Characteristics of permafrost, total organic carbon and nitrogen distribution in Northern Eurasia

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Annual-mean surface air temperature is expected to increase by 3–5 °C in Siberian region to the end of the 21st century [1]. The largest increase of precipitation rate is expected in winter for all river basins especially over northeastern part of Eurasia. It can result in changes in the thermal and hydrological conditions of permafrost [2]. Thawing of permafrost soils and increase of active layer thickness can intensify a decay of the organic matter and lead to an increase of greenhouse gases emission from soil to the atmosphere [3].

Main characteristics of permafrost are obtained using numerical scheme of heat and moisture transfer in the atmosphere-underlying surface-soil accounting for dynamics of frozen and thaw layers boundaries with water phase changes [2, 4]. External atmospheric forcing for this scheme is given for the period of 2006-2100 according to the RCP 2.6 and RCP 8.5 (Representative Concentration Pathways) anthropogenic scenarios using the global climate model IPSL-CM5A-LR from the CMIP5 (Coupled Model Intercomparison Project, phase 5) Multi-Model Database.

Assessment of seasonal active layer thickness and talik's depth (talik is part of thawed ground in the permafrost area) was performed. Annual thaw layer thickness was defined as the maximum of the seasonal thaw depth (if subsurface permafrost remains at the end of the 21st century) or the talik depth (if subsurface permafrost degrades at the end of the 21st century). The simulation results show a general increase of the annual thaw layer thickness to the end of the 21st century for the two selected scenarios. Zonal distribution analysis shows a maximum increase of the simulated thaw layer thickness at 57-61N for the RCP 2.6 scenario and at 63-67N for the RCP 8.5 for the period 2091-2100 relative to 2006-2015 (Fig. 1).

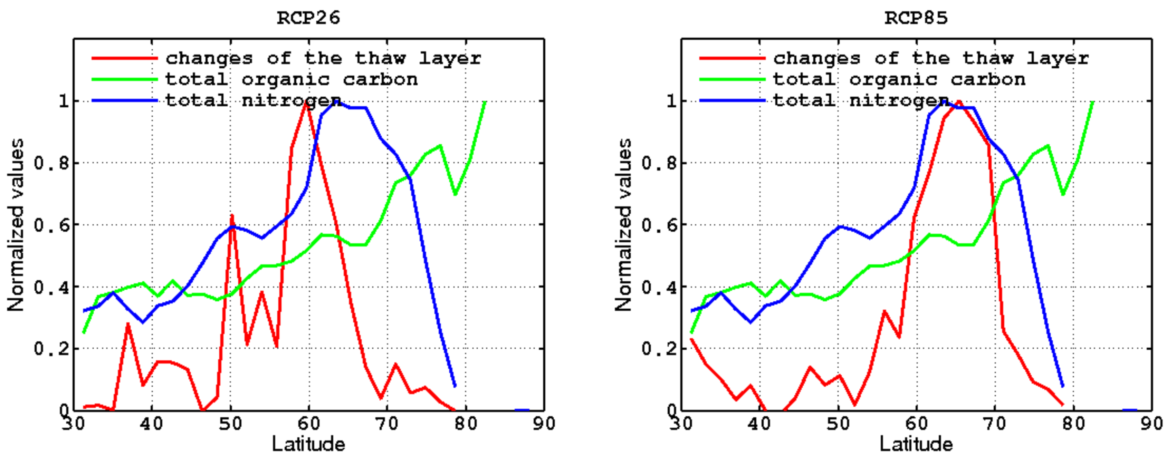

Fig. 1. Normalized changes of the simulated thaw layer thickness for the RCP 2.6 and RCP 8.5 scenarios for the period 2091-2100 relative to 2006-2015 (red line), total organic carbon distribution (green line), total nitrogen distribution (blue line) for Northern Eurasia.

In the late 21st century the simulated thaw layer thickness exceeds locally 4-6 m in the west Siberia under RCP 2.6 scenario. In the Baikal region, the thaw layer thickness exceeds 4 m. This occurs due to the formation of taliks. Subsurface permafrost turns to a relic form in the regions near contemporary permafrost southern boundary in the Northern Eurasia. In the northern regions of central and eastern Siberia increased thawing depth does not exceed 0.4-0.6 m by the end of the 21st century. For the most aggressive anthropogenic scenario RCP 8.5, simulated near-surface permafrost degradation is located in the West and parts of Eastern Siberia. For the most aggressive scenario of anthropogenic forcing, the spatial structure of the changes of the thaw layer thickness is similar, but absolute values increase. In the late 21st century, near-surface permafrost is expected to remain in high latitudes of Central and Eastern Siberia under the both RCP 2.6 and RCP 8.5 scenarios.

An analysis of the zonal distribution of the total organic carbon (TOC) and nitrogen (TN) in the permafrost of the Northern Eurasia was carried out. The soil carbon and nitrogen stocks distribution are taken from ORNL DAAC data set (http://daac.ornl.gov/SOILS/guides/zinke_soil.html). Latitudinal distribution of total nitrogen in the Northern Eurasia is characterized by a maximum at 61-70N (Fig. 1). Maximum of the total organic carbon is in high latitudes of Northern Eurasia. Using the results of modeling the changes of the thaw layer thickness and the data on the TOC and TN distribution, estimates of the organic substance which can be included in the biogeochemical cycle by the subsurface permafrost degradation at the end of the 21st century were made. Total organic carbon changes under the process of permafrost degradation in the Northern Eurasia are estimated to be 15 GtC to the end of the 21st century while the total nitrogen increase can amount to 5 GtN for the RCP 2.6 scenario. Under the RCP 8.5 scenario these estimates are 43GtC and 18GtN respectively. Increase of the global TOC under the RCP 8.5 scenario is estimated to be about 33-114GtC to the end of the 21st century [5].

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