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DYNAMICS OF ATMOSPHERIC PROCESSES AND THEIR ROLE IN ECOLOGICAL PROBLEMS OF GEORGIA

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ABSTRACT. Any regional microclimate is determined by common atmospheric circulation and Earth "radiative" surface conditions. The microclimate peculiarity considering certain factors is studied in the work and influence of seasonal stability parameter of relief and processes is taken into account. The rate of the air purification from bad admixtures and self purification period for some regions of Georgia are evaluated.

Modern civilization faces urgent problem of today. It includes study and analysis of ecological situations of separate regions of Georgia. It is well-known, that ecological or meteorological phenomena of the given region are caused primarily by the general long-scale circulation of air. This motion forms the background magnitudes of different value variation. Disturbances brought about by the local, thermal and orography reasons are added continuously to it. The events of these types are observed basically in the meso-scale boundary layer of the atmosphere (10-100 km).

Based on the above-mentioned, the dynamics of atmospheric processes should be studied with the consideration of physical and geographical features of a certain region. It is important to determine the leading factors that develop a process and evaluate their roles [1,2,6].

For realization of the stated problem we used a system of hydro-thermodynamic equations, which describes the regional atmospheric processes. Because of the small scales of the region, we assume that the effect of the Coriolis force can be omitted, and also $\partial\rho/\partial t$ is not taken into account as its variation in time is insignificant. After considering the admissions obtained for local processes the indicated system takes the following form [4,5,8]:

$$\frac{du}{dt} = -\frac{1}{\rho}\frac{\partial p}{\partial x} + k'\Delta u + \frac{\partial}{\partial z}\left(k\frac{\partial u}{\partial z}\right), \tag{1}$$

$$\frac{dv}{dt} = -\frac{1}{\rho}\frac{\partial p}{\partial y} + k'\Delta v + \frac{\partial}{\partial z}\left(k\frac{\partial v}{\partial z}\right), \tag{2}$$

$$\frac{dw}{dt} = -\frac{1}{\rho}\frac{\partial p}{\partial z} + \beta' T' + k'\Delta w + \frac{\partial}{\partial z}\left(k\frac{\partial w}{\partial z}\right), \tag{3}$$

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = \sigma w, \tag{4}$$

$$\frac{d\Theta}{dt} = \left(\frac{P}{p}\right)^{\lambda}\frac{\varepsilon}{C_p\rho} + k'\Delta\Theta + \frac{\partial}{\partial z}\left(k\frac{\partial \Theta}{\partial z}\right), \tag{5}$$

$$\frac{dq}{dt} = -\frac{m}{\rho} + k'\Delta q + \frac{\partial}{\partial z}\left(k\frac{\partial q}{\partial z}\right), \tag{6}$$

where *u, v, w* are the components of wind velocity along *x, y, z* coordinate axis accordingly, *t* – time, ρ - density, p – pressure, k' - the coefficient of turbulence on the horizontal plane, *k* - coefficient of turbulence along *z* axis, β - parameter of buoyancy, T – absolute temperature, Θ - potential temperature, q – specific humidity, λ - parameter of stability, ε - heat flux, $\sigma = \dfrac{g - \bar{\gamma} R}{RT}$, R - gas universal constant, g – free fall acceleration, *m* – water vapor mass, $\bar{\gamma}$ - vertical gradient of temperature, Δ - Laplace flat transform.

In any meso-meteorological problem the quantities characterizing the main state are considered being already known (so-called background magnitudes). The shape of relief and heterogeneity of the surface temperature have to be given too. By means of solving equations, the disturbances from the major state are found and then added to the background magnitudes.

The meso-meteorological problems based on the above-pointed (1) – (6) equation system include the studies of air streamlining around the mountain, local wind, the induced convection in the boundary layer. The physical and geographical conditions of the different regions of Georgia give the ability to eliminate the terms with turbulence in (1) – (6) system, and consider air internal friction by bringing in a special term.

While researching the dynamic processes we used the standard method of obtaining well-known equation for the vertical component of vortex velocity from the equations (1) and (2), [2,4]:

$$\frac{\partial \Omega_z}{\partial t} + u\frac{\partial(\Omega_z + f)}{\partial x} + v\frac{\partial(\Omega_z + f)}{\partial y} = -f\,D\,, \tag{7}$$

where $\Omega_z = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}$, f is Coriolis parameter and D flat divergence of velocity.

Let $\eta = P_z/P_o$ be a parameter that characterizes earth relief, where P_z is the magnitude of atmospheric pressure on the mountain surface, and P_o standard magnitude of pressure on the sea level. Then the wind velocity components could yield [3,7]:

$$u = -\frac{1}{\eta}\frac{\partial \psi}{\partial y}\,, \quad v = \frac{1}{\eta}\frac{\partial \psi}{\partial x}\,. \tag{8}$$

Here ψ is a current function. Then the vertical component of velocity takes the following form [7]:

$$\Omega = \frac{1}{\eta}\Delta\psi - \frac{1}{\eta}\left(\frac{\partial\psi}{\partial x}\frac{\partial \ln\eta}{\partial x} + \frac{\partial\psi}{\partial y}\frac{\partial \ln\eta}{\partial y}\right) = \frac{1}{\eta}\left(\Delta\psi + a\frac{\partial\psi}{\partial x} + b\frac{\partial\psi}{\partial y}\right), \tag{9}$$

where $a = -\frac{\partial \ln\eta}{\partial x}$ and $b = -\frac{\partial \ln\eta}{\partial y}$ are the parameters of the mountain influence along longitude and latitude, accordingly.

Let us assume, that the friction at the Earth's surface is directly proportional to the vortex velocity, or to the variation of the current function along the latitude or longitude. Thus, after considering all these the above stated equation (7) can be rewritten so:

$$\frac{\partial}{\partial t}\left(\Delta\psi + a\psi_x + b\psi_y\right) + \eta k\psi_x = f\left(\psi, \Delta\psi\right) - f\left(\psi, \ln\eta\right); \tag{10}$$

where the expression (A,B) is a Poisson's parentheses.

Next, we try to get the solution of the equation (10) in the form of wave:

$$\Psi = E_0 e^{i\left(mx + ny - \sigma t\right)}, \tag{11}$$

where *m* and *n* are wave numbers, E_o amplitude and σ frequency.

Now, let us discuss the two cases of friction impact and make an attempt to find corresponding phase velocity [5,8]: a) friction is proportional to Ωo, so F_F =kΩz, and then putting (11) into (10) yields the following expression:

$$\sigma = \frac{[f(na - mb) - (am + bn)k]\rho^2 + \rho^2 k(am + bn)}{\rho^4 + (am + bn)^2} +$$

$$+i\frac{[f(na-mb)-(am+bn)k](am+bn)-\rho^4 k}{\rho^4+(am+bn)^2}=\sigma_1+i\sigma_2\,, \qquad (12)$$

where

$$\rho^2=m^2+n^2\,.$$

The parameter characterizing relief and the wave numbers must satisfy the condition:

$$am + bn = 0 \qquad (13)$$

$$C=\frac{\sigma}{m}=\frac{f}{\rho^2}\left[(a\frac{n}{m}-b)-i\frac{k}{m^2}\right]. \qquad (14)$$

Considering it, the real part of the phase velocity depends only on (*am - bn*) combination and the virtual part of it relies on the friction coefficient and the ratio of the wave number k/m toward leading flux. This dependence is obtained for the first time and gives good opportunity to study dynamics of micro-regional processes. The only thing is to know the magnitudes of *a* and *b* parameters and the wave numbers of current region.

b) Friction coefficient is proportional to the derivative of current function along the latitude: $F_{xax}=k\Psi_x$. Then for the frequency we would have:

$$\sigma=\frac{[f(na-mb)-k_1 m]\rho^2}{\rho^4+(am+bn)^2}+$$

$$+i\frac{[f(na-mb)-\beta m](am+bn)}{\rho^4+(am+bn)^2}=\sigma_3+i\sigma_4 \qquad (15)$$

$$C = \frac{f(a\frac{n}{m} - b) - k_1}{\rho^2} \quad . \tag{16}$$

Now consider the waves of the neutral type. Their existence is observed on Transcaucasian territory. [3,5,6]. In this case C = 0 and friction coefficient is determined from (16):

$$k_1 = kf = f(a\frac{n}{m} - b)\,. \tag{17}$$

We have got quite strange, but very important result: air internal friction coefficient is defined by the parameters characterizing the mountain in the given region and with the corresponding wave numbers.

The validity of the obtained results was tested for Mengrelia. Nine meteorological stations were selected and all meteorological quantities were taken for the past 10 years.

The *a* and *b* parameters were estimated by consideration of the physical and geographical conditions of the region (Table 1).

Table 1

Locations	**Distance between locations, 10^4 m**	**Altitude from the sea level, m**	**Pressure, mb**	**Relief parameters**	
				a (10^{-6}) 1/m	**b (10^{-6}) 1/m**
Zugdidi	1.8	110	989		0.20
Gali		48	995.2		
Zugdidi	8.0			0.24	
Kutaisi		300	970		
Zugdidi	8.0				0.12
Kobuleti		5	999.5		

Zugdidi	3.2			0.3	
Senaki		28	997.2		
Zugdidi	4.0				0.11
Poti		3	999.7		
Zugdidi	20.0			0.08	
Lebarda		1610	839		
Zugdidi	6.0			0.10	
Martvili		170	983		
Sokhumi	15.0	140	986	0.10	
Kutaisi					

It appeared that *a* and *b* parameters did not change significantly along different directions in the region (center Zugdidi). It confirms the fact that the region is valley with small hills without gorges. The air phase velocity is low, but exists constantly because it is caused by the sea and land thermal radiation [2,6].

According to the definition of wave numbers from (13) it follows:

$$L_x = 1.5\, L_y \,, \tag{18}$$

which means that the air mass along the latitude expands 1.5 times longer than along the longitude. These kinds of processes are observed in operational practice.

Thus, the prolongation along the latitude observed during synoptic processes was proved theoretically. For this region it was done for the first time.

To make phase velocity of synoptic waves C ≠ 0, it is necessary according to (17) to fulfil the condition (*am* - *bn*) ≠ 0. Actually, this condition fulfils. The expression (*am* - *bn*) is not large. It is about (0.005-0.4) m/sec, but never equals to zero. If the length of the wave would be considered being congruent to the sizes of region along the longitude and latitude (Lx = 500 km and Ly = 160 km correspondingly), then C = 0.059 m/sec.

For displaying the microclimatic features caused by dynamics of the mentioned atmospheric processes by applying the data from the selected meteorological stations the correlative relationships between different elements could be determined. The correlation coefficients for the pairs of different meteorological elements on the same stations and the same elements on the different stations were calculated (Table 2,3).

The data from the Table show that the region is characterized by similar magnitudes of the meteorological elements. This conclusion indicates at the ecological alert. Pollution coefficients of air and soil are distributed evenly across the whole region and their alteration in time and space occurs at a low rate.

Indeed, from the equation describing the diffusion of an admixture (stationary case), we have [1,5]:

Table 2. Correlation coefficient for temperature

r coefficient	**Zugdidi**	**Senaki**	**Kutaisi**	**Poti**	**Sokhumi**	**Gali**	**Kobuleti**
Zugdidi	1	0.77	0.78	0.61	0.71	0.72	0.64
Senaki	0.77	1	0.70	0.55	0.63	0.60	0.71
Kutaisi	0.78	0.70	1	0.87	0.97	0.82	0.92
Poti	0.61	0.55	0.87	1	0.93	0.81	0.46
Sokhumi	0.71	0.63	0.97	0.93	1	0.83	0.96
Gali	0.72	0.60	0.82	0.81	0.83	1	0.78
Kobuleti	0.64	0.71	0.92	0.46	0.96	0.78	1

Table3. Correlation coefficient for temperature according to the seasons

r coefficient	Zugdidi	Kutaisi	Sokhumi	Poti	Gali	Kobuleti
Zugdidi (warm period)	0.93	0.96	0.93	0.93	0.94	0.94
Zugdidi (cold period)	0.99	0.97	0.98	0.88	0.98	0.99

$$u\frac{\partial q}{\partial x}+\left(w-u\frac{dh(x)}{dx}\right)\frac{\partial q}{\partial z'}=\frac{\partial}{\partial z'}\left(k\frac{\partial q}{\partial z'}\right), \tag{19}$$

where q is relative concentration of an admixture, h(x) – shape of relief, $Z'=Z-h(x)$ is a new coordinate.

It follows that for small magnitudes of u and w the stationary regime is retained for a long time. So, the period of self-clarification of air is prolonged significantly.

The seasonal characteristics of atmospheric processes' dynamics was also calculated:

$$A=\frac{t_{max}-t_{min}}{t_{საშ}} \tag{20}$$

It appeared that A parameter was altered according to the warm and cold seasons. But during the season its magnitude remained stable.

The calculations were done for the several regions of Georgia on the basis of the data for the period of 1990 – 2000 (Table 4). The magnitudes of A parameter given in the Table 4 show clearly the repetition of warm and cold periods with high accuracy. A parameter is new and requires more testing for another periods too.

Table 4. Magnitude of A according to seasons

seasons	1990	1991	1992	1993	1994	1995	1996

(warm period)	1.1	1.1	1.3	1.2	1.2	1.2	1.2
(cold period)	3.2	3.0	3.9	4.8	3.8	3.4	3.1

It is possible to draw a conclusion for the region of Mengrelia: both factors determining microclimate, general circulative processes and physical state of ground surface provide the stability of the atmospheric processes.

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ატმოსფერული პროცესების დინამიკა და მისი როლი საქართველოს ეკოლოგიურ პრობლემებში

დასკვნა

დღევანდელი მსოფლიო საზოგადოების წინაშე მდგარი აქტუალური პრობლემის, ცალკეული რეგიონის ეკოლოგიური სიტუაციების შესწავლის მიზნით სტატიაში ჰიდროთერმოდინამიკის განტოლებათა სისტემის გამოყენების საფუძველზე გათვლილ იქნა საქართველოს ტერიტორიაზე გაბატონებული სინოპტიკური მდგომარეობებისათვის ფაზური სიჩქარის მნიშვნელობები. აგრეთვე მცირე ტერიტორიის რეგიონებისათვის (10-50კმ) მიღებულ იქნა ჰაერში მინარევის ვერტიკალური გავრცელების სიჩქარის მნიშვნელობები ადგილის ფიზიკური რელიეფის გავლენის გათვალისწინებით. ეს სიდიდეები გამოიყენება ამა თუ იმ რეგიონის ეკოლოგიური სიტუაციების ანალიზისათვის. გამოთვლილი იქნა ატმოსფეროს დინამიკის სეზონური მდგრადობის ახალი პარამეტრი და აღმოჩნდა, რომ იგი სეზონების მიხედვით ინარჩუნებს სტაბილურ მდგომარეობას, რაც მიუთითებს მასზედ, რომ უახლოეს მომავალში (რამოდენიმე წელი) მეტეოროლოგიური სიდიდეების მკვეთრი სეზონური ცვალებადობა არ არის მოსალოდნელი.