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The Causes of Unequal Distribution of Rainfall in the Earth and Prediction Perspectives in Azerbaijan

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Abstract
This article investigated the reasons for changes in rainfall over the years. It was revealed that the change in the rate of rotation in regard to the Earth's atmosphere can wag to the distribution of rainfall. As subtropical and polar regions of the Northern Hemisphere are influenced by synoptic processes, the speed of the atmosphere often here exceeds the speed of the Earth. Therefore, in these regions the difference in rainfall is 400 - 500 mm or more over the years. In this regard, the paper analyzes the effects of atmospheric forces on the speed of movement and shows the direction of the actions. As a result, by the help of harmonic analysis the distribution of rainfall for a 60 year period was evaluated.
For the cycle of the years 1900-2009 the range of precipitation fluctuations was analysed with the use of Shuster's Method, which detected periods and divided them into harmonious ranges. At the end, distribution graphic was compiled, based on defined Fourier coefficients.
According this graphic its possible to forecast precipitation distribution of Lankaran Region for next 50 years and, based on ths, it is possible to forecast meteorological drought. Based on this calculation, in the 40 years after 2018 precipitation will decrease. The method employed here can be used for each region of the world.
Keyword: distribution of rainfall, synoptic processes, atmospheric forces, harmonic analysis, Baric gradient.

I. Introduction

The distribution structure of precipitation on space and time in the Earth is quite complex. Every day, in some regions rain falls while in others rain does not fall for years. Even in areas with a radius of 100 km, the rainfall distributions differ. Thus, the fluctuation of precipitation distributions on climate norms is larger, and varies between 500 to 600 mm in some regions.

For example, variation of precipitation in some southern regions is ± 500-600 mm and in northern regions varies between ± 200-300 mm. This kind of diversity is common in any region of the Earth. Therefore, along with the above-mentioned reasons of variation of precipitation distribution, other reasons are also acceptable.

II. Method and information

It is known that the movement of the atmosphere takes place as a result of the Earth's rotational movement. However, the forces influencing the atmosphere also influence it's movement direction in the relation of the Earth. By the influence of these forces, the speed of movement of the atmosphere in the relation of the Earth increases and decreases. Only Barik Gradient force influencing the atmosphere differs from others as being more changing force. Thus, if the direction of gradient force in the atmosphere coincides with the direction of movement of the atmosphere, the atmosphere acts are more than the rotational movement of the Earth, otherwise it is small. As a result of this movement over the surface of the Earth, the east wind blows at low latitude, and the west wind blows at moderate and high latitudes. So while the movement of the atmosphere at low latitudes is delayed to some degree in the respect of the Earth, on the contrary, at moderate and high latitudes the atmosphere movement is slightly higher than the rotational movement of the Earth. Impulse moment for the east wind is negative, but for the west wind it is positive. When impulse moment increases, ie, the west wind escalates, the rotational movement of the Earth weakens. When impulse moment of the atmosphere weakens, the east wind becomes stronger (and the west wind weakens), the rotational movement of the Earth increases [7]. According to the natural law of conservation and movement quantity of influencing forces on the atmosphere, we can define that the movement of the atmosphere in the respect of the Earth can be delayed or hastened (depending on the value and direction of the Barik gradient force) as well as the soon to be delayed, the delayed release in the atmosphere.

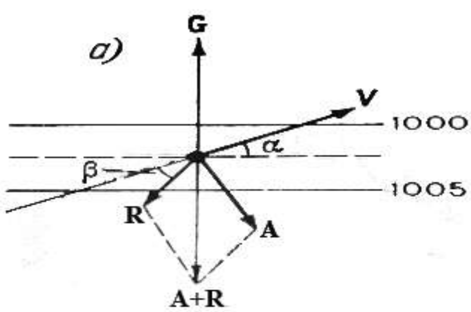
Against the centrifugal movement of the Earth's atmosphere, friction, and the Coriolis effect Barik gradient occurs under the influence of forces. The effect of centrifugal force and friction of the boundary layer (1.5 km) above shall not be considered as very low altitudes. As the effect of centrifugal and friction force is rarely at high latitudes of the boundary layer (1.5 km), it is not considered. The price of the centrifugal force on the surface of the Earth is stable, according to the wind in the friction force (in relation to the Earth's atmosphere) depends on the speed and orographic features. Coriolis force also depends on geographical latitudes and relative movement speed. It is also necessary to take into account that the value of the friction force is greater on dry surfaces than on the water surface. Therefore, with the complexity of orographic features, the value of the friction force increases at high latitudes, and in this connection the atmosphere movement breaks more (ground surface) at high latitudes.

Barik gradient force is the main force in the momentum of air masses. In the formation of the atmospheric processes the role of this force is great. Under the influence of these forces the direction of wind changes frequently, clouds and rains transfer to other parts of the Earth. The value of Barik gradient force depends on orographic features, and is compensated by friction coriolis forces. Unequal precipitation distribution is also connected with Barik gradient force. Value changes of this force are determined by the temperature contrast between the upper and lower latitudes. While the temperature contrast is high , the impact of advective processes increases in the region, otherwise, the value of the contrast is small and convective processes are dominant in the region. Frequent change of temperature contrast causes a change in the direction of the Barik gradient vector, and as a result the transferring of atmospheric precipitation changes over time. Surface cover around the equatorial regions is more homogeneous than at other latitudes, about 20% of the land area is dry, while the rest of the surface is water. Here, the value of friction force is less changeable, and is relatively weak at higher latitudes, where the Coriolis force is very small. The homogenity of the surface affects the changing of the Barik gradient force, and reduces it. One of the reasons for high precipitation at this latitude is the high humidity and little change in Barik gradient force. At the same time, the vector of Barik gradient force directed from moderate latitudes towards the equator can be regarded as a quantitative factors that causes more precipitation at moderate latitudes. In some studies it is known that 80% of precipitation is advection precipitation [1]. The amount of precipitation during the year is 1500 - 2000mm in a narrow zone around the equator. On the east coast of Africa it is less than 1000 mm, and, to a lesser extent, on the islands of Borneo and Sumatra, and the upper parts of the Amazon River, precipitation levels measure up to 3000 mm per year. Differences in precipitation distributions in separate regions of course depend on the orographic characteristics of the region. In general, differences in the structure of space-time in the regions around the Equator are smaller than at other latitudes.

The impact of friction and Coriolis forces increases towards high latitudes, and the influence of Barik gradient force and the rotational movement of the atmosphere in the respect of the Earth changes significantly. The rotational movement of the atmosphere in the respect of the Earth is slightly delayed. For this reason, the amount of precipitation in the western coastal regions is less than it is in the east. Though the Sahara Desert stretches to the Atlantic Ocean to the shores in the Northern Hemisphere, the amount of precipitation is less, no more than 250 mm in a year. The west coast of North America, especially from the Californian peninsula and furthere north, is characterized by a low amount of precipitation. In the eastern part of North America a corresponding arid region has not been found. In general, according to the general laws adopted for passat zones precipitation is less on the west cost than on the east coast. On the contrary, the situation varies in moderate zones, the west coast is relatively more humid than the east coast. In South America, on the coast from the equator from 32^0 latitude to the west, the precipitation increases by up to 2000 mm. Of course, the precipitation is observed only in a very small area, on the western slopes of the Andes Mountains, then it falls drastically, and decreases by less than 200mm per year.

Thus, one of the reasons for the unequal distribution of precipitation on space and time is the change of value and direction of Barik gradient force. In addition, it should be noted that in the upper layers, from the boundary layer of atmosphere, movement takes place by geostraphic law, ie Barik gradient and Coriolis are determined by mutual influence.

The atmosphere is relatively less stable and more homogeneous in the respect to the Earth. Therefore, the direction of the air speed in a very rare case and for a short period of time may correspond with the direction of the rotational movement of the Earth. Figure 1 shows the effect directions thatcause atmosphic movement during three different natural process. In all three processes the centrifugal force is perpendicular to the speed vector of the wind, and the Coriolis corresponds with the force vector in cyclones, but its direction is opposite in anticyclones.



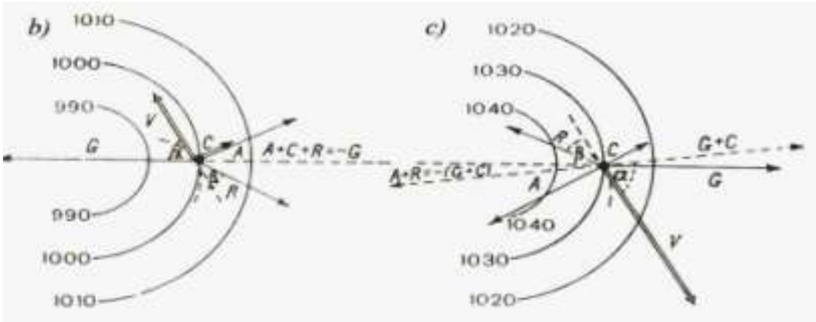


Figure 1. Mutual state of the forces affecting the atmosphere by taking into account the friction force. a-movement in isobaric rectangular, b-movement in cyclonic processes, and c-movement in anti-cyclonic processes.

As one of the reasons for precipitation distribution in continents, the study of atmospheric circulation is of a great deal of interest [3]. In a large part of the Eurasian continent, moving away from the Atlantic Ocean from the west coast to the east, the annual amount of precipitation decreases. In some areas the violation of this law only takes place in the mountainous areas. In this case, by the influence of Barik gradient force the atmosphere's movement breaks, so the movement speed of the atmosphere is delayed in the respet to the Earth. Water evaporated from the surface of the ocean does not reach to the dry surface, whose speed is relatively high.

Of course, the amount of precipitation is not only due to horizontal transfer, but also depends on vertical processes. In this term it rains a lot in the areas where cyclones dominate, but in anticyclone dominated areas there is less rainfall. In addition, in unstable starification ie, due to the thermal convection, rainfall is not excluded.

Thermal convection forms while the surface heats, but not all shielding movements can form precipitation. In arid areas of Russia (southern and south-eastern regions) the dry surface and the air layer above it heats in summer, the intensity of the raising air masses increases, but there is no cloud, and rain does not fall. The reasons for this are explained by the lack of humidity capacity of the air at high temperatures, and by the low relative humidity [8]. At the same time it should be noted that here it is impossible to ignore the impact of Barik gradient force. In arid areas at somewhat higher altitudes (middle troposphere), evaporated moist air masses are transferred to other areas by the influence of Barik gradient influence.

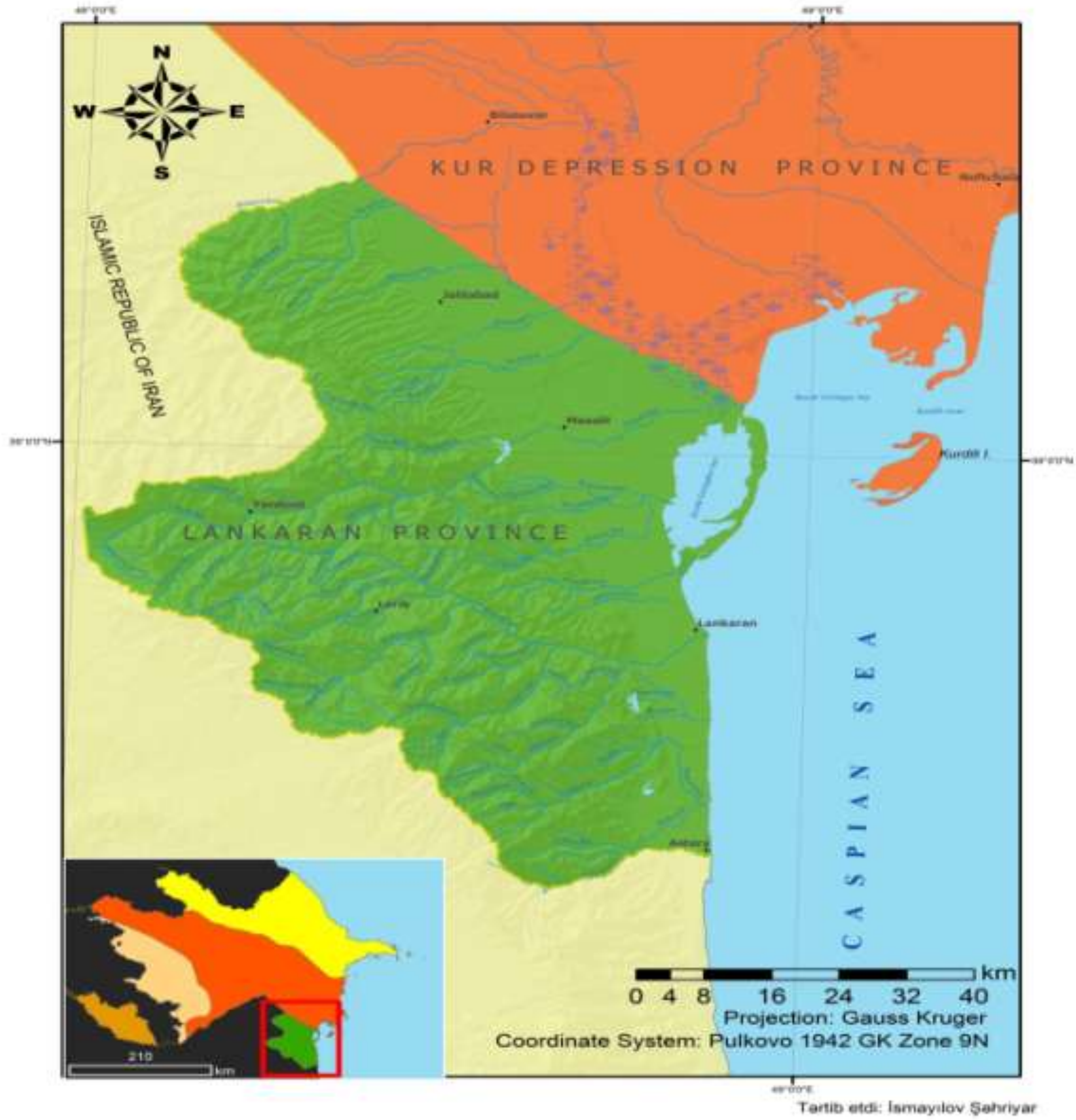


Figure2. Map scheme of Lankaran natural province of the Azerbaijan Republic

III. Counts

Thus, the structure of the precipitation distribution of is more complex, and it is more difficult to forecast. By taking into consideration the mentioned difficulties, precipitation forecast for one of the major economic regions (the Lankaran region) of Azerbaijan was studied. At this time the impact of factors having roles in rainfall distribution (above mentioned) is taken into account during revealing periodics in a hidden form. Lankaran natural province is located in the south of the Azerbaijan Republic, the area is approximately more than 6,1 thousand km^2. (fig. 2.)

For calculation rainfall data have been taken since 1900 from Lankaran synoptic observation station.

The row of this data is divided to the harmonic series and peroidicals are chosen. Periodicals are determined by the following analytical expression:

$$y = A_1 \sin\left(\frac{2\pi}{\tau_1} t + \phi_1\right),$$

Here:

$$A_1 = \sqrt{a^2 + b^2}, \qquad \varphi_1 = \operatorname{arctg}\frac{a}{b},$$

$$a = \frac{2}{\tau_c}\sum_{i=1}^{\tau_c} y \cos\frac{2}{\tau_c} t$$

$$b = \frac{2}{\tau_c} \sum_{i=1}^{\tau_c} y \sin \frac{2\pi}{\tau_c} t .$$

It is known that there are different periodical functions in the structures of each row. Therefore, the analytical expression of the row can be written as follows:

$$y = A_0 + A_1 \sin\left(\frac{2\pi}{\tau_1} t + \varphi_1\right) + A_2 \sin\left(\frac{2\pi}{\tau_2} t + \varphi_2\right) + ...$$

$$+ A_n \sin\left(\frac{2\pi}{\tau_n} t + \varphi_n\right) + ... + \theta$$

Here $\theta -$ is random section in the given line.

The result of these calculations, based on the descirbed method, is shown in the following figure. (fig. 3.):

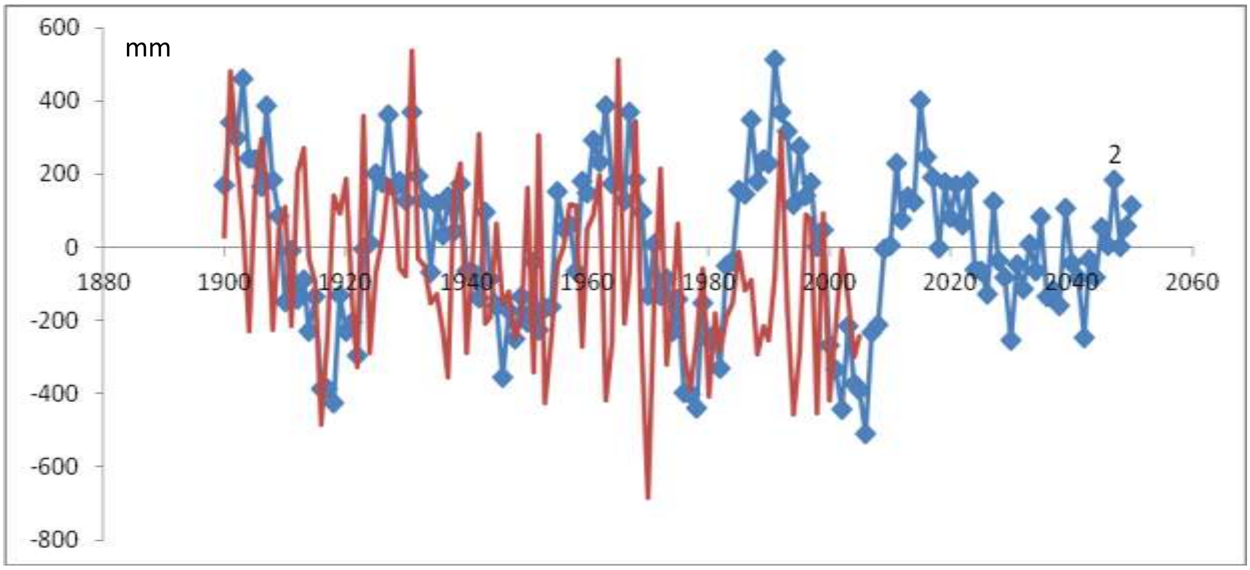


Figure 3. Changing of precipitation fluctuation on time during 1900-2050 in Lankaran. 1- actual, 2- calculated data.

IV. Results

Thus, while examining the causes of differences in precipitation distribution, in addition we must take into consideration the differences that occur in the rotational movement of the atmosphere and the value and directional change of Barik gradient force.

As is seen in Figure 3, precipitation fluctuations between 1990 – 1900 in Lankaran were estimated, and actual values of changes in a corresponding way. Only during the 4 years between 1985-1990 does the predicted data contradict actual data (anomalies have been recorded in most regions of the world). According to the obtained calculation results, between 2018 -2040 precipitation will be 200 mm below the norm in Lankaran,and in the next 10 years will increase 200 mm.

REFERENCES

[1.] Bagirov N. A. On monthly rainfall distributions - (Scientific Works) SİP, 1965, sec.130, ps. 3-21.

[2.] Budıko M.I. Climate of the past and future. Hydrometeoizdat, 1980, ps.351

[3.] Drozdov O. A., Qriqoryeva A.S.Long-term cyclical fluctuations of the atmospheric rainfall in the USSR. - L.: Hydrometeoizdat, 1971, ps. 158 .

[4.] Mamedov A. S., Mamedova A. R. Space-time structure of atmospheric rainfall in Azerbaijan territory.«Poisk», Natural and Technical Sciences,№3(1)/2010, ps.153 – 158. "Higher Education Centre of Kazakhstan"

[5.] World water balance and water resources .- L.: Hydrometeoizdat, 1974, ps. 638 .

[6.] Siderenkov N. S. An equal rotation of the Earth . "Physics", Russia Hydrometeorological Centre , 2003, №1. ps.4.

[7.] Khvichiya M.S. Atmospher rainfall.-: Climate resources of Georgia. ZakNİQMİ, sec. 44 (50). L., 1971, ps. 262- 271.

[8.] ShverT. A. Unequal rainfall distribution as the main landscape indicator.- L.: BGR (Scientific works), 1975, sec. 341, ps. 87-97.

[9.] Valiev S.S., Mamedov A.S., Tagiyeva E.N. Warming or colding? Published РГО e., 142, в. 6, 2010, c. 97-104.