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Research of regional atmospheric wave motion taking into consideration of relief singularities

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Abstract

Regional atmospheric wave motions are studied on the base of hydrothermodynamical combined equations. So called modified equations are analyzed in quasi-geostrophic, quasiadiabatic approach taking into consideration relief and influence of β-effect. Using functions of influence the proper solution is indicated and their functions are analyzed. On the base of analyze of these functions, some facts about Transcaucasia, already known in the synoptic practice are firstly approved theoretically, including the fact that almost no air masses are intruded in the Caucasus directly from the north. Besides, on the basis of the full system of hydrothermodinamical equations, wave motion is researched. In the result, the fact that atmospheric processes on the Caucasus have the elongated nature along the parallel (the Caucasian mountain range) was approved, wave relieves are spread from the west to the east. The theoretical opinion is expressed to explain why temperature is fallen in the East Georgia and raised in West Georgia on the background of global warming. It is noted that the waves of so called neutral type and stationary waves may be on Transcaucasia if some condition is fulfilled between mountain characteristic parameters and the corresponding wave quantities. Period of these waves was calculated and their existence is approved according to analyzing of the photos of clouds received from the artificial satellite. The most of conclusions and results are recommended in the weather forecast service of Georgia.

1. Introduction

Determining of the character of motions of masses, atmospheric air have the greatest theoretical and practical importance for everyday activity of a society. All of this is related to forecasting of weather –atmospheric processes with the new mathematic models, which are based on using of systems of hydro-thermo-dynamical equations.

It is known that the main part of kinetic energy of atmospheric motion is accumulated in the bottom layer, where the different meteorological derivatives - atmospheric fronts, cyclone areas, occlusive events are developed, so, it's reasonable to accept that wave disturbances are mainly developed in this layer exactly. Besides, according to the height, atmosphere is stratified with valley of density and temperature, which essentially influences on development of wave processes, their vertical distribution. The mentioned influence is especially strong for the mountain regions as Transcaucasia. Variety of physical relief of the Caucasus, proximity to two seas – the Black and Caspian seas, plenty of the river gorges and the other geological factors stipulate making and development of the different wave disturbances including the orthographic ones. A number of properties of such waves as for barotropic as baroclinic environment was studied by a lot of researchers [1-11]. The result of several practical values was accepted and their role for further theoretical researches was estimated. The purpose of this thesis is to research the influence of mountains' massif on the wide-range atmospheric processes and reveal their regional singularities.

2. Setting of problem

Fundamentals of beginning-development of the mentioned processes may be explained using of system of hydrothermodynamic equations. Hydrothermodynamic equations in quasi-geostrophic, quasi-static and adiabatic approach in the pressure related system have the following form [2, 5, 7- 9]:

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+\frac{\tau}{p_0}\frac{\partial u}{\partial \xi}=-\frac{\partial \varphi}{\partial x}+lv\,, \qquad (1)$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+\frac{\tau}{p_0}\frac{\partial v}{\partial \xi}=-\frac{\partial \varphi}{\partial x}+lu\,, \qquad (2)$$

$$T=-\frac{\xi}{R}\frac{\partial \varphi}{\partial \xi}\,, \qquad (3)$$

$$\frac{\partial u}{\partial x}+\frac{\partial u}{\partial y}+\frac{1}{p_0}\frac{\partial \tau}{\partial \xi}=0\;\;, \qquad (4)$$

$$\frac{\partial T}{\partial t}+u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\frac{c^2}{Rp_0\xi}\tau\,, \qquad (5)$$

where $c^2=R^2T(\gamma_a-\gamma)/g=\alpha RT$ where $\alpha=R(\gamma_a-\gamma)/g=0.12$ is parameter of stratification, u and v are determiners of wind speed toward ox and oy coordinate axes; $T-$absolute temperature; $R-$air universal constant; $g-$ acceleration of gravity; $\varphi-$geopotential; $\tau-$analog of vertical speed; γ_a-temperature adiabatic gradient; $l-$Coriolos parameter.

Using of (1) and (2) equations, according to the standard rule, the equation like to Fridman equation will be received for wind speed vortex $\Omega_z=\partial V/\partial x-\partial U/\partial y$ which has the following form after simplification [5,10-12]:

$$\frac{\partial \Omega_z}{\partial t}+u\frac{\partial(\Omega_z+l)}{\partial x}+v\frac{\partial(\Omega_z+l)}{\partial y}+\beta v=-lD \qquad (6)$$

where $D-$ plane divergence of speed, $\beta=dl/dy-$Rossby parameter, analogous with β-effect he influence of physical relief of earth should be taken into consideration with bringing of the new parameter $\eta=p_z/p_0$ where p_z is pressure value on z height, through the influence of this parameter, e.i. relief, wind is no more geostrophic and determiners of speed may be written as following[5, 14]:

$$U=-\frac{1}{l\eta}\frac{\partial \varphi}{\partial y}\,; \qquad V=-\frac{1}{l\eta}\frac{\partial \varphi}{\partial x} \qquad (7)$$

Consequently, Ω_z is expressed as following:

$$\Omega_z=\frac{1}{\eta}(\Delta\phi-(\frac{\partial\ln\eta}{\partial x}\frac{\partial\varphi}{\partial x}+\frac{\partial\ln\eta}{\partial y}\frac{\partial\varphi}{\partial y})) \qquad (8)$$

From (7), (8) and (6), the equation is received, which is introduced as following for barotropic atmosphere [5, 15, 17]:

$$\Delta\frac{\partial\varphi}{\partial z}+a(x,y)\frac{\partial^2\varphi}{\partial t\partial x}+b(x,y)\frac{\partial^2\varphi}{\partial t\partial y}+\beta(y)\frac{\partial\varphi}{\partial y}=F_1 \tag{9}$$

and for baroclinic model:

$$\Delta\frac{\partial\varphi}{\partial z}+a(x,y)\frac{\partial^2\varphi}{\partial t\partial x}+b(x,y)\frac{\partial^2\varphi}{\partial t\partial y}+\beta(y)\frac{\partial\varphi}{\partial y}+c_1\frac{\partial}{\partial\xi}(\xi^2\frac{\partial^2\varphi}{\partial t\partial\xi})=F_2 \tag{10}$$

where $c_1=(l\eta)^{-1}$, but

$$a=-\frac{\partial\ln\eta}{\partial x},\qquad b=-\frac{\partial\ln\eta}{\partial y}. \tag{11}$$

These parameters are characteristics of mountain influence accordingly along the parallel and meridian of earth. After estimation of the line of elements, it was founded that in the images of F_1 and F_2 the elements of relief influence $l\eta^{-1}(\eta,\varphi)$ and advection $(l\eta)^{-1}(\phi,\Delta\phi)$ are key elements, here symbol (A,B) is Jacobian matrix. For solving of a sum, the relevant initial is given, when $t=0$, $\varphi=\varphi_0(x,y)$ and boundary condition [5, 8-10]:

when $\xi\Rightarrow\infty(p\to 0)$ solution is bounded ,

$$\text{when } \xi=1,\ \frac{\partial^2\varphi}{\partial t\partial\xi}+\alpha\frac{\partial\varphi}{\partial t}=M(x,y)\Big|\Rightarrow_{Z=Z(x,y)}^{\frac{RA_T}{\eta}+\frac{c^2}{l}(\ln\eta,\varphi)}, \tag{12}$$

where $z(x,y)$ is relief reflecting equation, $A_T=\frac{\xi}{lR}(\varphi,\frac{\partial\varphi}{\partial\xi})$ is heat advection, in such circumstances, the sum may be generally solved only using of numerical quantities.

3. Private analytical solution of the sum and its results

a) If Laplace-Heaviside is used in the given (9) –(12) sums, toward t variable, and toward horizontal coordinates – transformation of Fourie [15, 17-20] , then solution of equation (9) in (r,θ) polar coordinates, will be given as following [5, 7, 17]:

$$\overline{\varphi}=\frac{1}{2\pi}\int_0^{2\pi}\int_0^{\infty}\frac{F_1}{q}e^{-\frac{r}{2}(a\cos\theta-b\sin\theta)}\cdot e^{-\frac{r\beta\cos\theta}{2q}}\cdot z^{K_0{}_0^{(1,2)}}(\frac{r}{2}\sqrt{\frac{(aq+\beta)^2+b^2q^2}{q^2}})rdrd\theta, \tag{13}$$

where K_0 is MakDonald function, Bessel function for imaginary argument [14,15], $\overline{\varphi}$ is function value in „image“ space.

For simple analyze, the main forecast equation is selected for barotropic atmosphere, in baroclinic case, Makdonald function is replaced with the cylindrical function selected according to boundary condition [5, 7, 16, 17].

Analyzing of the image showed that the solution for minor value of $t-$ may be represented as the lines of negative power of q parameter of Laplace. If using the known formula of operative calculation [15, 22, 23, 29]:

$$\frac{1}{q^n}\to\frac{t^n}{\Gamma(n+1)}, \tag{14}$$

where $\Gamma(n)$ is the Euler function, the following will be received:

$$e^{-\frac{r\beta\cos\theta}{2q}} K_0\left(\frac{r}{2}\sqrt{a^2+b^2+\frac{2a\beta}{q}+\frac{\beta^2}{q^2}}\right) = E_0 + E_1 t + E_2 t^2 + E_3 t^3 \qquad (15)$$

Coefficients E include the combinations of Bessel and expotential functions in the quite complex form, These so called influence or Green functions describe the simultaneous influence of mountains parameters and β effect on the geopotential valley of atmosphere. The relevant calculations were made as in barotropic as baroclinic models on the different height of atmosphere for an hour of time $t = 1-3, 6, 12, 24, 48$. It was found that symmetry is abolished toward central (forecast) point of function of influence which is caused by influence of relief (if in equations $a = b = \beta = 0$, so, solution coincides with the result of Buleev-Marchuk [7, 16]. For example, the graphics of influence function are given on drawings Figs. 1-3. Analyzing of these graphics enables us to conclude:

Qualitatively, on all levels of troposphere, 850 mb, 700 mb, 500 mb almost the same picture is found, in particular, above the Caucasia mountain range, influence functions get the minimal value toward the North ($\theta = \pi/2$), and the maximum one toward the South and South-west. In the synoptic practice, this fact was found for a long ago [24, 31, 34], but theoretically it is substantiated firstly;

By increasing of the horizontal spreading of mountain, their influence increases as well, but the degree of influence depends on the direction of air flow toward the mountain range;

For the small period of time, influence of β-effect is not visible, but by increasing of the period of time, the influence increases as well (compare the relevant drawings for hours $t = 1, t = 12, t = 24$). Fig. 1.

The form of the functions of influence of baroclinic atmosphere model (see. N 2, 3) approves the very important fact acknowledged in the synoptic practice, that the atmospheric processes of Transcaucasia territory have the tendency of elongation along the parallel. Indeed, almost 70% of air flow spread on Transcaucasia territory is the result of the West, East invasions[34]. Air masses are not practically inflawed from the North. Theoretically, in every 15-20 invasions, only one may be from the North, this is reflected in the numerical value of influence functions.

4. Research of wave motions on a mountainous territory

b) Let's discuss (9) and (10) equations and search the solution for their analyze as the plane wave of Marguless type [15, 19, 20, 23, 33]:

$$\varphi = \varphi_0 + N e^{i(mx+ny-\chi t)} , \qquad (16)$$

where χ is the phase frequency, $m = 2\pi / L_x$, $n = 2\pi / L_y$ - wave quantities accordingly – along the parallel and meridian, L_x and L_y -lengths of the appropriate wave, N – amplitude.

It is clear, by putting of (16) in (9) and (10) equations, the complex solution will be received (as the equations include the members with derivatives of the odd and even power), the clear dependence should be searched among the equation parameters, in order the imaginative part of solution to be zero and the analyze should be held only for the real part.

We have already noted that estimation of line of each member of equations enables us to leave only two summands in the right part of equation – conditioned by advection and mountain's massif influence. Thus, we have the following for equation (9):

$$F_1 = \frac{1}{l\eta}(\varphi, \Delta\varphi) - l(\ln\eta, \varphi) \qquad (17)$$

taking into consideration (17), the equation (9) will be rewritten as following:

$$\Delta\frac{\partial\varphi}{\partial t} + a\frac{\partial^2\varphi}{\partial t\partial x} + b\frac{\partial^2\varphi}{\partial t\partial y} + \beta\frac{\partial\varphi}{\partial x} = c_1\frac{\partial\varphi}{\partial y}\frac{\partial\Delta\varphi}{\partial x} - c_1\frac{\partial\phi}{\partial x}\frac{\partial\Delta\varphi}{\partial y} - lb\frac{\partial\varphi}{\partial x} + la\frac{\partial\varphi}{\partial y} \qquad (18)$$

put (19) in (21) , accordingly the following equation for σ – will be received:

$$\chi(i\rho^2 + ma + nb) + i(\beta m + lbm - lan) = 0\,,$$

where $\rho^2 = m^2 + n^2$ - phase speed will be complex value.

$$\chi = i\frac{lan - m(lb+\beta)}{i\rho^2 + am + bn} = \chi_1 + i\chi_2\,. \qquad (19)$$

This indicates to non-stability of solution – expotential increasing of amplitude. (if $a = b = 0$ then
$\chi = -\beta m/\rho^2$ is speed of Rossby wave [13,20]). It is clear that:

$$\chi_1 = \frac{\rho^2[lan - m(lb+\beta)]}{\rho^4 + (am+nb)^2}, \qquad (20)$$

$$\chi_2 = \frac{[lan - m(lb+\beta)]}{\rho^4 + (am+nb)^2}. \qquad (21)$$

For the waves, which may be conditionally called the neutral one, χ_2 will become zero, when the following circumstance is met:

$$am + bn = 0 \quad \text{or} \quad a/b = -m/n\,. \qquad (22)$$

Thus, the result is reached, which may be used in practice: If the circumstance (22) is met, among the values characterizing of mountain inclination and wave quntities, two-dimensional waves of neutral type may exist.

The necessary and enough circumstance for existing of stationary waves is the following:

$$\frac{m}{n} = \frac{1}{a}(b + \frac{\beta}{l}) \ \text{or} \ \frac{L_x}{L_Y} = \frac{1}{a}(b + \frac{\beta}{l}) \qquad (23)$$

According to comparison of (22) and (23), β-effect is not revealed in the waves of neutral type, but it is essential for stationary ones.

The following comes from the conditions (22) and (23) accepted among the key parameters:

Ratio of the lengths of wave for the neutral and stationary waves in dependence of the average inclination of mountain is are reciprocal to each other.

Ratio of the length of stationary wave along the parallel and meridian is inversely proportional, strengthened with β effect, to inclination of mountain massif confirmed with meridian direction to mountain's inclination along the parallel.

Thus, if condition (22) among the parameters characterizing wave quantities and mountain inclination, then frequency is real and accordingly, neutral and stationary waves exist. For revealing of β effect we can compare the parameters of the Caucasia and rocky mountain (USA), accept that for the Caucasia $m = 2\pi L_x = 2\pi(1.5 \cdot 10^8)^{-1} = 4 \cdot 10^{-6}$ 1/m and as $b/a \approx 10,\ n = 0.1\,m$.

As β effect is minor on the Caucasia, the stationary waves on the Caucasia (Transcaucasia) are pulled along the latitudinal circle (goes from the West to the East, the relevant wave period $\chi_1^{-1} = 1.3$ day and night. For rocky mountain $L_x = 700$ km, $L_y = 3200$ km and the period $T = 5$ days and night. Above this massif, the waves are pulled along the meridian. The waves of this period is found as on Trans-Caucasia as on the continent of America. [1, 21, 30].

For example, the satellite photos of clouds for the quite long time period were analyzed (see Figs. 1-3), the nature of spreading of quasi-stationary waves is clearly expressed on the photos.

Let's us assume that $m = n$ and calculate numerical value of $C = \chi / m$ speed of spreading of wave. It was found that $C = (15.2 + 13.4i)$ m/sec. received value coincides with the synoptic-Rossby wave speed. Thus it is substantiated, that the given approach assumes the solution with method of the long waves. [16, 29].

c) Let's represent the geopotential valley of atmosphere as the following:

$$\varphi = \varphi_0(x, y) + \varphi(x, y, t), \text{ where } \varphi_0(x, y) = \varphi_0' - \alpha y + Ne^{i(mx+ny)}.$$

Now consider baroclinic atmosphere and accept that the right part of (10) equation is represented as the following: [2, 5, 17]:

$$F_2 = -\frac{1}{l\eta}(\varphi, \Delta\varphi) + R\frac{l^2}{c^2}\frac{\partial}{\partial \xi}(\xi, A_T). \qquad (24)$$

Search the solution of equation (10) taking into consideration zonal flow, which is important for Trans-Caucasian region [23, 26, 30]:

$$\varphi = \varphi_0 + V_y + N\xi^{v} e^{i(mx+ny-\chi t)}, \qquad (25)$$

where $V = vt,\ v$ - is the degree of autobarotropism, which is to be determined for earth surface (12) through the formula given in boundary condition.

Put (25) in (10) equation and (12) boundary condition, accordingly:

$$\chi\rho^2 - i\chi(am + bn) + \beta m - \frac{l^2}{c^2}\eta\chi v(v+1) = \frac{m}{l\eta}\rho^2 v - \frac{l}{c^2}Vv(v+1).$$

Let's accept that (25) condition $am + bn = 0,$ is fulfilled, then for speed the following is received:

$$C_2 = \frac{\chi}{m} = \frac{V}{\ln} - \frac{\beta}{\rho^2 - c_1 v(v+1)}. \qquad (26)$$

According to formula (12), the following one is received:

$$C_2 = \frac{\frac{v}{l\eta}}{v-\alpha} + \frac{\frac{c^2}{l}\frac{a^2+b^2}{b}}{v-\alpha} \quad , \tag{27}$$

where $c_1 = l^2\eta / c^2$.

Using of (26) and (27), the following equation is received for v

$$\begin{aligned} & v^2[(c^2\frac{1}{l}c_1\frac{a^2+b^2}{b}+\frac{V}{\eta}c_1\alpha)]+v[c^2\frac{c_1}{l}\frac{a^2+b^2}{b}+\frac{Vc_1}{\eta}\alpha-\beta] \\ & +[c^2\frac{1}{l}\rho^2\frac{a^2-b^2}{b}+\frac{V\rho^2}{\eta}\alpha-\alpha l\beta]=0 \end{aligned} \tag{28}$$

By putting the numerical value, the following will be received from (28):

$v_1^{kav} = 8.4$, $\quad v_2^{kav} = -9.4$, $v_1^{kld} = 3.3$, $\quad v_2^{kld} = -4.8$.

As $v_2 < -1$, so, the second root should be neglected [19]. In given model, horizontal waves of neutral type are rapidly disappeared by height, influenced by mountain massif. They exist in the layers of relatively small thickness of atmosphere (hundred meter) with the great horizontal spreading (see Figs. 1, 2). This fact approves the abovementioned discussion once more, that atmospheric processes on Transcaucasia are spread along the parallel, the main mountain range of Caucasia, and above the rocky mountains – along the meridian. Such motions meets to resistance from Surami - tableland mountain range during invasion of the East and West on Caucasia. The influence of Surami mountain range causes rotary-twisted motions toward torrent flow on the other side of mountain range. This circumstance increases humidity in West Georgia, and in East Georgia in contrary – air masses becomes dryer. This point of view may be one factor for substantiation that on the background of global heating, the temperature in West Georgia is fallen, and in East Georgia is raised [24-27, 33, 35].

d) Let's discuss the full system of equations of hydrothermodynamic of atmosphere in so called σ-system, related with pressure [25, 27, 31]. This system provides quite enough foreseeing of influence of physical relief of earth.

It is known that

$$\sigma = \frac{p - p_T}{p_s(x,y) - p_T} \quad , \tag{29}$$

where $p_s(x,y)$ is a pressure on the earth surface, p_T - on tropopause, let's accept that $p_T = 0$ (as always) and linearizing of the full system of hydrodynamic equations toward background (gentle) condition [31], we will have the following equations

$$\begin{aligned} & \frac{\partial U}{\partial t} + \frac{\partial \varphi}{\partial x} + a\sigma\frac{\partial \varphi}{\partial \sigma} - lV = 0, \\ & \frac{\partial V}{\partial t} + \frac{\partial \varphi}{\partial y} + b\sigma\frac{\partial \varphi}{\partial \sigma} - lU = 0, \\ & \frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} + K^2\frac{\partial}{\partial \sigma}\sigma\frac{\partial^2 \varphi}{\partial t \partial \sigma} = 0, \end{aligned} \tag{30}$$

where $K^2 = C^{-2}$, $\quad C = \sqrt{\alpha RT}$.

This system should be solved protecting the following initial and boundary conditions:

$$\begin{aligned}
&\text{at } z=0, \quad U=U_0(x,y,\sigma); V=V_0(x,y,\sigma); \varphi=\varphi_0(x,y,\sigma);\\
&\text{at } \sigma\to 0, \quad \frac{\partial^2\varphi}{\partial t\partial\sigma}=0,\\
&\text{at } \sigma=1, \quad \sigma\frac{\partial^2\varphi}{\partial t\partial\sigma}+\alpha\frac{\partial\varphi}{\partial t}=\varphi(x,y).
\end{aligned} \tag{31}$$

Research wave solution of system of these equations, let's assume, that

$$\{U,V,\varphi\}=\{U_0,V_0,\varphi_0\}\sigma^v e^{i(mx+ny-\chi t)}$$

By putting in (30), the following system of equations similar toward U, V, φ [2]:

$$\begin{aligned}
&-i\chi U_0+im\varphi_0+av\phi_0-lV_0=0,\\
&-i\chi V_0+in\varphi_0+bv\phi_0-lU_0=0,\\
&imU_0+inV_0+iK^2v(v+1)\chi\varphi_0=0.
\end{aligned}$$

It is necessary for non-trivial solution that [31]

$$\begin{vmatrix} i\chi-l & im+av & \\ l-i\chi & in+bv & \\ mn & K^2v(v+1\chi) & \end{vmatrix}=0.$$

Cubic equation for phase speed is received from this:

$$-\chi^3K^2v(v+1)+\chi\{K^2l^2v(v+1)-\rho^2+iv(am+nb)\}+bv(na-mb)=0 \tag{32}$$

In order (32) equation to have at least one real root, the following known condition should be met:

$$am+bn=0 \tag{33}$$

Taking into consideration of (33) condition, after receiving that $\mathrm{v}=-0.12$, [8] the equation for χ should be rewritten as the following:

$$\chi^3-\chi[l^2+\frac{m^2(a^2+b^2)}{K^2v(v+1)b^2}]+\frac{lm}{K^2(v+1)}\frac{a^2+b^2}{b^2}=0 \tag{34}$$

The condition that this equation will have three roots will be rewritten as following:

$$\left(\frac{lm}{K^2(v+1)}\frac{a^2+b^2}{b^2}\right)^2<\frac{4}{27}\left[l^2+\frac{m^2}{K^2v(v+1)}\frac{a^2+b^2}{b^2}\right]^3. \tag{35}$$

It becomes clear that there is limitation for existence of wave solution. (34) Equation shows that it has only one real root. Putting of numerical values and calculation gives $\chi_{kld}=-0.4\cdot10^{-4}$ 1/sec, $\chi_{kld}=-0.2\cdot10^{-4}$ 1/sec. which equalizes the periods of wave disturbance, accordingly, $T_{kav} = 1.6$ twenty-four hour and T_{kld} =3,1 twenty-four hour. Wave disturbances of such period are seen in almost everyday synoptic practice.

On the basis of made research, the following conclusions are made:

The extra terms describing the simultaneous influence of β-effect and huge mountain massifs on atmosphere dynamic are foreseen in the equation systems of forecast hydrothermodynamic of atmospheric processes.

The solution of the mentioned forecast equation on the basis of Carson-Heaviside and Purie transformation of horizontal coordinates toward $t-$ parameter is accepted in the linear approach.

For minor value of $t-$ the solution is received in expanded form and the functions of the proper influence (Green) are analyzed.

Non-geostrophisity of wind along the mountain massif causes the abolition of circle symmetry of influence function, which is characteristic for these functions taking into consideration neither influence of mountain nor β-effect.

It is shown that, when some relationship among the parameters of mountain influence (average inclination toward parallel and meridian) and components of wave vector is fulfilled, neutral and stationary waves may exist. According to satellite photos of clouds, such waves are seen at the top of the Caucasia.

The fact found in synoptic practice that atmospheric processes on Trans-Caucasia are moving along the parallel, and on rocky mountains – along the meridian was substantiated theoretically.

Simultaneous influence of mountain massif and β-effect is stronger for those massifs, stretched toward meridian (rocky mountains) then along the parallel of mountain massif.

On all levels of atmosphere (6 km height from the earth surface), the same picture is seen. For baroclinic atmosphere, the functions of influence have the minimal value toward the North, and toward the South and South-West – the maximal one. This certifies that atmospheric masses on the Caucasia do not almost come from the north.

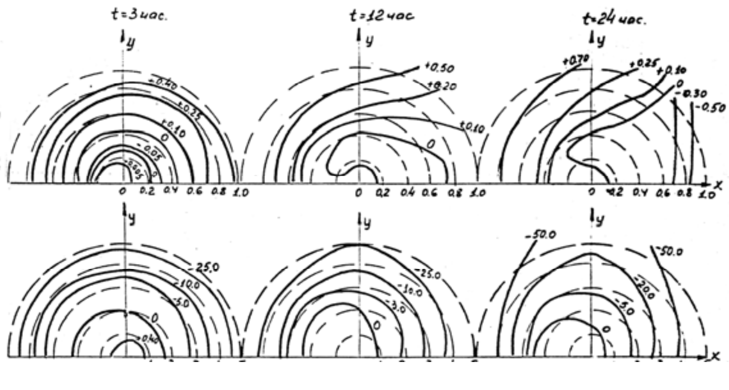

Fig. 1.

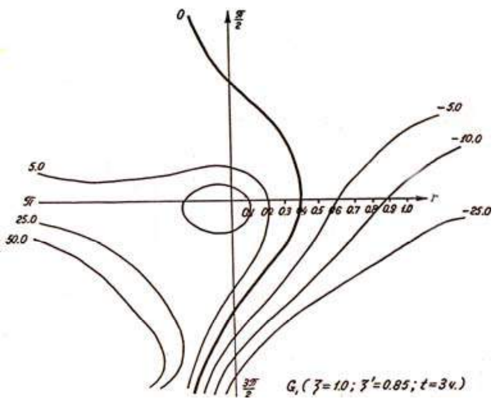

Fig. 2

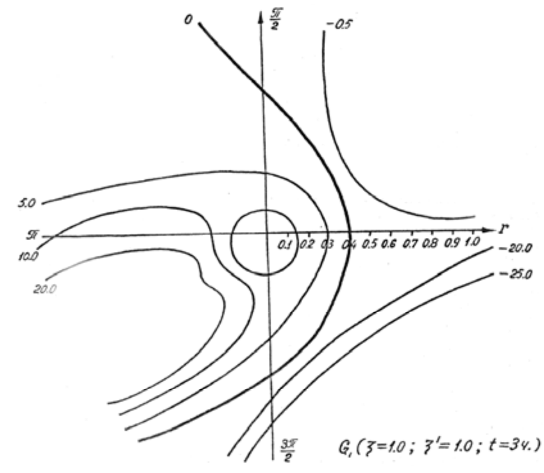

Fig. 3.

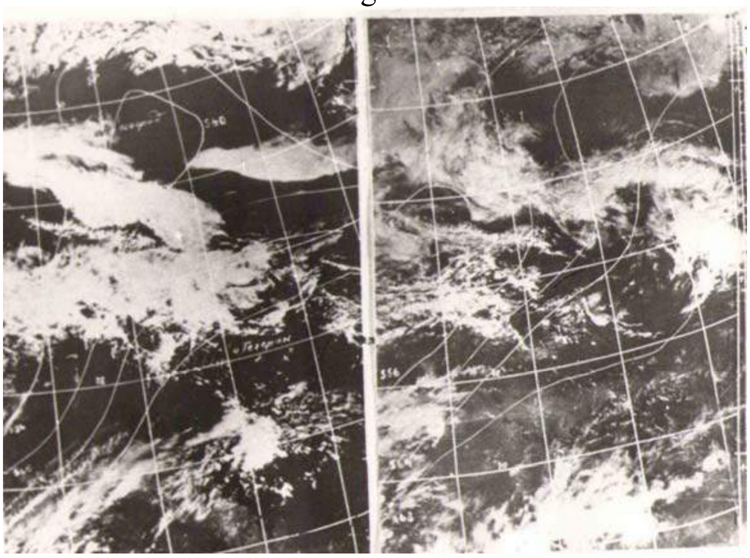

Foto 1.

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Исследование регионального атмосферного волнового движения с учетом рельефных особенностей

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Резюме

В статье изучены региональные атмосферные волновые движения с использованием системы уравнений гидро-термодинамики. Проанализированы видоизмененные уровнения в квазигеострофическом, адиабатическом приближении с учетом влияния β-эффекта u рельефа. Приведены найденное с помощью функций влиания соответствующее решение и результаты их анализа. Впервые теоретически подтверждаются несколько известных в синоптической практике Закавказья фактов, в частности, показано, что вторжение воздушных масс с севера почти не осуществляется. С помощью полной системы уравнений гидро-термодинамики изучены волновые движения с учетом влияния рельефа. Показано, что атмосферные процессы Закавказья имеют направленный поперек параллели (хребтов Заказказья) характер, причём, гребни волн распространяются с запада на восток. Высказано теоретическое соображение для разьяснения факта, почему на фоне глобального потепления западную Грузию характеризует похолодание, а восточную потепление. Было замечено, что в Закавказье могут существовать т.н. волны нейтрального и стационарного типа, если между параметрами, характерезующими горы, и соответствующими волновыми числами высполняется определенное условие. Был высчитан период этих волн, а их существование подтверждено анализом снимков облаков с искусственного спутника земли. Большинство полученных автором результатов рекомендовано для использования в практике прогноза погоды Грузии.

რეგიონალური ატმოსფერული ტალღური მოძრაობის გამოკვლევა რელიეფური თავისებურებების გათვალისწინებით

ზურაბ ხვედელიძე

რეზიუმე

სტატიაში განხორციელებულია რეგიონალური ატმოსფერული ტალღური მოძრაობების შესწავლა ჰიდროთერმოდინამიკის განტოლებათა სისტემის გამოყენებით. გაანალიზებულია ე. წ. სახეშეცვლილი განტოლებები კვაზიგეოსტროფიულ, კვაზიადიაბატურ მიახლოებაში რელიეფისა და β ეფექტის გავლენის გათვალისწინებით. მოყვანილია შესაბამისი ამოხსნა გავლენის ფუნქციების საშუალებით და მოხდენილია მათი ანალიზი. ამ ფუნქციების ანალიზის საფუძველზე თეორიულად პირველად მტკიცდება ამიერკავკასიაზე სინოპტიკურ პრაქტიკაში უკვე ცნობილი რამოდენიმე ფაქტი. მათ შორის ის რომ კავკასიონზე უშუალოდ ჩრდილოეთიდან ჰაერის მასათა შემოჭრა თითქმის არ ხორციელდება. ასევე მოხდენილია ჰიდროთერმოდინამიკის განტოლებათა სრული სისტემის საფუძველზე ტალღური მოძრაობის გამოკვლევა. შედეგად დადასტურდა ფაქტი, რომ ატმოსფერულ პროცესებს ამიერკავკასიაზე აქვთ პარალელის (კავკასიონის ქედის) გასწვრივ წაგრძელებული ბუნება, ტალღის ბურცობები ვრცელდებიან დასავლეთიდან აღმოსავლეთისაკენ. გამოთქმულია თეორიული მოსაზრება, იმის ასახსნელად თუ გლობალური დათბობის ფონზე, რატომ არის დასავლეთ საქართველოში აცივება და აღმოსავლეთში კი დათბობა, შემჩნეულ იქნა ,რომ ამიერკავკასიაზე შეიძლება არსებობდეს ე.წ. ნეიტრალური ტიპის და სტაციონალური ტალღები,თუ მთის მახასიათებელ პარამეტრებსა და შესაბამის ტალღურ რიცხვებს შორის სრულდება გარკვეული პირობა. გამოთვლილ იქნა ამ ტალღების პერიოდი, ხოლო მათი არსებობა დადასტურებულია დედამიწის ხელოვნური თანამგზავრიდან მიღებული ღრუბლების სურათების ანალიზიდან. მიღებული დასკვნების და შედეგების უმრავლესობა რეკომენდებულია გამოყენებისათვის საქართველოს ამინდის პროგნოზის სამსახურში.