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Decoupling aerosol and ground reflection signals in urban areas using spatial regression between V/NIR and MIR Hyperion channels

- Aerosol operational algorithms often assume constant correlations between the ground reflectance in the VIS and MIR channels which may not hold under different viewing and land surfaces conditions.
- Urban areas in particular do not fit the traditional correlation models.
- Improve aerosol retrieval and test ground reflectance correlation in urban areas with high spatial resolution sensors (Hyperion on EO-I satellite, and AVIRIS on aircraft)

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Application and validation of ground reflectance correlations (MODIS over vegetation)

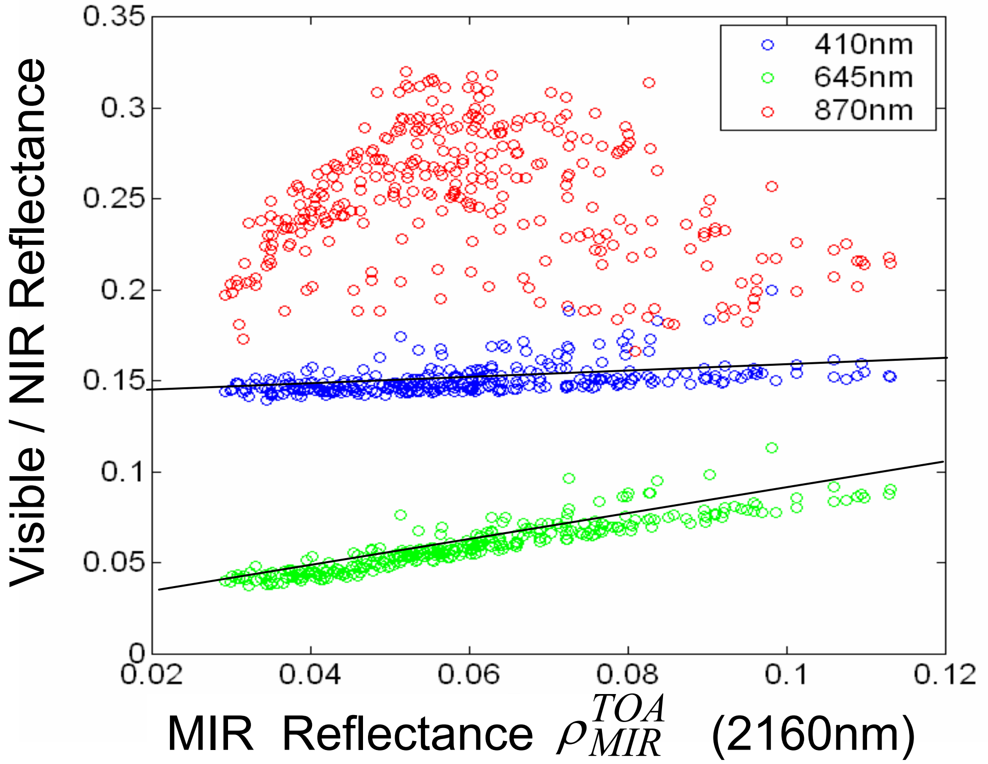
1) Correlation between ground reflection for different channels will result in correlations at the TOA

$$\rho_{vis}^{TOA} \approx m\rho_{MIR}^{TOA} + \rho_{vis}^{Atm}$$

2) This can be used to separate ground and atmosphere components by plotting the MIR and VIS reflectances and determining their regression coefficients

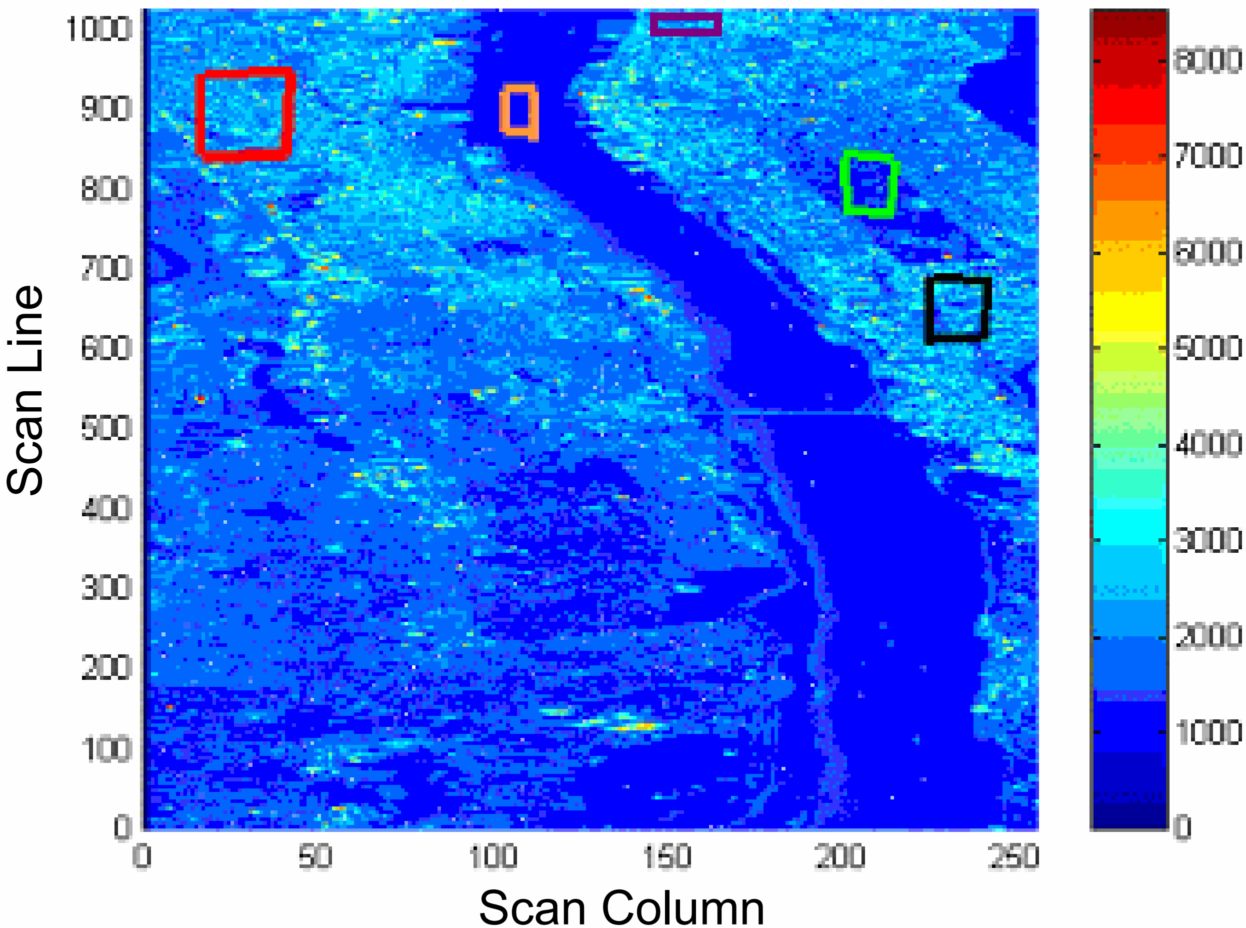
Y intercept gives atmospheric reflection while slope (m) is proportional to the ground correlation $C(470) \sim .18$

$C(660) \sim .47$



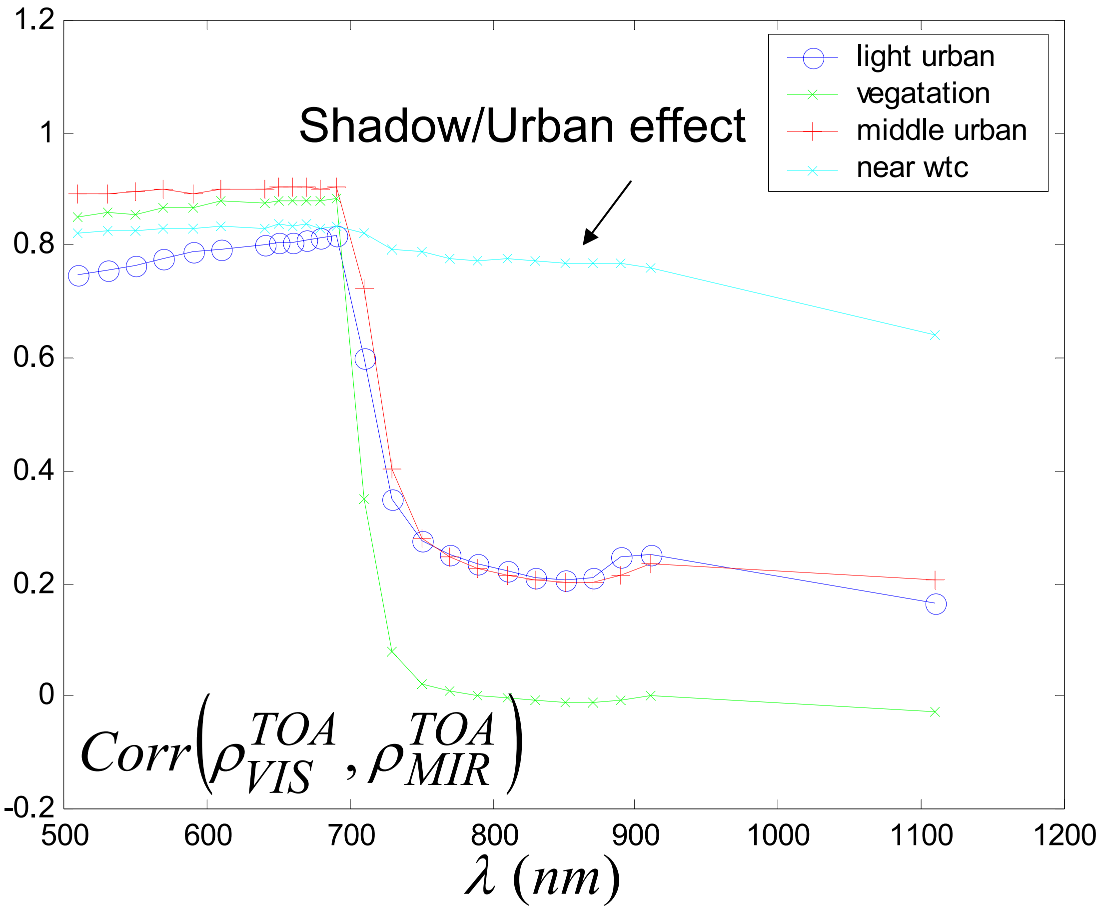
Probing aerosol retrieval and ground correlations over urban scales

New York observed through Hyperion (30 meter resolution)



Regions of interest include vegetation (central park – green), Urban areas (red-black) the river (orange), and lower manhattan

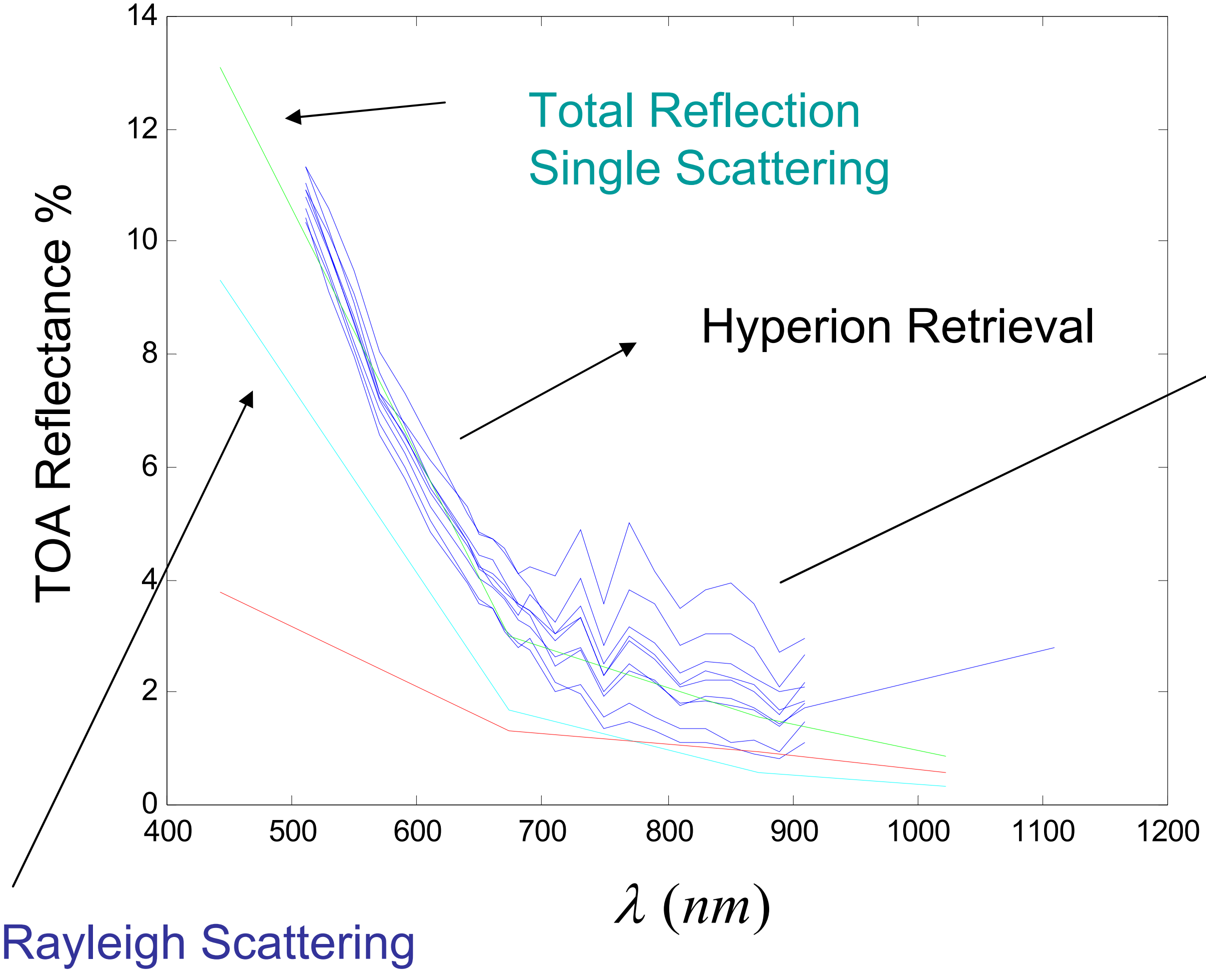
Correlation Coefficient vs wavelength



Urban environments have many wavelength independent reflection (geometric) mechanisms that improve the correlations between the VIS and MIR channels

Note a sharp difference for lower Manhattan due to shadowing /urban effect

Hyperion Retrieval of Aerosol Reflection over heavy urban zone



Larger Deviations above 700nm due perhaps to partial Vegetated scenes but Still much smaller than for vegetated scenes themselves

Aerosol Reflection based on Aeronet estimates of AOT and Phase Function

$$\omega_a = [.94]$$

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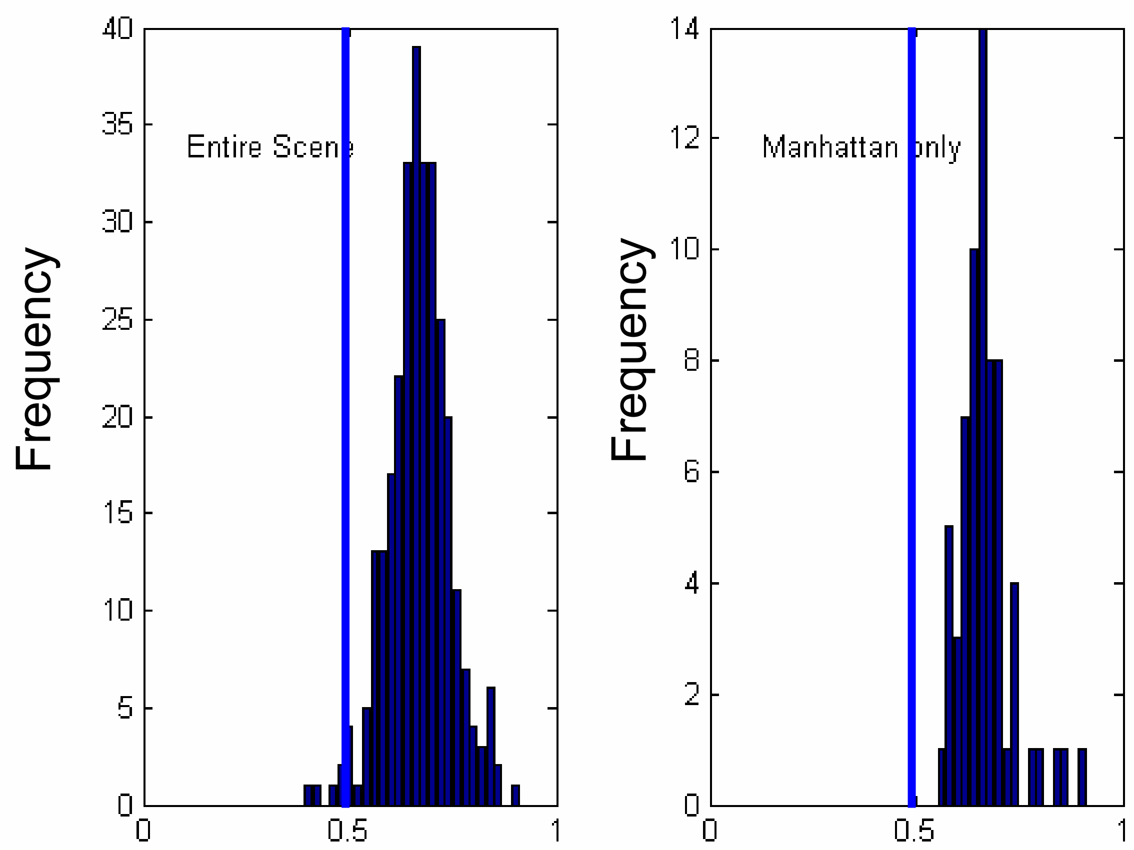
Ground reflection correlation frequency histogram

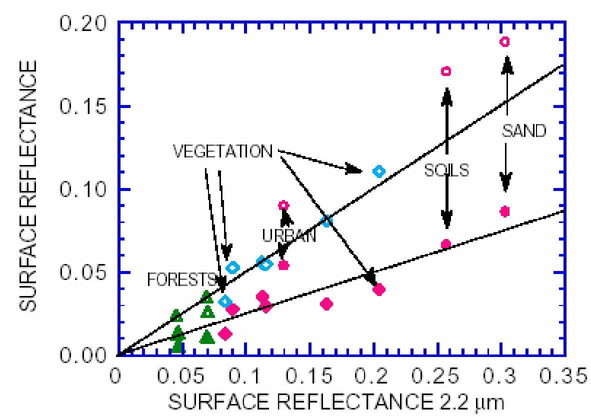
No angle dependence (Lambertian) assumption



$$c = \frac{\rho_{VIS,Ground}}{\rho_{MIR,Ground}}$$

Correlation larger than MODIS assumption of 0.5

Manhattan correlation coefficient > Full scene could explain overestimated MODIS Optical Depth



* Source MODIS ATBD Document

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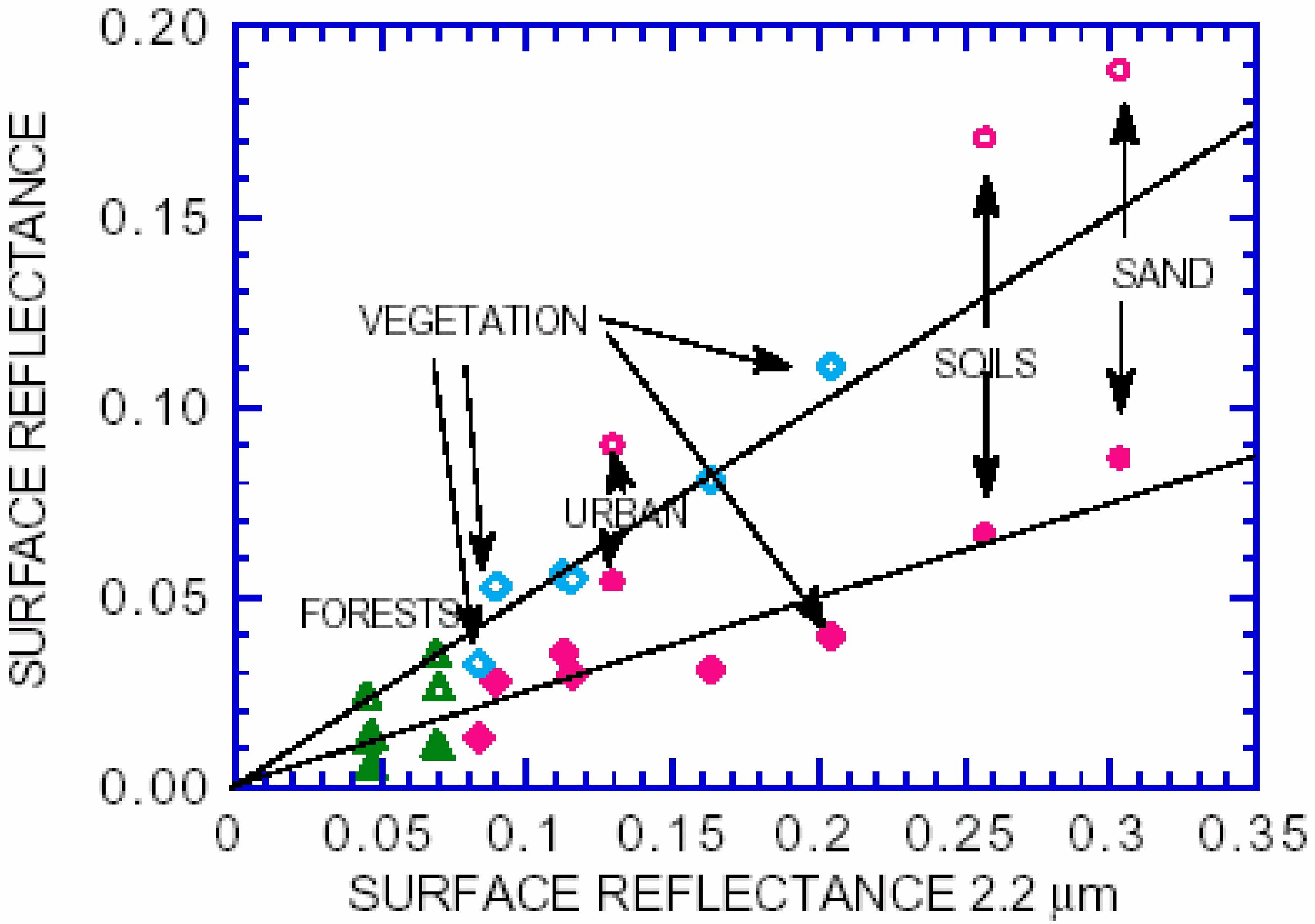
Conclusions

- Validation between NASA Aeronet and Hyperion aerosol reflectance spectra performed.(Low Optical Depth single scattering regime)
- Shadowing effects in heavily urban areas are shown to increase the spectral range of the decoupling process allowing aerosol retrieval from 400nm to 900nm
- Water leaving radiances in the spectral range of 400-900nm were obtained by eliminating the aerosol reflectance directly illustrating the improved aerosol retrieval with shadowing (especially above 700nm) in additional slides
- Calculations underway to assess BRDF effects on correlation coefficient values.

Additional Slides

Surface correlations from Landsat and AVIRIS



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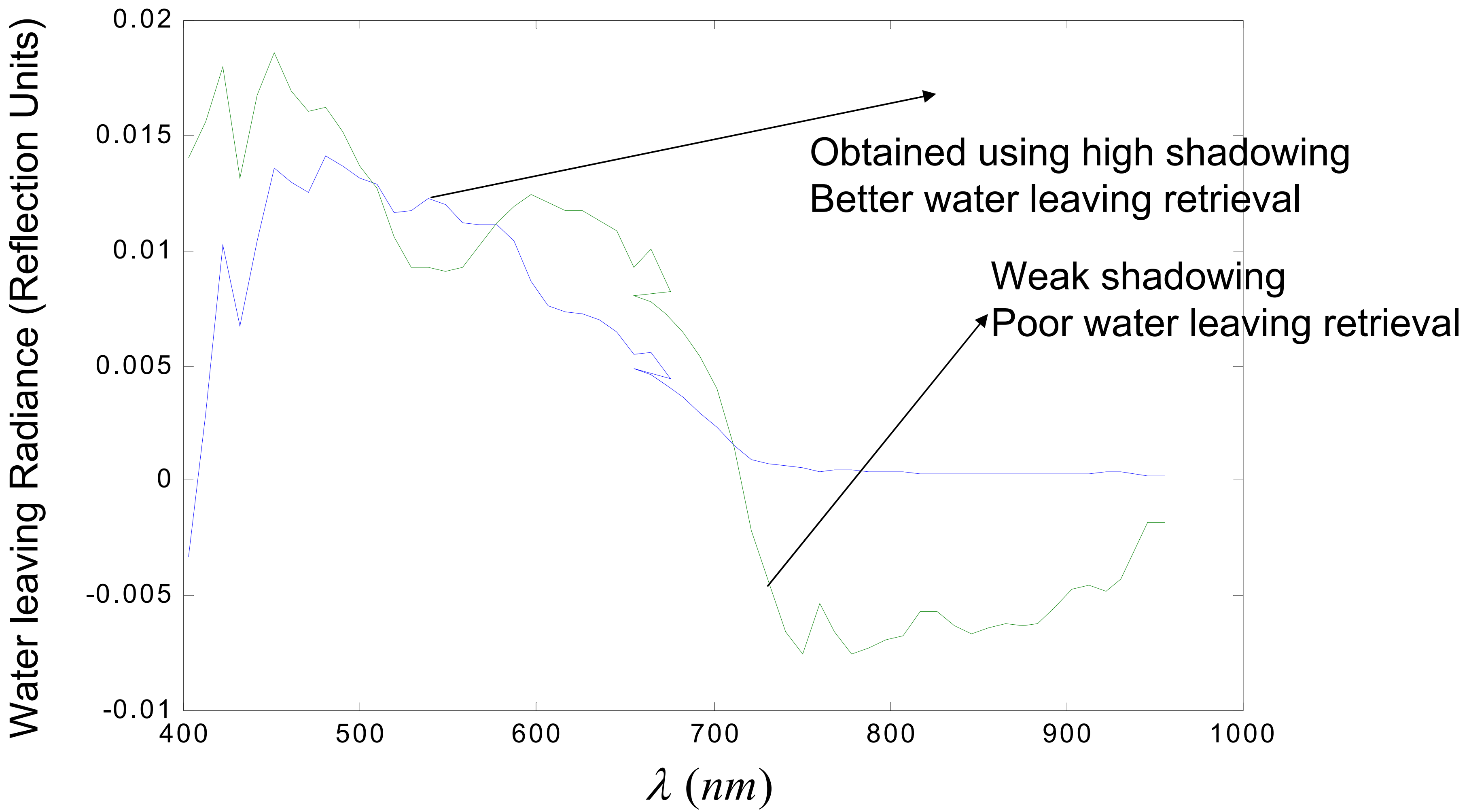
Water leaving radiance using AVIRIS (subtracting ground decoupled atmosphere signal from total water signal)



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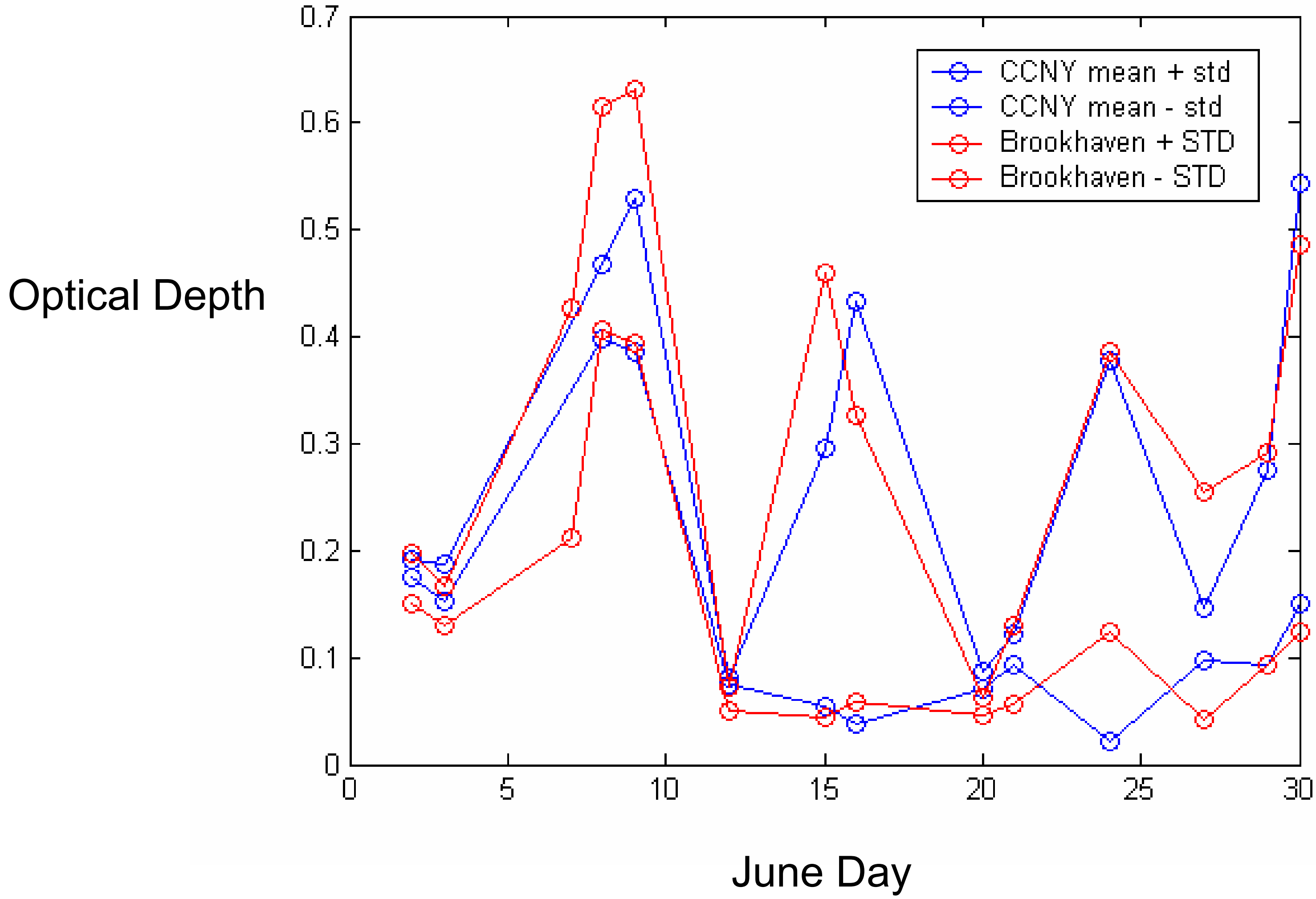
Variability capture



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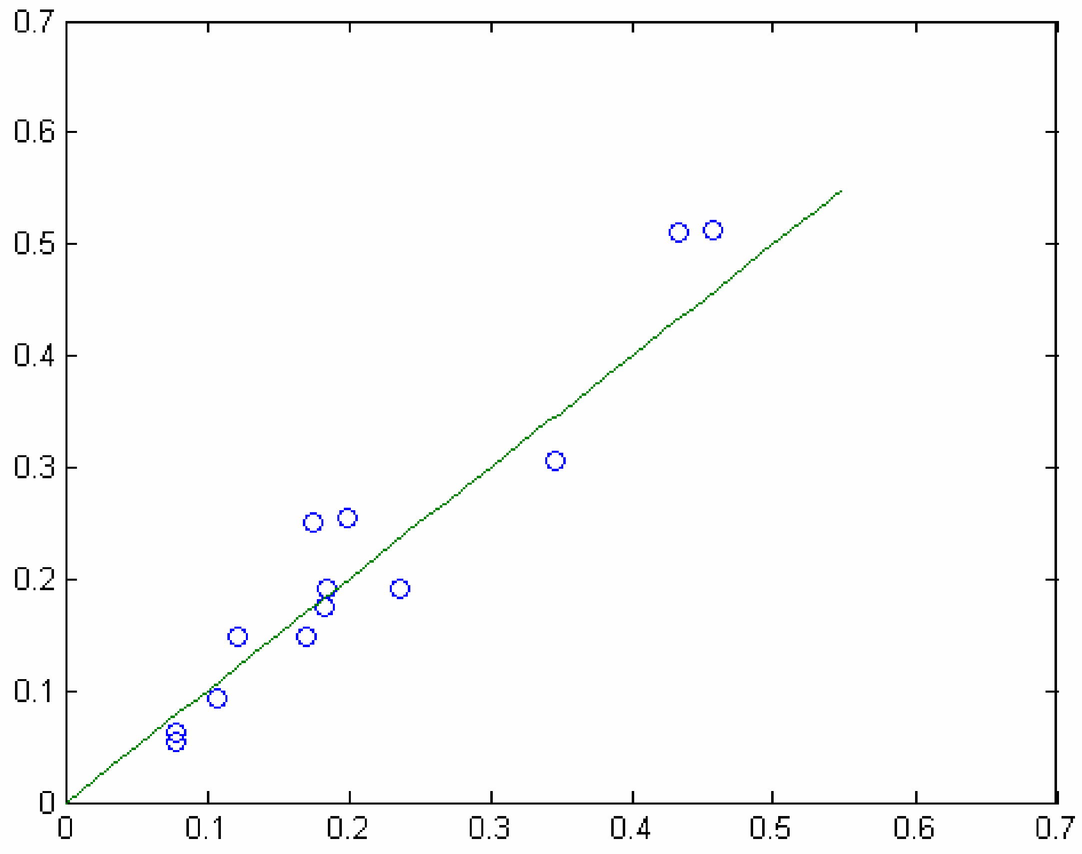
June 1-June 30
5 hour mean

AOT Brookhaven

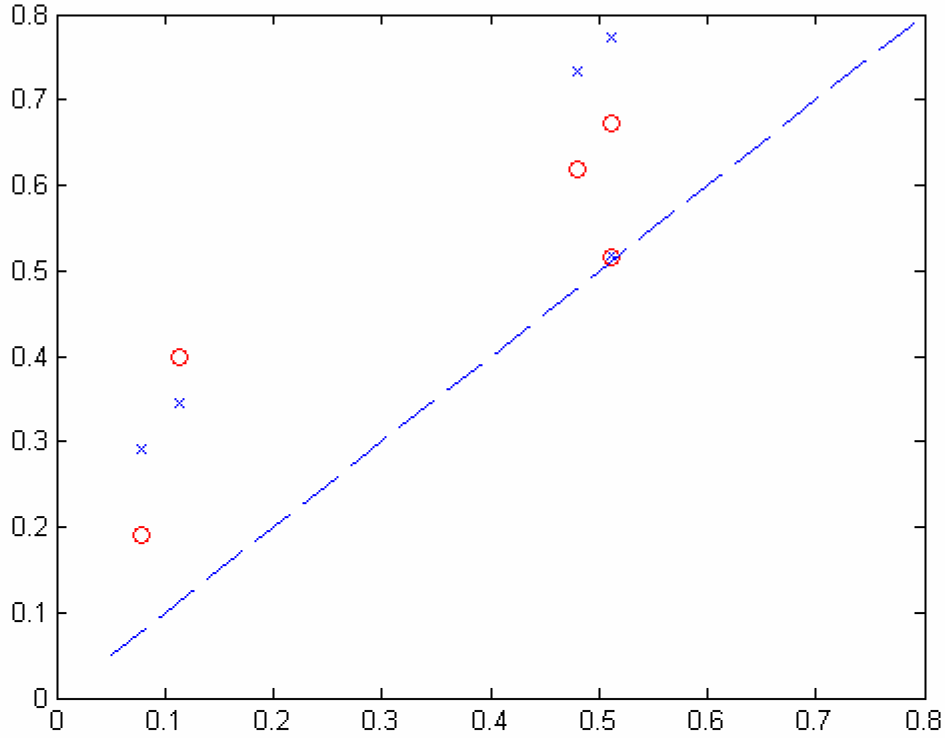


AOT CCNY

Over NYC – Brookhaven June

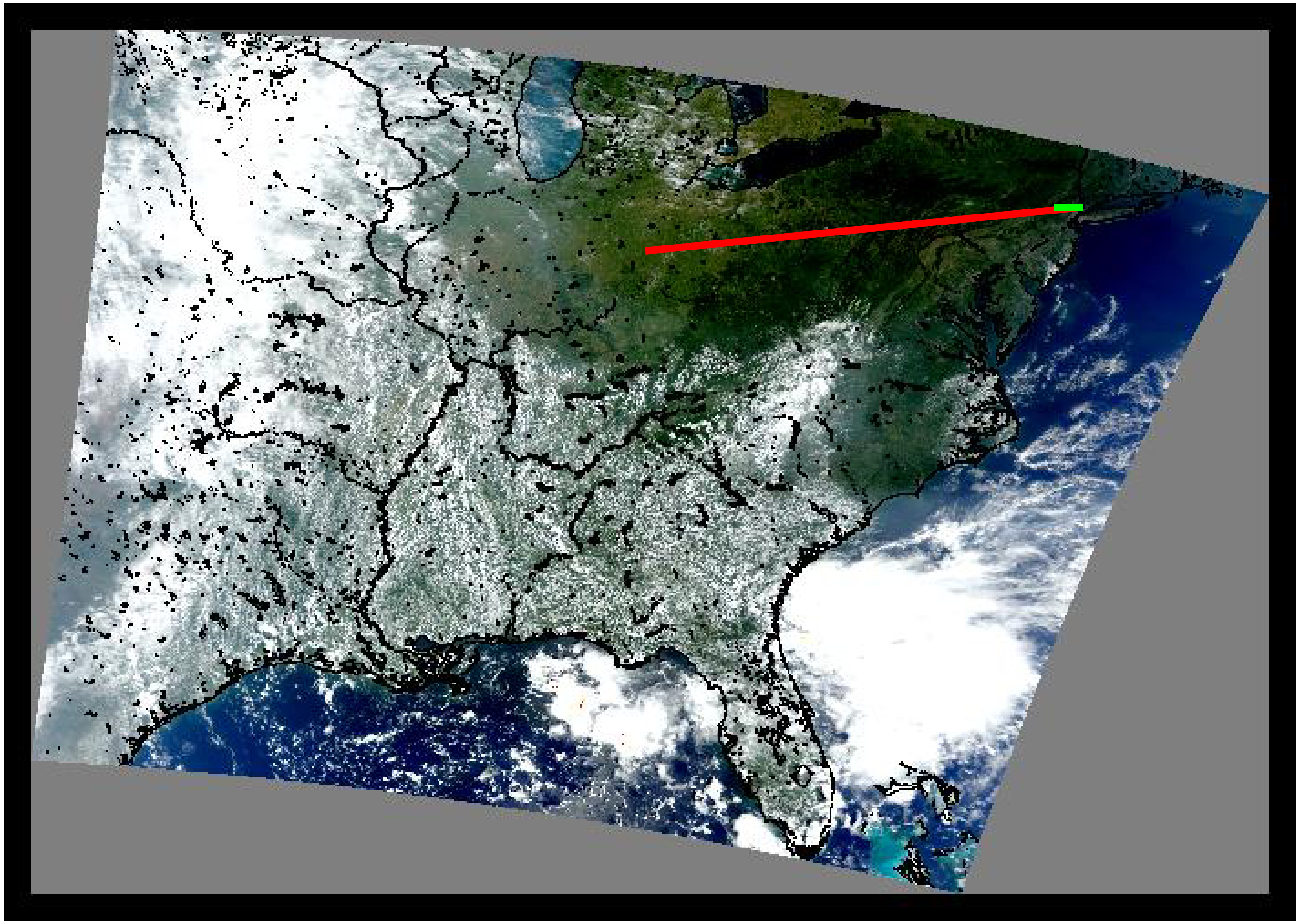
AOT MODIS

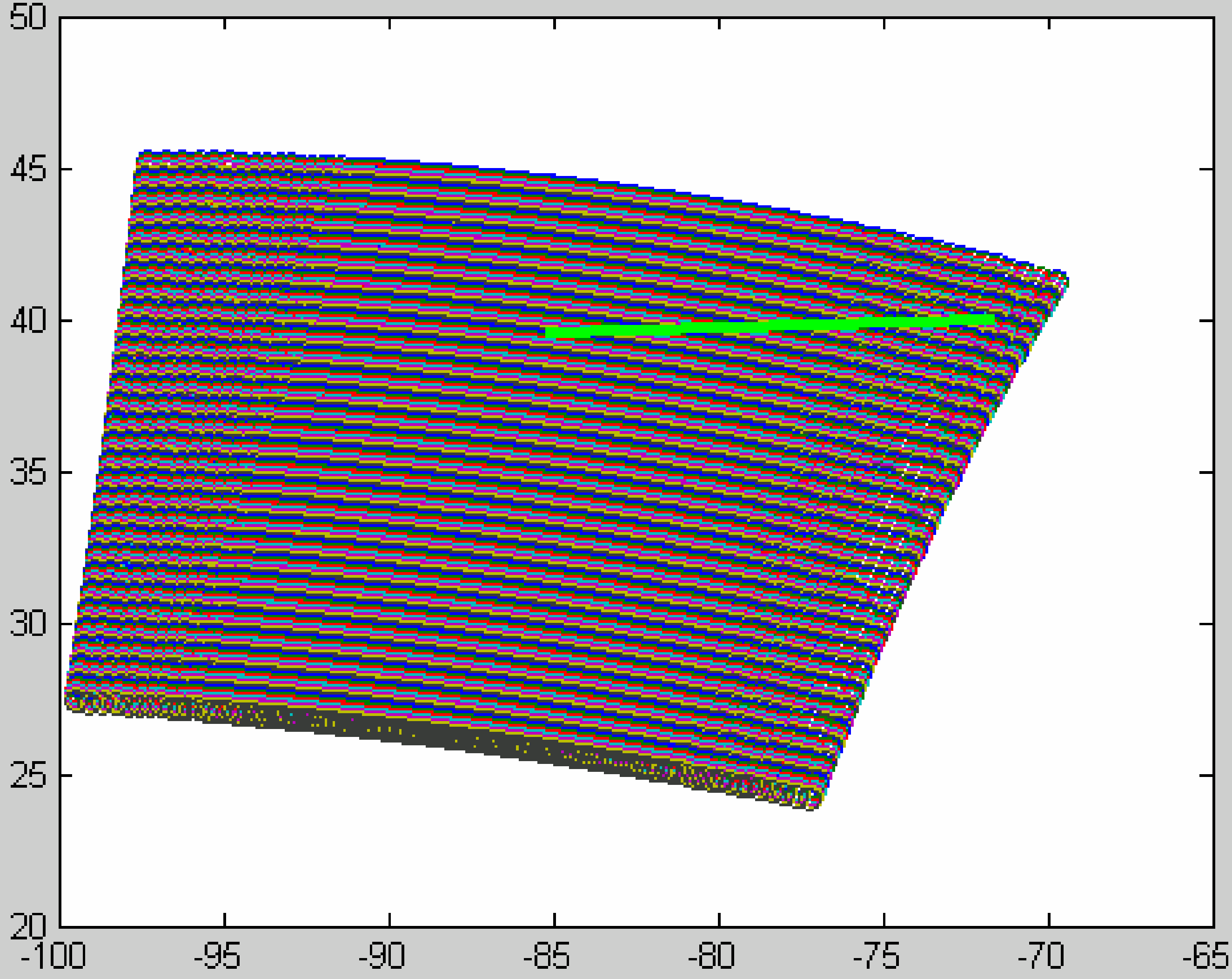
MODIS again overestimates



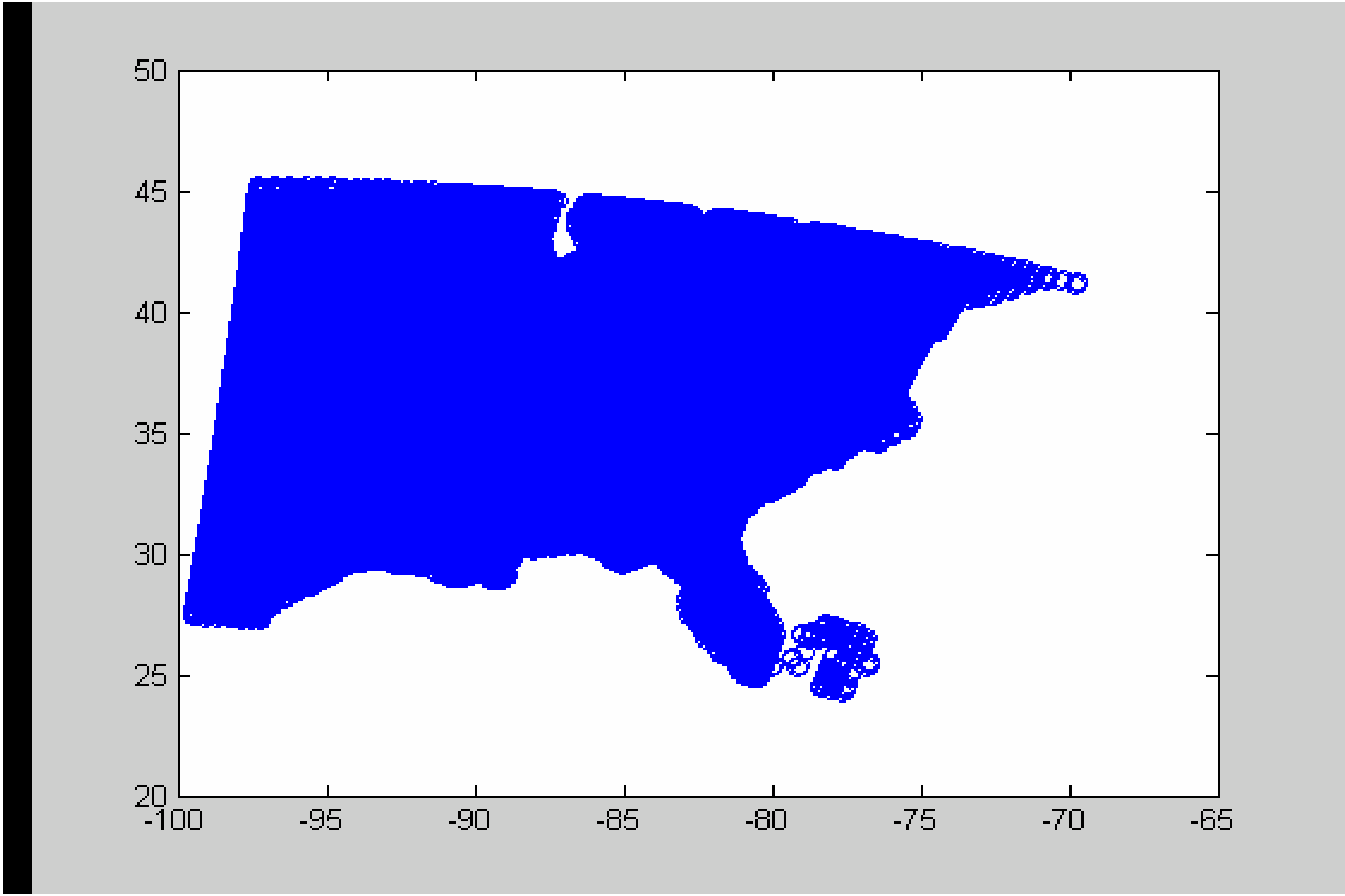
AOT Shadowband

MODIS Real Color Image

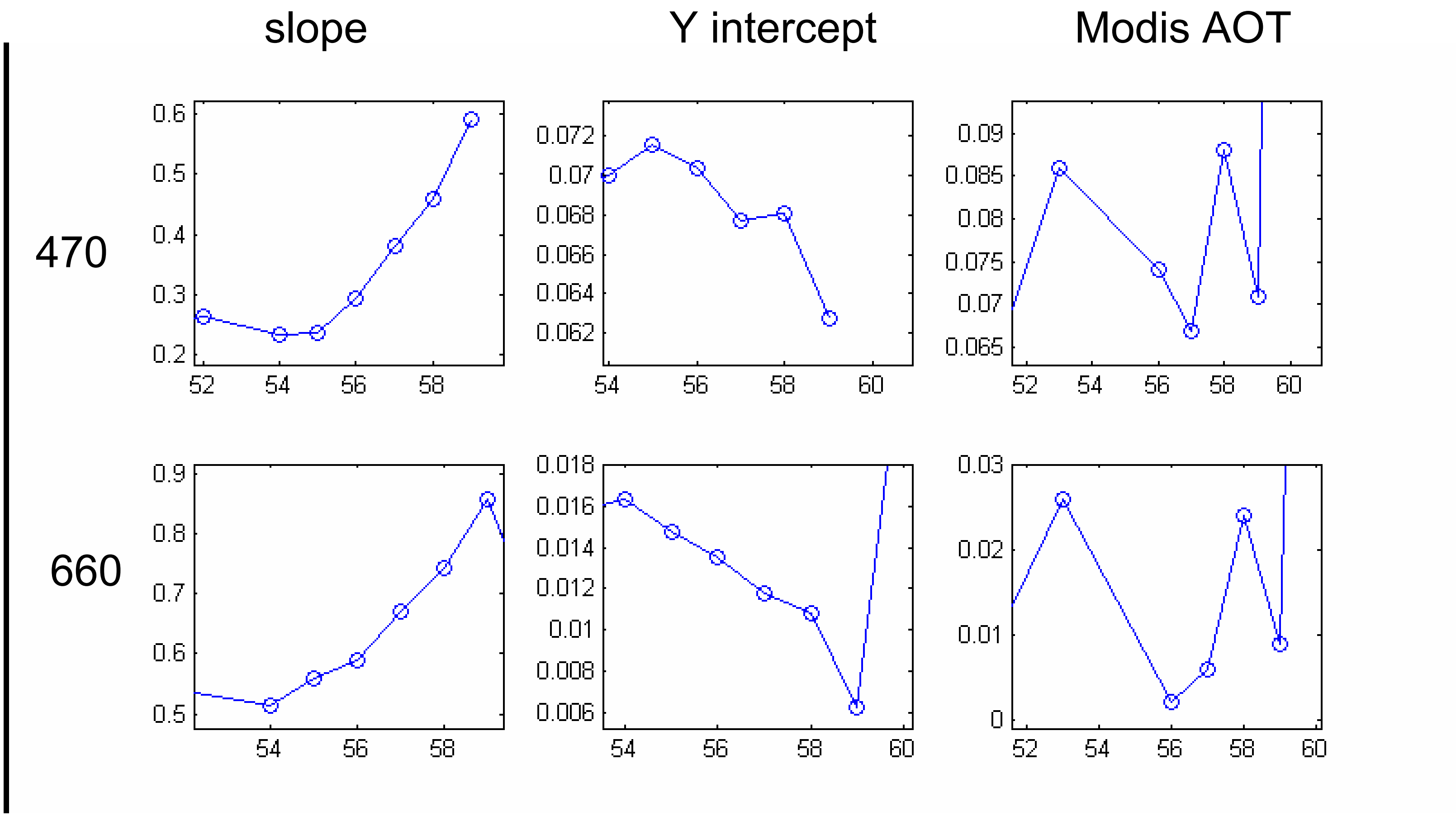



50
45
40
35
30
25
20
-100
-95
-90
-85
-80
-75
-70
-65

Test of cloud mask set to find all possible land pixels



Near NYC


slope
Y intercept
Modis AOT
470
660
0.6
0.5
0.4
0.3
0.2
52
54
56
58
0.072
0.07
0.068
0.066
0.064
0.062
60
0.09
0.085
0.08
0.075
0.07
0.065
0.9
0.8
0.7
0.6
0.5
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.03
0.02
0.01
0

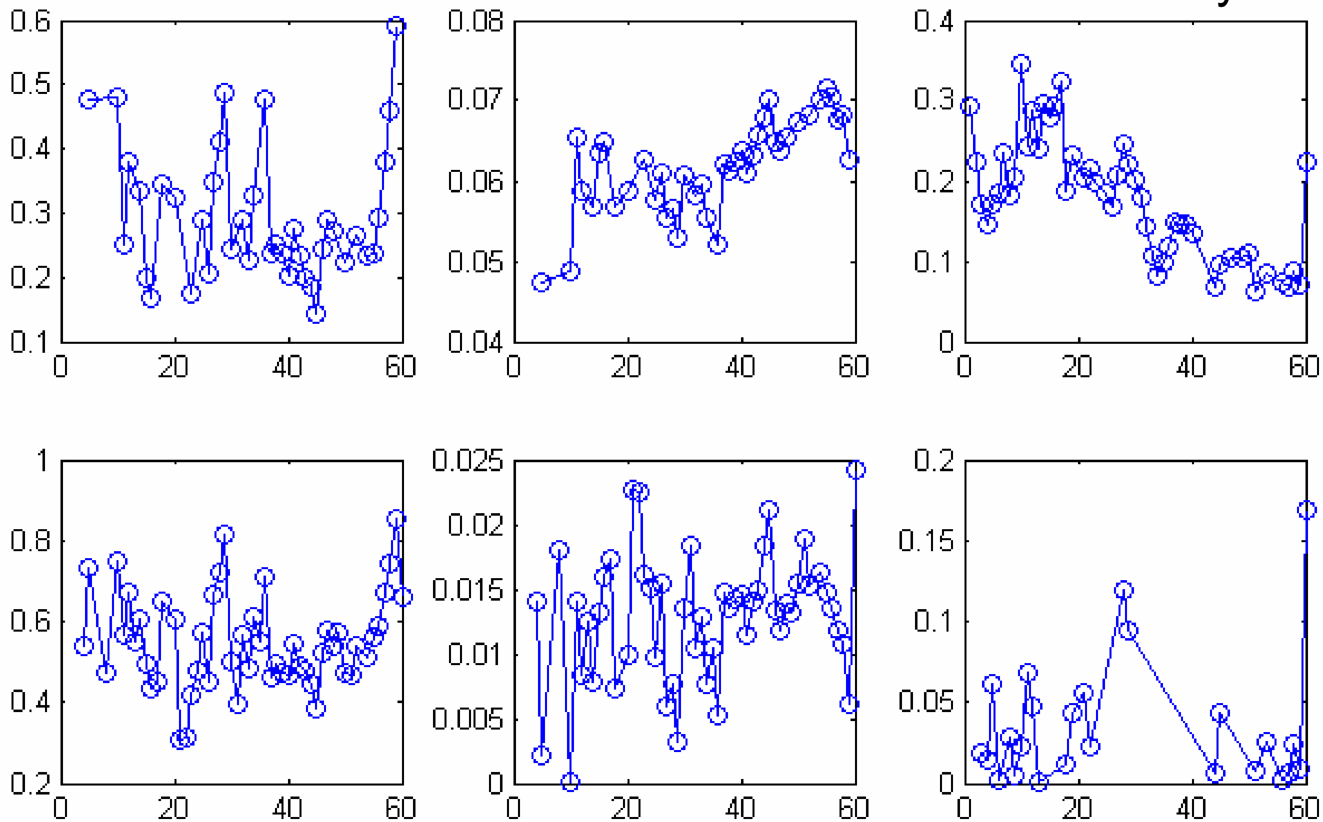
Total Transect

slope | Y intercept | Modis AOT

Anticorrelation Oh boy??

470

660



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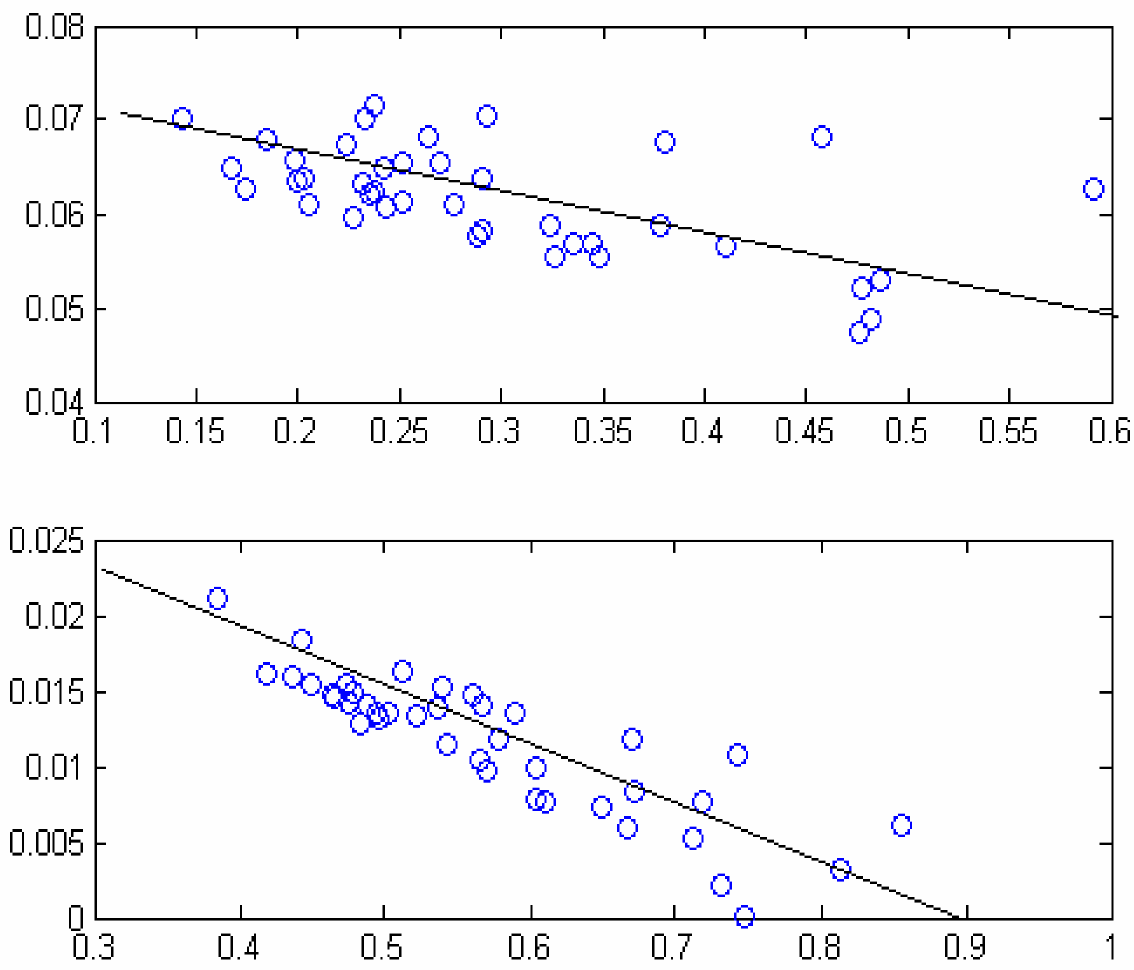
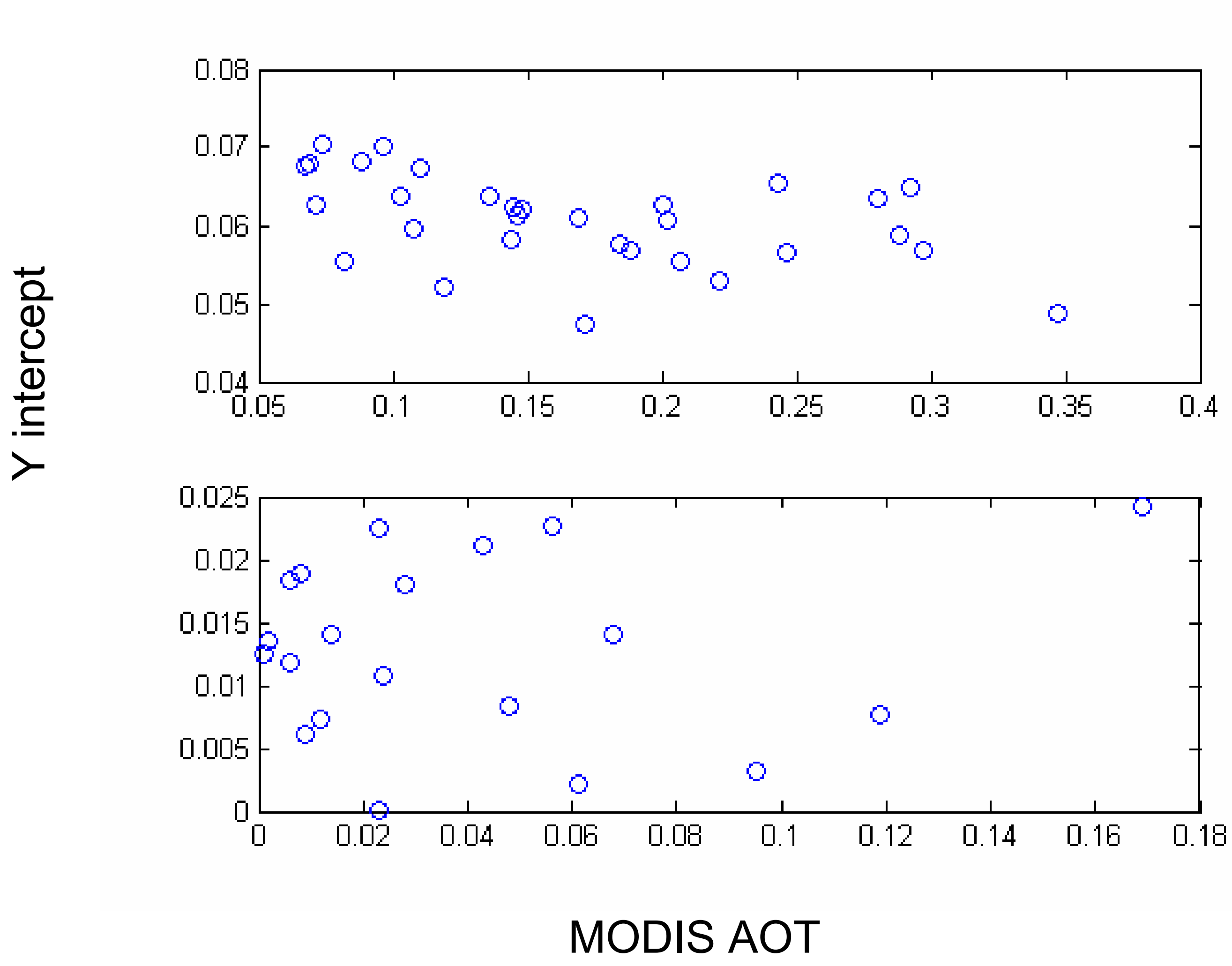
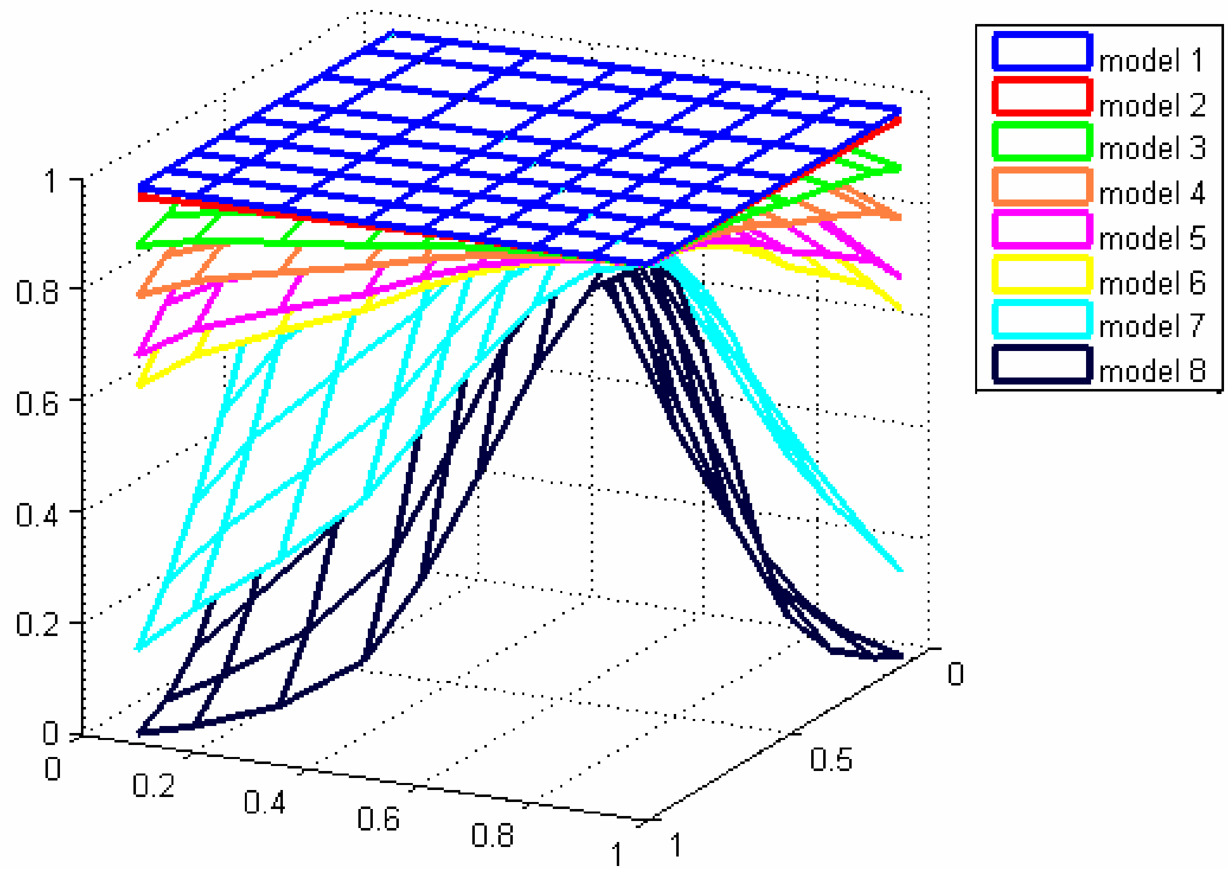
Coupling between slope and intercept



Horrible correlation (anticorrelation???)



Ground reflection model (model 1 lambertian)



$$Q_{il} = \sum_j \sum_k T_{ij} [\frac{R_{jk}}{R_{il}}] T_{kl}$$

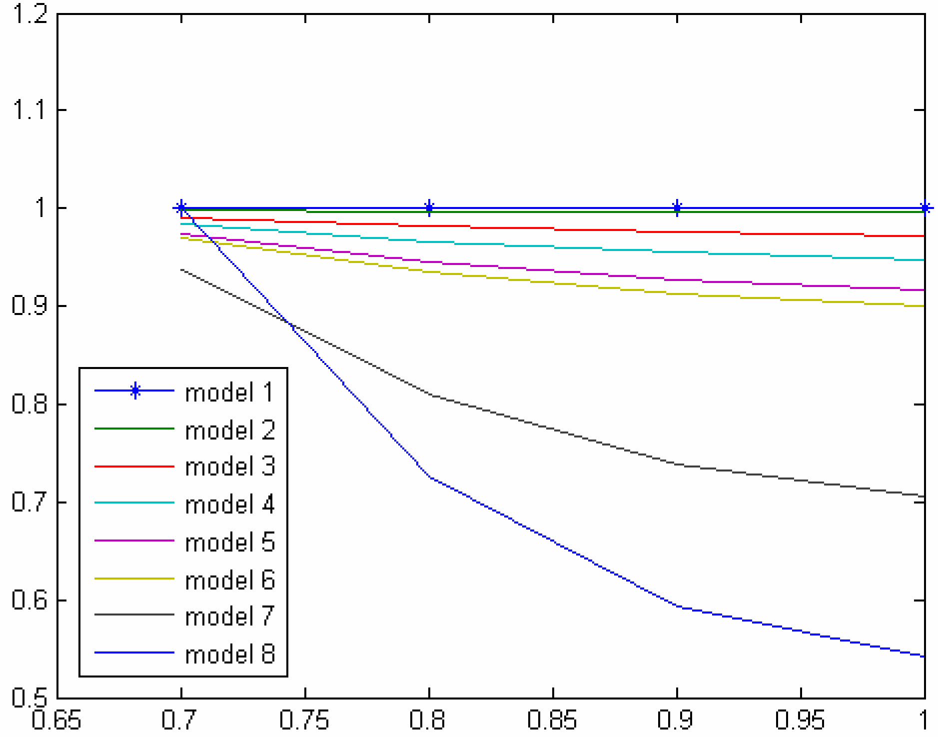
$$Q_{il} = T(i,:) \times \frac{R}{R_{il}} \times T(:,l)$$

i= 6:9, l =9

Sun zenith angle = acos(0. 7 0.8 0.9 1.0)

Q(6:9,9)

Satellite zenith angle= 0 deg



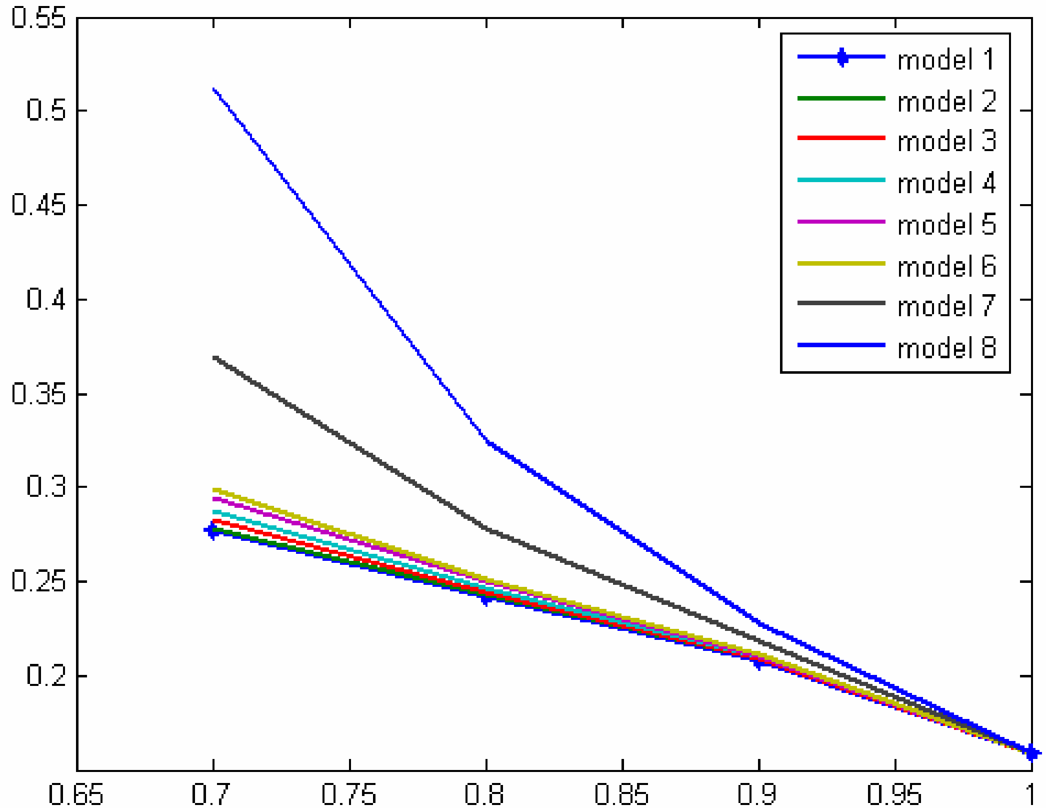
Cosine (Sun angle)

$$Q\_nor_{il}\_\mathrm{mod}(1:8) = C \times Q_{il}\_\mathrm{mod}(1:8)$$

$$C = \frac{Q_{i=9,l=9\_}\mathrm{mod}(1)}{Q_{i=9,l=9}\_\mathrm{mod}(1:8)}$$

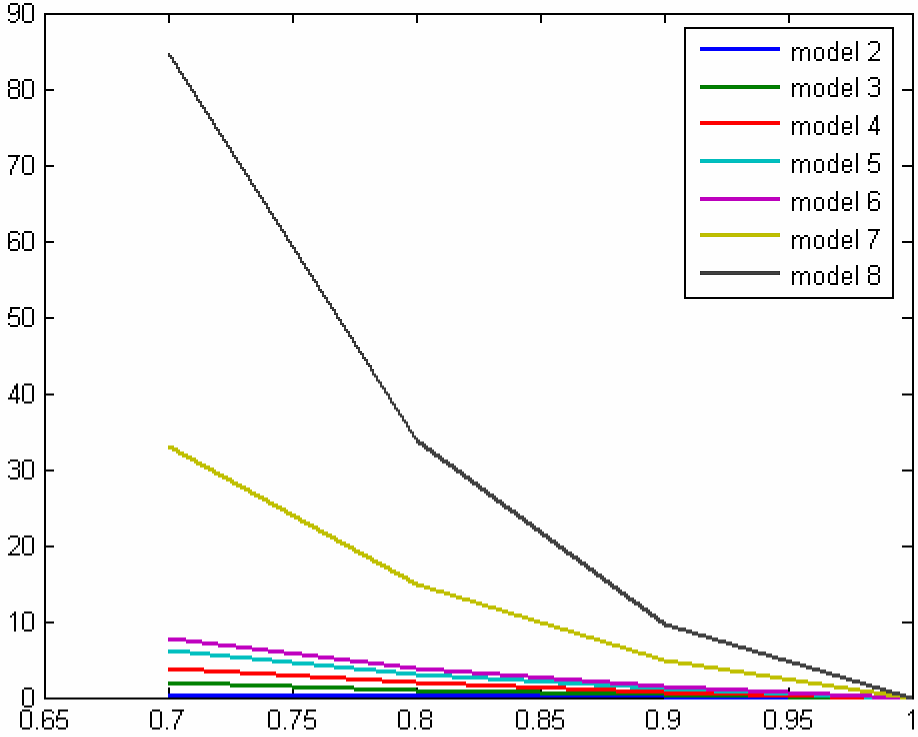
Q_nor_

(i=6:9,l=9)



$$\%Dev = \frac{Q\_nor\_model(2:8) - Q\_nor\_model(1)}{Q\_nor\_model(1)}$$

% of Deviation



Cosine (Sun angle)