Article

Measuring Landscape Albedo Using Unmanned Aerial Vehicles

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Abstract: Surface albedo is a critical parameter in surface energy balance, and albedo change is an important driver of changes in local climate. In this study, we developed a workflow for landscape albedo estimation using images acquired with a consumer-grade camera on board unmanned aerial vehicles (UAVs). Flight experiments were conducted at two sites in Connecticut, USA and the UAV-derived albedo was compared with the albedo obtained from a Landsat image acquired at about the same time as the UAV experiments. We find that the UAV estimate of the visibleband albedo of an urban playground (0.037 ± 0.063, mean ± standard deviation of pixel values) under clear sky conditions agrees reasonably well with the estimates based on the Landsat image (0.047 ± 0.012). However, because the cameras could only measure reflectance in three visible bands (blue, green, and red), the agreement is poor for shortwave albedo. We suggest that the deployment of a camera that is capable of detecting reflectance at a near-infrared waveband should improve the accuracy of the shortwave albedo estimation.

Keywords: Unmanned Aerial Vehicle (UAV); albedo; landscape; consumer-grade camera; radiometric calibration

Category	Property	Brooksvale Park	Yale Playground
Non-vegetation	Bright		
	Dark		
	Soil		
	Pitch		
	Wooden		
	Pebble		
Vegetation	Grass		

Figure S1. Some of the selected ground targets for Brooksvale Park and Yale Playground.

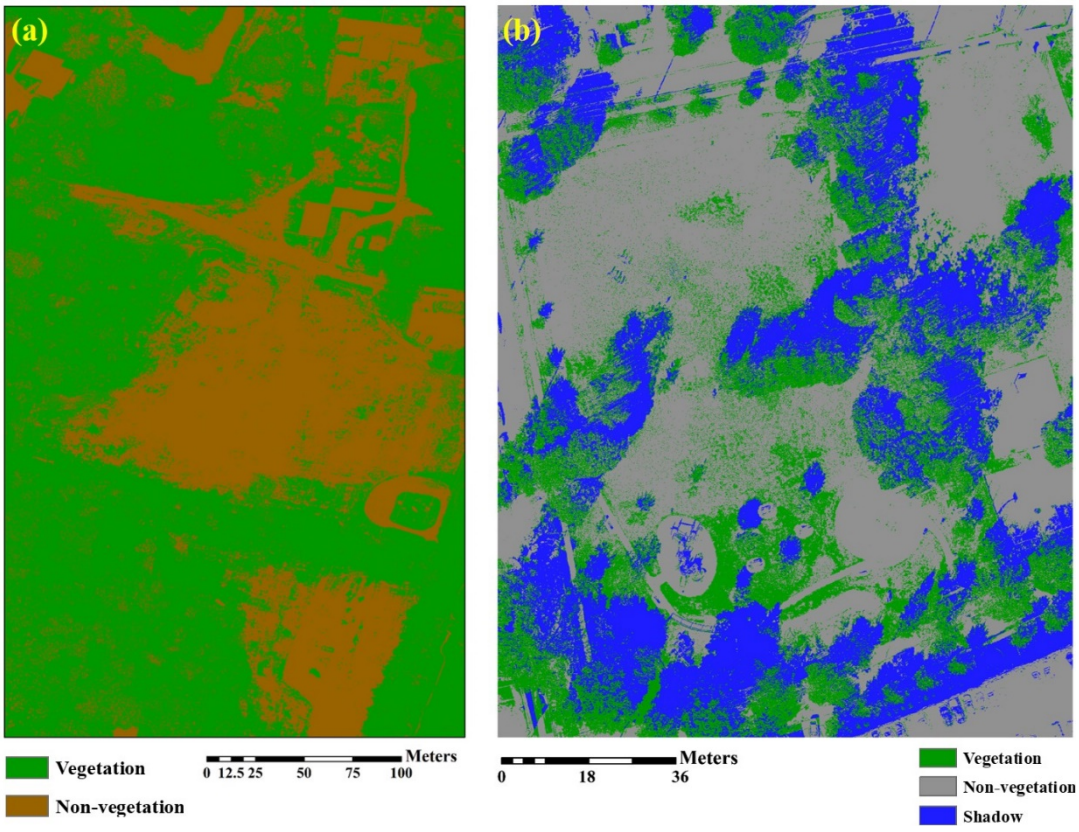

Figure S2. Classification of the mosaicked image for Brooksvale Park (**a**) and Yale Playground (**b**).

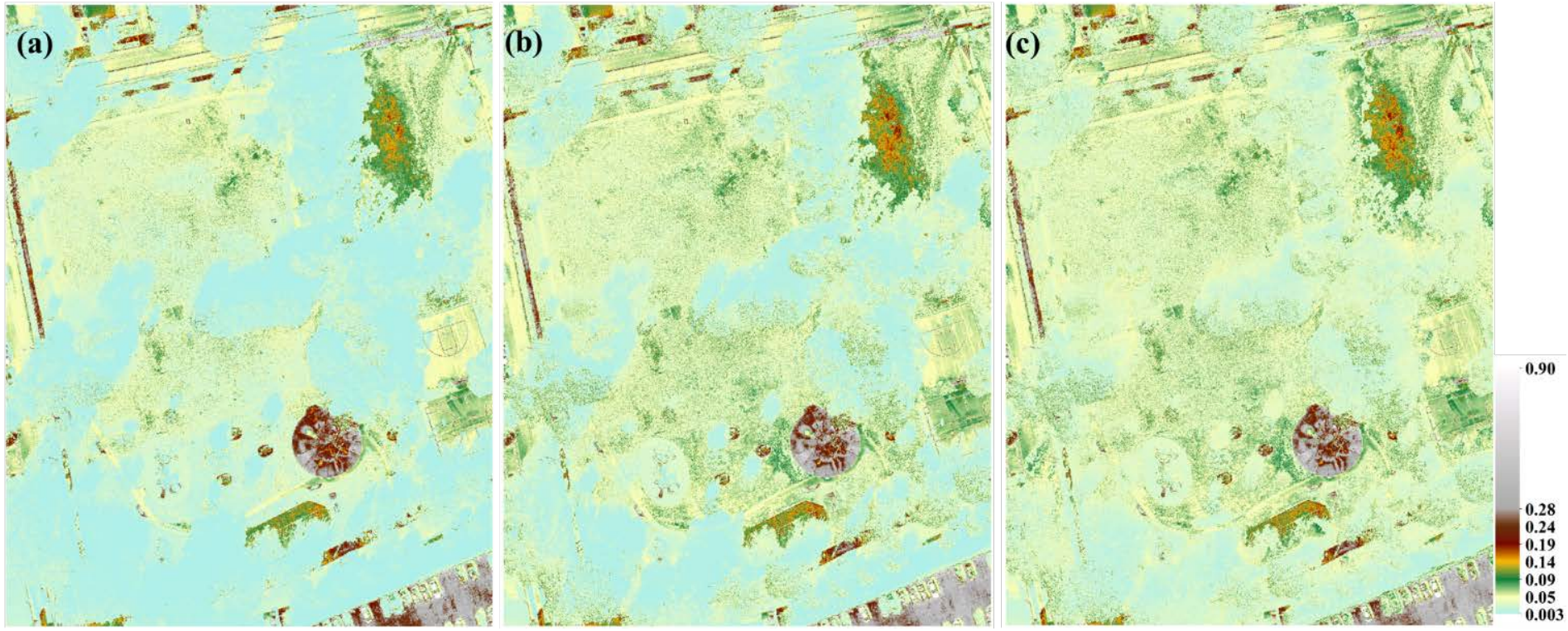

Figure S3. Visible (**a**), shortwave band albedo for the Yale Playground when all shadow were taken as non-vegetation (**b**) and vegetation (c) under clear sky conditions.

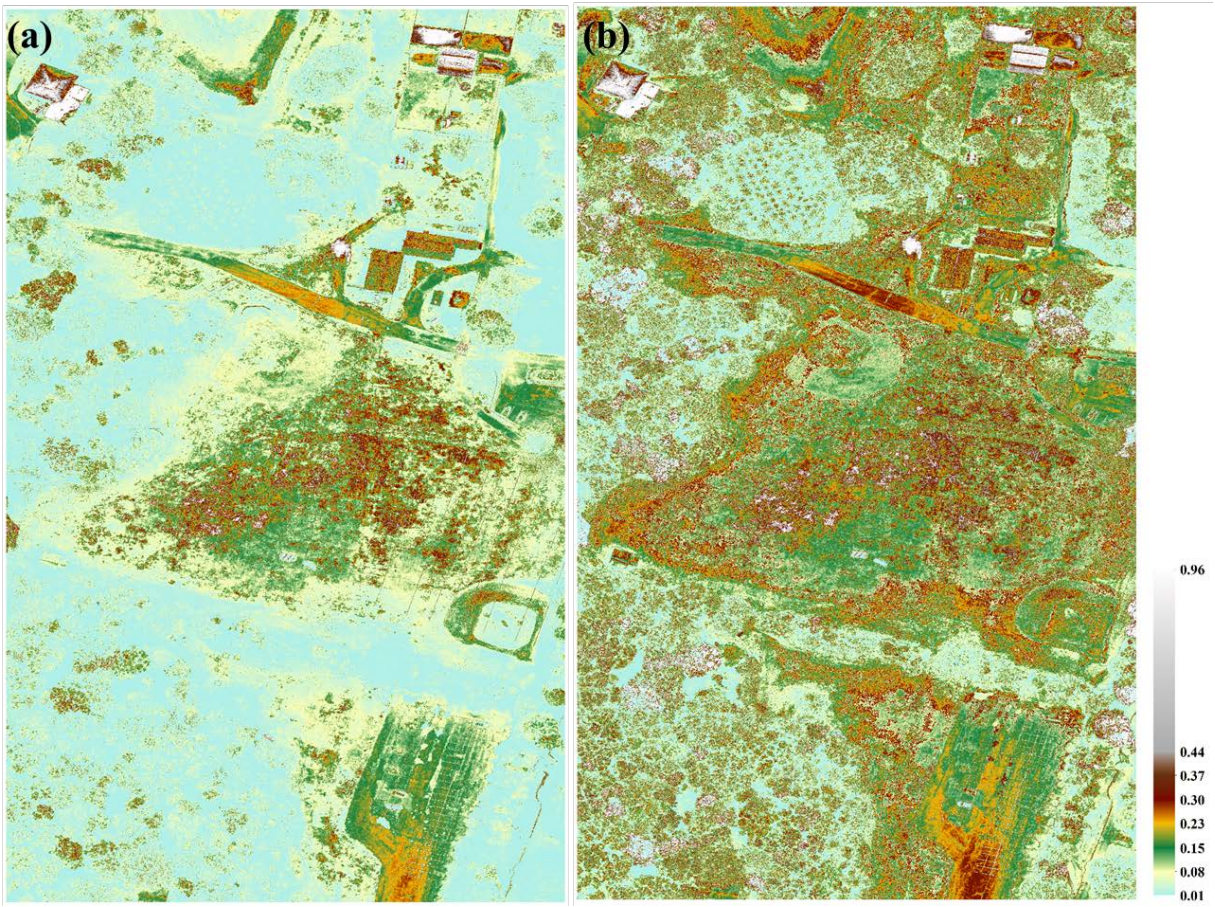

Figure S4. Visible (**a**) and shortwave band albedo (**b**) for the Brooksvale Park under clear sky conditions.

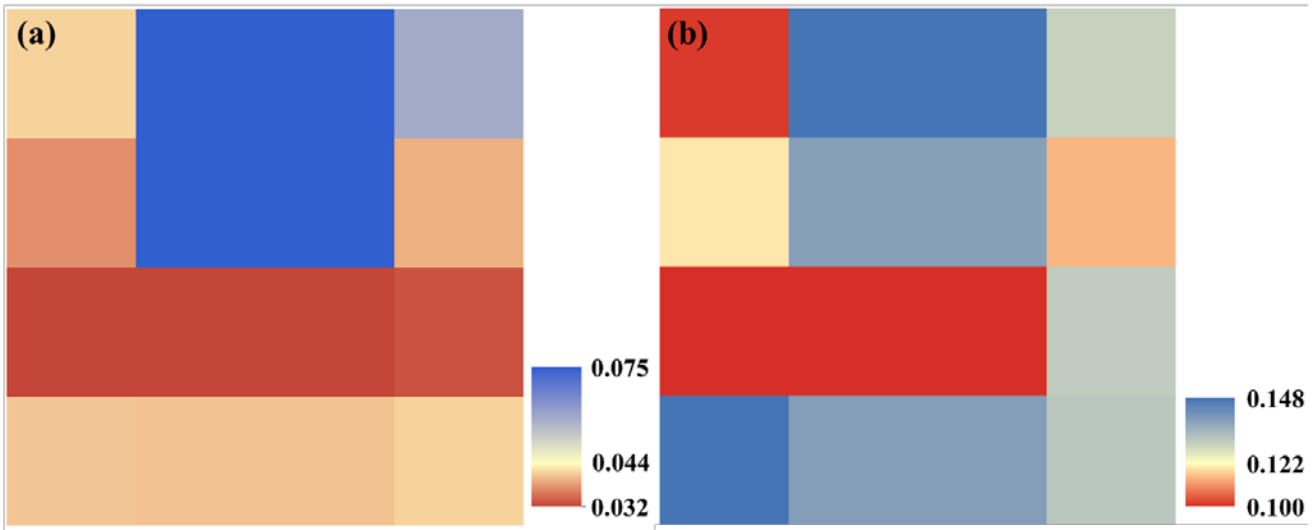

Figure S5. Landsat visible (a) and shortwave band albedo (b) for the Yale Playground.

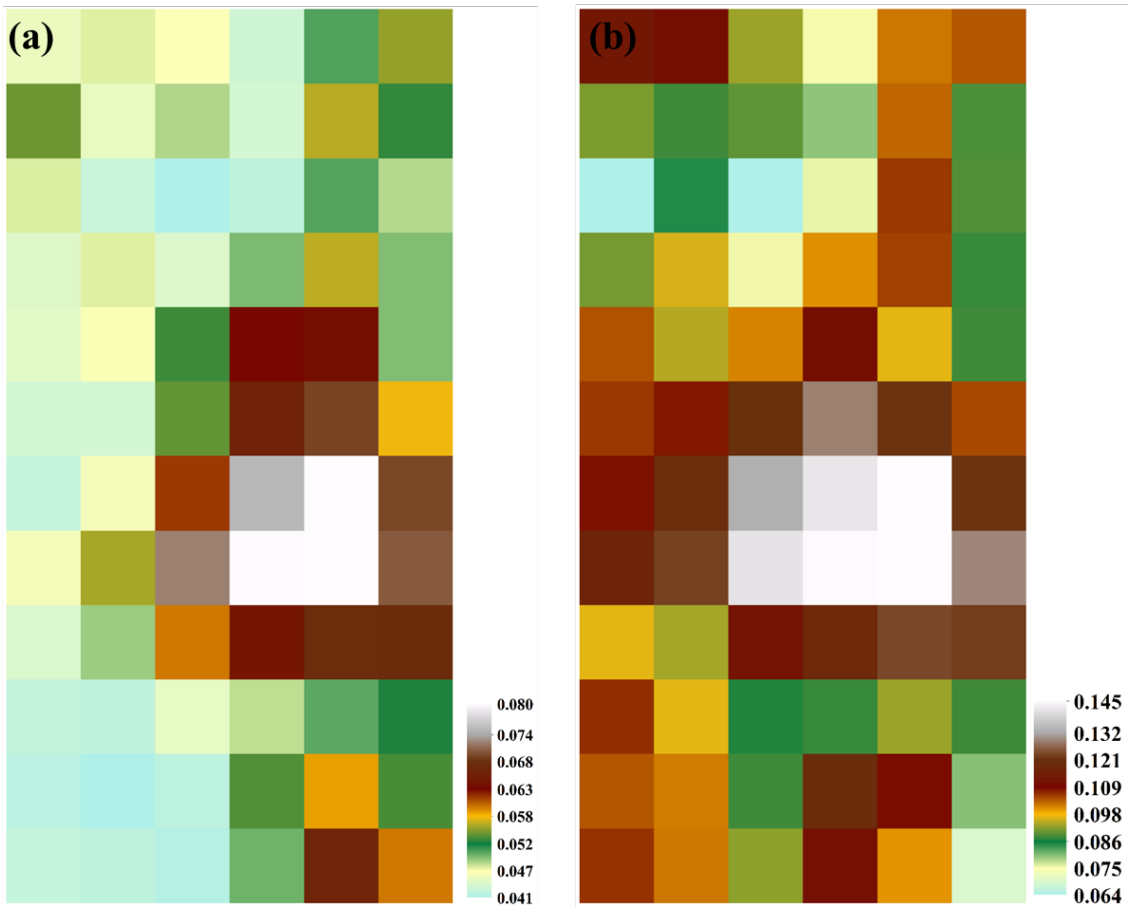

Figure S6. Landsat visible (**a**) and shortwave band albedo (**b**) for the Brooksvale Park.

Table S1. Input parameters for the SMART model.

Parameter	Abbrevation	BV_Clear	BV_Overcast	YP_Clear	YP_Overcast
Card2	ISPR	1	1	1	1
Card2a	Surface pressure (mb)	1020	1004	1020	1004
	Site's altitude (km)	0.044	0.044	0.01	0.01
	Height (km)	0	0	0	0
Card3	Atmosphere	1	1	1	1
Card3a	U.S. Standard Atmosphere	USSA	USSA	USSA	USSA
Card4	Water vapor data set	1	1	1	1
Card5	Ozone data set	1	1	1	1
Card6	Atmospheric pollution	1	1	1	1
Card7	CO2 concentration (ppmv)	420	420	420	420
Card7a	Extraterrestrial spectrum	1	1	1	1
Card8	Aerosol model	S&F_URBAN	S&F_URBAN	S&F_URBAN	S&F_URBAN
Card9	Turbidity data set	0	0	0	0
Card9a	AOD at 500 nm	0.25	0.25	0.25	0.25
Card10	Zonal albedo	1	1	1	1
Card10b	Tilted surface	0	0	0	0
Card11	Min wavelength	300	300	300	300
	Max wavelength	3000	3000	3000	3000
	Sun earth distance	1	1	1	1
	Solar constant	1367	1367	1367	1367
Card12	Printed results	2	2	2	2
Card12a	Min wavelength	300	300	300	300
	Max wavelength	3000	3000	3000	3000
	Interval	1	1	1	1
Card12b	Total number of output	2	2	2	2
Card12c	Spectral variable	1 4	1 4	1 4	1 4
Card13	Circumsolar radiation	0	0	0	0
Card14	Smoothing virtual filter	0	0	0	0
Card15	PAR	0	0	0	0
Card16	UV	0	0	0	0
Card17	Solar position	3	3	3	3
Card17a	Year	2016	2016	2016	2016
	Month	4	3	4	4
	Day	28	7	19	28
	Hour	10.5	13.5	13.5	13.5
	Latitude	41.4527	41.4527	41.3167	41.3167
	Longitude	−72.9178	−72.9178	−72.9284	−72.9284
	Zone	−5	−5	−5	−5