Estimation of High Resolution Land Surface Broadband Albedo for Urban Area from Quickbird

Shai Kaplan
Christopher Galletti
Winston Chow

ASU School of Geographical Sciences & Urban Planning
Central Arizona–Phoenix Long-Term Ecological Research CAP LTER

1. Introduction

Albedo is a key forcing parameter controlling the planetary radiative energy budget and its partitioning between the surface and atmosphere. Albedo is defined as the ratio of the radiant flux reflected from the Earth's surface (fu) to the incident flux (fd):

$$\alpha_\Lambda = \frac{f_u}{f_d}$$

Characterizing and developing high resolution albedo is important to understand how specific forms land transformations affect Earth's physical and biological dynamics.

In Recent decades many of the world's arid and semi arid environments have experienced high rates of urbanization. In urban environments the physical processes and spectral characteristics occur at the scale of 10-20m. Thus high resolution satellite imagery is being used more and more to observe and monitor land change processes and biophysical characteristics of urban environments. Understanding fine scale changes in albedo can offer new insights into how this ecosystem property can be managed sustainably, especially in drylands urban regions.

Remote sensing is the only feasible method to capture the spatio-temporal variability of albedo in urban environment. However, there has been little work in relating broadband albedo to the multispectral data from high resolution sensors.

2. Objective

Land covers can vary a great deal over small distances in urban areas, sometimes making the use of medium or low resolution satellites difficult for the study of fine details. Our aim is to develop a set of coefficients that can be applied to high resolution imagery, Quickbird specifically, so that broadband albedo can be assessed at the parcel scale.

3. Study area and data

A Quickbird multispectral image (2.4 m) was acquired over Phoenix on July 11 2012. the image covers 90km² area of West Phoenix.

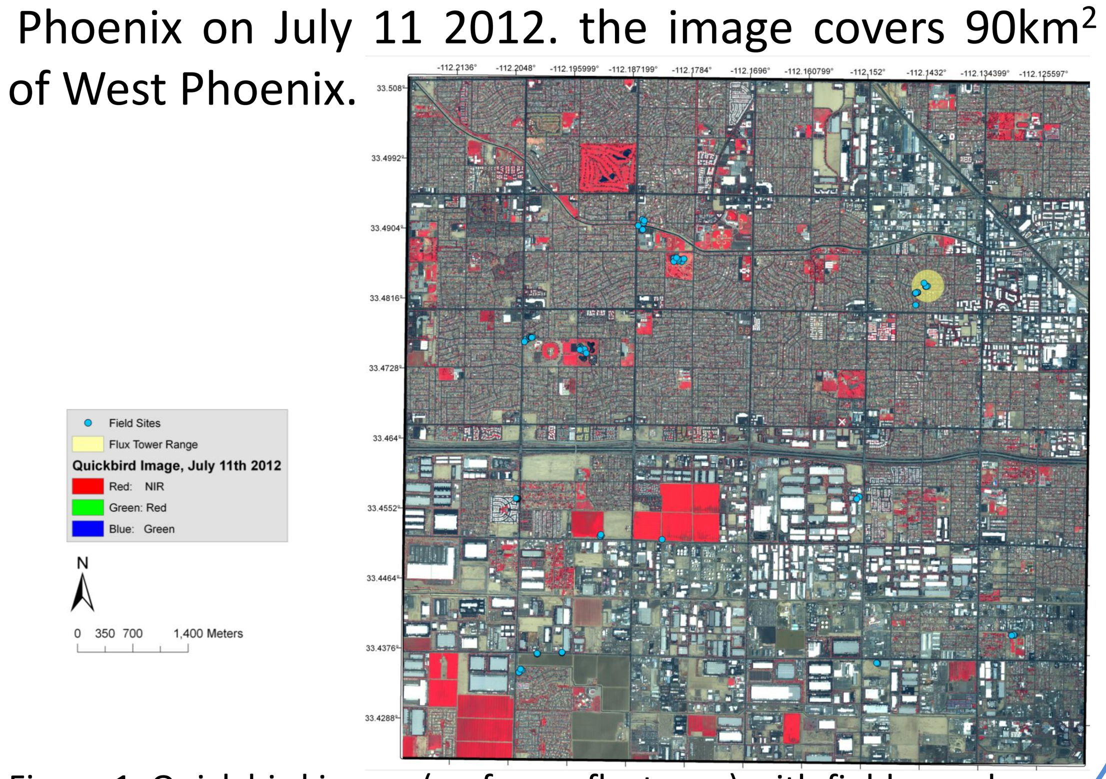


Figure 1. Quick bird image (surface reflectance) with field samples locations and flux tower source area

4. Methodology

Calculations of broadband albedo are essentially an integral estimated from narrowband albedo (r) measurements, also called spectral reflectance, between wavelengths λx and λy

$$\alpha_\Lambda = \int_{\lambda_x}^{\lambda_y} r\,d\lambda$$

two broad wavebands were considered : the short visible and near infra-red (450-900 nm, corresponds to Quickbird range) and the total visible and near infrared (350-2320nm)

Step 1: Broadband albedo on the ground at time of overpass.

Measurements were collected from 71 sites using an ASD FieldSpec-4 Wide-Res spectrometer. Samples included all major land uses/Land covers that represents the main urban features in the Phoenix metropolitan area.

Step 2: Conversion to reflectance

(a) radiometric calibration of the sensor - converting digital numbers (DNs) to top-of-atmosphere (TOA) radiance and then TOA reflectance; and

(b) convert the TOA radiance to surface reflectance using empirical line method.

Step 3: Multiple regression

Geo-reference the empirical broadband albedo and parameterize the coefficients using an OLS backward stepwise regression

Step 4: Model evaluation

- R^2 of the regression
- Comparison to broadband albedo as measured by a pyranometer located at a micrometeorological tower conducting eddy flux measurements.

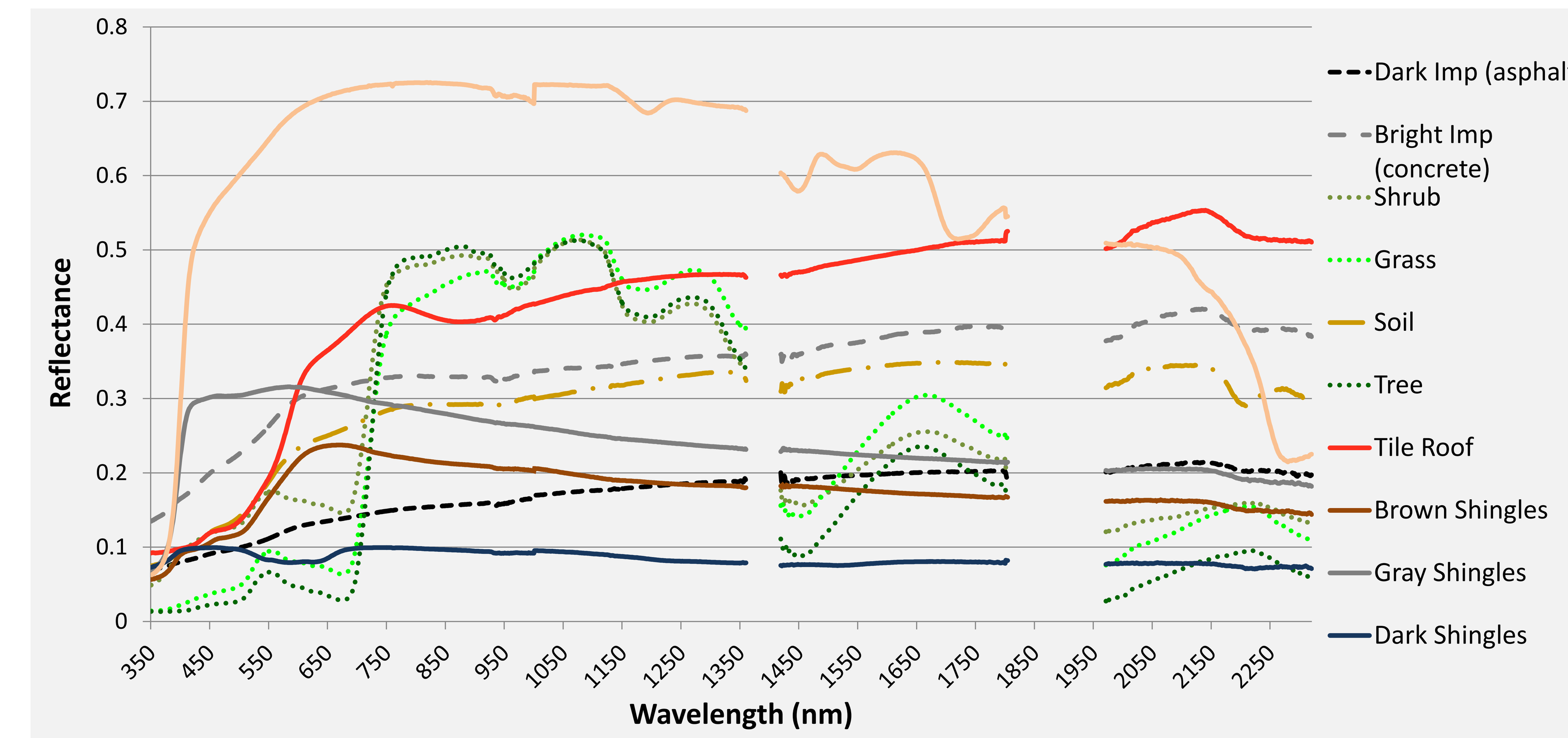
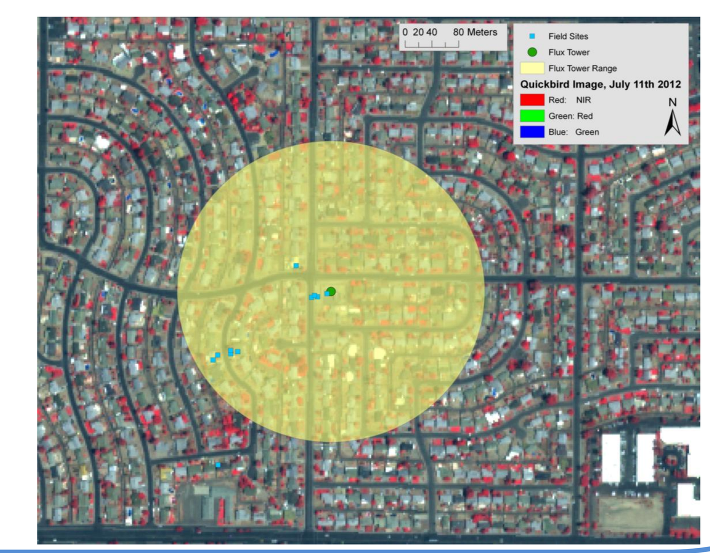


Figure 2 : Spectral signature for three land covers (soil, impervious , vegetation) collected at the time of the satellite overpass and the roof tops visited near the flux tower site.

Figure 3 : the validation area at the WPHX micrometeorological tower. Source area radius is 230m.



5. Results

- The following are the formulas for converting surface narrow-band albedo to two broadband albedo: VNIR - 0.4-0.9µm; and total shortwave (TOT) - 0.35-2.32µm, based on the multiple regression procedure

$$\alpha_{VNIR-TOA} = -1.0389b_1 + 1.7178b_2 + 0.2809b_4$$
$$\alpha_{VNIR-surf} = -1.7211b_1 + 2.2189b_2 + 0.4467b_4$$
$$\alpha_{TOT-TOA} = -0.2482b_1 + 0.7392b_3 + 0.3780b_4$$
$$\alpha_{TOT-surf} = -0.4513b_1 + 0.8322b_3 + 0.6087b_4$$

Table 1: Models evaluation

	Albedo at flux tower: 0.168		
Wavelength Range / Correction Type	Predicted Albedo at FT	Bias	RMS
VNIR / TOA	0.171	-0.033	0.071
VNIR / Surf	0.198	-0.002	0.059
TOT/ TOA	0.177	0.019	0.062
TOT / Surf	0.213	-0.003	0.055

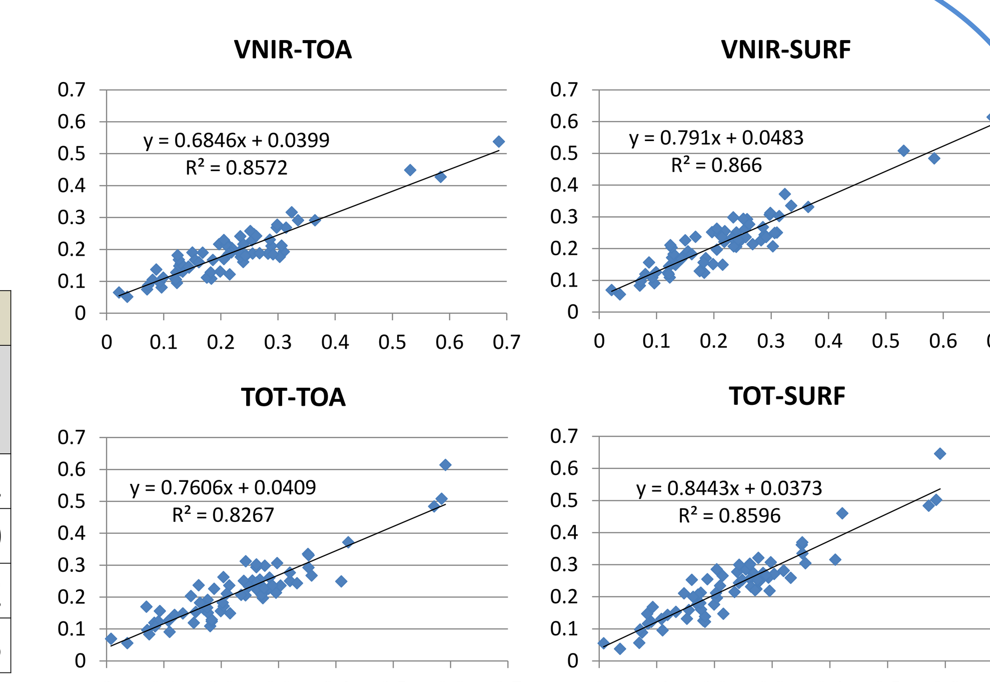
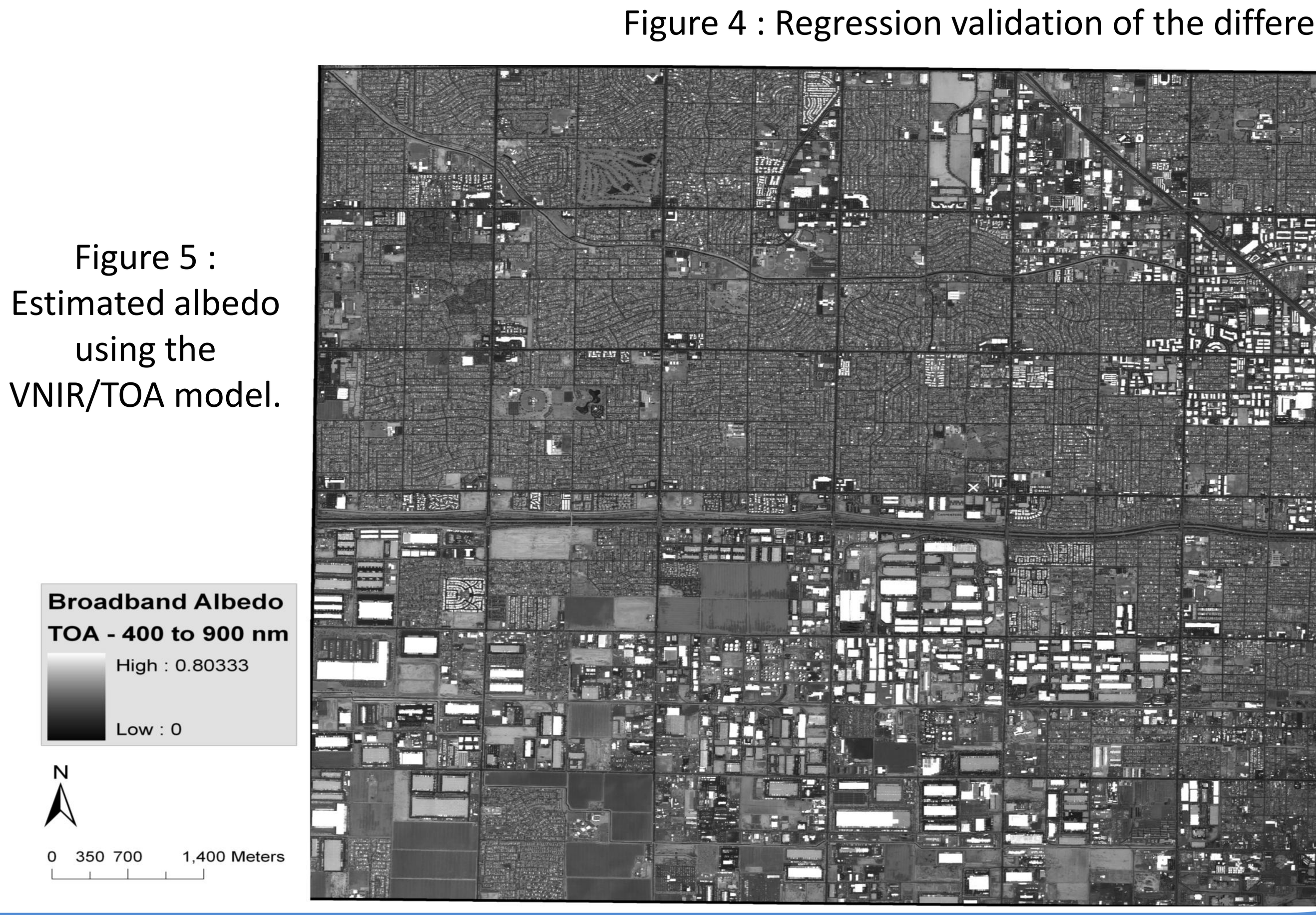


Figure 4 : Regression validation of the different models

- All models overestimate broadband albedo compared to the Pyranometer measurements.
- Statistically, surface models perform better, with higher R^2, lower RMS and lower Bias. Top-of-Atmosphere/VNIR was shown to be closest to flux tower measurements in term of absolute value (1.96% difference).
- For all models ,Albedo spatial pattern and magnitude look very reasonable, and follows general land cover properties.
- Magnitude and direction of the coefficients are consistent for the VNIR models and the TOT models.
- Blue and the near-infra-red bands are used in all models. TOT models replace b_2 (green band) with b_3 (red band). These bands also show the highest impact on albedo for all models (highest absolute coefficient value)

Figure 5 : Estimated albedo using the VNIR/TOA model.



Acknowledgments

The work presented here was funded by the School of Geographical Sciences and Urban Planning at ASU.
We wish to thank the Environmental Remote Sensing and Informatics lab and CAP-LTER for providing field equipment

6. Conclusions

- ➢ A new set of coefficients for estimating high resolution broadband albedo have been developed and validated. High resolution imagery, such as Quickbird, can be used to accurately estimate and monitor broadband albedo at the sub-city/neighborhood scale.
- ➢ Albedo can be reasonably estimated using just the VNIR bands.
- ➢ Although accurate estimation of broadband albedo can be estimated adequately using TOA reflectance, atmospheric correction is a critical step.