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Climatic and Physiological Controls for White Spruce across the North American Boreal Forests inferred from tree-ring stable isotopes

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High northern latitude regions are experiencing some of the most rapid environmental changes. Carbon sequestration might be enhanced by increased forest productivity due to warming temperatures and potentially higher atmospheric CO_2, but declines in tree growth and mortality due to drought stress could counteract this enhancement by releasing CO_2 to the atmosphere. Observed changes in boreal forest dynamics are already altering the global carbon and hydrological cycles, albedo and land surface feedbacks. Here, we combined ring-width data with annually resolved stable carbon (δ^{13}C) and oxygen isotope (δ^{18}O) records to investigate the physiological responses of white spruce (*Picea glauca* [Moench] Voss) trees to warming and increased atmospheric CO_2 concentrations at northern treeline sites. We developed an extensive network of δ^{13}C and δ^{18}O tree-ring chronologies covering the 20^{th} century derived from 10 sites across North America (NA) spanning from 60.5º to 68.7ºN and 104º to 162ºW. We used a range of observational data and a climate model to interpret signals in these annually-resolved tree-ring series. At most sites, the inter-tree correlations were higher for δ^{18}O than δ^{13}C series. Both δ^{13}C and δ^{18}O were highly influenced by temperature variations, although the dominant season was different: summer and spring, respectively. This suggests that different processes associated with temperature variations may be operating. Physiological processes occurring at leaf level during summer mainly influenced δ^{13}C. Spring climate had the strongest influence on tree-ring δ^{18}O via temperature effects on the δ^{18}O of source water, and to a lesser degree, in summer, physiological process at leaf level may also occur. Accordingly, we found weak relationships between the tree-ring δ^{18}O and atmospheric circulation (such as integrated moisture transport) during summer using the GISS ModelE2 isotopically-equipped general circulation model. Calibration and simulations of tree-ring data in the process-based mechanistic model MAIDENiso will help us to elucidate the complex linkages between increases in temperature and CO_2 driven tree responses. This tree-ring isotope network provides a unique opportunity to disentangle the climatic and physiological controls driving growth patterns at the northern treeline.