Article

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Study of Modeling of Large-Scale Atmospheric Circulation Using Mathematics

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دراسة نموذجية في دوران الغلاف الجوي على نطاق واسع باستخدام الرياضيات

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ABSTRACT

Background:

Type of turbulent isobaric surfaces in the geostrophic state of the environment. It has been proven that depending on the index of high air temperature at the equator in the geological state of the air, the isobaric surface has the state of an oblate or elongated geoid.

Materials and Methods:

As you know, the geostrophic state plays an extremely important role in the dynamics of the atmosphere. Analysis of the estimates of the quantities included in the equation of atmospheric dynamics (scale analysis) makes it possible to write the following expressions for the projections of the velocity of the geostrophic wind.

Results:

As a result, we get the accompanying image. When the temperature rise at the equator is positive, the isobaric surface is in the state of an elongated geoid, and the warm air moves clockwise in advection to the column, where there is a greatest adduct and the breeze velocity at the column is limited.

Conclusion:

Thus, from the above analysis of the geostrophic state of the atmosphere, it follows that the following situations are possible at the pole in the geostrophic state. The first situation: the isobaric surface at the pole has the shape of an oblate geoid, the pressure decreases in comparison with the static state - a global isobaric minimum takes place. The second situation: the isobaric surface has the shape of an elongated geoid, the pressure at the pole increases in comparison with the static state - a global maximum takes place.

Key words:

Atmospheric dynamics, geostrophic state of the atmosphere, Atmospheric circulation

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INTRODUCTION

The topic of the type of the bothered isobaric surfaces in the geostrophic condition of the environment. It is shown that, contingent upon the indication of air overheating at the equator in the geostrophic condition of the air, the isobaric surface has the state of an oblate or extended geoid. Also, if the speed of the geostrophic wind at the post is not the same as nothing, at that point a neighborhood baric least is framed at the shaft in the straightened geoid, and in the lengthened geoid - a nearby baric most extreme. This clarifies the presence of polar vortices and anticyclones. At the end of the day, the baric least and the most extreme at the shaft are highlights of the geostrophic condition of the atmosphere[1]. It was tracked down that the vortex of speed watches out for vastness at the shafts. This clarifies the way that polar vortices are steady arrangements. It is shown that for the event of zonal westerly vehicle, the air should be colder than the encompassing air. For the warm air mass, just the east wind will be observed[2]. It was discovered that, contingent upon the adjustment of the flat temperature inclination with height during warmth and cold shift in weather conditions, both left and right turn of the geostrophic wind can be noticed, as opposed to the by and large acknowledged assessment that warmth shift in weather conditions is related with the correct turn of the breeze in a free climate, turn - cold shift in weather conditions. The reason for the article is to discover, at any rate subjectively, the state of the upset isobaric surface in the geostrophic condition of the atmosphere[3].

MATERIALS AND METHODS

As you know, the geostrophic state plays an extremely important role in the dynamics of the atmosphere. Analysis of the estimates of the quantities included in the equation of atmospheric dynamics (scale analysis) makes it possible to write the following expressions for the projections of the velocity of the geostrophic wind [1],[2],[3]:

$$u_g = -\frac{1}{2\omega_0 \rho_e Sin\varphi}\frac{\partial p_s}{\partial y} \quad (1)$$

$$v_g = -\frac{1}{2\omega_0 \rho_e Sin\varphi}\frac{\partial p_s}{\partial x} \quad (2)$$

Here

- the projection of the geostrophic wind along the parallel (along x-axis).u_g

-the projection of the geostrophic wind along the meridian (along y-axis).v_g

- angular velocity of rotation of the earth.ω_0

-air density in a state of static atmosphere.ρ_e

φ-latitude.

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p_s- perturbation of pressure relative to the state of statics of the atmosphere.

Thus, knowing the disturbed isobaric surface, it is possible to determine the value of the geostrophic wind speed. But, as noted in [3], the question of the shape of the perturbed isobaric When deriving formulas (1) and (2), the following assumptions were made: .surface remains open the vertical speed is much less than the horizontal project velocity w << u, v, the equation of motion in projection onto the vertical direction is reduced to the equation of atmospheric statics. There is one more circumstance that forces us to pay more attention to the geostrophic state of the atmosphere. This is a well-known phenomenon called the polar vortex. As is known a polar vortex is a persistent large-scale cyclone located near both of the Earth's geographic poles. The inquiry normally emerges: the polar vortex is an outcome of the aggravation of the geostrophic condition of the climate, brought about by the inhomogeneous warming of the Earth from the equator to the shaft, or it is a type of presence of the very geostrophic condition of the environment. The examination did in this work shows that the baric least at the shaft is one of the indications of the geostrophic condition of the atmosphere[4]. Albeit polar vortices are a normally noticed element of the climate, and their life expectancy can be over one month, little is thought about the components that administer their arrangement and improvement. As per the for the most part acknowledged perspective, the polar vortex is an outcome of the aggravation of the geostrophic state, and isn't a component of the geostrophic condition of the actual environment [5]. Allow us to compose the condition of the air elements in vector structure [1–4]:

$$\frac{\partial v}{\partial t} + (v\nabla)v = g_0 - \frac{1}{\rho_i}\nabla p + 2[v\omega_0] + \omega_0^2 R + f_{TP} \quad (3)$$

Where

g_0- acceleration of gravity.

∇p-pressure gradient.

$2[v\omega_0]$-Coriolis acceleration.

$\omega_0^2 R$- centrifugal acceleration.

f_{TP}- the frictional force per unit mass.

- the density of the moving air is generally excellent on the density ρ_e in the static state.ρ_i

Here the organize framework is identified with the outside of the Earth the abscissa pivot is coordinated along the equal, the ordinate hub is coordinated along the meridian, and the applicate hub is opposite to the Earth's surface[6]. In the condition of static air, when v = 0, the condition will be written in the structure

$$0 = g_0 - \frac{1}{\rho_e}\nabla\bar{p} + \omega_0^2 R \quad (4)$$

It is more advantageous to present the vector of speed increase of gravity (speed increase free fall), equivalent to the vector amount of the speed increase of the gravitational force g_0 and the diffusive speed increase:

$$g = g_0 + \omega_0^2 R \quad (5)$$

Thus, the genocidal surface of the Earth is perpendicular to the acceleration of gravity g. Then the equation of atmospheric statics can be written in the form

∇p^{-} (6)$0 = g - \frac{1}{\rho_e}$

From this it follows that in the condition of static isobaric the surfaces are opposite to the gravitational speed increase vector, that is, corresponding to the genocidal surface of the Earth[7]. These isobaric surfaces are taken as the undisturbed condition of the air. Note that the regularly unperturbed isobaric surface in the state .statics are generally addressed as a circle. As a general rule, they are like a geoid [2] With consistent movement dv/dt = 0, isobaric surfaces with a genocidal shape are irritated, so the pressing factor can be addressed in the structure [8]

$$p = \bar{p} + p_s \quad (7)$$

Similarly, the density of air in the Bossiness approximation represent in the form [3].

$$\rho_i = \rho_e(1 - \alpha\Delta T) \quad (8)$$

Where ΔT-overheating function, which is positive when a warm air mass moves, and negative when a cold air mass moves. Therefore, the equation of steady motion in the absence of frictionf_{TP} = 0 will be written in the following form:

$$0 \approx -\alpha\Delta T g - \frac{1}{\rho_e}\nabla p_s + 2[v\omega_0] \quad (9)$$

The projections of the angular velocity of the Earth's rotation are determined by the expressions [9]:

$$\omega_{0x} = 0, \omega_{oy} = \omega_{0x} cos\varphi, \omega_{oz} = \omega_0 sin\varphi. \quad (10)$$

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Let us write down the projections of the equation of motion in the stationary

state (9) in a coordinate system in which the horizontal plane is tangent to the geoid:

$$0 = -\frac{1}{\rho_e}\frac{\partial p_s}{\partial x} + 2v\omega_0 sin\varphi - 2w\omega_0 cos\varphi \qquad (11)$$

$$0 = -\frac{1}{\rho_e}\frac{\partial p_s}{\partial y} - 2u\omega_0 sin\varphi \qquad (12)$$

$$0 = -\frac{1}{\rho_e}\frac{\partial p_s}{\partial y} + \alpha\Delta T g + 2u\omega_0 cos\varphi \qquad (13)$$

The free fall acceleration in the last equation is but

$$g = g_o - R_E\omega_0^2 cos^2 \varphi$$

The third term in condition (11) is the deduction of the upward segment of the air speed on the even projection of the precise speed of the Earth's revolution. Hence, we see that to get equations (1) and (2), we can make two suspicions: either disregard the upward speed, or disregard the even projection of the precise speed of the Earth's revolution ... In spite of the fact that the two suspicions lead to equations for the projections of the geostrophic wind speed, they are not same. In the geostrophic model of the air from the examination of assessments of the amounts remembered for Eq. (3), in the estimate of a fine air (Thin-Layer Approximations), it is inferred that lone the segment of the rakish speed of its turn ordinary to the Earth's surface is fundamental for the elements of the air. Thusly, the third term in conditions (11) and (13) is dismissed [10]. The significant job of the level projection of the rakish speed of the Earth's pivot in the elements of the climate is talked about in the article by A.A. White and R.A. Bromley [11]. In this manner, we can say that the geostrophic condition of the climate is a consistent state wherein the powers of gooey grinding and vertical speed are ignored. At that point we come to recipes (1) and (2), which portray the geostrophic condition of the air. Be that as it may, notwithstanding the examination of the geostrophic condition of the environment, condition (13) will be added. All things considered, the reason for the article is to discover what's going on comparable to the customary way to deal with the portrayal of the geostrophic express that condition (13) can give. Consequently, the distinction between our meaning of the geostrophic condition of the environment from the for the most part acknowledged one lies in the utilization of condition (13). When in doubt [1],[2],[12], the third condition remembered for the arrangement of conditions portraying the geostrophic state is the condition of statics air. This is because of the way that the terms of condition (13) are numerous significant degrees less than the terms remembered for the condition of climatic statics. Notwithstanding, as can be seen from the determination of equations (11) - (13), the geostrophic state is an aggravation comparative with the statics of the air. In this way, as we would see it, not it is right to think about static irritations

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in the initial two conditions and disregard them in the third equation .Then from the framework (11) - (13) we acquire the level projections of the geostrophic wind speed:

$$u_g = -\frac{1}{2\omega_0\rho_e sin\varphi}\frac{\partial p_s}{\partial y} \quad (14)$$

$$v_g = -\frac{1}{2\omega_0\rho_e sin\varphi}\frac{\partial p_s}{\partial x} \quad (15)$$

$$u_g = -\frac{1}{2\omega_0\rho_e sin\varphi}\frac{\partial p_s}{\partial z} - \frac{\alpha g}{2\omega_0 cos\varphi} \quad (16)$$

Vector and scalar multiplication of equation (9) by k, will give two expressions for the vector of the geostrophic wind speed:

$$v_g = \frac{1}{2\omega_0\rho_e(k,k_o)}[k, \nabla p_s] \quad (17)$$

Where k- a unit vector directed vertically upwards along the z-axis perpendicular to the genocidal surface of the Earth.

k_0-unit vector directed in the direction of the angular the speed of rotation of the Earth.

This shows that the geostrophic wind is opposite pressure slope, and hence coordinated along the isobaric surface. Equations (14) and (15) could be acquired straightforwardly from articulation (17). Allow us to consider a unique situation when ∂ps ∂x = 0, and −∂ps ∂y> 0, along the y-pivot, the pressing factor annoyance during consistent movement will fall toward the path from the equator to the shaft (on a worldwide scale, this is seen in the environment). For this situation, the geostrophic wind will be coordinated from the west. toward the east, for example a western stream will be noticed.

From (14) and (16) it follows that for the occurrence of a zonal western transport of warm air, the following condition must be met:

$$\frac{\partial p_s}{\partial z} > \alpha \Delta T \rho_e g \quad (18)$$

and the pressure perturbation gradients must obey ratio:

$$\Delta T = \frac{1}{\rho_e \alpha g} \cdot \left(\frac{\partial p_s}{\partial z} + ctg\varphi \frac{\partial p_s}{\partial z}\right) \quad (19)$$

Hence it follows that for the existence of the western the nose of warm air, the vertical gradient of the pressure disturbance must be positive and greater than a certain value:

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$$\frac{\partial p_s}{\partial z} > -ctg\varphi\frac{\partial p_s}{\partial y}, -\frac{\partial p_s}{\partial y} > 0 \qquad (20)$$

In the event that this condition isn't met, just the east wind (from east to west) will be noticed for the warm air mass, and cold air will move the east way. This will likewise be the situation if $\partial ps/\partial z \leq 0$.In different words, on the off chance that we expect that the geostrophic condition of the air compares to a specific state of the isobaric surface, which actually should be found, at that point with a given state of the isobaric surface, warm air will move toward the west, and cold air will how about we move east. It follows from equations (14) - (16) that the pressing factor bother angle

$$\nabla p_s = \left(\frac{\partial p_s}{\partial x}, \frac{\partial p_s}{\partial y}, \frac{\partial p_s}{\partial z}\right)$$

generally has all three nonzero components. Therefore, if in the static state ($\nabla\bar{p} = \rho_e$g) () the pressure gradient is directed along g, then in the geostrophic state, in the general case of an arbitrary point on the Earth's surface, the total pressure gradient

$$\nabla p = \nabla\bar{p} + p_s \qquad (21)$$

will be avoided from the bearing g, and the isobaric surface the ness will presently don't be opposite to g, however make some point with it. Contingent upon the indications of the pressing factor aggravation angle segments, the all-out pressure inclination can be diverted from the heading g, both away from the course of the Earth's pivot of revolution, and towards the hub of turn. The principal case will prompt the way that the isobaric surface will be significantly more leveled at the posts than in the static state. At the end of the day, if in the static express the isobaric surfaces have a genocidal shape (corresponding to the Earth's surface), at that point in the geostrophic express the isobaric surfaces are more straightened at the posts according to the isobaric surfaces in the static state. For curtness, we will call a particularly surface straightened geoid. For this situation, the pressing factor at the posts will be not exactly in the static state. Unexpectedly, the subsequent case will prompt the way that the isobaric surface at the posts will be more lengthened along the hub of revolution of the Earth along comparable to isobaric surfaces in a static state. For curtness, we will call a particularly surface a lengthened geoid. For this situation, the pressing factor at the posts will be more noteworthy than in the static state[13]. The above applies to self-assertive focuses on the Earth's surface, aside from the marks of the equator and posts, since these focuses are unique in this issue and require separate thought. How about we start with the places of the equator. To do this, we record the vector condition (9), which is legitimate for any point on the Earth's surface, in projections on the arrange hub in reference framework, the beginning of which is at the equator, the x-hub is coordinated digressively to the equator, the y-pivot is unrelated to the meridian (towards the north pole), the z-hub is opposite to the Earth's surface. For this situation, on the off chance that we disregard the upward segment of the speed, we get

$$\frac{\partial p_s}{\partial x} = 0, \frac{\partial p_s}{\partial y} = 0 \qquad (22)$$

$$u_g = \frac{1}{2\omega_{0y}}\left(\frac{1}{\rho_e}\frac{\partial p_s}{\partial z} - g\alpha\Delta T\right) \qquad (23)$$

at the equator are zero. Note that condition (23) harmonizes with condition (16). This furthermore shows the significance of this condition for the examination of the geostrophic condition of the air. Accordingly, it follows from conditions (22) and (23) that the heading of the absolute pressing factor slope ∇p corresponds with the direction $\nabla \bar{p}$. At the end of the day, at the equator, the isobaric surface is opposite to g, which implies it is corresponding to the genocidal surface in a static state. From conditions (22) and (23) it follows that at the equator there is just a single segment of the geostrophic wind coordinated along the equator. Condition (23) shows that this segment of the geostrophic wind speed will be positive, for example coordinated toward turn of the Earth, if the condition.

$$\frac{\partial p_s}{\partial z} > \rho_e g\alpha\Delta T$$

If we assume that $\partial p_y / \partial z = 0$, then from Eq. (23) it follows blowing that warm air ($\Delta T > 0$) will move in a negative direction (east, against the direction of rotation of the Earth), and cold air will move in a positive direction. At any point infinitely close to the equator along the meridian, according to equation (15), there is also a velocity component along the meridian. For definiteness, let us assume that vg> 0. If we try to draw a "streamline", the tangent to which coincides with the direction of the geostrophic wind at a given point, then we must conclude that the tangent to this line at the equator is directed along the equator. A remark should be made here. Although the "streamline" is a kind of curved line, we cannot, within the framework of geostrophic consideration, talk about movement along a curved line. This follows from the definition of a geostrophic state as a state in which acceleration is zero, which means that the movement can only occur in a straight line and with a constant speed. In other words, we can talk about the geostrophic state only locally, at a given specific point, and not imagine movement along the surface of the Earth. Thus, we get the following picture. Based on the continuity of the movement, we can conclude that warm air at the equator, starting in a negative direction, continues to "move" in a spiral (clockwise) to the North Pole. Likewise, cold air at the equator will “start moving” in a positive direction and “move” in a spiral (counterclockwise) also to the

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North Pole. The quotation marks were placed for the above reason that, within the framework of geostrophic consideration, we cannot speak of movement along a curved line. We can only talk about the direction of the geostrophic wind locally at each point. The question arises, what form does the isobaric surface at the North Pole have? For the answer, we will choose a Cartesian coordinate system, so that the origin of coordinates lies at the pole, and the O_{z1} axis is directed along the rotation axis, and the C_{x1} and C_{y1} axes are parallel, respectively, to the C_{x0} and C_{y0} axes, where C is the center of the Earth. At the North Pole, the distance from the axis of rotation to the origin is equal to zero R = 0, therefore the equation of motion of the atmosphere,
if $\Delta T \neq 0$ will be written as

$$-\alpha\Delta T g_0 - \frac{1}{\rho_e}\nabla p_s\Big|_0 + 2[v_g\omega_0] = 0 \qquad (24)$$

we write this equation in projections, taking into account that $2[v\omega_0]_{z1} = 0$

$$-\frac{1}{\rho_e}\frac{\partial p_s}{\partial x_1}\Big|_0 + 2v_g\omega_0 = 0 \qquad (25)$$

$$-\frac{1}{\rho_e}\frac{\partial p_s}{\partial y_1}\Big|_0 - u_g\omega_0 = 0 \qquad (26)$$

$$\alpha\Delta T g_0 - \frac{1}{\rho_e}\frac{\partial p_s}{\partial z_1} = 0 \qquad (27)$$

Hence, it can be seen that all three projections of the perturbation gradient pressures p_s are generally nonzero and the geostrophic wind speed is also nonzero. Therefore, if in the static state at the $\nabla\bar{p} = \rho_e g_0$, i.e. the pressure gradient at the North Pole is directed along g_0, then in the geostrophic state the total pressure gradient $\nabla p = \nabla\bar{p} + p_s$ will be deviated from the direction g_0, and the isobaric surface will no longer be perpendicular to the axis of rotation, but will make a certain angle with it. Let us determine the shape of the disturbed isobaric surface at the pole in the absence of overheating ($\Delta T = 0$). As can be seen from equations (25) - (26), two distinct alternatives are conceivable. The primary choice is that the speed of the geostrophic wind at the shaft is zero. At that point the segments of the pressing factor unsettling influence angle vector along the x and y tomahawks are additionally equivalent to nothing. For this situation, we have the above-portrayed instance of two types of an upset isobaric surface: as an oblate or prolonged geoid. On the off chance that we accept that cyclonic movement relates to low pressing factor at the pole with an oblate geoid, at that point we can reason that for this situation cold air starts to "move" from the equator counterclockwise in a twisting toward the North Pole, where the geostrophic wind speed gets zero. Likewise, we can reason that a prolonged geoid compares to the situation when warm air from the equator starts to "move" clockwise in a winding to the shaft, where its speed additionally gets zero. The subsequent choice is that the speed of the geostrophic wind at the post is unique. From nothing. For this situation, the parts of the pressing factor aggravation angle vector along the x and y

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tomahawks are nonzero. This prompts the way that the vector of the pressing factor bother slope ∇p_s makes a correct point with the vector of the pressing factor inclination in the condition of static ∇p¯. Therefore, the subsequent pressing factor angle vector ∇p digresses from the vertical, for example from vector ∇p¯. Such a game plan of the subsequent pressing factor slope vector prompts the way that the isobaric surface at the shaft is annoyed and isn't opposite to the hub revolution. From recipes (25) - (26) it is difficult to say unambiguously what kind of aggravation will be seen at the post. Just something single is clear, that the post is a solitary point in the feeling of the perfection of the capacity portraying the isobaric surface. Hence, the accompanying choices are conceivable. The primary choice is the point at which the isobaric surface has the state of an oblate geoid, and at the shaft there is either a base or a most extreme. The subsequent choice, likewise, the isobaric surface has the state of a stretched geoid, and there is a base or greatest at the shaft. In any case, in the event that we expect that the cyclonic movement relates to the baric least, and the anticyclone movement to the baric most extreme, at that point from the progression of the movement we should prohibit the situations when a baric greatest happens at the post of the smoothed geoid, and at the shaft prolonged geoid - baric least.

RESULTS AND DISCUSSION

Consequently, we get the accompanying picture. When at the equator the overheating is positive, the isobaric surface has the state of a prolonged geoid, and warm air "moves" clockwise in a twisting to the post, where there is a neighborhood greatest and the breeze speed at the shaft has a limited worth. At the point when the overheating at the equator is negative, at that point the isobaric surface has the state of an oblate geoid, and the virus air "moves" counterclockwise in a twisting to the post, where there is a nearby least and the breeze speed at the shaft is a limitless .worth Allow us to consider what overheating means for the state of the isobaric surface. We should begin with the situation when the geostrophic wind speed at the post is zero. As can be seen from equation (27), with positive superheating ($\Delta T > 0$), the upward segment of the pressing factor bother inclination is positive $\partial ps/\partial z > 0$ and is coordinated oppositely to ∇p¯, so the subsequent pressing factor angle diminishes. This prompts the way that the distance between the isobaric surfaces increments with positive superheat. In the event that the superheating is negative ($\Delta T > 0$), $\partial ps/\partial z > 0$, the subsequent pressing factor inclination increments. This prompts the way that the distance between the isobaric surfaces at the posts diminishes. Presently how about we proceed onward to the situation when the geostrophic wind at the posts is nonzero. Assuming the superheating is negative ($\Delta T > 0$), from recipes (25) - (27) it follows that the pressing factor bother inclination ps makes an intense point with the heading of the slope in the static state ∇p¯(or g_0), since the upward part $\partial ps/\partial z$ coordinated descending. In this way, the subsequent vector ∇p will be coordinated along the askew of the parallelogram made out of these two vectors. For this situation, the subsequent vector ∇p, just as for the situation when $\Delta T > 0$, is diverted from the heading of ∇p¯(vertical), however as of now at a more modest point. This will

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prompt the way that the isobaric surface at the post will have a baric least (we bar the baric most extreme, as shown above, for reasons of progression), however it will as of now be compliment. In the event that the .As such, negative superheat debilitates the profundity of the baric least. overheating is positive (ΔT> 0), the point between the vector of the pressing factor annoyance slope and the vector∇p^{-}will be in excess of 90 degrees. Hence, for this situation, the deviation of the subsequent vector ∇p from the course g0 will stray much more than in the past cases. At the end of the day, positive superheating makes the baric most extreme higher. For additional examination of the isobaric surface, we apply the congruity condition to the geostrophic wind, we get

$$\frac{\partial u_g}{\partial x}+\frac{\partial v_g}{\partial y}=\frac{1}{2\omega_0}\left\{\frac{\partial}{\partial y}\left(\frac{1}{\rho sin\varphi}\frac{\partial p_s}{\partial x}\right)-\frac{\partial}{\partial x}\left(\frac{1}{\rho sin\varphi}\frac{\partial p_s}{\partial y}\right)\right\}=$$

$$=-\frac{1}{2\omega_0\rho sin\varphi}\left\{\frac{\partial p_s}{\partial x}\left(\frac{1}{\rho}\frac{\partial\rho}{\partial y}-ctg\varphi\frac{\partial\varphi}{\partial y}\right)-\frac{\partial p_s}{\partial y}\left(\frac{1}{\rho}\frac{\partial\rho}{\partial x}-ctg\varphi\frac{\partial\varphi}{\partial x}\right)\right\}=0 \qquad (28)$$

Since ∂φ / ∂x = 0, we get

$$\frac{\partial p_s}{\partial x}\left(\frac{1}{\rho}\frac{\partial\rho}{\partial y}-ctg\varphi\frac{\partial\varphi}{\partial y}\right)-\frac{1}{\rho}\frac{\partial p_s}{\partial y}\frac{\partial\rho}{\partial x}=0 \qquad (29)$$

Hence it follows that for the geostrophic regime of the atmosphere ferry, the following conditions must be met:

$$\left(\frac{\frac{\partial p_s}{\partial x}}{\frac{\partial p_s}{\partial y}}\right)_g=\left(\frac{dy}{dx}\right)_g=\frac{\frac{\partial Ln\rho_e}{\partial x}}{\frac{\partial Ln(\rho_e sin\varphi)}{\partial y}} \qquad (30)$$

Therefore, the tangent of the angle of inclination between the tangent to the isobar and parallel is determined by the horizontal gradients of air density along the parallel and meridian. In the state of statics of the atmosphere $\frac{\partial Ln\rho_e}{\partial x}=0$. Therefore, if we assume that in the geostrophic state, the following expression takes place: (dy / dx) = 0. Hence it follows that the perturbed the isobaric .surface in the geostrophic state has a symmetrical appearance with respect to the axis of rotation If we assume the above assumption about the symmetry about the axis of rotation of the isobaric surface in the geostrophic state (∂p_s / ∂x = 0), then it follows that v_g = 0. In other words, in this case, only movement along the parallel should correspond to the geostrophic state: westerly

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movement of cold air and easterly movement of warm air in the northern hemisphere, and vice versa in the southern hemisphere. Otherwise not symmetrical isobaric surface, we will observe a "movement" in a spiral from the equator to the pole. Let's find the vertical projection of the geostrophic wind vortex:

$$\Omega_{gz} = \frac{\partial v_g}{\partial x} - \frac{\partial u_g}{\partial x} = \frac{1}{2\omega_0\rho_e}\left(\frac{\partial}{\partial x}\frac{1}{sin\varphi}\frac{\partial p_s}{\partial x} + \frac{\partial}{\partial y}\frac{1}{sin\varphi}\frac{\partial p_s}{\partial y}\right) =$$

$$= \frac{1}{2\omega_0\rho_e sin\varphi}\nabla_\perp^2 p_s - \frac{1}{2\rho_e\omega_0 R_E tg\varphi sin\varphi}\frac{\partial p_s}{\partial y}$$

Taking into account formula (16), for the case $\Delta T = 0$ and $u_g \neq 0$, we obtain

$$\frac{\frac{\partial p_s}{\partial y}}{\frac{\partial p_s}{\partial z}} = -tg\varphi, \quad \frac{\partial p_s}{\partial y} = -\frac{\partial p_s}{\partial z}tg\varphi,$$

$$\frac{\partial^2 p_s}{\partial y^2} = -\frac{\partial^2 p_s}{\partial y\partial z}tg\varphi - \frac{\partial p_s}{\partial z}\frac{1}{cos^2\varphi}\frac{\partial\varphi}{\partial y} =$$

$$= -\frac{\partial^2 p_s}{\partial y\partial z}tg\varphi - \frac{1}{R_E cos^2\varphi}\frac{\partial p_s}{\partial z}\frac{}{\varphi \to \frac{\pi}{2}} \to \infty$$

Since the quantity $\frac{\partial^2 p_s}{\partial y^2}$ enters into the expression for the vertical projection of the vortex, it follows that the vertical projection of the vortex at the pole tends to infinity.

CONCLUSIONS

Thus, from the above analysis of the geostrophic state of the atmosphere, it follows that the following situations are possible at the pole in the geostrophic state. The first situation: the isobaric surface at the pole has the shape of an oblate geoid, the pressure decreases in comparison with the static state - a global isobaric minimum takes place. The second situation: the isobaric surface has the shape of an elongated geoid, the pressure at the pole increases in comparison with the static state - a global maximum takes place. In both of these cases the velocity and vortex of velocity at the pole point are equal to zero. The following situation is possible when the pole is a singular point, the speed of the geostrophic wind at the pole is not zero, and the vortex of speed tends to infinity. In this case, as we concluded above from the continuity of motion, a local baric minimum will be observed at the pole point in an oblate geoid, and a local baric maximum in an elongated geoid. It follows from the above analysis that polar eddies and anticyclones are features of the geostrophic state of the atmosphere.

Conflict of interests.

The authors declare no conflicts of interest.

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الخلاصة

المقدمة:

نوع الأسطح متساوية الضغط المضطربة في الحالة الجيوستروفية للبيئة. لقد ثبت أنه اعتمادًا على مؤشر درجة حرارة الهواء المرتفعة عند خط الاستواء في الحالة الجيولوجية للهواء، فإن السطح متساوي الضغط له حالة مجسم جيودي مفلطح أو ممدود..

طرق العمل:

كما تعلمون، تلعب الحالة الجيوستروفية دورًا مهمًا للغاية في ديناميكيات الغلاف الجوي. تحليل تقديرات الكميات المتضمنة في معادلة ديناميكيات الغلاف الجوي (تحليل المقياس) يجعل من الممكن كتابة التعبيرات التالية لتوقعات سرعة الرياح الجيوستروفية.

النتائج:

ونتيجة لذلك، نحصل على الصورة المصاحبة. عندما يكون ارتفاع درجة الحرارة عند خط الاستواء موجبًا، يكون السطح متساوي الضغط في حالة مجسم أرضي ممدود، ويتحرك الهواء الدافئ في اتجاه عقارب الساعة في اتجاه عمودي إلى العمود، حيث يوجد التقريب الأكبر وتكون سرعة النسيم عند العمود محدودة.

الاستنتاجات:

من التحليل أعلاه للحالة الجيوستروفية للغلاف الجوي، يترتب على ذلك أن المواقف التالية ممكنة عند القطب في الحالة الجيوستروفية. الحالة الأولى: السطح متساوي الضغط عند القطب له شكل مجسم مفلطح، ويتناقص الضغط مقارنة بالحالة الساكنة – ويحدث حد أدنى متساوي الضغط عالمي. الوضع الثاني: السطح متساوي الضغط له شكل ممدود، ويزداد الضغط عند القطب مقارنة بالحالة الساكنة – ويحدث الحد الأقصى العالمي.

الكلمات المفتاحية: ديناميات الغلاف الجوي ، الحالة الجيوستروفية للغلاف الجوي ، دوران الغلاف الجوي