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Arctic greening, Arctic browning or Arctic drowning?

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Thawing of permafrost and the resulting decomposition of previously frozen organic matter constitute a positive feedback to global climate. However, contrasting mechanisms are at play. Gradual increases in thawing depth and temperature are associated with enhanced vegetation growth, most notably in shrubs (“greening”). In ice-rich permafrost, abrupt thaw (thermokarst) results in disturbance of vegetation and surface wetting, which may result in an opposing trend (“browning”).

We determined the balance of shrub decline and expansion in an ice-rich lowland tundra ecosystem in north-Eastern Siberia using vegetation classification and change analysis. We used random forest classification on 3 very high resolution commercial satellite images gathered between 2010 and 2019 (GeoEye-I and WorldView-II). To mitigate (slight) differences in sensor properties and vegetation phenology, a spatio-temporal implementation of Potts model was used to utilize both spectral properties of a pixel and its degree of correspondence with spatially and temporally neighbouring pixels. This reduced artefacts in change detection substantially and improved accuracy of classification for all three images.

We found that shrub vegetation declines in this lowland tundra ecosystem. Areas of thaw features (thermokarst ponds, thermoerosion gullies) and aquatic plant types (sedges and peat mosses) however show an increasing trend. Markov Chain analysis reveals that thaw features display a succession from open water / mud to sedges to peat moss.

This transition from shrub dominated to wetland species dominated tundra may have important implications for this ecosystem's greenhouse gas balance and is indicative of wetter conditions. Thermokarst may be an important driver of such change, as thaw features are found to expand at the expense of shrub vegetation and show rapid colonization by aquatic species.