Atmospheric and Radiometric Corrections for Remote Sensing Data

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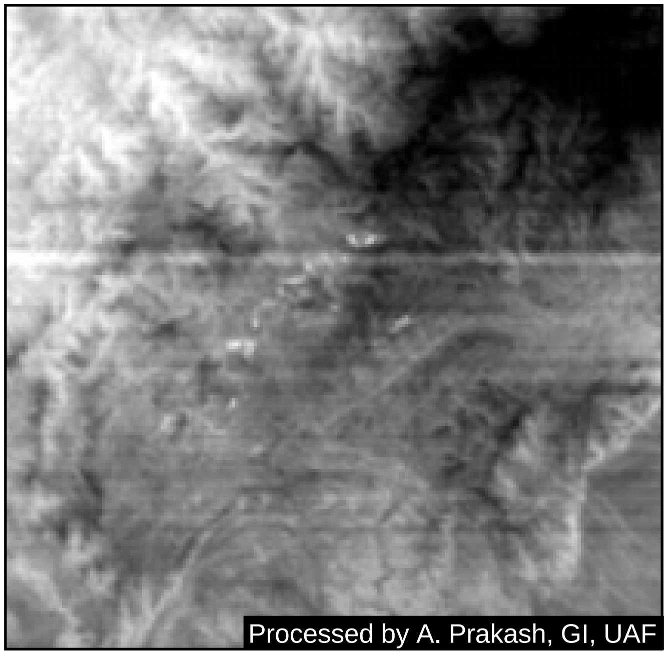
Outline

- radiometric correction
  - striping
  - (partially) missing lines
  - illumination and view angle effects
  - sensor calibration
  - terrain effects
- atmospheric correction

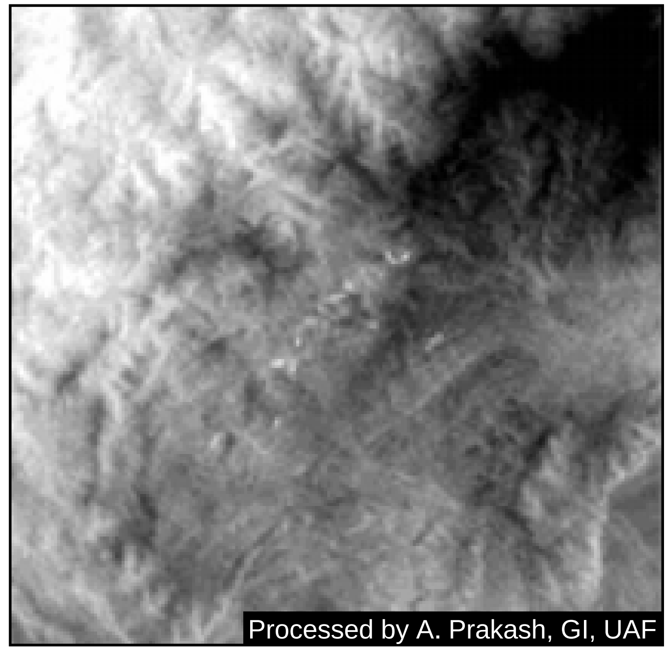
Striping

- due to non-identical detector response
  - detector characteristics
  - changes with time / rise of temperature
  - failure
- various methods (sometimes used in combination)
  - look up tables (radiometric response measurements at different brightness levels)
  - onboard calibration
  - histogram matching (gain and offset) – line pattern

Striping – Landsat TM



Striping



De-striped

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(Partially) missing lines

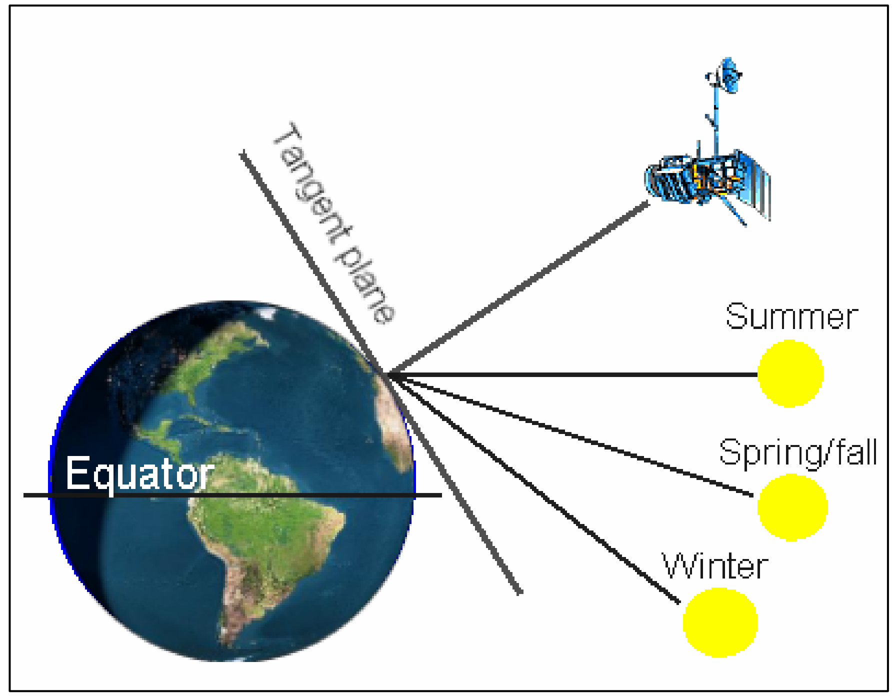
- errors in
  - sampling or scanning equipment
  - transmission or recording of image data
  - reproduction of the media containing the data
- two methods
  - interpolation using data from adjacent scan lines
  - interpolation data at the same scan line from different spectral bands

Partially missing lines - Example

Source: CCRS Remote Sensing Tutorial

Sun angle correction

- position of the sun relative to the earth changes depending on time of the day and the day of the year
- in the northern hemisphere the solar elevation angle is smaller in winter than in summer



Adapted from Lillesand and Kiefer

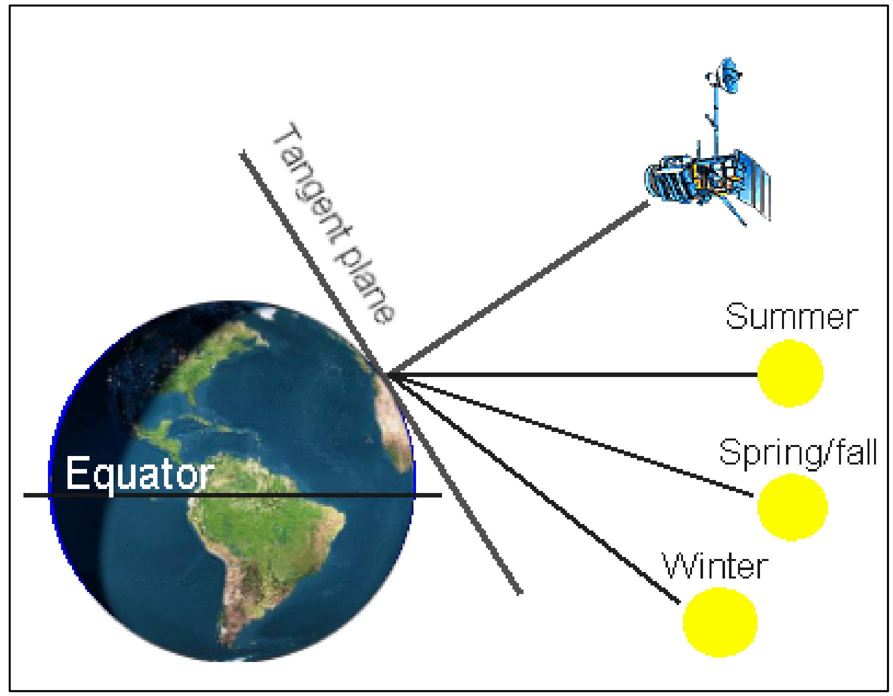
Sun angle correction

- an absolute correction involves dividing the DN-value in the image data by the sine of the solar elevation angle
- size of the angle is given in the header of the image data

$$DN_{corr} = \frac{DN}{\sin \alpha}$$

Sun Illumination

- position of sun
  - sun elevation (sun-angle)
  - sun - earth distance
- correction elevation
  - normalization
  - division of each pixel value by the sine of solar elevation angle for particular time and location per spectral band
- correction distance
  - sun irradiance decreases with square of distance
  - normalization



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Sensor calibration

- necessary to generate absolute data on physical properties
  - reflectance
  - temperature
  - emissivity
  - backscatter
- values provided by data provider / agency

Terrain effects

- cause differential solar illumination
  - some slopes receive more sunlight than others
- magnitude of reflected radiance reaching the sensor
  - topographic slope and aspect
  - bidirectional reflectance distribution function (BRDF)

Terrain correction

- Minnaert correction
  - first order correction for terrain illumination effects

$$L_n = L \cdot \cos(e)^{k-1} \cdot \cos(i)^k$$

L_n – normalized radiance

L – measured radiance

e – slope (derived from DEM)

i – incidence angle of solar radiation

k – Minnaert constant (estimated for each image)

Terrain correction

- shaded relief model (SRM)
  - requires digital elevation model
  - generated with constant albedo (brightness dependent solely on topographic effects)
  - ratio of image and SRM yields spectral radiance of ground cover (noisy)
  - alternative

$$DN_{corr} = m \cdot (DN - SRM_{DN}) + a$$

Why do atmospheric correction?

- physical relation of radiance to surface property
  - atmospheric component needs to be removed
- multispectral data for visual analysis
  - scattering increases inversely with wavelength
- image ratios
  - leads to biased estimate
- time difference between image acquisition and ground truth measurements

Atmosphere and radiation

- relationship between radiance received at the sensor (above atmosphere) and radiance leaving the ground

$$L_s = H \cdot \rho \cdot T + L_p$$

L_s – at sensor radiance

H – total downwelling radiance

ρ – reflectance of target

T – atmospheric transmittance

L_p – atmospheric path radiance (wavelength dependent)

Atmospheric correction methods

- image-based methods
  - histogram minimum method
  - regression method
- radiative transfer models
- empirical line method

Histogram minimum method

$$L_s = H \cdot \rho \cdot T + L_p$$

- histograms of pixel values in all bands
- pixel values of low reflectance areas near zero
  - exposures of dark colored rocks
  - deep shadows
  - clear water
- lowest pixel values in visible and near-infrared are approximation to atmospheric path radiance
- minimum values subtracted from image

Regression method

$$L_s = H \cdot \rho \cdot T + L_p$$

- applicable to dark pixel areas
- near-infrared pixel values are plotted against values in other bands
- least square line fit using standard regression methods
- resulting offset is approximation for atmospheric path radiance
- offset subtracted from image

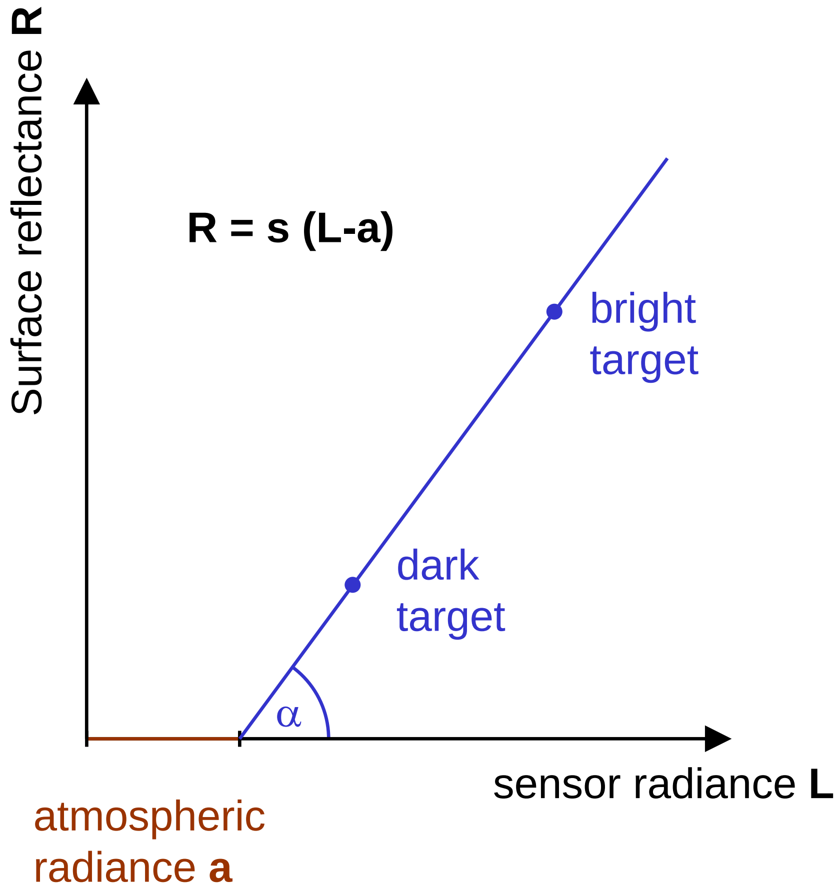
Radiative transfer models

- limited by the need to supply data about atmospheric conditions at time of acquisition
- mostly used with "standard atmospheres"
- available numerical models
  - LOWTRAN 7
  - MODTRAN 4
  - ATREM
  - ATCOR
  - 6S (**S**econd **S**imulation of the **S**atellite **S**ignal in the **S**olar **S**pectrum)

ATCOR

- originally developed DLR (Germany)
- different versions
  - satellite imagery – ATCOR 2 (flat terrain), ATCOR 3 (rugged terrain)
  - airborne imagery – ATCOR 4 (flat and rugged)
- various versions commercially available
  - standalone version in IDL
  - ERDAS Imagine
  - PCI Geomatics

Empirical line method

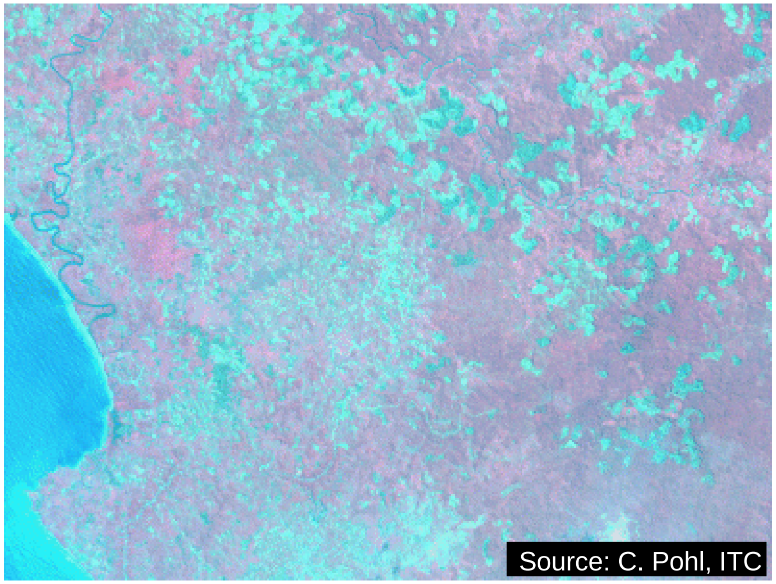


- selection of one dark and one bright target
- ground reflectance measurement
  - field radiometer
- sensor radiance computed from image
- slope **s** = cos (α) and intercept **a** of line joining two targets

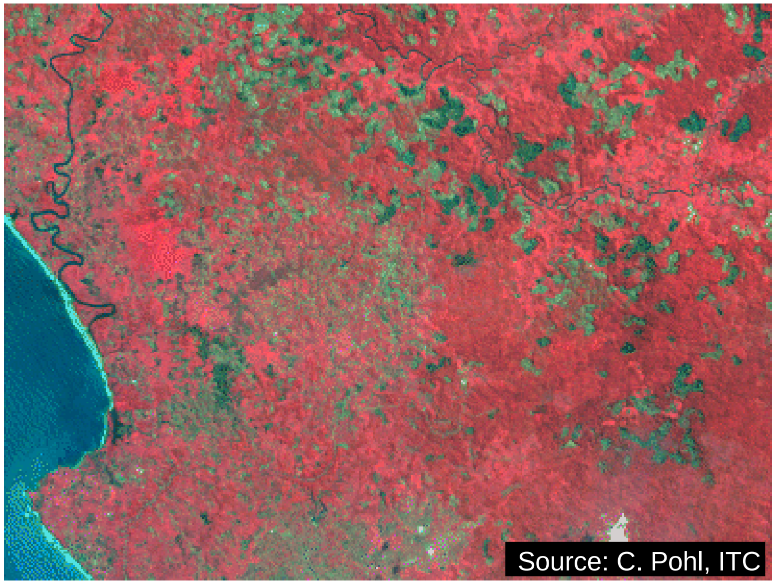
Haze

- due to Rayleigh scattering
  - particles size responsible for effect smaller than the radiation's wavelength (e.g. oxygen and nitrogen)
- haze has an additive effect resulting in higher DN values
- decreases the general contrast of the image
- effect is wavelength dependent
  - more pronounced in shorter wavelengths and negligible in the NIR

Haze – Example Indonesia



Hazy



Corrected

Questions

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