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Convolutional Neural Network Approach for Mapping Arctic Vegetation using Multi-Sensor Remote Sensing Fusion

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Accurate and high-resolution maps of vegetation are critical for projects seeking to understand the terrestrial ecosystem processes and land-atmosphere interactions in Arctic ecosystems, such as U.S. Department of Energy's Next Generation Ecosystem Experiment (NGEE) Arctic. However, most existing Arctic vegetation maps are at a coarse resolution and with a varying degree of detail and accuracy. Remote sensing-based approaches for mapping vegetation, while promising, are challenging in high latitude environments due to frequent cloud cover, polar darkness, and limited availability of high-resolution remote sensing datasets (e.g., 5 m). This study proposes a new remote sensing based multi-sensor data fusion approach for developing high-resolution maps of vegetation in the Seward Peninsula, Alaska. We focus detailed analysis and validation study around the Kougarok river, located in the central Seward Peninsula of Alaska.

We seek to evaluate the integration of hyper-spectral, multi-spectral, radar, and terrain datasets using unsupervised and supervised classification techniques over a 343.72 km^2 area for generating vegetation classifications at a variety of resolutions (5 m and 12.5 m). We first applied a quantitative goodness-of-fit method, called Mapcurves , that shows the degree of spatial concordance between the public coarse resolution maps and k-means clustering values and relabels the k values based on the best overlap. We develop a convolutional neural network (CNN) approach for developing high resolution vegetation maps for our study region in the Arctic. We compare two CNN approaches: (1) breaking up the images into small patches (e.g., 6×6) and predict the vegetation class for entire patch and (2) semantic segmentation to predict the vegetation class for every pixel. We also perform accuracy assessments of the developed data products and evaluate varying CNN architectures. The fusion of hyper-spectral and optical datasets performed the best, with accuracy values increased from 0.64 to 0.96–0.97 when using training labels produced by unsupervised clustering and Mapcurves method for both CNN models.