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Modeling the vegetation response to the 8.2 ka BP cooling event in Europe and Northern Africa

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The 8.2 ka BP cooling event is assumed to be the most clearly marked abrupt climate event in the Holocene at the northern mid-to-high latitudes. In this study, we use the 8.5 ka BP and 8.2 ka BP climates simulated by the iLOVECLIM(1) climate model to drive a vegetation model (LPJ-GUESS(2)) and investigate the vegetation responses to the 8.2 ka BP climate change over Europe and Northern Africa. iLOVECLIM simulates a 1.0 to 1.5 Celsius cooling during 200 years in Europe, and a reduction in precipitation, especially in Northern Africa, where precipitation declines by more than 40% in summer and autumn. Our LPJ-GUESS results show that all plant functional types (PFTs) over Europe and North Africa respond to these climate changes, but the magnitude and timing of their responses are different. Temperate broad-leaved summergreen trees (TempBS) decreases at the beginning of the event, but Temperate broad-leaved evergreen trees (TempBE) decreases with a lag of about 50 years relative to TempBS in western Europe. Similarly, Boreal needle-leaved evergreen trees (BoNE) lags behind TempBS by about 30 years in northern Europe. The responses of BoNE and TempBS in Northern Europe are primarily driven by temperature, while both changes in temperature and precipitation drive TempBS's decrease over Western and Eastern Europe (WE and EE). Further analysis suggests that TempBS is very close to its precipitation threshold at 8.5 ka BP. In addition, changes in precipitation contribute more to TempBE responses than temperature in Southern Europe (SE). In contrast, temperature is the main driver of tropical trees in SE and it is very close to the lower-bound of their requirements. In North Africa, however, the role of cooler temperature affects TempBE's growth positively due to lower evaporation. Compared with pollen-based vegetation reconstructions, our simulation generally captures the main features of vegetation responses to the 8.2 ka BP event, although the dominant PFT is often not consistent with dominant pollen species. Interestingly, in WE, the simulated vegetation after perturbation is different from its initial state, which is consistent with two high resolution pollen records. This alternative vegetation state indicates the persistent impact of abrupt climate change on vegetation through eco-physiological processes, like plant competition. This persistent impact suggests a possible bias in pollen-based climate reconstructions that assume that vegetation is in equilibrium with climate. Moreover, our simulations suggest a latitudinal gradient in the magnitude of the event, with more pronounced vegetation responses to the severe cooling in the north and weaker responses to less cooling in the south. This effect is not seen in pollen records, possibly because the climate-related signal is masked by local factors to some extent.

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