μόνον ἔτσι ἡ δύσκολη καὶ συνήθως τόσον ἄχαρις τέχνη τῆς μουσικῆς προικίζεται μὲ τὴν πραγματικήν της ἔννοιαν καὶ ἀξίαν. Τὸ πᾶν εἶναι ἡ ἐκτέλεσις. Χρέος εἶναι ἄρα τοῦ ἐρευνητοῦ τοῦ λαϊκοῦ πολιτισμοῦ λαογράφου νὰ εὑρίσκῃ κάθε φορὰ τὴν ἀρίστην δυνατὴν ἐκτέλεσιν τοῦ δημοτικοῦ τραγουδιοῦ καὶ αἱ σχετικαὶ ἐκπομπαὶ τῆς Ἐθνικῆς Ραδιοφωνίας ἀπαραίτητον εἶναι ὑπὸ τὸν αὐτὸν ὅρον νὰ ρυθμίζωνται.

ΑΝΑΚΟΙΝΩΣΕΙΣ ΜΗ ΜΕΛΩΝ

ΜΕΤΕΩΡΟΛΟΓΙΑ.— The rainfall in the Mediterranean region in relation to solar activity, *by* ***Leon. Carapiperis.**** Ἀνεκοινώθη ὑπὸ τοῦ κ. Βασιλ. Αἰγινήτου.

I. INTRODUCTION

In a series of three recent papers (5, 7, 8) I have examined the influence of solar activity a) on the rainfall of Athens, b) on the annual, winter and summer rainfall of 22 stations in Greece and c) on the summer rainfall of 30 selected stations of the Mediterranean.

The main conclusions of the above studies, were the following 1) The rainfall in the above mentioned regions shows a remarkable connection with the solar activity; 2) The influence of sunspots on the rainfall is well marked in winter; 3) The influence of sunspots on the summer rainfall is contrary to the annual and winter rainfall and 4) The variation of rainfall during the solar cycle shows sometimes a single oscillation and sometimes a double or triple oscillation,

In the present paper the influence of solar activity on the annual, winter and summer rainfall is examined in the whole of the Mediterranean maritime region.

2. OBSERVATIONAL MATERIAL AND METHOD USED

The rainfall data consist of annual, winter and summer totals from 30-35 selected coastal and island stations in the Mediterranean region having records covering at least four continuous cycles of sunspots. The number of stations which were taken into consideration were 35 for the annual 34 for the winter and 30 for the summer rainfall.

The missing data for a few months or years of the stations of Port-

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* ΛΕΩΝ. Ν. ΚΑΡΑΠΙΠΕΡΗΣ, Αἱ βροχοπτώσεις τῆς Μεσογείου καὶ ἡ ἡλιακὴ δρᾶσις.

Said, Tunis and Oran were estimated by regression methods using data from the nearest available stations.

Table I gives the name of the selected stations and the number of sunspot cycles which the rainfall data covered.

The available stations are scarce in the Dalmatian coast in the Asia Minor and along the coastal region of North Africa.

In order to examine the influence of sunspots on the rainfall, curves

TABLE I.

Stations	Number of sunspot-cycles	Stations	Number of sunspot-cycles
1) Alexandria.. ..	6	19) Marseille	8
2) Alger	6	20) Messina	4
3) Alicante..	7	21) Neaples	8
4) Ancona	4	22) Nicosia.. ..	5
5) Athens	8	23) Oran	5
6) Barcellona.. ..	6	24) Palermo	7
7) Beirut	6	25) Palma	6
8) Cape Corso ..	4	26) Port-Said.. ..	5
9) Cape Pertusato	4	27) Roma	8
10) Catania	5	28) Salonica	4
11) Corfou	4	29) Sassari	4
12) Genova	8	30) Trieste	8
13) Gibraltar	7	31) Tripolis	4
14) Haifa	5	32) Tunis	6
15) Hvar..	4	33) Valentia	6
16) Kalamata	4	34) Volos	4
17) Limassol	5	35) Zante	4
18) Malta	7		

have been outlined showing the variation of rainfall at the various stations during the sunspots cycle of approximately eleven years. As, however the solar cycles are of uneven length, in order to have a cycle of 11 years and to bring successive maxima and minima of sunspots into approximate concordance different various experiments have been carried out by many authors (2, 3, 4, 7, 9, 10, 16, 20).

In this study the numbers of sunspots have been smoothed through the formula (a + 2b + c) : 4 and then a cycle of 11 years was assumed starting always from the years of minimum of sunspots.

The processes which were made during the period 1855-1954 were the followings: In the annual sunspots between the years 1898 and 1901 the figure (1899 + 1900) : 2 was inserted and between the years 1932 and 1933 the figure (1932 + 1933):2. In the winter sunspots numbers between the years 1887 and 1890 the figure (1888 + 1889): 2, was inserted, between the years 1899 and 1902 the figure (1900 + 1901):2 between the years 1933 and 1934 the figure (1933 + 1934): 2 and between the years 1943 and 1944 the figure (1943 + 1944) : 2.

Finally in the summer sunspots numbers between the years 1864 and 1867 the figure (1865 + 1866) : 2 was inserted, between the years 1898 and 1901 the figure (1899 + 1900) : 2 between the years 1932 and 1933 the figure (1932 + 1933): 2 and between the years 1942 and 1943 the figure (1942 + 1943) : 2.

In the same way the annual, winter and summer rainfall for each of 35 stations of the Mediterranean were tabulated in eleven columns and the mean rainfall (in m.m.) for each year of sunspots cycle was obtained.

3. THE VARIATION OF ANNUAL RAINFALL DURING THE SUNSPOTS CYCLE

According to the course that the annual rainfall presents during the 11 years solar cycle the 35 stations were divided in 3 principal types a, b and c with the following characteristics:

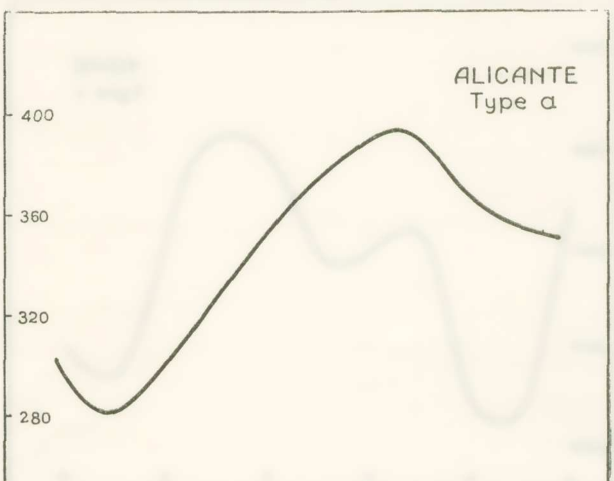

Fig. 1.

Type a. Single oscillation of the rainfall during the sunspots cycle. The maximum of the rainfall occurs in the maximum of sunspots or 1-2 years after it and the minimum of the rainfall in the beginning or in the

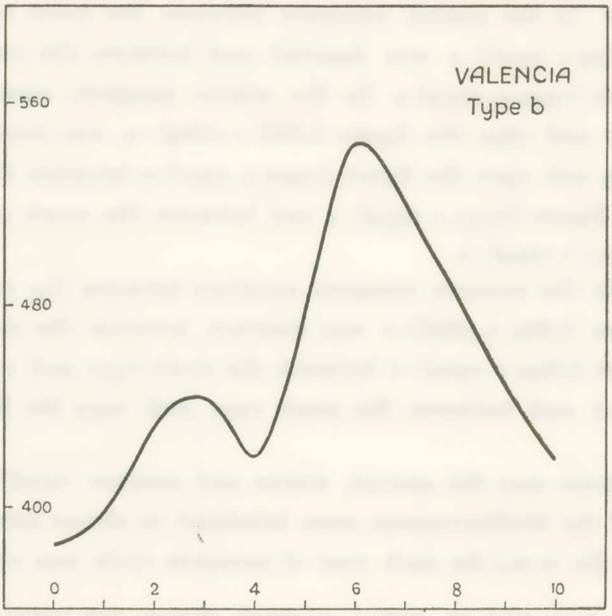

Fig. 2.

end of sunspots cycle (Stations of Alicante, Volos, Salonica, Beirut) (Fig. 1).

Type b. This type is caracterised by double oscillation of the rainfall

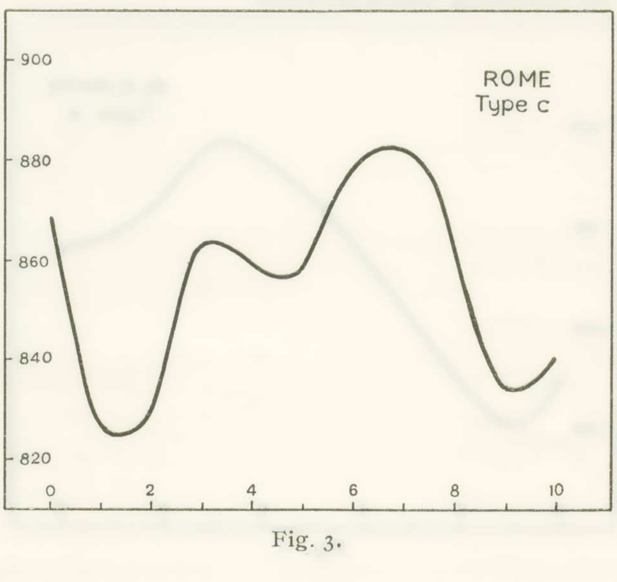

Fig. 3.

during the sunspots cycle. The principal maximum of the rainfall occurs near the maximum of sunspots and the principal minimum of the rainfall in the beginning or in the end of sunspots cycle. The stations of Alexandria, Ancona, Athens, Barcellona, Cape Pertusato, Haifa, Hvar, Nicosia, Oran, Palermo, Palma, Port-Said, Tripolis and Valentia belong to this type (Fig. 2).

As a variety of the above type (b1) can be considered the case in which the principal maximum and minimum of the rainfall occurs around the minimum of sunspots (Stations of Cape Corso, Catania, Corfu, Kalamata, Sassari and Zante).

Type c. To this type belong the stations in which the rainfall appears a triple oscillation during the sunspots cycle.

Two cases of the above type can be distinguished. In the first (c1) belong the stations in which the principal minimum and maximum of the rainfall occurs near the minimum and the maximum of sunspots respectively, while in the second case (c2) belong the stations in which the principal maximum and minimum of the rainfall do not present any tendency to appear near the maximum or minimum of sunspots. The stations of Limassol, Malta Naples and Roma belong to the first case and the stations of Algier, Genova, Gibraltar and Trieste in the second one (Fig. 3).

The more predominant type is the type b (49 %) while the type a is rarely met with (11 %).

A double oscillation of rainfall during the eleven years solar cycle is noted by Hellmann (12) in the rainfall or Europe and by De Lury (9) in the rainfall of different stations of the globe. Quayle (16) found in the Australian stations a triple oscillation of the annual rainfall during the sunspots cycle with the principal maxima of rainfall in the 4th year and the principal minima in the end of solar cycle. Kindson (13) found also a triple oscillation of annual rainfall within the solar cycle in New Zealand and Grew (10) in the rainfall of Armagh with the principal maximum near the maximim and the principal minimum near the minimum of sunspots.

4. THE VARIATION OF WINTER RAINFALL DURING THE SUNSPOTS CYCLE

According to the course that the winter rainfall presents during the sunpots cycle the stations have been divided into 3 principal types a, b and c.

Type a. Single oscillation of the winter rainfall during the sunpots cycle. The maximum of the rainfall occurs near the maximum and the minimum of the rainfall near the minimum of sunspots. To this type belong the stations of Alicante, Marseille and Volos (Fig. 4).

Type b. This type is characterised by double oscillation of the rainfall

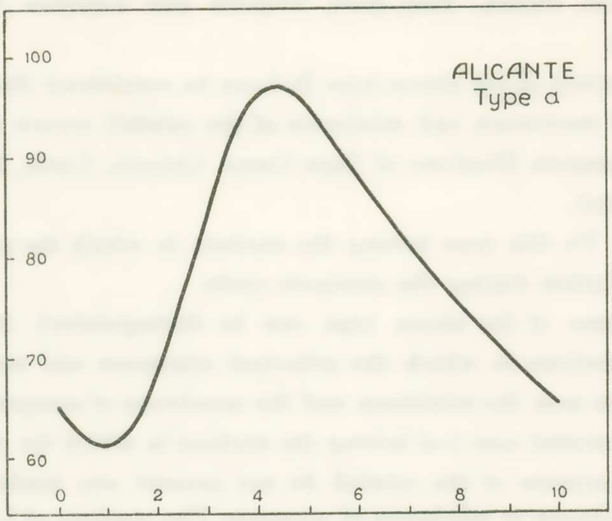

Fig. 4.

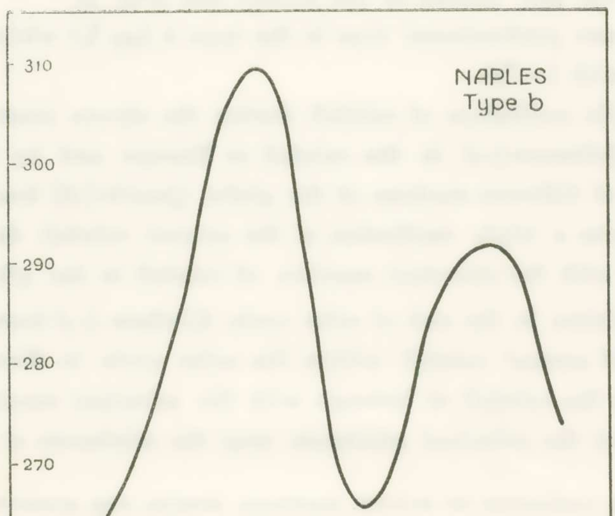

Fig. 5.

during the sunspots cycle. The principal maximum of rainfall occurs near the maximum of sunspots and the principal minimum in the end or in the beginning of sunspots cycle. The Stations of Alexandria, Algier, Ancona, Athens, Beirut, Cape Corse, Cape Pertusato, Corfu, Haifa, Hvar, Kalamata, Limassol, Malta, Messina, Naples, Nicosia, Oran, Palma, Port-Said, Rome, Salonica, Sassari, Trieste, Tripolis, Tunis, Valentia belong to this type. (Fig. 5).

Type c. To this type belong the stations in which the rainfall appears a triple oscillation during the sunspots cycle with the principal maximum

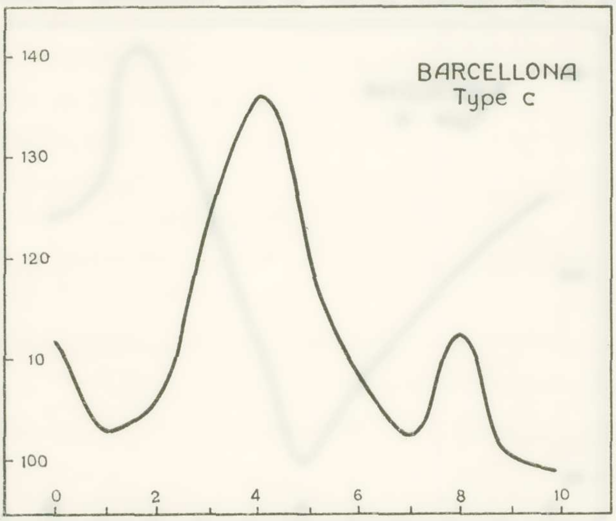

Fig. 6.

near the maximum and the principal minimum near the minimum of sunspots (Barcellona, Catania, Gibraltar, Palermo) (Fig. 6).

The more predominant type is the type b (79%) while the types a and c are rarely met with.

The most, however, important conclusion is the increase of winter rainfall in the vicinity of the maximum of sunspots and in general the more or less similar course of the solar activity and winter rainfall. Among the 34 stations which were taken into consideration in this study, the principal maximum of the winter rainfall occured between the 4th and 6th year of the solar cycle in 28 of them: i.e. with a percentage 82,4%. If we except the station of Catania in which in the 6th year of sunspots cycle the principal minimum of the winter rainfall occurred, in all the others stations not one principal minimum appeared between the 4th and 6th year of the solar cycle. The principal minimum occurred in the first, second and tenth year of solar cycle in 18 stations (53 %).

5. THE VARIATION OF SUMMER RAINFALL DURING THE SUNSPOTS CYCLE

According to the course that the summer rainfall presents during the sunspots cycle the 30 stations were divided in 3 principal types a, b and c with the following characteristics:

Type a. Single oscillation of the rainfall during the sunspots cycle. The minimum of the rainfall occurs in the maximum of sunspots or very

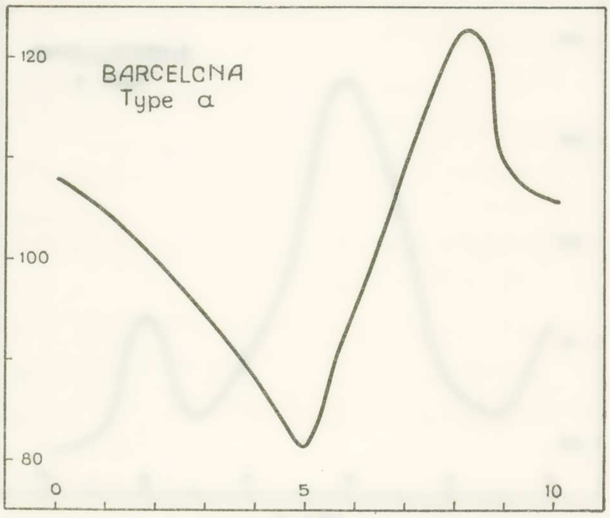

Fig. 7.

near it and the maximum of the rainfall near the beginning or the end of sunspots cycle. The stations which belong to this type are: Barcellona, Kalamata, Messina and Perpignan (Fig. 7).

Type b. This type is characterised by double oscillation of the rainfall during the sunspots cycle. The principal minimum of the rainfall occurs near the maximum of sunspots und the principal maximum of the rainfall 1-3 years after the minimum of sunspots or from 6th to 9th year of sunspots cycle. To this type belong the stations of Algier, Athens, Beirut, Cape Corso, Cape Pertusato, Catania, Corfu, Hvar, Marseille, Neaples, Nicosia, Palma, Roma, Salonica, Sassari, Trieste, Volos and Zante (Fig. 8).

As a variety of the above type can be considered the case in which the principal minimum of rainfall occurs near the minimum of sunspots while near the maximum of sunspots the secondary minimum of rainfall appears (Alicante, Limassol, Palermo).

Type c. To this type belong the stations in which the rainfall appears a triple oscillation during the sunspots cycle.

Two cases of this type can be distinguished. To the first (c1) belong

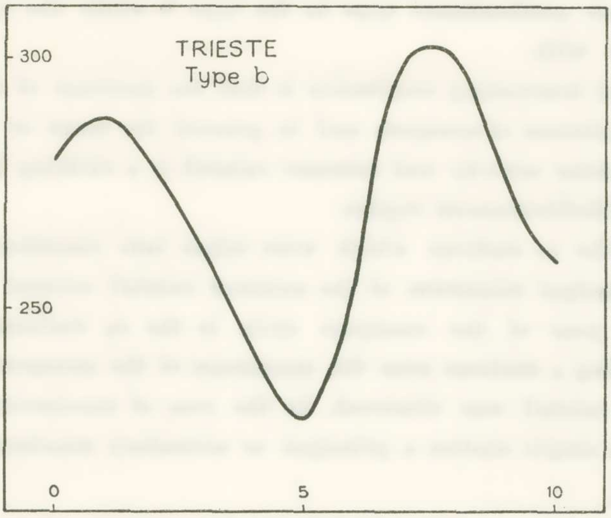

Fig. 8.

the stations in whice the principal minimum and maximum of rainfall occurs near the maximum and minimum of sunspots respectively and in

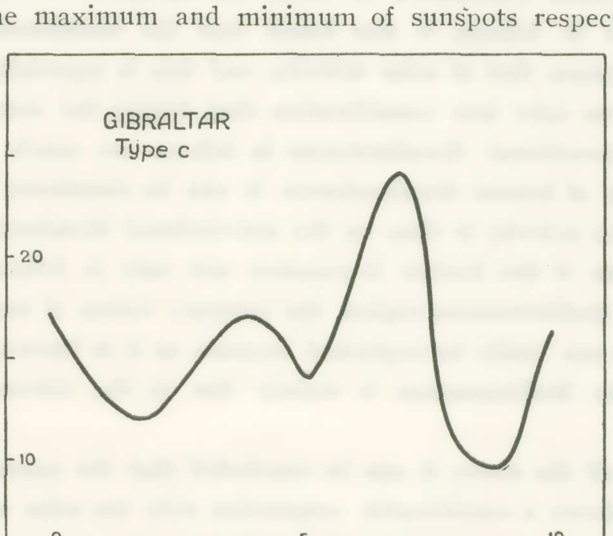

Fig. 9.

the second case (c2) the stations in which the principal minimum of rainfall occurs in the beginning or at the end of sunspots cycle and the principal maximum 1-2 years before or after the maximum of sunspots.

To the first case belongs the station of Valentia and in the second one the stations of Oran, Tunis and Gibraltar (Fig. 9).

The more predominant type in the type b while the types a and c are rarely met with.

The most interesting conclusion is that the decrease of summer rainfall in the maximum of sunspots and in general the more or less contrary course of the solar activity and summer rainfall is a striking feature of the whole of the Mediterranean region.

Among the 30 stations which were taken into consideration in this study, the principal minimum of the summer rainfall occured between the 4th and 6th year of the sunspots cycle in the 24 stations (86%). Yet in the remaining 4 stations near the maximum of the sunspots a secondary minimum of rainfall was observed. In the year of maximum of sunspots cycle at not a single station a principal or secondary maximum of rainfall was observed.

With regard to the cause of the contrary course of summer rainfall and sunspots in the Meditteranean the following could be mentioned:

In a previous publication (6) about the influence of sunspots on the thunderstorms in Athens, it was found that the thunderstorms present an opposite course that of solar activity, and this is especially in summer. If however you take into consideration that during the summer the frequency of convectional thunderstorms in Athens are much greater than the frequency of frontal thunderstorms it can be considered that the influence of solar activity is clear on the convectional thunderstorms.

Therefore if this feature is common not only in Athens but in the whole of the Mediterranean region, the contrary course of summer rainfall and sunspots can easily be explained because, as it is known, the summer rainfall in the Mediterranean is mainly due to the convectional thunderstorms.

From all the above it can be concluded that the rainfall in the Mediterranean shows a considerable connection with the solar activity as indicated by the sunspots numbers. The influence of sunspots on the winter and summer rainfall is clear. The increase of solar activity is followed by an increase of winter rainfall and by a decrease of summer rainfall in the majority of the stations.

ΠΕΡΙΛΗΨΙΣ

Ἐξετάζεται ἐνταῦθα ἡ ἐπίδρασις τῶν ἡλιακῶν κηλίδων ἐπὶ τῶν βροχοπτώσεων τῆς Μεσογείου, ἐπὶ τῇ βάσει τῶν δεδομένων 35 Σταθμῶν, τῶν ὁποίων αἱ παρατηρήσεις καλύπτουν τουλάχιστον τέσσαρας κύκλους τῆς ἡλιακῆς δράσεως.

Πρὸς τὸν σκοπὸν τοῦτον ὑπελογίσθησαν τὰ μέσα ὕψη βροχῆς τὰ ἀντιστοιχοῦντα εἰς ἕκαστον ἔτος τῆς ἡλιακῆς δράσεως καὶ ἀκολούθως ἐχαράχθησαν βάσει αὐτῶν καμπύλαι, παριστῶσαι τὴν πορείαν τῆς βροχῆς ἐντὸς τοῦ ἐν λόγῳ κύκλου.

Ἀναλόγως τῆς πορείας τὴν ὁποίαν παρουσιάζουν τὰ ἐτήσια, χειμερινὰ καὶ θερινὰ ὕψη βροχῆς διαρκοῦντος τοῦ κύκλου τῶν ἡλιακῶν κηλίδων, οἱ Σταθμοὶ διηρέθησαν εἰς τρεῖς τύπους: α, β, καὶ γ. Εἰς τὸν τύπον α ὑπήχθησαν οἱ Σταθμοὶ εἰς τοὺς ὁποίους ἡ ἐν λόγῳ πορεία τῶν ὑψῶν βροχῆς εἶναι ἁπλῆ, εἰς τὸν τύπον β οἱ παρουσιάζοντες πορείαν διπλῆν καὶ εἰς τὸν τύπον γ οἱ Σταθμοὶ οἵτινες παρουσιάζουν τριπλῆν πορείαν.

Ἡ ἐπίδρασις τῆς ἡλιακῆς δράσεως εἶναι σαφὴς ἐπὶ τῶν χειμερινῶν καὶ θερινῶν ὑψῶν βροχῆς. Ἡ αὔξησις ταύτης συνοδεύεται ὑπὸ αὐξήσεως τῶν χειμερινῶν καὶ ἐλαττώσεως τῶν θερινῶν ὑψῶν βροχῆς. Εἰς 84 % τῶν Σταθμῶν τὸ πρωτεῦον μέγιστον τῶν χειμερινῶν βροχῶν παρουσιάζεται μεταξὺ τοῦ 4 καὶ 6 ἔτους τῆς ἡλιακῆς δράσεως, ἤτοι ἐγγύτατα τοῦ μεγίστου τῶν κηλίδων. Ἐπίσης εἰς 86 % τῶν Σταθμῶν τὸ πρωτεῦον ἐλάχιστον τῶν θερινῶν ὑψῶν βροχῆς παρουσιάζεται μεταξὺ τοῦ 4 καὶ 6 ἔτους τῆς ἡλιακῆς δράσεως.

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