A climate-based model to predict potential treeline position around the globe

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In situ temperature measurements revealed that the position of the high-elevation treeline is associated with a minimum seasonal mean air temperature within a temperature-defined minimum season length across latitudes. Here, we build upon this experience and present the results of a global statistical analysis and a predictive model for low temperature treeline positions. We identified 376 natural treelines from satellite images across the globe, and searched for their closest climatic proxies using a climate database. The analysis included a snow and a water balance submodel to account for season length constraints by snow pack and drought. We arrive at thermal treeline criteria almost identical to those that emerged from the earlier in situ measurements: tree growth requires a minimum length of the growing season of 94 days. The model yields best fit when the season is defined as all days with a daily mean temperature > 0.9 A degrees C, and a mean of 6.4 A degrees C across all these days. The resultant treeline model 'TREELIM' offers a robust estimation of potential treeline elevation based on climate data only. Error terms include imprecise treeline position in satellite images and climate approximations in mountainous terrain. The algorithm permits constraining low temperature limits of forest growth worldwide (including polar treelines) and also permits a bioclimatic stratification of mountain biota, for instance, for biodiversity assessments. As a side product, the model yields the global potentially forested area. The results support the isotherm theory for natural treeline formation. This completely independent statistical assessment of the climatic drivers of the global treeline phenomenon confirmed the results of a multi-year measurement campaign.
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