Leveraging Multi-Scale Remote Sensing to Improve our Understanding of Arctic Vegetation Diversity, Structure and Function

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Rapid warming in the Arctic is driving changes in vegetation distribution, structure, and function, with widespread implications for energy balance and biogeochemical cycling of the high latitude ecosystems. These changes can in turn affect regional to global climates through their changes to snow cover, albedo, carbon, water, and energy cycling. An improved understanding of plant composition and functional properties in the Arctic is therefore critical to predict the consequences of climate change, but it is currently lacking. Moreover, a predictive understand of Arctic ecosystems is limited by a lack observational data, and the resulting inadequate representation of plant trait variation across space and time drives large uncertainties in Earth system models (ESMs). An approach is needed to bridge the scales between detailed *in- situ* observations in remote locations and the larger, landscape context needed to inform ESMs on plant composition, structure, and function. In particular we lack how details on plant responses to biotic and abiotic drivers, such as climate, soils, topography, and disturbance.

Remote sensing data acquired from various platforms (e.g. near-surface, unmanned aerial system (UAS), airborne, and satellite) are critical for multi-scale monitoring of vegetation status and dynamics. Here we present our efforts to derive detailed maps of species composition, canopy structure, and functional traits from UAS platforms, and linked them up with large-scale airborne and satellite observations. We showed that our plot-to-pixel scaling approach can yield accurate models for predicting plant traits (i.e. R^2 between 0.50 and 0.89), though issues and considerations remain. Using UAS maps as a benchmark, we explored the spectral consistency across multi-scale remote sensing observations to identify issues related to scale and spectral mismatch that affect the upscaling of plant traits. We found that, within ecotypes, remote sensing data is generally comparable, but spatial variation in plant composition and structure, as well as plant patch size, drives the observed mismatch in spectral reflectance acquired from different platforms. Although we show that we can effectively scale up our measurements, we also highlight the challenges and call for approaches to address scale and sensor mis-match.