COMPARISON BETWEEN SOME DETERMINIST AND CONCEPTUAL MODELS APPLIED IN THE HYDROGRAPHIC AREA BANAT FOR THE RIVERS DAILY FLOW SIMULATION

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***Abstract*:** Hydrological models are used to simulate catchment response, most frequently the discharge from the catchment as function of precipitation, temperature, potential evapotranspiration, and parameters that implicitly or explicitly characterise the hydrological condition in the watershed.

The developments in the field of hydrology, hydraulics, and mathematical modelling improve the capabilities of the hydrologist for performing reliable computations for operational purposes.

***Keywords*:** models, daily flow; model efficiency; forecast.

VERGLEICH ZWISCHEN EINIGEN DETERMINIST UND BEGRIFFLICHEN MODELLEN WANDTE IN DEM HYDROGRAPHISCHEN GEBIET BANAT FÜR DIE FLÜSSE AN TÄGLICHE STRÖMUNG-SIMULATION

Zusammenfassung: Hydrologische Modelle werden benutzt, um Reservoir-Antwort zu simulieren, das meisten häufig die Begleichung vom Reservoir als Funktion von Niederschlag, Temperatur, potentiellem evapotranspiration, und Parametern, die stillschweigend oder deutlich den hydrologischen Zustand in der Wasserscheide charakterisieren.

Die Entwicklungen im Feld von Hydrologie, Hydraulik, und mathematisches Modellstehen verbessern die Fähigkeiten des Hydrologen für das Aufführen von zuverlässigen Berechnungen für betriebsbereite Zwecke.

Schluesselworte: Modelle, tägliche Strömung,; modellhafte Tüchtigkeit; Vorhersage.

1. Introduction

In order to study the behaviours of rivers basin, to determine some hydrological parameters and to provide a reliable river daily flow forecast on some rivers situated into Banat area, a few models has been chosen. These models have been calibrated and used to simulate the daily flow of rivers Bega, Timis, Caras and Nera.

The current and expected problems of pollution control of rivers have resulted in a new requirement for an expended river forecasting service in order to predict reliably the low flows for this control. Thus, the parameters of all chosen models have been calibrated to obtain accurate daily flow simulation during low flow periods.

2. The models presentation

2.1. The River Forecasting System PROGSYS

The river forecasting system PROGSYS is designed to aid in quantitative warnings of high floods, and to support short time operations for reservoirs. There are no rigid rules to provide the user with one forecasting model corresponding to all demands under any circumstance. Thus PROGSYS became more universal by including different model types. The models included are both conceptual, derived from the laws governing the movement of water in river channels (discrete linear cascade -DLCM) and stochastic models based on statistical concepts (self-tuning predictor -ARMA- and multiple regression - LINREG).

The models ARMA and LINREG require a preceding period with a certain length for the estimation and/or updating of the parameters. These models cannot run without downstream observations.

The model DLCM works with off-line optimised parameters, which are stored. The optimisation of the parameters has been done by the Rosenbrock method.

For the model DLCM the preceding period and the downstream observation give an option for the estimation of reliability.

The models input data are daily discharge from the gauges situated in upstream of the gauge for which the forecast will be provided.

2.2. The Linear Perturbation Model (LPM)

The model has been developed by Mr. Zhang Jian-Yun (1993) at University College Galway, Ireland. It can be easily applied on any user's catchment.

The essence of this model is contained in the following two assumptions:

(1) If, in a particular year, the input series value, for each day of the year, is equal to its date expected (date-averaged) value x_d, the corresponding output will also equal to its expected value y_d. i.e., the input series x_d produces the output series y_d.

(2) Otherwise, perturbations (i.e. departures) from the date-expected values x_d are linearly related (through convolution summation with a series h_t) to the corresponding date-expected output values y_d.

These combined assumptions are much more robust than the simpler assumption, defining the Simple Linear Model (SLM), of a linear relationship between the total input series x_d and total output series y_d. The LPM assumption are equivalent to the operation of a convolution summation of the h_t series with the total input series x_d, the output which is added to the periodic output component z_d (having a one-year period) to yield the total LPM output series y_d. For a linear system, the LPM assumption would be satisfied exactly and satisfied approximately for a moderately non-linear system.

The simplest representation of a causal relationship between these inputs and their corresponding output is the multiple input/single-output linear, time invariant model LPM.

The application limitations: continuous daily data and, the maximum input numbers are 4 and maximum data length is 7500.

The model-input data are daily discharge from the upper basin and, average amount of daily precipitation.

2.3. The SMAR model presentation

The SMAR Project was formulated in the mid-eighties under the guidance of Professor J.E. Nash, Professor J.C.I. Dooge and Dr. K. M. O'Connor from the Department of Engineering Hydrology of University College Galway, Ireland.

The Soil Moisture Accounting and Routing (SMAR) model, also known as the Layers model, is a fairly simple conceptual model. The original water balance component, for generating the runoff volume, has the following parameters: *Z* (soil moisture capacity, in *mm*), *T* (potential evaporation factor, with $E_p = T \times E_0$, where E_p is potential evaporation and E_0 is measured Pan evaporation), *H* (the ratio of direct runoff to total net rainfall), *Y* (the surface soil moisture infiltration rate, in *mm/day*), and *C* (the soil evaporation decay coefficient). In the routing component, the Nash cascade model of linear reservoirs, with parameters *N* (the number of cascading linear reservoirs) and *NK* (the scale parameter, where, $K = (NK)/N$ is the storage coefficient of each reservoir), is employed to transform the generated runoff into discharge. All of the above parameters can be optimised.

In the SMAR model, it is assumed that the catchment is analogous to a vertical stack of horizontal soil layers, each of which can contain a certain amount of water at field capacity. Evaporation from the top layer occurs at the potential rate and from the second layer only on exhaustion of the first layer and the rate equal to the potential rate multiplied by a parameter *C* whose value is less than unity. On exhaustion of the second layer, evaporation from the third layer occurs at the rate equal to the potential rate multiplied by C^2

and so on. Thus, a constant potential evaporation applied to the basin would reduce the soil moisture storage in a roughly exponential manner. Continuing rainfall will replenish each layer to field capacity from the top one downwards until either all the rainfall is exhausted or all the layers are full, i.e. at field capacity. Any continuing surplus of rainfall then contributes the component r_3 of generated runoff.

Adding r_1, r_2 and $r_s^{'}$ together, as the total direct surface generated runoff r_s, this total (r_s) is then transformed into one of two discharge components by routing it through the Nash' cascade of equal linear reservoirs' model.

The application limitations: continuous daily data and, the maximum input numbers are 4 and maximum data length is 7500.

The model-input data are daily discharge from the upper basin and, average amount of daily precipitation and, pan-evaporation.

2.4. HEC -HMS Model Presentation

HEC-HMS is a Hydrologic Modelling System developed by US Army Corps of Engineers. Is designed to simulate the precipitation-runoff processes of dentritic watershed systems, to be applicable in a wide range of geographic areas for solving the widest range of problems, such as: large river basin water supply and flood hydrology, and small urban or natural watershed runoff. Hydrographs produced by the program are used for studies of water availability, urban drainage, flow forecasting, future urbanisation impact, reservoir spillway design, flood damage reduction, floodplain regulation and systems operation.

The physical representation of watershed or basins and rivers is configured in the basin model. Hydrologic elements are connected in a dentritic network to simulate runoff processes. Available elements are subbazin, reach, junction, reservoir, diversion, source, and sink.

HEC-HMS uses a separate model to represent each component of the runoff process, including models that compute runoff volume; models of direct runoff; models of base flow and models of channel flow. Meteorological data analysis is performed by the meteorological model and includes precipitation and evapotranspiration.

A basin model using the initial-constant loss, Snyder unit hydrograph transform and constant monthly baseflow methods have been created from the parameter data.

A meteorological model has been created for the precipitation gage data. Thiessen polygon technique has been used for user gage weighting precipitation method. Rainfall is to be distributed in time using the temporal pattern of cumulative precipitation.

Routing for reaches has been made by Lag method - routine without attenuation.

The optimisation of the model parameters has been made by recursively application of univariate-gradient search algorithm and peak-weighted root mean square error objective function (RMS). RMS compares all ordinates, squaring differences, and it weights the squared differences. The weight assigned to each ordinate is proportional to the magnitude of the ordinate. This function is an implicit measure of comparison of the magnitude of peaks, volumes, and time of peak of the two hydrographs.

3.The Models Application over the Catchments

Summary description of the chosen catchments is presented in table 1.

For simplicity, only four indices of model efficiency are used in this study. These are the mean square error (MSE), the Nash-Sutcliffe (1970) model efficiency criterion (R^2), the index of volumetric fit (IVF) and the relative error of annual peak flow (RE).

The chosen calibration and verification period is 1990-1997 (1990-1995 for calibration and, 1996-1997 for verification). The models parameters have been optimised to obtain a better daily flow simulation over low flow periods (Tables 2 -5).

Table 1. Summary description of the chosen catchments

Catchment	Gage	H_{mean} (m)	Area (km^2)
Timis	Sadova	335	1064
Timis	Lugoj	936	560
Bega	Balint	666	2706
Caras	Varadia	347	877
Nera	Naidas	590	1319

Table 2. The optimal parameter value of the model ARMA

Catchment	Gauge	Reach	Auto-regression	Multiple regression	Error parameter
Bega	Balint	Faget-Balint	2	1	1
Timis	Sadova	Teregova - Sadova	2	1	1
Timis	Lugoj	Sadova - Lugoj	2	1	1
Caras	Varadia	Izvoare - Varadia	2	1	1
Nera	Naidas	Dalboset-Naidas	2	1	1

Table 3. The optimal parameter values of the model DLCM

Catchment	Gage	Reach	*K*	*N*
Bega	Balint	Faget-Balint	1	0,02
Timis	Sadova	Izvoare - Sadova	1	0,10
Timis	Lugoj	Sadova - Lugoj	1	0,10
Caras	Varadia	Izvoare - Varadia	1	0,05
Nera	Naids	Dalboset-Naidas	2	0,25

Table 3. The optimal parameter values of the model LINREG

Catchment	Gage	Reach	*a*	*b*	*c*	*d*
Bega	Balint	Faget-Balint	1,40	1,40	-	-
Timis	Sadova	Izvoare - Sadova	1,20	1,20	1,20	-
Timis	Lugoj	Sadova - Lugoj	0,98	0,98	-	-
Caras	Varadia	Izvoare - Varadia	1,30	1,30	1,30	1,30
Nera	Naidas	Dalboset-Naidas	1,20	0,45	-	-

Table 4. The optimal parameter values of the model SMAR

Catchment	*C*	*Z*	*Y*	*H*	*T*	*G*	*N*	*NK*	K_G
Bega	0,77	400	200	0,20	0,46	0,77	1,81	2,16	49,59
Caras	0,70	400	200	0,26	0,99	0,78	1,01	4,73	599,9
Nera	0,33	368	171,2	0,26	0,68	1,00	1,10	4,30	37,04

Table 5. The optimal parameter values of the Hydrological Modelling System HEC-HMS

Catchment	Subbazin losses		Snyder's unit hydrograph for the precipitation excess transformation		Routine in channel
	Initial loss (mm)	Constant loss (mm)	t_p (hours)	C_p	Lag (min.)
Bega	0,5	0,02	40,3	0,900	150
Caras	1,0	0,001	26,99	0,503	150
Nera	2,0	1,0	26,7	0,500	200

The results of applying the models to the selected catchments are given in table 6 and, the relative errors of the estimated annual peaks between the model forms are given in tables 7 - 8.

Table 6. The model efficiency indices R^2, IVF and MSE of the model forms

Catchment	Gauge	Test period	Model	R^2 (%)	IVF	MSE (mm^2/day)
Timis	Sadova	Calibration	LINREG	92,4	0,99	13,2
			ARMA	89,1	1,02	6,34
			DLCM	85,7	0,87	8,28
		Verification	LINREG	84,4	0,92	10,8
			ARMA	60,8	1,01	27,1
			DLCM	78,3	0,89	15,0
	Lugoj	Calibration	LINREG	93,1	0,86	165,4
			ARMA	66,6	1,03	314,0
			DLCM	93,3	1,02	65,6
		Verification	LINREG	82,3	0,84	391,0
			ARMA	70,8	1,02	643,0
			DLCM	91,2	1,05	194,0
Bega	Balint	Calibration	LINREG	79,0	1,00	8,53
			ARMA	77,3	1,03	37,6
			LPM	83,2	1,00	7,00
			SMAR	83,5	1,00	7,00
			HEC	79,5	0,99	34,8
		Verification	LINREG	70,6	0,90	43,6
			ARMA	81,7	1,07	130,6
			LPM	81,7	1,02	31,6
			SMAR	84,8	1,03	26,4
			HEC	96,8	1,03	6,40
Caras	Varadia	Calibration	LINREG	85,5	0,99	4,55
			ARMA	73,4	1,05	8,37
			DLCM	68,9	0,71	9,82
			LPM	88,9	0,99	3,50
			SMAR	84,5	1,00	5,00
			HEC	84,5	1,00	12,0
		Verification	LINREG	80,8	1,00	34,8
			ARMA	20,6	1,04	166,0
			DLCM	67,7	0,65	58,5
			LPM	86,6	1,04	27,8
			SMAR	78,8	1,06	44,5
			HEC	78,8	1,06	34,5
Nera	Naidas	Calibration	LINREG	96,2	0,99	4,43
			ARMA	83,2	1,04	19,7
			DLCM	91,6	0,84	9,91
			LPM	93,2	1,00	7,80
			SMAR	88,6	1,00	13,2
			HEC	87,6	1,00	14,2
		Verification	LINREG	97,4	0,97	9,57
			ARMA	64,6	1,08	127,0
			DLCM	93,5	0,84	23,6
			LPM	92,9	1,05	32,3
			SMAR	82,2	1,02	81,8
			HEC	94,2	1,02	5,80

Table 7. The relative errors of the estimated annual peaks flow of the models forms on Timis and Bega catchements

Data set	Year	Timis catchment- Sadova Relative error ($\Delta Q/Q_0$)(%)			Timis catchment - Lugoj Relative error ($\Delta Q/Q_0$)(%)			Bega catchment- gauge Balint Relative error ($\Delta Q/Q_0$)(%)				
		ARMA	DLCM	LINREG	ARMA	DLCM	LINREG	ARMA	LINREG	LPM	SMAR	HEC
Calibration	1990	16,5	7,06	11,5	14,1	14,5	9,55	45,0	25,9	30,8	11,3	9,91
	1991	27,7	19,0	12,1	17,1	17,6	2,07	68,0	15,3	10,9	13,7	13,7
	1992	93,3	10,2	7,55	8,47	8,47	8,47	32,2	45,0	25,5	28,4	10,9
	1993	43,5	44,0	22,6	15,4	15,4	9,56	43,6	14,4	12,8	9,70	11,2
	1994	30,7	41,9	15,8	20,6	20,6	11,2	3,90	14,9	11,0	23,6	20,4
	1995	39,6	42,6	5,27	1,88	15,3	24,1	62,3	2,82	15,2	21,2	17,7
	ARE	**41,9**	**27,5**	**12,5**	**12,9**	**15,0**	**10,8**	**42,5**	**19,7**	**17,7**	**17,9**	**14,0**
Verification	1996	34,0	15,3	11,3	2,38	30,0	11,0	32,0	9,07	4,10	2,74	7,34
	1997	58,3	17,0	23,1	4,90	41,4	12,0	33,0	7,90	0,00	13,4	16,4
	ARE	**46,2**	**16,2**	**17,2**	**3,64**	**35,7**	**11,5**	**32,5**	**8,48**	**10,3**	**9,44**	**11,9**
1990-1997	ARE	**43,0**	**24,6**	**13,6**	**10,6**	**20,4**	**11,0**	**40,0**	**16,9**	**15,8**	**15,5**	**13,4**

Table 8. The relative errors of the estimated annual peaks flow of the models forms on Caras and Nera catchments

Data set	Year	Caras catchment- gauge Varadia Relative error ($\Delta Q/Q_0$)(%)						Nera catchment- Gauge Naidas Relative error ($\Delta Q/Q_0$)(%)					
		ARMA	DLCM	LINREG	LPM	SMAR	HEC	ARMA	DLCM	LINREG	LPM	SMAR	HEC
Calibration	1990	59,3	55,1	18,0	4,50	14,9	19,0	28,6	14,9	10,3	16,3	9,66	19,0
	1991	25,5	63,1	11,6	18,9	13,2	15,1	45,2	20,7	14,3	5,30	2,88	10,8
	1992	31,2	25,7	24,0	3,80	4,20	21,5	52,2	1,60	4,80	13,3	1,59	6,90
	1993	47,6	38,5	9,55	0,20	10,4	10,4	40,1	17,1	6,05	13,8	8,22	8,27
	1994	76,0	11,4	13,7	14,3	15,3	21,1	78,7	4,79	3,83	7,47	12,9	14,9
	1995	30,4	47,6	6,17	20,4	12,7	12,7	40,1	2,47	15,5	5,26	10,0	12,2
	ARE	**45,0**	**40,2**	**13,8**	**10,4**	**11,8**	**16,6**	**47,5**	**10,3**	**9,13**	**10,2**	**7,54**	**12,0**
Verification	1996	73,7	33,2	10,8	4,10	6,10	8,55	26,2	2,80	1,87	3,74	5,56	15,8
	1997	63,8	23,7	29,4	0,00	11,7	17,2	43,2	9,60	2,73	27,4	6,12	16,2
	ARE	**68,8**	**28,4**	**20,1**	**2,05**	**8,90**	**12,9**	**34,7**	**6,20**	**2,30**	**15,6**	**5,84**	**16,0**
1990-1997	ARE	**50,9**	**37,2**	**15,4**	**8,27**	**11,1**	**15,7**	**44,3**	**9,24**	**7,42**	**11,6**	**7,11**	**13,0**

The efficiency indices obtained for the calibration and verification period have been analyses. Thus, taking into account the condition that the model is suitable if the model efficiency $R^2 > 0.36$, is good if $R^2 > 0.50$ and is very good if $R^2 > 0.70$ (Iritz, 1990), result the following observation:

The hydrographic basin Timis

To the Timis catchment have been tested only the models included into PROGSYS - River Forecasting System.

During daily flow simulation, at gauge Sadova, all three models provide good and very good efficiency ($R^2 > 0.6$). The annual runoff volumes simulated by the models DLCM and LINREG are less then the observed volumes and, the model ARMA simulate with high accuracy the annual runoff volumes.

The model LINREG performed accurate daily flow simulation during years. The relative errors of the computed annual peak flow are less than 20% in 7 from 8 considered years. Models ARMA and DLCM perform accurate daily flow simulation during low flow periods, for which they have been calibrated.

The mean square errors (MSE) have relatively low values.

For the gauge Lugoj, all three models have a very good efficiency. In the simulation of the daily flow during considered years, high accuracy between simulated and observed discharge was obtained by the model LINREG. The models ARMA and DLCM perform accurate simulation of the daily flow within the years only during low flow periods.

The relative errors of the simulated annual peak discharge are less that 20% in 7 years from the 8 considered years for the models LINREG and DLCM and, in 5 years from the 8 considered years for the model ARMA.

The volumetric index (IVF) shown that the annual runoff volumes simulated by the models are less (DLCM) or high (ARMA) than observed annual runoff volumes.

The mean square errors (MSE) have high values, perhaps as a consequence of the model calibration for the low flow periods.

The hydrographic basin Bega

Into the basin of river Bega have been tested the models ARMA, LINREG, LPM, SMAR and HEC-HMS. The model DLCM, which is included into PROGSYS system, did not compute the daily flow, probably was a soft problem.

For the gauge Balint, all the models have a very good efficiency. In the simulation of the daily flow during considered years, high accuracy between simulated and observed discharge was obtained by the models LPM, SMAR and HEC-HMS. The models ARMA and LINREG perform accurate simulation of the daily flow within the years only during low flow periods.

The relative errors of the simulated annual peak discharge are less that 20% for the models LINREG, LPM, SMAR and HEC-HMS. The model ARMA performed a worth simulation of the annual peak flow.

The volumetric index (IVF) shown that the runoff volumes simulated by the models are more or less equals with the observed runoff volumes, with one exception, the runoff volumes in the verification period computed by the model ARMA, which are higher that the observed volumes into the same time interval.

The mean square errors (MSE) in the verification period have high values in the case of the model ARMA, perhaps as a consequence of the model calibration for the low flow periods. For the other models, the mean square errors (MSE) have acceptable values.

The hydrographic basin Caras

Into the basin of river Caras, at gauge Varadia have been tested the models ARMA, DLCM, LINREG, LPM, SMAR and HEC-HMS.

All the models have a very good efficiency for both calibration and verification periods. In the simulation of the daily flow during considered years, high accuracy between simulated and observed discharge was obtained by the models LPM and SMAR. The models ARMA, DLCM, LINREG and HEC-HMS perform accurate simulation of the daily flow within the years only during low flow periods.

The relative errors of the simulated annual peak discharge are less that 20% for the models LINREG, LPM, SMAR and HEC-HMS. The models ARMA and DLCM performed a worth simulation of the annual peaks flow (over 40%) perhaps, as a consequence of the models calibration for the low flow periods.

The volumetric index (IVF) shown that the runoff volumes simulated by the models are more or less equals with the observed runoff volumes, with one exception, the runoff volumes in the verification period computed by the models ARMA, which are lower than the observed volumes into the same time interval.

The mean square errors (MSE) in the verification period have high values in the case of the model ARMA, perhaps as a consequence of the model calibration for the low flow periods. For the other models, the mean square errors (MSE) have acceptable values.

The hydrographic basin Nera

Into the basin of river Nera, at gauge Naidas have been tested the models ARMA, DLCM, LINREG, LPM, SMAR and HEC-HMS.

All the models have a very good efficiency for both calibration and verification periods. In the simulation of the daily flow during considered years, high accuracy between simulated and observed discharge was obtained by the models LPM and SMAR. The models ARMA, DLCM, LINREG and HEC-HMS perform accurate simulation of the daily flow within the years only during low flow periods.

The relative errors of the simulated annual peak discharge are less that 20% for the models LINREG, LPM, SMAR and HEC-HMS. The model ARMA performed a worth simulation of the annual peak flow, over 40%.

The volumetric index (IVF) shown that the runoff volumes simulated by the models are more or less equals with the observed runoff volumes, with one exception. The runoff volumes in both calibration and verification period computed by the models DLCM are lower than the observed volumes into the same time interval.

The mean square errors (MSE) in the verification period have high values in the case of the model ARMA, perhaps as a consequence of the model calibration for the low flow periods. For the other models, the mean square errors (MSE) have acceptable values.

With data that were not used for model calibration and verification the accuracy of the daily flow simulation by using the calibrated models has been tested. For this purpose, the data from the year 2000 were chosen and the models have been applied to the same test catchments.

Figures 1 - 3 show the simulated hydrograph by the models LPM and HEC-HMS and observed daily flow between 1 January –31 March 2000, in Bega, Caras and Nera catchments.

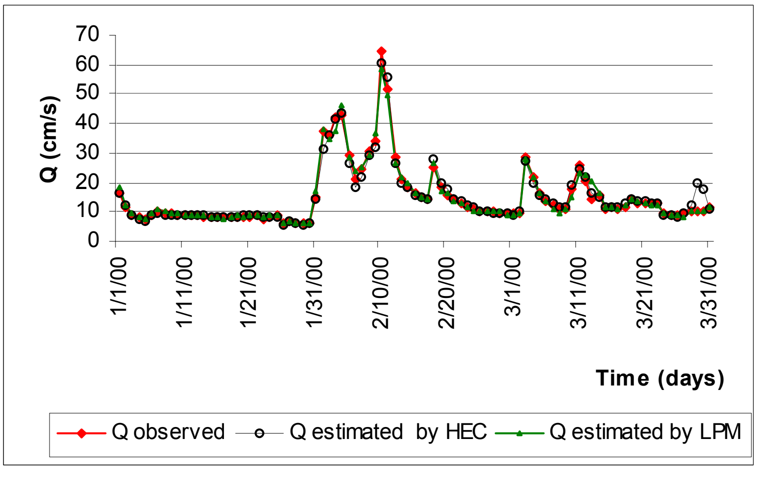

Figure 1. The catchment Bega. The observed and estimated daily flow between 1 January - 31 march 2000.

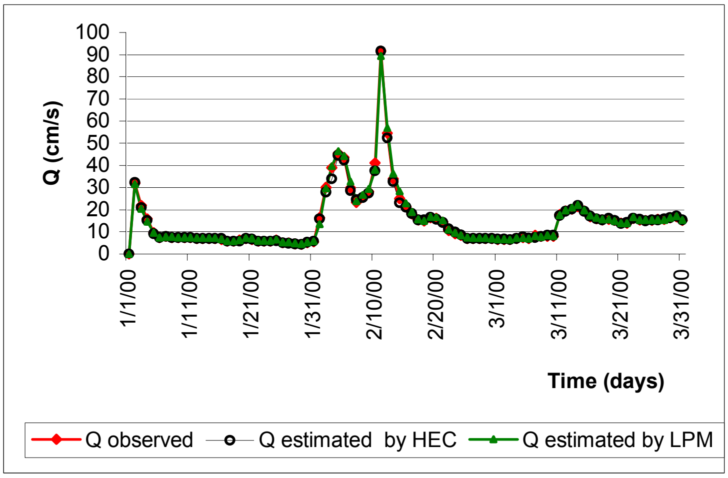

Figure 2. The catchment Caras. The observed and estimated daily flow between 1 January - 31 march 2000.

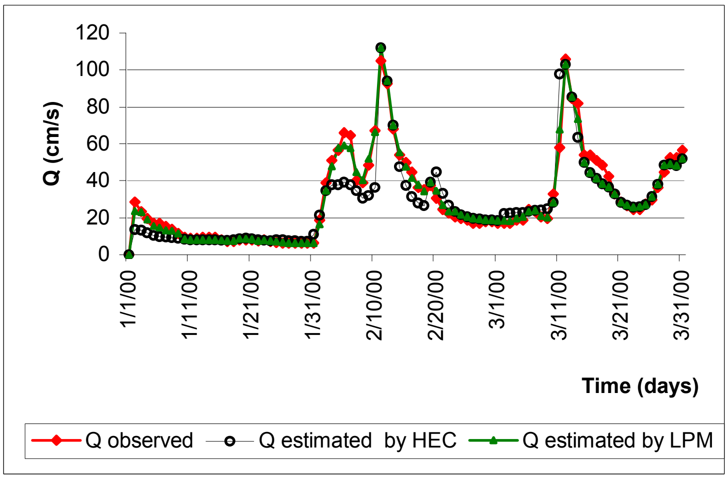

Figure 3. The catchment Nera. The observed and estimated daily flow between 1 January - 31 march 2000.

For all the models, the differences between simulated and observed daily flow are visible only during floods. During low flow period, all models provide accurate daily flow simulation compared with observed daily flow. Thus, the results obtained by applying the models for daily flow simulation confirms the optimised models parameters and the reliability of the models. The model efficiency $R^2 > 0,9$ for all tested models

As a comparison of the model efficiency and reliability for all tested models over fourth catchment, can be concluded that:

- In Timis hydrographic basin:

  - At gauge Sadova, the most suitable model for daily flow simulation is the model LINREG. Models ARMA and DLCM will be use for daily flow simulation only during low flow periods.

  - At gauge Lugoj, the most suitable model for daily flow simulation is the model LINREG. Models ARMA and DLCM will be use for daily flow simulation only in low flow periods. Is possible that daily data simulated with these models will have high mean square errors (MSE).

- In Bega and Caras hydrographic basins, using the models LPM, SMAR and HEC-HMS can be performed the daily flow simulation. The Models ARMA, DLCM and LINREG will be use for daily flow simulation only in low flow periods.

- In Nera hydrographic basins, using the models LPM and SMAR can be performed the daily flow simulation. The Models ARMA, DLCM, LINREG and HEC-HMS will be use for daily flow simulation only during low flow periods for which, these models have been calibrated.

4. Conclusions

Hydrological models are very useful tools for a better understanding of watershed behaviour.

The models forecast errors include only amplitude errors, which are synonymous with the deviation of water volume. It may be caused by an incorrect assumption concerning the initial state, e.g. the initial soil moisture and/or by incorrect model inputs, for example, by measurement error of precipitation.

Because the parameter values are optimised using the chosen historical data, they represent the average case for entire calibration series. However, each flood events has own special features, and maybe this is the reason for which the floods produced during the summer and autumns are under-predicted, in some cases.

In real time forecast, the hydrologist must take into account the previously results obtained by models perform and he has to decide the suitable parameters for the forecast estimation, especially during flood events.

In many ways, hydrologic modelling is more an art than a science, and it is likely to remain so (O'Connor, 1995). Predictive hydrologic modelling is normally carried out on a given catchment using a specific model under the supervision of an individual hydrologist. The usefulness of the result depends in large measure on talents and experience of the hydrologist and understanding of the mathematical nuances of the particular model and the hydrologic nuances of the particular catchment. It is unlikely that the results of an objective analysis of modelling methods can ever be substituted for the subjective talents of an experienced modeller.

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