Simulation of the C-N cycles of the tundra ecosystem in the Northern Eurasia

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The carbon pool in the permafrost regions of the Northern Hemisphere is estimated at about 1.7 billion tons [1]. This pool exceeds more than twice the total amount of carbon in the atmosphere. At the end of the 20th century the rate of the annual mean temperature increase in the Arctic regions was 0.03°C per year [2]. According to simulations with global climate models [3-4], it may increase up to 0.05°C per year in the 21st century. As a result, an increase in the depth of the active layer is expected along with the inclusion of organic matter into the biogeochemical cycle in the thawed permafrost, which can lead to the emission of greenhouse gases into the atmosphere [5-6].

Soil carbon was measured at the experimental site of the tundra zone (67°22'N,78°37'E) for 07.2013-10.2013 [7]. To estimate carbon contents in the mineral soil, the Tyurin method for low organic carbon content was used. The measured vertical distribution of soil carbon (mean for six experimental sites) is shown in Fig. 1.
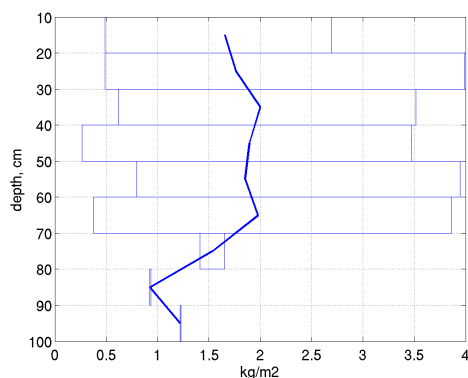

Fig. 1. The measured profile of soil carbon distributions in the mineral soil of the tundra zone (67°22'N,78°37'E). The blue bars show the observed range of soil carbon content at experimental sites.

According to the instrumental observations, the organic matter density in the upper one-meter soil layer in the ecosystems of Siberia, Alaska, Canada, and Tibet varies in a rather wide range from 2–8 to 9–14 kg C m^{-2} [8].

A one-dimensional version of the plant-soil model [9] was used. The distance between the vertical model levels in the soil was set to 10 cm in numerical simulations. The depth of the soil column in the experiments was 200 cm and the model time step was 1 day. The simulated soil carbon and nitrogen profiles in the equilibrium case are shown in Fig. 2.
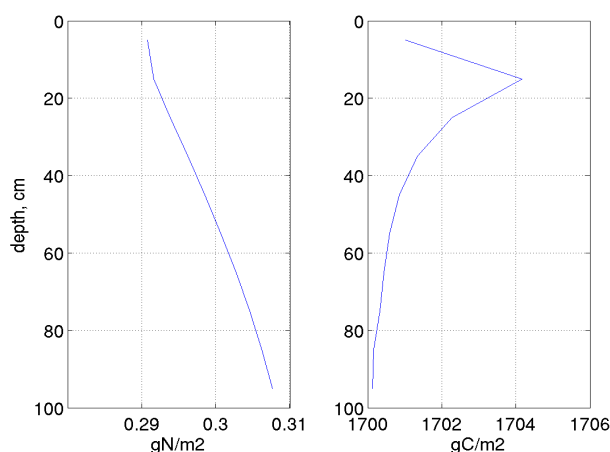

Fig. 2. The simulated profiles of soil carbon (left) and nitrogen (right) in the first meter of soil.

The carbon content in the first meter of soil estimated from model simulations was about 1.7 kg C m^{-2}. This agrees with observations (Fig. 1), 1.77±1.21 kg C m^{-2}.

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