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ANALYSIS OF RAINFALL IN THE KAZAKHSTAN

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ABSTRACT: Before building the storm sewer networks the analysis of precipitation is very important. The issues of assessing the reliability of the information on the annual amounts of precipitation in the meteorological monitoring system of the KazHydroMet State Hydrometeorological Service of Kazakhstan are considered. An assessment is made of the homogeneity of the spatial correlation function, as the basis of the cartographic modeling of the statistical parameters of annual precipitation amounts. A special study aimed at studying the processes of cyclical fluctuations in the temporal variability of annual and summer precipitation amounts for stations representing all regions of the country. The data of daily precipitation of Kazakhstan in the period 1936-2017 were processed. When processing data, an open-source computer program R was used. The results will be useful for designers and researchers. A statistically significant increase in the maximum daily precipitation of 2–4 mm per 10 years was recorded at the Arkalyk, Aksay, Atyrau, Ushtobe, Bektauat and Karabalyk meteorological stations. At some stations in the Akmola and Pavlodar regions, as well as in the south and southeast of the republic, a statistically significant reduction of 2-6 days per 10 years was observed for the maximum duration of the period without precipitation.

Keywords: KazHydroMet, Rainfall, Representative area, Linear trends analysis

1. INTRODUCTION

The climate of Kazakhstan is mainly dry. The climate map shows that the amount of precipitation falling on the territory of the country is insignificant and they are distributed unevenly. This is due to the location of the Republic in the Central part of Eurasia and its remoteness from the oceans.

The average annual rainfall in Kazakhstan ranges from 130 to 1600 mm. Thus, in the areas located in the North-East of the Aral Sea and in the Western part of lake Valkash, only 100 mm of precipitation falls, and in some years - even less. The greatest amount of precipitation falls on the Western Altai.

Modern meteorological monitoring covers a system of meteorological stations and posts that systematically monitor precipitation patterns, including measurements of the amount of semi-daily and daily liquid and solid precipitation, height and water reserves in snow, temporal rains and showers using rain gauges and radar observations.

The completeness and reliability of precipitation observations are assessed quite satisfactorily. The most complete information on annual precipitation, reduced to the period of continuous observations, is available from 91 stations (1936 to 2017). To date, the meteorological network according to KazHydroMet is represented by 339 meteorological stations and posts throughout Kazakhstan.

2. DATA AND METHODS

2.1 Data Used

2.1.1 Rainfall data

Dates of precipitation from the KazHydroMet state meteorological organization [1]:

- The total monthly precipitation for the period from 1941 to 2017, used as the main dates. Also, the dates of 190 weather stations were used to estimate the trend;

- Daily maximum and minimum precipitation for the period 1936 - 2017 (more than 90 meteorological stations).

2.1.2 Basic approaches and methods

The anomaly of average precipitation is a deviation from the norm.

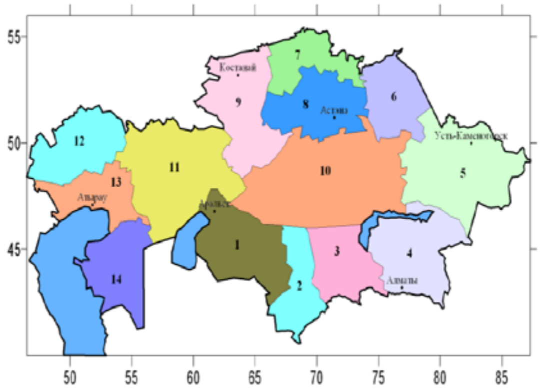
An estimate of the amount of precipitation has been carried out for 14 administrative districts of Kazakhstan. Fig. 1 was shown a map of the administrative regions of Kazakhstan.

To assess the extreme precipitation regimes for the period 1941–2017. The climate change index recommended by the World Meteorological

Organization was used (WMO). This index can estimate many aspects of climate change as the frequency and duration of precipitation.

Some indices are based on fixed uniform threshold values for all stations, others on threshold values, which can vary from station to station.

In the latter case, the threshold values are defined as the corresponding percentiles of the data series. Indices make it possible to assess many aspects of climate change, such as, for example, changes in the intensity, frequency, and duration of extreme rainfall.



1 – Kyzylorda region	8 – Akmola region
2 – Turkestan region	9 – Kostanay region
3 – Zhambyl region	10 – Karaganda region
4 – Almaty region	11 – Aktobe region
5 – East-Kazakhstan region	12 – West-Kazakhstan region
6 – Pavlodar region	13 – Atyrau region
7 – North-Kazakhstan region	14 – Mangystau region

Fig.1 Administrative-territorial scheme of Republic of Kazakhstan

2.1.3 Climate in Kazakhstan

In Kazakhstan, precipitation is insignificant, most fall in spring and early summer. The driest months are July and August. In August 2012 in the south of the country, there was no rain for more than 30 days. Only in the mountainous regions precipitation falls year-round. In winter, snowfalls. However, when the thaws can rain, causing ice. Snow falls in winter throughout the country, with the exception of the outskirts of the south-west and south. The greatest height of the snow cover is observed in the north and northeast of the country.

2.2 Data Analysis

For the spatial and temporal study of annual amounts of precipitation for the warm period, as the equivalent of landscape wetting, the entire network of existing meteorological monitoring was used, that is, long-term observations from 91 meteorological stations in Kazakhstan. The analysis of temporal and spatial patterns of changes in annual precipitation amounts requires the most complete long-term information, which includes observational data for the period of years, covering wet and low-water phases or closed wetting cycles [2]. To this end, it became necessary to systematize the network of meteorological observations in four economic and geographical regions, as shown in Table 1.

Table 1 The current condition of the study of precipitation in the meteorological monitoring system of Kazakhstan [3]

Regions	Area, km^2	Number of stations (1936-2017)	The density of measuring networks, km^2/1 station
South	711 443	25	28458
East-	283 226	10	28323
North	564 968	30	18832
Central	427 982	4	106996
West	736 241	22	33466
Total	2724902	91	216074

According to the results given in Table. 1, one point represents the average area of 216074 km^2. The largest representative territory in the center of the country indicates a lack of knowledge of this territory. If we assume that the representative area of 216074 km^2 is a circle with a radius R_x in the center at which the meteorological point is located, then the value of this radius is half the distance L_x between the observation points [4]:

$$\frac{L_X}{2} = R_X = \sqrt{\frac{f_X}{\pi}} \tag{1}$$

where f_X is the area representing the density of meteorological stations in an accepted region, given in Table. 1. In accordance with these data, the value of $L_x/2$ calculated by the Eq. (1), respectively, will be equal to for the southern and eastern regions - 95 km; for the north - 77 km; for the center - 185 km; for the west - 103 km and on average for the territory of Kazakhstan - 262 km.

3. RESULTS AND DISCUSSION

In contrast to the air temperature, the change in the mode of precipitation in Kazakhstan during the study period is a more interesting picture. Linear trends in the ranks of monthly, seasonal and annual precipitation were estimated by 121 stations.

The time series of anomalies of annual and seasonal precipitation for the period 1941-2017, calculated relative to the base period 1981-2010. and spatially averaged over the territory of Kazakhstan and regions give a general idea of the nature of modern changes in the regime of precipitation. Over the past decades, alternation of short periods with positive and negative precipitation anomalies has been observed as shown in Fig. 2, 3, 4, 5. On average in Kazakhstan for the period 1976-2016, there was a tendency to increase the annual precipitation amount by 5.9 mm/10 years. In the regional context, almost all the regions also showed an increase in precipitation, with the exception of Kyzylorda and West Kazakhstan regions, where precipitation decreases every 10 years by 5.1 mm and 1.0 mm, respectively. A statistically significant increase in annual precipitation amounts was found only in the North Kazakhstan region (13 mm/10% year).

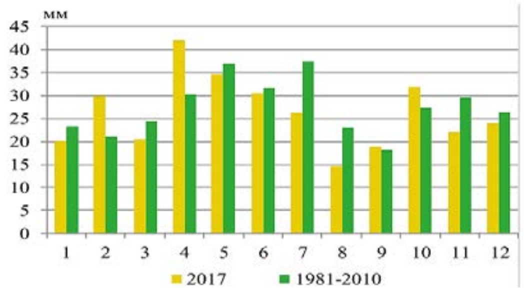


Fig.2 Monthly precipitation in 2017 and norms for the period 1981-2010, averaged over the territory of Kazakhstan

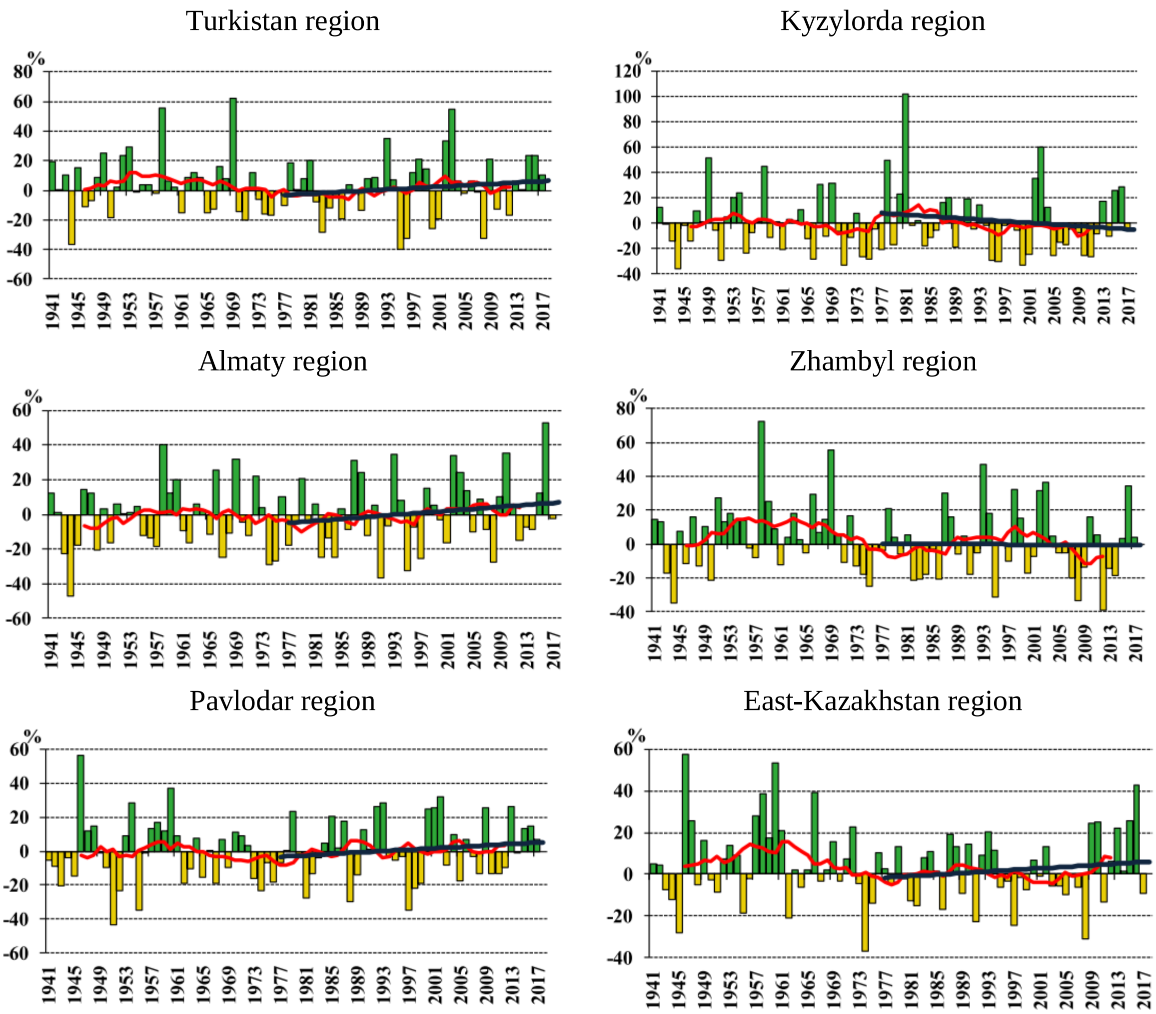
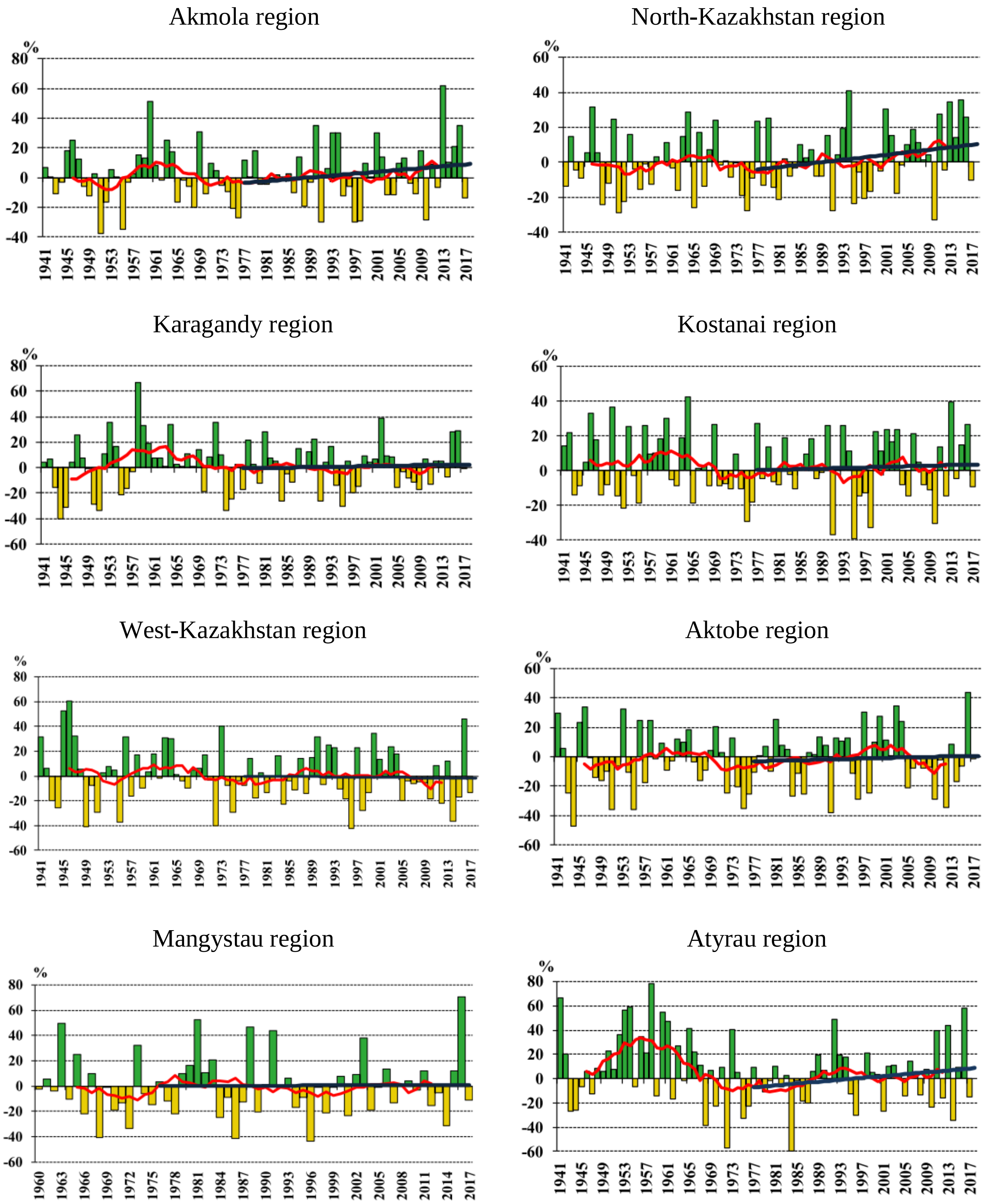


Fig. 3 Time series and linear trends of annual precipitation anomalies (in%) for the period 1941-2017, spatially averaged over the territory of Kazakhstan and its regions. Anomalies are calculated relative to the base period 1981-2010. The linear trend for the period 1976-2017 highlighted in blue. The smoothed curve was obtained by 11-year moving average. Sheet 1



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For the period 1976-2017 on average in the regions in all seasons, there is a tendency to an increase in the amount of precipitation, with the exception of the autumn season, when the decrease in the amount of precipitation was 1.3 mm/10 years. All obtained seasonal trends are statistically insignificant. More detailed information on the nature of changes in precipitation in Kazakhstan is provided by the spatial distribution of the linear trend coefficient values for annual, seasonal and monthly precipitation (%/10 years) calculated for the period 1941-2017. According to the data of individual meteorological stations, there is spotting in the distribution of the sign of the change in annual and seasonal precipitation. The trends in annual precipitation over most of Kazakhstan were mostly positive, but insignificant. A statistically significant increase in precipitation is observed at some meteorological stations in the western, northern, central and southeastern parts of the Republic (4-10%/10 years). At the weather stations Aktogay, Besoba (Karaganda region), Amangeldy (Kostanay region) and Uyuk (Zhambyl region), stable negative trends were 8-14%/10 years. The highest statistically significant rate of increase in the amount of winter precipitation (8–20%/10 years) is observed in the west, north, and south-east of Kazakhstan. The greatest contribution to the positive trend of the winter season for the western and southeastern regions was made in January and February, for the northern regions - in December.

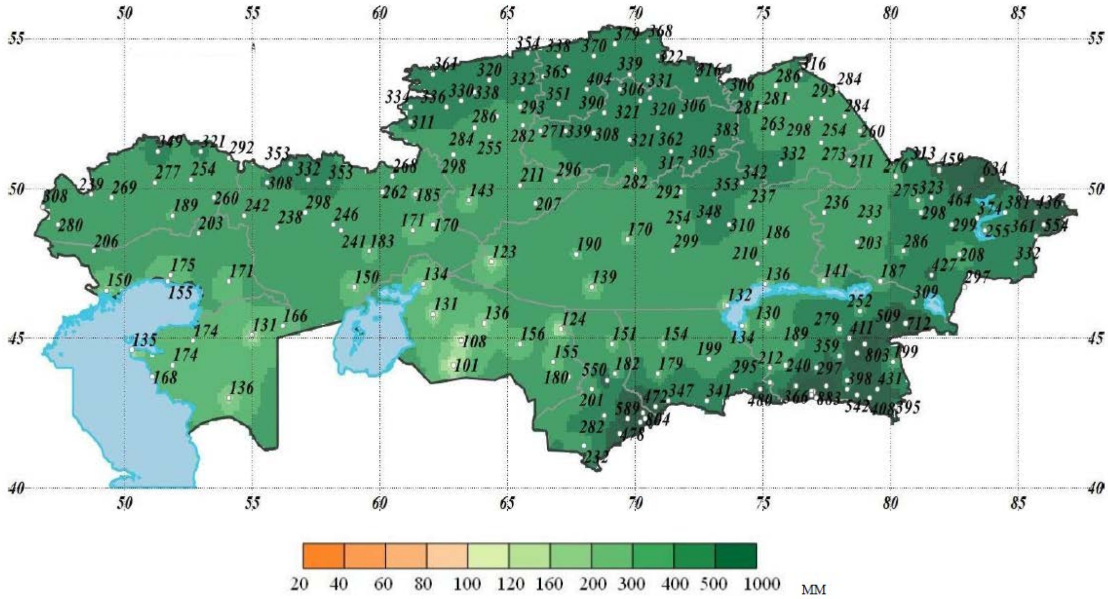

Fig. 4 Spatial distribution of the annual precipitation sum in the territory of Kazakhstan, calculated for the period 1981-2010

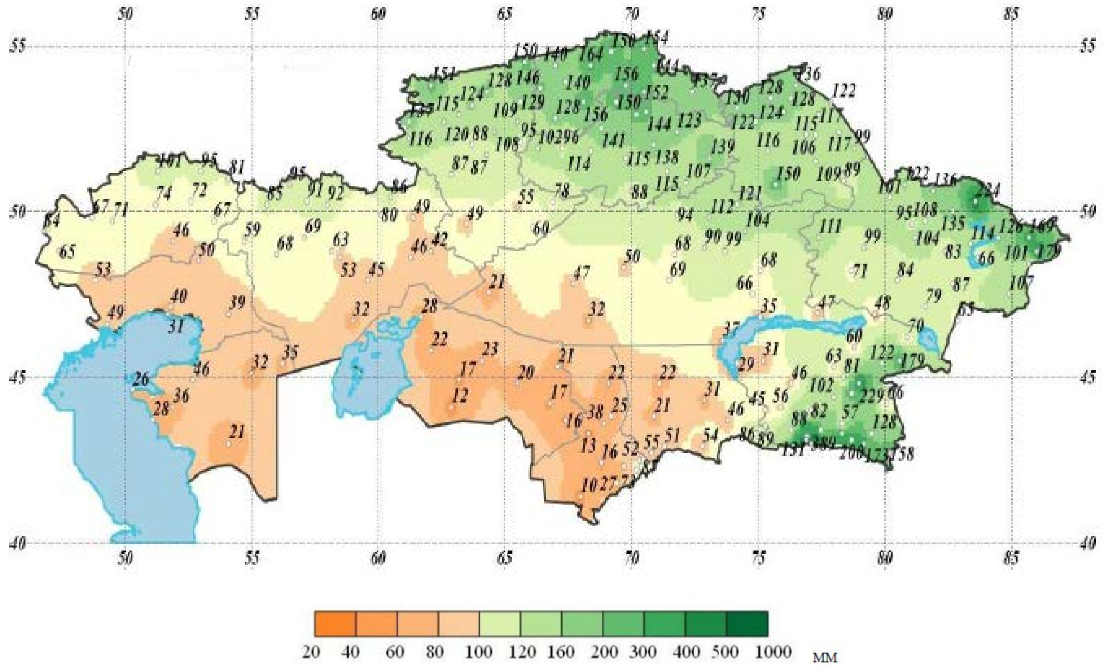

Fig. 5 Spatial distribution of the summer precipitation sum in the territory of Kazakhstan, calculated for the period 1981-2010

4. CONCLUSION

As an assessment of changes in climate characteristics over a certain time interval, linear trend coefficients are used that are determined by the least-squares method. The measure of the materiality of the trend is the coefficient of determination (R^2), which characterizes the contribution of the trend component to the total variance of the climate variable for the period of time under consideration (in percent).

It is known that an increase in the extreme amount of precipitation during the warm period leads to an increase in the risk of erosion processes, in mountainous areas - mudflows of rain genesis, and in the cold period - to an increase in the danger of avalanches.

In most parts of Kazakhstan, there has been a tendency to reduce the maximum duration of the period without precipitation (CDD index). At some stations of Akmola, Pavlodar regions, as well as meteorological stations in the south and south-east of the republic, a statistically significant reduction in the rain-free period was observed (from 2 to 6 days / 10 years).

The largest representative territory in the center of the country indicates a lack of knowledge of this territory.

In conclusion, it is proposed to use an empirical spatial correlation function to analyze and objectively estimate the errors of the initial information on annual precipitation amounts.

The use of neural networks to study the distribution of precipitation is also important [5].

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