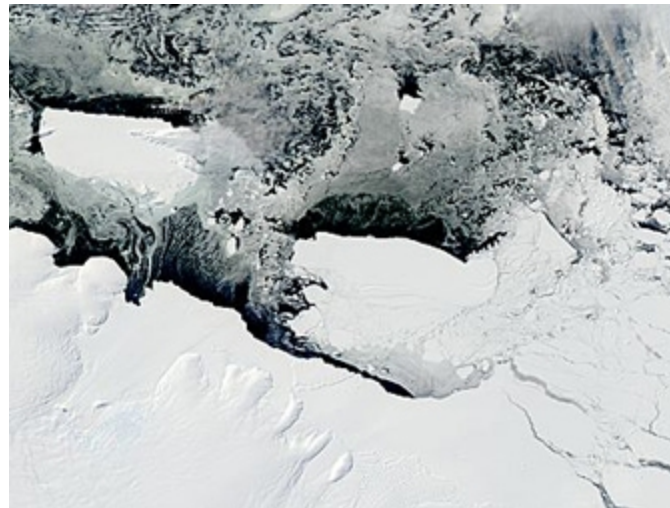
Różnice temperatur w Australii (11.02.2009)



# Obserwacje optyczne wysokiej rozdzielczości spektralnej w zakresie IR i VIS

## **MODerate resolution Imaging Spectroradiometer**

Dwie góry lodowe odrywające się od Antarktydy (15.03.2010)



# Obserwacje optyczne wysokiej rozdzielczości spektralnej w zakresie IR i VIS

## **MODerate resolution Imaging Spectroradiometer**

Biegun północny

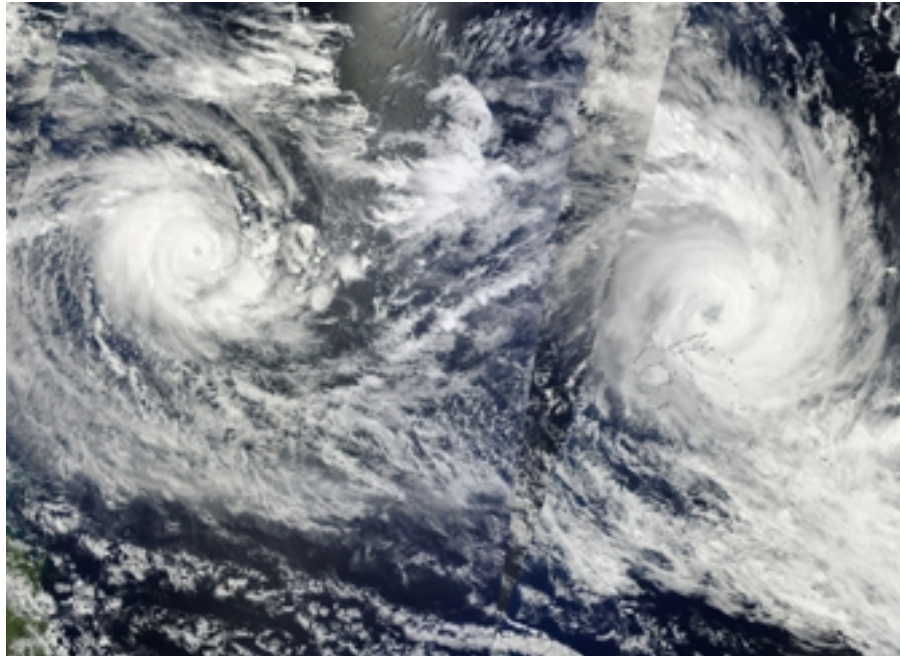
<http://www.youtube.com/watch?v=ro0-7U8UtvI&feature=related>

<http://www.youtube.com/watch?v=JMQ21p93JZc>

# Obserwacje optyczne wysokiej rozdzielczości spektralnej w zakresie IR i VIS

## **MODerate resolution Imaging Spectroradiometer**

Tropikalne cyklony – Thomas i Ului (18.03.2010)



# Obserwacje optyczne wysokiej rozdzielczości spektralnej w zakresie IR i VIS

## **MODerate resolution Imaging Spectroradiometer**

Pył nad Chinami (16.03.2010)

