MEASURING SYSTEM OF ADVERSE WEATHER PHENOMENA

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ABSTRACT. - **Measuring system of adverse weather phenomena**. The adverse weather phenomena in nowadays are becoming an extraordinary problem in human life and human activity. Therefore, it seems very important to know the thresholds of adverse weather phenomena. These thresholds can be calculated in different ways, but some experience has shown that for weather elements which departures from normal follow the normal distribution suits to use the Gaussian curve of frequency distribution (temperature and pressure). For such weather elements the normal curve of frequency distribution may be used for classification of thresholds. For weather elements which departures do not depend on such a frequency distribution configuration (precipitation amounts) may be used a decile method. For wind speed thresholds, the Beaufort scale units can be used for calculation. In this paper the threshold scales for four basic weather elemnts are presented. All these scales contain four steps each. They are defined: normal, above normal, much above normal and extraordinary above normal or normal, below normal, much below normal and extraordinary below normal. The examples by observations of Meteorological Observatory in Belgrade are presented.

Keywords: threshold scales, adverse weather phenomena, decile method, Gaussian curve of frequency.

1. INTRODUCTION

It seems very important to know the thresholds of adverse weather phenomena, which can be used in different weather reports. These thresholds can be calculated in different ways, but some experience has shown that for weather elements which follow the normal distribution suits to use the Gaussian curve of frequency distribution (temperature and pressure). For such weather elements the normal curve of frequency distribution may be used for classification of thresholds (Changnon, 1998; Coles, 2001).

For weather elements which departures do not depend on such a frequency distribution configuration (precipitation amounts) may be used a decile method (Coles, 2001). For wind speed thresholds, the Beaufort scale units can be used for calculation (Coles, 2001; WMO, 2006). In this paper the threshold scales for four basic weather elements are presented. All these scales contain four steps each. The spreadness of the adverse weather phenomena is expressed by the number of meteorological stations at which some adverse weather phenoimenon has been observed at the same day and calculated by decile method.

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2. METHODOLOGY OF THE THRESHOLD UNITS DEFINING

The standard deviation (σ) is used in a way that the area under the standard deviation curve (Coles, 2001; Gibbs, 1987) is divided as a unit in threshold scale, as it is shown in Table 1.

Table 1. ***Area under normal frequency distribution devided by standard deviation (σ)***

Standard deviation	Percent of frequency	T e r m
< -3σ	0 -0.15	Extraordinary below normal
-3σ to -2σ	0.16-2.30	Much below normal
-2σ to - σ	2.31-15.85	Below normal
- σ to + σ	15.86-84.15	Normal
+ σ to + 2σ	84.16-97.70	Above normal
+ 2σ to +3σ	97.71-99.85	Much above normal
> +3σ	99.86-100.00	Extraordinary above normal

The area under frequency distribution curve which does not depend on the distribution configuration is devided in ten equal parts, as it is shown in Table 2.

Table 2. ***Frequency distribution presented by decile method.***

Decile	Percent of frequency	T e r m
1	0.1-10	Extraordinary below normal
2	10.1-20	Much below normal
3	20.1-30	Below normal
4-7	30.1-70	Normal
8	70.1-80	Above normal
9	80.1-90	Much above normal
10	90.1-100	Extraordinary above normal

The units in threshold scale for wind as an adverse weather phenomenon seems to be convenient to use the units of Beaufort scale. It can be used in a way shown in Table 3.

Table 3. ***Threshold scale for wind as an adverse weather phenomenon***

Beaufort scale (B)	Type of wind	Speed (m/s)	T e r m
1-7	Calm to severe wind	≤ 17.1	Normal
8	Stormy wind	17.2-20.7	Above normal
9	Storm	20.8-24.4	Much above normal
≥ 10	Severe and hurricane storm	≥ 24.5	Extraordinary above normal

The threshold scale for any adverse weather element contains four steps. They are:

1. Normal		1. Normal
2. Below normal	or	2. Above normal
3. Much below normal		3. Much above normal
4. Extraordinary below normal		4. Extraordinary above normal

3. THRESHOLDS OF ADVERSE WEATHER ELEMENT

3.1. Thresholds of minimum daily air temperature

The air temperature is considered as one of the most important climate and weather element. It is, therefore, important to know the limits in which the air temperature should be considered as normal or how much departure from normal. That is particularly important in situation when the air temperature becomes an adverse weather phenomenon.

As a measure for cold weather, the negative departure of the minimum daily air temperature from the monthly normal value, is representative. In opposite, a positive departure of the maximum daily air temperature from the monthly normal value, is representative.

Table 4. ***Thresholds of minimum daily air temperature in Belgrade (°C) for the period from 1961 to 1990***

Scale		Months											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Normal	from	2.3	4.3	7.9	11.6	15.3	17.9	19.1	18.9	16.4	12.6	8.4	4.5
	to	-7.2	-4.4	-0.7	4.2	9.0	11.9	13.6	13.0	9.6	4.6	-0.3	-4.6
Below normal	from	-7.3	-4.5	-0.8	4.1	8.9	11.8	13.5	12.9	9.5	4.5	-0.4	-4.7
	to	-13.3	-10.2	-6.7	0.8	5.2	9.0	10.9	10.2	6.9	0.3	-5.0	-8.2
Much below normal	from	-13.4	-10.3	-6.8	0.7	5.1	8.9	10.8	10.1	6.8	0.2	-5.1	-8.3
	to	-20.9	-15.3	-12.6	-1.8	1.7	4.7	9.4	6.8	0.5	-2.5	-7.9	-15.0
Extraordinary below normal		≤ -21.0	≤ -15.4	≤ -12.7	≤ -1.9	≤ 1.6	≤ 4.6	≤ 9.3	≤ 6.7	≤ 0.4	≤ -2.6	≤ -8.0	≤ -15.1

The thresholds of minimum air temperature are derived from the frequency distribution of the minimum daily temperature in one month during the normal climate period 1961-1990 for the Belgrade meteorological observatory (44°48' N, 20°28'E, 132 m a. m. s. l.). They are given in Table 4.

3.2. Thresholds of maximum daily air temperature

The thresholds of maximum daily air temperature in Belgrade are presented in Table 5. From this Table can be seen that differences between thresholds are smaller in summer than in winter months. Also, the maximum daily temperature is considered, roughly, to be normal in the limits $\pm 5^0$C of monthly mean value. Daily maximum temperature above normal is roughly for whole year on average between 5^0C and 10^0C above the normal monthly value. The threshold of extraordinary above normal of daily maximum air temperature is change between 20.3 in January and 40.2^0C in July.

3.3. Thresholds of daily precipitation amount

In the most rainy days in Belgrade the amount of rainfall is relatively small. They are, therefore, not of interest for statistics of rainfall amounts much or very much above normal (Coles, 2001; Gibbs, 1987; Radinović and Ćurić, 2009).

For this reason, the thresholds for rainfall amounts much and much above normal, as well as extraordinary above normal, are calculated by the daily maximum amount of precipitation.

Table 5. ***Thresholds of maximum daily temperature in Belgrade (°C) for the period from 1961 to 1990.***

Scale		Months											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Normal	from	-2.0	0.8	5.0	12.1	17.6	20.8	23.1	23.1	19.7	12.5	5.0	-0.1
	to	9.4	12.9	17.6	22.8	27.2	29.9	31.6	31.8	28.7	23.8	17.6	11.2
Below normal	from	9.5	13.0	17.7	22.9	27.3	30.0	31.7	31.9	28.8	23.9	17.7	11.3
	to	14.5	19.4	24.3	27.2	30.5	33.1	35.3	35.3	32.4	27.7	22.8	16.3
Much below normal	from	14.6	19.5	24.4	27.3	30.6	33.2	35.4	35.4	32.5	27.8	22.9	16.4
	to	20.2	23.0	28.8	29.7	34.0	35.6	40.1	38.6	34.4	29.2	28.3	22.5
Extraordinary below normal		≥ 20.3	≥ 23.1	≥ 28.9	≥ 29.8	≥ 34.1	≥ 35.7	≥ 40.2	≥ 38.7	≥ 34.5	≥ 29.3	≥ 28.4	≥ 22.6

Each month has one daily maximum of precipitation. In a normal climatic period there are 360 values of daily maximum of precipitation. They amounts varies considerable from month to month and from year to year. For this reason we shall use the decile method representing the frequency distribution, which does not depend on the distribution configuration.

According to daily maximum amounts of precipitation in Belgrade and using the decile method of frequency distribution we obtained the thresholds shown in Table 6.

Table 6. ***Thresholds of daily maximum precipitation amounts in Belgrade (mm) for the period from 1961 to 1990***

Scale	Deciles	Amounts (mm)
Normal	1-7	≤ 21.0
Above normal	8	21.1 – 25.6
Much above normal	9	25.7 – 33.6
Extraordinary above normal	10	≥ 33.7

From Table 6 can be seen that the daily amounts ≤ 21 mm is consider as normal. The amounts between 21.1 and 25.6 mm a day is above normal, and amounts ≥ 33.7 mm a day is consider to be extraordinary above normal.

3.4. Wind as a dangerous weather phenomenon

The insurance companies (Changnon et al., 1997) for their practice established and the world wide accepted a standard according to which the wind speed of 8 Beaufort (≥ 17.2 m/s) or greater is destructive (Chan, 2010; Malney, 1974; Zielinski, 2002). The same is taken to be the threshold for wind speed as an adverse weather phenomenon.

In Table 7 are shown the frequencies of dangerous wind speed in Belgrade.

From Table 7 can be seen that the frequency of destructive wind occurrences in Belgrade has a very pronounced annual course. In winter they occur

on average four times more frequently than in summer. The categories hurricane storm and hurricane wind should be considered as catastrophic wind (Radinović, 1997, WMO, 2006). It appears in Belgrade extraordinary above normal, on average, 1.7 days in a year.

Table 7. ***Number of days with destructive wind observed in Belgrade (days) for the period from 1961 to 1990***

Scale	Type of wind	Beaufort scale	m/s	Months											
				I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Normal	Calm to several wind	≤ 7	0.0 – 17.1	855	772	836	842	898	875	914	910	884	847	834	837
Above normal	Stormy wind	8	17.2 – 20.7	57	44	71	42	29	19	13	15	13	57	45	67
Much above normal	Storm	9	20.8 – 24.4	14	22	20	11	2	5	0	2	3	20	16	15
Extraordinary above normal	Several and hurricane storm	≥ 10	≥ 24.5	4	9	3	5	1	1	3	3	0	6	5	11

4. CONCLUSIONS

Meteorological information may be imprecise, incomplete and ambiguous, and will be of no use to the disaster management despite the abandons of the accurate measurement data. The unification of the threshold scales and their units for the adverse weather phenomena will contribute to the better understanding and quantification of these types of phenomena in different area of the world. Also, the use of these scales in practice will improve the application of the weather reports and weather forecasts in the process of designing and implementing procedures for reducing the risk associated with the occurrence of a disaster.

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