Development and Sensitivity Analysis of High Resolution Land Surface Parameters for Mesoscale Atmospheric Modeling of Urban Areas

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- *Influence of Sub/Urban Land Cover on Atmospheric Processes*
- *Biophysical Land Surface Parameters from Spectral Mixture Analysis*
- *Heterogeneity of Urban Land Cover Parameters*
- *Mesoscale Sensitivity Analysis & Scale Dependence*

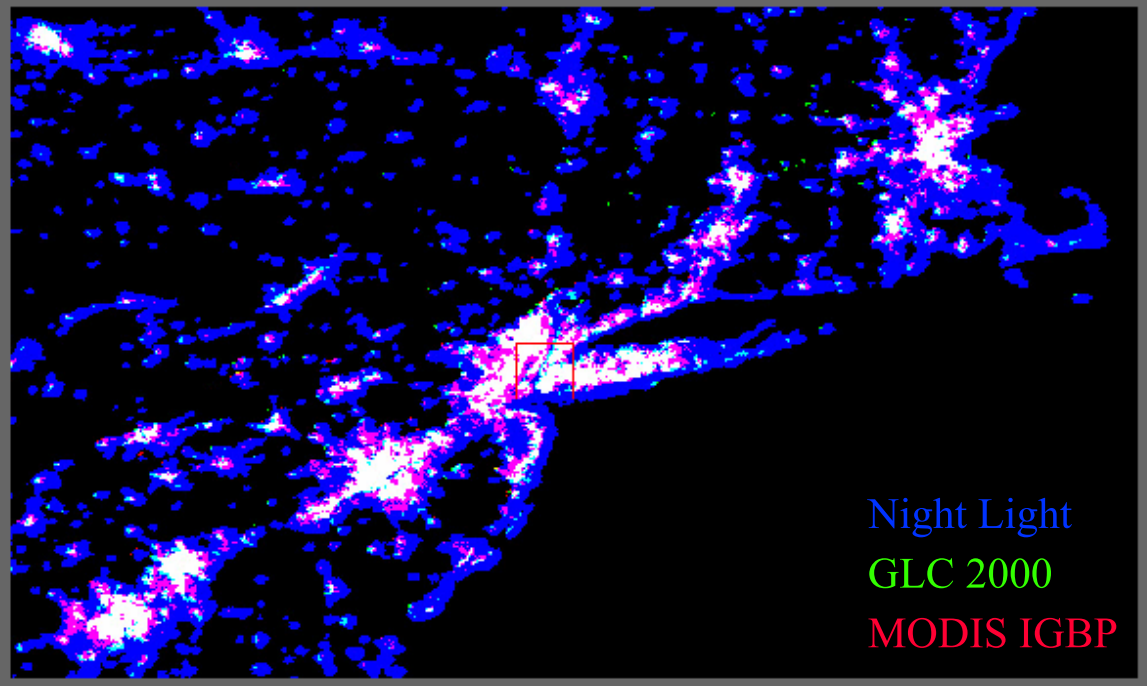
Multiscale Influence of Urban Land Cover

Global Scale

~3% of land area
strongly clustered

Regional Scale *(meso-□)*

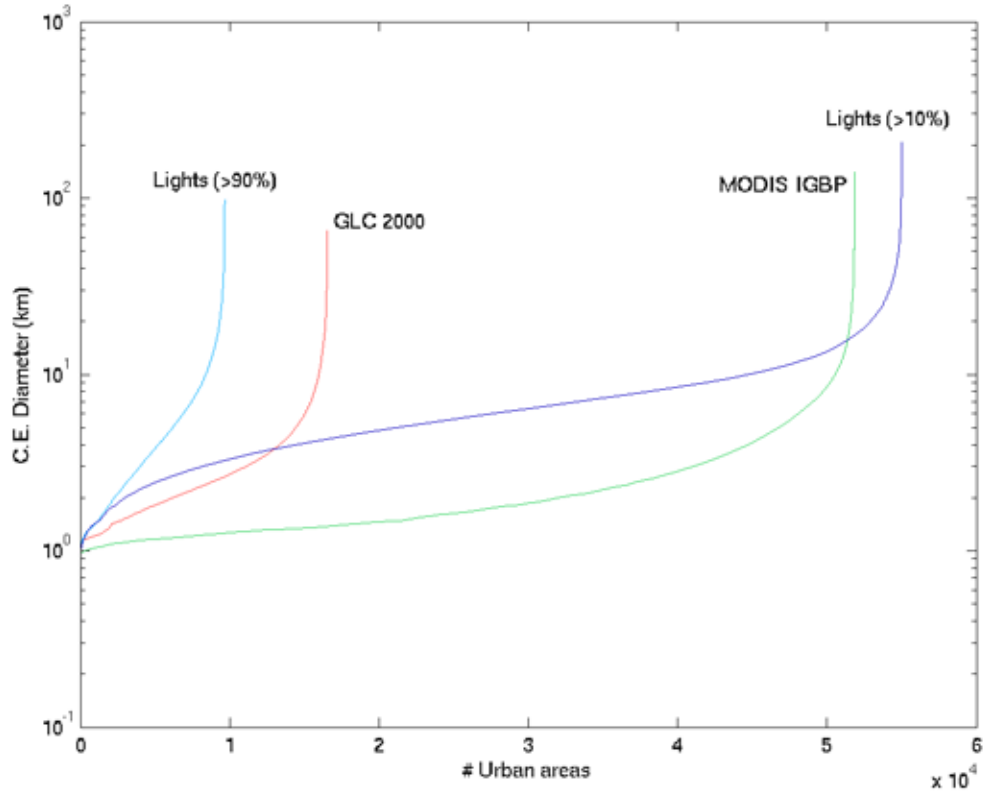
some connurbations 30-50%
of land area at regional scales.

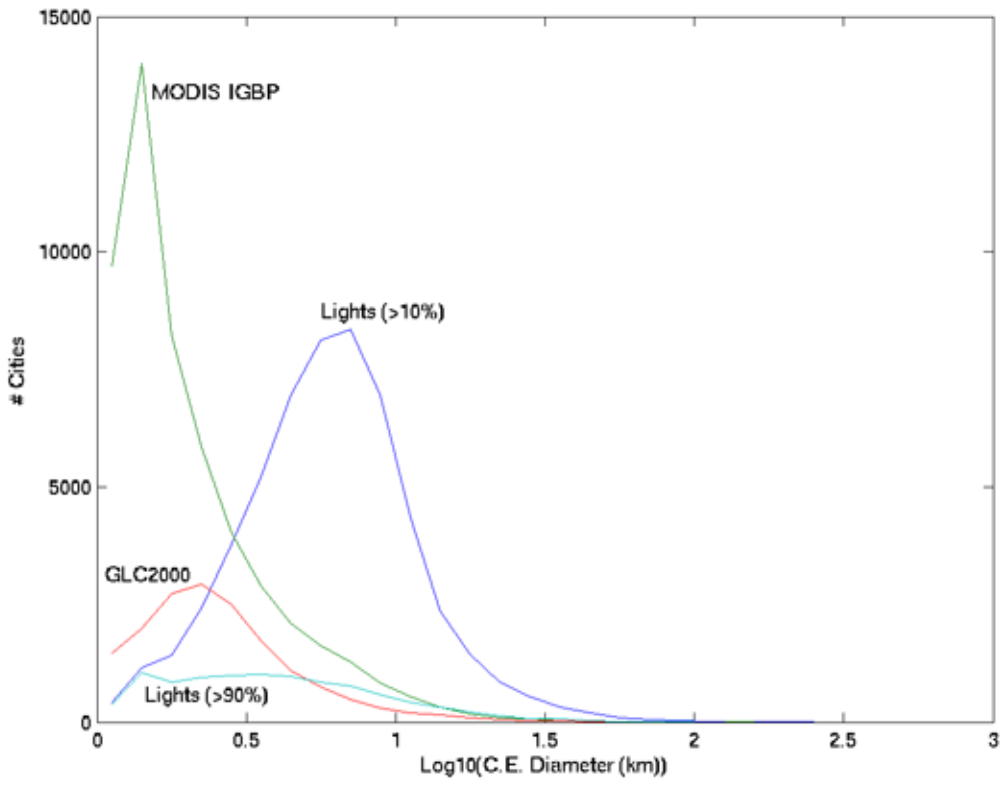


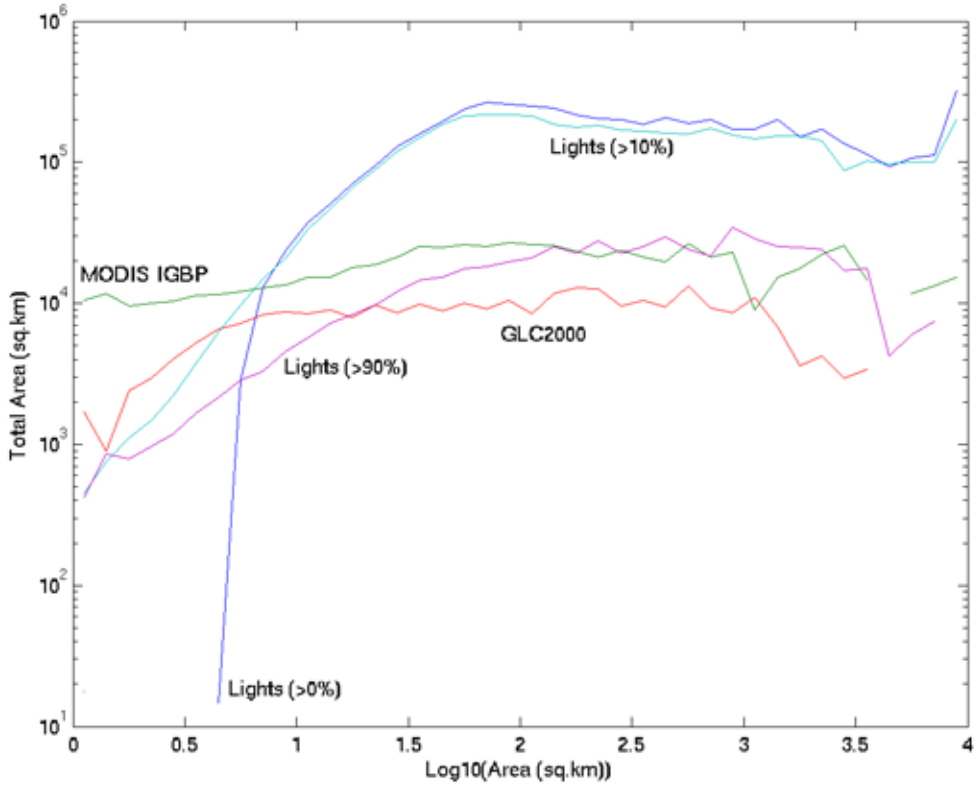
Local Scale *(< meso-)*

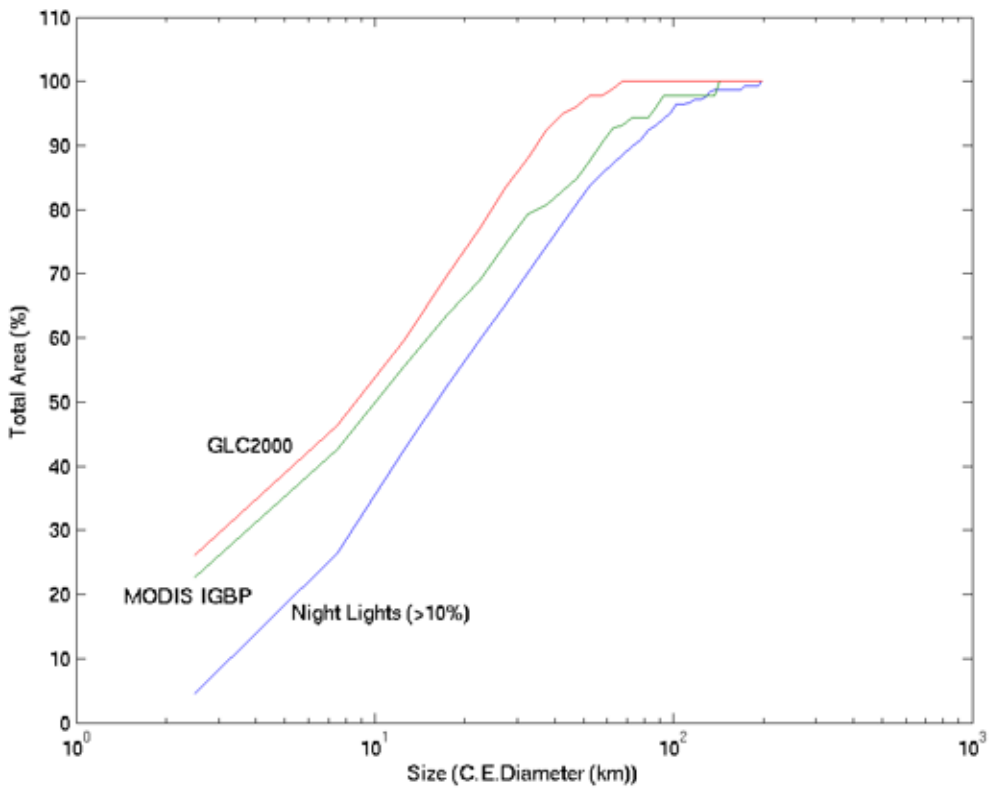
100% of land area

Global Size Distributions of Contiguous Urban Land Cover









Alternative Representations of Land Cover

Discrete Thematic vs. Continuous Physical

The Problem: Land surface parameters derived from thematic classifications assume discrete transitions in physical properties and cannot represent spatial variability within classes or gradational transitions in land cover.

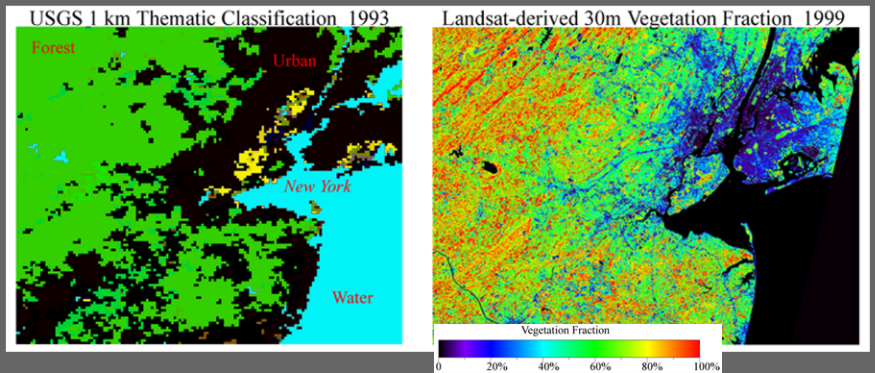
The Question: Can some physical properties (***Vegetation Fraction, LAI, Soil Exposure, Albedo, Surface Roughness***) be derived directly from spectral endmember fractions of moderate resolution optical & thermal imagery without thematic classification?

If so, does it matter?

Is model performance better for continuous physical fields than for discrete thematic?

If so, what, where and when?

What is the magnitude and scale dependence for which parameters?



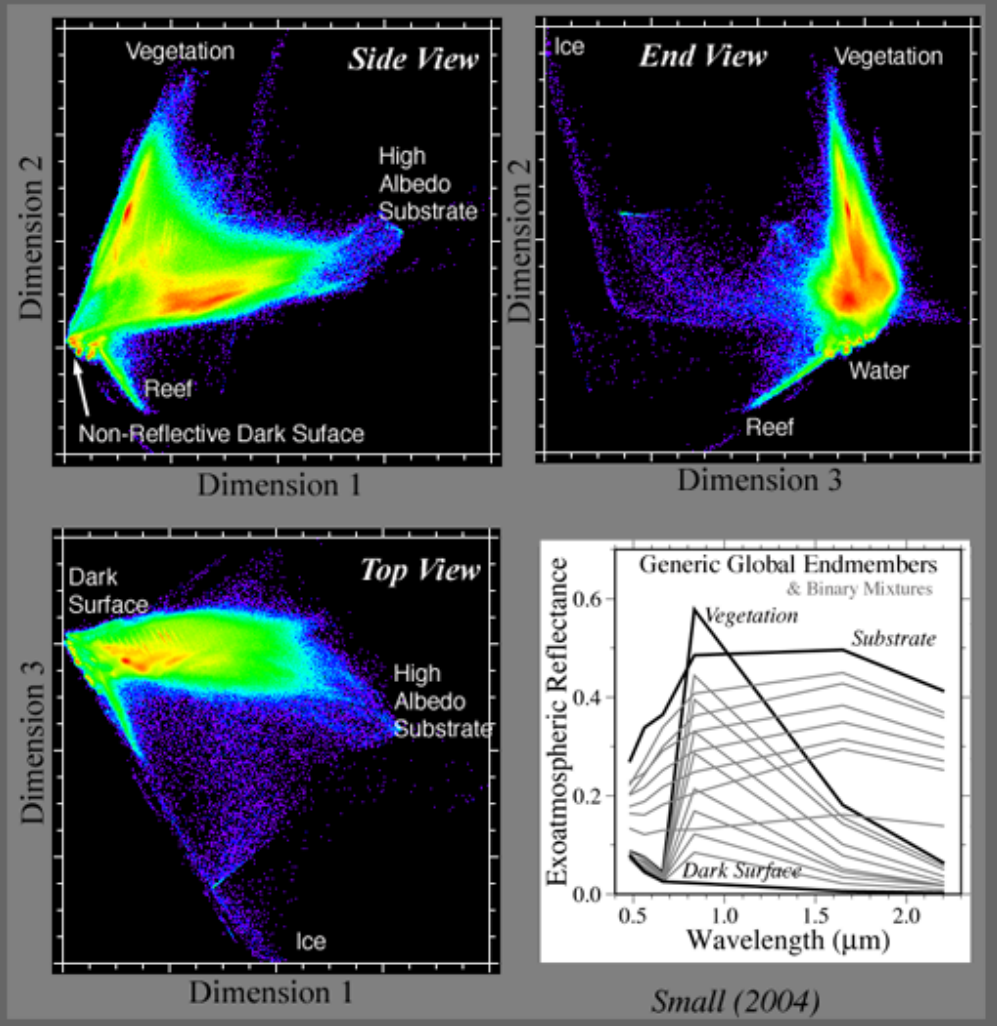
Physical Properties & Spectral Mixture Analysis

Spectral Mixture Analysis (SMA) represents spectrally mixed pixels as linear mixtures of spectrally pure endmembers.

Global analysis of spectrally diverse landscapes consistently reveals similar, biophysically distinct, spectral endmembers.

Estimates of endmember area fraction can be validated at multiple spatial scales.

Linear scaling properties can facilitate upscaling and downscaling of landcover fraction parameters.



Landsat ETM+ spectral mixing space with physically distinct endmembers

Urban Spectral Heterogeneity

Spectral heterogeneity corresponds to differences in physical properties.

Vegetation Fraction, Impervious Substrate, Shadow Fraction

Variations in physical properties influence mass & energy fluxes.

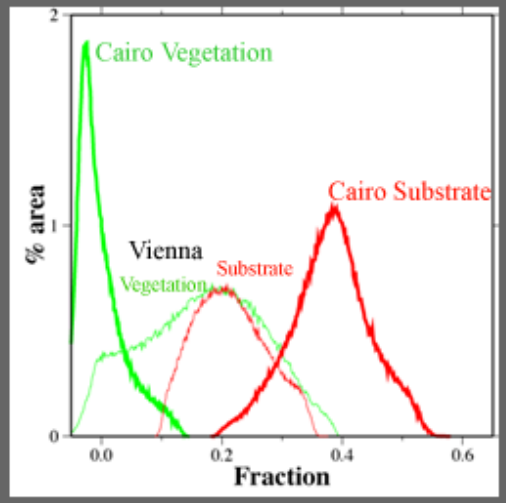
Intra-Urban Heterogeneity

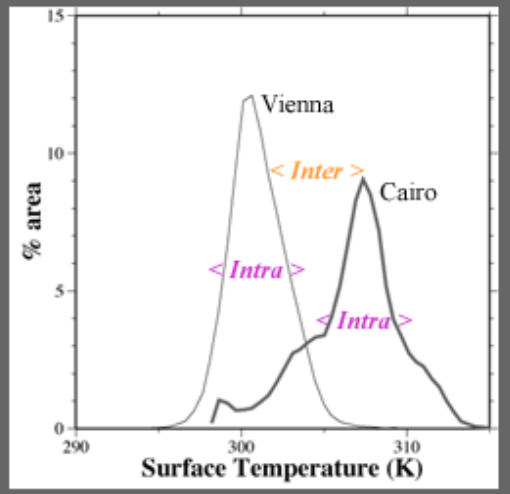
Variability within a single city

Inter-Urban Heterogeneity

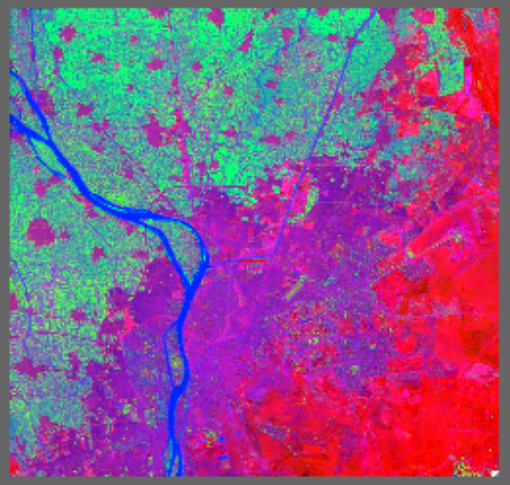
Variability among different cities

SMA of 28 cities worldwide reveals considerable variations in vegetation fraction, albedo & shadow fraction.

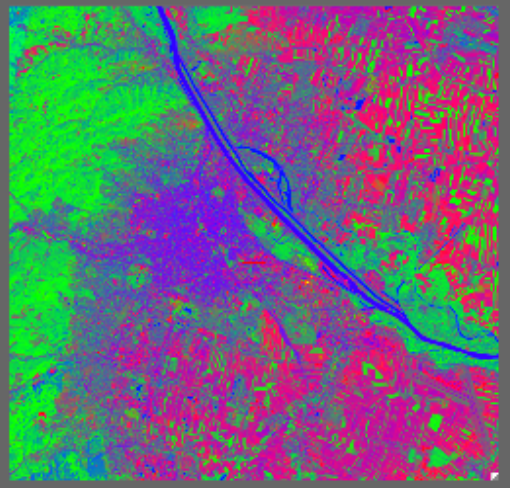




Cairo



Vienna



Temperature Vegetation % Dark Fraction

Urban Surface Temperature & Fraction Distributions

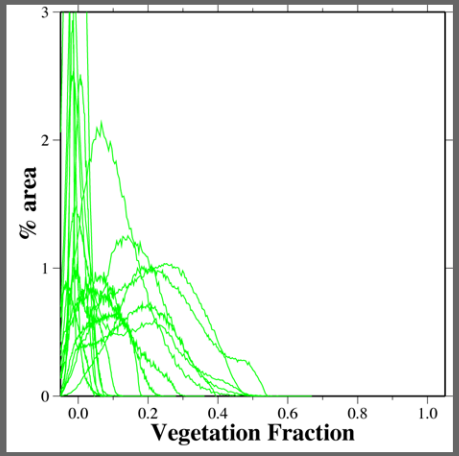
28 urban areas - 30x30 km @ 30 m & 60 m

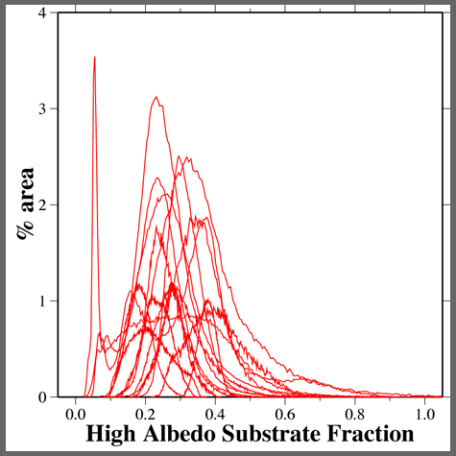
Surface temperature distributions of spectrally heterogeneous built up urban land cover are non-Gaussian, skewed and span ~ 25° K.

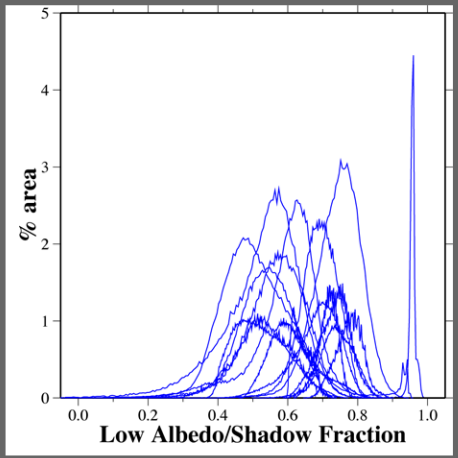
Vegetation fractions are heavily skewed toward zero but widely variable.

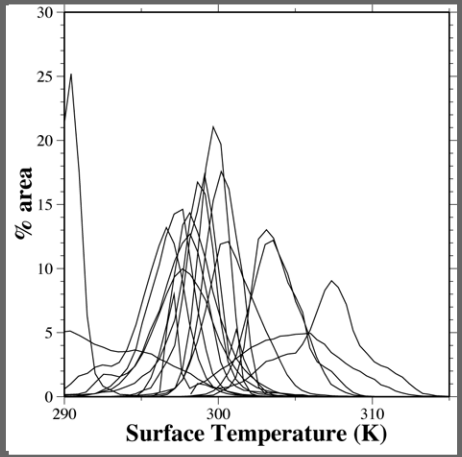
High Albedo Substrate fractions are also widely variable but in larger amounts (~10 - 50% of area).

Low Albedo & Shadow fractions are most variable but consistently high (~40 - 90% of area).









Preliminary Results

- Coalesence of suburbs & large cities into very large conurbations can dominate regional land cover and LC-related land surface processes.
- Spectral Mixture Analysis yields robust spatial estimates of biophysical endmember fractions (e.g. *water, vegetation, soil, rock, snow*) & shadow.
- Multiscale validation of urban vegetation fraction gives ~6% error.
- Comparative SMA of ETM+ imagery of 28 cities quantifies inter-urban and intra-urban LC heterogeneity not represented in thematic classes.

Current Work

- Estimate continuous LS parameter fields from EM fractions and incorporate parameter distributions into OLAM (Ocean Land Atmosphere Model).
- Quantify spatial scaling relationships between LS parameters and EM fractions to determine optimal scale for LS parameter estimation.
- Sensitivity & Scale Analysis of Parameter Fields vs. Thematic Maps.