Estimates of methane emissions from wet ecosystems of Western Siberia in the mid-Holocene and in the 21st century

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Observational data indicate a decrease in the area of wet ecosystems in Western Siberia due to the global warming, leading to thawing of permafrost and increased drainage [1]. Permafrost degradation also leads to the inclusion of thawed soil organic carbon into the global biogeochemical cycle. Changes in soil hydrology as well as soil temperature affect methane emissions from wet ecosystems. According to [2], global warming in 2000-2009 exceeded the Holocene optimum level. Regional changes in air temperature at high latitudes could be more significant. To estimate the methane emission from the wet ecosystems of Western Siberia, the main characteristics of the thermal regime of the soil for the mid-Holocene (around 6ka), the beginning (2000-2019) and the end (2080-2099) of the 21st century were calculated using a one-dimensional numerical scheme of heat transfer in the soil [3]. The scheme was forced by monthly air temperature and precipitation based on the global climate model ACCESS-ESM1-5 of the CMIP6 project (https: //esgf-node.llnl.gov/search/cmip6/) under scenarios midHolocene, historical and SSP5-8.5.

Fig. 1 shows the values of the average annual air temperature and the fraction of wet ecosystems in Western Siberia for the mid-Holocene, the beginning and end of the 21st century according to the ACCESS-ESM1-5 model. The regional air temperature at the beginning of the 21st century exceeds the mid-Holocene values. By the end of the 21st century, the air temperature is increasing, the negative average annual temperature persists only in the north of the region. A consistent decrease in the area of wet ecosystems has been revealed (fig. 1b).

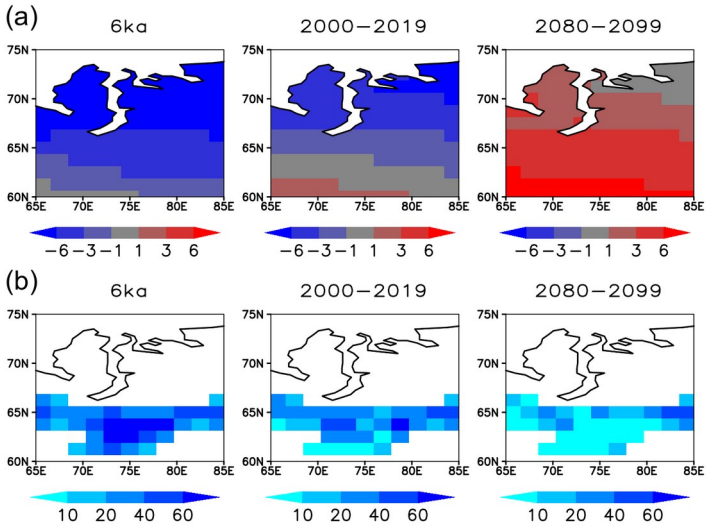

Fig. 1. a) Air temperature (ºC), b) Wetland fraction (%) according to calculations with the global climate model ACCESS-ESM1-5 for the mid-Holocene, the beginning and end of the 21st century.

According to the modeling results, at the beginning of the 21st century, the depth of seasonal thawing exceeded the values in the mid-Holocene (fig. 2a). By the end of the 21st century, the depth of seasonal thawing may exceed 2 m in the north of the region, and in the central and southern regions, seasonal thawing will change to seasonal freezing.

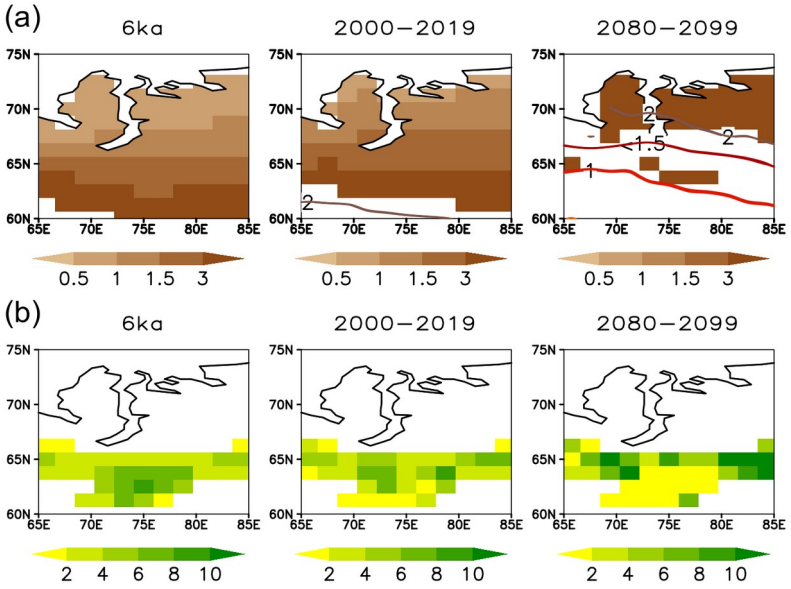

Fig. 2. a) Seasonal thaw (color fill) and frozen (isolines) depth (meters). b) Methane emissions ($gCH_4\ m^{-2}\ year^{-1}$) for the mid-Holocene, beginning and end of the 21st century.

Estimates of methane emissions in the south and in the central part of wetland are lower at the beginning of the 21st century compared to the mid-Holocene (fig. 2b). By the end of the 21st century, an increase in methane emission was revealed relative to the beginning of the 21st century and the mid-Holocene in the north and northeast of the wet ecosystems. The total methane emission from wet ecosystems of Western Siberia significantly increases in the 21st century (fig. 3).

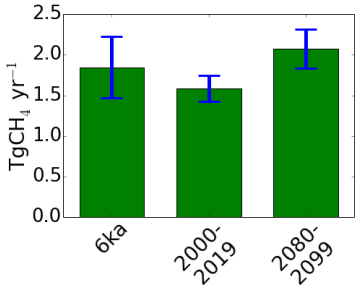

Fig. 3. Total methane emission ($TgCH_4\ year^{-1}$) from wet ecosystems of Western Siberia for the mid-Holocene, beginning and end of the 21st century.

The average values of methane emission at the end of the 21st century may exceed the values in the mid-Holocene, however, the interannual variability in the mid-Holocene is greater compared to the 21st century.

References

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