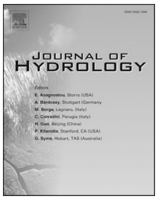
Journal of Hydrology 610 (2022) 127923

Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol



Research papers

Drought evolution in the NW Iberian Peninsula over a 60 year period (1960–2020)

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ARTICLE INFO

This manuscript was handled by Emmanouil Anagnostou, Editor-in-Chief, with the assistance of Viviana Maggioni, Associate Editor

Keywords:
Drought
Standardized precipitation index
Galicia
NW Iberian Peninsula

ABSTRACT

Droughts affect the environment, the economy, and society causing socioeconomic problems derived from water scarcity, and actions are therefore required to mitigate them. To efficiently manage water resources, and prevent and mitigate the consequences of water scarcity, it is important to identify and characterize drought events. A study of the evolution of drought episodes over Galicia (NW Iberian Peninsula) from 1960 to 2020 was conducted based on data from several rain gauges in the region. The standardized precipitation index (SPI) at different time scales was used to characterize drought conditions. The results revealed an increase in the number of periods under drought conditions and the intensity of drought events towards the end of the period analyzed. The events tended to become longer over time, with a clear increase in the worst drought conditions.

1. Introduction

Droughts are natural weather events that can potentially have a devastating effect on millions of people worldwide. Drought events can cause damage to agriculture, forestry, and land use by increasing the water consumption of crops and reducing their production. An increase in the occurrence of these episodes could modify the soil conditions producing changes in the geographical distribution of crops or a decrease in agricultural production in the affected areas. This will have important impacts on economic activities, ecosystems, and human health (Alary et al. 2014; Lesk et al. 2016; Stanke et al. 2013).

Despite their recurrence, droughts are among the most complex and poorly-understood extreme hydrological events (Wilhite, 2000). Drought is rarely predicted accurately and, unlike other natural weather disasters, it begins imperceptibly and goes unnoticed by the population until the damage becomes visible, at which point it is too late to mitigate the negative effects (Wilhite et al. 2007; Below et al. 2007; Bond et al. 2008; Funk, 2011; Wilhite and Pulwarty, 2018). In recent decades, there has been an increase in drought episodes in many regions of the world that has affected various aspects of society (e.g., economic output and demography…), and caused significant losses in agricultural production and health (Barnett, 2011; Briffa et al. 2009; Masih et al. 2014; McGree et al. 2016; Sobral et al. 2018; Xu et al. 2015). Therefore, it is important to understand the dynamics of this type of natural hazard, and to characterize and study these events. This will improve the human capacity to adapt to the problem and mitigate its effects.

Droughts can be measured through different variables, such as temperature, wind, or relative humidity; however, the main controlling factor is the amount of precipitation that an area receives compared to normal conditions. In the last two decades, several standardized drought indices have been developed to monitor droughts. This includes the Standardized Precipitation Index (SPI) (McKee et al. 1993), a simple index which calculation is based only on precipitation. This index has proven to be effective for analyzing both wet and dry periods (Guttman, 1999; Lloyd-Hughes and Saunders, 2002; Zin et al. 2013; Tošic and Unkaševic, 2014; Espinosa et al. 2019). The SPI is comparable in both time and space and is not affected by geographical or topographical differences. Its main advantage is that it can be calculated for several time scales, allowing the identification of various drought types as agricultural or hydrological droughts (McKee et al. 1995). The World Meteorological Organization (WMO) considers the SPI to be the best meteorological drought index for indicating a prolonged deficit in precipitation, and it is therefore one of the most widely-used indexes in Europe (Hayes et al. 2011; Spinoni et al. 2015).

In recent years, a clear trend towards severe drought events over the Iberian Peninsula (IP) has been identified. Several studies have found

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https://doi.org/10.1016/j.jhydrol.2022.127923
Received 14 February 2022; Received in revised form 29 April 2022; Accepted 7 May 2022

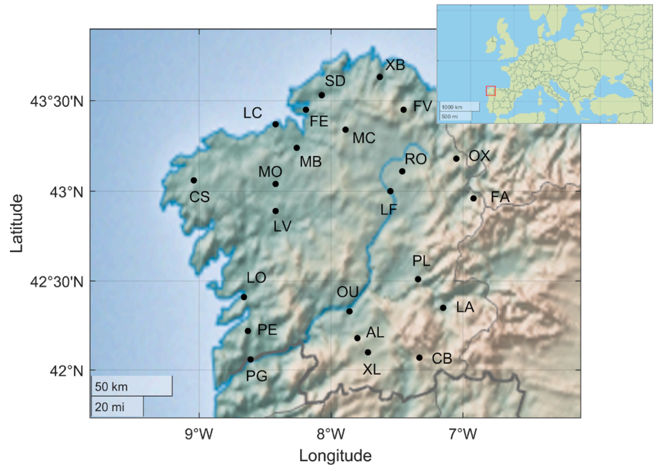

Fig. 1. Map of the study area and location of the 23 meteorological stations.

Table 1
Location and code of the stations represented on the map in Fig. 1.

Name	Code	Lon-W, Lat-N
Allariz	AL	7.80, 42.18
Campo Becerros	CB	7.33, 42.07
Castrelo	CS	9.04, 43.06
A Coruña	LC	8.42, 43.37
Ferrol	FE	8.19, 43.45
Folgueira de Aguias	FA	6.92, 42.96
Fragavella	FV	7.45, 43.45
Lavacolla	LV	8.42, 42.89
Larouco	LA	7.15, 42.35
Lugo Colexio Fingoi	LF	7.55, 43.00
Mabegondo	MB	8.26, 43.24
Marco da Curra	MC	7.89, 43.34
Montaos	MO	8.42, 43.04
Ourense	OU	7.86, 42.33
O Xipro	OX	7.05, 43.18
Paramos-Guillarei	PG	8.61, 42.06
Vigo Peinador	PE	8.63, 42.22
Ponte Lor	PL	7.34, 42.51
Lourizán	LO	8.66, 42.41
Rozas	RO	7.46, 43.11
Sadurniño	SD	8.07, 43.53
Xinzo de Limia	XL	7.72, 42.10
Xunqueira (Borreiros)	XB	7.63, 43.63

Table 2
SPI threshold (McKee et al. 1993).

Threshold	
SPI ≥ 2.00	Extremely wet
2.00 > SPI ≥ 1.50	Severely wet
1.50 > SPI ≥ 1.00	Moderately wet
1.00 > SPI ≥ -1.00	Normal
-1.00 > SPI ≥ -1.50	Moderately dry
-1.50 > SPI ≥ -2.00	Severely dry
SPI ≤ -2.00	Extremely dry

recurrent droughts and a significant trend towards more arid conditions. However, different drought trends have been identified in the different regions of the IP, indicating a need for more detailed local studies (Coll et al. 2016; Domínguez-Castro et al. 2019; Gallego et al. 2011; Garcia-Barron et al. 2011; González-Hidalgo et al. 2018; Páscoa et al. 2017a; Vicente-Serrano et al. 2004, Vicente-Serrano, 2006a, 2006b). Differences in the frequency, duration, and intensity of droughts between areas have been reported over the IP during the last century, with opposing signals identified in many regions. Droughts have tended to decrease in the northwest region and to increase in the central and southern areas, revealing a clear north–south difference in both duration and magnitude (Coll et al. 2016; Páscoa et al. 2017a). Evidence of an increase in the duration and magnitude of drought were found in the Ebro and Tagus basins, and some parts of the Valencia region (Vicente-Serrano et al. 2004; Vicente-Serrano, 2006a, Vicente-Serrano and Cuadrat-Prats, 2006). This contrasts with the observed pattern in the northwest region where humid or normal conditions have frequently been observed and a wetting trend has been identified (Sousa et al., 2011; Vicente-Serrano et al. 2011). These results show that caution should be exercised when analyzing averaged series for the entire IP because there are important differences between regions when dealing with extreme drought events. Drought is an extremely regionally-specific phenomenon and should possible only be examined at the regional scale to create regional management plans that can minimize its impact (Ficklin et al. 2015).

Galicia, located in the northwest IP, is characterized by a high availability of groundwater due to its shallow water table, which is the optimal source of water in rural areas (Raposo et al. 2012). Surface waters, such as shallow wells or springs, also represent an important resource in terms of the water volume consumed. These aquifers have limited storage capacity and short residence periods, and therefore an increase in the frequency and severity of droughts could cause a notable decrease in the availability of water resources (Feyen and Dankers, 2009; Raposo et al. 2013). However, few studies have focused on this area, with little analysis of drought evolution in recent decades. As previously mentioned, most studies have been performed over the IP, with Galicia representing a sub-region of the study domain. Differences in the patterns of drought have been analyzed using rainfall records over the IP based on a very small number of measuring stations over Galicia. The results indicated that the spatial distribution of drought episodes can be very diverse and no homogeneous regions with similar drought patterns could be defined throughout the IP. Some authors have therefore suggested that the northwest Iberian region is an exception to the predominant trend towards drier conditions detected over the IP in the twentieth century and that drought frequency has not increased in recent decades (Sousa et al., 2011; Vicente-Serrano et al. 2011). Recent studies have also detected an excess heat factor throughout the twentieth century that displayed a large regional variability over the IP, with the highest values located in the northwest area (Lorenzo et al. 2021). On the other hand, warm spells have increased throughout the entire Mediterranean Basin in the early decades of the 21st century, except in Portugal and Galicia (Vogel et al. 2021). These results indicate that further research is needed because of the uncertainty that remains in the regional responses to ongoing climate change.

The aim of this study was to characterize drought evolution in Galicia over a 60 year period (1960–2020), and therefore improve our overall understanding of drought episodes in the region. The SPI was applied at 3-, 6-, 12-, and 24-month time scales to assess dry spells across the region and determine the drought vulnerability of the study area.

2. Data and methods

2.1. Study area

Galicia is located in the European temperate-humid zone and covers the northwestern part of the IP (Fig. 1), extending approximately from 42 to 44° N and 7° to 9° W. The region occupies an area of 29,575 km^2 and almost the whole region has a warm temperate climate with dry and warm summers, according to the Köppen-Geiger climate classification scheme (Kottek et al. 2006).

The location of Galicia in the most northwestern sector of the IP makes it the first point of arrival of Atlantic disturbances, producing a different rainfall pattern to that of the wider IP. In addition, the intensity of rainfall over Galicia is influenced by the local orography. In general, the coastal and adjacent areas are characterized by a maritime climate with mild summers and wet winters, while the interior part of the region

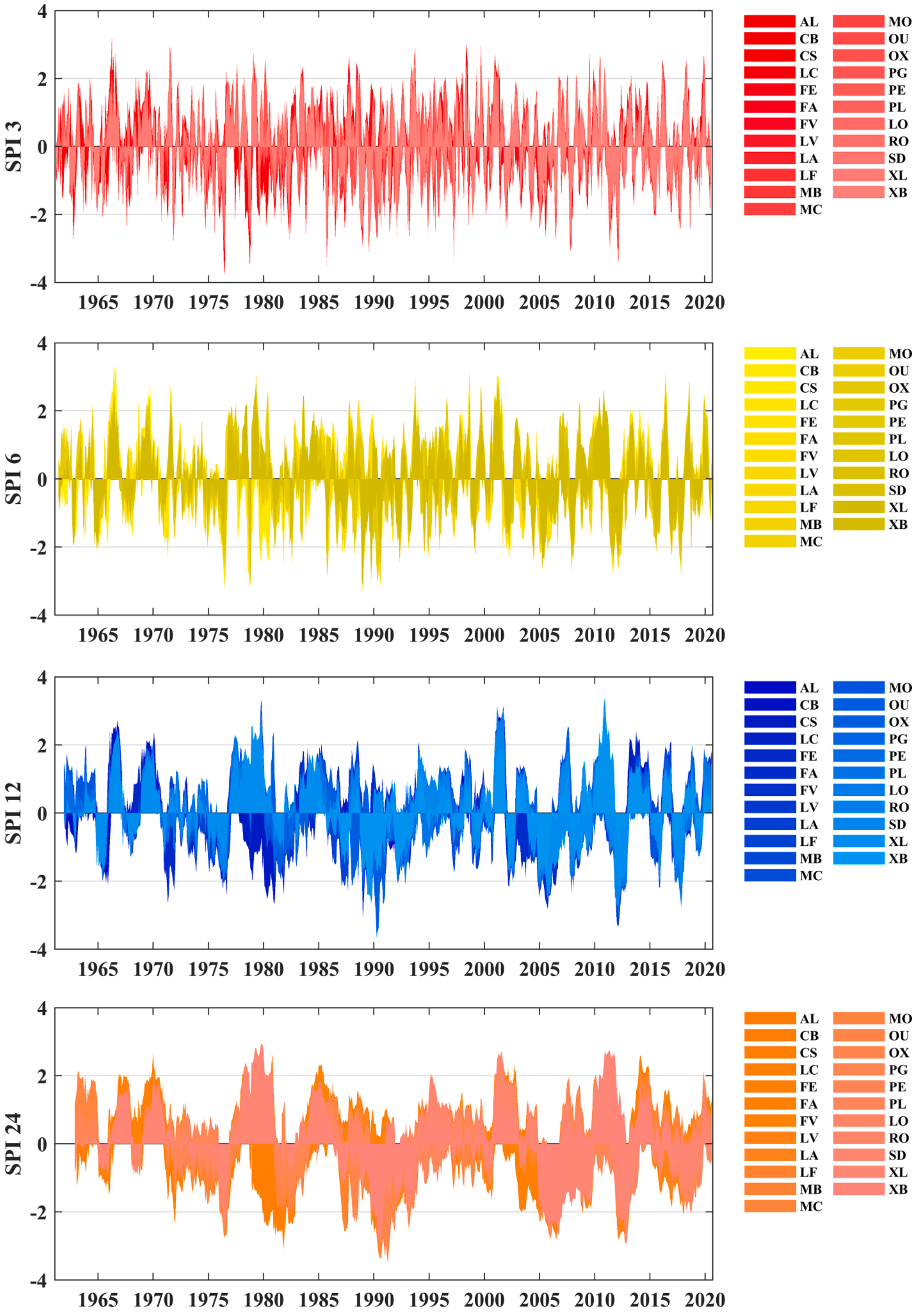

Fig. 2. Time series of the SPI at 3-, 6-, 12-, and 24-month time scales at the 23 stations.

is characterized by a continental climate with dry summers and cold winters (deCastro et al. 2008; Gomez-Gesteira et al. 2011; Lorenzo and Taboada, 2005). The average precipitation regime over Galicia indicates that the region is characterized by a high amount of rainfall. The mean annual accumulated precipitation is around 1300 mm, although it can reach values close to 2000 mm per year along the mountains. In the interior valleys, the mean precipitation values are lower (650–1000 mm per year) (Gomez-Gesteira et al. 2011).

2.2. *The SPI and surface observation dataset*

The SPI index is based on the long-term precipitation record for a specific period and represents the probability of occurrence of a certain deviation from the average in a given time scale (McKee et al. 1993). Using this index, it is possible to determine the beginning and end of a drought episode, as well as its intensity. The SPI is comparable in time and space (Hayes et al. 1999) and can be calculated at different time scales, enabling it to be used to indicate the impact of drought on the availability of different water resources. Soil moisture conditions respond to precipitation anomalies on a relatively short time scale, while long-term precipitation anomalies are reflected in groundwater, river flows, and storage in aquifer reservoirs.

Galicia is characterized by a high level of rainfall over the year, and therefore precipitation is the main driver in the temporal variability of droughts over this region (Noguera et al. 2021). The SPI index can therefore be considered an adequate tool to identify droughts in this area. Four different time scales of 3- (SPI-3), 6- (SPI-6), 12- (SPI-12), and 24-months (SPI-24) were analyzed to characterize seasonal and long-term drought patterns.

Monthly data from 23 rain gauges managed by the Regional and National Meteorological Agencies (METEOGALICIA and AEMET) were used to calculate the SPI (Fig. 1) for the period studied (1960–2020).

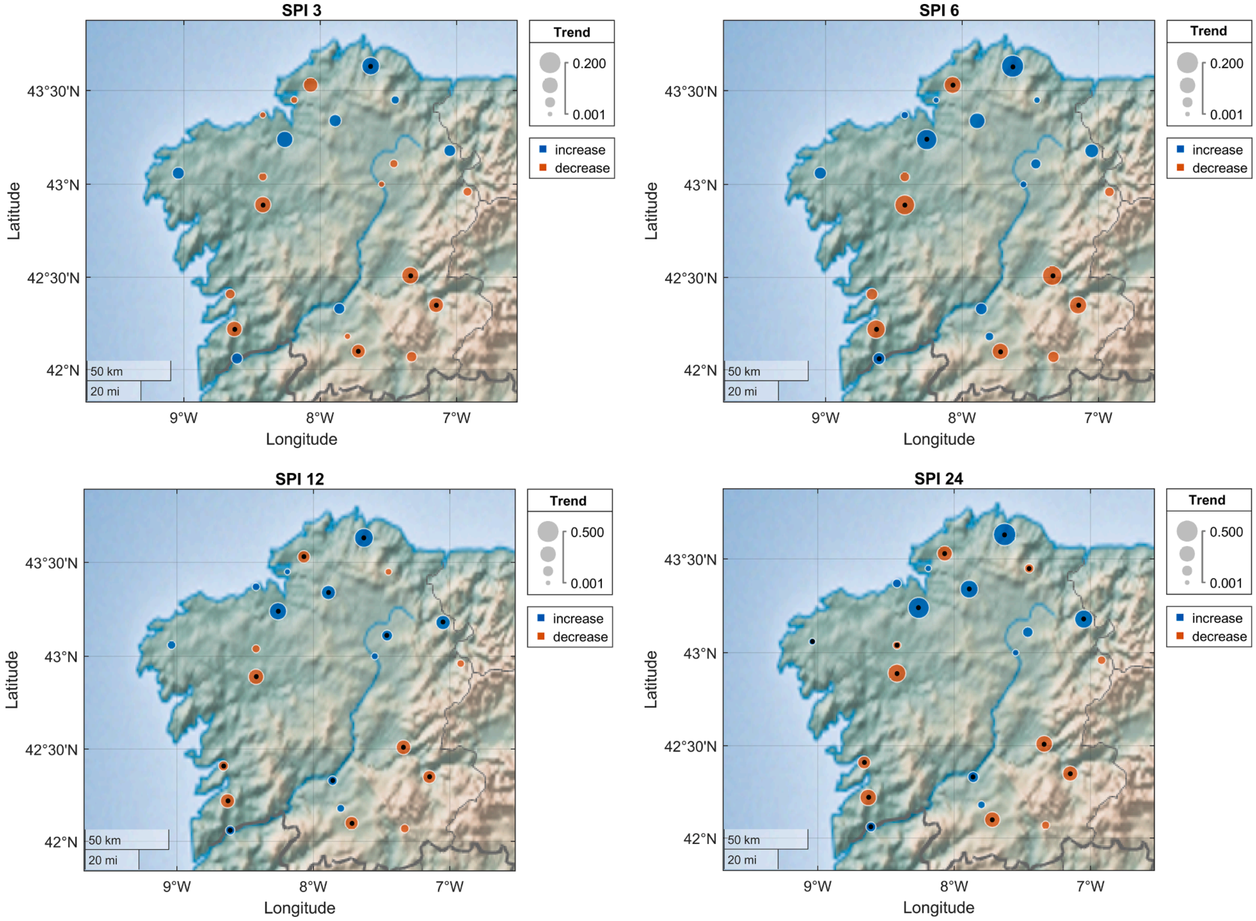

Fig. 3. Spatial distribution of the 23 stations according to the Man-Kendall test results for the SPI at 3-, 6-, 12-, and 24-month time scales from 1960 to 2020. The size of the bubbles indicates the magnitude of the trends. The central black point indicates the trends that had a significance greater than 95%. The red color indicates a decrease in the index and the blue color indicates an increase in the index.

These meteorological agencies have high data quality standards and are one of the main sources of Galician hydrological and hydrometeorological data. The monthly data were provided to us directly. Rainfall data from several meteorological stations throughout the Galician territory were subjected to a process of analysis and validation. Those stations that were suitable for a study of trends, due to their length and quality, were selected for use in the study. Thus, only stations with greater than 70% of the monthly precipitation data processed (23 stations) were considered to avoid bias in the results. Table 1 indicates the code and specific location of these rain gauges.

The SPI was first evaluated considering each station individually. Then, all stations were merged to simplify the drought analyses by calculating an average index value over the region.

The Mann-Kendall test (Mann, 1945; Kendall, 1975) is a robust, sequential, and non-parametric method used to determine if a data series has a statistically significant trend. This test was applied at a 5% probability to the SPI series at the four different time scales to identify statistically significant trends from 1960 to 2020.

To analyze the different drought events over the period under study, the duration, magnitude, and maximum intensity of each event were analyzed. Drought starts when the SPI value is equal to or below −1.0 and ends when the value reaches normal conditions. The duration was calculated as the number of consecutive months with SPI values below this threshold, lasting for at least two consecutive months. The drought magnitude was the sum of the index values throughout these consecutive months under drought conditions and the maximum intensity corresponded to the minimum SPI value reached in each event. Table 2 shows the scale of SPI values used to define the intensity of the drought, with reference to McKee et al. (1993).

3. Results and discussion

Fig. 2 depicts the SPI signals at each station at different time scales. Fig. 2(a) shows a spatiotemporal variation of wet and dry spells at the seasonal scale. Important extremely dry conditions were observed at the end of the seventies and in 2011–2012, with SPI values lower than −2.5. There were several consecutive years around 1990 with extremely dry conditions. The frequency of extremely wet conditions also displayed a seasonal variability. A similar pattern was observed for SPI-6 (Fig. 2(b)). On the other hand, there were clear drought spells in SPI-12 and SPI-24 (Fig. 2(c, d)), with several periods under extremely dry conditions around 1980, 1990, 2005, and 2012, indicating significant inter-annual variations. Most of these drought episodes coincided with those observed over the IP and wider Mediterranean regions, both of which have experienced severe drought events throughout the 20th century. These precipitation deficit episodes resulted in water scarcity problems and had significant economic, social, and environmental consequences (García-Herrera et al. 2007; Iglesias et al. 2009; Kennedy et al. 2006; Maheras et al. 1999; Páscoa et al. 2017b; Trigo et al. 2013).

To spatially analyze the SPI throughout the study region, the increasing or decreasing trends of the SPI were also analyzed at each station. Fig. 3 shows the spatial distribution of the stations and the observed trends per decade. In general terms, there was a decreasing trend in the SPI throughout the territory. A very similar pattern was observed for each of the four SPI time scales over the western region. Significant decreasing trends in the SPI were identified at Lavacolla and

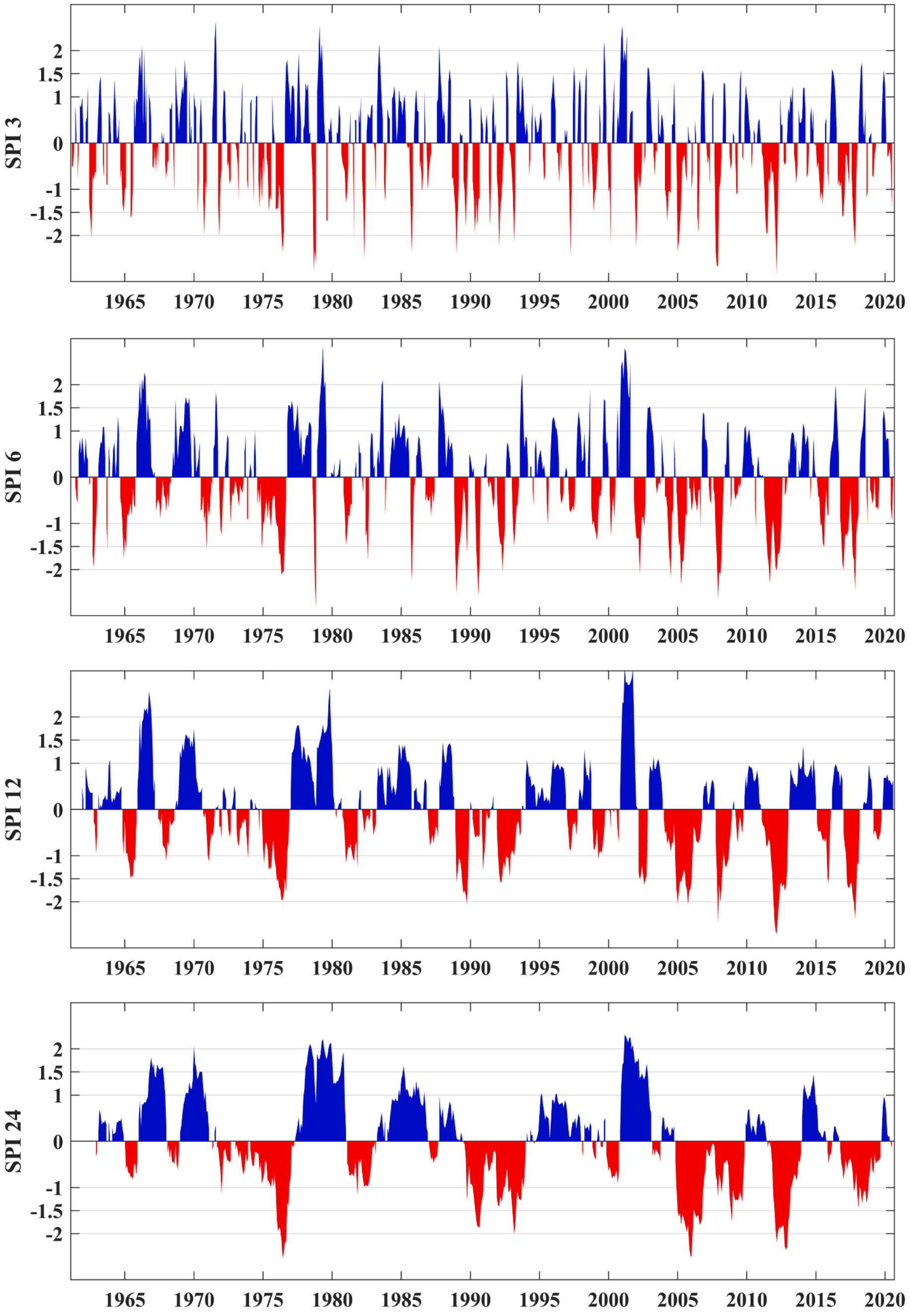

Fig. 4. Time series of SPI values at 3-, 6-, 12-, and 24-month time scales over the whole region.

Peinador stations, with values around −0.10 and −0.15 per decade for SPI-3 and SPI-6, respectively (Fig. 3(a, b)). For the longer time scales, i.e., SPI-12 and SPI-24 (Fig. 3(c, d)), significant decreasing trends were observed at these stations, although with larger magnitudes (-0.20 and −0.30 per decade). In this case, significant decreasing trends in the SPI were also recorded at Lourizan and Montaos stations, with lower values reached than at Lavacolla and Peinador stations. There was a similar pattern for the four time scales in the southeastern part of the study area (inner region), with significant decreasing trends at Xinzo de Limia, Ponte Lor, and Larouco stations. There was an increase in the magnitude of these significant trends as the time scale increased, reaching values around −0.10 per decade for SPI-3 and −0.25 per decade for SPI-24. In contrast, in the northern area there were increasing trends in the SPI at different stations. At the seasonal scale (Fig. 3(a, b)) these trends were only significant at Xunqueira and Mabegondo stations, while for SPI-12 and SPI-24 (Fig. 3(c, d)) Marco da Curra and O Xipro stations also displayed significant increasing trends. A strong increasing trend was detected at Xunqueira for the four SPI time scales ranging from 0.12 per decade for SPI-3 to 0.50 per decade for SPI-24. Sadurniño station, which was located further north of the stations with increasing trends, displayed a significant decreasing trend for SPI-6 (-0.10 per decade), SPI-12 (-0.13 per decade), and SPI-24 (-0.21 per decade).

The results obtained for all stations were merged to simplify the subsequent analysis of drought over the region. Fig. 4 shows the SPI signals as a regional series for the whole study area at the different scales. Most of the SPI-3 values (Fig. 4(a)) were classified as normal, but it was still possible to observe the occurrence of a large number of extremely dry conditions rather than extremely wet conditions. These dry conditions occurred more frequently in the last two decades. The most prominent episodes of drought emerged around 1978, 2007, and

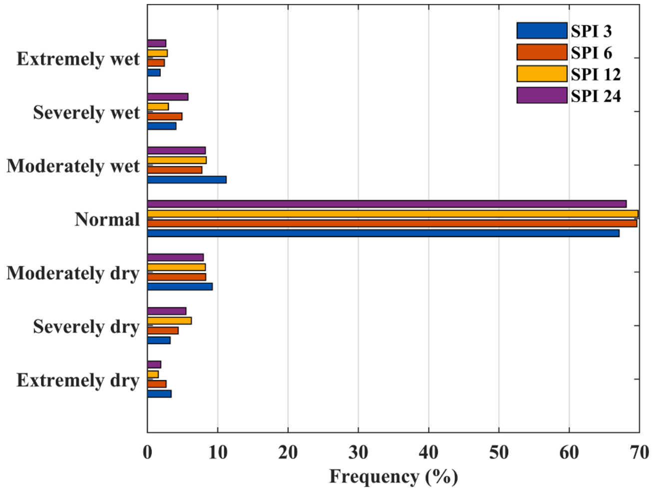

Fig. 5. Frequency of occurrence (%) of the different intensity ranges (based on SPI threshold values) at the 3-, 6-, 12-, and 24-month time scales from 1960 to 2020.

2012, with SPI values below −2.5. A significant decreasing trend of −0.04 per decade was obtained for the entire period. The value for SPI-6 (Fig. 4(b)) presented a similar pattern. Drought events with extremely dry conditions occurred regularly after 2000 and the observed negative trend was significant (-0.06 per decade). On a larger scale, several drought spells occurred over different periods of consecutive years under dry conditions (Fig. 4(c, d)). A significant negative trend was again obtained with values of −0.09 and −0.15 per decade for SPI-12 and SPI-24, respectively. Episodes with wet conditions were more recurrent in the early decades of the study period; however, since the nineties, extremely dry periods become more frequent. The 2012 event was particularly noteworthy, with values below −2 for SPI-12 and SPI-24 (Trigo et al. 2013). This episode began with low rainfall in the spring and early summer of 2011. The situation temporarily improved due to rain events in October and November, but the low rainfall in December 2011, January, and February 2012 generated a major drought episode. February 2012 was the driest since 1961 (classified as extremely dry). A very intense drought event was also observed around 2005, with SPI values indicating extremely dry conditions that were described as particularly dry throughout the whole of the IP. The low amount of precipitation and the wide spatial impact of the 2004/05 drought resulted in this event becoming one of the most distressing dry episodes experienced in the IP, leading to social unrest and creating disputes over future water infrastructure (Iglesias et al. 2009).

The frequency (%) of the SPI records at each time scale was also analyzed considering different intensity ranges (Table 2) to quantify drought events and characterize their occurrence (Fig. 5). A clear prevalence of normal conditions was observed, with a frequency of occurrence of around 70% at each of the four SPI time scales. The categories of moderately wet/dry conditions had frequencies lower than 10%, while extreme and severe episodes occurred for about 5% of the period considered. These results indicate a similarity in the occurrence of wet and dry events throughout the study period. Nevertheless, it was apparent that the occurrence of wet episodes was more frequent at the beginning of the study period, while dry conditions were recorded regularly from 1990 onwards.

To better identify episodes with a deficit or excess of precipitation, the SPI time series for the considered time scales were determined using the thresholds given in Table 2 (Fig. 6). Normal conditions were observed throughout the study period, although clear wet episodes were observed at the four SPI time scales at the beginning of the period (i.e., between 1965 and 1970), with severely and extremely wet conditions. Around 1975, an episode of extremely dry conditions was followed by marked wet episodes that were recorded until approximately 1980. Between 1990 and 1995 drought conditions were again observed at the different time scales, and around 2001 the last mayor wet event of the study period ocurred, with extremely wet conditions. After this event, dry episodes occurred with a greater frequency until 2020. These results therefore indicate a general increase in drought conditions. Previous studies have indicated that in the northwest IP region drought occurrence did not increase in the final decades of the twentieth century, and this region was considered to be an exception to the predominant trend towards drier conditions that was detected over most of the IP (Sousa et al., 2011; Vicente-Serrano et al. 2011). Nevertheless, taking into account the first two decades of the 21st century, it can be seen that droughts occurred more frequently.

Several consecutive periods with SPI values indicating dry conditions were also analyzed, and the duration and maximum intensity of each event were recorded for each of the four time scales (Fig. 7). At the seasonal scale, SPI-3 (Fig. 7(a)) showed several drought events throughout the study period. During the first three decades, most of these events lasted between two and three months, with extremely dry conditions occurring on several occasions. After 1990, drought events became common and lasted from two to four months. The two longest events (six months) were recorded in this period (1990 and 2004), with intensity values indicating severely dry conditions. According to Fig. 7 (b), a major drought event occurred in 1976 and lasted for eight months with a maximum intensity of −2.12. The most common drought events that occurred in the first three decades lasted from two to three months. Within this period, the most remarkable event in terms of intensity was observed (1978), reaching an intensity value of −2.83. During the last decades, the duration of drought episodes tended to increase relative to the beginning of the period. Most of the drought events recorded presented extremely dry conditions with SPI values below −2. On a larger scale, SPI-12 and SPI-24 (Fig. 7(c, d)) showed fewer drought events throughout the study period. A larger number of drought episodes were observed for both cases in the more recent decades and they had a longer duration and intensity than the earlier drought episodes. The most severe drought in terms of duration and intensity was observed in 2012 at the SPI-12 scale, lasting for 15 months with a maximum intensity of

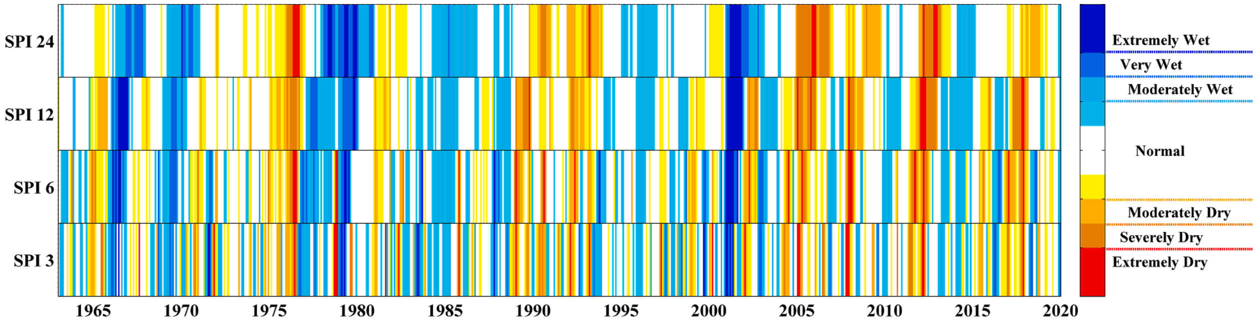

Fig. 6. Time series of SPI values at 3-, 6-, 12-, and 24-month time scales over the study region in relation to the thresholds given in Table 2.

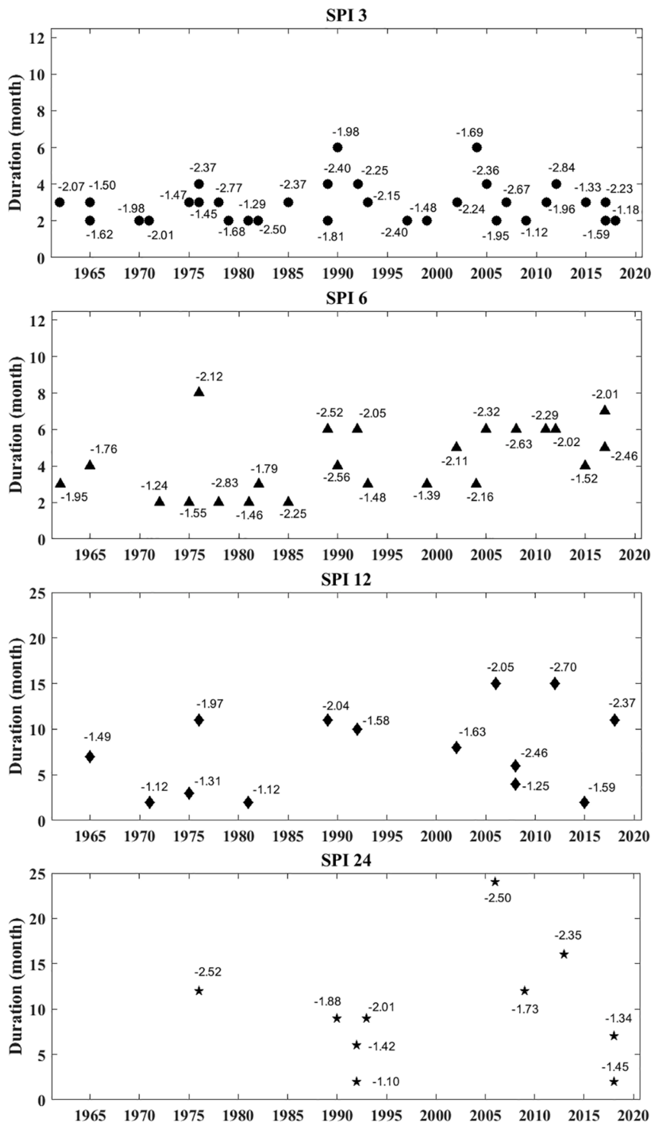

Fig. 7. Duration of drought events and maximum intensity recorded for each event at the 3-, 6-, 12-, and 24-month time scales.

−2.70. In contrast, SPI-24 presented two major drought events in terms of intensity, around 1976 (-2.52) and 2006 (-2.50), which lasted for 12 and 24 months, respectively. At this scale another important drought event also occurred at the end of the period registered in 2013 with a duration of 16 months and a maximum intensity of −2.35. These results indicated an increase in the number of periods under drought conditions and the intensity of drought events. Thus, the drought episodes tended to be longer with an increase in the consecutive periods under drought conditions towards the end of the study period.

Fig. 8 shows the duration and magnitude of drought events in different periods for the four different time scales, enabling their temporal evolution to be analyzed. There was an increase in drought duration and magnitude when the SPI time scale increased in the study period of 1960–2020. In addition, there were differences in drought duration and magnitude between the periods of 1960–1999 and 2000–2020. Drought severity increased in terms of both duration and magnitude between the first and second periods at 3-, 6-, 12-, and 24-month time scales. The results indicated a tendency for drought events to have a larger magnitude and longer duration towards the final decades of the study period.

The frequency of the drought events was also analyzed in terms of the number of events per decade. Fig. 9 indicates a widespread increase in the frequency of drought events at the four different time scales. When the SPI timescale increased, the number of events per decade decreased following the pattern described above. Drought events exhibited a decadal variability, although a clear increase in the occurrence of moderate, severe, and extreme droughts was observed in the final decades of the study period relative to the beginning of the period.

As mentioned earlier, few studies have been carried out over Galicia,

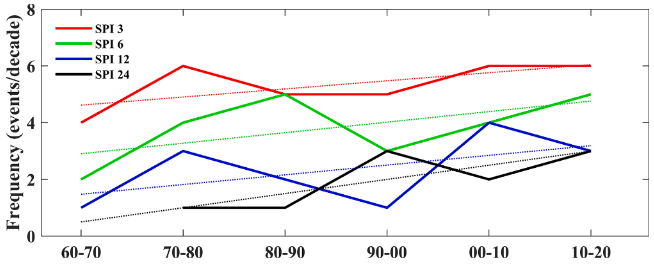

Fig. 9. Frequency of drought events calculated as the number of events per decade at the 3-, 6-, 12-, and 24-month time scales (solid lines). A trend line (dotted line) has been added to facilitate a visual analysis.

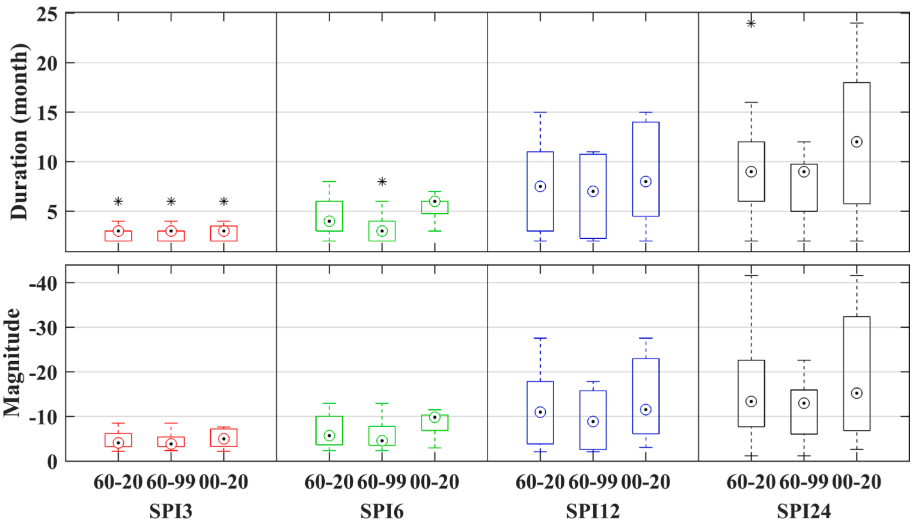

Fig. 8. Box-whisker plots of the duration and magnitude of the SPI at the 3-, 6-, 12-, and 24-month time scales in the periods of 1960–2020, 1960–1999, and 2000–2020. The black dots inside each box indicate the median, the boxes indicate the interquartile range, and the whiskers indicate the observed range.

which makes it difficult to compare the results obtained in this study with other data. As far as we know, only Vicente-Serrano et al. (2011) have analyzed droughts in the northwest IP from 1930 to 2006. Their study used precipitation data from the Climatic Research Unit (CRU) with a spatial resolution of 0.5°. The results indicated that the frequency of drought events has not increased over this period. Most of the published studies focused on the 20th century conducted throughout the IP have indicated strong spatial and temporal drought variability at the regional scale (Santos et al. 2010; Vicente-Serrano, 2006b, Vicente-Serrano et al. 2004, 2014). Recent studies have also shown a predominant trend toward drier conditions during the 20th century in most western and central Mediterranean regions, except for the northwest IP where no dominant long-term trends have been reported (García-Valdecasas et al., 2021; Sousa et al., 2011; Vogel et al. 2021). Thus, the results obtained in this study will lead to improvements in the understanding of the drought phenomenon in Galicia.

4. Conclusions

Several studies have shown that the IP experiences recurrent droughts with a predominant trend towards drier conditions in recent decades. Nevertheless, different behaviors have been found among several sub-regions, indicating that the spatial distribution of drought episodes can be very diverse. Opposing signals have been identified in many regions indicating that local studies can contribute to a better characterization of drought events throughout the IP.

This study investigated drought evolution in Galicia over a 60 year period (1960–2020) using data from a dense network of 23 stations located throughout the area in an attempt to improve the understanding of regional drought. Galicia is located in a transition zone between different types of air masses, and therefore the conclusions of studies of climatic variations, such as drought events, carried out for other areas of the IP, such as the Mediterranean, cannot be directly extrapolated to this area. An individualized study is required for this region. The results of this study revealed a general increase in drought conditions from 1960 to 2020. The main results could be summarized as follows:

- Spatially, the evolution of the SPI across Galicia tended to decrease indicating more droughts.
- Significant trends in SPI reduction were identified at seasonal and long-term scales.
- A low-frequency of severe/extreme drought was registered in the whole region, although the occurrence of dry episodes was more frequent from 1990 onwards.
- An increase in the frequency and severity of drought events was detected towards the end of the study period.
- Drought episodes tended to be longer with an increase in the number of consecutive periods under drought conditions.

CRediT authorship contribution statement

M.N. Lorenzo: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **I. Alvarez:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **J.J. Taboada:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This work was partially supported by Xunta de Galicia, Consellería de Cultura, Educación y Universidad under project ED431C 2021/44 (Programa de Consolidación e Estructuración de Unidades de Investigación Competitivas). I. Alvarez acknowledges financial support to CESAM by FCT/MCTES (UIDP/50017/2020+UIDB/50017/2020+ LA/P/0094/2020), through national funds. Open Access funding provided thanks to Universidade de Vigo/CISUG.

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