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Dormancy modeling for warming orchards

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The annual cycle of deciduous trees that evolved in cold-winter climates includes a period of winter dormancy. During this phase the trees drop their leaves and suspend most of their metabolic functions. This reduces their vulnerability to frost and allows them to resume growth in the following spring. To release dormancy, trees require a certain exposure to cool conditions, known as chill, followed by exposure to heat. Recent evidence suggests that additional heat can compensate for chill shortfalls to some extent, but only after a critical chill threshold has been reached. Temperature regimes that do not match the trees' requirements can lead to irregular flowering, low yields and poor fruit quality. These risks make tree dormancy a crucial point of interest for growers of deciduous fruit and nut trees, particularly in the context of climate change. Projections of future chill levels indicate severe chill losses in many important growing regions, which raises concerns about the future viability of cultivation in many places.

Due to the critical importance of matching the trees' chill and heat needs to local climate, horticultural researchers have been modeling these phenomena since at least the 1940s. The Chilling Hours Model, the Utah Model and the Dynamic Model are the most widely known frameworks that have emerged from this work. However, recent research has highlighted severe shortcomings in these chill models, especially in warm growing regions. It is striking that even the most recent of the three major models dates back to the 1980s and thus fails to include decades of scientific progress in plant dormancy research.

Our team at the University of Bonn aims to develop a new modeling framework for tree dormancy, one that can provide growers with robust projections on climate change impacts on fruit and nut orchards and best-practice recommendations for potential adjustments to the portfolios of cultivated species and varieties. To this end, we have begun summarizing the state of the art of scientific knowledge on tree dormancy and collecting high-quality datasets that are available for a number of species. Based on these efforts we will (i) review existing models in light of new knowledge and data, (ii) identify knowledge gaps with a focus on the biochemical and morphological processes driving dormancy dynamics, (iii) develop experimental approaches to narrow these gaps and (iv) synthesize the results into a process-based dormancy modeling framework. Through this work we hope to improve fruit and nut growers' resilience to climate change and prepare deciduous fruit and nut orchards for the challenges of warming winters.