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ANALYSIS AND SIMULATION OF WEATHER VARIABLES-PART II: TEMPERATURE AND SOLAR RADIATION

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ABSTRACT

In this report, we first reviewed several available simulation models that are useful in generating daily weather variables, particularly temperature and solar radiation. We have then documented some experience and results of the application of such techniques in analyzing weather data of Wageningen, The Netherlands, and los Banos, The Philippines. The computer programs involved are presented.

Ten years data of Wageningen (1975-1984) and twenty five years data of Los Banos (1959-1983) were available for the analyses. Weather data were generated with simulation models for a number of runs equal to the number of years of the original data from which model parameters were estimated. In general, this simulation of minimum and maximum temperatures was more satisfactory than that of solar radiation, and Wageningen weather variables were better simulated than those for Los Banos.

The effects of the mis-representation by the weather model on plant growth can be evaluated by the crop simulation models. Some possible future research in weather simulation models were discussed. A quantitative interpretation of the difference between the monthly fraction solar radiation and the percentage of dry days was attempted, and may be useful when only monthly summaries of radiation data are available, instead of daily values.

I. INTRODUCTION

Continuous energy supply is a basic requirement for all living organisms. The basic source of such supply comes primarily from the sun. Most part of the harmful shortwave radiation is absorbed by ozone layers in the ionosphere, and water vapor, oxygen and carbon dioxide have many strong absorption bands in the infrared.The small amount radiant absorbed by plants not only sustains the biomass, but also the vital processes of all living creatures of the food chain (Larcher, 1975). Plants capture light by pigments in the cells. Chlorophyll formed in chloroplasts of all green plants converts photo energy into chemical energy. So that photosynthesis which produces carbohydrates for plant to grow can proceed. Phytochrome presented in the cytoplasm reacts to photoperiod and regulates the developmental processes such as germination, root development, shoot development, flowering and fruit coloring (Treshow, 1979).

Temperature directly affects the rate of plant development. Besides its effect on photosynthesis (Bjorkman, 1979), temperature controls the rate of enzymatic reactions, determines the solubility of gases (O2 and CO2) in cell, influences the availability and absorption of mineral elements from the soil, changes the rate of water absorption by roots.

It is obvious that solar radiation and temperature are two of the most important meteorological variables in determining and shaping the growth and development of a plant. While it is interesting to investigate the impact of these variables on plant physiology and ecology, it is not the intent of this report.

Recognizing the importance of these variables on plant life cycles and crop production, we are interested in computer techniques whereby the amount and the distribution of solar radiation and temperature for a given location can be generated, and that may be used as tools to evaluate the crop growth and development. Methods of generating daily values of these variables are particularly useful, since large impact of weather on plant morphology, growth and reproductive processes may be the results of certain peculiar weather conditions lasting in only a few days.

In this report, we will first review some available simulation methods for weather variables, and then document some experience and results of the application of such techniques in analyzing weather variables of Wageningen, The Netherlands and Los Banos, The Philippines. Those who are interested in the physical properties of radiation and temperature or their impacts on plant physiology and ecology may find the following books informative: Rose, 1966; Gates and Papian, 1971; Monteith, 1973; Campbell, 1977; Goudriaan, 1977; and Seemann et al, 1979; in addition to Larcher(1975) and Treshow (1979).

2. SIMULATION MODELS

In this section we will briefly review some available models that are useful in generating daily values of temperature and solar radiation.

2.1 Nicks and Harp's Model (NHM)

The method proposed by Nicks and Harp (1980) resembles the approach by Thomas and Fiering (1962) in simulating stream flow. To generate representative data of solar radiation and temperature for a given day, the authors suggested that the rainfall conditions of the present day and the day before must be considered. The formula they used in the simulation is shown below,

$$X_i(k, n, m) = \bar{X}(k, n, m) + r(k, n, m)[X_{i-1}(k, n, m) - \bar{X}(k, n, m)] + Z\,S(k, n, m)[1 - r^2(k, n, m)]^{1/2}$$

Where k = 1, 2, 3, or 4, represents the four possible rain categories of two days. n = 1, 2 and 3 are subscripts of maximum temperature, minimum temperature and solar radiation respectively, m = 1, 2, ... ,12 is the number of the month.

$\bar{X}$ is the monthly mean and S is the standard deviation of X and they are calculated for each rainfall category in a month. r is the serial correlation, or lag - 1 correlation between X's on the i th day and the (i - 1) th day . Z is a random normal deviate with zero mean and unit variance.

By this method, the generation of daily weather values consists of generating a uniform random deviate between [0, 1] first. The value of k or the rainfall category, is determined by comparing the uniform random deviate with the estimated transitional probabilities which are assumed to follow the probability law of a first-order Markov Chain. After the rainfall status has been determined, one can then use the appropriate mean, standard deviation and serial correlation as well as a random normal deviate to generate daily values of temperature or solar radiation from the equation.

This method, however, ignores the seasonal trends which usually exist in temperature and solar radiation. Neither is any relationship between the weather variables used in the generation process. The required number of parameters for generating one year's data of temperature or solar radiation include two transitional probabilities, four sets of twelve monthly means, standard deviations and serial correlations for the four rainfall categories, or 168 parameters in total.

2.2 Bruhn , Fry and Fick's Model (BFFM)

Bruhn et al (1980) developed a rather comprehensive simulation program from which daily values of precipitation, maximum temperature , minimum temperature, minimum relative humidity and total solar radiation could be generated. First -order Markov Chain was used to generate precipitation data. All the other weather variables were generated according to the rainfall status of the day and were assumed to follow a multivariate normal distribution. Much of the developmental work of the method was based on an earlier work of Jones et al (1972). For minimum and maximum temperatures, the correlations between them and between current and previous days were used in the simulation. Furthermore these variables were assumed to be dependent on the rainfall condition of the previous day, while in generating data of relative humidity and total solar radiation, the rainfall conditions for both previous and present days were taken into account.

The functional forms of the weather variables used in the simulation model are shown below,

$$\text{maximum temperature} = f(\, m,\ R_{t-1},\ TM_{t-1},\ Z)$$

$$\text{minumum temperature} = f(\, m,\ R_{t-1},\ TM_{t},\ Z)$$

minimum relative humidity = f(m, R_{t-1}, R_t, Z)

total solar radiation = f(m, R_t, Z)

where m is the monthly mean; R_{t-1}, the rainfall status of (t - 1) th day; R_t, rainfall status of t th day . TM_{t-1} and TM_t are respectively the maximum temperature on day (t-1) and t. Z is a random normal variable. As in Nicks and Harp's model, overall seasonal trends of these weather variables were not considered and observed monthly means for each rainfall catagory were used in the regression model for data generation. In addition to serial correlations that were used by Nicks and Harp, however, they also used cross correlation between maximum and minimum temperatures to improve the simulation.

2.3 Richardson's Model (RM)

Richardson (1981) presented a method to generate samples of daily precipitation, maximum temperature, minimum temperature and solar radiation. Precipitation was assumed to follow a Markov chain - exponential model, while the other variables were supposed to be conditional multivariate normal random variables conditioned on the precipitation status of the day. Richardson took advantage of the existing seasonal variations and described the changes of daily means by Fourier series. Thus, a significant reduction of the number ofrequired parameters in the model was achieved, since monthly means were replaced by a few model coefficients. The form of the simplest Fourier series is

$$\bar{X}_{ij} = C_{0j} + C_{1j} \ \mathrm{COS}[\ 2\ \mathrm{Pi}\ (i - q)\ /\ 365\ ]$$

where j represents the weather variable; 1 is for the maximum temperature; 2, minimum temperature; 3, solar radiation. $\bar{X}_{ij}$ is the mean of the j th variable at the i th day. C_{0j}, C_{ij} and q are coefficients of the cosine curve.

Similarly, standard deviations that were calculated for each day, based on long historical data were also fitted by a Fourier Series as for the daily means.

The coefficients of the model can be estimated by a nonlinear least square procedure. Thus daily mean ($\bar{X}_{ij}$) and standard deviation (S_{ij}) can be generated by the Fourier Series to simulate daily values, X_{ij}'s, as shown by the following equation,

$$X_{ij} = \bar{X}_{ij} + d_{ij} S_{ij}$$

Where dij is a residual component and is correlated with other variables. If we denote

$$d'_i = (d_{i1}, d_{i2}, d_{i3})$$

the vector of residuals of maximimum temperature, minimum temperature and solar radiation for day i, and e_i is a vector of three elements that are independently and normally distributed with zero mean and unit variance. Then d_i can be expressed in the following equation which was also used by Matalas (1967),

$$d_i = A\, d_{i-1} + B\, e_i$$

where

$$A = M_1 M_0^{-1}, \qquad BB' = M_0 - M_1 M_0^{-1} M'_1$$

And

$$M_0 = \begin{matrix} 1 & r12 & r13 \\ r21 & 1 & r23 \\ r31 & r32 & 1 \end{matrix}$$

$$M_1 = \begin{matrix} r(11) & r(12) & r(13) \\ r(21) & r(22) & r(23) \\ r(31) & r(32) & r(33) \end{matrix}$$

rij is the cross correlation between the i th and j th variable, r(ij) is the serial correlation with log-1 between the i th and j th variable.

Through extensive analyses and tests of a large number of locations, Richardson (1982) showed that seasonal and spatial variations in the correlation coefficients were small, and therefore used the average values to define M_0 and M_1 matrices.

$$M_0 = \begin{matrix} 1 & 0.633 & 0.186 \\ 0.633 & 1 & -0.193 \\ 0.186 & -0.193 & 1 \end{matrix}$$

$$M_1 = \begin{matrix} 0.621 & 0.445 & 0.087 \\ 0.563 & 0.674 & -0.100 \\ 0.015 & -0.091 & 0.251 \end{matrix}$$

A and B matrices which are regression matrices can then be considered as constant matrices with elements,

$$A = \begin{pmatrix} 0.567 & 0.086 & -0.002 \\ 0.253 & 0.504 & -0.050 \\ -0.006 & -0.039 & 0.244 \end{pmatrix}$$

$$B = \begin{pmatrix} 0.781 & 0 & 0 \\ 0.328 & 0.637 & 0 \\ 0.238 & -0.341 & 0.873 \end{pmatrix}$$

Thus d_i can be calculated from yesterday residuals, d_{i-1}, and the standard normal random deviates, e_i. Together with $\bar{X}_{ij}$ and S_{ij} generated from the fitted Fourier Series, daily values of the three weather variables X_{ij} can be generated from the equation shown above.

Recently, Richardson and Wright (1984) developed a computer program, 'WGEN' for their weather simulation models with few minor modifications. A Markov Chain - gamma model was installed for generating precipitation data and coefficients of variation instead of standard deviations were fitted by the Fourier Series. Thus daily weather values are computed by,

$$X_{ij} = \bar{X}_{ij} \; (1 + d_{ij} \; C_{ij})$$

Where C_{ij} is the coefficient of variation for the i th day of the j th variable and is estimated from the fitted Fourier series model

In addition, several model parameters used in simulating temperature and solar radiation were substituted by constants. For instance, the positions of the harmonic in the Fourier series were assumed to be 200 days for temperature and 172 days for solar radiation. These simplifications further reduced the number of parameters required in the simulation model. But the validity of an application to locations other than in United States remains to be tested.

2.4 Larsen and Pense's Model (LPM)

The report of Larsen and Pense (1981) was subsequently published as a paper in 1982. In the report, these authors presented another version of the general approach which was adapted by the previous workers on stochastic simulation of the weather variables.

Precipitation is generated by the Markov chain -gamma model and other weather variables, maximum temperature, minimum temperature and solar radiation were generated based on the condition of the rainfall status of the day. Temperature means were generated from a fitted three - parameter sine curve. A daily deviation value was obtained from the relationship of today's temperature and yesterday's maximum temperature which were assumed to follow a bi-variate normal distribution. A daily temperature value , t_i (represents either the maximum or the minimum temperature of the i th day, i = 1,2,..., 365), was then computed by adding the deviation (d_i) to the mean($\bar{t}_i$)

$$t_i = \bar{t}_i + d_i$$

where

$$\bar{t}_i = SIN [(i - q) 2Pi / 365] C_1 + C_0$$

and

$$d_i = \bar{d} + S r_{12} (d^*_i - \bar{d}^*) / S^* + Z S (1 - r_{12}^2)^{1/2}$$

d_i is the deviation, ($t_i - \bar{t}_i$), with a monthly mean $\bar{d}$, and a standard deviation S. d^*_i represents either the deviation of previous day maximum temperature (i.e. d_{i-1} of the maximum temperature) or present day temperature (i.e. if d_i is the deviation of current maximum temperature, then d_i^* is the deviation of current minimum temperature or vice versa) depending on which one has stronger correlation with d_i. $\bar{d}^*$ and S^* are respectively the monthly mean and standard deviation of d_i^*. r12 is the correlation between d_i and d_i^*. Z is a standard random normal deviate. All calculations were based on the rainfall status within a month, i.e. separate models were fitted for wet and dry days and for each month.

One difference between LPM and RM is that monthly standard deviations were used in simulating d_i's in LPM, while daily standard deviations (or coefficients of variation) were used in RM. Also LPM did not include the correlations between solar radiation and temperatures in the model as RM did. In analyzing solar radiation data, Larsen and Pense found that the distribution of the actual solar radiation data was skewed in the negative direction on dry days and in the positive direction on wet days. The explanation they offered was that on dry days there was a preponderance of observations approaching the clear day maximum amount possible, but there were also many dry cloudy days where solar radiation values were relatively low. Hence, with an upper limit on the maximum amount possible and a lower limit a long way from the mode resulted in a negative skew. On wet days, the largest number of observations tended to be nearer to zero than the maximum clear day radiation but since some wet days had a relatively short period of cloud cover, observations approached the upper limit which resulted in the positive skewness. (In discussion section 3.3, we will suggest a possible way to examine these conditions based on interpetations of monthly means).

In an effort to cope with the skewness of the data, they proposed to use a Gamma function for dry days and a Beta function for wet days. That is, for the dry days, solar radiation was transformed first by the following equation.

$$t(X) = (X_{max} - X) - \min(X_{max} - X) + 3$$

where X is solar radiation, X_{max} is the calculated maximum solar radiation for a clear day and min(X_{max} - X) is the minimum of the difference. The number 3 is added to make sure that the lower limit of the transformed data is strictly greater than zero. Parameters of the Gamma function are then estimated from the observed t(X) and they are used to generate new values of t(X) for a given day. The solar radiation value, X, can then be computed from the above equation. For wet days, data were subject to the following transformation,

$$t(X) = (X - X_{min}) / (X_{max} - X_{min})$$

where X is the solar radiation, X_{min} and X_{max} are respectively the minimum and maximum solar radiation values within a month. These data are used to estimate parameters (p and q) of a Beta function

$$B (p, q) = T (p, 1) / [T (p, 1) + T (q, 1)]$$

and

$$p = [\bar{t}^2 (1 - \bar{t}) - S \bar{t}] / S$$

$$q = [\bar{t} (1 - \bar{t})^2 - S (1- \bar{t})] / S$$

Where $\bar{t}$ and S are mean and standard deviation of t(X) respectively, and T(*,*) represents the mathematical gamma function. In simulation, parameter estimates p and q are used to generate B(p,q) which is t(X), and X can be computed in the original scale by reversing the transformation formula.

3. SIMULATION RESULTS AND DISCUSSION

Among the four models that we have reviewed, RM and LPM are the most thoroughly tested ones. There are advantages and disadvantages between RM and LPM. LPM will probably produce better solar radiation data but requires considerable more parameters in the model than RM. The number of parameters that needs to be estimated in RM and LPM in order to generate one year data for a location are shown in table 3.1.

Table 3. 1 Number of parameters that needs to be estimated in simulation of one year weather variables

Variable	RM	LPM
Maximum temperature		
Sinusoidal curve for mean	3	6
for variation	2	24
Minimum temperature		
Sinusoidal curve for mean	2	6
for variation	2	24
Solar radiation	1	48
Precipitation		
Transitional probability	24	24
Gamma function	24	24
Other means, variances and correlations	-	168
total	58	324

Of the parameters, accurate and reliable estimates of transitional probabilities of precipitation are most difficult to obtain. All authors in weather simulation models stressed the point that a long series of historical data is required to provide reasonable estimates of these probabilities. For instance, Richardson and Wright (1984) stated that at least 20 years of precipitation and 10 years of temperature and solar radiation data are required to accurately estimate the model parameters needed to generate representative weather data for a location.

From the simulation results presented in RM and LPM papers, we feel that the difference between them in terms of goodness of fit is small. Since RM is somewhat more general and easier to apply, we chose RM to perform the analyses and simulation of the weather data at Wageningen and Los Banos.

3.1 Wageningen data

Ten years weather data (1975 - 1984) of Wageningen were available for the analyses. Richardson's program was installed on a VAX machine at CABO and modified to provide summary statistics of the raw data and the simulation results. The program is listed in section 5.

Based on the monthly averages of the last 10 years, the highest temperature during a year occurred in July and the greatest solar radiation occurred in June. These conditions seemed to fall in agreement with Richardson's analyses of the thirty one locations in The United States. Thus the assumed positions of the harmonic in the temperature and solar radiation cosine curves were appropriate for the weather pattern of Wageningen. The maximum total radiation which depends on only the latitute of a location and the date in a year, can be calculated for a clear day by a procedure described by Goudriaan (1977). The percent solar radiation received at a location and a day can then be obtained by dividing the actual solar radiation by the computed maximum amount and multipling it by 100. At Wageningen, it ranged from a 34% in December and January to a 55% in August. It is interesting to note that the sum of the percent radiation and percent wet days in a month is approximately 100 for all months. Thus an almost perfect compensational relationship exists between these two variables in Wageningen (Table 3.2)

The variations between years expressed as coefficients of variation (CV) tend to be smaller in months other than in winter (Table 3.3). For example, the CV's for the maximum temperature were less than 10% from April to October but were greater than 34% in December, January and February. The extremely large CV's in winter months for the minimum temperature, however, were artificially inflated because temperatures were expressed in degree Celsius, which were close to zero in winter months.

Table 3.2 Observed monthly averages of the percent wet days and the % solar radiation received at Wageningen

month	% wet day	% solar radiation	sum
1	65	35	100
2	39	43	82
3	58	44	102
4	50	53	103
5	52	53	105
6	50	51	101
7	39	52	91
8	45	55	100
9	47	51	98
10	52	46	98
11	60	39	99
12	58	34	92

For all three variables, maximum and minimum temperatures, and solar radiation, there definitely exist certain smooth, seasonal patterns among the monthly means and the monthly CVs' (see Table 3.3). These patterns support that Richardson's approach in using Fourier Series models to reduce the number of parameters in simulation is a reasonable one.

Table 3.3 The observed monthly averages and coefficients of variation for maximum and minimum temperatures (C), and solar radiation (J/cm2/day) at Wageningen

	Max-Temperature		Min-Temperature		Solar-Radiation	
MONTH	MEAN	CV	MEAN	CV	MEAN	CV
1	4.9	0.59	-0.3	9.10	220.1	0.15
2	5.2	0.42	-0.7	2.41	459.6	0.17
3	8.9	0.16	1.6	1.06	748.8	0.17
4	12.3	0.08	2.1	0.56	1302.9	0.13
5	16.8	0.09	6.4	0.13	1619.1	0.17
6	19.9	0.08	9.9	0.07	1688.0	0.13
7	22.2	0.10	11.7	0.09	1619.1	0.12
8	22.1	0.09	11.5	0.09	1446.2	0.12
9	18.7	0.07	9.4	0.11	982.5	0.14
10	13.9	0.09	6.4	0.22	557.4	0.11
11	9.0	0.13	3.2	0.47	275.7	0.10
12	5.3	0.34	0.3	6.86	174.8	0.17
yearly	13.3		5.1		926.8	

Simulations were run ten times to produce results that would be comparable with the actual data. On the monthly means, simulated temperatures were in close approximation to observations. For solar radiation, there was about 10% overestimation in summer and about 50% underestimation in winter. Thus expressed as percent solar radiation received, the overall yearly mean for simulation was smaller than the actual mean (0.43 versus 0.46) even though the total amount was greater for the simulation (943.4) than for the actual observation (926.8).

The less satisfactory result in simulation of solar radiation is partly a reflection of the fact that less estimated parameters and more assumed constants are used in the model for generating solar radiation than for generating temperatures. In order to provide a visual evaluation of the performance of the simulation, we also plotted the simulated means with two standard errors against the observed means with the range values of the last ten years. These plots were shown in Figures 3.1,3.2, and 3.3 for the maximum temperature, minimum temperature and solar radiation respectively.

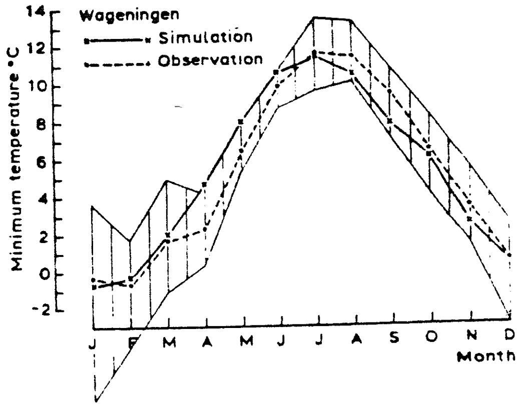

Figure 3.2 Min. temperature

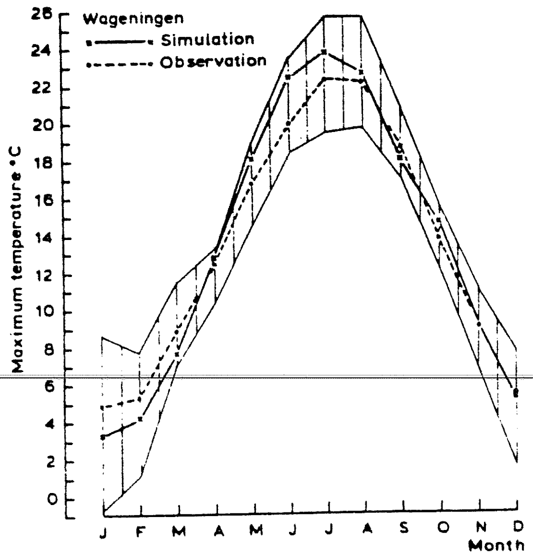

Figure 3.1 Max. Temprature

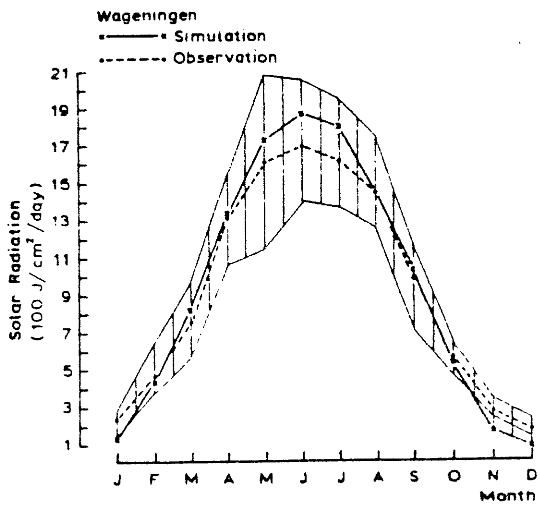

Figure 3.3 Solar Radiation

As can be seen from these figures, generally speaking overestimations tend to occur in the first half year and underestimations in the second half year. But all of them fall within the range limits. The errors of the simulation would produce higher heat sums and greater total solar radiation in a crop growing season. The consequence of such errors can be evaluated by crop growth models.

3.2 Los Banos data

Twenty five years daily weather data in Los Banos (1959 - 1983) were available to us for analysis. These data were arbitrarily divided into two periods, 1959 - 1970 and 1971 - 1983 so that separate analyses could be performed on them and the difference between the periods could be evaluated. The overall averages of the several major weather variables are shown in table 3.4 for the two periods.

Table 3.4 Overall yearly averages of the several weather variables in two periods.

variable	1959-1970	1971-1983
wet days	177	175
rainfall (mm)	1910.2	2062.9
maximum temperature (C)	31.3	31.5
minimum temperature (C)	22.5	22.5
solar radiation(J/cm2/day)	1751.4	1659.5
% solar radiation	64	61

On the average, the second period appeared to have 153 mm more rainfall and 92 J/cm2/day less solar radiation than the first period. However these differences are relatively small with respect to the yearly variations. The smallest within month between years CV for the amount of rainfall was 47% and for solar radiation was 7% (Appendix A.2, and A.3). Thus no statistical significance may be declared.

The percent raining days in Los Banos was less than 20% from February to April and was greater than 50% from June to December. The amount of precipitation was less than 6 mm per wet day between January to April and increased to more than 10 mm per wet day from May to November. Due to the typhoon which usually occurs in late summer or fall, the total amount of precipitation could be ten times greater in these months than in spring. Thus there is clearly a dry season from February to April and a wet season from May to November. Heavy showers in summer seem to be the dominant character of rainfall in Los Banos. Also the rainfall pattern appears to be one important factor which influences the fluctuations of temperature and solar radiation among years in Los Banos. The difference between the maximum and minimum temperatures decreased from an average of 10 degree C in dry months to an average of 8 degree C in the wet months. At the same time the fraction solar radiation received on earth decreased from 71% or higher to 60% or less.

Unlike Wageningen where monthly averages of the percent solar radiation were mostly less than 55%, the average monthly solar radiation in Los Banos was always greater than 50%. The negative correlation between the percent wet days and the ratio of solar radiation was not as strong as that of Wageningen, probably due to the fact that part of the wet days are also partly clear days.

The highest temperatures normally occur in May before the wet season begins, and the greatest solar radiation received usually occurs in April. These characteristics suggest that the assumed constants of the positions of harmonic of the cosine curves in Richardson's program are inappropriate for Los Banos. The results of simulation are plotted against the observed monthly means (1959-1970 data) and are shown in figures 3.4 to 3.6. Obviously there are misrepresentations of the simulation.

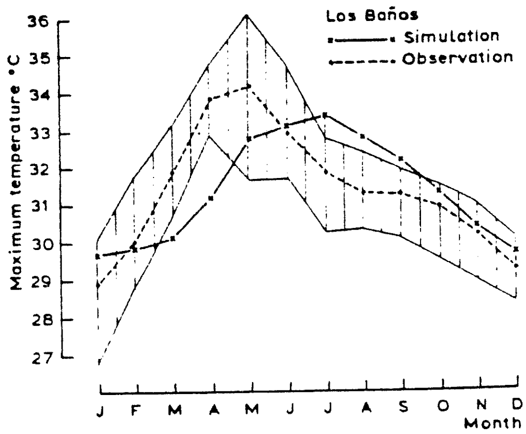

Figure 3.4 Max.Temperature

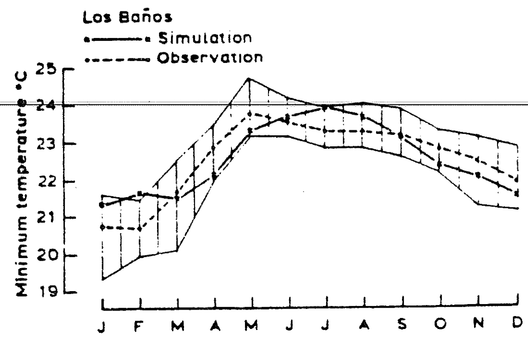

Figure 3.5 Min.Temperature

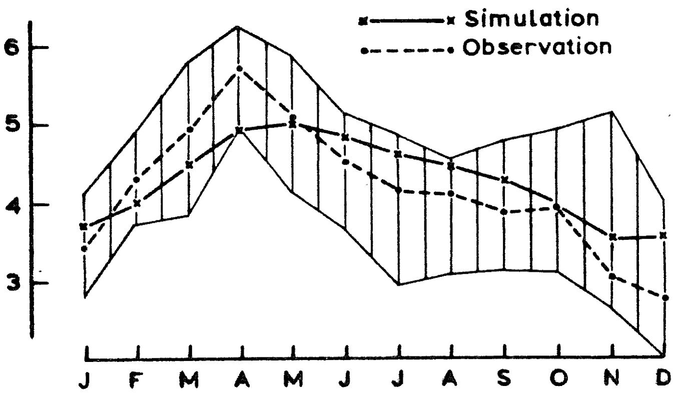

Figure 3.6 Solar radiation 418 J/cm²/day

Simulations were then re-runned by adjusting the days to the peaks which are 142 days and 112 days respectively for the temperature and solar radiation. All simulations were carried out with equal number runs as the number of years of the data from which model parameters were estimated. Results for both periods of the new runs with corrected position of the harmonic were shown in figures 3.7a to 3.8b.

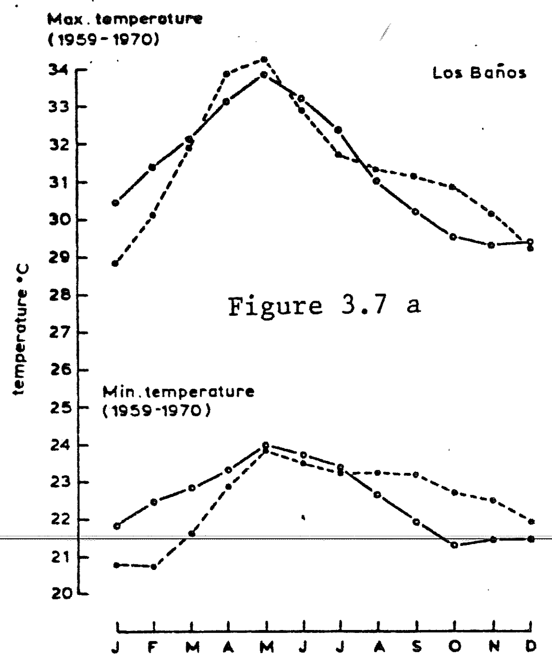

Figure 3.7 a

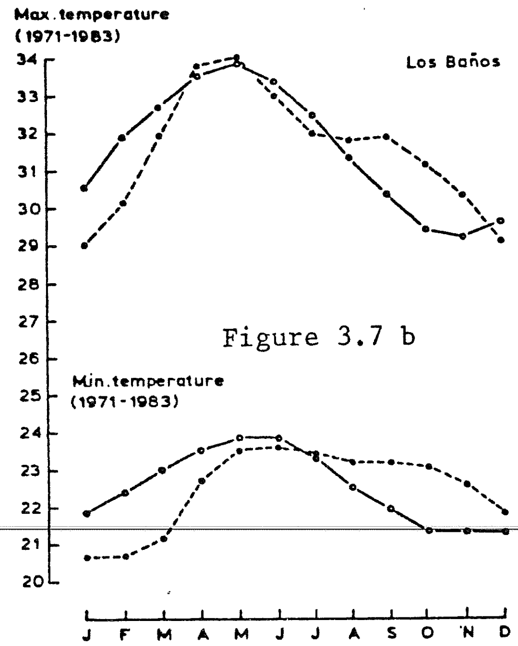

Figure 3.7 b

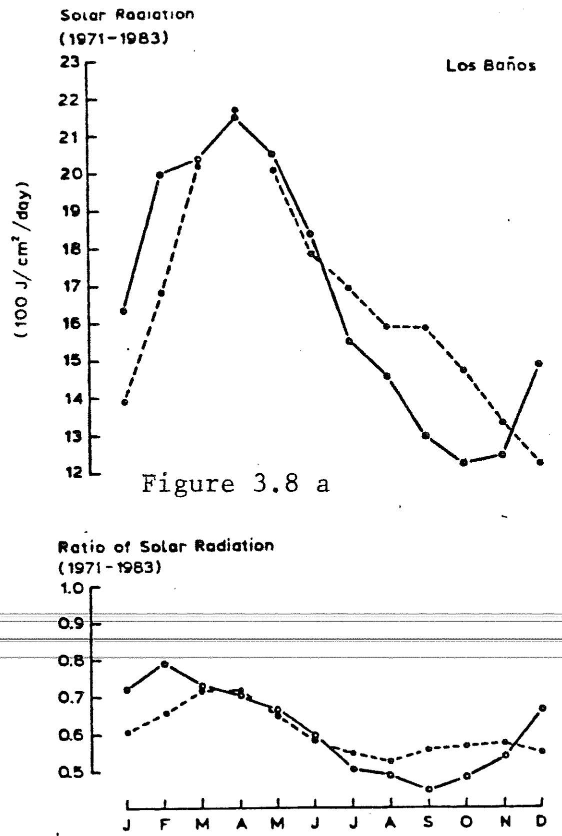

Figure 3.8 a

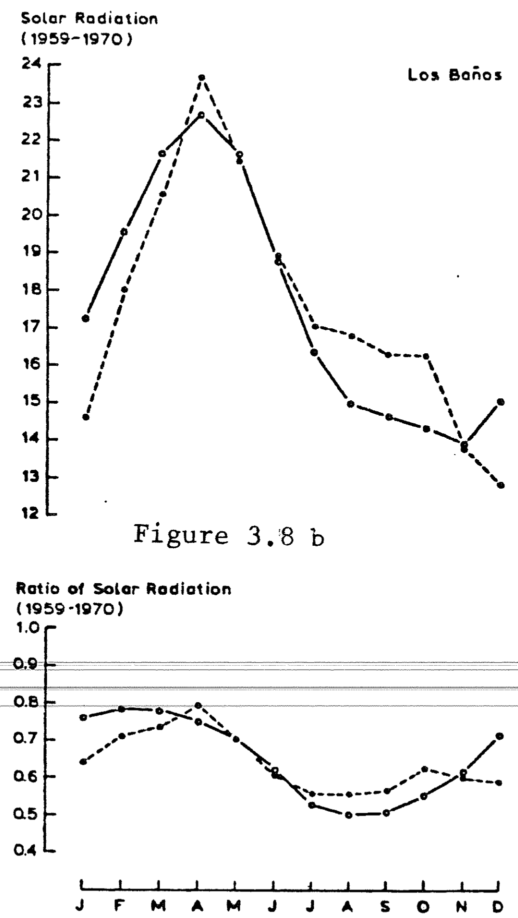

Figure 3.8 b

Slight improvements were made in those new runs. Two points should be made about these results. First, there are little differences between monthly averages of the two periods (Appendix A.2 and A.3). Second, simulation results overestimated the means in January, February and March, and underestimated the means from August to November for all three weather variables particularly noticeable for minimum temperature. Obviously, the stable minimum temperature from May to September at Los Banos does not follow a simple sinusoidal pattern as assumed in the simulation program.

In Richardson's program there is an option for corrections of the simulated outputs based on the actual monthly means. Either a ratio or a difference between the simulated or observed means will be used as an adjusting factor to correct daily output values. By doing so, the output monthly averages would be nearly identical to the actual monthly means. This however was not done, since the performance of the general model is of more interest to us than the artificial correction mechanisms.

3.3 Discussion

The greatest advantage of RM in comparison with other models is that RM utilizes the seasonal trends which exist in the daily means and coefficients of variations. These statistics are calculated from data between years but within days, and the cosine curves are fitted to account for the seasonal changes. By doing so not only a large reduction in the number of parameters required in the simulation model is achieved, yearly variations are also included in the simulation. Thus a generation of one year's weather data will represent a possible random year.The average of several simulated years will give an idea of the long term average or a 'normal' year of a location. Larsen and Pense use monthly variances which are calculated from data pooled over years and days in a month. Since no seasonal trends are considered in LPM, and all monthly estimates must be used, considerable more parameters are required in their simulation models.

In an effort of further reducing simulation parameters, Richardson substituted many parameters in his model by the average values, obtained from analyzing the weather data of thirty one locations in United States. This, however, seems inappropriate for locations such as Los Banos. Larsen and Pense, on the other hand, assumed few constants in their model. Thus the availability of long term historical data for model-parameter estimation is a prerequisite for an application of this simulation model.

3.3.1 Model development with respect to available data

A frequently asked question by users of weather simulation models is how many years of weather data are required to employ the program to simulate weather variables for a location. Of course the answer depends on the number of parameters used to define the model and the procedure used to estimate and to test the model. Ideally, different models with various levels of accuracy and sophistication are developed according to the amount of available data.

If long-term, historical daily weather information is available, then simulation models may be constructed without much concern for the number of parameters or computational steps involved in the model since the available computer power is rapidly becoming unlimiting to most scientists or research institutes. Perhaps the models should be flexible and need not be standardized. Programs can be developed with the capability of searching for the best available models based on a set of criteria and data fitting procedures. For instance, the order of the Markov chain can be determined numerically, and tests should be performed to select the best fitted model among alternatives such as negative binomial models. All possible seasonal trends existing in the data, whether yearly or monthly, should be incorporated in the model for mean predictions. Deviations from the means can be approximated from the relationships between weather variables or between times. Cross-correlation and serial correlations can be computed and adapted for specific locations. The distributions of the residuals may be characterized and fitted by various theoretical probability functions such as normal, gamma, beta, weibull etc. to determine the most appropriate one for the random component generation. In other words, if long-term data are available, the simulation program could be composed with a collection of many criteria and procedures. Specific models can then be selected and parameterized by the criteria to perform weather simulation for that location.

On the other hand, if long-term, daily weather values are not in existence or only monthly data are available , can weather simulation be performed for a location based on only summary information or monthly means? How accurately can daily values be simulated based on models constructed from monthly summaries? A model represents a synthesized description of certain knowledge or a condensed form of a set of raw data, and is characterized by few parameters. If we can understand how a set of data points can be described or summarized by few parameters of a model, perhaps it is possible to transform certain monthly information into the model parameters. In areas such as many developing countries where detailed weather data are scarce, this type of approach can increase the usefulness of the limited data considerably. The problem of how weather simulation models can be constructed without using daily values deserves further research.

3.3.2 Generation of extreme weather conditions

For purpose of risk assessment or production evaluation, sometimes the generation of possible extreme weather conditions for a location may be desirable and can be an interesting topic for future research. Depending on the objectives and requirements of a study, the definition of extreme conditions may be different. Apart from the definition problems, the generation of extreme dry or wet years that are realistic for a location, may be approached by the following several ways.

One approach is to use the weather simulation models to generate data for a large number of years, say 100 years. Then, based on the overall yearly means or certain monthly means to select the extreme conditions as desired.

The second method is to manipulate the model parameters to generate extreme conditions. This approach however, requires an understanding of the quantitative relationships between the models parameters and the simulation results, as well as the possible realistic parameter values for a location. For instance, we have found that a 10% change of the transitional probabilities would more or less increase or decrease about 1.5 raining days. (Geng et al., 1985). And the historical information in Wageningen revealed that a seven days deviation from the average wet days in a month would approach the extreme conditions. Thus by adding or subtracting 0.2 from the two transitional probabilities, from a dry day to a wet day and from a wet day to wet day, one would respectively obtain an extreme but still representative wet or dry month for Wageningen. The other weather variables all depend on the rainfall conditions and therefore would also be increased or decreased according to the number of wet days in the month.

The third method is to generate an empirical distribution function for each of the model parameters by the Monte Carlo technique. That is, simulations are performed repeatedly to provide data for renewed parameter estimations. Suppose twenty years data are used to estimate the parameters, then multiple sets of twenty years data are generated and each set provides the basis for estimation of the parameters. This process can continue untill the distributions of the parameters are characterized. One can then select parameters for simulation with specified confidence levels of dryness or wetness of a month or a year. To use this method, the simulation program must include parameters of yearly variations in the generation model.

3.3.3 Monthly fraction solar radiation and percent dry days

We have mentioned previously that there seems to exist a negative association between the percent wet days and ratio of solar radiation received on earth, or a positive correlation between % dry days and the ratio of solar radiation (Figure 3.9).

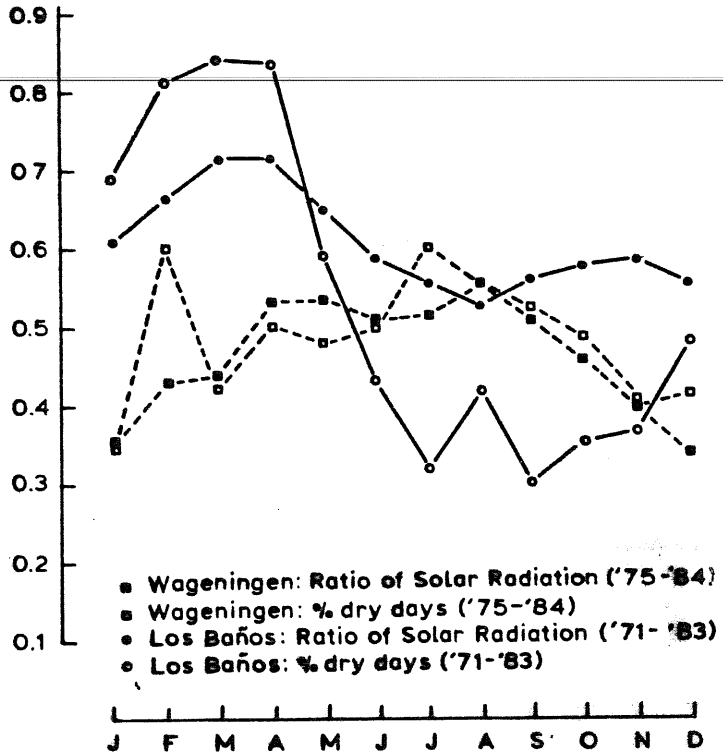

Figure 3.9 Monthly solar radiation and percent dry days for Wageningen and Los Banos

~~Intuitively, percent dry days should be closely parallel to the ratio of solar radiation (SR), if a dry day~~ means 100% SR and a wet day means 0% SR (Normally solar radiation ranges only between 20% and 80%).

A question is what does the discrepancy of these two variables represent? Suppose that we will call the %SR not received at a dry day the partial cloudiness of the dry day, and the %SR received on a wet day the partial clearness of the wet day. Then, Some interpretations may be deduced by partitioning the monthly %SR according to dry and wet days that is,

% dry days - % SR

= % dry days - [(%SR at dry days) (% dry days) + (% SR at wet days) (% wet days)]

= (1 - % SR at dry days) (% dry days) - (% SR at wet days) (% wet days)

= monthly partial cloudiness in dry days - monthly partial clearness in wet days

Thus the difference between them measures the difference of the partial cloudiness in dry days and partial clearness in wet days weighted respectively by percent dry days and percent wet days in the month. If the difference is small and the number of dry days is about the same as the number of wet days in a month which is the case of April to June at Wageningen, then one may conclude that the two partials have about the same value , that is there is about 50% cloudiness in dry days and 50% clearness in wet days.

Also, given information of one partial condition, the other partial can be estimated. For example in April at Los Banos, the percent dry day was 83 and % SR was 72. A rearrangement of the above formula gives the following equation,

%SR at dry day =100(72 / 83) - (17 / 83)(% SR at wet day)

= 86.7 - 0.205(% SR at wet days)

Thus, % SR at dry days in April ranged between 70% and 83% for 80% and 20% SR at wet days. If %SR at wet days was 50% then, % SR at dry days was about 77%. Or there was 50% clearness in wet days, and 23% cloudiness in dry days in April of Los Banos.

The large differences between the percent of solar radiation and the percent of dry days in Los Banos (Figure 3.9) reflect the differences between the two partials; the cloudiness in the dry days and the clearness in the wet days. In other words to say, there are only small partial cloudiness in the dry days but large partial clearness in the wet days for both dry and wet seasons in Los Banos. The smaller percentages of the salor radiation in Summer and Fall than in Spring are due to more raining days in those months. Thus the difference between the percent salor radiation and the percent dry days gives an indication of the type of cloud and the rainfall intensities of the area.

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5. PROGRAM LISTINGS

5.1. Estimation

```
C*****************************************************************************
C       ORIGINAL PROGRAM BY RICHARDSON
C       REVISED BY I. SUPIT
C
C       THIS PROGRAM ESTIMATES THE PARAMETERS WHICH ARE USED IN THE SIMULATION
C       PROGRAM 'WEATH.FOR'. THE DATA FILES CONSISTS OF ACTUAL DATA. ALSO A
C       SUMMARY OF THE ACTUAL DATA IS GIVEN IN OUTPUT FILE 'SUMMAR.DAT'.
C       THE ESTIMATED PARAMETERS ARE GIVEN IN OUTPUT FILE 'OUTWGEN.DAT'.
C*****************************************************************************
        DIMENSION TMAX(20,365),TMIN(20,365),RAIN(20,365),RAD(20,365)
        DIMENSION AA(20),RTO(20,365)
        DIMENSION RC(365)
        DIMENSION XDATA(30),YDATA(4,12)
        CHARACTER*30 INPNAM

        TYPE 90
 90     FORMAT(' HOW MANY YEARS OF DATA? ',$)
        READ(-3,91) NYRS
 91     FORMAT(I2)

        TYPE 85
 85     FORMAT(' STARTING YEAR=',$)
        READ(-3,86) LSTART
 86     FORMAT(I6)

        TYPE 92
 92     FORMAT(' NAME OF INPUT FILE ',$)
        READ(-3,93) INPNAM
 93     FORMAT(A15)

        TYPE 94
 94     FORMAT(' LATITUDE= ',$)
        READ(-3,95) ALAT
 95     FORMAT(F5.1)
C
        DO 1 I=1,30
            XDATA(I)=0.0
 1      CONTINUE

        DO 2 I=1,4
        DO 2 J=1,12
            YDATA(I,J)=0.0
 2      CONTINUE

C       CALCULATE MAXIMUM SOLAR RADIATION FOR EACH DAY

        XYRS=NYRS
        XLAT= ALAT*6.2832/360
        DO 6 I=1,365
           XI=I
           SD= 0.4102*SIN(0.0172*(XI-80.25))
           CH= -TAN(XLAT)*TAN(SD)
           IF(CH.GT. 1.0) H=0.
           IF(CH.GT. 1.0) GOTO 5
           IF(CH.LT.-1.0) H= 3.1416
           IF(CH.LT.-1.0) GOTO 5
           H=ACOS(CH)
 5         DD=1.0+0.0335*SIN(0.0172*(XI+88.2))
           RC(I)=889.2305*DD*((H*SIN(XLAT)*SIN(SD))+(COS(XLAT)*COS(SD)*
     $     SIN(H)))
           RC(I)=RC(I)*0.8
 6      CONTINUE
```

```
      WRITE(20,707)
707   FORMAT(///,20X,' INPUT CARDS FOR THE WEATHER GENERATOR ARE AS
     $ FOLLOWS--------------'////)
      WRITE(20,403)
403   FORMAT(///)
      WRITE(20,513) (YDATA(1,J),J=1,12)
      WRITE(20,514) (YDATA(2,J),J=1,12)
      WRITE(20,515) (YDATA(3,J),J=1,12)
      WRITE(20,516) (YDATA(4,J),J=1,12)
513   FORMAT(5X,' INPUT # 3 ---- P(W/W) ----',12F6.3)
514   FORMAT(5X,' INPUT # 4 ---- P(W/D) ----',12F6.3)
515   FORMAT(5X,' INPUT # 5 ---- ALPHA  ----',12F6.3)
516   FORMAT(5X,' INPUT # 6 ---- BETA   ----',12F6.3)
      WRITE(20,400)
400   FORMAT(////)
      WRITE(20,701)
      WRITE(20,501) XDATA(01)
      WRITE(20,502) XDATA(02)
      WRITE(20,503) XDATA(03)
      WRITE(20,504) XDATA(04)
701   FORMAT(5X,' INPUT # 7 ----',/)
501   FORMAT(15X,' 1     TXMD    ----   ',F10.3)
502   FORMAT(15X,' 2     ATX     ----   ',F10.3)
503   FORMAT(15X,' 3     CVTX    ----   ',F10.3)
504   FORMAT(15X,' 4     ACVTX   ----   ',F10.3)
      WRITE(20,702)
702   FORMAT(//,5X,' INPUT # 8 ----',/)
      WRITE(20,505) XDATA(05)
505   FORMAT(15X,' 5     TXMW    ----   ',F10.3)
      WRITE(20,703)
703   FORMAT(//,5X,' INPUT # 9 ----',/)
      WRITE(20,506) XDATA(09)
      WRITE(20,507) XDATA(10)
      WRITE(20,508) XDATA(11)
      WRITE(20,509) XDATA(12)
506   FORMAT(15X,' 6     TN      ----   ',F10.3)
507   FORMAT(15X,' 7     ATN     ----   ',F10.3)
508   FORMAT(15X,' 8     CVTN    ----   ',F10.3)
509   FORMAT(15X,' 9     ACVTN   ----   ',F10.3)
      WRITE(20,704)
704   FORMAT(//,5X,' INPUT # 10 ----',/)
      WRITE(20,510) XDATA(13)
      WRITE(20,511) XDATA(14)
510   FORMAT(15X,' 10    RMD     ----   ',F10.3)
511   FORMAT(15X,' 11    AR      ----   ',F10.3)
      WRITE(20,705)
705   FORMAT(//,5X,' INPUT # 11 ----',/)
      WRITE(20,512) XDATA(17)
512   FORMAT(15X,' 12    RMW     ----   ',F10.3)
      WRITE(20,600)
600   FORMAT(' 1')
      CLOSE(20)
      STOP
      END

      SUBROUTINE FOUR(ID,XM,SD,CV,XDATA)
      DIMENSION XM(13),SD(13),CV(13)
      DIMENSION XDATA(30)
      DATA JCT/0/

      S=0.
      S1=0.
```

```
      OPEN(UNIT=11,STATUS='OLD',FILE=INPNAM)

      DO 7 I=1,NYRS
C*********************************************************************
C     INPUT MO,DAY,YEAR,MAX TEMP,MIN TEMP,RAINFALL,RADIATION
C*********************************************************************
         READ(11,900) (TMAX(I,J),J=1,365)
         READ(11,901) (TMIN(I,J),J=1,365)
         READ(11,901) (RAIN(I,J),J=1,365)
         READ(11,901) (RAD(I,J),J=1,365)
 7    CONTINUE
      CLOSE(11)

C**CONVERSION TO FAHRENHEIT AND LANGLEY**
C  LOS BANOS RADIATION DATA ARE IN J/CM2/DAY
C  WAGENINGEN DATA ARE IN J/CM2/DAY

      DO 8 I=1,NYRS
      DO 8 J=1,365
         TMAX(I,J)=TMAX(I,J)*9/5 + 32
         TMIN(I,J)=TMIN(I,J)*9/5 + 32
         RAD(I,J)=RAD(I,J)*0.239
         IF(RAD(I,J).GT. RC(J)) RAD(I,J)=RC(J)
         RTO(I,J)=RAD(I,J)/RC(J)
 8    CONTINUE

 900  FORMAT(/////,37(10(F22.0),/))
 901  FORMAT(//,37(10(F22.0),/))

C*****************************************************
C               SUMMARY TABLES
C*****************************************************

      CALL XSUM(NYRS,RAIN,TMIN,TMAX,RAD,RTO,LSTART)

      OPEN(UNIT=20,STATUS='NEW',FILE='OUTWGEN.DAT')

      WRITE(20,104)
 104  FORMAT(//5X,' MAXIMUM TEMPERATURE',/)
C*****  CALCULATE TMAX PARAMETERS   ******
      CALL MSD(NYRS,TMAX,RAIN,1,XDATA)
      WRITE(20,105)
 105  FORMAT(' 1'///5X,' MINIMUM TEMPERATURE',/)
C*****  CALCULATE TMIN PARAMETERS   *****
      CALL MSD(NYRS,TMIN,RAIN,2,XDATA)
      WRITE(20,106)
 106  FORMAT(' 1'///,5X,' SOLAR RADIATION',/)
C*****  CALCULATE RAD PARAMETERS   *****
      CALL MSD(NYRS,RAD,RAIN,3,XDATA)
      WRITE(20,107)
 107  FORMAT(' 1',///,5X,' PRECIPITATION')
C*****  CALCULATE RAINFALL PARAMETERS   *****
      CALL PPRAIN(RAIN,NYRS,YDATA)

C--PHASE ANGLE SHIFTED BY 180 DEGREES
C--AND SIGNS CHANGED ON AMPLITUDES

      XDATA(02)=XDATA(02)*(-1.0)
      XDATA(04)=XDATA(04)*(-1.0)
      XDATA(10)=XDATA(10)*(-1.0)
      XDATA(12)=XDATA(12)*(-1.0)
      XDATA(14)=XDATA(14)*(-1.0)
```

```
      S2=0.
      WRITE(20,200)
200   FORMAT(//,33X,'  PERIOD    MEAN    STD DEV      CV')

      DO 10 I=1,13
         IF(ID.EQ.1 .OR. ID.EQ.2) THEN
            CXM=(XM(I)-32.)*5./9.
            CSD=SD(I)*5./9.
         ELSE
            IF(ID.EQ.3) THEN
               CXM=XM(I)*4.184
               CSD=SD(I)*4.184
            END IF
         END IF

         WRITE(20,201) I,CXM,CSD,CV(I)
201      FORMAT(30X,I10,3F10.2)
         S=S+XM(I)
         S1=S1+SD(I)
         S2=S2+CV(I)
10    CONTINUE

      XBAR=S/13
      XBAR1=S1/13
      XBAR2=S2/13
      SUMA=0.
      SUMB=0.
      SUMA1=0.
      SUMA2=0.
      SUMB1=0.
      SUMB2=0.

      DO 15 K=1,13
         XK=K
         SUMA=SUMA+(XM(K)-XBAR)*COS(6.2832*XK/13.)
         SUMA1=SUMA1+(SD(K)-XBAR1)*COS(6.2832*XK/13.)
         SUMA2=SUMA2+(CV(K)-XBAR2)*COS(6.2832*XK/13.)
         SUMB=SUMB+(XM(K)-XBAR)*SIN(6.2832*XK/13.)
         SUMB1=SUMB1+(SD(K)-XBAR1)*SIN(6.2832*XK/13.)
         SUMB2=SUMB2+(CV(K)-XBAR2)*SIN(6.2832*XK/13.)
15    CONTINUE

      A=SUMA*(2./13.)
      A1=SUMA1*(2./13.)
      A2=SUMA2*(2./13.)
      B=SUMB*(2./13.)
      B1=SUMB1*(2./13.)
      B2=SUMB2*(2./13.)
      T=ATAN(-B/A)
      T1=ATAN(-B1/A1)
      T2=ATAN(-B2/A2)
      C=A/COS(T)
      C1=A1/COS(T1)
      C2=A2/COS(T2)
      WRITE(20,100)
100   FORMAT(/,15X,' FOURIER COEFFICIENTS--MEAN')
      IF(ID.EQ.1 .OR. ID.EQ.2) THEN
        CXBAR=(XBAR-32.)*5./9.
        CC=C*5./9.
      ELSE
        IF(ID.EQ.3) THEN
          CXBAR=XBAR*4.184
          CC=C*4.184
```

```
          END IF
        END IF
        WRITE(20,101) CXBAR,CC,T
 101    FORMAT(15X,' MEAN =',F10.4,5X,' AMPLITUDE =',F10.4,5X,
     $  ' PHASE =',F10.4)
        JCT=JCT+1
        XDATA(JCT)=XBAR
        JCT=JCT+1
        XDATA(JCT)=C
        WRITE(20,102)
 102    FORMAT(/,15X,' FOURIER COEFFICIENTS--STD. DEV.')
        IF(ID.EQ.1 .OR. ID.EQ.2) THEN
          CXBAR1=(XBAR1-32.)*5./9.
          CC1=C1*5./9.
        ELSE
          IF(ID.EQ.3) THEN
            CXBAR1=XBAR1*4.184
            CC1=C1*4.184
          END IF
        END IF
        WRITE(20,101) CXBAR1,CC1,T1
        WRITE(20,103)
 103    FORMAT(/,15X,' FOURIERS COEFFICIENTS--CV')
        WRITE(20,101) XBAR2,C2,T2
        JCT=JCT+1
        XDATA(JCT)=XBAR2
        JCT=JCT+1
        XDATA(JCT)=C2
        RETURN
        END
C****THE FOLLOWING SUBROUTINE CALCULATES THE STATISTICS OOF TMAX, TMIN, AND RAD
C*******BY 28-DAY PERIOD OF THE YEAR AND FITS A FOURIER SERIES TO THE RESULTS.
        SUBROUTINE MSD(NYRS,W,RAIN,ID,XDATA)
        DIMENSION W(20,365),RAIN(20,365),XM(13),XM1(13),SD(13), SD1(13)
        DIMENSION CX(13), CX1(13)
        DIMENSION XDATA(30)
        DO 20 I = 1, 13
        NF = I*28
        NI=NF-27
        XN = 0.
        XN1 = 0.
        SUM = 0.
        SUM1 = 0.
        SS = 0.
        SS1 = 0.
        DO 15 JD=NI,NF
        DO 15 JY = 1,NYRS
        IF(ID  .EQ.  2) GO TO 11
        IF(RAIN(JY,JD))11,11,12
 11     CONTINUE
        XN = XN + 1.
        SUM = SUM+W(JY,JD)
        SS = SS + (W(JY,JD)*W(JY,JD))
        GO TO 15
 12     CONTINUE
        XN1=XN1 + 1.
        SUM1 = SUM1 + W(JY,JD)
        SS1=SS1+(W(JY,JD)*W(JY,JD))
 15     CONTINUE
        IF(XN  .LE.  2.  ) XM(I) = 0.
        IF(XN  .LE.  2.  ) SD(I) = 0.
        IF(XN  .LE.  2.  ) CX(I) = 0.
        IF(XN  .LE.  2.  ) GO TO 400
```

```
      XM(I) = SUM / XN
      SD(I) = SQRT((SS-SUM*SUM/XN)/(XN-1.))
      IF(XM(I)  .LT.  0.001) XM(I) = 0.001
      CX(I) = SD(I)  / XM(I)
400   CONTINUE
      IF(ID  .EQ.  2) GO TO 20
      IF(XN1 .LE.  2.) XM1(I) = 0.
      IF(XN1  .LE.  2. ) SD1(I) =0.
      IF(XN1  .LE.  2.) CX1(I) =0.
      IF(XN1  .LE.  2.) GO TO 500
      XM1(I) = SUM1 / XN1
      SD1(I) =SQRT((SS1-SUM1*SUM1/XN1)/(XN1-1.))
      IF(XM1(I)  .LT.  0.001) XM1(I) = 0.001
      CX1(I)=SD1(I)/XM1(I)
500   CONTINUE
20    CONTINUE
      IF(ID  .EQ.  2) GO TO 25
      WRITE(20,100)
100   FORMAT(10X,'DRY DAYS')
      CALL FOUR(ID,XM,SD,CX, XDATA)
      WRITE(20,101)
101   FORMAT(/, 10X,'WET DAYS')
      CALL FOUR(ID,XM1,SD1,CX1,XDATA)
      GO TO 30
25    WRITE(20,102)
102   FORMAT(10X,'WET AND DRY DAYS')
      CALL FOUR(ID,XM,SD,CX,XDATA)
30    CONTINUE
      RETURN
      END
C*******THIS SUBROUTINE CALCULATES THE RAINFALL GENERATION PARAMETERS
C*******USING THE MARKOV CHAIN-GAMMA MODEL
      SUBROUTINE PPRAIN(XRAIN,NYR,YDATA)
      DIMENSION XRAIN(20,365)
      DIMENSION NWD(12),NDD(12),NDW(12), NWW(12)
      DIMENSION SUM(12),SUM2(12),SUM3(12)
      DIMENSION SL(12),PWW(12),PWD(12),RBAR(12)
      DIMENSION ALPHA(12),BETA(12)
      DIMENSION NW(12),IC(12),SUML(12)
      DIMENSION RLBAR(12),AL2(12),BE2(12)
      DIMENSION PPPW(12),ND(12)
      DIMENSION YDATA(4,12)
      CHARACTER *36 A(2)
      CHARACTER *4 DATE(12)
      DATA DATE /'JAN.','FEB.','MAR.','APR.','MAY.','JUNE.',
     $ 'JULY.','AUG.','SEP.','OCT.','NOV.','DEC.'/
      DATA A(1) /'                                    '/
      DATA A(2) /'NOT ENOUGH DATA TO DEFINE PARAMETERS'/
      DO 10 I =1, 12
      ND(I) =0
      PPPW(I) =0.
      NWD(I) = 0
      NWW(I) = 0
      NDD(I) =0
      NDW(I) =0
      NW(I) =0
      SL(I) = 0.
      SUML(I) = 0.
      SUM(I) =0.
      SUM2(I) = 0.
      PWW(I) = 0.
      PWD(I) = 0.
      ALPHA(I) =0.
```

```
      BETA(I) = 0.
10    SUM3(I) = 0.
      XYR=NYR
      RIM1 = 0.
      DO 20 J = 1,NYR
      DO 30 K = 1,365
      IF(K  .GE.  001  .AND.  K  .LE.  031) MO = 1
      IF(K  .GE.  032  .AND. K  .LE. 059) MO = 2
      IF(K  .GE.  060  .AND. K  .LE. 090) MO = 3
      IF(K  .GE.  091  .AND. K  .LE. 120) MO = 4
      IF(K  .GE.  121  .AND. K  .LE. 151) MO = 5
      IF(K  .GE.  152  .AND. K  .LE. 181) MO = 6
      IF(K  .GE.  182  .AND. K  .LE. 212) MO = 7
      IF(K  .GE.  213  .AND. K  .LE. 243) MO = 8
      IF(K  .GE.  244  .AND. K  .LE. 273) MO = 9
      IF(K  .GE.  274  .AND. K  .LE. 304) MO = 10
      IF(K  .GE.  305  .AND. K  .LE. 334) MO = 11
      IF(K  .GE.  335  .AND. K  .LE. 365) MO = 12
      RAIN=XRAIN(J,K)
      IF(RAIN  .GT.  0.00) NW(MO)=NW(MO)+1
      ND(MO)=ND(MO)+1
      IF(RAIN) 5,5,3
3     IF(RIM1)2,2,4
2     NWD(MO)=NWD(MO)+1
      GO TO 6
4     NWW(MO)=NWW(MO)+1
6     CONTINUE
      SUML(MO)=SUML(MO)+ALOG(RAIN)
      SUM(MO)=SUM(MO)+RAIN
      SUM2(MO)=SUM2(MO)  + RAIN * RAIN
      SUM3(MO)=SUM3(MO)  +RAIN*RAIN*RAIN
      SL(MO)  =  SL(MO)+ALOG(RAIN)
      GO TO 9
5     IF(RIM1) 7,7,8
7     NDD(MO)=NDD(MO)+1
      GO TO 9
8     NDW(MO)=NDW(MO)+1
9     RIM1 = RAIN
30    CONTINUE
20    CONTINUE
      DO 120 I = 1, 12
      XXND=ND(I)
      YYNW=NW(I)
      PPPW(I) = YYNW/XXND
      III=1
      IF(NW(I)  .LT.  3) III=2
      IC(I) = III
      IF(NW(I)  .LT.  3) GO TO 120
      XNWW=NWW(I)
      XNWD=NWD(I)
      XXNW=NWW(I)+NDW(I)
      XND=NDD(I)+NWD(I)
      XNW=NW(I)
      PWW(I)=XNWW/XXNW
      PWD(I)=XNWD/XND
      RBAR(I)=SUM(I)/XNW
      RLBAR(I)=SUML(I)/XNW
      Y=ALOG(RBAR(I))-RLBAR(I)
      ANUM=8.898919+9.05995*Y+0.9775373*Y*Y
      ADOM=Y*(17.79728+11.968477*Y+Y*Y)
      ALPHA2=ANUM/ADOM
      IF(ALPHA2  .GE.  1.0) ALPHA2=0.998
      BETA2=RBAR(I)/ALPHA2
```

```
      ALPHA(I)=ALPHA2
      BETA(I)=BETA2
120   CONTINUE
      WRITE(20,201)
201   FORMAT(///,8X,'--MARKOV CHAIN--',16X,'-GAMMA DIST-',/,
     $ 1X,' MONTH  P(W/W)      P(W/D)',11X,' ALPHA    BETA',/)
      DO 130 I = 1, 12
      WRITE(20,202) DATE(I),PWW(I),PWD(I),ALPHA(I),BETA(I),A(IC(I))
202   FORMAT(1X,A4,F8.3,F10.3,11X,F11.3,F7.3,5X,A36)
130   CONTINUE
      DO400J=1,12
      YDATA(1,J)=PWW(J)
      YDATA(2,J)=PWD(J)
      YDATA(3,J)=ALPHA(J)
      YDATA(4,J)=BETA(J)
400   CONTINUE
      RETURN
      END


      SUBROUTINE XSUM(NYRS,RAIN,TMIN,TMAX,RAD,RTO,LSTART)

      DIMENSION CRRT(12)
      DIMENSION RTO(20,365),ATRT(12),SDRT(20,12),SRRT(12)
      DIMENSION TMAX(20,365),TMIN(20,365),RAIN(20,365),RAD(20,365)
      DIMENSION LANW(12),ATRAIN(12),ATTMIN(12),ATTMAX(12),ATRAD(12)
      DIMENSION LBMON(12),LEMON(12),SDRN(20,12),SDTX(20,12)
      DIMENSION NW(12),SDR(20,12),SDWET(20,12),SDTN(20,12)
      DIMENSION SRQWT(12),SRQRN(12),SRDTN(12),SRDTX(12),SRRD(12)
      DIMENSION CRQWT(12),CRQRN(12),CRDTN(12),CRDTX(12),CRRD(12)
      DIMENSION QWT(12),QDRN(12),QDTN(12),QDTX(12),QRD(12),QRTO(12)
      DATA DATE /'JAN.','FEB.','MAR.','APR.','MAY.','JUNE.',
     $ 'JULY.','AUG.','SEP.','OCT.','NOV.','DEC.'/
      DATA LBMON/1,32,60,91,121,152,182,213,244,274,305,335/
      DATA LEMON/31,59,90,120,151,181,212,243,273,304,334,365/
      CHARACTER*4 DATE(12)

      OPEN(UNIT=11,STATUS='NEW',FILE='SUMMAR.DAT')
      DO 871 L=1,12
         ATRAIN(L)=0.
         ATTMIN(L)=0.
         ATTMAX(L)=0.
         ATRAD(L)=0.
         ATRT(L)=0.
         LANW(L)=0
871   CONTINUE
      DO 872 I=1,NYRS
      DO 872 L=1,12
         SDRN(I,L)=0.
         SDTX(I,L)=0.
         SDTN(I,L)=0.
         SDR(I,L)=0.
         SDWET(I,L)=0.
         SDRT(I,L)=0.
872   CONTINUE
         STRAIN=0.
         STMIN=0.
         STMAX=0.
         STRAD=0.
         LWET=0
         STRT=0.
```

```
      WRITE(11,882)
882   FORMAT(' SUMMARY OF THE ACTUAL DATA OF WAGENINGEN, 1975-1984')

      DO 20 I = 1,NYRS
         PYTMAX=0.
         PYTMIN=0.
         PYRAD=0.
         NYWET=0
         RYR=0.
         PYRT=0.

         KYEAR=LSTART+I-1
         WRITE(11,201) KYEAR
201   FORMAT(//,5X,'SUMMARY FOR YEAR',I5,/)
         WRITE(11,202)
202   FORMAT(' MONTH',2X,'WET DAYS',2X,'RAINFAL',2X,'MAX TEMP',2X
     $ 'MIN TEMP',2X,'SOLAR RAD',4X,'RATIO',/,18X,
     $ ' (MM)',5X,'(C)',7X,'(C)',6X,'(J/CM2/DAY)')

      DO 25 K=1,12
         NW(K)=0
         QRAIN=0.
         QTMIN=0.
         QTMAX=0.
         QRAD=0.
         QRT=0.
      DO 30 J = LBMON(K),LEMON(K)

      IF(RAIN(I,J).GT.0.0) THEN
         NW(K)=NW(K)+1
         LANW(K)=LANW(K)+1
         LWET=LWET+1
      END IF

      QRAIN=QRAIN+RAIN(I,J)
      QTMIN=QTMIN+TMIN(I,J)
      QTMAX=QTMAX+TMAX(I,J)
      QRAD=QRAD+RAD(I,J)
      QRT=QRT+RTO(I,J)

         ATRAIN(K)= ATRAIN(K)+RAIN(I,J)
         ATTMIN(K)=ATTMIN(K)+TMIN(I,J)
         ATTMAX(K)=ATTMAX(K)+ TMAX(I,J)
         ATRAD(K)=ATRAD(K)+RAD(I,J)
         ATRT(K)=ATRT(K)+RTO(I,J)

30    CONTINUE

         NYWET=NYWET+NW(K)
         RYR=RYR+QRAIN

         AVTMIN=QTMIN/(FLOAT(LEMON(K)-LBMON(K))+1)
         AVTMAX=QTMAX/(FLOAT(LEMON(K)-LBMON(K))+1)
         AVRAD=QRAD/(FLOAT(LEMON(K)-LBMON(K))+1)
         AVRT=QRT/(FLOAT(LEMON(K)-LBMON(K))+1)
         AVTMAX=(AVTMAX-32.)*5./9.
         AVTMIN=(AVTMIN-32.)*5./9.
         AVRAD=AVRAD*4.184

         SDRN(I,K)=QRAIN
         SDTX(I,K)=AVTMAX
         SDTN(I,K)=AVTMIN
         SDR(I,K)=AVRAD
```

```
      SDWET(I,K)=NW(K)
      SDRT(I,K)=AVRT

      WRITE(11,203) DATE(K),NW(K),QRAIN,AVTMAX,AVTMIN,AVRAD,
     $ AVRT
203   FORMAT(A5,3X,I4,5X,F6.1,3X,F5.1,5X,F5.1,6X,F6.1,5X,F6.2)

      PYTMAX=PYTMAX+AVTMAX
      PYTMIN=PYTMIN+AVTMIN
      PYRAD=PYRAD+AVRAD
      PYRT=PYRT+AVRT
25    CONTINUE
      PYTMAX=PYTMAX/12.
      PYTMIN=PYTMIN/12.
      PYRAD=PYRAD/12.
      PYRT=PYRT/12.

      WRITE(11,205) NYWET,RYR
205   FORMAT(/' TOTAL',2X,I3,5X,F7.1,6X,'__',8X,'__',10X,'__',
     $  8X,'__')
      WRITE(11,350) PYTMAX,PYTMIN,PYRAD,PYRT
350   FORMAT(' AVER.',3X,'__',10X,'__',3X,F5.1,5X,F5.1,5X,F7.1,
     $ 5X,F6.2)

20    CONTINUE
      WRITE(11,861) NYRS
861   FORMAT(//,5X,'OVERALL SUMMARY FOR',I3,'YEARS',/,5X,
     $ '(AVERAGED OVER THE YEARS)')
      WRITE(11,862)
862   FORMAT(' MONTH',2X,'WET DAYS',2X,'RAINFAL',2X,'MAX TEMP',2X
     $ 'MIN TEMP',2X,'SOLAR RAD',4X,'RATIO'/
     $ ,18X,' (MM)',5X,'(C)',7X,'(C)',6X,'(J/CM2/DAY)')

      DO 863 K=1,12
      STRAIN=STRAIN+ATRAIN(K)
      STMIN=STMIN+ATTMIN(K)
      STMAX=STMAX+ATTMAX(K)
      STRAD=STRAD+ATRAD(K)
      STRT=STRT+ATRT(K)

      XYZ= 1/(FLOAT(NYRS)*(FLOAT(LEMON(K)-LBMON(K))+1))
      ATTMIN(K)=ATTMIN(K)*XYZ
      ATTMAX(K)=ATTMAX(K)*XYZ
      ATRAD(K)=ATRAD(K)*XYZ
      ATRT(K)=ATRT(K)*XYZ

      ATTMIN(K)=(ATTMIN(K)-32.)*5./9.
      ATTMAX(K)=(ATTMAX(K)-32.)*5./9.
      ATRAD(K)=ATRAD(K)*4.184

      LANW(K)=LANW(K)/FLOAT(NYRS)
      ATRAIN(K)=ATRAIN(K)/FLOAT(NYRS)

      WRITE(11,864) DATE(K),LANW(K),ATRAIN(K),ATTMAX(K),
     $ ATTMIN(K),ATRAD(K),ATRT(K)
864   FORMAT(A5,3X,I4,6X,F5.1,3X,F5.1,5X,F5.1,6X,F6.1,5X,F6.2)
863   CONTINUE

      STMIN=STMIN/(365*FLOAT(NYRS))
      STMAX=STMAX/(365*FLOAT(NYRS))
      STRAD=STRAD/(365*FLOAT(NYRS))
      STRT=STRT/(365*FLOAT(NYRS))
```

```
          LWET=LWET/NYRS
          STRAIN=STRAIN/NYRS

          STMAX=(STMAX-32.)*5./9.
          STMIN=(STMIN-32.)*5./9.
          STRAD=STRAD*4.184

       WRITE(11,865) LWET,STRAIN
865    FORMAT(/' TOTAL',X,I5,4X,F7.1,6X,'__',8X,'__',10X,'__',
     $ 8X,'__')
       WRITE(11,866) STMAX,STMIN,STRAD,STRT
866    FORMAT(' AVER.',3X,'__',10X,'__',3X,F5.1,5X,F5.1,6X,F6.1,
     $ 5X,F6.2)

       WRITE(11,867)
867    FORMAT(///,' SUMMARY OF STANDARD DEVIATIONS'//)
       WRITE(11,876)
876    FORMAT(' MONTH',2X,'WET DAYS',2X,'RAINFAL',2X,'MAX TEMP',2X
     $ 'MIN TEMP',2X,'SOLAR RAD',5X,'RATIO')

       DO 873 K=1,12
          DRN=0.
          DTX=0.
          DTN=0.
          DWET=0.
          DRAD=0.
          DRT=0.

          SQRN=0.
          SQDTX=0.
          SQDTN=0.
          SQRAD=0.
          SQWET=0.
          SXRTO=0.

       DO 874 I=1,NYRS
          DRN=DRN+SDRN(I,K)
          DTX=DTX+SDTX(I,K)
          DTN=DTN+SDTN(I,K)
          DWET=DWET+SDWET(I,K)
          DRAD=DRAD+SDR(I,K)
          DRT=DRT+SDRT(I,K)

          SQRN=SQRN+SDRN(I,K)*SDRN(I,K)
          SQDTX=SQDTX+SDTX(I,K)*SDTX(I,K)
          SQDTN=SQDTN+SDTN(I,K)*SDTN(I,K)
          SQRAD=SQRAD+SDR(I,K)*SDR(I,K)
          SQWET=SQWET+SDWET(I,K)*SDWET(I,K)
          SXRTO=SXRTO+SDRT(I,K)*SDRT(I,K)
874    CONTINUE

          QDRN(K)=SQRT((SQRN-(DRN*DRN/FLOAT(NYRS)))/FLOAT(NYRS-1))
          QDTX(K)=SQRT((SQDTX-(DTX*DTX/FLOAT(NYRS)))/FLOAT(NYRS-1))
          QDTN(K)=SQRT((SQDTN-(DTN*DTN/FLOAT(NYRS)))/FLOAT(NYRS-1))
          QRD(K)=SQRT((SQRAD-(DRAD*DRAD/FLOAT(NYRS)))/FLOAT(NYRS-1))
          QWT(K)=SQRT((SQWET-(DWET*DWET/FLOAT(NYRS)))/FLOAT(NYRS-1))
          QRTO(K)=SQRT((SXRTO-(DRT*DRT/FLOAT(NYRS)))/FLOAT(NYRS-1))

          SRQRN(K)=QDRN(K)/SQRT(FLOAT(NYRS))
          SRDTX(K)=QDTX(K)/SQRT(FLOAT(NYRS))
          SRDTN(K)=QDTN(K)/SQRT(FLOAT(NYRS))
          SRRD(K)=QRD(K)/SQRT(FLOAT(NYRS))
```

```
          SRQWT(K)=QWT(K)/SQRT(FLOAT(NYRS))
          SRRT(K)=QRTO(K)/SQRT(FLOAT(NYRS))

          CRQRN(K)=QDRN(K)/ATRAIN(K)
          CRDTX(K)=QDTX(K)/ATTMAX(K)
          CRDTN(K)=QDTN(K)/ATTMIN(K)
          CRRD(K)=QRD(K)/ATRAD(K)
          CRQWT(K)=QWT(K)/LANW(K)
          CRRT(K)=QRTO(K)/ATRT(K)

      WRITE(11,877) DATE(K),QWT(K),QDRN(K),QDTX(K),QDTN(K),QRD(K),
     $ QRTO(K)
877       FORMAT(A5,X,F6.2,4X,F8.2,3X,F5.2,5X,F5.2,6X,F8.2,5X,F6.2)

873   CONTINUE

      WRITE(11,879)
879   FORMAT(///,' SUMMARY OF STANDARD ERRORS'//)
      WRITE(11,876)
      DO 878 K=1,12
      WRITE(11,877) DATE(K),SRQWT(K),SRQRN(K),SRDTX(K)
     $ ,SRDTN(K),SRRD(K),SRRT(K)
878   CONTINUE

      WRITE(11,880)
880   FORMAT(///,' SUMMARY OF COEFFICIENTS OF VARIATION'//)
      WRITE(11,876)
      DO 881 K=1,12
      WRITE(11,877) DATE(K),CRQWT(K),CRQRN(K),CRDTX(K)
     $ ,CRDTN(K),CRRD(K),CRRT(K)
881   CONTINUE
      CLOSE(11)
      RETURN
      END
```

5.2. Simulation

```
C       ADAPTED FOR LOS BANOS
C       ORIGINAL IS: DT = COS(0.0172*(XJ-200.)
C                    DR = COS(0.0172*(XJ-172.)

C***********************************************************************
C       ORIGINAL PROGRAM BY RICHARDSON
C       REVISED BY I. SUPIT
C       APRIL 1985
C***********************************************************************
        DIMENSION RTO(20,366)
        DIMENSION RN(20,366),TMX(20,366),TMN(20,366),RD(20,366)
        DIMENSION TXM(366),TXS(366),TXM1(366),TXS1(366),TNM(366)
        DIMENSION RMO(366),RSO(366),RM1(366),RS1(366),RC(366),RAIN(366)
        DIMENSION TMIN(366),RAD(366),ACOM(20),NI(12),SR(12),SSTX(12)
        DIMENSION SSRAD(32),SRAIN(12),STMAX(12),STMIN(12),SRAD(12)
        DIMENSION PWD(12),ALPHA(12),BETA(12),TM(12),PW(12),TG(12),RM(12)
        DIMENSION RCF(12),NWET(12),XNW(12),TMAX(366),PWW(12),RG(12)
        DIMENSION TAMAX(12),TAMIN(12),TNS(366),NII(12),SSTN(12)
        DIMENSION TTMAX(12), TTMIN(12),TCFMAX(12),TCFMIN(12)
        DIMENSION PTMAX(12),PTMIN(12),PRAD(12),RATIO(366)
        DIMENSION ZTMAX(366),ZTMIN(366),ZRAD(366),QTMX(12),QTMN(12),QRAD(12)
        DATA NI/31,59,90,120,151,181,212,243,273,304,334,365/
        DATA NII/31,60,91,121,152,182,213,244,274,305,335,366/
        DATA DATE/ ' JAN.',' FEB.',' MAR.',' APR',' MAY',' JUNE',' JULY',
     $           ' AUG.',' SEP.',' OCT.',' NOV.',' DEC.'/
        CHARACTER*15 INPNAM
        CHARACTER*5 DATE(12)
C***********************************************************************
C*    INPUT # 01 - TITLE
C*       ACOM(I) - LOCATION IDENTIFIDATION OR OTHER USER                 *
C*                 COMMENTS.  80 CHARACTER MAXIMUM                       *
C***********************************************************************
C***********************************************************************
C*     INPUT # 02 - NUMBER OF YEARS, GENERATION CODES, AND LATITUDE
C*           NYRS - YEARS OF DATA TO BE FENERATED
C*           KGEN - GENERATION OPTION CODE
C*                  IF KGEN = 1,RAIN, MAX TEMP, MIN TEMP, AND
C*                  SOLAR RADIATION WILL BE GENERATED
C*                  IF KGEN = 2 OBSERVED RAIN WILL BE USED AND
C*                  MAX TEMP, MIN TEMP, SOLAR RADIATION WILL
C*                  BE GENERATED
C*           ALAT - STATION LATITUDE IN DEGREES
C*           KTCF - TEMP. CORRECTION FACTOR OPTION CODE
C*                  IF KTCF = 0 NO TEMP CORRECTION WILL BE MADE
C*                  IF KTCF = 2 GENERATED MAX TEMP AND
C*                  MIN TEMP. WILL BE CORRECTED BASED ON
C*                  OBSERVED MEAN MONTHLY MAX AND MIN TEMP
C*                  IF KTCF = 1 GENERATED MAX TEMP AND MIN TEMP
C*                  WILL BE CORREATED BASED ON OBSERVED MEAN
C*                  MONTHLY TEMP
C*           KRCF - RAIN CORRECTION FACTOR OPTION CODE
C*                  IF KRCF = 1 GENERATED RAIN WILL BE CORRECTED
C*                  BASED ON OBSERVED MEAN MONTHLY RAIN
C*                  IF KRCF = 0 NO RAIN CORRECTION WILL BE MADE
C***********************************************************************

        KGEN=1
        KTCF=0
        KRCF=0
        TYPE 111
 111    FORMAT(' ARE YOU USING LOS BANOS(1) OR WAGENINGEN(2) DATA?'/
     $  ' TYPE 1 OR 2 ',$)
```

```
          READ(-3,222) LYT
  222     FORMAT(I2)

          TYPE 333
  333     FORMAT(' LATITUDE=',$)
          READ(-3,444) ALAT
  444     FORMAT(F5.1)
          TYPE 95
  95      FORMAT(' NAME OF INPUTFILE=',$)
          READ(-3,96) INPNAM
  96      FORMAT(A15)
          TYPE 99
  99      FORMAT(' HOW MANY YEARS OF DATA HAVE TO BE GENERATED? ',$)
          READ(-3,100) NYRS
  100     FORMAT(I5)
C***** CALCULATE MAXIMUM SOLAR RADIATION FOR EACH DAY
        XLAT = ALAT*6.2832/360.
        DO 6 I = 1,366
        XI = I
        SD = 0.4102*SIN(0.0172*(XI-80.25))
        CH = -TAN(XLAT)*TAN(SD)
        IF(CH .GT. 1.0) H = 0.
        IF(CH .GT. 1.0)GO TO 5
        IF( CH .LT. -1.0)H=3.1416
        IF(CH .LT. -1.0) GO TO 5
        H = ACOS(CH)
  5     DD = 1.0+0.0335*SIN(0.0172*(XI+88.2))
        RC(I)=889.2305*DD*((H*SIN(XLAT)*SIN(SD))+(COS(XLAT)*COS(SD)*SIN(H)
       1))
C      MAYBE A 10% REDUCTION HAVE TO BE USED TO ADJUST WAGENINGEN
C      SOLAR RADIATION
        RC(I) = RC(I) * 0.8
  6     CONTINUE
        DO 7 I = 1,12
        TTMAX(I)=0.
        TTMIN(I)=0.
        RM(I) = 0.
  7     CONTINUE
        IF(KGEN .EQ. 2) GO TO 10

C***********************************************************************
C         INPUT # 3  PROBABILITY OF WET GIVEN WET PWW(I)
C         INPUT # 4  PROBABILITY OF WET GIVEN DRY PWD(I)
C         INPUT # 5  GAMMA DISTRIBUTION SHAPE PARAMETER ALPHA(I)
C         INPUT # 6  GAMMA DISTRIBUTION SCALE PARAMETER BETA(I)
C         ALL INPUTS CONTAIN 12 MONTHLY VALUES
C***********************************************************************
          OPEN(UNIT=11,STATUS='OLD',FILE=INPNAM)
        READ(11,103) (PWW(I),I=1,12)
        READ(11,103) (PWD(I),I=1,12)
        READ(11,103) (ALPHA(I),I=1,12)
        READ(11,103) (BETA(I),I=1,12)
  103   FORMAT(12F22.0)

C**********************************************************************
C*     INPUT #07 - FOURIER COEFFICIENTS OF MAX TEMP ON DRY DAYS
C*                 TXMD   - MEAN OF TMAX - DRY
C*                 ATX    - AMPLITUDE OF TMAX - WET OR DRY
C*                 CVTX   - MEAN OF COEF. OF VAR. OF TMAX - WET OR DRY
C*                 ACVTX  - AMPLITUDE OF COEF.OF VAR. OF TMAX - WET OR DRY
C*     INPUT # 08 - FOURIER COEFFICIENTS OF MAX TEMP ON WET DAYS
C*                 TXMW   - MEAN OF TMAX - WET
C*     INPUT # 09 - FOURIER COEFFICIENTS OF MIN TEMP
```

```
C*                  TN     - MEAN OF TMIN - WET OR DRY
C*                  ATN    - AMPLITUDE OF TMIN - WET OR DRY
C*                  CVTN   - MEAN OF COEF. OF VAR. OF TMIN - WET OR DRY
C*                  ACVTN  - AMPLITUDE OF COEF. OF VAR. OF TMIN - WET OR DRY
C*     INPUT # 10 - FOURIER COEFFICIENTS OF RAD ON DRY DAYS
C*                  RMD    - MEAN OF RAD - DRY
C*                  AR     - AMPLITUDE OF RAD - WET OR DRY
C*     INPUT # 11 - FOURIER COEFFICIENTS OF RAD ON WET DAYS
C*                   RMW   - MEAN OF RAD - WET
C***********************************************************************

 10      READ(11,101) TXMD,ATX,CVTX,ACVTX
         READ(11,901) TXMW
         READ(11,101) TN,ATN,CVTN,ACVTN
         READ(11,902) RMD,AR
         READ(11,901) RMW
 101     FORMAT(4(F22.0))
 901     FORMAT(F22.0)
 902     FORMAT(2(F22.0))

         WRITE(20,801) TXMD,ATX,CVTX,ACVTX
 801     FORMAT(' TXMD=',F10.5,/,' ATX=',F10.5,/,' CVTX=',F10.5,/,' ACVTX='
     $   ,F10.5)

         WRITE(20,802) TXMW
 802     FORMAT(' TXMW=',F10.5)

         WRITE(20,803) TN,ATN,CVTN,ACVTN
 803     FORMAT(' TN=',F10.5,/,' ATN=',F10.5,/,' CVTN=',F10.5,/,' ACVTN='
     $   ,F10.5)

         WRITE(20,804) RMD,AR
 804     FORMAT(' RMD=',F10.5,/,' AR=',F10.5)

         CVRD = 0.24
         ACVRD = -0.08


         WRITE(20,805) RMW
 805     FORMAT(' RMW=',F10.5)

         CVRW = 0.48
         ACVRW = -0.13
       D1 = TXMD - TXMW
       D2 = RMD - RMW
       IF(KTCF  .EQ. 0) GO TO 12
       IF(KTCF  .EQ. 2) GO TO 8
C***********************************************************************
C*     INPUT # 12 - MONTHLY VALUES OF ACTUAL MEAN TEMP
C*                  OMIT IF KTCF = 1 OR 2
C*         TM(I) - 12 MONTHLY VALUES OF ACTUAL MEAN TEMP
C***********************************************************************
       READ(2,103)(TM(I),I=1,12)
       GO TO 12
C***********************************************************************
C*     INPUT # 13 - MONTHLY VALUES OF ACTUAL MEAN MAX TEMP
C*                  OMIT IF KTCF = 0 OR 1
C*         TTMAX(I) - 12 MONTHLY VALUES OF ACTUAL MEAN MAX TEMP
C***********************************************************************
 8     READ(2,103) (TTMAX(I),I=1,12)
C***********************************************************************
C*     INPUT # 14 - MONTHLY VALUES OF ACTUAL MEAN MIN TEMP
C*                  OMIT IF KTCF = 0 OR 1
```

```
C*        TTMIN(I) - 12 MONTHLY VALUES OF ACTUAL MEAN MIN TEMP
C***********************************************************************
      READ(2,103) (TTMIN(I),I=1,12)
 12   IF(KRCF .EQ. 0) GO TO 13
C***********************************************************************
C*    INPUT # 15 - MONTHLY VALUES OF ACTUAL MEAN RAINFALL
C*                 OMIT IF KRCF = 0
C*        RM(I) = 12 MONTHLY VALUES OF ACTUAL MEAN RAINFALL
C********************************************************************
      READ(2,103)(RM(I),I=1,12)
        CLOSE(11)
 13   WRITE(20,700)
 700  FORMAT(////,10X,'GENERATION PARAMETERS',//,15X,'PRECIPITATION')
      WRITE(20,701)(PWW(I),I=1,12)
 701  FORMAT(20X,'P(W/W) ',12F7.3)
      WRITE(20,702) (PWD(I),I=1,12)
 702  FORMAT(20X,'P(W/D) ',12F7.3)
      WRITE(20,703) (ALPHA(I),I=1,12)
 703  FORMAT(20X,'ALPHA   ',12F7.3)
      WRITE(20,704) (BETA(I),I=1,12)
 704  FORMAT(20X,'BETA    ',12F7.3)
      WRITE(20,705)TXMD,ATX,CVTX,ACVTX,TXMW
 705  FORMAT(15X,'MAXIMUM TEMPERATURE',/,20X,'TEMD = ',F8.3,/,20X,
     * 'ATX = ',F8.3,/,20X,'CVTX = ',F8.3,/,20X,'ACVTX = ',F8.3,/,20X,
     * 'TXMW = ',F8.3,//)
      WRITE(20,706)TN,ATN,CVTN,ACVTN
 706  FORMAT(15X,'MINIMUM TEMPERATURE',/,20X,'TN = ',F8.3,/,20X,
     *'ATN = ',F8.3,/,20X,'CVTN = ',F8.3,/,20X,'ACVTN = ',F8.3,//)
      WRITE(20,707)RMD,AR,RMW
 707  FORMAT(15X,'SOLAR RADIATION',/,20X,'RMD = ',F8.3,/,20X,
     * 'AR = ',F8.3,/,20X,'RMW = ',F8.3,///)

C****TEST IF LOS BANOS DATA OR WAGENINGEN DATA ARE USED****

        IF(LYT.EQ.1) THEN
           SX=142.
           SY=112.
        ELSE
           IF(LYT.EQ.2) THEN
             SX=200.
             SY=172.
           END IF
        END IF

      DO 11 J = 1,366
      XJ = J
      DT = COS(.0172*(XJ-SX))
      DR = COS(.0172*(XJ-SY))
      TXM(J) = TXMD+ATX*DT
      XCR1=CVTX+ACVTX*DT
      IF(XCR1 .LT. 0.0) XCR1=0.06
      TXS(J)=TXM(J)*XCR1
      TXM1(J) = TXM(J) - D1
      TXS1(J)=TXM1(J)*XCR1
      TNM(J) = TN + ATN*DT
      XCR2=CVTN+ACVTN*DT
      IF(XCR2 .LT. 0.0) XCR2=0.06
      TNS(J)=TNM(J)*XCR2
      RMO(J) = RMD+AR * DR
      XCR3=CVRD+ACVRD*DR
      IF(XCR3 .LT. 0.0)XCR3=0.06
      RSO(J)=RMO(J)*XCR3
      RM1(J) = RMO(J) - D2
```

```
      XCR4=CVRW+ACVRW*DR
      IF(XCR4 .LT. 0.0) XCR4=0.06
      RS1(J)=RM1(J)*XCR4
 11   CONTINUE
      DO 22 IM=1,12
      XNW(IM) = 0.
      SR(IM) = 0.
      SSTX(IM) = 0.
      SSTN(IM) = 0.
      SSRAD(IM) = 0.
      TCFMAX(IM) = 0.0
      TCFMIN(IM) = 0.0
      RCF(IM) = 1.0
      PW(IM) = PWD(IM)/(1. -PWW(IM)+PWD(IM))
      S1 = 0.
      S2 = 0.
      S3 = 0.
      NL = NI(IM)
      IF(IM .EQ. 1) GO TO 14
      NF = NI(IM-1) + 1
      GO TO 15
 14   NF = 1
 15   CONTINUE
      ZN = NL - NF + 1
      DO 16 J = NF,NL
      S1 = S1 + TXM(J)/ZN
      S2 = S2 + TXM1(J)/ZN
      S3 = S3 + TNM(J)/ZN
 16   CONTINUE
C*****CALCULATE MONTHLY RAINFALL CORRECTION FACTOR
      RG(IM) = ALPHA(IM)*BETA(IM)*ZN*PW(IM)
      IF(KRCF .EQ. 0) GO TO 17
      RCF(IM) = RM(IM)/RG(IM)
 17   IF(KTCF .EQ. 0) GO TO 22
C*****CALCULATE MONTHLY TEMP CORRECTION FACTOR
      IF(KTCF .EQ. 2) GO TO 18
      TMD = (S1 + S3) / 2.
      TMW = (S2 + S3) / 2.
      TG(IM) = TMW*PW(IM)+TMD*(1-PW(IM))
      TCFMAX(IM) = TM(IM) - TG(IM)
      TCFMIN(IM) = TCFMAX(IM)
      GO TO 22
 18   TAMAX(IM)=S2*PW(IM) + S1*(1. -PW(IM))
      TAMIN(IM)=S3
      IF(KTCF .EQ. 0.) GO TO 22
      TCFMAX(IM)=TTMAX(IM)-TAMAX(IM)
      TCFMIN(IM)=TTMIN(IM)-TAMIN(IM)
 22   CONTINUE
      IF(KRCF .EQ. 0) GO TO 52
      WRITE(20,712)(RM(I),I=1,12)
 712  FORMAT(10X,'ACT MEAN RAIN',12F7.2)
      WRITE(20,713) (RG(I),I=1,12)
 713  FORMAT(10X,'EST MEAN RAIN',12F7.2)
      WRITE(20,714)(RCF(I),I=1,12)
 714  FORMAT(10X,'RAIN CF       ',12F7.3)
 52   IF (KTCF .EQ. 0) GO TO 19
      IF(KTCF .EQ. 2) GO TO 51
      WRITE(20,708) (TM(I),I=1,12)
 708  FORMAT(10X,'ACT MEAN TEMP',12F7.1)
      WRITE(20,711)(TG(I),I=1,12)
 711  FORMAT(10X,'EST MEAN TEMP',12F7.1)
      GO TO 50
 51   WRITE(20,722) (TTMAX(I),I=1,12)
```

```
722   FORMAT(10X,'ACT MEAN TMAX',12F7.1)
      WRITE(20,723) (TTMIN(I),I=1,12)
723   FORMAT(10X,'ACT MEAN TMIN',12F7.1)
      WRITE(20,720) (TAMAX(I),I=1,12)
720   FORMAT(10X,'EST MEAN TMAX',12F7.1)
      WRITE(20,721) (TAMIN(I),I=1,12)
721   FORMAT(10X,'EST MEAN TMIN',12F7.1)
50    WRITE(20,709) (TCFMAX(I),I=1,12)
709   FORMAT(10X,'CF. MEAN TMAX',12F7.1)
      WRITE(20,724) (TCFMIN(I),I=1,12)
724   FORMAT(10X,'CF. MEAN TMIN',12F7.1)
19    XYR = NYRS
      SYTX = 0.
      SYTN = 0.
      SYRAD = 0.
      SYR = 0.
      SYNW = 0.
      DO 40 I = 1,NYRS
      IYR = I
      IF(KGEN .EQ. 1) GO TO 20
      KK = 0
      IJ = 1
C*************************************************************
C*    INPUT # 16 - MEASURED RAINFALL FOR NYRS
C*                 OMIT IF KGEN = 1
C*         RAIN(I) - ACTUAL RAINFALL DATA - ONE VALUE PER DAY
C*                   FOR NYRS
C*************************************************************
21    READ(2,102) IYR,MO,IDAY,RAIN(IJ)
102   FORMAT(4X,3I2,20X,F10.0)
      IF(KK .EQ. 1) GO TO 24
20    IDAYS = 365
      IFLG = MOD(IYR,4)
      IF(IFLG .EQ. 0) IDAYS = 366
      KK = 1
      IF(KGEN .EQ. 1) GO TO 28
24    IJ = IJ + 1
      IF(IJ .LE. IDAYS) GO TO 21
28    CONTINUE
      CALL WGEN(PWW,PWD,ALPHA,BETA,TXM,TXS,TXM1,TXS1,TNM,TNS,RMO,RSO,
     *RM1,RS1,RAIN,TMAX,TMIN,RAD,KGEN,RC,IDAYS,NI,NII,
     *TCFMAX,TCFMIN,RCF)
      DO 23 IM = 1,12
      SRAIN(IM) = 0.
      STMAX(IM) = 0.
      STMIN(IM) = 0.
      SRAD(IM) = 0.
      NWET(IM) = 0.
23    CONTINUE
      IM = 1
      YTMAX = 0.
      YTMIN = 0.
      YRAD = 0.
      RYR = 0.
      NYWET = 0.
      IDA = 0

        WRITE(20,851)
851     FORMAT(//,' SIMULATED DAILY WEATHER VALUES',//)
        WRITE(20,852)
852     FORMAT(' MONTH',2X,'DATE',2X,'YEAR',2X,'JUL.DATE',2X,'RAINFALL',
     $  2X,'MAX TEMP',2X,'MIN TEMP',2X,'SOLAR RAD',4X,/
     $  ,31X,' (MM)',5X,'(C)',7X,'(C)',6X,'(J/CM2/DAY)')
```

```
      DO 30 J=1,IDAYS
      IDA = IDA + 1
      IF(IDAYS .EQ. 366) GO TO 27
      IF(J .GT.NI(IM)) GO TO 251
      GO TO 29
 251  IM = IM + 1
      IDA = 1
      GO TO 29
 27   IF(J .GT. NII(IM)) GO TO 251
 29   CONTINUE
C*****THE FOLLOWING STATEMENT WRITES DAILY GENERATED WEATHER ON AN
C*****EXTERNAL FILE (UNIT 20).

        DO 853 LL=1,366
           ZTMAX(LL)=(TMAX(LL)-32.)*5./9.
           ZTMIN(LL)=(TMIN(LL)-32.)*5./9.
           ZRAD(LL)=RAD(LL)
C          ZRAD(LL)=RAD(LL)*4.184
           RATIO(LL)=ZRAD(LL)/RC(LL)
 853    CONTINUE

        RN(IYR,J)=RAIN(J)
        TMX(IYR,J)=ZTMAX(J)
        TMN(IYR,J)=ZTMIN(J)
        RD(IYR,J)=ZRAD(J)
        RTO(IYR,J)=RATIO(J)
      WRITE(20,200)IM,IDA,IYR,J,RAIN(J),ZTMAX(J),ZTMIN(J),ZRAD(J)
     $,RATIO(J)
 800  CONTINUE
C*****THE FOLLOWING STATEMENT PRINTS DAILY GENERATED WEATHER
 200  FORMAT(2X,I2,5X,I2,4X,I2,5X,I3,6X,F5.1,3X,F5.1,5X,F5.1,8X
     $,F5.0,6X,F4.2)
 25   CONTINUE
      IF(RAIN(J) .LT. 0.005) GO TO 26
      NWET(IM) = NWET(IM) + 1
      NYWET = NYWET + 1
 26   CONTINUE
      SRAIN(IM) = SRAIN(IM) + RAIN(J)
      STMAX(IM) = STMAX(IM) + TMAX(J)
      STMIN(IM) = STMIN(IM) + TMIN(J)
      SRAD(IM) = SRAD(IM) + RAD(J)
      RYR = RYR + RAIN(J)
 30   CONTINUE
 40   CONTINUE

C*****************************************
C       CREATING INPUT FILES FOR CSMP
C*****************************************

        OPEN(UNIT=15,STATUS='NEW',FILE='ABC.DAT')
        DO 124 I=1,NYRS
        WRITE(15,123) ALAT
 123    FORMAT(' PARAM LAT=',F5.2)
        WRITE(15,126) (TMX(I,J),J=1,365)
 126    FORMAT(/,' TABLE TMPHT(1-365)=...'//,37(10(F5.1,','),'...',/))
        WRITE(15,128) (TMN(I,J),J=1,365)
 128    FORMAT(/,' TABLE TMPLT(1-365)=...'//,37(10(F5.1,','),'...',/))
        WRITE(15,130) (RD(I,J),J=1,365)
 130    FORMAT(/,' TABLE RDTMT(1-365)=...'//,37(10(F5.1,','),'...',/))
        WRITE(15,132) (RN(I,J),J=1,365)
 132    FORMAT(/,' TABLE RAINT(1-365)=...'//,37(10(F5.1,','),'...',/))
 124    CONTINUE
```

```
         CLOSE(15)

         CALL XSUM(NYRS,RN,TMN,TMX,RD,RTO)
 999       STOP
           END

C*****THE FOLLOWING SUBROUTINE GENERATES DAILY WEATHER DATA FOR
C*****ONE YEAR.
      SUBROUTINE WGEN(PWW,PWD,ALPHA,BETA,TXM,TXS,TXM1,TXS1,TNM,
     1TNS,RMO,RSO,RM1,RS1,RAIN,TMAX,TMIN,RAD,KGEN,RC,IDAYS,NI,
     2NII,TCFMAX,TCFMIN,RCF)
      DIMENSION TXM(366),TXS(366),TXM1(366),
     1 TXS1(366),TNM(366),TNS(366),RMO(366),RSO(366),RM1(366),
     2 RS1(366),RAIN(366),TMAX(366),TMIN(366),RAD(366),RC(366),
     3A(3,3),B(3,3),XIM1(3),E(3),R(3),X(3),RR(3),PWW(12),
     4PWD(12),ALPHA(12),BETA(12),NI(12),NII(12),TCF(12),RCF(12)
      DIMENSION TCFMAX(12),TCFMIN(12)
      DATA A/0.567,0.253,-0.006,0.086,0.504,-0.039,-0.002,
     *-0.050,0.244/
      DATA B/0.781,0.328,0.238,0.0,0.637,-0.341,0.0,0.0,0.873/
      DATA XIM1/0.,0.,0./
      DATA IX/9398039/
      DATA IP/0/
      IM = 1
      DO 50 IDAY=1,IDAYS
      IF(IDAYS .EQ. 366) GO TO 2
      IF(IDAY .GT. NI(IM)) IM = IM + 1
      GO TO 4
  2   IF(IDAY .GT. NII(IM)) IM = IM + 1
  4   CONTINUE
      IF(KGEN .EQ. 2) GO TO 15
C*****DETERMINE WET OR DRY DAY USING MARKOV CHAIN MODEL
      CALL RANDN(RN)
      IF(IP-0) 7,7,10
  7   IF(RN - PWD(IM  ))11,11,8
  8   IP = 0
      RAIN(IDAY) = 0.
      GO TO 18
 10   IF(RN-PWW(IM  ))11,11,8
 11   IP = 1
C*****DETERMINE RAINFALL AMOUNT FOR WET DAYS USING GAMMA
C*    DISTRIBUTION
      AA = 1./ALPHA(IM)
      AB = 1./(1.-ALPHA(IM))
      TR1 = EXP(-18.42/AA)
      TR2 = EXP(-18.42/AB)
      SUM = 0.
      SUM2 = 0.
 12   CALL RANDN(RN1)
      CALL RANDN(RN2)
      IF(RN1-TR1) 61,61,62
 61   S1 = 0.
      GO TO 63
 62   S1 = RN1**AA
 63   IF(RN2-TR2) 64,64,65
 64   S2 = 0.
      GO TO 66
 65   S2 = RN2**AB
 66   S12 = S1 + S2
      IF(S12-1.) 13,13,12
 13   Z = S1/S12
      CALL RANDN(RN3)
      RAIN(IDAY) = -Z*ALOG(RN3)*BETA(IM)*RCF(IM)
```

```
C*****RAIN(IDAY) IS GENERATED RAINFALL FOR IDAY
 15    IF(RAIN(IDAY)) 16,16,17
 16    IP = 0
       GO TO 18
 17    IP = 1
 18    IF(IP-1) 25,26,26
C*****GENERATE TMAX,TMIN, AND RAD FOR IDAY
 25    RM=RMO(IDAY)
       RS = RSO(IDAY)
       TXXM = TXM(IDAY)
       TXXS = TXS(IDAY)
       GO TO 27
 26    RM = RM1(IDAY)
       RS = RS1(IDAY)
       TXXM = TXM1(IDAY)
       TXXS = TXS1(IDAY)
 27    CONTINUE
       DO 30 K = 1,3
 131   AA = 0.
       CALL RANDN(RN1)
       CALL RANDN(RN2)
       V = SQRT(-2.*ALOG(RN1))*COS(6.283185*RN2)
       IF(ABS(V) .GT. 2.5) GO TO 131
       E(K) = V
 30    CONTINUE
       DO 31 I = 1,3
       R(I) = 0.
       RR(I) = 0.
 31    CONTINUE
       DO 32 I = 1,3
       DO 32 J = 1,3
       R(I) = R(I)+B(I,J)*E(J)
       RR(I) = RR(I) + A(I,J)*XIM1(J)
 32    CONTINUE
       DO 37 K = 1,3
       X(K) = R(K) + RR(K)
       XIM1(K) = X(K)
 37    CONTINUE
       TMAX(IDAY) = X(1) * TXXS + TXXM
       TMIN(IDAY) = X(2)*TNS(IDAY)+TNM(IDAY)
       IF(TMIN(IDAY) .GT. TMAX(IDAY)) GO TO 38
       GO TO 39
 38    TMM = TMAX(IDAY)
       TMAX(IDAY) = TMIN(IDAY)
       TMIN(IDAY) = TMM
 39    CONTINUE
       TMAX(IDAY)=TMAX(IDAY)+TCFMAX(IM)
       TMIN(IDAY)=TMIN(IDAY)+TCFMIN(IM)
C*****TMAX(IDAY) IS GENERATED TMAX FOR IDAY
C*****TMIN(IDAY) IS GENERATED TMIN FOR IDAY
       RAD(IDAY) = X(3)*RS+RM
       RMIN = 0.05*RC(IDAY)
       IF(RAD(IDAY) .LT. RMIN) RAD(IDAY) = RMIN
       IF (RAD(IDAY) .GT. RC(IDAY)) RAD(IDAY) = RC(IDAY)
C*****RAD(IDAY) IS GENERATED RAD FOR IDAY
 50    CONTINUE
       RETURN
       END
C*****THE FOLLOWING SUBROUTINE GENERATES A UNIFORM RANDOM
C*****NUMBER ON THE INTERVAL 0 - 1
       SUBROUTINE RANDN(YFL)
       DIMENSION K(4)
       DATA K/2510,7692,2456,3765/
```

```
      K(4) = 3*K(4)+K(2)
      K(3) = 3*K(3)+K(1)
      K(2)=3*K(2)
      K(1)=3*K(1)
      I=K(1)/1000
      K(1)=K(1)-I*1000
      K(2)=K(2) + I
      I = K(2)/100
      K(2)=K(2)-100*I
      K(3) = K(3)+I
      I = K(3)/1000
      K(3)=K(3)-I*1000
      K(4)=K(4)+I
      I = K(4)/100
      K(4)=K(4)-100*I
      YFL=(((FLOAT(K(1))*.001+FLOAT(K(2)))*.01+FLOAT(K(3)))*.001
     *+FLOAT(K(4)))*.01
      RETURN
      END


        SUBROUTINE XSUM(NYRS,RN,TMN,TMX,RD,RTO)

        DIMENSION CRRT(12)
        DIMENSION RTO(20,366),ATRT(12),SDRT(20,12),SRRT(12)
        DIMENSION TMX(20,366),TMN(20,366),RN(20,366),RD(20,366)
        DIMENSION LANW(12),ATRAIN(12),ATTMIN(12),ATTMAX(12),ATRAD(12)
        DIMENSION LBMON(12),LEMON(12),SDRN(20,12),SDTX(20,12)
        DIMENSION NW(12),SDR(20,12),SDWET(20,12),SDTN(20,12)
        DIMENSION SRQWT(12),SRQRN(12),SRDTN(12),SRDTX(12),SRRD(12)
        DIMENSION CRQWT(12),CRQRN(12),CRDTN(12),CRDTX(12),CRRD(12)
        DIMENSION QWT(12),QDRN(12),QDTN(12),QDTX(12),QRD(12),QRTO(12)
        DATA DATE /'JAN.','FEB.','MAR.','APR.','MAY.','JUNE.',
     $  'JULY.','AUG.','SEP.','OCT.','NOV.','DEC.'/
        DATA LBMON/1,32,60,91,121,152,182,213,244,274,305,335/
        DATA LEMON/31,59,90,120,151,181,212,243,273,304,334,365/
        CHARACTER*4 DATE(12)

        OPEN(UNIT=11,STATUS='NEW',FILE='SUMWEATH.DAT')
        DO 871 L=1,12
           ATRAIN(L)=0.
           ATTMIN(L)=0.
           ATTMAX(L)=0.
           ATRAD(L)=0.
           ATRT(L)=0.
           LANW(L)=0
871     CONTINUE
        DO 872 I=1,NYRS
        DO 872 L=1,12
           SDRN(I,L)=0.
           SDTX(I,L)=0.
           SDTN(I,L)=0.
           SDR(I,L)=0.
           SDWET(I,L)=0.
           SDRT(I,L)=0.
872     CONTINUE
           STRAIN=0.
           STMIN=0.
           STMAX=0.
           STRAD=0.
           LWET=0
           STRT=0.
```

```
      WRITE(11,882)
882   FORMAT(' SUMMARY OF THE SIMULATED DATA OF WAGENINGEN')
         DO 20 I = 1,NYRS
         PYTMAX=0.
         PYTMIN=0.
         PYRAD=0.
         NYWET=0
         RYR=0.
         PYRT=0.

         WRITE(11,201) I
201   FORMAT(//,5X,'SUMMARY FOR YEAR',I5,/)
         WRITE(11,202)
202   FORMAT(' MONTH',2X,'WET DAYS',2X,'RAINFAL',2X,'MAX TEMP',2X
     $ 'MIN TEMP',2X,'SOLAR RAD',4X,'RATIO',/,18X,
     $ ' (MM)',5X,'(C)',7X,'(C)',6X,'(J/CM2/DAY)')

      DO 25 K=1,12
         NW(K)=0
         QRAIN=0.
         QTMIN=0.
         QTMAX=0.
         QRAD=0.
         QRT=0.
      DO 30 J = LBMON(K),LEMON(K)

      IF(RN(I,J).GT.0.0) THEN
         NW(K)=NW(K)+1
         LANW(K)=LANW(K)+1
         LWET=LWET+1
      END IF

      RD(I,J)=RD(I,J)*4.184

      QRAIN=QRAIN+RN(I,J)
      QTMIN=QTMIN+TMN(I,J)
      QTMAX=QTMAX+TMX(I,J)
      QRAD=QRAD+RD(I,J)
      QRT=QRT+RTO(I,J)

         ATRAIN(K)= ATRAIN(K)+RN(I,J)
         ATTMIN(K)=ATTMIN(K)+TMN(I,J)
         ATTMAX(K)=ATTMAX(K)+ TMX(I,J)
         ATRAD(K)=ATRAD(K)+RD(I,J)
         ATRT(K)=ATRT(K)+RTO(I,J)

30    CONTINUE

         NYWET=NYWET+NW(K)
         RYR=RYR+QRAIN

         AVTMIN=QTMIN/(FLOAT(LEMON(K)-LBMON(K))+1)
         AVTMAX=QTMAX/(FLOAT(LEMON(K)-LBMON(K))+1)
         AVRAD=QRAD/(FLOAT(LEMON(K)-LBMON(K))+1)
         AVRT=QRT/(FLOAT(LEMON(K)-LBMON(K))+1)

         SDRN(I,K)=QRAIN
         SDTX(I,K)=AVTMAX
         SDTN(I,K)=AVTMIN
         SDR(I,K)=AVRAD
         SDWET(I,K)=NW(K)
         SDRT(I,K)=AVRT
```

```
      WRITE(11,203) DATE(K),NW(K),QRAIN,AVTMAX,AVTMIN,AVRAD,
    $ AVRT
203   FORMAT(A5,3X,I4,5X,F6.1,3X,F5.1,5X,F5.1,6X,F6.1,5X,F6.2)

         PYTMAX=PYTMAX+AVTMAX
         PYTMIN=PYTMIN+AVTMIN
         PYRAD=PYRAD+AVRAD
         PYRT=PYRT+AVRT
25    CONTINUE
         PYTMAX=PYTMAX/12.
         PYTMIN=PYTMIN/12.
         PYRAD=PYRAD/12.
         PYRT=PYRT/12.

      WRITE(11,205) NYWET,RYR
205   FORMAT(/' TOTAL',2X,I3,5X,F7.1,6X,'__',8X,'__',10X,'__',
    $  8X,'__')
      WRITE(11,350) PYTMAX,PYTMIN,PYRAD,PYRT
350   FORMAT(' AVER.',3X,'__',10X,'__',3X,F5.1,5X,F5.1,5X,F7.1,
    $ 5X,F6.2)

20    CONTINUE

      WRITE(11,861) NYRS
861   FORMAT(//,5X,'OVERALL SUMMARY FOR',I3,'YEARS',/,5X,
    $ '(AVERAGED OVER THE YEARS)')
      WRITE(11,862)
862   FORMAT(' MONTH',2X,'WET DAYS',2X,'RAINFAL',2X,'MAX TEMP',2X
    $ 'MIN TEMP',2X,'SOLAR RAD',4X,'RATIO'/
    $ ,18X,' (MM)',5X,'(C)',7X,'(C)',6X,'(J/CM2/DAY)')

      DO 863 K=1,12
         STRAIN=STRAIN+ATRAIN(K)
         STMIN=STMIN+ATTMIN(K)
         STMAX=STMAX+ATTMAX(K)
         STRAD=STRAD+ATRAD(K)
         STRT=STRT+ATRT(K)

         XYZ= 1/(FLOAT(NYRS)*(FLOAT(LEMON(K)-LBMON(K))+1))
         ATTMIN(K)=ATTMIN(K)*XYZ
         ATTMAX(K)=ATTMAX(K)*XYZ
         ATRAD(K)=ATRAD(K)*XYZ
         ATRT(K)=ATRT(K)*XYZ
         ATRAD(K)=ATRAD(K)
         LANW(K)=LANW(K)/FLOAT(NYRS)
         ATRAIN(K)=ATRAIN(K)/FLOAT(NYRS)

      WRITE(11,864) DATE(K),LANW(K),ATRAIN(K),ATTMAX(K),
    $ ATTMIN(K),ATRAD(K),ATRT(K)
864      FORMAT(A5,3X,I4,6X,F5.1,3X,F5.1,5X,F5.1,6X,F6.1,5X,F6.2)
863   CONTINUE

         STMIN=STMIN/(365*FLOAT(NYRS))
         STMAX=STMAX/(365*FLOAT(NYRS))
         STRAD=STRAD/(365*FLOAT(NYRS))
         STRT=STRT/(365*FLOAT(NYRS))

         LWET=LWET/NYRS
         STRAIN=STRAIN/NYRS
      WRITE(11,865) LWET,STRAIN
865   FORMAT(/' TOTAL',X,I5,4X,F7.1,6X,'__',8X,'__',10X,'__',
    $ 8X,'__')
```

```
      WRITE(11,866) STMAX,STMIN,STRAD,STRT
866   FORMAT(' AVER.',3X,'__',10X,'__',3X,F5.1,5X,F5.1,6X,F6.1,
     $ 5X,F6.2)

      WRITE(11,867)
867   FORMAT(///,' SUMMARY OF STANDARD DEVIATIONS'//)
      WRITE(11,876)
876   FORMAT(' MONTH',2X,'WET DAYS',2X,'RAINFAL',2X,'MAX TEMP',2X
     $ 'MIN TEMP',3X,'SOLAR RAD',5X,'RATIO')

      DO 873 K=1,12
         DRN=0.
         DTX=0.
         DTN=0.
         DWET=0.
         DRAD=0.
         DRT=0.

         SQRN=0.
         SQDTX=0.
         SQDTN=0.
         SQRAD=0.
         SQWET=0.
         SXRTO=0.

      DO 874 I=1,NYRS
         DRN=DRN+SDRN(I,K)
         DTX=DTX+SDTX(I,K)
         DTN=DTN+SDTN(I,K)
         DWET=DWET+SDWET(I,K)
         DRAD=DRAD+SDR(I,K)
         DRT=DRT+SDRT(I,K)

         SQRN=SQRN+SDRN(I,K)*SDRN(I,K)
         SQDTX=SQDTX+SDTX(I,K)*SDTX(I,K)
         SQDTN=SQDTN+SDTN(I,K)*SDTN(I,K)
         SQRAD=SQRAD+SDR(I,K)*SDR(I,K)
         SQWET=SQWET+SDWET(I,K)*SDWET(I,K)
         SXRTO=SXRTO+SDRT(I,K)*SDRT(I,K)
874   CONTINUE

         QDRN(K)=SQRT((SQRN-(DRN*DRN/FLOAT(NYRS)))/FLOAT(NYRS-1))
         QDTX(K)=SQRT((SQDTX-(DTX*DTX/FLOAT(NYRS)))/FLOAT(NYRS-1))
         QDTN(K)=SQRT((SQDTN-(DTN*DTN/FLOAT(NYRS)))/FLOAT(NYRS-1))
         QRD(K)=SQRT((SQRAD-(DRAD*DRAD/FLOAT(NYRS)))/FLOAT(NYRS-1))
         QWT(K)=SQRT((SQWET-(DWET*DWET/FLOAT(NYRS)))/FLOAT(NYRS-1))
         QRTO(K)=SQRT((SXRTO-(DRT*DRT/FLOAT(NYRS)))/FLOAT(NYRS-1))

         SRQRN(K)=QDRN(K)/SQRT(FLOAT(NYRS))
         SRDTX(K)=QDTX(K)/SQRT(FLOAT(NYRS))
         SRDTN(K)=QDTN(K)/SQRT(FLOAT(NYRS))
         SRRD(K)=QRD(K)/SQRT(FLOAT(NYRS))
         SRQWT(K)=QWT(K)/SQRT(FLOAT(NYRS))
         SRRT(K)=QRTO(K)/SQRT(FLOAT(NYRS))

         CRQRN(K)=QDRN(K)/ATRAIN(K)
         CRDTX(K)=QDTX(K)/ATTMAX(K)
         CRDTN(K)=QDTN(K)/ATTMIN(K)
         CRRD(K)=QRD(K)/ATRAD(K)
         CRQWT(K)=QWT(K)/LANW(K)
         CRRT(K)=QRTO(K)/ATRT(K)

      WRITE(11,877) DATE(K),QWT(K),QDRN(K),QDTX(K),QDTN(K),QRD(K),
```

```
      $   QRTO(K)
877         FORMAT(A5,X,F6.2,4X,F8.2,3X,F5.2,5X,F5.2,6X,F8.2,5X,F6.2)

873       CONTINUE

          WRITE(11,879)
879       FORMAT(///,' SUMMARY OF STANDARD ERRORS'//)
          WRITE(11,876)
          DO 878 K=1,12
          WRITE(11,877) DATE(K),SRQWT(K),SRQRN(K),SRDTX(K)
      $   ,SRDTN(K),SRRD(K),SRRT(K)
878       CONTINUE

          WRITE(11,880)
880       FORMAT(///,' SUMMARY OF COEFFICIENTS OF VARIATION'//)
          WRITE(11,876)
          DO 881 K=1,12
          WRITE(11,877) DATE(K),CRQWT(K),CRQRN(K),CRDTX(K)
      $   ,CRDTN(K),CRRD(K),CRRT(K)
881       CONTINUE
          CLOSE(11)
          RETURN
          END
```

APPENDIX A.

PQC
SUMMARY OF THE ACTUAL DATA OF WAGENINGEN, 1975-1984
RUN ON MAY 28 1985

SUMMARY FOR YEAR 1975

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	24	84.5	8.6	3.7	228.5	0.36
FEB.	6	28.5	7.2	-0.4	652.2	0.61
MAR.	25	77.2	7.6	1.7	668.3	0.38
APR.	23	56.9	11.0	2.9	1079.1	0.43
MAY.	12	40.9	15.4	5.5	1724.5	0.57
JUNE	14	86.2	19.9	8.8	1963.4	0.60
JULY	14	92.4	22.8	11.9	1726.4	0.55
AUG.	11	53.2	25.5	13.2	1752.6	0.66
SEP.	18	72.5	20.2	10.0	1128.7	0.59
OCT.	15	14.5	12.1	4.9	621.9	0.51
NOV.	18	86.1	7.9	2.0	280.5	0.40
DEC.	12	22.5	5.2	0.1	188.9	0.37
TOTAL	192	715.4				
AVER.	--	--	13.6	5.4	1001.3	0.50

SUMMARY FOR YEAR 1976

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	22	99.4	6.4	1.4	234.5	0.35
FEB.	7	18.0	5.7	0.4	399.8	0.37
MAR.	10	29.6	7.0	-1.1	962.8	0.58
APR.	3	7.0	13.0	0.2	1547.0	0.62
MAY.	15	34.4	18.9	6.4	1765.5	0.58
JUNE	4	34.6	23.4	10.3	2059.2	0.63
JULY	10	28.6	24.8	12.6	1855.1	0.59
AUG.	9	20.5	23.8	10.4	1749.1	0.67
SEP.	17	42.1	18.4	8.8	975.4	0.51
OCT.	13	36.2	14.6	7.4	584.4	0.48
NOV.	19	49.5	8.9	3.9	262.8	0.37
DEC.	19	49.6	3.3	-1.6	242.0	0.47
TOTAL	148	449.5				
AVER.	--	--	14.0	4.9	1053.1	0.52

SUMMARY FOR YEAR 1977

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	25	54.6	4.8	0.0	214.1	0.33
FEB.	20	84.9	7.8	1.8	462.3	0.43
MAR.	15	39.4	10.7	2.7	913.8	0.53
APR.	24	50.4	10.3	1.2	1212.5	0.49
MAY.	15	55.2	16.4	6.0	1750.5	0.57
JUNE	18	64.3	18.7	10.0	1415.4	0.43
JULY	13	68.0	20.9	11.8	1559.8	0.47
AUG.	24	134.4	20.4	11.6	1250.6	0.48
SEP.	7	6.1	17.5	8.9	974.6	0.50
OCT.	18	36.9	15.4	7.3	594.2	0.48
NOV.	25	170.3	8.8	3.8	257.0	0.36
DEC.	22	42.3	7.1	2.0	175.8	0.34
TOTAL	226	806.8				
AVER.	--	--	13.2	5.6	898.4	0.45

SUMMARY FOR YEAR 1978

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	22	61.8	4.8	0.6	211.7	0.33
FEB.	15	51.5	3.5	-2.4	483.1	0.44
MAR.	25	82.3	9.3	2.6	652.3	0.39
APR.	15	34.8	12.2	1.6	1507.7	0.61
MAY.	14	33.1	17.3	6.8	1524.6	0.50
JUNE	19	61.6	19.4	10.0	1690.6	0.51
JULY	14	56.7	19.9	9.6	1546.0	0.50
AUG.	18	31.0	19.7	10.0	1346.1	0.52
SEP.	16	68.8	17.0	9.0	835.5	0.43
OCT.	10	16.1	14.0	6.4	522.7	0.43
NOV.	11	21.5	8.4	3.1	318.6	0.46
DEC.	15	98.9	4.3	-0.9	182.7	0.36
TOTAL	194	618.1				
AVER.	—	—	12.5	4.7	901.8	0.46

SUMMARY FOR YEAR 1979

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	17	35.5	-1.2	-7.0	289.7	0.46
FEB.	12	43.6	1.1	-3.7	431.0	0.42
MAR.	20	81.5	8.0	1.4	739.5	0.43
APR.	19	50.7	11.8	3.2	1166.6	0.48
MAY.	19	75.7	16.5	6.6	1664.3	0.55
JUNE	15	148.4	19.9	9.8	1642.4	0.50
JULY	14	31.4	24.7	10.9	1487.6	0.47
AUG.	15	84.8	19.8	10.3	1319.9	0.50
SEP.	8	17.8	18.6	7.1	1107.5	0.58
OCT.	8	36.6	14.8	6.6	625.8	0.51
NOV.	19	59.9	8.7	1.8	286.2	0.40
DEC.	24	94.1	7.7	2.7	143.9	0.28
TOTAL	190	760.0				
AVER.	—	—	12.5	4.1	908.7	0.47

SUMMARY FOR YEAR 1980

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	16	46.9	2.3	-2.6	230.3	0.36
FEB.	12	46.5	7.8	1.6	378.7	0.37
MAR.	15	54.9	8.2	1.1	658.5	0.38
APR.	13	40.6	12.4	2.0	1356.5	0.55
MAY.	6	9.3	17.9	5.2	2094.2	0.69
JUNE	21	66.2	19.8	9.6	1626.5	0.50
JULY	18	145.7	19.4	11.7	1370.5	0.44
AUG.	17	46.4	21.3	12.3	1362.7	0.51
SEP.	14	27.4	19.6	10.9	1109.2	0.57
OCT.	22	67.4	12.7	4.0	600.6	0.49
NOV.	19	52.6	6.8	1.8	288.0	0.39
DEC.	20	56.2	5.9	0.6	153.4	0.30
TOTAL	193	660.1				
AVER.	—	—	12.8	4.8	937.4	0.46

SUMMARY FOR YEAR 1981

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	15	82.4	4.6	-0.8	205.9	0.33
FEB.	13	47.3	3.9	-1.7	449.5	0.41
MAR.	24	132.4	11.4	5.0	560.6	0.32
APR.	9	14.5	13.1	3.0	1193.7	0.48
MAY.	23	64.4	18.3	7.8	1598.3	0.53
JUNE	18	64.4	18.3	10.3	1396.7	0.43
JULY	14	49.4	20.7	11.3	1420.9	0.45
AUG.	8	19.9	21.4	11.0	1308.3	0.50
SEP.	14	57.9	19.7	9.5	1036.7	0.53
OCT.	26	137.2	12.1	5.5	664.0	0.38
NOV.	24	70.7	9.5	3.0	251.1	0.35
DEC.	18	58.4	1.6	-3.4	177.4	0.35
TOTAL	206	798.9				
AVER.	—	—	12.9	5.1	838.6	0.42

SUMMARY FOR YEAR 1982

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	13	54.1	4.3	-2.4	233.4	0.38
FEB.	9	16.5	6.3	-0.3	439.1	0.42
MAR.	17	74.8	9.5	1.2	806.9	0.47
APR.	14	18.2	12.9	1.7	1404.3	0.57
MAY.	15	33.9	17.9	6.6	1721.5	0.56
JUNE	19	61.3	20.9	10.6	1593.4	0.49
JULY	11	16.7	23.4	12.6	1766.8	0.56
AUG.	18	52.0	21.4	12.1	1354.0	0.51
SEP.	11	31.6	20.8	9.5	1054.1	0.54
OCT.	18	83.0	14.3	7.8	497.5	0.41
NOV.	20	65.8	10.3	5.2	227.7	0.32
DEC.	18	59.3	5.7	0.5	136.7	0.27
TOTAL	183	567.2				
AVER.	—	—	14.0	5.4	936.3	0.46

SUMMARY FOR YEAR 1983

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	22	81.7	8.3	3.1	167.9	0.26
FEB.	12	37.7	3.6	-2.1	500.0	0.47
MAR.	19	66.9	9.2	1.8	686.6	0.41
APR.	20	80.4	12.7	4.3	1133.6	0.46
MAY.	25	132.1	14.5	7.3	1157.6	0.38
JUNE	15	52.4	21.2	10.7	1931.3	0.59
JULY	5	11.7	25.6	13.5	1952.1	0.62
AUG.	10	32.7	23.9	12.1	1532.4	0.59
SEP.	18	91.4	18.2	10.2	904.8	0.48
OCT.	17	35.7	14.3	5.5	581.9	0.48
NOV.	12	74.0	9.8	1.4	300.3	0.41
DEC.	16	74.2	6.1	0.8	181.6	0.35
TOTAL	191	770.9				
AVER.	—	—	13.9	5.7	919.2	0.46

SUMMARY FOR YEAR 1984

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	27	90.4	5.8	0.5	185.3	0.29
FEB.	11	60.6	4.9	-0.6	380.6	0.36
MAR.	13	43.5	8.1	-0.5	838.5	0.49
APR.	13	14.9	13.2	1.3	1428.0	0.57
MAY.	18	78.9	14.7	5.4	1189.7	0.39
JUNE	12	55.3	17.8	8.7	1561.7	0.47
JULY	9	37.2	20.3	11.5	1505.8	0.48
AUG.	11	11.7	23.3	11.6	1486.1	0.56
SEP.	24	159.4	17.0	9.9	698.8	0.36
OCT.	19	119.4	14.8	8.3	480.9	0.40
NOV.	16	49.2	10.9	5.7	284.5	0.39
DEC.	18	31.9	6.5	2.0	165.3	0.32
TOTAL	191	752.4				
AVER.	--	--	13.1	5.3	850.4	0.43

OVERALL SUMMARY FOR 10YEARS
(AVERAGED OVER THE YEARS)

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	20	69.1	4.9	-0.3	220.1	0.35
FEB.	11	43.5	5.2	-0.7	459.6	0.43
MAR.	18	68.2	8.9	1.6	748.8	0.44
APR.	15	36.8	12.3	2.1	1302.9	0.53
MAY.	16	55.8	16.8	6.4	1619.1	0.53
JUNE	15	69.5	19.9	9.9	1688.0	0.51
JULY	12	53.8	22.2	11.7	1619.1	0.52
AUG.	14	48.7	22.1	11.5	1446.2	0.55
SEP.	14	57.5	18.7	9.4	982.5	0.51
OCT.	16	58.3	13.9	6.4	557.4	0.46
NOV.	18	70.0	9.0	3.2	275.7	0.39
DEC.	18	58.7	5.3	0.3	174.8	0.34
TOTAL	191	689.9				
AVER.	--	--	13.3	5.1	926.8	0.46

SUMMARY OF STANDARD DEVIATIONS

MONTH	WET DAYS	RAINFAL	MAX TEMP	MIN TEMP	SOLAR RAD	RATIO
JAN.	4.72	21.23	2.85	3.10	32.74	0.05
FEB.	4.00	20.36	2.19	1.76	77.57	0.07
MAR.	5.23	29.31	1.39	1.69	128.12	0.08
APR.	6.45	23.36	0.98	1.19	165.92	0.07
MAY.	5.43	34.42	1.53	0.86	277.85	0.09
JUNE	4.88	30.57	1.63	0.67	226.74	0.07
JULY	3.58	40.45	2.29	1.04	194.37	0.06
AUG.	5.13	36.89	1.97	1.03	180.53	0.07
SEP.	5.10	44.62	1.34	1.05	137.17	0.07
OCT.	5.38	42.53	1.19	1.37	60.33	0.05
NOV.	4.47	39.39	1.20	1.48	26.31	0.04
DEC.	3.43	24.71	1.83	1.84	29.41	0.06

SUMMARY OF STANDARD ERRORS

MONTH	WET DAYS	RAINFAL	MAX TEMP	MIN TEMP	SOLAR RAD	RATIO
JAN.	1.49	6.71	0.90	0.98	10.35	0.02
FEB.	1.27	6.44	0.69	0.56	24.53	0.02
MAR.	1.65	9.27	0.44	0.53	40.52	0.02
APR.	2.04	7.39	0.31	0.38	52.47	0.02
MAY.	1.72	10.88	0.48	0.27	87.87	0.03
JUNE	1.54	9.67	0.52	0.21	71.70	0.02
JULY	1.13	12.79	0.72	0.33	61.47	0.02
AUG.	1.62	11.67	0.62	0.33	57.09	0.02
SEP.	1.61	14.11	0.42	0.33	43.38	0.02
OCT.	1.70	13.45	0.38	0.43	19.08	0.02
NOV.	1.41	12.46	0.38	0.47	8.32	0.01
DEC.	1.08	7.81	0.58	0.58	9.30	0.02

SUMMARY OF COEFFICIENTS OF VARIATION

MONTH	WET DAYS	RAINFAL	MAX TEMP	MIN TEMP	SOLAR RAD	RATIO
JAN.	0.24	0.31	0.59	-9.10	0.15	0.16
FEB.	0.36	0.47	0.42	-2.41	0.17	0.17
MAR.	0.29	0.43	0.16	1.06	0.17	0.18
APR.	0.43	0.63	0.08	0.56	0.13	0.13
MAY.	0.34	0.62	0.09	0.13	0.17	0.17
JUNE	0.33	0.44	0.08	0.07	0.13	0.13
JULY	0.30	0.75	0.10	0.09	0.12	0.12
AUG.	0.37	0.76	0.09	0.09	0.12	0.12
SEP.	0.36	0.78	0.07	0.11	0.14	0.14
OCT.	0.34	0.73	0.09	0.22	0.11	0.10
NOV.	0.25	0.56	0.13	0.47	0.10	0.10
DEC.	0.19	0.42	0.34	6.89	0.17	0.17

POD

PQC
SUMMARY OF THE SIMULATED DATA OF WAGENINGEN

SUMMARY FOR YEAR 1

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	19	48.0	2.2	-1.8	132.5	0.20
FEB.	16	76.2	4.1	-0.1	358.7	0.35
MAR.	20	72.6	9.3	2.8	842.5	0.49
APR.	24	50.8	14.0	6.2	1206.3	0.49
MAY.	18	71.9	18.1	8.1	1819.9	0.60
JUNE	17	81.7	22.9	11.5	1816.6	0.55
JULY	11	60.6	24.5	11.7	1861.2	0.59
AUG.	16	35.7	20.6	10.2	1457.9	0.55
SEP.	14	47.7	16.7	6.0	1112.3	0.58
OCT.	16	33.6	12.2	4.3	582.7	0.48
NOV.	17	78.6	8.7	2.8	159.4	0.22
DEC.	23	59.8	5.9	1.1	72.4	0.14
TOTAL	211	717.2				
AVER.	__	__	13.3	5.2	951.9	0.44

SUMMARY FOR YEAR 2

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	18	68.6	4.6	0.3	115.5	0.18
FEB.	13	31.8	5.4	0.7	443.5	0.39
MAR.	21	72.8	6.1	0.3	758.1	0.44
APR.	23	61.9	12.2	3.3	1313.8	0.53
MAY.	12	61.4	19.2	8.2	1700.3	0.56
JUNE	16	34.5	20.9	10.8	1715.8	0.52
JULY	13	87.5	23.3	11.4	1626.5	0.52
AUG.	17	33.6	21.6	10.7	1421.3	0.54
SEP.	14	59.7	18.2	8.4	1053.2	0.55
OCT.	24	87.8	14.8	4.8	482.6	0.38
NOV.	23	165.5	11.3	4.6	116.0	0.17
DEC.	19	66.4	4.6	0.3	75.1	0.15
TOTAL	213	831.5				
AVER.	__	__	13.5	5.3	901.8	0.41

SUMMARY FOR YEAR 3

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	25	86.4	4.4	-0.3	66.1	0.10
FEB.	11	31.7	4.8	-0.6	475.6	0.44
MAR.	25	100.4	6.3	1.2	808.3	0.46
APR.	13	20.2	11.7	4.9	1146.1	0.46
MAY.	14	58.6	19.3	10.0	1611.3	0.53
JUNE	18	94.2	20.8	9.1	1842.4	0.56
JULY	7	66.9	21.8	10.2	1846.9	0.59
AUG.	11	25.0	24.5	11.7	1343.3	0.51
SEP.	13	43.2	20.6	10.0	1035.2	0.53
OCT.	14	59.1	14.0	6.0	532.2	0.43
NOV.	13	34.1	8.4	1.6	211.7	0.31
DEC.	16	83.8	2.2	-2.1	95.4	0.19
TOTAL	180	703.7				
AVER.	__	__	13.2	5.1	917.9	0.43

SUMMARY FOR YEAR 4

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	24	80.2	2.6	-2.2	77.3	0.12
FEB.	7	27.7	3.8	-0.8	489.3	0.45
MAR.	22	80.0	5.4	-0.6	794.4	0.46
APR.	11	23.3	11.4	2.7	1313.4	0.53
MAY.	15	66.5	18.5	7.3	1722.4	0.57
JUNE	14	85.1	23.3	11.4	1765.8	0.54
JULY	6	8.5	24.5	12.5	1862.5	0.59
AUG.	10	21.8	22.7	10.4	1610.5	0.61
SEP.	16	58.1	18.2	9.0	1070.7	0.56
OCT.	15	52.2	14.3	6.5	460.8	0.37
NOV.	13	41.4	7.3	0.1	246.5	0.34
DEC.	18	42.8	6.4	1.8	81.9	0.16
TOTAL	171	587.4				
AVER.	—	—	13.2	4.8	958.0	0.44

SUMMARY FOR YEAR 5

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	22	67.9	4.9	1.2	105.6	0.16
FEB.	9	32.1	2.4	-0.8	370.9	0.35
MAR.	10	47.9	8.3	2.6	855.7	0.49
APR.	22	42.1	14.4	6.5	1400.8	0.57
MAY.	21	66.6	19.7	9.5	1663.5	0.55
JUNE	16	67.6	23.5	12.0	1950.8	0.59
JULY	10	118.2	24.6	12.7	1802.2	0.57
AUG.	12	29.0	24.2	12.5	1383.3	0.52
SEP.	16	73.5	16.2	6.3	1033.4	0.53
OCT.	13	33.5	17.1	9.1	602.9	0.50
NOV.	15	68.1	8.7	2.3	193.3	0.28
DEC.	22	49.4	5.5	-0.2	72.1	0.14
TOTAL	188	696.0				
AVER.	—	—	14.1	6.1	952.9	0.44

SUMMARY FOR YEAR 6

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	22	74.0	2.9	-1.1	98.7	0.16
FEB.	16	42.3	4.9	0.8	375.4	0.36
MAR.	21	76.5	8.2	2.0	804.7	0.46
APR.	19	35.3	13.7	5.0	1338.7	0.54
MAY.	19	78.1	14.9	5.3	1703.7	0.56
JUNE	12	63.8	24.3	10.8	1984.8	0.60
JULY	13	42.4	21.5	9.7	1773.0	0.57
AUG.	6	34.0	22.8	9.9	1477.4	0.56
SEP.	10	11.1	17.3	6.1	1127.3	0.58
OCT.	15	85.0	16.0	5.9	601.7	0.49
NOV.	21	40.4	9.6	3.0	144.8	0.20
DEC.	14	34.5	6.7	1.6	98.4	0.20
TOTAL	188	617.4				
AVER.	—	—	13.6	4.9	960.7	0.44

SUMMARY FOR YEAR 7

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	24	105.5	3.1	-0.4	98.7	0.15
FEB.	11	63.1	5.1	1.8	354.8	0.33
MAR.	10	33.7	9.1	3.1	945.4	0.55
APR.	11	25.9	12.8	5.1	1299.6	0.53
MAY.	12	21.3	18.5	8.9	1646.8	0.54
JUNE	14	60.8	21.9	9.4	1966.5	0.60
JULY	12	59.0	25.4	13.4	1711.8	0.54
AUG.	15	32.6	22.7	9.5	1436.9	0.54
SEP.	14	51.5	17.3	8.1	978.1	0.52
OCT.	18	47.8	13.2	5.8	480.6	0.40
NOV.	23	74.3	10.2	3.7	104.5	0.15
DEC.	16	55.8	4.8	-0.3	98.0	0.19
TOTAL	180	631.2				
AVER.	--	--	13.7	5.7	926.8	0.42

SUMMARY FOR YEAR 8

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	19	56.9	1.3	-3.4	146.7	0.22
FEB.	7	15.1	4.4	0.4	484.1	0.44
MAR.	16	51.7	8.9	2.0	870.7	0.51
APR.	9	9.4	11.4	3.9	1442.4	0.59
MAY.	16	47.6	15.8	6.7	1567.7	0.51
JUNE	13	45.0	23.5	10.4	1976.6	0.60
JULY	19	93.4	24.5	11.9	1796.0	0.57
AUG.	12	31.9	22.6	11.2	1608.0	0.61
SEP.	14	29.9	17.7	7.2	1045.0	0.54
OCT.	19	53.1	15.3	5.8	540.5	0.42
NOV.	14	42.7	9.7	3.5	196.5	0.28
DEC.	19	65.4	6.6	2.0	82.5	0.16
TOTAL	177	541.9				
AVER.	--	--	13.5	5.1	979.7	0.45

SUMMARY FOR YEAR 9

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	20	58.7	3.0	-1.5	165.7	0.24
FEB.	16	76.8	2.9	-2.3	335.5	0.31
MAR.	22	89.8	7.4	2.4	746.8	0.44
APR.	14	50.4	13.6	6.6	1214.0	0.50
MAY.	7	50.2	18.8	8.7	1804.8	0.59
JUNE	17	100.1	21.7	10.5	1769.7	0.54
JULY	19	86.8	23.4	10.8	1802.6	0.57
AUG.	22	102.2	23.8	11.4	1224.3	0.46
SEP.	18	110.4	19.6	9.6	947.6	0.49
OCT.	22	95.1	14.6	6.7	466.1	0.37
NOV.	17	70.1	6.5	0.8	179.8	0.23
DEC.	28	113.9	4.4	0.1	41.7	0.08
TOTAL	222	1004.5				
AVER.	--	--	13.3	5.3	891.5	0.40

SUMMARY FOR YEAR 10

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	20	59.1	4.1	0.2	129.4	0.19
FEB.	2	22.3	2.8	-1.8	499.7	0.48
MAR.	21	80.6	6.5	2.2	732.4	0.42
APR.	13	18.8	13.4	3.8	1382.1	0.56
MAY.	17	77.4	17.5	7.1	1822.4	0.60
JUNE	11	71.6	21.7	9.1	1859.1	0.57
JULY	9	47.6	24.5	11.8	1928.4	0.61
AUG.	12	28.6	19.8	8.6	1510.2	0.58
SEP.	18	61.8	18.3	8.5	932.9	0.48
OCT.	16	45.0	14.1	5.8	503.7	0.40
NOV.	13	68.9	9.8	3.7	231.6	0.32
DEC.	21	54.9	4.5	0.6	75.3	0.15
TOTAL	173	636.6				
AVER.	--	--	13.1	5.0	967.3	0.45

OVERALL SUMMARY FOR 10YEARS
(AVERAGED OVER THE YEARS)

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	RATIO
JAN.	21	70.5	3.3	-0.9	113.6	0.17
FEB.	10	41.9	4.1	-0.3	418.7	0.39
MAR.	18	70.6	7.6	1.8	815.9	0.47
APR.	15	33.8	12.9	4.8	1305.7	0.53
MAY.	15	60.0	18.0	8.0	1706.3	0.56
JUNE	14	70.5	22.4	10.5	1864.8	0.57
JULY	11	67.1	23.8	11.6	1801.1	0.57
AUG.	13	37.5	22.5	10.6	1447.3	0.55
SEP.	14	54.7	18.0	7.9	1033.6	0.54
OCT.	17	59.2	14.6	6.1	525.4	0.42
NOV.	16	68.4	9.0	2.6	178.4	0.25
DEC.	19	62.7	5.2	0.5	79.3	0.16
TOTAL	190	696.8				
AVER.	--	--	13.5	5.3	943.4	0.43

SUMMARY OF STANDARD DEVIATIONS

MONTH	WET DAYS	RAINFAL	MAX TEMP	MIN TEMP	SOLAR RAD	RATIO
JAN.	2.45	16.85	1.16	1.36	30.74	0.04
FEB.	4.66	22.23	1.04	1.26	65.34	0.06
MAR.	5.14	20.34	1.40	1.18	64.82	0.04
APR.	5.57	17.02	1.12	1.36	93.42	0.04
MAY.	4.07	17.04	1.56	1.42	88.17	0.03
JUNE	2.35	20.74	1.19	1.03	99.19	0.03
JULY	4.41	30.98	1.28	1.15	84.96	0.03
AUG.	4.40	23.17	1.52	1.13	116.85	0.04
SEP.	2.41	26.36	1.30	1.45	64.54	0.03
OCT.	3.55	22.37	1.38	1.28	55.18	0.05
NOV.	4.07	37.89	1.40	1.41	47.12	0.06
DEC.	4.09	22.56	1.37	1.22	16.78	0.03

SUMMARY OF STANDARD ERRORS

MONTH	WET DAYS	RAINFAL	MAX TEMP	MIN TEMP	SOLAR RAD	RATIO
JAN.	0.78	5.33	0.37	0.43	9.72	0.01
FEB.	1.47	7.03	0.33	0.40	20.66	0.02
MAR.	1.62	6.43	0.44	0.37	20.50	0.01
APR.	1.76	5.38	0.35	0.43	29.54	0.01
MAY.	1.29	5.39	0.49	0.45	27.88	0.01
JUNE	0.74	6.56	0.38	0.33	31.37	0.01
JULY	1.39	9.80	0.40	0.37	26.87	0.01
AUG.	1.39	7.33	0.48	0.36	36.95	0.01
SEP.	0.76	8.34	0.41	0.46	20.41	0.01
OCT.	1.12	7.08	0.44	0.40	17.45	0.02
NOV.	1.29	11.98	0.44	0.45	14.90	0.02
DEC.	1.29	7.13	0.43	0.39	5.31	0.01

SUMMARY OF COEFFICIENTS OF VARIATION

MONTH	WET DAYS	RAINFAL	MAX TEMP	MIN TEMP	SOLAR RAD	RATIO
JAN.	0.12	0.24	0.35	-1.51	0.27	0.24
FEB.	0.47	0.53	0.26	-4.70	0.16	0.15
MAR.	0.29	0.29	0.19	0.65	0.08	0.08
APR.	0.37	0.50	0.09	0.28	0.07	0.07
MAY.	0.27	0.28	0.09	0.18	0.05	0.05
JUNE	0.17	0.29	0.05	0.10	0.05	0.05
JULY	0.40	0.46	0.05	0.10	0.05	0.05
AUG.	0.34	0.62	0.07	0.11	0.08	0.08
SEP.	0.17	0.48	0.07	0.18	0.06	0.06
OCT.	0.21	0.38	0.09	0.21	0.11	0.12
NOV.	0.25	0.55	0.15	0.54	0.26	0.26
DEC.	0.22	0.36	0.27	2.49	0.21	0.21

POD

APPENDIX C.

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P0C
ONE YEAR SIMULATION FOR WAGENINGEN
RUN ON MAY 28, 1985

TXMD=  56.40300
ATX=  18.93000
CVTX=   0.13600
ACVTX=   -0.04900
TXMW=  55.25200
TN=  41.29100
ATN=  11.28500
CVTN=   0.17300
ACVTN=  -0.07900
RMD= 263.83899
AR= 226.00999
RMW= 180.19000
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GENERATION PARAMETERS

     PRECIPITATION
          P(W/W)     0.803  0.706  0.736  0.715  0.689  0.651  0.579  0.633  0.605  0.680  0.772  0.724
          P(W/D)     0.374  0.205  0.383  0.302  0.336  0.378  0.266  0.310  0.379  0.362  0.367  0.395
          ALPHA       0.809  0.767  0.797  0.806  0.808  0.614  0.551  0.604  0.676  0.652  0.707  0.787
          BETA        4.211  4.847  4.679  2.986  4.262  7.305  8.003  5.710  5.790  5.387  5.405  4.101
     MAXIMUM TEMPERATURE
          TEMD =    56.403
          ATX =   18.930
          CVTX =     0.136
          ACVTX =    -0.049
          TXMW =    55.252

     MINIMUM TEMPERATURE
          TN =    41.291
          ATN =    11.285
          CVTN =     0.173
          ACVTN =    -0.079

     SOLAR RADIATION
          RMD =   263.839
          AR =   226.010
          RMW =   180.190
```

SIMULATED DAILY WEATHER VALUES

MONTH	DATE	YEAR	JUL.DATE	RAINFALL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)	
1	1	1	1	0.0	3.5	0.5	45.	0.36
1	2	1	2	0.4	5.1	-4.2	6.	0.05
1	3	1	3	0.3	3.3	-5.6	6.	0.05
1	4	1	4	5.9	0.3	-8.1	6.	0.05
1	5	1	5	5.1	-2.9	-7.8	6.	0.05
1	6	1	6	0.1	0.3	-2.9	7.	0.05
1	7	1	7	0.1	-0.3	-0.6	7.	0.05
1	8	1	8	0.5	2.6	0.9	7.	0.05
1	9	1	9	0.2	2.0	1.6	7.	0.05
1	10	1	10	0.7	5.1	1.9	7.	0.05
1	11	1	11	0.1	5.1	3.3	7.	0.05
1	12	1	12	1.4	1.4	-5.0	7.	0.05
1	13	1	13	0.0	5.7	2.3	60.	0.42
1	14	1	14	5.8	5.6	3.2	7.	0.05
1	15	1	15	0.0	5.3	3.6	60.	0.41
1	16	1	16	0.0	3.9	-0.3	72.	0.43
1	17	1	17	0.0	8.4	4.1	58.	0.38
1	18	1	18	0.0	1.3	0.5	56.	0.37
1	19	1	19	0.0	0.9	-7.8	57.	0.37
1	20	1	20	0.0	3.0	1.3	48.	0.30
1	21	1	21	1.7	5.1	-0.8	8.	0.05
1	22	1	22	3.9	2.3	-0.8	8.	0.05
1	23	1	23	4.6	0.2	-6.1	8.	0.05
1	24	1	24	4.4	-1.6	-5.0	8.	0.05
1	25	1	25	10.1	1.6	-1.3	9.	0.05
1	26	1	26	0.0	1.3	-4.4	107.	0.61
1	27	1	27	0.0	-0.8	-0.9	90.	0.50
1	28	1	28	0.0	1.8	-6.5	89.	0.49
1	29	1	29	2.5	-0.4	-3.3	9.	0.05
1	30	1	30	0.0	-1.3	-3.1	10.	0.06
1	31	1	31	0.0	1.2	-2.9	100.	0.52
2	1	1	32	0.0	0.4	-0.8	121.	0.62
2	2	1	33	0.0	1.2	-2.6	133.	0.67
2	3	1	34	0.0	2.4	-4.6	117.	0.58
2	4	1	35	0.0	5.8	-0.3	66.	0.32
2	5	1	36	0.0	5.4	2.4	89.	0.43
2	6	1	37	0.0	5.1	-2.3	104.	0.49
2	7	1	38	0.0	7.4	-0.3	156.	0.72
2	8	1	39	4.8	7.4	1.3	27.	0.12
2	9	1	40	4.3	5.1	-1.8	33.	0.14
2	10	1	41	11.2	2.9	-3.2	57.	0.25
2	11	1	42	6.9	1.6	0.8	12.	0.05
2	12	1	43	6.7	3.0	-1.8	67.	0.28
2	13	1	44	2.8	2.7	-2.4	86.	0.35
2	14	1	45	0.3	0.2	-1.5	47.	0.19
2	15	1	46	0.9	2.0	0.3	32.	0.13
2	16	1	47	0.0	5.2	-0.5	101.	0.39
2	17	1	48	0.0	5.7	2.7	119.	0.46
2	18	1	49	0.0	1.6	0.6	50.	0.19
2	19	1	50	0.0	7.7	5.4	112.	0.41
2	20	1	51	0.0	3.5	-0.7	143.	0.52
2	21	1	52	0.1	2.8	-2.6	14.	0.05
2	22	1	53	0.2	4.9	3.5	85.	0.30
2	23	1	54	18.9	2.5	-3.3	116.	0.40
2	24	1	55	0.7	7.3	0.7	50.	0.17
2	25	1	56	3.1	4.6	3.9	76.	0.25
2	26	1	57	11.4	6.9	3.4	149.	0.48
2	27	1	58	3.5	2.1	-0.2	137.	0.46
2	28	1	59	0.3	6.3	1.2	100.	0.32
3	1	1	60	1.0	4.1	-1.4	92.	0.28
3	2	1	61	9.4	8.8	-0.6	126.	0.38
3	3	1	62	1.6	0.9	-2.3	137.	0.41
3	4	1	63	0.0	3.7	2.2	180.	0.53
3	5	1	64	0.0	8.0	-1.2	201.	0.58
3	6	1	65	0.0	7.3	2.3	196.	0.56
3	7	1	66	1.3	9.0	5.4	104.	0.29
3	8	1	67	2.0	13.5	5.7	205.	0.56
3	9	1	68	1.4	7.8	-1.5	210.	0.57
3	10	1	69	4.8	8.6	2.8	100.	0.27

3	11	1	70	0.1	6.0	3.3	62.	0.18
3	12	1	71	0.0	8.0	7.7	185.	0.48
3	13	1	72	0.0	8.3	3.2	244.	0.62
3	14	1	73	0.0	12.1	6.6	238.	0.60
3	15	1	74	0.0	4.3	1.9	186.	0.46
3	16	1	75	0.0	8.2	3.6	177.	0.43
3	17	1	76	4.5	8.3	-0.4	81.	0.20
3	18	1	77	0.0	12.8	2.9	269.	0.64
3	19	1	78	5.8	13.3	1.1	190.	0.44
3	20	1	79	6.7	9.5	2.1	253.	0.58
3	21	1	80	9.4	14.4	8.0	263.	0.60
3	22	1	81	1.3	15.0	11.6	196.	0.44
3	23	1	82	1.5	17.4	7.7	363.	0.80
3	24	1	83	4.1	15.0	7.2	274.	0.60
3	25	1	84	8.3	15.4	2.5	284.	0.61
3	26	1	85	0.0	11.6	2.9	359.	0.76
3	27	1	86	0.0	8.8	-0.4	287.	0.60
3	28	1	87	0.1	9.0	4.0	234.	0.48
3	29	1	88	8.0	6.6	2.9	145.	0.30
3	30	1	89	0.6	3.6	-2.5	109.	0.22
3	31	1	90	0.6	9.7	-1.5	283.	0.57
4	1	1	91	3.1	7.6	-1.4	280.	0.55
4	2	1	92	0.2	7.7	-0.3	333.	0.65
4	3	1	93	3.7	7.8	3.7	187.	0.36
4	4	1	94	0.0	10.5	6.3	275.	0.53
4	5	1	95	0.0	12.5	8.0	353.	0.67
4	6	1	96	0.0	16.1	4.2	356.	0.66
4	7	1	97	0.7	9.2	6.0	213.	0.39
4	8	1	98	0.0	12.1	6.9	343.	0.63
4	9	1	99	0.0	14.1	2.1	325.	0.52
4	10	1	100	6.0	11.6	4.3	134.	0.24
4	11	1	101	1.1	12.0	11.2	254.	0.45
4	12	1	102	1.4	11.5	7.4	68.	0.12
4	13	1	103	0.7	12.5	2.7	415.	0.72
4	14	1	104	1.2	12.8	5.1	63.	0.11
4	15	1	105	0.3	13.8	5.4	335.	0.57
4	16	1	106	1.0	17.7	3.8	372.	0.63
4	17	1	107	0.2	16.9	7.7	314.	0.52
4	18	1	108	1.9	20.0	7.0	266.	0.44
4	19	1	109	2.6	15.3	8.5	229.	0.38
4	20	1	110	0.1	21.5	11.4	436.	0.71
4	21	1	111	2.3	16.4	4.0	371.	0.60
4	22	1	112	5.9	15.6	1.6	470.	0.75
4	23	1	113	0.3	16.1	5.1	544.	0.86
4	24	1	114	0.4	14.8	9.3	80.	0.13
4	25	1	115	1.4	15.9	10.9	232.	0.36
4	26	1	116	3.0	12.7	9.1	242.	0.38
4	27	1	117	10.6	14.3	11.3	157.	0.24
4	28	1	118	2.3	16.2	6.9	283.	0.43
4	29	1	119	0.7	16.7	9.0	216.	0.33
4	30	1	120	0.0	16.9	7.7	503.	0.76
5	1	1	121	0.0	16.1	8.7	500.	0.75
5	2	1	122	0.0	18.3	12.6	435.	0.65
5	3	1	123	0.0	17.1	12.1	399.	0.59
5	4	1	124	0.0	13.4	4.0	393.	0.58
5	5	1	125	6.3	16.1	4.2	385.	0.56
5	6	1	126	0.0	15.9	5.8	500.	0.72
5	7	1	127	0.0	18.3	7.1	478.	0.69
5	8	1	128	0.0	19.5	8.2	518.	0.74
5	9	1	129	0.0	12.0	9.5	247.	0.35
5	10	1	130	0.0	13.0	7.5	393.	0.56
5	11	1	131	3.9	13.6	6.1	355.	0.50
5	12	1	132	3.1	14.7	7.2	338.	0.47

5	13	1	133	7.9	16.9	8.2	390.	0.54
5	14	1	134	11.0	19.7	10.9	422.	0.58
5	15	1	135	0.0	20.9	8.0	422.	0.58
5	16	1	136	1.6	18.2	8.9	364.	0.50
5	17	1	137	3.1	22.9	8.0	523.	0.71
5	18	1	138	1.0	21.4	7.4	407.	0.55
5	19	1	139	1.5	22.3	7.2	537.	0.73
5	20	1	140	0.5	19.4	6.4	262.	0.35
5	21	1	141	0.2	19.8	6.8	431.	0.58
5	22	1	142	1.9	16.6	6.8	278.	0.37
5	23	1	143	0.4	18.4	8.8	374.	0.50
5	24	1	144	0.5	19.5	10.0	312.	0.41
5	25	1	145	16.6	17.1	8.8	589.	0.78
5	26	1	146	0.3	15.0	9.9	538.	0.71
5	27	1	147	0.0	17.4	4.5	481.	0.63
5	28	1	148	0.0	21.8	8.7	518.	0.68
5	29	1	149	0.0	20.3	6.4	546.	0.71
5	30	1	150	11.7	20.5	9.2	538.	0.70
5	31	1	151	0.4	25.4	11.8	612.	0.79
6	1	1	152	10.9	24.6	8.5	427.	0.55
6	2	1	153	0.4	24.3	11.1	420.	0.54
6	3	1	154	0.8	24.4	10.8	545.	0.70
6	4	1	155	0.0	26.9	14.2	451.	0.58
6	5	1	156	3.5	23.3	11.0	306.	0.39
6	6	1	157	6.8	25.4	10.5	330.	0.42
6	7	1	158	0.6	22.8	10.8	274.	0.35
6	8	1	159	0.0	26.2	10.6	472.	0.60
6	9	1	160	0.0	21.0	10.2	550.	0.70
6	10	1	161	2.0	20.0	9.9	484.	0.62
6	11	1	162	6.5	17.1	10.0	426.	0.54
6	12	1	163	19.3	17.8	10.6	305.	0.39
6	13	1	164	3.4	17.9	10.2	229.	0.29
6	14	1	165	0.0	20.2	8.5	501.	0.64
6	15	1	166	2.9	24.3	11.0	435.	0.55
6	16	1	167	0.0	25.5	13.2	451.	0.57
6	17	1	168	0.0	26.1	11.5	599.	0.76
6	18	1	169	9.6	23.9	15.6	258.	0.33
6	19	1	170	2.6	27.3	18.5	76.	0.10
6	20	1	171	0.0	22.7	15.1	322.	0.41
6	21	1	172	0.5	21.0	13.3	379.	0.48
6	22	1	173	0.0	21.9	13.7	543.	0.69
6	23	1	174	0.0	18.9	10.0	513.	0.65
6	24	1	175	0.0	21.7	10.5	580.	0.73
6	25	1	176	1.4	21.4	9.7	619.	0.78
6	26	1	177	4.3	25.9	14.2	488.	0.62
6	27	1	178	6.3	27.6	15.2	521.	0.66
6	28	1	179	0.0	22.0	10.4	556.	0.71
6	29	1	180	0.0	23.4	7.1	560.	0.71
6	30	1	181	0.0	20.3	9.3	407.	0.52
7	1	1	182	0.0	19.1	10.6	567.	0.72
7	2	1	183	0.0	20.0	8.3	484.	0.62
7	3	1	184	0.0	25.7	10.6	537.	0.69
7	4	1	185	0.0	25.5	7.7	482.	0.62
7	5	1	186	0.0	26.8	13.5	519.	0.67
7	6	1	187	0.4	22.7	13.1	383.	0.49
7	7	1	188	0.9	24.2	12.0	394.	0.51
7	8	1	189	1.7	22.6	10.8	451.	0.58
7	9	1	190	4.9	21.6	13.7	230.	0.30
7	10	1	191	0.0	20.1	9.2	427.	0.56
7	11	1	192	0.0	18.8	8.0	424.	0.55
7	12	1	193	0.0	20.1	7.0	469.	0.61
7	13	1	194	0.0	24.4	10.1	612.	0.80
7	14	1	195	0.0	24.1	9.7	490.	0.65

7	15	1	196	0.0	22.0	10.1	451.	0.60
7	16	1	197	0.0	22.4	10.4	373.	0.49
7	17	1	198	0.0	21.8	10.0	495.	0.66
7	18	1	199	5.2	22.9	11.7	291.	0.39
7	19	1	200	3.5	21.6	14.6	147.	0.20
7	20	1	201	5.8	25.3	12.1	507.	0.68
7	21	1	202	0.8	20.3	9.2	307.	0.42
7	22	1	203	0.3	19.6	9.0	390.	0.53
7	23	1	204	13.1	23.1	12.5	474.	0.65
7	24	1	205	24.0	27.4	11.9	498.	0.68
7	25	1	206	0.0	32.8	12.6	505.	0.70
7	26	1	207	0.0	28.8	15.0	465.	0.64
7	27	1	208	0.0	33.3	14.3	391.	0.54
7	28	1	209	0.0	31.6	17.1	335.	0.47
7	29	1	210	0.0	33.5	17.6	503.	0.71
7	30	1	211	0.0	30.5	17.8	585.	0.83
7	31	1	212	0.0	26.7	13.6	602.	0.86
8	1	1	213	0.0	24.0	13.9	401.	0.57
8	2	1	214	1.5	25.0	14.3	497.	0.71
8	3	1	215	0.2	20.1	11.1	212.	0.31
8	4	1	216	2.7	19.0	11.7	435.	0.63
8	5	1	217	0.0	23.0	8.5	465.	0.68
8	6	1	218	0.0	25.7	9.7	505.	0.74
8	7	1	219	0.0	25.8	10.7	478.	0.71
8	8	1	220	2.0	24.7	12.6	449.	0.67
8	9	1	221	1.0	19.2	10.8	399.	0.60
8	10	1	222	1.0	21.7	9.0	149.	0.23
8	11	1	223	10.8	24.6	10.5	295.	0.45
8	12	1	224	0.4	21.6	11.2	247.	0.38
8	13	1	225	0.0	24.7	12.6	475.	0.74
8	14	1	226	0.0	23.8	10.7	385.	0.60
8	15	1	227	0.0	21.8	11.1	375.	0.59
8	16	1	228	11.3	18.3	9.6	123.	0.19
8	17	1	229	0.1	14.8	7.8	299.	0.48
8	18	1	230	0.0	18.4	9.5	358.	0.58
8	19	1	231	0.0	16.8	7.5	290.	0.47
8	20	1	232	0.0	1.8.7	7.9	342.	0.56
8	21	1	233	0.0	17.2	10.7	332.	0.55
8	22	1	234	0.0	18.2	8.7	322.	0.54
8	23	1	235	0.0	14.0	7.0	333.	0.56
8	24	1	236	0.0	20.6	4.1	368.	0.62
8	25	1	237	0.1	16.5	6.7	495.	0.85
8	26	1	238	2.6	20.9	10.6	234.	0.40
8	27	1	239	0.0	23.3	12.4	263.	0.46
8	28	1	240	1.8	21.3	13.6	252.	0.44
8	29	1	241	0.0	17.3	13.5	426.	0.76
8	30	1	242	0.2	15.5	8.3	297.	0.53
8	31	1	243	0.0	21.4	10.3	302.	0.55
9	1	1	244	0.1	15.5	5.4	342.	0.63
9	2	1	245	0.0	16.3	4.5	307.	0.57
9	3	1	246	0.0	17.8	4.8	388.	0.73
9	4	1	247	0.0	17.3	5.2	396.	0.75
9	5	1	248	13.5	15.3	5.5	468.	0.90
9	6	1	249	0.0	12.6	5.8	321.	0.62
9	7	1	250	5.5	17.7	6.4	236.	0.46
9	8	1	251	4.0	17.6	8.5	237.	0.47
9	9	1	252	3.8	16.7	10.3	75.	0.15
9	10	1	253	6.8	18.2	8.0	287.	0.58
9	11	1	254	0.1	18.6	9.4	214.	0.44
9	12	1	255	1.6	20.1	7.5	273.	0.57
9	13	1	256	0.1	20.6	9.0	142.	0.30
9	14	1	257	0.0	18.4	12.5	132.	0.28
9	15	1	258	1.3	18.6	10.2	93.	0.21

9	16	1	259	0.0	11.9	4.1	212.	0.46
9	17	1	260	0.0	15.2	4.2	249.	0.55
9	18	1	261	0.0	15.1	7.8	193.	0.43
9	19	1	262	0.0	18.9	6.0	373.	0.85
9	20	1	263	0.0	12.2	0.0	309.	0.71
9	21	1	264	0.0	19.0	1.8	413.	0.96
9	22	1	265	0.0	15.7	2.0	272.	0.64
9	23	1	266	0.0	13.4	2.0	287.	0.69
9	24	1	267	0.0	16.7	5.0	317.	0.77
9	25	1	268	0.0	16.2	6.9	286.	0.71
9	26	1	269	0.0	19.1	6.9	303.	0.76
9	27	1	270	9.6	20.7	7.0	233.	0.59
9	28	1	271	0.1	16.6	6.7	159.	0.41
9	29	1	272	0.9	17.6	3.0	223.	0.58
9	30	1	273	0.3	12.0	2.0	231.	0.61
10	1	1	274	2.7	8.7	3.9	106.	0.29
10	2	1	275	0.0	14.7	3.0	339.	0.93
10	3	1	276	1.8	13.1	3.2	252.	0.70
10	4	1	277	0.0	12.2	4.6	228.	0.64
10	5	1	278	7.8	12.0	3.6	139.	0.40
10	6	1	279	0.2	8.4	3.1	115.	0.34
10	7	1	280	0.0	11.1	0.5	219.	0.65
10	8	1	281	2.7	11.8	1.3	82.	0.25
10	9	1	282	3.2	9.3	1.0	51.	0.16
10	10	1	283	0.2	9.1	5.8	103.	0.32
10	11	1	284	0.0	12.7	3.3	136.	0.43
10	12	1	285	0.0	14.5	6.6	210.	0.68
10	13	1	286	0.0	8.2	2.1	140.	0.46
10	14	1	287	0.0	11.8	3.5	175.	0.59
10	15	1	288	0.0	9.6	6.2	159.	0.54
10	16	1	289	0.4	12.1	2.7	94.	0.33
10	17	1	290	2.1	8.8	4.2	14.	0.05
10	18	1	291	0.0	11.0	0.6	175.	0.63
10	19	1	292	0.0	16.2	-0.7	217.	0.79
10	20	1	293	0.3	14.3	5.9	61.	0.23
10	21	1	294	4.2	15.4	5.4	138.	0.52
10	22	1	295	0.1	14.7	2.9	88.	0.34
10	23	1	296	0.0	15.2	6.7	177.	0.69
10	24	1	297	0.0	10.9	3.9	186.	0.75
10	25	1	298	0.8	8.5	1.0	86.	0.35
10	26	1	299	0.0	6.8	3.4	152.	0.63
10	27	1	300	1.5	8.6	7.9	52.	0.22
10	28	1	301	0.3	17.5	12.3	85.	0.37
10	29	1	302	5.1	18.6	10.2	69.	0.30
10	30	1	303	0.0	20.6	8.6	159.	0.71
10	31	1	304	0.0	12.9	6.7	110.	0.50
11	1	1	305	0.0	13.3	6.6	86.	0.40
11	2	1	306	9.2	8.3	5.1	36.	0.17
11	3	1	307	0.0	11.8	4.8	125.	0.60
11	4	1	308	0.0	9.9	1.2	93.	0.45
11	5	1	309	0.0	11.5	5.6	53.	0.26
11	6	1	310	2.3	8.4	7.0	10.	0.05
11	7	1	311	7.0	13.0	3.3	15.	0.07
11	8	1	312	2.9	12.6	6.4	12.	0.06
11	9	1	313	14.0	11.5	0.7	16.	0.09
11	10	1	314	7.5	18.0	5.9	12.	0.07
11	11	1	315	4.1	16.9	7.9	9.	0.05
11	12	1	316	3.5	15.5	7.9	9.	0.05
11	13	1	317	0.0	14.7	8.0	49.	0.28
11	14	1	318	0.0	11.9	6.5	59.	0.35
11	15	1	319	0.0	13.6	5.9	99.	0.59
11	16	1	320	9.2	9.3	6.0	8.	0.05
11	17	1	321	1.0	3.5	-0.6	8.	0.05

11	18	1	322	0.0	4.6	-2.1	84.	0.53
11	19	1	323	0.6	7.2	-3.7	8.	0.05
11	20	1	324	3.6	3.9	2.4	8.	0.05
11	21	1	325	1.7	3.0	0.0	8.	0.05
11	22	1	326	3.0	4.4	4.2	7.	0.05
11	23	1	327	0.0	2.5	0.1	55.	0.37
11	24	1	328	0.0	3.4	2.4	65.	0.45
11	25	1	329	0.0	5.8	1.2	55.	0.38
11	26	1	330	4.4	4.0	1.1	7.	0.05
11	27	1	331	2.1	3.9	0.4	7.	0.05
11	28	1	332	2.4	7.9	0.2	7.	0.05
11	29	1	333	0.0	4.8	-1.8	64.	0.47
11	30	1	334	0.0	2.8	-7.8	71.	0.53
12	1	1	335	3.0	4.9	-7.5	7.	0.05
12	2	1	336	6.4	4.5	-4.3	7.	0.05
12	3	1	337	2.7	6.2	2.5	6.	0.05
12	4	1	338	1.7	8.8	5.3	6.	0.05
12	5	1	339	0.0	9.7	3.9	51.	0.40
12	6	1	340	0.7	5.2	4.7	6.	0.05
12	7	1	341	1.5	9.7	-0.6	6.	0.05
12	8	1	342	1.2	5.8	-0.7	6.	0.05
12	9	1	343	2.4	5.2	4.3	6.	0.05
12	10	1	344	0.0	4.1	0.2	62.	0.51
12	11	1	345	0.0	7.9	-2.4	55.	0.46
12	12	1	346	2.5	6.4	-0.8	6.	0.05
12	13	1	347	0.8	5.4	5.1	20.	0.16
12	14	1	348	0.0	6.9	3.5	43.	0.36
12	15	1	349	1.1	8.8	3.2	6.	0.05
12	16	1	350	0.0	14.3	6.3	43.	0.36
12	17	1	351	0.0	15.9	7.9	47.	0.40
12	18	1	352	0.0	16.8	9.2	44.	0.37
12	19	1	353	12.2	9.7	9.1	6.	0.05
12	20	1	354	0.7	6.1	3.9	6.	0.05
12	21	1	355	5.7	2.8	0.4	6.	0.05
12	22	1	356	0.8	6.3	5.4	6.	0.05
12	23	1	357	0.1	5.2	-1.4	6.	0.05
12	24	1	358	0.9	0.9	-1.6	6.	0.05
12	25	1	359	2.2	0.2	-7.9	6.	0.05
12	26	1	360	3.4	-0.7	-4.4	6.	0.05
12	27	1	361	0.3	-0.8	-4.6	6.	0.05
12	28	1	362	0.0	-2.4	-5.7	36.	0.30
12	29	1	363	7.0	-0.9	-5.0	6.	0.05
12	30	1	364	0.7	4.2	2.4	6.	0.05
12	31	1	365	1.6	5.3	2.8	6.	0.05

SUMMARY OF THE SIMULATION FOR YEAR 1

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)
JAN.	19	48.0	2.2	-1.8	132.5
FEB.	16	76.2	4.1	-0.1	358.7
MAR.	20	72.6	9.3	2.8	842.5
APR	24	50.8	14.0	6.2	1206.3
MAY	18	71.9	18.1	8.1	1819.9
JUNE	17	81.7	22.9	11.5	1816.6
JULY	11	60.6	24.5	11.7	1861.2
AUG.	16	35.7	20.6	10.2	1457.9
SEP.	14	47.7	16.7	6.0	1112.3
OCT.	16	33.6	12.2	4.3	582.7
NOV.	17	78.6	8.7	2.8	159.4
DEC.	23	59.8	5.9	1.1	72.4
TOTAL	211	717.2			
AVER.	—	—	13.3	5.2	951.9

SUMMARY FOR 1YEARS

MONTH	WET DAYS	RAINFAL (MM)	MAX TEMP (C)	MIN TEMP (C)	SOLAR RAD (J/CM2/DAY)
JAN.	19.	48.0	2.2	-1.8	31.7
FEB.	16.	76.2	4.1	-0.1	85.7
MAR.	20.	72.6	9.3	2.8	201.4
APR	24.	50.8	14.0	6.2	288.3
MAY	18.	71.9	18.1	8.1	435.0
JUNE	17.	81.7	22.9	11.5	434.2
JULY	11.	60.6	24.5	11.7	444.8
AUG.	16.	35.7	20.6	10.2	348.5
SEP.	14.	47.7	16.7	6.0	265.9
OCT.	16.	33.6	12.2	4.3	139.3
NOV.	17.	78.6	8.7	2.8	38.1
DEC.	23.	59.8	5.9	1.1	17.3
TOTAL	211.	717.2			
AVER.	—	—	13.3	5.2	227.5

PQD