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DROUGHT EVALUATION BASED ON SPEI, SPI INDICES FOR GEORGIAN TERRITORY

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Abstract: *Drought is a frequent phenomenon in Georgia. The drought indices are good indicators of climate change, as they involve temperature and humidity variations. The objective of the study was to evaluate the correlation of SPI and SPEI for selected locations on the territory of Georgia. Based on the conducted statistical analysis drought indices were evaluated. The study is important for drought monitoring.*
Key words: *Drought indices, climate change, Pearson correlation, hydrometeorological disaster*

Introduction

Drought is frequent phenomena over the Earth. Especially its intensity has been increased due to global climate change. It is also frequent event in Georgia too. Its frequency in some areas exceeded 40% in the 80-ies of the last century by certain early estimates. As a result of frequent droughts accompanying the global warming in past decades transformation of many types of natural landscapes has been observed. The desertification probability of steppe and semi-desert landscape of eastern Georgia by the end of the twentieth century has reached 25-30%. According to official figures, by the result of intense droughts area of over than 200 000 ha is strongly affected for present. Property damage caused by drought is very significant [1].

The observation analysis shows that various degree drought may take place all over the Georgian territory. The event frequency is expected mainly on spring, summer and fall seasons. During winter due to frequent cyclonic and frontal periods dry day duration is less. The drought day number and dry period frequency increase from the Black Sea regions through east or in direction of continental climate [2].

Drought genesis in Georgia is depending on cyclonic and anticyclone motions. In first case rainy days are frequent and in second dry periods, with high temperature and low humidity of different durations have been taken place. If air masses directed from Arctic are dry and cold. They spread over long territories and stable anticyclone system is established on east-south parts of Europe. During such situation dry period happens in Georgia. If air masses are invading from east high temperature and low humidity dry weather is standing. Such periods are more brutal and dangerous [3].

Data and methods

Many drought indices were developed and used ranged from simple indices such as percentage of normal precipitation and precipitation percentiles to more complicated indices such as the Palmer Drought Severity Index. The understanding that a deficit of precipitation has different impacts on groundwater, reservoir storage, soil moisture, snowpack and stream flow led American scientists McKee, Doesken and Kleist to develop the Standardized Precipitation Index (SPI) in 1993.

In 2010 WMO selected the SPI as a key meteorological drought indicator to be produced operationally by meteorological services. he Standardized Precipitation Index (SPI-n) is a statistical indicator comparing the total precipitation received at a particular location during a period of n months with the long-term rainfall distribution for the same period of time at that location. SPI is calculated on a monthly basis for a moving window of n months, where n indicates the rainfall accumulation period, which is typically 1, 3, 6, 9, 12, 24 or 48 months. The Standardized Precipitation Index (SPI) is a widely used index to characterize meteorological drought on a range of timescales. On short timescales, the SPI is closely related to soil moisture, while at longer timescales, the SPI can be related to groundwater and reservoir storage. The SPI can be created for differing periods of 1-to-36 months, using monthly input data. For the operational community, the SPI has been recognized as the standard index that should be available worldwide for quantifying and reporting meteorological drought. Concerns have been raised about the utility of the SPI as a measure of changes in drought associated with climate change, as it does not deal with changes in evapotranspiration. Alternative indices that deal with evapotranspiration have been proposed [1].

The SPEI is designed to take into account both precipitation and potential evapotranspiration (PET) in determining drought. Thus, unlike the SPI, the SPEI captures the main impact of increased temperatures on water demand. Like the SPI, the SPEI can be calculated on a range of timescales from 1-48 months. At longer timescales (>~18 months), the SPEI has been shown to correlate with the self-calibrating PDSI (sc-PDSI). If only limited temperature and precipitation data are available, PET can be estimated with the simple Thornthwaite method. In this simplified approach, variables that can affect PET such as wind speed, surface humidity and solar radiation are not accounted for. In cases where more data are available, a more sophisticated method to calculate PET is often preferred in order to make a more complete accounting of drought variability. However, these additional variables can have large uncertainties. Calculation of the SPEI is implemented in the R package SPEI [4].

In order to conduct research meteorological observation data of National Environmental Agency has been used for selected stations during 2001-2019 year period. The selected station data satisfy all requirements of research: passed QC, are continuous and homogeny. Those stations are: Bolnisi, Dedoplistskaro, Gori, Khashuri, Tbilisi, Telavi, Tsalka, Sachkhere and Zestaphoni

In study Pearson correlation coefficient (PCC), determination coefficient (R^2), and root mean square error (RMSE) criteria, which are among the strong statistical criteria, were used. R^2 ranges from 0 to 1, with higher values indicating less error variance. The **RMSE** is the square root of the variance of the residuals. It indicates the absolute fit of two data set and lower the RMSE the better performance is.

Discussion

In order to compare drought indices, scatter diagrams of indices were drawn and statistically evaluated. For this, R^2 and the RSME were used. Correlation between data sets is a measure of how well they are related.

At Gori, SPEI index decreased while SPI has an increasing tendency. At the Tbilisi location all indices indicate that monthly precipitation decreases while water vapor evaporation increases. At Telavi station all SPEI indices have the decreasing tendency and SPI indices increasing, which demonstrates on precipitation amount is increasing. Thus, SPEI and SPI indices reflect the complex mosaic character of Georgian climate change.

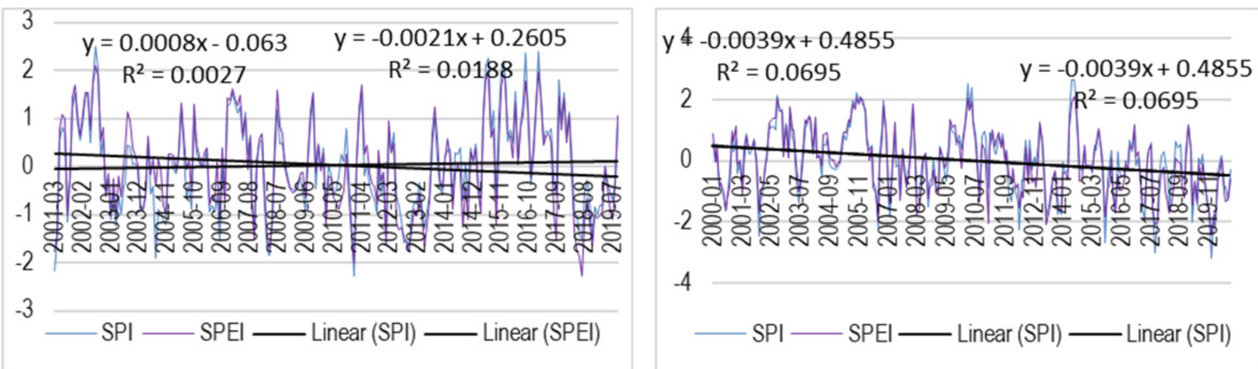

Fig.1. SPI, SPEI indices for Zestaponi and Tsalka stations in 2001-2019 year period

The most common measure of correlation in stats is the Pearson Correlation Coefficient (PCC), which shows linear relationship between SPI-SPEI is quite high, RMSE (SPI-SPEI) is low especially for Khashuri and Telavi;

PCC for SPI-SPEI is high. $R^2$is low for all stations. RMSE (SPI-SPEI) is low which means perfect fitting, (Tab.1).

Table 1. Statistical parameters of selected stations

Station	Covar	Kurt	Pearson	R^2-spi	R^2-spei	RMSE
Zestaponi	0.857534	-0.49676	0.942305	0.0027	0.0188	0.025909
Tsalka	0.857534	-0.49676	0.942305	0.0695	0.0695	0.009268
Telavi	0.857534	-0.49676	0.942305	0.0013	0.0263	0.015006
Tbilisi	0.857534	-0.49676	0.942305	0.0058	0.0347	0.017471
Sachkhere	0.857534	-0.49676	0.942305	0.0241	0.0016	0.021206
Khashuri	0.857534	-0.49676	0.942305	0.0064	0.0918	0.009364
Gori	0.857534	-0.49676	0.942305	0.0034	0.0315	0.000938
Dedoplistskaro	0.857534	-0.49676	0.942305	0.0233	0.0785	0.016065
Bolnisi	0.857534	-0.49676	0.942305	0.0006	0.0102	0.010778

The obtained results may be used in modeling of hydrometeorological disasters to develop forecasting system in Georgia [5].
The research shows that related studies must be carried out for a relatively long series of data using different indices, which allow a clearer picture of the droughts evolution and may be used in early warning system to protect environment and citizens.

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