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Modeling the Impact of Climate Change on Hydrological and Carbon Cycle of a Pine Forest Ecosystem

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An effective tool for studying the interactions between the carbon and hydrological cycles and the climate system is a physically based modeling because it allows, on one hand, the coupled description of physical, biochemical, physiological, biological etc. processes occurring in a complex and multifactor soil-vegetation/snow cover -atmosphere system (SVAS), on the other hand, utilization of a vast amount of observations obtained from standard measurements and numerous laboratory and field experiments in different branches of Earth's science. Here, a physically based land surface model (LSM) SWAP (Soil Water - Atmosphere - Plants) developed by the authors is used. Initially, the model treated only the processes of heat and water exchange between the land surface and the atmosphere and was successfully validated on a long-term basis, under different natural conditions and on different spatial scales. By the moment, carbon exchange processes occurring within a SVAS have been incorporated into the model. The carbon block of SWAP treats the following processes related to the carbon cycle: photosynthesis; respiration with its partitioning between autotrophic and heterotrophic components; carbon allocation towards different compartments of plants; plants growth; fading, mortality and falling of different compartments of plants; formation of the litter with its further decomposition; carbon dynamics in a soil. The new version of the model was validated using the data measured at the experimental site of the EuroFlux program network - Loobos (the Netherlands). The Loobos site is unique because the pine forest was planted there in 1906 on sand dunes. This circumstance, along with the fact that a meteorological station near the site exists since the beginning of the 20th century, gives a unique opportunity to model almost

100-year evolution of carbon in the soil and vegetation. The information for model validation was provided within the framework of the international PILPS-C1 project. The validation of the model has shown that it treats carbon exchange processes occurring within the pine forest ecosystem fairly well. This allows the application of the model for the solution of different problems, in particular, related to studying the impact of climatic changes on hydrological and carbon cycles of coniferous forest ecosystems. To illustrate such possibility, SWAP was used for modeling the response of the components of water and carbon budgets of the pine forest ecosystem growing at the Loobos site on climate change, resulted from anthropogenic change in the concentration of green-house gases and aerosols in the atmosphere in the 21st century (according to IS92a IPPC scenario of economic, political and demographic development of the human civilization until 2100). The results of modeling has shown that changes in the water balance components (for this case study) in 21st century will be minor compared to 20th century, while the carbon budget (the net ecosystem exchange) will increase up to 44% in 21th century. In both centuries, the studied ecosystem represents a considerable sink of the atmospheric carbon. This confirms the fact that growing coniferous ecosystem is one of the best compensator for increase in CO_2 consentration in the atmosphere.