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Simulating tillage practices at the global scale with the detailed process model LPJmL

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The impact of human land use on global biogeochemistry and greenhouse gas (GHG) emissions is typically modeled with terrestrial ecosystem models that are increasingly capable of accounting for different land use types. However, various management aspects that allow for substantial modifications of the impacts of land use on biogeochemical cycles and GHG emissions are typically not explicitly represented in these models. Agriculture and food systems are responsible for approximately 30% of the global GHG emissions. Soil management, such as tillage practices, can alter these emissions. Depending on tillage type and intensity (for example the amount of residues that are incorporated) it causes various effects on soil physical and chemical properties, including hydraulic properties and soil organic carbon stocks. Ecosystem models with sufficient process representation can be used to assess such alterations on agricultural greenhouse gas emissions. At the global scale however, applications are often constrained because tillage is not considered explicitly.
We present a new process-based approach that allows tillage practices to be simulated in the global dynamic vegetation, hydrology and crop growth model LPJmL (version 5). This approach includes the effects of tillage on soil physical properties, in particular on soil hydraulic properties, which have a pronounced effect on different processes, including mineralization of soil organic matter and the soil water available to plants. The application of the approach shows large impacts of tillage on the water cycle and soil carbon- and nitrogen dynamics. The results further highlight that tillage effects are highly dependent on other factors such as climate or soil type, which is consistent with literature on field trials. We discuss major feedback mechanisms and spatial patterns of tillage effects dissecting mechanisms in a set of modeling experiments.