The Likelihood of Extended Dry Periods in Northeast Missouri

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1. A dry period defined

For many years agricultural climatologists and plant scientists have been interested in the probability of periods with little or no rain which lead to plant injury. During this time there has developed considerable confusion in the distinction between rain-free or dry periods and periods of drought. Blumenstock [1] did not attempt to separate the two occurrences, but defined a drought day as any day with less than 0.10 inch of rain. More recently van Bavel [2] argued that a drought day could not occur until the plant had exhausted its supply of soil water. By this contention there is a distinction between a climatologically defined dry day and a plant-designated drought day. The former occurs on days with no precipitation or an insignificant amount, while the latter results from the exhaustion of the plant's supply of soil water.

This paper describes a method for estimating the likelihoods of dry periods where a climatologically defined dry day is defined as any day with less than 0.20 inch of rain. This rainfall limit was arbitrarily selected because it represents the approximate amount of water used by a rapidly transpiring plant on a summer day. By this definition, the length of a dry period is the number of consecutive days with less than 0.20 inch of precipitation.

2. Method of analysis

For use as an example, the records of three weather stations located in northeast Missouri were analyzed. For the period of record beginning in 1918, all of the dry periods occurring during the months of May through August were tabulated. The length of each dry period was noted and each was assigned to the semimonthly interval in which it originated. It should be noted that the dry periods were not terminated at the end of the semimonthly interval to which they had been assigned but were allowed to continue until terminated by a day with more than 0.20 inch of rain.

The frequencies of dry periods of each length were tabulated according to the semimonthly interval in which they originated. These frequencies were transformed in accumulatives on the basis of number of occurrences of dry periods of \( n \) or more days length. Such an accumulative frequency has been plotted as points on Fig. 1 for the three stations in northeast Missouri, for the second half of June.

Fig. 1. Accumulated frequency of dry periods originating during the second half of June in northeast Missouri.
If it is assumed that the dry days and rain days are independently and randomly distributed and that the probability of a dry day is constant, then the expected frequency of a dry period of \( n \) or more days length is:

\[
E = Sp^{n-1} \tag{1}
\]

where:

- \( E \) is the expected frequency of \( n \) or more consecutive dry days,
- \( S \) is the total number of dry periods observed,
- \( p \) is the probability of a dry day.

When plotted on semilogarithmic paper, equation (1) becomes a straight line whose slope is determined by the magnitude of \( p \). There is a number of ways for estimating \( p \), the probability of a dry day. A simple estimate was suggested by Hann [3] where \( p \) was taken as the ratio of number of dry days \( (D) \) to the total number of days \( (T) \). Because the assumption of nonindependence of rain days was not valid, Blumenstock found that this value of \( p \) underestimated the frequency of occurrence of dry periods. He derived another estimate which was

\[
p = 1 - S/D
\]

The accumulative frequency of dry periods of \( n \) or longer days length for the northeast region of Missouri during the second half of June is plotted on semilogarithmic paper in fig. 1. The solutions to equation (1) using both Hann's and Blumenstock's estimates of \( p \) are shown. Hann's estimate is totally inadequate, while Blumenstock's estimate applies only to those dry periods of shorter duration than 20 days.

Examination of fig. 1 reveals that the plotted points do not exactly follow a straight line as indicated by equation (1). This indicates that the assumption that \( p \) remains constant throughout the season is incorrect. Curvilinear regression lines were fit to these data, with a separate curve being applied to the data for dry periods of less than 20 days length and for dry periods more than 20 days length. These regression lines are shown for the same data in fig. 2. These curved regression lines are quite typical for other semimonthly periods and regions. Chief difference between the curves of other regions and periods was in the shape of the regression lines for the longer dry periods. Some of these curves were concave as shown in fig. 2 while others were convex. The shape of the curve was determined by the magnitude of \( p \) for the period into which the dry period extended.

The least squares solutions for the curvilinear regression lines provided the expected frequency of dry periods of \( n \) or more days length. These expectancies were in terms of the number of station years used in the analysis. Regression solutions were obtained for each semimonthly period May through September.

3. Interpretation of results

The expected frequencies obtained from regression lines were transformed to a base of the number of occurrences expected in a 40-year period. Fig. 3 shows these expected frequencies for dry periods of 7, 14, 21, and 28 or more days length for the northeastern region of Missouri.

There is a sharp decline in the expectancy of dry periods during the first half of June. Seven-day dry periods may be expected to begin during early June 27-percent fewer times than during the second half of May, while early June experiences a 50-percent reduction over May in the expected number of 14-day dry periods. The likelihood of dry periods of all lengths sharply rises during the
Knowledge of the seasonal variations in the expectancy of dry periods should assist the agricultural producer in planning production so that the critical periods of crops do not occur when there is a high dry-period expectancy. Crops, varieties of crops, and planting dates should be selected that minimize the risks of dry-weather injury. In the case of northeast Missouri early June is a time when dry periods are not likely to delay germination and seedling development. Similarly, crops which reach their critical flowering period in early August are less liable to dry weather injury than when this stage is reached in late August.

REFERENCES


An Aid for Accurate Wind Plotting

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In a recent study of the structure of the jet stream [1] extensive use of upper-wind charts was made. These charts had to be plotted to the best possible degree of accuracy. For this purpose a rather simple plotting aid was devised by the author and built after his specifications in the machine shop of the Hydrodynamics Laboratory, Department of Meteorology, University of Chicago.

Fig. 1 shows a view and cross-section of the plotting aid. It consists essentially of two transparent Lucite rings A and B which are held together by four stub-nails D whose round heads serve as supports and permit easy moving of the plotting aid on the chart without smearing over still wet ink, and of a center disk C which is also made of Lucite, and which can be turned by the two handles G.

The plotting aid is placed on the map to be plotted, so that the center of the slot S coincides with the station circle, and the north-south direction which is marked on ring A is parallel to the meridian through the station. By turning disk C until arrow H points toward the desired number one can dial any wind direction. Interpolation to the nearest two degrees is easily possible. By
means of a Leroy (or any other brand) lettering pen a line is drawn for the wind arrow along slot S, and without removing the plotting aid from the map the values for wind direction and wind speed are written down through the cut-out window F, according to the station model shown in fig. 2. If the conventional type of plotting model with barbed wind arrows is preferred, disk C can be substituted by one with a cut-out piece of the shape shown in fig. 3, instead of slot S. Else, flags and barbs can also be added later when all arrows for wind direction have been plotted.

![Fig. 2. Plotting model for wind speed and wind direction: dd direction, ff speed.](image)

If disk C has been made of heavier Lucite material so that the lettering pens would not reach through slot S, the area around the slot should be milled down to proper thickness instead of making the slot excessively wide.

The plotting aid described above has been tried out at the Department of Meteorology, University of Chicago, under Research Contract No. Noas-55-262-C with Project AROWA, Bureau of Aeronautics, Department of the Navy. It was found to be a very helpful and easy-to-handle gadget whenever wind directions had to be marked down to a better than freehand degree of accuracy.

![Fig. 3. Cut-out pattern instead of slot S in fig. 1, if conventional plotting model with barbed wind arrows is used.](image)

**REFERENCE**

1. Reiter, Elmar R., 1957: *The layer of maximum wind*. University of Chicago, Department of Meteorology, Final Report to Project AROWA, Bureau of Aeronautics, Department of the Navy, Contract No. Noas-55-262-C. Also accepted for publication in *J. Meteor.*

**CORRESPONDENCE**

Relation Between Point and Areal Rainfall

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The short note by F. A. Huff on the subject of point and areal rainfall frequencies has strongly attracted my attention. Although the title of this note suggests a comparison between frequencies, it is obvious, in my opinion, that the author also meant to stress the important question of present interest about the so-called "representativity": "Can a central station (point measurement) be called representative for an area?" I believe that the statistician must be somewhat surprised by the very fine results obtained by Huff. In such a case it always appears desirable to examine the statistical value of an investigation as exactly as possible. For this reason, I give my objections here.

Let me, first of all, summarize Huff’s procedure shortly: A 12-raingages network was laid on an area of 100-square

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