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Modification of the Land Surface Model SWAP to Reproduce Heat and Water Exchange Processes under Permafrost and Highland Conditions

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The aim of the present work is to modify a physically-based model SWAP (Soil Water–Atmosphere–Plants), developed previously by the authors, to make it suitable for the simulation of heat and water exchange between the land surface and the atmosphere in the permafrost zone and to validate the new version of the model against observations performed in a permafrost region. The first modification concerns modeling the dynamics of soil freezing and thawing depth under permafrost and highland conditions. The second modification deals with modeling the water regime of a seasonally-thawed soil. The data for the model validation were obtained at the Kolyma water-balance station (KWS, 61˚53 N, 147˚43 E, East Siberia, Russia) located within the Kontaktovyi Creek basin, the upper curse of the Kolyma River. The absolute heights of the station territory vary from 830 m in the Kontaktovyi Creek mouth area to 1700 m on the watersheds. The climate of the region is subarctic continental. In order to validate the new version of the SWAP model one should have information about (a) forcing data, (b) the land surface parameters, and (c) validation data. As to the forcing data, the 10-year observations from the KWS were used. Vegetation and soil parameters were derived on the basis of qualitative description of vegetation and soil classes located within the basin. The validation data represented daily values of (i) soil temperature at different depths, (ii) soil surface and snow surface temperature, (iii) snow evaporation; monthly values of evaporation from the soil covered by moss and grass; snow depth and soil thawing depth, as well as daily values of runoff from different catchments and river basins located within the KWS. Analysis of the results of model validation has shown that the new version of the model SWAP is able to reproduce heat and water exchange processes under permafrost and highland conditions quite reasonable.