Shifting sedimentation patterns in the Curonian Lagoon under climate change

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Introduction: The sediment transport mechanisms and their influence to the system is very little explored in the Curonian lagoon, a shallow lagoon with the average depth of 3.8 m, placed in the south-eastern part of the Baltic Sea with only one narrow connection to the sea in the North. It is a biggest lagoon in Europe with a very high river discharge and sediment loading coming to it. The Nemunas River discharge exceeds the water volume of the lagoon itself by about 3.6 times per year. In the lagoon, the main types of the sediments vary from medium sand, fine sand to coarse silt and fine silty mud.

Methods: For this study the framework of numerical models were used. The SHYFEM modeling system was applied for the sediment dynamics analysis in the lagoon for the period 2004-2015. SHYFEM is a finite element 3-D hydrodynamic model that includes a transport and diffusion model and a radiation transfer model of the heat at the water surface and other modules. For the sediment transport simulations the SEDTRANS05 module was used.

For the hydrodynamic part of the model a more detailed description of the model equations and discretization method is given in [1] and its 3D implementation to the Curonian Lagoon in [2]. It is the first time that a sediment model is applied to the Curonian lagoon. The reader can refer to [3], [4] for further details on the SEDTRANS05 model application and validation in other environments.

For the climate change two scenarios were studied, the RCP4.5 and RCP8.5. Predicted meteorological data and sea data in the Baltic Sea were available, as well as forecast of Nemunas discharges.

Results: The sediment model calibration and validation were carried out for the year 2014-2015 in two lagoon stations with the different sediment characteristics. The validation gave satisfactory results.

Validated model gave us a possibility to identify the erosion-accretion zones in the lagoon and evaluate the Nemunas sediment propagation in the system. The results showed that even if the Nemunas River brings a lot of the sediments to the system, the strong storm events can wash a lot of sediments out of the system, and that big erosion zones in the lagoon are formed.

The presents of the ice cover in the model for the winter period shelters the water from strong wind events and its influence on sediment transport is important, as the validation results clearly showed.

Climate change scenarios will be investigated and the sensitivity of the sediment deposition mechanisms and suspended sediments will be studied.

Discussion: Sediment transport is a crucial feature in the Curonian lagoon because of the high input of the sediments through the Nemunas River that are continuously changing the physical characteristics of the Curonian Lagoon. The development of sediment transport model for Curonian lagoon will lead to obtain holistic view of this system, forecast the processes and foresee the measures for mitigation of negative consequences.

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