How robust are the Holocene treeline simulations? A model-data comparison in the European arctic treeline region

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Arctic treeline exists near the minimum temperature tolerances of the tree taxa and the position of Arctic treeline is sensitive to changes in climate, specifically growing season temperature. Arctic treeline enroachments and retractions can provide global-scale feedbacks to the climate and the treeline dynamics are therefore of great relevance to the 21st century climate modeling. To assess the accuracy of long-term treeline simulations based on the generalized dynamic vegetation model LPJ-GUESS, we simulate European arctic treeline dynamics over the past 9000 years and compare the results with proxy-based reconstructions. The results show that while the LPJ-GUESS is limited in its ability to simulate species-level modern treeline pattern and past dynamics it is in general able to realistically simulate the Holocene changes of the boreal coniferous forest with a cutoff carbon biomass of 2 C kg/m2. The simulation captures the northward expansion of the boreal forest during the mid Holocene and the treeline retreat in response to cooling during the last 3000 years. However, there are data-simulation mismatches particularly during the early Holocene, which mainly result from differences between the two palaeoclimate model scenarios used to in the treeline simulations. In addition, in the simulations there are unrealistically frequent short-lived switches between boreal forest and tundra in the treeline zone, indicating that the model needs to incorporate tree species life history characteristics, microclimate and other the potential ecological factors that increase the resilience of the treeline forests during short periods of climatic stress. The spatial accuracy of the model can also be improved by incorporating the influences of the non-climatic factors, such as the topographic features and the extent of the arctic peatlands.