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Classification of The Climate Based on the Combination Between Potential Evapotranspiration and Rainfall

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ABSTRACT
The sum of all climatic parameters known until now, in a strict understanding, cannot be the same as climate itself. The climate is the parameters we know plus potential evapotranspiration. The objective of this paper is first, to quantify the evapotranspiration and then, combining it with the rainfall values, to classify the climate of Albania. For that, fifty six meteorological stations throughout Albania were taken into consideration. The potential evapotranspiration was quantified by applying Penman-Monteith formulae. To quantify the functions of potential evaporation and rainfall over time the regression analysis was applied. The data were collected over last six years, on daily basis. The period of time between the curves respective intersections was considered as the duration of pluviometric deficit, whereas the area between curves is defined as the magnitude of pluviometric deficit. The north western part of Albania seems to have a humid climate. The rest part of the country will be characterized between subhumid and dry climate scale.
Key words: evapotranspiration, rainfall, pluviometric deficit.

I. INTRODUCTION

The most common parameters taken into consideration to characterize the climate of a country, until now, are precipitation, sun radiation, temperature, wind speed and relative humidity. However, the climate itself is much more than these indicators. The climate parameter we miss is the evapotranspiration, which represents an upward flow of water getting transformed into vapor exactly at the contact surface between plant leaves and soil (field in the common sense) and atmosphere. In substance, the evapotranspiration is the inverse of rainfall. If the rainfall brings water to the field, evapotranspiration takes the water away from the field to the atmosphere [1]. In general, researchers are well known with the distribution of the rain in time and space; namely, the change of rainfall from one year to another and from one place to the other one. Even the devices by which the amount and intensity of rainfall will be measured are well known and extensively used. But, from another side, many times, the potential evapotranspiration is not accepted as a climate parameter and the information on its magnitude and its distribution in time and space is not known. In these conditions, it becomes impossible to classify a given climate whether it is dry or humid. To determine this one, we must know whether the rainfall is less or greater than the evapotranspiration or vice versa. The present study is focused on quantifying the evapotranspiration based on the Penman-Monteith formulae [2], [3], [4], [5] and comparing it with the rainfall [6], [7], in various points (56 meteorologic stations) spread throughout Albania. The humidity factor, as it is determined by Thornthwaite, based on the present study, will be quantified and used to divide Albanian area into humid, subhumid and arid zones.

II. MATERIALS AND METHODS

2.1. Applying Penman-Monteith formula to quantify the potential evapotranspiration

The following one is the formula applied to determine the potential evapotranspiration [8], [9], for each meteorological station under consideration. Temperature, sun radiation, wind speed and relative humidity are measured on daily basis for a period of six years.

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34 u_2)} \tag{1}$$

;where:
ET_o is potential evapotranspiration, mm/day,
R_n is net sun radiation, MJoul/m^2 day,
G is density of the heat flux from the soil to the atmosphere, MJoul/m^2 day
T is the air temperature at 2m height, °C
u_2 is the wind speed at 2m height, m/sec
e_s saturated vapor pressure, kPascal
e_a actual vapor pressure, kPascal
e_s - e_a vapor pressure deficit, kPascal
Δ slope of curve vapor pressure-air temperature,

γ psychrometric constant, kPascal/°C.

To do the calculations, the computer programme released by FAO was used.

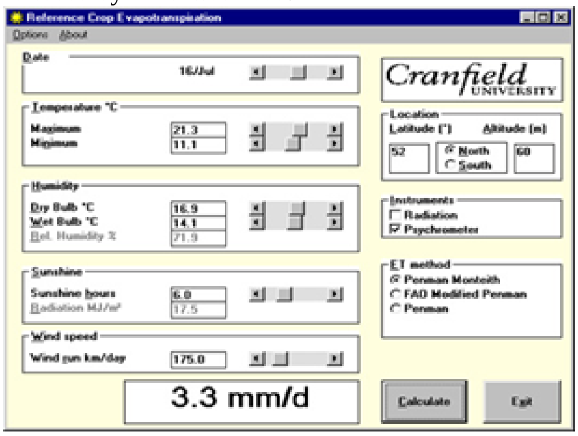

Fig 1. The program (software) used to apply the formulae Penman-Monteith

2.2 Rainfall

Determination of the rainfall has been done at the same time as the potential evapotranspiration was. The rainfall readings were done in a classic manner.

2.3 Pluviometric deficit determination

The regression analysis was done in order to determine the ET_p fonctions over time and the R functions over time. The respective functions were plotted in e respective graph, accompanied by the respective equations and determination coefficients (R^2). The metereologic locations are spread all over the country and this ish shown in the fig. 2.

III. RESULTS AND DISCUSSIONS

The curves Etp=f_1(time) and R=f_2(time) are given. Being as there are fifty six locations whose curves should be presented, which is going to occupy a space that goes beyond the standard limits of publication, only the curves of three typical areas (regions, zones) will be shown and discussed in the present article. Concretely, because of the significant differences found among curves belonging to various zones of the country, the most representative curves of the most significantly different zones are going to be discussed in this article instead of every single curve quantified per each of 56 locations throughout the country. The six curves belonging to the three regions defined already being very different from each other, are going to be presented in the figures: fig. 3, fig 4, fig5, fig6, fig7, fig8.

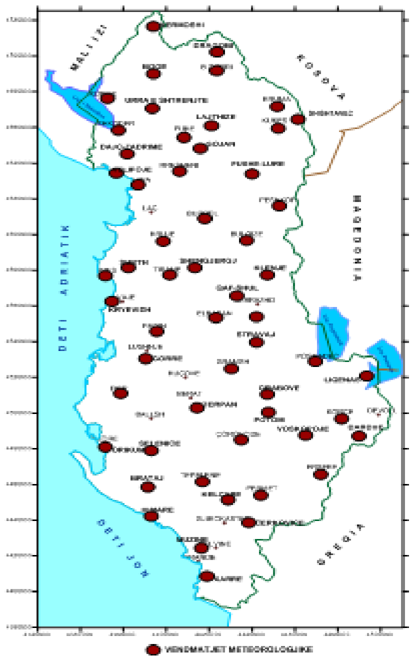

Fig 2. Locations of the meteorological stations

The following table contains the data on potential evapotranspiration and rainfall collected from the Boga location.

Table1 The data collected for the Boga meteorological location

Months	ETp Perennial average mm	Rainfall Perennial average mm
January	16.45	256.38
February	21.20	298.16
March	43.65	226.70
Aprile	65.89	216.72
May	100.08	123.92
June	119.58	108.52
July	138.12	66.14
August	113.53	120.32
September	74.61	164.60
October	44.63	315.08
November	23.63	350.52
December	15.95	333.74

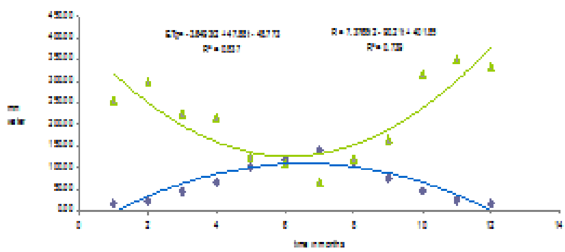

Figure3 The respective functions of potential evapotranspiration and rainfall over time. Boga location; north west of Albania

Table2 The data collected for the Dragobi meteorological location

Months	ETp Perennial average mm	Rainfall Perennial average mm
January	15.68	399.70
February	21.97	346.20
March	48.34	278.88
Aprile	71.02	234.78
May	104.32	171.56
June	126.25	148.62
July	145.52	120.74
August	123.13	184.98
September	76.37	231.06
October	43.58	423.42
November	20.93	419.64
December	13.95	427.12

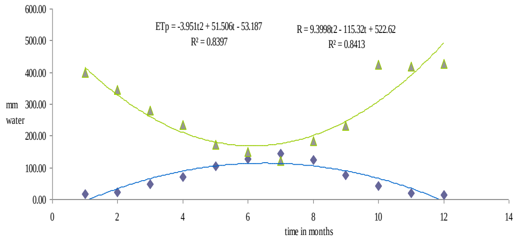

Figure4 The respective functions of potential evapotranspiration and rainfall over time. Dragobi location; north west of Albania

The north-west zone of Albania, which is represented by the locations in the figure 3, 4, is characterized merely by the lack of the pluviometric deficit, which means that statistically the two curves, $ET_p=f_1(t)$ and $R=f_2(t)$, do not intersect with each other, consequently, there is no time for deficit beginning or ending, or, there is not any surface created between the respective curves.

Table3 The data collected for the Corovoda meteorological location

Months	ETp Perennial average mm	Rainfall Perennial average mm
January	21.81	95.26
February	28.09	86.56
March	57.46	87.34
Aprile	82.42	83.54
May	111.85	56.74
June	139.44	61.12
July	159.87	50.78
August	129.94	42.90
September	84.40	98.74
October	53.06	95.26
November	27.76	109.56
December	17.73	132.88

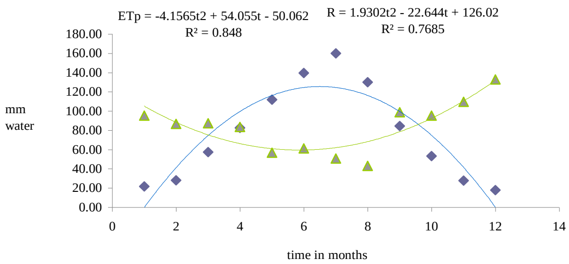

Figure5 The respective functions of potential evapotranspiration and rainfall over time. Corovode location; south east of Albania

Table4 The data collected for the Cerkovine meteorological location

Months	ETp Perennial average mm	Rainfall Perennial average mm
January	28.93	187.26
February	34.07	151.30
March	64.88	138.04
Aprile	88.97	129.40
May	123.40	64.88
June	151.37	43.10
July	178.17	41.08
August	151.04	59.36
September	97.97	170.66
October	63.10	161.50
November	37.64	195.54
December	29.58	263.70

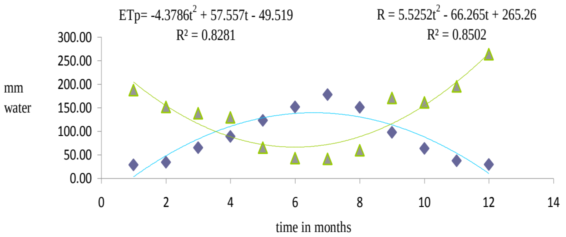

Figure6 The respective functions of potential evapotranspiration and rainfall over time. Cerkovine location; south east of Albania

The south-east zone of Albania, which is represented by the locations in the fig. 5, 6, is characterized by a medium magnitude of the pluviometric deficit, which means that statistically the two curves, $ET_p=f_1(t)$ and $R=f_2(t)$, do intersect with each other, but, the duration of the deficit doesn't last long and its magnitude will be somewhat between 150-300 mm.

Table5 The data collected for the Fier meteorological location

Months	ETp Perennial average mm	Rainfall Perennial average mm
January	23.24	75.22
February	32.46	68.90
March	59.06	67.82
Aprile	85.14	50.96
May	122.35	26.42
June	149.82	20.34
July	166.31	17.34
August	145.01	24.74
September	91.15	89.38
October	58.72	66.32
November	31.56	96.84
December	21.11	97.18

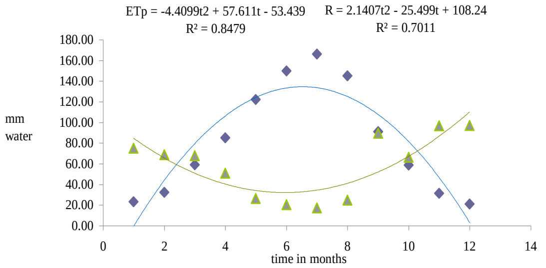

Figure7 The respective functions of potential evapotranspiration and rainfall over time. Fier location; central part of Albania

Table6 The data collected for the Peqin meteorological location

Months	ETp Perennial average mm	Rainfall Perennial average mm
January	28.85	121.00
February	37.12	86.00
March	64.81	58.80
Aprile	87.96	70.70
May	130.70	36.86
June	150.91	31.36
July	163.64	45.34
August	125.33	25.52
September	97.47	74.90
October	64.42	54.24
November	35.16	40.76
December	25.73	69.82

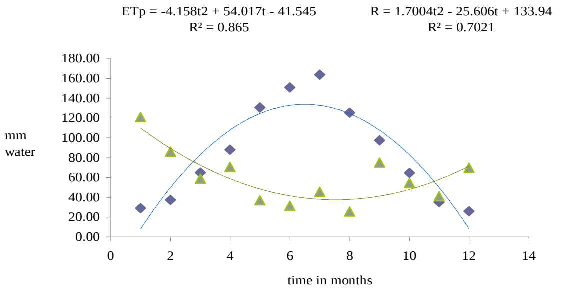

Figure8 The respective functions of potential evapotranspiration and rainfall over time. Peqin location; central part of Albania

The central zone of Albania, which is represented by the locations in the fig. 7, 8, is characterized by a large magnitude of the pluviometric deficit, which means that statistically the two curves, $ET_p=f_1(t)$ and $R=f_2(t)$, do intersect with each other and the duration of the pluviometric deficit does last long and its magnitude will be between 400-550mm.

IV. CONCLUSIONS

1. All the determined functions are represented basically by curves and the maximum of each of them for the $ET_p=f_1(t)$ will be reached when the minimum of $R=f_2(t)$ has already been reached.
2. Both types of functions are characterized by high determination coefficients.
3. At the north west zone of the country the respective maximum and the minimum of the curves don't intersect or intersect slightly, which means that it is expected that the mentioned zone will be characterized by the high humidity coefficients.
4. The rest part of the country, so, approximately 3/4 of it, is characterized by the medium to large pluviometric deficits.
5. The work and the results presented are going to be a very useful base for the classification of the Albanian climate from the humidity and aridity point of view in a more detailed scale.

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