Long-term hydrodynamic modeling and analysis of flooding characteristics sensitivity to changes in natural and anthropogenic factors for key areas in Russia

Inna Krylenko (1,2), Vitaly Belikov (2), Pavel Golovlyov (1), Ekaterina Kornilova (1), Aleksey Sazonov (1,2), Eugeniya Fingert (1,2)

(1) Lomonosov Moscow State University, Faculty of Geography, Moscow, Russian Federation (krylenko_i@mail.ru), (2) Water Problems Institute of the Russian Academy of Sciences, Moscow, Russian Federation (belvv@bk.ru)

Changes in flooding characteristics are usually caused by a complex of natural and anthropogenic factors, and the role of the latter is often underestimated. In this research for the several populated floodplain areas in the different part of Russia (the Lena river near city Yakutsk, the Northern Dvina river - Veliky Ustyug, the Oka river – Ryazan and Tom river – Tomsk) continuous simulations of flooding dynamics for the long period from the end of 1970th till present were carried out using two-dimensional hydrodynamic model STREAM_2D (author V.Belikov). Detailed topography and bathymetry data were used for model setup. Data about water levels from gauging stations and inundation zones from satellite images were attracted for model calibration and validation. Floods for the key areas at the Yakutsk, Tomsk and Veliky Ustyug are combined runoff - ice jams induced, thus special approach taking into account ice jam parameters such as additional roughness and decreasing of water depths in ice jam was implemented. Changing in floodplain development (roads construction, settlement area increasing), daily water discharges and information about ice jams formation were taken into account during modeling.

Long-term dynamic of flooding areas, water depths, floods duration and intensity were analyzed; dependencies of the main flow characteristics averaged for the modeling area from the input water discharges at modern condition and for the different scenarios of the floodplain development were obtained as result of the numerical experiments. For the less populated floodplains near Yakutsk city tendency in increasing of mean maximum water discharges in the 2001-2015 in comparison with 1985-2000 onto 13% led to expansion of inundation area on 8%, but duration of flooding became less. The Veliky Ustyug city has suffered from ice-jam induced floods repeatedly, and more than half of the city was inundated in the 1998, 2013, 2016 years. Protective dam is under construction here. According to the modeling results inundation area during ice jams on 15-30% higher than during of the same water discharges without ice jam formation.

Decrease in floodplains areas due to anthropogenic activity leads to an increase in the flow intensity on the remaining floodplains (up to 15-20%), this is most pronounced for the Oka and Tom river study areas, where bridges and road embankments crossing floodplains were constructed in 1970-1990 years. At the Tom river increasing of the ice jams frequency and the fast growing of the settlement areas on the floodplain in the last two decades led to hazardous flooding situations of the 2010 and 2015 years which has showed that uncontrolled floodplain development should be stopped here. Thus, the combination of ice jams formation and anthropogenic development of floodplains can be more significant in terms of the flooding hazard growing up than runoff increasing for the key study areas.