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In Search of Climate Crisis in Greece Using Hydrological Data: 404 Not Found

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Abstract: In the context of implementing the European Flood Directive in Greece, a large set of rainfall data was compiled with the principal aim of constructing rainfall intensity–timescale–return period relationships for the entire country. This set included ground rainfall data as well as non-conventional data from reanalyses and satellites. Given the European declaration of climate emergency, along with the establishment of a ministry of climate crisis in Greece, this dataset was also investigated from a climatic perspective using the longest of the data records to assess whether or not they support the climate crisis doctrine. Monte Carlo simulations, along with stationary Hurst–Kolmogorov (HK) stochastic dynamics, were also employed to compare data with theoretical expectations. Rainfall extremes are proven to conform with the statistical expectations under stationarity. The only notable climatic events found are the clustering (reflecting HK dynamics) of water abundance in the 1960s and dry years around 1990, followed by a recovery from drought conditions in recent years.

Keywords: climate; stochastics; Hurst–Kolmogorov dynamics; rainfall; flood; drought

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Καὶ τὴν εἰωθυῖαν ἀξίωσιν τῶν ὀνομάτων ἐς τὰ ἔργα ἀντήλλαξαν τῇ δικαιώσει

They even changed the usual meaning of the words to justify their actions

(Thucydides [1])

1. Introduction

Following the decision of the European Parliament to declare a climate emergency [2], and in accord with related announcements by the United Nations' Secretary General (e.g., [3]), the Greek Government established the Ministry of Climate Crisis and Civil Protection (November 2021), also advertising it as "*an important innovation of our country*" [4]. The establishment of the ministry was preceded by several catastrophic events, such as floods and wildfires, which politicians and journalists effortlessly attributed to a worsening of climate. However, a more careful investigation of the causes would reveal the omissions of the central and local administration (e.g., the intervention of river beds without flood protection [5]) and the absence of climate-related trends [6].

Changes in hydrological processes and their extremes, starting from rainfall, are important [7–9], especially if one wishes to emphasize climate-related threats. The general public opinion is that such threats have substantially increased as the climate has worsened. In particular, international polls show that Greeks are top among people from all countries worldwide in seeing climate change as a top international threat [10]. However, the formation of such opinion is related to socio-political practices, tactics, or strategies and does not necessarily reflect physical reality. It is thus useful to investigate the physical reality using the scientific method. This requires checking assumptions by utilizing the longest records of measurements, which in turn involves much effort in gathering and processing hydrometeorological measurements.

An analysis of the water-related data for the entire country of Greece was conducted in 2008 in the framework of the compilation of the national programme for water resource management and preservation [11]. Recently, in the framework of the implementation of the European Union Flood Directive [12], a comprehensive project was conducted to construct a new set of ombrian curves (rainfall intensity–timescale–return period relationships, more commonly known by the misnomer intensity–duration–frequency curves) for the entire Greek territory [13]. The data of 940 hydrometeorological stations were gathered and investigated in this project, among which 783 stations were found to fulfil criteria of reliability and were utilized in the construction of ombrian curves. Some of these had sufficient length (of about 60 years or more) to allow the investigation of climatic variation and identification of possible climatic events. Additionally, non-conventional data were also examined, such as reanalysis and satellite data, with the former also being suitable for the climatic investigation, but the latter not, as they cover a short period (21 years only). These data are analysed in this study to draw relevant conclusions regarding the possible existence or severity of a climate crisis in Greece.

The data are described in Section 2, the methods are presented in Section 3, and the analyses and their results are contained in Section 4. As will be seen, the most notable climatic event over a century-long period was a prolonged and intense drought around 1990. Its successful management, which, in fact, prevented a crisis from occurring, is further discussed in Section 5.

2. Data

Unfortunately, only two stations with available data of more than a century in length were found. The first is the station in Athens located at Lophos Nymphon (Hill of Nymphs), operated by the National Observatory of Athens. The available monthly data begin in 1860, with a total length of 161 years, while daily and maximum daily values start in 1864, with a total length of 155 years. Furthermore, the hourly data start in 1927, resulting in a total length of 95 years. Some of the data (daily) are publicly available through the Climate Explorer of the Dutch Royal Netherlands Meteorological Institute (KNMI; [14]). The properties of the maxima of this dataset were examined more than 20 years ago [15], and, as will be seen below, the conclusions stand firm to this day.

The second over-century-long dataset is that of Thessaloniki. In fact, to compile this dataset, several stations were used (starting with Austrian and Bulgarian stations before Thessaloniki was incorporated into Greece [13]). At the monthly and annual scale, the compiled time series starts in 1892, resulting in a total length of 127 years, while daily and maximum daily values start in 1930, resulting in a total length of 93 years.

While additional stations existed before the World Wars, their data have not been found yet. Data from a few hundred stations were found for the period after World War II. Specifically, the study [13] searched for data series that:

- Cover a period of 60 years (two 30-year climatic periods), even with some missing values, but without the number of years with values falling below 50 years; and
- End at a year that belongs to the last decade.

With these criteria, for the entire Greek territory, the study identified the following:

- A total of 238 time series of annual maximum daily rainfall depths;
- A total of 62 stations with complete daily or monthly time series with a large size, from which the annual average daily rainfall can be determined.

However, due to missing data, the actual number of values varies from year to year, as shown in Figure 1.

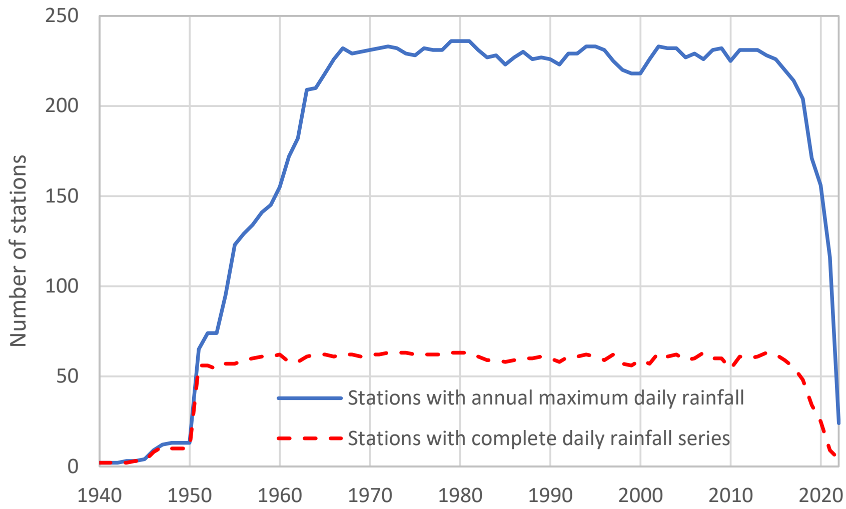


Figure 1. Number of stations with long maximum daily rainfall time series and with complete annual average daily time series in the entire Greek territory in the period 1940–2022. Before 1940, there were two stations, Athens and Thessaloniki.

Hourly data were also analysed, but the stations with long records were too few. By relaxing the selection criteria, i.e., a total time coverage of 50 years (instead of 60) and a number of values (minus missing values) of 40, 18 stations were found to meet them, whose data were further processed.

Non-conventional data were also examined, of which the most useful were those of the ERA5 reanalysis [16]. This is the fifth-generation atmospheric reanalysis of the European Centre for Medium-Range Weather Forecasts (ECMWF), where the name ERA refers to *ECMWF ReAnalysis*. The observation period spans from 1940 onward, with daily updates continuing forward in time. The fields are available at a horizontal resolution of 31 km on 139 levels, from the surface up to 0.01 hPa (around 80 km). It has been produced as an operational service, and its fields compare well with the ECMWF operational analyses. ERA5 provides hourly estimates of a large number of atmospheric, land, and oceanic climate variables. ERA5 combines vast amounts of historical observations into global estimates using advanced modelling and data assimilation systems. The data were retrieved and spatially aggregated through the ClimExp platform [14], where they are available for the period from 1950 to the present at a spatial resolution of 0.25° for Europe.

Regarding the reliability of the ERA5 data, a comparison was made by Koutsoyiannis [17] at a global level with other datasets, including the dataset of the Global Precipitation Climatology Project (GPCP), which combines gauge and satellite precipitation data over a global grid. It was found that the ERA5 precipitation data compare well with GPCP data at the annual time scale, both on land and at sea, as well as across the entire globe. Similarly, Hassler and Lauer [18] found that ERA5 agrees well with satellite observations for Central Europe and the South Asian Monsoon region but underestimates very low precipitation rates in the Tropics. Bandhauer et al. [19] found that ERA5 agrees qualitatively well with reference datasets but overestimates mean precipitation in all regions, which is related to too many wet days. However, Longo-Minnolo et al. [20], who assessed precipitation in Sicily (Italy) at the catchment scale, found underestimations on the ERA5-Land precipitation estimates and suggested that adjustments are required to reduce site-specific uncertainties due to local microclimatic conditions.

The study [13] also used satellite data. From the various platforms of openly available satellite data, that of NASA was chosen [21]. Specifically, the IMERG (multi-satellite precipitation estimate with gauge calibration, final run, recommended for general use, half-hourly 0.1 deg; GPM GPM_3IMERGHH v06 [22]) satellite data were retrieved for the entire geographical area of Greece with extension to neighbouring countries. The data allow the analysis on a fine time scale since they have a time resolution of 0.5 h. The spatial resolution of the data is 0.1°, and thus, the wider area of the country is represented by 8991 grid cells, 1373 of which correspond to the entire land area of the country. The time coverage starts on 1 June 2000 and ends on 30 September 2021, thus covering 21 full hydrological years. The spatial coverage is very satisfactory and allows the production of detailed maps. However, the temporal coverage (21 years only) is not suitable for climatic investigation.

The IMERG data were independently tested in Greece by Kazamias et al. [23], who found that they adequately captured the pattern and distribution of precipitation across Greece with a slight overestimation (5.1%). However, the study [13] found systematic errors in these data as the geographical variability of the rainfall regime is not properly reproduced. In particular, the large rain depths in northwestern Greece are underestimated, while the smaller rain depths in the Aegean islands are overestimated. For this reason, the satellite data had to be re-calibrated with ground data. To this aim, in addition to the ground stations of Greece, the monthly data of the Global Historical Climatology Network (GHCN) from neighbouring countries were also retrieved through the ClimExp platform [14], thus forming a set of 128 ground stations, whose locations are shown in Figure 2. A comparison of satellite data with the ground data resulted in a rather low coefficient of determination (R^2 = 0.33). To adapt the former so as to agree with the latter, the surface bilinear smoothing method with an explanatory variable (BSSE [24,25]) was used. This allowed to produce a map of the geographical distribution of average daily precipitation, which is depicted in Figure 2. The map shows remarkably high climatic diversity in Greece, with average daily precipitation ranging geographically within an order of magnitude, from 0.6 mm/d (219 mm/year) to 7.3 mm/d (2666 mm/year). The wettest part is northwestern Greece, and the driest parts include Athens, some of the Aegean islands, and parts of central Macedonia and Thessaly.

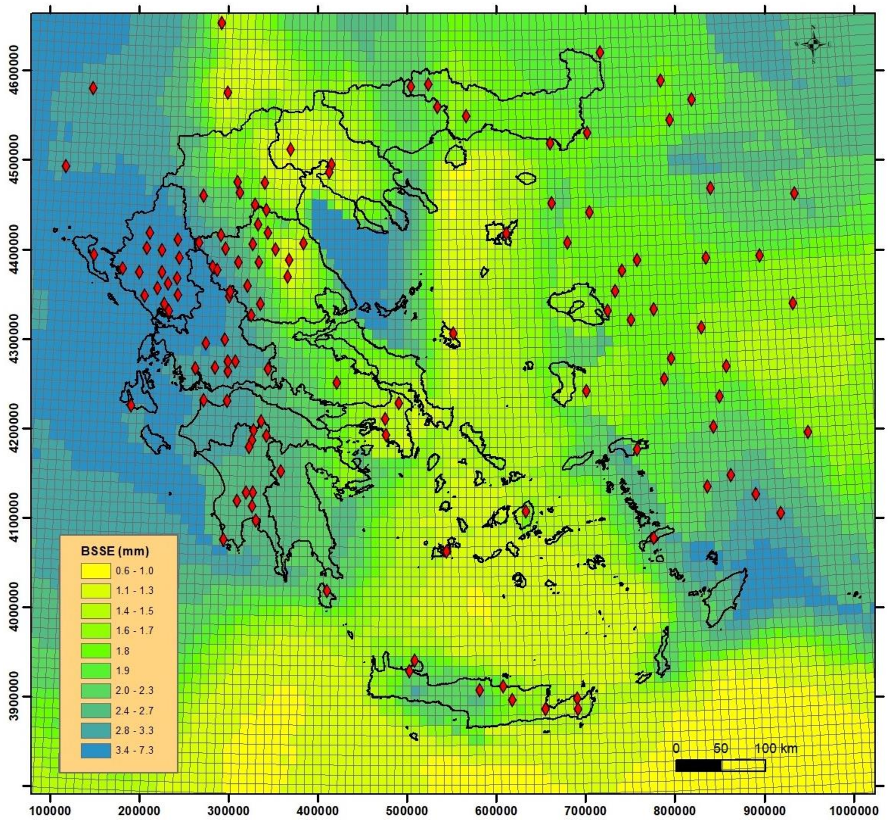


Figure 2. Map of geographical distribution of average daily precipitation produced by the BSSE method combining ground data at 128 stations (red diamonds) in Greece and neighbouring countries with IMERG satellite data. The black lines shown are the divides of the water districts of Greece. The colour divisions (classes) are based on quantile classification so that each class contains equal number of grid points. The lower class, 0.6–1.0 mm, is seen only in the sea (not on land).

In addition to precipitation data, the single river flow record in Greece with over-centennial length, namely that of the Boeoticos Kephisos River, is also analysed and compared to the results found for rainfall.

3. Methods

The methods used in the analyses that follow in the next section are simple. Graphical depictions of the time series constitute a self-explanatory tool. In such depictions, the plotting of time averages on a 30-year (and occasionally 10-year) time scale gives a direct view of possible climatic fluctuations. The difference between the last two 30-year climatic values provides a formal statistical criterion relevant to such analyses [26]. Similar information is given by calculating and plotting linear trends over the period of data availability.

The earmarking of record values, high or low, also provides relevant information. The time distribution of high and low records (maxima or minima of the entire period of observations) from a sufficiently large set of stations can provide an indication of potentially significant climatic events.

It is noted that in all analyses and depictions that involve the year as a time scale or time window, this is meant as the hydrological (rather than the calendar) year starting on 1 October and ending on 30 September. In all graphs where time appears in years, the convention is used to note the ending year (e.g., the hydrological year 1899–1900 is plotted as 1900).

Numerous methods of trend analyses have been developed and applied in the literature for assessing possible changes in data series. They range from the simple significance testing of trends to sophisticated techniques such as the rescaled adjusted partial sums (RAPS [27,28]) and the innovative polygon trend analysis (IPTA [29,30]) methods. However, in the last two decades, the very concept of a trend, which lacks definition and reflects an artificial imposition of deterministic thinking into stochastics, has been criticized, along with its statistical testing [31–35] (see also [5], chapter 1). In particular, Cohn and Lins [32] tried different underlying hypotheses about the time dependence of the examined process and formed different tests corresponding to these hypotheses. They concluded that "*changing from one test to another, 25 orders of magnitude of significance vanished*". This important finding undermined the foundation of the entire idea. Additionally, Iliopoulou and Koutsoyiannis [35] concluded that trends identified in data series, if applied to cast future predictions, worsen, rather than improve, a model's predictive capacity. This finding refutes the usefulness of trend detection.

For these reasons, here, we avoided sophisticated trend analyses methods. Nonetheless, because of its popularity, our analyses included the concept of linear trends—the simplest of all—as well as the differences in the climatic values of consecutive periods. In assessing whether or not these indices of change occur in accord with statistical expectations, the method of choice is stochastic (Monte Carlo) simulation.

Simulations were made assuming a *Hurst–Kolmogorov* (HK) *process* defined through its climacogram as follows. Let us consider any stochastic process $\underline{x}(t)$ (which may represent rainfall, river flow, etc.) in continuous time t, and let us define the cumulative process as

$$\underline{X}(k) := \int_0^k \underline{x}(t)\,\mathrm{d}t \tag{1}$$

Then, $\underline{X}(k)/k$ is the time-averaged process. The climacogram $\gamma(k)$ of the process $\underline{x}(t)$ is the variance of the time-averaged process at time scale k [36], i.e.,

$$\gamma(k) := \mathrm{var}\left[\frac{\underline{X}(k)}{k}\right] \tag{2}$$

The climacogram of the HK process is given as a power function of the time scale k, i.e.,

$$\gamma(k) = \lambda^2 \left(\frac{\alpha}{k}\right)^{2-2H} \tag{3}$$

where α and λ are scale parameters with units of time and $[x]$, respectively, and H is the Hurst parameter. In a purely random process, $H = 1/2$, while in most natural processes, $1/2 \leq H \leq 1$, as first observed by Hurst in 1951 [37]. This natural behaviour is known as long-range dependence (LRD), (long-term) persistence or Hurst–Kolmogorov (HK) dynamics. A high value of H (approaching 1) indicates the enhanced presence of patterns such as groupings of similar events (e.g., floods, droughts) in time, enhanced change, and enhanced uncertainty (e.g., in future predictions). A low value of H (<1/2) indicates enhanced fluctuation or antipersistence.

The generation of simulated time series from the HK process is made with a simple method termed the multiple timescale fluctuation approach [38]. This generates a Gaussian stochastic variable, $\underline{u}$, with a climacogram that closely approximates that of Equation (3) by adding three independent linear Markov processes (autoregressive of order 1), each having a different lag-one autocorrelation coefficient, calculated as a function of H, as described in [38]. The Gaussian series are subsequently transformed to have any desired distribution F (e.g., generalized Pareto or generalized extreme value distribution for the maxima) by $\underline{x} = F^{-1}(\Phi(\underline{u}))$, where Φ is the normal distribution function.

In the case of testing the temporal distribution of records, stochastic simulation can be avoided as the confidence limits can be readily determined in an analytical manner using the binomial distribution.

4. Results

4.1. Over-Century-Long Time Series

To start the hydroclimatic analyses in Greece, it is useful to study the longest available records. In this study, it is useful to use as a benchmark series one of the longest series worldwide, which is also nearest to Greece, the daily precipitation series of Bologna, Italy. This is presented in Appendix A to avoid a digression from the focus area on Greece.

Figure 3 shows the characteristics of daily rainfall in Athens, Greece. Compared to Bologna (Appendix A; Figure A1), Athens shows remarkable climate stability. In the last 30 years, there has been no remarkable climatic event. The largest annual (equivalently, average daily) rainfall in history was recorded in the hydrological year 1885–86, and the smallest was recorded in 1989–90; we will discuss the latter in more detail shortly. The all-time high record of rainfall depth, 150.2 mm/d, occurred at the end of the 19th century (the hydrological year 1899–90).

Likewise, as seen in Figure 4, Thessaloniki shows climatic stability similar to Athens. In the last 30 years, no remarkable climatic event has occurred. The largest annual rainfall in history was recorded in the hydrological year 1918–19, and the smallest was recorded in 1984–85. The all-time high record of rainfall depth, 115.9 mm/d, occurred in the hydrological year 1985–86.

4.2. Daily Rainfall Maxima

A more representative depiction of possible climatic events can be provided by plotting the all-time records of annual maximum daily rainfall from all 238 stations with the longest time series in Greece and identifying when these records occurred. This is shown in Figure 5. The upper panel shows the record highs at all stations, where it is observed that the highest of all (580.5 mm) occurred in the hydrological year 1956–57. The lower panel shows the frequency of record occurrences per year, along with confidence intervals. The latter were calculated assuming independence and stationarity, i.e., identical distribution, which is binomial with the number of repetitions equal to the number of values per year depicted in Figure 1.

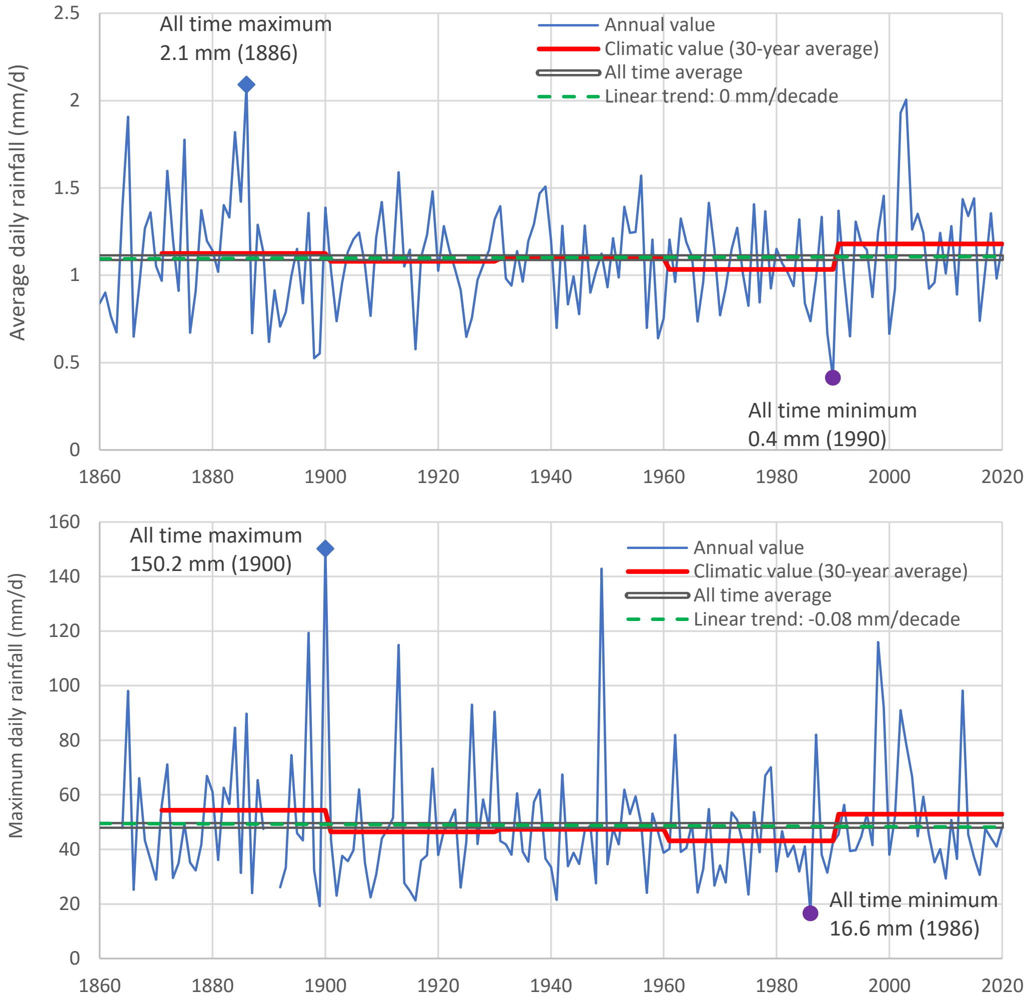


Figure 3. Time series of daily precipitation series in Athens at the Hill of Nymphs station of the National Observatory of Athens (average daily values start in 1860 with a total length of 161 years; daily and maximum daily values start in 1864 with a total length of 155 years). The graph also shows (a) the high and low records, (b) the climatic values (30-year averages), and (c) the fitted linear trends. (**Upper**): average daily rainfall; (**Lower**): maximum daily rainfall.

The temporal distribution of record rainfall is within statistical expectations (Figure 5). Exceedances of the 95% confidence limits occurred in the years 1997–98 and 2002–03, which is also not surprising since 2.5% of values are expected to be located out of (upper and lower than) the 95% confidence limits. The only notable finding is the absence of any record high in the three-year period 1982–83 to 1984–85, which, as we will see below, is at the onset of a dry period that peaked around 1990.

With respect to climatic variations, these are studied by determining the linear trends over the entire observation period, expressed as percentages of the average value per decade, as well as the differences of the last two 30-year climatic values, also expressed as percentages of the all-time average. In order for the two indicators to be compatible, the second one has been divided by 3 to express climate differences per decade. Figure 6 shows that trends exist, and if one focused on particular parts of the graph (e.g., by cherry-picking some of the stations), one would be able to make alarming assertions. However, the fact is a balance of positive and negative trends, as well as an impressive agreement of the empirical fluctuations with the theoretically expected fluctuations for a stationary process. The latter were calculated by Monte Carlo simulation using the generalized extreme value distribution. Specifically, we generated 200 synthetic series of a length of 60 years, and for each one, we estimated the time averages of the two consecutive 30-year periods and the difference thereof, as well as the linear trend for the entire 60-year period. Then, we estimated the sampling distributions of the climatic differences and the linear trends in the same manner we did for the historical samples, and we plotted them in Figure 6. For the simulation, we used a rather low Hurst parameter of 0.60 (the reasons for using a low value are explained by Iliopoulou and Koutsoyiannis [39]). Alternatively, a Hurst parameter of 0.50 was also used (which is equivalent to considering stochastic independence) without resulting in any notable difference.

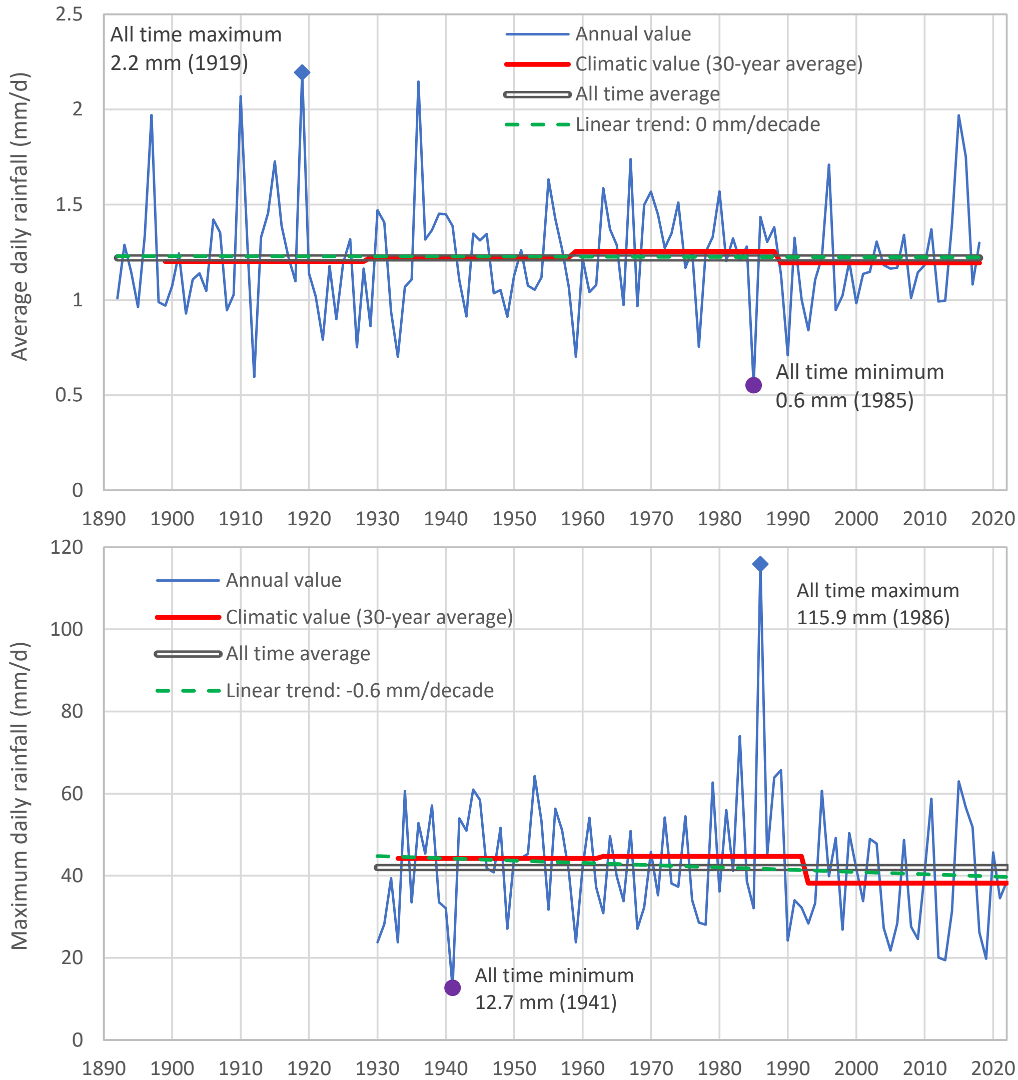


Figure 4. Time series of daily precipitation in Thessaloniki (average daily values start in 1892 with a total length of 127 years; daily and maximum daily values start in 1930 with a total length of 93 years). The graph also shows (a) the high and low records, (b) the climatic values (30-year averages), and (c) the fitted linear trends. (**Upper**): average daily rainfall; (**Lower**): maximum daily rainfall.

4.3. Annual Averages of Daily Rainfall

More interesting is the picture in Figure 7, whose upper panel shows the high and low records (magnitudes) of the annual average daily precipitation at the 62 stations with long and complete daily or monthly time series. The lower panel of this figure shows the frequency of occurrence thereof per year, along with 95% confidence limits, determined in the same way as above.

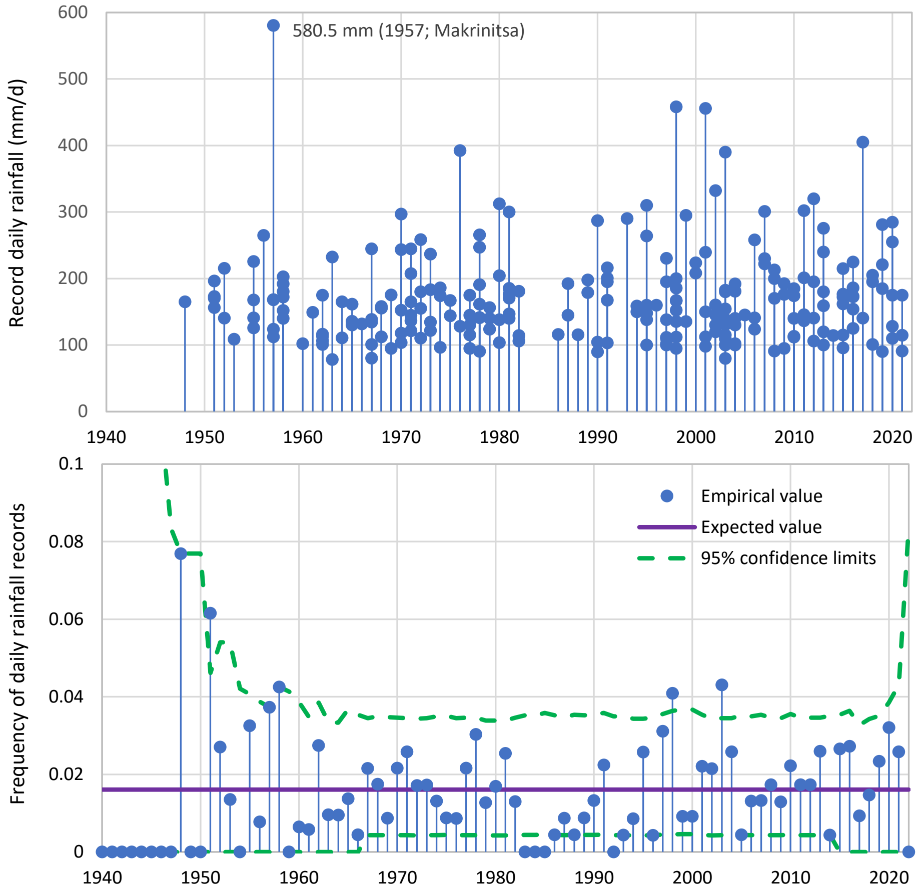


Figure 5. Records of maximum daily precipitation depth (**upper**) and frequency thereof per year (**lower**) for the 238 stations with long time series of annual maxima in the entire Greek territory. The confidence limits in the lower panel have been calculated from the binomial distribution, assuming independence and identical distribution.

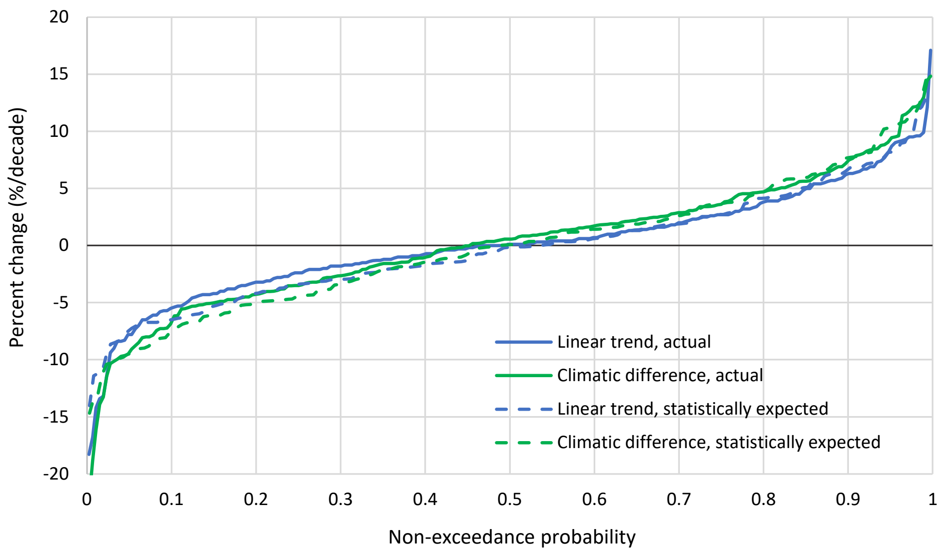


Figure 6. Probability distribution of the changes of annual maximum daily precipitation (as percentages of the all-time averages of the maximum rain depth) for the 238 stations with long time series of annual maxima in the entire Greek territory. Climate difference, expressed as a percentage per decade, is 1/3 of the difference between the last two 30-year climatic values. Statistical expectations have been estimated by the Monte Carlo method with the generalized extreme value distribution and a Hurst parameter of 0.60.

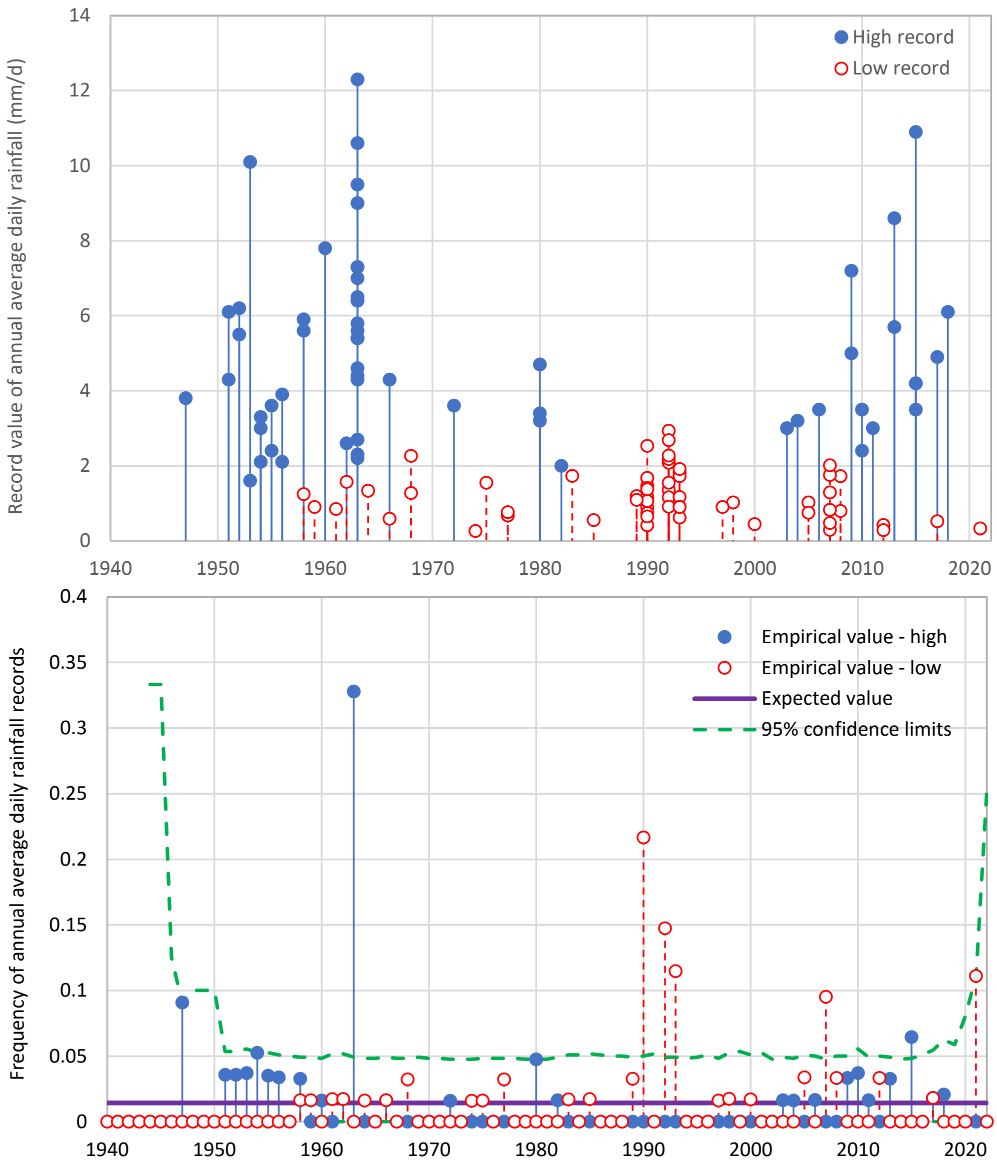


Figure 7. High and low records of average daily precipitation depth per year (**upper**) and frequency thereof per year (**lower**) for the 62 stations with long and complete daily or monthly time series in the entire Greek territory. The confidence limits in the lower panel have been calculated from the binomial distribution, assuming independence and identical distribution.

The graphs allow us to make useful observations about the climate regime of the previous decades:

1. The 1950s and early 1960s were particularly wet.
2. This wet season reached its peak but also ended in the hydrological year 1962–63, in which 1/3 of all records of average annual rainfall are gathered.
3. A 20-year climatically neutral period followed until the early 1980s.
4. The climate then entered a 20-year drought, peaking in the five-year period from 1988–89 to 1992–93. It is characteristic that in four of these five years (excluding 1990–91, which was not dry), more than 50% of record lows occurred.
5. The last twenty years, after the hydrological year 2002–03, are characterized by a return to neutral climatic conditions, although the hydrological years 2006–07 and 2014–15 marked deviations from neutrality, with a dry and a wet year, respectively.

6. In summary, the most important climatic events are the intensely wet hydrological year 1962–63 and the grouping of dry years shortly before and after 1990, while the alternation of dry and wet periods is notable.

Furthermore, the climatic variations are depicted in the form of their sampling distribution in Figure 8. Specifically, the graph shows the probability distributions of both the linear trends over the entire observation period, expressed as percentages of the all-time average per decade, and the differences of the last two 30-year climatic values, also expressed as percentages of the all-time average (divided by 3, in order to express climate difference per decade). For comparison, the theoretical distributions calculated by the Monte Carlo method assuming a normal distribution and a Hurst parameter of 0.75 (much lower than that reported for Bologna (see Appendix A) due to the lower intensity of climatic fluctuations) are also plotted. We notice that:

7. The two change indices, linear trends and climate differences, are practically identical in terms of their statistical distributions.
8. Negative trends outweigh positive ones, and empirical values are generally less than theoretically expected.

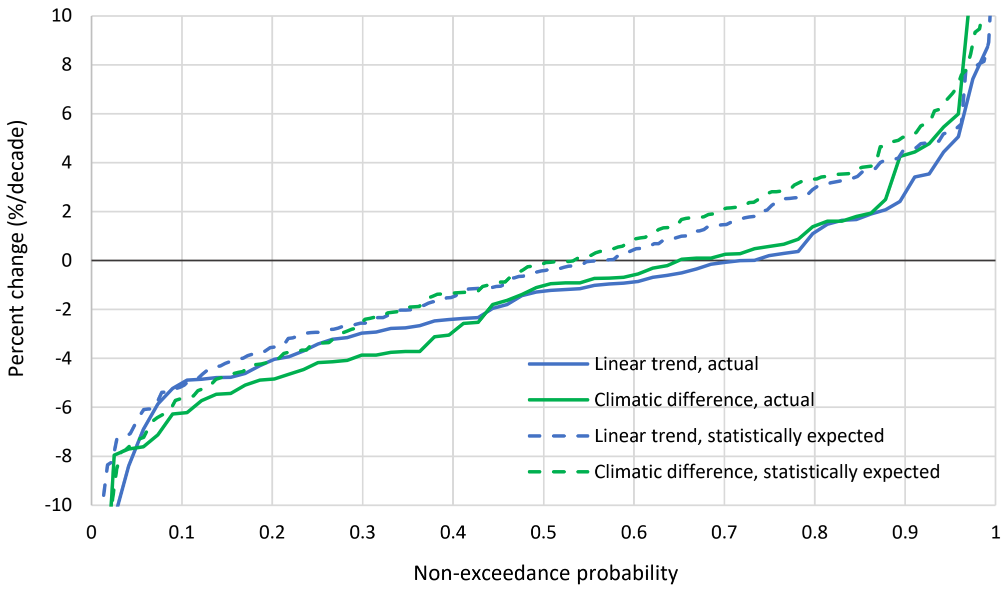


Figure 8. Probability distribution of the changes of annual average daily precipitation (as percentages of the all-time average rainfall depths) for the 62 stations with long time series of daily or monthly time series in the entire Greek territory. Climate difference, expressed as a percentage per decade, is 1/3 of the difference between the last two 30-year climatic values. Statistical expectations have been estimated by the Monte Carlo method with normal distribution and a Hurst parameter of 0.75.

The last point has an explanation, which is that the last three decades contain most of the peak drought period since the average value of the end year of the 62 time series is 2018 (and the start year is 1988.) In other words, point 8 is a direct consequence of points 4 and 6 above.

4.4. Hourly Rainfall Maxima

An attempt for a similar climatic analysis was also made for the time series of annual maximum hourly rainfall depths with a long length. Although less stringent criteria were adopted for station selection (see Section 2), only 18 stations were found to meet them. This small number does not allow detailed analyses and results. Nonetheless, the temporal distribution of record highs is shown in Figure 9. The behaviour is similar to that of maximum daily rainfall, and, in general, there is no climatic event worthy of comment.

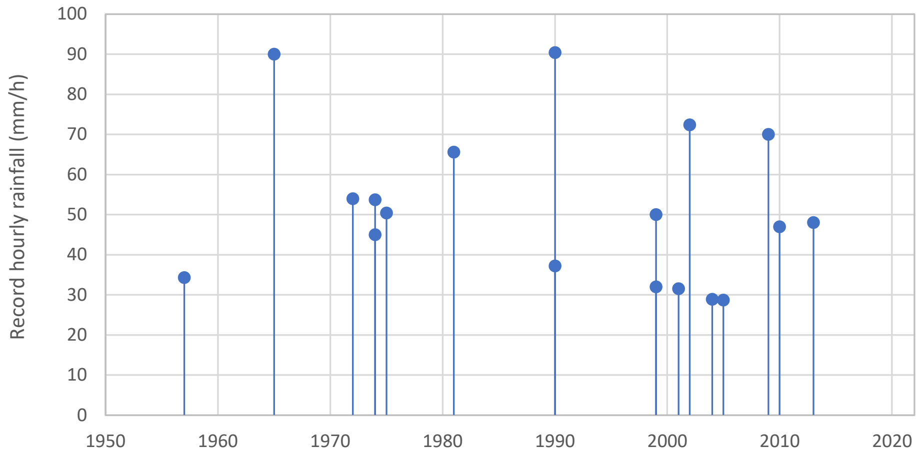


Figure 9. Records of maximum hourly precipitation depth for the 18 stations with long time series of hourly precipitation in the entire Greek territory.

4.5. Reanalysis of Data

A final analysis of climatic fluctuations was also carried out using the data from the ERA5 reanalysis (see Section 2) for the territory of Greece. For comparison, a similar analysis for the land around the Mediterranean is also made and presented in Appendix B.

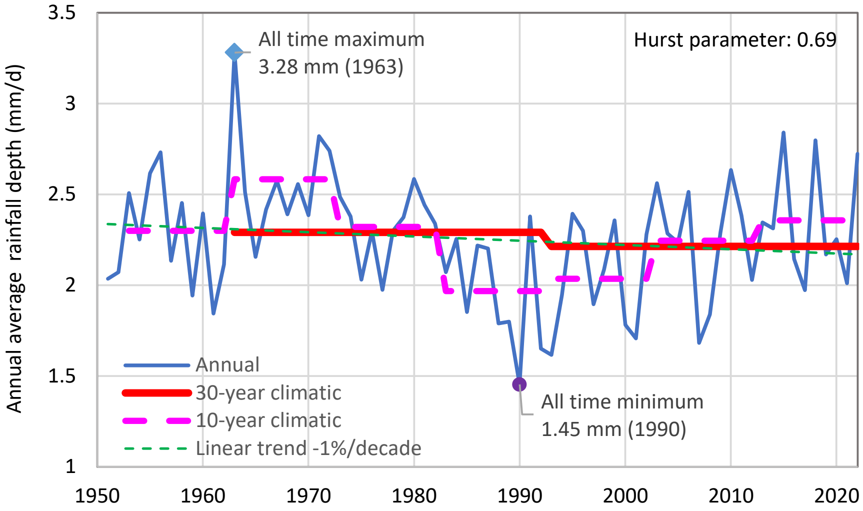
As mentioned in Section 2, the ERA5 data have been found to compare well with other datasets. With reference to Greece, no systematic comparison to ground data has been found in a literature search. It is thus meaningful to see whether or not the ERA5 data depict similar behaviour as the ground data. Figure 10 (upper panel) depicts the time series of the annual average daily rainfall depth averaged over the entire land area of the Greek territory. The chart confirms what was stated earlier about annual average rainfall depths on a point basis. The drought around 1990 and the exceptionally heavy rainfall in 1962–63 are again evident. The overall period does not show a linear trend nor an appreciable difference in the two 30-year climate periods, even though at a 10-year climatic scale, also plotted in the figures, changes are prominent, but not monotonic.

The lower panel of Figure 10 shows the standard deviation of the daily rainfall depth averaged over the entire land area of the Greek territory per year. A possible increasing trend of the standard deviation would mean a trend for the intensification of extremes. However, no such trend appears.

These results do not contradict earlier studies by Stefanidis et al. [40] and Varlas et al. [41], both of which found climatic fluctuations rather than linear trends. The former identified precipitation decreases in 1981–2000 and increases since 2000. The latter concluded that precipitation did not linearly change during the past 7 decades, but it first increased from the 1950s to the late 1960s, consequently decreased until the early 1990s and, afterwards, presented an increase until 2020 with a lower rate than the 1950–1960s.

Figure 11 shows the time series of annual maximum values over the entire Greek territory. The record high occurred in the year 2016–17, but there was a similar high in 1956–57. The overall statistical trend is decreasing, albeit slightly (−1.4 mm/decade), thus not supporting the allegation of the intensification of extremes.

The reanalysis data are particularly useful for assessing possible changes in ungauged areas. Such an area in Greece is the Central Aegean. As can be seen in Figure 2, the rectangular area with the diagonal at 23° E, 37°15′ N (X = 411,166 m, Y = 4,122,787 m) and 26° E, 38°45′ (X = 673,651 m, Y = 4,290,646 m) is not properly gauged. On the other hand, the climate of this area is of particular interest as it contains several Greek islands (e.g., Cyclades), which attract many international tourists. The time series of annual maximum values over that area of Central Aegean area is shown in Figure 12. The record high occurred in 1980–81. The last two 30-year climatic values do not show any change. In terms of 10-year climatic values of rainfall extremes, the latest period is characterized by a low value, as was also the case 60 years ago.



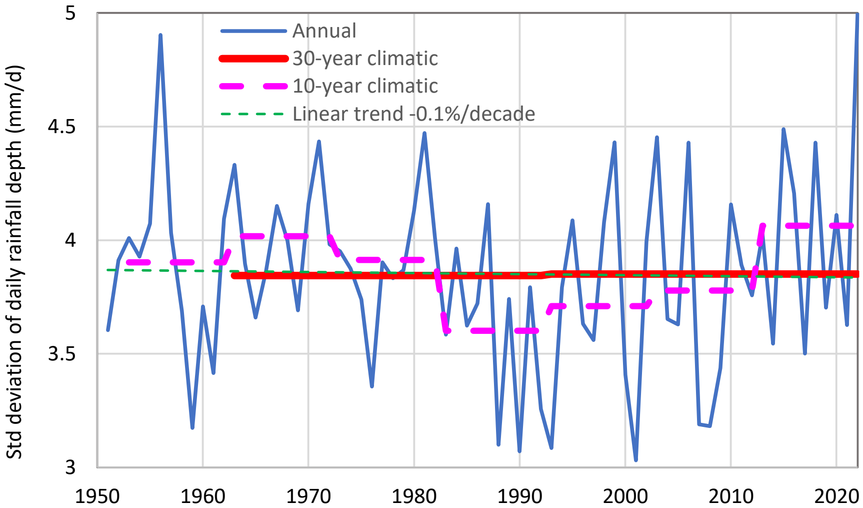


Figure 10. Annual average (**upper**) and standard deviation (**lower**) of daily precipitation series in the Greek territory from the daily European ERA5 reanalysis. The graphs also show (a) the high and low records, (b) the climatic values (10-year and 30-year averages), and (c) the fitted linear trends.

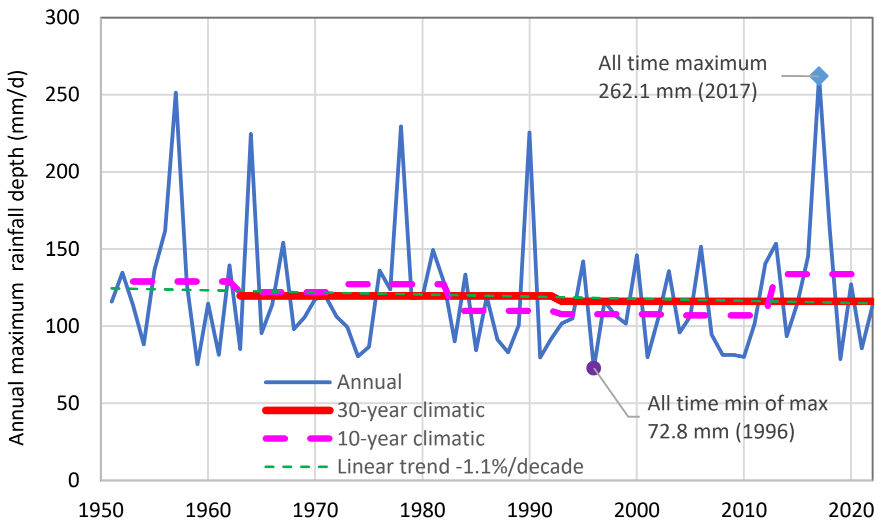


Figure 11. Annual maximum daily precipitation series in the Greek territory from the daily European ERA5 reanalysis. The graph also shows (a) the high and low records, (b) the climatic values (10-year and 30-year averages), and (c) the fitted linear trend.

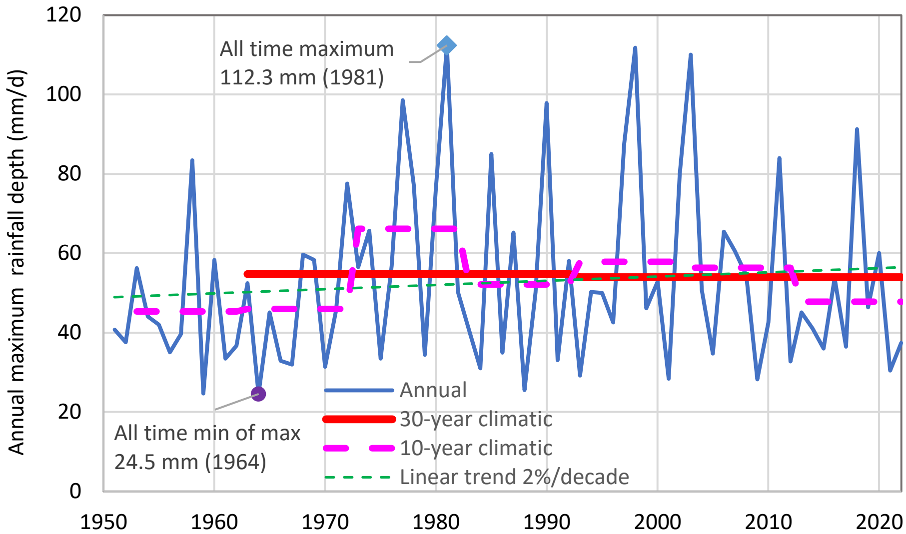


Figure 12. Annual maximum daily precipitation series in the Central Aegean region, i.e., the land grid points in the area 37.15° N–38.45° N, 23° E–26° E, from the daily European ERA5 reanalysis. The graph also shows (a) the high and low records, (b) the climatic values (10-year and 30-year averages), and (c) the fitted linear trend.

A final indicator we analysed that was related to drought is the rainfall frequency. This is shown in Figures 13 and 14 for Greece and the Central Aegean, respectively. The highest frequency of days with very low areally averaged rainfall depth occurred in 1988–89 and 1989–90, respectively. In recent decades, no sign of unprecedented drought has appeared.

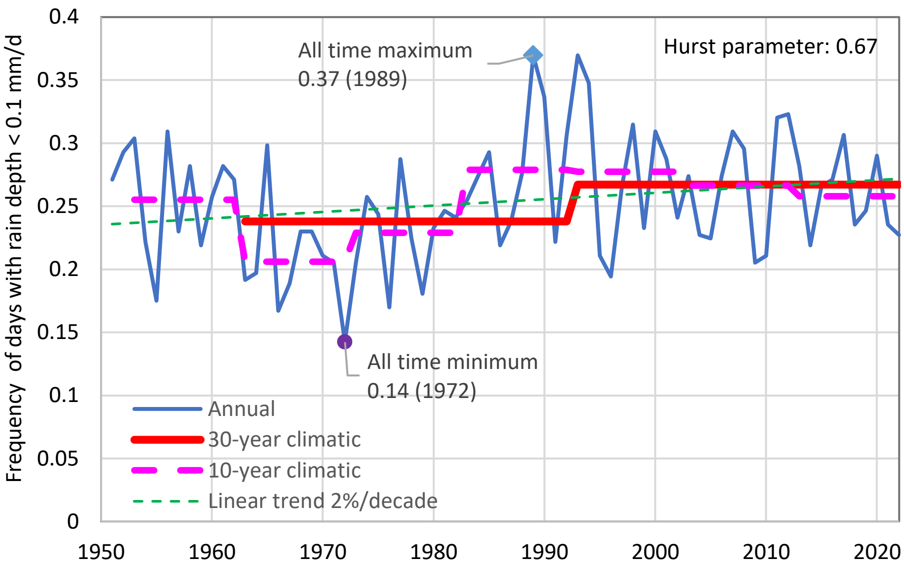


Figure 13. Frequency of days with low average rainfall depth (<0.1 mm) per year in the Greek territory from the daily European ERA5 reanalysis. The graph also shows (a) the high and low records, (b) the climatic values (10-year and 30-year averages), and (c) the fitted linear trend.

4.6. River Flow Data

Unfortunately, river flow data have not been organized yet in Greece. Thus, there is not an adequate database to make analyses similar to those of precipitation. However, as a further indication, we present in Figure 15 the longest river flow record of the country, that of the Boeoticos Kephisos River at the Karditsa hydrometric station (close to the outlet to Karditsa tunnel; catchment area 1930 km^2). The data have been retrieved from [5] and cover the period 1908 to 2019 (112 years in total) on a monthly time scale. This river is one of the three major ones that supply water to Athens, where withdrawals are made downstream of the hydrometric station and thus do not modify the natural flows. No reservoirs have been constructed upstream of the hydrometric station, yet the basin is not entirely free of anthropogenic influences, mostly groundwater pumping. Nonetheless, most of the long-term variation of the river flow is explained by the respective long-term variation of rainfall [42,43].

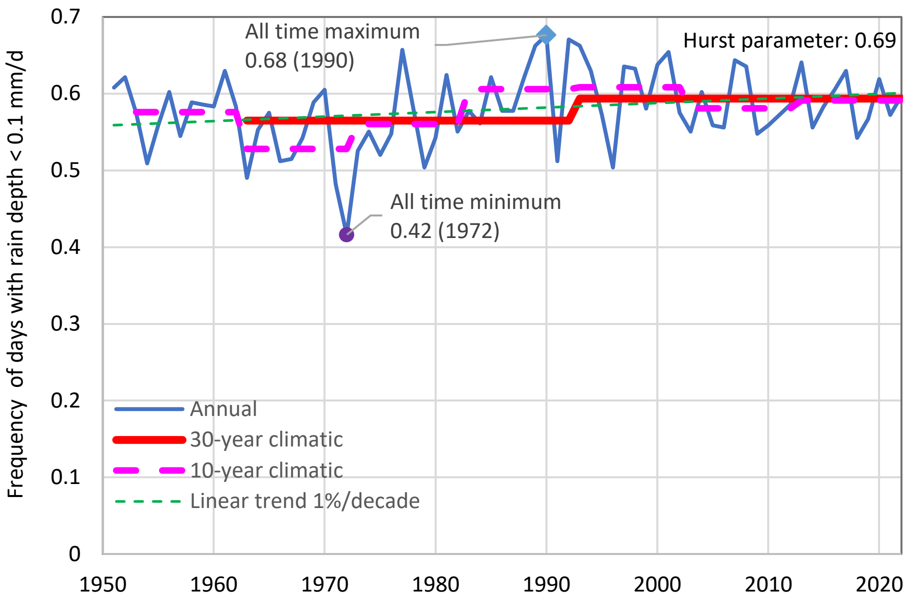


Figure 14. Frequency of days with low average rainfall depth (<0.1 mm) per year in the Central Aegean region, i.e., the land grid points in the area 37.15° N–38.45° N, 23° E–26° E, from the daily European ERA5 reanalysis. The graph also shows (a) the high and low records, (b) the climatic values (10-year and 30-year averages), and (c) the fitted linear trend.

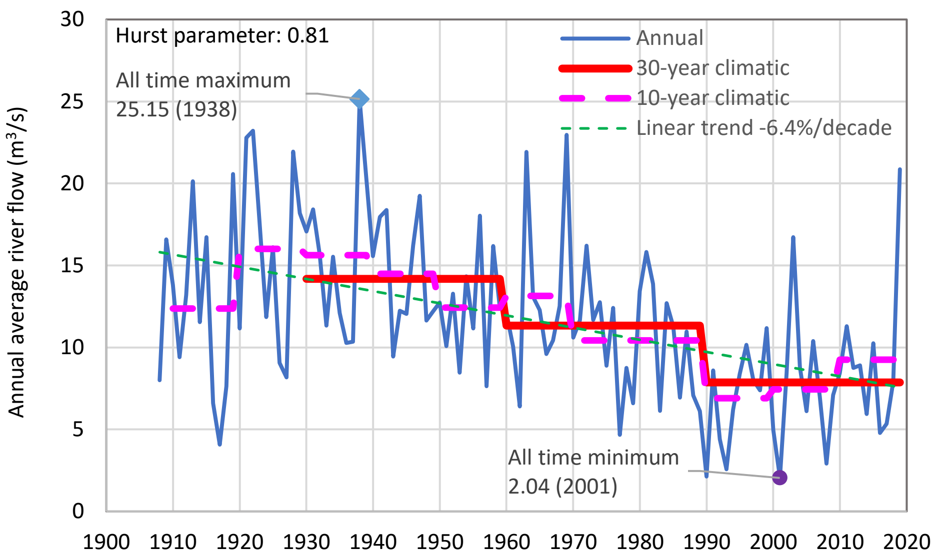


Figure 15. Annual average river flow (discharge) of the Boeoticos Kephisos River at Karditsa gauge. The graph also shows (a) the high and low records, (b) the climatic values (10-year and 30-year averages), and (c) the fitted linear trend.

At first sight, the time series shows a remarkable downward linear trend. The trend is also confirmed by the plotted climatic values at the 30-year time scale. However, if we take into consideration the above analyses of rainfall deficits and, in particular, the occurrence of the major drought affecting the entire country around 1990, we understand that this trend is mostly the reflection of the rainfall deficits in this period to the runoff process (see also [42,43]). The plot of the climatic trend at the 10-year time scale, also plotted in the figure, shows that the trend has reversed after the big drought, with a very high annual value at the end of the period covered by the data.

5. Discussion

The most remarkable climatic event identified from the analysis of rainfall data in Greece and confirmed by the flow data of the Boeoticos Kephisos River is the major rainfall deficit around 1990. Indeed, the latter event shook major parts of Greece and, in particular, the water supply system of Athens (one of the most extended in the world). However, the management of that drought was quite successful. Indeed, not even in one house in not even one day throughout the 7-year period that the drought affected the system was there a water supply failure due to the drought. The successful management of this event included the following measures:

- The close collaboration of scientific, technological and administrative bodies (National Technical University of Athens, Athens Water Supply and Sewerage Company—EYDAP, Ministry of Environment and Public Works).
- Understanding that droughts are regular natural events—not associated with human influences and not predictable.
- Proper modelling of the drought within a stochastic Hurst–Kolmogorov framework [43] and development of a sophisticated decision support system [44].
- Transparency and veritable information to the population of Athens and engagement of the latter in the management of the crisis.
- Design and implementation of an increasing block rate pricing structure, combined with water conservation legislation measures, which, along with the active engagement of the population, resulted in a decrease in the water consumption of Athens by 1/3 [45].
- Increased water supply through technological measures: New groundwater resources were exploited; floating pumping stations were installed on reservoirs to maximize the water release; in 1.5 years, a new 29.4 km tunnel was constructed and operated, diverting water from the Evinos River to Athens; and in another 4 years, the new dam on the Evinos River was completed, thus increasing the water quantity transferred to Athens.

The successful management of this drought shows the ability of human intervention in adverse natural events to prevent a crisis from occurring. The instruments for such prevention are science, technology, and reason-based management.

6. Summary and Conclusions

The two over-century-long rainfall time series of Greece (Athens and Thessaloniki) show that the record average and maximum rainfall depths occurred in the 19th or early 20th century. Compared to other locations on the globe with long time series, these two time series of Greece show much smaller to negligible climate variability, both in mean and maximum rainfall heights.

The current period can be characterized as normal without notable climatic events. Regarding maximum daily precipitation, the number of stations with time series of 60 years or more (238 stations in all water districts) allows us to safely conclude that there are no notable climatic events during the period in question. Both the temporal distribution of record highs and climatic fluctuations thereof are in impressive agreement with theoretical expectations under stationarity, while there is a balance between positive and negative climatic trends.

In terms of the annual average rainfall, the two most important climatic events that have occurred in Greece from the middle of the 20th century to the present day are (a) the grouping of the high records of the annual average rainfall depth, namely 1/3 of all stations, in one year, the hydrological year 1962–63, and (b) the intense and persistent drought before and after 1990, where the five-year period from 1988–89 to 1992–93 saw more than 50% of all record lows.

The alternation of dry and wet periods is also a notable characteristic revealed by the study of hydrological data. This behaviour has been known to Greek philosophers since the 6th century BC (cf. Xenophanes; see [46]). Besides, the dry conditions in Greece have not been an obstacle to the development of Greek civilization but rather a trigger for the development of science, technology, and management [47,48]. The ancient aqueducts of Athens that are still operational to date are a living testimony of this fact [49].

A modern repetition of the latter achievement is that, as a result of the successful management of the big drought 30 years ago, Athens now has a perfect water supply system. The successful handling of this crisis is arguably one of the greatest achievements of modern Greek public policy. It would have been impossible without competent and pragmatic leadership and public participation.

However, by now, the successful management of that drought may have been forgotten as there is a tendency to associate everything with anthropogenic climate change and manage it in such a framework. Climate, renamed climate change, climate emergency, climate crisis etc., has been the post-modern scapegoat on which every disaster is blamed. For example, in Greece, even the new coronavirus was blamed on it [50]. The most recent train crash in Greece [51] (widely referred to as a "national tragedy"), in which dozens were killed (and which was not blamed on climatic events yet), may be viewed as a dramatic call for a return to reason (the Aristotelian «ορθός λόγος» [52]) and meritocracy (the necessary companion of democracy, according to Pericles [53]), and for the reverse of post-modern socio-political decline and decadence.

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Data Availability Statement: The data that were retrieved from the ClimExp platform are available online for free (http://climexp.knmi.nl/ (accessed on 25 March 2023)). The data of the General Directorate of Water of the Greek Ministry of Environment and Energy are available online for free from the Hydroscope platform (http://www.hydroscope.gr/ (accessed on 25 March 2023)). All other data belong to other Greek organizations and are not publicly available.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Precipitation Time Series in Bologna as a Benchmark

The daily rainfall time series in Bologna, Italy, is one of the longest worldwide, and it is one of the time series nearest to Greece. A series of 206 years of data, starting in 1813, was compiled in [5] and plotted in Figure A1. In addition to the daily values, the figure shows (a) the annual maximum daily values ranging from 17.6 to 155.7 mm/d (ratio 1:8.8), (b) the climatic maximum daily values (30-year averages) ranging from 48.1 to 61.3 mm (ratio 1:1.3), and (c) the climatic mean daily values (30-year mean values) ranging from 1.5 to 2.2 mm/d (ratio 1:1.5). The recent decades do not signify anything remarkable, and the record maximum occurred 90 years ago. Climatic fluctuations are evident and irregular. They are most effectively and parsimoniously described in a stochastic framework as strongly persistent behaviour, or HK stochastic dynamics, with a Hurst parameter $H = 0.86$ [5]. As happens with most long time series, the Bologna precipitation series shows that change is perpetual [34].

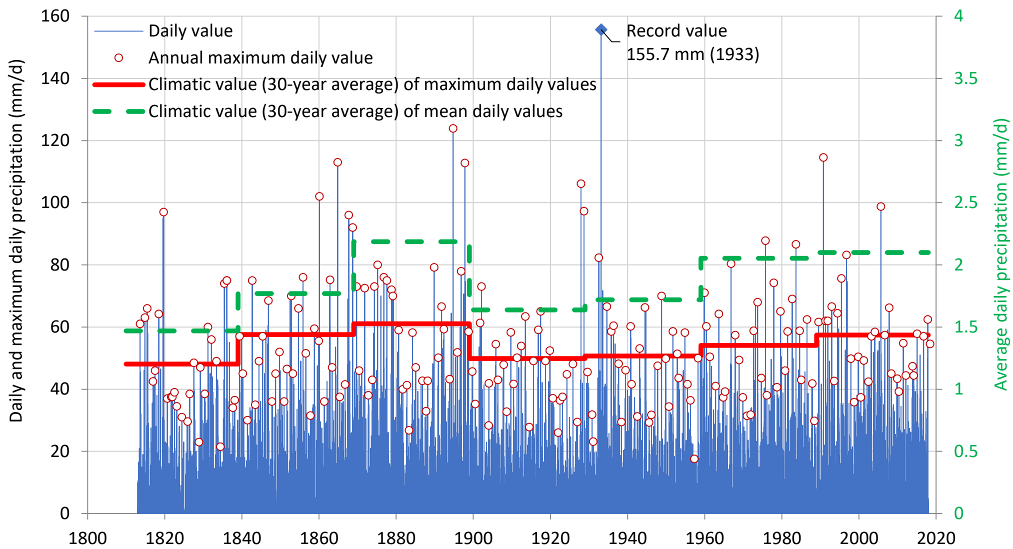

Figure A1. Time series of daily precipitation series in Bologna (start 1813; total length 206 years), with annual maximum rainfall depths marked and additionally showing climatic values (30-year averages) of annual maxima and of daily averages (adapted from Koutsoyiannis [5]).

Appendix B. Precipitation in the Mediterranean

For comparison with Greece, a similar analysis using ERA5 data for the Mediterranean, specified as the land grid points in the area 30° N–46° N, 6° W–36° E, is presented in this Appendix. The entire area, including the sea points, was also considered, but no essential difference appeared. Figure A2 (Mediterranean) is similar to Figure 10 (Greece).

The Mediterranean has been regarded by IPCC [54] and numerous publications of the climate literature as one of the most prominent and vulnerable climate change hotspots. However, no such indications are seen in Figure A2, even though prominent change is again evident, particularly in the 10-year scale, which had occurred long earlier, in the 1960s and 1970s. This also happened in Greece, even though in the Mediterranean, the wettest year was 1971–72 instead of 1962–63.

Figure A3 shows the annual maximum daily precipitation series in the Mediterranean region. The fact that the record highs in the years 2016–17 and 1956–57 are identical to those in Figure 11 means that these highs were located in Greece.

Finally, Figure A4 shows the frequency of days with low average rainfall depth, an indicator of drought. This is similar to Figure 13 (for Greece). The highest frequency of days with very low areally averaged rainfall depth occurred in 1955–56. In recent decades, no sign of unprecedented drought has appeared.

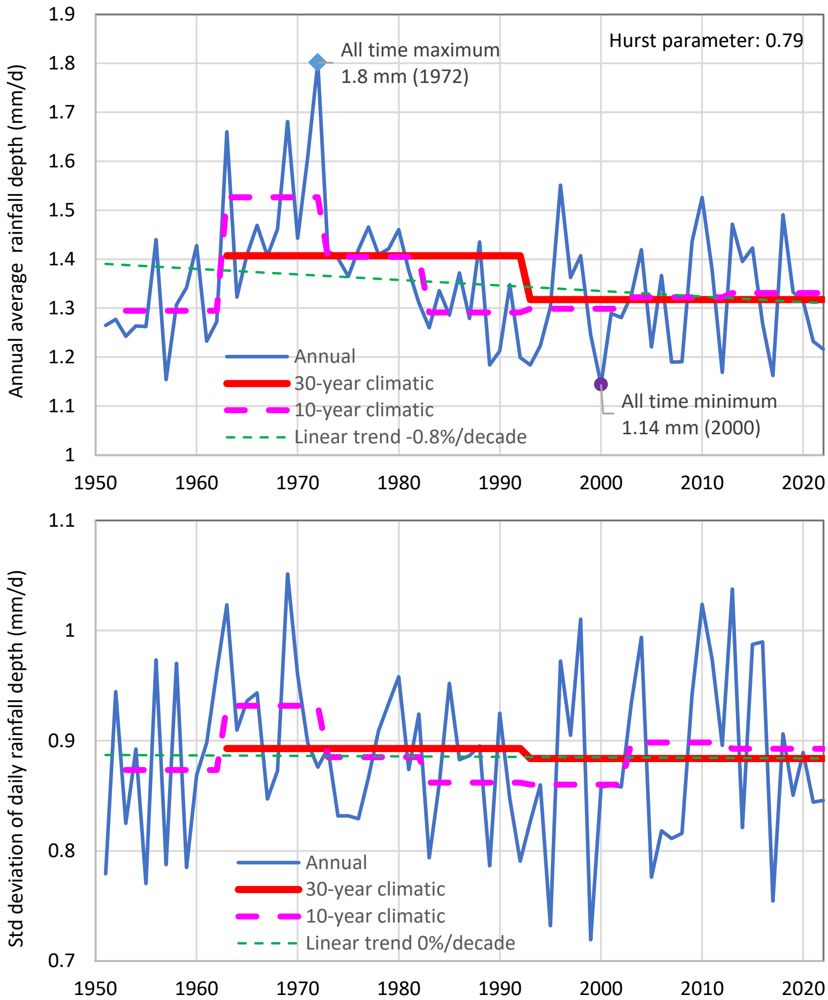

Figure A2. Annual average (**upper**) and standard deviation (**lower**) daily precipitation series in the Mediterranean territory, i.e., the land grid points in the area 30° N–46° N, 6° W–36° E, from the daily European ERA5 reanalysis. The graphs also show (a) the high and low records, (b) the climatic values (10-year and 30-year averages), and (c) the fitted linear trends.

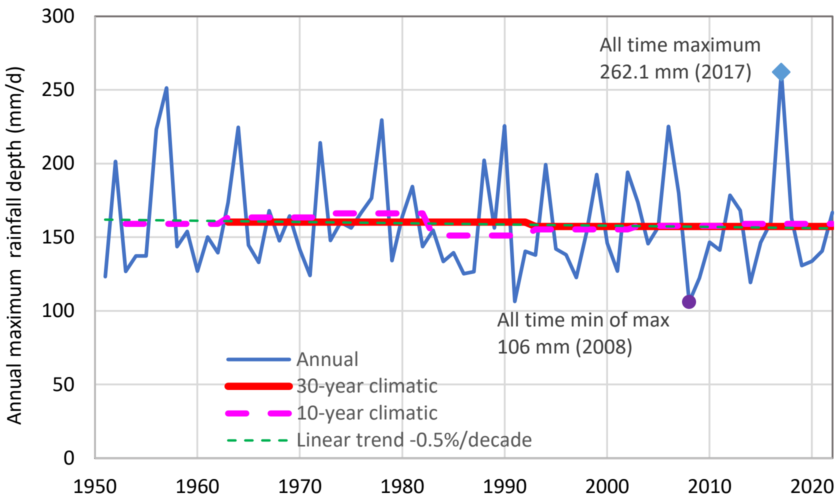

Figure A3. Annual maximum daily precipitation series in the Mediterranean territory, i.e., the land grid points in the area 30° N–46° N, 6° W–36° E, from the daily European ERA5 reanalysis. The graph also shows (a) the high and low records, (b) the climatic values (10-year and 30-year averages), and (c) the fitted linear trend.

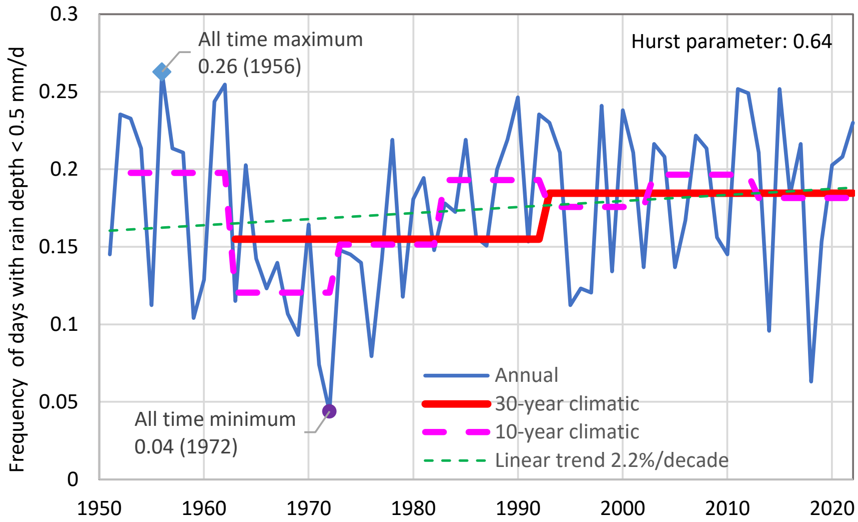

Figure A4. Frequency of days with low average rainfall depth (<0.5 mm) per year in the Mediterranean territory, i.e., the land grid points in the area 30° N–46° N, 6° W–36° E, from the daily European ERA5 reanalysis. The graph also shows (a) the high and low records, (b) the climatic values (10-year and 30-year averages), and (c) the fitted linear trend.

References

1. Thucydides. History of the Peloponnesian War 3.82.4. Available online: https://www.greek-language.gr/digitalResources/ancient_greek/library/browse.html?text_id=73&page=105 (accessed on 20 April 2023).
2. The European Parliament Declares Climate Emergency. Available online: https://www.europarl.europa.eu/news/en/press-room/20191121IPR67110/the-european-parliament-declares-climate-emergency (accessed on 25 March 2023).
3. Secretary-General Warns of Climate Emergency, Calling Intergovernmental Panel's Report 'a File of Shame', while Saying Leaders 'Are Lying', Fuelling Flames. Available online: https://press.un.org/en/2022/sgsm21228.doc.htm (accessed on 25 March 2023).
4. Κλιματική Κρίση [Climate Crisis; in Greek]. Available online: https://civilprotection.gov.gr/klimatiki-krisi (accessed on 25 March 2023).
5. Koutsoyiannis, D. *Stochastics of Hydroclimatic Extremes—A Cool Look at Risk*, 2nd ed.; Kallipos Open Academic Editions: Athens, Greece, 2022; 346p, ISBN 978-618-85370-0-2. [CrossRef]
6. Sargentis, G.-F.; Ioannidis, R.; Bairaktaris, I.; Frangedaki, E.; Dimitriadis, P.; Iliopoulou, T.; Koutsoyiannis, D.; Lagaros, N.D. Wildfires vs. Sustainable Forest Partitioning. *Conservation* **2022**, *2*, 195–218. [CrossRef]
7. Majone, B.; Avesani, D.; Zulian, P.; Fiori, A.; Bellin, A. Analysis of high streamflow extremes in climate change studies: How do we calibrate hydrological models? *Hydrol. Earth Syst. Sci.* **2022**, *26*, 3863–3883. [CrossRef]
8. Liu, X.; Li, Z.; Attarod, P. Understanding hydrological extremes and their impact in a changing climate: Observations, mod-eling and attribution. *Front. Earth Sci.* **2021**, *8*, 632186. [CrossRef]
9. Tabari, H. Climate change impact on flood and extreme precipitation increases with water availability. *Sci. Rep.* **2020**, *10*, 13768. [CrossRef]
10. Climate Change Still Seen as Top Global Threat, but Cyberattacks Rising Concern | Pew Research Center. Available online: https://www.pewresearch.org/global/2019/02/10/climate-change-still-seen-as-the-top-global-threat-but-cyberattacks-a-rising-concern/ (accessed on 25 March 2023).
11. Koutsoyiannis, D.; Andreadakis, A.; Mavrodimou, R.; Christofides, A.; Mamassis, N.; Efstratiadis, A.; Koukouvinos, A.; Karavokiros, G.; Kozanis, S.; Mamais, D.; et al. *National Programme for the Management and Protection of Water Resources, Support on the Compilation of the National Programme for Water Resources Management and Preservation*; Department of Water Resources and Environmental Engineering—National Technical University of Athens: Athens, Greece, 2008; 748p. [CrossRef]
12. European Commission. *Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the Assessment and Management of Flood Risks*; L 288, 6.11.2007; Official Journal of the European Communities: Aberdeen, UK, 2007; p. 27.
13. Koutsoyiannis, D.; Iliopoulou, T.; Koukouvinos, A.; Malamos, N.; Mamassis, N.; Dimitriadis, P.; Tepetidis, N.; Markantonis, D. *Τεχνική Έκθεση [Technical Report; in Greek]. Production of Maps with Updated Parameters of the Ombrian Curves at Country Level (Implementation of the EU Directive 2007/60/EC in Greece)*; Department of Water Resources and Environmental Engineering—National Technical University of Athens: Athens, Greece, 2023.
14. Climate Explorer. Dutch Royal Netherlands Meteorological Institute (KNMI). Available online: https://climexp.knmi.nl/ (accessed on 25 January 2023).
15. Koutsoyiannis, D.; Baloutsos, G. Analysis of a long record of annual maximum rainfall in Athens, Greece, and design rainfall inferences. *Nat. Hazards* **2000**, *22*, 29–48. [CrossRef]

16. ERA5: Data Documentation—Copernicus Knowledge Base—ECMWF Confluence Wiki. Available online: https://confluence.ecmwf.int/display/CKB/ERA5%3A+data+documentation#heading-Relatedarticles (accessed on 25 March 2023).
17. Koutsoyiannis, D. Revisiting the global hydrological cycle: Is it intensifying? *Hydrol. Earth Syst. Sci.* **2020**, *24*, 3899–3932. [CrossRef]
18. Hassler, B.; Lauer, A. comparison of reanalysis and observational precipitation datasets including ERA5 and WFDE5. *Atmosphere* **2021**, *12*, 1462. [CrossRef]
19. Bandhauer, M.; Isotta, F.; Lakatos, M.; Lussana, C.; Båserud, L.; Izsák, B.; Szentes, O.; Tveito, O.E.; Frei, C. Evaluation of daily precipitation analyses in E-OBS (v19. 0e) and ERA5 by comparison to regional high-resolution datasets in European regions. *Int. J. Climatol.* **2022**, *42*, 727–747. [CrossRef]
20. Longo-Minnolo, G.; Vanella, D.; Consoli, S.; Pappalardo, S.; Ramírez-Cuesta, J.M. Assessing the use of ERA5-Land reanalysis and spatial interpolation methods for retrieving precipitation estimates at basin scale. *Atmos. Res.* **2022**, *271*, 106131. [CrossRef]
21. Giovanni. The Bridge Between Data and Science. Available online: https://giovanni.gsfc.nasa.gov/giovanni/ (accessed on 25 January 2023).
22. IMERG: Integrated Multi-Satellite Retrievals for GPM | NASA Global Precipitation Measurement Mission. Available online: https://gpm.nasa.gov/data/imerg (accessed on 25 January 2023).
23. Kazamias, A.P.; Sapountzis, M.; Lagouvardos, K. Evaluation of GPM-IMERG rainfall estimates at multiple temporal and spatial scales over Greece. *Atmos. Res.* **2022**, *269*, 106014. [CrossRef]
24. Malamos, N.; Koutsoyiannis, D. Bilinear surface smoothing for spatial interpolation with optional incorporation of an ex-planatory variable. Part 1: Theory. *Hydrol. Sci. J.* **2016**, *61*, 519–526. [CrossRef]
25. Malamos, N.; Koutsoyiannis, D. Bilinear surface smoothing for spatial interpolation with optional incorporation of an ex-planatory variable. Part 2: Application to synthesized and rainfall data. *Hydrol. Sci. J.* **2016**, *61*, 527–540. [CrossRef]
26. Koutsoyiannis, D.; Montanari, A. Statistical analysis of hydroclimatic time series: Uncertainty and insights. *Water Resour. Res.* **2007**, *43*, W05429. [CrossRef]
27. Đurin, B.; Kranjčić, N.; Kanga, S.; Singh, S.K.; Sakač, N.; Pham, Q.B.; Hunt, J.; Dogančić, D.; Di Nunno, F. Application of rescaled adjusted partial sums (RAPS) method in hydrology—An overview. *Adv. Civ. Archit. Eng.* **2022**, *13*, 58–72. [CrossRef]
28. Đurin, B.; Raič, M.; Sušilović, P. Application of the RAPS method of time series analysis to the assessment of grout curtain performance in karst—A case study of the hydro energy power plant (HEPP) Mostar Dam in Bosnia and Herzegovina. *Hydrology* **2022**, *9*, 192. [CrossRef]
29. Şen, Z.; Şişman, E.; Dabanli, I. Innovative polygon trend analysis (IPTA) and applications. *J. Hydrol.* **2019**, *575*, 202–210. [CrossRef]
30. Mazrekaj, R.; Đurin, B.; Shala, A.; Lajqi, S.; Alamatian, E. A novel approach to analysis of road accidents using the trend analysis and IPTA method: A case study of Kosovo. *Balt. J. Road Bridge Eng.* **2022**, *17*, 1–17. [CrossRef]
31. Koutsoyiannis, D. Climate change, the Hurst phenomenon, and hydrological statistics. *Hydrol. Sci. J.* **2003**, *48*, 3–24. [CrossRef]
32. Cohn, T.A.; Lins, H.F. Nature's style: Naturally trendy. *Geophys. Res. Lett.* **2005**, *32*, L23402. [CrossRef]
33. Hamed, K.H. Trend detection in hydrologic data: The Mann-Kendall trend test under the scaling hypothesis. *J. Hydrol.* **2008**, *349*, 350–363. [CrossRef]
34. Koutsoyiannis, D. Hydrology and Change. *Hydrol. Sci. J.* **2013**, *58*, 1177–1197. [CrossRef]
35. Iliopoulou, T.; Koutsoyiannis, D. Projecting the future of rainfall extremes: Better classic than trendy. *J. Hydrol.* **2020**, *588*, 125005. [CrossRef]
36. Koutsoyiannis, D. A random walk on water. *Hydrol. Earth Syst. Sci.* **2010**, *14*, 585–601. [CrossRef]
37. Hurst, H.E. Long term storage capacities of reservoirs. *Trans. Am. Soc. Civil Eng.* **1951**, *116*, 776–808. [CrossRef]
38. Koutsoyiannis, D. The Hurst phenomenon and fractional Gaussian noise made easy. *Hydrol. Sci. J.* **2002**, *47*, 573–595. [CrossRef]
39. Iliopoulou, T.; Koutsoyiannis, D. Revealing hidden persistence in maximum rainfall records. *Hydrol. Sci. J.* **2019**, *64*, 1673–1689. [CrossRef]
40. Stefanidis, K.; Varlas, G.; Papadopoulos, A.; Dimitriou, E. Four decades of surface temperature, precipitation, and wind speed trends over lakes of Greece. *Sustainability* **2021**, *13*, 9908. [CrossRef]
41. Varlas, G.; Stefanidis, K.; Papaioannou, G.; Panagopoulos, Y.; Pytharoulis, I.; Katsafados, P.; Papadopoulos, A.; Dimitriou, E. Unravelling precipitation trends in greece since 1950s using ERA5 climate reanalysis data. *Climate* **2022**, *10*, 12. [CrossRef]
42. Koutsoyiannis, D.; Efstratiadis, A.; Georgakakos, K. Uncertainty assessment of future hydroclimatic predictions: A comparison of probabilistic and scenario-based approaches. *J. Hydrometeorol.* **2007**, *8*, 261–281. [CrossRef]
43. Koutsoyiannis, D. Hurst-Kolmogorov dynamics and uncertainty. *J. Am. Water Resour. Assoc.* **2011**, *47*, 481–495. [CrossRef]
44. Koutsoyiannis, D.; Karavokiros, G.; Efstratiadis, A.; Mamassis, N.; Koukouvinos, A.; Christofides, A. A decision support system for the management of the water resource system of Athens. *Phys. Chem. Earth* **2003**, *28*, 599–609. [CrossRef]
45. Xenos, D.; Passios, I.; Georgiades, S.; Parlis, E.; Koutsoyiannis, D. Water demand management and the Athens water supply. In Proceedings of the 7th BNAWQ Scientific and Practical Conference Water Quality Technologies and Management in Bulgaria, Sofia, Bulgaria, 20–22 February 2002; Bulgarian National Association on Water Quality: Sofia, Bulgaria, 2002; pp. 44–50. [CrossRef]
46. Koutsoyiannis, D.; Mamassis, N.; Efstratiadis, A.; Zarkadoulas, N.; Markonis, Y. Floods in Greece. In *Changes of Flood Risk in Europe*; Kundzewicz, Z.W., Ed.; IAHS Press—International Association of Hydrological Sciences: Wallingford, UK, 2012; Chapter 12; pp. 238–256.

47. Koutsoyiannis, D.; Patrikiou, A. Water control in Ancient Greek cities. In *A History of Water: Water and Urbanization*; Tvedt, T., Oestigaard, T., Eds.; I.B. Tauris: London, UK, 2014; pp. 130–148.
48. Koutsoyiannis, D.; Mamassis, N. From mythology to science: The development of scientific hydrological concepts in the Greek antiquity and its relevance to modern hydrology. *Hydrol. Earth Syst. Sci.* **2021**, *25*, 2419–2444. [CrossRef]
49. Koutsoyiannis, D.; Zarkadoulas, N.; Angelakis, A.N.; Tchobanoglous, G. Urban water management in Ancient Greece: Lega-cies and lessons. *J. Water Resour. Plan. Manag.* **2008**, *134*, 45–54. [CrossRef]
50. Ζερεφός: Πιθανότατα ο κορωνοϊός προέρχεται από λιώσιμο πάγων της Σιβηρίας—Ο πλανήτης εκπέμπει «SOS» [Zerefos: Most Likely the Coronavirus Comes from Melting Siberian Ice—The Planet Sends an SOS; in Greek]. Available online: https://www.tovima.gr/2021/06/30/science/zerefos-pithanotata-o-koronoios-proerxetai-apo-liosimo-pagon-tis-sivirias-o-planitis-ekpempei-sos/ (accessed on 25 March 2023).
51. Greece Train Crash: Pictures of Devastation as Dozens Killed—BBC News. Available online: https://www.bbc.com/news/world-europe-64808123 (accessed on 25 March 2023).
52. Aristotle. Nicomachean Ethics, 1144b. Available online: https://www.greek-language.gr/digitalResources/ancient_greek/library/browse.html?text_id=78&page=72 (accessed on 20 April 2023).
53. Thucydides. History of the Peloponnesian War 2.37.1. Available online: https://www.greek-language.gr/digitalResources/ancient_greek/library/browse.html?text_id=73&page=58 (accessed on 20 April 2023).
54. IPCC (Intergovernmental Panel on Climate Change). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2021; p. 2391.