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Projected impact of climate change on runoff of northern rivers in Russia

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Due to possible climate changes in the nearest future, the problem of assessment of their impact on water resources, in particular, on resources of terrestrial surface and ground water is of great topicality and importance. Since river runoff is a measure of surface and ground water resources, it is important to predict its response to projected climatic changes.

The objective of the present study is to project impacts of climate change on runoff of northern rivers in Russia up to 2100. Two models were used: the atmosphere-ocean global climate model (AOGCM) INMCM 4.0 (Institute of Numerical Mathematic Climate Model, version 4.0), developed in the Institute of Numerical Mathematic of the Russian Academy of Science (RAS), and the land surface model (LSM) SWAP (Soil Water – Atmosphere – Plants), developed in the Institute of Water Problems of RAS. River runoff hydrographs for several northern rivers (the Mezen, the Northern Dvina, the Indigirka and the Kolyma) were obtained by two ways. First, instantaneous runoff, simulated by INMCM4.0, was transformed by a river routing model (RRM) to obtain river runoff at the outlet of each basin. In so doing, we optimized the effective velocity of water movement in a channel network using daily values of measured river runoff. Second, the near surface meteorological outputs (incoming longwave and shortwave radiation, precipitation, air temperature and humidity, wind speed and atmospheric pressure) from INMCM4.0 were used (both directly and after hybridization with observations to reduce systematic errors resulted from application of the AOGCM) to force the LSM SWAP coupled with the same RRM in order to simulate river runoff hydrographs. In the second case, some model parameters influencing river runoff to the greatest extent were optimized using three different forcing data sets: (1) meteorological data simulated by INMCM4.0, (2) meteorological outputs from INMCM4.0 hybridized with observations and (3) real meteorology. Then different sets of optimal parameters were used for simulating river runoff hydrographs. For historical period, the simulated hydrographs were compared with measured ones.

The river runoff projections were calculated for two greenhouse gas emission scenarios: a high emissions scenario (RCP8.5) and a medium mitigation scenario (RCP4.5) prepared for the phase five of the Coupled Model Intercomparison Project (CMIP5). For each scenario, we obtained several hydrological projections using the above described techniques. Differences among the projections illustrate uncertainties resulted from application of different techniques for simulating river runoff hydrographs