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Suitability of temperature sum models to simulate the flowering period of birches on regional scale as basis for realistic predictions of the allergenic potential of atmospheric pollen loads

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Persons susceptible to allergenic pollen grains need to apply suppressive pharmacy before the occurrence of the first allergy symptoms. Patient targeted medication could be improved if forecasts of the allergenic potential of pollen (biochemical composition of the pollen grain) and the onset, duration, and end of the pollen season are precise on regional scale. In plant tissue the biochemical composition may change within hours due to the resource availability for plant growth and plant internal nutrient re-mobilization. As these processes highly depend on both, the environmental conditions and the development stage of a plant, precise simulations of the onset and duration of the flowering period are crucial to determine the allergenic potential of tissues and pollen. Here, dynamic plant models that consider the dependence of the chemical composition of tissue on the development stage of the plant embedded in process-based ecosystem models seem promising tools; however, today dynamic plant growth is widely ignored in simulations of atmospheric pollen loads.

In this study we raise the question whether frequently applied temperature sum models (TSM) could precisely simulate the plant development stages in case of birches on regional scale. These TSM integrate average temperatures above a base temperature below which no further plant development is assumed. In this study, we therefore tested the ability of TSM to simulate the flowering period of birches on more than 100 sites in Bavaria, Germany over a period of three years (2010-2012). Our simulations indicate that the often applied base temperatures between 2.3°C and 3.5°C for the integration of daily or hourly average temperatures, respectively, in Europe are too high to adequately simulate the onset of birch flowering in Bavaria where a base temperature of 1°C seems more convenient. A more regional calibration of the models to sub-regions in Bavaria with comparable climatic conditions could further improve the simulation results if compared to simulations using a model that was adjusted to only one representative location in Bavaria.

Our simulation results suggest that birch phenology needs to be modelled on a more regional scale to derive precise predictions of the flowering period. Some weak simulation results are suspected to be due to the high genetic diversity of birches and their high adaptive potential to a wide range of environmental conditions which indeed is a characteristic for many pioneer species. The high adaptive potential could be an explanation why authors who calibrate their models to other climatic regions observe better simulation results using higher base temperatures. However, our simulations indicate that the simulation results may be biased if the base temperatures are assumed constant for one species and transferred to larger or smaller scales, to other regions with different climatic conditions, or when applied to extrapolate birch pollen seasons to future climate conditions.