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Classification of vegetation in the Tundra-Taiga transition zone in Far North-East Siberia, Chukotka

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Global warming causes strong temperature increases at high latitudes. In Siberia, boreal forests reach their maximum northwards position and form a treeline ecotone, which is a transition zone from open forest stands in the south and decreasing stand densities towards treeless tundra in the harsh north. The recent dramatically increasing temperatures allow tree species to migrate farther north and colonize currently treeless tundra. Such range expansions cause environmental changes and might lead to positive feedbacks to climate warming, due to albedo decreases. Therefore, it is of high importance to understand ecosystem changes in the Arctic of the recent past to predict future trajectories.

To approach the aim of projecting vegetation dynamics into the future, we constructed at first a consistent ecosystem map over a large area at one specific time point, based on time series derived from satellite data. With this methodology we are able to gain knowledge about trends revealed by remote sensing by comparing them with in situ data. Our study area is situated in North-East Siberia, Chukotka, and covers approximately 75,000 km2 within 162.5-170.0° E and 65.8-68° N. This remote area covers a natural treeline from south-west to north-east. We used 2,522 peak summer scenes from the extensive Landsat archive (mission 4-5 TM, 7 ETM+, 8 OLI), which cover the years 1995 to 2016.

Our methods involve, (1) processing the large number of scenes, (2) calculating vegetation indices for each scene, and, (3) deriving consistent maps for each index (NDVI, NDWI, NDMI, TCG, TCW, TCM) by trend-analysis. Subsequently, (4) combining these maps with in situ vegetation survey data by multivariate statistics to identify vegetation classes, and finally, (5) creating with automated mapping a vegetation map. At last, (6) we evaluated the accuracy of our new vegetation map with high-resolution satellite images and compared it to current global land cover models.

Based on the produced index maps, we found that the three satellite indices NDVI, NDWI and TCG explained significantly the variation of our field data in the ordination analysis. Five vegetation classes could be differentiated, of which the strongest separation was found between treeless tundra and areas dominated by larch forests. The newly derived vegetation map could be characterized by a higher resolution and an improved accuracy, especially of the transition from dense to open tree stands, compared to current global vegetation maps.