

TERMOSSFERİK RÜZGARLAR ÜZERİNDEKİ TÜRKİYE

Mehmet AYDOĞDU, Osman ÖZCAN

F.U. Faculty of Arts and science Physics Department, Elazığ-TURKEY.

ABSTRACT

Horizontal motion of the neutral atmosphere in thermosphere at a higher of 300 km over Turkey is investigated. Wind velocities of 50-200 m/sec are found. The direction and magnitude of the velocity of wind vary with local time. During the daytime, velocity components U_x and U_y are westward and northward respectively. At night, their directions are reversed.

TÜRKİYE ÜZERİNDEKİ TERMOSSFERİK RÜZGARLAR

ÖZET

Türkiye üzerindeki termosferde 300 km yükseklikte nötr atmosferin yatay hareketi araştırıldı. Rüzgar hızlarının 50-200 m/sn arasında değiştiği bulundu. Rüzgarın yönü ve büyüklüğü yerel zamanla değişmektedir. Gündüz saatlerinde, hız bileşenlerinden U_x 'in yönü batıya U_y 'nin ise kuzeye doğrudur. Gece ise yönler ters olmaktadır.

INTRODUCTION

It is well-known that the electron density (N) in F2-layer is affected by production (Q), loss rate (L) and also by the transport processes as follows[1]:

$$\frac{\partial N}{\partial t} = Q - L - \nabla(NV) \quad (1)$$

in which, the velocity V includes the plasma diffusion, neutral winds, thermal expansion and contraction of the atmosphere and the drift due to electric field generated by dynamo action in the ionosphere. At middle latitudes, neutral wind is more important than the other transport mechanisms.

At heights above about 200 km, the daily variation of temperature amounts to 20-30 percent in middle and low latitudes. So, this gives rise to high pressure on the equator at about 14 00 Local Time(LT), and low pressure at about 02 00 - 04 00 LT. This horizontal pressure gradient provides the driving force for the horizontal thermospheric winds. The important atmospheric winds exist at

F-layer heights and affects on the electron density.

The vertical diffusion velocity is about 20 m/sec at night and 4 m/sec during the daytime over Turkey[2]. In this paper, neutral wind velocity at height of 300 km over Turkey will be computed.

THE EQUATION OF MOTION THE NEUTRAL ATMOSPHERE

To calculate the velocity of the neutral winds, we have to consider the following forces:

a) The inertial force $\rho (\partial \mathbf{U} / \partial t + (\mathbf{U} \cdot \nabla) \mathbf{U})$. Here \mathbf{U} is the atmospheric wind velocity, ρ is the atmospheric density and $(\mathbf{U} \cdot \nabla) \mathbf{U}$ is non-linear term. The non-linear term $(\mathbf{U} \cdot \nabla) \mathbf{U}$ is neglected, since this term is only significant in the equatorial region [3].

b) The viscous force $\rho \mu (\partial \mathbf{U} / \partial h^2)$. Here μ is the kinematic coefficient of viscosity.

c) The coriolis force $2\rho (\omega \times \mathbf{V})$, ω is the angular frequency of the Earth's rotation and is taken as 7.3×10^{-5} rad/sec.

d) Pressure gradient ∇p where p is the atmospheric pressure.

e) The force due to gravity pg .

f) The ion drag force $\rho v_i (N_i / N_n) (\mathbf{U} - \mathbf{V})$. Here \mathbf{V} is the ion velocity, v_i is the collision frequency of an ion with all neutral particles and N_i and N_n are the concentration of ion and neutral particles respectively.

If these forces are combined, the equation of the motion of the neutral atmosphere becomes

$$\frac{\partial \vec{U}}{\partial t} + 2 \vec{\omega} \times \vec{U} = \frac{1}{\rho} \vec{\nabla} P - \frac{N_i v_i}{N_n} (\vec{U} - \vec{V}) + \mu \frac{\partial^2 \vec{U}}{\partial h^2} + \vec{g} \quad (2)$$

For the purpose of computation, this equation has to be resolved into equations for the components of \vec{U} at geographic latitude ϕ . It is convenient to write the equation for horizontal components of ∇P and \vec{U} . Horizontal components provide the driving force for the winds because, the diurnal air pressure gradient is not vertical [1], hence, eq.(2) takes form

$$\frac{d\vec{U}_x}{dt} = \vec{F}_x + \mu \frac{\partial^2 \vec{U}_x}{\partial z^2} - \frac{N_i v_i}{N_p} (\vec{U}_x - \vec{V}_x) + 2 \vec{\omega} \vec{U}_y \sin \phi \tag{3}$$

$$\frac{d\vec{U}_y}{dt} = \vec{F}_y + \mu \frac{\partial^2 \vec{U}_y}{\partial z^2} - \frac{N_i v_i}{N_p} (\vec{U}_y - \vec{V}_y) - 2 \vec{\omega} \vec{U}_x \sin \phi \tag{4}$$

In which (+x), (+y) and (+z) are eastward, northward and upward respectively and $F_x = -\partial P/\rho \partial x$, $F_y = -\partial P/\rho \partial y$. In calculations we only take into account the ion motion due to winds, and the velocity of the ions in a magnetic field B is given by

$$\vec{V} = (\vec{U} \cdot \vec{B}) \frac{\vec{B}}{B^2} \tag{5}$$

[4]. The magnetic declination over Turkey is about 3°E. So, the declination can be taken as zero. Then, from eq.(5), $V_x=0$ and $V_y=U_y \cos^2 I$ where I is dip angle. Above a heights of 120 km, $\partial^2 U_x / \partial z^2$ becomes small [1]. Therefore, many authors [5 - 7] neglected this force, in their calculations as we will do here. For the steady-state condition ($d/dt=0$), the solutions for eqs. (3) and (4) are

$$\vec{U}_x = \frac{\lambda \vec{F}_x \sin^2 I + f \vec{F}_y}{\lambda \sin^2 I + f} \tag{6}$$

$$\vec{U}_y = \frac{\lambda \vec{F}_y \sin^2 \theta + f \vec{F}_x}{\lambda^2 \sin^2 \theta + f^2} \quad (7)$$

respectively. Here we use notation $\lambda = N_i v_i / N_n$, $f = 2 \omega \sin \phi$. The eqs. (6) and (7) can be used to calculate the components of the horizontal neutral winds velocity at the latitude ϕ .

CALCULATION

The object of the paper is to calculate the horizontal wind velocity from the eqs. (6) and (7) at height of 300 km over Turkey. Calculations are carried out for the latitudes of 36°N, 39°N, and 42°N at each longitudes of 25°E, 30°E, 35°E, 40°E and 45°E. The value of v_i / N_i is 5.2×10^{-4} m³/sec. [5], and the ion density is assumed to be equal the electron density N . So, λ in eqs. (6) and (7) is taken is 5.2×10^{-4} N. Electron density over Turkey is produced by using International Reference Ionosphere (IRI-79) [8]. The pressure driving forces are given by.

$$\vec{F}_x = \frac{1}{\rho} \frac{\partial P}{\partial x} = A(h) \sin \omega t \quad (8)$$

$$\vec{F}_y = - \frac{1}{\rho} \frac{\partial P}{\partial y} = A(h) \sin \phi \cos \omega t \quad (9)$$

Where t is time in hour [6]. The constant $A(h)$ is obtained from the Fig.4 of [6], and $A(h) = 2.87$ for the height of 300 km. We obtained the diurnal, latitudinal and longitudinal variations eastward (U_x) and northward (U_y) components of the wind velocity at the height of 300 km over Turkey. The azimuth (θ) and the magnitude of the wind velocity are found from the equations. $\tan \theta = U_x / U_y$ and $U = (U_x^2 + U_y^2)^{1/2}$ respectively.

RESULTS AND DISCUSSION

Fig 1 a and Fig 1 b show the wind velocities at 300 km height over Turkey at local noon and midnight respectively. As shown in

figures, the velocity of the wind at night is higher than the values at daytime. The direction of the wind is toward the north of Turkey during daytime, and toward the south at night. It is noted that the velocity of the wind does not vary much with longitude over Turkey. This is expected because the longitude variation of the neutral wind velocity is small [4]. So, the coordinate of (35°E, 39°N) is considered to represent Turkey. Diurnal variations of the global wind pattern over Turkey is given in Fig.2. The highest velocity (~200 m/sec) is obtained around midnight while the lowest velocities occur around 14 00 LT. The wind blows northward during daytime and southward at night. The wind vector changes its direction twice, that is around 02 00 LT and 14 00 LT. Comparing our wind pattern with others author's results shows good agreement [3,6,7,9,10].

To show the seasonal variations of the wind velocity U_x and U_y are computed 21 June, 21 September and 21 December. These results are given in Fig.3a and 3b. From these figures, It can be concluded that the wind velocity does not vary much with seasons. The direction of U_y is northward between 04 00 - 18 00 and for the rest of day is southward (Fig.3a). U_x is eastward between 14 00 - 02 00 LT (Fig.3b). Similar results are reported by various authors [3,7,9].

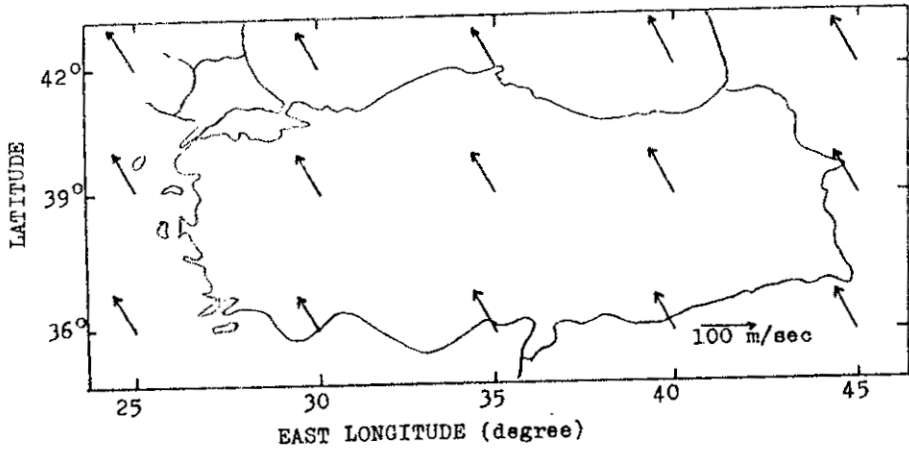


FIGURE 1a. The wind pattern at 300 km height over Turkey for local noon .

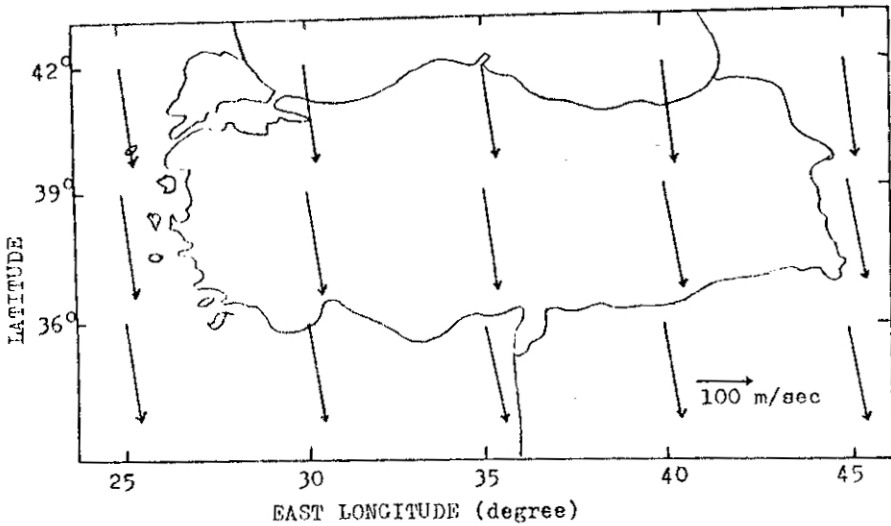


FIGURE 1b. The wind pattern at 300 km height over Turkey for local midnight.

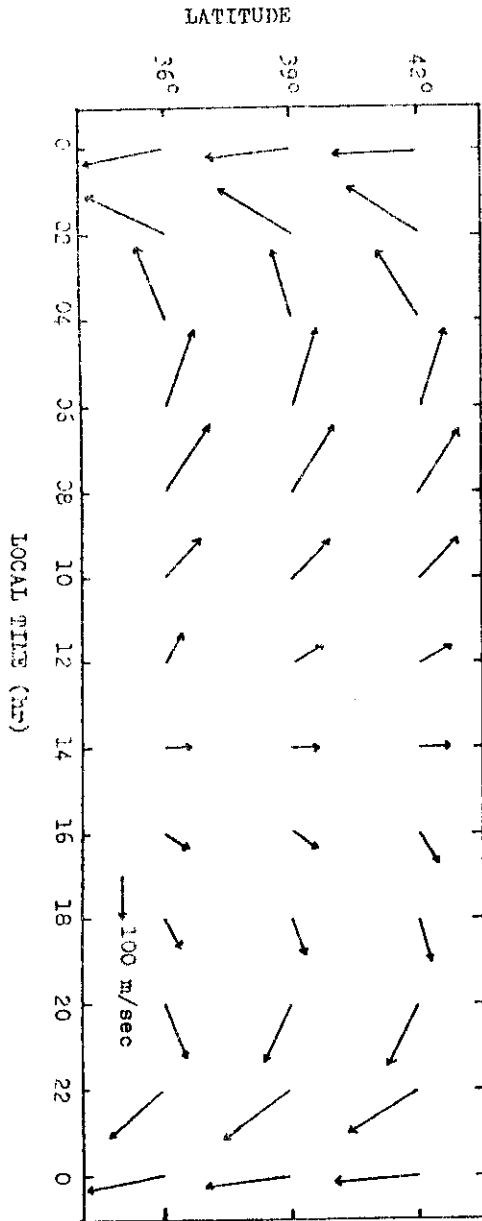


FIGURE 2. Diurnal variations of the Global wind pattern at 300 km height over Turkey (for 36°N, 39°N, 42°N)

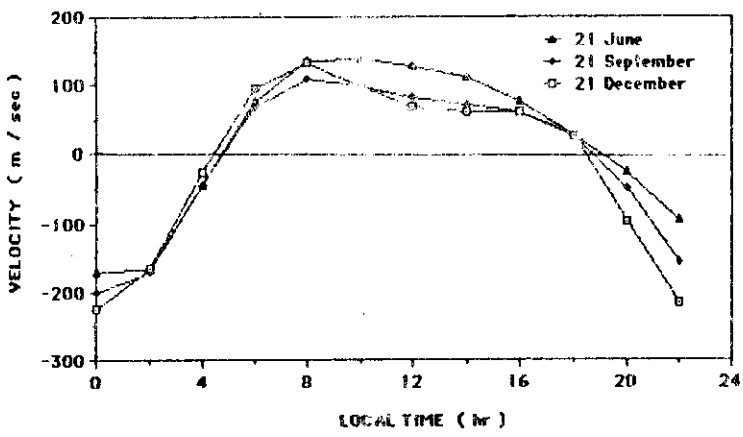


FIGURE 3a Diurnal and seasonal variations of U_y components over Turkey (35°E, 39°N). (+: northward)

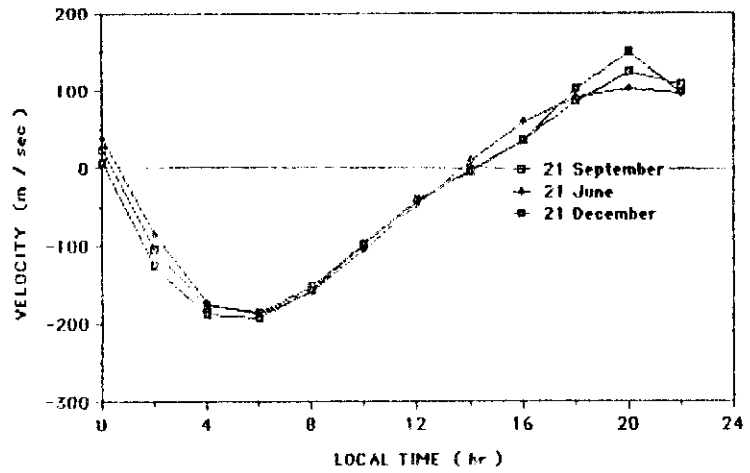


FIGURE 3b Diurnal and seasonal variations of U_x components over Turkey (35°E, 39°N). (+: eastward)

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