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Wishing for Good Weather: A Natural Experiment in Group Consciousness

ROGER D. NELSON

Princeton Engineering Anomalies Research, Princeton University, Princeton, NJ 08540
email rdnelson@princeton.edu

Abstract — Many human activities are affected by the weather, and there is a long history of rituals and ceremonial efforts aimed at controlling it. In modern societies, such efforts are largely vestigial and amount to informal hoping or wishing for good weather for special occasions. Reunion and commencement activities at Princeton University, involving thousands of alumni, graduates, family and others, are held outdoors, and it is often remarked that they are almost always blessed with good weather. A comparison of the recorded rainfall in Princeton vs. nearby communities shows that there is significantly less rain, less often, in Princeton on those days with major outdoor activities.

Introduction

Large gatherings of people with a common interest provide opportunities to assess a possible effect of their collective intentions or wishes on the environment. Repeated gatherings may provide the essential components of a natural experiment allowing formal assessment of potential effects of group consciousness. For example, many of the year-end ceremonies at Princeton University traditionally bring huge numbers of people together in planned outdoor events. Of course everyone involved hopes the weather will be pleasant and dry for Reunions, the traditional P-Rade of alumni, and all the varied activities associated with Princeton's Commencement, and it seems remarkably often to be so. It is quite common to hear someone remark, "As usual, the rain stayed away, but no wonder, with all those people wishing for good weather." Indeed, it is likely that most Princetonians have heard this idea expressed, and many will half-seriously have said something along these lines themselves. President Clinton was invited to give an address at the 1996 Commencement, making contingency plans considerably more difficult than usual. An article in the local newspaper[1] about the complex preparations included a description of the conditions that could require moving 10,000 people indoors:

> The third scenario is the Monsoon scenario, where it rains hard and commencement has to be moved to Jadwin Gym. Traditionally, this never happens at a Princeton University commencement. Those few times in recent years when precipitation is not only forecast but seems imminent, the rain has miraculously held off.

[1]Barbara Johnson, *Princeton Town Topics*, Wednesday, May 22, 1996.

For most people it feels natural to wish and hope for good weather for the springtime alumni celebrations and the ceremonies of Commencement, but it's something else again to expect any corresponding result. Nevertheless, whether there might indeed be some effect of those hopes and wishes is an interesting question. By modern, scientifically conditioned standards, it seems unlikely, but with a properly formulated analytical approach it is possible to obtain an objective answer to the question.

The Archives

The Seeley G. Mudd Library archives includes documents on Commencement and related activities going back 250 years. Autumn was the season for graduation during Princeton's first century, with nearly all ceremonies held in September, but in 1844 the University began celebrating Commencement in the Spring, nearly always in June. Beginning in 1922 the graduates received their degrees on the lawn outside Nassau Hall and, weather permitting, this has been the venue since that time.

By tradition, the day of Commencement is a Tuesday, with Baccalaureate and Class Day on the preceding Sunday and Monday, respectively. The actual date varies considerably, and in this century the Tuesday chosen has gradually moved from late and middle June to earlier dates until, as in 1995, Commencement was held in late May.

Traditionally, the graduation festivities begin with the Reunions of the large and deeply interconnected Princeton alumni family, a gathering that culminates in the renowned Alumni P-Rade on the Saturday preceding commencement. Thus, there are actually four days packed with major events related to Reunions and Commencement, and most of the activities are planned for the outdoors, with large numbers of people sharing an interest in having good weather. In recent times, as many as 15,000 alumni, their families and friends, and many well-wishers from the town, crowd the campus for the P-Rade. On the day of Commencement, some 9000 tickets are provided to the 1100-odd graduating seniors, 300 graduate students, their families and friends to attend the ceremonies, planned for the green in front of Nassau Hall, with a contingency plan for relocation to Jadwin Gymnasium in the event of bad weather.

The Weather Database

Given the dates of graduation over the years, the second part of our developing analytical picture requires data from the daily records of weather for stations at Princeton and surrounding communities. The most important question for the graduates, the alumni and the University administration, concerns rain, since it definitely affects outdoor activities, and makes a rain contingency plan necessary where possible. Although the weather is notoriously fickle, because it is of abiding interest, our government provides services that measure and document practically anything one might want to know about

temperature, pressure, precipitation, *etc.*, on a daily basis. A widely dispersed network of stations records weather parameters in a standardized way, and some have been doing so for much of the present century. One of these stations operated in Princeton from 1950 to 1986, and some stations in surrounding communities, *e. g.*, New Brunswick, have daily records going back more than 70 years.

An Analytical Question

With the history of Princeton Commencements and the historical record of local weather in hand, we can ask whether there is any difference in rainfall on Commencement Tuesday in Princeton over the years, compared with rainfall in nearby New Brunswick or Trenton on the same day. For a clearer picture, the survey can be extended to other communities surrounding Princeton, and the question formulated more specifically: Does the amount of precipitation on the Tuesday of Princeton's Commencement tend to be less than the average across surrounding communities on the same day? Such a comparison can be made for the P-Rade, Baccalaureate and Class Day as well, and the days with significant outdoor activities can be combined to give a larger and more general sample. The question needs refinement, however, to address the possibility that Princeton might have a slightly different micro-climate relative to the surrounding area (many people apparently do think of Princeton as something of an oasis). An appropriate check on this possibility is a repetition of the analysis on days that should be otherwise similar, but do not have a coherent group motivated to wish away the rain. Presuming everyone's attention has turned to other things, the days immediately following Commencement would seem to provide a reasonably apt comparison standard for the eventuality that Princeton's weather at this time of year is typically different from that of its neighbors.

Because any analysis of already existing data must be considered *post hoc*, it is essential to consider the implications of the choices made in conducting such a "natural experiment". Given an explicit experimental hypothesis, *e. g.*, the weather is susceptible to influence from the conscious or unconscious wishes of a group, and a well-justified choice of venue made before any actual analysis, the results will correctly represent the viability of the hypothesis. The present case meets these criteria, in that the experimental question was raised specifically for the Princeton situation, with no prior examination of any relevant data, and the records chosen for analysis were specific and appropriate to the hypothesis. Replications of this natural experiment elsewhere will be required to assess the robustness and generality of its findings, and they can readily be performed using the same approach. For example, the Rosebowl game and parade in Pasadena are said nearly always to have good weather, despite that they occur on New Years day, during California's rainy season. Again there is a human expectation and desire for good weather, and a simple analysis can compare the rainfall in Pasadena on New Years day with sur-

rounding locales and days to determine whether there is a difference in accordance with the hypothesis.

The Analysis

The daily records of precipitation at Princeton and six surrounding stations were obtained from the National Climatic Data Center, in Asheville, North Carolina.[2] The other communities used for comparison were Trenton, Moorestown, Indian Mills, New Brunswick, Boonton and Belvidere, and the data, measured in 100ths of an inch, were obtained for each day in June for all years with daily records. Figure 1 is a map of the area, with Princeton and the six surrounding stations indicated; their distance from Princeton varies from about 10 to 40 miles.

For each station, an epoch of the nine days centered on the date of Princeton's Commencement was generated for each of the years the Princeton station was operating, and the precipitation index for those days was retrieved from the database. Most measurements were made at either 6:00 AM, or 6:00 PM and, although the activities of interest are typically set closer to noon, the readings were used directly as the amount of rain for the day. Averaging each day separately across the 36-year period (1984 is missing from the Princeton data) for Princeton and for all six of the other stations, a mean precipitation index was obtained for each of the stations and days of interest. Figure 2 shows a comparison of Princeton's average precipitation during the four days from Reunions to Commencement with the corresponding composite for the six other communities, and it does appear that the mean level of rain is lower for Princeton on the days of the P-Rade, Baccalaureate and Class Day. However, the average rainfall on Commencement over this period is slightly higher at Princeton, mainly attributable to a downpour of some 2.6 inches on June 12, 1962. (The average for the surrounding stations on that day was a mere 0.95 inches.) Interestingly, members of the class of 1962 report that the rain held off until after the ceremony.

Although they look suggestive, the variability of these data is too great to justify a conclusion that any of the apparent differences are meaningful, and a more incisive approach is needed. The common statistical tests for differences are not appropriate because the data are not normally distributed. Figure 3 displays the frequency with which various amounts of rain occur, and indicates why a simple test of the mean differences would be inappropriate. Both the median and the modal precipitation levels are zero, and because of the enormously skewed distribution, the mean is clearly not an ideal measure of centrality for the comparisons we wish to make.

The figure clearly shows the large number of days with very little rain, and progressively fewer days with larger amounts. About 72% of days in this time period have no rain at all in Princeton, while the surrounding communities av-

[2]More information may be found at http://www.ucar.edu/, or by contacting data support specialist Will Spangler, spangler@niwot.scd.ucar.edu.

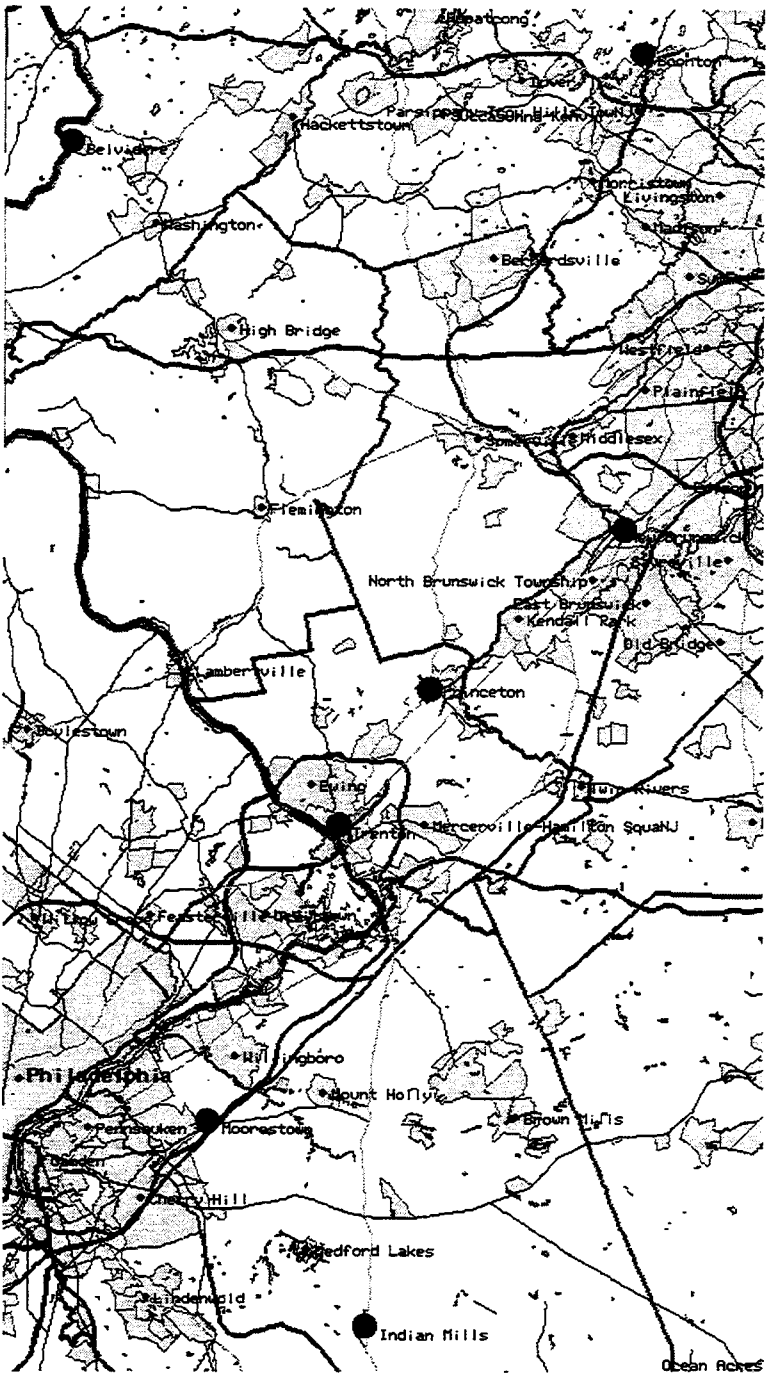


Fig. 1. Central New Jersey, with Princeton and the six comparison stations indicated. Map generated by Tiger Mapping Service, http://tiger.census.gov.

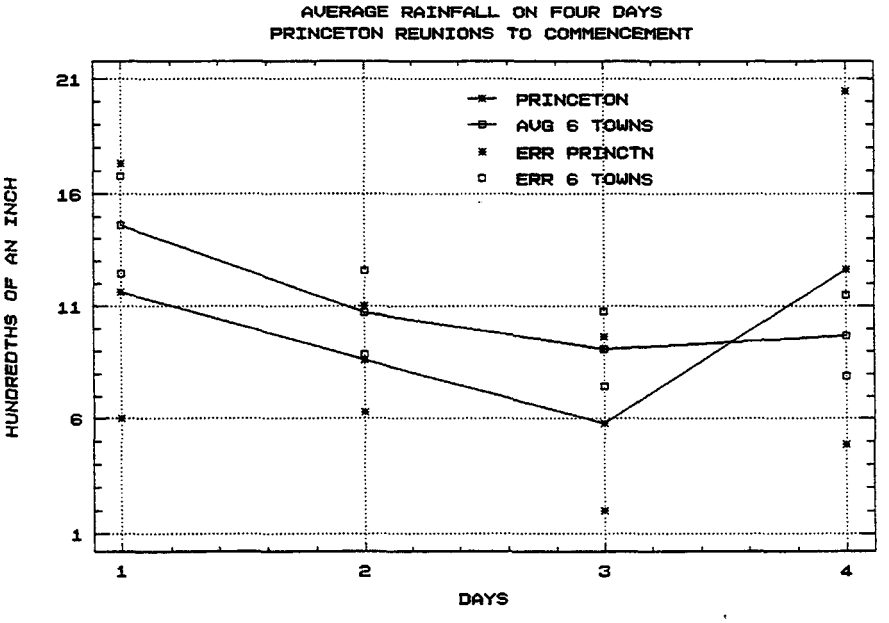


Fig. 2. Mean precipitation for Princeton compared with six surrounding towns on the four days: P-Rade, Baccalaureate, Class Day and Commencement. One sigma error is indicated.

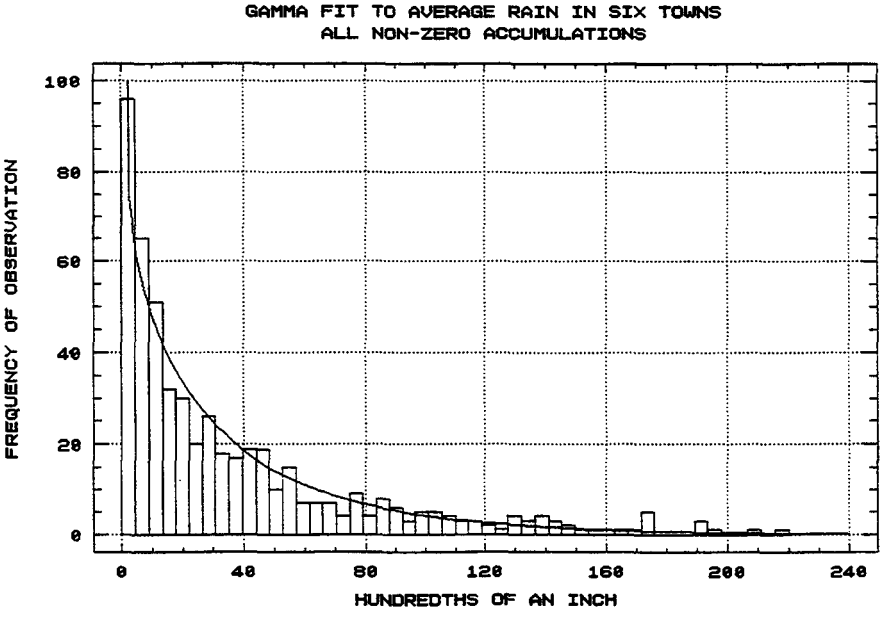


Fig. 3. A distribution of daily precipitation amounts displays a rapid decrease in the proportion of larger accumulations.

erage about 67% dry days, again suggesting that Princeton's weather tends to be better than might be expected for the period of interest.

Proceeding to a more formal assessment, a non-parametric analytical approach that is designed to accommodate variables of this nature compares cumulative distributions of the daily precipitation totals. Figure 4 displays, for each of the four days of interest, Princeton's cumulative rainfall against the composite of the six surrounding stations.

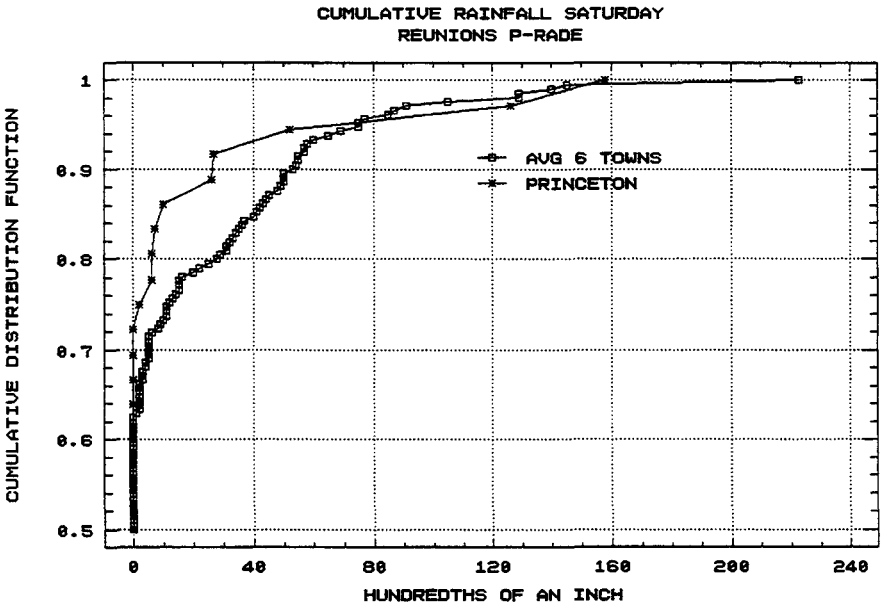
In this display, where the extraordinary rainfall recorded in 1962 plays a less weighty role, Commencement day appears to be fair and dry somewhat more often in Princeton than in the neighboring communities (Fig. 4d). Such a trend toward less rain, less often, is quite persuasive on Saturday, Monday and Tuesday, but on Sunday, the day of Baccalaureate (Fig. 4b), no clear tendency is evident. The amount of data available for these comparisons is too small to justify much interpretation, but it is noteworthy that this is the only day without major outdoor activities since the Baccalaureate ceremonies take place inside the University Chapel, regardless of the weather. In the other cases, the Princeton data are shifted toward lower daily precipitation rates, but only on Class Day (Fig. 4c) does the difference approach conventional statistical significance, based on a non-parametric Mann-Whitney Ranks test, yielding a Z-score of 1.607, with a corresponding probability of 0.054.

When we combine the data from the three days with major outdoor activities, the distributions are smoother, as can be seen in Figure 5, and the statistical power to determine whether there is a consistent difference between Princeton and its neighbors is enhanced.

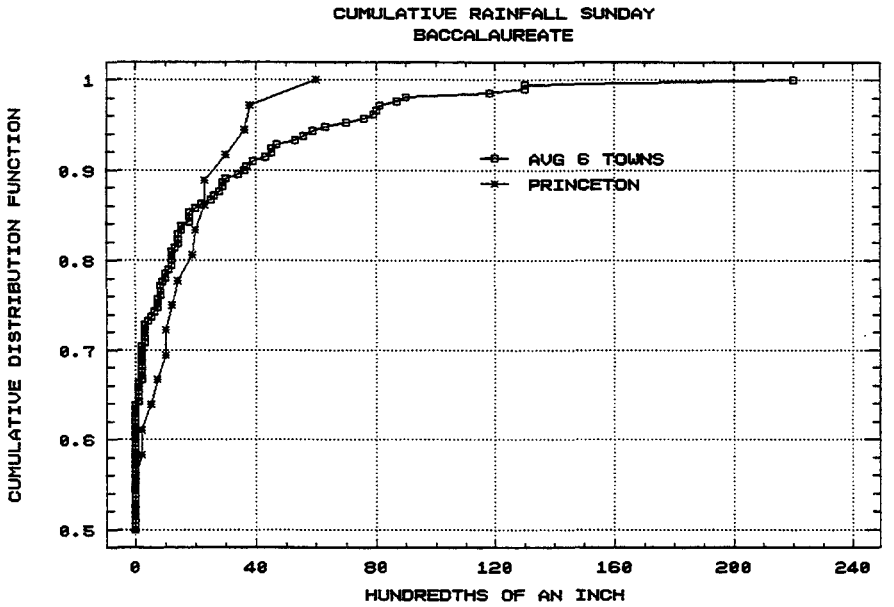
In this case it is necessary to consider any autocorrelation indicating non-independence among the days, but this is negligible for the sample in hand, with a lag-one autocorrelation coefficient of 0.049. Pooling the rainfall accumulations for these three days in Princeton to compare with the corresponding pooled data from the surrounding stations, the Mann-Whitney test for a difference in the predicted direction yields a Z-score of 1.656, just exceeding the conventional 5% threshold for statistical significance.

Thus, although the graphical displays are striking, and consistent with the hypothesis, the formal statistical assessment based on data from 1950 to 1986 yields only nominally significant evidence that the apparent difference between Princeton and the surrounding communities is other than a chance fluctuation. Moreover, to evaluate the situation fairly, we still must consider whether Princeton might have a micro-climate that is different from its geographical surround. A similar comparison of the days following Commencement, using the same cumulative distribution approach, is shown in Figure 6. Here, the curves are scarcely distinguishable, and the Mann-Whitney test for the pooled data comparing Princeton to the surrounding area yields a Z-score of 0.222, with a related probability of 0.412.

While the formal comparison appropriately uses data for the surrounding towns only from the years 1950 to 1986, most of these stations have a longer

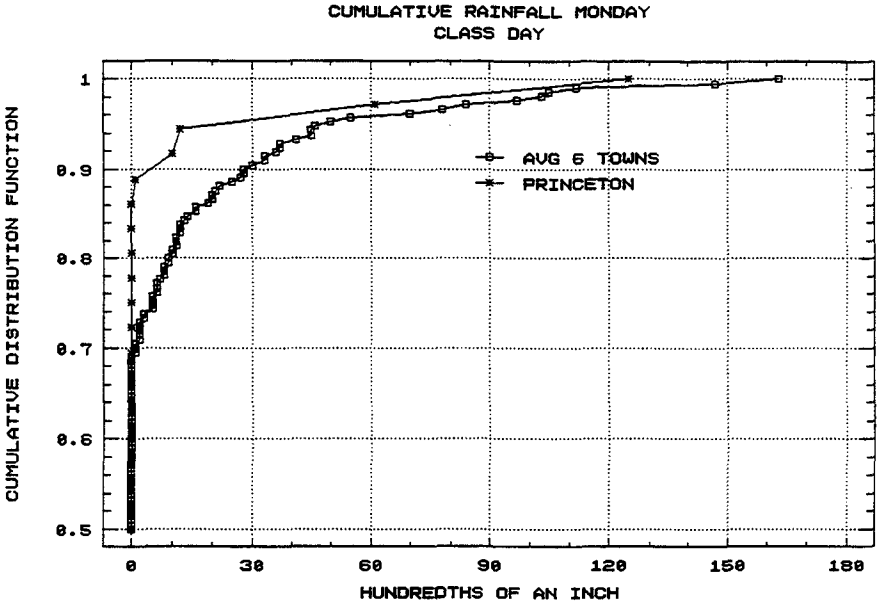


(4a)



(4b)

Fig. 4. An ordered accumulation of daily precipitation totals shows less frequent, and smaller amounts of precipitation in Princeton for three of the four days.



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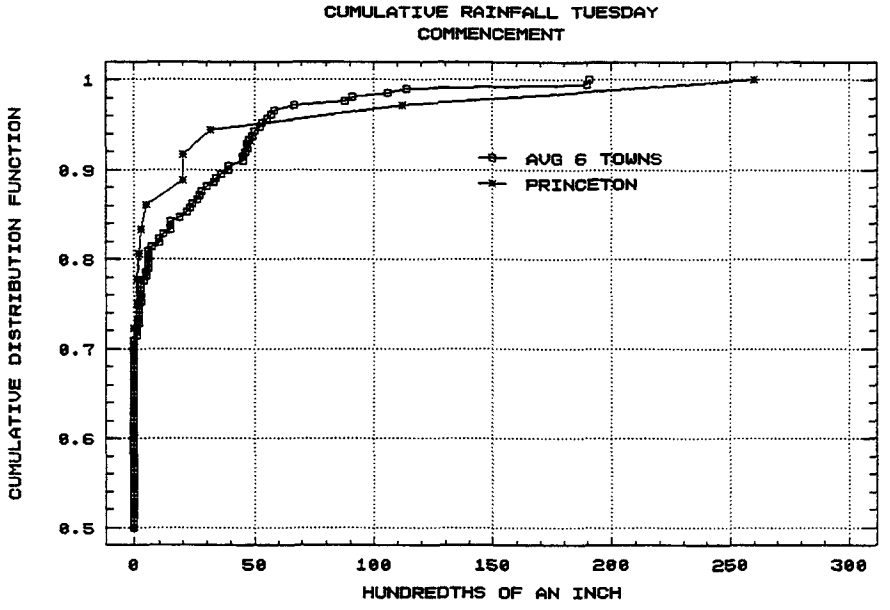

(4d)

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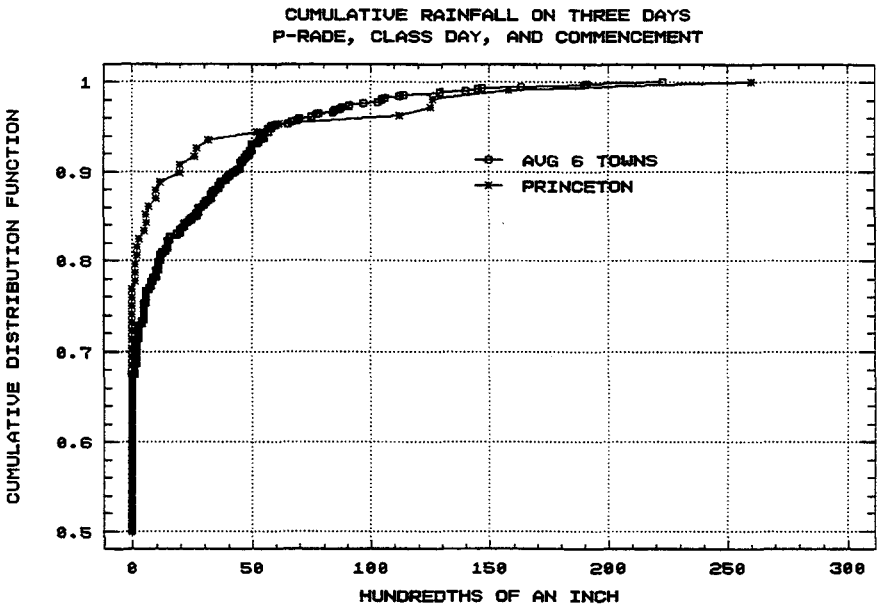

Fig. 5. Comparison of Princeton vs. the surrounding area, of rainfall accumulating on the three days with planned outdoor activities: P-Rade, Class Day, and Commencement.

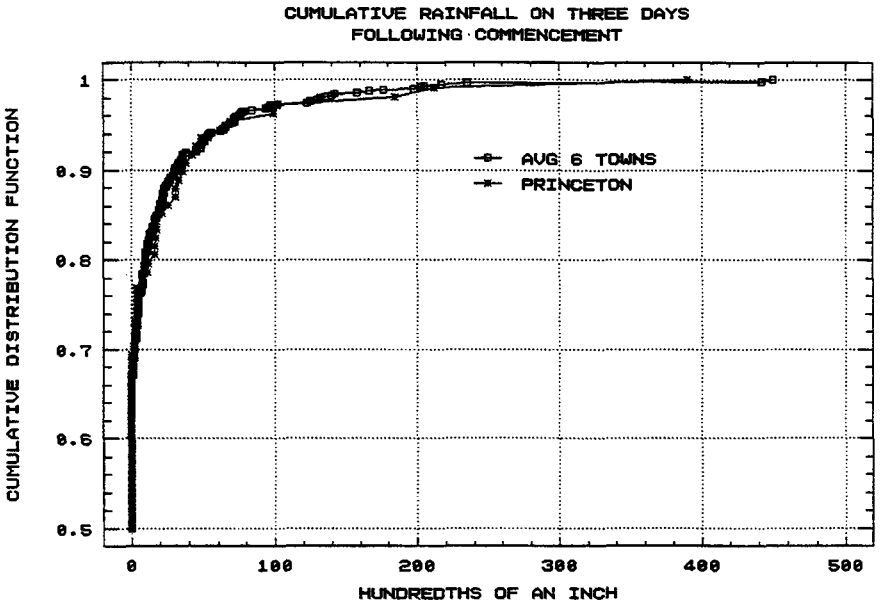

Fig. 6. Comparison of rainfall accumulating on three days just after Commencement, in Princeton vs. the surrounding area.

record, and if all years are used, nearly twice as many days are available to estimate the amount of precipitation accumulating in the surrounding area around the time of Princeton's Commencement. If Class Day is compared with this more comprehensive estimate, the Z-score is 1.814, with $p = 0.035$. When this estimate is used in the comparison of the three outdoor days combined, the result is $Z = 1.996$, and $p = 0.023$. Comparison of the three days following commencement yields a corresponding result of $Z = 0.540$, $p = 0.295$. Though consistent with the formal calculations, these "full database" values are vulnerable to any longer-term changes in weather patterns. A direct comparison of the data from the 36-year period of the Princeton weather station against the remaining data shows a marginally significant Z-score of 1.610, suggesting that there may have been a change, and that we should not place as much weight on these as on the statistically less powerful formal calculations.

Finally, we may ask whether the amount of precipitation is different over time in Princeton itself, by comparing the days of interest with immediately surrounding days, to see if this time period in Princeton differs from the seasonal trend. This temporal comparison has a pattern similar to that of the spatial differences. The composite Z- score ranges from 1.370 to 1.972 ($p = 0.085$, 0.024, respectively), depending on the number of surrounding days chosen for the comparison. No obvious criterion is available for a fully formal comparison of the temporal trends, but again the data suggest that a small decrease in the probability of rain is correlated with this large gathering of people for shared enjoyment of outdoor ceremonies and activities.

A Curious Situation

Although many of us wish fervently for nice weather for special occasions, and some are even motivated to offer up a little prayer, it doesn't seem likely that many of us believe it will do any good. A modern education (such as Princeton delivers) tends to include a surfeit of implicit reasons and arguments against such an eventuality, and it certainly doesn't fit easily within our current scientific models of the world. Yet, we recognize that these models are incomplete, perhaps most glaringly because they have so little to say about human consciousness, including such hopes and wishes as might, possibly, affect the weather.

We have recently learned to view weather patterns in terms of chaos theory, where infinitesimally small effects can expand into great changes; the beat of a Brazilian butterfly wing may propagate through complex weather systems to cause a downpour in a small New Jersey town. Could the effects of communal interest from a great concentration of Princetonians compete with that butterfly wing?

A look at actual weather data seems to suggest that precipitation tends to stay away from Princeton for the P-Rade, and Class Day, and Commencement, to a somewhat unlikely degree. These intriguing results certainly aren't strong enough to compel belief, but the case presents a very challenging possibility,

because if the analysis is correct, the only good candidate to explain the apparent differences, other than chance, would seem to be an influence from an informal but powerful communal wish for dry weather. In any case, it surely is premature to conclude, as the graffito has it, that God went to Princeton, but we may need to reconsider the old saw, "Everyone talks about the weather, but nobody does anything about it."

Acknowledgments

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