Remote Sensing & Photogrammetry

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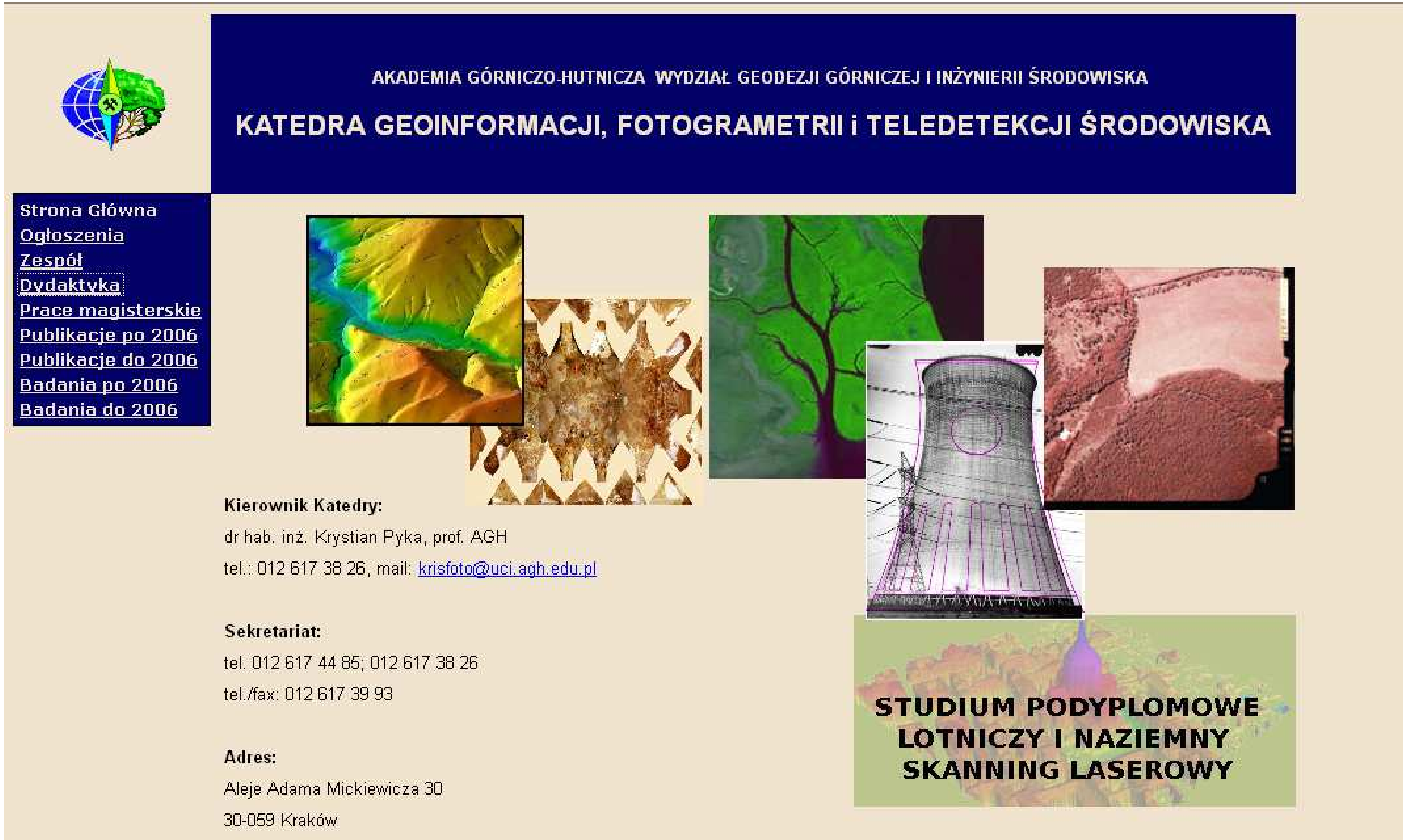


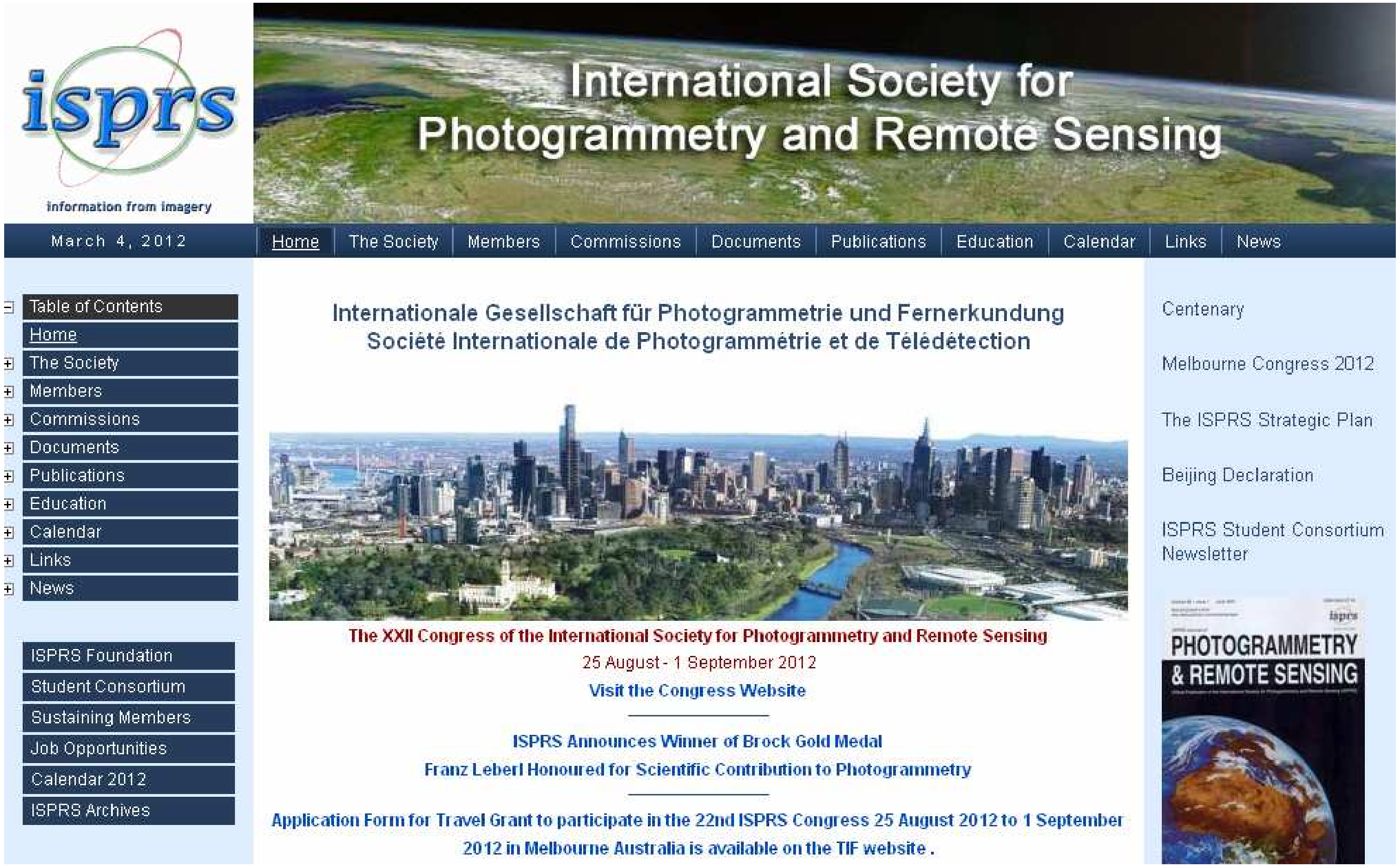
STUDY IN ENGLISH: Photogrammetry and Remote Sensing

Background of remote sensing

- Electromagnetic radiation. Interactions with the atmosphere. Radiation – target interactions. Passive and active sensing. Image characteristic (DN, spectral curves).
- Satellite and sensors. Spatial, spectral, radiometric and temporal resolutions. Thermal and microwave imaging. Backgrounds of thermovisin.
- Image interpretation and analysis. Pre-processing. Image enhancement. Image Transformation. Image Classification.

Literature

- **http://www.isprs.org/ Tutorials**



http://www.isprs.org/

EducationTutorials

South Africa), by Manos Baltsavias, ETH Zurich: part 1 (1.7 MB), part 2 (2.1 MB), part 3 (3.2 MB)

- Workshop on 'Remote Sensing and GIS for Watershed Managment', by ISPRS Special Interest Group 'Technology Transfer Caravan'
- Extraction of Geospatial Information from High Resolution Optical Satellite Sensors, ISPRS Technical Commission IV Symposium 'Geospatial Databases for Sustainable Development', Goa, India, 27-30 September 2006
- "Space technologies to support the conservation of natural and cultural sites", 25-27 November 2005, Campeche, Mexico

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Tutorials in REMOTE SENSING

- ~~The Remote Sensing Core Curriculum, an ASPRS Initiative for Space Age International Education~~
- Introduction to Remote Sensing, by CSIRO

projects

- Canada Centre for Remote Sensing, Education Section
- The use of Satellite Remote Sensing, CIESIN Thematic Guides
- NASA's Remote sensing Tutorial
- Remote Sensing and Image Analysis lecture, Berkeley lecture
- Principles of Remote Sensing, Singapore Science Center
- ~~Workshop "Satellite-based Photogrammetry", La Habana, Cuba, 9-13 February 2009~~

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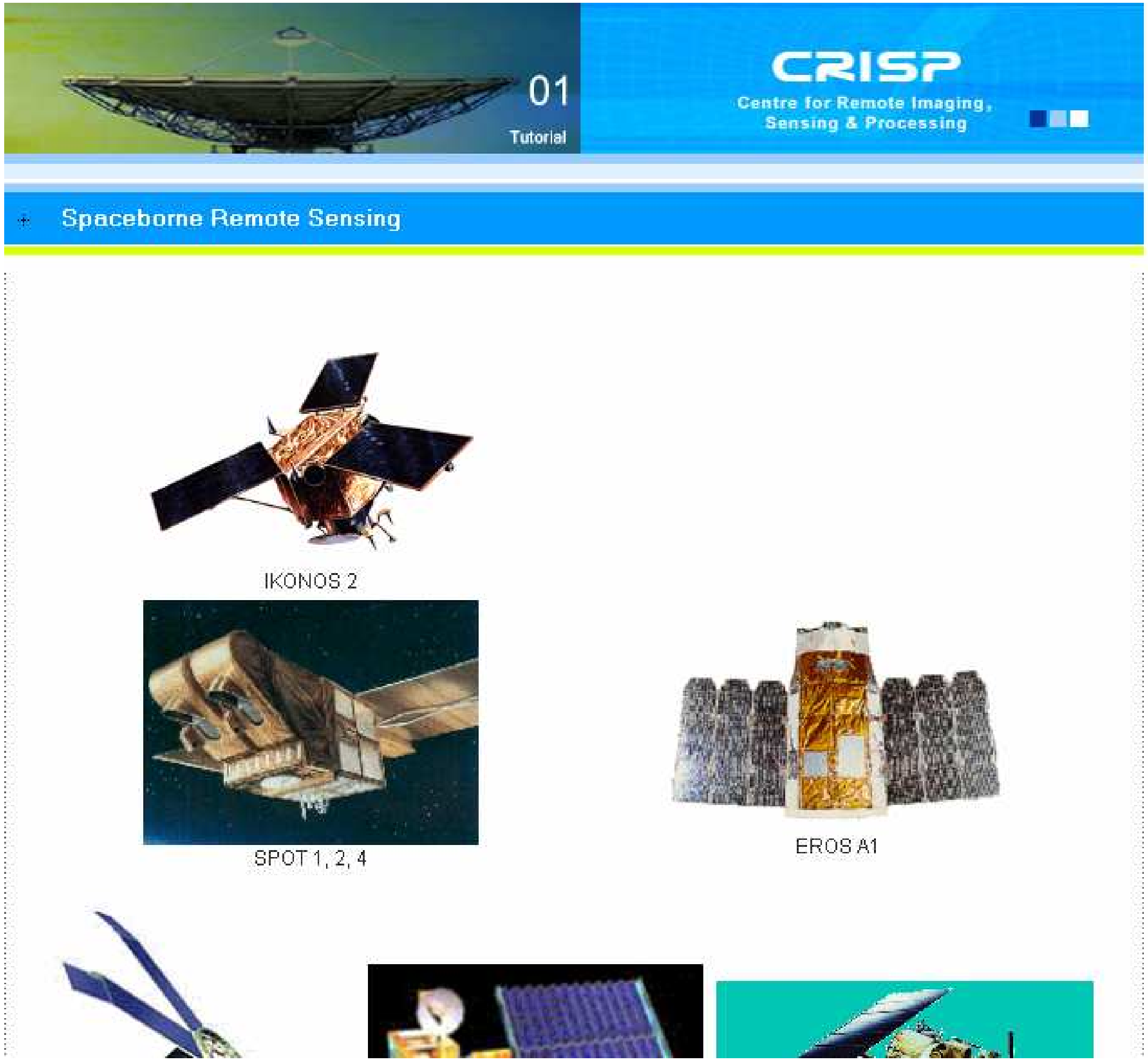
Tutorials in PHOTOGRAMMETRY

- Theory of Close Range Photogrammetry,Ch.2 of 'Close Range Photogrammetry and Machine Vision', K.B.Atkinson ed., 1996
- Air Photo Interpretation and Photogrammetry, by International Center for Remote Sensing of Environment
- Tutorials on optical measurements, by Gigahertz Optik

CRISP


01
Tutorial
CRISP
Centre for Remote Imaging, Sensing & Processing
Spaceborne Remote Sensing
IKONOS 2
SPOT 1, 2, 4
EROS A1

STATUTES

INTERNATIONAL SOCIETY FOR PHOTOGRAMMETRY AND REMOTE SENSING
July, 2008

- **STATUTE II - *Definitions***
- Photogrammetry and Remote Sensing is the art, science, and technology of obtaining reliable information from non-contact imaging and other sensor systems about the Earth and its environment, and other physical objects and processes through recording, measuring, analyzing and representation.

  Spatial Information Science is the art, science, and technology of obtaining reliable spatial, spectral and temporal relationships between physical objects, and of processes for integration with other data for analysis, portrayal and representation, independently of scale.

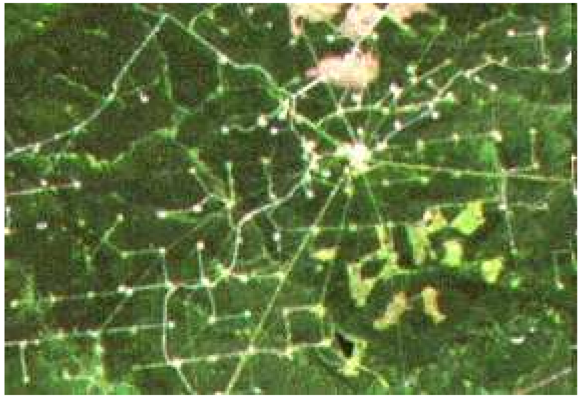
Milestones in the History of Remote Sensing

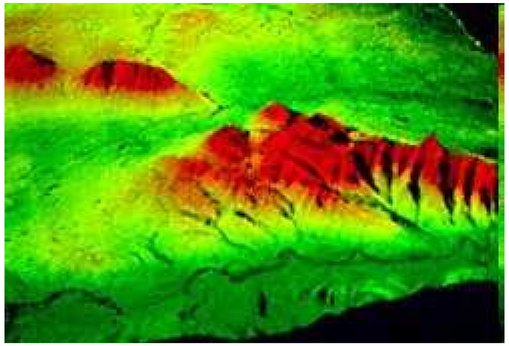
- 1839 Photography was invented
- 1858 Parisian Photographer, Gaspard Felix Tournachon used a balloon to ascend to a height of 80m to obtain the photograph over Bievre, France
- 1962 The term "Remote Sensing" first appeared
- 1972 The launch of Landsat-1, originally ERTS-1, Remote sensing has been extensively investigated and applied since then
- 1990 Proposed EOS aiming at providing data for global change monitoring. Various sensors have been proposed.
  - Japan's JERS-1 SAR,
  - European ERS Remote Sensing Satellite SAR,
  - Canada's Radarsat
  - Radar and imaging spectrometer data will be the major theme of this decade and probably next decade as well

http://www.cnr.berkeley.edu/~gong/textbook/

Applications

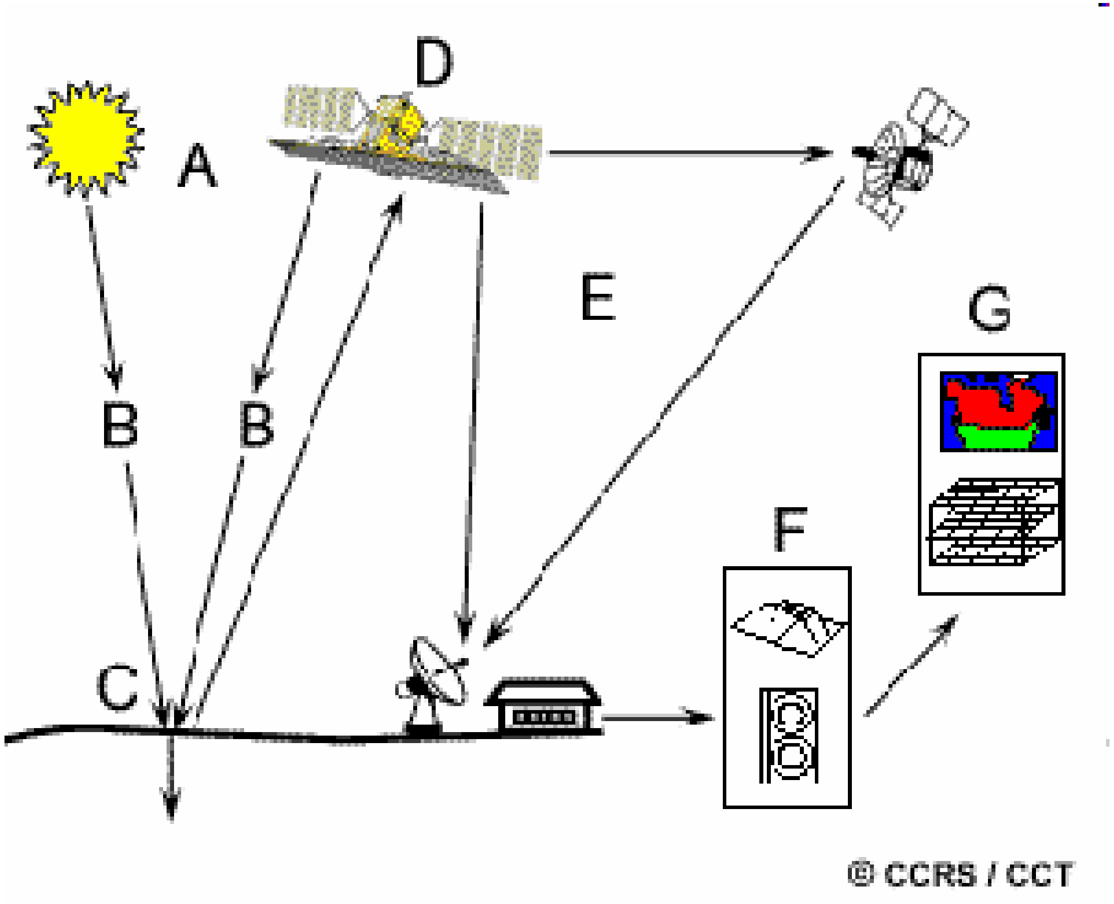
Agriculture (crop type monitoring,
damage assessment)
Forestry (forest cover type discrimination
agroforestry mapping, clear cut mapping / regeneration assessment
burn delineation , infrastructure mapping / operations support
forest inventory, biomass estimation, species inventory)
Geology (lithological, structural mapping,
sedimentation mapping and monitoringgeo-hazard mapping)
Hydrology (flood delineation&mapping, soil mapping)
Sea Ice (ice type&concentration, ice motion)
Land Cover (Land Cover & Land Use, Land Use Change)
Mapping (Planimetry, Digital Elevatin Model, Thematic Mapper)
Oceans&Coastal Monitoring
(Ocean Features, Ocean Colour, Oil Spill Detecion)





www.nrcan.gc.ca

Introduction



Electromagnetic Energy

- „Energy is a group of particles travelling through a certain media. Electromagnetic energy is a group of particles with different frequencies travelling at the same velocity. These particles have a dual-mode nature. They are particles but they travel in a wave form.
- Electromagnetic waves obey the following rule:"

$$\mathbf{V = c/\lambda}$$

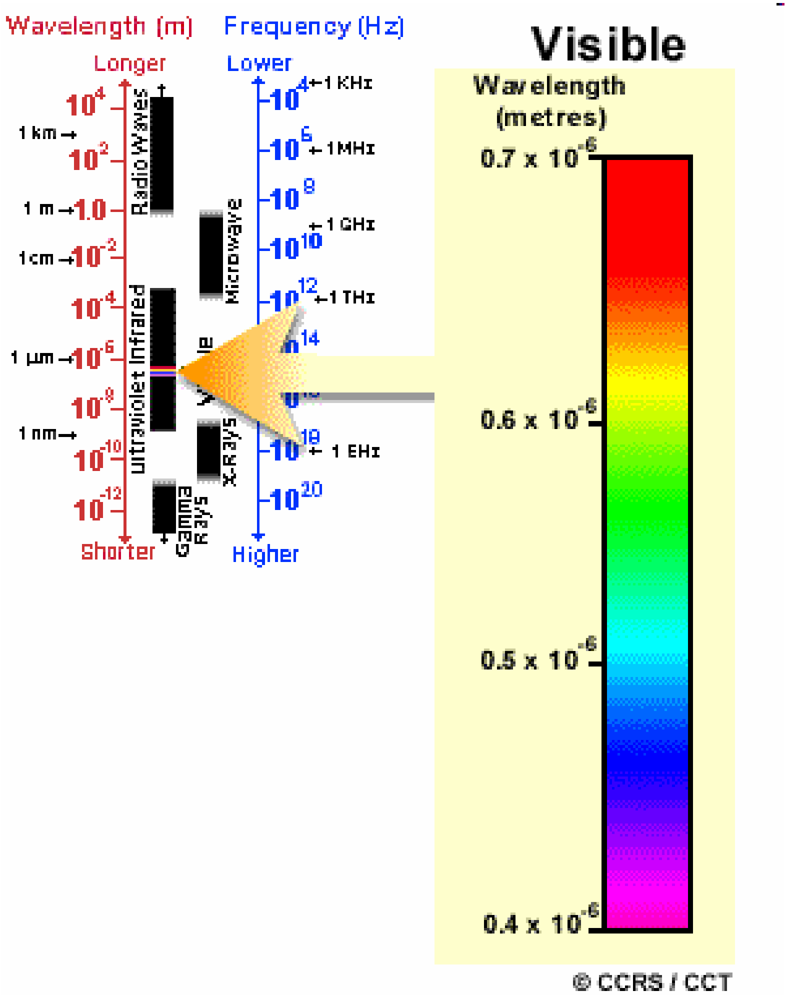
c : the speed of electromagnetic wave

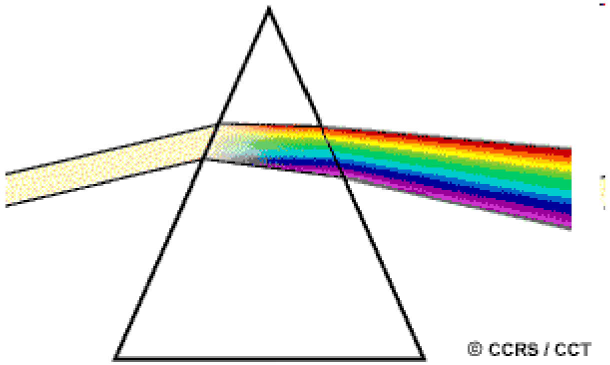
λ : wave length

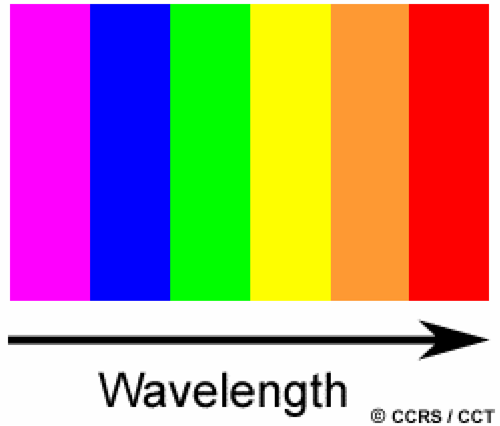
v : frequency.

http://www.cnr.berkeley.edu/~gong/textbook/

The Electromagnetic Spectrum







Violet: 0.4 - 0.446 µm
Blue: 0.446 - 0.500 µm
Green: 0.500 - 0.578 µm
Yellow: 0.578 - 0.592 µm
Orange: 0.592 - 0.620 µm
Red: 0.620 - 0.7 µm

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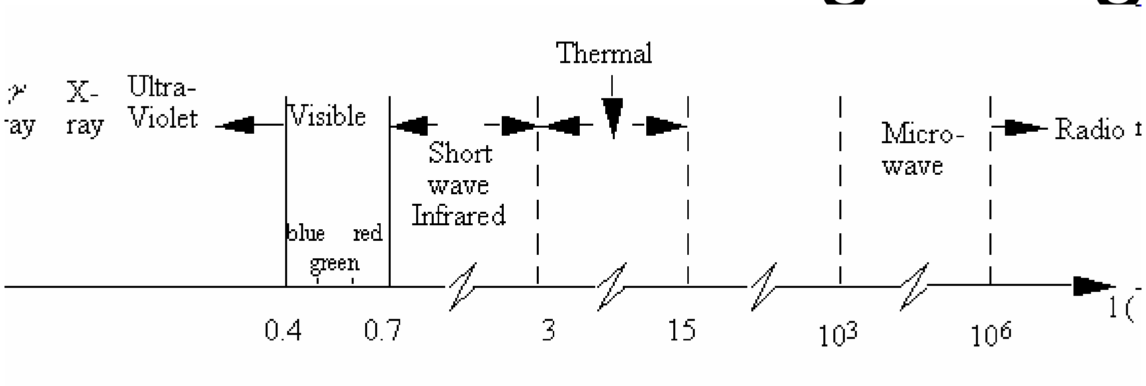
Major uses of some spectral wavelength regions



http://www.cnr.berkeley.edu/~gong/textbook/

Wavelength	Use	Wavelength	Use
g ray	Mineral	1.55-1.75 µm	Water content in plant or soil
X ray	Medical	2.04-2.34 µm	Mineral, rock types
Ultraviolet(UV)	Detecting oil spill	10.5-12.5 µm	Surface temperature
0.4-0.45 µm	Water depth, turbidity	3 cm - 15 cm	Surface relief, soil moisture
0.7-1.1 µm	Vegetation vigor	20 cm - 1 m	Canopy penetration, woody biomass

Radiation Laws

The **first** theory treats electromagnetic radiation as many discrete particles called photons or quanta (terms in Physics).

The energy of a quantum is given by

$$E=hv$$

where

- E energy of a quantum (Joules)
- h = 6.626 x 10-34 (Planck's constant)
- v frequency

Energy and wavelegth

http://www.cnr.berkeley.edu/~gong/textbook/

Radiation Laws

This has implications to remote sensing sensor design. To use the available sensing technology at hand, we will have to balance between wavelength and spatial resolution. If we wish to make our sensor to have higher spatial resolution, we may have to use short wavelength regions.

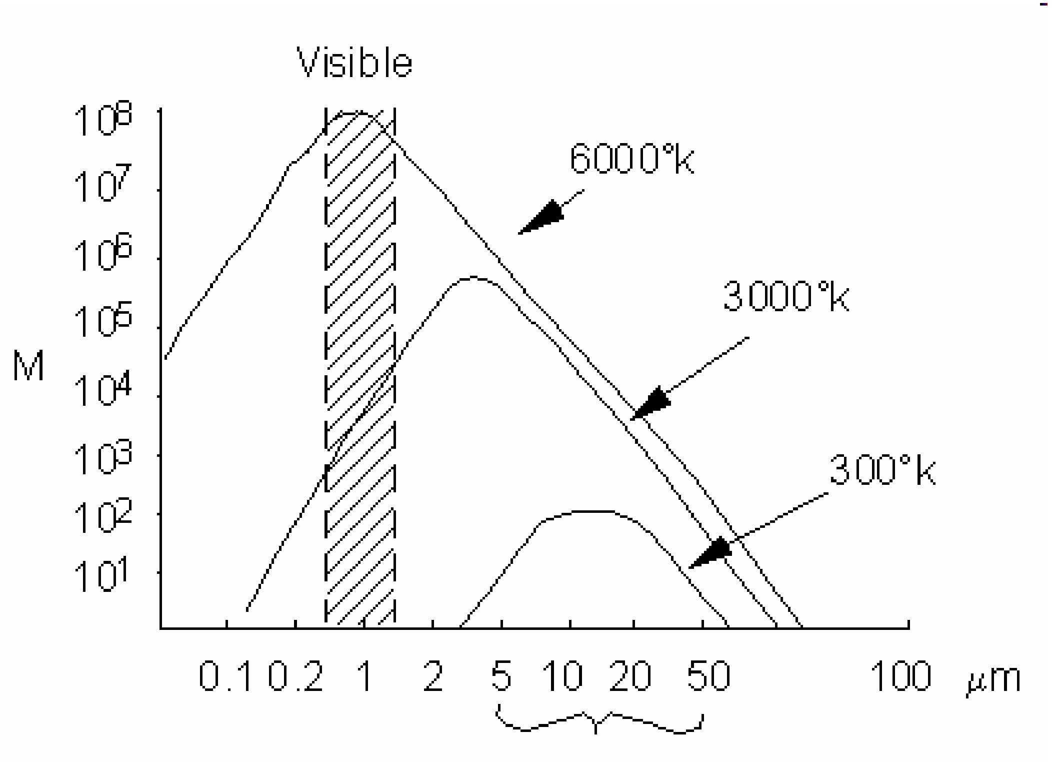
The **second** radiation theory is Stefan-Boltzmann Law:

$$M = \delta T^4$$

- M: total radiant existence for a surface of a material watts/m^2
- δ Stefan-Boltzmann constant, 5.6697 x 10-8 Wm^-2 ℃K^-4
- T: absolute temperature, K

http://www.cnr.berkeley.edu/~gong/textbook/

Blackbody radiation



Planck's law

$$M_\lambda = \frac{c_1}{\lambda^5[\exp(c_2/\lambda T)-1}$$

c_1 = 3,74•10-16 W m^2
c_2 = 1,44•10-2 K m

Wien's displacement law

λ max = 2897.8/T

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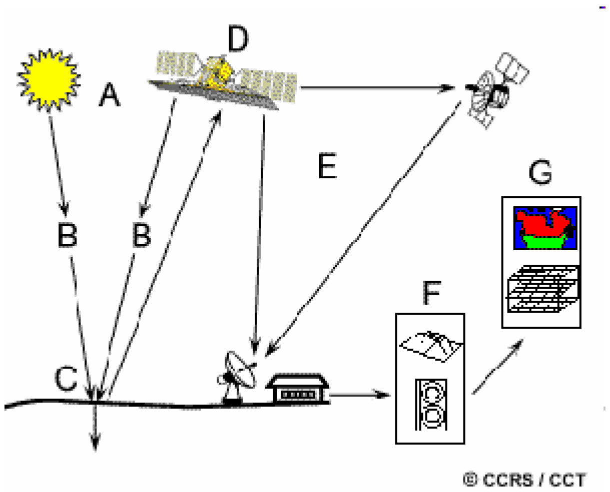
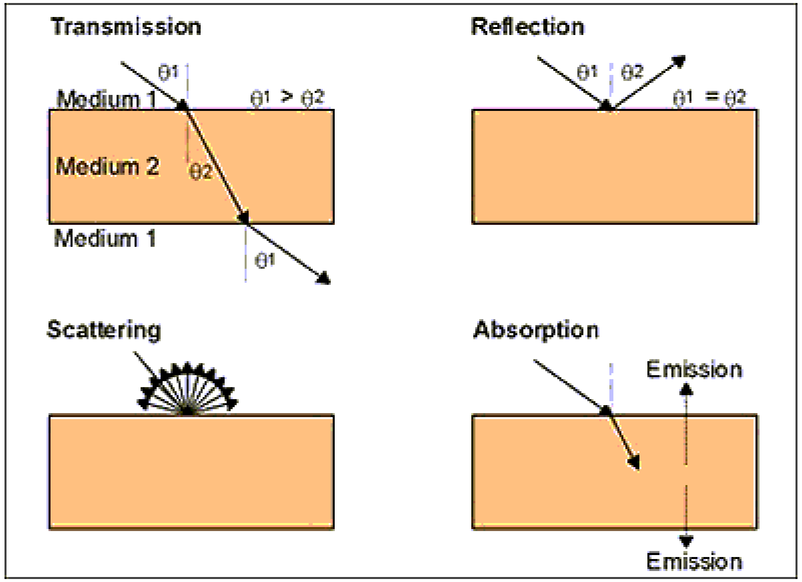
Radiation - Target Interactions



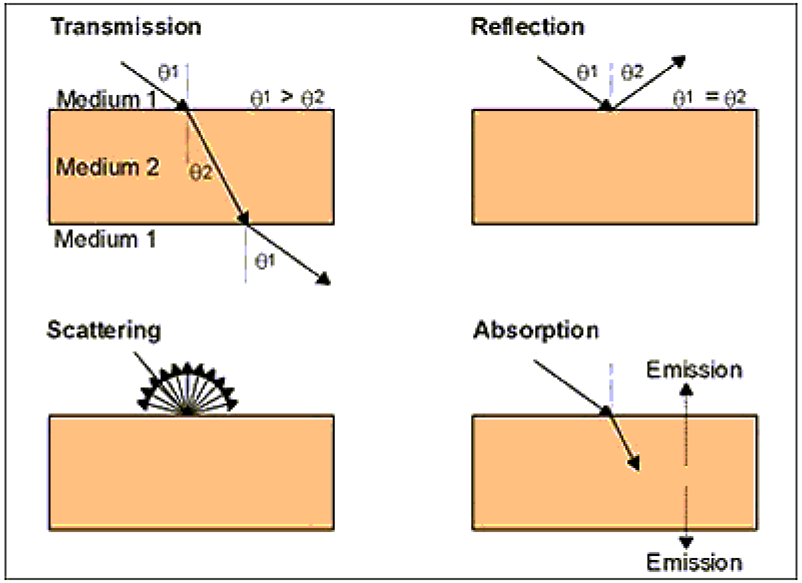


$$1 = \rho + \alpha + \tau$$

Real objects

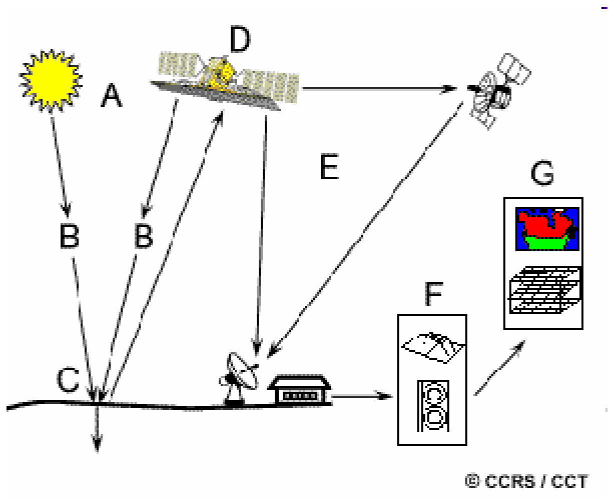
$M= \sigma\delta T^4$

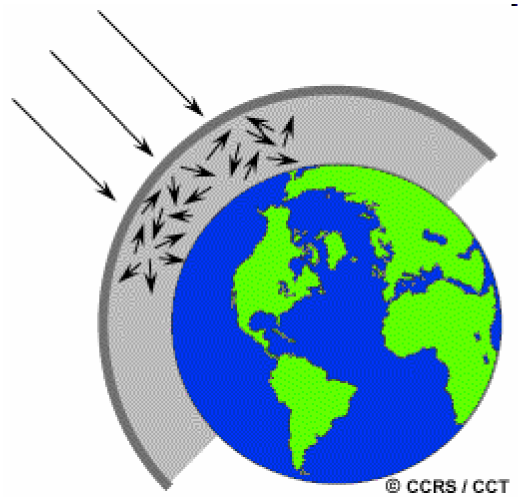
- M: total radiant existence for a surface of a material watts/m^2
- δ Stefan-Boltzmann constant, 5.6697 x 10^-8 Wm^-2 °K^-4
- T: absolute temperature,
- σ – emmisivity coefficient



Interactions with the Atmosphere

Scattering occurs when particles or large gas molecules present in the atmosphere interact with and cause the electromagnetic radiation to be redirected from its original path. How much scattering takes place depends on several factors including the wavelength of the radiation, the abundance of particles or gases, and the distance the radiation travels through the atmosphere. There are three (3) types of scattering which take place.



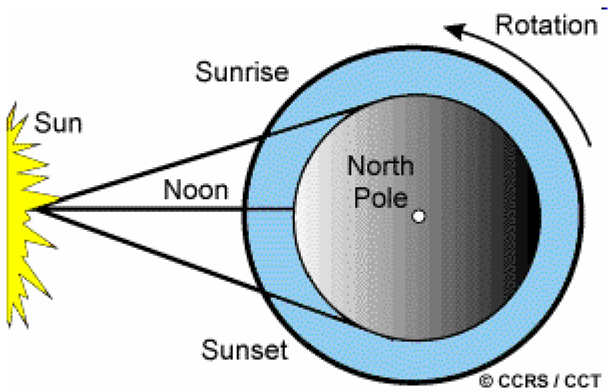


scattering and **absorption**

Rayleigh scattering

Occurs when particles are very small compared to the wavelength of the radiation.

These could be particles such as small specks of dust or nitrogen and oxygen molecules. Rayleigh scattering causes shorter wavelengths of energy to be scattered much more than longer wavelengths. Rayleigh scattering is the dominant scattering mechanism in the upper atmosphere. The fact that the sky appears "blue" during the day is because of this phenomenon. As sunlight passes through the atmosphere, the shorter wavelengths (i.e. blue) of the visible spectrum are scattered more than the other (longer) visible wavelengths. At **sunrise and sunset** the light has to travel farther through the atmosphere than at midday and the scattering of the shorter wavelengths is more complete; this leaves a greater proportion of the longer wavelengths to penetrate the atmosphere.



Mie scattering

Occurs when the particles are just about the same size as the wavelength of the radiation. Dust, pollen, smoke and water vapour are common causes of Mie scattering which tends to affect longer wavelengths than those affected by Rayleigh scattering. Mie scattering occurs mostly in the lower portions of the atmosphere where larger particles are more abundant, and dominates when cloud conditions are overcast.

The final scattering mechanism of importance is called **nonselective scattering**. This occurs when the particles are much larger than the wavelength of the radiation. Water droplets and large dust particles can cause this type of scattering. Nonselective scattering gets its name from the fact that all wavelengths are scattered about equally. This type of scattering causes fog and clouds to appear white to our eyes because blue, green, and red light are all scattered in approximately equal quantities (blue+green+red light = white light).

Absorption

Is the **other main** mechanism at work when electromagnetic radiation interacts with the atmosphere. In contrast to scattering, this phenomenon causes molecules in the atmosphere to absorb energy at various wavelengths. Ozone, carbon dioxide, and water vapour are the three main atmospheric constituents which absorb radiation.

- **Ozone** serves to absorb the harmful (to most living things) ultraviolet radiation from the sun. Without this protective layer in the atmosphere our skin would burn when exposed to sunlight.
- You may have heard **carbon dioxide** referred to as a greenhouse gas. This is because it tends to absorb radiation strongly in the far infrared portion of the spectrum - that area associated with thermal heating - which serves to trap this heat inside the atmosphere. Water vapour in the atmosphere absorbs much of the incoming longwave infrared and shortwave microwave radiation (between 22µm and 1m). The presence of water vapour in the lower atmosphere varies greatly from location to location and at different times of the year. For example, the air mass above a desert would have very little water vapour to absorb energy, while the tropics would have high concentrations of water vapour (i.e. high humidity).

EM radiation

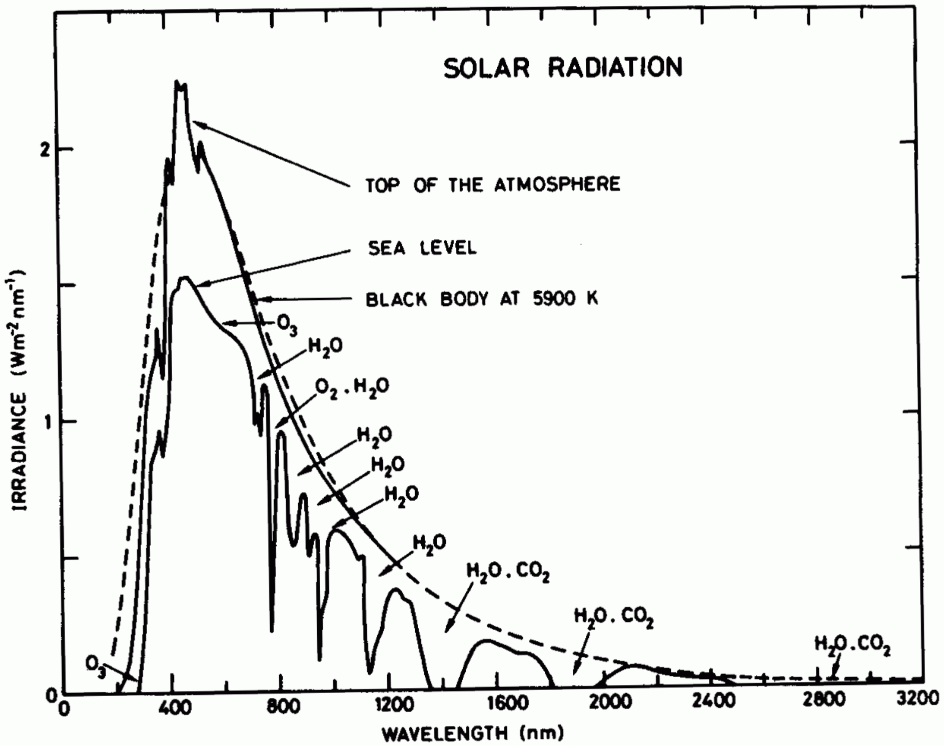
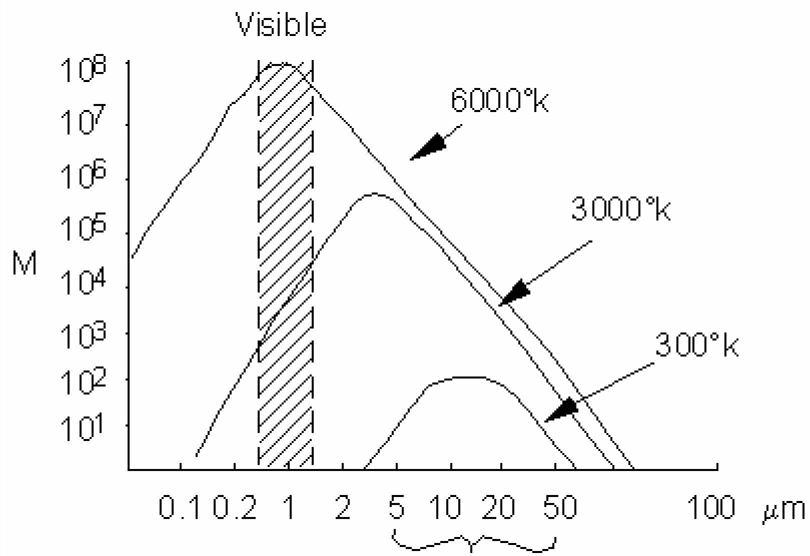
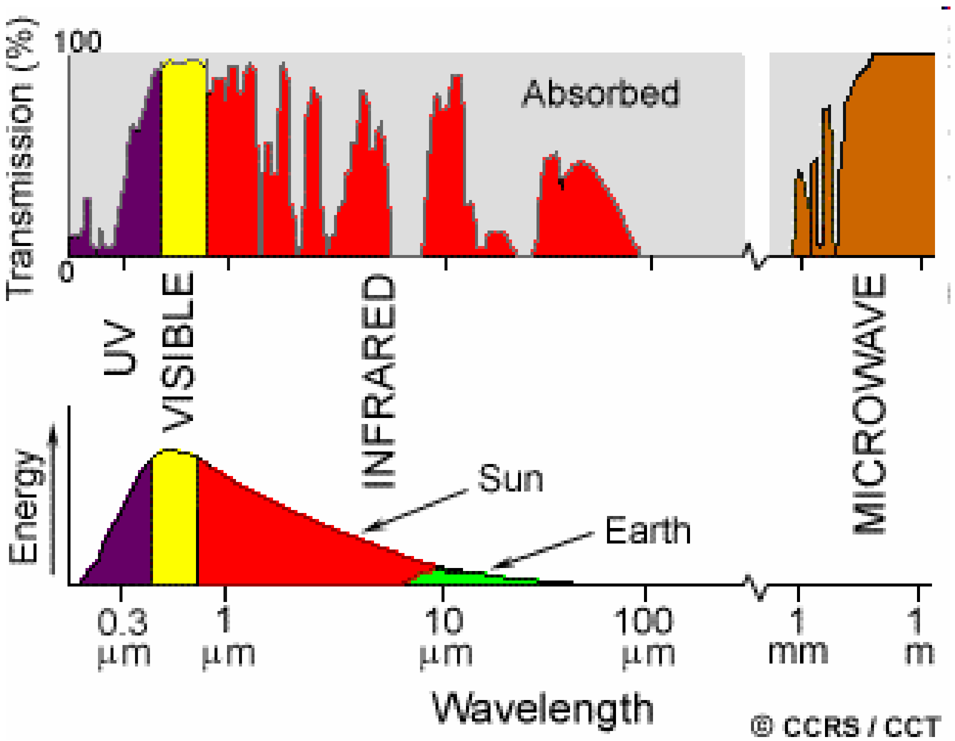


Fig. 4.6. Spectrum of solar radiation (UV, visible, IR) outside the earth's atmosphere and at sea level. (Adapted from Coulson, 1975).



Atmospheric windows



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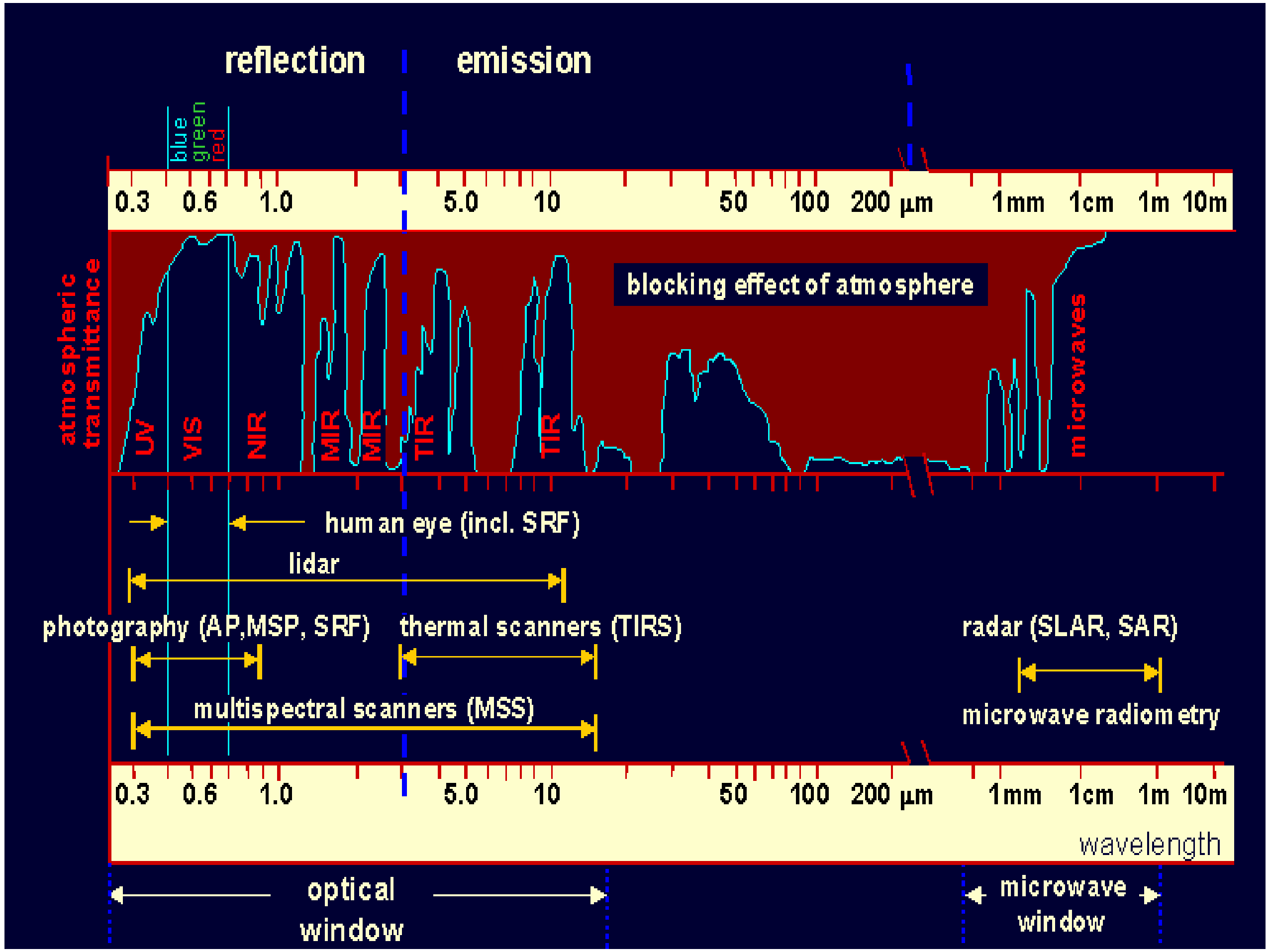
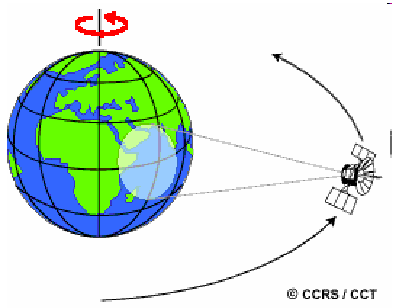
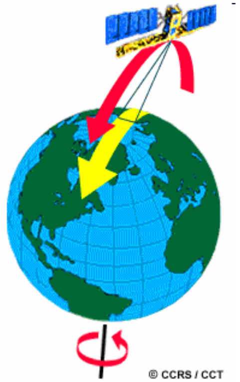
EM radiation

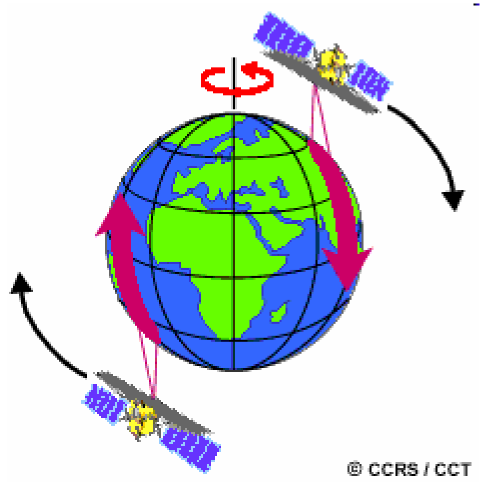


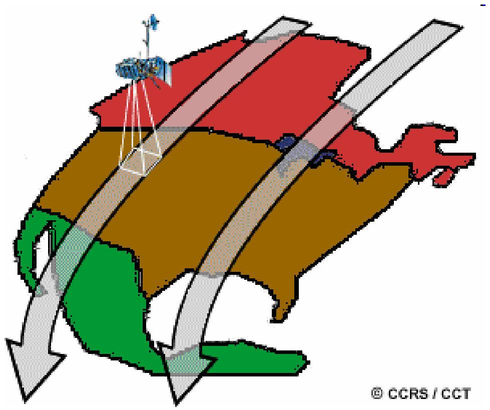
Satellite characteristic

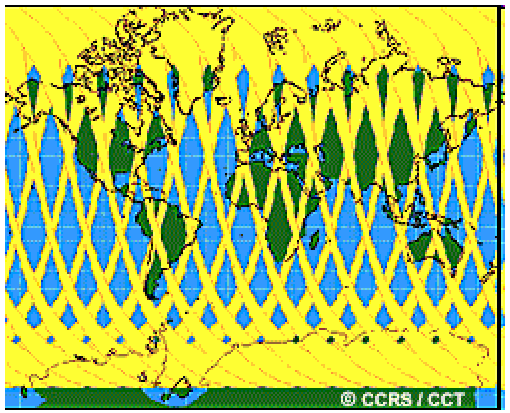
- Geostationary
- Sun-synchronous, local sun time





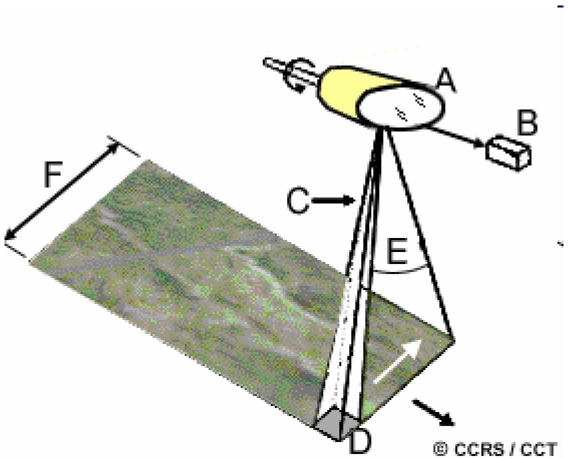




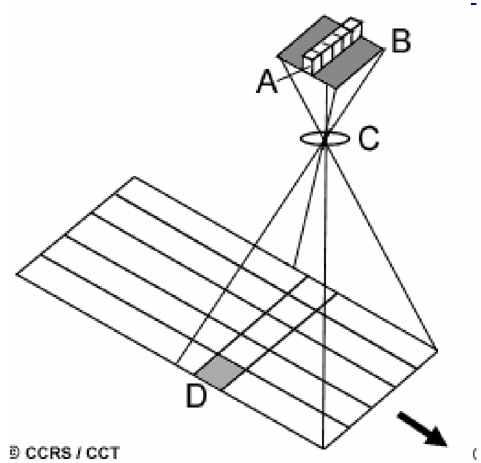


Multispectral Scanning

- **multispectral scanner (MSS)**
- **Across-track scanners**
- **Along-track scanners, pushbroom scanners**

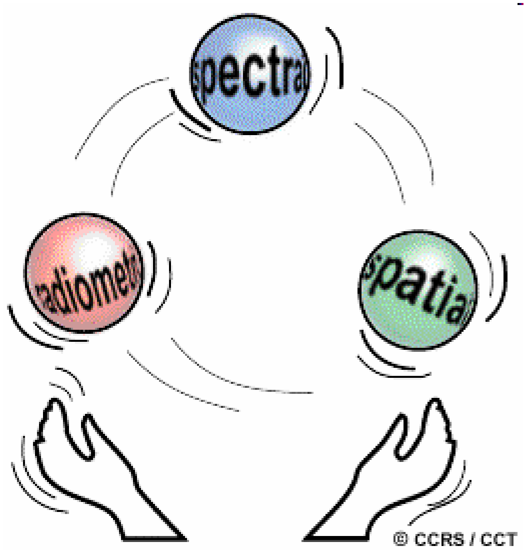


The **IFOV (C)** of the sensor and the altitude of the platform determine the **ground resolution cell viewed (D)**, and thus the spatial resolution. The **angular field of view (E)** is the sweep of the mirror, measured in degrees, used to record a scan line, and determines the width of the imaged **swath (F)**.



Resolution

- Spatial
- Spectral
- Radiometric
- Temporal



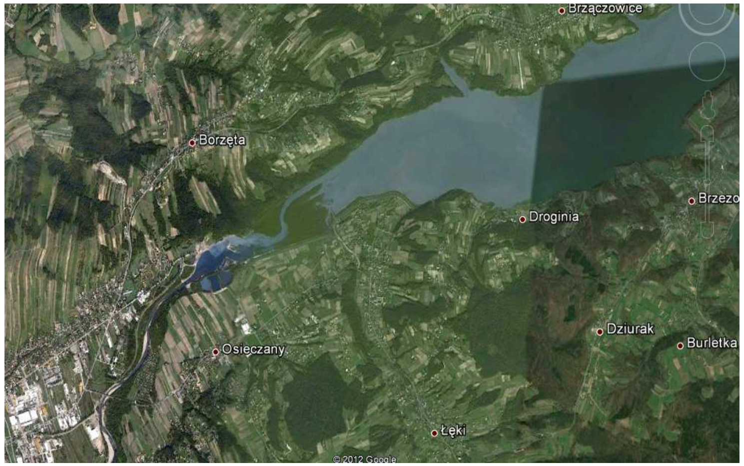
Spatial

	
Pixel Size = 10 m Image Width = 160 pixels, Height = 160 pixels	Pixel Size = 20 m Image Width = 80 pixels, Height = 80 pixels
	
Pixel Size = 40 m Image Width = 40 pixels, Height = 40 pixels	Pixel Size = 80 m Image Width = 20 pixels, Height = 20 pixels

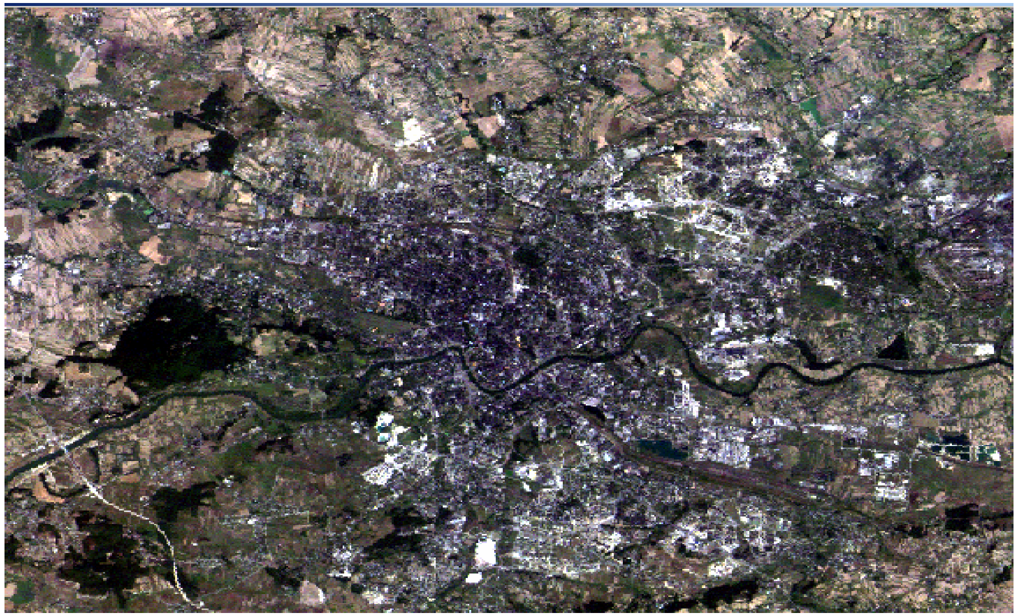
http://www.crisp.nus.edu.sg/~research/tutorial/image.htm

Spatial

Spatial resolution: 0,5; 1,0; 5,0; 30

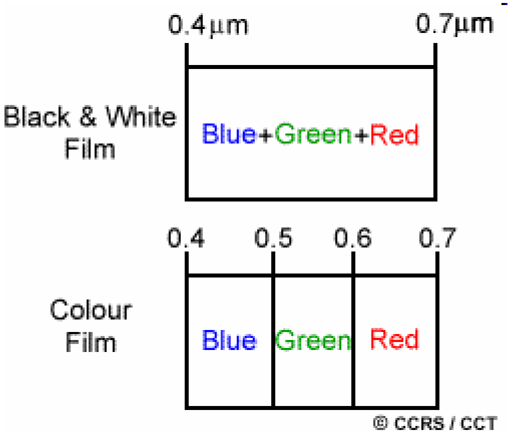


Spatial

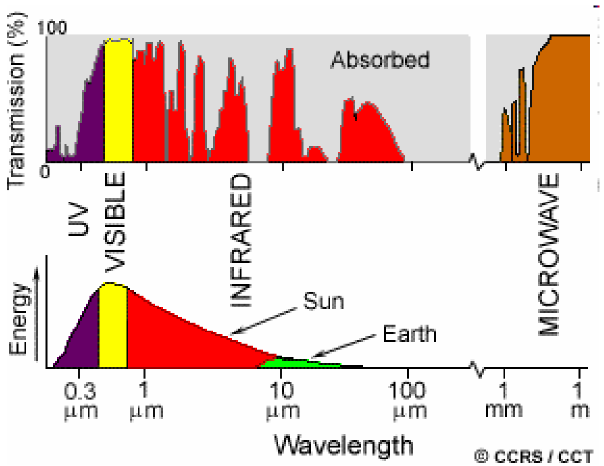


Spectral

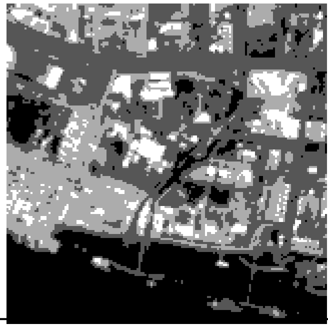
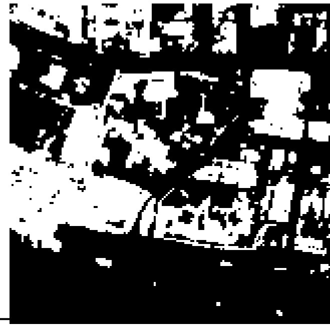
- Spectral range (µm):
- UV (0,3-0,4)
- VIS (0,4-0,7)
- VNIR (0,4-1,4)
- IR
- SWIR (1,4-2,5)
- TIR (2,5-14)
- MV (0,75-100cm)



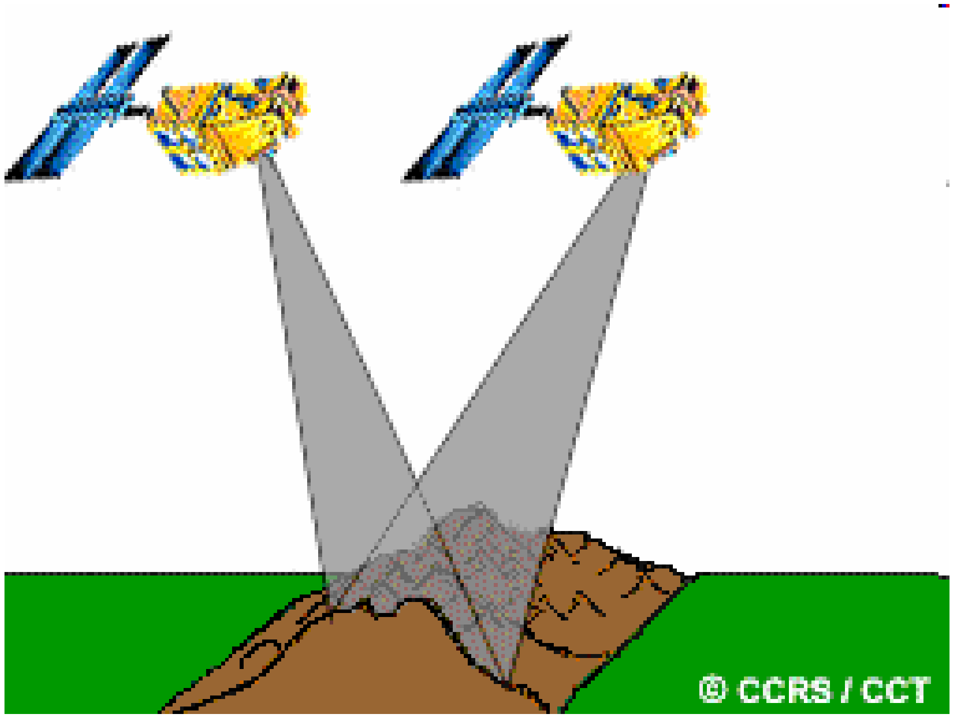
Spectral resolution
-PAN 0,3
-MSS 0,1



Radiometric

	
8-bit quantization (256 levels)	6-bit quantization (64 levels)
	
4-bit quantization (16 levels)	3-bit quantization (8 levels)
	
2-bit quantization (4 levels)	1-bit quantization (2 levels)

Temporal



LANDSAT, USA

- The LANDSAT program consists of a series of **optical/infrared remote sensing** satellites for land observation. The program was first started by The National Aeronautics and Space Administration (NASA) in 1972, then turned over to the National Oceanic and Atmospheric Administration (NOAA) after it became operational. Since 1984, satellite operation and data handling were managed by a commercial company EOSAT. However, all data older than 2 years return to "public domain" and are distributed by the Earth Resource Observation System (EROS) Data Center of the US Geological Servey (USGS).
- The first satellite in the series, LANDSAT-1 (initially named as the Earth Resource Technology Satellite ERTS-1) was launched on 23 July 1972. The satellite had a designed life expectancy of 1 year but it ceased operation only on January 1978. LANDSAT-2 was launched on 22 January 1975 and three additional LANDSAT satellites were launched in 1978, 1982, and 1984 (LANDSAT-3, 4, and 5 respectively). LANDSAT-6 was launched on October 1993 but the satellite failed to obtain orbit. A new satellite LANDSAT-7 was launched in 15 April 1999. Currently, only LANDSAT-5 and 7 are operational .

http://www.crisp.nus.edu.sg/~research/tutorial/landsat.htm

LANDSAT

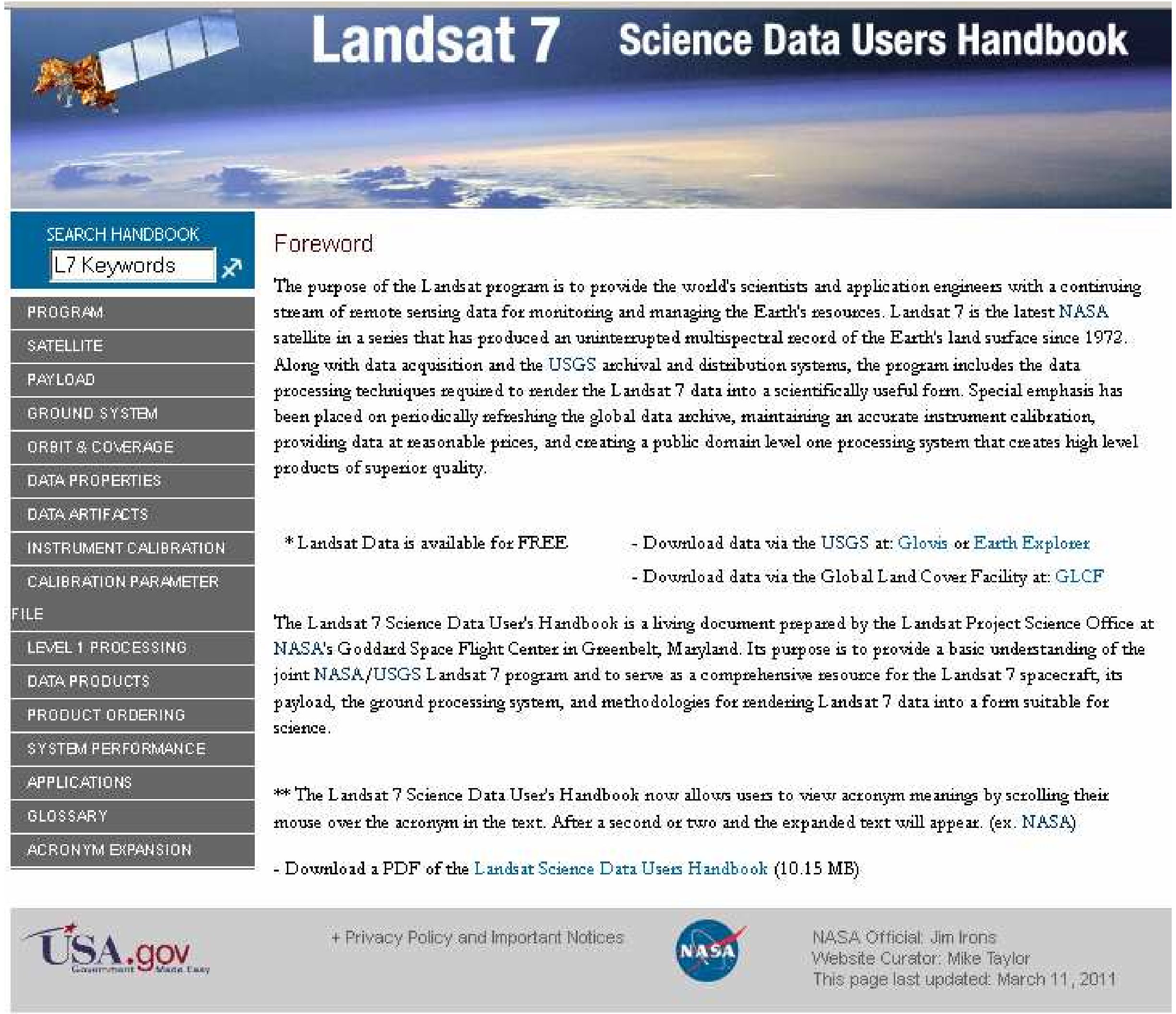
- **LANDSAT Orbit**
- **LANDSAT 4,5 MSS Sensor Characteristics**
- **LANDSAT TM, ETM+ Sensor Characteristics**

Type	Sun-Synchronous
Altitude	705 km
Inclination	98.2 deg
Period	99 min
Repeat Cycle	16 days

	Band	**Wavelength (µm)**	**Resolution (m)**
Blue	**1**	0.45 - 0.52	30
Green	**2**	0.52 - 0.60	30
Red	**3**	0.63 - 0.69	30
Near IR	**4**	0.76 - 0.90	30
SWIR	**5**	1.55 - 1.75	30
Thermal IR	**6**	10.40 - 12.50	120 (TM) 60 (ETM+)
SWIR	**7**	2.08 - 2.35	30
Panchromatic		0.5 - 0.9	15

	Band	**Wavelength (µm)**	**Resolution (m)**
Green	**1**	0.5 - 0.6	82
Red	**2**	0.6 - 0.7	82
Near IR	**3**	0.7 - 0.8	82
Near IR	**4**	0.8 - 1.1	82

Landsat handbook
Landsat Data is available for FREE



Landsat 7 Science Data Users Handbook

SEARCH HANDBOOK
L7 Keywords

PROGRAM
SATELLITE
PAYLOAD
GROUND SYSTEM
ORBIT & COVERAGE
DATA PROPERTIES
DATA ARTIFACTS
INSTRUMENT CALIBRATION
CALIBRATION PARAMETER FILE
LEVEL 1 PROCESSING
DATA PRODUCTS
PRODUCT ORDERING
SYSTEM PERFORMANCE
APPLICATIONS
GLOSSARY
ACRONYM EXPANSION

Foreword

The purpose of the Landsat program is to provide the world's scientists and application engineers with a continuing stream of remote sensing data for monitoring and managing the Earth's resources. Landsat 7 is the latest NASA satellite in a series that has produced an uninterrupted multispectral record of the Earth's land surface since 1972. Along with data acquisition and the USGS archival and distribution systems, the program includes the data processing techniques required to render the Landsat 7 data into a scientifically useful form. Special emphasis has been placed on periodically refreshing the global data archive, maintaining an accurate instrument calibration, providing data at reasonable prices, and creating a public domain level one processing system that creates high level products of superior quality.

* Landsat Data is available for FREE
- Download data via the USGS at: Glovis or Earth Explorer
- Download data via the Global Land Cover Facility at: GLCF

The Landsat 7 Science Data User's Handbook is a living document prepared by the Landsat Project Science Office at NASA's Goddard Space Flight Center in Greenbelt, Maryland. Its purpose is to provide a basic understanding of the joint NASA/USGS Landsat 7 program and to serve as a comprehensive resource for the Landsat 7 spacecraft, its payload, the ground processing system, and methodologies for rendering Landsat 7 data into a form suitable for science.

** The Landsat 7 Science Data User's Handbook now allows users to view acronym meanings by scrolling their mouse over the acronym in the text. After a second or two and the expanded text will appear. (ex. NASA)

- Download a PDF of the Landsat Science Data Users Handbook (10.15 MB)

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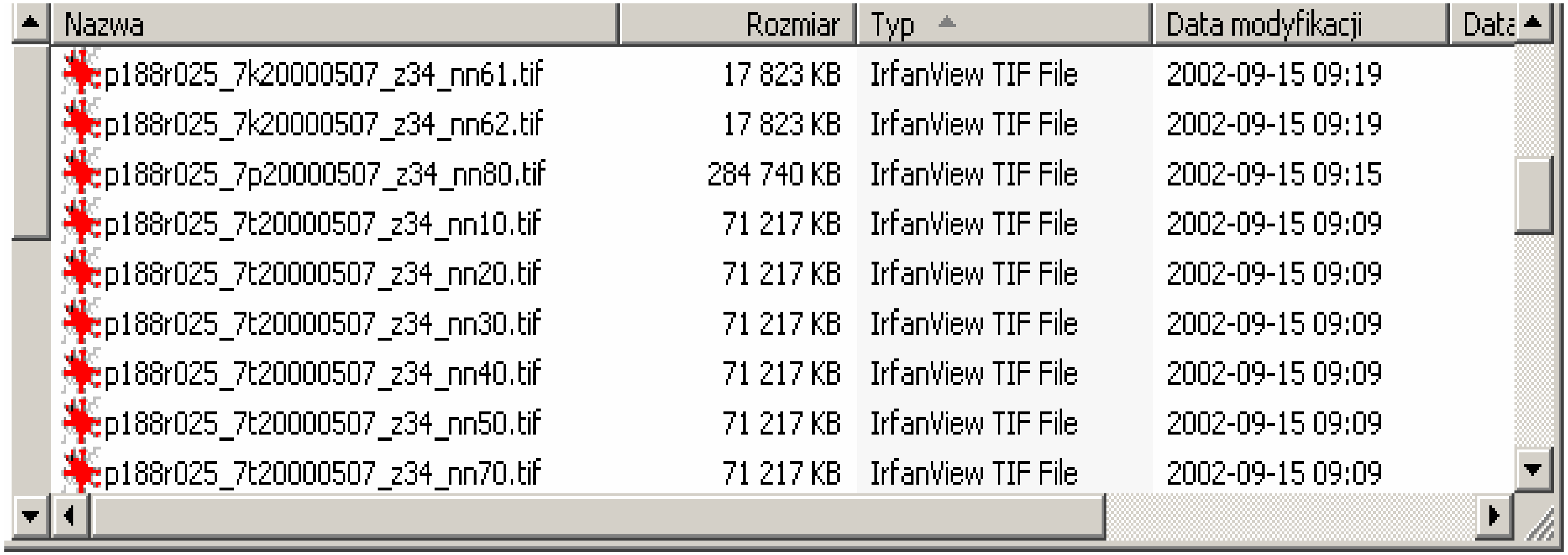
NASA Official: Jim Irons
Website Curator: Mike Taylor
This page last updated: March 11, 2011

Landsat Data is available for FREE

- Path: 188, Row: 25
- elp188r025_7t20000507.tar.gz
- GEOTIF

	Band	Wavelength (µm)	Resolution (m)
Blue	**1**	0.45 - 0.52	30
Green	**2**	0.52 - 0.60	30
Red	**3**	0.63 - 0.69	30
Near IR	**4**	0.76 - 0.90	30
SWIR	**5**	1.55 - 1.75	30
Thermal IR	**6**	10.40 - 12.50	120 (TM) 60 (ETM+)
SWIR	**7**	2.08 - 2.35	30
Panchromatic		0.5 - 0.9	15



Nazwa	Rozmiar	Typ	Data modyfikacji	Data
p188r025_7k20000507_z34_nn61.tif	17 823 KB	IrfanView TIF File	2002-09-15 09:19	
p188r025_7k20000507_z34_nn62.tif	17 823 KB	IrfanView TIF File	2002-09-15 09:19	
p188r025_7p20000507_z34_nn80.tif	284 740 KB	IrfanView TIF File	2002-09-15 09:15	
p188r025_7t20000507_z34_nn10.tif	71 217 KB	IrfanView TIF File	2002-09-15 09:09	
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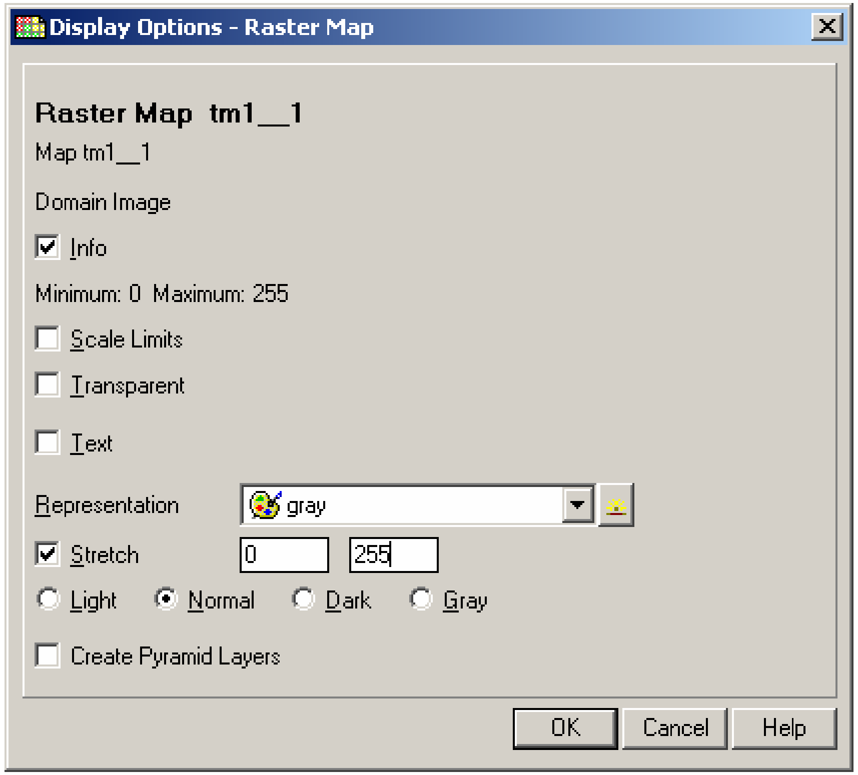
p188r025_7t20000507_z34_nn70.tif	71 217 KB	IrfanView TIF File	2002-09-15 09:09	

Image processing

- Pre-processing
- Image enhancement
- Data extraction

Why?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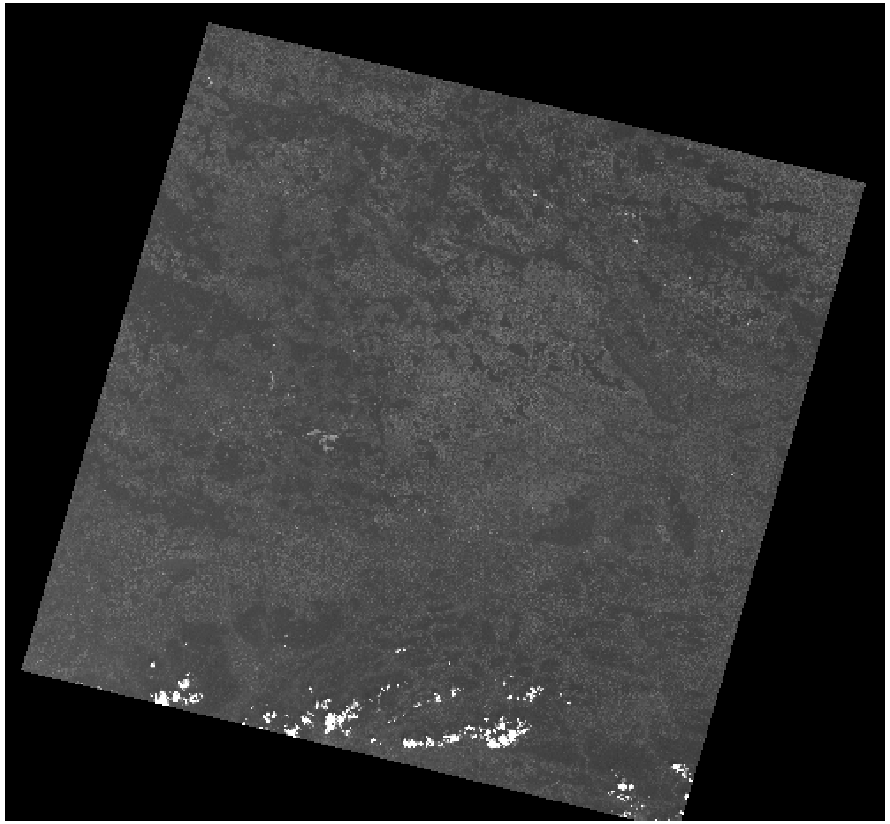
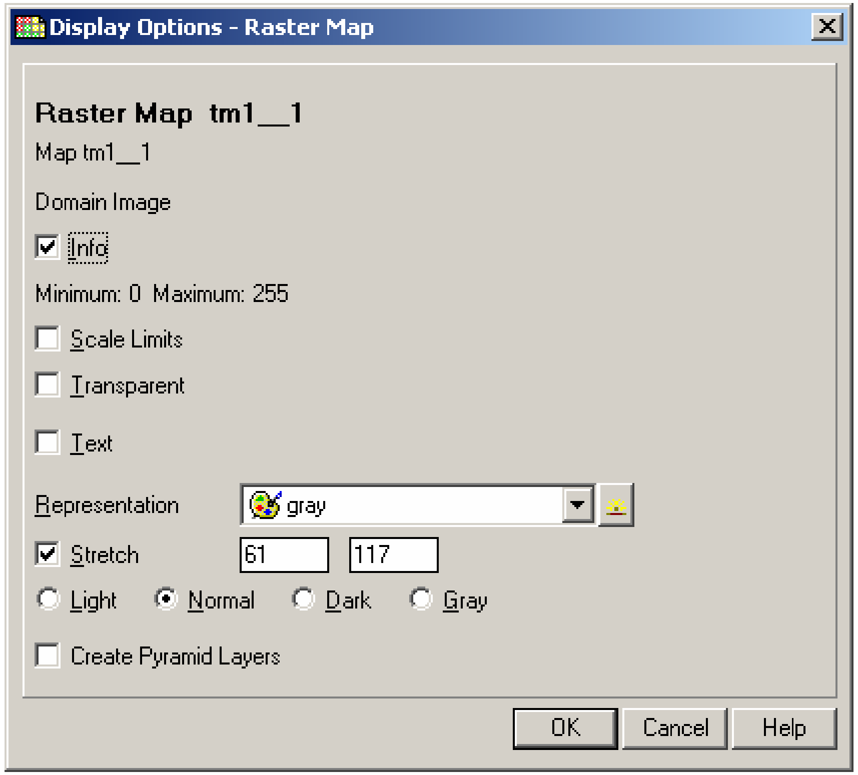
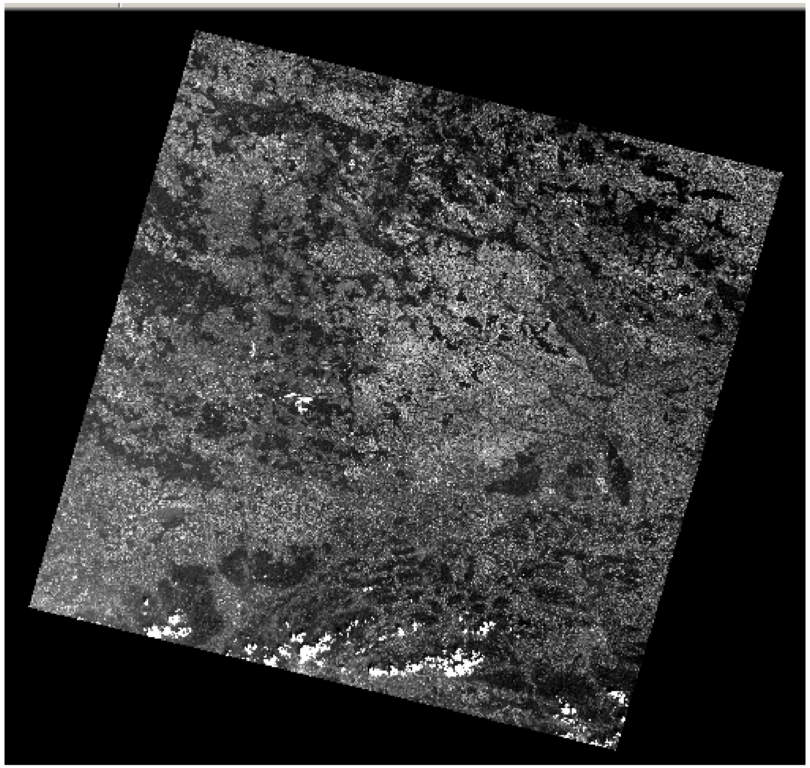
Raster Map tm1__1
Map tm1__1
Domain Image
Info
Minimum: 0 Maximum: 255
Scale Limits
Transparent
Text
Representation
gray
Stretch
0
255
Light
Normal
Dark
Gray
Create Pyramid Layers
OK
Cancel
Help



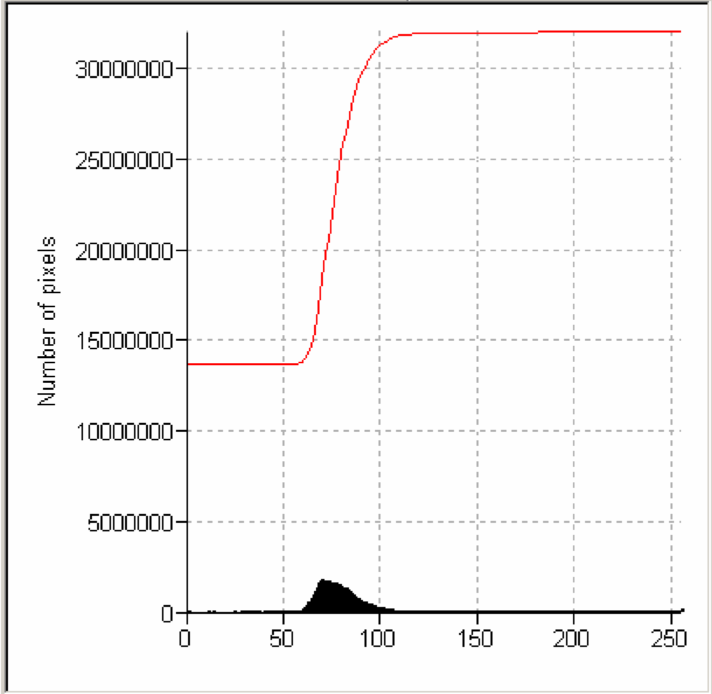

Display Options - Raster Map
Raster Map tm1__1
Map tm1__1
Domain Image
Info
Minimum: 0 Maximum: 255
Scale Limits
Transparent
Text
Representation
gray
Stretch
61
117
Light
Normal
Dark
Gray
Create Pyramid Layers
OK
Cancel
Help



Histogram

Histogram "tm1__1" - TableHistogram(tm1__1.mpr) - ILWIS

File Edit Columns Records View Help



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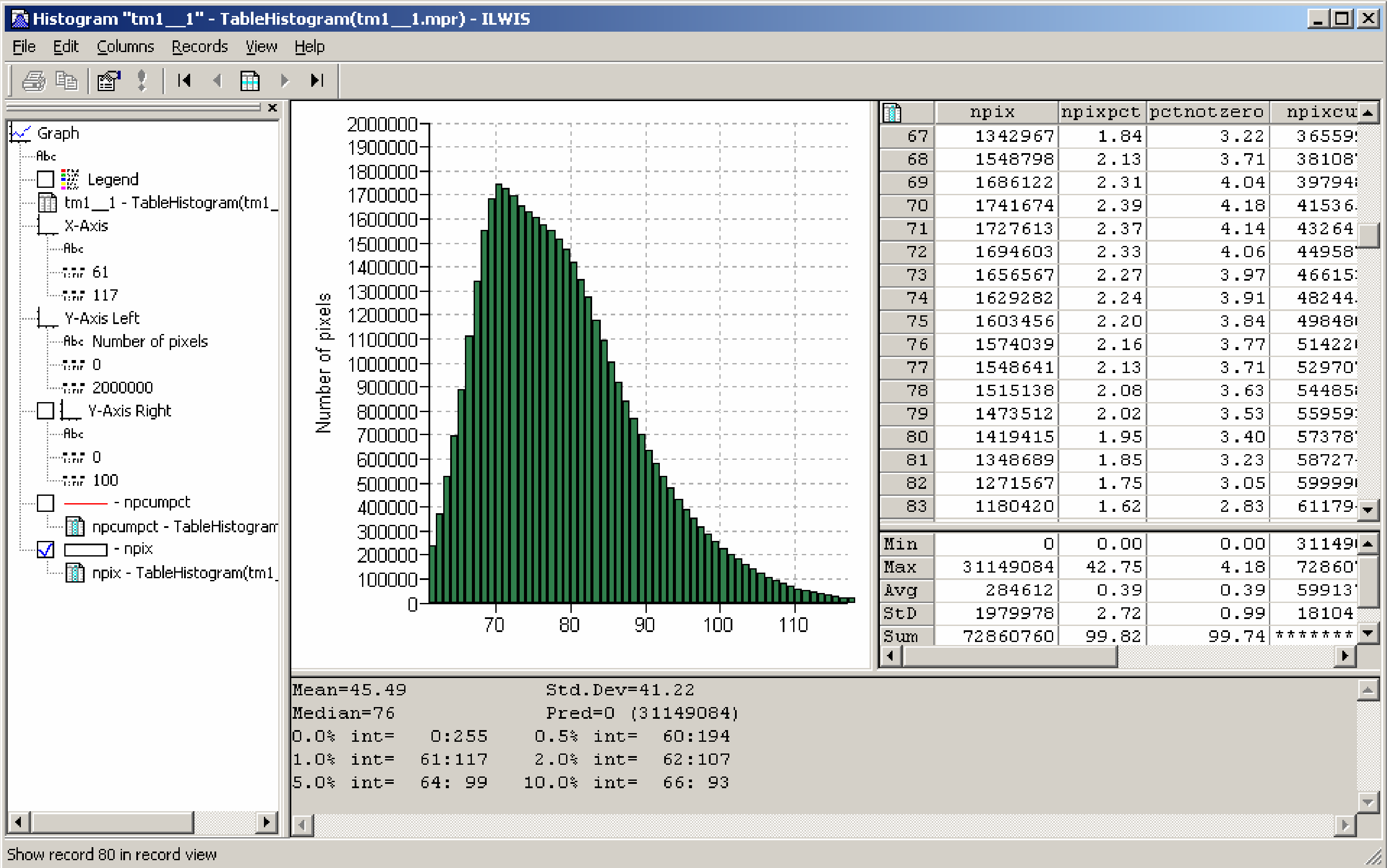
56	2879	0.00	0.01	31153783	42.76	2338467.8
57	8530	0.01	0.02	31162313	42.77	6928492.5
58	24573	0.03	0.06	31186886	42.80	19959419.3
59	62251	0.09	0.15	31249137	42.89	50563374.8
60	132591	0.18	0.32	31381728	43.07	107697039.8
61	237723	0.33	0.57	31619451	43.40	193090506.8
62	371673	0.51	0.89	31991124	43.91	301891394.3
63	525295	0.72	1.26	32516419	44.63	426670863.8
64	697396	0.96	1.67	33213815	45.59	566459901.0
65	891517	1.22	2.14	34105332	46.81	724134683.3
66	1111640	1.53	2.67	35216972	48.33	902929590.0
67	1342967	1.84	3.22	36559939	50.18	1090824945.8
68	1548798	2.13	3.71	38108737	52.30	1258011175.5
69	1686122	2.31	4.04	39794859	54.62	1369552594.5
70	1741674	2.39	4.18	41536533	57.01	1414674706.5
71	1727613	2.37	4.14	43264146	59.38	1403253659.3

	npix	npixpct	pctnotzero	npixcum	npcumpct	Area
Min	0	0.00	0.00	31149084	42.75	0.0
Max	31149084	42.75	4.18	72860760	100.00	25300843479.
Avg	284612	0.39	0.39	59913757	82.23	231176376.2
StD	1979978	2.72	0.99	18104192	24.85	1608236740.3
Sum	72860760	99.82	99.74	**********	21050.98	************

```
Mean=45.49              Std.Dev=41.22
Median=76               Pred=0 (31149084)
0.0% int=    0:255     0.5% int=   60:194
1.0% int=   61:117     2.0% int=   62:107
5.0% int=   64: 99    10.0% int=   66: 93
```

Minimum of values in column: Area: Area for pixel value

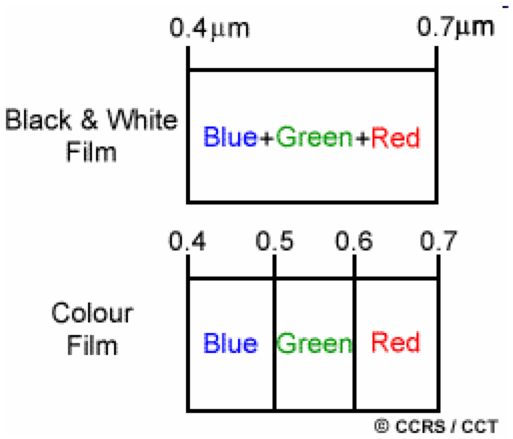
Histogram stretching



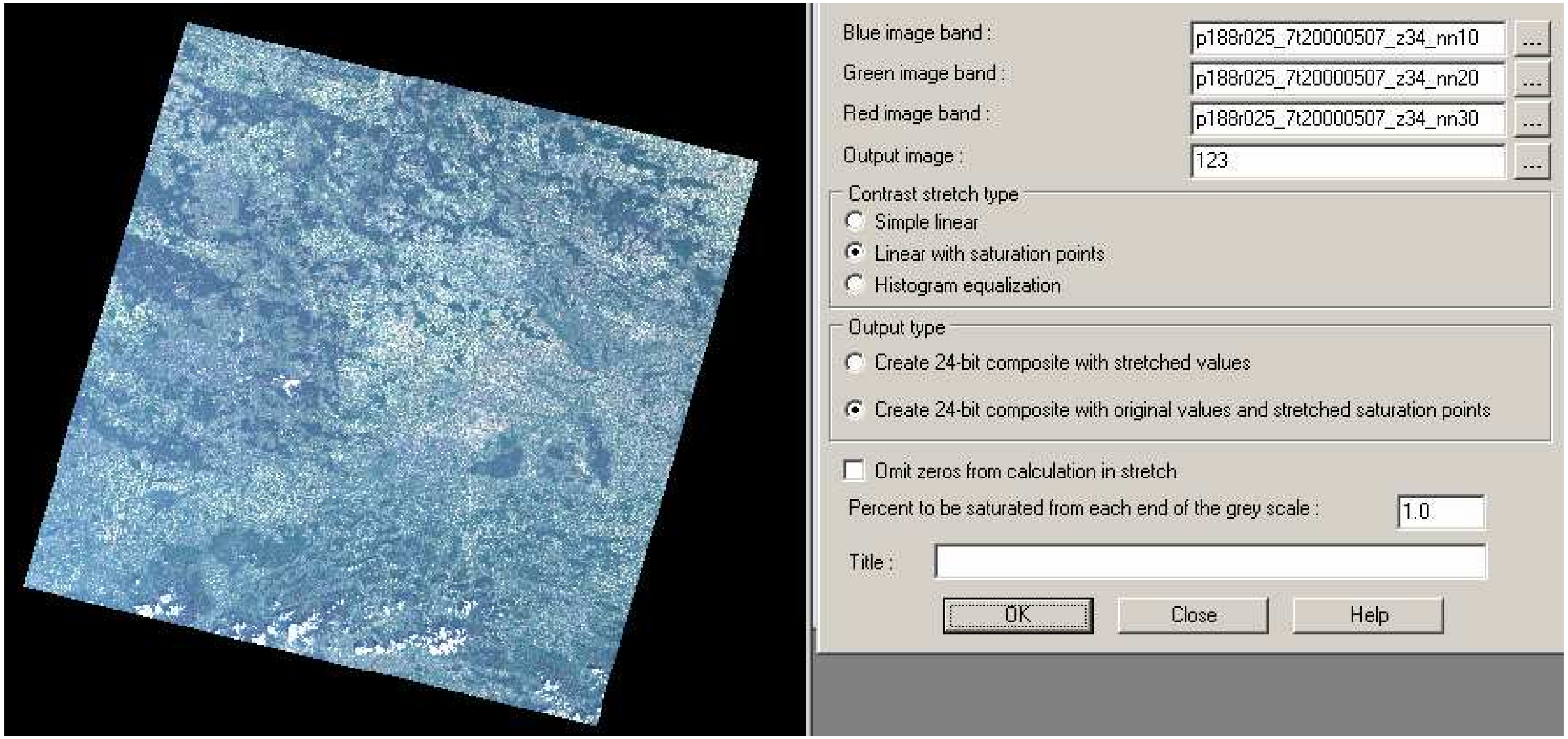
Histogram stretching

- Linear
- With saturation
- Histogram equalization

Color composite



Color composite 123



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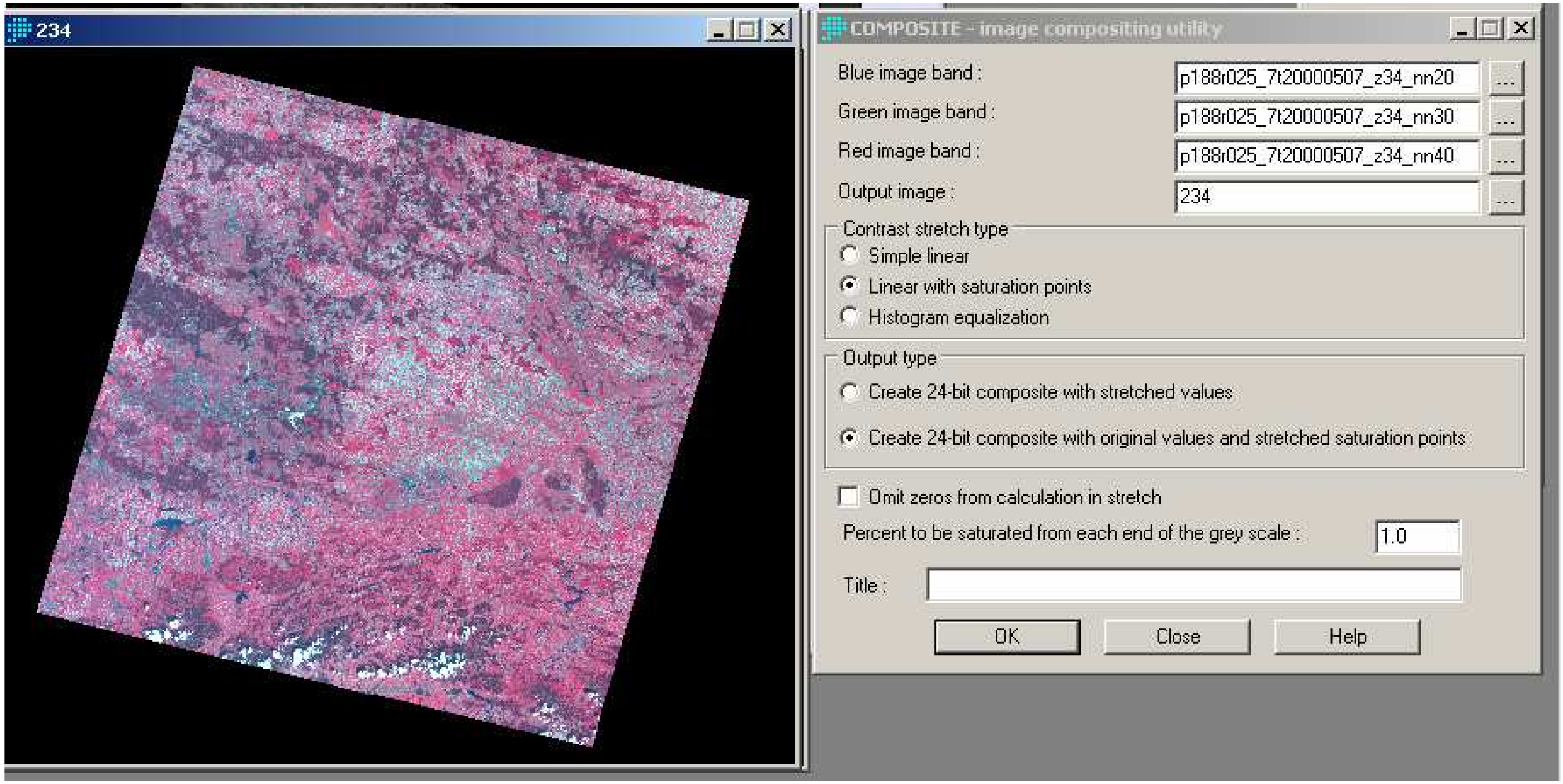
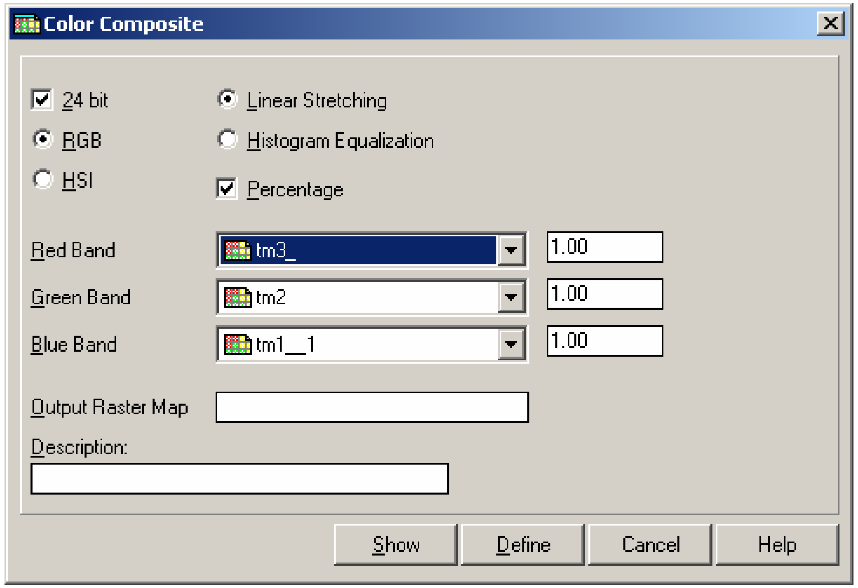
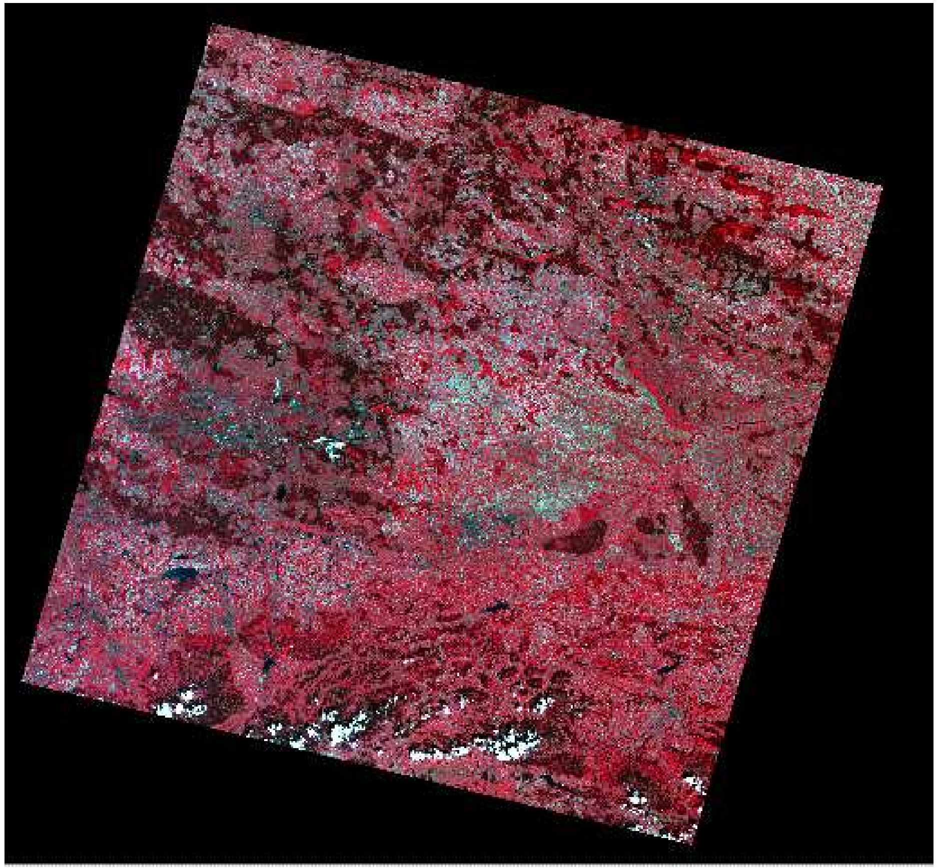
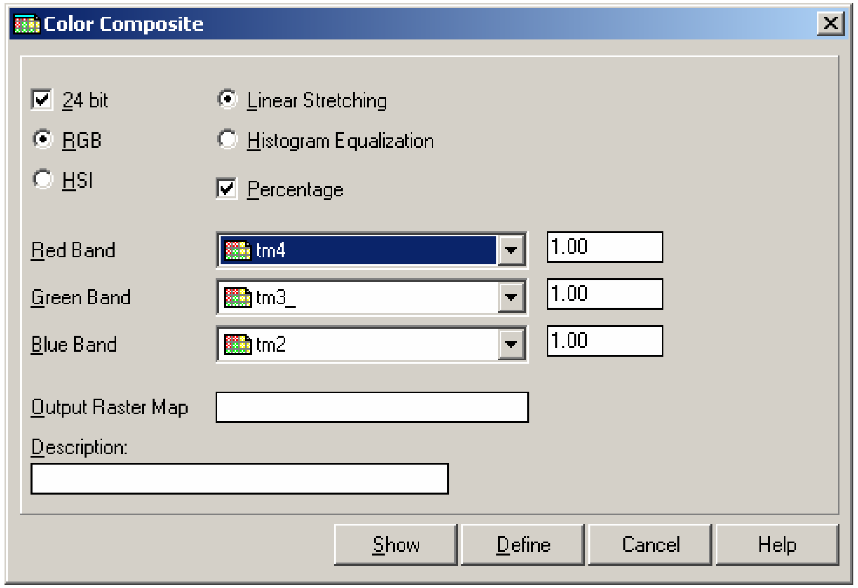


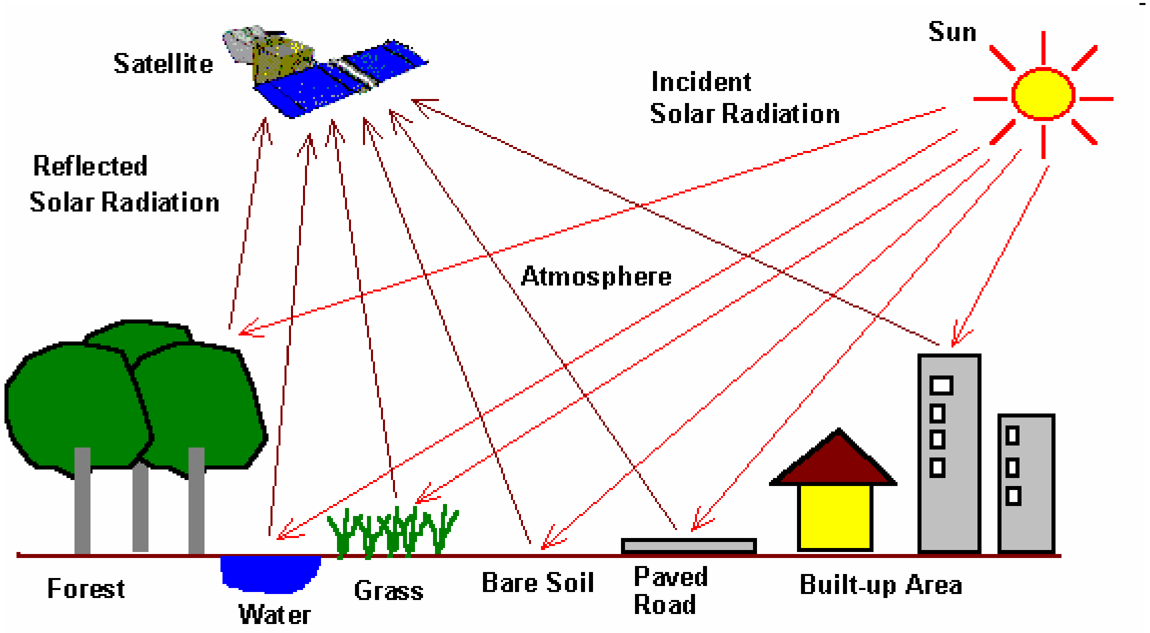
Color composite 123



Color composite 123







Satellite
Sun
Incident
Solar Radiation
Reflected
Solar Radiation
Atmosphere
Forest
Water
Grass
Bare Soil
Paved
Road
Built-up Area