DROUGHT AND IRRIGATIONS OF ROMANIAN AGRICULTURAL AREAS

Lucian LASLO, CS III Ph.D - National Institute for Research and Development in Environmental Protection, e-mail: lucianlaslo@yahoo.com
Nicu CIOBOTARU, CS Ph.D Stud. - National Institute for Research and Development in Environmental Protection, e-mail: ciobotaru_nicu@yahoo.com
Theodor LUPEI, CS - National Institute for Research and Development in Environmental Protection, e-mail: theolupei@gmail.com
Monica MATEI, CS III Ph.D - National Institute for Research and Development in Environmental Protection, e-mail: monicamatei06@gmail.com
Ana-Maria VELCEA, CS III Ph.D Stud. - National Institute for Research and Development in Environmental Protection, e-mail: anamaria_velcea@yahoo.com
Madalina BOBOC, CS Ph.D Stud. - National Institute for Research and Development in Environmental Protection, e-mail: mada91mada@yahoo.com
Gabriel BADEA, CS - National Institute for Research and Development in Environmental Protection, e-mail: badeagab@yahoo.com
Deak GYORGY, CS I Ph.D - National Institute for Research and Development in Environmental Protection, e-mail: dkrcontrol@yahoo.com

***Abstract**: This article presents the DROUGHTSAT project and its preliminary results related to the soil moisture accounting based on self-calibrated Palmer drought severity index and water use for irrigation in the main agricultural areas. The used data and methods consist in monthly temperature and precipitation amounts, from ECAD database covering 27 meteorological stations and statistical data regarding the water use for irrigation. The results present the relationship between drought and water use.*

***Keywords:** drought, scPDSI, irrigation, agriculture*

1. Introduction

Observations and measurements made at global and national level, on the climate parameters and on the effects of climate change on water resources, show some significant signs which support the hypothesis of climate change (IRMA, 2016). The main consequences of global warming can be: decreasing productivity of grains in low latitudes, increasing mortality due to amplifying extreme phenomena, increasing the frequency of floods and droughts (IPCC, 2007).

Most probably, in the near future, climate change will increase irrigation needs, which will be constrained by reduced runoff, demand from other sectors, and by highly economic costs (Kovats, R.S. et al., 2014).

In Romania, the drought phenomenon has increased in frequency and intensity, with important consequences on the agriculture sector. About 2% of the total agricultural area of Romania is affected annually by extremely severe drought, in this case the plant cultivation not being possible without irrigation, while on 38% of the total agricultural area, the irrigation has the role to complete the precipitation for ensuring the water demand for agricultural crops (Nicolescu C. et al., 2007).

Romania's water resources are relatively reduced and non-uniform distributed over time and space. The theoretical volume of fresh water resources is about 134.6 billion

m^3/year, which consist of surface water (rivers, lakes, Danube River) and groundwater (ANAR, 2016).

According to Water Statistics Report of Eurostat, the total volume of fresh water that can be technical used is estimated to about 36.3 billion m^3/year (long-term annual mean), so Romania belong to the category of European countries with modest water resources (22^{nd} place for total water resources and 16^{th} place for the water resources formed on its territory). The Danube River and the inland rivers have a contribution of about 90% to the total volume of fresh water that can be technically used, while the groundwater had a contribution of about 10%.

The specific availability of fresh water resources is about 1840 m^3/inhabitant, a situation that is considered to be modest (Eurostat, 2017). According to the World Water Development Report of United Nations Organization, a country is affected by water stress when its annual water resources are below the critical value of 1700 m^3/inhabitant.

Romania has modest water resources that can be technically used, so these will be intensely exploited in the future due to intensification of drought phenomenon predicted in the actual context of climate change.

In order to assess the drought phenomenon at national level, in the present paper has been calculated the self-calibrated Palmer drought severity index – scPDSI, which is a variant on the original PDSI index developed by Wayne Palmer in 1960s (Palmer, 1965). The scPDSI has been developed to make results from different climate regions comparable and is calculated from time series of precipitation and air temperature, together with fixed parameters related to the soil characteristics at each location (Osborn et al., 2017).

This index is useful to understand drought phenomenon associated with agriculture, by calculating water supply and demand. The results of this paper present the correlation between drought and volume of water use for irrigation in Romanian agricultural areas.

The paper is structured as follows: section 2 describes the data and the methods that were used, while section 3 outlines the results. Section 4 summarizes the conclusions.

2. Data and methods

Based on information presented above, this paper aims to present the correlation between drought conditions (based on self-calibrated Palmer drought severity index - scPDSI) and water volume used for irrigation, for given locations and time periods.

For this, has been used monthly air temperature data and precipitation amounts for the time period 1990-2016, at 27 meteorological stations, distributed all over the Romanian territory (Figure 1). Monthly meteorological parameters were calculated using daily air temperature data and precipitation amounts provided by the European Climate Assessment and Dataset (ECA&D) database (Wijngaard et al. 2003), as primary source, while the missing data were completed from ROCADA and Reliable prognosis weather databases[1] (which includes reanalysis data from NCEP/NCAR database).

An R package for PDSI which represents a modified version of the University of Nebraska's C++ PDSI implementation was used to calculate the self-calibrated Palmer drought severity index, by using the monthly meteorological data. In Table 1 are presented the classes of PDSI, where near 0 values represents normal conditions and the outer values extreme conditions.

Table1. The Palmer Drought Severity Index Classes

[1] http://rp5.ru

Severity Index	Class of Conditions
<= -4.00	extreme drought
-3.00 to –3.99	severe drought
-2.00 to –2.99	moderate drought
-1.00 to –1.99	mild moderate
-0.50 to –0.99	incipient drought
-0.49 to +0.49	near normal
+0.50 to +0.99	incipient wet spell
+1.00 to +1.99	slightly wet
+2.00 to +2.99	moderately wet
+3.00 to +3.99	very wet
>= +4.00	extremely wet

The evolution of scPDSI was represented monthly for 1990-2016 period. The values were presented in meteorological stations, selected based on their position related to counties where the irrigation quantities are presented: Arad, Calarasi, Constanta, Craiova, Galati, Iasi, Miercurea Ciuc, Rosiorii de Vede, Sulina and Turnu Magurele.

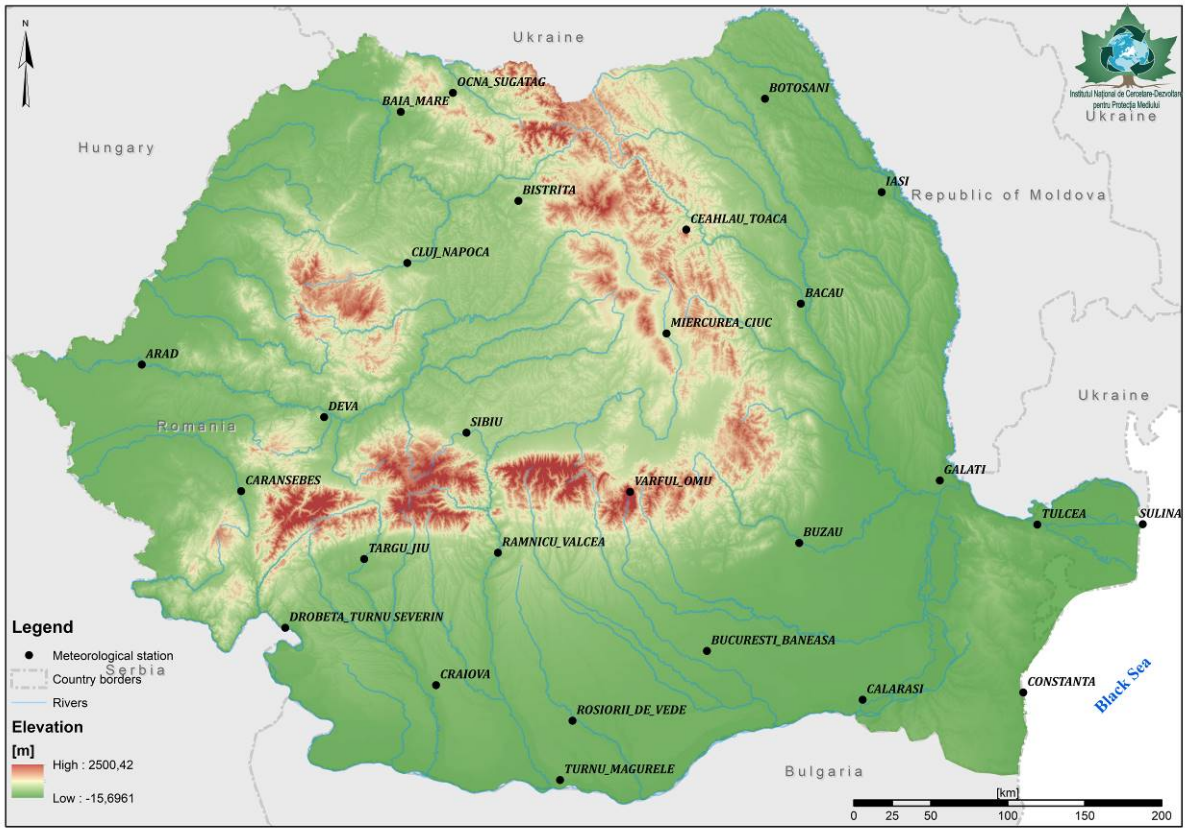

Fig.1. Localization of meteorological stations

DEM data source: EU-DEM

The information regarding the irrigated area (ha) and the volume of water used for irrigation (m^3) are presented as the specific volume of water used for irrigation (m^3/ha) at county level. The data was processed from reports provided by the National Administration on Land Development (ANIF[2]). These information are presented as monthly cumulative quantities, calculated as sum of the irrigation campaigns per month for the following years

[2] http://www.anif.ro

2010-2012 and 2016. The analysed counties were selected based on their location and drought vulnerability: Braila, Calarasi, Constanta, Covasna, Dolj, Iasi and Teleorman.

The GIS environment is represented by the shapefiles with the positioning of the meteorological stations, countries and county borders, the digital elevation model and the rasters with the scPDSI values resulted from Spline interpolation for the entire country with the default setting.

3. Results

The results presents the evolution of the PDSI for 27 stations, for 1990-2016 and are depicted in Figure 2 where it can be observed the periods with drought events or high moisture deficit. Intervals with water deficit are specific between 1992 and 1996 for most of the stations, especially for the southern part of Romania. Another years marked by severe drought are 2000, 2007, and 2012, and generally there is regional pattern in the development of drought process as it resut from the figure below where stations Turnu Măgurele, Roșiorii de Vede, Craiova, and Călărași have similar patterns (Figure 2).

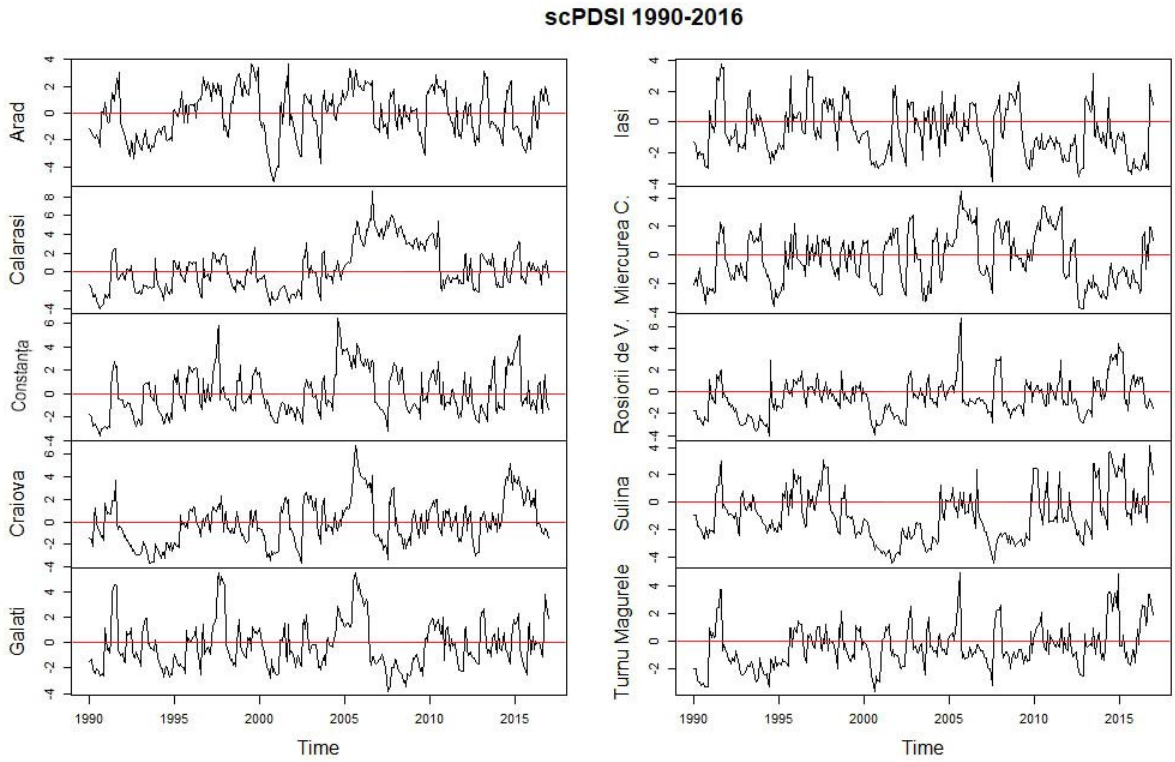

Fig. 2. The evolution of scPDSI to the analyed meteorological stations for (1990-2016) period

In scatches below (Figure 3) are presented the monthly volumes of water per hectar used to irrigate during vegetation season. The irrigation process is strongly related with the seasonal and multi-annual fluctuations of the scPDSI, therefore during a low value of the scPDSI we have high values of the water used to irrigate. As an exemnple, the values from 2012 for all the stations in the figure 2 are coresponding to the higher share of water per hectare in comparation with the 2010 wich is a wet year for most of the stations.

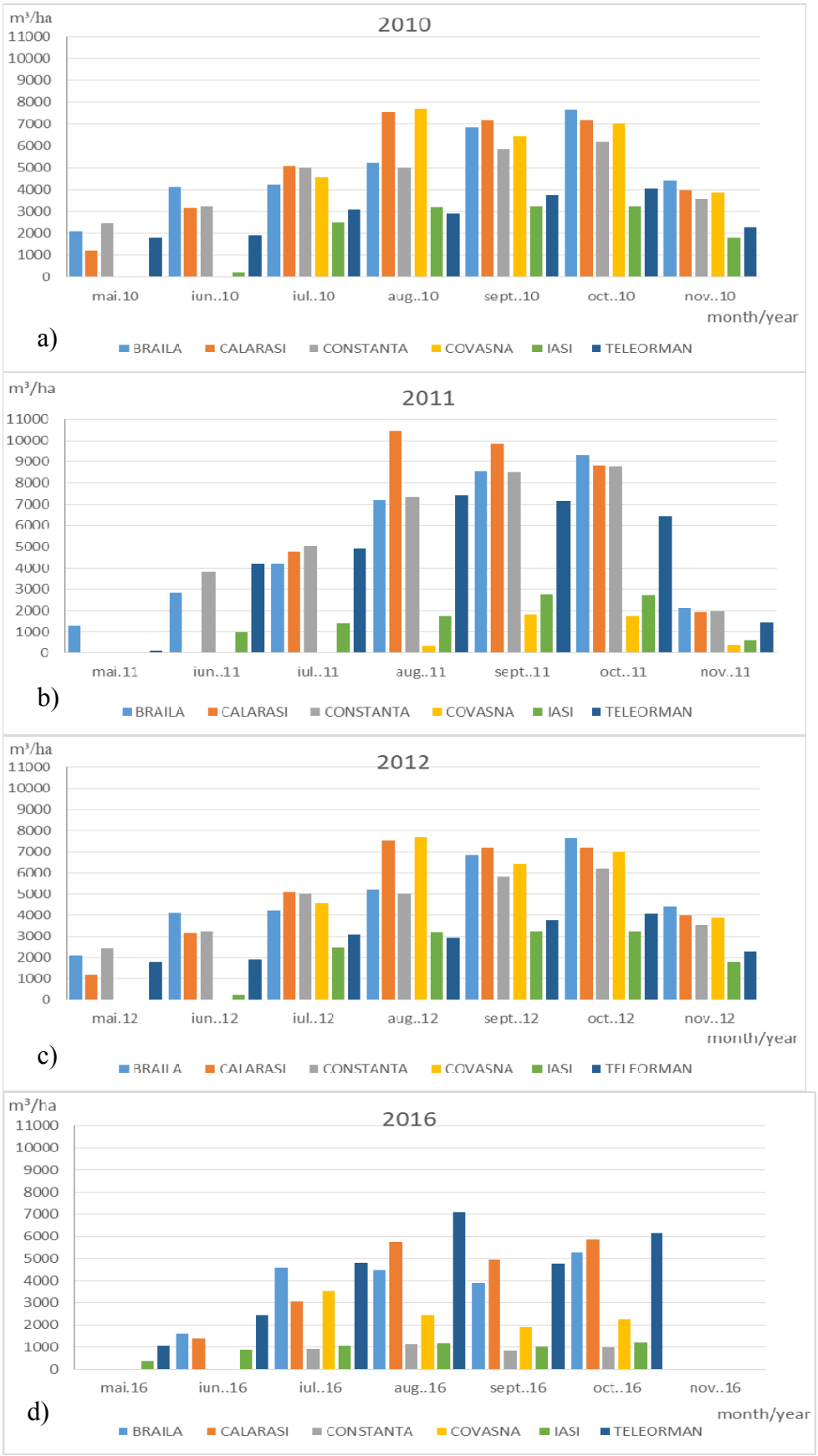

Fig. 3 (a-d). The irrigated volumes per hectare between 2010-2012 and 2016
Source: ANIF

The selected counties can be grouped by the irrigated quantities in regional patterns, this corelation being observed also for the PDSI, calculated from metheorological stations data. As example, in the counties situated in suthern Romania (Brăila, Călărași, Constanța and Teleorman) are apllied higher irrigated volumes of water than in center of the country (Covasna county) or est (Iași county). There are also exceptions recorded for Covasna county in 2010 and 2012, when the irrigated quantities were similare to the southern counties. Another exception is for Constanța county in the year 2016, when the reported quantities were smaller than for the others counties from south of Romania. From those figures results the management practices for the irrigated agricultural area during water deficit periods.

In the figures 4 and 5 is presented the pedo-metheorological status during the October and November 2012. Those months were selected in the context of extreme drought over Central Romania and South-South-Vest and severe drought in North-East. Those periods corresponds also to the maximum reported values for monthly irrigation per hectare.

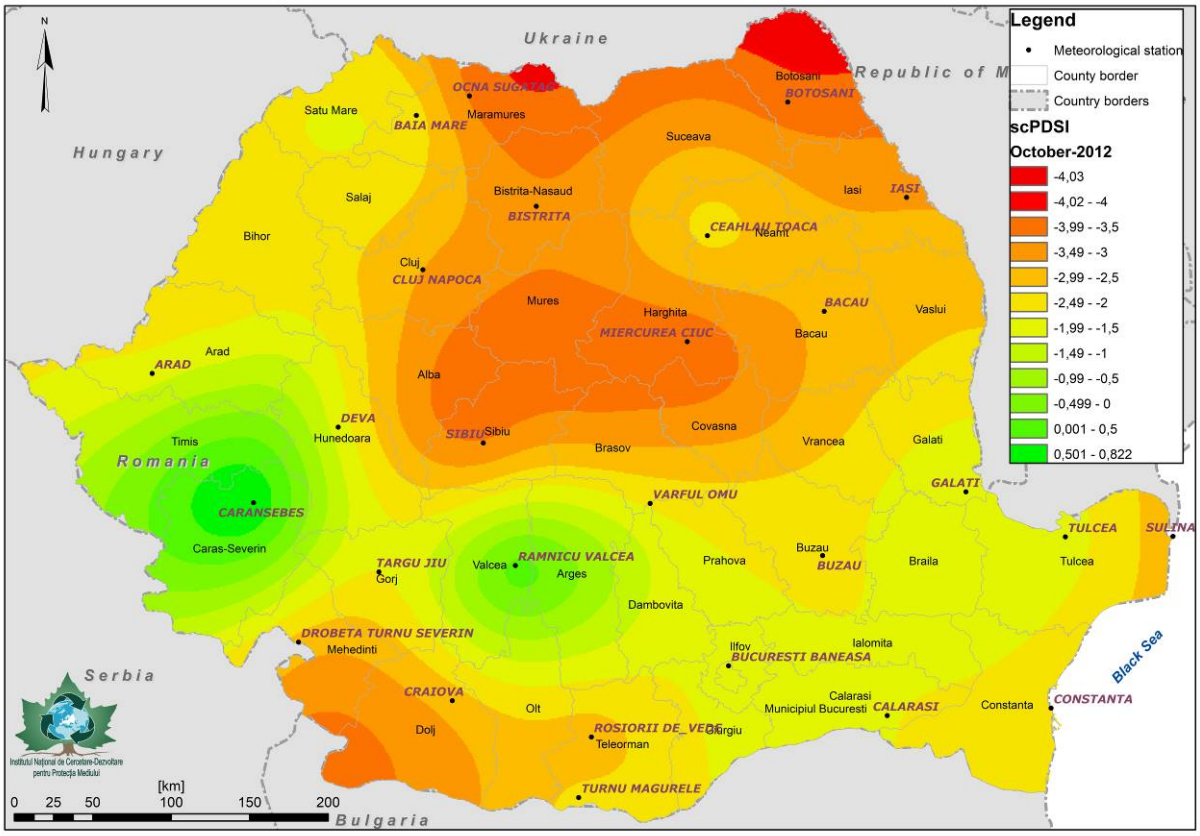

Fig. 4. Spatial distribution of soil water reserve in October 2012, based on scPDSI

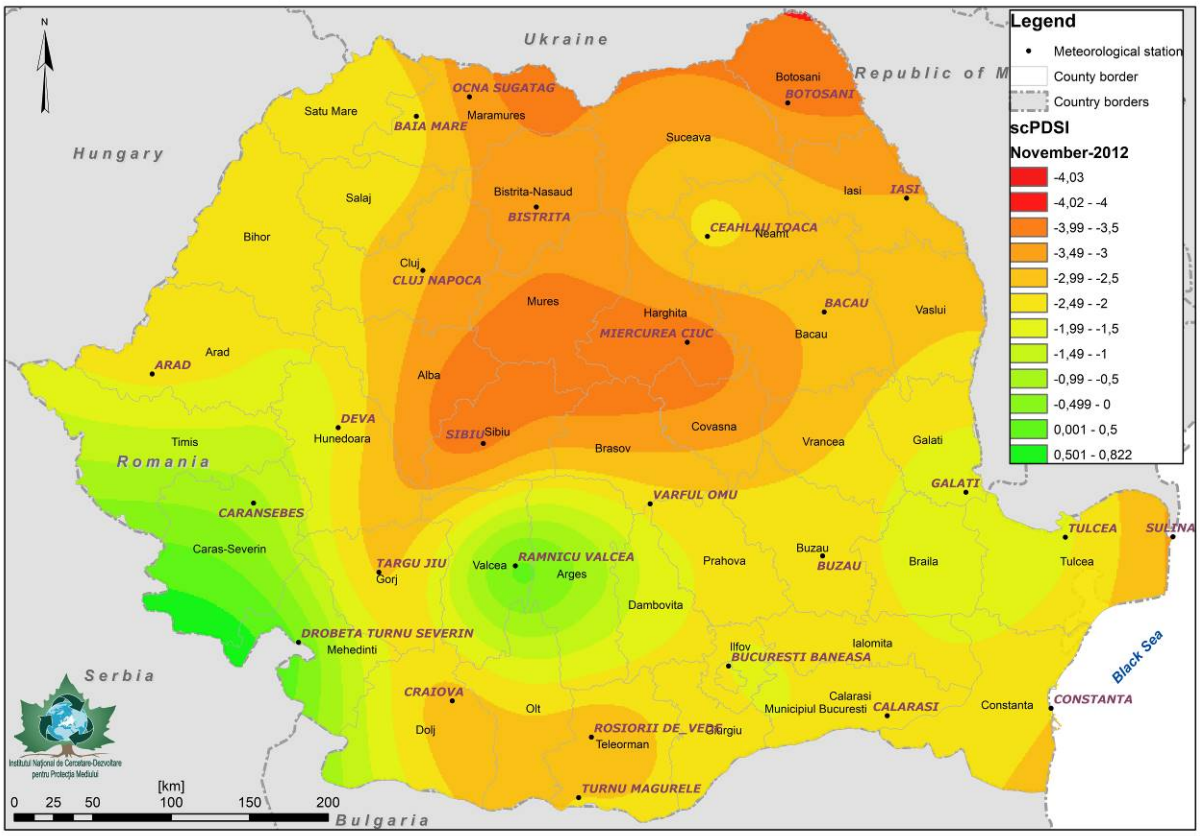

Fig. 5. Spatial distribution of soil water reserve in November 2012, based on scPDSI

From the above figures it is outlined the temporal and spatial evolution of the pedological drought as a low developing event, during the pick of the maximum intensity of the phenomena. The regional distribution of drought (Figure 4 and 5) is related to the water use for irrigation in the selected counties, presented in figure 3. Therefore the quantities used for irrigation in central part of the Romania in Covasna county were about to 7000 m^3/ha in October, similar to the others counties from Southern Romania.

4. Conclusions

From the performed analysis it can be concluded that scPDSI is an indicator of the pedo-meteorological state, useful for the management of agricultural lands, especially during water deficit periods. From the 2012 drought event we can conclude that the water use for irrigation was related to the regional distribution of the scPDSI.

The multiannual values of PDSI indicates in good manner the periods with water deficit, such as 1992-1995, 2000-2004 intervals, or single events like 2007 and 2012 droughts. Also, this indicator presents the long term evolution of the soil moisture.

The irrigation activities can use the scPDSI to schedule the water volumes for maximum efficiency. This observation is related to the water use in irrigation during the drought event of 2012, accurately detected by the scPDSI.

Additional information is necessary for the precise management of water during the drought events by considering the detailed analysis of the presented parameters and index and also supplementary data regarding the agricultural crops and irrigation systems.

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