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# Model requirements for estimating and reporting soil C stock changes in national greenhouse gas inventories

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Globally, soils are the largest terrestrial store of carbon (C) and small changes may contribute significantly to the global C balance. Due to the potential implications for climate change, accurate and consistent estimates of C fluxes at the large-scale are important as recognized, for example, in international agreements such as the United Nations Framework Convention on Climate Change (UNFCCC). Under the UNFCCC and also under the Kyoto Protocol it is required to report C balances annually. Most measurement-based soil inventories are currently not able to detect annual changes in soil C stocks consistently across space and representative at national scales. The use of models to obtain relevant estimates is considered an appropriate alternative under the UNFCCC and the Kyoto Protocol.
Several soil carbon models have been developed but few models are suitable for a consistent application across larger-scales. Consistency is often limited by the lack of input data for models, which can result in biased estimates and, thus, the reporting criteria of accuracy (i.e. emission and removal estimates are systematically neither over nor under true emissions or removals) may be met. Based on a qualitative assessment of the ability to meet criteria established for GHG reporting under the UNFCCC including accuracy, consistency, comparability, completeness, and transparency, we identified the suitability of commonly used simulation models for estimating annual C stock changes in mineral soil in European forests. Among six discussed simulation models we found a clear trend toward models for providing quantitative precise site-specific estimates which may lead to biased estimates across space. To meet reporting needs for national GHG inventories, we conclude that there is a need for models producing qualitative realistic results in a transparent and comparable manner. Based on the application of one model along a gradient from Boreal forests in Finland to Mediterranean forests in Spain, we present the challenges for meeting the reporting criteria with a modeling approach.