International Conference on Hydroinformatics

2014

Multifactorial Linear Regression Method For Prediction Of Mountain Rivers Flow

Arestak Sarukhanyan

Levon Vardanyan

Levon Azizyan

Yelizaveta Yeroyan

MULTIFACTORIAL LINEAR REGRESSION METHOD FOR PREDICTION OF MOUNTAIN RIVERS FLOW

ARESTAK SARUKHANYAN (1), LEVON VARDANYAN (1), LEVON AZIZYAN (1), YELIZAVETA YEROYAN (1)
(1): Yerevan State University of Architecture and Construction, Teryan 105, Yerevan, Armenia.

Long-term river flow forecasting methoods are used for the theoretical basis for the development of river basin water balance equation : the basins with high marks nascent river basin water balance should be organized according to higher zones .

Spring flood water balance equation is used for the calculation of the measure or impossibillness to get through , so they are replaced by the flow and the approximate korelyatsion connections between the key factors , including the multifactorial flow prediction recommend using multifactorial linear regression method , which is believed to be the predicted size (prediktant) and the variables (factors or prediktorner) .There is a linear connection between the above mentioned method to calculate flow of the number of rivers of Armenia which are forecasts for 25 stations. The experimental and calculated results are about 80 %.

Long term river flow for casting methods are used for the development of meteorological forecasting and those forecasting methods are completely different and depends on the level of intervention of meteorological conditions.

Typically, for the long term river flow forecasting there exist more efficient conditions in that regions where accumulated snow for the cold season of the year is the general resource for the river. First of all it is related to highland basins.

The academic base for the long term river flow forecasting is river basin water balance equation. The general specification for the mountainous basins is considered to be water rivers basins water calculations which should be undertaken depending on highland zone. Taking into account the specifications for fragrant distributions at the time of spring flood the water balance equation for the higher zones

$$
\begin{aligned}
Y = \sum_{i=1}^{n} S_i f_i + \sum_{i=1}^{n} X_{1,i} f_i + \sum_{i=1}^{n} X_{2,i} f_i + \sum_{i=1}^{n} h_u f_{ui} - \sum_{i=1}^{n} E_{sn,i} f_i - \sum_{i=1}^{n} E_{h,i} f_i - \\
- \sum_{i=1}^{n} E_{t,i} f_i \pm \Delta_g \pm \Delta_u \pm \Delta_m .
\end{aligned}
\qquad (1)
$$

where Y is spring flood plus basin flood, T is snow melted water resource, i present higher layer zone, total n zone, X_1 is the amount of precipitation on the snow surface X_2 presented spring flood water balance in the end of spring flood, h_u is the layer of ice and snow melting layer, E_{sn} is water evaporation not including condensation, E_h evaporation from the soil, E_t is the moisture evaporation from the forest and the transpiration fi is the surface of higher zone Δ_g is the water sources soil changes on the upper level of flood, Δ_u is the source changes in the based flood layers and Δ_m is the moisture source changes in the soil.

The first equation is not yet possible to get through the calculations because of the time of processing seasonal flood forecasting practical methods inquire differences between flood and general factors predicting of them. Those methods of forecasting called physical statistic. Generally for the mountainous river prediction the equation is as shown

$$Q_t = f(S_t + X)\,, Q_t = f(\sum X_m),\ Q_t = f(S_t, Q_m, \Theta^0{}_m): \tag{2}$$

In the recent years using the computers for prediction of the flood is used the method of multifunctional linear method, which is specified in [3,5] scientific works. This methods shows that between the predictant and preserving factors there is existing linear connection which is shown as

$$Y = C_0 + C_1X_1 + C_2X_2 ... + C_nX_n, \tag{3}$$

where Y is a predictant, C_0 is a free agent, C_1, $C_2 \ldots C_n$ the regression agents which are determined with the smallest quadrial method, where X_1, $X_2 \ldots X_n$ are independent changeable. At the time of mountainous river prediction methods implementation it is important to implement the stations and observing stations where the observations could be used for the further forecasting. As general those observations are acting in two ways. First they should be informative second they should be typical for many regions.

The spring flood of the rivers in Armenia are in not similar physical geometric conditions, which Is the result of changeable processes in the river basins . That is the reason why it is very difficult to forecast some details of water flood regimes of the rivers.

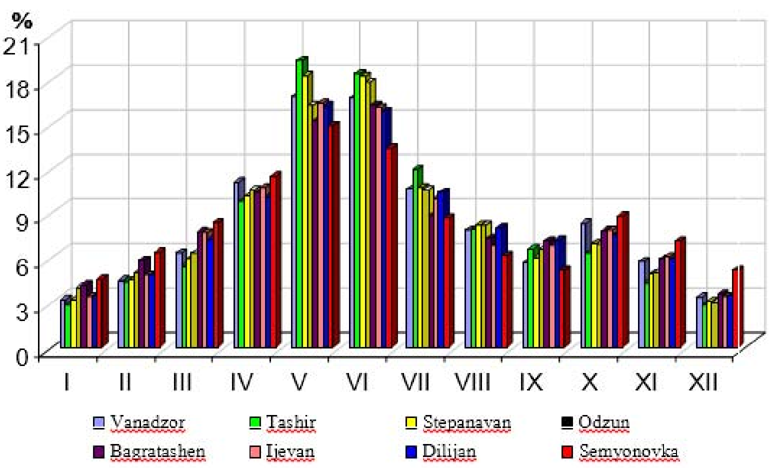
We could determine some scientific works which include an information about river flood forecasting methods, such as in the book written by Vazhnov A.N. and Shahinyan M. V. where are shown singular correlation connections, but the forecasting of water elements without any general factor will not bring sufficient result.

We found here to present multifactor correlation connections, which are more reliable and could be used for flood forecasting for the rivers of Armenia.

It is important to mention that the methods of forecasting

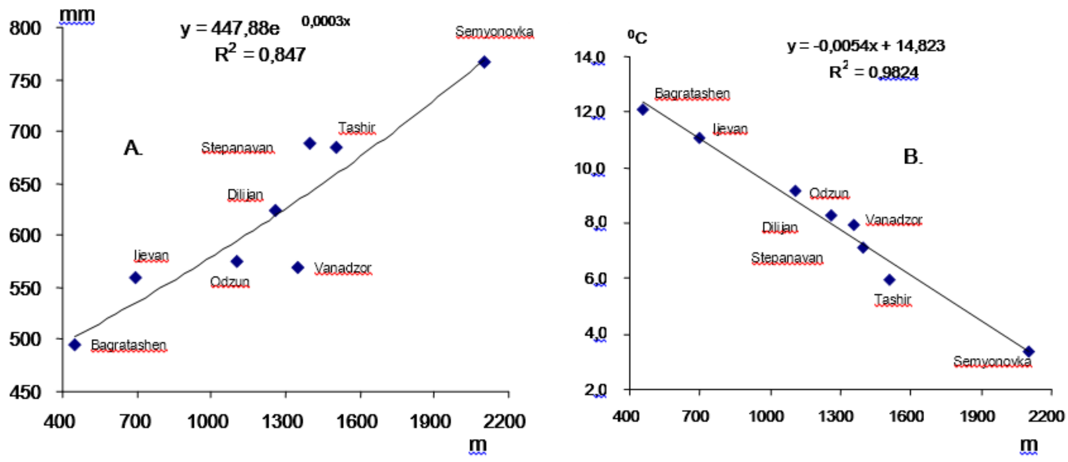
Kure and Araks basins river flood are deferent, which are specified in 1,2,7 scientific works.

Here above are shown the methods of forecasting for Kure and Araks basin rivers spring flood which are processed by us. The average balanced picks in the north-eastern regions of the country rivers basins are located between 1800-1900m and are under the non-stable snow precipitation zones. Warm winters here are about 40-60% which has a great influence on the flood of the rivers in that area as as well as on the other rivers in the territory of RA. At the time of cold temperature the annual precipitation is 15-20% but in April-June it reaches up to 40-50% (graph 1) and those precipitations are the reasons of spring flood changes. Here above is shown the picture



Graph 1. Annual distribution of precipitation in the basin Khur river.

Graph 2 shows the precipitation and air temperature in the basin of Khur river based on the data provided by meteorological stations.



Graph 2. Average annual precipitation in the Khur basin A. water temperature distribution, B. and it's distribution.

The pointed connections show that of the data of meteorological stations could be used for calculation and forecasting spring flood for Khur Basin Rivers. Using the observation data for Semyoniovka (210m), vanadzon (1360m.), Tashir (1506m.), Stepanavan (1400m), Bagratashen (453m.), Ijevan (695m.), Dilijan (1256m.) it is established multifunction regression connection between Khur basin waters spring flood and those data, which could be shown as

$$W_{IV-VI} = C_o + C_1 W_{I-III} + C_2 \sum X_{XI-III} + C_3 K_{IV-VI} + C_4 T_I + C_5 T_{II} + \\ + C_6 T_{III} + C_7 \Delta T_{IV} , \qquad (4)$$

where (and in the further equations) W_{IV-VI} is the spring flood capacity, W_{I-III} is the first semester flood capacity, $\sum W_{XI-III}$ shows the precipitation level for November-march K_{IV-VI} module agent for April-June precipitation, T the average temperature of the month, ΔT_{IV} is the water temperature for April, C_0 free agent, C_1, $C_2 \dots C_7$ are regression agents. The water temperature data and precipitations level is determined based on data from seven meteorological stations.

In the table 1 are shown the regression agent prices for spring flood forecasts and their correlation agents (R), $\overline{S} / \overline{\sigma}$ and forecasts errors possibilities.

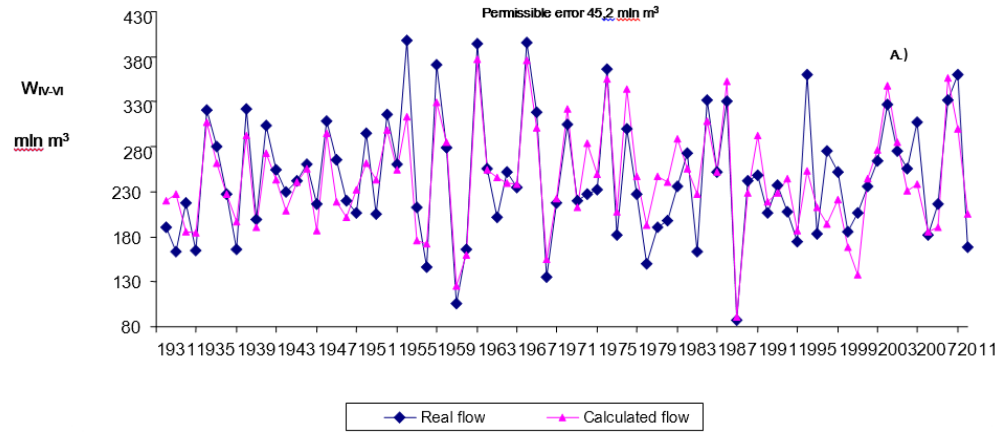
Table 1. Spring flood forecast regression connection agents with the details

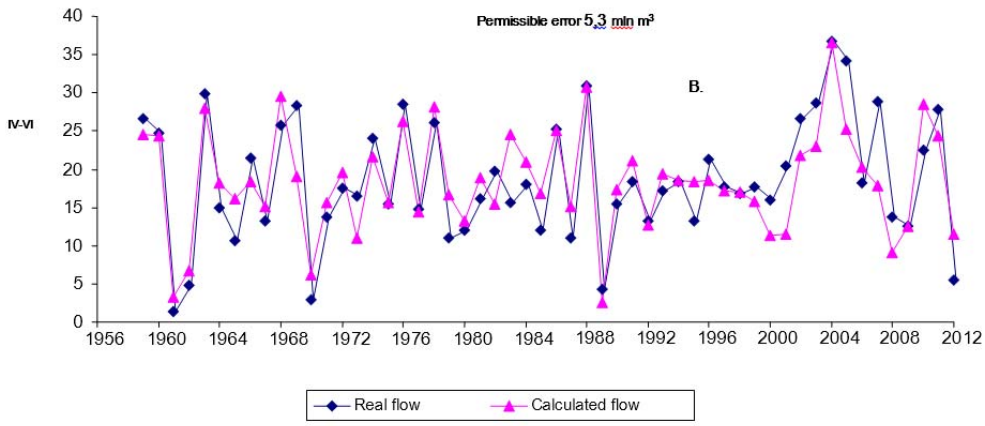
	River – observation point	0	1	2	3	4	5	6	7		$\overline{S}$	%
	Pambak-Shirakamut	-25,7	0,73	0,24	28,9	0,74	0,17	-1,02	-0,33	0,68	0,73	63
	Pambak-Vanadzor	-30,9	-0,82	0,62	38,2	-1,12	-4,42	7,37	-5,56	0,81	0,59	78
	Pambak-Meghrut	-57,0	0,84	0,54	90,4	-0,48	-0,08	-2,28	-4,88	0,77	0,64	77
	Pambak-k.Tumanyan	-55,6	0,99	0,68	111	-0,66	1,67	-5,98	-6,22	0,82	0,57	83
	Debed-Tumanyan	-299	1,16	1,67	372	9,64	-3,07	-10,0	1,81	0,96	0,27	97
	Debed-	-	0	2	3	6	-	-	-	0	0	9

	Akhtala	254	,81	,04	91	,44	5,51	16,6	2,51	,93	,37	3
	Debed-Ayrum	- 228	0 ,27	1 ,80	4 93	2 ,82	- 5,66	- 14,4	- 1,96	0 ,90	0 ,44	8 7
	Hajighara- Lernapat	- 20,9	1 ,73	0 ,14	1 4,9	0 ,28	- 0,39	0 ,42	0 ,11	0 ,74	0 ,68	7 2
	Tandzut- Vanadzor	8 ,11	1 ,37	0 ,05	2 0,9	0 ,76	- 1,15	- 1,17	- 1,11	0 ,64	0 ,77	7 0
0	Alaqers- Debed	- 5,01	0 ,30	0 ,06	2 2,9	- 0,15	- 0,05	- 0,59	- 0,67	0 ,82	0 ,58	7 7
1	Dzoraget- Katnarat	2 ,47	1 ,23	0 ,13	1 6,3	1 ,14	- 1,03	- 0,18	0 ,18	0 ,77	0 ,64	6 9
2	Dzoraget- Stepanavan	- 28,4	0 ,48	0 ,42	1 44	2 ,14	- 0,93	- 7,41	- 3,06	0 ,83	0 ,56	8 3
3	Dzoaget - low Gargar	- 58,1	0 ,48	0 ,62	1 94	2 ,22	- 1,68	- 8,52	- 2,76	0 ,86	0 ,51	8 3
4	Tashir- Saratovka	- 17,8	0 ,47	0 ,13	4 0,9	0 ,98	- 0,04	- 0,58	1 ,17	0 ,65	0 ,76	7 2
5	Gargar-Kurtan	- 9,10	0 ,47	0 ,08	1 9,2	- 0,13	0 ,06	- 0,95	0 ,25	0 ,82	0 ,57	7 4
6	Marciget- Tumanyan	- 17,6	0 ,52	0 ,12	4 0,5	- 0,54	- 0,25	- 0,84	- 1,37	0 ,77	0 ,64	7 2
7	Aghstev- Fioletovo	- 2,33	0 ,67	0 ,09	1 ,34	0 ,10	- 0,59	0 ,39	0 ,01	0 ,67	0 ,75	7 8
8	Aghstev- Dilijan	- 19,4	1 ,42	0 ,12	4 1,5	- 0,29	- 0,75	- 2,10	- 0,34	0 ,77	0 ,64	7 1
9	Aghstev- Ijevan	- 62,0	1 ,70	0 ,61	1 04	1 ,03	- 1,24	- 5,72	- 4,24	0 ,72	0 ,69	6 9
0	Bldanget- Dilijan	- 8,88	0 ,74	0 ,06	1 2,8	0 ,13	- 0,37	- 0,22	0 ,18	0 ,92	0 ,39	9 1
1	Shamlugh- Dilijan	- 7,62	1 ,49	0 ,03	8 ,15	- 0,10	- 0,16	0 ,14	- 0,12	0 ,77	0 ,64	7 0
2	Getik-Gosh	- 24,1	1 ,36	0 ,23	4 5,9	- 0,77	0 ,51	- 3,29	- 0,74	0 ,70	0 ,72	6 6
3	Getik- Tchambarak	- 2,94	1 ,46	0 ,07	6 ,40	0 ,20	0 ,26	- 1,08	0 ,03	0 ,74	0 ,68	6 9
4	Voskepar- Voskepar	- 29,5	0 ,84	0 ,10	3 3,6	0 ,43	- 0,32	- 0,86	- 0,89	0 ,87	0 ,50	8 6
5	Paghjur- Getahovit	- 13,6	0 ,70	0 ,14	2 7,1	- 0,50	0 ,62	- 3,05	0 ,83	0 ,78	0 ,63	6 9
6	Kiranc- Atcharkut	- 9,65	1 ,04	0 ,03	1 9,8	0 ,37	- 0,13	- 0,75	- 0,58	0 ,87	0 ,50	8 3
7	Hakhut- Tsaghkavan	- 8,98	2 ,12	0 ,09	2 0,9	0 ,19	- 0,01	- 1,08	- 0,61	0 ,81	0 ,59	8 0
8	Tavush-Berd	- 11,8	1 ,31	0 ,08	1 0,6	0 ,41	0 ,16	- 0,41	0 ,49	0 ,64	0 ,77	6 9
9	Hakhinja- Aygedzor	- 27,8	0 ,88	0 ,13	6 0,3	- 0,43	1 ,35	- 4,22	- 1,23	0 ,83	0 ,56	7 4
0	Naltiget- Gandzaqar	- 7,55	1 ,06	0 ,02	1 3,3	0 ,03	- 0,08	- 0,30	- 0,79	0 ,83	0 ,56	8 3

Based on forecasts we could say that all the analyze of the table which has 80% justification are done for Debet, Dzoraget, Voskepar rivers and the correlation agents are low for Tandzut, Tshir, Tavush rivers because of the small basins of them.

The equation 4 is used for controlled forecasting and in graph 3 is shown the flood real and flood calculating synchronization.





Graph 3. Real and calculating synchronization for spring flood for A. Dzoraget-Gargar, B. Kirants-Atcharkut.

We tried to get the connection for Arax basin rivers spring flood forecasting but because of isolation of river basins relief separation and a lot of hydro geological conditions it was not possible to establish the connection only it was possible to establish it for Arpa Basin Rivers.

Arpa Basin Rivers has generally high level of flood which is annually about 60-70%. It is also examined Arpa, Vaik, Gladzor, Yeghegis, Artabuyq and Salegiz rivers for Arpa Basin Rivers forecasting methods. For forecasting the flood in these rivers we use predictors as Ananun canyon, Jermuk and Vorotan canyon meteorological stations observations. Because of Arpa-Sevan water pipe had high influence on Arpa river from 1981, the forecasting methods for particular rivers are used data for 1981 and after 1981.

Here are introduced the equation for them, where

$$W_{IV-VI} = C_0 + C_1 \sum X_{Anan.l/gp.X-III} + C_2 \sum X_{Jer.XI-III} + C_3 \sum X_{Vorot.l/gp.XII-III} + \\ + C_4 T_{Jer.I} + C_5 T_{Jer.II}, \quad (5)$$

where C_0, $C_1 \ldots, C_5$ are shown in the above table 2.

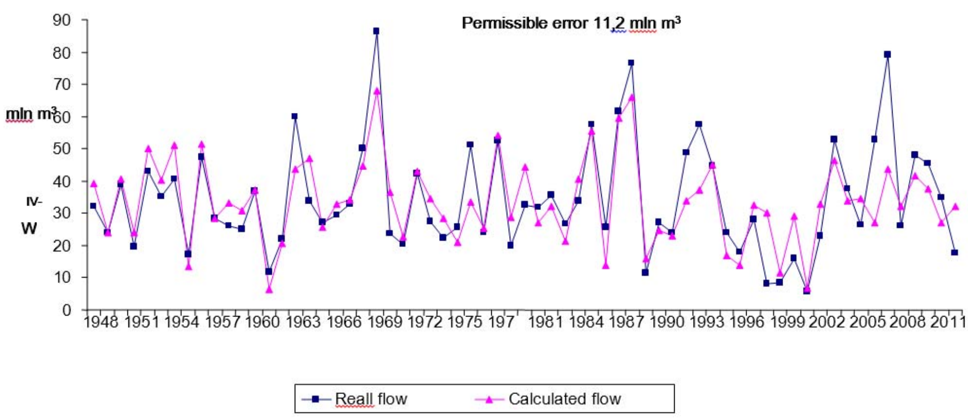
Table2.

Spring flood forecast regression agents and their connections descriptions for Arpa Basin Rivers

N	River – observation point	C_0	C_1	C_2	C_3	C_4	C_5		$\overline{S}$	%
1	Arpa-Jermuk	4,24	0,16	0,14	-0,04	-0,18	-1,36	0,81	0,59	73
2	Arpa-Yeghegnadzor*	-93,2	0,51	0,11	0,77	6,07	-2,96	0,93	0,36	88
3	Arpa-Yeghegnadzor	-119	0,80	0,11	0,19	-6,73	11,4	0,90	0,44	92
4	Arpa-Areni *	-89,4	0,82	0,35	0,76	9,88	-5,15	0,90	0,44	91
5	Arpa-Areni	-252	1,34	0,17	0,58	-17,2	22,0	0,91	0,42	89
6	Vaik-Zaritap	-4,79	0,03	0,02	-0,004	0,09	-0,23	0,81	0,59	71
7	Gladzor-Vernashen	-3,68	0,01	0,01	-0,001	0,04	-0,16	0,86	0,51	84
8	Yeghegis-Hermon*	17,6	0,09	0,13	0,07	1,72	-0,63	0,87	0,50	82
9	Yeghegis-Hermon	-16,7	0,29	0,07	0,04	-2,16	5,58	0,86	0,52	81
10	Yeghegis-Shatin*	-5,94	0,23	0,20	0,19	3,54	-2,35	0,90	0,44	85
11	Yeghegis-Shatin	-64,3	0,56	0,09	0,12	-4,64	7,85	0,91	0,42	89
12	Artabuyq-Artabuyq	-7,46	0,04	0,04	-0,01	0,10	-0,29	0,83	0,56	74
13	Saliget-Shanin	-26,1	0,14	0,04	0,01	0,14	-0,48	0,84	0,55	80

**flood up to Arpa-Sevan water pipe exploitation*

In the graph 4 are shown spring flood and flood calculation for Saliget river.



Graph4. In the graph 4 are shown spring flood and flood calculation for Saliget river.

As it is shown the real and calculated flood lines are completely close to which is the sign of better data calculation.

REFERENCES

[1] L.V.Azizyan – Spring flood forecast method for Aghstev river, Yerevan, Agrogitutyun, 2009, N1-2, pg 81-86.

[2] L.V.Azizyan - Specifications for forecasting spring flood for Khur and Arax basin rivers, Yerevan Information Technologies and Management, 2009 N1, pg 66-71

[3] A.V.Aguchinceva – Methods of statistic observations and analyze of hydro meteorological processing, Inrkutsk, state university of Irkutsk, 2007, pg 105

[4] A.N. Vazhnov– Analyze and forecasts for Caucasus rivers flow, Hydrometeoizdat, 1966, pg 284

[5] Yu.M.Geogevskiy, S.V.Shanochkin – Hydrological forecasts, Students manual, 2007, pg 436

[6] Forecasts reports, 1962, pg 193

[7] M.V.Shahinyan – General rules of element formations of the rivers of Armenia and the methods of their forecasting, Hydrometeoizdat, 1981, pg 176