Phenological modelling: Can spatial data substitute temporal data?

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Not only long-term information, but also urbanisation gradients may be supportive to assess phenological responses to global warming. A substitution of phenological data collected over a longer period with data collected over a spatial gradient might be appropriate if plant phenology responds to climate change over time similarly as climate variability over space. However, the inherent methodological, spatial and temporal peculiarities of different data sources could hinder generalisations.

We investigated whether phenological responses of birch (Betula pendula Roth) assessed by temperature variations are comparable over time and space and whether spatially calibrated models can predict long-term phenological data adequately. Therefore, we used flowering data sampled along urbanisation gradients in Germany in 2010 and 2011 and long-term data (1991–2010) in Bavaria. These data was explored using linear regression models based on mean temperature as well as process-based models (DORMPHOT model) incorporating forcing and chilling temperatures and photoperiod.

A time-for-space substitution might not always be suitable since models calibrated on spatial data were only found to be useful to predict spatial data, but not to predict long-term data. This finding was also confirmed by a comparison of temperature response rates. The temperature response derived from spatial data (-4.4 days/°C) was significantly higher than the response calculated from the long-term data (-1.9 days/°C). Furthermore, the predictive performance of the linear model was comparable to that of the DORMPHOT model. A possible explanation might be that the process-based DORMPHOT model also includes the description of the responses of trees to chilling and photoperiod and to their interaction, but there is not enough information in only two study years to adequately model this response.

Consequently, models calibrated on spatial data cannot necessarily reflect changes that occur in phenological responses over years. It is important not to generalize results derived from one specific study method.