Assessment of anthropogenic impact on flood dynamics in Moldova using hydrological modeling

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Abstract

Main hydrological disasters that occur in the Republic of Moldova are floods. In the last 70 years (1947-2015) floods caused losses of 583 mil. US$. Thereby, a proportion of 55% of the damage was determined by flash floods and 40% - by fluvial floods. Increasing human impact on environment is considered to be the main factor for modifications of flood runoff regimes. Moldova features intense economic activity resulting in the fact that over 60% of the territory is used for agriculture and almost all rivers' morphology is heavily modified. Therefore, the evaluation of anthropogenic impact on floods generation and propagation processes is of particular interest. Environmental change scenario modelling was performed to analyze the modification of flood wave hydrograph features with the help of the JAMS/J2000 hydrological model. 11 pilot basins have been utilized for this analysis, which represent different parts of the country. Assessment of land cover changes impact over the past 3 decades on flood runoff was performed by consecutive change of land cover layer for 1982 and 2013 for each flood event. The results showed that land cover changes caused a slight decrease of flood runoff in the northern part of the country (-4-10%) due to processes of basins naturalization in areas that were left fallow with undergoing natural succession. In the central and southern rivers basins an increase of flood features could be identified (+2-35%) because of intensified agricultural and urbanization processes. Assessment of reservoir impact on floods was performed on example of the Byc River, which is subject to change due to the Ghidighici reservoir. Thus, first, hydrological model was calibrated and validated for the Byc River natural runoff period and later applied for runoff simulation for the reservoir operation period. Differences of real and naturalized modeled runoff showed that Ghidighici reservoir causes a significant decrease of flood runoff which is from 3 up to 20 times lower than in the case of natural runoff modeling. Resulted hydrological models are well suited for land planning, hydraulic engineering and flood control. They can serve as support for authorities in decision making in flood protection and water resources management.

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Assessment of land cover impact on regional flood dynamics on the rivers of Moldova using hydrologic modeling

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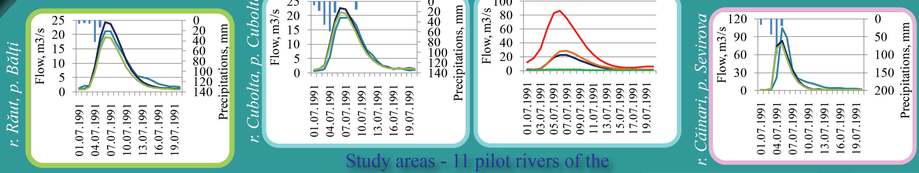
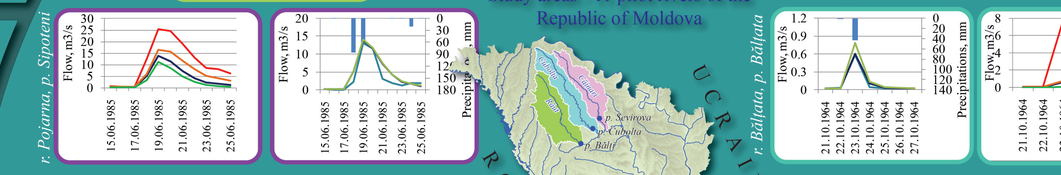
Background

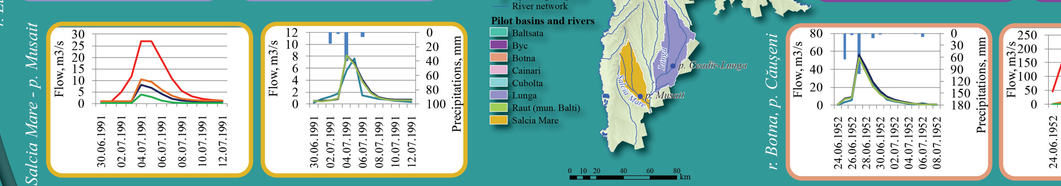
Main hydrological disasters that occur in the Republic of Moldova are floods. In the last 70 years (1947-2015) floods caused losses of 583 mil. US$. Thereby, 55% of the damage was determined by flash floods and 40% - by fluvial floods. Increasing human impact on environment is considered to be the main factor for modifications of flood runoff regimes. Moldova features intense economic activity resulting in the fact that over 60% of the territory is used for agriculture and almost all rivers' morphology is heavily modified. Therefore, the evaluation of anthropogenic impact on floods generation and propagation processes represents the main objective of presented study.

Factors and variables that contribute to generation and propagation of foods

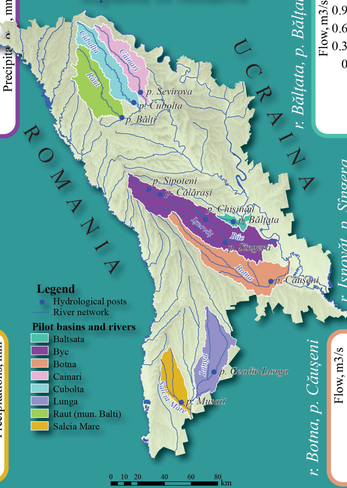
Real and modeled flood hydrographs







Study areas - 11 pilot rivers of the Republic of Moldova

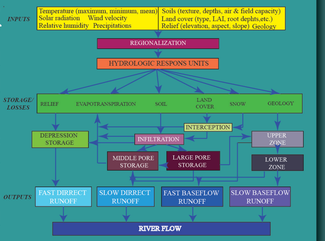


Legend to hydrographs

Precipitations
Measured flow
Modeled flow, LU1982
Modeled flow, LU2013
Modeled flow, LU Settlements
Modeled flow, LU Arable
Modeled flow, LU Forest

Methodology

Modeling of flood generation processes was performed using the physically-based, spatially distributed JAMS/J2000 model. Regionalization of environmental properties was done by applying the HRUs concept. Flood processes were studied using the biggest pluvial flood events that occurred during 1945-2012 on pilot rivers. Assessment of land cover changes impact over the past 3 decades on flood runoff was performed by consecutive change of land cover layer for 1982 and 2013 for each flood event. 3 analytical extreme scenarios which show the theoretical possible variation of stream flow modifications caused by different land covers (basin cover by settlements, forest and arable area) were used.



Conceptual framework of JAMS/J2000

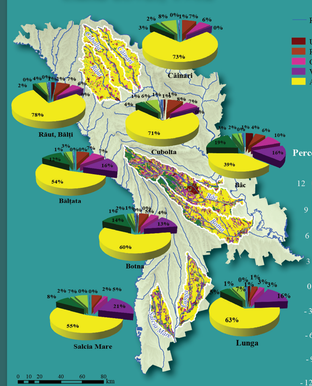
Study areas

Moldova is a small landlocked country situated in South-Eastern part of Central Europe. The river network includes more than 3000 rivers, main being cross border rivers Prut and Dniester. Modification of flood wave hydrograph features in conditions of changing environment was performed on example of 11 pilot basins that conventionally represent the northern, central and southern parts of the country.

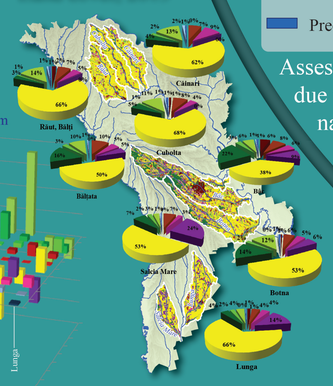
Results

General modifications in land cover on bazinal level are expressed by increases in of areas with grassland (max 11%) and decreases of vineyards (max. 10%). In the basins from central part of the country expansion of areas with forest, grassland and settlements can be observed. In northern part of the country certain arable areas are replaced by grassland. The southern river basins do not have specific changes in land cover.

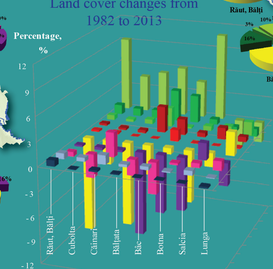
Land cover, 1982



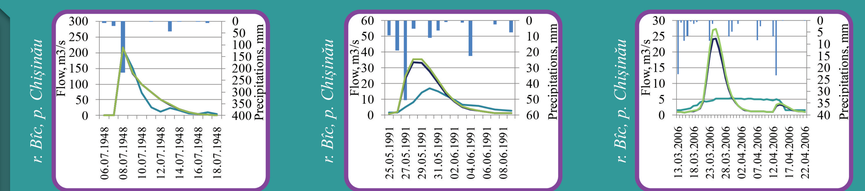
Land cover, 2013



Land cover changes from 1982 to 2013



Assessment of reservoir impact on floods was performed on example of the Byc River, which is subject to change due to the Ghidighici reservoir. Thus, first, hydrological model was calibrated and validated for the Byc River natural runoff period and later applied for runoff simulation for the reservoir operation period. Differences of real and naturalized modeled runoff showed that Ghidighici reservoir causes a significant decrease of flood runoff which is from 3 up to 20 times lower than natural runoff .



Conclusions

The results showed that land cover changes caused a slight decrease of flood runoff in the northern part of the country (-4-10%) due to processes of basins naturalization in areas that were left fallow with undergoing natural succession. In the central and southern rivers basins an increase of flood features could be identified (+2-35%) because of intensified agricultural and urbanization processes.

Modification of modeled flood runoff characteristics using different land cover scenarios compared to those modeled basing on LU 1982, mean %

River, post	Land cover of the river basin / flood characteristics											
	LU 2013			100 % arable			100 % forest			100 % settlements		
	Peak flow	Mean flow	Flood volume	Peak flow	Mean flow	Flood volume	Peak flow	Mean flow	Flood volume	Peak flow	Mean flow	Flood volume
r. Răut, p. Bălți	-11.1	-12.3	-12.3	-14.4	-11.4	-11.8	-85.3	-80.6	-81.1	586	566	571
r. Căinari, p. Sevirova	-10.0	-11.3	-11.4	2.0	6.1	6.0	-69.7	-67.8	-68.3	471	409	414
r. Cubolta, p. Cubolta	-4.2	-4.3	-4.4	9.6	11.6	11.6	-85.5	-81.1	-81.5	334	341	341
r. Bălțata, p. Bălțata	16.2	14.2	14.5	-18.2	-4.7	-5.8	-52.9	-51.2	-51.6	705	820	829
r. Pojarna, p. Sipoteni	1.7	0.9	0.9	12.2	38.5	37.4	-14.4	-23.0	-22.8	117	169	167
r. Bîc, p. Chișinău	4.3	3.6	3.7	-	-	-	-	-	-	-	-	-
r. Ișnovăț, p. Șingera	34.7	36.5	37.0	-36.9	-34.2	-35.2	-84.0	-85.7	-85.7	436	684	684
r. Botna, p. Căușeni	-4.1	-7.5	-7.3	24.6	31.3	31.5	-63.2	-66.0	-66.2	651	617	622
r. Ialpug, p. Comrat	-10.5	-10.1	-10.4	22.2	34.6	32.5	-94.3	-95.4	-95.4	1446	1590	1579
r. Lunga, p. Ceadîr-Lunga	9.6	10.1	10.0	-65.3	-30.4	-34.8	-93.8	-85.7	-87.1	1294	1323	1354
r. Salcia Mare - p. Musait	6.9	1.6	1.8	52.3	63.3	63.1	-73.9	-75.9	-76.1	602	600	614

Application of 3 LU analytical extreme scenarios showed that flood characteristic will change dramatically. In case of basin cover by forest flood characteristics will decrease by aprox. 80%, in comparison in case of basin cover by settlement they will increase by 100-1600%.

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