THE CITY COLLEGE
OF THE CITY UNIVERSITY OF NEW YORK

National Oceanic and Atmospheric Administration
Cooperative Remote Sensing Science and Technology Center

NOAA CREST

Improvement of Aerosol Retrieval over Urban Scenes by Refining Surface Albedo Model

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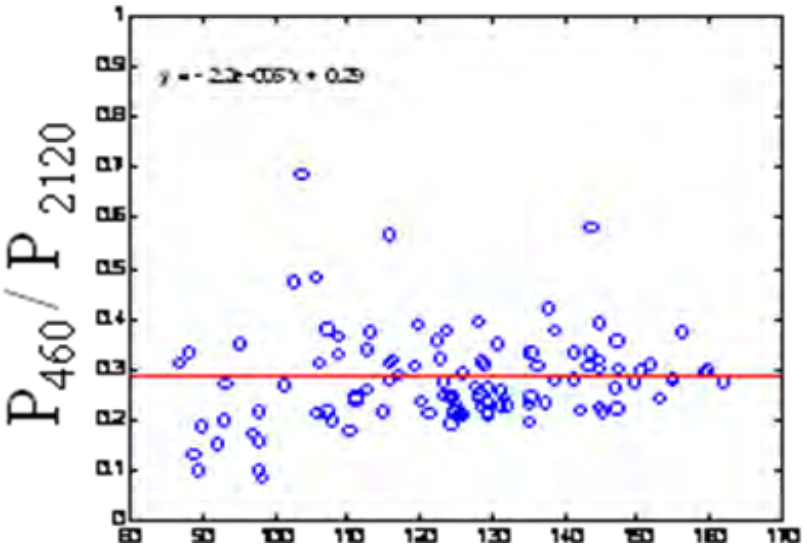
Satellite Retrieval of Aerosols

- Retrieving aerosols over land is essential to obtain accurate assessment of anthropogenic effects.
- Aerosol retrieval requires dark surfaces so that ground contamination can be avoided.
- However, aerosol retrievals over urban areas where high pollutants can be expected to occur does not satisfy this requirement.
- Operational algorithms based on vegetation models need to be assessed and refined.
- Surface reflection can be estimated using AERONET estimates of atmosphere to strip the atmosphere leaving the surface.

Validation of Surface albedo model over vegetation (rural)

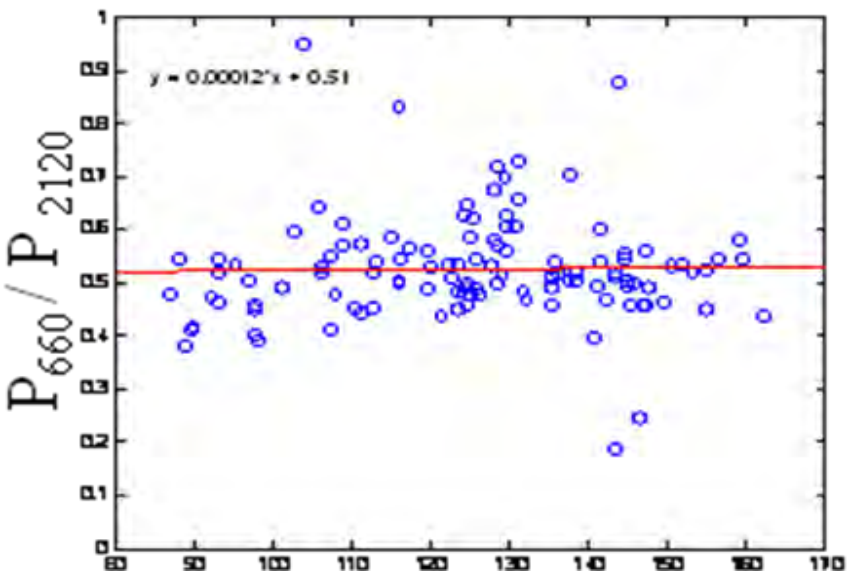
1.5 Km resolution

460/2120



Scattering angle

660/2120



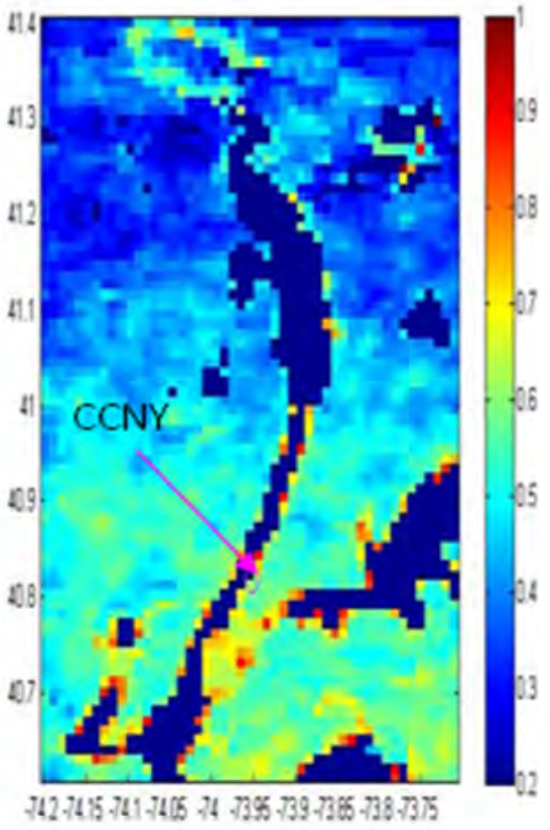
Scattering angle

- Good agreement to C004 and C005 reference

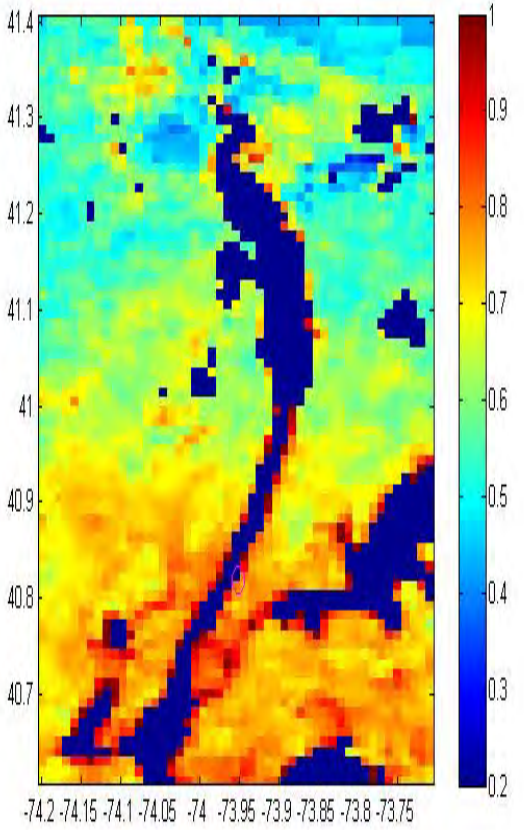
Surface Reflectance Ratio MAP

Google MAP

$\rho_{460}^{surface} / \rho_{2120}^{surface}$

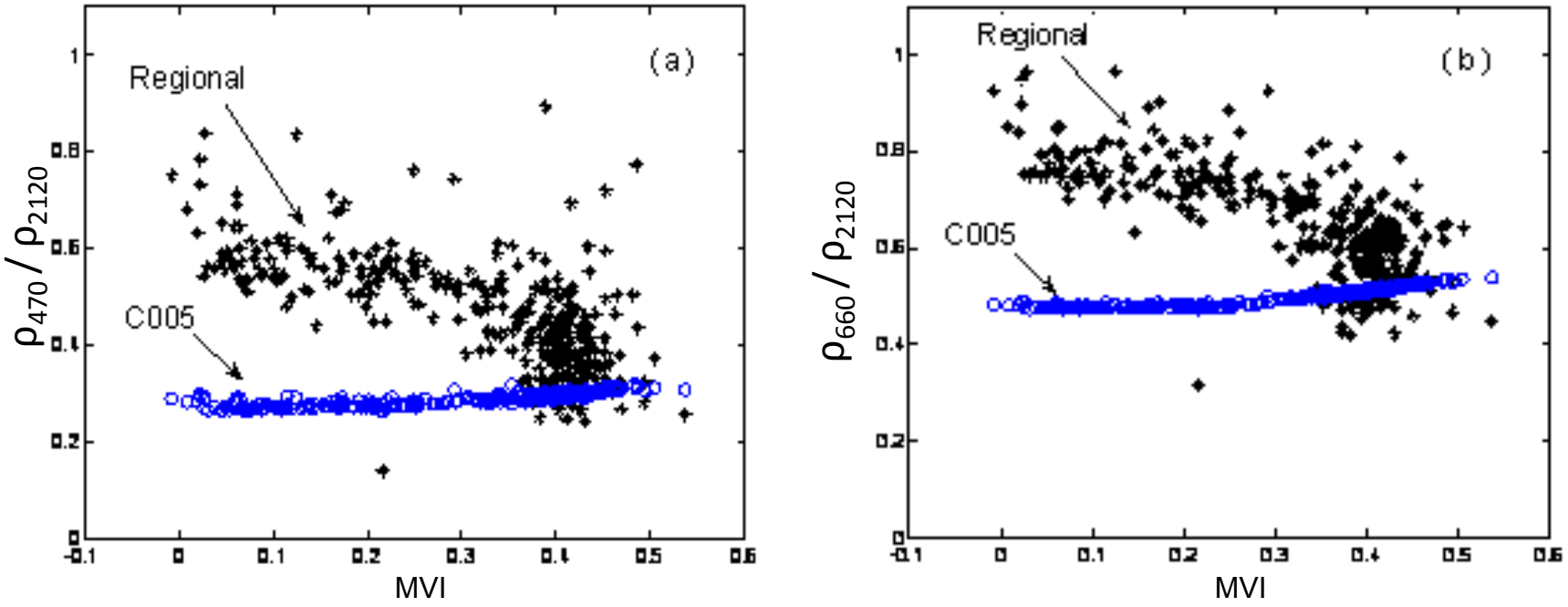


$\rho_{660}^{surface} / \rho_{2120}^{surface}$



VIS/MIR correlation coefficient ratios of 460nm/2120nm and 660nm/2120nm in nearby New York City area. VIS/MIR ratio is significantly higher in the urban area compared to the vegetated areas

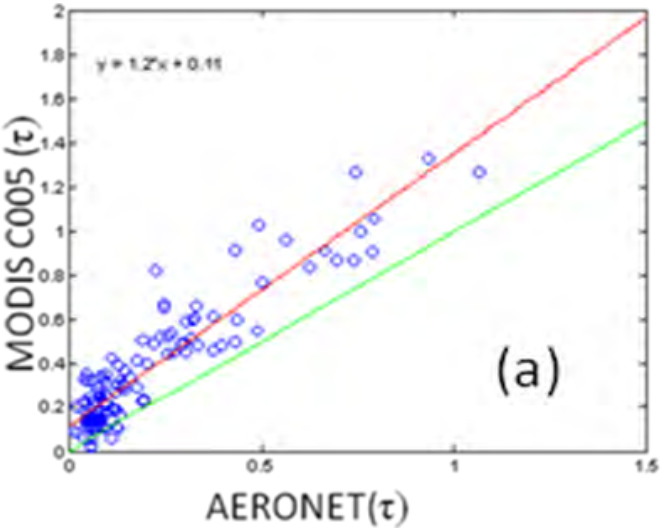
Modified Vegetation Index (MVI) calculations

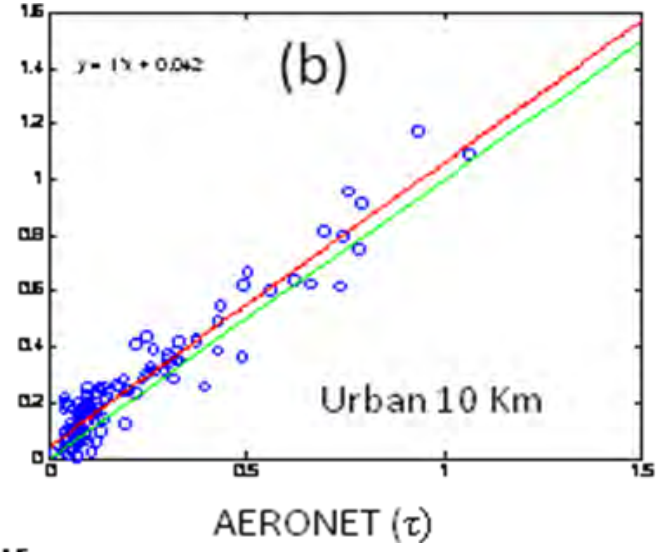


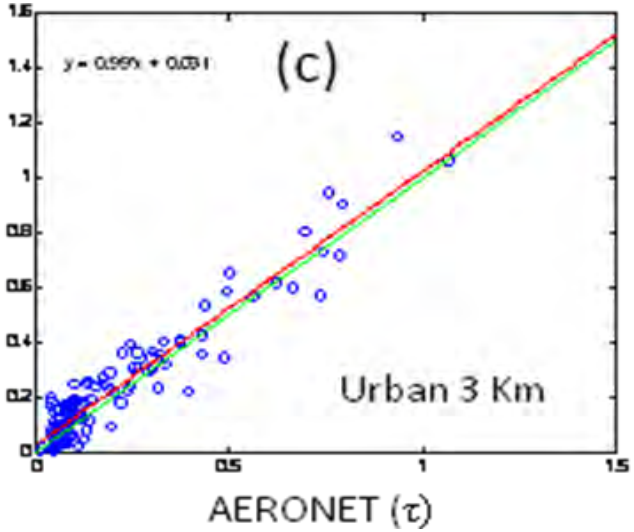
Modified Vegetation Index versus VIS/SWIR surface reflectance ratios for both refined surface model and operational MODIS C005 surface model (a) 0.47 μm/ 2.12 μm (b) 0.66 μm/ 2.12 μm.

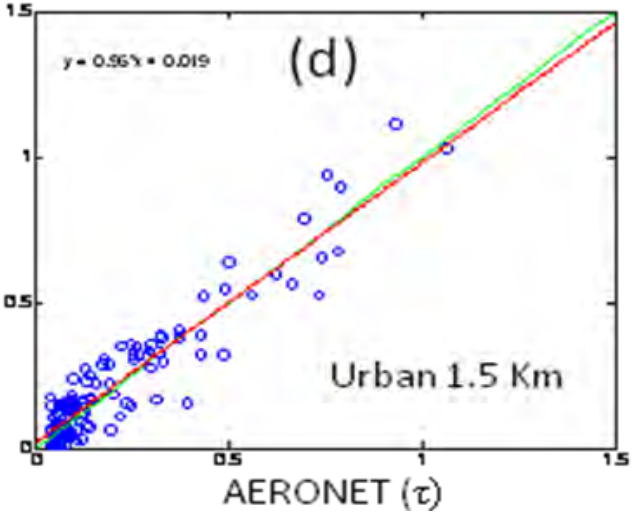
$$MVI = \frac{\rho^{TOA}_{1.24\,\mu m} - \rho^{TOA}_{2.12\,\mu m}}{\rho^{TOA}_{1.24\,\mu m} + \rho^{TOA}_{2.12\,\mu m}}$$

AOD Retrieval with refined model at different resolutions

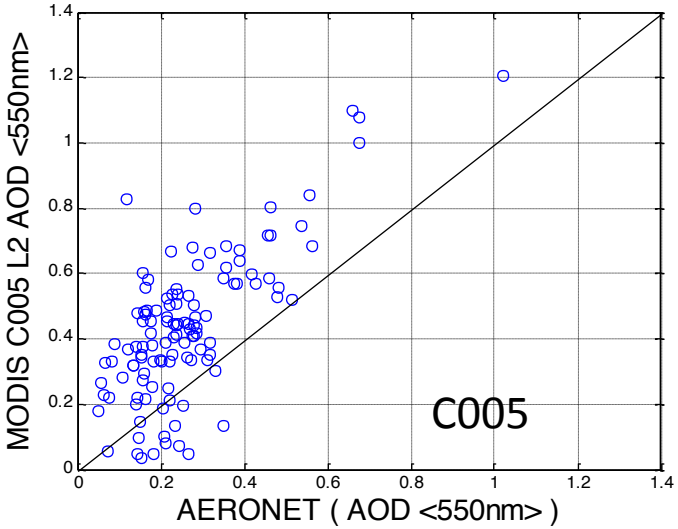


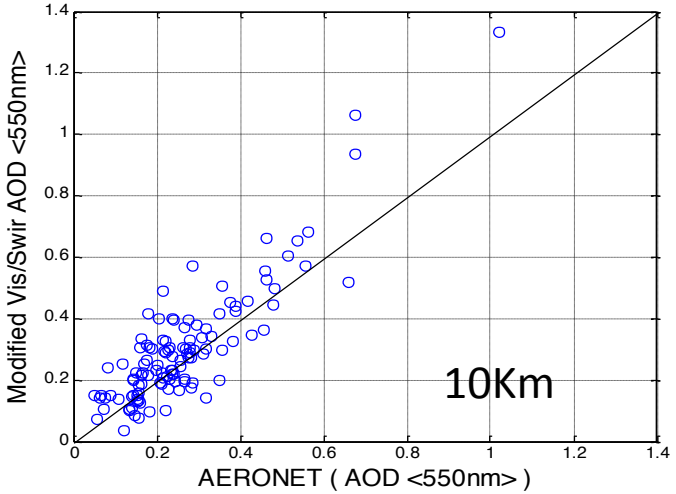




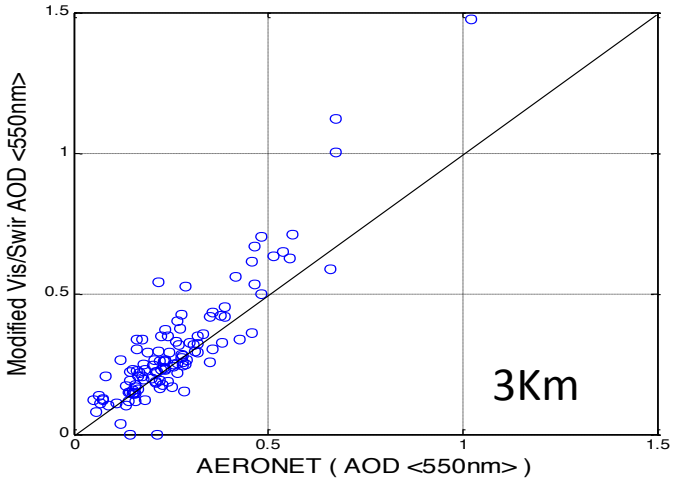


Mexico City AOD Retrieval with local (tune) VIS/ MIR surface reflectance ratio

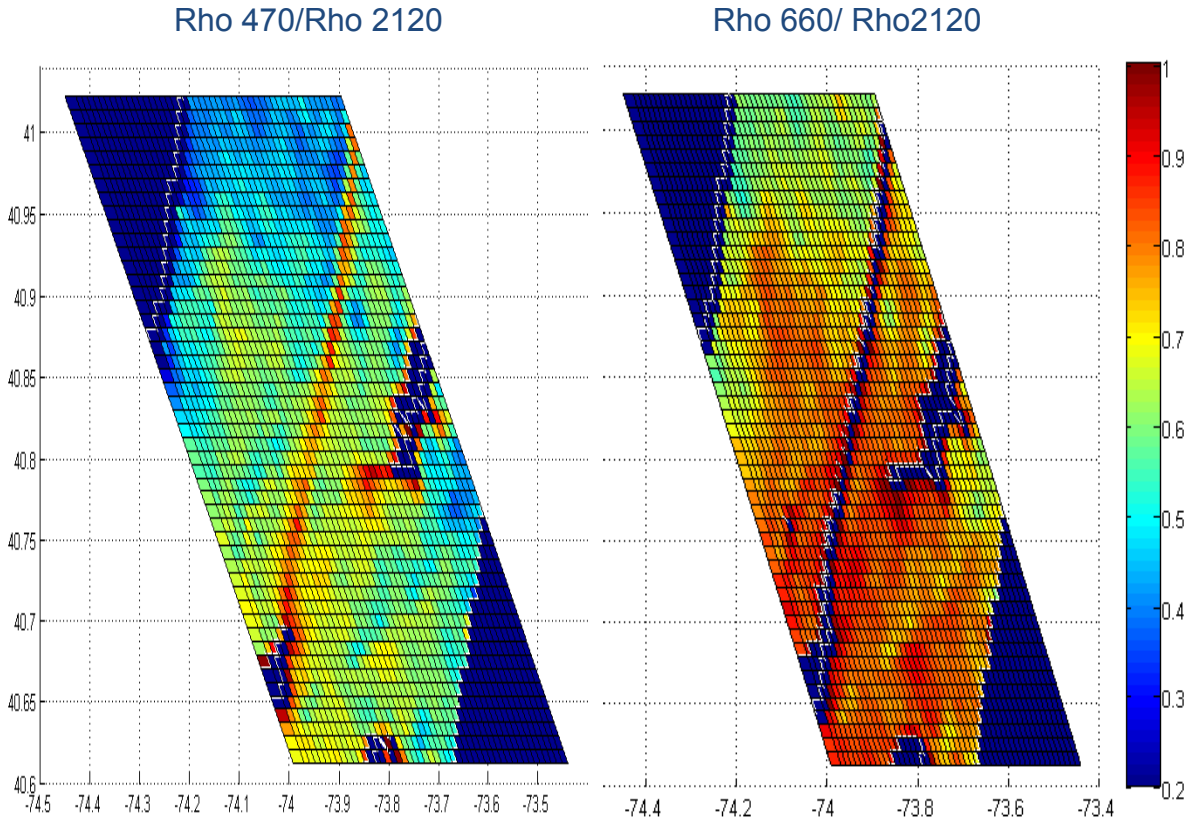




- Using local Vis/MIR surface reflectance ratios, significant improvement in retrieved AOD matchup with Mexico City's AERONET station is obtained



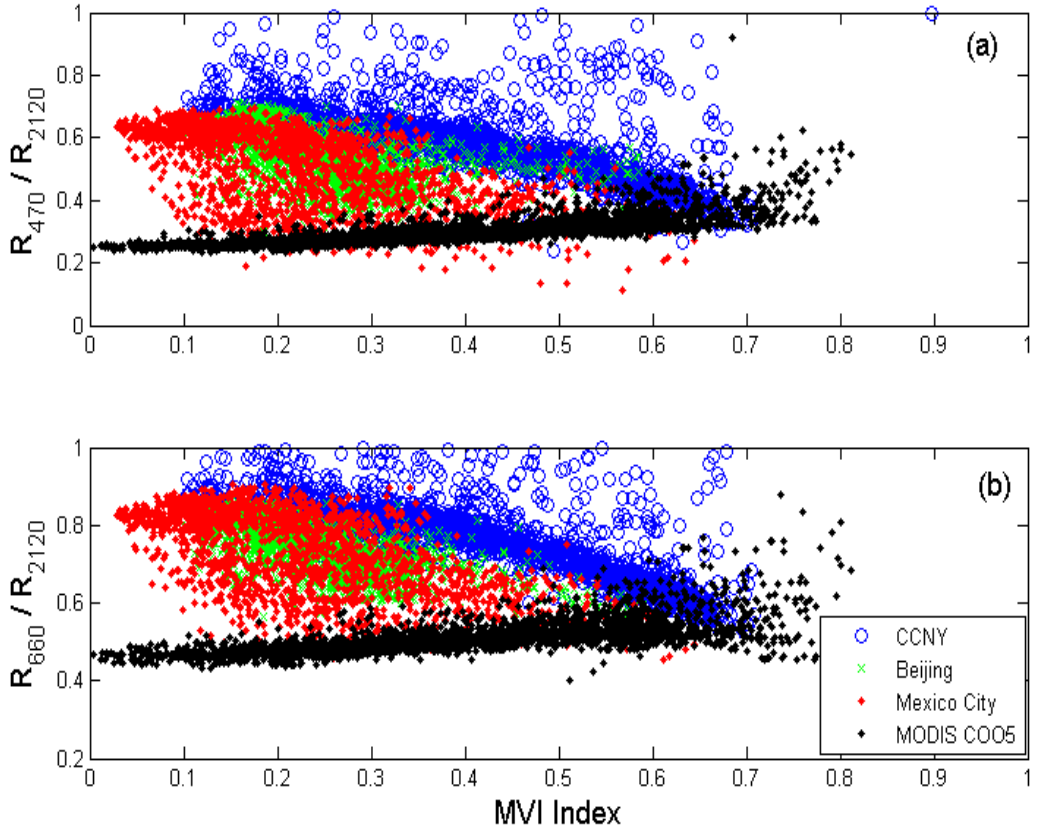
ASRVN(AERONET-based Surface Reflectance Validation Network)



•Spectral surface bidirectional reflectance and albedo based on MODIS TERRA and AQUA data.

•ASRVN data is particularly important in assessing the relationship between MVI and the spectral ratio coefficients (SRC's) used by MODIS C005. .

Relationship between Surface Type and the VIS/ SWIR reflection ratios in urban areas



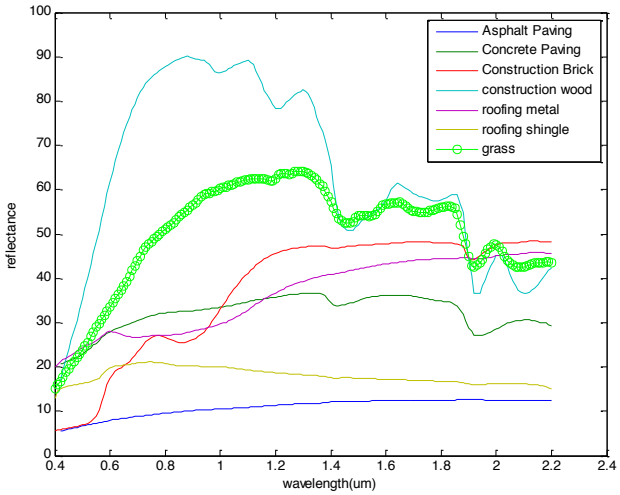
ASRVN surface data retrievals (50km x 50km) from different cities where it is shown that the VIS/SWIR ratios decrease with MVI index in contradiction to the MODIS operational models.

Significant Differences

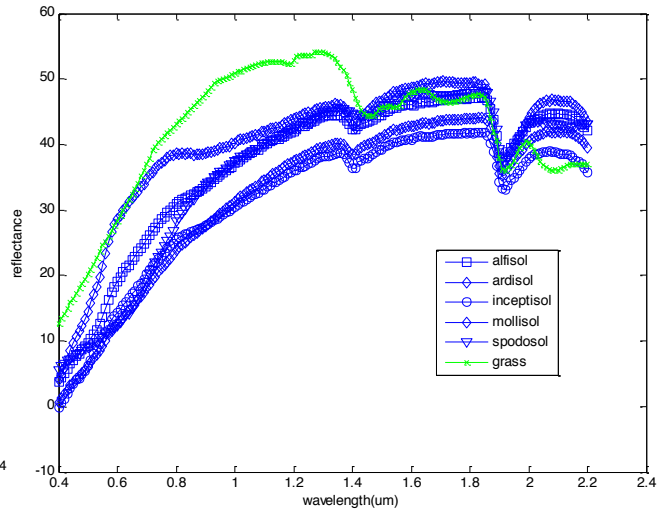
- A clear pattern opposite to the MODIS relationship connecting the MVI index to the spectral ratios is observed over many urban areas.
- Using the C005 in these cases leads to significant overestimating biases.
- Would like to get a better understanding of the result.
- Look at spectral mixing models for urban and non urban scenes.

Spectral responses of different Materials

Urban materials + grass (vegetation)



Soils + grass (vegetation)

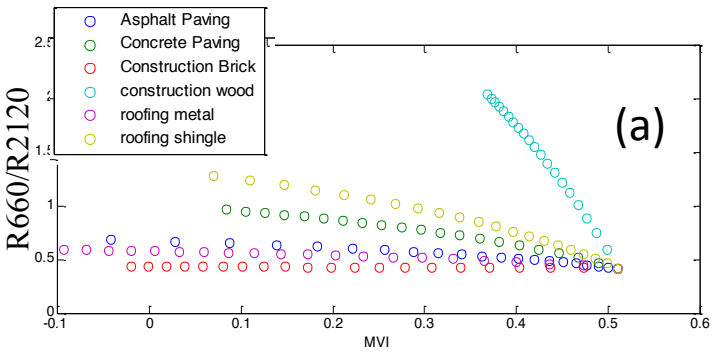


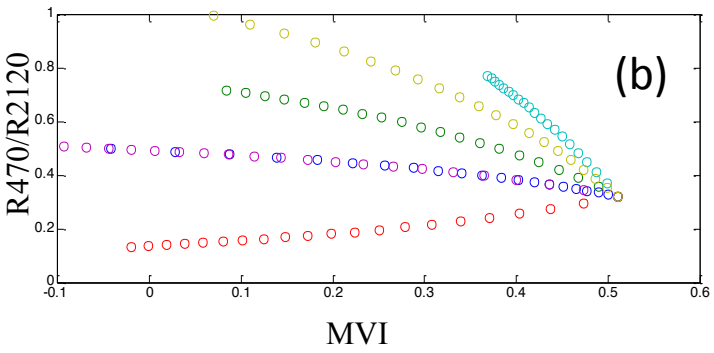
ASTER Spectral Libraries Provide reflection Spectra of many Different materials.

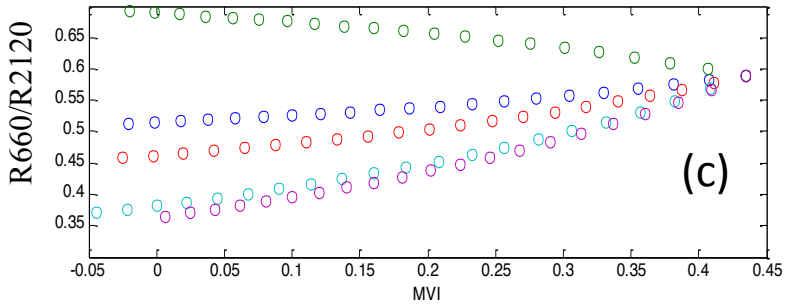
Use end member mixing to construct spectral Relationships including MVI vs VIS/SWIR ratios

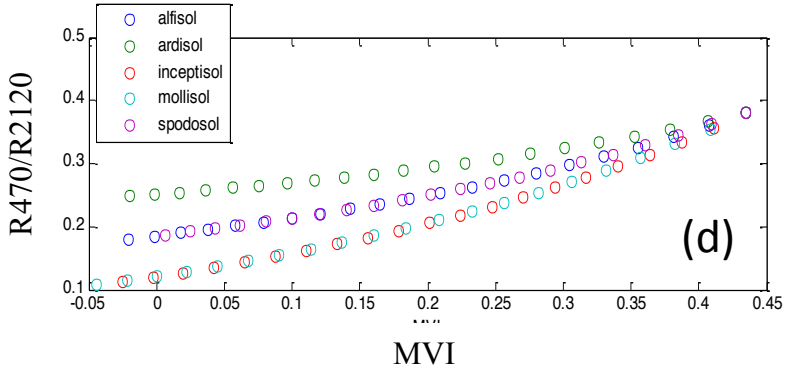
Using Mixing Models over Urban Areas and Nearby Surroundings

Model 1: Simple two endmember analysis from ASTER Spectral Library









Vegetation / Manmade material endmember mixing for different man made classes

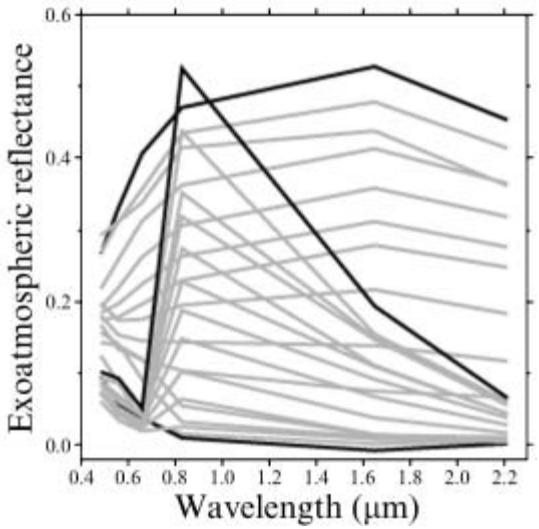
Vegetation / soil material endmember mixing for different soil classes

Vegetation / Soil Model fits C005 behavior while Urban / Vegetation matches urban observations better.

Further evidence of urban surface behavior

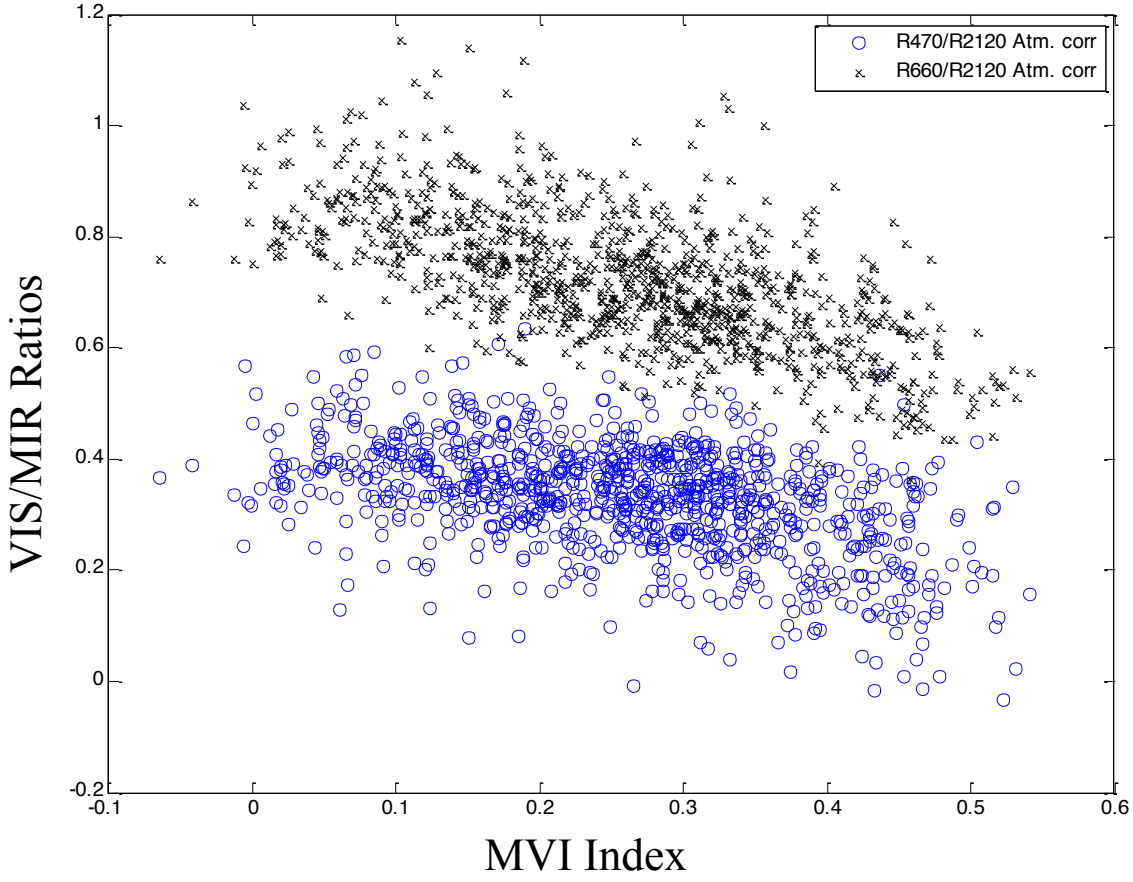
- Landsat datasets have been used for extracting surface properties from many urban cities
- We borrow this data to see the universal nature of the trends we are seeing.
- Make use of the results of C.Small who provided first three primary principal components for 28 cities
- By endmember mixing, generate realistic TOA reflectance variability.
- Assuming statistical atmospheric variability, (Rayleigh + 0.1 AOD aerosol background), generate realistic surface reflection variability.

Landsat TOA
Spectral endmembers
Solid black lines



Reference: Chris Small, "A global analysis of urban reflectance" International Journal of Remote Sensing 26, 661– 681, (2005).

Results of three endmember analysis from Landsat Imagery (28 urban targets)



Similar trends again seen in the VIS/MIR ratios

Conclusions

- With the new VIS/MIR ratio model, the MODIS and AERONET optical thickness agreement is significantly improved even at higher resolution.
- Results are robust for different urban areas such as Mexico City.
- Realistic atmospheric correction results in very good qualitative agreement with the ASRVN data.
- Surface retrievals at different urban areas illustrate a general trend of decreasing spectral ratios with MVI in direct opposition to C005 model results.
- The differences between urban and non urban VIS/SWIR vs MVI trends can be understood using the spectral properties of vegetation and a wide class of man made and why the operational algorithm based mainly on soil / vegetation observations is qualitatively incorrect.
- Similar Urban signatures using Landsat Urban Signatures (first 3 Principle components) are observed.
- Special Urban algorithms must account for this fundamental difference.

Acknowledgement

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Questions?