SIMULATION OF WATER RESERVOIR FUNCTIONING.

PROF. VITALY V. ILINICH

Moscow State University of Environmental Engineering, 19, Prianishnikov str.,

Moscow, 127550, Russia, vv_ilinitch@mail.ru.

Abstract:

The article is devoted scientific approach to simulative functioning of irrigative water reservoir, which gives possibility to considerate different scenarios of management by water recourses and to estimate probabilities of water consumption for several water users and for accident situation during floods

Key worlds: stochastic flow model, water reservoir, irrigation, probability, ecological water discharge, maximum floods, stochastic simulation

There are many water reservoirs in different regions of World, where the main water user is irrigation. However, almost all reservoirs have else other water users (industry water supply, ecological water discharge and etc.). The necessary function of reservoir is protection of territory from catastrophic floods. Every water user requires his own probabilistic guarantee usually in the frame 75 – 95%, but probability of safe management by maximum flow has to be within 0,1 – 1 % (for small reservoirs 1- 10 % in different countries). It is not simple problem [3,5,6] – to obtain management rules by reservoir for sufficiently accurate solution respect to different probabilities of water consumption for every water users and small probability of maximum flow transformation. Such fact is explained by short time series data of observations (30-50 years) and traditional differed estimations respect to water balance for water users (usually time unit – month) and for transformation of maximum flow (usually time unit – 1 day). We have to notice that we need take to consideration the water level before maximum flood. The maximum flood and water level before that can have different probability. Therefore we need use stochastic model (for river flow and water reservoir functioning), which has possibility take to consideration very much amount of scenarios on the base very long time hydrological rank series.

Consequently, aim of the scientific work – development stochastic simulative model for water reservoir functioning, which shell allow to evaluate risks both water deficit for every water user and dangerous situation during transformation catastrophic floods by water reservoir.
The aim has determined next problems:

- development stochastic model for river flow to water reservoir;

- development stochastic simulative model for irrigative water reservoir functioning;

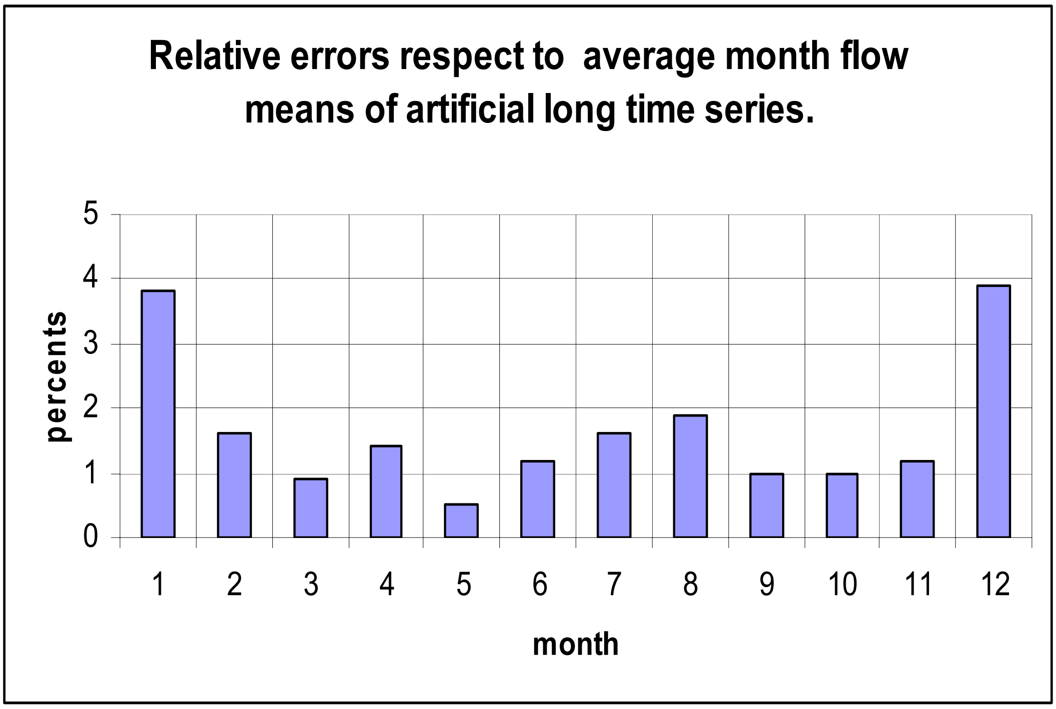
- risk evaluation both for every water users respect to water deficit and for accident situation during transformation catastrophic floods on example of the concrete irrigative water reservoir.

Krasnodar water reservoir was object of research. That is located in the southern part of Russia on the Cuban River. The river has rain-ice floods during summer period and the biggest water irrigative demand, however there are other water users (water supply, requirements to ecological water discharge after spillway of dam etc.). Research was made on the base of daily time series data of observations of river flow to water reservoir during 32 years (1974-2005).
Stochastic simulation of daily time series of river flow was made by Monte-Carlo method (fragment method [2, 7]). Preliminary the statistical parameters of flow discharges (averages, variability, correlation coefficients between discharges of adjacent intervals) were calculated both for the year and for the internal year intervals (month) on the time data series of observation. Asymmetry of

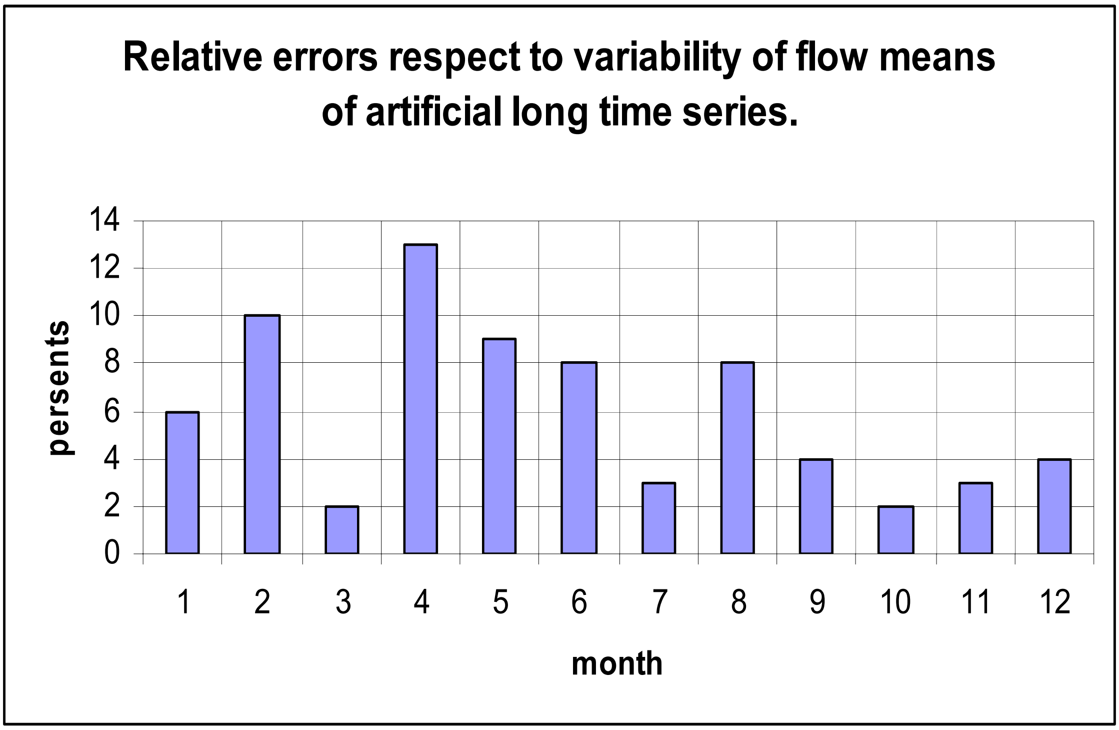
probabilistic distribution was evaluated according to traditional dependence between skewneess coefficient and variability.

The method involves double simulation by the Monte-Carlo method: at first - simulation of annual river flow discharges, and after that - simulation of discharges for internal year intervals. Fragments of river flow hydrograph of 365 daily river flow discharges were obtained according to natural time series data of observations for 32 years. Every fragment was represented by hydrograph relative ordinates, which were determined by ratio of daily discharge to the corresponding year discharge. Every simulated year river discharge of artificial time series was multiplied on 365 ordinates of the fragment chosen by occasional manner according to Monte-Carlo method. So, the artificial long time series of daily discharges have been simulated [2, 7].

Analysis of main statistical parameters (average, variability, auto correlative coefficient) of artificial long time series respect to annual and month internal year intervals have showed that they corresponds to accuracy of statistical parameters of real time series data of observations. Relative errors of average and variability for month flow means of artificial long time series (respect to same means of natural time series data) are represented on the pitchers 1 and 2. The errors are less statistic errors of the same means of natural time series data for the 30 year rank of observation.



Pitch. 2. Relative errors respect to average month flow means of artificial long time series.



Pitch. 3. Relative errors respect to variability of month flow means of artificial long time series.

So, we can accept that both the real observed time series data and artificial long time series are elements of general totality of values of the corresponding probabilistic distribution.

Simulation of water reservoir functioning was made on the base of artificial daily time series according to management rules for Krasnodar water reservoir. Theoretical and practice research [1-4] requires to evaluate probability of rare values on the base of its appearance not less 10 times. Since normative probability of accident flood situation is 0,001 (0,01%) for the Krasnodar water reservoir, length of the artificial time series was taken 20 000 years.

Next equation of water reservoir balance for every internal year interval (t) was used:

$$Vend = Vst + W - U - S \quad (1)$$

Where:

Vst and Vend – water reservoir storage at the start and end of every internal year interval accordingly;

W – river flow volume, which go to water reservoir;

U –water consumption volume including water losses from water reservoir;

S – water volume which outputs water reservoir without use for consumers.

In equation 1 value W is determined according to probabilistic model of river flow which was represented upper text.

Water consumption U involves U1 and U2:

$$U=U1+U2 \quad (2)$$

Here, U1 is water volume of consumption befor dam of water reservoir (includes consumption of different water users + filtration and evaporation losses); U2 – water volume of consumption after dam of water reservoir (includes consumption of different water users). Together value U2 and value S consists sum volume of water, which outputs water reservoir (Wb):

$$Wb = U2+S \quad (3)$$

Notice, that U1 and U2 are real volumes of consumption, which can be less of the plan water consumption (U1pl and U2pl) in the case of water deficit (D). Consequently, total physical limits of water consumption are 0 ÷ Upl and 0 ÷ Up2. Real values of water consumption depend on both water demands and water reservoir storages during same time and consequently depend on management rules by water reservoir. Physical limits of value S in equation 1 are 0 ÷ ∞. Water volume after dam (S+U1) can create accident situation during catastrophic flood.

Values of Vend in equation 1 are determined according to other values of equation and management rules for water reservoir functioning. Values of Vst for every internal year interval (t) are taken equal to values of Vend of previous internal year interval. Precipitation, which fall down on the surface of water reservoir did not take in attention because there are not precipitation during dry period and value of that is small in comparatively to other compositions of water balance during flood period.

Real consumption means determined according to management rules by water reservoir. If any kind of consumption was less plan mean, then the deficit fixed and calculated. The cases of exceeding of maximum water reservoir level were fixed by accident situation.

Different rules of management by water reservoir were tested in the frame of upper represented simulative model according to different scenarios. So, we could do choice relevant rules respect to economic profitability and probability for every kind of plan water consumption (for different water users) and probability of accident situations during floods. Today step of research have allowed to increase probability for ecological discharge until 90% and for plan irrigated consumption until 74%, to remain same probability for industry water supply, to decrease probability of accident flood situations from 0,1% until 0,06%.

REFERENCES

[1] Beck N.N., Golenco D.I. Statisticheskie metodi optimizatciy v economicheskih issledovaniah (In Russian), Moscow, (1971), pp 1-237.

[2] Ilinitch V.V. “Imitatcionnaia model vodohranilisha”. (In Russian), Express informatia, Moscow, (1982), pp 1-4.

[3] Ilinitch V., Perminov A. “Management technology by multi-purpose water reservoirs for protection of territory from floods”, Proceedings of Scientific Conference: “Natural and technological problems of protection and development of agricultural and forest environment”, book 2, Poznan, (1999), pp. 17-22.

[4] Ilinitch V.V. Probabilistic approach for modeling hydrological catchments. India, Chennai, (2004), pp 1-78.

[5] Ismailov G.H. Veroiatnostnie rascheti vodohranilish kompleksnogo (irrigatcionno- protivopavodochnogo naznachenia. (in Russian), .Vodnie resursi, ν2, Moscow (1973), pp 81-94.

[6] Ilinitch V.V. Search of Anti-Accident Function for Flood Flow Management by Water Reservoir. Proceedings of the 7-th International Conference on Hydroinformatics 2006,V.2,p.1025-1031.

[7] Svanidze G.G. Osnjvi rascheta regulirovania rechnogo stoka metodom Monte-Carlo. (in Rusian), Tbilisi, (1964), pp 1-232.