HYDROLOGICAL MODELING OF THE HIGH FLOW IN MARITZA RIVER BASIN IN AUGUST 2005
ANALYSIS OF THE INFLUENCE OF THE TOPOLNITZA RESERVOIR

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Abstract

High waters that streamed down the beds of nearly all rivers of Maritza river basin and especially down the bed of Topolnitza river from the fourth till the seventh day of August 2005 were an event of major influence upon all aspects of life in this region of Bulgaria. They were caused by the extreme amount of rainfall in the areas of Ihtiman, Kostenets, Dolna Banya etc., in the North-West part of the river basin on the fourth and the fifth day of August and in the Rhodopy and the Gornotrakiyska valley regions on the following days. The high water stream itself caused overflow of the rivers Mativir, Topolnitza and Maritza in a number of areas downstream of their river beds and caused substantial material damages and even took away a human life. In the Rhodopi region, the waters of Chepinska, Cherna, Shirokolashka and Chepelarska rivers also caused substantial disruption of their river banks. Supporting walls and other items of infrastructure were pulled down at many places. Large areas of road covering sank down. Considerable material damages were caused in the towns of Smolyan, Velingrad and Chepelare.

To find the numerical expression of the approximate flow in the river network near the city of Plovdiv for the purposes of this research, the physical processes in the ground layer of the atmosphere, in the ground – under ground combination and in the river network for the period from the first till the tenth of August were simulated. Streamflow is calculated for profiles with monitored river flow and in separate, additional profiles like outlets of rivers to Maritza (Ochushnitza, Yadenitza, Luda Yana, Vacha). The purpose of this analysis is to explain the genesis of the high wave rather than to give a precise numerical expression of its existence. Therefore, the numerical results achieved during the modeling shall be considered as tentative.

Due to the decisive influence of the artificial lake of Topolnitza over the hydrological processes in the river beds of the rivers Topolnitza and Maritza, an evaluation was made in this research of the influence of the Topolnitza reservoir over the maximum water quantities that flew down through the cities of Pazardzhik and Plovdiv. The natural water feed at the wall of the artificial lake of Topolnitza was simulated. The daily average flow of the Maritza river at the city of Pazardzhik and at the city of Plovdiv was simulated on the following three conditional hypothesis: A) natural flow down the whole basin with the exclusion of the Vacha cascade; B) Evaluation of the regulative influence of the artificial lake of Topolnitza by data given by “Irrigation systems” PLC; C) option with closed valves of the artificial lake.

Numerical models adapted for the basin of Maritza were used for the simulation. These models have been developed by CNRM Météo-France and “Ecole de Mines de Paris” (France). The first organization is a research center at the National Institute of Meteorology of France and there the ISBA (Interface Soil Biosphere Atmosphere) scheme has been developed. The second one is the Higher Institute of Mining – Paris, where the hydrological and hydro geological method Modcou has been developed. The scheme and the model are consecutively connected and are usually used jointly for hydrological modeling and prognosis on national scale in France, Canada and other countries.

Representation of the ISBA scheme:

The ISBA scheme simulates the single dimensional model of the interface between atmosphere and soil. It includes the influence of the periodical vegetation at the calculation of the actual evaporation, which in general, consists of evaporation from the soil surface, from the foliar mass and transpiration of vegetation. The soil characteristics are given as parameters through the mechanical composition of the types of soil.

The scheme calculates the water contents and height (thickness) of the snow pack and respectively the snow piling and the snow melting during the autumn – spring period. The problem solved by the scheme ISBA (figure 1) is to determine the water quantity for surface flow (Qr) and the infiltration (D) by given values of: quantity of rainfall, temperature of air, moisture of air, and other meteorological parameters, variable in space and time.

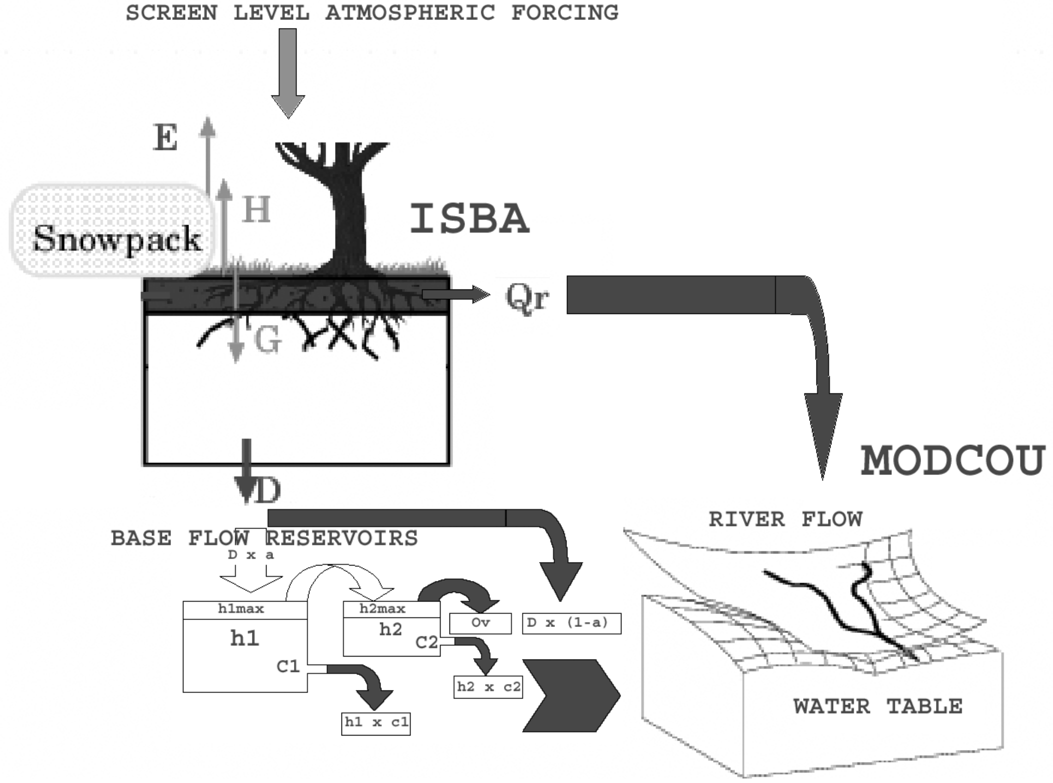


Figure 1: scheme of joint application ISBA – Drainage reservoirs – Modcou

During the modeling of the processes at the surface of the Maritza river basin, the single dimensional scheme ISBA (Noilhan and Mahfouf, 1995) is applied on 638 cells with dimensions of 8x8 kilometers. The scheme uses input data with different intervals in time and calculations are performed at intervals of 5 minutes.

Representation of the hydrological model Modcou

Modcou is a hydrodynamic hydrological and hydro geological model with distributed parameters (Ledoux, 1980). The problem solved by the model is to transport the calculated water volumes through the mathematically represented river network and in the end to calculate the average daily flow amount at certain points of the river network without prejudice to whether monitoring was carried out there or not. The hydrological network is represented by a tree-like network of cells (figure 2). Each one of them receives the surface and the soil water flow and transfers it to the next cell down the river. The flow velocity is determined by isochronal zones (Ledoux, et al. 1989) – with equal times of runoff to the river mouth. On the grounds of a numerical model of the terrain for each call, the time for runoff to the outlet of the cachement area is calculated as part of the maximum runoff time.

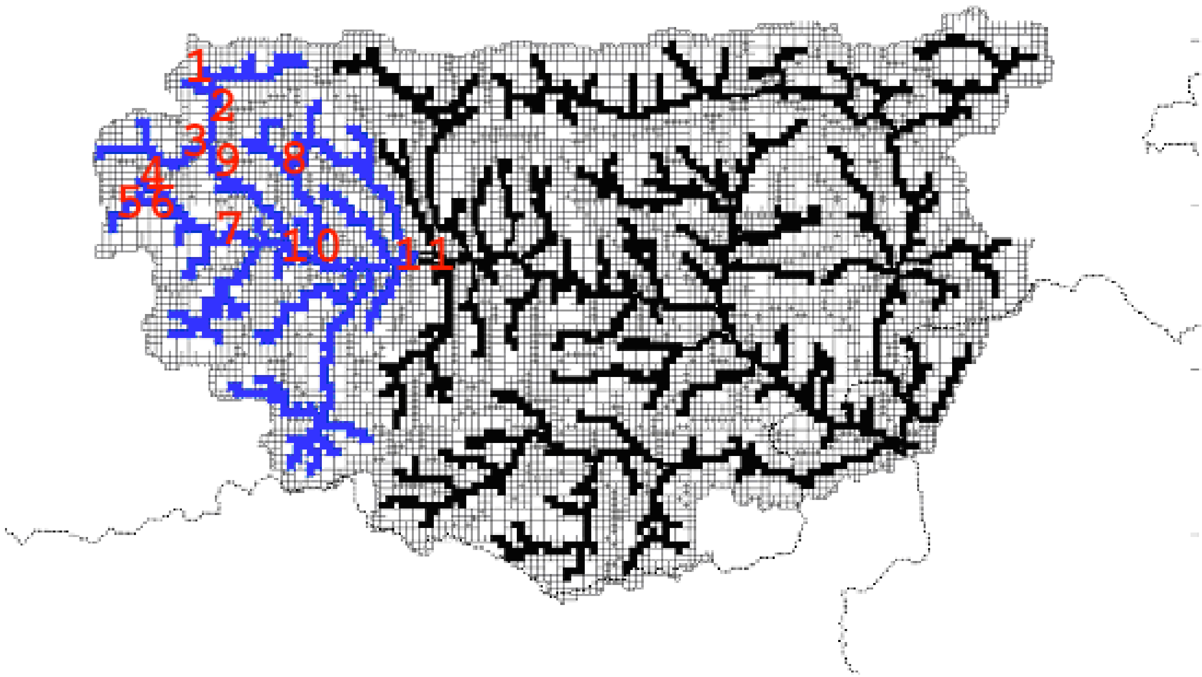


Figure 2: The network of cells of the hydrological model and hydrographic network of the Maritza river basin to the city of Edirne. The part of the basin near the city of Plovdiv is given in blue. Simulation is made at the points with red color where streamflow measurements are also available.

The maximum runoff time is calibrated in an experimental way. The network of surface cells for the Maritza river basin comprises of total 11661 cells with dimensions from 1x1 kilometer to 4x4 kilometers and 2387 of those are river cells. The time interval of the model by which the outflow is calculated is one day an in this research, the average twenty four hour outflow (m^3/sec) is calculated for 77 of the river cells.

Hydrological modeling of the river flow for the Maritza river basin down to the city of Plovdiv.

Preparation of the input data

In this particular case the values of temperature, air humidity, wind velocity and radiation, necessary for the input of the system are received as output data from a short-term meteorological model ALADIN, used by the National Institute of Meteorology and Hydrology (NIMH) for meteorological prognosis. In previous research works it was pointed out that the output fields from ALADIN for temperature and humidity of the near the ground air at time intervals of three hours, as well as those for the sun and air radiation and wind velocity may be used for hydrological modeling (Noilhan, 2002; Artinyan, et al. 2003). The necessary space fields of rainfall are received by space interpolation of the combined rainfall measuring measurements, carried out for the period from the first to the seventh of August by the monitoring networks of NIMH and “Irrigation systems” PLC. These round the clock sums of rainfall quantities (from 07:30 a.m. till 07:30 a.m. of the next day) were critically analyzed. For the purpose of not omitting of measurements and to achieve a satisfactory density of the actually measured values of rainfall quantities, in some cases the data were logically corrected. For the achievement of a space field, rainfall measurements were interpolated by the technology of “point” krigging. This technology gives advantage to experimental values, whilst the “block” krigging gives advantage to the general characteristics of the field and smooths the iso-lines. It must be pointed out that it is technologically impossible and not necessary for the interpolated field to reflect with absolute precision each one of the measured values. Practical experience shows that the field of rainfall has an ultimately uneven distribution in space. Different measurement points in one and the same area show substantially different valued of the measured rainfall quantities for one and the same time. In such cases, prior to the interpolation of the respective points, they are assigned their average values. Such are the cases with Ihtiman and Etropole, where the data given by NIHM and "Irrigation systems" PLC are substantially different for some of the days between the fourth and the seventh of August.

Calibration of the system with drainage reservoirs and maximum runoff time

At the calibration of the system with drainage reservoirs (SDR) for long periods of time – two and more years, parameters are determined which reflect the average status of soil humidity, rainfall with average intensity and low to average high waters. In this particular case, the intense (extreme) rainfall in the Topolnitza basin and the upper stream of Maritza (above the town of Belovo), the SDR parameters for the above named areas had to be calibrated once again. The daily average streamflow quantities calculated by NIMH, which strictly reflect the direct measurements of the flow, were used as base. It was determined that the maximum runoff time to the city of Edirne, which is an important parameter for the high wave that went downstream is a little over five days, but not as the prior to that determined six days for low and average waters.

Limitation conditions for the modeling

In general, the soil humidity, the water content of the snow pack and the water saturation of the under ground reservoirs, prior to the beginning of the simulation, determine the limitation conditions for the modeling. In this particular case, there is no snow pack and the soil humidity and the contents of the underground reservoirs were initialized by the previous simulation which included the months from September 2004 till august 2005.

Registration of the rainfall intensity

In the course of the analysis, the hypothesis was adopted that in the particular case of extreme rainfall, at modeling with even intensity of rainfall in time ($i = \frac{P_{24}}{86400}[mm \times \sec^{-1}]$), the separation between the infiltrated and the surface outflow may be not realistic. Due to the lack of detailed numerical information about the intensity of rainfall (NIMH and "Irrigation systems" do not have automatic rainfall measuring stations in the region with the exception of those in the city of Plovdiv and the town of Chepelare) and for the purpose of applying a more realistic amount of rainfall, radar pictures for the period fourth to seventh of August made by the meteorological radar of NIMH in Gelemenovo and rain gauge records from rainfall measuring stations were analyzed. The beginning and the end of three separate periods of rainfall with duration of less than twenty-four hours were summarized (items 1, 2 and 4):

1. For the time from 11:00 a.m. of the fourth of August till 05:00 a.m. of the fifth of August, the applied multiplier for intensity was 1.33.
2. From 17:00 p.m. of the fifth of August till 08:00 a.m. of the sixth of August the applied multiplier for intensity was 1.6.
3. From 08:00 a.m. of the sixth of August till 08:00 a.m. of the seventh of August, the intensity was not changed.
4. Form 08:00 a.m. of the seventh of August till 14:00 p.m. of the seventh of August, the intensity was multiplied by 4.0, because rainfall stopped at 14:00 p.m. of the seventh of August.

For the periods 1, 2 and 4 the intensity was changed and for the rest of the time of the same period (from 08:00 a.m. till 08:00 a.m.), rainfall was made zero for the purpose to preserve the total rainfall quantity. The transformation was applied to the whole Maritza river basin. The method has not been proved by detailed investigations, because the ISBA scheme, in general, was calibrated for the basin of the Maritza river basin with daily sum of rainfall evenly distributed over twenty- four hours.

Results from the hydrological modeling of the river flow for the Maritza river basin down to the city of Plovdiv - Simulation of the natural river flow.

The daily average water quantities simulated by the Modcou model from the first to the tenth of August at each station are given in tables 1 and 2. The first results reflect the daily average natural outflow at stations where the artificial lake of Topolnitza has no influence. In addition the simulated natural outflow is given at ranges without direct measurements: at the wall of the artificial lake of Topolnitza, at the outflows to the Maritza river bed of the rivers Ochushnitza, Topolnitza, Luda Yana and Yadenitza (table 2).

Date	Bunovska Bunovo [m^3/sec]	Topolnitza Poibrene [m^3/sec]	Mativir Mirovo [m^3/sec]	Ochushnitza Ochusha [m^3/sec]	Maritza Raduil [m^3/sec]	Let. Kostenets [m^3/sec]	Maritza Belovo [m^3/sec]	Luda Yana Rosen
1/8/05	0.000	1.251	0.138	0.031	0.240	0.007	0.425	0.805
2/8/05	0.000	1.152	0.141	0.031	0.346	0.008	0.561	0.775
3/8/05	0.000	1.070	0.137	0.030	0.237	0.009	0.435	0.747
4/8/05	2.500	33.239	33.966	9.260	5.550	2.261	74.015	1.566
5/8/05	9.495	138.877	103.100	21.185	15.218	10.473	238.827	19.458
6/8/05	12.086	271.485	134.765	22.897	24.038	16.318	329.132	28.682
7/8/05	5.365	130.574	62.317	12.467	13.890	7.091	153.270	1.613
8/8/05	2.453	61.411	38.826	9.862	7.717	3.186	93.106	1.167
9/8/05	0.839	22.960	23.718	6.976	3.647	1.150	55.048	1.158
10/8/05	0.085	6.001	13.202	4.570	1.859	0.242	31.811	1.130

Table 1: Simulated daily average streamflow at stations where the artificial lake of Topolnitza has no influence for the period from the first to the tenth of August 2005.

For comparison, the results from the calculated average daily natural outflow, calculated on the base of direct measurements and registered water levels, in stations where the artificial lake of Topolnitza has no influence, are represented in table 3. The average daily water quantities reported by the sector Hydrology of NIMH – branch Plovdiv were received through values of water levels reported by the monitoring network and rating curves, achieved by registration of direct measurements of water quantities and less often by calculated maximum water quantities. It may be noticed that due to the calibration of the SDR, "higher waters", the model as a whole considerably lowers the low outflow. This fact does not substantially influence the whole picture, but it exclusively demonstrates the role of the type of calibration.

Date	Wall reservoir Topoln.	outflow Topoln.	outflow Ochush.	outflow Chepinska	outflow Luda Yana	outflow Yadenitza	outflow St. reka Peshtera	Wall. Krich. reservoir	outflow Vacha
1/8/05	1.484	1.516	0.052	2.373	0.823	0.067	0.308	9.003	9.313
2/8/05	1.389	1.421	0.052	2.334	0.793	0.076	0.292	8.813	9.113
3/8/05	1.300	1.332	0.050	2.303	0.765	0.085	0.276	8.643	8.934
4/8/05	107.74	110.96	20.463	18.349	1.584	6.384	0.263	8.816	9.103
5/8/05	341.82	367.50	48.815	56.063	21.08	25.362	2.235	56.666	59.848

6/8/05	516.54	574.26	50.861	69.156	32.53	55.859	13.125	132.75	138.16
7/8/05	238.74	261.67	26.843	18.043	1.682	26.079	18.469	56.857	57.698
8/8/05	136.19	151.21	21.000	12.002	1.191	12.481	5.224	32.663	33.052
9/8/05	74.655	84.016	15.529	9.818	1.182	4.967	2.527	26.712	27.102
10/8/05	36.712	42.086	10.872	8.642	1.155	1.256	1.771	23.619	23.998

Table 2: Simulated daily average outflow at river ranges where no hydrological monitoring is performed.

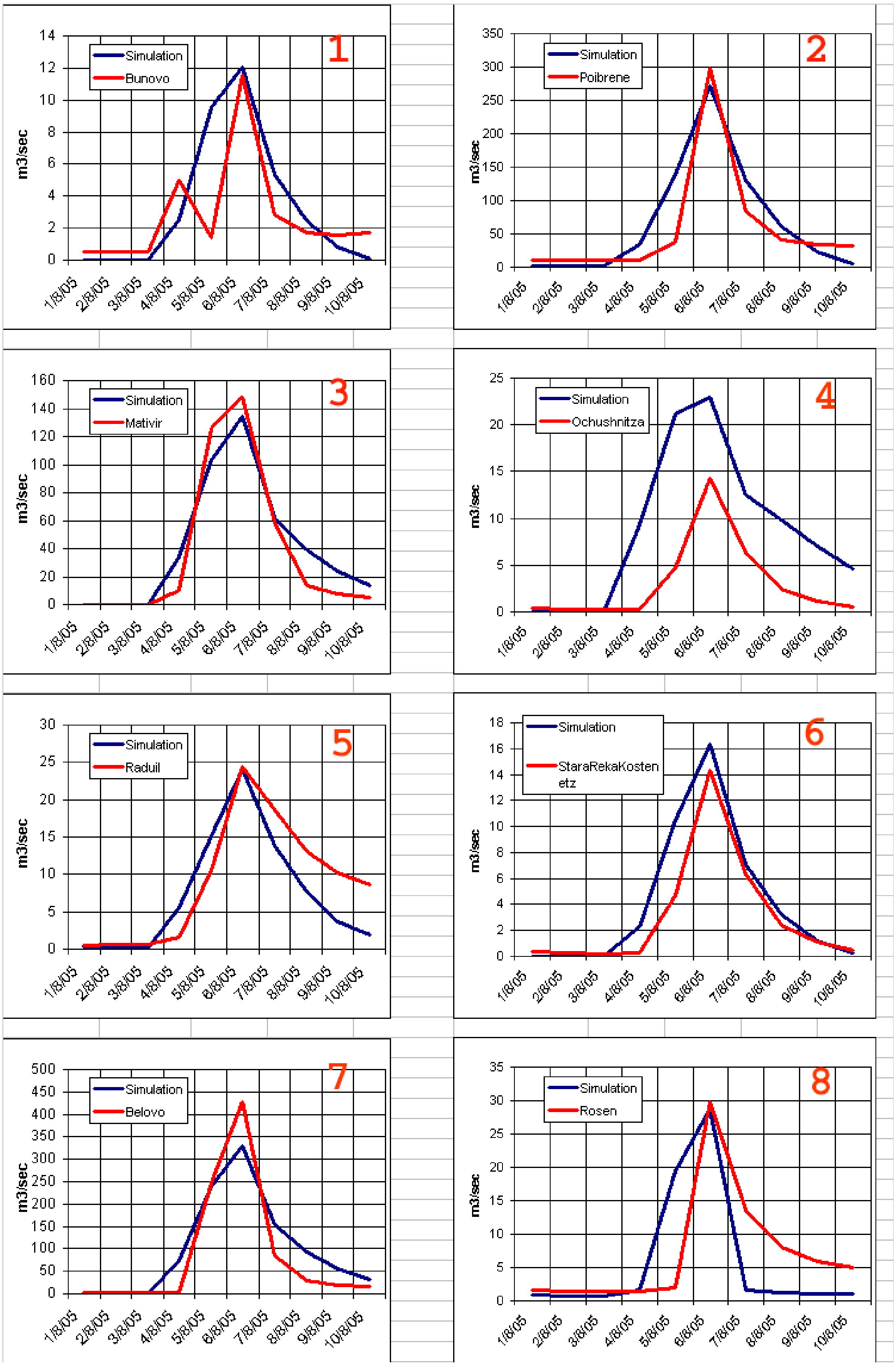
Date	Bunovska Bunovo [m^3/sec]	Topolnitza Poibrene [m^3/sec]	Mativir Mirovo [m^3/sec]	Ochushnitza Ochusha [m^3/sec]	Maritza Raduil [m^3/sec]	Let. Kostenets [m^3/sec]	Maritza Belovo [m^3/sec]	Luda Yana Rosen
1/8/05	0.540	10.200	0.311	0.391	0.482	0.391	2.980	1.550
2/8/05	0.500	10.200	0.285	0.310	0.633	0.310	2.820	1.460
3/8/05	0.500	10.200	0.256	0.210	0.717	0.210	2.820	1.460
4/8/05	5.000	10.200	10.000	0.297	1.540	0.297	3.600	1.380
5/8/05	1.400	37.000	126.000	4.700	10.600	4.700	246.300	2.020
6/8/05	11.550	298.544	148.000	14.330	24.360	14.330	429.500	29.740
7/8/05	2.850	84.000	59.000	6.345	18.660	6.345	84.200	13.500
8/8/05	1.710	41.250	13.500	2.395	13.085	2.395	28.700	8.070
9/8/05	1.560	34.500	7.900	1.096	10.280	1.096	19.100	5.960
10/8/05	1.710	31.800	5.350	0.486	8.680	0.486	16.180	5.050

Table 3: Average daily outflow calculated by direct measurement at the stations not influenced by the artificial lake of Topolnitza for the period from the first to the tenth of August 2005. – source NIMH.

The results given in tables 1 and 2 and in figures 3 and 4, where the same results are represented in a graphic way, naturally lead to the following conclusions:

- The inflow to the artificial lake of Topolnitza for the cited ten-day-period was formed by the rivers Topolnitza and Mativir in almost equal proportion.
- The additional inflow to Mativir in the section after the village of Mirovo, together with the own watershed of the reservoir of Topolnitza, form about 25% of the total inflow of the artificial lake for the cited period.
- For the period from the fourth to the tenth day of August, the outflow of the river of Topolnitza represents 50 – 55 % (Figure 5) of the total outflow of the Maritza river at Pazardzhik.
- Substantial outflow was simulated at the outlets to Maritza of the rivers Ochushnitza, Chepinska and Yadenitza (Table 2).

A comparison between the simulated (natural outflow) daily average quantities and those daily average values, computed on the base of a key curve for the stations where the artificial lake of Topolnitza has no influence is represented on figure 3.



Figures 3: Comparison of simulated values (blue) and values calculated on the base of direct measurements and reported water levels (red) for daily average river flow [m^3/sec] at the stations where the artificial lake of Topolnitza has no influence.

Figure 4 represents a comparison between the simulated daily average natural inflow in the reservoir of Topolnitza and the inflow to the artificial lake of Topolnitza as calculated by the

NIMH. The total volume of the simulated inflow to the artificial lake for the period from the first to the tenth day of August 2005 is 128.5 x 10^6 m^3 and the volume calculated by NIMH is 100.7 x 10^6 m^3 and the maximum values of the inflow per day are as follows 44.6 and 45.7 x 10^6 m^3 for the sixth of August. It is possible the difference on the fourth, fifth and the seventh day of August (20 x 10^6 m^3) to be due to changes in the intensity of rainfall applied at the simulation. Figure 5 represents diagrams of the components of the simulated natural river flow of Maritsa river at the cities of Pazardzhik and Plovdiv.

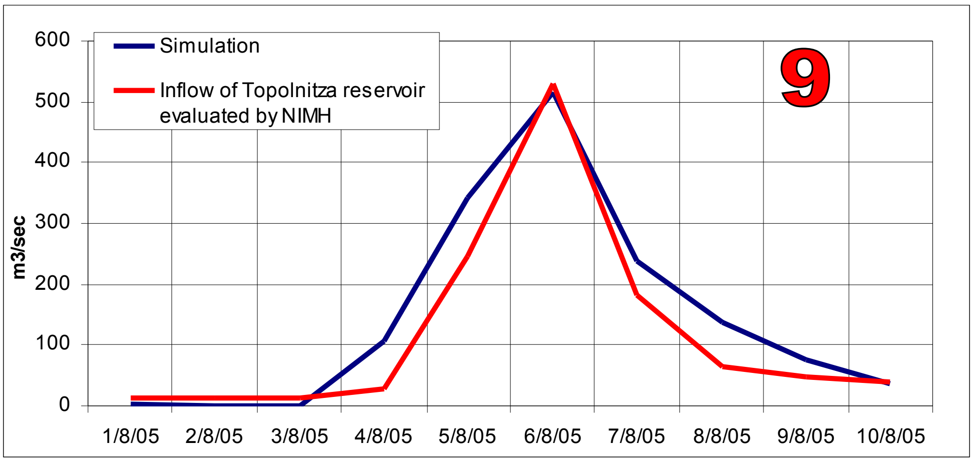
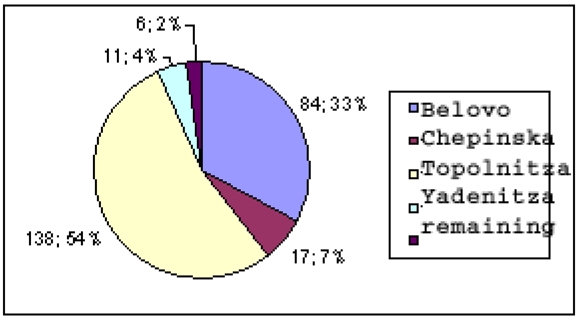


Figure 4: Comparison between the average daily inflow to the artificial lake of Topolnitza, computed by NIMH (in red) and the inflow to the artificial lake simulated by the numerical model (blue color).



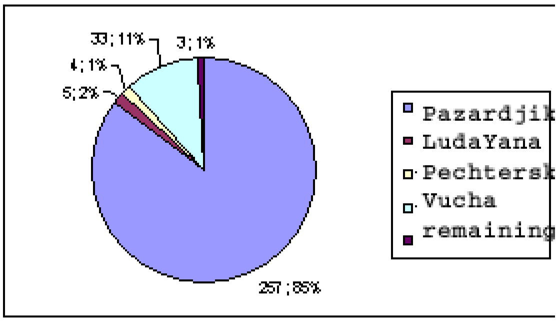


Figure 5: On the left: components of the simulated natural flow of the Maritsa river, Pazardzhik – m^3 x 10^6 for the period from the first to the tenth day of August 2005; on the right: components of the simulated natural flow of the Maritsa river, Plovdiv – m^3 x 10^6 for the period from the first to the tenth day of August 2005

Figure 5 leads to the following conclusions:

- For the riverflow at Pazardzhik: Substantial part of the flow of the Maritsa river at Pazardzhik is formed in Topolnitza river basin – 54%;
- For the riverflow at Plovdiv: 85 % of the riverflow of the Martsa river at Plovdiv is formed by the inflow at Pazardzhik. In other words, 46% of the riverflow at Plovdiv come from the river of Topolnitza; 28% are formed by the feeders of Maritsa upstream from Belovo and another 11% come from the river of Vacha.

Evaluation of the influence of the Topolnitza reservoir over the daily average water quantities at the cities of Pazardzhik and Plovdiv.

The artificial lake of Topolnitza ranks third in volume (137 m^3 x 10^6), but second large in catchment area (1381 km^2) after the Zhrebchevo reservoir in the zone of the northern feeders of the Maritsa river. The main purpose of this artificial lake is along with the Pyasachnik reservoir, to provide water for irrigation purposes in the agricultural areas of the counties of Pazardzhik and Plovdiv, between the rivers of Stryama and Topolnitza.

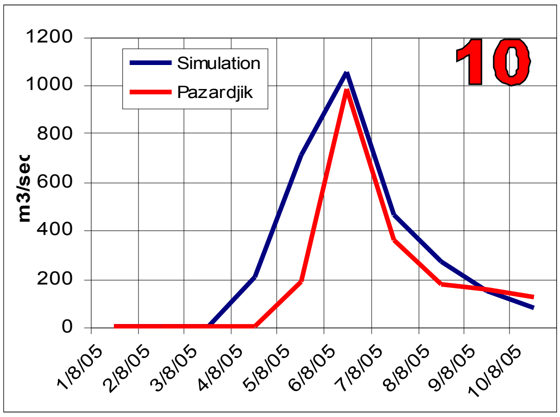
At the simulation of the river flow, the influence of the artificial lakes may be considered only if data is supplied for the outflow of water quantities of each of the artificial lakes, water collectors and derivations within the basin under research. This research work uses the supplied data for the daily average water quantities outlet from the artificial lake of Topolnitza from the first to the tenth day of August 2005. (table 4). According to information provided by specialists, during the period under research no substantial quantities of water have been outlet from the artificial lake of Krichim for protective purposes. On the other hand, the analysis shows that upstream the bed of Maritsa, near the town of Belovo, the outflow was just like the natural outflow, without disturbances. The simulation provides satisfactory reflection of the measured flow of the Maritsa river at the village of Raduil, the town of Belovo and the Stara Reka of Kostenets.

To analyze the sole influence of the artificial lake of Topolnitza, the flow graphics of the simulated daily average water quantities for Pazardzhik and Plovdiv are presented, on the following three hypotheses:

1. Natural outflow with the outflow from the cascade of Vacha excluded. (Influences the river flow at Plovdiv);
2. Regulative influence of the artificial lake of Topolnitza, included in accordance with the provided data for the daily average water quantities outlet from the reservoir of Topolnitza;
3. Influence of retention by the reservoir of Topolnitza if the outlet valves are closed, included.

Hypothesis of natural outflow

The red color on figure 6 shows the hydrographs of the daily average flow, measured by NIMH and the blue color – those of the simulated natural flow (without the participation of the Topolnitza reservoir.) of the Maritsa river at the cities Pazardzhik and Plovdiv. The same data are to be found in the table 4 as well.



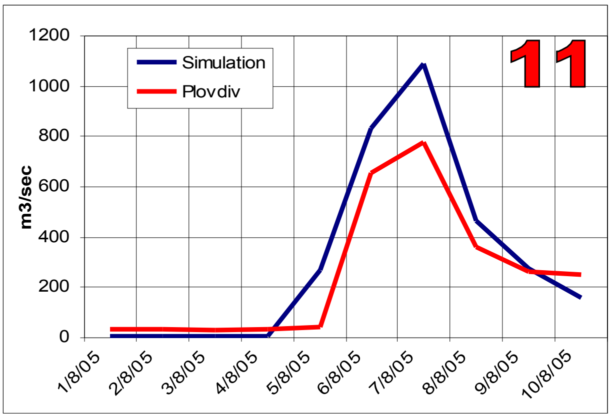


Figure 6: Hydrographs of the daily average natural flow [m^3/sec] (without the influence of the Topolnitza reservoir) in blue – the daily average natural flow [m^3/sec] measured by NIMH – in red – at Pazardzhik and Plovdiv.

Date	Simulated inflow to the artificial	Simulated natural inflow at Pazardzhik	Simulated natural inflow at Plovdiv	Simulated natural inflow at the wall of	Reported outgo artificial lake of	Simulated flow at Pazardzhik with the	Simulated flow at Plovdiv with the influence	Measured outgo Pazardzhik	Measured outgo Plovdiv

	lake of Topolnitza		without Vacha	the artificial lake of Krichim	Topolnitza	influence of reservoir Topolnitza, taken into consideration	of reservoir Topolnitza, taken into consideration		
1/8/05	1.484	4.872	7.85	9.003	18.50	21.90	24.831	8.7	27.4
2/8/05	1.389	4.884	7.72	8.813	18.50	21.95	24.745	8.5	25.1
3/8/05	1.300	4.645	7.65	8.643	18.50	21.80	24.711	8.5	28.52
4/8/05	107.744	211.695	7.64	8.816	18.50	175.67	24.801	8.5	25.15
5/8/05	341.819	706.952	268.52	56.666	152.47	567.65	232.502	194	43.547
6/8/05	516.542	1060.782	831.91	132.746	324.44	870.05	692.617	992	655
7/8/05	238.720	466.601	1090.95	56.857	307.32	404.85	900.221	365	777
8/8/05	136.194	272.324	465.14	32.663	281.75	379.40	403.395	178	362
9/8/05	74.655	155.526	276.72	26.712	158.36	270.16	383.798	159.9	258.5
10/8/05	36.712	84.754	160.54	23.619	79.15	147.83	275.169	128.5	249.95

Table 4: The daily average flow [m^3/sec] of the Maritsa river at the cities Pazardzhik and Plovdiv with and without taking into consideration of the influence of the reservoir of Topolnitza at the simulation. In the last two columns, there are the results for the daily average flow at the two stations, presented by NIMH.

Regulative influence of Topolnitza reservoir, according to the presented data for the daily average quantities outlet from the Topolnitza reservoir.

At accessible data for the outgo part of the balance of the Topolnitza reservoir (Table 4, column 5), the daily average water quantities at Pazardzhik and Plovdiv may be simulated with the purpose to determine whether the modeling may reproduce the effect of the retention, exercised by the artificial lake. Figure 7 represents a comparison between the measured (in red) and the simulated (in blue) daily average quantities at Pazardzhik and Plovdiv. It may be seen that at Plovdiv the results from the simulation, when the influence of the artificial lake of Topolnitza is taken into consideration, are very close to the daily average quantities presented by NIMH

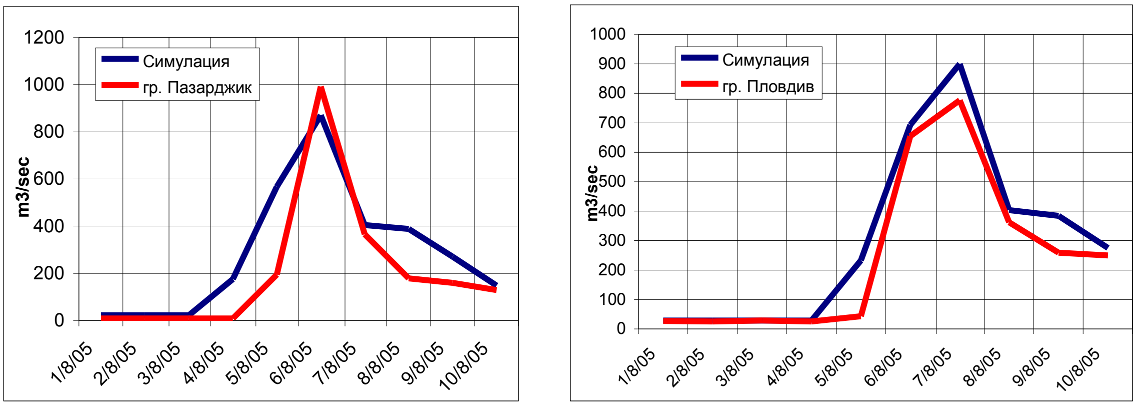
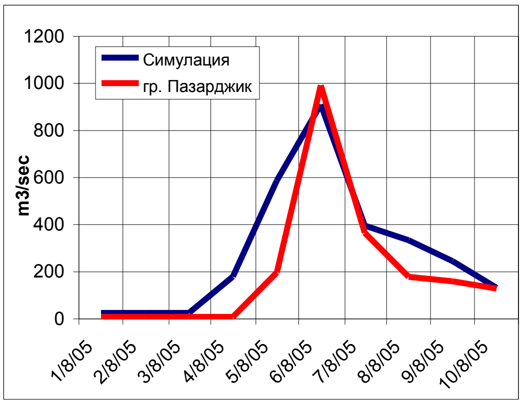


Figure 7: Simulated and measured daily average quantities at Pazardzhik – on the left and at Plovdiv (on the right) with the influence of the artificial lake of Topolnitza, taken into consideration [m^3/sec].

Retention of the Topolnitza reservoir when the outlet valves are closed

For this hypothesis, data for the outgo of the artificial lake of Topolnitza with closed outlet valves. The data for the simulated outflow are summarized in Table 5 and Figure 8.



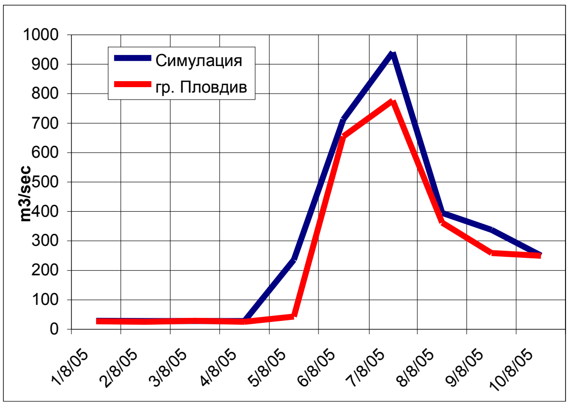


Figure 8: Simulated and measured by NIMH daily average quantities at Pazardzhik – on the left and Plovdiv (on the right) with influence of the artificial lake of Topolnitza with closed outlet valves, [m^3/sec] taken into consideration.

Date	Reported outflow, reservoir of Topolnitza with closed outlet valves	Simulated outflow Pazardzhik with the influence of the Topolnitza taken into consideration	Simulated flow Plovdiv with the influence of the Topolnitza reservoir taken into consideration	Measured streamflow Pazardzhik NIMH	Measured streamflow Plovdiv NIMH
1/8/05	22.04	25.44	28.37	8.7	27.4
2/8/05	22.04	25.49	28.29	8.5	25.1
3/8/05	22.04	25.34	28.25	8.5	28.52
4/8/05	22.04	179.21	28.34	8.5	25.15
5/8/05	188.44	587.41	236.04	194	43.547
6/8/05	369.09	910.37	712.37	992	655
7/8/05	246.23	396.63	940.53	365	777
8/8/05	251.18	333.58	395.18	178	362
9/8/05	139.11	245.25	337.97	159.9	258.5
10/8/05	67.43	132.34	250.26	128.5	249.95

Table 5: Daily average river flow [m^3/sec] of the Maritsa river at the city of Pazardzhik and the city of Plovdiv with the influence of the artificial lake of Topolnitza taken into consideration with the hypothesis of closed outlet valves.

Conclusion

The represented results from the hydrological modeling of the river flow in the Maritsa river basin till the city of Plovdiv (Tables 4 and 5) lead to the following inferences: The simulated water volumes that went through the ranges of the Maritsa river at the city of Pazardzhik and the city of Plovdiv for the first four days of the high wave – 4^{th} – 7^{th} of August (5^{th} – 8^{th} of August for Plovdiv) have been reduced to a considerable extent by the influence of the artificial lake of Topolnitza. At the city of Pazardzhik, the simulated volume at natural outflow for the period is 211 x $10^6 m^3$ and for Plovdiv – 229 x $10^6 m^3$. When the Topolnitza reservoir is included in the simulation, the volumes are 174 x $10^6 m^3$ and 193 x $10^6 m^3$ respectively. The maximum daily average water quantities are reduced by 17-18%. With the hypothesis of closed outlet valves, the influence is substantially less demonstrated – the daily average quantity at the day of the maximum is 14% lower.

However, it is obligatory to mention that in this paper was not discussed the possible influence of a larger free volume in the reservoir at the beginning of the event, which is an exercise beyond the objectives of that research.

On the other hand those results are proving the efficiency of the modeling method to simulate the interaction between natural phenomena – the intense precipitation event and the following high flow in the rivers and the artificial infrastructure – as reservoirs, derivations etc.

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