Spectral response at various targets
Outlines

• Satellite Sensor
• Pushbroom vs Wiskbroom Sensors
• Spectral Signature
• Spectral Reflectance Curve of Snow
• Spectral Reflectance Curve of Vegetation
• Spectral Reflectance Curve of Soil, Water and Cloud
Airborne Multispectral Scanner

Visible and Near-Infrared Detectors, um

Electronics

Monitor Power Digitizer Data Recorder

Optics

Prism

Dichoric Grating

Radiant Flux from the Earth's Surface

Multispectral Scanner Data Collection Along A Flight Line

Line of Flight

Beta

Alpha
Pushbroom vs Wiskbroom Sensors

A. CROSS-TRACK SCANNER.

B. WISKBROOM SCANNER.

C. ALONG-TRACK SCANNER.
Hyperspectral Image Acquisition
Spectral Signature

• Every natural and synthetic object on the earth’s surface and near surface
  – Reflects & Emits

• EMR over a range of wavelengths in its own characteristic way according to its
  – Chemical composition
  – Physical state.
Spectral Signature

- Spectral characteristics do not remain static rather change with
  - Geographic location
  - Time.
- For example, forest canopy may be green in July, red, yellow or brown in September.
Spectral Reflectance Curves / Signatures

• Spectral reflectance curves are graphical representations of the spectral response of a certain type of features as a function of wavelength.

1. Each feature has its own unique spectral reflectance curve.
2. These curves are defined by the varying percent of reflectance.
Spectral Signature – Image Interpretation

• Plotting the spectral reflectance curves in graphic format will allow us
  – To determine which bands are most useful for **discriminating** certain type of features.

• The higher the contrast (gaps) between the signature curves of any two types of features:
  – The easier it should be to distinguish them
  – The greater the potential is for fast and accurate image interpretation and mapping.
SPECTRAL REFLECTANCE CURVE OF SNOW
What is Snow?

- Snow is actually a form of precipitation in the form of ice crystals.
- These ice crystals are hexagonal prisms.

- **Snowflakes** -- Collections of snow crystals
- **Rime** -- Super cooled tiny water droplets that quickly freeze onto whatever they hit.
- **Grapuel** -- Loose collections of frozen water droplets,
- **Hail** -- Large, solid chunks of ice
Spectral Properties of Snow

It depends upon the following snow parameters:

- Grain Size and Shape
- Impurity Contents
- Near Surface Liquid Water Content
- Depth And Surface Roughness
- Solar elevation
• Fresh fallen snow has a very high reflectance in the visible wavelengths.
• As snow ages, the reflectivity of snow decreases in the visible and specially in the NIR wavelengths.
• This decrease in reflection is due to melting and refreezing with in the surface layers and to the natural addition of impurities.
• Melting of snow increase the mean grain size and density.
Continued...

• In the wavelength region between approximately (0.65 - 1.4 micro m); the difference in snow crystal radius leads to the greater difference in the reflection.

• The greater the size of grain the greater will be the decrease in the reflection.

• The reflection of glacier ice is quite low.

• But the glacier ice covered with snow increases the reflection.

• Presence of melt water decreases the reflection.
Distinguishing Snow and Cloud

- Snow and cloud has same reflectance in visible portion of the spectrum.

- So how can we discriminate between these two features ...???
Snow can be distinguished from cloud in middle infrared band

- At the wavelength of 1.6 m, snow has very low reflectance, while the reflectance of clouds remains high.
SPECTRAL REFLECTANCE CURVE OF VEGETATION
Vegetation

• Vegetation covers a large portion of the Earth's land surface.
• Obtaining quantitative information about vegetation with remote sensing has proven difficult.
• All vegetation is chemically similar, and most healthy plants are green showing absorption bands.
Types of vegetation

- Broad leaf
- Conifers
- Shrubs & herbs
- Grasses
Structure of Leaf

- epidermis
- vein
- palisade mesophyll
- spongy mesophyll
- moist air space
- stoma
- guard cells

$\text{CO}_2 \text{ in} \quad \text{O}_2 \text{ out}$
Internal structure of leaf

- **Epidermis**: protects the leaf and is transparent to let light through.

- **Palisade mesophyll**: cells are tall and closely packed to absorb maximum light. They contain many chloroplasts. Most photosynthesis takes place in the palisade cells.
Contd..

- **Spongy mesophyll**: also captures light and makes food. Spongy mesophyll cells have air spaces between them to allow easy gas exchange.

- **Veins**: contain *xylem* (top part of vein) for water transport and *phloem* (lower part of vein) to take away dissolved food.
Contd..

- **Stomata**: (mostly on the underside of the leaf) allow gas exchange; since a lot of water vapor can be lost through the stomata they only open for photosynthesis in daylight.

- At night they close to reduce loss of water vapour.
Major factors of Vegetation Mapping

- Chlorophyll and other pigments
- Structural biochemical molecules
- Water absorption bands
Leaf Structure

Vegetation Spectral Reflectance Curve

- Chlorophyll absorption
- Water absorption

Visible, Near-Infrared, Shortwave Infrared

Dominant factors controlling leaf reflectance
Primary absorption bands
Mesophyll vs NIR Reflectance

• Lots of palisade mesophyll = low NIR reflectance
• Lots of spongy mesophyll = higher NIR reflectance
Leaf Water Content

Vegetation Spectral Reflectance Curve

- Chlorophyll absorption
- Water absorption
- Visible, Green, Red, Near-Infrared, Shortwave Infrared

Dominant factor controlling leaf reflectance

Primary absorption bands
The Red Edge

Vegetation Spectral Reflectance Curve

- Leaf pigments
- Cell structure
- Water content

Dominant factor controlling leaf reflectance

Primary absorption bands

Reflectance [%]

Wavelength (µm)

Visible
Near-infrared
Shortwave infrared

The Red Edge
Vegetation Spectral Reflectance Curve

- Leaf pigments
- Cell structure
- Water content

Dominant factor controlling leaf reflectance

Primary absorption bands

- Chlorophyll absorption
- Water absorption

Reflectance (%) vs. Wavelength (μm)

Visible, Near-Infrared, Shortwave Infrared
MIR REGION (1350-2500 nm)

Moisture Contents

• Beyond 1300 nm incident energy upon vegetation is essentially absorbed or reflect.
• The dips in the reflectance occur at 1400, 1900 and 2700 nm; because water in the leaves strongly absorb energy in these wavelengths; often known as “WATER ABSORPTION BANDS”.
• The peaks in this region occur at 1600 & 2200 nm.
NIR Reflectance Model

multilayer foliage

\[ 0.6 + 0.125 + 0.031 = 0.656 \]

Leaf 1

Leaf 2
Leaf Area

Percent Reflectance

Wavelength (μm)

1
2
4
6
1, 2, 4
6
Leaf Moisture Content

Percent Reflectance vs. Wavelength (μm)

Decreasing Moisture Content
- (wet)
- (dry)

Waveform graph showing percent reflectance changes with wavelength for different moisture content levels.
Healthy, Stressed & Severely Stressed Vegetation
Snow, vegetation, rock: spectra of mixed pixels

- Snow
- Vegetation
- Rock

- Equal snow-veg-rock
- 0.8 snow, 0.1 veg, rock
- 0.2 snow, 0.5 veg, 0.3 rock
Spectral Reflectance Curves of Different Land Covers

Source: Yasir Yaqoob
Wateen Telecom