Tall Shrub Abundance on the North Slope of Alaska from MISR, 2000-2010

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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: About 90 MISR Level 1B2 Terrain radiance scenes -- out of the 572 from the Terra satellite available between June 15th- July 31st (from 2000 to 2010) -- 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, together with model-fitting RMSE and Weights of Determination.

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.

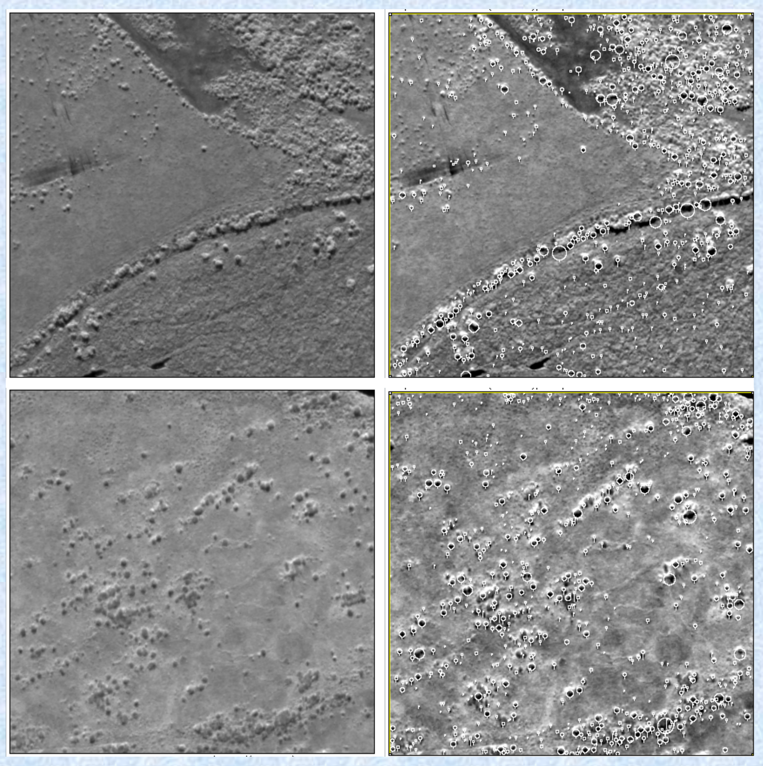
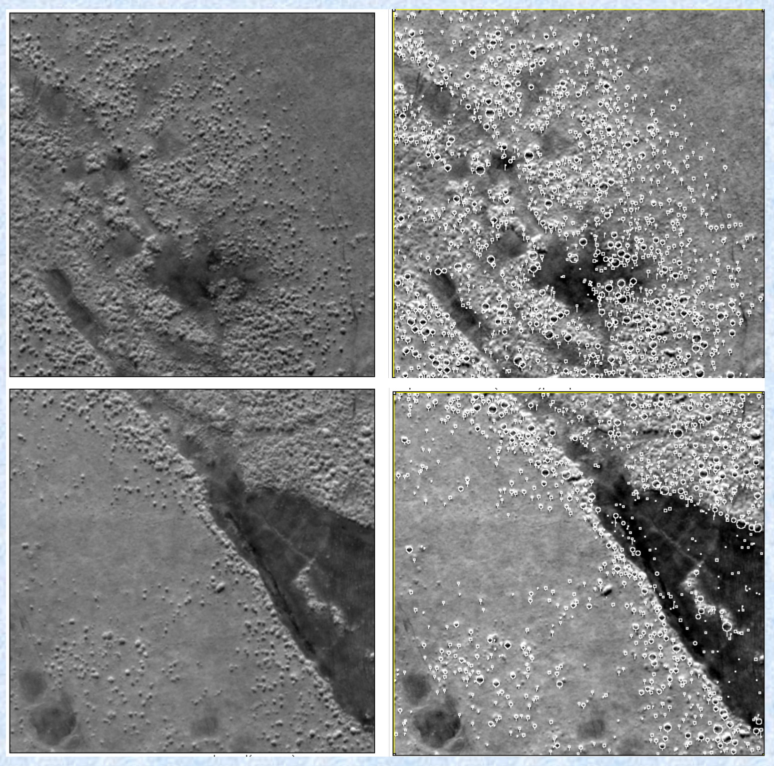


Fig 1. Typical CANAPI-derived shrub maps for 250 x 250 m sites. Left: original panchromatic image; Right: image with shrub crown detections superimposed.



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 (Fig. 1) and calibrated using estimates based on field survey data (Fig 2). The database was enlarged to 444 sites of 250 x 250 m.

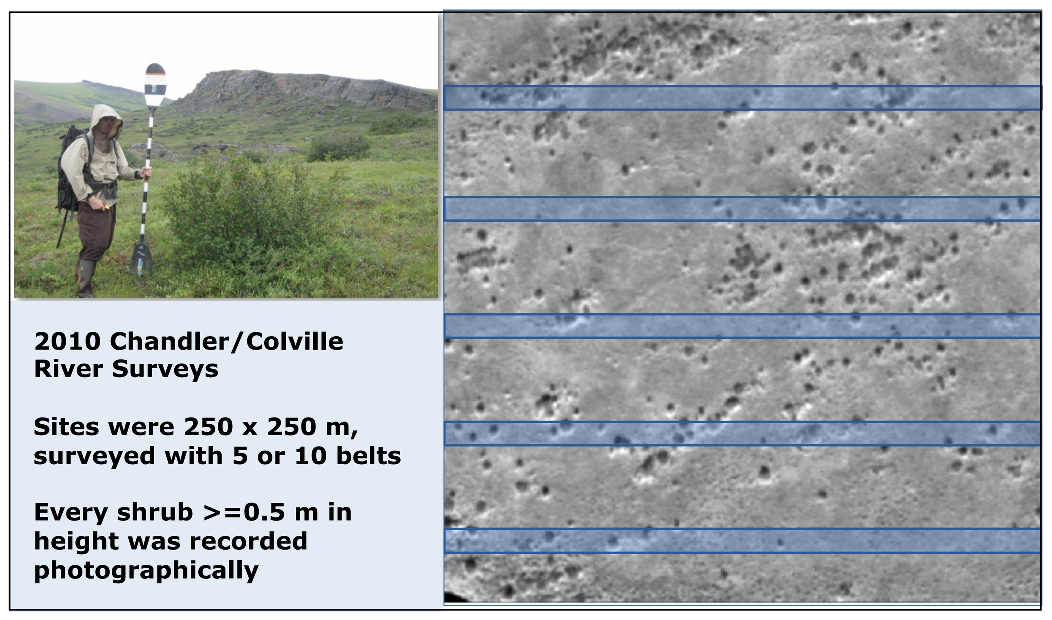
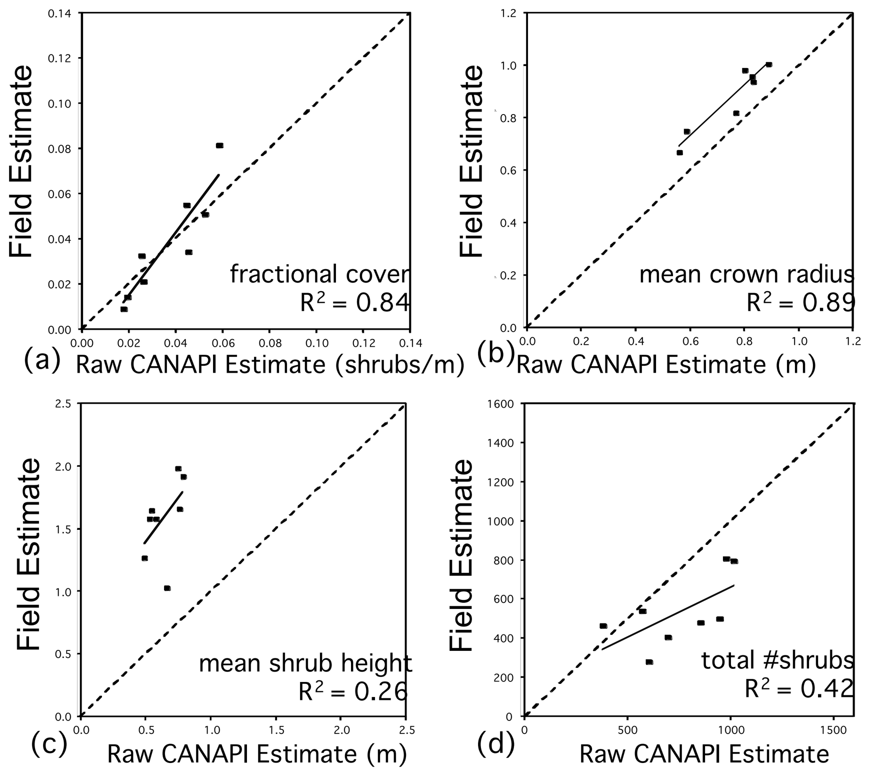


Fig 2. Field Survey. Above: method. Right: use of field data to adjust CANAPI estimates.



Modeling: Tall shrub fractional cover maps for the North Slope of Alaska were constructed using the bootstrap forest machine learning algorithm that exploits the surface information provided by MISR. The 444 observations of the reference database were randomly divided into two datasets for training and validation (N=215, 229). The algorithm used a set of 19 independent variables: isotropic, volumetric, and geometric scattering kernel weights, ratios and interaction terms; white and black sky albedos; and blue, green, red, and NIR nadir camera BRFs, to grow a forest of 9 decision trees. The final estimate is the average of the predicted values from each tree. Observations not used in constructing the trees were used in validation. The R^2 values for the training and validation datasets were 0.89 and 0.46, respectively (Fig. 3).

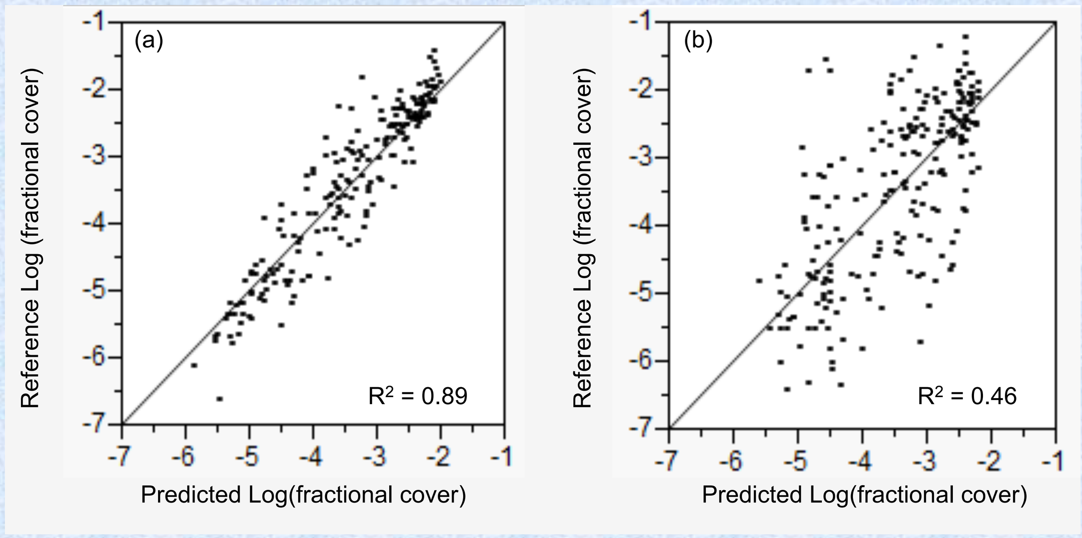
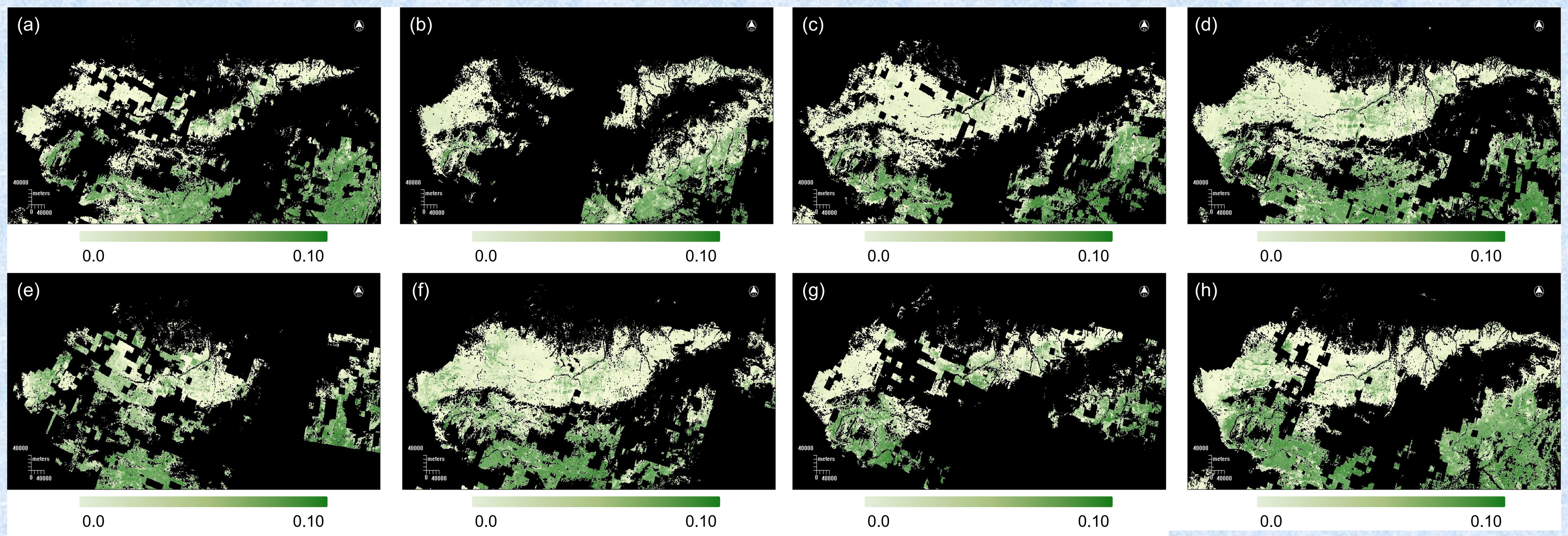


Fig 3. Regression of predicted log(fractional cover) from bootstrap forest algorithm vs. reference log(fractional cover). Using (a) training data, (b) validation data.

Mapping: The model was applied with a large volume of MISR data and the resulting fractional cover estimates were combined into yearly maps using a compositing algorithm that flags results affected by clouds (using model-fitting RMSE as the criterion), surface water (NIR) BRF, extreme outliers, and topographic shading. In a second phase burned areas and cloud shadows will be screened out.



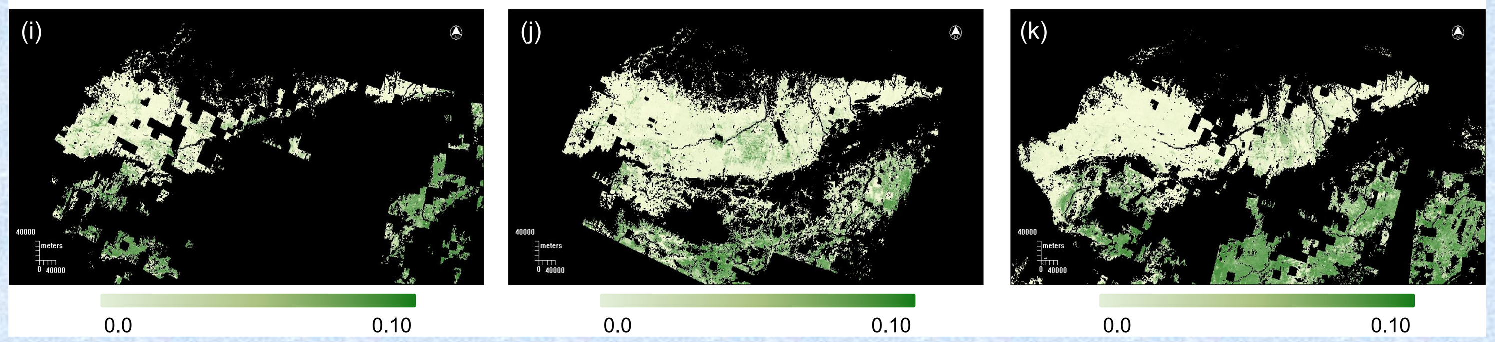


Fig 4. Yearly fractional cover map for the North Slope of Alaska using Bootstrap Forest method. (a) 2000, (b) 2001, (c) 2002, (d) 2003, (e) 2004, (f) 2005, (g) 2006, (h) 2007, (i) 2008, (j) 2009, and (k) 2010.

A preliminary assessment of the fractional cover change over the last decade was achieved by averaging fractional cover values for 2000-2002 and 2008-2010 and then calculating the change between the two periods.

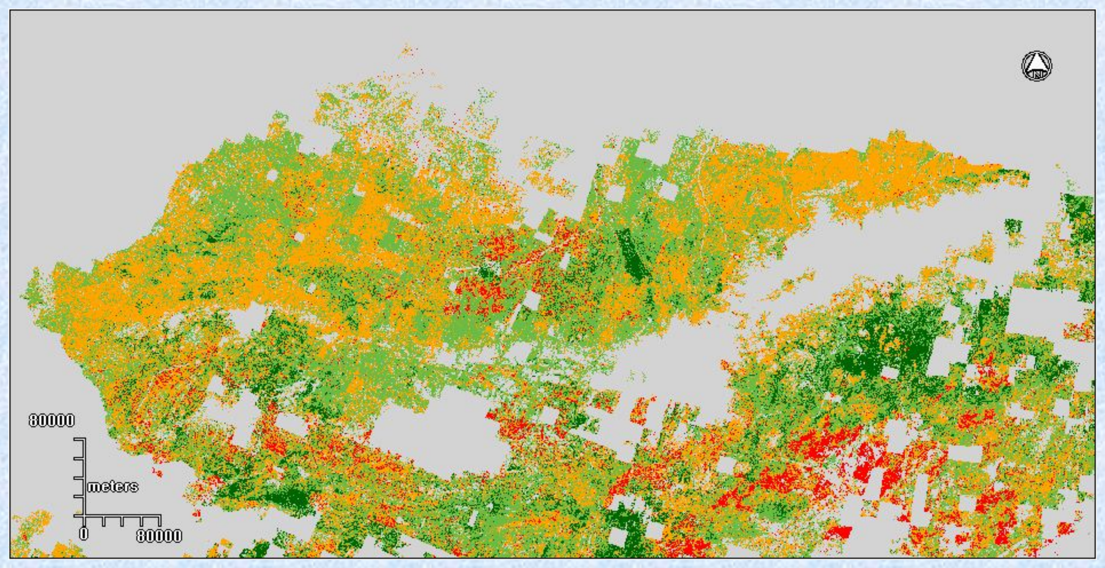


Fig 5. Fractional tall shrub cover difference map using maps composited for 2000-2003 and 2008-2010. It is clear that there are large areas for which we cannot determine the sign of the the change with high confidence, as the precision of our estimate is close to the magnitude of the cover values.

Future Work: We will enlarge our reference database to include sites across the Arctic using high resolution imagery from the National Geospatial-Intelligence Agency (NGA) Commercial Data Archive. We will then be able to refine the bootstrap forest model to predict more reliable fractional cover values. We will also use a larger number of MISR data sets increase coverage.

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