ESTIMATION OF IRRIGATION REQUIREMENT FOR VENEZUELA

by

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ABSTRACT

Estimation of Irrigation Requirement for Venezuela

by

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Christiansen's formula was used to compute evaporation and potential evapotranspiration using 1013 months of data from 19 stations in Venezuela.

Thirteen probability levels of precipitation were determined for each station.

Potential irrigation requirements for 16 stations were computed based on gamma distribution of 5 probability levels subtracted from the potential evapotranspiration.

A formula for computing precipitation at any level of probability
eveloped based on gamma distribution and average monthly value
s of record available.

(113 pages)

INTRODUCTION

During the last decade the Venezuelan Government has given much attention to problems related to irrigation water requirements in order to provide better planning and effective management of its irrigation projects. The irrigation requirements of crops to be grown on new projects must be estimated in advance in order to know the amount of water that will be needed for irrigation of the new area to be developed.

The irrigation water requirement is defined as the amount of water required to maintain the desired soil moisture and salinity level during the crop growing season, in addition to precipitation. This is basically a function of two basic parameters:

1. Effective precipitation
2. Evapotranspiration

Other factors that may affect the irrigation water requirement are: topography, soil characteristics, carry-over soil moisture, economical and social environment, ground water contribution, and water application efficiency.

Effective precipitation supplies a portion of the water needed by the crop; the remaining part must be supplied by irrigation in order to maintain an adequate soil moisture level.

The amount of water required for leaching is directly proportional to the evapotranspiration, ET, and the concentration of the salt in the irrigation water, and inversely proportional to salinity tolerance of the crop. The water application efficiency has to be considered when planning irrigation projects because the estimated overall water requirement is inversely proportional to this estimated parameter.

All factors concerned with the soil and crops to be grown can best be considered on a specific project basis. Part of the overall irrigation requirement is dependent upon the climate and, more specifically, the precipitation. The potential irrigation requirement is defined as the difference between potential evapotranspiration and this precipitation at some previously assumed dependable level, called the dependable precipitation. The terminology used in this study is defined in the next section.

The objectives of this study then are to:

1. Analyze available climatic data to enable computation of the potential evapotranspiration

2. To analyze available precipitation to determine the dependable precipitation

3. To combine the dependable precipitation and potential evapotranspiration, to determine potential irrigation water requirement.

Definition of Terms

Evaporation

Evaporation is water lost to the atmosphere due to vaporization from adjacent soil, water surface, or from surface of leaves of the plant. The main factors which affect evaporation are: incoming radiation, relative humidity, wind velocity, temperature and advective conditions.

Transpiration

Transpiration is the amount of water entering the plant through the roots and passed through the leaves of the plant into the atmosphere, also including the small amounts of water used in building plant tissue.

Evapotranspiration

Evapotranspiration, or consumptive use, is the amount of water transpired by the plants of an area during vegetative growth, and retained in plant tissue, plus the water evaporated from the adjacent surface of the soil and vegetation.

Potential Evapotranspiration

Potential evapotranspiration, ETP, is defined as the consumptive use, or the evapotranspiration loss, from a short, green, vigorously growing crop that completely shades the ground and provides full crop cover under conditions where the moisture supply does not limit the moisture use.

Dependable Precipitation

The term dependable precipitation is used to denote the precipitation that occurs on a specified probability basis.

Christiansen and Hargreaves (1971) define dependable precipitation as the mean monthly precipitation that occurs on a probability basis of three years out of four, or 75 percent of the time. This 75 percent probability level is arbitrary but has been selected by them as being practical and realistic for use in connection with irrigation requirements for agricultural conditions. Dependable precipitation data can be estimated from anaanalysis of the available precipitation data and is independent of the crop and soil factors.

Moisture Available Index (MAI)

Moisture available index (MAI) is defined by Christiansen and Hargreaves (1971) as an index of the adequacy of precipitation in supplying moisture requirements. It is computed by dividing the dependable precipitation by the potential evapotranspiration.

Net Irrigation Requirement

Net irrigation requirement is the quantity of water, exclusive of precipitation, required to maintain the desired soil moisture and salinity level during the crop season.

Irrigation Water Requirement

Irrigation water requirement is defined by the Soil Conservation

Service as the net irrigation requirement divided by the stimated irrigation efficiency.

Effective Precipitation

Effective precipitation is that part of the dependable precipitation that enters the soil and can be effectively stored and utilized by the crops grown. It excludes the surface runoff and deep percolation. Effective precipitation can best be estimated on a specific project basis where soil conditions and crops grown are known. It cannot be estimated from climatic data alone.

Crop Coefficients

Crop coefficient is the ratio of actual evapotranspiration to potential evapotranspiration, or the ratio of evapotranspiration to Class A pan evaporation. These crop coefficients can, therefore, be used with either potential evapotranspiration or with pan evaporation to estimate actual evapotranspiration. One must, therefore, be specific when using a crop coefficient and designate whether it refers to estimated potential evapotranspiration or to pan evaporation.

Moving Average

A moving average for a specified length of period is the average value for that period as the period advances over the full length of record. For example, a five-year moving average applied to a twenty-year record of precipitation first computes the average for the first five years, then drops the first year record and adds the sixth year record to obtain the second average value. Thus, there are sixteen averages of five consecutive years in a twenty-year period. The moving average is a useful concept in determining the probable reliability of short precipitation records when there are some longer records with which comparisons can be made.

A moving average can be computed on relative values such as the actual precipitation divided by the mean for the entire period.

REVIEW OF LITERATURE

Evapotranspiration is an important factor in water resource development and management. It is a primary factor in the estimation of water requirements for new projects. For effective management of irrigation systems it is also necessary to know the approximate evapotranspiration requirements of the crops grown. Precipitation must also be considered.

To understand the dynamic phenomenon of evaporation and evapotranspiration we have to know the factors affecting evaporation.

Taylor and Wiegand (1961) listed the most important factors affecting evaporation as:

1. Atmospheric factors: wind speed, humidity, radiation (daytime hours, sunshine, sky condition, temperature)
2. Soil factors: compaction and layering, water table depth, soil mulches and crop residues, vapor concentration in soil, moisture distribution
3. Plant factors: plant cover, leaf surface, type of plant and plant species, plant height, rooting depth, stage of growth.

Evapotranspiration Measurements

Soil Moisture Depletion

The moisture in the soil is measured using some direct measuring device such as a resistance block, neutron meter, gravimetric sample, etc. This method is usually suitable for areas where soil is fairly uniform and the depth to groundwater is such that it will not influence soil moisture fluctuation within the root zone.

Soil moisture in the major root zone must be determined before and after each irrigation. When rate of use is plotted against time, a curve can be drawn from which the monthly and seasonal use can be obtained.

Although this method has been widely and successfully used in arid areas, it is difficult to obtain satisfactory results in humid areas. With frequent and/or heavy precipitation, errors due to drainage usually result. These errors may be of significant magnitude. Errors also result from high water-table conditions that affect the moisture within the root zone.

Lysimetry

Lysimeters or evapotranspirometers are devices used to measure the amount of water used by crops. A lysimeter consists of a tank buried in the ground and filled with soil in such a way that it is representative of the surrounding conditions. The reliability of the evapotranspiration measurement depends on the degree to which natural conditions are approximated and the accuracy with which the moisture loss can be determined.

Lysimeters can be grouped as follows:

1. Nonweighing, drainage type. The difference between water applied to the lysimeter and that which drains is measured to determine the evapotranspiration. The principal advantage is the low cost.
2. Weighing. Weighing lysimeters provide the most direct and accurate means for the determination of evapotranspiration. This type is very expensive in comparison with nonweighing types.

Other Methods of Evapotranspiration Measurements

Other methods successfully applied for measuring evapotranspiration are: integration method, inflow-outflow for large areas, and field experimental plots where the water applied and the runoff, if any, are measured.

Evaporation and Evapotranspiration Formulas

Evapotranspiration is the combined evaporation from all surfaces and the transpiration by the plants. The potential evapotranspiration depends on the evaporative power of the air as determined by temperature, wind, humidity and radiation. Several formulas have been proposed for computing evaporation and potential evapotranspiration. Most evapotranspiration formulas now in use are suitable for the climatic regions within which they have been derived. Few, however, have wide or general application to all the regions of the world where irrigation is practiced.

In general the development of the formulas proposed can be classified as:

1. Aerodynamic approach
2. Energy budget approach
3. Empirical approach.

Aerodynamic Approach

Dalton Equation

The Dalton equation, probably the oldest equation used to estimate evaporation from a water surface, can be written:

$$Eo = (e_s - e)\, f(u)$$

where

Eo = rate of evaporation

e = the vapor pressure at some height above the surface

e_s = the vapor pressure of the evaporating surface

$f(u)$ = a function of the horizontal wind velocity.

Rohwer's Formula

Rohwer (1931) developed a general formula for pan evaporation based on Dalton's law. It can be written:

$$Ev = (1.465 - 0.0186\ B)\ (0.44 + 0.118\ W)\ (E_o - e_a)$$

in which

Ev = evaporation in inches per day

B = barometric pressure in inches of mercury at 32°F

W = wind velocity near the ground, in miles per hour

$(e_o - e_a)$ = vapor pressure deficit in inches of Hg.

Although the Rohwer formula has a theoretical base, the barometric and wind functions were empirically determined.

Thornthwaite-Holzman Equation

Thornthwaite and Holzman, as cited by Chang (1968), derived the first aerodynamic equation for evapotranspiration over short vegetation. This equation is dependent for its validity on the propositions that (1) the principle of similarity is valid, and (2) the wind profile near the ground can be described by a logarithmic equation. (These two conditions are valid only under stable atmospheric conditions.) Pruitt (1964) showed that this equation holds when the wind speeds exceed three to four meters per second. The equation as written by Chang is (He does not specify the units.):

$$E = \rho k^2 (q_1 - q_2)(u_2 - u_1)/(\ln (z_2/z_1))^2$$

where

E = evaporation

ρ = air density

k = Von Karman's constant = 0.40

u_1, u_2 are wind speeds at heights of z_1 and z_2, respectively

q_1, q_2 are specific humidities at the same heights.

Energy Budget Approach

The energy budget approach assumes that evaporation is a process dependent upon the available energy from both radiation and advection which is dependent on turbulent air transfer.

The energy budget equation may be written as follows:

$$R_I (1 - r) + R_d - R_u - E - Q - S = 0$$

where

R_I = short-wave radiation income on a horizontal surface

R_d, R_u are downward and upward fluxes of long-wave radiation

r = reflection coefficient of the surface

E = energy available for evaporation

Q = sensible heat transfer to the atmosphere

S = sensible heat transfer to the soil.

The measurements required for the energy budget method are simpler to make than those involved in the aerodynamic method. A consistant set of units must be used.

Penman Method

Penman (1948) has presented another theoretical approach showing that consumptive use is more highly correlated with incoming solar energy than was previously assumed.

His formula for potential evapotranspiration is as follows:

$$E_t = \frac{\Delta H + 0.27\ Ea}{\Delta + 0.27}$$

where

E_t = evapotranspiration in mm of water/day

Δ = slope of saturated vapor pressure curve of the air at absolute temperature Ta in ^{o}F (mm Hg/^{o}F)

$H = R_a\ (1 - r)\ (.18 + .55\ n/N) - \sigma Ta^4\ (.56 - .092\ \sqrt{e_d})$
$(.10 + .90\ n/N)$

$Ea = .35\ (e_a - e_d)\ (1 + .0098\ u_2)$

in which

Ea = evaporation in mm of water per day

H = daily heat budget at surface in mm of water/day

R_a = mean monthly extraterrestrial radiation expressed as evaporation in mm of water/day

r = reflection coefficient of surface

n = actual duration of bright sunshine

N = maximum possible duration of bright sunshine

σ = Botzmann constant - 2.01×10^{-9} mm/day/$^{o}K^{4}$, therefore

σTa^{4} = mm of water/day

e_d = saturation vapor pressure at mean dew point (i.e., actual vapor pressure in the air) in mm Hg

e_a = saturation vapor pressure at mean air temperature in mm Hg

u_2 = wind speed in miles per day at 2 meters above ground level.

The principal limitation of the Penman approach is the lack of sufficient weather measurements in most localities. This equation was developed from data from humid areas covered with growing vegetation and may not give reliable results for arid areas without modification. Another limitation is the complexity of the computations involved which discourages its use.

Empirical Approaches

Thornthwaite's Method

Thornthwaite (1948) presented a formula for estimating potential evapotranspiration based on lysimeter and watershed observations of water loss in the central and eastern United States.

The Thornthwaite formula is:

$$E = 1.6\ (10\ T/I)^{a}$$

where

E = unadjusted potential evapotranspiration which is corrected by actual day length in hours and days in the month to give the adjusted potential evapotranspiration (expressed in centimeters per month)

T = mean monthly temperature in °C

I = annual heat index or the summation of i

$i = (T/5)^{1.514}$, the monthly heat index

a = a constant that also depends on temperature and which can be computed by the equation:

$a = 0.000000675\, I^3 - 0.0000771\, I^2 + 0.01792\, I + 0.4924.$

The Thornthwaite formula depends only on mean monthly temperature and day length and neglects other important parameters such as saturation, humidity and wind.

Blaney and Morin

Blaney and Morin (1942) derived am empirical formula to relate evaporation to temperature, relative humidity and daytime hours. The equation can be written:

$$u = k\, T_f\, p\, (114 - h)$$

in which

u = monthly consumptive use in inches

k = crop coefficient, dimensionless

T_f = mean monthly air temperature in °F

p = monthly percentage of daytime hours in the year

h = mean monthly relative humidity.

Blaney-Criddle

Blaney and Criddle (1962) modified the Blaney and Morin formula (1942) by dropping the humidity term. Expressed mathematically the formula is:

$$u = k\, f$$

$$U = K\, F$$

where

u = monthly consumptive use in weeks

U = consumptive use of crop in inches for the growing season

k = monthly crop coefficient, dimensionless

K = empirical crop coefficient (for [illegible] rowing season)

$f = T_i \cdot p/100$, the consumptive use factor

p = percentage of daytime hours of the year occurring during the month; these values have been tabulated for all months and latitudes

F = sum of the consumptive use factors, f, for the season, Σf.

The Blaney-Criddle formula has been extensively used to estimate actual evapotranspiration in many places in the world. It depends on only the day length and mean monthly temperature and an artibrarily assumed coefficient, k. The computed u value depends primarily on the judgment of the user in selecting the proper k value whic varies widely from place to place and month to month. Values of k have been determined for many crops for western United States conditions, but they do not apply to tropical conditions where both day length and temperature are fairly constant throughout the year, but where the relative humidity, sunshine and wind may vary greatly from month to month.

Lowry-Johnson Method

The method used by Lowry and Johnson (1942) was developed for western United States conditions to estimate water requirements for irrigation projects. This method was applied to a valley, not to an individual farm.

The method uses values of "effective heat" which can be defined as accumulated degree-days of maximum temperature above $32^{\circ}F$ during the growing season.

The seasonal consumptive use, U in feet, can be approximated by the equation:

$$U = 0.8 + 0.156^{o} Q$$

in which

U = seasonal consumptive use in feet (acre-feet per acre)

Q = effective heat in thousands of degree-days.

Hargreaves

Hargreaves (1956) proposed the use of Class A pan evaporation data as the climatic index and gives a formula to estimate pan evaporation and evapotranspiration. The formula is based on mean temperatures, mean relative humidity at noon and a monthly daytime coefficient.

Hargreaves' formula can be written:

$$Ep = 0.38\, d\, (1.0 - Hn)\, (T_f - 32)$$

where

Ep = Class A pan evaporation in inches

d = a monthly daytime coefficient dependent upon the day length and number of days in the month; these values had been tabulated for all months and latitudes

Hn = mean monthly relative humidity at noon expressed in decimal form (Hn = 60% = .60).

The formula expressed in metric units becomes:

$$Ep = 17.4\, d\, Tc\, (1.0 - Hn)$$

where

Ep = Class A pan evaporation in mm per month

Tc = average mean monthly temperature in °C.

The formula for computing evapotranspiration is:

$$ET = K\, Ep$$

where

ET = evapotranspiration in the same units as Ep

K = a crop coefficient or crop factor, dimensionless.

Recently Hargreaves* suggested a modification of this equation based on an analysis of 529 months of data for Ecuador. The modified equation can be written:

$$Etp = 7.20\ d\ Tc\ CH\ CW\ CE$$

in which

Etp = the potential evapotranspiration in mm per month

$CH = .05 + 1.58\ (1.00 - HM)^{1/2}$, a humidity coefficient

HM = mean relative humidity expressed decimally

$CW = .64 + 0.45\ W10$, a wind coefficient

W10 = mean wind speed at an instrument height of 10 meters measured at 7:00 am, 10:00 pm and 7:00 pm

$CE = 1.00 + .23\ EL/1000$; an elevation coefficient

EL = elevation in meters.

For the 529 months of data, the above equation predicted the measured monthly evaporation with a standard deviation of 15.6 mm.

Norero's Formula for Actual Evapotranspiration

Norero (1969) developed an equation which takes both the soil water status and the climatic factors into account. This equation can be written:

$$ETA = ETP/(1 + (\theta'/\theta)^m)$$

where

ETA = actual evapotranspiration in mm

ETP = potential evapotranspiration in mm

θ = actual average water content in the root zone

θ', m are variables depending on the soil and plant as well as ETP, in mm in which, for corn, Hanks (1971) gives:

$$\theta' = (20.4 + 1.1\ ETP)/100$$

$$m = 27.3 - 2.06\ ETP.$$

Formulas Developed at Utah State University

Christiansen (1968) and graduate students at Utah State University developed several formulas for calculating evaporation and evapotranspiration. The primary objective of this research was to develop practical formulas for estimating potential evapotranspiration from radiation and climatic data, especially in foreign countries where actual data on evapotranspiration are very limited. The objective was to develop formulas that were dimensionally sound and could be applied in either English or metric units. They should:

1. Take into consideration most of the available climatic parameters that affect evaporation and evapotranspiration

2. Use only data of the kind that are available to the user. These data should be the same as were used in the development of the equations.

3. Be easy to apply using tabulated coefficients for the climatic parameters.

The basic formula can be written:

$$E = K\ R_t\ CT\ CH\ CW\ CS\ CE$$

in which

E = evaporation or evapotranspiration, expressed in the desired units

K = dimensionless constant developed from an analysis of many data

R_t = theoretical solar radiation reaching the earth's outer atmosphere, expressed in the same units of E. This extraterrestrial radiation is computed from the latitude and month of the year and is based on a solar constant of 2 cal/cm^2 min.

CT, CH, CW, CS, CE are coefficients for temperature, relative humidity, wind velocity, sunshine and elevation.

Each coefficient can be expressed by an empirical equation generally of the form:

$$CX = A + B\ (X/Xo) + C\ (X/Xo)^2$$

except in cases where the data suggested a different type of equation. In this equation X represents parameters of climatic or other factors, and Xo is a standard value, preferably an approximate mean value of the parameter X. When expressed in this manner the equation shows that the coefficients are dimensionless. The coefficient(s) CX = 1.0 for the standard values Xo, thus A + B + C = 1.

For ease in applying the formulas where computer facilities are not readily available, these climatic factors and the corresponding coefficients can be computed and tabulated so that only a minimum amount of work is involved in making the calculations with a slide rule or desk calculator.

Mathison's Formula

Mathison (1963), a graduate student from Venezuela, developed a formula for pan evaporation which he believed would apply to the tropical zone, although it was developed from western United States data. Because relative humidity was not always available, he found a correlation between humidity and the difference in maximum and minimum temperature, ΔT, and used a coefficient for the temperature difference as an index of humidity. Mathison wrote his formula:

$$Ev = CR\ CT\ CW\ C\quad T\ Ccos\ CS\ CM\ CE$$

where

$$CR = 0.20\ R_t + 0.015\ R_t^2$$

$$CT = -0.26 + 0.02425\ Tf - 0.000075\ Tf^2, \text{ or}$$

$$CT = 0.440 + 0.0350\ Tc - 0.000243\ Tc^2$$

$$CW = 0.8 + 0.0035\ W - 0.0000027\ W^2$$

$$C\Delta T = 0.45 + 0.00096\ \Delta Tf^2 - 0.000000276\ \Delta Tf^4, \text{ or}$$

$$C\Delta T = 0.45 + 0.00311\ \Delta Tc^2 - 0.00000290\ \Delta Tc^4$$

$$Ccos = 1.16 + 0.42 \cos (L - D) - 0.7 [\cos (L - D)]^2$$

$$CS = 0.622 + 0.005875\ S - 0.000011\ S^2$$

$$CM = 1.0 + 0.00155 (L - D) \cos [\pi/6) (N + 1)]$$

$$CE = .967 + 0.035\ E - 0.00156\ E^2$$

in which

L = latitude, in degrees N

D = mean declination of sun for the month, degrees

E = units of 1000 feet

W = wind velocity in miles per day at height of 60 cm

CR, Ccos, and CM are functions of the same factors; they can be combined into one coefficient, Cc, where

Cc = CR Ccos CM.

The final equation is:

$$Ev = Cc\ CT\ CW\ C\Delta T\ CS\ CE.$$

Mathison's formula could also be written in the dimensionless form with the proper units in the constant

$$Ev = XKM\ Ccc\ CT\ CW\ C\Delta T\ CS\ CE$$

where XKM = 6.39 inches for month, or 162.2 mm per month, and

$$CR = .47 (R/15) + .53 (R/15)^2, \text{ and}$$

$$Ccc = Cc/6.39, \text{ or } Cc/162.2.$$

It was found later that the substitution of his coefficient C ΔT for the humidity coefficient, CH, did not give good results with Venezuelan data.

Grassi Equation

Grassi (1964) developed several formulas from which actual evapotranspiration of crops can be estimated for hydrologic studies by using available climatic and crop data.

He developed three equations for crop evapotranspiration based on extraterrestrial radiation, incoming measured radiation, and pan evaporation, respectively.

The first formula, using extraterrestrial radiation, R_t, can be written:

$$Et = XRG\ CR\ CClc\ CT\ CTd\ CCrc\ F$$

where

XRG is a constant equal to 0.215 inches per day or 5.46 mm/day

F = crop factor.

The equation for the dimensionless coefficients are:

$CR = 0.18 + 1.46\ R_t$

$CClc = 1.15 - 0.05\ Clc$

$CT = 0.036 + 0.0219\ Tf - 0.0001136\ Tf^2$, or

$CT = .630 + .0202\ Tc - .000336\ Tc^2$

$CTd = 0.936 + 0.00426\ Tdf$, or

$CTd = 0.936 + 0.00767\ Tdc$

$CCrc = 0.111 + 0.0141\ Crc - 0.0000521\ Crc^2$.

Et = evapotranspiration in inches per day

R_t = theoretical radiation, expressed as evaporation in inches per day or mm per day

Clc = cloud cover scale from 0 to 10

Td = difference between the mean maximum daily temperature and the mean temperature for the period

Crc = percentage of time from planting to 100 percent crop cover.

Some values of the crop factors, F, were:

Alfalfa = 1.088
Beans = 0.983
Corn = 1.003
Cotton = 1.082
Oats = 0.890
Sugar beets = 1.017
Potatoes = 1.162
Sorghum = 1.004
Winter wheat = 1.100

Grassi's equation for the vegetative cycle coefficient is Cvc.

$$Cvc = 0.0895 + 0.02738\ vc - 0.0002058\ vc^2.$$

The second formula, using measured or estimated Rs values instead of theoretical radiation, R_t, and temperature and crop cover, Crc, can be written:

$$Et = XSG\ Rs\ CT\ CCrc\ F$$

where

$$KSG = 0.513 \text{ inches per day, or } 13.0 \text{ mm per day}$$

$$CCrc = 0.099 + 0.1347\ Crc - 0.0000446\ Crc^2.$$

The third formula, using measured or computed pan evaporation, EV, instead of R or Rs, can be written:

$$ET = 0.968\ EV\ CT\ CCrc$$

where

$$CT = 1.754 - 0.0111\ Tf, \text{ or}$$

$$CT = 1.40 - 0.200\ Tc, \text{ and}$$

$$CCrc = 0.121 + 0.0148\ Crc - 0.0000592\ Crc^2.$$

Guillen's Formula

Guillen (1967), another graduate student from Venezuela, developed a formula for estimating evaporation as measured with the Fuess evaporimeter in a shelter from Venezuelan and Colombian data. His formula can be written:

$$EV = KG\ CT\ CH\ CW\ CS\ CM\ CDP$$

in which

EV = evaporation in a shelter in mm per day

$K = 2.957$

$CH = 2.12 - 1.75\ Hm^2$

$CT = -0.490 + 0.0621\ Tc$

$CS = 0.53 + 0.784\ X$

$CW = 0.728 + 0.0494\ W2$

$CDP = 1.15 - 0.015\ DP$

$CM = EV\ (\text{Fuess})/KCT\ \ CH\ CW\ CS\ CDP$

where

DP = days in month with 1 mm or more precipitation

CM = monthly coefficient, the average value of which varies from 0.925 for November and 1.065 for April.

Guillen's formula, without his monthly coefficient, but multiplied by the following monthly factor, MF, should yield a fair approximation of pan evaporation for Venezuelan conditions.

Month	MF	Month	MF	Month	MF
Jan	1.68	May	1.78	Sept	1.80
Feb	1.56	June	1.97	Oct	1.81
Mar	1.48	July	1.98	Nov	1.79
Apr	1.55	Aug	1.90	Dec	1.78

Fuess evaporation is measured at several stations where pan evaporation is not measured operated by the Venezuelan Meteorological Service of the Ministry of Defense.

Christiansen's Formulas

Christiansen (1968) published a formula for estimating Class A pan evaporation using extraterrestrial radiation, R_t, as a base.

The basic formula can be written:

$$Ev = XK\ R_t\ CT\ CW\ CH\ CS\ CE\ CM$$

in which

XK = .459, a dimensionless constant

R_t = extraterrestrial radiation reaching the earth's atmosphere, computed from a solar constant of two calories per cm^2 per minute, expressed as equivalent evaporation in the same units as Ev.

For mean temperature in °F, and To = 68°,

$$CT = -0.070 + 0.898\ (T_f/To) + 0.172\ (T_f/To)^2.$$

For mean temperature in °C, and To = 20°,

$$CT = 0.393 + 0.559\ (Tc/To) + 0.048\ (Tc/To).$$

For mean wind velocity, W, above the evaporation pan, or at 2 feet above the ground, and for Wo = 60 miles per day, or 96.56 kilometers per day,

$$CW = 0.708 + 0.328\ (W/Wo) - 0.036\ (W/Wo)^2.$$

For mean humidity at noon, Hn, and Ho - 0.40 (40%),

$$CH = 1.250 - 0.348\ (Hn/Ho) + + 0.120\ (Hn/Ho)^2 - 0.022\ (Hn/Ho)^4.$$

For mean sunshine percentage, S, and So = .80,

$$CS = 0.542 + 0.640\ (S/So) - 0.499\ (S/So)^2 + 0.317\ (S/So)^3.$$

For elevation, E, and Eo = 1000 feet or 305 meters,

$$CE = 0.970 + 0.030\ (E/Eo)$$

CM = monthly coefficient with a mean value of 1.0; usually CM is omitted, especially in the tropics.

Christiansen and Hargreaves' Formula for Potential Evapotranspiration

Christiansen and Hargreaves (1969) presented three formulas for computing potential evapotranspiration developed using data from Pruitt (1966) for rye grass in a 6.1 meter diameter weighing lysimeter.

Their first formula using measured pan evaporation, Ev, as a base can be written:

$$Etp = 0.755\ Ev\ CT\ CW\ CH\ CS$$

where

Ev = measured Class A pan evaporation

$$CT = 0.670 + 0.476\ (T_f/68) - 0.146\ (T_f/68)^2,$$

or in metric units,

$$CT = 0.862 + 0.179\ (Tc/20) - 0.041\ (Tc/20)$$

$CW = 1.189 - 0.240\ (W2/Wo) - 0.051\ (W2/Wo)^2$, where

W2 - mean wind velocity 2 meters above the ground level in miles per day, or Km per hour, and Wo = 100 miles per day, or 6.7 Km per hour

$CH = 0.499 + 0.620\ (Hm/60) - 0.119\ (Hm/60)^2$, where

Hm = the mean daily relative humidity

$CS = 0.904 + 0.008\ (S/80) + 0.088\ (S/80)^2$, where

S = percentage of possible sunshine, expressed decimally.

Their second formula, using extraterrestrial radiation, R_t, as a base, can be written:

$$Etp = .324\ R_t\ CTT\ CWT\ CHT\ CST\ CE$$

where

$CTT = 0.174 + 0.428\ (T_f/68) + 0.398\ (T_f/68)^2$, or

$CTT = 0.463 + 0.425\ (Tc/20) + 0.122\ (Tc/20)^2$

$CWT = 0.672 + 0.406\ (W2/Wo) - 0.078\ (W2/Wo)^2$

$CHT = 1.035 + 0.240\ (Hm/60)^2 - 0.275\ (Hm/60)^3$

$CST = 0.340 + 0.856\ (S/80) - 0.196\ (S/80)^2$

$CE = 0.970 + 0.030\ (E/Eo)$.

Their third formula, using measured incoming radiation, Rs, as a base, can be written:

$$Etp = 0.492\ Rs\ CTT\ CWT\ CHT$$

in which

Rs is expressed as equivalent depth of evaporation.

The coefficients, CTT, CWT, CHT, are the same as defined for the second formula.

Hargreaves' Formula

Hargreaves (1972) has proposed an equation for computing evaporation from a Class A pan located in an irrigated grass area. The equation can be written:

$$EV = .43\ R_t\ CT\ CH\ CW\ CE\ CTD$$

in which

EV = Class A pan evaporation

$CT = .40 + .024\ Tc$

$CH = .05 + 1.58\ (1.00 - Hm)^{.5}$

$CW = .68 + .04\ W10$, where W10 is wind at an elevation of 10 meters in Km/Hr

$CE = 1.00 + .07\ EL/1000$, where EL is elevation in meters

$CTD = .76 + .0375\ Td$, where Td is the difference in mean maximum and mean minimum temperatures.

The coefficient .43 can vary if temperature, humidity and wind measurement are not 24-hour mean values, or if pan exposure is not typical of a vegetated area.

The potential evapotranspiration, Etp, equivalent to that from a short, green, rapidly growing grass vegetation with a continuously adequate moisture supply, is given by the equation:

$$Etp = .82\ CHTV\ CWTV\ CETV$$

in which

$CHTV = .55 + .75\ Hm$, but with maximum value of 1.03

$CWTV = 1.08 = .01\ W10$

$CETV = 1.0 - .04\ EL/1000$.

Methods Used for Computing Precipitation Probabilities

According to the Soil Conservation Service (1967) monthly and seasonal rainfall can be expected to vary widely from year to year; the net irrigation requirement has wide variations caused by the variation of the climatic factors. The dependable water supply cannot be based on average requirements since this would provide an adequate supply less than approximately half the time.

It is better practice, therefore, to estimate dependable rainfall and irrigation water requirements on a probability basis, the percent chance of occurrence, this being an economical consideration.

Frequency Plot or Ranking Distribution

Kimball (1946) developed a procedure to solve the problem of forecasting by extrapolation from a fitted curve, provided that the form of the function fitted expressed the true behavior of the universe from which the data were drawn. Another equation basic by analysis of data with a frequency plot has been proposed. According to Linsley, Kohler, and Paulhus (1958), the Kimball equation can be written:

$$F = m/(n+1), \text{ or}$$

$$T = (n+1)/m = 1/F$$

where

F = percent frequency or probability

T = return period in years, or recurrence interval

m = order number assigned to data, ranked in descending order, $m = 1, 2, 3, \ldots, n$,

n = number of years of record.

Monthly values seldom approach a normal distribution. Arithmetic and log probability paper can be used to plot the precipitation data. When the data approaches a normal distribution a straight line gives a good fit when the data are plotted on arithmetic probability paper. If a straight line results when the data are plotted on log probability paper, the data are said to have log-normal distribution.

Normal Distribution

The normal distribution curve is completely determined by two parameters: the mean value, $\bar{x}$, and the standard deviation. When the data does not fit a normal distribution, log probability transformation (by Hazen and Chow) permits a normal curve to be assumed. The equation of the normal curve is:

$$f(x) = \frac{1}{S\sqrt{2\pi}} e^{-.5 \left(\frac{x - \bar{x}}{S}\right)^2}$$

where

S = the standard deviation of the distribution

π = a constant, approximately 3.1416

e = the number for which the natural logarithm = 1.0, approximately 2.7183

$\bar{x}$ = the mean value of the distribution.

The normal distribution curve is symmetrical about the mean, tails out at the extreme values, and has a shape resembling a bell. The mean, median, and the mode are coincident. The total area between this curve and the x axis is one square unit, thus the area under the curve between the point x = a and x = b is equal to the expected probability.

In theory a normal frequency distribution extends from negative infinity to positive infinity along the x axis. This means that a normally distributed variable can assume any positive value however large or small, although values farther from the mean plus or minus three standard deviations are quite improbable because their relative expected frequency of occurrence is rare.

Incomplete Gamma Distribution Function

Thom (1958) considers precipitation and zero precipitation as being produced by different physical systems. The precipitation distribution is then found to be a mixed distribution instead of a simple distribution. The first (discrete population occurrence) is fitted by a binomial and the second (non-occurrence) by the incomplete gamma distribution forced through zero. It can be used for weekly, monthly, or seasonal rainfall. Barger and Thom (1949) and Thom (1958) have shown that the incomplete gamma distribution gives good fit to climatological series of precipitation.

The incomplete gamma frequency distribution as presented by Thom (1958) for random variable x is given by

$$f(x) = Ie^{-x/\beta}x^{m-1})/(\beta^{m} \; \Gamma(m))$$

in which

x = precipitation amount

β and m are parameters.

The gamma function, $\Gamma(m)$, is given by

$$\Gamma(m) = \int_0^x e^{-x} x^{m-1} \, dx$$

$$0 \leq x \leq \infty, \; m > 0.$$

The probability that precipitation will not exceed x amount, as well as the precipitation associated with any probability, can be found from:

$$f(x) = \int_0^x e^{-x/\beta} x^{m-1}/(\beta^{m} \; \Gamma(m))$$

where

x is the amount of precipitation (daily, weekly, monthly, annually, etc.)

Miller and Weaver (1968), using the incomplete gamma distribution for a climatic division in Ohio, determined the monthly and annual precipitation amounts for the 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 95 percent probability levels. Rather than utilizing a desk calculator and the Thom monogram of Pearson's tables of the incomplete gamma distribution function (which are related to probability [abcissa] and the ratio x/β [ordinate]. [In Thom's graphs, the value of precipitation associated with a given probability and gamma parameter is the x term in the ratio x/β.]).

Weaver and Miller (1967) wrote a computer program for the purpose of computing precipitation associated with selected probabilities. This program calculated gamma and beta parameters. Precipitation,

x_i, for a given probability, P, is estimated from:

$$x_i = x_j - \frac{x_j}{m}(S) - P\,\Gamma(m)\,e^{x_j}/(x_j^{m-1})$$

where

$$j = i - 1$$

$$S = 1 + \frac{x}{m+1} + \frac{x^2}{(m+1)(m+2)} + \frac{x^3}{(m+1)(m+2)(m+3)}$$

$$\beta = \bar{x}/m$$

m = the gamma parameter.

The gamma parameter, m, is found by solving for m in the quadratic equation:

$$12\,(\ln x - 1/N \; \Sigma \ln x)\, m^2 - m - 1 = 0.$$

If m is less than 36, the gamma function, $\Gamma(m)$, is calculated by using an algorithm developed by Collinge (1961). If the m value is greater than 36, the gamma functions were found by linear interpolation of Pearson's gamma function table.

Crop Coefficients

Plant species differ as to time of the year when growth is made, rooting depth, plant density and spacing. Because of this, different plant species have different crop coefficients.

Different plant species that are short, dense, and uniformly vegetated, actively growing and transpiring under unlimited soil water have virtually identical evapotranspiration. Penman has stated two basic principles supporting this statement. They are:

1. For complete crop covers of different plants having about the same color, i.e., the same reflection coefficient, the potential rate is the same irrespective of plant or soil type.

2. This potential transpiration rate is determined by the prevailing weather.

Crop coefficients can be used with potential evapotranspiration to evaluate actual evapotranspiration. Those given in Appendix C, Table 14, are ratios of evapotranspiration to Class A pan evaporation. Crop evapotranspiration is not a fixed value. Evapotranspiration from high soil moisture levels for some crops may average as much as twice the evapotranspiration from conditions of low average soil moisture availability, sometimes without great difference in crop yields. With increased annual rainfall, there is also an increased opportunity for more soil moisture carry-over into the dry season. Therefore, with changes in annual rainfall, corresponding changes in actual evapotranspiration may be anticipated.

PROCEDURE

Data Collection

The first step in the present study was the collection of data from 20 climatological stations in Venezuela. The data were tabulated and keypunched. One of the stations was eliminated due to insufficient data, leaving 19 for this study. The stations used are given in Table 1.

Table 1. Climatological Stations Used in this Study

Station ID	Name	State	Lat. deg.	Long. deg.	Elev. m	Months of Data
25	Cua-Tovar	Miranda	10.15	66.88	240	95
26	Jusepin UDO[1]	Monagas	9.75	63.4	146	74
27	Mayalito	Guarico	9.52	66.20	270	80
28	San Juan de los Morros	Guarico	9.90	67.35	430	51
29	Zona Arida. MAC[2]	Lara	10.15	69.30	630	51
30	Santa Cruz	Aragua	10.18	67.50	438	80
31	Shell Foundation[3]	Aragua	10.30	67.75	432	60
32	Uranon	Apure	6.93	67.12	90	70
33	Yaritagua	Yaracuy	10.07	69.12	374	33
34	Punta de Piedra	Nueva Esparta	10.90	64.07	10	54
35	Barcelona MOP 2	Anzoategui	10.18	64.78	5	49
36	Guanapito	Guarico	9.93	66.40	600	50
37	Hotel Santo Domingo	Merida	8.87	70.67	2035	13
38	Las Piedras	Merida	8.90	70.63	1644	13
40	Rio Verde	Guarico	9.53	67.67	250	50
41	Merida	Merida	8.60	71.15	1870	28
42	Santa Barbara	Zulia	9.00	71.92	5	41
43	Guanare	Portuguesa	8.95	69.23	117	46
44	Majaguas	Portuguesa	9.60	69.03	146	23

All stations were of Ministry of Public Works (MOP) except as indicated:

[1] UDO = Universidad de Oriente (Eastern University)
[2] MAC = Ministry of Agriculture and Livestock
[3] Private station

Computer Programs Used

The Univac 1108 in Salt Lake City, Utah, operated with a Univac 9200 remote terminal located at Utah State University (Engineering Building), was utilized to process the data and make this study.

Program 660.5, Appendix D, developed by Professor J. E. Christiansen, was used to read the basic climatological data and to compute sunshine, solar radiation, evaporation and evapotranspiration.

Program 691-GV, Appendix D, developed by Hardee (1971) and Ramirez (1971), with modification by Richard Conn, was used to read the basic precipitation data and calculate the gamma distribution of precipitation data on a monthly and annual basis. The same program computes precipitation for different probability levels according to the normal distribution and ranking distribution. The gamma distribution is computed for 13 different probability levels.

A subroutine was used to calculate potential evapotranspiration using a modified Christiansen formula. Potential irrigation requirements at five probability levels was also calculated.

Program 645, Appendix D, written by Professor Christiansen was used to make an analysis of the influence of the length of record on the reliability of the mean values of precipitation. The methods used in computing the reliability of the mean values of precipitation were based on moving averages. The intervals considered in the analysis were 5, 10, 15, and 20 years.

Two other programs were written in order to study the relationship between the precipitation probability at different levels and the mean monthly precipitation. The first one was a least square program to find the relationship between the precipitation probability at 13 different probability levels and the mean monthly precipitation. The second program was developed to evaluate the intercept and slope as a function of probability. The formula developed is discussed later.

RESULTS AND DISCUSSION

Evapotranspiration

The basic equations developed by Professor Christiansen for evaporation and evapotranspiration from Venezuelan data can be written:

$$EVPC = .356\ RMM\ CT\ CWV\ CH\ CS\ CE\ CDP$$

$$ETPC = .302\ RMM\ CT\ CWT\ CH\ CS\ CE\ CDP$$

in which

RMM = extraterrestrial radiation, in mm per month

$$CT = .40 + .50\ (TM/25) + .10\ (TM/25)^2$$

$$CWV = .58 + .47\ (W10/8) - .05\ (W10/8)^2$$

$$CWT = .70 + .36\ (W10/8) - .06\ (W10/8)^2$$

$$CH = 1.15 + .44\ (HM/75) - .59\ (HM/75)^2 \text{ if } (HM\ .\ LT\ .\ 0.28)$$

$$CHV = 1.232$$

$$CS = .48 + .66\ (S/.5) - .14\ (S/.5)^2$$

$$CE = .94 + .06\ (EL/1000)$$

$$CDP = 1.15 - .15\ (DP/10)^{.35}.$$

When sunshine is missing, it can be computed by the following formula:

$$SC = .612\ CSTD\ CSHM\ CSDP.$$

The coefficients for computed sunshine were modified by the writer to fit the Venezuelan data. The new coefficients can be written:

$$IF\ (HM\ .\ LE\ .\ 0.75)$$

$$CSHM = .50 + .70\ (HM/.75) - .20\ (HM/.75)^2$$

$$IF\ (HM\ .\ GT\ .\ 0.75)$$

$$CSHM = 1.0 - .40\ [(HM - .75)/.75]^2$$

$$CSTD = .79 + .15\ (TD/10) + .06\ (TD/10)^2$$

$$CSDP = 1.20 - .20\ (DP/10)^{.56}$$

The coefficient for sunshine using the computed sunshine is then:

$$CS = .48 + .66\ (SC/.5) - .14\ (SC/.5)^2.$$

The values of all of these coefficients have been computed and are given in Table 2. The values of extraterrestrial radiation are given in Table 3.

The sunshine data for the Shell Foundation station were obtained by multiplying the measured sunshine by 1.18 to make the sunshine values the same as at the nearby Santa Cruz. This was done because it is believed that the Santa Cruz sunshine data were more consistent with the data for other stations than those reported for the Shell Foundation station.

The computed sunshine correlates very well with the measured sunshine. The average absolute errors for the computed sunshine for 19 stations ranged between 5.7 and 19.5 percent with an overall error of 10.3 percent (Appendix A, Table 6).

The computed radiation is also in good agreement with the measured radiation. The absolute errors for 19 stations range between 4.7 and 11.7 percent with an overall mean error of 6.2 percent.

This indicates that pan evaporation and evapotranspiration can be computed, using computed radiation and computed sunshine, to a very close approximation. Some climatological stations in Venezuela do not have devices for measuring either radiation or sunshine. ETP can then be obtained using the calculated values of S.

A statistical analysis for evaporation, both measured and computed was made in order to show how well the Christiansen formula computes evaporation. Only 7 stations were used in this analysis. These were chosen because they have records for more than five years.

The F-test for these 7 stations shows that the formula fits the Venezuelan data quite well at the 95 percent confidence level.

Appendix C, Table 8, shows the confidence interval at the 95 percent level for 7 stations in millimeters, and Table 9, Appendix C, gives the percent of possible deviation of the mean of measured evaporation at the 95 percent probability level. For example, at Cua-Tover

TABLE 2. COEFFICIENTS FOR COMPUTING PAN EVAPORATION . POTENTIAL EVAPOTRANSPIRATION AND SUNSHINE FOR VENEZUELA

(COEFFICIENTS FOR EVAPORATION AND EVAPOTRANSPIRATION) (COEFFICIENTS FOR SUNSHINE)

TM	CT	HM	CH	WIO	CWV	CWT	DP	CD	S	CS	ELEV	CE	TD	CSTD	DP	CSDP	HM	CSHM
0.	.400	.60	1.129	0.	.590	.700	0.	1.150	.45	.951	0.	.940	0.	.790	0.	1.200	.60	.932
1.	.420	.61	1.118	1.	.638	.744	1.	1.083	.46	.959	100.	.946	1.	.806	1.	1.145	.61	.937
2.	.441	.62	1.111	2.	.694	.786	2.	1.065	.47	.977	200.	.952	2.	.822	2.	1.119	.62	.942
3.	.461	.63	1.103	3.	.749	.827	3.	1.052	.48	.985	300.	.958	3.	.840	3.	1.098	.63	.947
4.	.483	.64	1.096	4.	.803	.865	4.	1.041	.49	.992	400.	.964	4.	.860	4.	1.080	.64	.952
5.	.504	.65	1.088	5.	.854	.902	5.	1.032	.50	1.000	500.	.970	5.	.880	5.	1.064	.65	.956
6.	.526	.66	1.080	6.	.904	.936	6.	1.025	.51	1.008	600.	.976	6.	.902	6.	1.050	.66	.961
7.	.548	.67	1.072	7.	.953	.969	7.	1.018	.52	1.015	700.	.982	7.	.924	7.	1.036	.67	.966
8.	.570	.68	1.064	8.	1.000	1.000	8.	1.011	.53	1.022	800.	.988	8.	.949	8.	1.023	.68	.970
9.	.593	.69	1.055	9.	1.045	1.029	9.	1.005	.54	1.030	900.	.994	9.	.974	9.	1.011	.69	.975
10.	.616	.70	1.047	10.	1.089	1.056	10.	1.000	.55	1.037	1000.	1.000	10.	1.000	10.	1.000	.70	.979
11.	.639	.71	1.038	11.	1.132	1.082	11.	.995	.56	1.044	1100.	1.006	11.	1.028	11.	.989	.71	.983
12.	.663	.72	1.029	12.	1.172	1.105	12.	.990	.57	1.050	1200.	1.012	12.	1.056	12.	.979	.72	.988
13.	.687	.73	1.019	13.	1.212	1.127	13.	.986	.58	1.057	1300.	1.018	13.	1.086	13.	.968	.73	.992
14.	.711	.74	1.010	14.	1.249	1.146	14.	.981	.59	1.064	1400.	1.024	14.	1.118	14.	.959	.74	.996
15.	.736	.75	1.000	15.	1.285	1.164	15.	.977	.60	1.070	1500.	1.030	15.	1.150	15.	.949	.75	1.000
16.	.761	.76	.990	16.	1.320	1.180	16.	.973	.61	1.077	1600.	1.036	16.	1.184	16.	.940	.76	.999
17.	.786	.77	.980	17.	1.353	1.194	17.	.969	.62	1.083	1700.	1.042	17.	1.218	17.	.931	.77	.997
18.	.812	.78	.969	18.	1.384	1.206	18.	.966	.63	1.089	1800.	1.048	18.	1.254	18.	.922	.78	.994
19.	.838	.79	.959	19.	1.414	1.217	19.	.962	.64	1.095	1900.	1.054	19.	1.292	19.	.913	.79	.989
20.	.864	.80	.948	20.	1.443	1.225	20.	.959	.65	1.101	2000.	1.060	20.	1.330	20.	.905	.80	.982
21.	.891	.81	.937	21.	1.469	1.232	21.	.956	.66	1.107	2100.	1.066	21.	1.370	21.	.897	.81	.974
22.	.917	.82	.925	22.	1.494	1.236	22.	.952	.67	1.113	2200.	1.072	22.	1.410	22.	.889	.82	.965
23.	.945	.83	.914	23.	1.518	1.239	23.	.949	.68	1.119	2300.	1.078	23.	1.452	23.	.881	.83	.954
24.	.972	.84	.903	24.	1.540	1.240	24.	.946	.69	1.124	2400.	1.084	24.	1.496	24.	.873	.84	.942
25.	1.000	.85	.891	25.	1.560	1.239	25.	.943	.70	1.130	2500.	1.090	25.	1.540	25.	.866	.85	.929
26.	1.028	.86	.879	26.	1.579	1.236	26.	.940	.71	1.135	2600.	1.096	26.	1.586	26.	.858	.86	.914
27.	1.057	.87	.866	27.	1.597	1.232	27.	.938	.72	1.140	2700.	1.102	27.	1.632	27.	.851	.87	.898
28.	1.085	.88	.854	28.	1.613	1.225	28.	.935	.73	1.145	2800.	1.108	28.	1.680	28.	.844	.88	.880
29.	1.115	.89	.841	29.	1.627	1.217	29.	.932	.74	1.150	2900.	1.114	29.	1.730	29.	.837	.89	.861
30.	1.144	.90	.828	30.	1.639	1.206	30.	.930	.75	1.155	3000.	1.120	30.	1.780	30.	.830	.90	.840
31.	1.174	.91	.815	31.	1.650	1.194	31.	.927	.76	1.160	3100.	1.126	31.	1.832	31.	.823	.91	.818
32.	1.204	.92	.802	32.	1.660	1.180	31.	.927	.77	1.164	3200.	1.132	32.	1.884	31.	.823	.92	.794
33.	1.234	.93	.788	33.	1.668	1.164	31.	.927	.78	1.169	3300.	1.138	33.	1.938	31.	.823	.93	.770
34.	1.265	.94	.775	34.	1.674	1.146	31.	.927	.79	1.173	3400.	1.144	34.	1.994	31.	.823	.94	.743

EVP=.356 RMM CT CWV CS CE CH COP

ETP=.302 RMM CT CWT CS CE CH COP

SC=.612 CSTD CSHM CSOP

TABLE 3. MEAN MONTHLY VALUES OF EXTRATERRESTRIAL RADIATION EXPRESSED AS EQUIVALENT EVAPORATION IN MILLIMETERS PER MONTH AT 20 DEGREES C.

LATITUDE DEGREES NORTH	MONTH												
	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
20	349.8	354.8	445.5	471.7	508.3	497.7	512.1	498.3	450.1	413.6	350.9	336.7	5189.5
19	356.6	359.8	448.9	472.3	506.5	494.9	509.7	497.9	452.3	418.5	357.2	343.8	5218.6
18	363.3	364.8	452.2	472.8	504.7	492.0	507.1	497.4	454.4	423.2	363.4	350.9	5246.2
17	370.0	369.6	455.3	473.2	502.7	488.9	504.5	496.7	456.4	427.8	369.5	357.8	5272.4
16	376.5	374.3	458.4	473.4	500.6	485.7	501.7	495.9	458.2	432.2	375.5	364.7	5297.1
15	383.0	379.0	461.2	473.5	498.3	482.4	498.7	494.9	459.9	436.6	381.4	371.5	5320.4
14	389.3	383.5	464.0	473.5	495.9	479.0	495.7	493.8	461.4	440.8	387.2	378.2	5342.2
13	395.6	387.9	466.5	473.3	493.4	475.5	492.5	492.5	462.9	444.8	392.9	384.8	5362.6
12	401.8	392.2	469.0	473.0	490.7	471.8	489.2	491.1	464.1	448.8	398.5	391.4	5381.5
11	407.8	396.4	471.3	472.5	487.9	468.1	485.7	489.6	465.2	452.6	404.0	397.8	5398.9
10	413.8	400.4	473.4	471.9	485.0	464.2	482.2	487.9	466.2	456.3	409.4	404.2	5414.8
9	419.6	404.4	475.5	471.1	481.9	460.2	478.5	486.1	467.1	459.8	414.7	410.4	5429.7
8	425.4	408.3	477.3	470.2	478.7	456.1	474.7	484.1	467.8	463.2	419.8	416.5	5442.2
7	431.0	412.0	479.1	469.2	475.4	451.9	470.7	482.0	468.3	466.5	424.9	422.6	5453.6
6	436.6	415.5	480.5	468.0	472.0	447.5	466.7	479.8	468.7	469.6	429.8	428.5	5463.5
5	442.0	419.1	482.1	466.7	468.4	443.1	462.5	477.4	469.0	472.6	434.6	434.3	5471.8
4	447.3	422.5	483.4	465.3	464.7	438.5	458.2	474.9	469.1	475.5	439.4	440.1	5478.7
3	452.5	425.7	484.5	463.7	460.9	433.8	453.8	472.3	469.1	478.2	443.9	445.7	5484.1
2	457.5	428.8	485.5	462.0	457.0	429.1	449.3	469.5	468.9	480.7	448.4	451.2	5487.9
1	462.5	431.9	486.3	450.1	452.9	424.2	444.6	466.6	468.6	483.2	452.8	456.6	5490.2
0	467.3	434.7	487.0	458.1	448.7	419.2	439.9	463.5	468.2	485.5	457.0	461.8	5490.9
-1	472.0	437.5	487.6	456.0	444.4	414.1	435.0	460.3	467.6	487.6	461.1	467.0	5490.2
-2	476.6	440.1	488.0	453.7	440.0	408.9	430.0	457.0	466.9	489.6	465.1	472.0	5487.9
-3	481.0	442.6	488.2	451.3	435.4	403.6	424.9	453.6	466.0	491.5	468.9	476.9	5484.1
-4	485.3	445.0	488.3	448.8	430.7	398.2	419.7	450.0	465.0	493.2	472.7	481.7	5478.7
-5	489.5	447.3	488.3	446.1	426.0	392.7	414.4	446.3	463.8	494.7	476.2	486.4	5471.8
-6	493.6	449.4	488.1	443.3	421.1	387.1	409.0	442.5	462.6	495.1	479.7	491.0	5463.5
-7	497.5	451.4	487.8	440.4	416.1	381.5	403.5	438.5	461.1	497.4	483.1	495.4	5453.6
-8	501.3	453.2	487.3	437.3	411.0	375.7	397.9	434.4	459.5	498.5	486.3	499.7	5442.1
-9	505.0	455.0	486.6	434.2	405.7	369.8	392.1	430.2	457.8	499.5	489.3	503.8	5429.2

the confidence interval for March is EVC = EVM ± 19.4 and the percent of deviation from the true mean (measured evaporation) is within the limits of 7.7 percent of the record mean values. In brief, EVC is an accurate approximation of EVM.

The absolute error of the computer evaporation (Appendix A, Table 6), for 19 stations range between 13.1 percent and 4.9 percent with an overall mean error of 9.7 percent.

Unfortunately, measured evapotranspiration data are not available for Venezuela. Formulas for computing potential evapotranspiration have been derived for conditions where the climate is significantly different from that of Venezuela. These data are used together with known relationships between pan evaporation and potential evapotranspiration to evaluate methods of estimating potential evapotranspiration for Venezuela.

Potential Irrigation Requirements

The gamma distribution analysis was used to compute precipitation probability values for 16 stations. The results are given in Appendix B. Three other stations were not included in this study because the precipitation data available were for less than three years.

Monthly and annual probabilities of receiving equal to or greater than a certain amount for 13 given probability levels were calculated. Arithmetic mean, the gamma distribution parameter (LAMBA and R), and the natural logarithm of the evaluation of the complete gamma distribution (LNGAM) for each month and theannual value were computed. The annual values do not correspond with the sum of the monthly values at a given probability, since they represent the distribution of the annual totals for each year of record. As an example, in Appendix B, Table 7, for Cua-Tovar, we found under the 60 percentile column and across from January, 23.0. This indicates that in 6 years out of 10, the January precipitation total is expected to be equal to or greater than 23.0

millimeters, or alternatively, that in 4 years out of 10, the January precipitation total is expected to be less than 23.0 millimeters.

The potential irrigation requirements at 5 precipitation probability levels also appear in Appendix B, Table 7. The computed values of potential evapotranspiration (ETP) for each month and the annual values are given. Potential irrigation requirements are calculated by subtracting from the precipitation values at the 5 probability levels ETCH values. Positive values indicate a deficit of and negative values a surplus of precipitation.

Also in Appendix B, values of the maximum and minimum precipitation are given for each month as well as the annual value, dependable precipitation, evapotranspiration deficit (ETDF) and moisture available index (MAI) at the 75 percent level of probability.

Formula for Estimating Dependable Precipitation from Mean Values

To calculate the gamma distribution, the Univac 1108 computer and a very complex program were used. It seemed desirable that a simpler method be developed to estimate precipitation at any level of probability based on precipitation means.

Sixteen stations with records varying from 4 to 27 years were used for development of this method. The monthly values of precipitation for 13 probability levels (gamma distribution) were plotted against the monthly mean values and analyzed by the method of least squares. Thirteen equations giving the best straight line relationships for each probability were found.

A general equation for all probability levels was developed. This general equation can be written:

$$\text{PD(P)} = \text{CPI} + \text{CPR(PM)}$$

in which

PD(P) = dependable precipitation at any probability level, P

$\text{CPI} = 79.566\, e^{-5.38\, P} - 15$

$$CPR = 1.43 - 0.876\ P.$$

The coefficients of correlation for the 13 equations ranged from 0.924 for P = 95% to 0.997 for P = 30%.

The coefficients of correlation for CPI was 0.991 and for CPR was 0.993, indicating that this equation explains nearly 98 percent of the variance of the gamma distribution function.

Reliability of Short Time Mean Values of Precipitation

A study of the influence of the length of record on the mean precipitation values was made. A moving average program, Appendix D, was used to study the reliability of mean values from short records using 4 stations with data ranging from 19 to 27 years. The moving average periods considered in the analysis were 5, 10, 15, and 20 years.

Appendix C, Tables 10, 11, 12 and 13, shows the ratios of moving average precipitation for various percentages of the total length of record to the mean precipitation for the total length of record. The maximum and minimum values are given, indicating that for short records the mean precipitation was between the values given. For example, using Cua-Tovar, Table 10, with 25 years of record, the 10-year moving average ratio for 10 years (40 percent of the length of record) for June (a wet month) varied from 0.925 to 1.123. This indicates that the mean precipitation for a consecutive 10-year period ranged from 92.4 to 112.3 percent of the 25-year mean.

Figure 4, Appendix C, shows that the variation for March, a dry month, was much greater. A 10-year mean ranged from 59.8 to 122.2 percent of the 25-year mean. In general, this indicates that the short term means for a wet month, such as June, are much more reliable than a short term mean for a dry month such as March.

APPLICATION OF THE STUDY TO WATER RESOURCE DEVELOPMENT

Example

As stated in the introduction, the objectives of this study were to analyze the available data to compute the potential evapotranspiration, the dependable precipitation and potential irrigation water requirement. These objectives have been accomplished. The purpose of this section is to show how the information developed can be used in a practical way in a feasibility study of a proposed irrigation project. For this purpose the analysis of the data for the Guanare Station (Ser. No. 3208) was used. This station is located at latitude 8°57'N, longitude 69°14'W at an elevation of 117 meters. It is in the state of Portuguesa in the plains just southeast of the Andes.

Dependable Precipitation

The dependable monthly precipitation for different probability levels is given in Appendix B, Table 7. Column 2 of this table gives the mean values of the monthly precipitation and the mean annual precipitation. As will be noted, most of the precipitation occurs during the months April through October, leaving five months with relatively low precipitation, less than 100 mm.

The probable precipitation at 13 probability levels is also given. Assuming a probability of 80 percent, it is shown that 6 months have less than 100 mm, and that the maximum dependable precipitation occurs in July.

Computer Potential Evapotranspiration

The computed potential evapotranspiration is given in the column under the heading ETP. The month values vary from 104 mm for June, the wettest month on the basis of the mean precipitation, to 193 mm for March, which has the lowest mean precipitation. This is the assumed evapotranspiration for a short, vigorously growing crop such as grass. It could be applied directly to an irrigated pasture.

Potential Irrigation Requirement

Combining the dependable precipitation at different probability levels from 60 to 90 percent with the ETP values, the potential irrigation requirement is obtained and given in the table. Using the 80 percent probability value, it is shown that a deficit occurs during 8 of the 12 months, beginning with September. However, the deficits for September and October are very small and would be supplied by the carry-over soil moisture. Irrigation would not be required for any crop before November 1. For annual crops that are planted after the rainy season, irrigation might not be required before December of January. For perennial crops, irrigation should start in November and be continued through March and into April until the first rains occur.

Actual Irrigation Requirement

As explained in the introduction, the actual irrigation water requirement depends on soil and crop factors, and the irrigation efficiency as well as the climate.

For the Guanare station one would need to consider the crops to be grown under irrigation.

Table 4 gives some of the crops grown in that area and the approximate planting and harvesting dates and rooting depths.

Effective Precipitation

In order to apply the dependable precipitation values intelligently one must know some of the soil factors and the precipitation intensities. The important soil factors are:

1. Soil texture and moisture holding capacities
2. Topography and slopes
3. The infiltration rates under the average rainfall intensities

Table 4. Crops Grown in the Guanare Area

Crop	Dates		Rooting Depth cm
	Planting	Harvesting	
Cotton	Sept-Oct	Feb-Mar	120-160
Bananas	Perrenial	All year	50- 80
Black beans	Dec	Feb	30- 50
Sesame	Oct-Nov	Jan-Mar	40- 80
Sorghum	Nov	Mar	50- 80
Soybeans	Nov-Dec	Feb-Mar	30- 60
Pastures	Perrenial	All year	40- 60
Maise	Apr-May	Sept-Oct	100-150

4. The probable osoting depths for the crops to be grown
5. Drainage conditions.

These factors are all important if one is to reliably estimate the effective precipitation. Since detailed information on these factors is not available, some assumptions will be made based on a general knowledge of the area and soils. These assumptions are:

1. The soils are generally fine textured and classified as heavy loam to heavy clay loam.

2. The topography of most of the area that might be irrigated is relatively flat with slopes less than three or four percent, mostly less than one percent. Because of microrelief, land grading is necessary to prepare fields for surface irrigation. Sprinkling could be practiced with a minimum of land grading.

3. From the MOP study of maximum precipitation intensities,* at five stations in the vicinity of Guanare, it can be assumed that the mean annual extreme precipitation amounts in mm are approximately as follows:

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*Ministerio de Obras Publicas, Direccion de Obras Hidraulicas, Lluvias Extremas para 1, 3, 6, 9, 12 y 24 horas de 84 estaciones escogidas. Publicacion Tecnica 3, Dec. 1968 - Caracas, Venezuela.

Table 5. Analysis of Actual Irrigation Requirements for Sesame and Corn

Month	Dep. P (80%) mm	Est. Runoff mm	Infiltrated Prec. mm	ETP mm	Crop Coeff.	ETA mm	Moisture Carry-over	Deficit	IR	Excess Moisture
Sesame										
Oct	101	20	81	137	.70	27	120	-	-	24
Nov	34	-	34	135	.50	68	86	-	-	-
Dec	10	-	10	136	.90	122	-	26	37	-
Jan	0	-	-	151	.70	105	-	105	150	-
Feb	0	-	-	154	.40	61	-	61	87	-
Mar	1	-	1	193	.20	39	-	39	56	-
Corn										
Apr	33	-	33	143	.20	28	5	-	-	-
May	142	28	114	129	.40	56	63	-	-	-
Jun	182	36	146	104	.90	94	115	-	-	-
Jul	196	39	157	111	.80	89	120	-	-	63
Aug	135	27	108	120	.50	60	120	-	-	48
Sep	123	24	99	127	.20	25	120	-	-	74
Total	1340			1641				231	330	239

Month	1-hr	3-hr	6-hr	12-hr	24-hr
May	30	48	52	56	73
June	35	53	56	50	57
July	38	58	58	57	60
Aug	36	50	49	48	61

Although these are mean maximum values that occurred over a period of about ten years, it is obvious that some runoff will occur and that the effective precipitation will be somewhat less than the tabulated dependable precipitation. For the purpose of this example, it is assumed that the runoff will be approximately 20 percent. More precise determinations of mean runoff would be desirable.

4. The available soil moisture storage capacities within the root zone of the crops to be grown are estimated to be within the range of 10-15 cm for pasture grasses to 20-30 for deep rooted crops such as cotton. When monthly precipitation amounts are appreciably in excess of crop requirements, some of the precipitation that enters the soil will pass beyond the root zone and will not be available to supply the crop requirements.

5. Some of the precipitation which passes through the root zone may leave the area through natural soil drainage, and some may contribute to a rise in the water table and create a drainage problem and may necessitate the construction of a sub-surface drainage system. Comparing the dependable precipitation with the ETP values, and considering the possible runoff, it appears that on vegetated areas there may not be much deep percolation loss, but on fallow ground where the actual ET may be much less than the computed ETP values, considerable excess moisture will be available during the rainy season. This may necessitate attention to both surface and sub-surface drainage.

In summary, it might be assumed that for the 7 wettest months, October through March, the effective precipitation may be in the range of 26 to 52 percent of the tabulated dependable precipitation. With more detailed data, this range could be narrowed and more specific values could be given for different soil types and crops.

Irrigation Efficiency

For the purpose of this study, and considering the soils, topography, drainage conditions, and methods of irrigation (borders and furrows), an irrigation efficiency of 70 percent is assumed. This is somewhat higher than often assumed for surface irrigation, but it is believed to be a realistic value for the conditions mentioned above.

Estimated Irrigation Requirement

An analysis of actual irrigation requirements for sesame followed by maise, two important crops for the area, has been made and is presented in Table 5.

This example shows that for the two crops, sesame followed by maise, irrigation would be needed only during the four months, December through March. Although the deficit, or irrigation requirement, for December was only 37 mm, more water could be applied because the soil is assumed to have a maximum carryover capacity of 120 mm. Thus it would be possible to apply as much as 157 mm in December without waste. The total irrigation for the four months was 330 mm, which could be applied in three or four irrigations of 83 to 110 cm each during the four-month period.

From this analysis it appears that maise would not benefit from irrigation except during years of low precipitation.

A similar analysis could be made for the other crops grown in the area.

SUMMARY AND CONCLUSION

The objectives of this study were to:

1. Analyze available climatic data to enable computation of the potential evapotranspiration
2. Analyze available precipitation to determine the dependable precipitation.
3. Combine the dependable precipitation and potential evapotranspiration to determine potential irrigation water requirements.

Christiansen's formula was used to compute evaporation and potential evapotranspiration using 1013 months of data from 19 stations in Venezuela.

The factors considered were mean monthly temperature, humidity, wind, sunshine, elevation, days of precipitation and extraterrestrial radiation.

Evapotranspiration data is not available in Venezuela, so comparisons with potential evapotranspiration computed from Christiansen's formula could not be made. However, the results of computation with the formula gave reasonable values. Christiansen's formula which takes into consideration more of the climatic factors is believed to be the most reliable.

A check on the Christiansen formula indicated that it fits the Venezuela data, and only adjustment for computed sunshine was made. The value for computed evaporation and potential evapotranspiration is given in Table 6, Appendix A.

Thirteen probability levels of precipitation were determined for each station. Each precipitation amount is that which is expected to be equaled or exceeded at the given probability level (Table 7, Appendix B).

Potential irrigation requirements for sixteen stations were computed based on gamma distribution of five probability levels subtracted from the potential evapotranspiration. The irrigation requirements presented provide a useful index of actual irrigation requirements. Obviously each location must be evaluated to modify this index.

A formula for computing precipitation at any level of probability was developed based on gamma distribution and average monthly value of the years of record available. The formula was tested and appears to be fairly reliable for estimating precipitation probability for Venezuelan data.

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APPENDICES

APPENDIX A

Data used to compute sunshine, radiation, pan evaporation and potential evapotranspiration

TABLE 6.1 DATA AND COMPUTED SUNSHINE, RADIATION, PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 582. ID NO. 25. NAME AND STATE. CUA-TOVAR MIRANDA LAT. 10.15, LONG. 66.83, ELEVATION 240.

MO	YR	TM	TD	WID	PREC	DP	HM	S	SC	VPD	RMM	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERV
1	9	23.2	11.5	10.9	45.6	7.6	.71	.57	.64	9.15	413.	186.	182.	165.	175.	142.	.892	1.022	.945	.811	12.6	5.3	9.1
2	8	23.9	12.6	13.0	16.9	3.6	.71	.64	.71	10.04	404.	201.	185.	189.	205.	162.	.901	1.078	.924	.789	11.0	7.3	10.6
3	7	25.3	13.4	15.0	12.1	2.6	.69	.66	.74	11.89	475.	242.	227.	252.	280.	215.	.894	1.094	.902	.769	12.5	8.6	11.4
4	7	26.2	11.9	14.2	34.3	4.6	.68	.54	.69	12.07	474.	218.	205.	229.	257.	193.	.789	1.062	.892	.776	26.7	5.9	15.4
5	7	25.7	11.5	11.6	110.3	10.6	.68	.53	.62	12.26	484.	219.	208.	211.	227.	182.	.853	1.052	.931	.804	19.7	4.9	8.5
6	8	25.3	9.6	9.0	206.7	20.5	.77	.52	.54	8.57	461.	212.	197.	150.	165.	138.	.963	1.079	.910	.837	9.0	7.3	11.9
7	8	24.9	9.5	8.7	196.7	20.0	.79	.56	.54	7.45	479.	226.	210.	153.	167.	140.	1.029	1.074	.916	.840	6.3	6.9	9.7
8	9	25.2	10.5	8.7	127.6	15.4	.79	.58	.58	7.93	488.	231.	218.	162.	178.	150.	1.010	1.059	.908	.841	4.5	5.5	11.3
9	9	25.5	11.5	8.5	95.9	12.8	.76	.57	.62	9.28	468.	221.	208.	169.	179.	151.	.925	1.069	.948	.843	8.4	6.5	9.3
10	8	25.4	11.9	8.6	89.9	10.6	.74	.59	.64	9.73	458.	216.	206.	178.	182.	153.	.929	1.049	.980	.842	10.1	4.7	4.4
11	9	24.8	11.6	9.3	59.3	8.4	.75	.60	.65	9.24	409.	188.	184.	164.	167.	139.	.912	1.031	.981	.831	10.0	3.4	9.3
12	8	24.0	10.9	9.7	76.5	8.6	.74	.57	.64	8.73	403.	184.	178.	157.	160.	132.	.891	1.037	.983	.827	12.3	3.9	4.8
YR	95	25.0	11.4	10.5	90.3	10.6	.74	.58	.63	9.61	450.	212.	200.	180.	193.	157.	.914	1.059	.933	.815	11.5	5.9	9.8

TABLE 6.2 DATA AND COMPUTED SUNSHINE. RADIATION. PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 2881. ID NO. 26. NAME AND STATE. JUSEPIN MONAGAS LAT. 9.75. LONG. 63.45. ELEVATION 146.

MO	YR	TM	TD	WID	PREC	DP	HM	S	SC	VPD	RHM	RSM	RSC	EVM	EVC	ETC	RSS	RAR	RCV	RET	EPS	ERR	ERV
1	6	25.7	8.3	14.5	45.8	11.3	.79	.63	.56	9.20	415.	223.	189.	190.	196.	151.	1.121	1.129	.973	.772	12.9	11.4	16.9
2	5	25.9	8.8	14.5	32.6	6.0	.74	.69	.62	10.60	405.	211.	191.	193.	218.	169.	1.102	1.076	.885	.775	9.3	7.1	13.4
3	5	27.1	9.7	16.4	9.4	3.4	.68	.71	.66	13.28	477.	244.	226.	276.	309.	233.	1.083	1.033	.893	.755	14.5	3.2	13.2
4	6	28.1	8.9	15.1	13.3	3.8	.65	.67	.62	15.13	474.	241.	221.	259.	299.	230.	1.083	1.102	.866	.769	8.3	9.2	15.4
5	6	28.0	8.3	14.7	81.0	10.7	.70	.60	.57	13.47	484.	257.	217.	232.	269.	207.	1.061	1.186	.863	.772	10.7	15.7	18.3
6	6	26.6	7.0	12.0	168.0	21.2	.83	.50	.48	8.06	460.	233.	197.	153.	174.	140.	1.040	1.191	.880	.801	12.1	16.1	13.6
7	6	26.5	7.0	11.0	196.8	22.5	.83	.54	.47	8.16	479.	241.	206.	150.	179.	145.	1.160	1.168	.840	.813	13.8	14.4	19.1
8	6	26.5	7.7	9.4	194.3	24.0	.83	.57	.46	8.26	488.	249.	214.	155.	174.	145.	1.238	1.158	.893	.832	19.2	13.6	13.2
9	7	27.5	8.4	9.6	98.0	13.9	.77	.63	.55	10.67	470.	241.	214.	181.	200.	166.	1.144	1.137	.904	.829	13.7	12.1	11.1
10	7	27.4	8.5	9.8	101.7	13.4	.78	.65	.55	10.35	460.	239.	212.	180.	198.	163.	1.170	1.118	.909	.826	14.6	10.6	10.6
11	7	26.7	8.3	10.0	96.0	14.1	.80	.61	.54	9.31	414.	209.	187.	154.	169.	139.	1.129	1.103	.911	.824	11.6	9.3	9.7
12	7	25.9	8.3	10.8	82.7	13.1	.82	.66	.54	8.41	406.	217.	188.	160.	169.	138.	1.239	1.137	.949	.814	19.3	12.1	9.7
94	74	26.8	8.3	12.1	95.3	13.4	.77	.62	.55	10.33	452.	233.	204.	188.	210.	167.	1.131	1.133	.896	.796	13.4	11.7	13.7

TABLE 6.3 DATA AND COMPUTED SUNSHINE, RADIATION, PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 2575. ID NO. 27. NAME AND STATE. MAYALITO-CUJIALOTE GUARICO LAT. 9.52. LONG. 66.20. ELEVATION 270.

MO	YR	TM	TD	WID	PREC	DP	HM	S	SC	VPD	RMM	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERV
1	8	25.4	12.0	9.3	19.4	3.1	.71	.70	.71	10.39	417.	188.	199.	206.	199.	166.	.994	.985	1.034	.833	4.7	5.9	6.7
2	8	26.2	11.5	10.5	4.7	.3	.68	.76	.74	12.14	408.	197.	199.	227.	232.	190.	1.033	.987	.976	.818	7.9	2.8	9.4
3	7	27.1	12.9	11.3	1.8	.4	.66	.74	.75	13.55	478.	234.	232.	272.	288.	233.	.987	1.008	.945	.809	3.8	2.1	6.2
4	7	27.7	11.8	10.4	26.5	3.1	.64	.60	.69	14.29	474.	206.	213.	251.	256.	209.	.859	.965	.980	.818	15.0	4.5	7.1
5	7	27.3	10.9	8.2	115.7	11.6	.69	.59	.61	12.53	483.	210.	216.	230.	208.	176.	.964	.959	1.105	.846	9.4	3.3	9.5
6	7	25.3	8.9	6.2	233.7	20.7	.78	.55	.53	7.70	459.	201.	201.	159.	144.	127.	1.043	1.003	1.100	.877	3.5	1.6	9.4
7	7	24.9	8.7	5.6	214.1	20.7	.83	.62	.51	6.31	478.	219.	219.	154.	143.	126.	1.230	1.000	1.084	.886	18.7	1.4	8.6
8	7	24.9	9.7	5.1	211.0	19.3	.83	.62	.52	6.27	487.	220.	223.	152.	142.	127.	1.183	.986	1.075	.896	15.5	2.6	7.0
9	7	25.2	9.8	4.9	127.3	15.1	.83	.64	.55	6.58	469.	216.	217.	154.	140.	126.	1.158	.996	1.101	.898	13.7	2.4	9.1
10	7	25.5	10.6	5.9	98.7	10.7	.79	.67	.62	7.72	460.	212.	217.	168.	160.	141.	1.094	.977	1.049	.882	9.7	2.7	7.0
11	9	25.7	11.0	6.6	64.9	7.5	.77	.70	.65	8.66	413.	186.	196.	167.	159.	138.	1.069	.988	1.049	.869	9.0	5.5	7.3
12	8	25.4	11.6	8.1	30.4	4.2	.75	.76	.69	9.40	408.	189.	199.	185.	180.	153.	1.103	.949	1.027	.849	11.1	5.3	4.5
MN	88	25.9	10.8	7.7	95.6	9.5	.75	.67	.63	9.65	451.	206.	210.	194.	188.	159.	1.052	.977	1.032	.849	10.3	3.3	7.6

TABLE 6.4 DATA AND COMPUTED SUNSHINE, RADIATION, PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 2417. ID NO. 28. NAME AND STATE. SAN JUAN LOS MORROS GUARICO LAT. 9.90. LONG. 67.35. ELEVATION 430.

MO	YR	TM	TD	WIO	PREC	DP	HM	S	SC	VPD	RMK	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERV
1	7	23.7	13.7	6.2	16.1	1.7	.70	.71	.76	10.42	414.	189.	199.	180.	167.	147.	.930	.947	1.079	.877	8.0	5.6	7.3
2	9	24.6	14.4	7.1	5.7	1.3	.64	.74	.76	12.51	406.	196.	198.	206.	190.	164.	.966	.989	1.093	.862	5.5	2.5	8.9
3	8	25.7	14.4	7.5	2.2	.3	.60	.73	.77	14.54	476.	224.	232.	256.	244.	209.	.945	.968	1.050	.858	7.6	4.0	7.8
4	8	26.4	12.1	6.3	55.1	7.6	.62	.59	.64	14.19	474.	198.	213.	225.	193.	169.	.921	.925	1.165	.875	13.3	8.1	14.2
5	7	26.0	9.8	5.3	162.1	13.7	.70	.53	.58	11.24	483.	190.	210.	191.	163.	145.	.916	.936	1.173	.891	13.1	10.4	14.7
6	8	24.7	8.3	5.0	263.5	22.6	.80	.51	.51	7.17	459.	184.	197.	145.	124.	111.	1.006	.930	1.169	.897	5.7	7.5	14.5
7	8	23.6	8.2	4.6	215.9	19.2	.79	.58	.52	7.07	478.	201.	214.	151.	132.	119.	1.103	.938	1.141	.904	9.8	6.6	12.8
8	8	23.8	9.1	4.2	195.7	18.9	.79	.59	.54	7.32	487.	209.	221.	158.	134.	122.	1.103	.943	1.176	.911	10.1	6.0	16.2
9	8	24.0	9.7	4.3	168.2	17.5	.80	.59	.55	7.25	468.	202.	212.	154.	129.	118.	1.073	.954	1.191	.911	7.5	4.9	16.1
10	8	24.4	10.6	4.0	135.6	13.7	.78	.60	.60	7.81	458.	200.	209.	164.	132.	121.	1.011	.957	1.244	.916	8.6	5.0	19.6
11	9	24.3	12.0	4.6	64.9	7.8	.76	.65	.66	8.78	412.	179.	194.	150.	133.	121.	.991	.924	1.126	.904	6.9	8.2	11.6
12	8	23.9	13.0	5.2	31.4	4.4	.73	.69	.72	9.30	405.	181.	194.	162.	146.	130.	.964	.931	1.115	.893	6.9	7.4	10.3
SM	95	24.5	11.3	5.3	110.1	10.8	.73	.63	.63	9.77	451.	196.	208.	178.	157.	139.	.989	.943	1.135	.888	8.4	6.3	12.5

TABLE 6.5 DATA AND COMPUTED SUNSHINE. RADIATION. PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 1286. ID NO. 29. NAME AND STATE. ZONAS ARIDAS MAC LARA LAT. 10.15. LONG. 69.30. FLEVATION 630.

MO	YR	TM	TD	W10	PREC	DP	HM	S	SC	VPD	RHM	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERV
1	4	22.6	13.4	9.3	6.7	3.2	.80	.66	.73	5.71	413.	0.	197.	180.	163.	136.	.899	.000	1.106	.833	11.2	.0	9.6
2	4	23.0	14.2	10.4	2.7	2.0	.77	.72	.77	6.41	404.	0.	199.	195.	181.	149.	.941	.000	1.078	.820	6.4	.0	10.2
3	4	23.9	14.1	11.7	2.5	2.2	.70	.66	.76	8.70	475.	0.	227.	254.	238.	191.	.872	.000	1.071	.804	14.7	.0	6.6
4	4	24.5	11.7	10.4	66.7	9.0	.77	.47	.65	6.72	473.	0.	198.	204.	179.	146.	.720	.000	1.139	.817	39.0	.0	12.2
5	4	24.2	10.0	11.8	87.5	11.2	.84	.50	.57	4.67	495.	0.	213.	179.	181.	145.	.879	.000	.992	.800	13.8	.0	8.7
6	4	23.5	9.3	12.1	119.7	19.0	.88	.54	.48	3.45	460.	0.	204.	163.	156.	125.	1.108	.000	1.044	.801	9.7	.0	7.0
7	4	23.3	9.6	10.1	140.0	22.0	.87	.57	.48	3.34	479.	0.	217.	163.	154.	126.	1.177	.000	1.065	.822	15.0	.0	10.8
8	4	23.7	10.5	10.5	72.7	15.0	.84	.65	.56	4.23	488.	0.	232.	189.	181.	148.	1.174	.000	1.043	.817	14.8	.0	5.1
9	4	24.4	11.9	11.6	34.5	9.0	.82	.63	.63	5.32	468.	0.	219.	191.	192.	155.	.993	.000	.992	.805	6.2	.0	6.4
10	5	24.4	12.3	9.3	28.6	9.4	.78	.63	.65	6.75	457.	0.	215.	197.	180.	150.	.963	.000	1.099	.833	4.2	.0	9.5
11	5	23.9	12.3	7.9	62.2	10.4	.80	.60	.63	6.06	409.	0.	189.	162.	143.	121.	.954	.000	1.138	.851	6.7	.0	12.1
12	5	22.8	12.2	7.8	29.4	8.2	.81	.63	.65	5.29	403.	0.	189.	151.	137.	117.	.977	.000	1.104	.854	5.5	.0	9.4
94	51	23.7	11.8	10.1	53.6	10.0	.81	.61	.63	5.58	450.	0.	208.	185.	172.	142.	.960	.000	1.073	.821	11.3	.0	9.0

TABLE 6.6 DATA AND COMPUTED SUNSHINE. RADIATION. PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 417. ID NO. 30. NAME AND STATE. SANTA CRUZ MOP ARAGUA LAT. 10.18. LONG. 67.03. ELEVATION 408.

MO	YR	TM	TD	VIO	PREC	DP	HM	S	SC	VPD	RMM	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERV
1	7	24.9	12.2	10.3	7.1	1.1	.70	.73	.74	10.65	413.	210.	201.	195.	215.	176.	.991	1.042	.910	.820	2.6	5.6	12.1
2	7	25.3	12.8	11.9	1.9	.9	.65	.79	.73	11.84	403.	219.	201.	218.	236.	189.	1.071	1.089	.925	.802	9.9	8.7	8.1
3	6	26.0	12.8	12.2	11.0	1.5	.62	.77	.72	13.35	476.	255.	236.	265.	292.	233.	1.067	1.080	.908	.793	6.5	7.4	10.1
4	6	26.4	11.6	10.4	40.7	4.3	.63	.62	.65	13.23	474.	224.	218.	232.	242.	198.	.948	1.028	.956	.818	7.3	4.5	5.2
5	6	26.5	9.7	8.0	126.0	11.2	.70	.55	.59	10.99	484.	215.	213.	185.	193.	164.	.936	1.008	.960	.849	15.0	2.7	4.1
6	6	25.1	9.7	6.6	189.8	17.2	.76	.53	.56	8.94	451.	208.	201.	141.	150.	130.	.948	1.036	.945	.870	11.0	3.5	8.1
7	7	24.8	9.7	6.4	191.9	18.4	.79	.56	.55	7.97	479.	215.	213.	150.	153.	133.	1.023	1.007	.984	.872	5.9	2.2	8.0
8	7	24.9	10.1	6.2	186.3	15.9	.79	.61	.57	8.19	488.	223.	223.	152.	161.	141.	1.067	1.000	.945	.875	6.3	2.5	11.7
9	7	24.9	10.7	5.8	135.4	13.1	.77	.60	.60	8.34	468.	202.	213.	145.	153.	135.	.997	.946	.942	.883	4.8	8.4	6.4
10	7	25.1	11.4	5.9	145.7	11.9	.78	.65	.62	8.59	458.	218.	214.	157.	156.	138.	1.044	1.018	1.001	.881	4.7	4.0	5.2
11	7	25.0	11.7	6.6	83.0	6.7	.76	.68	.67	9.12	409.	198.	195.	145.	155.	135.	1.024	1.015	.935	.869	6.2	3.6	8.8
12	7	24.8	12.1	8.3	30.7	3.6	.75	.72	.71	9.11	403.	200.	196.	164.	176.	148.	1.017	1.020	.932	.845	4.0	3.5	9.1
SM	80	25.3	11.7	8.2	96.0	8.8	.73	.65	.64	9.91	450.	215.	210.	178.	189.	159.	1.014	1.023	.942	.843	6.7	4.7	8.2

TABLE 6.7 DATA AND COMPUTED SUNSHINE, RADIATION, PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 1467. ID NO. 31. NAME AND STATE. SHELL FOUNDATION ARAGUA LAT. 10.30. LONG. 67.75. ELEVATION 432.

MO	YR	TM	TD	WID	PREC	DP	HM	S	SC	VPD	RMH	RSM	RSC	EVN	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERY
1	5	23.6	11.8	11.9	3.0	1.0	.68	.74	.72	8.99	413.	0.	203.	214.	228.	183.	1.029	.000	.939	.802	2.8	.0	15.1
2	5	24.5	12.5	14.0	.2	.2	.64	.79	.74	10.82	407.	0.	204.	235.	261.	203.	1.073	.000	.901	.780	8.7	.0	11.0
3	5	25.2	13.0	14.4	.6	.2	.59	.67	.73	12.45	475.	0.	224.	278.	304.	236.	.907	.000	.913	.776	10.9	.0	11.2
4	5	25.9	11.9	12.8	39.2	3.6	.61	.54	.66	12.53	474.	0.	207.	243.	250.	198.	.821	.000	.973	.792	21.9	.0	9.1
5	5	25.6	10.9	10.2	110.6	10.2	.67	.56	.60	10.26	484.	0.	215.	201.	216.	177.	.927	.000	.931	.819	8.5	.0	9.7
6	5	24.2	9.5	7.3	181.8	16.2	.73	.53	.56	7.57	460.	0.	201.	166.	157.	135.	.953	.000	1.058	.860	7.3	.0	9.2
7	5	24.1	9.6	7.8	183.8	15.8	.76	.60	.56	6.74	479.	0.	218.	179.	169.	144.	1.066	.000	1.056	.853	9.4	.0	8.5
8	5	24.3	9.9	7.3	138.2	13.2	.75	.63	.58	7.23	438.	0.	227.	172.	177.	152.	1.081	.000	.972	.859	7.5	.0	10.1
9	5	24.2	10.6	6.4	147.6	14.4	.78	.54	.59	6.37	468.	0.	204.	163.	147.	128.	.917	.000	1.108	.874	15.8	.0	9.7
10	5	24.6	10.9	6.8	147.2	11.4	.75	.67	.61	7.23	457.	0.	217.	184.	167.	145.	1.094	.000	1.103	.867	9.8	.0	13.1
11	5	24.3	11.1	7.4	48.6	5.8	.73	.68	.65	7.70	409.	0.	194.	159.	163.	140.	1.043	.000	.979	.858	12.8	.0	8.0
12	5	23.8	11.5	9.0	14.6	2.2	.71	.76	.71	8.31	403.	0.	199.	181.	188.	157.	1.082	.000	.964	.835	7.6	.0	5.0
94	60	24.5	11.1	9.6	84.6	7.8	.70	.64	.64	8.85	451.	0.	209.	198.	202.	167.	1.000	.000	.979	.823	9.9	.0	10.1

TABLE 68 DATA AND COMPUTED SUNSHINE, RADIATION, PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 5408, ID NO. 32, NAME AND STATE, URANON APURE LAT. 6.93, LONG. 67.12, ELEVATION 90.

MO	YR	TM	TD	W10	PREC	DP	HM	S	SC	VPD	RMM	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERV
1	6	27.0	9.4	16.3	2.0	.5	.73	.74	.70	10.80	435.	200.	209.	285.	288.	218.	1.050	.957	.992	.757	7.9	5.9	2.3
2	6	27.7	10.8	17.5	4.2	.5	.67	.75	.72	13.05	419.	199.	197.	308.	300.	273.	1.047	1.009	1.026	.744	23.9	7.5	7.1
3	6	28.7	11.2	15.2	10.2	2.0	.65	.73	.69	14.90	484.	221.	232.	363.	333.	255.	1.068	.955	1.090	.767	7.5	6.1	8.6
4	5	28.3	9.5	11.7	90.4	9.6	.69	.54	.60	12.93	475.	188.	203.	274.	237.	190.	.893	.925	1.156	.803	15.8	9.4	13.5
5	5	27.2	8.1	8.9	192.0	17.4	.77	.45	.54	9.38	475.	173.	191.	207.	172.	144.	.839	.906	1.199	.837	19.2	10.3	16.6
6	6	26.1	7.5	7.7	384.0	24.0	.83	.41	.48	7.05	449.	162.	174.	152.	131.	112.	.862	.930	1.162	.355	17.2	8.1	13.9
7	6	26.0	7.5	7.9	454.7	23.7	.83	.42	.48	7.17	469.	171.	183.	149.	138.	118.	.884	.934	1.074	.851	14.7	8.0	7.7
8	6	26.5	7.4	8.1	344.2	23.3	.83	.45	.48	7.37	483.	178.	194.	162.	150.	128.	.944	.917	1.081	.849	8.6	9.1	8.4
9	6	26.8	8.0	7.8	236.5	17.5	.81	.49	.53	8.00	472.	180.	196.	171.	157.	134.	.935	.921	1.086	.853	10.9	8.6	8.2
10	6	27.2	8.4	8.7	142.2	12.8	.80	.60	.56	8.09	471.	191.	210.	206.	185.	155.	1.067	.937	1.114	.839	7.1	10.3	10.2
11	6	27.3	8.5	11.1	64.7	7.0	.79	.70	.61	8.57	429.	181.	202.	212.	204.	165.	1.153	.898	1.040	.811	16.4	11.4	6.6
12	6	27.4	9.4	14.0	10.2	1.2	.76	.77	.70	10.00	427.	190.	207.	254.	259.	202.	1.099	.917	.980	.779	9.0	9.0	3.7
SM	70	27.2	8.8	11.3	161.8	11.6	.76	.59	.59	9.74	457.	186.	200.	228.	213.	170.	1.001	.932	1.071	.800	12.9	8.5	8.4

TABLE 6.9 DATA AND COMPUTED SUNSHINE, RADIATION, PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 1288. ID NO. 33. NAME AND STATE. YARITAGUA MOP YARACUY LAT. 10.07. LONG. 69.12. ELEVATION 374.

MO	YR	TM	TD	VID	PREC	DP	HM	S	SC	VPD	RMM	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERV
1	3	24.4	11.0	14.8	4.7	2.7	.74	.66	.69	8.97	414.	208.	195.	201.	219.	169.	.963	1.079	.918	.772	6.3	7.3	8.9
2	3	24.8	11.9	17.8	2.7	1.7	.67	.73	.71	11.15	402.	219.	195.	222.	262.	194.	1.022	1.137	.850	.743	6.3	12.0	17.6
3	3	25.5	12.6	19.1	3.3	1.7	.67	.71	.72	12.04	476.	240.	229.	285.	317.	231.	.986	1.061	.899	.731	4.8	5.7	11.3
4	3	25.6	9.9	16.7	91.3	10.0	.76	.49	.62	8.56	473.	179.	198.	220.	229.	172.	.789	.969	.963	.750	26.7	3.2	6.5
5	3	25.2	8.7	13.6	90.3	16.0	.82	.43	.54	6.53	483.	200.	194.	163.	183.	143.	.807	.984	.892	.784	23.9	1.7	12.1
6	2	24.4	7.8	10.0	206.5	21.5	.84	.44	.49	4.48	460.	0.	186.	120.	143.	118.	.900	.000	.941	.824	11.6	.0	18.9
7	4	24.2	7.5	9.5	206.0	22.7	.84	.53	.48	5.28	479.	197.	208.	138.	157.	130.	1.107	.993	.884	.830	9.7	.7	13.1
8	4	24.5	8.6	9.0	115.7	18.5	.83	.57	.52	5.42	488.	206.	218.	150.	165.	138.	1.105	.945	.911	.837	9.5	5.8	9.8
9	3	25.0	10.2	8.8	94.0	16.0	.83	.57	.55	6.43	468.	196.	209.	159.	161.	135.	1.039	.947	.984	.839	4.2	5.6	5.5
10	1	25.4	9.8	9.2	131.0	11.0	.81	.58	.59	7.12	458.	0.	206.	156.	171.	143.	.983	.000	.911	.834	1.7	.0	9.7
11	2	24.7	9.7	8.9	73.0	12.5	.83	.53	.57	6.09	410.	166.	178.	128.	140.	117.	.942	.966	.916	.837	12.3	3.5	9.1
12	2	24.7	10.2	11.3	39.0	8.5	.79	.60	.62	7.91	404.	175.	184.	156.	168.	136.	.969	.983	.933	.809	8.1	1.7	7.2
99	33	24.8	9.8	12.6	88.3	12.3	.78	.57	.59	7.51	455.	204.	202.	178.	196.	154.	.975	1.015	.907	.787	10.1	5.8	10.8

TABLE 6.10 DATA AND COMPUTED SUNSHINE. RADIATION. PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 1707. ID NO. 34. NAME AND STATE. PUNTA DE PIEDRAS NUEVA ESPARTA LAT. 10.90. LONG. 64.07. ELEVATION . 10.

MO	YR	TM	TD	VID	PREC	DP	HM	S	SC	VPD	RMM	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERV
1	4	25.8	6.7	10.6	31.7	5.7	.77	.72	.73	7.78	409.	213.	194.	207.	189.	153.	.995	1.099	1.094	.807	6.9	9.0	12.9
2	5	25.9	7.0	12.5	25.0	4.8	.73	.73	.73	9.03	401.	202.	191.	212.	208.	165.	1.002	1.060	1.017	.792	5.5	5.7	9.0
3	5	26.6	7.7	11.1	16.6	3.2	.71	.74	.77	10.31	474.	242.	226.	246.	256.	207.	.966	1.069	.960	.809	3.6	6.5	13.0
4	5	27.5	7.6	12.5	20.0	3.0	.73	.71	.78	10.53	475.	234.	223.	248.	267.	211.	.912	1.049	.929	.792	9.7	6.1	16.5
5	4	27.9	7.6	14.4	1.3	.3	.70	.80	.81	11.41	486.	254.	238.	268.	325.	252.	.981	1.057	.825	.774	5.2	6.3	21.2
6	4	27.7	6.9	10.9	18.2	3.2	.73	.73	.76	10.17	464.	237.	220.	237.	253.	206.	.963	1.078	.936	.813	5.1	7.3	7.3
7	5	27.4	6.6	9.5	17.6	4.4	.75	.74	.73	9.10	482.	211.	231.	224.	236.	196.	1.016	.913	.947	.831	2.0	20.5	5.6
8	5	27.5	6.7	8.0	55.6	6.6	.74	.73	.72	9.48	490.	242.	233.	220.	276.	192.	1.017	1.036	.973	.849	5.0	5.0	10.6
9	5	28.0	6.4	7.3	13.6	2.2	.74	.76	.76	9.93	469.	238.	225.	220.	220.	184.	.998	1.058	1.001	.860	3.4	5.5	5.4
10	5	28.3	6.5	8.5	21.2	3.8	.75	.75	.75	9.61	456.	228.	219.	240.	223.	188.	1.007	1.040	1.076	.842	8.3	4.8	7.1
11	4	27.5	6.9	5.9	75.2	8.5	.75	.74	.70	9.07	406.	201.	193.	204.	160.	141.	1.051	1.041	1.275	.881	10.5	3.9	21.6
12	3	27.0	6.9	7.9	44.7	8.7	.78	.73	.70	8.73	399.	197.	190.	165.	170.	144.	1.038	1.039	1.093	.851	3.7	4.4	11.0
SY	54	27.3	7.0	10.0	27.6	4.4	.74	.74	.75	9.63	454.	226.	216.	227.	230.	189.	.993	1.043	.989	.821	5.7	7.1	11.6

TABLE 6.11 DATA AND COMPUTED SUNSHINE, RADIATION, PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 1706, ID NO. 35. NAME AND STATE. BARCELONA MOP 2 ANZOATEGUI LAT. 10.14. LONG. 64.78. ELEVATION 5.

MO	YR	TM	TD	WID	PREC	DP	HM	S	SC	VPD	RHM	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERV
1	5	24.7	13.2	9.4	16.6	2.4	.68	.78	.73	11.03	413.	216.	200.	192.	206.	171.	1.069	1.077	.934	.832	6.9	7.1	9.1
2	5	24.8	13.4	8.4	5.2	2.6	.66	.78	.72	11.78	404.	218.	196.	201.	195.	164.	1.091	1.092	1.034	.844	10.3	8.5	10.9
3	5	25.5	13.7	10.8	.6	.4	.64	.80	.76	12.61	476.	239.	233.	260.	279.	227.	1.052	1.040	.932	.815	5.0	3.8	7.3
4	5	26.5	12.0	10.6	13.0	1.8	.67	.71	.71	12.14	474.	224.	223.	240.	256.	209.	.999	1.031	.938	.818	5.0	3.0	8.7
5	5	27.0	11.5	9.2	41.2	6.8	.67	.69	.64	12.42	484.	233.	226.	227.	236.	197.	1.077	1.019	.962	.834	11.2	1.8	11.8
6	4	25.8	10.2	7.4	123.2	14.7	.74	.59	.57	9.37	461.	223.	203.	170.	172.	147.	1.025	1.058	.989	.857	5.7	5.5	6.1
7	4	25.5	10.7	6.8	128.5	17.5	.76	.61	.58	8.65	480.	219.	215.	161.	169.	146.	1.068	1.055	.953	.867	6.4	5.2	5.0
8	3	25.1	11.7	6.8	110.0	15.7	.75	.60	.60	9.19	488.	231.	217.	158.	172.	149.	1.002	1.040	.920	.867	6.9	7.4	8.7
9	3	26.7	12.9	6.9	135.7	14.3	.75	.65	.63	9.91	469.	222.	215.	166.	180.	156.	1.032	1.032	.923	.865	8.5	3.1	8.3
10	2	26.1	13.2	7.6	20.0	10.5	.71	.68	.66	10.60	458.	217.	212.	176.	191.	164.	1.030	1.037	.920	.855	4.8	.7	8.7
11	4	25.8	12.1	7.7	57.7	10.2	.71	.66	.63	10.37	410.	169.	188.	162.	168.	144.	1.046	.918	.962	.854	6.1	9.0	5.4
12	4	25.3	12.9	7.9	37.7	4.2	.69	.75	.70	10.97	403.	202.	194.	169.	183.	155.	1.072	1.069	.925	.851	6.7	6.5	8.1
SM	49	25.7	12.3	8.5	52.0	7.5	.70	.70	.67	10.94	450.	218.	210.	195.	205.	173.	1.051	1.040	.952	.841	7.1	4.9	8.4

TABLE 6.12 DATA AND COMPUTED SUNSHINE, RADIATION, PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 2415. ID NO. 36. NAME AND STATE. GUANAPITO GUARICO LAT. 9.93. LONG. 66.43. FLEVATION 600.

MO	YR	TM	TD	WIO	PREC	DP	HM	S	SC	VPD	RMH	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ESS	ERR	ERV
1	5	24.0	7.7	12.4	6.6	.8	.71	.69	.66	9.00	417.	203.	202.	208.	221.	176.	1.048	1.008	.940	.796	9.2	6.0	7.1
2	5	24.4	8.1	14.4	2.2	.2	.69	.76	.68	10.03	406.	213.	203.	275.	251.	194.	1.132	1.038	.898	.775	15.1	5.5	11.4
3	4	25.1	8.5	15.5	5.7	.5	.68	.74	.67	10.88	477.	248.	236.	272.	306.	234.	1.098	1.052	.888	.765	10.1	5.4	12.6
4	4	25.8	8.4	14.0	39.2	6.7	.69	.56	.59	10.75	473.	212.	213.	239.	242.	189.	.948	.992	.989	.780	6.4	0.5	3.1
5	4	25.6	8.4	9.5	146.0	14.0	.71	.54	.55	10.29	482.	215.	214.	191.	198.	165.	.982	1.001	.961	.829	8.5	9.1	4.7
6	4	24.7	7.5	7.6	177.2	[illegible]	.76	.53	.53	8.05	459.	198.	202.	155.	155.	132.	1.006	.981	1.003	.855	7.4	4.2	5.1
7	4	24.3	7.7	7.2	165.2	17.7	.78	.57	.53	7.49	477.	210.	216.	151.	159.	137.	1.074	.974	.950	.860	7.4	4.1	5.3
8	4	24.4	7.9	7.0	187.0	19.5	.77	.56	.52	7.57	487.	210.	219.	151.	159.	137.	1.066	.958	.954	.864	6.2	5.5	4.9
9	4	24.8	8.9	6.6	123.5	15.2	.77	.57	.56	7.95	469.	201.	213.	148.	156.	136.	1.025	.944	.949	.869	4.5	6.0	6.4
10	4	25.1	9.3	7.1	107.7	12.0	.76	.58	.59	-8.71	460.	195.	210.	157.	164.	141.	.993	.930	.956	.862	3.9	7.6	4.6
11	4	25.8	7.5	9.0	61.5	9.2	.74	.68	.58	9.26	413.	188.	199.	167.	179.	149.	1.180	.945	.937	.837	15.3	7.2	7.5
12	4	24.6	8.3	8.7	23.2	5.2	.72	.68	.62	9.22	407.	186.	196.	181.	175.	147.	1.110	.949	1.036	.838	12.3	7.5	3.4
YR	50	24.9	8.7	10.1	83.8	9.6	.73	.63	.59	9.12	451.	207.	210.	188.	199.	162.	1.059	.984	.948	.818	9.4	6.0	6.8

TABLE 6.13 DATA AND COMPUTED SUNSHINE, RADIATION, PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 3077. ID NO. 37. NAME AND STATE. HOTEL SANTO DOMINGO MERIDA LAT. 8.87. LONG. 70.67. ELEVATION 2035.

MO	YR	TM	TO	WID	PREC	DP	HM	S	SC	VPD	RHM	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERV
1	1	13.5	8.2	7.6	7.0	1.0	.72	.00	.66	4.47	417.	0.	217.	106.	126.	108.	.000	.000	.843	.856	.0	.0	18.6
2	1	13.6	7.9	3.5	.0	.0	.70	.00	.68	4.70	402.	0.	211.	119.	105.	97.	.000	.000	1.130	.926	.0	.0	11.5
3	1	13.9	6.9	3.9	13.0	2.0	.74	.00	.63	4.41	473.	0.	242.	131.	108.	100.	.000	.000	1.217	.929	.0	.0	17.9
4	1	14.1	5.3	1.7	162.0	19.0	.84	.00	.47	2.99	468.	0.	214.	71.	68.	66.	.000	.000	1.037	.970	.0	.0	3.6
5	1	14.6	6.0	3.5	99.0	13.0	.84	.00	.50	3.13	476.	0.	224.	92.	85.	79.	.000	.000	1.078	.926	.0	.0	7.2
6	1	14.2	5.6	3.0	260.0	24.0	.88	.00	.45	3.03	452.	0.	204.	82.	71.	66.	.000	.000	1.159	.937	.0	.0	13.7
7	1	13.8	5.6	3.2	281.0	25.0	.81	.00	.46	3.30	471.	0.	214.	69.	77.	72.	.000	.000	.896	.934	.0	.0	11.5
8	1	14.1	5.9	4.6	172.0	20.0	.77	.00	.50	4.14	481.	0.	225.	86.	96.	87.	.000	.000	.893	.904	.0	.0	12.0
9	1	14.5	6.2	4.5	188.0	21.0	.79	.00	.49	3.91	465.	0.	217.	86.	91.	82.	.000	.000	.945	.905	.0	.0	5.8
10	1	14.5	6.5	3.3	106.0	14.0	.76	.00	.54	4.28	458.	0.	220.	79.	90.	84.	.000	.000	.877	.930	.0	.0	14.1
11	1	15.0	7.2	4.2	22.0	4.0	.76	.00	.62	4.59	412.	0.	209.	91.	98.	89.	.000	.000	.927	.912	.0	.0	7.8
12	2	13.8	7.0	3.5	34.5	6.0	.74	.00	.59	4.39	407.	0.	203.	91.	87.	81.	.000	.000	1.046	.927	.0	.0	4.4
SM	13	14.1	6.6	3.8	106.1	11.9	.77	.00	.55	3.98	445.	0.	216.	92.	92.	84.	.000	.000	1.004	.918	.0	.0	10.6

TABLE 6.14 DATA AND COMPUTED SUNSHINE, RADIATION, PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 3099. ID NO. 38. NAME AND STATE. LAS PIEDRAS MERIDA LAT. 8.90. LONG. 70.63. ELEVATION 1644.

MO	YR	TM	TD	WID	PRFC	DP	HM	S	SC	VPD	RMM	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERV
1	1	14.3	11.2	9.5	7.0	1.0	.82	.00	.70	3.75	417.	0.	216.	121.	130.	108.	.000	.000	.933	.830	.0	.0	7.2
2	1	14.8	10.4	6.5	.0	.0	.82	.00	.72	3.74	402.	0.	211.	129.	118.	103.	.000	.000	1.089	.872	.0	.0	8.1
3	1	15.2	9.6	6.4	8.0	1.0	.82	.00	.67	3.86	474.	0.	247.	144.	130.	113.	.000	.000	1.111	.874	.0	.0	10.0
4	1	15.8	6.5	3.6	200.0	27.0	.87	.00	.48	3.73	468.	0.	212.	84.	86.	79.	.000	.000	.977	.925	.0	.0	2.3
5	1	15.9	7.7	6.4	172.0	16.0	.78	.00	.53	4.29	476.	0.	274.	90.	115.	100.	.000	.000	.784	.874	.0	.0	27.5
6	1	15.6	6.7	5.7	264.0	25.0	.85	.00	.45	3.28	453.	0.	200.	34.	88.	78.	.000	.000	.958	.885	.0	.0	4.4
7	1	15.0	7.3	4.6	261.0	24.0	.85	.00	.46	3.03	471.	0.	210.	85.	84.	76.	.000	.000	1.009	.904	.0	.0	.9
8	1	15.2	7.6	6.3	212.0	27.0	.83	.00	.49	3.50	482.	0.	219.	100.	101.	88.	.000	.000	.990	.875	.0	.0	1.0
9	1	15.5	8.4	6.3	202.0	22.0	.83	.00	.50	3.56	465.	0.	213.	91.	99.	86.	.000	.000	.923	.875	.0	.0	8.3
10	1	15.5	8.5	4.8	99.0	13.0	.82	.00	.55	3.74	450.	0.	218.	80.	97.	87.	.000	.000	.827	.902	.0	.0	20.9
11	1	16.0	10.0	4.6	25.0	5.0	.82	.00	.63	4.03	413.	0.	206.	105.	98.	88.	.000	.000	1.073	.904	.0	.0	6.8
12	2	15.4	9.7	5.5	37.0	6.5	.82	.00	.61	3.85	408.	0.	202.	100.	97.	86.	.000	.000	1.038	.889	.0	.0	3.7
SM	13	15.3	8.7	5.8	113.4	12.6	.82	.00	.57	3.71	446.	0.	213.	101.	103.	91.	.000	.000	.982	.882	.0	.0	8.0

TABLE 615 DATA AND COMPUTED SUNSHINE. RADIATION. PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 2431. ID NO. 40. NAME AND STATE. RIO VERDE GUARICO LAT. 9.53. LONG. 67.67. ELEVATION 250.

MO	YR	TM	TD	WIO	PREC	DP	HM	S	SC	VPD	RMM	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERV
1	5	26.8	12.1	11.4	2.4	.8	.63	.68	.72	14.13	419.	187.	198.	279.	249.	201.	.951	.947	1.118	.807	7.8	7.5	10.6
2	5	27.7	12.4	11.9	2.6	.2	.56	.75	.71	15.76	409.	195.	199.	318.	275.	221.	1.060	.983	1.157	.802	9.2	7.8	13.6
3	4	29.5	12.3	11.5	.5	.5	.53	.69	.69	19.19	479.	228.	227.	413.	317.	256.	1.002	1.034	1.302	.807	7.4	5.0	23.2
4	4	29.0	9.4	9.9	112.7	12.5	.59	.54	.55	16.97	474.	197.	205.	304.	234.	193.	.976	.961	1.304	.825	8.9	5.2	23.3
5	4	28.7	7.4	7.9	194.2	20.2	.72	.56	.53	11.18	483.	204.	211.	221.	195.	166.	1.055	.963	1.132	.850	20.9	4.8	11.7
6	4	25.7	7.6	7.6	249.5	23.0	.80	.55	.49	7.80	458.	190.	200.	161.	151.	129.	1.103	.950	1.066	.856	9.3	5.3	6.2
7	4	25.2	7.7	7.0	189.5	21.0	.83	.59	.49	6.78	477.	207.	213.	160.	151.	131.	1.193	.974	1.058	.863	20.1	6.0	5.6
8	4	25.3	8.1	6.7	235.7	23.2	.83	.58	.49	6.89	487.	201.	217.	156.	151.	131.	1.186	.929	1.035	.868	15.7	7.6	3.4
9	4	25.7	9.0	6.8	130.7	14.7	.81	.59	.55	7.78	469.	197.	211.	158.	156.	136.	1.076	.937	1.009	.867	7.1	6.7	3.9
10	4	25.9	9.6	7.6	128.0	13.2	.80	.60	.58	8.06	461.	196.	208.	172.	166.	142.	1.046	.943	1.038	.855	7.9	6.0	3.7
11	4	25.3	11.4	8.3	67.0	9.5	.75	.72	.65	10.27	414.	182.	199.	188.	184.	155.	1.101	.916	1.025	.845	10.5	9.2	6.0
12	4	26.5	11.9	10.2	29.2	4.5	.68	.73	.68	12.32	409.	188.	197.	237.	216.	177.	1.065	.953	1.097	.821	6.1	7.8	8.9
99	50	26.8	10.1	9.0	107.5	11.5	.71	.63	.60	11.59	452.	197.	207.	233.	206.	171.	1.059	.956	1.132	.832	10.6	6.6	12.1

TABLE 6.16 DATA AND COMPUTED SUNSHINE. RADIATION. PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 3050. ID NO. 41. NAME AND STATE. MERIDA MERIDA LAT. 8.60. LONG. 71.15. ELEVATION 1870.

MO	YR	TM	TD	VID	PREC	DP	HM	S	SC	VPD	RMM	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERV
1	2	16.2	8.9	6.3	47.5	7.5	.61	.60	.57	7.76	421.	239.	209.	113.	128.	112.	1.040	.145	.887	.874	8.1	12.6	12.8
2	2	16.6	10.4	6.8	42.5	7.0	.60	.62	.60	8.04	405.	244.	204.	112.	131.	113.	1.035	1.196	.861	.867	3.4	16.4	16.2
3	2	17.7	11.6	7.2	75.5	11.0	.61	.67	.59	8.85	476.	294.	245.	140.	162.	140.	1.122	1.199	.967	.861	10.9	16.6	15.3
4	2	17.5	9.0	6.3	251.0	22.5	.64	.41	.50	7.52	469.	229.	201.	109.	119.	104.	.805	1.139	.920	.874	24.2	13.0	8.7
5	2	17.6	9.1	5.9	187.0	20.5	.67	.48	.52	7.05	476.	254.	218.	112.	124.	109.	.923	1.163	.904	.881	8.3	14.0	10.6
6	2	17.6	8.8	5.6	163.0	19.0	.68	.44	.53	6.99	452.	221.	199.	102.	111.	98.	.832	1.108	.919	.886	20.2	13.0	8.8
7	3	16.9	9.1	6.0	114.7	14.7	.67	.53	.55	7.01	471.	244.	273.	115.	128.	112.	.959	1.092	.904	.880	5.1	8.5	10.6
8	2	16.9	9.5	6.0	84.5	13.5	.71	.51	.57	6.21	482.	234.	275.	109.	174.	109.	.895	1.039	.883	.880	11.7	3.8	13.2
9	3	17.1	9.5	6.2	171.3	19.3	.67	.53	.53	7.03	466.	239.	271.	117.	125.	110.	.996	1.092	.931	.877	5.3	7.6	7.4
10	3	17.0	8.4	5.8	288.0	24.0	.71	.46	.50	6.35	460.	219.	207.	109.	109.	96.	.908	1.059	.999	.883	12.9	5.6	3.3
11	3	16.6	8.4	6.0	217.7	21.0	.70	.56	.51	6.11	416.	208.	201.	108.	107.	94.	1.100	1.036	1.007	.880	11.2	5.9	7.1
12	2	16.3	10.0	6.3	95.0	12.5	.71	.68	.58	6.33	412.	256.	214.	119.	118.	103.	1.174	1.199	1.011	.875	14.9	16.6	3.3
SM	28	17.0	9.4	6.2	152.4	16.6	.67	.54	.54	7.04	451.	238.	214.	114.	123.	108.	.987	1.115	.926	.877	10.6	10.8	9.5

TABLE 6.17 DATA AND COMPUTED SUNSHINE, RADIATION, PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 2099, ID NO. 42, NAME AND STATE, SANTA BARBARA ZULIA LAT. 9.00, LONG. 71.92, ELEVATION 5.

MO	YR	TM	TD	WID	PREC	DP	HM	S	SC	VPD	RMM	RSM	RSC	EVM	EVC	ETC	RST	RAR	REV	RET	ERS	ERR	ERV
1	4	25.8	7.4	4.1	33.2	5.2	.87	.49	.54	5.48	471.	173.	173.	96.	110.	101.	.897	1.001	.874	.914	11.4	4.0	14.4
2	4	25.5	8.5	4.5	87.5	10.0	.85	.48	.56	6.64	410.	166.	167.	93.	112.	102.	.861	.990	.833	.905	17.7	3.3	20.0
3	3	26.3	7.8	4.4	57.3	9.0	.85	.45	.53	7.03	478.	171.	190.	111.	125.	113.	.844	.899	.894	.908	18.5	15.1	11.9
4	3	26.9	7.8	4.8	225.0	18.3	.87	.34	.48	6.38	473.	170.	170.	104.	110.	99.	.710	1.001	.947	.901	40.8	4.2	16.6
5	3	27.7	9.9	4.5	106.7	14.0	.82	.50	.53	8.13	482.	207.	200.	137.	138.	125.	.933	1.035	.984	.906	7.2	5.5	3.1
6	3	27.4	8.8	4.6	102.3	13.3	.83	.54	.54	7.19	458.	199.	195.	129.	134.	122.	.989	1.018	.963	.905	13.4	5.4	8.5
7	3	27.1	9.1	4.7	127.0	15.7	.82	.53	.54	7.69	477.	209.	203.	138.	140.	126.	.997	1.030	.990	.903	1.8	4.1	7.3
8	4	27.0	9.3	4.9	124.7	16.5	.83	.55	.53	7.48	487.	219.	213.	141.	143.	128.	1.031	1.022	.990	.899	4.9	3.4	7.0
9	4	26.9	9.2	4.6	111.7	14.2	.84	.56	.54	6.89	470.	214.	204.	137.	137.	124.	1.030	1.050	1.002	.904	11.5	4.8	9.8
10	4	26.7	8.7	4.4	120.2	17.2	.80	.52	.54	8.01	462.	197.	195.	119.	132.	120.	.968	1.012	.901	.909	11.9	4.3	11.0
11	3	26.4	8.0	4.5	147.3	13.7	.86	.50	.52	6.17	416.	169.	173.	105.	112.	102.	.968	.990	.935	.907	6.0	4.4	9.6
12	3	26.3	7.8	4.2	113.3	16.7	.89	.50	.46	5.16	411.	167.	171.	103.	101.	92.	1.078	.977	1.023	.903	10.5	3.7	10.6
SM	41	26.7	8.5	4.5	110.9	13.5	.84	.50	.53	6.86	453.	189.	188.	118.	125.	113.	.944	1.005	.945	.906	11.9	5.0	10.5

TABLE 6.18 DATA AND COMPUTED SUNSHINE, RADIATION, PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 3208, ID NO. 43, NAME AND STATE, GUANAPE MOP PORTUGESA LAT. 8.95, LONG. 69.23. FLEVATION 117.

MO	YR	TM	TD	WID	PREC	DP	HM	S	SC	VPD	RMM	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERV
1	4	25.5	11.6	7.6	18.5	2.5	.73	.64	.70	10.17	423.	182.	194.	187.	176.	151.	.912	.977	1.061	.856	12.8	2.3	5.8
2	4	26.2	12.5	8.1	38.0	3.2	.70	.65	.71	11.32	412.	184.	189.	198.	188.	159.	.909	.975	1.056	.847	10.4	4.4	5.3
3	3	27.2	12.7	8.4	5.7	1.3	.67	.60	.72	12.84	480.	212.	215.	239.	229.	193.	.830	.938	1.047	.845	20.4	3.8	4.5
4	3	27.0	9.1	7.9	144.0	8.7	.73	.41	.61	10.35	473.	167.	184.	174.	169.	144.	.688	.912	1.030	.853	47.0	9.6	3.9
5	4	26.4	8.4	7.6	184.2	12.7	.80	.42	.56	7.96	480.	178.	188.	159.	153.	131.	.758	.947	1.041	.856	32.0	5.6	4.5
6	4	25.6	8.5	7.0	296.2	18.0	.87	.35	.52	6.95	456.	166.	167.	132.	123.	106.	.676	.994	1.078	.865	47.9	2.9	8.3
7	4	25.0	8.7	6.7	228.0	18.8	.83	.41	.52	6.80	475.	177.	184.	138.	130.	113.	.795	.959	1.064	.869	25.8	4.3	6.2
8	4	25.3	8.9	6.7	177.5	17.0	.82	.44	.53	7.48	486.	183.	194.	142.	140.	122.	.826	.946	1.016	.869	21.1	5.7	2.5
9	4	25.9	9.6	6.6	201.0	14.0	.80	.50	.57	8.48	470.	186.	195.	152.	148.	129.	.873	.950	1.029	.871	14.5	5.3	7.0
10	4	26.3	9.6	6.7	129.2	10.5	.79	.53	.60	9.07	464.	195.	198.	151.	158.	137.	.889	.986	.962	.869	12.4	4.4	5.0
11	4	26.0	10.4	6.7	58.0	5.7	.77	.61	.65	9.51	418.	177.	188.	153.	156.	136.	.931	.939	.980	.869	7.4	6.5	2.7
12	4	25.5	11.1	7.2	37.5	5.7	.75	.61	.67	9.96	414.	180.	185.	163.	159.	137.	.914	.974	1.026	.851	12.8	3.2	2.9
SM	46	25.9	10.1	7.2	128.7	10.1	.77	.51	.61	9.14	453.	183.	190.	164.	159.	137.	.842	[illegible]	1.032	.860	19.5	4.7	4.9

TABLE 6.19 DATA AND COMPUTED SUNSHINE, RADIATION, PAN EVAPORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA

SERIAL 2219. ID NO. 44. NAME AND STATE, MAJAGUAS MOP PORTUGESA LAT. 9.60, LONG. 69.03, ELEVATION 146.

MO	YR	TM	TD	WID	PREC	DP	HM	S	SC	VPD	RHM	RSM	RSC	EVM	EVC	ETC	RSS	RAR	REV	RET	ERS	ERR	ERV
1	2	27.0	10.3	6.8	6.5	1.5	.65	.65	.67	12.86	419.	187.	193.	216.	192.	167.	.975	.957	1.124	.857	11.4	10.1	11.0
2	2	27.7	10.7	7.3	16.5	2.0	.62	.79	.66	14.43	405.	209.	199.	255.	208.	179.	1.194	1.051	1.228	.860	16.2	4.8	18.6
3	1	28.3	11.6	7.6	.0	.0	.64	.70	.73	14.21	478.	223.	226.	293.	259.	222.	.950	.986	1.131	.856	5.2	1.4	11.6
4	2	28.2	9.8	7.1	72.5	6.5	.72	.50	.63	11.24	474.	164.	198.	230.	186.	161.	.805	.826	1.237	.863	24.2	21.1	19.2
5	2	26.7	9.5	6.8	223.5	12.5	.81	.48	.57	6.86	482.	193.	200.	147.	155.	134.	.853	.935	.953	.867	17.2	6.9	4.9
6	2	25.9	7.2	6.3	198.5	20.0	.86	.39	.47	5.37	458.	0.	174.	105.	115.	100.	.825	.000	.919	.875	21.2	.0	11.2
7	2	24.8	7.4	6.0	319.0	20.0	.86	.48	.48	4.57	477.	189.	196.	119.	126.	111.	1.002	.919	.943	.879	13.3	8.8	8.6
8	2	25.1	8.5	6.0	211.5	21.0	.88	.50	.49	5.24	487.	188.	204.	128.	135.	119.	1.011	.936	.948	.879	1.1	6.8	5.5
9	2	25.7	9.0	5.9	166.5	14.5	.86	.54	.52	5.84	469.	183.	202.	140.	136.	120.	1.043	.964	1.026	.881	10.9	3.8	2.5
10	2	26.5	9.7	6.0	89.5	10.0	.80	.53	.59	8.08	461.	190.	197.	152.	150.	132.	.894	.982	1.019	.879	11.9	1.8	1.9
11	2	26.8	9.5	6.0	58.0	5.5	.75	.61	.64	8.86	414.	192.	187.	180.	156.	137.	.950	1.007	1.154	.879	5.3	.7	13.3
12	2	27.0	9.1	6.5	60.0	8.5	.70	.62	.60	11.09	409.	187.	185.	160.	163.	143.	1.036	1.010	.979	.872	7.6	2.2	3.5
[illegible]	23	26.5	9.3	6.5	123.7	10.6	.77	.56	.58	8.83	452.	190.	196.	172.	161.	140.	.964	.962	1.070	.871	12.1	6.8	10.3

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TABLE 6.20 OVERALL AVERAGES FOR VENEZUELA

 NO YRS     TM     TD    W10  PREC     DP     HM      S     SC   VPD  RMM  RSM  RSC  EVM  EVC  ETC   RSS    RAR    REV    RET  ERS  ERR  ERV

ON 1013   25.1  10.1    8.8  97.0  10.3    .75    .62    .62  9.17 452. 205. 206. 185. 185. 154. 1.000 1.000 1.000   .834 10.3  6.2  9.7
        XSC        XSR         XVC         XTC        ZNT         ZNS         ZNR
       .613       .442        .356        .303      1013.        987.        760.
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APPENDIX B

Gamma Distribution of Precipitation and Potential Irrigation Requirements

TABLE 7.1 PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DISTRIBUTION. IN MM.

STATION NAME CUA-TOVAR MIRANDA SER. NO. 582 ID NO. 25
LAT. 10 9. LONG. 66 53. ELEV. 240. YEARS OF DATA 20

PROBABILITY		95.	90.	80.	75.	70.	60.	50.	40.	30.	25.	20.	10.	5.		90.	80.	75.	70.	60.
MONTH	MEAN	PRECIPITATION AT VARIOUS PROBABILITY LEVELS													ETP	IRRIGATION REQUIREMENTS				
JAN	37.	5.	9.	14.	16.	19.	23.	28.	33.	40.	44.	49.	62.	76.	142.	132.	128.	125.	123.	119.
FEB	15.	0.	1.	2.	3.	4.	6.	9.	13.	18.	21.	25.	39.	53.	158.	157.	156.	155.	154.	152.
MAR	12.	0.	0.	1.	1.	2.	3.	5.	9.	12.	15.	19.	32.	46.	213.	213.	212.	212.	211.	210.
APR	34.	0.	0.	2.	3.	5.	9.	15.	24.	36.	45.	56.	93.	133.	197.	197.	195.	194.	192.	188.
MAY	114.	32.	43.	61.	68.	76.	90.	106.	123.	143.	155.	170.	211.	250.	175.	132.	115.	107.	100.	85.
JUN	191.	98.	114.	135.	144.	153.	168.	184.	200.	219.	230.	242.	278.	309.	136.	22.	0.	-9.	-17.	-32.
JUL	179.	99.	113.	131.	139.	146.	160.	173.	187.	203.	212.	223.	252.	278.	138.	25.	7.	-1.	-8.	-22.
AUG	125.	59.	69.	84.	91.	97.	108.	119.	131.	145.	153.	162.	189.	212.	148.	79.	64.	55.	52.	40.
SEP	105.	40.	50.	64.	70.	75.	87.	98.	110.	124.	133.	142.	170.	195.	151.	101.	87.	81.	75.	64.
OCT	92.	4.	8.	18.	24.	30.	44.	61.	82.	110.	127.	149.	216.	284.	158.	150.	140.	134.	128.	114.
NOV	62.	12.	18.	27.	31.	36.	44.	53.	64.	76.	83.	92.	119.	144.	137.	119.	110.	105.	101.	93.
DEC	59.	11.	16.	25.	29.	33.	41.	50.	60.	72.	79.	88.	114.	139.	134.	118.	109.	105.	101.	93.
ANN	1027.	719.	778.	855.	865.	913.	964.	1014.	1066.	1123.	1155.	1192.	1293.	1381.	1887.	1109.	1033.	1002.	975.	923.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
LAMBA	.0566	.0444	.0409	.0141	.0250	.0454	.0586	.0558	.0452	.0099	.0351	.0351	.0252
R	2.146	.683	.479	.482	2.969	8.676	10.474	6.981	4.756	.913	2.192	2.074	25.850
LOGAM	.0896	.2820	.6149	.6098	.6650	9.9172	13.8804	6.5435	2.8172	.0570	.0924	.0329	57.5196

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

PMAX	97.	57.	38.	110.	324.	380.	278.	243.	206.	222.	120.	190.	1307.
PMIN	8.	0.	0.	0.	22.	104.	100.	48.	14.	0.	4.	12.	647.
PD75	16.	3.	1.	3.	68.	144.	139.	91.	70.	24.	31.	29.	885.
ETDF	125.	155.	212.	194.	107.	-9.	-1.	58.	81.	134.	105.	105.	1002.
MAI	.116	.017	.005	.016	.388	1.063	1.007	.612	.464	.152	.230	.215	.469

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH TOGETHER WITH ELEVATION AND SOLAR RADIATION DETERMINE ETCH

TEMP	23.2	23.9	25.3	26.2	26.5	25.3	24.8	25.1	25.5	25.4	24.8	24.0	25.0
HUM	.71	.71	.68	.68	.69	.77	.80	.79	.76	.73	.75	.74	.73
WIND	11.1	13.3	15.3	14.4	11.7	9.1	8.8	8.7	8.6	8.7	9.3	9.9	10.7
PREC.DAYS	10.	5.	1.	3.	6.	20.	19.	14.	12.	8.	10.	8.	10.
SUNSHINE	.58	.65	.65	.53	.46	.48	.51	.55	.57	.60	.60	.58	.56

TABLE 7.2 PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DISTRIBUTION. IN MM.

STATION NAME JUSEPIN . MONAGAS SER. NO. 2841 ID NO. 26
LAT. 9.45. LONG. 63.27. ELEV. 146. YEARS OF DATA 25

PROBABILITY		95.	90.	80.	75.	70.	60.	50.	40.	30.	25.	20.	10.	5.		90.	80.	75.	70.	60.
MONTH	MEAN	PRECIPITATION AT VARIOUS PROBABILITY LEVELS													ETP	IRRIGATION REQUIREMENTS				
JAN	43.	3.	6.	12.	15.	18.	24.	32.	41.	52.	60.	68.	95.	122.	149.	143.	137.	134.	131.	124.
FEB	26.	1.	1.	4.	5.	7.	11.	15.	22.	30.	36.	42.	64.	87.	168.	167.	165.	163.	162.	158.
MAR	14.	0.	0.	1.	1.	2.	4.	6.	10.	15.	19.	23.	38.	55.	233.	233.	232.	231.	231.	229.
APR	26.	0.	0.	1.	2.	3.	7.	11.	18.	27.	34.	42.	70.	100.	227.	227.	226.	225.	224.	220.
MAY	114.	29.	40.	57.	64.	71.	86.	101.	118.	138.	149.	164.	205.	243.	199.	159.	142.	135.	128.	113.
JUN	190.	107.	121.	141.	149.	156.	170.	184.	199.	215.	225.	236.	266.	293.	135.	14.	-5.	-13.	-21.	-35.
JUL	184.	86.	102.	124.	134.	142.	159.	176.	193.	214.	226.	239.	278.	313.	142.	39.	17.	8.	-1.	-17.
AUG	171.	79.	94.	115.	124.	132.	147.	163.	180.	199.	210.	223.	259.	292.	143.	48.	28.	19.	11.	-5.
SEP	97.	26.	35.	49.	55.	61.	73.	85.	99.	115.	125.	136.	169.	200.	166.	131.	117.	111.	105.	93.
OCT	90.	39.	48.	59.	63.	68.	76.	85.	94.	104.	111.	118.	138.	156.	164.	117.	106.	101.	97.	88.
NOV	82.	24.	32.	43.	49.	54.	64.	74.	86.	99.	107.	117.	145.	170.	138.	106.	94.	89.	84.	74.
DEC	70.	21.	28.	38.	42.	46.	55.	63.	73.	84.	91.	99.	121.	142.	138.	110.	100.	96.	91.	83.
ANN	1108.	927.	882.	951.	978.	1013.	1049.	1094.	1139.	1189.	1218.	1250.	1337.	1412.	2001.	1120.	1050.	1023.	998.	952.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
LAMBDA	.0274	.0282	.0352	.0186	.0248	.0579	.0376	.0396	.0313	.0686	.0386	.0485	.0346
R	1.184	.729	.500	.477	2.819	11.008	6.926	6.783	2.985	6.149	3.195	3.395	38.214
LNGAM	-.0805	.2273	.5727	.6187	.5324	15.1233	6.9415	6.1768	.6794	5.0430	.8800	1.0874	100.1056

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

PMAX	131.	75.	70.	182.	318.	324.	342.	358.	184.	153.	197.	139.	1422.
PMIN	2.	0.	0.	0.	16.	82.	70.	90.	6.	25.	19.	12.	783.
PE75	15.	5.	1.	2.	64.	149.	134.	124.	55.	63.	49.	42.	978.
ETDF	134.	163.	231.	225.	135.	-13.	8.	19.	111.	101.	89.	96.	1023.
MAI	.099	.030	.006	.010	.322	1.099	.944	.866	.330	.386	.353	.306	.489

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH TOGETHER WITH ELEVATION AND SOLAR RADIATION DETERMINE ETCH

TEMP	25.7	25.9	27.1	28.1	28.0	26.6	26.5	26.5	27.5	27.4	26.7	25.9	26.8
HUM	.79	.74	.68	.65	.70	.83	.83	.83	.77	.78	.80	.82	.77
WIND	13.3	14.5	16.4	15.1	14.7	12.0	11.0	9.4	9.6	9.8	10.0	10.8	12.2
PREC.DAYS	13.	5.	2.	4.	15.	24.	25.	25.	14.	13.	16.	13.	13.
SUNSHINE	.63	.69	.71	.65	.55	.45	.50	.54	.62	.65	.61	.66	.61

TABLE 7.3 PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DISTRIBUTION. IN MM.

STATION NAME MATALITO-CUJIALOTE GUARICO SER. NO. 2575 ID NO. 27
LAT. 9 31. LONG. 66 12. ELEV. 270. YEARS OF DATA 8

PROBABILITY		95.	90.	80.	75.	70.	60.	50.	40.	30.	25.	20.	10.	5.		90.	80.	75.	70.	60.
MONTH	MEAN	PRECIPITATION AT VARIOUS PROBABILITY LEVELS													ETP	IRRIGATION REQUIREMENTS				
JAN	18.	0.	0.	0.	1.	1.	2.	5.	9.	15.	20.	27.	50.	77.	162.	162.	162.	162.	161.	160.
FEB	5.	0.	0.	0.	0.	0.	1.	1.	2.	4.	5.	7.	12.	19.	182.	182.	182.	182.	182.	182.
MAR	7.	0.	0.	0.	0.	0.	0.	0.	1.	1.	2.	2.	5.	7.	227.	227.	227.	227.	227.	227.
APR	26.	0.	0.	0.	0.	1.	2.	6.	11.	21.	28.	39.	76.	119.	208.	208.	208.	208.	207.	206.
MAY	139.	42.	55.	75.	84.	92.	109.	126.	145.	167.	180.	196.	241.	283.	176.	121.	102.	93.	85.	68.
JUN	255.	115.	138.	169.	187.	195.	218.	242.	268.	297.	314.	334.	389.	440.	129.	-14.	-45.	-58.	-71.	-94.
JUL	206.	122.	137.	157.	165.	173.	187.	200.	215.	231.	241.	251.	281.	307.	123.	-19.	-33.	-42.	-49.	-63.
AUG	205.	150.	161.	175.	180.	185.	194.	203.	212.	222.	227.	234.	251.	266.	126.	-35.	-49.	-54.	-59.	-68.
SEP	133.	71.	83.	98.	105.	110.	122.	133.	145.	158.	165.	175.	200.	222.	126.	43.	28.	22.	16.	4.
OCT	93.	17.	25.	39.	45.	51.	64.	78.	94.	113.	125.	139.	180.	219.	141.	116.	102.	96.	90.	77.
NOV	67.	13.	19.	28.	32.	36.	45.	54.	64.	76.	83.	91.	117.	141.	134.	115.	106.	102.	98.	89.
DEC	29.	10.	13.	17.	19.	21.	24.	27.	31.	35.	37.	40.	49.	56.	152.	138.	134.	133.	131.	128.
ANN	1177.	960.	1012.	1078.	1104.	1127.	1170.	1212.	1254.	1300.	1326.	1356.	1436.	1504.	1882.	870.	804.	779.	755.	712.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
LAMBDA	.0187	.0794	.1716	.0110	.0242	.0253	.0638	.1644	.0640	.0219	.0376	.1437	.0444
R	.321	.335	.270	.281	3.369	6.469	13.117	33.658	8.836	2.035	2.339	4.222	54.141
LNSAM	1.0239	.9793	1.2080	1.1635	1.0590	5.6069	20.2835	83.8538	10.7560	.0150	.1781	2.0775	160.8910

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
PMAX	51.	25.	6.	96.	304.	425.	327.	268.	213.	213.	160.	53.	1451.
PMIN	0.	0.	0.	0.	49.	145.	123.	158.	84.	15.	13.	12.	884.
PD75	1.	0.	0.	0.	84.	187.	165.	180.	105.	45.	32.	19.	1104.
ETDF	162.	182.	227.	208.	93.	-58.	-42.	-54.	22.	96.	102.	133.	779.
MAI	.003	.001	.000	.002	.474	1.470	1.337	1.428	.929	.319	.241	.125	.586

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH TOGETHER WITH ELEVATION AND SOLAR RADIATION DETERMINE ETCH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
TEMP	25.4	26.2	27.1	27.7	27.3	25.3	24.9	24.9	25.2	25.4	25.7	25.4	25.9
HUM	.71	.68	.66	.64	.69	.78	.83	.83	.83	.79	.77	.75	.75
WIND	9.3	10.5	11.3	10.4	8.2	6.2	5.6	5.1	4.9	5.7	6.6	8.1	7.7
PREC.DAYS	4.	1.	1.	1.	6.	20.	21.	17.	14.	9.	10.	4.	9.
SUNSHINE	.70	.76	.74	.58	.55	.50	.57	.59	.64	.68	.70	.76	.65

TABLE 7A PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DISTRIBUTION. IN MM.

STATION NAME SAN JUAN LOS MORROS GUARICO SER. NO. 2417 ID NO. 28
LAT. 9 54. LONG. 67 21. ELEV. 430. YEARS OF DATA 8

PROBABILITY		95.	90.	80.	75.	70.	60.	50.	40.	30.	25.	20.	10.	5.		90.	80.	75.	70.	60.
MONTH	MEAN	PRECIPITATION AT VARIOUS PROBABILITY LEVELS													ETP	IRRIGATION REQUIREMENTS				
JAN	18.	0.	0.	0.	0.	1.	1.	3.	6.	12.	15.	21.	47.	66.	144.	144.	144.	144.	144.	143.
FEB	5.	0.	0.	0.	0.	0.	0.	0.	1.	3.	4.	6.	15.	27.	161.	161.	151.	161.	161.	161.
MAR	3.	0.	0.	0.	0.	0.	0.	0.	1.	2.	2.	3.	6.	9.	206.	206.	206.	206.	205.	206.
APR	49.	2.	5.	10.	14.	17.	25.	34.	43.	59.	69.	80.	115.	151.	173.	169.	163.	160.	156.	[illegible]
MAY	[illegible]	[illegible]	93.	112.	120.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-8.
JUN	[illegible]	[illegible]	144.	[illegible]	[illegible]	[illegible]	211.	229.	248.	270.	287.	298.	336.	371.	109.	-39.	-64.	-74.	-84.	-102.
JUL	219.	111.	131.	158.	170.	180.	201.	222.	243.	268.	281.	300.	347.	389.	117.	-14.	-41.	-53.	-63.	-84.
AUG	199.	103.	120.	142.	151.	159.	175.	191.	208.	227.	238.	251.	286.	318.	122.	2.	-20.	-29.	-37.	-53.
SEP	187.	99.	114.	134.	143.	151.	165.	180.	195.	213.	224.	235.	268.	297.	118.	4.	-16.	-24.	-32.	-47.
OCT	144.	48.	62.	80.	89.	96.	112.	127.	145.	164.	175.	190.	229.	266.	122.	60.	42.	33.	26.	10.
NOV	59.	5.	10.	18.	22.	26.	36.	46.	59.	75.	85.	97.	133.	169.	119.	109.	101.	97.	93.	83.
DEC	37.	6.	9.	14.	16.	18.	23.	28.	34.	41.	45.	50.	65.	80.	129.	120.	115.	113.	111.	106.
ANN	1332.	1056.	1114.	1188.	1217.	1249.	1293.	1339.	1387.	1440.	1469.	1503.	1593.	1670.	1659.	585.	471.	442.	415.	366.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
LAMBDA	.0202	.0350	.1935	.0143	.0504	.0428	.0313	.0453	.0500	.0300	.0207	.0588	.0385
R	.285	.179	.287	.256	8.114	10.139	7.266	8.990	9.205	4.149	1.274	1.963	51.836
LNGAM	1.1484	1.6417	1.1421	.0273	8.7555	13.1167	7.0829	10.5927	11.3503	1.9874	-.1034	-.0153	151.7648

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

PMAX	78.	30.	7.	175.	275.	418.	321.	377.	293.	291.	183.	87.	1670.
PMIN	0.	0.	0.	1.	84.	120.	89.	133.	108.	44.	15.	10.	1065.
PO75	0.	0.	0.	14.	120.	183.	170.	151.	143.	89.	22.	16.	1217.
ETDF	144.	161.	206.	160.	18.	-74.	-53.	-29.	-24.	33.	97.	113.	442.
MAI	.002	.000	.000	.078	.869	1.681	1.450	1.237	1.206	.727	.185	.123	.739

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH TOGETHER WITH ELEVATION AND SOLAR RADIATION DETERMINE ETCH

TEMP	23.7	24.6	25.7	26.4	25.8	24.2	23.6	23.8	24.0	24.4	24.2	23.9	24.5
HUM	.70	.64	.60	.62	.71	.80	.79	.79	.80	.78	.76	.73	.73
WIND	6.2	7.1	7.5	6.3	5.2	5.0	4.6	4.2	4.3	4.0	4.6	5.2	5.3
PREC.DAYS	2.	1.	0.	3.	9.	20.	19.	16.	15.	11.	8.	4.	9.
SUNSHINE	.71	.74	.73	.56	.47	.46	.53	.56	.58	.60	.65	.69	.61

TABLE 7.5 PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DISTRIBUTION. IN MM.

STATION NAME ZONAS ARIDAS MAC LARA SER. NO. 1286 ID NO. 29
LAT. 10 9. LONG. 69 18. ELEV. 630. YEARS OF DATA 4

PROBABILITY		95.	90.	80.	75.	70.	60.	50.	40.	30.	25.	20.	10.	5.		90.	80.	75.	70.	60.
MONTH	MEAN	PRECIPITATION AT VARIOUS PROBABILITY LEVELS													ETP	IRRIGATION REQUIREMENTS				
JAN	7.	0.	0.	0.	0.	1.	1.	2.	4.	6.	8.	11.	19.	29.	133.	133.	133.	133.	133.	132.
FEB	4.	0.	0.	0.	0.	0.	1.	1.	2.	3.	3.	4.	8.	11.	145.	145.	145.	145.	145.	145.
MAR	3.	0.	0.	0.	0.	0.	0.	1.	1.	2.	3.	4.	7.	11.	188.	188.	188.	188.	188.	188.
APR	57.	3.	6.	13.	18.	22.	32.	45.	60.	80.	93.	108.	157.	206.	143.	137.	130.	125.	121.	111.
MAY	89.	24.	32.	45.	50.	56.	67.	78.	91.	105.	114.	125.	155.	184.	139.	106.	94.	88.	83.	72.
JUN	120.	52.	63.	73.	84.	90.	101.	113.	126.	140.	148.	158.	195.	210.	122.	59.	44.	38.	32.	20.
JUL	140.	51.	65.	83.	92.	99.	114.	130.	145.	166.	177.	191.	229.	264.	124.	59.	40.	32.	24.	9.
AUG	77.	39.	45.	53.	56.	59.	65.	70.	76.	83.	87.	91.	104.	115.	146.	101.	93.	90.	87.	61.
SEP	34.	10.	14.	19.	21.	23.	27.	31.	36.	41.	45.	48.	60.	70.	154.	141.	136.	134.	132.	127.
OCT	31.	11.	13.	17.	19.	20.	23.	27.	30.	34.	36.	39.	47.	54.	150.	136.	133.	131.	129.	126.
NOV	71.	10.	15.	25.	29.	33.	42.	52.	63.	76.	84.	94.	123.	151.	172.	106.	97.	93.	89.	80.
DEC	34.	9.	12.	16.	18.	19.	23.	27.	31.	35.	38.	41.	51.	60.	117.	105.	101.	93.	95.	94.
ANN	669.	435.	479.	536.	558.	579.	619.	657.	696.	741.	765.	795.	874.	943.	1682.	1203.	1147.	1124.	1103.	1064.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
LAMDA	.0540	.1455	.1519	.0138	.0343	.0496	.0319	.1330	.0992	.1578	.0300	.1152	.0277
P	.365	.400	.380	.921	3.004	5.934	4.463	9.673	3.427	4.514	1.865	3.386	18.528
LNGAM	.4918	.7967	.8500	.0507	.6966	4.6751	2.4028	12.0714	1.1162	2.4729	-.0509	1.0778	35.0256

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

PMAX	11.	4.	5.	139.	184.	199.	257.	97.	60.	52.	118.	57.	870.
PMIN	0.	0.	0.	3.	40.	73.	73.	39.	13.	14.	20.	16.	486.
PD75	0.	0.	0.	18.	50.	84.	92.	55.	21.	19.	29.	19.	558.
ETDF	133.	145.	188.	126.	88.	38.	32.	90.	134.	131.	93.	99.	1124.
MAI	.002	.001	.001	.123	.364	.690	.791	.383	.135	.175	.236	.151	.332

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH TOGETHER WITH ELEVATION AND SOLAR RADIATION DETERMINE ETCH

TEMP	22.6	23.0	23.9	24.5	24.2	23.5	23.3	23.7	24.4	24.4	23.9	22.8	23.7
HUM	.90	.77	.70	.77	.84	.88	.87	.84	.82	.78	.80	.81	.81
WIND	9.3	10.4	11.7	10.4	11.8	12.1	10.1	10.5	11.6	9.3	7.9	7.8	10.2
PREC.DAYS	3.	2.	2.	9.	11.	19.	22.	15.	9.	9.	10.	8.	10.
SUNSHINE	.66	.72	.66	.45	.46	.49	.52	.62	.62	.63	.60	.63	.59

TABLE 7.6 PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DISTRIBUTION. IN MM.

STATION NAME SANTA CRUZ MOP. ARAGUA SER. NO. 417 ID NO.30
LAT. 10 11. LONG. 67 0. ELEV. 404. YEARS OF DATA 8

PROBABILITY		95.	90.	80.	75.	70.	60.	50.	40.	30.	25.	20.	10.	5.		90.	80.	75.	70.	60.
MONTH	MEAN	PRECIPITATION AT VARIOUS PROBABILITY LEVELS													ETP	IRRIGATION REQUIREMENTS				
JAN	5.	0.	0.	0.	0.	0.	0.	1.	2.	5.	7.	10.	20.	33.	173.	173.	173.	173.	173.	172.
FEB	2.	0.	0.	0.	0.	0.	0.	1.	1.	2.	2.	3.	5.	7.	185.	186.	196.	165.	186.	186.
MAR	4.	0.	0.	0.	0.	0.	0.	1.	3.	6.	8.	12.	26.	42.	232.	232.	232.	232.	232.	231.
APR	44.	4.	7.	13.	16.	20.	27.	36.	46.	59.	68.	77.	108.	138.	195.	188.	182.	179.	175.	168.
MAY	172.	64.	74.	87.	93.	98.	108.	118.	128.	140.	146.	154.	176.	195.	162.	88.	75.	69.	64.	54.
JUN	194.	129.	141.	157.	163.	169.	180.	191.	202.	214.	221.	229.	251.	270.	127.	-14.	-30.	-36.	-42.	-53.
JUL	189.	70.	88.	113.	124.	134.	154.	174.	196.	222.	237.	254.	304.	350.	130.	42.	17.	6.	-4.	-24.
AUG	181.	65.	82.	107.	118.	128.	147.	168.	190.	215.	230.	248.	298.	344.	139.	56.	32.	21.	11.	-9.
SEP	135.	89.	97.	109.	113.	118.	126.	133.	142.	151.	156.	162.	178.	192.	135.	38.	26.	22.	18.	10.
OCT	135.	70.	81.	96.	102.	108.	119.	130.	141.	154.	162.	170.	194.	215.	138.	56.	42.	35.	30.	19.
NOV	75.	9.	15.	26.	31.	37.	48.	60.	75.	93.	104.	117.	157.	196.	135.	120.	109.	104.	99.	87.
DEC	28.	0.	0.	1.	2.	3.	6.	11.	18.	29.	36.	45.	78.	113.	147.	147.	145.	145.	144.	140.
ANN	1125.	895.	941.	1000.	1023.	1043.	1082.	1118.	1156.	1197.	1220.	1246.	1316.	1376.	1899.	958.	899.	876.	855.	817.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
LAMBA	.0349	.2618	.0273	.0292	.0750	.1034	.0747	.0238	.1349	.0671	.0204	.0155	.0523
P	.237	.836	.232	1.183	9.154	20.077	4.627	4.324	18.329	9.042	1.548	.434	58.791
LNGAM	1.3453	.7083	1.3662	-.0803	10.9348	39.5681	2.6322	2.2129	34.4499	10.6954	-.1180	.7132	179.5675

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

PMAX	15.	4.	33.	107.	155.	273.	407.	351.	191.	207.	219.	67.	1422.
PMIN	0.	0.	0.	2.	62.	115.	90.	69.	88.	58.	25.	0.	868.
PD75	0.	0.	0.	16.	93.	163.	124.	118.	113.	102.	31.	2.	1023.
ETDF	173.	186.	232.	179.	69.	-36.	6.	21.	22.	35.	104.	145.	876.
MAI	.000	.001	.000	.084	.573	1.287	.951	.849	.838	.743	.232	.014	.539

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH TOGETHER WITH ELEVATION AND SOLAR RADIATION DETERMINE ETCH

TEMP	24.9	25.3	26.0	26.4	26.5	25.1	24.8	24.9	24.9	25.1	25.0	24.8	25.3
HUM	.70	.65	.62	.63	.70	.76	.79	.79	.77	.78	.76	.75	.72
WIND	10.3	11.9	12.2	10.4	8.0	6.6	6.4	6.2	5.8	5.9	6.6	8.3	8.2
PREC.DAYS	1.	1.	1.	5.	10.	18.	17.	15.	13.	11.	6.	3.	8.
SUNSHINE	.73	.79	.77	.60	.51	.48	.52	.57	.59	.65	.68	.72	.63

TABLE 7.7 PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DISTRIBUTION. IN MM.

STATION NAME SHELL FOUNDATION ARAGUA SER. NO. 1462 ID NO.31
LAT. 10 18. LONG. 67 45. ELEV. 432. YEARS OF DATA 5

PROBABILITY		95.	90.	80.	75.	70.	60.	50.	40.	30.	25.	20.	10.	5.		90.	80.	75.	70.	60.
MONTH	MEAN	PRECIPITATION AT VARIOUS PROBABILITY LEVELS													ETP	IRRIGATION REQUIREMENTS				
JAN	3.	0.	0.	0.	0.	0.	0.	0.	1.	1.	2.	4.	9.	16.	166.	166.	166.	166.	166.	166.
FEB	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	186.	186.	186.	186.	186.	186.
MAR	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	2.	3.	219.	219.	219.	219.	219.	219.
APR	39.	4.	6.	12.	14.	17.	23.	30.	38.	48.	54.	62.	85.	107.	194.	178.	173.	170.	167.	161.
MAY	111.	72.	80.	89.	93.	96.	102.	109.	115.	122.	126.	131.	144.	155.	163.	83.	74.	70.	67.	60.
JUN*	182.	158.	163.	170.	172.	174.	178.	182.	185.	190.	192.	194.	200.	206.	124.	-39.	-46.	-48.	-50.	-54.
JUL	144.	57.	75.	100.	112.	123.	144.	167.	191.	220.	237.	257.	315.	359.	133.	58.	32.	21.	10.	-12.
AUG	134.	58.	70.	88.	96.	103.	116.	130.	145.	162.	172.	184.	216.	246.	141.	70.	52.	45.	38.	24.
SEP	148.	89.	99.	113.	119.	124.	134.	144.	154.	166.	172.	180.	201.	219.	121.	21.	7.	2.	-4.	-14.
OCT	147.	103.	112.	123.	127.	131.	138.	145.	153.	161.	165.	171.	185.	197.	137.	25.	14.	10.	6.	-2.
NOV	49.	10.	15.	22.	25.	28.	35.	42.	50.	59.	65.	72.	91.	110.	132.	117.	110.	107.	103.	97.
DEC	15.	0.	0.	0.	0.	1.	2.	4.	8.	13.	17.	23.	43.	65.	147.	147.	147.	147.	146.	145.
ANN.	1015.	819.	862.	915.	935.	952.	985.	1015.	1046.	1079.	1096.	1116.	1169.	1212.	1852.	990.	937.	917.	900.	867.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG.	SEP	OCT	NOV	DEC	ANN
LAMBA	.0550	1.1143	.3231	.0333	.1721	1.0109	.0191	.0404	.0924	.1796	.0476	.0226	.0876
n	.165	.223	.194	1.304	19.036	183.773	3.510	5.577	13.643	26.438	2.311	.329	88.942
LNGAM	1.7265	1.4096	1.5571	-.1088	36.5015	772.6764	1.2117	4.0817	21.6276	59.4259	.1609	.9981	308.9051

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

PMAX	15.	1.	3.	72.	143.	195.	373.	196.	182.	208.	126.	57.	1157.
PMIN	0.	0.	0.	4.	76.	157.	77.	64.	83.	121.	21.	0.	886.
PD75	0.	0.	0.	14.	93.	172.	112.	96.	119.	127.	25.	0.	935.
ETDF	166.	186.	219.	170.	70.	-48.	21.	45.	2.	10.	107.	147.	917.
MAI	.000	.000	.000	.078	.570	1.388	.843	.680	.987	.930	.190	.003	.505

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH TOGETHER WITH ELEVATION AND SOLAR RADIATION DETERMINE ETCH

TEMP	23.6	24.5	25.2	25.9	25.6	24.2	24.1	24.3	24.2	24.6	24.3	23.8	24.5
HUM	.68	.64	.59	.61	.67	.73	.76	.75	.78	.75	.73	.71	.70
WIND	11.9	14.0	14.4	12.8	10.2	7.3	7.8	7.3	6.4	6.8	7.4	9.0	9.6
PREC.DAYS	1.	0.	0.	4.	10.	16.	16.	13.	14.	11.	6.	2.	8.
SUNSHINE	.63	.67	.56	.44	.44	.41	.47	.50	.45	.57	.58	.65	.53

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TABLE 7.8 PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DISTRIBUTION. IN MM.

                   STATION NAME    UPANON                   APURE   SER. NO.  5408    ID NO.32
                   LAT.   6 56. LONG.  67   7. ELEV.     90. YEARS OF DATA   5

PROBABILITY    95.   90.   80.   75.   70.   60.   50.   40.   30.   25.   20.   10.    5.          90.   80.   75.   70.   60.

MONTH   MEAN                PRECIPITATION AT VARIOUS PROBABILITY LEVELS                     ETP    IRRIGATION REQUIREMENTS

  JAN     2.     0.    0.    0.    0.    0.    0.    0.    1.    1.    2.    3.    6.   10.    222.  222.  222.  222.  222.  222.
  FEB     5.     0.    0.    0.    0.    0.    0.    1.    1.    3.    4.    6.   13.   21.    231.  231.  231.  231.  230.  230.
  MAR    10.     0.    0.    0.    0.    0.    1.    2.    4.    8.   11.   15.   30.   48.    251.  251.  251.  251.  251.  250.
  APR    90.    10.   17.   29.   35.   42.   55.   70.   88.  110.  124.  141.  190.  239.    182.  165.  153.  147.  140.  127.
  MAY   192.   119.  133.  150.  157.  164.  176.  188.  200.  214.  222.  231.  257.  279.    139.    7.  -11.  -19.  -24.  -36.
  JUN   389.   215.  245.  285.  301.  316.  344.  372.  402.  435.  455.  477.  538.  593.    109. -135. -175. -191. -205. -235.
  JUL   477.   265.  299.  344.  362.  379.  411.  442.  475.  513.  534.  558.  626.  686.    117. -182. -227. -245. -262. -294.
  AUG   333.   279.  292.  309.  315.  321.  332.  342.  353.  365.  371.  379.  398.  415.    128. -164. -181. -189. -194. -204.
  SEP   257.   128.  147.  172.  183.  192.  211.  229.  248.  269.  282.  296.  336.  372.    137.  -10.  -35.  -46.  -55.  -74.
  OCT   163.    19.   30.   50.   60.   70.   91.  114.  141.  174.  194.  219.  292.  363.    157.  127.  107.   97.   87.   66.
  NOV    71.     5.    9.   17.   21.   26.   36.   47.   61.   78.   89.  103.  144.  185.    166.  158.  150.  145.  141.  131.
  DEC     4.     0.    0.    0.    0.    1.    2.    3.    6.   10.   12.   15.   29.   44.    193.  193.  193.  192.  192.  191.

  ANN. 1993. 1809. 1851. 1902. 1921. 1937. 1969. 1999. 2028. 2060. 2076. 2095. 2146. 2189.   2033.  182.  131.  112.   96.   63.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH        JAN       FEB       MAR       APR       MAY       JUN       JUL       AUG       SEP       OCT       NOV       DEC       ANN
LAMBA      .1147     .0514     .0275     .0159     .0805     .0285     .0272     .1998     .0422     .0112     .0177     .0347     .1832
  R         .229      .214      .280     1.835    15.462    10.951    12.380    68.758     9.973     1.588     1.141      .352   366.226
LNGAM     1.3790    1.4515    1.1692    -.1211   26.4332   14.9895   18.4379  220.9331   12.7410    -.1141    -.0662     .9273 1793.6628

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

PMAX         10.       20.       25.      199.      271.      551.      667.      370.      394.      250.      189.       33.     2110.
PMIN          0.        0.        0.       10.      139.      227.      273.      280.      208.       21.        4.        0.     1816.
PD75          0.        0.        0.       35.      157.      301.      362.      315.      183.       60.       21.        0.     1921.
ETDF        222.      231.      251.      147.      -18.     -191.     -245.     -188.      -46.       97.      145.      192.      112.
MAI         .000      .000      .001      .194     1.128     2.749     3.093     2.470     1.333      .380      .127      .002      .945

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH  TOGETHER WITH ELEVATION AND SOLAR RADIATION  DETERMINE ETCH

TEMP        27.0      27.7      28.7      28.3      27.2      26.1      26.0      26.5      26.8      27.2      27.3      27.4      27.2
HUM          .73       .67       .65       .69       .77       .83       .83       .83       .81       .80       .79       .76       .76
WIND        16.3      17.5      15.2      11.7       8.9       7.7       7.9       8.1       7.8       8.7      11.1      14.0      11.2
PREC.DAYS     0.        0.        2.       13.       21.       27.       21.       20.       11.        9.        6.        2.        3.
SUNSHINE     .74       .75       .73       .52       .43       .39       .40       .44       .49       .60       .70       .77       .58
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TABLE 7.9 PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DISTRIBUTION. IN MM.

STATION NAME YARITAGUA M.P YARACUY SER. NO. 1288 ID NO.33
LAT. 10 4. LONG. 69 7. ELEV. 374. YEARS OF DATA 27

PROBABILITY		95.	90.	80.	75.	70.	60.	50.	40.	30.	25.	20.	10.	5.		90.	80.	75.	70.	60.
MONTH	MEAN	PRECIPITATION AT VARIOUS PROBABILITY LEVELS													ETP	IRRIGATION REQUIREMENTS				
JAN	5.	0.	0.	0.	0.	0.	0.	0.	1.	3.	5.	7.	17.	30.	169.	169.	169.	169.	169.	169.
FEB	12.	0.	0.	0.	0.	0.	0.	1.	3.	6.	10.	15.	37.	65.	191.	191.	191.	191.	191.	191.
MAR	5.	0.	0.	0.	0.	0.	0.	1.	1.	3.	5.	7.	15.	26.	231.	231.	231.	231.	231.	231.
APR	64.	0.	0.	2.	4.	6.	13.	24.	40.	65.	82.	104.	181.	265.	168.	167.	165.	164.	161.	155.
MAY	123.	35.	46.	64.	72.	79.	94.	110.	127.	148.	160.	174.	216.	254.	140.	94.	76.	68.	61.	46.
JUN	190.	82.	100.	123.	134.	143.	161.	180.	199.	222.	235.	251.	294.	334.	115.	16.	-8.	-18.	-28.	-46.
JUL	163.	91.	103.	120.	127.	134.	146.	158.	171.	185.	193.	203.	229.	257.	127.	23.	6.	-1.	-7.	-19.
AUG	123.	45.	57.	74.	81.	88.	101.	114.	129.	146.	156.	168.	202.	232.	136.	79.	62.	55.	48.	35.
SEP	69.	31.	37.	45.	49.	52.	58.	65.	71.	79.	84.	89.	104.	117.	135.	98.	90.	86.	83.	76.
OCT	66.	22.	29.	38.	42.	45.	53.	60.	68.	78.	84.	90.	110.	127.	144.	115.	106.	102.	99.	91.
NOV	55.	9.	13.	21.	25.	29.	37.	46.	56.	69.	77.	85.	113.	140.	119.	106.	98.	94.	90.	82.
DEC	21.	0.	0.	1.	1.	2.	5.	8.	13.	21.	27.	34.	59.	86.	140.	140.	139.	139.	138.	136.
ANN	899.	660.	707.	766.	790.	811.	851.	889.	928.	972.	996.	1074.	1100.	1166.	1815.	1108.	1049.	1026.	1004.	964.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
LAMBA	.0314	.0145	.0347	.0064	.0254	.0313	.0660	.0363	.0949	.0610	.0306	.0200	.0377
D	.178	.176	.198	.409	3.120	5.949	10.761	4.481	6.459	3.999	1.726	.422	33.878
LNGAM	1.6480	1.6568	1.5354	.7735	.8065	4.7011	14.5447	2.4268	5.5901	1.7899	-.0901	.7421	84.6246

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

PMAX	97.	85.	46.	214.	295.	394.	300.	237.	132.	116.	151.	80.	1215.
PMIN	0.	0.	0.	0.	30.	74.	85.	32.	14.	18.	3.	0.	614.
PD75	0.	0.	0.	4.	72.	134.	127.	81.	49.	42.	25.	1.	790.
ETDF	169.	191.	231.	164.	68.	-18.	-1.	55.	86.	102.	94.	139.	1026.
MAT	.000	.000	.000	.024	.510	1.156	1.004	.596	.361	.290	.209	.010	.435

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH TOGETHER WITH ELEVATION AND SOLAR RADIATION DETERMINE ETCH

TEMP	24.4	24.8	25.5	25.5	25.2	24.4	24.2	24.5	25.0	25.4	24.7	24.7	24.9
HUM	.74	.67	.67	.76	.87	.84	.84	.83	.83	.81	.83	.79	.79
WIND	14.8	17.8	19.1	16.7	13.6	10.0	9.5	9.0	8.8	9.2	8.9	11.3	12.4
PREC.DAYS	3.	2.	2.	10.	16.	21.	23.	18.	16.	10.	9.	4.	5.
SUNSHINE	.66	.73	.71	.47	.40	.40	.48	.54	.57	.58	.53	.60	.56

TABLE 7.10PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DISTRIBUTION. IN MM.

STATION NAME PUNTA DE PIEDRAS NUEVA ES SER. NO. 1707 ID NO.34
LAT. 10 54. LONG. 64 4. ELEV. 10. YEARS OF DATA 6

PROBABILITY		95.	90.	80.	75.	70.	60.	50.	40.	30.	25.	20.	10.	5.		90.	80.	75.	70.	60.
MONTH	MEAN	PRECIPITATION AT VARIOUS PROBABILITY LEVELS													ETP	IRRIGATION REQUIREMENTS				
JAN	27.	3.	5.	10.	12.	14.	19.	24.	31.	39.	44.	50.	68.	85.	154.	149.	144.	142.	140.	135.
FEB	22.	7.	9.	12.	14.	16.	19.	22.	26.	30.	33.	36.	45.	53.	163.	155.	151.	149.	148.	145.
MAR	15.	1.	2.	4.	5.	7.	9.	12.	16.	20.	23.	26.	37.	47.	203.	201.	199.	198.	197.	194.
APR	25.	0.	0.	0.	0.	0.	1.	3.	7.	14.	20.	28.	60.	99.	205.	205.	205.	205.	204.	204.
MAY	1.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	2.	4.	6.	254.	254.	254.	254.	254.	254.
JUN	18.	0.	0.	0.	0.	1.	[illegible]	4.	8.	15.	20.	28.	54.	85.	197.	197.	196.	196.	196.	195.
JUL	27.	0.	0.	0.	1.	[illegible]	3.	6.	10.	17.	22.	28.	50.	75.	192.	192.	192.	191.	191.	189.
AUG	63.	0.	1.	4.	7.	10.	17.	27.	41.	61.	75.	92.	148.	207.	182.	181.	178.	175.	173.	165.
SEP	15.	1.	2.	4.	5.	[illegible]	[illegible]	10.	13.	17.	19.	21.	29.	37.	188.	186.	184.	183.	182.	180.
OCT	24.	1.	2.	5.	6.	7.	[illegible]	15.	19.	25.	29.	34.	49.	64.	185.	183.	181.	179.	178.	175.
NOV	75.	19.	26.	37.	42.	46.	56.	66.	78.	91.	99.	109.	137.	163.	142.	116.	105.	100.	96.	86.
DEC	45.	14.	18.	24.	27.	30.	35.	40.	46.	54.	58.	63.	77.	90.	145.	127.	120.	118.	115.	110.
ANN	355.	232.	249.	271.	280.	288.	303.	317.	332.	348.	357.	368.	396.	421.	2211.	1962.	1940.	1931.	1923.	1908.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
LAMBA	.0430	.1139	.0591	.0116	.2001	.0157	.0219	.0098	.0957	.0463	.0358	.0773	.0959
R	1.359	2.848	1.146	.231	.250	.287	.377	.543	1.301	.981	2.695	3.451	30.732
LNGAM	-.1168	.5574	-.0680	1.3715	1.2875	1.1433	.8586	.4918	-.1089	.0110	.4307	1.1475	73.7425

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

PMAX	46.	40.	47.	51.	4.	60.	31.	169.	25.	44.	159.	73.	443.
PMIN	3.	6.	3.	0.	0.	0.	6.	1.	1.	1.	29.	18.	263.
PD75	12.	14.	5.	0.	0.	0.	1.	7.	5.	6.	42.	27.	280.
ETDF	142.	149.	198.	205.	254.	196.	191.	175.	183.	179.	100.	118.	1931.
MAI	.078	.086	.027	.000	.000	.002	.005	.037	.026	.032	.293	.187	.127

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH TOGETHER WITH ELEVATION AND SOLAR RADIATION DETERMINE ETCH

TEMP	25.8	25.9	26.6	27.5	27.9	27.7	27.4	27.5	28.0	28.3	27.5	27.0	27.3
HUM	.77	.73	.71	.73	.70	.73	.75	.74	.74	.75	.75	.78	.74
WIND	10.1	11.8	10.8	11.9	14.1	10.9	9.5	8.1	7.4	8.6	6.3	8.0	9.8
PREC.DAYS	6.	5.	3.	3.	0.	3.	3.	9.	2.	4.	11.	7.	26.
SUNSHINE	.72	.73	.74	.68	.74	.66	.68	.69	.75	.75	.74	.73	.72

TABLE 7.11 PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DISTRIBUTION, IN MM.

STATION NAME BARCELONA MOP 2 ANZOATEG SER. NO. 1706 ID NO.35
LAT. 10 11. LONG. 64 47. ELEV. 5. YEARS OF DATA 4

PROBABILITY		95.	90.	80.	75.	70.	60.	50.	40.	30.	25.	20.	10.	5.		90.	80.	75.	70.	60.
MONTH	MEAN	PRECIPITATION AT VARIOUS PROBABILITY LEVELS													ETP	IRRIGATION REQUIREMENTS				
JAN	15.	0.	0.	0.	1.	1.	2.	5.	9.	15.	20.	26.	48.	74.	170.	170.	169.	169.	169.	167.
FEB	6.	1.	1.	2.	2.	3.	4.	4.	5.	6.	7.	8.	10.	13.	163.	162.	161.	161.	160.	160.
MAR	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	2.	3.	223.	223.	223.	223.	223.	223.
APR	15.	0.	0.	0.	0.	1.	2.	3.	6.	11.	15.	20.	39.	59.	206.	206.	205.	205.	205.	204.
MAY	40.	3.	6.	12.	15.	17.	24.	31.	39.	50.	57.	65.	90.	114.	193.	186.	191.	178.	175.	169.
JUN	123.	80.	88.	99.	103.	107.	114.	121.	128.	137.	141.	147.	161.	174.	144.	56.	45.	41.	37.	30.
JUL	128.	52.	64.	81.	88.	94.	107.	121.	135.	151.	161.	172.	203.	232.	143.	79.	62.	55.	48.	36.
AUG	110.	36.	47.	62.	69.	75.	88.	101.	115.	131.	141.	153.	195.	216.	143.	100.	85.	79.	72.	59.
SEP	135.	43.	56.	75.	83.	91.	107.	123.	141.	162.	175.	189.	231.	270.	155.	99.	80.	72.	64.	48.
OCT	20.	15.	16.	17.	18.	18.	19.	20.	21.	21.	22.	22.	24.	25.	172.	156.	155.	154.	154.	153.
NOV	58.	19.	24.	32.	36.	39.	46.	53.	60.	69.	74.	80.	98.	119.	144.	120.	112.	108.	105.	98.
DEC	39.	5.	8.	13.	16.	18.	24.	30.	37.	46.	52.	58.	78.	98.	155.	148.	142.	140.	137.	132.
ANN.	693.	621.	644.	672.	682.	691.	709.	724.	740.	758.	767.	777.	805.	828.	2016.	1372.	1344.	1333.	1325.	1307.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH	JAN.	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
LAMBA	.0199	.3633	.4027	.0237	.0304	.1484	.0412	.0346	.0267	2.2057	.0640	.0407	.3654
B	.330	1.889	.242	.309	1.251	18.293	5.292	3.803	3.616	44.113	3.696	1.538	264.733
LNGAM	.9971	-.0428	1.3240	1.0663	-.0986	34.3465	3.6265	1.5501	1.3313	121.9598	1.4232	-.1187	1210.2685

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

PMAX	48.	12.	2.	47.	95.	175.	223.	177.	233.	23.	78.	84.	769.
PMIN	0.	3.	0.	1.	3.	95.	75.	47.	62.	17.	18.	10.	563.
PD75	1.	2.	0.	0.	15.	103.	88.	69.	83.	18.	36.	16.	682.
ETDF	169.	161.	223.	205.	178.	41.	55.	78.	72.	154.	108.	140.	1333.
MAI	.003	.015	.000	.002	.075	.714	.619	.467	.537	.104	.248	.100	.338

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH TOGETHER WITH ELEVATION AND SOLAR RADIATION DETERMINE ETCH

TEMP	24.7	24.8	25.5	26.5	27.0	25.8	25.5	25.1	26.7	26.1	25.8	25.3	25.7
HUM	.68	.66	.64	.67	.67	.74	.76	.75	.75	.71	.71	.69	.70
WIND	9.4	8.4	10.8	10.6	9.7	7.4	6.8	6.8	6.9	7.6	7.7	7.9	8.3
PREC.DAYS	2.	3.	0.	2.	7.	15.	17.	16.	14.	3.	10.	4.	7.
SUNSHINE	.78	.78	.80	.68	.64	.53	.56	.57	.65	.68	.66	.75	.67

TABLE 7.12 PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROPABILITY LEVELS BASED ON GAMMA DISTRIBUTION. IN MM.

STATION NAME GUANARITO GUARICO SER. NO. 2415 ID NO.36
LAT. 9 56. LONG. 66 24. ELEV. 600. YEARS OF DATA 4

PROBABILITY		95.	90.	80.	75.	70.	60.	50.	40.	30.	25.	20.	10.	5.		90.	80.	75.	70.	60.
MONTH	MEAN	PRECIPITATION AT VARIOUS PROBABILITY LEVELS													ETP	IRRIGATION REQUIREMENTS				
JAN	9.	3.	3.	4.	5.	5.	6.	6.	7.	8.	8.	9.	10.	12.	172.	168.	164.	167.	167.	166.
FEB	3.	0.	0.	0.	0.	0.	0.	0.	1.	2.	2.	3.	7.	10.	195.	195.	195.	195.	195.	195.
MAR	6.	0.	0.	0.	0.	0.	1.	2.	3.	5.	7.	9.	17.	25.	275.	225.	225.	225.	225.	224.
APR	39.	21.	24.	29.	30.	32.	35.	38.	41.	45.	47.	49.	56.	62.	187.	163.	158.	157.	155.	152.
MAY	146.	15.	27.	43.	54.	68.	90.	114.	143.	178.	200.	227.	307.	385.	158.	131.	110.	100.	99.	68.
JUN	177.	103.	116.	134.	141.	147.	160.	172.	185.	200.	208.	218.	245.	268.	129.	13.	-5.	-12.	-19.	-31.
JUL	165.	46.	62.	85.	96.	106.	126.	140.	171.	199.	216.	235.	292.	345.	133.	71.	47.	37.	27.	6.
AUG	147.	102.	117.	137.	145.	152.	167.	181.	195.	213.	223.	234.	265.	293.	184.	18.	-2.	-10.	-18.	-32.
SEP	123.	43.	60.	77.	83.	90.	103.	115.	129.	145.	155.	166.	197.	226.	135.	74.	58.	51.	45.	32.
OCT	108.	63.	71.	81.	86.	90.	97.	105.	113.	121.	127.	132.	143.	163.	140.	69.	59.	54.	50.	42.
NOV	61.	25.	31.	39.	42.	45.	51.	58.	64.	72.	77.	82.	97.	111.	149.	118.	110.	107.	104.	98.
DEC	23.	9.	11.	15.	16.	17.	19.	22.	24.	27.	29.	31.	37.	42.	148.	137.	135.	132.	131.	129.
ANN	1047.	674.	743.	834.	870.	904.	966.	1027.	1091.	1162.	1202.	1248.	1375.	1486.	1904.	1161.	1070.	1034.	1000.	938.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
LAMBA	.6905	.1243	.0506	.2519	.0097	.0684	.0185	.0541	.0409	.1147	.0861	.2220	.0169
A	5.877	.273	.349	5.885	1.449	12.118	3.065	10.121	5.052	12.357	5.296	5.161	17.722
LMEAN	4.5795	1.1933	.9395	12.5446	-.1214	17.7920	.7536	13.0760	3.2571	18.3799	3.6338	3.4235	32.7115

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

PMAX	11.	7.	15.	56.	377.	242.	263.	287.	223.	145.	103.	31.	1369.
PMIN	5.	0.	0.	25.	35.	108.	96.	117.	68.	65.	30.	9.	765.
PD75	5.	0.	0.	30.	58.	141.	96.	145.	83.	96.	42.	16.	870.
ETDF	167.	195.	275.	157.	100.	-12.	37.	-10.	51.	54.	107.	132.	1034.
MAI	.027	.000	.001	.162	.365	1.095	.722	1.078	.620	.614	.282	.107	.457

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH TOGETHER WITH ELEVATION AND SOLAR RADIATION DETERMINE ETCH

TEMP	24.0	24.4	25.1	25.8	25.6	24.7	24.3	24.4	24.8	25.1	25.8	24.6	24.9
HUM	.71	.69	.68	.69	.71	.76	.78	.77	.77	.76	.74	.72	.73
WIND	12.4	14.4	15.5	14.0	9.5	7.6	7.2	7.0	6.6	7.1	9.0	8.7	9.9
PREC.DAYS	1.	0.	1.	7.	18.	20.	19.	21.	16.	14.	9.	4.	27.
SUNSHINE	.69	.77	.74	.54	.51	.48	.52	.53	.57	.58	.68	.68	.61

TABLE 7.13PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DISTRIBUTION. IN MM.

STATION NAME RIO VERDE GUARICO SER. NO. 2831 ID NO.40
LAT. 9 32. LONG. 67 40. ELEV. 250. YEARS OF DATA 8

PROBABILITY		95.	90.	80.	75.	70.	60.	50.	40.	30.	25.	20.	10.	5.		90.	80.	75.	70.	60.
MONTH	MEAN	PRECIPITATION AT VARIOUS PROBABILITY LEVELS													ETP	IRRIGATION REQUIREMENTS				
JAN	4.	0.	0.	0.	0.	0.	1.	1.	2.	3.	4.	6.	10.	15.	207.	207.	207.	207.	207.	206.
FEB	3.	0.	0.	0.	0.	0.	0.	1.	1.	2.	3.	5.	10.	16.	222.	222.	222.	222.	222.	222.
MAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	2.	262.	262.	262.	262.	262.	262.
APR	77.	9.	15.	26.	31.	37.	48.	61.	76.	94.	106.	119.	161.	201.	193.	177.	167.	161.	156.	144.
MAY	194.	71.	89.	115.	127.	137.	158.	180.	203.	231.	247.	265.	319.	368.	162.	73.	47.	35.	25.	4.
JUN	243.	134.	153.	179.	189.	199.	218.	236.	255.	276.	289.	303.	343.	373.	126.	-28.	-53.	-64.	-73.	-92.
JUL	191.	132.	143.	158.	164.	169.	179.	189.	199.	210.	216.	223.	243.	260.	128.	-15.	-30.	-35.	-41.	-51.
AUG	212.	127.	143.	163.	172.	179.	194.	208.	223.	239.	249.	260.	290.	317.	129.	-13.	-34.	-42.	-50.	-64.
SEP	139.	97.	102.	113.	118.	122.	130.	137.	145.	153.	158.	164.	179.	193.	134.	32.	21.	16.	12.	4.
OCT	99.	36.	46.	59.	65.	70.	81.	97.	104.	118.	126.	135.	163.	188.	142.	96.	83.	77.	72.	61.
NOV	103.	9.	16.	30.	38.	45.	62.	81.	103.	131.	149.	171.	236.	301.	147.	131.	117.	109.	102.	85.
DEC	31.	0.	0.	0.	1.	1.	3.	7.	13.	25.	34.	46.	91.	143.	171.	170.	170.	170.	169.	168.
ANN	1304.	1007.	1067.	1142.	1171.	1198.	1247.	1295.	1343.	1397.	1427.	1461.	1553.	1632.	2023.	956.	881.	852.	825.	776.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
LAMBA	.0983	.0750	.6659	.0195	.0226	.0432	.1241	.0633	.1500	.0444	.0114	.0091	.0360
P	.350	.242	.250	1.510	4.400	10.507	23.747	13.473	20.885	4.410	1.231	.280	46.883
LNGAM	.9358	1.3292	1.2993	-.1209	2.3155	13.9568	50.8083	21.1907	41.9871	2.3304	-.0937	1.1691	132.5050

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
PMAX	18.	16.	1.	155.	276.	376.	282.	358.	189.	209.	212.	110.	1742.
PMIN	0.	0.	0.	4.	64.	174.	153.	147.	108.	32.	3.	0.	1106.
PC75	0.	0.	0.	31.	127.	189.	164.	172.	118.	65.	38.	1.	1171.
ETDF	207.	222.	262.	161.	35.	-64.	-35.	-42.	16.	77.	109.	170.	852.
MAI	.001	.000	.000	.163	.782	1.506	1.276	1.325	.878	.456	.256	.003	.579

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH TOGETHER WITH ELEVATION AND SOLAR RADIATION DETERMINE ETCH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
TEMP	26.8	27.7	28.5	29.0	28.7	25.7	25.2	25.3	25.7	25.9	26.3	26.5	26.8
HUM	.63	.56	.53	.59	.72	.80	.83	.83	.81	.80	.75	.68	.71
WIND	11.8	11.9	11.5	9.9	7.9	7.6	7.0	6.7	6.8	7.6	8.3	10.2	8.9
PREC.DAYS	0.	0.	0.	11.	21.	24.	21.	22.	17.	13.	14.	6.	27.
SUNSHINE	.68	.75	.69	.52	.57	.50	.54	.55	.59	.60	.72	.73	.62

TABLE 7.14 PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DISTRIBUTION. IN MM.

STATION NAME MERIDA MERIDA SER. NO. 3050 ID NO.41
LAT. 8 35. LONG. 71 9. ELEV. 1870. YEARS OF DATA 2

PROBABILITY		95.	90.	80.	75.	70.	60.	50.	40.	30.	25.	20.	10.	5.		90.	80.	75.	70.	60.
MONTH	MEAN	PRECIPITATION AT VARIOUS PROBABILITY LEVELS													ETP	IRRIGATION REQUIREMENTS				
JAN.	47.	38.	40.	42.	42.	43.	44.	45.	46.	48.	48.	49.	51.	53.	127.	87.	85.	84.	84.	83.
FEB	29.	6.	9.	13.	15.	18.	22.	26.	32.	38.	42.	46.	54.	72.	128.	119.	114.	112.	110.	106.
MAR	65.	55.	59.	62.	63.	64.	67.	69.	71.	74.	75.	77.	81.	85.	161.	103.	100.	98.	97.	95.
APR	311.	126.	149.	177.	190.	201.	223.	245.	260.	295.	311.	328.	379.	424.	124.	-24.	-53.	-66.	-77.	-99.
MAY	315.	115.	140.	175.	190.	209.	231.	259.	288.	322.	342.	365.	431.	491.	129.	-11.	-47.	-61.	-75.	-102.
JUN	206.	130.	140.	154.	159.	164.	173.	182.	191.	201.	207.	213.	231.	246.	115.	-25.	-39.	-44.	-49.	-58.
JUL	109.	80.	89.	97.	101.	105.	112.	118.	125.	133.	137.	142.	156.	169.	129.	42.	32.	28.	24.	17.
AUG	115.	63.	70.	79.	82.	86.	92.	98.	105.	112.	116.	121.	134.	145.	108.	38.	29.	26.	22.	16.
SEP	205.	140.	148.	158.	162.	166.	172.	179.	185.	193.	197.	201.	214.	275.	110.	-38.	-48.	-52.	-56.	-62.
OCT	314.	167.	186.	212.	222.	232.	250.	267.	286.	307.	318.	332.	369.	402.	97.	-90.	-115.	-126.	-135.	-153.
NOV	213.	140.	153.	169.	175.	181.	192.	202.	213.	225.	232.	240.	262.	280.	94.	-58.	-74.	-81.	-86.	-97.
DEC	71.	26.	33.	44.	48.	52.	60.	68.	77.	88.	94.	101.	122.	141.	105.	71.	61.	57.	53.	45.
ANN.	1999.	1901.	1923.	1949.	1959.	1967.	1984.	1999.	2014.	2031.	2039.	2049.	2075.	2097.	1426.	-497.	-523.	-533.	-541.	-558.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
LAMDA	3.3551	.0691	.8392	.0303	.0202	.1458	.1659	.1589	.2693	.0525	.1120	.0579	1.1327
R	157.144	7.141	53.182	7.756	5.564	26.870	19.996	15.947	48.474	14.376	22.988	4.282	2264.298
LNGAM	610.7586	.0659	177.1348	8.0366	4.0616	60.8356	39.3276	27.7549	138.6337	23.5353	48.4340	2.1570	15224.5074

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

PMAX	45.	50.	74.	357.	451.	227.	138.	132.	206.	398.	259.	110.	2041.
PMIN	41.	8.	57.	266.	181.	185.	79.	98.	205.	231.	168.	32.	1957.
PD75	42.	15.	63.	190.	190.	159.	101.	82.	162.	227.	175.	48.	1959.
ETDF	94.	112.	98.	-66.	-61.	-44.	28.	26.	-52.	-126.	-81.	57.	-533.
MAI	.339	.121	.391	1.529	1.476	1.383	.785	.763	1.473	2.302	1.853	.457	1.373

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH TOGETHER WITH ELEVATION AND SOLAR RADIATION DETERMINE ETCH

TEMP	16.2	16.6	17.7	17.5	17.6	17.6	16.9	16.9	17.1	17.0	16.6	16.3	17.0
HUM	.61	.60	.61	.64	.67	.68	.67	.71	.67	.71	.70	.71	.66
WIND	6.3	6.8	7.2	6.3	5.9	5.6	6.0	6.0	6.2	5.8	6.0	6.3	6.2
PREC.DAYS	0.	0.	0.	0.	0.	0.	0.	14.	20.	25.	22.	11.	27.
SUNSHINE	.60	.62	.67	.39	.45	.40	.49	.48	.52	.46	.56	.68	.53

TABLE 7.15 PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DISTRIBUTION. IN MM.

STATION NAME SANTA BARBARA ZULIA SER. NO. 7099 ID NO.42
LAT. 9 0. LONG. 71 55. ELEV. 5. YEARS OF DATA 6

PROBABILITY		95.	90.	80.	75.	70.	60.	50.	40.	30.	25.	20.	10.	5.		90.	80.	75.	70.	60.
MONTH	MEAN	PRECIPITATION AT VARIOUS PROBABILITY LEVELS													ETP	IRRIGATION REQUIREMENTS				
JAN	61.	0.	1.	3.	4.	6.	12.	22.	35.	54.	58.	85.	145.	208.	111.	110.	108.	107.	104.	98.
FEB	77.	0.	0.	2.	4.	6.	13.	24.	40.	66.	83.	107.	187.	275.	113.	112.	111.	109.	107.	100.
MAR	31.	0.	0.	1.	1.	2.	5.	9.	17.	29.	38.	50.	91.	137.	130.	130.	129.	123.	120.	125.
APR	179.	19.	32.	57.	69.	87.	109.	139.	174.	219.	246.	279.	380.	478.	115.	83.	59.	46.	34.	7.
MAY	130.	40.	53.	71.	79.	87.	102.	118.	136.	156.	168.	183.	224.	262.	145.	92.	73.	65.	58.	42.
JUN	105.	31.	41.	56.	62.	69.	82.	95.	110.	127.	138.	150.	185.	218.	138.	98.	83.	76.	70.	57.
JUL	97.	34.	43.	56.	62.	68.	78.	90.	107.	116.	124.	134.	162.	188.	145.	102.	89.	83.	78.	67.
AUG	127.	32.	43.	60.	68.	75.	90.	105.	122.	142.	155.	169.	211.	249.	127.	84.	67.	60.	52.	38.
SEP	89.	30.	38.	51.	57.	62.	73.	84.	96.	110.	118.	128.	156.	182.	124.	86.	73.	67.	62.	51.
OCT	123.	37.	49.	64.	70.	77.	90.	103.	118.	135.	145.	157.	190.	222.	121.	73.	58.	51.	44.	31.
NOV	139.	31.	45.	67.	78.	88.	109.	132.	158.	189.	207.	230.	295.	358.	99.	54.	32.	21.	11.	-10.
DEC	113.	12.	20.	35.	42.	49.	65.	83.	104.	130.	146.	166.	224.	282.	93.	73.	58.	51.	44.	28.
ANN.	1273.	1003.	1027.	1056.	1067.	1076.	1094.	1111.	1128.	1146.	1155.	1166.	1195.	1219.	1461.	434.	405.	394.	385.	367.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
LAMSA	.0097	.0060	.0110	.0078	.0269	.0303	.0420	.0249	.0409	.0337	.0141	.0135	.3404
B	.452	.394	.346	1.401	3.501	3.203	4.083	2.941	3.708	3.802	2.179	1.442	378.185
LNGAM	.6735	.8017	.9466	-.1197	1.2021	.8882	1.8975	.6399	1.4371	1.5489	.0854	-.1213	1864.4397

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

PMAX	112.	238.	82.	408.	258.	171.	170.	162.	165.	221.	169.	229.	1849.
PMIN	28.	14.	0.	72.	51.	32.	49.	20.	30.	66.	17.	9.	1041.
PR75	4.	4.	1.	69.	79.	62.	62.	68.	57.	70.	78.	42.	1067.
ETDF	107.	109.	128.	46.	65.	76.	83.	60.	67.	51.	21.	51.	394.
MAI	.038	.034	.009	.599	.548	.451	.427	.530	.458	.581	.787	.451	.730

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH TOGETHER WITH ELEVATION AND SOLAR RADIATION DETERMINE ETCH

TEMP	25.8	25.8	26.3	26.9	27.7	27.4	27.1	27.0	26.9	26.7	26.4	26.3	26.7
HUM	.87	.85	.85	.87	.82	.83	.82	.83	.84	.80	.86	.89	.84
WIND	4.1	4.5	4.4	4.8	4.5	4.6	4.7	4.9	4.6	4.4	4.5	4.2	4.5
PREC.DAYS	0.	0.	0.	0.	0.	0.	0.	15.	13.	15.	18.	14.	27.
SUNSHINE	.49	.48	.45	.33	.46	.49	.49	.52	.56	.52	.50	.50	.48

TABLE 7.16PRECIPITATION AND POTENTIAL IRRIGATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DISTRIBUTION. IN MM.

STATION NAME GUANARE MOP PORTUGESA SER. NO. 3208 ID NO.43
LAT. 8 57. LONG. 69 14. ELEV. 117. YEARS OF DATA 19

PROBABILITY		95.	90.	80.	75.	70.	60.	50.	40.	30.	25.	20.	10.	5.		90.	80.	75.	70.	60.
MONTH	MEAN	PRECIPITATION AT.VARIOUS PROBABILITY LEVELS													ETP	IRRIGATION REQUIREMENTS				
JAN	15.	0.	0.	0.	1.	1.	3.	5.	9.	15.	20.	26.	48.	72.	151.	151.	150.	150.	150.	148.
FEB	15.	0.	0.	0.	0.	0.	1.	3.	6.	12.	16.	22.	45.	72.	154.	154.	154.	154.	154.	153.
MAR	7.	0.	0.	1.	1.	1.	2.	4.	5.	8.	9.	11.	18.	25.	193.	193.	192.	192.	192.	191.
APR	104.	11.	19.	33.	41.	48.	63.	81.	101.	127.	143.	162.	220.	276.	143.	124.	109.	102.	95.	79.
MAY	209.	100.	119.	142.	153.	162.	180.	199.	218.	241.	253.	268.	310.	348.	129.	11.	-14.	-24.	-33.	-52.
JUN	258.	131.	153.	182.	194.	205.	226.	248.	270.	296.	311.	328.	376.	419.	104.	-49.	-77.	-89.	-101.	-122.
JUL	252.	155.	173.	196.	206.	214.	231.	247.	264.	282.	293.	305.	340.	369.	111.	-62.	-86.	-95.	-104.	-120.
AUG	207.	92.	110.	135.	145.	155.	173.	192.	212.	235.	249.	264.	308.	347.	120.	10.	-15.	-25.	-35.	-53.
SEP	166.	93.	106.	123.	130.	137.	149.	161.	174.	189.	197.	205.	233.	255.	129.	23.	5.	-2.	-8.	-20.
OCT	155.	67.	81.	101.	109.	117.	132.	147.	164.	183.	194.	207.	244.	277.	137.	56.	36.	28.	20.	5.
NOV	84.	14.	22.	34.	40.	45.	57.	70.	84.	102.	113.	125.	164.	200.	135.	114.	101.	96.	90.	78.
DEC	25.	4.	6.	10.	12.	13.	17.	21.	25.	30.	33.	37.	48.	58.	136.	130.	126.	125.	123.	120.
ANN	1493.	1205.	1265.	1340.	1369.	1396.	1445.	1492.	1540.	1592.	1621.	1655.	1744.	1820.	1641.	376.	301.	272.	245.	196.

PARAMETERS FOR GAMMA DISTRIBUTION

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
LAMBA	.0211	.0173	.0848	.0137	.0353	.0326	.0583	.0325	.0662	.0367	.0233	.0804	.0428
P	.347	.260	.581	1.422	7.355	8.470	14.727	6.579	11.006	5.746	1.942	1.973	64.151
LNGAM	.9938	1.2458	.4289	-.1707	7.2541	9.3836	24.4648	5.8050	15.1177	4.3502	-.0233	-.0114	201.6347

MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC. EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C.PROB.LEVEL

PMAX	103.	81.	25.	295.	447.	484.	355.	368.	263.	377.	171.	76.	1905.
PMIN	0.	0.	0.	2.	92.	86.	134.	98.	88.	77.	13.	3.	1119.
PD75	1.	0.	1.	41.	153.	194.	206.	145.	130.	109.	40.	12.	1369.
ETDF	150.	154.	192.	102.	-24.	-89.	-95.	-25.	-2.	28.	96.	125.	272.
MAI	.009	.001	.005	.784	1.185	1.855	1.859	1.208	1.012	.797	.292	.086	.834

CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH TOGETHER WITH ELEVATION AND SOLAR RADIATION DETERMINE ETCH

TEMP	25.5	26.2	27.2	27.0	26.4	25.6	25.0	25.3	25.9	26.3	26.0	25.5	26.0
HUM	.73	.70	.67	.73	.80	.82	.83	.82	.80	.79	.77	.75	.77
WIND	7.6	8.1	8.4	7.9	7.6	7.0	6.7	6.7	6.6	6.7	6.7	7.2	7.3
PREC.DAYS	3.	3.	1.	9.	13.	18.	19.	17.	14.	10.	6.	6.	10.
SUNSHINE	.64	.65	.60	.40	.40	.33	.38	.42	.49	.53	.61	.61	.50

APPENDIX C

Table 8. Confidence Interval at 95% Level for 7 Stations. (Calculated evaporation = measured evaporation ± value shown in mm.)

Sta. No.	Station Name	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
25	Cua-Tovar	19.1	21.4	19.4	19.3	24.6	15.9	10.5	7.5	13.4	7.5	10.0	10.9
26	Jusepin	42.5	8.7	20.0	22.6	16.7	19.4	17.0	9.3	17.9	9.7	12.5	22.2
27	Mayalito	13.5	23.4	15.4	25.6	34.0	22.0	10.0	8.09	7.85	13.2	12.5	10.8
28	San Juan de los Morros	18.3	21.9	22.6	30.2	30.9	10.1	12.7	11.5	3.76	17.0	12.8	12.6
30	Santa Cruz	14.1	18.2	24.7	32.8	26.1	12.1	13.5	11.9	9.65	12.7	14.7	17.1
31	Shell Foundation	17.5	16.4	31.1	28.1	24.6	27.5	17.8	14.5	5.5	11.6	20.3	20.9
32	Uranon	18.8	28.4	16.1	57.7	25.5	11.5	16.4	4.34	9.6	20.9	11.9	20.9

Table 9. Percent of Possible Deviation of Mean of Measured Evaporation at 95% Level. (95% of values fall within % shown of the true mean)

Sta. No.	Station Name	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
25	Cua-Tovar	11.6	11.35	7.7	8.4	11.7	10.55	6.8	4.6	7.9	4.2	6.1	6.95
26	Jusepin	22.4	4.5	7.25	8.85	6.6	8.3	11.3	6.0	9.9	5.4	8.0	13.9
27	Mayalito	6.58	10.3	5.6	10.2	14.8	13.8	6.5	5.3	5.1	8.85	7.5	5.86
28	San Jaun de los Morros	10.2	10.6	8.85	13.4	16.2	6.97	8.45	7.29	2.44	10.4	8.5	7.78
30	Santa Cruz	7.25	8.35	9.35	14.1	14.1	8.6	9.0	7.8	6.65	8.1	10.1	10.4
31	Shell Foundation	8.2	6.95	11.2	11.5	12.2	16.6	9.95	8.1	3.4	6.3	12.8	11.5
32	Uranon	6.0	9.22	4.44	21.1	12.3	7.58	11.0	2.68	5.61	10.1	5.61	8.23

Table 10. Ratio of Moving Average Precipitation to Mean Precipitation for Cua-Tovar, Aragua, Venezuela. Precip. data with. 20 years.

Percent of years of moving average	Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
	Mean	33.1	15.9	11.7	34.1	118.8	191.1	178.8	125.0	105.2	91.9	126.3	59.1	1091.2
5	Max.	1.864	1.673	1.333	1.798	1.232	1.165	1.265	1.299	1.178	1.528	2.633	1.475	1.307
25%	Min.	.446	.403	.137	.305	.786	.741	.804	.733	.794	.664	.361	.680	.887
10	Max.	1.195	1.044	1.222	1.139	1.137	1.123	1.086	1.138	1.094	1.159	1.547	1.108	1.097
50%	Min.	.618	.761	.598	.395	.939	.924	.869	.962	.870	.847	.503	.772	.889
15	Max.	1.038	1.069	1.014	.880	1.071	1.026	1.010	1.087	1.032	1.074	1.243	1.069	1.033
75%	Min.	.750	.872	.826	.697	1.002	.995	.921	.972	.921	.923	.476	.843	.907

Table 11. Ratio of Moving Averages Precipitation to Mean Precipitation for Jusepin, Managas, Venezuela. Precip. data with. 25 years.

Percent of years of moving averages	Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
	Mean	43.2	25.8	14.2	25.6	113.8	190.0	184.4	171.2	97.2	90.0	82.4	70.0	1107.8
5	Max.	1.528	1.440	2.380	2.172	1.634	1.256	1.200	1.299	1.357	1.234	1.367	1.292	1.165
20%	Min.	.296	.279	.352	.289	.624	.746	.765	.764	.630	.676	.668	.702	.884
10	Max.	1.326	1.258	1.782	1.416	1.316	1.218	1.108	1.088	1.015	1.175	1.251	1.116	1.068
40%	Min.	.648	.786	.711	.527	.721	.798	.824	.769	.880	.784	.799	.848	.921
15	Max.	.991	1.269	1.362	1.362	1.201	1.115	1.023	1.012	1.093	1.103	1.089	1.021	1.037
60%	Min.	.770	.906	1.023	.974	.834	.913	.879	.817	.828	.909	.881	.904	.929
20	Max.	.988	1.078	1.137	1.102	1.118	1.044	.995	1.007	.989	1.036	1.025	1.024	1.003
80%	Min.	.872	1.022	1.095	.947	.905	.958	.915	.922	.928	.942	.953	.926	.967

Table 12. Ratio of Moving Averages Precipitation to Mean Precipitation for Yaritagua, Yaracuy, Venezuela. Precip. data with 27 years.

Percent of years of moving averages	Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
	Mean	5.7	12.2	5.1	64.4	122.6	190.2	163.0	123.5	68.1	65.6	56.3	21.1	897.8
5	Max.	3.424	2.675	2.191	1.652	1.237	1.321	1.201	1.344	1.213	1.461	1.328	1.904	1.118
18.5%	Min.	.000	.000	.000	.224	.737	.733	.747	.774	.664	.613	.763	.284	.857
10	Max.	1.853	1.912	1.761	1.154	1.033	1.221	1.038	1.189	1.153	1.278	1.173	1.369	1.078
37.0%	Min.	.053	.057	.253	.671	.867	.784	.867	.950	.909	.767	.898	.521	.892
15	Max.	1.588	1.702	1.435	1.081	1.053	1.094	1.061	1.110	1.105	1.184	1.097	1.118	1.035
55.5%	Min.	1.141	.345	.887	.816	.891	.853	.885	.936	.928	.854	.942	.669	.948
20	Max.	1.191	1.276	1.193	1.026	1.015	1.007	.994	1.069	1.103	1.095	1.076	1.040	1.007
74.0%	Min.	.918	.743	.851	.804	.941	.920	.935	1.003	.962	.925	.974	.872	.963

Table 13. Ratio of Moving Average Precipitation to Mean Precipitation for Guanare, Portugesa, Venezuela. Precip. data with 19 years.

Percent of years of moving averages	Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
	Mean	15.4	15.3	6.8	104.1	208.1	257.9	252.4	202.3	160.3	156.4	83.5	24.5	1493.1
5	Max.	1.718	1.907	1.549	1.428	1.177	1.233	1.181	1.254	1.195	1.212	1.367	1.476	1.030
26.3%	Min.	.586	.078	.438	.434	.797	.755	.869	.782	.780	.759	.611	.530	.925
10	Max.	1.327	1.149	1.228	.997	1.127	1.157	1.104	1.087	1.026	1.185	1.148	1.040	1.013
52.6%	Min.	.794	.248	.760	.629	.899	.839	.955	.993	.847	.938	.936	.718	.974
15	Max.	1.080	.853	1.033	.923	1.031	1.061	1.066	1.033	.996	1.075	1.081	1.033	1.005
79%	Min.	1.020	.470	.809	.819	.967	.960	1.012	.966	.944	.923	.969	.840	.981

Table 14. Crop Coefficients; K: +

Crop consumptive use coefficients by percent of growing season; Et/Ev ratios (to be multiplied by actual or estimated Class A pan evaporation). *

Annual Crops	0	10	20	30	40	50	60	70	80	90	100
Beans	0.20	0.30	0.40	0.65	0.85	0.90	0.90	0.80	0.60	0.35	0.20
Corn	0.20	0.30	0.50	0.65	0.80	0.90	0.90	0.85	0.75	0.60	0.50
Cotton	0.10	0.20	0.40	0.50	0.75	0.90	0.90	0.85	0.75	0.55	0.35
Grain sorghum	0.20	0.35	0.55	0.75	0.85	0.90	0.85	0.70	0.60	0.35	0.15
Peanuts	0.15	0.25	0.35	0.45	0.55	0.60	0.65	0.65	0.60	0.45	0.30
Potatoes	0.20	0.35	0.45	0.65	0.80	0.90	0.95	0.95	0.95	0.90	0.90
Rice	0.80	0.95	1.05	1.15	1.20	1.30	1.30	1.20	1.10	0.90	0.50
Soybeans	0.15	0.20	0.25	0.30	0.45	0.55	0.70	0.80	0.70	0.60	0.50
Tomatoes	0.20	0.25	0.40	0.60	0.70	0.75	0.75	0.65	0.55	0.30	0.20

Crop consumptive use coefficients; Et/Ev ratio (to be multiplied by actual or estimated Class A pan evaporation)* (Full developed)

Perennial crops	Range in K
Avocado	0.50 - 0.60
Citrus	0.50 - 0.60
Grapes	0.45 - 0.60
Pasture grass	0.55 - 0.70
Bermuda grass	0.70 - 0.80
Pangola grass	0.80 - 1.15
Platano	0.80 - 1.10
Sugar cane	0.65 - .90

*These values multiplied by 1.25 may by used with computed potential evapotranspiration to estimate actual crop evapotranspiration.

+ Taken from Christiansen and Hargreaves, 1969.

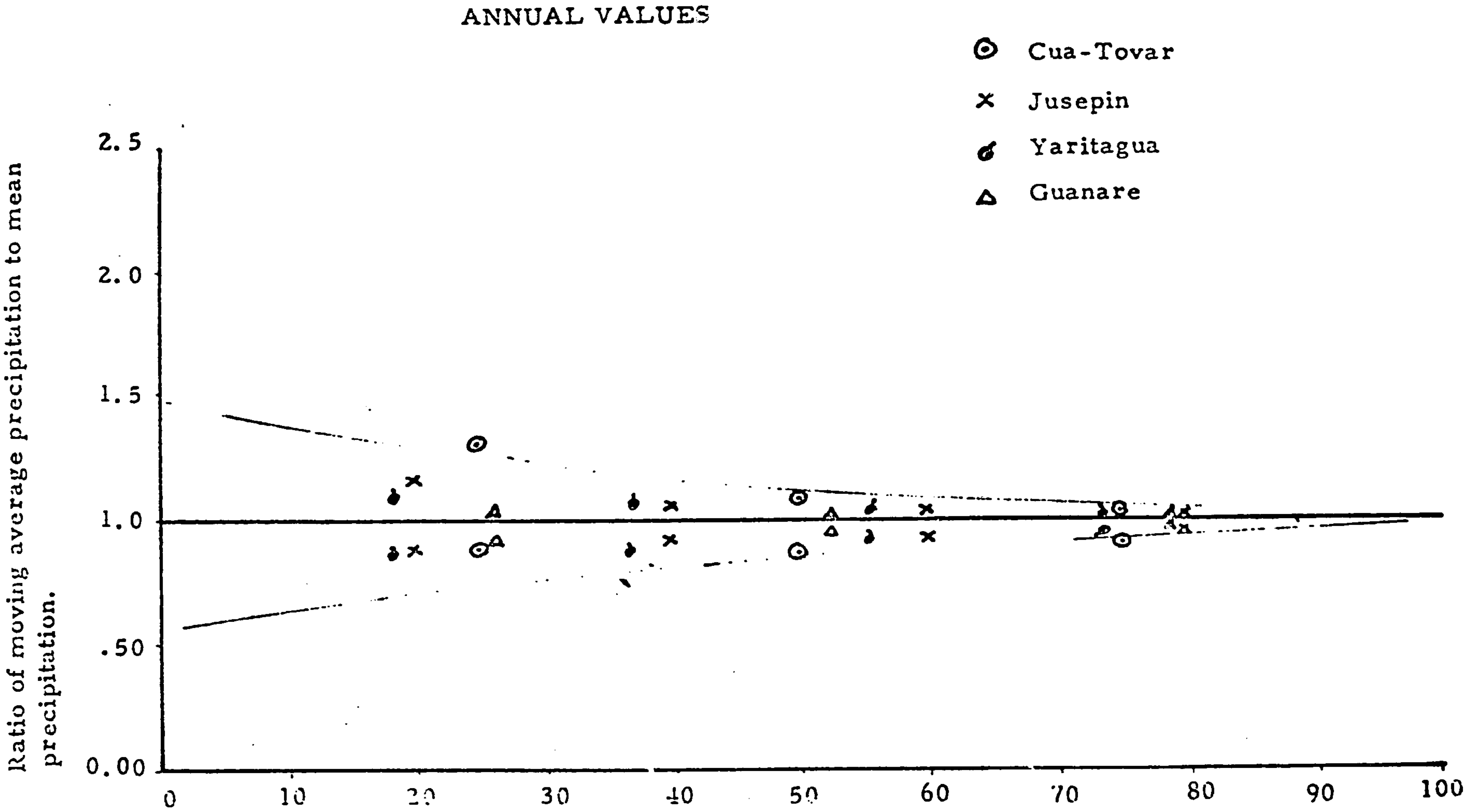

Figure 1. Percent of year of moving average.

MARCH (dry month)

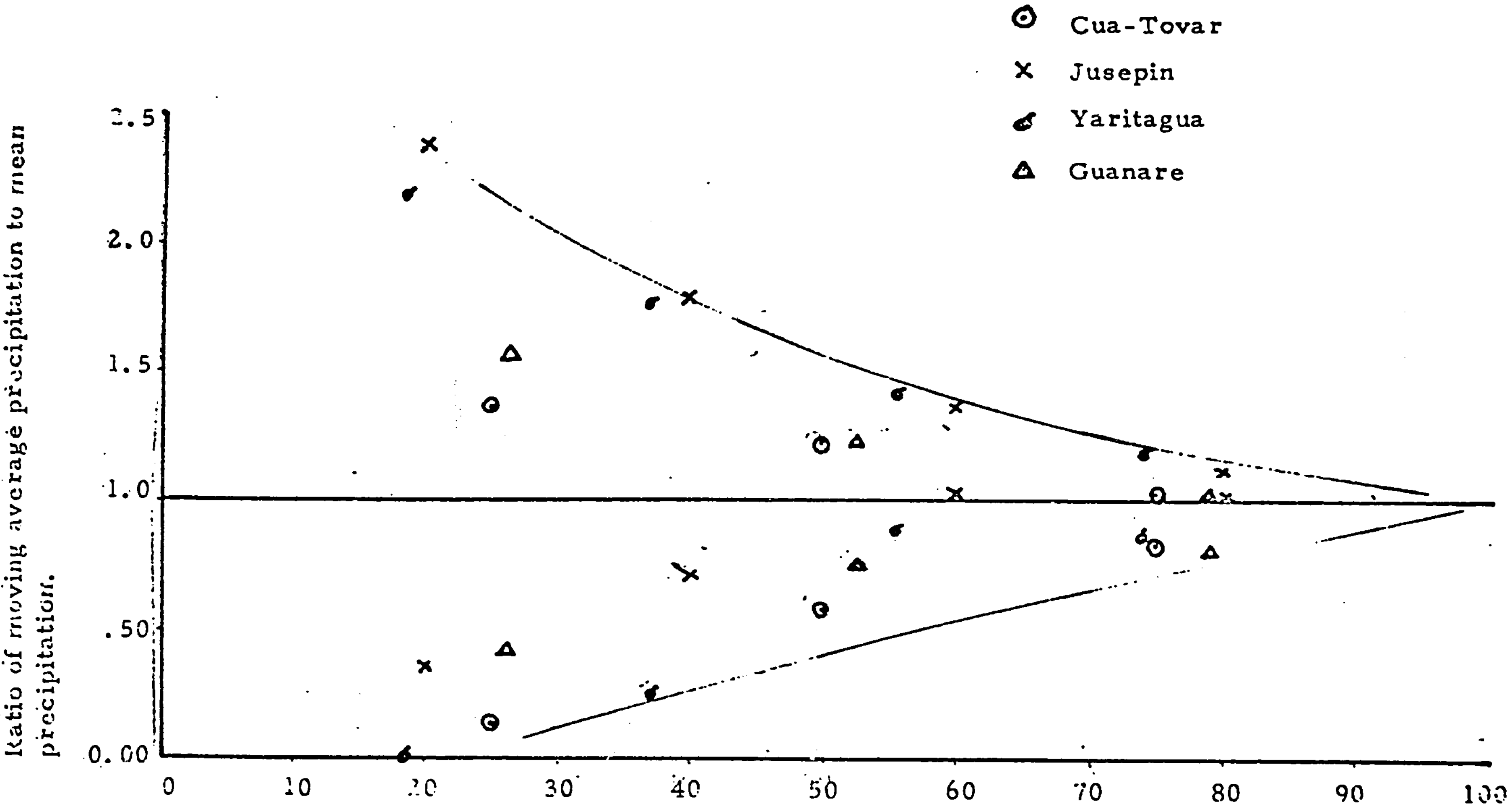

Figure 2. Percent of year of moving averages.

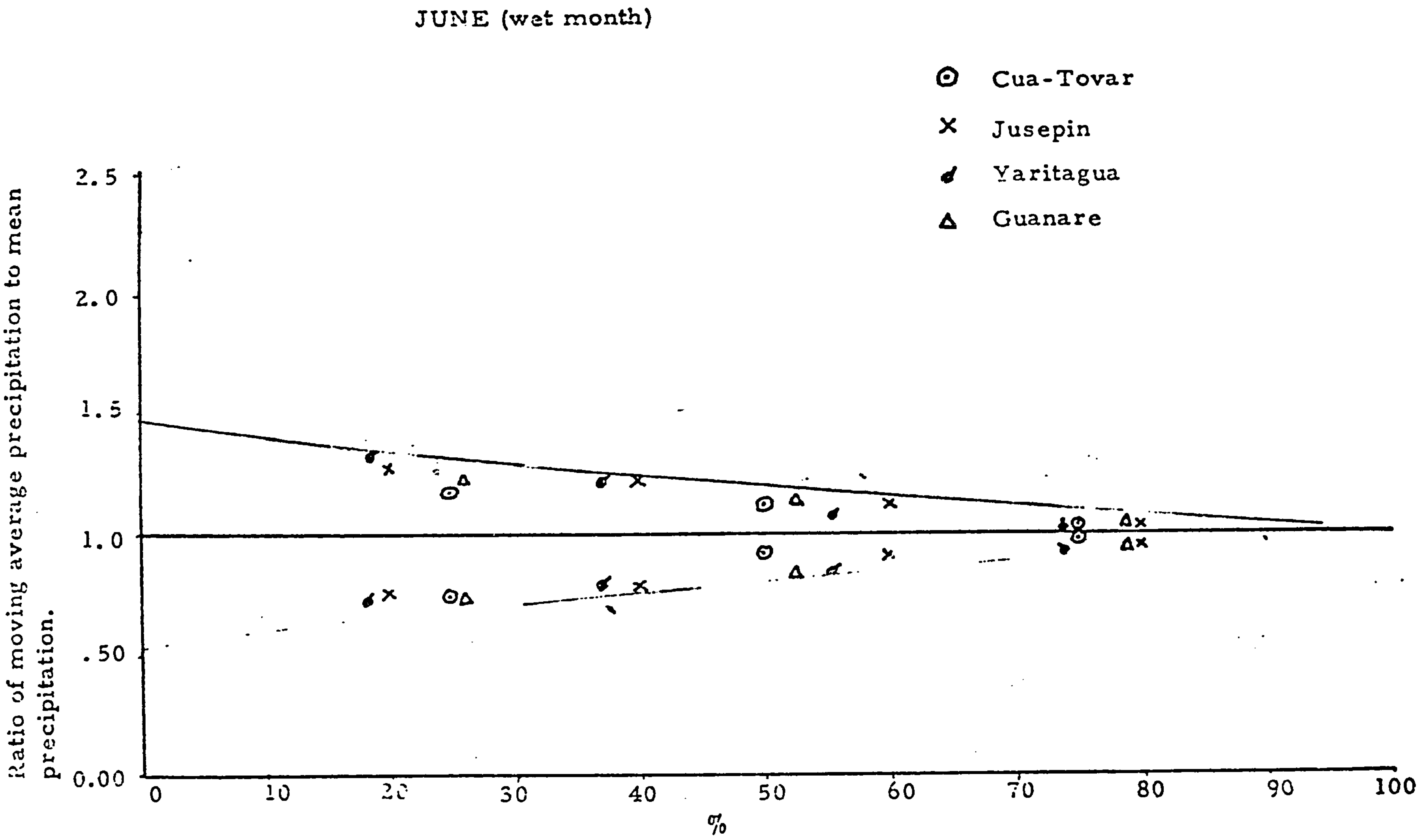

Figure 3. Percent of year of moving averages.

APPENDIX D

Computer program used

First program

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C     PROGRAM GEO.5  TO LIST DATA  AND COMPUTE PAN EVAPORATION
C     FROM CHRISTIANSENS FORMULA
C     CORRECTIONS FOR WIND. ASSUMING THAT WIND WAS MEASURED AT .6 M.
C     AND THAT EITHER S OR SC WAS IN ERROR.
C     VENEZUELA DATA. M O P STATIONS.
C     TABLE HEADINGS ARE
C        MO = MONTH
C        YR = YEAR
C        TM = MEAN TEMPERATURE DEGREES C.
C        TD = TX - TI, WHERE TX IS MAX TEMP AND TI IS MIN TEMP
C        W10 = WIND VELOCITY CORRECTED TO 10 METERS HEIGHT
C        PREC = MONTHLY PRECIPITATION IN MM
C        DP = DAYS OF PRECIPITATION OF MORE THAN 1 MM
C        S = SUNSHINE PERCENTAGE EXPRESSED DECIMALLY
C        SC = COMPUTED SUNSHINE
C        VPD = VAPOR PRESSURE DEFICIT IN MILLIBARS
C        RMM = EXTRATERRESTRIAL RADIATION. COMPUTED. IN MM
C        RSC = RADIATION COMPUTED FROM S AND ELEVATION
C        RSM = MEASURED RADIATION EXPRESSED AS EVAPORATION IN MM
C        EVM = MEASURED PAN EVAPORATION IN MM
C        EVC = COMPUTED PAN EVAPORATION MM
C        EVPH = COMPUTED PAN EVAPORATION. HARGREAVES EQUATION.
C        ETC = COMPUTED POTENTIAL EVAPOTRANSPIRATION IN MM
C        ETPH = COMPUTED POTENTIAL ET. HARGREAVES EQUATION)
C        RSS = RATIO. S/SC
C        RAR = RATIO. RSM/RSC
C        REV = RATIO. EVM/EVC
C        RET = RATIO. ETC/EVC
C        ERS = ABSOLUTE ERROR IN COMPUTED SUNSHINE = 100 * ABS(S-SC)/S
C        ERR = ABSOLUTE ERROR IN COMPUTED RADIATION = 100 * ABS(RSM-RSC)/RSM
C        ERV = ABSOLUTE ERROR IN COMPUTED EVAPORATION = 100*ABS(EVM-EVC)/EVM
      COMMON  HM,TM,W10,CS,CF,X,CHV,CHT,CTV,CTT,CWV,CWT,CDP,XVC,XTC,DP,
     1EVPC,ETPC,RMM,EL, WMAJ(15),RSX,SC,RSC,XSR,SCX,XSC ,TD ,S ,ID
      DIMENSION DEC(15),ES(15),DER(15),X(28),SX(28),AX(28),SXT(28),AXT(2
     18),OZS(28),OZA(28),NAME(10)
  102 FORMAT(12F6.3)
  103 FORMAT(12F6.5)
  104 FORMAT(3I3)
  105 FORMAT(2I5,I3,7A5,F5.0,F2.0,F3.0,F2.0,F5.0,)
  106 FORMAT (12F5.1 )
  110 FORMAT(I3,1X,I1,I3,F6.2,2I3,3F5.1,3F3.2,F4.1,F4.0,F4.1,F4.0,F5.0,F
     15.1,,F4.0)
  112 FORMAT(I3,1X,I1,F3.2,F6.2,2I3,3F5.1,3F3.2,F4.1,F4.0,F4.1,F4.0,F5.0
     1,F5.1,,F4.0)
  203 FORMAT(1H1'TABLE      DATA AND COMPUTED SUNSHINE, RADIATION, PAN EV
     1APORATION AND POTENTIAL EVAPOTRANSPIRATION FOR VENEZUELA',12X,'PAG
     2E',F4.0,/)
  205 FORMAT(1H0'SERIAL',I5,',  ID NO.',I3,',  NAME AND STATE, ',7A5,' L
     1AT.'F5.2,',  LONG.'F6.2,',  ELEVATION',F6.0)
  210 FORMAT(1H0' MO  YR     TM     TD   W10  PREC    DP     HM      S     SC
     1   VPD  RMM  RSM  RSC  EVM  EVC  ETC   RSS   RAR   REV   RET  ERS
     2 ERR  ERV',/)
  211 FORMAT(1H0' MO YRS     TM     TD   W10  PREC    DP     HM      S     SC
     1   VPD  RMM  RSM  RSC  EVM  EVC  ETC   RSS   RAR   REV   RET  ERS
     2 ERR  ERV',/)
  220 FORMAT(1H ,I3,  I4,5F6.1,4F6.2,6F5.0,4F6.3,3F5.1)
  221 FORMAT(1H0,I3,  I4,5F6.1,4F6.2,6F5.0,4F6.3,3F5.1,/)
  224 FORMAT(1H0' SM',I4,5F6.1,4F6.2,6F5.0,4F6.3,3F5.1)
  226 FORMAT(1H1'TABLE      OVERALL AVERAGES FOR VENEZUELA',/)
  228 FORMAT(1H0'DAM',I4,5F6.1,4F6.2,5F5.0,4F6.3,3F5.1)
  233 FORMAT(1H0,7X,'XSC',7X,'XSR',7X,'XVC',7X,'XTC',7X,'ZNT',7X,'ZN
     1X,'ZNP')
  234 FORMAT(1H0,4F10.3,4F10.0)
  299 FORMAT(1H1)
      READ(5,104) NS
      READ (5,102) (DEC(M),M=1,12)
      READ(5,103) (ES(M),M=1,12)
      READ (5,106) (WMAJ(M),M=1,12 )
      ZNT=0.
      ZNP=0.
      ZNS=0.
      ZNP=0.
      MOX=0
      PG=0.
      DO  2 I=1,27
    2 OZS(I)=0.
      DO 80   J=1,NS
      DO   3 I=1,27
    3 SXT(I)=0.
      MOT=0
      MOS=0
      MOR=0
      MOP=0
      READ(5,105)NSR,ID,NN,(NAME(MM),MM=1,7),XLD,XLM,XLOD,XLOM,EL
      XLA=XLD+XLM/60.
      XLO=XLOD+XLOM/60.
      PG=PG+1.
      WRITE(6,203)PG
      WRITE(6,205)NSR,ID,(NAME(MM),MM=1,7),XLA,XLO,EL
      WRITE(6,210)
      DO 30 L=1,NN
      READ(5,104) MM,N
      DO 30 KK=1,MM
      DO 4  I=1,27
    4 SX(I)=0.
      SN=0.
      PN=0.
    5 TN=0.
      TP=0.
      MT=0
      WCGM=4.71*0.6**.296
      W2M=4.71*2.0**.296
      DO 25 K=1,N
      READ(5,110)NST,NYR,LE,XLA,MO,MO,TM,TX,TI,HM,HX,HI,W10,EV,SH,R
     1DP,EVF
      IF(EV.LT.1.0) GO TO 25
      IF(P.LT.-.01) GO TO 71
      GO TO 22
   71 P=0.
      TP=TP-1
      MOP=MOP-1
      ZNP=ZNP-1
   22 CONTINUE
      IF(DP) 6,6,7
    6 NDP=2.+14.*(P/100.)-2.*(P/100.)**2
      IF(P.GT.350.) NDP=27
```

```
      IF(P.LT.25.) NOP=.7*P
      CP=NOP
    7 CONTINUE
      IF(NTP.EQ.0) NTP=10
      IF(ID.EQ.25.OR.ID.EQ.34.OR.ID.EQ.43) GO TO 8
      IF(ID.EQ.38) GO TO 8
      IF(ID.EQ.26) GO TO 11
      GO TO 9
   11 IF(NTP.EQ.7) GO TO 13
      GO TO 9
   13 IF(MO.NE.1) GO TO 9
      W2=W10
      XP=.579-.609*(W2/W2M)+.126*(W2/W2M)**2
      IF((W2/W2M).GT.1.6) XP=.249
      W10=W2*(10./2.)**XP
      GO TO 9
    8 W06=W10
      XP=.579-.410*(W06/W06M)+.125*(W06/W06M)**2
      IF((W06/W06M).GT.1.6) XP=.249
      W10=W06*(10./.6)**XP
    9 IF(NTP.EQ.1) NTP=11
      NTP=NTP+60
      M = MO
      IF (ID.EQ.44) W10= .90*WMAJ (M )
      CM=MD
      IP =IP+1
      NCP=NCP+1
      ZNP=ZNP+1
      NOT=NOT+1
      NT=NT+1
      NGT=NGT+1
      TN=TN+1.
      XNT=XNT+1.
      ZNT=ZNT+1.
      TD=TX-TI
      IF(HI.LT.0.01) HI=.665*HM
      IF(HX.LT.0.01) HX=2.08*HM-HI
      HA=(HX+HI)/2.
      PHM=HM/HA
      HUL=.91+.14*(HM/.7)
      HLL=.97+.13*(HM/.7)
      CHMC=.39+.14*(HM/.7)

      IF(PHM-HLL) 64,64,65
   65 IF(PHM-HUL) 66,66,64
   64 HM=HA*CHMC
   66 CONTINUE
      TA=(TX+TI)/2.
      IF(ID.NE.25) GO TO 14
      TA=TM/.965
      TC=2.*(TX-TA)
   14 CONTINUE
      RTM=TM/TA
      CTMC=.955
      IF(ID.EQ.28) CTMC=1.01-.03*(HM/.7)
      IF(RTM-0.999) 61,61,62
   62 IF(RTM-0.990) 63,63,61
   61 TM=TA*CTMC
   63 CONTINUE
      DER(M)=(DEC(M))/57.2958
```

```
      XLR=XLA/57.2958
      Z=-TAN(XLR)*TAN(DER(M))
      OM= ATAN(SQRT(1.0-Z*Z)/ABS(Z))
      DL=OM/0.1309
      IF(DL.LT.0.0)  DL=24.-DL
      RLD=120.*(DL*SIN(XLR)*SIN(DER(M))+7.6394*COS(XLR)*COS(DER(M))*SI
     1OM))/ES(M)
      S=SM/DL
      IF(HM)19,19,20
   19 HM=(HX+HI)/2
   20 RMD=10.*RLD/(595.9-0.55*TM)
      RMM=RMD*DM
      RSD=10.*RSL/(595.9-0.55*TM)
      RSM=RSD*DM
      TKM=273.16+TM
      TKI=273.16+TI
      TKX=273.16+TX
      EAM=EXP(47.226-6463./TKM-3.927*ALOG(TKM))-(.061+.0002*TM**2)
      EAI=EXP(47.226-6463./TKI-3.927*ALOG(TKI))-(.061+.0002*TI**2)
      EAX=EXP(47.226-6463./TKX-3.927*ALOG(TKX))-(.061+.0002*TX**2)
      VPMN=0.5*(HI*EAX+HX*EAI)
      VPDMB=1.333*(EAM-VPMN)
      IF (RSM)  44,46,44
   44 NOR=NOR+1
      ZNR=ZNR+1.
      RN=RN+1.
      XNR=XNR+1.
   46 CONTINUE
      IF(S)  54,55,54
   54 ZNS=ZNS+1.
      NOS=NOS+1
      SN=SN+1.
      XNS=XNS+1.
   55 CONTINUE
      CALL VENEN
      X(1)=TM
      X(2)=TD
      X(3)=W10
      X(4)=P
      X(5)=DP
      X(6)=HM
      X(7)=S
      X(8)=SC
      X(9)=VPDMB
      X(10)=RMM
      X(11)=RSM
      X(12)=RSC
      X(13)=EV
      X(14)=EVPC
      X(15)=ETPC
      X(16)=S/SC
      X(17)=RSM/RSX
      X(18)=EV/EVPC
      X(19)=ETPC/EVPC
      X(20)=100.*ABS(S-SCX)/S
      X(22)=100.*ABS(EV-EVPC)/EV
      X(23)=ABS(S-SCX)
      X(24)=ABS(RSM-RSX)
      X(25)=ABS(EV-EVPC)
      X(26)=RSX
```

```
      X(27)=SCX
      IF (RSM) 48,47,48
   47 X(25)=0.
      X(17)=0.
      X(21)=0.
      X(24)=0.
      GO TO 49
   48 X(21)=100.*ABS(RSM-RSC)/RSM
   49 CONTINUE
      DO 24 I=1,27
      SX(I)=SX(I)+X(I)
      SXT(I)=SXT(I)+X(I)
   24 OZS(I)=OZS(I)+X(I)
      IF(N.EQ.1) WRITE(6,221) MO,N,(X(I), I=1,27)
   25 CONTINUE
      IF(N.EQ.1)  GO TO 30
      DO 27 I=1,15
   27 AX(I)=SX(I)/IN
      AX(4)=SX(4)/IP
      AX(7)=SX(7)/SH
      AX(11)=SX(11)/IR
      AX(16)=SX(7)/SX(27)
      AX(17)=SX(11)/SX(25)
      AX(18)=SX(13)/SX(14)
      AX(19)=SX(15)/SX(14)
      AX(20)=100.*SX(23)/SX(07)
      AX(21)=100.*SX(24)/SX(11)
      AX(22)=100.*SX(25)/SX(13)
   28 WRITE(6,222)MO,MT,(AX(I), I=1,22)
   30 CONTINUE
      DO 35 I=1,15
   35 AXT(I)=SXT(I)/FLOAT(MOT)
      AXT(4)=SXT(4)/FLOAT(MOP)
      AXT(7)=SXT(7)/FLOAT(MOS)
      AXT(11)=SXT(11)/FLOAT(MOR)
      AXT(16)=SXT(7)/SXT(27)
      AXT(17)=SXT(11)/SXT(25)
      AXT(18)=SXT(13)/SXT(14)
      AXT(19)=SXT(15)/SXT(14)
      AXT(20)=100.*SXT(23)/SXT(07)
      AXT(21)=100.*SXT(24)/SXT(11)
      AXT(22)=100.*SXT(25)/SXT(13)
      WRITE(6,224)MOT,(AXT(I),I=1,22)
   80 CONTINUE
      WRITE(6,225)
      WRITE(6,211)
      DO 85 I=1,15
   85 OZA(I)=OZS(I)/ZNT
      OZA(4)=OZS(4)/ZNP
      OZA(7)=OZS(7)/ZNS
      OZA(11)=OZS(11)/ZNR
      OZA(16)=OZS(7)/OZS(27)
      OZA(17)=OZS(11)/OZS(26)
      OZA(18)=OZS(13)/OZS(14)
      OZA(19)=OZS(15)/OZS(14)
      OZA(20)=100.*OZS(23)/OZS(07)
      OZA(21)=100.*OZS(24)/OZS(11)
      OZA(22)=100.*OZS(25)/OZS(13)
      WRITE(6,228)MOX,(OZA(I),I=1,22)
      WRITE(6,233)
      WRITE(6,234)XSC,XSR,XVC,XTC,ZNT,ZNS,ZNR
      WRITE(6,299)
      STOP
      END

END OF COMPILATION:        NO  DIAGNOSTICS.


      SUBROUTINE  VENEN
      COMMON  HM,TM,V10,CS,CE,X,CHV,CHT,CTV,CTT,CWV,CWT,COP,XVC,XTC,
     1EVPC,ETPC,RMM,EL, MMAJ(15),RSX,SC,RSC,XSR,SCX,XSC ,ID ,S ,ID
      DIMENSION X(29)
      CE=.94+.06*(EL/1000.)
      IF(HM.LE.0.75) CSHM=.50+.70*(HM/.75)-.20*(HM/.75)**2
      IF(HM.GT.0.75) CSHM=1.0-.4*((HM-.75)/.75)**2
      CSID=.79+.15*(ID/10.)+.06*(ID/10.)**2
      CSOP=1.20-.20*(OP/10.)**.56
      XSC=.593*.985*1.001*1.034*1.014
      SC=XSC*CSID*CSHM*CSOP
      IF (ID.EQ.31 )  S= 1.19 * S
      IF(ID.EQ.34) SC=1.22*SC
      CS=.48+.66*(S/.5)-.14*(S/.5)**2
      IF(S.LT.0.01) CS=.48+.66*(SC/.5)-.14*(SC/.5)**2
      XSR=.445*1.020 *1.003*.968
      RSC=XSR*RMM*CS*CE
      RSX=RSC
      SCX=SC
      IF(S.LT.0.01) SCX=0
      CHV=1.15+.44*(HM/.75)-.59*(HM/.75)**2
      IF(HM.LT.0.28) CHV=1.232
      CHT=CHV
      CTV=.40+.50*(TM/25.)+.10*(TM/25.)**2
      CTT=CTV
      CWV=.59+.47*(W10/8.)-.05*(W10/8.)**2
      CWT=.70+.36*(W10/9.)-.05*(W10/8.)**2
      COP=1.15-.15*(OP/10.)**.35

      CE=.94+.06*(EL/1000.)
      CE=1.0
      XVC=.43*.88*.943 *.998
      EVPC=XVC*RMM*CTV*CWV*CS*CE*CHV*COP
      XTC=.85*XVC
      ETPC=XTC*RMM*CTT*CWT*CHT*CS*CE*COP
      RETURN
      END

END OF COMPILATION:        NO  DIAGNOSTICS.
```

APPENDIX D

Computer program used

Second program

```
C     PROGRAM  691-CV  TO COMPUTE A GAMMA DISTRIBUTION PROGRAM FOR VENEZUELA
C     . INCLUDING IRRIGATION REQUIREMENTS
C     MAIN PROGRAM TO READ IN ALL DATA.FIND MO. AVES..AND SORT PREC. ALSO TO
C     PRINT TABLES OF IRRIGATION PARAMETERS FOR ALL STATIONS
C......  STATIO = STATION NAME
C......  Z = NORMAL DISTRIBUTION PARAMETER
C......  PFREQ = PROBABILITY LEVELS
C......  NFREQ = NUMBER OF PROBABILITY LEVELS
C......  LD.LM = LATITUDE  IN DEGREES AND MINUTES
C......  LOD.LOM= LONGITUDE IN DEGREES AND MINUTES
C......  LE = ELEVATION IN METERS
C......  RUNP = DISTRIBUTION OF PRECIPITATION
C......  KTAB = COUNTER FOR TABLE HEADINGS
C......  DELIP = IRRIGATION REQUIREMENT AT GIVEN PROBABILITIES
C......  ETC = EACH POTENTIAL EVAPOTRANSPIRATION CALCULATED WITH THE
C......  CHRISTIANSEN HARGREAVES FORMULA
C......  PREC = MONTHLY PRECIPITATION FOR EACH YEAR IN MILLIMETERS
C......  NYEARS = NUMBER OF YEARS OF DATA
C......  NSER = SERIAL NUMBER OF THE STATION
C......  NPRINT. LRANK = CONTROL FOR A LIST OF THE BASIC DATA AND
C......  FOR THE RANKING TO BE CARRIED OUT
C......  PMEAN = MEAN MONTHLY AND ANNUAL PRECIPITATION
C......  IYEARS  = CALENDAR YEAR
      COMMON/E/ TM(13).RHM(13).W10(13).S(13).HM(13).TD(13).DP(13)
      COMMON/C/NKTOP.ID
      COMMON/F/ LLD(20).LLM(20).LLOD(20).LLOM(20).LLE(20).NS(20)
      COMMON /PP/PREC(13. 40).NYEARS.NSTA.NPRINT.LRANK.PMEAN(13).IYEARS(
     $ 40).SM AI(20.15).SDELIR(20.15).SRUNP(20.15)
      COMMON STATIO(12).Z(6).PFREQ(13).NFREQ.LD.LM.LOD.LOM.LE.RUNP(13.13
     $).KTAB.DELIP(13.13).ETC(13).PMIN(15).PMAX(15).PDP(15).NSER.CLIS. 4
     10).DUE(15.15).PLEV(40).PREK(13.40).APREX(13).JYR(40)
      DIMENSION                JYEAR( 40).              PREX(15. 40)
      DIMENSION DM(13).DEC(13).DEP(13).ES(13).TMX(12.13).TX(12.13).TI(12
     1.13).EVF(13.13).DPMN(13).WD6(13).
     2       SM(12.13).HMX(12.13).EVPM(13.13).TMEAN(13).ZZ(13).OM(13).DL(1
     33).SIND(13).PLD(13).SHMN(13). HMEAN(13).TXMN(13).TIMN(13).
     4              RMD(13).WMEAN(13).                        JY(40).DPX(13.13).
     5MX(13.13).W10X(13.13).HI(13.13).RSL(13.13)
      DATA (JY(M).M=1.10)/62.63.64.65.66.67.68.69.70.71/
      DATA (DM(M). M=1.12)/31..28..31..30..31..30..31..31..30..31..30..
     131./
      DATA (DEC(M).M=1.12)/-20.949.-13.553.-2.683.9.207.18.606.23.016.21
     $.135.13.523.2.289.-9.565.-18.854.-23.040/
      DATA (ES(M).M=1.12)/.97104..98136..99653.1.01313.1.02625.1.03241.1
     $.02987.1.01916.1.00347..98693..97369..96812/
      DATA (JY(M).M=1.10)/62.63.64.65.66.67.68.69.70.71/
      READ(5.126)NFREQ.(PFREQ(I).I=1.NFREQ)
  126 FORMAT(I5.13F5.1)
      NTAB=0
      KTAB=0
      NPH=NFREQ/2
      READ(5.127)(Z(I).I=1.NPH)
  127 FORMAT(6F10.5)
      READ(5.1170) NPRINT.LRANK
 1170 FORMAT(2I5)
  102 FORMAT(I3)
  103 FORMAT(I5)
  104 FORMAT(2I3)
  106 FORMAT(2I5.I3.7A5.F5.0.F2.0.F3.0.F2.0.F5.0.I6)
  107 FORMAT(1IX.I2)
  108 FORMAT(I5.12F5.0.5X.I3)
  109 FORMAT(I3.I2    .I3.F6.2.2I3.3F5.1.3F3.2.F4.1.F4.0.F4.1.F4.0.F5.
     15.1..F4.0)
  210 FORMAT(1H .'BAD DATA')
      WD6M=4.71.0.6..296
      READ(5.102)NSTA
      DO 59 K=1.NSTA
      ETC(13)=0.
      TM(13)=0.
      HM(13)=0.
      DP (13)=0.
      S(13)=0.
      W10(13)=0.
      TD(13)=0.
      PMEAN(13)=0.
      KTAB=KTAB.1
      READ(5.106.END=707) ID.NSER.NN.(STATIO(M).M=1.7).XLD.XLM.XLOD.X
     1.EL.NYEARS
      LD=XLD
      LM=XLM
      LOD=XLOD
      LOM=XLOM
      LE=EL
      NS(KTAB)=NSER
      LLD(KTAB)=LD
      LLM(KTAB)=LM
      LLOD(KTAB)=LOD
      LLOM(KTAB)=LOM
      LLE(KTAB)=LE
      DO 50 M=1.NYEARS
      IF(NYEARS.EQ.0) GO TO 27
      READ(5.108.ERR=71) NSER.(PREK(J.M).J=1.12).JYEAR(M)
      JYR(M)=JYEAR(M)
      GO TO 50
   71 WRITE(6.210)
   50 CONTINUE
   27 XLO=XLOD.XLOM/60.
      XLA=XLD.XLM/60.
      DO 1011 J=1.12
      DO 1011 M=1.10
 1011 PREK(J.M.NYEARS)=-11.
      NY=NYEARS.10
      DO 1012 M=1.NY
 1012 PREK(13.M)=0.
      J=0
      DO 25 L=1.NN
      READ(5.104) I.NYRCD
      DO 25 JJ=1.I
      J=J.1
      MJ=0
      M=0
   28 M=M.1
      MJ=MJ.1
      READ(5.109.ERR=77)NSER.JYEAR(MJ.NYEARS).LE.XLAX.MD.MO.TMX(MJ.J)
     1(MJ.J).TI(MJ.J).HMX(MJ.J).HX(MJ.J).HI(MJ.J).W10X(MJ.J).EVPM(MJ.
     2SM(MJ.J).RSL(MJ.J).PREY.DPX(MJ.J).EVF(MJ.J)
      GO TO 26
```

```
   77 WRITE(5,210)
   26 CONTINUE
      TA=(TX(MJ,J)+TI(MJ,J))/2.
      IF(NSER.NE.26) GO TO 14
      TA=TMX(MJ,J)/.965
   14 CONTINUE
      RTM=TMX(MJ,J)/TA
      CTMC=.965
      IF(NSER.EQ.28) CTMC=1.01-.03* HMX(MJ,J)/.7
      IF(RTM-0.989) 81,81,82
   82 IF(RTM-0.990) 93,83,81
   81 TMX(MJ,J)=TA*CTMC
   93 CONTINUE
      IF(HI(MJ,J).LT.0.01) HI(MJ,J)=.665*HMX(MJ,J)
      IF(HX(MJ,J).LT.0.01) HX(MJ,J)=2.08*HMX(MJ,J)-HI(MJ,J)
      HA=(HX(MJ,J)+HI(MJ,J))/2.
      RHM=HMX(MJ,J)/HA
      HUL=.91+.10*(HMX(MJ,J)/.7)
      HLL=.87+.13*(HMX(MJ,J)/.7)
      CHMC=.39+.14*(HMX(MJ,J)/.7)
      IF(RHM-HLL) 64,64,65
   65 IF(RHM-HUL) 66,66,64
   64 HMX(MJ,J)=HA*CHMC
   66 CONTINUE
      IF(JYEAR(MJ,NYEARS).LT.70) JYEAR(MJ,NYEARS)=JYEAR(MJ,NYEARS)+60
      IF(JYEAR(MJ,NYEARS).GT.JY(M)) GO TO 452
      GO TO 433
  452 JYR(M,NYEARS)=JY(M)
  441 M=M+1
      IF(JYEAR(MJ,NYEARS).NE. JY(M  )) GO TO 440
      GO TO 433
  440 JYR(M,NYEARS)=JY(M)
      GO TO 441
  433 PREK(J,M,NYEARS)=PREY
      JYR(M,NYEARS)=JY(M)
      IF(MJ.LT.NYRCD) GO TO 28
  442 IF(JY(M).LT.71) GO TO 443
      GO TO 35
  443 M=M+1
      JYR(M,NYEARS)=JY(M)
      GO TO 442
   35 CONTINUE
      NKTDP=0
      CALL VAR(NYRCD,TMX,TMEAN,12,13,I,NN,J)
      TM(J)=TMEAN(J)
      DER(J)=(DEC(J))/57.2959
      ZZ(J)=-TAN(XLA/57.2958)*TAN(DER(J))
      OM(J)=ATAN(SQRT(1.-ZZ(J)*ZZ(J))/ABS(ZZ(J)))
      DL(J)=OM(J)/0.1309
      IF(ZZ(J))32,32,33
   32 DL(J)=24.-DL(J)
   33 SINO(J)=SIN(OM(J))
      RLO(J)=120.*(DL(J)*SIN(XLA/57.2958)*SIN(DER(J))+3.8197*COS(XLA/57.
     12958)*COS(DER(J))*2.*SINO(J))/ES(J)
      RMO(J)=10.*RLO(J)/(595.9-0.55*TM(J))
  515 RMM(J)=RMO(J)*DM(J)
      CALL VAR(NYRCD,HMX,HMEAN,12,13,I,NN,J)
      CALL VAR(NYRCD,TX,TXMN,12,13,I,NN,J)
      CALL VAR(NYRCD,TI,TIMN,12,13,I,NN,J)
      CALL VAR(NYRCD,WIDX,WMEAN,13,13,I,NN,J)
      CALL VAR(NYRCD,SH,SHMN,12,13,I,NN,J)
      SHMM(J)=SHMN(J)/DL(J)
      NKTDP=1
      CALL VAR(NYRCD,DPX,DPMN,13,13,I,NN,J)
      TD(J)=TXMN(J)-TIMN(J)
      HM(J)=HMEAN(J)
      WID(J)=WMEAN(J)
      IF(NSER.EQ.25.OR.NSER.EQ.34.OR.NSER.EQ.38.OR.NSER.EQ.43)GO TO 8
      GO TO 9
    8 WO6(J)=WID(J)
      XP=.579-.409*(WO6(J)/WO6M)+.176*(WO6(J)/WO6M)**2
      IF(WO6(J)/WO6M .GT.1.6) XP=.249
      WID(J)=WO6(J)*(10./.6)**XP
    9 DP(J)=DPMN(J)
      S(J)=SHMN(J)
      TM(13)=TM(13)+TM(J)/12.
      HM(13)=HM(13)+HM(J)/12.
      DP(13)=DP(13)+DP(J)/12.
      S(13)=S(13)+S(J)/12.
      WID(13)=WID(13)+WID(J)/12.
      TD(13)=TD(13)+TD(J)/12.
      NYEARS=10+NYEARS
      KL=0
      M=2
 1006 IF(M.GT.(NYEARS-1)) GO TO 1007
      DO 1005 N= M,NYEARS
      IF(JYR(M-1).NE.JYR(N)) GO TO 1005
      KL =KL + 1
      NYEARS=NYEARS - 1
      DO 1008 NYR=N,NYEARS
      PREK(J,NYR)=PREK(J,NYR + 1 )
 1008 JYR(NYR)=JYR(NYR+1)
 1005 CONTINUE
      M=M+1
      GO TO 1006
 1007 CONTINUE
C   TO FIND AVE. MONTHLY PREC.
      APREX(J)=0.
      MM=NYEARS
      DO 2 M=1,NYEARS
      PREX(J,M)=PREK(J,M)
      PREK(13,M)=PREK(13,M)+PREK(J,M)
      IF(PREK(J,M).LT.-.01)  PREK(13,M)=-99999.
      IF(PREX(J,M))61,2,2
   61 PREX(J,M)=0.
      MM=MM-1
    2 APREX(J)=APREX(J)+PREX(J,M)
      APREX(J)=APREX(J)/FLOAT(MM)
      PMEAN(J)=APREX(J)
      CALL GPACK(J)
      NYEARS=NYEARS-10+KL
   29 CONTINUE
      J=13
      NYEARS=NYEARS+10-KL
      CALL GPACK(J)
      CALL OUTPUT(KL)
   59 CONTINUE
  707 CALL TABLE
      STOP
      END

END OF COMPILATION:       NO  DIAGNOSTICS.
```

```
      SUBROUTINE GPACK(J)
C•••••  SUBROUTINE 701  TO CALCULATE THE GAMMA DISTRIBUTION OF PRECIPITATION
C•••••  ON A MONTHLY BASIS.  THE GAMMA PARAMETERS ARE CALCULATED WITH THE
C•••••  USE OF MAXIMUM LIKELIHOOD ESTIMATORS.  THE GAMMA FUNCTION IS
C•••••  EVALUATED WITH THE USE OF A UNIVAC 1108 MATH PAK GAMMA.
C•••••  THE PRECIPITATION BASED ON A GAMMA DISTRIBUTION AT A GIVEN
C•••••  PROBABILITY IS CALCULATED USING A NEWTON APPROXIMATION
C•••••  VALUES IN COMMON CORRESPOND TO THOSE IN PROGRAM MAIN 700
C•••••  AMBA = LAMBA THE SCALE PARAMETER OF THE GAMMA
C•••••  GAMMAX = EVALUATION OF THE GAMMA BASED ON RPAR FROM 0 TO INFINITY
C•••••  RPAR = SHAPE PARAMETER OF THE GAMMA
C•••••  P = PRECIPITATION IN MM.
C•••••  RUN1 = STORAGE FOR PRECIPITATION AT A GIVEN PROBABILITY
C•••••  DIFN = DENOTATION IF DISTRIBUTION FOR MONTH IS NORMAL
      DOUBLE PRECISION RPIE•GAMMA1
      COMMON/A/ IH(13)•PMM(13)•W10(13)•S(13)•HM(13)•TD(13)•DF(13)
      COMMON/C/AMBA(13)•GAMMAX(13)•RPAR(13)•DIFN(13)•NPRBP
      COMMON /PE/PREC(13• 40)•NY•NSTA•NPRINT•LRANK•PMEAN(13)•IYEARS( 40)
     1•SMAT(20•15)•SCFLIP(20•15)•SPUNP(20•15)
      COMMON NAME(12)•Z(6)•P(13)•NPRB•LD•LM•LOD•LOM•LE•RUNP(13•13)•KTAB•
     4CFLIP(13•13)•ETC(13)•PMIN(15)•PMAX(15)•PDP(15)•NSER•C(15•40)•DNR(1
     15•15)•PLEV(40)•FREK(13•40)•APREX(13)•JYR(40)
      REAL AV(13)•NAME•R(40•13)•RUN1(13)
      DATA AST•BLANK/'*'•' '/
      NPH=NPRB/2
      NPRBP=NPRB•1
C•••••  EXCHANGE OF STORAGE LOCATION FOR PRECIPITATION DATA
      MN=0
      MJ=0
    2 MN=MN•1
    1 MJ=MJ•1
      IF(MJ.GT.NY) GO TO 3
      IF(PPEK(J•MJ).LT.-.01) GO TO 1
      R(MN•J)=PPEK(J•MJ)
      GO TO 2
    3 MN=MN-1
      FN=MN
      IF(J.LT.13) GO TO 4
      DO 5 I=1•MN
    5 PMEAN(13)=PMEAN(13)• P(I•J)
      PMEAN(13)=PMEAN(13)/FN
C•••••  TABLE HEADINGS
C•••••  BEGINING OF LOOP TO CALCULATE THE MONTHLY AND ANNUAL DISTRIBUTIONS
    4 DIFN(J)= BLANK
      AV(J)=PMEAN(J)
      SX2=(R(1•J)-AV(J))•(R(1•J)-AV(J))
      ALSX=ALOG(R(1•J)•.001)
      DO 1405 I=2•MN
      SX2=SX2•(R(I•J)-AV(J))•(R(I•J)-AV(J))
 1405 ALSX=ALSX•ALOG(R(I•J)•.001)
      ALXBAR=ALOG(PMEAN(J)•.001)
      ALXBAR=ALXBAR-ALSX/FN
C•••••  MAXIMUM LIKELIHOOD ESTIMATORS. R AND LAMBA. FOR THE GAMMA ARE CALCUL
      RPAR(J)=1./(4.•ALXBAR)•(1.•SQRT(1.•4.•ALXBAR/3.))                   ATED
      AMBA(J)=RPAR(J)/AV(J)
      RPAR1=RPAR(J)-1.0
C•••••  SAMPLE STANDARD DEVIATION (STD1) CALCULATED
      STD1=SQRT(SX2/(FN-1.0))
C•••••  FOR VALUES OF R GREATER THAN 85 THE DISTRIBUTION IS ASSUMED NOR
C       IF(RPAR(J) .GE. 85.0) GO TO 4430
C•••••  UNIVAC 1108 MATH PAK GAMMA EVALUATES THE GAMMA FUNCTION WITH P
      CALL GAMMA(RPAR(J)•GAMMAX(J)•$1252•$1253)
      GAMMAX(J)=ALOG(ABS(GAMMAX(J)))
      GO TO 1521
 1253 WRITE(6•1254)
 1254 FORMAT(1H1•'GAMMA FUNCTION IS NOT DEFINED')
      GO TO 800
 1252 GAMMAX(J)=2.302585•GAMMAX(J)
 1521 GAMMA1=GAMMAX(J)
C•••••  LOOP TO CALCULATE A PRECIPITATION FOR A GIVEN PROBABILITY BASE
C•••••  A NEWTON APPROXIMATION
      DO 4020 II=1•NPRB
      NEST=0
      TEST=.0001
      DEST=.0004
      X0=RPAR1
      IF(RPAR(J)-1.0) 4051•4100•4100
 4100 IF(X0) 4050•4050•4015
 4051 X0=.0001
      GO TO 4015
 4050 X0=.01
 4015 Z1=2.0
      NEST=NEST•1
      T1=X0/(RPAR1•Z1)
      SS=T1•1.0
C•••••  LOOP TO CALCULATE S IN THE NEWTON APPROXIMATION
      DO 4016 L=1• 100
      Z1=Z1•1.0
      T1=(T1•X0)/(RPAR1•Z1)
      CALL OVERFL(IFL)
      IF(IFL.NE.1) GO TO 4075
      WRITE(6•4444)
 4444 FORMAT(1H •'OVERFLOW STOP AT 4444')
      STOP
 4075 SS=SS•T1
      IF(T1-TEST) 4017•4017•4016
 4016 CONTINUE
 4017 DL=P(II)/100.
      IF(DL)4041•4101•4101
 4101 RPIE=X0
C•••••  FOR VALUES OF X0 GREATER THAN 86 THE DISTRIBUTION IS ASSUMED
      IF(X0 .GT. 86.0) GO TO 4430
      RPIE=EXP(GAMMA1-(RPAR1•DLOG(RPIE)))
      X1=X0-(X0/RPAR(J))•SS•(DL•RPIE•EXP(X0))
      DX=X1-X0
      CALL OVERFL(IFL)
      IF(IFL .NE. 1) GO TO 4078
      WRITE(6•4445)
 4445 FORMAT(1H •'OVERFLOW STOP AT 44445')
      STOP
 4078 X0=X1
      IF(X0) 4041•4018•4019
 4019 IF(ABS(DX) .LE. DEST) GO TO 4018
      IF(NEST .LE. 100) GO TO 4015
```

```
      4041 X1=0.0
C*****  THE VALUE OF PRECIPITATION IS CALCULATED FOR THE PROBABILITY
      4019 RUN1(I)=X1/AMDA(J)
      4020 CONTINUE
           GO TO 400
C*****  LOOP TO CALCULATE A NORMAL DISTRIBUTION
      4030 DO 4008 I=1,NPH
           FACD=STD1*Z(I)
           RUN1(I)=AV(J)-FACD
           RUN1(NPPBP-I)=AV(J)+FACD
           IF(RUN1(I) .LT. 0.) RUN1(I)=0.
      4008 IF(RUN1(NPPBP+1).LT. 0.) RUN1(NPPBP+1)=0.
           RUN1(NPH+1)=PMEAN(J)
           DIFN(J)=AST
       400 CONTINUE
       402 DO 4007 I=1,NPH
           DNF=STD1*Z(I)
           DNR(J,I)=AV(J)-DNF
           DNR(J,NPPBP-I)=AV(J)+DNF
      4007 IF(DNR(J,I).LT.0.) DNR(J,I)=0.
           DNR(J,NPH+1)=PMEAN(J)
       403 DO  405 I=1,NPPB
       405 RUNP(I,J)=RUN1(I)
       401 CONTINUE
           CALL CHET2(J)
           RETURN
           END

END OF COMPILATION:        NO  DIAGNOSTICS.
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```
           SUBROUTINE CHET2(M)
     C     SUBROUTINA ZUS FOR COMPUTING POTENTIAL EVAPOTRANSPIRATION USING
     C     CHRISTIANSEN FORMULA ADJUSTED BY RONDON  TO FIT ADDITIONAL  VENE-
     C     ZUELA DATA
           COMMON/B/ TM(13),RMM(13),W10(13),S(13),HM(13),TD(13),DP(13)
           COMMON /PP/PREC(13, 40),NYEARS,NSTA,NPRINT,LRANK,PMEAN(13)
           COMMON STATID(12),Z(6),PFREQ(13),NFREQ,LD,LM,LOD,LOM,LE,RUNP(13,13
          1),KTAP,DELIR(13,13),ETC(13),PMIN(15),PMAX(15),PD(15),NSER,C(15, 40
          2),DNR(15,15),ELEV( 40)
           DIMENSION CHV(13),CTT(13),CWT(13),CDP(13)
           DIMENSION                 CSHM(13),CSTD(13),CSDP(13),SC(13),
          1   CS(13),CHT(13),CTV(13),        NDP(13)
     C*****  LOOP TO CALCULATE ETCH FROM THE BASIC DATA READ IN
           EL=LE
           CE=.79+.05*EL/1000.
           IF(HM(M).LE.0.75) CSHM(M)=.50+.70*(HM(M)/.75)-.20*(HM(M)/.75)**2
           IF(HM(M).GT.0.75) CSHM(M)=1.0-4.*((HM(M)-.75)/.75)**2
           CSTD(M)=.79+.15* TD(M)/10.+.06*(TD(M)/10.)**2
           IF(DP(M).LT.-.01) GO TO 60
           GO TO 70
        60 NDP(M)=2.+14.*(PMEAN(M)/100.)-2.*(PMEAN(M)/100.)**2
           IF(PMEAN(M).GT.350.) NDP(M)=27
           IF(PMEAN(M).LT.25.) NDP(M)=.2*PMEAN(M)
           DP(M)=NDP(M)
        70 CSDP(M)=1.20-.20*(DP(M)/10.)**.56
           XSC=.593*.985*1.001*1.034*1.014
           SC(M)=XSC*CSTD(M)*CSHM(M)*CSDP(M)
           IF(ID.EQ.31) S(M)=1.18*S(M)
           IF(ID.EQ.34) SC(M)=1.22*SC(M)
           CS(M)=.48+.66*S(M)/.5  -.14*(S(M)/.5)**2
           IF(S(M).LT.0.01) CS(M)=.48+.66*(SC(M)/.5)-.14*(SC(M)/.5)**2
           CHV(M)=1.15+.44*(HM(M)/.75)-.59*(HM(M)/.75)**2
           IF(HM(M).LT.0.28) CHV(M)=1.232
           CHT(M)=CHV(M)
           CTV(M)=.40+.50*(TM(M)/25.)+.10*(TM(M)/25.)**2
           CTT(M)=CTV(M)
           CWT(M)=.70+.36*(W10(M)/8.)-.06*(W10(M)/8.)**2
           CDP(M)=1.15-.15*(DP(M)/10.)**.35
           XVC=.93*.88*.963 *.99
           XTC=.85*XVC
           CE=1.00
           IF(M.GT.12) GO TO 41
           ETC(M)=XTC*RMM(M)*CTT(M)*CWT(M)*CHT(M)*CS(M)*CE*CDP(M)
        40 ETC(13)=ETC(13)+ETC(M)
        41 CONTINUE
     C*****  LOOP TO CALCULATE IRRIGATION REQUIREMENT AT GIVEN PROBABILITI
           DO 50 I=1,7
        50 DELIR(I,M)=ETC(M)-RUNP(I,M)
           RETURN
           END

END OF COMPILATION:        NO  DIAGNOSTICS.
```

```
           SUBROUTINE VAP(NYEARS,PREC,PMEAN,   KK,NN,I,NC,M)
           COMMON/C/NKTOP
           DIMENSION PREC(KK ,NN),PMEAN(NN),PREX( 15,13)
           PMEAN(M)=0.
           MM=NYEARS
           LLL=50
           IF(NKTOP.EQ.1) LLL=NYEARS
           DO 2 L=1,NYEARS
           PREX(L,M)=PREC(L,M)
           IF(NKTOP.EQ.1) GO TO 63
           GO TO 64
        63 IF(PREX(L,M))61,2,2
        64 IF(PREX(L,M))61,61,2
        61 PREX(L,M)=0.
           IF(NKTOP.EQ.1) LLL=LLL-1
           MM=MM-1
         2 PMEAN(M)=PMEAN(M)+PREX(L,M)
           IF(LLL.LT.3) PMEAN(M)=-11.
        33 PMEAN(M)=PMEAN(M)/FLOAT(MM)
        82 RETURN
           END

END OF COMPILATION:        NO  DIAGNOSTICS.
```

```
      SUBROUTINE OUTPUT(KL)
      COMMON/A/ TM(13),PMM(13),W10(13),S(13),HM(13),TD(13),DP(13)
      COMMON/C/WIDTH,ID
      COMMON/E/ LLD(20),LLM(20),LLOD(20),LLOM(20),LLE(20)
      COMMON/C/AMBA(13),GAMMAX(13),RPAR(13),DIFN(13),NPRBP
      COMMON /ZP/PREC(13, 80),NYEARS,NSTA,NPRINT,LRANK,PMEAN(13),IYEARS(
     $ 80),SUM A1(20,15),SDELIP(20,15),SRUNP(20,15)
      COMMON STATIO(12),Z(6),PFREQ(13),NPRB ,LD,LM,LOD,LOM,LE,RUNP(13,13
     3),KTAB,DELIP(13,13),ETC(13),PMIN(15),PMAX(15),POP(15),NSER,C(15, 8
     10),ONE(15,15),PLEV(80),PREK(13,80),APREX(13),JYR(80)
      DIMENSION PRES(13,80),P(13),    OYR(80),          MONTH(13),XMAX(13)
      INTEGER OYR
      DATA MONTH/' JAN',' FEB',' MAR',' APR',' MAY',' JUN',' JUL'
     *,' AUG',' SEP',' OCT',' NOV',' DEC',' ANN'/
  200 FORMAT(1H0)
  201 FORMAT(1H ,13F8.0,I9)
  205 FORMAT(1H0,4X,'JAN     FEB     MAR     APR     MAY     JUNE     JULY
     1     AUG     SEPT     OCT     NOV     DEC     ANN', 7X,'YR',/)
  220 FORMAT(1H ,12X,'PRECIPITATION DATA RANKED IN ASCENDING ORDER',54X,
     1'PL'/)
  485 FORMAT(1H1,12X,'STATION NAME',2X,6A5,1X,'SER. NO.',1X,I2,', LAT.'
     5,I3,I3,', LONG.',I3,I3,', ELEV.',I5,)
 2301 FORMAT(1H ,13F8.0,F8.1)
      L=0
      MM=0.
      LYRS=NYEARS
      MYEARS=NYEARS
C   TO ELIMINATE A YEAR OF DATA IF MORE THAN 3 MONTHS PER YEAR ARE MISSING
      DO 63 M=1,NYEARS
      OYR(M)=JYR(M)
      DO 66 J=1,13
      PRES(J,M)=PREK(J,M)
   66 CONTINUE
      LL=0
      DO 64 J=1,12
   64 IF(PREK(J,M).LT.-.01) LL=LL+1
      IF (LL.GT.3) GO TO 67
      L=L+1
      MM=MM+1
      C(13,L)=0.
      PREK(13,MM)=0.
C   IF LESS THAN 3 MONTHS ARE MISSING CHANGE MISSING DATA TO MEAN VALUE FOR
C   RESPECTIVE MONTH.
      DO 65 J=1,12
      PREK(J ,MM)=PREK(J,M)
      IF(PREK(J ,MM).LT.-.01)PREK(J ,MM)=APREX(J)
      C(J,L)=PREK(J,MM)
      PREK(13,MM)=PREK(13,MM)+PREK(J ,MM)
      C(13,L)=C(13,L)+C(J,L)
   65 CONTINUE
      JYR(MM)=JYR(M)
      GO TO 63
   67 MYEARS=MYEARS-1
   63 CONTINUE
C  TO RECOMPUTE MEAN VALUES OF SELECTED DATA
      DO 700 J=1,13
      APREX(J)=0.
      DO 701 L=1,MYEARS
  701 APREX(J)=APREX(J)+C(J,L)
  700 APREX(J)=APREX(J)/FLOAT(MYEARS)
      DO 8 J=1,13
    8 PMEAN(J)=APREX(J)
C     TO SORT PRECIPITATION IN ASCENDING ORDER
   41 DO 150 J=1,13
      L=1
  136 MM=L+1
  137 IF (C(J,L)-C(J,MM))238,238,139
  238 MM=MM+1
      IF(MM.LE.MYEARS) GO TO 137
      L=L+1
      IF(L.LE.(MYEARS-1)) GO TO 136
      GO TO 51
  139 TEMP=C(J,L)
      C(J,L)=C(J,MM)
      C(J,MM)=TEMP
      IF(MM.LE.MYEARS) GO TO 137
      L=L+1
      IF(L.LE.(MYEARS-1)) GO TO 136
   51 PMIN(J)=C(J,1)
  150 PMAX(J)=C(J,MYEARS)
      M=0
      DO 42 MM=1,MYEARS
      M=M+1
      DO 83 J=1,13
   83 PREC(J,M)=PREK(J ,MM)
   42 IYEARS(M)=JYR    (MM)
      NYEARS=MYEARS
      YEARS = NYEARS
C.....  OUT PUT CONTROLS
      WRITE(6,485) (STATIO(I),I=1,6),NSER, LD, LM, LOD, LOM,LE
      WRITE(6,205)
      DO 81 M=1,LYRS
   81 WRITE(6,201)(PRES(J,M),J=1,13),OYR(M)
      WRITE(6,200)
      DO 881 M=1,NYEARS
  881 WRITE(6,201)(PREC(J,M),J=1,13),IYEARS(M)
      WRITE(6,200)
      WRITE(6,220)
      FNP=100./(FLOAT(NYEARS+1 ))
      DO 91  L=1,NYEARS
      PLEV(L)=100.-FNP*FLOAT(L)
   91 WRITE(6,2301)(C(J,L),J=1,13),PLEV(L)
      WRITE(6,450)
  450 FORMAT(1H0)
      WRITE(6,470)
  470 FORMAT(1H ,12X,'PREC.DATA RANKED IN A NORMAL DIST.AT GIVEN PRO
     1VELS',44X,'PL'/)
      DO 101 L=1,NPRB
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      P(L)=PFREQ(L)
      P(L)=100.-P(L)
  101 WRITE(6,301)(DVE(J,L),J=1,13),P(L)
  301 FORMAT(1H ,13F8.0,F8.1)
      DO 9001 L=1,NPRB
 9001 P(L)=100.-P(L)
      WRITE(6,521) KTAB
  521 FORMAT(1H1,/,1X,'TABLE',1X, I2,' PRECIPITATION AND POTENTIAL IRRIG
     1ATION REQUIREMENTS FOR GIVEN PROBABILITY LEVELS BASED ON GAMMA DIS
     2TRIBUTION. IN MM.')
      WRITE(6,485)(STATIO(I),I=1,6),ID
  485 FORMAT(1H0,16X,'STATION NAME',2X,6A5,1X,'SER. NO.',1X,I5)
      WRITE(6,1496)LLD,LM,LOD,LOM,LE,NYEARS
 1496 FORMAT(1H ,16X,'LAT.',I4,I3,', LONG.',I4,I3,', ELEV.',I5,', YEARS
     1OF DATA',1X,I3)
  524 WRITE(6,520) (P(NPRBP-I),I=1,NPRB),(P(NPRBP-I),I=2,6)
  520 FORMAT(1H0,'PROBABILITY',1X,13F6.0,10X,5F6.0)
 2403 WRITE(6,522)
  522 FORMAT(1H0,'MONTH ',2X,'MEAN',3X,'PRECIPITATION',15X,'ETC  IS COMP
     1UTED PARTLY FROM CLIMATIC DADA',11X,'ETP ',3X,'IRRIGATION REQUIREM
     2ENTS',/)
 2400 DO 2401 J=1,12
 2401 WRITE(6,530) MONTH(J),DIFN(J),PMEAN(J),(RUNP(I,J),I=1,NPRB),ETC(J)
     $,(DELIR(I,J),I=2,6)
      J=13
      WRITE(6,531) MONTH(J),DIFN(J),PMEAN(J),(RUNP(I,J),I=1,NPRB),ETC(J)
     $,(DELIR(I,J),I=2,6)
  530 FORMAT(1H ,A5,A1,14F6.0,F10.0,5F6.0)
  531 FORMAT(1H0,A5,A1,14F6.0,F10.0,5F6.0)
      WRITE(6,533)
  533 FORMAT(1H0,33HPARAMETERS FOR GAMMA DISTRIBUTION)
      WRITE(6,535) (MONTH(I),I=1,13)
  535 FORMAT(1H0,'MONTH',4X,A5,4X,A5,4X,A5,4X,A5,4X,A5,5X,A5,5X,A5,5X,A5
     $,5X,A5,5X,A5,5X,A5,5X,A5,5X,A5)
      WRITE(6,534) (AMDA(J),J=1,13)
  534 FORMAT(1H ,5HLAMBA,5F9.4,8F10.4)
      WRITE(6,536) (BPAR(I),I=1,13)
  536 FORMAT(1H ,5H  B  ,5F9.3,8F10.3)
      WRITE(6,537) (GAMMAX(I),I=1,13)
  537 FORMAT(1H ,5HLNGAM,5F9.4,8F10.4)
      WRITE(6,539)
  539 FORMAT(1H0,'MAX.AND MIN.PRECIP. AND A SUMMARY OF DEPENDABLE PREC.
     1EVAPOTRANSPIRATION DEFICIT AND MOISTURE AVAILABILITY AT THE 75 P.C
     2.PROB.LEVEL',/)
      WRITE(6,440)(PMAX(J),J=1,13)
  440 FORMAT(1H ,5HPMAX ,5F9.0,8F10.0)
      WRITE(6,441)(PMIN(J),J=1,13)
  441 FORMAT(1H ,5HPMIN ,5F9.0,8F10.0)
      WRITE(6,442)(RUNP(4,J),J=1,13)
  442 FORMAT(1H ,5HPD75 ,5F9.0,8F10.0)
  443 FORMAT(1H ,5HETDF ,5F9.0,8F10.0)
      WRITE(6,443)(DELIR(4,J),J=1,13)
      DO 153 J=1,13
      XMAI(J)=RUNP(4,J)/ETC(J)
      SRUNP(KTAB,J)=RUNP(4,J)
      SDELIR(KTAB,J)=DELIR(4,J)
  153 SMAI(KTAB,J)=XMAI(J)
      WRITE(6,444)(XMAI(J),J=1,13)
  444 FORMAT(1H ,5HMAI  ,5F9.3,8F10.3)
      WRITE(6,454)
  454 FORMAT(1H0,'CLIMATIC DATA USED TO COMPUTE COEFFICIENTS WHICH
     1THER WITH ELEVATION AND SOLAR RADIATION  DETERMINE ETCH',/)
      WRITE(6,446)(TM(M),M=1,13)
  446 FORMAT(1H ,5HTEMP ,5F9.1,8F10.1)
      WRITE(6,447)(HM(M),M=1,13)
  447 FORMAT(1H ,5HHUM  ,5F9.2,8F10.2)
      WRITE(6,448)(WID(M),M=1,13)
  448 FORMAT(1H ,5HWIND ,5F9.1,8F10.1)
      WRITE(6,449)(DP(M),M=1,13)
  449 FORMAT(1H ,9HPREC.DAYS,F5.0,4F9.0,8F10.0)
      WRITE(6,453)(S(M),M=1,13)
  453 FORMAT(1H ,9HSUNSHINE ,F5.2,4F9.2,8F10.2)
      RETURN
      END

END OF COMPILATION:        NO  DIAGNOSTICS.


      SUBROUTINE TABLE
      COMMON/FZ/ LLD(20),LLM(20),LLOD(20),LLOM(20),LLE(20),NS(20)
      COMMON /PP/PREC(13, 40),NYEARS,NSTA,NPRINT,LRANK,PMEAN(13),IY
     $ 40),SMAI(20,15),SDELIR(20,15),SRUNP(20,15)
      COMMON ST(12),Z(6),PF(13),NF,LD,LM,LOD,LOM,LE,PP(13,13),KTAB
  302 FORMAT(1H1,'TABLE OF DEPENDABLE PRECITATION AT THE 75 P.C. PR
     1LITY LEVEL',/)
  303 FORMAT(1H0,' STN       LAT      LONG  ELEV     JAN     FEB     MAR
     1PR     MAY    JUNE    JULY     AUG    SEPT     OCT     NOV     DEC
     2',/)
  304 FORMAT(I5,I6,I3,I6,I3,I6,13F7.0)
  305 FORMAT(1H0,'TABLE OF EVAPOTRANSPIRATION DEFICIT AT THE 75 P.C
     1RABILITY LEVEL',/)
  306 FORMAT(1H0,'TABLE OF MOISTURE AVAILABILITY INDEX AT THE 75 P.
     1OBABILITY LEVEL',/)
  307 FORMAT(I5,I6,I3,I6,I3,I6,13F7.2)
      WRITE(6,302)
      WRITE(6,303)
  707 DO 1001 I=1,KTAB
 1001 WRITE(6,304) NS(I),LLD(I),LLM(I),LLOD(I),LLOM(I),LLE(I),(SRUN
     1),J=1,13)
      WRITE(6,305)
      WRITE(6,303)
      DO 1002 I=1,KTAB
 1002 WRITE(6,304) NS(I),LLD(I),LLM(I),LLOD(I),LLOM(I),LLE(I),(SDEL
     1J),J=1,13)
      WRITE(6,306)
      WRITE(6,303)
      DO 1003 I=1,KTAB
 1003 WRITE(6,307) NS(I),LLD(I),LLM(I),LLOD(I),LLOM(I),LLE(I),(SMAI
     1,J=1,13)
      RETURN
      END

END OF COMPILATION:        NO  DIAGNOSTICS.
```

APPENDIX D

Computer program used

Last program

```
C     PROGRAM NO. 645 TO COMPUTE MOVING AVERAGES FOR SEVERAL COLUMNS OF NUMBERS
C     PROGRAM NO 25 A PREPARED BY JUSTIS SEELEY, JULY 1963.
C     MODIFIED BY LEON HUBER FOR F IV (HV) FEB. 1967.
C     MODIFIED BY J F CHRISTIANSEN AND RICHARD CONN, MAR 8, 1971.
C     MODIFIED BY HENRY CHRISTIANSEN, MARCH 9, 1971.
C     MODIFIED AGAIN BY ROLAND JEPPSON, MARCH 10, 1971.
C     N=NUMBER OF YEARS DESIRED TO MAKE AVERAGE ON
C     NN=NUMBER OF FIELDS DESIRED TO HAVE AVERAGE ON PER CARD
C     NCDS = NUMBER OF CARDS IN DECK
C     NT = NUMBER OF  N  YEAR AVERAGES
C     TB = NUMBER OF TABLES
C     NO=ID= STATION IDENTIFICATION
C     NYRS= NUMBER OF YEARS OF RECORD
C     NS= NUMBER OF STATION
      DIMENSION S(110,15),A(110),R(113),NY(110),X(110),NAME(10)
      REAL MAX(13) , MIN(13)
   90 FORMAT (I5)
  100 FORMAT(I3,6X,3A5)
  101 FORMAT(5I5)
  102 FORMAT(I2,I2,I6,12F5.0)
  105 FORMAT(I5,5X,I5,6A5)
  200 FORMAT(1H1)
  201 FORMAT(1H0,'TABLE', 4X ,I3,'-YEAR MOVING AVERAGES FOR ',6A5,' PREC
     1IP. DATA WITH',I4,' YEARS')
  203 FORMAT(1H0,'   YR    JAN    FEB    MAR    APR    MAY   JUNE   JULY
     1   AUG    SEP    OCT    NOV    DEC ANNUAL')
  204 FORMAT(1H0,' MEAN',13F7.1,/)
  205 FORMAT(1H ,I5,14F7.3)
      READ(5,90)   NS
      DO 45 II=1,NS
      READ(5,101)N,NN,NCDS,NT
      TB=1.
      AN=N
      READ(5,105)NO,NYRS,  (NAME(MM),MM=1,6)
      YRS=NYRS
      DO 1  J=1,NCDS
    1 READ(5,102)NY(J),(S(J,I), I=1,NN)
      DO 10 J=1,NCDS
      S(J,13)=0.
      DO 10 I=1,NN
   10 S(J,13)=S(J,13)+S(J,I)
      NN=NN+1
      DO 3  I=1,NN
      X2=0.
      DO 2  J=1,NCDS
    2 X2=X2+S(J,I)
    3 A(I)=X2/NCDS
      DO 30 KK=1,NT
      WRITE(6,200)
      WRITE(6,201)   N,(NAME(M),M=1,6),NCDS
      WRITE(6,203)
      WRITE(6,204)(A(I), I=1,NN)
      N1=N+1
      DO 5  I=1,NN
      X(I)=S(1,I)
      DO 7  J=2,N
    7 X(I)=X(I)+S(J,I)
    5 R(I)=X(I)/(A(I)*AN)
      WRITE(6,205)NY(N),(R(I),I=1,NN)
      DO 4  I=1,13
      MAX(I)=R(I)
      MIN(I)=R(I)
    4 CONTINUE
      DO 8  K=N1,NCDS
      KN=K-N
      DO 9  I=1,NN
      X(I)=X(I)+S(K,I)-S(KN,I)
    9 R(I)=X(I)/(A(I)*AN)
      DO  6 I=1,13
      IF(MAX(I).LT.R(I))MAX(I)=R(I)
      IF(MIN(I).GT.R(I))MIN(I)=R(I)
    6 CONTINUE
    8 WRITE(6,205)NY(K),(R(I),I=1,NN)
      WRITE(6,99)  (MAX(I),I=1,13),(MIN(I),I=1,13)
   99 FORMAT('0MAX   ',13F7.3/' MIN   ',13F7.3)
      N=N+5
      AN = N

   30 TB=TB+1.
      WRITE(6,200)
   45 CONTINUE
      STOP
      END

END OF COMPILATION:        NO  DIAGNOSTICS.
```

VITA

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