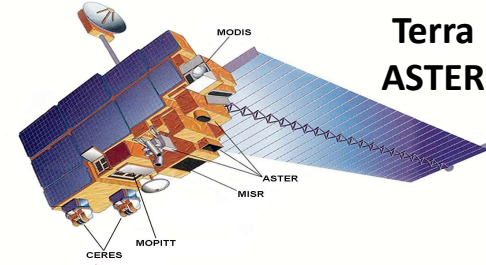




هيئة المساحة الجيولوجية السعودية  
SAUDI GEOLOGICAL SURVEY  
www.sgs.org.sa

سلسلة لقاءات علمية في الجيولوجيا  
برعاية مبادرة البرنامج العام للمسح الجيولوجي  
بهيئة المساحة الجيولوجية السعودية



Terra  
ASTER

## تقنيات الإستشعار عن بعد في الجيولوجيا

د محمد إبراهيم متساه

أستاذ مساعد بقسم الجيولوجيا البنائية والإستشعار عن بعد  
مستشار سابق في أمانة محافظة جدة لثلاث سنوات

دكتورة في تطبيقات الإستشعار عن بعد في الجيولوجيا من جامعة بوسطن 2000  
بكالوريوس وماجستير الجيولوجيا الهندسية من جامعة الملك عبد العزيز

[momatsah@kau.edu.sa](mailto:momatsah@kau.edu.sa) +966503680753

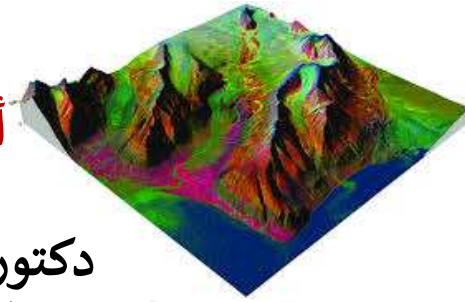
نعود بحذر



Landsat-8



SPOT



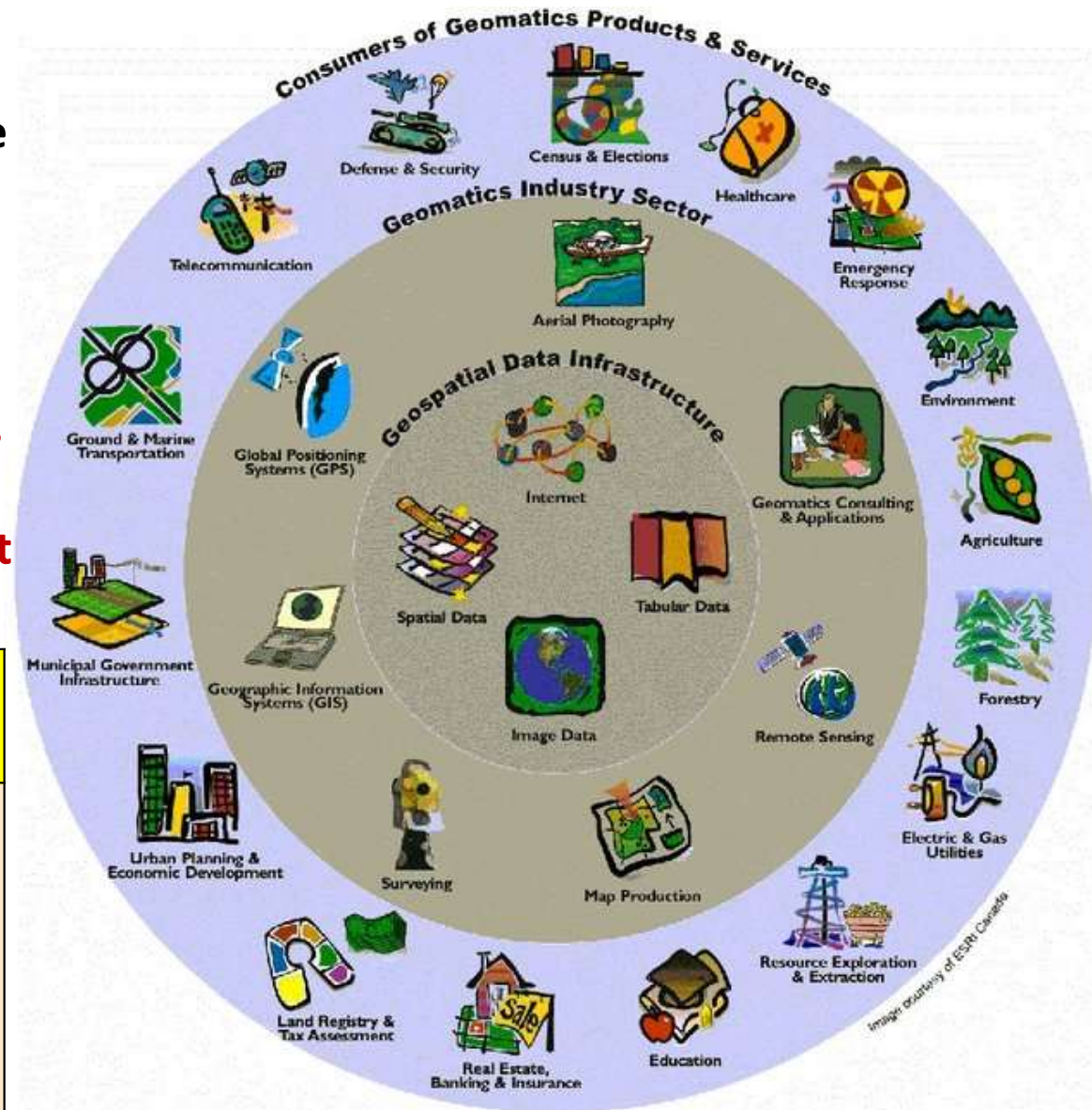
## What is Geomatics ?

**Geomatics** (Geospatial Technology) is the discipline of gathering, **storing**, processing, and **delivering geographic information**, or spatially referenced information.

It consists of **products**, services and **tools** in the **collection**, integration, **processing**, modeling, and **management** of geographic or **geospatial** data.

### Geomatics includes tools and techniques used in:

- Land Surveying,
- Geodetic Surveying
- Remote Sensing,
- Photogrammetry,
- GIS,
- GPS,
- Geophysics,
- Geography,
- Cartography,
- and any related forms of earth mapping



# Scope of the Geoinformatics

The term 'Geoinformatics' is a combination of two words- **Geology** or **Geography** and **Informatics**.

The **realm of Geoinformatics** is very broad because it comprises of subjects like:

- Remote sensing,
- GPS,
- GIS,
- Cartography,
- Hydrology,
- Climatology,
- Aerial photography,
- Photogrammetry **etc.**

## ما هي تقنية الإستشعار عن بعد ؟

• هو الحصول على البيانات و المعلومات عن شئ أو ظاهرة على سطح الأرض (هدف) باستخدام أجهزة (كاميرات أو مستشعرات) موضوعة على منصات (طائرات أو أقمار صناعية) تطير أو تسبح بعيدا عن ذلك الهدف (عن بعد) وبدون أي إتصال فيزيائي بذلك الهدف.

• الكاميرات والمستشعرات تقوم بتصوير وإستشعار الطاقة والإشعاع الكهرومغناطيسي EMR & EME (الضوء والأشعة) المنعكسة و المنبعثة من الهدف ثم تحويلها وتخزينها على شكل صور ومرئيات ورقية ورقمية Digital Image

## مميزات التصوير بالأقمار الصناعية

- تغطي مساحات شاسعة قد يصعب الوصول إليها
- أراضي بعيدة ( غابات - صحاري - المحيطات - المناطق الثلجية - قد تكون هناك عوائق طبوغرافية أو سياسية - مناطق جبلية عالية)
- تجانس البيانات - القمر الصناعي يصور كل المناطق بنفس المستشعر وبنفس الكيفية وفي نفس ظروف الإضاءة فالصور متجانسة ومتصلة.
- الصور والبيانات رقمية وليست ورقية - يمكن معالجتها وتحليلها وتحسينها بالحاسب الآلي.
- تردداتها عالية - بمعنى أنها تصور نفس المنطقة عدة مرات وهذا يتيح دراسة التغيرات مع الزمن. **Change Detection.**
- أسعار البيانات والصور رخيصة وفي متناول الجميع يمكن تنزيلها من الإنترنت مجاناً (لبعض الأقمار الصناعية مثل القمر الأمريكي لاندسات وآستر و سينتال وغيرها).
- البيانات من الأقمار الصناعية مكمل للبيانات الأرضية وتصحيح كل منهما الأخرى ويمكن تعميم الظاهرة على مساحات شاسعة باستخدام عينات مكانية بسيطة.

# The Global Satellite Observation System



1- EMR Energy Source  
(Natural or Artificial)

# منظومة ومتطلبات الإستشعار عن بعد

7- Data Interpretation & Analysis



4- Sensors for Recording EMR

Satellite

ATMOSPHERE

Incident Solar Radiation

Reflected Solar Radiation

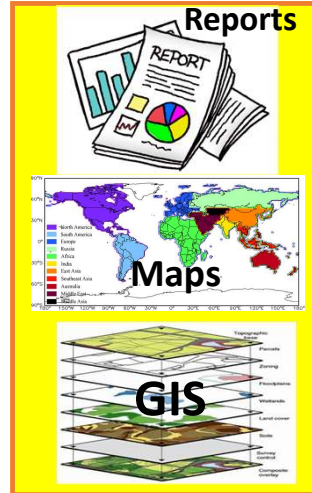
5- Data Transmission & Reception

DATA

2- Atmospheric Interactions with EMR

6- Image & data Processing, Correction, and Enhancement

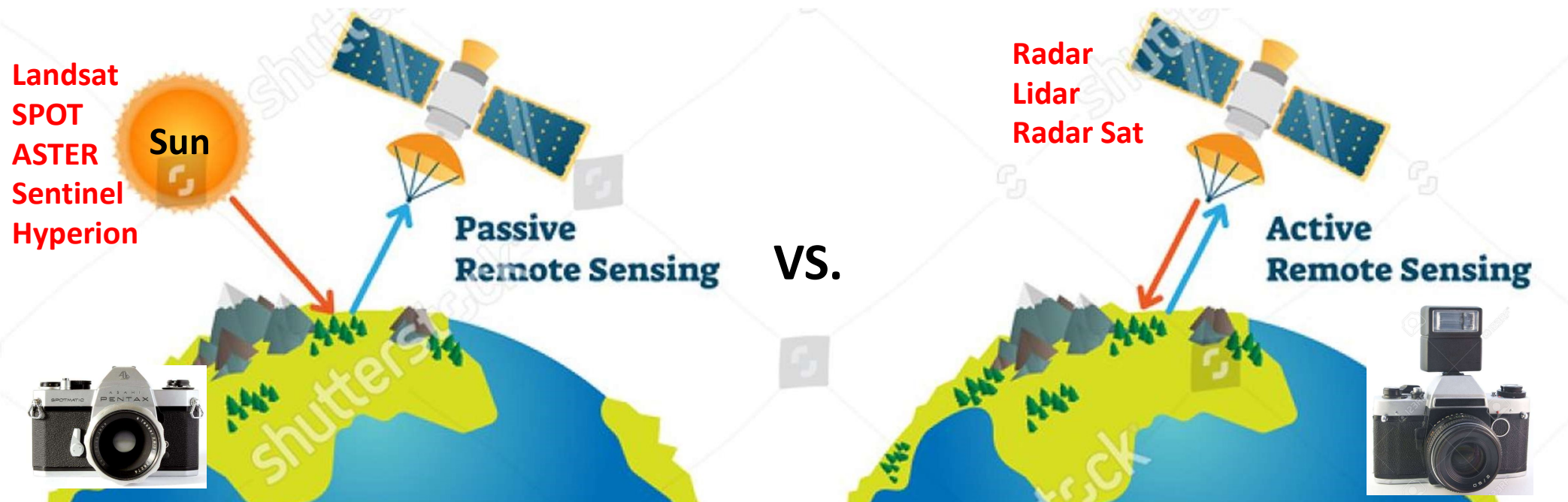
Server



3- Target Interaction with EMR

8- Applications & Decision Making

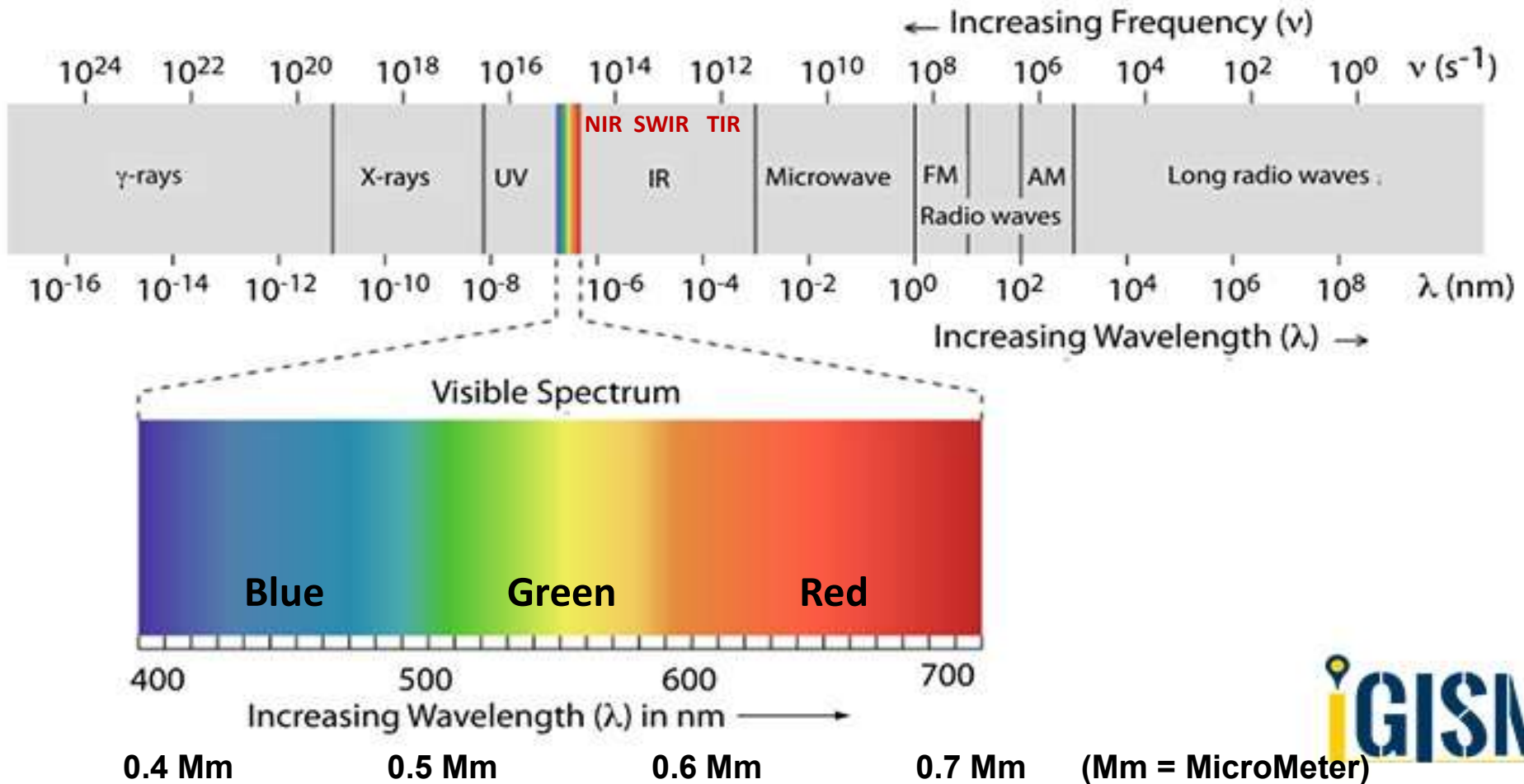




<ul style="list-style-type: none"> <li>• Uses Visible, NIR, SWIR, and TIR bands (Mm) and it depends on the Sun</li> </ul>	<ul style="list-style-type: none"> <li>• Uses Microwave bands (cm-m), does not depend on the Sun (Day or night)</li> </ul>
<ul style="list-style-type: none"> <li>• <b>Good for Soils, Rocks, Minerals, and Vegetation mapping</b></li> </ul>	<ul style="list-style-type: none"> <li>• <b>Good for Mapping Topography, waves, ground roughness</b></li> </ul>
<ul style="list-style-type: none"> <li>• For Sensing the top millimeters of the ground</li> </ul>	<ul style="list-style-type: none"> <li>• Can penetrate down to 4-5 m in dry sandy materials detecting Archeology, Buried Drainage Channels in dry Sand</li> </ul>
<ul style="list-style-type: none"> <li>• <b>Clouds and dust can not be penetrated</b></li> </ul>	<ul style="list-style-type: none"> <li>• <b>Can penetrate Cloud, Dust, and Rain (all-weather)</b></li> </ul>
	<ul style="list-style-type: none"> <li>• Good for mapping Geol. Structures: Faults, Folds, Joints, Fractures, Dikes ... etc</li> </ul>

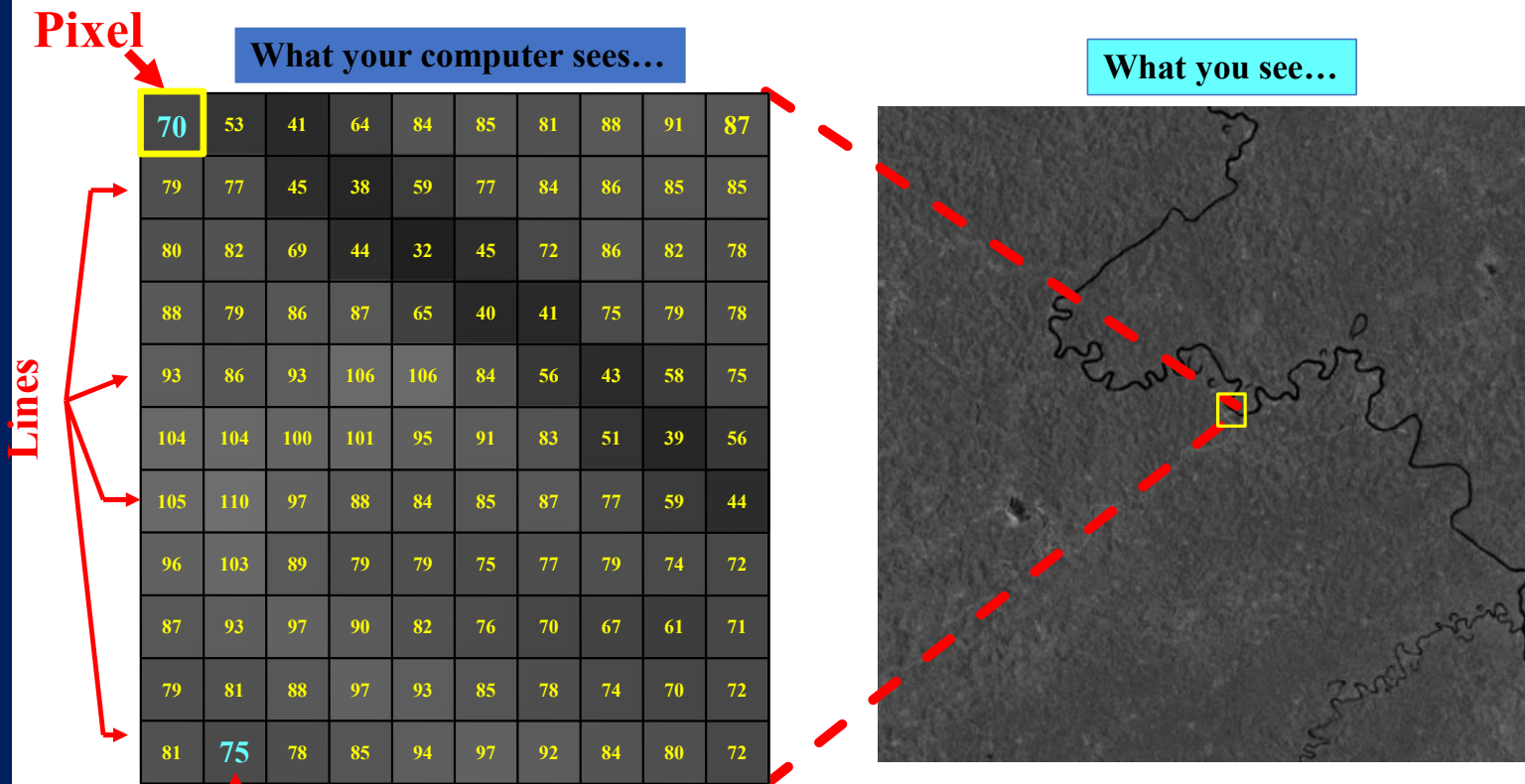


# الطيف الكهرومغناطيسي Electromagnetic Spectrum



# What Is A Digital Image?

- It is a rectangular array of horizontal lines.
- Each line is made of picture elements called pixels.
- Each pixel has a digital number called DN value.
- The DN value represents the EM energy that was sensed by a sensor in a certain spectral band (range) from an area (ground spatial resolution cell) on the earth's surface.

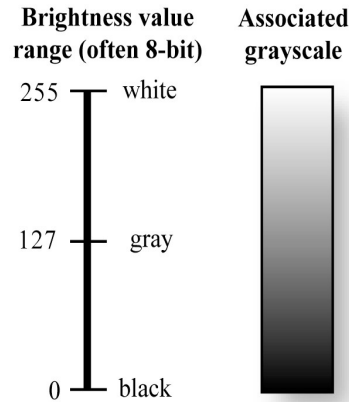
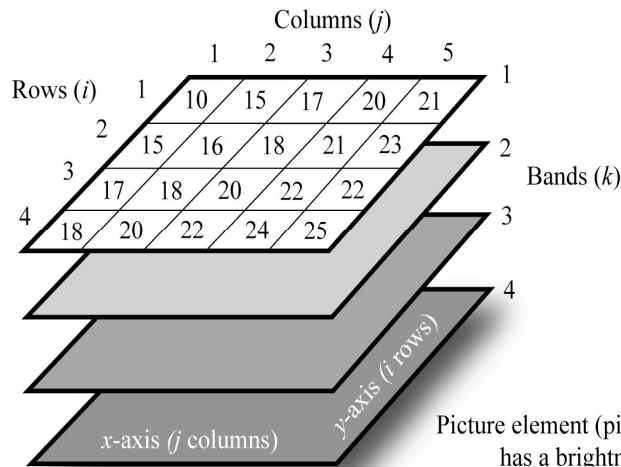


- Digital numbers (DNs) typically range from 0 to 255; 0 to 511; 0 to 1023, etc.
- These ranges are binary scales:  $2^8=256$ ;  $2^9=512$ ;  $2^{10}=1024$ .

# What Is A Digital Image?

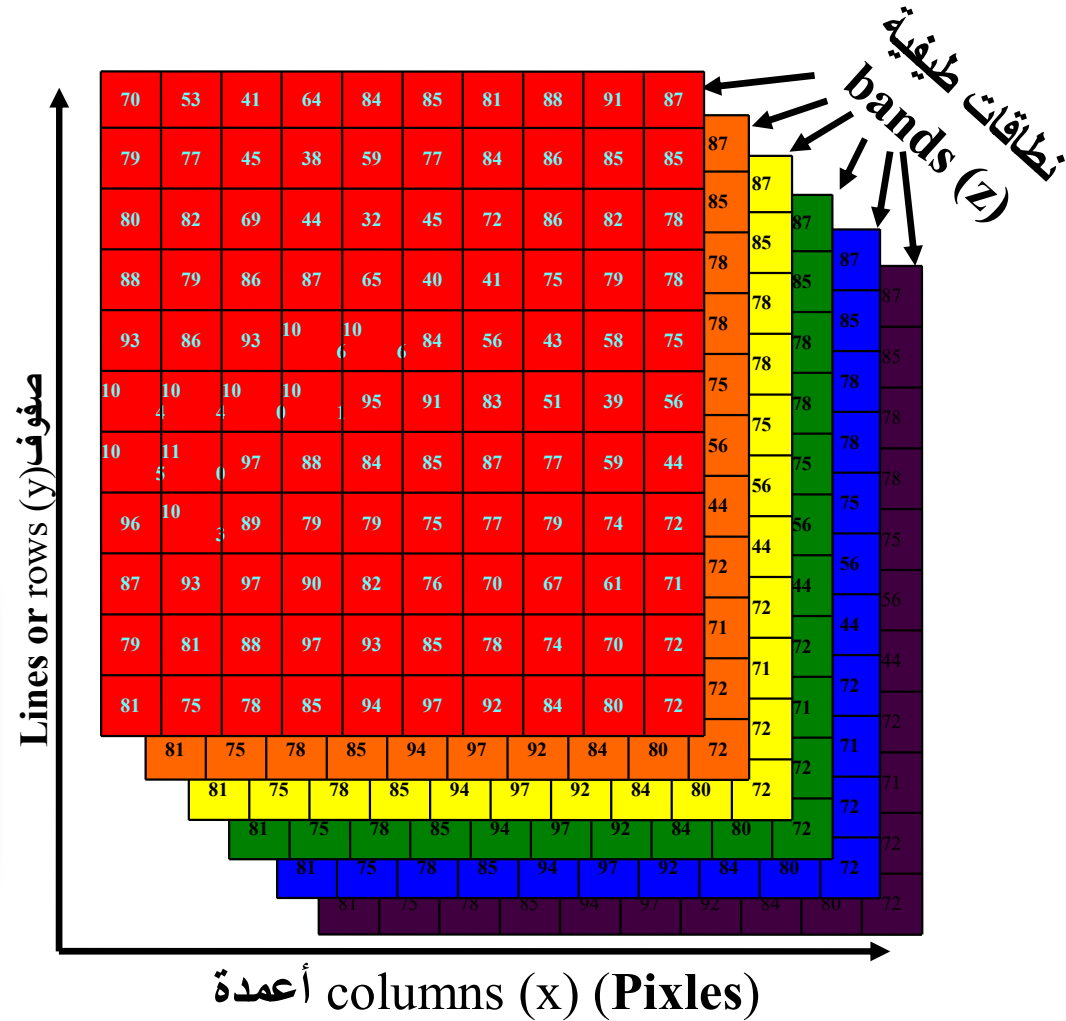
- A satellite images comprises of spectral bands (layers) (from 1 - > 200 bands)
- Each band represents values of sensed EMR in a different spectral range e.g. Blue band 0.4 – 0.5 Micrometer

## Digital Image Terminology



Picture element (pixel) at location row 4, column 4, band 1 has a brightness value of 24, i.e.,  $BV_{4,4,1} = 24$

- **DN values (8 bit 0-255)** قيمة البكسل التي وضعها المستشعر
- **Radiance** القيمة المطلقة للطاقة المستشعرة
- **Spectral Reflectance** الإنعكاسية النسبية هي النسبة المئوية للطاقة المنعكسة إلى الطاقة الساقطة



## Spectral Signatures البصمات الطيفية للمواد

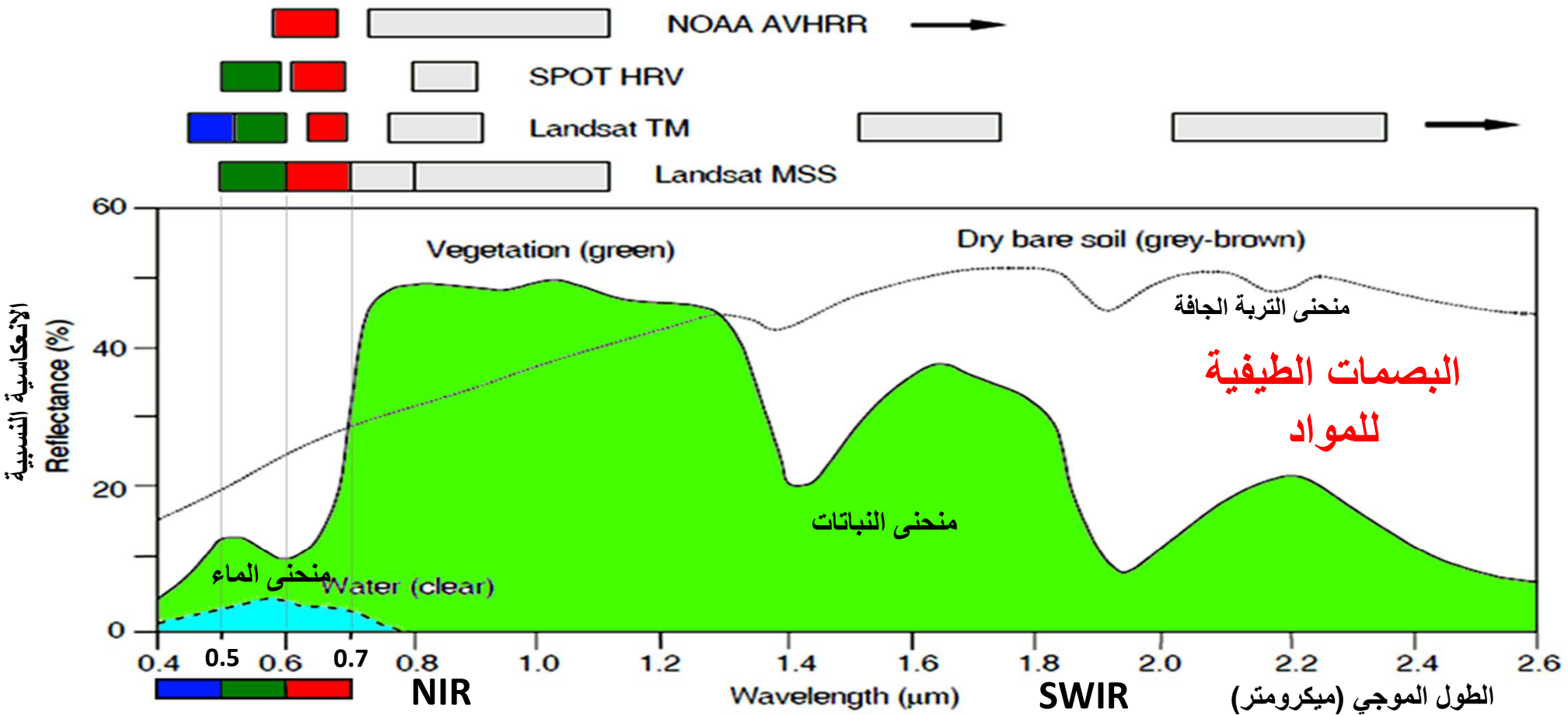
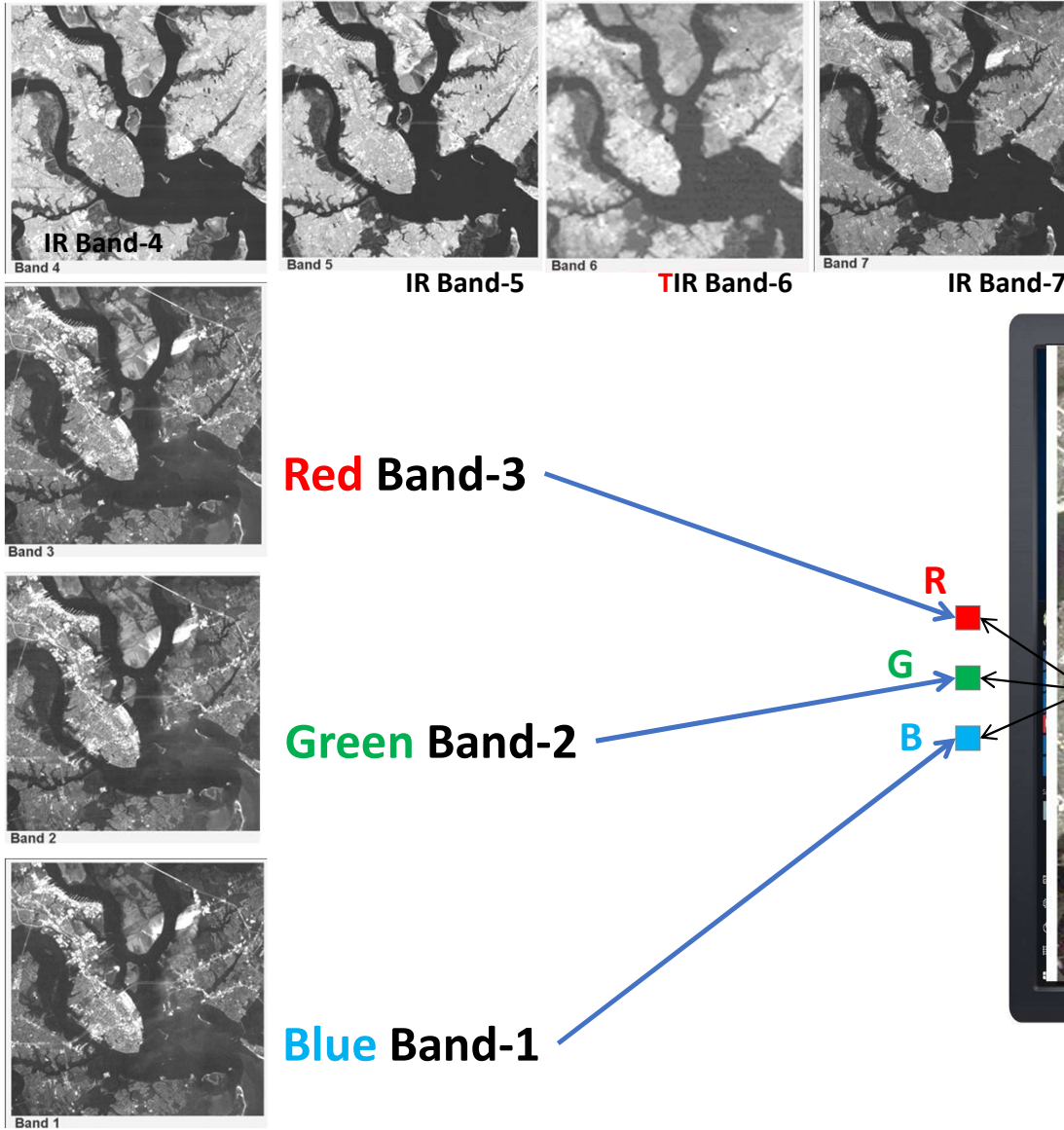


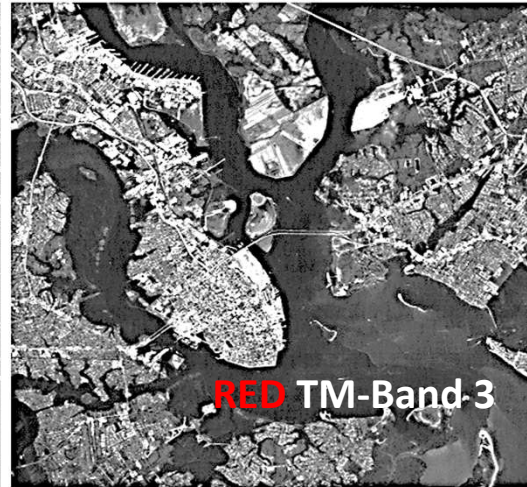
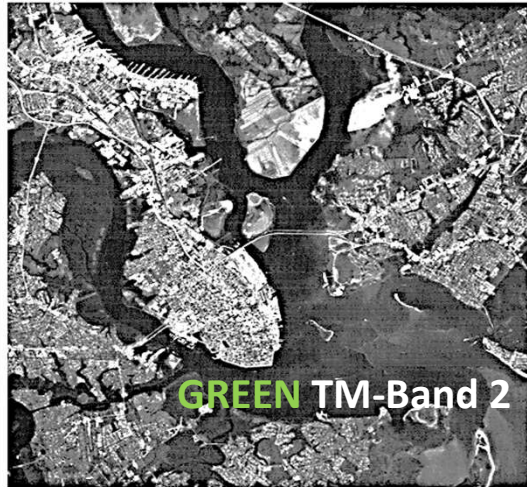
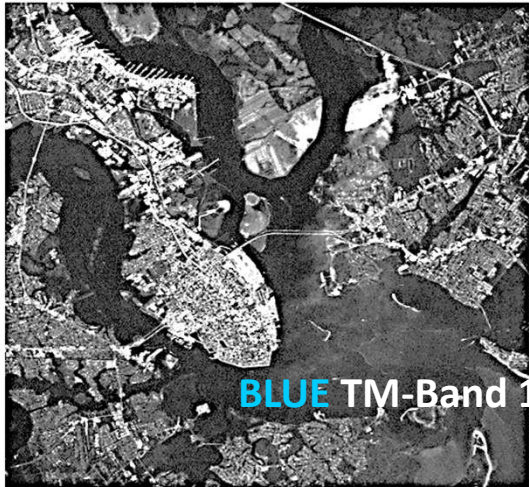
Figure 20. Typical spectral reflectance curves of common earth surface materials in the visible and near-to-mid infrared range. The positions of spectral bands for some remote sensors are also indicated (after Richards, 1993).



## Band Combination

Computer Screen شاشة الكمبيوتر  
or RGB monitor





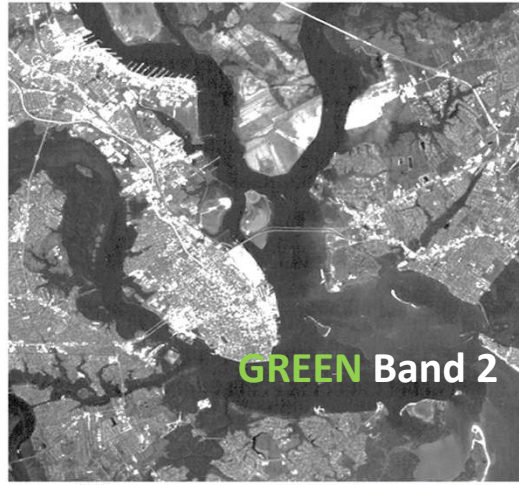
## TCC image

TM1 (Blue Band) → Blue gun of Screen

TM2 (Green Band) → Green gun of Screen

TM3 (Red Band) → Red gun of Screen





## FCC image

TM2 (Green Band) → Blue gun of Screen

TM3 (Red Band) → Green gun of Screen

TM4 (Infrared Band) → Red gun of Screen

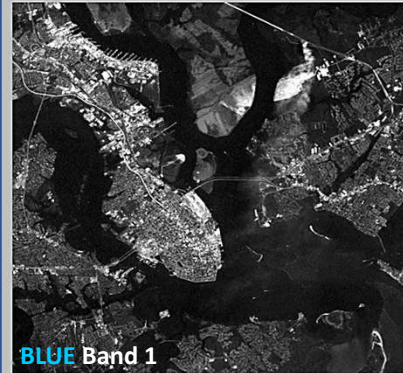


# Landsat

## Thematic Mapper (TM) Scanner

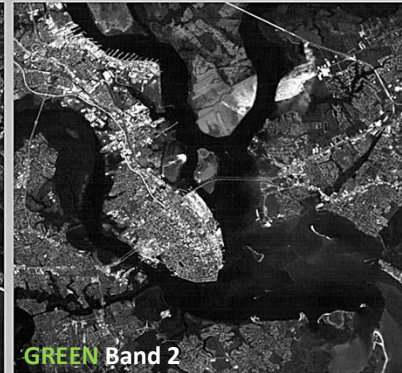
### Bands

Band #	Band width in Mm	Spatial Resolution
Band 1	0.45-0.52	30 m
Band 2	0.52-0.60	30 m
Band 3	0.63-0.69	30 m
Band 4	0.76-0.90	30 m
Band 5	1.55-1.75	30 m
Band 6	10.4-12.5	120 m
Band 7	2.08-2.35	30 m



BLUE Band 1

Band 1



GREEN Band 2

Band 2



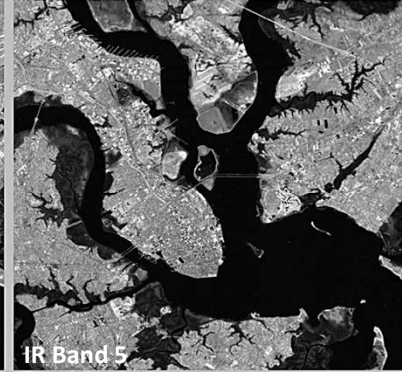
RED Band 3

Band 3



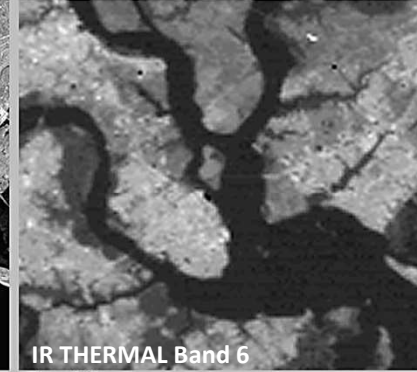
IR Band 4

Band 4



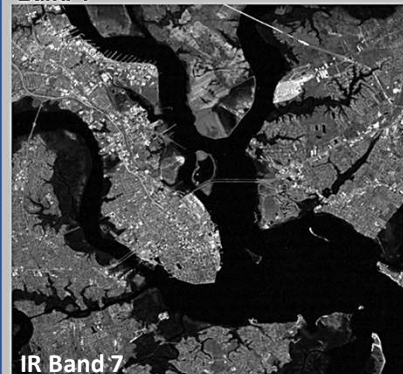
IR Band 5

Band 5



IR THERMAL Band 6

Band 6



IR Band 7

Band 7



TCC 3 2 1 B

True Color Composite 321



FCC 4 3 2 B

False Color Composite 432



## Types of Satellite Image Resolutions

Satellite images have 4 types of resolutions:

- **Spatial resolution** الدقة المكانية
- **Spectral resolution** الدقة الطيفية
- **Radiometric resolution** (حساسية المستشعر للطاقة) الدقة الراديومترية
- **Temporal resolution** الدقة الزمانية

# Spatial Resolution الدقة المكانية

- **Spatial resolution** refers to the size of the smallest object that can be resolved on the ground.
- ويقصد بها المساحة التي تغطيها الخلية (البكسل) على سطح الأرض وتقاس بالمتر
- In a digital image, the resolution is limited by the **pixel size in meters**, i.e. the **smallest resolvable object cannot be smaller than** the pixel size.
- A "**High Resolution**" image refers to one **with a small resolution size**.
  - Fine details can be seen in a high resolution image.
- A "**Low Resolution**" image is one with a large resolution size,
  - Only coarse features can be observed in the image..



Pixel Size = 10 m

Width = 160 pixels, Height = 160 pixels



Pixel Size = 20 m

Width = 80 pixels, Height = 80 pixels



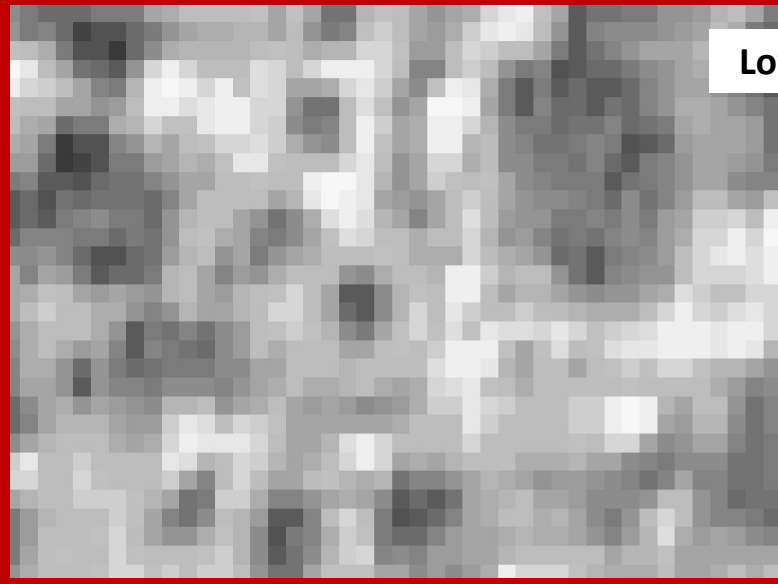
Pixel Size = 40 m

Width = 40 pixels, Height = 40 pixels



Pixel Size = 80 m

Width = 20 pixels, Height = 20 pixels



**Low spatial resolution**

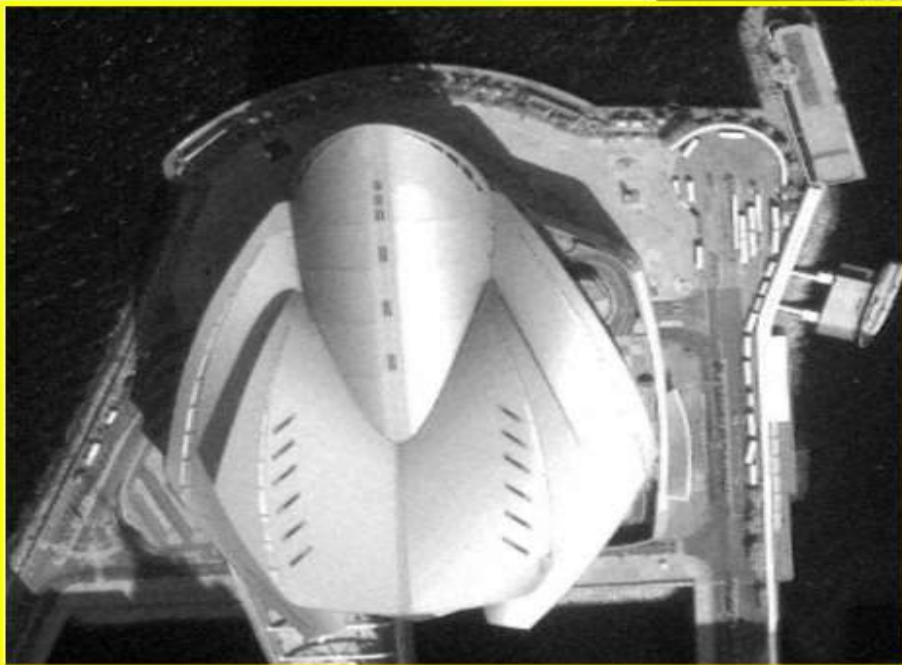


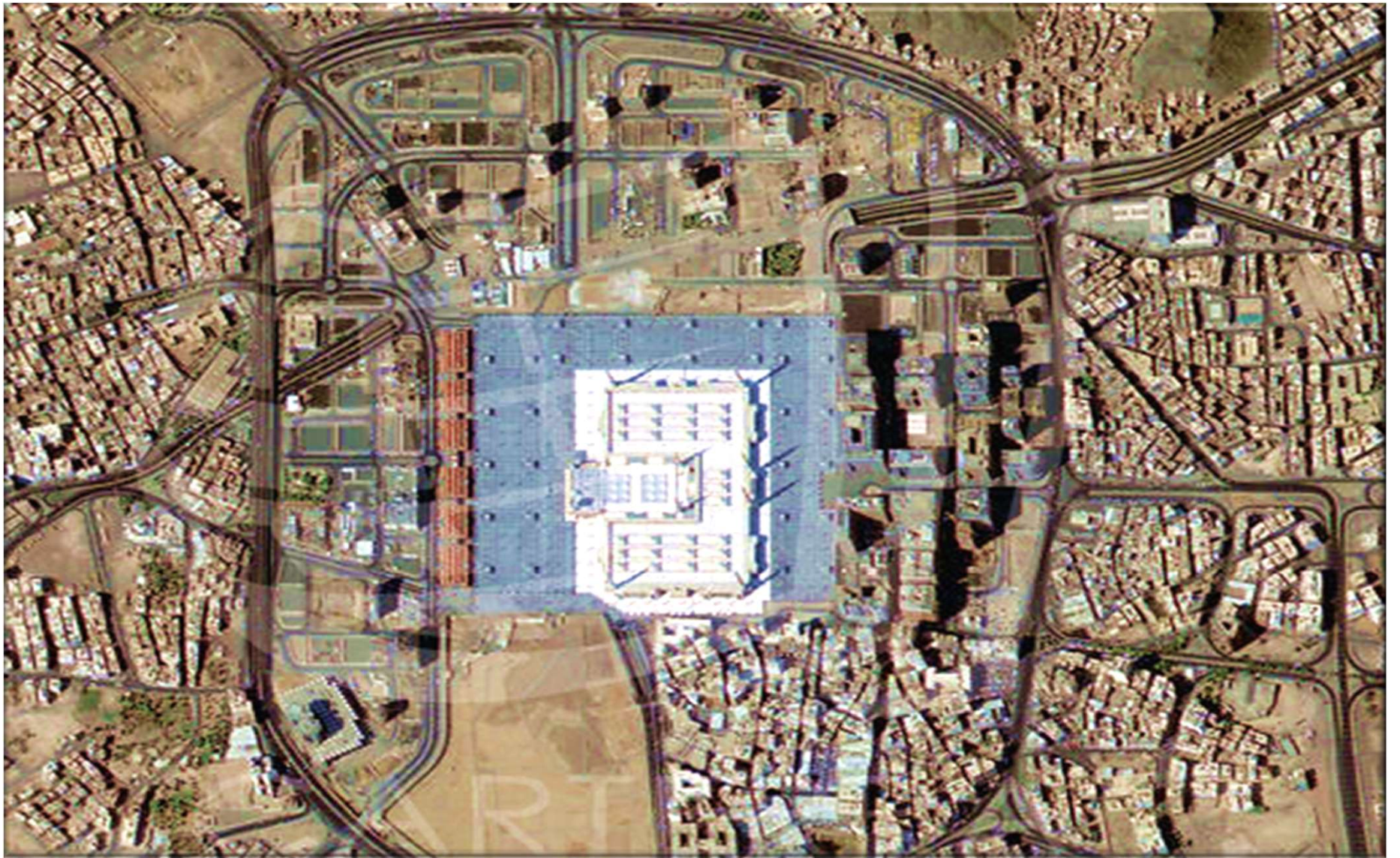
**High spatial resolution**

# IKONOS panchromatic image

Wan Chai and Hong  
Kong Convention  
and Exhibition  
Centre, 21/11/1999.

Courtesy spaceimaging.com







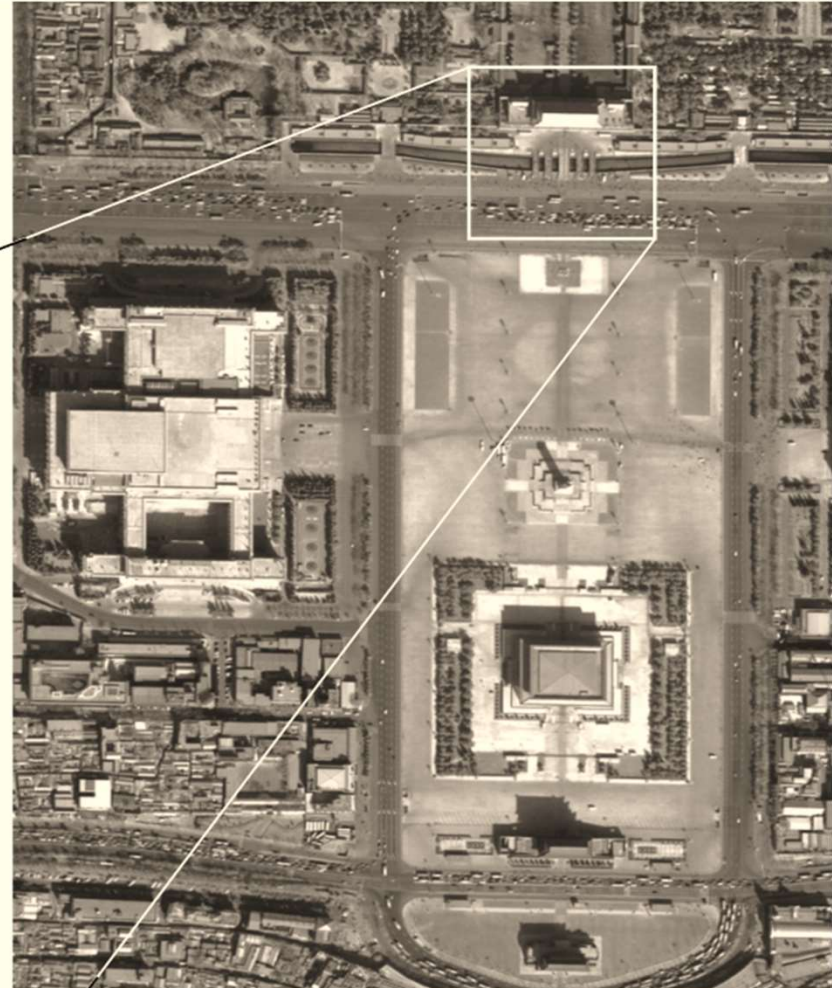
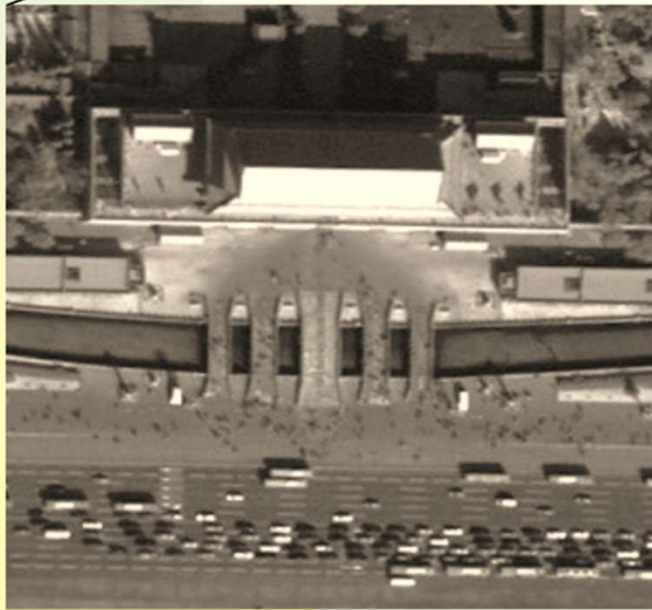






# QuickBird panchromromatic image

QuickBird Panchromatic image over  
Tian-an-men Square of Beijing





[www.satimagingcorp.com](http://www.satimagingcorp.com)

QuickBird Satellite Sensor, February 2002  
© 2007 - DigitalGlobe All rights reserved

**QuickBird 60cm Satellite Image**  
**Riyadh, Saudi Arabia**  
**Acquired: 30-Dec-2005**



**Riyadh, Saudi Arabia**

Copyright © 2006 by DigitalGlobe. All rights reserved.

[www.satimagingcorp.com](http://www.satimagingcorp.com)

satellite image  
Riyadh  
2005

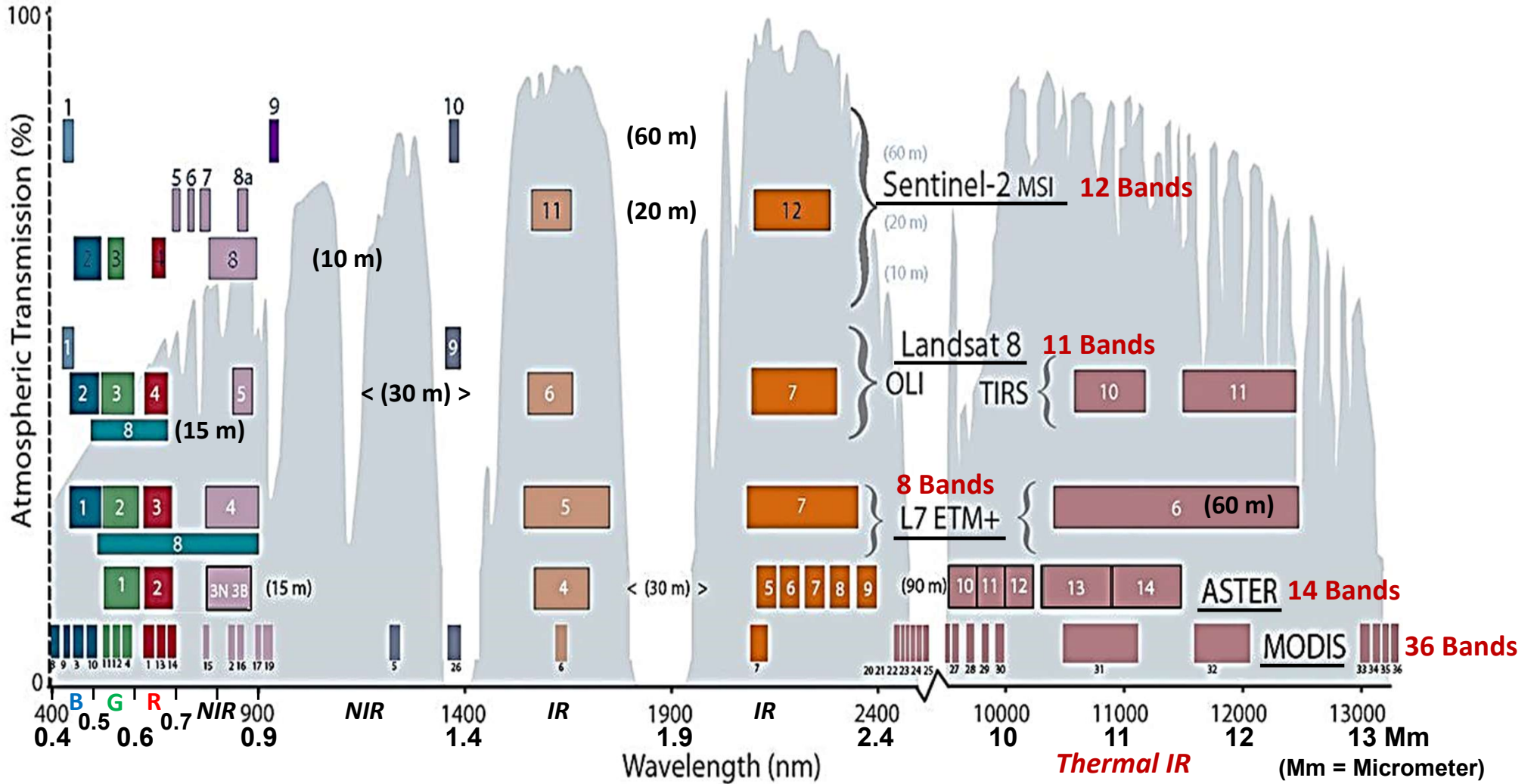


Riyadh, Saudi Arabia

# Spectral Resolution الدقة الطيفية

- **Spectral Resolution** refers to:
  - **Number of specific wavelength intervals (spectral bands)** in the electromagnetic spectrum **to which a sensor is sensitive.** and
  - The **size of the interval or band**
- The **size of the interval or band** may be:
  - **large (coarse)**  
as the panchromatic band of LandSat (**0.50 – 0.90**  $\mu\text{m}$ ), or
  - **small (fine)**  
as with band 3 of the LandSat (**0.63-0.69**  $\mu\text{m}$ ).

# Comparison of Sentinel-2 MSI bands with Landsat 7 & 8, ASTER, and MODIS.



## الدقة الراديومترية Radiometric Resolution

- **Radiometric Resolution or sensitivity** to the **number of digital levels** used to express the data collected by the sensor.
  - وهو يعبر عن حساسية المستشعر لمستويات الطاقة القادمة له
- In general, **the greater the number of levels** the **greater the detail in the information**.
- At one extreme one could consider a digital image composed of only **two levels** in which level **0** is known **as black** and level **1** **as white**.
- The **number of levels** is commonly expressed in terms of **the number of binary digits (bits)** needed to store the value of the maximum level. **تقاس الحساسية بالبت**  
القيمة الإلكترونية
- **For example,**
  - **The MSS of Landsat** records the reflected radiant flux in **7 bits** (values ranging from **0 to 127**). The spatial ground resolution is 80 x 80 m in 4 bands.
  - **The TM of Landsat** Radiant flux in **8 bits** (values from **0 to 255**) at 30 x 30m spatial resolution in six of **7 bands**. Thus, the system has improved radiometric and spatial resolution.

**8-bit quantization (256 levels)**



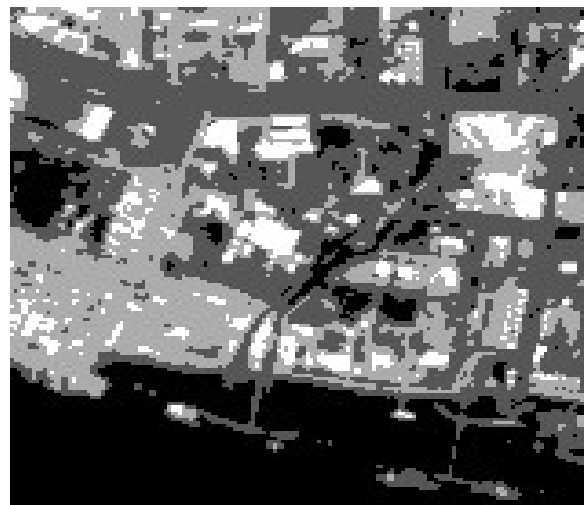
**6-bit quantization (64 levels)**



**4-bit quantization (16 levels)**



**3-bit quantization (8 levels)**



**2-bit quantization (4 levels)**



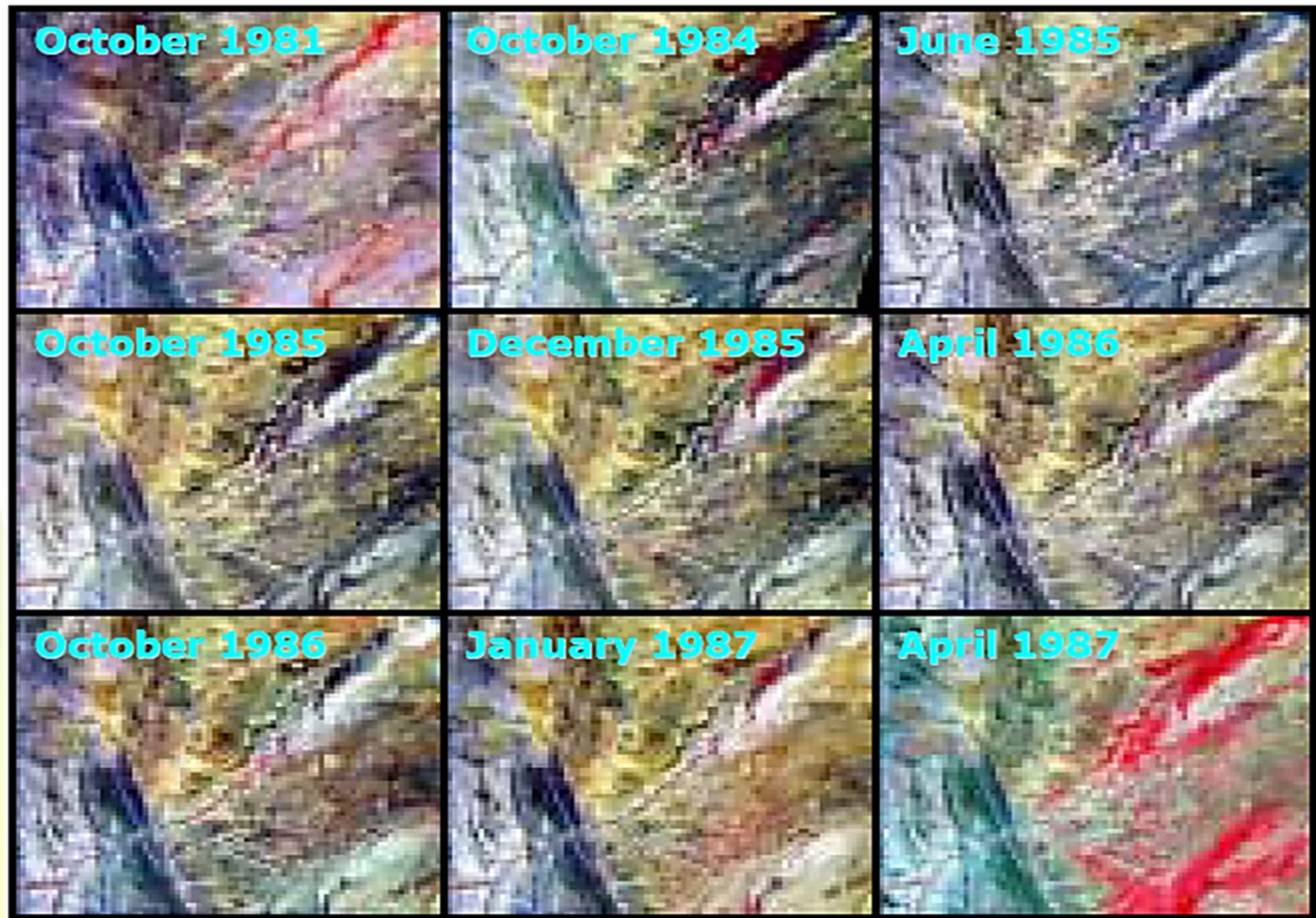
**1-bit quantization (2 levels)**



## الدقة الزمانية Temporal Resolution

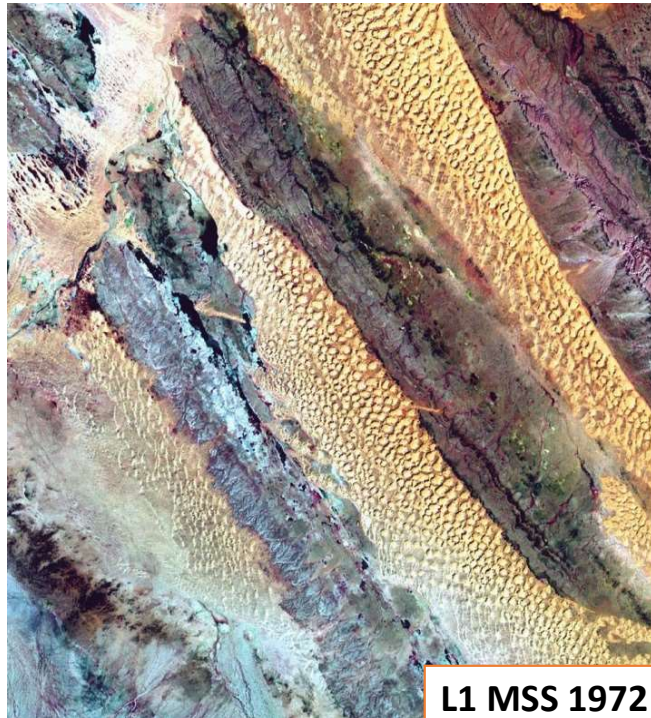
- **Temporal Resolution** of a sensor system refers to:
  - **How often** a given sensor obtains imagery of a particular area. (*revisit period*).
  - الفترة الزمنية التي يحتاجها المستشعر لإعادة تصوير لنفس المكان الصورة التالية
  - **How many days**, it takes the sensor to cover the whole earth with pictures.
  - وكم يوم يحتاج لتغطية كل الكرة الأرضية بالتصوير بصورة كاملة
  - فائدتها في مجال استكشاف ومتابعة التغيرات الحاصلة على سطح الأرض

Multi-  
temporal  
MSS  
Images  
80 m

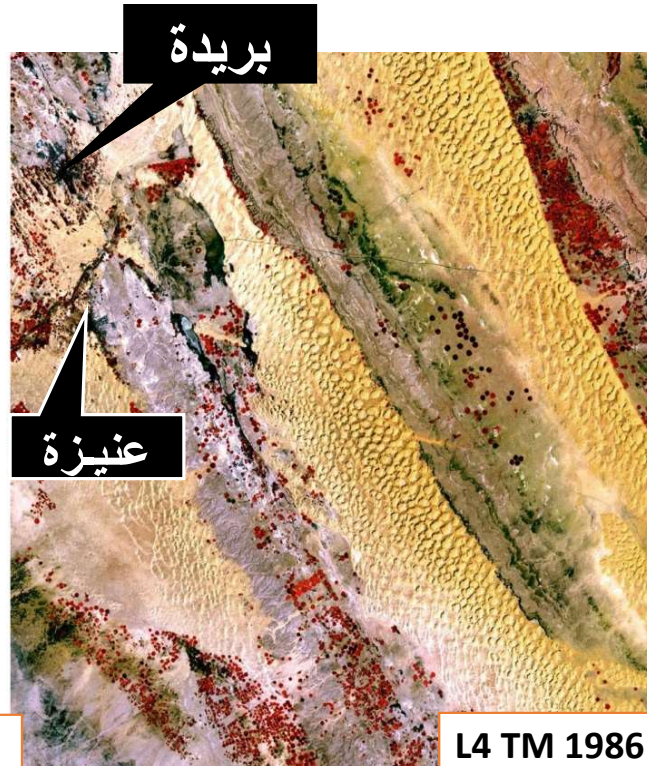


Landsat MSS images of Fowlers Gap station, broken Hill, Western New South Wales, Australia. The image series shows the effect of **3-year draught** (starting in 1984, ending February 1987) on the semiarid rangeland vegetation.

## Central Saudi Arabia



L1 MSS 1972

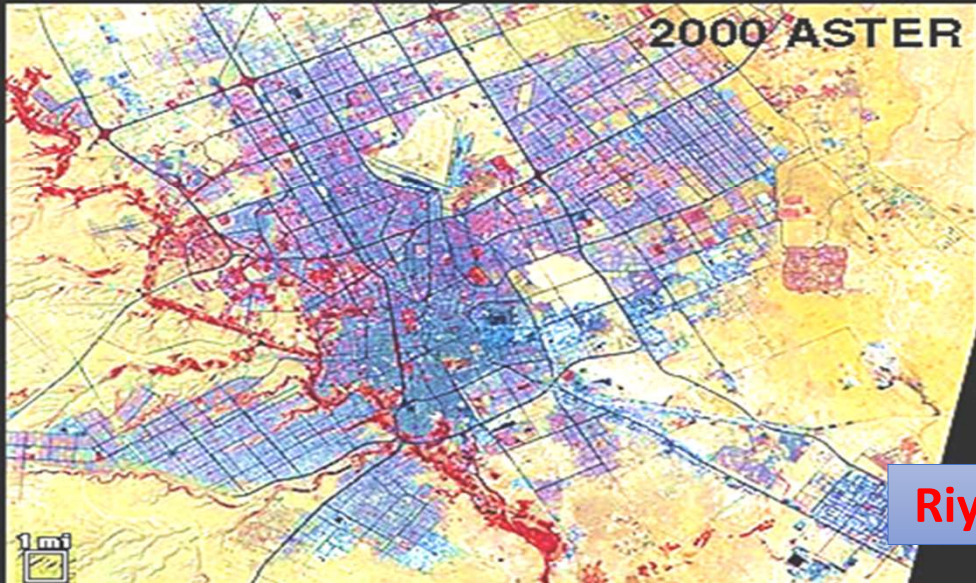
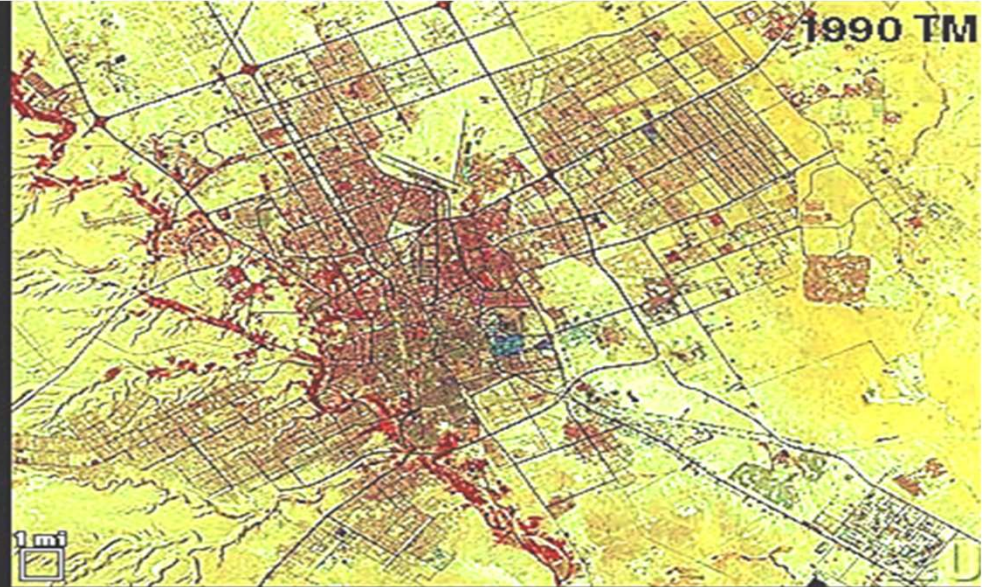
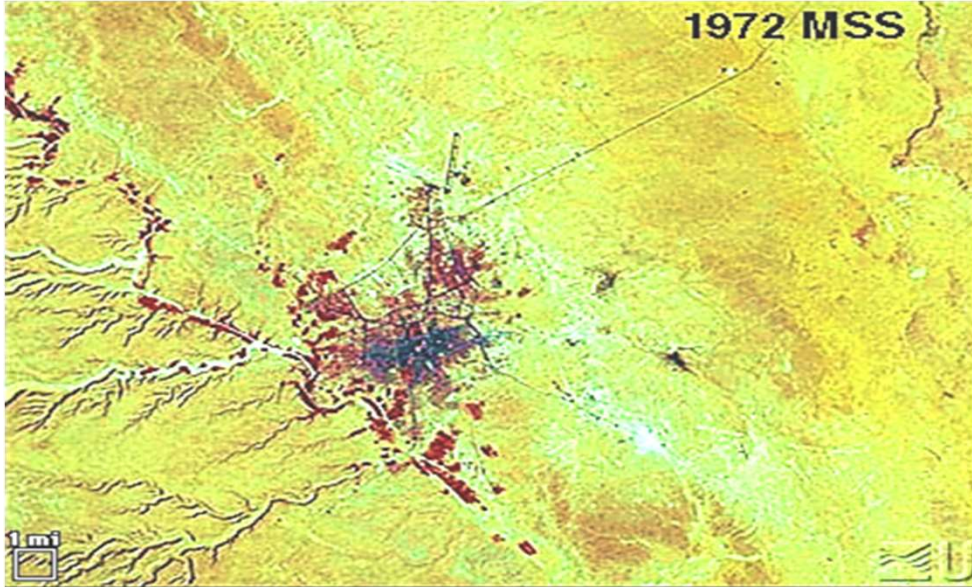


L4 TM 1986



L7 ETM+ 2003

- **Sensor:** L1 MSS (December 25, 1972), L4 TM (February 15, 1986), L7 ETM+ (January 5, 2003)  
**Lat/Long:** 25.993/44.720, **Path/Row:** 167/42
- These images show the development of center-pivot irrigation agriculture in Saudi Arabia. **Areas under this type of irrigation appear as red circles.**
- The **1972** image shows little development in the region, and the cities of **Buraydah** and **Unayzah** are barely discernible on the west edge.
- The cities, as well as a new highway, are shown more clearly at the western edge of the **1986** and **2003** images.
- The **1986** image *shows the dramatic impact of center-pivot irrigation systems.*
- The **2003** image *shows areas of increasing irrigation and areas that have actually decreased.*



Riyadh, Saudi Arabia

**Time lapse  
Animation of  
Construction in  
China.  
(QuickBird Satellite  
Image -  
DigitalGlobe - ©  
2010 All rights  
reserved)**

