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Trend analysis of monthly rainfall data using the Innovative Polygon Trend Analysis (IPTA) in the Tafna Watershed (Northwestern Algeria)

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Abstract. Trend analysis of hydroclimatic data is essential for assessing climate variability. Precipitation is an important parameter affected by climate change in the Mediterranean climate, particularly in sensitive regions like the Tafna watershed in Northwestern Algeria. This study used the Innovate Polygon Trend Analysis (IPTA) to study the change between two successive months. Additionally, the Mann-Kendall (MK) test was compared to the IPTA method in detecting trends. Total monthly rainfall data was collected from 14 stations in the Tafna watershed over 50 years from the hydrological year 1970-71 to 2019-20. The maximum trend length using the IPTA method was found in the transition May-June for most stations. The MK test does not indicate any significant trend (increase and decrease) in most of the months at all stations. In contrast, the IPTA method shows an increasing trend in October and January in all stations; August, September, November, and December show an increasing trend in most stations. A decreasing trend was found in February and March at all stations and in May at most stations. The results showed that the MK test detected a significant trend in 6.5% of the total months analyzed in this study, whereas the IPTA method identified a trend in 88.7% of the total months. The findings revealed that the IPTA method was more sensitive to detecting trends in precipitation data than the MK test, which suggests the IPTA method could be a valuable tool for assessing trends of precipitations in the Tafna watershed.

Keywords: rainfall, trend, Mann-Kendall test, IPTA, Tafna Watershed.

1. INTRODUCTION

Precipitation is one of the most important components of the hydrological cycle and the environment, particularly in regions with a Mediterranean climate, where it is significantly affected by climate change (Şan et al., 2024). Several precipitation variability and trends studies have been conducted in the Mediterranean basin to understand this effect better (Khomsi et al., 2015; Longobardi & Villani, 2010; Martínez et al., 2007; Mehta & Yang, 2008; Nouaceur & Murărescu, 2016; Philandras et al., 2011; Tramblay et al., 2013). In Algeria, many researchers have studied spatiotemporal trends of precipitation in many parts of the country, such as Meddi and Meddi (2009), Meddi et al. (2010), Ghenim and Megnounif (2016), Taibi et al. (2017), Bessaklia et al. (2018), Otmane et al. (2018), Merniz et al. (2019), and Gherissi et al. (2021).

One of the classical methods to detect trends in hydrometeorological data is the Mann-Kendall (MK) test (Kendall, 1975; Mann, 1945). In Algeria, the MK test was used to indicate the trend of rainfall at different time scales in many studies, such as in the North-East (Merniz et al., 2019; Mrad et al., 2018), in the northern part of Algeria (Ghenim & Megnounif, 2016; Ghorbani et al., 2021), in the North-West of Algeria, such as in two watersheds Coastal-Oran and Macta (Oufrigh et al., 2023), in the Macta watershed (Benzater et al., 2024). One of the latest graphical methods developed for detecting trends, especially at the monthly scale, is the Innovate Polygon Trend Analysis (IPTA) method developed by Şen et al. (2019). It was recently used to detect the trend in some regions in Algeria, such as in the Wadi Sly Basin (Achite et al., 2021), in the North Coast Algerian (Boudiaf et al., 2022), and in the Wadi Mina Basin (Hallouz et al., 2024).

Many studies around the world compared the IPTA method with the MK test, such as Hallouz et al. (2024) in Algeria; Akçay et al. (2022), Hırca et al. (2022), Esit (2023), and Esit et al. (2024) in Turkey; and Şan et al. (2021) in Vietnam. All these researchers found that the IPTA method was more sensitive in detecting trends with precipitation data than the MK test.

In the Tafna watershed, Bougara et al. (2020) used the MK test to identify the trend in precipitations for nine stations from 1979–2011. The findings showed an increasing trend in rainfall in September and October, meaning the increase was found in autumn. Bouklikha et al. (2021) used the Innovate Trend Analysis (ITA) method to identify the trend in rainfall time series for 17 stations over the period 1970-2016; the results showed a decreasing trend in February, March, April, and May in all stations, June and July for the majority of stations.

This study aims to analyze monthly precipitation trends in the Tafna watershed using data from 14 rainfall stations over a 50-year period (1970-71 to 2019-20). To achieve this, both the Mann-Kendall (MK) test and the Innovate Polygon Trend Analysis (IPTA) method are employed to examine monthly rainfall trends. Notably, the IPTA method uniquely allows for the analysis of trend patterns between two consecutive months. The study is structured around two main objectives: (1) investigating trends between consecutive months using the IPTA method, and (2) comparing the effectiveness of the MK test and IPTA in detecting monthly precipitation trends.

2. STUDY AREA AND DATA

The research area is located in the Tafna watershed in (Northwestern Algeria), covering an area of 7200 km^2. It is situated between latitude North 34°3’ and 35°9’ and longitude West 1° and 2°, and its altitude is between 0 and 1773 m (Figure. 1). Monthly precipitation data of 14 rainfall stations from 1970-71 to 2019-20 was collected from the National Hydraulic Resources Agency (ANRH) (https://anrh.dz/). The names of the stations, their IDs, coordinates (longitude, latitude), and elevation are presented in Table 1. The selection of stations was based on the duration of the time series and their spatial distribution, ensuring comprehensive coverage of the study area. The analysis period for the selected stations extended over 50 years, started with the hydrological year 1970–1971, which begins in September and closes in August. The selected data demonstrates a highly uniform distribution within the research area.

3. METHODOLOGY

3.1 IPTA method

The Innovate Polygon Trend Analysis (IPTA) method developed by Şen et al. (2019) was modified recently

Table 1. The rainfall stations utilized in this study

Station	Name	ID	Longitude (DD)	Latitude (DD)	Elevation (m)
S1	Maghnia	160302	-1.80254	34.79900	395
S2	Sebdou	160401	-1.32548	34.65515	875
S3	Beni Bahdel	160403	-1.50369	34.71165	660
S4	Sidi Medjahed	160407	-1.64262	34.77520	360
S5	Sebra	160502	-1.52886	34.82671	600
S6	Hennaya	160516	-1.38812	34.92100	515
S7	Zaouia Ben Amar	160517	-1.65752	35.03999	370
S8	Djebel Chouachi	160518	-1.49698	35.05436	110
S9	Oued Lakhdar	160601	-1.13454	34.86408	700
S10	Meurbah	160602	-1.17134	34.74197	1100
S11	Ouled Mimoun	160607	-1.03406	34.90429	705
S12	Mefrouche	160701	-1.28586	34.84734	1110
S13	Lalla Setti	160705	-1.30650	34.86604	1020
S14	Pierre Du Chat	160802	-1.43970	35.14572	80

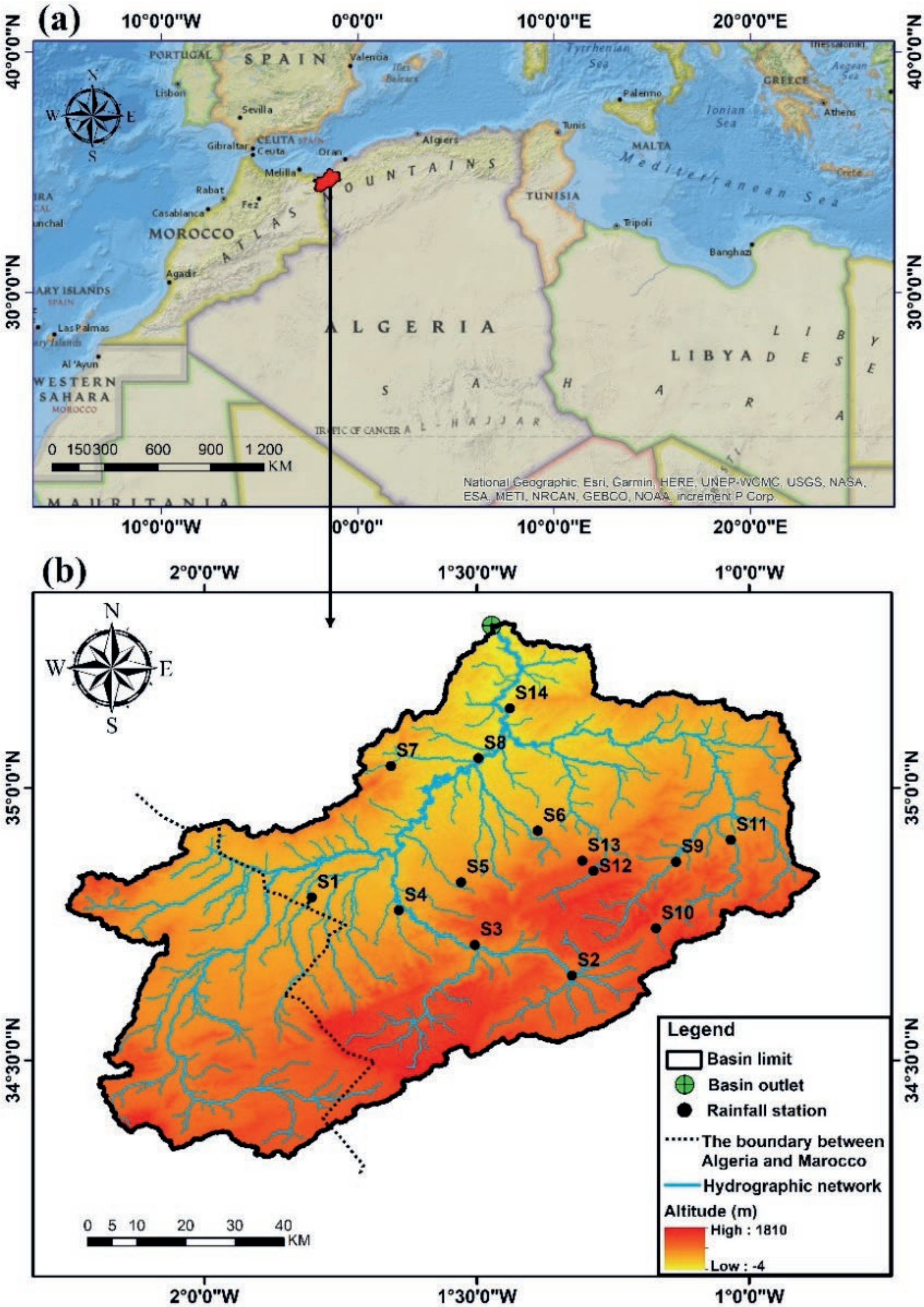

Figure 1. Study area: (a) location of the Tafna watershed in Algeria, (b) DEM, Hydrographic Network, and location of rainfall stations used in this study.

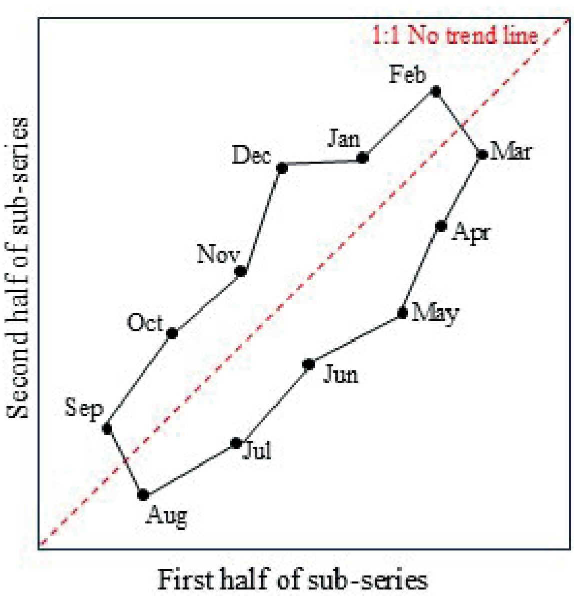

Figure 2. IPTA template for monthly records.

from the Innovate Trend analysis (ITA) created by Şen (2012). This study applied the IPTA method to monthly precipitation data following seven processing steps. Step (1): the monthly precipitation data was divided into two equal periods. Step (2): the monthly mean for each month is calculated in both periods. Step (3): the first and second periods are placed on the horizontal and vertical axis in a cartesian coordinate system. Step (4): the points of consecutive months are joined by straight lines that result in a polygon (Figure. 2).

Step (5): the trend length (TL) and the trend slope (TS) between consecutive points were calculated as follows:

$$|TL| = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \tag{1}$$

$$TS = \frac{y_2 - y_1}{x_2 - x_1} \tag{2}$$

Where TL and TS are trend length and trend slope, x1 and x2 are two consecutive months in the first period, and y1 and y2 are two consecutive months in the second period. The TL indicates the magnitude of change in precipitation (mm) between two consecutive months, while the TS reflects the direction and rate of this change. Step (6): Draw the no-trend line (1:1 line) at 45° in the cartesian coordinate system. Step (7): The months above the no-trend line indicate an increasing trend, whereas the months below the no-trend line indicate a decreasing trend, while the months found on the no-trend line do not show any trend. According to Boudiaf et al. (2022), the trend length can be classified into four categories as follows.

1) weak for 0 < TL < 30 mm,
2) medium for 30 mm < TL < 50 mm,
3) strong for 50 mm < TL < 75 mm,
4) very strong for TL > 75 mm.

Although the TS is computed as part of the IPTA method, it is not a central focus of the present study. The interpretation of monthly trends relies primarily on the TL and its visual positioning relative to the no-trend line. These thresholds are empirical and not based on statistical significance testing. Unlike the Mann-Kendall test, the IPTA method does not offer a formal statistical framework, which represents a known limitation of this graphical technique. However, it provides a valuable visual and comparative assessment of monthly changes that complements statistical approaches.

3.2 Mann-Kendall (MK) trend test

One of the non-parametric tests used to detect trends is the MK test (Kendall, 1975; Mann, 1945), which is particularly useful for meteorological, climatological, and hydrological time series. The following equations give the MK test statistic (S):

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sgn(x_j - x_i) \tag{3}$$

$$sgn(\mathrm{x_j} - \mathrm{x_i}) = \begin{cases} +1 & if\ (\mathrm{x_j} - \mathrm{x_i}) > 0 \\ 0 & if(\mathrm{x_j} - \mathrm{x_i}) = 0 \\ -1 & if(\mathrm{x_j} - \mathrm{x_i}) < 0 \end{cases} \tag{4}$$

Where xi and xj represent the data points in periods i and j, while the amount of data series is larger than or equivalent to ten (n ≥ 10), since n ≥ 10, the MK test is then categorised by a standard distribution with the mean E(S) = 0 and variance Var(S) given as:

$$Var(S) = \frac{n(n-1)(2n+5) - \sum_{k=1}^{m} t_k(t_k-1)(2t_k+5)}{18} \tag{5}$$

Where m is the number of the tied groups in the time series and t_k is the number of ties in the k_{th} tied group. From this, the test Z statistics is obtained using an approximation as follows:

$$Z = \begin{cases} \frac{\mathrm{s}-1}{\sqrt{\mathrm{Var(S)}}} & if \quad S > 0 \\ 0 & if \quad S = 0 \\ \frac{\mathrm{s}+1}{\sqrt{\mathrm{Var(S)}}} & if \quad S < 0 \end{cases} \tag{6}$$

In a Z test, the null hypothesis (H_0) indicates no trend in the time series, the alternative hypothesis (H_a) indicates a significant change. At the 5% significance level, negative values indicate decreasing trends, and positive values indicate an increasing trend. If $|Z| > 1.96$, H_0 is rejected (Sneyers, 1990).

4. RESULTS AND DISCUSSION

4.1 IPTA results

IPTA graphics are shown in Figure 3 for Maghnia, Sebdou, Beni Bahdel, Sidi Medjahed, Sebra, Hennaya stations, in Figure 4 for Zaouia Ben Amar, Djebel Chouachi, Oued Lakhder, Meurbah, Ouled Mimoun, and Mefrouche stations, and in Figure 5 for Lalla Setti, and Pierre Du Chat stations. The rainiest month during the first half of 1970-71/1994-95 is March in all stations, with an average of 54.1 mm for Sidi Medjahed, Djebel Chouachi, Ouled Mimoun, Pierre Du Chat, and Maghnia Stations, an average of 70.5 mm for Sebdou, Meurbah, and Sebra stations, an average of 79.7 mm for Zaouia Ben Amar, Oued Lakhdar, Beni Bahdel, and Hennaya stations. The highest values were found in Lalla Setti (103.7 mm) and Mefrouche stations (121.5 mm). The driest month during the first half of 1970-71/1994-95 is July in Maghnia, Sebdou, Hennaya, Djebel Chouachi, and Pierre du chat stations, with values not exceeding 4.5 mm; for the other stations, the driest month is August with values not exceeding 4.9 mm. The rainiest month during the second half of 1995-96/2019-20 in November for the half of stations such as Maghnia, Sidi Medjahed, and Djebel Chouachi stations with an average of 45.6 mm, Hennaya and Sebra stations with an average of 59.4 mm, the highest values were found in Lalla Setti (76.8 mm) and Mefrouche stations (85 mm). for the other half of stations January is the rainiest month. The driest month during the second half of 1995-96/2019-20 is July in all stations, with values not exceeding 6.4 mm.

Table 2 shows statistical values (trend length and trend slope) of arithmetic mean for each station. The maximum trend slopes were observed in the transition July-August, with values of 21.62, -8.0, -32.28, -32.39, -7.13, 2.79, -7.85, -14.94, and 9.68 for the Maghnia, Beni Bahdel, Sidi Medjahed, Sebra, Zaouia Ben Amar, Djebel Chouachi, Meurbah, Ouled Mimoun, and Pierre Du Chat stations, respectively. Additionally, trend slopes of 10.66, -8.37, and 4.38 were recorded in the transition April-May for the Sebdou, Mefrouche, and Lalla Setti stations, respectively. A trend slope of 2.77 was observed in the transition November-December for the Hennaya station and -13.3 in the transition December-January for the Oued Lakhdar station.

The trend length is weak in all stations in the transition of November-December, December-January, January-February, June-July, July-August, and August-September. The trend length is medium in the transition September-October in Mefrouche and Pierre du chat stations, in the transition October-November in Beni Bahdel, Hennaya, Zaouia Ben Amar, Oued Lakhdar, and Lalla Setti stations, in the transition February-March in Mefrouche and Lalla Setti stations, in the transition March-April in Beni Bahdel, Zaouia Ben Amar, and Lalla Setti stations, in the transition April-May Mefrouche station only, in the transition May-June for most of stations such as Maghnia, Sebdou, Beni Bahdel, Sidi Medjahed, Sebra, Hennaya, Zaouia Ben Amar, Oued Lakhdar, Meurbah, and Ouled Mimoun stations. The trend length is strong in the transition of October-November, March-April, and May-June in Mefrouche station. The transition May-June also shows another strong trend length in Lalla Setti station. The maximum trend length was found in the transition May-June (ranging between 31.09 mm and 69.66 mm) for most stations, and these strongest values explain the change between the two seasons, from Spring to Summer.

4.2 Comparison between the IPTA method and the MK test

Table 3 shows the results of the MK test on monthly rainfall data for all stations. It clearly appears that there is no significant trend in most months for all stations. An increasing trend is found in September at Beni Bahdel and Meurbah stations, in October at Beni Bahdel and Sidi Medjahed stations. Whereas, a decreasing trend appears in February at Sebra and Hennaya stations, in March at Pierre Du Chat station, in June and July at Maghnia and Ouled Mimoun stations.

Bougara et al. (2020) studied the trend analysis in the Tafna watershed using the MK test for a period of data from 1979 to 2011 with some stations can found in this study such as Sebdou, Beni Bahdel, Djbel Chouachi, Hennaya, Oued Lakhder (ex-Chouly), Meurbah, and Ouled Mimoun stations. The results showed a significant increasing trend for rainfall in two months only (September and October) for most of stations, the other months do not show any trend except August at Meurbah station, wich indicated an increasing trend. The variations observed among stations and throughout different months underline the complexity of precipitation trends in this region. The study's extended timeframe and inclusion of more stations improve the understanding of the spatial and temporal variability in precipita-

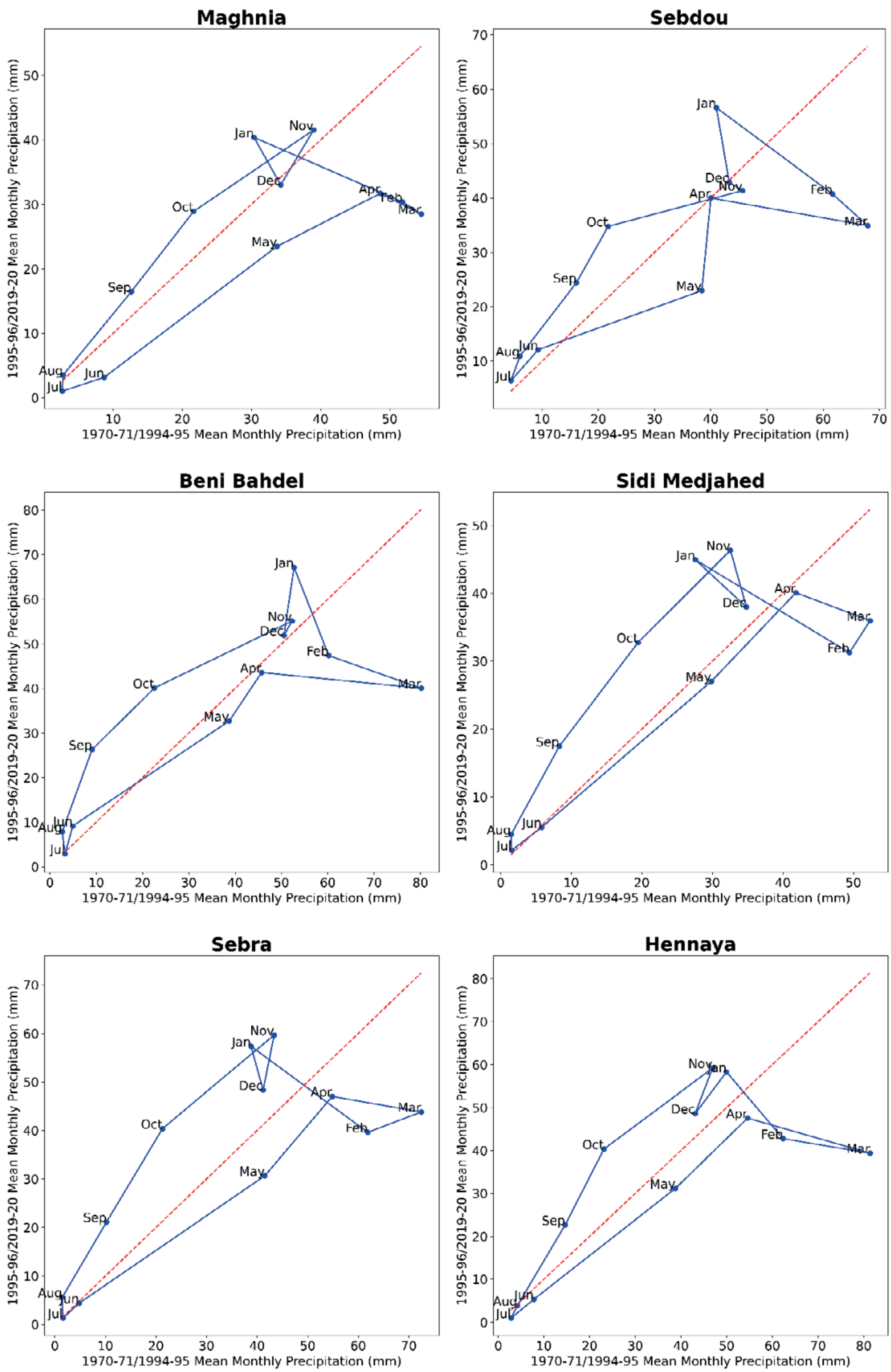

Figure 3. IPTA graphics for Maghnia, Sebdou, Beni Bahdel, Sidi Medjahed, Sebra, Hennaya stations.

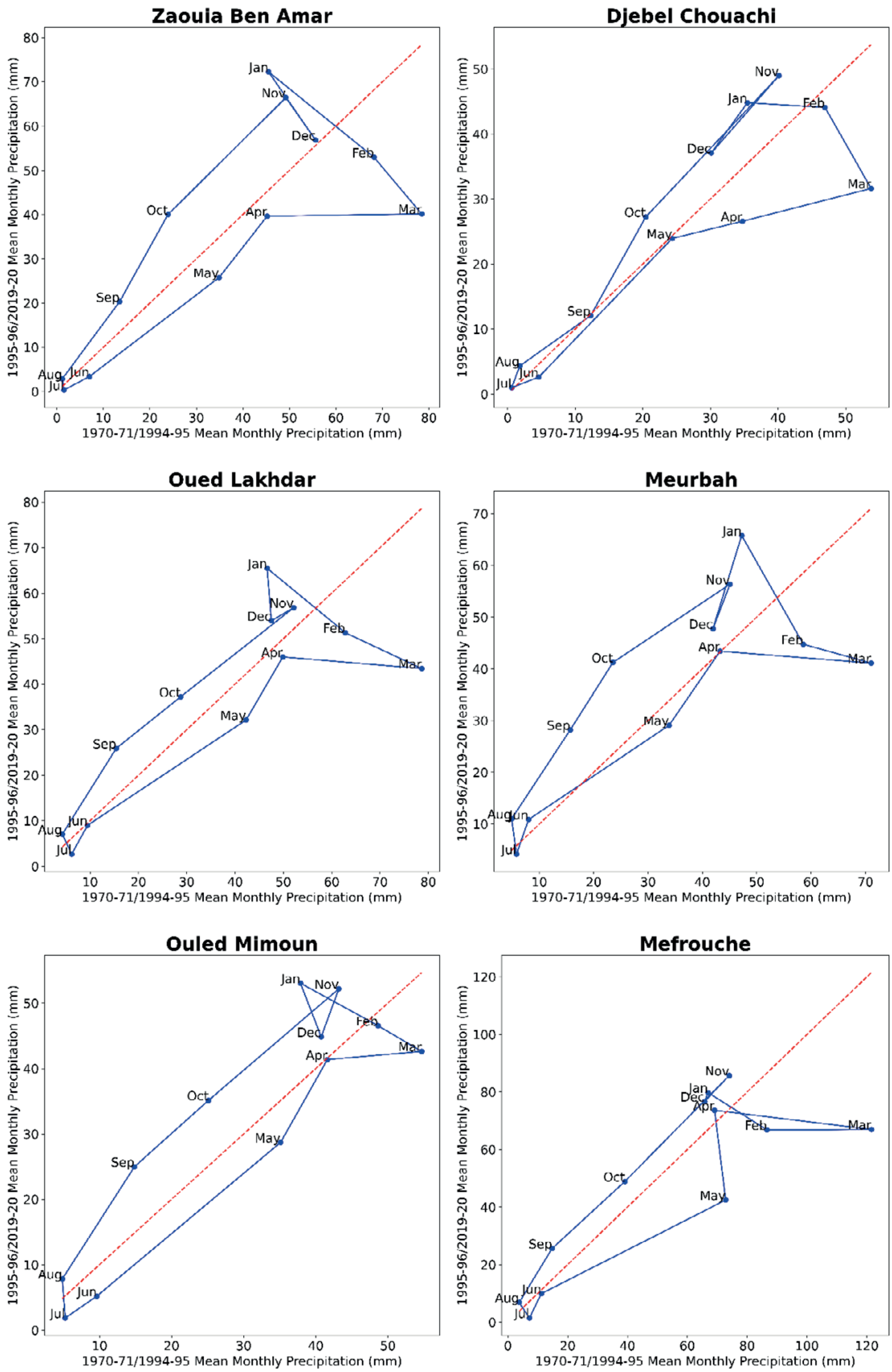

Figure 4. IPTA graphics for Zaouia Ben Amar, Djebel Chouachi, Oued Lakhder, Meurbah, Ouled Mimoun, and Mefrouche stations.

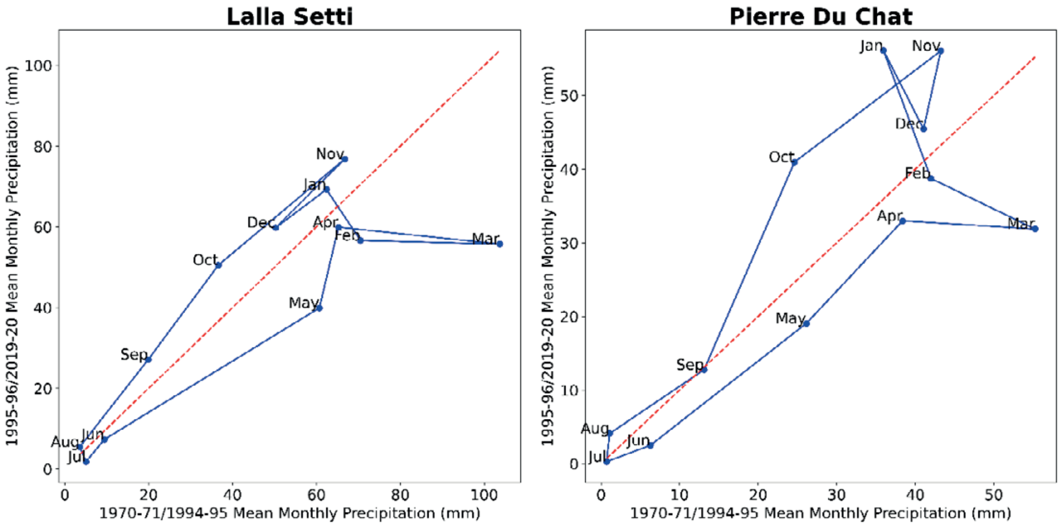

Figure 5. IPTA graphics for Lalla Setti, and Pierre Du Chat stations.

Table 2. Statistical values of arithmetic mean for each station.

		Sep-Oct	Oct-Nov	Nov-Dec	Dec-Jan	Jan-Feb	Feb-Mar	Mar-Apr	Apr-May	May-Jun	Jun-Jul	Jul-Aug	Aug-Sep
S1	TL (mm)	15.38	21.46	9.75	8.31	23.67	3.31	6.72	17.03	32.22	6.43	2.51	16.26
	TS	1.38	0.73	1.79	-1.90	-0.47	-0.69	-0.54	0.55	0.81	0.36	21.62	1.31
S2	TL (mm)	11.76	24.84	2.83	13.94	26.05	8.59	28.38	17.09	31.09	7.45	4.76	16.86
	TS	1.84	0.28	-0.64	-5.97	-0.77	-0.93	-0.18	10.66	0.37	1.17	2.85	1.34
S3	TL (mm)	19.29	33.31	3.67	15.43	21.17	21.28	34.64	12.94	41.18	6.48	5.00	19.53
	TS	1.03	0.51	1.84	6.97	-2.64	-0.37	-0.10	1.55	0.70	3.80	-8.00	2.87
S4	TL (mm)	18.93	18.85	8.65	10.03	25.75	5.54	11.29	17.71	32.25	5.43	2.33	14.66
	TS	1.37	1.04	-3.70	-0.96	-0.63	1.61	-0.39	1.09	0.89	0.79	-32.28	1.90
S5	TL (mm)	22.21	29.32	11.55	9.33	29.11	11.37	17.89	21.08	45.16	4.42	4.28	17.80
	TS	1.74	0.87	5.18	-3.77	-0.77	0.40	-0.18	1.23	0.72	0.96	-32.39	1.77
S6	TL (mm)	19.58	30.37	11.27	11.89	19.86	19.34	28.03	22.75	40.35	6.61	3.20	21.50
	TS	2.08	0.79	2.77	1.41	-1.25	-0.18	-0.31	1.04	0.83	0.88	2.11	1.80
S7	TL (mm)	22.28	36.63	11.55	18.46	29.80	16.41	33.24	17.31	35.74	6.26	2.56	21.33
	TS	1.89	1.04	-1.50	-1.52	-0.85	-1.25	0.02	1.34	0.80	0.56	-7.13	1.42
S8	TL (mm)	17.24	29.33	15.55	9.41	11.50	14.21	19.70	10.71	29.07	4.31	3.54	13.02
	TS	1.86	1.10	1.19	1.45	-0.06	-1.83	0.27	0.25	1.08	0.40	2.79	0.74
S9	TL (mm)	17.50	30.53	5.46	11.58	21.46	17.69	28.86	15.80	40.14	7.14	4.80	21.88
	TS	0.85	0.84	0.63	-13.30	-0.88	-0.50	-0.09	1.82	0.70	1.93	-2.28	1.69
S10	TL (mm)	15.23	26.30	9.16	18.78	23.89	12.98	27.89	17.13	31.63	7.05	6.90	20.29
	TS	1.66	0.70	2.74	3.41	-1.85	-0.29	-0.08	1.53	0.70	3.00	-7.85	1.59
S11	TL (mm)	14.44	24.85	7.74	8.70	12.58	7.21	13.14	14.24	34.66	5.52	5.99	19.86
	TS	0.99	0.94	3.00	-2.84	-0.60	-0.65	0.10	1.95	0.92	0.76	-14.94	1.71
S12	TL (mm)	33.69	50.72	12.20	3.28	23.63	34.90	52.85	31.40	69.66	9.39	6.38	21.72
	TS	0.96	1.06	1.09	2.77	-0.66	0.00	-0.13	-8.37	0.53	2.11	-1.60	1.71
S13	TL (mm)	28.71	40.01	23.68	15.38	15.02	33.20	38.66	20.53	60.69	7.09	3.95	27.11
	TS	1.40	0.87	1.03	0.78	-1.56	-0.03	-0.11	4.38	0.64	1.26	-2.51	1.33
S14	TL (mm)	30.47	23.98	10.84	11.82	18.41	14.91	16.89	18.55	25.85	6.00	3.85	14.80
	TS	2.45	0.81	4.82	-2.09	-2.87	-0.52	-0.07	1.14	0.83	0.40	9.68	0.72

Table 3. Results of the MK test on monthly rainfall data for all stations (significant values in bold at ≤ 0.05 level of significance)

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
S1	0.737	1.398	0.318	0.000	0.703	-1.782	-1.815	-1.430	-0.778	**-2.182**	**-2.004**	-1.004
S2	1.733	1.449	-0.527	-0.418	0.100	-1.397	-1.372	0.084	-1.481	0.151	1.000	0.604
S3	**2.988**	**1.974**	0.125	-0.184	0.477	-1.163	-1.280	-0.368	-0.125	1.155	0.569	1.384
S4	1.398	**2.085**	1.882	0.485	1.138	-1.832	-1.021	-0.159	0.142	0.200	1.219	2.313
S5	1.801	1.518	1.732	0.134	1.096	**-2.267**	-1.573	-0.995	-0.343	-0.353	0.435	1.888
S6	0.854	1.514	1.397	0.042	0.736	**-1.974**	-1.857	-0.318	-0.611	-1.307	-0.511	-0.979
S7	1.811	1.842	1.497	-0.611	1.757	-1.314	-1.958	-0.636	-0.627	-0.103	-0.646	1.516
S8	0.394	0.988	0.728	0.176	0.636	-0.870	-1.865	-1.297	0.376	-0.526	0.000	1.140
S9	1.189	0.569	-0.176	0.184	1.071	-0.803	-1.631	-0.410	-0.326	-0.354	-0.329	1.290
S10	**2.394**	1.372	0.845	-0.477	0.996	-0.820	-1.949	0.402	0.033	0.862	1.344	1.567
S11	1.080	0.662	1.548	-0.728	0.929	-0.318	-0.862	0.067	-0.502	**-2.443**	**-2.701**	-0.511
S12	1.691	0.310	0.527	0.075	0.552	-1.339	-1.899	0.042	-1.514	-1.561	-1.254	0.654
S13	1.708	0.929	0.435	-0.393	-0.243	-0.669	-1.840	-0.435	-1.305	-1.454	-0.822	0.086
S14	0.452	0.736	1.372	-0.360	1.489	-0.419	**-2.459**	-0.803	-0.502	-1.182	-0.510	1.864

tion patterns. This emphasises the need of conducting detailed analyses at the station level to precisely evaluate the effects of climate change in the Tafna watershed.

The IPTA method shows an increasing trend in October and January at all stations; November also shows an increasing trend at all stations except Sebdou station, which indicates a decreasing trend; September and December show an increasing trend at most of the stations (12 and 11 stations, respectively), August shows an increasing trend in all stations except Maghnia and Hennaya stations. A decreasing trend is found in February, March, and May in all stations except Djebel Chouachi station, which shows no significant trend in May. Ten stations in April show a decreasing trend. June indicates a decreasing trend at seven stations, while the other stations, such as Sebdou, Beni Bahdel, and Meurbah stations, show an increasing trend; the rest do not show any trend. Jule indicates a decreasing trend in 8 stations; only Sebdou station shows an increasing trend this month, and the other stations do now show any significant trend.

Table 4 presents the trends detected by the MK test and IPTA method for monthly precipitation data for all stations. The MK test indicates a significant trend (increase and decrease) in 11 of 168 months (12 months × 14 stations), representing 6.5% of the total months analyzed in this study. However, the IPTA method identifies a significant trend in 149 of 168 months, accounting for 88.7% of the total months. It can be concluded that the IPTA method is more sensitive than the MK test in detecting rainfall trends. However, this increased sensitivity may lead to an over-identification of trends, as the IPTA method does not incorporate any statistical significance threshold . The appearance of Table 4 would change if a stricter significance level (e.g., 0.01 instead of 0.05) or a larger one were applied to MK results, thereby highlighting differences in methodological sensitivity and interpretability. Many studies in different countries can support these findings, such as Hallouz et al. (2024) in Algeria; Akçay et al. (2022), Hırca et al. (2022), Esit (2023), and Esit et al. (2024) in Turkey; and Şan et al. (2021) in Vietnam.

5. CONCLUSIONS

In this study, the IPTA method was applied to monthly total rainfall data from 14 stations in the Tafna watershed over a 50-year period (1970-71 to 2019-20). The trend length and slope were calculated for consecutive months, and IPTA graphs were created for all stations. Additionally, a comparison was made between the IPTA method and the MK test in detecting monthly rainfall trends. The main findings are as follows:

- The rainiest month in the first half of the period (1970-71 to 1994-95) was March across all stations, whereas in the second half (1995-96 to 2019-20), November was the rainiest month in half of the stations, while January was for the others. The driest month in the first half was July for five stations, while it was August for the rest.
- The trend length was weak in all stations for the transitions of November-December, December-January, January-February, June-July, July-August, and August-September. The maximum trend length occurred in the transition May-June (ranging from

Table 4. comparison between MK and IPTA for monthly precipitation for all stations.

■ increasing; ■ decreasing; ■ No Trend

31.09 mm to 69.66 mm) in most stations, reflecting the seasonal shift from spring to summer.

– The MK test indicates a significant trend (increase and decrease) in 11 of 168 months (12 months × 14 stations), representing 6.5 % of the total months analyzed in this study. However, the IPTA method identifies a significant trend in 149 of 168 months, accounting for 88.7% of the total months.
– The MK test indicated a significant trend (increase or decrease) in only 11 of 168 months (12 months × 14 stations), or 6.5% of all months analyzed. In contrast, the IPTA method identified significant trends in 149 of 168 months, representing 88.7% of the total.

In conclusion, the IPTA method proved more sensitive in detecting monthly rainfall trends than the MK test, suggesting its potential as a valuable tool for assessing rainfall trends in regions affected by climate variability, particularly in Mediterranean climates like that of the Tafna watershed.

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