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Spatial pattern of North Atlantic Oscillation impact on rainfall in Serbia

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ABSTRACT

This study examines the spatial pattern of relationships between annual, seasonal and monthly rainfall in Serbia, and the North Atlantic Oscillation (NAO) for the period of 1961–2009. The first correlation analysis between rainfall and the NAO was performed using a Pearson product-moment test. Results suggested negative, mainly statistically significant correlations at annual and winter scales as was expected. However, the highest percentage of stations showed significant result in October suggesting a strong impact of a large scale atmospheric mode throughout a wet season in Serbia. Further spatial analysis that incorporated a spatial autocorrelation statistic of correlation coefficients showed significant clustering at all temporal scales.

1. Introduction

Large scale modes of atmospheric circulation influencing Europe are very well studied in previous literature (Krichak and Alpert, 2005; Jones et al., 1997; Qian et al., 2000; Rodó et al., 1997; Trigo et al., 2002, 2004; Jerez et al., 2013; Türkeş and Erlat, 2005; Ulbrich et al., 1999). A variety of methods were

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used to test the impact of different modes. However, without a doubt, it is clear that the North Atlantic Oscillation (NAO) has a considerable influence on the overall climate of Europe.

1.1. North Atlantic Oscillation pattern

The NAO is one of the most dominant parameters of global climate. The term itself was introduced by Walker (1923). Traditionally, the NAO is defined as a sea level pressure difference between a subtropical anticyclone over the Azores and a Sub polar depression over Iceland. It has a considerable impact on winter weather conditions in Europe and some parts of the North American continent. This pressure difference occurs regularly and is a normal condition that becomes more intensive during winter. Two phases of the NAO are distinguished as positive and negative. During the positive phase, winters in Northern Europe are generally warmer and wetter, and drier over Southern and Central Europe. On the other hand, the negative phase is usually followed by colder and drier winters in North Europe and higher precipitation amounts in Southern Europe. The North Atlantic Oscillation is also quantified by the NAO index. There are several NAO indices suggested by different authors: one given by Rogers (1984) that presents pressure difference between Iceland (Akureyri) and Azores (Ponta Delgada), whereas the second index was introduced by Hurrell (1995) and describes pressure differences between Iceland (Stykkisholmur) and Portugal (Lisbon). Portis et al. (2001) have introduced a "mobile" NAO index that changes in space depending on the season and shows higher correlations with the intensity of western winds over mid-latitudes in the North Atlantic then traditional NAO indices.

Presently, there is not a scientific consensus as to how the mechanism of the NAO originates. What has be proven is that NAO presents an atmospheric phenomenon which is the result of ocean–atmosphere interactions.

1.2. Previous research

Previous studies approach the impact of the NAO at different levels monthly, annually, and decadal. Decadal and annual NAO changes could be determined by anomalies of ocean surface temperature and could have significant impact on precipitation throughout Europe (Hurrell, 1995). Hurrell and Van Loon (1997) pointed out that strong positive phases of the NAO impact on precipitation by influencing dry weather conditions in Southern Europe and the Mediterranean region, and wet conditions in Northern Europe and Scandinavia. They also noticed that the NAO can influence the tracks of storms by shifting their prevalence northward, thereby no, highlighting the fact that the NAO should be investigated in the upper parts of the troposphere to examine regional patterns of change caused by the NAO. It should be emphasized that this is also valid for southern Europe.

Since the Mediterranean region is particularly sensitive in terms of rainfall variability, many papers examine the impact of the NAO on rainfall patterns over this region as a whole or on particular countries/stations (Ferrari et al., 2013; Trigo et al., 2004; Ulbrich et al., 1999).

Krichak and Alpert (2005) study of Mediterranean regions found that NAO-negative winter periods are characterized by wetter than normal conditions over the western and northern parts. On the other hand, NAO-positive periods are associated with wetter than normal weather over West Europe and drier than normal weather over Mediterranean region.

Assessing the impact of the North Atlantic Oscillation (NAO) on winter precipitation and river flow regimes for the Iberian Peninsula, Trigo et al. (2004) suggested that large rainfall inter-annual variability is negatively related to NAO. Similar results are obtained for the southern Italian (Calabria) region, for which Ferrari et al. (2013) observed negative relationships between winter rainfall series and the North Atlantic Oscillation Index (NAOI).

Being located in transitional areas between the Mediterranean and the continental inland and being subjected to both continental and maritime air masses, Serbia is particularly interesting to assess NAO impact. So far, there were few studies examining NAO impact on rainfall pattern in Serbia. Ducić et al. (2007) studied rainfall in relation to El Nino Southern Oscillation (ENSO) and NAO in the period from 1951 to 2000. They observed NAO impact on stations with a continental precipitation regime,