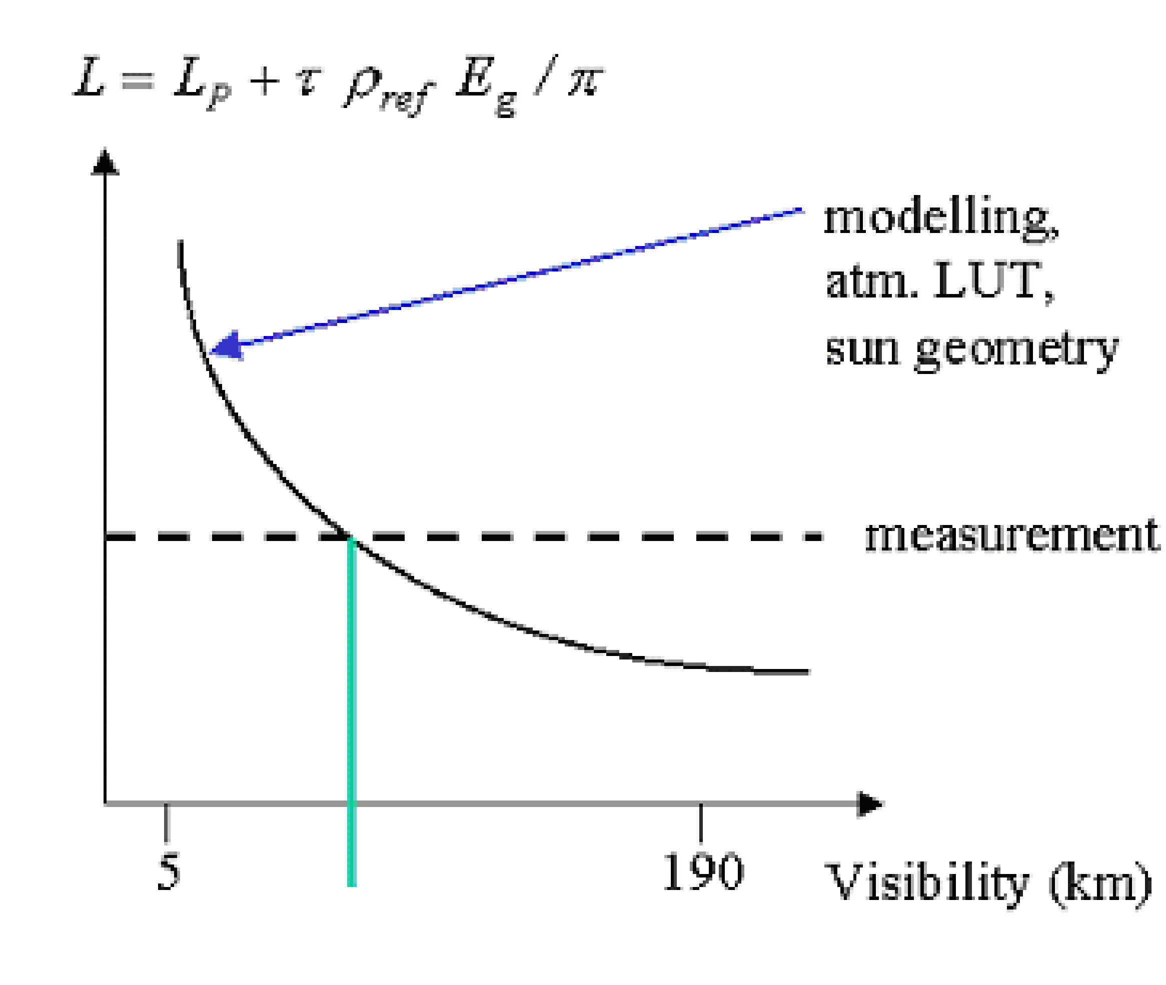
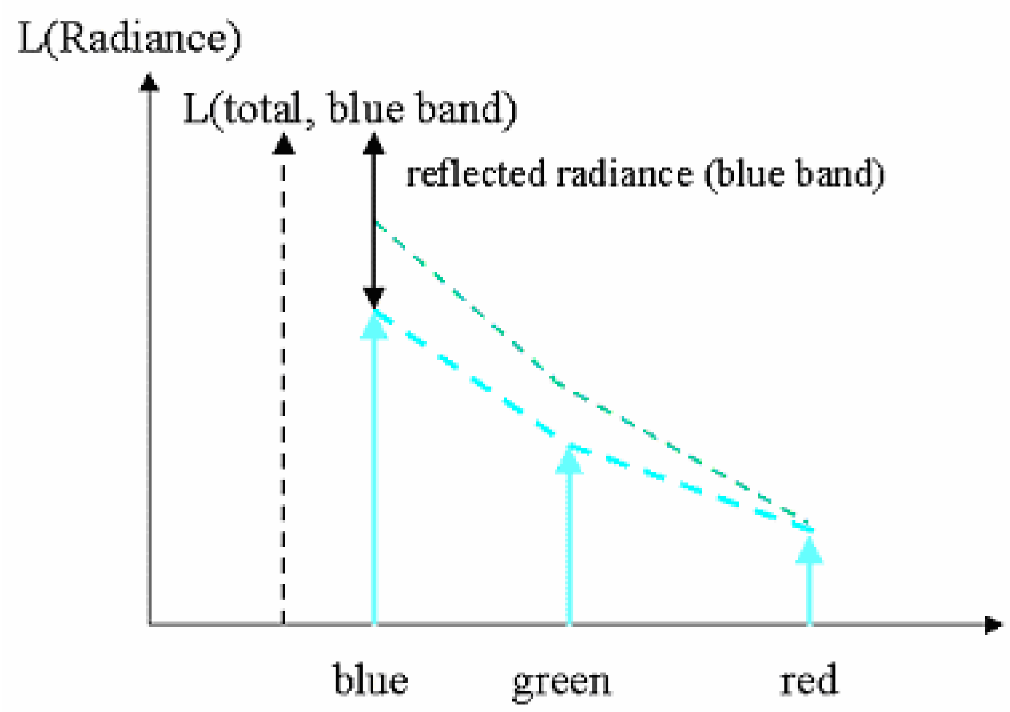
AOT / Visibility Retrieval

VIS / AOT evaluated with red spectral band



Aerosol Type Retrieval



1. Calculate L_p(blue), L_p(red) by subtracting L(reflected) from L(at-sensor)

   ρ(reflected, blue, red) is known from spectral correlation with ρ(SWIR)

2. Calculate double ratio of L_p(scene) to L_p(MODTRAN)

   for standard aerosol types: rural, urban, maritime, desert

3. Select aerosol with closest match to one of the standard types Ratio=1

$$Ratio = \frac{L_p(blue, scene) \,/\, L_p(red, scene)}{L_p(blue, MODTRAN) \,/\, L_p(red, MODTRAN)}$$

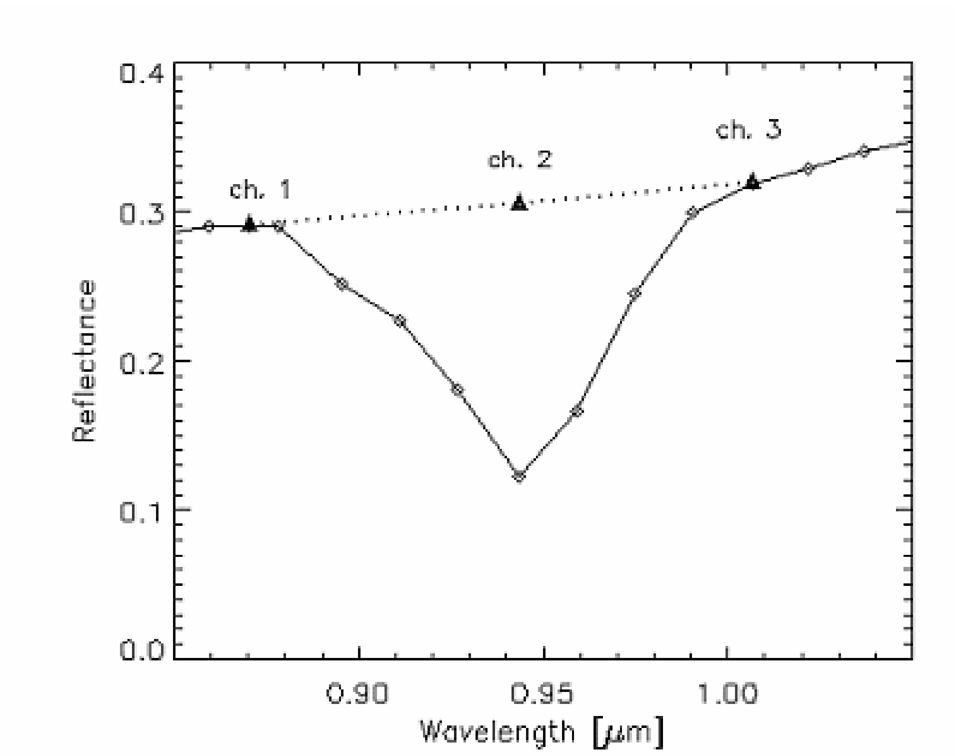
Water Vapor Retrieval

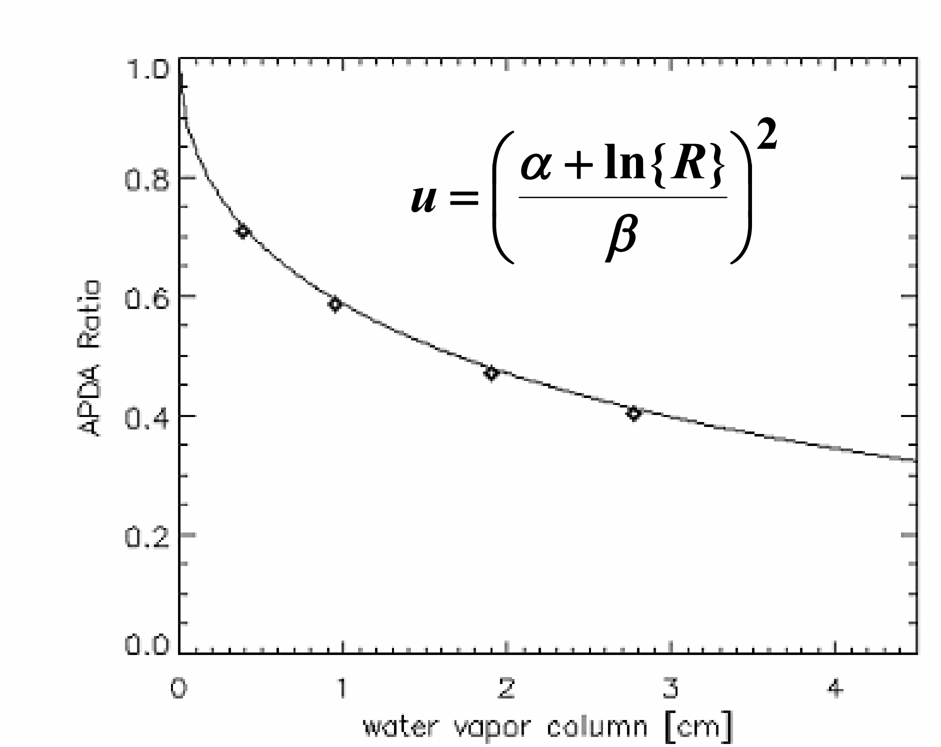
APDA (Atm. Precorrected Differential Absorption) algorithm

Minimum: 2 channels, better performance: 3 channels

APDA-LIRR (linear regression ratio) n ≥ 3 channels

$$R = \frac{L_2(\rho_2, u) - L_{2p}(u)}{w_1\{L_1(\rho_1, u) - L_{1p}(u)\} - w_3\{L_3(\rho_3, u) - L_{3p}(u)\}} = \exp(-\alpha + \beta\sqrt{u})$$





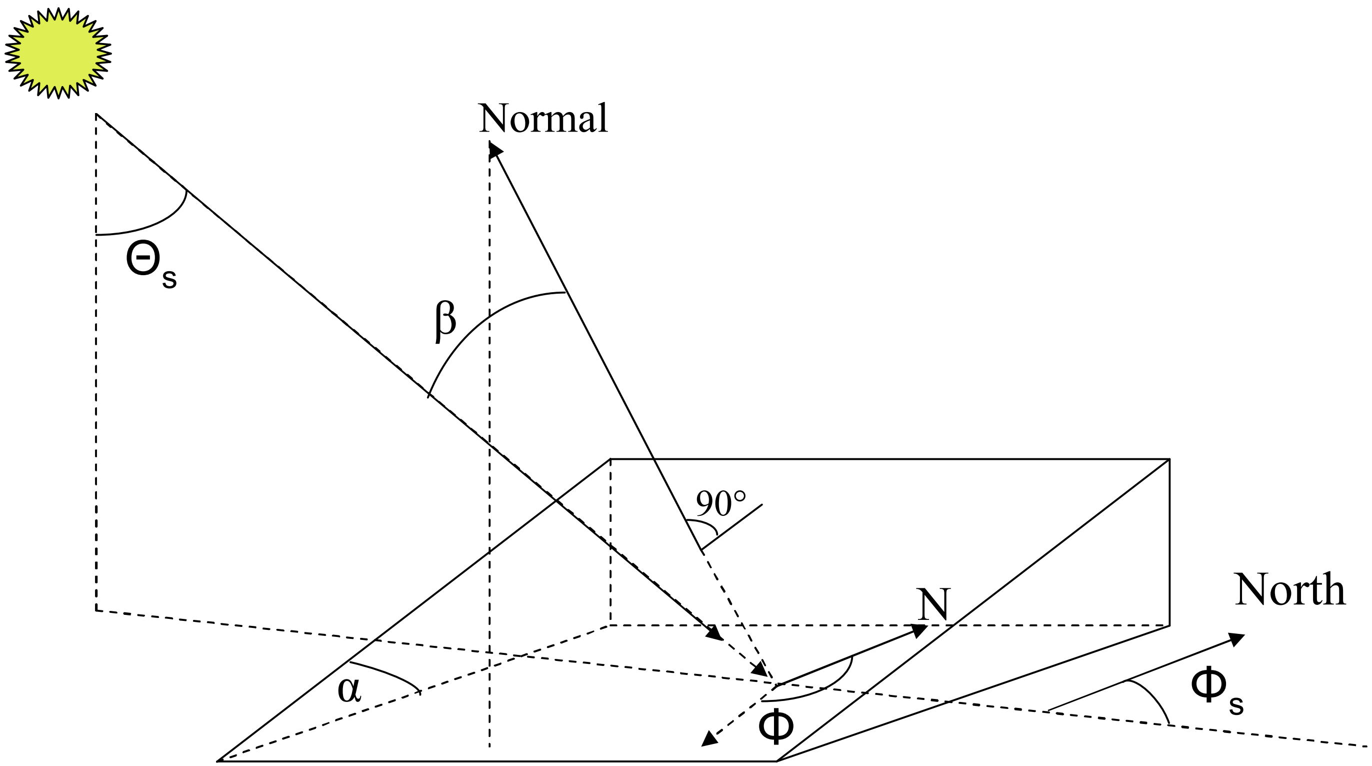
Topographic Correction Methods (1)

Problems:

1. Lambertian Cos - Law overestimates topographic influence in steep terrain
2. Bidirectional reflectance behavior especially pronounced in steep terrain
3. BRDF surface cover dependent

Illumination angle =
Local solar zenith β :

$$\cos\beta = \cos\theta_s \cos\alpha - \sin\theta_s \sin\alpha \cos(\phi_s - \phi)$$



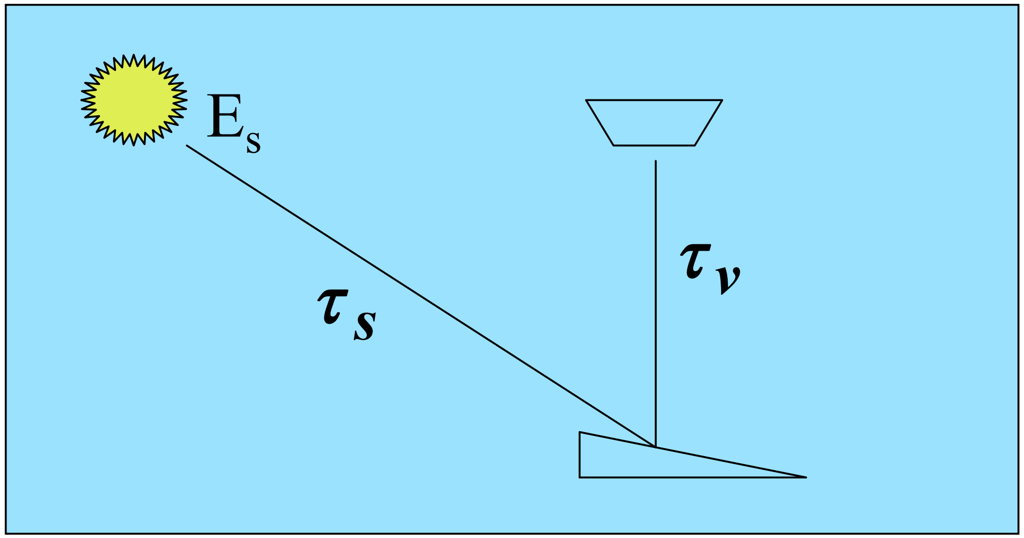
Topographic Correction Methods (2)

Problem with cos correction

Simplified:

$$\rho(horizontal) = \rho(slope)\frac{\cos\theta_s}{\cos\beta}$$

$$\beta \rightarrow 90° \Rightarrow \cos\beta = 0 \Rightarrow \rho(h) \rightarrow \infty$$



Better: also include E(diffuse)

But: problem cosβ→0 remains

i.e. overcorrection

$$\rho = \frac{\pi(L - L_p)}{\tau_v\left(\tau_s\, E_s \cos\beta + E_{dif} + E_{terrain}\right)}$$

Topographic Correction Methods (3)

Lambertian

$$\rho(horizontal) = \rho(slope)\frac{\cos\theta_s}{\cos\beta}$$

Non-Lambertian

Minnaert

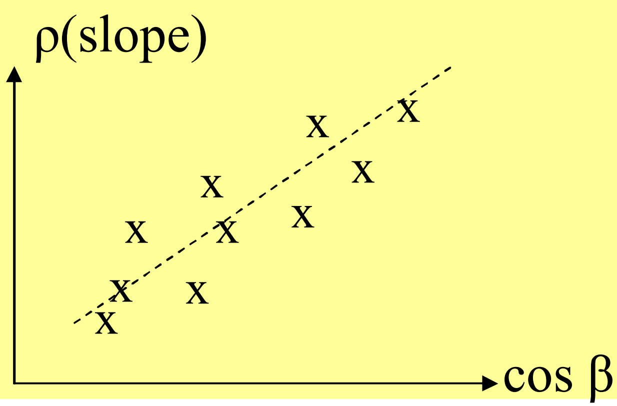
$$\rho(horizontal) = \rho(slope)\left[\frac{\cos\theta_s}{\cos\beta}\right]^{K_i}$$

K_i depends on channel i obtained with linear regression of:
(constant intercept $\ln(\rho_{hor})$, slope K_i)
empirical-statistical

$$\ln(\rho_{slope}) = \ln(\rho_{hor}) + K_i \ln\left(\frac{\cos\beta}{\cos\theta_s}\right)$$

C correction (empirical-statistical)

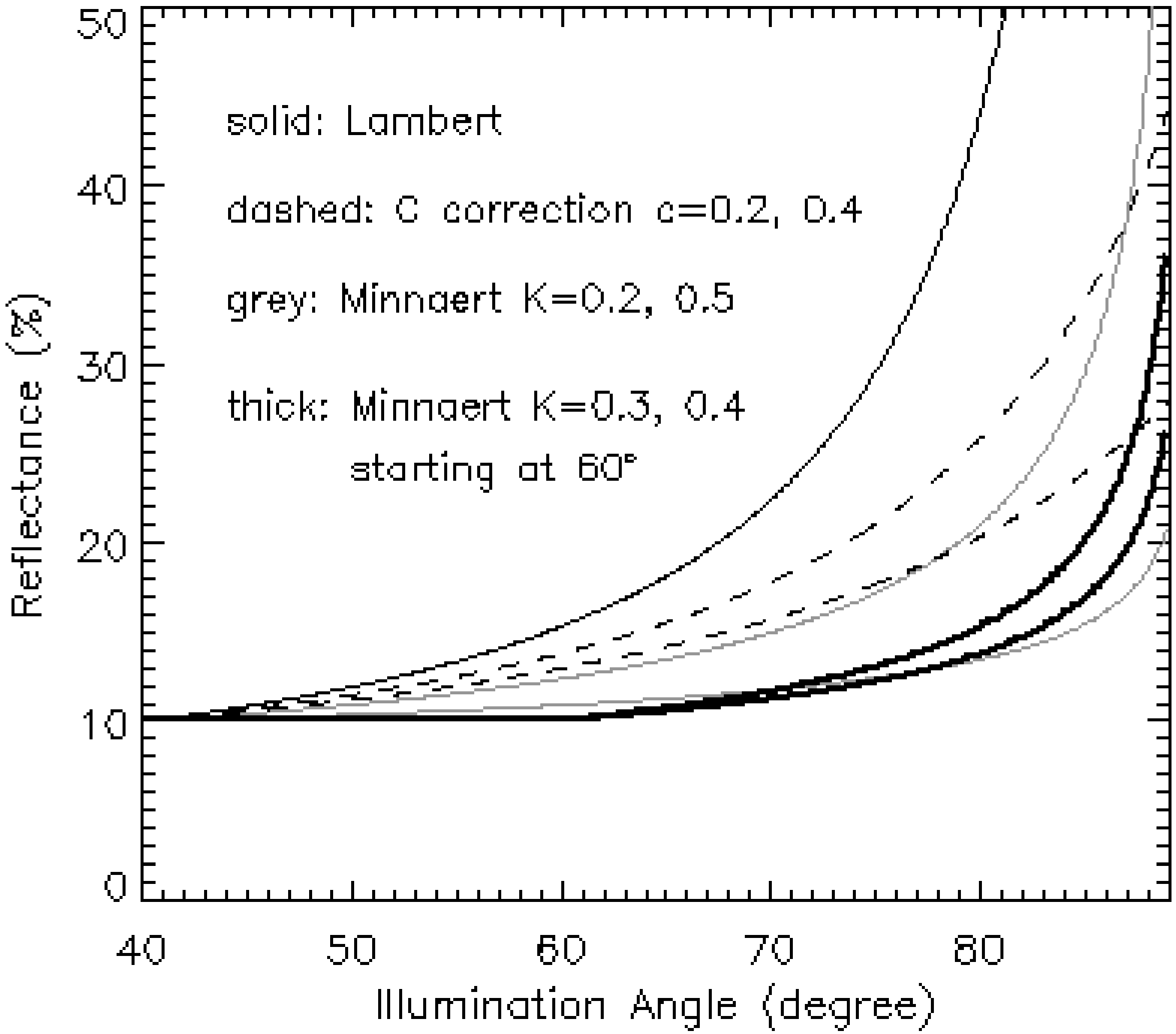
$$\rho(h) = \rho(slope)\frac{\cos\theta_s + c_i}{\cos\beta + c_i}$$



$$c_i = m_i / b_i$$

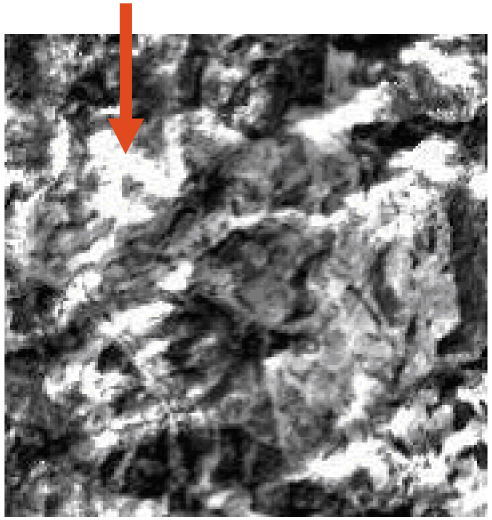
$$\rho(slope) = b_i + m_i \cos\beta$$

Topographic Correction Methods (4)

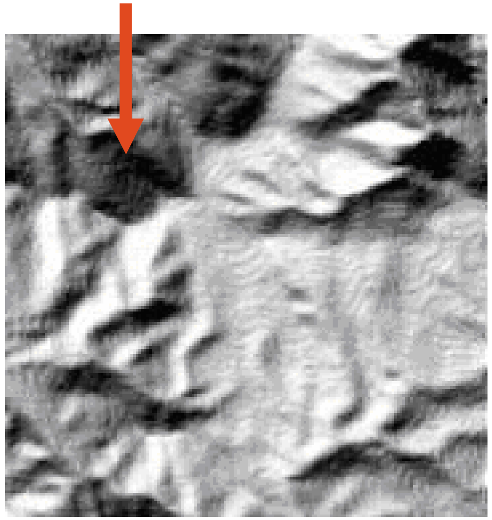


Empirical-statistical correction functions

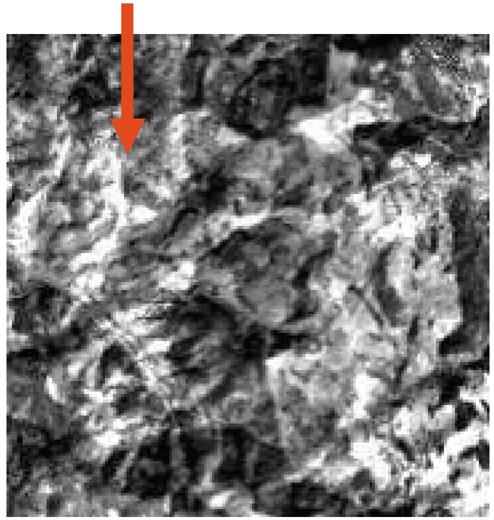
Topographic Correction Methods (5)



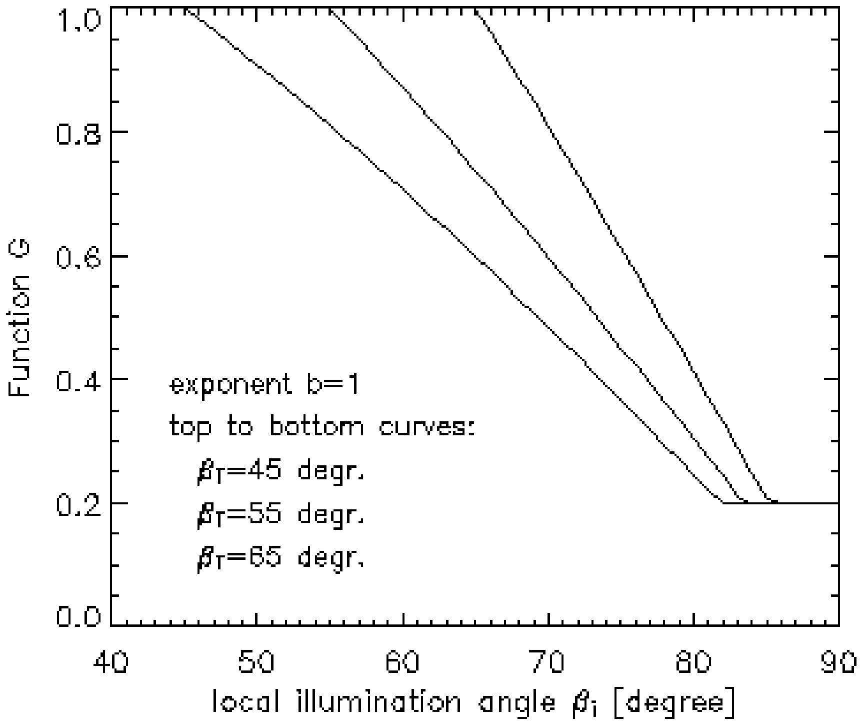
Lambert correction



Illumination β(x,y)



Empirical geometric correction



Empirical correction starts at a threshold angle $\beta_T > \theta_s$ and reduces reflectance:

$$\rho(corrected) = \rho(Lambert)\, G$$

Haze Removal

- Boundary layer haze often occurs in the visible bands (400-700 nm) of satellite imagery.
- As a first approximation, haze is an additive component to the radiance signal at the sensor. It can be estimated and removed.
- The following algorithm is based on the method of Zhang et al. (RSE Vol. 82, 173-187, 2002) and works for land areas. It was improved and runs fully automatic.

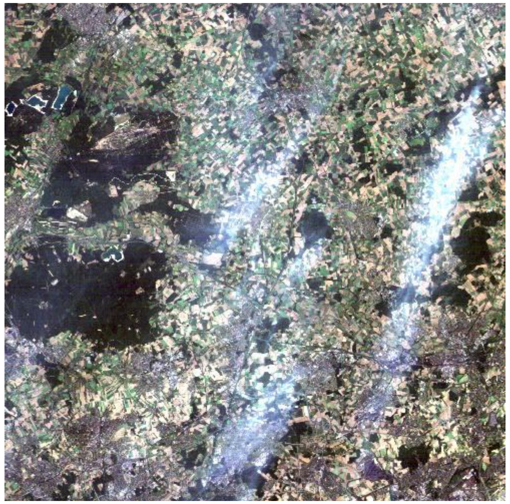
Haze Removal

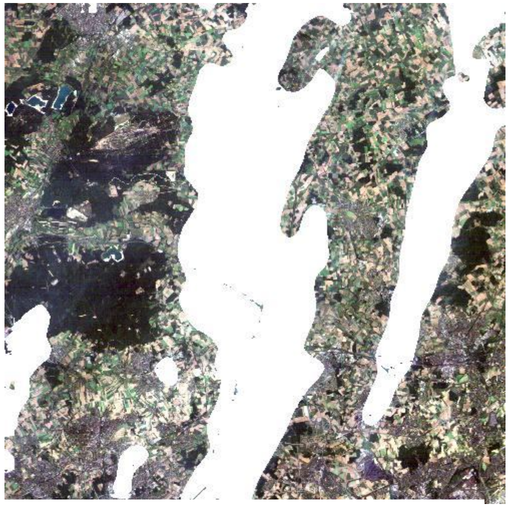
Processing Steps

1. Masking of clear and hazy areas
2. Calculation of the correlation for clear areas in the blue and red channel: regression line (“clear line“) , slope α
3. Haze areas are orthogonal to the “clear line“ :
   Haze Optimized Transform = HOT = Blue*sin α - Red*cos α
4. Calculation of histogram HOT(haze)
5. Digital Number (DN) histograms for each HOT Level j:
   - calculation of Δ
   - DN(de-haze) = DN - Δ

Haze Removal

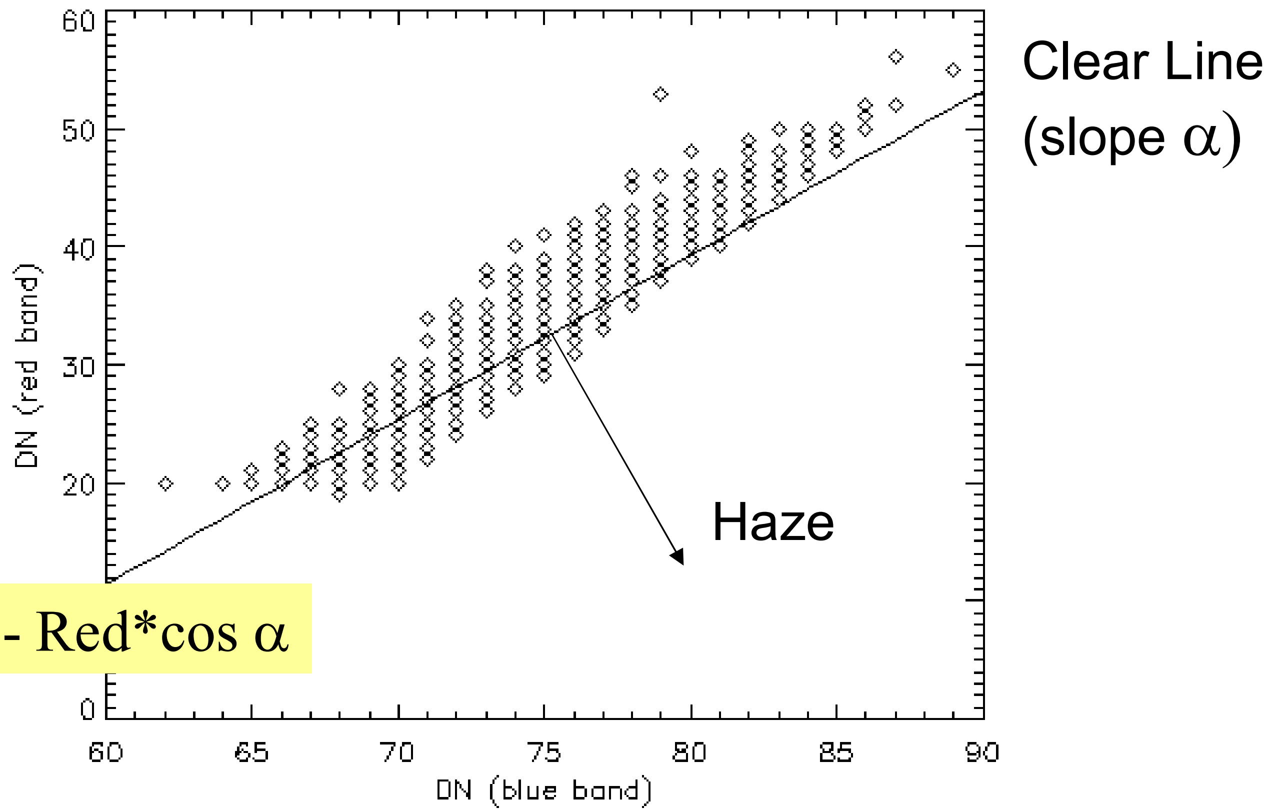
1. Mask clear & haze





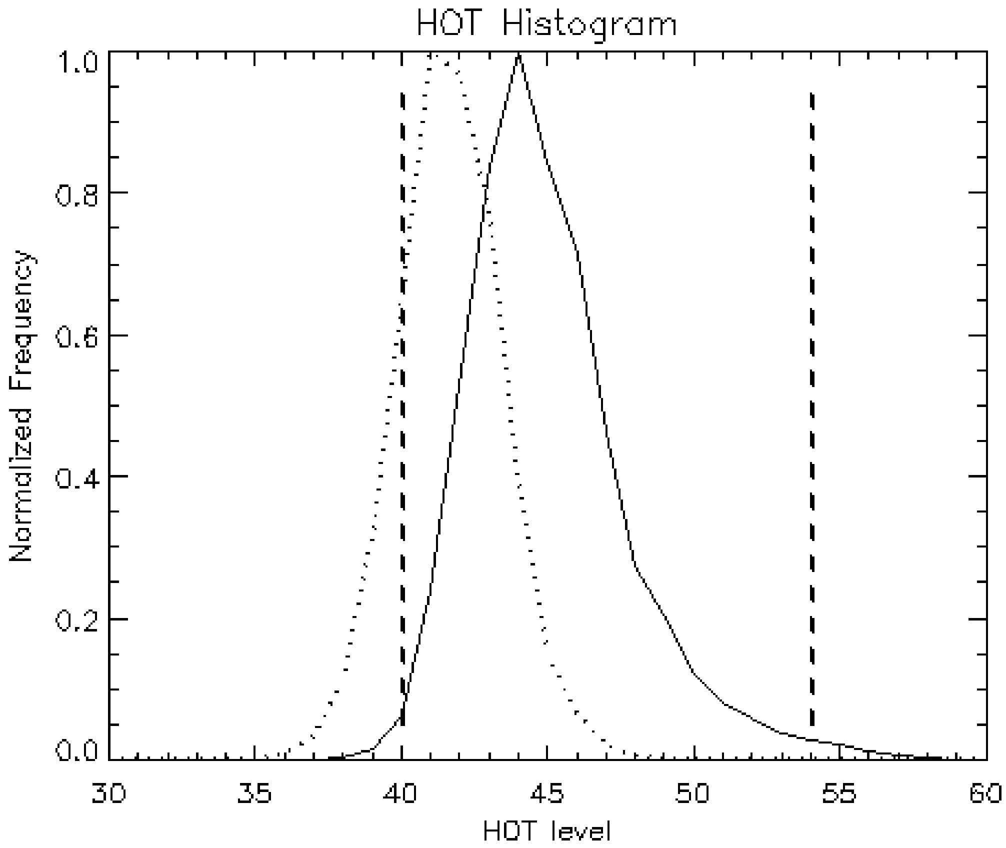
2. Calc. “Clear Line“

(correlation red/blue)

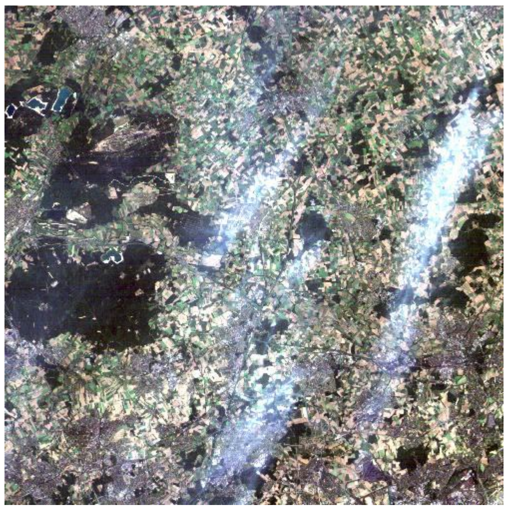


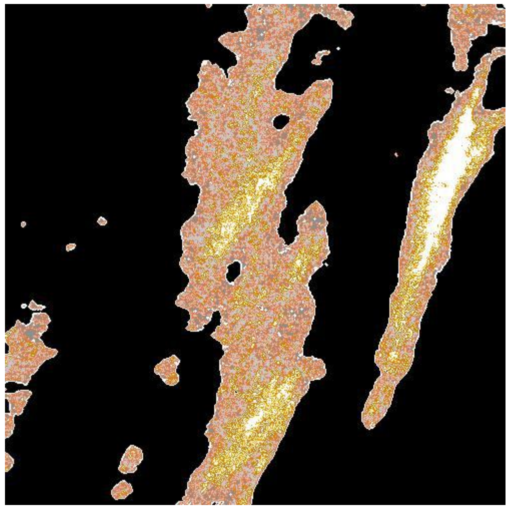
3. HOT = Blue*sin α - Red*cos α

Haze Removal



4. HOT histogram





Color coded haze levels

Haze Removal

5. Calculate de-hazing term: DN(de-haze) = DN - Δ