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How well do budburst models perform in Germany, Austria, UK and Finland?

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The phenology of trees affects the productivity of forests making phenological representation an important component of ecosystem models. The response to cues in temperature and day length varies among provenances, with the differences among provenances not fully understood.

We evaluated the accuracy of eleven budburst models for birch and Norway spruce in Germany, United Kingdom (UK), Austria and Finland; covering gradients in latitude, altitude and continentality. The models were not able to accurately predict the timing of budburst, especially in the Alps. Early budburst were in general predicted too early and late budburst predicted too late, hence were budburst predicted too early in UK and too late in Austria. Models to be used in climate change assessments should be able to capture extreme events since budburst that today are considered very early could become the norm in a warmer climate. Our results imply that the models accuracy varied with spring temperatures and along geographical gradients.

Model complexity was in this study assumed to represent the models level of plant physiological realism. All phenological models contain empirical components, and the model performance is therefore to some degree dependent on the calibration data, and cannot be considered truly process-based. The more complex models were in general less able to capture the variation in budburst and their performance was more dependent on the calibration data. Four different calibration schemes were employed; models predicted budburst of birch more accurately when fitted with one site in Germany, while the models performed better for Norway spruce when fitted with multiple sites in Germany.

Among the two best performing models were an empirical model based on spring temperatures and the Alternating model based on growing degree days with a dynamic forcing requirement. However, both models could be considered unsuitable for climate change impact assessments. The empirical model is for example unable to capture changes in phenology due to insufficient chilling that potentially could delay budburst. The underlying theory of the Alternating model is not fully supported by our understanding of provenance differences as different provenances growing under the same conditions flush at different times.