Machine learning approach to understanding vegetation distribution and dynamics using high resolution remote sensing

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Motivation

- Next Generation Ecosystem Experiments (NGEE) – Arctic project aims to deliver a process-rich ecosystem model, extending from bedrock to the top of the vegetative canopy, in which the evolution of Arctic ecosystems in a changing climate can be modeled at the scale of a high resolution Earth System Model grid cell.
- Arctic landscape consist of diverse and heterogeneous vegetation distribution which are undergoing rapid change under changing climate. Understanding of patterns and distribution of vegetation and environmental conditions driving their dynamics is key for their improved representation in land surface models.

Remote Sensing of Arctic Vegetation

- Satellite remote sensing is a powerful tool for monitoring natural and anthropogenic temporal and spatial changes in these environments; however, cloud cover, polar darkness, and a sparse number of publicly available high-resolution datasets are often limiting factors.
- Multi-sensor fusion techniques allows combining the information content from different sensor platforms and spatial resolution to accurately resolve the fine scale heterogeneity in vegetation.
- We combined data from multi-spectral (SPOT5, Landsat 8), hyperspectral (EO-1 Hyperion), platforms and topography to differentiate among Arctic vegetation communities of interest at NGEE-Arctic study sites in Alaska.

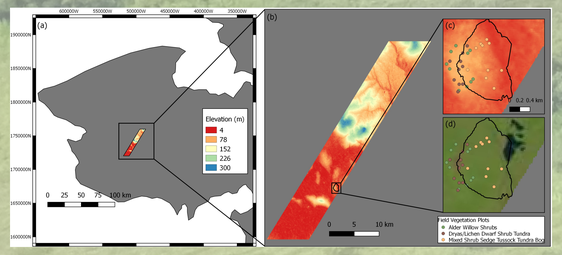
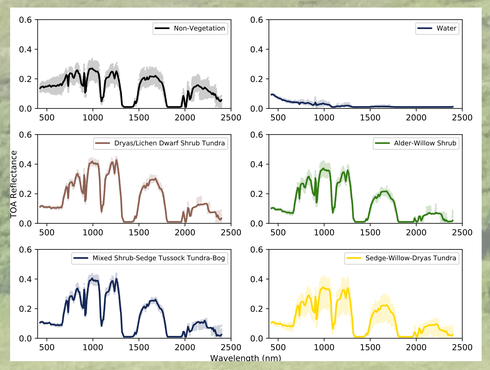
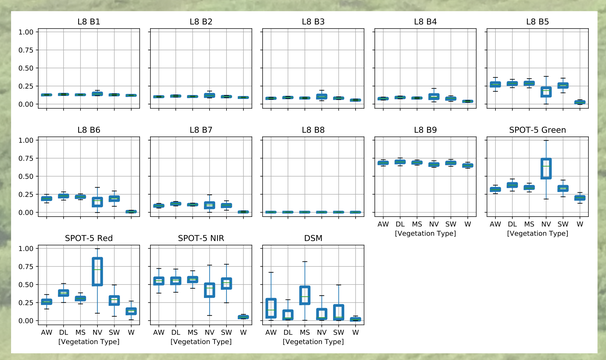


Figure 1: *NGEE-Arctic study sites at Seward Peninsula, Alaska*



(a) EO-1 Hyperion



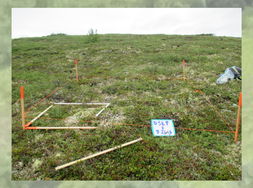
(b) SPOT-5, Landsat 8, IfSAR DSM

Figure 2: *Different vegetation types exhibit distinct spectral response.*

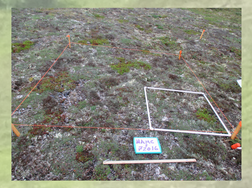
Field vegetation observation

Field surveys were conducted at the site to collected observations of vegetation community composition using ($5\ m \times 5\ m$/$2.5\ m \times 2.5\ m$ plots) with five replicates to provide ground based training/validation for machine learning models.

(a) Alder Shrubland



(b) Dwarf Shrub Lichen Tundra



(c) Non-Acidic Mountain Complex

(d) Tussock Tundra

Figure 3: *Field vegetation surveys were conducted to collect data for training and validation*

Convolutional Neural Networks

Convolutional Neural Networks (CNNs) are artificial neural networks that learn spatial-contextual features in several hierarchical nonlinear layers. We developed deep CNN models using multi-sensor remote sensing fusion data sets to classify Arctic vegetation communities on the landscape.

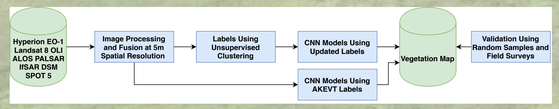


Figure 4: *Convolutional Neural Network approach for remote sensing-based mapping of vegetation.*

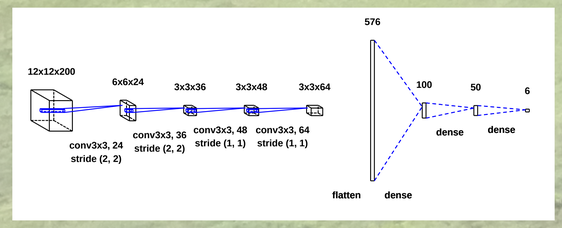


Figure 5: *Convolutional Neural Network architecture was implemented using TensorFlow.*

CNN models were trained, optimized and validated to develop high resolution ($5\ m$) maps of Arctic vegetation distributions at NGEE-Arctic study sites.

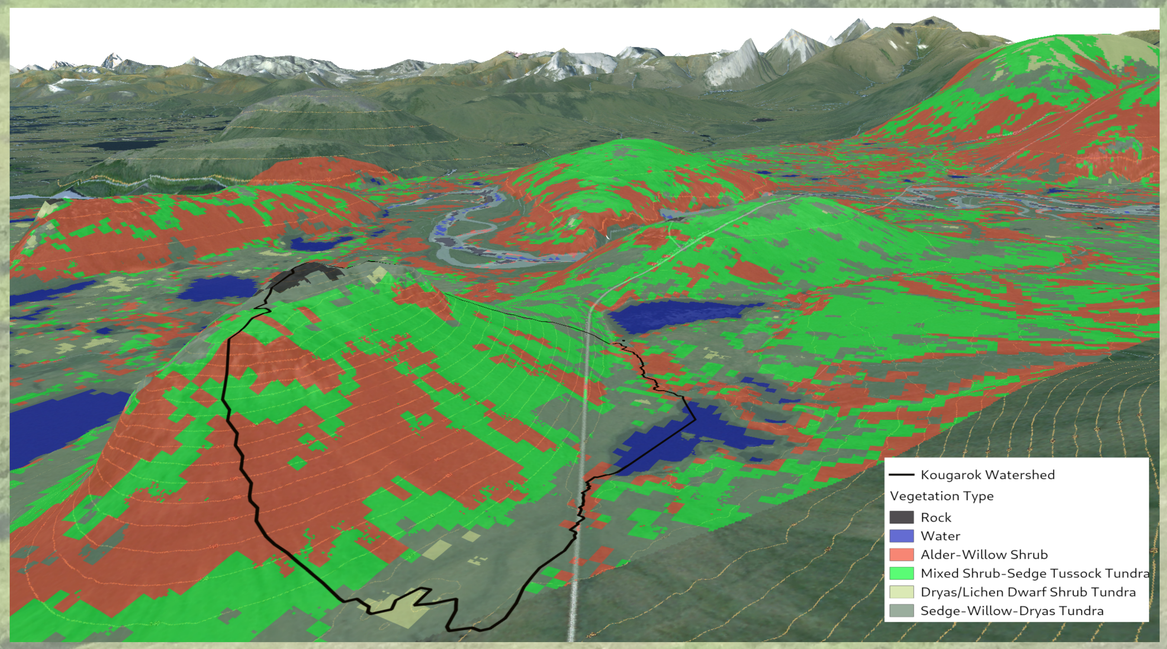


Figure 6: *Distribution of Arctic vegetation type across NGEE-Arctic study watershed at Kougarok, Seward Peninsula, AK.*

Summary

- A multisensor data fusion approach was developed to exploit data available from a variety of different remote sensing platforms at a range of spatial resolutions to characterize and map vegetation in Arctic ecosystem.
- CNN based classification of multi-sensor fusion remote sensing dataset produced accurate high resolution maps of Arctic vegetation distribution.

Acknowledgments

The Next-Generation Ecosystem Experiments (NGEE Arctic) project is supported by the US Department of Energy, Office of Science, Biological and Environmental Research Program. Oak Ridge National Laboratory (ORNL) is managed by UT-Battelle, LLC, for the U.S. Department of Energy under contract DE-AC005-00OR22725.