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RECENT TEMPORAL DYNAMICS OF ARCTIC TUNDRA VEGETATION WITHIN THE CONTEXT OF SPATIAL BIOMASS-TEMPERATURE RELATIONSHIPS

Howard Epstein *(University of Virginia, United States)*
Uma Bhatt *(University of Alaska Fairbanks, United States)*
Martha Raynolds *(University of Alaska Fairbanks, United States)*
Donald Walker *(University of Alaska Fairbanks, United States)*
Leah Reichle *(University of Virginia, United States)*

hee2b@virginia.edu

Large-scale spatial gradients are particularly useful for developing relationships between ecosystem properties and environmental variables. Assuming these variables and system properties are dynamic over time, the spatial relationships may be used as a first approximation for how ecosystems respond to environmental changes, i.e. space-for-time substitutions. We used data from two spatial gradients within the arctic tundra to examine how the observed temporal dynamics of tundra vegetation compared to space-for-time projections based on spatial biomass-temperature relationships. Over the past several decades, data were collected on vegetation, soil, climate, and other ecosystem properties, across two long latitudinal gradients in the arctic tundra, spanning all of the major tundra subzones on two continents (North American Arctic Transect and Eurasian Arctic Transect). Field-harvested, aboveground vegetation biomass data were related to satellite-derived temperature data, in this case the Summer Warmth Index (SWI - sum of mean monthly temperatures > 0 °C); total aboveground vegetation biomass increases exponentially as a function of SWI. Field-harvested biomass has also been related to the satellite-derived Normalized Difference Vegetation Index (NDVI), with total aboveground vegetation biomass also increasing exponentially with NDVI. We used a 32-year record (1982-2013) of satellite-derived Land Surface Temperatures and NDVI from Advance Very High Resolution Radiometer (AVHRR) sensors onboard NOAA satellites (GIMMS 3g dataset) to evaluate projected and observed changes in total aboveground vegetation biomass over this time period; SWI was determined from the Land Surface Temperature data. We calculated the annual values of *projected* vegetation biomass as a function of SWI (space-for-time substitution), and we calculated the annual values of *observed* vegetation biomass as a function of NDVI. Finally, we evaluated the 32-year trends in projected and observed biomass for three regions: the arctic tundra as a whole, as well as for North American tundra and Eurasian tundra. We hypothesized that 1) NDVI-derived (observed) biomass would have less interannual variability than SWI-derived (projected) biomass, as actual vegetation changes from year-to-year are constrained by biological and abiotic factors other than temperature, and 2) the rate of change in NDVI-derived biomass over the entire record would be less than the projected rate of change (SWI-derived), again likely due to ecosystem constraints. As we expected, interannual standard deviations for SWI-derived biomass were 2.0 – 2.5 times greater than those for NDVI-derived biomass (for all three regions of interest), and the trendlines for NDVI-derived biomass were much “tighter” with greater r^2 values than those for SWI-derived biomass. Surprisingly however, the observed rates of change (NDVI-based) in total aboveground vegetation biomass (range of 2.5 to 2.6 g m^{-2} y^{-1}) were greater than the projected rates of change based on temperature (SWI) dynamics (range of -0.2 to 2.2 g m^{-2} y^{-1}) , for all three regions. These results suggest that 1) in addition to changing temperatures, there are other factors (including direct/indirect effects of temperature changes) that are yielding high vegetation biomass responses, and 2) there is the potential for at least the temporary formation of novel tundra ecosystems with respect to the zonal climate (e.g. tall shrublands).