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Effects of winter chilling vs. spring forcing on the spring phenology of trees in a cold region and a warmer reference region

Yue Yang[1,2], Mai-He Li[2], Zhengfang Wu[1], Hong S. He[1,3], Haibo Du[1], and Shengwei Zong[1]
[1]Key Laboratory of Geographical Processes and Ecological Security in Changbai Mountains, Ministry of Education, School of Geographical Sciences, Northeast Normal University, Changchun, China
[2]Forest Dynamic, Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Switzerland
[3]School of Natural Resources, University of Missouri, Columbia, MO, USA

Regions at high latitudes and high altitudes are undergoing a more pronounced winter warming than spring warming, and such asymmetric warming will affect chilling and forcing processes and thus the spring phenology of plants. We analyzed winter chilling and spring forcing accumulation in relation to the spring phenology of three tree species (Ulmus pumila, Populus simonii, and Syringa oblata) growing in a cold region (CR) compared with trees in a warmer reference region (WR, using the Dynamic Model and the Growing Degree Hour (GDH) model. We tested that forcing rather than chilling affects the spring phenology of trees in CR (hypothesis I), and that trees in CR have both lower chilling and lower forcing temperatures and thus longer accumulation periods than trees in WR (hypothesis II). In line with our hypotheses, forcing played a crucial role in spring phenology in CR, but chilling and forcing combined to determine spring phenology in WR. The temperatures during the chilling and forcing periods were lower and the accumulation period started earlier and ended later in CR than in WR. Moreover, the chilling accumulation was broken into two periods by the low deep winter temperature in CR. We conclude that asymmetric warming, with a stronger temperature increase in winter than in spring, could decrease the forcing accumulation effects and increase the chilling effects on the spring phenology of plants in CR. This change in the balance between chilling and forcing will lead to a shift in plant phenology, which will further have major impacts on biogeochemical cycles and on ecosystem functioning and services.