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Development of a new phenological model based on the carbon balance of tree in boreal conifers

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Traditional phenological models use the concepts of chilling and thermal forcing (temperature sum or degree-days) to predict buds break. Even if new model formulations get more sophisticated with time, the bases of phenological model still rely on the effect of the time of chilling and forcing temperature in interaction, or not, with photoperiod. Because of the increasing impact of climate or other related biotic or abiotic stressors, a model with more biological support is urgently needed in order to accurately predict bud break. We have developed and calibrated a new mechanistic model that is based on the physiological processes taking place before and during budbreak in several conifers species. This model describes the phenology and growth dynamics of a conifer branch as representative of the whole tree. As a general assumption, we assume that phenology will be driven by the carbon status, which is closely related to the annual cycle of dormancy – activity state through the year and to the environmental variables. The carbon balance of a branch was thus modelled i) from autumn to winter–when aboveground parts exhibit cold acclimation and dormancy– and ii) from winter to spring and summer –when deacclimation and growth resumption occurs. After being calibrated in a field experiment, the model was tested across a large area in Québec (Canada), based on observed phenological data. For the 20 field sites in Quebec, the model proved to be accurate in predicting the date of budbreak with an average error of ±3.8 days (R2=0.72). This model also allowed us to better understand the effects of winter and spring temperature on bud burst, offering new simulation perspectives under global warming and insect defoliation.