1 ❑ # EMR response: water properties

2 ❑ # Introduction

- Open water – 74% of earth'surface
  - 95% - oceans
  - 0.4% - freshwater lakes & river
  - 4.69% - permanent icecap
- Monitor the earth's water
  - Measurements at specific points
  - Collections of samples from specific locations

3 ❑ # Water sampling

- Water sampling using Van Dorn sampler
- Groundwater – wells, boreholes
- Samples
  - chemical & physical tests to measure levels of pollution
  - detect bacteria & other biological phenomena
  - examine oxygen, sediment content & other qualities
- Sampling is for discrete points within the water body

4 ❑ # Water measurements

- Remote sensing analyst interested in examining entire water bodies, regions within water bodies
- Measurements can be done for several locations – build up a record of place-to-place variation
- Piecemeal approach – need to study complex & dynamic characteristics of water body

5 ❑ # Remote sensing of water

- Valuable perspective – broad-scale, dynamic patterns – difficult to determine with point measurement only
- Coordination & placement of surface samples – establish relationship between sample data & remote sensing data
- Satellite data – regular observation, remote areas
- Supplement field data measurements

6 ❑ # Spectral characteristics of water bodies

- Radiation incident to the water surface
- Optical properties of water
- Roughness of the surface
- Angles of observation & illumination
- Reflection of light from bottom (some cases)

7 ❑ # Spectral characteristics of water bodies

- Incident radiation
  - Reflected radiation from water surface – some to atmosphere; little info, except for roughness of the surface, wind & waves
- Spectral properties – "color"
  - Energy scattered & reflected within the water body
    - "volume reflection" – range of depths
    - "underlight" – directed back to surface, surface to atmosphere, primary source of color of water body

8 ❑ # Spectral characteristics of water bodies

- Light that enters water body
  - Influenced by absorption & scattering by pure water
  - Scattering, reflection & diffraction by particles suspended in the water
- Scattering by particles small relative to wavelength (Rayleigh scattering) cause short wavelengths to be scattered the most
  - Deep water bodies (absence of impurities) – water is blue or blue-green in color
  - Maximum transmittance in range of 0.44-0.54 μm, peak transmittance at 0.48 μm

9 Spectral characteristics of water bodies

- Color of water determined by volume scattering, rather than surface reflection
- Spectral properties of water bodies are determined by transmittance, rather than surface characteristics only
- Penetration greater at blue-green wavelengths – better opportunity for recording features on bottom

10 Spectral characteristics of water bodies

- Longer wavelengths (red region) – absorption of sunlight is greater – detect shallow features
- Near infrared region – absorption is greatest – only make land-water distinctions

11 Spectral characteristics of water bodies

- As impurities added to water, spectral properties change
  - Sediments from natural sources & human activities
- Sediment-laden water – "turbid water"

12 Spectral characteristics of water bodies

- Sample the water, use devices that estimate turbidity by transparency of the water
  - Secchi disk depth
    - White disk – given diameter – lowered into water
    - Turbidity decreases transparency
    - Disk no longer visible – relate to sediment content
  - Nephometric turbidity units (NTUs)
    - Measure intensity of light passing through a water sample
    - Detect differences in light intensity

13 Spectral characteristics of water bodies

- As sediment concentration increases – spectral properties change
  - Overall brightness in visible region increases – no more "dark" object, becomes more of a "bright" object
  - Wavelength of peak reflectance shifts from the blue to the green region
- Presence of larger particles
  - Wavelength of maximum scattering shifts towards the blue-green and green regions

14 Spectral characteristics of water bodies

- As sediment content increases:
  - Increase in brightness
  - Shift in peak reflectance towards longer wavelengths
  - Peak itself becomes broader
    - High levels of turbidity, color becomes a less precise indicator of sediment content
    - As sediment content approaches very high levels, the color of water begins to approach that of the sediment itself

15 Spectral changes as water depth increases

- Clear water body

- Near surface, overall shape of curve resembles the spectrum of solar radiation
- Water body influences the spectral composition of light as depth increases
- 20 m depth – little or no IR radiation present – water body is effective absorber of these longer wavelengths – only blue-green wavelengths remain
- B-G wavelengths available for scattering back to surface, from water itself, & from the water bottom

16 Attenuation coefficient - k

- Attenuation coefficient – k – describes the rate at which light becomes dimmer as depth increases

$E_z = E_0^{-2kz}$

E_0 is brightness at the surface, E_z is brightness at depth z(E_z)

17 Influence of atmosphere

- Atmosphere alters the spectral properties of incident radiation
- Atmosphere influences the characteristics of the reflected signal
- Especially significant in hydrologic studies
  - Hydrologic studies depend upon subtle spectral differences (easily lost in atmospheric haze)
  - Hydrologic information is carried by the short wavelengths that are easily scattered by atmosphere

18 Water bodies

- Water bodies are typically dark
  - Restricted range of brightness values
  - Need to be concerned with radiometric qualities of RS data
  - RS data – assess quality of data, effects of atmosphere, sun angle

19 Water bodies

- Sometimes look at average brightness over blocks of contiguous pixels
  - Reduce noise from clouds, whitecaps
  - Isolate permanent features (shallows, shoals) from temporary features (waves, atmospheric effects) using scenes of same area, acquired at different times
  - Estimate original radiometric brightness from DNs – to accurately assess differences in color & brightness