Modelling of the transboundary Vistula lagoon catchment for climate and land use impact assessment

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ABSTRACT

Vistula Lagoon in the Baltic Sea is one of the largest inner marine water basins in Europe. It covers an area of 838 km² and has a drainage basin of 23870 km². The lagoon as well as its catchment is shared by the two states Poland and Russia, additionally representing a bridge between EU and non-EU countries.
More than 20 rivers are draining to the Vistula lagoon (3.49 km³ water per year on average), whereof the Pregolya River is the most important one, delivering more than 40% of the incoming water discharge and covering almost 60% of the total lagoon catchment. The most significant Polish river flowing to the Vistula lagoon is the Pasleka River with a catchment size of about 2250 km².
The drainage basin of the Vistula lagoon is mainly used by agriculture (54%), which causes nutrient inputs to the marine water body. Other sources of nutrients are: release of nutrients from sediments and emissions from sewage treatment plants or industrial point sources. Besides, due to poor technical condition of anti-flood and drainage infrastructure there is danger of flooding of low-laying areas.
The status of the Vistula lagoon highly depends on the condition of its catchment and inflowing rivers. Changes in climate and land use, which can be expected due to overall global trends and regional development, may cause variations in water quantity and quality coming from the drainage basin and affect the lagoon's ecological and socio-economical potential. To tackle possible future threats and problems, a coordinated transboundary water management is needed. This can be effectively supported by the use of watershed models to evaluate possible future problems and feasible adaptation measures.
The objective of the study presented here is modelling of the runoff conditions and freshwater inflows coming from the total catchment to the Vistula lagoon with the Soil and Water Integrated Model (SWIM) using available climate data within and around the basin as well as spatial data for elevation, land use, and soil types. Time series of measured water discharge are used for model calibration. As a next step, the model can be calibrated for water quality and applied for analysis of nutrient input to the lagoon.
SWIM is a process based semi-distributed eco-hydrological model for the river basin and regional scale calculating processes by subdividing the catchment into subbasins and hydrotopes. These smallest spatial units (defined by overlaying land use, soil and subbasin maps) are used to simulate hydrological processes and nutrient cycles as well as vegetation growth in the basin. Climate data as one of the most important drivers of the different model processes are interpolated to the subbasin centroids by using an inverse weighted distance method.
After successful hydrological calibration and validation of the SWIM model comparing observed and simulated daily discharges measured at the two influents Pregolya and Pasleka with satisfactory results (NSEdaily=0.66/0.62, NSEmonthly=0.74/0.73, PBIAS=6/-3%) the model was extended to the entire Vistula lagoon basin to estimate total inflows from the watershed. Long term averages and seasonal dynamics of the total water inflow into the Vistula lagoon for the reference period were estimated for further comparisons with scenario simulations.
This model setup and calibration delivered a base for water quality modelling and climate and land use change impact assessment taking into account projected future climate and land use options according to the ENSEMBLES and regional land use change scenarios to evaluate flooding and eutrophication risks of the Vistula lagoon system.
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KEY WORDS: *Vistula lagoon, model calibration, watershed modelling, impact assessment, water discharge.*