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Estimates of northern Eurasian permafrost degradation and induced changes in soil carbon storage and methane emissions in the 21st century

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The carbon storage in frozen soils of the Northern Hemisphere (equals to about 1670 Gt) is by more than two times greater than its current content in the atmosphere. An increase of the permafrost active layer depth and subsequent microbial degradation of the thawed organic carbon stocks cause the growth of greenhouse gas emissions from soil to the atmosphere and therefore, can establish the positive feedback under projected climate change. In this study, based on the results of calculation of the permafrost soil thermal state forced by atmospheric parameters from the ensemble of CMIP5 project models and the content and the vertical distribution of soil carbon data NCSCDv2 (The Northern Circumpolar Soil Carbon database, version 2) estimated the carbon stocks, which may be included in the global biogeochemical cycle by the end of the 21st century.
The largest estimated increase in the thaw layer thickness is more than 7-8 m (including the depth of seasonal thaw and taliks) to the 2090-2099 period from the beginning of the 21st century under the RCP 8.5 scenario. It takes place on the southern boundary of the permafrost zone, Western Siberia and the Baikal region. In Chukotka, the thickness of active layer increases by 5-6 m. Increase of the active layer thickness leads to the permafrost thaw and degradation of soil organic matter. Increasing the carbon pool in the thawed layer is the most pronounced in the northern part of the permafrost zone, and much suppressed in the southern part due to the exponential form of the vertical distribution of carbon in the soil with the highest values in the upper soil layers. In the permafrost regions, the increase of the active layer thickness, soil temperature, and the length of the warm period leads to significant increase in methane emissions from soil to the atmosphere. Under the most aggressive scenarios of anthropogenic forcing RCP 8.5, these methane emissions here increase more than three-fold in the 21st century. The largest increase in emissions (up to 10 mgCH4 / m2 / year) is obtained for the northern regions of Western Siberia.