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Ice-jam floods modeling in frameworks of intelligent system for river monitoring

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This paper presents the research results related to the development of an intelligent system for monitoring and assessing the state of natural systems (PROSTOR), which was tested in the area from the city of Velikiy Ustyug to the city of Kotlas on the Northern Dvina River. It is one of the most vulnerable places in Russia to spring snow-melt and ice-jams induced floods.

The proposed automated flood forecasting technology is based on the concept of a multi-model description of complex natural objects implementing a mechanism of the selection and adaptation of parameters of the most adequate model for each specific situation. The computational core of PROSTOR is the two-dimensional hydrodynamic model STREAM_2D and its newer version STREAM_2D_CUDA based on the numerical solution of the shallow water equations with discontinuous bottom. Additional hydraulic resistance due to the ice roughness and decrease in the flow cross-section due to ice-caused congestion were taken into account for modeling the ice-jams water levels. The forecasting capabilities of the system are secured by the prediction of water levels at the gauging stations located upstream from Velikiy Ustyug basing either on neural networks, or by means of linking with the runoff formation model ECOMAG and using prognostic meteorological information.

The system was built with the use of a service-oriented architecture, that provides flexible interaction between software modules, implementing hydrodynamic and hydrological models; modules of collecting and processing of heterogeneous data, including data from gauging stations and remote sensing data; control modules, etc. All system components are realized as web services and can be geographically distributed and localized in various organizations, cities and countries. All results of the system implementation, including the results of flooded zones calculations, flow parameters there, as well as satellite images are available via the geoportal.

Models parameters were justified on the base of numerical experiments and simulations of the floods of 1980-2016 period, including more than 18 significant cases of ice-jamming. Grouping of model parameters according to the height of the ice-jam induced water levels suggested for the implementation of the hydrodynamic model incorporated into intelligent information system of

river floods monitoring. Operational flood forecasting mode of the system was tested during 2017 – 2019 years under support of Russian Science Foundation project № 17-11-01254.