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OROGRAPHIC FACTORS ROLE IN THE ATMOSPHERE SURFACE LAYER DURING DEVELOPMENT OF THE WIND FIELD

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Abstract
Studying of the mode of a wind in this or that territory has theoretical and practical value, proceeding from the point of view of practical use of its many properties. This question always was and still remains actual, in particular, for mountain regions. In work, for determination of vertical speed of a wind, is obtained the formula, in which is described the additional new member reflecting influence of orography, by the mentioned the formula differs from similar dependence, known in literature. Orographic effects were estimated in the concrete territory of Georgia, and were received good results. In particular, the calculated size of vertical speed almost equals to its value on the flat area. Therefore, there is clear an increase of air speed stream in mountain areas, which is observed in practice. Also the "“Spline " method for determination of speed of a wind in the region of Imereti, in Tskhaltubo, Kutaisi, Zestafoni was for the first time used. The model calculated speed within (2-18) % coincided with observed value in expeditious practice that for a field of a wind it is recognized as admissible result. The received conclusions give us the chance to apply the given models to study a field of a wind in any mountain regions.
Keywords: Wind, Relief, Iakobian, Model, Speed.

Introduction

Wind, it's the only invisible atmospheric phenomenon and it should be taken into account into human life. It has both positive and negative results. Wind causes significant destruction even having speed 10-12m/s, damages the electricity and communication means; and above the speed 35 m/s it causes damage of buildings; There is no building, which stands 90 m/s velocity. The change of the direction and speed is a major factor in the weather formation; It is a clean source of energy; A man has chance of comfortable existence when the speed is 2-3m /s.

Wind significantly impacts on meteorological processes: causes change of climate in the nature, erosion of rocks and accelerates different geological and geographical events. It carries a large amount of dust and other impurities; it has influence on the animals and people. Transformation of wind kinetic energy into electricity is particularly noteworthy, due to which the wind has a quite great importance in ensuring the energy.

It is especially bad local origin strong winds - tornado, storm and other complex, highland originating local winds, which are characterized by specific events. Hence, it is clearly seen theoretical and practical importance of local-regional wind regime study.

Wind is horizontal and vertical air masses movement and temperature, it generates in the atmosphere by pressure and temperature gradient. The earth is rotating around its own axis; the wind is strengthens by the corolis effect. Thus in a global scales is generated atmosphere circulation by this factor. In the mid-latitudes is dominated the movement generated by pressure gradient which is parallel of wind isobar. Air masses movement is important, friction and orography influence with

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the earth's surface, which restricts air movement and force the air to move toward the low pressure area. The difference between the real and gradient wind is non-geostrophic wind. Exactly it determines the volume of air traffic, and sets cyclones and anticyclones, which itself determines the daily weather. The magnitude and direction of the wind in the surface layer of the atmosphere depends on the local geographical conditions [1,2,3,4]. Therefore, it is diverse, and requires the study and analysis of local conditions.

Wind field theory in surface laye

The basics of the wind field study is atmosphere hydrothermodynamic [1,2,3,4,5]. In the surface layer of the highland area, due to the influence of the terrain the wind is not geostrophic and friction force has an influence on its nature, which should be taken into consideration. At the same time if we consider the lack of molecular viscosity as compared to the turbulent and disregards it, then the complete system of equations dynamics of the atmosphere for the horizontal movement of air will be given in the following form [3,4]:

$$\frac{du}{dt}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+lv+\frac{\partial}{\partial z}(k\frac{\partial u}{\partial z});\frac{dv}{dt}=-\frac{1}{\rho}\frac{\partial p}{\partial y}-lu+\frac{\partial}{\partial z}(k\frac{\partial v}{\partial z})$$

$\frac{d}{dt}=\frac{\partial}{\partial t}+u\frac{\partial}{\partial x}+v\frac{\partial}{\partial y}+w\frac{\partial}{\partial z}$ Euler is a symbol, and u, v, w are the speed identifiers toward ox, oy and oz coordinate axis, p density, t the time, $l=2\omega\sin\varphi$ koriolisis parameter, ω the angular speed of the Earth's rotation, φ geographical latitude, k turbulence ratio. In the balanced condition considering stationality the system is written as follows: [1-4]:

$$\left.\begin{aligned}&\frac{\partial}{\partial z}(k\frac{\partial u}{\partial z})-l(v+v_g)=o\\&\frac{\partial}{\partial z}(k\frac{\partial v}{\partial z})+l(u-u_g)=o\end{aligned}\right\}\quad(1)$$

We should make (1) system integration from zero to the lower border of the boundary layer and should take into account the fact that in the mentioned layer (1) on the left side of the equasion the numeric value of the other members is a maximum of 10% of turbulent member importance [3.5.6.7.8], due to which we may receive their neglect:

$$k\frac{du}{dz}=|k\frac{du}{dz}|_{z\to 0}=\frac{\tau_{0x}}{\rho};k\frac{dv}{dz}=|k\frac{dv}{dz}|_{z\to 0}=\frac{\tau_{0y}}{\rho}\qquad(2)$$

In which τ_{0x} and τ_{0y} are turbulent i.e. friction of the surface tension of the tangent component of the axis projections.

To make it easier we received that ox axis is directed to the air flow direction, then $v=o$ and $\tau_{0y}=o$, therefore

$$k\frac{dc}{dz}=\frac{\tau_0}{\rho}\qquad(3)$$

Where c is complete horizontal velocity and its dependence on the height implied by formula plant. [1.2.3.7]

$$c(z)=\frac{v_*}{\gamma}\ln\frac{z+z_0}{z_0}\qquad(4)$$

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Where $v^{*}=\sqrt{\dfrac{\tau_0}{\rho}}$ is Dynamic speed, γ-Carmen constant, z_0 earth „mosilobis“ altitude. Thus, as on the picture (4) is seen, wind velocity in the underground layers are near the surface growth fast and after this it slows according to the proportion of growth, considering atmosphere stratification. In fact the wind is always more or less different from geostrophic. This difference is 3.5 m/s, i.e. the actual wind reaches 32% and the minimum is 1 m/s (10%). For the deviation module from the wind geostrophic importance are obtained: [1.3]:

$$\lfloor \bar{V} \rfloor=\frac{1}{l}\sqrt{\frac{d_r u}{dt}+\frac{d_r v}{dt}} \quad (5). \quad \text{where} \quad \frac{d_r}{dt}=\frac{\partial}{\partial t}+u\frac{\partial}{\partial x}+v\frac{\partial}{\partial y}$$

For the geostrophic wind direction is established rule having practical importance: toward the flw direction, while absolute magnitude growth, the ageostrophic wind is directed on the left of speed direction, but in case of weakening in the right.

Orographic influence of surface layer can be made by different approach. Let us discuss a simple, practical method of “Spline”. The basis of the method is logarithmic rules of changes according to the height of wind speed. [1.2.3.4]:

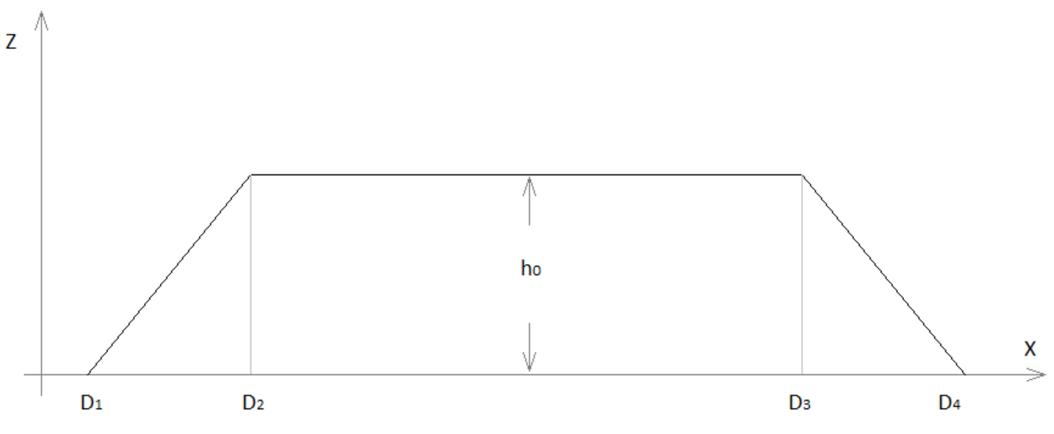
$$U=U_1\frac{\lg\frac{z}{z_o}}{\lg\frac{z_1}{z_0}} \qquad (6)$$

If the air flow meets to the mountain it means that there is upward flow in this case this formula will be written in th following way:

$$U=U_1(x)\frac{\lg\frac{z-h(x)}{z_0}}{\lg\frac{z_1}{z_0}} \qquad (7)$$

When there is downward flow in this case $U_1(x)=U_1^{*}(x)$, which may be defined by data of extinguish in air flow concerns. Practically

$$U_1^{*}(x)=U_1|_{x=d_4} \qquad (8)$$



drawing 1.

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the drawing relief is represented by curve, (se drawing 1) which is described by formula

$$h(x) = h_0[1-(\frac{x-d_2}{d_2-d_1})^2]^2 \quad (9) \qquad \text{when } d_1 \le x \ge d_2 \quad \text{and}$$

$$h(x) = h_0[1-(\frac{x-d_3}{d_4-d_3})^2]^2 \quad (10), \qquad \text{when } d_4 \le x \ge d_3$$

But $h(x) = h_0$, when $d_2 \le x \ge d_3$; $h(x) = 0$, when $x \le d_1$ and $x \ge d_4$. In this formula U_1 is wind velocity in the start point (in the beginning of relief), there should be taken thee value maximum, minimum and middle) z_0 is altitude of earth "mosiloba" and is changed from 3sm snow cover to 130sm (cornfield, bushes, low height forests and so on); h_0 =(30-50)m. z_1 is changed from the several meters to the fluger height. Wind velocity on the z_1 level may be approximately calculated as folows: from the literature is known that on the altitude 100m reaches to the maximum whoch equlas to 40m/s. It is accepted that by height decrease proportionally is reducing wind velocity. Hence, for example 6m high wind velocity will be 2,4 m/s. The contact between wind velocity and turbulence coefficient by given method, is based on the probability, that proportional attitude between them is fair. Fr example in the following form [3.4]:

$$k_z = \nu + \alpha_1 U_1(x)[z - h(x)] \qquad (11)$$

Where v empirically selection within 0 to 1; $\alpha_1 = \frac{k_1{}^0}{u_1{}^0}, k_1{}^0 = k_1$ meaning on the flat-right area $U_1{}^*$ will be in the last point of the speed relief. May be "curve" method was used in several times, in sequence with parameters corresponding changes.

For example we will take sections of Tskaltubo, Kutaisi, Zestaphoni and the obtained parameters have the following meanings:

$d_1 = 0$ should be match to geodetic head; $d_2 = 10^4$ m distance from Tskaltubo to Kutaisi; $d_3 = 5.10^4$ distance from Kutaisi to Sakara; $d_4 = 1,5.10^4$ distance from Sakara to Zestaphoni; z_0 the altitude of earth „mosilobis" changes from 30sm to 2m; $Z_1 = 12$ m flugel heigh; Z is changed from 2m to 60m; $h_0 = 60$ m.; because $u_1 = u|_{x=d_4}$ therefore it is defined with the proportional attitude, separately for air upward and downward flow toward mountain range. If in the first example we took 12 meter as an original height and in the second it is 4 meter, then

$$U_1{}^{\uparrow} = 4,8 \text{ m/sec end } U_1{}^{\downarrow} = 1,6 \text{ m/sec}$$

For the upward flow (9) formula we will obtain $h\ (x)$=33, 75მ. But $U(x)$ =5,6m/s. For the downward flow: h_o =35,6m and $U(x)$ =1,76m/s. On the discussed section wind obtained values it is in a good harmony with observed values of operational practice (in Kutaisi the wind speed multiannual value was 5,6 m/sec, and in Zestaphoni it was 1,5 m/sec), the margin of error (2-18)%, which is considered as an acceptable approximation for wind across fields. In the discussed example if $\nu = 0,5$, but k_1^0 is changed within (4-10)sq.m/s than in accordance with the (11) we will receive:

k_z =(9,9-20,6)sq. m/sec

This amount is 5 meters from the surface of the mountain, is acceptable.

The wind obviously has a vertical component of the wind, which is relatively small to horizontal movement and only intense convective motion may be (10-20) cm/s and more. Such convection movements very often are observed on the uneven, mountainous territory. Hence, the surface layer of the mountainous area is not acceptable wind divergence equality to zero, as it allowed with the

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flat surface and therefore it should be considered. Experimental measurements of vertical wind velocity w is related to the principal challenges and therefore it becomes necessary to w to rate by using theoretical methods.

Let us consider that in the ground surface layer w is created only the surface friction and relief, namely, w is determined by the continuity equation by integrating [3-5] from 0 to H altitude i.e.

$$W = -\int_0^H (\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}) dz \qquad (12)$$

Equation (10) system and for u and v horizontal gradients will have:

$$\frac{\partial u}{\partial x} = \frac{1}{l}\frac{\partial}{\partial x}(\frac{\partial}{\partial z} k \frac{\partial v}{\partial z}) + \frac{\partial u_g}{\partial x}; \frac{\partial v}{\partial y} = -\frac{1}{l}\frac{\partial}{\partial y}(\frac{\partial}{\partial z} k \frac{\partial u}{\partial z}) + \frac{\partial v_g}{\partial y} \qquad (13)$$

where u_g and v_g is originated by relief influence, ageostrophic wind inputs, given by the following attitude. [1.3.4]:

$$u_g = -\frac{1}{l\rho\eta}\frac{\partial p}{\partial y}; v_g = \frac{1}{l\rho\eta}\frac{\partial p}{\partial x} \qquad (14)$$

here $\eta = \frac{p_z}{p_0}$ is relief parameter, p_z pressure value of the surface of the mountain, p_0 pressure standard importance to put the 13th and 14th in the 12th will make integration, than taking into consideration The upper boundary layer friction tension is zero, we get:

$$W = \frac{1}{l}\frac{\partial}{\partial x}(k\frac{\partial v}{\partial z})_{z\to 0} - \frac{1}{l}\frac{\partial}{\partial y}(k\frac{\partial u}{\partial z})_{z\to 0} - (\frac{\partial u_g}{\partial x} + \frac{\partial v_g}{\partial y})H \qquad (15)$$

By the fieldwork material analyze has been determined that dynamic gear ratio with u_g is depended on the δ deviation angle of flow from isobar [2.35.6.7], so we will have:

$$(k\frac{\partial u}{\partial z})_{z\to 0} = v_*^2 \cos\delta; (k\frac{\partial v}{\partial z})_{z\to 0} = v_*^2 \sin\delta \qquad (16)$$

Speed flat divergantion via influence of relief isn't zero, but it is η and P taking into consideration that the wind ageostrophic is originate from the ground surface layer, thus:

$$\frac{\partial u_g}{\partial x} + \frac{\partial v_g}{\partial y} = \frac{1}{l\rho\eta^2}(\eta, p) \qquad (17)$$

The vertical speed will be displayed in the friction torque vector vertical tension inputs and iakobiani:

$$W = \frac{1}{l}[\frac{\partial}{\partial x}(v_*^2 \sin\delta) - \frac{\partial}{\partial y}(v_*^2 \cos\delta)] - \frac{1}{l\rho\eta^2}(\eta, p)H = \frac{1}{l\rho}[rot_z\tau + \frac{1}{\eta}(p, \ln\eta)H] \qquad (18)$$

Obtained formula (18) is new and differs from already existing approach by adding iakobiani on the right side, which expresses orography factor infuance. Lets us evaluate this member for orographic territory. Let us select Cross Pass area of Jvari. 0x axis is to be directed

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toward to parallel form the west to east; oy axis toward meridian from south to north. $\Delta x = 4.10^4$ m., $\Delta y = 3.10^4$ m the altitude toward the parallel alters from 600 to 200, but toward meridian from 10005 meter to 990 meter (Pass height); Accordingly $p_{z1x} = 940$ mb; $p_{z2x} = 980$ მბ; $p_{z1y} = 999{,}5$ mb; $p_{z2y} = 990$ mb. With this $l = 1{,}4.10^{-4}$ 1/s; $\rho = 1{,}3$ kg/m; $H = 10^3$ m. With this data we can calculated orographic effect size:

$$\frac{1}{l\mathrm{P}\eta}(P, \ln\eta) = \frac{1}{l\rho\eta}\left(\frac{\partial p}{\partial x}\frac{\partial \ln\eta}{\partial y} - \frac{\partial p}{\partial y}\frac{\partial \ln\eta}{\partial x}\right) ,$$

It is obvious:

$$\frac{\partial \ln\eta}{\partial x} = \frac{\ln p_{z2x} - \ln p_{z1x}}{\Delta x} = \frac{6{,}88 - 6{,}87}{4.10^4} = 1.10^{-6}\ 1/\text{მ},$$

$$\frac{\partial \ln\eta}{\partial y} = \frac{\ln p_{z2y} - \ln p_{z1y}}{\Delta y} = \frac{6{,}90 - 6{,}91}{3.10^4} = -0{,}3.10^{-6}\ 1/\text{მ};$$

$$\frac{\partial \ln\eta}{\partial y} = \frac{\ln p_{z2y} - \ln p_{z1y}}{\Delta y} = \frac{6{,}90 - 6{,}91}{3.10^4} = -0{,}3.10^{-6}\ \text{მბ/მ};$$

$$\frac{\partial p}{\partial y} = \frac{10{,}5}{3.10^4} = 0{,}35.10^{-3}\ \text{მბ/მ}.$$

Orographic effects will have

$$\frac{1}{l\rho\eta}(P, \ln\eta) = \frac{10^4}{1{,}4.1{,}3.0{,}7}(10^{-3}.10^{-6} + 035.10^{-3}.0{,}3.10^{-6}).10^3 = 8{,}7\ \text{სმ/წმ}.$$

Wmeaning, which equails to the meanings in the ground surface layers, that indicates that orographic effect is important and should be taken into account.

Results:

1. For determination of wind vertical inputs is created formula, which included orgraphic effect and its use of the highland area gains importance.
2. Agiostrophic Magnitude of the wind via relief influence has the same constituents quantitatively, as an ordinar vertical velocity. These values of the vertical velocity are sum up and this explains the strengthen of wind velocity and upward flow on the highland.
3. For the first time in certain regions of Georgia is possible to use "spline" method, because the wind speed determined by this method is close to the size excepted in the the operational practice, the margin of error (2-18)%.

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