

Analysis of rainfall trend in southern Italy through the application of the ITA technique

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Abstract: In the last decades, climate change has been the focus of considerable international attention due to the increase of phenomena such as flood, heat waves, forest fires and droughts. In this context, research on the patterns of precipitation trends, both at regional and local scale, has been paramount because these variations can negatively impact on ecosystems, agriculture, water supply and management, human welfare and regional political stability. In this paper, an investigation of the temporal rainfall variability has been carried out using a homogeneous monthly rainfall dataset of 559 rain gauges with more than 50 years of observation. The region under investigation is a large portion of the Italian peninsula, ranging from the Campania and the Apulia regions in the North, to Sicily in the South, and covering an area of about 85,000 km². Possible trends in monthly and seasonal rainfall values have been investigated by means of a new graphical methodology (Innovative Trend Analysis), which allows the trend identification of the low, medium and high values of a series. As a result, different values and tendencies of the highest and the lowest rainfall values have emerged among the five regions considered in the analysis. Especially at seasonal scale, a negative trend has been detected in winter and in autumn in the whole study area, whereas not well defined trend signals have been identified in summer and spring.

Key words: rainfall, trend, graphical techniques, southern Italy

1. INTRODUCTION

The latest Assessment Report (AR5) issued by the Intergovernmental Panel on Climate Change (IPCC 2013) has highlighted the global impact of human activities on climate and the effects that such activities produce. In Italy, numerous investigations carried out using long-term precipitation databases have detected a decreasing precipitation trend, even if rarely significant (e.g. Brunetti et al. 2006). The regions in which these trends were observed are principally located in southern Italy: Campania (Longobardi and Villani 2010), Basilicata (Piccarreta et al. 2004), Sicily (Liuzzo et al. 2016) and Calabria (Caloiero et al. 2015). These studies did not specify if low or high precipitation contributed to the detected trends. They were principally based on non-parametric tests, which are better suited than parametric ones to deal with non-normally distributed data in hydrometeorology (Onyutha 2016). However, as Kundzewicz and Robson (2000) showed, a powerful graphical technique for exploratory data analysis is required to avoid errors in identifying significant hidden (short-duration) sub-trends. For this reason, Şen (2012) proposed a new Innovative Trend Analysis (ITA) technique, which has found wide application in hydrology. Haktanir and Citakoglu (2014) applied the ITA method to 14 standard duration annual maximum rainfall series of Turkey. Kisi and Ay (2014) used ITA and MK to study the trends of some water quality parameters registered at five different Turkish stations. Temperature data recorded at the Marmara region in Turkey have been studied using ITA (Şen 2014); also, the monthly total precipitation trend of six different provinces in Turkey has been studied using MK and ITA methods (Ay and Kisi 2015). Further applications of ITA and Spearman's rho test include changes observed in temperature trends and heat waves in Northwestern Mexico (Martínez-Austria et al. 2015), and the trend analysis of monthly pan evaporations (Kisi 2015). In addition, a streamflow trend analysis in the

northwest of Iran has been carried out verifying the utility of ITA for these applications (Tabari and Willems 2015).

In this study, the monthly and seasonal high quality rainfall series recorded in southern Italy have been analysed and the temporal changes of the different series have been detected using the ITA technique. In particular, the investigation was carried out considering five different regions of the study area. The application of the ITA technique allowed to distinguish the trend of the low, medium and high precipitation monthly data at regional scale.

2. STUDY AREA AND DATA

The region under investigation is a large portion of the Italian peninsula, extending from the Campania and the Apulia regions in the North, to Sicily in the South, and covering an area of about 85,000 km² (Figure 1). The study area is located within the Mediterranean basin and is characterized by particular climatic conditions. The climate regime of the study area is typically a Mediterranean climate, which dominates in particular the islands and the coastal areas; the winter season is a rather mild and rainy period, whereas the summer season is very hot and dry.

The database used in this study was the one presented in Longobardi et al. (2016) in which available precipitation time series have been tested for time series homogeneity through the combined use of direct and indirect methods. The database consists of 559 monthly precipitation series, in the period 1917–2006, with an average density of 1 station per 138 km² (Figure 1).

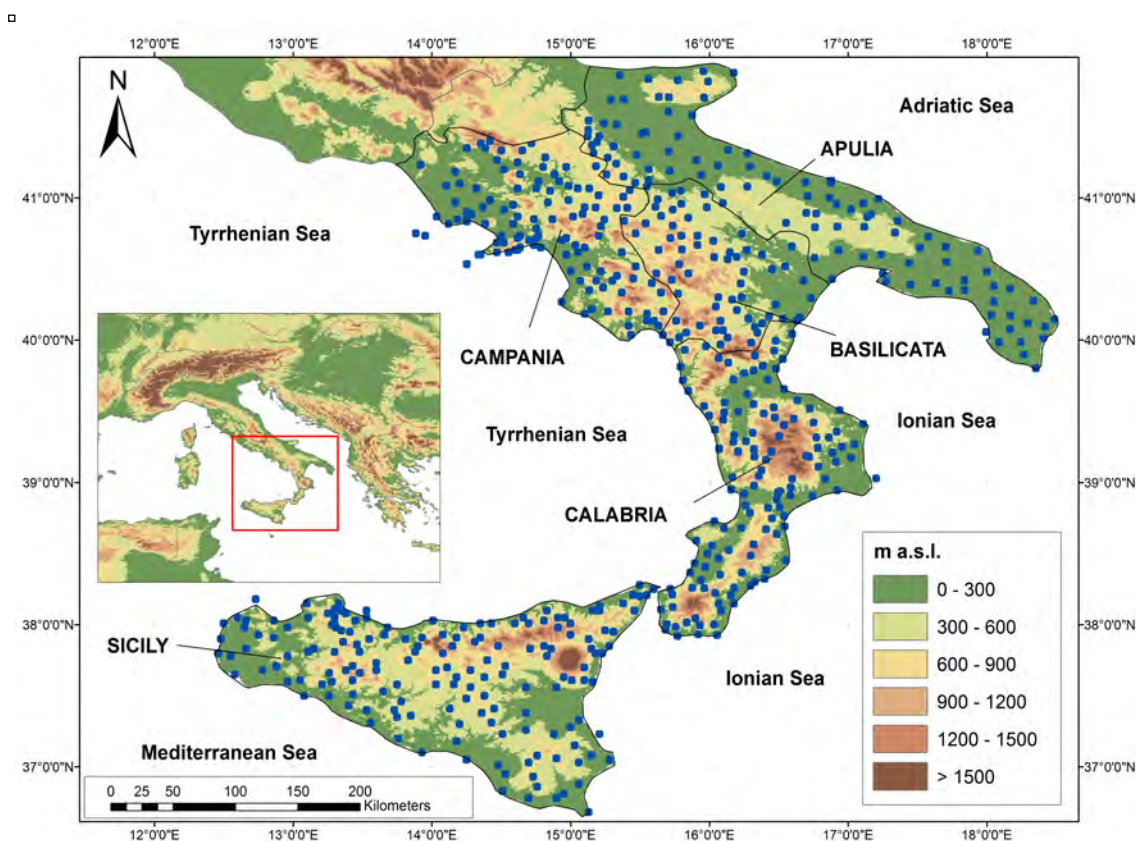


Figure 1. The study area with the localization of the 559 rain gauges.

3. METHODOLOGY

The ITA method has been first proposed by Şen (2012) and presents the main advantage that it does not require any assumptions (e.g., serial correlation, non-normality, sample number etc.) as in

case of the non-parametric tests. First, the time series is divided into two equal parts, which are separately sorted in ascending order. Then, the first and the second half of the time series are located on the x-axis and on the y-axis, respectively. If the data are collected on the 1:1 ideal line (45° line), there is no trend in the time series. If data are located on the upper triangular area of the ideal line, an increasing trend in the time series exists. If data are accumulated in the lower triangular area of the 1:1 line, there is a decreasing trend in the time series (Şen, 2012, 2014). Thus, trends of low, medium and high values of any hydro-meteorological or hydro-climatic time series can be clearly identified through this method, even if it does not allow to evaluate the significance of the trends.

4. RESULTS AND DISCUSSION

The aim of this study was to analyse rainfall trend at regional scale in southern Italy. With this aim, for each region, an average rainfall series has been evaluated for every time-scale.

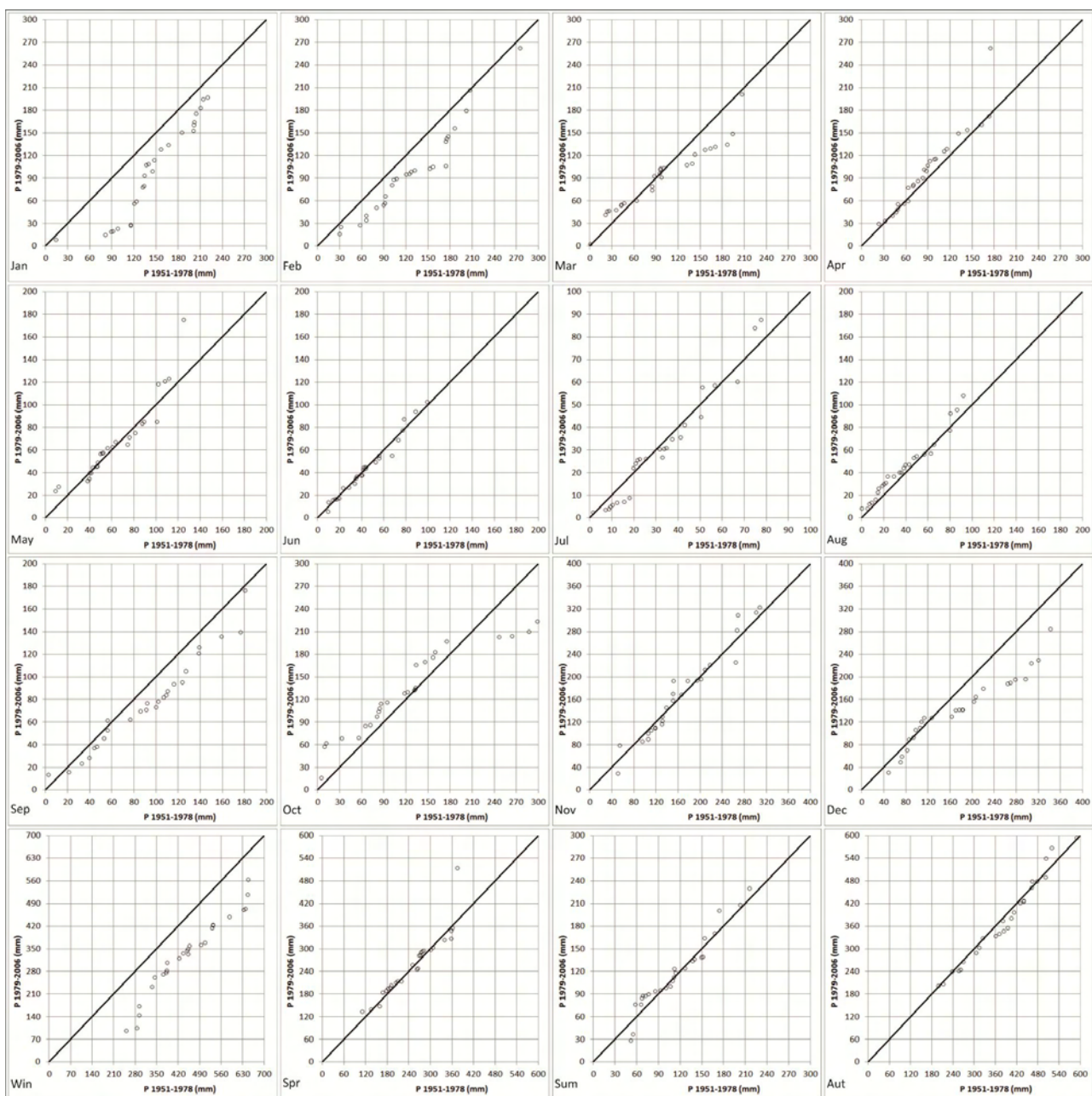


Figure 2. Results of the ITA method for the Campania region.

The results of the Campania region (Figure 2) showed a prevailing negative trend for all the rainfall values (low, medium and high) in January, February, September and in the winter season. A negative trend has also been observed in October and in December but only for the high and for the medium-high values, respectively. Some positive tendencies were detected in March (for the low values) and in October (for the low-medium values). The other months and seasons do not show clear tendencies.

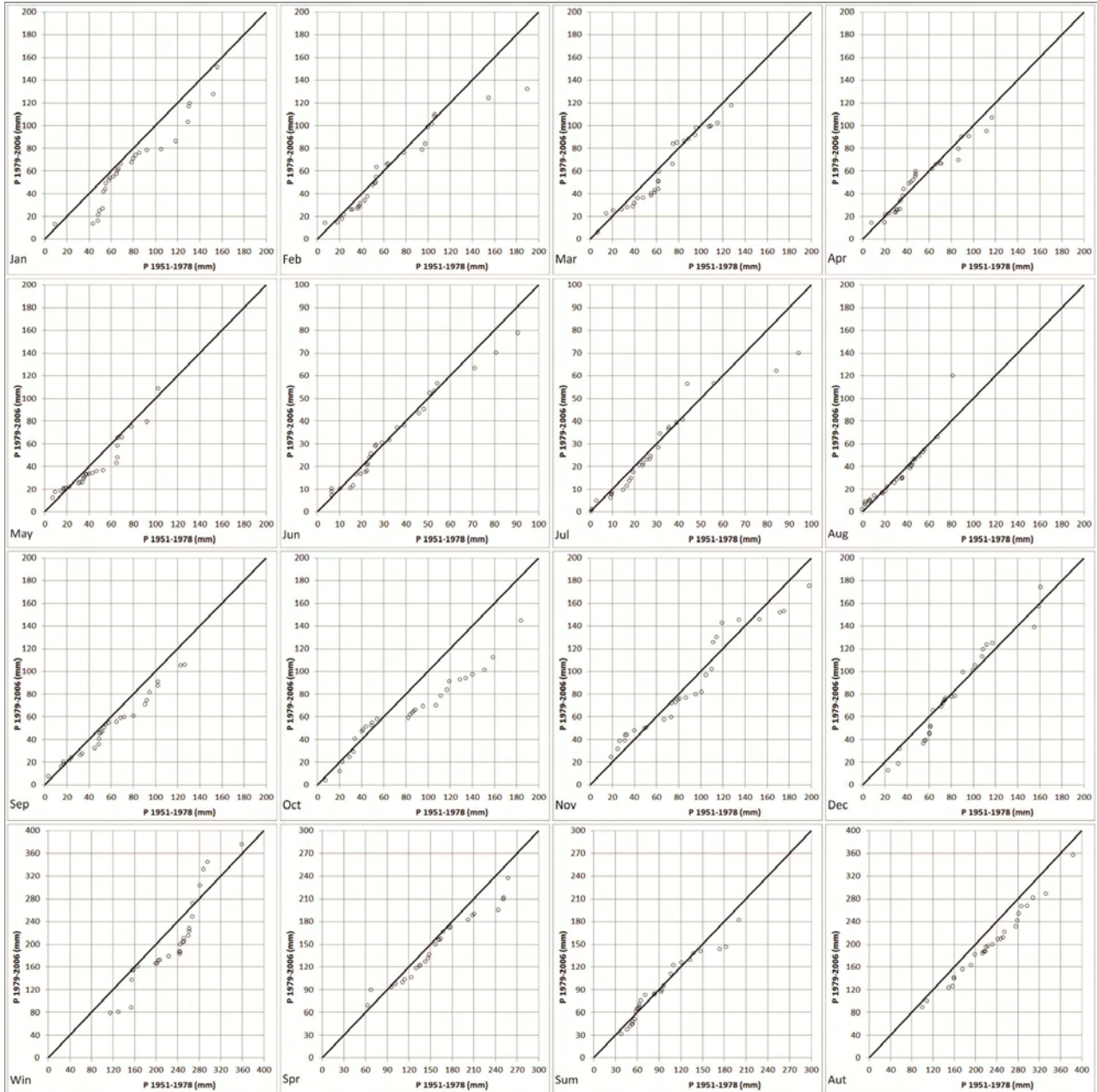


Figure 3. Results of the ITA method for the Apulia region.

Also in Apulia (Figure 3) January and September showed a clear negative trend for all the monthly values. Negative trends, but only for the medium-high values, also appear in February, in October and in the autumn season. Conversely, few positive trends have been evidenced in November (for the medium values) and in the winter season (for the high values).

In the Basilicata region (Figure 4) marked negative trends have been detected in January, in February and in autumn for all the values, in May, in spring and in summer for the medium values, in September and November for the medium-high values, and in October and in winter for the low-medium values. On the contrary, clear positive trends were also evidenced in March, July and in

summer for the medium values, in April and in May for the low values, and in August for all the values.

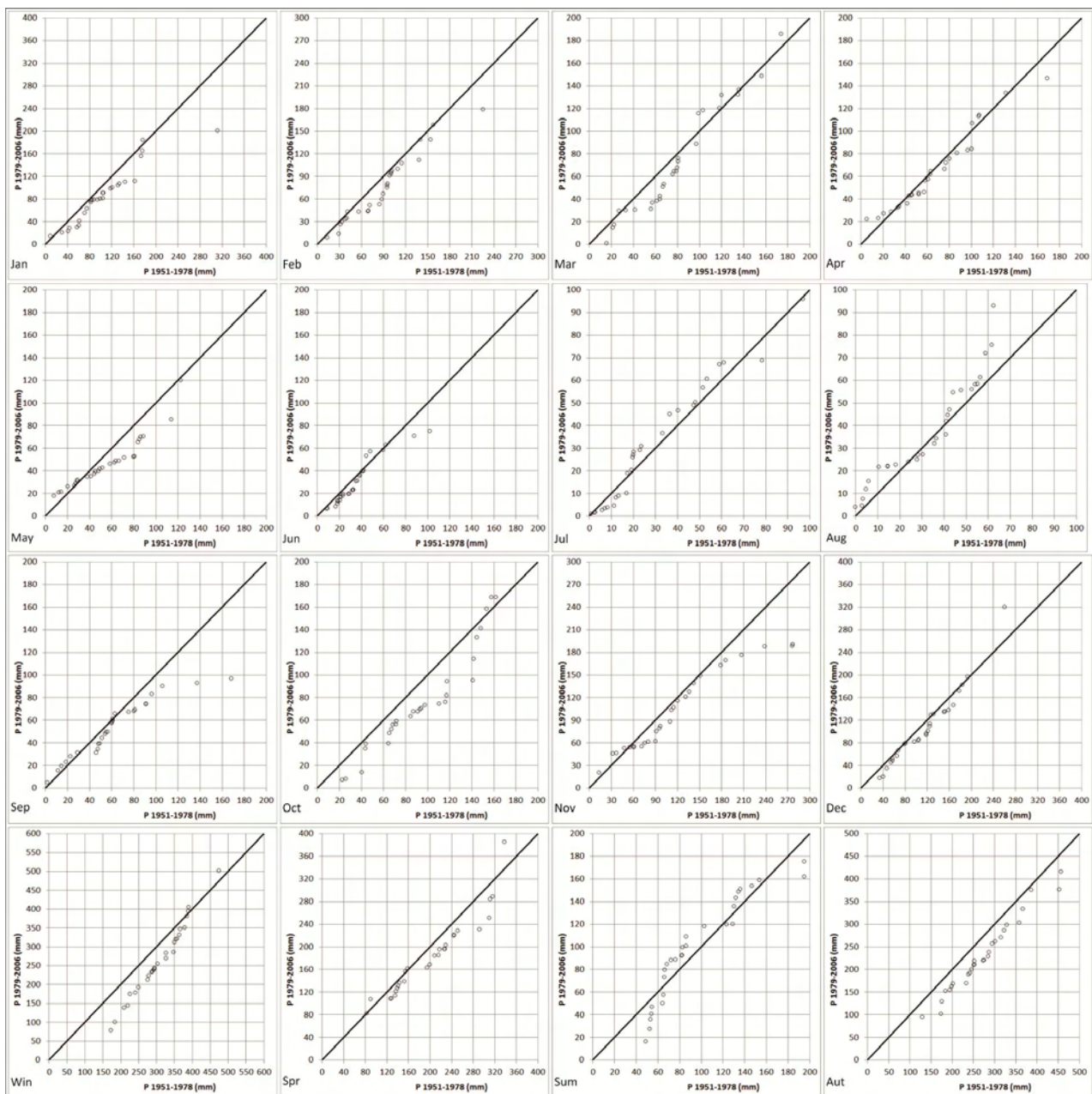


Figure 4. Results of the ITA method for the Basilicata region.

Figure 5 shows the results of the Calabria region, which presented a prevailing negative tendency. This trend behaviour has been evidenced especially in January and winter for the low-medium precipitation, in February, October and in autumn for all the precipitation classes, in May, June and November for the high values, in July only for the medium values. The few positive tendencies were detected in July for the low and high values, in August for the high values, in November for the low values.

Finally, the results for the Sicily region (Figure 6) showed a prevailing negative trend, more evident in February and October for all the values, in March for the low-medium values, in May, September, November, December, in summer and in autumn, especially for high values. Conversely, few positive tendencies were detected in April, August, September and November but only for the low values.

The results for the five regions, with some differences, show a general negative tendency of the

precipitation monthly data. These trends are particularly clear in some winter and autumn months, mostly for the medium and high values. Few positive trends have been evidenced only for the low data of the autumn months. At seasonal scale, a negative trend has been detected in winter and in autumn in the whole study area, whereas not well defined trend signals have been identified in summer and spring.

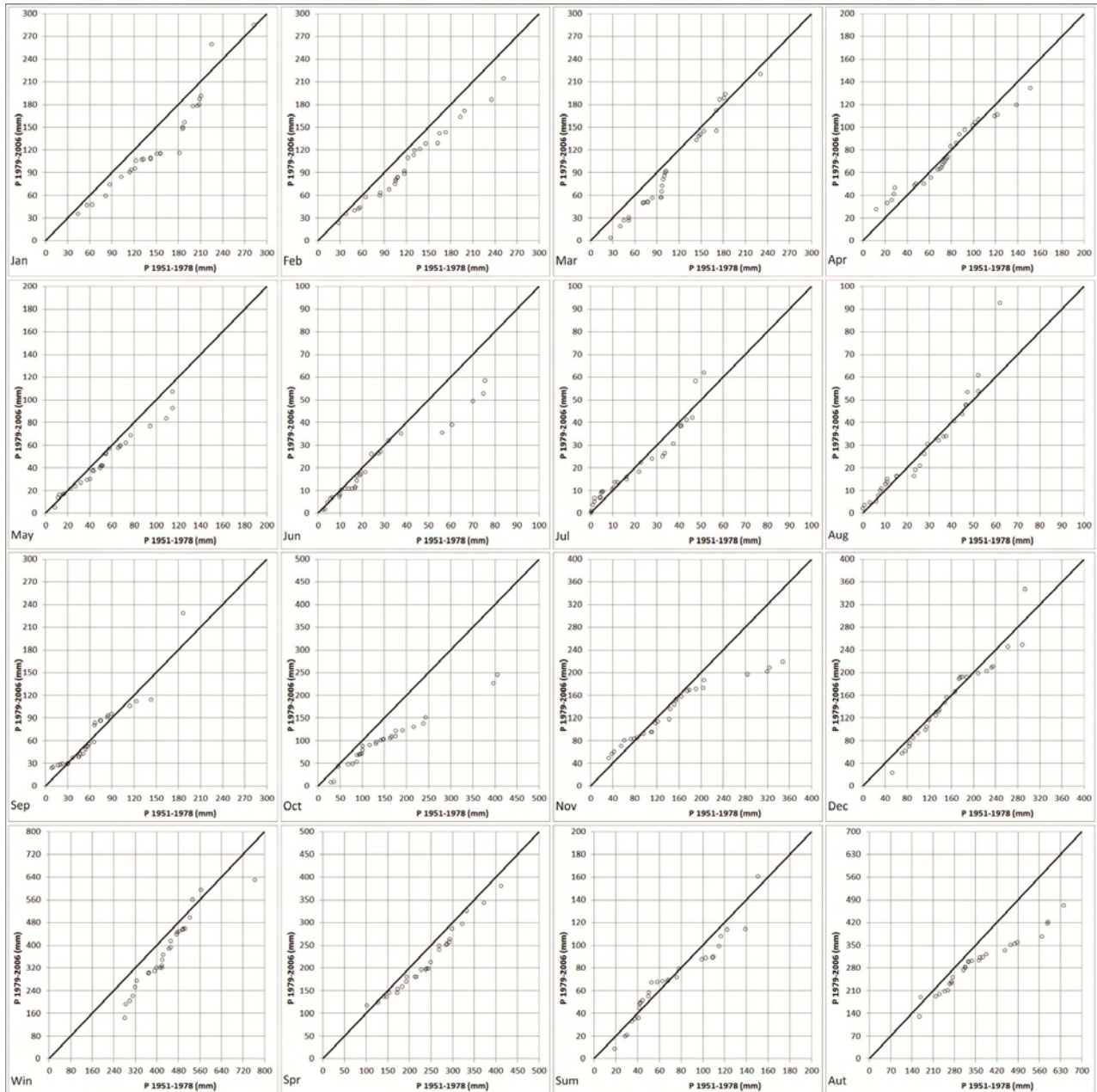


Figure 5. Results of the ITA method for the Calabria region.

5. CONCLUSIONS

This study analyses the temporal changes of the monthly and seasonal rainfall series, recorded in five regions of southern Italy, by means of the ITA technique. By applying this methodology, which allows to detect separately the trends of the low, medium and high precipitation data, it was possible to better explain the clear tendencies previously evidenced in past studies in some of the investigated regions. For example, for the Calabria region, the ITA technique allowed to state that the negative trends in January and in the autumn season, are mainly due to the medium-low values

and, conversely, that the high values contribute to the positive trends in summer. This feature of the ITA methodology is useful because low rainfall values trends are important for water management while high values ones are useful for investigating extreme phenomena, such as flood and soil erosion.

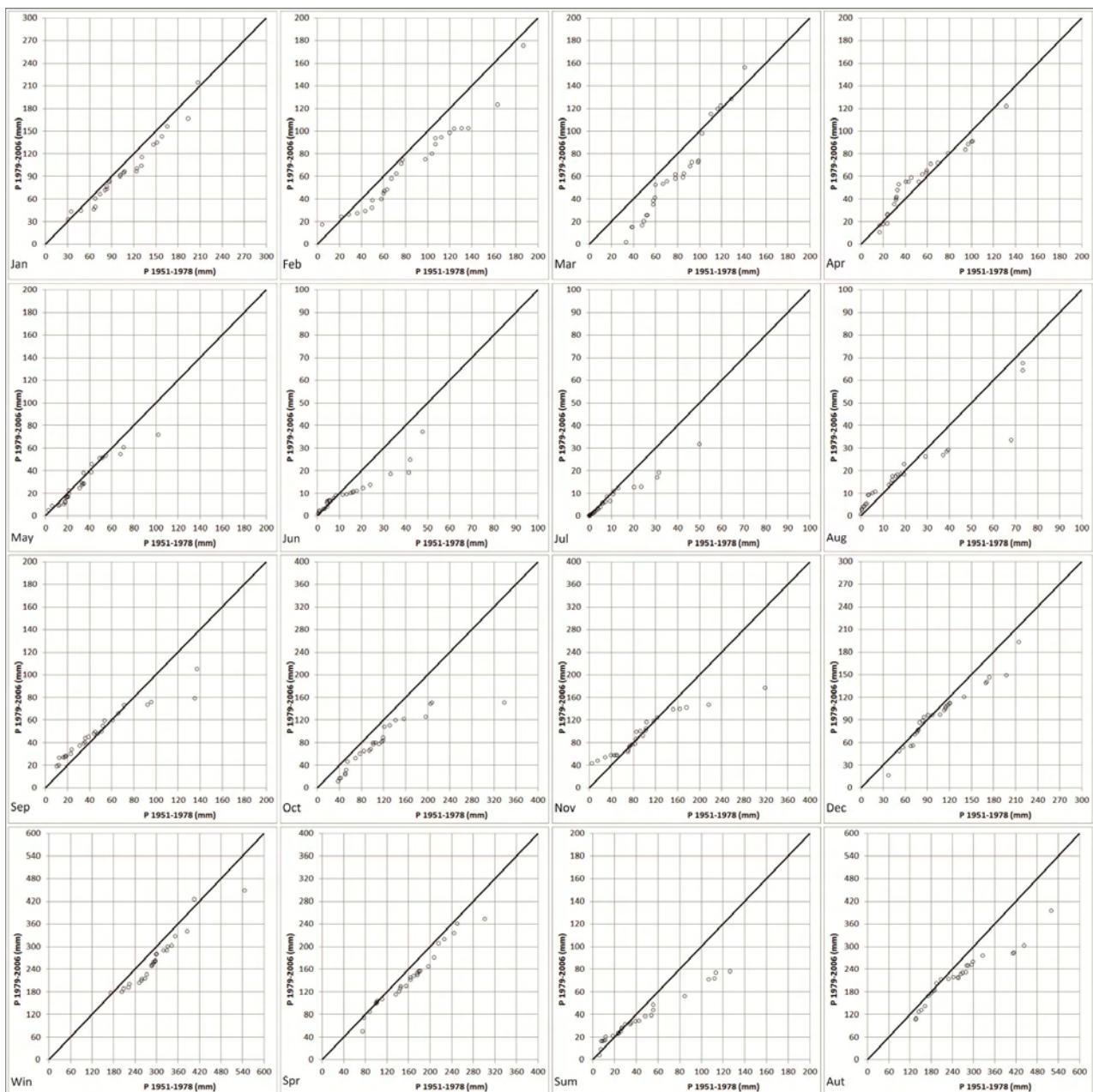


Figure 6. Results of the ITA method for the Sicily region.

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