3rd International Conference on Earth System Modelling
Vol. , 3ICESM-10, 2012
3rd International Conference on Earth System Modelling

Multiple–valued dependence of near–surface permafrost extent on global surface temperature in transient simulations with a global climate model

A. V. Eliseev, P. F. Demchenko, M. M. Arzhanov, and I. I. Mokhov

A.M.Obukhov Institute of Atmospheric Physics RAS, Laboratory of the Climate Theory, Moscow, Russian Federation (eliseev@ifaran.ru, +7 (495) 9531652)

Estimates of changes in near–surface permafrost (NSP) area S_p relative to change in globally averaged surface air temperature T_g are made by using the global climate model developed at the A.M. Obukhov Institute of Atmospheric Physics RAS (IAP RAS CM). For ensemble of runs forced by scenarios constructed as return–to–preindustrial continuations of the RCP (Representative Concentration Pathways) scenarios family, a possibility of hysteresis in dependence of S_p vs T_g is exhibited: in some temperature range which depends on imposed scenario of external forcing, for a given value of T_g, NSP area is larger in the case of warming climate than in the case when climate cools. This hysteresis is visible more clearly for more aggressive scenarios in comparison to less aggressive ones. Hysteresis details are not sensitive to the type of the prescribed continuation path which is used to return the climate to the preindustrial state. The multiple–valued dependence of S_p on T_g arises due to dependence of soil state in the regions of extra–tropical wetlands and near the contemporary NSP boundaries on sign of external climatic forcing.

To study the dependence of permafrost hysteresis on amplitude and temporal scale of external forcing, additional model runs are performed. These runs are forced by idealised scenarios of atmospheric CO_2 content varying, depending on run, with periods from $100\ yr$ to $1000\ yr$ and with different amplitudes. It is shown that the above–mentioned hysteresis is related to the impact of phase transitions of soil water on apparent inertia of the system as well as to the impact of soil state on atmospheric hydrological cycle and radiation transfer in the atmosphere. Further, it is obtained that response of potential permafrost area (which is determined by using empirical indices based on surface air temperature; potential permafrost area is used frequently in paleoclimate studies) to external forcing drastically overestimates corresponding response of NSP area at time scales up to one millennium. At longer time scales, potential permafrost area may be used as an approximation of the NSP area provided that external forcing is large enough.