

EGU21-204

<https://doi.org/10.5194/egusphere-egu21-204>

EGU General Assembly 2021

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Climate change impact on water exchange processes in the cryolithozone of the North-East of Russia

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Climate warming cause the transformation of hydrological cycle in cold regions of the Northern Hemisphere. The aim of this research is to study the climate change impact on water exchange processes in the cryolithozone of the North-East of Russia.

The study presents the results of the analysis of changes in the characteristics of the climate (air temperature, precipitation), water discharge, soil temperature at the 80 cm depth and river-ice cover for a period of 50 years (1966-2018) and historical and modern data of aufeis area.

Climate. The annual air temperature in the region increased by 2.3 °C on average. The analysis of annual precipitation showed multidirectional changes. However, most of the stations are characterized by a significant negative trend of precipitation in the winter and a positive annual trend of mixed and liquid precipitation with an increase in their share in the autumn months.

Permafrost. The average annual soil temperature at the 80 cm depth increased by 1.7 °C at 7 of the 11 stations in the studied area. The maximum change reached 4.8 °C in June at the Verkhoyansk station.

Streamflow. Significant increase of streamflow in the autumn-winter period (from August to December) at most of the rivers have been established. Even though permafrost warming is leading to deepening of active layer, we hypothesized that the main reason of base flow increase is the transition of precipitation from solid to liquid and corresponding increase of streamflow in September, continuing in the following months. There is a significant shift in the dates of spring freshet floods in May. But it does not lead to a decrease of runoff in June. This may indicate an increase of contribution to streamflow of such sources as thawing permafrost, glaciers and aufeis.

The river-ice cover. There are significant changes in the characteristics of the river ice cover and the time of the river ice formation. On average, at 19 analyzed river gauges the decrease of river ice cover maximum depth was 41 cm (28%) and the period of formation of river ice with a thickness of 60 cm (necessary for using winter roads for passenger cars) has shifted to later period by 7-40 days.

The aufeis. Aufeis is an important part of groundwater and surface flow interaction in the studied area. The analysis of the historical data and its comparison to modern distribution of aufeis in the region have shown significant changes. The total number (area) of aufeis was 4642 (7181 km²), according to the historical data (Cadastre of aufeis, 1958), and 6217 (3579 km²), according to Landsat data (2013-2019), which is 1.3 times higher by number, but 2 times less by total area.

The study indicates that considerable transformations are going on in all parts of hydrological cycle. The analysis results are used as the base for planning new multidisciplinary research to assess and project the changes in the natural conditions and water cycle in the cryolithozone of the North-East of Russia.

The study was carried out with the support of RFBR (projects 19-35-90090, 19-55-80028).