IDENTIFICATION OF DROUGHT EXTENT BASED ON VCI USING SENTINEL DATA: A CASE STUDY OF THE EASTERN OF IAȘI COUNTY

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Abstract: In this study was analyzed zones affected by drought using Vegetation Condition Index (VCI), that is based on Normalized Difference Vegetation Index (NDVI). This fact, drought, is one of the most wide -spread and least understood natural phenomena. In this paper was used remote sensing (RS) data, kindly provided by The European Space Agency (ESA), namely Sentinel-2 (S-2) Multispectral Instrument (MSI) and wellkonwn images Landsat 8 Operational Land Imager (OLI). The RS images was processed in SNAP and ArcMap. Study Area, was considered the eastern of Iasi county. The main purpose of paper was to investigating if Sentinel images can be used for VCI analysis.

Introduction

Drought, one of the most costly disaster, can affect agricultural systems, ecosystems, wild habitats, and urban water supplies (Heim et al., 2002; Zhang et al., 2012). As a consequence, a lot of techniques for monitoring drought have been developed.

Drought is natural hazard which frequently occurs in some regions caused by the deficiency of precipitation (Zhang et al., 2013, Knutson, 1998). Drought has causing several impacts, like reducing of water quality and air, forest fire, land degradation, reducing of agricultural crops production. This situation may led to water conflict and bring people to immigrate to better place (Amarsaikhan et al., 2014; Neri et al., 2010). Therefore thus drought monitoring and evaluation is essential to prevent and minimize the impact of this phenomenon occurrence. Drought monitoring could be assessed by using drought indices (DI). The DI is defined as a combination of drought indicators (temperature, precipitation,

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vegetation condition, evapotranspiration, etc.) and provide more comprehensive information for drought analysis than using raw data of each indicators (Zargar et al., 2011).

Remote sensing technology can be used to monitor effectively over large areas of drought. Satellite-borne remote sensing data gives a synoptic view of Earth surface, so can be used to evaluate drought occurrence spatially. Have been developed and applied, a few remote-sensed (RS) drought indices, which including spatial extent, duration, intensity, and severity (Kogan 1995 & 1997, Bajgiran et al. 2008, Xu 2011, Liang et al. 2015, 2016, Li, 2003; Sivakumar, 2004; Sruthi et al., 2015). One of these, the Normalized Difference Vegetation Index (NDVI) has been one of most usually used approaches to drought episode monitoring and as a probe for vegetation health. Many drought indexes based on vegetation have been constructed, such as the NDVI and vegetation condition index (VCI) (Rouse et al. 1974, Kogan 1990, Sandholt et al. 2002, Tonini et al. 2012, Tadesse et al. 2015, Skakun et al. 2016). NDVI is sensitive to geographic environment and location, many problems can arise when carrying out drought monitoring over non-homogeneous areas (Kogan 1990 & 1995, Liu et al., 2017). To overcome these problems, Kogan (1990) proposed the VCI, which is based on the concept of the NDVI.

In this paper was evaluated drought using VCI. The input data was Sentinel images.

1.Data and methods

1.1. Study Area

Study Area is geographically situated on latitude 47°32'N to 46°49'N and longitude 26°36'E to 28°05'E.

RS data

Sentinel-2A satellite sensor was successfully launched on June 23rd, 2015 from a Vega launcher from the spaceport in Kourou, French Guiana. S-2A satellite, the first optical Earth observation satellite in Copernicus programme was developed and built under the industrial leadership of Airbus for the European Space Agency (ESA).

The S-2 Multispectral Instrument (MSI) has 13 spectral bands: 4 bands at 10 metres, 6 bands at 20 metres and 3 bands at 60 metres spatial resolution. The S-2 MSI measures the Earth's reflected radiance in 13 spectral bands from the visible and near-infrared (VNIR) to Shortwave Infrared (SWIR).

S-2A satellite image data support:

- Generic land cover, land use (LC/LU) and change detection maps
- Maps of geophysical variables for vegetation indices

S-2A satellite is able to see very changes in plant health due to its high temporal, spatial resolution and three red (R) edge bands.

The Landsat 8 satellite payload consists of 2 science instruments the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS).

Preprocessing of the Landsat-8 OLI images suppose operations that prepare images for subsequent analysis that try to compensate/ correct for systematic errors. The data are subjected of a few corrections like radiometric or atmospheric (miningeology.blogspot).

In this study was used a S-2A images taken on 20th April and 3rd September 2017 and Landsat 8 images taken on 25 th April and 9th September 2017.

1.2. Data processing

Normalized Difference Vegetation Index

NDVI was first suggested by Rouse (1973) and is a numerical indicator that uses the Red and NIR bands of the electromagnetic spectrum. Scientific community adopted to analyze RS measurements and assess whether the purpose being observed contains live green vegetation or not (Rouse, 1974). The formula to calculated NDVI values suppose subtracts the red reflectance values from the NIR reflectance and after divides it by the sum of them.

The value range from -1 to 1. Negative values of NDVI, for S-2, (values approaching -1) correspond to water. Values close to 0 (-0.1 to 0.1) generally correspond to barren areas of rock, sand, or snow. Low, positive values represents low vegetation (approximately 0.2 to 0.4), while high values indicates high vegetation (values approaching 1). For L-8 0 means the water cover, moderate values indicates low density of vegetation (0.1 to 0.3), while high values represent dense vegetation (0.6 to 0.8)

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

Vegetation Condition Index (VCI)

This index was developed to control the local differences in agricultural system productivity. VCI is a pixelwise normalization of vegetation index (VI) (NDVI, EVI etc.) that is useful for making relative assessments of variations in the VI signal by separating out the contribution of regional/local geographic resources to the spatial flexibility of VI. This index is computed as:

$$VCI = \frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}} * 100$$

The corresponding grades of the VCI values, according to Liang (2017), are shown in Table 1.

Table 1. Drought grades defined by the VCI

Grade	Type	VCI values
1	Normal	>70
2	Slight drought	50-70
3	Moderate drought	30-50
4	Severe drought	<30

2. Results and discussion

Figure 1 shows NDVI and VCI map obtained from Sentinel data (for 20th April and 3rd September 2017) and Landsat data (for 25th April and 9th September 2017). The remote sensing data was processed in SNAP (an open source software created by ESA) and ArcMap while Landsat images were processed just in ArcMap.

Table 2 shows statistics data for NDVI values for both Remote Sensing systems used in this research.

Sentinel				Landsat			
Min	Max	Mean	St. dev	Min	Max	Mean	St. dev
-0.994	0.998	0.43	0.17	-0.995	0.999	0.31	0.16
-0.138	0.713	0.368	0.13	-0.232	0.645	0.29	0.13

NDVI had high values for parameter mean for both RS systems that means the study area, in eastern Iasi county, is vegetated and drought was not so severe. NDVI value over 0.4 indicated area covered by high vegetation for S-2, and for L-8 value must be over 0.6.

Based on NDVI was developed Vegetation Condition Index (VCI), that was used in this paper to study drought. In this study were used drought classes suggested by Liang (2017) namely: normal, slight, moderate and severe drought.

NDVI map L-8 (25th April)

VCI map L-8 (25th April)

NDVI map S-2 (20th April)

VCI map S-2 (20th April)

NDVI map L-8 (9th September)
NDVI map

VCI map L-8 (9th September)
VCI map S-2 (3rd September)

Figure 1. Map drought analysis

VCI analysis indicated most of the study area is covered by class named “normal” or slight drought for both RS system images. Severe drought, confirmed by L-8 and S-2, occurs in small zones in September. Also, moderate drought affects an important area by Iasi county in April. Landsat 8 data is well known that these images can determine the area affected by drought phenomenon. VCI calculated from S-2 was confirmed by L-8 images.

Conclusions

In this paper, we evaluated drought in eastern Iasi county (study area), using Vegetation Condition Index developed by Kogan. To determine areas affected by drought using VCI, we used remote sensing data kindly provided by ESA, namely Sentinel-2 Multispectral Instrument (MSI) and Landsat 8 OLI. The main purpose for this paper was to evaluate if S-2 images can be used for calculating VCI.

Vegetation Condition Index is based on the Normalized Difference Vegetation Index. NDVI values had high values for parameter mean, indicating that the study area, in eastern Iasi county, had not unhealthy vegetation for a large area. VCI indicated a small zone affected by severe drought.

S-2 has a better resolution than L-8 and because it had similar results for VCI, S-2 is recommended to be used to determine the area affected by drought.

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