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INVESTIGATION OF THE TRENDS IN RAINFALL DATA IN SLOVAKIA, PORTUGAL AND LIBYA

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ABSTRACT

One of the goals of the hydrological risk assessment is to reduce the impacts of droughts and floods. The objective of study is to investigate rainfall trends in climatic stations in Slovakia, Portugal and Libya. Annual and seasonal precipitation trends were detected by the Mann-Kendall non-parametric statistical test. The annual rainfall series at the Portuguese and Libyan climatic stations show mostly downwards trends (decreasing rainfall) while the series at the Slovak climatic stations show upwards trends (increasing rainfall). The results are in accordance with the IPCC forecasts. They also indicate that the variability of extreme rainfall and the climate uncertainty are greater in recent times.

Keywords: precipitation; trend; Mann-Kendall; climatic change.

Introduction

Observations show that changes are occurring in the amount, intensity, frequency and type of precipitation. These aspects of precipitation generally exhibit large natural variability, and El Niño and changes in atmospheric circulation patterns such as the North Atlantic Oscillation have a substantial influence. Pronounced long-term trends from 1900 to 2005 have been observed in precipitation amount in some places: significantly wetter in eastern North and South America, northern Europe and northern and central Asia, but drier in the Sahel, southern Africa, the Mediterranean and southern Asia. More precipitation now falls as rain rather than snow in northern regions. Widespread increases in heavy precipitation events have been observed, even in places where total amounts have decreased. These changes are associated with increased water vapour in the atmosphere arising from the warming of the world's oceans, especially at lower latitudes. There are also increases in some regions in the occurrences of both droughts and floods (IPCC, 2007).

In recent years, a number of studies have been published focusing on the evolution of precipitation, drought conditions and moisture availability in the Mediterranean during the 20th century (e.g., Paulig and Paeth, 2006; Lopez-Moreno *et al.*, 2009; Sousa *et al.*, 2011). El Kenawy *et al.* (2009) investigated spatial variability of temperature trends over Libya in the second half of the 20th century. One of the most extensive analyses of the spatial and temporal patterns of precipitation in Portugal was developed by Portela *et al.* (2013), Santos *et al.*

(2010), Santos and Portela (2008). Trends in precipitation in Libya were studied in Zeleňáková *et al.* (2013), Zeleňáková *et al.* (2014).

The detection of trends in meteorological data, in particular rainfall is essential for the assessment of the impacts of climate variability and change on the water resources of a region. This paper deals with the research of monthly precipitation trends in climatic stations in Libya and Slovakia in different time series - annual, half year, seasons. The Mann-Kendall test is example of non-parametric tests and was applied to detect trends and to assess the significance of the trends in the time series in presented paper.

Material and methods

Monthly rainfall data recorded at four stations in eastern Slovakia provided by Slovak Hydrometeorological Institute with length from 1980 to 2010 were collected for this study. In Portugal monthly rainfall data from 1910 to 2004 at four stations were used for statistical trend analysis. In Libya four stations and 40 years of data observation operated by Libya's Meteorological Service from 1970 to 2010 were set up to study precipitation trends. The evaluation was done for the time period from November to October in Slovakia and Libya and from October to September in Portugal. We have selected four stations in each country exactly with the altitude around 400 m asl. to exclude the effect of altitude to precipitation trends. In Libya: Ghadames, Sabha, Al Kufrah are situated in the desert (in the south) and Shahat is situated near the seaside.

The Mann-Kendall (MK) test (Kendall, 1975; Mann 1945) is a rank-based nonparametric test for assessing the significance of a trend, and has been widely used in hydroclimatological trend detection in many studies (Burn and Elnur, 2002). The significance level is chosen as $\alpha = 0.05$ and $Z_{\alpha/2}$ is the value of normal distribution function, in this case $Z_{\alpha/2} = 1.95996$. Hypothesis H_0 - no trend is if ($Z < Z_{\alpha/2}$) and H_1 - there is a trend if $Z > Z_{\alpha/2}$. The magnitude of the trend was determined using Sen's estimator (Sen, 1968). A positive value indicates an upward (increasing) trend and a negative value indicates a downward (decreasing) trend in the time series.

Results

The results of trend analysis for the precipitation data are discussed in the following. Results of precipitation analysis are presented for annual, half year, seasons in Table I for climatic stations in Slovakia, in Table II for stations in Portugal and in Table III for climatic stations in Libya. Two signs (++ or --) indicate statistical significance at 95% confidence level as per the Mann-Kendall test (+ for increasing and - for decreasing).

Table I Sen's estimator for annual, half year and seasons trends in precipitation in Slovakia

Station	Altitude	Annual	Half year			Seasons			
		XI-X	XI-IV	V-X	XI-I	II-IV	V-VII	VIII-X	
Spišská Nová Ves	456	++	+	+	+	+	++	+	
Spišské Vlachy	380	+	+	++	+	+	++	+	
Mníšek nad Hnilcom	410	++	++	++	+	+	++	+	
Jakubovany	410	+	+	+	-	+	+	+	

Table II Sen's estimator for annual, half year and seasons trends in precipitation in Portugal

Station	Altitude	Annual	Half year			Seasons			
		X-IX	X-III	IV-IX	X-XII	I-III	IV-VI	VII-IX	
Chaves	350	-	-	0	+	--	-	+	
Sao Miguel da Acha	376	--	--	0	-	--	-	0	
Mosteiro de Cabril	389	-	--	+	-	--	-	0	
Torre de Dona Chama	359	0	-	+	+	--	-	+	

Table III Sen's estimator for annual, half year and seasons trends in precipitation in Libya

Station	Altitude	Annual	Half year			Seasons			
		XI-X	XI-IV	V-X	XI-I	II-IV	V-VII	VIII-X	
Ghadames	330	--	--	-0	-0	--	-0	-0	
Sabha	420	+0	+0	+0	-0	-0	+0	+0	
Shahat	531	++	++	++	++	++	+0	++	
Al Kufrah	436	-0	-0	-0	-0	-0	-0	-0	

Trend analysis of rainfall series in Slovakia shows the mainly positive values. Significant positive trends are mainly in station Mníšek nad Hnilcom which is situated in southern part of study area. The trend slope is increase of annual precipitation e.g. in Mníšek nad Hnilcom it is 0.057 mm/year (Zeleňáková *et al.*, 2014). Significant positive trend is in stations - Spišská Nová Ves, Spišské Vlachy, Mníšek nad Hnilcom mainly in summer, in winter the trend is slightly decreasing. The trend is opposite in Portugal climatic stations. All evaluated stations present mainly decreasing trend in rainfall amount, significant in spring. Slightly positive trend is detected in station Torre de Dona Chama.

Rainfall data series did not show any clear trend for the Libya's stations. Rainfall trends show large variability. It depends upon many factors, as was said, namely latitude, altitude, and distance from the sea. Declining trend in rainfall presents desert stations: Ghadames and Al Kufrah. The Shahat station presents increasing trend.

Conclusion

The objective of this study was to investigate precipitation trends in chosen climatic stations in Slovakia, Portugal and Libya. We investigated 4 climatic stations in different time series.

Almost all the gauging stations in Slovakia show positive trend of annual precipitation. Annual, half year and seasons trends in precipitation in Portugal show decreasing trend. It proved pronounced long-term trends from Intergovernmental Panel for Climatic Changes from 1900 to 2005 that have been observed in precipitation amount in some places: wetter in northern Europe (Slovakia), but drier in the Mediterranean. The exception is Shahat station in Libya in which the precipitation trends are positive. The influence of other factor such as exposition of the station etc. is probable. The high risk of drought is presented in western and souther part of Libya.

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