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The effect of a dynamic soil scheme on the climate of the mid-Holocene and the Last Glacial Maximum

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In order to account for coupled climate-soil processes, we have developed a soil scheme, which is asynchronously coupled to a comprehensive climate model with dynamic vegetation. This scheme considers vegetation as the primary control of changes in physical soil characteristics. We test the scheme for a warmer (mid-Holocene) and colder (Last Glacial Maximum) climate relative to the preindustrial climate. We find that the computed changes of physical soil characteristics lead to significant amplification of global climate anomalies, representing a positive feedback. The inclusion of the soil feedback yields an extra surface warming of 0.24°C for the mid-Holocene and an additional global cooling of 1.07°C for the Last Glacial Maximum. Transition zones such as desert/savannah and taiga/tundra exhibit a pronounced response in the model version with dynamic soil properties. Energy balance model analyses reveal that our soil scheme amplifies the temperature anomalies in the mid-to-high northern latitudes via changes in the planetary albedo and the effective longwave emissivity. As a result of the modified soil treatment and the positive feedback on climate, part of the underestimated mid-Holocene temperature response to orbital forcing can be reconciled in the model.