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Climate change impact on the carbon cycle in Russian peatlands

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Dynamic compartment model with annual time resolution of carbon cycle functioning with elements of nitrogen and water cycles for three basic types of peatlands (oligotrophic, mesotrophic, eutrophic) is designed and verified based on data for several peatland ecosystems from Russian European part and Western Siberia as well as on estimates of relative areas occupied by these types in each of wetland provinces marked by Kats (1970). Flows between three main reservoirs and input-output fluxes can have donor-, recipient-, Volterra-controlled forms or be saturation functions of storages in participating reservoirs. Possible steady states of combined cycles allow to distinguish forest, forest-swamp and swamp for each of three types of peatland ecosystems as stable equilibria. Stability and bifurcation analysis of the dynamic model, as well as numerical modeling of transient non-equilibrium dynamic regimes, is carried out in the space of three parameters corresponding to intensities of atmospheric carbon assimilation by vegetation, output runoff from soils and litter, decay of dead organic matter by animals and microorganisms. These parameters depend on climatic magnitudes – annual temperature and total precipitation, soil moisture, availability of nitrogen in the litterfall. Atmospheric CO2 concentration increase can lead to appearance of oscillations in system compartments or to transition into other steady states depending on two other parameter values. Numerical simulations and analytical findings allow establish stability boundaries of each peatland type as an equilibrium of the model, and to calculate critical values of external parameters for which stable functioning of matter cycles is provided. Change in climatic or human perturbation parameters initiates a shift in the model parameter space corresponding to the temporal evolution of carbon cycle capable to change the ecosystem state significantly. Estimations of relative areas occupied by peatland types in some regions of European Russia and Western Siberia help to make predictions on the contribution of large peatland regions to the carbon cycle dynamics at regional and global scales and clarify future biotic contribution into carbon emissions from peatland ecosystems to the atmosphere under several CO2 doubling climate change scenarios taken as an output of different climate models. Changes in areas occupied by oligotrophic, mesotrophic and eutrophic peatlands in wetland provinces under these scenarios are also studied.

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