INTERANNUAL VARIABILITY OF ATMOSPHERIC PRESSURE AND VARIATION IN THE TOTAL ANGULAR MOMENTUM IN THE ATMOSPHERE OF THE EARTH

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Abstract: *statistical connections of variability of mean monthly atmospheric pressure values at the station level over the Earth's surface and volatility of total angular momentum of the Earth's atmosphere were studied. The regions of the world where these connections are statistically significant were identified. Such regions are the largest in November, December, January, and March. They are located mainly in the intertropical zone of the planet. The trends in the strength of the identified connections, which occurred over the period 1958-2016, were studied. It was found that the reason for their intensification in November, December, and January is the increased influence of the total angular momentum of the Earth's atmosphere and the field of atmospheric pressure of El Niño-South Oscillation process on the interannual variability. In March, intensification of the identified connection is caused by the combined effect of Pacific Decadal Oscillation and Atlantic Multi-decadal Oscillation on the process under consideration. Their influence also intensifies in February and April, which suggests that the size of the regions where the connections of the process under study with interannual variations of monthly mean atmospheric pressure values in these months will be significant, will increase in the coming years.*

Keywords: *atmospheric pressure, the total angular momentum of the Earth's atmosphere, El Niño-Southern Oscillation, Pacific Decadal Oscillation, Atlantic Multi-Decadal Oscillation.*

МЕЖГОДОВАЯ ИЗМЕНЧИВОСТЬ АТМОСФЕРНОГО ДАВЛЕНИЯ И ВАРИАЦИИ ПОЛНОГО УГЛОВОГО МОМЕНТА ЗЕМНОЙ АТМОСФЕРЫ

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Аннотация: *изучены статистические связи изменчивости среднемесячных значений атмосферного давления на поверхности Земли и вариаций полного углового момента земной атмосферы. Выявлены регионы мира, для которых эти связи являются статистически значимыми. Установлено, что наибольшими размерами такие регионы обладают в ноябре, декабре, январе и марте. Расположены они в основном во внутритропической зоне планеты. Изучены тенденции изменения силы выявленных связей, которые произошли за период 1958-2016 гг. Показано, что причиной их усиления в ноябре, декабре и январе является возросшее влияние на межгодовую изменчивость полного углового момента земной атмосферы и поля атмосферного давления процесса Эль-Ниньо - Южное колебание. В марте усиление выявленных связей обусловлено совместным влиянием на рассматриваемый процесс Тихоокеанского декадного колебания и Атлантической мультидекадной осцилляции. Усиление их влияния происходит также в феврале и апреле, что позволяет предположить увеличение в ближайшие годы размеров регионов, где в эти месяцы связи изучаемого процесса с межгодовыми вариациями среднемесячных значений атмосферного давления будут являться значимыми.*

Ключевые слова: *атмосферное давление, полный угловой момент земной атмосферы, ЭНЮК, ТДК, АМО.*

Introduction

The total angular momentum of the Earth's atmosphere (hereinafter TAM) is one of the integral indicators of the state of its general circulation. Its interannual changes can largely affect the climate in a number of regions of our planet and make a significant contribution into volatility of angular velocity of its diurnal rotation. Therefore, improving the methods for their simulation and forecasting is an urgent problem for both climatology and geophysics.

According to modern concepts [1], TAM volatility is a complex multifactor process that is insufficiently studied. Statistical methods can be applied for its modeling and forecasting [2]. Its most common quantitative characteristic is the GLAAM global climate index, which is calculated as an anomaly of mean monthly value of TAM relative to its average value at the same month for the period 1958-1988 [1].

Quality of the results that can be obtained using statistical methods largely depends on the list of factors taken into account. Therefore, one of the most promising ways to solve this problem is to identify the natural processes that can significantly affect the interannual variability of TAM, as well as the conditions under which it occurs.

One of the main factors in dynamics of general circulation of the Earth's atmosphere is volatility of the atmospheric pressure field (hereinafter AP) [3]. This is why changes in atmospheric pressure in some segments of the atmosphere can be among the natural processes that can significantly affect TAM variations. However, location of the regions of the world where the links between the processes under consideration in certain months are significant, remain poorly known.

Trends in the strength of such links that manifested themselves while under research remain unascertained, too. It limits the ability to take them into account when modeling and predicting the volatility of TAM, as well as the climate. Thus, the study of these features of the connections in question is of considerable theoretical and practical interest.

The subject of this study is the connections in of TAM changes that correspond to a particular month, as well as variations in distribution of mean monthly values of AP over the earth's surface that coincide with them.

The aim of the study is to identify locations where interannual variations of mean monthly values of AP in a particular month are strongly connected with the changes in TAM, and to assess the current trends in variability of the strength of these connections.

Materials and methods

To achieve this goal, statistical connections of interannual AP variations in different regions of the world were investigated, as well as changes in the GLAAM index that took place at different time intervals for the entire period of TAM monitoring.

In this paper, correlation coefficient of the corresponding fragments of their time series is considered as a characteristic of the strength of statistical connection between the studied processes [2]. This is why correlation analysis was chosen as a method for investigating the connections between them.

Taking into account that the studied processes are non-stationary, statistical connections within the corresponding fragments of the time series that reflect interannual changes in mean monthly values of AP for a given month in each study point, and variations in values of the GLAAM index are studied in a “sliding window”. The duration of this “window” – 19 years – was chosen with an account for periodization of the circulating epochs in the Northern Hemisphere [4], according to which exactly so much time has now passed from 1998 (the beginning of the modern, fourth period of the third circulating epoch).

Variations in AP are considered in all parts of the world which correspond to certain nodes of the coordinate grid with a step of 2.5°x2.5°.

Linear trend is compensated in each fragment of the compared time series corresponding to a given “window”. This allows us to apply Student's criterion for approximate estimation of reliability of statistical inference about the importance of connection between the fragments under consideration [5].

The value of 95% of reliable correlation threshold in this criterion is 0.46, which is determined taking into account the number of degrees of freedom of the fragments, according to the procedure [2, 6].

The area of a part of its surface contoured by an isoline where the value of the correlation coefficient of these processes is modulo equal to the level of 95% of the reliable correlation threshold was considered as a characteristic of the coupling strength of interannual variations of TAM with changes in the AP in a certain region.

To determine this indicator, the boundaries of the identified regions (which correspond to the above mentioned isolines +0.46 and -0.46) are displayed on the contour map of the world using the Delaunay triangulation method [7].

Such maps are constructed for each month and each “window” under consideration, which made it possible to determine the tendency of changes in the strength of each identified connection which manifested itself over the period 1950-1996.

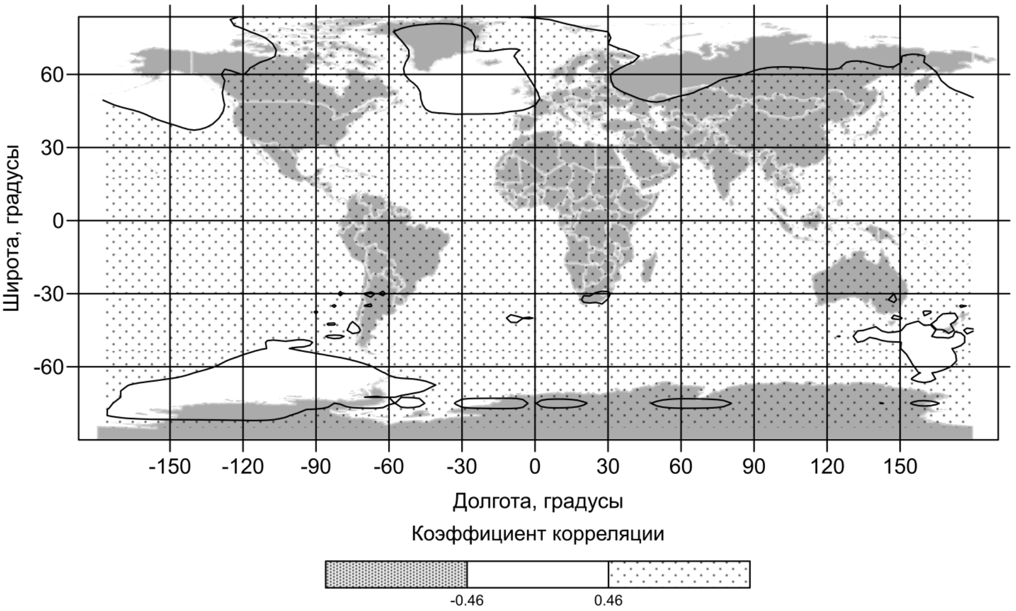
The results of the reanalysis of mean daily values of this characteristic at the level of stations for the period from 1958 to 2016, which are given in [8], were used as an actual material on changes in the distribution of AP at the station level over the surface of our planet. Information from this source was converted into the time series of mean monthly values of AP that correspond to each month and all points of our planet located in the considered nodes of the grid (there are 10368 nodes).

The time series of the values of the GLAAM index in a given month for the period from January 1958, which were used as factual material on changes in the TAM, were obtained from [9].

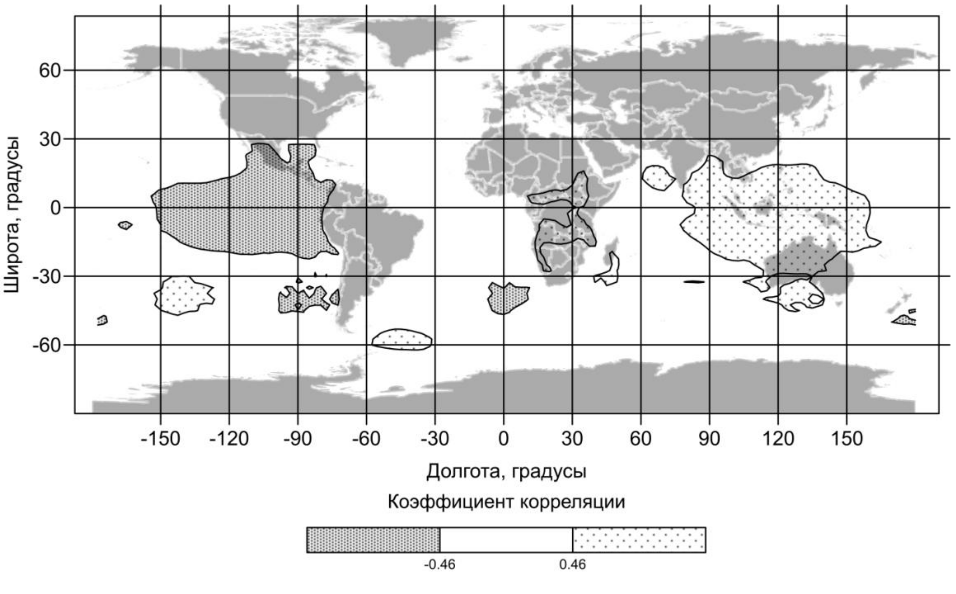
Results and Discussion

Using this method, correlation coefficient (K) of the corresponding fragments of the time series of interannual changes in mean monthly values of AP, as well as variations in GLAAM index values that coincide with them in time, were calculated for each month, each “window” of 19 years and each considered point on the Earth surface. Every calculated value is compared modulo with the level of 95% of reliable correlation threshold by the Student's criterion. This allowed to identify the regions where the correlation of the investigated processes is significantly positive, or significantly negative.

It was found that such regions could be set for any “windows” under consideration. At the same time, their sizes are the largest, provided that interannual changes in mean monthly values of AP are taken into account, as well as the GLAAM index, which correspond to November, December, January and March. As an example, Figure 1 shows maps with the regions set for these cases, and for the “window” of 1996-2014.



A)



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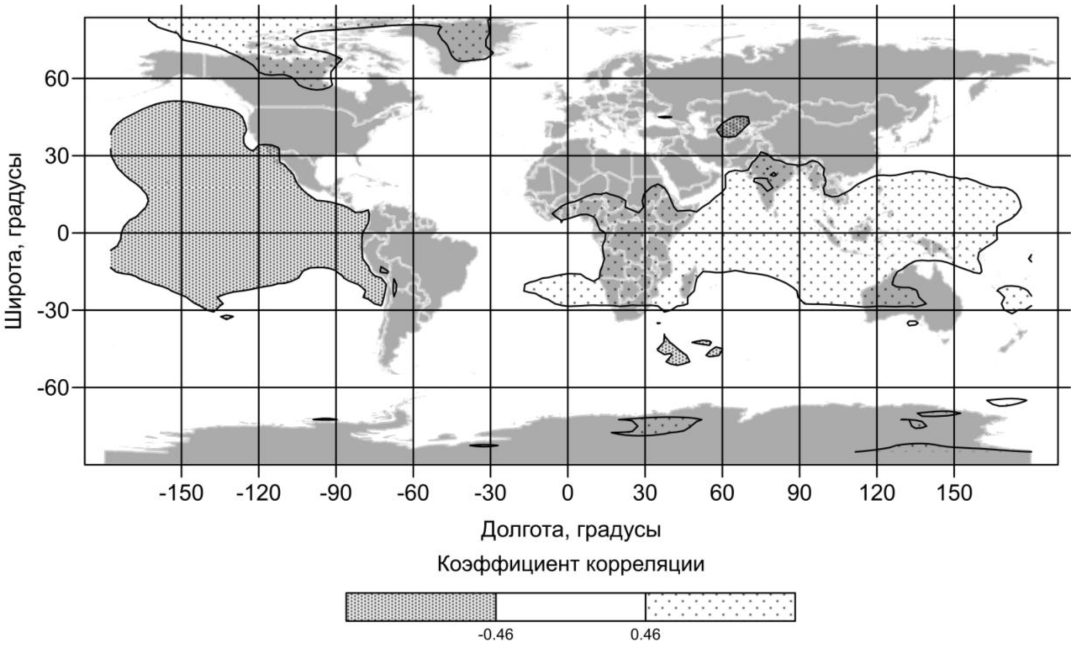
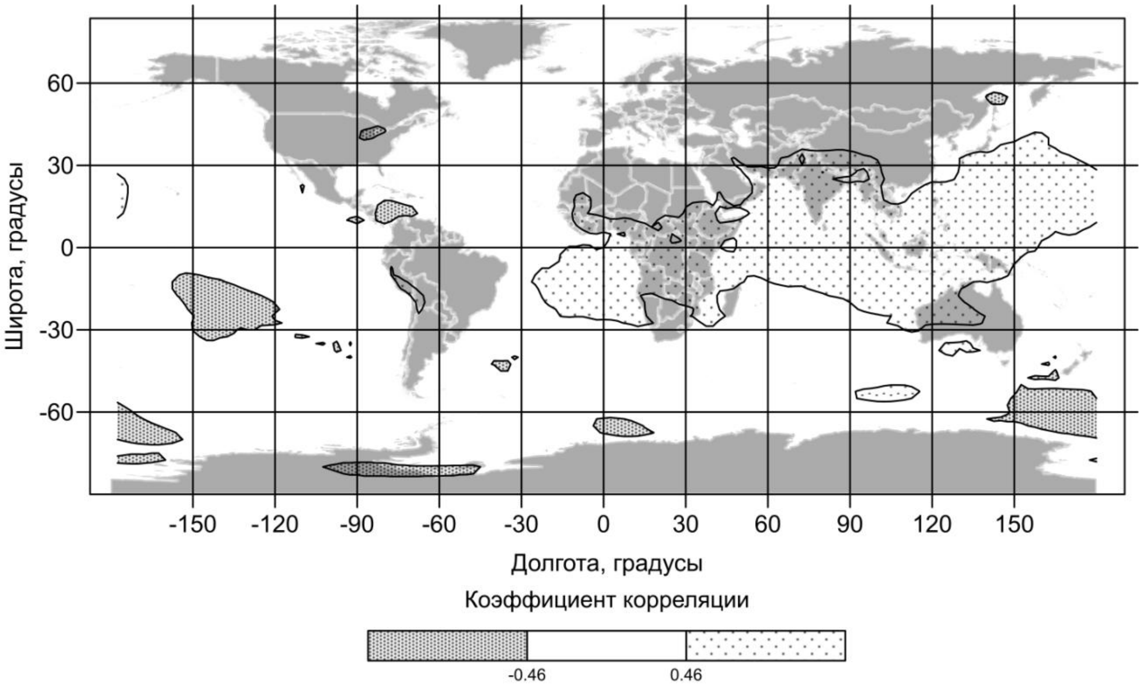


C)



D)

Fig. 1. Location of regions where the correlation between interannual changes in mean monthly AP values, as well as the GLAAM index is significant in 1996-2014 for months:
A) November; B) December; C) January; D) March

Figure 1A shows that in November, significant positive correlation of the processes under consideration during the period 1996-2014 was identified in most regions of the world. The strongest connection between them is in the equatorial zone.

As can be seen from Figure 1B, in 1996-2014 the largest areas where the connection between the interannual changes in the values of the GLAAM index in December, as well as mean monthly values of AP is recognized as significant, are located in the intertropical zone of our planet. Here, the region where the significant correlation of the studied processes is negative, is located in the eastern sector of the Pacific Ocean, as well as the Gulf of Mexico. Almost all of Central America, and the northeastern regions of Ecuador and Colombia, also belong there.

Regions where significant positive correlation of these processes is found include a number of areas in Africa, the southern part of the Arabian Sea, the Bay of Bengal, the eastern part of the Indian Ocean, and the western part of the Pacific Ocean.

One can see that the regions identified in the intertropical zone of the Pacific form a dipole structure. Due to this, during periods when the GLAAM index decreases, intensity of the zonal components of the atmospheric circulation increases over the intra-tropical Pacific zone, and decreases over the analogous zone of the Atlantic and the Indian Ocean.

A few comparatively small regions are also located outside the intra-tropical zone (in the Southern Hemisphere). A significant negative correlation of the processes under consideration is observed in the eastern parts of the southern subtropical zones of the Pacific and Atlantic Oceans, while their significant positive correlation is in the central part of the subtropical zone of the Pacific Ocean, in the northern part of the Weddell Sea, near the southeastern coast of Madagascar, as well as in the Great Australian Gulf. These areas also form dipole structures, which can affect not only the zonal, but also the meridional components of atmospheric circulation in the southern hemisphere due to their location. In the Northern Hemisphere, similar areas for the period under consideration were not identified.

It follows from Figure 1B that location of the largest areas where the correlation between the interannual changes in the values of the GLAAM index, as well as the mean monthly values of AP which correspond to January, is considered significant, remained mostly changed, but their areas increased significantly.

The region with significant negative correlation of the studied processes for January includes not only the eastern, but also the central sector of the intertropical zone of the Pacific Ocean (up to the date line), as well as the corresponding part of its northern subtropical zone. California belongs there, too.

The region with significant positive correlation of these processes includes most of the areas in the intertropical zone of our planet, which are located between the 15°W and 165°E meridians. It includes the whole Africa, the Hindustan Peninsula, the eastern regions of Southeast Asia, the north-western regions of Australia, all the waters of the Indian Ocean located in this zone, and the western part of the Pacific Ocean. Obviously, their areas are much larger than these of the same regions corresponding to December, which indicates an intensifying correlation between changes in TAM and AP variations. However, in February, the size of the regions in question decreases by many times, and the connection between the processes under study practically loses its significance. A similar conclusion is true for other months.

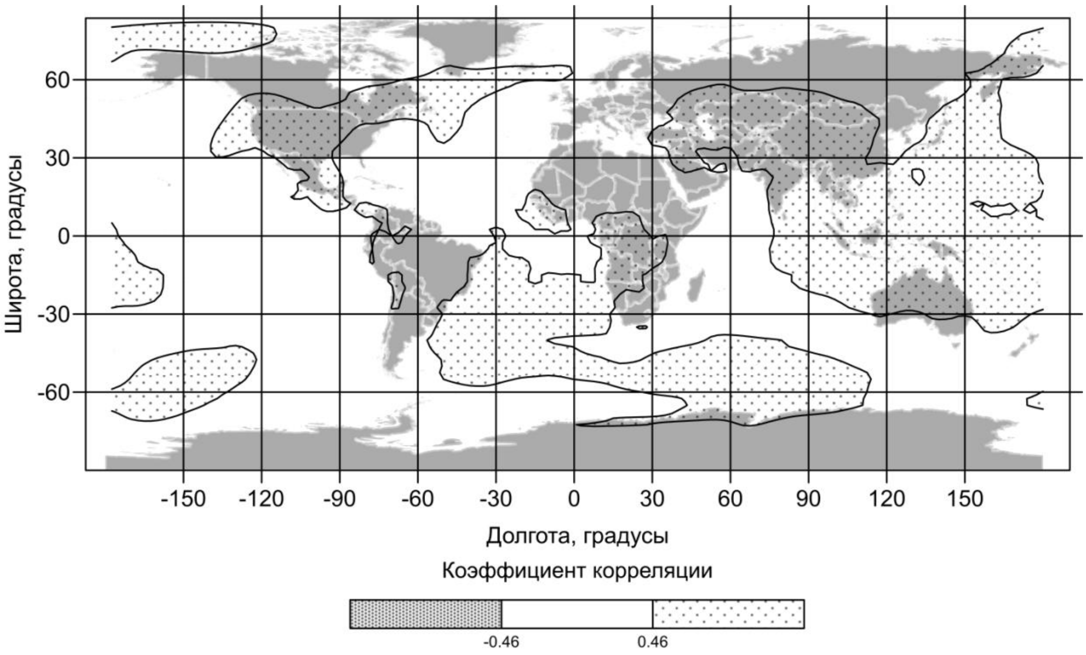
One can see that the regions detected in the intertropical zone of the world also form a dipole structure and are in many respects similar to those shown in Figure 2A (which is another argument in favor of significance of the influence of this process on TAM).

Outside the intertropical zone, the region with the largest positive correlation of the processes under study is located in the high latitudes of the American (120°W - 60°W) and Atlantic (60°W - 0°W) sectors of the Northern Hemisphere. The interaction of antiphase changes in AP here, as well as in the region that lies southward in the intertropical zone, cannot but lead to the corresponding changes in characteristics of the components of atmospheric circulation in the temperate latitudes of this hemisphere.

In the Southern hemisphere, several small areas of significant correlation of the processes under research were also identified. Areas with significant negative correlation are located in the temperate zone of the Indian Ocean (to the south of Madagascar). Areas with significant positive correlation are above Antarctica. Antiphase changes in AP in these areas also cause corresponding changes in atmospheric circulation in the Southern hemisphere.

Figure 1D shows that in March, significant positive correlation of the studied processes is observed in the region which includes most of the intertropical zone of the Eastern hemisphere of the planet. Regions with significant negative correlation are located in the Pacific Ocean, in the same zone (anticyclone of Easter Island), and also southward (in the zone of the Western winds and off the coast of Antarctica).

It was found that from 1958 to 2016, the strength of the interannual changes in TAM and APvolatility in the identified regions, changed greatly (as evidenced by the changes in their areas). As an example confirming this, Figure 2 shows the locations with significant correlation of mean monthly AP values and GLAAM index for November, December, January and March, which correspond to the window of 1962-1980.


Широта, градусы
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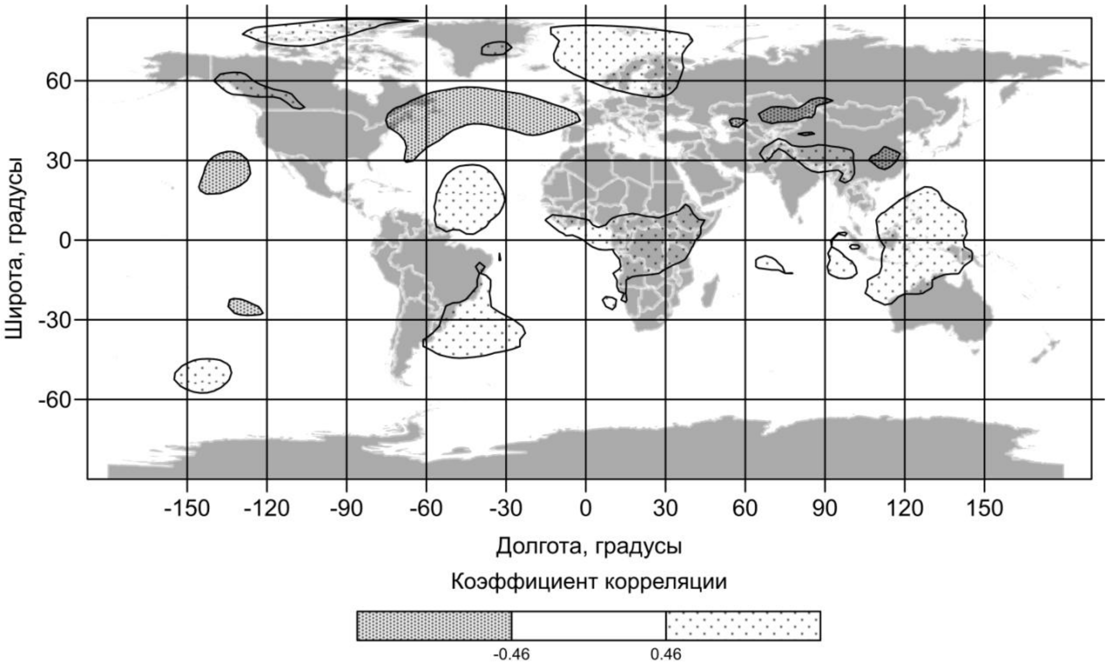
Долгота, градусы
Коэффициент корреляции
-0.46
0.46

A)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Долгота, градусы
Коэффициент корреляции
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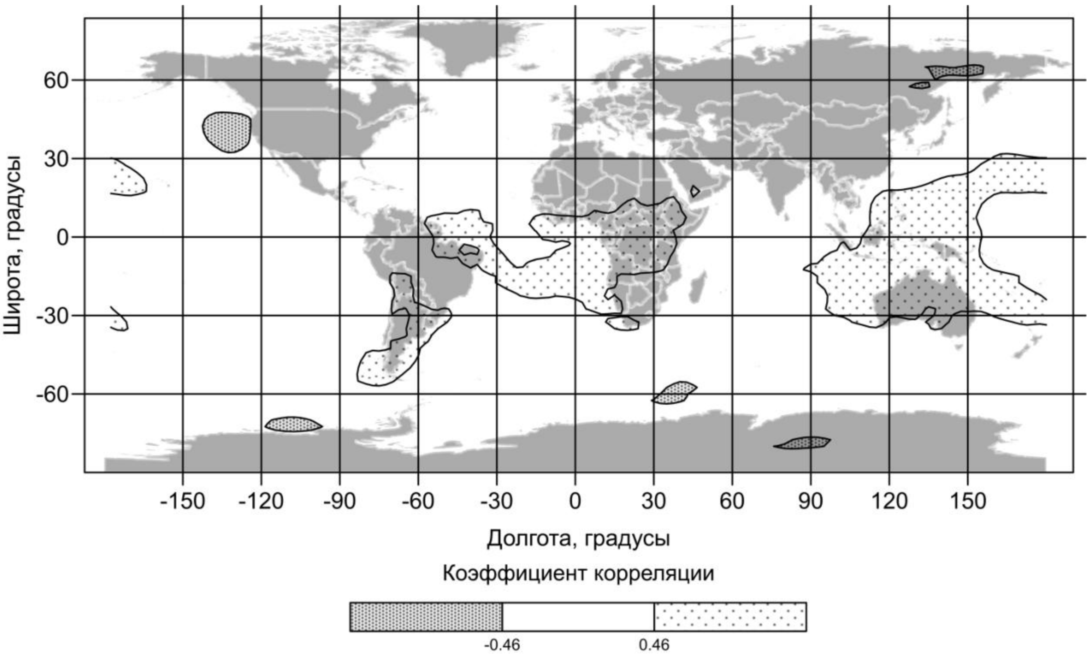

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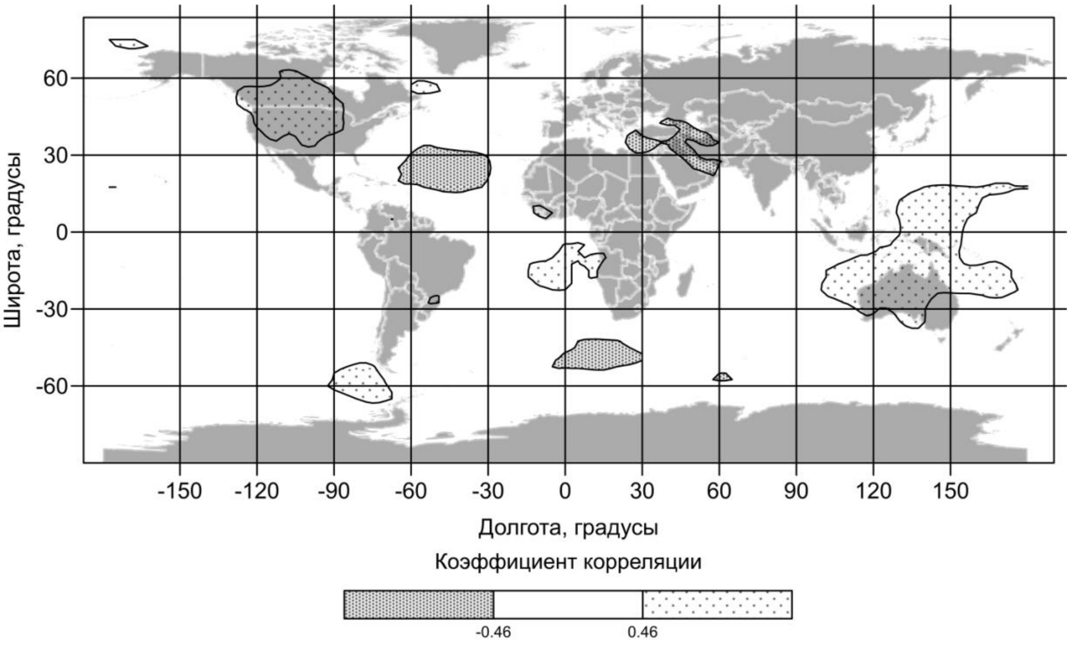

D)

Fig. 2. Location of regions where the correlation between interannual changes in mean monthly AP values, as well as the GLAAM index is significant in 1962-1980 for months:
A) November, B) December; C) January; D) March

According to Figure 2A, in the period 1962-1980, in all regions where the connection between the interannual changes in the TAM and the AP variations in November was significant, correlation of these processes was positive. The largest of these regions included the western part of the Pacific Ocean, the eastern part of the Indian Ocean, the Kamchatka and Chukotka Peninsulas, the Beaufort Sea and the Chukchi Sea. The second largest region consisted of the southern parts of the Indian and Atlantic Oceans. Another vast region was located in the northern part of the North Atlantic (in the North Atlantic Current region), and over North America. A similar region is also found in the South Pacific. Comparison of Figures 2A and 1A shows that during this period the dimensions of the region, in which the correlation between the processes under consideration was significant, increased greatly.

As can be seen from Figure 2B, two regions where the correlation of the investigated processes, which correspond to December and the period of 1962-1980, is significantly negative, are located in the eastern part of the intertropical zone of the Pacific Ocean. These regions are located almost symmetrically from the equator, near the North and South Tropics. As follows from the comparison of Figures 2B and 1B, during the considered period, a pronounced tendency to increase was observed in changes in the total area of these regions.

Figure 2B also shows that in the intertropical zone, there are four regions where the correlation of the studied processes in 1962-1980 is significantly positive. Two of them are located symmetrically relative to the equator in the tropical Atlantic, one region including a vast area of Africa, and another one covering the western part of the Pacific and the eastern part of the Indian Ocean. Comparing their position with Figure 1B, one can notice that the area of the regions in the Atlantic and Africa decreased during the period under review, while for the corresponding region in the eastern part of the Indian-western part of the Pacific it increased.

It also follows from Figure 2B that in the temperate climate zone of the Northern hemisphere, in 1962-1980 regions with significant negative correlation of the studied processes prevailed, the largest one located over the North Atlantic.

Regions with significant positive correlation here were located above the Arctic (in American (120 °W - 60°W) and European (0°E - 60°E) sectors). Location of these regions indicates that they underwent a noticeable influence on both zonal and meridional components of the atmospheric circulation in the Northern hemisphere. In the period 1996-2014, none of these areas were found, which indicates that the connections between the studied processes weakened greatly.

An important feature of Figures 1B and 2B is the region with significant positive correlation of the studied processes, which belongs to the temperate zone of the South Pacific (its location roughly corresponds to the South Pacific minimum).

Note that for any windows that belong to the period under study, location and size of this region change very little. Since the size of the northbound intertropical region with negative correlations of the processes under investigation for the period 1958-2016 increased, the influence of their interaction on atmospheric circulation and TAM increased, too.

Similar features are typical of the relations between the studied processes in January as well, which is confirmed by Figure 2B. One can see that the region with their significant negative correlation in the period 1962-1980 is also located in the eastern part of the Pacific Ocean, but north of the Northern Tropic. Its dimensions are much smaller than for the period 1996-2014.

Regions with significant positive correlation of the same processes in 1962-1980 are located over South America, the Inter-Tropical Atlantic, Africa and the Western Pacific. Their total areas are many times larger than the areas of the negative correlation region, but much smaller than the sizes of the positive correlation region for the period 1996-2014.

In 1962-1980, the regions with significant positive correlation of interannual AP changes in March, with variations in the GLAAM index, included almost all of Australia, waters that wash it from the west and north, the Indian Ocean waters, the areas in the Intra-Tropical zone of the South Atlantic, similar parts in the Western Pacific, and the Drake Passage area.

Significant negative correlation in the same period took place at a significant part of the territory of North America, South Caucasus, the Persian Gulf, the North Atlantic Passage and the South Atlantic Current.

Comparison of Figures 2G and 1G shows that during the period under consideration, the total area of the regions with significant positive correlation of the studied processes increased greatly, while the areas of the regions with significant negative correlation areas noticeably decreased.

In general, comparison of Figures 1 and 2 indicates that in all the selected months, the areas of the regions in the Inter-Tropical zone where the statistical connections between the interannual variations in AP, and changes in TAM were significant, in the period 1996-2014 were much greater than in the period 1962-1980. In November, the areas of similar regions outside the zone also increased, but in December, January and March, the areas of such regions in the Northern hemisphere decreased. The same features are typical of all the other studied time intervals, which refer to the period 1958-2016.

Results Discussion

Most of the mass of the terrestrial atmosphere is concentrated in the intertropical zone [10], which is the farthest from the axis of rotation of the Earth. Therefore, variations in features of the zonal components of the general atmospheric circulation that are located in this zone, and hence variations in distribution of AP in it, cannot but have a significant influence on changes in the GLAAM index [11]. The main reason for variations in AP occurring in this zone is changes in temperatures distribution at the station level there, which largely determine the fluxes of thermal radiation and water vapor entering the corresponding segments of the atmosphere. These changes are caused by large-scale processes in the “Ocean-Atmosphere” system, the most significant being El Niño-Southern Oscillation (hereinafter ENSO) [12], the Pacific Decadal Oscillation (hereinafter PDO) [13] and the Atlantic Multidecadal Oscillation AMO) [14].

ENSO is the main mode of natural climatic variability of atmospheric circulation and distribution of AP in the intertropical zone of our planet, which relates to the interannual interval. This process manifests itself in significant quasiperiodic (with the maximum in variability spectrum at a period of about 4 years) surface temperature fluctuations near the equatorial region of the Pacific Ocean and associated fluctuations of surface pressure in its tropical zone [12]. The influence of ENSO on meteorological conditions is significant not only in the intertropical zone of our planet [10], but also in many regions of temperate latitudes [15, 16, 17, 18].

The importance of statistical connection of ENSO with the irregularity of daily rotation of our planet, as well as fluctuations in zonal circulation of its atmosphere, is shown in [19], which suggests that this process can largely determine the connection between the interannual variability of AP distribution in this zone, with variations in TAM.

Connection between AP variations and the process under study to some extent may also be caused by the influence of the PDO and AMO on atmospheric circulation [20].

Both these oscillations are caused by variations in mean values of the surface temperature anomalies of the respective water areas in the Atlantic and Pacific Oceans and have the most significant influence on atmospheric circulation over the inter-decadal interval of its variability. As a rule, the warm and cold phases of the PDO last from 10 to 40 years. For the AMO, their values lie within 25-50 years. Nevertheless, these processes can have some impact on variability of atmospheric circulation at the interannual interval.

Responses of the global atmospheric circulation to changes in the state of ENSO, the PDO and AMO were studied by a number of Russian [15, 21, 22, 23, 16, 17, 24, 10, 3] and foreign researchers [25, 14, 26, 18]. It is found that their formation involves the processes that occur in the meridional vertical Hadley cell [27] as well as Rossby waves [18]. However, the features of influence of these processes on connections between interannual variations of TAM and AP nowadays need further study.

The results obtained suggest that the corresponding changes for the period 1958-2014 could have some connection of the studied process not only with variations in AP, but also with ENSO, PDO, and AMO.

Global climatic indices (GCI) are the most informative characteristics of these processes. They are determined by the average values of the surface temperature anomaly in different regions of the World Ocean.

One of the most effective indices of the state of the ENSO process is Nino34 [23,13], which is defined as the average value of mean monthly temperature anomaly in the equatorial region of the Pacific Ocean (5°N - 5°S, 170°W - 120°W).

State of the AMO process is usually characterized by the AMO index, which is defined as an anomaly of the mean surface temperature in the North Atlantic between parallels 70° - 0° N relative to the temporal basis of 1951 - 1980 [14].

The value of the PDO index, which characterizes the state of the PDO process, is estimated as an anomaly of mean surface temperature in the North Pacific Ocean between parallels 60° N and 20° N relative to the same temporal basis [13]. With positive values of these indices, surface temperatures increase and AP decreases over the entire water areas of the World Ocean, where these values are determined, significantly affecting the atmospheric circulation.

Paper [9] contains the values of the mentioned indices for all the processes considered for each month starting with January 1958. These data were used to detect changes in connections of interannual variations of TAM with changes in the indices of ENSO, the PDO and AMO, which occurred during the period under review. To do this, we applied the above described methodology and made correlation analysis of connections between different fragments of the respective time series lasting for 19 years.

Table 1 contains the calculated correlation coefficients between some fragments of time series of the GLAAM and Nino34 indices.

Table 1. Values of correlation coefficient between some fragments of the time series of the Nino34 and GLAAM indices, for different months (the 95% significance threshold is 0.46)

Year	1958-1976	1967-1985	1977-1995	1986-2004	1996-2014
January	0,726	0,756	0,723	0,878	0,896
February	0,715	0,712	0,692	0,824	0,853
March	0,620	0,711	0,638	0,818	0,830
April	0,586	0,647	0,564	0,767	0,818
May	0,620	0,624	0,428	0,603	0,644
June	0,426	0,575	0,432	0,621	0,668
July	0,277	0,330	0,386	0,693	0,716
August	0,376	0,505	0,639	0,813	0,755
September	0,424	0,509	0,601	0,803	0,694
October	0,355	0,462	0,554	0,704	0,624
November	0,290	0,502	0,506	0,599	0,569
December	0,558	0,723	0,732	0,737	0,719

According to Table 1, the values of correlation coefficient between the fragments of the time series of the Nino34 and GLAAM indices are maximal in January and minimal in June-July for any considered time interval.

Dependencies of the strength of connections between ENSO and TAM from the year when the corresponding "window" began, which correspond to all months, have obvious tendencies to increase, which manifest themselves over the whole period of 1958-2016. At the same time, from August to December (in the second half of the year) connection between the processes under consideration reached its maximum at a time interval of 1986-2004.

Table 1 indicates that the intensifying connection between volatility of TAM and ENSO can be the reason for the observed increase in size of the regions where correlation between the interannual changes in values of TAM and AP for November, December, and January is significant.

Table 2 contains the values of correlation coefficient between the fragments of the time series of the GLAAM and PDO indices that correspond to the same "windows".

Table 2. Values of correlation coefficient between the fragments of the time series of the PDO and GLAAM indices, for different months and periods under consideration (the 95% significance threshold is 0.46)

Year	1958-1976	1967-1985	1977-1995	1986-2004	1996-2014
January	0,362	0,052	-0,248	0,223	0,434
February	0,367	0,258	0,053	0,327	0,613
March	0,306	0,412	0,219	0,253	0,59
April	0,146	0,37	0,27	0,321	0,372
May	0,211	0,229	0,213	0,467	0,358
June	0,049	0,16	0,237	0,569	0,483
July	0,005	0,463	0,569	0,642	0,396
August	0,248	0,501	0,504	0,741	0,495
September	0,371	0,501	0,631	0,739	0,507
October	0,489	0,499	0,309	0,529	0,594
November	0,277	-0,145	-0,155	0,209	0,342
December	0,365	-0,083	-0,255	0,075	0,128

Table 2 shows that statistical connections between the processes under consideration in the period 1958-2004 are only significant for the months from May to October. At the same time, the strength of connection between them is maximal for the whole period of 1958-2014 in August and September for the "window" of 1986-2004.

For the "window" of 1996-2014, connections between the same processes are also significant in February and March. Thus, in the modern period statistical connections between the interannual variations of TAM and the PDO in May-October retain their significance, but their strength is noticeably decreasing. In February and March, on the contrary, strength of connections between the processes under consideration has been increasing since 1977, and in the modern period has already exceeded the selected level of significance.

Table 3 contains the correlation coefficient values between the fragments of the time series of GLAAM and AMO values that were calculated for the same "windows".

Table 3. Values of correlation coefficient between some fragments of time series of GLAAM and AMO values (the 95% significance threshold is 0.46)

Year	1958-1976	1967-1985	1977-1995	1986-2004	1996-2014
January	-0,068	0,204	0,172	0,433	0,517
February	0,195	0,356	0,359	0,484	0,586
March	0,54	0,537	0,531	0,434	0,58
April	0,632	0,497	0,456	0,417	0,459
May	0,155	0,285	0,259	0,241	0,311
June	-0,114	0,342	0,319	-0,005	0,039
July	0,013	0,331	0,209	-0,074	-0,047
August	0,003	0,107	0,184	-0,102	-0,174
September	0,196	0,216	0,278	0,13	-0,012
October	0,381	0,234	0,323	0,438	0,199
November	0,449	0,243	0,128	0,291	0,03
December	-0,071	0,002	-0,106	0,321	0,106

According to Table 3, only the links between the processes in question in February, March and April are statistically significant in some "windows". In February, the strength of their connection steadily increased throughout the entire period of 1958-2014.

In March and April it declined during the period 1958-1990, and only increased in the interval 1991-2014. In March, the strength of the connection between these processes in the modern period has already exceeded the level of significance, but in April it has not reached it yet.

Comparison of Tables 2 and 3 suggests that the increased influence of PDO and AMO on the process under consideration may be the reason for the increase in the size of regions where the connection between the interannual changes in TAM in March is significant, as well as the variations in AP.

It follows from Tables 1-3 that statistical connection between the interannual variations of TAM with ENSO, AMO, and PDO is only amplified from February to April. In other months, the connection between the interannual variations of TAM with PDO remains significant, but weakens. Connection between the interannual variability of TAM and AMO in other months is not significant. Connection of the studied process with ENSO from January to July is significant and intensifies. In the second half of the year it is also significant, but in the modern period it is weaker than it was in 1986-2004.

Conclusions

1. Statistical connections between the interannual changes of TAM (GLAAM index) in November, December, January and March with variations in AP are significant for a number of regions of the world. For the period 1958-2016 they were steadily increasing. Regions located in the intertropical zone of our planet prevail among the areas for which the identified connections are significant.
2. The increased influence of ENSO on changes in TAM and variations in AP may cause the detected phenomenon for November, December and January.
3. In March, it may be caused by the increased influence of the PDO and AMO processes on changes in TAM and variations in AP.
4. One-way strengthening of connection between the interannual changes in TAM with the variations in the PDO and AMO indices, which occurred in February, March, and April in the period 1977-2016, suggests that the areas of regions where the connection between TAM and AP variations for these months is significant, will increase in the next decade.

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