UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON

October 5, 1960

IN REPLY, PLEASE ADDRESS
CHIEF, U. S. WEATHER BUREAU
WASHINGTON 25, D. C.
AND REFER TO
C-3.1

MEMORANDUM

TO : Area and State Climatolgists, Field Aides (HC), Field Aides, WRPCs, River Forecast Centers, River District Offices, and Area Engineers (with copies to Regional Offices for information)

FROM : Office of Climatology

SUBJECT : Climatological Services Memorandum No. 82

GENERAL

1. RESEARCH AGREEMENTS IN AGRICULTURAL CLIMATOLOGY: The Office of Climatology has a modest allotment for support of investigations in agricultural climatology. During recent years this money has been spent in support of research agreements with some of the universities having a competent climatologist, adequate facilities, and an interest in problems of concern to the Weather Bureau.

It has not been possible to support a complete research program at any university, but by augmenting university funds it has been possible to stimulate and assist in investigations which might not otherwise have been carried out.

It has been recognized for a long time that most of the problems in agricultural climatology can best be studied by collaborating teams of experts from the several disciplines concerned. At some universities these teams exist and are doing some very worthwhile work. The Office of Climatology is lending all practicable support.

The following resumé very briefly describes the nature of some of these projects.

THE EFFECTS OF WEATHER ON CROPS

This is a continuing research agreement between the Weather Bureau and Iowa State University (Ames). The work is under the direction of Dr. Robert H. Shaw, Professor of Agricultural Climatology, Iowa State University. These studies are aimed at evaluating the effect of weather on crop production in Iowa. An understanding of the relationships between weather and crops must involve an understanding of the effects of critical weather factors on the biological processes of plant growth.

This cooperative effort has directly and indirectly produced more than 60 additions to the literature concerning crops and weather. The subjects

covered by these papers have ranged from meteorological instruments to the phenology of corn and from soil and plant temperatures to soil moisture and evapotranspiration. Many articles were of a popular nature intended primarily to inform the public on methods and advances in, and new applications of, climatology. A recent article discusses evapotranspiration in relation to the development of the corn crop from planting through silking to maturity. This paper demonstrates that at the time of silking, the corn crop in Iowa approaches the condition of an actively growing green crop which completely shades the soil. This condition exists for only a 2- to 3-week period during which the ratio of evapotranspiration to open pan evaporation is at a maximum near 0.81. Before this period the ratio increases with increasing leaf area, and afterwards declines with the declining physiological activity of the crop.

METEOROLOGICAL FACTORS AFFECTING EVAPOTRANSPIRATION

This is a continuing research agreement between the Weather Bureau and the University of Missouri (Columbia). The work is under the direction of Dr. Wayne L. Decker, Associate Professor of Climatology, University of Missouri. These studies are aimed at evaluating in Missouri the weather conditions that influence the movement of water from plants and soils to the atmosphere. The research has a bearing on the determination of the amount of water needed by plants and on the solution of various problems in irrigation, agriculture, and climatology.

Bowen's ratio is a term used to express the relationship between the energy flux of sensible heat and the energy used in evaporation. The magnitude of this quantity has been determined by many investigations. Theoretical considerations describe this ratio over smooth and open water surfaces, but little data have been presented for the magnitude of the quantity over a rough plant surface such as corn.

During one phase of this study, observations of the heat budget were made within a 10-acre corn field. All quantities of the budget except the sensible heat transfer were measured, and the quantity of sensible heat was determined by differences. Bowen's ratios were obtained for 2- or 3-day periods throughout the summer. In general the ratios were positive and reasons have been given for the observed variation in the ratios.

AGRICULTURAL USES OF CLIMATOLOGICAL DATA

This research agreement is between the Weather Bureau and Kansas State University (Manhattan). The work is under the direction of Drs. Willem van der Bijl and L. Dean Bark, Physics Department, Kansas State University. Until recently, efforts have been directed largely toward a review and evaluation of foreign literature on evapotranspiration. The work has been summarized in the annual reports from the University.

During the past couple of years the investigations have turned more toward a detailed examination of the agriculturally significant aspects of the climate of Kansas - precipitation and evapotranspiration in particular. This more recent work will be summarized in subsequent reports.

WEATHER AND AGRICULTURE IN THE NORTH CENTRAL STATES

This research agreement is between the Weather Bureau and the University of Wisconsin (Madison). The work is under the direction of Dr. J.Y. Wang, Assistant Professor, Department of Meteorology, University of Wisconsin. The purpose is to investigate methods and procedures for making more adequate use of climatological data as applied to agriculture in the states of the North Central Region.

Climatological analyses have been made and reports prepared on the distribution and variability of the duration of the growing season, on the variation of the occurrence of various soil and air temperatures, and on the variability of precipitation during various periods with major emphasis on accumulations and extremes during the growing season.

MICROCLIMATIC RESEARCH IN HORTICULTURE

This recently established agreement is between the Weather Bureau and the University of Georgia (Athens). The investigations are under the supervision of Dr. F. E. Johnstone, Jr., Head, Department of Horticulture, University of Georgia, with active participation by Mr. Horace Carter, Weather Bureau State Climatologist for Georgia. The purpose of this investigation is to study microclimatic temperature relationships with respect to horticultural crops.

Maximum and minimum air temperature and maximum and minimum soil temperatures are being measured at two levels above the ground and at three depths in the soil. Installations have been made at four sites in a horticultural crop. In addition to any crop-weather relationships which may benefit the field of horticulture, the data obtained will:

(a) Establish definite relationships among the temperature regimes at the several levels in air and soil as influenced by exposure,

(b) Provide conversion factors for relating data from "standard" climatological stations with several types of microclimate,

(c) Provide an estimate of the length of time required to accomplish (b) at new locations, and

(d) Add to the rather meager store of soil temperature data.

2. TEXT FOR COUNTY SOIL SURVEY REPORTS: In MAL 39-60 we stated that a description of the material that should be discussed in the above texts would be furnished. This description follows:

The Soil Conservation Service, Soil Survey, Committee on Climate meeting at St. Louis in April 1960 made three recommendations wholly concerning the text portion of the climate section of the soil survey report. In addition, 5 others of the total number of 15 recommendations applied in part to the text. These eight recommendations were concerned in a general way with

size, content, and reader level, rather than in a specific way with such things as form, style, or check list of items to be included. While the committee did specifically recommend two tables and one figure in order to clearly state requirements, it refrained from preparing a model text for fear that such recommended prototype might automatically become a stereotype. Nevertheless, a need for some guidance in the writing of a climate text appears to have arisen and the following analysis is an attempt to answer that need.

The analysis consists of stating the several ways in which the climate text has been useful in past soil survey reports in creating, amplifying or completing the climatic picture of the county. Each statement is followed by one or more illustrations. Most of these were copied exactly from climatic texts of published (or manuscript) soil survey reports. These samples are not meant to be models; they have not been particularly selected as samples of good writing or of recommended kinds of facts but rather as ways of depicting various aspects of the climate. It should be remembered that most of these samples were prepared not by climatologists but by soil scientists, who did, however, draw freely from whatever climatological literature was available.

Of the following statements, numbers I, II, and III should apply to the writing of every climate text, and at least one short paragraph under each category should probably be regarded as the minimum text content desirable. Number IV, also, is of primary importance where unfamiliar tabulations are included in the climate section. Statement numbers V, VI, VII, and VIII characterize some of the ways which have been used in climate texts to enhance the climatic picture. The maximum text content recommended by the Climate Committee is 10 double-spaced typewritten pages minus one page for each table; ordinarily the text would not be this long.

I. The text should serve to orient the reader toward the general climatic regime in the broader area of which the county is a part. Brief geographic and topographic locator phrases and judicious use of a climatological vocabulary including such words as continental and maritime, arid and humid will serve to compare the given regime with the regimes in other parts of the state, nation, and world. Sample statements:

> The climate in Brookings County is continental. Because the county is a great distance from a large body of water, temperature extremes are common. Moreover, this region is alternately influenced by air masses from northern regions and from the Gulf of Mexico. Therefore, seasonal and even daily fluctuations of temperature are great.
>
> Terrebonne Parish has a mild, humid, subtropical climate ... The summers are long and hot. Fall weather is warm and is often without freezes. There are a few cool days. The winters are usually mild and cool, but a few days are cold. Spring weather is mild and warm.
>
> The Roosevelt-Duchesne Area has a semiarid to arid, continental

climate. It is characterized by wide daily and seasonal variations in temperature and by well-defined seasons. The winters are generally cold, but snowfall is light. Summers are mild, though there is an occasional hot spell.

The climate of Lynn County is sub-humid. It is characterized by (1) low annual precipitation, (2) a very high rate of evaporation, (3) high average wind velocity, (4) hot summer days followed by cold nights, and (5) moderate winter temperatures punctuated by severe cold spells.

Island county has one of the most uniform marine climates of any area in the United States. The islands are sheltered from the cold continental winds by the Cascade Range to the east.

II. The text is necessary for the presentation of climatic information which is recognized as important to the agriculture in a particular county but which can be most clearly expressed as a summary statement. The text is also necessary when the important information is a single fact or just a few facts. Sample statements:

During the summer the temperature often rises to between 100° F. and 105° F. Because of the low humidity the heat is not too oppressive and nights are generally cool. In winter the temperature occasionally drops to 15° F., but extremely cold spells seldom last for more than a few days.

The rainfall at Guthrie averages about 32 inches a year. This is enough for good yields of crops when the rainfall is well distributed through the year. In about 2 or 3 years in 10, one-third of the rain falls during spring and nearly as much during summer. Long dry spells occur in midsummer in most years.

Occasionally, the ground is frozen 4 to 6 inches deep, but cold spells seldom last longer than 4 or 5 days.

The average hourly windspeed noted at La Crosse ranges from 7.0 miles per hour in August to 11.2 miles per hour in April. The highest recorded windspeed of 69 miles per hour ...

During the period 1916-1956 only 3 tornadoes have been reported in the county. Destruction from tropical storms is rare and blizzard conditions during a recent 40 year period were non-existent. Hailstorms at a given locality are observed about 3 times a year with most of these occurring during March, April, and May.

Hurricanes occur once or twice in every 3 to 7 years. These destructive winds bring the waters of the gulf and spread them over large areas of the marshes and lower-lying natural levee ridges to depths of 10 feet. The normal daily tides inundate

the lower coastal marshes to depths of 12 to 18 inches.

III. Text statements are by far the best way in the climate section of the soil survey report to relate agricultural practices to climatic facts or factors. Sample statements:

The growing season is long enough for cotton, which can be planted as late as June 30 and still mature if the first killing frost does not come unusually early. Grain sorghums do not require as long a growing season as cotton.

Late freezes in spring do more damage than early freezes in fall (see Table 2). A severe freeze late in spring is particularly harmful to tomatoes because the young plants can be injured or lost while still in the coldframe ... Hailstorms are infrequent and occur locally, but occasionally they severely damage crops, especially tomatoes.

The dry weather in the latter part of July and the first week or two of August coincides with the silking of corn, and consequently it affects corn yields. In most years corn crops are reduced materially by dry weather. It is seldom, however, that the drought is severe enough to cause complete failure of all crops.

The range of rainfall, temperature, wind, humidity, and other climatic characteristics favor a wide variety of agricultural crops. The soil through the winter and early spring months is quite consistently moist to wet although there are periods dry enough to permit tillage operations.

With the exception of small grains and most grasses and clovers, crops are chiefly planted and established in April, May, and June. In general, moisture conditions are favorable for field work and germination during this period. During a 10-year period one can expect rainfall in excess of 1.5 inches per week, 13 times in April, 9 times in May, and 12 times in June. Rains of this magnitude delay field operations materially, and moreover, may cause notable soil loss as this is the season of the year when vegetative cover is most lacking.

Moisture conditions during most falls are quite favorable for seedbed preparation and germination, although in some falls dryness does retard germination and in the less friable soils, makes seedbed preparation difficult.

The freeze-free growing season is long enough that crops such as cotton, corn, grain sorghum, millet, tomatoes, watermelons, beans, and potatoes may be planted over a period of many weeks and still have plenty of time to mature. The winters are mild enough that fall sown small grains have good survival and if seeded early furnish some grazing for livestock during the winter.

Perennial pasture plants as fescue grass and clovers make some growth during the winter when temperatures are above 40° F. There are normally sufficient low temperature hours during each winter to meet the minimum dormant season requirements of such crops as peaches.

IV. Where a novel or uncommon type of material has been selected to appear in the tables and figures of the climate section, text statements can provide guidance in how to use these materials. Sample statements:

Carroll County, like most of Iowa, experiences a wide range of temperatures throughout the year, as illustrated by columns 3 and 4 of Table 1. These columns which show the probability of getting very high and very low temperatures indicate that an average of 2 years in 10 will have at least 4 days during July with temperatures of 100 degrees or higher. At the other extreme, 2 years in 10 will have Januarys with at least 4 days with temperatures of 12 degrees or more below zero. In both cases, the 4 or more days are not necessarily consecutive.

Average precipitation amounts during the growing season are suitable for a wide variety of crops, but in some years precipitation amounts are either inadequate or excessive. In Table 1, the column showing very low and very high precipitation amounts for each month indicates that an average of 1 year in 10 will have a July with a total precipitation amount of less than 1.1 inches, and in about 1 year in 10, July will get more than 6.1 inches.

Estimates of the frequency of drought days at Savannah are shown in Table 2. These estimates are obtained by using the Penman method for computing the consumption of soil moisture by both plants and evaporation, or "evapotranspiration", and by defining a drought as a day on which all of the soil moisture available to plants is exhausted. The total possible amount of stored moisture available to plants varies with soils and rooting depth; the table shows the estimated number of drought days, therefore, at several levels of available soil moisture storage capacity for five probability levels. For example, during June on a soil with a 3-inch storage capacity, there is a 10% chance of having 25 or more drought days.

V. Text statements may be used to highlight, enhance or interpret material appearing in tables. The recommendation that they not "contain material which can be read or easily inferred from tables or figures." should not preclude mention of tabular items that are necessary for a clear exposition. Sample statements:

As shown in Table 12, more than 13 inches, or about 62 percent of the average annual precipitation, falls from May through September. About a third of the yearly moisture falls as light rain that adds little if any moisture to the subsoil. Approximately

a fourth falls as heavy, dashing rains that total 1 or more inches. Winters are uniformly dry.

The pattern of annual precipitation is somewhat irregular in Harper County (fig. 19). Both the amount and the distribution of precipitation affect agriculture. The low amount of annual precipitation, especially the low amount that fell during the 1930's, makes the conservation and proper use of moisture an important factor if crops are to be grown.

VI. Text statements can be used effectively as supplemental information where tabular data fail to represent significant parts of the county. This will usually occur when some topographically contrasting area which is large enough or important enough to be significant does not have a climatological record. Sample statement:

Climatic data recorded at Hamilton and Darby are given in Table 1. These show the range for the lower valley. Complete records are not available for the higher locations which generally are somewhat cooler and wetter than the valley floor and have shorter growing seasons.
As the elevation increases on either side of the valley, the amounts of rainfall and snowfall increase, the average temperature becomes lower, and the growing season becomes shorter. Precipitation ranges from 15 to 18 inches in the lower forested parts of the Area and the high grasslands on the east side, to probably 40 inches on the mountain summits. In the mountains, or in the valleys of the East Fork and West Fork, freezing temperatures may occur in any month of the year, and the average freeze-free season is probably less than 100 days.

VII. Insofar as important climatological variability within the county remains unmentioned or unindicated in the tables or graphs, the text can be used to correct this deficiency. Sample statements:

In spring, strong winds from the southwest are common. The buttes and lava flows at the western edge of the Area break the force of these winds and protect the southern part of the Area, but in the northern part the winds are likely to cause severe erosion.

Frost damage is less likely to occur along the foot slopes of the mountains, where air drainage is good. "Frost pockets" occur where ridges or hills prevent the cold air from circulating freely, as at Flowell. The growing season is shorter in these localities.

VIII. Reconciliation of contrasting sets of tabular material or of contrasting facts chosen to represent different parts of the county can be accomplished in the text. Sample statements:

Records at Coupeville show the average annual precipitation to be 18.64 inches. Records kept at Everett show the average annual

precipitation at that location to be nearly 33 inches. In Island County most of the precipitation comes in winter. Though records are not available, it appears that the normal rainfall on the southern end of Widbey Island is 10 to 15 in. more than at Coupeville. Differences in precipitation are caused largely by the proximity of the Olympic Mountains on the west. The moisture in the prevailing southwesterly winds condenses when the air strikes these mountains. The winds have lost much of their moisture before they reach the central part of the county, where Coupeville is located, because Coupeville lies to the leeward of the mountains.

No records were available to show the length of the growing season at Coudersport, but at Wellsboro, in adjacent Tioga County, the average growing season is 133 days. The average growing season on West Bingham in the northeastern part of the county is only 77 days. West Bingham, however, is at a high altitude and its growing season is therefore short.

IX. In addition to the eight points of analysis made above, the following general comments apply to the climate text:

A. Uniformity between texts for counties in widely different geographical areas should not be sought. Climatic elements which are not important to a given area should be omitted and not be given if the only reason is "for completeness". Even where marked differences in agriculture exist between geographically close areas, marked differences in text should correspond to them.

B. The climatologist should consult with the soil scientist, or if that is not possible, with a competent agriculturalist before relating the climate to agriculture. Such consultation would insure the relation of climate was important to agricultural practice.

C. Preparation of the climate text does not necessarily call for original writing. Pertinent, well written material already prepared for other purposes can often be taken in its entirety, or be freely excerpted or be adapted.

D. Most soil survey reports are prepared for entire counties or parishes. In other cases, however, particularly in the west, where counties are large, the unit of preparation is often the "Area". Areas may lie entirely within one county or in two or more counties but area reports have the same status as county reports.

E. It is not necessary that the guidance statements suggested under point IV (novel or uncommon material) comprise a paragraph by themselves. Frequently they can be easily and satisfactorily worked in with the paragraphs called for by

points I and II.

3. SUBSTATION SUMMARIES FOR OBSERVERS: A small supply of the above summaries should be made available by the State Climatologist to the substation observer at the station for which the summary is prepared.

4. INFORMATION ON COOPERATIVE OBSERVERS: State Climatologists, Field Aides (HC) and others are reminded that the WRPCs would welcome appropriate items for the Cooperative Observer newsletter.

Material that would be helpful includes pictures, clippings, correspondence, etc., pertaining to unusual or interesting uses of cooperative observers' records; reflecting unusual savings or benefits resulting from such records; featuring unusual or heroic action in connection with weather observations, etc.

5. PUBLICATIONS SENT TO STATE & AREA CLIMATOLOGISTS SINCE CSM 81: "A New Temperature Term for the Calculated Heat Loss Method" Manuscript by HCS Thom of the Office of Climatology.

Palmer-Havens Diagram for Computing Potential Evapotranspiration by the Thornthwaite Method, published by Soil Conservation Service.

Precipitation Probabilities in the North Central States, Bulletin 753 University of Missouri, Agricultural Experiment Station.

Three Chapters on Climatological Analysis, manuscript by HCS Thom.

6. WEATHER BUREAU FORM 274-1: State Climatologists need not furnish a copy of the above form to this office in the future.

H. E. Landsberg
Director, Climatology

GUIDE TO CLIMATOLOGICAL SERVICES MEMORANDUM NO. 82

USCOMM-WB-DC