Effect of wetland types on methane emission from Russian frozen wetlands under conditions of climate change

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Introduction

Natural wetlands are responsible for the majority of global methane emissions from natural sources, accounting for about 175 Mt of methane per year (IPCC 2007). The climate change will have significant impact on permafrost, leading to thawing of the frozen wetlands and release of carbon to the atmosphere. The potential feedback to climate system depends on both the soil pool size and the rate of release to the atmosphere. Earlier studies suggest that Northern peat deposits store about 500 Pg C, of which about 278 Pg C is located in permafrost regions. More recent data indicate that the circumpolar permafrost region may contain 1024 Pg of soil C in the surface 0–3 m depth, and additional 648 Pg C in deeper layers up to 25 m thick. This carbon may become available for decomposition under warmer climatic conditions.

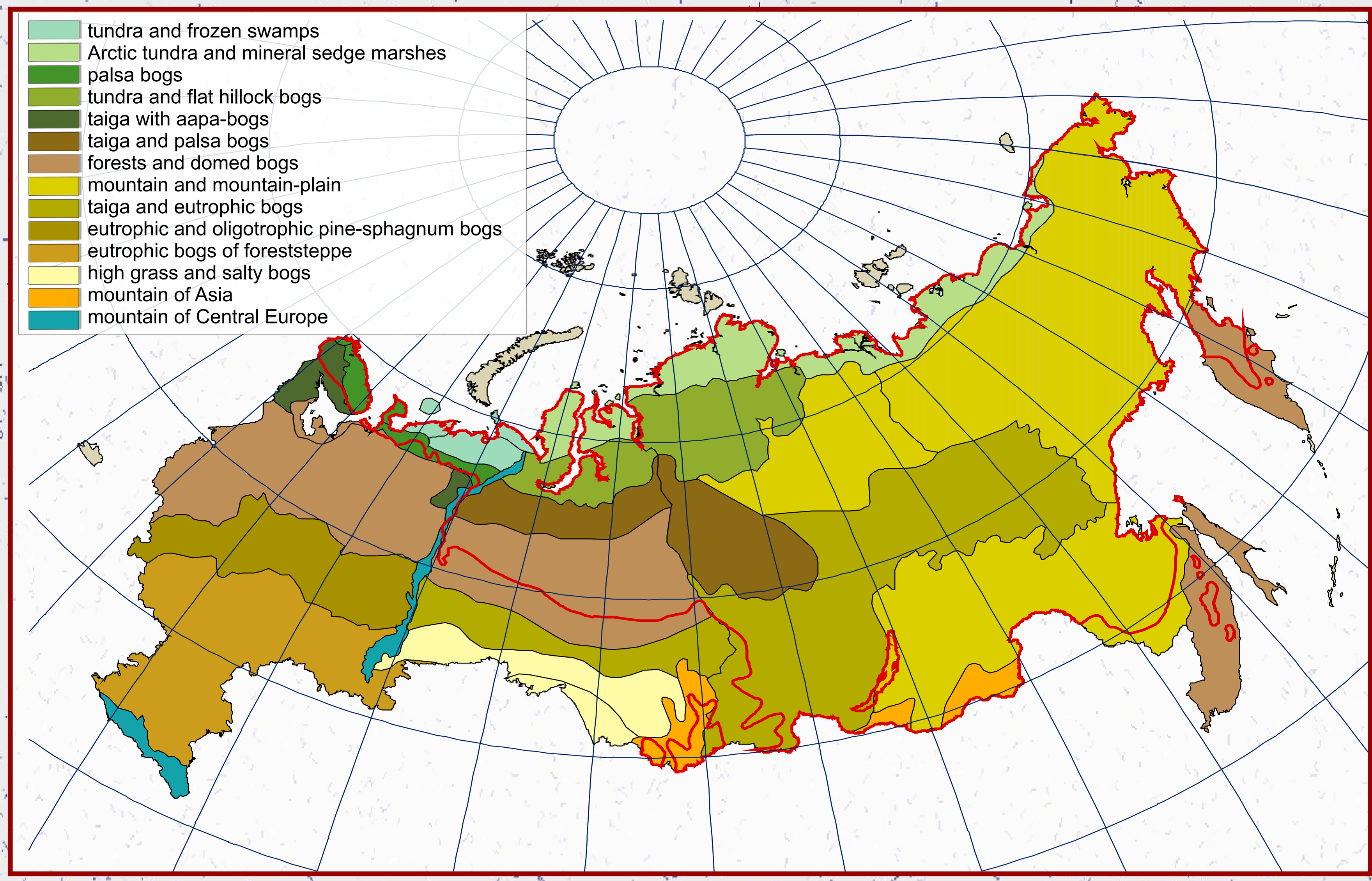

Fig.1 The wetland provinces map classified by Katz

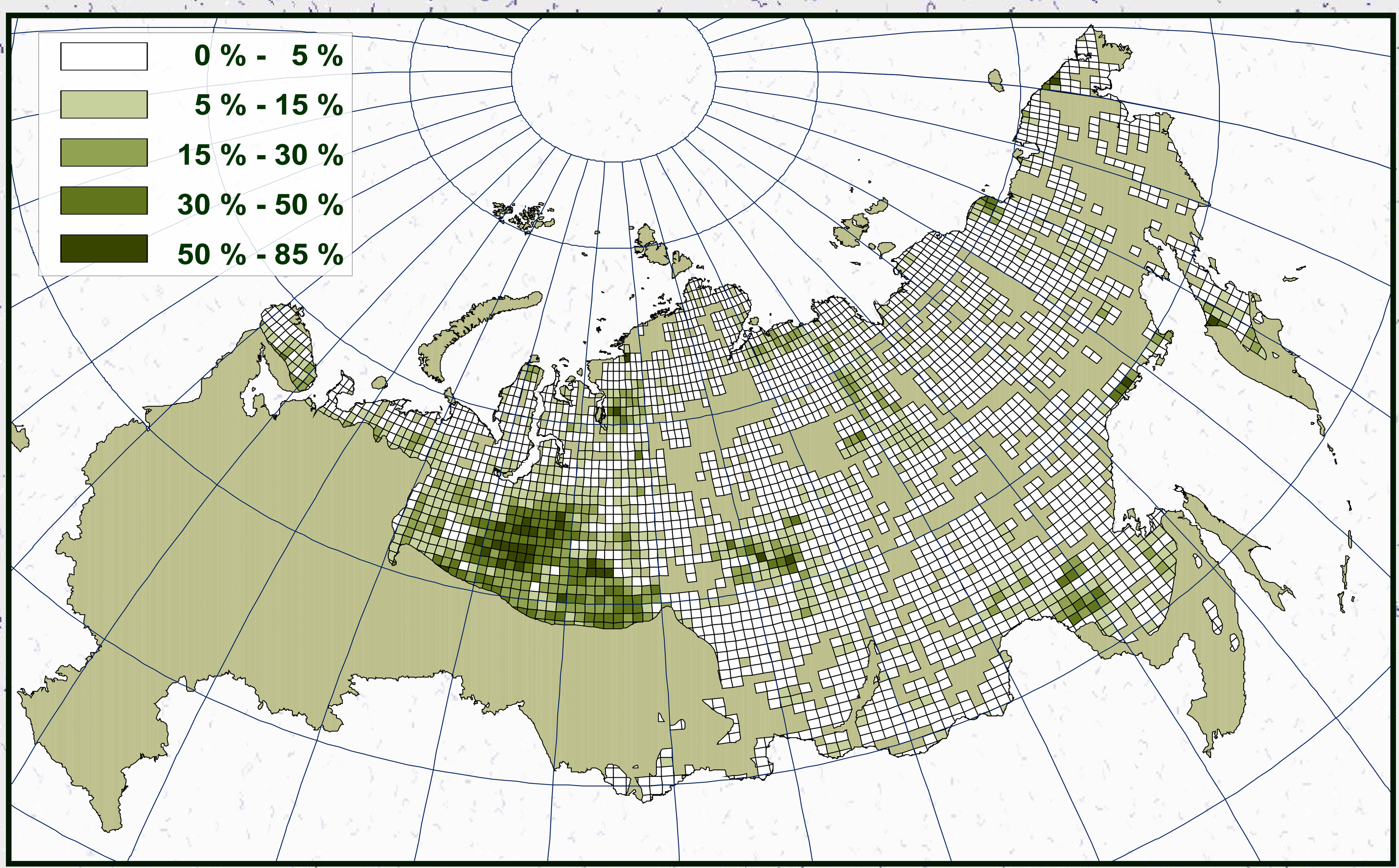

Fig.2 Fraction of land occupied by wetlands in Russia

In this study we focus on permafrost wetlands because they favour the production of methane in the anaerobic carbon-rich soil layer. Methane has 21-times stronger greenhouse effect than the equal amount of CO2, and there are growing concerns that enhanced CH4 emission may have significant effect on the global radiative forcing.

The goal of our study was to estimate the potential increase in the methane emission from Russian frozen wetlands under the projected for the mid-21st century climatic conditions and to evaluate the effect it may have on global radiative forcing.

Unlike it was a case with the preceding study, we explicitly take into account the difference in methane production rates in different wetland types. To accomplish this goal, we constructed the map of different wetland provinces, as defined by Katz classification (fig.1) and overlaid it by the digital geographically referenced contours of Russian wetlands from 1:1,000,000-scale topographic maps (fig.2). As a result, we calculated the total area and the fraction of land each wetland type occupies in the nodes of 0.5 by 0.5 degree lat/long regular grid spanning permafrost regions. These data were combined with the results from predictive permafrost model forced by CCC, HadCM3, GFDL (fig.3), NCAR and ECHAM climatic projections for 2050 under B1 emission scenario. Ultimately, we calculated the increase in the amount of organic material that may potentially become available for decomposition due to deeper seasonal thawing of wetlands in the Russian part of Arctic.

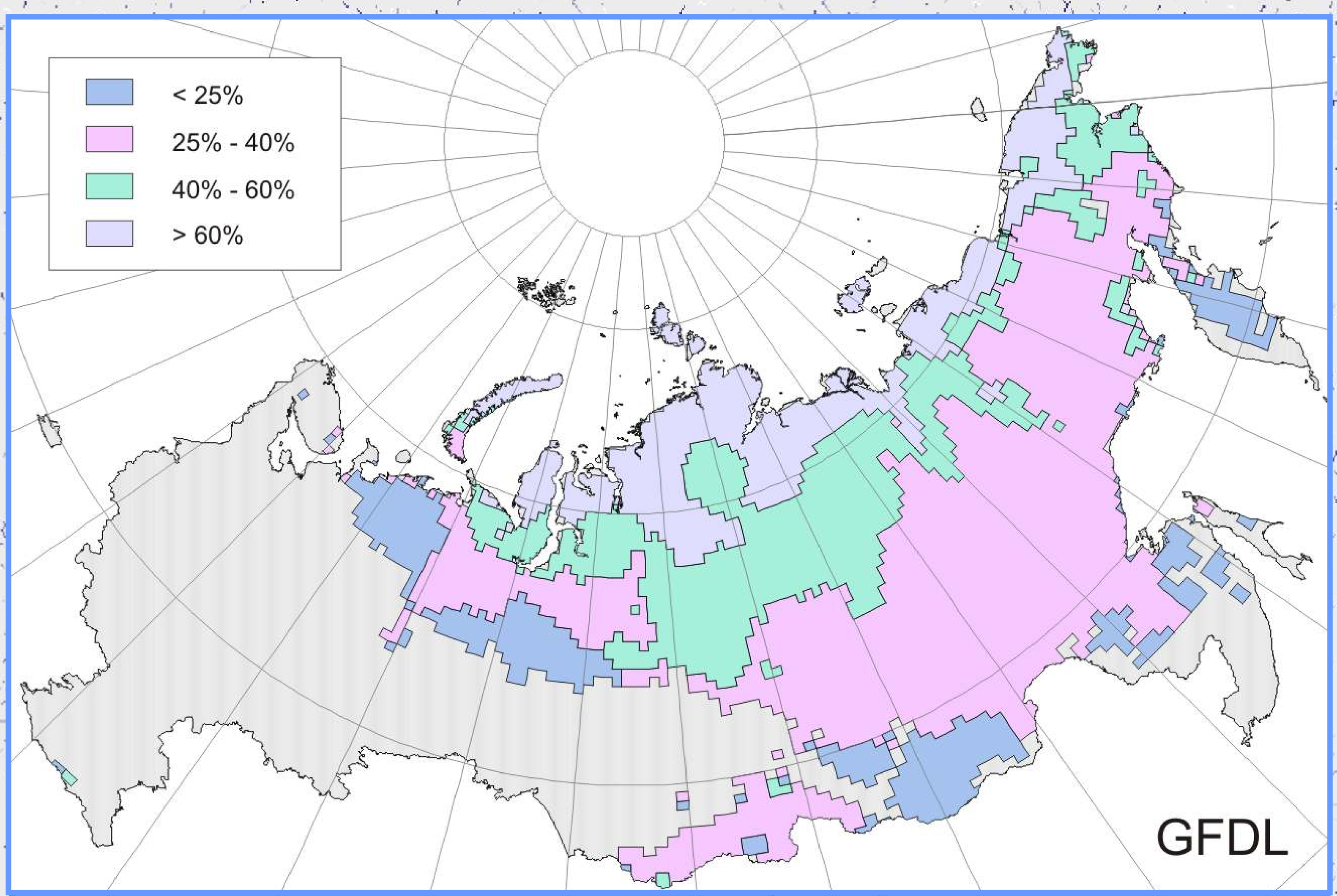

Fig.3 Projected by the 2050 changes of the active-layer thickness, relative to present-day simulations, based on GFDL scenario

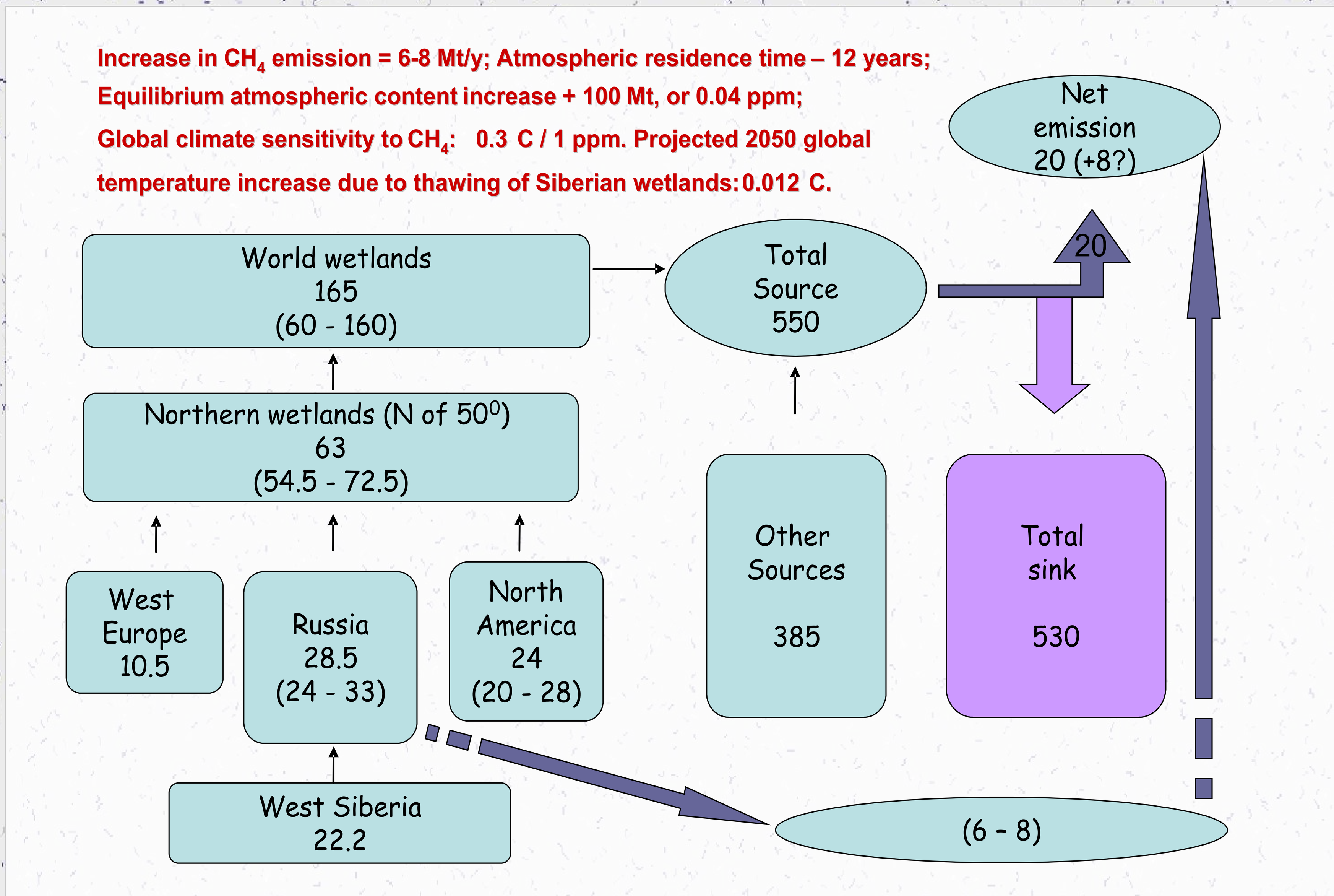

Fig.5 Annual CH4 fluxes to the atmosphere, Mt

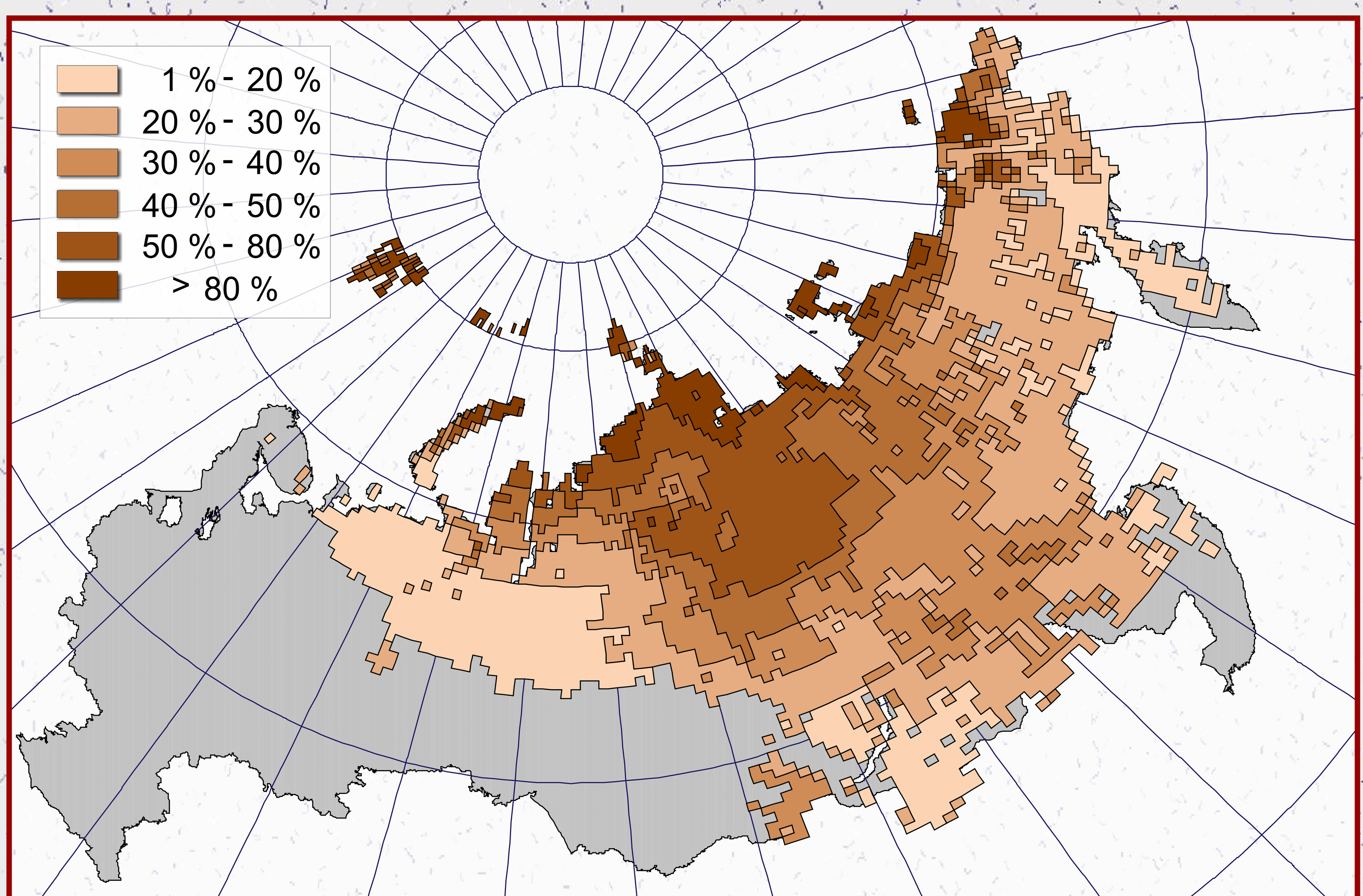

Fig.4 Predicted changes of methane emission from Russian Arctic wetlands, % from modern

Conclusions

The results indicated 6-8 Mt per year potential increase of methane emission from the thawing frozen wetlands in Russian permafrost region by mid-21st century (fig.4). Although the overall impact of such additional emission on global climate is small (fig.5), at regional level it may shift the balance between the sinks and sources of carbon.

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