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A plant's perspective of extremes: Plant and ecosystem responses to changing climatic variability

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We review observational, experimental, and model results on how plants respond to extreme climatic conditions induced by changing climatic variability. Distinguishing between impacts of changing mean climatic conditions and changing climatic variability on terrestrial ecosystems is generally underrated in current studies. The goals of our review are thus (1) to identify plant processes that are vulnerable to changes in the variability of climatic variables rather than to changes in their mean, and (2) to depict/evaluate available study designs to quantify responses of plants to changing climatic variability. We find that phenology is largely affected by changing mean climate but also that impacts of climatic variability are much less studied, although potentially damaging. We note that plant water relations seem to be very vulnerable to extremes driven by changes in temperature and precipitation and that heatwaves and flooding have stronger impacts on physiological processes than changing mean climate. Moreover, interacting phenological and physiological processes are likely to further complicate plant responses to changing climatic variability. Phenological and physiological processes and their interactions culminate in even more sophisticated responses to changing mean climate and climatic variability at the species and community level. Generally, observational studies are well suited to study plant responses to changing mean climate, but less suitable to gain a mechanistic understanding of plant responses to climatic variability. Experiments seem best suited to simulate extreme events. In models, temporal resolution and model structure are crucial to capture plant responses to changing climatic variability. We highlight that a combination of experimental, observational, and/or modeling studies have the potential to overcome important caveats of the respective individual approaches.

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