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Spatial Variability of Drought: An Analysis of the SPI in Sicily

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Abstract. An analysis of drought in Sicily from 1926 to 1996 is presented. In identifying drought over the region, both the NCEP/NCAR reanalysis precipitation data and those observed in 43 gauges, located quite uniformly over the territory of the Island, are used. Drought occurrence is estimated by means of the Standardized Precipitation Index (SPI). To study long-term drought variability, a Principal Component Analysis was applied to the SPI field. Results suggest that the entire Island is characterised by a drought variability with a multi-year fluctuations and a tendency towards drier periods from the seventies onward. A preliminary comparison between results obtained using the meteorological large-scale analysis and that derived from actual observations on the ground shows a general good agreement, although further efforts are needed to get a better downscaling of the large-scale precipitation fields. Furthermore, by applying orthogonal rotations to the principal component patterns, it has been found that three distinct areas having coherent climatic variability may be identified. Finally, the sensitivity of the SPI values on the calibration period is also investigated.

Key words: drought analysis, NCEP/NCAR reanalysis precipitation data, Principal Component Analysis, Sicily, Standardized Precipitation Index

1. Introduction

Studies on climate variability are important for the design and management of water resource systems. However, social benefits derived from these systems are directly related to the reliability of climate statistics. Water resource systems have been planned and are operating on the assumption that future climate features might be similar to those observed in the last 30 years. Recently, there has been a debate on the apparent increase in large parts of the planet of dry events and on the possible physical causes of these phenomena. Therefore, in order to assess objectively drought occurrence and better understand the recent climatic fluctuations, it is worthwhile to study long-term series of precipitation in regions with no homogeneous climatic hydrological conditions.

In Bordi and Sutera (2001a, b) the large-scale analysis of drought variability during the last fifty years, both in Europe and Italy, has shown that some regions have been driven towards drier climate in the last decades. These studies have been carried out by assessing drought occurrence by means of the Standardized Precipitation Index (SPI) (McKee *et al*., 1993) and the Palmer Drought Severity Index (PDSI) (Palmer, 1965). The raw precipitation and temperature data were those derived from the NCEP/NCAR re-analysis data set (Kalnay *et al*., 1996), which represent the general features but do not describe in detail the precipitation field on a limited region. Thus, the reliability of these precipitation data remains an open question, especially when an assessment of drought variability is sought. A contribution to the solution of this problem may be given by comparing drought estimates using NCEP/NCAR re-analysis with those using rainfall gauge data.

On these grounds, the present paper aims at exploring if the trend shown by NCEP/NCAR data, as discussed in Bordi and Sutera (2001a,b), is shared by precipitation records observed in 43 gauges over Sicily and covering the period 1926–1996. Moreover, the paper intends to ascertain whether drought occurrence in Sicily shows any sub-regional character.

The outline of the paper is as follows. In Section 2 methods used for the analysis of drought in Sicily and data sources are described. In Section 3 a discussion of some of the major results on the spatial variability of drought and on a preliminary comparison between the large-scale analysis and that derived from rain gauge observations are presented. Section 4 contains a summary and some conclusions.

2. Method and Data

Drought is still one of the least understood of the all weather phenomena that affects large worldwide areas and has serious impacts on society, environment and economy (Rossi *et al*., 1992; Obasi, 1994). During the recent years various indices have been developed to detect and monitor drought (Palmer, 1965; McKee *et al*., 1993; Meyer *et al*., 1993). Among them, those that have been more commonly used are the PDSI and the SPI.

In the present paper, only the SPI is adopted to assess drought occurrence in Sicily. This choice is motivated by the following reasons. The index offers the capability to monitor climatic conditions over a wide spectrum of time scales; it permits to compare dry and wet periods on different locations (it is worth to recall that the index is a standardized quantity); moreover, it is based on precipitation alone, so that a drought assessment is possible even if other meteo-hydrological measurements are not available. Further, Hayes *et al*. (1999) argued that the SPI detects moisture deficits more rapidly than the PDSI, which has a response time scale of approximately 8–12 months. Finally, the cited study by Bordi and Sutera (2001a) has shown that the main patterns of drought variability obtained by using both the SPI on 24-month time scale and the PDSI compare favorably, at least when a large-scale assessment is considered.

Details about the SPI computation can be found in the appendix of the just mentioned paper or in Guttman (1999) and references therein. Here, only the main assumptions are briefly summarized. Computing the SPI requires the knowledge of a frequency distribution from the historical precipitation data (al least 30 years of data) at a location for a given time period. A gamma probability density function is fitted to the empirical distribution of precipitation frequency for the selected time scale. An equiprobability transformation is then applied from the fitted distribution to the Normal one. Then the negative values of the standardized normal variable are compared with the boundaries of different classes of drought proposed by McKee *et al*. (1993). The latter step identifies the severity level of a drought event.

Among users there is a general consensus about the fact that the SPI on shorter time scales (say 3 or 6 months) describes drought events affecting agricultural practices, while on the longer ones (say 12 or 24 months) it is more suitable for water resources management purposes. In this paper, results concerning the longest time scales are discussed. This leaves securely off the effect on drought due to the seasonal cycle. Of course, the latter is an important issue for a drought assessment; however, for the aim of the paper, a study concerning drought seasonal variability may represent a digression.

In studying drought variability in Sicily, a Principal Cmponent Analysis (PCA) has been applied to the SPI field computed for 24 and 12-month time scale. The PCA is a standard statistical method, often used in meteorological studies, to reduce the original intercorrelated variables in a small number of new linearly uncorrelated ones that explain most of the total variance (Rencher, 1998). The new (uncorrelated) variables are called principal components (or PCs scores) and consist of linear combinations of the original variables. The coefficients of the linear combinations are called 'loadings' and they represent the weight of the original variables in the PCs. In brief, this method consists in computing the eigenvalues and the eigenvectors of the covariance matrix, where the eigenvectors, properly normalized, are the loadings (i.e. the spatial patterns), while each eigenvalue tells about the fraction of the total variance explained by each loading (Bordi and Sutera, 1001a and references therein). It must be noted that, under this decomposition, the loadings represent the correlation between the associated PC scores and observation time series.

Moreover, it may be useful to rotate the eigenvectors in a way that the corresponding loadings are more spatially localized, i.e. the rotated loadings have high correlation with a smaller set of spatial variables and low correlation with the remained variables. In the present study this technique will allow to find areas within the region that have rather independent climatic variability. Here, only orthogonal rotations are considered and they are computed according to the VARIMAX criterion (the algorithm used is FROTA, IMSL 1987). Of course, each rotated pattern will not explain the same variance of the unrotated one, although the total variance explained remains unchanged.

The monthly data used to compute the SPI for the large-scale analysis have been retrieved from the NCEP/NCAR reanalysis data set from the period 1948 to 1996. Data are approximately 1.9×1.9 grid spacing in longitude and latitude. It is worth to recall that the NCEP/NCAR reanalysis system consists in the outputs of an atmospheric General Circulation Model coupled with a data assimilation scheme able to handle meteorological observations coming from different sources. In so far, the model does not assimilate precipitation observations. Therefore, daily precipitation fields are obtained by means of a short-range forecast (four forecasts 6 h long are summed to give total precipitation for each day). For a detailed description of the reanalysis procedure (previously outlined) see Kalnay *et al*. (1996). It must be noted that, in this data set, there is only one grid point that falls in Sicily and therefore it can be considered as representative of precipitation over the Island.

As mentioned in the introduction, a drought analysis has been carried out using long records of precipitation measurements. The monthly data used in the procedure above have been extracted from the longer database available at the Department of Civil and Environmental Engineering of the University of Catania. In extracting these recods, a preliminary selection of rainfall stations was made according to the following criteria:

1. the size of the series had to be long enough in order to yield a reliable estimation of the parameters related to the index;
2. the spatial distribution of the stations had to allow an homogeneous coverage of the region under study.

The database consists of precipitation data from the Sicilian Hydrographic Service rain gauges network. This network has been selected, rather than other ones, because of the size of its time series and the quite uniform spatial distribution of the stations considered over the region. The quality of the data has been checked through a double mass analysis and few tests of randomness, which led to a selection of the longest and more reliable series. Once the preliminary selection of stations was achieved, a check on the network spatial coverage of Sicily region has been carried out. In performing this task some stations were included regardless the record size (Alecci *et al*., 2000; Department of Civil and Environmental Engineering, 2001; Alecci and Rossi, 2002). The outcome of these requirements was a network including 43 stations with an average density of one station over $\sim$ 600 km^2. The main characteristics of the stations are listed in Table I, while their location in Sicily region is shown in Figure 1.

Missing data in the original recods were estimated by using linear regression equations fitted to the available monthly data observed at the station and at a nearby reference station. In particular, when contemporary data have been recorded, correlation coefficients between the annual precipitation observed at a given station and few neighbour stations were evaluated. Then, the site with the highest correlation coefficient was selected as reference station and missing monthly data at the station of interest were estimated by using 12 linear equations, one for each month. The analysis of annual precipitation series (here not shown) has detected that some stations show a significative negative trend at 0.05 significance level. This trend appears to be similar to that shown by using the NCEP/NCAR reana-

Table I. Characteristics of the rainfall station

Station	Elevation (a.m.s.l.)	Station code	Starting period of measures	No of yearly recods '26–'96	Geographic Coordinates Latitude N	Longitude E[a]
Northern hydrographic district						
Tindari	280	10	1919	63	38°08′	2°36′
San Fratello	690	16	1920	75	38°01′	2°09′
Cefalù	30	25	1918	70	38°02′	2°34′
Ciminna	500	35	1909	68	37°54′	1°06′
Ficuzza	681	37	1918	72	37°53′	0°55′
Partinico	189	43	1919	74	38°03′	0°40′
Palermo (oss. Astr.)	31	45	1943	51	38°06′	0°52′
San Giuseppe Jato	450	46	1919	66	37°58′	0°44′
Trapani	2	51	1881	75	38°01′	0°03′
San Vito Lo Capo	6	52	1928	61	38°11′	0°17′
Southern hydrographic district						
Marsala	12	55	1919	75	37°48′	0°01′
Ma zara del Vallo	8	57	1918	68	37°39′	0°08′
Partanna	407	59	1921	69	37°43′	0°26′
Corleone	588	63	1924	73	37°49′	0°51′
Sciacca	56	69	1908	75	37°30′	0°38′
Piano del Leone	831	71	1929	42	37°40′	1°02′
Bidona	503	76	1919	76	37°37′	0°59′
Lercara Friddi	658	77	1919	73	37°44′	1°09′
Racalmuto	475	86	1918	68	37°24′	1°17′
Agrigento	313	92	1880	76	37°19′	1°07′
Petraia Sottana	930	96	1895	76	37°48′	1°38′
Enna	950	99	1919	76	37°34′	1°50′
Caltanissetta	570	103	1876	73	37°29′	1°37′
Licata	142	107	1917	72	37°06′	1°29′
Gela	45	110	1905	73	37°03′	1°49′
Monterosso Almo	691	112	1923	71	37°05′	2°19′
Vittoria	168	115	1905	76	36°57′	2°05′
Ragusa	515	116	1921	76	36°56′	2°17′
Cozzo Spadaro	50	120	1919	68	36°41′	2°41′
Piazza Armerina	721	111	1919	64	37°23′	1°55′

Table I. continued

Station	Elevation (a.m.s.l.)	Station code	Starting period of measures	No of yearly recods '26–'96	Geographic Coordinates	
					Latitude N	Longitude E[a]
Eastern hydrographic district						
Siracusa	23	127	1868	62	37°03′	2°50′
Lentini (cittá)	43	130	1916	75	37°17′	2°33′
Caltagirone	513	151	1919	76	37°14′	2°04′
Nicolosi	698	154	1920	65	37°37′	2°34′
Zafferana Etnea	590	156	1920	67	37°42′	2°39′
Linguaglossa	560	157	1893	70	37°50′	2°42′
Acireale	194	160	1913	74	37°36′	2°43′
Catania (osservatoria)	65	161	1892	72	37°30′	2°38′
Floresta	1250	162	1921	75	37°59′	2°28′
Taormina	260	165	1920	76	37°51′	2°50′
Messina (osservatoria)	54	170	1881	73	38°12′	3°06′
Ganzirri	1	171	1920	66	38°15′	3°09′
Adrano	589	141	1904	62	37°40′	2°23′

[a] Longitude referred to Rome, Monte Mario.

Figure 1. Location of the selected stations.

lysis. Moreover, when the SPI was computed for each station, a visual inspection of the results revealed that a trend was present also for the drought index.

3. Results

Since the reanalysis data set is available only from 1948, while rainfall series are from 1926, the analysis of these last ones has been carried out for two periods: from 1926 to 1996 and from 1948 to 1996. For the last period a preliminary comparison between the large-scale result and that obtained by using rain gauge observations is presented.

A first investigation on the impact of using different reference record sizes (hereafter calibration periods) on the SPI values has been done. At this aim the SPI series at the 43 selected stations have been computed from 1926 to 1996 both calculating the probability function for the entire record and for the shorter period 1948–1996. For illustrative purpose, Figures 2 and 3 show the series of the monthly precipitation and the 24-month SPI for the two calibration periods computed for the stations 52 and 69 respectively.

In the case of station 52, differences in the SPI values are very small, as it could be expected because the largest values of monthly precipitation are quite uniformly distributed over the entire record. In the case of station 69, instead, the differences in the SPI values are easily detectable. In particular, wet periods are more intense when the calibration period 1948–1996 is applied. This is because in the latter case the probability distribution has been computed exluding the several wet periods occurred in the first part of the record. This means that, if a trend is present in most part of the record, the choice of the calibration period may affect sensibly the SPI values and consequently the magnitude of the detected climatic variability. With this in mind, the entire record 1926–1996 has been used as a calibration period for the rain gauges analysis, while, in making a comparison with the meteorological large-scale analysis, the 1948–1996 period was used for calibration.

To study possible trends, a PCA to the SPI on 24-month time scale has been applied for the 43 stations. In Panel I the first nine loadings, related to the analysis on 1926–1996, are shown. Moreover, in Table II the percentage of the total variance explained by each loading is listed in the second column.

It must be noted that the first spatial mode, which explains 43.4% of the total variance, shows high values over the whole Island, meaning high positive and spatially homogeneous correlation between drought variability in the stations and the corresponding first factor score. In Panel II corresponding first nine scores are shown for the period 1926–1996.

The leading score reveals multi-year variability and a marked tendency towards drier periods starting from the seventies onward. The other patterns explain a minor portion of the total variance (from 9.7% the second loading to 2.3% the nine loading) and are not characterized by any particular areas with high positive/negative values. This means that the long-term drought variability in Sicily is mainly rep-

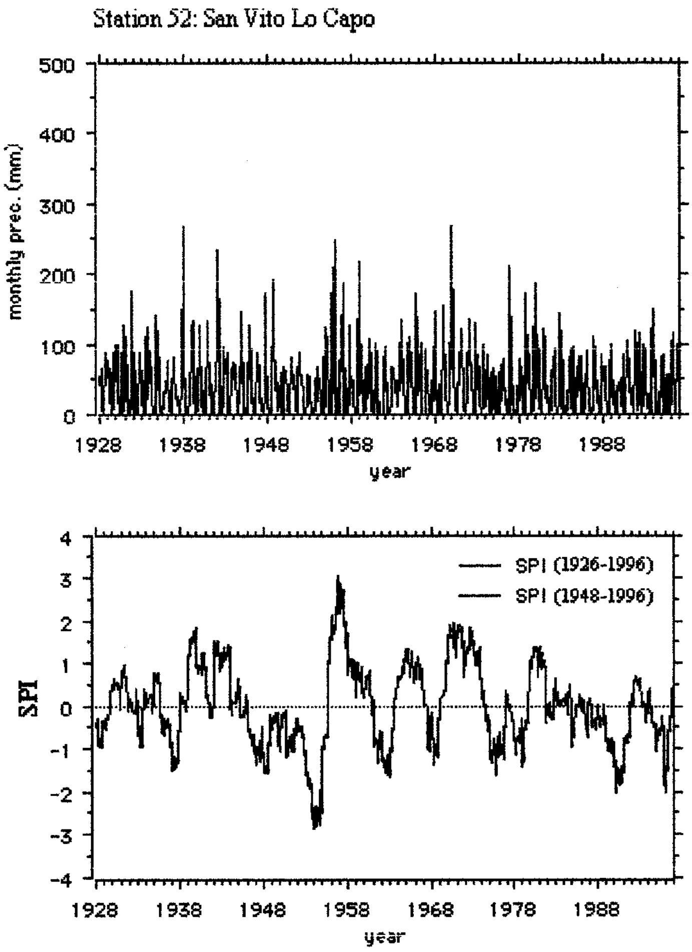


Figure 2. Time behaviours of the monthly precipitation and the 24-month SPI computed for the two calibration periods: 1948–1996 (black line) and 1926–1996 (red line) for San Vito Lo Capo (no. 52).

resented by the first factor score. By applying a rotation to the patterns above, it is possible to distinguish more localized areas of variability. In Panel III ad IV the nine VARIMAX rotated loadings and the corresponding factor scores are shown respectively.

The percentage of the total variance explained by each pattern is listed in the third column of Table II. It must be noted that the first three rotated patterns, explaining 14.5%, 15.9% and 12.6% of the total variance respectively, characterize three regions within the Island that mostly correlate to the corresponding scores: northern, south-eastern and south-western Sicily. Thus, it is possible to conclude

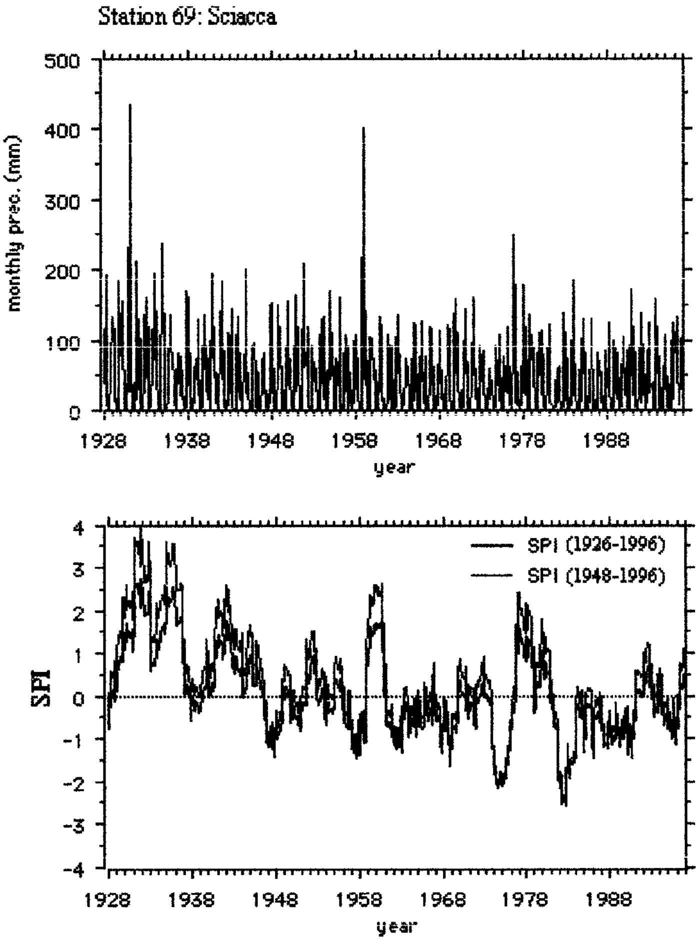
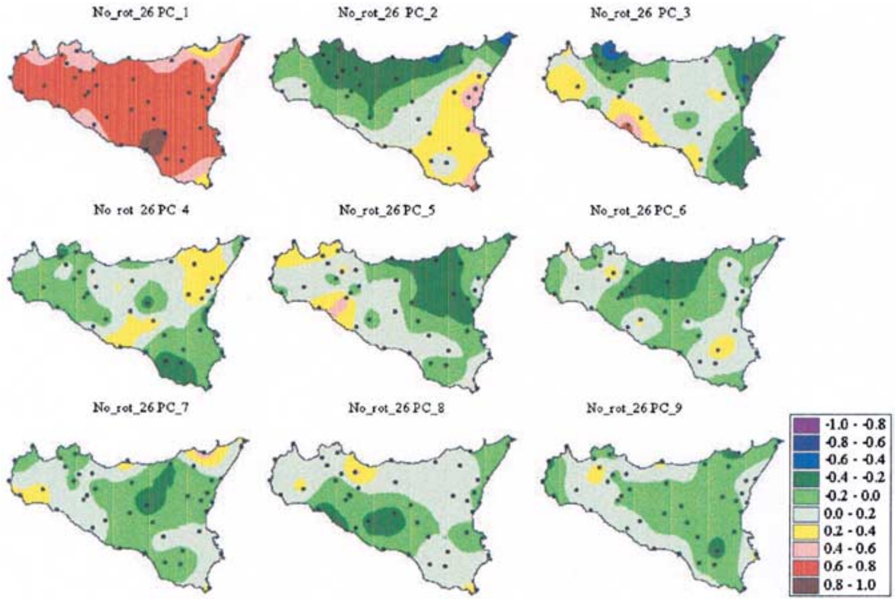


Figure 3. Time behaviours of the monthly precipitation and the 24-month SPI computed for the two calibration periods: 1948–1996 (black line) and 1926–1996 (red line) for Sciacca (no. 69).

that the observed trend, despite it is a feature of the whole Island, appears different on a sub-regional scale.

Next, a tentative comparison between the rain gauge and the large-scale temporal variability of drought in the Island is made. Thus, the SPI analysis obtained using the rainfall series has been repeated for the shorter period 1948–1996 (it is worth to recall that the NCEP/NCAR re-analysis is available from January 1948). Results are shown in Panels V and VI for the unrotated case and in Panels VII and VIII for the VARIMAX rotated one.

In Table III the percentages of the total variance explained by each pattern for the two cases are listed.

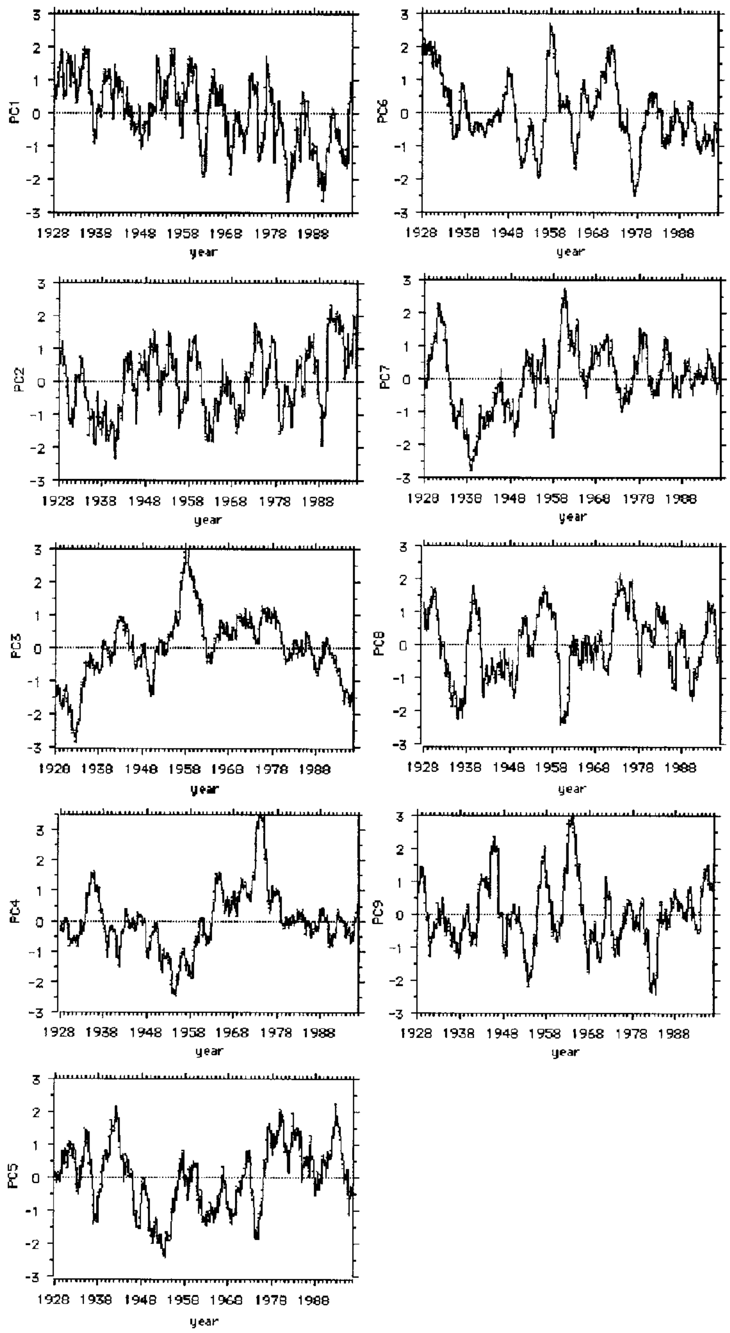


Panel I. Loading patterns of the first unrotated nine principal components (PCs) of the SPI field on 24-month time scale for period 1926–1996.

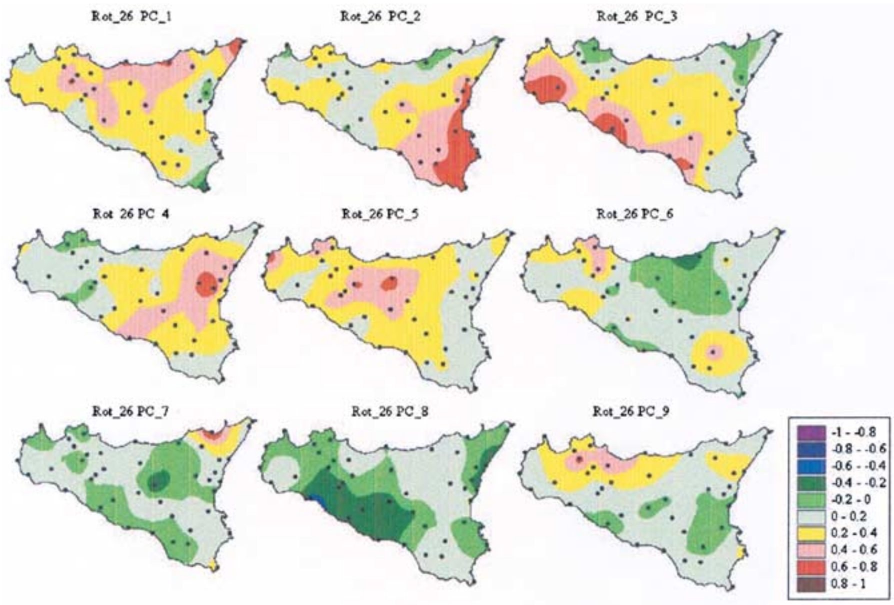
Table II. Variance contributions of the first nine unrotated and VARIMAX rotated loadings resulting from the PCA of the SPI on 24-month time scale for the period 1926–1996

n. PCs	Variance (%)	VARIMAX (%)
1	43.41	14.50
2	9.73	15.85
3	6.93	12.62
4	5.07	9.86
5	4.39	10.37
6	3.35	5.40
7	3.18	3.70
8	2.85	3.55
9	2.26	5.32

A cursory inspection of the figures suggests that the analysis gives similar results as the previous ones. The first loading in Panel V, which explains 45% of the total variance, shows high positive values over the whole Island and the corresponding score is characterized by multi-year fluctuations superimposed to a tendency towards drier conditions. The rotated modes that explain the higher



Panel II. Time series of the first unrotated nine principal components scores (PCs) of the SPI field on 24-month time scale for the period 1926–1996.



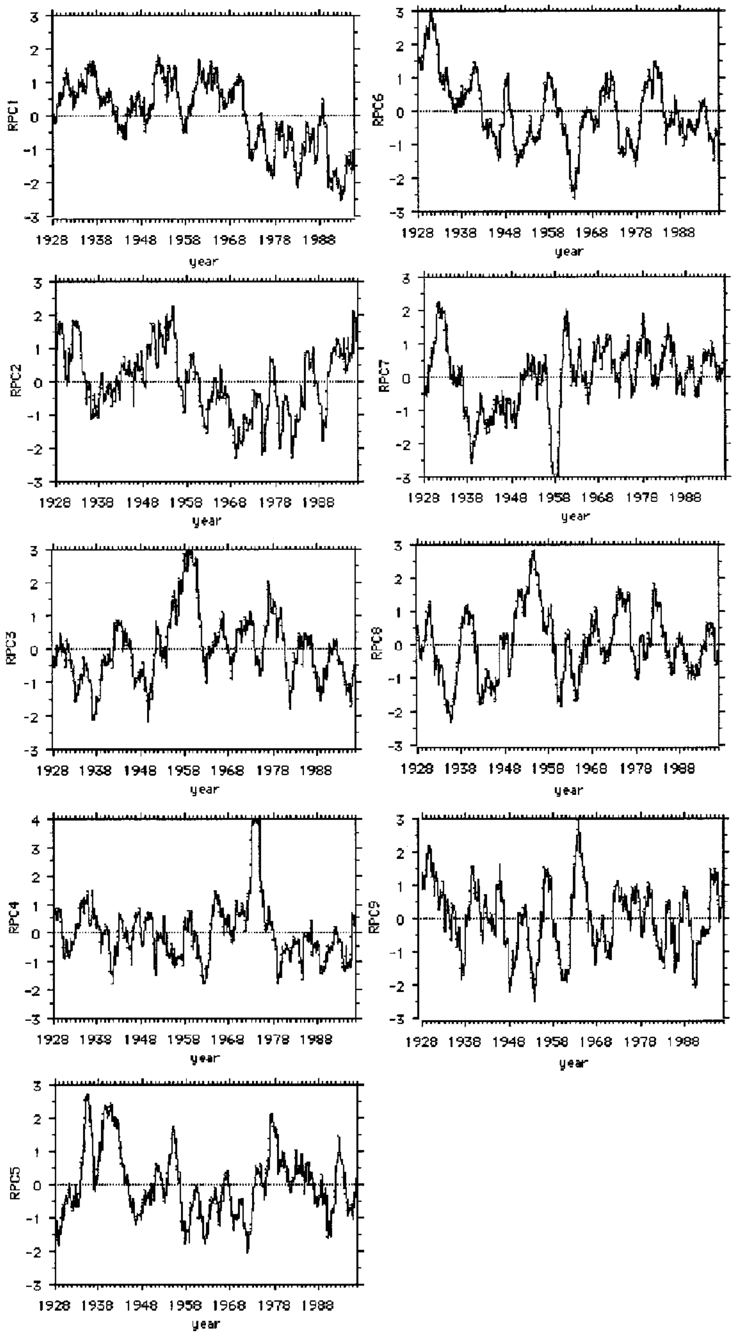
Panel III. Loading patterns of the first rotated components (RPCs) of the SPI on 24-month time scale for the period 1926–1996.

percentage of variance (say the second, the third, the fourth and the fifth) denote areas of variability very similar to those of Panel III.

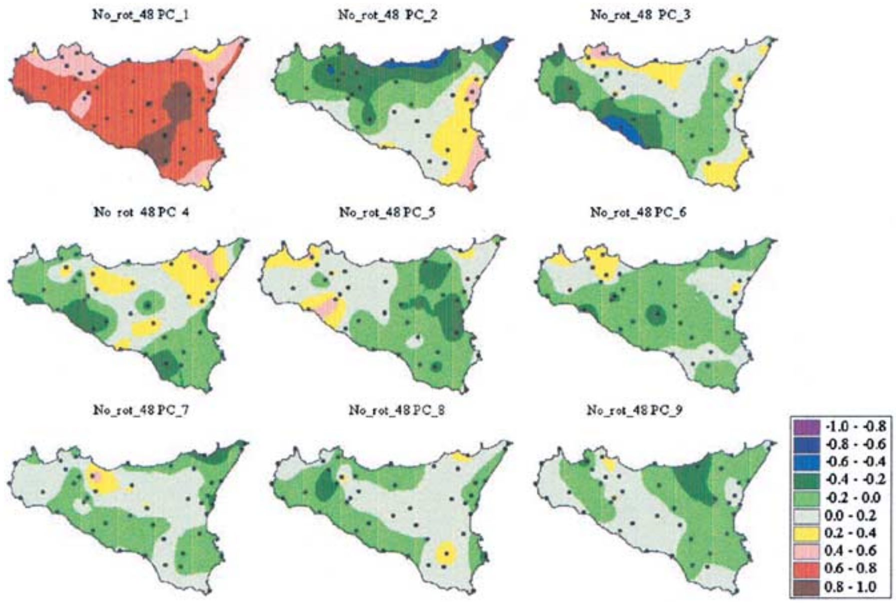
Given that most of the variability of the 24-month SPI in Sicily is described by the first unrotated score in Panel VI, it is convenient to compare this behaviour with

Table III. Variance contributions of the first nine unrotated and VARIMAX rotated loadings resulting from the PCA of the SPI on 24-month time scale for the period 1948–1996

n. PCs	Variance (%)	VARIMAX (%)
1	45.12	3.33
2	10.32	17.45
3	6.96	14.01
4	6.61	15.65
5	4.50	14.04
6	3.52	4.36
7	3.17	7.04
8	2.82	4.76
9	2.30	4.68



Panel IV. Time series of the first rotated nine principal components (RPCs) of the SPI on 24-month time scale for the period 1926–1996.



Panel V. Loading patterns of the first unrotated nine principal components (PCs) of the SPI field on 24-month time scale for the period 1948–1996.

that obtained by the large-scale analysis. In Figure 4 the first PC score obtained on the SPI computed by using rain gauges data in 43 stations for the period 1948–1996 is compared with the 24-month SPI computed by using re-analysed data at the grid point representative of Sicily.

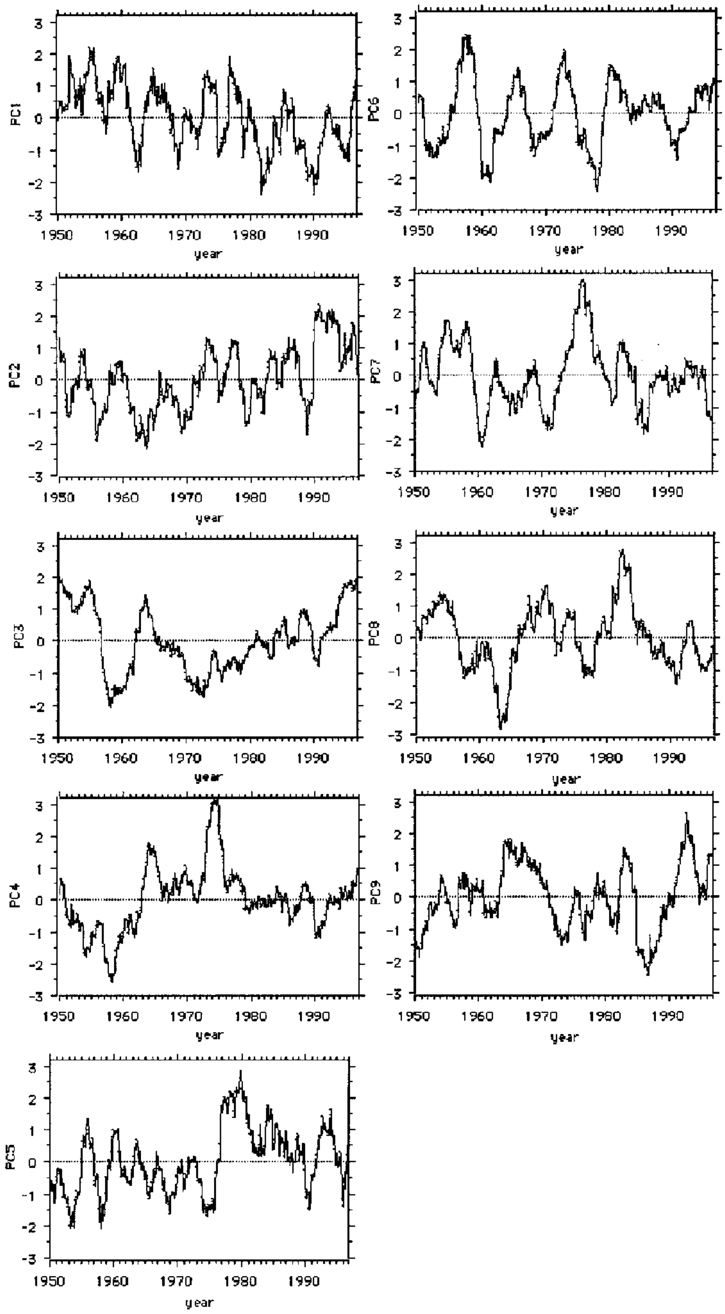
The correlation coefficient of the two curves (0.71) results significant at 95% probability level. The figure shows not only a similar behaviour (a tendency towards negative values in the last decades), but also that the character of the major severe drought episodes, such as the 1988–1990 occurrence, has been properly caught by the reanalysed data. However, as expected, the magnitudes of some events appear to be different (see for example the period 1977–1979). This is probably due to the higher sensitivity of the rain gauge observations to local climatic variations. Straight lines in the figure denote the linear regressions of the two curves. In particular, angular coefficients and intercepts result to be as follows:

$$angularcoeff. \begin{cases} (-0.040 \pm 0.003) dimensionless \cdot year^{-1} & \text{(for PC1)} \\ (-0.047 \pm 0.002) dimensionless \cdot year^{-1} & \text{(for SPI NCEP)} \end{cases}$$

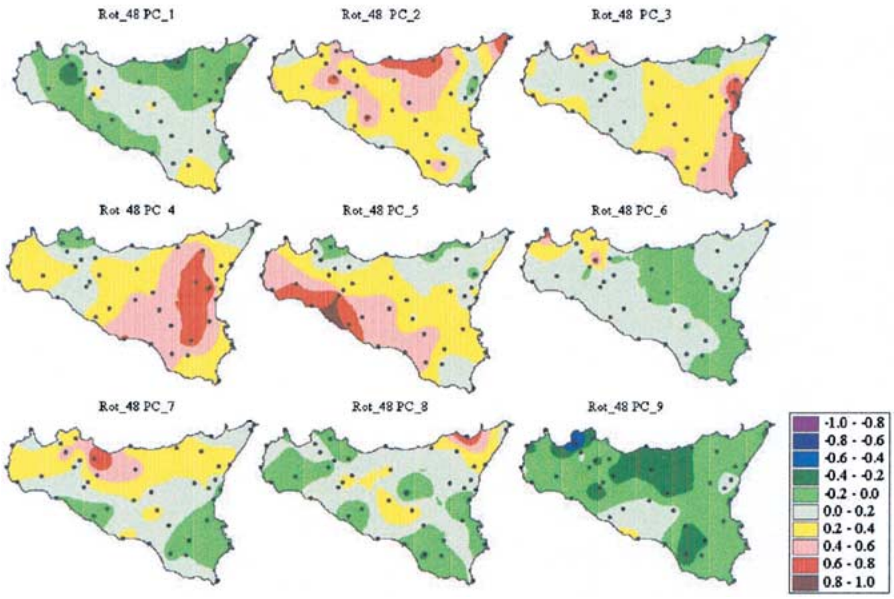
$$intercept \begin{cases} (1973.414 \pm 0.481) year^{-1} & \text{(for PC1)} \\ (1973.415 \pm 0.442) year^{-1} & \text{(for SPI NCEP)} \end{cases}$$

It is remarked again that the negative trends in the two series are similar and the slightly difference are almost within the error bands.

Finally, in Table IV the variations of the detected trend as a function of the calibration period and plotting period are shown. As reported in the last two rows



Panel VI. Time series of the first unrotated nine principal components scores (PCs) of the SPI on 24-month time scale for the period 1948–1996.



Panel VII. Loading patterns of the first rotated nine principal components (RPCs) of the SPI on 24-month time scale for period 1948–1996.

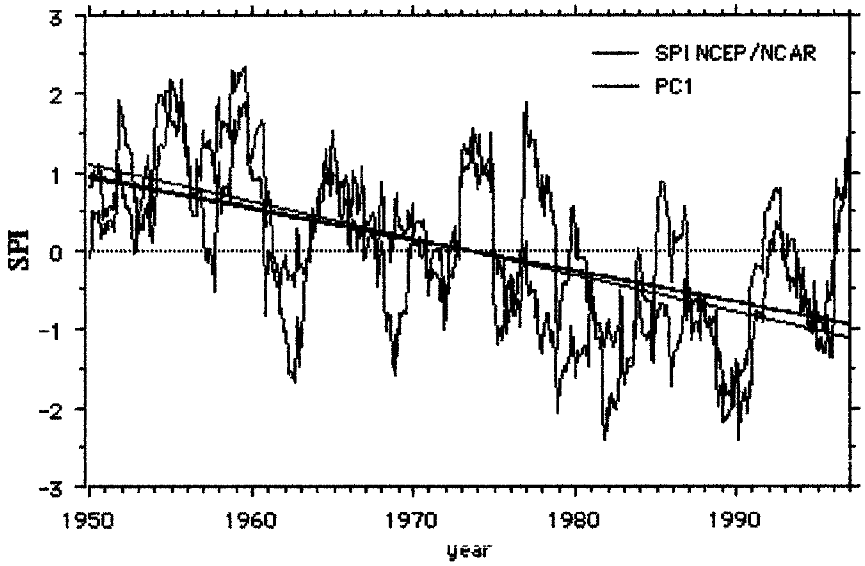


Figure 4. Time behaviours and linear regressions of the first PC score of the 24-month SPI computed for the period 1948–1996 respectively by using rain gauge observations (red line) and by the NCEP/NCAR data.

Table IV. Intercepts and angular coefficients of the linear regression of the 24-month SPI NCEP/NCAR and of the PC1 of the SPI on 24-month computed using rain gauge observations, as a function of the calibration and plotting period

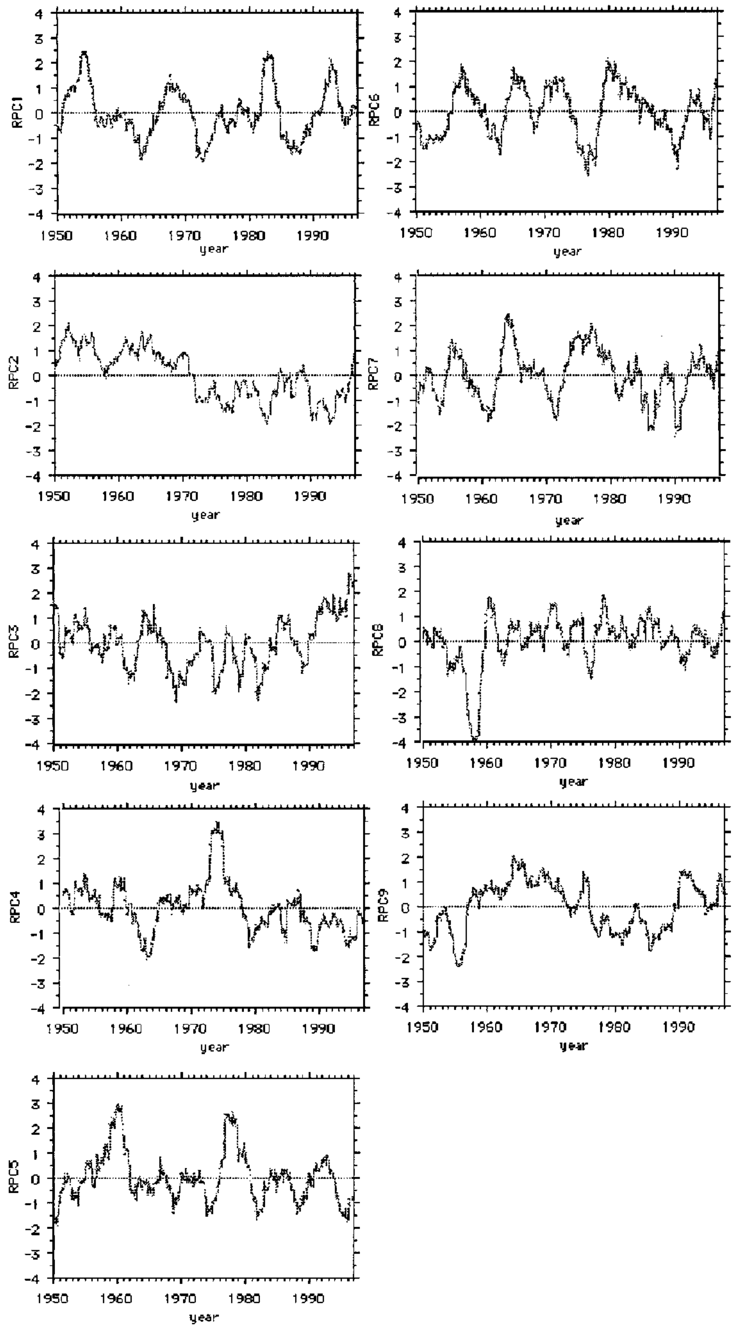
Variable	Plotting period (year)	Calibration period (year)	Intercept (year)	Angular coefficient ($year^{-1}$)
SPI24 NCEP/NCAR	1949–1996	1948–1996	1973.415 ± 0.442	–0.047 ± 0.002
PC1 SPI24 obs.	1949–1996	1948–1996	1973.414 ± 0.481	–0.040 ± 0.003
PC1 SPI24 obs.	1928–1996	1926–1996	1962.414 ± 0.562	–0.029 ± 0.001
PC1 SPI24 obs.	1928–1996	1948–1996	1962.417 ± 0.565	–0.029 ± 0.001

of the table, when the entire record is considered the intercept value moves roughly from year 1973 to year 1962 rather independently from the calibration period. A similar feature is found for the angular coefficient: it is unaffected by the calibration period, but it varies considerably as a function of the plotting period. Not surprisingly, the analysis of a trend greatly depends on the data record size considered, suggesting a deterministic nature of the detected phenomenon. In fact, if the trend has a stochastic source, it would not depend on the selection of the record size. We will not dwell further on this issue, since, in putting this point in a firmer ground, we would need a more detailed analysis.

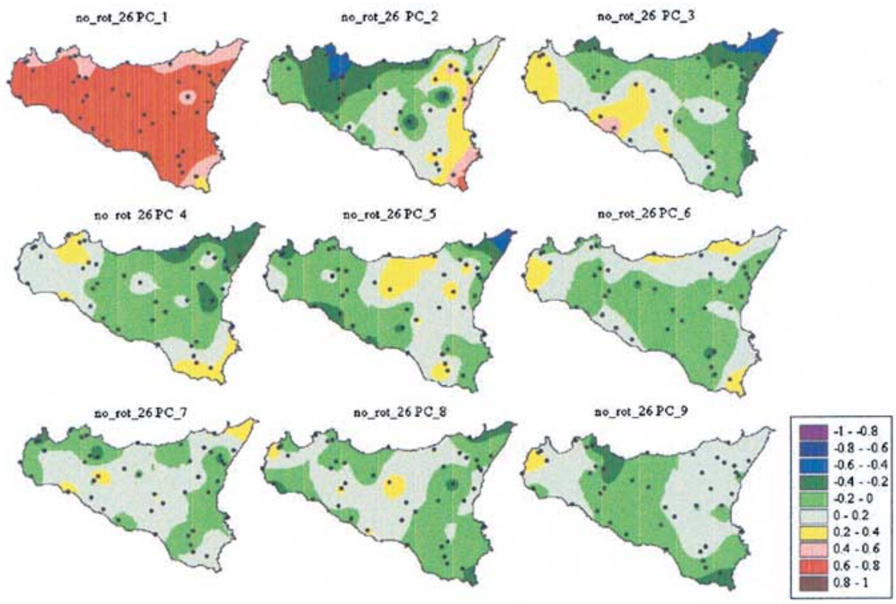
4. Behaviour of the SPI on 12-Month Time Scale

The impact of a long time-scale drought depends on the kind of mitigation structures that are available in the region where the phenomenon occurs. In Sicily there are areas where a significant portion of the available water reservoirs are managed on a time scale of one single year (i.e. they are filled in during the rainy season and empty out in the dry season). Thus, the study in so far presented would exclude information about a drought impact on these mitigation facilities.

In this section we shall address this question by repeating the analysis previously presented also for the SPI on 12-month time scale (hereafter SPI12). Notice that, by using this time scale, we avoid the seasonal cycle, while the memory effect associated with the interannual variability is still accounted for. Moreover, it is easy to show that the SPI12 is highly correlated with the Palmer Drought Severity Index (Palmer, 1968). A cursory look to the SPI12 at few selected rain gauges (here not shown) already signals that most of the results previously discussed carry on those of the SPI24, except with respect to the variance explained by the spatial patterns previously found. In Panel IX and X the first 9 loadings and their associated scores are presented.



Panel VIII. Time series of the first rotated nine principal components (RPCs) of the SPI on 24-month time scale for the period 1926–1996.



Panel IX. Loading patterns of the first unrotated nine principal components (PCs) of the SPI field on 12-month time scale for period 1926–1996.

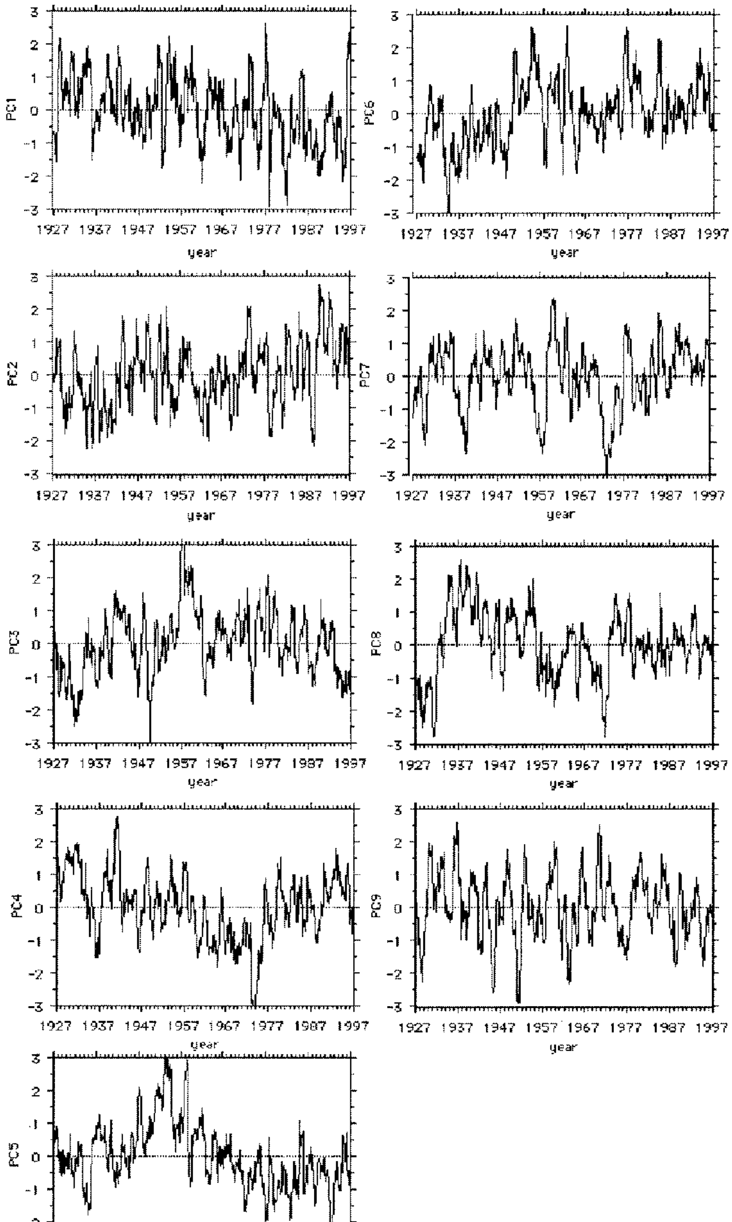
The trend on the first PC score is detectable and the associated spatial pattern explains again most of the variance. The other patterns resemble very much those relative to the SPI24. We only remark that the total variance (see Table V) accounted by these loadings is slightly less than that associated to the SPI24 as it could be expected (higher variability is in order at this time scale).

Some new information is, instead, gained by rotating these nine loadings. In fact, as it can be seen by inspecting Panel XI and XII we find again the three distinct areas of variability as we had with the SPI24 (compare the RPC (1, 2, 3) of the SPI24 with the RPC (4, 1, 3) of the SPI12).

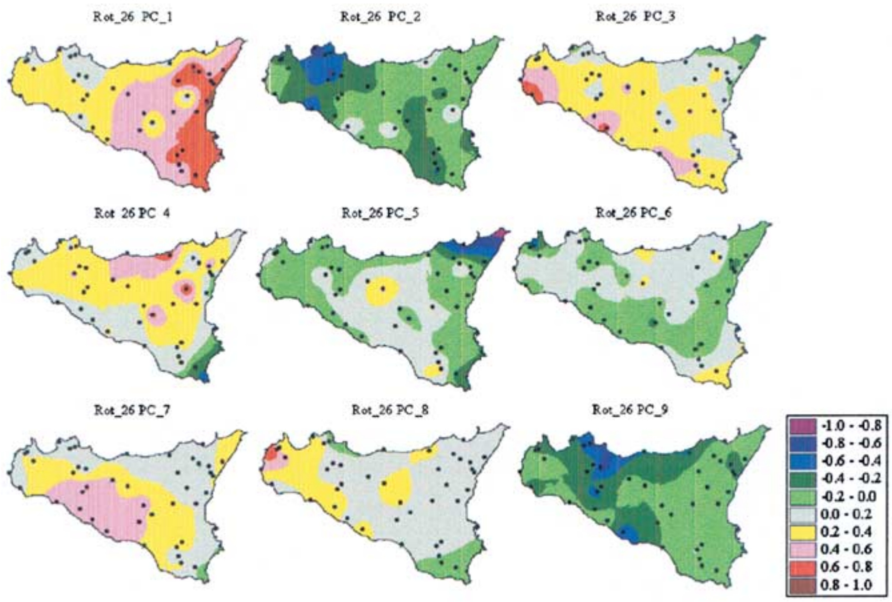
However, the relative variance explained changes as it is summarized in Table V. This implies that we may still subdivide the region into the same three areas as we have proposed in the previous section, however their sensitivity to the drought variability on this time scale is dissimilar from that described by the SPI24. The analysis suggests, then, different mitigation strategies for these time scales for the main three sub-areas.

5. Discussion and Conclusions

The long-term drought variability in Sicily was studied by using rain gauge data and the reanalysis product. A preliminary comparison between the first PC score computed on the SPI at 43 rain gauges and the SPI computed by using NCEP data of the grid point representative of Sicily, suggests that there is a common tendency



Panel X. Time series of the first unrotated nine principal components scores (PCs) of the SPI on 12-month time scale for period 1926–1996.

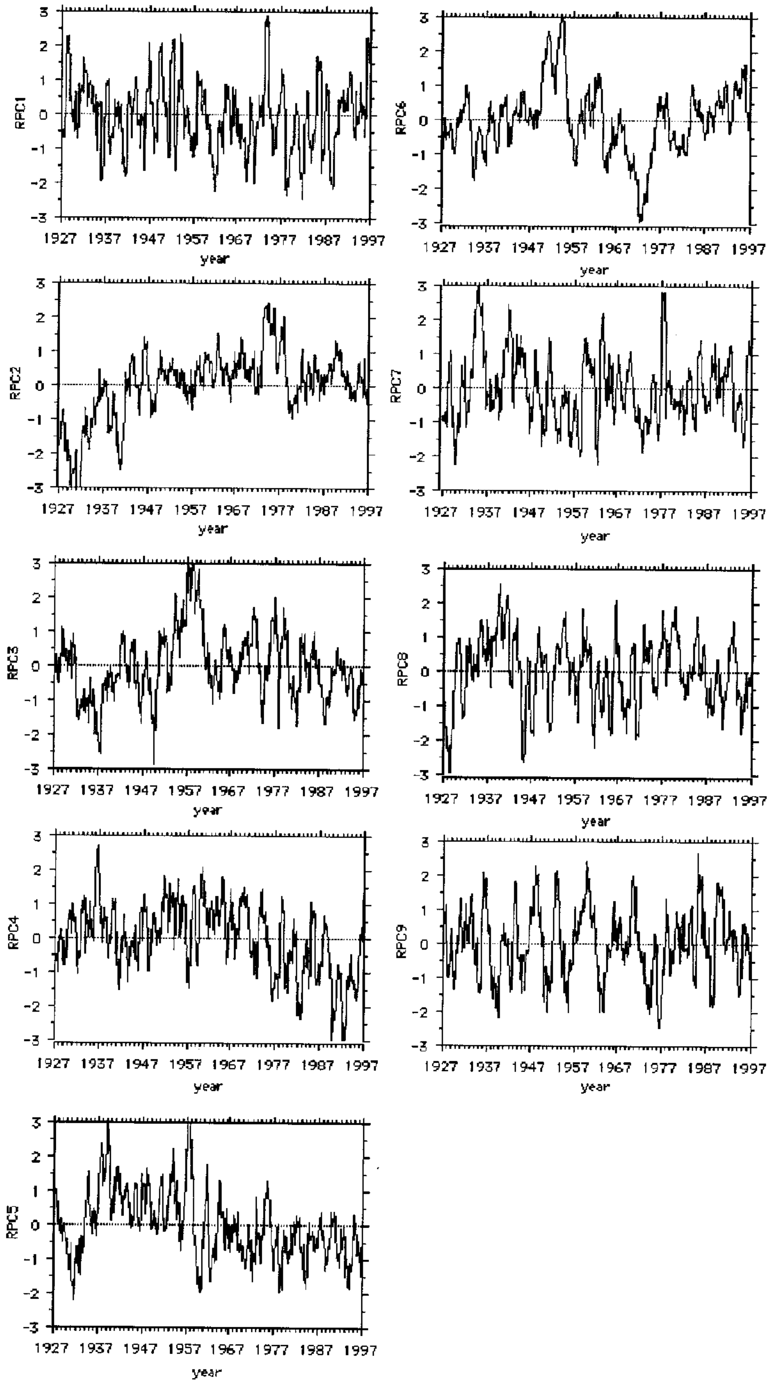


Panel XI. Loading patterns of the first rotated components (RPCs) of the SPI on 24-month time scale for the period 1926–1996.

towards drier periods from the seventies onward. The general agreement seems good, especially by considering that the two precipitation data sets are computed quite diferently and refer to areas not perfectly coincident.

Table V. Variance contributions of the first nine unrotated and VARIMAX rotated loadings resulting from the PCA of the SPI on 12-month time scale for the period 1926–1996

n. PCs	Variance (%)	VARIMAX (%)
1	46.32	23.66
2	9.52	8.11
3	5.33	9.91
4	3.99	9.89
5	3.51	3.24
6	2.81	3.03
7	2.47	8.45
8	2.42	4.64
9	2.13	7.57



Panel XII. Time series of the first rotated nine principal components (RPCs) of the SPI on 24-month time scale for the period 1926–1996.

The grid-point selected as representative of Sicily region describes, in fact, the precipitation occurring on a broader area covering not only Sicily, but also part of the southern Calabria and Ionian Sea (Bordi and Sutera, 2001b). On the other hand the rain gauge data refer only to Sicily. Nevertheless, some discrepancies in the magnitude of variability between the two times series above occur. They might be due to the sensitivity of the observed precipitation to local climatic fluctuations. Despite these shortcomings, the study suggests that the use of meteorological data, which have low spatial resolution, may give information on drought occurrence in a general agreement with local observations.

The test on the sensitivity of the SPI computation to different calibration periods suggests that the index values may be affected by the choice of the reference period, though the main features of variability remains unchanged. Moreover, the PCA shows that the main spatial pattern of the SPI variability for the period 1926–1996 characterizes uniformly Sicily. However, after a rotation of the principal components it is possible to distinguish three areas of independent variability such as northern, eastern and south-western Sicily, suggesting that different physical causes maybe are acting on the system.

The analysis restricted to the period 1948–1996 displays similar results both for the trend and the three areas of the observed variability. The detection of the source of this spatial variability would require further investigations. Finally, analysing the SPI12 the three areas of variability above mentioned are found, though the variance explained by each pattern changes.

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