The Bausch & Lomb Photogrammetric Award

Expectancy of Cloudless Photographic Days in the Contiguous United States

*James E. Lee**
Steven D. Johnson
Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

Graduate Award

ABSTRACT: The Sette Weather Chart was produced in 1939 using data collected from the years 1900 to 1936 to predict cloudless photographic days in the United States. Inadvertent climate modifications that have taken place since this time period makes this chart obsolete. Using current National Weather Service records from the period 1950 to 1982, the number of days having 0.1 cloud cover or less are tabulated. A new chart is produced that can predict cloudless photographic days based on current data. Forty-five cities are common both to Sette's original study and the current study. Forty-four out of the forty-five cities have had their annual monthly average of cloudless photographic days decrease between the time periods 1900-1936 and 1950-1982. Fort Worth, Texas is the only city that had its monthly average photographic days increase between the time periods studied.

INTRODUCTION

PROBLEM DEFINITION

THE LOCAL WEATHER is one of the most significant factors of any aerial photographic mission plan. If the sky is obscured by clouds or haze, the data that may be derived from the photographs are greatly reduced in quantity and quality. When a photogrammetric flight contract is written, the air survey company is usually given a maximum allowable cloud cover percentage. The number of permissible flight days is limited by the cloud cover conditions at the site. If the number of cloudless days can be predicted, the mission planner can estimate future flight activity. In 1939, F. J. Sette of the United States Department of Agriculture produced a chart of the United States depicting the average number of days per month when the sky is obscured 0.1 or less by clouds. Sette's chart is shown in Figure 1. This chart was produced using data collected from the time period of 1900 to 1936.

Since the Sette Weather Chart's publication, knowledge of the micrometeorological processes involved in cloud formation has expanded. Studies by Chagnon (1981), Kuhn (1970), Harami (1968), and Reinking (1968) have shown that inadvertent climate modification by man has shifted local weather conditions over certain portions of the United States and Japan. It is probable that the original Sette chart, based on 1939 data, is no longer valid and that an up-to-date chart produced from recent meteorological data should be developed for use by photogrammetrists, Landsat users, and other remote sensing system users.

OBJECTIVES AND SCOPE

The primary objective of this study is to evaluate the need to update the Sette Weather Chart and to produce a chart using current data. The existing Sette Weather Chart is currently being used in the photogrammetric field for mission planning. The updated chart will give mission planners a more accurate flying time prediction model. In this project, National Weather Service cloud cover data for 65 cities is collected and analyzed. At 45 cities in common with the original Sette Chart, the differences in the number of cloudless days from Sette's epoch to the present epoch are statistically tested. If a significant decrease in the number of cloudless days is found, it validates the hypothesis that an updated chart should be prepared. Finally a proposed chart showing expectancy of cloudless photographic days is prepared using the new data set.

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* Now with The MITRE Corporation, McLean, VA 22102.

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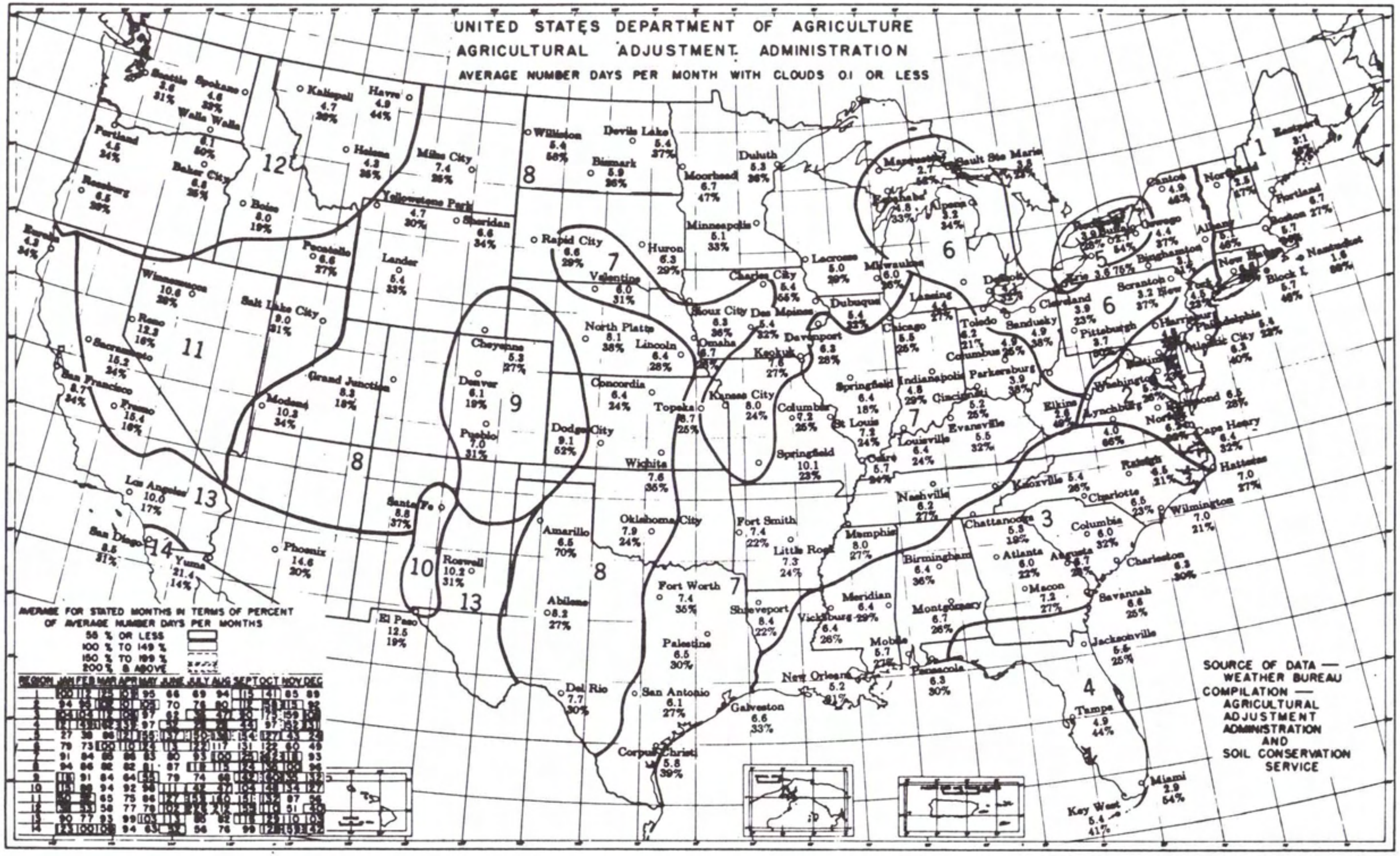


FIG. 1. Sette Weather Chart (Slama, 1980).

BACKGROUND

HISTORY AND EXPLANATION OF THE SETTE WEATHER CHART

The Sette Weather chart was developed in 1939 by F. J. Sette of the United States Department of Agriculture (USDA). It is reproduced in the *Manual of Photogrammetry*, 4th Edition, (Slama, 1980) without references citing its origin. The chart was originally produced for internal use at USDA for planning of aerial projects, and references describing the chart's development are not available.

The Sette chart is composed of a map of the United States that is divided into regions having similar cloud producing topographic features and/or climate types. On the map, selected cities are plotted with the average number of days per month when the sky is 0.1 or less obscured by clouds (a condition that may be termed a cloudless photographic day). The cloudless days per month figure is an average for the entire year.

In order to obtain greater detail, a table in the lower left hand portion of the Sette chart gives the percentage of the average yearly cloudless photographic days for every month of the year. For example, Washington, D.C. has an annual average of 5.3 days per month when the sky is 0.1 or less obscured by clouds. If we wanted to find the averaged number of cloudless days for the month of July, we would observe that Washington, D.C. is in Region 2. Referring to the table, we would find that 76 percent of the annual average would be the expected number of days in July that would be termed cloudless and suitable for aerial photography. The result is that 76 percent of the average yearly figure of 5.3 days per month would be equal to 4 days in July.

The second figure below each city is the percentage of average annual cloudless days that we would expect in the worst year out of ten years. Continuing our example, we would expect Washington to have at least 26 percent of 5.3 days as the worst year in ten years. The worst year in this context is defined as the year with the most days having a sky cover greater than 0.1

PROCESSES OF CLOUD FORMATIONS

In order for clouds to develop, two conditions must occur. The first condition is that aerosol must be present in the atmosphere. The second condition is that this aerosol laden air must ascend in the atmosphere. Atmospheric aerosols are liquid or solid particles that are suspended in the atmosphere. Aerosols descend very slowly through the atmosphere, and the rate at which they descend is directly proportional to their size, shape, and weight. Wallace (1977) has shown that the size of these particles range from $10^{-4}\mu m$ to tens of micrometres. Aerosols serve as the nucleus to which water and ice coalesce to form cloud particles. The concentration of aerosol in the atmosphere is a variable dependent upon the height above the Earth's surface and the type of location over which the sample is taken. As the altitude increases, the concentration of aerosol decreases. Wallace (1977) states that some rough estimates of aerosol concentrations are $10^3 cm^{-3}$ over oceans, $10^4 cm^{-3}$ over rural areas, and $10^5 cm^{-3}$ over urban areas. The source of these aerosols are primarily from combustion processes, including human activities, volcanoes, and forest fires. Gas-to-particle conversions and bursting air bubbles over the ocean are also important sources of aerosols.

Clouds are formed when aerosol laden air parcels ascend through the atmosphere, which results in expansion of the air and adiabatic cooling. During ascent, water vapor condenses onto available aerosols that are termed cloud condensation nuclei. The two basic ways that air ascends through the atmosphere are by natural effects of atmospheric motion and by orographic lifting.

Natural effects are due to large scale atmospheric motions and are directly related to the current weather conditions. It is well known that cold air is denser than warm air. When a cold front passes through a region, the warmer air preceding the front is pushed upward rapidly by the denser cold air. When a warm front passes through a region, the warm air slowly rises above the colder, denser preceding air. The conditions previously described are presented in Figure 2. Frontal passages of warm or cold air masses are two examples of natural ascension of air.

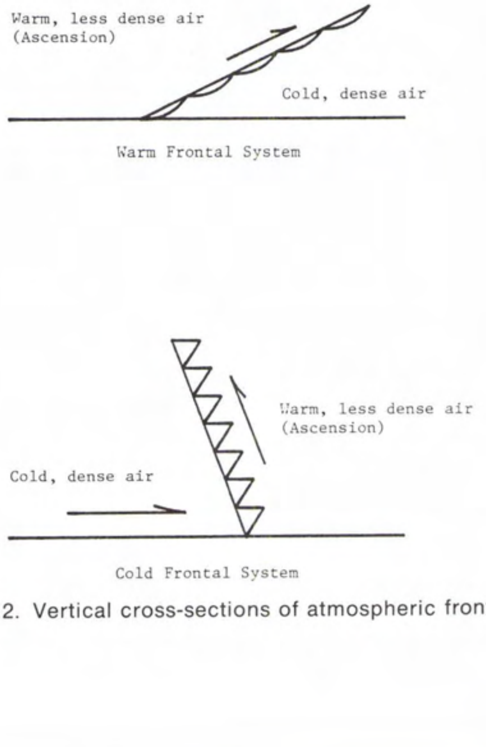


FIG. 2. Vertical cross-sections of atmospheric fronts.

Orographic lifting is defined as the forced lifting of air as it passes over hills or mountains. Over some mountains in the Western United States, a cloud may seem to be constantly over the peaks. This is caused by orographic lifting of the air.

INADVERTENT CLOUD COVER MODIFICATION

The cloud cover over certain protions of the nation has been shown by Chagnon (1981) to be increasing during the period 1901 to 1977. Chagnon also found that the frequency of clear days has been decreasing dramatically since 1930. This fact may be the result of the following three reasons:

- A major climate shift is taking place over a large period of time.
- Error in the National Weather Service data due to observer error (sky cover is a subjective measurement; there is no instrument to calculate it).
- Man's influence on the atmosphere is forcing rapid change in weather patterns (not climatic changes).

It is not within the scope of this paper to discuss the first two factors, though the second factor of observer error is considered minimal because the National Weather Service has been teaching their observers similar techniques to make cloud observations since the early 1900's.

Man's influence on the atmosphere is essentially determined by the amount of pollutants he adds to it. Landsberg (1970) has shown that there has been a 5 to 10 percent increase in clouds associated with the ability of some pollutants to serve as cloud condensation nuclei. These increased clouds are mostly low-level stratus clouds that effect aerial photography drastically. In addition to these low-level clouds, high clouds such as the cirrus variety have also been increasing due to jet contrails. When warm, moist air is introduced to a colder clime, condensation occurs and clouds may be produced. Exhaling your breath on a winter day may produce a small cloud that evaporates rapidly. Likewise, as a jet flies across the sky introducing its hot exhaust into the colder atmosphere, a false cirrus cloud (contrail) may be produced. It has been observed by Murcray (1970) that a contrail can grow into an overcast covering the whole sky. It is uncertain how significant this condition is to an increase in high cloudiness, but a sharper decrease in clear days has been shown by Chagnon to have taken place over the decade beginning in 1960. This period corresponds roughly to the time when jet air traffic increased dramatically in the United States. It should also be noted that Chagnon's study was taken over the upper midwest corridor of the United States (upper

TABLE 1. CITIES USED IN STUDY

Albany, New York
Albuquerque, New Mexico
Apalachicola, Florida
Atlanta, Georgia
Billings, Montana
Bismarck, North Dakota
Boise, Idaho
Brownsville, Texas
Buffalo, New York
Burns, Oregon
Caribou, Maine
Casper, Wyoming
Charleston, South Carolina
Columbus, Ohio
Denver, Colorado
Des Moines, Iowa
Detroit, Michigan
Dodge City, Kansas
El Paso, Texas
Ely, Nevada
Eugene, Oregon
Fort Worth, Texas
Glasgow, Montana
Grand Junction, Colorado
Great Falls, Montana
Huron, South Dakota
Indianapolis, Indiana
International Falls, Minnesota
Jackson, Mississippi
Jacksonville, Florida
Kansas City, Missouri
Knoxville, Tennessee
Las Vegas, Nevada
Lexington, Kentucky
Little Rock, Arkansas
Los Angeles, California
Lubbock, Texas
Madison, Wisconsin
Miami, Florida
Minneapolis, Minnesota
Montgomery, Alabama
Nashville, Tennessee
New Orleans, Louisiana
New York, New York
Norfolk, Virginia
North Platte, Nebraska
Oklahoma City, Oklahoma
Phoenix, Arizona
Pittsburgh, Pennsylvania
Portland, Maine
Raleigh, North Carolina
Red Bluff, California
Reno, Nevada
Roanoke, Virginia
Saint Louis, Missouri
Salt Lake City, Utah
San Antonio, Texas
San Diego, California
San Francisco, California
Sault Ste. Marie, Michigan
Seattle, Washington
Spokane, Washington
Tampa, Florida
Washington, D.C.
Winslow, Arizona

Missouri, Illinois, Indiana, and lower Iowa and Michigan), where the U.S. Geological Survey (1970) has shown that air traffic volume is at the highest level in the country. These clouds would only directly influence small scale aerial photography missions and not affect large scale photography.

PROJECT DESIGN

The National Weather Service (NWS) keeps stringent weather records at the National Climatic Center (NCC) in Asheville, North Carolina. Weather data are collected from the major cities and towns across the country and placed in archival storage. A monthly publication, *Local Climatological Data*, is published from over 200 cities in the United States and its possessions. Many of these periodicals can be found in the National Oceanic and Atmospheric Administrations Library located at the NWS Headquarters in Silver Spring, Maryland.

Included in *Local Climatological Data* is a daily record of pertinent weather parameters. One of these is sky cover from sunrise to sunset. Weather observations (including sky cover) are taken continuously at three-hour intervals throughout the day. Sky cover is defined as the amount of the celestial sphere that is obstructed from the observer by smoke, haze, fog, or clouds. It is recorded in tenths of celestial sphere obstructed. For example, if the sky is covered three-tenths by clouds, then a three would be recorded as the observation. Eight of these types of observations are taken daily and classified either as occurring between sunrise and sunset (day) or sunset and sunrise (night). Averages are determined for each of these two groups, and the averages are reported in *Local Climatological Data*. Only the observations categorized in the daylight hours are used in this study.

The information in *Local Climatological Data* is available in both hardcopy and computer tapes. However, the cost to lease the required computer tapes from NCC was estimated to be nine thousand dollars. The financial consideration forced a decision to compile data by hand and placed a limitation on the number of cities that could be collected in a realistic amount of time. The average collecting time was about three hours per station. A well-spaced grid over the United States is needed to interpolate regions easily. A final base of 65 cities was selected. The cities are listed in Table 1.

The process of data collection from the *Local Climatological Data* for a particular city involved counting the number of occurrences that the sky cover was recorded as zero or one each month. Sky cover data were collected for the time period from 1950 to 1982. The time period was chosen because the sunrise to sunset sky cover data collection was not standard in the NWS records until 1950. Sette's study included data from 1900 to 1936, a total of thirty-seven years. This project includes data for a total of thirty-three years.

RESULTS

Comparing Sette's Study to Current Study

Forty-five cities are common to both Sette's study and the current study. Of these 45 cities, 44 show a decrease in the number of days with sky cover 0.1 or less per month between the time period from 1900-1936 to 1950-1982. Table 2 summarizes the data at the locations common to the two epochs. The hypothesis that a significant decrease in cloudless days has occurred is tested using a Paired-*t* statistic.

The Paired-*t* test is valid only if the differences of

Table 2. Data Table of Forty-Five Common Cities

City	1900-1936	1950-1982	Differences
Albany	5.1	2.7	2.4
Atlanta	6.0	5.3	0.7
Bismarck	5.9	3.8	2.1
Boise	8.0	7.0	1.0
Buffalo	2.7	1.9	0.8
Charleston	6.3	4.8	1.5
Columbus	4.9	3.2	1.7
Denver	6.1	5.3	0.8
Des Moines	5.4	5.0	0.4
Detroit	4.1	3.2	0.9
Dodge City	9.1	6.9	2.2
El Paso	12.5	11.1	1.4
Fort Worth	7.4	7.5	−0.1
Grand Junction	8.3	7.2	1.1
Huron	6.3	4.8	1.5
Indianapolis	4.8	3.8	1.0
Jacksonville	5.6	4.2	1.4
Kansas City	8.0	5.8	2.2
Knoxville	5.4	4.2	1.2
Little Rock	7.3	5.8	1.5
Los Angeles	10.0	7.6	2.4
Miami	2.9	1.9	1.0
Minneapolis	5.1	4.6	0.5
Montgomery	6.7	5.4	1.3
Nashville	6.2	4.8	1.4
New Orleans	5.2	5.1	0.1
New York	4.5	3.7	0.8
Norfolk	6.2	5.1	1.1
North Platte	8.1	5.4	2.7
Oklahoma City	7.9	7.5	0.4
Phoenix	14.6	13.7	0.9
Pittsburgh	3.7	2.3	1.4
Portland	6.7	4.4	2.3
Raleigh	6.5	5.2	1.3
Reno	12.3	9.6	2.7
St. Louis	7.2	4.7	2.5
Salt Lake City	9.0	6.5	2.5
San Antonio	6.1	5.2	0.9
San Diego	8.5	6.5	2.0
San Francisco	8.7	8.5	0.2
Sault St. Marie	3.8	2.8	1.0
Seattle	3.6	2.8	0.8
Spokane	4.6	4.3	0.3
Tampa	4.9	3.6	1.3
Washington, DC	5.3	4.4	0.9
TOTALS	$\overline{y}_1 = 6.6$ $s_1 = 2.5$	$\overline{y}_2 = 5.3$ $s_2 = 2.3$	$\overline{d} = 1.3$ $s_d = 0.7$

the two sample means are from a normal distribution. Lilliefors (1967) developed a test which checks the goodness-of-fit to determine normality. The Lilliefors Test to check the normality of the differences in the sample means is presented in Table 3. The hypotheses can be stated as

H_o: The random sample came from a normal population, and
H_1: The random sample is not from a normal population.

At a significance level of 90 percent and $n = 45$ the critical value is

$$D_{\text{critical}} = 0.1321$$

Because

$$D_{\text{critical}} > D_{\text{max}}$$
$$0.1321 > 0.1269,$$

we accept the null hypothesis. From the results of the Lilliefors Test, an assumption can be made with 90 percent confidence level that the sample differences are from a normal population, and a Paired-*t* test is valid for these data.

The results of the Paired-*t* test are then computed from the means and standard deviations computed in Table 2. The hypothesis may be stated as

H_o No difference between epoch means, and
H_1: Sette's epoch mean is larger than the current epoch mean.

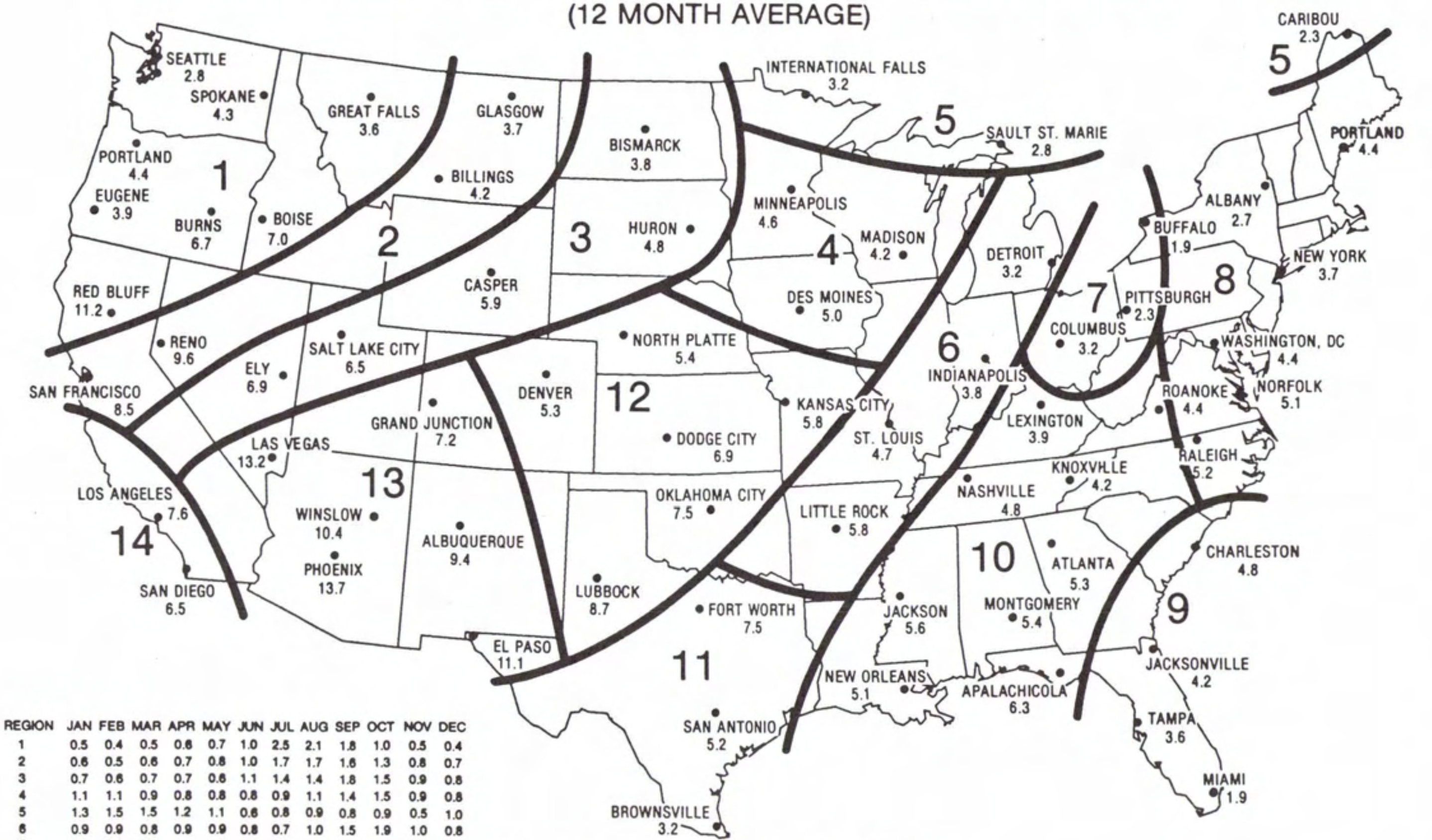
TABLE 3. LILLIEFORS TEST FOR NORMALITY

d_i	$Z_i = d_i - \overline{d}/s$	$P_r(z < z_i) = F_0(d_i)$	$S(d_i) = i/n$	$\lvert F_0(d_i) - S(d_i)\rvert$
2.7	2.0	0.9772	1.0000	0.0228
2.7	2.0	0.9772	0.9778	0.0006
2.5	1.7	0.9554	0.9556	0.0002
2.5	1.7	0.9554	0.9333	0.0221
2.4	1.6	0.9452	0.9111	0.0341
2.4	1.6	0.9452	0.8889	0.0563
2.3	1.4	0.9192	0.8667	0.0525
2.2	1.3	0.9032	0.8444	0.0588
2.2	1.3	0.9032	0.8222	0.0810
2.1	1.1	0.8643	0.8000	0.0643
2.0	1.0	0.8413	0.7778	0.0635
1.7	0.6	0.7257	0.7556	0.0299
1.5	0.3	0.6179	0.7333	0.1154
1.5	0.3	0.6179	0.7111	0.0932
1.5	0.3	0.6179	0.6889	0.0710
1.4	0.1	0.5398	0.6667	*0.1269
1.4	0.1	0.5398	0.6444	0.1046
1.4	0.1	0.5398	0.6222	0.0824
1.4	0.1	0.5398	0.6000	0.0602
1.3	0.0	0.5000	0.5778	0.0778
1.3	0.0	0.5000	0.5556	0.0556
1.3	0.0	0.5000	0.5333	0.0333
1.2	−0.1	0.4602	0.5111	0.0509
1.1	−0.3	0.3821	0.4889	0.1068
1.1	−0.3	0.3821	0.4667	0.0846
1.0	−0.4	0.3446	0.4444	0.0998
1.0	−0.4	0.3446	0.4222	0.0776
1.0	−0.4	0.3446	0.4000	0.0554
1.0	−0.4	0.3446	0.3778	0.0332
0.9	−0.6	0.2743	0.3556	0.0813
0.9	−0.6	0.2743	0.3333	0.0590
0.9	−0.6	0.2743	0.3111	0.0368
0.9	−0.6	0.2743	0.2889	0.0146
0.8	−0.7	0.2420	0.2667	0.0247
0.8	−0.7	0.2420	0.2444	0.0024
0.8	−0.7	0.2420	0.2222	0.0198
0.8	−0.7	0.2420	0.2000	0.0420
0.7	−0.9	0.1841	0.1778	0.0063
0.5	−1.1	0.1357	0.1556	0.0199
0.4	−1.3	0.0968	0.1333	0.0365
0.4	−1.3	0.0968	0.1111	0.0143
0.3	−1.4	0.0808	0.0889	0.0081
0.2	−1.6	0.0548	0.0667	0.0119
0.1	−1.7	0.0446	0.0444	0.0002
−0.1	−2.0	0.0228	0.0222	0.0006

EXPECTANCY OF CLOUDLESS PHOTOGRAPHIC DAYS

MEAN NUMBER OF DAYS PER MONTH WITH SKY COVER 0.1 OR LESS

(12 MONTH AVERAGE)



REGION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.5	0.4	0.5	0.6	0.7	1.0	2.5	2.1	1.8	1.0	0.5	0.4
2	0.6	0.5	0.6	0.7	0.8	1.0	1.7	1.7	1.6	1.3	0.8	0.7
3	0.7	0.6	0.7	0.7	0.6	1.1	1.4	1.4	1.8	1.5	0.9	0.8
4	1.1	1.1	0.9	0.8	0.8	0.8	0.9	1.1	1.4	1.5	0.9	0.8
5	1.3	1.5	1.5	1.2	1.1	0.6	0.8	0.9	0.8	0.9	0.5	1.0
6	0.9	0.9	0.8	0.9	0.9	0.8	0.7	1.0	1.5	1.9	1.0	0.8
7	0.4	0.6	0.8	1.1	1.1	0.9	0.9	1.1	1.6	2.1	0.7	0.5
8	1.2	1.1	1.1	1.0	0.7	0.6	0.5	0.7	1.1	1.6	1.1	1.1
9	1.5	1.6	1.3	1.3	0.9	0.4	0.1	0.1	0.3	1.3	1.6	1.6
10	1.0	1.0	0.9	1.0	0.9	0.6	0.4	0.6	1.1	2.0	1.4	1.1
11	1.1	1.2	0.9	0.8	0.6	0.6	0.8	0.9	1.0	1.5	1.4	1.3
12	1.0	0.8	0.8	0.8	0.6	0.9	0.9	1.0	1.4	1.7	1.1	1.1
13	0.8	0.8	0.8	0.9	1.0	1.3	0.7	0.8	1.4	1.4	1.1	0.9
14	1.1	1.1	1.0	1.0	0.7	0.6	0.7	0.8	1.0	1.2	1.4	1.4

TO FIND THE NUMBER OF DAYS EXPECTED FOR A SPECIFIC MONTH, FIND THE APPROPRIATE REGION WHERE THE CITY IS LOCATED IN. USING TABLE IN LOWER LEFT, MULTIPLY THE FIGURE GIVEN ON CHART WITH THE CORRESPONDING NUMBER FOUND IN THE TABLE.

COMPILED BY: JAMES LEE
CIVIL ENGINEERING DEPT
VPI & SU
DATA SOURCE: NATIONAL WEATHER SERVICE

FIG. 3. Updated weather chart.

At a significance level of 95 percent and $n = 45$, the t value is 1.64. The test statistic is

$$t_s = \frac{\overline{d}}{s_d/\sqrt{n}} = 12.46$$

Because

$$t_s > t$$

$$12.46 > 1.64,$$

the null hypothesis is rejected, and it can be concluded that the population mean cloudless photographic days from the years 1950 to 1982 is smaller than the population mean cloudless photographic days from the years 1900 to 1936. Thus, it is appropriate to consider producing a new weather chart based on recent cloud cover data.

GROUPING OF GRAPHS (REGIONALIZING)

It is necessary to compare cloud cover statistics among the cities studied in order that data with similar characteristics will be grouped together to form homogeneous regions over the United States. Graphs of month versus average percentage of cloudless days during that particular month were made for each of the 65 cities.

The graphs were constructed with identical scale on both axes; month number on the x-axis (i.e., January = 1, February = 2, etc.), and the percentage of cloudless days on the y-axis. The graphs were visually inspected for similarities, and placed accordingly into different regional groupings. The graphs are not included here but can be found in Lee (1984).

Initially, regionalizing was done in inspection of the general shape of the graphs. The following three main groups were found:

- The first group exhibited percentages that were very low in the summer compared to the rest of the year. This group was located usually in the Southeastern U.S. and Southwestern U.S. (U-shaped distribution).
- The second group exhibited percentages that peaked in the fall. This group was the largest group and included the Northeastern U.S.
- The third group exhibited a mound shape (or inverted-U) graph that encompassed much of the Western portion of the U.S.

After these charts were grouped initially by their general shape, the magnitudes of cloudless day percentages were compared. Magnitudes were very important in the final grouping into regions. After grouping by shape only, the magnitudes of the peaks and valleys were the primary determinant of regionalization, although topographic effects were also considered in constructing region boundaries.

DEVELOPMENT OF UPDATED SETTE WEATHER CHART

After the regionalization discussed in the previous section, there are a total of 14 regions identified in the current study (coincidently, there were also 14 regions in Sette's study). The boundaries delineating the regions are shown in Figure 3.

The average number of cloudless days can be predicted for each month at a given location using a procedure analogous to the original Sette Weather Chart.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

From the cloud cover data collected for 65 cities between 1950 and 1982, it is shown that relative to the 1900 to 1936 period studied by Sette there has been a decrease in the number of cloudless photographic days expected per month in the United States. Flight planners using the original Sette Weather Chart will obtain estimates of the number of days available for aerial photography that are consistently too optimistic.

A new chart based on the more recent epoch is developed for use by photogrammetric flight planners to decide when the most opportune month of the year would be to plan a mission or to calculate the number of days that could be expected with sky cover 0.1 or less in a month.

RECOMMENDATIONS

From the results obtained with this limited data set, it is recommended that a more extensive data set be obtained in computer compatible format. The higher density of sampled observing stations should be included in the analysis described herein to refine the region boundaries and compile a final weather chart for current use.

Furthermore, it may be possible to develop mathematical models of the regions to predict number of cloudless photographic days if it is desirable to eliminate the graphic chart.

ACKNOWLEDGMENTS

The authors wish to express their appreciation for the assistance received from Dr. William Seaver and Dr. James Baker during this project.

As this paper is being published, additional studies are in progress. A larger number of cities are to be included in the data set, and a more statistically rigorous method of grouping similar data points into regions is to be evaluated. These studies are under the supervision of Dr. Seaver of the VPI Statistics Department.

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Forthcoming Articles

Wm. Befort, Large-Scale Sampling Photography for Forest Habitat Type Identification.
David. E. Brown and *Arthur M. Winer*, Estimating Urban Vegetation Cover in Los Angeles.
E. P. Crist and *R. J. Kauth*, The Tasseled Cap De-Mystified.
P. E. R. Dale, K. Hulsman, and *A. L. Chandica*, Seasonal Consistency of Salt-Marsh Vegetation Classes Classified from Large-Scale Color Infrared Aerial Photographs.
S. F. El-Hakim, The Detection of Gross and Systematic Errors in the Combined Adjustment of Terrestrial and Photogrammetric Data.
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Robert L. Wildey, Radarclinometry for the Venus Radar Mapper.
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