Atmospheric Correction – 2

Overall goal

- Want a *calibration* system to relate image digital counts to surface parameters – atmospheric calibration

Examples

- Examples:
  - Ocean reflectance to water quality parameters
  - Correlate water reflectance in visible region to chlorophyll, suspended solids, gelbstoffe
  - Soil texture & moisture to reflectance values
  - Laboratory reflectance data to rock characterization
  - Reflectance to various vegetation parameters – chlorophyll concentration, water content, LAI (leaf area index)
- To do this, need to remove the effects of the atmosphere

Radiometric preprocessing

- Image restoration
  - Remove undesirable influence of atmospheric interference
  - By knowing the nature of these effects, possible to estimate the magnitude, then remove (or minimize) their influence from imagery
  - Remove these effects – *restore* the data to correct condition

Radiometric preprocessing

- Sensor records 2 kinds of brightness
  - Reflectance from earth's surface (that's what we want)
  - Observes the brightness from the atmosphere – effects of scattering
    - 56 recorded – 45 is surface reflectance, 11 is atmospheric scattering
    - Objective is to identify & separate these 2 components

Preprocessing operations – 3 categories

- Procedures based on efforts to model the physical behavior of the radiation as it passes through the atmosphere
- Examine reflectance from an object of known, or assumed, brightness recorded by multispectral imagery
- Examine the brightness of objects within each scene, but attempt to exploit knowledge of interrelationships between separate spectral bands

Physical models

- Model the physical process of scattering at the level of individual particles & molecules
- Advantages: rigor, accuracy, & applicability to a wide variety of circumstances
- Disadvantages: complex, need detailed meteorological information (humidity, concentrations of atmospheric particles), conditions vary with altitude, radiosonde data are collected only at a few locations

Atmospheric propagation models

- Use numerical solutions to radiance equations, coupled with tables of data on the spectral properties of the atmospheric constituents
- LOWTRAN, MODTRAN

Examining reflectances

- Examine reflectance from an object of known, or assumed, brightness recorded by multispectral imagery
  - Ground truth at time of image acquisition
- Amount of scattering related to the wavelength of the energy
- Relationships between values in the separate bands helps to assess the effect of the atmosphere on the data

Examining reflectances

- Ideally, observe the target with airborne & ground instruments at time of image acquisition
- Seldom have these measurements, so identify a very dark object (large, clear water body; asphalt runway, shadows from clouds or topographic feature; control panels)
  - These areas will vary from band to band – amount contributed by atmospheric scattering in @ band
  - Histogram minimum method – HMM; dark object subtraction method

Interrelationships between spectral bands

- Regression technique – paired values from @ band with values from band 7
- Y intercept of a regression line is taken as correction value for specific band
- Can apply to local areas (10×10 pixels), rather than entire scene – tailor to specific regions

Interrelationships between spectral bands

- Examine variance-covariance matrix
  - Set of variances & covariances between all band pairs on the data - covariance matrix method – CMM
  - Some variations in brightness caused by small-scale topographic shadowing; dark regions reveal the effects of atmospheric scattering

Relative calibration (reflectance)

- Use of ratios or relative spectral information between multiple spectral bands
- Use normalization techniques to reduce atmospheric variations between multiple images of the same area acquired at different times

Spectral ratio techniques

- Don't need absolute reflectance
- B-G ratio can be useful in water quality; NIR-R ratios to characterize vegetation conditions
  - NDVI ratio – reduces atmospheric & illumination effects by using a differencing & ratioing method

Scene-to-scene normalization

- Histogram matching – histogram specification
  - Pass one image through a look-up table that attempts to adjust the histogram to match some specified histogram
  - Nonquantitative – just to improve the visual appearance
  - Normalize images of the same scene taken at different times – removes the dominant brightness variations caused by illumination & sensor response variations

Scene-to-scene normalization

- Histogram matching – simple numerical fit – can mask real changes between the images
  - $DC_1 = mDC_2 + b$
  - m & b are coefficients to transform a digital count on day 2 to have the same digital count on day 1 for pixels that have the same reflectance on each day; can do for each spectral band of interest; use a dark object & a light object – 2 point solution

How to decide on atmospheric correction?

- Examine summary statistics for each scene – means, variances & frequency histograms for each band
- Look for absence of dark values, particularly if image contains large water bodies
- Loss of resolution, low contrast indicates poor atmospheric conditions
- Date of image – summertime implies high humidity, haze, & poor visibility; winter, spring & autumn dates indicate clearer atmospheric conditions