中山大學
SUN YAT-SEN UNIVERSITY

HYPERCOMP
Hyperspectral Computing Laboratory

Hyperspectral Image Analysis:
高光谱遥感分析
Lecture 1: Remote Sensing(Part 1)

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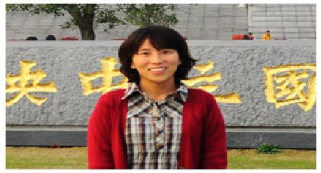
www.lx.it.pt/~jun/#courses



Welcome to Jun Li's home page

I am a Professor (download my CV) in School of Geography and Planning, Sun Yat-Sen University, China

E-mail: jun@lx.it.pt; lijun48@mail.sysu.edu.cn

My Google Scholar Site is available HERE

My Web Site in Sun Yat-Sen University is available HERE

Publications Courses Students Professional Service

- News and Upcoming Events

---Where Are You? IT Newsletter

---TALK by Jon Atli Benediktsson: Morphological and Attribute Profiles for Classification of Hyperspectral Remote Sensing Imagery

---International Workshop on Multi-Sensor Data Fusion for Remote Sensing Image Analysis, Guangzhou, China, September 9-11, 2014 (Download Presentations!)

• Courses

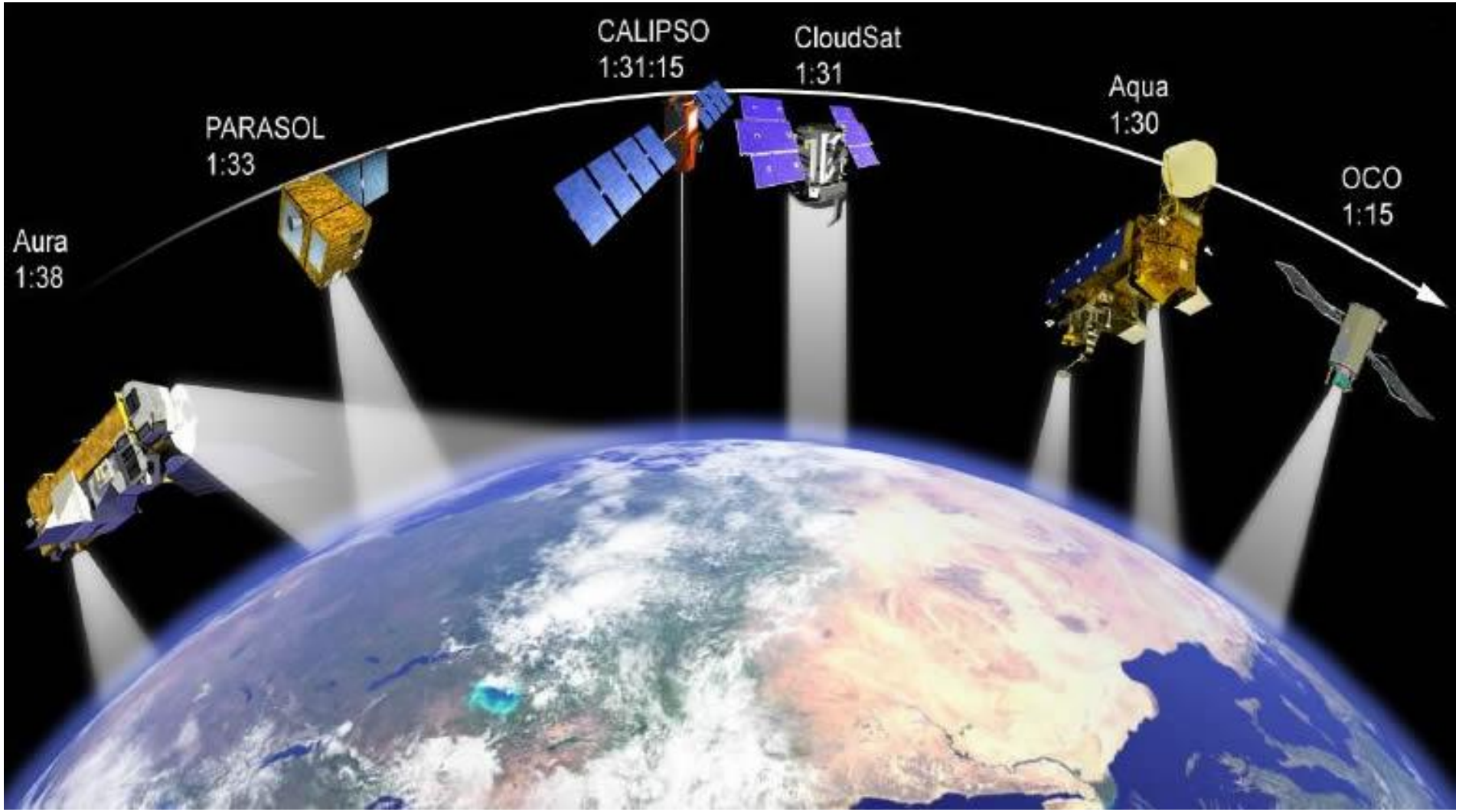
1. Hyperspectral Remote Sensing Analysis: Lecture0, Lecture1

2. Multivariate Statistical Learning: book, Lecture0, Lecture1

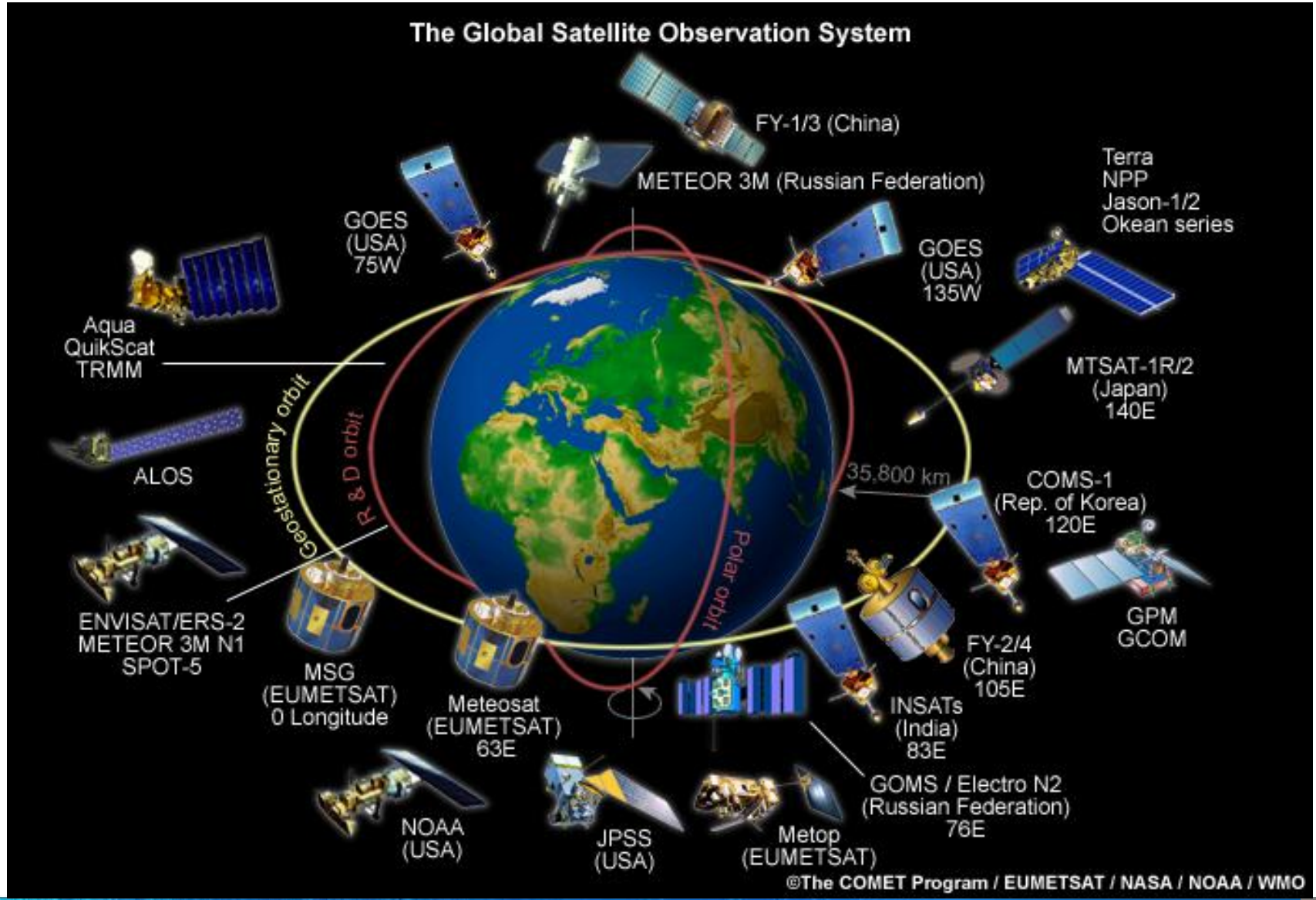
Remote Sensing（遥感）

航空遥感　　航天遥感

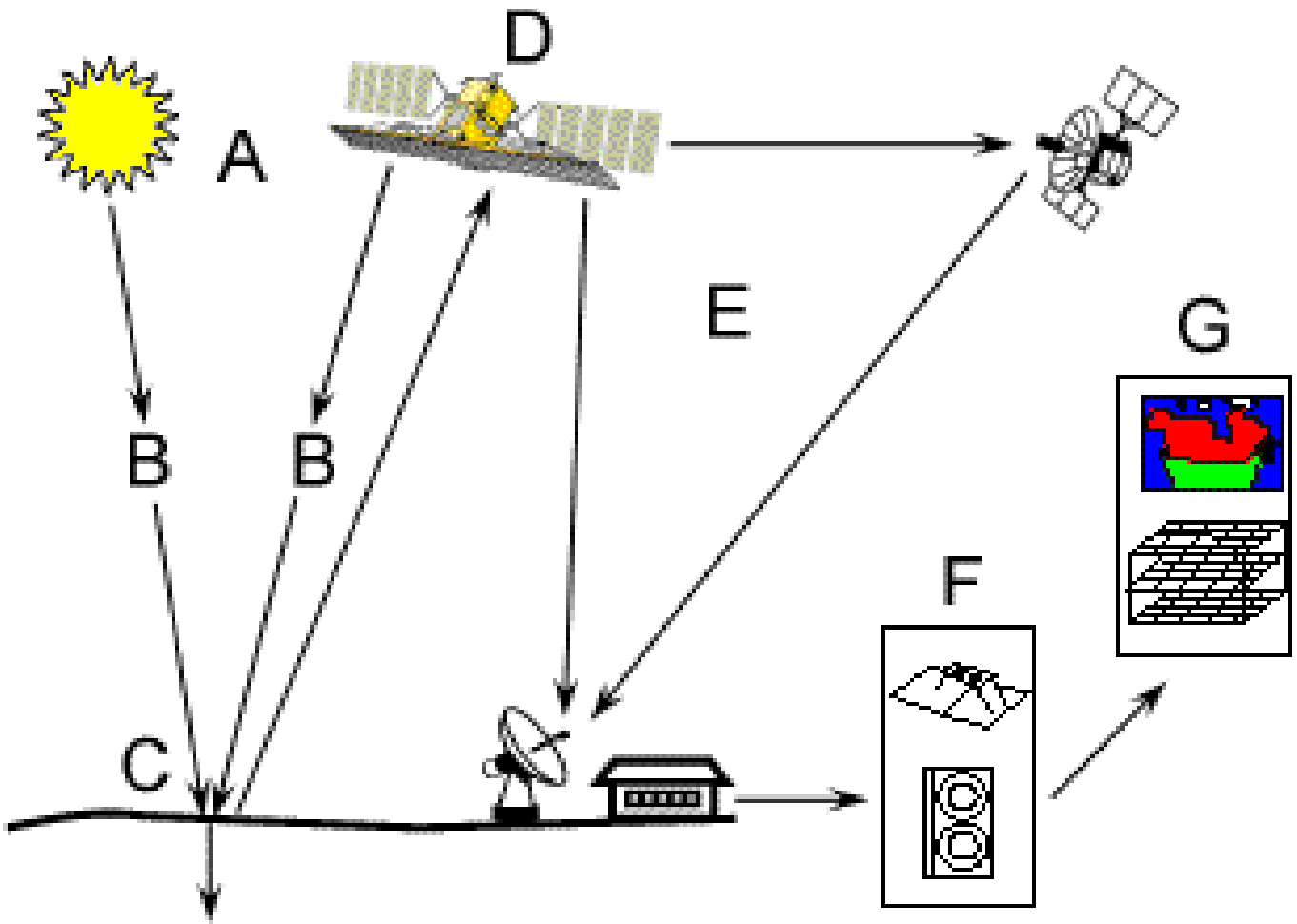
Remote Sensing（遥感）



Remote Sensing（遥感）



Remote Sensing（遥感）



Remote Sensing（遥感）

Remote sensing is the acquisition of information about an object or phenomenon **without making physical contact** with the object and thus in contrast to on site observation.

遥感，遥远的感知，是指**非接触的**，**远距离**的探测技术。

Remote Sensing（遥感）

In modern usage, the term generally refers to the use of **aerial sensor technologies** to detect and classify **objects on Earth** (both on the surface, and in the atmosphere and oceans) by means of propagated signals (e.g. **electromagnetic radiation**).

一般指运用传感器/遥感器对物体的**电磁波的辐射、反射特性**的探测，并根据其特性对物体的性质、特征和状态进行分析的理论、方法和应用的科学技术。

Remote Sensing（遥感）

1983年美国摄影测量与遥感协会ASPRS：

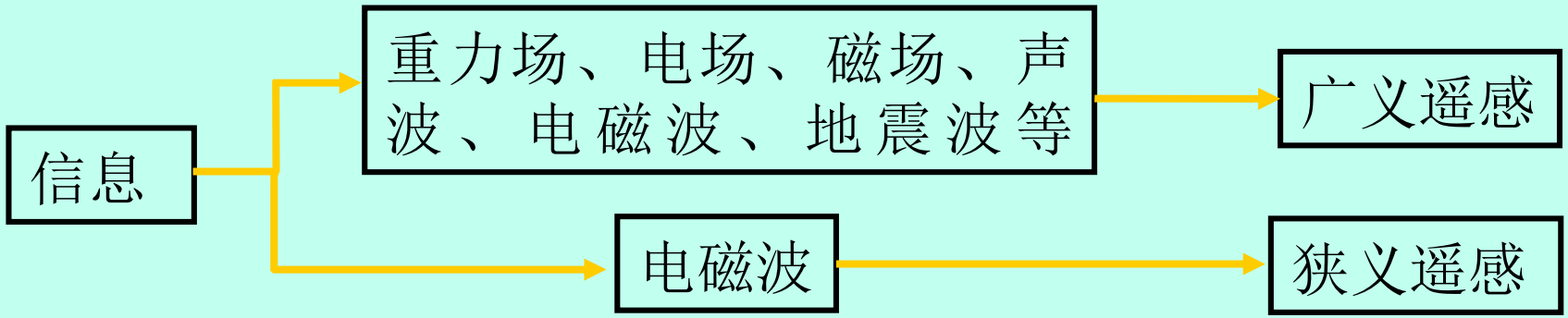
The measurement or acquisition of information of some property of an object or phenomenon, by a recording device that is not in physical or intimate contact with the object or phenomenon under study.

1988年ASPRS结合摄影测量与遥感：

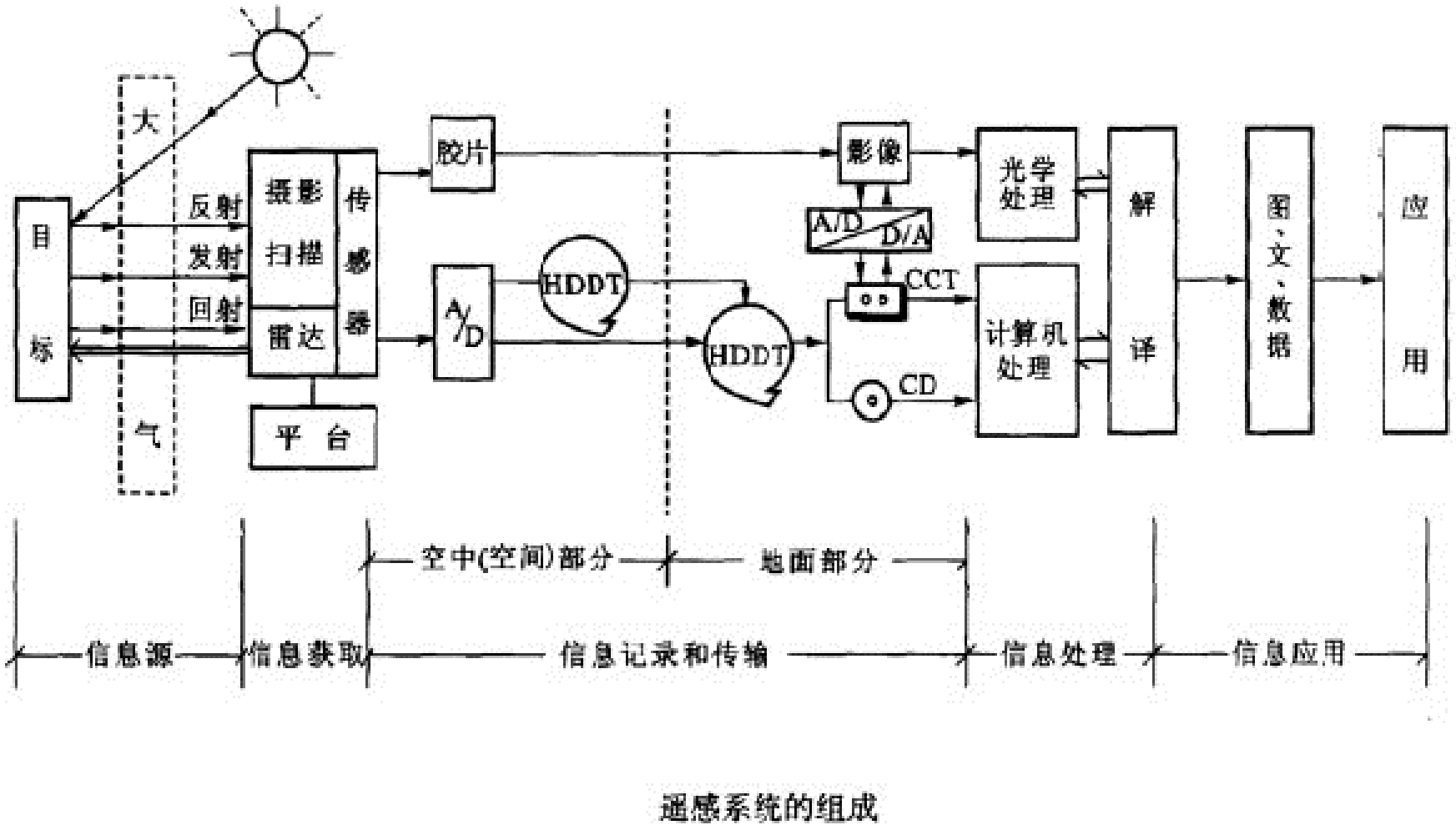
The art, science, and technology of obtaining reliable information about physical objects and the environment, through the process of recording, measuring and interpreting imagery an digital representations of energy patterns derived from non-contact sensor systems.

Remote Sensing（遥感）

遥感是指**不直接接触**物体本身，从工作平台上通过传感器探测和**接收**来自目标物体的信息，经过信息**传输**、加工**处理**及分析解译，识别物体和现象的属性及其空间分布等特征与变化规律的技术。

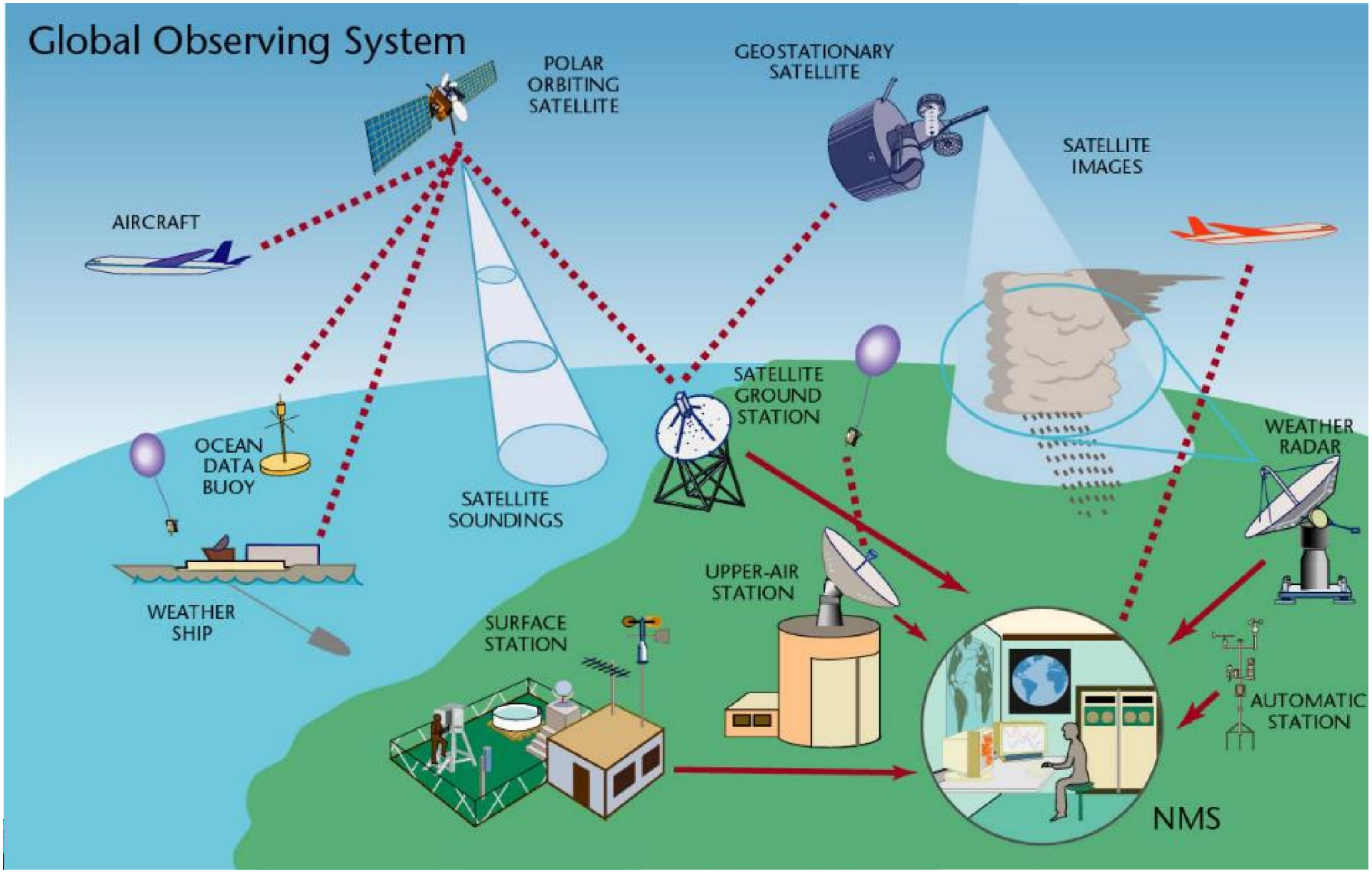


Remote Sensing（遥感）



遥感系统的组成

Remote Sensing（遥感）



Remote Sensing（遥感）

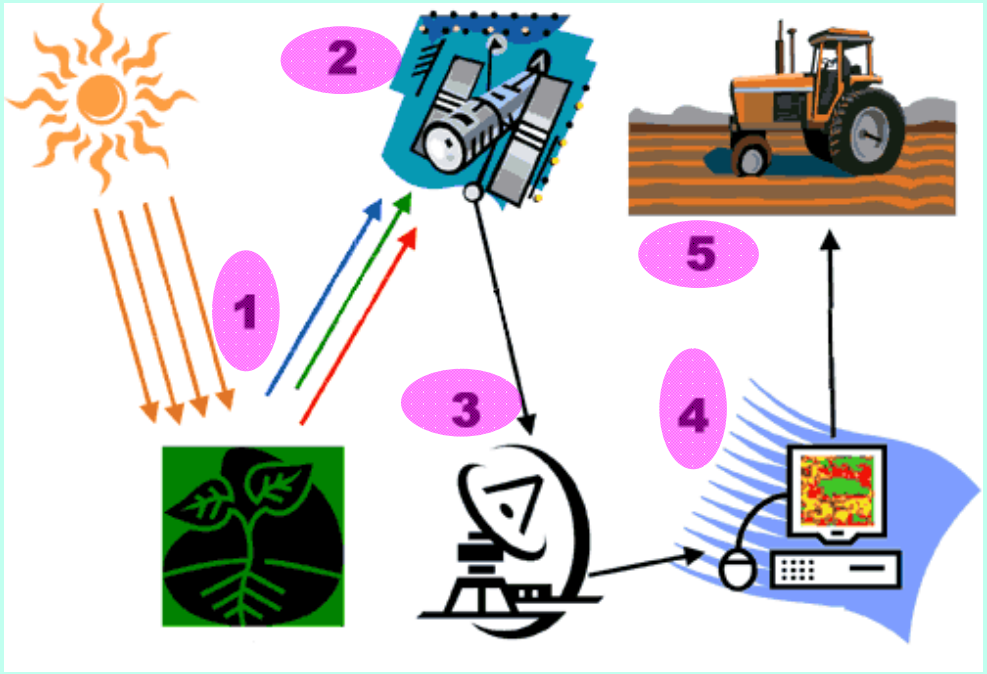
1、信息源

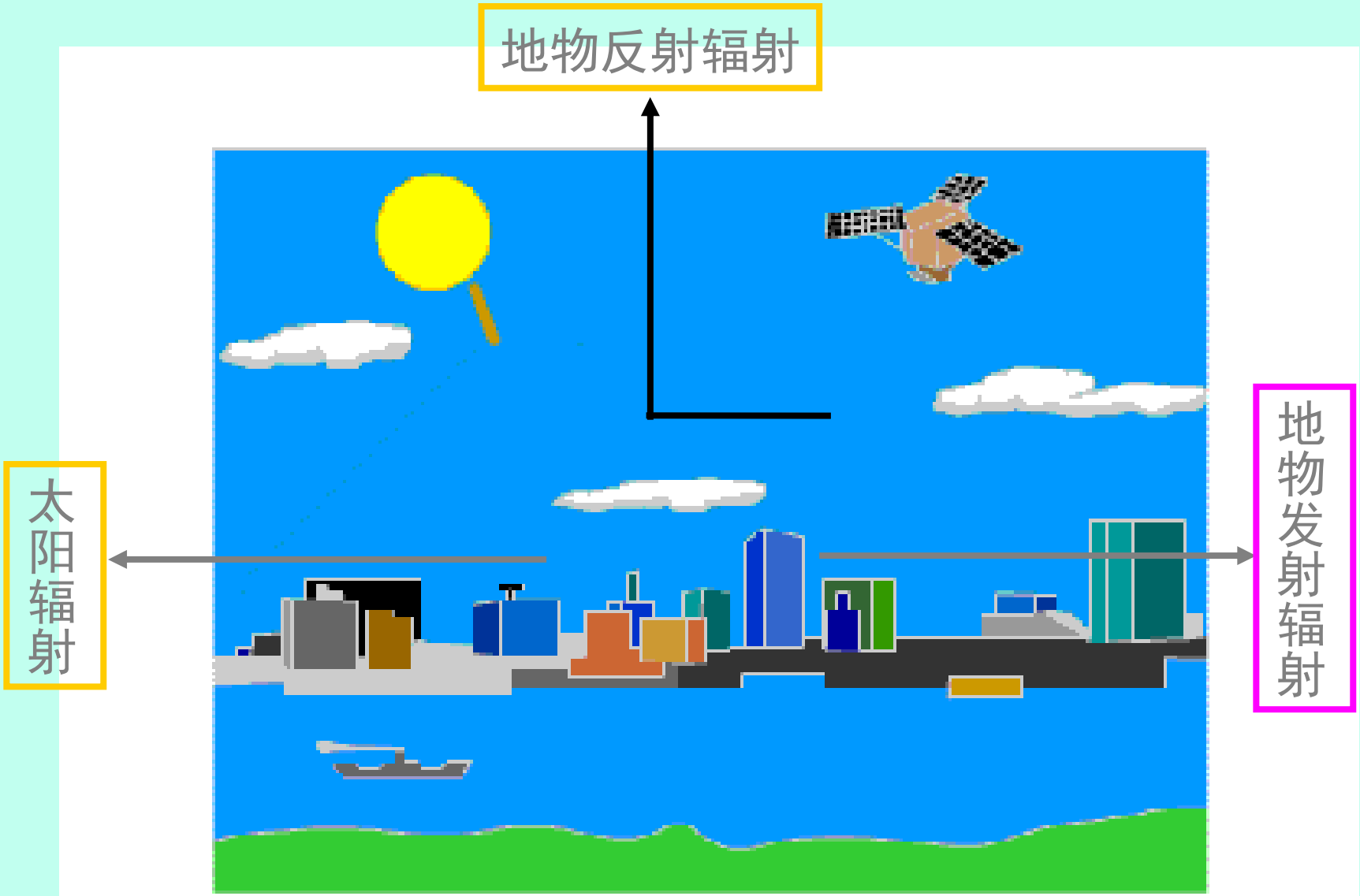
2、信息获取

3、信息传输记录

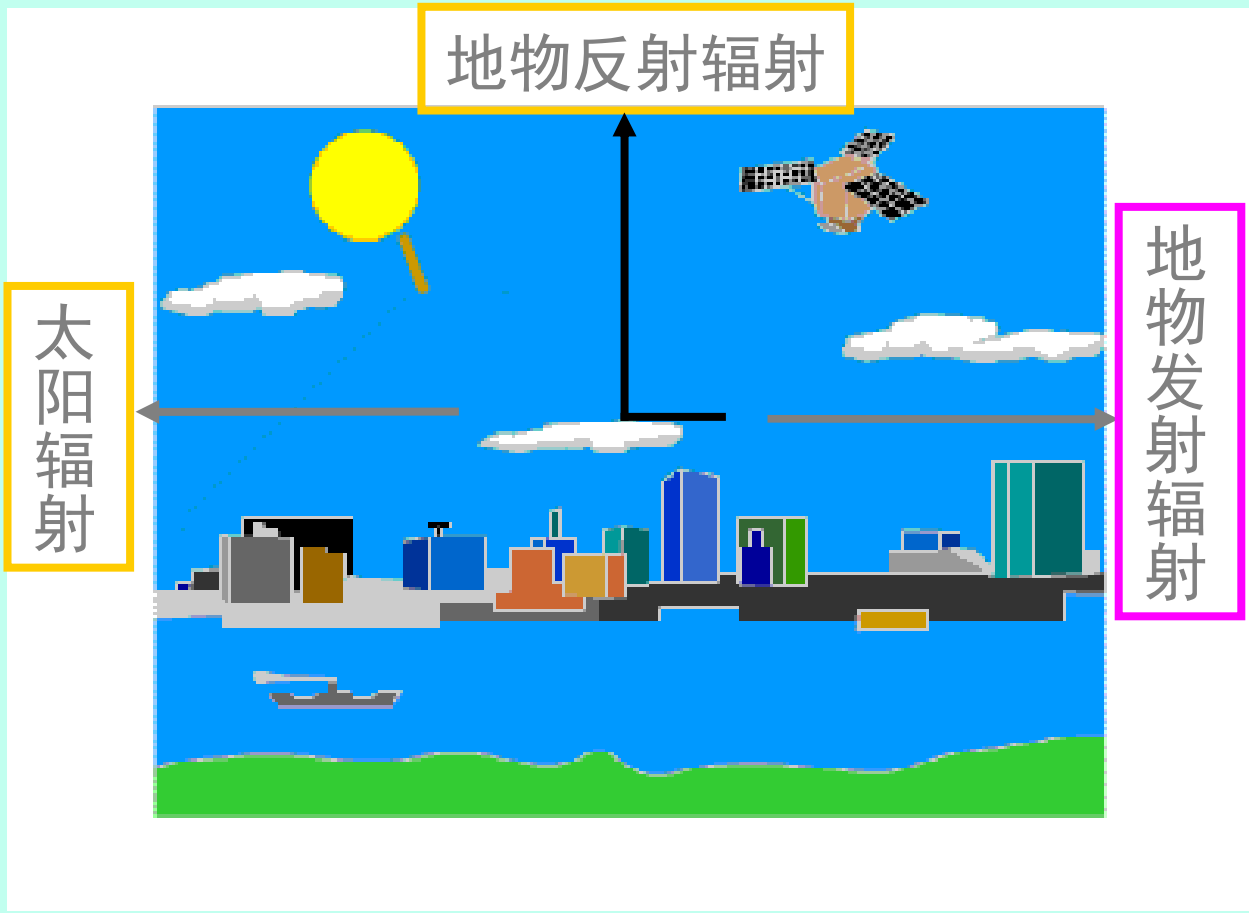
4、信息处理分析

5、信息应用

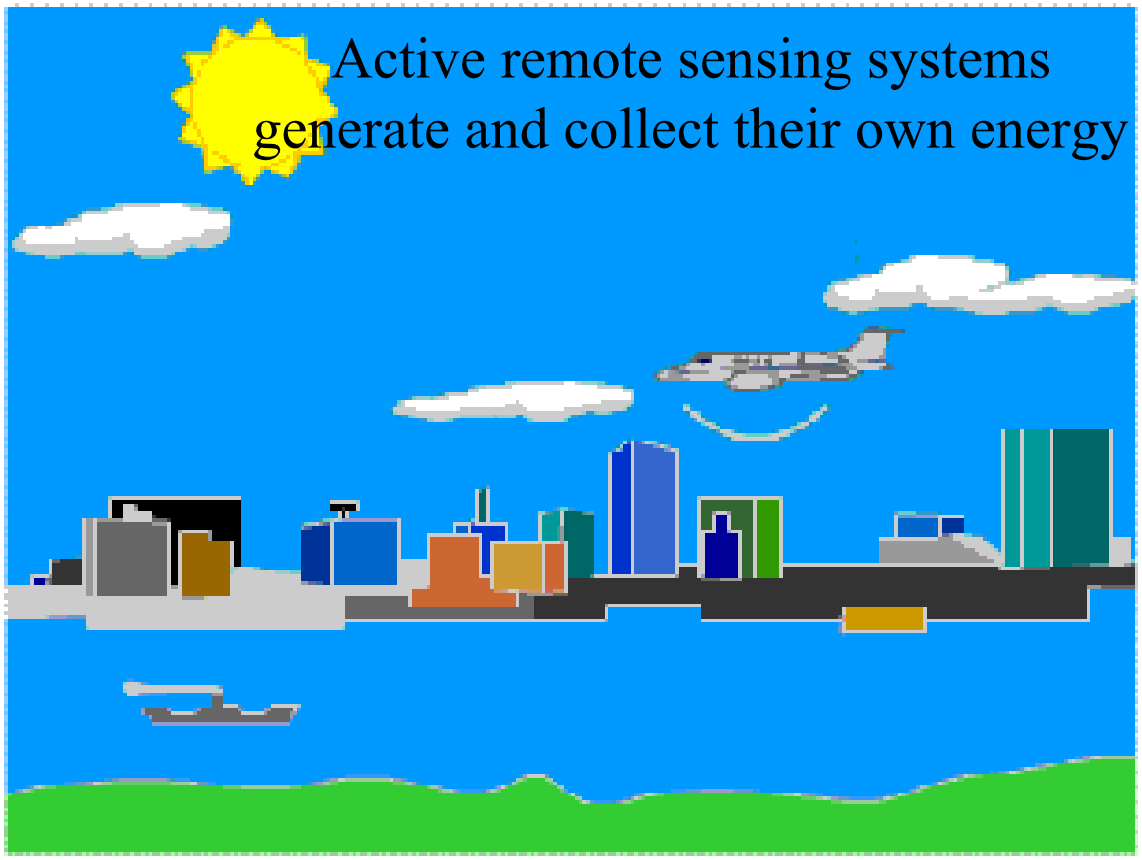



地物反射辐射
太阳辐射
地物发射辐射

Passive Remote Sensing（被动遥感）



Active Remote Sensing（主动遥感）

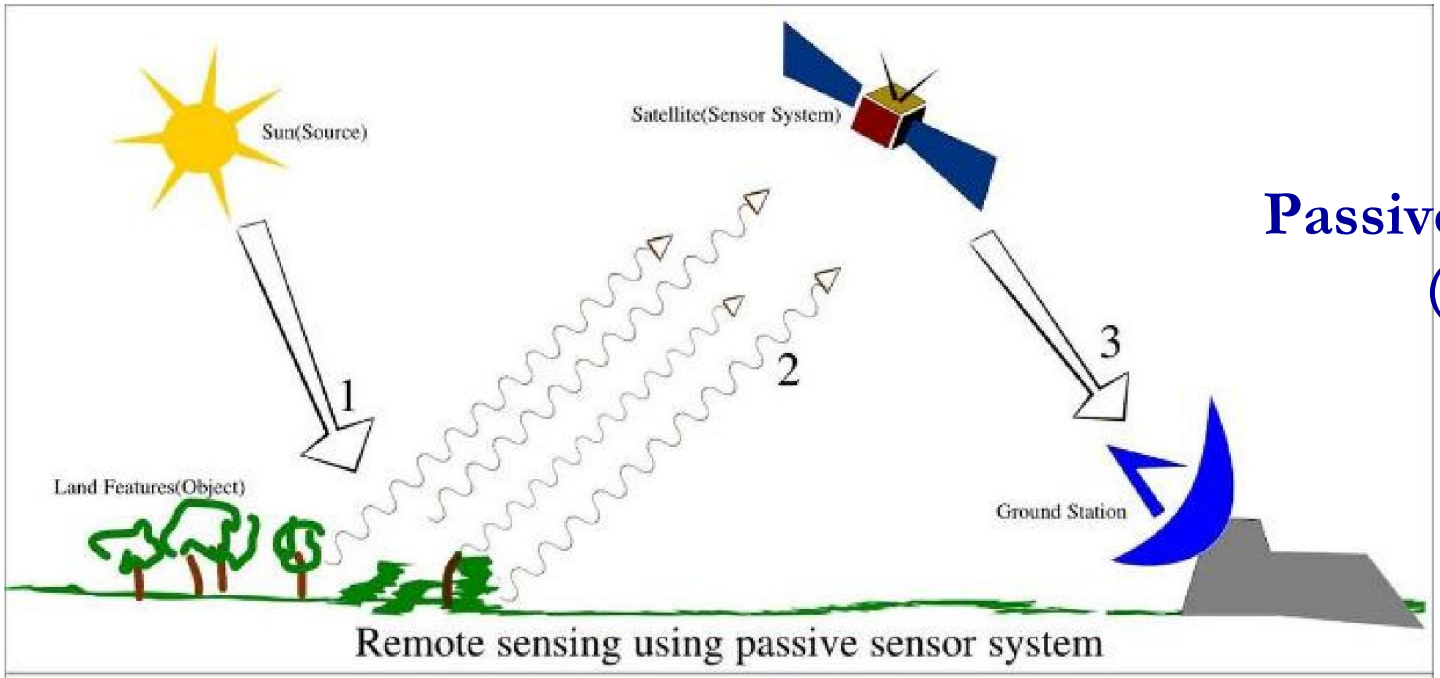


Remote Sensing（遥感）

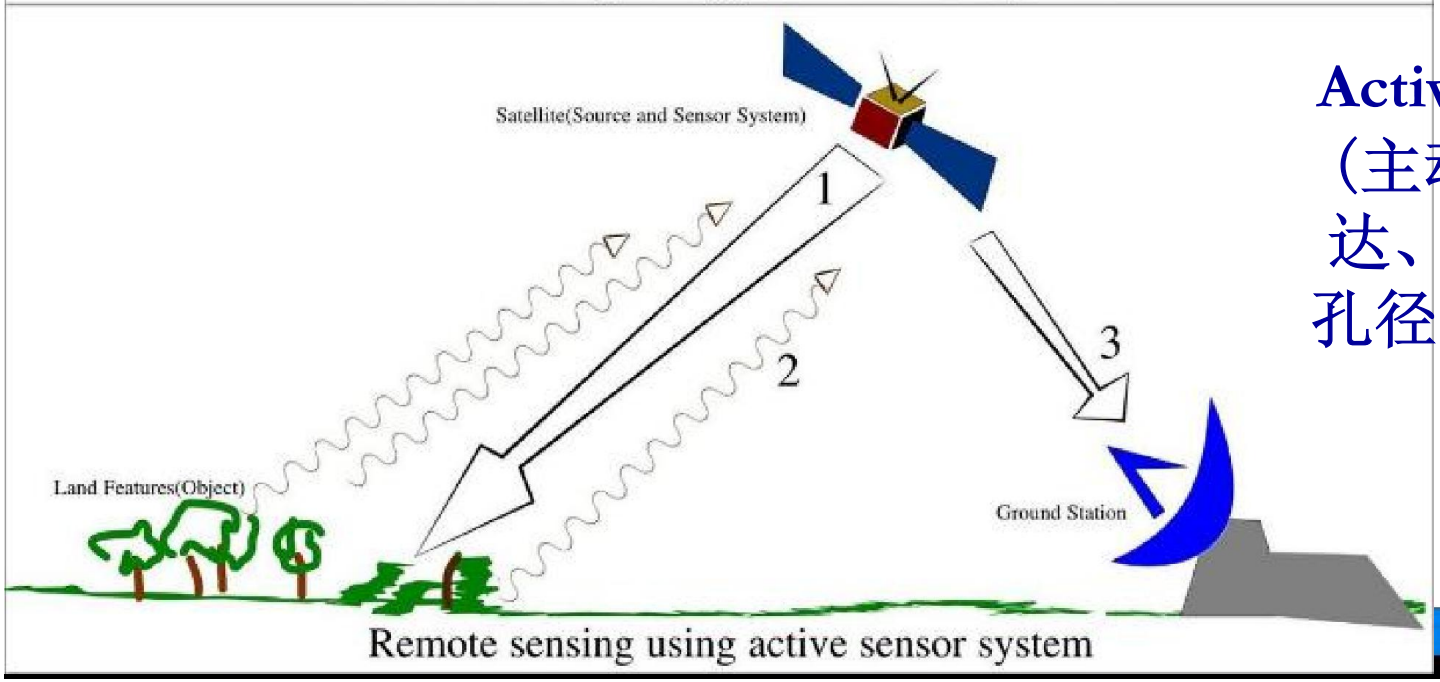
It may be split into **active remote sensing** (when a signal is first emitted from aircraft or satellites) or **passive** (e.g. sunlight) when information is merely recorded.

主动式遥感，即由传感器主动地向被探测的目标物发射一定波长的电磁波，然后接受并记录从目标物反射回来的电磁波.

被动式遥感，即传感器不向被探测的目标物发射电磁波，而是直接接受并记录目标物反射太阳辐射或目标物自身发射的电磁波。



Passive remote sensing
（被动遥感）



Active remote sensing
（主动遥感）：普通雷达、侧视雷达，合成孔径雷达，红外雷达、激光雷达

Remote Sensing（遥感）

1、信息源

2、信息获取

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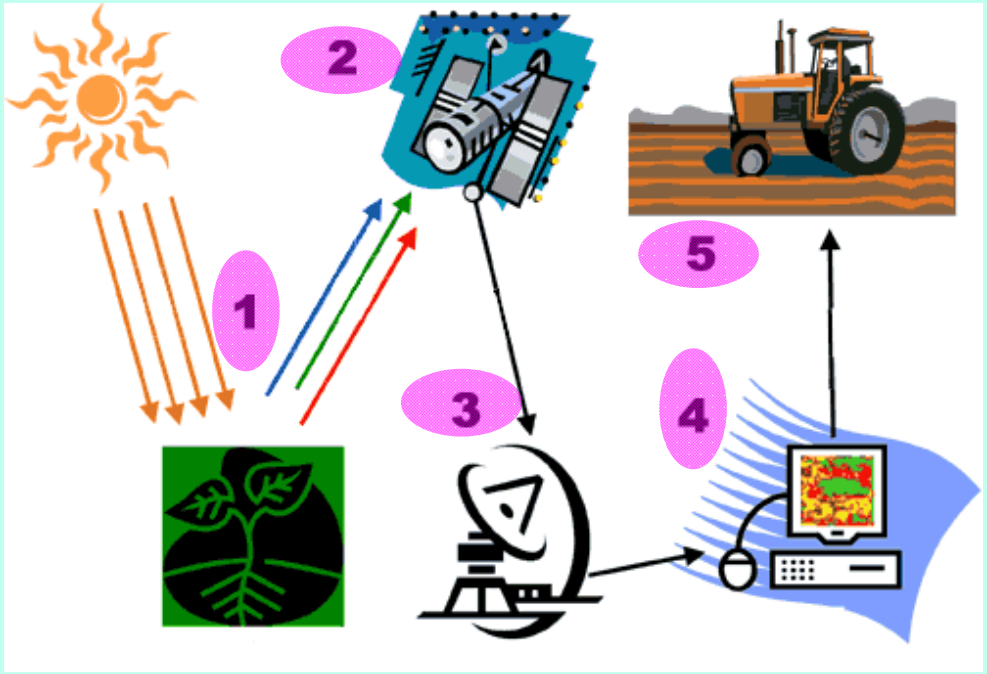
5、信息应用



Remote Sensing（遥感）

照相机

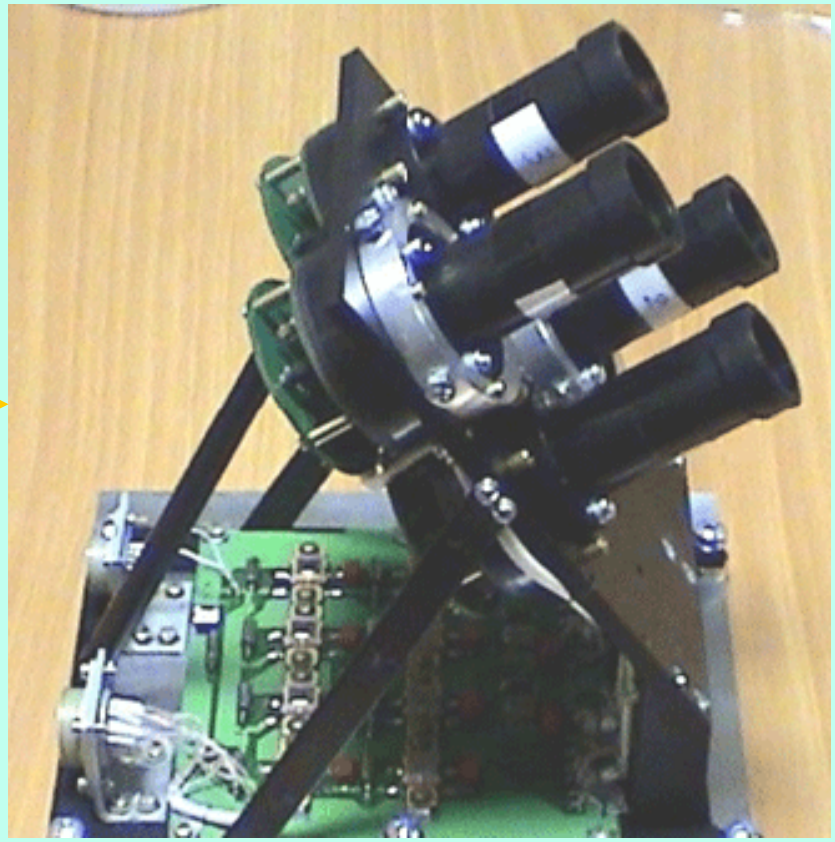
三角架

传感器

遥感平台

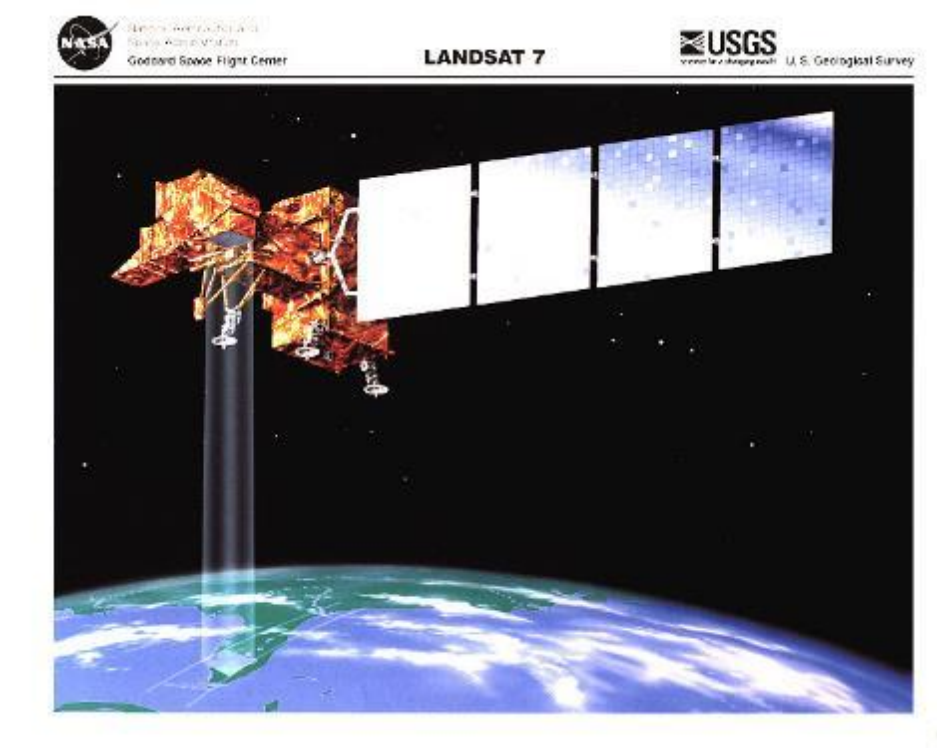
Remote Sensing（遥感)-Sensors

- 摄影机(Camera)
- 扫描仪(Scanner)
- 雷达 (Radar)



Remote Sensing（遥感)-Sensors

- 摄影机(Camera)
- 扫描仪(Scanner)
- 雷达 (Radar)



Remote Sensing（遥感)-Sensors

摄影机(Camera)

扫描仪(Scanner)

雷达 (Radar)

Remote Sensing（遥感)-Platform

地面平台
(Ground Platform)

航空平台
(Airborne Platform)

航天平台
(Space Platform)

Remote Sensing（遥感)-Platform

地面平台
(Ground Platform)

航空平台
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Remote Sensing（遥感)-Platform

地面平台
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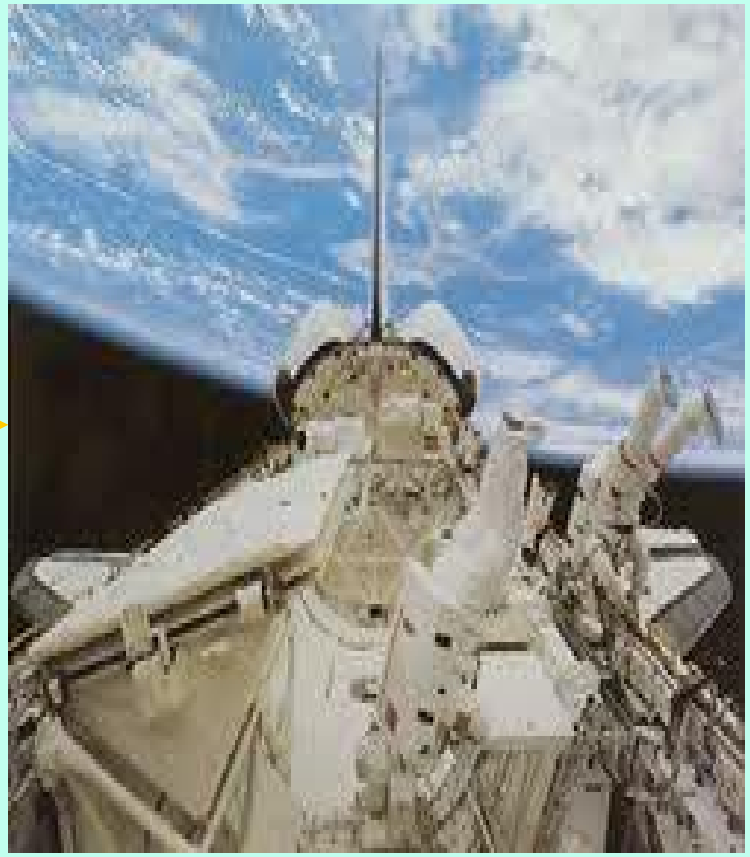

Remote Sensing（遥感）

1、信息源

2、信息获取

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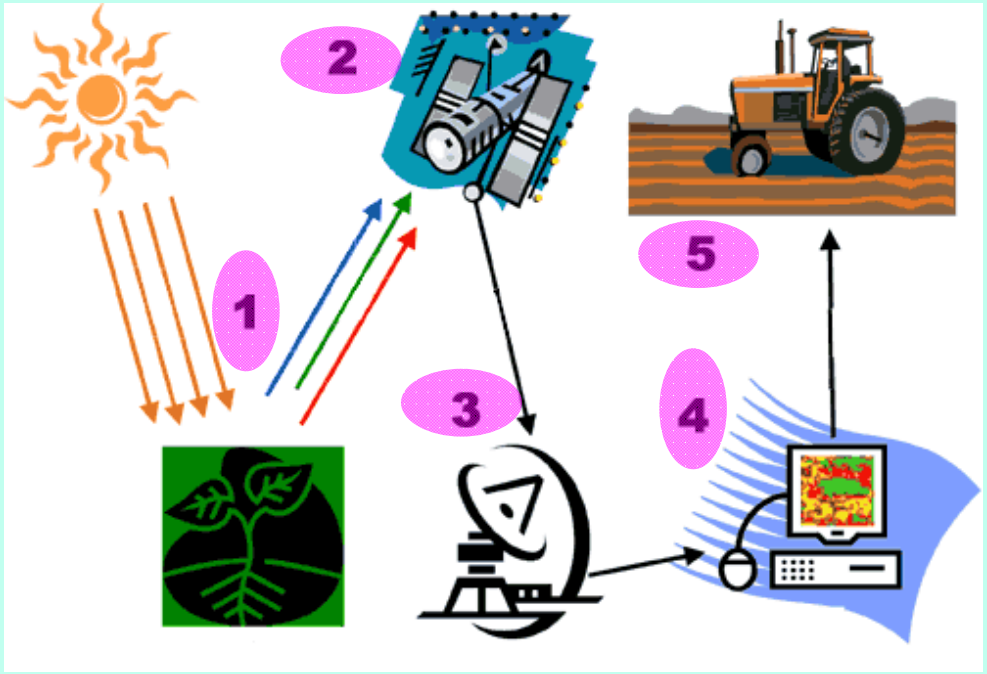
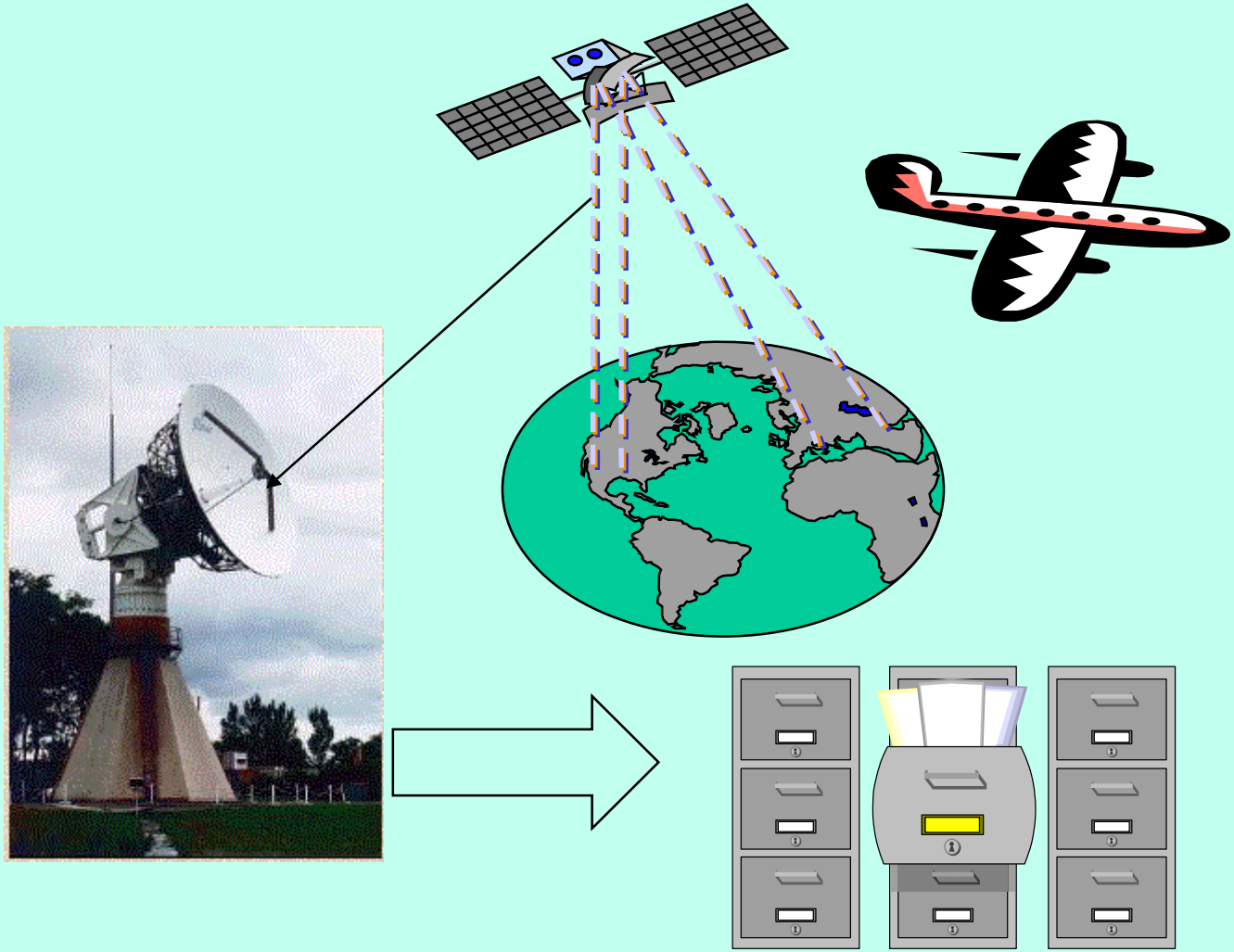
5、信息应用



Remote Sensing（遥感）



Remote Sensing（遥感）

密云地面站全景

嫦娥工程昆明地面站

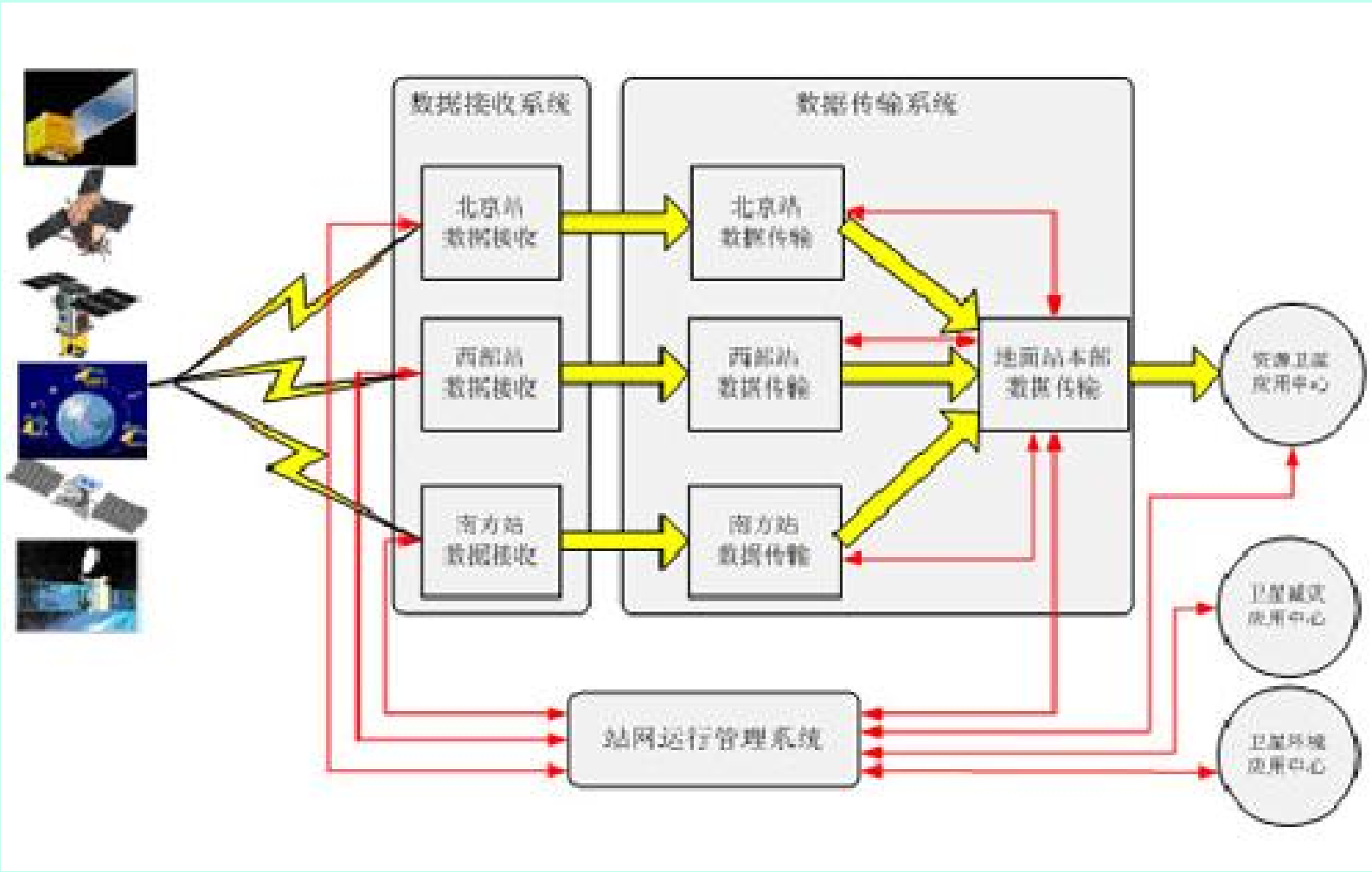
Remote Sensing（遥感）

喀什地面站全景

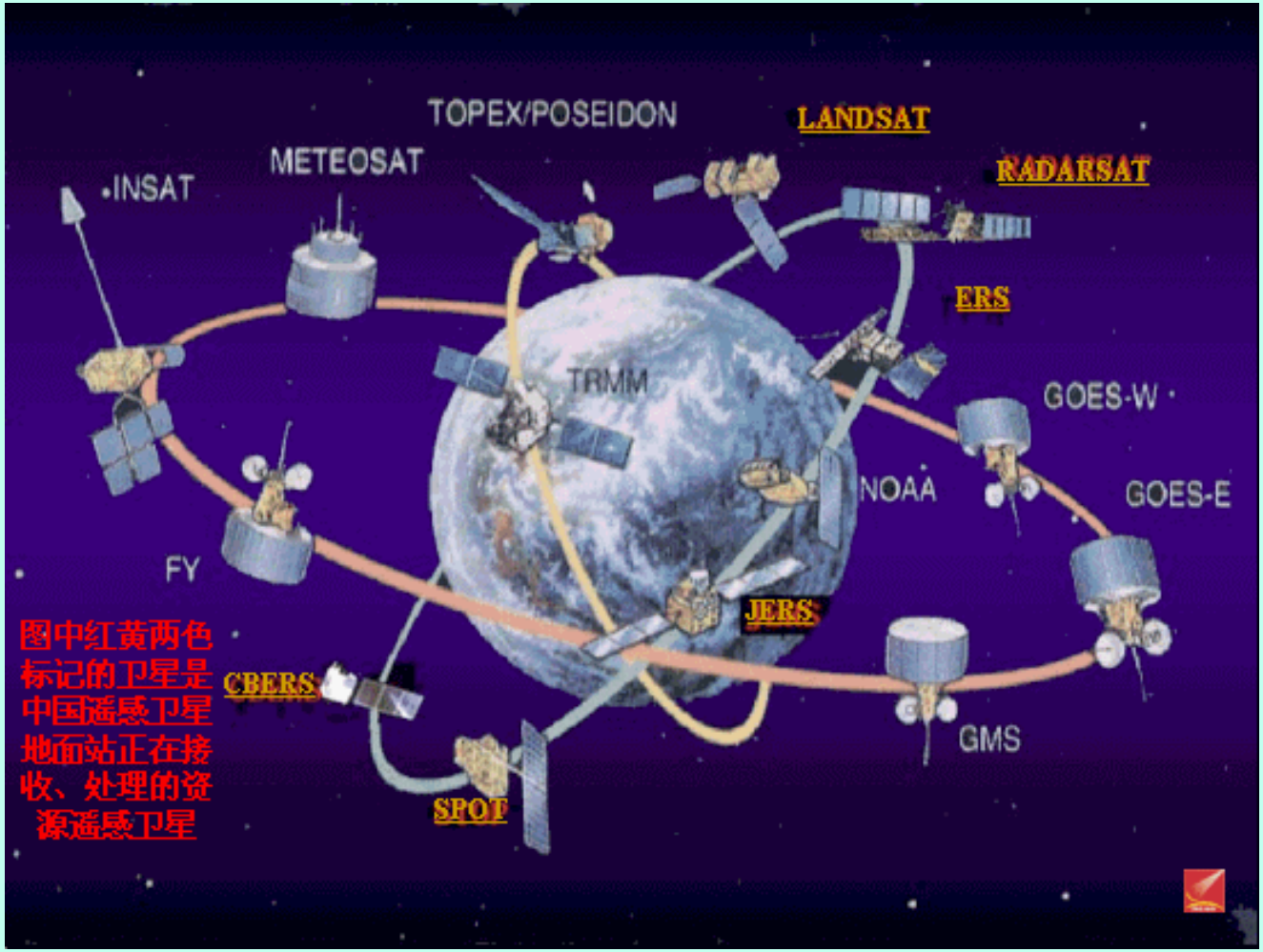
三亚地面站

Remote Sensing（遥感）

Remote Sensing（遥感）



中国遥感卫星地面站正在接收处理的卫星示意图



Remote Sensing（遥感）

中国遥感卫星地面站与国际卫星管理机构签约情况

卫星	国家	卫星管理组织	年份
LANDSAT-5	美国	NASA/NOAA/EOSAT	1986 年
JERS-1	日本	NASDA	1993 年
ERS-1	欧空局	ESA	1994 年
ERS-2	欧空局	ESA	1996 年
RADARSAT	加拿大	CSA/RSI	1997 年
SPOT-1/2/4	法国	CNES/SPOT IMAGE	1997 年
LANDSAT-7	美国	USGS	2000 年
SPOT-5	法国	SPOT IMAGE	2001 年
ENVISAT	欧空局	ESA	2003 年

Remote Sensing（遥感）

2002 年度卫星接收统计

序号	卫星种类	轨道数
1	Landsat5	671
2	Landsat7	644
3	SPOT5	36
4	SPOT2	435
5	SPOT4	294
6	RADARSAT	182
7	ERS	144
8	CBERS1	1354
	总 计	3760

中科院遥感卫星地面站宣传片

Remote Sensing（遥感）

1、信息源

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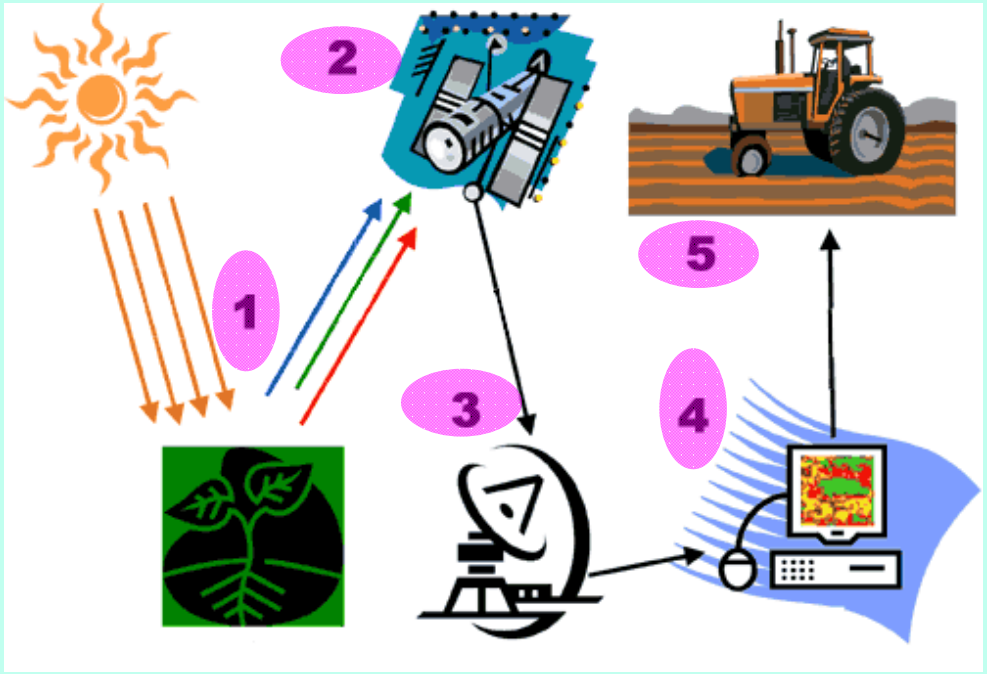
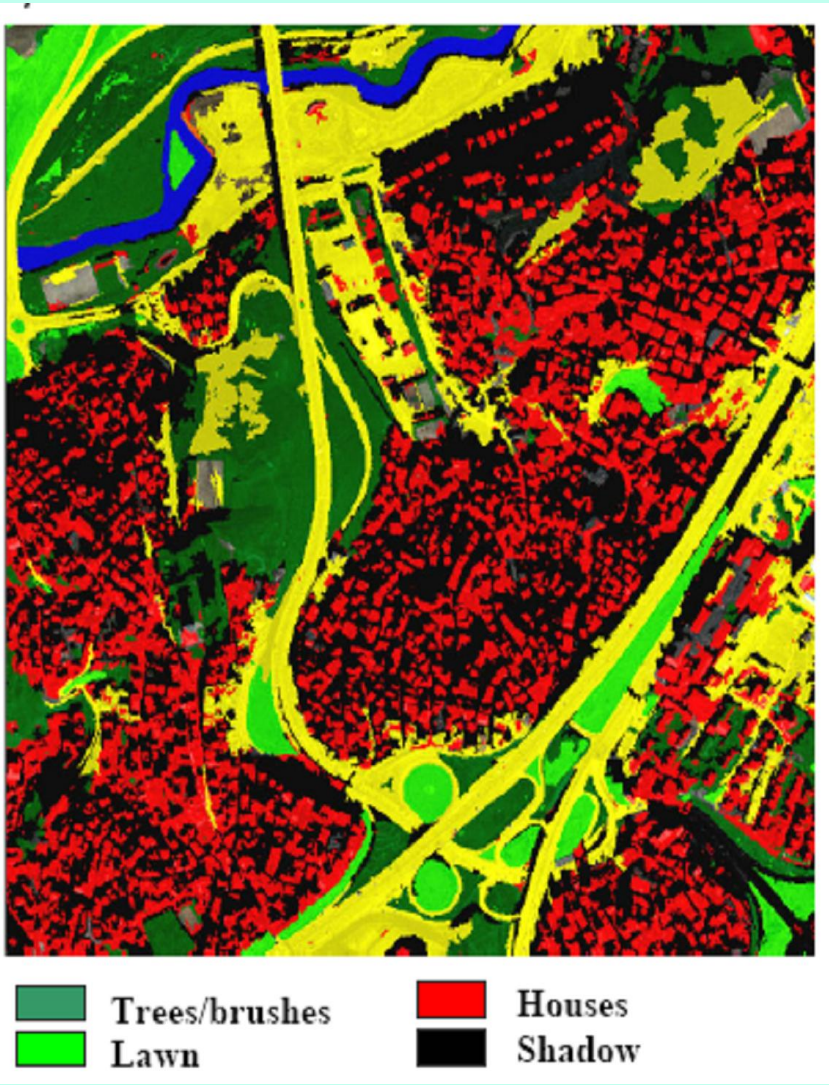


Remote Sensing（遥感）

Remote Sensing（遥感）



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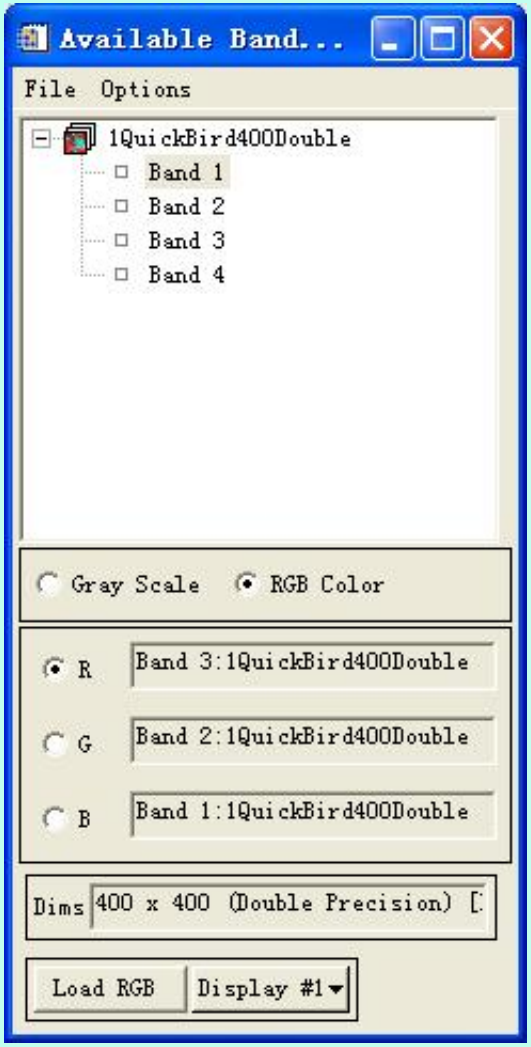
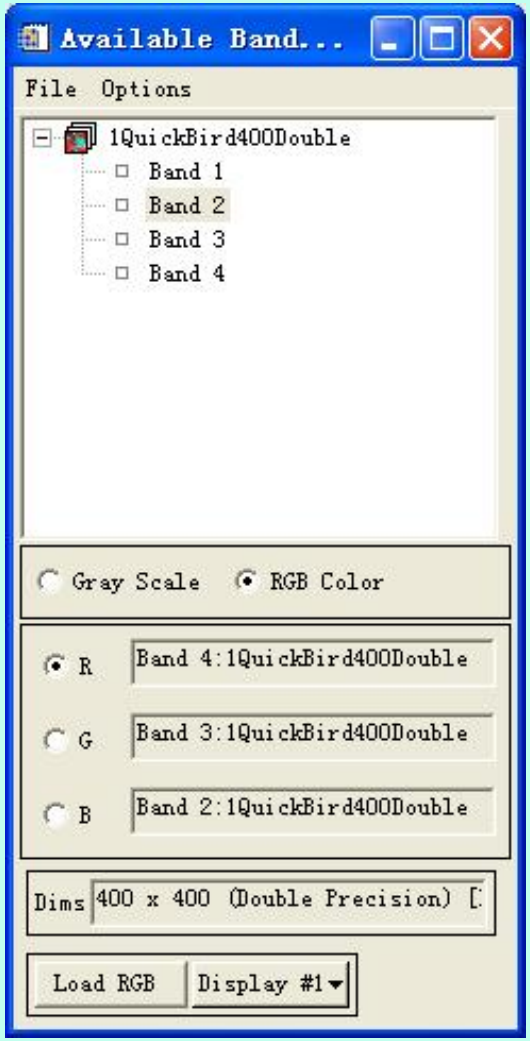


Remote Sensing（遥感）



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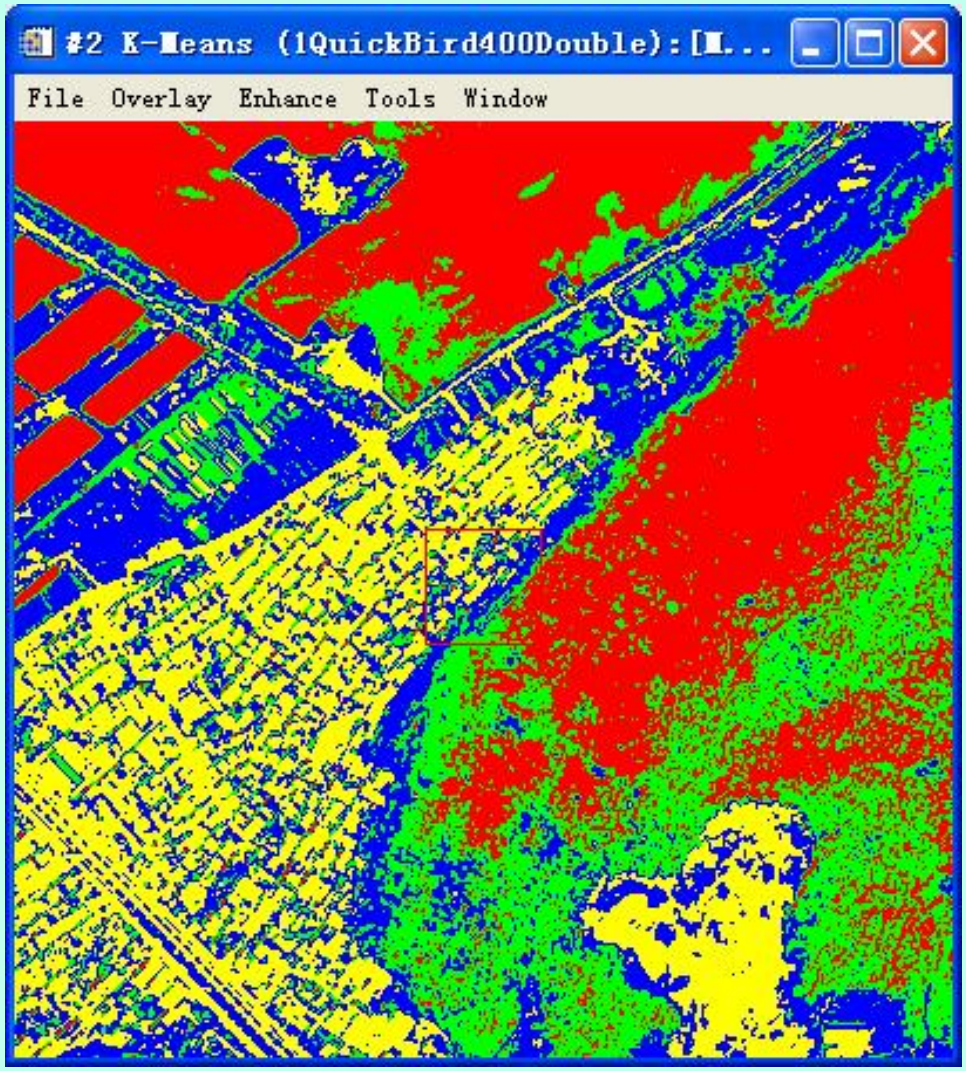
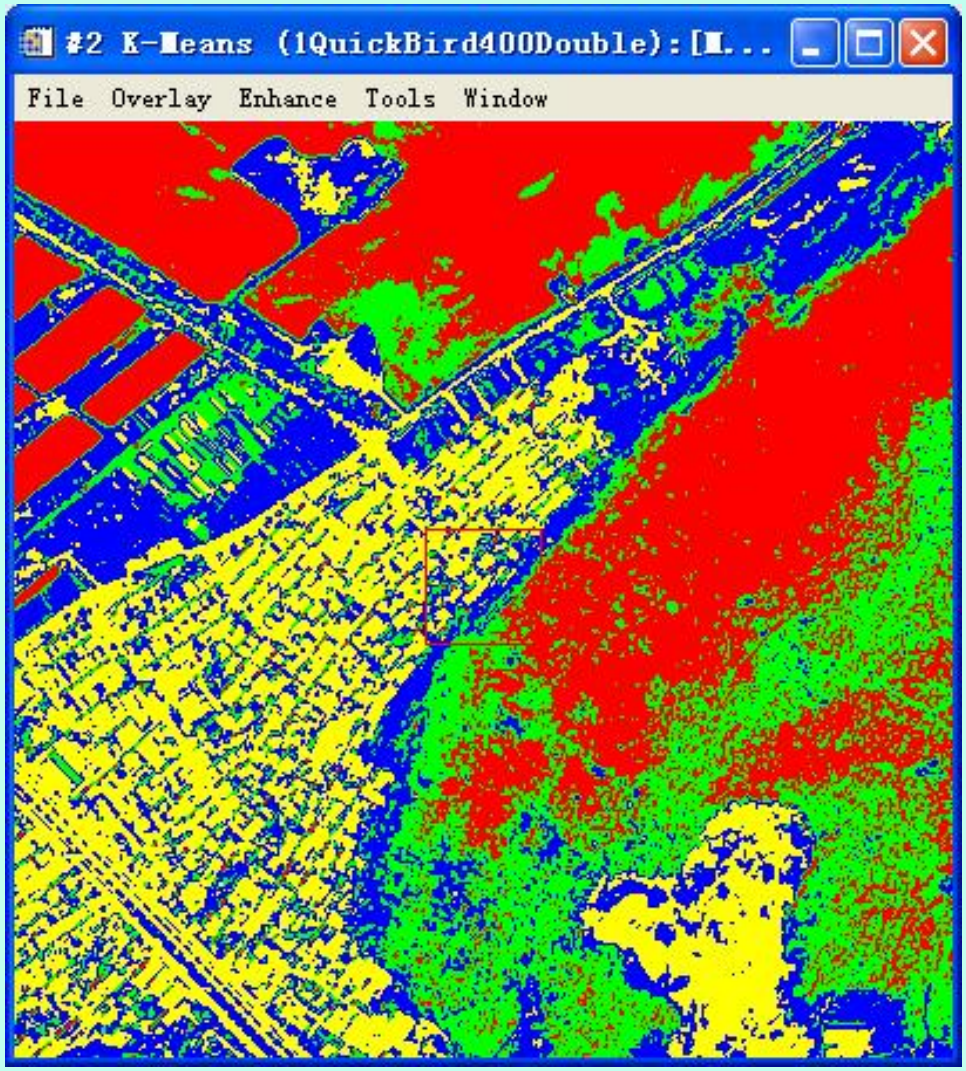


Remote Sensing（遥感）



Remote Sensing（遥感）

Remote Sensing（遥感）

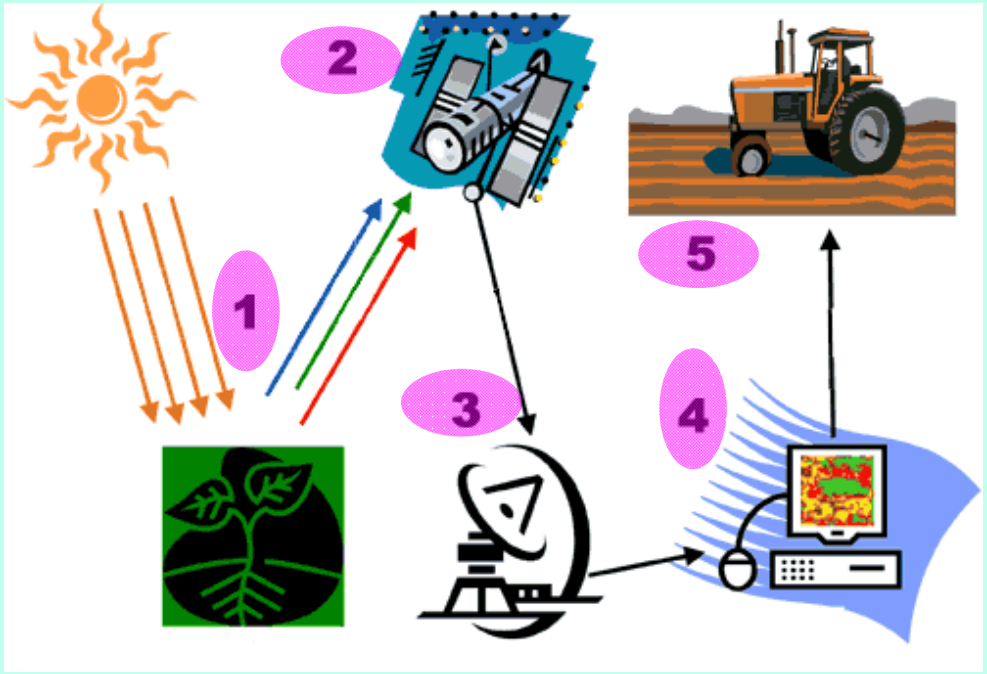
1、信息源

2、信息获取

3、信息传输记录

4、信息处理分析

5、信息应用



Remote Sensing（遥感）

Mineral
Exploration

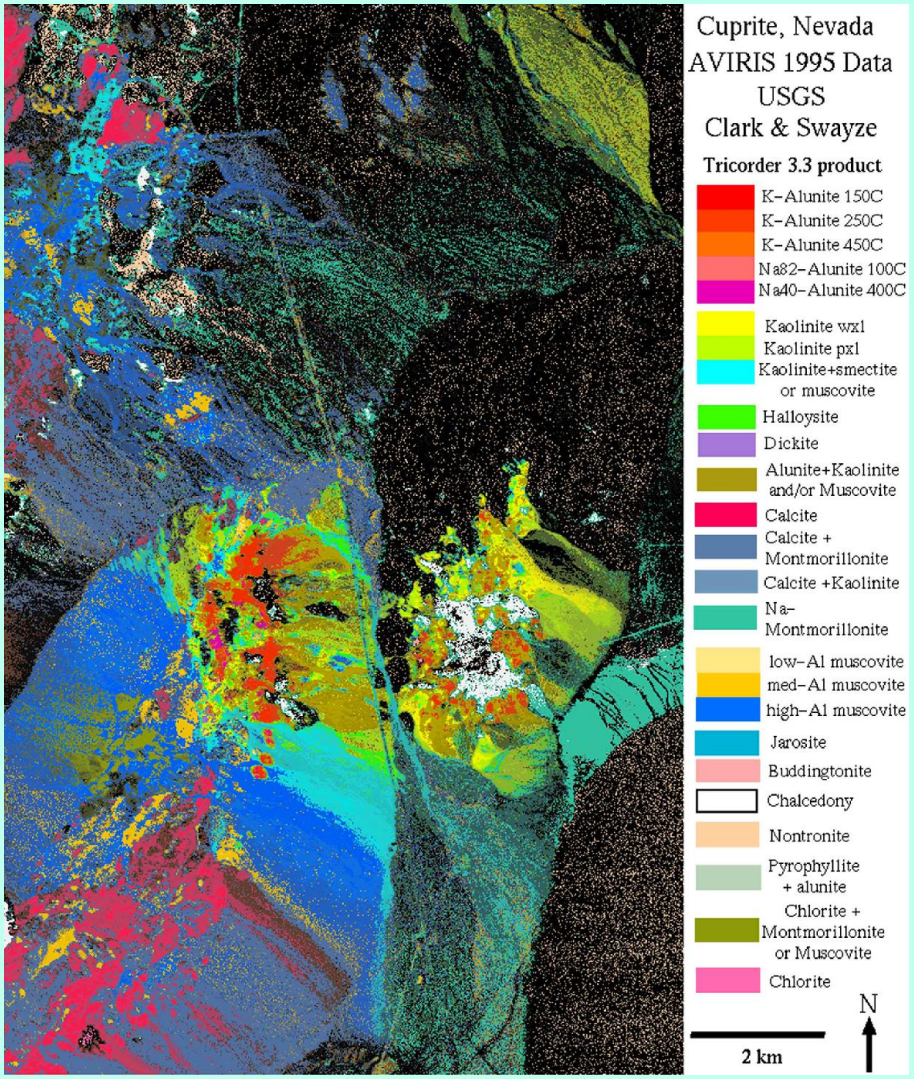
Environment
Forestry

Agriculture
Military

Remote Sensing（遥感）

RS Application - Mineral Exploration

Remote Sensing（遥感）



Mineral
Exploration

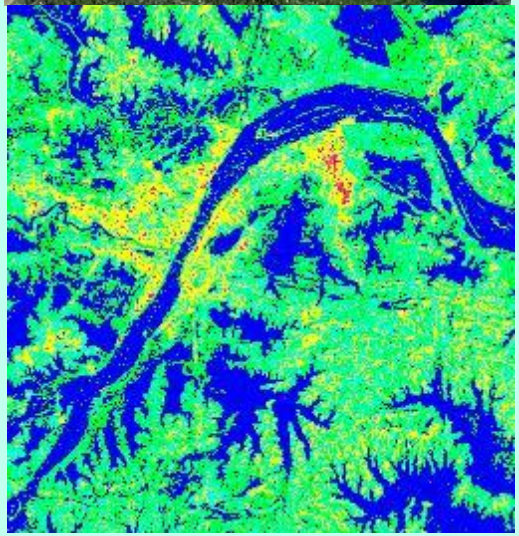
Environment
Forestry

Agriculture
Military

Application: Monitoring of Urban Heat Island

Temperature distribution maps of Wuhan city for several years

TM Image



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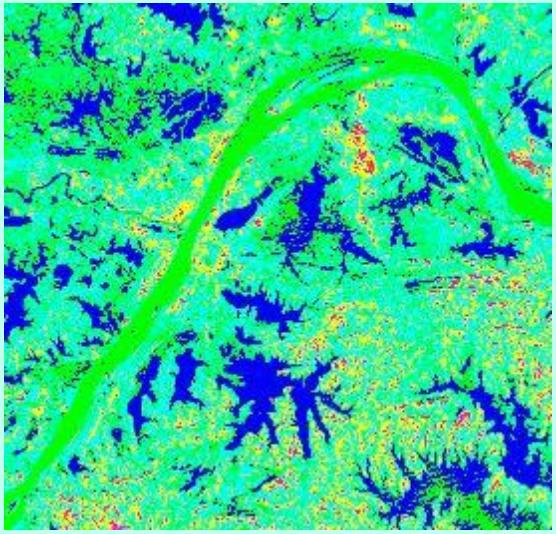
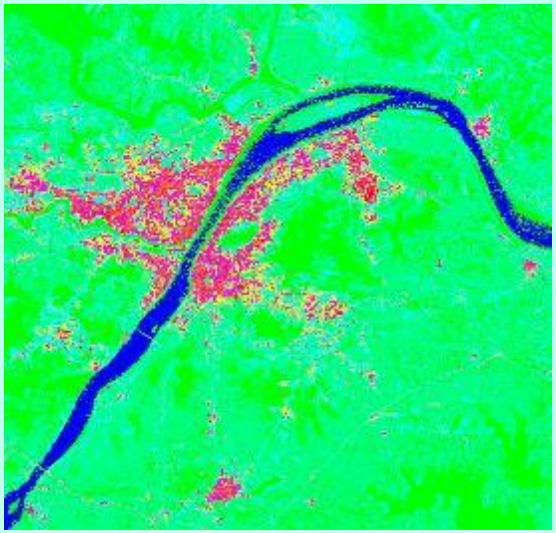


1988-10-30



2002-7-9

Mineral
Exploration

Environment
Forestry

Agriculture
Military

Remote Sensing（遥感）

RS Application - Agriculture

健康的糖用甜菜

不健康的糖用甜菜

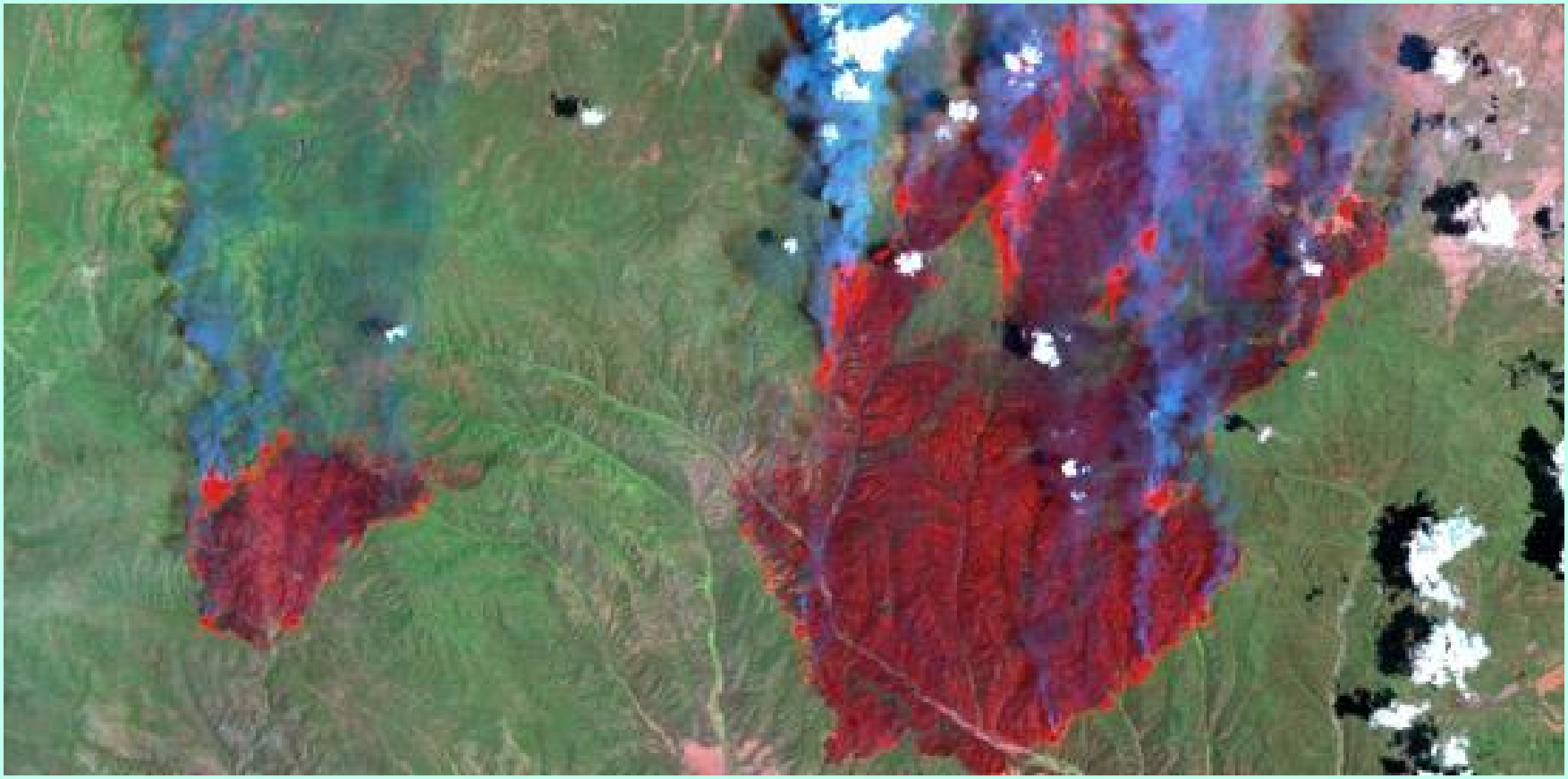
Mineral
Exploration

Environment
Forestry

Agriculture
Military

Remote Sensing（遥感）

RS Application - Forestry



Mineral
Exploration

Environment
Forestry

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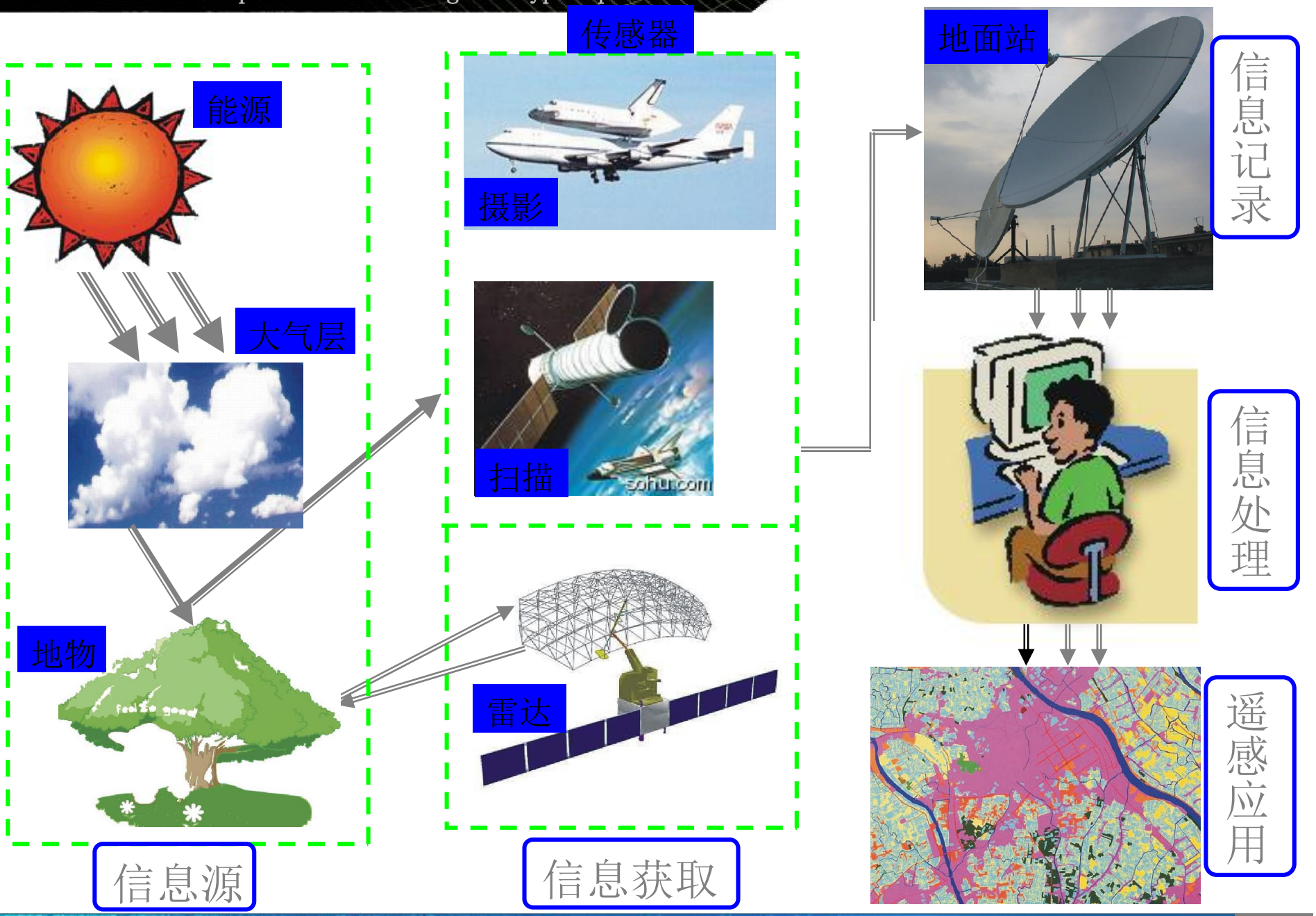
Military

Remote Sensing（遥感）

RS Application - Military

US Army Topographic Engineering Centre http:// www.tec.army.mil/tio/

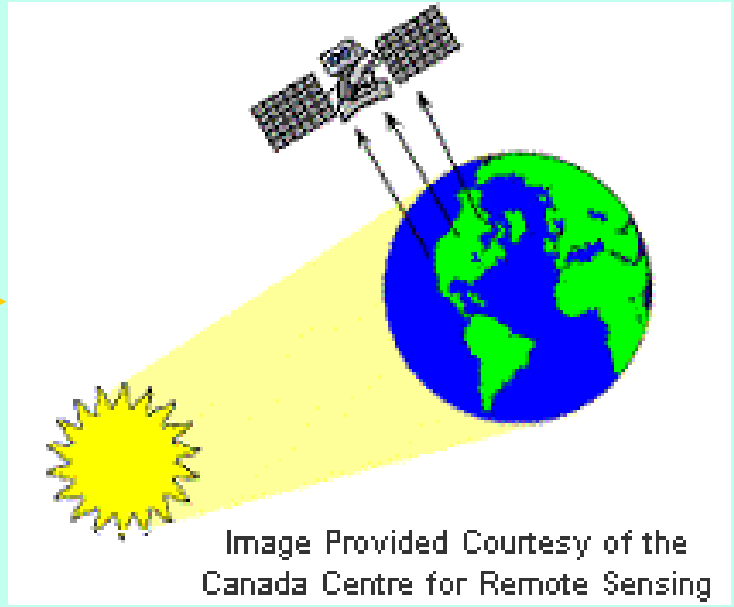

传感器
能源
摄影
地面站
信息记录
大气层
扫描
信息处理
地物
雷达
遥感应用
信息源
信息获取

Remote Sensing Categories（遥感分类）

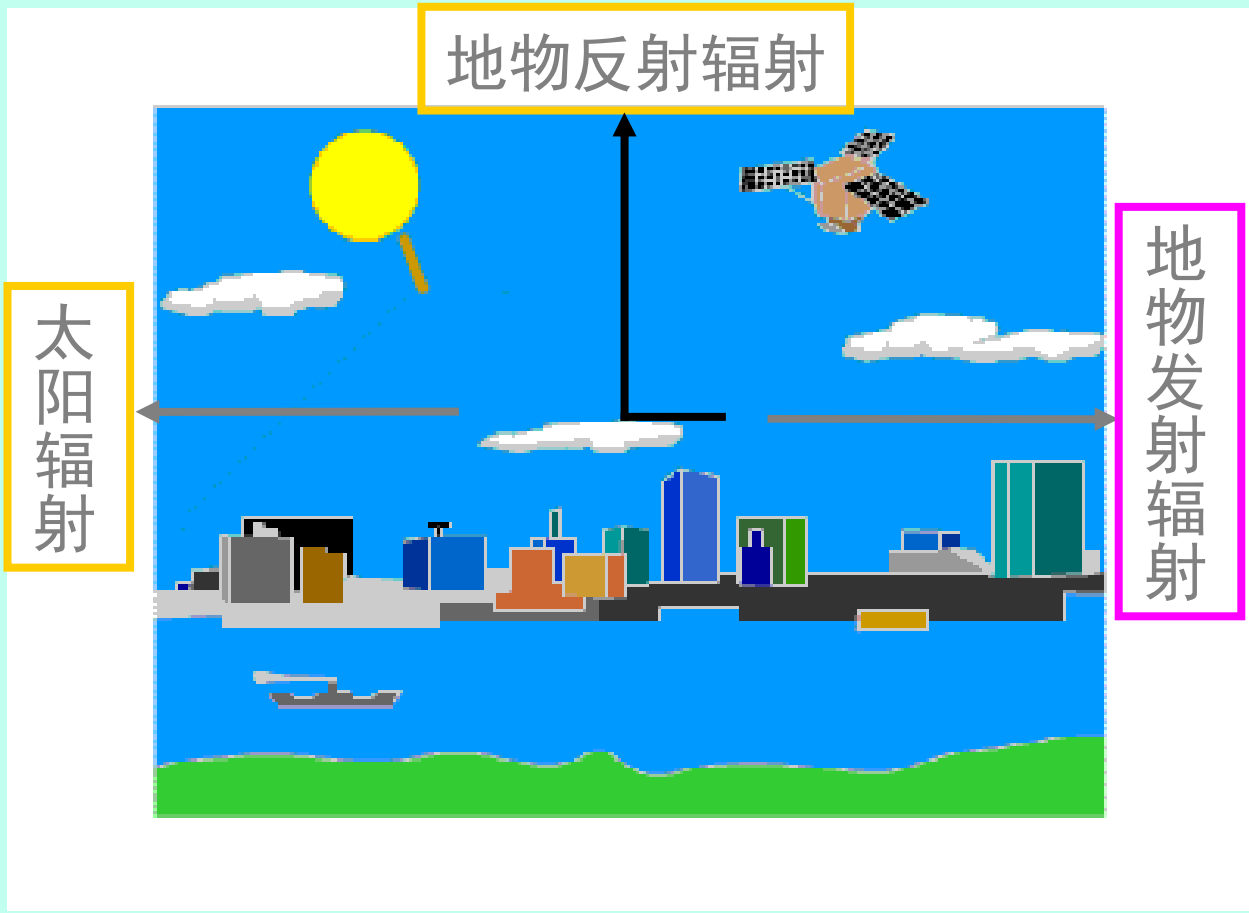
一、 按信息源分类

被动遥感

主动遥感



Passive Remote Sensing（被动遥感）

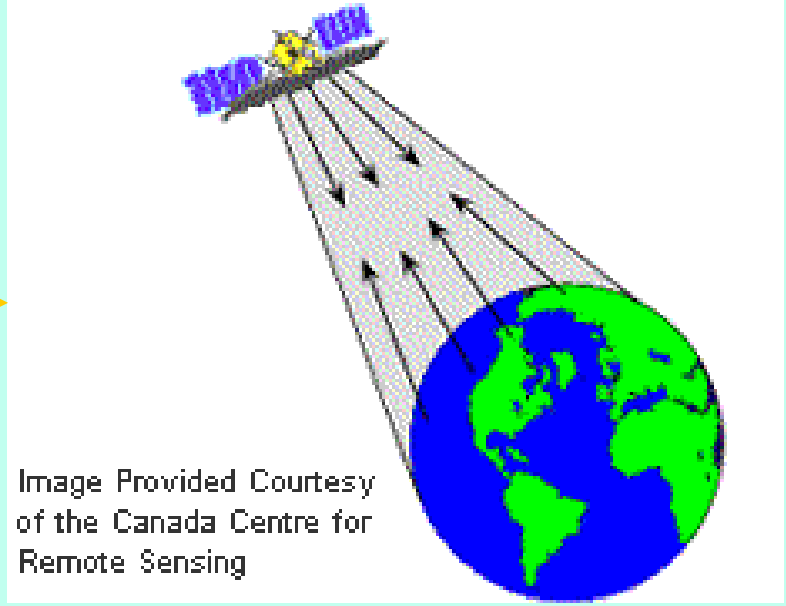


Remote Sensing Categories（遥感分类）

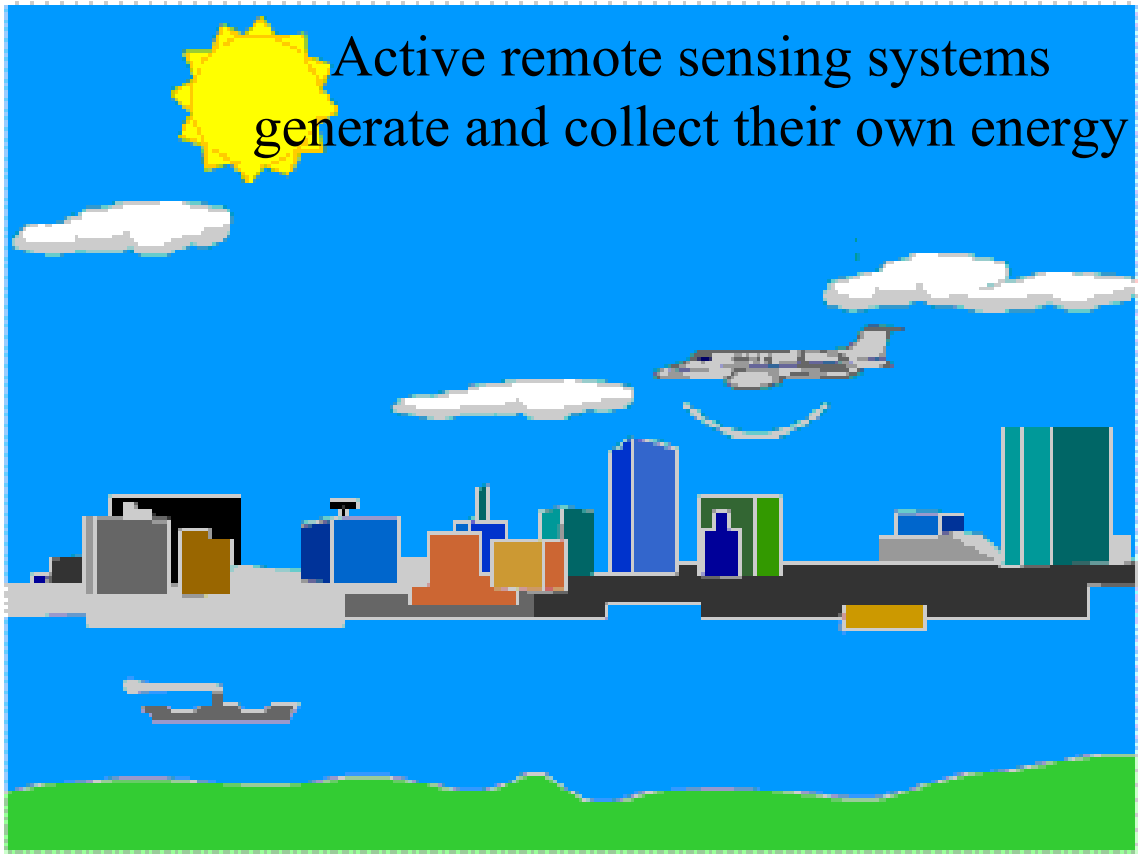
一、 按信息源分类

被动遥感

主动遥感



Active Remote Sensing（主动遥感）



Remote Sensing Categories（遥感分类）

二、按遥感平台分类

- 地面遥感
- 航空遥感
- 航天遥感

Remote Sensing Categories（遥感分类）

二、按遥感平台分类

- 地面遥感
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Remote Sensing Categories（遥感分类）

二、按遥感平台分类

- 地面遥感
- 航空遥感
- 航天遥感

Remote Sensing Categories（遥感分类）

三、按数据记录方式分类

成像遥感

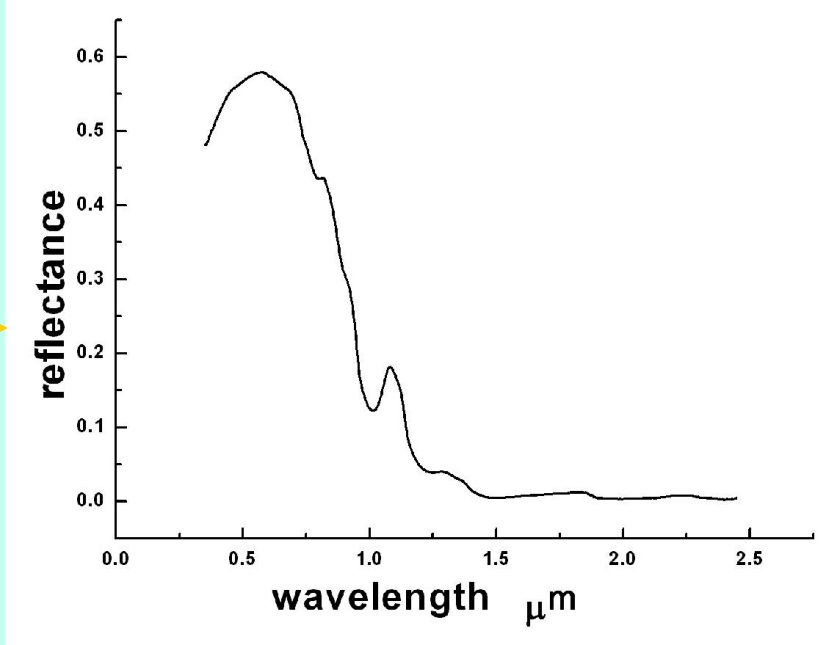
非成像遥感

Remote Sensing Categories（遥感分类）

三、按数据记录方式分类

成像遥感

非成像遥感



Remote Sensing Development（遥感发展史）

一、无纪录的地面遥感阶段:1608-1838

1608年，汉斯·李波尔赛制造了世界第一架望远镜，1609年伽利略制作了放大倍数3倍的科学望远镜，从而为观测远距离目标开辟了先河。但望远镜观测不能把观测到的事物用图像的方式记录下来。

Remote Sensing Development（遥感发展史）

二、有记录的地面遥感阶段：1839-1857

对探测目标的记录与成像始于摄影技术的发明，并与望远镜相结合发展为远距离摄影。1839年，达盖尔发表了他和尼普斯拍摄的照，第一次成功地把拍摄到事物形象地记录在胶片上。1849年，法国人艾米·劳塞达特制定了摄影测量计划，成为有目的有记录的地面遥感发展阶段的标志。

Remote Sensing Development（遥感发展史）

三、航空遥感摄影阶段：1858-1956

1858年，G·F·陶纳乔用气球拍摄了法国巴黎的"鸟瞰"像片。

1860年，J·W·布莱克与S·金乘气球升空至603 m 成功地拍摄了美国波士顿市的照片。

1903年W·莱特和O.莱特发明了飞机，促进了航空遥感向实用化的迈进。

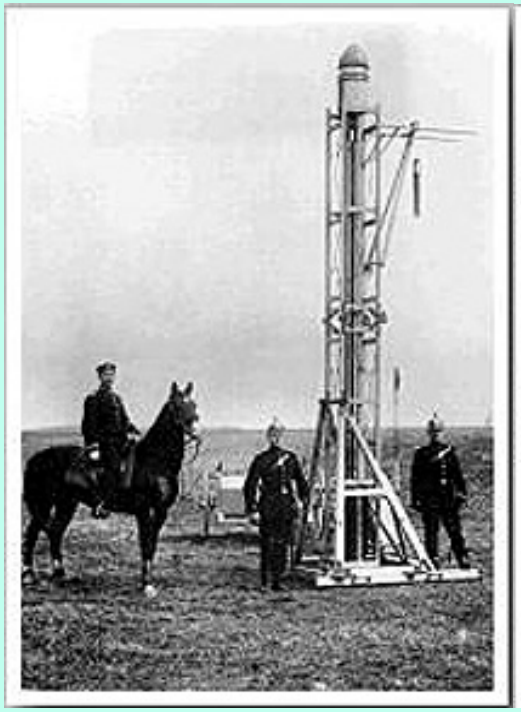
在第一次世界大战期间1914—1918，航空摄影成了军事侦察的重要手段，并形成了一定的规模。

在第二次世界大战期间1939—1945，出现微波雷达及红外技术并应用于军事侦察，扩展了遥感探测的电磁波谱段。

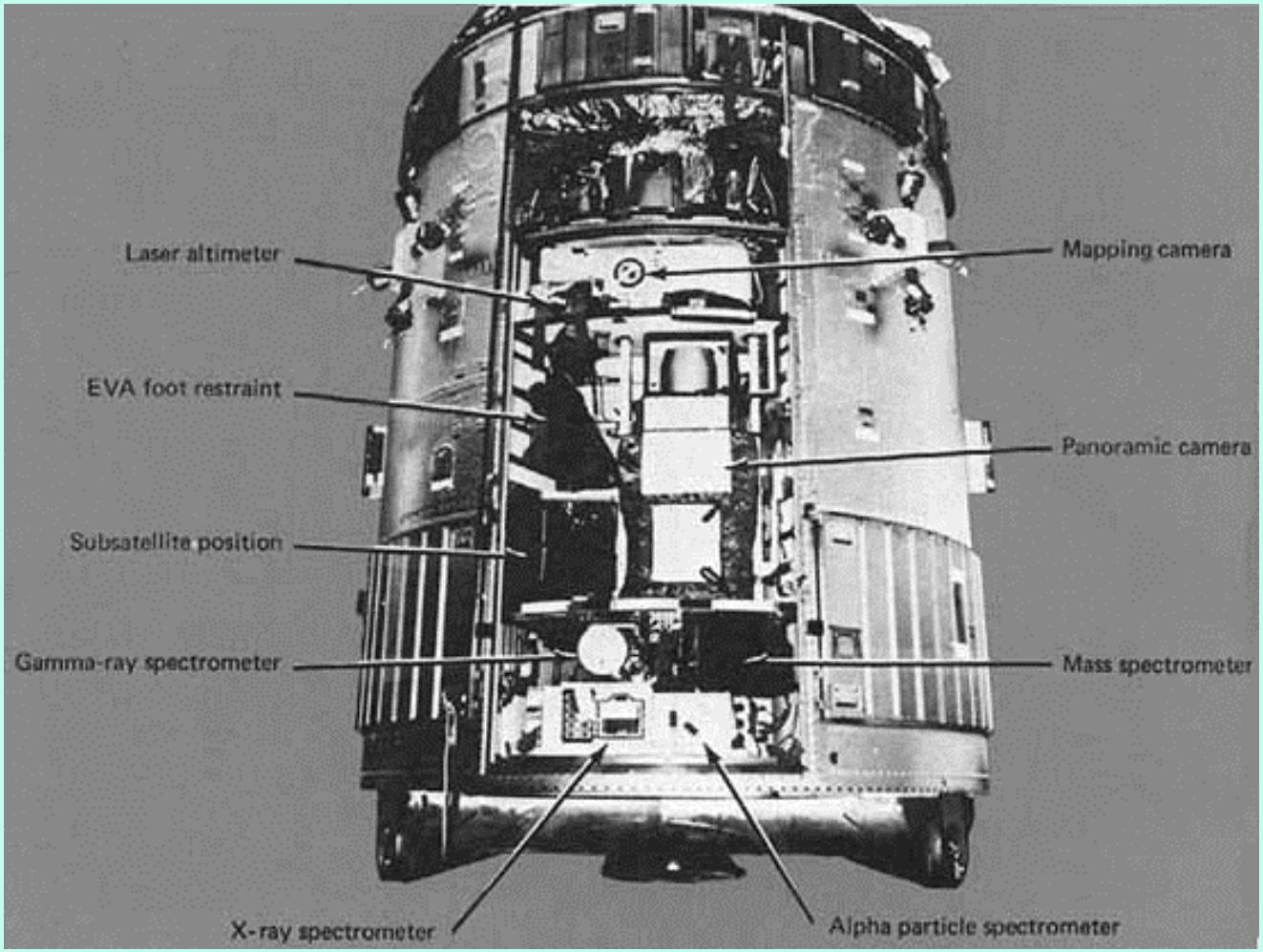
Remote Sensing Development（遥感发展史）

四、航天遥感摄影阶段：1957-

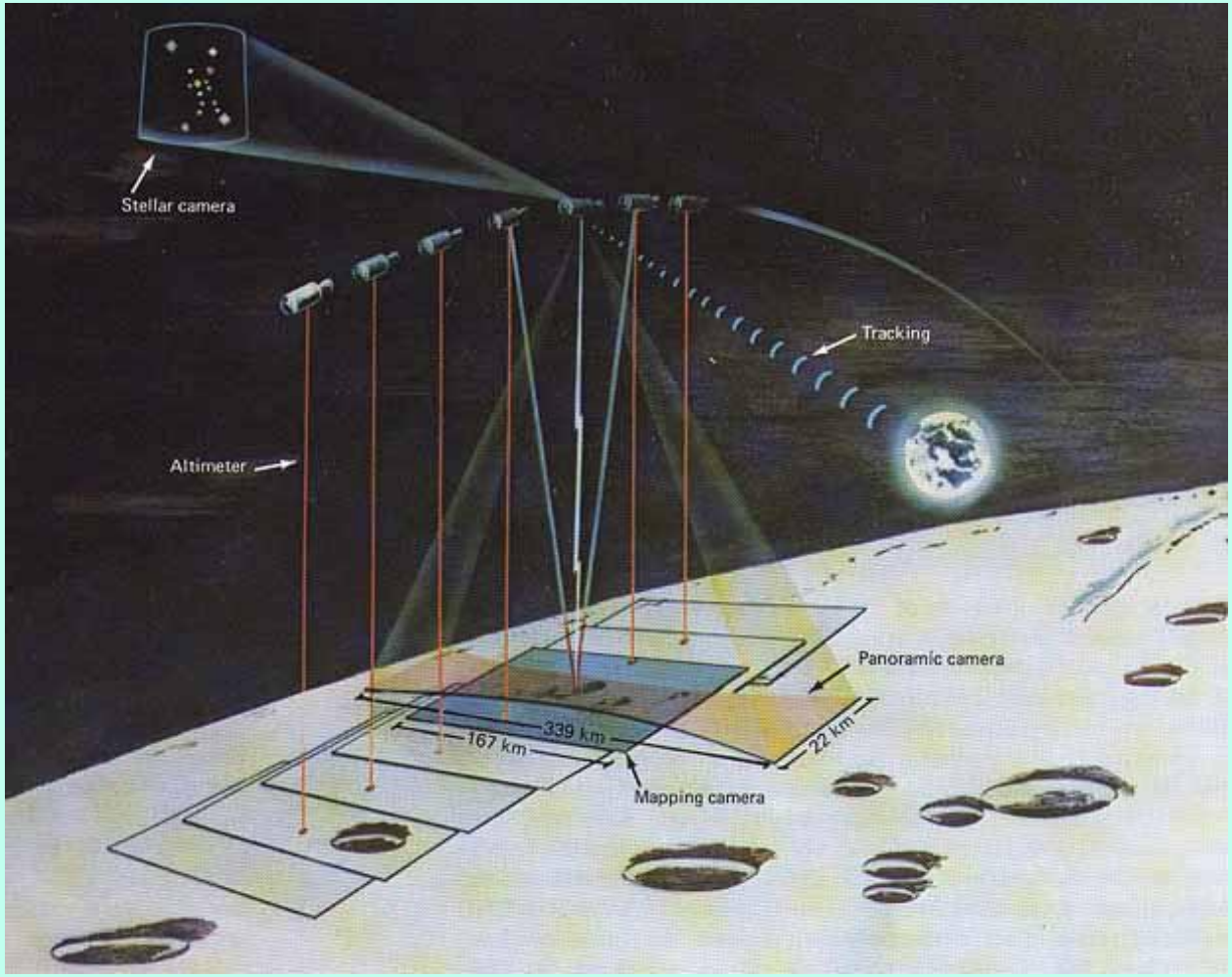
1912年，德国人摩尔发射了一枚火箭，将一架 200毫米 × 250毫米的照像机带到 790米的高空摄影。



Apollo photographic system



The mapping camera system consisted of a terrain camera coupled to a stellar camera and a laser altimeter. Each exposure of the terrain camera was accompanied by a stellar camera exposure of the star field to provide a means of determining the orientation of the spacecraft in space. Simultaneously the laser altimeter recorded the height of the spacecraft above the Moon's surface.

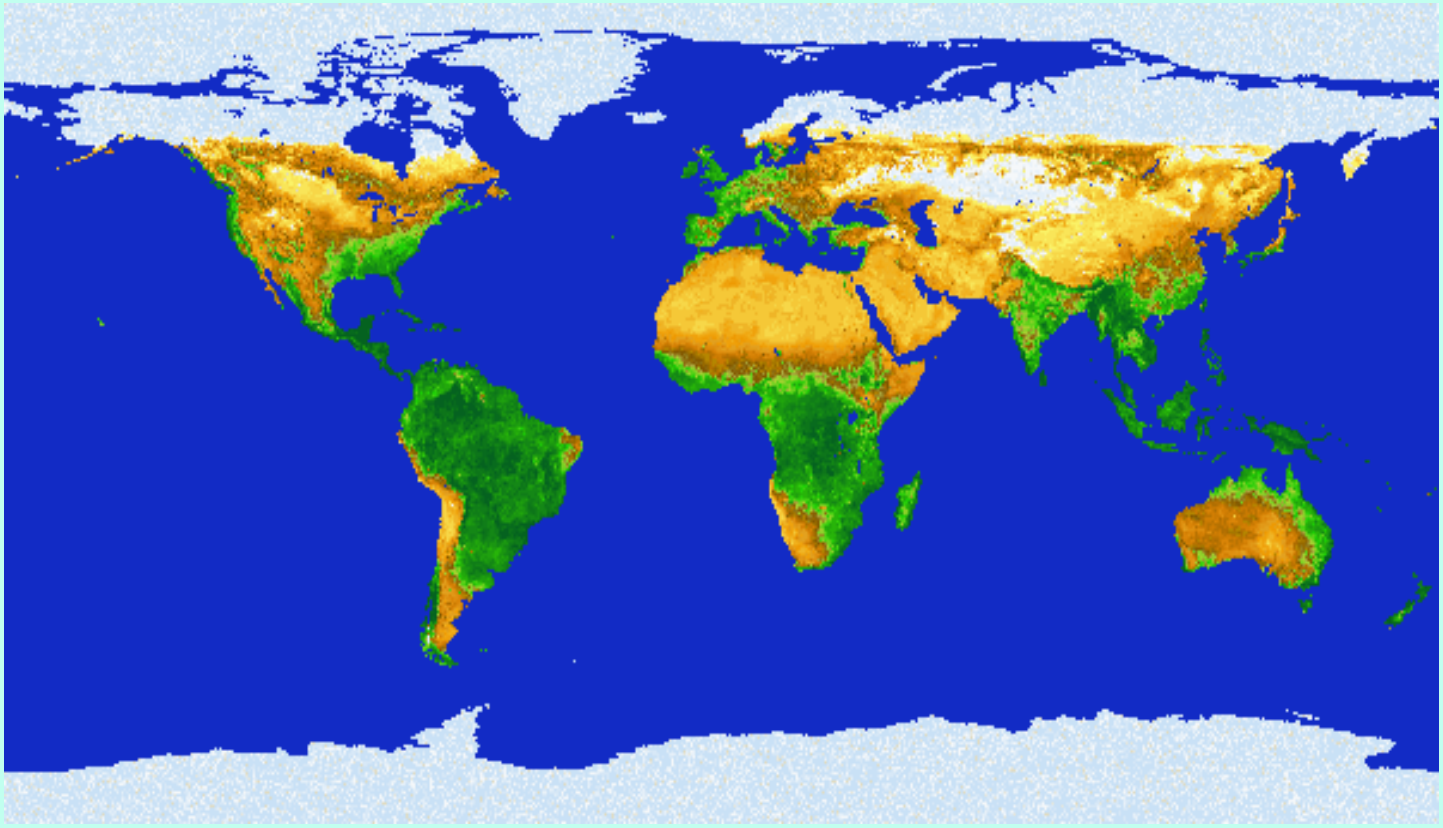


From "*APOLLO OVER THE MOON: A VIEW FROM ORBIT*" by Harold Masursky et al

For the mapping camera, when the axis is perpendicular to the surface (red lines), each exposure outlines a square area (the blue parallelogram in this perspective view).
For the panoramic camera, the areas covered by each exposure overlap to form a continuous strip across the surface.

World Vegetation 1999

World vegetation 2000-2001



Source: http://www.spotimaging.fr

HYPERCOMP
Hyperspectral Computing Laboratory

Discusssion !

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HYPERCOMP
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Hyperspectral Image Analysis:
高光谱遥感分析
Lecture 1: Remote Sensing(Part2)

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Basic Concept（基本概念）

Spatial resolution（空间分辨率）

Spectral resolution（光谱分辨率）

Temporal resolution（时间分辨率）

Panchromatic（全色）

Multispectral（多光谱）

Hyperspectral（高光谱）

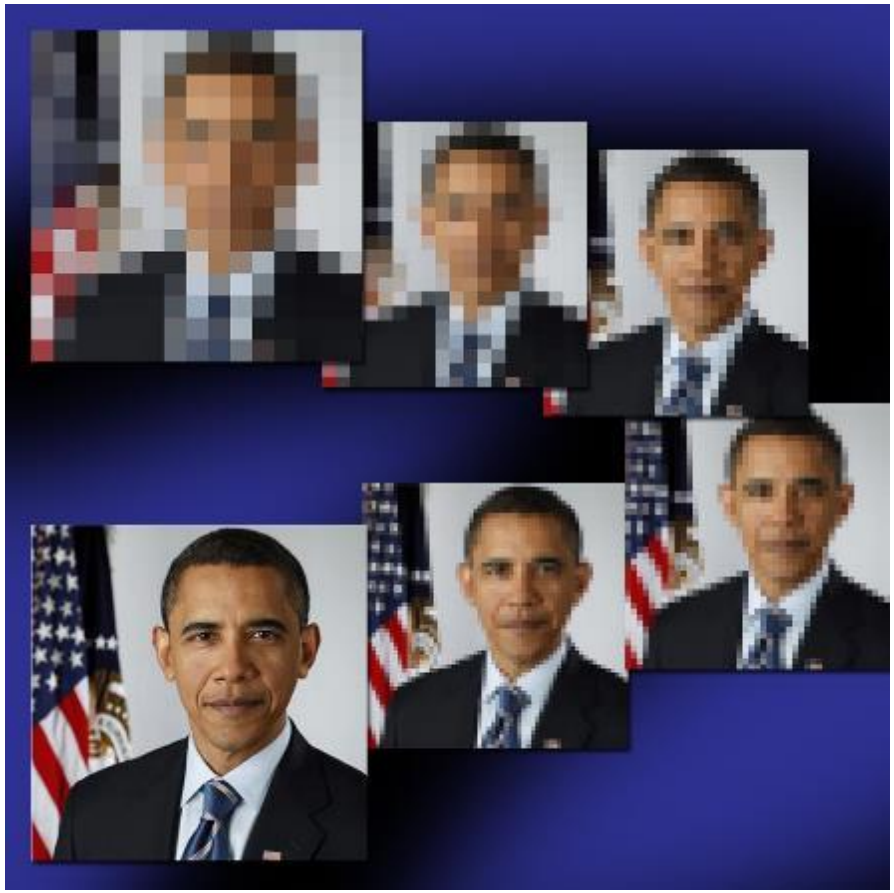
Spatial resolution（空间分辨率）

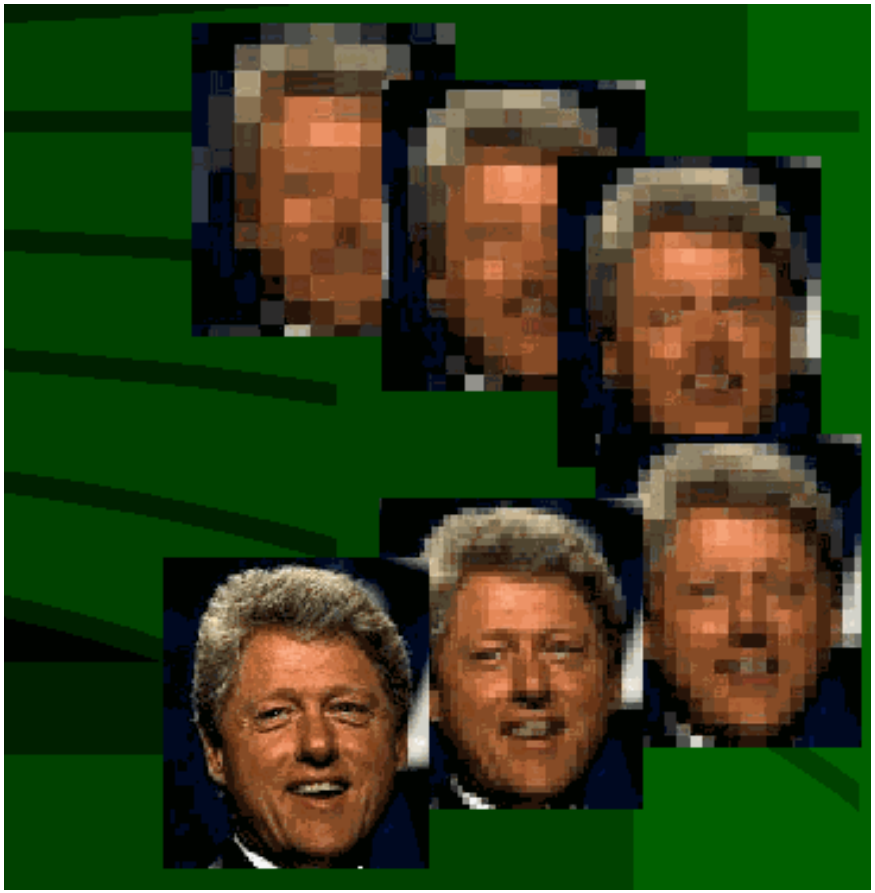
Spatial resolution is a term that refers to **the number of pixels** utilized in construction of a digital image. Images having higher spatial resolution are composed with a greater number of pixels than those of lower spatial resolution.

空间分辨率是指像素所代表的的地面范围的大小，即扫描仪的瞬时视场，或地面物体能分辨的最小单元。

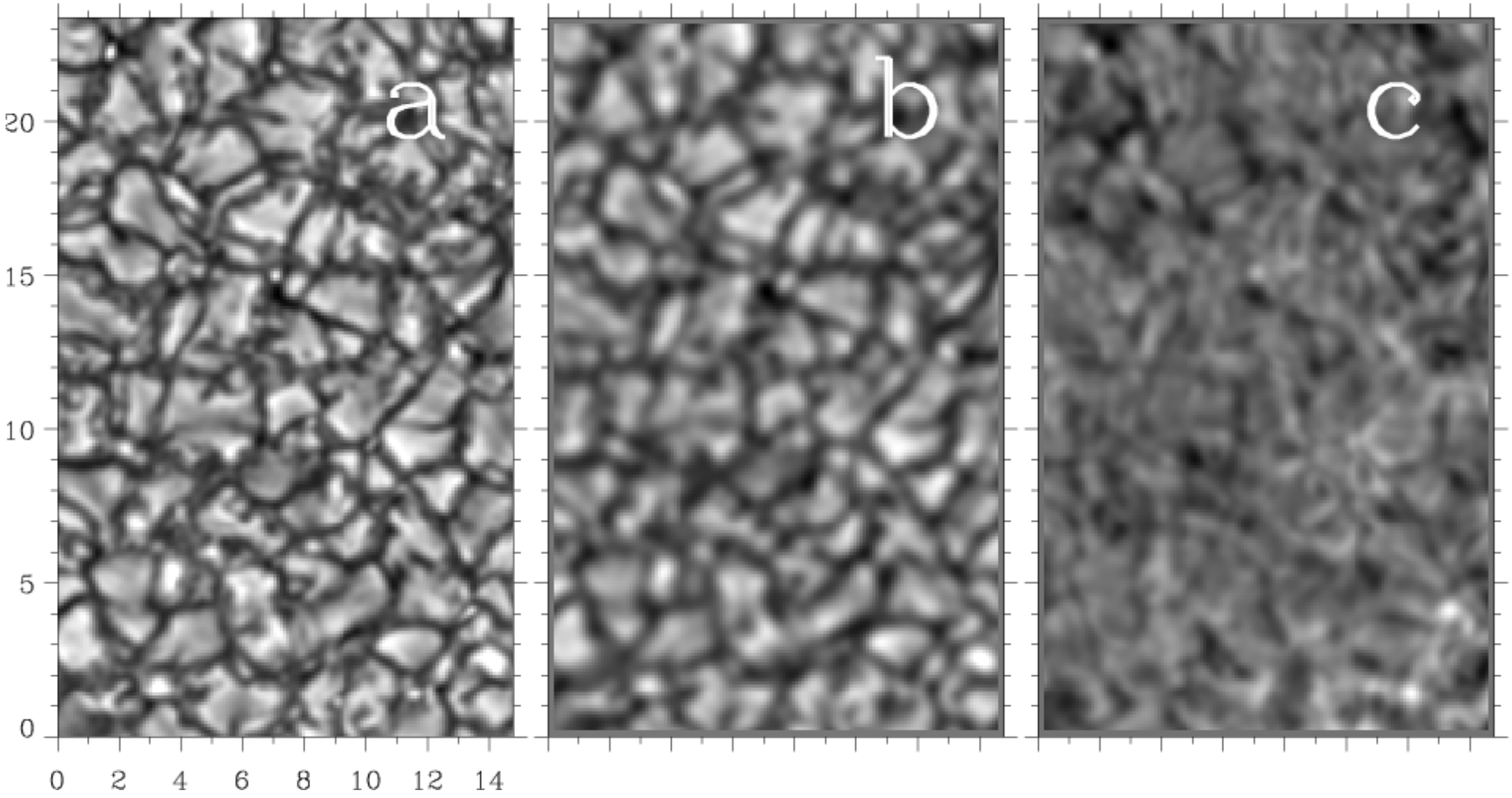
空间分辨率是指遥感影像上能够识别的两个相邻地物的最小距离。

Spatial resolution（空间分辨率）



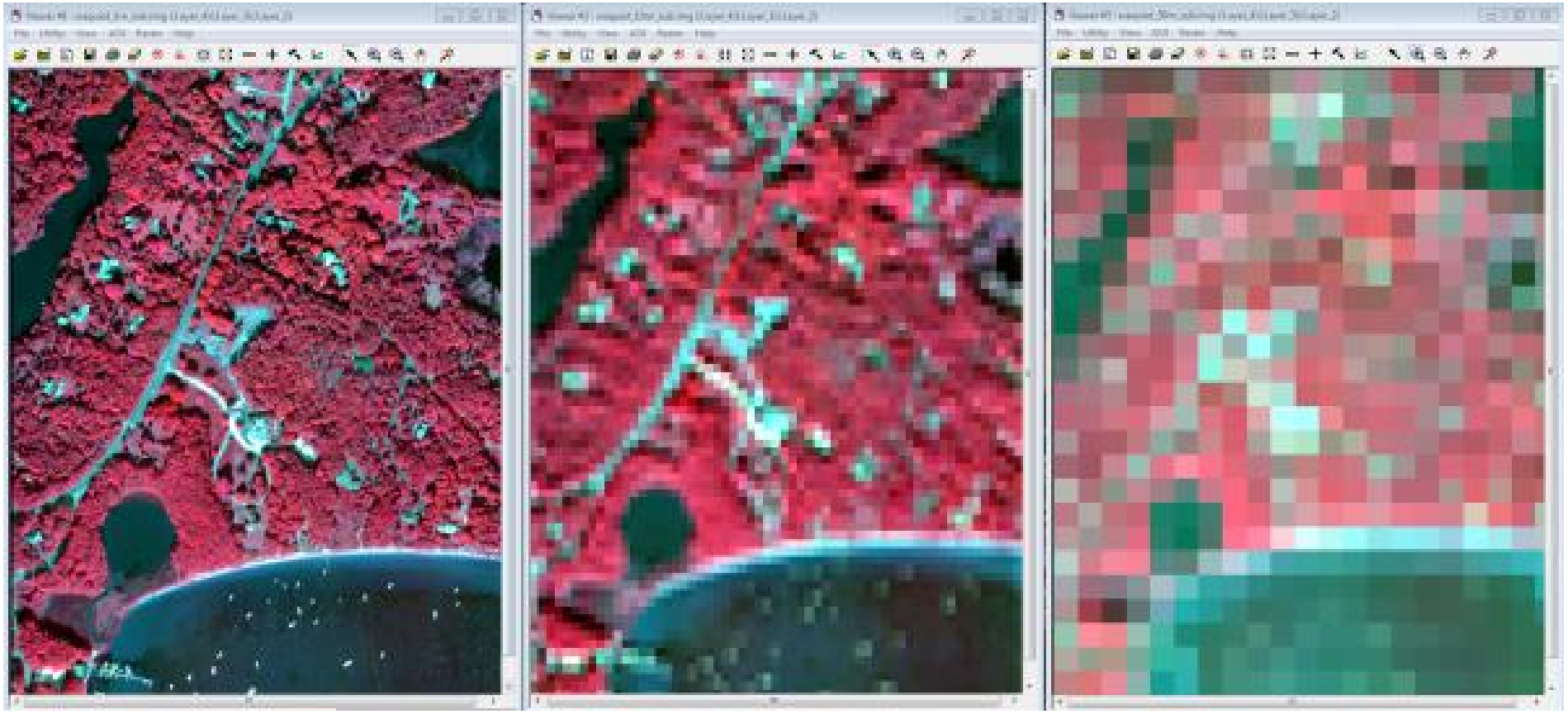


Spatial resolution（空间分辨率）



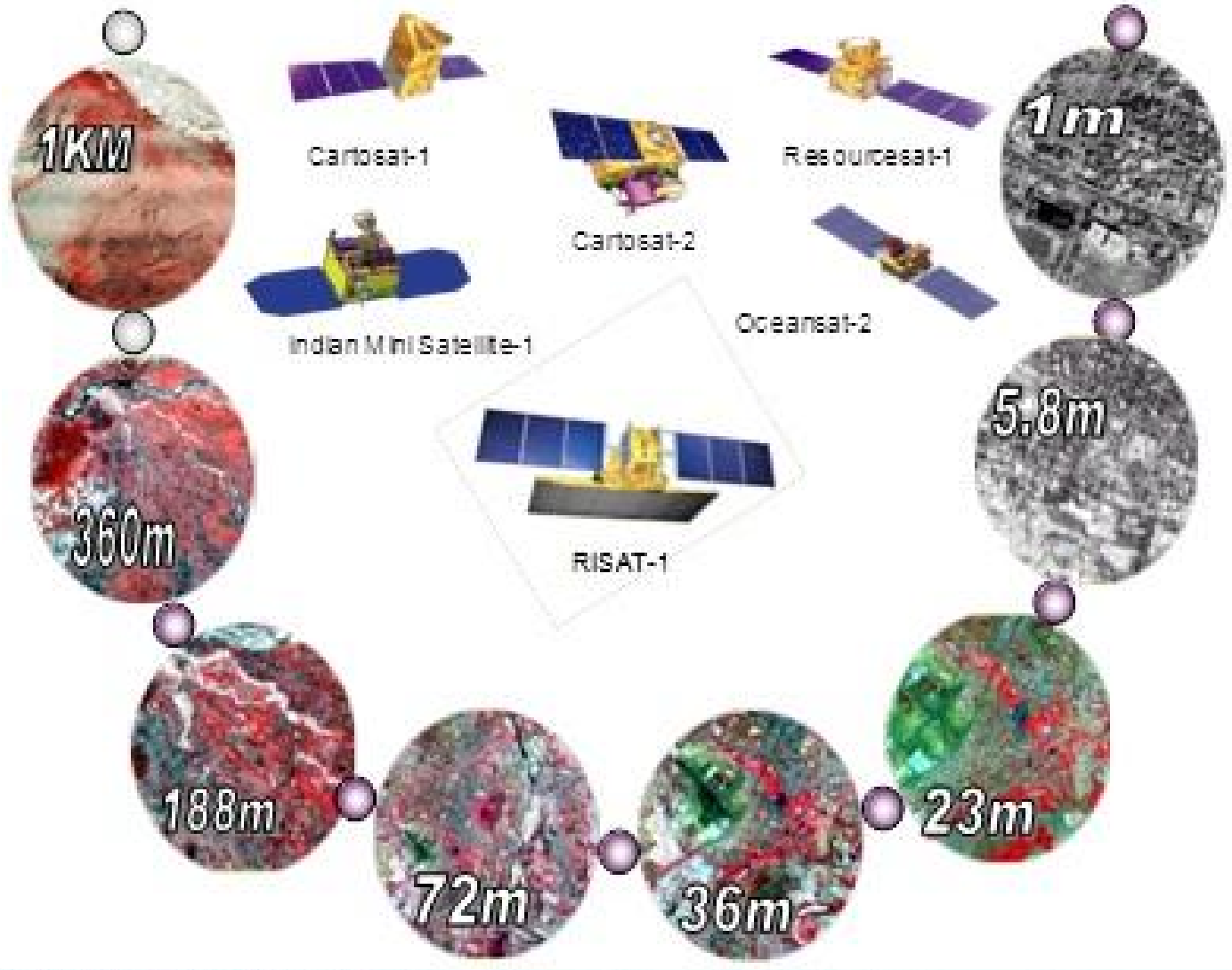
High resolution ⟷ Low resolution

Spatial resolution（空间分辨率）



High resolution ⟷ Low resolution

Spatial resolution（空间分辨率）



Basic Concept（基本概念）

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Hyperspectral（高光谱）

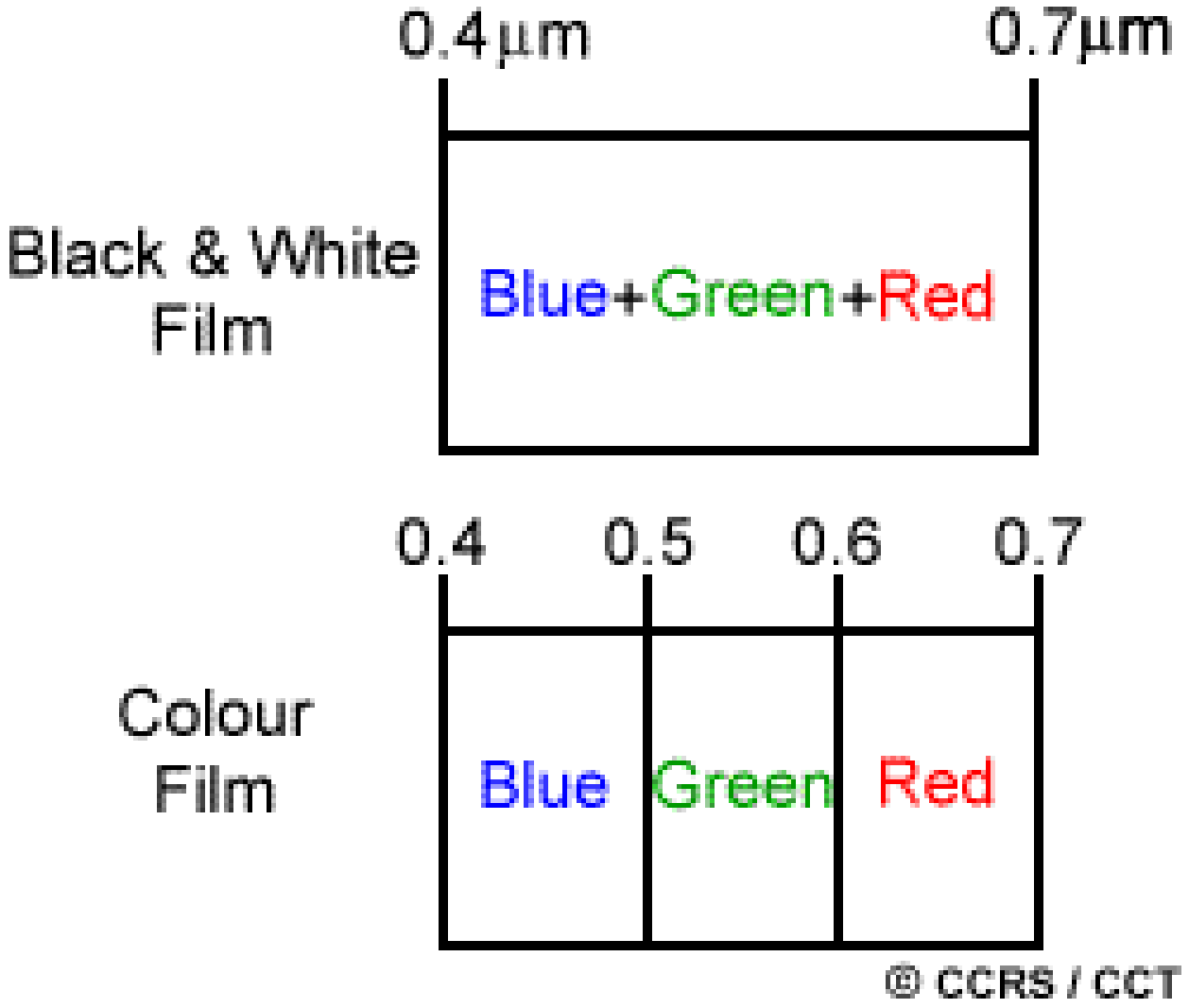
Spectral resolution（光谱分辨率）

The **spectral resolution** of a spectrograph, or, more generally, of a frequency spectrum, is a measure of its ability to resolve features in the electromagnetic spectrum.

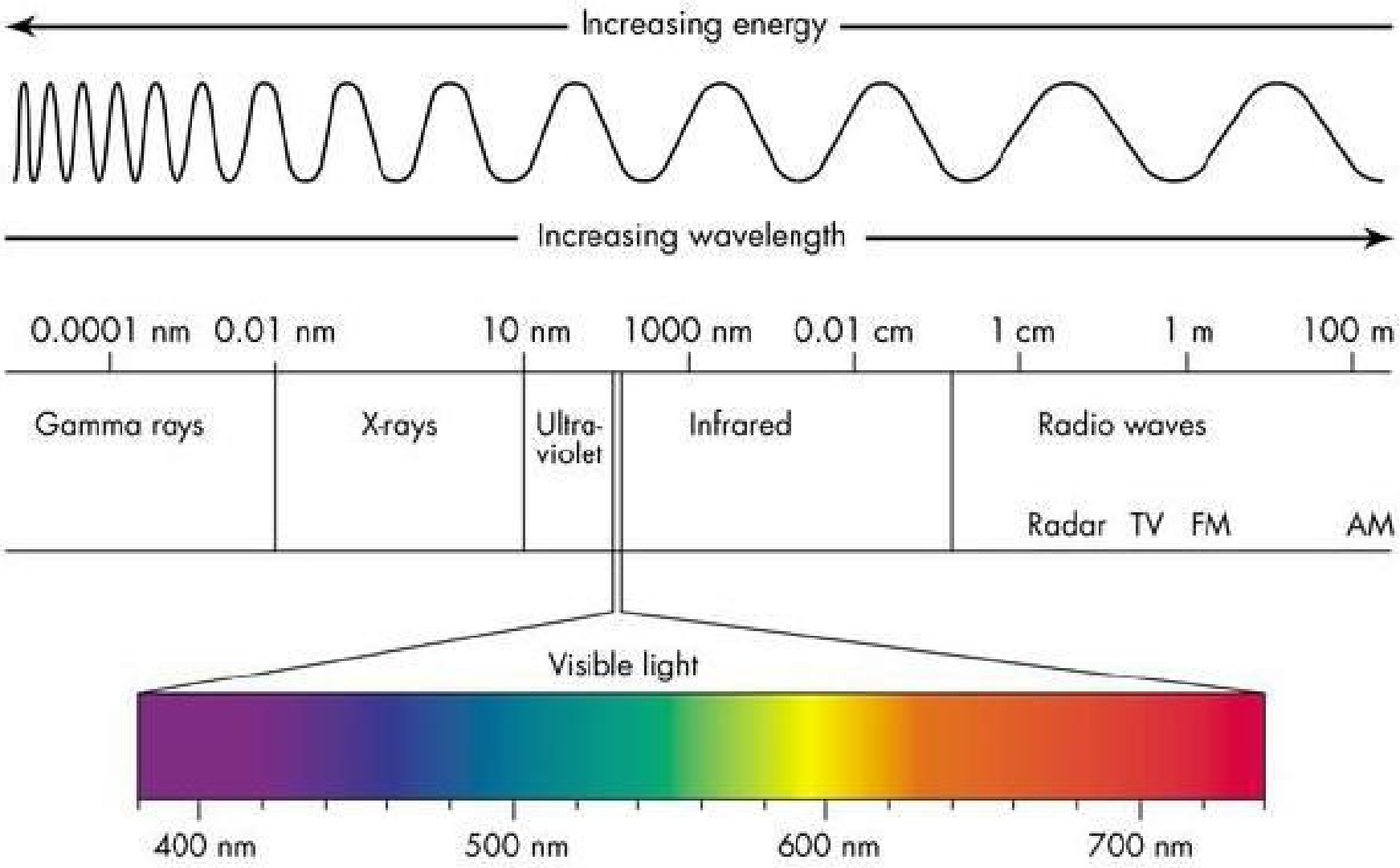
光谱分辨率是指探测器在波长方向上的记录宽度，又称波段宽度(band width)。

光谱分辨率为探测光谱辐射能量的最小波长间隔，而确切的讲，为光谱探测能力。

Spectral resolution（光谱分辨率）



Spectral resolution（光谱分辨率）



Basic Concept（基本概念）

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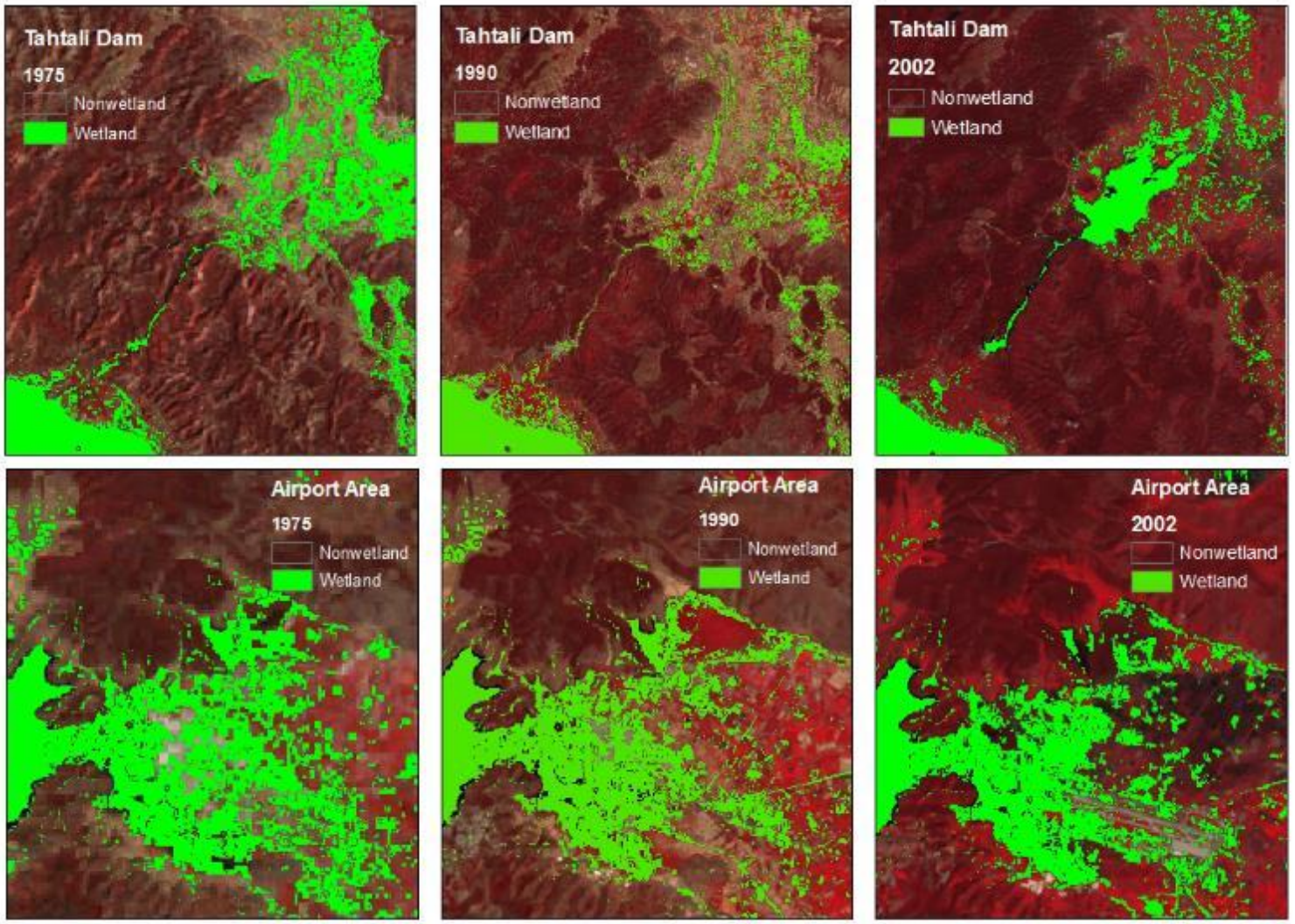
Temporal resolution（时间分辨率）

Temporal resolution (TR) refers to the precision of a measurement with respect to **time**. Often there is a tradeoff between temporal resolution of a measurement and its spatial resolution.

时间分辨率是指在同一区域进行的相邻两次遥感观测的最小时间间隔。对轨道卫星而言，亦称覆盖周期。

时间间隔大，时间分辨率低，反之时间分辨率高。

Temporal resolution（时间分辨率）



Basic Concept（基本概念）

Remote Sensing（遥感）

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Spectral resolution（光谱分辨率）

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Hyperspectral（高光谱）

Panchromatic(全色)

Panchromatic refers to black and white imagery exposed by all visible light. However, panchromatic photography and digital imagery is often acquired using a minus blue filter to reduce the scattering that occurs in those blue wavelengths.

全色波段，一般指使用0.5微米到0.75微米左右的单波段，即从绿色往后的可见光波段。全色遥感影象也就是对地物辐射中全色波段的影象摄取，因为是单波段，在图上显示是灰度图片。全色遥感影象一般空间分辨率高，但无法显示地物色彩。

Panchromatic（全色）

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Multispectral（多光谱）

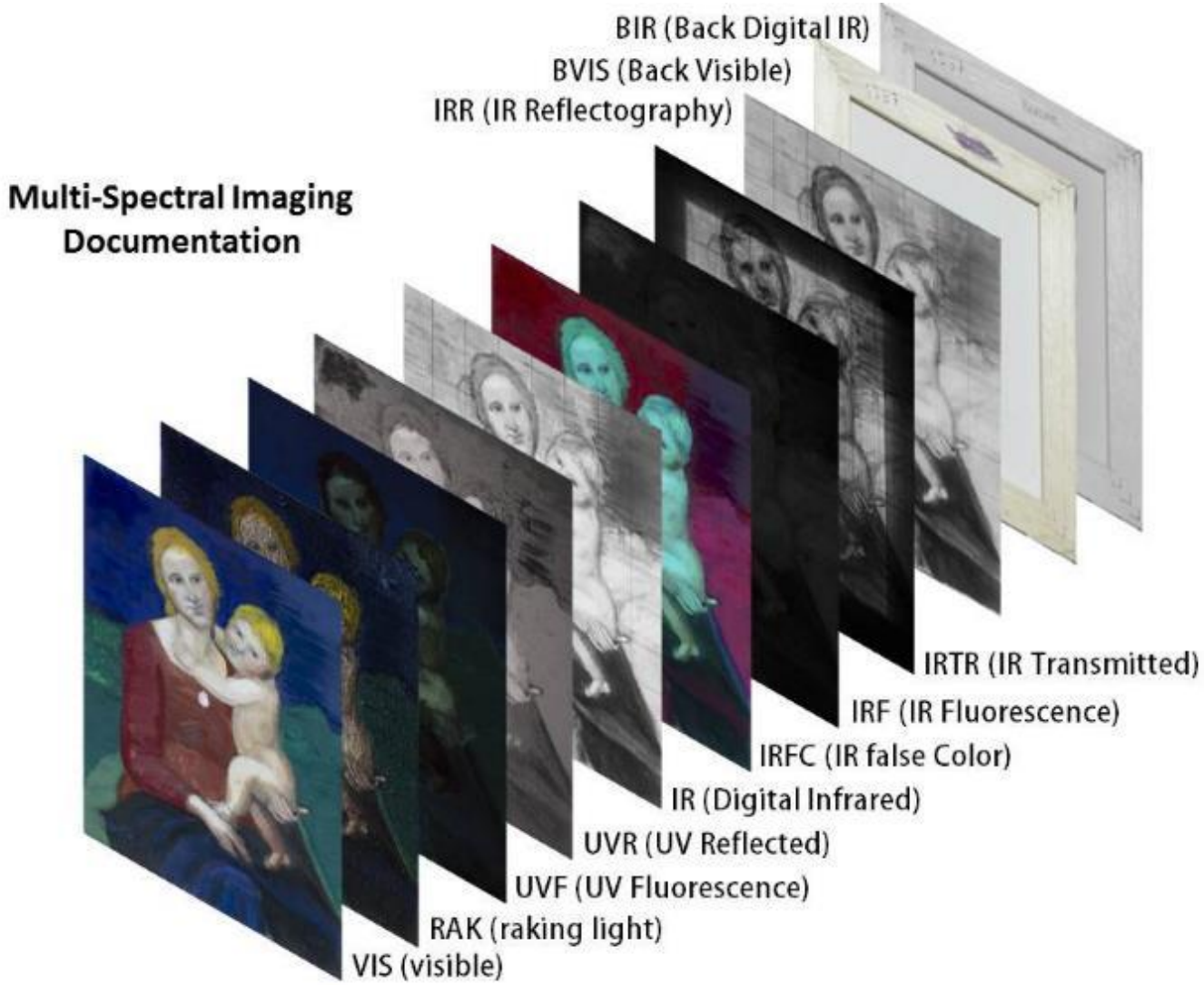
Hyperspectral（高光谱）

Multispectral（多光谱）

A **multispectral** image is one that captures image data at specific frequencies across the electromagnetic spectrum. The wavelengths may be separated by filters or by the use of instruments that are sensitive to particular wavelengths, including light from frequencies beyond the visible light range, such as infrared.

多光谱分辨率遥感，是利用具有两个以上波谱通道的传感器对地物进行同步成像的一种遥感技术，它将物体反射辐射的电磁波信息分成若干波谱段进行接收和记录。

Multispectral（多光谱）



Basic Concept（基本概念）

Remote Sensing（遥感）

Spatial resolution（空间分辨率）

Spectral resolution（光谱分辨率）

Temporal resolution（时间分辨率）

Panchromatic（全色）

Multispectral（多光谱）

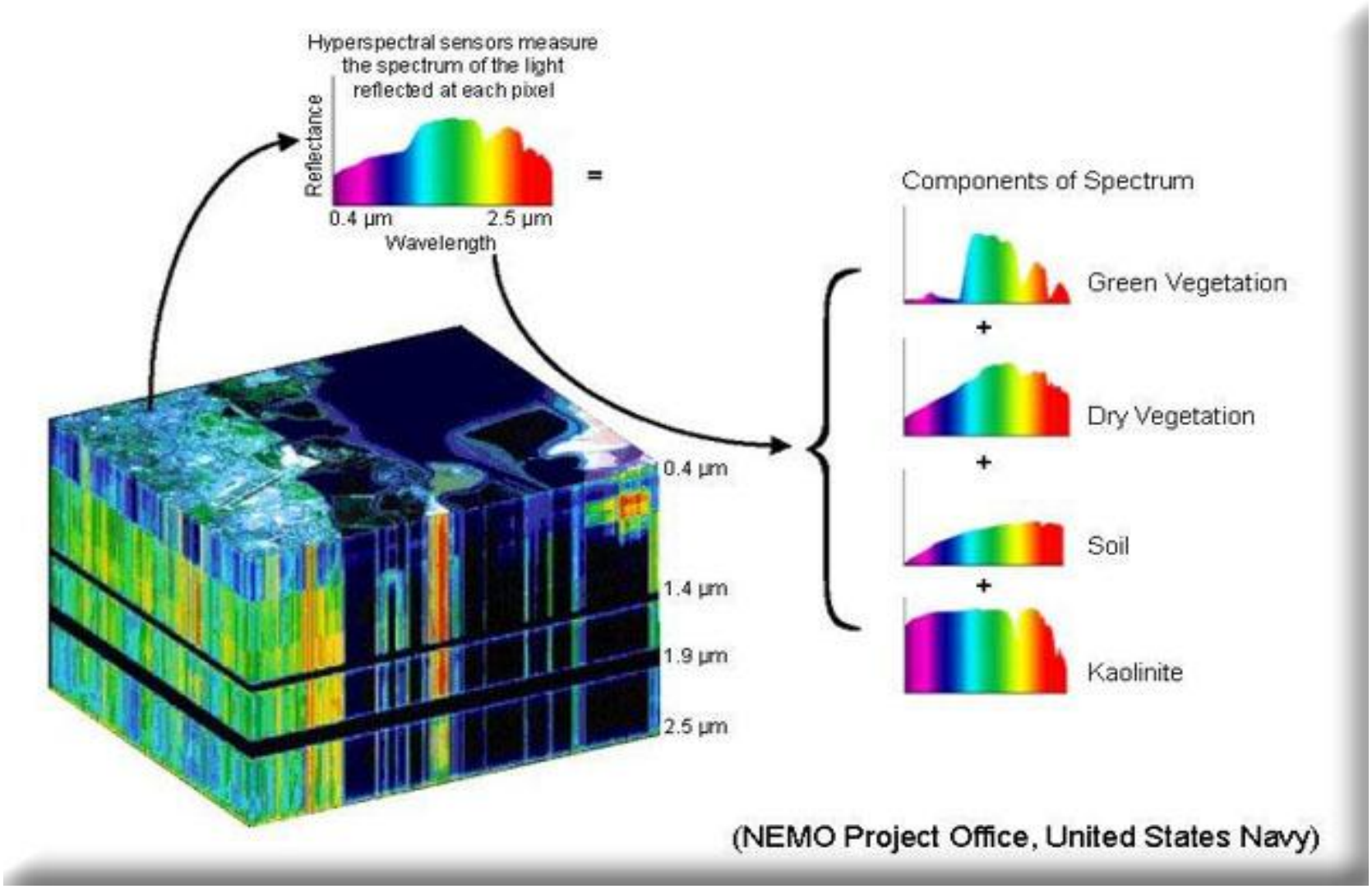
Hyperspectral（高光谱）

Hyperspectral（高光谱）

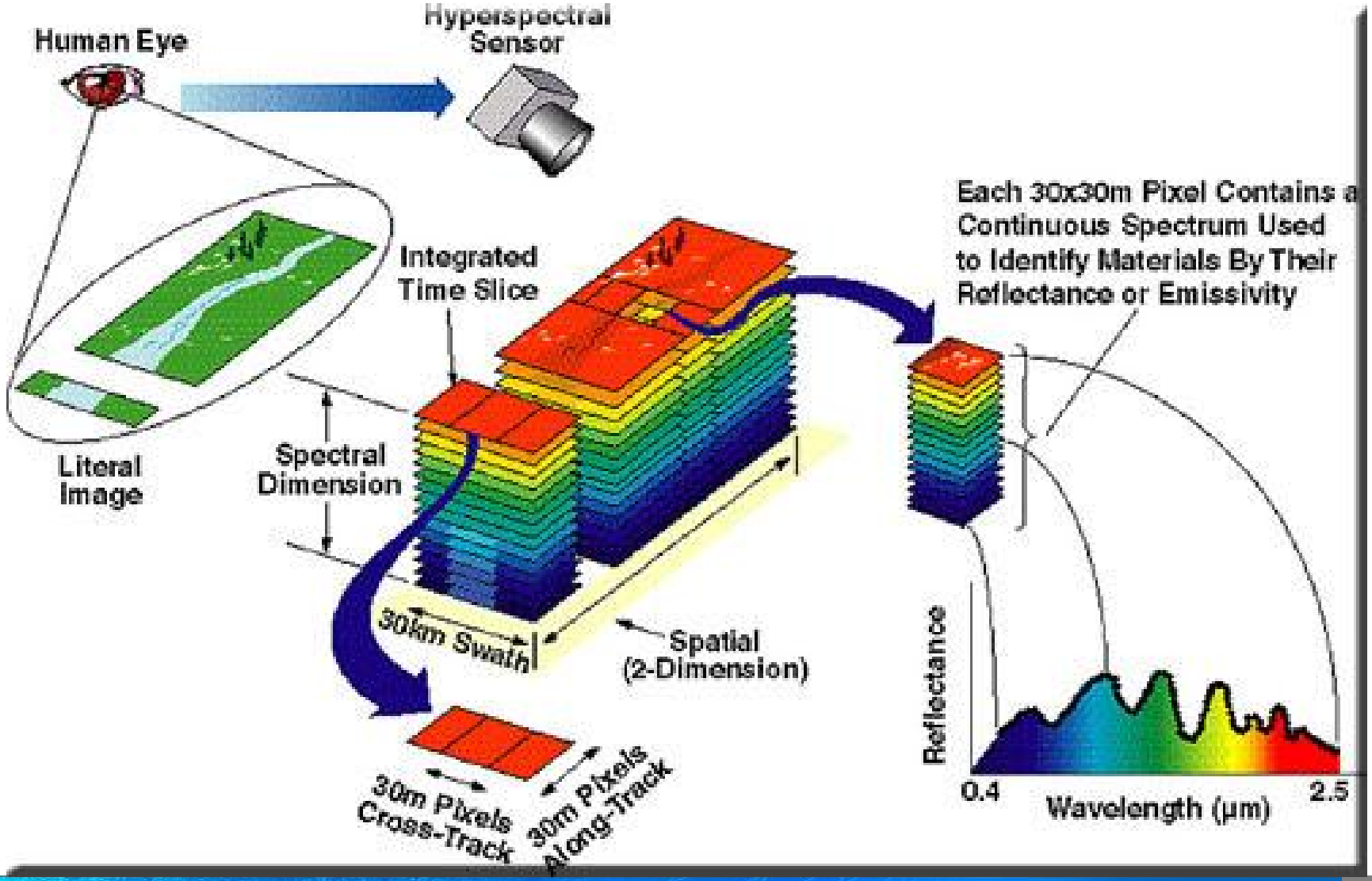
Hyperspectral imaging, like other spectral imaging, collects and processes information from across the electromagnetic spectrum. The goal of hyperspectral imaging is to obtain the spectrum for each pixel in the image of a scene, with the purpose of finding objects, identifying materials, or detecting processes.

高光谱分辨率遥感在电磁波谱的可见光、近红外、中红外和热红外波段范围内，获取许多非常窄的光谱连续的影像数据的技术。其成像光谱仪可以收集到上百个非常窄的光谱波段信息。

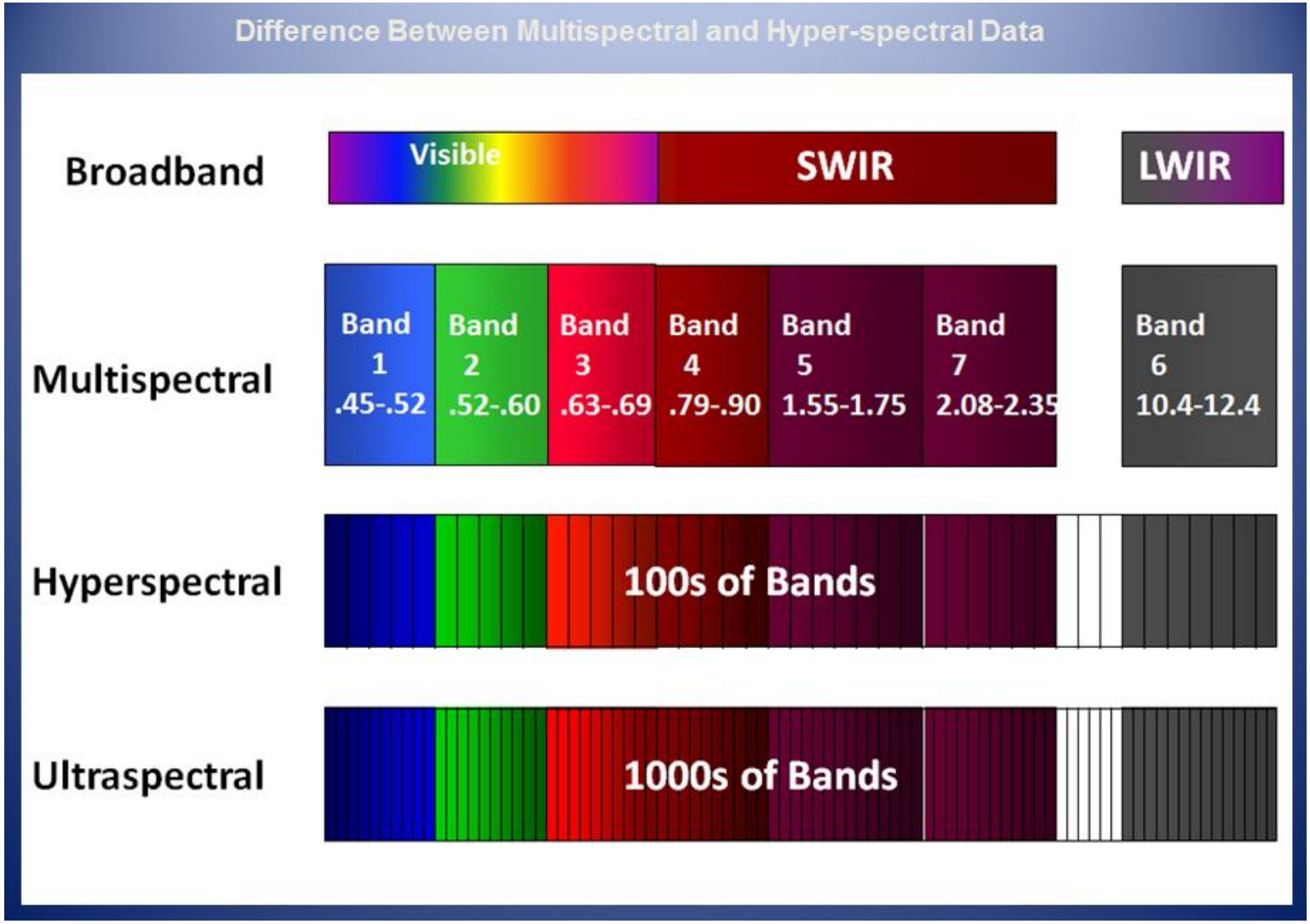
Hyperspectral（高光谱）



Hyperspectral（高光谱）



Multispectral & Hyperspectral



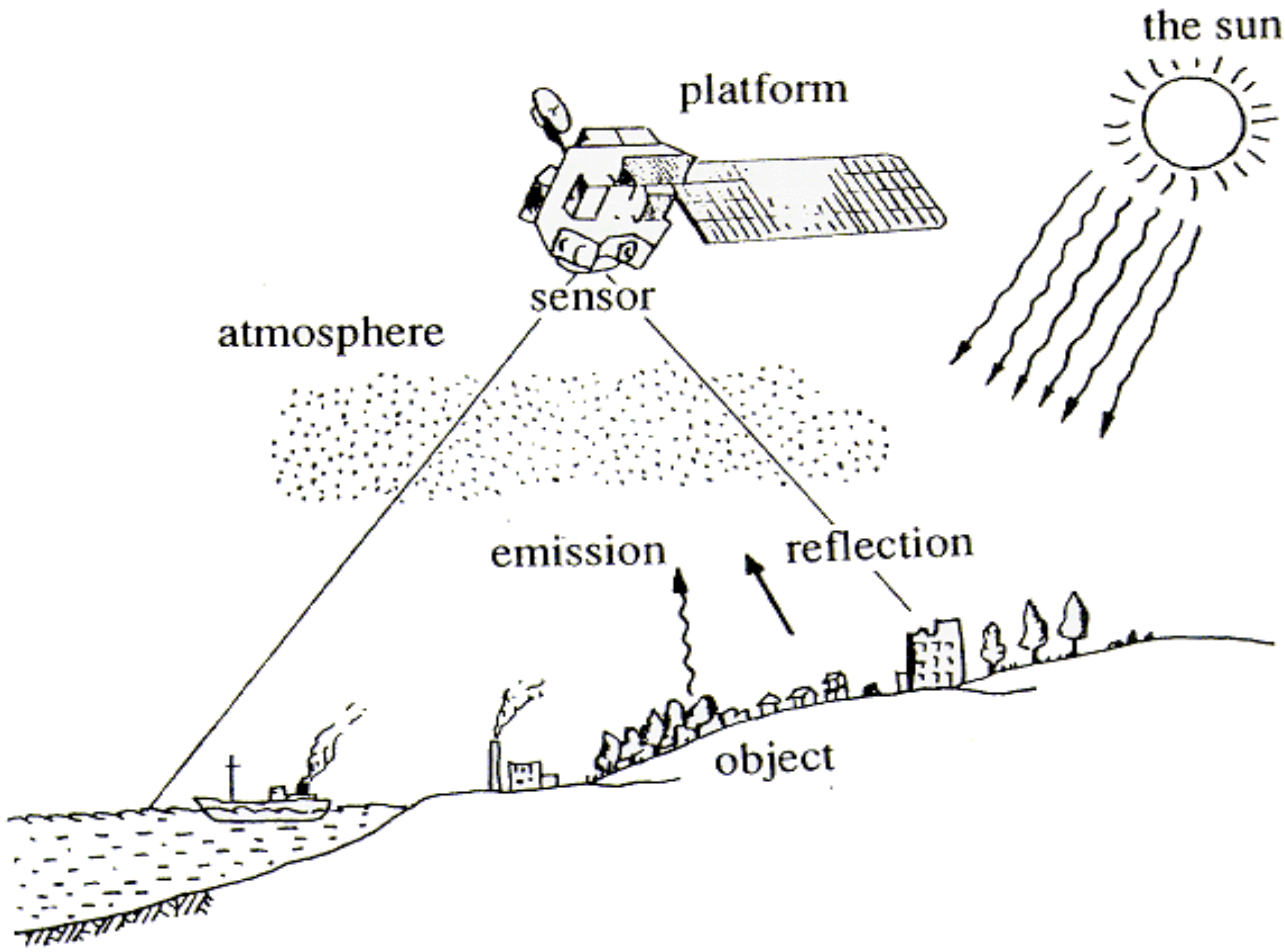


Figure1.1.1 Data collection by remote sensing

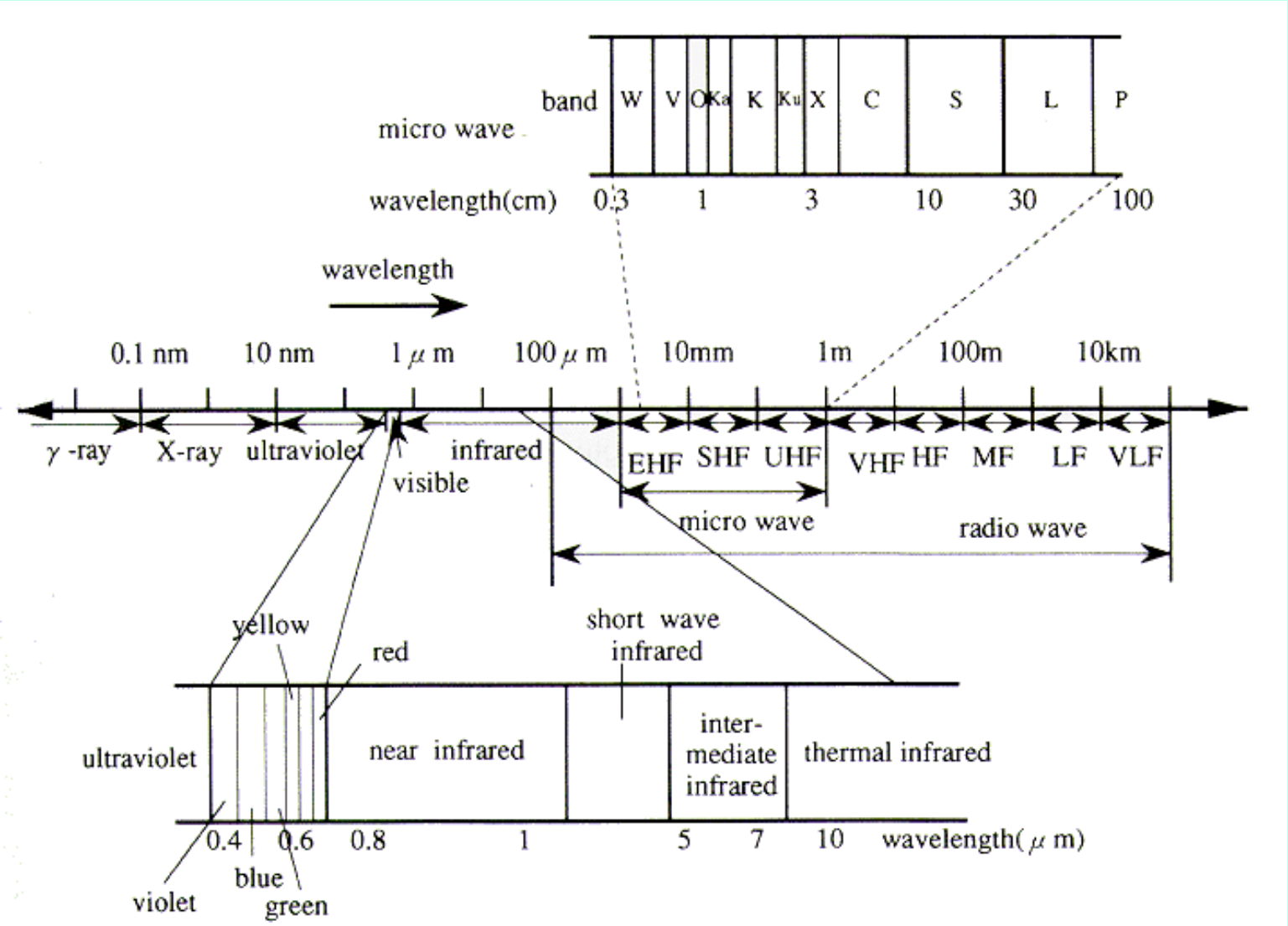
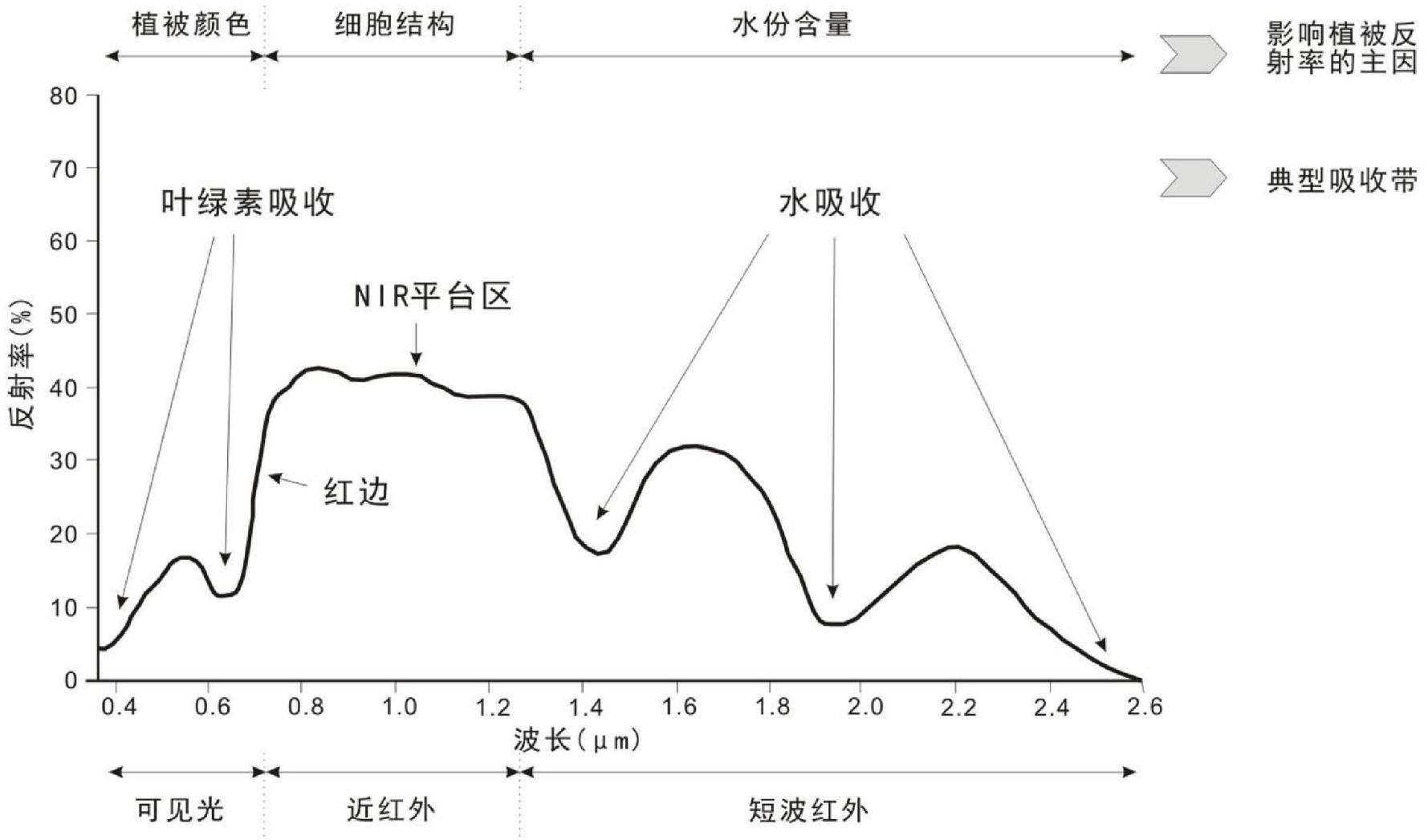


Figure 1.4.1 The bands used in remote sensing

Parameter	HYDICE	AVIRIS	HYPERION	EnMAP	PRISMA	CHRIS	HyspIRI	IASI
Altitude (Km)	1.6	20	705	653	614	556	626	817
Spatial resolution (m)	0.75	20	30	30	5-30	36	60	V: 1-2 km H: 25 km
Spectral resolution (nm)	7-14	10	10	6.5-10	10	1.3-12	4-12	0.5 cm^{-1}
Coverage (µm)	0.4-2.5	0.4-2.5	0.4-2.5	0.4-2.5	0.4-2.5	0.4-1.0	0.38-2.5 & 7.5-12	3.62-15.5 (645-2760 cm^{-1})
Number of bands	210	224	220	228	238	63	217	8461
Data cube size (samples x lines x bands)	200x320 x210	512x614 x224	660x256 x220	1000x1000 x228	400x880 x238	748x748 x63	620x512 x210	765x120 x8461


植被颜色
细胞结构
水份含量
影响植被反射率的主因
典型吸收带
叶绿素吸收
水吸收
NIR平台区
红边
反射率(%)
80
70
60
50
40
30
20
10
0
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
波长(μm)
可见光
近红外
短波红外

HYPERCOMP
Hyperspectral Computing Laboratory

Discusssion !

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