REGIONAL DISTRIBUTION OF AERODYNAMIC ROUGHNESS PARAMETERS OVER TURKEY

Doç. Dr. Melih ERKMEN

Abstract

By analyzing the data on the areal distribution of defined types of plant cover in the sixtyseven provinces of Turkey, the regional distribution of major vegetation types is obtained. Combining the vegetation cover survey, phenological data and estimates of vegetation height, the average seasonal and regional distributions of roughness parameter over Turkey are evaluated. An emprical numerical relationship between plant height and aerodynamic roughness parameter (z_0) is used to estimate weighted area - average of z_0.

Résumée

La distribution régionale des types prépondérants de végétation est obtenue par l'analyse des données sur la distribution superficielle de certains types de couverture florale dans les soixante - sept provinces de la Turquie. Les distribution moyennes saisonnières et régionales du paramètre de rugosité en Turquie sont évaluées en combinant les informations relatives à la couverture végétale, les donnés phénologiques et les estimations de la hauteur de la végétation. Une relation numérique d'ordre empirique entre la hauteur de la végétation et le paramètre de rugosité aérodynamique (z_0) est employée pour évaluer la valeur moyenne de z_0 pondérée par rapport à la surface

I.1. Introduction

Non - uniformity of the earth - air interface and the degrees of its physical variability from section to section require special consideration in the field of atmospheric dynamics. It is well known that inhomogeneity of the earth's surface exert profound influences upon the natural aerodynamic processes which occur in the lower atmosphere. Ba-

sically, these processes are differential parts of a complex integral phenemenon which we call the general circulation of the atmosphere. An improvement of knowledge appears necessary concerning the dependency of these atmospheric processes on the physical structure of the lower boundary.

The roughness structure of the ground surface plays a very important part in determining the nature of the atmospheric motion. Frictional forces in the lower atmosphere, and the dissipation of kinetic energy of large - to - small - scale air surrents depend primarily on the roughness structure of the earth's surface.

Micrometeorological information indicates that the frictional effeeta at the lower boundary can be expressed in terms of aerodynamic - roughess parameter (b_0, cm), which depends significantly on the type of vegetation cover. Hung and Lettau (1961) obtained a numerical relationship between plant height and aerodynamic roughness parameter from the reanalysis of the available wind profile measurements above tall vegetations ,ineluding corn, bruch fields, orchards, fir forest, etc.). In order to obtain the roughness prameter for a region, in contrast to that of a defined micrometeorological site, it is necessary to combine the above rlationship with data on the horizontal distribution of plant covers.

In the present paper, an attempt is made to study the regional and seasonal variations of aerodynamic roughness for an area of 772,091 km^2 as represented by Turkey.

1.2 Method and Data

The evaluation of the aerodynamic roughness of a selected region involves the following four steps :

(1) Classify the vegetation into major types and determine the area - percentage of each type (i.e., the land use).

(2) Estimate representative heights for each vegetation type with a breakdown by season.

(3) On the basis of (2) assign roughness parameters to each vegetation type.

(4) Compute the regional mean of the roughness parameters, employing the percentage area of each vegetation type as a weight factor, with a breakdown by season.

For the present study, the data on land use were obtained from the following sources: Statistics by the Turkish State Institute of Statistics (1967), Turkish State Department of Forestry (1968), Defne (1955) and Tarman (1964).

Phenological data and estimates of plant heights were obtained by personal communication with staff members of the Agricultural Research Institute of the Department of Agriculture and the Department of Forestry of the University of Istanbul.

For the estimate of roughness parameters, on the basis of plant height, the following relationship derived by Kung and Lettau (1961) was used.

$$\log z_0 = -1.24 + 1.19 \log h$$

where z_0 and plant height h are in cm.

The area of Turkey was divided into seven regions on a province basis, in the following manner ;

Region	Provinces Included
1. Northwest	İstanbul, Edirne, Kırklareli, Tekirdağ, Kocaeli, Bursa, Bilecik, Balıkesir, Çanakkale, Sakarya.
2. West	İzmir, Manisa, Kütahya, Uşak, Afyon, Denizli, Aydın, Muğla.
3. North	Artvin, Bolu, Çorum, Amasya, Zonguldak, Kastamonu, Sinop, Samsun, Tokat, Ordu, Giresun, Trabzon, Gümüşhane, Rize.
4. Central	Ankara, Eskişehir, Konya, Niğde, Sivas, Yozgat, Çankırı, Nevşehir, Kırşehir, Kayseri.
5. South	Burdur, İsparta, İçel, Adana, Maraş, Hatay, Antalya.
6. East	Erzincan, Erzurum, Ağrı, Kars, Van, Muş, Tunceli, Bingöl, Elâzığ, Malatya, Bitlis, Hakkâri.
7. Southeast	Adıyaman, Diyarbakır, Siirt, Mardin, Urfa, Gaziantep.

According to land use in these regions twelve major categories of vegetation cover were distinguished. Each category involves either one, or more two main kinds of vegetation, as follows :

(1) Grains (Wheat, Barley, Rye and Oats) — (2) Maize — (3) Other cereals — (4) Sunflower — (5) Industrial crops (Tobacco, Cotton, Sugar beets, etc.) — (6) Vineyards — (7) Meadows and pastures — (8) High - forest — (9) Degraded high - forest — (10) Low - forest — (11) Degraded low - forest — (12) Fruit trees. The results of vegetation survey for each region are shown in Table I, in percentages of total region area.

Combining the vegetation cover survey, phenological data and estimates of vegetation height, the average seasonal roughness parameter was evaluated for each region of Turkey. Results are given in Table 2. For this evaluation a roughness parameter for snow cover of $z_0 = 0.10$ cm was adopted from Deacon's study (1953).

1.3 Discussion of Results

The distribution of average roughness parameters over different regions and their seasonal change can be summarized as follows :

The northern and southern parts of Turkey have high annual z_0 - averages: $z_0 = 71.65$ cm in north, and 56,86 cm in South. In the other regions, the annual average z_0 - values are $z_0 = 34.35$ cm in West, 36.36 cm in Northwest, 7.74 cm in East, 8.56 cm in Central and 6.73 cm in Southeast. It can be seen from Table 2 that z_0 - values decrease sharply in the eastern and central parts of the State. This regional difference of characteristic roughness parameter is mainly due to relatively heavy acreage of forest trees in the northern and southern parts of Turkey, while in the eastern, southeastern and central parts of the State farm crops and grass - type natural vegetation dominate. Since z_0 - value is proportional to the 1.19 th power of the vegetation height, these characteristic differences in vegetation cover are emphasized. On the other hand, the seasonal change of roughness parameters is generally small for the whole State. The surface roughness is maximum in summer and minimum in winter. This is due to the phenological cycle. The lush summer vegetation produces relatively high z_0 - values. The spring and fall values are intermediate between the summer maximum and winter minimum. We also notice that the seasonal change of roughness parame

Table I. Percentage area covered with indicated vegetation types for seven regions of Turkey

Vegetation	Regions						
	I-NW	2-W	3-N	4-C	5-S	6-E	7-SE
Grains	17.20	11.42	11.24	25.63	13.25	7.03	16.57
Maize	2.41	0.53	3.41	0.04	0.20	0.13	0.04
Other cereals	1.32	0.35	1.30	0.56	0.81	0.20	0.43
Sunflower	2.04	0.04	0.04	0.02	0.01	-	-
Industrial crops	3.68	5.61	2.19	1.60	7.29	0.59	2.10
Vineyards	1.02	1.38	0.29	1.30	0.18	0.17	2.94
Meadows and pastures	22.23	38.13	25.44	33.36	28.34	62.42	28.79
High-forest	3.33	3.47	8.45	0.80	5.61	8.40	-
Degraded high-forest	2.74	5.46	6.77	0.88	10.43	1.43	0.96
Low-forest	10.06	1.74	2.93	0.39	2.76	0.89	0.01
Degraded low-forest	5.22	8.56	5.96	1.55	10.12	3.21	5.74
Fruit trees	0.59	0.57	1.75	0.10	0.38	0.05	0.25
Waste land and built-on	28.16	22.74	30.23	33.77	20.62	23.48	42.17
Total area (10^3 km^2)	72.48	111.36	90.33	89.75	182.74	147.14	73.89

Table 2. Seasonal trend of estimated area-averages of the aerodynamic roughness parameter (z_o,cm) for seven regions of Turkey

Regions

Season	1-NW	2-W	3-N	4-C	5-S	6-E	7-SE	State Average
Spring	35.59	33.87	71.07	9.02	56.34	7.13	6.45	27.96
Summer	38.74	35.53	73.44	10.21	58.47	9.62	7.58	30.18
Fall	36.89	34.68	72.05	9.92	57.22	8.15	6.91	28.87
Winter	34.23	33.03	70.05	7.09	55.42	6.05	5.96	27.00
Annual Mean	36.36	34.35	71.65	8.56	56.86	7.74	6.73	28.50

Note : State averages are the weighted area-averages of z_o - values.

ter ise greater in the eastern and central Anatolia than in the other parts of Turkey. This is illustrated by the following ratio of winter to summer z_0 values :

Regions	Winter z_0/Summer z_0 (%)
Northwest	88.4
West	92.2
North	95.4
Central	69.3
South	94.8
East	62.9
Southeast	78.6
State Average	80.1

This is caused by the withering of field crops and grasstype vegetations, with snow cover over these low vegetation areas in eastern and central Anatolia.

1.4 Some Remarks and Conclusions

In an attempt to establish a basis for utilizing micrometeorological information in large-scale meteorological problems, the regional distribution and seasonal variation of vegetative surface roughness over Turkey are studied.

In the estimation of roughness parameters, vegetation height was considered the major factor in causing aerodynamical roughness. The forests, therefore, play an important role. It must be expected that the density of forest trees and the effect of topography and towns are the additional factors. Due to the lack of pertinent information these factors could not be considered here.

The main conclusions concerning the results of the present investigation may be summarized as follows:

(I) The areal distribution of major vegetation types are evaluated for the seven regions of Turkey.

(2) The regional distribution and seasonal variation of average aerodynamic roughness parameter over Turkey are estimated. The annual mean of roughness parameter for Turkey was about 28.5 cm.

(3) The seasonal changes of regional roughness parameters reflect the phenological cycle. These changes are generally small over Turkey.

(4) The crop growth and phenological sequences of vegetation height over the study area cause roughness maxima in summer and minima in winter.

(5) The autumn - wilting of low - type vegetations, and winter snow covering them, affect significantly the seasonal changes in roughness parameter.

Ö Z E T

Yeryüzü pürüzlülüğünün atmosfer dinamiği üzerinde önemli etkileri vardır. Aşağı troposferdeki sürtünme kuvvetleri ve değişik ölçekli hava hareketlerinin kinetik enerjisinin disipasyonu başlıca, arz yüzeyinin pürüzlülük karakterine bağlıdır.

Mikrometeorolojik malûmatın büyük ölçekli meteorolojik problemlerde kullanılmasında bir temel teşkil etmek üzere, Türkiyede, aerodinamik yeryüzü - pürüzlülük parametrelerinin bölgesel ve mevsimlik dağılışları hesaplanmıştır. Bu gaye ile, Türkiyenin altmışyedi vilâyetindeki bitki örtüsü tiplerinin dağılışlarına ait malûmat analiz edilerek, ana vejetasyon türlerinin bölgesel dağılışları elde edilmiştir. Bitki örtüsü dağılışları, bitki boyları ve fenolojik malûmat birleştirilerek aerodinamik pürüzlülük parametrelerinin Türkiye üzerindeki bölgesel ve mevsimlik dağılışları bulunmuştur. Bahis konusu parametrelerin elde edilmesinde, aerodinamik pürüzlülük parametresi (z_0) ile bitki boyu arasındaki bağıntıyı veren ve, Kung ve Lettau (1961) tarafından geliştirilmiş deneysel formül kullanılmıştır.

Çalışmanın bazı sonuçları şöyle özetlenebilir :

I — Türkiyede aerodinamik pürüzlülük parametrelerinin yıllık ortalamalarının bölgesel dağılışları şöyledir :

Bölge	Aerodinamik pürüzlülük parametresi (z_0), cm.
Marmara	36.36
Ege	34.35
Karadeniz	71.65
İç Anadolu	8.56
Akdeniz	56.86
Doğu Anadolu	7.74
Güneydoğu Anadolu	6.73
	28.50 (Ortalama)

2 — Aerodinamik pürüzlülük parametresinin mevsimlik değişimleri fenolojik dönemdeki evreleri yansıtmaktadır. Bu değişimler Türkiye üzerinde genel olarak küçüktür.

3 — Tarım bitkilerinin büyümesi ve vejetasyon boylarındaki fenolojik dönemler, Türkiyede, yaz mevsiminde maksimum, kışın ise minimum bir pürüzlülüğe sebep olmaktadır.

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