THE STATISTICAL ANALYSIS OF MOUNTAIN WAVES OVER SOUTHERN ANATOLIA

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ABSTRACT

In this paper, the mountain wave probability and wave characteristics have been studied over Darvas (2635m) Mountains at the Southwestern Anatolia. The climatological observations in Isparta between 1990 and 1994 have been considered. The radiosonde data (0000GMT) in Isparta has also been used as an input data for the Caswell Method to forecast the mountain wave characteristics. Cloud cover and height of altocumulus clouds have been analyzed by using the statistical methods. This study is useful to understand the probability of mountain waves in late autumn. The seasonal variation of mountain wave characteristics have illustrated the similar trend between 1990 and 1994.

1. INTRODUCTION

Mountain waves were first explored by German soaring pilots in 1993. Observations show that wave flow occurs up to a height of 30 km (100, 000 ft). Several sources of waves can be used by sailplanes. The strongest waves are observed above and in the lee of mountains, WMO (1993). Air stream characteristics, topographic effects, the height of the tropopause, and the nature of rotors play important roles on the formation of mountain waves. The occurrence of mountain waves varies from season to season. Observation in the northern hemisphere has established that mountain waves are a cold season phenomenon. There are two basic types of mountain waves: one propagating its energy mostly vertically up and so called "vertically propagating wave" and one propagating it mostly horizontally downwind and so called "trapped wave." Which of the two types prevails depends on the vertical wind and temperature profiles, and the shape and height of the mountain range. This paper discusses the preliminary results of a study on the statistical analysis of mountain waves over southern Anatolia.

2. MATERIAL AND METHODS

Isparta (Latitude: 37°45"N, Longitude: 30°33"E) represents the study area. The climatological and aerological data have been collected between 1990 and 1994. Forecasts of mountain wave activity and related turbulence are made routinely today, often as part of a daily aviation forecast. While these general wave forecasts are quite satisfactory, the prediction of details of interest to the glider pilot such as precise timing, wave and rotor intensity etc. are extraordinarily difficult. The Caswell Method has been used for the prediction of wave char-

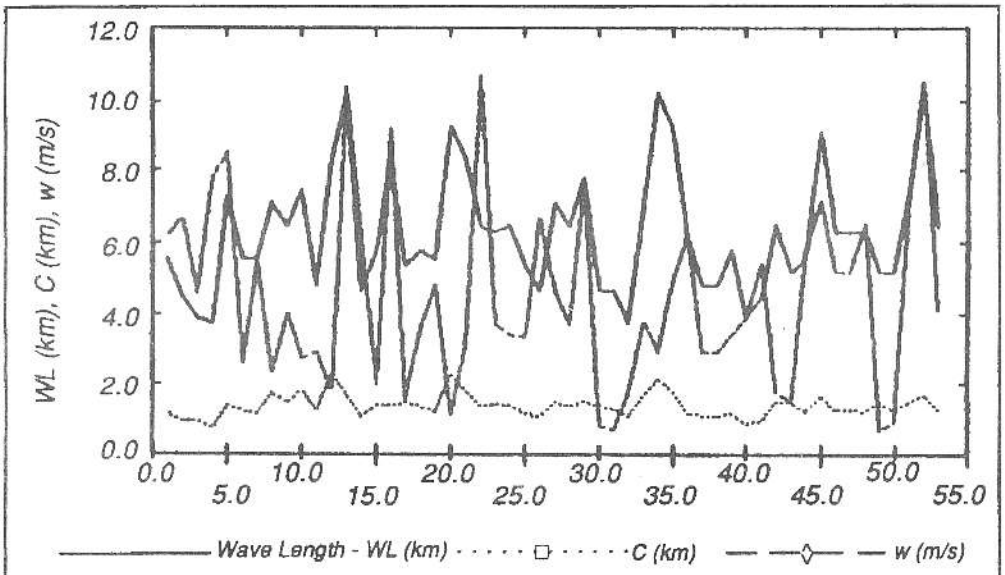

Figure 1. Time variation of wave length (WL, km), height of maximum amplitude level (C, km) and vertical wind speed (w, m/s) in Isparta (1990-1994).

acteristics in this study. The input data for the Caswell Method are surface pressure (Ps), surface temperature (Ts), air temperature at 700 hPa level (T700), horizontal wind speeds (V850, V700 and V500) at 850 hPa, 700 hPa and 500 hPa pressure levels, tropopause level, temperature differences between surface and 700 hPa, and 700 hPa and 300 hPa pressure levels.

The model outputs are wave length of lee wave (WL), maximum amplitude level (C), vertical wind speed factor (D) and the vertical wind speed (w) on the top of mountain, Aslan and Tokgözlü (1990), Wallington (1986). The vertical component of wind speed can be defined by using the following equation, Wallington (1986):

$$w = D \times V700 \times (30.48/6000) \quad (1)$$

Where,

D : vertical wind speed factor, V700: horizontal wind speed at 700 hPa pressure level (m/s).

3. RESULTS

The mountain wave characteristics (wave length, heights of maximum amplitude level and vertical wind speed) for five years period between 1990 and 1994 are illustrated in Figure 1.

Maximum wave length is observed in April and October, minimum one is in January and February. Height of maximum amplitude level is observed in April, March and May, minimum one is in December. Maximum value of vertical wind speed is observed in February, April and March. Minimum one is in July, January and September.

Figure 2 shows the favorable wind speed for some mountain waves in Turkey and elsewhere. The minimum horizontal wind speed associated with the mountain waves over Darvas Mountain is approximately 14.5 m/s. The comparison of the horizontal wind speed for the other mountain waves in Turkey and else-

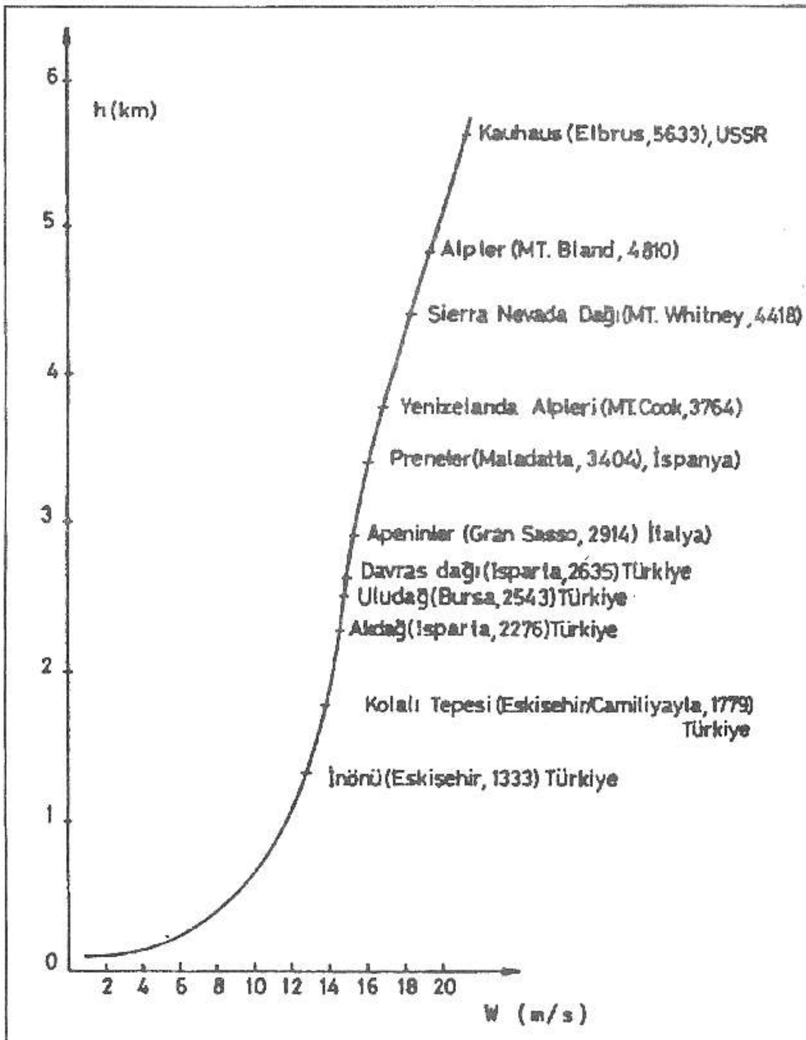

Figure 2. Favorable horizontal wind speed for mountain waves.

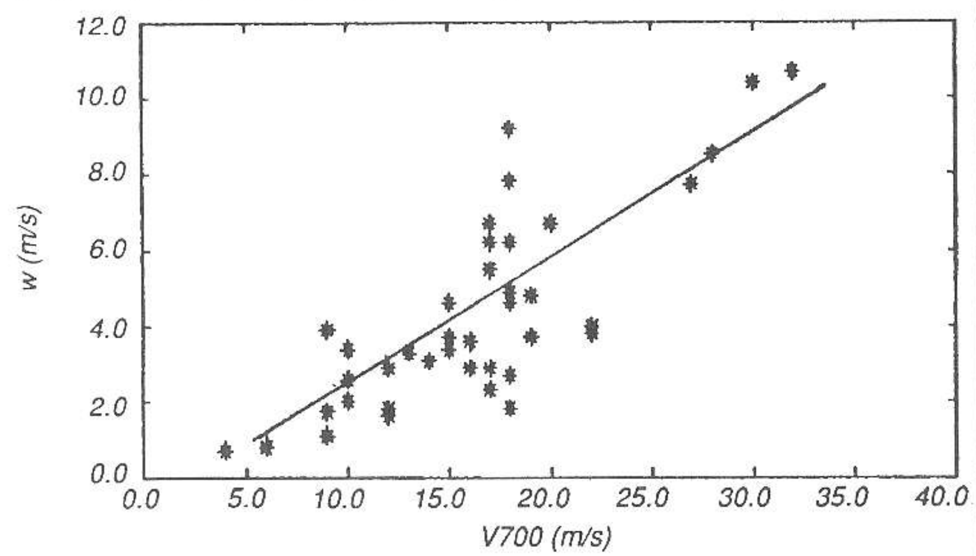

Figure 3. The relationship between vertical component of wind speed and horizontal wind speed observed in 700 hPa pressure level in Isparta.

where is illustrated in the same figure.

In this study, the correlation coefficients between wave characteristics (WL, C and w) and horizontal wind speed for three different levels (850 hPa, 700 hPa, 500 hPa) are defined. The highest correlation coefficient (0.64) is between vertical wind speed and horizontal one at 700 hPa pressure level. The linear relation is given in Equation 2.

$$w = 0.341 \times V700 - 1.224 \quad (2)$$

Reliability of relationship is greater than 95% and regression error is less than 0.02.

Equation 2 is defined with the data recorded at 700 hPa between 1990-1992. The correlation coefficient between the vertical velocity defined by the Caswell Method and the linear regression equation is 0.95 for w > 1.5 m/s. The error of the regression is 0.69%. The equation is tested for the data observed in 1993-1994. Relative error is in the range of 0.1 and 0.2. An example of the relationship between vertical and horizontal wind components is given in Figure 3.

The correlation coefficient between vertical velocity (w) and horizontal wind speed at 850 hPa (V850) and at 500 hPa (V500) are 0.003 and 0.32 respectively. The correlation coefficient between wavelength, maximum amplitude level and horizontal wind speed are in the range of 0.004 and 0.34.

It has been concluded that the linear equation given above can be used to predict the available vertical wind speed over Darvas Mountain in Isparta.

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REFERENCES

(1). Aslan, Z., and A. Tokgözlü, 1990: Dag Dalgalari ve Planör Ucuslari, Ucantürk, p. 6-10, Haziran, THK.

(2). Cruette, R., 1976: Experimental Study of Mountain Lee-waves by Means of Satellite Photographs and Aircraft Measurements. Tellus, Vol. 28, 499523.

(3). Jochum, A.M., et al, 1991: Measurements in the Inhomogeneous Convective Boundary Layer Using Three Powered Gliders, DLR-FB 91-30, p. 223-228.

(4). Lindemann, L., 1985: "Die Provence Mochts Möglich," Aerokurier. No. 6.

(5). Wallington, C.E., 1986: Meteorology for Glider Pilots, pp. 331. J. Murray Ltd., London.

(6). WMO, 1993: Handbook of Meteorological Forecasting for Soaring Flight, WMO-No.495, pp. 83, Geneva.