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CHANGES IN PRECIPITATION OVER THE EAST HERZEGOVINA REGION

Abstract: Changes in annual and seasonal precipitation over the East Herzegovina region in Bosnia and Herzegovina during the 1961–2016 periods were analyzed based on data sets of daily precipitation from 14 meteorological stations and rainfall gauges. The results show a downward trend in annual precipitation over the entire East Herzegovina region. Seasonal trend analysis showed that negative trends prevailed throughout the year, except in autumn season. Most prominent negative trends were registered in summer season throughout the region. In winter and spring season, precipitation displayed trends of both sign (although a downward trend prevailed). In the autumn season, precipitation has increased almost throughout the entire East Herzegovina region. However, a majority of estimated trends in annual and seasonal precipitation were weak and statistically insignificant. Prevailing negative values of the Rainfall Anomaly Index since the 1990s also suggest that precipitation reduction was present over the East Herzegovina region. Analysis of the Cumulative Precipitation Anomalies showed that a dry period started in 1981 and still continues. Precipitation variability was strongly dictated by the large-scale atmospheric circulation patterns over the Northern Hemisphere, such as the North Atlantic Oscillation, the East Atlantic/West Russia pattern and the Arctic Oscillation, particularly during winter season.

Key words: precipitation, trend analysis, Rainfall Anomaly Index, Cumulative Precipitation Anomalies, East Herzegovina region (Bosnia and Herzegovina).

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Introduction

The Mediterranean region is one of the hotspots of climate change (i.e. a region with climate system particularly responsive to global change) (Giorgi, 2006). The Eastern Mediterranean region is greatly affected by climate change, associated with increases in the frequency and intensity of droughts and hot weather conditions (Lelieveld et al., 2012). Significant changes in mean and extreme temperatures, consistent with a global warming were found all over the Mediterranean region (Kioutsioukis et al., 2010; Burić et al., 2015; Fioravanti et al., 2016; Fonseca et al., 2016; Espirito Santo et al., 2014).

Unlike to many mid-latitude and high-latitude regions of the world in which positive precipitation trends were reported, over the Mediterranean region decreasing trends were dominant (Alpert et al., 2002). However, in spite of the general reduction in the total precipitation, extreme daily rainfall increased due to increased temperature and atmospheric water vapor content (Alpert et al., 2002). Significant negative trends in annual precipitation were found over the majority of Mediterranean areas, with an exception of northern Africa, southern Italy and western Iberian Peninsula, where slight positive trends appeared (Philandras et al., 2011). During the second half of the 20th century and at the beginning of the 21st century, a decrease in annual precipitation has predominated in the vast majority of areas across the Mediterranean region (Philandras et al., 2011; Kelley et al., 2012; López-Moreno et al., 2010; De Luis et al., 2009; Caloiero et al., 2018; Hatzianastassiou et al., 2008). Particularly prominent was a change in wintertime precipitation towards drier conditions, which has occurred since the beginning of the 20th century (Hoerling et al., 2012). Hoerling et al. (2012) state that during the observed 1902–2009 periods, 10 of the 12 driest winters occurred in just the last 20 years.

Over the Mediterranean areas in southeastern part of Europe, seasonal precipitation displayed trends mixed in sign - in winter, spring and summer precipitation generally decreased, whereas in autumn season an increasing tendencies were found (Gajić-Čapka et al., 2015; Burić et al., 2015b).

Given that previous research on precipitation changes in Bosnia and Herzegovina (e.g. Popov et al., 2017; Popov et al., 2018; Popov et al., 2018b; Trbic et al., 2010) were mainly focused on Peripannonian part of the country, the East Hercegovina region remain poorly examined so far did. This study focuses on the analysis of changes in precipitation over this mediterranean area in order to overcome the existing knowledge gaps in climate change research. The main aim of this study was to analyze changes in precipitation over the East Herzegovina region during the 1961-2016 periods. Main research tasks were to estimate trends in annual and seasonal precipitation, to analyse the Rainfall Anomaly Index (RAI) and Cumulative Precipitation Anomalies (CPA), and finally, to investigate the relationship between the precipitation variability and the large-scale circulation patterns over the Northern Hemisphere.

Study area, material and methods

Study area covers the East Herzegovina region located in the southeastern part of Bosnia and Herzegovina. It encompasses the part of the Herzegovina region east of the Neretva River, within the boundaries of the Republic of Srpska. It is located at 42°33'23"–43°29'22"N and 17°55'23"–18°43'3"E. With a total area of 3,756 km^2, it covers 7 % of the Bosnia and Herzegovina total area and 15 % of the Republic of Srpska territory. Analysis of precipitation variability over the study area during the 1961–2016 periods was carried out based on daily precipitation from 14 meteorological stations and rainfall gauges located in all physical regions of the East Herzegovina: Humine (up to about 400 m), Rudine (about 400–600 m) and mountainous area in the northern and southeastern part of the region (over 600 m) (Fig. 1). The vast majority of the region is represented by mezozic limstone and dolomite, whereas the youngest paleogen sediments (conglomerates, flysch, clay and sandy limestone) is characteristic for mountainous areas. As a result of prevailing limestone geology, permanent surface river flows are poorly represented, whereas surface runoff is extremely weak and almost does not exist.

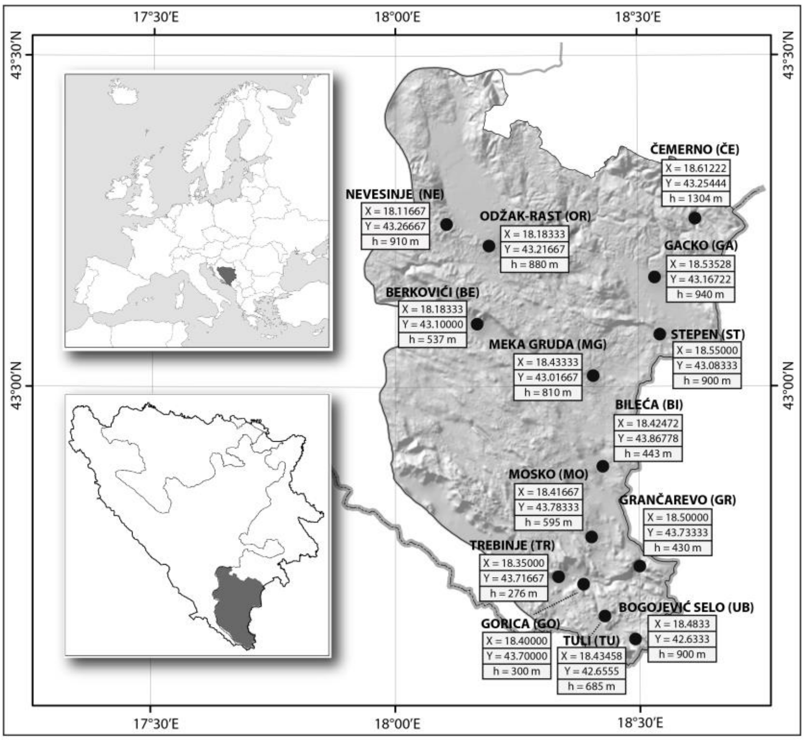

Fig. 1. The geographical location of the study area

Selected stations cover a wide range of altitudes - the relative height difference between Trebinje (276 m) and the highest-located station Čemerno (1,304 m) is being 1,028 m. Data were provided by the Republic Hydrometeorological Service of the Republic of Srpska and the Public Company Hydropower Plants on the Trebišnjica River A.D. Trebinje. Given that there were certain interruptions in measurements at majority of stations (specifically during the war periods), missing data were extrapolated based on data from the Mostar station, the earest station with continuous measurements during the study period.

Trends in annual and seasonal precipitation were estimated for the 1961–2016 periods using the nonparametric Mann-Kendall test and Sen's nonparametric estimator of slope. Further, differences in average precipitation values between two long-term periods – the 1961–1990 period and the 1991–2016 period, were investigated. Interannual precipitation variability was also analyzed using the Rainfall Anomaly Index (RAI) and Cumulative Precipitation Anomalies (CPA).

Rainfall Anomaly Index was calculated by the following formula:

$$\mathrm{RAI} = -3 \times \frac{P_i - \overline{P}}{\overline{E} - \overline{P}}$$

where Pi is the total annual precipitation for each year, $\overline{P}$ is the average annual precipitation for the 1961–2016 periods, and $\overline{E}$ is the average precipitation in the ten driest 10 years during the observed period (Van Rooy, 1965). Cumulative Precipitation Anomalies (CPA) was used to identify wet and dry periods in precipitation time series – a wet/dry period correspond to the positive/negative slopes of the graphs (Nikolova & Vassilev, 2005). Cumulative Precipitation Anomalies (CPA) were calculated as cumulated anomalies of the differences between annual (seasonal) precipitation for each year (season) (Pi) and average values for the 1961–2016 periods ($\overline{P}$):

$$\mathrm{CPA} = \sum_{i=1}^{n} (P_i - \overline{P})$$

Precipitation Concentration Index (PCI) was analyzed as a measure of intra-annual precipitation variability. It was calculated by the following formula:

$$\mathrm{PCI} = \sum_{i=1}^{12} p_i^2 \Bigg/ \left(\sum_{i=1}^{12} p_i\right)^2 \times 100$$

where pi is the monthly precipitation in month i (Oliver, 1980). PCI values below 10 indicate a uniform monthly precipitation throughout the year; values from 11 to 20 denote seasonality in precipitation distribution, whereas values above 20 correspond to climates with substantial monthly precipitation variability.

Precipitation variability over the study area is strongly affected by large-scale atmospheric circulation patterns such as the North Atlantic Oscillation (NAO), the East Atlantic/West Russia pattern (EATL/WRUS) and the Arctic Oscillation (AO) (Hurrell, 1995; Krichak, 2005; Thompson & Wallace, 1998). Data on indices of these teleconnection patterns were collected from the Climate Prediction Center of the National Oceanic and Atmospheric Administration's National Weather Service (NOAA CPC, 2017). For relation quantification, the Pearson correlation coefficients were calculated on annual and seasonal levels. Correlation analysis was performed for regionally averaged precipitation values. All tests and calculations were performed in XLSTAT Version 2014.5.03.

Results and discussion

The average annual and seasonal precipitation over the East Herzegovina region in the observed 1961-2016 periods are shown in Tab. 1. Mean annual precipitation over majority areas is in the range of 1,492.7–1,892.9 mm. Spatial pattern of precipitation is complex, but in general, precipitation sum is the highest in the mountains areas – in the northern and the extreme southeastern parts of the region. The highest annual precipitation were registered over the mountainous area in the extreme southeast where more than 2000 mm occurs annually – in Tula and Ubla-Bogojević selo area 2,056.6 mm and 2,694.8 mm, respectively. Orographic influence has the greatest importance for such high precipitation amounts at the Orijen Mountain region (Ducić et al., 2012).

Tab. 1. Average annual and seasonal precipitation over the East Herzegovina region in 1961–2016

M. s.	Winter	Spring	Summer	Autumn	Growing season	Year
			mm			
ČE	534.6	433.5	255.5	579.1	676.1	1,796.2
NE	550.3	425.8	230.4	532.3	635.4	1,732.1
OR	484.9	360.6	214.5	514.2	568.1	1,568.3
GA	523.9	383.3	213.0	567.5	593.6	1,682.4
BE	476.4	355.1	207.7	524.0	557.9	1,556.9
ST	487.5	364.5	214.8	497.9	570.4	1,558.4
MG	524.9	380.9	207.5	542.1	578.4	1,648.0
BI	507.9	366.8	205.7	522.3	560.6	1,596.5
MO	643.6	424.5	203.8	629.6	606.0	1,892.9
GR	487.5	319.5	172.2	519.7	491.8	1,492.7
TR	547.2	370.0	201.8	566.1	568.5	1,678.4
GO	537.7	371.2	171.1	543.9	525.7	1,618.5
TU	756.4	455.5	196.4	658.3	604.4	2,056.6
UB	1,049.7	602.9	219.5	832.2	729.4	2,694.8
REGION	579.5	401.0	208.1	573.5	590.4	1,755.2
			%			
ČE	29.8	24.1	14.2	32.2	37.6	100.0
NE	31.8	24.6	13.3	30.7	36.7	100.0
OR	30.9	23.0	13.7	32.8	36.2	100.0
GA	31.1	22.8	12.7	33.7	35.3	100.0
BE	30.6	22.8	13.3	33.7	35.8	100.0
ST	31.3	23.4	13.8	31.9	36.6	100.0
MG	31.8	23.1	12.6	32.9	35.1	100.0
BI	31.8	23.0	12.9	32.7	35.1	100.0
MO	34.0	22.4	10.8	33.3	32.0	100.0
GR	32.7	21.4	11.5	34.8	32.9	100.0
TR	32.6	22.0	12.0	33.7	33.9	100.0
GO	33.2	22.9	10.6	33.6	32.5	100.0
TU	36.8	22.1	9.6	32.0	29.4	100.0
UB	39.0	22.4	8.1	30.9	27.1	100.0
REGION	33.0	22.8	11.9	32.7	33.6	100.0

Precipitation regime over the East Herzegovina region is defined by wet winters and drier summers, and is characterized by substantial spatial and temporal variability. Maximum precipitation occurs in winter season, during which 29.8–39.0% of total annual precipitation is registered, and then in autumn (30.7–34.8%). Minimum precipitation is a characteristic of summer season. During this warmest part of the year substantially less precipitation occurs – only 8.1–14.2% of total annual precipitation. The Precipitation Concentration Index (PCI) values in the range of 12–14% also suggest that intra-annually precipitation does not show uniform distribution (Fig. 2).

Precipitation regime over the Mediterranean region is defined by wet winters and drier summers, and is characterized by substantial spatial and temporal variability (Kelley et al., 2012). Over the East Herzegovina region, maximum precipitation occurs in winter season, during which 29.8–39.0% of total annual precipitation is registered, and then in autumn (30.7–34.8%). Minimum precipitation is a characteristic of summer season. During this warmest part of the year substantially less precipitation occurs – only 8.1–14.2% of total annual precipitation. The Precipitation Concentration Index (PCI) values in the range of 12–14% also suggest that intra-annually precipitation does not show uniform distribution, but denotes a seasonal distribution characterized by monthly heterogeneity (Fig. 2).

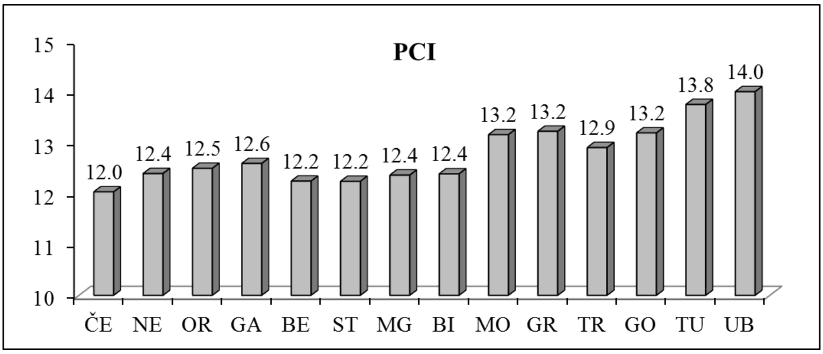

Fig. 2. Average PCI values over the East Herzegovina region in 1961–2016

Decadal trends in annual and seasonal precipitation in the 1961-2016 periods are shown in Tab. 2. Annual precipitation decreased over the entire East Herzegovina region. However, estimated trend values were not statistically significant at most of the stations, except at Tula and Berkovići station (-78.9 mm per decade and -39.9 mm per decade, respectively). Seasonal trend analysis showed that negative trends prevailed throughout the year (except in autumn season). Most prominent negative trends were registered in summer season, which represents the driest and the hottest part of the year. In summer, precipitation was reduced throughout the region, whereas in winter and spring season precipitation displayed less coherent patterns of change, with trends spatially mixed in sign, but mainly weak and insignificant. However, it should be noted that a downward trend prevailed. At majority of stations, precipitation increased in autumn season.

Tab. 2. Decadal trends in annual and seasonal precipitation over the East Herzegovina region in 1961–2016 (mm per decade)

M. s.	Winter	Spring	Summer	Autumn	Growing season	Year
ČE	-9.8	-9.6	-8.0[d]	0.5	-2.2	-29.1
NE	0.3	-2.6	-12.7[d]	-6.4	-0.6	-33.3
OR	-8.4	-11.0	-13.3[c]	6.2	-7.1	-28.0
GA	10.7	-4.2	-11.8[d]	3.8	-4.1	-13.2
BE	-24.8[d]	-2.3	-11.9[d]	-1.9	-12.3	-39.9[d]
ST	9.5	-0.9	-12.7[c]	12.8	-10.6	-14.2
MG	-0.1	-4.8	-8.6	16.2	2.9	-10.7
BI	2.3	-3.4	-14.8[c]	12.4	-10.8	-6.2
MO	-8.6	-6.1	-5.9	1.8	-2.2	-21.1
GR	8.4	-1.0	-12.4[c]	5.8	-9.3	-15.3
TR	-4.0	-5.0	-14.7[d]	0.3	-16.2	-26.7
GO	2.6	-6.4	-5.5	7.5	-12.3	-10.8
TU	-32.4	-12.3	-15.5[c]	-9.7	-31.4[c]	-78.9[c]
UB	-1.7	-6.7	-14.8[c]	8.1	-13.7	-4.8
REGION	-3.2	-4.4	-12.0[c]	5.7	-6.1	-25.2

Note: Statistical significance at the 99.9% ([a]), 99% ([b]), 95% ([c]) and 90% ([d]) level

Average summer precipitation over the East Herzegovina region in the 1991–2016 periods decreased by 9.0–25.9% relative to the reference 1961–1990 periods, whereas in autumn increased by 1.8–14.6% (Fig. 3).

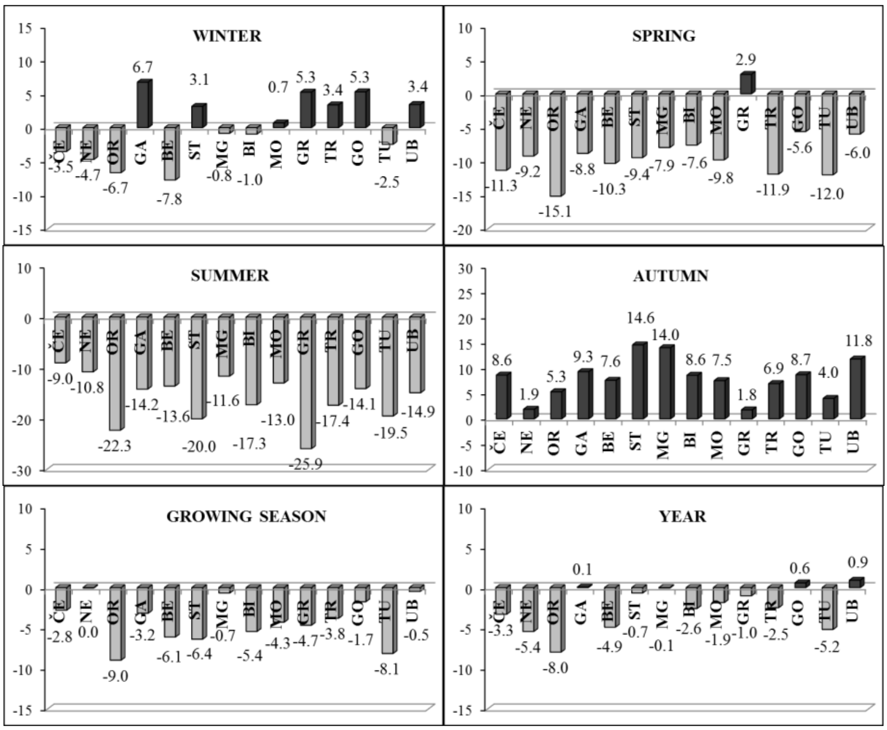

Fig. 3. Changes in average annual and seasonal precipitation over the East Herzegovina region in 1991–2016 relative to 1961–1990 (in %)

Prevailing negative values of the Rainfall Anomaly Index since the 1990s also confirm that rainfall has been reduced (Fig. 4). In the observed period, two wet periods (positive slops on the graphs displayed in Fig. 4) can be identified: during the first decade (1961–1970/1971) and in 1976–1981 (Fig. 5). Dry periods were registered in 1971–1975/1976 and since 1980/1981. Analysis of the Cumulative Precipitation Anomalies (CPA) showed that at majority of stations, a dry period (negative slope of the graphs) started in 1981 and continues. It is evident that duration of dry events was substantially longer than duration of wet periods. Moreover, the intensity of drought events was much more prominent than the intensity of wet events (Fig. 6), which is typically for Mediterranean region. Similar results were obtained for summer season, during which even more prominent changes towards drier conditions occurred. In summer, a dry period began in 1979 over the entire region. It should be noted that precipitation anomalies have been particularly strong since the 1990s, and especially since the beginning of the 21st century.

According to the RAI classification (Tab. 3), over the East Herzegovina region there was 10–15 extremely dry years or very dry years, whereas 5–12 years were in the category extremely wet or very wet. The driest years were 1994, 2011, 1983, 1989, 1990 etc., whereas very wet years were 2010, 1979, 1996, 1964, 2009 etc. (Fig. 4).

Tab. 3. Annual precipitation according to the RAI classification (Van Rooy, 1965)

Description	RAI	ČE	NE	OR	GA	BE	ST	MG
Extremely wet	≥3.00	3	5	2	3	2	4	6
Very wet	2.00 to 2.99	5	4	3	6	5	6	3
Moderately wet	1.00 to 1.99	10	8	10	8	9	10	8
Slightly wet	0.50 to 0.99	4	4	6	9	5	2	4
Near normal	−0.49 to 0.49	8	7	8	3	7	10	12
Slightly dry	−0.99 to −0.50	4	2	5	7	6	4	4
Moderately dry	−1.99 to −1.00	6	13	7	7	11	8	7
Very dry	−2.99 to −2.00	13	10	12	10	6	8	8
Extremely dry	≤−3.00	3	3	3	3	5	4	4
Description	RAI	BI	MO	GR	TR	GO	TU	UB
Extremely wet	≥3.00	4	2	5	4	4	4	6
Very wet	2.00 to 2.99	7	5	7	4	8	4	6
Moderately wet	1.00 to 1.99	4	9	6	8	3	8	3
Slightly wet	0.50 to 0.99	6	4	2	5	3	1	7
Near normal	−0.49 to 0.49	8	11	8	10	11	12	11
Slightly dry	−0.99 to −0.50	3	6	5	3	7	7	5
Moderately dry	−1.99 to −1.00	14	8	12	10	10	9	6
Very dry	−2.99 to −2.00	5	7	8	8	6	7	8
Extremely dry	≤−3.00	5	4	3	4	4	4	4

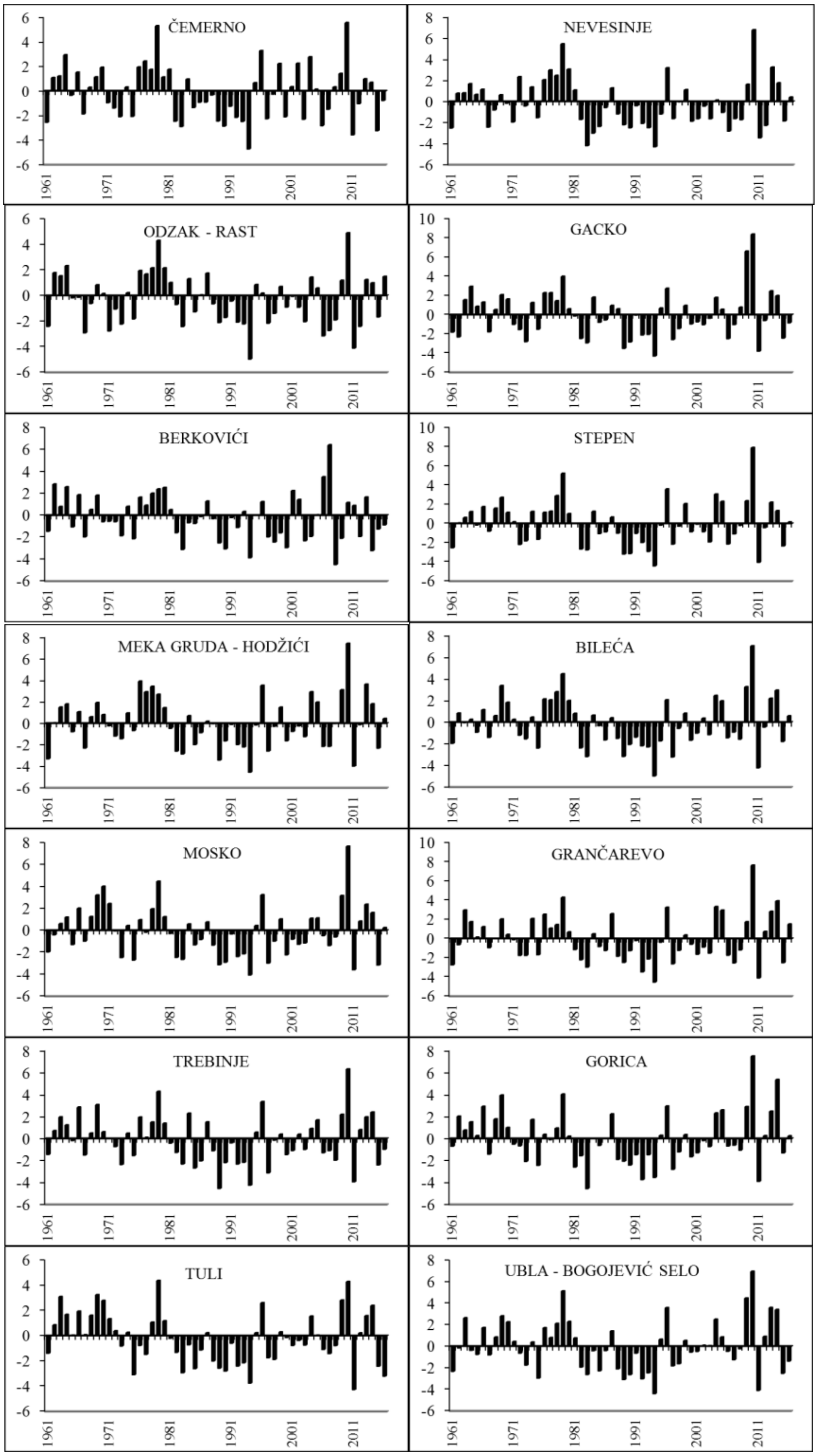

Fig. 4. RAI for annual precipitation over the East Herzegovina region in 1961–2016

Precipitation variability over the East Herzegovina region is strongly dictated by the large-scale atmospheric circulations over the Northern Hemisphere - the North Atlantic Oscillation (NAO), the East Atlantic/West Russia (EAWR) pattern and the Arctic Oscillation (AO) (Tab. 4). During times of a high NAO index, a significant reduction of the total atmospheric moisture transport occurs over parts of southern Europe and the Mediterranean region (Hurrell, 1995; Trigo et al., 2002). Strong positive phases of the NAO are associated with above-average precipitation over northern Europe and Scandinavia in winter, and below-average precipitation over southern and central Europe (Hurrell, 1995; NOAA CPC, 2017). Changing precipitation patterns in the Mediterranean region during winter are significantly anticorrelated with the NAO index values (Philandras et al., 2011; Hatzianastassiou et al., 2008).

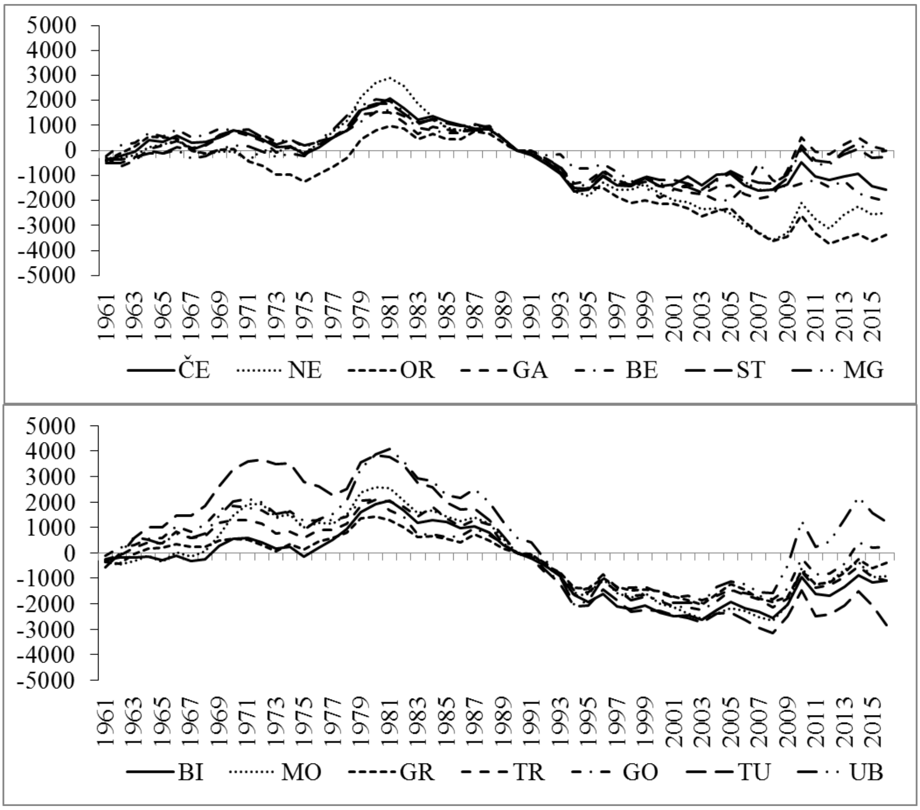

Fig. 5. CPA for annual precipitation over the East Herzegovina region in 1961–2016

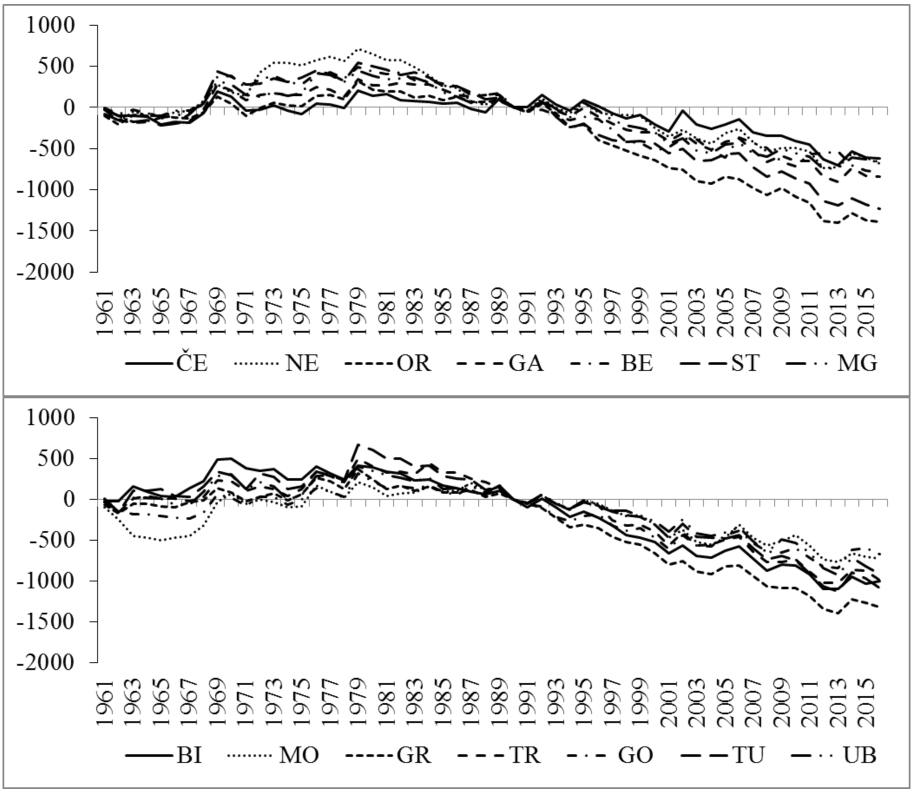

Fig. 6. CPA for summer precipitation over the East Herzegovina region in 1961–2016

The NAO has especially strong impact on precipitation over the East Herzegovina region during winter season and then in spring (correlation coefficients of -0.493 and -0.272, respectively). Negative, mainly statistically significant correlations were also found in winter in Serbia (Luković et al., 2015), Montenegro (Burić et al., 2015) and Slovenia (Milošević et al., 2016). The positive phases of the EATL/WRUS pattern were also generally linked to below-average precipitation across this part of Europe (NOAA CPC, 2017). A significant negative correlation with the EATL/WRUS pattern index was found in winter (-0.573) and autumn (-0.294). The observed precipitation decline over the East Mediterranean region during the last several decades occured in terms of the positive trend of the EATL/WRUS (Krichak, 2005). Further, even stronger negative correlation was found with the AO index, which significantly affects climate variability throughout the year (correlation coefficients -0.460 to -0.738), except during summer. When the AO is in the negative phase, the jet stream moves southward, bringing with it cooler weather with precipitation to the Mediterranean region (Pavlović Berdon, 2012; Thompson & Wallace, 1998).

Tab. 4. Pearson correlation coefficients between seasonal and annual regionally averaged precipitation over the East Herzegovina region and teleconection patterns indices in 1961-2016

Index	Winter	Spring	Summer	Autumn	Year
NAO	**-0.493**	**-0.272**	**0.296**	-0.080	**-0.516**
EATL/WRUS	**-0.573**	-0.125	0.162	**-0.294**	**-0.348**
AO	**-0.738**	**-0.481**	0.040	**-0.460**	**-0.732**

Note: Statistical significance at the 99% ([a]), 95% ([b]) and 90% ([c]) level

Conclusion

Changes in annual and seasonal precipitation over the East Herzegovina region in Bosnia and Herzegovina during the 1961–2016 periods were analyzed based on data sets of daily precipitation from 14 meteorological stations and rainfall gauges. The obtained results found a negative trend in annual precipitation over the entire region. Cumulative Precipitation Anomalies showed that a dry period started in 1981 and continues. A downward tendency prevailed throughout the year. The only exception is autumn season, suggesting positive change. Most prominent negative trends were registered in summer throughout the entire region. In winter and spring, precipitation displayed less coherent patterns of change, with trends of both sign (although a downward tendency prevailed). In the autumn season, precipitation increased almost throughout the entire study area.

The determined patterns of precipitation change in this part of the country are somewhat different from the patterns found for the northern, Peripannonian part of the Bosnia and Herzegovina. Over the Peripannonian region, the positive trends in precipitation prevailed throughout the year (except in summer season, during which there was also a declining tendency) (Popov et al., 2018). Determined patterns of change were neither spatially nor temporally coherent and the estimated trends values were mixed in sign and mostly insignificant (Popov et al., 2018). However, the pattern of precipitation changes obtained in this survey is in concordance with the results of other studies carried out in Mediterranean regions of the Southeast Europe. Gajić-Čapka et al. (2015) showed that the changes in annual and seasonal precipitation in Croatia were predominantly weak. A significant negative trend was found for summer season in the mountainous littoral region, associated with a decrease in frequency of moderate wet days, maximum 1-day and 5-day precipitation and with an increase in light precipitation, whereas the upward tendencies were detected in autumn (Gajić-Čapka et al., 2015). The annual precipitation in Montenegro decreased (in majority cases insignificantly) over the southwestern parts of the country (Burić et al., 2015b). Seasonal precipitation decreased in winter and spring, whereas positive trends were dominant in autumn season (Burić et al., 2015b). A general decrease in annual precipitation at most locations, a decrease in the number of rainy days and an increase in the duration of dry spells were found over the numerous Mediterranean and Submediterranean regions of Europe (López-Moreno et al., 2010; Philandras et al., 2011; Alpert et al., 2002; De Luis et al., 2009; Kelley et al., 2012).

Global and regional climate models project drier future for the Mediterranean region – projections for the 21st century suggest a continual, gradual and relatively strong warming (particularly during summer) (Polade et al., 2017; Lelieveld et al., 2012). Consequently, hot summer conditions that rarely occurred in the 1961–1990 reference periods may become the norm by the middle or the end of the 21st century (Lelieveld et al., 2012). The Balkan Peninsula is one of the regions in which daytime maximum temperatures are projected to increase most rapidly (Lelieveld et al., 2012). Projected precipitation changes show that annual precipitation is expected to decrease over the southern Europe (Lelieveld et al., 2012). On the other hand, frequencies of extreme precipitation are projected to increase (Lelieveld et al., 2012). For instance, projections of precipitation changes over the Croatian coastal zone show no clear signal in the first half of the 21st century, but a reduction in precipitation during summer prevails during the second half of the century (Branković et al., 2013). Projections of climate change in Bosnia and Herzegovina show that precipitation is projected to decrease by the end of the 21st century over the entire territory, with the anomalies most pronounced in summer season (Radusin et al., 2013). The East Herzegovina is the region for which the greatest reductions in precipitation are projected.

Given that the region is already characterized by extreme climate conditions, particularly during the hottest part of the year, it is expected that the impacts of climate change on natural and socio-economic systems will be disproportionally high. As East Herzegovina lacks surface water, decreasing precipitation trends could have severe impact on energy production and supply, hydropowers, water supply, agriculture (irrigation) etc. Future research should be focused on implementation of strategies for mitigation and adaptation to climate change in all these sectors.

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ПРОМЈЕНЕ ПАДАВИНА У РЕГИОНУ ИСТОЧНЕ ХЕРЦЕГОВИНЕ (1961–2016)

Резиме: У раду су анализиране годишње и сезонске падавине на подручју Источне Херцеговине у Босни и Херцеговини на основу података о дневним количинама падавина са 14 метеоролошких и падавинских станица у периоду 1961–2016. године. Резултати показују да је у целом региону Источне Херцеговине присутан тренд смањења годишње количине падавина. Анализа трендова сезонских падавина показала је да су негативни трендови превладавали током целе године, осим у сезони јесен. У целом региону, најзначајнији негативни трендови забележени су у сезони лето. У сезонама зима и пролеће, падавине су показивале трендове оба знака (иако је превладавао опадајући тренд). У сезони јесен, падавине су повећане готово у целом региону Источне Херцеговине. Ипак, трендови годишњих и сезонских падавина већином су слаби и статистички инсигнификантни. Преовлађујуће негативне вредности индекса аномалија падавина од 1990-их такође указују да је смањење падавина присутно у региону Источне Херцеговине. Анализа кумулативних аномалија падавина показала је да је сушни период почео 1981. године и да и даље траје. Варијабилност падавина снажно је условљена атмосферским циркулацијама великих размера на северној хемисфери, као што су Северноатлантска осцилација, Источноатлантска/Западноруска осцилација и Арктичка осцилација, нарочито у сезони зима.