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Modeling Above-Ground Biomass Across Multiple Circum-Arctic Tundra Sites Using High Spatial Resolution Remote Sensing

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Biomass is one of the central bio-geophysical variables in Earth observation for tracking plant productivity, and flow of carbon, nutrients, and water. Most of the satellite based biomass mapping exercises in Arctic environments have been performed by using rather coarse spatial resolution data, e.g. Landsat and AVHRR which have spatial resolutions of 30 m and >1 km, respectively. While the coarse resolution images have high temporal resolution, they are incapable of capturing the fragmented nature of tundra environment and fine-scale changes in vegetation and carbon exchange patterns. Very high spatial resolution (VHSR, spatial resolution 0.5-2 m) satellite images have the potential to detect environmental variables with an ecologically sound spatial resolution. The usage of VHSR images has, nevertheless, been modest so far in biomass modeling in the Arctic. Our objectives were to use VHSR for predicting above ground biomass in tundra landscapes, evaluate whether a common predictive model can be applied across circum-Arctic tundra and peatland sites having different types of vegetation, and produce knowledge on distribution of plant functional types (PFT) in these sites. Such model development is dependent on ground-based surveys of vegetation with the same spatial resolution and extent with the VHSR images. In this study, we conducted ground-based surveys of vegetation composition and biomass in four different arctic tundra or peatland areas located in Russia, Canada, and Finland. First, we sorted species into PFTs and developed PFT-specific models to predict biomass on the basis of non-destructive measurements (cover, height). Second, we predicted overall biomass on landscape scale by combinations of single bands and vegetation indices of very high resolution satellite images (QuickBird or WorldView-2 images of the eight sites). We compared area-specific empirical regression models and common models that were applied across all sites. We found that NDVI was usually the highest scoring spectral indices in explaining biomass distribution with good explanatory power. Furthermore, models which had more than one explanatory variable had higher explanatory power than models with a single index. The dissimilarity between common and site-specific model estimates was, however, high and data indicates that variation in vegetation properties and its impact on spectral reflectance needs to be acknowledged. Our work produced knowledge on above-ground biomass distribution and contribution of PFTs across circum-Arctic low-growth landscapes and will contribute to developing space-borne vegetation monitoring schemes utilizing VHSR satellite images.