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Predictive modelling of tundra changes in mountain treeline ecotone over the last 60 years with remote sensing time series data (case study of Western Brooks Range, USA)

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Mountain treeline ecotone responses to climate change by mainly increasing of forest cover and altitudinal position of uppermost trees. However, on the landscape scale, more subtle patterns of ecotone vegetation dynamics become distinguishable, i.e. particular slopes are being inhabited with trees, or particular species are forming new communities, etc. To reveal which factors control and form these patterns is one of the main tasks of modelling the vegetation dynamics for a given landscape.
Here is presented a case study of treeline ecotone dynamics in the Agashashok river valley, Western Brooks Range, USA. Using very high-resolution satellite imagery of 1952, 1979 and 2015 we compared the position and abundance of five main vegetation types of the valley: closed forest, open woodland, shrubs, tundra and unvegetated areas for these dates. We created a dataset of random points all over the territory and classified them into these classes according to each image in the time series. For better result, a circle of 3-meter radius around each point was considered in the classification.
Over the last 63 years, more than 30% of river valley landscape had changed. With the general trend of acceleration in trees and shrub occurrence after 1979, different spatio-temporal patterns of changes were observed before and after 1979.
Based on the point classification, in the most part of the valley there were two possible scenarios of tundra changes: turning to shrubs or to open woodland. We analyzed how different environmental variables (elevation, slope, aspect, geomorphology, solar radiation) influenced the process of turning tundra to shrubs or to open woodland. We used generalized linear models to model the shrub and trees occurrence depending on the elevation and two types of geomorphology, as they were the most significant variables. We compared the same variables in the models of two periods: 1952 -1979 and 1979-2015.
Morphometric variables have the potential to explain the tree versus shrub occurrences in former tundra after 1979. Summarizing our results, trees were more likely to appear in low elevations, steep and east-facing slopes, while new shrubs mostly occupied high elevations, less steep and more north-facing slopes.
The models developed in this study will be used for further mapping of future treeline position and vegetation structure.