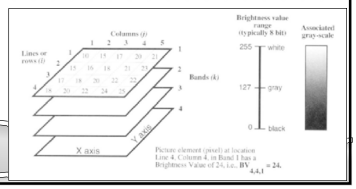
REMOTE SENSING

Topic 10 Fundamentals of Digital Multispectral Remote Sensing

Chapter 5: Lillesand and Keifer
Chapter 6: Avery and Berlin

MULTISPECTRAL SCANNERS

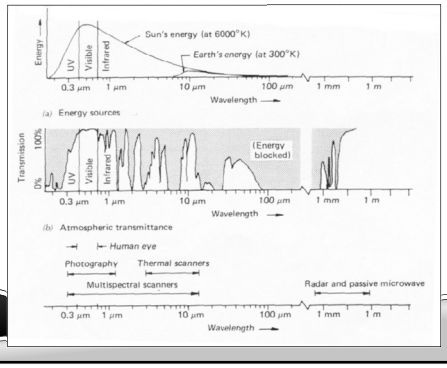
- Record EMR in a <u>number</u> of <u>discrete portions</u> or ranges of EM spectrum
- Single brightness or DN value recorded for each pixel in each band or channel (e.g. 8-bit records DN values 0-255)



MULTISPECTRAL SCANNERS

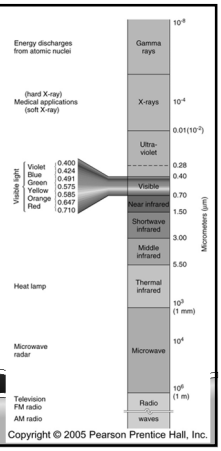
- Advantages of a MSS over aerial photography:
  1. Ability to sense over <u>greater</u> portion of EM spectrum
  2. Ability to sense very narrow portions of EM spectrum
  3. Collected in digital format so:
     - ready for computer analysis, processing, classification
     - easily transferred and stored

Spectral Sensitivity



Landsat-7 Payload

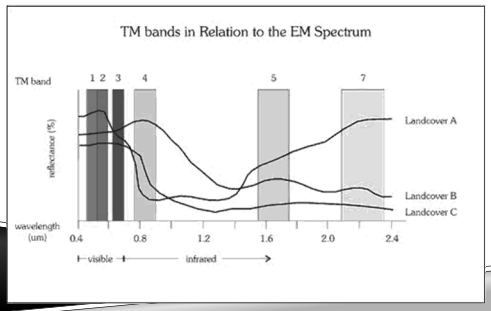
ETM - Enhanced Thematic Mapper	
Multispectral Bands	
Resolution	**30 m**
Bands (microns)	**0.45-0.52 0.52-0.60 0.63-0.69 0.76-0.90 1.55-1.75 2.08-2.35**
Thermal Band	
Resolution	**60 m**
Band (microns)	**10.4-12.5**
Panchromatic Band	
Resolution	**15 m**
Swath	**185 km**
Band (microns)	**0.5-0.9 (panchromatic)**



CHARACTERISTICS OF THE TM MSS

Band	Wavelength Range (μm)	APPLICATIONS
TM 1	0.45 - 0.52 (blue)	soil/vegetation discrimination; bathymetry/coastal mapping; cultural/urban feature identification
TM 2	0.52 - 0.60 (green)	green vegetation mapping (measures reflectance peak); cultural/urban feature identification
TM 3	0.63 - 0.69 (red)	vegetated vs. non-vegetated and plant species discrimination (plant chlorophyll absorption); cultural/urban feature identification
TM 4	0.76 - 0.90 (near IR)	identification of plant/vegetation types, health, and biomass content; water body delineation; soil moisture
TM 5	1.55 - 1.75 mid IR)	sensitive to moisture in soil and vegetation; discriminating snow and cloud-covered areas
TM 6	10.4 - 12.5 (thermal IR)	vegetation stress and soil moisture discrimination related to thermal radiation; thermal mapping (urban, water)
TM 7	2.08 - 2.35 (mid IR)	discrimination of mineral and rock types; sensitive to vegetation moisture content

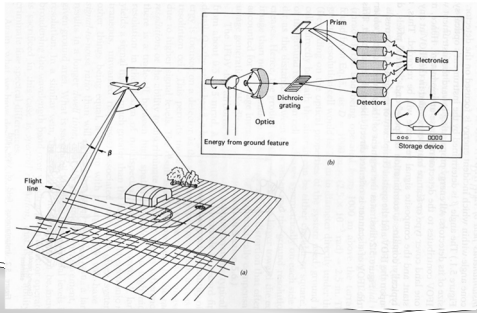
THEMATIC MAPPER BANDS



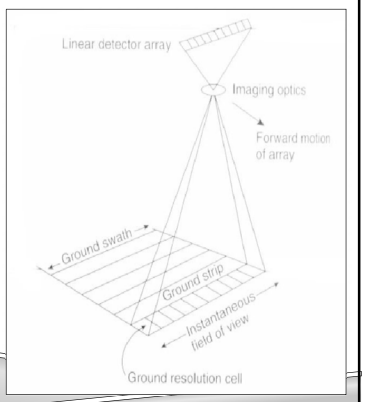
TYPES OF MSS

- Two basic types of MSS:
  1.
  2.
- Both have advantages and disadvantages

ACROSS TRACK MSS



ALONG TRACK MSS



SPATIAL RESOLUTION

- Area on the ground captured by pixel
- Determined by size of IFOV

IFOV = H β

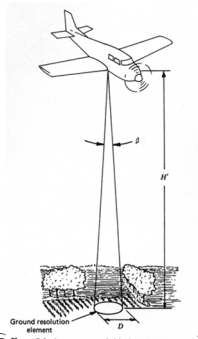


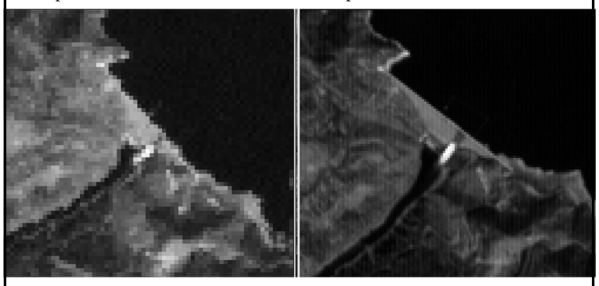
Figure 5.2 Instantaneous field of view and resulting ground area sensed directly beneath an aircraft by a MSS.

SPATIAL RESOLUTION

- The higher the spatial resolution:
  - the smaller the ground resolution cell
  - the higher the resolving power of the system
  - the greater the spatial detail attainable
- Note: to discriminate a feature from its surroundings:
  - It must be at least as large as the ground resolution cell
  - Should be 2x larger to ensure that it is detected
  - Or, may be smaller if it is spectrally unique & overwhelming

Spatial Resolution = 30 m

Spatial Resolution = 15 m



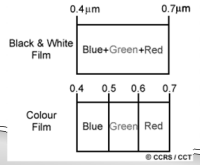
Which image has better spatial resolution?

What's the difference in the scale of the two images?

How does the spatial resolution and scale of this image compare?

SPECTRAL RESOLUTION

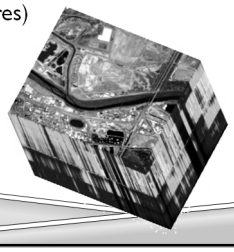
- Ability to detect slight variations in <u>wavelength</u>
- How narrow a portion of the EMS a sensors "sees"
  - Determined by width of each individual band



Which has better spectral resolution?

HYPERSPECTRAL SCANNERS

- Acquire imagery over many (>200) very narrow (e.g. 5 – 10 μm) spectral bands
- Enables discrimination based on slight variations in spectral reflectance (signatures)



RADIOMETRIC RESOLUTION

- Ability to detect slight variations in the amount of EMR reaching the sensor
  - Determined by number of quantization levels (DN values) used to measure reflectance; fcn of bit format:
    - 6 bits able to record values from 0-63, 64 quantization levels
    - 7 bit data from 0-127, 128 DN values
    - 8 bit data from 0-255, 256 DN values (Landsat TM)
    - 11 bit data from 0 – 2047, 2048 DN values
    - 12 bit data from 0 – 4095, 4096 DN values (Landsat 8 OLI)

2 bit data

4 quantization levels

8 bit data

256 quantization levels

Which image has better radiometric resolution?

RADIOMETRIC RESOLUTION

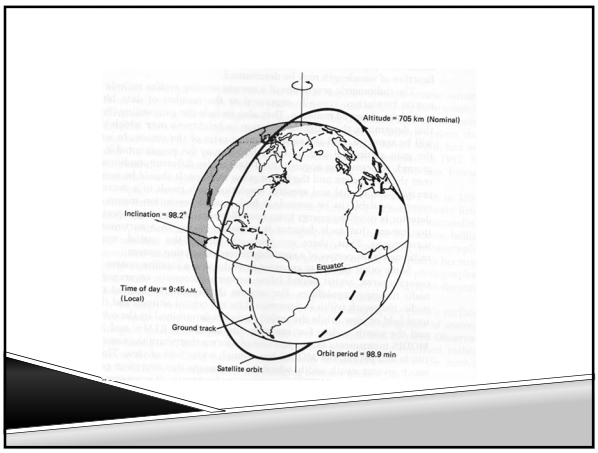
- Since total EMR received is directly proportional to spatial resolution, there is an inverse relationship between spatial and radiometric resolution
  - low spatial resolution (large ground area) means more total energy received, so slight variations in EMR can be detected, this results in a high signal to noise ratio
  - conversely, if spatial resolution is high (small ground area) less total energy is received, slight variations are more difficult to detect, so lower signal to noise ratio, poorer radiometric resolution
  - however, modern commercial satellites have v. high spatial and radiometric resolution; they achieve this by using along track sensors which have longer dwell times

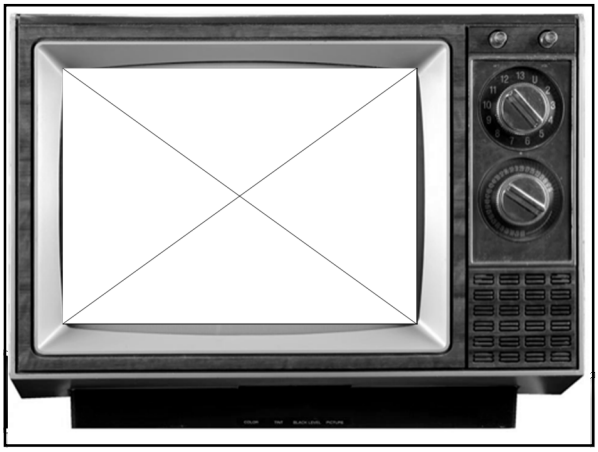
TEMPORAL RESOLUTION

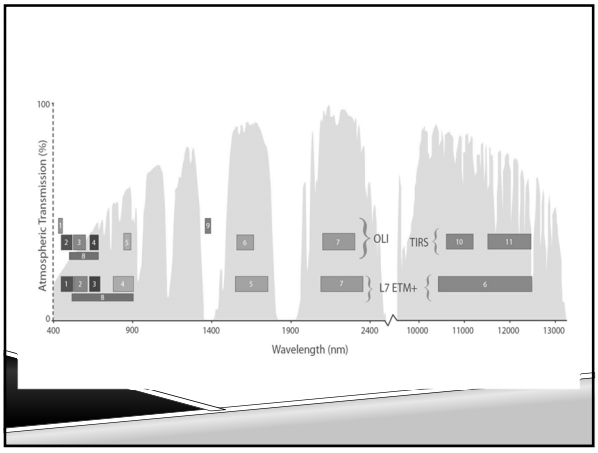
- Time between repeat coverage; revisit time
  - Determined by:
    - Orbital period of satellite
    - Refresh period of airborne imagery
    - Pointable optics capture images on adjacent orbital paths

TEMPORAL RESOLUTION

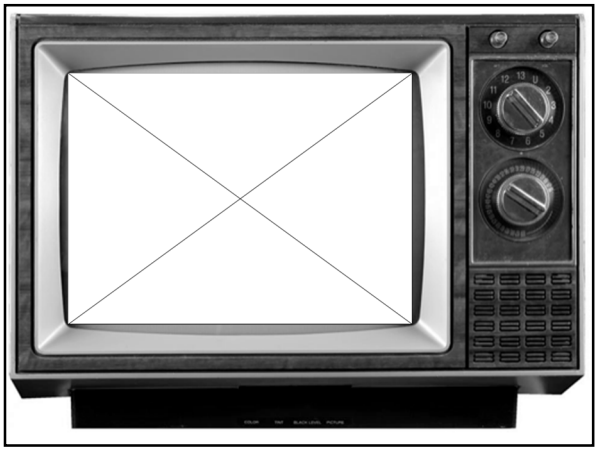
- Important when multitemporal images are desired
  - Land cover monitoring/change detection
  - Progression of an event
    - Forest fire
    - Natural Disaster
    - Etc.
  - Acceptable temporal resolution must be greater (shorter) than duration of event


Altitude = 705 km (Nominal)
Inclination = 98.2°
Equator
Time of day = 9:45 A.M. (Local)
Ground track
Orbit period = 98.9 min
Satellite orbit




Atmospheric Transmission (%)
100
0
OLI
TIRS
L7 ETM+
400
900
1400
1900
2400
10000
11000
12000
13000
Wavelength (nm)

Landsat-7 ETM+ Bands (μm)			Landsat-8 OLI and *TIRS* Bands (μm)		
			30 m Coastal/Aerosol	0.435 - 0.451	Band 1
Band 1	30 m Blue	0.441 - 0.514	30 m Blue	0.452 - 0.512	Band 2
Band 2	30 m Green	0.519 - 0.601	30 m Green	0.533 - 0.590	Band 3
Band 3	30 m Red	0.631 - 0.692	30 m Red	0.636 - 0.673	Band 4
Band 4	30 m NIR	0.772 - 0.898	30 m NIR	0.851 - 0.879	Band 5
Band 5	30 m SWIR-1	1.547 - 1.749	30 m SWIR-1	1.566 - 1.651	Band 6
Band 6	60 m TIR	10.31 - 12.36	*100 m TIR-1*	*10.60 – 11.19*	Band 10
			100 m TIR-2	*11.50 – 12.51*	Band 11
Band 7	30 m SWIR-2	2.064 - 2.345	30 m SWIR-2	2.107 - 2.294	Band 7
Band 8	15 m Pan	0.515 - 0.896	15 m Pan	0.503 - 0.676	Band 8
			30 m Cirrus	1.363 - 1.384	Band 9



EXTRA CREDIT ASSIGNMENT - 5%

- Select and Review <u>any</u> existing remote sensing <u>system</u>
- Include a description of:
  - The platform
    - Satellite, aircraft, etc
  - The sensor(s)
    - Spatial resolution
    - Spectral Resolution
    - Radiometric Resolution
    - Temporal Resolution
  - Applications of imagery
  - Availability/Cost/Source(s)
  - Up to 3 pages, double-spaced, not including figures
  - Due any time up to the date/time of the final exam