

Estimating carbon stock and greenhouse gas emissions from forest soils in the permafrost regions of northeastern Siberia

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Forest soils store a large amount of organic matters, which can be a significant source of greenhouse gases when decomposition is accelerated by increasing temperatures. Understanding carbon release from the soils is particularly critical in high latitude forests where more organic carbon would be available for microbial decomposition when soil temperature rises and permafrost thaws. The goal of this study is to estimate the amount of soil carbon and to predict carbon emissions under future climate change in the permafrost regions of northeastern Siberia. We use a model simulation and field observations to project carbon dynamics in the forest soils in this region. We are developing a soil carbon dynamic simulation model by incorporating soil physical and biological processes such as soil temperature, moisture, decomposition by microbes, and vertical movements of organic materials. Organic litter inputs that are computed daily from an existing vegetation model are divided into three parts with different decomposability and allocated vertically at 10 cm intervals. Decomposition rates for the three organic parts are computed as a function of soil temperature and moisture content of each soil layer. Remaining soil organic materials are subsequently relocated vertically through cryoturbation, which is the movement of organic materials in the soil layers caused by freeze-thaw actions. Simulation was conducted using 150-years of historical climate records and 95-years of future climate under RCP8.5 scenarios. Simulations were conducted in the Spasskaya-Pad Scientific Forest Station in Yakutsk, Russia, where time series observed data are available. Results show that slowly decomposable materials tend to accumulate and move downward into deeper soil layers, while small amounts of easily and intermediately decomposable parts stay on shallower layers. Around 12 kgC/m² of soil organic matter was estimated to be stored at that site, which was within the range of observed soil carbon stock in eastern Siberia regions obtained from observation-based global soil databases. Regional-scale distribution patterns of carbon stock were compared between the simulation results and global databases of soil properties.

Keywords: climate change, decomposition, soil organic matter