Geophysical Research Abstracts
Vol. 19, EGU2017-10457, 2017
EGU General Assembly 2017

Application of a hybrid method for downscaling of the global climate model fields for evaluation of future surface mass balance of mountain glaciers

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Mountain glaciers in the Caucasus have been degrading during the last century. During this time period they lost approximately one-third in area and half of their volume. Prediction of their evolution in changing climate is crucial for the local economy because hydrological regime in the territory north to the Main Caucasus Chain is mainly driven by glacier run-off. For future projections of glaciers' surface mass balance (SMB) we apply a hybrid method of downscaling of GCM-generated meteorological fields from the global scale to the characteristic spatial resolution normally used for modeling of a single mountain glacier SMB.
A method consists of two stages. On the first, dynamical stage, we use the results of calculations of regional climate model (RCM) HadRM3P for the Black Sea-Caspian region with a spatial resolution of approximately 25 km. Initial and boundary conditions for HadRM3P are provided by an AO GCM INMCM developed in the Institute of Numerical Mathematics (Moscow, Russia). Calculations were carried out for two time slices: the present (reference) climate (1971-2000 years) and climate in the late 21st century (2071-2100 years) according to scenario of greenhouse gas emissions RCP 8.5.
On the second stage of downscaling, further regionalization is achieved by projecting of RCM-generated data to the high-resolution (25 m) digital elevation models in a domain enclosing target glaciers (Marukh in the Western Caucasus and Djankuat in the Central Caucasus, both being typical valley glaciers). Elevation gradient of surface air temperature and precipitation were derived from the model data. Further, results were corrected using data of observations. The incoming shortwave radiation is calculated separately, taking into account slopes, aspects and shade effect.
In the end of the current century expected air temperature growth in the Central and Western Caucasus is about 5-6 °C (summer), and 2-3 °C (winter). Reduction in annual precipitation is not significant, less than 10%. Absorbed shortwave radiation will increase by approximately 5%. These changes yield in dramatic shifting of the ELAs to the positions much higher than at present. This will inevitably cause degradation of the glaciers and their gradual disappearance. The main contribution to glacier shrinking will be made by increase of air surface temperature via enhanced ablation and extension of the melting season duration.