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Active layer depth as a key factor of runoff formation in permafrost: process analysis and modelling using the data of long-tem observations

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Improving understanding of the physical processes within the permafrost zone is necessary for the evaluation of the climate change effects on frozen soils and their consequences for water and energy fluxes in Northern environments. Seasonal thawing of permafrost has critical impact on runoff formation process. Active layer depth relates to soil properties as well as other landscapes components such as vegetation and topography. Process studies strongly depend on observational data of experimental sites in permafrost zone. Long-term high-quality measurements are provided by little number of small research basins or experimental sites. One of them is Kolyma water-balance station (KWBS) in Russia.

KWBS is situated within the upstream of Kolyma River (61º54'N, 147º25'E) and is unique for mountainous regions of continuous permafrost. Since 1948, special observations of water balance components, active layer depth and other characteristics were carried out at this station. The elevation varies within 800–1700 m range. The average annual temperature is -13ºC, precipitation is about 400 mm. The main types of landscapes depending on elevation are mountainous tundra and larch taiga. Some description of soils, vegetation, geological structure and other information is accompanying the observational data.

The objective of the on-going research is to investigate the aspects of permafrost-runoff interaction, to analyze the patterns of distribution of active layer depth in different landscapes and main factors determining it, to link the runoff formation in particular basin (for example, with rock debris surface) with soil thawing and freezing, and use it for improvement of algorithms and assessment of parameters of the hydrological model.

It was found out that the active layer depth is determined mainly by vegetation and soil type whereas the slope aspect has indirect influence. Landscapes vary consecutively from bare rock debris in the top part of the slope peat soil covered with swamp forest near the stream body. The difference in active layer depth may reach 1 m in the different parts of the slope.

In this study we use the hydrological process-based model Hydrograph developed in the State Hydrological Institute (Russia). The results of the model application on the KWBS data will be presented. They will include simulations of snow formation and melting, runoff, soil thawing and freezing on plot and small scale watersheds in Kolyma River basin.

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