CRITERIA FOR ABNORMALITY EVALUATION OF SELECTED WEATHER PARAMETERS IN THE SLOVAK REPUBLIC

MARTIN DANILOVIČ[1*], HELENA HLAVATÁ[2], BOŽENA ŠOLTYSOVÁ[1]

[1]National Agricultural and Food Centre – Research Institute of Agroecology, Michalovce,
Slovak republic
[2]Slovak Hydrometeorological Institute, Košice, Slovak republic

The paper describes the procedure of calculation and assessment of deviations of the average air temperature from the normal (in relation to the normal 1961–1990) or long-term average and the percentage of normal precipitation or long-term sum of precipitation, valid for the Slovak Republic. Three evaluation tables clearly indicate both threshold limit values, which facilitate the classification of the calculated indices for air temperature and precipitation. Criteria presented in this work are fully applicable for weather conditions evaluation during the growing season of cultivated plants in the Slovak Republic.

Key words: air temperature, precipitation, normality, evaluation worksheet, evaluative criteria

Evaluation of weather conditions during the growing season of cultivated plants, during the year or during the various months of the year has been an essential part of research papers, students' theses, scientific and technical works, projects, vegetation tests and creation of growth models. The most commonly measured weather parameters are air temperature and precipitation, and they are frequently evaluated at many kinds of scientific and technical works, especially in agricultural and natural sciences.

Climate data are more useful when they are compared with normal values (WMO 2007). Climate normals, as discussed by the World Meteorological Organization, are not only used as predictors of future climate conditions, but are also used to provide a reference value for the computation of climate anomalies. A climatological normal is defined as the arithmetic average of a climate element (e.g., temperature) over a 30-year period. The current climate normal period is calculated from 1st January 1961 to 31st December 1990 and will be used until 2020 (WMO 1989). Climate normals valid for the territory of Slovakia are calculated and published by the Slovak Hydrometeorological Institute (Mikulová *et al.* 2015 a,b).

Calculated deviation from a normal value was the simplest way to express the relationship between observed and normal conditions and is widely used to detect climate changes. In meteorology, it is a very common way to approach drought or warmth situation by generating an index using meteorological data. These indices can be calculated for a variety of time scales. Usually, these time scales range from a single month to a group of months. For climate data comparison with the normal values, it is necessary

Ing. Martin Danilovič, PhD. (*Corresponding author), Ing. Božena Šoltysová, PhD., National Agricultural and Food Centre – Research Institute of Agroecology Michalovce, Špitálska 1273, 071 01 Michalovce, Slovak republic. E-mail: danilovic@minet.sk
Ing. Helena Hlavatá, PhD., **Slovak Hydrometeorological Institute**, Regional branch Košice, Ďumbierska 26, 040 01 Košice, Slovak Republic. E-mail: Helena.Hlavata@shmu.sk

to process them using evaluative criteria calculated for the observed territory. There are some differences within the processing data of air temperature and data of precipitation. The aim of this work is to make the evaluation criteria available and provide missing guidance for air temperature and precipitation data processing during the growing season of the cultivated plants in Slovak republic, in relation to the climate normal 1961–1990.

Air temperature

In cases when concurrent values of monthly or annual air temperature average are compared with normal, the difference tends to be constant (index). Deviation from a normal value is calculated as a difference between the valuated average air temperature and normal for identical period (e.g., month, year).The index is calculated as:

T a b l e 1

Class limits [°C] for evaluating the air temperature abnormality of months, years, half years and winter months in the Slovak Republic

Month / period	Normal						
	extraordinary below normal[1]	very below normal[2]	below normal[3]	normal[4]	above normal[5]	very above normal[6]	extraordinary above normal[7]
	Long-term average						
	extraordinary cold[8]	very cold[9]	cold[10]	normal[11]	warm[12]	very warm[13]	extraordinary warm[14]
I.	< −6.5	−6.5 to −4.1	−4.0 to −2.1	−2.0 to 2.0	2.1 to 3.5	3.6 to 5.0	> 5.0
II.	< −7.0	−7.0 to −4.1	−4.0 to −1.6	−1.5 to 2.0	2.1 to 3.0	3.1 to 5.0	> 5.0
III.	< −5.0	−5.0 to −3.6	−3.5 to −2.1	−2.0 to 1.5	1.6 to 3.0	3.1 to 4.5	> 4.5
IV.	< −4.0	−4.0 to −2.6	−2.5 to −1.1	−1.0 to 1.0	1.1 to 2.5	2.6 to 4.0	> 4.0
V.	< −3.0	−3.0 to −2.1	−2.0 to −1.6	−1.5 to 1.5	1.6 to 2.5	2.6 to 3.5	> 3.5
VI.	< −2.5	−2.5 to −1.6	−1.5 to −1.1	−1.0 to 1.0	1.1 to 2.0	2.1 to 3.0	> 3.0
VII.	< −2.0	−2.0 to −1.6	−1.5 to −1.1	−1.0 to 1.0	1.1 to 1.5	1.6 to 2.5	> 2.5
VIII.	< −2.5	−2.5 to −1.6	−1.5 to −1.1	−1.0 to 1.0	1.1 to 1.5	1.6 to 2.5	> 2.5
IX.	< −3.0	−3.0 to −2.1	−2.0 to −1.1	−1.0 to 1.0	1.1 to 2.0	2.1 to 3.5	> 3.5
X.	< −3.5	−3.5 to −2.1	−2.0 to −1.1	−1.0 to 1.0	1.1 to 2.0	2.1 to 3.5	> 3.5
XI.	< −4.0	−4.0 to −2.1	−2.0 to −1.1	−1.0 to 1.0	1.1 to 2.0	2.1 to 3.5	> 3.5
XII.	< −5.5	−5.5 to −3.1	−3.0 to −1.6	−1.5 to 1.5	1.6 to 3.0	3.1 to 4.5	> 4.5
I.–XII.	< −1.5	−1.5 to −1.1	−1.0 to −0.6	−0.5 to 0.5	0.6 to 1.0	1.1 to 1.5	> 1.5
IV.–IX.	< −1.5	−1.5 to −1.1	−1.0 to −0.6	−0.5 to 0.5	0.6 to 1.0	1.1 to 1.5	> 1.5
X.–III.	< −3.5	−3.5 to −2.1	−2.0 to −1.1	−1.0 to 1.0	1.1 to 1.5	1.6 to 2.5	> 2.5
XII.–II.	< −5.0	−5.0 to −3.1	−3.0 to −1.1	−1.0 to 1.5	1.6 to 2.0	2.1 to 3.0	> 3.0

IV.–IX. – warm half-year; X.–III. – cold half-year; XII.–II. – winter;
Note that in Slovak language we never use term 'extrémne' and classes translate as: [1]mimoriadne podnormálny, [2]silne podnormálny, [3]podnormálny, [4]normálny, [5]nadnormálny, [6]silne nadnormálny, [7]mimoriadne nadnormálny, [8]mimoriadne studený, [9]veľmi studený, [10]studený, [11]normálny, [12]teplý, [13]veľmi teplý, [14]mimoriadne teplý

$$T - n(T)$$

where:

T denotes the longer period's average air temperature, *n(T)* is air temperature normal for the same period and valid for the evaluated site of Slovak Republic (Lapin *et al.* 1987).

Class limits for the calculated temperature difference categories are presented in the evaluation worksheet (Table 1). Presented class limits were elaborated following the methodology of Slovak Hydrometeorological Institute (Lapin *et al.* 1987) and are valid for the territory of Slovakia in relation to the normal 1961–1990. Each class has a verbal designation of abnormality level. If data are compared with normal, it is allowed to use just verbal designation for normal.

Evaluative criteria can be used if the air temperature deviation was calculated from long-term average (note that it must be clearly indicated for which period the long-term average was calculated; e.g. 1951–1980). In this case, the deviation is calcu-

T a b l e   2

The index classes [%] for evaluating the precipitation abnormality of months, half years and years in the Slovak Republic, Zone I.

Month / period	Normal						
	extraordinary below normal[1]	very below normal[2]	below normal[3]	normal[4]	above normal[5]	very above normal[6]	extraordinary above normal[7]
	Long-term average						
	extraordinary dry[8]	very dry[9]	dry[10]	normal[11]	wet[12]	very wet[13]	extraordinary wet[14]
I.	< 20	20 to 39	40 to 59	60 to 130	131 to 170	171 to 230	> 230
II.	< 20	20 to 39	40 to 59	60 to 130	131 to 180	181 to 240	> 240
III.	< 20	20 to 39	40 to 59	60 to 130	131 to 180	181 to 250	> 250
IV.	< 30	30 to 49	50 to 69	70 to120	121 to 160	161 to 200	> 200
V.	< 30	30 to 49	50 to 69	70 to 120	121 to 160	161 to 210	> 210
VI.	< 30	30 to 49	50 to 69	70 to 130	131 to 160	161 to 210	> 210
VII.	< 20	20 to 49	50 to 69	70 to 130	131 to 170	171 to 220	> 220
VIII.	< 30	30 to 49	50 to 69	70 to 120	121 to 160	161 to 210	> 210
IX.	< 20	20 to 39	40 to 59	60 to 130	131 to 170	171 to 230	> 230
X.	< 0	0 to 29	30 to 59	60 to 130	131 to 170	171 to 230	> 230
XI.	< 10	10 to 29	30 to 59	60 to 130	131 to 180	181 to 240	> 240
XII.	< 20	20 to 39	40 to 69	70 to 130	131 to 170	171 to 220	> 220
I.–XII.	< 60	60 to 79	80 to 89	90 to 110	111 to 120	121 to 140	> 140
IV.–IX.	< 60	60 to 69	70 to 79	80 to 120	121 to 130	131 to 150	> 150
X.–III.	< 50	50 to 69	70 to 79	80 to 120	121 to 130	131 to 160	> 160

IV.–IX. – warm half-year; X.–III. – cold half-year;
Note that in Slovak language we never use term 'extrémne' and classes translate as: [1]mimoriadne podnormálny, [2]silne podnormálny, [3]podnormálny, [4]normálny, [5]nadnormálny, [6]silne nadnormálny, [7]mimoriadne nadnormálny, [8]mimoriadne suchý, [9]veľmi suchý, [10]suchý, [11]normálny, [12]vlhký, [13]veľmi vlhký, [14]mimoriadne vlhký

lated as a difference between the valuated average air temperature and long-term average for identical period (month, year), valid for the evaluated site of Slovak Republic. The index is calculated as:

$$T - l(T)$$

where:

T denotes the longer period's average air temperature, $l(T)$ is long-term average for the same period and valid for the evaluated site of Slovak Republic (Lapin *et al.* 1987).

If data are compared with long-term average, it is allowed to use verbal designation for normal and long-term average as well.

Precipitation

Drought is considered as one of the biggest natural disasters that affects the society more than others. Drought as well as wet can be computed by using quantitative indices in the time scale. Indices measure how much precipitation for a given period of time has deviated from historically established

T a b l e 3

The index classes [%] for evaluating the precipitation abnormality of months, half years and years in the Slovak Republic, Zone II.

Month / period	Normal						
	extraordinary below normal[1]	very below normal[2]	below normal[3]	normal[4]	above normal[5]	very above normal[6]	extraordinary above normal[7]
	Long-term average						
	extraordinary dry[8]	very dry[9]	dry[10]	normal[11]	wet[12]	very wet[13]	extraordinary wet[14]
I.	< 10	10 to 29	30 to 49	50 to 140	141 to 190	191 to 280	> 280
II.	< 0	0 to 29	30 to 59	60 to 140	141 to 190	191 to 260	> 260
III.	< 10	10 to 29	30 to 49	50 to 130	131 to 190	191 to 280	> 280
IV.	< 10	10 to 39	40 to 59	60 to 130	131 to 170	171 to 210	> 210
V.	< 10	10 to 39	40 to 59	60 to 130	131 to 160	161 to 220	> 220
VI.	< 10	10 to 39	40 to 69	70 to 140	141 to 180	181 to 250	> 250
VII.	< 10	10 to 39	40 to 59	60 to 140	141 to 180	181 to 260	> 260
VIII.	< 20	20 to 39	40 to 59	60 to 130	131 to 170	171 to 250	> 250
IX.	< 0	0 to 19	20 to 49	50 to 130	131 to 180	181 to 260	> 260
X.	< 0	0 to 19	20 to 49	50 to 130	131 to 190	191 to 280	> 280
XI.	< 0	0 to 29	30 to 59	60 to 140	141 to 180	181 to 250	> 250
XII.	< 10	10 to 39	40 to 69	70 to 140	141 to 180	181 to 230	> 230
I.–XII.	< 60	60 to 79	80 to 89	90 to 110	111 to 120	121 to 140	> 140
IV.–IX.	< 60	60 to 69	70 to 79	80 to 120	121 to 130	131 to 150	> 150
X.–III.	< 50	50 to 69	70 to 79	80 to 120	121 to 130	131 to 160	> 160

IV.–IX. – warm half-year; X.–III. – cold half-year;
Note that in Slovak language we never use term 'extrémne' and classes translate as: [1]mimoriadne podnormálny, [2]silne podnormálny, [3]podnormálny, [4]normálny, [5]nadnormálny, [6]silne nadnormálny, [7]mimoriadne nadnormálny, [8]mimoriadne suchý, [9]veľmi suchý, [10]suchý, [11]normálny, [12]vlhký, [13]veľmi vlhký, [14]mimoriadne vlhký

norms. Any forms of drought and wet are related to some antecedent and relative precipitation amounts for the previous period. The simplest expression of difference from the normal could be defined as a drought index, the so called precipitation index percent of normal:

$$P / n(P) \times 100$$

where:
P denotes the longer period's sum of precipitation, *n(P)* is precipitation normal for the same period and valid for the evaluated site of Slovak Republic (Lapin *et al.* 1987).

Table 2 and 3 shows the precipitation index thresholds elaborated following the methodology of Slovak Hydrometeorological Institute (Lapin *et al.* 1987) valid for the territory of Slovakia in relation to the normal 1961–1990.

In case of annual and half-year precipitation, the evaluation index thresholds are the same in both tables and are valid for all sites in Slovakia.

To rate the monthly precipitation abnormality evaluation, it is necessary to see and use the Figure 1. Evaluated site (site belongs to evaluated precipitation data) must be integrated into the zone in relation to the evaluated period of year using the map

presented in Figure 1. The territory of Slovakia is divided into two zones (Zone I and Zone II) for each period of the year, and the year is divided into four periods (three months in period). There are two periods of the year (February to April and August to October) in the map with the same zoning. Table 2 is valid for the sites integrated to Zone I and Table 3 is valid for sites integrated to Zone II.

Verbal designation of abnormality levels is presented in Table 2 and 3 together with the mentioned precipitation index thresholds. If data are compared with normal, it is allowed to use just verbal designation for normal.

Evaluative criteria can be used if precipitation index is calculated from long-term sum (note that the period of long-term average calculation must be clearly indicated; e.g., 1951–1980). In this case, the precipitation index percent of normal is calculated as:

$$P / l(P) \times 100$$

where:
P denotes the longer period's sum of precipitation, *l(P)* is the precipitation long-term average for the same period and valid for the evaluated site of Slovak Republic (Lapin *et al.* 1987).
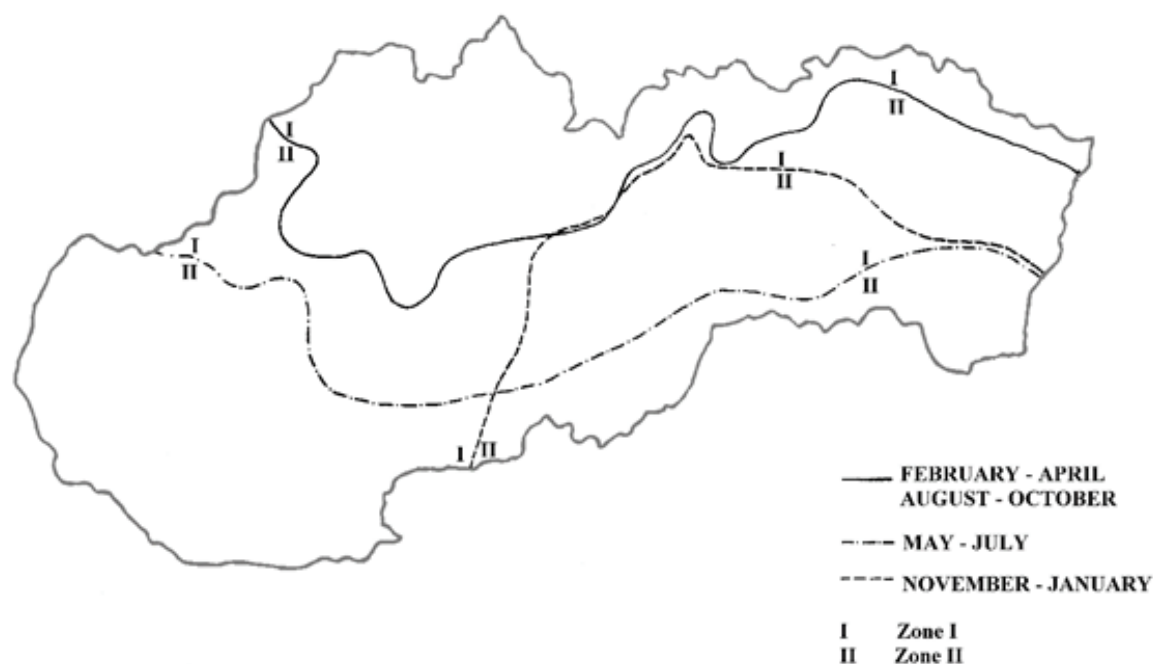

Figure 1. Division of territory of Slovak Republic into Zone I and II based on the amount of precipitation over a period of three months (Lapin *et al.* 1987)

Next step in the procedure is the same as for comparing with normal, in case of monthly precipitation evaluation, the site must be integrated in to one of two zones (see above). If data are compared with long-term sum, it is allowed to use verbal designation for normal and for long-term sum as well.

CONCLUSIONS

Air temperature and precipitation data are more useful when they are compared with normal values or long-term values. Relationship between observed and baseline conditions is simply expressed by climate index. The purpose of the index is to reduce complex conditions to a single number that retains some physical meaning and can be used to monitor a particular process. Climate indices are widely used to characterise features of the climate for climate prediction and to detect climate change. They may apply to individual climatological stations or describe some aspect of climate of the area. Climate indices must be calculated using the relevant data of normal or long-term averages and relevant evaluative criteria. The criteria presented in this work are fully applicable for weather evaluation in the Slovak Republic.

REFERENCES

WMO, 2007: *The Role of Climatological Normals in a Changing Climate*. Geneva : WMO. WCDMP-No. 61, WMO TD/No.1377. Available at http://www.wmo.int/pages/prog/wcp/wcdmp/documents/WCDMPNo61.pdf. (accessed February 16, 2017)

WMO, 1989. *Calculationofmonthly and annual 30-year standardnormal*. Geneva: WMO. WCDP-No.10, WMO-TD/No.341, 12 pp. Available at http://www.inmet.gov.br/html/clima/OMM_WCDP_N10.pdf. (accessed February 16, 2017)

MIKULOVÁ, K. – ŠŤASTNÝ, P. – BOCHNÍČEK, O. – BORSÁNYI, P. – ČEPČEKOVÁ, E. – ONDRUŠKA, P. 2015a. *National Climate Program of The Slovak Republic : Climatological normals in the period 1961–1990 in Slovakia : Part I – Climatological normals of airtemperature in Slovakia in the period 1961–1990* : Ministry of Environment of the Slovak Republic, Slovak Hydrometeorological Institute, 135 pp. ISBN 978-80-88907-92-3

MIKULOVÁ, K. – FAŠKO, P. – ŠŤASTNÝ, P. 2015b. *National Climate Program of The Slovak Republic : Climatological normals in the period 1961–1990 in Slovakia : Part II – Climatological normals of precipitation in Slovakia in the period 19611990* : Ministry of Environment of the Slovak Republic, Slovak Hydrometeorological Institute, 640 pp. ISBN 978-80-88907-93-0

LAPIN, M. – FAŠKO, P. 1987. *Climatological normal*. Methodical regulation. Bratislava : Slovak Hydrometeorological Institute, 22 pp.