Natural CO_2 fluxes in Russia in the 21st century and their contribution to climate change: Multimodel estimates

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Russia's carbon balance plays an important role in the global carbon cycle due to large areas of forests, peatlands and wetlands and significant soil carbon pool. Most of Russia's territory is located in the permafrost zone. In these areas over thousands of years, large reserves of carbon have formed in lake sediments and in marsh, forest and tundra soils. As a result of climatic changes, the balance between carbon inflow to soil reservoirs and its emission in the form of CO_2 may change greatly due to increased heterotrophic respiration of the soil.

In [1], estimates of changes in natural CO2 fluxes in Russia in the 21st century and their possible contribution to climate change were obtained using the Earth System Model of the A.M. Obukhov Institute of Atmospheric Physics RAS (IAP RAS ESM). It was shown that the uptake of CO_2 by terrestrial ecosystems in Russia under all the scenarios of anthropogenic impact considered reaches a maximum by the middle of the 21st century and then decreases. Carbon dioxide fluxes have a high variability and their estimates according to different models differ greatly even for the modern period. Therefore, it is important to estimate the possible range of changes in greenhouse gas fluxes and their contribution to climate change on a larger data set. To investigate the range of CO_2 flux estimates, data from Earth System Models of the CMIP6 project for the 21st century under various scenarios of anthropogenic forcings were used (see also [2]).

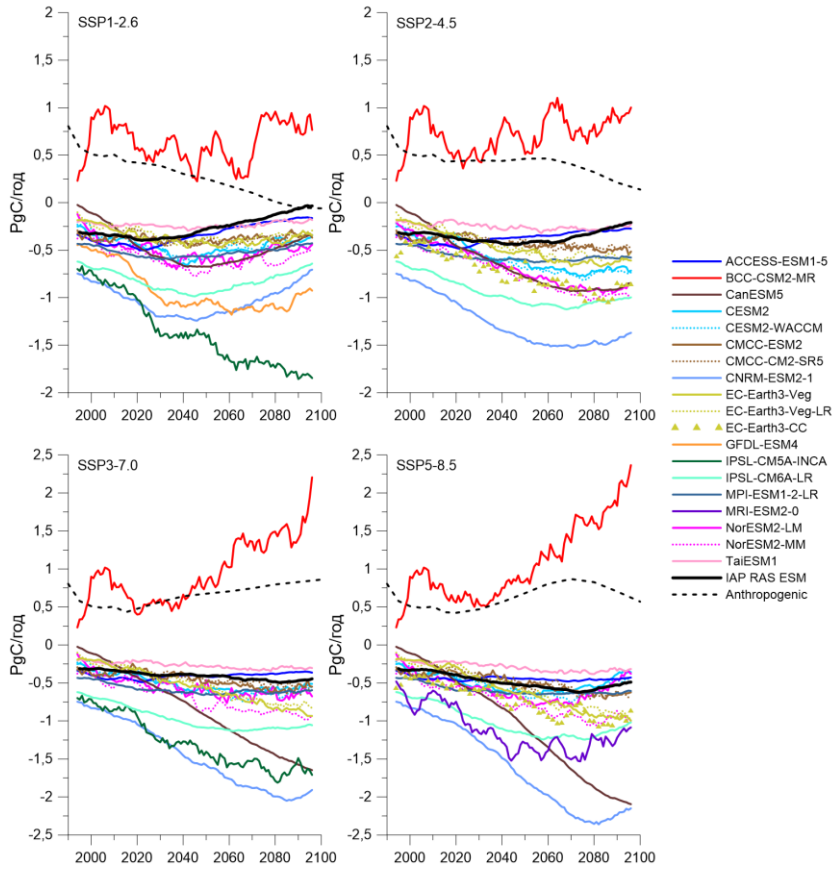

Figure 1. Natural CO2 fluxes into the atmosphere from the terrestrial territory of Russia under different scenarios of anthropogenic impact on the climate.

Fig. 1 shows the total natural annual fluxes of CO_2 from terrestrial ecosystems into the atmosphere on the territory of Russia (the so-called net ecosystem production, NEP). The negative values correspond to

the absorption of CO_2 from the atmosphere. Due to the high variability of the fluxes, all data are presented with a 9-year moving averaging.

In the 21st century, the discrepancy in flux estimates between models is growing. The largest range of estimates from -2.5 to 2.5 GtC/yr is reached at the end of the 21st century under the scenario with the greatest anthropogenic impact on the climate SSP5-8.5. Anthropogenic CO_2 emissions from the territory of Russia are in the same range as natural fluxes and can be largely compensated by them.

Estimates of CO_2 fluxes using the IAP RAS ESM correspond to the range of CMIP6 estimates throughout the 21st century under all anthropogenic forcing scenarios. The trend towards reduction of carbon dioxide uptake by terrestrial ecosystems by the end of the 21st century obtained for the IAP RAS ESM [1] is also characteristic of many other CMIP6 models.

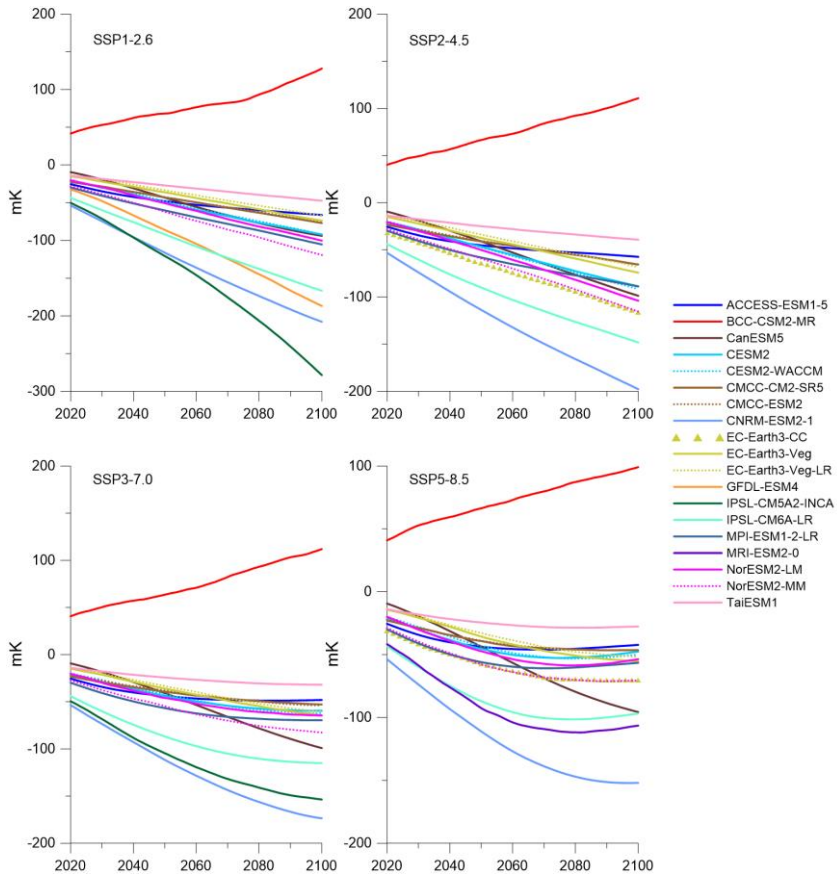

Figure 2. Cumulative temperature potential of natural CO2 fluxes [mK] in the territory of Russia since 1990 under different scenarios of anthropogenic impact on the climate.

The cumulative temperature potential of natural CO_2 fluxes in Russia from 1990 to the end of the 21st century according to estimates based on data from CMIP6 models equals, depending on the scenario of anthropogenic impact, from -0.3 to 0.1 K (Fig. 2). As in the case of CO_2 fluxes, the range of estimates is reduced if the main group of models is distinguished. The trend noted earlier for the IAP RAS ESM of slowing growth and even weakening of the stabilizing contribution of terrestrial ecosystems of Russia to global climate change [1] can also be noted for many of the CMIP6 models, especially under scenarios with strong anthropogenic forcings.

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1. Denisov S.N., Eliseev A.V., Mokhov I.I. Contribution of natural and anthropogenic emissions of CO_2 and CH_4 to the atmosphere from the territory of Russia to global climate change in the 21st century. Doklady Earth Sciences, 2019, **488**(1), 1066–1071.

2. Denisov S.N., Mokhov I.I. Estimates of contemporary natural carbon dioxide fluxes in Russia and their uncertainties based on CMIP6 ensemble data. Research Activities in Earth System Modelling. E. Astakhova (ed.), 2022, WCRP Rep. No. 4/2022, S. 7, 5-6.