Lecture 7

Remote Sensing & Image Analysis

Lecture Outline

I. Intro to Remote Sensing
II. Basic Principles
III. Aerial Photographs
   A. Film, Formats and Systems
   B. Distortion & Errors
   C. Geometric Correction
   D. Stereo Photos
   E. Photointerpretation
IV. Satellite Imagery
V. Aerial Photos vs Satellite Imagery
VI. Image Analysis

I. Intro to Remote Sensing

- Remote collection of both aerial photos and satellite images commonly referred to as “remotely-sensed” data.

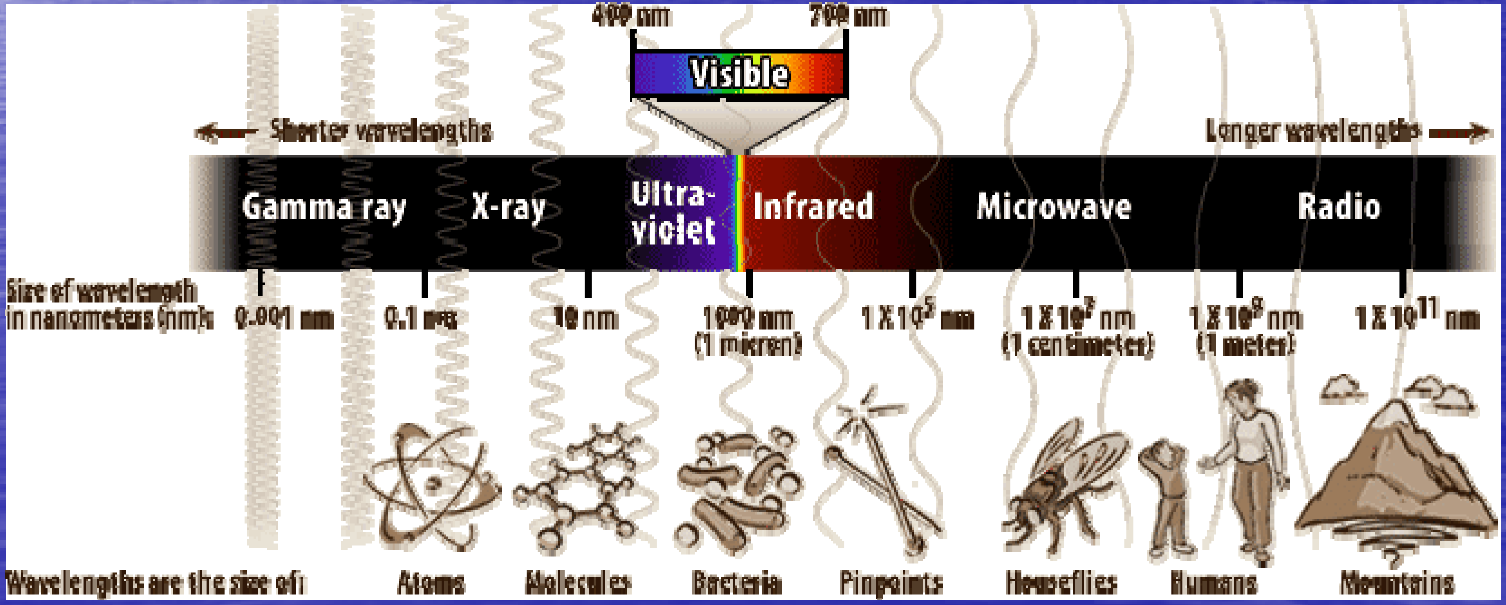
- Primary sources: Large format aerial cameras and satellite scanners.

I. Benefits of Remotely Sensed Images

- Large Area Coverage
- Extended Spectral Range
- Geometric Accuracy
- Permanent Record

II. Basic Principles Electromagnetic Spectrum

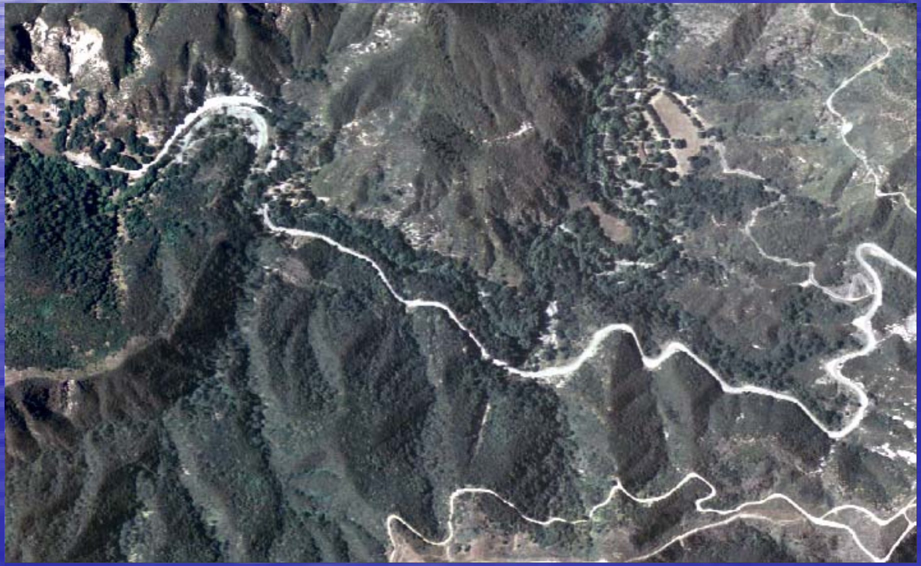
- Electromagnetic Spectrum: The full range of wavelengths that characterizes light energy.
- Wavelength in micrometers (µm) is the distance between peaks in the electromagnetic stream.
- Each color of light has a distinctive wavelength.



1 micrometer = 1000 nanometers

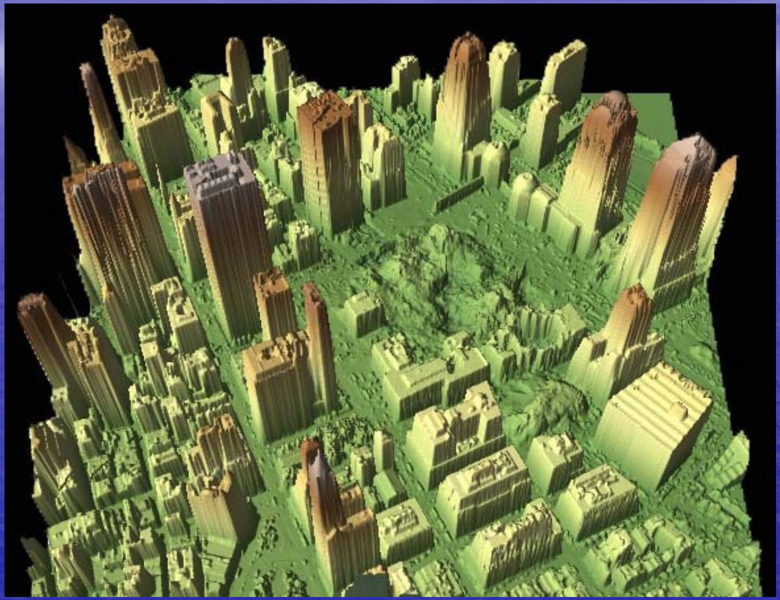
II. Basic Principles Imagery and Light

- Most Remotely Sensed imagery based on reflected, absorbed or transmitted *light* energy.
- Light “imagery” characterized by wavelength. i.e. 0.5-0.6 is green.
- Natural objects tend to be the color they most reflect.



II. Basic Principles Remote Sensing Systems

- **Passive**
  - Most commonly use system.
  - Uses energy generated by the sun and reflected off target objects.



- **Active**
  - Alternative system
  - Used under cloudy or nighttime conditions
  - Actively generate an energy signal and detect energy returned.
  - Ex. RADAR (Radio Detection and Ranging) & LIDAR (Light Detection & Ranging).

II. Basic Principles
Attributes of Remotely Sensed Data

Scale

- Relative distance on the image corresponding to relative distance on the ground.

Extent

- Area covered by the image

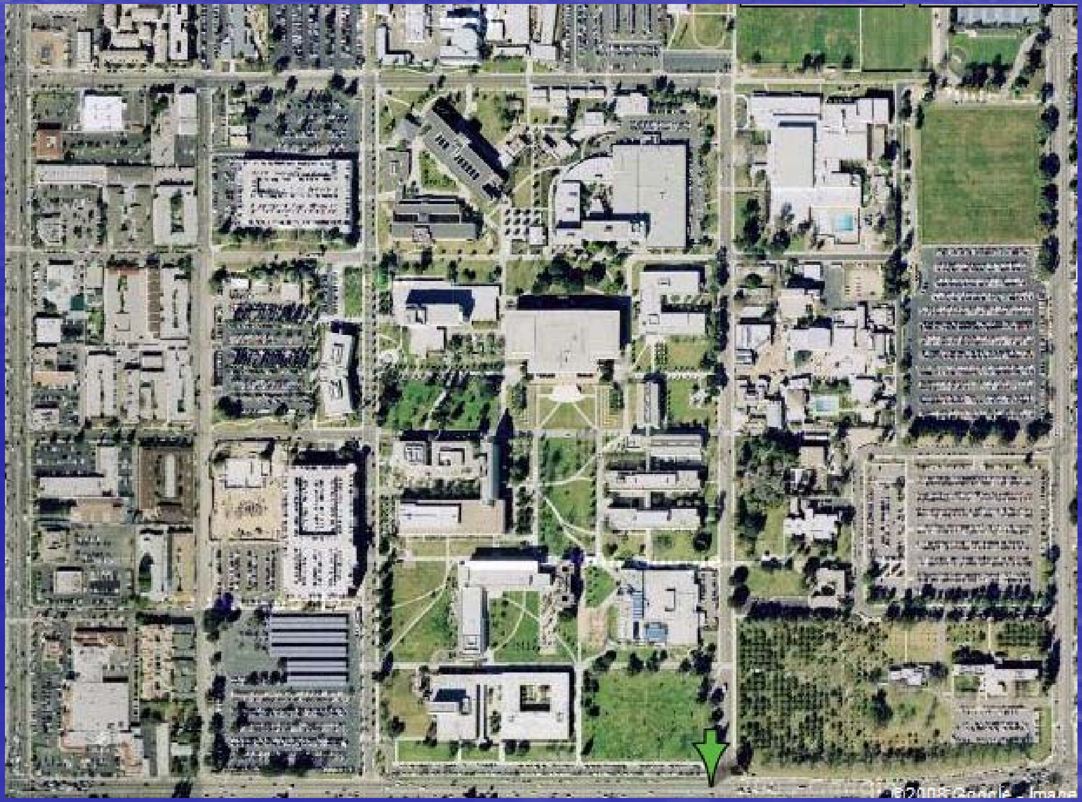
Resolution

- Smallest object that can be reliably detected on the image.

III. Aerial Photographs

Primary Uses:

1. Basis for surveying and topographic mapping.
   - Photogrammetry: The science of measuring geometry from photographs.
2. Use to categorize or assign attributes to topographic features.
3. Often used as a background layer for maps of other features.



III. Aerial Photographs

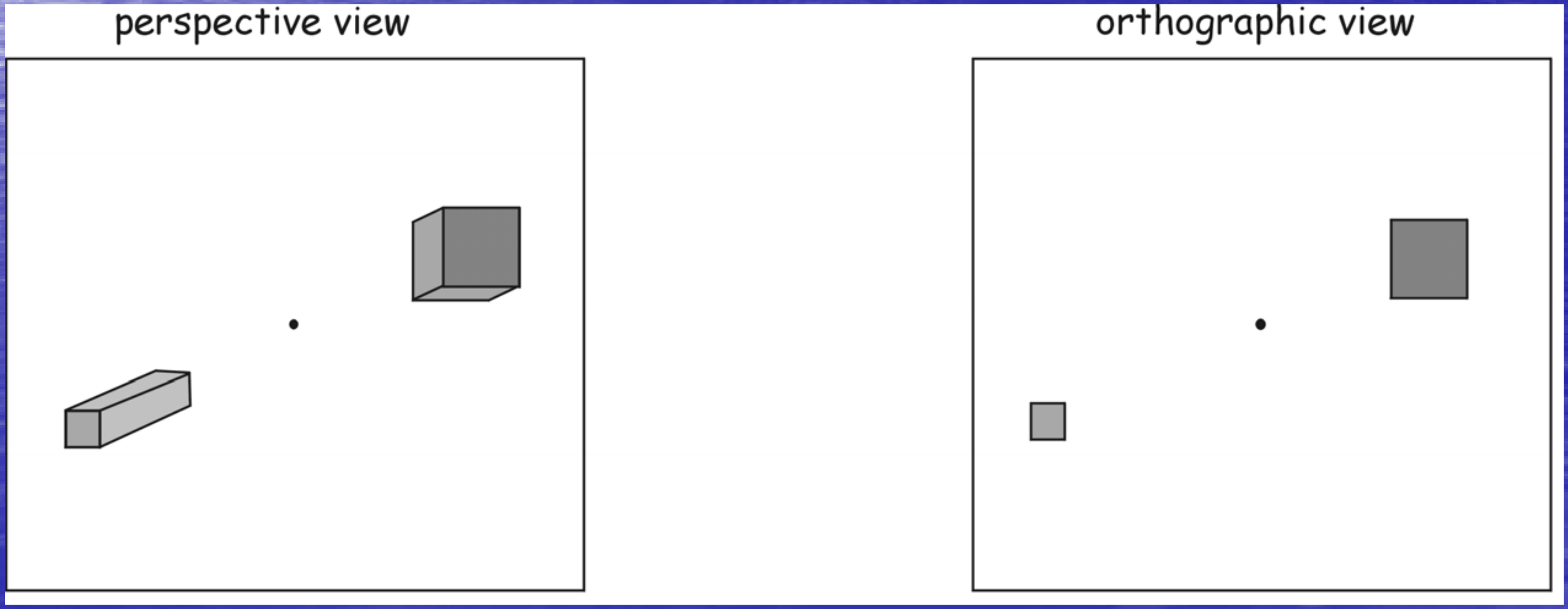
Photographic Film and Digital Cameras

- Photographic Film:
  - Black and White (Panchromatic)
  - True Color
  - Infrared

- Digital Cameras
  - Increasingly used
  - Higher cost
  - Sharper images

III. Aerial Photographs Geometric Quality

- Orthographic (Cartometric) maps are geometrically precise.
- Most aerials provide a perspective view.



III. Aerial Photographs Types of Geometric Distortion

- **Terrain Variation:** Differences in elevation within image.
  - Causes *relief displacement.*
  - Affects angles, distances and scale.
- **Camera Tilt:** When the optical axis points at a non-vertical angle.
  - Results in *perspective convergence*.
  - Objects further away appear closer together than objects nearer to the observer.

III. Aerial Photographs Geometric Correction

- Geometric Correction: Photogrammetry provides tools.
- Distortion at each point is calculated and then the image location is shifted accordingly.
- Use of simple geometry calculations to calculate displacement.
- Creation of orthophotographs.
- DOQ's from USGS.

Photointerpretation

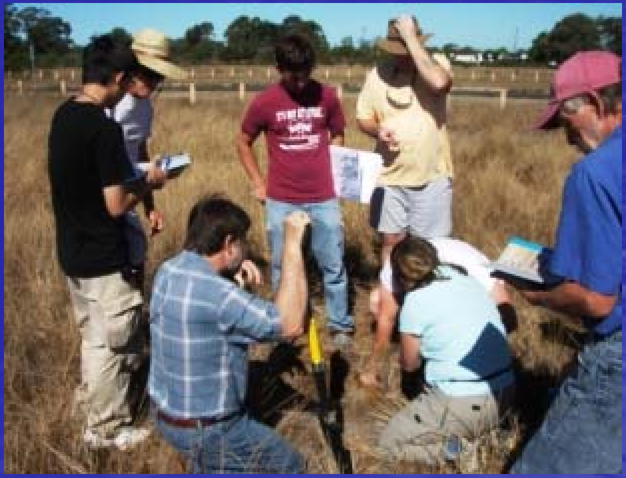
- The process of converting images into information, usually through digitizing.

- Use of size, shape, color, brightness and texture to aid interpretation.

- MMU (Minimum Mapping Unit)

Photointerpretation

- Numerous specialized techniques.
- Importance of ground-truthing to develop local knowledge.



Aerial Photo Sources

- National Aerial Photography Program (NAPP/NAIP):
  - 1:40,000
  - Ten year interval (or less)
  - USDA Geospatial Data Gateway: http://datagateway.nrcs.usda.gov/
- USGS Seamless server: http://seamless.usgs.gov
- USGS Eros: http://eros.usgs.gov/
- State Data (California):
  - CA Spatial Information Library: http://gis.ca.gov

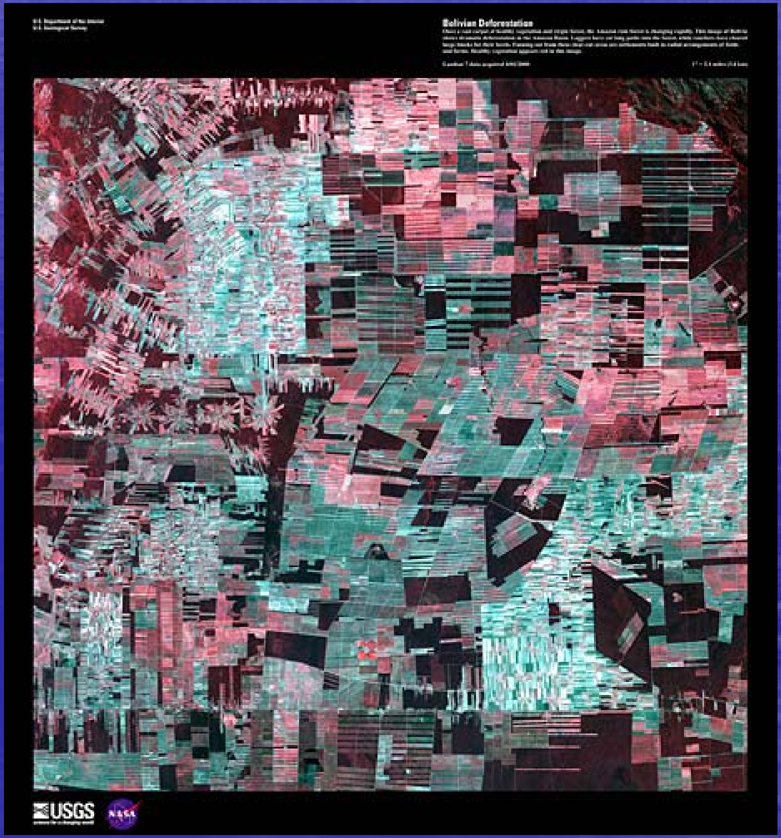
IV. Satellite Imagery

Satellite *Scanners*: Used to capture imagery.

Uses in GIS:

- Create and update landcover data layers.
- Classify Landuse
- Used to detect and monitor change.
  - Ex. Urbanization, deforestation & landuse.

Deforestation in Bolivia



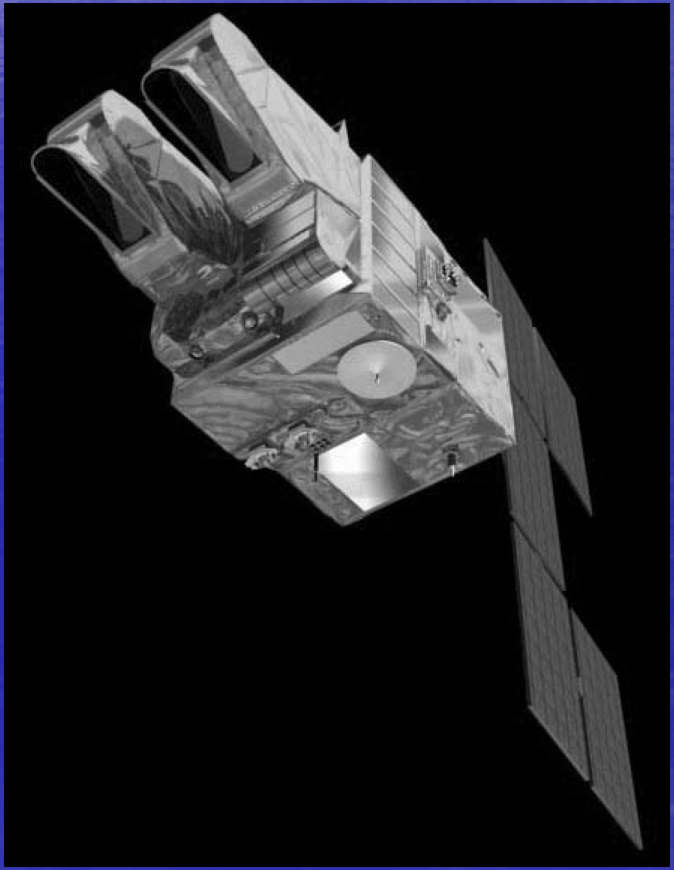
IV. Satellite Imagery

- Advantages:
  - Extended spectral range useful for landcover and geologic mapping.
  - High perspective that significantly reduces terrain distortion.
  - Coverage of large areas.
- Disadvantages:
  - May require specialized processing software.
  - Less flexible in terms of scheduling.
  - Effective resolution is typically worse than aerial photos.
  - May be more expensive, especially when area of interest is small.

IV. Satellite Imagery *High* Resolution Systems

- Typically provide resolution below one meter.

- Orbimage
- Ikonos
- QuickBird



IV. Satellite Imagery Other Systems

- **SPOT:** (Systeme Pour l' Observation de la Terre)
  - The first operational satellite to serve commercial interests.
  - Resolution: 2.5 meters

- **Landsat:**
  - First satellite to specifically collect data about the land surface.
  - Resolution: Based on imagery scanner used. From 15 to 120 meters.

Geology of Oman (Landsat)

IV. Satellite Imagery
Other Systems

- **AVHRR:** (Advanced Very High Resolution Radiometer):
  - High frequency data over large areas. Ex. Storms, fires, floods
  - Resolution : 1.1 kilometers
- **MODIS:** Moderate Resolution Imaging Sensor
  - NASA system that provides large area coverage at an intermediate level of detail.
  - Resolution: 250 meters to 1 kilometer.
  - http://nsidc.org/iceshelves/larsenb2002/animation.html

Hurricane Isabel - AVHRR

V. Satellite vs. Aerial Imagery What to Consider...

- Spatial detail required.
- Size of analysis area
- Terrain: Distortion related to relief change.
- Spectral Range: Satellites can often detect beyond the visible and near IR portions of the spectrum. Ex. RADAR
- Availability of specialized software and associated training.

Image Analysis

- Data Preparation
- Spatial Enhancement
- Radiometric Enhancement
- Spectral Enhancement
- GIS Analysis
- Classification

Image Analysis Data Preparation

- Subset Image
  - Subset spatially
  - Subset spectrally
    - Original bands 1-7
    - Subset bands 3, 4, 5
- Mosaic (merge) Images
- Re-project Images

Image Analysis
Spatial Enhancement

- Low-pass filters
  - Smooth (generalize an image
  - Moving windows (average)

Morro Bay

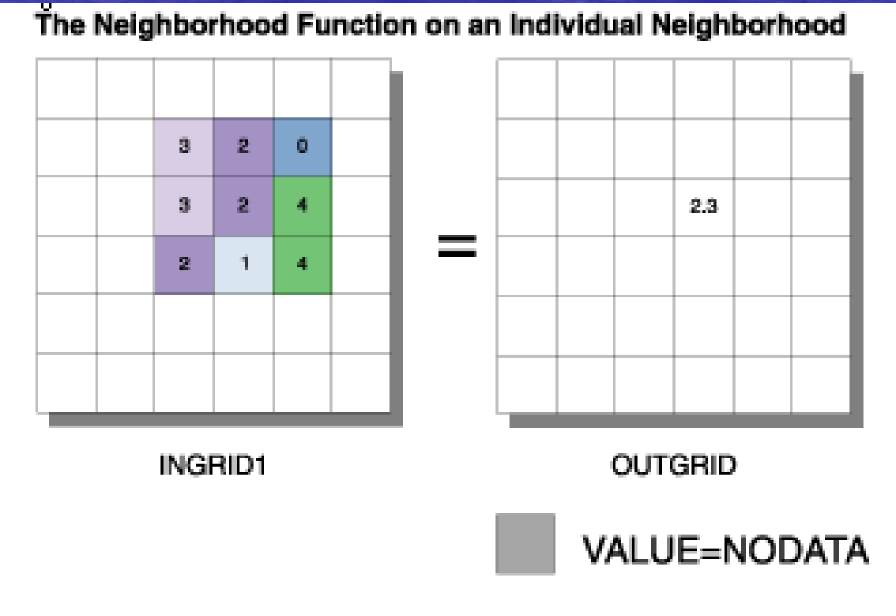


Image Analysis
Spatial Enhancement

- High-pass filters (high-frequency kernels)
  - Accentuate differences between adjacent cells
  - Useful for identifying the spikes or pits that are possible noisy data
  - Useful for highlighting edges (Edge Enhancement)
- For a low value surrounded by high values, its value gets lower
- For high values surrounded by low values, its value gets higher

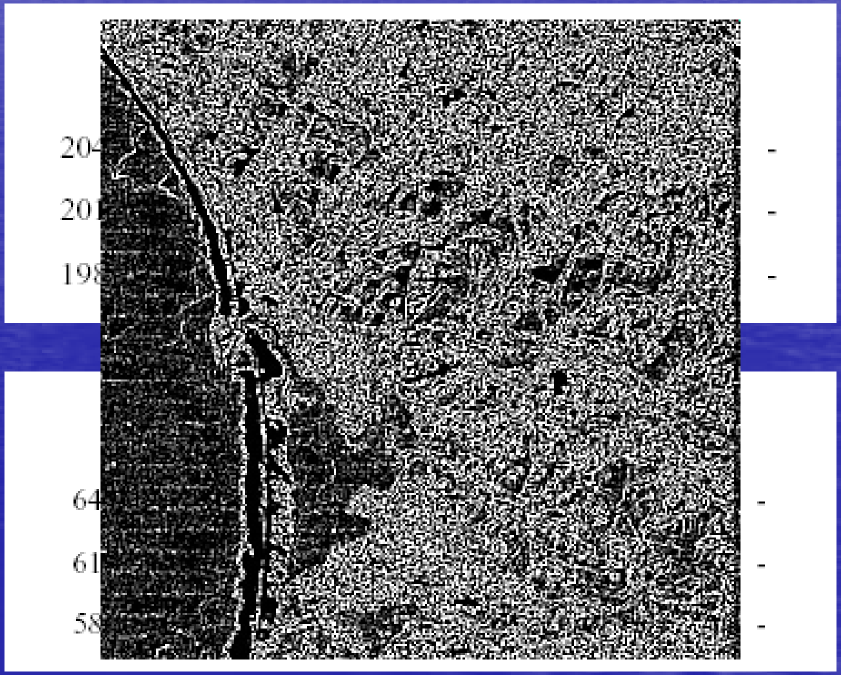
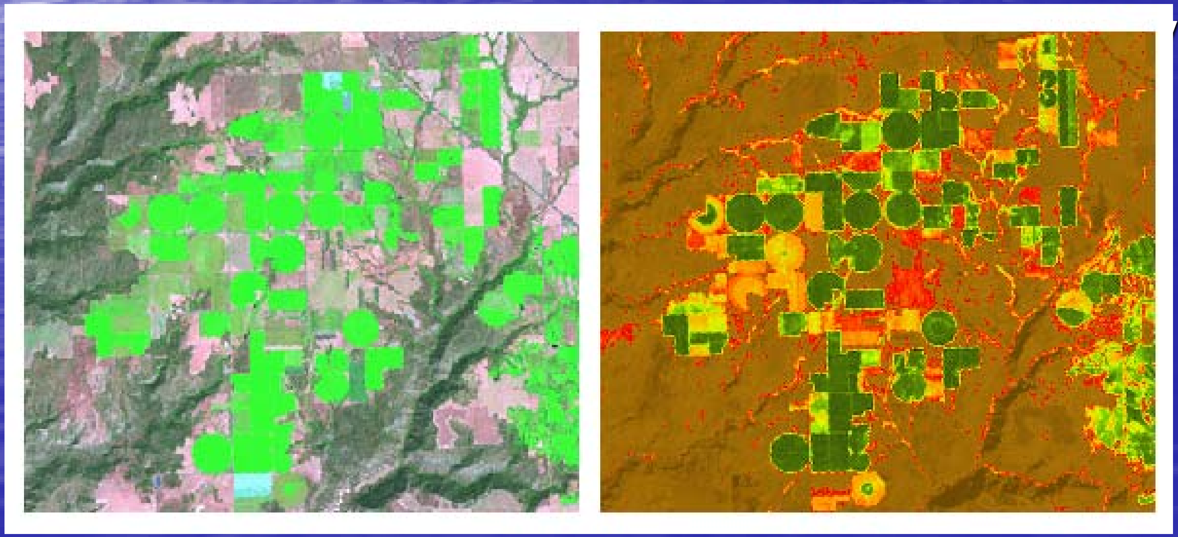


Image Analysis
Spectral Enhancement

- Change the value of each cell based on multi-bands
  - Extract new bands of data that are more interpretable to eyes.
    - Ex. From IR (infrared) to Normalized Difference Vegetation Index (NDVI).
    - e cover on the Earth's



Landsat 7,4,3 band combination (left) and an NDVI using a color map that highlights the agricultural activity of the area

Image Analysis Classification

- Classify pixels to categories
- Based on pixel values in different bands

- **Unsupervised classification**: Does not require the user to specify any information about the features contained in the images. Software does the work.

- **Supervised classification**: Spectral signatures (training sites) are developed from specified locations in the image and are defined by the user.

Image Analysis Geocorrection Tools

- Georeferencing
  - The process of assigning map coordinates to image data.
- Rectify
  - The grid of an image is changed to fit a map projection system or a reference image.

Image Analysis Georeferencing Process

- To use some raster datasets in conjunction with your other spatial data, you may need to align, or georeference, to a map coordinate system.

The general steps for georeferencing a raster dataset are:

1. Add the raster dataset that you want to align with your projected data in ArcMap.
2. Add control points that link known raster dataset positions to known positions in map coordinates.
3. Save the georeferencing information when you're satisfied with the alignment (also referred to as registration).

Online Tutorial: http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Georeferencing_video_sample

Image Analysis Geocorrection

- Ground Control Points (GCP's)
  - Pixels in an image for which the output map coordinates are known
  - Source X, Y coordinates (in the original image file)
  - Reference coordinates (in the desired output image)
- Distribution
  - Spread control points around
- Number of control points
  - Three minimum for 1st order transformation
  - At least six GCPs are required for 2nd order transformation

Image Analysis Transformation

- A transformation in a raster dataset defines how the pixels will be transformed
- Number of GCPs and Transformation
  - The higher the order of the transformation, the more GCPs needed.
  - -Always choose more than the minimum required GCPs.

Number of GCPs

Order of Transformation	Minimum GCPs Required
1	3
2	6
3	10
4	15
5	21
6	28
7	36
8	45
9	55
10	66

Image Analysis Transformation - RMSE

- RMSE (Root Mean Square Error)
- Good measure of accuracy.
- Provides a summary of the difference between the true and predicted control point coordinates.
- When the error is particularly large, you can remove and add control points to adjust (lower) the error.