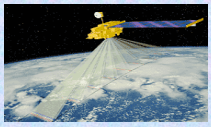


Mapping Shrubs in Arctic Tundra with NASA's MISR Instrument

Mark Chopping[1], Rocio Duchesne[1], Zhuosen Wang[2], Crystal Schaaf[2], and Ken Tape[3]

[1] Montclair State University [2] University of Massachusetts Boston [3] University of. Alaska, Fairbanks

Context: This research is aimed at providing a record of observations of Arctic tundra ecosystems using data from the NASA Multiangle Imaging Spectro-Radiometer (MISR), mapped to a 250 m grid. Shrub mapping at high latitudes using moderate resolution instruments presents many challenges: shrub cover is often < 5% at 250 m scales, so the signal is small; tundra surfaces are dark and often highly heterogeneous; solar zenith angles are high, so path lengths are long; and cloud cover frequently prohibits observation of the surface. Furthermore, this region is remote, so the collection of ground reference data is difficult and expensive. We present here large area shrub mapping supported by reference data collated using extensive field inventory data and high resolution panchromatic imagery.

MISR Data: MISR Level 1B2 Terrain radiance data from the Terra satellite overpass on 08/06/00 (Path 185, Blocks 35-36), were converted to surface bidirectional reflectance factors (BRF) using MISR Toolkit routines and the MISR 1 km LAND product BRFs and resampled onto a 250 m Albers Conic Equal Area grid. The red band data in all available cameras were used to invert the RossThick-LiSparse-Reciprocal (RTLS-R) BRDF model to retrieve *iso*, *vol*, and *geo* kernel weights

Reference Database: The database was constructed with the aid of aerial survey (for site selection), three field campaigns (field inventory and photography for shrub abundance, count, cover, mean radius and height), and high resolution panchromatic imagery. The field data allow checking and calibration of cover and height results obtained using image-based methods; this has allowed us to extend the reference database to well over four hundred 250 x 250 m locations.

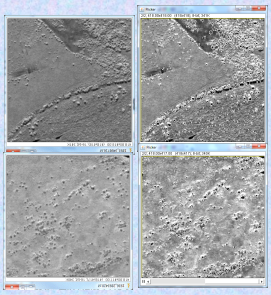
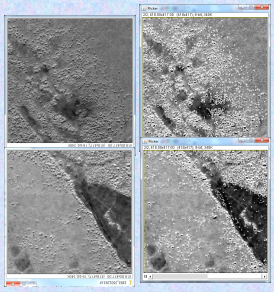


Fig 1. Typical CANAPI-derived shrub maps for 250 x 250 m sites. Left: original panchromatic image; Right: image with shrub crown detections superimposed.



Reference Data Calibration: Estimates of tall shrub number, mean radius, cover. and mean height were obtained from QuickBird 250 x 250 m panchromatic image chips, interpreted using the CANAPI algorithm(Chopping 2011; Fig. 1) and calibrated using estimates based on field survey data (Fig 2).

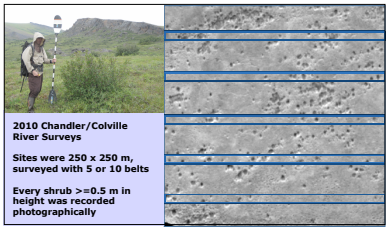
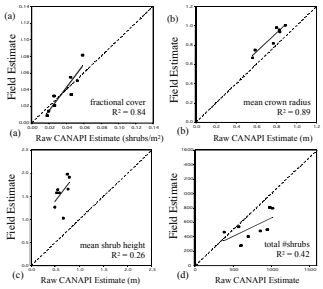


Fig 2. Field Survey. Above: method. Right: use of field data to adjust CANAPI estimates.



Mapping: We used the calibrated reference data to develop a regression model to predict fractional shrub cover for a large portion of the North Slope of Alaska, using MISR-based RTLS-R BRDF model kernel weight Z scores and nadir camera BRFs.

This approach was based partly on observations of a strong spatial correspondence between the Landsat-based "Baseline 2000" all-shrub and tall-shrub (>=1 m) cover maps (LB2000A and LB2000T, respectively) from Beck et al. (2011) and RTLS-R kernel weight false color composites (Figs. 3 and 4).

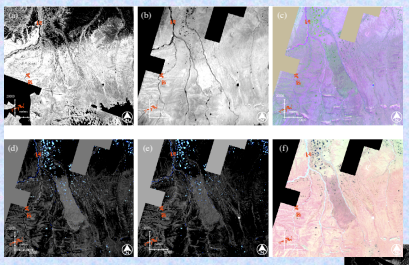


Fig.3. Anaktuvuk Area (a) Landsat-based 2000 All Shrub map (black through white = 0 - 100%) (b) MISR/GO cover retrievals (0.0-0.1) (c) iso, vol, geo kernel weight false color composite (d) tall shrub cover predicted using RTLS-R model kernel weights (0.0-0.3) (e) tall shrub cover predicted using MISR nadir camera BRFs plus RTLS-R model kernel weights (0.0-0.3) (f) MISR nadir camera standard false color composite (RGB = NRG). The red dots indicate the locations of our reference sites. In (d) and (e) surface water is masked to cyan/blue using NIR < 0.15.

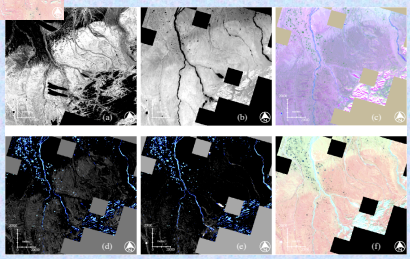
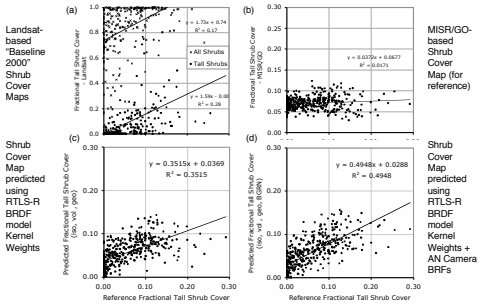


Fig. 4. Sagavanirktok River Area (a) Landsat-based 2000 All Shrub map (black through white = 0 - 100%) (b) MISR/GO cover retrievals (0.0 - 0.1) (c) iso, vol, geo kernel weight false color composite (d) tall shrub cover predicted using RTLS-R model kernel weights (0.0-0.3) (e) tall shrub cover predicted using MISR nadir camera BRFs plus RTLS-R model kernel weights (0.0-0.3) (f) MISR nadir camera standard false color composite (RGB = NRG). In (d) and (e) surface water is masked to cyan/blue using NIR < 0.15.

Fig. 5. Shrub cover vs reference data:

(a) Landsat-based all and tall shrub cover maps
(b) MISR/GO tall shrub (> 50 cm) cover map,
(c) cover predicted from MISR RTLS-R kernel weight Z scores
(d) cover predicted using MISR RTLS-R kernel weight Z scores and nadir camera BRFs.



Results: MISR-based estimates of tall shrub cover were correlated with reference data (R^2=0.50, N=418, p=0.01) with RMSE=0.04 (Fig. 5). LB2000T (tall) shrub cover estimates aggregated at the MISR scale were low with respect to the reference data, with R^2=0.28 and RMSE=0.14, although this may partly reflect an increase in tall shrub cover over the intervening 10 years. The LB2000A (all) shrub cover estimates seem very high but we can quantitatively assess only the LB2000T estimates because our reference data refer to shrubs >=0.5 m in height. These results show that MISR multiangle data can be used to map shrubs in Arctic tundra with an accuracy that is comparable to that obtained using medium-resolution multispectral imagery from Landsat.

References:

Beck P., Horning N., Goetz S., Loranty M., & Tape K. (2011). Shrub cover on the North Slope of Alaska: a circa 2000 baseline map. *Arctic, Antarctica and Alpine Research*. 43(3):355-363.

Chopping, M. (2011). CANAPI: Canopy analysis with panchromatic imagery, *Remote Sensing Letters* 2(1): 21–29.

Acknowledgments: This work was supported by NASA Terrestrial Ecology Award NNX09AL03G and NASA/JPL subcontract #1365499. Data credits: NASA LARC/ASDC, Digital Globe, Inc. More info., maps & code: **http://csam.montclair.edu/~chopping/tundra**

Montclair State University · UMASS Boston · UAF University of Alaska Fairbanks · North American Carbon Program · 4th NACP All-Investigators Meeting · February 4 - 7, 2013, Albuquerque, NM