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SINE MODELING AND LONG RANGE PREDICTION OF WATER LEVEL OF AMU DARYA RIVER NEAR SAMANBAY VILLAGE

Abstract: analyzed the time series of water level of Amu Darya River near the Samanbai Village is subdivided for the interval of its high values of 1934 – 1970 and low values 1978 – 2002 by the method of Periodicities.

The last ten points of the time series were applied for computation of the training forecasts with the lead time of five and ten years and estimation of its results.

Key words: Amy Darya, water level, approximation, periodicities, long range forecast

Introduction

The Amu Darya River originates at the confluence of the Panj and Vakhsh near the border of Afghanistan and Tajikistan, and runs along the northern border of Afghanistan with Tajikistan, Uzbekistan and Turkmenistan. It then turns north and flows through eastern Turkmenistan and further on its border with Uzbekistan, and empties into the southern part of the Aral Sea.

The river is the confluence of the Panj and Vakhsh 1415 km and 2540 km from the source of the Panj, originating in the Pamir Mountains. The basin is divided into two parts - an area of - flow formation bounded by mountain areas of Afghanistan and

Tajikistan, and the scope of its depletion. After the merger, Panj and Vakhsh, into the Amu Darya flow three large right tributaries - Kafirnigan, Surkhandarya and Sherabad and left tributary - Kunduz.

In the middle and lower reaches of the Amu Darya water lost to evaporation and used for irrigation. Runoff used for agricultural purposes, gradually increased in the XX century, causing a decrease in water content of the Amudarya in its lower reaches. The sharp, almost abrupt drop in runoff occurred during the decade 1970 - 1980 years. Use of the Amu Darya river flow for agriculture causes urgency of the problem of its forecasting in the near future.

The purpose of this paper is to analyze the method of "periodicity" of the time series of average annual values - of the water level of the Amu Darya near the settlement Samanbay located in Nukus district of Karakalpakstan in Uzbekistan. Some analyzed for the period 1934 - 2002 years. Carried out the verification calculations forecast its value to 2003 - 2007 years and 2003 - 2012 years, evaluated the results of prediction.

1. Criterion for assessing the long-term forecast of the time series of water level of the Amu Darya

Long-term prognosis of the water level in the river to be Considered to be justified, if the difference between the observed and calculated its value not greater than the allowable prediction error Δ, equal to 0.674 of its standard deviation σ [1]

$$\Delta = 0{,}674\sigma, \tag{1}$$

the standard deviation of the time series was calculated as follows:

$$\sigma = \sqrt{\frac{\sum_{1}^{n}(Q_i - Q_s)^2}{n}}, \tag{2}$$

Where Q_i – water level of the river during a year i;

Q_s – The mean value of water level for the calculating period;

n – The length of the time series.

Prediction results on 5 and 10 year interval measured at the amount Forecasts for individual years. Their quality is also determined by the sum of squared errors annual forecasts for these intervals, and the mean square error of forecasting. Standard deviation σ predictions are the square root of the ratio of the sum of squared errors and span the length of the interval forecast.

Successful long-term forecast of the water level in the river has to be better than its future estimates of the mean value. The average value of a time series of the water level of the Amu Darya for 1934 - 2002 years as follows: 1,171 m, standard deviation is - 0,794 m, and the allowable prediction error - 0,535 m.

However, as the water level in the river as a result of parsing its flow to agriculture fell, systematically located on the lower elevations, the results of forecasts, it is advisable to compare not only its average value for the entire observation period, and the average value over the past decade - the time low water interval 1978 - 2002 years. At the same time, the permissible error is forecast for the time interval of low water of the Amu Darya should be lower than for the entire observation period 1934 - 2002 years., Since the standard deviation is calculated without taking into account the fall of the water level of the high values of the first decades of the observation period, to low.

The mean value of the water level of the Amu Darya for 1978 - 2002 years equals to 0.262 m. The standard deviation and allowable prediction error constituted 0.229 m and 0.155 m.

2. The method of "periodicity" in the analysis of time series of water level of the Amu Darya

The method of "Periodicity" is based on an approximation of hydrometeorological time series of sinusoidal functions in series with the step change period. The amplitude and phase of the constant value which fluctuates around best approximating sinusoid calculated by least squares method. For each period, calculated the amount of quadratic differences of the time series and best approximates the sine wave [2].

At certain periods the minimum of the sum of quadratic differences between the best approximating sinusoid and the values of the time series were observed. The minimum sum of the squares of the difference between approximating a sine wave, and time series depend on the approximation may be a sign of the presence here of periodicity [3, 4].

In Figure 1, A) is a water level fluctuations Amu Darya River near the settlement Samanbay. The period of the sinusoid approximating the number of water level with the smallest sum of squares of the differences with him turned out to be 104 years old. Correlations of the sine wave and a number of water levels are equal to 0.911.

It was established and other periods in which the sinusoid approximating sums are characterized by a local minimum-square-difference time-series. Their length was 18, 36, 25 years old, and others. The correlation ratio of sine waves with periods of rest and time series of water level of the Amu Darya does not exceed 0.241.

Figure 1 b) shows the remaining number - the difference between the number of water level of the river Amu Darya and its approximating a sine wave with a period of 104 years. By adding a unit for each value of this difference to avoid they are not less than 0. This residual series is also analyzed by "periodicity" resulting in the smallest sum of its differences with the quadratic approximating sine waves is set at the time, the length of 31 years.

Correlations and residual number of sine wave with a period equal to 0.516 in '31. In periods with a length of 19, 5 and 12 years marked the local minima of the residual sum of squares of the differences of the series and its approximate sine waves. The correlation ratio of sine waves and residual number is significantly lower than 0.516.

Verification forecasts for the water level of the Amu Darya will count on a sinusoid with a period of 104 years and its combination with a sine wave with a period of 31 years, as these sine waves, respectively, the highest correlation with the time series of water level of the Amu Darya and its residue. Sine wave with periods of 104 years and '31 combined methodology of multiple correlations [5].

3. Verification forecasts for the water level of the Amu Darya

Figure 1 a) and b) a dotted line shows the range of the forecast span 2003 - 2012. The values of the correlation relationship with the time series of water level of the Amu Darya sinusoid with a period of 104 years, and its combination with a sine wave with a period of 31 years, in the caption under the pictures are marked accordingly and η2 η3. Correlations and residual number of approximating its sine wave with a period of '31 through designated η5.

Projections calculated as the residual of a number of sine wave with a period of 31 years, and the main series. The average value of the remaining number was 1 m, standard deviation - 0.328 m, and the allowable prediction error - 0.221 m.

In Table 1, respectively, in columns 1, 2, 3 and 4 are indicated during the verification interval, residual values yea- Qfo number of years, their difference with the average value of the number-Qso Qfo and squares of the differences (Qso-Qfo) 2. In columns 5, 6 and 7 show the values of a sine wave with a period of 31 years, the remaining number of approximating the level of water of the Amu Darya and its differences with the values of this series for the respective years and the squares of these differences.

In the bottom two rows of columns 3, 4 and 6, 7 evaluates the results of a number of forecasting the residual water level of the Amu Darya in its average value and a sine wave with a period of '31.

The forecast for the average value during the 2003 - 2007 years justified 4 times. It was not only justified in 2007. The sum of the squares of the errors amounted to 0.169 m2 and the mean square error of prediction - 0.184 m.

When forecasting the number of residual water level of the Amu Darya in the 2003 - 2012 years the average value of 5 justified projections. In the second five-year period the forecast was justified in 2010. The sum of squared errors of prediction was 0.661 m2. Its standard error is 0.257 m.

Sinusoid with a period of 31 years in the interval 2003 – 2007 4 predictions came true, and the entire range of 2003 - 2012. - 8 projections. The forecasts were not justified for 2005 and 2010. The sum of squared errors of forecasts out to five years amounted to 0.090 m2 and its average relative error of - 0.134. When forecasting the residual number of the Amu Darya with a lead time of 10 years is equal to the sum of squared errors 0.272. The average relative error of prediction was 0.165.

When forecasting the number of residual water levels with a lead time of 5 years was justified as forecasts of the average value. The sum of squared errors and mean square error of prediction were below the sinusoid with a period of '31. When forecasting for the entire calibration interval sinusoid with a period of '31 predictions come true more and the sum of squared errors and mean square error of prediction were lower than the average value of this series. Thus, forecasts of a number of the remainder of the water level of the Amu Darya in the 2003 - 2007 years and 2003 - 20012 years a sinusoid with a period of 31 years were better than the average value.

Table 2 presents the results of forecasting the water level of the river Amu Darya that are associated with forecast estimates the average value of its time series. At 2, 3 and 4 columns of this table, the actual water level, respectively, for the years, its difference with the average value of the water level and the total number of squares of these differences. Years of considerations were given in the first column.

The column 5 shows the results of calculations of the level of water of the Amu Darya sinusoid with a period of 104 years, and 8 - by a combination of sine waves with periods of 104 and 31 per year. At 7 and 9 column shows the difference among the water level of the Amu Darya, respectively, calculated on a sinusoid with a period of 104 years and its combination with a sine wave with a period of 31 and the actual level. At 8 and 10 columns represent the squares of these differences.

In the bottom two lines the results of prediction of the analysis and synthesis were given. At 3, 6 and 9 columns represent the number Forecasts to these methods with a lead time of 5 and 10 years. In 4, 7 and 10 columns, calculate the sum of squared errors of the forecasts and their standard errors.

As the average value of the time series in the whole verification intervals 2003 - 2012 years not justified any forecast. In forecasting with a lead time of 5 years, the sum of squared errors and mean square error were found to be respectively 4.936 m2 and

0.994 m. The span the entire range of its forecast of the sum of squared errors and mean square error amounted to 10.111 m2 and 1.006 m.

Thus, considering the allowable error forecasting total number of water level of the Amu Darya, it is clear that in calculating the future level of a sine wave with a period of 104 years and its combination with a sine wave with a period of '31 with a lead time of 5 and 10 years, an equal number of justified expectations. But the sum of squared errors of prediction in the 2003 - 2007 years and 2003 - 2012 years and its standard error by a combination of sine waves with periods of 104 and 31 year less than a sinusoid with a period of 104 years. So the results of the forecast for 5 and 10 years ahead by a combination of sine waves with periods of 104 years and the '31 is better than a sinusoid with a period of 104 years. A forecast for the mean value of the entire series was worse than a sinusoid with a period of 104 years and its combination with a sine wave with a period of '31.

Table 3 analyzes the results of prediction of the water level of the Amu Darya, taking into account the average value in the range of low values of its 1978 - 2002. The difference of the actual water level and the average value for the lower range of its time series are calculated in column 3 and 4 - the squares of these differences. At 5 and 8 column indicates the value of the water level of the Amu Darya, respectively, calculated on a sinusoid with a period of 104 years and its combination with a sine wave with a period of 31 years, and at 6 and 9 columns - their difference with the actual level values. The squares of the differences, respectively, and a number of water level sinusoid with a period 104, and its combination with a sinusoid with a period of 31 years, and their amounts are shown in Table 2.

In the bottom two rows of Table 3 shows the number of unnecessary projections, as well as the sum of squared errors and mean square error of the water level of the Amu Darya by the average number of its 1978 - 2002. The forecasting on the average value with a lead time of 5 and 10 years, respectively, justified 2 and 3 of the forecast. The sum of squares of errors and root mean square error in the forecasts for 2003 - 2007 years constituted to 0.133 m2 and 0.163 m. In calculating the future level of water of the Amu Darya with a lead time of 10 years, the sum of squared errors and mean square error is found to be 0.358 m2 and 0.189 m.

Sinusoid with a period of 104 years to span the range of 2003 - 2007 years taking into account the allowable prediction error associated with the average value of a number of water levels of the Amu Darya 1978 - 2002. Being justified 2 forecasting and in the prediction with a lead time of 10 years - 3 forecast. By the combination of the sine wave and sine wave with a period of 31 years for 2003 – 2007 years 4 forecast proved correct, and for 2003 - 2012. - 7 forecasts.

When forecasting the water level of the Amu Darya sinusoid with a period of 104 years, and the average value of its series of 1978 - 2002 with lead times of 5 and 10 years, justified the same number of projections. The sum of squared errors of prediction and standard error of the mean value is less than a sinusoid with a period of 104 years. Hence, the forecast by the average number of late interval of the water level of the Amu Darya in the 2003 - 2007 years and 2003 - 2012 years better than a sinusoid with a period of 104 years.

By a combination of sine waves with periods of 104 years and 31-year forecasts for 2003 - 2007 and 2003 - 2012 years justified more than the average value for 1978 - 2002 years (taking into account allowable prediction error calculated in this range), and the sum of squares of errors and mean square error of prediction is less. Consequently, the outlook for the combination of sine waves with periods of 104 and 31 the year with a lead time of 5 and 10 years were better than the average value of a time series of water level of the Amu Darya for 1978 - 2002.

Conclusion

In the analysis of time series of water level of the Amu Darya 1934 - 2002 years. By "periodicity" found that the lowest sum of the squares of the differences observed in him approximating a sine wave with a period of 104 years. In the remainder of (number of difference values of the water level and the sinusoid with a period of 104 years), the smallest sum of squared differences with it approximates the sinusoid is obtained from the period length '31. The time interval 2003 - 2012 years used to calculate calibration forecasts with a lead time of 5 and 10 years, and evaluate their results.

Calculated calibration forecasts residual number of water level of the Amu Darya with a period of '31. The results were better than forecast estimates the average value of this series.

Some of the Amu Darya water level can be divided into time slots of its high value to 1970, and low values since 1978. Calibration projections calculated by the average value over the entire observation period, and the time interval of low values of the water level of the river. They are also calculated on a sinusoid with a period of 104 years and its combination with a sine wave with a period of '31.

The results of verification predictions were compared with each other. The best results of forecasting the water level of the Amu Darya with a lead time of 5 and 10 years were obtained by a combination of sine waves with periods of 104 and 31 per year. Slightly worse results were predicting the average value for the period 1978 - 2002 g. worse than the average value for the time interval results were forecasting a sinusoid with a period of 104 years. The results forecast for the average value of the time series proved to be the worst.

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