Soil subsidence in the 21st century simulated using anthropogenic climate change scenarios

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Projected warming is most pronounced in the northern high latitudes. The surface temperature increase can result in changes in the thermal and hydrological conditions of permafrost [1]. Permafrost degradation and associated soil subsidence are assessed in simulations with a soil model developed at A.M. Obukhov Institute of Atmospheric Physics RAS [2-4]. This model is forced by monthly mean atmospheric fields simulated by the ECHAM5/MPI-OM coupled general circulation model using anthropogenic scenarios SRES A1B and A2.

Total extent of simulated near-surface permafrost in the Northern Hemisphere in 2001-2010 is about 16.7±2.3 million km^2. This area shrinks to 11.2±1.1 (7.9±0.8) million km^2 to the end of the 21st century under SRES A1B (A2) scenario. A similar value (7 million km^2) has been obtained for MIROC 3.2 model [5]. An even smaller permafrost area (about 1-4 million km^2) for the end of the 21st century is simulated by the CCSM3 model [6]. In the late 21st century, near-surface permafrost is expected to remain in central and eastern Siberia and in the high latitudes of northern America. In these regions, the active layer depth exceeds 1.5 m (2.0 m) under SRES A1B (A2) scenario. Subsurface permafrost turns to a relic form since 2050 (2030) in the regions near contemporary permafrost southern boundary in the Northern Hemisphere (Fig. 1). The model simulates substantial permafrost degradation in western Siberia and Alaska. Permafrost degradation is accompanied by a formation of taliks which penetrate to the depth of several meters within a few decades [7].

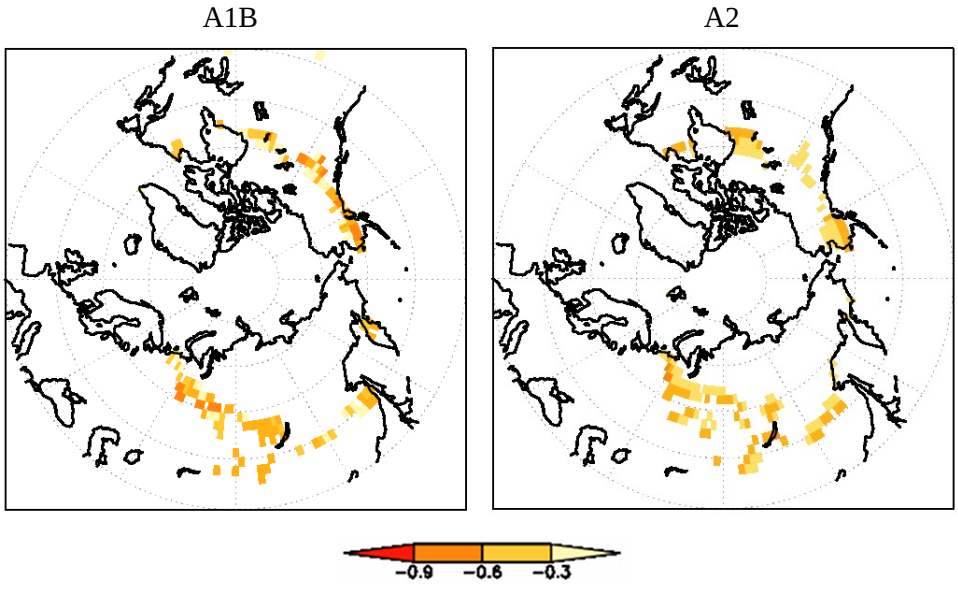

Fig. 1. Simulated thaw subsidence (meters) due to the subsurface permafrost degradation when applying SRES A1B and A2 scenarios in 2046-2055.

Most marked near-surface permafrost degradation is simulated for the last decades of the 21st century (Fig. 2). Permafrost thaw leads to cavities in soil pores, and the soil subsidence due to gravity. This soil subsidence is estimated based on [8].

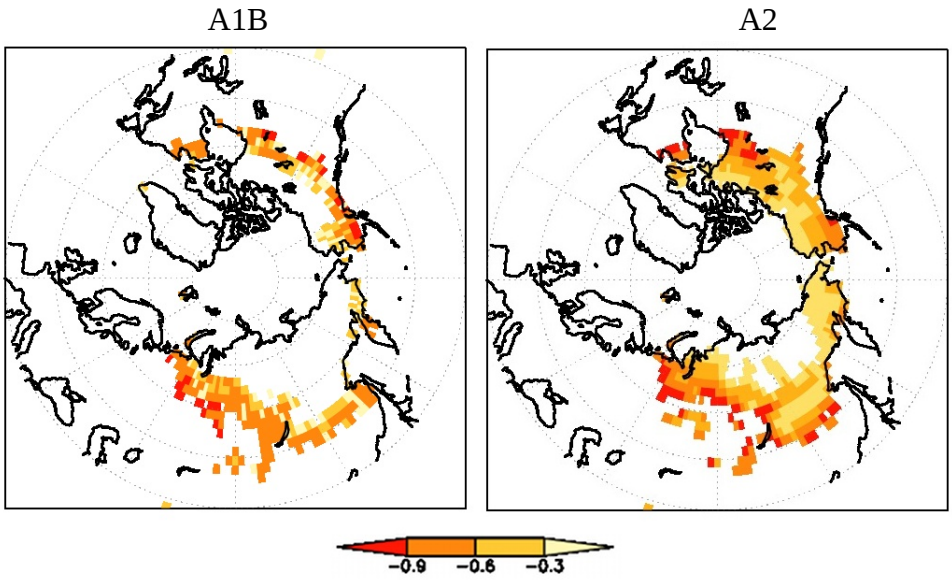

Fig. 2. Simulated thaw subsidence (meters) due to the subsurface permafrost degradation when applying SRES A1B and A2 scenarios in 2091-2100.

During the second half of the 21st century, simulated near-surface permafrost area with subsidence enlarges rapidly. Typical values of vertical shifts of soil layers amount to several tens of centimeters and reach up to 1.2 m locally (Fig. 2).

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