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Spring frost risk for regional apple production under a warmer climate

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Spring frosts, as experienced in Europe in April 2016 and 2017, pose a considerable risk to agricultural production, with the potential to cause significant damages to agricultural yields. Meteorological blocking events (stable high-pressure systems) have been shown to be one of the factors that trigger cold spells in spring. While current knowledge does not allow for drawing conclusions as to any change in future frequency and duration of blocking episodes due to climate change, the combination of their stable occurrence with the biological system under a warming trend can lead to economic damage increases. To evaluate future frost risk for apple producers in south-eastern Styria, we combine a phenological sequential model with highly resolved climate projections for Austria. Our model projects a mean advance of blooming of -1.6 ± 0.9 days per decade, shifting the bloom onset towards early April by the end of the 21st century. Our findings indicate that overall frost risk for apple cultures will remain in a warmer climate and potentially even increase due to a stronger connection between blocking and cold spells in early spring that can be identified from observational data. To prospectively deal with frost risk, measures are needed that either stabilize crop yields or ensure farmers' income by other means. We identify appropriate adaptation measures and relate their costs to the potential frost risk increase. Even if applied successfully, the costs of these measures in combination with future residual damages represent additional climate change related costs.