Dynamic-stochastic modeling variability of the snow cover within a large river basin

Alexander Gelfan and Vsevolod Moreido

Water Problems Institute, Russian Academy of Sciences, Moscow, Russian Federation (hydrowpi@iwp.ru)

Snow accumulation and melt is spatially variable due to the spatial variability in the driving processes and inputs. This spatial variability in turn results in spatially variable surface water inputs from snowmelt that affects runoff and soil moisture. Measurements of snow-related quantities are commonly carried out irregularly in space, and do not often provide representation of spatial snow variability as it is necessary for correct estimation of the river basin water balance or for describing influence of snow on the runoff generation processes. A dynamic-stochastic snow model with spatially distributed random inputs was developed in order to describe snow spatial variability within the Middle Volga River watershed (area of 376 500 km2) The model consists of two components: (1) deterministic one-layer snow model describing temporal changes of snow characteristics over a small uniform area, and (2) stochastic weather generator allowing one to simulate multi-year artificial time series of daily weather variables considering the observed spatial and temporal correlation structure of these variables. First, the deterministic snow model forced by meteorological observations was calibrated and evaluated against daily snow survey data (snow water equivalent, SWE, and snow depth, D) and demonstrated good performance. Then, multi-year time series of spatially distributed daily weather variables were Monte-Carlo simulated and used as random inputs into the snow model. The dynamic model driven with the generated weather data reproduced spatially distributed series of SWE and D. Spatial semi-variograms of SWE and D were derived from simulated data and compared with the corresponding variograms obtained from snow observations. Variograms of SWE and D showed close fit with the observed ones. Also, it was shown that both simulated and observed variograms can be approximated with power functions that demonstrate the fractal structure of the snow cover characteristics.