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**AIR WEATHER SERVICE  
TECHNICAL REPORT 105-25**

**STUDY OF LENGTH OF RECORD  
NEEDED TO OBTAIN  
SATISFACTORY CLIMATIC SUMMARIES  
FOR VARIOUS METEOROLOGICAL ELEMENTS**



**NOVEMBER 1943**

**HEADQUARTERS  
AIR WEATHER SERVICE  
WASHINGTON, D. C.**

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STUDY OF LENGTH OF RECORD  
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*Air Weather Service*  
~~REPORT NO. 500~~  
*Tech. Rpt. 105-25*

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By authority of

CHIEF, AIR WEATHER SERVICE

NOV 21 1946 *G.N.G.H.*

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Prepared by the Weather Information Branch  
Headquarters Army Air Forces  
November 1943

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STUDY OF LENGTH OF RECORD  
NEEDED TO OBTAIN  
SATISFACTORY CLIMATIC SUMMARIES  
FOR VARIOUS METEOROLOGICAL ELEMENTS

I. PURPOSE OF STUDY

The purpose of this study was to establish the number of years that are needed in order to obtain a relatively constant frequency distribution of various meteorological elements. The limits within which a distribution function may fluctuate and still be considered satisfactory are arbitrary, but they were chosen in such fashion that, for all practical purposes of military planning, addition of further years of record would not add significantly to the interpretation of the climatic records. After the number of years which will yield this result are satisfactorily established, the work of compiling climatic records can be reduced to the absolute minimum necessary to gain the desired information. In the limited amount of time available for this study, it was not possible to choose and study stations representing all the possible climatic regions of the world, but the stations chosen will at least convey as far as possible the length of the approximate shortest records which will permit reliable deductions.

II. ELEMENTS STUDIED

The elements subjected to statistical analysis were those which had not been studied previously by climatologists with regard to the significant levels obtained by varying length of record. Such studies heretofore were largely restricted to temperature and precipitation amounts. This study extends our knowledge with respect to the elements significant for military aviation, such as:

- (a) Horizontal visibility;
- (b) Cloud heights;
- (c) Cloudiness;
- (d) Persistence of rain spells;
- (e) Wind velocity (surface).

III. DATA USED

The stations and data used are shown in table 1.

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Table 1.--Stations and Data

Meteorological Element	Station	Hours of Obs. (Local time)	Length of Record, Years	Climatic Area
Horizontal visibilities	Le Bourget	0700	8	Region of westerlies, maritime climate, inland, airport near city
	Abbeville	0700	8	Maritime climate, coastal station
	Perpignan	0700	8	Subtropical region, Mediterranean maritime climate, coastal station
	Palermo	0700	10	Subtropical region, Mediterranean maritime climate, coastal station
	Roma	0700	10	Subtropical region, station somewhat off coast, near city
	Genova	0700	10	Subtropical region, coastal station near city
	Washington, D.C.	1930	8	Region of westerlies, continental type climate, station near city
Cloud heights	Le Bourget		8	See above
	Abbeville		8	" "
	Perpignan		8	" "
Cloudiness	Washington, D.C.	1930	35	" "
Persistence of rain spells	Washington, D.C.	0000 to 0000	35	" "
Wind velocities (surface)	Palermo	1300	10	" "
	Roma	1300	10	" "
	Genova	1300	10	" "
	St. Inglevert	0700	8	Region of westerlies, maritime climate, coastal station
	Thyna	3 obs. daily	11 (not consec.)	Subtropical region, Mediterranean climate, coastal station
	Ras Engelah	3 obs. daily	12 (not consec.)	Subtropical region, Mediterranean climate, coastal station
	Shanghai	2 obs. daily	5 and 13	Monsoon region, coastal station

The frequency distributions by steps were obtained from monthly summaries, as follows:

For Italian stations from Ministero dell'Aeronautica - "Reassuniti Mensili delle Osservazioni di Visibilita Orizzontale della Velocita e Direzione del Vento al Suolo ed in Quota."

For French stations from Office Nationale Met. de France - "Climatologie Aeronautique."

For Washington, D.C., from Forms 1001, 1002, and 1014 met'l, U.S. Weather Bureau.

For North African stations from "Weather in the Mediterranean" - Great Britain Meteorological Office.

For Shanghai from "Bulletin Mensuel Observatoire Zi-Ka-Wei."

The group intervals used for study of the frequency distributions are shown in table 2.

Table 2.--Group Intervals Used for Study of the Frequency Distributions

Element	Station	Intervals
Visibility	All stations	International scale: 0-4, 5, 6, 7, 8, 9
Wind velocity	Italian and French stations	km. per hr.: 0-5, 6-25, 26-50, 51-75, 76 or more
	African stations	m.p.h.: less than 2, 2-5, 5-13, 13-18, 18-22, 22-45, greater than 45
	Shanghai	m.p.h.: calms, 1-8, 9-18, 19-32, greater than 32. (These were further classified by wind direction, N., NE., E., SE., S., SW., W., NW.)
Cloud heights	French stations	Meters: less than 100, 100-200, 200-300, 300-600, 600-1000, 1000-1500, 1500-2500, greater than 2500
Cloudiness	Washington, D.C.	Tenths: 0-2, 3-5, 6-8, 9-10
Rain spells	Washington, D.C.	Consecutive days of precipitation: 1-2, 3-4, 5-6, 7-8, greater than 9

## IV. PROCEDURE

The methods of approach and the techniques of analysis were the same for all elements. The original data were compiled, in some cases grouped (where not originally grouped at the source); and distributions of daily observations by months, by years, were made according to the intervals given in table 2. The distributions were added successively from 1, 2, 3, 4, etc. years, for each month at each station, and the percentage frequencies for each distribution calculated for the cumulative sums of 1, 2, 3, 4, etc. years. An example is shown in table 3.

Table 3.--January Cloudiness (in Tenths) - Washington, D.C.

Year	Frequencies in days, individual years				Year	Cumulative Frequencies in days (years added)				Year	Cumulative Frequencies, percentages			
	0-2	3-5	6-8	9-10		0-2	3-5	6-8	9-10		0-2	3-5	6-8	9-10
1940	13	6	2	10	1940	13	6	2	10	1940	41.9	19.4	6.5	32.3
1939	10	2	4	15	1939	23	8	6	25	1939	37.1	12.9	9.7	40.3
1938	13	1	2	15	1938	36	9	8	15	1938	38.7	9.7	8.6	43.0
1937	6	1	5	19	1937	42	10	13	59	1937	33.9	8.0	10.5	47.6
1936	13	2	3	13	1936	55	12	16	72	1936	35.5	7.7	10.3	46.4
1935	17	1	2	11	1935	72	13	18	83	1935	38.7	7.0	9.7	42.9

Seasons were treated similarly by grouping together; for winter, the months from December-February; spring, March-May; summer, June-August, and autumn, September-November.

For the present purpose an arbitrary limit, 5 percent, was set to obtain the number of years after which the distribution became constant within this limit. In other words, by adding one or more years to the distribution, none of the subsequent values in any class interval varied by more than 5 percent from the year in which the "limit" was reached. An example is shown in table 4.

As can be seen from table 4, after 6 years none of the percentage frequency values in any step changes by more than 5 percent in any additional subsequent years. This holds even if the series is extended to 35 years. For purposes of comparison, the 35-year values are given at the end of the table. Compared to the 10-year level, none of the subsequent steps differs by more than 2 percent. This shows that no significant gain in accuracy would have been attained by the use of 35 years of data.

Table 4.--Cumulative Percentage Frequency of Cloudiness Steps,  
October, Washington, D.C., for Varying Lengths of Record

No. of Years of Data	Cloudiness			
	0-2	3-5	6-8	9-10
1	48.39	9.68	3.22	38.71
2	46.77	6.45	4.84	41.94
3	56.99	5.38	4.30	33.33
4	58.06	4.84	4.84	32.26
5	56.77	5.81	7.10	30.32
6	58.45	6.45	8.60	28.49
7	58.53	6.91	7.83	26.73
8	60.89	6.05	7.26	25.80
9	59.86	5.38	6.81	27.95
10	60.00	4.84	7.10	28.06
⋮				
35	58.34	6.82	9.12	25.71

#### V. RESULTS

The results are shown in summarizing tables which give the number of years necessary to reach the 5 percent constancy limit set for the purpose.

Table 5.--Number of Years of Monthly Data  
Necessary for a Frequency Distribution by Steps  
(as Shown in Table 2) of Horizontal Visibilities  
To Be Accurate within 5 Percent for Various Stations

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Abbeville	2	5	4	1	2	3	1	2	4	3	2	3
Le Bourget	7	7	2	3	6	2	4	6	4	6	5	7
Perpignan	7	8	7	7	6	7	7	7	7	7	7	7
Palermo	8	8	8	10	6	9	6	9	9	9	10	9
Roma	6	6	4	5	4	5	6	5	5	7	7	4
Genova	3	4	4	4	9	5	9	5	5	7	8	9
Washington, D.C.	4	5	4	5	6	5	5	6	6	4	3	6

Table 6.--Number of Years of Monthly Data Necessary for Frequency Distribution by Steps of Cloud Heights to be Accurate within 5 Percent, for Various Stations

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Abbeville	4	4	5	6	5	3	3	6	5	3	5	5
Le Bourget	3	4	5	3	4	5	4	3	4	2	2	3
Perpignan	5	7	6	3	4	4	3	6	6	6	6	6

Table 7.--Number of Years of Monthly Data Necessary for Frequency Distribution by Steps of Cloudiness to be Accurate within 5 Percent

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Washington, D.C.	7	6	11	3	5	5	11	11	9	6	3	3

Table 8.--Number of Years of Monthly Data Necessary for Frequency Distribution by Steps of Rainfall Persistence (in Days) to be Accurate within 5 Percent

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Washington, D.C.	9	6	13	14	13	8	20	13	11	12	10	10

Table 9.--Number of Years of Monthly Data Necessary for Frequency Distribution by Steps of Wind Velocities to be Accurate within 5 Percent for Various Stations

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
St. Inglevert	3	3	2	4	3	4	5	4	3	3	3	1
Palermo	4	3	4	4	2	2	7	7	7	6	5	5
Roma	8	7	8	8	8	7	7	7	7	5	5	3
Genova	5	4	4	7	7	7	6	5	7	5	6	5
Pas Engelah	8	8	8	9	8	8	9	9	9	8	9	8
Thyna	7	8	8	6	8	8	8	9	9	8	8	6

The same data are repeated for seasons\*, with the difference in the number of years which will yield a constant distribution within the 5 percent limit for the individual months as compared to the respective seasonal limits.

Table 10.--Number of Years of Seasonal Data Necessary for Frequency Distribution by Steps of Visibility to be Accurate within 5 Percent, and (in Parentheses) the Average Number of Years More (+) or Less (-) of Data Needed for a Monthly and Seasonal Summary

Station	Winter	Spring	Summer	Autumn
Abbeville	2 (+1)	2 (0)	1 (+1)	2 (+1)
Le Bourget	7 (0)	3 (+1)	3 (+1)	5 (0)
Perpignan	7 (0)	7 (0)	7 (0)	7 (0)
Palermo	9 (-1)	8 (0)	9 (-1)	9 (0)
Roma	7 (-2)	7 (-3)	5 (0)	3 (+3)
Genova	5 (+1)	7 (-1)	5 (-1)	4 (+3)
Washington, D.C.	4 (+1)	5 (0)	6 (-1)	5 (-1)

Table 11.--Number of Years of Seasonal Data Necessary for Frequency Distribution by Steps of Cloud Heights to be Accurate within 5 Percent, and (in Parentheses) the Average Number of Years More (+) or Less (-) Needed for a Seasonal and Monthly Summary

Station	Winter	Spring	Summer	Autumn
Abbeville	3	3	3	2
Le Bourget	3 (0)	3 (+1)	3 (+1)	2 (+1)
Perpignan	5	6	6	6

Table 12.--Number of Years of Seasonal Data Necessary for Frequency Distribution by Steps of Wind Velocities to be Accurate within 5 Percent, and (in Parentheses) the Average Number of Years More (+) or Less (-) Needed for a Seasonal and Monthly Summary

Station	Winter	Spring	Summer	Autumn
St. Inglevert	1 (+1)	3 (0)	4 (0)	2 (+1)
Palermo	4 (0)	3 (0)	7 (-2)	5 (0)
Roma	7 (-1)	8 (0)	8 (-1)	1 (+5)
Genova	5 (0)	7 (-1)	6 (0)	5 (+2)

\*Time did not permit the extension of the seasonal study to all stations and elements.

A comparison of wind direction and velocity frequency distribution by seasons, as obtained from a 13-year record and a 5-year record at Shanghai, was also made. Two independent series in a monsoon region were used for this study. The results are shown in table 13.

Table 13.--Percentage Frequencies of Wind Directions and Velocities as Given by a 5-Year Record and a 13-Year Record

Direction	Calm		N.		NE.		E.		SE.		S.		S.		W.		NW.	
	Years	5 13	Years	5 13	Years	5 13	Years	5 13	Years	5 13	Years	5 13	Years	5 13	Years	5 13	Years	5 13
Winter (Dec.-Feb.)																		
Velocity, m.p.h.																		
1-8			10	10	6	5	4	2	3	2	2	1	2	2	3	2	8	7
9-18			9	12	8	10	6	8	5	5	3	2	2	1	6	5	11	16
19-32			2	1	1	0	0	0	1	0	0	0	0	0	2	2	5	4
Greater than 32			0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Calm	0	3																
Spring (Mar.-May)																		
1-8			5	5	5	4	4	4	6	4	2	3	1	2	2	2	3	3
9-18			6	6	8	7	13	13	14	16	5	8	2	2	3	3	6	6
19-32			1	0	1	1	2	1	4	3	2	1	0	0	2	1	2	2
Greater than 32			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calm	1	3																
Summer (June-Aug.)																		
1-8			4	2	4	3	5	5	7	5	5	5	2	4	2	2	2	2
9-18			3	2	6	4	13	11	17	19	10	13	3	5	1	3	2	2
19-32			0	0	1	1	3	3	5	4	3	1	0	0	1	1	0	0
Greater than 32			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calm	1	3																
Autumn (Sept.-Nov.)																		
1-8			10	9	7	7	6	5	4	4	2	2	2	3	3	3	9	7
9-18			10	10	9	10	8	9	5	6	3	3	1	1	4	4	8	9
19-32			1	1	1	1	0	0	1	0	0	0	0	0	2	1	3	1
Greater than 32			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calm	1	3																

The result is that only in one group did the difference between the two records amount to as much as 5 percent (winter, N.E., 9-18 m.p.h.). In three additional cases the difference amounted to 3 percent, but in all other groups the difference between the records is 2 percent or less. As a matter of fact, the two series are amazingly alike, and the picture conveyed by the 5-year record gives as much information on the mean wind conditions at Shanghai as the 13-year record.

## VI. DISCUSSION

For practical purposes, the difference shown for various months cannot be exploited. The month which needs the longest series of records governs the number of years for which data have to be compiled for climatic studies, unless they are carried on for an individual season only.

There are considerable differences between stations, with those in the maritime zone of the westerly cyclonic circulation reaching constant values much earlier than those in the subtropical zone.

A general length of record needed for westerly and subtropical circulations, by elements, is shown in table 14.

Table 14.—Summary of Lengths of Records Needed

Element	Westerly Circulation	Subtropical Circulation
Visibility	5-7 yrs.; monthly basis	8-10 yrs.; monthly basis
	2-7 yrs.; seasonal basis	7-9 yrs.; seasonal basis
Cloud height	5-6 yrs.; monthly basis	7 yrs.; monthly basis
	3 yrs.; seasonal basis	6 yrs.; seasonal basis
Cloudiness	11 yrs.; monthly basis	---
Wind velocity	5-7 yrs.; monthly basis	8-9 yrs.; monthly basis
	4 yrs.; seasonal basis	7-8 yrs.; seasonal basis
Persistence of precipitation	20 yrs.; monthly basis	---

## VII. ILLUSTRATIONS

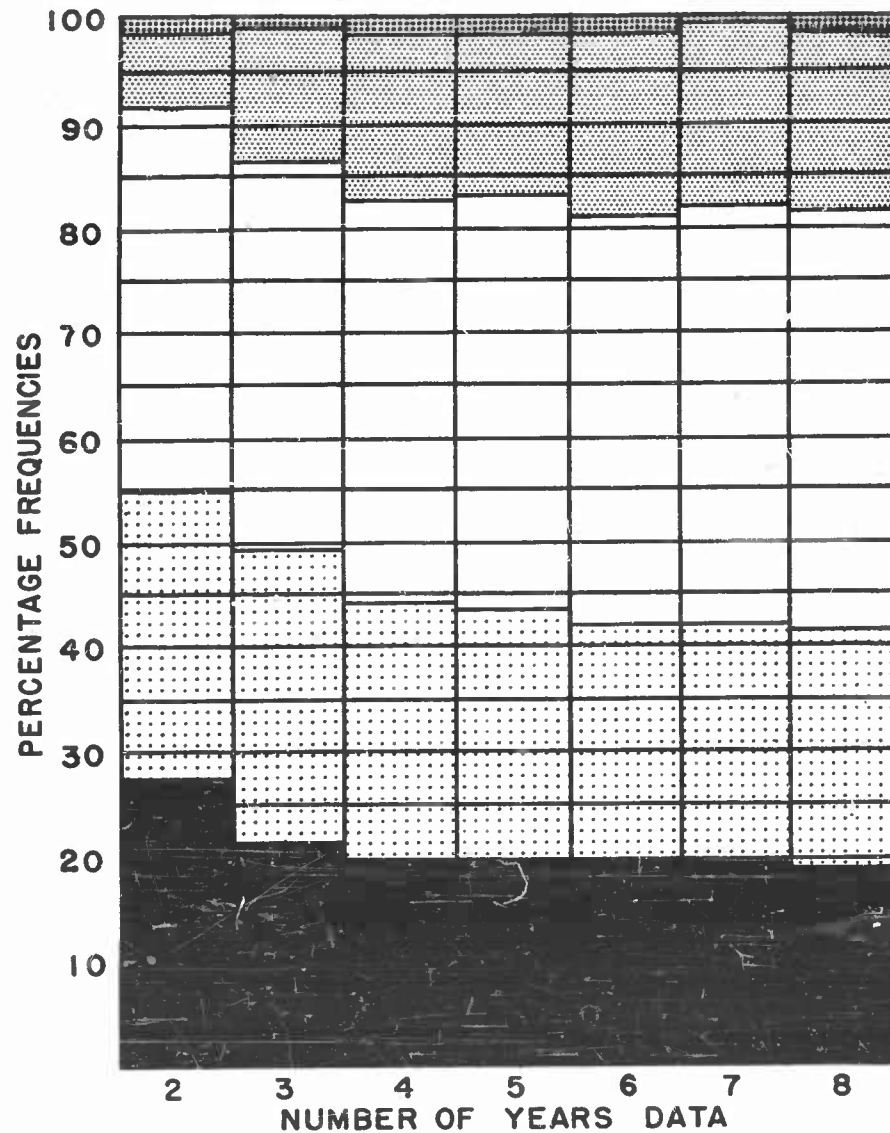
Attached are some graphical illustrations of the effect of length of record.

## VIII. CONCLUSION

In order to play safe, the upper limit of years, indicated in table 14, should be used, as far as data are available, for summarization of climatic elements, as shown in table 15.

Table 15.--Summarization of Climatic Elements

	<u>Westerly Circulation</u>		<u>Subtropical Circulation</u>	
	<u>Monthly basis</u>	<u>Seasonal basis</u>	<u>Monthly basis</u>	<u>Seasonal basis</u>
Visibility	7	7	10	9
Cloud height	6	3	7	6
Cloudiness	11	*	*	*
Wind velocity	7	4	9	8
Wind direction	*	*	*	5
Persistence of precipitation on successive days	20	*	*	*

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LEGEND  
(HORIZONTAL VISIBILITIES—INTERNATIONAL SCALE)

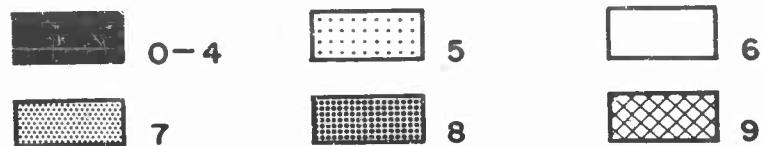
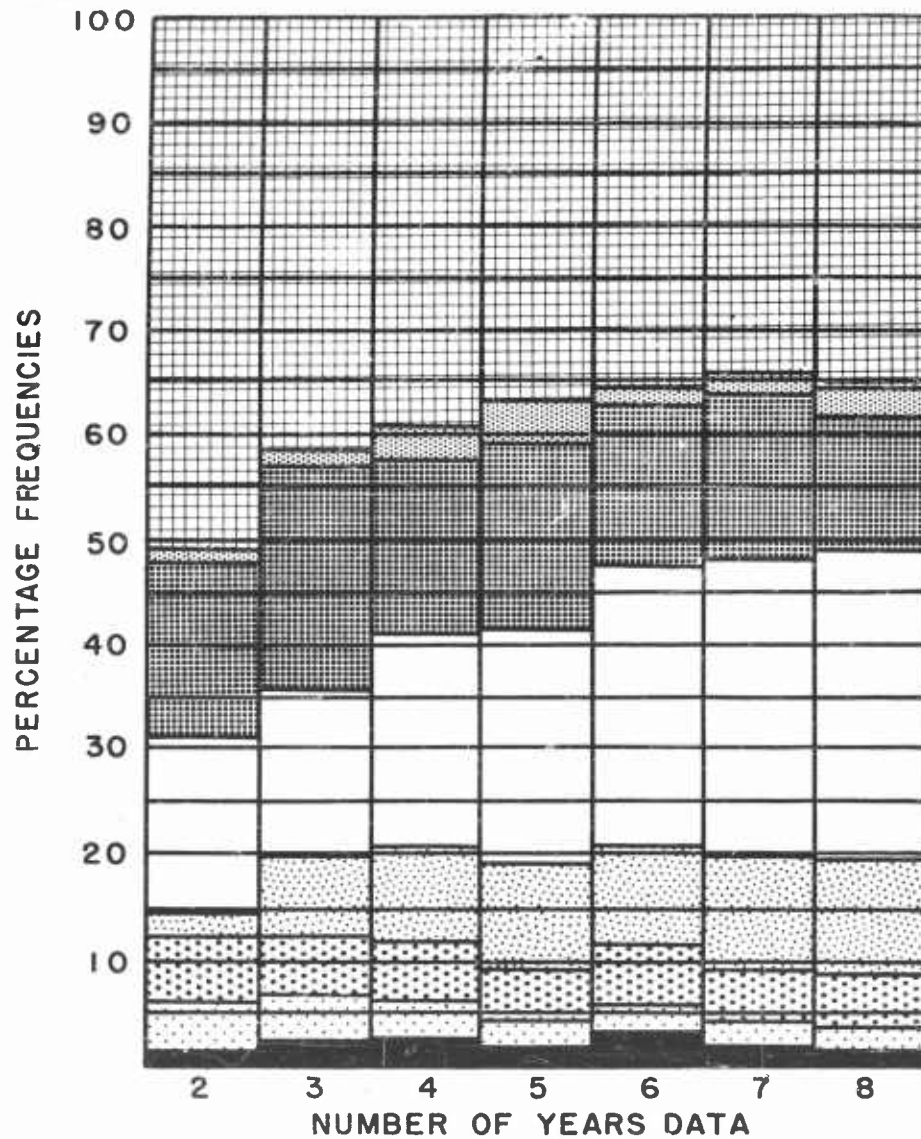


FIG. I.- CUMULATIVE DISTRIBUTIONS OF PERCENTAGE FREQUENCIES OF APRIL. HORIZONTAL VISIBILITIES AT LE BOURGET, 0700 L.T., USING 2 TO 8 YEARS OF DATA.

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LEGEND  
(CLOUD HEIGHTS IN METERS)

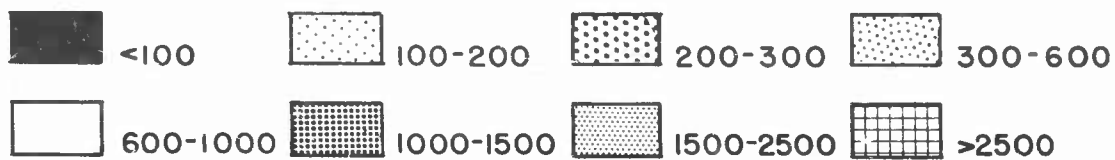
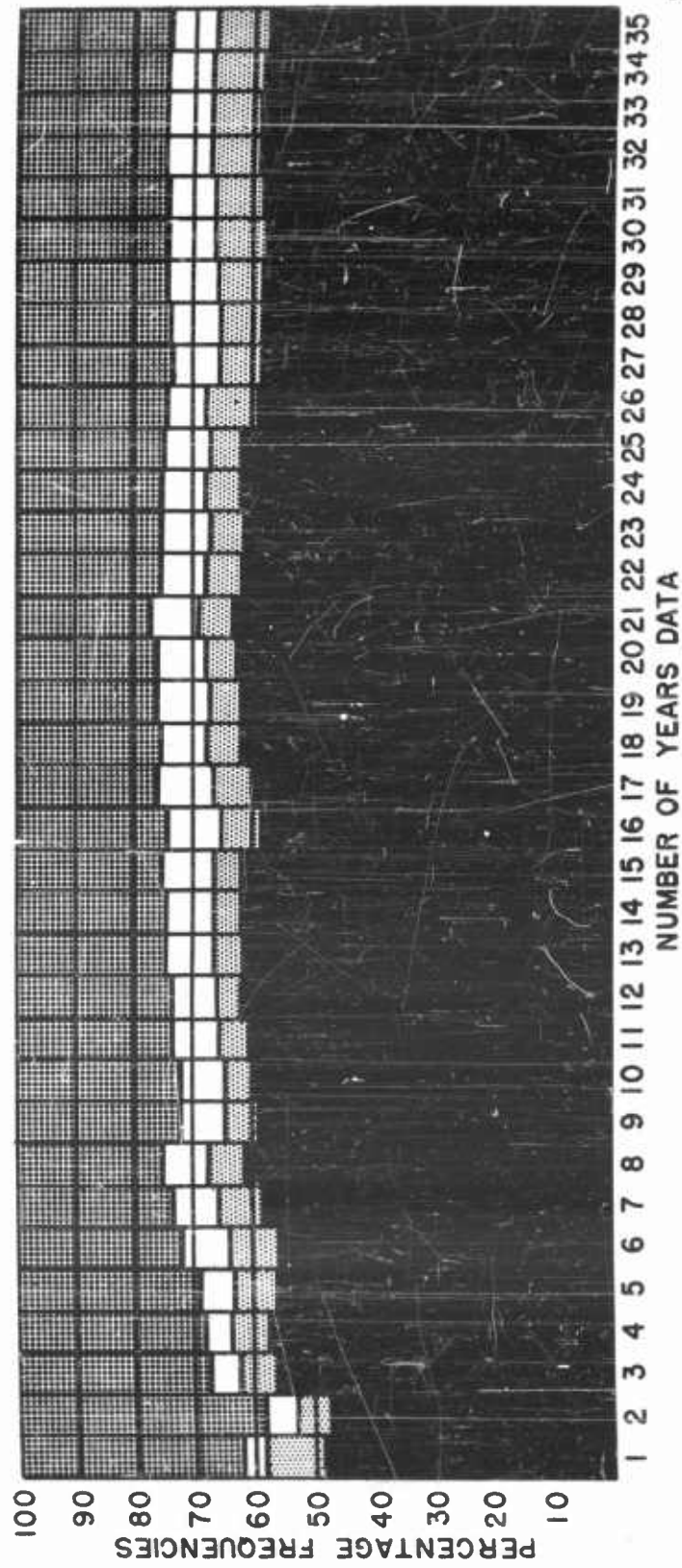


FIG.2.- CUMULATIVE DISTRIBUTIONS OF PERCENTAGE FREQUENCIES OF OCTOBER CLOUD HEIGHTS AT PERPIGNAN, 0700 L.T., USING 2 TO 8 YEARS OF DATA.



LEGEND  
(CLOUDINESS IN TENTHS OF SKY COVERAGE)

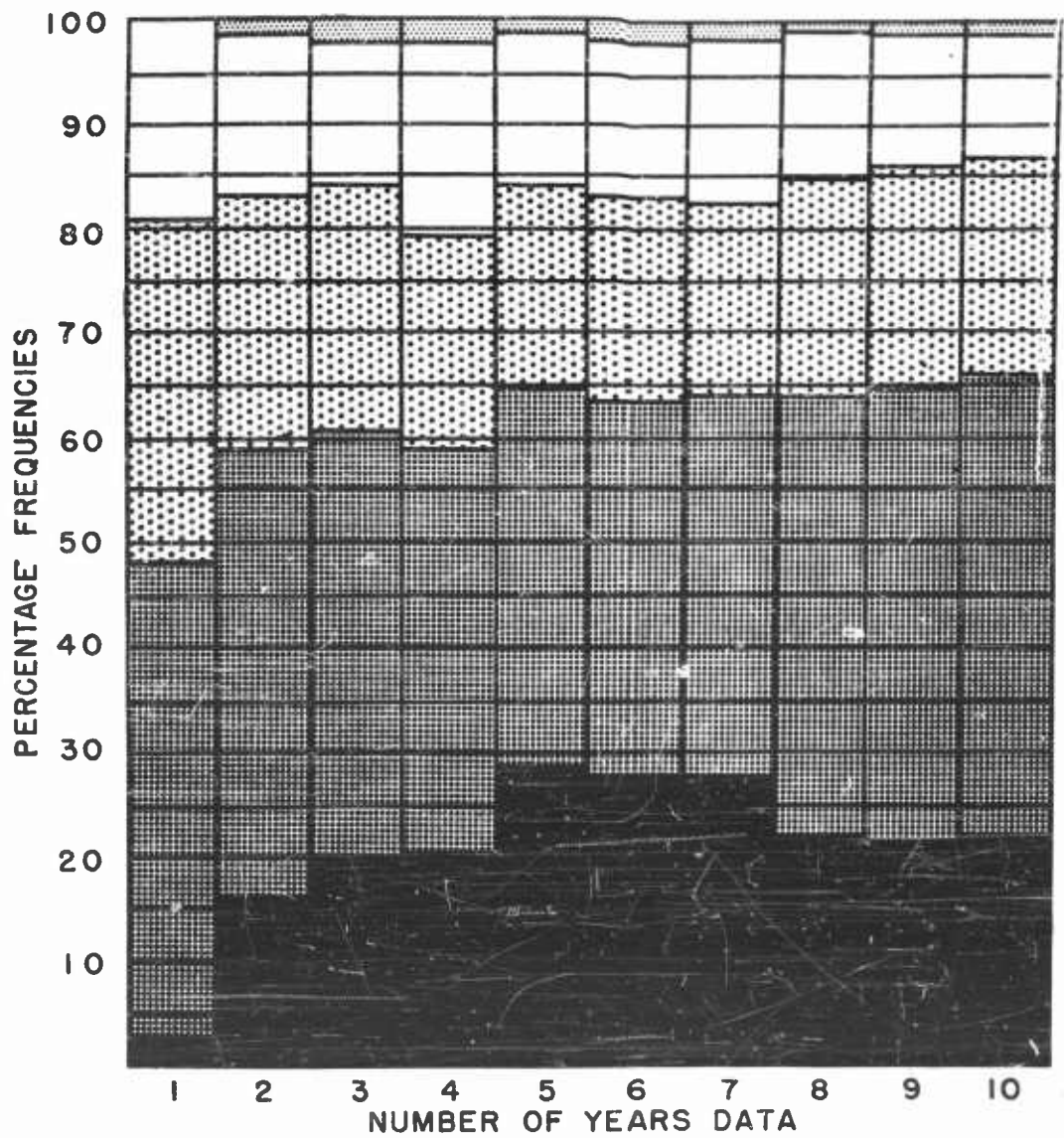


FIG. 3 - CUMULATIVE DISTRIBUTIONS OF PERCENTAGE FREQUENCIES OF AMOUNTS OF CLOUDINESS, 1930 L.T., OCTOBER, WASHINGTON, D.C., USING 1 TO 35 YEARS OF DATA.

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LEGEND  
( WIND VELOCITIES - KMS. PER HR.)

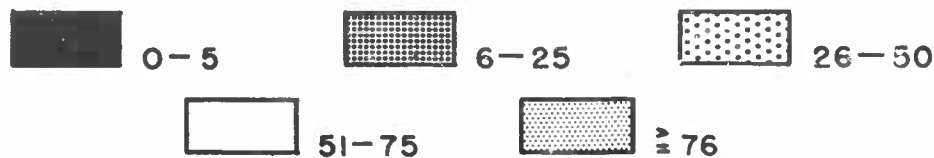


FIG.4.-CUMULATIVE DISTRIBUTIONS OF PERCENTAGE FREQUENCIES OF VARIOUS INTENSITIES OF JANUARY. WIND VELOCITIES AT GENOVA, 1300 LT., USING 1 TO 10 YEARS OF DATA.

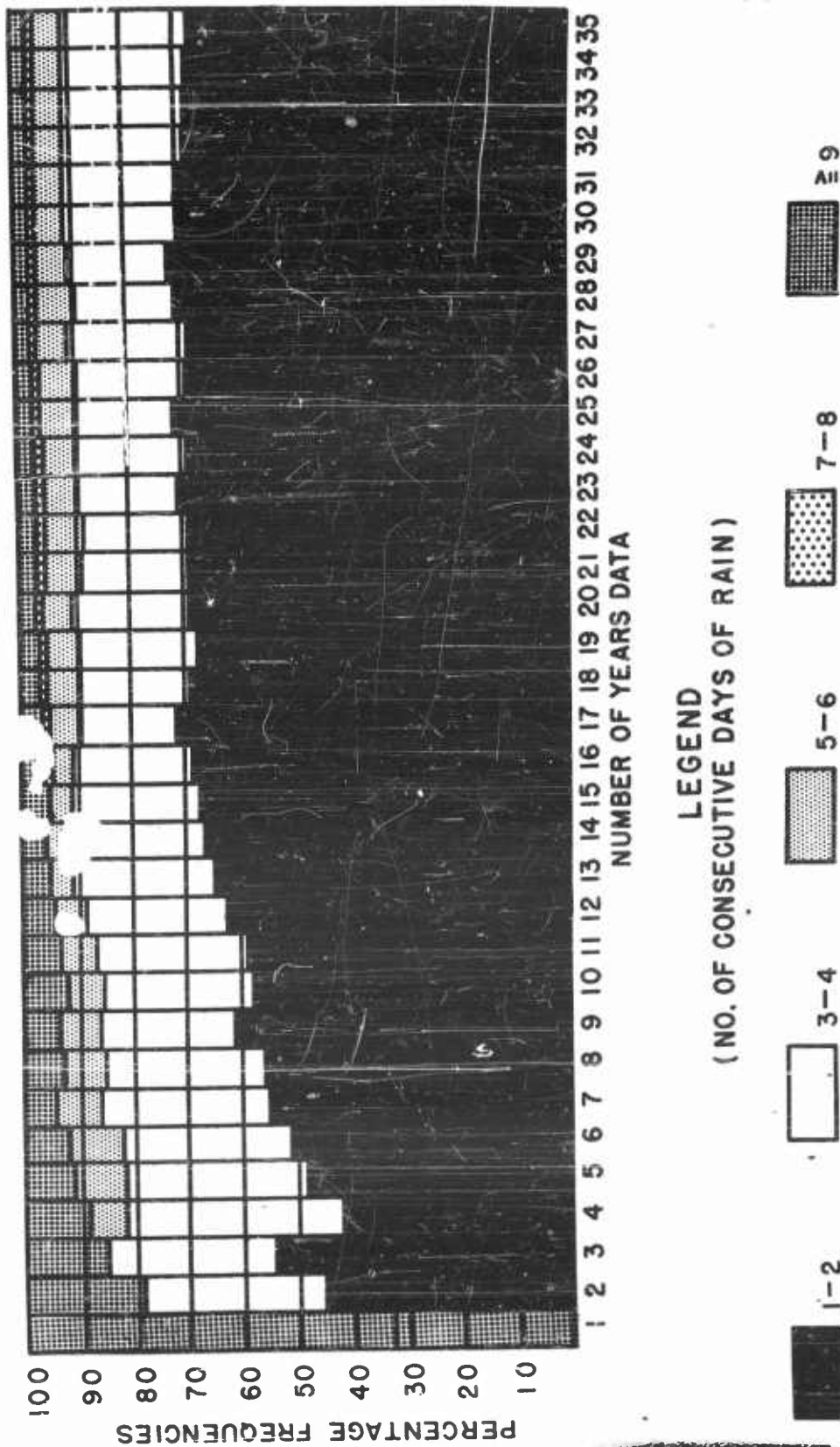


FIG. 5.- CUMULATIVE DISTRIBUTIONS OF PERCENTAGE FREQUENCIES OF RAINFALL PERSISTENCE ON SUCCESSIVE DAYS IN AUGUST, WASHINGTON, D.C., USING 1 TO 35 YEARS OF DATA.

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**Study of Length of Record Needed to Obtain Satisfactory Climatic Summaries for Various Meteorological Elements**

(Not known)

U.S. Army Air Forces Weather Information Branch, Washington, D. C.

U.S. Air Force, Air Weather Service, Washington, D. C.

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(None)

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The number of years needed to obtain a relatively constant frequency distribution of various meteorological elements were determined. The elements which were analyzed were those which had not been studied previously by climatologists with regard to the significant levels obtained by varying length of record. These elements are horizontal visibility, cloud altitudes, cloudiness, persistence of rain, and surface-wind velocity. Places from which data were obtained included stations in Italy, France, Africa, China, and the U.S. The results are shown in summarizing tables which give the number of years necessary to reach the five-percent constancy limit set for the purpose of obtaining the number of years after which the distribution became constant within this limit.

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