# Past and possible future tree growth over circurmpolar forest ecosystems deduced from tree-ring width, delta-$^{13}$C and a DGVM

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Arctic and boreal ecosystems are exposed to rapid and strong increases in temperature and related environmental changes under Arctic amplification. Yet, there is uncertainty how trees in these ecosystems respond to the changes due to an insufficiency of such long term records and this is where tree-rings can provide an advantage. Early dendrochronological studies in the region focused on the positive growth of trees to warmth (D`Arrigo and Jacoby, 1993). However, A number of more recent studies have demonstrated a reduced sensitivity of tree growth to rising temperatures (now referred to as “ divergence problem ” ) at least since the 1960s (e.g.,Wilson et al., 2007). Although several studies (e.g., Barber et al., 2000) suggested that temperature-induced drought may limit tree growth under the limited availability of soil moisture, the underlying processes for the phenomenon are not well understood.

We here investigated past tree response to climate changes, especially to warming, using retrospective analyses from tree-ring width and carbon isotope ratios (delta-$^{13}$C) of three genera (*Larix*, *Picea* and *Pinus*) in 6 forest sites with a strong gradient of temperature and precipitation, reaching from northern Europe to northern America; Kalina (59N, 27E), Yakutsk (62N, 129E), Ust'Maya (60N, 133E), Chokurdakh (70N, 148E), Inuvik (68N, 133W) and Fort Smith (60N, 112W). The results suggest that tree response to past climate changes have varied with regions. The tree responses to warming are negative in eastern Siberia forests, resulting in decreasing trend of tree growth over past 60 years. On the other hand, the negative effect of warming is not seen in European and Canadian forests, where no decrease trend of growth is observed. The results then have been used in testing a dynamic global vegetation model (SEIB-DGVM, Sato et al., 2007). The simulated annual net primary productions (NPP) show no decreasing trend over the study period and discrepancy from tree-ring based long-term (more than half-decadal) growth variations in eastern Siberian forests, although relatively better reproductions of the model for the variations are obtained in European and Canadian forests.

The observed discrepancy in eastern Siberian forest may become more severe for future projection. We developed a climate-driven statistical growth equation that uses regional climate variables to model tree-ring width values for each site and then applied these growth models to predict how tree growth will respond to twenty-first-century climate change (RCP8.5 scenario). Although caution should be taken when extrapolating past relationships with climate into the future, we observed future continues reduction of the growth in central part of eastern Siberia, which is opposite trend from the DGVM based estimate. Our results imply that the negative effect of warming override the expected positive effects i.e., warming-induced lengthened growing season and increase in photosynthetic ratio, in arid region such as eastern Siberia, suggesting further reduction of tree growth by future warming, and no reproduction of the negative effect in the DGVM seems to be a cause for the observed discrepancy between tree-ring and DGVM estimates. The negative effect of warming for tree growth is a key process for accurate future projection of ecosystem functions and therefore further field and modeling investigations are essential to deep understanding of the underlying processes for the phenomenon.

**References**

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