REMOTE SENSING: A condensed overview
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Remote-Sensing (101)
“The art and science of obtaining information about an object without being in direct contact with the object” (Jensen 2000).
For our purposes…
… the collection of information about Earth surfaces and phenomena using sensors not in physical contact with the surfaces and phenomena of interest.

Remote-Sensing (101)
Our Discussion largely limited to two main Sources of Remotely-Sensed data:
1) Aerial Photography
   (Analog)
2) Satellite Imagery
   (Digital)
Reflection, Absorption (and Re-Emission) of EMR

- EMR that is returned from the surface with angle that is equal and opposite to the angle of incidence.
- Reflection includes scattering (diffuse reflection) as well as specular (mirror-like) reflection.
- Absorption is the retention of energy by a body, involves transformation of some energy to heat, with the re-emission of the remainder of the energy.
- Emitted energy is always lower energy than absorbed energy, corresponding to black-body radiation for the temperature of the body.

Remote-Sensing (101)

- Active: $E'$ emitted and return is measured (e.g., radar, sonar)
- Passive: $E'$ not emitted, but only collected (e.g., photography, satellite imagery)
Remote sensing uses the radiant energy that is reflected and emitted from objects at various "wavelengths" of the electromagnetic spectrum.

Our eyes are only sensitive to the "visible light" portion of the EM spectrum.

Why do we use nonvisible wavelengths (later)?

3 Basic colors of visible light

Varying amounts of R, G, & B make all visible colors.
**Milestones in Remote Sensing of the Environment**

1826 – 1st photograph
1858 – 1st aerial photograph from a balloon
1913 – 1st aerial photograph from an airplane
1935 – Radar invented
1942 – Kodak® patents color infrared “camouflage detection” film
1950s – 1st airborne thermal scanner
1962 – 1st airborne multispectral scanner
1972 – 1st LANDSAT satellite

**History of Remote Sensing**

Bavarian Pigeon Corp (1903)
Puget Sound 1931-1940
US Civil War Balloon Spies
Nadir over Boston

**Aerial Photography (Passive Remote Sensing)**

Trench Systems in France
Royal Canadian Air Force Photography Crew World War I

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Basic Photo Formats

- Vertical (On Nadir)
- Oblique (Off Nadir)

Geometric distortion

- Aerial photo gives us perspective view (it distorts geometry of geographic features)
- Transformation (Rectification) from central to parallel perspective results in planimetrically correct photo or orthophoto

Processing Photos

- Raw Photograph
- Rectified (flattened etc.)
- Georeferenced (GCPs)
The output (raw data, level 0) from an airborne line scanner has a jumbled appearance; the ground footprints are not parallel, owing to the movement of the aircraft.

**DOQ**

**Digital Ortho Quadrangle**

A digital, uniform-scale image created from an aerial photograph. They are true photographic maps—effects of tilt and relief are removed by a mathematical process called rectification. The uniform scale of a DOQ allows accurate measures of distances. DOQQ = ¼ quad.

**Color Aerial Photo**
Image/Photo Interpretation

Seven Interpretation Characteristics
- Size
- Pattern
- Shape
- Tone
- Texture
- Shadow
- Associated Features

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Image Interpretation Keys

Table 7.5.1 Interpretation keys for forestry

<table>
<thead>
<tr>
<th>Species</th>
<th>Crown Shape</th>
<th>Edge to Edge</th>
<th>Edge Color</th>
<th>Outer Color</th>
<th>Associated Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pines</td>
<td>Long, narrow</td>
<td>Sharp edges</td>
<td>Light green</td>
<td>Green</td>
<td>White and brown</td>
</tr>
<tr>
<td>Spruce</td>
<td>Short, broad</td>
<td>Blunt edges</td>
<td>Dark green</td>
<td>Green</td>
<td>White and brown</td>
</tr>
<tr>
<td>Birch</td>
<td>Round</td>
<td>Blunt edges</td>
<td>Light brown</td>
<td>Brown</td>
<td>White and brown</td>
</tr>
<tr>
<td>Aspen</td>
<td>Round</td>
<td>Blunt edges</td>
<td>Light brown</td>
<td>Brown</td>
<td>White and brown</td>
</tr>
<tr>
<td>Firs</td>
<td>Round</td>
<td>Blunt edges</td>
<td>Light brown</td>
<td>Brown</td>
<td>White and brown</td>
</tr>
<tr>
<td>Deciduous</td>
<td>Irregular</td>
<td>Unclear</td>
<td>Light brown</td>
<td>Brown</td>
<td>White and brown</td>
</tr>
</tbody>
</table>

Satellite Imagery

(Passive Remote Sensing)
The amount of solar radiation that it reflects, absorbs, transmits, or emits varies with wavelength. When that amount (usually intensity, as a percent of maximum) coming from the material is plotted over a range of wavelengths, the connected points produce a curve called the material’s spectral signature (spectral response curve).


**Typical Reflectance Signatures**

- Water
- Green vegetation
- Dry bare soil

**Albedo = Reflection Coefficient**

Surface Albedo (%):
- Snow 85-95
- Vegetation 10-30
- Sand 35-40
- Loam 10
- Water 5
- Cities 10-20
- Blackbody albedo = 0
- Whitebody albedo = 100
The Four Resolutions

1. Spatial Resolution: what size we can resolve (pixel size)
2. Spectral Resolution: what wavelengths do we use (number of spectral bands)
3. Radiometric Resolution: detail recordable for each bandwidth (bits/band)
4. Temporal Resolution: how often are data collected

Spatial Resolution

- The fineness of detail visible in an image.
- (coarse) Low resolution
- (fine) High resolution
- Factors affecting spatial resolution:
  - Atmosphere, haze, smoke, low light, particles or blurred sensor systems
- General rule of thumb: the spatial resolution should be less than half of the size of the smallest object of interest

Typical Spatial Resolution Values of Some Remote Sensing Instruments

- IRS-1C Panchromatic 6 meters
- SPOT Panchromatic 10 meters
- Seasat Radar 25 meters
- Landsat Thematic Mapper 30 meters
- IRS-1B LESS-II 36 meters
- Landsat Multispectral Scanner 80 meters
- Advanced VHRR 1,100 meters
**TEMPORAL RESOLUTION**

- Temporal resolution: the shortest amount of time between image acquisitions of a given location
- Temporal extent: the time between sensor launch and retirement
Radiometric resolution, or radiometric sensitivity refers to the number of digital levels used to express the data collected by the sensor. The greater the number of levels, the greater the detail of information.
**Hyperspectral Scanners**

- Detects tens or hundreds of narrow contiguous spectral bands simultaneously.
- Imaging spectroscopy has been used in the laboratory by physicists and chemists for over 100 years for identification of materials and their composition.
- Spectroscopy can be used to detect individual absorption features due to specific chemical bonds in a solid, liquid, or gas. With advancing technology, imaging spectroscopy has begun to focus on identifying and mapping Earth surface features.

**Hyperspectral Signatures**

**Sensor Systems 1986-present**

- IKONOS – Space Imaging (Commercial satellite)
- SPOT – Systeme Probatoire d’Observation de la Terre.
- IRS – Indian Remote Sensing (1C, 1D)
- SPIN-2 – Russian Resurs Satellites
- GOES – Geostationary Operational Environmental Satellite
- ERS-1 – European Space Agency
- JERS-1 – Japanese Environmental Remote Sensing
- Radarsat – Canadian Radar Satellite
- Several high resolution satellites such as IKONOS (1m), EROS
- A1 (1.8m), Quickbird (.6m pan and 2.44m MS)
- Hyperspectral Imagery (200+ bands)
Satellites (Sensors)

Major differences = data acquisition via the four resolutions (spectral, radiometric, temporal, spatial)

- MODIS (36 Bands; 8 bit; 16 day; 250, 500, 1000 m)
- Landsat TM & ETM (6 Bands; 8 bit; 14 day; 30–60 m)
- SPOT (3 Bands; 8 bit; 2–3 days; 10–20 m)
- IKONOS (4 Bands; 11 bit; 16 day; 4 m)
- NOAA-AVHRR (5 Bands; 10 bit; 1 day; 1100 m)

Landsat Data: Oahu, Hawaii

ASTER Data: Rinjani volcano, Lombok, Indonesia

Image source: Hawaii Mapping Research Group

Image source: NAS
ASTER data (Anchorage, Alaska)

MODIS: 1km resolution  SPOT: 4m resolution

Hurricane Katrina, before and after satellite images of Biloxi

Image source: CRISP, 2001
Figure 13.14  Deforestation in the Amazon Basin
Source: Satellite imagery (LANDSAT Pathfinder)

Figure 13.11  Before and after images of areas hit by 2004 Boxing Day tsunami
Source: DigitalGlobe (www.digitalglobe.com/tsunami_gallery.html), used by permission

(Continued)
Comprehensive Guide to Remote Sensing

http://rst.gsfc.nasa.gov/