Estimates of changes in soil thermal regime and methane emissions in the northern regions of Western Siberia in the 21st century

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According to observational data, climate warming in the western sector of the Russian Arctic since 1970 is characterized by an increase in the surface temperature of the atmosphere and the duration of the warm period, a change in the amount of precipitation, and an increase in the thickness of the snow cover. Due to regional climatic changes over the last 40-50 years, the temperature of permafrost in the northern regions of Western Siberia has increased with the growth of the seasonally thawed layer thickness [Streletskiy et al., 2015; Biskaborn et al., 2019].

Estimates of possible changes in the thermal state of the cryolithozone, obtained using equilibrium and dynamic ground heat transfer models, which differ in the degree of detail of the processes described, also show that in the next 50-100 years, the dynamics of the permafrost temperature increase may persist, leading to a reduction in the permafrost spread area due to partial or complete permafrost degradation in some regions [Nicolsky et al., 2018].

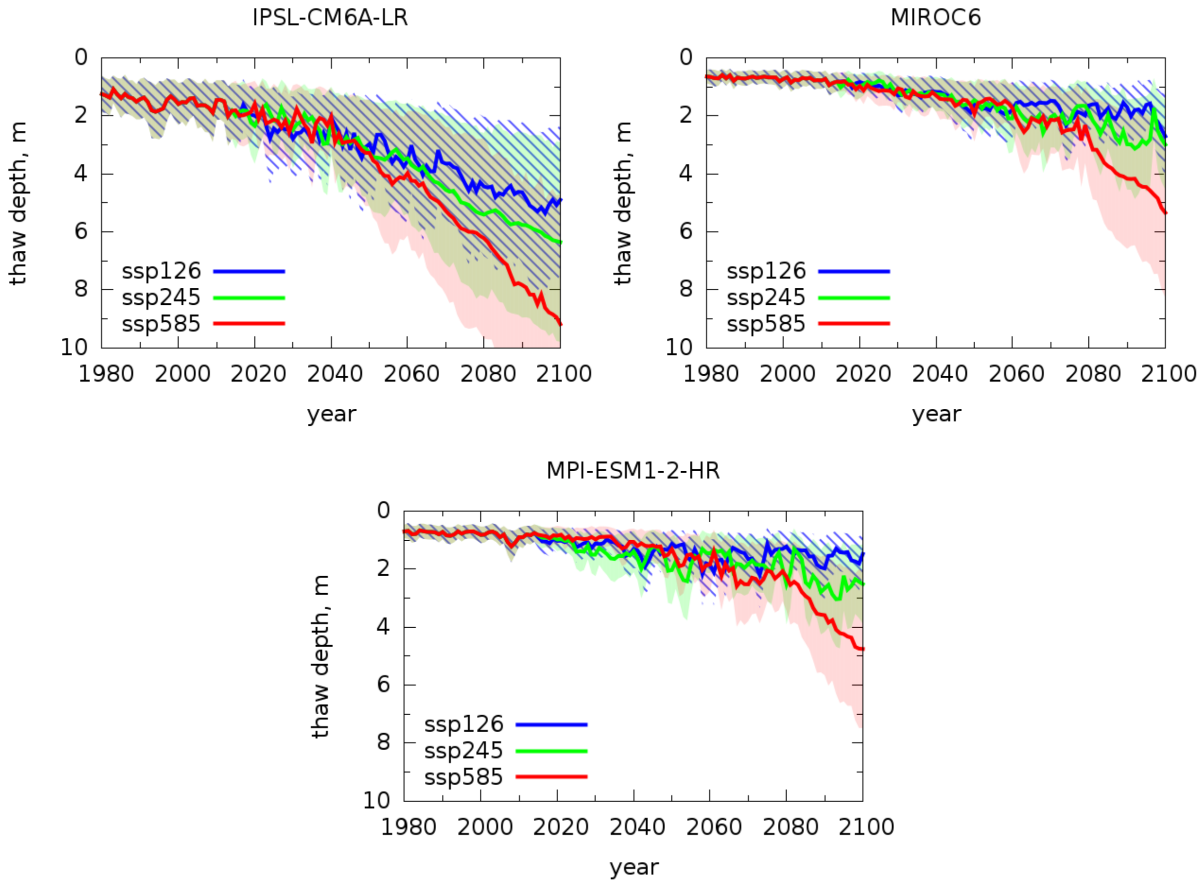

Figure 1. Model estimates of interannual changes in maximum seasonal thaw depth (m) in Western Siberia.

Using a one-dimensional model of heat transfer in soils, developed for the IAP RAS climate model, the depth of seasonal thawing in northern Siberia was calculated (Fig. 1). As input data (temperature, precipitation) the results of calculations with global climate models of the CMIP6 project (IPSL-CM6A-LR, MIROC6, MPI-ESM1-2-HR) under three scenarios of anthropogenic forcing (ssp1-26, ssp2-45, ssp5-85) were used. The results obtained show that in the coming decades, the continuing growth of the near-surface temperature will lead to an increase in the maximum depth of seasonal thawing in the northern regions of Siberia.

Methane emissions from wetlands were estimated using the IAP RAS methane cycle model. Contemporary annual emissions from Western Siberia equal to 3.8 TgCH4 with more than 2 TgCH4 emitted in the second half of warm period (i.e., August-September) when the thaw depth is largest and the soil temperature is highest. As the surface temperature increases and the warm period lengthens, demonstrating most pronounced effects in the high latitudes of the northern hemisphere, methane emissions increase rapidly. According to estimates, in the northern regions of Western Siberia, under the most unfavorable scenarios in the 21st century, their growth may reach up to 600-700%. It is also worth considering possible variations in emission due to changes in the soil moisture regime.

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