Carbon research centers in Russia: the main objectives, challenges and perspectives

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A pilot project "Carbon research centers" was launched in the first half of 2021 in the Russian Federation under the national plan for adaptation to modern climate change and its impacts, ensuring environmental security and improving the environmental conditions. The main goal of the project is to create the regional monitoring network for measurements of the main greenhouse gas (GHG) fluxes in natural ecosystems of the Russian Federation. Application of aggregated (ground surface (*in situ*) measurements, remote sensing, mathematical modeling) approach for estimating the carbon sequestration and the main GhG fluxes (release and uptake) will provide a multifaceted information on both the total GhG fluxes, and the spatial and temporal variability of GhG fluxes for different terrestrial (forests, forest-steppes, steppes, tundra, wetlands, croplands, etc.) and marine ecosystems, including areas underlined by permafrost. Long-term observations will also make it possible to quantify existed uncertainties in estimation of total GhG fluxes, both for the entire Russia and for individual landscape types.
The main objectives of the Carbon research centers are:
1. Monitoring of GhG emission and uptake in natural ecosystems using *in situ* and remote sensing measurements.
2. Assessment of the spatial and temporal variability of GhG release and uptake for representative natural ecosystems, and estimation of accumulated GhG fluxes for different areas (including the administrative and physical-geographical divisions) for different time intervals (day, month, year).
3. Development of innovative technologies to control GHG emissions and uptake in natural ecosystems, aimed at reducing their emissions and increasing their uptake from the atmosphere.
4. Development and adaptation of new methods for remote monitoring of vegetation and land cover properties, GhG emissions and uptake rates using results of *in situ* measurements and mathematical modeling.
5. Education and training of the specialists in environmental control techniques and monitoring of GHG fluxes, as well as promising technologies for low-carbon industries, agriculture and municipal economy.
As an important part of the project research activities to reduce GhG emissions and increase GhG uptake in natural ecosystems, various experimental studies are planned, including: high-yield planting, restoration of antropogenically disturbed lands, peatland and wetland restoration, sustainable forest management and afforestation, regenerative agriculture and livestock, etc.
Carbon research centers for monitoring of GhG fluxes are planned to be evenly distributed in the most representative natural terrestrial and aquatic ecosystems, allowing to estimate the spatial and temporal variability of GhG emissions and releases in the territory of the Russian Federation, taking into account the existing diversity and variability of climatic conditions, land use, vegetation and soil cover, surface topography.
Carbon research center network integrates nowadays 14 regions of the Russian Federation: Krasnodar Krai, Chechen Republic, Republic of Tatarstan, Republic of Bashkortostan, Yamalo-Nenets and Khanty-Mansi Autonomous Areas, Moscow, Kaliningrad, Novosibirsk, Tyumen, Sverdlovsk, Voronezh, Twer and Sakhalin regions. The Carbon research centers are operated by leading universities and research institutes of the Russian Federation.

The application of modern research methods and technologies corresponding all international standards will provide representative data on GhG emissions and uptakes in natural terrestrial and marine ecosystems, allow us to develop new technologies for sustainable use and conservation of natural resources and to reduce the negative impact of the anthropogenic emission growth on climate, and finally help us to be closer to the strategic goal of achieving climate neutrality in the Russian Federation by 2060.

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