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Multi-site evaluation of flow simulation by SWAT model in the Narew basin

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In this study the Soil & Water Assessment Tool (SWAT) has been applied in the Narew basin in northeastern Poland. SWAT is a river basin scale model developed to quantify the impact of land management practices in large, complex river basins. SWAT2005 model version under ArcSWAT 2.3 interface was used. The study area is a mesoscale (ca. 28 000 sq. km) lowland catchment which is not heavily human impacted and has extraordinary natural values including e.g. large wetland areas in the north-east, primeval forests in the east and lake district in the north. The overall objective of adapting SWAT for the Narew basin is to assess climate change, land use change and water management practices change effect on the quantity and quality of its water resources. The Narew basin is one of the pilot areas in the SCENES research project (GOCE 036822) and the objective mentioned above is consistent with SCENES project objectives. However, before any scenario assessment can be made, the model obviously needs to be calibrated and validated and this is what we focus on in this study.

The following numbers describe the model structure that was built for the Narew basin with SWAT: 151 subbasins, 1303 Hydrologic Response Units, 8 land use classes, 27 soil classes, 12 precipitation gauges and 6 climate gauges. The Narew basin is non-homogeneous in terms of all three major model components: climate, land use and soils, although some patterns of similarity obviously exist. In order to capture the internal diversity of the catchment, SWAT model has been calibrated against daily flow records from 11 water gauges across the basin for the period 2001-2006 and validated for the period 2007-2008. A set of SWAT Autocalibration Tools incorporated in SWAT2005, including sensitivity analysis, autocalibration and uncertainty analysis, was used in the whole model evaluation process in 11 calibration areas. Parameter sensitivities were estimated using Latin Hypercube – One-factor-At-a-Time (LH – OAT) technique, whereas best parameter values and parameter uncertainties were found using ParaSol tool that uses Shuffled Complex Evolution (SCE) optimization algorithm. The goodness-of-fit measures were reasonably good on a monthly basis and at least satisfactory for 10 out of 11 gauges on a daily basis. Monthly Nash-Sutcliffe Efficiency for the main outlet equaled 0.79 and coefficient of determination equaled 0.83.

In this study we compare the model evaluation results from 6 calibration areas: Upper Narew, Suprasl, Biebrza, Pisa, Omulew and Orzyc, which are all headwater catchments of the Narew basin of similar size, ranging from 1 730 to 4 200 sq. km. We attempt to explain the differences and similarities in these results in terms of spatial differences and similarities of the model components: climate, land use and soils. We also compare them with results obtained for the whole Narew catchment. Although the number of analyzed areas is too small to draw statistically significant conclusions, it is sufficient to describe the existing patterns.