Sun-Weather Relationships in Taiwan

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ABSTRACT

The study of meterological and climatic responses to solar variations has been of interest since the recongnition of the sunspot cycle in the early 1800's. Many people have suggested in the past that the weather is influenced by the 11 and 22 year sunspot cycles. In this report, the temperature and rainfall data obtained at 7 sites in Taiwan from 1897 to 1967 were used to investigate the possible relationships between the weather and sunspot cycles in Taiwan. No statistically significant connection between the weather and sunspot cycles was found.

1. Introduction

The study of meterological and climatic response to solar variations has been of interest since the recognition of the sunspot cycle in the early 1800's. Many workers have suggested in the past that the weather is influenced by the 11 and 22 year sunspot cycles. For examples, Xanthakis (1973) observed that at high northern latitudes, the 11 year solar cycle was positively correlated with the annual rain fall total; at latitudes between 60°N and 70°N the opposite behavior occurred; while at still lower latitudes a negative correlation existed before about 1915 and a positive one after that. Bowen (1974) reported that, in the southern hemisphere, the correlation between the 11-year solar cycle and difference from normal rainfall exhibited opposite phase at 17°S and 4.3°S. King (1973) also reported that the sunspot cycle influenced the rainfall in opposite ways at 55°N and 35°N. Markham (1974) reported that the annual rainfall totals at Fortaleza, Brazil, and at three sites in South Africa were positively correlated with the double sunspot cycle. Cornish (1954) reported that the ten year smoothed means of annual rainfall quartile date at Adelaide (35°S; 139°E) oscillated between August 15 and May 25 in phase with the double sunspot cycle. The July temperature in Central England was found to exhibit an oscillation in phase with the double sunspot cycle. Many other examples have been reviewed by King (1975).

Although there were some examples showing the dependence of weather on solar cycle, the dependence was found only in certain parts of the world and was not widely accepted. There were also some reports stating no significant relations between weather and sunspot cycle (e. g. Shaw, 1965 and Lawrence, 1966). At present, it seems that our knowledge in this field is still so limited that we cannot either deny or confirm the existence of connections between weather and sunspot cycle and further study in this respect is necessary. The routine meterological observations in Taiwan were started more than 70 years ago. In this report, the temperature and precipitation data observed at seven meterological observation stations in Taiwan were used to

Table 1. List of stations

Name	North Lat.	East Long.	Elevation (m)
Chilung	25°08′	121°45′	3.4
Taipei	25°02′	121°31′	8.0
Taichung	24°09′	120°41′	83.8
Hwalien	23°58′	121°37′	17.6
Tainan	23°00′	120°13′	14.3
Taitung	22°45′	121°09′	8.9
Hengchun	22°00′	120°45′	22.3

study possible relationship between weather and sunspot cycle in Taiwan. The name and locality of each meterological station whose data were used in the present study are given in Table 1.

2. Relationship between Temperature and Sunspot Cpcle

a. Relation between annual mean temperature and annual mean sunspot number

The solid lines in Fig. 1 show the variations of the annual mean temperature, $\overline{T}$, for seven stations in Taiwan. At the top of the figure, the variation of the annual mean sunspot number, $\overline{R}$, is also shown. From this figure, it can be seen that there is no significant relationship between $\overline{T}$ and $\overline{R}$. To be more rigorous, the regression analysis was made for the variation of $\overline{T}$ vs. $\overline{R}$ for each station. Fig. 2 shows one example of the scattering diagram for $\overline{T}$ vs. $\overline{R}$ obtained for Taipei. The scattering is very large and the regression line is almost a flat line.

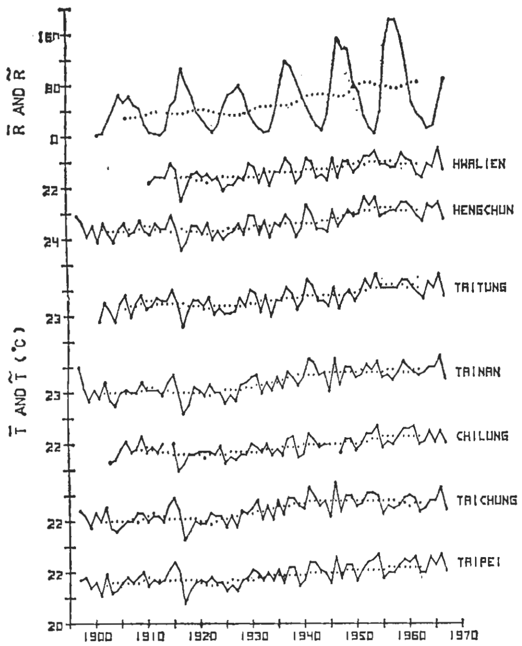

Fig. 1. Year to year variatiohs of the annual mean temperature $\bar{T}$ (full line) and its 11 year running mean value $\tilde{T}$ (dotted line) for 7 weather stations in Taiwan. The variations of annual mean sunspot number $\bar{R}$ and its 11 year running mean value $\tilde{R}$ are also shown at the top of the figure.

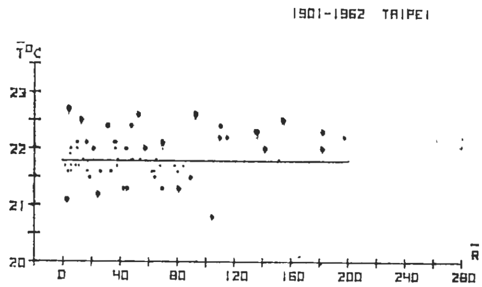

Fig 2. Scattering diagram for $\bar{T}$ vs. $\bar{R}$ The full line represents the regression line.

Table 2. Annual Mean Temperature (°C)

Station Name	Correl. Coef.	Slope (°C/SSN)	Stand. Error of Estimate (°C)	Mean (°C)
Chilung	0.16	0.00	0.36	21.82
Taipei	0.19	0.00	0.40	21.78
Taichung	0.21	0.00	0.46	22.31
Hwalien	0.21	0.00	0.39	22.51
Tainan	0.24	0.00	0.48	23.24
Taitung	0.25	0.00	0.43	23.52
Hengchun	0.29	0.00	0.44	24.43
Average of 7 Stations	0.22	0.00	0.40	22.83

Table 2 shows the correlation coefficent, r, slope of the regression line, m, defined by the following equation:

$$\overline{T}=a+m\overline{R} \qquad (1)$$

standard error of estimate, E, and the mean value of $\overline{T}$ for each station. The values of m are all zero and the correlation coefficients are all smaller than 0.3. It seems there are no relationship between annual mean temperature and sunspot number.

b. Relation between the secular components of $\tilde{T}$ and $\tilde{R}$

The 11 year solar cycle variation of the annual mean sunspot number, $\overline{R}$, is clearly seen in Fig. 1. In order to remove this 11 year periodic variation to obtain the secular variation, 11 year running average values of $\overline{R}$, denoted by $\tilde{R}$, were calculated for each year and plotted as a dotted line in Fig. 1.

Since the 11 year variation has been removed, $\tilde{R}$ can be considered as secular component of sunspot number and its variation with time will be called as a secular variation of sunspot number. A slight increase of secular component, $\tilde{R}$, from 1900 to 1970 can be seen in Fig. 1. Similar treatments were made to obtain the secular components of temperature, denoted by $\tilde{T}$, for each station and plotted as dotted lines in Fig. 1. The secular variation of temperature also shows a slight increase. It seems there is positive correlation between the secular components of temperature and sunspot number.

c. Reletion between monthly mean temperature and monthly mean sunspot number in a solar cycle

Fig. 3(a)-(f) show the variations of the 12 month running averge values of monthly mean temperature for Taipei, denoted by T, and 12 month running average value of monthly mean sunspot number, denoted by R, for each solar cycle starting from cycle 13 to 18. It can be

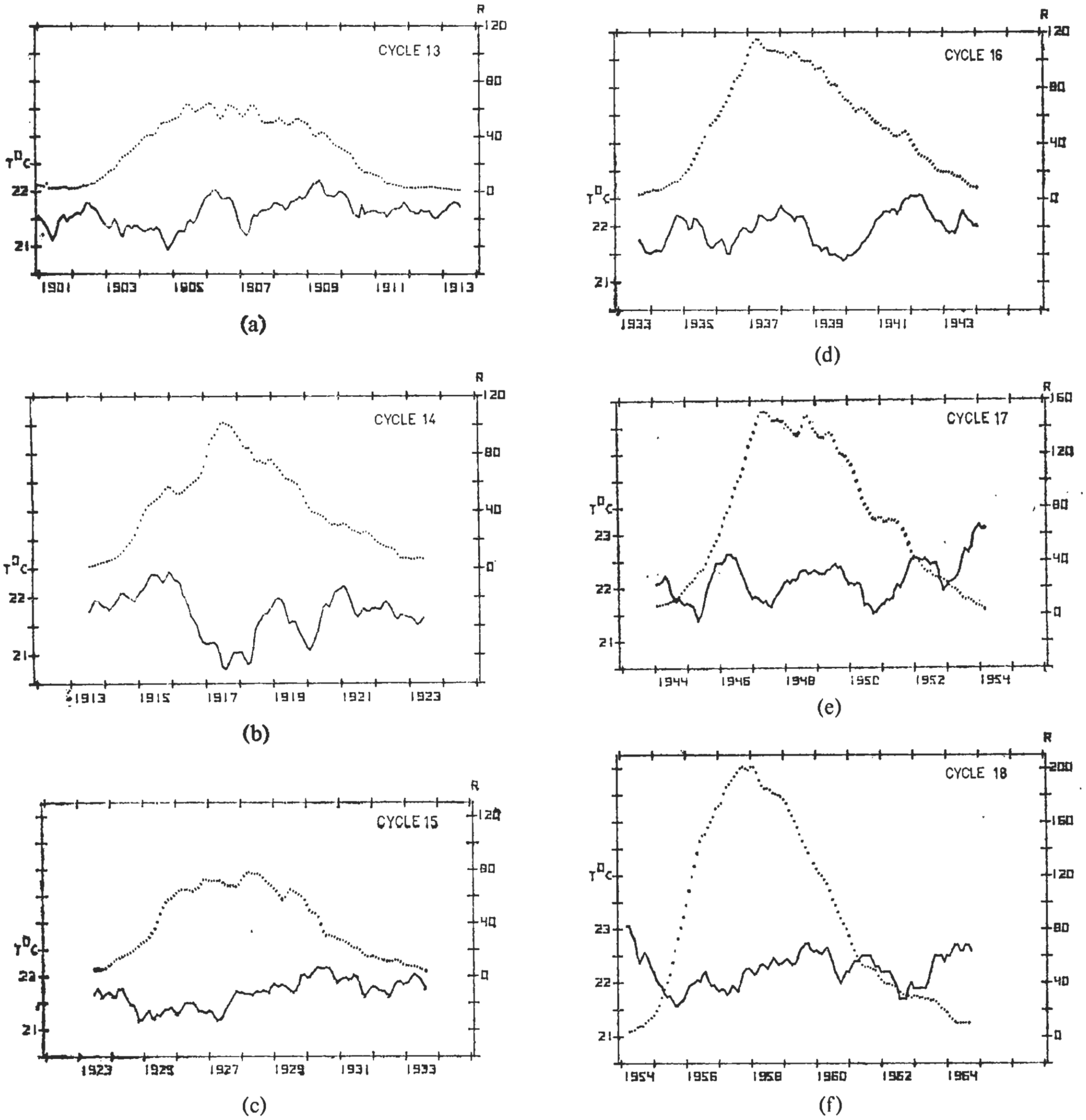

Fig. 3. Month to month variations of 12 month running mean values of monthly mean temperature T at Taipei (full line) and monthly mean sunspot number R (dotted line) for (a) solar cycle 13; (b) solar cycle 14; (c) solar cycle 15; (d) solar cycle 16; (e) solar cycle 17; and (f) solar cycle 18.

seen there is no significant correlation between T and R for each solar cycle.

3. Relationship Between Precipitation and Sunspot Cycle

a. Relation between annual mean precipitation and annual mean sunspot number

Solid lines in Fig. 4 show the variations of the annual mean precipitations, $\bar{P}$, for seven stations in Taiwan. The solar cycle variation of the annual mean sunspot number, $\bar{R}$, is also shown at the top of the figure. Similar to the result obtained for the case of annual mean temperature, $\bar{T}$, there seems no relation between $\bar{P}$ and $\bar{R}$. Fig. 5 shows the scattering diagram for $\bar{P}$ vs. $\bar{R}$ obtained for Taipei station. The solid line represents the regression line for $\bar{P}$ vs. $\bar{R}$. Although the regression line sho wsa slight positive slope, the individual data points are so widely scattered that this positive correlation is hardly convincing. Table 3 shows the correlation coefficient, slope of the regression

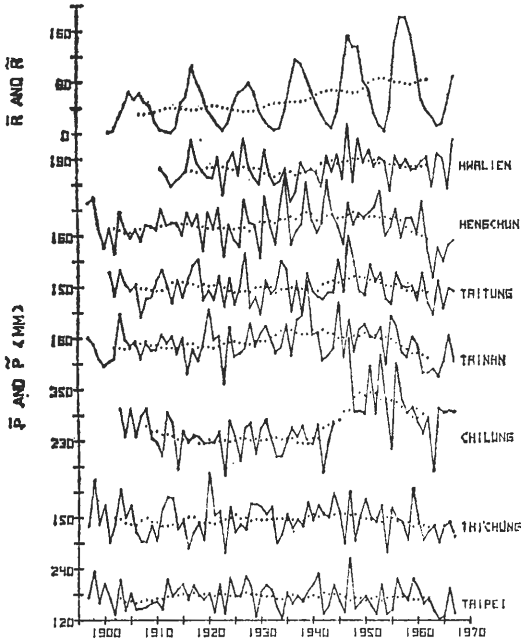

Fig. 4. Year to year variations of the annual mean precipitation $\bar{P}$ (full line) and its 11 year running mean value $\tilde{P}$ (dotted line) for 7 weather stations in Taiwan. Variations of the sunspot numbers are shown at the top of the figure.

line for $\bar{P}$ vs. $\bar{R}$, standard error of estimate, and the mean value of $\bar{P}$ for each station. Although the slopes of regression lines are all slightly positive (except for Taichung), the correlation coefficients are so small (smaller than 0.37) and the standard errors of estimate are so large that it seems there is no convincing relationship between $\bar{P}$ and $\bar{R}$.

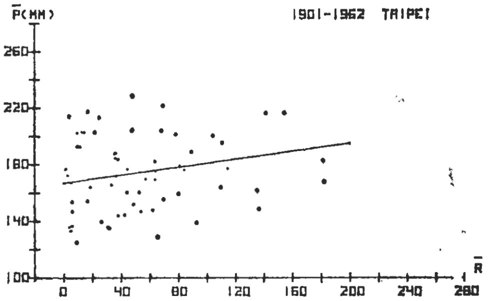

Fig. 5. Scattering diagram for $\bar{P}$ vs. $\bar{R}$. The full line represents the regression line.

Table 3. Annual Mean Precipitation (mm)

Station Name	Correl. Coef.	Slope of Reg. Line (mm/SSN)	Stand. Error of Est. (mm)	Mean Value (mm)
Chilund	0.37	0.49	60.01	234.17
Taipei	0.23	0.14	28.92	166.99
Taichung	0.00	0.00	39.66	149.65
Hwalien	0.30	0.22	36.74	157.18
Tainan	0.14	0.12	42.29	145.64
Taitung	0.15	0.12	37.88	145.82
Hengchun	0.03	0.02	40.55	189.36
Average of 7 Stations	0.29	0.17	28.24	168.23

b. Relationship between the secular components of $\bar{P}$ and $\bar{R}$

The dotted lines in Fig. 4 shows the variations of the secular components $\tilde{R}$ and $\tilde{P}$ for each station obtained by taking 11 year running average values of $\bar{R}$ and $\bar{P}$ respectively. Unlike the result obtained for temperature, there seems no significant relation between the secular components of $\bar{P}$ and $\bar{R}$.

c. Relation between monthly mean precipitation and monthly mean sunspot number in a solar cycle

Fig. 6(a)-(f) shows the variations of the 12 month running average values of the monthly total precipitation, P, for Taipei station and the

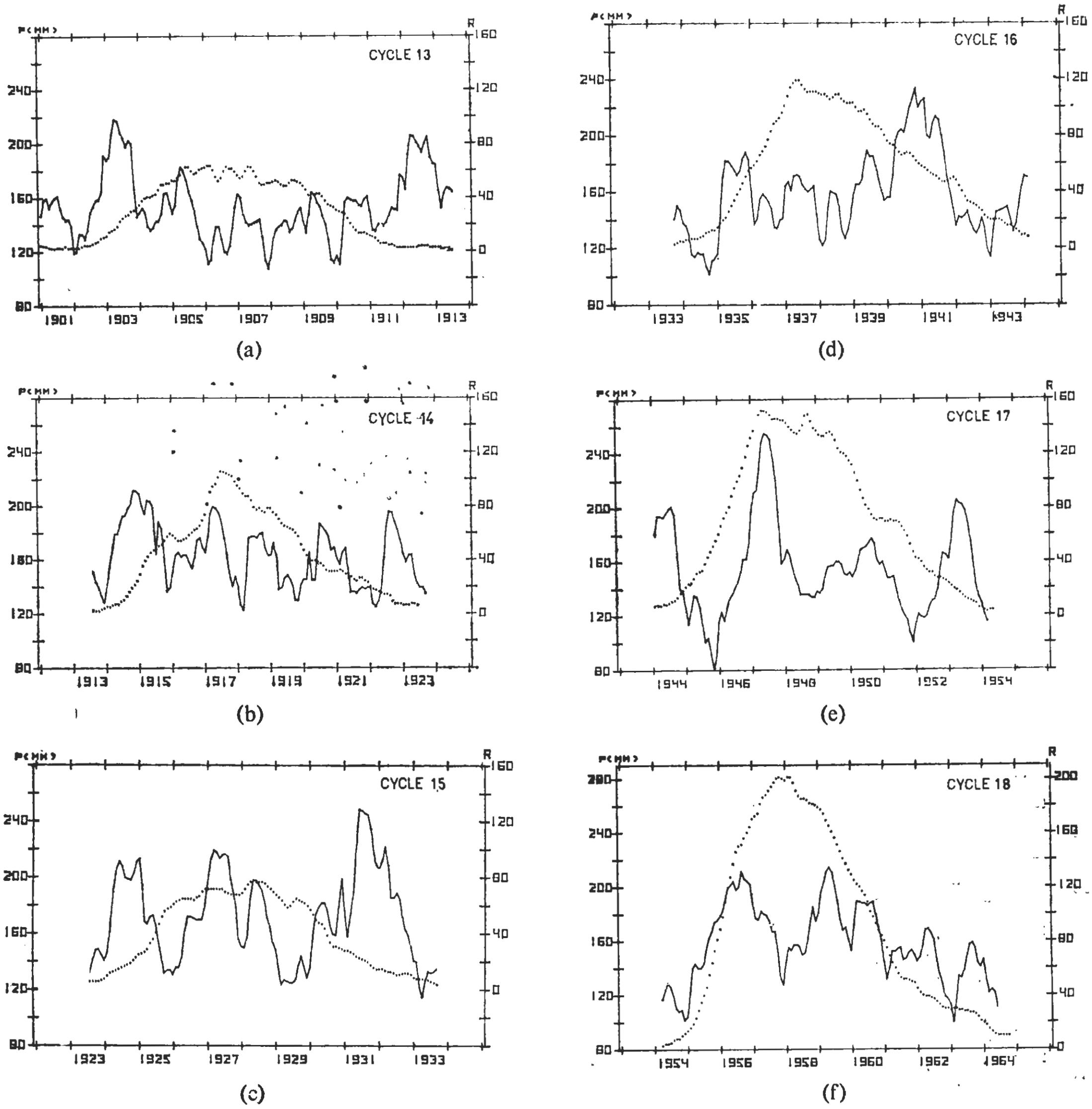

Fig. 6. Month to month variations of 12 month running mean values of monthly mean precipitation *P* at Taipei (full line) and monthly mean sunspot number *R* (dotted line) for (a) solar cycle 13; (b) solar cycle 14; (c) solar cycle 15; (d) solar cycle 16; (e) solar cycle 17; and (f) solar cycle 18.

12 month running average value of monthly mean sunspot number, *R*, for each solar cycle 13 to 18. Although *P* does show a fluctuation with a period of few years, there seems no significant relation between *P* and *R*.

4. Conclusions

Using temperature and precipitation data obtained at seven stations in Taiwan, the relationship between weather and sunspot cycle was studied. The followings are the major findings of the present study.

(1) No significant relationships were found between $\overline{T}$ and $\overline{R}$ and also between $\overline{P}$ and $\overline{R}$.
(2) The secular component of $\overline{T}$ was found to be positively correlated with the secular component of $\overline{R}$. However, no significant relationships were found between the secular components of $\overline{P}$ and $\overline{R}$.
(3) No significant relationship was found between the variations of *T* and *R* in a solar cycle.

(4) Although there showed a periodic fluctuation of P, there seems no significant relation between P and R in a solar cycle.

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臺灣地區太陽黑子與氣象之關係

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摘 要

自從十八世紀早期學者發現太陽活動有 11 年週期之後，地球上之氣象因素及氣候是否會受到太陽活動週期之影響一問題即引起學者的注意。在過去曾有不少學者認爲氣象與太陽黑子之 11 年及 22 年週期有相當密切的關係，但也有學者提出相反的意見。本文利用中央氣象局自 1897 年至 1967 年間在臺灣 7 個測候站觀測到之氣溫及降雨量數據以分析其與太陽黑子間之可能關係。結果顯示：臺灣地區之氣溫及降雨量與太陽黑子間並無統計學上可信賴的相關關係之存在。