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Hydrological modeling of the Desna river basin using SWAT (Soil and Water Assessment Tool)

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The distributed hydrological models are actively developing with the increase of computer power and remote sensing abilities which allow to approach to the diversity of the nature in time and space. Today, such models are widely used to assess the pollution of water ecosystems, flood risk, the climate change impact, etc. In general, the sustainable development of aquatic ecosystems starts from the modeling of water flow, which is the engine of migration processes within a catchment.

The purpose of this study is to calibrate, validate and assess water resources of the Desna river basin using SWAT.

SWAT is process based, semi-distributed, continuous-time model. Major model components include weather, hydrology, soil temperature and properties, plant growth, nutrients, and land management. In SWAT, a watershed is divided into multiple subbasins, which are further subdivided into hydrologic response units (HRUs) that consist of unique land use, soil type, and slope. The program operates on a daily time step.

The Desna is the main public water supply source in the capital of Ukraine, Kyiv. The Desna basin (88,800 km2) is located within the Russian Federation (0.68) and Ukraine (0.32) and is mainly covered with agricultural lands (0.55), forests (0.32), and grasslands (0.1). The Desna is a typical plain stream with a slight slope of 1 m/km average. Elevation varies within 100–227 m. The annual average temperature varies from 6.3° in the upper half till 7.0° in the lower one. The catchment is characterized by a good wetness. Annual values of precipitation are 650–700 mm. Soddy-podzolic, grey forest soils, and chernozem are the main soils of the basin territory, they occupy 40 percent, 14 percent, and 12 percent, respectively.

The calibration was based on snow cover depth (13 stations), river discharge (12 stations), along with soft data constraints on crop yield and evapotranspiration. The calibration flowchart is proposed to aid with streamflow simulation for the snowmelt-driven watersheds (Osypov, 2018). The date of snow cover loss was identified as a key factor of successful calibration because of its linkage with the peak discharge timing of spring flood hydrograph. Furthermore, the forest snow cover lose dynamics differs from uncovered lands which has to be reflected in the model parameters during calibration.

Good values of the performance criteria were obtained almost for all gauges (NS > 0.7, R2 > 0.75). The main reason of the error is the sparse network of weather stations.

The SWAT model for the Desna watershed could be used to calculate cross-boundary water transfers, perform flood risk assessment, and conduct climate change studies. As a first step, blue water resources, green water flow, and green water storage were spatially calculated for the catchment.

Osypov V., Osadcha N., Hlotka D., Osadchyi V., Nabyvanets J. (2018). The Desna river daily multi-site streamflow modeling using SWAT with detail snowmelt adjustment. Journal of Geography and Geology. Vol. 10(3), pp. 92-110.