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The uncertainty of assessments of the water balance components of river basins due to the climate noise

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Assessments of hydrological consequences resulted from climate change impact performed by different authors are characterized by a large scatter or uncertainty caused by a number of reasons. Some reasons are subjective, while others are objective. In the present work, the objective uncertainty, which cannot be reduced by means of better physical description of the processes under study or by means of improvement of the quality of input data for atmospheric and hydrological models, and which is an internal feature of the atmosphere – hydrosphere – land surface system, is considered. This uncertainty is caused by a chaotic character of atmospheric processes (i.e. by so-called climatic noise), their instability with respect to small errors in determination of initial conditions for modeling the evolution of meteorological variables.

Here, the impact of climatic noise on the uncertainty of hydrological variables (river runoff and evapotranspiration) is studied for two northern river basins located in the Russian Federation: the Lena and Indigirka basins. Such a selection was motivated by the fact, that northern high-latitude land areas are the major source of fresh water resources of our planet, at the same time these areas will be subjected to the earliest and most significant changes, caused by anthropogenic greenhouse gas emissions.

The methodology of solving the problem is based on application of the global climate model (GCM) ECHAM5 and the land surface model (LSM) SWAP that allows an estimation of monthly and annual uncertainties in the simulated water balance components (precipitation, river runoff and evapotranspiration) of the selected river basins, resulted from the climatic noise. The ensemble simulations (45 versions) of meteorological fields were performed by ECHAM5. Since meteorological fields modelled by any GCM differ from observations, the post-processing bias-correction was carried out. Then for each river basin and computational experiment, simulations of the water balance components were performed by SWAP with 6-hour time step for 33 years (from 1980 to 2012) using the corrected meteorological fields. The simulated 45 evolutions of the water balance components of the river basins allowed us to estimate their average trajectories (which showed a good agreement with observations) and their uncertainty on different time scales (annual and monthly) due to climate noise.

The obtained results showed that monthly uncertainties for all water balance components are higher than annual ones. Besides that the larger a river basin, the less the uncertainties in the estimates of the water balance components. In addition, the spectral densities of the water balance components were calculated for the river basins. It was shown that a river basin filters high-frequency components of precipitation (corresponding to synoptic or some more scale) during the transformation of precipitation into evapotranspiration and especially into river runoff.