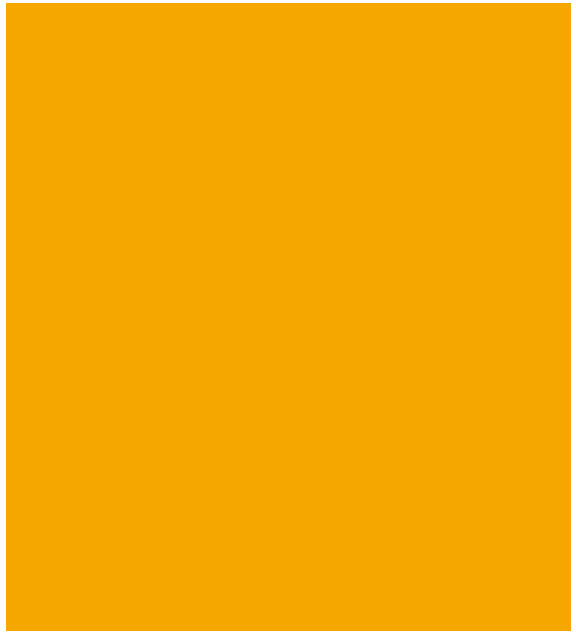
GEOG 357

LECTURE 19

Final Exam: Nov 30th
Project Presentation and Submission:
Dec 2nd and Dec 6th respectively

GEOG 311: Drainage Basin Morphology
Please Register ASAP (Risk of Cancellation due to low numbers)



Definition and History

- Remote Sensing: Derivation of information using images acquired from an overhead perspective. The images are from EM radiation reflected or emitted from the Earth's surface.
- History of RS:
  - Note the importance of the postwar period (50s-60s), 1972, 80s,

EM Spectrum

- Objects emit and reflect EM radiation
- Properties of EM radiation/energy
  - Differentiate and relationship between wavelength, amplitude, frequency, phase
  - Speed of EM radiation is constant
  - Units of measurement for EM radiation
    - Unit Conversion e.g. nanometers => microns/micrometers

EM Spectrum

- Major Divisions of EM spectrum
  - Gamma, X-Rays, UV,…
- Wavelength range for UV, B, G, R, IR

Imagery

- A pixel
  - Brightness as a numerical value
  - Separate value for each region of the EM spectrum
- Band Combinations
- Difference between Linear Array and Optical Mechanical Scanner

Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)

Reference

Barsi, J.A.; Lee, K.; Kvaran, G.; Markham, B.L.; Pedelty, J.A. The Spectral Response of the Landsat-8 Operational Land Imager. *Remote Sens.* **2014**, *6*, 10232-10251 doi:10.3390/rs61010232

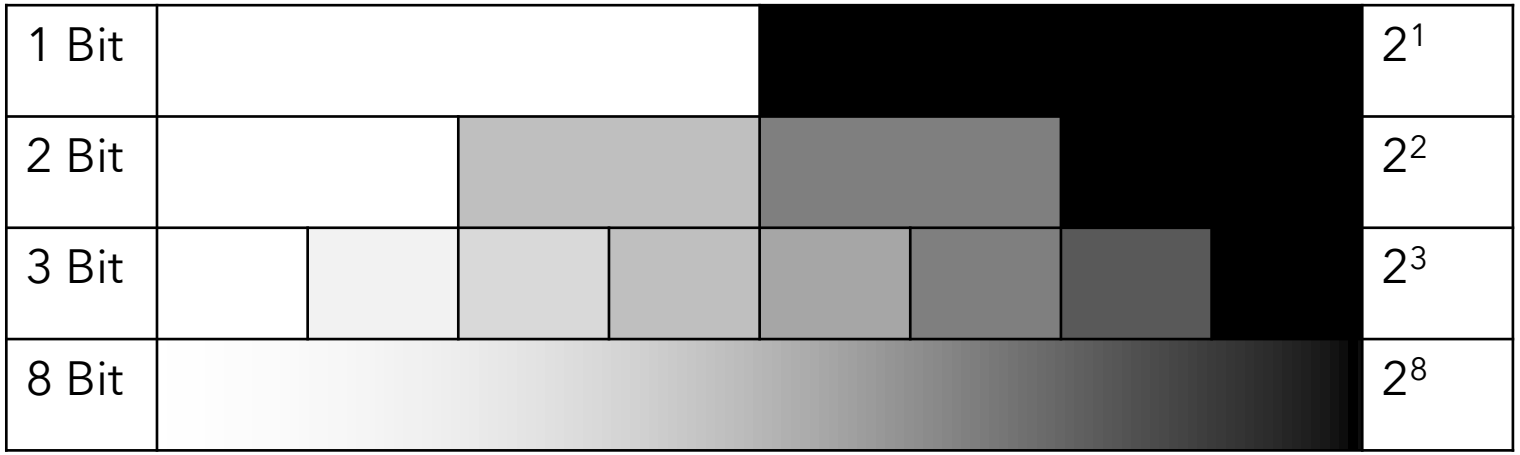
Band	Wavelength	Useful for mapping
Band 1 – Coastal Aerosol	0.435 - 0.451	Coastal and aerosol studies
Band 2 – Blue	0.452 - 0.512	Bathymetric mapping, distinguishing soil from vegetation, and deciduous from coniferous vegetation
Band 3 - Green	0.533 - 0.590	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4 - Red	0.636 - 0.673	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	0.851 - 0.879	Emphasizes biomass content and shorelines
Band 6 - Short-wave Infrared (SWIR) 1	1.566 - 1.651	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 - Short-wave Infrared (SWIR) 2	2.107 - 2.294	Improved moisture content of soil and vegetation and thin cloud penetration
Band 8 - Panchromatic	0.503 - 0.676	15 meter resolution, sharper image definition
Band 9 – Cirrus	1.363 - 1.384	Improved detection of cirrus cloud contamination
Band 10 – TIRS 1	10.60 – 11.19	100 meter resolution, thermal mapping and estimated soil moisture
Band 11 – TIRS 2	11.50 - 12.51	100 meter resolution, Improved thermal mapping and estimated soil moisture

Landsat 4-5 Thematic Mapper (TM) and Landsat 7 Enhanced Thematic Mapper Plus (ETM+)

Band	Wavelength	Useful for mapping
Band 1 - Blue	0.45 - 0.52	Bathymetric mapping, distinguishing soil from vegetation, and deciduous from coniferous vegetation
Band 2 - Green	0.52 - 0.60	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 3 - Red	0.63 - 0.69	Discriminates vegetation slopes
Band 4 - Near Infrared	0.77 - 0.90	Emphasizes biomass content and shorelines
Band 5 - Short-wave Infrared	1.55 - 1.75	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 6 - Thermal Infrared	10.40 - 12.50	Thermal mapping and estimated soil moisture
Band 7 - Short-wave Infrared	2.09 - 2.35	Hydrothermally altered rocks associated with mineral deposits
Band 8 - Panchromatic (Landsat 7 only)	0.52 - 0.90	15 meter resolution, sharper image definition

Imagery

- Radiometric Resolution: Defines the sensitivity of the sensor

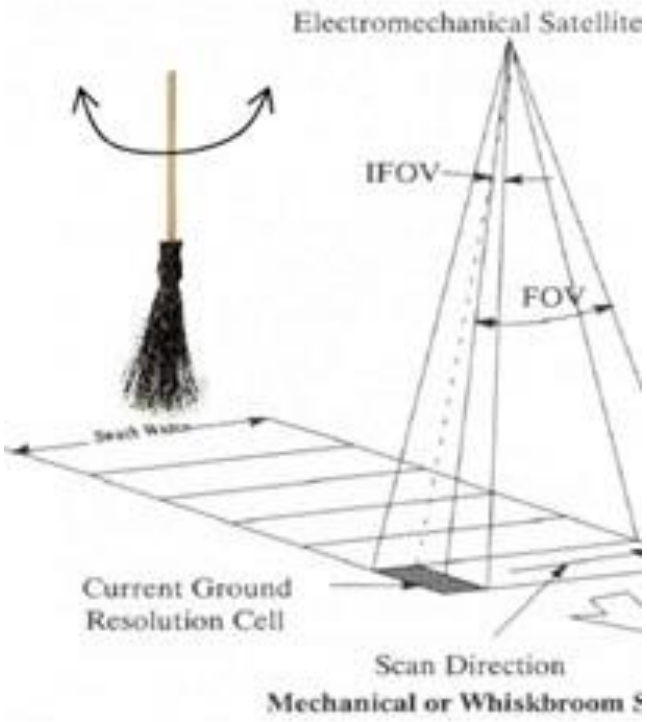


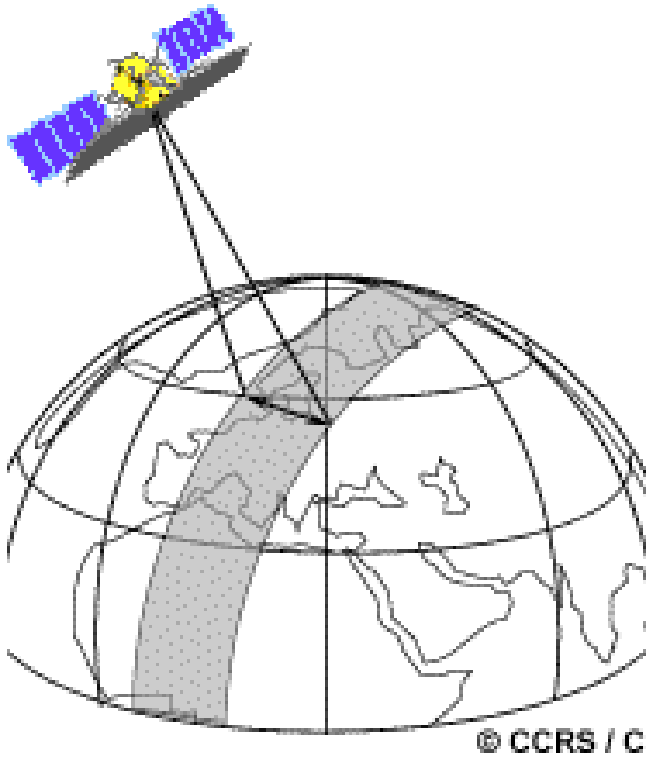
Satellite orbits

- **Geostationary / geosynchronous :** 36,000 km above the equator, stays vertically above the same spot, rotates with earth, such as weather images, communications, e.g. GOES

- **Sun-synchronous satellites:** 400-900km altitude, rotate at ~81- 82 degree angle to equator: imagery ~ the same local time each day (~10.30am)

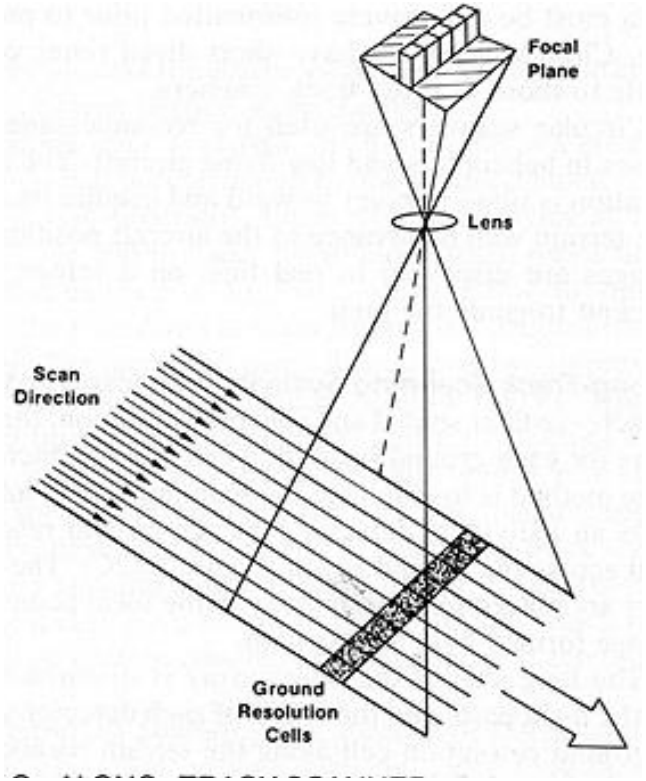
Scanner types (Sensor Types)





a. Whiskbroom (mirror/ cross-track): a small number of sensitive diodes for each band sweep perpendicular to the path or swath, centred directly under the platform, i.e. at 'nadir' e.g. LANDSAT MSS /TM/ETM

Scanner types (Sensor Types)



- **b. Pushbroom (along-track)**
- an array of diodes (one for each column of pixels) can be 'pointed' in a selected direction, **nadir or off-nadir**, on request, usually 0-30 degrees (max.), e.g. SPOT HRV, Landsat 8 OLI* - almost all now ..
- * Landsat 8 is not redirectionned; swath = 185km = ~ 6000 pixels

Image Classification

- Supervised classification requires the identification of areas on the image that are known to belong to each category/class

- Unsupervised classification minimal input when searching for natural groups of pixels present within the image.

Unsupervised classification methods

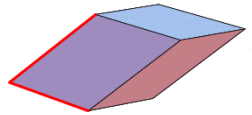
- **K-means, Fuzzy k-means, Isodata**
  - **K-means** and **Isodata**
    - Both are iterative and assign initial clusters evenly distributed in the data space. Next each pixel is assigned to the closest cluster. Next new cluster means are calculated based on all the pixels in one cluster. The second and third steps are repeated until the "change" between the iteration is minimal. However, **ISODATA** algorithm allows for different number of clusters while the k-means assumes that the number of clusters is known a priori.
  - **Fuzzy K-means** enables mixed membership. A pixel can have a degree of membership in multiple clusters. **K-means** has *hard/crisp* clusters, fuzzy k-means has *soft/fuzzy* clusters

Unsupervised classification steps

- Steps
  - determine how many classes / clusters
  - determine which input bands / channels to use
  - run classifier : K-means or Isodata
  - Rerun with more clusters if needed
  - assign names to classes (merge classes if needed)

Supervised classification methods

- **Minimum distance**, **Parallelepiped** and **Maximum likelihood**
  - **Minimum distance:** each pixel is assigned to the class whose mean is closest to data point
  - **Parallelepiped:** Each pixel is assigned to the class whose range it falls in. The class boundaries form an n-dimensional parallelepiped classification in the image data space



a parallelepiped

  - **Maximum Likelihood:** assumes that the statistics for each class are normally distributed. It calculates the probability that a given pixel belongs to a specific class. Each pixel is assigned to the class that has the highest probability (i.e., the maximum likelihood).

Accuracy assessment

This requires knowing what is reality at some pixels (ground truthing), and how they were classified. This generates a **'confusion matrix'**

		Reference test information					
	Class	Road	Building	Green	Bare	Row total	User's Accuracy
Remote sensing classification	Road	101	0	25	20	146	69.18%
	Building	0	128	0	17	145	88.28%
	Green	10	0	104	1	115	90.43%
	Bare	2	4	2	105	113	92.92%
	Column total	113	132	131	143	519	
	Producer's accuracy	89.38%	96.97%	79.39%	73.43%		

Overall accuracy = 84.4%, Kappa coefficient: 0.825.

The diagonal represents pixels correctly classified
An off diagonal column element = an 'error of omission'
An off diagonal row element = 'error of commission'

http://www.gisdevelopment.net/application/nrm/overview/mma09_Mustapha.htm

Table 4. Some commonly used Landsat MSS ratios and their applications.Adapted from Avery and Berlin (1992, p. 442).

MSS Ratios	Applications
1/2, 1/4, 3/4	Characterizing rocks and soils
1/2 or 2/1	Suspended sediment in water
1/2 or 2/1	Iron-oxide content in rocks
3/1, 3/2	Vegetation and water bodies
4/1, 4/2	Vegetation and water bodies

Note: the inverse ratios create negative images, which may be more pleasing visually for certain features.

Band ratios

- **Band ratios**
  - A band ratio is a new channel of data created by the simple division of two sets of band digital numbers for each pixel
- **Role of ratios**
  - Spectral slope enhancement
  - Reduce topographic effect
  - Include as input to classification

Vegetation indices

- DVI
- RVI
- NDVI
- Tasseled Cap Transformation
  - Brightness, Greenness, Yellowness, Non-such
    - Brightness => is associated with bare or partially covered soil,
    - greenness => green vegetation,
    - Yellowness/wetness => soil moisture, water, and other moist features
    - Non-such => image noise and atmospheric influences

Image Interpretation

- Elements:
  - tone
  - shape
  - size
  - pattern
  - texture
  - shadow
  - association

Thermal RS

- The Role of Water
  - has a high heat capacity so it takes a long time to heat and cool.
  - absorbs Visible / IR during the day and releases energy at night as thermal IR
  - in temperate climates, water is warmer in winter than land surfaces and cooler in summer; and may be warmer at night than land and cooler during the day.

Thermal RS

- Lower thermal wavelengths can get mixed with reflected solar energy (3-5 microns).
- Nighttime is preferred to avoid shadowing (topographic / clouds) and solar heating.
- The larger the pixel area, the finer temperature differences can be detected. …. Temperature resolution can be as fine as 0.1° C.
  - pixel size is larger (courser resolution), than for reflected bands …. as there is less energy to capture

Thermal RS

- Landsat thermal bands are affected by:
  - low radiance = reduced DN range (60-120m pixels)
  - shadows (10.30am)
  - recent moisture
  - it is mostly daytime so not ideal for thermal remote sensing
- Thermal RS applications
  - Urban heat island effects
  - Volcanic hazard assessment
  - Mapping lake thermal plumes from power plants
  - Burnt area mapping and active fires

Other Subjects

- LiDAR and RADAR
- Commercial sensors

Terms

- Refraction, Reflection, Scattering
- Emissivity
- Fluorescence
- CCD
- CMOS
- Enhancement / Histogram Stretching
- Land use vs Land cover
- Feature extraction
- Resolution: Temporal, Spatial, Radiometric, Spectral
- DEM, DTM , DSM, BEM