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Numerical modelling based analysis of the hydrotechnical constructions impact on the Amur river near Blagoveshchensk and Heihe cities

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The paper presents the results of numerical modeling of the water flow and sediments transport at the confluence of the Amur and the Zeya rivers. The Russian-Chinese state boundary passes along the Amur river between Blagoveshchensk (Russia) and Heihe (China) cities here. Based on the methods of mathematical modeling, the analysis of hydrological conditions and channel processes under the influence of hydrotechnical construction on the site of Blagoveshchensk (Russia) - Heihe (China) was carried out. STREAM_2D program complex (authors V. Belikov et al.), which is based on the numerical solution of two-dimensional Saint-Venant equations on a hybrid curvilinear quadrangular and rectangular mesh and take into account sediment transport, was used for the simulations. More than 10 line structures in river channels and floodplains, including dams from the Chinese side, embankments of Blagoveshchensk, existing and under construction bridges, road embankments on the floodplain were taken into account in the model grid and relief. The calibration and validation of the model was carried out according to the engineering surveys of 2017, as well as from the hydrology data of the Amur and Zeya gauge stations over a long period, including extreme flood of 2013 year. For additional model validation for the flood of 2013 year Radarsat satellite image with a spatial resolution 6 m was used. The results of the STREAM_2D model validation demonstrated that the model reproduces the situations rather well. The differences in simulated and observed water levels for the control gauges: ‘Amur – Blagoveshensk’, ‘Amur – Zeya’ never exceeded 30 cm, and the relative errors were 10 % in terms of flood area at the time of peak flow.
Continuous simulation of water flow and sediment transport for long-term period from 2011 until 2016 year was carried out. From 2014 year two scenarios were considered: dams construction between Chinese islands and the city Heihe was taken into account in the first case, and the simulation were finished without additional constructions in the second case. The comparison of the simulation results showed two main tendencies: with hydrotechnical construction and shutting of the side channels from the right bank, an increase in erosion in the mainstream below the confluence near the left bank and a simultaneous increase in accumulation near the right bank of the river Amur below the island system can take place. The main reason for the observed changes is the concentration of the flow in the main river channel and a reduction in the water flow entering the island system. Based on the simulation results, the water discharges in the main river channel above the confluence during the flood period with input discharges 1500-5000 m3/c can increase by 15-25%, during peak flow - by 5-6%.
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