IDŐJÁRÁS

Quarterly Journal of the Hungarian Meteorological Service
Vol. 113, No. 1–2, January–June 2009, pp. 23–37

Brief surveying and discussing of drought indices used in agricultural meteorology

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(Manuscript received in final form January 8, 2009)

Abstract—The paper summarizes the indices used for identification of drought phenomenon in the agricultural meteorology practice. Many drought definitions and indices are known. Drought indices seem to be the simplest tools in drought analysis. The indices are classified into six groups, namely *atmospheric*, *precipitation*, *water balance*, *soil moisture*, *recursive*, and *remote sensing* indices. For each group typical expressions are given and analyzed for their performance and comparability. Taking into consideration that the drought is a compound concept, a few drought definitions are examined together with the drought indices. As any classification, the presented categories have got their limitation. The discussion on drought definition together with the survey of the indices tries to highlight the wide possible categorization of this very important phenomenon mainly from the meteorological point of view.

Key-words: drought, drought definition, drought index, meteorological drought, Palmer drought severity index, index surveying

1. Introduction

Drought is undoubtedly one of the human being's worst natural enemies (*WMO*, 1975, 1986). Among the extreme meteorological events, drought is possibly the most slowly developing and long existing event, and probably is the least predictable among the atmospheric hazards. Due to these characteristics, particularly their temporal character, drought cannot be compared with other natural hazards such as flood, hurricane, tornado, lightening, hailstorm, frost, or plague of locust, which also significantly can contribute to a nation's annual loss due to disadvantageous natural circumstances. We can record flood and drought in the same vegetation period in some part of the world. Because of its peculiar character, *drought* deserves the greatest scientific and operative/practical investigation. The goal was to collect the known and used drought indices and to compare their theoretical and practical advantages, limitations, interrelations, and numerical effectiveness. It seems to be necessary to re-evaluate the types of the indices and the definition itself. We can find interesting and important reviews (*Heim*, 2000; *Sivertsen*, 2005a, b) and almost impossible to refer all of them. Taking size limitations of present issue into consideration, only a summary of the definition and mathematical formulation will be given without any numerical evaluation. Some numerical evaluation was carried out in other particular reviews (*Jankó Szép et al.*, 2005; *http://drought.unl.edu*, 2008; *Mika et al.*, 2005).

More exact determination of drought could be made by means of plant-specific indicators of moisture deficiency, characterizing the water demand during the consecutive phenological phases of plants if the information was available and could be mathematically formulated. The drought is a compound concept. As a first guess, it seems that everybody determines it similarly. But, if we go into details, we can compare the phenomenon from different parts of the world; from different types of climate zones we cannot find an absolute acceptable definition and absolute categorization. It means, on one side, a prolonged absence or marked deficiency of precipitation, on the other side, a yield decrease caused by the precipitation deficit.

Many drought definitions are known. Several of them use meteorological parameters. Dealing with the drought problem we can take the following types of investigation, not only from the meteorological point of view:

- Drought frequency can be examined in long time series mainly using the long meteorological data series (for 30, 50, or 100 years). This is the *climatic description.*
- Based on territorial distribution of drought-affected areas for a given territory (region, country) generating homogeneous data series, the territorial distribution of drought tendency can be determined. This is the *regionalization*.
- Detection and prediction of drought during a given year (vegetation period) can be performed using weather information, to provide *forecast and warning of drought.*
- Direct detection of the plant water supply, the water stress detection is the key to *irrigation and plant protection advice*.

In all these approaches the same parameters and methods of drought identification can be used (*Budyko*, 1952; *Eitzinger et al.*, 2008; *Ivanov*, 1948; *Koshelenko* and *Volevakha*, 1971; *Ped*, 1975; *Sun* and *Ward*, 2007; *Theophilou*, 2006; *Tsiros et al.*, 2006; *Wilhite*, 2005), which can also be based on the same definition.

Without any ambition to give an absolute definition, that is acceptable for everybody, some kind of survey of the existing drought definitions will be introduced before the evaluation of drought indices. We start with the most authentic drought definition could be read in the International Meteorological Vocabulary (*WMO*, 1992). The survey will be not able to incorporate all existing drought indices, it only highlights the most important categories.

2. Drought definitions and categories

The problem involves a wide variety of definitions, indicators, indices, and methods of evaluation. As a consequence, almost all agrometeorologists, climatologists, and agronomists, engaged in this field, have their own time series, methods, and conclusions about the drought events. Drought may be studied from a number of different points of view. But, what is the drought, at all? If we would like to give any quantitative criteria for the drought, we must identify its quality before its parameterization. Drought has been defined very commonly and frequently as a period of precipitation deficiency (*Wilhite*, 1983). It seems to be a nice definition, but nobody speaks about drought in case of Sahara or other regions, where the weather is generally dry. In any case when we mention drought, we somehow involve the agricultural product into our consideration, or, more simply, the vegetation production or plant life cycle. It seems to be very easy to produce any combination of meteorological elements and define a threshold value, but if we neglect the behavior of natural or artificial vegetation, we cannot determine good or acceptable categories and threshold values to identify the drought situation. The International Meteorological Vocabulary (*WMO*, 1992), the most authentic source, gives two definitions of drought:

(1) *Prolonged absence or marked deficiency of precipitation;*

(2) *Period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance.*

Both of them are very simple, but if we compare them with the definition given for the dry season: *Period of the year characterized by the (almost) complete absence of rainfall. The term is mainly used for low latitude regions*, we can state that is not very simple task to answer the question. Another category is given in the vocabulary, the *dry spell*. Its definition is more or less close to the drought: *Period of abnormally dry weather. Use of the term should be confined to conditions less severe than those of a drought*.

Drought may be identified from a number of different points of view. It means different things to various people, depending on their specific interest or historical, economical background. It is difficult to find a completely adequate definition of drought, which could be acceptable everywhere in the world. Sometimes the definition is confused with categories. To get a better understanding, some categories or types have been introduced, namely we can speak about the following terms:

- Atmospheric drought occurs if too high saturation deficit has been measured for a durable time. This category more or less refers to the dry spell category.
- Meteorological drought means a longer period of time with considerably less than average precipitation amounts. The definition is more or less the same given for drought in general.
- Agricultural drought has got two approaches. The first one is *the available soil moisture is inadequate*, the second one is: *yield is considerably less than the average because of water shortage*. As it was earlier mentioned, the real drought definition somehow should involve the less than normal vegetation production, so the agricultural drought seems to be close enough to the expected definition.
- Hydrological drought refers to a period of below-normal stream-flow. Another import approach is expressed in this category that the drought is not at all a very local phenomena, it occurs on a larger area, for example it is at least a problem of a water catchment.
- Physiological drought can occur when the plant is unable to take up water in spite of the present sufficient soil moisture. This situation refers to the circumstances when plant shows drought symptom but there is no drought at all in terms of the obvious drought related atmospheric conditions. This phenomenon could be caused by abnormally cold weather or in the case when the plant is infected.
- Socio-economical drought is some kind of integration of several drought categories. It implies any disadvantageous influence of the consecutively repeating dry spells. It is the lack of some economic goods due to meteorological, hydrological, and agricultural drought. In the specific case its definition can be close the definition of famine.

Following the structure of the picture is given in the homepage *http://drought.unl.edu* but making some modification we can summarize the categories and give a hierarchy in the definitions in the *Fig. 1*.

Anyway, we can determine *drought* as *a period during which prolonged and abnormal moisture deficiency produces reduced plant growth and productivity can cause significant loss in nation's economy*.

3. Drought indices definitions and categories

Drought index is *an index which is related to some of the cumulative effects of a prolonged and abnormal moisture deficit* (*WMO*, 1986). To describe the temporal and spatial distribution of drought or dry spell situation, we can mostly use meteorological parameters (*Budyko*, 1952). The practice is that any single meteorological element is unable to identify a drought situation, by itself, or, at least there are not uniform categories for drought in this case.

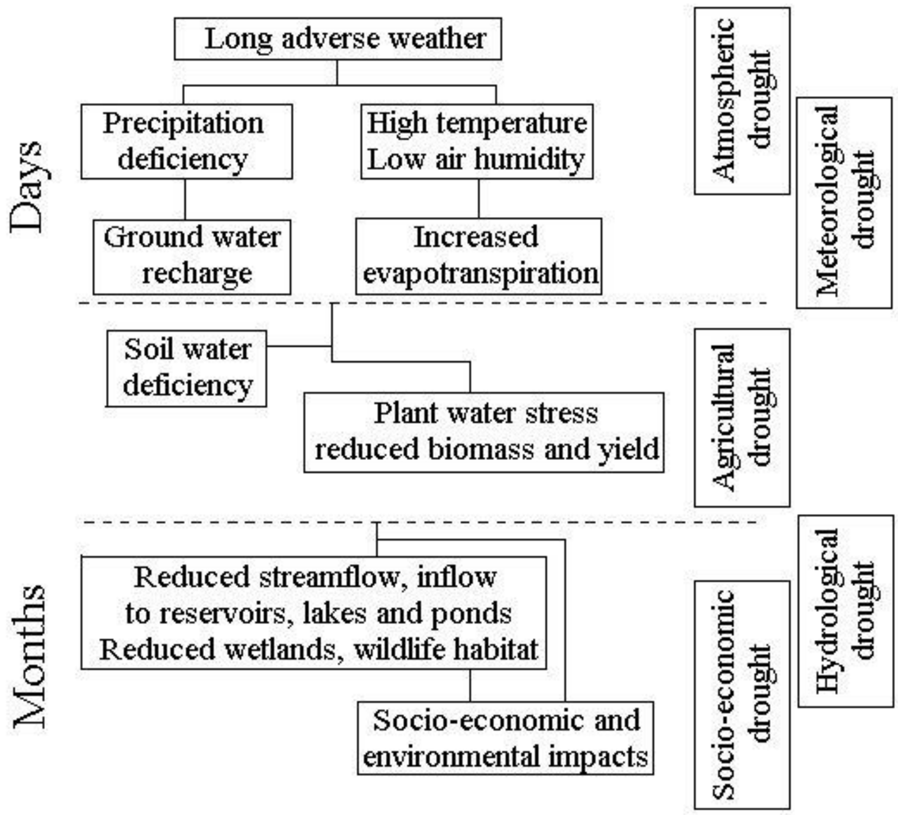

Fig 1. Logical scheme of the drought definition, in combination with the time frame and other water-, plant-, and environment-related phenomena (*http://drought.unl.edu,* 2008).

A more or less acceptable approach is to combine the meteorological variables in order to develop a so-called drought index. Some of these indices can be used only in special circumstances; the other ones can be used for wider area. Anyway, it is very difficult to give universal categories for drought situation that were suitable to determine the drought situation anywhere and anytime, and which could identify the drought for any types of vegetation.

The expectation of the everyday agronomic practice differs from the climatic approach, but the drought index and any kind of irrigation decision signal are not far from each other from meteorological point of view. Until now, many kinds of drought indices were developed, using classical meteorological variables. In this short paper we would like to give a short categorization of drought and dry spell indices, dealing with not only the traditional observations but with some possibilities of using remotely sensed information. The knowledge of temporal and spatial distribution of drought allows us to prevent its damage choosing proper (drought-resistant) species, or to build up a well-working irrigation system in the endangered area. The use of remote sensing technique gives new possibilities to detect the water deficit or drought situation. Vegetation indices derived from satellite's measurements give information about the plant cover of large area and can be the basis of the detection of general condition of vegetation. From this information we can derive a temporal change of water supply and water-stress status, too. Surface temperature measured from satellite or near the surface informs us about plant water supply, too. The practical use of the near-to-surface gradients and water vapor deficit, combined with other standard meteorological observations, opens new possibilities not only in the everyday coping with water deficit and drought but in the climatic detection, too.

In meteorology, it is a very common way to approach drought situation by generating an index using meteorological data. If an index is properly formulated, and its limitations are well recognized, then the index could be very useful. With very moderate criticism on their different types, we try to classify the reviewed indices. To compare drought or dry spell events either on spatial or temporal scale requires a quantitative expression. Drought indices appear to be more or less the simplest way to carry out this work. Nevertheless, finally we can use either a simple meteorological value with more or less 'natural' thresholds or a combination of meteorological elements, sometimes without any physical meanings. Following and partly modifying *Farago et al.* (1989), a compendium of indices are shown where the indices are grouped according to their similarity:

- atmospheric drought,
- indices of precipitation anomaly,
- aridity indices,
- soil moisture indices,
- combined or recursive indices, and
- indices based on remotely sensed information.

Independently of the categorization, the *drought index* is used very widely as a research and operative tool, not only within the agrometeorology, but in many related sciences, as well (*Alexandrov et al*., 2008).

3.1. Indices of atmospheric drought

The standard signal of dry spell is the low humidity. The water vapor saturation deficit is commonly used for characterization of atmospheric drought, although the temporal scale for similar analysis is usually much shorter than a month, sometimes only a few days, but consequence of these days could be catastrophic in case of few species. These indices are not the commonly accepted indices (*Selyaninov,* 1958), but sometimes it is worth to introduce them mostly in the irrigation practice. The simplest form is a simple meteorological element, called saturation deficit (*WMO,* 1992),

$$E - e = E\,(1 - f)\,,$$

where E is the pressure of the water vapor at saturation, e is the measured water vapor pressure, both of them given in SI unit, hPa, f is the relative humidity in percent. For a shorter period threshold values for the identification of atmospheric drought, the so-called *atmospheric dryness*, could be 20–29 hPa, for weak, 30–39 hPa for moderate, 40–49 hPa for intensive, and more than 50 hPa for very intensive dry spell. Dry conditions of longer periods can be described with threshold values of at least weak or moderate dryness.

3.2. Indices of precipitation anomalies

Any forms of drought are related to some antecedent and relative precipitation amounts for the previous period. This period could be last from 3–4 weeks to years. The drought occurs after the anomalous rainy season or period. For example, agricultural drought could be a consequence of dry autumn and winter period. Therefore, the simplest drought index is the deviation from a normal precipitation value. We can generate some combination of deviation, or can somehow normalize the deviation values for a better comparison of generalization. We have to stress that a good drought index is unimaginable without a long-term comparison with yield values before the establishment of threshold values.

Finally, the simplest expression of the difference from the normal could be defined as drought index, the so-called *precipitation index*:

$$P - m(P),$$

where P denotes the longer period's precipitation sum, $m(P)$ is its long term average, standard value, or *climate normal* for the same period. It could be expressed in standard precipitation unit, i.e., in mm. It is desirable to use as long as possible period for the generation of the mean value. The anomalies for non homogeneous regions or larger areas with different climatic conditions are not comparable. To avoid this problem, either relative amounts, or standardized values should be introduced.

Following the same categorization, other indices could be generated as relative values, like the r*elative precipitation amount or relative precipitation anomaly index:*

$$\frac{P}{m(P)} \quad \text{or} \quad \frac{P - m(P)}{m(P)}.$$

In practice both of them are multiplied by 100, and the index is used in percentage form. The difference could be normalized with the standard deviation of the precipitation data series. In this case we can introduce the s*tandardized precipitation anomaly index* (SAI):

$$\frac{P - m(P)}{d(P)},$$

where $d(P)$ is the standard deviation. Each relative index could be a drought indicator if its value is less than apreviously established threshold value, e.g., *75%* on an annual basis, or *50%* for a shorter period for example for a month. The use of other, slightly different levels was suggested by *WMO* (1975*)*. For a recent worldwide drought assessment, to outline desertification, smaller than 60% annual value was given for the relative precipitation anomaly index for more than two consecutive years.

3.3. Aridity indices

Aridity is the characteristic of climate relating to insufficiency of inadequacy of precipitation to maintain vegetation. For a single station, where the usual probability levels can be applied to choose particular threshold values in accordance with the hypothetical distribution of standard approximation of potential evapotranspiration, we can found many types of aridity indices. The simplest way to approximate the evaporation is using temperature alone or a kind of temperature sum and degree-days. The theoretical base form of the aridity index is the evapotranspiration/precipitation ration (*Bristov,* 1987; *Budyko*, 1952). The difference in the aridity indices is in the approximation of the evaporation (evapotranspiration). In principle, the aridity index looks like the following formulas:

$$\frac{P}{PE} \quad \text{or} \quad \frac{P}{\frac{R_n}{L}},$$

where PE is the evapotranspiration expressed in precipitation unit, i.e., mm, R_n is the radiation balance, and L is the latent heat of water vaporization. Taking into consideration the difficulty of evaporation calculation, many approaches were used to determine the evaporation substituting its value with other meteorological elements. The well known types from this category are as follows:
Lang's rainfall index

$$\frac{P}{T},$$

where P is the sum of precipitation for the examined period, expressed in precipitation unit, i.e., mm. T is the average temperature of the same period given in °C unit. It is a very simple approximation. A little more adjusted index using the similar variables is the
De Martonne aridity index

$$\frac{12P}{T+10},$$

written for monthly calculation. Similar construction is followed in the

Thornthwaite index

$$1{,}65\left[\frac{P}{T+12{,}2}\right]^{\frac{10}{9}}.$$

We have to mention that the form of the three last formulas is a typical *agrometeorological index* approach like different types of degree-days. Another type of this category is the degree-days approximation used in Selyaninov index. This index is known as hydro-thermal index. It uses daily values for the calculation of the period.
Selyaninov's hydro-thermal coefficient

$$\frac{P}{\sum\limits_{T\geq 10} T},$$

where T means the consecutive daily mean air temperature above 10 °C. The threshold values for categories of drought or aridity (*Selyaninov*, 1958) are 0.4–0.7 for very dry, 0.7–1.0 for dry, 1–1.3 for insufficiently wet category, and if the coefficient is higher than 1.3 the category is wet. A specific type of the supply-demand category is the comparison of standardized values of the temperature and precipitation in
Ped's drought index, 1st approximation

$$\frac{\Delta T}{d(T)} - \frac{\Delta P}{d(P)}.$$

Not only in the agricultural meteorology but in any near-to-surface energy transfer studies, a well known parameter is the Bowen ratio (*Skvortsov*, 1950) expressing the relation between latent and sensible heat transfer. Because of measurement difficulties, before the continuous data logging the Bowen ration was determined only among very restricted trial circumstances. Not only of its theoretical importance but of its growing direct measuring practice, we have to mention as an *aridity index* among the drought indices. Theoretically, the *Bowen ratio* could be expressed in the form

$$\frac{H}{LE},$$

where H denotes the sensible heat flux and LE is the latent heat flux. Both of them are given in standard flux unit, W $m^{-2}s^{-1}$.

3.4. Soil moisture indices

Using measured or calculated soil moisture data (*Budagovsky*, 1956), we can generate the same type of indices for expressing drought.

Relative soil moisture content

$$\frac{W}{AWC},$$

with *W* and *AWC* denoting the actual soil moisture and the available (or disponsible) water capacity for a fixed soil depth (e.g., the upper 1 m layer or the root zone for a given plant). Besides this well-known ratio, an extended form of Ped's (*Ped*, 1975) drought index incorporates the standardized value of the soil moisture amount.

Ped's drought index, 2nd approximation

$$\frac{\Delta T}{d(T)} - \frac{\Delta P}{d(P)} - \frac{\Delta W}{d(W)},$$

where $d(W)$ is the standard deviation of soil moisture content, as it was calculated for temperature and precipitation in the 1st approximation of *PDI*.

3.5. Recursive indices

Indices describing the moisture conditions for a relatively long time period through the integrated values of the related meteorological elements provide only a rough picture of the adverse conditions within this period. It is thought that, above all, the cumulative effect of prolonged moisture deficits (month by month) should be properly expressed. These indices proved to be of high utility in the delineation of meteorologically determined droughts or dry spell, which possess a kind of memory of which actual values depend on previous values of the related meteorological variables. Because of their calculation method, they could be called as *recursive* indices. A summarization of consecutive monthly precipitation is

Foley's anomaly index (*FAI*)

$$FAI_1 = \Delta P_1,$$

$$FAI_k = FAI_{k-1} + \Delta P_k.$$

The calculation starts with a simple difference for the 1st month. The *k*th month value is calculated using the *index* of the previous month adding the precipitation difference of the standard and actual precipitation value. Finally the series of the yearly indices could be produced to evaluate the drought tendency from climate change point of view (*Fensham* and *Holman*, 1999). Conceptually, the Bhalme-Mooley drought index (*BMDI*) can be considered as a simplified version of the well-known and widely used Palmer drought severity index (PDSI) (*Alley*, 1984). The base of the generation is the monthly precipitation amounts in the *Bhalme-Mooley drought index*

$$i_0 = 0,$$

$$i_k = c_1 i_{k-1} + \frac{SAI_k}{c_2},$$

$$BMDI = \frac{\sum_1^n i_k}{n}.$$

The coefficients c_1 and c_2 are region specific values. The *SAI* is the above mentioned *standardized precipitation anomaly index* (*Bhalme* and *Mooley*, 1980). The calculation is carried out for the vegetation period, starting in April, closing in September. Finally one number will be determined for the year as a sign of drought situation.

A very commonly used and accepted index is the *Palmer drought severity index* (PDSI). The PDSI index is based on the thorough analysis of the elements of surface water balance and on the comparison of their actual values to their climatically or physically potential values. The computing procedure of the PDSI consists of several steps. It considers monthly precipitation, evapotranspiration, and soil moisture conditions. In general, several methods can be used to calculate the potential evapotranspiration, a key variable of the water balance and also of the PDSI computation procedure. Palmer (*Alley*, 1984) applied the Thornthwaite-formula which is rather a climatic character; while later the Blaney-Criddle method provided better estimations (*Alley*, 1984), especially for vegetation specific alternatives. PDSI is standardized for different regions and time periods, which is useful in common assessment for a wide area with different climate. The steps of computation are:

- *Hydrological accounting.* Computation begins with a climatic water balance using series of monthly precipitation and temperature records. An empirical procedure is used to account for soil moisture storage by dividing the soil into two arbitrary layers. The upper layer is assumed to contain the available moisture at field capacity. The loss from the underlying layer depends on the initial moisture content, as well as on the computed *potential evapotranspiration* (PE) and *the available water capacity* (AWC). Runoff is assumed to occur if both layers reach their combined moisture capacity, AWC. In addition to PE, three more potential terms are used and defined as follows: *potential recharge* is the amount of moisture required to bring the soil to its water holding capacity. *Potential loss* is the amount of moisture that could be lost from the soil by evapotranspiration during a zero precipitation period. *Potential runoff* is defined as the difference between precipitation and potential recharge.
- *Calculation of climatic coefficients.* This is accomplished by simulating the water balance for the period of available weather records. Monthly coefficients are computed as proportions between climatic averages of actual vs. potential values of evaporation, recharge, runoff, and loss, respectively.
- *Calculation of CAFEC* (Climatically Appropriate for Existing Conditions) *values.* The derived coefficients are used to determine the amount of precipitation required for the CAFEC, i.e., *normal* weather during each individual month.

- *Moisture anomaly index.* Difference between the actual and CAFEC precipitation is an indicator of water deficiency or surplus in that month and station, expressed as $D = P–I$. These departures are converted into indices of moisture anomaly as $Z = K(j)D$, where $K(j)$ is a weighting factor, also accounting for spatial variability of the departures (D).
- *Calculation of drought severity.* In the final step the Z-index time series are analyzed to develop criteria for the start and end of drought periods and an empirical formula for determining PDSI

Palmer drought severity index

$$PDSI_k = PDSI_{k-1} + \frac{Z_k}{3} - 0{,}103\ PDSI_{k-1},$$

where Z is the moisture anomaly index. The equation indicates that PDSI of a given month strongly depends on its value in the previous months and on the moisture anomaly of the actual month. It causes strong autocorrelation of PDSI. In general, monthly PDSI time series range between –9 and +9, specifically, severe and extreme conditions are characterized by absolute values greater than 4 and 6, respectively. These thresholds may vary among the geographic regions of the world, whereas the original attribution (monthly PDSI time series range between –4 and +4) is considered to be the extremity threshold. Furthermore, drought events occur in the case of negative PDSI values, while positive values imply wet conditions. Compared to other traditional drought indices, PDSI can demonstrate several advantages. It is able to simulate moisture content of the soil month by month, and it is suitable to compare the severity of drought events at regions having rather different climate and seasons.

3.6. Indices based on remotely sensed parameters

The spectral reflectance of vegetation is markedly different from that of most soil materials (*Wagner et al.*, 1996). It is determined by the absorption of chlorophyll at blue and red wavelengths. In the near infrared the radiation is scattered by leaves. This results in generally high reflection which depends mainly on the geometry and size of the leaves. By contrast, vegetation reflectance is low in the visible region with small secondary maximum around 0.55 μm. When vegetation is stressed by shortage of water, and also at the end of the growing period, the chlorophyll absorption weakens and the ratio of near infrared to red or visible reflectance decreases. This ratio is the so-called *vegetation index*

$$\frac{NIR}{VIS},$$

where NIR denotes the reflected radiation in the near infrared interval and VIS denotes the red or visible intervals according to the satellite channel. It is, therefore, a measure for physiological activity of plants. In practice, the *normalized difference vegetation index* (NDVI)

$$\frac{NIR - VIS}{NIR + VIS}$$

is often used to characterize the state of vegetation. Because the state of vegetation highly depends on the water supply condition, we can use the normalized vegetation difference index as drought index. Stress induced by water shortage results in a reduction of the magnitude of the vegetation index. The NDVI is difficult to interpret in case of sparse vegetation, because also the reflectance of most soils increases slightly with wavelength.

The surface temperature can be measured remotely. The difference between the near surface and surface temperatures is the indicator of the latent and heat flux ration. Following the approximation of *Jackson et al.* (1981, 1984), a standardized index the so-called crop water stress index (CWSI) could be generated the
crop water stress index

$$\frac{PE - ET}{PE},$$

where *PE* denotes the potential, while *ET* the actual evapotranspiration. The CWSI in this theoretical form is neither drought nor remote sensing index. The remotely sensed surface temperature and the combination of other meteorological elements could be the base (*Bristow*, 1987) of the CWSI mainly used in irrigation advisory systems. Its consecutive daily values could be used as drought indices too. The difference of the surface and near surface temperatures (*Idso et al.*, 1981; *Seguin et al.*, 1994) could be alone a drought indicator. Using the well known degree day analogue we can generate the
stress degree day (*SDD*)

$$SDD = \sum_K (T_C - T_A),$$

where T_C is the remotely sensed surface (canopy), T_A is the standard air temperature of consecutive days of dry period.

4. Concluding remarks

Drought indices can be calculated at an individual weather station or for a larger area using data of many stations. A simple area-mean can be produced, or a weighted average can be computed. The goal in any cases is to generate a simple and well interpretable *number* or physical variable with its dimension, which can answer the question if there is a drought, or not. Sometimes, when soil moisture measurements or its reasonably good estimations are available, the respective soil moisture indices are more advantageous. Taking into consideration the data collection and computation capacity, we can use a very simple index (*Budyko, 1*952) and produce a quick, but rough result, or we can prepare a very sophisticated map using GIS technique (*Eitzinger et al.,* 2008). The use of remote sensing technique gives new possibilities for the research worker and decision makers mainly in the investigation of larger areas and longer time frames.

In the present survey, the systematic classification of *Farago et al.* (1989) was followed with some modifications, re-evaluations, and extensions. The investigations of indices showed limited agreement among the drought indices. Actually, the imperfect agreement is a direct consequence of the relative nature of drought and the related specific characteristics of all droughts and indices. It has been revealed that the best identification of drought can be achieved by recursive indices like the *Palmer-index*. It could be acceptable for the author to propose new, refined, or extended definitions of drought, by using the existing definitions of the phenomenon. The paper tried to summarize many drought indices with a restricted philosophical approach of how complicated and mixed the definitions and their explanations are. The only thing which should be highlighted is that many drought definitions and numerical categorizations exist, and it is almost impossible to determine any absolute categorization. On the other hand, we can exactly define the drought quantitatively as a numerical category, and qualitatively as a period with prolonged and abnormal moisture deficiency, which produces reduced plant growth and productivity, causing further significant loss in the economy of the affected nation or region.

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