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THE INFLUENCE OF MICRO LOCATION ON THE AIR FREEZING INDEX

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Abstract. *In this paper are exposed research results of air freezing index values occurring in area of Bosnia and Herzegovina. Theoretic probabilities of air freezing index occurrence are calculated, based on data of 26 meteorologic stations, in order to deterimine its return periods of appearing (the probability of air freezing index appearance average once in period considered). To this purpose five the most frequent in praxis theoretic distribution functions are used: GAUSS, GALTON, LOG-PEARSON, PEARSON and GUMBEL. As the most appropriate function for all meteorogic stations the LOG-PEARSON was sellected because it on the best way approximates values of calculated air freezing index.*
Regarding to influence of micro location on the value of air freezing index some independent parameters of location, which are measurable (variables) and have supposed influence, are took in analysis. To this purpose the mathematic model of multi variant regression analysis was used and the regression equation of the associated influence of independent parameters was determined. Using this discovered equation, designers of road pavement can for each micro-location cutted by the road line, calculate the air freezing index and check the pavement structure on the harmful freezing effects.

Key words: *negative air temperature, air freezing index, micro location.*

1. INTRODUCTION

In the design proces of road pavement constructions, its protection and maintenance always is present a problem of determining the value of air freezing index. The reason of it is insufficient covering of territory with meteorologic stations, from the road engineering point of view. If we know that former SFRY had approximately 88.300 km of categorised roads and 463 meteorologic stations that measure air temperature (average 191 km of roads per one station), it is obvious that covering is not sufficient. It happens that one road section is distant from the nearest meteorologic station even for hunded

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kilometers, what additionally complicates the checking of road pavement construction from freezing effect point of view.

In order to overcome this problem, in this research was explored and established the law of dependecy of air freezing index on some parameters of micro location.

2. Exploration of Probability of the Air Freezing Index Appearance

In order to calculate the air freezing index, some historic air temperature data from chosen meteorologic stations are collected. The all data of average daily air temperatures in a period from November to April from 26 meteorological stations of BiH (Bosnia and Herzegovina) from the day of its foundation to the season 1988/89 were gathered, analysed and arranged.

2.1. Theoretic probabilities of air frezzing index occurence

On the basis of colected meteorologic data, all air freezing index values were calculated by years (annually) for each meteorologic station from year of its foundantion. These values make the statistic sample for meteorologic station studied.

Considering the derived value of the air freezing index, the question about probability of its particular values appears.

The answer on this question gives statistic analysis of air freezing index values from 26 involved meteorologic stations, with goal of determination of its return periods of appearing.

Besause it deals with derived (depended) climatic variable the term returns period of appearance was used, that means the same as well as probability of appearance average once in period considered.

Because we have had samples of non sufficient size, for purpose of determination of small probabilites of appearance or actually bigger return periods of appearance, it was necessary previously determine functions of probability distribution for that depended variable.

Under function determining is the selection of certain type of theoretic functions of probability distribution considered, but also the estimation of its parameters from the data in the sample included.

In this analysis are discussed five of most frequently used in practice, theoretic function of probability distribution: GAUSS, GALTON, LOG-PEARSON, PEARSON, and GUMBEL.

In order to select one of five given theoretic functions of probabiliy distribution, it was previously constructed an empiric function of distribution of sample frequency, as estimation of the distribution for very long serie. For determining of empiric probabilities of some sample members, and for graphic presentation of that empiric function, and also for its comparison with someone of theoretic functions of probability distribution, following equation was used:

$$P_{e(F)} \frac{m-0.3}{n+0.4} 100 \quad (\%) \tag{1}$$

where:

$P_{e(\mathrm{F})}$ – probability of air freezing index value appearance (%),

m – ordinal number of random variable in arranged sample (elements are increasing or decreasing), and

n – total number of variable in the sample (number of members in sample).

Because the type of theoretic function of probability distribution, that is best adjusted to the observed sample or precisely to the determined empiric function of probability distribution, was not known in advance, on the samples were implemented adjustments of all quoted theoretic function. For the final selection of the best adjustable theoretic function were used well-known tests of accordance – adaptabilness: χ^2 (chi square)–test end Kolmogorov′s test.

Values of selected probabilities of appearance, or its returned periods of appearance were calculated by an especially prepared computer software, according to quoted theoretic functions of probability distribution, established empiric functions of probability and adequate tests of accordance.

As theoretic function of probability distribution for all meteorologic stations, the function LOG-PEARSON is chosen, because that function on the best way approximates the calculated extreme values of air freezing index, Figure 1.

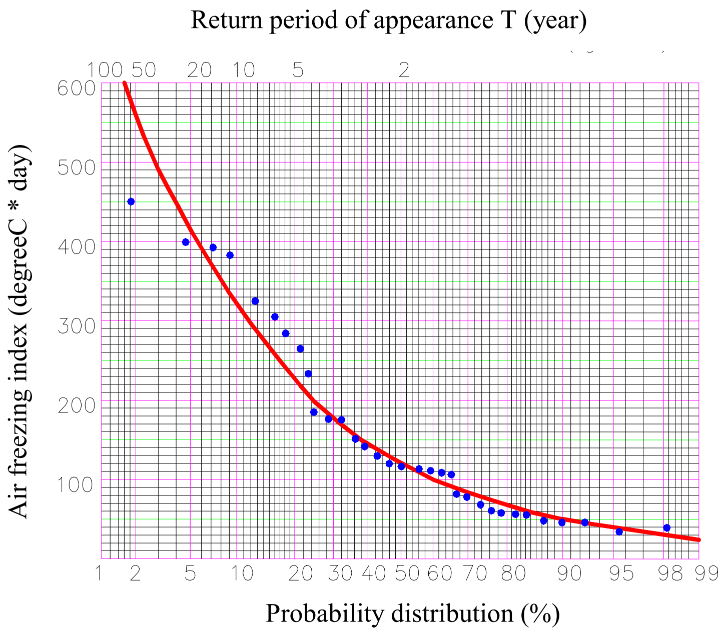

Fig. 1. Function of probability LOG-PEARSON

So, on the basis of determined functions of probability distribution, for each meteorologic station it is possible to determine probability, or wanted return periods of appearance (T) of the air freezing index.

2.2. Research results

Obtained results enabled determination of air freezing index, for chosen return periods of appearance: 5, 10, 20, 30, 50 and 100 years, Table 1.

Table 1. Values of Air freezing index (degreeC*day) according to return period as well as theoretic function of probability distribution

Ordinal number	Metereologic Station	Return period of appearance (years)					
		5	10	20	30	50	100
		Characteristic values of probability distribution					
		20%	10%	5%	4%	2%	1%
		Values of Air freezing index (degree C*day) according to return period as well as theoretic function of probability distribution					
1	Banja Luka	173	227	273	285	323	354
2	Bihać	153	217	291	320	407	510
3	Bijeljina	174	237	299	320	380	439
4	Bileća	35	54	77	86	114	148
5	Bosanska Dubica	169	236	306	330	406	487
6	Bugojno	227	315	415	450	567	701
7	Čemerno	360	431	496	516	579	639
8	Derventa	197	275	356	380	466	553
9	Doboj	168	227	283	300	356	409
10	Drvar	177	243	313	336	414	496
11	Goražde	148	199	250	270	319	372
12	Han Pijesak	500	580	651	672	737	797
13	Ivan Sedlo	316	387	451	470	526	577
14	Jajce	167	214	255	270	300	329
15	Kalinovik	225	298	371	395	468	542
16	Kupres	506	572	617	628	654	672
17	Lastva	22	32	43	49	57	67
18	Lištica	24	38	55	60	84	111
19	Livno	140	185	226	239	277	313
20	Mostar	10	23	47	58	106	185
21	Sanski Most	167	228	290	310	373	438
22	Sarajevo ops.	202	272	342	365	434	504
23	Sarajevo Butmir	230	302	377	402	485	572
24	Sokolac	511	580	633	674	686	718
25	Tuzla	173	225	273	288	330	371
26	Zenica	160	219	282	304	374	450

The values of Air freezing index (degree C*day) according to return period as well as theoretic function of probability distribution (Table 1) are related to the micro location of meteorologic stations.

Because the final goal of this research was establishing of law of the influence of physical characteristics of any point (place) of B&H territory on the air freezing index, the exploration was continued.

3. EXPLORATION OF THE INFLUENCE OF MICRO LOCATION CHARACTERISTICS ON THE VALUE OF AIR FREEZING INDEX

3.1.Input values of parameters of micro location

For exploration of the influence of micro location characteristics (as independent variables) are taken those physical parameters for which was assumed that affect on the value of air freezing index, and which can be expressed numerically. Those are:

– altitude (NV),
– spot level / relative height (RV),
– longitude (GD),
– latitude (GŠ), and
– distance from the sea (UM).

The values of independent variables are expressed in appropriate units as:

– NV – altitude in km,
– RV – spot level, as relative height regarding dominant field (NV – altitude of meteorologic station / NV – altitude of the field) in km

For latitude and longitude, zero-point of coordinate system was taken in section x-axis on 40 degrees of latitude and y-axis on 15 degrees of longitude, so that all parameter values could be nearly equal.

GD – longitude is determined as real longitude -15 degrees,
GŠ – latitude, is determined as real latitude - 40 degrees, and
UM – distance from the sea, has been measured as distance from the coast, parallel to the line putted under angle of +50 degrees in cross section of x-axis on 40 degrees latitude and y-axis on 16 degrees longitude, in hundreds of km.

3.2. Input values of the air freezing index

Input values of dependent variable, the air freeezing index, are taken from the Table 1, with various return periods of appearance, from 5 to 100 years. In our case, for further exploration of dependent variable was chosen return period of 30 years.

3.3. Research method

Research method is based on the establishing of matrix of the independent variables values (parameters of micro location) for each meteorologic station, range 26x5, and vector of dependent variable vaues, the air freezing index, for 30 years return period. Mathematical model of multi variant regression analysis has been used and the most credible regression equation of the associated influence of independent parameters was obtained:

$$AFI = 726{,}87-352{,}53*RV+141{,}08*UM \quad (degreeC*day) \qquad (2)$$

Obtained value of the coefficient of correlation $r = 0.8089$ points out on close connection between dependent variable and associated influences of some independent variables, while obtained value of the coefficient of determination $r^2 = 0.6543$ gives reasonable degree of interpretation of the occurrence analysed.

4. Application of Research Results

By use of the regression equation for determining of the air freezing index, for territory of Bosnia and Herzegovina, and also territory of Montenegro, the maps of air freezing index values are made. To this purpose the geographic map was shared by the mesh (raster) in range of 5 by 5 minutes of latitude and longitude. Besides of that mesh-intersection points, still some points are taken, like all mountain peaks higher than 1500m altitude, and points in river valleys where the main isohypses crosse the river water current.

For all that points from the map in scale 1:750.000 the sea distance and the altitude were taken (spot level - relative height was calculated separately). On the basis of that data, using regression equation (2), all air freezing index values were calculated.

By the putting of obtained values on the map and using the interpolation technique with computer software, the map with izo-lines of air freezing index value, with equidistance of 100 (50) degreeC*days, is constructed.

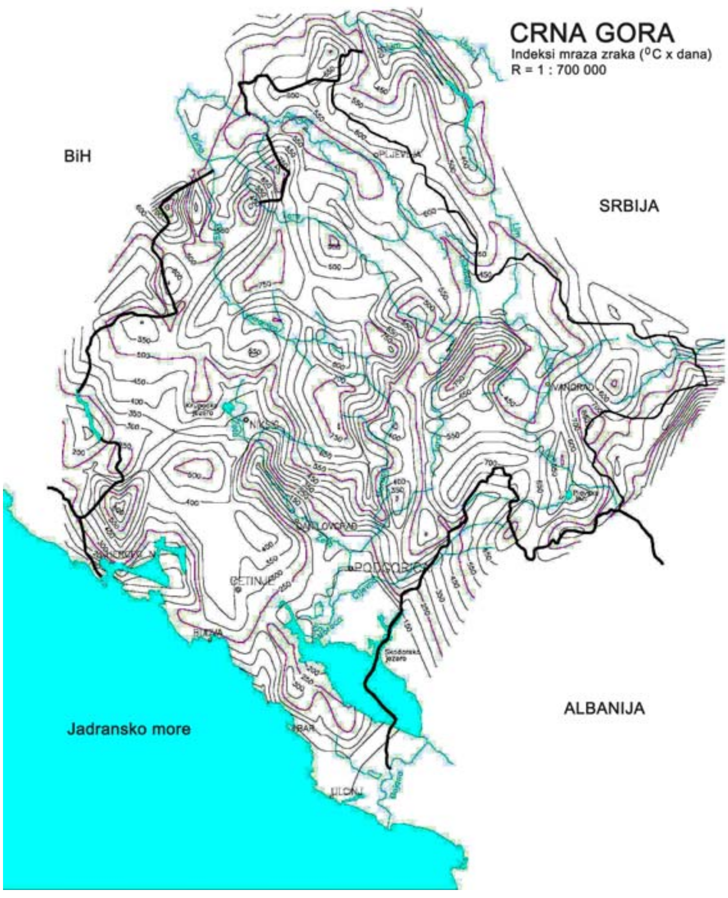

Fig. 2. Map of the air freezing index

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UTICAJ MIKRO LOKALITETA NA VELIČUNU INDEKSA MRAZA ZRAKA

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U ovom radu izloženo je istraživanje veličine pojave indeksa mraza zraka na teritoriji BiH. Sračunate su teoretske vjerovatnoće pojave indeksa mraza zraka na 26 obrađivanih meteoroloških snanica, sa ciljem da se definišu njihovi povratni periodi javljanja (vjerovatnoća pojave prosječno jedanput u razmatranom periodu). Za ovu analizu korišteno je pet najčešće u praksi teoretskih funkcija raspodjele: GAUS, GALTON, LOG. PEARSON, PEARSON i GUMBEL. Za teoretsku funkciju raspodjele kod svih meteoroloških stanica usvojena je funkcija log. Pearson, jer ona najbolje aproksimira sračunatim vrijednostima indeksa mraza zraka.

Za istraživanje uticaja mikrolokaliteta na veličinu indeksa mraza zraka uzete su nezavisno promjenljive veličina za koje se pretpostavljalo da utiču, i koje se mogu numerički izraziti. Primjenjen je matematički model multivarijantne regresione analize i dobijena je jednačina združenog uticaja. Otkrivenom zakonitošću projektanti kolovoznih konstrukcija mogu da na bilo kom mikrolokalitetu, kuda putni pravac prolazi, sračunaju indeks mraza zraka i provjere kolovoznu konstrukciju na štetno dejstvo mraza.