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Sequential chilling-forcing models predict budburst phenology best in deciduous trees: results from a climate warming experiment

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Modeling budburst phenology is important for assessing the impact of climate change on ecosystem processes. Based on historical datasets, the simple growing degree days models were thought to successfully reproduce budburst date. However, many tree species require a certain amount of winter chilling and the future warming may result in insufficient chilling. Therefore, modeling future phenology shifts needs evaluation of the budburst process based on warming experiments. In this study, we conducted a 2-year warming experiment, with different warming levels. The main aims of this study were to assess the budburst response to winter and spring warming and to estimate the accuracy of five budburst models. One-meter-high saplings of three deciduous tree species were used, i.e. birch (Betula pendula L.), oak (Quercus robur L.) and beech (Fagus sylvatica L.). The results showed that the manipulated warming results in a wide range of budburst dates across the three studied species. Both warming winter and spring substantially advanced the timing of budburst. Model evaluation shows that both one-(without chilling) and two-(with chilling) phase models are able to accurately predict the observation date. The best performing model differed among the three species. The growing degree days model performed best for oak and birch. The model with sequential chilling and forcing yielded similar good results for these two species, but was by far the best model for beech. Therefore, a model with a sequential budburst pattern may be more appropriate to simulate budburst data in a future warmer climate in which chilling progressively becomes more limiting.