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A Microcomputer-based Weather Simulator of the Soybean and Peanut Growing Regions of Alabama

A MICROCOMPUTER-BASED WEATHER SIMULATOR FOR THE SOYBEAN AND PEANUT GROWING REGIONS OF ALABAMA

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INTRODUCTION

A microcomputer-based weather simulation model can be used for a "hard" and a "soft" application. A hard application means that the model can be used to control a man-made weather environment, such as a weather chamber or greenhouse (2), and a soft application means the use of a model in weather-dependent management, such as agricultural crop management. Both applications are increasingly needed in agricultural research. Use of observed weather data provides a solution which is based on only one weather scenario. No weather data are available for some locations, which limits model utility. A weather model is often required for solving these problems so that weather-dependent IPM strategies can be assessed.

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Described herein is a stochastic weather model that generates weather data for the soybean and peanut growing regions in Alabama. Nine locations were examined in these regions: Belle Mina, Birmingham, Fairhope, Headland, Huntsville, Marion Junction, Mobile, Muscle Shoals, and Selma, figure 1.

MODEL DESCRIPTION

The simulation model can generate daily maximum and minimum temperatures (tmax and tmin), precipitation (p), and solar radiation (r). Called ALWGEN, it has been developed from WGEN, which is a weather model for simulating weather in 139 locations in the United States (6). ALWGEN is written in GWBASIC (1) for IBM compatible personal computers with a 5.25-inch disk drive. The model provides daily weather data (tmax, tmin, p, and r) for an arbitrary n-year period at one of the 11 previously mentioned locations. ALWGEN keeps the all structural characteristics of WGEN. Its temperature and solar radiation generation parameters are evaluated with interpolation from the results by Richardson and Wright (6). Principles and assumptions used in ALWGEN are the same as those in WGEN. The model consists of three sets of algorithms: a first-order Markov chain, a gamma distribution, and two sets of weakly stationary generating process equations. The Markov chain determines the occurrence of rain on any given day. The outcome of this not only determines whether precipitation should be given a zero value for that day, but also influences daily maximum and minimum temperatures and solar radiation. Rainfall amount is generated with a gamma distribution according to whether rainfall occurs on that day. A weakly stationary process (6) is used in simulating daily maximum and minimum temperatures and solar radiation. The model mimics seasonal characteristics of actual weather data for the given locations.

Precipitation: The precipitation component of ALWGEN is a two-part algorithm which contains the Markov chain and the gamma distribution. The Markov chain has two parameters: P(W/W) and P(W/D), denoting transitional probabilities of a wet day followed by a wet day, and a wet day followed by a dry day, respectively. A wet day is defined as a day with ≥0.01 inch of rain. The probability density function of p is given by:

$$f(p)=exp(\alpha\, ln\beta+(\alpha-1)\, ln p-\beta p\, ln(e)-ln(\Gamma(\alpha))), \quad p,\ \alpha,\ \beta>0$$

where $f(p)$ is the probability density function of p, the α and β are shape and scale parameters, respectively; $\Gamma(\alpha)$ is the gamma function of α, and e is the base of natural logarithms; *exp* and *ln* are notations of exponential and natural logarithmic functions, respectively. For $0<\alpha<1$, $f(p)$ decreases with increasing p, and this is appropriate rainfall since small amounts occur more frequently than large amounts.

The four parameters, P(W/W), P(W/D), α, and β, are called rainfall generation parameters. They are constant for a given month but vary from month to month. Using 20 years of actual weather data, Richardson and Wright (6) estimated the parameters for 139 locations in the United States. Three were in Alabama: Birmingham, Mobile, and Montgomery.

A geographical nearest-neighbor technique was employed to estimate the rainfall generation parameters for other locations in Alabama, figure 1. The method used the parameters for Birmingham, Mobile, or Montgomery as a starting point in an optimal searching technique for the parameters of the locations nearest to each of these cities.

An assumption is made for locations where no information is available on the mean number of wet days per month that there exists an identifiable series of wet and dry days for that location, and that the series is similar to the city used as the starting point. This implies that values of P(W/W) and P(W/D) remain those which were estimated by Richardson and Wright (6). For example, P(W/W) and P(W/D) have same values for Auburn, Selma, Marion Junction, and Headland as for Montgomery. Thus, the estimation of four parameters descends to two-parameter problem. Only α and β need to be estimated.

Estimation of α and β can be done with a method of random perturbation on the basis of the relationship $\beta = M/\alpha$, where M is the arithmetic mean of daily precipitation for wet days. Grey target bleaching was used for optimization as described in Shen and Mack (8,9), for α and β at each of the eight locations other than Birmingham, Montgomery and Mobile, table 1.

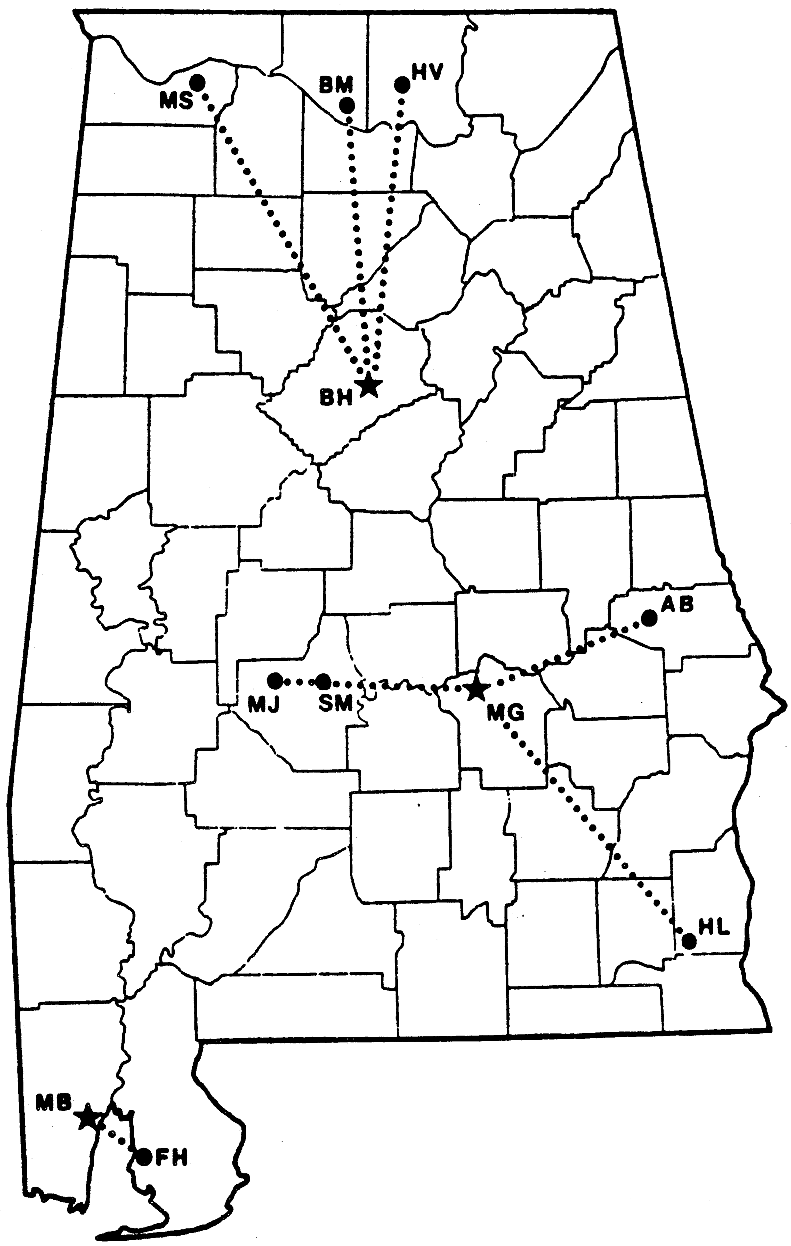

Fig. 1. Locations in Alabama chosen for weather simulation by ALWGEN. Stars indicate locations where parameter estimates were estimated by Richardson and Wright (6), and dots indicate locations where parameters were estimated by research reported in this paper. Dashed lines indicate the nearest-neighbor location used for the estimation of P(W/W) and P(W/D). AB=Auburn, BH=Birmingham, BM=Belle Mina, FH=Fairhope, HL=Headland, HV=Huntsville, MB=Mobile, MG=Montgomery, MJ=Marion Junction, MS=Muscle Shoals, and SM=Selma.

Temperature and Solar Radiation: The procedure for generating daily values of tmax, tmin, and r has been presented by Richardson (5). They are determined by multiplying the residuals by a seasonal standard deviation and adding a seasonal mean using the equation:

$$t_i(j)=m_i(j)[X_i(j) \cdot c_i(j)+1]$$

where $t_i(j)$ is the daily value of tmax (j=1), tmin (j=2), and r (j=3); $X_i(j)$ is the residual; $m_i(j)$ is the mean; and $c_i(j)$ is the coefficient of variation for day i.

The $X_i(j)$ may be generated with the weakly stationary generating process (4), described by

$$X_i(j)=AX_{i-1}(j)+B\epsilon_i(j)$$

where $\epsilon_i(j)$ is a (3 x 1) matrix of independent random components that are normally distributed with a mean of zero and a variance of unity, A and B are (3 X 3) matrices whose elements are defined such that the new sequences of residuals have the desired serial correlation and cross-correlation coefficients. The values of the elements have been calculated by Richardson and Wright (6) and have not been changed in ALWGEN.

The values of $m_i(j)$ and $c_i(j)$ change seasonally and are both dependent on the wet or dry status as determined from the precipitation component of the model. The change is described by a finite Fourier series:

$$u_i = \ddot{u} + C \cdot \cos(2\pi/365 \cdot (i-T)), \quad i=1, \ldots, 365$$

where u_i is the value of the $m_i(j)$ or $c_i(j)$ on day i, $\ddot{u}$ is mean of u_i, C is the amplitude of the harmonic, and T is the position of the harmonic in days. Values of ü, C, and T must be determined for the mean and coefficient of variation of each weather variable (tmax, tmin, r). The values of T for temperature (tmax, tmin) are assumed to be 200 days, and for solar radiation to be 172 days for any location in the United States. The values of ü and C have been estimated from weather data and have been plotted in contour maps by Richardson and Wright (6). The values of ü and C for ALWGEN were obtained by interpolation in the contour maps, table 2.

The ALWGEN Program: ALWGEN can be used to generate daily values of precipitation, maximum temperature, minimum temperature, and solar radiation. The program listing of ALWGEN is in the appendix, and inputs required for the program are shown in table 3. A compiled version of the program is available upon request from the second author.

This program maintains the function of precipitation and temperature correction of WGEN (6). There will be differences between simulated and actual weather patterns caused by the temporal and spatial smoothing that is inherent in the model and by topographic features inherent to the location. Procedures are incorporated that correct these differences if actual mean monthly values are available.

The precipitation correction factor for a given month is calculated as the mean monthly precipitation from actual data divided by the mean monthly precipitation generated with the Markov chain and gamma distribution algorithms. The generated daily precipitation amounts are multiplied by the precipitation correction factor for the appropriate month to obtain a corrected precipitation amount.

Temperature correction is based on the actual mean monthly temperature. Temperature correction is calculated as the differences between the actual mean monthly temperature for the location and the mean monthly temperature theoretically generated using the parameters for the location. The user may choose to (1) make no corrections, (2) correct both precipitation and temperature, (3) correct only precipitation, or (4) correct only temperature. The codes that are required for the various options are given in the list of inputs in table 3.

The program prints daily values of the four variables, and a summary of the monthly and annual amounts is printed at the end of each year. At the end of the n-year run, the mean monthly and mean annual amount is also printed.

<u>Comparison of ALWGEN weather variables to observed data:</u> Mean monthly observed values for rainfall amount and maximum and minimum temperatures at Belle Mina, Headland, and Selma were compared to values generated by ALWGEN for model validation. Observed values for weather variables were obtained from the National Weather Service. The residuals (observed minus generated values) were tested for normality with a Shapiro-Wilk

test (7). These analyses evaluated the null hypothesis that the residuals are normally distributed. A probability level of ≥0.05 indicates that the residuals are normally distributed, and that a statistically acceptable model has been used to describe the data.

RESULTS AND DISCUSSION

The ALWGEN model has been tested for all of the eight selected locations in the peanut and soybean growing regions of Alabama. A 30-year sample of weather data was generated for each location. Several statistics were selected in comparing the generated weather data with observed data. The following statistics were compared for each month: mean precipitation amount, mean daily maximum temperature, and mean daily minimum temperature, tables 4-6. The null hypothesis that the residuals were not normally distributed could not be rejected (P >0.05) at any of the three locations tested. Thus, ALWGEN was a statistically acceptable description of the rainfall and temperature data at all three locations.

Richardson and Wright (6) indicated that in most instances, the differences between observed and WGEN generated temperature and solar radiation values were due to the actual data not having a simple sinusoidal shape as assumed in the model. They suggested that this could be corrected by the use of the actual weather data as previously described. The correction options provide generated daily values that compare very closely with the monthly means derived from the actual observations. Mean monthly precipitation and/or temperatures for selected locations are compiled by the National Climatic Center and are available from a number of sources.

The usefulness of this model is in its ability to stochastically simulate weather events in 11 locations in Alabama. Several variables could be calculated from these simulated data, such as the mean number of consecutive wet days per month and the number of days per month with a daily maximum temperature of ≥95°F. These variables could be used to determine the probability of the occurrence of a specific plant disease or the probability of a given growth rate of an insect population in a given month. Probabilistic calculations such as these can be informative and cannot be done with observed weather data. Further, ALWGEN could be connected with pest or plant models to simulate population growth, such as ***AUSIMM***, the ***A***uburn ***U***niversity ***I***ntegrated ***S***oybean ***M***anagement ***M***odel (3). This would allow for realistic plant growth or pest development scenarios to be simulated.

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Table 1. Rainfall Generation Parameters, 11 locations[1]

Location		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Auburn	P(W/W)	0.447	0.456	0.435	0.380	0.475	0.457	0.436	0.408	0.514	0.444	0.348	0.471
	P(W/D)	0.269	0.289	0.262	0.219	0.185	0.220	0.317	0.264	0.166	0.117	0.175	0.279
	α	0.758	0.691	0.863	0.853	0.718	0.714	0.724	0.771	0.543	0.728	0.820	0.725
	β	0.797	0.680	0.944	1.037	0.755	0.635	0.801	0.496	1.179	0.720	0.773	0.788
Belle Mina	P(W/W)	0.491	0.505	0.475	0.444	0.530	0.481	0.548	0.426	0.480	0.395	0.457	0.495
	P(W/D)	0.264	0.299	0.285	0.245	0.183	0.220	0.307	0.265	0.175	0.144	0.213	0.267
	α	0.643	0.669	0.683	0.746	0.687	0.639	0.851	0.670	0.676	0.677	0.797	0.647
	β	0.710	0.701	0.943	0.818	0.764	0.645	0.456	0.529	0.744	0.724	0.648	0.769
Birmingham	P(W/W)	0.491	0.505	0.475	0.444	0.530	0.481	0.548	0.426	0.480	0.395	0.457	0.495
	P(W/D)	0.264	0.299	0.285	0.245	0.183	0.220	0.307	0.265	0.175	0.144	0.213	0.267
	α	0.643	0.640	0.648	0.712	0.675	0.626	0.802	0.660	0.676	0.630	0.715	0.647
	β	0.710	0.765	0.845	0.724	0.662	0.699	0.499	0.629	0.744	0.716	0.593	0.769
Fairhope	P(W/W)	0.419	0.483	0.514	0.340	0.419	0.547	0.593	0.515	0.538	0.444	0.375	0.493
	P(W/D)	0.294	0.286	0.257	0.197	0.202	0.280	0.446	0.351	0.232	0.135	0.193	0.271
	α	0.577	0.629	0.675	0.515	0.644	0.624	0.713	0.768	0.672	0.675	0.665	0.667
	β	0.766	0.816	0.875	1.434	0.902	0.796	0.697	0.626	1.102	0.875	0.828	0.786

Headland	P(W/W)	0.447	0.456	0.435	0.380	0.475	0.457	0.436	0.408	0.514	0.444	0.348	0.471
	P(W/D)	0.269	0.289	0.262	0.219	0.185	0.220	0.317	0.264	0.166	0.117	0.175	0.279
	α	0.755	0.697	0.699	0.668	0.647	0.798	0.629	0.863	0.611	0.636	0.686	0.691
	β	0.767	0.749	0.786	0.939	0.885	0.733	0.892	0.631	1.011	0.747	0.811	0.687
Huntsville	P(W/W)	0.491	0.505	0.475	0.444	0.530	0.481	0.548	0.426	0.480	0.395	0.457	0.495
	P(W/D)	0.264	0.299	0.285	0.275	0.183	0.220	0.307	0.265	0.175	0.144	0.213	0.267
	α	0.643	0.640	0.648	0.712	0.773	0.626	0.802	0.729	0.676	0.630	0.747	0.683
	β	0.710	0.765	0.845	0.724	0.684	0.699	0.499	0.454	0.744	0.716	0.799	0.742
Marion Jct.	P(W/W)	0.447	0.456	0.435	0.380	0.475	0.457	0.436	0.408	0.514	0.444	0.348	0.471
	P(W/D)	0.269	0.289	0.262	0.219	0.185	0.220	0.317	0.264	0.166	0.117	0.175	0.279
	α	0.760	0.737	0.800	0.690	0.683	0.715	0.620	0.838	0.546	0.601	0.755	0.691
	β	0.622	0.706	0.784	0.927	0.716	0.697	0.648	0.471	1.179	0.767	0.647	0.687
Mobile	P(W/W)	0.419	0.483	0.514	0.340	0.419	0.547	0.593	0.515	0.538	0.444	0.375	0.493
	P(W/D)	0.294	0.286	0.257	0.197	0.202	0.280	0.446	0.351	0.232	0.135	0.193	0.271
	α	0.577	0.629	0.556	0.512	0.644	0.623	0.713	0.686	0.548	0.645	0.613	0.624
	β	0.766	0.816	0.969	1.434	0.902	0.799	0.697	0.774	1.109	0.659	0.628	0.894

Montgomery	P(W/W)	0.447	0.456	0.435	0.380	0.475	0.457	0.436	0.408	0.514	0.444	0.348	0.471
	P(W/D)	0.269	0.289	0.262	0.219	0.185	0.220	0.317	0.264	0.166	0.117	0.175	0.279
	α	0.713	0.691	0.699	0.634	0.634	0.706	0.620	0.762	0.546	0.601	0.684	0.691
	β	0.525	0.680	0.786	0.852	0.681	0.589	0.648	0.408	1.179	0.767	0.619	0.687
Muscle Shoals	P(W/W)	0.491	0.505	0.475	0.444	0.530	0.481	0.548	0.426	0.480	0.395	0.457	0.495
	P(W/D)	0.264	0.299	0.285	0.245	0.183	0.220	0.307	0.265	0.175	0.144	0.213	0.267
	α	0.643	0.675	0.688	0.755	0.719	0.626	0.802	0.707	0.676	0.630	0.762	0.647
	β	0.710	0.663	0.913	0.678	0.724	0.699	0.499	0.481	0.744	0.716	0.665	0.769
Selma	P(W/W)	0.447	0.456	0.435	0.380	0.475	0.457	0.436	0.408	0.514	0.444	0.348	0.471
	P(W/D)	0.269	0.289	0.262	0.219	0.185	0.220	0.317	0.264	0.166	0.117	0.175	0.279
	α	0.760	0.737	0.800	0.690	0.683	0.715	0.620	0.838	0.546	0.601	0.755	0.691
	β	0.622	0.706	0.784	0.927	0.716	0.697	0.648	0.471	1.179	0.767	0.647	0.687

[1]For Birmingham, Mobile, and Montgomery, the parameters are from Richardson and Wright (6).

Table 2. Temperature and solar radiation generation parameters, 11 locations[1]

Location	ALAT	TXMD	ATX	CVTX	ACVTX	TXMW	TN	ATN	CVTN	ACVTN	RMD	AR	RMW
Auburn	32.7	74.5	18.0	0.110	-0.076	72.5	54.0	18.1	0.150	-0.120	455	170	272
Belle Mina	34.75	72.0	20.6	0.130	-0.089	70.5	50.7	19.7	0.193	-0.142	441	192	259
Birmingham	33.1	73.3	19.9	0.120	-0.084	71.7	52.3	18.9	0.175	-0.130	446	183	264
Fairhope	30.5	77.3	15.8	0.096	-0.067	74.7	57.9	16.3	0.138	-0.093	462	165	283
Headland	31.3	75.8	16.5	0.100	-0.070	74.0	55.8	17.0	0.143	-0.100	460	167	282
Huntsville	34.7	72.0	20.5	0.129	-0.084	71.7	52.3	18.9	0.175	-0.130	442	190	259
Marion Jct .	32.4	75.3	18.1	0.107	-0.076	73.5	55.3	17.9	0.152	-0.109	452	175	271
Mobile	30.7	77.1	16.0	0.098	-0.070	74.8	57.7	16.5	0.145	-0.095	461	167	281
Montgomery	32.4	74.9	18.2	0.106	-0.074	73.0	55.0	17.6	0.150	-0.110	455	172	275
Muscle Shoals	34.7	72.0	21.2	0.13	-0.090	70.5	50.8	19.8	0.193	-0.143	440	193	259
Selma	32.4	75.2	18.0	0.11	-0.075	73.5	55.2	17.8	0.151	-0.109	453	174	273

[1]Variable names are identical to those in WGEN.

Table 3. Important Program Variables and Their Description (Values of the Inputs are Shown in tables 1 and 2)

Input no.	Variable name	Description	Source
1	ACOM	Up to 80 characters of user comments.	User supplied
2	NYRS	Number of years of data to be generated.	User supplied
	ALAT	location latitude, degrees.	User supplied
3	KTCF	Temperature correction factor code 0, if no temperature correction 1, if some correction factor for maximum and minimum temperatures	User supplied
	KRFC	Rainfall correction factor code 0, if no precipitation correction 1, if precipitation to be corrected.	User supplied
4	PWW(I)	Monthly probability of wet day given wet on previous day.	Program
5	PWD(I)	Monthly probability of wet day given dry on previous day.	Program

6	ALPHA(I)	Monthly values of gamma distribution shape parameter.	Program
7	BETA(I)	Monthly values of gamma distribution scale parameter.	Program
8	TXMD	Mean of tmax (dry)	Program
	ATX	Amplitude of tmax (wet or dry)	Program
	CVTX	Mean of coef. of var. of tmax (wet or dry).	Program
	ACVTX	Amplitude of coef. of var. of tmax (wet or dry).	Program
9	TXMW	Mean of tmax (wet)	Program
10	TN	Mean of tmin (wet or dry)	Program
	ATN	Amplitude of tmin (wet or dry)	Program
	CVTN	Mean of coef. var. tmin (wet or dry)	Program
	ACVTN	Amplitude of coef. var. tmin (wet or dry).	Program
11	RMD	Mean of r (dry)	Program
	AR	Amplitude of r (wet or dry)	Program
12	RMW	Mean of r (wet)	Program
13	TM(I)	Monthly values of actual mean temperature (°F).	User supplied[1]
14	RM(I)	Monthly values of actual mean precipitation amount (in.).	User supplied[1]

[1]Necessary only if temperature and/or rainfall correction is requested by the user.

Table 4. Comparison of ALWGEN-generated Weather Variables with National Weather Service Means, Belle Mina

Variable	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Precipitation													
No. of wet days													
Observed mean	--[1]	--	--	--	--	--	--	--	--	--	--	--	--
Generated mean	9.17	9.57	9.27	8.57	8.57	8.10	12.9	9.37	7.50	5.47	7.40	9.53	105.4
Amount (in.)													
Observed mean	5.21	4.64	6.50	4.82	4.36	3.38	4.54	3.23	3.71	2.94	4.39	5.37	--
Generated mean	4.66	4.81	6.87	4.22	4.26	3.55	4.95	3.56	3.70	2.67	4.14	5.23	52.62
Temperature													
Daily maximum (°F)													
Observed mean	50.4	55.0	63.2	74.2	81.3	87.9	90.6	90.5	84.6	74.5	62.8	53.8	--
Generated mean	51.0	53.6	60.6	70.5	81.0	88.8	92.0	89.0	82.3	72.5	62.6	54.3	71.5
Daily minimum (°F)													
Observed mean	30.3	32.5	39.7	48.9	56.7	63.9	67.3	66.0	60.2	47.3	38.2	32.6	--
Generated mean	30.4	32.7	39.5	49.6	59.9	67.2	70.1	67.6	60.8	51.3	41.8	34.0	50.4
Solar radiation													
Mean daily (ly.)													
Observed mean	--	--	--	--	--	--	--	--	--	--	--	--	--
Generated mean	205.7	246.9	329.0	421.0	478.5	511.1	445.5	430.3	378.8	308.6	225.2	190.7	347.6

[1]Missing data.

Table 5. Comparison of ALMGEN-generated Weather Variables with National Weather Service Means, Headland

Variable	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Precipitation													
No. of wet days													
Observed mean	--[1]	--	--	--	--	--	--	--	--	--	--	--	
Generated mean	9.77	8.63	9.07	7.57	6.93	8.93	10.4	9.77	7.23	5.03	5.80	9.87	99.0
Amount (in.)													
Observed mean	5.27	4.96	5.44	4.58	4.35	4.62	5.95	4.96	4.08	2.33	3.23	4.88	--
Generated mean	6.04	4.84	5.33	4.13	3.87	4.90	5.86	5.33	4.20	2.25	3.15	5.04	54.9
Temperature													
Daily maximum (°F)													
Observed mean	58.8	62.3	69.7	78.8	84.8	89.9	90.9	90.5	87.1	78.6	68.8	61.6	--
Generated mean	58.6	59.9	65.1	73.3	81.1	87.7	90.1	88.2	82.7	74.0	66.3	60.3	74.0
Daily minimum (°F)													
Observed mean	37.0	39.3	46.0	54.5	61.8	67.6	70.0	69.6	66.0	54.0	44.4	38.6	--
Generated mean	39.5	41.0	46.4	55.1	63.3	70.0	72.5	70.6	64.7	56.3	47.5	41.4	55.7
Solar radiation													
Mean daily (ly.)													
Observed mean	--	--	--	--	--	--	--	--	--	--	--	--	--
Generated mean	235.1	275.8	343.8	439.1	493.7	499.6	457.2	431.2	398.1	339.2	274.1	217.9	367.1

[1]Missing data.

Table 6. Comparison of ALWGEN-generated Weather Variables with National Weather Service Means, Selma

Variable	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Precipitation													
No. of wet days													
Observed mean	--[1]	--	--	--	--	--	--	--	--	--	--	--	
Generated mean	9.13	9.20	11.0	7.27	8.18	8.50	10.6	9.43	6.43	5.00	6.03	10.4	101.2
Amount (in.)													
Observed mean	4.87	4.84	6.90	5.05	4.01	4.20	4.61	3.47	4.15	2.81	3.13	5.47	--
Generated mean	4.72	4.91	5.98	4.68	4.03	4.38	4.28	3.03	4.24	2.50	3.09	5.27	51.11
Temperature													
Daily maximum (°F)													
Observed mean	58.3	62.7	70.2	78.9	85.5	91.1	92.8	92.6	88.2	79.0	68.1	61.1	--
Generated mean	57.6	59.9	64.7	74.0	82.7	90.0	92.4	90.3	84.4	75.8	65.7	58.7	74.7
Daily minimum (°F)													
Observed mean	37.8	40.2	46.8	54.1	61.8	68.4	71.4	70.8	66.0	53.6	44.0	39.4	--
Generated mean	37.2	39.8	45.5	54.3	63.0	70.1	72.8	70.6	64.4	55.8	46.5	39.5	55.0
Solar radiation													
Mean daily (ly.)													
Observed mean	--	--	--	--	--	--	--	--	--	--	--	--	--
Generated mean	225.9	269.7	339.7	434.6	484.2	505.9	458.6	436.9	389.2	329.9	258.5	210.1	362.0

[1]Missing data.

APPENDIX

Program lisiting for ALWGEN

```
5 KEY OFF
10 REM Stochastic Alabama Weather Simulator
15 REM Written by Z. R. Shen, People's Republic of China
17 REM Version 1.0, June 7, 1988
20 WIDTH "lptl:",137
30 LPRINT CHR$(27);CHR$(15)
32 COLOR 7,1,1
33 CLS:COLOR 4,7,1
34 PRINT TAB(22) "ALWGEN Weather Simulator" TAB(160):COLOR 7,1,1
36 LOCATE 10,1:PRINT" This program simulates daily weather at one of 11
locations within the peanut  and soybean growing regions of Alabama.  It can be
used for stochastic"
37 PRINT"simulation modeling and for estimation of pest growth/development rates
in"
38 PRINT"normal years.  The program requires a printer.  Please verify that the
printer  is ready."
39 LOCATE 20,20:PRINT" Press any key to continue":A$=INKEY$:IF A$="" THEN GOTO
39
45 V=TIMER
50 RANDOMIZE (V)
1000 DIM TXM(366),TXS(366),TXM1(366),TXS1(366),TNM(366),TNS(366),RMO(366),
RSO(366),RM1(366),RS1(366),RC(366),RAIN(366),TMAX(366),TMIN(366),RAD(366)
1010 DIM ACOM$(20)
1020 DIM NI(12),SR(12),SSTX(12),SSTN(12),SSRAD(12),SRAIN(12),STMAX(12),
STMIN(12), SRAD(12),NII(12)
1030 DIM PWW(12),PWD(12),ALPHA(12),BETA(12)
1040 DIM TM(12),PW(12),TG(12),RM(12),RG(12),RCF(12),TCF(12),NWET(12),XNW(12)
```

```
1050 DIM TAMAX(12),TAMIN(12)
1060 DIM TTMAX(12),TTMIN(12),TCFMAX(12),TCFMIN(12)
1070 DIM A(3,3),B(3,3),XIM1(3),E(3),R(3),X(3),RR(3)
1080 FOR I=1 TO 12:READ NI(I):NEXT I
1090 FOR J=1 TO 12:READ NII(J):NEXT J
1100 LLC=1:CLS:COLOR 4,7,1
1105 PRINT TAB(22) "ALWGEN Weather Simulator" TAB(160):COLOR 7,1,1:LOCATE 5,1
1110 INPUT "Enter the number of years data to be simulated:";NYRS
1111 IF NYRS<1 OR NYRS>10 THEN GOTO 1100
1112 CLS:COLOR 4,7,1
1115 PRINT TAB(22) "ALWGEN Weather Simulator" TAB(160):COLOR 7,1,1:LOCATE 5,1
1120 KGEN=1
1121 IF KGEN <>1 AND KGEN <>2 THEN GOTO 1112
1122 CLS:COLOR 4,7,1
1124 PRINT TAB(22) "ALWGEN Weather Simulator" TAB(160):COLOR 7,1,1:LOCATE 5,1
1130 PRINT "KTCF=0: No temp. correction will be made;
1150 PRINT "KTCF=1: Max. and min. temp corrected based on observed mean monthly
temp."
1152 INPUT "Please enter a value for KTCF";KTCF
1153 IF KTCF<>0 AND KTCF<>1 THEN GOTO 1122
1155 CLS:COLOR 4,7,1
1157 PRINT TAB(22) "ALWGEN Weather Simulator" TAB(160):COLOR 7,1,1:LOCATE 5,1
1158 PRINT "KRCF=0: No correction will be made to simulated rainfall data."
1160 PRINT "KRCF=1: Rain will be corrected based on observed mean monthly rain"
1165 INPUT "Please enter a value for KRCF=";KRCF
1170 IF KRCF<>1 AND KRCF<>0  THEN GOTO 1155
1180 PRINT :PRINT
```

```
1190 FOR I=1 TO 3
1200   FOR J=1 TO 3
1210     READ A(I,J)
1220   NEXT J,I
1230 FOR I=1 TO 3
1240     FOR J=1 TO 3
1250         READ B(I,J)
1260 NEXT J,I
1290 LC=0
1300 LC=LC+1: IF LC>LLC GOTO 7000
1305 CLS:COLOR 4,7,1
1306 PRINT TAB(22) "ALWGEN Weather Simulator" TAB(160):COLOR 7,1,1:LOCATE 5,1
1310 LOCATE 5,5:PRINT"Please select one location for simulation of 365 days of
daily weather"
1315 LOCATE  9,10:PRINT"1. Auburn"
1320 LOCATE 10,10:PRINT"2. Belle Mina"
1321 LOCATE 11,10:PRINT"3. Birmingham"
1322 LOCATE 12,10:PRINT"4. Fairhope"
1323 LOCATE 13,10:PRINT"5. Headland"
1324 LOCATE 14,10:PRINT"6. Huntsville"
1325 LOCATE 15,10:PRINT"7. Marion Junction"
1326 LOCATE 16,10:PRINT"8. Mobile"
1327 LOCATE 17,10:PRINT"9. Montgomery"
1328 LOCATE 18,10:PRINT"10. Muscle Shoals"
1329 LOCATE 19,10:PRINT"11. Selma"
1330 LOCATE 21,10:COLOR 14,1,1:PRINT"Enter a number and press ENTER";:COLOR
7,1,1
```

```
1332 INPUT ANS

1334 IF ANS <1 OR ANS>12 THEN GOTO 1330

1336 IF ANS=1 THEN NAM$="AUBURN"

1337 IF ANS=2 THEN NAM$="BELLE MINA"

1338 IF ANS=3 THEN NAM$="BIRMINGHAM"

1339 IF ANS=4 THEN NAM$="FAIRHOPE"

1340 IF ANS=5 THEN NAM$="HEADLAND"

1341 IF ANS=6 THEN NAM$="HUNTSVILLE"

1342 IF ANS=7 THEN NAM$="MARION JUNCTION"

1343 IF ANS=8 THEN NAM$="MOBILE"

1344 IF ANS=9 THEN NAM$="MONTGOMERY"

1345 IF ANS=10 THEN NAM$="MUSCLE SHOALS"

1346 IF ANS=11 THEN NAM$="SELMA"

1347 READ NAMELOC$

1348 IF NAM$ <> NAMELOC$ GOTO 1340

1360 READ ALAT

1380 READ TXMD,ATX,CVTX,ACVTX

1400 READ TXMW

1420 READ TMN,ATMN,CVTN,ACVTN

1440 READ RMD,AR

1460 READ RMW

1700 LPRINT "* NAME OF LOCATION STUDIED: ";NAMELOC$

1710 LPRINT "* ALAT=STATION LATITUDE: ";ALAT:LPRINT

1720 LPRINT "MAXIMUM TEMP:";TAB(20)"TXMD="TXMD;TAB(32)"ATX="ATX;

TAB(44)"CVTX="CVTX; TAB(56)"ACVTX="ACVTX;TAB(68)"TXMW="TXMW

1730 LPRINT"MINIMUM TEMP:"TAB(20)"TMN="TMN;TAB(32)"ATMN="ATMN;

TAB(44)"CVTN="CVTN;TAB(56)"ACVTN="ACVTN
```

```
1740 LPRINT"SOLAR RADIATION:"TAB(20)"RMD="RMD;TAB(32)"AR="AR;TAB(44)"RMW="RMW
2090 REM calculate maximum solar radiation for each day
2100 XLAT=ALAT*6.2832/360
2105 CLS
2200 FOR I=1 TO 366
2210    XI=I:LOCATE 10,20:PRINT "Loop number three: Day=";I
2220    SD=.4102*SIN(.0172*(XI-80.25))
2230    CH=-TAN(XLAT)*TAN(SD)
2240    IF CH>1 THEN H=0: GOTO 2270
2250    IF CH<-1 THEN H=3.1416: GOTO 2270
2260    H=1.570796-ATN(CH/SQR(1-CH*CH))
2270    DD=1+.0335*SIN(.0172*(XI+88.2))
2280    RC(I)=889.2305*DD*((H*SIN(XLAT)*SIN(SD))+(COS(XLAT)*COS(SD)*SIN(H)))
2290    RC(I)=RC(I)*.8
2300 NEXT I
2400 FOR I=1 TO 12
2410    TTMAX(I)=0:TTMIN(I)=0:RM(I)=0
2420 NEXT I
2500 IF KGEN=2 THEN 2569
2510 REM following rainfall parameters are:
2512 REM PWW(I) -- 12 monthly values of P(W/W), probability of given wet
2514 REM PWD(I) -- 12 monthly values of P(W/D), probability of given dry
2516 REM ALPHA(I) -- 12 monthly values of shape parameter of gamma distribution
2518 REM BETA(I) -- 12 monthly values of scale parameter of gamma distribution
2520 FOR I=1 TO 12
2522    READ PWW(I)
2524 NEXT I
```

```
2528 FOR I=1 TO 12
2530     READ PWD(I)
2532 NEXT I
2534 FOR I=1 TO 12
2536     READ ALPHA(I)
2538 NEXT I
2540 FOR I=1 TO 12
2542     READ BETA(I)
2544 NEXT I
2569 CVRD=.24:ACVRD=-.08:CVRW=.48:ACVRW=-.13
2570 D1=TXMD-TXMW:D2=RMD-RMW
2580 IF KTCF=0 GOTO 2800
2602 PRINT "You have selected that you will supply monthly temperature datato
the program.  The data should be in the following format:  XX.X  XX.X  (degrees
F). Supply 12 temperature estimates.";
2603 PRINT "Enter one line for each year that you wish to simulate.":PRINT:PRINT
2604 PRINT " Please enter the file name and drive designation for the
temperature data.  For example, A:Weath.dta";
2605 INPUT FILNAM3$
2606 OPEN FILNAM3$ FOR INPUT AS #3
2607 FOR I=1 TO 12
2610     INPUT#3,TM(I)
2620 NEXT I
2630 GOTO 2800
2652 FOR I=1 TO NYRS
2653     INPUT#2,TTMAX(1),TTMAX(2),TTMAX(3),TTMAX(4),TTMAX(5),
TTMAX(6),TTMAX(7),TTMAX(8),TTMAX(9),TTMAX(10),TTMAX(11),TTMAX(12)
```

```
2655    INPUT#2,TTMIN(1),TTMIN(2),TTMIN(3),TTMIN(4),TTMIN(5),
TTMIN(6),TTMIN(7),TTMIN(8),TTMIN(9),TTMIN(10),TTMIN(11),TTMIN(12)
2657 NEXT I
2800 IF KRCF=0 GOTO 2840
2802 CLS:COLOR 4,7,1
2804 PRINT TAB(22) "ALWGEN Weather Simulator" TAB(160):COLOR 7,1,1:LOCATE 5,1
2806 PRINT "You have selected that you will supply monthly rainfall to the
program.  The data should be in the following format:  XX.X  XX.X  (inches).
Supply 12 rainfall  estimates.";
2807 PRINT "Enter one line for each year that you wish to simulate.":PRINT:PRINT
2808 PRINT " Please enter the file name and drive designation for the rainfall
data.  For example, A:Weath.dta";
2810 INPUT FILNAM3$
2812 OPEN FILNAM3$ FOR INPUT AS #3
2815 FOR IJ=1 TO NYRS
2820    INPUT#3,RM(1),RM(2),RM(3),RM(4),RM(5),RM(6),RM(7),RM(8),
RM(9),RM(10),RM(11),RM(12)
2830 NEXT IJ
2840 FOR I=1 TO 12
2850    RCF(I)=1
2860 NEXT I
2870 LPRINT:LPRINT
2910 LPRINT
2920 LPRINT
"Mo.";TAB(5)"Day";TAB(10)"Yr.";TAB(15)"Date";TAB(25)"Rain";TAB(40)"Max.
Temp.";TAB(55)"Min. Temp.";TAB(70)"Sol. Rad.":LPRINT
2930 LPRINT
```

```
2940 ' FOR IK=1 TO 9
2950 PRINT ACOM$(IK);
2970 PRINT TAB(23)"P(W/W)  ";
3000 ' FOR I=1 TO 12
3010 ' PRINT USING "#.###  ";PWW(I);
3020 ' NEXT I
3030 ' PRINT TAB(23)"P(W/D)  ";
3040 ' FOR J=1 TO 12
3050 ' PRINT USING "#.###  ";PWD(J);
3060 ' NEXT J
3070 ' PRINT TAB(23)"ALPHA   ";
3080 ' FOR K=1 TO 12
3090 ' PRINT USING "#.###  ";ALPHA(K);
3100 ' NEXT K
3110 ' PRINT TAB(23)"BETA    ";
3120 ' FOR I=1 TO 12
3130 ' PRINT USING "#.###  ";BETA(I);
3140 ' NEXT I
3170 ' PRINT
3180 ' NEXT IK
3200 ' PRINT "MAXIMUM TEMP:";TAB(20)"TXMD="TXMD;TAB(32)"ATX="ATX;
TAB(44)"CVTX="CVTX; TAB(56)"ACVTX="ACVTX;TAB(68)"TXMW="TXMW
3210 ' PRINT"MINIMUM TEMP:"TAB(20)"TMN="TMN;TAB(32)"ATMN="ATMN;
TAB(44)"CVTN="CVTN;TAB(56)"ACVTN="ACVTN
3220 ' PRINT"SOLAR RADIATION:"TAB(20)"RMD="RMD;TAB(32)"AR="AR;TAB(44)"RMW="RMW
3299 CLS
3300 FOR J=1 TO 366
```

```
3305     LOCATE 10,20:PRINT "Loop number two: Day=";J

3310     XJ=J:DT=COS(.0172*(XJ-200)):DR=COS(.0172*(XJ-172))

3320     TXM(J)=TXMD+ATX*DT

3330     XCR1=CVTX+ACVTX*DT

3340     IF XCR1<0 THEN XCR1=.06

3350     TXS(J)=TXM(J)*XCR1

3360     TXM1(J)=TXM(J)-D1

3370     TXS1(J)=TXM1(J)*XCR1

3380     TNM(J)=TMN+ATMN*DT

3390     XCR2=CVTN+ACVTN*DT

3400     IF XCR2<0 THEN XCR2=.06

3410     TNS(J)=TNM(J)*XCR2

3420     RMO(J)=RMD+AR*DR

3430     XCR3=CVRD+ACVRD*DR

3450     IF XCR3<0 THEN XCR3=.06

3460     RSO(J)=RMO(J)*XCR3

3470     RM1(J)=RMO(J)-D2

3480     XCR4=CVRW+ACVRW*DR

3500     IF XCR4<0 THEN XCR4=.06

3530     RS1(J)=RM1(J)*XCR4

3550     NEXT J

3600 FOR IM=1 TO 12

3610     XNW(IM)=0:SR(IM)=0:SSTX(IM)=0:SSTN(IM)=0:

SSRAD(IM)=0:TCFMAX(IM)=0:TCFMIN(IM)=0

3620     PW(IM)=PWD(IM)/(1-PWW(IM)+PWD(IM))

3630     S1=0:S2=0:S3=0

3640     NL=NI(IM)
```

```
3650    IF IM=1 GOTO 3680
3660    NF=NI(IM-1)+1
3670    GOTO 3700
3680    NF=1
3700    ZN=NL-NF+1
3800    FOR J=NF TO NL
3810      S1=S1+TXM(J)/ZN
3820      S2=S2+TXM1(J)/ZN
3830      S3=S3+TNM(J)/ZN
3840    NEXT J
3850    IF KGEN=2 GOTO 3950
3900 ' CALCULATE MONTHLY RAINFALL CORRECTION FACTOR
3910    RG(IM)=ALPHA(IM)*BETA(IM)*ZN*PW(IM)
3920    IF KRCF=0 GOTO 3940
3930    RCF(IM)=RM(IM)/RG(IM)
3940    IF KTCF=0 GOTO 4080
3950 ' CALCULATE MONTHLY TEMP CORRECTION FACTOR
3960    IF KTCF=2 GOTO 4010
3970    TMD=(S1+S3)/2:TMW=(S2+S3)/2
3980    TG(IM)=TMW*PW(IM)+TMD*(1-PW(IM))
3990    TCFMAX(IM)=TM(IM)-TG(IM):TCFMIN(IM)=TCFMAX(IM)
4000    GOTO 4080
4010    TAMAX(IM)=S2*PW(IM)+S1*(1-PW(IM)):TAMIN(IM)=S3
4050    IF KTCF=0 GOTO 4080
4060    TCFMAX(IM)=TTMAX(IM)-TAMAX(IM)
4070    TCFMIN(IM)=TTMIN(IM)-TAMIN(IM)
4080 NEXT IM
```

```
4100 IF KRCF=0 GOTO 4300
4140 LPRINT"ACT MEAN RAIN   ";
4150 FOR I=1 TO 12
4160     LPRINT USING "#.### ";RM(I);
4170 NEXT I
4180 IF KGEN=2 GOTO 4300
4200 LPRINT"EST MEAN RAIN   ";
4210 FOR J=1 TO 12
4220    LPRINT USING "#.### ";RG(J);
4230 NEXT J
4250 LPRINT"RAIN CF         ";
4260 FOR K=1 TO 12
4270    LPRINT USING "#.### ";RCF(K);
4280 NEXT K
4300 IF KTCF=0 GOTO 4800
4310 IF KTCF=2 GOTO 4430
4330 LPRINT"ACT MEAN TEMP   ";
4340 FOR I=1 TO 12
4350    LPRINT USING "#.### ";TM(I);
4360 NEXT I
4380 LPRINT"EST MEAN TEMP   ";
4390 FOR J=1 TO 12
4400    LPRINT USING "#.### ";TG(J);
4410 NEXT J
4420 GOTO 4630
4430 LPRINT"ACT MEAN TMAX   ";
4440 FOR I=1 TO 12
```

```
4450    LPRINT USING "#.### ";TTMAX(I);
4460 NEXT I
4480 LPRINT"ACT MEAN TMIN     ";
4490 FOR J=1 TO 12
4500    LPRINT USING "#.### ";TTMIN(J);
4510 NEXT J
4530 LPRINT"EST MEAN TMAX     ";
4540 FOR I=1 TO 12
4550    LPRINT USING "#.### ";TAMAX(I);
4560 NEXT I
4580 LPRINT"EST MEAN TMIN     ";
4590 FOR J=1 TO 12
4600    LPRINT USING "#.### ";TAMIN(J);
4610 NEXT J
4630 LPRINT"CF. MEAN TMAX     ";
4640 FOR I=1 TO 12
4650    LPRINT USING "#.### ";TCFMAX(I);
4660 NEXT I
4670 LPRINT"CF. MEAN TMIN     ";
4680 FOR J=1 TO 12
4690    LPRINT USING "#.### ";TCFMIN(J);
4700 NEXT J
4800 XYR=NYRS
4810 SYTX=0:SYTN=0:SYRAD=0:SYR=0:SYNW=0
5000 FOR II=1 TO NYRS
5010    IYR=II
5020    IF KGEN=1 GOTO 5060
```

```
5030    KK=0:IJ=1
5050    IF KK=1 GOTO 5110
5060    IDAYS=365
5070    FLG=IYR MOD 4
5080    IF FLG=0 THEN IDAYS=366
5090    KK=1
5100    IF KGEN=1 GOTO 5150
5110    IJ=IJ+1
5150    GOSUB 10000
5170    FOR IM=1 TO 12
5180        SRAIN(IM)=0:STMAX(IM)=0:STMIN(IM)=0:SRAD(IM)=0:NWET(IM)=0
5190    NEXT IM
5200    IM=1:YTMAX=0:YTMIN=0:YRAD=0:RYR=0:NYWET=0:IDA=0
5300    FOR J=1 TO IDAYS
5310      IDA=IDA+1
5320      IF IDAYS=366 GOTO 5380
5330      IF J>NI(IM) GOTO 5350
5340      GOTO 5410
5350      IM=IM+1
5360      IDA=1
5370      GOTO 5410
5380      IF J>NII(IM) GOTO 5350
5410      LPRINT IM;TAB(5)IDA;TAB(10)IYR;TAB(15)J;TAB(25)RAIN(J);
TAB(40)TMAX(J);TAB(55)TMIN(J);TAB(70)RAD(J)
5500      IF RAIN(J)<.01 GOTO 5530
5510      NWET(IM)=NWET(IM)+1
5520      NYWET=NYWET+1
```

```
5530     SRAIN(IM)=SRAIN(IM)+RAIN(J)
5540     STMAX(IM)=STMAX(IM)+TMAX(J)
5550     STMIN(IM)=STMIN(IM)+TMIN(J)
5560     SRAD(IM)=SRAD(IM)+RAD(J)
5570     RYR=RYR+RAIN(J)
5590   NEXT J
5600   XNM1=0
5610   FOR IM=1 TO 12
5620     XXN=NI(IM)
5630     XNI=XXN-XNM1
5640     XNM1=XXN
5650     ANW=NWET(IM)
5660     XNW(IM)=XNW(IM)+ANW/XYR
5670     SR(IM)=SR(IM)+SRAIN(IM)/XYR
5680     STMAX(IM)=STMAX(IM)/XNI
5690     SSTX(IM)=SSTX(IM)+STMAX(IM)/XYR
5700     STMIN(IM)=STMIN(IM)/XNI
5710     SSTN(IM)=SSTN(IM)+STMIN(IM)/XYR
5720     SRAD(IM)=SRAD(IM)/XNI
5730     SSRAD(IM)=SSRAD(IM)+SRAD(IM)/XYR
5740     YTMAX=YTMAX+STMAX(IM)/12
5750     YTMIN=YTMIN+STMIN(IM)/12
5760     YRAD=YRAD+SRAD(IM)/12
5780   NEXT IM
5800   SYTX=SYTX+YTMAX/XYR
5810   SYTN=SYTN+YTMIN/XYR
5820   SYRAD=SYRAD+YRAD/XYR
```

```
5830    SYR=SYR+RYR/XYR
5840    XYNW=NYWET
5850    SYNW=SYNW+XYNW/XYR
5855    LPRINT:LPRINT
5860    LPRINT"SUMMARY FOR YEAR ";IYR
5900    LPRINT"MONTH";TAB(16)"JAN";TAB(23)"FEB";TAB(30)"MAR";
TAB(37)"APR";TAB(44)"MAY";TAB(51)"JUNE";TAB(58)"JULY";
TAB(65)"AUG";TAB(72)"SEPT";TAB(79)"OCT";TAB(86)"NOV";TAB(93)"DEC";TAB(100)"YR"
5910    PRINT"WET DAYS";TAB(15)" ";
5920    FOR IM=1 TO 12
5930      PRINT USING "##.##  ";NWET(IM);
5940    NEXT IM
5950    PRINT TAB(100)NYWET
6000    PRINT"RAINFALL";TAB(15)" ";
6010    FOR IM=1 TO 12
6020      PRINT USING "#.###  ";SRAIN(IM);
6030    NEXT IM
6040    PRINT TAB(100)RYR
6100    PRINT"AVE MAX TEMP";TAB(15)" ";
6110    FOR IM=1 TO 12
6120      PRINT USING "##.##  ";STMAX(IM);
6130    NEXT IM
6150    PRINT TAB(100)YTMAX
6160    PRINT"AVE MIN TEMP";TAB(15)" ";
6170    FOR IM=1 TO 12
6180      PRINT USING "##.##  ";STMIN(IM);
6190    NEXT IM
```

```
6200    PRINT TAB(100)YTMIN
6210    PRINT"AVE RAD";TAB(15)" ";
6220    FOR IM=1 TO 12
6230      PRINT USING "###.#  ";SRAD(IM);
6240    NEXT IM
6250    PRINT TAB(100)YRAD
6300 NEXT II
6370 LPRINT :PRINT
6410 LPRINT "WET DAYS";TAB(15)" ";
6420 FOR IM=1 TO 12
6430   LPRINT USING "##.##  ";XNW(IM);
6440 NEXT IM
6450 LPRINT TAB(100)SYNW
6480 LPRINT "RAINFALL";TAB(15)" ";
6490 FOR IM=1 TO 12
6500    LPRINT USING "#.###  ";SR(IM);
6510 NEXT IM
6520 LPRINT TAB(100)SYR
6540 LPRINT "AVE MAX TEMP";TAB(15)" ";
6550 FOR IM=1 TO 12
6560   LPRINT USING "##.##  ";SSTX(IM);
6570 NEXT IM
6580 LPRINT TAB(100)SYTX
6600 LPRINT "AVE MIN TEMP";TAB(15)" ";
6610 FOR IM=1 TO 12
6620   LPRINT USING "##.##  ";SSTN(IM);
6630 NEXT IM
```

```
6640 LPRINT TAB(100)SYTN
6650 LPRINT "AVE RAD";TAB(15)" ";
6660 FOR IM=1 TO 12
6670   LPRINT USING "###.#  ";SSRAD(IM);
6680 NEXT IM
6690 LPRINT TAB(100)SYRAD
6800 LPRINT :LPRINT
6850 GOTO 1300
7000 END
10000 REM THE FOLLOWING SUBROUTINE GENERATES DAILY WEATHER DATA FOR ONE YEAR
10010 IF KGEN=1 GOTO 10050
10020 GOSUB 13000
10050 FOR I=1 TO 3
10051    XIM1(I)=0
10052 NEXT I
10070 IX=9398039!:IP=0
10100 IM=1:CLS
10110 FOR IDAY=1 TO IDAYS
10120    LOCATE 10,20:PRINT"Loop number one: Day=";IDAY
10150    IF IDAYS=366 GOTO 10190
10160    IF IDAY>NI(IM) THEN IM=IM+1
10170    GOTO 10200
10190    IF IDAY>NII(IM) THEN IM=IM+1
10200    IF KGEN=2 GOTO 10805
10210 REM DETERMINE WET OR DRY DAY USING MARKOV CHAIN MODEL
10240    RN=RND
10250    IF IP<=0 GOTO 10260 ELSE 10370
```

```
10260     IF RN<=PWD(IM) GOTO 10380 ELSE 10300
10300     IP=0
10330     RAIN(IDAY)=0
10340     GOTO 10870
10370     IF RN<=PWW(IM) GOTO 10380 ELSE 10300
10380     IP=1
10400 REM DETERMINE RAINFALL AMOUNT FOR WET DAYS USING GAMMA DISTRIBUTION
10430     AA=1/ALPHA(IM):AB=1/(1-ALPHA(IM))
10440     TR1=EXP(-18.42/AA):TR2=EXP(-18.42/AB)
10460     SUM=0:SUM2=0
10500     RN1=RND:RN2=RND
10530 IF RN1<=TR1 GOTO 10550 ELSE 10580
10550 S1=0: GOTO 10600
10580     S1=RN1^AA
10600     IF RN2<=TR2 GOTO 10620 ELSE 10640
10620     S2=0: GOTO 10670
10640     S2=RN2^AB
10670     S12=S1+S2
10700     IF S12<=1 GOTO 10720 ELSE 10500
10720     Z=S1/S12
10750     RN3=RND
10760     IF RN3=0 GOTO 10750
10770     RAIN(IDAY)=-Z*LOG(RN3)*BETA(IM)*RCF(IM)
10800 REM RAIN(IDAY) IS GENERARED RAINFALL FOR IDAY
10802     GOTO 10820
10805 REM GET OBSERVED RAIN(IDAY)
10810     GOSUB 14000
```

```
10820    IF RAIN(IDAY)<.01 GOTO 10830 ELSE 10850

10830    IP=0:GOTO 10870

10850    IP=1

10870    IF IP<1 GOTO 10910 ELSE  10950

10900 REM GENERATE TMAX, TMIN, AND RAD FOR IDAY

10910    RM=RMO(IDAY):RS=RSO(IDAY)

10920    TXXM=TXM(IDAY):TXXS=TXS(IDAY)

10930    GOTO 11000

10950    RM=RM1(IDAT):RS=RS1(IDAY)

10960    TXXM=TXM1(IDAY):TXXS=TXS1(IDAY)

11000    FOR K=1 TO 3

11010       AA=0

11040       RN1=RND:RN2=RND

11050       U=SQR(-2*LOG(RN1))*COS(6.283185*RN2)

11070       IF ABS(U)>2.5 GOTO 11010

11080       E(K)=U

11090    NEXT K

11100    FOR I=1 TO 3

11120       R(I)=0:RR(I)=0

11130    NEXT I

11150    FOR I=1 TO 3

11160       FOR J=1 TO 3

11180          R(I)=R(I)+B(I,J)*E(J)

11190          RR(I)=RR(I)+A(I,J)*XIM1(J)

11200    NEXT J,I

11250    FOR K=1 TO 3

11260       X(K)=R(K)+RR(K)
```

```
11270        XIM1(K)=X(K)
11290     NEXT K
11300     TMAX(IDAY)=X(1)*TXXS+TXXM
11310     TMIN(IDAY)=X(2)*TNS(IDAY)+TNM(IDAY)
11350     IF TMIN(IDAY)>TMAX(IDAY) GOTO 11360 ELSE 11380
11360     TMM=TMAX(IDAY):TMAX(IDAY)=TMIN(IDAY):TMIN(IDAY)=TMM
11380     TMAX(IDAY)=TMAX(IDAY)+TCFMAX(IM)
11390     TMIN(IDAY)=TMIN(IDAY)+TCFMIN(IM)
11400 REM TMAX(IDAY) is generated TMAX for IDAY
11410 REM TMIN(IDAY) is generated TMIN for IDAY
11500     RAD(IDAY)=X(3)*RS+RM
11510     RMIN=.2*RC(IDAY)
11550     IF RAD(IDAY)<RMIN THEN RAD(IDAY)=RMIN
11560     IF RAD(IDAY)>RC(IDAY) THEN RAD(IDAY)=RC(IDAY)
11570 REM RAD(IDAY) is generated RAD for IDAY
11590 NEXT IDAY
11600 RETURN
12000 REM following subroutine generates a uniform random number on the
 interval 0 -- 1
12010 DIM K(4)
12050 K(1)=2510:K(2)=7692:K(3)=2456:K(4)=3765
12070 K(4)=3*K(4)+K(2):K(3)=3*K(3)+K(1)
12080 K(2)=3*K(2):K(1)=3*K(1)
12100 I=CINT(K(1)/1000):K(1)=K(1)-I*1000:K(2)=K(2)+I
12110 FIELD #1, 4 AS Y$, 4 AS M$, 4 AS D$, 10 AS R$:PRINT :PRINT
12120 I=CINT(K(3)/1000):K(3)=K(3)-I*1000:K(4)=K(4)+I
12130 I=CINT(K(4)/100):K(4)=K(4)-100*I
```

```
12150 YFL=(((K(1)*.001+K(2))*.01+K(3))*.001+K(4))*.01
12200 RETURN
13000 REM RAIN(IDAY) IS OBSERVED RAINFALL FOR IDAY
13500 RETURN
14000 REM GET RAIN(IDAY)
14160 RETURN
50000 REM DATA OF ALABAMA SOYBEAN AND PEANUT REGIONS (only rain & 100 YR)
50010 DATA 31,59,90,120,151,181,212,243,273,304,334,365:REM for NI(12)
50020 DATA 31,60,91,121,152,182,213,244,274,305,335,366:REM for NII(12)
50030 DATA .567,.253,-.006,.086,.504,-.039,-.002,-.05,.244
50040 DATA .781,.328,.238,0,.637,-.341,0,0,.873
50100 DATA AUBURN
50110 DATA 32.7,74.5,18,.11,-.076,72.5,54,18.1,.15,-.12,455,170,272
50120 DATA .447,.456,.435,.380,.475,.457,.436,.408,.514,.444,.348,.471
50130 DATA .269,.289,.262,.219,.185,.220,.317,.264,.166,.117,.175,.279
50140 DATA .758,.691,.712,.681,.648,.706,.620,.762,.546,.634,.679,.691
50150 DATA .546,.680,.809,.884,.703,.589,.652,.408,1.179,.793,.621,.687
50160 DATA 50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0
50200 DATA BELLE MINA
50210 DATA 34.75,72,20.6,.13,-.089,70.5,50.7,19.7,.193,-.142,441,192,259
50220 DATA .491,.505,.475,.444,.530,.481,.548,.426,.480,.395,.457,.495
50230 DATA .264,.299,.285,.245,.183,.220,.307,.265,.175,.144,.213,.267
50240 DATA .643,.649,.683,.746,.687,.639,.852,.670,.676,.677,.797,.647
50250 DATA .710,.701,.943,.818,.764,.645,.456,.529,.744,.724,.648,.769
50260 DATA 50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0
50300 DATA BIRMINGHAM
50310 DATA 33.1,73.3,19.9,.12,-.084,71.7,52.3,18.9,.175,-.13,446,183,264
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```
50320 DATA .491,.505,.475,.444,.530,.481,.548,.426,.480,.395,.457,.495
50330 DATA .264,.299,.285,.245,.183,.220,.307,.265,.175,.144,.213,.267
50340 DATA .643,.640,.648,.712,.675,.626,.802,.660,.676,.630,.715,.647
50350 DATA .710,.765,.845,.724,.662,.699,.499,.629,.744,.716,.593,.769
50360 DATA 43.9,46.9,53.4,63.3,70.5,77.4,79.9,79.2,73.9,63.3,52.0,45.3
50400 DATA FAIRHOPE
50410 DATA 30.5,77.3,15.8,.096,-.067,74.7,57.9,16.3,.138,-.093,462,165,283
50420 DATA .419,.483,.514,.340,.419,.547,.593,.515,.538,.444,.375,.493
50430 DATA .294,.286,.257,.197,.202,.280,.446,.351,.232,.135,.193,.271
50440 DATA .577,.634,.556,.512,.644,.623,.713,.709,.553,.658,.687,.623
50450 DATA .766,.794,.969,1.434,.902,.799,.697,.776,1.132,.658,.616,.896
50460 DATA 50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0
50500 DATA HEADLAND
50510 DATA 31.3,73.8,16.5,.1,-.07,74,55.8,17,.143,-.1,460,167,282
50520 DATA .447,.456,.435,.380,.475,.457,.436,.408,.514,.444,.348,.471
50530 DATA .269,.289,.262,.219,.185,.220,.317,.264,.166,.117,.175,.279
50540 DATA .755,.697,.699,.668,.647,.798,.629,.863,.611,.636,.686,.691
50550 DATA .767,.749,.786,.939,.885,.733,.892,.631,1.011,.747,.811,.687
50560 DATA 50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0
50600 DATA HUNTSVILLE
50610 DATA 34.7,72,20.5,.129,-.084,71.7,52.3,18.9,.175,-.13,442,190,259
50620 DATA .491,.505,.475,.444,.530,.481,.548,.426,.480,.395,.457,.495
50630 DATA .264,.299,.285,.245,.183,.220,.307,.265,.175,.144,.213,.267
50640 DATA .643,.655,.658,.712,.675,.626,.802,.634,.676,.630,.724,.647
50650 DATA .710,.764,.846,.724,.662,.699,.499,.616,.744,.716,.600,.769
50660 DATA 40.8,43.7,50.7,61.7,69.6,76.8,79.5,79.0,72.9,62.1,50.2,42.4
50700 DATA MARION JUNCTION
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50710 DATA 32.4,75.3,18.1,.107,-.076,73.5,55.3,19.7,.152,-.109,452,175,271
50720 DATA .447,.456,.435,.380,.475,.457,.436,.408,.514,.444,.348,.471
50730 DATA .269,.289,.262,.219,.185,.220,.317,.264,.166,.117,.175,.279
50740 DATA .764,.691,.739,.638,.634,.714,.620,.767,.552,.616,.701,.691
50750 DATA .546,.680,.837,.858,.681,.587,.648,.401,1.185,.763,.624,.687
50760 DATA 50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0
50800 DATA MOBILE
50810 DATA 30.7,77.1,16,.098,-.07,74.8,57.7,16.5,.145,-.095,461,167,281
50820 DATA .419,.483,.514,.340,.419,.547,.593,.515,.538,.444,.375,.493
50830 DATA .294,.286,.257,.197,.202,.280,.446,.351,.232,.135,.193,.271
50840 DATA .577,.629,.556,.512,.644,.623,.713,.686,.548,.645,.613,.624
50850 DATA .766,.816,.969,1.434,.902,.799,.697,.774,1.109,.659,.628,.894
50860 DATA 51.1,54.0,59.4,67.8,74.3,80.2,81.5,81.5,77.5,68.9,58.5,52.9
50900 DATA MONTGOMERY
50910 DATA 32.4,74.9,18.2,.106,-.074,73,55,17.6,.15,-.11,455,172,275
50920 DATA .447,.456,.435,.380,.475,.457,.436,.408,.514,.444,.348,.471
50930 DATA .269,.289,.262,.219,.185,.220,.317,.264,.166,.117,.175,.279
50940 DATA .713,.691,.699,.634,.634,.706,.620,.762,.546,.601,.684,.691
50950 DATA .525,.680,.786,.852,.681,.589,.648,.408,1.179,.767,.619,.687
50960 DATA 47.5,50.5,56.7,65.3,72.5,79.0,81.1,80.0,75.9,65.7,54.9,48.6
51000 DATA MUSCLE SHOALS
51010 DATA 34.7,72,21.2,.13,-.09,70.5,50.8,19.8,.193,-.143,440,193,259
51020 DATA .491,.505,.475,.444,.530,.481,.548,.426,.480,.395,.457,.495
51030 DATA .264,.299,.285,.245,.183,.220,.307,.265,.175,.144,.213,.267
51040 DATA .643,.584,.648,.712,.682,.626,.817,.660,.676,.632,.715,.647
51050 DATA .710,.839,.845,.724,.671,.699,.501,.629,.744,.723,.593,.769
51060 DATA 50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0
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```
51100 DATA SELMA
51110 DATA 32.4,75.2,18,.11,-.075,73.5,55.2,17.8,.151,-.109,453,174,273
51120 DATA .447,.456,.435,.380,.475,.457,.436,.408,.514,.444,.348,.471
51130 DATA .269,.289,.262,.219,.185,.220,.317,.264,.166,.117,.175,.279
51140 DATA .760,.737,.800,.690,.683,.715,.620,.838,.548,.601,.756,.703
51150 DATA .622,.706,.784,.927,.716,.700,.648,.471,1.083,.767,.647,.802
51160 DATA 50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0,50.0
```