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Permafrost degradation and associated soil subsidence assessed in offline simulation with a soil model under the SRES A2 scenario

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Permafrost degradation and associated soil subsidence is assessed in offline simulations with a soil model developed at the A.M. Obukhov Institute of Atmospheric Physics RAS. This model is forced by the monthly mean atmospheric fields simulated by the ECHAM5/MPI–OM general circulation model under the anthropogenic scenario SRES A2. In the late 20th century, modelled permafrost extents over 17.0 mln sq km. This area shrinks to 3.4 mln. sq km to the end of the 21st century. In regions where permafrost remains in the late 21st century, active layer thickness increases by 0.6–0.8 m. Most marked permafrost degradation is simulated for the last decades of the 21st century. However, subsurface permafrost turns to relic form even in decade 2010–2020 in the regions near the contemporary permafrost southern boundary in the Northern Hemisphere. Permafrost degradation is accompanied by formation of taliks which penetrate to the depth of several metres in a few decades.

Permafrost thaw leads to cavities in soil pores, and, in turn, to soil subsidence due to gravity. This soil subsidence is estimated based on

$$d_h = (\xi_2 - \xi_1)\left(1 - \frac{\rho_i}{\rho_w}\right)$$

where ξ_1 is annual mean depth of the top of relic permafrost, ξ_1 is the penetration depth of seasonal frost, ρ_i and ρ_w stand for ice and water density respectively. During the second half of the 21st century, modelled area experiencing subsidence enlarges rapidly with typical values of vertical shifts of soil layers amounting several tens of centimetres and reaching up to 1.2 m locally.