ANALYSIS OF SURFACE TEMPERATURE HEAT AND MOMENTUM FLUXES IN ANKARA

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1. INTRODUCTION

Surface heat fluxes determine the thermic efficiency of the atmospheric boundary layer. Large heat fluxes intensify vertical motions, increase the height of inversion layers and present favourable soaring conditions. In this study, the average sensible heat and momentum fluxes are obtained from observed profiles of the wind and temperature using the similarity relations for the lower part of the atmospheric surface layer in Ankara for the year of 1985. The effect of spatial variations of the sensible surface heat and momentum fluxes is studied for various topographies. These analyses show the principal boundary conditions for weather forecasting, micro and meso-scale analysis, soaring activities and air pollution models.

2. MATERIAL AND METHOD

The heat and momentum fluxes are calculated for unstable conditions and compared to the model results of the surface radiation and energy budget (Öney, Aslan, and Topçu, 1989) and the other papers (Jochum and Reinhardt, 1984, Hacker, 1990). The wind speed, air temperature and vertical temperature profile in the atmospheric boundary layer are used. The bulk formulas for sensible heat and momentum fluxes are based on the Monin-Obukhov similarity theory. This theory assumes stationary and horizontally homogeneous conditions. The sensible heat flux is related to the frictional velocity and the temperature scale by

$$H = -\rho C_p u_* \theta_* \quad (2.1)$$

where ρ is density of air, C_p specific heat at constant pressure, u_* frictional velocity, θ_* temperature scale. A simplified method for computing frictional velocity and temperature scale is given by Holtslag and Ulden (1983). This method is based on a single wind speed Uz at level z, surface roughness length zo (Erkmen ,1969), and a temperature difference $D\theta$ between two heights z_1 (=2m) and z_2 (=l0m) in the atmospheric surface layer. u_* and θ_* can be calculated in following flux profile relations

$$u_* = kU_z[\mathrm{Ln}(z/z_o) - \Psi_m(z/L) + \Psi m(z_o/L]^{-1} \quad (2.2)$$

$$\theta_* = k\Delta\theta[\mathrm{Ln}\,(z_2/z_1) - \Psi_H(z_2/L) + \Psi_H(z_1/L)]^{-1} \quad (2.3)$$

where k is the Von Karman constant (k = 0.41), L the Monin-Obukhov stability parameter. This parameter is evaluated from the estimated values of frictional velocity and the temperature scale.

$$L = (T\, u_*^2)/(kg\theta_*) \qquad (2.4)$$

where g is gravity, T air temperature for L < 0 (unstable conditions),

$$\Psi_m = 2\,\mathrm{Ln}\,[(1+x)/2] + \mathrm{Ln}\,[\,(1+x^2)/2] - 2\tan^{-1}(x) + (\pi/2) \quad (2.5)$$

$$\Psi_H = 2\mathrm{Ln}\,[(1+x^2)/2] \qquad (2.6)$$

where

$$x = [1 - 16\,(z/L)]^{1/4} \qquad (2.7)$$

The momentum fluxis related to the frictional velocity u_* by

$$T = \rho\, u_*^2 \qquad (2.8)$$

We start with a prescribed value of the Monin-Obukhov stability parameter L=-36. u_* and θ_* are calculated by using the equations from (2.2) - (2.7). L is computed by considering the estimated values of u_* and θ_*. The new value of L is substituted in (2.2) - (2.7) to obtain improved values for u_* and θ_*. Three cycles are needed in order to achieve the required accuracy of 5% for L. Therefore, the sensible and momentum heat fluxes can be calculated with the equations from (2.1) to (2.8). In this study daily mean temperature and wind velocity values from seven meteorological stations - Ankara (Etimesgut), Kizilcahamam, Kirikkale, Beypazari, Polatli, İkizce, Keskin, located in the rural and urban sides of Ankara (39° 57` N, 32° 53`E) are used.

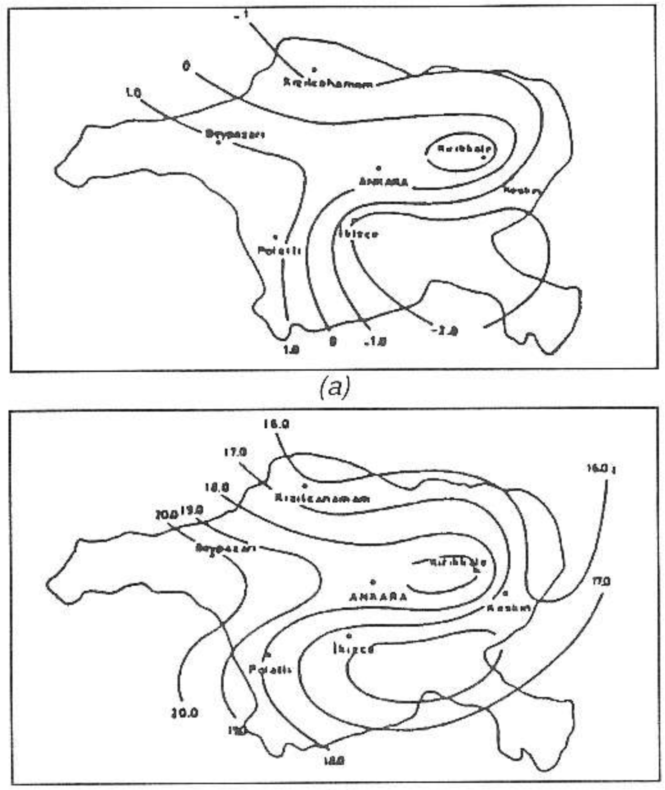
Öney, Aslan and Topçu (1989) show that the maximum values of sensible heat fluxes computed in Ankara are observed in May and the minimum ones in January for the year 1985. Therefore, in this study we consider these two extreme months.

3. RESULTS

The temperature field for January and May is shown in Figure 1. This figure shows that the low temperatures are observed in the north and south parts of Ankara. These areas correspond to rural parts of Ankara The maximum temperature values are observed in the central and western parts of city. The large temperature gradient observed in the east and south parts of the domain is due to topography.

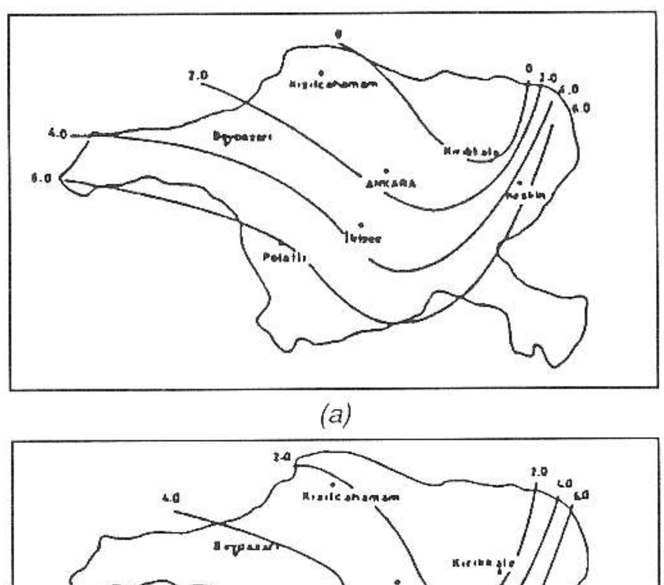
Figure 2 shows the sensible heat flux variations for unstable conditions in January and May (1985). Sensible heat fluxes are varied from 0 to 6.4 W / m^2 in January and from 1.7 to 6 .8 W/m^2 in May .

The monthly mean variations of momentum fluxes under unstable conditions in Ankara in January and



(a) (b)

FIGURE 1. The mean air temperature field (°C) in Ankara. a) for January, 1985; b) for May, 1985.



(a) (b)

FIGURE 2. The mean heat fluxes (W/m²) in Ankara. a) for January, 1985; b) for May, 1985

May of 1985 are also computed. The momentum flux variations are very similar to those of the sensible heat fluxes. The value of mean momentum fluxes increases from North to South, from 0 to 0.090 Pa in January and f rom 0.012 to 0.099 Pa in May .

The heat flux values calculated at the earth's surface are in the same order of magnitude with the results from Jochum (1984), Reinhardt (1987) and Hacker (1990) .

Turkish Air Association has a glider school in the central part (Etimesgut) of the map. The flight observations of the glider pilots show that the convenient areas for soaring dependent on thermics are in the east, central and southwestern parts of Ankara province where the large values of heat and momentum fluxes are found. It is thought that the results of this study will encourage the soaring activities carried on at the Glider School in Ankara.

4. REFERENCES

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