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FINAL REPORT

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ERTS CLOUD COVER STUDY

March 1971

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16. Abstract

This report presents the results of a study to develop cloud statistics and probability-of-seeing values especially applicable to Earth Resources Technology Satellites (ERTS). Basic cloud statistics developed in a prior NASA-MSFC funded study are adjusted to the ERTS field-of-view and probability-of-seeing values are determined for single look, one- or two-look, and continuous viewing (look on every pass) modes. Two further adjustments are studied and reported upon. First, the cloud statistics adjustment for variable sensor resolution in terms of variable sizes of cloud-free viewing elements is developed from U-2, Apollo, and ESSA photographs. Second, the validity of the U.S. homogeneous cloud regions is studied and recommendations for improvement for ERTS viewing are made.

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FOREWORD

This final report is submitted to NASA-GSFC in accordance with requirements of NASA Contract NAS5-11231, ERTS Cloud Cover Study by the Space Division of North American Rockwell Corporation.

This report was prepared by C. D. Martin (Program Manager) and B. Liley of the Advanced Research Group of the Flight Technology Department. Programming assistance to the study was supplied by S. C. Hamilton, F. Rosenthal, and M. Figoten.

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1.0 INTRODUCTION

1.1 STUDY OBJECTIVE

Platforms such as the earth resources technology satellites (ERTS's) are scheduled to carry remote sensors to map parameters that will permit evaluation of mineralogical, hydrological, oceanographic, and agricultural resources. The sensors will operate primarily in the visible and infrared portions of the electromagnetic spectrum, hence the extent and validity of the measurements can be seriously degraded by clouds between the sensors and the earth's surface.

Reference 1 has recently described the use of cloud statistics in ERTS mission planning. It is noted therein that, for the design of the ERTS system to be evaluated and optimized, it is necessary that the frequency of cloud-free areas of appropriate size be known. Further, the broad objective of cloud statistics studies related to the ERTS program is stated to be:

> "For a specified location and time of day, and defining the cloud-free portion of the sky as consisting only of 'elemental areas,' each of which is completely devoid of clouds, what is the probability that a 'basic sampling area' will be at least a selected percentage cloud free?"

The subject study objective was to develop estimates of the probability of seeing and cloud-free element statistics that will contribute to the attainment of the aforementioned objective.

1.2 TASK DESCRIPTIONS

The study was divided into four tasks:

1. Probability-of-seeing analyses
2. Cloud photograph analyses
3. Cloud statistics adjustment for sensor resolution
4. Cloud region adjustment

The probability-of-seeing task involved computing the probability-of-seeing values for the ERTS field of view (FOV) of 100 by 100 nautical miles.

The analyses were accomplished by adjusting perfect-resolution cloud statistics derived in a previous NASA-MSFC study for so-called standard-size FOV areas of 30 by 30 nautical miles (Reference 2) and developing and/or using three different modes of viewing. The three modes of viewing were single look, one or two looks, and continuous viewing. These modes are described in subsequent sections of this report and in more detail in Reference 3. Probabilities were derived for world-wide cloud regions for mid-season months for 1000 local standard time (LST) and 2200 LST.

The cloud photograph task involved deriving the variation of total cloud-free area as the resolution, in terms of square elemental or unit areas within the FOV, varies. Data were derived from U-2, Apollo, and ESSA photographs in order to provide a large range of elemental square areas. The minimum resolution square unit for which statistics were derived was about 30 meters on a side.

The statistics task required summarizing data derived in the cloud photograph analyses into representative curves of resolution versus total cloud free area. The representative curves are developed for selected cloud-amount categories of the perfect-resolution data. Thus, they provide a means of using the basic cloud statistics (perfect resolution) to compute the probability of seeing for varying sensor resolutions.

An additional potential adjustment to the basic cloud-cover statistics is one of improved cloud region definition. This study used conventional cloud statistics as collected by ground observers at United States locations and at the time of maximum interest to ERTS (1000 LST). The task scope involves whether the single-station cloud statistics are representative for relatively small fields of view scattered throughout the very large homogeneous cloud-cover regions of Reference 2.

1.3 APPLICABLE CLOUD DATA RESOURCES

The basic cloud-data resources consist of conventional, ground-based cloud observations commonly taken at one-hour intervals and of photographic observations taken from above by aircraft and satellites.

The aircraft and satellite pictorial data are somewhat limited in length of observations, geographical extent, and time of observations. The U-2 aircraft and Apollo data provide the high resolutions required for determining cloud cover versus small cloud-free resolution units and have been used for this purpose in the cloud photograph analyses. Photographs from the ESSA satellite have also been analyzed to provide data for larger fields of view, higher latitudes, and larger resolution square elements.

The ground-based observations are best from length of record, availability of summarized data, and frequency of observation viewpoints. These observations, however, are very limited over ocean areas and sparsely populated land areas. For the United States, these data represent the best resource for potential homogeneous region subdivision and have been used in that aspect of this study.

A recent publication by Salomonson (Reference 1) presents a thorough discussion and evaluation of basic cloud data available for earth resources technology satellite mission planning. Reference should be made to this publication for a more complete discussion of basic cloud data resources.

2.0 PROBABILITY OF SEEING ANALYSES

In this section, results are presented of analyses to determine the probability of seeing for the ERTS field of view of 100 x 100 nautical miles (~185 x 185 kilometers). These probability values are based upon cloud statistics (frequency distributions) prepared in a previous NASA-MSFC study (Reference 2). These basic statistics are assumed to represent the true cloud cover for an area 30 by 30 nautical miles and are referred to herein as perfect-resolution, standard-area, cloud statistics.

An adjustment of the basic cloud statistics for the standard area to the larger ERTS field of view was required prior to the probability computations. After this enlarged area adjustment to the basic cloud statistics, the probability-of-seeing values were determined for single-look, one- or two-look, and continuous viewing modes. Results were computed for worldwide locations (all 29 homogeneous cloud regions) and for 1000 LST and 2200 LST.

A discussion and results from each of the elements of the probability of seeing analyses follow.

2.1 BASIC CLOUD STATISTICS RESOURCE

The basic cloud-statistics resource depends almost entirely upon two types of observations. The first consists of conventional cloud observations in which the horizon-to-horizon cloud amount is estimated by a ground-based observer and expressed as the amount of total sky obscured by clouds. The second consists of cloud data collected by satellites. The recent amalgamation and summarization of such data for 29 regions, selected as exhibiting climatically homogeneous cloud cover, has been published (Reference 2). It was undertaken by Allied Research Associates, Inc., for the NASA Marshall Space Flight Center. In spite of limitations as to accuracy, compatibility, and completeness of the basic data and the validity of the selection of the 29 climatically homogeneous regions, the worldwide statistics of this report represent a significant improvement in basic cloud statistics.

The basic cloud observations have been assembled into unconditional and conditional frequency distributions in Reference 2. The unconditional cloud-cover statistics are frequency distributions of fractions of the sky covered by clouds, expressed in percent frequency, for each month and for three-hour intervals throughout the day, for a standard-size area of about 30 to 60 nautical miles in diameter. The diameter of 30 nautical miles is representative of ground observations. The diameter of 60 nautical miles is more appropriate for satellite data from over the oceans. Conditional distributions for both space and time domains for seasons are presented for separations of 200 nautical miles and 24 hours for a standard-size area of 60 nautical miles in diameter.

The fraction of the sky covered by clouds in the basic observations was grouped into five cloud categories in Reference 2. These categories were:

Cloud Category	Cloud Cover Amount (Tenths)
1	0
2	1, 2, 3
3	4, 5
4	6, 7, 8, 9
5	10

Figure 2-1 is an example of the basic cloud statistics as provided in punched card format for Climatological Region 1 and for the month of January.

Region 1, Month 1

UNCONDITIONAL PROBABILITIES (UNCON)

Time (LST)

Cat	01	04	07	10	13	16	19	22
1	.62	.63	.49	.44	.42	.39	.46	.59
2	.14	.12	.17	.16	.18	.19	.18	.15
3	.06	.07	.10	.09	.07	.10	.10	.08
4	.11	.10	.14	.20	.22	.20	.17	.10
5	.07	.08	.10	.11	.11	.12	.09	.08

CONDITIONAL PROBABILITIES

24-HR TEMPORAL (TCOND)

		1	2	3	4	5
G	1	.85	.08	.05	.02	.0
I	2	.78	.12	.05	.05	.0
V	3	.75	.10	.10	.05	.0
E	4	.80	.05	.05	.05	.05
N	5	.80	.08	.05	.05	.02

200 NM SPATIAL (SCOND)

		1	2	3	4	5
G	1	.81	.07	.03	.09	.0
I	2	.70	.10	.0	.20	.0
V	3	.57	.29	.0	.14	.0
E	4	.50	.0	.07	.29	.14
N	5	.0	.0	.0	.01	.99

Figure 2-1. Basic Cloud Cover Statistics for Climatological Region 1 for January

Selection of the 29 climatically homogeneous cloud regions of Reference 2 was based upon standard climatological summaries and upon satellite summaries. The regions selected exhibit straight-line boundaries for computer simulation. The final cloud statistics for each region were derived from a "representative" station. Figure 2-2 is a map of the location of the 29 regions selected as representative of world-wide cloud cover. The variation in cloud cover within U.S. regions and potential subregionalization for ERTS studies are discussed in a subsequent section of this report.

The unconditional probabilities (UNCON), the spatial conditional probabilities (SCOND), and the homogeneous cloud regions of Figure 2-2 represent the basic cloud statistics resource used to develop ERTS probability-of-seeing analyses in the following sections. It should be noted that the UNCON basic statistics are for a standard-size area of approximately 30 nautical miles on a side and that an area enlargement to 100 nautical miles on a side was required before use in ERTS seeing-probability analyses.

2.2 PROBABILITY OF SEEING MODES

The three repeated-pass seeing modes for which ERTS probability-of-seeing values were derived consisted of the single-look, one- or two-look, and continuous-viewing modes. Two additional sets of statistics consisting of mean cloud cover values and cumulative frequency distributions were also derived. For all of these derivatives it was necessary first to convert the basic statistics frequency distributions for 30 nautical miles to those for 100 nautical miles.

2.2.1 Single-Look Viewing Definition

The single-look viewing mode is defined herein as seeing all (100 percent) of a target area in a single look during repeated passes. This definition allows the relationship between the number of passes to see all of a target area in a single look and a selected probability level to be determined. Seeing all of an area is related to the relative frequency of Category 1 cloud cover, but a similar relationship could be developed for seeing amounts other than 100 percent. Derivation of the single-look relationship and discussion of results for ERTS FOV are presented in Section 2.4.

2.2.2 One or Two-Look Viewing Definition

The one- or two-look viewing mode allows a selected percentage of an area to be "seen" in either a single look or in combining the amounts seen in each of two looks. A smaller number of passes would be required than

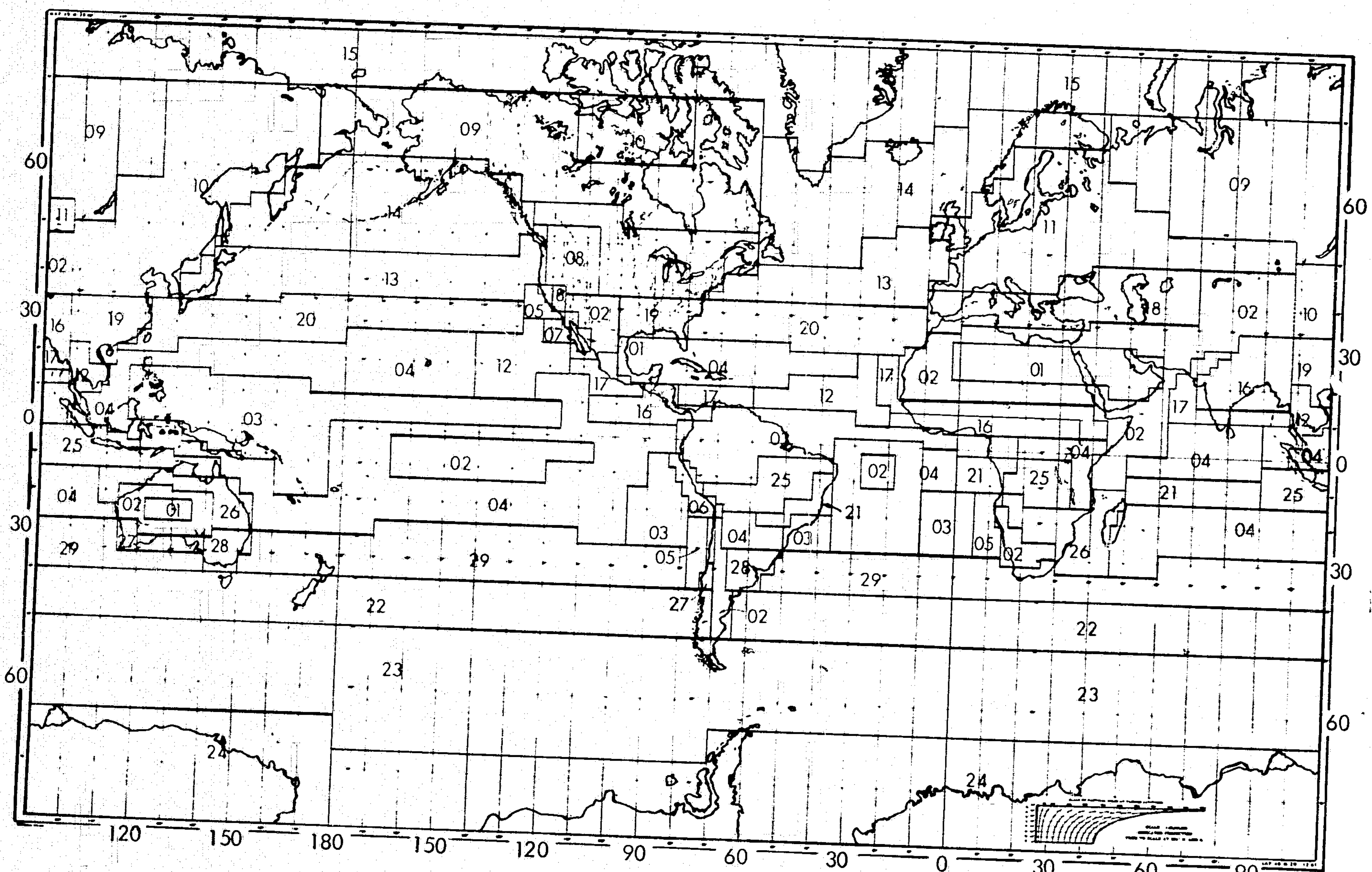


Figure 2-2. Cloud Regions of the World

for seeing in a single look, and the continuous operation of the cameras (or other instruments) is also not programmed as in the continuous viewing mode. This latter case results in the acquisition of little or no data on many passes in high-cloudiness areas and the requirement of large film availability and data analysis. The one- or two-look case as envisioned in real life, however, would require advance information as to real-time cloud cover and on-off sensor operation capability.

Presented in Section 2.5 are derivation of the probability relationship and results for the ERTS field of view at a selected time of day.

2.2.3 Continuous Viewing Definition

Continuous viewing is defined as operation of cameras or other sensors on every pass over a selected area and the piecing together of cloud-free segments acquired during each pass. As in other surveillance modes, the question is the number of passes required to provide a selected probability of "seeing" at least a selected percentage of an area.

A disadvantage of this mode is the operation of sensors when the target area is totally or nearly totally obscured by clouds so that no or little information is acquired. On the other hand, near-real-time cloud data and an on-off sensor operation capability are not required.

Presented in Section 2.6 are a more complete discussion of a continuous viewing simulation scheme and results for typical ERTS operations as regards field of view and time of day.

2.3 ADJUSTMENT OF STATISTICS FOR ERTS FOV

Cloud statistics depend upon area size. For example, at a global area size, the amount of cloud cover is almost constant at near four-tenths. At the other extreme, a small point, the cloud cover may have only two values, i.e., 0/10 or 10/10. For areas between these extremes:

1. The smaller the area viewed, the more U-shaped the cloud frequency distribution.

2. The larger the area viewed, the more bell-shaped the cloud frequency distribution.

Since, the ERTS field of view is larger than the basic cloud statistics field of view, the ERTS cloud frequency distributions should exhibit fewer frequencies of clear (Category 1 or 0/10) and overcast (Category 5 or 10/10) and greater frequencies, in total, of the scattered and broken cloud cover.

2.3.1 Assumed Spatial Relationships

Before the perfect-resolution probabilities of seeing were computed for ERTS missions, it was necessary to adjust the basic cloud statistics for the ERTS field of view. For this purpose the basic statistics field of view is assumed to be a square of 30 nautical miles, whereas the ERTS field of view is assumed to be a square of 100 nautical miles (~185 kilometers).

The objective is to produce scaled unconditional statistics (SUNCON) for the enlarged area of 100 nautical miles on a side. The technique selected is that recommended in Section 7 of Reference 2. The procedure, detailed in Reference 2, involves the following steps:

1. Scale the spatial conditional statistics for 200 nautical miles (SCOND) for the scale distance of 100 to get CONNEW matrix.

2. Construct PJOINT matrix for the joint distribution of data of the basic size and the enlarged size. This is done by multiplying the unconditional distribution UNCON into the scaled conditional matrix CONNEW.

3. Sum the PJOINT matrix for all elements of PJOINT having the same entry in the matching location of the KWHERE matrix. This results in the desired SUNCON distribution.

The procedures followed in deriving the adjusted cloud statistics in this study were identical to those of Reference 2 with one exception. This exception was an adjustment to the KWHERE matrix, as follows:

	KWHERE (Reference 2)					Revised KWHERE Values (This Study)				
Cloud Category	1	2	3	4	5	1	2	3	4	5
1	1	2	2	3	3					4
2	2	2	2	3	3					
3	2	2	3	4	4					
4	3	3	4	4	4					
5	3	3	4	4	5		4			

Revised KWHERE Values: Same except for two indicated values

Verbal communication with the authors of Reference 2 has achieved an agreement that the two revised KWHERE values are more representative than the original values for the NR representative values for the cloud categories. It should be noted that the revised KWHERE values combine

Category 5 (representative value 10/10) with Category 2 (representative value of 2/10) for an average value of (10/10 + 2/10)/2 = 6/10, which falls within Category 4 (6/10, 7/10, 8/10, 9/10) rather than Category 3 (4/10, 5/10).

2.3.2 Computer-Derived Results, Frequencies and Mean Values

The basic statistics were adjusted to those for the ERTS field of view via a computer program developed to generate a magnetic tape of the basic cloud statistics from punched card data supplied by investigators from the NASA Marshall Space Flight Center, sponsor of the development of the basic cloud statistics. The computer program performed the operations listed in the previous section and produced the desired unconditional statistics scaled to the ERTS field of view for all the 29 worldwide regions for each month and for the eight selected times of day. In addition, this program computes cumulative frequency distributions, mean cloud-cover values, and the probability-of-seeing values for single-look, one- or two-look, and continuous viewing. The computer program is described in detail in Appendix A.

2.3.2.1 Frequencies for ERTS Field of View

The SUNCON frequency distributions for the enlarged field of view of 100 nautical miles were derived for each month, each cloud region, and for each of the eight times of day. Results may be illustrated by a comparison of the unconditional frequency distributions for the basic data (standard area) and for the ERTS field of view for the major cloud regions of the United States for 1000 LST for the months of January and July (Table 2-1).

From Table 2-1 it may be noted that the frequency distributions for the enlarged viewing areas of 100 nautical miles demonstrate decreasing probability of clear and overcast skies (Category 1 and 5, respectively) and increasing probability of scattered and broken cloudiness (Categories 2, 3, and 4, respectively). A survey of the computerized printout indicated that this anticipated result also occurred for all regions and times of day. This result verifies the nature of the procedure to produce adjusted cloud statistics for enlarged areas.

Table 2-1. Comparison of Unconditional Frequency Distributions for Standard and Enlarged Areas

Region	Cloud Category and Size: 1/30, 1/100	2/30,2/100	3/30, 3/100	4/30, 4/100	5/30, 5/100
	Jan (1000 LST)				
2	18.0, 14.7	21.0, 17.9	10.0, 14.0	35.0, 41.5	16.0, 12.0
8	7.0, 4.9	11.0, 10.8	5.0, 5.4	21.0, 31.2	56.0, 47.6
11	14.0, 9.9	12.0, 12.6	4.0, 5.8	19.0, 28.4	51.0, 43.3
18	22.0, 16.9	9.0, 12.0	3.0, 7.7	19.0, 32.8	47.0, 30.5
19	16.0, 13.2	8.0, 9.8	4.0, 9.2	16.0, 26.9	56.0, 52.8
	July (1000 LST)				
2	64.0, 58.6	25.0, 28.3	7.0, 7.9	4.0, 5.2	0.0, 0.0
8	51.0, 40.8	23.0, 29.5	7.0, 11.0	15.0, 15.4	4.0, 3.2
11	13.0, 10.4	18.0, 19.8	12.0, 14.0	32.0, 35.7	25.0, 20.0
18	56.0, 52.4	16.0, 19.5	6.0, 11.8	11.0, 10.3	11.0, 6.0
19	12.0, 8.9	22.0, 26.5	17.0, 15.0	32.0, 36.9	17.0, 12.7

In several of the probability-of-seeing modes to be discussed in subsequent sections, it is desirable to have the cloud frequency data in terms of cumulative frequency distributions. For example, the unconditional distribution for January, 1000 LST for Region 2 in Table 2-1 may be converted to the following cumulative frequency distribution:

Cloud Cat.	Uncon	Cum Uncon
1	14.7	14.7
2	17.9	32.6
3	14.0	46.6
4	41.4	88.0
5	12.0	100.00

The computer program described in Appendix A also accumulates the cloud statistics in the aforementioned manner. Figure 2-3 presents a sample computer output of cloud cover frequency distributions adjusted for the enlarged viewing area of ERTS. Figure 2-4 similarly presents results for cumulative frequency distributions.

No.	Reg.	Cat.	Unconditional Probabilities (Uncon)								Cond. 100 n. mi Spatial (Connew)				
											1	2	3	4	5
1	1	1	56.1	57.0	44.3	39.8	38.0	35.3	41.6	53.4	90.5	3.5	1.5	4.5	0.0
1	1	2	18.3	17.0	22.0	20.5	21.3	23.3	22.8	19.9	35.0	55.0	0.0	10.0	0.0
1	1	3	9.9	10.0	12.4	13.1	12.7	13.7	13.1	10.7	28.5	14.5	50.0	7.0	0.0
1	1	4	8.7	8.0	11.2	15.7	17.0	15.8	13.5	8.1	25.0	0.0	3.5	64.5	7.0
1	1	5	7.0	8.0	9.9	10.9	10.9	11.9	9.0	8.0	0.0	0.0	0.0	0.5	99.5
1	2	1	30.2	31.0	17.9	14.7	13.9	13.9	18.7	25.3	81.5	5.5	1.0	10.5	1.5
1	2	2	17.7	15.3	17.5	17.9	18.1	16.7	19.2	18.2	25.0	50.0	0.0	0.0	25.0
1	2	3	14.4	13.8	14.6	14.0	15.0	15.7	14.9	15.2	10.0	0.0	60.0	10.0	20.0
1	2	4	28.8	28.7	39.4	41.4	39.6	40.3	34.4	31.6	11.0	0.0	11.0	61.0	17.0
1	2	5	9.0	11.2	10.5	12.0	13.5	13.5	12.7	9.7	12.5	0.0	6.0	6.5	75.0
1	3	1	11.0	11.7	3.2	2.6	0.6	0.6	2.6	5.8	65.0	10.0	10.0	10.0	5.0
1	3	2	21.4	22.3	16.7	15.0	8.4	9.9	14.3	18.8	0.0	62.5	12.5	25.0	0.0
1	3	3	17.3	18.4	15.5	17.0	14.6	15.8	14.6	16.3	0.0	0.0	73.0	23.0	4.0
1	3	4	34.3	30.8	42.2	42.8	51.7	49.7	43.9	42.0	0.0	0.0	2.5	86.5	11.0
1	3	5	15.9	16.7	22.3	23.1	24.6	23.8	24.6	17.5	0.0	0.0	0.0	20.5	79.5
1	4	1	33.2	33.2	20.5	16.6	12.6	11.1	19.0	30.0	79.0	10.0	3.5	7.5	0.0
1	4	2	20.5	19.5	23.9	25.7	27.5	29.1	27.8	24.8	20.0	63.5	13.5	3.0	0.0
1	4	3	10.2	10.1	11.8	12.9	14.7	14.5	12.8	12.3	14.0	11.0	61.0	11.0	3.0
1	4	4	21.1	20.9	26.2	27.3	32.0	31.5	27.9	20.4	5.0	11.0	15.0	66.0	3.0
1	4	5	15.0	16.2	17.5	17.5	13.1	13.7	12.5	12.5	5.0	1.0	6.5	25.0	62.5

Figure 2-3. Example of Computer Program Output, Frequency Distributions for ERTS FOV

Cumulative Distributions

Month 1, Region 1

Cumulative Unconditional Distributions

1	56.11	57.01	44.34	39.82	38.01	35.29	41.63	53.39
2	74.39	73.97	66.39	60.29	59.32	58.64	64.43	73.28
3	84.33	84.01	78.80	73.37	72.01	72.30	77.55	83.94
4	93.03	92.04	90.05	89.05	89.05	88.06	91.04	92.04
5	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Cumulative Conditional - Temporal

1	85.00	93.00	98.00	100.00	100.00
2	78.00	90.00	95.00	100.00	100.00
3	75.00	85.00	95.00	100.00	100.00
4	80.00	85.00	90.00	95.00	100.00
5	80.00	88.00	93.00	98.00	100.00

Cumulative Conditional - Spatial

1	90.50	94.00	95.50	100.00	100.00
2	35.00	90.00	90.00	100.00	100.00
3	28.50	43.00	93.00	100.00	100.00
4	25.00	25.00	28.50	93.00	100.00
5	0.0	0.0	0.0	0.50	100.00

Figure 2-4. Example of Computer Program Output, Cumulative Frequencies for ERTS FOV

2.3.2.2 Mean Cloud Cover Values for ERTS FOV

The mean cloud cover value is a statistic of value in some satellite mission analyses and it has been derived from the unconditional cloud statistics (SUNCON) for the ERTS FOV.

Computation of the arithmetic mean cloud-cover value from the basic unconditional frequency distributions requires substitution of a representative value of cloud cover for each of the cloud categories of the basic data. Presented here are the cloud categories, cloud cover intervals, and the representative value selected for each category for ERTS mean cloud cover computations:

Cloud Category	Cloud Cover Amount (Tenths)	Representative Value
1	0	0
2	1, 2, 3	0.2
3	4, 5	0.45
4	6, 7, 8, 9	0.75
5	10	1.0

Derivation of the mean cloud cover may be illustrated for 0100 LST for Region 1, January. The basic cloud statistics for this time, location, and month are:

Cloud Category	Percentage Frequency
1	56.1
2	18.3
3	9.9
4	8.7
5	7.0

Using the representative values of the previous section for each cloud category, we may compute the mean cloud cover as:

$$MCC = 0.561\ (0) + 0.183\ (0.2) + 0.099\ (0.45) + 0.087\ (0.75) + 0.070\ (1) = 21.6\%$$

Mean-cloud-cover values were computed for the ERTS field of view by using the SUNCON frequency distributions discussed in the previous section. Figure 2-5 illustrates the computer printout for the example of January, Region 1, for each of the eight times of day at three-hour intervals beginning with 0100 LST. Similar data were computed for all months and

Month 1

Mean Cloud Cover for Region 1 (8 times of day)

21.62	21.89	28.38	32.69	33.70	34.57	29.54	22.8

Day Averages (29 Regions)

32.34 52.69 67.90 48.80 49.18 46.43 46.43 73.35 58.57 40.18
67.81 55.51 78.62 80.43 42.65 39.24 41.39 58.89 66.86 67.47
71.45 73.30 90.41 72.52 85.41 81.99 24.29 54.12 67.85

By Night (29 Regions)

23.97 43.92 58.32 40.74 44.08 50.94 50.94 68.65 42.74 33.01
60.28 64.00 77.19 76.90 38.19 17.43 27.26 51.29 57.79 70.92
81.04 72.32 92.56 75.38 72.50 75.84 30.83 39.69 71.08

By Month (29 Regions)

28.15 48.30 63.11 44.77 46.63 48.68 48.68 71.00 50.65 36.60
64.05 59.76 77.91 78.67 40.42 28.34 34.32 55.09 62.32 69.19
76.25 72.81 91.49 73.95 78.96 78.91 27.56 46.91 69.46

Winter, Spring, Summer Fall, and Annual

Region	W	S	Su	F	A
1	32.07	32.52	13.78	12.11	22.62
2	47.59	41.40	16.67	37.17	35.71
3	64.15	60.81	83.22	77.46	71.41
.					
.					
.					
.					
29	69.29	63.33	70.86	74.47	69.49

Figure 2-5. Example of Computer Program Output, Mean Cloud Cover Values for ERTS FOV

each of the 29 worldwide cloud regions. In addition, the 0700, 1000, 1300, 1600 LST cloud statistics and the 1900, 2200, 0100, and 0400 LST cloud statistics were combined to compute a daytime and nighttime mean percentage cloud cover amount, respectively, for each month and region. Finally, the cloud statistics for the ERTS field of view have been used to compute mean cloud amounts for all hours combined for the entire year and for seasons of December-January-February, March-April-May, June-July-August, and September-October-November.

Table 2-2 presents selected mean cloud cover values for the ERTS FOV as extracted from the computer printout. These selected values are for the major cloud regions of the United States at 1000 LST and 2200 LST.

Table 2-2. Selected Mean Cloud Cover Values Versus Regions, ERTS FOV

Region/ Months	1000 LST/ 2200 LST	Daytime	Nighttime	All Hours (Mo.)	All Hours (Season)	All Hours (Annual)
2 Jan	52.9/43.9	52.7	43.9	48.3	47.6	
Apr	46.8/34.9	46.8	37.2	42.0	41.4	
July	13.1/10.2	13.2	12.6	12.9	16.7	
Oct	46.6/33.8	46.9	35.5	41.2	37.2	
Annual						35.7
8 Jan	75.6/67.8	73.4	68.6	71.0	67.9	
Apr	64.4/54.0	65.2	54.8	60.0	59.1	
Jul	25.6/26.1	28.1	25.1	26.6	33.4	
Oct	45.4/35.5	44.9	35.6	40.2	42.4	
Annual						50.7
11 Jan	69.8/59.4	67.8	60.3	64.0	63.1	
Apr	66.8/55.8	66.8	56.6	61.7	60.2	
July	57.1/38.1	56.8	42.3	49.5	49.1	
Oct	45.5/37.1	46.2	37.0	41.6	45.6	
Annual						54.4
18 Jan	61.0/49.1	58.9	51.3	55.1	53.2	
Apr	45.9/35.0	44.3	38.4	41.4	43.4	
Jul	23.0/24.2	24.3	30.8	27.6	30.6	
Oct	43.8/32.7	40.6	36.2	38.4	37.2	
Annual						41.1
19 Jan	68.5/56.2	66.9	57.8	62.3	58.7	
Apr	64.0/45.2	62.6	51.0	56.8	55.9	
Jul	52.5/36.9	54.1	39.7	46.9	45.3	
Oct	46.7/32.0	46.3	34.6	40.5	43.2	
Annual						50.8

2.3.3 Comparison of Enlarged-Area Statistics With Standard-Area Statistics

Section 2.3.2.1 presented a discussion wherein frequency distributions derived for the field of view of 100 by 100 nautical miles were compared with the standard-area frequency distributions. The expected greater frequencies for the intermediate cloud cover values were exhibited.

The mean values for the enlarged field of view of ERTS would not be expected to shift a great deal from the values for the standard area. Since the major result of the larger viewing area is to produce a frequency distribution of greater central tendency, i.e., more bell shaped, many of the low mean values would tend to increase slightly, and many of the high mean values would be expected to decrease slightly.

Table 2-3 presents mean cloud cover values for the standard-size areas and the enlarged ERTS FOV areas for selected U.S. cloud regions, as extracted from computer-derived results. Both the small actual change and the movement toward a central value of most of the mean values were noted in the table data and in the computer values from which it was extracted.

Table 2-3. Comparison of Mean Cloud Cover Values

	January 1000 LST		July 1000 LST	
Region	30 NM	100 NM	30 NM	100 NM
2	51	52.9	11	13.1
8	76	75.6	23	25.6
11	69	69.8	58	57.1
18	64	61.0	25	23.0
19	71	68.5	53	52.5

2.4 SINGLE-LOOK VIEWING

2.4.1 Cumulative Frequency Distributions

The mean-cloud-cover amount may be very unrepresentative of the expected cloud cover over a region. This is particularly true for cloud regions that exhibit a U-shaped cloud frequency distribution. In this case, the mean amount may be near 0.5 or 50 percent, whereas this value is the amount least frequently observed. The requirement to use the basic frequency distribution of cloud amount in probability determinations, rather than an unrepresentative single value, becomes evident.

In some mission analysis studies, it is useful to be able to determine quickly the probability of encountering cloud cover less than some arbitrary amount on a single pass or look. This probability is easily determined from a linear interpolation of the cumulative percentage frequency cloud cover distribution for the time, month, and region of interest. Additionally, the cumulative statistics are required in probability programs such as the Monte Carlo and Look 12, to be discussed in subsequent sections. As discussed in Section 2.3, the cumulative frequency distributions for the ERTS field of view were developed in this study from the basic data and use of the computer program described in Appendix A.

For interpolation, a plot of the cumulative frequency versus cloud amount is derived by the computer. A somewhat arbitrary choice exists of what cloud amount value to use for each of the cloud categories of the basic data. For example, the representative amounts for each category were discussed previously, but the upper limit of the cloud category must be used for the cumulative distribution plot.

The possible choices for the upper limit are illustrated in Table 2-4.

Table 2-4. Intervals and Upper Limits for Cloud Categories

Category	Amount	Representative Amount	Theoretical Interval	Limit	Observation Interval	Limit
1	<0.1	0	0 -0.05	0.05	<0.1	0.1
2	0.1, 0.2, 0.3	0.2	0.06-0.35	0.35	0.1-0.3	0.3
3	0.4, 0.5	0.45	0.36-0.55	0.55	0.4-0.5	0.5
4	0.6, 0.7, 0.8, 0.9	0.75	0.56-0.95	0.95	0.6-0.9	0.9
5	>0.9	1.0	0.96-1.0	1.0	>0.9-1.0	1.0

The observation limits exist because of the standard observing practices as regards cloud-cover amount. For example, clear skies are reported whenever the amount is less than one-tenth. Overcast skies are reported whenever cloud cover is greater than nine-tenths. For computer interpolation, the "observation" upper limits was used in the plotting of the data accumulated for the cloud categories. Figure 2-6 is an example plot for 1000 LST, January and July, for cloud region 11.

2.4.2 Single-Look Probability of Seeing 100 Percent of an Area

Mean-cloud-cover values are inadequate for most repeated-pass analyses. The question of the number of passes to see all (100 percent) of a target area in a single look at a given probability level is of some importance and may be answered by determining the probability of at least one pass with clear skies (Category 1 cloud cover) in N passes. The basic relationship for repeated, independent looks may be shown to be

$$P_S = 1 - [1 - P(1)]^N \tag{1}$$

where

P_S = probability of success or seeing 100 percent of an area in one look

$P(1)$ = relative frequency of Category 1 clouds

$[1 - P(1)]^N$ = probability of failure or not seeing 100 percent of an area in one look

N = number of passes.

From the above, N may be determined from

$$N = \frac{\ln [1-P_S]}{\ln [1 - P(1)]}$$

The right side of Figure 2-7 presents a nomogram from which may be determined the number of passes required for selected combinations of probability of success and the relative frequency of clear skies (Category 1 in the basic cloud frequency statistics). The probability of success in this instance is defined as the probability of seeing 100 percent of an area in a single look. From Figure 2-7 the probability of success for a selected number of passes or the number of passes required for a selected probability of success may be easily determined. It is only necessary to ascertain the relative frequency of clear skies from the cloud-cover frequency distributions for the appropriate viewing area size, time, month, and cloud region of interest.

REGION II, 1000 LST

CATEGORY	JANUARY UNCON	JANUARY CUM UNCON	JULY UNCON	JULY CUM UNCON
1	9.9	9.9	10.4	10.4
2	12.6	22.5	19.8	30.2
3	5.8	28.3	14.0	44.2
4	28.4	56.7	35.8	80.0
5	43.3	100.0	20.0	100.0

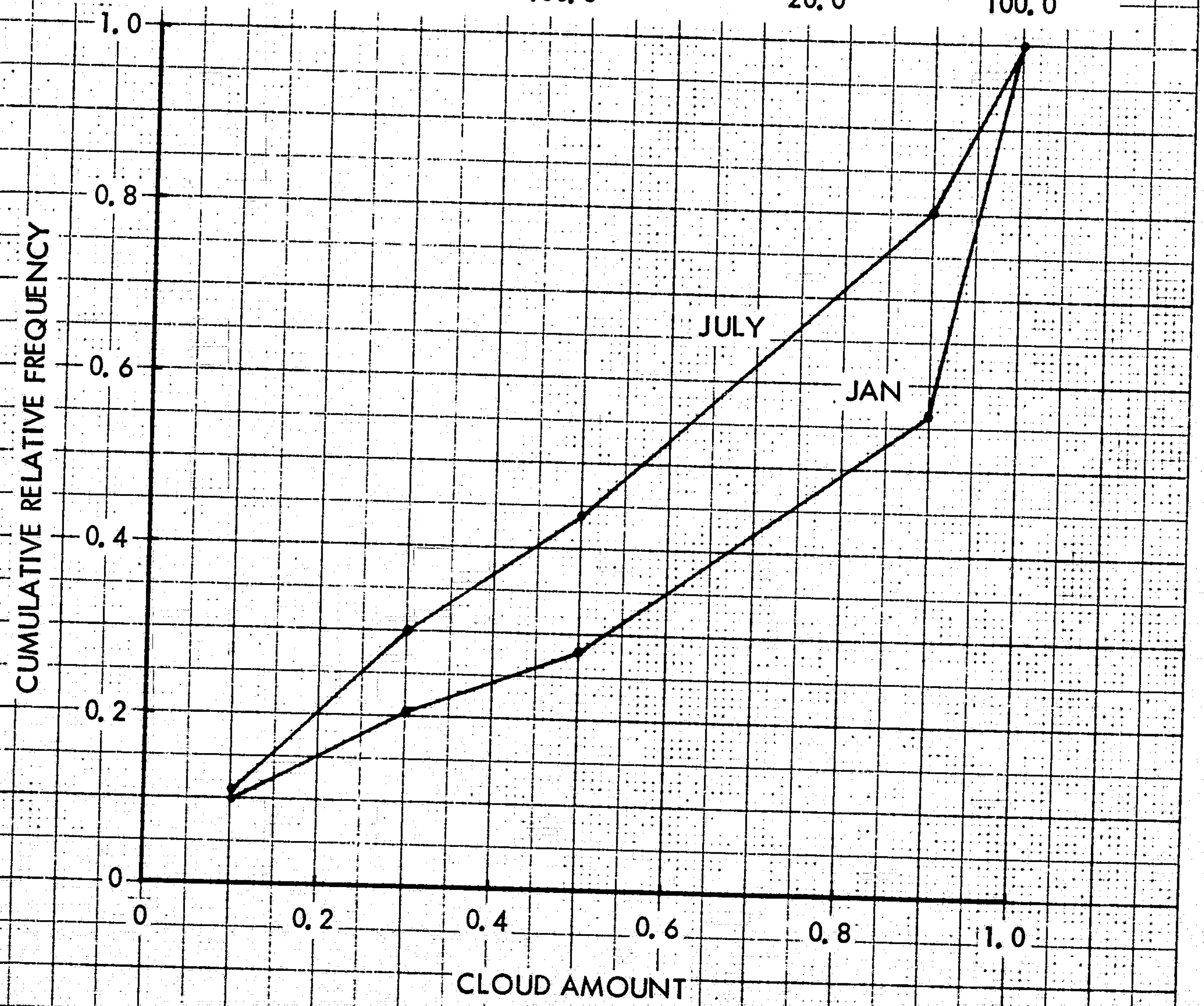


Figure 2-6. Example Plot of Cumulative Frequency Distribution

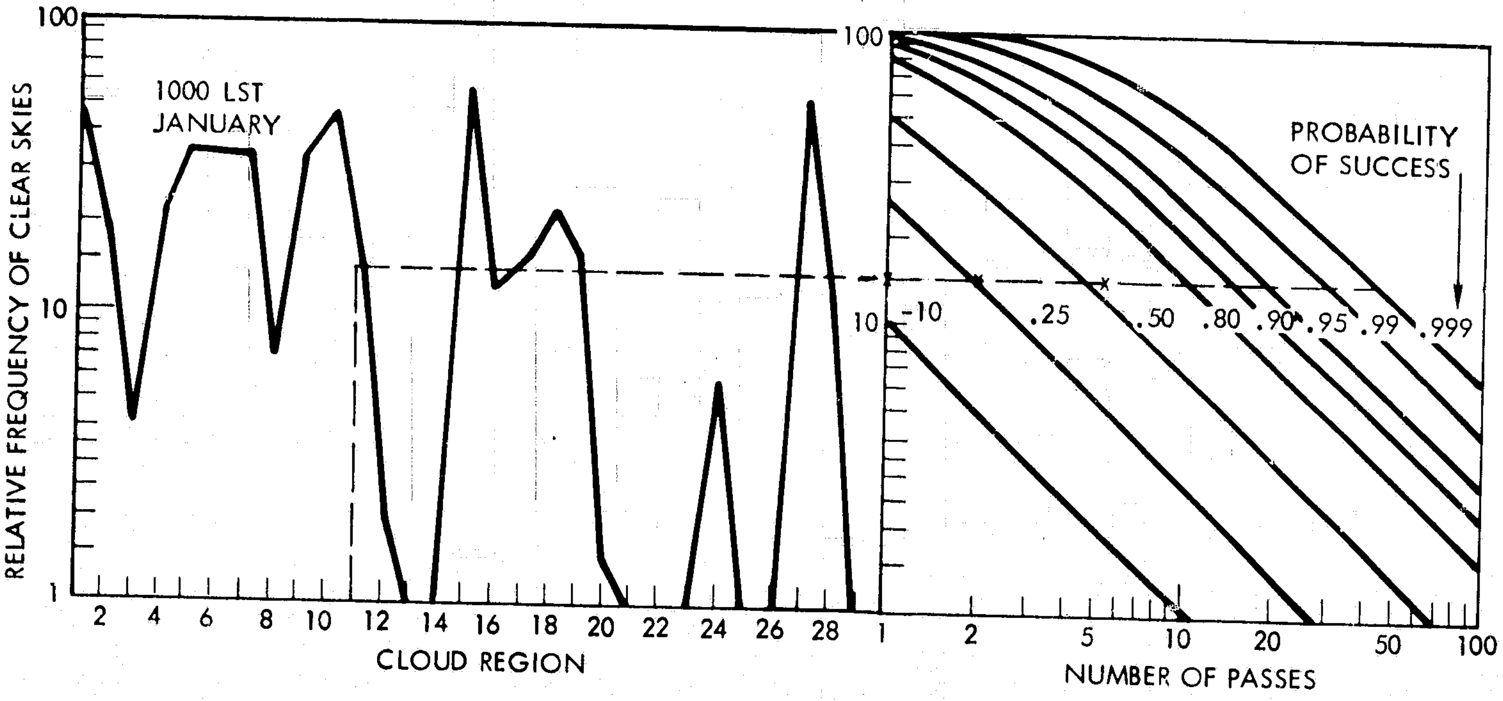


Figure 2-7. Nomogram of Probability of Observing Cloud-Free Areas

To facilitate use of the aforementioned nomogram, we may plot the frequency of clear skies for a selected time and month for all regions and place it beside the nomogram for easy reading. Figure 2-7 illustrates such a combination of data.

It should be noted that the single-look mode is not restricted to seeing all or 100 percent of an area in a single look. Rather, the amount of the area required to be seen in a single look could be any amount, and the basic probability of success of Figure 2-7 would be appropriate. For any other value, the relative frequency of clouds equal to or less than the prescribed successful seeing value would be determined from the cumulative frequency distribution plot. Then this value would be used as the relative frequency value in Figure 2-7.

2.4.3 Computer-Derived Results, Single-Look Viewing

As noted, a single nomogram is applicable for determining the number of passes versus the probability of successful seeing in a single look for any relative frequency of selected cloud amounts or less. The relative frequency of clear skies, or Category 1 cloud cover, is related to the probability of seeing 100 percent of an area in the single look. This is a statistic of interest to ERTS.

For ERTS, the area to be seen in the single look is 100 by 100 nautical miles. Hence the enlarged-area cloud statistics (SUNCON) of Section 2.3 must be used. Use of the computer output tabular values for SUNCON is somewhat laborious when several regions are of interest. A computer program was developed to derive graphical representations similar to Figure 2-7. Figures 2-8 and 2-9 are sample outputs of this program for the ERTS field of view. Data for all months at 1000 LST and 2200 LST are presented in Appendix C of this report.

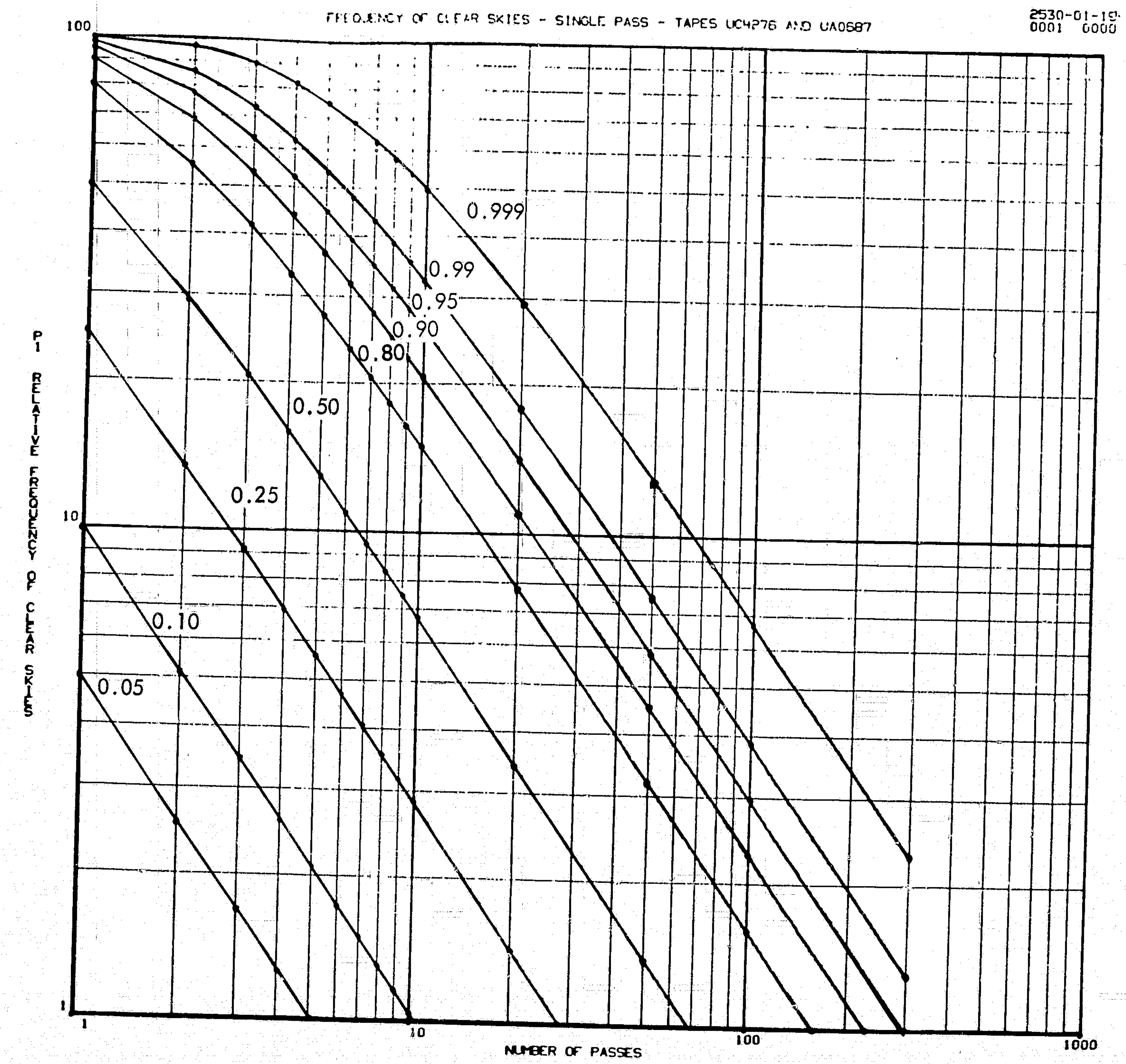


Figure 2-8. Nomogram of Generalized Probability of Observing Cloud-Free Areas

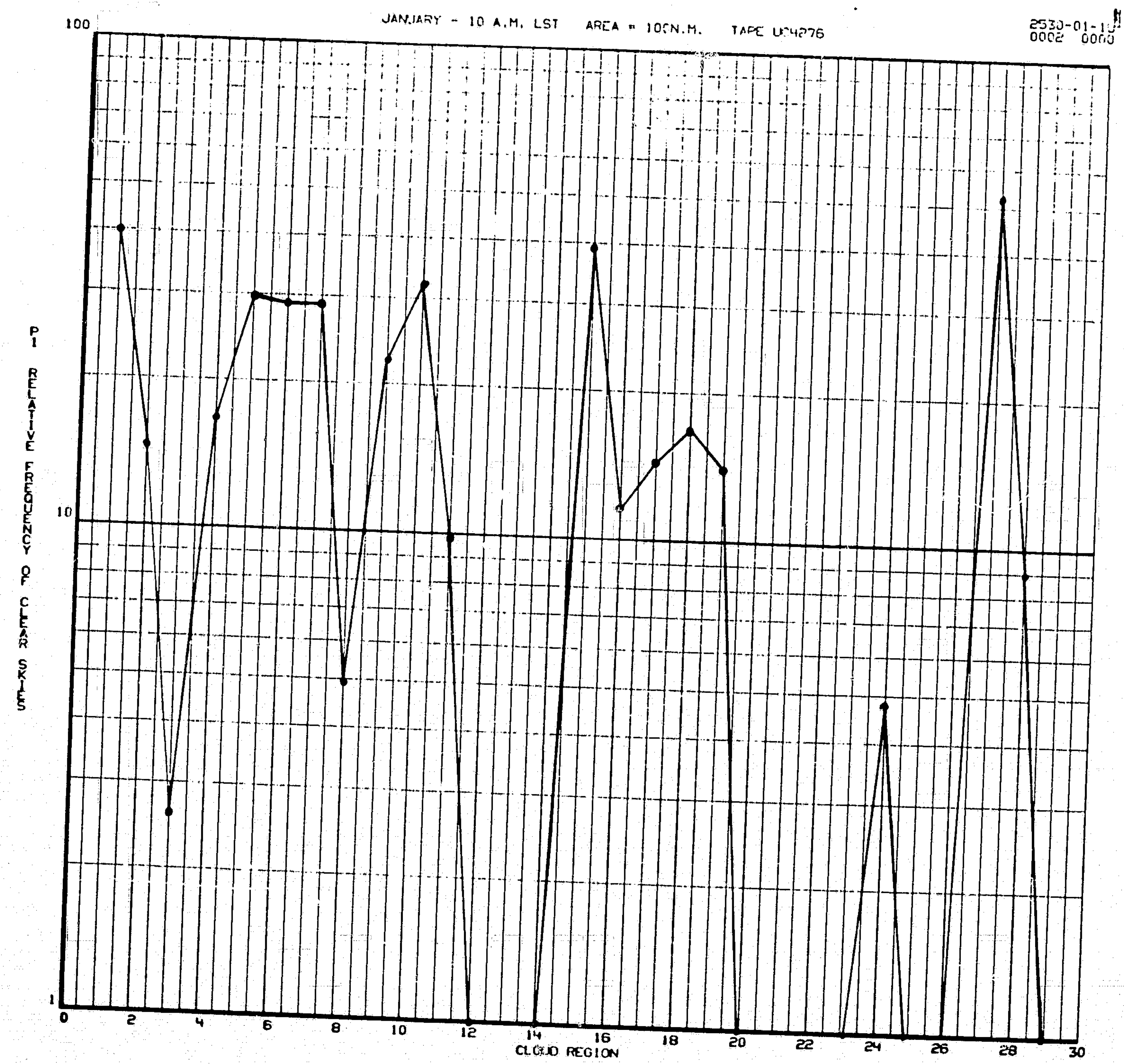


Figure 2-9. Relative Frequency of Clear Skies (Single Look) for January-10 a.m., LST

2.5 ONE- OR TWO-LOOK VIEWING

2.5.1 General Failure-Success Probability

The basic probability of "seeing" an area from a satellite involves a situation where alternatives (success or failure) are possible for each of a number of independent repeated trials. Success is defined as seeing whatever portion of the area is required to achieve the objectives of the mission. The binomial distribution is appropriate for such a situation and it is well known that for this distribution

$$P_{m \text{ in } N} = \frac{N!}{m!\,(N-m)!}\, p^m\,(1-p)^{N-m}$$

where

$P_{m \text{ in } N}$ = probability of m occurrences in N repeated, independent trials

p = probability of event occurring in one trial

Further, the probability of success, P_S, may be defined as the probability, or occurrence at least once, of a prescribed event. For cloud cover analyses, this event is the seeing of a prescribed amount or more of the area. Similarly, the probability of failure would be $1 - P_S$ or the probability of not seeing (seeing zero times) the prescribed amount or more of the area.

The probability of success (seeing) is the statistic of interest. However, it is much easier to compute P_F and determine P_S from $(1 - P_F)$. For example, when

$$N = 1,\ P_S = P_{1 \text{ in } 1} = \frac{1!}{1!\,0!}\, p\,(1-p)^0 = P$$

$$N = 2,\ P_S = P_{1 \text{ in } 2} + P_{2 \text{ in } 2} = \left[\frac{2!}{1!\,1!}\, p\,(1-p)\right] + \left[\frac{2!}{2!\,0!}\, p^2\,(1-p)^0\right]$$

$$N = N,\ P_S = P_{1 \text{ in } N} + P_{2 \text{ in } N} + \cdots\cdots P_{N \text{ in } N}$$

For the foregoing

$$N = 1, \; P_F = P_{0 \text{ in } 1} \quad \frac{1!}{0!1!} p^0 (1 - p)^1 = (1 - p)^1$$

$$N = 2, \; P_F = P_{0 \text{ in } 2} + \frac{2!}{0!2!} p^0 (1 - p)^2 = (1 - p)^2$$

$$N = N, \; P_F = P_{0 \text{ in } N} = \frac{N!}{0!N!} p^0 (1 - p)^N = (1 - p)^N$$

The utility of computing P_S from $(1 - P_F)$ is obvious. The simplest form of this relationship was previously used in determining the passes to see 100 percent of an area in one look. In that section, the relationship

$$P_S = 1 - (1 - P)^N$$

was used without proof.

2.5.2 Failure-Success Probability for One- or Two-Look Viewing

The success event related to cloud cover in satellite mission studies is defined as the occurrence of total cloud amount over the target or data-acquisition area such that the required amount of the area may be "seen." This seeing of any arbitrary amount of the area may be specified as (1) occurring in a single look; (2) occurring through the incremental addition during repeated continuous looks; or, (3) in a compromise case, occurring in one or two looks.

The one- or two-look case is of considerable interest in that not all the area is required to be seen in one look, yet continuous operation of the cameras or other sensors is also not programmed. This latter case results in the acquisition of little or no data on most passes in high-cloudiness areas and the requirement for large film availability and/or data analysis. The one- or two-look case as envisioned in real life would require advance information as to real-time cloud cover and on-off sensor operation capability.

For mission planning and design, it is extremely useful to be able to estimate the probability of securing information from or "seeing" a selected percentage of the target area for a selected number of passes. For the one- or two-look case, we have used the previously discussed failure probability concept:

success = "seeing" arbitrary selected amount of target area

P_S = probability of success

C_1 = cloud cover when success occurs in one look

C_2 = cloud cover when success occurs in two looks = $\sqrt{C_1}$

p_1 = percentage frequency of cloud cover $\leq C_1$ (from basic cloud statistics)

p_2 = percentage frequency of cloud cover $\leq C_2$ and $> C_1$ (from basic cloud statistics)

$\tilde{p} = \frac{P_2}{1 - P_1}$ = probability of cloud cover between C_2 and C_1, given C_1 has not occurred

Further, if

A = zero occurrence of cloud cover $\leq C_1$

B = zero or one occurrence of cloud cover $\leq C_2$ and $> C_1$

B/A = occurrence of B, given that A has occurred

then P(A, B) is the probability of A and B, i.e., the probability of failure.

Since A and B are not independent events, P(A, B) = P(A) • P(B/A); thus, P(A) is the probability of 0 occurrences in N passes:

$$P(A) = \frac{N!}{m!\,(N - m)!}\, p_1^{m}\, (1 - p_1)^{N-m} = (1 - p_1)^N, \text{ since } m = 0$$

and P(B/A) is the sum of probability that B = 0, given A, and of probability that B = 1, given A. Further, since B = 0 and B = 1 are mutually exclusive events,

$$P(B/A) = \left[\frac{N!}{0!N!}\,\tilde{p}^0\,(1 - \tilde{p})^N\right] + \left[\frac{N!}{1!(N - 1)!}\,\tilde{p}\,(1 - \tilde{p})^{N-1}\right]$$

$$= \left[(1 - \tilde{p})^N\right] + \left[N\tilde{p}\,(1 - \tilde{p})^{N-1}\right]$$

The probability of success is

$$P_S = (1 - P_F) = 1 - [P(A, B)] = 1 - [P(A)] [P(B/A)]$$

$$P_S = 1 - \left[(1 - p_1)^N\right] \left[(1 - \tilde{p})^N + N_{\tilde{p}} (1 - \tilde{p})^{N-1}\right]$$

2.5.3 Computer-Derived Results for ERTS FOV

Look 12 is the computer program for determining the relationship between probability levels, area required to be "seen" in either one or two independent looks, and the number of passes from the aforementioned equation.

The probability of success is tested for successive values of N until the required probability level of success is achieved. This program, which combines some of the features of both the single-look and continuous-viewing programs, is described in detail in Appendix A.

For ERTS viewing results, use is required of the enlarged-area cloud statistics and the cumulative frequency plots discussed in previous sections. With these adjusted data used, results were computed for all 29 regions for January, April, July, and October for 1000 LST and 2200 LST. These results were achieved for seeing 50, 60, 70, 80, 90, 95, and 99 percent more of the ERTS FOV in 1 to 20 passes. The computer results are in tabular output. Figure 2-10 illustrates the format of the computer output for seeing 70 percent or more of the ERTS field-of-view area of 100 by 100 nautical miles at 1000 LST in July. The complete results are presented in Appendix D.

2.6 CONTINUOUS VIEWING

2.6.1 Probability-of-Seeing Relationship

Another typical surveillance mission involves continuous viewing or looking (on every pass or orbit over a selected area) and the piecing together of cloud-free segments for each look. Once again, the question is: How many passes are required to provide a selected probability of "seeing" at least a selected percentage of an area?

Other investigators (References 4 and 5) have proposed a Monte Carlo simulation scheme that adequately covers the foregoing question for incremental seeing of an area. The clouds over the area are assumed to be randomly distributed such that the incremental coverage of pass n is given by

$$B(n) = [1 - B(n - 1)] [1 - c(n)]$$

PROBABILITY OF SEEING 70. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 7 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	78.7	96.6	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	86.9	99.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	0.7	2.5	5.1	8.2	11.8	15.7	19.8	24.0	28.3	32.5	36.6	40.7	44.6	48.4	52.0	55.4	58.6	61.7	64.6	67.3
4	24.0	48.1	66.6	79.3	87.5	92.6	95.7	97.5	98.6	99.2	99.6	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
5	44.2	69.5	83.6	91.3	95.4	97.6	98.7	99.4	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	60.2	85.8	95.2	98.4	99.5	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	15.7	31.7	46.1	58.3	68.2	76.0	82.1	86.8	90.3	92.9	94.8	96.3	97.3	98.1	98.6	99.0	99.3	99.5	99.6	99.7
8	70.3	92.9	98.4	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	29.2	51.8	68.1	79.3	86.8	91.6	94.8	96.8	98.0	98.8	99.3	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
10	15.5	29.7	42.2	52.9	61.9	69.4	75.6	80.6	84.6	87.9	90.5	92.6	94.2	95.5	96.5	97.3	97.9	98.4	98.7	99.0
11	30.2	54.7	71.8	83.0	90.0	94.2	96.7	98.1	98.9	99.4	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
12	4.3	13.1	23.8	34.8	45.3	54.7	62.9	70.0	75.8	80.7	84.6	87.9	90.4	92.5	94.1	95.4	96.4	97.2	97.9	98.3
13	13.7	26.7	39.5	48.9	58.0	65.6	72.0	77.4	81.8	85.4	88.3	90.7	92.6	94.1	95.4	96.3	97.1	97.7	98.2	98.6
14	1.9	3.9	6.0	8.1	10.4	12.7	15.0	17.3	19.7	22.1	24.4	26.8	29.1	31.4	33.7	36.0	38.2	40.3	42.5	44.5
15	20.4	37.2	51.0	62.0	70.7	77.5	82.9	87.0	90.1	92.6	94.4	95.8	96.9	97.6	98.2	98.7	99.0	99.3	99.5	99.6
16	2.2	5.2	8.6	12.4	16.5	20.6	24.9	29.2	33.4	37.5	41.5	45.4	49.1	52.7	56.1	59.3	62.3	65.1	67.8	70.3
17	0.0	1.3	3.7	6.9	10.6	14.7	19.1	23.6	28.1	32.6	37.0	41.4	45.5	49.5	53.3	56.9	60.3	63.5	66.4	69.2
18	71.8	93.8	98.8	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	35.4	62.0	78.8	88.6	94.1	96.9	98.5	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	17.3	33.9	48.5	60.7	70.4	77.9	83.7	88.1	91.3	93.7	95.5	96.8	97.7	98.4	98.8	99.2	99.4	99.6	99.7	99.8
21	20.4	47.3	68.0	81.6	89.7	94.4	97.0	98.4	99.2	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
22	12.8	26.3	39.2	50.6	60.5	68.7	75.4	80.8	85.2	88.6	91.2	93.3	94.9	96.1	97.1	97.8	98.3	98.8	99.1	99.3
23	3.6	8.9	15.2	22.1	29.0	35.9	42.5	48.7	54.4	59.7	64.5	68.9	72.8	76.3	79.3	82.1	84.5	86.6	88.4	90.0
24	53.3	81.4	93.1	97.6	99.2	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25	68.0	92.0	98.2	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
26	40.9	69.5	85.4	93.3	97.0	98.7	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
27	28.9	50.8	66.6	77.7	85.3	90.4	93.8	96.0	97.4	98.4	99.0	99.3	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0
28	21.1	39.2	54.1	65.8	74.8	81.6	86.7	90.4	93.2	95.1	96.6	97.6	98.3	98.8	99.2	99.4	99.6	99.7	99.8	99.9
29	18.5	37.6	54.0	67.0	76.8	84.0	89.0	92.6	95.0	96.7	97.8	98.5	99.0	99.4	99.6	99.7	99.8	99.9	99.9	100.0

Figure 2-10. Example Computer Output, One- or Two-Look Viewing, ERTS

where

B(n) = the incremental area seen on the nth pass

B(n - 1) = the accumulated areas seen through the (n - 1)st pass

c(n) = the amount of cloud cover on the nth pass

The computer program (Monte Carlo) developed for this question incorporates a random number program draw that is fitted into the appropriate unconditional cumulative percentage frequency distribution to determine the cloud cover for pass 1. Should this cloud cover be Category 1, a 100-percent coverage is tabulated, and a new mission is begun. If this cloud cover is not Category 1, a new random draw is made for pass 2, and the incremental cloud cover and total cloud cover are determined. This is repeated for the N passes of interest. Any draw of cloud cover 1 results in 100-percent seeing and is so recorded in that and subsequent value(s) of N in that mission. The next mission repeats the procedure. After the desired number of missions (about 100 to 300, selected to give reasonable confidence without excessive computer time), the program derives a cumulative frequency distribution and provides a CRT output of area seen versus probability for all number of passes from 1 to N.

The simulation for which this program was developed at North American Rockwell was for viewing of areas of about 1-degree-latitude diameter at 3- to 18-day intervals. The assumption of independent looks is thereby justified, and the use of conditional statistics is not required. For such intervals in viewing of the same area, it is desirable to select a time of minimum cloudiness and sufficient illumination. For many applications, 1000 LST is used. The Monte Carlo computer program is described in more detail in Appendix A.

2.6.2 Computer-Derived Results, ERTS FOV

The Monte Carlo computer program has been used to derive the probability of seeing any selected amount of an area of 100 by 100 nautical miles in a selected number of passes. The ERTS viewing of the same area at 3- to 18-day intervals justifies the independency of the looks and the use of the unconditional statistics SUNCON developed for the ERTS field of view.

The program was used to derive the probability of seeing a given percent or more of an area for passes 1 through 8. Figure 2-11 presents an example of the Monte Carlo continuous viewing computer program output for cloud region 11, July, 1000 LST. The probabilities were derived for all of the 29 regions for 1000 LST and 2200 LST for the months of January, April, July, and October. Appendix E presents a selected portion of the derived probabilities that are of greatest interest to probable ERTS missions.

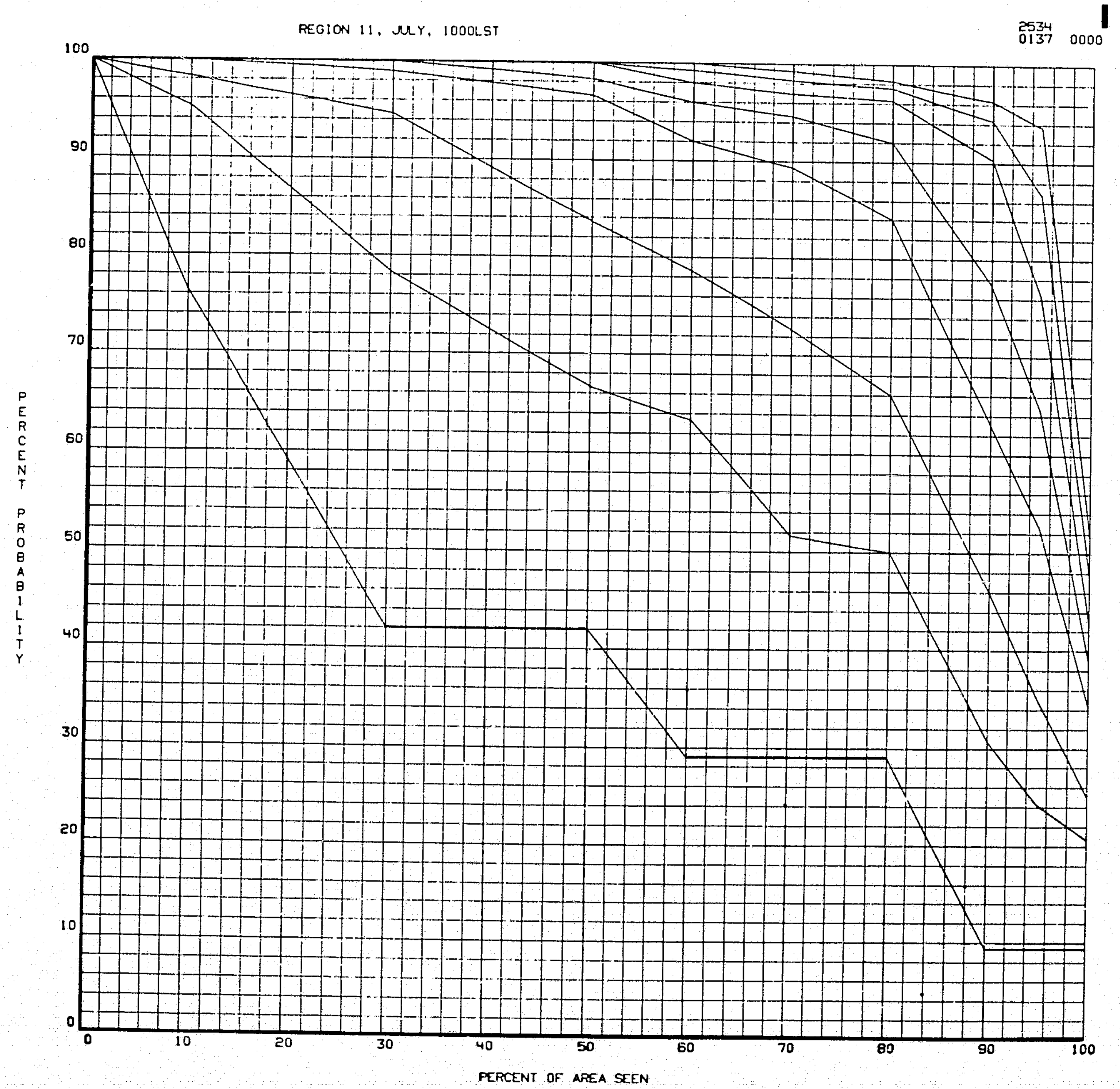


Figure 2-11. Example Computer Output, Continuous Viewing, ERTS

3.0 CLOUD PHOTOGRAPH ANALYSES

3.1 STUDY OBJECTIVE

The standard-area cloud statistics and the enlarged-area statistics used in the previous section to derive probability of seeing assumed a perfect-resolution sensor. As the resolution degrades and the elemental areas required to be completely cloud-free increase in size, the amount of cloud cover in the FOV will increase; i. e., the cloud-free area will decrease. Thus, a FOV of 100 nautical miles may be 40 percent covered with clouds or 60 percent cloud-free, but the percent of the FOV with elemental areas completely cloud-free will decrease from this 60 percent for the perfect-resolution case to 0 percent, or nearly so, for large elemental areas. The objective of this phase of the study is to determine this change in cloud cover (or cloud-free area) as the resolution decreases (the elemental unit area size increases).

To derive the variation of total cloud-free area as the resolution, in terms of cloud-free square elemental or unit areas, varies from about 30 meters to 185 kilometers, it was necessary to use cloud photographs from U-2, Apollo, and ESSA flights. The U-2 flights provided resolution elements down to 30 meters. The ESSA flights provided photographs for analysis of cloud-free elements of the larger size. The Apollo photographs provided cloud-free elements that overlapped the larger U-2 and the smaller ESSA elements.

3.2 OTHER STUDIES

Several previous or concurrent studies provided information related to the objectives of this study. Results of studies of cumulus cloud distributions and dimensions from U-2 photographs during cross-country flights were published by Blackmer and Serebreny in 1962 (Reference 6 and 7). Plank reported upon Florida cumulus distributions in 1969 (Reference 8), ATS photographs are being studied at the NASA Institute for Space Studies (Arking, Weinstein, and Fleischman, Reference 9) and at the University of Wisconsin (Stamm, Vonder Haar, Reference 10) to derive cloud statistics relating to cloud-free area distributions. Salomonson and Shenk (Reference 11) are using Apollo photographs to study such cloud statistics. The most significant results of these studies as regards the subject study are presented in the subsequent discussion.

For the very high resolution U-2 photographs, the cumulus cloud distributions were classified as CL1, CL2, and CL3 in Reference 6. CL1 comprises only small clouds, CL2 comprises small and medium clouds, and CL3 comprises small, medium, and large clouds. Table 3-1 presents the percentage of total cloud cover contributed by clouds of various sizes for the flights studied. It may be noted that small fair weather cumuli may be 200 feet to 1 mile in diameter and single-cell cumulo-nimbus are on the order of 1 to 5 miles in diameter. CL1 distributions are found in areas where observers report small numbers of tenths cloud cover; CL2 generally exist in areas of four- to six-tenths cloud cover; and CL3 would generally be representative of six- to 9-tenths cumulus cloud cover. These statements are for fields of view representative of the U-2 photographs.

Table 3-1. Percentage of Total Cloud Cover Contributed by Clouds of Various Sizes (Reference 6)

Cloud Size (sq nm)		Reported Clouds (%)					
		CL1		CL2		CL3	
Small	0.1	55.0	100.0	25.0	85.5	20.0	57.5
	0.5	25.0		24.0		11.5	
	1.0	16.0		18.5		11.0	
	2	3.0		12.0		9.5	
	3	1.0		6.0		5.5	
Medium	4			4.0	14.5	5.0	24.00
	5			3.0		4.0	
	6			2.5		3.5	
	7			2.0		3.0	
	8			1.5		3.0	
	9			1.0		2.5	
	10			0.5		3.0	
Large	12					3.5	18.5
	14					3.5	
	16					3.5	
	18					2.5	
	20					3.0	
	25					3.0	
	30					0.5	

In Reference 7, Blackmer reported upon length and width of cumulus clouds from cross-country flights. The study indicated lengths from one-fourth to nine and one-half nautical miles with a median near one nautical mile. The median width was about three-fourths nautical miles with a maximum of 8.5 nautical miles. Spaces between clouds ranged from one-fourth to twenty-two nautical miles with a median near one and eight-tenths nautical miles.

Plank, in Reference 8, presented the following conclusions for the Florida cumulus cloud distributions.

1. The number density of the cumuli decreased nearly exponentially with increasing cloud-size.

2. The size distribution characteristics did not appear to be materially influenced by the patterform state of the clouds.

3. A maximum amount of the sky cover occurred in association with an intermediate size cumulus diameter (modal diameter).

4. As the total cloud cover increased from morning to afternoon, the minimum cloud diameter, the modal cloud diameter, and the maximum cloud diameter increased. Thus, convection operated to favor and enhance the development of larger cumuli.

5. The variation of cloud number density with cloud size was similar to that of the Blackmer-Serebreny cross country populations and other locations, thus suggesting the size distribution characteristics of cumuli over uniform terrain are relatively similar, irrespective of the geographical location.

Stamm and Vonder Haar (Reference 10) found from an analysis of an ATS photograph the expected decrease of clear area in a region as the spatial resolution of the sensor decreased. In addition, the rate of decrease of the measured parameter was increased as cloud "contaminants" smaller than the instantaneous field of view (IFOV) of the instrument were considered. The rate of decrease of clear area was dependent upon total cloud cover and the types of clouds present. Fifteen kilometers was suggested as a good spatial resolution at nadir for the geosynchronous satellite to obtain vertical temperature profiles via an infrared sounder.

Arking, et al. (Reference 9) present results of study of 11 ATS pictures at ±12.5° latitude and 25° of longitude for a best resolution of five kilometers. As expected, the percentage clear area was sensitive to the resolution of the sounding instrument, and a change of resolution from 11 kilometers to 60 kilometers reduced by a factor of two the time the instrument could collect useful data. The average cloudiness of these 11 pictures was 31 percent. The sensitivity of percentage clear area to resolution was similar for high and low cloudiness within the pictures studied.

Shenk and Salomonson (Reference 11) using simulated cloud pattern fields and an Apollo photograph, presented results of studies of the effects of sensor resolution upon estimated cloud amounts. They found that sensor spatial resolution strongly affected estimates of cloud cover. When R is defined as the ratio of areal cloud size to areal resolution element size, R values of 100 or greater for a single cloud threshold (cloud, no cloud) are required to measure directly the percentages of cloud cover with approximately 10 percent accuracy. For a two-threshold cloud criterion, an $R \geq 10$ was required for good cloud-cover-percentage estimates.

3.3 ANALYSIS OF U-2 PHOTOGRAPHS

3.3.1 Description of U-2 Photographs

3.3.1.1 General

The photographs taken by the camera aboard the U-2 aircraft are contained in 1000-ft reels of 70-mm film. Each frame is about 10 inches long and depicts a panorama of the daytime cloud cover in a strip extending from horizon to horizon, perpendicular to the flight path. The area of the earth's surface photographed on each frame varies with the height and speed of the aircraft. If an altitude of 50,000 feet is assumed, the horizon is some 200 nautical miles away, but detailed studies of dimensions are possible only to about 10 miles on either side of the flight path. Resolution of a few meters is indicated by the easy identification of small section-line roads in some of the photographs.

3.3.1.2 Selection of Photographs

Several reels of U-2 film for flights over various sections of the United States were secured for analysis through the courtesy of the Air Force Cambridge Research Laboratories. These reels were surveyed to select pictures demonstrating varying amounts of cloud cover within the central part of the frame. The central portion of each frame was used to provide an essentially vertically down-looking photograph. This was necessary because of the requirement to achieve cloud statistics from these U-2 photographs for cloud-free elements as small as 30 meters on a side.

The altitude varied considerably on the various flights, but the speed was relatively constant. In each frame the distance along the flight path was approximately four to eight nautical miles. For FOV, the same distance normal to the flight path was used, thus providing a square FOV from four to eight nautical miles.

Selection of photographs was then restricted to partial-cloud-cover photographs consisting of either small cloud elements or the edges of large cloud elements within the field of view of four to eight nautical miles since neither overcast nor clear photographs provide any cloud statistics data. Additionally, all clouds in such a limited field of view must necessarily be cellular, and cumulus, stratocumulus, and altocumulus cloudiness was reported in the flight observer's log.

The photographs selected for analysis occurred on three flights numbered ML-62, ML-69, and ML-89 in the USAF-AFCRL nomenclature. ML-62 was a February W-E cross-country flight; ML-69 was a N-S east coast flight; and ML-89 was a local five-hour flight over the environs of Boston, Massachusetts. The number of photographs selected were as follows:

ML-62	6
ML-69	20
ML-89	9
Total	35

Cloud amounts in the selected photographs ranged from one-tenth to nine-tenths in visual estimates prepared prior to analysis.

3.3.2 Analysis Procedures

The analysis to derive the cloud-free element statistics from the U-2 photographs consisted of the following steps:

1. Selection of the 1 x 1 element size for digitization
2. Digitization of the photograph to provide brightness numbers from 0 to 63
3. Selection of the cloud/no-cloud threshold brightness value
4. Extraction of cloud-free statistics as basic element size increased

The methodology of the process used to derive cloud-free statistics is depicted in Figure 3-1. The statistics were derived in a three stage process including: (1) scanning of film and cloud background threshold selection; (2) threshold criteria development; and (3) cloud statistics. The schematic is referenced by numbers and the computer program blocks are designated by "C1" and "C2". The subsequent discussion will describe each functional component.

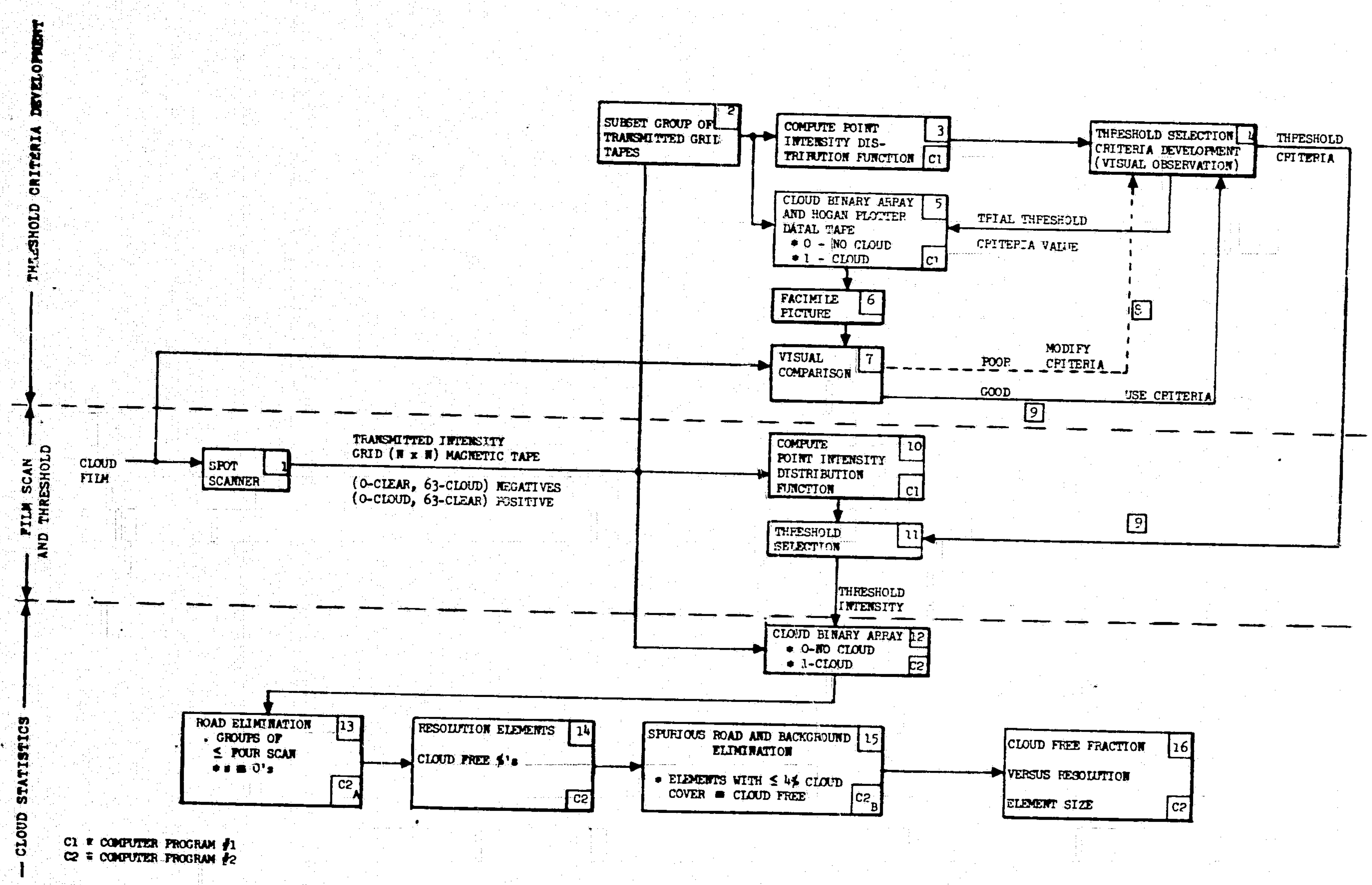


Figure 3-1. Schematic of Cloud Statistic Methodology

3.3.3 Digitization Procedure and Threshold Selection

3.3.3.1 Digitization

Selection of the 1-by-1 or basic element size requires a consideration of the FOV and the required smallest basic element size. For the U-2 photographs, it was desired to provide a 1-by-1 element of approximately 30 by 30 meters. The other possible digitization elements were 2 by 2, 4 by 4, 8 by 8, 16 by 16, 32 by 32, 64 by 64, 128 by 128, 256 by 256, 512 by 512, or 1024 by 1024. A 512-by-512 digitization of the 8- by 8-nm. FOV was selected, thus providing a 1-by-1, or basic, element of approximately 30 by 30 meters.

The photographs were digitized on the Information International Programmable film reader/recorder (see Figure 3-2). A source of light produced at a programmed x-y point location (with an 8.4 micron spot size for 33 mm film) on the face of a CRT was used. The density of the transmitted light for each point is stored on magnetic tape. The system is capable of digitizing a selected film negative or positive into 16,384 by 16,384 basic units. The numerical intensity values of the digitization process were placed on magnetic tape as six-bit numbers for statistical analysis.

3.3.3.2 Selection of Threshold Intensity (TI)

Before the cloud statistics were derived from the digitized values on the magnetic tapes, it was necessary to determine the threshold between cloud/no-cloud. Accurate determination of this value is a formidable task, as evidenced by the inability of investigators to decide upon the presence or nonpresence of clouds when visually observing photographs when the clouds are cirrus or thin or when the background contrast is small. Different investigators have derived different schemes to separate cloud from non-cloud areas in digitized data (References 9, 10, 11), but none is entirely satisfactory.

The procedures selected for this study consisted of the following steps:

1. Use of a computer to produce a facsimile representation of the photograph, utilizing an arbitrary TI, and to produce a frequency distribution of the brightness values

2. Use of the frequency distribution of brightness values to select subsequent TI for facsimile representations or final TI selection

3. Comparison of the subsequent facsimile representations with the original photograph, and selection of the TI that produces the best representation

INFORMATION (PFR)
INTERNATIONAL

P - PROGRAMMABLE

F - FILM

R - READER

6 BIT INTENSITY
(64 INCREMENTS: 0-63)

3072 INTENSITY
POINTS/TAPE RECORD

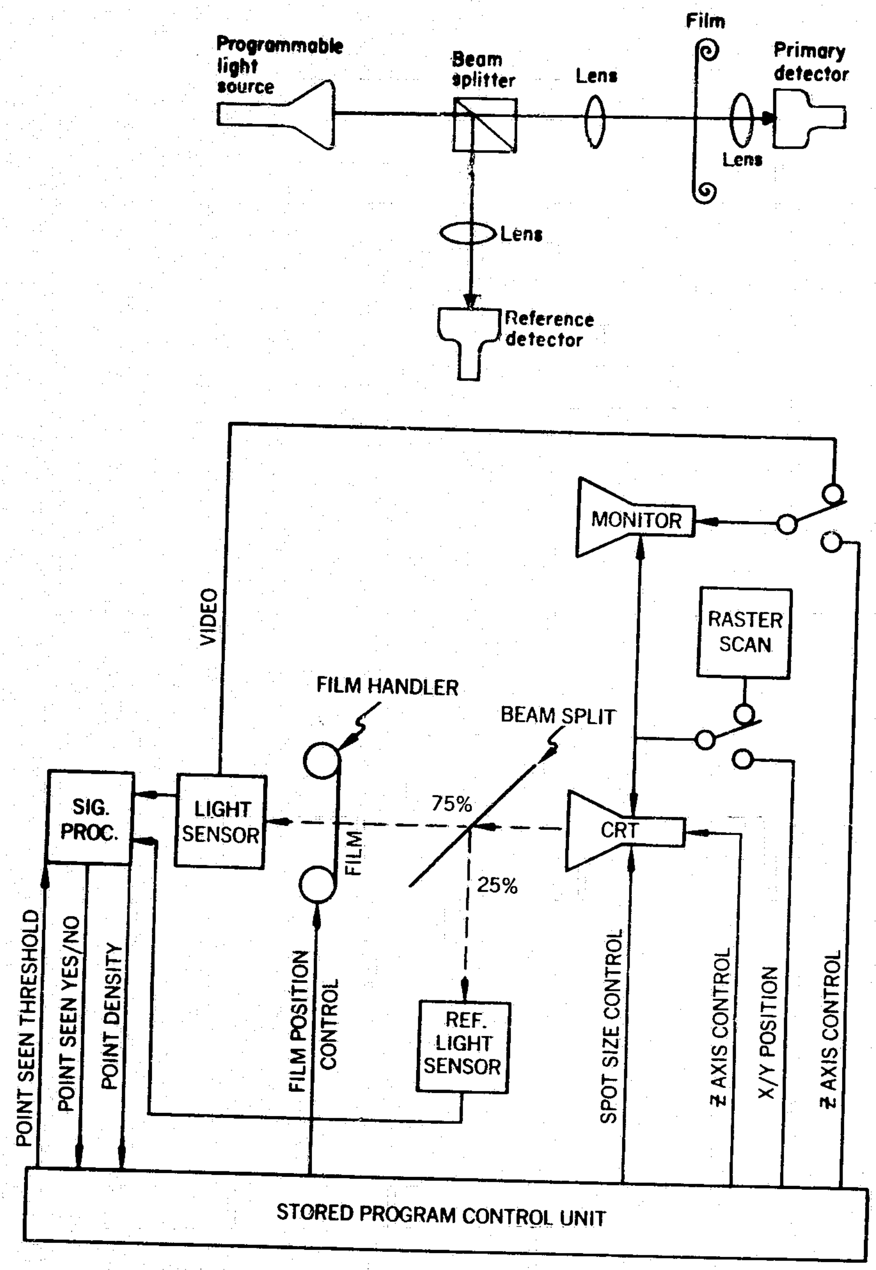


Figure 3-2. Film Reader Schematic

Steps 1 through 3 were performed for all the Apollo and ESSA photographs but a requirement to return the U-2 film allowed all steps only on the ML-62 photographs. This required development of a criterion from the frequency distribution for selecting the TI of the other U-2 photographs.

The TI criterion developed from the frequency distribution was also determined by the comparison of facsimile representations. Arbitrary TI values and the original photographs were used. It was noted that a sharp change in the slope of the cumulative frequency distribution of brightness values occurred at or near the TI value that produced the best representation. Figure 3-3 illustrates this criterion as shown on Frame 186A of the ML-62 flight of the U-2. For this photograph a TI brightness value of 45 is indicated by the intersection of the mean slope lines above and below this value. The facsimile representation using 45 as the threshold intensity value is also presented in Figure 3-3 and may be compared with the actual U-2 photograph, presented as Figure 3-4. In the facsimile representation, the clouds are dark rather than light as in the actual photograph.

The above criterion was used for selecting the TI values for the U-2 photographs for which a comparison of facsimile representations and the original photograph was not possible. A crude check of the selected value was possible by comparing the total cloud cover amount derived by using the selected TI value with cloud amounts prepared from visual analyses of the original photographs. In general, these values were in reasonable agreement, with the ML-69 values being excellent and the ML-89 values less so. When the estimates varied widely, the resulting statistics were suspect and were not used in the final U-2 statistics.

Specific cases will now be used to illustrate the threshold selection method and validate its utility and accuracy. Figure 3-3 shows a composite facsimile plot which contains a cumulative frequency histogram for the film transmitted light intensity and a facsimile picture of the digitized film data. This type of plot was generated with a Hogan plotter. The Hogan plotter is a high-speed digital plotter with a resolution determined by 1024 stylus wires covering a 10-inch scan length. At the bottom of the lower half of Figure 3-3 is a histogram of the intensity frequency distribution function. After study of numerous histograms a slope discontinuity criterion was developed to locate the threshold intensity. The intersection of the two slopes in Figure 3-3 should be at the intensity threshold between background and the clouds. Figures 3-3 through 3-8 show the variation of the cloud picture versus threshold. The significant change in the picture for a small threshold change between 40 (Figure 3-3) and 42 (Figure 3-5) is due to the relatively large slope on the background side of the cumulative intensity frequency distribution function. Also, this sizable change illustrates the high sensitivity of the cloud/background threshold intensity value and that it is preferable to

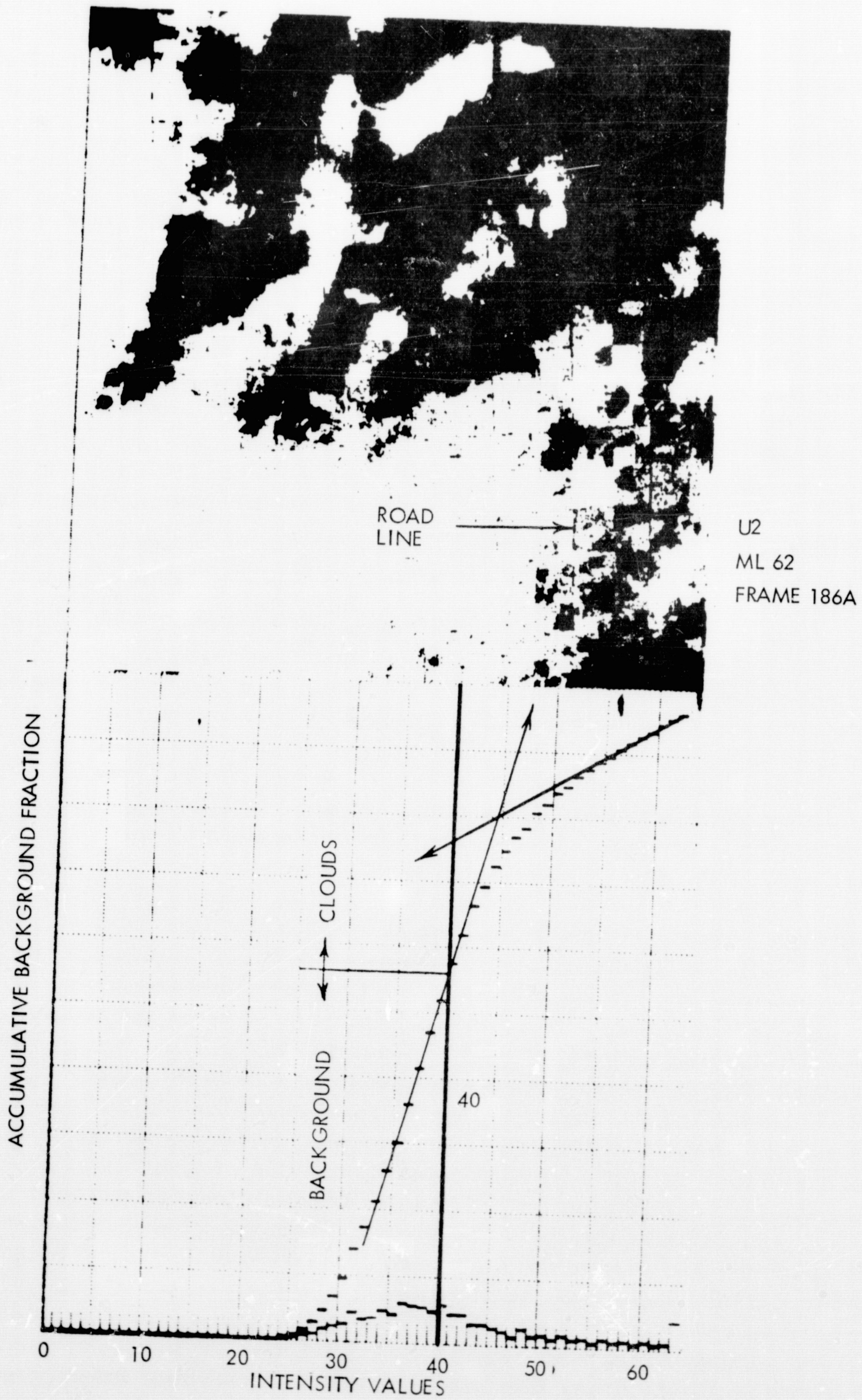


Figure 3-3. U2 (Frame 186A/Flight ML62) Facsimile and Histogram With the Intensity Threshold = 40

Figure 3-4. U2 (Frame 186A/Flight ML62) Photograph Print

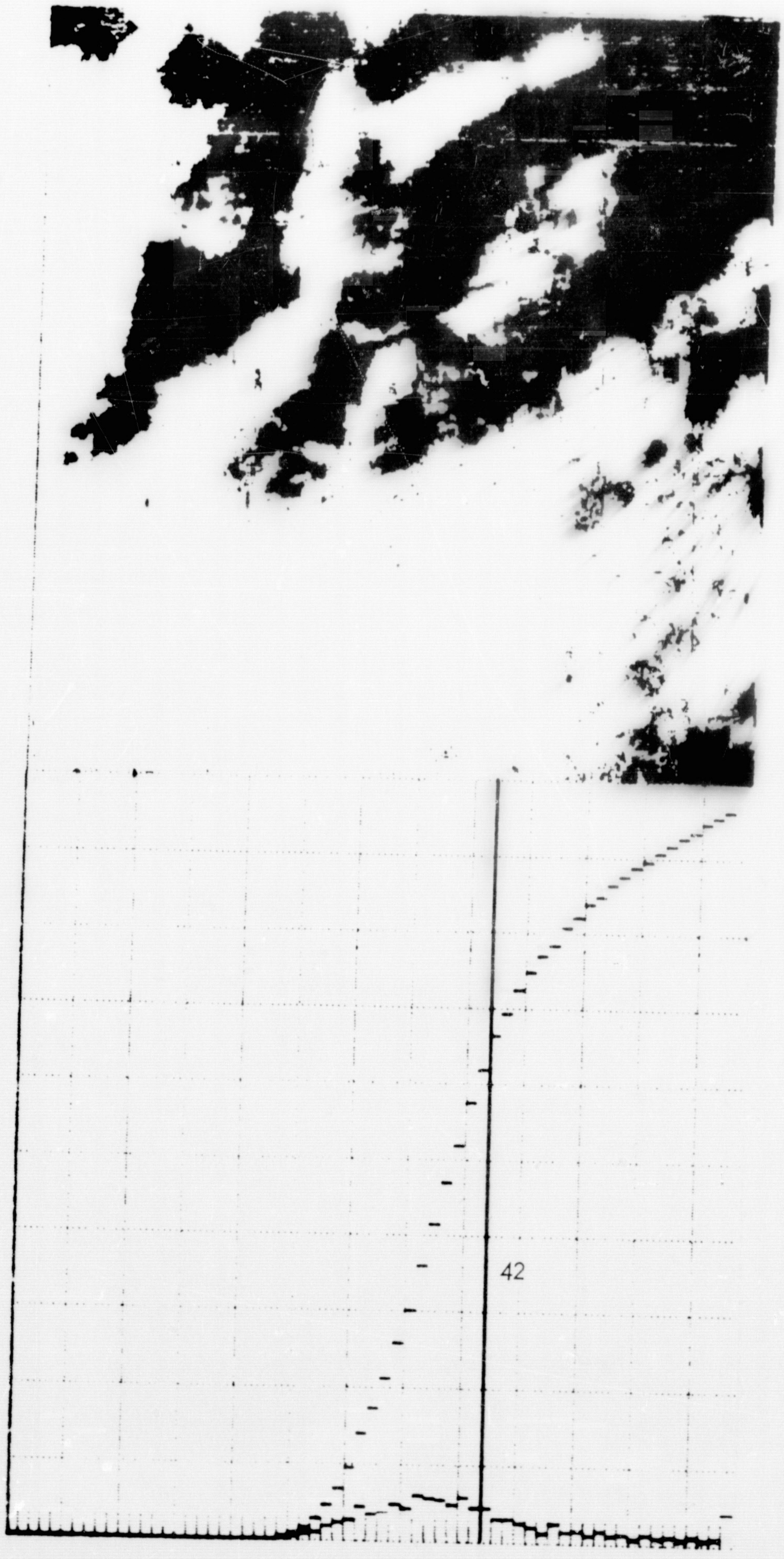


Figure 3-5. U2 (Frame 186A/Flight ML62) Facsimile and Histogram With the Intensity Threshold = 40

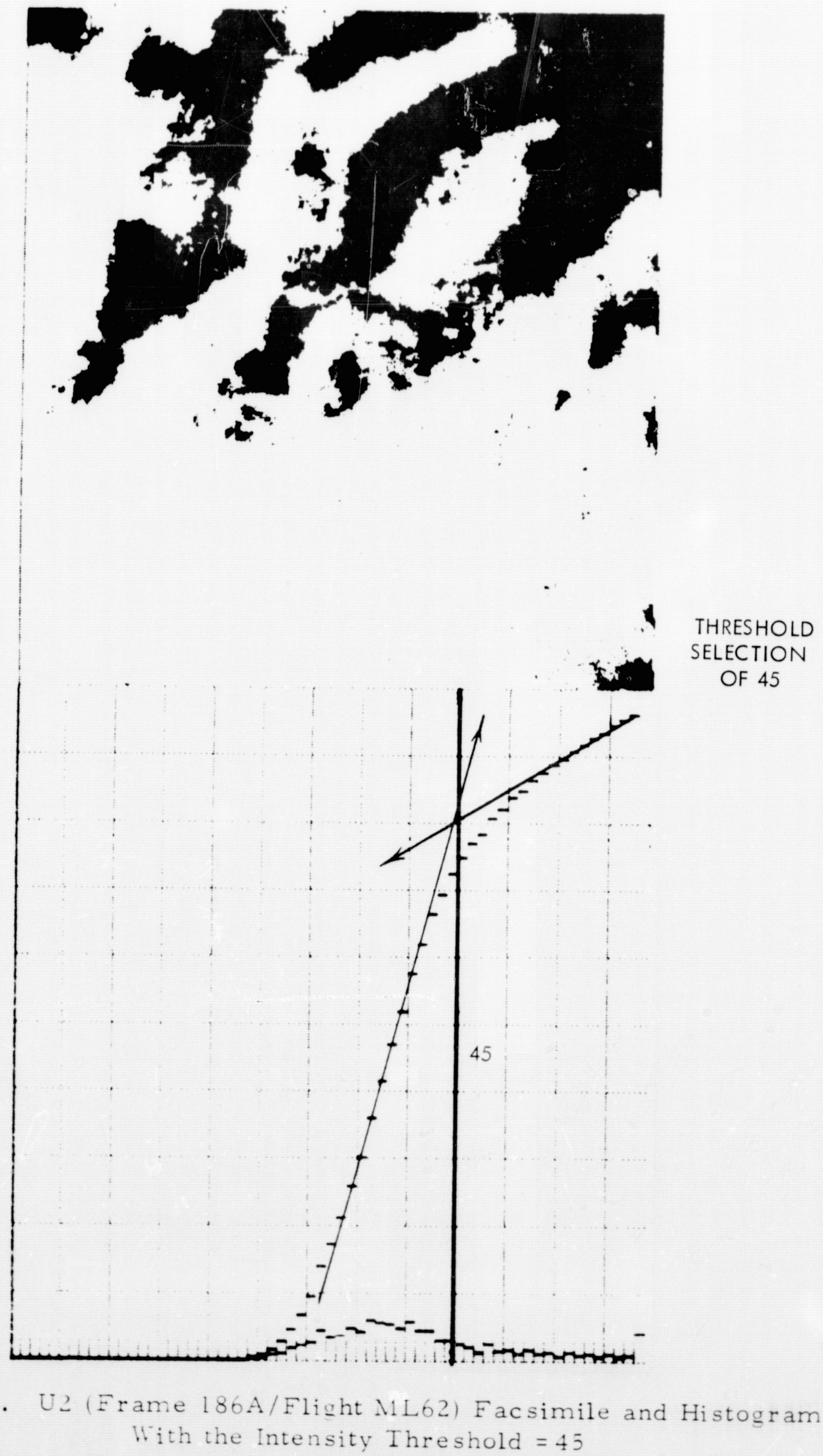


Figure 3-6. U2 (Frame 186A/Flight ML62) Facsimile and Histogram With the Intensity Threshold = 45

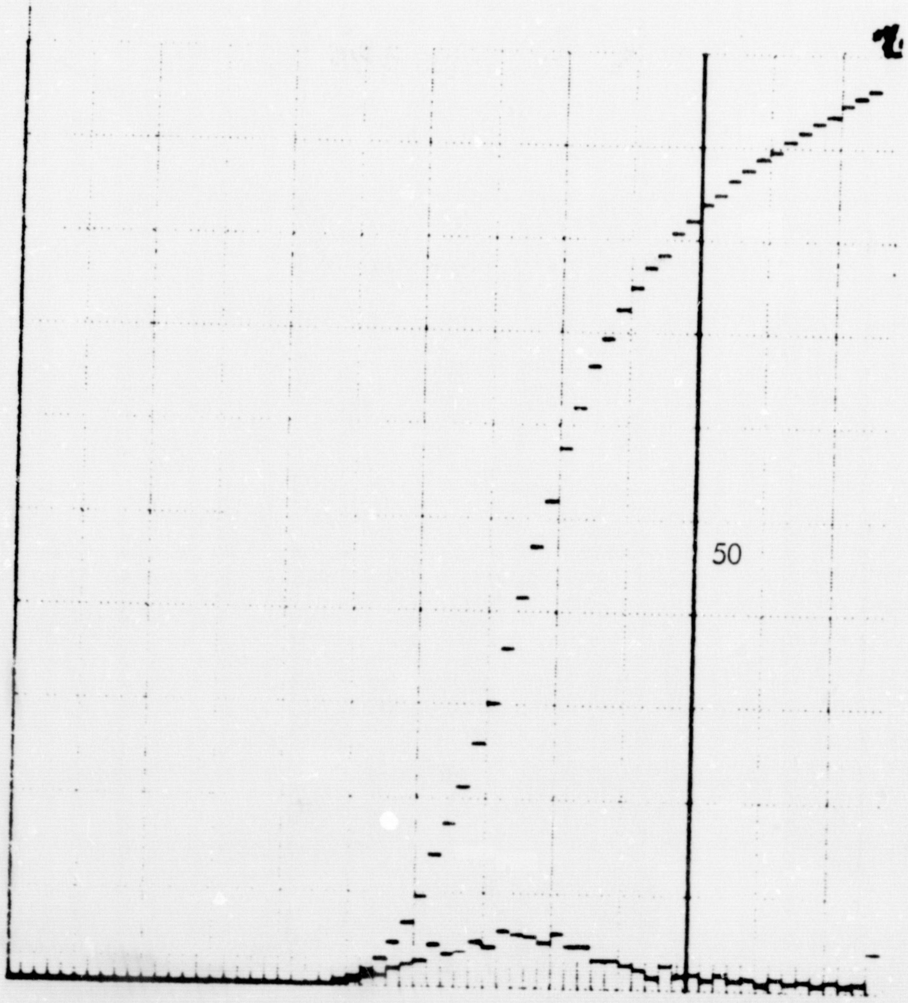


Figure 3-7. U2 (Frame 186A/Flight ML62) Facsimile and Histogram With the Intensity Threshold = 50

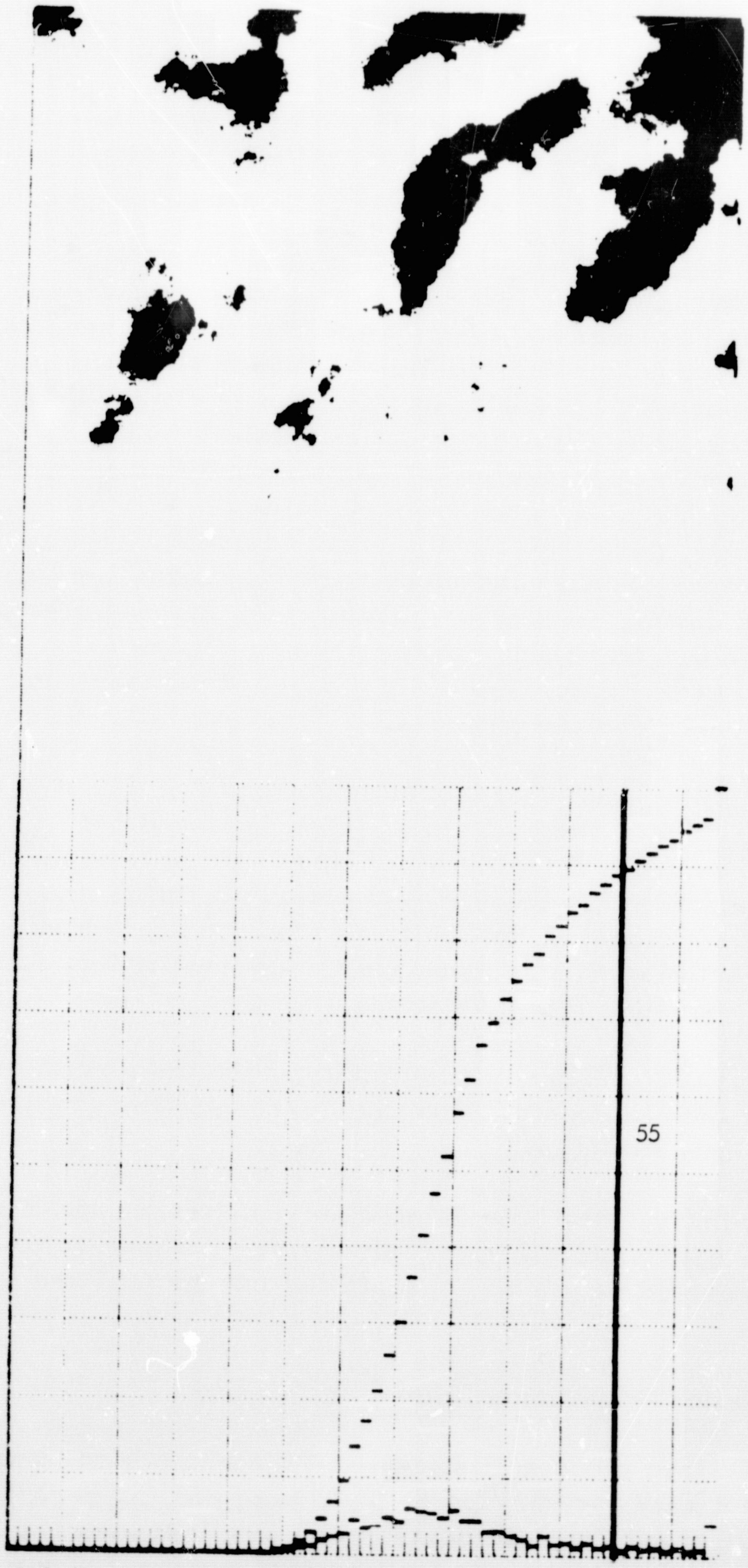


Figure 3-8. U2 (Frame 186A/Flight ML62) Facsimile and Histogram With the Intensity Threshold = 55

have the intensity on the smaller slope side of cumulative distribution. The remaining Figures 3-6 through 3-8 show the cloud picture for intensity thresholds of 45, 50, and 55. The picture for the selected threshold (Figure 3-6) of 45 compares very well with the actual film print in Figure 3-4.

An example of threshold selection for an Apollo case is depicted in Figures 3-9 through 3-15. This case shows the background and cloud intensity value positions switched on the cumulative frequency because the Apollo film is a positive and the aforementioned U-2 film is a negative. This Apollo case (A59-22-3436) has a different characteristic form, but it conforms to the slope criteria selection method. Figures 3-9 through 3-12 show the change in the cloud picture as the threshold is reduced from 55 to a value of 20. The final selected value of 20 is near the slope discontinuity at 23. Also, the cloud picture is not very sensitive to small threshold changes because the slopes are much smaller than those in the previous U-2 cases. Figures 3-13 and 3-14 show an enlarged facsimile plot which can be compared with the print in Figure 3-15. Extensive examination of the figures showed a very good comparison for the gross as well as microscopic cloud patterns.

Three other Apollo threshold selections are depicted in Figures 3-16 through 3-21. Of all the cases mentioned here and before, the only anomaly is the Apollo AS6-2-995 frame which does not have a sharply defined threshold discontinuity. However, it was determined that this special case tended to have a slope discontinuity as a point of inflextion. The favorable comparison between Figure 3-16 and the corresponding Apollo film print in Figure 3-17 validates this deduction.

In general, the slope discontinuity indicates a smaller gradient in intensity for the cloud points than the corresponding gradient for the background intensity points.

In summary, the slope discontinuity criteria can be used in conjunction with the estimated FOV total cloud-free percentage to efficiently select intensity threshold values to separate the background and cloud digitize data points.

3.3.4 Statistics Generation Computer Program

The desired cloud statistics were the number of totally cloud-free elements in a FOV for varying element size and the percentage of the total FOV of these cloud-free elements. The smallest element (1 by 1) is defined by the number of points in the digitization process. The presence of clouds within each smallest element was derived via the selection and use of the threshold intensity for each photograph.

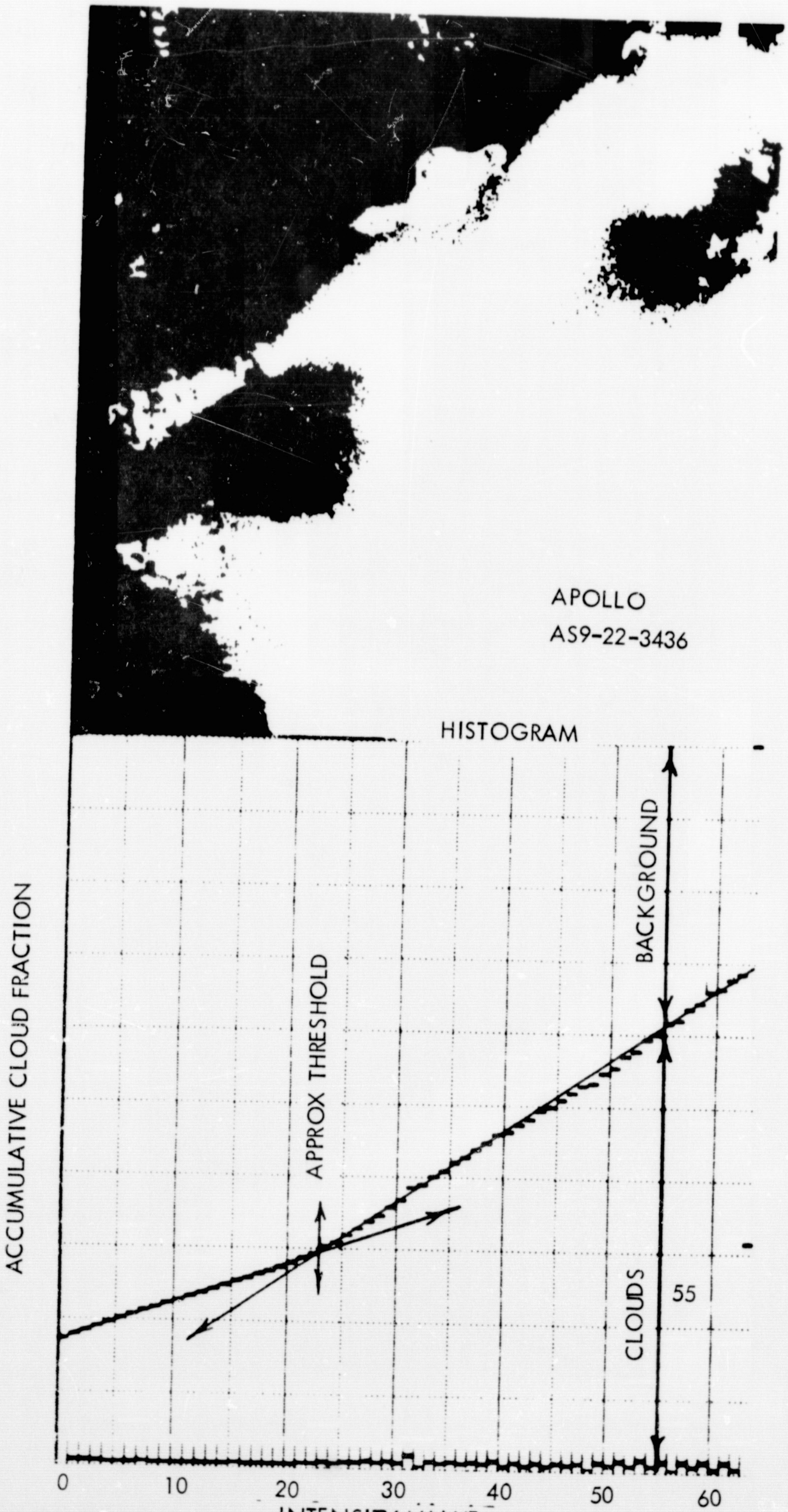


Figure 3-9. Apollo (Frame AS9-22-3436) Facsimile and Histogram With the Intensity Threshold = 55

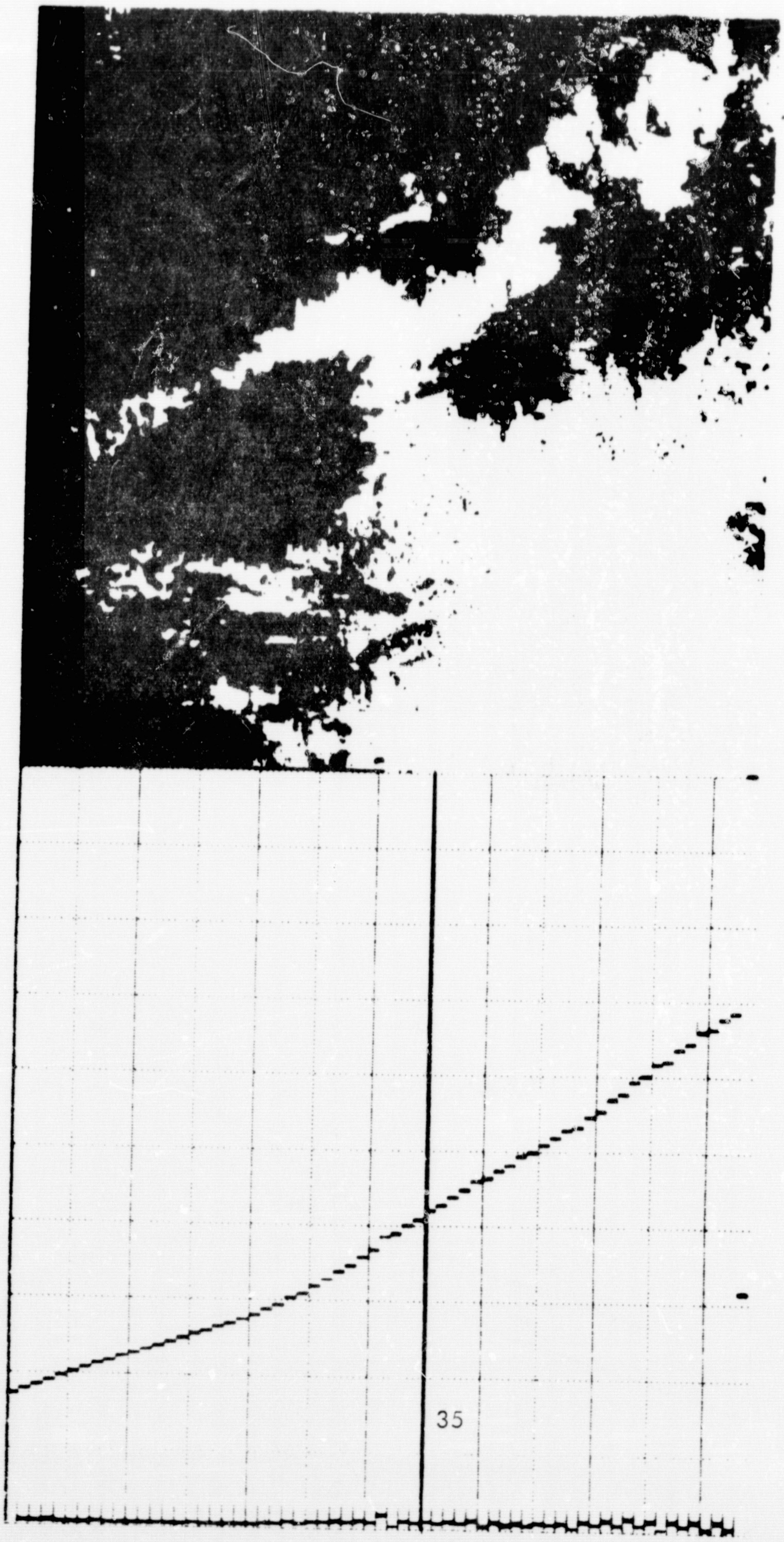


Figure 3-10. Apollo (Frame AS9-22-3436) Facsimile and Histogram With the Intensity Threshold = 35

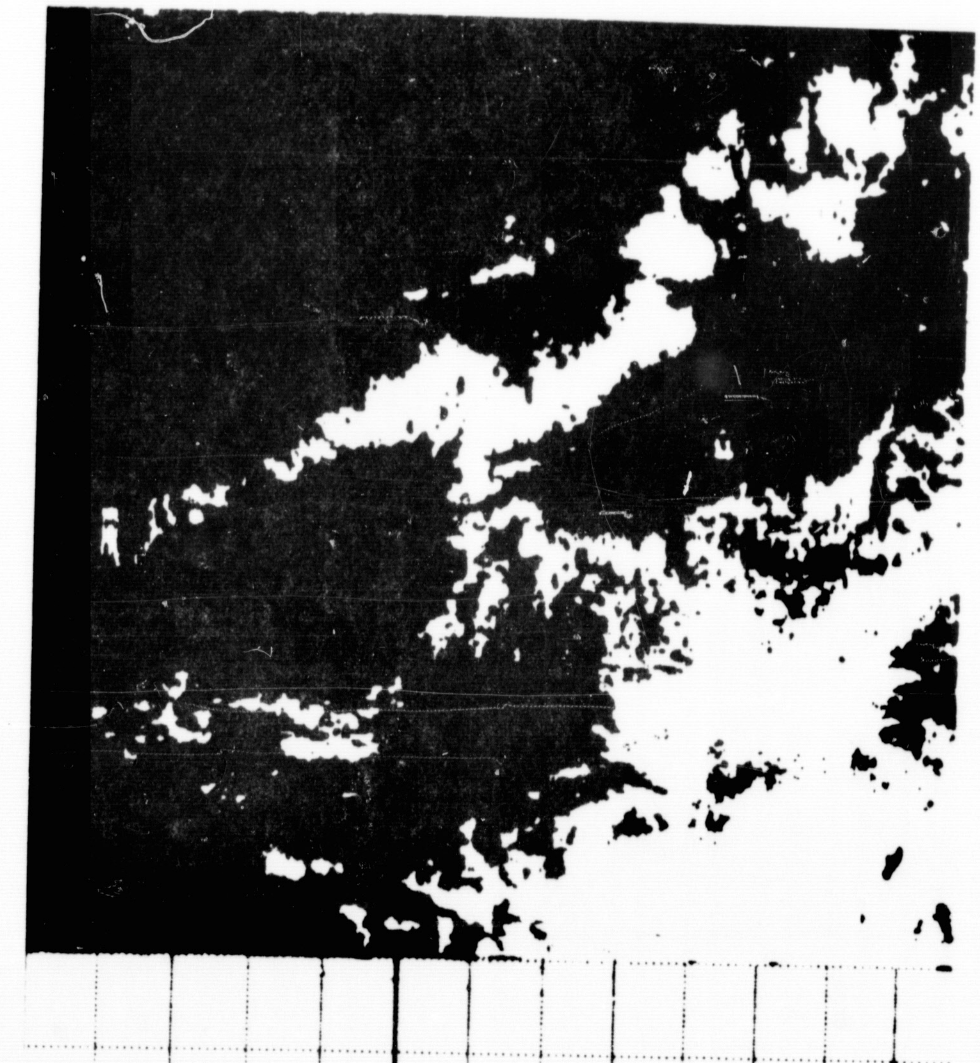


Figure 3-11. Apollo (Frame AS9-22-3436) Facsimile and Histogram With the Intensity Threshold = 25

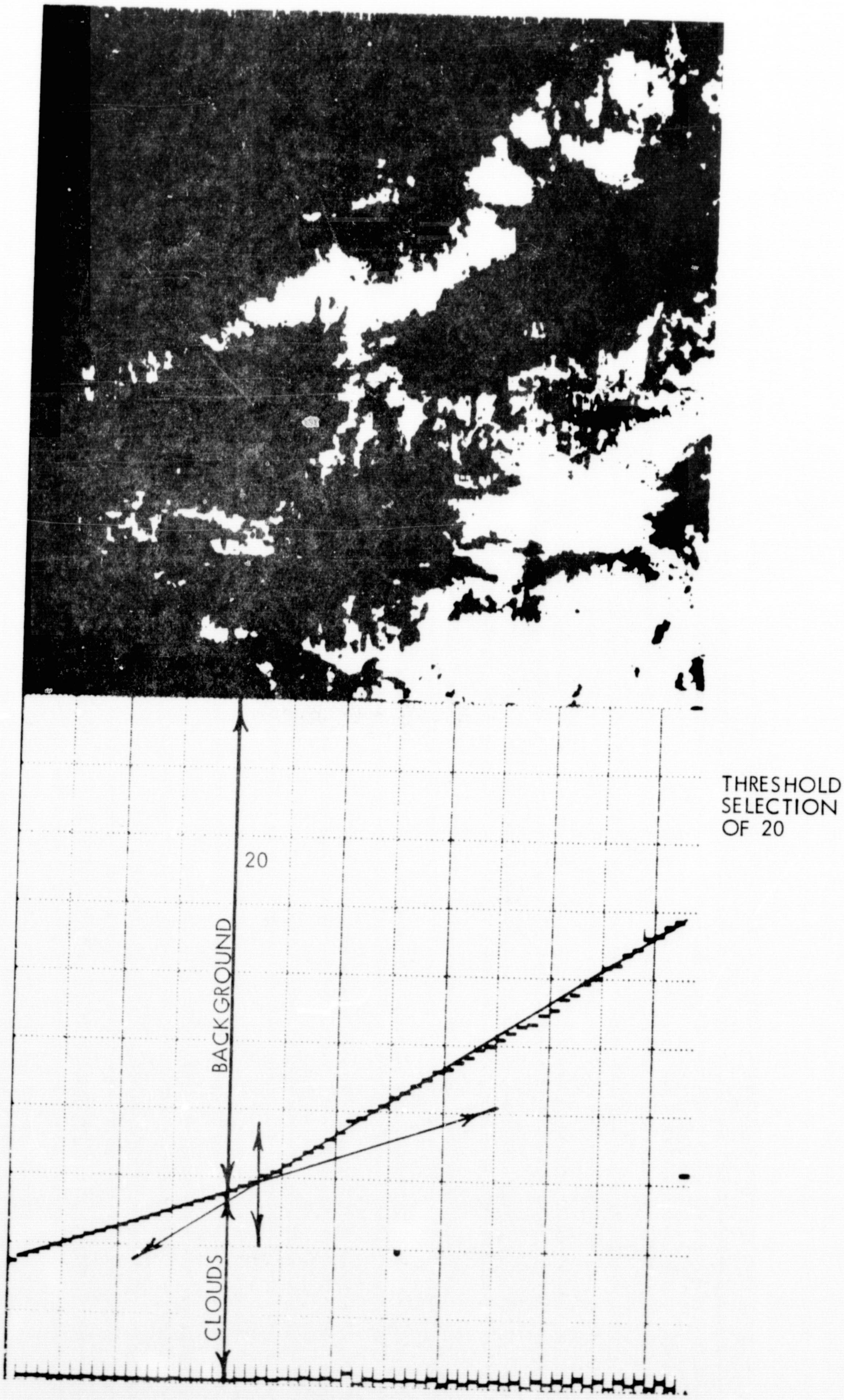


Figure 3-12. Apollo (Frame AS9-22-3436) Facsimile and Histogram With the Intensity Threshold = 20

Figure 3-13. U2 (Frame 186A/Flight ML62) Enlarged Facsimile (Upper Half) With the Intensity Threshold = 20

Figure 3-14. U2 (Frame 186A/Flight ML62) Enlarged Facsimile (Lower Half) With the Intensity Threshold = 20

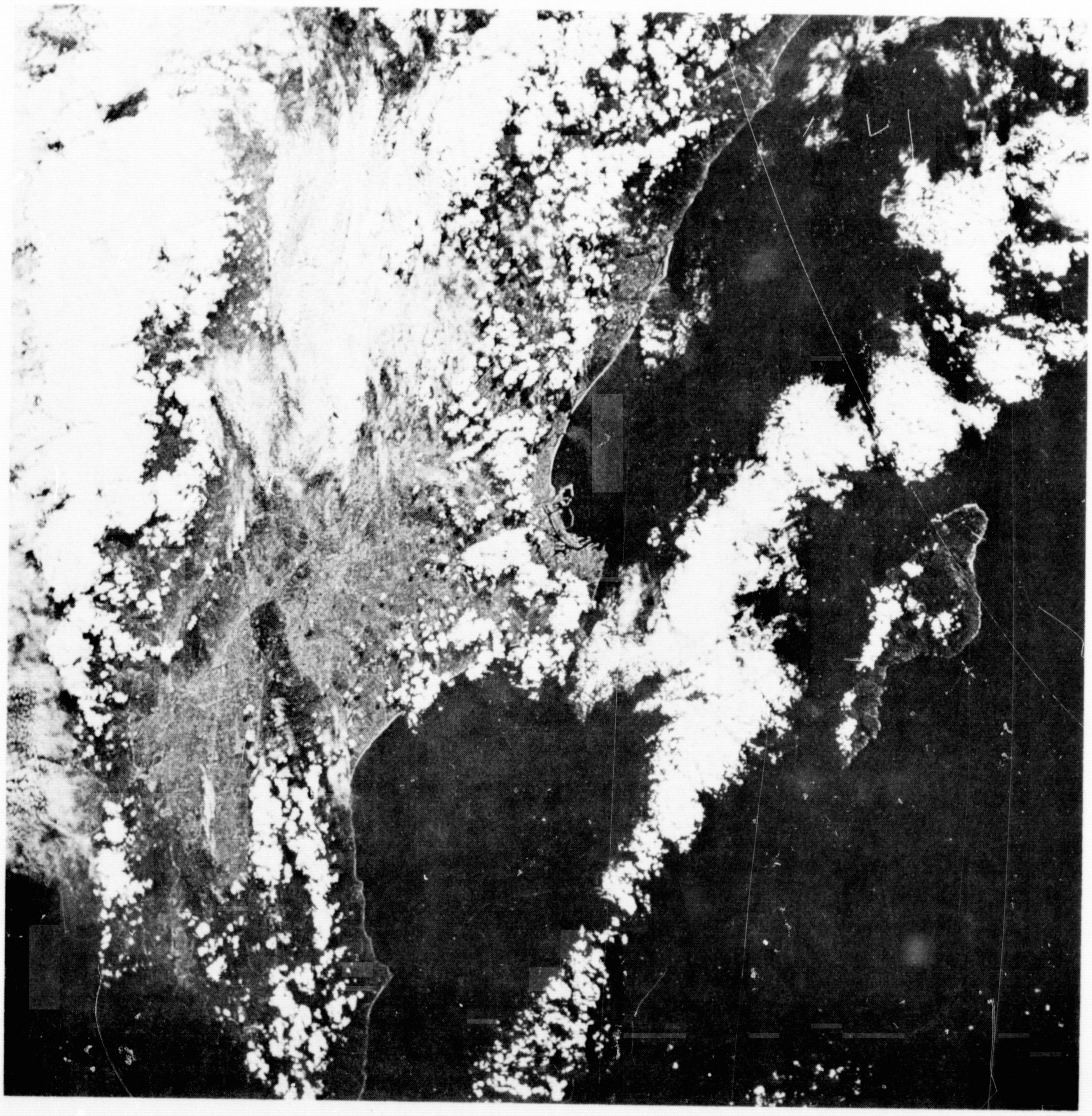


Figure 3-15. Apollo (Frame AS9-22-3436) Photograph Print

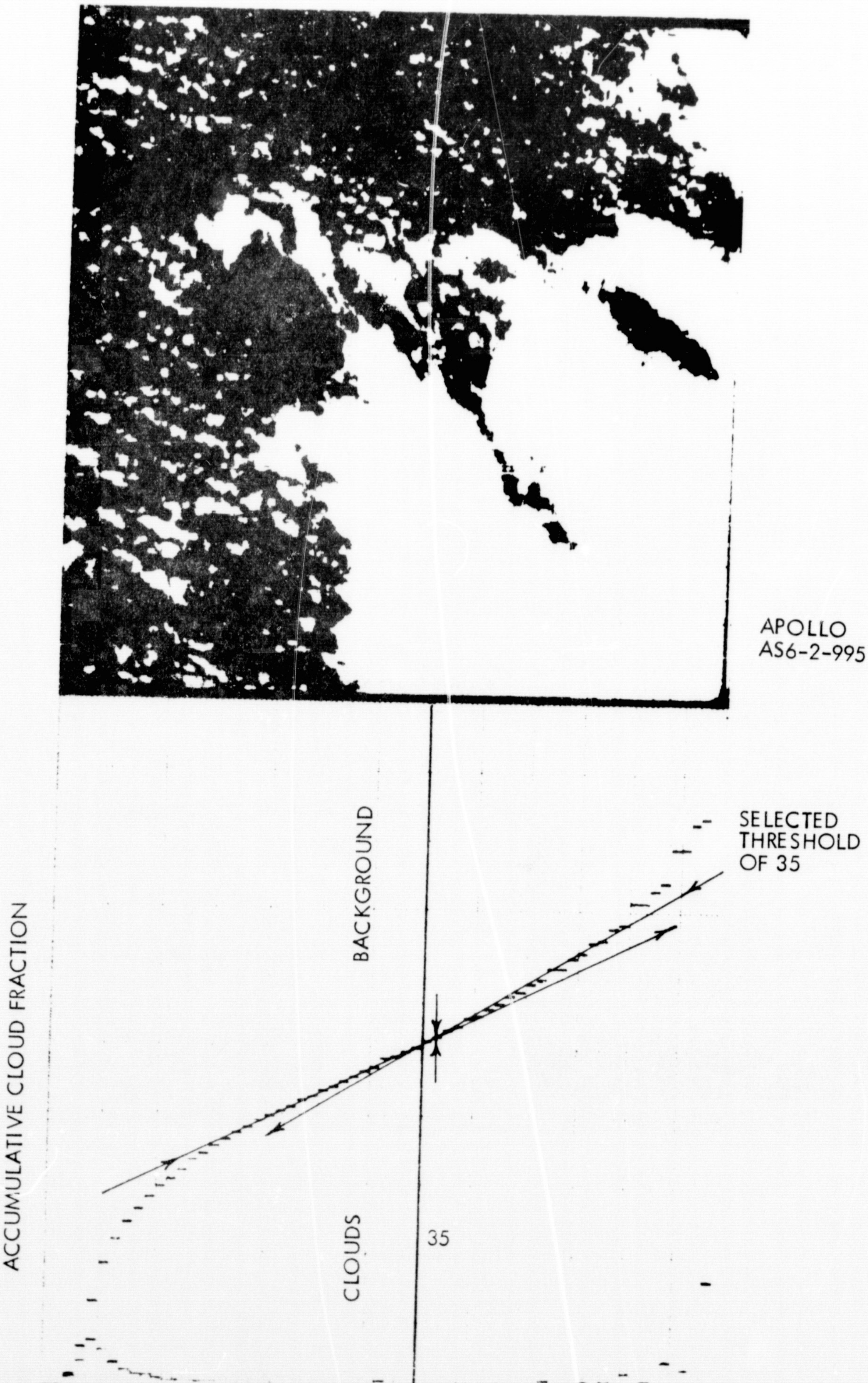


Figure 3-16. Apollo (Frame AS6-2-995) Facsimile and Histogram With the Intensity Threshold = 35

Figure 3-17. Apollo (Frame AS6-2-995) Photograph Print

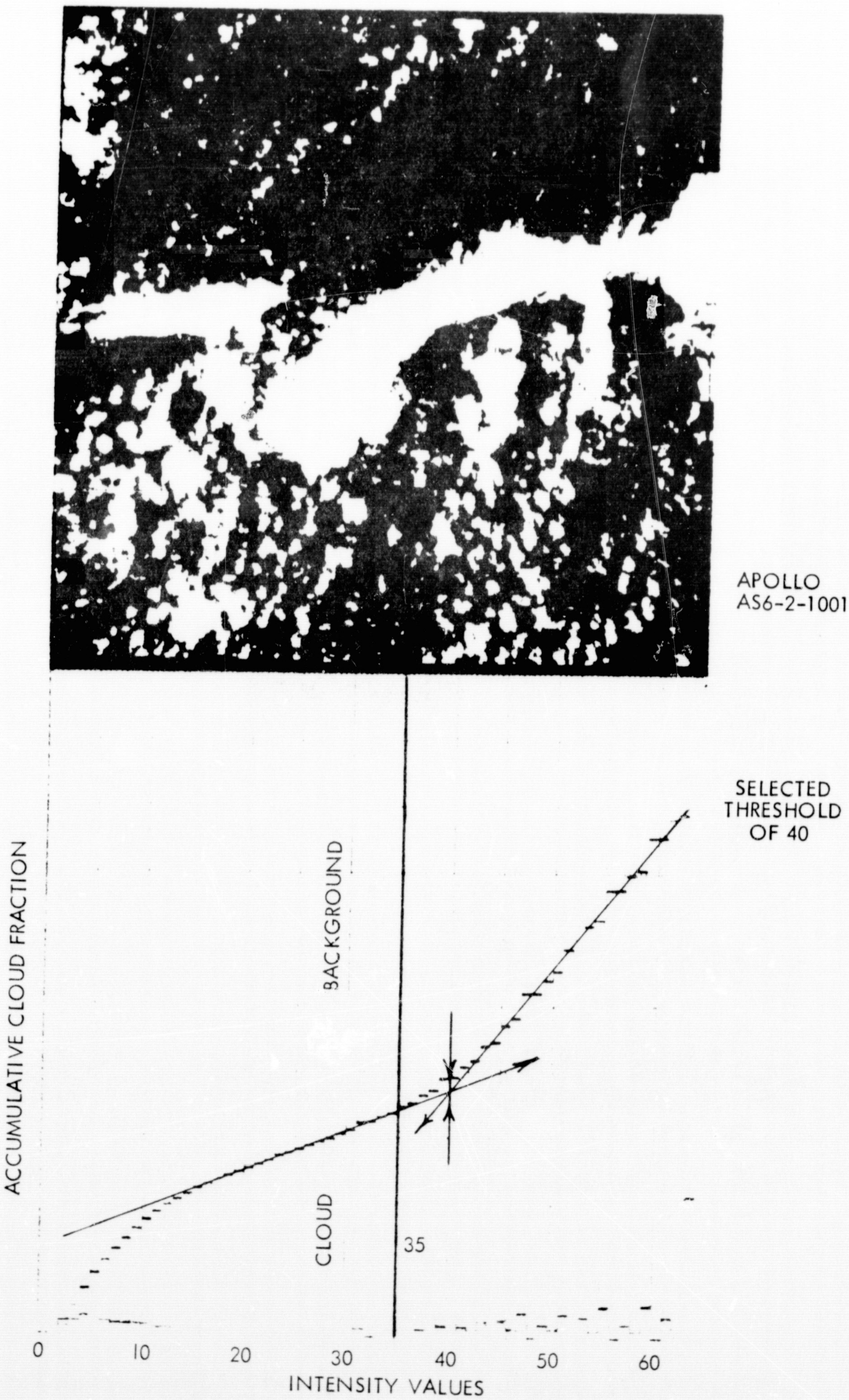


Figure 3-18. Apollo (Frame AS6-2-1001) Facsimile and Histogram With the Intensity Threshold = 35

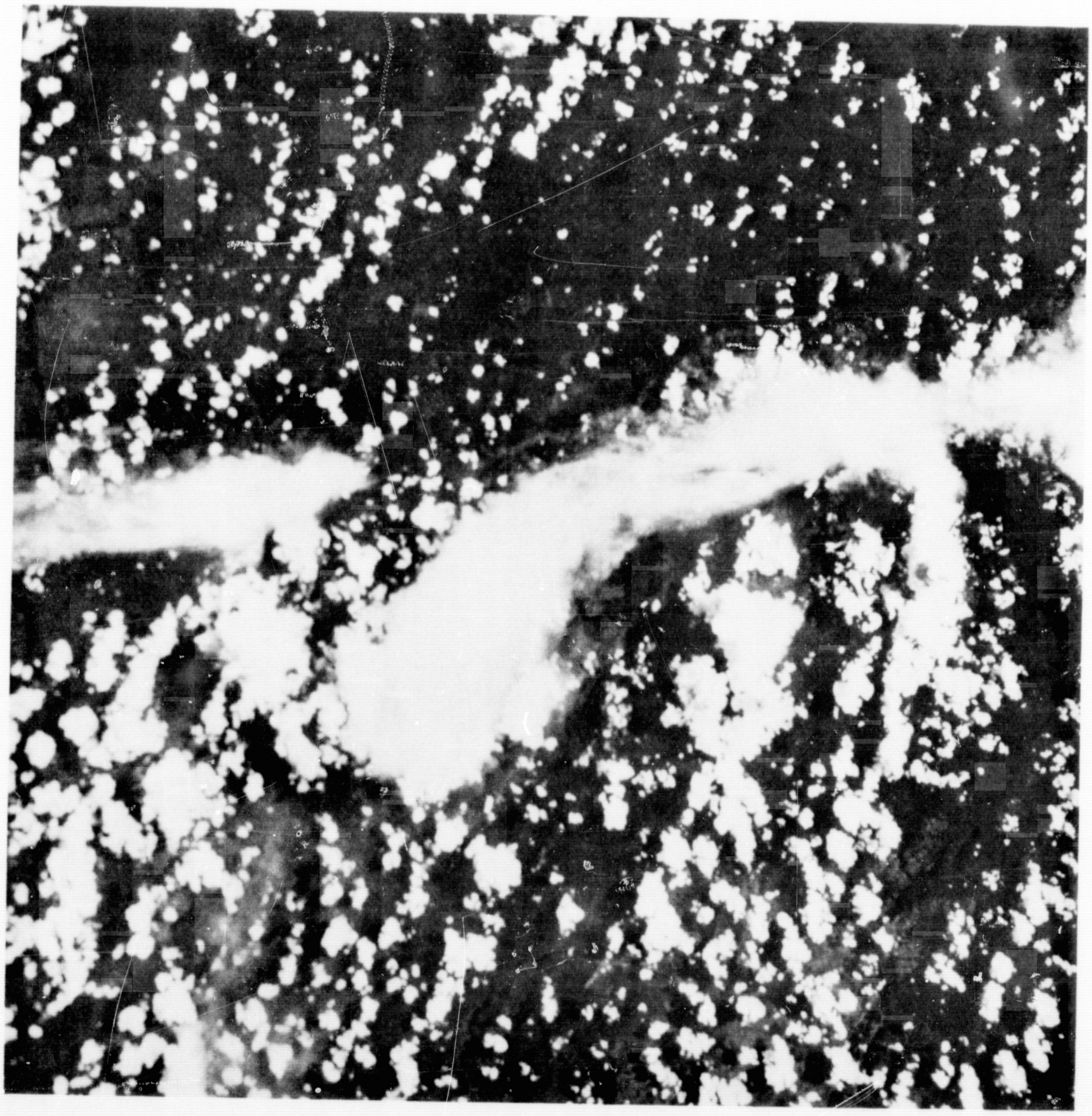


Figure 3-19. Apollo (Frame AS6-2-1001) Photograph Print

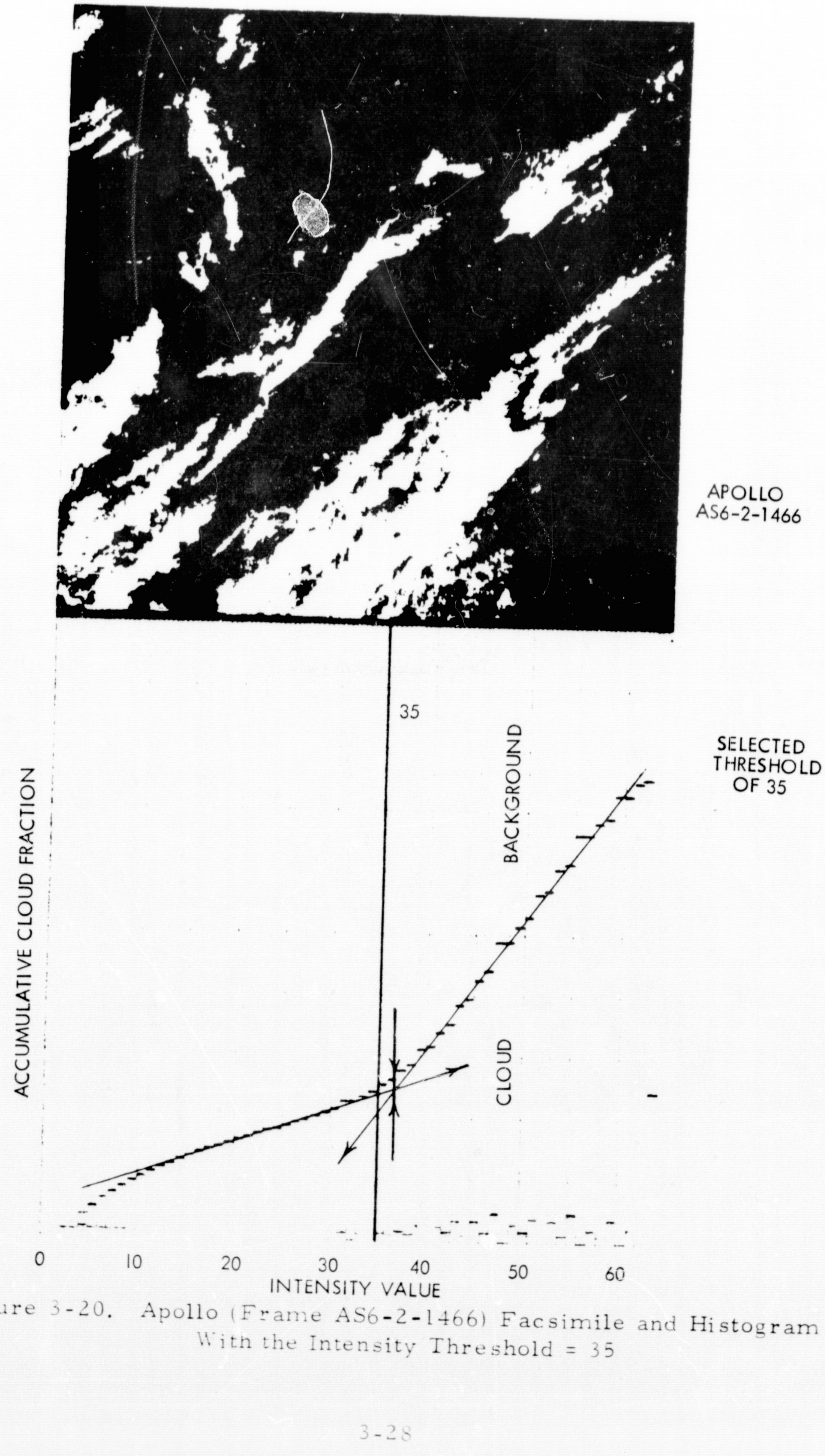


Figure 3-20. Apollo (Frame AS6-2-1466) Facsimile and Histogram With the Intensity Threshold = 35

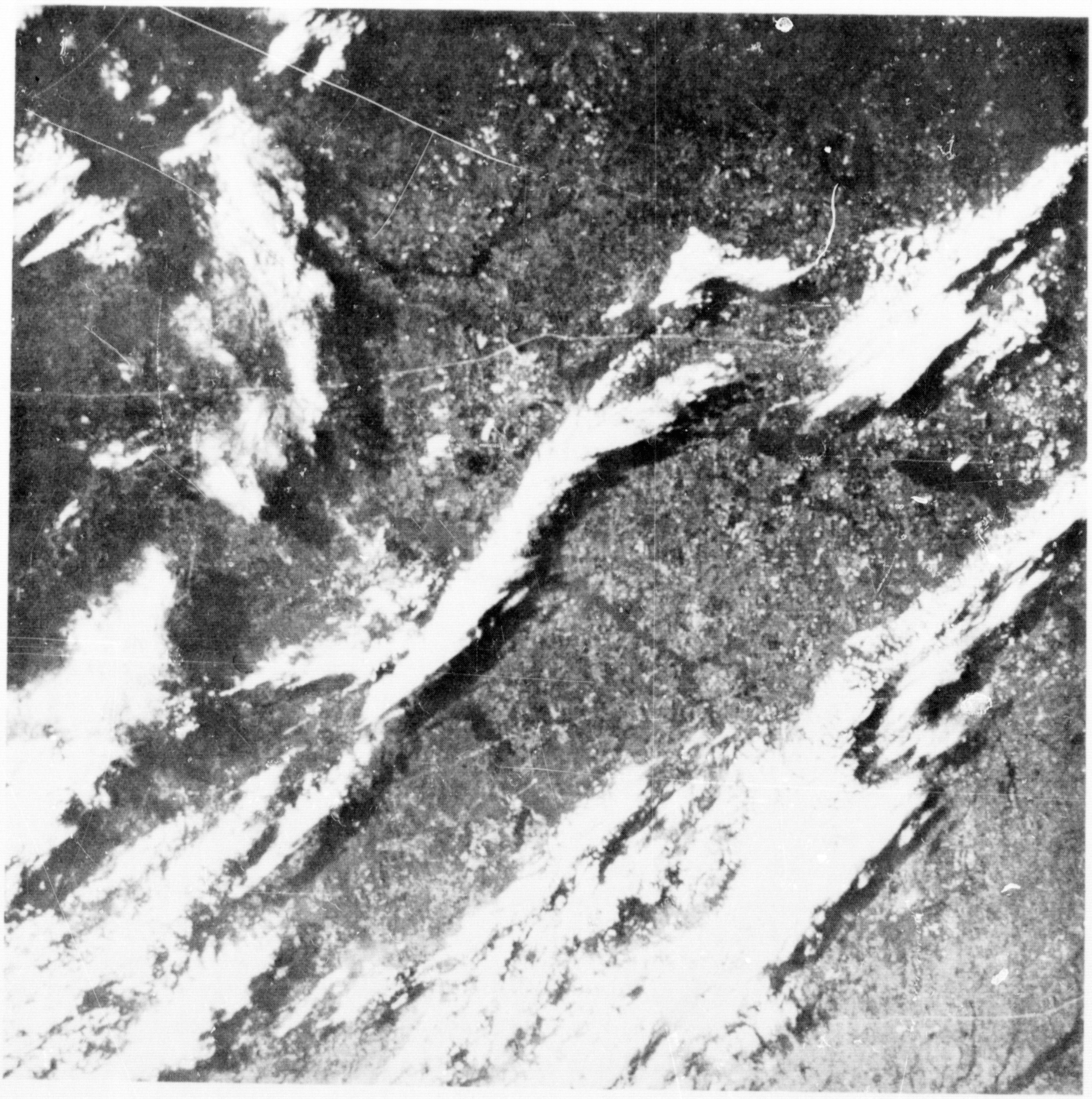


Figure 3-21. Apollo (Frame AS6-2-1446) Photograph Print

The computer program developed to derive the cloud statistics basically involved the summation of cloud-free elements as the element size increased from 1 x 1 to 2 x 2 to 4 x 4 to 8 x 8 to....512 x 512 or 1024 x 1024. Also developed were two important improvements to provide greater accuracy by overlapping of the element summation procedure and the elimination of roads and/or grid lines showing as clouds. The program is described in detail in Appendix B. Figure 3-22 illustrates the statistics derivation output.

3.3.4.1 Overlapping Routine

The statistics-generation computer code performs the major statistical computations with a deterministic straightforward method rather than a stochastic method. However, the deterministic method has the handicap of requiring up to 1024 x 1024 intensity grid points. This is equivalent to more than one million core-storage words, which is beyond the capacity of the IBM System 360 Model 85 computer system. Also the cost would be prohibitive even if storage was available.

However, a method of using the data for each scan line was developed by building up accumulated point data for each square resolution element by processing each line separately. This method reduces the storage requirement to 1024 points on 1024 words.

The limiting number of resolution elements and corresponding accuracy can be obtained by moving the basic element size one point at a time in the vertical and horizontal directions to obtain all possible resolution elements in the N x N scanned grid.

This method would require excessive computer time without significantly increasing the accuracy (< 0.5 percent increase). Therefore, the overlap method was selected. It moved the resolution element in increments of 25 percent of the resolution element length until the dispaced element overlaped the basic element by 25 percent. Figure 3-23 shows the possible combinations considered. Considerable error can be introduced when only the 100 percent case is used. The table in Figure 3-24 shows results for a sample problem where the actual cloud-free percentage is 40 percent for 8 x 8 points and 50 percent for the 100-percent overlap. Table 3-2 shows the format of the data in the table in Figure 3-24 . With the overlap used, the five additional cloud-free elements are included in the results, thereby eliminating this 20-percent error.

The number of resolution elements versus overlap type for horizontal and vertical overlap is illustrated for a 16 x 16 grid sample case in Table 3-3. Even for the small point number case, there are 25 resolution elements for the 8 x 8 or half size (in linear length). For a 512 by 512 point grid, the number of elements at half size is increased by a factor of ~4000.

```
VERTICAL   HORIZONTAL  NO. VERTICAL  NO. HORIZONTAL  ELEMENT
ORIGIN     ORIGIN      ELEMENTS      ELEMENTS        GRID SIZE
   1          1            1             1              512
INPUT GRID TAPE UNIT =  7                TAPE FILE USED =  1
PACKING MODE (1-NO/2-YES) =  1             NO. LINES/RECORD =   6
 FILE  1, A525/3960, 65P CLOUDS
THRESHHOLD INTENSITY =   32   CLOUD ELIM. =   4   MINIMUM CLOUD POINTS - 1 =   4


NUMBER OF 1X1 CLOUD POINTS =        91879
ELEMENT GRID SIZE   OVERLAP INDEX     NO. GRID ELEMENTS   NO. CLOUD FREE ELEMENTS
      2                   1              130816                81694.00003
      2                   3              130305                81773.00004
NO. 1X1 CLOUD POINTS =             2  TOT. NO. CLOUD + CLOUD FREE PTS =      261121
CLOUD FREE FRACTION =         .62602
ELEMENT GRID SIZE   OVERLAP INDEX     NO. GRID ELEMENTS   NO. CLOUD FREE ELEMENTS
      4                   1              65152                 38281.0000C
      4                   2              64643                 38217.0000C
      4                   3              64643                 38088.0000C
      4                   4              64643                 38243.00000
NO. 1X1 CLOUD POINTS =             4  TOT. NO. CLOUD + CLOUD FREE PTS =      259081
CLOUD FREE FRACTION =         .58989
ELEMENT GRID SIZE   OVERLAP INDEX     NO. GRID ELEMENTS   NO. CLOUD FREE ELEMENTS
      8                   1              16192                 8780.00000
      8                   2              15939                 8725.0000C
      8                   3              15939                 8799.0000C
      8                   4              15939                 8769.0000C
NO. 1X1 CLOUD POINTS =             8  TOT. NO. CLOUD + CLOUD FREE PTS =      64009
CLOUD FREE FRACTION =         .54794
ELEMENT GRID SIZE   OVERLAP INDEX     NO. GRID ELEMENTS   NO. CLOUD FREE ELEMENTS
     16                   1              4000                  1941.00000
     16                   2              3875                  1982.0000C
     16                   3              3875                  1958.0000C
     16                   4              3875                  1923.0000C
NO. 1X1 CLOUD POINTS =            16  TOT. NO. CLOUD + CLOUD FREE PTS =      15625
CLOUD FREE FRACTION =         .49946
ELEMENT GRID SIZE   OVERLAP INDEX     NO. GRID ELEMENTS   NO. CLOUD FREE ELEMENTS
     32                   1              976                   396.00000
     32                   2              915                   406.0000C
     32                   3              915                   412.0000C
     32                   4              915                   411.00000
NO. 1X1 CLOUD POINTS =            32  TOT. NO. CLOUD + CLOUD FREE PTS =      3721
CLOUD FREE FRACTION =         .43671
ELEMENT GRID SIZE   OVERLAP INDEX     NO. GRID ELEMENTS   NO. CLOUD FREE ELEMENTS
     64                   1              232                   78.0000C
     64                   2              203                   78.00000
     64                   3              203                   78.0000C
     64                   4              203                   80.0000C
NO. 1X1 CLOUD POINTS =            64  TOT. NO. CLOUD + CLOUD FREE PTS =      841
CLOUD FREE FRACTION =         .37337
ELEMENT GRID SIZE   OVERLAP INDEX     NO. GRID ELEMENTS   NO. CLOUD FREE ELEMENTS
    128                   1              52                    11.00000
    128                   2              39                    14.00000
    128                   3              39                    15.00000
    128                   4              39                    13.00000
NO. 1X1 CLOUD POINTS =           128  TOT. NO. CLOUD + CLOUD FREE PTS =      169
CLOUD FREE FRACTION =         .31361
ELEMENT GRID SIZE   OVERLAP INDEX     NO. GRID ELEMENTS   NO. CLOUD FREE ELEMENTS
    256                   1              10                    C
    256                   2              5                     1.00000
    256                   3              5                     1.0000C
    256                   4              5                     1.00000
NO. 1X1 CLOUD POINTS =           256  TOT. NO. CLOUD + CLOUD FREE PTS =      25
CLOUD FREE FRACTION =         .12000
ELEMENT GRID SIZE   OVERLAP INDEX     NO. GRID ELEMENTS   NO. CLOUD FREE ELEMENTS
    512                   1              1                     0
NO. 1X1 CLOUD POINTS =           512  TOT. NO. CLOUD + CLOUD FREE PTS =      1
CLOUD FREE FRACTION =         0
NO. 1X1 CLOUD POINTS =         91879  TOT. NO. CLOUD + CLOUD FREE PTS =      262144
CLOUD FREE FRACTION =         .64951
```

Figure 3-22. Illustration of Statistics Derivation Program Output

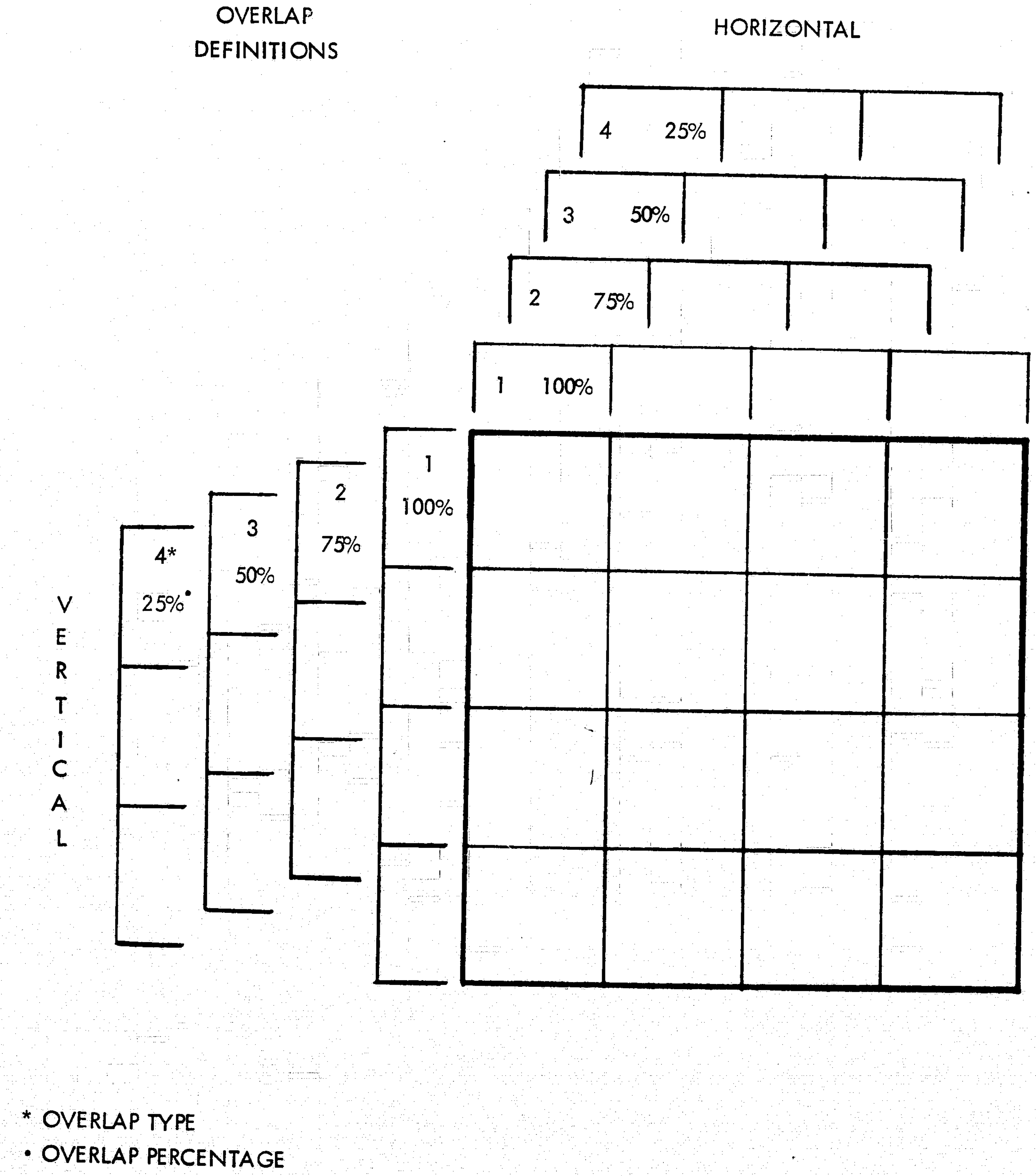
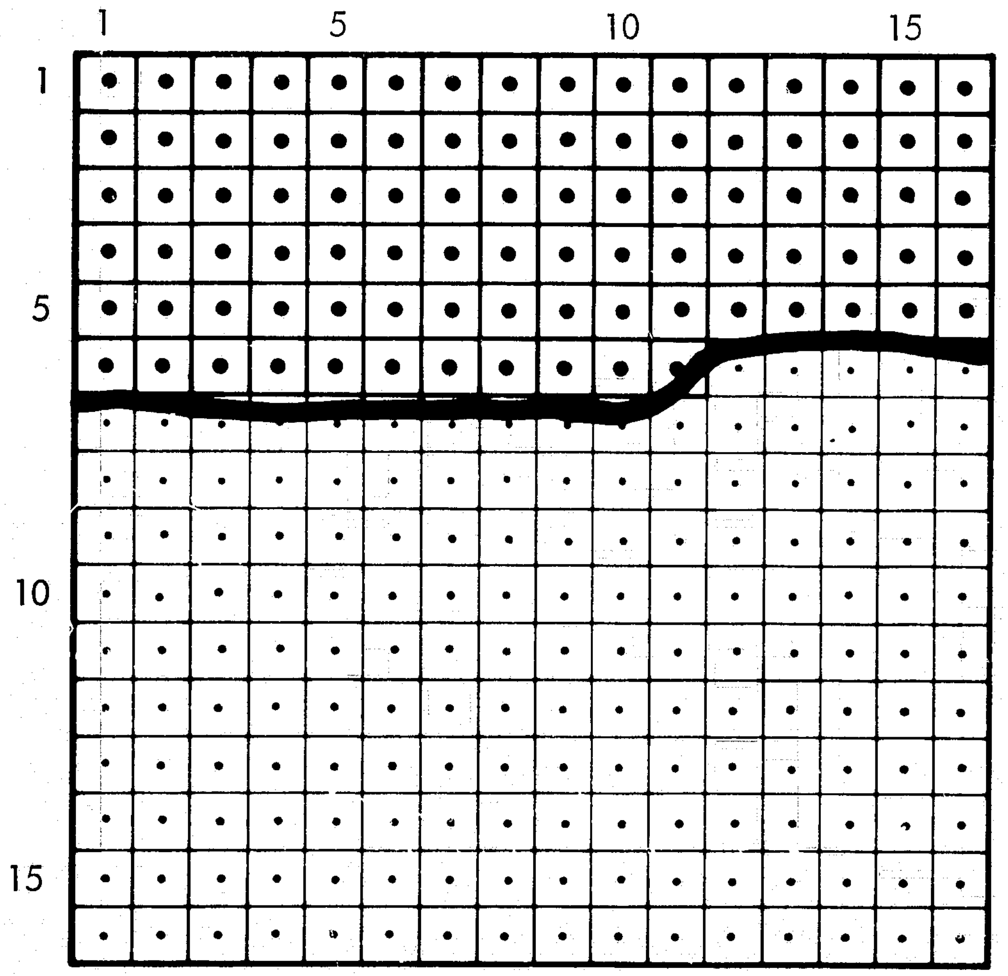


Figure 3-23. Resolution Element Overlap Combinations



91			
2	1	120	75.
2	3	105	64.
2	225	0.61778	
4	1	52	26.
4	2	39	15.
4	3	39	26.
4	4	39	26.
4	169	0.55030	
8	1	10	5.
8	2	5	0.
8	3	5	0.
8	4	5	5.
8	25	0.40000	
16	1	1	0.
16	1	0.00000	
91	256	0.35547	

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

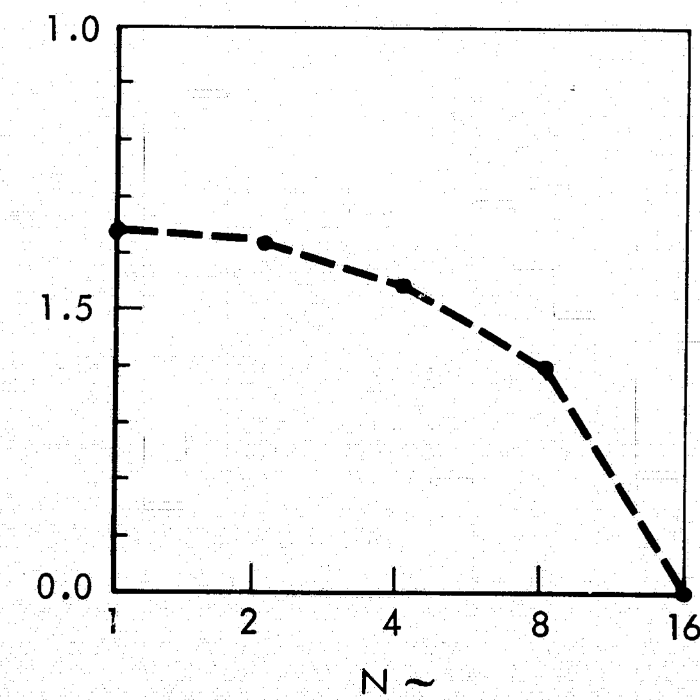


Figure 3-24. Hypothetical Cloud Statistics, Layer Clouds

Table 3-2. Data Table Format

OUTPUT DATA FORMAT
For Sample Data Cases

No. of (1 x 1)'s With Clouds
91

N of (N x N)	Vertical Overlap Type	No. of (N x N)'s	No. of Cloud-Free (N x N)'s
2	1	120	42.
2	3	105	39.

N of (N x N)	Total No. of (N x N)'s	Fraction of (N x N)'s Cloud Free	
2	225	0.360	= (81. /225)

No. of (1 x 1)'s With Clouds	Total No. of (1 x 1)'s	(1 x 1)'s Cloud-Cover Fraction
91	256	0.35547

Overlap Type	% Overlap
1	100
2	75
3	50
4	25

Table 3-3. Number of Resolution Elements Versus Overlap Type for Sample Case

Grid Size	Overlap Direction: Vertical — Overlap (%)	Vertical — No. of N's	Horizontal — Overlap (%'s)	Horizontal — No. of N's	No. of N x N's	Total
1	100	16	100	16	256	256
2	100	8	100, 50	8, 7	64, 56	120*
	50	7	100, 50	8, 7	56, 49	105*
						225
4	100	4	100, 75, 50, 25	4, 3, 3, 3	16, 12, 12, 12	52*
	75	3	100, 75, 50, 25	4, 3, 3, 3	12, 9, 9, 9	39*
	50	3	100, 75, 50, 25	4, 3, 3, 3	12, 9, 9, 9	39*
	25	3	100, 75, 50, 25	4, 3, 3, 3	12, 9, 9, 9	39*
						169
8	100	2	100, 75, 50, 25	2, 1, 1, 1	4, 2, 2, 2	10*
	75	1	100, 75, 50, 25	2, 1, 1, 1	2, 1, 1, 1	5*
	50	1	100, 75, 50, 25	2, 1, 1, 1	2, 1, 1, 1	5*
	25	1	100, 75, 50, 25	2, 1, 1, 1,	2, 1, 1, 1	5*
						25
16	100	1	100	1	1	1

No. of N x N's versus vertical and horizontal overlap for a 16 x 16 grid sample problem

* Sub-Totals

An efficient method for computing the contribution of each scan line to the various resolution elements is depicted in Figure 3-25 for the sample case of 16 x 16. The n + 1 resolution size is selected as twice the linear size for the n^{th} resolution size. This increase by multiples of 2 permit a simple method of summing pairs of values of the n^{th} resolution element cumulative cloud point arrays to generate the summation of cloud points for the n + 1 resolution size elements.

Table 3-4 shows the pairs of points in the n^{th} resolution size elements, which are summed to generate cloud point summations for the n + 1 resolution size elements. (See the 8 x 8 and 4 x 4 case in Figure 3-6.)

Table 3-4 also denotes the initial point of the n^{th} resolution size points to be used in the pair summations of the n + 1 resolution size cloud point summation.

A similar method is also used for vertical overlap as the date are accumulated for successive lines and the summation arrays are examined for cloud-free elements as the proper multiple of lines have been processed for the respective resolution size (for example, 4 lines for the 4 x 4 resolution element size). After the data are stored for the number of cloud-free elements have been stored in another array, the summation arrays are zeroed, and the process is continued for the next scan line.

This overlap method has been demonstrated to solve the problems of core storage requirement and provides efficient computations through the use of successive summations. A factor of 2 for successive resolution element sizes linear dimension was adequate to assure accurate interpolation as a function of FOV size. The computer routine that implements the overlap method is designated as subroutine STAHOL and is described in detail in Appendix B.

Table 3-4. Transformation Logic Between N and N + 1 Resolution Elements Cloud Point Summations

N + 1 Resolutions Size Being Generated in Terms of Percent Overlap	N - Resolution Size Arrays Used Percent Overlap Case	Array Starting Position For Summation
100	100	First
75	50	First
50	100	Second
25	50	Second

Intensity Grid Points Converted to Cloud/No Cloud (1/0) Values (16 Point Sample Case)	Resolution Point Size	Overlap Type (%)
• • • • • • • • • • • • • • • •	1 x 1	100
11* | 12 | 13 | 14 | 15 | 16 | 17 | 18	2 x 2	100
21 | 22 | 23 | 24 | 25 | 26 | 27	2 x 2	50
(11 + 12) | (13 + 14) | (15 + 16) | (17 + 18)	4 x 4	100
(21 + 22) | (23 + 24) | (25 + 26)	4 x 4	75
(12 + 13) | (14 + 15) | (16 + 17)	4 x 4	50
(22 + 23) | (24 + 25) | (26 + 27)	4 x 4	25
(11 + 12) + (13 + 14) | (15 + 16) + (17 + 18)	8 x 8	100
(12 + 13) + (14 + 15)	8 x 8	75
(13 + 14) + (15 + 16)	8 x 8	50
(24 + 25) + (26 + 27)	8 x 8	25
[(11 + 12) + (13 + 14)] + [(15 + 16) + (17 + 18)]	16 x 16	100

*An Index Number Denoting the Summation of the Number of Cloud Points (1's)

Figure 3-25. Efficient Method of Constructing Cloud Point Summations for Resolution Elements From Single Line by Successive Summations

3.3.4.2 Road Elimination Routine

This routine was designed to eliminate problems associated with roads that appear as lines of the same transmitted intensity as clouds. Figure 3-4 shows a case of roads that appeared in the facsimile of the digitize tape data (Figure 3-3). It is obvious from Figures 3-4 and 3-3 that the roads will eliminate a large percentage of the cloud-free resolution elements of larger size. Another problem was observed because of numerous 1- to 3-point groups that could not be clouds but possibly transmitted intensity noise as a result of the film resolution or development process or possibly the digitization process. The latter possibility is considered to be unlikely. Another possible cause of single or small number point groups is scanning at the tangent point of small clouds. However, irrespective of the origin of these spurious points, they had to be eliminated.

If the point elimination criterion is selected as 4 points, all groups of 4 points or less, which are cloud points, will be eliminated, i.e. defined as cloud free. Those cloud point sequences along the scan line with greater than 4 consecutive points were not changed.

An additional method of eliminating the effect of spurious points is defining resolutions elements which have a small percentage of clouds as cloud free. It is obviously incorrect to define an element with one cloud point in a total of 512 x 512 points as cloudy for earth resources applications. If resolution elements are accepted as cloud free with less than a prescribed small percentage, both the spurious point and insignificant cloud percentage effect problems are solved.

After selecting the point and area methods for elimination of erroneous cloud points and cases, the problem exists of selecting the number of points and the threshold percentage for cloudy resolution elements. These values were selected empirically, as illustrated in Figure 3-26 for the U2 frame 89A from flight ML62. This figure shows parametric curves for point elimination of 0 to 4 points and area elimination of 0 to 4 percent.

This figure will illustrate the necessity for the road elimination scheme. Table 3-5 shows the cloud-free percentage statistics data for percentage and point combinations of 0/0, 0/4, 1/0, 4/0, and 4/4 for Frame 198A of U-2 Flight ML-62. Visual examination of this frame showed about 10 to 15 percent estimated cloud cover with extensive road patterns at intervals throughout the photograph of one, one-half, and one-fourth miles.

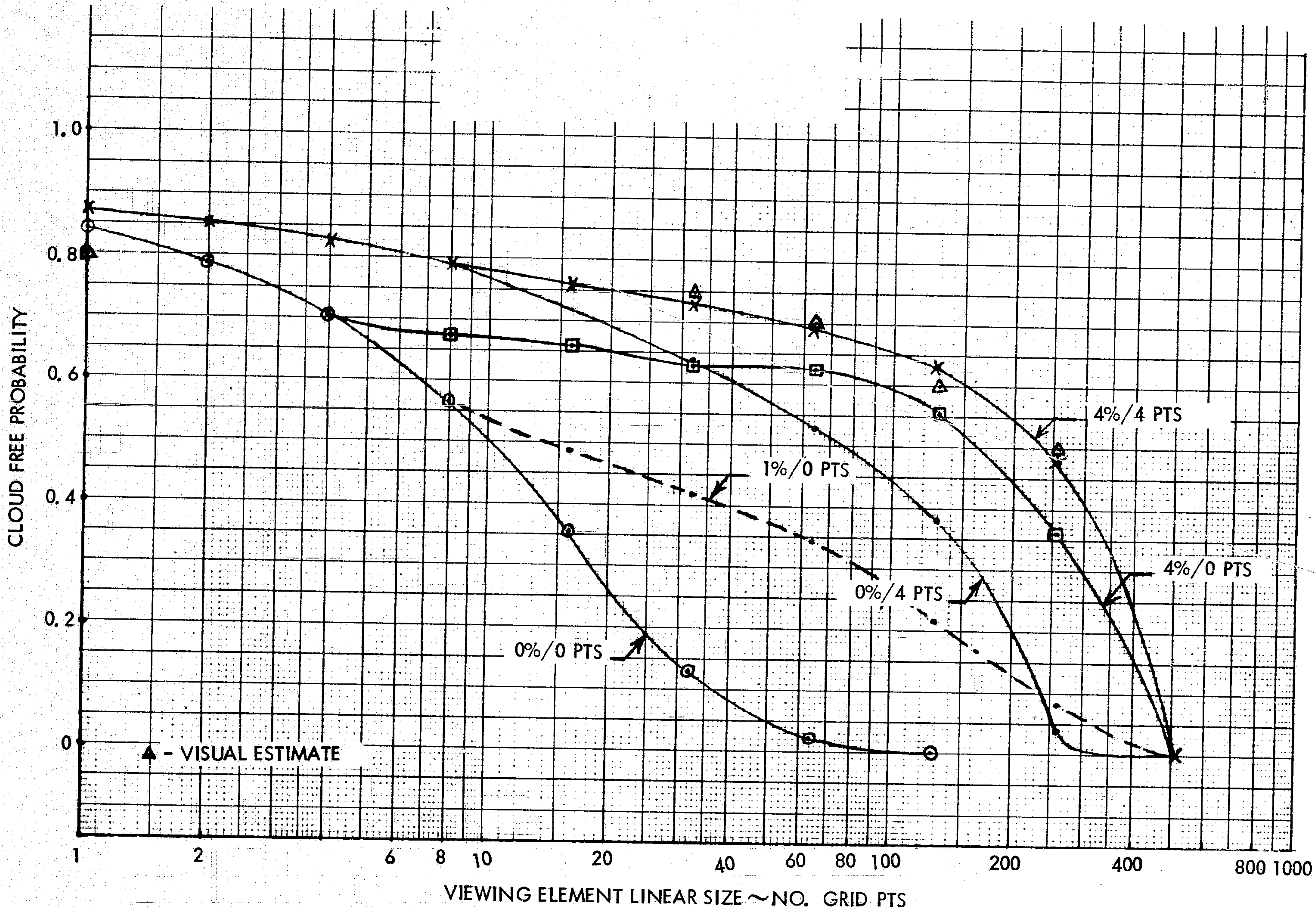


Figure 3-26. ML62 Frame 89A Cloud Free Probability Versus Viewing Element Size

Table 3-5. Example of Road Elimination Routine on Cloud-Free Statistics

Element No.	Element Size	0%/ 0 Pts	0%/ 4 Pts	1%/ 0 Pts	4%/ 0 Pts	4%/ 4 Pts
1 x 1	30 m x 30 m	0.842	0.873	0.842	0.842	0.873
2 x 2	60 m x 60 m	0.789	0.852	0.789	0.789	0.852
4 x 4	120 m x 120 m	0.705	0.823	0.705	0.705	0.823
8 x 8	240 m x 240 m	0.567	0.779	0.567	0.675	0.791
16 x 16	0.5 km x 0.5 km	0.352	0.719	0.491	0.661	0.759
32 x 32	1 km x 1 km	0.130	0.636	0.415	0.635	0.729
64 x 64	2 km x 2 km	0.021	0.530	0.346	0.625	0.693
128 x 128	4 km x 4 km	0	0.385	0.213	0.556	0.633
256 x 256	8 km x 8 k m	0	0.040	0.080	0.360	0.480
512 x 512	16 km x 16 km	0	0	0	0	0

In Figure 3-26, the triangle symbol denote cloud-free percentage values derived from an 8- x 8-in. print of the original U2 film frame. A comparison of the curves shows that with no road and spurious point elimination, the cloud-free percentage drops off with a large-percentage error for resolution-element linear sizes greater than 2 points. (See 0 percent/0 points case.) Also there is better than expected agreement between the 4 percent/4 point criterion case and the visual estimate. This agreement in slope and magnitude validates the utility of the method of elimination. The 4 percent/4 point criteria was used for all the U2 pictures. The same method was used to empirically derive the elimination parameters for the Apollo and ESSA data.

The final test for the validity of the elimination method and specific parameters used is a comparison of the original photograph and equivalent pictures constructed with the digitized data tape. Comparison of prints and digitized data tape facsimile photo in Figures 3-3 through 3-21 and Figure 3-26 illustrates excellent agreement between the digitized data cloud facsimile photo and the original prints for the U2 and Apollo pictures. Similar agreement was obtained for the ESSA pictures.

The road elimination and spurious point elimination are implemented by the computer subroutine designate as ELMSL and explained in detain in Appendix B. The area criterion is applied in the later portion of the statistics generation subroutine STAHOL, which is also explained in Appendix B.

3.3.5 Resulting Statistics (U-2)

The U-2 photographs were digitized into 512-by-512 basic elements thus providing a 1-by-1 element size of approximately 30 by 30 meters.* The summation of cloud elements of this size should provide the so-called perfect-resolution cloud cover such as estimated by ground observers and used in the probability-of-seeing analyses of the previous section. The cloud-cover amount derived from the 1-by-1 element summation should also be representative of an observer's estimate of the cloud cover when visually observing the photograph, but an exact correspondence would not be expected.

Tables 3-6 and 3-7 present a description of the U-2 photographs and the derived cloud-free element statistics for these U-2 photographs. Figures 3-27 through 3-29 present plots of the derived statistics.

Results show the anticipated result of increasing cloud-free percentage of the FOV of the photograph as the basic elements required to be cloud free decrease in size. The entire FOV of these U-2 photographs varies from about eight by eight n miles for the high-altitude flights of about 65,000 feet to about four by four n miles for the low-altitude frames near 35,000 feet. The equivalent 1-by-1 element sizes thus vary from 30 by 30 meters to 15 by 15 meters, respectively. A number of the ML-69 frames were for altitudes of about 50,000 feet and an equivalent 1-by-1 element size of about 22.5 by 22.5 meters.

The results in Figures 3-27, 3-28, and 3-29 also indicate a rather consistent slope of the curves for the smaller element sizes with a negligible increase in cloud-free area at the smallest size. The small variation that does occur is probably because of variations in the size of the clouds elements in the photographs. It should be noted that for these small FOV's of less than eight n miles on a side, all of the clouds are cellular.

At the larger element sizes, the cloud-free percentages are constrained to reach zero at the size of the photograph FOV since all photographs had some cloud amount present. Thus, the reliability of the cloud-free percentages for the largest elements is low. This does not present a problem in the eventual combination of the U-2 data with Apollo data, however.

*Some low-altitude photographs had 1-by-1 element sizes near 15 by 15 meters.

Table 3-6. Description of U-2 Photographs

No.	Flight	Frame	Mo/Time	Location	Cloud Cover %/Category
1	ML-62	185B	Feb 12 LST	Iowa	31.0/2
2		186A			25.3/2
3		191B			30.8/2
4		192B			19.2/2
5		195B			41.4/3
6		198A			12.7/2
7	ML-69	508B	Mar 12	Virginia	86.6/4
8		509B			57.5/4
9		509A			34.9/2
10		510A			39.3/3
11		613A	Mar 14	Georgia	24.5/2
12		617A			37.8/3
13		640A		Florida	49.9/3
14		641A			39.0/3
15		645A			75.8/4
16		665B	Mar 15	N. Carolina	76.4/4
17		717B	Mar 16	Virginia	16.6/2
18		719B			29.4/2
19		720A			35.5/3
20		732B		New York	69.6/4
21		733B			69.4/4
22		742B			29.5/2
23		743A			52.7/3
24		748A		Mass.	65.2/4
25		756B			62.8/4
26		759B			82.1/4
27	ML-89	108B	Apr 28/07	Mass.	47.5/3
28		172A	Apr 28/08		72.2/4
29		172B			47.2/3
30		173A			47.0/3
31		175B			29.3/2
32		179A			8.0/1
33		187B			85.7/4
34		194A			81.7/4
35		205A			31.2/2

Table 3-7. Cloud Statistics Derived From U2 Photographs

No.	1 x 1, m	Cloud Cover %	Cloud-Free Percentage Versus Resolution Element									
			1 x 1	2 x 2	4 x 4	8 x 8	16 x 16	32 x 32	64 x 64	128 x 128	256 x 256	512 x 512
1	30 x 30	31.0	69.0	66.7	63.8	60.5	55.6	46.0	31.9	21.3	1.2	0
2		25.3	74.7	72.6	69.5	65.9	60.6	50.4	39.6	30.2	8.0	0
3		30.8	69.2	65.8	60.6	54.3	45.2	32.8	21.4	11.8	0	0
4		19.2	80.8	78.0	74.0	68.8	62.0	52.3	36.5	11.8	0	0
5		41.4	58.6	55.0	49.5	43.1	34.9	25.4	15.0	5.3	0	0
6		12.7	87.3	85.2	82.3	79.1	75.9	72.9	69.3	63.3	48.0	0
7	22.5 x 22.5	86.6	13.4	11.5	9.2	6.7	4.1	1.5	0	0	0	0
8		57.5	42.5	39.2	35.4	31.2	25.9	19.1	11.4	4.7	0	0
9		34.9	65.1	60.3	54.2	47.7	39.1	28.1	16.2	3.0	0	0
10		39.3	60.7	57.1	52.6	47.2	39.4	27.7	12.6	0	0	0
11	15 x 15	24.5	75.5	73.3	70.4	66.8	62.0	55.1	43.0	19.5	0	0
12		37.8	62.2	59.9	56.8	53.3	48.7	41.8	31.0	14.8	0	0
13		49.9	50.1	48.3	45.4	42.1	37.3	29.5	16.1	1.2	0	0
14		39.0	61.0	58.9	56.2	52.9	48.5	41.6	29.0	5.9	0	0
15		75.8	24.2	23.0	21.7	20.2	18.2	15.3	10.0	0	0	0
16	22.5 x 22.5	76.4	23.6	21.4	18.3	14.8	9.9	4.9	1.7	0	0	0
17		16.6	83.4	81.6	79.1	75.8	71.1	63.8	53.6	24.9	0	0
18		29.4	71.6	69.6	67.0	63.6	58.6	50.5	38.5	18.3	0	0
19		35.5	64.5	61.9	58.0	53.3	46.9	37.6	24.9	6.5	0	0
20		69.6	30.4	29.0	27.4	25.4	22.8	18.9	13.1	3.0	0	0
21		69.4	30.6	28.6	26.6	24.4	21.4	16.3	10.1	0	0	0
22		29.5	70.5	68.4	65.9	63.1	58.8	51.3	36.5	16.0	0	0
23		52.7	47.3	45.0	42.0	38.5	33.5	26.7	19.4	9.5	0	0
24		65.2	34.8	33.5	31.7	29.3	25.5	19.8	12.2	3.6	0	0
25		62.8	37.2	35.2	32.4	28.9	24.3	18.7	14.3	5.9	0	0
26		82.1	17.9	16.5	14.9	13.3	11.2	7.9	3.2	0	0	0
27	15 x 15	47.5	52.5	49.0	44.9	40.5	35.4	28.9	20.7	5.3	0	0
28		72.2	27.8	25.3	22.0	18.4	13.3	6.9	1.8	0	0	0
29		47.2	52.8	49.3	44.7	39.3	31.7	22.1	11.9	0.6	0	0
30		47.0	53.0	47.2	40.5	34.4	28.4	19.5	9.3	0	0	0
31		29.3	70.7	67.9	64.5	61.0	57.0	50.9	43.3	34.9	8.0	0
32		8.0	92.0	90.8	89.0	86.8	84.5	81.8	77.1	0	60.0	0
33		85.7	14.3	12.0	9.3	6.7	3.9	1.3	0	0	0	0
34		81.7	19.3	15.5	11.5	8.2	5.0	2.2	0	0	0	0
35		31.2	68.8	65.7	61.5	56.8	51.1	41.7	25.4	8.3	0	0

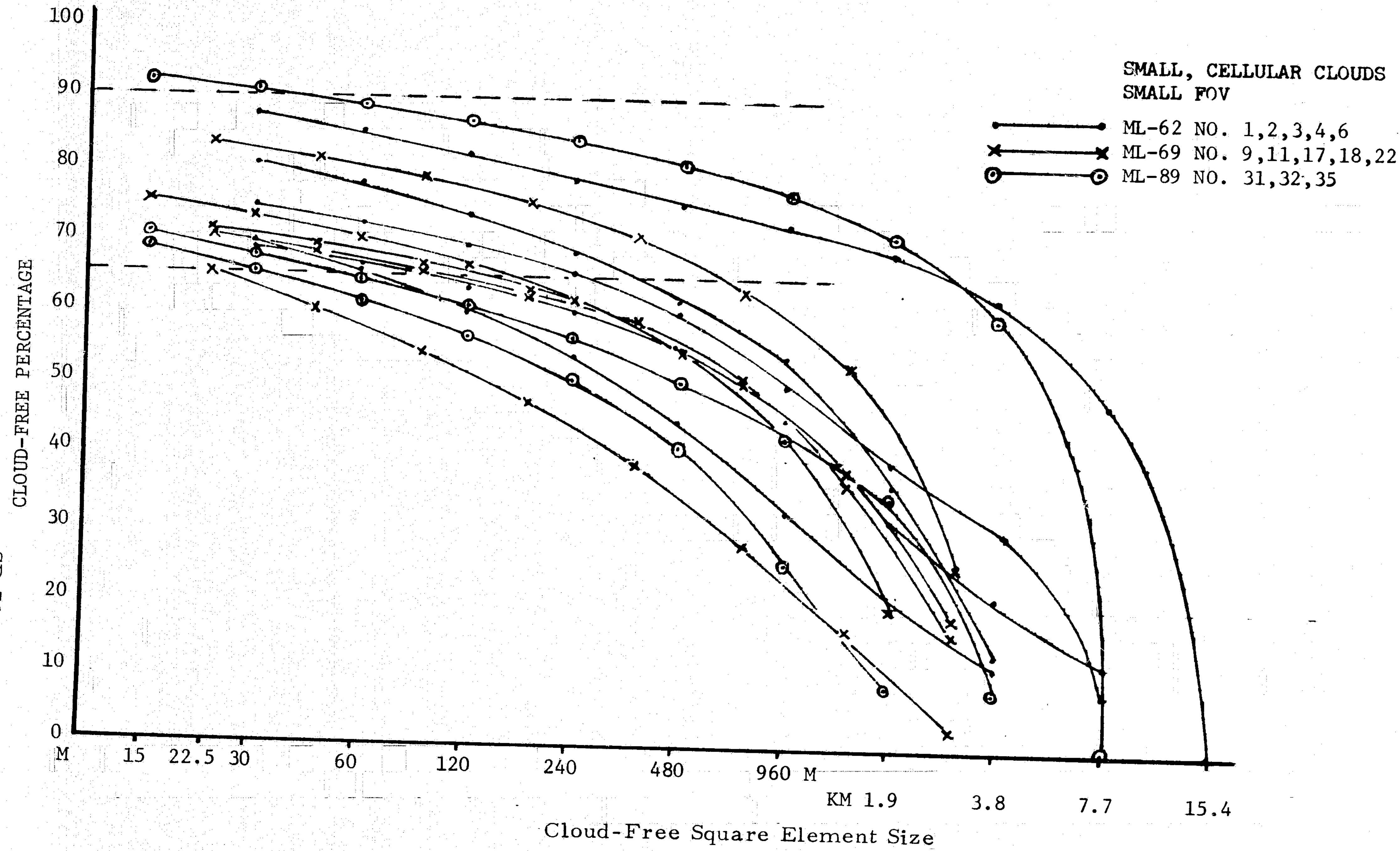


Figure 3-27. U-2 Cloud Category 2 Statistics

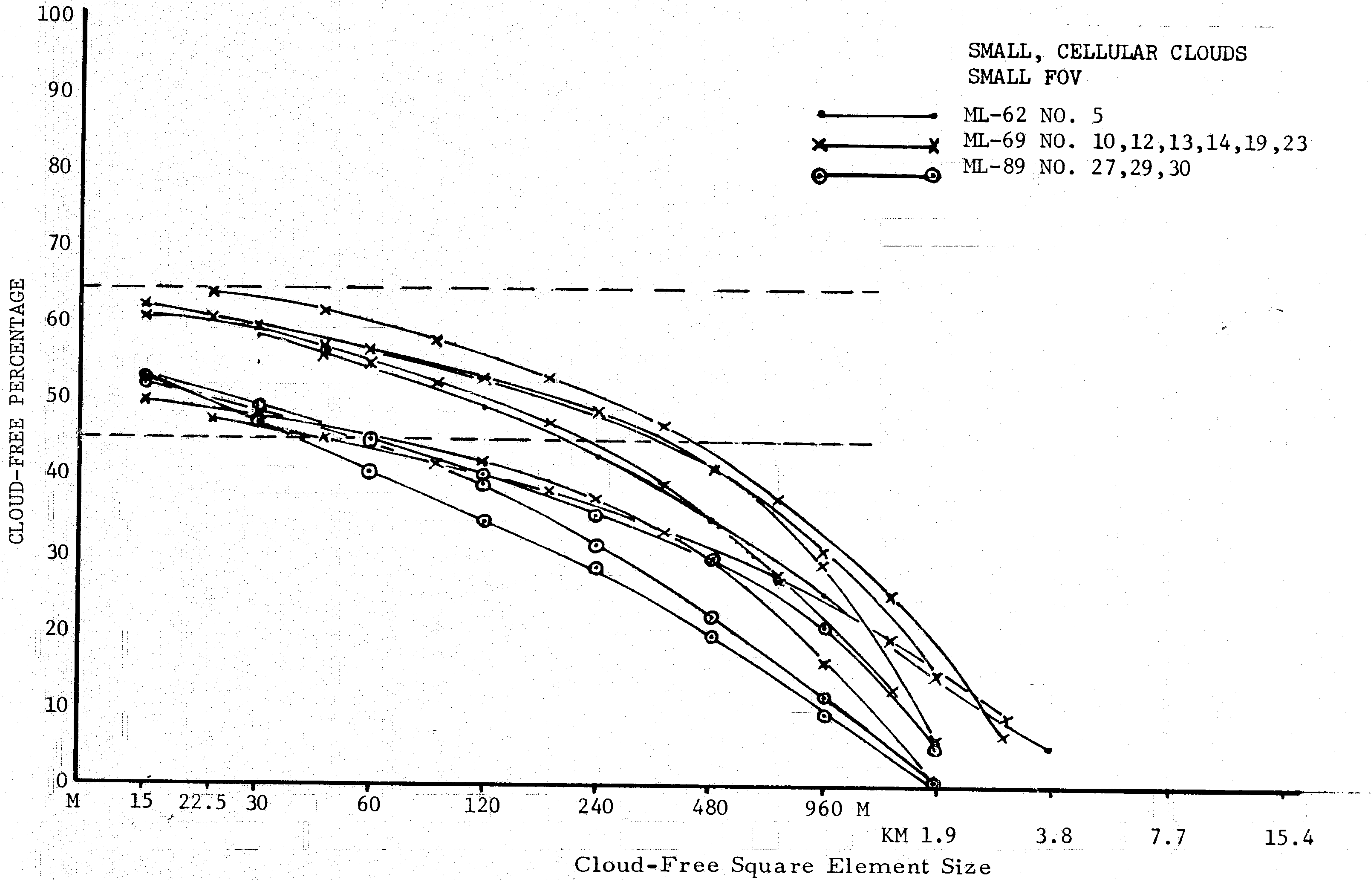


Figure 3-28. U-2 Cloud Category 3 Statistics

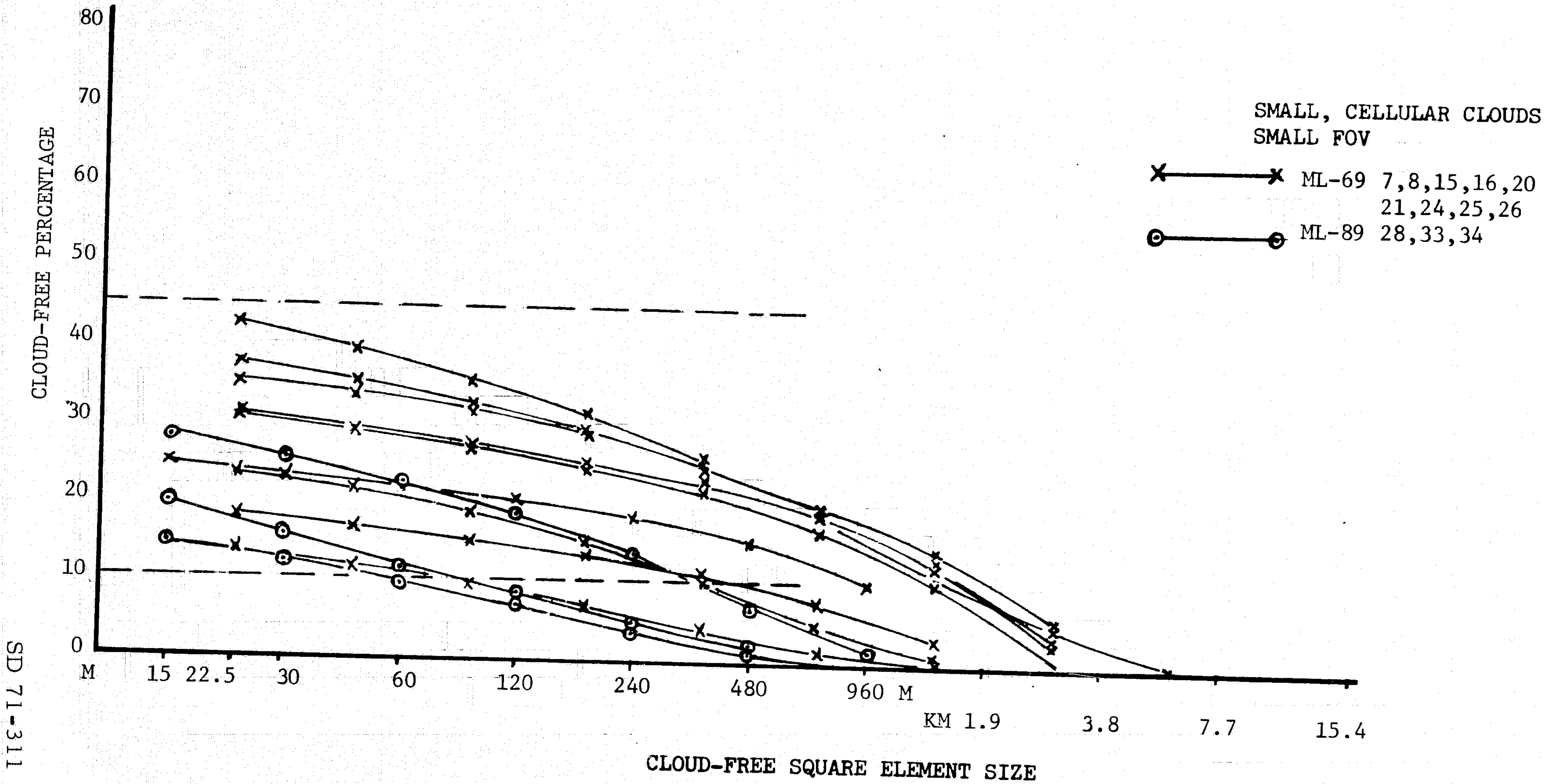


Figure 3-29. U-2 Cloud Category 4 Statistics

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North American Rockwell

A considerable overlap of element sizes occurs, and the Apollo data are most reliable at those element sizes of least reliable U-2 data. Obviously, the Apollo data should be used for these overlap element sizes.

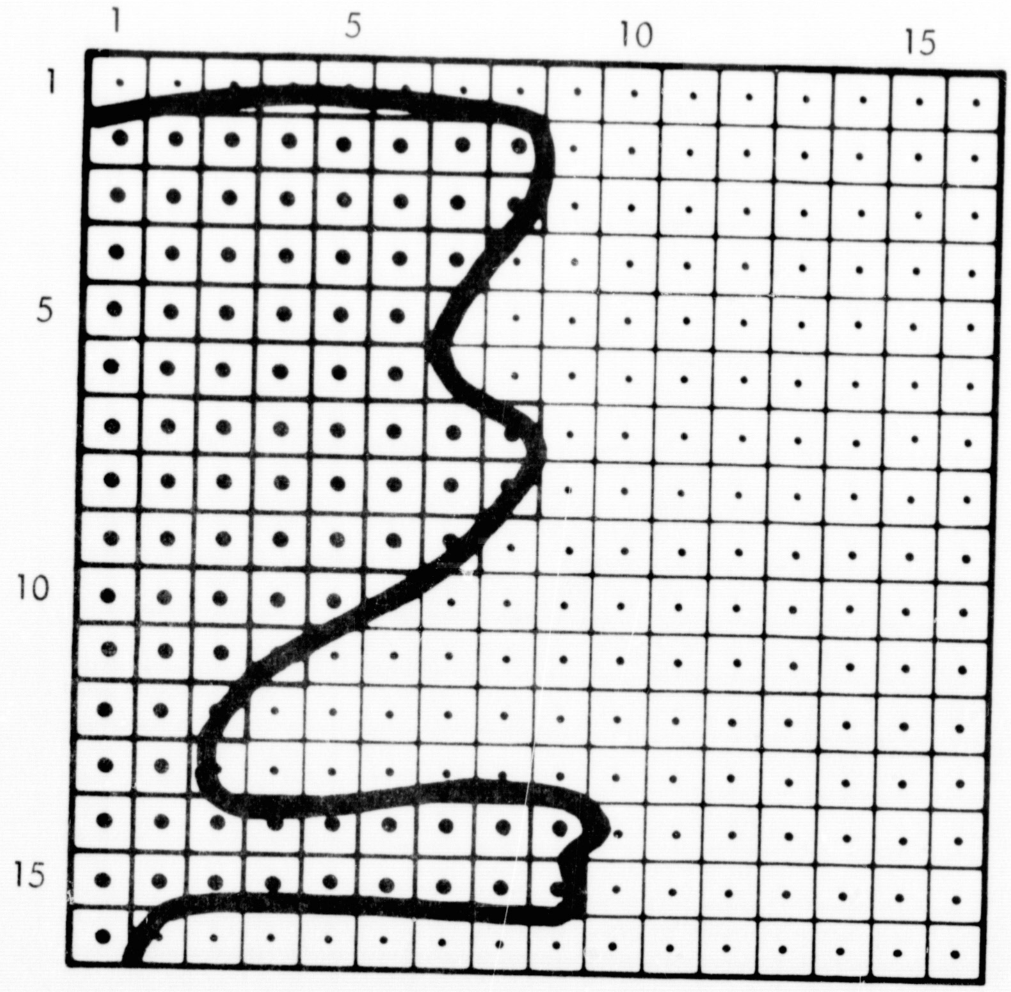
The data in general can be best approximated by a single curve near the center of the curves on the U-2 figures, but it is noted that the slope is not constant for all the curves. The variation that exists is because of the difference in cloud amount and forms that exist within the photographs.

The major difference in the rate of loss of clear area as the required cloud-free element size is increased is because of the cellular/layer cloud factor. This is illustrated in Figures 3-24 and 3-30 through 3-32, wherein statistics for different cloud forms, but identical cloud amounts, are derived for three hypothetical cases. The differences in the case of Figure 3-24, wherein layer clouds are illustrated, and Figure 3-31, wherein cellular clouds are illustrated, is particularly large. A relatively slow rate of loss of clear area as the element size increases occurs in the layer case. Such "edge variations" account for the major part of the slope variations in the data from the actual photographs analyzed, and are a function of the magnitude of the length of outside edges of the clouds contained in a photograph.

Figure 3-33 presents the nominal variations of cloud-free percentage for cloud amounts from 20 percent to 90 percent as derived from the illustrated U-2 cloud statistics.

Figure 3-34 presents nominal and extreme variations of cloud-free square resolution elements for cloud Categories 2, 3, and 4 as fitted from the U-2 data. The most striking feature of the curves is the greater slope for Category 3 clouds than either Category 2 or 4. This greater slope for the middle cloudiness represented by Category 3 is believed to be a further reflection of the edge effect, which is most strongly demonstrated in middle cloudiness.

While the actual change in cloud-free percentage is greater for the Category 3, the relative change is progressively greater as one considers Categories 2, 3, and 4. This is illustrated by the increase in cloud-free percentage that occurs for the nominal curves as the square resolution element varies from 480 meters to 30 meters on a side. Table 3-8 presents the values derived from Figure 3-34.



91			
2	1	120	61.
2	3	105	57.
2	225		0.52444
4	1	52	20.
4	2	39	18.
4	3	39	14.
4	4	39	14.
4	169		0.39053
8	1	10	1.
8	2	5	1.
8	3	5	1.
8	4	5	0.
8	25		0.12000
16	1	1	0.
16	1		0.00000
91	256		0.35547

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

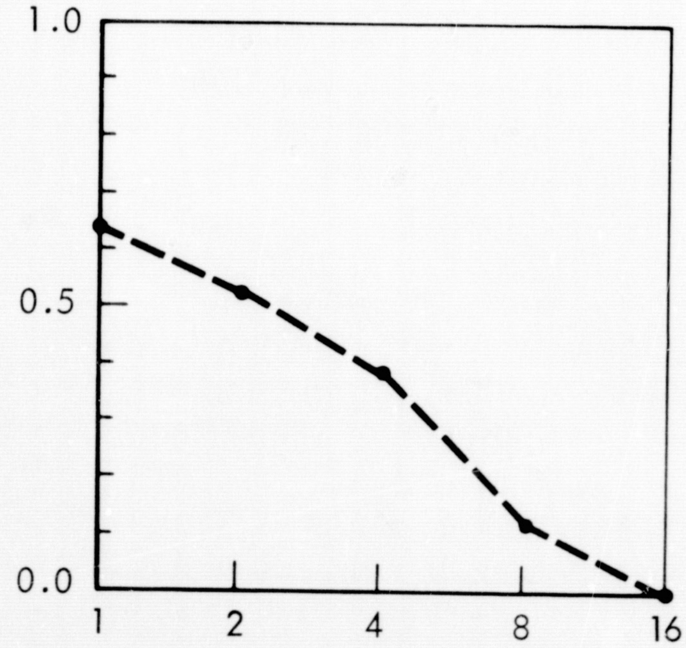
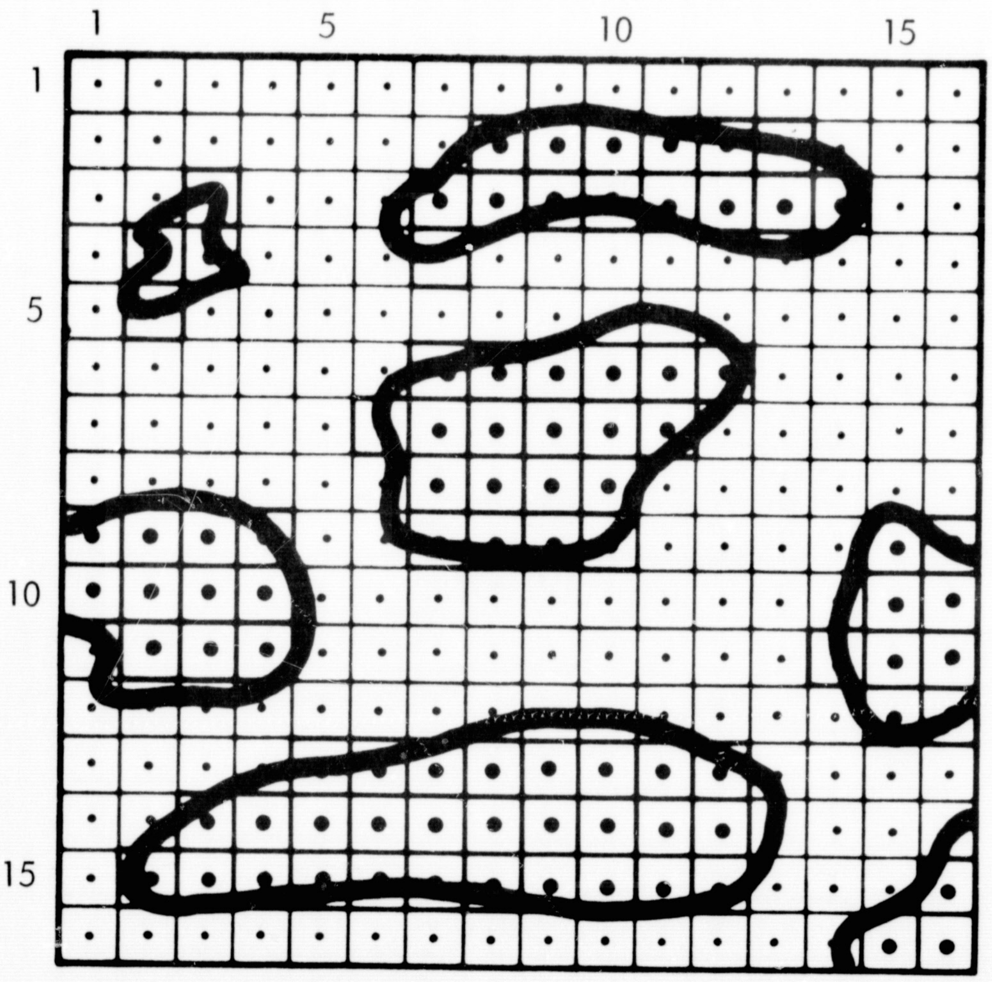


Figure 3-30. Hypothetical Cloud Statistics, Mixed



91			
2	1	120	42.
2	3	105	39.
2	225		0.36000
4	1	52	1.
4	2	39	0.
4	3	39	0.
4	4	39	1.
4	169		0.01183
8	1	10	0.
8	2	5	0.
8	3	5	0.
8	4	5	0.
8	25		0.00000
16	1	1	0.
16	1		0.00000
91	256		0.35547

CLEAR = 0.64453

1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0
3	0	0	1	0	0	0	1	1	1	1	1	1	1	1	0	0
4	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0
7	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
8	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0
9	1	1	1	1	0	0	1	1	1	1	0	0	0	0	1	1
10	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1
11	0	1	1	1	0	0	0	0	0	0	0	0	0	1	1	1
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
13	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
14	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
15	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

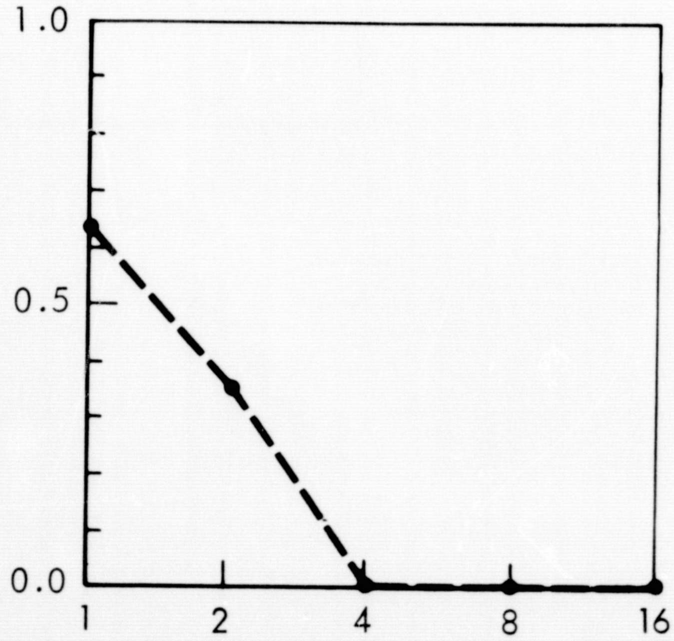


Figure 3-31. Hypothetical Cloud Statistics, Cellular

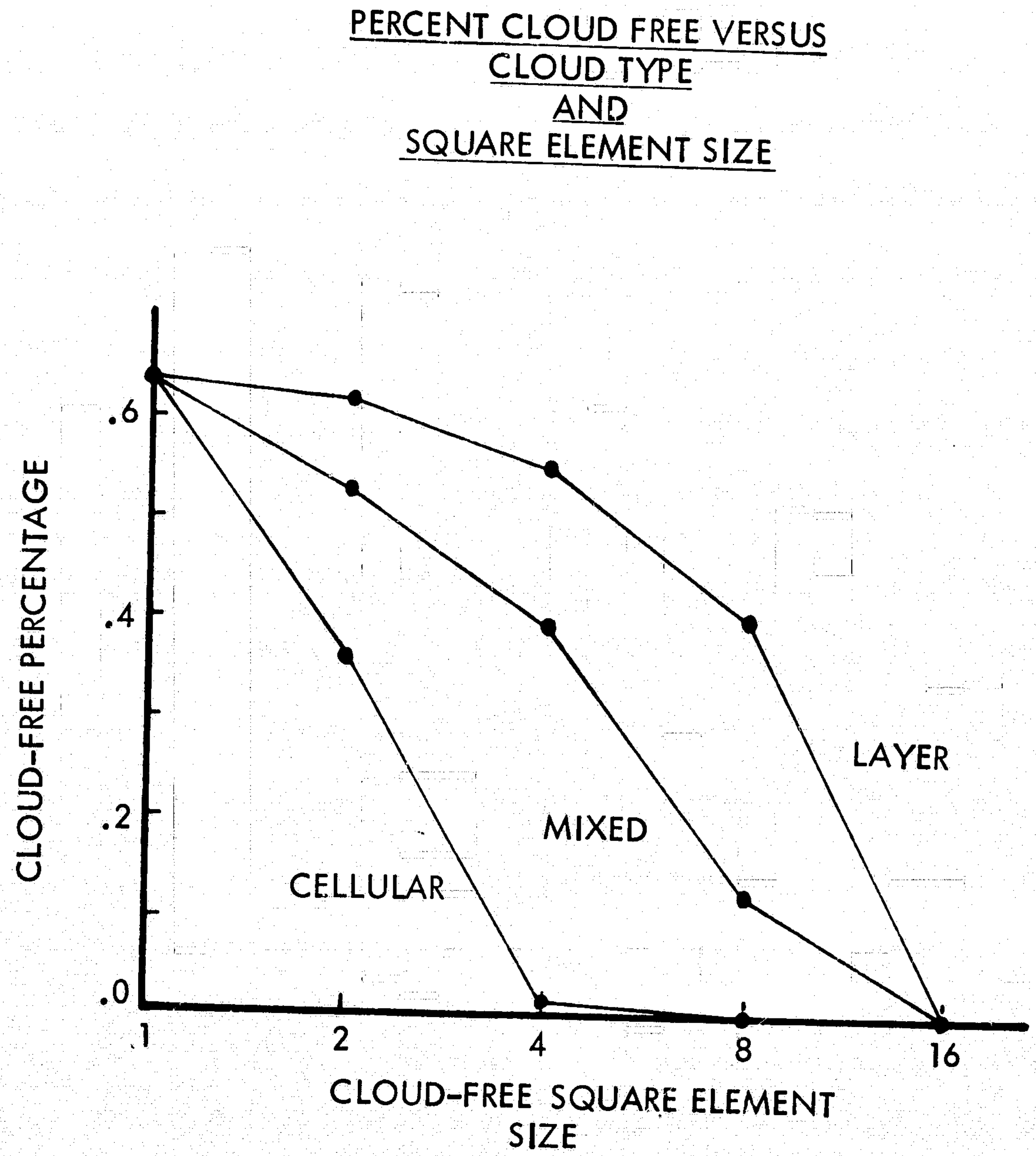


Figure 3-32. Effect of Cloud Distribution on Cloud Statistics

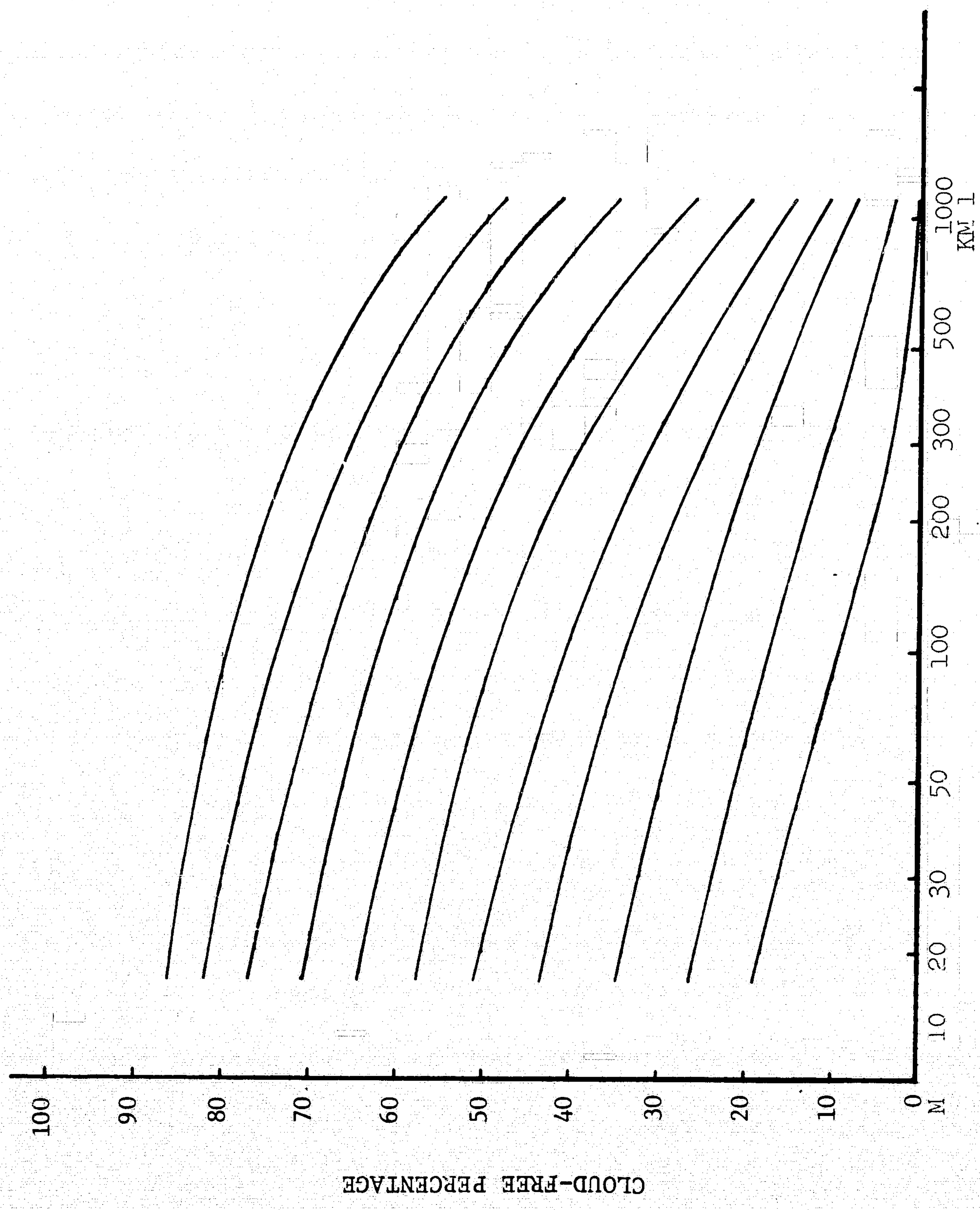


Figure 3-33. Nominal Variation of Cloud Statistics, U2 Photographs

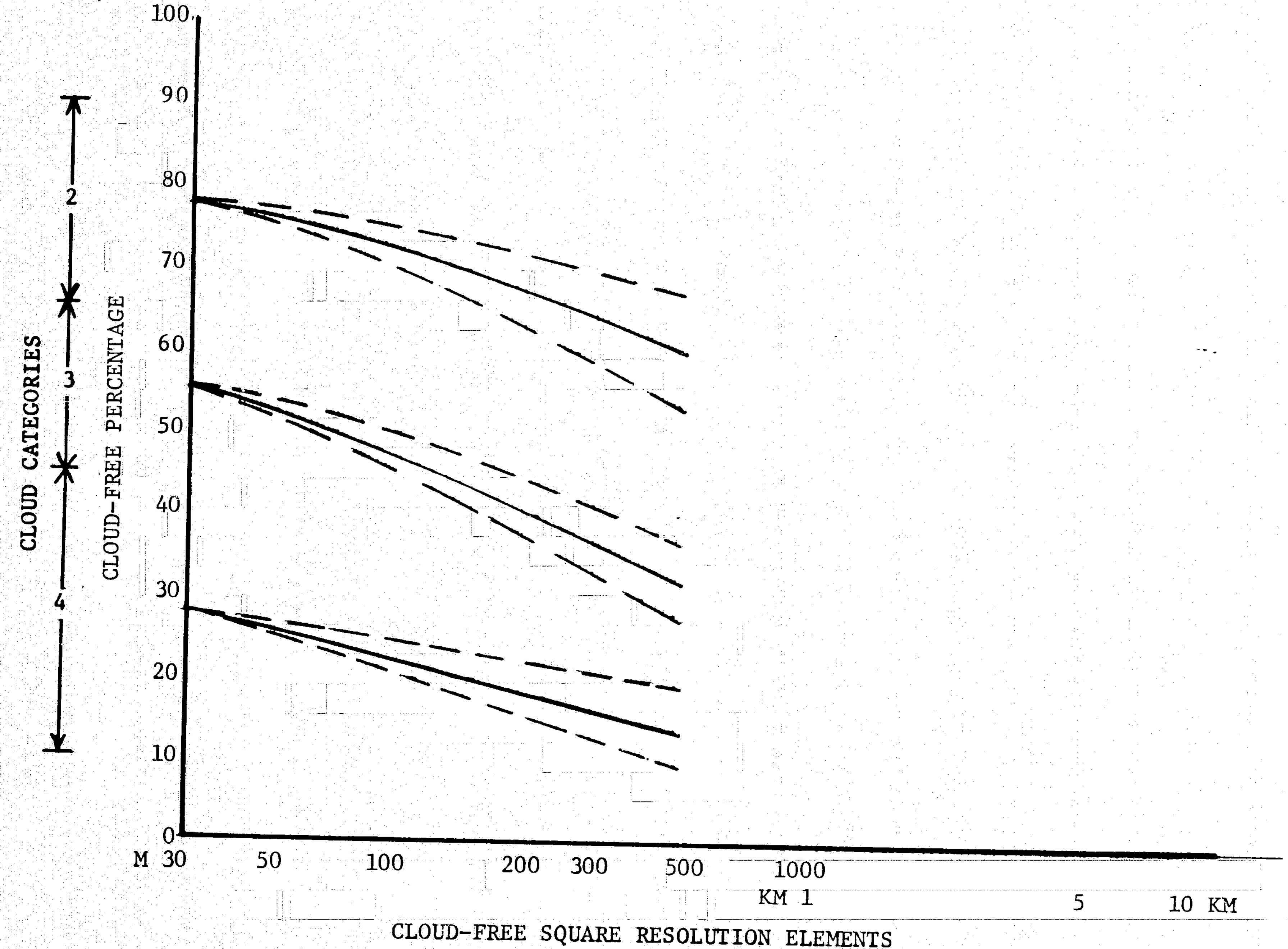


Figure 3-34. Nominal and Extreme Variations of Cloud Statistics, U-2 Photographs

Table 3-8. Relative Change in Cloud-Free Percentage With Resolution Element (U-2 Cloud Photographs)

Cloud Category	Cloud Amount	Cloud-Free Range	Resolution Range	Cloud-Free Percentage Change	Relative Percent Change
2	0.1, 0.2, 0.3	0.90 to 0.65	480m to 30m	61.5 to 78.5 = 17	27.6
3	0.4, 0.5	0.65 to 0.45	480m to 30m	32.5 to 55 = 22.5	70.0
4	0.6, 0.7, 0.8, 0.9	0.45 to 0.10	480m to 30m	14.5 to 27 = 13	90.0

3.4 ANALYSIS OF APOLLO PHOTOGRAPHS

3.4.1 Analysis Procedures

The analysis procedures for the Apollo photographs were identical to those of the U-2 analyses. They consisted of:

1. Selection of photographs for digitization
2. Digitization of the photographs
3. Selection of cloud/no-cloud threshold intensity
4. Derivation of desired cloud statistics.

The 37 Apollo pictures selected for digitization were from those taken during the Apollo 9 and Apollo 6 flights. Reference 12, which describes the flight data for the photographs of the Apollo 9 flight, was used, in addition to catalogs of actual flight photographs from both flights to select the 37 photographs. An effort was made to select photographs displaying a variety of cloud amounts and cloud forms from small cellular to large layer.

The 37 photographs were subdivided into two sets for digitization and statistics derivation. Set A consisted of 20 Apollo 9 photographs, which are described in detail in Table 3-9. Cloud amounts for Set A were all Category 2 cloud cover of less than 3.5/10. Set B included four Apollo 9 photographs and 13 Apollo 6 photographs, as described in detail in Table 3-10. These Set B photographs contained mostly Category 3 and Category 4 cloud fields.

3.4.2 Digitization Procedure

3.4.2.1 Digitization

The digitization procedure for the Apollo photographs was the same as for the U-2 photographs and is described in Section 3.3.3. The 1024-by-1024 digitization of the Set A Apollo pictures produced a 1-by-1 square element of approximately 140 by 140 meters for a mean FOV of 75 n miles. The 512-by-512 digitization for Set B would produce a unit element of 280 by 280 meters for the same FOV.

The actual 1-by-1 elements varied because of the variation in the A-9 and A-6 flight altitudes and camera focal lengths. These variations are shown in Tables 3-9 and 3-10. For the Set B altitude variation of 90 to 172 n miles and the indicated camera focal length, a 1-by-1 element

Table 3-9. Apollo Photograph Description (Set A)

Picture Number	Frame Number	Date	Picture Center		Attitude/FOV* (nm)	Background Threshold	Percent Cloud Amount		
							Estimated		Computer Program
			Latitude	Longitude			NASA	NR	
1	AS9-19-3032	3-9-69	0°26'S	90°50'W	102/69.4	35	16	17	16.5
2	AS9-20-3162	3-12-69	9°40'S	75°40'W	133/90.5	20	40	26	20.5
3	AS9-20-3112	3-12-69	8°45'N	36°35'E	108/73.5	50	30	28	22.9
4	AS9-20-3113	3-12-69	8°28'N	37°15'E	108/73.5	25	50	36	30.3
5	AS9-20-3114	3-12-69	8°05'N	37°50'E	108/73.5	40	40	33	28.3
6	AS9-20-3115	3-12-69	7°50'N	38°20'E	108/73.5	32	35	35	31.3
7	AS9-20-3160	3-12-69	9°00'S	76°35'W	132/89.9	30	50	30	22.0
8	AS9-21-3267	3-12-69	33°52'N	84°34'W	125/85.1	25	20	23	15.7
9	AS9-22-3352	3-8-69	18°15'N	70°58'W	107/72.8	40	23	25	19.6
10	AS9-22-3372	3-8-69	14°42'N	87°58'W	105/71.5	17	30	15	11
11	AS9-22-3436	3-9-69	33°40'N	118°18'W	105/71.5	20	43	28	24.2
12	AS9-22-3437	3-9-69	33°10'N	116°05'W	106/72.2	15	30	25	16.7
13	AS9-22-3448	3-9-69	33°50'N	105°23'W	105/71.5	30	27	18.5	16.0
14	AS9-22-3468	3-9-69	22°25'N	79°00'W	101/68.8	25	38	23	28.1
15	AS9-22-3470	3-9-69	20°50'N	76°30'W	101/68.8	30	6	4	2.7
16	AS9-23-3535	3-9-69	13°45'N	40°28'E	116/79.0	25	15	24	19.5
17	AS9-25-3691	3-8-69	13°20'N	80°51'W	118/80.3	25	30	19	14.1
18	AS9-25-3685	3-8-69	19°15'N	98°38'W	113/76.9	15	45	22	18.5
19	AS9-25-3692	3-8-69	8°52'N	79°35'W	120/81.7	25	40	24	17.8
20	AS9-19-3006	3-9-69	4°20'N	50°50'W	102/69.4	25	50	21	19.5

*A-9 cameras mean focal length = 80.8 mm

Table 3-10. Apollo Photograph Description (Set B)

Picture Number	Frame Number	Date	Picture Center		Altitude/FOV* (nm)	Background Threshold	Percent Cloud Amount		
			Latitude	Longitude			Estimated NASA	Estimated NR	Computer Program
1	AS9-25-3690	3-8-69	14°38'N	90°25'W	116/ 79.6	32	85	65	61.3
2	AS9-25-3693	3-8-69	01°15'N	71°50 W	137/ 94.0	40	90	65	79.5
3	AS9-20-3164	3-8-69	10°00'S	74°00 W	134/ 91.9	18	70	60	63.0
4	AS9-24-3668	3-9-69	—	—	Est 90/ 61.7	50	90	90	96.3
5	AS6-2-868	4-4-68	32°04'N	62°11'W	119/ 86.1	30	~94	85	79.2
6	AS6-2-870	4-4-68	30°52'N	53°07'W	117/ 84.7	35	83	65	64.5
7	AS6-2-875	4-4-68	30°14'N	49°55'W	116/ 84.0	23	25	15	20.2
8	AS6-2-878	4-4-68	30°06'N	49°18'W	116/ 84.0	40		10	8.6
9	AS6-2-947	4-4-68	14°09'N	10°38'W	122/ 88.3	15	70	25	18.1
10	AS6-2-992	4-4-68	00°07'N	10°36'E	139/100.6	35	67	55	47.1
11	AS6-2-995	4-4-68	00°51'S	11°55'E	141/102.1	35	65	50	46.4
12	AS6-2-1001	4-4-68	2°43'S	14°44'E	144/104.3	35	40	40	29.3
13	AS6-2-1012	4-4-68	6°09'S	19°42'E	150/108.6	35	57	57	51.5
14	AS6-2-1049	4-4-68	17°07'S	37°28'E	172/124.5	62	4	5	2.5
15	AS6-2-1466	4-4-68	32°42'N	94°51'W	127/ 91.9	35	30	20	21.1
16	AS6-2-1469	4-4-68	32°40'N	93°44'W	126/ 91.2	35	80	78	71.2
17	AS6-2-1468	4-4-68	32°40'N	93°27'W	126/ 91.2	25	60	50	38.4

*A-9 mean focal length = 80.8 mm
A-6 focal length = 76 mm

variation from about 224 by 224 meters to about 450 by 450 meters would be experienced for FOV's of 161.7 to 124.5 n miles, respectively. Similarly, for Set A, the 1-by-1 element size varies from 125 by 125 miles to 164 by 164 miles.

The FOV of the photographs was determined from the relationship C = WH/F

where

C is the side of the FOV

W is film format size (55 millimeters for 70-mm film)

H is the altitude

F is the camera focal length of 80.8 millimeters and 76 millimeters for A-9 and A-6, respectively.

3.4.2.2 Threshold Selection Procedure

The cloud/no-cloud threshold intensity selection procedure to be applied to the digitized values from the Apollo cloud photographs was identical to that described in Section 3.3.3.2 for the U-2 photographs. In the case of the Apollo photographs, however, increased emphasis was placed upon a comparison of facsimile reproductions at selected threshold values with the original photographs. The slope-change criterion for the frequency distribution of brightness values was again used in the preliminary threshold intensity values for the facsimile reproductions. In most cases it provide a reasonable approximation to the final best value selected.

The values of the final threshold intensity values for the selected Apollo photographs are presented in Tables 3-9 and 3-10.

3.4.3 Statistics Generation Procedure

The cloud statistics generation procedure for the Apollo photographs was the same as for the U-2 photographs, as described in Section 3.3.4. The computer program used is completely described in Appendix B.

One additional requirement for the Apollo photographs was the necessity to determine the value of the 1-by-1 element for each photograph. The FOV for the 1024-by-1024 and 512-512 digitized points varied with the Apollo spacecraft altitude and the camera focal length, thus resulting in different sizes for the 1-by-1 element. Values of this variation were discussed in the previous section.

The point and area constraints selected as inputs to the statistics generation computer program were 8 points, 4 percent and 4 points, 4 percent for the Set A and Set B photographs, respectively. It should be noted that the 8 points for the 1024-by-1024 digitization of Set A corresponds to 4 points for the 512-by-512 digitization of Set B.

The 4 percent area constraint results produces a clear element for all those elements in which the cloud cover is less than 4 percent of the total elemental area, a constraint that seems entirely justified from a practical viewpoint. Little or no change in the cloud-free statistics would result from this area constraint for the smaller elements, but the largest elements would tend to be reported cloud free in those cases of very small total cloud amounts. This would normally occur only in the case of very isolated small clouds.

3.4.4 Resulting Statistics (Apollo)

The cloud statistics derived from the Apollo photographs provide the variation of cloud-free percentages of the FOV as the cloud-free square elements vary in size from about 0.1 kilometer (100 meters) for the 1-by-1 element to the full picture size of about 150 by 150 kilometers. As in the U-2 photographs, the constraint to be essentially 0 percent cloud-free at the entire field-of-view reduces the confidence of the results at the largest-sized elements. From a practical viewpoint, the data have decreasing validity beyond the 64-by-64 element size for 1024-by-1024 digitization and 32-by-32 for the 512-by-512 digitization.

The computer output format is illustrated in the Apollo sample output of Figure 3-22. Tables 3-11 and 3-12 present the statistics extracted from the computer output for Set A and Set B, respectively. The data derived are shown for all the element sizes. Data for the largest element sizes, however, are subject to the limitations discussed above.

3.4.4.1 Set A Statistics

Figures 3-35 through 3-37 provide a comparison of the cloud statistics derived for varying sensor resolutions for the Apollo Set A photographs of low cloud-cover amounts. As in the U-2 photograph analyses, the sharpest distinction in the data is the difference between FOV's that include uniformly distributed cellular cloudiness and those predominately of layer cloudiness or clusters of cellular clouds.

The FOV filled with layer cloudiness displays the expected slower loss of clear area as the cloud-free element size increases. Figure 3-32 presents curves that demonstrate the slower loss of cloud-free percentage typical of layer cloudiness or of cellular cloudiness in clusters rather than

FOLDOUT FRAME 1

Number	FOV nm x nm	FOV km x km	C			
			1 x 1	2 x 2	4 x 4	8 x 8
Mean	~76	~141	0.14 x 0.14	0.28 x 0.28	0.56 x 0.56	1.12 x 1.1
1	69.4	126	84.5	83.6	82.2	81.0
2	90.5	164	79.5	77.9	75.1	71.6
3	73.5	133	77.2	75.0	70.7	64.7
4	73.5	133	69.7	67.7	63.9	58.8
5	73.5	133	71.7	69.4	65.0	59.2
6	73.5	133	68.8	66.7	63.0	58.4
7	89.8	162	78.0	75.4	70.6	64.4
8	85.1	154	84.3	82.4	79.6	76.7
9	72.8	132	80.4	78.2	74.3	69.3
10	71.5	130	88.8	87.3	84.4	81.0
11	71.5	130	75.8	74.2	71.2	68.0
12	72.2	131	83.0	80.4	75.7	70.0
13	71.5	130	84.0	82.6	79.9	76.9
14	68.8	125	72.0	69.6	65.5	60.5
15	68.8	125	97.4	97.3	96.0	94.8
16	79.0	143	80.5	78.7	75.4	71.8
17	80.3	146	86.0	84.1	80.5	76.2
18	76.9	139	81.5	80.2	77.8	75.2
19	81.7	148	82.2	80.3	76.6	72.2
20	69.4	126	80.6	79.2	76.9	74.0

FOLDOUT FRAME 2

Table 3-11. Cloud

Cloud-Free Percentage Versus Resolution Element
(1024 x 1024 Digitization, 8 Point, 4%)

2 x 2	4 x 4	8 x 8	16 x 16	32 x 32	64 x 64	128 x 128
0.28 x 0.28	0.56 x 0.56	1.12 x 1.12	2.25 x 2.25	4.5 x 4.5	9.0 x 9.0	18.0 x 18.0
83.6	82.2	81.0	78.4	74.4	68.6	62.0
77.9	75.1	71.6	66.1	57.9	49.0	37.9
75.0	70.7	64.7	54.6	38.1	22.0	9.6
67.7	63.9	58.8	50.9	38.8	26.7	15.7
69.4	65.0	59.2	50.1	38.4	28.4	19.7
66.7	63.0	58.4	51.6	42.6	35.6	29.1
75.4	70.6	64.4	55.9	44.7	32.6	17.2
82.4	79.6	76.7	73.1	68.4	62.7	54.4
78.2	74.3	69.3	62.3	53.2	43.2	28.0
87.3	84.4	81.0	75.3	68.3	62.8	58.7
74.2	71.2	68.0	63.4	57.1	49.7	38.0
80.4	75.7	70.0	62.0	51.6	40.6	29.9
82.6	79.9	76.9	72.4	66.7	61.2	56.5
69.6	65.5	60.5	53.5	44.5	35.0	24.4
97.3	96.0	94.8	92.2	88.0	83.8	78.2
78.7	75.4	71.8	66.4	59.7	52.1	44.7
84.1	80.5	76.2	69.6	60.3	50.7	42.2
80.2	77.8	75.2	71.1	65.2	57.8	46.0
80.3	76.6	72.2	65.8	57.5	48.5	34.8
79.2	76.9	74.0	68.5	61.5	46.9	35.0

Table 3-11. Cloud Statistics for Apollo Photographs (Set A)

ge Versus Resolution Element gitization, 8 Point, 4%)					
32 x 32	64 x 64	128 x 128	256 x 256	512 x 512	1024 x 1024
4.5 x 4.5	9.0 x 9.0	18.0 x 18.0	36 x 36	72 x 72	144 x 144
74.4	68.6	62.0	0	0	0
57.9	49.0	37.9	23.0	0	0
38.1	22.0	9.6	0	0	0
38.8	26.7	15.7	2.0	0	0
38.4	28.4	19.7	4.0	0	0
42.6	35.6	29.1	9.0	0	0
44.7	32.6	17.2	0	0	0
68.4	62.7	54.4	42.0	0	0
53.2	43.2	28.0	12.0	0	0
68.3	62.8	58.7	52.0	0	0
57.1	49.7	38.0	23.0	0	0
51.6	40.6	29.9	21.0	0	0
66.7	61.2	56.5	0	0	0
44.5	35.0	24.4	8.0	0	0
88.0	83.8	78.2	72.0	0	0
59.7	52.1	44.7	36.0	0	0
60.3	50.7	42.2	31.0	0	0
65.2	57.8	46.0	33.0	0	0
57.5	48.5	34.8	13.0	0	0
61.5	46.9	35.0	0	0	0

Table 3-12. Cloud Statistics for Apollo Photographs (Set B)

Number	FOV nm x nm	IXI Element (meters)	Cloud-Free Percentage Versus Resolution Element (512 x 512 Digitization, 4 Point, 4%)									
			1 x 1	2 x 2	4 x 4	8 x 8	16 x 16	32 x 32	64 x 64	128 x 128	256 x 256	512 x 512
1	79.6	287	38.7	36.2	32.1	27.6	23.1	19.2	16.9	7.7	0.0	0.0
2	94.0	340	20.5	19.1	17.0	14.8	12.0	8.5	3.4	0.0	0.0	0.0
3	91.9	333	37.0	34.7	31.7	28.8	25.4	22.0	18.3	11.8	0.0	0.0
4	61.7	224	3.8	2.8	2.1	1.6	1.1	0.5	0.0	0.0	0.0	0.0
5	86.1	312	20.8	17.5	13.1	8.8	4.7	1.0	0.0	0.0	0.0	0.0
6	84.7	307	35.5	32.9	28.7	23.9	18.4	11.8	5.0	0.0	0.0	0.0
7	84.0	305	79.8	77.3	73.1	68.9	63.4	56.4	51.1	42.0	12.0	0.0
8	84.0	305	91.4	87.7	80.0	69.5	58.3	47.6	35.4	16.6	0.0	0.0
9	88.3	320	81.9	77.5	69.1	57.9	42.7	32.3	25.7	16.6	0.0	0.0
10	100.6	364	52.9	48.8	41.5	32.2	21.9	13.2	8.0	2.4	0.0	0.0
11	102.1	370	53.6	49.9	42.7	33.1	22.5	13.4	5.5	0.6	0.0	0.0
12	104.3	378	70.1	65.8	56.7	44.6	31.2	20.7	11.7	3.0	0.0	0.0
13	108.6	393	48.5	46.2	41.9	36.2	29.7	22.0	14.9	4.1	0.0	0.0
14	124.5	450	97.5	96.6	94.6	92.8	90.0	86.8	84.3	85.2	92.0	100.0
15	91.9	333	78.8	75.8	70.6	65.5	58.5	47.8	28.7	7.1	0.0	0.0
16	91.2	330	28.8	27.4	24.9	22.0	18.6	14.4	7.8	0.0	0.0	0.0
17	91.2	330	61.6	58.6	54.1	49.6	43.6	36.3	25.8	5.9	0.0	0.0

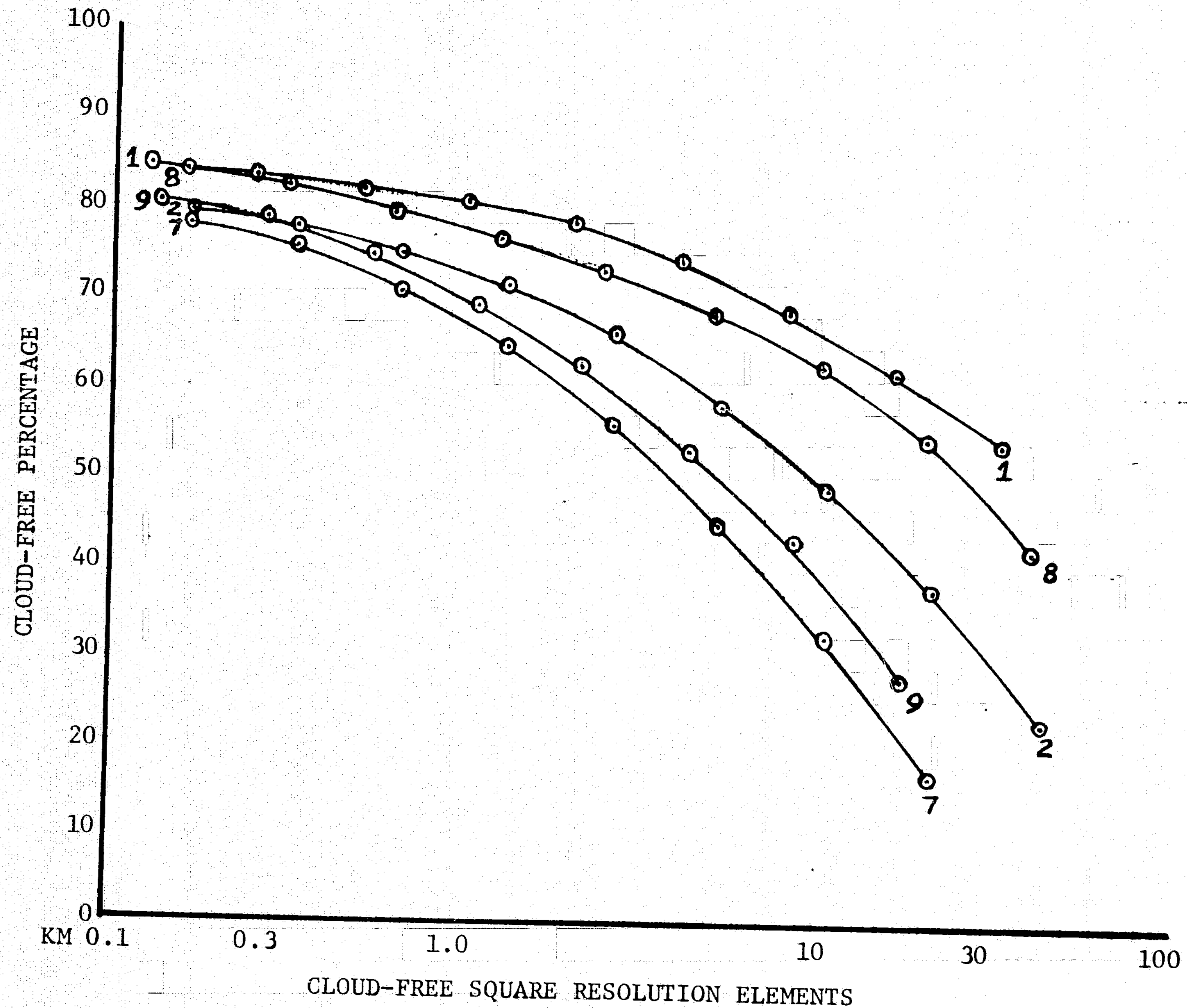


Figure 3-35. Apollo Set A Cloud-Free Element Statistics (Layer-Type Cloudiness)

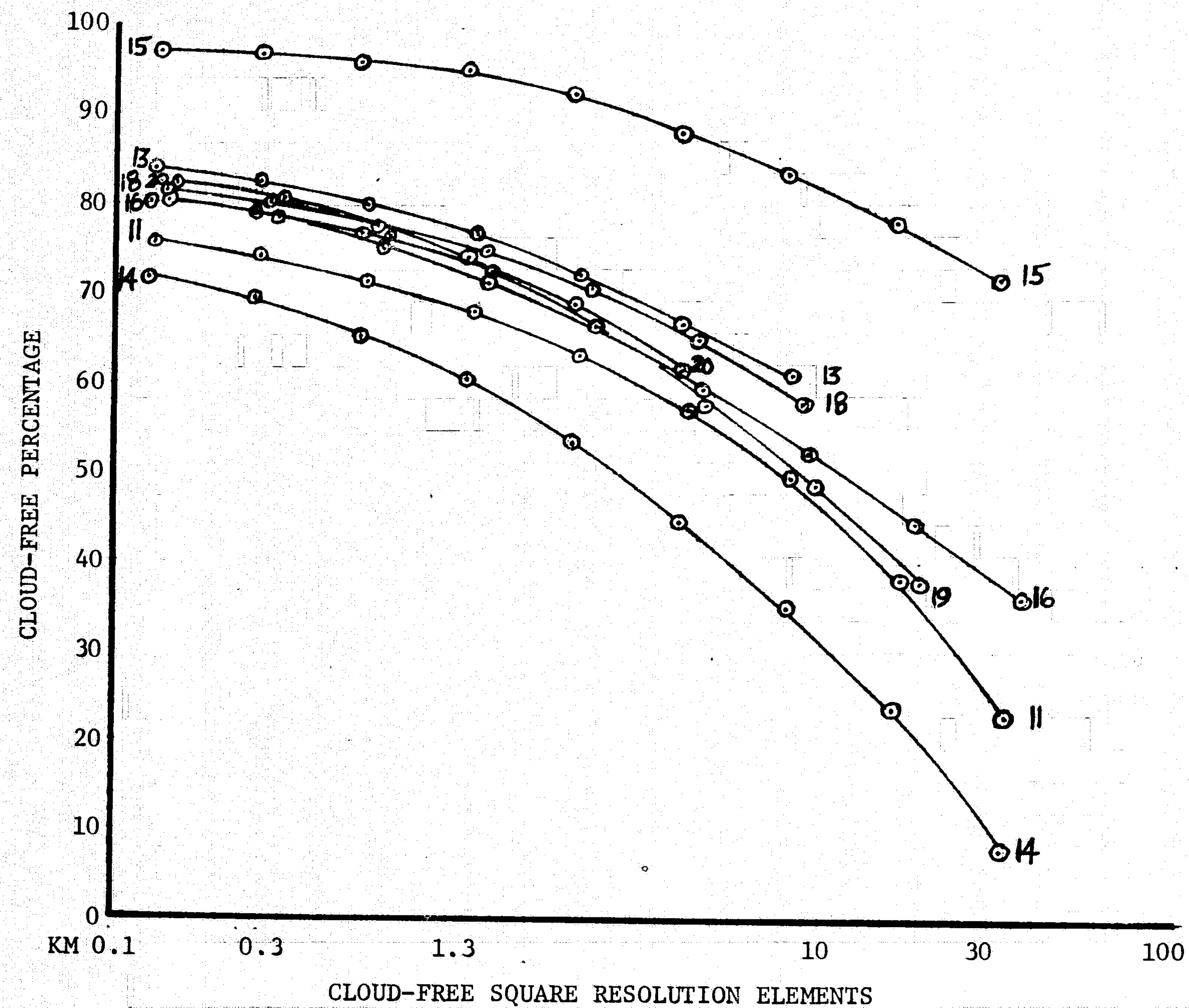


Figure 3-36. Apollo Set A Cloud-Free Element Statistics (Layer-Type Cloudiness, Cont)

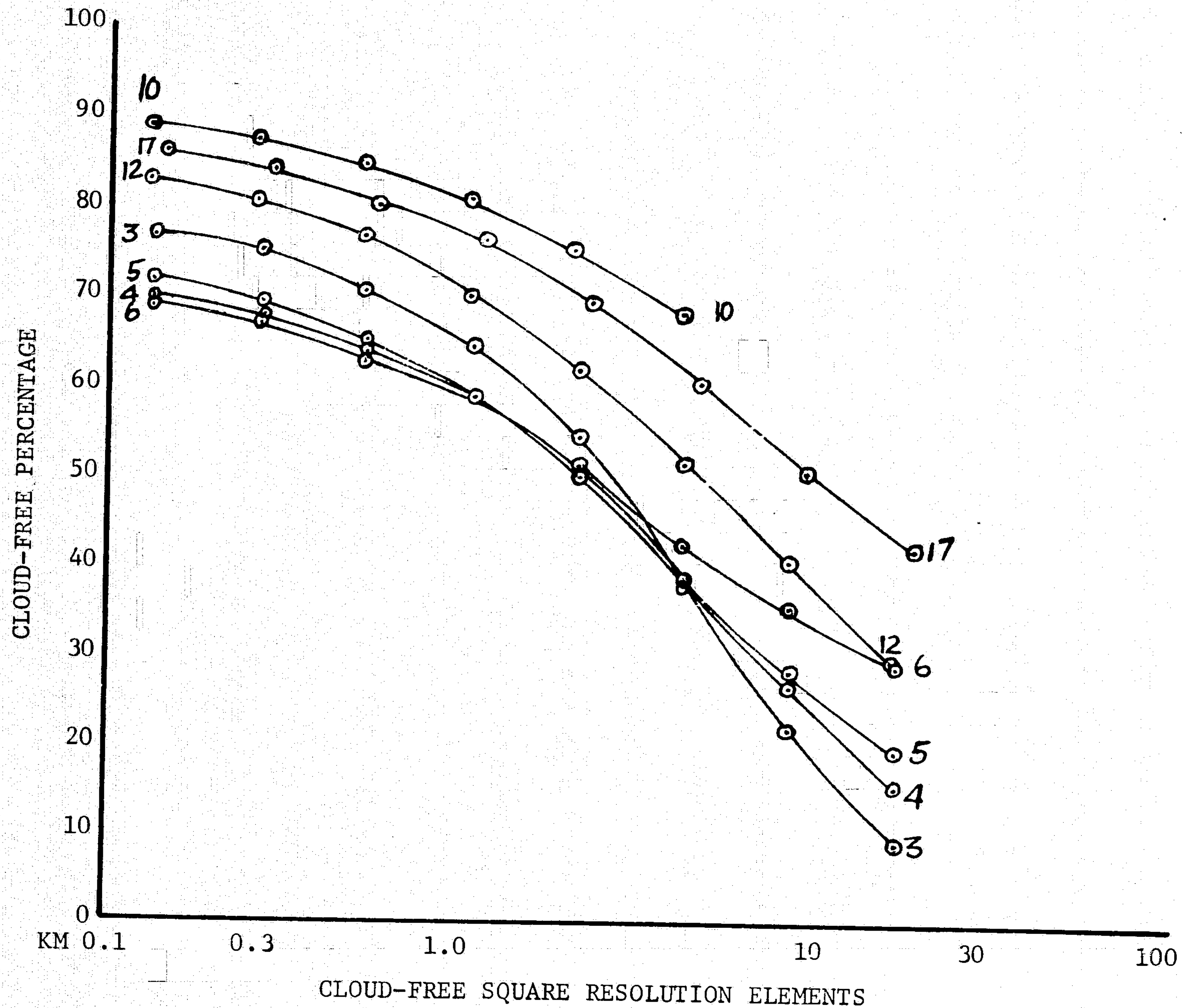


Figure 3-37. Apollo Set A Cloud-Free Element Statistics
(Cellular Cloudiness)

distributed throughout the FOV. Figure 3-38 is the Apollo photograph AS9-19-3032, which is curve number 1 in Figure 3-35. Figure 3-39 is the Apollo photograph for curve 15 of Figure 3-36, wherein cellular cloudiness is clustered into groups, with the overall result of having the appearance of layer cloudiness. Were this small amount of cellular cloudiness uniformly distributed through the FOV, the loss in large clear elements would be much greater.

Figure 3-37 presents cellular cloudiness, which is more uniformly distributed throughout the FOV, particularly for curves 3, 4, and 5. The rapid loss of large cloud-free elements is especially well demonstrated in curve 3. The Apollo photograph for this curve is shown in Figure 3-40. Figure 3-41 shows the photograph for curve 6 of Figure 3-37, wherein the small element cloud-free percentage is less than that of curve 3, but becomes greater than that of curve 3 at the large cloud-free elements because of clustering of the cellular cloudiness.

3.4.4.2 Set B Statistics

The Apollo Set B statistics are predominately for higher cloud amount photographs and are predominately from Apollo 6 flights. As in the U-2 and Set A statistics discussed previously, the statistics may be crudely classified as for cellular or layer-type cloudiness.

Figure 3-42 presents data for photographs of cloud fields demonstrating cellular cloudiness. Figure 3-43 presents data for photographs of cloud fields demonstrating layer-type cloudiness. It should again be noted that cellular clouds that are clustered into widely spaced groups rather than more or less uniformly distributed throughout the picture are best classified as layer-type.

3.4.4.3 Combined Apollo Statistics - Extreme Variations

It was shown in the discussion of the U-2 and Apollo statistics that the least loss in cloud-free percentage as the square element increased in size occurred with layer-type clouds. The greatest loss occurred with cellular clouds distributed uniformly throughout the field-of-view.

The Apollo statistics discussed in the previous sections have been fitted for the extreme variations because the cloud type at the midpoint of Category 2, 3, and 4 cloud amounts. These extreme variations are illustrated in Figure 3-44.

These data for the Apollo photographs will be combined in a subsequent section with similar data for U-2 and ESSA photographs.

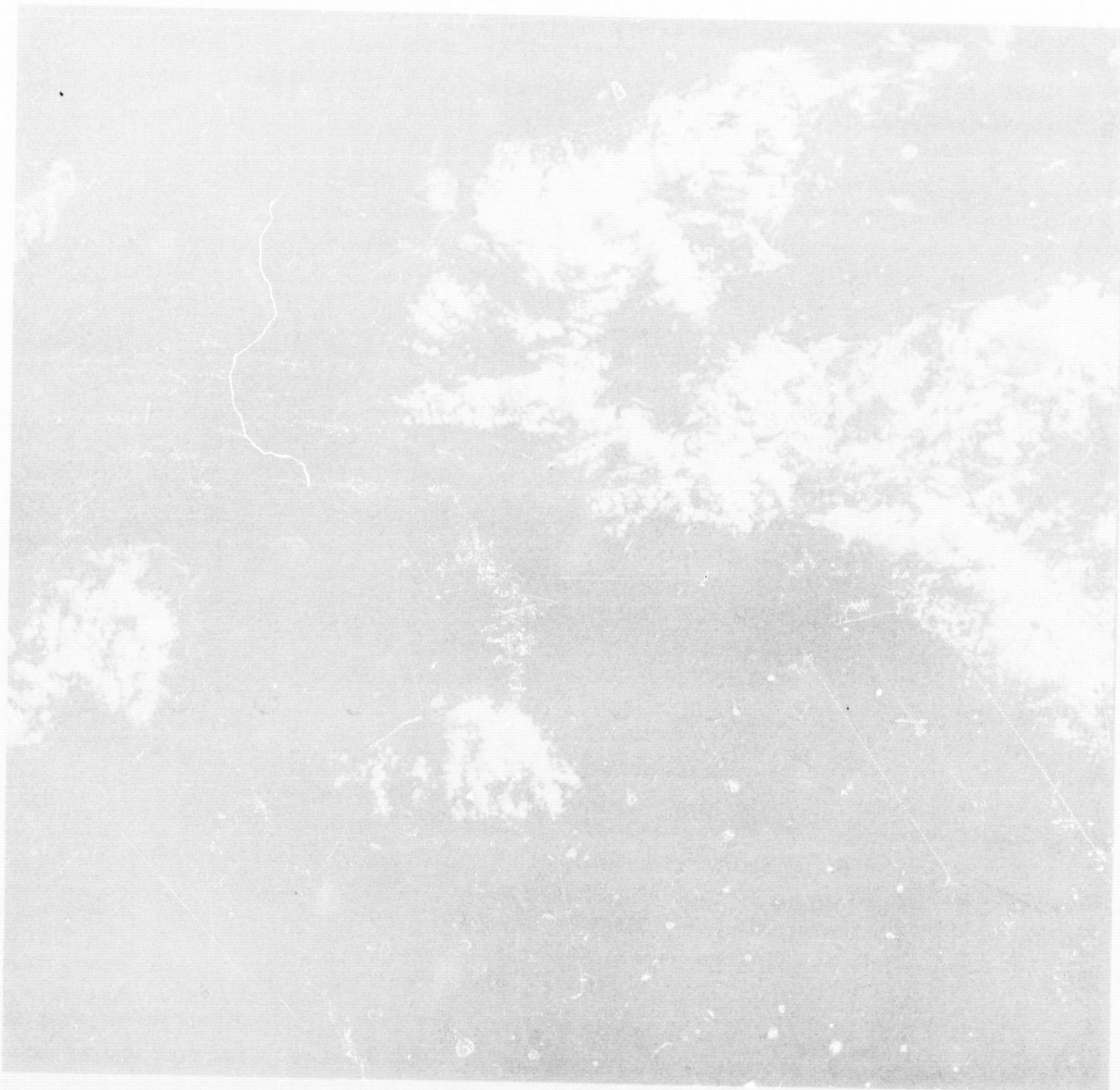


Figure 3-38. Apollo (Frame AS9-19-3032) Photograph Print

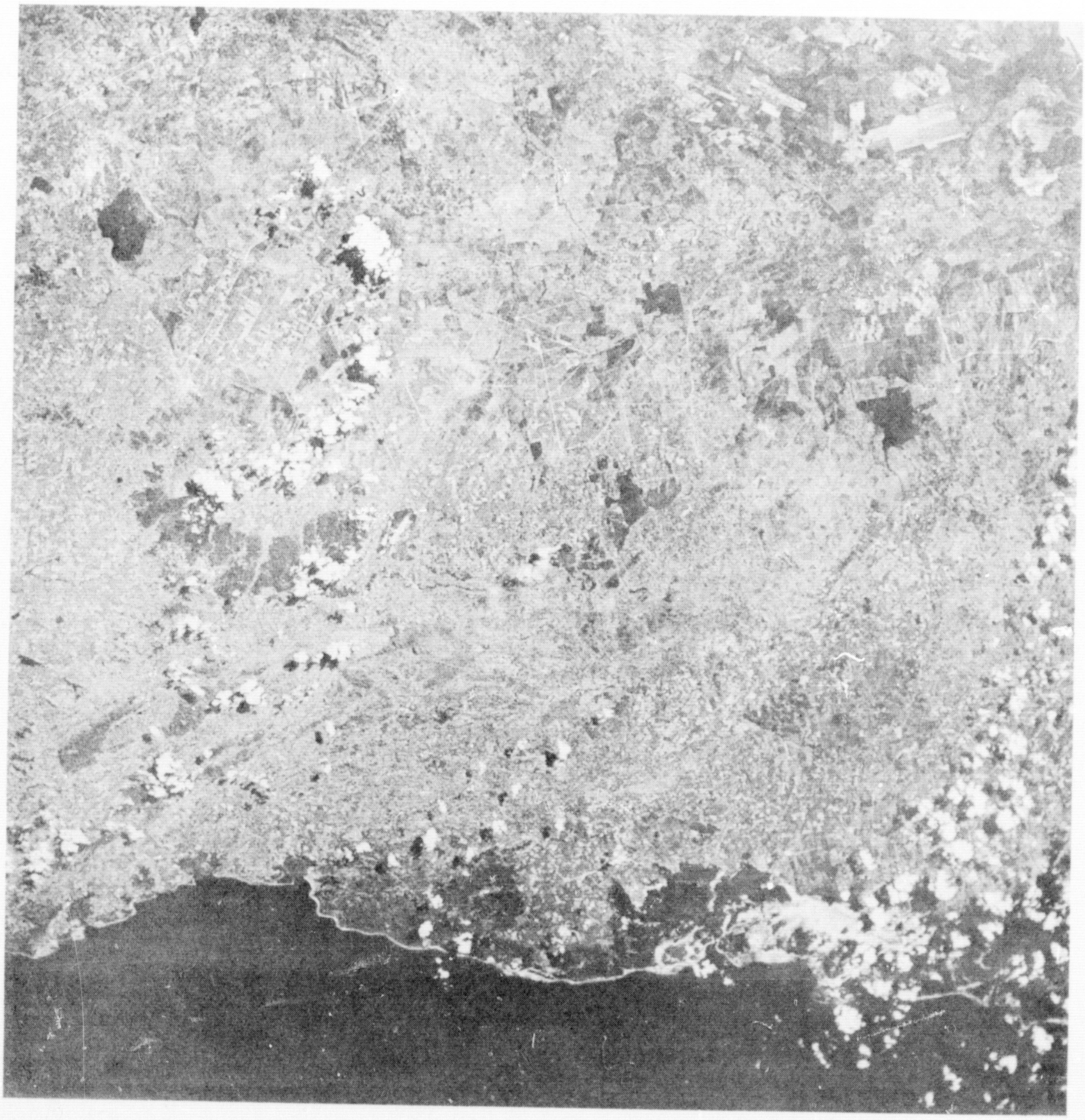


Figure 3-39. Apollo (Frame AS9-22-3470) Photograph Print

Figure 3-40. Apollo (Frame AS 9-20-3112) Photograph Print

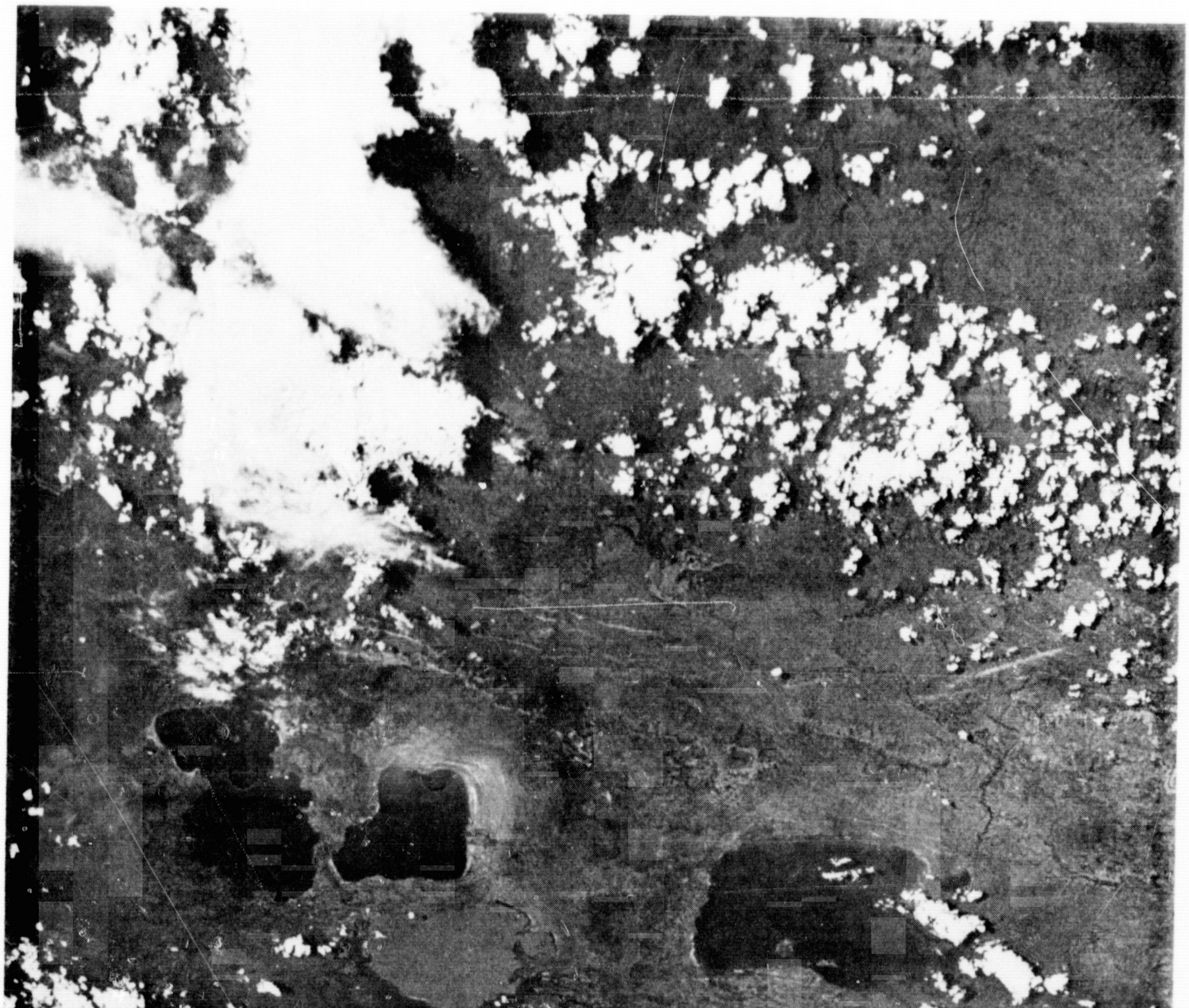


Figure 3-41. Apollo (Frame AS 9-20-3114) Photograph Print

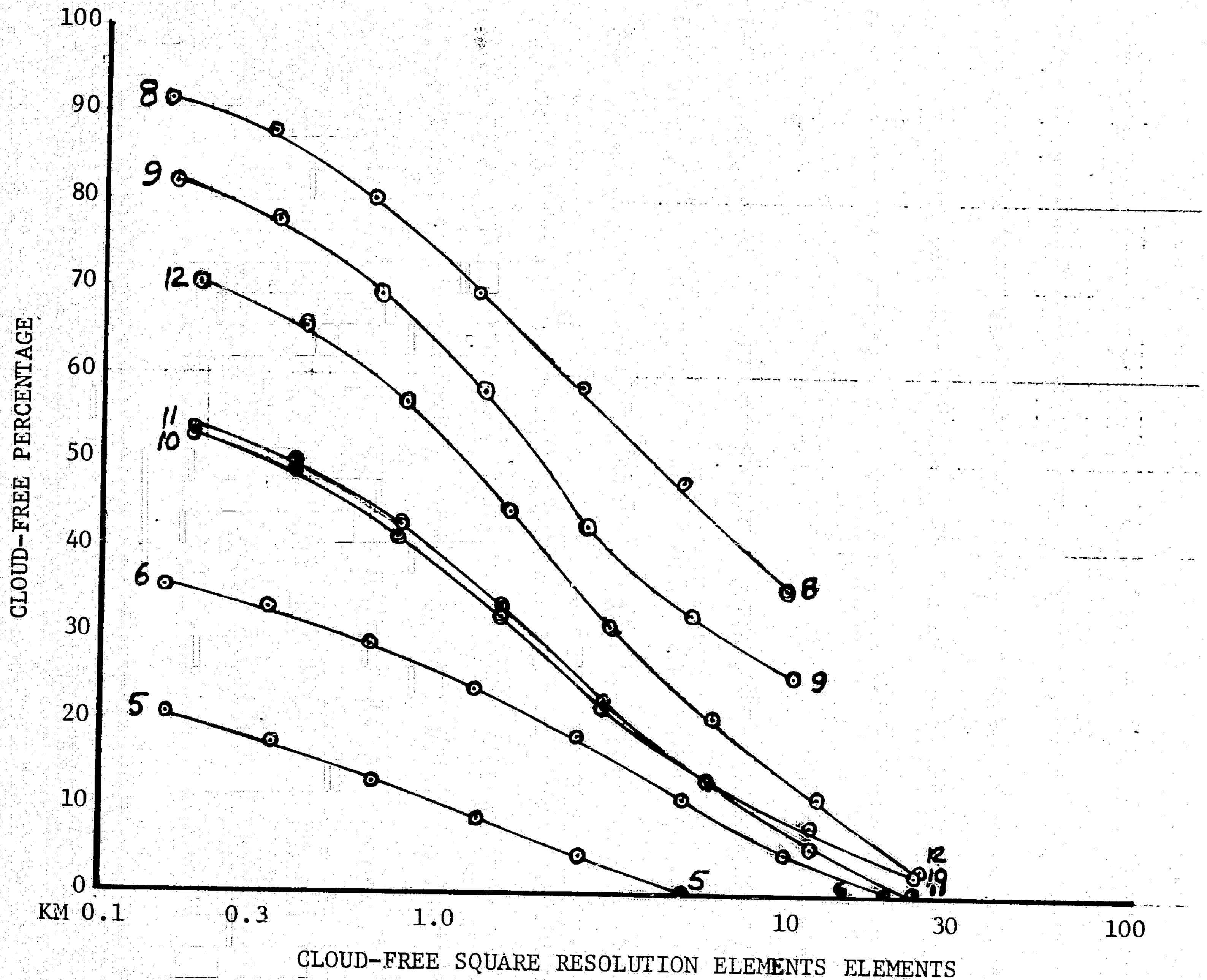


Figure 3-42. Apollo Set B Cloud-Free Element Statistics (Cellular Cloudiness)

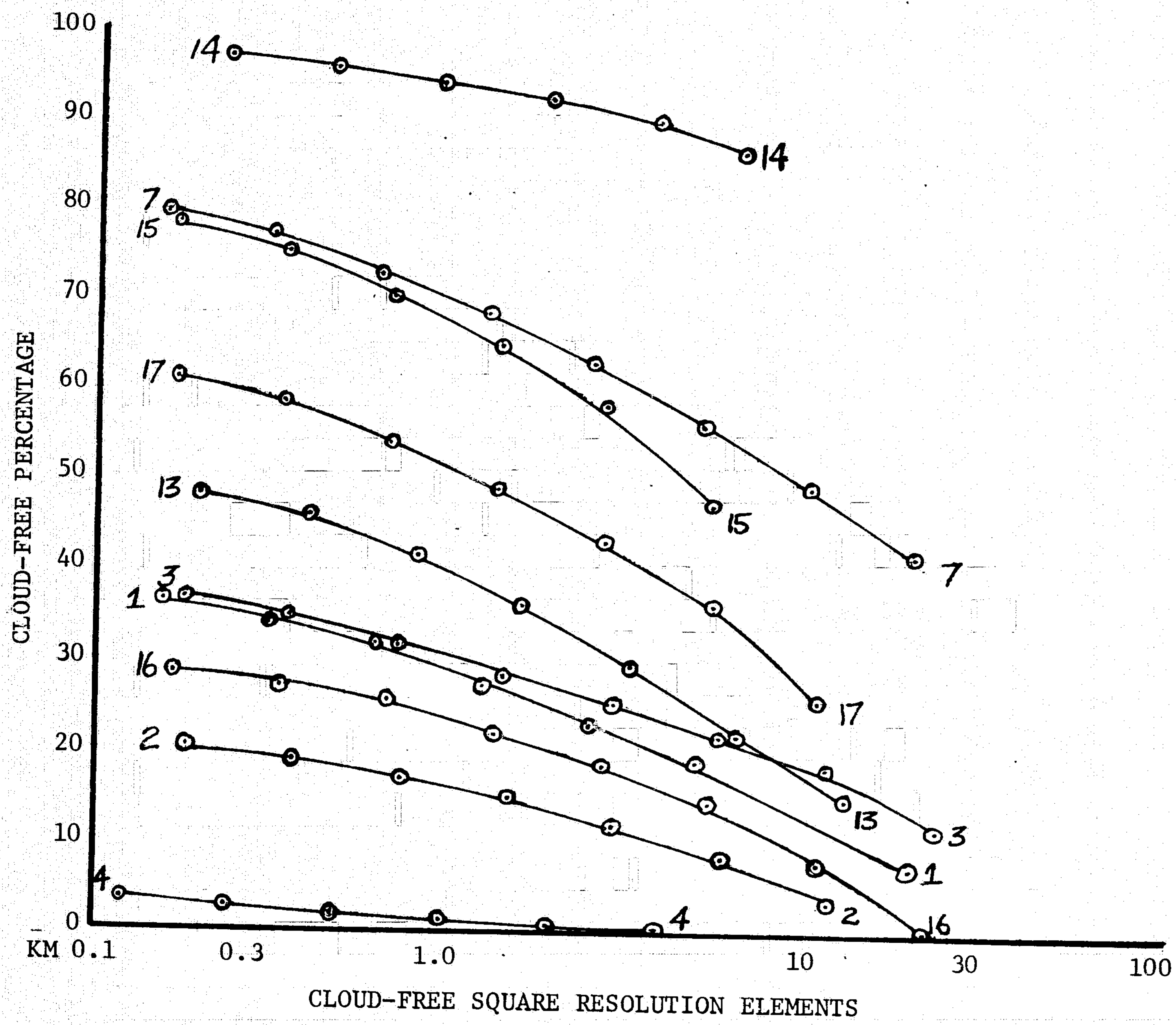


Figure 3-43. Apollo Set B Cloud-Free Element Statistics (Layer-Type Cloudiness)

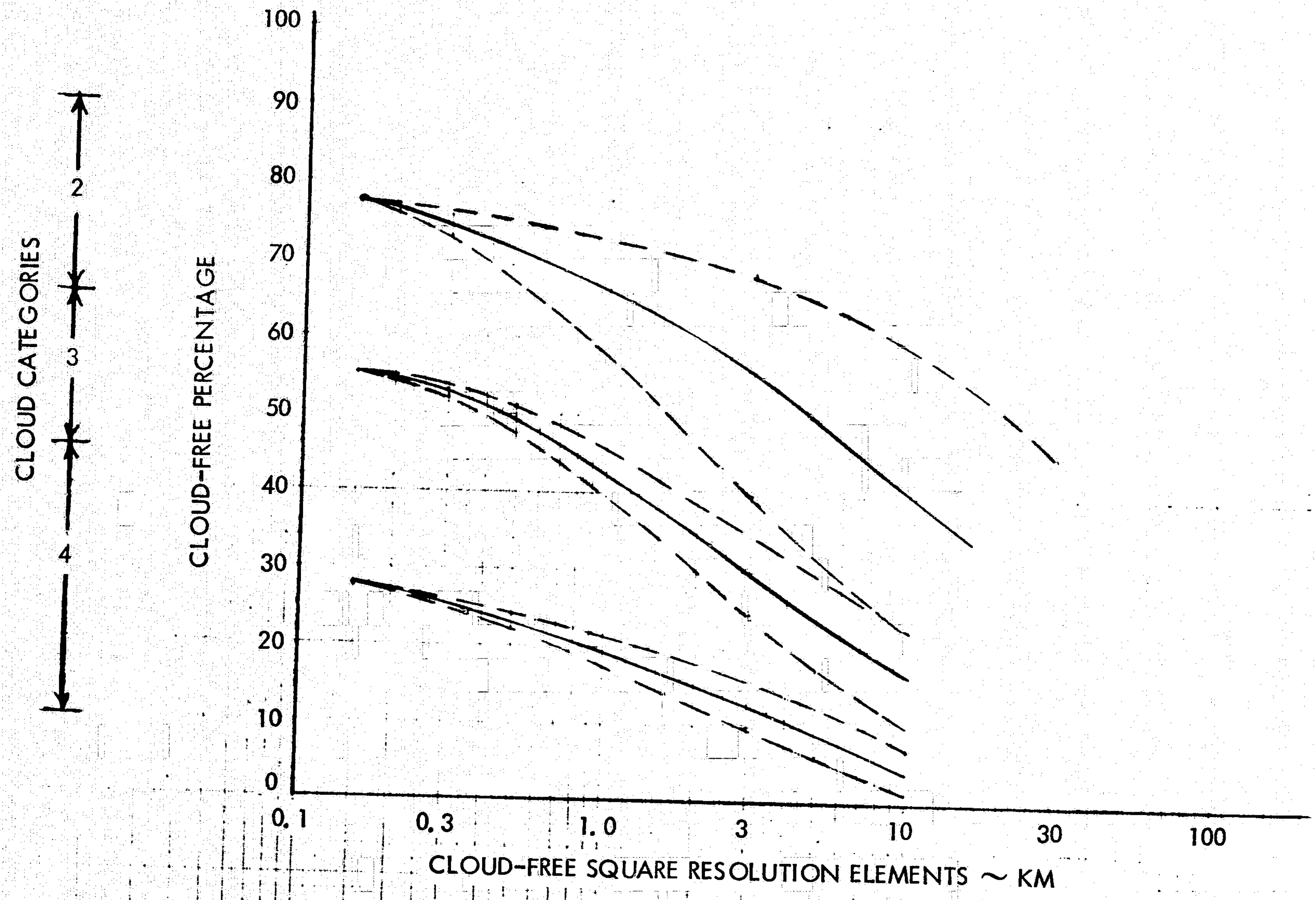


Figure 3-44. Nominal and Extreme Variations, Apollo Cloud Statistics

3.5 ANALYSIS OF ESSA PHOTOGRAPHS

3.5.1 Description of ESSA Photographs

3.5.1.1 General

The ESSA photographs analyzed were from ESSA 7 and ESSA 9 reels of film for the year 1969. The reels were obtained from the National Weather Records Center. The set chosen for analysis contained the grid lines of latitude and longitude.

3.5.1.2 Selection of Photographs

A rather thorough survey of the ESSA photographs contained in the film reels was conducted to select 30 photographs for analysis. The characteristics sought in the final photographs included a variety of total cloud amount from various geographical locations and seasons. The final choice of ESSA photographs is shown in Table 3-13. The following characteristics are depicted for each picture:

1. Assigned picture number
2. Satellite number designating particular satellite
3. Date, time, and season photograph was taken
4. Geographic coordinates of the center of each picture
5. Percentage of the picture occupied by land and water

All these pictures were made in 1969. Table 3-13 indicates that more pictures were selected in the northern hemisphere to concentrate on the United States because of its pertinence to the ERTS objectives.

The 30 pictures selected were taken on ESSA 7 and 9 flights, after careful study and screening of about 1000 film frames.

3.5.2 Digitization Procedure

3.5.2.1 Digitization

The method of digitization is identical to that explained in Section 3.3.3 for the U2-photographs. A 512 x 512 digitization grid was used in conjunction with a $15^{\circ} \times 15^{\circ}$ square segment of the unit sphere. The resultant 1 x 1 grid element is (1.75 x 1.75 nautical miles) or (3.3 x 3.3 kilometers)

Table 3-13. Descriptive Data for the ESSA Film Frames Selected

Picture Number	Satellite Number	Orbital Pass Number	Date*	Time	Season**	Selected Geographic Location of Picture Center		Land/Water Percent Ratio
						Latitude	Longitude	
1	7	10	1/15	0955	Eq	0°	75°E	5%/95°
2	7	11	1/15	1136	Su	40S	60E	0/100
3	7	2	1/15	1717	Su	55S	20W	0/100
4	7	3	1/15	1925	Su	15S	16W	6/94
5	7	6	2/1	0038	W	15N	150W	0/100
6	7	9	2/1	0628	W	25N	115E	65/35
7	7	8	1/20	0507	W	35N	130E	30/70
8	7	3	1/20	2027	W	35N	100W	95/5
9	7	4	1/20	2222	W	40N	120W	55/45
10	9	3	4/10	1841	Sp	40N	80W	100/0
11	9	4	4/10	2023	~Eq	5N	90W	6/94
12	9	4	4/10	2015	F	20S	80W	10/90
13	9	3	4/9	1929	Sp	20N	80W	20/80
14	9	3	4/2	1806	F	35S	45W	18/82
15	9	3	7/1	2005	Su	35N	90W	75/25
16	9	3	7/3	2011	Su	45N	100W	100/0
17	9	4	7/3	2154	Su	10N	115W	0/100
18	9	3	7/4	1906	Su	20N	75W	15/85
19	9	3	7/5	2010	Su	35N	95W	90/10
20	9	3	7/6	1913	Su	35N	80W	60/40
21	9	3	7/6	1900	~Eq	5S	65W	0/100
22	9	4	7/6	2112	Su	50N	115W	93/7
23	9	3	7/10	1908	Su	10N	70W	30/70
24	9	4	7/10	2121	Su	60N	125W	85/15
25	9	3	10/1	1948	F	35N	90W	85/15
26	9	3	10/5	1943	F	10N	80W	35/65
27	9	3	10/6	1842	~Eq	10S	65W	5/95
28	9	3	10/7	1954	F	35N	90W	80/20
29	9	4	10/13	2134	Sp	35S	00W	0/100
30	9	3	10/14	1847	Sp	20S	60W	0/100

*All Dates for 1969

**Season	Symbol
Winter	W
Spring	Sp
Summer	Su
Fall	F
Equatorial	Eq

and the total digitized FOV is (900 x 900 nautical miles). The FOV was constant for all pictures because the film used was reduced satellite data with reference longitude and latitude points. Through the use of a standard area template overlay, the FOV was standardized for each picture digitized.

3.5.2.2 Threshold Selection Procedure

The method used to select the cloud/no-cloud threshold for film was transmitted light intensity. As each ESSA 35 mm film frame was selected, a 7- x 7-in. copy was made for later comparison with digitized tape facsimile photo to aide in threshold intensity selection. The threshold was efficiently selected by a combination of techniques including:

1. Comparison of film frame 7- x 7-in. print and a 5- x 5-in. facsimile plot of the digitized intensity data

2. Slope discontinuity criteria for the intensity cumulative frequency histogram

3. Estimated cloud-cover percentage

Unlike similar methods, this approach provides permanent data that could be used later to resolve unanticipate errors and conveniently verify the threshold selections. Initial thresholds were sufficiently accurate to require generation of only one additional facsimile plot for verification. On five of the 30 selected pictures, three facsimile plots were required. The ESSA film is a black and white positive film, and the extreme intensity values of 0 and 63 correspond to clouds and background, respectively.

The selected thresholds for the 30 ESSA film frames are listed in Table 3-14. Intensity values greater than threshold value denote background or cloud-free points. Specific geographic and time data for the pictures listed in Table 3-14 are tabulated in Table 3-13.

3.5.3 Statistics Generation Procedure

The method and associated computer program used to generate ESSA cloud-free probability statistics as a function of element size are described in Sections 3.3.4 and Appendix B.

Point and area constraints for line cloud segments and cloud elements were systematically selected as 15 points and 4 percent, respectively. The point criteria will have a negligible effect except for the case of isolated small clouds (small relative to a FOV of 900 x 900 nautical miles). The 4-percent area criterion will result in insignificant error effects

Table 3-14. ESSA Film Frames (Picture) Cloud-Free Percentage

Picture Number	Background Threshold	Percent Cloud Amount		Cloud-Free Percentage Versus Resolution Element*									
		Estimated	Computed	1 x 1	2 x 2	4 x 4	8 x 8	16 x 16	32 x 32	64 x 64	128 x 128	256 x 256	512 x 512
1	37**	23.0	24.0	76.0	73.3	69.2	64.2	56.3	45.5	34.2	20.1	0.0	0.0
2	37	41.0	43.7	56.3	54.0	50.7	46.7	40.1	30.0	17.0	3.0	0.0	0.0
3	28	72.0	58.4	41.6	37.1	31.9	26.8	20.9	14.6	7.6	1.8	0.0	0.0
4	32	50.0	53.6	46.4	42.7	37.2	31.2	23.0	13.1	3.8	0.0	0.0	0.0
5	40	35.0	42.1	57.9	54.1	48.8	42.5	33.9	22.6	11.4	3.6	0.0	0.0
6	22	87.0	75.1	24.9	19.9	15.4	11.3	6.7	1.7	0.0	0.0	0.0	0.0
7	35	60.0	50.1	49.9	46.8	42.8	38.8	33.2	25.9	17.6	6.5	0.0	0.0
8	35	50.0	61.6	38.4	35.9	33.3	31.1	28.2	24.5	18.5	7.7	0.0	0.0
9	35	40.0	47.9	52.1	48.4	43.6	38.7	32.7	24.3	12.5	1.2	0.0	0.0
10	35	40.0	36.1	63.9	61.3	57.7	53.5	47.6	39.7	28.8	14.2	0.0	0.0
11	30	30.0	20.0	80.0	77.7	73.9	69.2	62.0	52.8	40.9	28.4	8.0	0.0
12	17	65.0	50.0	50.0	44.3	39.3	35.1	30.2	23.2	12.0	1.8	0.0	0.0
13	35	25.0	24.3	75.7	72.9	68.7	63.9	56.8	46.4	34.1	16.0	0.0	0.0
14	35	35.0	13.7	86.3	83.0	78.3	72.9	64.7	52.1	38.8	29.0	0.0	0.0
15	42	20.0	14.8	85.2	82.9	78.8	73.6	65.3	53.0	34.2	14.4	0.0	0.0
16	40	32.0	31.7	68.3	65.6	61.3	55.6	47.3	36.9	27.0	10.7	0.0	0.0
17	40	40.0	41.1	58.9	55.6	50.9	45.0	36.3	23.4	11.4	1.2	0.0	0.0
18	47	50.0	12.0	88.0	86.0	82.3	77.5	69.4	55.8	36.6	21.9	4.0	0.0
19	43	25.0	23.0	77.0	74.4	70.0	64.6	55.8	43.5	27.7	12.4	0.0	0.0
20	45	50.0	25.0	75.0	72.9	69.4	65.1	58.6	50.0	38.5	29.0	8.0	0.0
21	43	27.0	21.1	78.9	76.2	71.4	65.0	55.0	41.5	26.4	17.8	0.0	0.0
22	40	65.0	56.9	43.1	39.3	33.6	27.3	19.9	11.2	3.4	0.0	0.0	0.0
23	47	25.0	34.7	65.3	62.0	57.1	51.2	42.9	31.3	16.9	1.2	0.0	0.0
24	40	60.0	46.9	53.1	49.1	43.5	37.8	30.9	22.9	14.5	5.3	0.0	0.0
25	40	45.0	41.1	58.9	56.7	53.0	48.7	42.5	33.5	22.0	9.5	0.0	0.0
26	40	25	25.1	74.9	72.3	68.0	62.5	53.5	39.7	19.26	8.3	0.0	0.0
27	45	50	44.4	55.6	53.3	49.8	45.3	38.4	28.2	18.0	5.9	0.0	0.0
28	50	25	28.6	71.4	69.5	66.4	62.8	56.8	46.7	31.6	16.0	4.0	0.0
29	45	35	18.2	81.8	79.0	75.0	70.8	63.8	51.9	33.3	19.5	0.0	0.0
30	50	35	46.3	53.7	50.9	46.8	41.9	34.6	23.8	11.2	0.6	0.0	0.0

*Resolution element cloud threshold parameters

- Linear length = 15 points
- % resolution cloud area > 4

**Maximum intensity = 63

because the minimum computed total cloud cover is 12 percent (Table 3-14) which is substantially greater than 4 percent of any individual element.

3.5.4 Resulting Statistics (ESSA)

Cloud statistics derived from the ESSA composite photograph cloud pictures provide the FOV cloud-free percentage as of function of the elements for sizes of 3.3 x 3.3 kilometers up to 1280 x 1280 kilometers. Since the minimum cloud percentage is 12 percent for the ESSA pictures, all the statistics will approach zero cloud-free percentage for the total picture FOV. This limitation restricts the valid range of the computed data to the element size range corresponding to 64 x 64 points or less). The computed cloud-free percentage versus resolution element size is listed in Table 3-14 for the 32 selected ESSA pictures (see Table 3-13).

3.5.4.1 Resulting Statistics Versus Cloud Category

The computed cloud free statistics in Table 3-14 have been grouped by cloud-free percentage for the basic or minimum element size (1 x 1 grid point = 3.3 x 2.2 kilometers). Three categories used for data group are (1) greater than 65 percent cloud free, (2) 45- to 65-percent cloud free, and (3) less than 45-percent cloud free. Plots of the data by category are depicted in Figures 3-45 to 3-47 for Categories 2 through 4, respectively. Except for picture numbers 19 and 26 in Figure 3-45, the curves for Categories 2 and 3 exhibit uniform slopes per each category, thereby showing relatively small effects due to cloud type variation (e.g., layer versus cellular). However, the effects of cloud clustering are evident in the curves for cloud Category 4 in Figure 3-47. Nominal or mean curves were constructed from Figures 3-45 through 3-47 by visual inspection. These nominal curves are shown in Figures 3-48 through 3-50. The next step is to combine the data for the different categories.

3.5.4.2 Composite ESSA Statistics

By visual interpolation, the curves in Figures 3-47 through 3-50 were combined to form composite curves. The composite curves are depicted in Figure 3-51. These curves represent nominal or mean values. For the ESSA data, the variation in slope with cloud type was much smaller than in the smaller resolution element data of U-2 and Apollo. Because of this small variation with cloud type for the larger resolution elements, only nominal curves are presented. These curves should be interpreted linearly on the ordinate scale for intermediate values.

These composite statistics were subsequently combined with similar nominal statistics for the U2 and Apollo resolution element range.

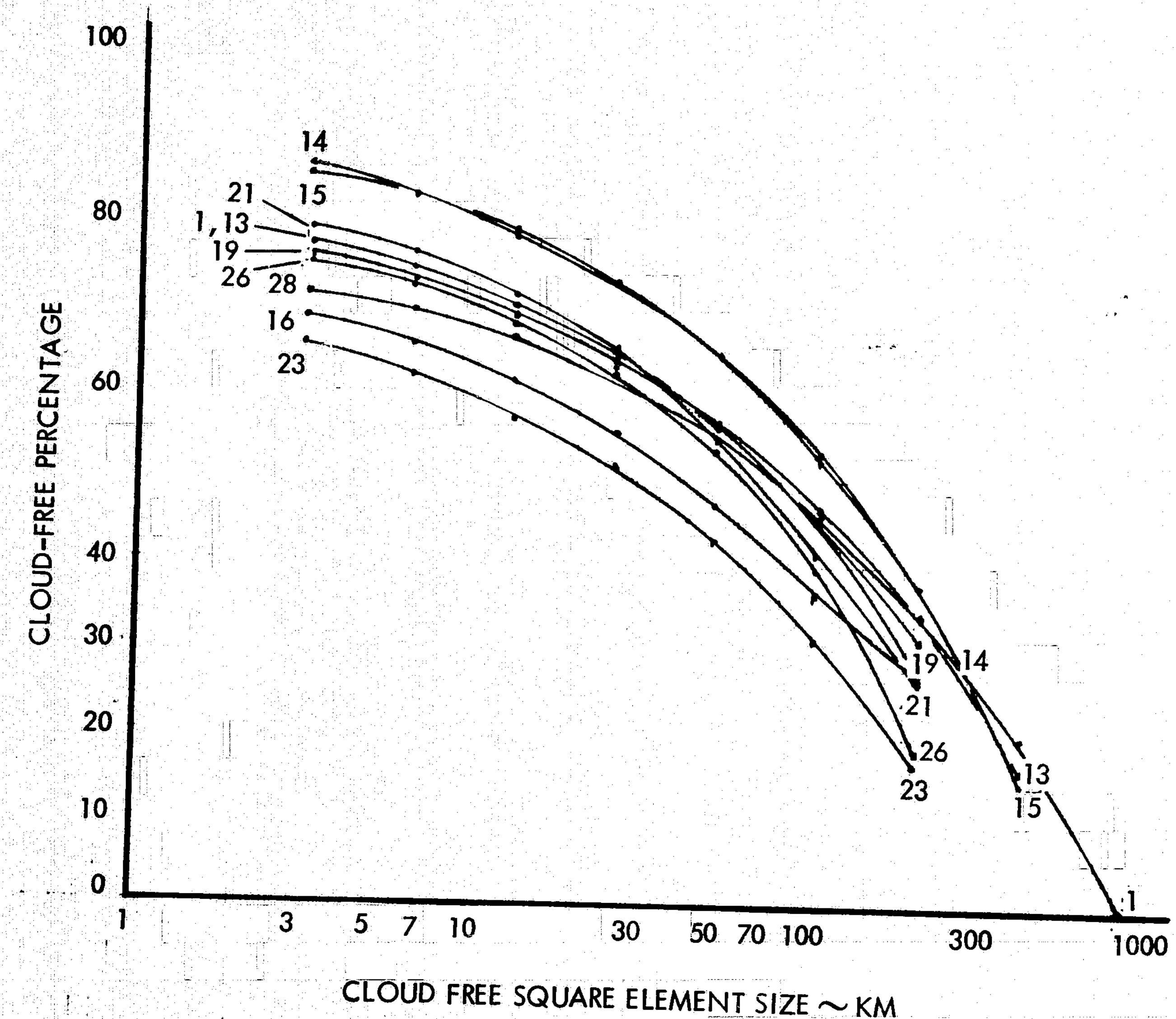


Figure 3-45. ESSA-Category 2 (>65 Percent Cloud Free)

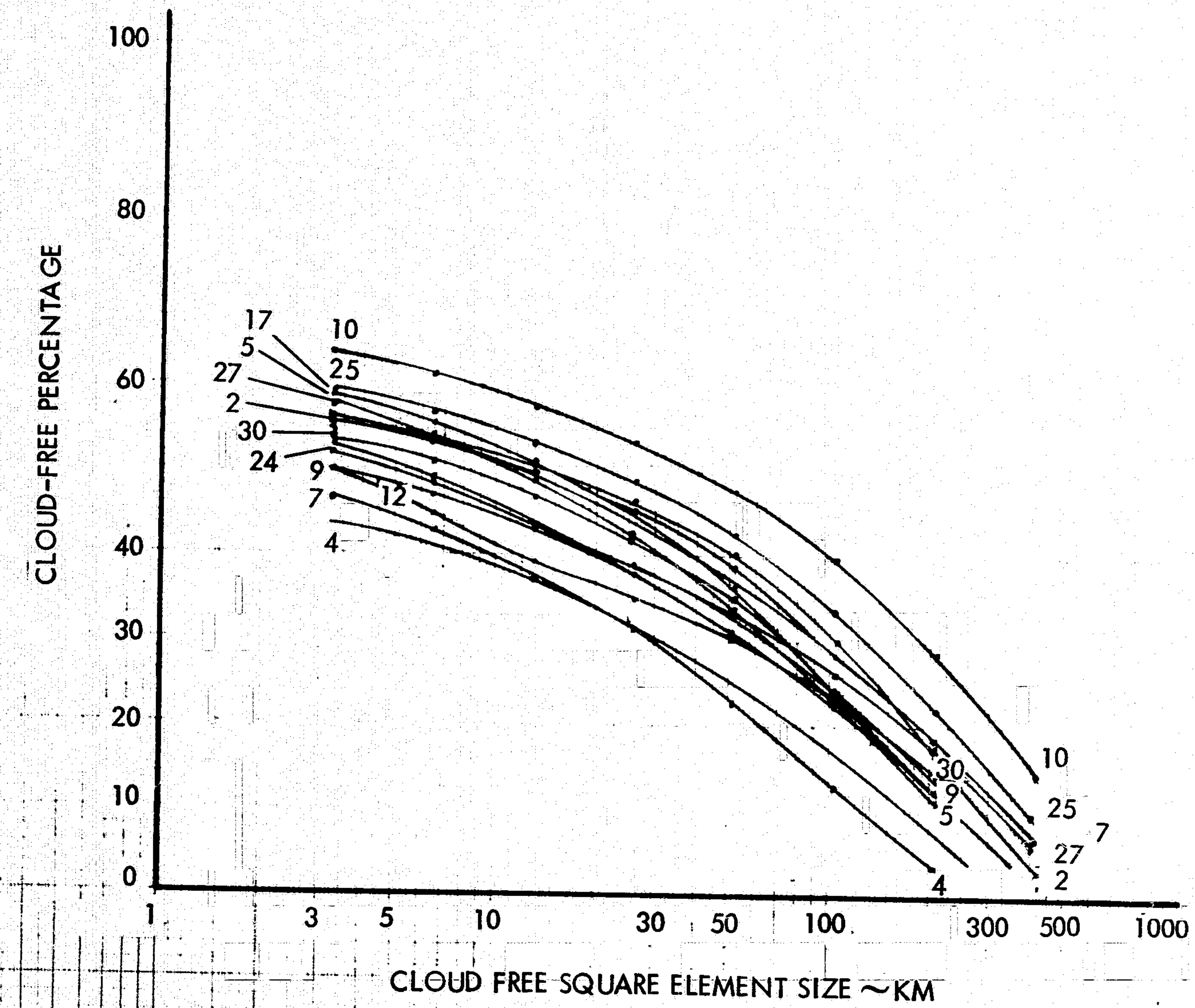


Figure 3-46. ESSA-Category 3 (45-65 Percent Cloud Free)

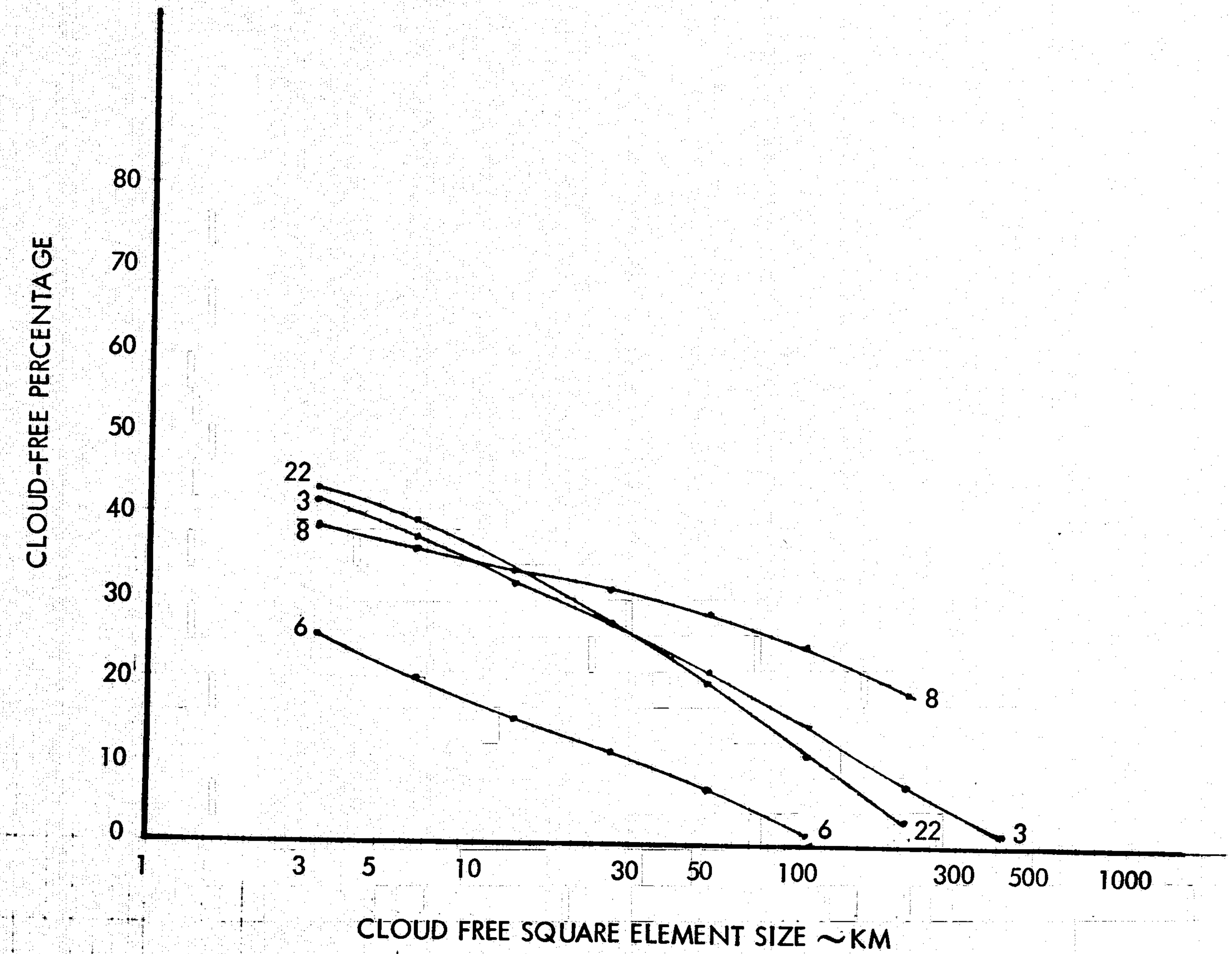


Figure 3-47. ESSA-Category 4 (<45 Percent Cloud Free)

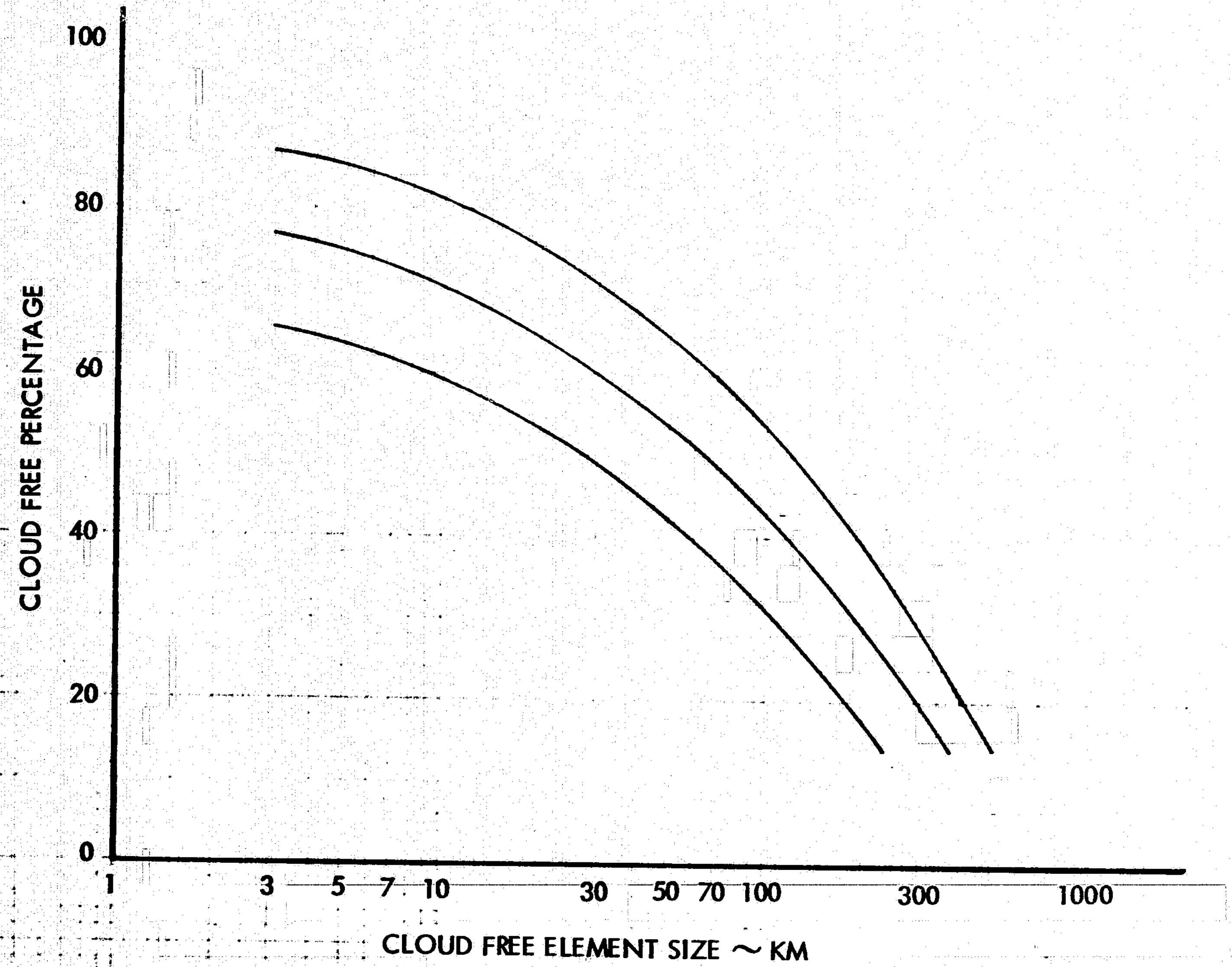


Figure 3-48. Nominal Curves for ESSA-Category 1 (>65 Percent Cloud Free)

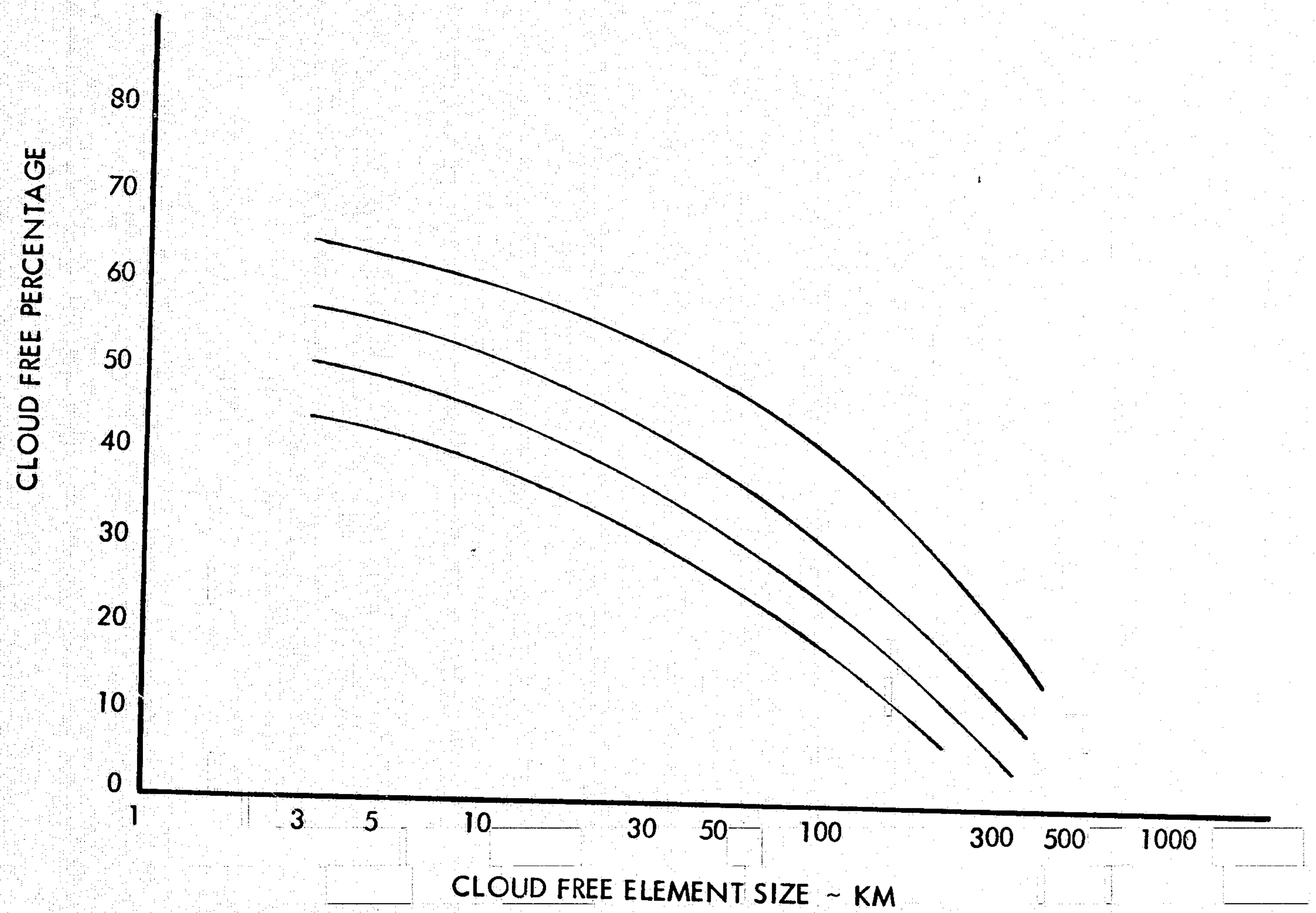


Figure 3-49. Nominal Curves for ESSA-Category 2 (45-65 Percent Cloud Free)

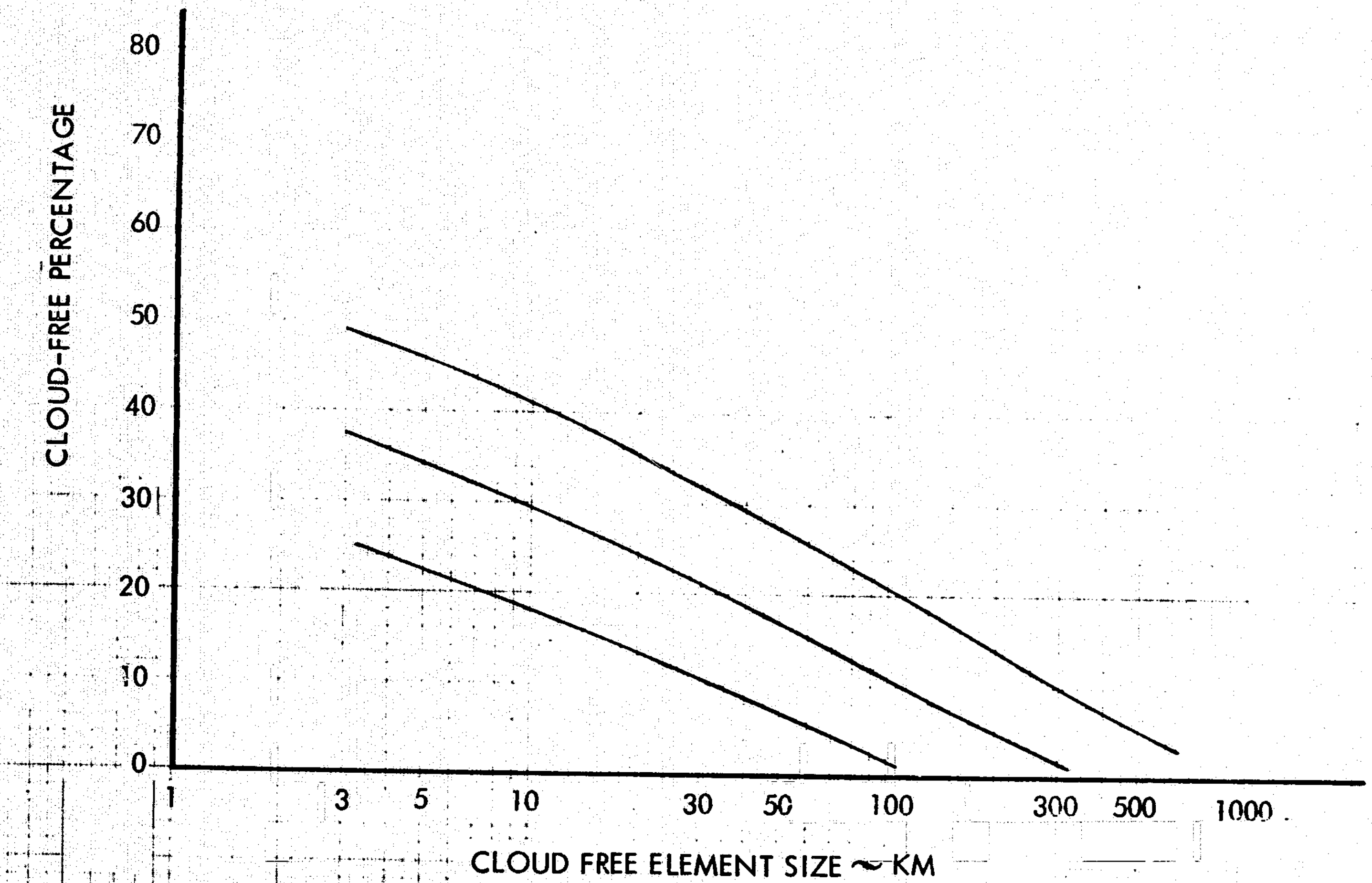


Figure 3-50. Nominal Curves for ESSA-Category 3 (<45 Percent Cloud Free)

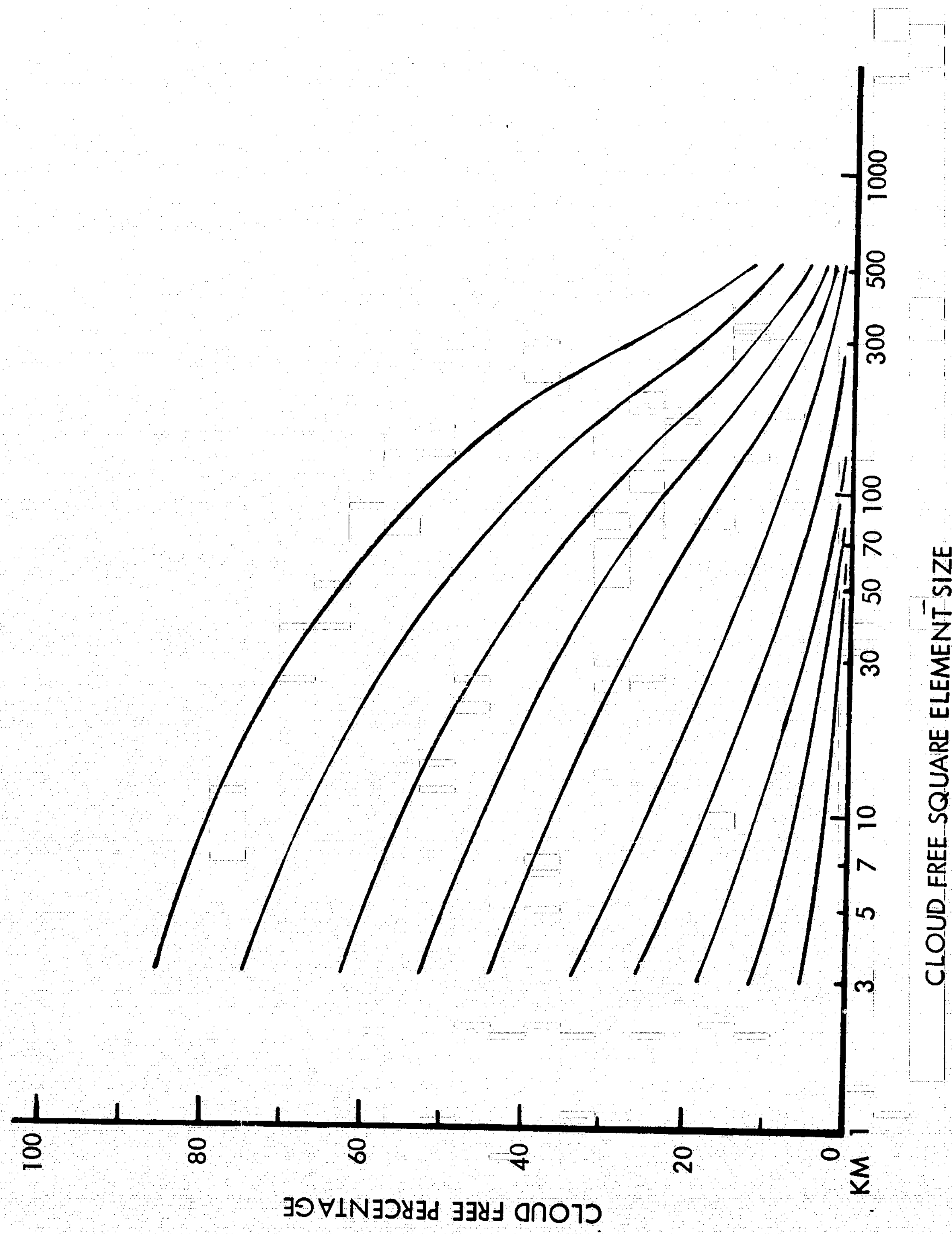


Figure 3-51. ESSA-Composite Data

3.6 COMBINED STATISTICS

Data from U-2 (Figure 3-33), Apollo (Figure 3-44), and ESSA (Figures 3-48 through 3-50) were combined as illustrated in Figure 3-52. The dashed lines in Figure 3-44 denote the extreme envelopes as a function of cloud type and the solid lines denote the nominal values for each cloud category. The combined data curves and the basic data curve segments are illustrated in Figure 3-52. The component curves are compatible and fit well at midrange of the U2 and Apollo data. Although the fit is not as good at the Apollo/ESSA interface at about seven kilometers, it does show a relatively smooth transition. The solid curves in Figures 3-52 and 3-53 represent the combined values representative of each cloud category and each 10 percent intervals, respectively. These resultant statistics define the effect on the cloud-free area percentage of resolution element statistics for the range of 0.03 to 200 kilometers. When augmented with the U2 and Apollo envelope data, these data completely define the sensor resolution effect as a function of cloud-free resolution element size.

3.7 CONCLUSIONS AND RECOMMENDATIONS

1. There is a large percentage increase in cloud-free area within a given FOV with decrease in cloud-free resolution element size (increase in resolution).

2. The rate of increase in cloud-free area with increased resolution is less for layer-type cloudiness than for cellular-type cloudiness in the mid-range of element size (Apollo curves).

3. The increase (gain) in cloud-free area is relatively small for cloud-free resolution elements from 300 km to about 30 km; relatively large from 30 km to 1 km; and relatively small at smaller resolution element sizes.

4. The resolution interval of maximum gain in cloud-free area is a function of the FOV total cloud amount and cloud spatial distribution.

5. Future probability-of-seeing analyses for ERTS should utilize the variation in cloud-free area as a function of resolution element size and cloud-type (spatial distribution).

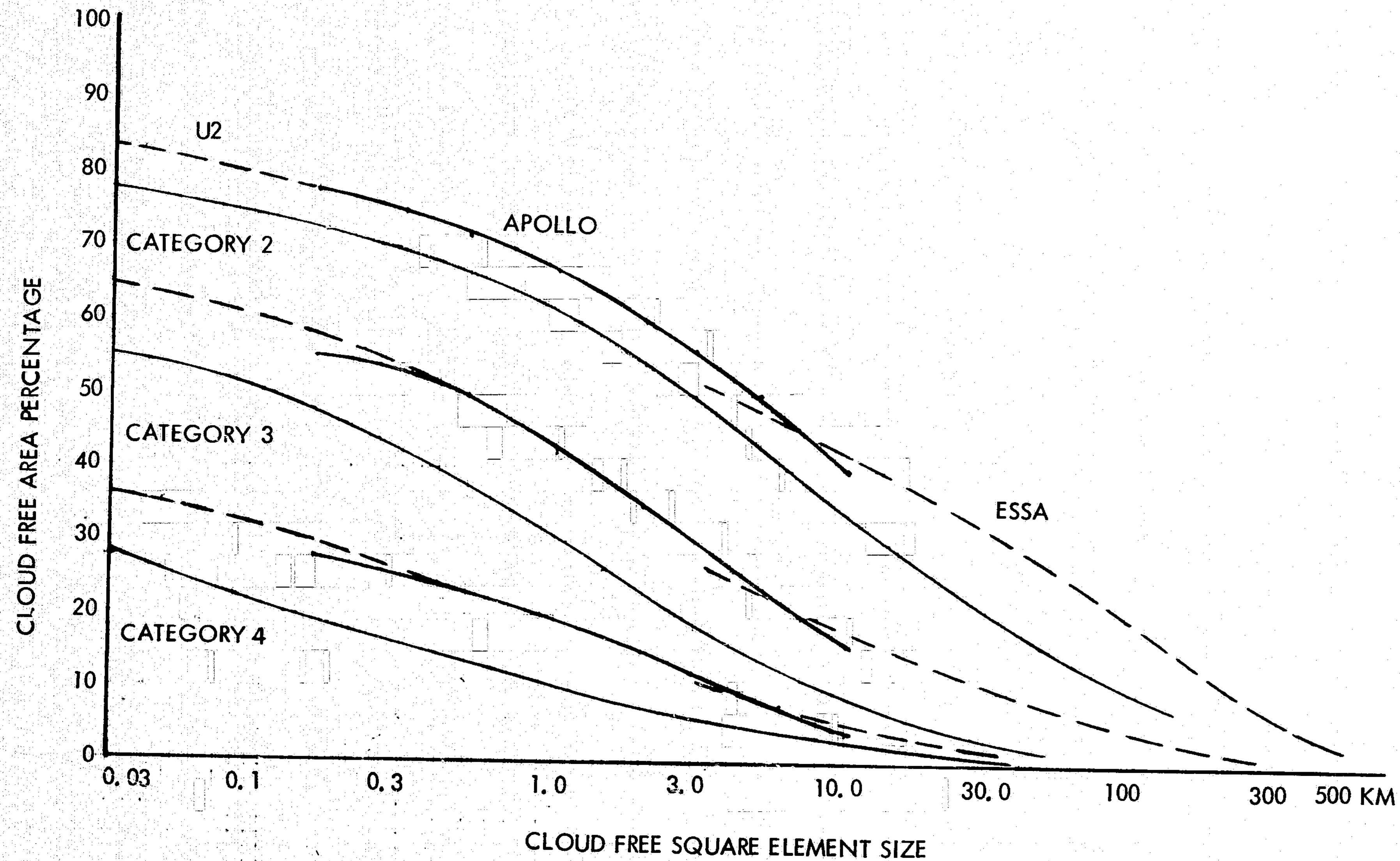


Figure 3-52. Combined Statistics for Cloud-Free Resolution Elements Versus Cloud Category

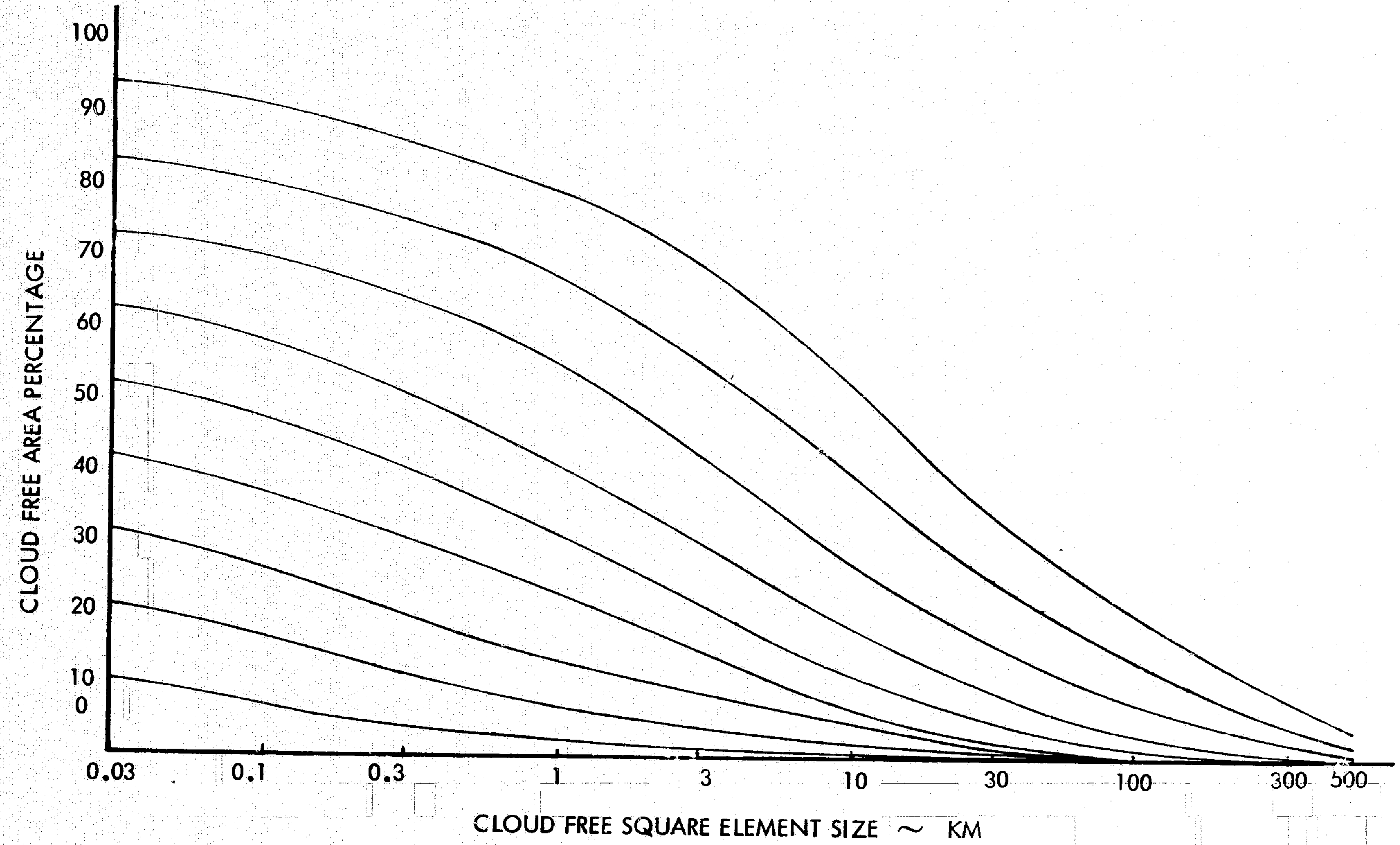


Figure 3-53. Combined Statistics for Cloud-Free Resolution Elements in 10-Percent Cloud Amount Intervals

4.0 CLOUD REGION HOMOGENEITY ANALYSIS (U.S.)

The objective of this phase of the study was to evaluate the validity of the homogeneous cloud regions of the United States for ERTS probability-of-seeing studies. Maximum ERTS interest lies in the Chesapeake Bay, Phoenix, and the Feather River areas. Emphasis is placed upon these locations.

4.1 DATA RESOURCES

The homogeneous cloud regions used in the probability-of-seeing analyses were delineated in Reference 2 and they are illustrated for the United States in Figure 4-1. The cloud statistics of Reference 2 were presented for each of these homogeneous regions. The unconditional cloud statistics for each region were for a single station selected as being representative of the entire cloud region. For the homogeneous cloud regions of the United States, the following information is applicable:

Homogeneous Cloud Region (U.S.)	Representative Station
1	Dhahran, Saudi Arabia
2	Tripoli, Libya
4	Tampa, Florida
5	Los Angeles, California
8	Mountain Home, Idaho
11	Belleville, Illinois
13	Ship D, Atlantic
18	San Francisco, California
19	Shreveport, Louisiana

As a first step in checking the validity of a single station's statistics for the U.S. homogeneous cloud regions, a survey was made of the summarized cloud statistics available within the National Climatic Center of the Environmental Data Service, at Asheville, North Carolina. The U.S. cloud statistics of interest consist of hourly (or three-hourly) frequency distributions of cloud cover amounts for each month of the year, for periods of at least ten years. The most appropriate data are published as Uniform Summaries of Surface Weather Observations, Part A (prepared from hourly observations). Figure 4-1 presents results of the survey to identify stations in the U.S. that have at least ten years of such data. From these approximately 150 stations, uniform or revised uniform summaries of sky cover

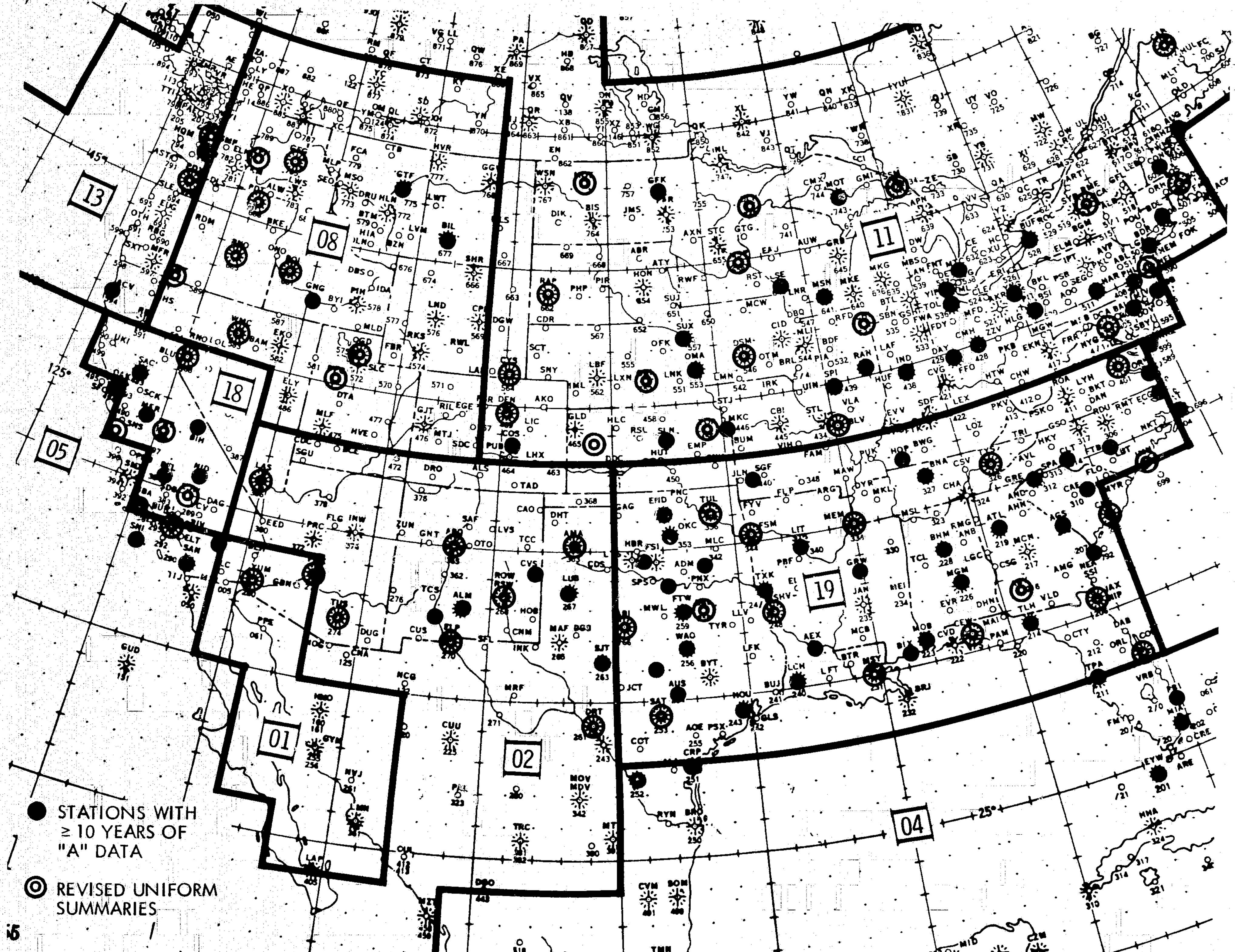


Figure 4-1. Cloud Regions of the U. S.

for 60 stations scattered evenly throughout the U. S. were acquired and used in frequency distribution comparisons. It should be noted that the revised uniform summaries present the cloud amount frequency distributions in terms of relative or percentage frequencies, the most useful form. The uniform summaries' data are for frequencies only and had to be converted to percentage frequency data.

4.2 COMPARISON OF FREQUENCY DISTRIBUTIONS - STANDARD-SIZE AREAS

4.2.1 General

Figure 4-2 illustrates a comparison of the frequency distributions for all of the 29 homogeneous cloud regions of Reference 2 for 1000 LST, August. Although the shapes vary with time of day and with season or month, it is possible to generally describe the frequency distributions as having an L, M, U, or J shape. These descriptors will be used in subsequent discussion. Figures 4-3, and 4-4 present the frequency distributions for 1000 LST, January (winter) and July (summer) for the five largest (areally) cloud regions of the U. S. (2, 8, 11, 18, and 19) and for Region 1, which contains the Phoenix area of special interest to ERTS. Distributions for these U. S. regions demonstrate the wide seasonal differences that occur.

The 1000 LST, winter distributions of Figure 4-3 show the J distribution typical of high amounts of overcast skies for all regions of the U. S. except for the southwest desert regions of 1 and 2. During summer, however, the entire western U. S. (1, 2, 8, and 18) shows the L distribution typical of high amounts of clear skies, while the eastern U. S. (11 and 19) still shows relatively high percentages of overcast and broken cloud amounts.

4.2.2 Frequency Distributions Within Cloud Regions

A cursory survey of the frequency distributions was made for the entire 60 selected U. S. stations. A more detailed analysis was made for the three regions of greatest interest to ERTS studies (Chesapeake Bay, Phoenix, and Feather River).

Figures 4-5 through 4-8 demonstrate the variation that occurs for selected stations, times, and seasons in Region 11. In general, the poorest agreement with the Region 11 data (Belleville, Illinois) occurs at Grand Island and Cheyenne, the stations near the west end of the region. Cheyenne, in particular, demonstrates poor agreement at all four times/seasons illustrated. Surprisingly, Washington, D. C., shows a better agreement with the Belleville data than does Des Moines, which is much closer. All the five

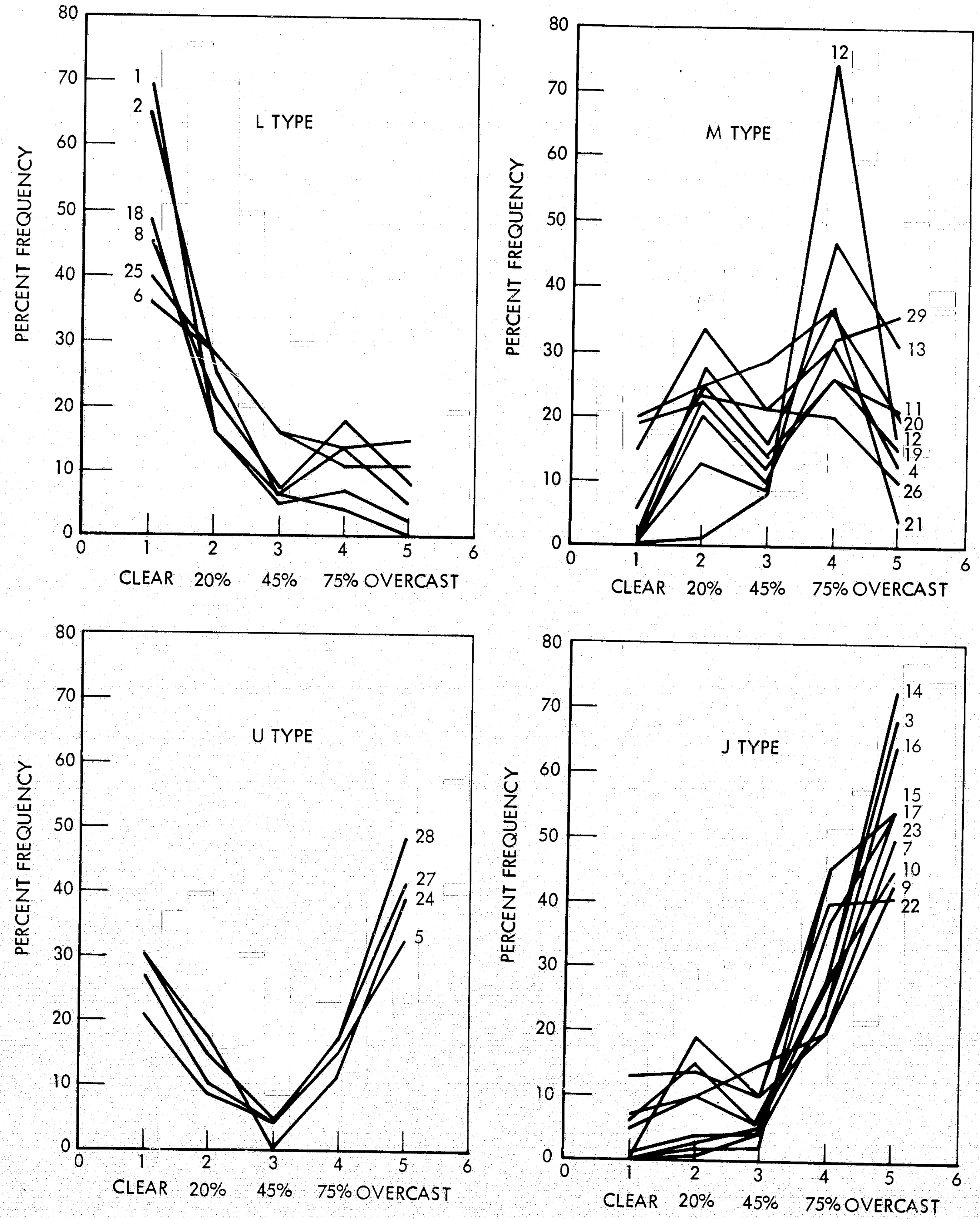


Figure 4-2. Cloud Amount Frequency Distributions Versus Cloud Type for 29 Homogeneous Cloud Regions

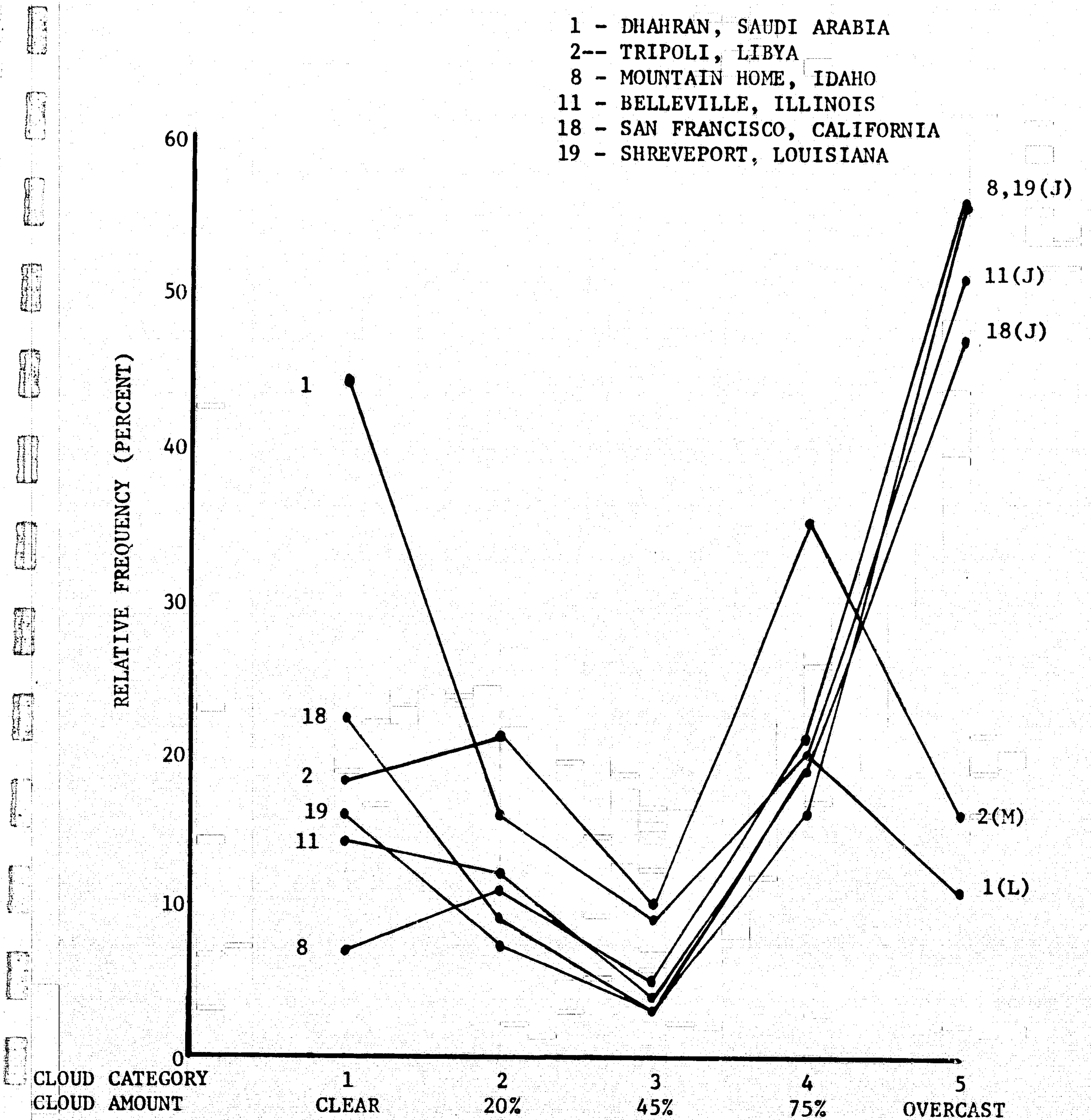


Figure 4-3. U.S. Homogenous Regions 1000 LST - January

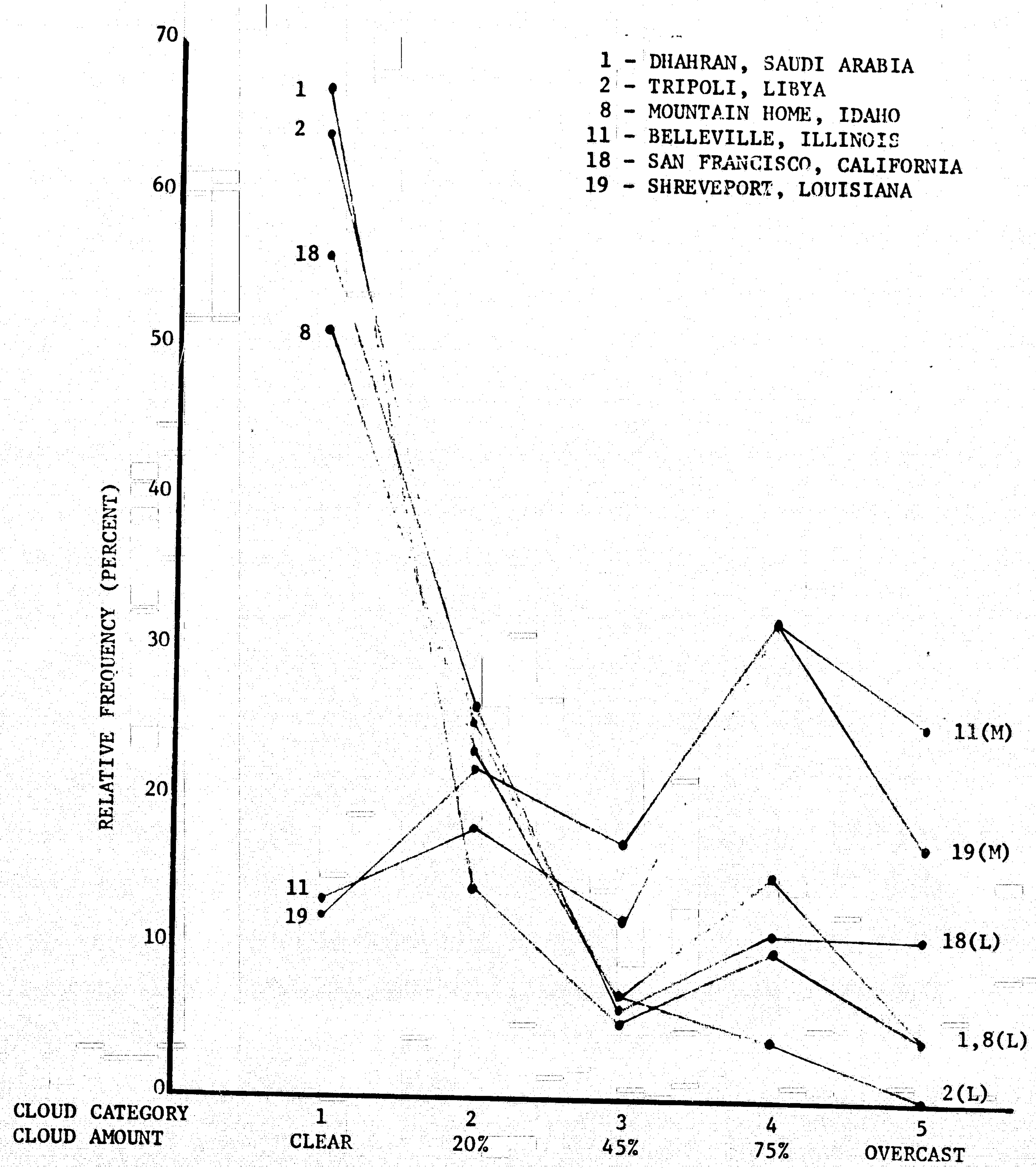


Figure 4-4. U. S. Homogenous Regions 1000 LST - July

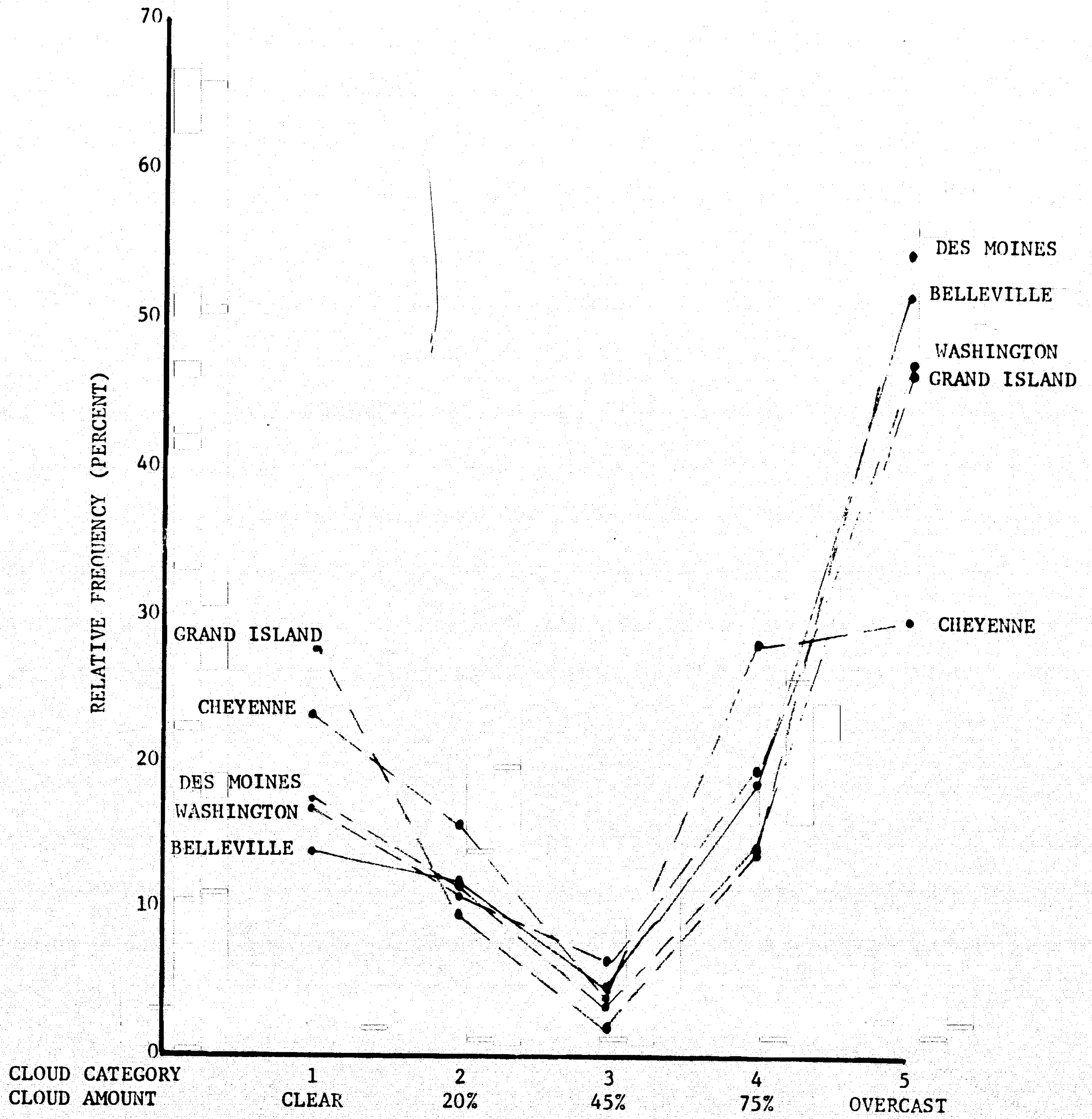


Figure 4-5. Region 11 Stations 1000 LST - January

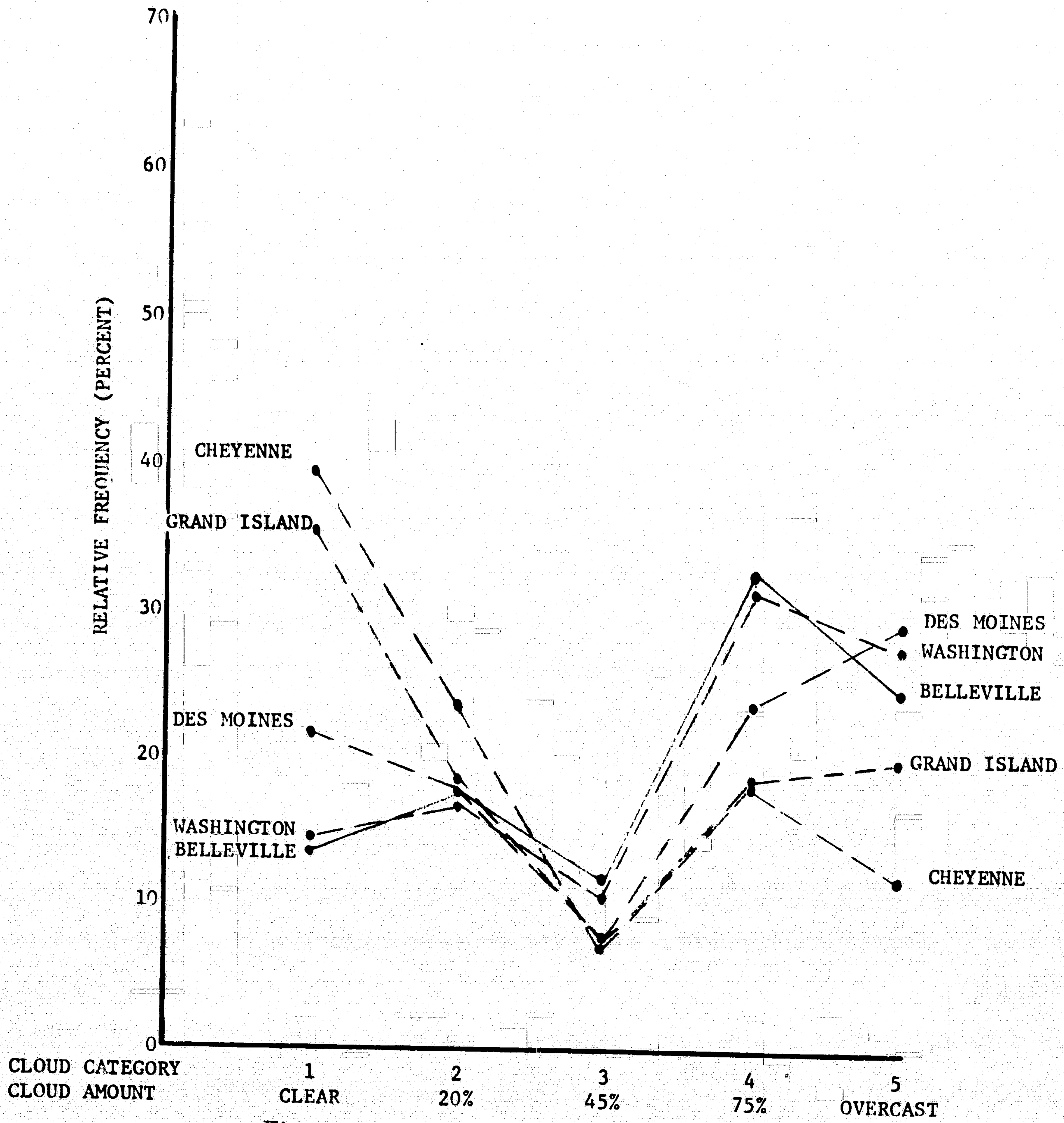


Figure 4-6. Region 11 Stations 1000 LST - July

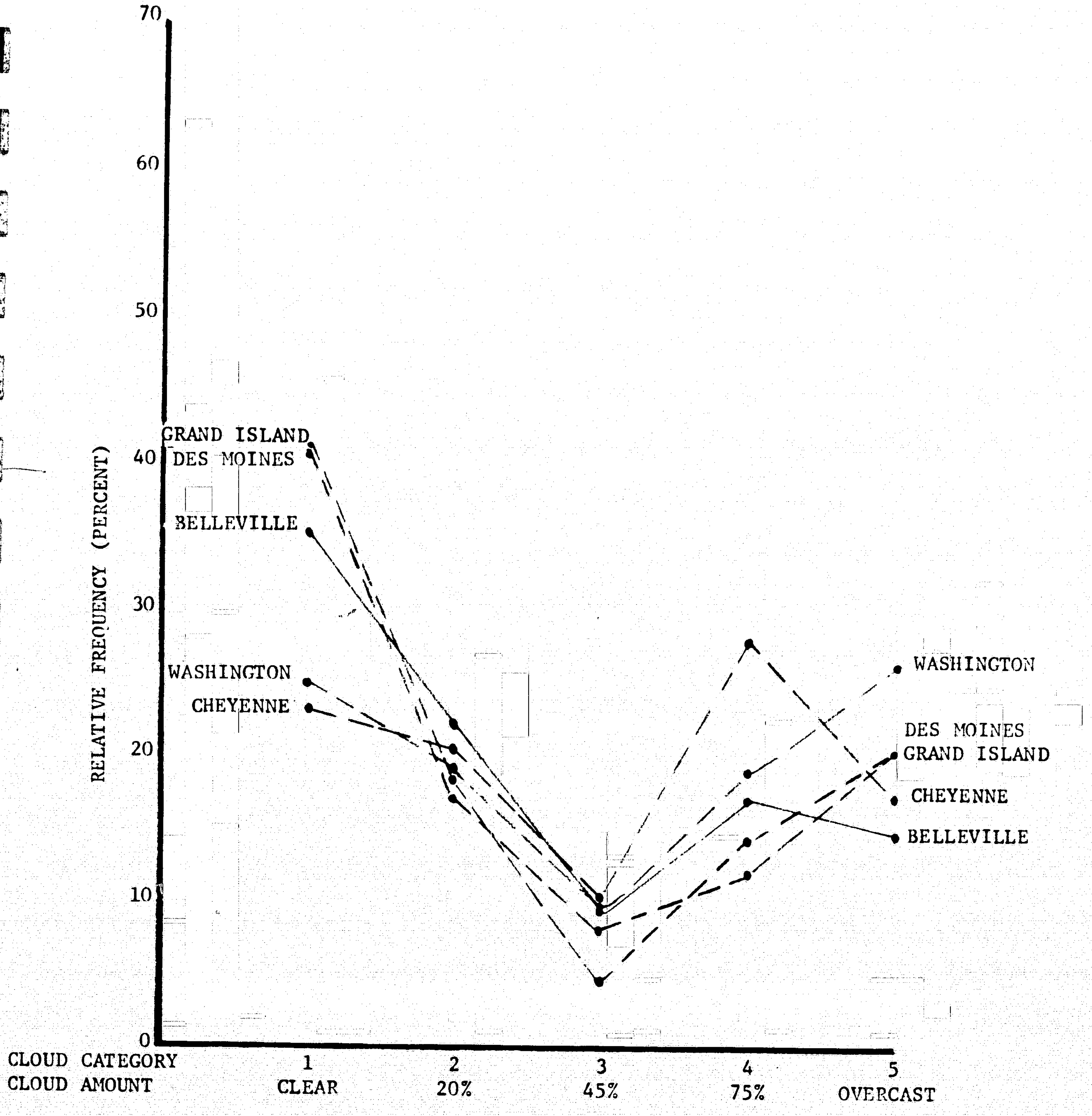


Figure 4-7. Region 11 Stations 2200 LST - July

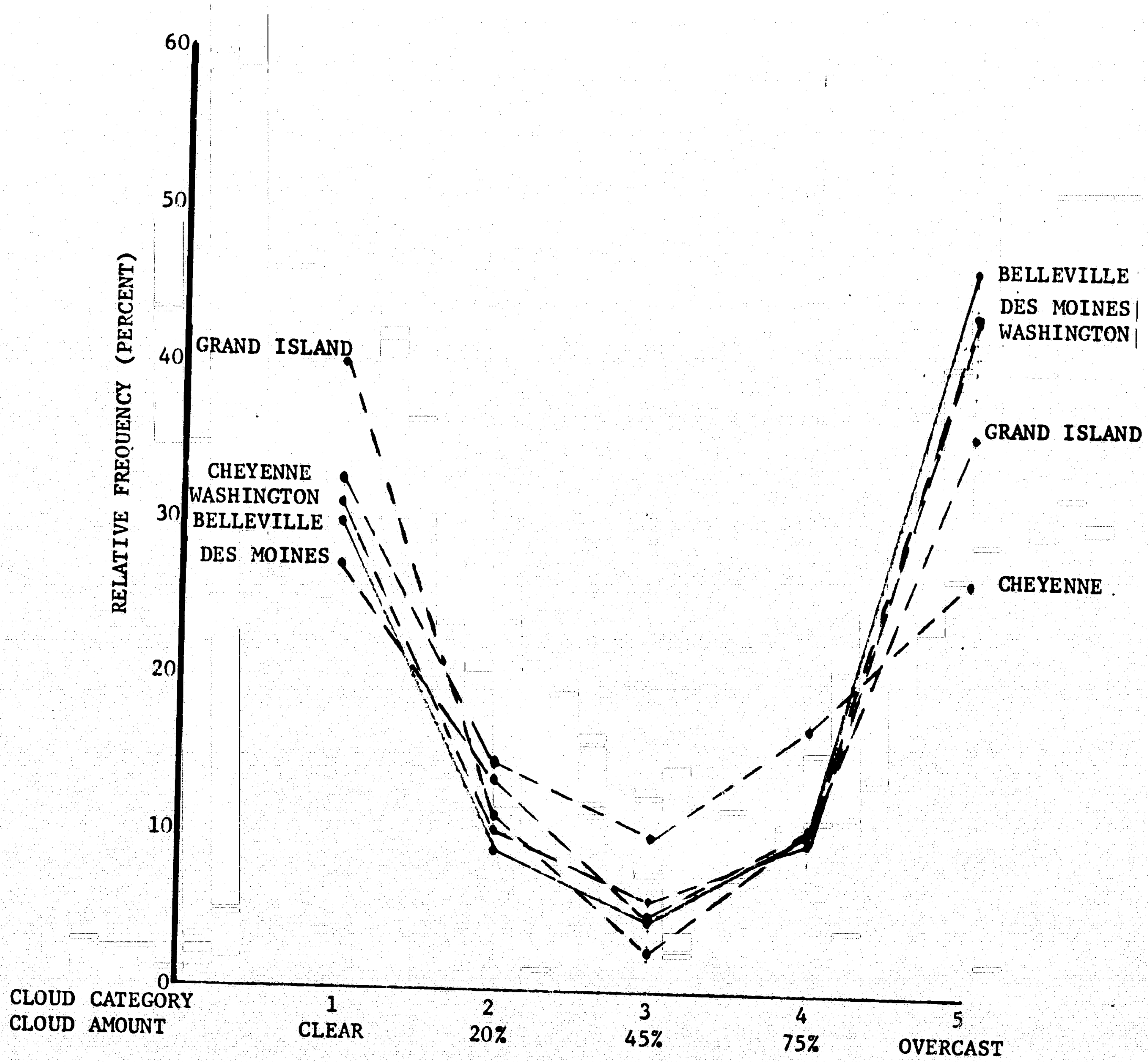


Figure 4-8. Region 11 Stations 2200 LST - January

stations selected are within ±2° latitude of the center latitude of the stations. The best seasonal agreement for the five Region 11 stations are nighttime (2200 LST) in the winter (January). The poorest was daytime (1000 LST) in summer (July). The poorest agreement was at the clear and overcast cloud amounts.

The diurnal variation is particularly large at Cheyenne in the summer. There the greatest frequency (of the five stations) occurs in the daytime (1000 LST) but the lowest frequency (of the five stations) occurs at nighttime (2200 LST). Region 11 statistics (Belleville) show the opposite diurnal trend, or lowest clear at 1000 LST, and high clear at 2200 LST.

The extreme variation of the frequency of clear skies at Cheyenne and Grand Island at 1000 LST in July (39 and 35 percent) compared with Region 11 (Belleville) and Washington (13 and 14 percent) should be noted.

The survey of frequency distributions within the other U.S. cloud regions similarly showed a great variety of distributions according to time-of-day, geography, or season. These variations produced distributions which "fitted" the data for the cloud region (representative station) at some locations, times, and seasons and others that did not. The inescapable conclusion was that unconditional frequency distributions for individual stations within the U.S. cloud regions should be used in preference to the "representative station" data. Of course, for worldwide areas, where a coverage of data similar to that of the United States is not possible, such as the oceans and underobserved land areas, the cloud regions of Reference 2 provide a most useful concept and the most appropriate data for use in probability-of-seeing studies. In addition, for studies requiring conditional cloud statistics, the individual station data are inadequate since no such data are available. The use of the cloud region data of Reference 2 for the conditional statistics is therefore necessary. Current efforts are being made by Allied Research under a NASA-MSFC contract to update the data of this reference. Such updated data should be used in preference to that of Reference 2 when they become available.

4.2.2.1 Chesapeake Bay Area

Cloud frequency data for the Chesapeake Bay Area (Washington, D.C.) were compared with Region 11 data (Belleville, Illinois) in the previous section, and a fair agreement was noted. For detailed probability-of-seeing studies, however, an improvement in the accuracy of the probability values would be achieved by using the unconditional cloud statistics from Washington, D.C.

Uniform Summary of Surface Weather Observations, Part A & B, is available for Washington, D.C./Andrews AFB at the National Climatic Center, Environmental Data Service, Asheville, North Carolina. Figure 4-9 presents an example of the basic data format. Table 4-1 presents a summary of the percentage frequency distributions for selected months and times of day as derived from the basic data.

Table 4-1. Selected Cloud Statistics* for Chesapeake Bay Area

Month and Time	Cloud Category					
1000 LST	1	2	3	4	5	Mean Tenths
Jan	16.6	10.8	6.1	19.6	46.9	6.7
Apr	15.0	15.2	7.2	23.7	38.9	6.3
July	14.2	16.5	10.3	31.4	27.6	6.0
Oct	26.4	16.3	8.5	16.5	33.3	5.2
2200 LST						
Jan	31.0	10.2	5.9	9.7	43.2	5.5
Apr	31.7	12.9	5.3	12.9	37.2	5.2
July	25.2	19.2	10.0	19.1	26.4	4.9
Oct	44.7	12.2	4.0	11.2	27.9	4.1
All Hours						
Jan	23.7	11.0	5.1	14.5	45.7	6.1
Apr	21.3	13.6	6.3	20.1	38.8	6.0
July	16.0	16.9	11.6	29.2	26.3	5.7
Oct	33.9	13.6	6.3	16.1	30.1	4.8
All months	23.4	14.3	7.4	19.6	35.4	5.6

*Percentage frequencies, unconditional, standard-size areas

4.2.2.2 Phoenix Area

As may be seen from Figure 4-1, the Phoenix area is located just inside homogeneous cloud region 1 and near the boundary with cloud region 2. For this reason, a comparison was made with stations in both regions. Stations for Region 1 were the representative station (Dhahran, Saudi Arabia) and

13705 — WASHINGTON DC/ANDREWS AFB (Station Name) — JAN (Month)

46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63

Years

Month	Hours (List)	Frequency of Tenths of Total Sky Cover by Groups							Mean Tenths of Sky Cover	Sum of Tenths of Sky Cover	Total No. of Observations
		0	1-2	3	4-5	6-7	8-9	10			
	00	190	39	16	18	31	28	234	5.3	2969	556
	01	187	30	19	21	31	27	240	5.4	3019	555
	02	183	31	16	22	36	26	241	5.5	3048	555
	22	173	38	19	33	24	30	241	5.5	3070	558
	23	185	33	17	20	32	33	238	5.5	3050	558
Totals		3166	994	465	678	812	1126	6098	6.1	81628	13339

Figure 4-9. Example Format of Uniform Summary of Surface Weather Observations

Yuma, Arizona. Stations for Region 2 were the representative station (Tripoli, Libya) and El Paso, Texas. Both Yuma and El Paso are near the center of the U.S. portions of Regions 1 and 2, respectively.

Cloud frequency distributions for the Phoenix area were derived from the Sky Cover portion of the Uniform Summary of Surface Weather Observations for Phoenix, Arizona (Luke Air Force Base). The derived percentage frequencies for the standard cloud categories are presented in Table 4-2, and in Figures 4-10 and 4-11. It may be noted from the figures that for both daytime (1000 LST) and nighttime (2200 LST), and for all four seasons, an L-shaped frequency distribution occurs except for a U-shape in the winter at 1000 LST. Additionally, the consistently higher frequency of clear skies in the transition seasons of spring and fall should be noted. Finally, the higher frequency of clear skies at night (2200 LST) than in the daytime (1000 LST) should be noted.

Table 4-2. Selected Cloud Statistics* for Phoenix, Arizona Area

Month and Time	Cloud Category					
1000 LST	1	2	3	4	5	Mean Tenths
Jan	32.8	12.9	4.3	23.1	26.9	4.9
Apr	52.1	13.9	5.2	17.0	11.8	3.0
July	33.2	24.9	7.8	22.6	11.5	3.7
Oct	57.6	15.2	5.1	17.5	4.6	2.3
2200 LST						
Jan	44.6	17.2	6.4	18.3	13.5	3.3
Apr	65.5	12.9	1.0	10.8	9.8	2.1
July	28.5	19.8	7.3	24.4	20.0	4.5
Oct	69.6	13.8	5.5	7.4	3.7	1.4
All Hours						
Jan	40.8	14.5	5.9	18.1	20.6	4.0
Apr	54.1	14.1	6.4	14.5	11.0	2.8
July	32.0	23.6	9.8	21.4	13.2	3.8
Oct	63.9	14.8	5.3	11.9	4.2	1.8
All months	54.3	15.6	6.1	14.3	9.6	2.6

*Percentage frequencies, unconditional, standard-size areas.

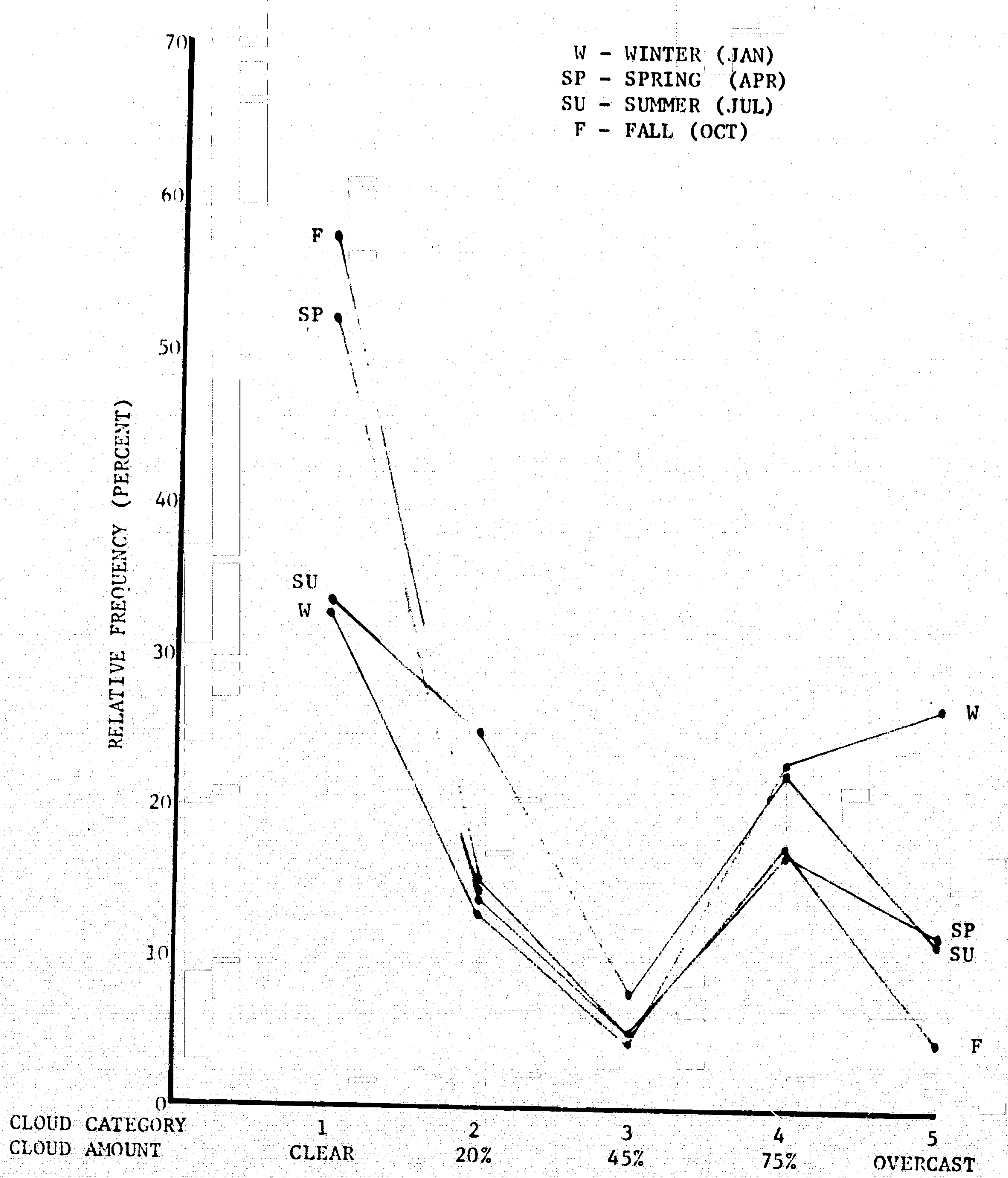


Figure 4-10. Phoenix, 1000 LST

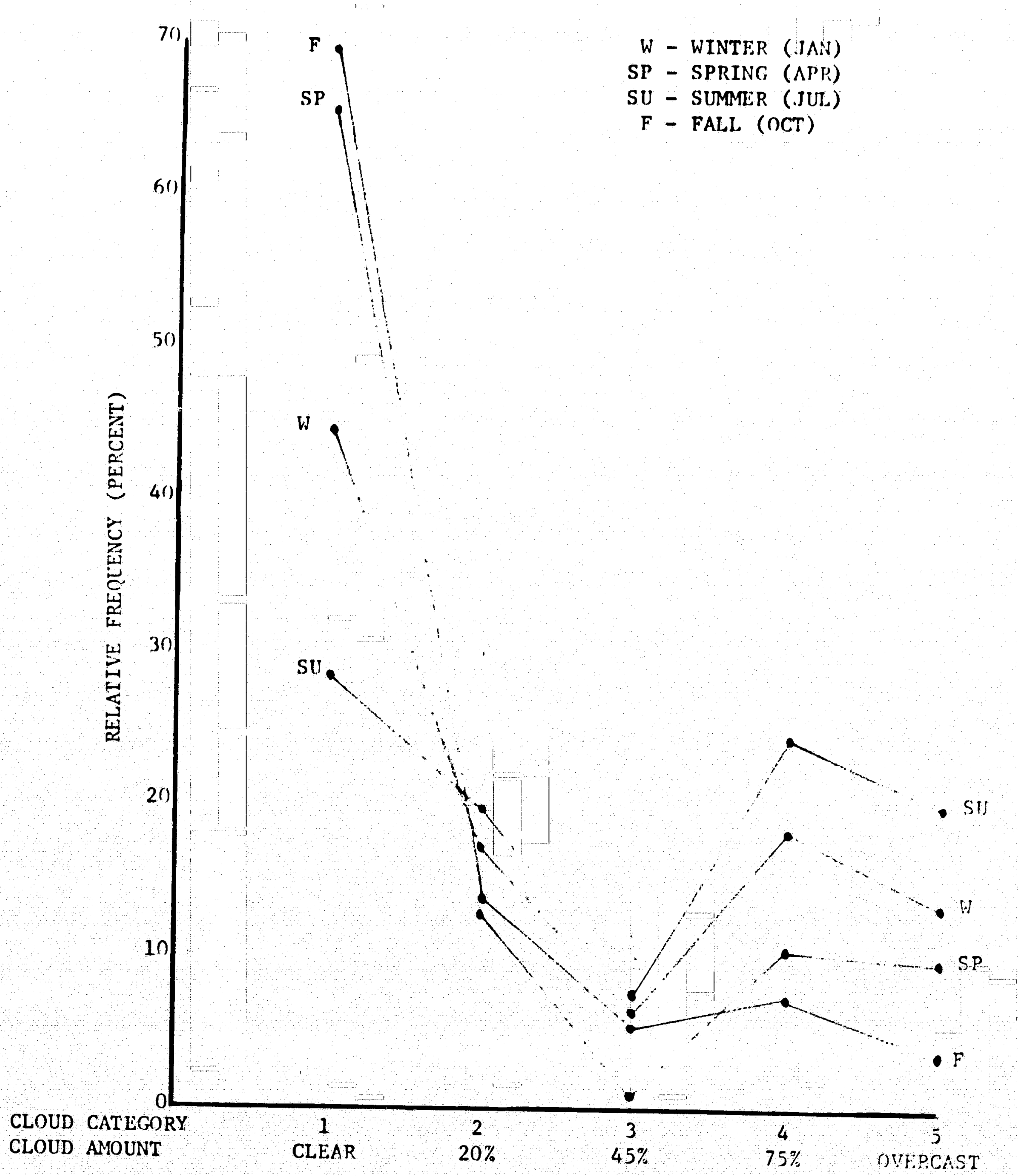


Figure 4-11. Phoenix, 2200 LST

Figures 4-12 and 4-13 present a winter (January) and summer (July) comparison of the Phoenix area cloud statistics with Region 1 and Region 2 stations at 1000 LST. In the winter, the three U.S. stations of Yuma, Phoenix, and El Paso show fair agreement with each other but a considerably smaller agreement with either Region 1 or Region 2. All three U.S. stations are essentially U-shaped, whereas Region 1 is L-shaped, and Region 2 is M-shaped. In the summer, Regions 1 and 2 are distinctly L-shaped with a great deal more clear skies than at the U.S. stations (Regions 1 and 2 are approximately 66 percent clear, whereas Phoenix is 33 percent clear). Yuma is L-shaped, Phoenix is L/M-shaped, and El Paso is M-shaped. These variations indicate the necessity of using single-station data when they are available rather than homogeneous region data.

4.2.2.3 Feather River Area

The station selected as being representative of the Feather River Area is Fresno, California. This area is in homogeneous cloud Region 18. San Francisco data have been used as the Region 18 representative data. Other Region 18 stations selected for comparison are Sunnyvale and Edwards Air Force Base, California.

Table 4-3 presents cloud frequency data for the Feather River Area as derived from the Uniform Summary of Surface Weather Observations, Sky Cover for Fresno, California.

Figure 4-14 demonstrates the seasonal variations in the Feather River Area at 1000 LST. The outstanding feature of the distribution is the extreme variation from summer L-shape, when skies are clear an extremely large percent of the time (>80 percent) to the winter J-shape, when overcast skies predominate (≥60 percent). Fall is also L-shaped, whereas spring is a true mixture with a U-shape.

The diurnal variation for this area is illustrated for winter and summer in Figures 4-15 and 4-16. The summer distributions stand out for their very small diurnal variation, but clear skies even more dominant in the nighttime (2200 LST and 89 percent) than in the daytime (1000 LST and 80.6 percent). The winter distributions also show relatively little diurnal variation with a maximum variation of 2200 LST/28.5 percent to the 1000 LST/12.4 percent occurring for the clear category.

The variation of cloud statistics within Region 18 is illustrated in Figures 4-17 and 4-18. All of the four stations exhibit an L-shape in the summer (July) but the variation of the percentage occurrence of clear skies is quite large, ranging from a high of 80.6 percent in the Feather River Area (Fresno) to a low of 44.4 percent at Sunnyvale. There is also a surplus in

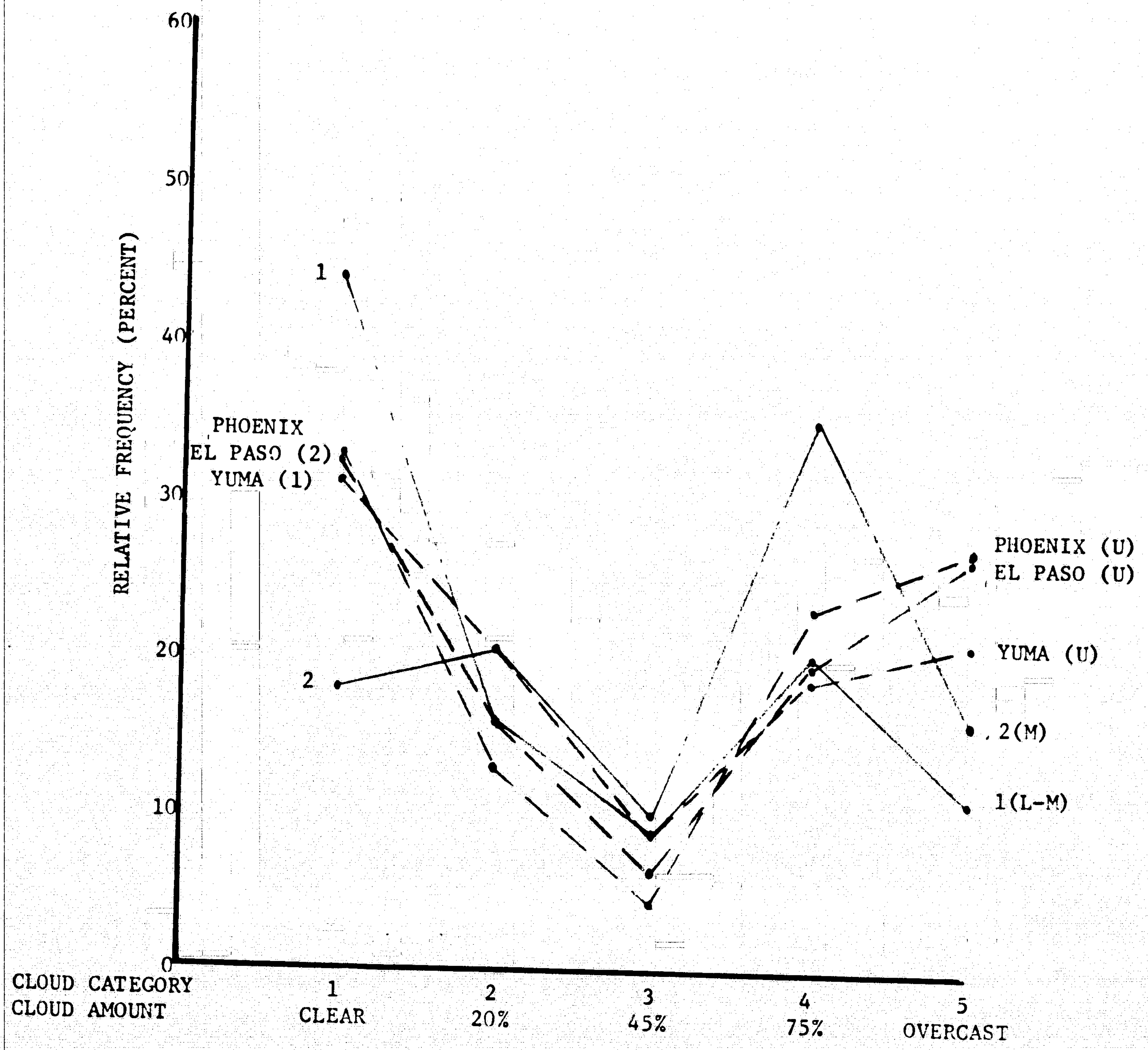


Figure 4-12. 1000 LST - January
Phoenix Area

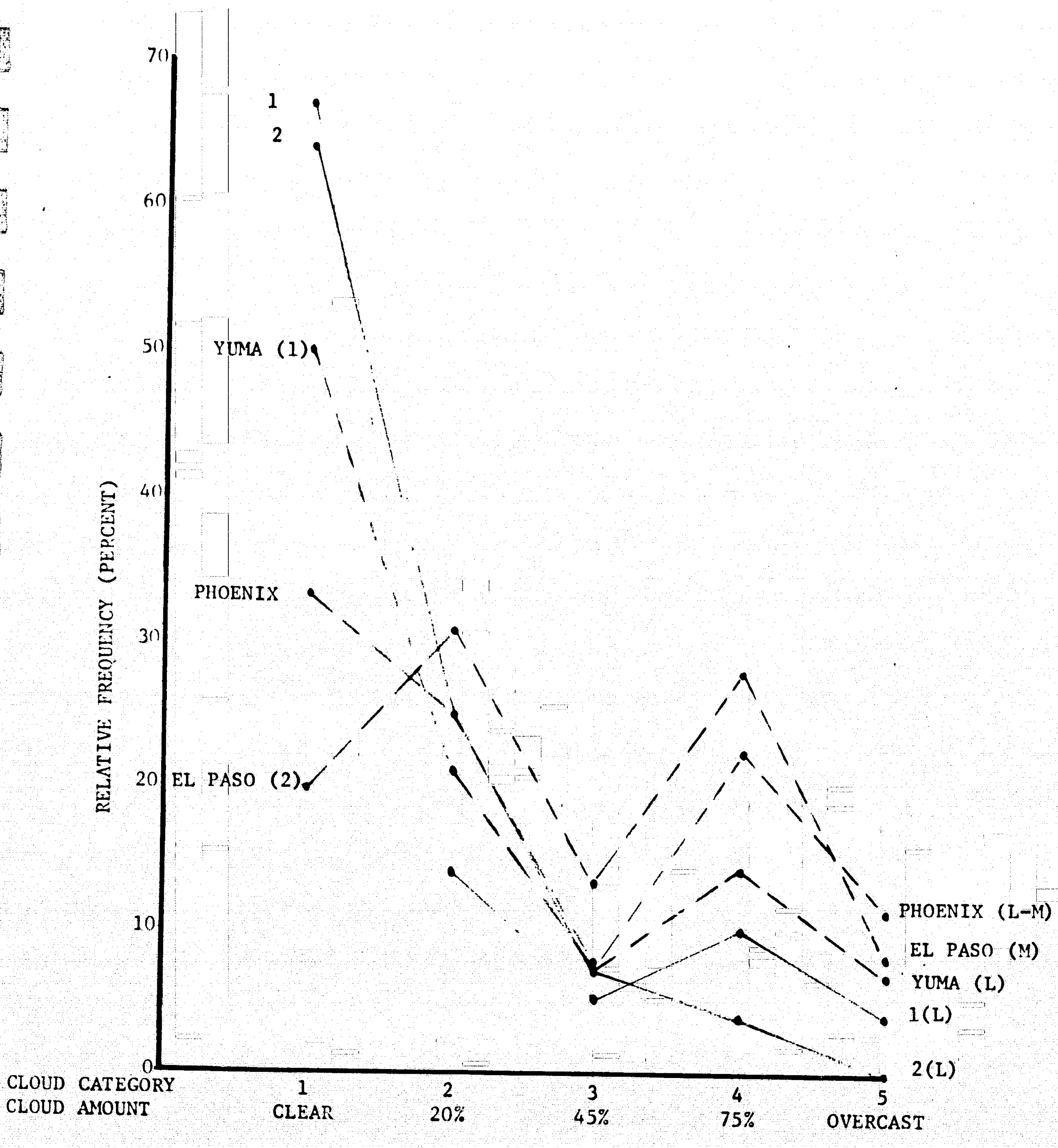


Figure 4-13. 1000 LST - July
Phoenix Area

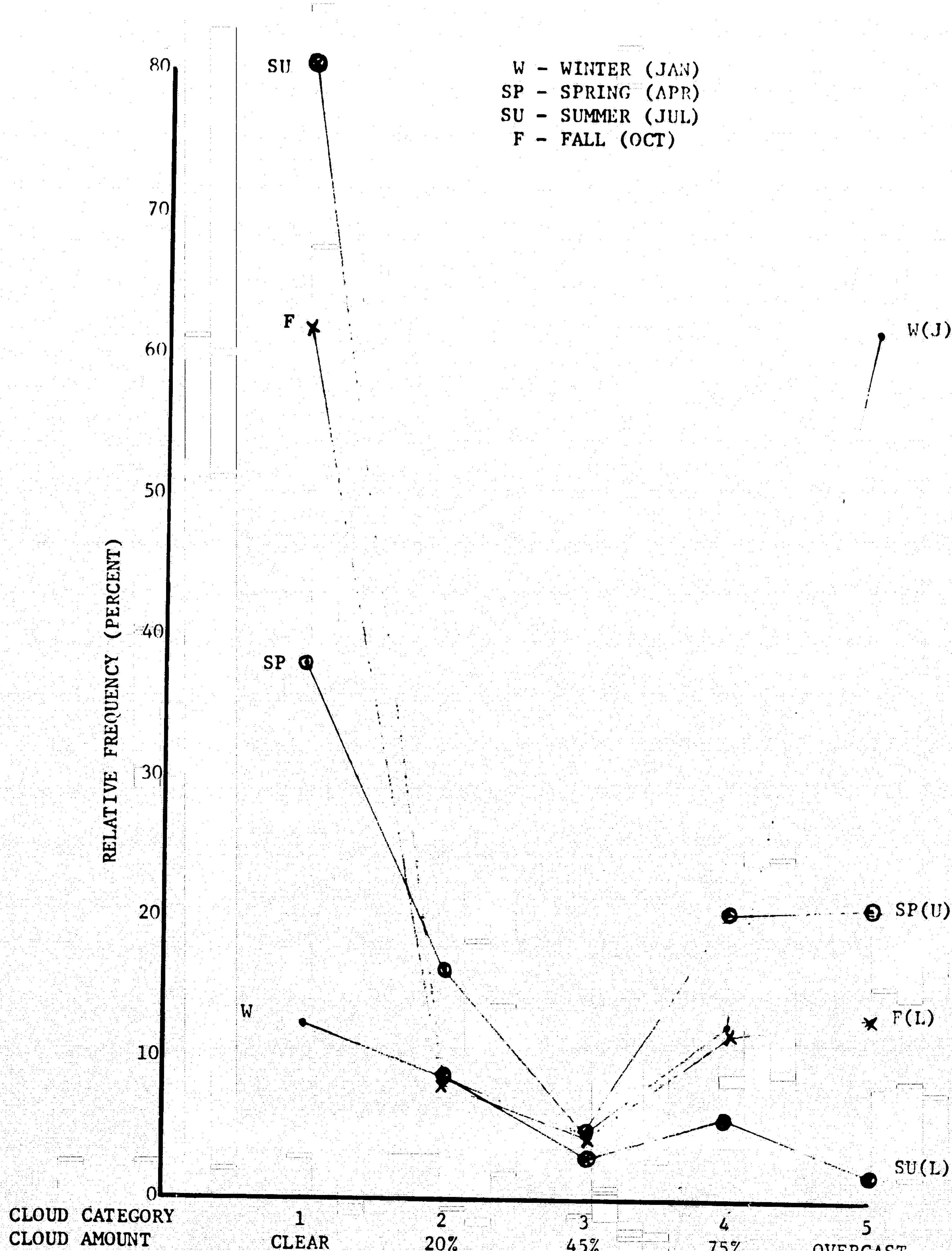


Figure 4-14. Feather River Area (Fresno) Seasonal Variations at 1000 LST

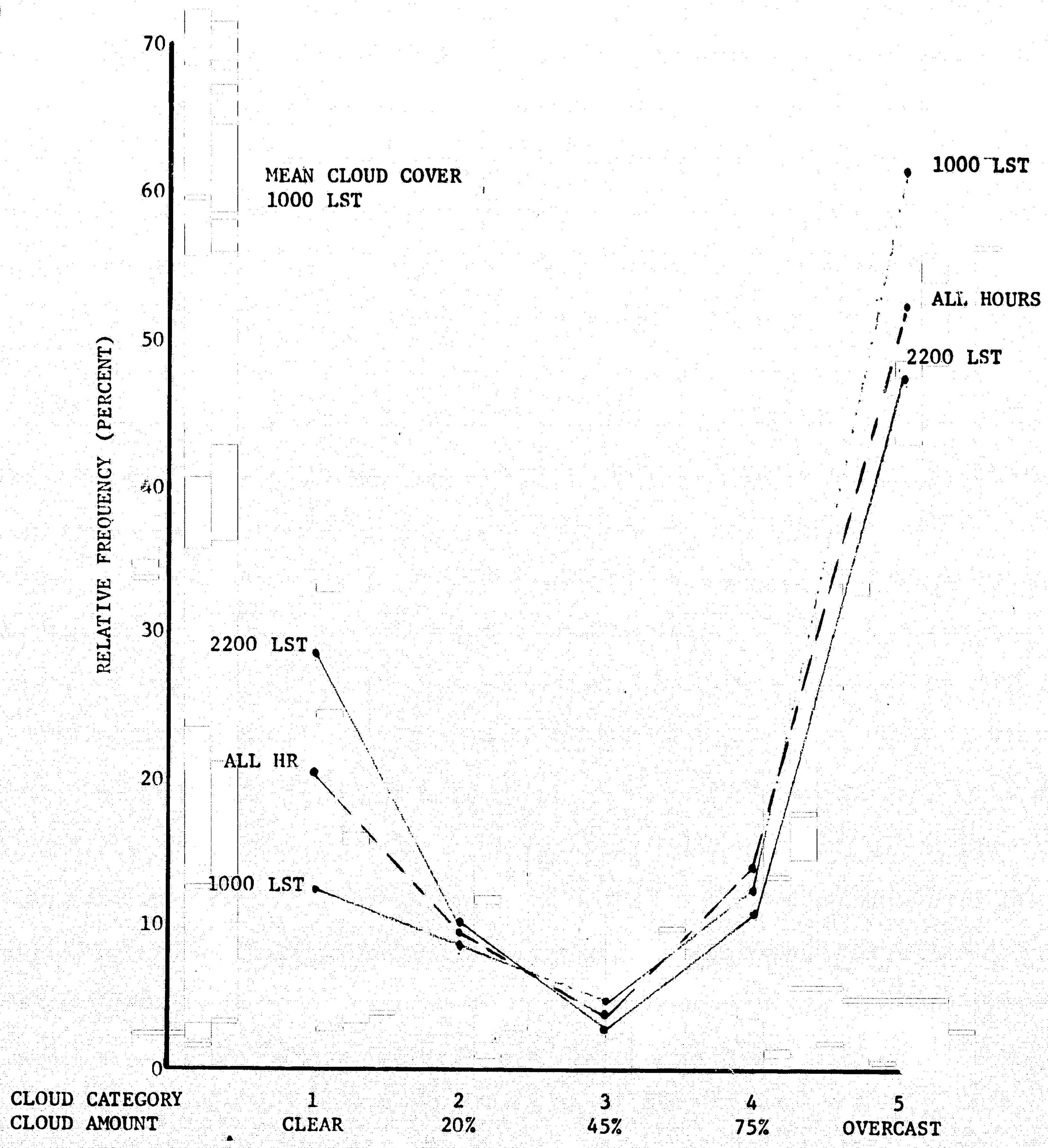


Figure 4-15. Diurnal Variations, Fresno - January

Space Division
North American Rockwell

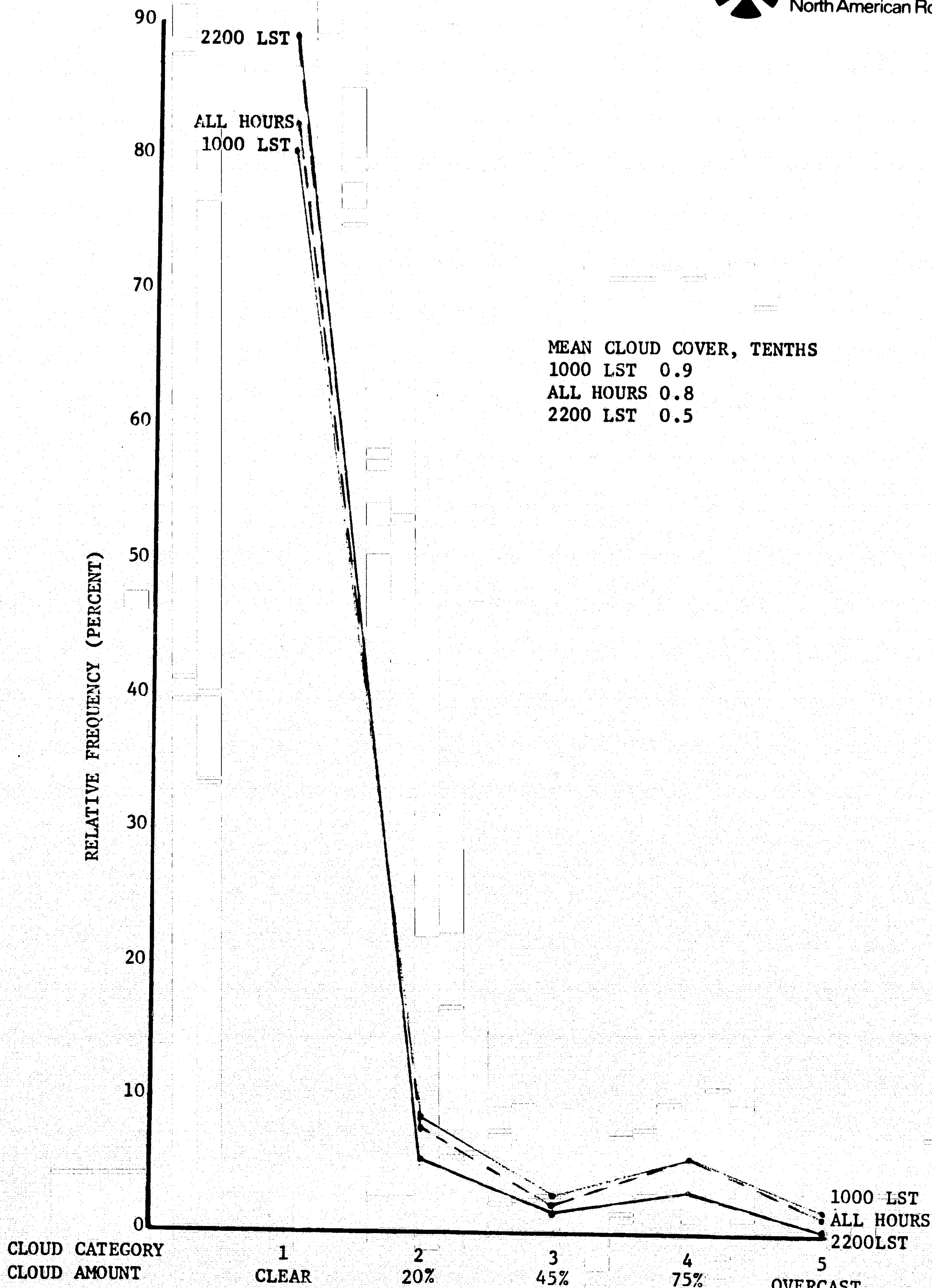


Figure 4-16. Diurnal Variations, Fresno - July

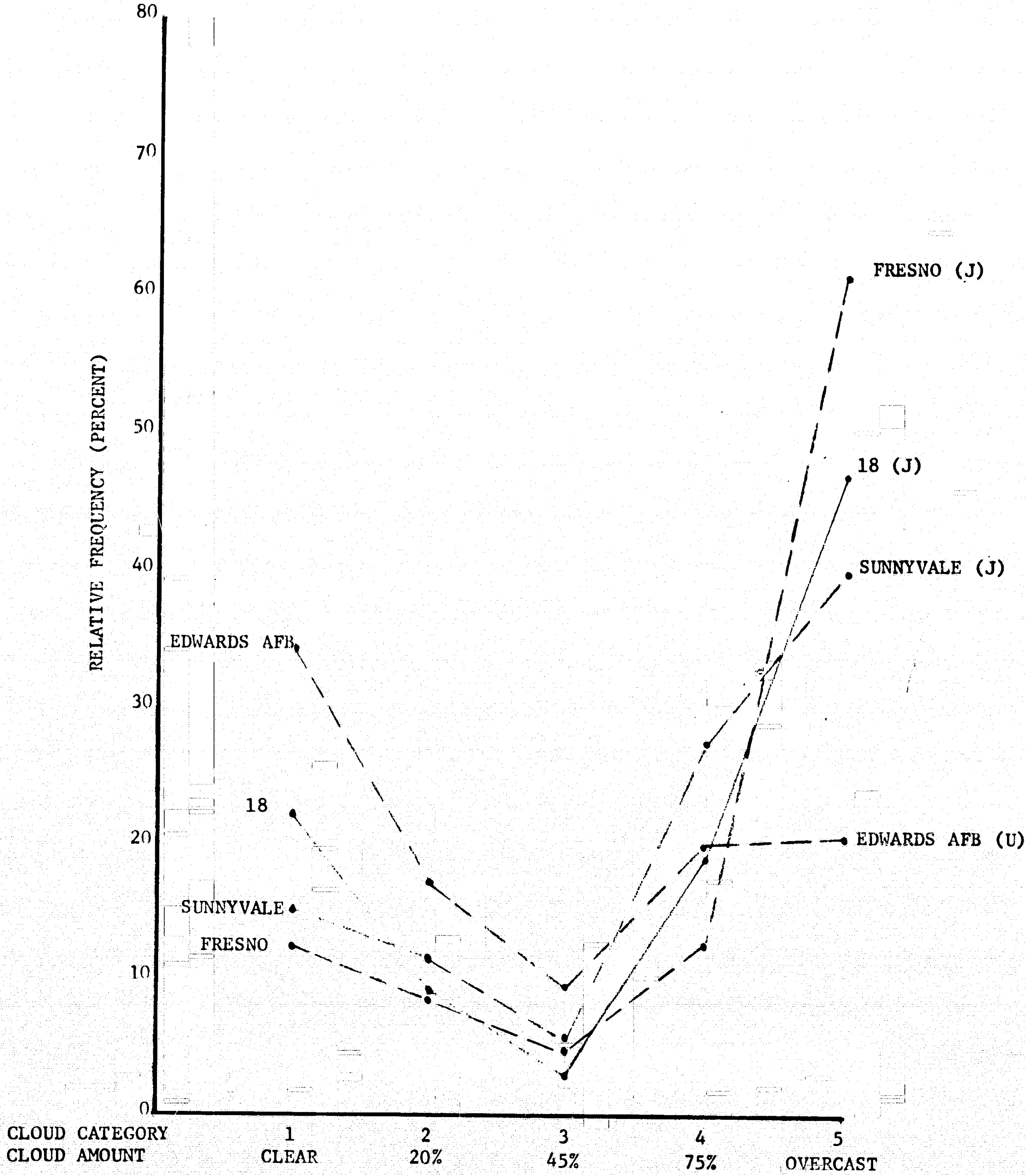


Figure 4-17. Region 18 (San Francisco) 1000 LST - January

Space Division
North American Rockwell

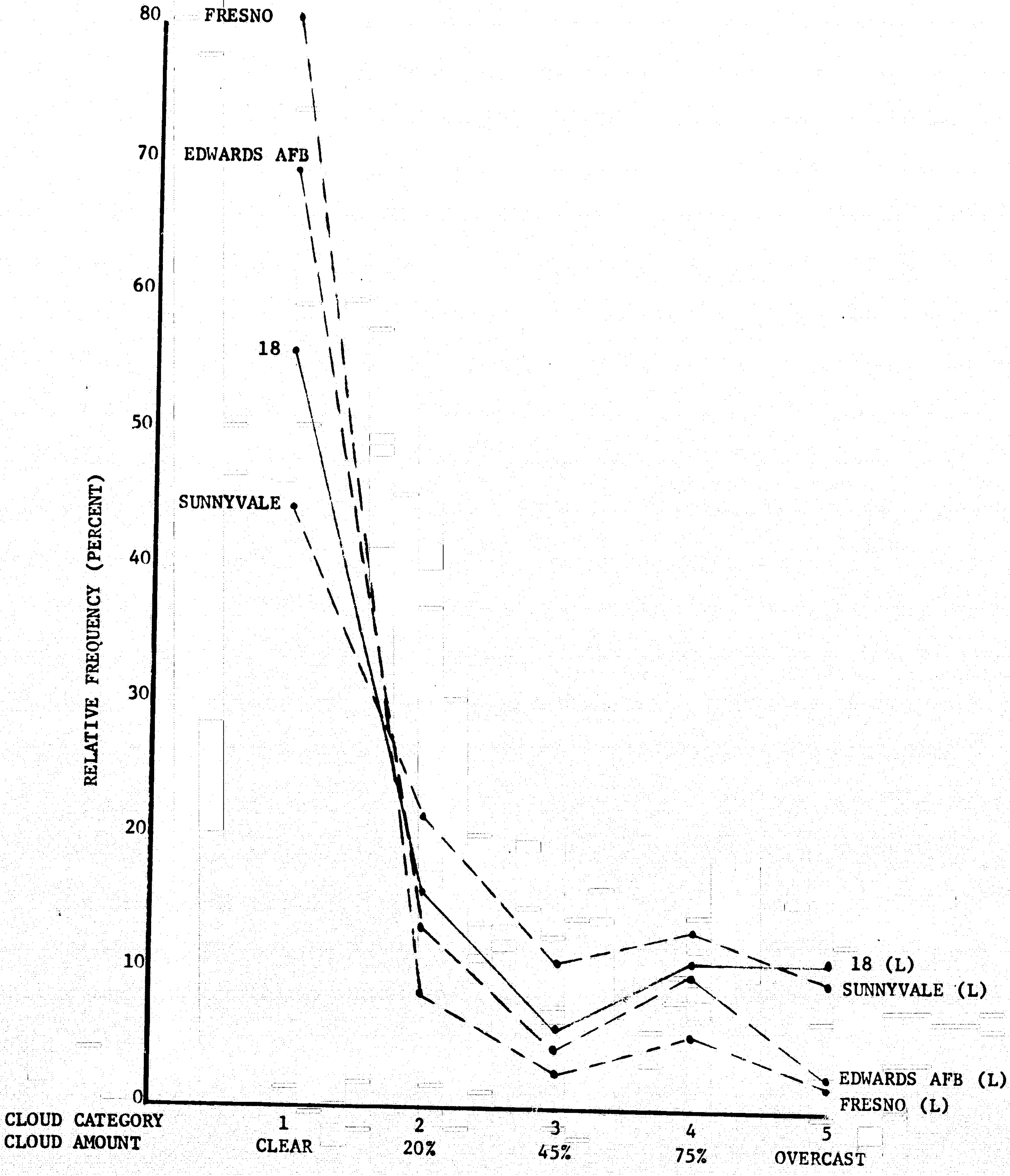


Figure 4-18. Region 18 (San Francisco) 1000 LST - July

Table 4-3. Selected Cloud Statistics* for Feather River Area

Month and Time	Cloud Category					
1000 LST	1	2	3	4	5	Mean Tenths
Jan	12.3	8.7	4.8	12.6	61.6	7.6
Apr	38.0	16.3	5.0	20.7	21.0	4.2
July	80.6	8.7	2.9	5.8	1.9	0.9
Oct	61.8	8.1	4.5	12.0	13.6	2.6
2200 LST						
Jan	28.7	10.0	2.9	10.9	47.5	5.9
Apr	59.0	11.0	4.7	10.0	15.3	2.7
July	89.0	5.5	1.6	3.2	0.7	0.5
Oct	74.5	7.7	2.6	7.8	8.4	1.6
All Hours						
Jan	20.3	9.6	3.9	14.0	52.3	6.7
Apr	47.9	13.6	4.7	15.6	18.2	3.5
July	82.6	7.9	2.1	5.8	1.7	0.8
Oct	66.7	9.3	3.2	10.8	10.0	2.1
All months	55.5	9.7	3.4	11.4	20.0	3.2

*Percentage frequencies, unconditional, standard-size areas.

clear sky frequency of about 25 percent in the summer for the Feather River Area (80.6 percent) over Region 18 (59.8 percent), and probability-of-seeing values using Region 18 statistics would be far too low for the Feather River Area. In winter, Feather River Area, Region 18, and Sunnyvale exhibit a J-shape, but Edwards AFB, which lies across the Sierra range from the other stations, exhibits a greatly different shape, is best classified as a U-shape. Again, the desirability of determining probability-of-seeing values from localized stations when possible is demonstrated.

4.3 COMPARISON OF PROBABILITY-OF-SEEING RESULTS, 100-NM AREAS

For the most useful comparison of the variation of the probability-of-seeing results for ERTS that may occur within U.S. cloud regions, the basic statistics for standard-size areas were converted to 100-nm statistics before use in the various probability-of-seeing programs. Again, the probabilities were derived for three areas of interest to ERTS.

4.3.1 Single-Look Viewing

The perfect-resolution probability of seeing all (100 percent) of an area of 100 by 100 nautical miles in a single look will vary directly with the variation in the occurrence of clear skies. The values for the three selected ERTS locations and their corresponding cloud regions for N = 5 passes in January and July at 1000 LST are presented in Table 4-4.

As may be seen from Table 4-4, the probabilities for Chesapeake Bay are in fair agreement with those of Region 11, as would be expected since the cloud statistics were shown in Section 4.2 to be in fair agreement. Corresponding agreement between other stations in Region 11 would be less favorable. Similarly, the agreement of the other areas of ERTS interest (Phoenix and Feather River) is poor, as would be expected from the cloud distributions discussed in Section 4.3.

4.3.2 One- or Two-Look Viewing

For illustration, the probability of seeing 50, 70, and 90 percent or more of an area of 100 by 100 nautical miles for selected numbers of passes is presented in Table 4-4. Results illustrated are for 1000 LST in July.

The good agreement for results for Chesapeake Bay and the relatively poor agreement of results of Phoenix and Feather River with their respective Region results is again illustrated in the table.

4.3.3 Continuous Viewing (Monte Carlo)

The probability of seeing 90 percent or more of an area of 100 by 100 nautical miles in five independent passes in the continuous viewing mode (a look is made on every pass) may be used to illustrate the variation in probability-of-seeing results for the selected ERTS locations and their corresponding cloud regions. A comparison is presented in Table 4-4 for 1000 LST, July.

4.4 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations have been drawn from the analyses described in the preceding sections:

1. For ERTS probability-of-seeing analyses for localized areas, cloud frequency distribution data from the nearest representative station should be used in preference to the data for the homogeneous cloud region in which the area is located.

Table 4.4. Comparison of Probability-of-Seeing Results, 100-nm Areas

A. SEEING 100% IN SINGLE LOOK IN 5 PASSES AT 1000 LST

Location	Freq of Clear Skies Jan.	Freq of Clear Skies July	Probability, Percent Jan.	Probability, Percent July
Chesapeake Bay	12.0	11.0	47.1	44.1
Region 11	10.0	10.5	41.0	42.5
Phoenix	30.00	30.00	83.1	83.1
Region 1	40.00	60.00	92.1	99.0
Feather River	9.0	75.0	37.6	99.9
Region 18	17.0	52.0	60.6	97.5

B. ONE OR TWO LOOKS, 1000 LST, JULY

Location	≥50% of 100-nm Area			≥70% of 100-nm Area			≥90% of 100-nm Area		
	N = 1	N = 5	N = 10	N = 1	N = 5	N = 10	N = 1	N = 5	N = 10
Chesapeake Bay	42.5	96.9	*	30.0	88.9	99.2	17.5	88.9	92.7
Region 11	44.3	97.5	*	30.2	90.0	99.4	17.0	90.0	92.8
Phoenix	71.2	99.9	*	57.4	99.0	*	39.1	95.9	99.9
Region 1	88.1	*	*	78.7	*	*	66.7	*	*
Feather River	93.0	*	*	87.0	*	*	79.0	*	*
Region 18	83.6	*	*	71.8	*	*	58.8	99.5	*
*>99.95									

C. CONTINUOUS VIEWING DURING FIVE PASSES, JANUARY 1000 LST

Location	50% or More	70% or More	90% or More
Chesapeake Bay	90.0	82.2	63.2
Region 11	85.6	79.4	63.0
Phoenix	99.0	97.0	91.3
Region 1	*	*	99.6
Feather River	85.0	75.5	55.0
Region 18	94.5	87.2	76.5
*>99.9			

2. In the absence of sufficient data for the prveious recommendation (as over ocean and underdeveloped land areas), the homogeneous cloud region concept and data provide the best source of cloud statistics.

3. Since only unconditional cloud statistics are available for localized areas, the use of the homogeneous cloud region conditional statistics are recommended for ERTS analyses requiring such data.

4. Results of current contract efforts to improve the basic homogeneous cloud region statistics should be incorporated into future probability-of-seeing analyses.

5. A data bank consisting of card or tape data for a large number of U.S. stations should be developed in preference to a smaller number of subdivisions of the current U.S. homogeneous cloud regions.

5.0 NEW TECHNOLOGY

Two reportable technology items consisting of the Probability of Seeing Computer Programs (Appendix A) and the Cloud Free Resolution Element Statistics Program (Appendix B) have been submitted through the Technology Utilization Department of the North American Rockwell Space Division.

These items were submitted in accordance with Article IV of the subject Contract (NAS5-11231) for this study.

6.0 REFERENCES

1. V. V. Salomonson. Cloud Statistics in Earth Resources Technology Satellite (ERTS) Mission Planning. NASA-GSFC X-622-69-386 (August 1969).

2. P. E. Sherr, et al. Worldwide Cloud Cover Distribution for Use in Computer Simulations. NASA-MSFC CR-61225 (June 1968).

3. C. D. Martin. Worldwide Cloud Cover Effects Upon Earth Resources Satellite Viewing. North American Rockwell, SD 69-477 (September 1969).

4. S. C. Brown. "A Cloud Cover Simulation Procedure," Astronautics and Aeronautics, Volume 7, No. 8 (August 1969).

5. Greaves, J. R., et al. Use of Cloud Statistics in Planning Remote Sensing Missions. Allied Research Associates, Inc. (1969).

6. R. H. Blackmer and S. M. Serebreny. Dimensions and Distributions of Cumulus Clouds as Shown by U-2 Photographs. AFCRL-62-609 (July 1962).

7. R. H. Blackmer. Statistical Distribution of Cumulus Clouds From U-2 Photographs. SRI TR No. 1, Project No. 3892 (November 1962).

8. V. G. Plank. "The Size Distribution of Cumulus Clouds in Representative Florida Populations." Journal of Applied Meteorology, Volume 8, No. 1 (February 1969).

9. A. Arkeng, et al. Cloud Statistics Affecting the Sounding of the Lower Atmosphere From a Satellite. NASA Institute for Space Studies, Preliminary Report (July 1969).

10. A. J. Stamm and T. H. Vonder Haar. A Study of Cloud Distributions Using Reflected Radiance Measurements From the ATS Satellites (January 22, 1970).

11. W. E. Shenk and V. V. Salomonson. A Simulation Study Exploring the Effects of Sensor Spatial Resolution on Estimates of Cloud Cover From Satellites. Goddard Space Flight Center.

12. Apollo 9 Preliminary Plotting and Indexing Report. Mapping Sciences Laboratory, NASA-MSC (1 April 1969).

APPENDIX A. CLOUD STATISTICS ADJUSTMENT AND ENLARGED FOV SEEING PROBABILITY COMPUTER PROGRAMS

This section describes the analysis equations, FORTRAN variables equivalenced to analysis variables, logical operations, and the input data format for the clouds statistics adjustment and probability-of-seeing computer programs.

The relationship between the programs and resultant computed output are depicted in Figure A-1.

Subsequent sections will document the program's content, capability, and method of utilization.

A.1 ROUTINE FOR GENERATION OF BASIC CLOUD COVER DATA TAPES FOR ENLARGED FIELD OF VIEW

A.1.1 General

The basic cloud statistics are those compiled at the Marshall Space Flight Center. They consist of the percentages of cloud cover for five cloud categories from an observation point at eight times a day; the percentages of cloud cover for the category for 24 hours later; and the percentages for given and resultant categories for an area 200 nautical miles away from the observation point. The data were collected for 29 representative cloud regions earthwide and for 12 months.

In this section the analysis and FORTRAN variable names are synonymous.

This routine performs three functions (See Table A-1):

1. Generation of basic cloud statistics for standard area on an unformatted tape with 32-bit standard IBM S360 word length. Each record contains the constant scale factor, month and region numbers, unconditional statistics for eight times of day, temporal statistics for five conditional categories. The statistics are sequentially written on the tape for the five cloud categories.

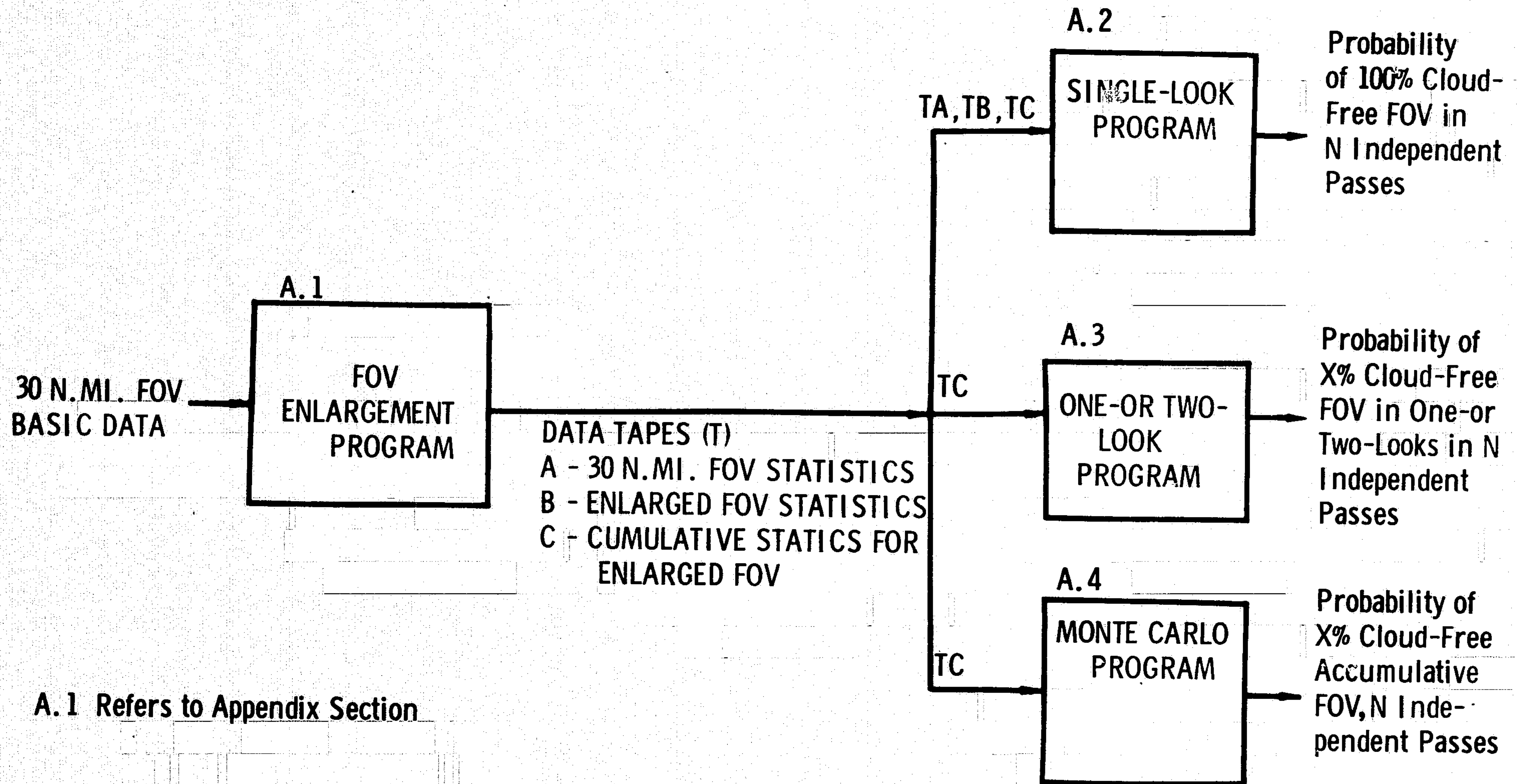


Figure A-1. Schematic of Computer Program Components: Cloud Statistics Adjustment and Probability of Seeing for Enlarged FOV

Table A-1. Computer Program Listing - Basic Cloud Cover Data

```
FORTRAN IV G LEVEL 1, MOD 2              MAIN              DATE = 70104          11/33/37           PAGE 0001

          C          CALCULATION AND STORAGE OF CLOUD COVER DATA ON TAPES
          C          TAPE 8 - RAW DATA STATISTICS FOR 12 MONTHS, 29 REGIONS                  CLOD0010
          C                   AND THE CLOUD CATEGORIES                                       CLOD0020
          C          TAPE 9 - RAW DATA FOR EXPANSION OF AREA                                 CLOD0030
          C          TAPE 10 - CUMULATED DATA OF CLOUD COVER FOR EXPANDED AREA               CLOD0040
          C                                                                                  CLOD0050
0001            REAL * 4   MEAN(29,12,8), DAY(29,12), NIGHT(29,12), MONTH(29,12),            CLOD0060
               *           WINTER(29), SUMMER(29), SPRING(29), FALL(29),                     CLOD0070
               *           ANNUAL(29), CSUNCN(29,12,8,5), CCT(29,12,5,5),                    CLOD0080
               *           CSCON(29,12,5,5), SUNCON(29,5,8), TEMPOR(29,5,5),                 CLOD0090
               *           SCOND(29,5,5), UNC(5,8), COND(5,5), PJOINT(5,5)                   CLOD0100
0002            DIMENSION KWHERE(5,5), MO(12), MREG(29)                                      CLOD0110
0003            DATA  KWHERE/ 1, 2, 2, 3, 3,  2, 2, 2, 3, 4,  2, 2, 3, 4, 4,                 CLOD0120
               *             3, 3, 4, 4, 4,  3, 4, 4, 4, 5/                                  CLOD0130
          C                                                                                  CLOD0140
0004            REWIND 8                                                                     CLOD0150
0005            REWIND 9                                                                     CLOD0160
0006            REWIND 10                                                                    CLOD0170
0007            READ (5, 1)  SDIST, MOMAX, NREG                                              CLOD0180
0008          1 FORMAT (E12.8, 2I6)                                                          CLOD0190
0009            WRITE (6, 9001)  SDIST                                                       CLOD0200
0010       9001 FORMAT ('1', 10X, 'CLOUD COVER RAW DATA FOR ENLARGED AREA OF',               CLOD0210
               *        F7.2, ' N. M.')                                                      CLOD0220
0011            WRITE (6, 2)                                                                 CLOD0230
0012          2 FORMAT ('OMO. REG CAT', 3X, 'UNCONDITIONAL PROBABILITIES', 14X,              CLOD0240
               *        'COND. TEMPORAL', 12X, 'CONDITIONAL SPATIAL')                        CLOD0250
0013          3 FORMAT ('0')                                                                 CLOD0260
0014          4 FORMAT (1X, I3, 1X, I3, 2X, I2, 1X, 8F5.1, 1X, 5F5.1, 1X, 5F5.1)             CLOD0270
0015            S = 1.0                                                                      CLOD0280
          C                                                                                  CLOD0290
          C          GENERATE TAPE OF ORIGINAL CLOUD DATA AND EXPANDED AREA                  CLOD0300
0016            DO  100  IM = 1, MOMAX                                                       CLOD0310
0017            DO  100  IR = 1, NREG                                                        CLOD0320
0018            DO  10   IC = 1, 5                                                           CLOD0330
0019            READ (5, 6, END=105)  MM, MR, (UNC(IC,KT), KT=1,8),                          CLOD0340
               *    (TEMPOR(IR,IC,J), J=1,5), (COND(IC,J), J=1,5)                            CLOD0350
0020          6 FORMAT (1X, 2I2, 1X, 18F2.0)                                                 CLOD0360
0021            MO(IM) = MM                                                                  CLOD0370
0022            MREG(IR) = MR                                                                CLOD0372
0023            WRITE (8)  S, MM, MR, IC, (UNC(IC,KT), KT=1,8),                              CLOD0374
                                                                                             CLOD0380
```

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Table A-1. Computer Program Listing - Basic Cloud Cover Data (Cont)


```
     *      (TEMPOR(IR,IC,J), J=1,5), (COND(IC,J), J=1,5)
   10 CONTINUE
      DO  15  IC = 1, 5
      DO  11  KT = 1, 8
   11 SUNCON(IR,IC,KT) = 0.0
      DO  15  J = 1, 5
   15 SCOND(IR,IC,J) = 0.0
C
C        SCALE COND. SPATIAL FOR ENLARGED AREA
      RATIO = SDIST / 200.0
      IF  (RATIO .GT. 1.0)  GO TO 30
      DO  25  I = 1, 5
      DO  25  J = 1, 5
      IF  (J .EQ. I)  GO TO 20
      SCOND(IR,I,J) = RATIO * COND(I,J)
      GO TO 25
   20 SCOND(IR,I,J) = 100. - RATIO *(100. - COND(I,J) )
   25 CONTINUE
      GO TO 60
C
C        AREA GREATER THAN 200 N.M.
   30 DO  50  IC = 1, 5
      DO  40  J = 1, 5
      JR = J
      IF  (IC .EQ. J)  GO TO 35
      SCOND(IR,IC,J) = RATIO * COND(IC,J)
      IF  (SCOND(IR,IC,J) .GT. UNC(IC,1))  GO TO 45
      GO TO 40
   35 SCOND(IR,IC,J) = 100. - RATIO *(100. - COND(IC,J) )
      IF  (SCOND(IR,IC,J) .LT. UNC(IC,1))  GO TO 45
   40 CONTINUE
      GO TO 50
   45 DO  46  JH = JR, 5
   46 SCOND(IR,IC,JH) = UNC(IC,1)
   50 CONTINUE
C
C        COMPUTE UNCONDITIONAL DISTRIBUTIONS SCALED TO SDIST
   60 DO  80  KT = 1, 8
      DO  65  IC = 1, 5
      DO  65  I = 1, 5
```

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Table A-1. Computer Program Listing - Basic Cloud Cover Data (Cont)

```
FORTRAN IV G LEVEL  1, MOD 2                MAIN              DATE = 70104         11/33/37          PAGE 000?

0057          65 PJOINT(IC,J) = UNC(IC,KT) * SCOND(IR,IC,J) / 100.0                      CLOD0790
0058             DO  70  IC = 1, 5                                                       CLOD0800
0059             SUNCON(IR,IC,KT) = 0.0                                                  CLOD0810
0060             DO  70  I = 1, 5                                                        CLOD0820
0061             DO  70  J = 1, 5                                                        CLOD0830
0062             IF  (KWHERE(I,J) .EQ. IC)  SUNCON(IR,IC,KT) = PJOINT(I,J)               CLOD0840
                *     + SUNCON(IR,IC,KT)                                                 CLOD0850
0063          70 CONTINUE                                                                CLOD0860
0064          80 CONTINUE                                                                CLOD0870
0065             WRITE (6, 3)                                                            CLOD0880
0066             DO  90  IC = 1, 5                                                       CLOD0890
0067             WRITE (6, 4)  MM, MR, IC, (SUNCON(IR,IC,KT), KT=1,8),                   CLOD0900
                *    (TEMPOR(IR,IC,J), J=1,5), (SCOND(IR,IC,J), J=1,5)                   CLOD0910
0068             WRITE (9)  MM, MR, IC, (SUNCON(IR,IC,KT), KT=1,8),                      CLOD0920
                *    (TEMPOR(IR,IC,J), J=1,5), (SCOND(IR,IC,J), J=1,5)                   CLOD0930
0069          90 CONTINUE                                                                CLOD0940
0070         100 CONTINUE                                                                CLOD0950
           C                                                                             CLOD0960
0071         105 END FILE 8                                                              CLOD0970
0072             END FILE 9                                                              CLOD0980
0073             REWIND 8                                                                CLOD0990
0074             REWIND 9                                                                CLOD1000
           C                                                                             CLOD1010
           C        COMPUTE CUMULATIVE DISTRIBUTIONS FOR ENLARGED AREA                   CLOD1020
           C        AND STORE ON TAPE 10                                                 CLOD1030
0075             DO  150  IM = 1, MOMAX                                                  CLOD1040
0076             DO  110  IR = 1, NREG                                                   CLOD1050
0077             DO  110  IC = 1, 5                                                      CLOD1060
0078             READ (9)  I1,I2,I3, (SUNCON(IR,IC,KT), KT=1,8),                         CLOD1070
                *    (TEMPOR(IR,IC,J), J=1,5), (SCOND(IR,IC,J), J=1,5)                   CLOD1080
0079         110 CONTINUE                                                                CLOD1090
0080             DO  120  IR = 1, NREG                                                   CLOD1100
0081             DO  120  KT = 1, 8                                                      CLOD1110
0082             MEAN(IR,IM,KT) = 0.20*SUNCON(IR,2,KT) + 0.45*SUNCON(IR,3,KT)            CLOD1120
                *    + 0.75*SUNCON(IR,4,KT) + SUNCON(IR,5,KT)                            CLOD1130
0083         120 CONTINUE                                                                CLOD1140
0084             DO  130  IR = 1, NREG                                                   CLOD1150
0085             DAY(IR,IM) = (MEAN(IR,IM,3) + MEAN(IR,IM,4) + MEAN(IR,IM,5)             CLOD1160
                *    + MEAN(IR,IM,6) ) / 4.0                                             CLOD1170
0086             NIGHT(IR,IM) = (MEAN(IR,IM,1) + MEAN(IR,IM,2) + MEAN(IR,IM,7)           CLOD1180
```

Table A-1. Computer Program Listing - Basic Cloud Cover Data (Cont)


```
           *    + MEAN(IR,IM,8) ) / 4.0
0087     130 MONTH(IR,IM) = (DAY(IR,IM) + NIGHT(IR,IM) ) / 2.0                CLOD1190
0088         DO  135  IR = 1, NREG                                             CLOD1200
0089         DO  135  KT = 1, 8                                                CLOD1210
0090         CSUNCN(IR,IM,KT,1) = SUNCON(IR,1,KT)                              CLOD1220
0091         CSUNCN(IR,IM,KT,2) = CSUNCN(IR,IM,KT,1) + SUNCON(IR,2,KT)         CLOD1230
0092         CSUNCN(IR,IM,KT,3) = CSUNCN(IR,IM,KT,2) + SUNCON(IR,3,KT)
0093         CSUNCN(IR,IM,KT,4) = CSUNCN(IR,IM,KT,3) + SUNCON(IR,4,KT)         CLOD1250
0094     135 CSUNCN(IR,IM,KT,5) = 100.0                                        CLOD1260
0095         DO  140  IR = 1, NREG                                             CLOD1270
0096         DO  140  IC = 1, 5                                                CLOD1280
0097         CCT(IR,IM,IC,1) = TEMPOR(IR,IC,1)                                 CLOD1290
0098         CSCON(IR,IM,IC,1) = SCOND(IR,IC,1)                                CLOD1300
0099         DO  136  J = 2, 5                                                 CLOD1310
0100         CCT(IR,IM,IC,J) = CCT(IR,IM,IC,J-1) + TEMPOR(IR,IC,J)             CLOD1320
0101     136 CSCON(IR,IM,IC,J) = CSCON(IR,IM,IC,J-1) + SCOND(IR,IC,J)          CLOD1330
0102     140 CONTINUE                                                          CLOD1340
0103     150 CONTINUE                                                          CLOD1350
0104         IF  (MOMAX .LT. 12)  GO TO 170                                    CLOD1360
0105         DO  160  IR = 1, NREG                                             CLOD1370
0106         WINTER(IR) = (MONTH(IR,1) + MONTH(IR,2) + MONTH(IR,12)) / 3.0     CLOD1380
0107         SPRING(IR) = (MONTH(IR,3) + MONTH(IR,4) + MONTH(IR,5)) / 3.0      CLOD1390
0108         SUMMER(IR) = (MONTH(IR,6) + MONTH(IR,7) + MONTH(IR,8)) / 3.0      CLOD1400
0109         FALL(IR) = (MONTH(IR,9) + MONTH(IR,10) + MONTH(IR,11)) / 3.0      CLOD1410
0110     160 ANNUAL(IR) = (WINTER(IR) + SPRING(IR) + SUMMER(IR) + FALL(IR))/4.0CLOD1420
       C                                                                       CLOD1430
0111     170 WRITE (6, 171)  SDIST                                             CLOD1440
0112     171 FORMAT ('1', 10X, 'CUMULATIVE DISTRIBUTIONS FOR EXPANDED AREA',   CLOD1450
           *            F8.2, ' N.M.')                                        CLOD1460
0113     172 FORMAT ('0', 7X, 'MONTH', I4)                                     CLOD1470
0114     173 FORMAT ('0 MEAN CLOUD COVER FOR REGION', I3/ (5X, 8F10.2))        CLOD1480
0115     174 FORMAT (2X, 'CUMULATIVE UNCONDITIONAL DISTRIBUTIONS'/(5X,8F10.2)) CLOD1490
0116     175 FORMAT (2X, 'CUM. CONDITIONAL - TEMPORAL'/ (5X, 5F10.2))          CLOD1500
0117     176 FORMAT (2X, 'CUM. CONDITIONAL - SPATIAL'/ (5X, 5F10.2))           CLOD1510
0118         DO  180  IM = 1, MOMAX                                            CLOD1520
0119         WRITE (6, 172)  MO(IM)                                            CLOD1530
0120         DO  177  IR = 1, NREG                                             CLOD1540
0121         WRITE (6, 173)  MREG(IR), (MEAN(IR,IM,KT), KT=1,8)                CLOD1550
0122         WRITE (6, 174)  ((CSUNCN(IR,IM,KT,IC), KT=1,8), IC=1,5)           CLOD1560
0123         WRITE (6, 175)  ((CCT(IR,IM,IC,J), J=1,5), IC=1,5)                CLOD1570
                                                                               CLOD1580
```

```
FORTRAN IV G LEVEL 1, MOD 2            MAIN            DATE = 70104          11/33/37          PAGE 0005
                WRITE (6, 176)  ((CSCON(IR,IM,IC,J), J=1,5), IC=1,5)                  CLOD1590
          177 CONTINUE                                                                 CLOD1600
                WRITE (6, 178)  (DAY(IR,IM), IR=1,NREG)                                CLOD1610
          178 FORMAT ('0 DAY AVERAGES'/ (5X, 10F6.2))                                  CLOD1620
                WRITE (6, 179)  (NIGHT(IR,IM), IR=1,NREG)                              CLOD1630
          179 FORMAT (2X, 'BY NIGHT'/ (5X, 10F6.2))                                    CLOD1640
                WRITE (6, 181)  (MONTH(IR,IM), IR=1,NREG)                              CLOD1650
          181 FORMAT (2X, 'BY MONTH'/ (5X, 10F6.2))                                    CLOD1660
          180 CONTINUE                                                                 CLOD1670
                IF  (MOMAX .LT. 12)  GO TO 190                                         CLOD1680
                WRITE (6, 182)                                                         CLOD1690
          182 FORMAT ('0 SEASONAL - WINTER, SPRING, SUMMER, FALL, AND ANNUAL')         CLOD1700
                WRITE (6, 183)  (WINTER(IR), SPRING(IR), SUMMER(IR),                   CLOD1710
               *   FALL(IR), ANNUAL(IR), IR = 1, NREG)                                 CLOD1720
          183 FORMAT (5X, 5F10.2)                                                      CLOD1730
          190 WRITE (10)  ((((CSUNCN(IR,IM,KT,IC), IR=1,NREG),                         CLOD1740
               *   IM=1,MOMAX), KT=1,8), IC=1,5)                                       CLOD1750
                WRITE (10)  ((((CCT(IR,IM,IC,J), IR=1,NREG), IM=1,MOMAX),              CLOD1760
               *   IC=1,5), J=1,5)                                                     CLOD1770
                WRITE (10)  ((((CSCON(IR,IM,IC,J), IR=1,NREG),                         CLOD1780
               *   IM=1,MOMAX), IC=1,5), J=1,5)                                        CLOD1790
                WRITE (10)  (((MEAN(IR,IM,KT), IR=1,NREG), IM=1,MOMAX), KT=1,8),       CLOD1800
               *   (MO(I), I=1,MOMAX), (MREG(J), J=1,NREG)                             CLOD1810
                WRITE (10)  ((DAY(IR,IM), IR=1,NREG), IM=1,MOMAX),                     CLOD1820
               *   ((NIGHT(IR,IM), IR=1,NREG), IM=1,MOMAX),                            CLOD1830
               *   ((MONTH(IR,IM), IR=1,NREG), IM=1,MOMAX)                             CLOD1835
                IF  (MOMAX .LT. 12)  GO TO 200                                         CLOD1840
                WRITE (10)  (WINTER(IR), IR=1,NREG),                                   CLOD1850
               *   (SPRING(IR), IR=1,NREG), (SUMMER(IR), IR=1,NREG),                   CLOD1860
               *   (FALL(IR), IR=1,NREG), (ANNUAL(IR), IR=1,NREG)                      CLOD1870
          200 CONTINUE                                                                 CLOD1880
                END FILE 10                                                            CLOD1890
                REWIND 10                                                              CLOD1900
                STOP                                                                   CLOD1910
                END                                                                    CLOD1920
```

Table A-1. Computer Program Listing - Basic Cloud Cover Data (Cont)

```
FORTRAN IV G LEVEL  1, MOD 2              MAIN            DATE = 70104          11/33/37              PAGE 000
```

SCALAR MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOC
SDIST	288	MOMAX	28C	NREG	290	S	294	IM	
IP	29C	IC	2A0	MM	2A4	MR	2A8	KT	
J	2B0	RATIO	2B4	I	2B8	JP	2BC	JH	
I1	2C4	I2	2C8	I3	2CC				

ARRAY MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOC
MEAN	2D0	DAY	2F50	NIGHT	33C0	MONTH	3930	WINTER	
SUMME?	3E14	SPRING	3F88	FALL	3FFC	ANNUAL	4070	CSUNCN	
CCT	11A64	CSCON	1A254	SUNCON	22A44	TEMPOR	23C64	SCOND	2
UNC	2530C	COND	253AC	PJOINT	25410	KWHERE	25474	MO	2
MREG	25508								

SUBPROGRAMS CALLED

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOC
IBCOM#	2557C								

FORMAT STATEMENT MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOC
1	25580	9001	25589	2	255C6	3	2561E	4	2
6	25646	171	25655	172	25692	173	256A2	174	2
175	25707	176	25733	178	2575E	179	2577B	181	2
182	257AD	183	257F6						

2. Adjustment of the unconditional statistics for enlarged field of view (FOV) and generation of statistics on another binary tape. The tape is written exactly as that for the basic cloud statistics with the unconditional statistics replaced by the adjusted values.

3. Generation of cumulative cloud statistics for enlarged FOV on a binary tape. These statistics are cumulative for unconditional, temporal, and spatial conditional data. Also generated are data for average cloud cover according to day time, night time, month, season of year, and annually.

A.1.2 Program Variable Definitions in FØRTRAN

Subscripts are:

IM = month number (maximum of 12 = MØMAX)
IR = region number (maximum of 29 = NREG)
IC = cloud category number (defined as 1 through 5)
KT = time of day index, 8 observations, where
KT = 1, 2, . . . , 8 means LST of 0100, 0400, 0700, 1000, 1300, 1600, 1900, and 2200, respectively
J = conditional cloud category (defined as 1 through 5)

Arrays of statistics are:

UNC(IC,KT) = basic unconditional statistics for any month and region
TEMPØR (IR, IC,J) = basic conditional temporal statistics (24 hours later)
CØND(IC, J) = basic conditional spatial statistics (200 nautical miles from center of viewing area)
SUNCØN (IR,IC,KT) = unconditional statistics for enlarged FOV
SCØND(IR,IC,J) = conditional spatial statistics for enlarged FOV
PJØINT(IC,J) = joint matrix used to compute P (a b)
KWHERE(IC,J) = locator matrix used for SUNCØN computation
CSUNCN(IR,IM,KT,IC) = cumulative unconditional statistics for enlarged area
CCT(IR,IM,IC,J) = cumulative conditional temporal statistics for enlarged area
CSCØN(IR,IM,IC,J) = cumulative conditional spatial statistics for enlarged area

MØ(IM) = month number of data from card input; these may not be in order
MREG(IR) = region number for which set of statistics is applicable; these may not be in order
MEAN(IR, IM, KT) = hourly mean cloud cover for enlarged area
DAY(IR, IM) = average day time cloud cover for enlarged area (LST = 0700, 1000, 1300, and 1600)
NIGHT(IR, IM) = average night time cloud cover for enlarged area (LST = 1900, 2200, 0100, and 0400)
MØNTH(IR, IM) = monthly mean cloud cover
WINTER(IR), SPRING(IR), SUMMER(IR), FALL(IR),
ANNUAL(IR) = seasonal and annual average cloud cover for each region

Input constants are:

SDIST = distance between centers of new area of viewing
MØMAX = number of months to be used
NREG = number of regions to be used

A.1.3 Computation of Cloud Statistics for Enlarged FOV

First the KWHERE matrix, which is constant, is set up.

The constants (SDIST, MØMAX and NREG) to be used to control all calculations are the first input.

The first major section of computations is for month IM of MØMAX months and region IR of NREG regions. The process begins by reading the five cards corresponding to the categories (cloud cover = 0 percent, 20 percent, between 20 and 45 percent, between 45 and 75 percent, and 100 percent), each card containing the following parameters:

MM = month number of this set of data stored in MØ(IM)
MR = region number of this set of data, stored in MREG(IR)
UNC(IC, KT) = unconditional statistics for the eight times of day
TEMPØR(IC, J) = conditional temporal statistics
CØND(IC, J) = conditional spatial statistics

This set of parameters is stored on the basic area size tape as input.

Then the spatial conditional statistics are scaled for the enlarged area, as follows:

If SDIST $\leq$ 200 nautical miles, the elements on the diagonal (I = J) of the SCØND(IR, I, J) matrix are SCØND(IR, I, J) = SDIST/200 [CØND(I, J)] and for the off diagonal elements (I $\neq$ J) SCØND(IR, I, J) = 100 - SDIST/200 [100 - CØND(I, J)] where J = 1, 2 . . . , 5 conditional categories and I = 1, 2 . . . , 5 cloud category indices.

But if SDIST > 200 nautical miles, the process differs slightly:

For IC = 1, 2 . . . , 5 cloud category, and J = 1, 2 . . . , 5 conditional category, JR is set to J for later use. If IC = J, the diagonal elements are computed by

$$\text{SCØND(IR, IC, J)} = 100 - \frac{\text{SDIST}}{200}\,[100 - \text{CØND(IC, J)}]$$

but if SCØND(IR, IC, J) is less than UNC(IC, 1), the elements of SCØND(IR, IC, JH) are set equal to UNC(IC, 1) where JH = JR, . . . 5. On the other hand, when IC $\neq$ J, the off-diagonal elements are:

SCØND(IR, IC, J) = SDIST/200 · CØND(IC, J) and if SCØND(IR, IC, J) > UNC(IC, 1) then the elements of SCØND(IR, IC, JH) are replaced by UNC(IC, 1) for JH = JR, . . . 5.

The next sequence of calculations performs the scaling of the new unconditional distributions.

The PJØINT(IC, J) matrix is formed by UNC(IC, KT)*SCØND(IR, IC, J)/100. The 100 is to keep units consistent in percentages. The PJØINT(IC, J) is formed for one LST at a time. Then the new unconditional statistics are calculated for the KT time, using the KWHERE matrix as follows:

The SUNCØN(IR, IC, KT) is initially zero. Then for I = 1, . . . 5 and J = 1, . . . 5, if KWHERE (I, J) = the IC cloud category, then SUNCØN(IR, IC, KT) accumulates the corresponding PJØINT(I, J). The process continued for all five cloud categories (IC) and the eight times of day (KT).

The final step of this section of computations stores the MØ(IM), MR(IR), IC, the new scaled unconditional statistics SUNCØN(IR, IC, KT), TEMPØR(IR, IC, J), and the new scaled spatial conditional statistics SCØND(IR, IC, J) for all five cloud categories on another tape (9). The above process continued for all NREG regions and MØMAX months.

The next major section of this routine computes the cumulative cloud distributions and the various types of means, using the above-computed statistics for the enlarged FOV. These calculations depend on the origianl input cards being in order according to month number. Also, all 29 regions and all months should be included in the input data set.

First all adjusted statistics for the IMth month of MØMAX are read from the newly created data set (tape 9). Then the mean cloud cover by hour (KT) for the IR region and IM month are computed by

$$\text{MEAN(IR, IM, KT)} = 0.25\ \text{SUNCØN(IR, 2, KT)} + 0.45\ \text{SUNCØN(IR, 3, KT)} + 0.75\ \text{SUNCØN(IR, 4, KT)} + \text{SUNCØN(IR, 5, KT)}$$

The day time and night time averages follow:

$$\text{Day(IR, IM)} = \frac{1}{4} \sum_j \text{MEAN (IR, IM, j) for j = 1, 2, 7 and 8.}$$

Monthly average is simply

$$\text{MONTH(IR, IM)} = \frac{1}{2} [\text{DAY(IR, IM)} + \text{NIGHT(IR, IM)}]$$

The seasonal averages then are computed by use of the monthly averages. That is,

$$\text{WINTER(IR)} = \frac{1}{3} [\text{MØNTH(IR, 1)} + \text{MØNTH(IR, 2)} + \text{MØNTH(IR, 12)}]$$

The other three seasonal cloud cover averages are similarly computed with the monthly regional averages used. For spring the month numbers used are IM = 3, 4, and 5. Summer uses IM = 6, 7, and 8. The nominal regional averages are then the arithmetic mean of the seasonal averages.

The last set of calculations performed by the routine for adjustment of cloud statistics is the accumulation of the scaled unconditional, temporal, and scaled spatial conditional statistics.

The cumulative unconditional statistics are computed for IM = 1, ..., MØMAX months, IR = 1, ..., NREG regions, KT = 1, ..., eight times of day and the five cloud categories where for category 1, CSUNCN(IR, IM, KT, 1) = SUNCØN(IR, 1, KT).

For categories j:

$$\text{CSUNCN(IR, IM, KT, j)} = \sum_j \text{SUNCØN(IR, j, KT)} + \text{CSUNCN(IR, IM, KT, j-1)}$$

and j = 2, 3, 4, and 5.

The cumulative temporal conditional statistics, CCT (IR, IM, IC, J), accumulate TMPØR(IR, IC, J) in the same fashion as above. Also, the newly scaled spatial conditional statistics, SCØND(IR, IC, J), are accumulated likewise into CSCØN(IR, IM, IC, J).

After these above calculations have been completed, the three types of cumulative statistics are written on tape, which are followed by the various averages. All of this is also printed for the user's information.

A.1.4 Input Data Specifications

Card Sequence	FORTRAN Nomenclature	Variable Definition and Limitations	Format
1	SDIST	Diameter of new area (FOV in nautical miles	E12.8, 2I6
	MØMAX	Number of months (≤ 12)	
	NREG	Number of regions (≤ 29)	
	MM	Month number for five-card data set	1X, 2I2, 1X, 18F2.0
(5 cards)*	MR	Homogeneous region number for five-card data set	
	UNC(IC,KT), KT=1,8	Unconditional cloud cover probability for eight time points	
	TEMPØR(IR, IC, J) J=1,5	Temporal conditional probability for five conditional categories	
	CØND(IR, IC, J) J=1,5	Spatial conditional probability for five conditional categories	
Comment*		The set of five cards is indexed by IC = 1, 5, which corresponds to five cloud cover categories	
Comment		The five card sets are repeated for each region (≤ 29 regions)	

Card Sequence	FORTRAN Nomenclature	Variable Definition and Limitations	Format
Comment		Another group of five-card sets is used for the second month (MM) until completion of the five-card data sets	
Last card		/ and * in card colums 1 and 2, respectively	

A.2 SINGLE-LOOK ROUTINE

A.2.1 General

The single-look routine computes the probability of seeing 100 percent of an area in N independent passes. The basic relationship used in this routine is (See Table A-2).

$$P_s = 1 - \left[1 - P_{(1)}\right]^N$$

where

P_s = desired probability of success, or seeing 100 percent of an area in a single look

$P_{(1)}$ = relative frequency of clear skies (Category 1)

$\left[1 - P_{(1)}\right]^N$ = probability of failure of seeing 100 percent of an area in one look

N = number of passes

Then, N may be determined by

$$N = \frac{\log\left[1 - P_s\right]}{\log\left[1 - P_{(1)}\right]}$$

Table A-2. Computer Program Listing - One Look

```
FORTRAN IV G LEVEL 1, MOD 2            MAIN               DATE = 70104          20/00/43              PAGE 0001

              C       PROGRAM TO COMPUTE THE PROBABILITY OF AT LEAST ONE PASS         KLAR0010
              C       WITH CLEAR SKIES IN N PASSES                                    KLAR0020
              C                                                                       KLAR0030
 0001               DIMENSION  SUNCON(29,8,12), PS(300,100), NP1(100), P1(100),       KLAR0040
                   *           PTM(29), REG(29), NDUM(4), TX(18), TY(18),             KLAR0050
                   *           TTOP(18), TR(18)                                       KLAR0060
 0002               DIMENSION  TIME(8)
 0003               REAL * 4  N(300,100)                                              KLAR0070
 0004               DATA  TX/ 7*'     ', 'NUMBER OF PASSES', 7*'     '/,              KLAR0080
                   *      TY/ 4*'     ', 'PS PROBABILITY OF SUCCESS OF CLEAR SKIES',
                   *      4*'     '/, TR/ 7*'     ', 'CLOUD REGION', 8*'     '/       KLAR0100
 0005               DATA  TIME/ '0100', '0400', '0700', '1000', '1300', '1600',
                   *            '1900', '2200'/
              C                                                                       KLAR0110
 0006               REWIND 10                                                         KLAR0120
              C                                                                       KLAR0130
              C       NTAPE IS EITHER THE BASIC UNACCUMULATED STATISTICS OR THAT      KLAR0140
              C       FOR THE EXPANDED AREA. FIRST NDM WORDS SKIPPED.                 KLAR0150
              C                                                                       KLAR0160
 0007             1 READ (5, 2, END=500)  NTAPE, NDM, INPOPT
 0008             2 FORMAT (12I6)                                                     KLAR0180
 0009               REWIND NTAPE                                                      KLAR0190
 0010               DO  10  IM = 1, 12                                                KLAR0200
 0011               DO  10  IR = 1, 29                                                KLAR0210
 0012               DO  10  IC = 1, 5                                                 KLAR0220
 0013               IF  (IC .NE. 1)   GO TO 5                                         KLAR0230
 0014               READ (NTAPE)  (NDUM(I), I=1,NDM), (SUNCON(IR,KT,IM), KT=1,8),     KLAR0240
                   *      (TEMP, J=1,5), (SCOND, J=1,5)                               KLAR0250
 0015               GO TO 10                                                          KLAR0260
 0016             5 READ (NTAPE)  (NDUM(I), I=1,NDM)                                  KLAR0270
 0017            10 CONTINUE                                                          KLAR0280
 0018               IF  (INPOPT .NE. 0)   GO TO 20
              C
              C       INPUT THE PS, N, AND P1 FROM THE NOMOGRAM
 0019               READ (5, 3)  (TTOP(I), I = 1, 18)
 0020               WRITE (6, 4)  (TTOP(I), I = 1, 18)
 0021               DO  15  I = 1, 100
 0022               READ (10)  K, JMAX, P1(I), (N(J,I), PS(J,I), J = 1, JMAX)
 0023               NP1(I) = JMAX
 0024            15 CONTINUE
```

Table A-2. Computer Program Listing - One Look (Cont)

```
FORTRAN IV G LEVEL  1, MOD 2                MAIN                 DATE = 70104          20/00/43             PAGE 0002
              GO TO 110
      C
           20 READ (5, 3, END=500)  (TTOP(I), I=1,18)                                 KLAR0290
            3 FORMAT (18A4)                                                           KLAR0300
              READ (5, 2)  NMAX, NC, (NP1(I), I=1,NC)                                 KLAR0310
              WRITE (6, 4)  (TTOP(I), I=1,18)                                         KLAR0320
            4 FORMAT ('1', 10X, 18A4)                                                 KLAR0330
              P1(1) = 0.01                                                            KLAR0340
              DEL = 0.01                                                              KLAR0350
              DO  25   I = 2, 99                                                      KLAR0360
           25 P1(I) = P1(I-1) + DEL                                                   KLAR0370
              P1(100) = 0.999                                                         KLAR0380
              YB = 1.0                                                                KLAR0390
              YT = 100.0
              XL = 1.0                                                                KLAR0410
              XR = FLOAT (NMAX)                                                       KLAR0420
              CALL LIMITI (XL, XR, YB, YT)                                            KLAR0430
              CALL SMXYV (1, 1)                                                       KLAR0440
              IGR = -1                                                                KLAR0450
      C                                                                               KLAR0460
      C         COMPUTATION OF PROBABILITY OF SUCCESS                                 KLAR0470
              DO  100  I = 1, 100                                                     KLAR0480
              DEN = ALOG (1.0 - P1(I))                                                KLAR0490
              JMAX = NMAX
              DO  30   J = 1, NMAX
              JP = J                                                                  KLAR0510
              PS(J,I) = 1.0 - (1.0 - P1(I)) **JP
              IF  (ABS (PS(J,I) - 1.0) .LE. 1.0E-4)  GO TO 34
           33 N(J,I) = ALOG (1.0 - PS(J,I)) / DEN
              GO TO 30
           34 N(J,I) = J
              JMAX = J
              PS(J,I) = 100.0 * PS(J,I)
              GO TO 335
           30 PS(J,I) = PS(J,I) * 100.0
          335 DO  35   NP = 1, NC                                                     KLAR0550
              IF  (NP1(NP) .EQ. I)  GO TO 36
           35 CONTINUE                                                                KLAR0570
              GO TO 50                                                                KLAR0580
           36 CALL GRAPH (IGR, 42, -JMAX, N(1,I), PS(1,I), TX, TY, TTOP)              KLAR0590
```

Table A-2. Computer Program Listing - One Look (Cont)

```
FORTRAN IV G LEVEL 1, MOD 2          MAIN          DATE = 70104          20/00/43          PAGE 0003
0062          IGR = 0
0063          WRITE (6, 31)  P1(I)                                                    KLAR0610
0064       31 FORMAT ('0', 10X, 'P1 - RELATIVE FREQUENCY OF CLEAR SKIES',             KLAR0620
             *   F6.3, ' (PLOTTED)'/ 2X, 8(3X, 'N', 5X, 'PS', 1X))
0065       32 FORMAT (2X, 8(F5.0, F7.2))
0066       37 DO  40  J = 1, JMAX, 8
0067          JEND = J + 7
0068          IF  (JEND .GT. JMAX)  JEND = JMAX                                       KLAR0670
0069          WRITE (6, 32)  (N(K,I), PS(K,I), K = J, JEND)
0070       40 CONTINUE                                                                KLAR0690
0071          GO TO 60                                                                KLAR0700
0072       50 WRITE (6, 51)  P1(I)                                                    KLAR0710
0073       51 FORMAT ('0', 10X, 'P1 - RELATIVE FREQUENCY OF CLEAR SKIES',             KLAR0720
             *   F6.3, ' (NOT PLOTTED)'/ 2X, 8(3X, 'N', 5X, 'PS', 1X))
0074          GO TO 37
0075       60 WRITE (10)  I, JMAX, P1(I), (N(J,I), PS(J,I), J = 1, JMAX)              KLAR0750
0076      100 CONTINUE
        C                                                                             KLAR0770
0077      110 READ (5, 2, END=500)  MO, KTM, IRTN                                     KLAR0780
0078          READ (5, 3)  (TTOP(I), I = 1, 18)                                       KLAR0790
0079          NREG = 29                                                               KLAR0800
0080          IGR = -1                                                                KLAR0810
0081          XL = 0.0                                                                KLAR0820
0082          XR = 30.0                                                               KLAR0830
0083          YB = 1.0                                                                KLAR0840
0084          YT = 100.0
0085          DO  120  I = 1, NREG                                                    KLAR0860
0086          PTM(I) = SUNCON(I,KTM,MO)                                               KLAR0870
0087      120 REG(I) = I                                                              KLAR0880
0088          CALL LIMITI (XL, XR, YB, YT)                                            KLAR0890
0089          CALL SMXYV (0, 1)                                                       KLAR0900
        C                                                                             KLAR0910
0090          CALL GRAPH (IGR, 42, -NREG, REG, PTM, TR, TY, TTOP)                     KLAR0920
0091          IF  (IRTN .EQ. 0)  GO TO 110                                            KLAR0930
0092          IF  (INPOPT .EQ. 0)  GO TO 130                                          KLAR0940
0093          END FILE 10
0094          GO TO (130, 20, 1), IRTN                                                KLAR0950
        C
        C         COMPUTE PS OR N GIVEN N OR PS FROM TIME & REGION
0095      130 READ (5, 131, END=500) IREG, MO, KTM, IOP, NPASS, PSC
```

Table A-2. Computer Program Listing - One Look (Cont)

```
FORTRAN IV G LEVEL  1, MOD 2               MAIN              DATE = 70104         20/00/43            PAGE 0004

0096          131 FORMAT (5I6, 6X, E12.8)
0097              IF  (IOP .NE. 0)  GO TO 140
0098              IF  (IRTN - 2)   130, 20, 1
0099          140 GO TO (150, 160), IOP
            C
0100          150 PGIV = SUNCON(IREG,KTM,MO) / 100.0
0101              PSC = (1.0 - (1.0 - PGIV) **NPASS) * 100.0
0102              WRITE (6, 151)  IREG, MO, TIME(KTM), NPASS,
                 *                    SUNCON(IREG,KTM,MO), PSC
0103          151 FORMAT ('0REGION', I3, 3X, 'MONTH', I3, ' AT ', A4, 'LST', 3X,
                 *           'GIVEN', I4, ' PASSES', 3X, 'P1 =', F7.1,
                 *           3X, 'PS IS', F8.3)
0104              GO TO 130
0105          160 TOP = ALOG (1.0 - PSC / 100.0)
0106              DEN = ALOG (1.0 - SUNCON(IREG,KTM,MO) / 100.0 )
0107              NPASS = TOP / DEN
0108              WRITE (6, 161)  IREG, MO, TIME(KTM), PSC,
                 *                    SUNCON(IREG,KTM,MO), NPASS
0109          161 FORMAT ('0REGION', I3, 3X, 'MONTH', I3, ' AT ', A4, 'LST',
                 *           3X, 'FOR PS OF', F8.2, 3X, 'P1 =', F7.1,
                 *           3X, 'NUMBER OF PASSES', I5)
0110              GO TO 130
0111          500 WRITE (6, 501)                                                  KLAR0970
0112          501 FORMAT ('0',10X, 'COMPUTATION OF FREQUENCY OF CLEAR SKIES ',     KLAR0980
                 *           'COMPLETED. ')                                        KLAR0990
0113              STOP                                                            KLAR1000
0114              END                                                             KLAR1010
```

Table A-2. Computer Program Listing - One Look (Cont)

FORTRAN IV G LEVEL 1, MOD 2 MAIN DATE = 70104 20/00/43 PAGE 0005

SCALAR MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOC
NTAPE	1A4	NDM	1A8	INPOPT	1AC	IM	1B0	IR	
IC	1B8	I	1BC	KT	1C0	TEMP	1C4	J	
SCOND	1CC	K	1D0	JMAX	1D4	NMAX	1D8	NC	
DEL	1E0	YB	1E4	YT	1E8	XL	1EC	XR	
IGR	1F4	DEN	1F8	JP	1FC	NP	200	JEND	
MO	208	KTM	20C	IRTN	210	NREG	214	IREG	
IOP	21C	NPASS	220	PSC	224	PGIV	228	TOP	

ARRAY MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOC
SUNCON	230	PS	2DB0	NP1	20270	PI	20400	PTM	20
REG	20604	NDUM	20678	TX	20688	TY	206D0	TTOP	20
TR	20760	TIME	207A8	N	207C8				

SUBPROGRAMS CALLED

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOC
IBCOM#	3DC88	LIMITI	3DC8C	SMXYV	3DC90	FRXPI#	3DC94	GRAPH	3D
ALOG	3DC9C								

FORMAT STATEMENT MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOC
2	3DD38	3	3DD3E	4	3DD44	31	3DD4E	32	3D
51	3DDAD	131	3DE02	151	3DE0D	161	3DE5D	501	3D

A.2.2 Routine Variable Definitions in FORTRAN

Constants and input are:

NTAPE = tape unit designation from which the cloud cover Category 1 statistics are read; this tape must have been generated by the routine described in Section A-1; it may be either the basic area or the enlarged area data tape and not accumulated

NDM = number of variable to skip on the first part of a data record (four for basic statistics and three for the enlarged area)

INPØPT = an option for another tape input or generation [i.e., $P_{(1)}$ versus N and P_s]; see method of solution for usage

Arrays are:

P1(100) = 100 program set values of the relative frequency of clear skies (0.01, 0.02 ... 0.99, 0.999)

PS(J, I) = probability of success of clear skies, given $P_{(1)}$ for N passes and maximum I = 100

NJ(100) = maximum number of passes for a value of $P_{(1)}$, initialized as 300 each

NP1(20) = maximum of 20 sets of P's versus N to be plotted given $P_{(1)}$ for the nomogram (see method of solution for nomogram)

SUNCØN(29, 8, 12) = the unconditional cloud cover statistics for Category 1 input from NTAPE

PTM(29) = probability of success of clear skies, given number of passes, time and region of N given P_s, time and region

A.2.3 FORTRAN Logic and Equations

First the values of NTAPE, NDM, and INPØPT are input. Then the unaccumulated cloud cover statistics, SUNCØN(IR,KI,IM), for Category 1 only are read from tape NTAPE.

Then, if INPØPT = 0, a previously existing data set (scratch tape or reserved tape) containing 100 sets of P1(I), N(J,I), PS(J,I), J = 1, number of points computed and I = 1,2 . . . , 100. On the other hand, for INPØPT ≠ 0, these parameters will be computed and stored on a data set (tape or disk).

In either event, the nomogram will be plotted where NC = subscript of P1. Therefore, a title card is read containing any user descriptive information for printout and plotting.

But for INPØPT ≠0, NMAX, NC and (NP1(k), k = 1, NC) are input where NMAX = maximum number of passes, NC = number of curves to plot on nomogram. Also, the values that P1(I) take are set. See the definition of P1(I).

Initialization of the nomogram graph takes place next. The subroutine LIMITI is called to set the grid limits. This subroutine is part of the GRAPH package, which was written by several NR systems programmers and is in general use. Then the NR system library subroutine, SMXYV , is called to inform the GRAPH package that the first plotted output is to be performed on a log-log scale. The nomogram is to be plotted in this fashion. The values are Pl versus N and the curves are drawn for various values of Ps, the probability of seeing 100 percent of an area. At this point, all initialization has been performed.

The next major section of the routine is the computation of P_s for P1(I) and N, only if INPØPT ≠0. For I = 1, 2. . . , 100, the following is performed:

For P1(I), the demonimator in the computation of N remains a constant and is

$$DEN = \log \left[1 - P1(I) \right]$$

JMAX is initially defined as NMAX, which may be computed and result with the number of passes for 100 percent probability of success, P_s, to be reached. It is also the number of points of Ps(J, I) versus N(J, I) computed.

Then an attempt is made to compute the values of Ps and N for J = 1, 2, . . . NMAX. So, Ps is computed by

$$Ps(J,I) = 1. - \left[1. - P1(I) \right]^J$$

An indeterminate form of N is produced when Ps approaches 1, and then N(J,I) equals J and JMAX = J. Also, Ps(J,I) = 100 percent and the computation of Ps versus N is complete for the value of Pl(I). These values are then printed and possibly plotted

Otherwise, the computed value of Ps(J,I) is accepted, and N(J,I) proceeds to be computed:

$$N(J,I) = \frac{\log\,(1. - Ps(J,I))}{DEN}$$

Since Ps(J,I) lies between 0 and 1, it is converted to a percentage. The above process for Pl(I) proceeds until the condition that Ps(J,I) is nearly 1.0 or J becomes NMAX and, therefore, JMAX is known. At this time, if NC for some curve number is I, then the set of above-computed values is plotted. Also, these are printed with an indication of "plotted" or "not plotted."

Finally, within this section of the routine, the tape (10) is written containing the following set of parameters:

I, JMAX, Pl(I), (N(J,I), Ps(J,I), J=1, . . . , JMAX)

The second major section of the single-look routine uses the unconditional cloud statistics for Category 1. This section plots on a semi-log scale the frequency of clear skies given a month and time of day for all 29 regions. The plot requires two input cards per time and month where the values read are:

1. MØ = month number to select

   KTM = time number to select where it may be computed by

   LST = 0100 + 300(KTM - 1)

   IRTN = an option, indicating the operation to be performed upon completion of the plot of the particular set of SUNCØN desired.

2. Title card containing user identification of plotted values

Then the grid is initialized for the semi-log plot. The particular set of values of SUNCØN (29 regions, KTM, MØ) is stored in PTM(I) and REG(I) = I, I = 1, 2. . . , 29. Then these values are plotted, PTM on the log scale versus REG on the linear scale.

Now the IRTN parameter is tested. If IRTN is zero, another month and time may be selected for plotting. Otherwise, IRTN must be positive and ≤ 3, where

IRTN = 3, returns control to beginning of the single-look routine

IRTN = 2, returns to new nomogram input

If IRTN = 1, the last section of this routine performs its calculations as follows:

This section performs the calculation of PS, called PSC, given N, time and region or calculation of N, given PSC, time and region from SUNCØN(29, 8, 12).

The input card for this calculation contains the following:

IREG = region number to select

MØ = month number to be used

KTM = time number where LST = 0100 + 300(KTM - 1) and KTM ≤ 8.

IØP = calculation option, where IØP = 0 uses IRTN to go to repeat this input card, return to new nomogram control input, or beginning of routine, if another tape (NTAPE) is to be used; but if IOP = 1, PSC is computed, given NPASS (N is called NPASS here); or if IØP - 2, NPASS is computed, given PSC

NPASS = number of passes if PSC is to be computed

PSC = probability of success of clear skies if NPASS is to be computed

The procedure of either calculation is as follows:

First, if IØP = 1, the probability of success is computed using

$$PSC = 100. \left\{ 1. - \left[\left(1. - \frac{SUNC\O N(IREG, KTM, M\O)}{100}\right)\right]^{NPASS} \right\}$$

All values are then printed.

Second, if IØP = 2, the number of passes is computed by

$$NPASS = \frac{\log \left[1. - \frac{PSC}{100}\right]}{\log \left[1. - \frac{SUNC\O N(IREG, KTM, M\O)}{100}\right]}$$

The reader may notice that factors of 100 are being used with a degree of frequency. This is because of consistency in percentages and values between 0 and 1.

The last operation performed by this routine returns for another card for computation of Ps given N or vice versa and any further computations the user may desire.

A. 2. 4 Input Data Specifications

Card Sequence	FORTRAN Nomenclature	Variable Definition and Limitations	Format
1		Tape usage options card	I2I6
	NTAPE	Tape unit number from which unconditional statistics are to be read; this must correspond to that in the JCL; for example, if NTAPE=8, the correspondence would be to FT08F001; also NTAPE must not have values of 5, 6, 10, 1, 14 or 16	
	NDM	The number of words skipped in a data record; the value must be 4 for basic area statistics and 3 for the enlarged area statistics	

Card Sequence	FORTRAN Nomenclature	Variable Definition and Limitations	Format
	INPØPT	Option for reading or generation of the tape of relative frequency of clear skies; if zero, the tape is read; if one, a new tape is generated	
2	(TTØP(I), I=1, 18)	Problem title card for printed output and CRT output	18A4
3		Parameters for nomogram plotting:	12I6
	NMAX	Maximum number of passes	
	NC	Number of curves to be plotted of nomogram given a PS plot P_1 versus N (maximum of 20 curves)	
	(NP1(I), I=1, NC)	Curve numbers of PS to be plotted (i.e. values of PS rounded off to nearest percent)	
4		Parameters for plotting actual frequency of clear skies as function of region using NTAPE	3I6
	MØ	Month number to be selected	
	KTM	Time number to be selected, LST = 0100 + 300 (KTM-1)	
	IRTN	Parameter indicating type of data to be read next, if any:	
		If IRTN = 0, another Card 4 follows	
		If IRTN ≠ 0 and INPØPT = 0, Card 5 next	

Card Sequence	FORTRAN Nomenclature	Variable Definition and Limitations	Format
		If IRTN = 1, Card 5 next	
		If IRTN = 2, repeat sequence from Card 2, but tape is generated	
		If IRTN = 3, repeat sequence from Card 1	
5		Parameters for computation of PS given N, or N given PS for region and time from unconditional statistics on NTAPE	5I6, 6X, E12.8
	IREG	Region number (1 → 29)	
	MØ	Month number	
	KTM	Time number, see Card 4	
	IØP	Type of computation to be done	
		If IØP = 0, then IRTN = 1, 2, or 3 test is applied as above to determine return point; if IØP = 1, PS is computed given number of passes; if IØP = 2, number of passes is computed given probability of success	
	NPASS	Number of passes for option	
	PSC	Probability of success for option; this card may be repeated for as many computations as required	
Last Card		/ and * in columns 1 and 2, respectively.	

A.3 ONE- OR TWO-LOOK VIEWING ROUTINE

This routine determines the probability of seeing a desired percentage or more of an area in either one or two looks and in N independent passes. The basic relationship used for the probability of success is (See Table A-2).

$$P_s = 1 - \left[(1 - P1)^N\right] \left[(1 - \tilde{p})^N + N\tilde{p}(1 - \tilde{p})^{N-1}\right]$$

where

N = number of independent passes

$P1$ = percentage frequency of cloud cover, $\leq$ success criterion for one-look viewing, i.e., $\leq C_1$

$P2$ = percentage frequency of cloud cover in two-look interval, i.e., cloud cover $\leq \sqrt{C_1}$ and $> C_1$.

$\tilde{p} = \dfrac{P2}{1 - P1}$ = probability of cloud cover in two-look interval, given that success in one look has not occurred

A.3.1 Routine Variables and Computations

Input includes:

MØNTH = computations desired for this month
ITIME = time of day (from LST)
AREA = percentage or more area to be viewed
CCU(29, 12, 8, 5) = cumulative unconditional cloud cover statistics generated by the routine discussed in Section A.1

Variables are:

N = number of independent passes, 1 through 20
IREGØN = region number index, 1 through 29
A(IREGØW, N) = probability of success of seeing AREA %, computed by subroutine LØØK12, also = PRØB
CLOUDS = one-look cloud cover success = (100 - AREA) and after one look used, set to $\sqrt{\text{CLOUDS}} * 10$

Table A-3. Computer Program Listings One or Two Looks

```
FORTRAN IV G LEVEL  18                    MAIN              DATE = 70138          11/35/45              PAGE 000
      C
      C        MAIN PROGRAM TO CALL LOOK12 FOR AREA >70%, MONTH = 8, TIME = 4
      C
               COMMON  /UNIT/ NTAPE
               DIMENSION A(29,20)
             1 IN = 1
               READ (5, 3, END = 90)  NTAPE
               REWIND NTAPE
            10 READ (5, 3)  MONTH, ITIME, AREA
             3 FORMAT (2I6, F12.0)
               IF  (MONTH .LE. 0)  GO TO 1
               PROB=0.
               DO 20 N=1,20
               DO 20 IREGON=1,29
               CALL LOOK12  (IN,IREGON,MONTH,ITIME,AREA,PROB,N)
               A(IREGON,N)=PROB
               IN=0
            20 PROB=0.
               WRITE (6, 21)  AREA, MONTH, ITIME
            21 FORMAT ('1PROBABILITY OF SEEING', F4.0, ' PERCENT OR MORE OF ',
              *        'AREAS IN ONE-OR TWO-LOOKS'/ '0MONTH',I3,11X,'TIME', I2//
              2  118H REGION  N=1  N=2  N=3  N=4  N=5  N=6  N=7  N=8  N=9 N=10 N=
              311 N=12 N=13 N=14 N=15 N=16 N=17 N=18 N=19 N=20              ,/)
               DO 70 IREGON=1,29
            70 WRITE (6,80) IREGON, (A(IREGON,N),N=1,20)
            80 FORMAT (1X, I3, 4X, 20F5.1)
               GO TO 10
            90 STOP
               END
```

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Table A-3. Computer Program Listings - One or Two Looks

```
FORTRAN IV G LEVEL  18                MAIN              DATE = 70138         11/35/45          PAGE 000

                                 COMMON BLOCK /UNIT    / MAP SIZE       4
SYMBOL     LOCATION      SYMBOL     LOCATION       SYMBOL     LOCATION       SYMBOL     LOCATION       SYMBOL    LO
NTAPE          0

                                 SUBPROGRAMS CALLED
SYMBOL     LOCATION      SYMBOL     LOCATION       SYMBOL     LOCATION       SYMBOL     LOCATION       SYMBOL    LO
IBCOM#        C0         LOOK12        C4

                                 SCALAR MAP
SYMBOL     LOCATION      SYMBOL     LOCATION       SYMBOL     LOCATION       SYMBOL     LOCATION       SYMBOL    LO
IN            F4         MONTH         E8          ITIME         FC          AREA          F0          PROB
N             F8         IREGON        FC

                                 ARRAY MAP
SYMBOL     LOCATION      SYMBOL     LOCATION       SYMBOL     LOCATION       SYMBOL     LOCATION       SYMBOL    LO
A            100

                                 FORMAT STATEMENT MAP
SYMBOL     LOCATION      SYMBOL     LOCATION       SYMBOL     LOCATION       SYMBOL     LOCATION       SYMBOL    LO
    3        A10            21        A19            80        AF7
```

Table A-3. Computer Program Listings - One or Two Looks (Cont)

```
FORTRAN IV G LEVEL  18              LOOK12            DATE = 70138         11/35/45         PAGE 000

            SUBROUTINE LOOK12 (IN,IREGON,MONTH,ITIME,AREA,PROB,N)
            DIMENSION CCU (29,12,8,5)
            COMMON  /UNIT/ NTAPE
            IF(IN-1) 20,10,20                                                 00017050
      C                                                                       00017010
      C     INITIALIZATION                                                    00017040
      C                                                                       00017020
         10 READ (NTAPE) CCU
            LASTR=0                                                           00017070
            AREAL=0.                                                          00017080
            LASTN=0                                                           00017090
         20 CONTINUE
      C                                                                       00017290
      C     BRANCH TO DETERMINE N OR AREA                                     00017300
      C                                                                       00017310
         50 IF(N) 600,100,600                                                 00017320
      C                                                                       00017330
      C     DETERMINATION OF N                                                00017340
      C                                                                       00017350
        100 IF (IREGON-LASTR) 150,110,150                                     00017360
        110 N=LASTN                                                           00017370
            GO TO 999                                                         00017380
        150 CLOUDS= 100. -AREA                                                00017390
            K=1                                                               00017400
            GO TO 950                                                         00017410
        155 P1=F*.01                                                          00017420
            CLOUDS=SQRT(CLOUDS)*10                                            00017430
            K=2                                                               00017440
            GO TO 950                                                         00017450
        160 P2=(F*.01)-P1                                                     00017460
            PS= P2/(1.-P1)                                                    00017470
            NP=1                                                              00017480
            FN=NP                                                             00017490
        162 SUCCES=1.-((1.-P1)**NP)*((((1.-PS) **NP) + (FN*PS*((1.-PS)**(NP-1))00017500
           1))                                                                00017510
            IF (SUCCES*100.-PROB) 165,175,175                                 00017520
        165 NP=NP+1                                                           00017530
            FN=NP                                                             00017540
            GO TO 162                                                         00017550
        175 N=NP                                                              00017560
```

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Table A-3. — Computer Program Listings - One or Two Looks (Cont)

```
FORTRAN IV G LEVEL  18                LOOK12              DATE = 70138        11/35/45            PAGE 000

                LASTN=N
                LASTR=IREGON
                GO TO 999
      C
      C         DETERMINATION OF AREA
      C
            600 IF (AREA) 700,610,700
            610 IF (IREGON-LASTR) 620,615,620
            615 AREA=AREAL
                LASTR=IREGON
                GO TO 999
            620 CLOUDO=0.
            621 CLOUDS=CLOUDO
                K=3
                GO TO 950
            625 P1=F*.01
                CLOUDS=SQRT(CLOUDS)*10
                K=4
                GO TO 950
            630 P2=(F*.01)-P1
                PS= P2/(1.-P1)
                FN=N
                SUCCES=1.-((1.-P1)**N)*((((1.-PS)**N)+(FN*PS*((1.-PS)**(N-1))))
                IF( SUCCES*100.-PROB) 640,650,650
            640 CLOUDO=CLOUDO +1.
                GO TO 621
            650 AREA= 100.-CLOUDO
                AREAL=AREA
                LASTR=IREGON
                GO TO 999
      C
      C         DETERMINATION OF PROBABILITY
      C
            700 IF (PROB) 705,710,705
            705 WRITE (6,706) IREGON,PLAT,PLONG
            706 FORMAT(66H ERROR HAS OCCURED IN CALLING PASS. N AREA AND PROB WERE
               1 NON ZERO.,10H REGION = ,I3,7H PLAT= ,F12.1,8H PLONG= ,F12.1)
                GO TO 999
            710 IF(IREGON-LASTR) 720,715,720
            715 PROB=PROBL
```

```
FORTRAN IV G LEVEL  18                LOOK12              DATE = 70138        11/35/45                PAGE 0

0064           GO TO 999
0065      720  CLOUDS=100.-AREA
0066           K=5
0067           GO TO 950
0068      725  P1=F*.01
0069           CLOUDS= SQRT(CLOUDS)*10.
0070           K=6
0071           GO TO 950
0072      730  P2=(F*.01)-P1
0073           PS=P2/(1.-P1)
0074           FN=N
0075           PROB=1.-((1.-P1)**N)*((((1.-PS)**N)+(FN*PS*((1.-PS)**(N-1))))
0076           PROB=PROB *100.
0077           LASTR=IREGON
0078           PROBL=PROB
0079           GO TO 999
          C
          C    CLOUD FREQUENCY INTERPOLATION                                            00017910
          C                                                                             00017920
0080      950  C=CLOUDS                                                                 00017930
0081           IF  (CLOUDS .GT. 30.) GO TO 960                                          00017940
0082      955  F=CCU(IREGON,MONTH,ITIME,1) + CLOUDS*((CCU(IREGON,MONTH,ITIME,2)-
              1CCU(IREGON,MONTH,ITIME,1))/30.)                                          00017960
0083           GO TO 995                                                                00017970
0084      960  IF  (CLOUDS .GT. 50.)  GO TO 970                                         00017980
0085      965  F=CCU(IREGON,MONTH,ITIME,2)+(C-30.)*((CCU(IREGON,MONTH,ITIME,3) -
              1CCU(IREGON,MONTH,ITIME,2))/20.)                                          00017000
0086           GO TO 995                                                                00017010
0087      970  IF  (CLOUDS .GT. 90.)  GO TO 980                                         00017020
0088      975  F=CCU(IREGON,MONTH,ITIME,3)+(C-50.)*((CCU(IREGON,MONTH,ITIME,4) -
              1CCU(IREGON,MONTH,ITIME,3))/40.)                                          00017040
0089           GO TO 995                                                                00017050
0090      980  F=CCU(IREGON,MONTH,ITIME,4)+(C-90.)*((CCU(IREGON,MONTH,ITIME,5) -        00017060
              1CCU(IREGON,MONTH,ITIME,4))/10.)                                          00017070
0091      995  GO TO (155,160,625,630,725,730),K                                        00017080
0092      999  RETURN
0093           END                                                                      00017100
                                                                                        00017110
```

Table A-3. Computer Program Listings - One or Two Looks (Cont)

FORTRAN IV G LEVEL 18 LOOK12 DATE = 70138 11/35/45 PAGE 000

COMMON BLOCK /UNIT / MAP SIZE 4

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LO
NTAPE	0								

SUBPROGRAMS CALLED

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LO
IBCOM#	1A4	FRXPI#	1A8	SQRT	1AC				

SCALAR MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LO
IN	204	LASTR	208	AREAL	20C	LASTN	210	N	
IREGON	218	CLOUDS	21C	AREA	220	K	224	P1	
F	22C	P2	230	PS	234	NP	238	FN	
SUCCES	240	PROB	244	CLOUDO	248	PLAT	24C	PLONG	
PROBL	254	C	258	MONTH	25C	ITIME	260		

ARRAY MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LO
CCU	264								

FORMAT STATEMENT MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LO
706	DBE4								

$F = P_1$ = percentage frequency of cloud cover, from CLOUDS and input CCU

P1 = 0.01 * F

P2 = percentage frequency for two-look interval

PS = P2/(1 - P1)

PRØB = P

A.3.2 Method of Solution of One- or Two-Look Viewing

The subsequent operations are performed for a desired level of success, AREA, a given month, and time of day. For N = 1, 20 passes and IREGØN = 1, 29 regions, the subroutine LØØK12 is called to compute the probability of success of the desired event, PRØB. The general process is to compute the PRØB and test successive values of N until the required AREA% is achieved.

First the one-look and two-look success, cloud covers (CLØUDO and then CLØUDS) are computed from the input AREA.

The computed CLØUDS and cumulative cloud statistics are then used to compute F (F = 100.*P1), the frequency distribution. This distribution is computed in one of four ways according to cloud category in which CLØUDS falls. CI1, CI2, ... C15 refer to the cumulative unconditional cloud cover statistics as a function of region, time (month and time of day), and cloud category number (i),

$$CIi = CCU(IREGØN, MØNTH, ITIME, i)$$

where

i = 1, 2..., 5.

1. If CLØUDS ≤ 30., the distribution function is

$$F = CI1 + CLØUDS(CI2 - \frac{CI1}{30.})$$

2. If 30.< CLØUDS ≤ 50., the distribution is

$$F = CI2 + (CLØUDS - 30.)(CI3 - \frac{CI2}{20.})$$

3. If 50. < CLØUDS ≤ 90., the frequency is

$$F = CI3 + (CL\O UDS - 50.)(CI4 - \frac{CI3}{40.})$$

4. If CLØUDS >90., the frequency is

$$F = CI4 + (CL\O UDS - 90.)(CI5 - \frac{CI4}{10.})$$

Then P_2, the frequency of cloud cover for two looks, is computed from the cumulative frequency distribution function F as follows:

$$P2 = .01*F - P1$$

The probability of cloud cover in two-look interval follows, PS where

$$PS = \frac{P2}{1 - P1}$$

If N = 1, that is first pass, then

$$PR\O B = P1$$

Then PRØB is tested to determine if the desired percentage of area has been seen in one or two looks for the Nth pass.

The process continues for N = 2, 3 . . . , 20 until the PRØB becomes ≥ the input value of success (AREA) for all 29 regions.

Finally, the computed values of PRØB for each region and pass (A(IREGØN,N)) are printed for all 29 cloud regions of the world. The same procedure may then be repeated for another month, or time of day, or required level of success.

A. 3. 3. Input Data Specifications (One-or Two-Look Routine)

Card Sequence	FORTRAN Nomenclature	Variable Definitions and Limitations	Format
1	NTAPE	Tape unit number from cumulative unconditional cloud statistics are read CCU (29 regions, 12 months, 8LST values, 5 cloud categories	I6
2	MØNTH	Month number of statistics to be used (≤12)	2I6, F12.0

Card Sequence	FORTRAN Nomenclature	Variable Definitions and Limitations	Format
	ITIME AREA	Index of LST to be used (≤8) X percent or more of areas to be seen in one or two looks	
Comment		Card 2 is repeated for as many combinations of the three parameters as required by the analysis to be performed until an input value of MØNTH is =0	
Comment		Upon input of MØNTH of 0, card 2 may be repeated, followed by card(s) 2, if desired	
Last Card		/ and * in card columns 1 and 2, respectively	

A.4 MONTE CARLO ROUTINE FOR CONTINUOUS VIEWING

A.4.1 General

This routine computes the probability of continuous viewing of an area by piecing together the cloud-free elements from each look. The basic relationship used within this routine is as follows (See Table A-4):

$$B(M,N) = \left[100 - B(M,N-1)\right]\left[1 - \frac{C(N)}{100}\right] = DB$$

where

DB = incremental area seen on Nth pass

M = mission iteration number

C(N) = amount of cloud cover on Nth pass

B(M, N - 1) = cumulative area seen to (N - 1) st pass

Table A-4. Computer Program Listings - Monte-Carlo


```
      C      MONTE CARLO CLOUD COVER SIMULATION PROGRAM
      C
             DIMENSION CCU(29,12,8,5), B(300,51), D(10), P(10), X(10),TITLE(18)
            1, CLOUD(5) ,BCDX(18),BCDY(18)
        1001 READ (5, 1002, END=1010)  INTG, NTAPE
        1002 FORMAT (2I12)
             CALL IRNDM (INTG)
             CLOUD(1)=0.
             CLOUD(2)= 20.
             CLOUD (3)= 45.
             CLOUD(4)= 75.
             CLOUD(5)= 100.
             X(1)=0.
             X(2)=10.
             X(3)=30.
             X(4)=50.
             X(5)=60.
             X(6)=70.
             X(7)=80.
             X(8)=90.
             X(9)=95.
             X(10)=100.
             NOM=300
             IF  (NTAPE .LE. 0)  GO TO 1003
             REWIND NTAPE
             READ (NTAPE)  CCU
        1003 READ (5, 6)  BCDX, BCDY
           1 READ (5,6) TITLE
           6 FORMAT(18A4)
             READ (5, 7)  IREGON, IMONTH, ITIME, NOP, IRET
           7 FORMAT (5I4)
             M=1
             DO 2 I=1,300
             DO 2 J=0,50
           2 B(I,J)=0.
           4 N=1
           5 RAN = URNDM(E)*100.
             IF (RAN- CCU(IREGON,IMONTH,ITIME,1)) 10,10,11
          10 I=1
             GO TO 30
```

Table A-4. Computer Program Listings -- Monte Carlo (Cont)

```
FORTRAN IV G LEVEL 1, MOD 2                MAIN          DATE = 70118          20/42/40          PAGE 000

      11 IF (RAN- CCU(IREGON,IMONTH,ITIME,2))12,12,15
      12 I=2
         GO TO 30
      15 IF (RAN- CCU(IREGON,IMONTH,ITIME,3))16,16,20
      16 I=3
         GO TO 30
      20 IF (RAN- CCU(IREGON,IMONTH,ITIME,4))21,21,25
      21 I=4
         GO TO 30
      25 I=5
      30 CONTINUE
         IF(I-1) 35,100,35
      35 VIEW=100. - CLOUD(I)
         DB=((100.-B(M,N-1))*VIEW)/ 100.
         B(M,N)=B(M,N-1) +DB
         IF (B(M,N)-100.) 40,100,100
      40 IF (N-NOP) 41,50,50
      41 N=N+1
         GO TO 5
      50 IF (M-NOM) 51,200,200
      51 M=M+1
         GO TO 4
     100 DO 105 J=N,NOP
     105 B(M,J)=100.
         GO TO 50
     200 CONTINUE
         DO 400 N=1,NOP
         DO 205 J=1,10
         P(J)=0.
     205 D(J)=0.
         DO 300 M=1,NOM
         IF(B(M,N)-100.) 210,207,207
     207 D(10)=D(10) +1.
         GO TO 300
     210 IF(B(M,N) -95.) 215,212,212
     212 D(9)=D(9)+1.
         GO TO 300
     215 IF(B(M,N) -90.) 220,217,217
     217 D(8)=D(8) +1.
         GO TO 300
```

Table A-4. Computer Program Listings - Monte Carlo (Cont)


```
      220 IF(B(M,N)-80.)  225,222,222
      222 D(7)=D(7) +1.
          GO TO 300
      225 IF(B(M,N)-70.) 230,227,227
      227 D(6)=D(6) +1.
          GO TO 300
      230 IF(B(M,N)-60.) 235,232,232
      232 D(5)=D(5)+1.
          GO TO 300
      235 IF(B(M,N)-50.) 240,237,237
      237 D(4)=D(4) +1.
          GO TO 300
      240 IF(B(M,N)-30.) 245,242,242
      242 D(3)=D(3) +1.
          GO TO 300
      245 IF(B(M,N)-10.) 250,247,247
      247 D(2)=D(2)+1.
          GO TO 300
      250 D(1)=D(1)+1.
      300 CONTINUE
          FNOM = NOM
          P(10)=(D(10)/FNOM)*100.
          DO 310 I=1,8
          K=10-I
      310 P(K)=((D(K)*100.)/FNOM)+P(K+1)
          P(1)=((D(1)*100.)/FNOM)+P(2)
          IF(N-1) 350,320,350
      320 CALL PLOT (1,BCDX,BCDY,
         110,X,P,10,TITLE,72,0.,100.,0.,100.,1)
          GO TO 400
      350 CALL PLOT (0,BCDX,BCDY,10,X,P,10,TITLE,72,0.,100.,0.,100.,1)
      400 CONTINUE
          IF  (IRET)  1, 1, 1001
     1010 STOP
          END
```

Table A-4. Computer Program Listings - Monte Carlo (Cont)

FORTRAN IV G LEVEL 1, MOD 2 MAIN DATE = 70118 20/42/40 PAGE 000

SCALAR MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOC
INTG	218	NTAPE	21C	NOM	220	IREGON	224	IMONTH	
ITIME	22C	NOP	230	IRET	234	M	238	I	
J	240	N	244	RAN	248	E	24C	VIEW	
DB	254	FNOM	258	K	25C				

ARRAY MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOC
CCU	260	B	DBF0	D	1CAF0	P	1CB18	X	1(
TITLE	1CB68	CLOUD	1CBB0	BCDX	1CBC4	BCDY	1CC0C		

SUBPROGRAMS CALLED

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOC
IBCOM#	1CC54	IRNDM	1CC58	URNDM	1CC5C	PLOT	1CC60		

FORMAT STATEMENT MAP

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOC
1002	1CCDC	6	1CCE2	7	1CCE8				

A.4.2 Routine Variable Definitions in FØRTRAN

NØM = pre-set (300) mission iteration number

X(10) = percentages of area seen (routine constants, equal to 0, 10, 30, 50, 60, 70, 80, 90, 95 and 100 for I = 1, 2... 10)

CLØUD (5) = the representative cloud cover percentages corresponding to the five cloud categories (defined as 0, 20, 40, 75, and 100)

N = current pass number

NØP = maximum number of passes

DB = defined above

B(M, N) = cumulative area seen

A.4.3 Input Variables

1. INTG = an integer which is used for initialization of the random number generator process

   NTAPE = tape unit number from which cumulative unconditional statistics are read

2. If NTAPE > 0, the tape is read once for CCU(29, 12, 8, 5) unconditional cumulative cloud cover statistics generated by the routine discussed in Section A.1

3. BCDX, BCDY, TITLE = X - axis, Y - axis, and case title information for plotted output (three cards)

4. IREGØN = region number of CCU to be used

   IMØNTH = month number to be used

   ITIME = time index to be used

   NØP = maximum number of passes

   IRET = option to be used upon completion of calculations for this case (if IRET ≤ 0, cards 3 and 4 are repeated; If IRET > 0, return to card 1)

A.4.4 Method of Solution for Continuous Viewing

The Monte Carlo solution begins by reading INTG, NTAPE, and the CCU. Initialization then proceeds for setup of [X(I), I = 1, 10] as defined above and for [CLØUD(J), J = 1, 5]. The random number generation process is initiated by calling the NR system library routine IRNDM(INTG).

For each case using the set of CCU input, Cards 3 and 4 are read. Initialized to zero are all elements of B(M, N).

The following computation of B(M, N) is then performed for the region and time. The mission iteration counter, M, is set to 1. For pass number N = 1, 2, . . . , NØP, the following is performed:

A random number RAN is computed by using URNDM (NR system function routine for random number generation) and converting the number to a percentage. Then the cloud category, I, is computed by comparison of RAN with CCU (IREGØN, IMØNTH, ITIME, I). For convenience, CC(I) will be defined as the cumulative cloud statistics CCU for the region and time. If RAN $\leq$ CC(1), I = 1 and all B(M, J) for J = N, NØP are set to 100 percent and the next mission is taken. Otherwise, the determination of I is made such that CC(I-1) < RAN $\leq$ CC(I). Then DB is computed as follows:

$$DB = \left[100 - B(M, N - 1)\right] \left[1 - \frac{CL\O UD(I)}{100}\right]$$

DB is then accumulated into B(M, N) as (B(M, N - 1) + DB). If B(M, N) becomes 100 percent, then the mission is completed and the remainder of B(M, N) is 100 percent for N to NØP passes.

The process of computation of DB and resultant B(M, N) continues for all NØP passes and until M becomes equal to NØM.

The final portion of the continuous viewing routine performs the computation of the frequency distributions from B and the normalized percent probabilities as functions of X percent area seen.

The process is performed as follows for N = 1, . . . NØP passes:

Frequencies and probabilities (%) are set to zero (P(J) and D(J), J = 1, . . . 10).

Then for the Nth mission of NØM, B(M, N) is compared with x(k), k = 10, 9. . . 2, 1. That is, if B(M, N) X(K), then D(K) = D(K) + 1. Upon completion of all NØM missions, the normalized percentage probabilities are computed as P(K) where

$$P(10) = \frac{D(10)}{N\emptyset M} * 100$$

$$P(9) = \frac{D(9) * 100}{N\emptyset M} + P(10)$$

$$\vdots$$

$$P(1) = \frac{D(1) * 100}{N\emptyset M} + P(2)$$

Finally, P(K) vs. X(K), K = 1,...10 are plotted for the Nth pass.

The routine finally returns for input of another region, time, and title cards, if indicated by IRET ≤ 0, or to the routine beginning for input of another tape.

A.4.5 Input Data Specifications (Monte Carlo for Continuous Viewing Routine)

Card Sequence	FORTRAN Nomenclature	Variable Definitions and Limitations	Format
1	INTG	An odd integer value to initiate random number generation (on the NR-IBMS360 a recommended value is 1220703125	2I12
	NTAPE	Tape unit number from which cumulative unconditional statistics are read CCU(29 regions, 12 months, 8LST values, five cloud categories	
2	BCDX	Alphameric description of variable plotted along X axis of output CRT's	18A4
3	BCDY	Alphameric description of variable plotted along Y axis of output CRT's	18A4
4	TITLE	Alphameric description of area plotted	18A4

Card Sequence	FORTRAN Nomenclature	Variable Definitions and Limitations	Format
5	IREGØN IMØNTH ITIME NØP IRET	Region number to be used (≤29) Month number to be used (≤12) Index of LST to be used (≤12) Maximum number of passes Option to be used upon completion of calculations for this case	5I4
Comments on IRET		a. IRET ≤0, Cards 4 and 5 are repeated for another case. Continue input for all required calculations using NTAPE. b. Input IRET >0 on last card of the case using NTAPE, then card sequence from 1 may be repeated.	
Last card		/ and * in card column 1 and 2, respectively.	

APPENDIX B. CLOUD FREE RESOLUTION ELEMENT STATISTICS PROGRAM

This computer program was developed to compute the number of cloud-free elements in a FOV as a function varying element size and the percentage of the total FOV for these cloud elements. The analytical and logic methods are described in Section 3.3.4.2 (Overlapping Routine) and Section 3.3.4.3 (Road Elimination Routine).

This FORTRAN-IV (Level G) computer code consist of a main program and two subroutines, which perform the general functions listed in Table B-1.

Table B-1. Computer Program Routines

Routine Name	Reference	Functional Use
Main Program	Figure B-1	Reads the input data, selects the desired digitized picture tape file, prints the input data and calls subroutines STAHOL to compute statistics
Subroutine STAHOL	Figure B-2	Reads the input tape intensity data, computes basic and normalized percentage of cloud-free resolution elements, applies area elimination criteria, prints computed statistics, and calls subroutine ELMSC
Subroutine	Figure B-2	Implements point elimination criteria by converting cloud points (1's) to cloud-free points (0's)

B. 1 MAIN PROGRAM

The main program (Figure B-1) reads the input data according to the format in Table B-2 and prints the input data. Then NELPER (minimum scan line cloud length) is converted to minimum cloud fraction (CELPER). From statement numbers 11 to 14, tape file NF is selected for the first digitized data case to be processed. The identification record is skipped and subroutine STAHOL is called to read for the next data case. If there is no additional data, the computer run is terminated after reading an end-of-file. Otherwise, the program continues by reading the data for the next case and either skipping to the next file or rewinding the tape and going to statement number 11 to search for the file. The FORTRAN variable KT is used as a record counter for diagnostic print out if a record read error is encountered.

If the next picture file directly follows the previously used tape file, a transfer is made to statement number 15 to computer the cloud statistics by call subroutine STAHOL.

B. 2 SUBROUTINE STAHOL

This routine (Figure B-2) executes the cloud-free probability statistics and is the major portion of the program. This routine begins by defining four data arrays and the computing the number of resolution sizes, for square resolution elements, in the input scan line point length (NMAXL). Since the resolution element lengths are selected to increase by multiples of 2, the number of different resolution element sizes is (NNS) where

$$2^{NNS} = NMAXL$$

Solving for NNL and adding a small value to compensate for round-off errors, we get

$$NNS = \text{Integral part of } \frac{\ln NMAXL}{\ln 2.0} + 0.1$$

The repetitive loop controlling statement number 1100 computes the number of resolution elements (NMAXL1) in the total line point length (FOV) as a function of the particular resolution length. The values are summed as NMAXIA which is the amount of core storage required for (see Section 3.3.4.2) all the horizontal resolution elements for 100 percent overlap. The "DO LOOPS" ending with statement numbers 10, 1, 9, and 11 initialize or zero several arrays and compute NNI where

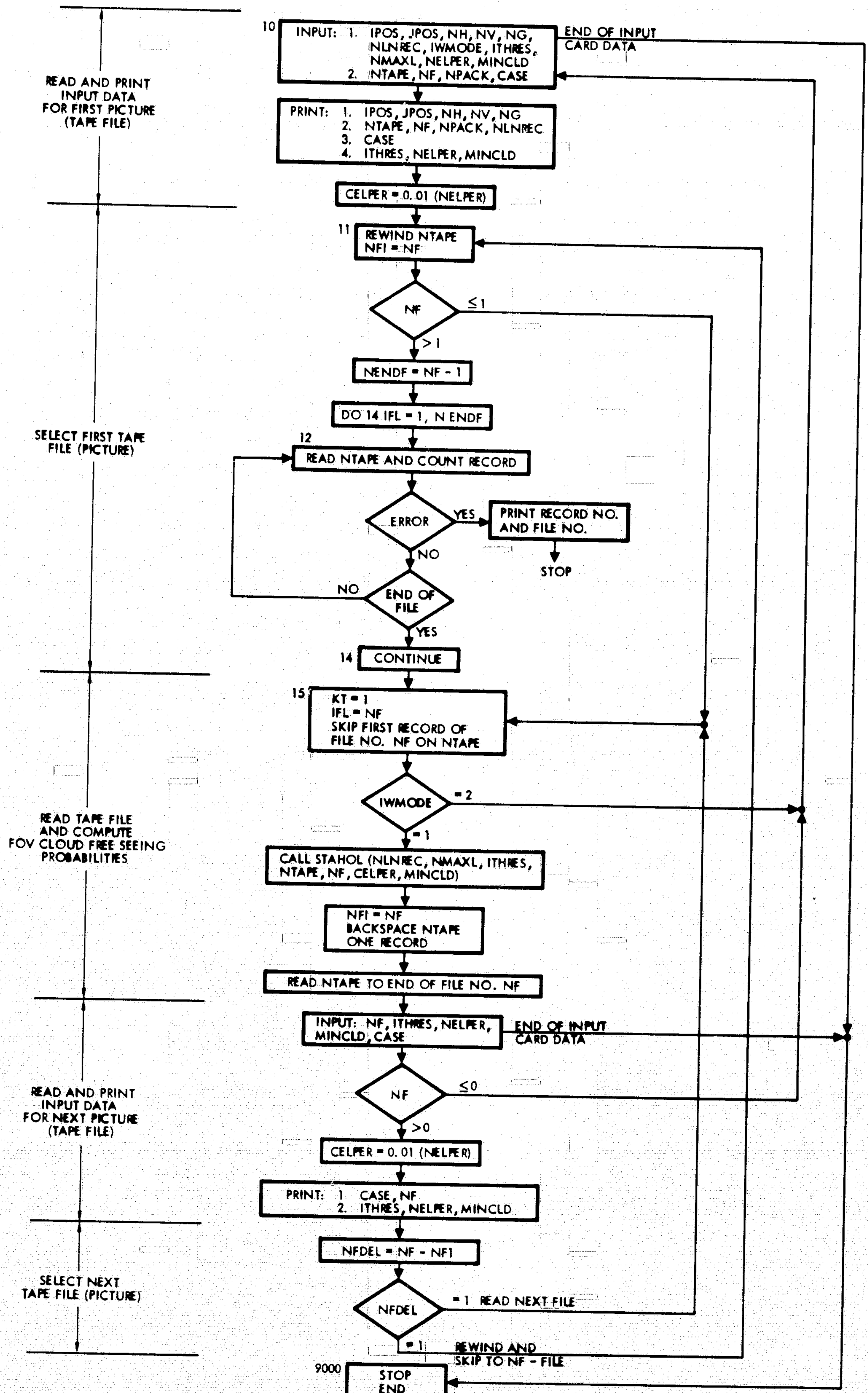


Figure B-1. Cloud Free Resolution Element Statistics Program (Main Program Routine)

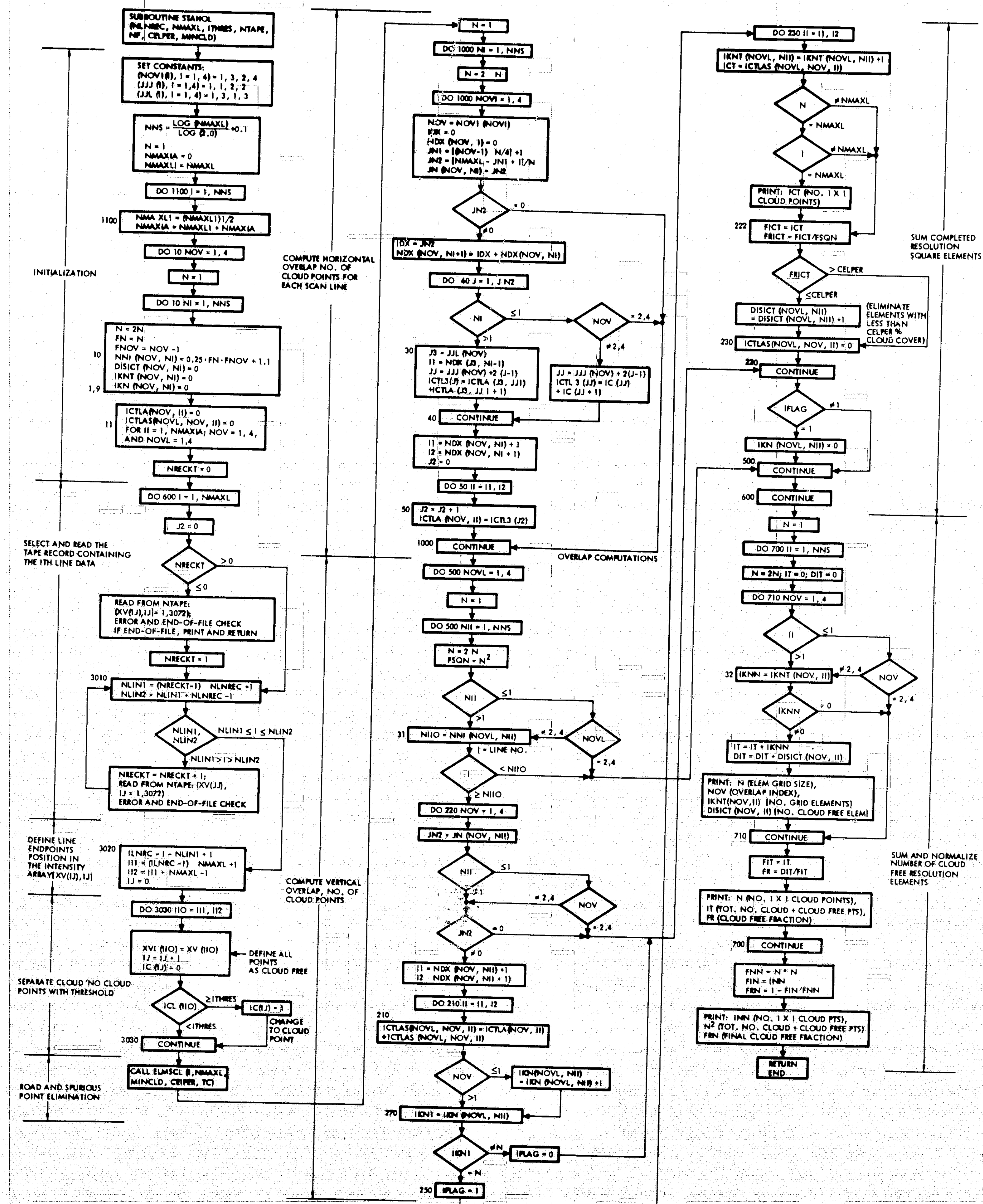


Figure B-2. Cloud Statistics Computation Routine (Subroutine STAHOL)

Table B-2. Cloud Statistics Program Input Data Format

Card Sequence	Variable Description	FORTRAN Nomenclature	Format
1	a. Vertival origin of resolution element in intensity grid (use 1)	IPOS	12I6
	b. Horizontal origin of resolution element in intensity grid (use 1)	IPOS	
	c. Number of horizontal and vertical resolution elements (use 1, 1)	NH, NV	
	d. Resolution element linear point length (number of points per line)	NG	
	e. *Number of lines (intensity points) per input tape record	NLNREC	
	f. A special logic dummy variable to be used for program expansion	IWMODE	
	g. Cloud/background threshold intensity	ITHRES	
	h. Number of scan lines per digitized picture	NMAXL	
	i. Maximum permissible percentage FOV cloud area defined as cloud-free	NELPER	
	j. Minimum permissible cloud length or road length or spurious point length	MINCLD	

*Several lines may be packed in one input tape record and the Information International (Los Angeles, Calif.) digitization process usually uses 3072 points per record.

Table B-2. Cloud Statistics Program Input Data Format (Continued)

Card Sequence	Variable Description	FORTRAN Nomenclature	Format
2	a. Tape unit number which contains intensity point input data	NTAPE	3I6
	b. File number of the picture to be processed	NF	
	c. A dummy variable for future use (use 1)	NPACK	
	d. Problem identification title	CASE	15A4
Comment	This concludes the data for the first case. For additional cases, the following cards must be added for each case	Comment	Comment
3 etc.	a. For an additional case use the same value used at card location (2b). If NF ≤ 0, return to card location (1a.) or the end of the data set.	NF	2I6
	b. See (1g)	ITHRES	
	c. See (1i)	NELPER	2I3
	d. See (1j)	MINCLD	
	e. See (2d)	CASE	15A4

NNI (NOV, NNI) = number of whole resolution element lengths for a line length as a function of overlap type (NOV) and resolution size index, NI.

The rather large "DO LOOP" terminating at 600 computes the number of cloud-free resolution elements for the entire FOV as a function of resolution element size. Index I refers to the Ith scan line.

The section of routine, starting at DO 600 and up to statement number 3020, performs the following functions:

1. Counts the number of tape records (NRECKT) which have been read

2. Computes the first (NLIN1) and last (NLIN2) scan line numbers in the last record read into core

3. Continues to read records until the record containing the Ith scan line is located i.e. until

$$NLIN1 \leq I \leq NLIN2$$

4. Prints diagnostic messages and data if a tape read error is encountered.

5. Reads the six bit word intensity data as 1 byte - 8 bit Logical *1 variables

If the program successfully locates and reads the desired scan line data, at statement number 3020, the first and last position subscripts of the Ith line in the intensity point array (XV) is computed as II1 and II2. This is necessary because each record contains NLNREC scan lines.

Next, in the DO LOOP 3030, the intensity points variables are transformed from Logical *1 variables (XV) to Logical *4 variables (XVI = ICL), which are necessary for computations. The use of Logical *1 variables was an intermediate step required to read the 6-bit format which is not directly compatable with the IBM 32-bit word configuration. After initializing the cloud indicator array IC (cloud = 1, clear = 0) to all clour-free points, the points intensities (ICL) are compared with the threshold intensity (ITHRES) and cloud points are redefined as ones in the IC array. The direction of the threshold inequality is reversed for positive and negative film.

Then subroutine EMSCL is called to convert roads and spurious points misabled as clouds into clear points (zeros) in the IC array.

After point elimination, the DO 1000 LOOP computes the cloud point accumulative contribution to the horizontal overlap resolution elements. It starts by computing the first resolution elements first point location in the cloud indicator array (IC) and the number (JN2) of whole resolution element lengths in the scan line as a function of the element size (NI) and the horizontal overlap type (NOV). Then the cloud points contributions to the 2 by 2 resolution elements are computed followed by successive summations to compute contributions for the remaining resolution element sizes. These accumulative cloud points are stored in the ICTLA array.

The next program sequence controlled by the loop DO 500 vertical accumulates the scan line data to complete resolution elements and stores the data in the ICTLAS array as the number of cloud points for IIth resolution element size, NOVth horizontal overlap type and the NOVLth vertical overlap type. At statement number 222, the resolution element cloud cover fraction (FRICT) is computed and compared with the minimum threshold cloud fraction (CELPER) for a cloud resolution element. Next, the number of cloud-free resolution elements are stored in the DISICT array as a function of the IIth resolution element size and the NOVLth overlap type. The number of resolution cloud-free elements have been accumulated for all horizontal overlap configurations in the DISICT array.

In the final segment of the program, starting at DO LOOP 700, the number of cloud-free resolution elements is summed as the variable DIT and normalized by the total number of resolution elements FIT. Then the cloud-free percentages are printed as a function of resolution element size.

B.3 SUBROUTINE ELMSCL

This subroutine's logic is relatively easy to follow. It converts the input cloud point array IC into a modified array with the same name by eliminating spurious points and roads (See Figure B-3).

B.4 INPUT AND OUTPUT DATA FORMAT

The format of the input data is described in Table B-2 and the output data format is illustrated in Figure 3-22.

B.5 PROGRAM EXECUTION TIME AND COST PER PICTURE

The program execution time is approximately 1 minute of IBM S360 - Model 85 time for a 512 x 512 grid. The cost is approximate $15 on the IBM system for the 512 x 512 grid.

The corresponding rerunning time for the CDC 924-A Model is approximately 40 times the IBM S360 - Model 85 execution time.

Because of the large number of computations performed by this computer program, it is computationally bound rather than input/output bound.

B.6 PROGRAM LISTINGS

Table B-3 includes a FORTRAN IV type listing of the computer routines as designated in Table B-1.

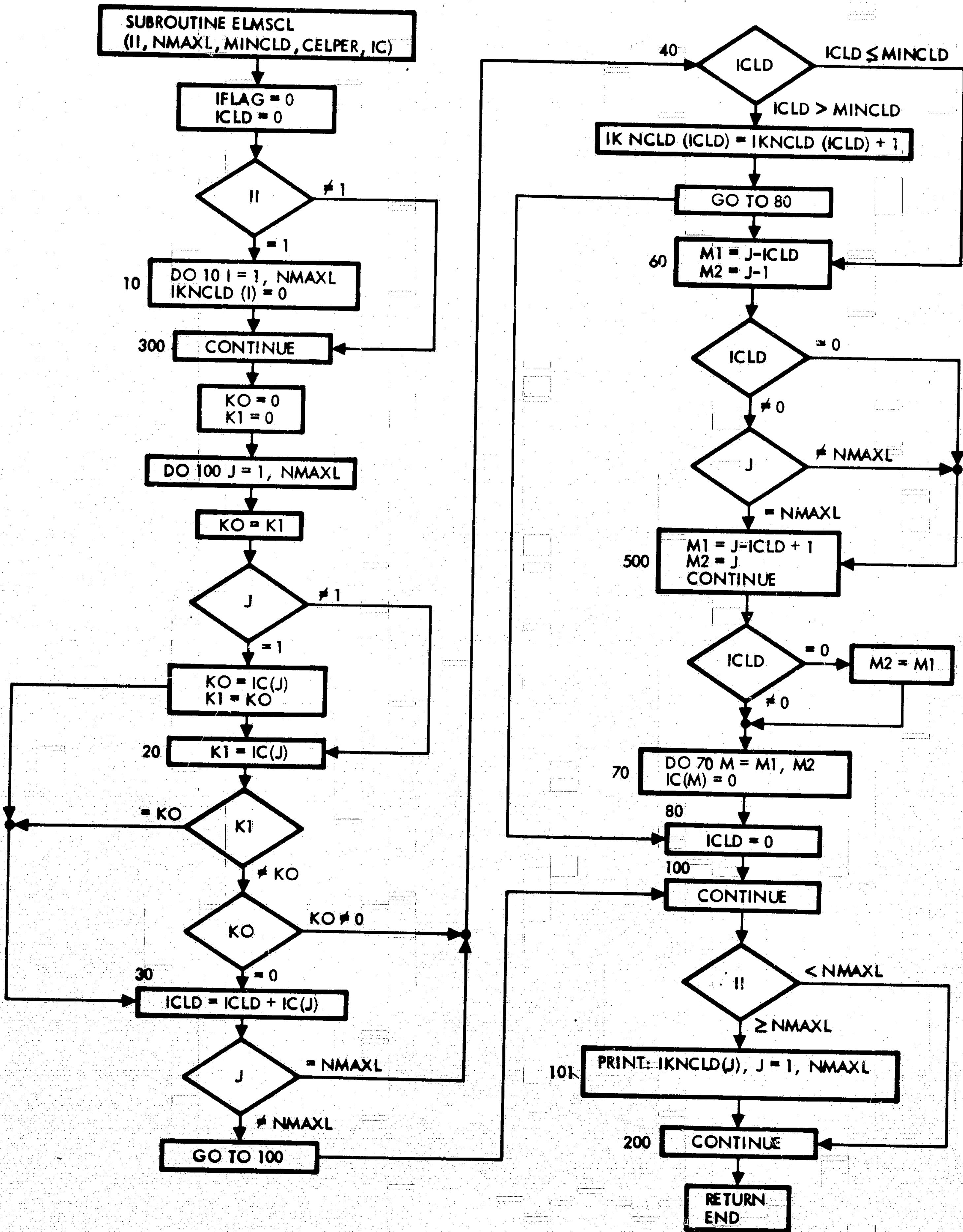


Figure B-3. Road and Spurious Point Elimination Routine
(Subroutine ELMSCL)

Table B-3. Cloud Distribution Statistics (FOV) Program

```
C                MAIN PROGRAM FOR CLOUD DISTRIBUTION STATISTICAL COMPUTATIONS         ==01
C                CLOUD FREE SEEING PROBABILITY VERSUS SENSOR FIELD-OF-VIEW SIZE
C                TAPES INPUT CONTAIN DIGITIZED FILM INTENSITY GRID DATA
C
      DIMENSION  CASE(15)
C
    1 FORMAT (12I6)
    2 FORMAT (3I6, 15A4)
    3 FORMAT ('1', 4X,'VERTICAL', 2X, 'HORIZONTAL', 2X, 'NO. VERTICAL',
     *        2X, 'NO. HORIZONTAL', 2X, 'ELEMENT'/ 5X, 'ORIGIN', 4X,
     *        'ORIGIN',6X, 'ELEMENTS',5X, 'ELEMENTS',6X, 'GRID SIZE'/
     *        (5X, I7, 5X, I5, 7X, I5, 8X, I5, 9X, I5) )
    4 FORMAT ('0', 4X, 'INPUT GRID TAPE UNIT =', I3, 10X,
     *        'TAPE FILE USED =', I4/ 5X, 'PACKING MODE (1-NO/2-YES) =',
     *        I3, 10X, 'NO. LINES/RECORD =', I5)
    5 FORMAT ('0', 4X, 15A4, 5X, I6)
    6 FORMAT (5A4)
    7 FORMAT ('0', 4X, 'THRESHHOLD INTENSITY =', I6,4X,'CLOUD ELIM. (=',
     1I4,'MINIMUN CLOUD POINTS-1=',I4)
C
   10 READ (5, 1, END=9000)  IPOS, JPOS, NH, NV, NG, NLNREC,
     *        IWMODE, ITHRES, NMAXL,NELPER,MINCLD
      READ (5, 2)  NTAPE, NF, NPACK, CASE
      WRITE (6, 3)  IPOS, JPOS, NH, NV, NG
      WRITE (6, 4)  NTAPE, NF, NPACK, NLNREC
      WRITE (6, 5)  CASE
      WRITE (6, 7)  ITHRES,NELPER,MINCLD
      AELPER=NELPER
      CELPER=AELPER*1.0E-2
C
C        LOCATE FILE NF
   11 REWIND NTAPE
      NF1 = NF
      IF  (NF .LE. 1)  GO TO 15
      NENDF = NF - 1
      DO  14  IFL = 1, NENDF
      KT = 0
   12 READ (NTAPE, 6, ERR=13, END=14)  (DUM, I = 1, 5)
      KT = KT + 1
      GO TO 12
   14 CONTINUE
      GO TO 15
C        ERROR EXIT
```

Table B-3. Cloud Distribution Statistics (FOV) Program (Cont)

```
   13 WRITE (6, 16)  IFL, KT                                                    ==02
   16 FORMAT ('0', 4X, 'FILE',I4, ' IS NOT READABLE AT RECORD', I7)
      STOP
C
   15 KT = 1
      IFL = NF
      READ (NTAPE, 6, ERR=333) (DUM, I = 1, 5)
  333 CONTINUE
      GO TO (21, 31), IWMODE
C
   21 CALL STAHOL (NLNREC, NMAXL, ITHRES, NTAPE, NF,CELPER, MINCLD)
      NF1 = NF
      BACKSPACE NTAPE
   22 READ (NTAPE, 6, END=23)  (DUM, I = 1, 5)
      GO TO 22
   23 READ (5, 24, END=9000)  NF, ITHRES, NELPER, MINCLD, CASE
   24 FORMAT (2I6, 2I3, 15A4)
      CELPER = 0.01 * FLOAT (NELPER)
      IF  (NF .LE. 0)  GO TO 10
      WRITE (6, 5)  CASE, NF
      WRITE (6, 7)  ITHRES, NELPER, MINCLD
      NFDEL = NF - NF1
      IF  (NFDEL - 1)  11, 15, 11
C
C        OPTION TO BE ADDED
   31 CONTINUE
      GO TO 10
 9000 STOP
      END                                                          ENDM
      SUBROUTINE STAHOL (NLNREC, NMAXL, ITHRES, NTAPE, NF,
     *                   CELPER, MINCLD)
C
C           COMPUTES CLOUD-FREE SEEING PROBABILITY
C
      LOGICAL * 1  XV(3072)
      LOGICAL * 4  XVI(3072)
      DIMENSION  ICL(3072), IC(1024), NOV1(4), JJJ(4), NB(16),
     *           NNI(4,12), DISICT(4,12), IKNT(4,12), IKN(4,12),
     *           ICTLA(4,1023), ICTLAS(4,4,1023), JN(4,12), JJL(4),
     *           ICTL3(1023), NDX(4,12), TDN(12)
      EQUIVALENCE  (XVI(1), ICL(1) )
C
      DATA NOV1/1,3,2,4/
```

```
      DATA JJJ/1,1,2,2/                                                 ==03
      DATA JJL/1,3,1,3/
 3000 FORMAT (255(6A1), 255(6A1), 2(6A1) )
      FNMAXL=NMAXL
      NNS=(ALOG(FNMAXL)/ALOG(2.0))+0.1
      N=1
      DO 3001 I=1,NNS
      N=2*N
      FNSQ=N*N
      TDN(I)=10.0/FNSQ
 3001 CONTINUE
      NMAXIA=0
      NMAXL1=NMAXL
      DO 1100 I=1,NNS
      NMAXL1=NMAXL1/2
 1100 NMAXIA=NMAXIA+NMAXL1
      DO 10 NOV=1,4
      N=1
      DO 10 NI=1,NNS
      N=2*N
      FN=N
      FNOV=NOV-1
   10 NNI(NOV,NI)=0.25*FN*FNOV+1.1
      DO 1 NOV=1,4
      DO 1 NI=1,NNS
      DO 1 L=1,11
    1 DISICT(NOV,NI )=0.0
      DO 9 NOV=1,4
      DO 9 L=1,NNS
      IKNT(NOV,L)=0.0
    9 IKN(NOV,L)=0
      DO 11 NOVL=1,4
      DO 11 NOV=1,4
      DO 11 II=1,NMAXIA
      ICTLA(NOV,II)=0
   11 ICTLAS(NOVL,NOV,II)=0
C
      NRECKT = 0
      DO  600  I = 1, NMAXL
      J2=0
      IF  (NRECKT .GT. 0)  GO TO 3010
      READ (NTAPE, 3000, ERR=3002, END=3090)  (XV(IJ), IJ = 1, 3072)
      NRECKT = 1
```

Table B-3. Cloud Distribution Statistics (FOV) Program (Cont)

```
      GO TO 3010                                                                ==04
 3002 WRITE (6, 3003)  NF, NRECKT
 3003 FORMAT ('0', 5X, 'FILE', I4, ' IS NOT READABLE, RECORD IS', I5)
      STOP
C        COMPUTE INDICES OF LINES IN RECORD
 3010 NLIN1 = (NRECKT - 1) * NLNREC + 1
      NLIN2 = NLIN1 + NLNREC - 1
      IF  (NLIN1 .LE. I .AND. I .LE. NLIN2)  GO TO 3020
      NRECKT = NRECKT + 1
      READ (NTAPE, 3000, ERR=3002, END=3090)  (XV(IJ), IJ = 1, 3072)
      GO TO 3010
C        PICK UP ELEMENTS OF I-TH LINE
 3020 ILNRC = I - NLIN1  + 1
C        DEFINE CLOUDS WITH IC COMPARED TO THRECHHOLD INTENSITY,
C        WHERE IC = 0, CLEAR AND IC = 1, CLOUD.
      II1 = (ILNRC - 1) * NMAXL + 1
      II2 = II1 + NMAXL - 1
      IJ = 0
      DO  3030  II0 = II1, II2
      XVI(II0) = XV(II0)
      IJ = IJ + 1
      IC(IJ) = 0
      IF  (ICL(II0) .GE. ITHRES)  IC(IJ) = 1
 3030 CONTINUE
      CALL ELMSCL( I,NMAXL,MINCLD,CELPER,IC)
C
      N=1
      DO 1000 NI=1,NNS
      N=2*N
      DO 1000 NOVI=1,4
      NOV=NOV1(NOVI)
      IDX=0
      NDX(NOV,1)=0
      JN1=(((NOV-1)*N)/4)+1
      JN2=(NMAXL-(JN1-1))/N
      JN(NOV,NI)=JN2
      IF(JN2.EQ.0) GO TO 1000
      IDX =JN2
      NDX(NOV,NI+1)=IDX+NDX(NOV,NI)
      DO 40 J=1,JN2
      IF(NI.GT.1) GO TO 30
      IF(NOV.EQ.2) GO TO 1000
      IF(NOV.EQ.4) GO TO 1000
```

Table B-3. Cloud Distribution Statistics (FOV) Program (Cont)

```
      JJ=JJJ(NOV)+2*(J-1)                                              ==05
      ICTL3(J)=IC(JJ)+IC(JJ+1)
      GO TO 40
   30 J3=JJL(NOV)
      I1=NDX(J3,NI-1)
      JJ=JJJ(NOV)+2*(J-1)
      JJ1=I1+JJ
      ICTL3(J)=ICTLA(J3,JJ1)+ICTLA(J3,JJ1+1)
   40 CONTINUE
      I1=NDX(NOV,NI)+1
      I2=NDX(NOV,NI+1)
      J2=0
      DO 50  II=I1,I2
      J2=J2+1
   50 ICTLA(NOV,II)=ICTL3(J2)
 1000 CONTINUE
      DO 500 NOVL=1,4
      N=1
      DO 500 NII=1,NNS
      N=2*N
      FSQN=N*N
      IF(NII.GT.1) GO TO 31
      IF(NOVL.EQ.2) GO TO 500
      IF(NOVL.EQ.4) GO TO 500
   31 CONTINUE
      NIIO=NNI(NOVL,NII)
      IF(I.LT.NIIO) GO TO 500
      DO 220 NOV=1,4
      JN2=JN(NOV,NII)
      IF(NII.GT.1) GO TO 33
      IF(NOV.EQ.2) GO TO 220
      IF(NOV.EQ.4) GO TO 220
   33 CONTINUE
      IF(JN2.EQ.0) GO TO 220
      I1=NDX(NOV,NII)+1
      I2=NDX(NOV,NII+1)
      DO 210 II=I1,I2
      ICTLAS(NOVL,NOV,II)=ICTLAS(NOVL,NOV,II)+ICTLA(NOV,II)
  210 CONTINUE
      IF(NOV.GT.1) GO TO 270
      IKN(NOVL,NII)=IKN(NOVL,NII)+1
  270 CONTINUE
      IKN1=IKN(NOVL,NII)
```

Table B-3. Cloud Distribution Statistics (FOV) Program (Cont)

==06

```
      IF(IKN1.EQ.N) GO TO 250
      IFLAG=0
      GO TO 220
  250 CONTINUE
      IFLAG=1
      DO 230 II=I1,I2
      IKNT(NOVL,NII)=IKNT(NOVL,NII)+1
       ICT=ICTLAS(NOVL,NOV,II)
       IF(N.NE.NMAXL) GO TO 222
       IF(I.NE.NMAXL) GO TO 222
      WRITE (6, 9001)  ICT
 9001 FORMAT (6X, 'NUMBER OF 1X1 CLOUD POINTS =', I12)
      INN=ICT
  222 CONTINUE
      FICT=ICT
      FRICT=FICT/FSQN
C
C             TEST FOV CLOUD FREE PERCENTAGE (FRICT) AND DEFINE AS
C             CLOUD FREE IF LESS THEN PRESELECTED VALUE (CELPER).
      IF(FRICT.GT.CELPER) GO TO 240
      DISICT(NOVL,NII)=DISICT(NOVL,NII)+1.0
  240 CONTINUE
  230 ICTLAS(NOVL,NOV,II)=0
  220 CONTINUE
      IF(IFLAG.NE.1) GO TO 500
      IKN(NOVL,NII)=0
  500 CONTINUE
  600 CONTINUE
      N=1
      DO 700 II=1,NNS
      N=2*N
      IT=0
      DIT=0
      WRITE (6, 9002)
 9002 FORMAT (6X, 'ELEMENT GRID SIZE', 3X, 'OVERLAP INDEX', 7X,
     *        'NO. GRID ELEMENTS', 3X, 'NO. CLOUD FREE ELEMENTS')
      DO 710 NOV=1,4
      IF(II.GT.1) GO TO 32
      IF(NOV.EQ.2) GO TO 710
      IF(NOV.EQ.4) GO TO 710
   32 CONTINUE
      IKNN=IKNT(NOV,II)
      IF(IKNN.EQ.0) GO TO 710
```

Table B-3. Cloud Distribution Statistics (FOV) Program (Cont)

```
      IT=IT+IKNN                                                        ==07
      DIT=DIT+DISICT(NOV,II)
      WRITE(6,2010)  N,NOV,IKNT(NOV,II), DISICT(NOV,II)
 2010 FORMAT (6X, I10, 9X, I10, 10X, I10, 14X, F12.5)
  710 CONTINUE
      FIT=IT
      FR=DIT/FIT
      WRITE(6,211) N,IT,FR
  211 FORMAT (6X, 'NO. 1X1 CLOUD POINTS =', I12, 6X,
     *        'TOT. NO. CLOUD + CLOUD FREE PTS =', I12/
     *        6X, 'CLOUD FREE FRACTION =', F12.5)
  700 CONTINUE
      NSQ=N*N
      FNN=NSQ
       FIN=INN
      FRN=FIN/FNN
      FRN=1.0-FRN
      WRITE(6,211) INN,NSQ,FRN
      RETURN
 3090 WRITE (6, 3091)  NF, NRECKT
 3091 FORMAT ('0', 4X, 'NO. RECORDS IN FILE', I4, ' IS', I5)
      RETURN
      END                                                     ENDS1
      SUBROUTINE ELMSCL (II,NMAXL, MINCLD,CELPER, IC)
C
C             ELIMINATES ROADS AND SPURIOUS POINTS
C
      DIMENSION  IC(1024), IKNCLD(1024)
C        THIS ROUTINE COMPUTES THE CLOUD SIZE DISTRIBUTION
C
      IFLAG = 0
      ICLD = 0
      IF(II.NE.1) GO TO 300
      DO  10  I = 1, NMAXL
   10 IKNCLD(I) = 0
  300 CONTINUE
C
      KO=0
      K1=0
      DO  100  J = 1, NMAXL
      KO=K1
      IF  (J .NE. 1)  GO TO 20
      KO = IC(J)
```

Table B-3. Cloud Distribution Statistics (FOV) Program (Cont)

```
      K1=K0                                                    ==08
      GO TO 30
   20 K1 = IC(J)
      IF  (K1 - K0 .EQ. 0)  GO TO 30
      IF  (K0 .NE. 0)  GO TO 40
   30 ICLD = ICLD + IC(J)
      IF(J.EQ.NMAXL) GO TO 40
      GO TO 100
   40 IF  (ICLD .LE. MINCLD)  GO TO 60
      IKNCLD(ICLD) = IKNCLD(ICLD) + 1
      GO TO 80
   60 M1 = J - ICLD
      M2 = J - 1
      IF(ICLD.EQ.0) GO TO 500
      IF(J.NE.NMAXL) GO TO 500
      M1=J-ICLD+1
      M2=J
  500 CONTINUE
      IF(ICLD.EQ.0) M2=M1
      DO  70  M = M1, M2
   70 IC(M) = 0
   80 ICLD = 0
  100 CONTINUE
      IF(II.LT.NMAXL) GO TO 200
      WRITE (6, 101)  (IKNCLD(J), J = 1, NMAXL)
  101 FORMAT ('0', 10X, 'CLOUD SIZE DISTRIBUTION FUNCTION'/
     *          (2X, 16I6) )
  200 CONTINUE
      RETURN
      END
                                                 ENDS2
```

APPENDIX C. SINGLE LOOK PROBABILITY OF SEEING RESULTS

SAMPLE OUTPUT

Perfect Resolution Probability of Seeing Computer Program

Subroutine: Single-Look Viewing (Seeing Prescribed Amount in Single-Look)

Cloud Statistics: Basic 30-nm FOV Enlarged for 100-nm FOV

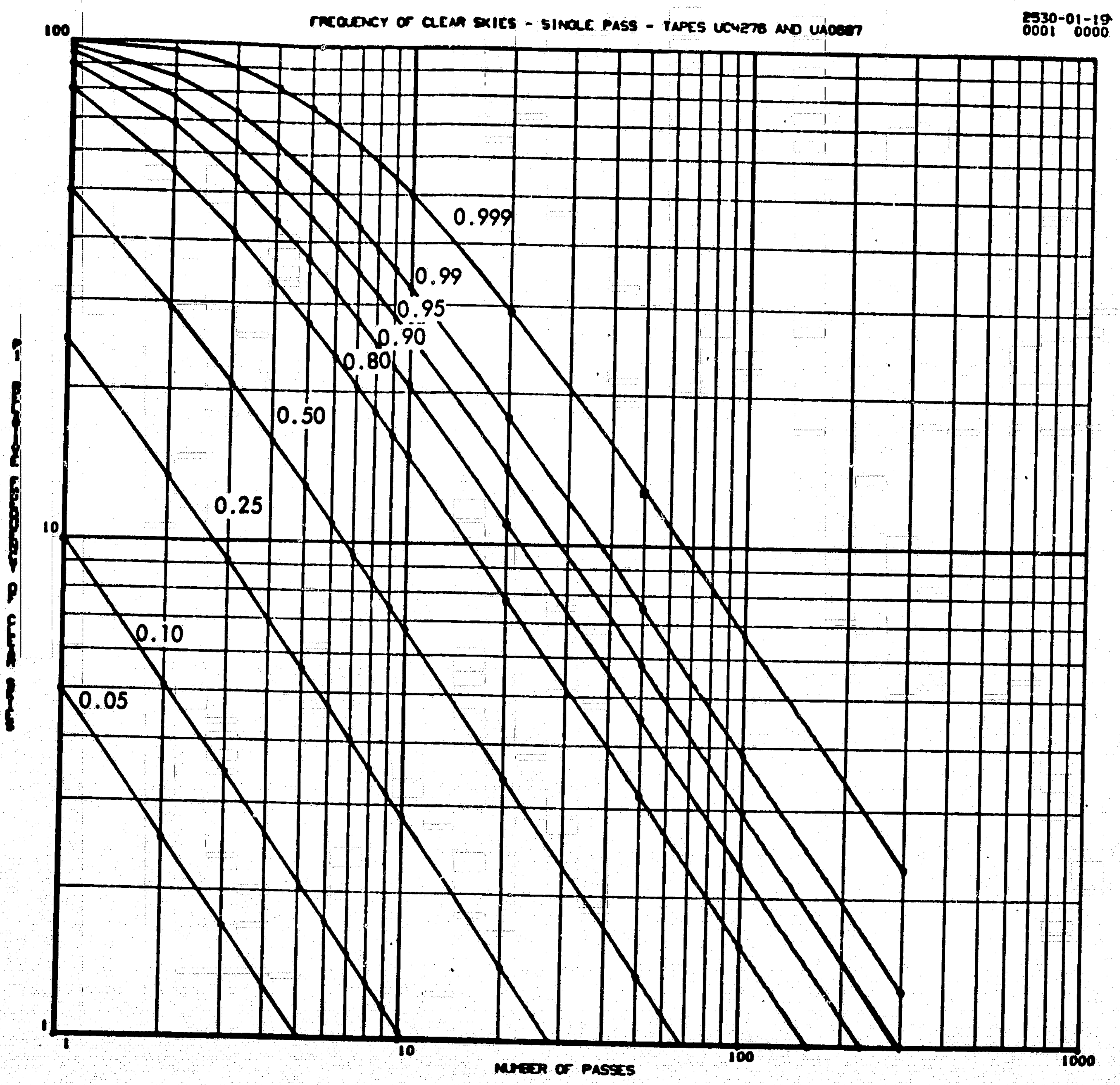
Computed Relationship: The relationship between the probability of seeing* all of an area and a given number of satellite passes over the area. Required input is the relative frequency of clear skies over the area. Output may be either CRT plot (as in sample) or tables of relationship.

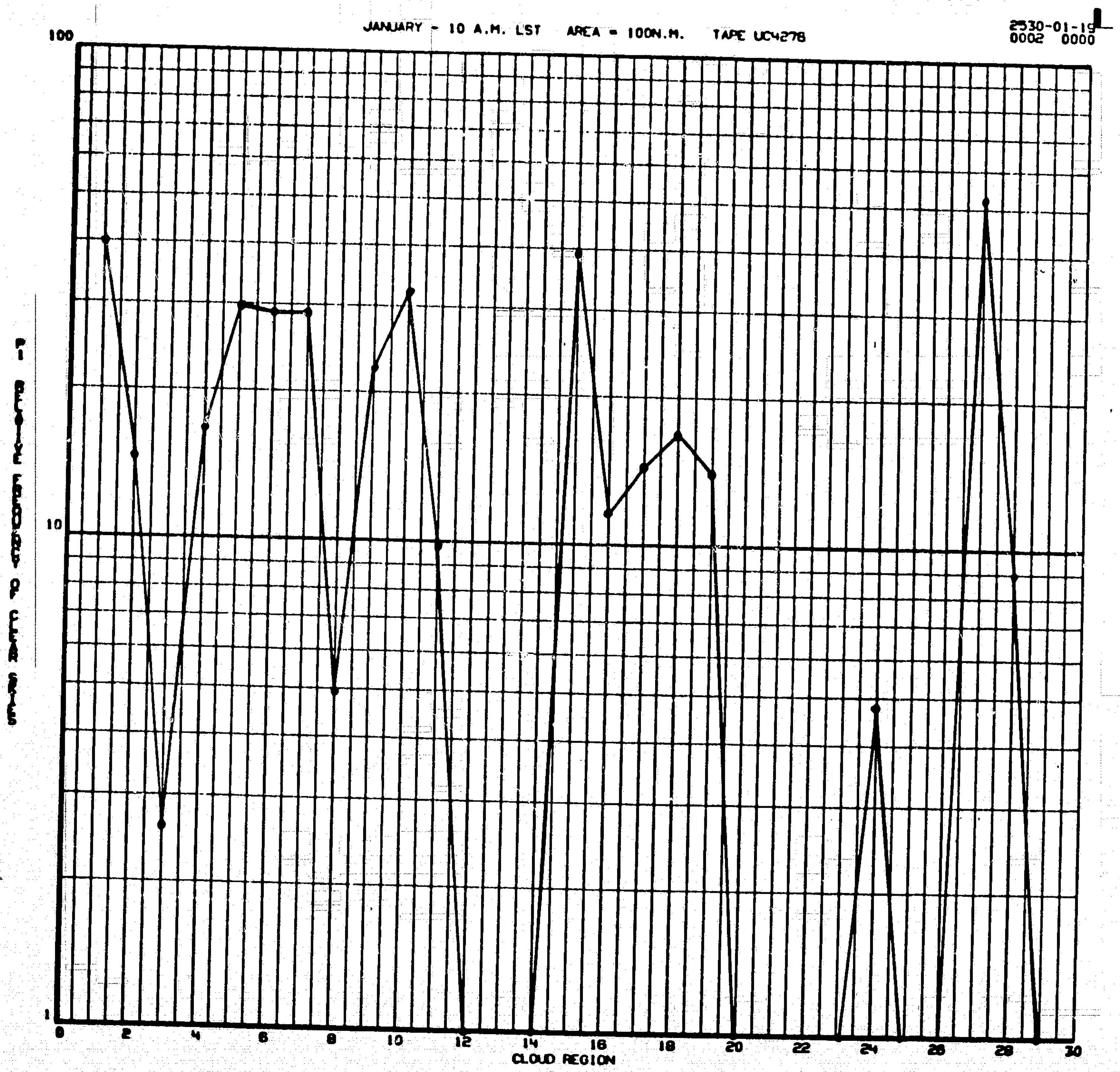
Sample Output: Page C-2: Nomogram demonstrating relationship among selected probabilities (frequency of clear skies-single pass), number of passes, and the relative frequency of clear skies.

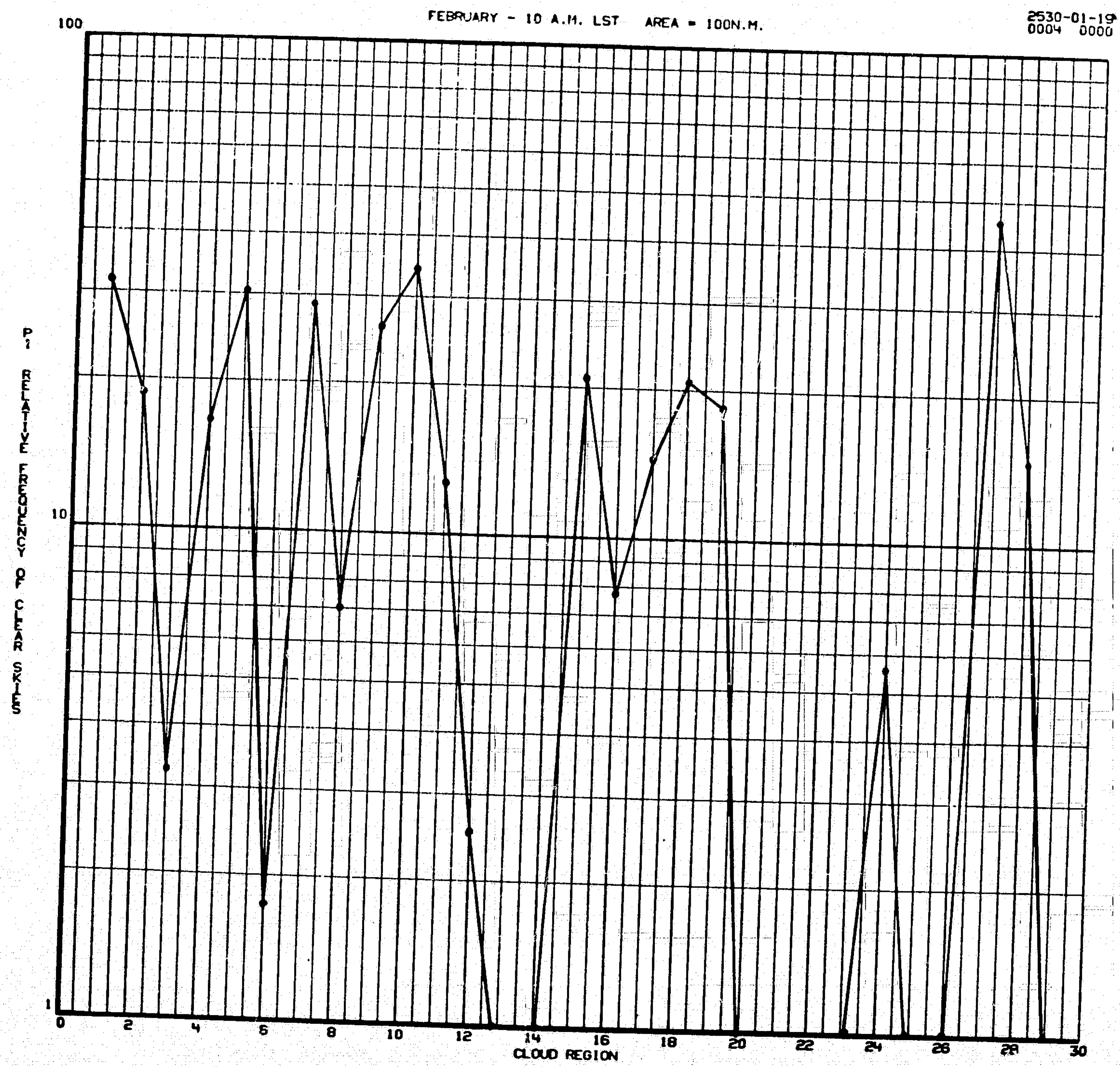
Page C-3: Relative frequency of clear skies for areas of 100 n miles by 100 n miles, all 29 homogeneous cloud regions, January, 1000 LST.

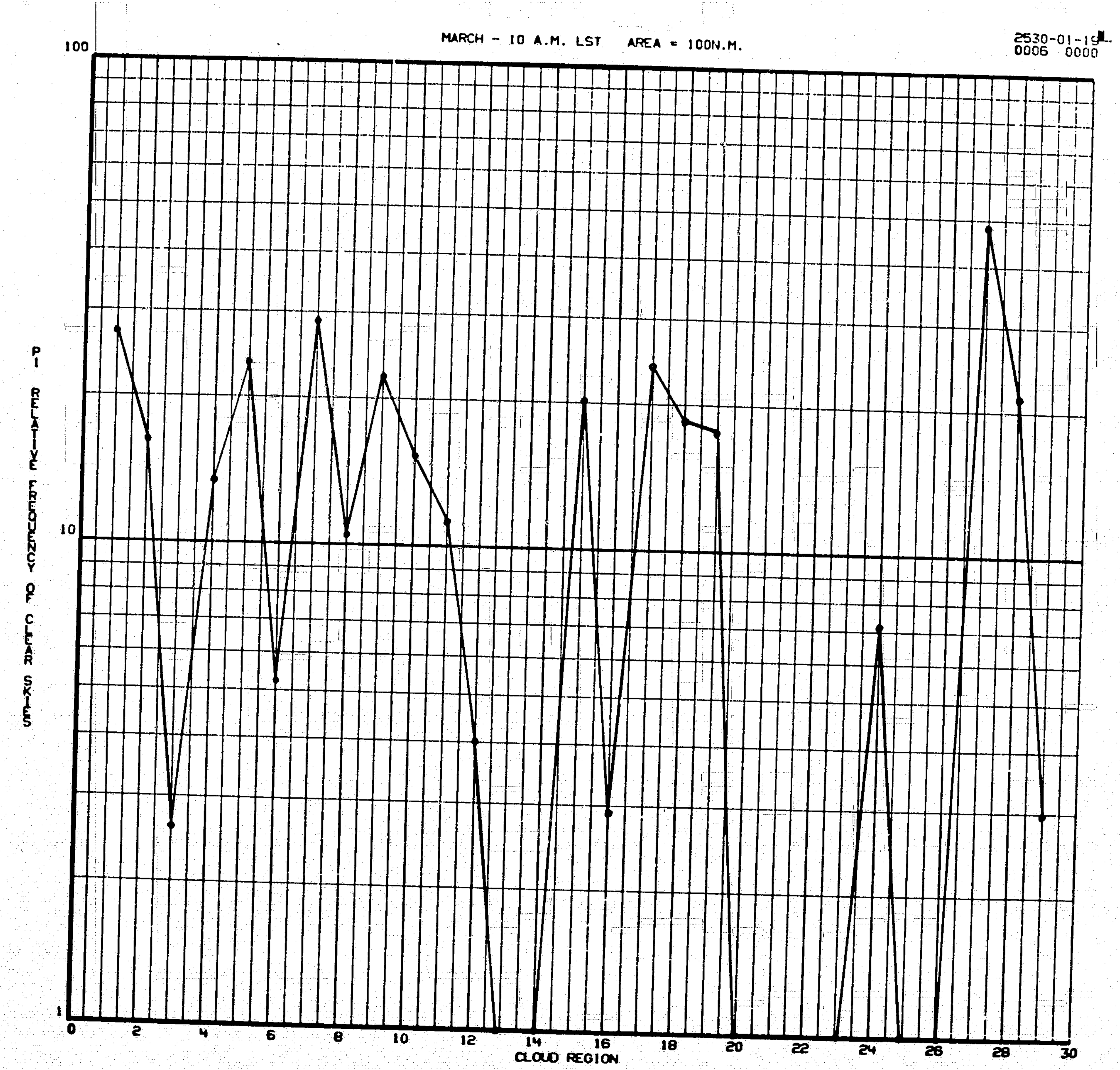
Other pages in section: Same as second page for every month.

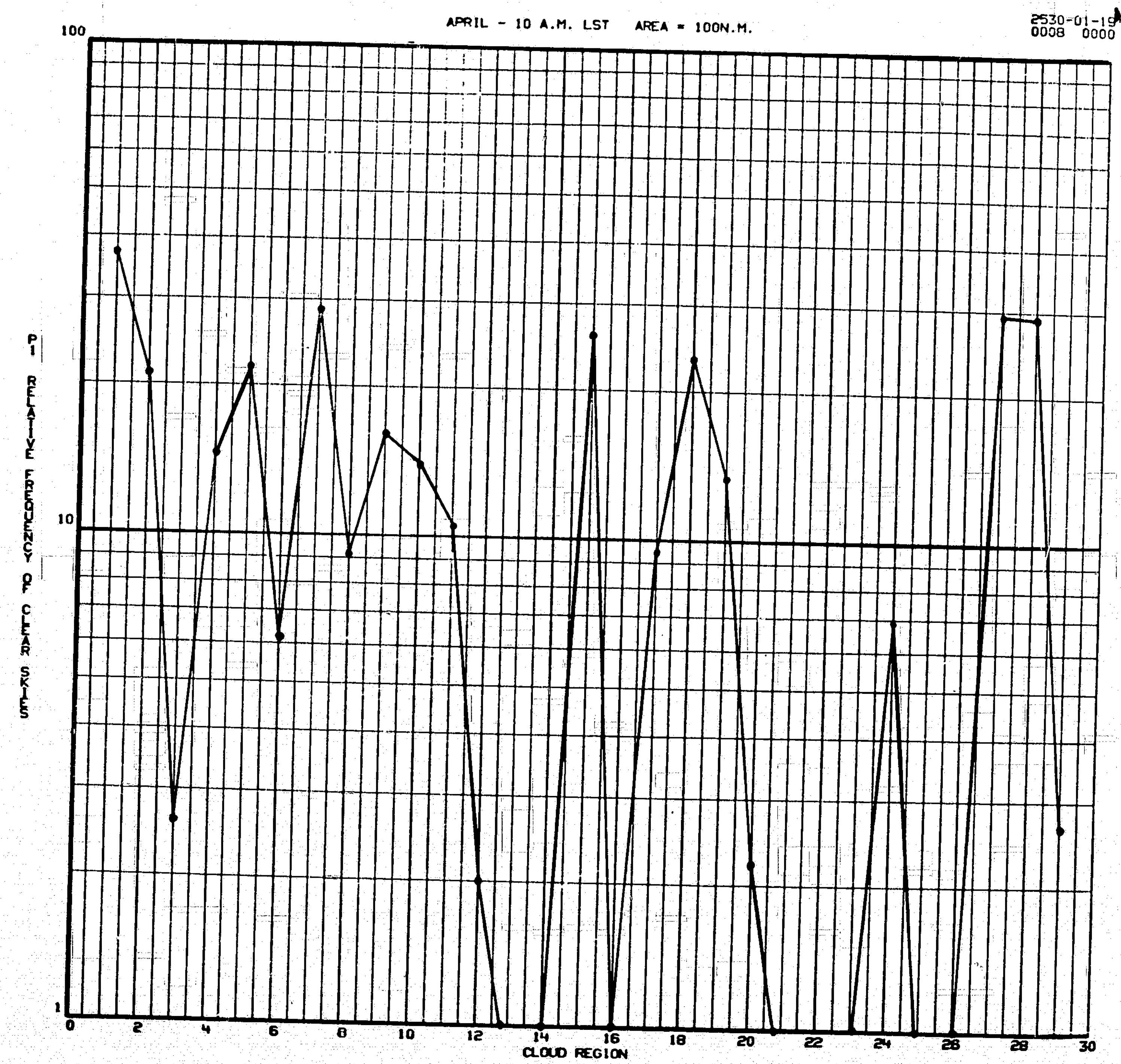
*"All in this concept refers to the definition of clear skies, i.e., if clear skies are less than 10 percent sky cover, "all" would be > 90 percent. The same nomogram is applicable to use of seeing in a single look more than "X" percent of an area with "Y" frequency of cloud cover $\leq$ (1-X) percent.


FREQUENCY OF CLEAR SKIES - SINGLE PASS - TAPES UC4278 AND UA0687
2530-01-19
0001 0000
100
10
1
0.999
0.99
0.95
0.90
0.80
0.50
0.25
0.10
0.05
1
10
100
1000
NUMBER OF PASSES


JANUARY - 10 A.M. LST AREA = 100N.M. TAPE UC4278
2530-01-19
0002 0000
100
10
1
% RELATIVE FREQUENCY OF CLEAR SKIES
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
CLOUD REGION


FEBRUARY - 10 A.M. LST AREA = 100N.M.
2530-01-19
0004 0000
100
10
1
P
RELATIVE FREQUENCY OF CLEAR SKIES
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
CLOUD REGION


MARCH - 10 A.M. LST AREA = 100N.M.
2530-01-19
0006 0000
100
10
1
PI RELATIVE FREQUENCY OF CLEAR SKIES
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
CLOUD REGION


APRIL - 10 A.M. LST AREA = 100N.M.
2530-01-19
0008 0000
100
10
1
PI RELATIVE FREQUENCY OF CLEAR SKIES
0
2
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6
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12
14
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22
24
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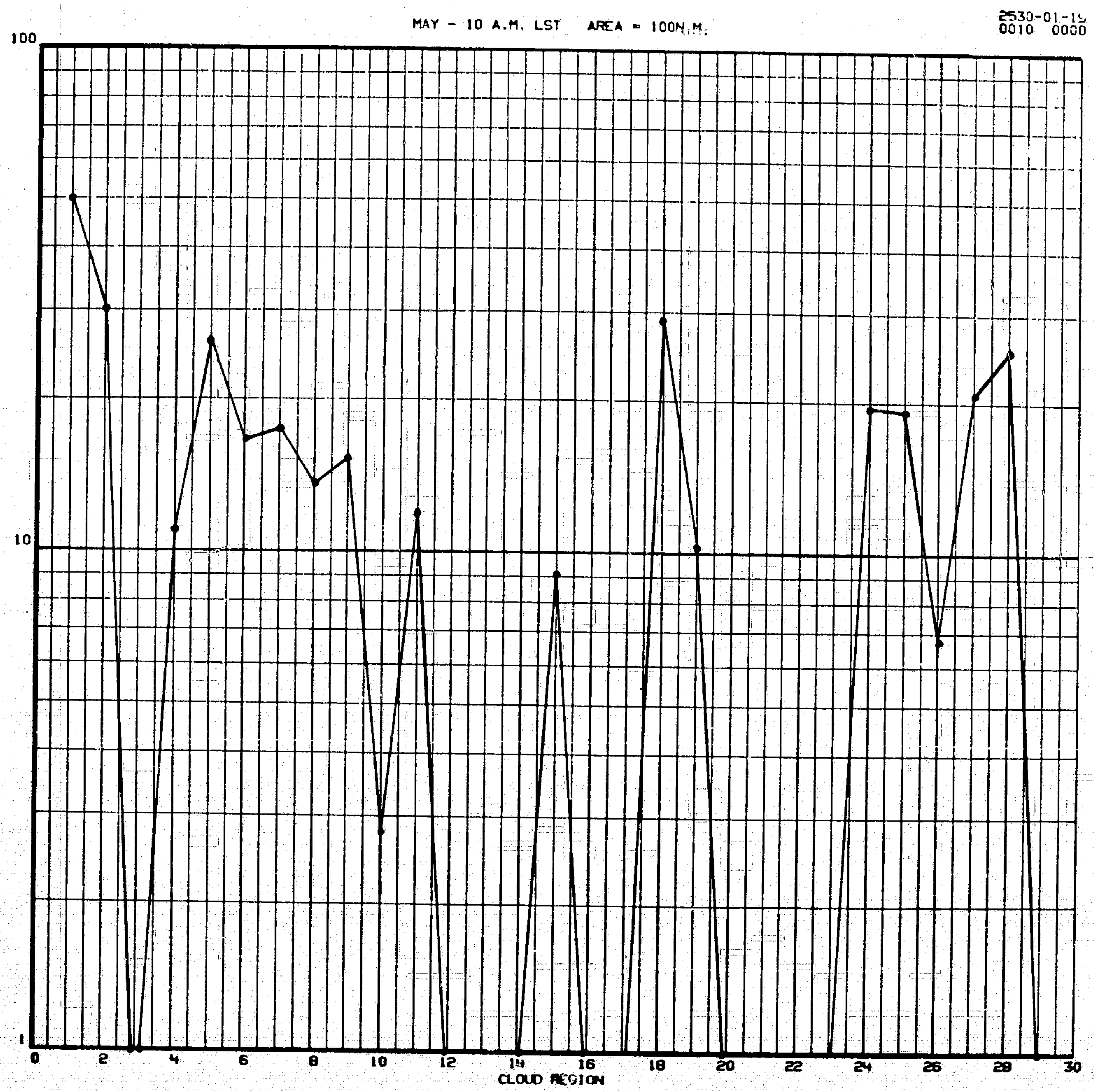
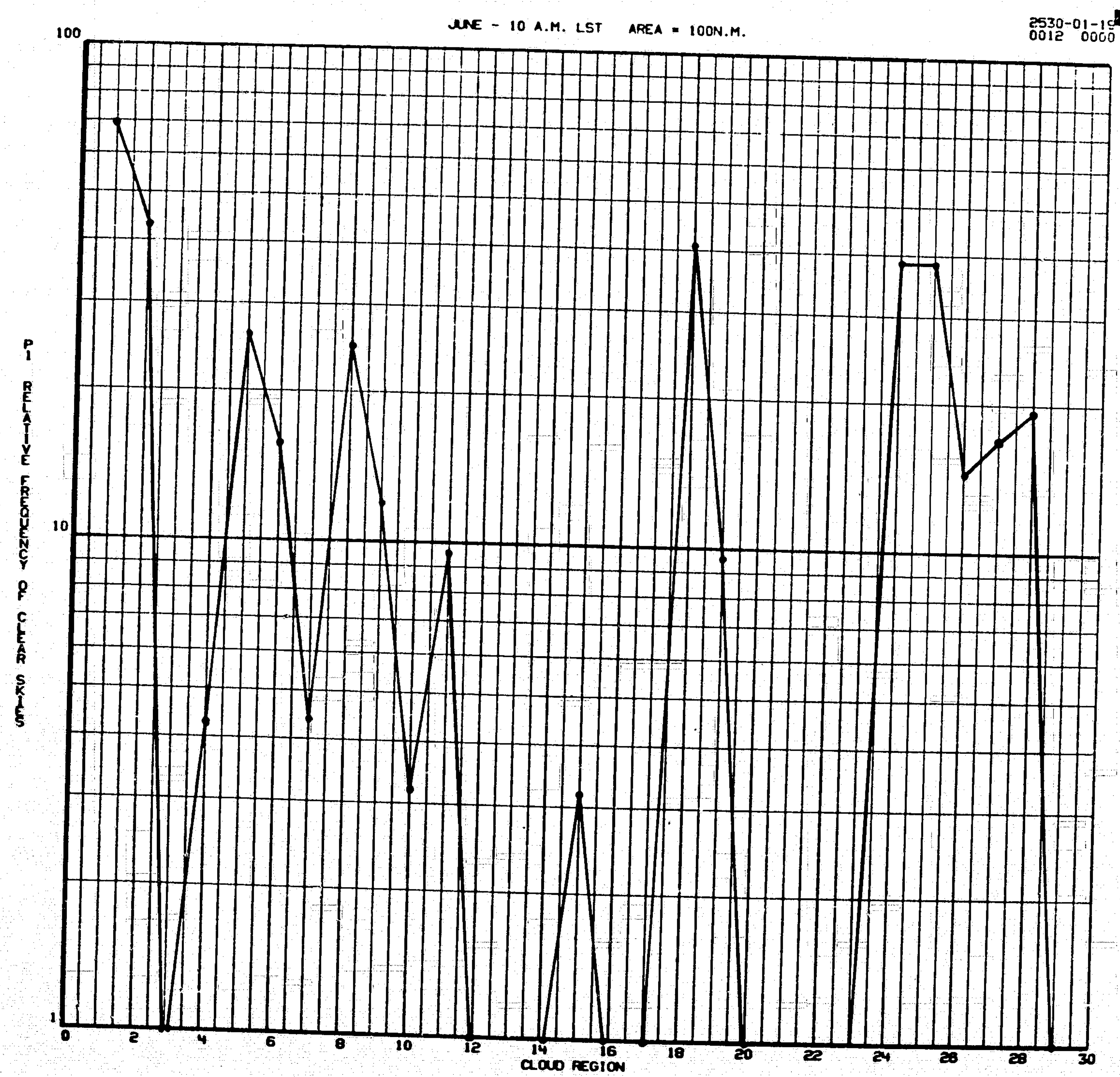
28
30
CLOUD REGION


MAY - 10 A.M. LST AREA = 100N.M.
2530-01-15
0010 0000
100
10
1
PI RELATIVE FREQUENCY OF CLEAR SKIES
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
CLOUD REGION


JUNE - 10 A.M. LST AREA = 100N.M.
2530-01-19
0012 0000
100
10
1
PI RELATIVE FREQUENCY OF CLEAR SKIES
0
2
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24
26
28
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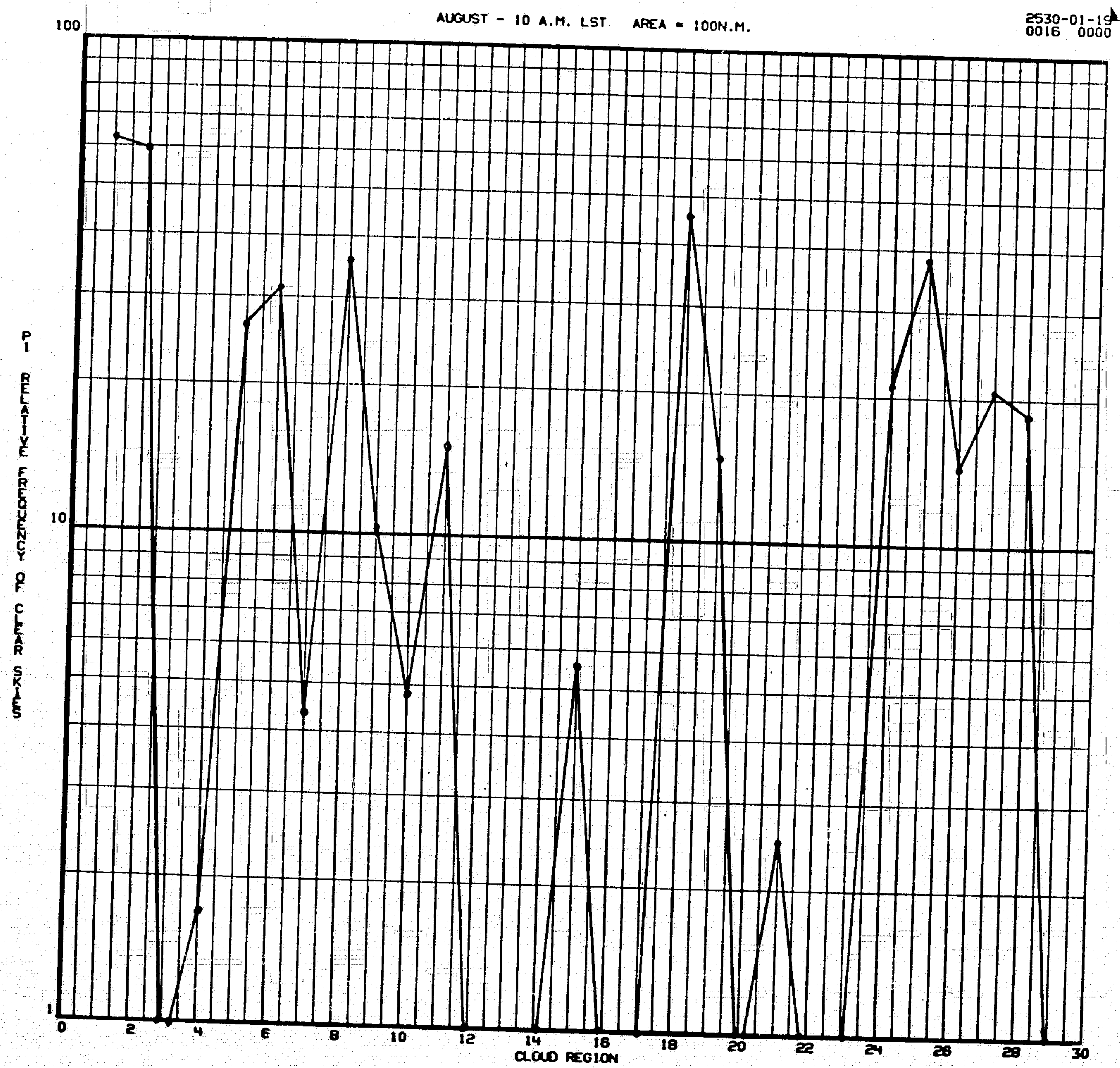
CLOUD REGION


JULY - 10 A.M. LST AREA = 100N.M.
2530-01-19
0014 0000
100
10
1
PI RELATIVE FREQUENCY OF CLEAR SKIES
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
CLOUD REGION


AUGUST - 10 A.M. LST AREA = 100N.M.
2530-01-19
0016 0000
100
10
1
PI RELATIVE FREQUENCY OF CLEAR SKIES
0
2
4
6
8
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12
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16
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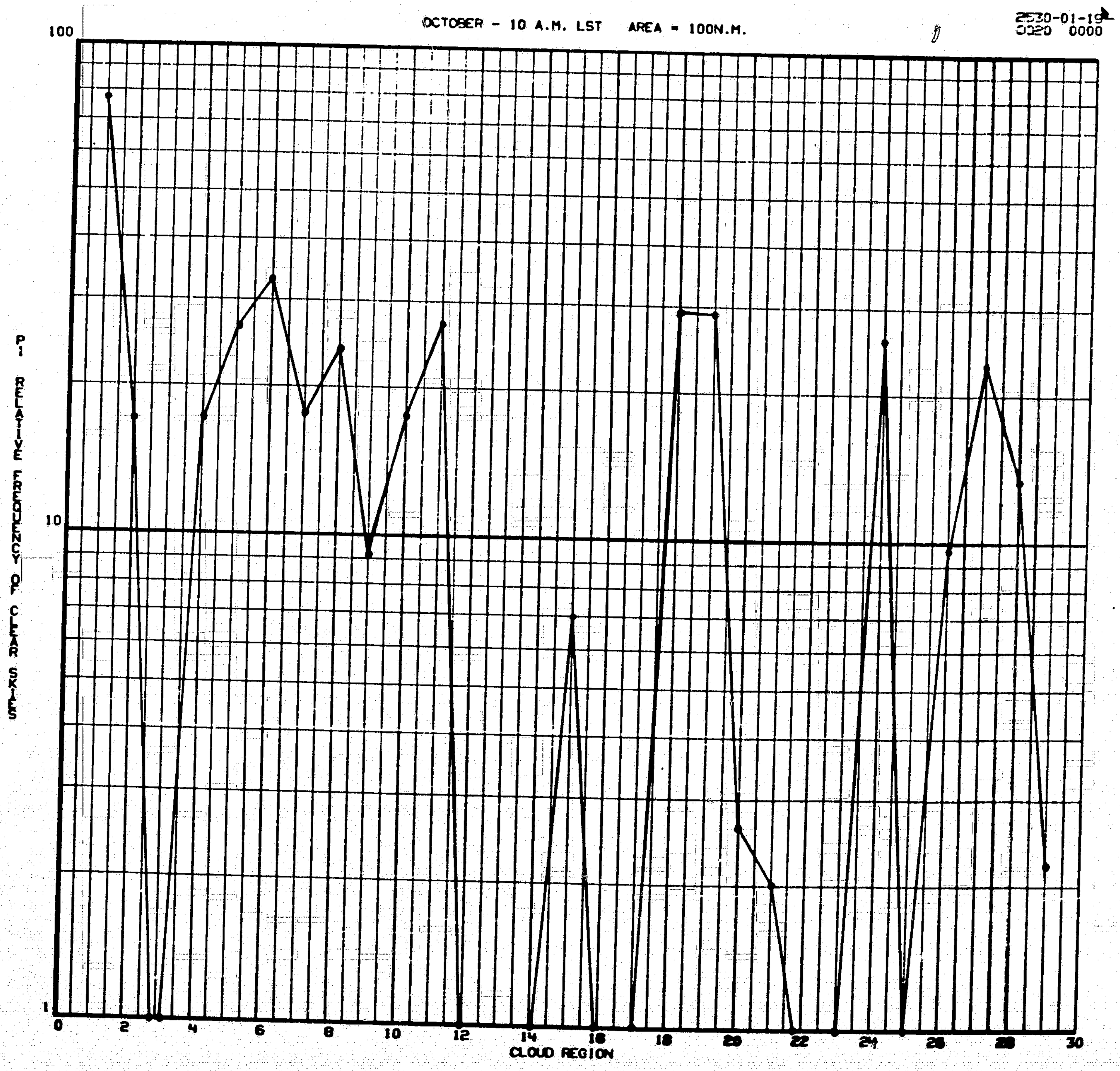
20
22
24
26
28
30
CLOUD REGION


SEPTEMBER - 10 A.M. LST AREA = 100N.M.
2530-01-19
0018 0000
100
10
1
PI RELATIVE FREQUENCY OF CLEAR SKIES
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
CLOUD REGION


OCTOBER - 10 A.M. LST AREA = 100N.M.
2530-01-19
0020 0000
100
10
1
PI RELATIVE FREQUENCY OF CLEAR SKIES
0
2
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16
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22
24
26
28
30
CLOUD REGION


NOVEMBER - 10 A.M. LST AREA = 100N.M.
2530-01-19
0022 0000
100
10
1
PI RELATIVE FREQUENCY OF CLEAR SKIES
0
2
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6
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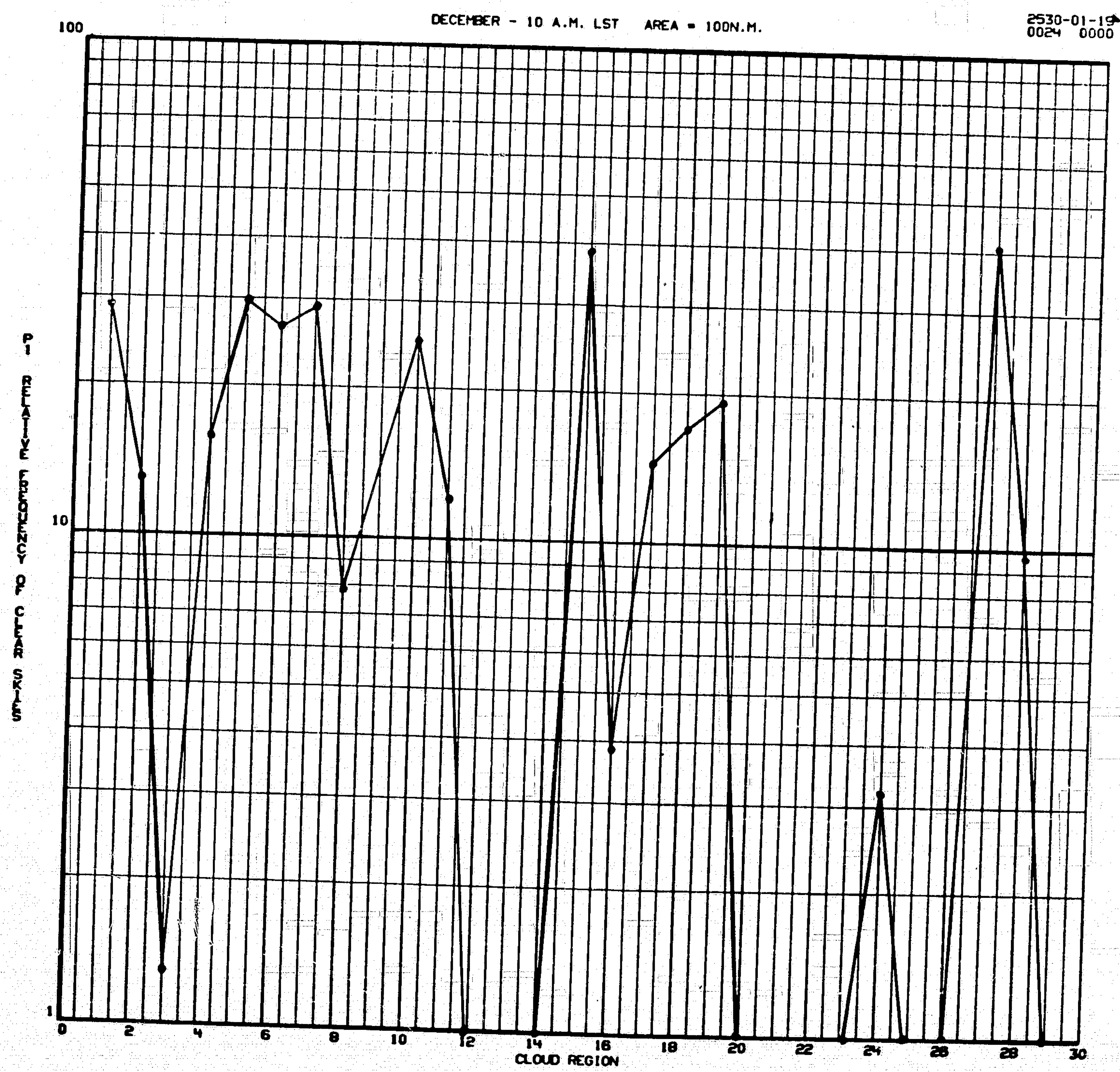
CLOUD REGION


DECEMBER - 10 A.M. LST AREA = 100N.M.
2530-01-19
0024 0000
PI RELATIVE FREQUENCY OF CLEAR SKIES
100
10
1
0
2
4
6
8
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12
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24
26
28
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CLOUD REGION

APPENDIX D. ONE- OR TWO-LOOK PROBABILITY OF SEEING RESULTS

SAMPLE OUTPUT

Perfect Resolution Probability of Seeing Computer Program

Subroutine:	One- or Two-Look Viewing
Cloud Statistics:	Basic 30-nm FOV Enlarged for 100-nm FOV
Sample Output:	Pages D-2 through D-33: Tables of probability of seeing X percent or more of a 100-nm area in one or two looks in N independent passes for 29 worldwide homogeneous cloud regions. Data given for N = 1 through 20, for months 1, 4, 7, 10 (Jan, Apr, Jul, Oct), for times 4, 8 (1000, 2200 LST), and for seeing 50, 70, 90, and 95 percent or more of the area.

PROBABILITY OF SEEING 50. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 1 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	73.4	93.6	98.5	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	46.6	76.1	90.2	96.2	98.5	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	34.7	62.1	79.4	89.3	94.6	97.3	98.7	99.4	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
4	55.2	81.9	93.1	97.5	99.1	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	50.8	77.0	89.6	95.4	98.0	99.1	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	58.0	84.4	94.6	98.2	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	58.0	84.4	94.6	98.2	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8	21.2	40.5	56.4	68.7	77.9	84.6	89.4	92.7	95.1	96.7	97.8	98.5	99.0	99.3	99.6	99.7	99.8	99.9	99.9	99.9
9	42.8	68.1	82.5	90.6	95.0	97.3	98.6	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
10	63.4	87.9	96.2	98.9	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	28.3	50.7	67.1	78.5	86.2	91.2	94.5	96.6	97.9	98.7	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
12	47.1	78.5	92.1	97.3	99.1	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
13	23.4	45.7	63.3	76.0	84.6	90.3	94.0	96.3	97.8	98.6	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
14	11.2	27.7	44.1	58.2	69.5	78.2	84.6	89.2	92.6	94.9	96.5	97.6	98.4	98.9	99.3	99.5	99.7	99.8	99.9	99.9
15	70.1	91.3	97.5	99.3	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
16	72.3	93.6	98.7	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
17	58.1	85.4	95.3	98.6	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
18	36.6	62.7	79.0	88.6	93.9	96.8	98.4	99.2	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	30.3	53.3	69.6	80.6	87.8	92.5	95.4	97.2	98.3	99.0	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
20	33.9	60.1	77.2	87.4	93.2	96.4	98.1	99.0	99.5	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
21	17.4	45.8	67.8	82.0	90.3	94.9	97.4	98.7	99.3	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
22	19.6	39.9	57.1	70.3	79.9	86.6	91.2	94.3	96.3	97.6	98.5	99.1	99.4	99.6	99.8	99.9	99.9	99.9	100.0	100.0
23	2.6	7.1	12.7	19.0	25.6	32.2	38.6	44.8	50.6	56.0	60.9	65.4	69.5	73.2	76.5	79.4	82.0	84.3	86.4	88.3
24	24.9	46.1	62.5	74.5	82.9	88.7	92.6	95.2	96.9	98.0	98.7	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0
25	5.9	16.0	27.4	38.9	49.4	58.7	66.7	73.4	78.9	83.4	87.0	89.8	92.1	93.9	95.3	96.4	97.2	97.9	98.4	98.8
26	4.5	18.3	34.2	49.1	61.7	71.7	79.4	85.2	89.5	92.6	94.8	96.4	97.5	98.3	98.8	99.2	99.4	99.6	99.7	99.8
27	83.6	97.6	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	50.4	79.0	91.8	97.0	98.9	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	27.6	52.5	70.6	82.5	89.8	94.2	96.7	98.2	99.0	99.5	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0

PROBABILITY OF SEEING 50. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 1 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	83.9	97.6	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	58.7	85.6	95.4	98.6	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	40.5	69.3	85.3	93.3	97.0	98.7	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
4	67.1	90.3	97.3	99.3	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	59.6	84.2	94.0	97.8	99.2	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	59.3	84.9	94.7	98.2	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	59.3	84.9	94.7	98.2	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8	31.1	54.3	70.5	81.3	88.3	92.8	95.6	97.3	98.4	99.0	99.4	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
9	59.5	84.1	93.9	97.7	99.1	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
10	77.5	95.5	99.2	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	42.0	67.3	82.0	90.2	94.8	97.2	98.5	99.2	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	30.7	56.4	74.1	85.2	91.7	95.5	97.5	98.7	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
13	14.2	32.3	49.1	62.9	73.6	81.6	87.3	91.4	94.2	96.1	97.4	98.3	98.9	99.3	99.5	99.7	99.8	99.9	99.9	99.9
14	19.0	38.0	54.2	67.0	76.7	83.7	88.8	92.4	94.8	96.5	97.7	98.5	99.0	99.3	99.6	99.7	99.8	99.9	99.9	99.9
15	68.3	90.3	97.1	99.1	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
16	89.4	99.1	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
17	90.9	99.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
18	52.2	78.7	90.9	96.3	98.5	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	43.9	70.0	84.4	92.1	96.1	98.1	99.1	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	25.9	52.8	72.1	84.3	91.4	95.4	97.6	98.8	99.4	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
21	2.3	8.5	16.6	25.7	34.8	43.5	51.6	58.8	65.2	70.8	75.6	79.7	83.2	86.1	88.6	90.6	92.3	93.8	94.9	95.9
22	19.7	40.0	57.3	70.4	80.0	86.7	91.3	94.3	96.4	97.7	98.5	99.1	99.4	99.6	99.8	99.9	99.9	99.9	100.0	100.0
23	2.6	6.1	10.1	14.5	19.1	23.9	28.6	33.4	38.0	42.5	46.8	50.8	54.7	58.4	61.8	65.0	68.0	70.8	73.3	75.7
24	18.5	36.8	52.5	65.2	74.9	82.2	87.5	91.3	94.0	95.9	97.2	98.1	98.7	99.1	99.4	99.6	99.7	99.8	99.9	99.9
25	23.8	46.8	64.8	77.4	85.9	91.4	94.8	96.9	98.2	98.9	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
26	21.3	46.1	65.7	79.1	87.7	92.9	95.9	97.7	98.7	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
27	81.6	96.9	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	68.5	91.5	97.8	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	21.4	46.2	65.8	79.2	87.7	92.9	96.0	97.7	98.7	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0

PROBABILITY OF SEEING 50. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 4 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	67.9	90.5	97.3	99.3	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	55.8	82.4	93.3	97.6	99.1	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	39.3	68.6	85.0	93.1	97.0	98.7	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
4	55.9	83.4	94.2	98.1	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	46.7	72.9	86.6	93.6	97.0	98.6	99.3	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	54.5	83.6	94.7	98.4	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	58.0	84.4	94.6	98.2	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8	34.8	60.2	76.8	86.8	92.7	96.0	97.8	98.8	99.4	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	40.0	65.5	80.7	89.4	94.3	96.9	98.4	99.2	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
10	37.2	63.9	79.0	88.4	93.7	96.7	98.2	99.1	99.5	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	30.2	54.6	71.7	82.9	89.8	94.1	96.6	98.1	98.9	99.4	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
12	60.6	88.1	96.8	99.2	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
13	11.4	30.0	48.1	63.1	74.4	82.6	88.4	92.4	95.0	96.8	97.9	98.7	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0
14	5.9	17.7	31.2	44.3	55.9	65.6	73.6	79.9	84.8	88.7	91.6	93.8	95.4	96.6	97.5	98.2	98.7	99.1	99.3	99.5
15	50.1	75.9	88.6	94.7	97.6	98.9	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
16	45.1	74.5	89.1	95.5	98.2	99.3	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
17	55.8	84.7	95.2	98.6	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
18	61.4	86.3	95.3	98.5	99.5	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	33.6	58.7	75.4	85.8	91.9	95.5	97.5	98.7	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	25.6	49.1	66.9	79.1	87.2	92.3	95.4	97.3	98.4	99.1	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
21	20.9	50.3	71.8	84.9	92.2	96.1	98.1	99.1	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
22	14.2	33.7	51.6	66.0	76.8	84.4	89.7	93.3	95.7	97.2	98.2	98.9	99.3	99.6	99.7	99.8	99.9	99.9	100.0	100.0
23	9.3	25.3	41.8	56.3	68.0	77.0	83.7	88.6	92.1	94.5	96.3	97.5	98.3	98.8	99.2	99.5	99.7	99.8	99.8	99.9
24	23.5	42.3	57.1	68.4	76.9	83.2	87.9	91.3	93.8	95.6	96.9	97.8	98.4	98.9	99.2	99.5	99.6	99.7	99.8	99.9
25	3.9	14.6	27.6	40.5	52.2	62.3	70.7	77.4	82.7	86.9	90.2	92.6	94.5	95.9	97.0	97.8	98.4	98.8	99.1	99.4
26	18.5	41.4	60.6	74.6	84.1	90.3	94.1	96.5	97.9	98.8	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
27	58.6	84.5	94.5	98.1	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	54.3	81.2	92.7	97.2	99.0	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	37.6	65.5	82.2	91.2	95.8	98.0	99.1	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

PROBABILITY OF SEEING 50. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 4 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	79.9	96.3	99.4	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	69.0	91.4	97.7	99.4	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	47.2	75.8	89.7	95.8	98.3	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
4	66.3	90.1	97.3	99.3	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	52.8	78.5	90.4	95.8	98.2	99.2	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	41.3	70.6	86.4	94.0	97.5	98.9	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	59.3	84.9	94.7	98.2	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8	46.9	74.1	88.0	94.6	97.6	99.0	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	42.6	68.0	82.6	90.7	95.1	97.4	98.7	99.3	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
10	46.1	72.5	86.4	93.5	96.9	98.6	99.3	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	44.9	71.3	85.5	92.9	96.6	98.4	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	34.8	61.7	78.8	88.7	94.2	97.0	98.5	99.3	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
13	13.2	32.2	50.1	64.7	75.7	83.5	89.0	92.8	95.3	97.0	98.0	98.8	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0
14	12.5	27.4	41.9	54.7	65.3	73.8	80.5	85.6	89.4	92.3	94.4	96.0	97.1	97.9	98.5	98.9	99.3	99.5	99.6	99.7
15	54.3	79.6	91.0	96.1	98.3	99.3	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
16	69.2	92.0	98.1	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
17	59.5	86.8	96.1	98.9	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
18	71.7	92.5	98.1	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	57.6	83.1	93.5	97.6	99.1	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	15.1	34.1	51.5	65.6	76.1	83.7	89.1	92.8	95.2	96.9	98.0	98.7	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0
21	31.9	57.8	75.2	86.0	92.2	95.8	97.8	98.8	99.4	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
22	17.9	39.4	58.0	71.9	81.8	88.4	92.7	95.5	97.2	98.3	99.0	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0
23	17.9	36.7	53.1	66.2	76.1	83.4	88.6	92.2	94.7	96.5	97.6	98.4	99.0	99.3	99.6	99.7	99.8	99.9	99.9	99.9
24	27.0	47.7	63.0	74.1	82.0	87.6	91.6	94.3	96.1	97.4	98.2	98.8	99.2	99.5	99.7	99.8	99.8	99.9	99.9	100.0
25	13.1	30.5	47.0	60.9	71.9	80.1	86.1	90.4	93.4	95.6	97.0	98.0	98.7	99.1	99.4	99.6	99.7	99.8	99.9	99.9
26	39.8	69.7	85.9	93.8	97.4	98.9	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
27	71.8	92.8	98.3	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	70.6	92.1	98.0	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	29.5	57.6	76.5	87.5	93.6	96.8	98.4	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

PROBABILITY OF SEEING 50. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 7 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	88.1	98.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	94.7	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	5.4	16.2	28.8	41.1	52.4	62.1	70.2	76.8	82.1	86.3	89.5	92.1	94.0	95.5	96.6	97.5	98.1	98.6	99.0	99.2
4	42.6	72.8	88.2	95.1	98.1	99.3	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	49.7	75.7	88.6	94.7	97.6	98.9	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	70.3	92.4	98.2	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	28.9	51.4	67.6	78.8	86.4	91.3	94.6	96.6	97.9	98.7	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
8	81.3	97.2	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	39.2	66.0	81.9	90.7	95.3	97.7	98.9	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
10	20.9	41.9	59.1	72.1	81.4	87.8	92.1	95.0	96.8	98.0	98.7	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0
11	44.3	72.4	87.1	94.3	97.5	98.9	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	17.4	45.8	67.8	82.0	90.3	94.9	97.4	98.7	99.3	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
13	19.6	39.9	57.1	70.3	79.9	86.6	91.2	94.3	96.3	97.6	98.5	99.1	99.4	99.6	99.8	99.9	99.9	99.9	100.0	100.0
14	2.6	7.1	12.7	19.0	25.6	32.2	38.6	44.8	50.6	56.0	60.9	65.4	69.5	73.2	76.5	79.4	82.0	84.3	86.4	88.2
15	24.9	46.1	62.5	74.5	82.9	88.7	92.6	95.2	96.9	98.0	98.7	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0
16	5.9	16.0	27.4	38.9	49.4	58.7	66.7	73.4	78.9	83.4	87.0	89.8	92.1	93.9	95.3	96.4	97.2	97.9	98.4	98.8
17	4.5	18.3	34.2	49.1	61.7	71.7	79.4	85.2	89.5	92.6	94.8	96.4	97.5	98.3	98.8	99.2	99.4	99.6	99.7	99.8
18	83.6	97.6	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	50.4	79.0	91.8	97.0	98.9	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	27.6	52.5	70.6	82.5	89.8	94.2	96.7	98.2	99.0	99.5	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
21	47.1	78.5	92.1	97.3	99.1	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
22	23.4	45.7	63.3	76.0	84.6	90.3	94.0	96.3	97.8	98.6	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
23	11.2	27.7	44.1	58.2	69.5	78.2	84.6	89.2	92.6	94.9	96.5	97.6	98.4	98.9	99.3	99.5	99.7	99.8	99.9	99.9
24	70.1	91.3	97.5	99.3	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25	81.3	97.0	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
26	58.1	85.4	95.3	98.6	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
27	36.6	62.7	79.0	88.6	93.9	96.8	98.4	99.2	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	30.3	53.3	69.6	80.6	87.8	92.5	95.4	97.2	98.3	99.0	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
29	33.9	60.1	77.2	87.4	93.2	96.4	98.1	99.0	99.5	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

PROBABILITY OF SEEING 50. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 7 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	93.0	99.6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	94.4	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	11.8	26.8	41.6	54.6	65.4	74.1	80.8	85.9	89.7	92.6	94.7	96.2	97.3	98.1	98.6	99.0	99.3	99.5	99.7	99.8
4	39.6	68.6	84.9	93.0	96.9	98.7	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	55.8	81.1	92.1	96.8	98.7	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	77.6	95.8	99.3	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	38.6	65.5	81.6	90.6	95.3	97.7	98.9	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8	81.1	97.0	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	42.6	69.5	84.6	92.4	96.4	98.3	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
10	53.6	80.9	92.7	97.3	99.0	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	68.0	90.9	97.5	99.4	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	2.3	8.5	16.6	25.7	34.8	43.5	51.6	58.8	65.2	70.8	75.6	79.7	83.2	86.1	88.6	90.6	92.3	93.8	94.9	95.9
13	19.7	40.0	57.3	70.4	80.0	86.7	91.3	94.3	96.4	97.7	98.5	99.1	99.4	99.6	99.8	99.9	99.9	99.9	100.0	100.0
14	2.6	6.1	10.1	14.5	19.1	23.9	28.6	33.4	38.0	42.5	46.8	50.8	54.7	58.4	61.8	65.0	68.0	70.8	73.3	75.7
15	18.5	36.8	52.5	65.2	74.9	82.2	87.5	91.3	94.0	95.9	97.2	98.1	98.7	99.1	99.4	99.6	99.7	99.8	99.9	99.9
16	23.8	46.8	64.8	77.4	85.9	91.4	94.8	96.9	98.2	98.9	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
17	21.3	46.1	65.7	79.1	87.7	92.9	95.9	97.7	98.7	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
18	81.6	96.9	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	68.5	91.5	97.8	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	21.4	46.2	65.8	79.2	87.7	92.9	96.0	97.7	98.7	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
21	30.7	56.4	74.1	85.2	91.7	95.5	97.5	98.7	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
22	14.2	32.3	49.1	62.9	73.6	81.6	87.3	91.4	94.2	96.1	97.4	98.3	98.9	99.3	99.5	99.7	99.8	99.9	99.9	99.9
23	19.0	38.0	54.2	67.0	76.7	83.7	88.8	92.4	94.8	96.5	97.7	98.5	99.0	99.3	99.6	99.7	99.8	99.9	99.9	99.9
24	68.3	90.3	97.1	99.1	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25	89.4	99.1	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
26	90.9	99.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
27	52.2	78.7	90.9	96.3	98.5	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	43.9	70.0	84.4	92.1	96.1	98.1	99.1	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	25.9	52.8	72.1	84.3	91.4	95.4	97.6	98.8	99.4	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

PROBABILITY OF SEEING 50. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 12 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	95.6	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	55.2	84.0	94.8	98.4	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	17.8	38.2	55.9	69.6	79.5	86.5	91.2	94.3	96.4	97.7	98.6	99.1	99.4	99.7	99.8	99.9	99.9	100.0	100.0	100.0
4	61.5	87.3	96.2	98.9	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	49.7	75.7	83.6	94.7	97.6	98.9	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	59.8	85.7	95.2	98.5	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	44.0	70.9	85.6	93.1	96.8	98.5	99.3	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8	57.2	83.7	94.2	98.0	99.3	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	21.1	38.7	52.8	64.0	72.8	79.5	84.7	88.6	91.5	93.8	95.4	96.6	97.5	98.2	98.7	99.0	99.3	99.5	99.6	99.7
10	51.5	79.0	91.5	96.7	98.8	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	56.9	82.9	93.6	97.7	99.2	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	20.9	50.3	71.8	84.9	92.2	96.1	98.1	99.1	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
13	14.2	33.7	51.6	66.0	76.8	84.4	89.7	93.3	95.7	97.2	98.2	98.9	99.3	99.6	99.7	99.8	99.9	99.9	100.0	100.0
14	9.3	25.3	41.8	56.3	68.0	77.0	83.7	88.6	92.1	94.5	96.3	97.5	98.3	98.8	99.2	99.5	99.7	99.8	99.8	99.9
15	23.5	42.3	57.1	68.4	76.9	83.2	87.9	91.3	93.8	95.6	96.9	97.8	98.4	98.9	99.2	99.5	99.6	99.7	99.8	99.9
16	3.9	14.6	27.6	40.5	52.2	62.3	70.7	77.4	82.7	86.9	90.2	92.6	94.5	95.9	97.0	97.8	98.4	98.8	99.1	99.4
17	18.5	41.4	60.6	74.6	84.1	90.3	94.1	96.5	97.9	98.8	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
18	58.6	84.5	94.5	98.1	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	54.3	81.2	92.7	97.2	99.0	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	37.6	65.5	82.2	91.2	95.8	98.0	99.1	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
21	60.6	88.1	96.8	99.2	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
22	11.4	30.0	48.1	63.1	74.4	82.6	88.4	92.4	95.0	96.8	97.9	98.7	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0
23	5.8	17.7	31.2	44.3	55.9	65.6	73.6	79.9	84.8	88.7	91.6	93.8	95.4	96.6	97.5	98.2	98.7	99.1	99.3	99.5
24	50.1	75.9	88.6	94.7	97.6	98.9	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25	45.1	74.5	89.1	95.5	98.2	99.3	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
26	55.8	84.7	95.2	98.6	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
27	61.4	86.3	95.3	98.5	99.5	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	33.6	58.7	75.4	85.8	91.9	95.5	97.5	98.7	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	25.6	49.1	66.9	79.1	87.2	92.3	95.4	97.3	98.4	99.1	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0

PROBABILITY OF SEEING 50. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 10 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	98.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	71.0	93.1	98.5	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	19.3	39.7	57.1	70.4	80.0	86.7	91.3	94.4	96.4	97.7	98.5	99.1	99.4	99.6	99.8	99.9	99.9	99.9	100.0	100.0
4	69.5	92.0	98.0	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	55.9	81.1	92.1	96.7	98.7	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	54.0	81.7	93.3	97.6	99.2	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	49.0	76.2	89.5	95.5	98.1	99.2	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8	68.3	90.9	97.5	99.3	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	35.8	59.5	74.7	84.4	90.4	94.2	96.5	97.9	98.7	99.2	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
10	66.4	89.8	97.1	99.2	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	67.1	89.8	97.0	99.1	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	31.9	57.8	75.2	86.0	92.2	95.8	97.8	98.8	99.4	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
13	17.9	39.4	58.0	71.9	81.8	88.4	92.7	95.5	97.2	98.3	99.0	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0
14	17.9	36.7	53.1	66.2	76.1	83.4	88.6	92.2	94.7	96.5	97.6	98.4	99.0	99.3	99.6	99.7	99.8	99.9	99.9	99.9
15	27.0	47.7	63.0	74.1	82.0	87.6	91.6	94.3	96.1	97.4	98.2	98.8	99.2	99.5	99.7	99.8	99.8	99.9	99.9	100.0
16	13.1	30.5	47.0	60.9	71.9	80.1	86.1	90.4	93.4	95.6	97.0	98.0	98.7	99.1	99.4	99.6	99.7	99.8	99.9	99.9
17	39.9	69.7	85.9	93.8	97.4	98.9	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
18	71.9	92.9	98.3	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	70.6	92.1	98.0	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	29.5	57.6	76.5	87.5	93.6	96.8	98.4	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
21	34.8	61.7	78.8	88.7	94.2	97.0	98.5	99.3	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
22	13.2	32.2	50.1	64.7	75.7	83.5	89.0	92.8	95.3	97.0	98.0	98.8	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0
23	12.5	27.4	41.9	54.7	65.3	73.8	80.5	85.6	89.4	92.3	94.4	96.0	97.1	97.9	98.5	98.9	99.3	99.5	99.6	99.7
24	54.3	79.6	91.0	96.1	98.3	99.3	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25	69.2	92.0	98.1	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
26	59.5	86.8	96.1	98.9	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
27	71.7	92.5	98.1	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	57.6	83.1	93.5	97.6	99.1	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	15.1	34.1	51.5	65.6	76.1	83.7	89.1	92.8	95.2	96.9	98.0	98.7	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0

PROBABILITY OF SEEING 70. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 1 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	60.3	86.5	95.7	98.7	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	32.6	58.1	75.3	85.9	92.1	95.7	97.7	98.7	99.3	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	17.6	37.1	54.0	67.5	77.5	84.7	89.7	93.2	95.5	97.0	98.1	98.8	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0
4	42.3	69.3	84.5	92.4	96.4	98.3	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	46.1	71.5	85.1	92.3	96.1	98.0	99.0	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	44.0	71.6	86.4	93.7	97.2	98.8	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	44.0	71.6	86.4	93.7	97.2	98.8	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8	15.8	29.9	42.2	52.7	61.6	69.0	75.1	80.1	84.1	87.4	90.0	92.1	93.8	95.1	96.2	97.0	97.7	98.2	98.6	98.9
9	31.9	55.3	71.4	82.1	88.9	93.2	95.9	97.5	98.5	99.1	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
10	48.5	76.5	90.0	95.9	98.4	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	22.5	40.8	55.2	66.5	75.1	81.6	86.5	90.1	92.8	94.8	96.2	97.3	98.1	98.6	99.0	99.3	99.5	99.6	99.7	99.8
12	20.4	47.3	68.0	81.6	89.7	94.4	97.0	98.4	99.2	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
13	12.8	26.3	39.2	50.6	60.5	68.7	75.4	80.8	85.2	88.6	91.2	93.3	94.9	96.1	97.1	97.8	98.3	98.8	99.1	99.3
14	3.6	8.9	15.2	22.1	29.0	35.9	42.5	48.7	54.4	59.7	64.5	68.9	72.8	76.3	79.3	82.1	84.5	86.6	88.4	90.0
15	53.3	81.4	93.1	97.6	99.2	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
16	56.6	84.5	95.0	98.5	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
17	40.9	69.5	85.4	93.3	97.0	98.7	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
18	28.9	50.8	66.6	77.7	85.3	90.4	93.8	96.0	97.4	98.4	99.0	99.3	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0
19	21.1	39.2	54.1	65.8	74.8	81.6	86.7	90.4	93.2	95.1	96.6	97.6	98.3	98.8	99.2	99.4	99.6	99.7	99.8	99.9
20	18.5	37.6	54.0	67.0	76.8	84.0	89.0	92.6	95.0	96.7	97.8	98.5	99.0	99.4	99.6	99.7	99.8	99.9	99.9	100.0
21	4.3	13.1	23.8	34.8	45.3	54.7	62.9	70.0	75.8	80.7	84.6	87.9	90.4	92.5	94.1	95.4	96.4	97.2	97.9	98.3
22	13.7	26.7	38.5	48.9	58.0	65.6	72.0	77.4	81.8	85.4	88.3	90.7	92.6	94.1	95.4	96.3	97.1	97.7	98.2	98.6
23	1.9	3.9	6.0	8.1	10.4	12.7	15.0	17.3	19.7	22.1	24.4	26.8	29.1	31.4	33.7	36.0	38.2	40.3	42.5	44.5
24	20.4	37.2	51.0	62.0	70.7	77.5	82.9	87.0	90.1	92.6	94.4	95.8	96.9	97.6	98.2	98.7	99.0	99.3	99.5	99.6
25	2.2	5.2	8.6	12.4	16.5	20.6	24.9	29.2	33.4	37.5	41.5	45.4	49.1	52.7	56.1	59.3	62.3	65.1	67.8	70.3
26	0.0	1.3	3.7	6.9	10.6	14.7	19.1	23.6	28.1	32.6	37.0	41.4	45.5	49.5	53.3	56.9	60.3	63.5	66.4	69.2
27	71.8	93.8	98.8	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	35.4	62.0	78.8	88.6	94.1	96.9	98.5	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	17.3	33.9	48.5	60.7	70.4	77.9	83.7	88.1	91.3	93.7	95.5	96.8	97.7	98.4	98.8	99.2	99.4	99.6	99.7	99.8

Space Division
North American Rockwell

PROBABILITY OF SEEING 70. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 1 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	73.3	94.2	98.9	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	43.5	71.6	86.7	94.0	97.4	98.9	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	24.1	47.0	64.8	77.4	85.8	91.2	94.7	96.8	98.1	98.9	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
4	54.9	81.8	93.1	97.5	99.1	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	53.1	78.7	90.5	95.9	98.2	99.2	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	49.5	76.1	89.1	95.2	97.9	99.1	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	49.5	76.1	89.1	95.2	97.9	99.1	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8	24.5	43.9	58.9	70.2	78.5	84.7	89.1	92.3	94.6	96.2	97.4	98.2	98.7	99.1	99.4	99.6	99.7	99.8	99.9	99.9
9	46.2	73.3	87.4	94.2	97.4	98.9	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
10	60.5	87.9	96.7	99.1	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	34.0	57.5	73.2	83.3	89.7	93.7	96.2	97.7	98.6	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
12	12.5	28.7	44.5	58.1	69.0	77.5	83.8	88.5	91.9	94.3	96.1	97.3	98.1	98.7	99.1	99.4	99.6	99.7	99.8	99.9
13	7.4	15.8	24.5	33.1	41.2	48.7	55.6	61.7	67.2	72.0	76.2	79.8	82.9	85.6	87.9	89.8	91.5	92.9	94.0	95.0
14	11.3	22.7	33.7	43.7	52.7	60.5	67.3	73.1	77.9	82.0	85.3	88.1	90.4	92.3	93.8	95.0	96.0	96.8	97.5	98.0
15	52.0	80.0	92.3	97.2	99.0	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
16	82.6	97.6	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
17	82.1	97.7	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
18	42.9	68.9	83.6	91.5	95.7	97.8	98.9	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	34.2	58.3	74.2	84.3	90.6	94.5	96.8	98.1	98.9	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
20	9.7	23.5	37.9	50.9	62.0	71.1	78.2	83.8	88.0	91.2	93.6	95.3	96.6	97.6	98.3	98.8	99.1	99.4	99.6	99.7
21	0.8	2.0	3.5	5.2	7.2	9.3	11.6	14.0	16.5	19.0	21.6	24.2	26.8	29.5	32.1	34.6	37.2	39.7	42.1	44.5
22	13.4	26.3	38.1	48.5	57.6	65.3	71.8	77.2	81.6	85.3	88.2	90.6	92.5	94.1	95.3	96.3	97.1	97.7	98.2	98.6
23	1.9	3.8	5.8	7.8	9.8	11.8	13.9	15.9	18.0	20.0	22.1	24.1	26.1	28.1	30.1	32.0	34.0	35.9	37.7	39.6
24	14.3	27.2	38.7	48.7	57.3	64.6	70.8	76.0	80.4	84.0	87.0	89.4	91.4	93.1	94.4	95.5	96.4	97.1	97.7	98.1
25	11.4	24.6	37.6	49.3	59.5	68.0	75.0	80.6	85.1	88.6	91.3	93.4	95.0	96.2	97.2	97.9	98.4	98.8	99.1	99.4
26	10.1	22.4	34.8	46.3	56.4	65.1	72.3	78.2	83.0	86.8	89.8	92.1	94.0	95.4	96.5	97.3	98.0	98.5	98.9	99.1
27	70.3	92.7	98.4	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	57.9	84.0	94.3	98.0	99.3	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	12.7	26.2	38.9	50.3	60.0	68.2	75.0	80.4	84.8	88.2	90.9	93.1	94.7	96.0	96.9	97.7	98.2	98.7	99.0	99.3

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PROBABILITY OF SEEING 70. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 4 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	55.2	82.1	93.3	97.6	99.2	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	46.7	73.1	86.9	93.8	97.1	98.7	99.4	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	18.4	40.3	58.9	72.8	82.5	89.0	93.1	95.8	97.4	98.5	99.1	99.4	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
4	42.0	69.5	84.8	92.7	96.6	98.4	99.3	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	40.4	65.3	80.1	88.8	93.7	96.5	98.1	99.0	99.4	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	34.8	63.5	81.1	90.6	95.5	97.9	99.0	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	44.0	71.6	86.4	93.7	97.2	98.8	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8	26.3	47.2	62.9	74.4	82.5	88.2	92.1	94.7	96.5	97.7	98.5	99.0	99.4	99.6	99.7	99.8	99.9	99.9	100.0	100.0
9	29.3	51.8	68.0	79.2	86.7	91.5	94.7	96.7	98.0	98.7	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
10	27.7	49.5	65.5	76.9	84.7	90.0	93.5	95.8	97.3	98.3	98.9	99.3	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0
11	22.8	41.8	56.8	68.4	77.1	83.6	88.3	91.7	94.2	95.9	97.1	98.0	98.6	99.0	99.3	99.5	99.7	99.8	99.9	99.9
12	31.0	63.9	83.2	92.7	96.9	98.7	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
13	5.4	12.1	19.5	27.1	34.5	41.7	48.4	54.6	60.3	65.4	69.9	73.9	77.5	80.6	83.4	85.7	87.8	89.6	91.1	92.4
14	1.3	3.6	6.7	10.4	14.5	18.9	23.4	28.0	32.5	36.9	41.3	45.5	49.5	53.3	56.9	60.3	63.5	66.4	69.2	71.8
15	37.2	62.8	78.8	88.2	93.6	96.5	98.2	99.0	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
16	22.1	47.1	66.6	79.8	88.2	93.2	96.2	97.9	98.8	99.4	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
17	34.9	64.2	81.9	91.3	95.9	98.2	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
18	41.7	71.0	86.6	94.1	97.5	99.0	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	26.7	47.4	62.9	74.2	82.2	87.8	91.7	94.4	96.3	97.5	98.3	98.9	99.3	99.5	99.7	99.8	99.9	99.9	99.9	100.0
20	16.9	32.7	46.7	58.3	67.9	75.4	81.4	86.0	89.5	92.2	94.2	95.7	96.9	97.7	98.3	98.8	99.1	99.3	99.5	99.7
21	5.2	15.8	28.4	40.7	52.0	61.7	69.9	76.5	81.8	86.1	89.4	91.9	93.9	95.4	96.6	97.4	98.1	98.6	98.9	99.2
22	7.4	16.0	24.9	33.7	42.0	49.7	56.7	62.9	68.4	73.2	77.3	80.9	84.0	86.6	88.8	90.6	92.2	93.5	94.6	95.6
23	2.5	6.8	12.0	17.9	24.1	30.4	36.6	42.5	48.2	53.5	58.4	62.9	67.0	70.7	74.1	77.1	79.8	82.3	84.4	86.4
24	17.8	33.1	46.0	56.6	65.4	72.5	78.2	82.8	86.5	89.4	91.7	93.6	95.0	96.1	97.0	97.7	98.2	98.6	98.9	99.2
25	0.7	2.3	4.6	7.4	10.6	14.0	17.7	21.5	25.3	29.2	33.0	36.8	40.5	44.1	47.6	50.9	54.1	57.1	60.0	62.7
26	2.2	9.6	19.4	29.9	40.2	49.7	58.2	65.6	71.9	77.2	81.6	85.2	88.2	90.6	92.5	94.1	95.3	96.3	97.1	97.7
27	47.7	74.6	88.2	94.7	97.6	99.0	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	43.0	69.7	84.5	92.3	96.3	98.2	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	24.2	45.8	62.8	75.1	83.7	89.4	93.3	95.7	97.3	98.3	99.0	99.4	99.6	99.8	99.9	99.9	99.9	100.0	100.0	100.0

Space Division
North American Rockwell

PROBABILITY OF SEEING 70. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 4 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	68.5	91.7	98.0	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	60.3	85.5	94.9	98.3	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	29.2	54.9	73.0	84.4	91.2	95.2	97.4	98.6	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
4	57.1	83.0	93.6	97.7	99.2	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	48.1	73.5	86.6	93.3	96.7	98.4	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	19.4	42.4	61.4	75.2	84.5	90.5	94.3	96.6	98.0	98.8	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
7	49.5	76.1	89.1	95.2	97.9	99.1	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8	36.1	61.2	77.2	87.0	92.7	95.9	97.8	98.8	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	31.0	54.3	70.6	81.5	88.5	93.0	95.7	97.4	98.5	99.1	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
10	35.5	60.2	76.2	86.0	92.0	95.4	97.4	98.6	99.2	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	35.9	60.3	76.0	85.8	91.7	95.2	97.3	98.4	99.1	99.5	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	17.5	36.8	53.7	67.2	77.2	84.5	89.5	93.0	95.4	97.0	98.0	98.7	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0
13	6.3	13.9	22.2	30.5	38.5	46.1	53.0	59.3	64.9	69.9	74.3	78.1	81.4	84.3	86.7	88.8	90.6	92.1	93.4	94.5
14	6.3	13.3	20.7	28.1	35.3	42.1	48.5	54.4	59.8	64.6	69.0	72.9	76.4	79.5	82.2	84.6	86.7	88.5	90.1	91.5
15	42.4	68.6	83.5	91.5	95.8	97.9	99.0	99.5	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
16	53.6	81.9	93.5	97.8	99.3	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
17	40.8	70.2	86.1	93.9	97.4	98.9	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
18	56.2	83.8	94.5	98.2	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	49.6	75.7	88.6	94.8	97.6	99.0	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	9.3	19.1	28.8	37.9	46.4	54.0	60.7	66.7	71.9	76.3	80.1	83.4	86.2	88.5	90.5	92.1	93.5	94.6	95.6	96.4
21	23.7	43.5	59.0	70.7	79.4	85.6	90.0	93.1	95.3	96.8	97.8	98.5	99.0	99.3	99.6	99.7	99.8	99.9	99.9	99.9
22	9.6	20.3	31.1	41.2	50.5	58.7	65.8	71.8	77.0	81.2	84.8	87.7	90.1	92.1	93.7	94.9	96.0	96.8	97.5	98.0
23	9.5	19.8	30.1	39.8	48.7	56.6	63.6	69.6	74.8	79.2	82.9	85.9	88.5	90.6	92.4	93.8	95.0	96.0	96.7	97.4
24	21.0	38.2	52.2	63.2	71.9	78.6	83.9	87.8	90.9	93.2	94.9	96.2	97.2	97.9	98.5	98.9	99.2	99.4	99.5	99.7
25	6.1	13.4	21.3	29.3	37.0	44.3	51.1	57.3	62.9	67.9	72.3	76.2	79.6	82.6	85.2	87.4	89.3	90.9	92.3	93.5
26	15.7	37.8	57.2	71.8	82.0	88.7	93.1	95.8	97.5	98.5	99.1	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
27	60.8	86.3	95.5	98.6	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	61.0	86.1	95.3	98.5	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	14.0	30.8	46.6	59.9	70.6	78.7	84.8	89.2	92.5	94.8	96.4	97.5	98.3	98.8	99.2	99.5	99.6	99.8	99.8	99.9

PROBABILITY OF SEEING 70. PERCENT OR MORE OF AREAS IN ONE OR TWO-LOOKS

MONTH 7 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	78.7	96.6	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	86.9	99.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	0.7	2.5	5.1	8.2	11.8	15.7	19.8	24.0	28.3	32.5	36.6	40.7	44.6	48.4	52.0	55.4	58.6	61.7	64.6	67.3
4	24.0	48.1	66.6	79.3	87.5	92.6	95.7	97.5	98.6	99.2	99.6	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
5	44.2	69.5	83.6	91.3	95.4	97.6	98.7	99.4	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	60.2	85.8	95.2	98.4	99.5	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	15.7	31.7	46.1	58.3	68.2	76.0	82.1	86.8	90.3	92.9	94.8	96.3	97.3	98.1	98.6	99.0	99.3	99.5	99.6	99.7
8	70.3	92.9	98.4	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	29.2	51.8	68.1	79.3	86.8	91.6	94.8	96.8	98.0	98.8	99.3	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
10	15.5	29.7	42.2	52.9	61.9	69.4	75.6	80.6	84.6	87.9	90.5	92.6	94.2	95.5	96.5	97.3	97.9	98.4	98.7	99.0
11	30.2	54.7	71.8	83.0	90.0	94.2	96.7	98.1	98.9	99.4	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
12	4.3	13.1	23.8	34.8	45.3	54.7	62.9	70.0	75.8	80.7	84.6	87.9	90.4	92.5	94.1	95.4	96.4	97.2	97.9	98.3
13	13.7	26.7	38.5	48.9	58.0	65.6	72.0	77.4	81.8	85.4	88.3	90.7	92.6	94.1	95.4	96.3	97.1	97.7	98.2	98.5
14	1.9	3.9	6.0	8.1	10.4	12.7	15.0	17.3	19.7	22.1	24.4	26.8	29.1	31.4	33.7	36.0	38.2	40.3	42.5	44.5
15	20.4	37.2	51.0	62.0	70.7	77.5	82.9	87.0	90.1	92.6	94.4	95.8	96.9	97.6	98.2	98.7	99.0	99.3	99.5	99.6
16	2.2	5.2	8.6	12.4	16.5	20.6	24.9	29.2	33.4	37.5	41.5	45.4	49.1	52.7	56.1	59.3	62.3	65.1	67.8	70.3
17	0.0	1.3	3.7	6.9	10.6	14.7	19.1	23.6	28.1	32.6	37.0	41.4	45.5	49.5	53.3	56.9	60.3	63.5	66.4	69.2
18	71.8	93.8	98.8	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	35.4	62.0	78.8	88.6	94.1	96.9	98.5	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	17.3	33.9	48.5	60.7	70.4	77.9	83.7	88.1	91.3	93.7	95.5	96.8	97.7	98.4	98.8	99.2	99.4	99.6	99.7	99.8
21	20.4	47.3	68.0	81.6	89.7	94.4	97.0	98.4	99.2	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
22	12.8	26.3	39.2	50.6	60.5	68.7	75.4	80.8	85.2	88.6	91.2	93.3	94.9	96.1	97.1	97.8	98.3	98.8	99.1	99.3
23	3.6	8.9	15.2	22.1	29.0	35.9	42.5	48.7	54.4	59.7	64.5	68.9	72.8	76.3	79.3	82.1	84.5	86.6	88.4	90.0
24	53.3	81.4	93.1	97.6	99.2	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25	68.0	92.0	98.2	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
26	40.9	69.5	85.4	93.3	97.0	98.7	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
27	28.9	50.8	66.6	77.7	85.3	90.4	93.8	96.0	97.4	98.4	99.0	99.3	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0
28	21.1	39.2	54.1	65.8	74.8	81.6	86.7	90.4	93.2	95.1	96.6	97.6	98.3	98.8	99.2	99.4	99.6	99.7	99.8	99.9
29	18.5	37.6	54.0	67.0	76.8	84.0	89.0	92.6	95.0	96.7	97.8	98.5	99.0	99.4	99.6	99.7	99.8	99.9	99.9	100.0

Space Division
North American Rockwell

PROBABILITY OF SEEING 70. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 7 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	85.7	98.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	89.3	99.2	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	4.6	10.5	17.0	23.9	30.8	37.6	44.0	50.0	55.6	60.7	65.3	69.5	73.3	76.7	79.6	82.3	84.6	86.6	88.4	90.0
4	26.1	48.8	66.0	78.1	86.2	91.4	94.7	96.8	98.1	98.8	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
5	51.0	76.4	88.8	94.8	97.6	98.9	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	51.0	84.3	95.6	98.9	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	21.0	42.3	59.8	72.9	82.2	88.4	92.6	95.3	97.1	98.2	98.9	99.3	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0
8	69.6	92.5	98.3	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	33.9	57.8	73.8	84.0	90.4	94.3	96.6	98.0	98.8	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
10	47.5	73.4	86.9	93.6	96.9	98.6	99.3	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	55.4	82.4	93.5	97.7	99.2	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	0.8	2.0	3.5	5.2	7.2	9.3	11.6	14.0	16.5	19.0	21.6	24.2	26.8	29.5	32.1	34.6	37.2	39.7	42.1	44.5
13	13.4	26.3	38.1	48.5	57.6	65.3	71.8	77.2	81.6	85.3	88.2	90.6	92.5	94.1	95.3	96.3	97.1	97.7	98.2	98.6
14	1.9	3.8	5.8	7.8	9.8	11.8	13.9	15.9	18.0	20.0	22.1	24.1	26.1	28.1	30.1	32.0	34.0	35.9	37.7	39.6
15	14.3	27.2	38.7	48.7	57.3	64.6	70.8	76.0	80.4	84.0	87.0	89.4	91.4	93.1	94.4	95.5	96.4	97.1	97.7	98.1
16	11.4	24.6	37.6	49.3	59.5	68.0	75.0	80.6	85.1	88.6	91.3	93.4	95.0	96.2	97.2	97.9	98.4	98.8	99.1	99.4
17	10.1	22.4	34.8	46.3	56.4	65.1	72.3	78.2	83.0	86.8	89.8	92.1	94.0	95.4	96.5	97.3	98.0	98.5	98.9	99.1
18	70.3	92.7	98.4	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	57.9	84.0	94.3	98.0	99.3	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	12.7	26.2	38.9	50.3	60.0	68.2	75.0	80.4	84.8	88.2	90.9	93.1	94.7	96.0	96.9	97.7	98.2	98.7	99.0	99.3
21	12.5	28.7	44.5	58.1	69.0	77.5	83.8	88.5	91.9	94.3	96.1	97.3	98.1	98.7	99.1	99.4	99.6	99.7	99.8	99.9
22	7.4	15.8	24.5	33.1	41.2	48.7	55.6	61.7	67.2	72.0	76.2	79.8	82.9	85.6	87.9	89.8	91.5	92.9	94.0	95.0
23	11.3	22.7	33.7	43.7	52.7	60.5	67.3	73.1	77.9	82.0	85.3	88.1	90.4	92.3	93.8	95.0	96.0	96.8	97.5	98.0
24	52.0	80.0	92.3	97.2	99.0	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25	82.6	97.6	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
26	82.1	97.7	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
27	42.9	68.9	83.6	91.5	95.7	97.8	98.9	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	34.2	58.3	74.2	84.3	90.6	94.5	96.8	98.1	98.9	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
29	9.7	23.5	37.9	50.9	62.0	71.1	78.2	83.8	88.0	91.2	93.6	95.3	96.6	97.6	98.3	98.8	99.1	99.4	99.6	99.7

PROBABILITY OF SEEING 70. PERCENT OR MORE OF AREAS IN ONE OR TWO LOOKS

MONTH 10 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	89.2	99.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	39.5	67.6	83.7	92.2	96.3	98.3	99.2	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	6.8	15.9	25.8	35.7	45.0	53.4	60.9	67.5	73.1	77.8	81.9	85.2	88.0	90.2	92.1	93.6	94.9	95.9	96.7	97.4
4	49.6	76.9	90.0	95.8	98.3	99.3	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	44.2	69.5	83.6	91.3	95.4	97.6	98.7	99.4	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	54.0	79.6	91.2	96.3	98.5	99.4	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	30.4	54.4	71.4	82.5	89.5	93.8	96.4	97.9	98.8	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
8	45.9	72.9	87.0	94.0	97.3	98.8	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	14.4	27.5	39.1	49.2	58.0	65.4	71.6	76.8	81.1	84.7	87.6	90.0	92.0	93.6	94.8	95.9	96.7	97.4	97.9	98.3
10	40.3	66.6	82.0	90.6	95.2	97.6	98.8	99.4	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	47.0	73.5	87.3	94.0	97.3	98.8	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	5.2	15.8	28.4	40.7	52.0	61.7	69.9	76.5	81.8	86.1	89.4	91.9	93.9	95.4	96.6	97.4	98.1	98.6	98.9	99.2
13	7.4	16.0	24.9	33.7	42.0	49.7	56.7	62.9	68.4	73.2	77.3	80.9	84.0	86.6	88.8	90.6	92.2	93.5	94.6	95.6
14	2.5	6.8	12.0	17.9	24.1	30.4	36.6	42.5	48.2	53.5	58.4	62.9	67.0	70.7	74.1	77.1	79.8	82.3	84.4	86.4
15	17.8	33.1	46.0	56.6	65.4	72.5	78.2	82.8	86.5	89.4	91.7	93.6	95.0	96.1	97.0	97.7	98.2	98.6	98.9	99.2
16	0.7	2.3	4.6	7.4	10.6	14.0	17.7	21.5	25.3	29.2	33.0	36.8	40.5	44.1	47.6	50.9	54.1	57.1	60.0	62.7
17	2.2	9.6	19.4	29.9	40.2	49.7	58.2	65.6	71.9	77.2	81.6	85.2	88.2	90.6	92.5	94.1	95.3	96.3	97.1	97.7
18	47.7	74.6	88.2	94.7	97.6	99.0	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	43.0	69.7	84.5	92.3	96.3	98.2	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	24.2	45.8	62.8	75.1	83.7	89.4	93.3	95.7	97.3	98.3	99.0	99.4	99.6	99.8	99.9	99.9	99.9	100.0	100.0	100.0
21	31.0	63.9	83.2	92.7	96.9	98.7	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
22	5.4	12.1	19.5	27.1	34.5	41.7	48.4	54.6	60.3	65.4	69.9	73.9	77.5	80.6	83.4	85.7	87.8	89.6	91.1	92.4
23	1.3	3.6	6.7	10.4	14.5	18.9	23.4	28.0	32.5	36.9	41.3	45.5	49.5	53.3	56.9	60.3	63.5	66.4	69.2	71.8
24	37.2	62.8	78.8	88.2	93.6	96.5	98.2	99.0	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25	22.1	47.1	66.6	79.8	88.2	93.2	96.2	97.9	98.8	99.4	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
26	34.9	64.2	81.9	91.3	95.9	98.2	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
27	41.7	71.0	86.6	94.1	97.5	99.0	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	26.7	47.4	62.9	74.2	82.2	87.8	91.7	94.4	96.3	97.5	98.3	98.9	99.3	99.5	99.7	99.8	99.9	99.9	99.9	100.0
29	16.9	32.7	46.7	58.3	67.9	75.4	81.4	86.0	89.5	92.2	94.2	95.7	96.9	97.7	98.3	98.8	99.1	99.3	99.5	99.7

PROBABILITY OF SEEING 70. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 10 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	92.8	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	57.5	84.6	94.9	98.4	99.5	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	9.2	19.9	30.7	41.0	50.4	58.8	66.0	72.1	77.3	81.6	85.2	88.1	90.5	92.4	93.9	95.2	96.2	97.0	97.6	98.1
4	60.6	85.8	95.2	98.4	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	51.9	77.2	89.3	95.0	97.7	99.0	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	40.1	67.3	83.1	91.6	95.9	98.0	99.1	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	35.2	61.0	77.6	87.5	93.2	96.3	98.1	99.0	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8	58.8	84.4	94.4	98.0	99.3	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	26.5	47.2	62.8	74.1	82.2	87.8	91.8	94.5	96.3	97.5	98.4	98.9	99.3	99.5	99.7	99.8	99.9	99.9	99.9	100.0
10	51.3	79.3	91.8	96.9	98.9	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	58.5	83.9	94.0	97.8	99.2	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	23.7	43.5	59.0	70.7	79.4	85.6	90.0	93.1	95.3	96.8	97.8	98.5	99.0	99.3	99.5	99.7	99.8	99.9	99.9	99.9
13	9.6	20.3	31.1	41.2	50.5	58.7	65.8	71.8	77.0	81.2	84.8	87.7	90.1	92.1	93.7	94.9	96.0	96.8	97.5	98.0
14	9.5	19.8	30.1	39.8	48.7	56.6	63.6	69.6	74.8	79.2	82.9	85.9	88.5	90.6	92.4	93.8	95.0	96.0	96.7	97.4
15	21.0	38.2	52.2	63.2	71.9	78.6	83.9	87.8	90.9	93.2	94.9	96.2	97.2	97.9	98.5	98.9	99.2	99.4	99.5	99.7
16	6.1	13.4	21.3	29.3	37.0	44.3	51.1	57.3	62.9	67.9	72.3	76.2	79.6	82.6	85.2	87.4	89.3	90.9	92.3	93.5
17	15.7	37.8	57.2	71.8	82.0	88.7	93.1	95.8	97.5	98.5	99.1	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
18	60.8	86.3	95.5	98.6	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	61.0	86.1	95.3	98.5	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	14.0	30.8	46.6	59.9	70.6	78.7	84.8	89.2	92.5	94.8	96.4	97.5	98.3	98.8	99.2	99.5	99.6	99.8	99.8	99.9
21	17.5	36.8	53.7	67.2	77.2	84.5	89.5	93.0	95.4	97.0	98.0	98.7	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0
22	6.3	13.9	22.2	30.5	38.5	46.1	53.0	59.3	64.9	69.9	74.3	78.1	81.4	84.3	86.7	88.8	90.6	92.1	93.4	94.5
23	6.3	13.3	20.7	28.1	35.3	42.1	48.5	54.4	59.8	64.6	69.0	72.9	76.4	79.5	82.2	84.6	86.7	88.5	90.1	91.5
24	42.4	68.6	83.5	91.5	95.8	97.9	99.0	99.5	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25	53.6	81.9	93.5	97.8	99.3	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
26	40.8	70.2	86.1	93.9	97.4	98.9	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
27	56.2	83.8	94.5	98.2	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	49.6	75.7	88.6	94.8	97.6	99.0	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	9.3	19.1	28.8	37.9	46.4	54.0	60.7	66.7	71.9	76.3	80.1	83.4	86.2	88.5	90.5	92.1	93.5	94.6	95.6	96.4

PROBABILITY OF SEEING 90. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 1 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	46.6	73.7	87.6	94.4	97.5	98.9	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	20.6	38.7	53.7	65.5	74.6	81.5	86.6	90.4	93.2	95.1	96.6	97.6	98.3	98.8	99.2	99.4	99.6	99.7	99.8	99.9
3	7.6	16.0	24.5	32.8	40.7	48.0	54.7	60.7	66.1	70.8	75.0	78.6	81.8	84.5	86.9	88.9	90.6	92.1	93.3	94.4
4	25.2	47.3	64.3	76.5	84.8	90.3	93.9	96.2	97.7	98.6	99.1	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
5	35.2	59.3	75.0	84.9	91.0	94.7	96.9	98.2	99.0	99.4	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
6	33.9	57.6	73.4	83.5	90.0	93.9	96.4	97.8	98.7	99.2	99.6	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
7	33.9	57.6	73.4	83.5	90.0	93.9	96.4	97.8	98.7	99.2	99.6	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
8	8.5	17.0	25.0	32.7	39.8	46.4	52.4	57.9	62.9	67.3	71.3	74.9	78.0	80.8	83.3	85.5	87.4	89.0	90.5	91.8
9	25.6	45.1	59.8	70.8	78.9	84.8	89.1	92.2	94.5	96.1	97.2	98.1	98.6	99.0	99.3	99.5	99.7	99.8	99.8	99.9
10	37.6	62.5	78.1	87.4	92.9	96.0	97.8	98.8	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	14.1	27.0	38.5	48.5	57.2	64.6	70.9	76.1	80.5	84.1	87.1	89.6	91.6	93.2	94.5	95.6	96.5	97.2	97.8	98.2
12	7.5	16.7	26.4	36.0	45.0	53.3	60.6	66.9	72.5	77.2	81.1	84.5	87.3	89.6	91.5	93.1	94.4	95.5	96.4	97.1
13	4.3	9.2	14.6	20.2	25.9	31.5	37.0	42.2	47.2	51.9	56.3	60.4	64.2	67.7	70.9	73.9	76.5	79.0	81.2	83.2
14	1.2	2.5	3.8	5.3	6.7	8.2	9.8	11.4	13.0	14.6	16.3	17.9	19.6	21.3	23.0	24.7	26.3	28.0	29.7	31.3
15	43.9	69.7	84.0	91.8	95.8	97.9	98.9	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
16	26.6	55.9	75.9	87.5	93.8	97.0	98.5	99.3	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
17	23.2	44.7	61.7	74.2	83.0	89.0	92.9	95.5	97.2	98.2	98.9	99.3	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0
18	20.9	38.2	52.2	63.3	72.0	78.8	84.0	88.0	91.0	93.3	95.0	96.3	97.3	98.0	98.5	98.9	99.2	99.4	99.6	99.7
19	16.4	30.4	42.3	52.3	60.7	67.7	73.5	78.3	82.3	85.6	88.2	90.4	92.2	93.7	94.9	95.9	96.7	97.3	97.8	98.3
20	6.8	14.8	23.3	31.7	39.9	47.4	54.4	60.6	66.2	71.1	75.4	79.1	82.3	85.1	87.4	89.4	91.2	92.6	93.8	94.8
21	1.4	3.0	4.7	6.4	8.3	10.2	12.2	14.2	16.3	18.4	20.5	22.6	24.7	26.8	28.9	31.0	33.0	35.1	37.1	39.0
22	4.9	10.5	16.4	22.4	28.4	34.2	39.9	45.2	50.3	55.0	59.4	63.4	67.2	70.5	73.6	76.4	79.0	81.3	83.4	85.2
23	0.6	1.3	1.9	2.6	3.3	3.9	4.6	5.3	6.0	6.8	7.5	8.2	9.0	9.7	10.5	11.2	12.0	12.7	13.5	14.3
24	10.0	20.1	29.9	39.1	47.5	55.0	61.7	67.5	72.6	76.9	80.7	83.8	86.5	88.8	90.7	92.3	93.6	94.7	95.7	96.4
25	0.7	1.5	2.3	3.2	4.0	4.9	5.7	6.6	7.6	8.5	9.4	10.4	11.4	12.3	13.3	14.3	15.3	16.3	17.3	18.3
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
27	58.8	85.0	94.9	98.3	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	17.7	35.9	51.7	64.6	74.5	81.9	87.3	91.2	93.9	95.8	97.2	98.1	98.7	99.1	99.4	99.6	99.7	99.8	99.9	99.9
29	5.8	12.7	20.2	27.9	35.4	42.5	49.2	55.3	60.9	65.9	70.4	74.4	77.9	81.0	83.7	86.0	88.0	89.8	91.3	92.6

PROBABILITY OF SEEING 90. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 1 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	60.0	86.0	95.4	98.6	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	31.3	54.6	70.8	81.6	88.6	93.0	95.7	97.4	98.5	99.1	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
3	11.9	24.3	36.1	46.8	56.2	64.2	71.0	76.7	81.3	85.1	88.2	90.7	92.7	94.2	95.5	96.5	97.2	97.9	98.3	98.7
4	38.3	65.0	81.1	90.2	95.0	97.5	98.8	99.4	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	41.6	67.4	82.3	90.6	95.1	97.5	98.7	99.3	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	28.2	53.3	71.3	83.0	90.2	94.5	96.9	98.3	99.1	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	28.2	53.3	71.3	83.0	90.2	94.5	96.9	98.3	99.1	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8	16.6	31.2	43.7	54.2	63.0	70.3	76.2	81.0	84.9	88.1	90.6	92.6	94.2	95.4	96.4	97.2	97.8	98.3	98.7	99.0
9	36.4	60.8	76.3	85.9	91.7	95.2	97.2	98.4	99.1	99.5	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
10	45.8	73.2	87.5	94.3	97.5	98.9	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	25.4	45.3	60.3	71.5	79.7	85.6	89.9	92.9	95.1	96.6	97.6	98.4	98.9	99.2	99.5	99.6	99.8	99.8	99.9	99.9
12	5.2	10.9	16.8	22.8	28.8	34.6	40.2	45.5	50.4	55.1	59.4	63.4	67.1	70.4	73.5	76.3	78.8	81.1	83.1	85.0
13	2.5	5.2	8.1	11.1	14.3	17.5	20.7	24.0	27.2	30.4	33.6	36.7	39.7	42.6	45.5	48.3	50.9	53.5	56.0	58.4
14	4.8	9.9	15.1	20.4	25.6	30.7	35.6	40.4	44.9	49.2	53.2	57.0	60.6	63.9	67.0	69.9	72.5	75.0	77.2	79.3
15	44.9	70.3	84.3	91.8	95.8	97.8	98.9	99.4	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
16	68.5	92.2	98.3	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
17	59.4	89.0	97.4	99.4	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
18	32.3	55.4	71.3	81.8	88.6	92.9	95.7	97.3	98.4	99.0	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
19	29.0	50.0	64.9	75.6	83.0	88.3	91.9	94.5	96.2	97.4	98.2	98.8	99.2	99.4	99.6	99.7	99.8	99.9	99.9	99.9
20	3.2	7.0	11.0	15.3	19.8	24.3	28.7	33.1	37.4	41.6	45.6	49.4	53.1	56.5	59.8	62.9	65.7	68.4	71.0	73.3
21	0.3	0.6	0.8	1.1	1.4	1.7	2.0	2.3	2.6	2.9	3.2	3.5	3.8	4.2	4.5	4.8	5.1	5.4	5.8	6.1
22	5.6	11.5	17.7	23.8	29.8	35.7	41.2	46.5	51.4	56.0	60.3	64.2	67.8	71.1	74.1	76.8	79.3	81.5	83.6	85.4
23	0.6	1.3	1.9	2.6	3.3	3.9	4.6	5.3	6.0	6.8	7.5	8.2	9.0	9.7	10.5	11.2	12.0	12.7	13.5	14.3
24	7.4	14.8	22.0	28.9	35.5	41.7	47.4	52.7	57.6	62.0	66.1	69.8	73.1	76.1	78.8	81.3	83.4	85.4	87.1	88.6
25	4.7	9.8	15.0	20.4	25.7	31.0	36.1	41.0	45.6	50.1	54.2	58.1	61.8	65.1	68.3	71.2	73.8	76.3	78.5	80.6
26	4.7	9.6	14.6	19.6	24.5	29.3	34.0	38.5	42.8	46.9	50.8	54.5	58.0	61.2	64.3	67.1	69.8	72.2	74.5	76.7
27	59.6	85.0	94.7	98.2	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	37.0	65.1	81.9	91.0	95.7	97.9	99.0	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	4.2	9.2	14.5	20.0	25.6	31.1	36.5	41.7	46.6	51.3	55.7	59.7	63.5	67.0	70.2	73.2	75.9	78.3	80.6	82.6

PROBABILITY OF SEEING 90. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 4 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	43.1	69.4	84.1	91.9	96.0	98.0	99.0	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	29.6	53.6	70.7	82.0	89.2	93.6	96.2	97.8	98.8	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
3	7.9	16.6	25.6	34.3	42.5	50.1	56.9	63.0	68.4	73.2	77.3	80.8	83.8	86.4	88.6	90.5	92.1	93.4	94.5	95.4
4	23.6	45.4	62.6	75.2	83.8	89.6	93.4	95.9	97.4	98.4	99.0	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0
5	28.1	49.9	65.9	77.2	85.0	90.2	93.7	95.9	97.4	98.4	99.0	99.3	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0
6	15.7	33.2	49.1	62.3	72.6	80.4	86.2	90.3	93.3	95.4	96.8	97.8	98.5	99.0	99.3	99.6	99.7	99.8	99.9	99.9
7	33.9	57.6	73.4	83.5	90.0	93.9	96.4	97.8	98.7	99.2	99.6	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
8	14.9	29.0	41.7	52.7	62.0	69.8	76.1	81.2	85.3	88.6	91.1	93.1	94.7	95.9	96.9	97.6	98.2	98.6	98.9	99.2
9	20.5	37.7	51.8	63.1	71.9	78.8	84.1	88.1	91.1	93.4	95.1	96.4	97.4	98.1	98.6	99.0	99.3	99.5	99.6	99.7
10	18.6	34.7	48.2	59.4	68.3	75.5	81.2	85.6	89.0	91.7	93.7	95.2	96.4	97.3	98.0	98.5	98.9	99.2	99.4	99.5
11	14.7	27.9	39.7	49.9	58.6	66.0	72.2	77.4	81.6	85.1	88.0	90.4	92.3	93.8	95.0	96.1	96.9	97.5	98.0	98.4
12	11.7	26.7	41.5	54.6	65.5	74.2	80.9	86.0	89.8	92.7	94.7	96.3	97.3	98.1	98.7	99.1	99.3	99.5	99.7	99.8
13	1.8	3.7	5.8	7.9	10.1	12.3	14.7	17.0	19.3	21.7	24.1	26.4	28.8	31.1	33.4	35.6	37.9	40.1	42.2	44.3
14	0.4	0.9	1.3	1.8	2.3	2.7	3.2	3.7	4.3	4.8	5.3	5.9	6.4	7.0	7.5	8.1	8.7	9.2	9.8	10.4
15	29.7	51.3	66.6	77.4	84.8	89.8	93.2	95.5	97.1	98.1	98.7	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0	100.0
16	8.0	17.9	28.4	38.6	48.0	56.4	63.8	70.1	75.5	80.0	83.8	86.9	89.4	91.5	93.2	94.6	95.7	96.6	97.3	97.8
17	17.9	36.2	52.0	64.8	74.7	82.1	87.4	91.3	94.0	95.9	97.2	98.1	98.7	99.1	99.4	99.6	99.7	99.8	99.9	99.9
18	29.5	52.2	68.5	79.6	87.0	91.8	94.9	96.9	98.1	98.8	99.3	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
19	17.8	33.3	46.4	57.4	66.3	73.6	79.4	84.0	87.6	90.4	92.6	94.4	95.7	96.7	97.5	98.1	98.6	98.9	99.2	99.4
20	7.1	14.8	22.7	30.4	37.8	44.7	51.2	57.0	62.4	67.1	71.4	75.2	78.5	81.4	84.0	86.2	88.2	89.9	91.3	92.6
21	1.7	3.6	5.7	7.9	10.3	12.7	15.1	17.6	20.2	22.7	25.3	27.8	30.4	32.9	35.4	37.8	40.2	42.5	44.8	47.0
22	2.5	5.2	8.1	11.1	14.3	17.5	20.7	24.0	27.2	30.4	33.6	36.7	39.7	42.6	45.5	48.2	50.9	53.5	56.0	58.4
23	0.8	1.7	2.7	3.6	4.6	5.7	6.7	7.8	8.9	10.1	11.2	12.4	13.5	14.7	15.9	17.1	18.3	19.6	20.8	22.0
24	10.6	20.7	30.1	38.7	46.5	53.5	59.7	65.2	70.1	74.3	78.0	81.2	83.9	86.3	88.4	90.1	91.6	92.9	94.0	94.9
25	0.2	0.5	0.8	1.0	1.3	1.6	1.9	2.1	2.4	2.7	3.0	3.3	3.6	3.9	4.2	4.5	4.9	5.2	5.5	5.8
26	0.7	1.6	2.5	3.4	4.4	5.5	6.6	7.7	8.9	10.1	11.4	12.7	14.0	15.3	16.6	17.9	19.3	20.7	22.0	23.4
27	35.4	60.0	76.0	85.9	91.8	95.3	97.4	98.5	99.2	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	33.7	57.1	72.7	82.9	89.4	93.5	96.0	97.6	98.6	99.1	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
29	9.8	21.1	32.4	43.0	52.6	61.0	68.1	74.2	79.2	83.3	86.7	89.4	91.6	93.4	94.8	95.9	96.8	97.5	98.0	98.5

Space Division
North American Rockwell

PROBABILITY OF SEEING 90. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 4 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	55.4	82.1	93.2	97.5	99.1	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	44.5	72.0	86.6	93.8	97.2	98.8	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	16.2	31.9	45.9	57.7	67.4	75.1	81.1	85.8	89.4	92.1	94.2	95.7	96.8	97.7	98.3	98.8	99.1	99.4	99.5	99.7
4	41.1	68.1	83.6	91.8	96.0	98.1	99.1	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	38.8	63.5	78.6	87.6	92.9	96.0	97.8	98.8	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	8.2	17.5	26.9	36.0	44.6	52.4	59.4	65.5	70.9	75.6	79.5	82.9	85.8	88.2	90.3	92.0	93.4	94.6	95.5	96.3
7	28.2	53.3	71.3	83.0	90.2	94.5	96.9	98.3	99.1	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8	24.7	44.8	60.4	72.0	80.4	86.4	90.7	93.6	95.7	97.1	98.0	98.7	99.1	99.4	99.6	99.7	99.8	99.9	99.9	100.0
9	23.4	42.0	56.6	67.8	76.2	82.6	87.3	90.8	93.3	95.2	96.5	97.5	98.2	98.7	99.1	99.4	99.5	99.7	99.8	99.8
10	26.3	46.7	62.0	73.2	81.3	87.0	91.1	93.9	95.8	97.2	98.1	98.7	99.1	99.4	99.6	99.7	99.8	99.9	99.9	100.0
11	26.5	47.0	62.4	73.6	81.6	87.3	91.3	94.1	96.0	97.3	98.2	98.8	99.2	99.5	99.6	99.8	99.8	99.9	99.9	100.0
12	8.5	17.4	26.2	34.6	42.5	49.7	56.3	62.1	67.4	71.9	76.0	79.5	82.5	85.1	87.4	89.3	91.0	92.4	93.6	94.6
13	3.2	6.4	9.6	12.8	16.0	19.2	22.3	25.4	28.4	31.4	34.2	37.1	39.8	42.5	45.0	47.5	49.9	52.3	54.5	56.7
14	2.6	5.4	8.2	11.0	13.9	16.8	19.7	22.6	25.5	28.3	31.1	33.9	36.6	39.2	41.8	44.2	46.7	49.0	51.3	53.5
15	32.3	55.4	71.2	81.7	88.5	92.8	95.6	97.3	98.3	99.0	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
16	36.4	63.0	79.6	89.1	94.3	97.1	98.5	99.3	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
17	19.9	40.9	58.4	71.7	81.2	87.7	92.1	95.0	96.8	98.0	98.8	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0
18	45.5	71.8	85.8	93.1	96.7	98.4	99.3	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	35.8	60.8	76.9	86.7	92.5	95.8	97.7	98.7	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	3.1	6.6	10.3	14.2	18.2	22.2	26.2	30.2	34.1	38.0	41.7	45.2	48.7	52.0	55.1	58.1	60.9	63.6	66.1	68.5
21	11.9	24.0	35.4	45.8	54.9	62.8	69.6	75.2	80.0	83.8	87.0	89.6	91.7	93.4	94.8	95.9	96.7	97.4	98.0	98.4
22	3.2	6.8	10.6	14.7	18.9	23.1	27.3	31.4	35.5	39.4	43.2	46.9	50.4	53.8	56.9	60.0	62.8	65.5	68.0	70.4
23	3.7	7.7	11.9	16.1	20.4	24.8	29.0	33.2	37.2	41.2	44.9	48.5	52.0	55.3	58.4	61.3	64.1	66.7	69.2	71.4
24	14.0	26.6	37.7	47.5	55.9	63.1	69.3	74.5	78.9	82.6	85.7	88.2	90.3	92.1	93.5	94.7	95.7	96.5	97.2	97.7
25	2.5	5.0	7.7	10.5	13.2	16.1	18.9	21.7	24.5	27.3	30.0	32.7	35.4	38.0	40.5	43.0	45.4	47.7	50.0	52.2
26	6.5	13.9	21.6	29.2	36.6	43.6	50.1	56.1	61.5	66.4	70.8	74.6	78.0	81.0	83.7	86.0	88.0	89.7	91.2	92.5
27	48.5	75.2	88.6	94.9	97.8	99.0	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	52.6	78.4	90.4	95.8	98.2	99.2	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	5.3	11.3	17.6	24.1	30.6	36.8	42.8	48.4	53.6	58.5	62.9	67.0	70.7	74.0	77.0	79.7	82.1	84.2	86.1	87.8

PROBABILITY OF SEEING 90. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 7 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	66.7	90.5	97.5	99.4	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	68.0	93.6	98.9	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	0.2	0.5	0.8	1.0	1.3	1.6	1.9	2.2	2.5	2.8	3.1	3.4	3.7	4.1	4.4	4.7	5.1	5.4	5.8	6.1
4	8.6	19.3	30.5	41.2	51.0	59.6	67.0	73.3	78.5	82.8	86.3	89.1	91.4	93.2	94.7	95.8	96.7	97.5	98.0	98.5
5	32.2	55.6	71.7	82.2	89.0	93.3	95.9	97.5	98.5	99.1	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
6	32.3	62.4	81.0	90.9	95.8	98.1	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	8.2	16.4	24.5	32.2	39.5	46.2	52.4	58.0	63.1	67.6	71.7	75.3	78.5	81.4	83.8	86.0	87.9	89.6	91.0	92.3
8	50.6	79.9	92.5	97.4	99.1	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	16.7	32.3	46.1	57.7	67.2	74.8	80.8	85.4	89.0	91.8	93.9	95.4	96.6	97.5	98.2	98.7	99.0	99.3	99.5	99.6
10	7.3	14.8	22.3	29.6	36.5	43.0	49.1	54.7	59.8	64.4	68.5	72.3	75.6	78.6	81.3	83.6	85.7	87.6	89.2	90.6
11	17.0	33.2	47.4	59.2	68.8	76.4	82.3	86.8	90.2	92.8	94.7	96.2	97.2	98.0	98.5	98.9	99.2	99.5	99.6	99.7
12	1.4	3.0	4.7	6.4	8.3	10.2	12.2	14.2	16.3	18.4	20.5	22.6	24.7	26.8	28.9	31.0	33.0	35.1	37.1	39.0
13	4.9	10.5	16.4	22.4	28.4	34.2	39.9	45.2	50.3	55.0	59.4	63.4	67.2	70.5	73.6	76.4	79.0	81.3	83.4	85.2
14	0.6	1.3	1.9	2.6	3.3	3.9	4.6	5.3	6.0	6.8	7.5	8.2	9.0	9.7	10.5	11.2	12.0	12.7	13.5	14.3
15	10.0	20.1	29.9	39.1	47.5	55.0	61.7	67.5	72.6	76.9	80.7	83.8	86.5	88.8	90.7	92.3	93.6	94.7	95.7	96.4
16	0.7	1.5	2.3	3.2	4.0	4.9	5.7	6.6	7.6	8.5	9.4	10.4	11.4	12.3	13.3	14.3	15.3	16.3	17.3	18.3
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
18	58.8	85.0	94.9	98.3	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	17.7	35.9	51.7	64.6	74.5	81.9	87.3	91.2	93.9	95.8	97.2	98.1	98.7	99.1	99.4	99.6	99.7	99.8	99.9	99.9
20	5.8	12.7	20.2	27.9	35.4	42.5	49.2	55.3	60.9	65.9	70.4	74.4	77.9	81.0	83.7	86.0	88.0	89.8	91.3	92.6
21	7.5	16.7	26.4	36.0	45.0	53.3	60.6	66.9	72.5	77.2	81.1	84.5	87.3	89.6	91.5	93.1	94.4	95.5	96.4	97.1
22	4.3	9.2	14.6	20.2	25.9	31.5	37.0	42.2	47.2	51.9	56.3	60.4	64.2	67.7	70.9	73.9	76.5	79.0	81.2	83.2
23	1.2	2.5	3.8	5.3	6.7	8.2	9.8	11.4	13.0	14.6	16.3	17.9	19.6	21.3	23.0	24.7	26.3	28.0	29.7	31.3
24	43.9	69.7	84.0	91.8	95.8	97.9	98.9	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25	48.3	77.6	91.1	96.6	98.8	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
26	23.2	44.7	61.7	74.2	83.0	89.0	92.9	95.5	97.2	98.2	98.9	99.3	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0
27	20.9	38.2	52.2	63.3	72.0	78.8	84.0	88.0	91.0	93.3	95.0	96.3	97.3	98.0	98.5	98.9	99.2	99.4	99.6	99.7
28	16.4	30.4	42.3	52.3	60.7	67.7	73.5	78.3	82.3	85.6	88.2	90.4	92.2	93.7	94.9	95.9	96.7	97.3	97.8	98.3
29	6.8	14.8	23.3	31.7	39.9	47.4	54.4	60.6	66.2	71.1	75.4	79.1	82.3	85.1	87.4	89.4	91.2	92.6	93.8	94.8

PROBABILITY OF SEEING 90. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 7 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	75.6	95.2	99.1	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	77.9	96.5	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	2.0	4.0	6.1	8.2	10.4	12.6	14.7	17.0	19.2	21.4	23.5	25.7	27.9	30.0	32.1	34.2	36.2	38.2	40.2	42.1
4	12.1	25.0	37.4	48.5	58.3	66.5	73.4	79.0	83.5	87.1	90.0	92.2	94.0	95.4	96.5	97.3	97.9	98.4	98.8	99.1
5	40.9	66.2	81.1	89.6	94.4	97.0	98.4	99.2	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	25.7	52.4	71.7	83.9	91.1	95.2	97.5	98.7	99.3	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	12.8	24.9	36.0	45.9	54.5	62.0	68.5	73.9	78.5	82.4	85.6	88.2	90.4	92.2	93.7	94.9	95.9	96.7	97.3	97.8
8	50.4	79.5	92.2	97.2	99.0	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	17.7	35.1	50.3	62.8	72.6	80.0	85.6	89.7	92.7	94.9	96.4	97.5	98.3	98.8	99.2	99.4	99.6	99.7	99.8	99.9
10	23.8	47.9	66.4	79.1	87.4	92.5	95.6	97.5	98.6	99.2	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
11	37.1	64.2	80.8	90.0	95.0	97.5	98.8	99.4	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	0.3	0.6	0.8	1.1	1.4	1.7	2.0	2.3	2.6	2.9	3.2	3.5	3.8	4.2	4.5	4.8	5.1	5.4	5.8	6.1
13	5.6	11.5	17.7	23.8	29.8	35.7	41.2	46.5	51.4	56.0	60.3	64.2	67.8	71.1	74.1	76.8	79.3	81.5	83.6	85.4
14	0.6	1.3	1.9	2.6	3.3	3.9	4.6	5.3	6.0	6.8	7.5	8.2	9.0	9.7	10.5	11.2	12.0	12.7	13.5	14.3
15	7.4	14.8	22.0	28.9	35.5	41.7	47.4	52.7	57.6	62.0	66.1	69.8	73.1	76.1	78.8	81.3	83.4	85.4	87.1	88.6
16	4.7	9.8	15.0	20.4	25.7	31.0	36.1	41.0	45.6	50.1	54.2	58.1	61.8	65.1	68.3	71.2	73.8	76.3	78.5	80.6
17	4.7	9.6	14.6	19.6	24.5	29.3	34.0	38.5	42.8	46.9	50.8	54.5	58.0	61.2	64.3	67.1	69.8	72.2	74.5	76.7
18	59.6	85.0	94.7	98.2	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	37.0	65.1	81.9	91.0	95.7	97.9	99.0	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	4.2	9.2	14.5	20.0	25.6	31.1	36.5	41.7	46.6	51.3	55.7	59.7	63.5	67.0	70.2	73.2	75.9	78.3	80.6	82.6
21	5.2	10.9	16.8	22.8	28.8	34.6	40.2	45.5	50.4	55.1	59.4	63.4	67.1	70.4	73.5	76.3	78.8	81.1	83.1	85.0
22	2.5	5.2	8.1	11.1	14.3	17.5	20.7	24.0	27.2	30.4	33.6	36.7	39.7	42.6	45.5	48.3	50.9	53.5	56.0	58.4
23	4.8	9.9	15.1	20.4	25.6	30.7	35.6	40.4	44.9	49.2	53.2	57.0	60.6	63.9	67.0	69.9	72.5	75.0	77.2	79.3
24	44.9	70.3	84.3	91.8	95.8	97.8	98.9	99.4	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25	68.5	92.2	98.3	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
26	59.4	89.0	97.4	99.4	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
27	32.3	55.4	71.3	81.8	88.6	92.9	95.7	97.3	98.4	99.0	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
28	29.0	50.0	64.9	75.6	83.0	88.3	91.9	94.5	96.2	97.4	98.2	98.8	99.2	99.4	99.6	99.7	99.8	99.9	99.9	99.9
29	3.2	7.0	11.0	15.3	19.8	24.3	28.7	33.1	37.4	41.6	45.6	49.4	53.1	56.5	59.8	62.9	65.7	68.4	71.0	73.3

PROBABILITY OF SEEING 90. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 10 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	81.0	97.2	99.6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	24.6	45.7	62.2	74.2	82.7	88.6	92.5	95.2	96.9	98.0	98.7	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0
3	2.7	5.6	8.6	11.8	15.0	18.2	21.4	24.6	27.8	31.0	34.1	37.1	40.1	42.9	45.7	48.4	51.0	53.5	56.0	58.3
4	27.9	53.1	71.3	83.0	90.3	94.5	97.0	98.3	99.1	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	32.2	55.6	71.7	82.2	89.0	93.3	95.9	97.5	98.5	99.1	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
6	40.2	66.2	81.7	90.3	95.0	97.4	98.7	99.4	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	21.8	39.8	54.2	65.5	74.2	80.9	85.9	89.6	92.4	94.5	96.0	97.1	97.9	98.5	98.9	99.2	99.4	99.6	99.7	99.8
8	31.3	55.2	71.8	82.7	89.6	93.8	96.3	97.9	98.8	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
9	10.9	20.7	29.6	37.6	44.8	51.2	56.9	62.0	66.6	70.6	74.2	77.4	80.1	82.6	84.8	86.7	88.4	89.8	91.1	92.3
10	25.1	46.5	63.0	74.9	83.3	89.1	92.9	95.4	97.1	98.1	98.8	99.3	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0
11	33.8	58.1	74.3	84.6	90.9	94.7	97.0	98.3	99.0	99.4	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
12	1.7	3.6	5.7	7.9	10.3	12.7	15.1	17.6	20.2	22.7	25.3	27.8	30.4	32.9	35.4	37.8	40.2	42.5	44.8	47.0
13	2.5	5.2	8.1	11.1	14.3	17.5	20.7	24.0	27.2	30.4	33.6	36.7	39.7	42.6	45.5	48.2	50.9	53.5	56.0	58.4
14	0.8	1.7	2.7	3.6	4.6	5.7	6.7	7.8	8.9	10.1	11.2	12.4	13.5	14.7	15.9	17.1	18.3	19.6	20.8	22.0
15	10.6	20.7	30.1	38.7	46.5	53.5	59.7	65.2	70.1	74.3	78.0	81.2	83.9	86.3	88.4	90.1	91.6	92.9	94.0	94.9
16	0.2	0.5	0.8	1.0	1.3	1.6	1.9	2.1	2.4	2.7	3.0	3.3	3.6	3.9	4.2	4.5	4.9	5.2	5.5	5.8
17	0.7	1.6	2.5	3.4	4.4	5.5	6.6	7.7	8.9	10.1	11.4	12.7	14.0	15.3	16.6	17.9	19.3	20.7	22.0	23.4
18	35.4	60.0	76.0	85.9	91.8	95.3	97.4	98.5	99.2	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	33.7	57.1	72.7	82.9	89.4	93.5	96.0	97.6	98.6	99.1	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
20	9.8	21.1	32.4	43.0	52.6	61.0	68.1	74.2	79.2	83.3	86.7	89.4	91.6	93.4	94.8	95.9	96.8	97.5	98.0	98.5
21	11.7	26.7	41.5	54.6	65.5	74.2	80.9	86.0	89.8	92.7	94.7	96.3	97.3	98.1	98.7	99.1	99.3	99.5	99.7	99.8
22	1.8	3.7	5.8	7.9	10.1	12.3	14.7	17.0	19.3	21.7	24.1	26.4	28.8	31.1	33.4	35.6	37.9	40.1	42.2	44.3
23	0.4	0.9	1.3	1.8	2.3	2.7	3.2	3.7	4.3	4.8	5.3	5.9	6.4	7.0	7.5	8.1	8.7	9.2	9.8	10.4
24	29.7	51.3	66.6	77.4	84.8	89.8	93.2	95.5	97.1	98.1	98.7	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0	100.0
25	8.0	17.9	28.4	38.6	48.0	56.4	63.8	70.1	75.5	80.0	83.8	86.9	89.4	91.5	93.2	94.6	95.7	96.6	97.3	97.8
26	17.9	36.2	52.0	64.8	74.7	82.1	87.4	91.3	94.0	95.9	97.2	98.1	98.7	99.1	99.4	99.6	99.7	99.8	99.9	99.9
27	29.5	52.2	68.5	79.6	87.0	91.8	94.9	96.9	98.1	98.8	99.3	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
28	17.8	33.3	46.4	57.4	66.3	73.6	79.4	84.0	87.6	90.4	92.6	94.4	95.7	96.7	97.5	98.1	98.6	98.9	99.2	99.4
29	7.1	14.8	22.7	30.4	37.8	44.7	51.2	57.0	62.4	67.1	71.4	75.2	78.5	81.4	84.0	86.2	88.2	89.9	91.3	92.6

PROBABILITY OF SEEING 90. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 10 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	87.1	98.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	42.0	69.1	84.3	92.3	96.3	98.3	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	3.9	8.1	12.4	16.7	21.1	25.4	29.6	33.8	37.8	41.7	45.4	49.0	52.4	55.6	58.7	61.5	64.3	66.8	69.3	71.5
4	42.9	70.8	85.9	93.5	97.1	98.7	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	43.0	68.3	82.8	90.8	95.1	97.4	98.7	99.3	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	25.0	46.4	62.9	74.9	83.3	89.1	92.9	95.4	97.1	98.2	98.8	99.3	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0
7	20.5	39.3	55.0	67.2	76.6	83.4	88.4	91.9	94.4	96.2	97.4	98.2	98.8	99.2	99.5	99.6	99.8	99.8	99.9	99.9
8	45.2	72.0	86.3	93.5	97.0	98.6	99.4	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	20.5	37.3	50.8	61.6	70.2	76.9	82.2	86.3	89.5	92.0	93.9	95.4	96.5	97.3	98.0	98.5	98.8	99.1	99.3	99.5
10	37.6	63.3	79.2	88.5	93.8	96.7	98.3	99.1	99.5	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	44.6	71.4	85.9	93.3	96.8	98.5	99.3	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	11.9	24.0	35.4	45.8	54.9	62.8	69.6	75.2	80.0	83.8	87.0	89.6	91.7	93.4	94.8	95.9	96.7	97.4	98.0	98.4
13	3.2	6.8	10.6	14.7	18.9	23.1	27.3	31.4	35.5	39.4	43.2	46.9	50.4	53.8	56.9	60.0	62.8	65.5	68.0	70.4
14	3.7	7.7	11.9	16.1	20.4	24.8	29.0	33.2	37.2	41.2	44.9	48.5	52.0	55.3	58.4	61.3	64.1	66.7	69.2	71.4
15	14.0	26.6	37.7	47.5	55.9	63.1	69.3	74.5	78.9	82.6	85.7	88.2	90.3	92.1	93.5	94.7	95.7	96.5	97.2	97.7
16	2.5	5.0	7.7	10.5	13.2	16.1	18.9	21.7	24.5	27.3	30.0	32.7	35.4	38.0	40.5	43.0	45.4	47.7	50.0	52.2
17	6.5	13.9	21.6	29.2	36.6	43.6	50.1	56.1	61.5	66.4	70.8	74.6	78.0	81.0	83.7	86.0	88.0	89.7	91.2	92.5
18	48.5	75.2	88.6	94.9	97.8	99.0	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	52.6	78.4	90.4	95.8	98.2	99.2	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	5.3	11.3	17.6	24.1	30.6	36.8	42.8	48.4	53.6	58.5	62.9	67.0	70.7	74.0	77.0	79.7	82.1	84.2	86.1	87.8
21	8.5	17.4	26.2	34.6	42.5	49.7	56.3	62.1	67.4	71.9	76.0	79.5	82.5	85.1	87.4	89.3	91.0	92.4	93.6	94.6
22	3.2	6.4	9.6	12.8	16.0	19.2	22.3	25.4	28.4	31.4	34.2	37.1	39.8	42.5	45.0	47.5	49.9	52.3	54.5	56.7
23	2.6	5.4	8.2	11.0	13.9	16.8	19.7	22.6	25.5	28.3	31.1	33.9	36.6	39.2	41.8	44.2	46.7	49.0	51.3	53.5
24	32.3	55.4	71.2	81.7	88.5	92.8	95.6	97.3	98.3	99.0	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
25	36.4	63.0	79.6	89.1	94.3	97.1	98.5	99.3	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
26	19.9	40.9	58.4	71.7	81.2	87.7	92.1	95.0	96.8	98.0	98.8	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0
27	45.5	71.8	85.8	93.1	96.7	98.4	99.3	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	35.8	60.8	76.9	86.7	92.5	95.8	97.7	98.7	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	3.1	6.6	10.3	14.2	18.2	22.2	26.2	30.2	34.1	38.0	41.7	45.2	48.7	52.0	55.1	58.1	60.9	63.6	66.1	68.5

PROBABILITY OF SEEING 95. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 1 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	43.2	69.2	83.8	91.6	95.8	97.9	98.9	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	17.7	33.3	46.6	57.7	66.8	74.1	79.9	84.5	88.1	90.9	93.1	94.7	96.0	97.0	97.7	98.3	98.7	99.0	99.3	99.5
3	5.1	10.7	16.6	22.5	28.4	34.2	39.7	45.0	49.9	54.6	58.9	62.9	66.5	69.9	73.0	75.8	78.3	80.6	82.7	84.6
4	20.9	39.6	55.1	67.2	76.4	83.2	88.2	91.7	94.2	96.0	97.3	98.1	98.7	99.1	99.4	99.6	99.7	99.8	99.9	99.9
5	32.5	55.3	70.9	81.2	88.0	92.4	95.2	97.0	98.2	98.9	99.3	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
6	31.4	53.7	69.2	79.7	86.7	91.4	94.4	96.4	97.7	98.6	99.1	99.4	99.6	99.8	99.9	99.9	99.9	100.0	100.0	100.0
7	31.4	53.7	69.2	79.7	86.7	91.4	94.4	96.4	97.7	98.6	99.1	99.4	99.6	99.8	99.9	99.9	99.9	100.0	100.0	100.0
8	6.7	13.4	19.9	26.2	32.2	37.9	43.3	48.3	53.0	57.3	61.3	65.0	68.4	71.5	74.3	76.9	79.2	81.3	83.2	85.0
9	24.0	42.5	56.7	67.6	75.8	81.9	86.6	90.1	92.7	94.6	96.0	97.1	97.9	98.4	98.8	99.2	99.4	99.6	99.7	99.8
10	34.9	58.5	74.0	83.9	90.1	94.0	96.4	97.8	98.7	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
11	12.0	23.0	33.1	42.2	50.2	57.3	63.5	68.9	73.6	77.6	81.1	84.0	86.6	88.7	90.5	92.0	93.3	94.4	95.4	96.1
12	4.2	9.6	15.5	21.8	28.2	34.4	40.5	46.2	51.6	56.6	61.2	65.5	69.3	72.8	75.9	78.8	81.3	83.5	85.5	87.3
13	2.1	4.8	7.8	11.1	14.6	18.3	22.0	25.8	29.6	33.3	36.9	40.5	43.9	47.3	50.5	53.6	56.5	59.3	62.0	64.5
14	0.6	1.2	1.9	2.6	3.4	4.2	5.0	5.8	6.7	7.6	8.5	9.4	10.3	11.3	12.2	13.2	14.2	15.2	16.2	17.2
15	41.5	66.5	81.1	89.4	94.2	96.8	98.3	99.1	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
16	19.0	41.3	59.9	73.7	83.2	89.5	93.5	96.1	97.6	98.6	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
17	18.8	36.4	51.5	63.7	73.2	80.4	85.9	89.9	92.8	94.9	96.4	97.5	98.2	98.8	99.1	99.4	99.6	99.7	99.8	99.9
18	18.9	34.8	47.8	58.5	67.1	74.1	79.6	84.0	87.5	90.3	92.5	94.1	95.5	96.5	97.3	97.9	98.4	98.8	99.1	99.3
19	15.2	28.3	39.5	49.1	57.2	64.0	69.9	74.8	78.9	82.4	85.3	87.8	89.8	91.5	93.0	94.2	95.1	96.0	96.7	97.2
20	3.8	8.5	13.8	19.5	25.2	30.9	36.5	41.9	47.0	51.8	56.3	60.5	64.4	68.0	71.3	74.2	77.0	79.4	81.6	83.6
21	0.7	1.5	2.3	3.2	4.1	5.0	6.0	7.0	8.1	9.2	10.3	11.4	12.6	13.7	14.9	16.1	17.3	18.5	19.7	20.9
22	2.7	6.0	9.6	13.5	17.5	21.7	25.8	30.0	34.1	38.0	41.9	45.6	49.2	52.7	55.9	59.0	61.9	64.7	67.3	69.7
23	0.3	0.6	1.0	1.3	1.7	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.7	6.1	6.6	7.0	7.5	7.9
24	7.4	15.1	22.7	30.1	37.2	43.8	49.9	55.6	60.7	65.4	69.5	73.3	76.6	79.6	82.2	84.5	86.5	88.3	89.9	91.2
25	0.4	0.8	1.2	1.6	2.0	2.5	2.9	3.4	3.9	4.4	4.9	5.4	5.9	6.5	7.0	7.5	8.1	8.7	9.2	9.8
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	55.6	81.6	92.7	97.2	98.9	99.6	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	13.3	27.2	40.2	51.8	61.6	69.7	76.4	81.7	85.9	89.2	91.8	93.7	95.3	96.4	97.3	98.0	98.5	98.9	99.2	99.4
29	2.9	6.7	11.1	15.9	21.0	26.1	31.3	36.3	41.2	45.8	50.3	54.5	58.4	62.1	65.5	68.7	71.6	74.3	76.8	79.0

PROBABILITY OF SEEING 95. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 1 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	56.7	82.6	93.3	97.5	99.1	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	28.3	49.7	65.3	76.4	84.1	89.4	92.9	95.3	96.9	98.0	98.7	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0	100.0
3	8.9	18.1	27.2	35.9	43.9	51.3	57.9	63.8	69.0	73.5	77.5	80.9	83.8	86.3	88.5	90.3	91.9	93.2	94.3	95.2
4	34.2	58.7	74.9	85.1	91.3	95.0	97.2	98.4	99.1	99.5	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	38.7	63.5	78.6	87.7	93.0	96.1	97.8	98.8	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	22.8	43.9	60.7	73.2	82.1	88.2	92.3	95.1	96.8	98.0	98.7	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0
7	22.8	43.9	60.7	73.2	82.1	88.2	92.3	95.1	96.8	98.0	98.7	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0
8	14.7	27.6	39.0	48.8	57.2	64.3	70.4	75.5	79.8	83.3	86.3	88.8	90.8	92.5	93.9	95.0	95.9	96.7	97.3	97.8
9	34.0	57.1	72.5	82.6	89.0	93.2	95.8	97.4	98.4	99.0	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
10	42.2	68.2	83.0	91.2	95.5	97.7	98.9	99.4	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	23.3	41.7	56.1	67.1	75.5	81.9	86.6	90.2	92.8	94.7	96.2	97.2	98.0	98.5	98.9	99.2	99.5	99.6	99.7	99.8
12	3.3	7.0	10.8	14.8	18.8	22.9	26.9	30.9	34.8	38.6	42.2	45.8	49.2	52.4	55.5	58.4	61.2	63.9	66.4	68.7
13	1.2	2.6	4.2	5.9	7.7	9.5	11.5	13.5	15.6	17.7	19.8	21.9	24.1	26.2	28.4	30.5	32.6	34.7	36.8	38.8
14	3.2	6.6	10.2	13.9	17.6	21.3	25.0	28.7	32.3	35.8	39.3	42.6	45.8	48.9	51.8	54.7	57.4	60.0	62.4	64.8
15	43.1	68.0	82.2	90.1	94.6	97.0	98.4	99.1	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
16	65.0	89.2	96.9	99.2	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
17	53.7	82.5	93.9	98.0	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
18	29.6	51.3	66.8	77.6	85.0	90.0	93.4	95.7	97.2	98.2	98.8	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0	100.0
19	27.7	47.9	62.6	73.3	80.9	86.4	90.4	93.2	95.2	96.6	97.6	98.3	98.8	99.2	99.4	99.6	99.7	99.8	99.9	99.9
20	1.6	3.5	5.7	8.0	10.5	13.1	15.8	18.5	21.4	24.2	27.0	29.8	32.6	35.3	38.0	40.7	43.3	45.8	48.3	50.7
21	0.1	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.3	1.5	1.6	1.8	1.9	2.1	2.3	2.4	2.6	2.8	2.9	3.1
22	3.6	7.6	11.7	16.0	20.4	24.8	29.1	33.3	37.5	41.5	45.3	49.0	52.5	55.8	58.9	61.9	64.7	67.4	69.8	72.1
23	0.3	0.6	1.0	1.3	1.7	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.7	6.1	6.6	7.0	7.5	7.9
24	5.7	11.5	17.1	22.7	28.1	33.3	38.2	42.9	47.4	51.6	55.5	59.1	62.6	65.7	68.7	71.4	73.9	76.2	78.4	80.3
25	3.0	6.2	9.7	13.2	16.9	20.6	24.2	27.9	31.5	35.0	38.4	41.8	45.0	48.1	51.1	54.0	56.8	59.4	61.9	64.2
26	3.4	6.9	10.4	14.0	17.6	21.1	24.7	28.1	31.5	34.9	38.1	41.2	44.2	47.2	50.0	52.7	55.3	57.8	60.1	62.4
27	56.9	82.3	92.9	97.3	99.0	99.6	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	31.8	56.8	73.8	84.6	91.2	95.0	97.2	98.5	99.2	99.5	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	2.1	4.7	7.7	11.0	14.5	18.2	21.9	25.6	29.4	33.1	36.7	40.3	43.7	47.0	50.2	53.3	56.2	59.0	61.7	64.2

PROBABILITY OF SEEING 95. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 4 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	40.1	65.2	80.3	89.0	93.9	96.7	98.2	99.0	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	25.3	46.4	62.6	74.4	82.8	88.6	92.5	95.1	96.8	97.9	98.7	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0	100.0
3	5.2	11.0	17.1	23.3	29.4	35.3	41.0	46.4	51.5	56.2	60.6	64.6	68.2	71.6	74.6	77.4	79.9	82.1	84.1	85.9
4	19.0	37.0	52.3	64.6	74.1	81.3	86.6	90.5	93.3	95.3	96.7	97.7	98.4	98.9	99.3	99.5	99.7	99.8	99.8	99.9
5	25.0	44.9	60.1	71.5	79.8	85.9	90.1	93.2	95.3	96.8	97.8	98.5	99.0	99.3	99.5	99.7	99.8	99.9	99.9	99.9
6	10.9	23.4	35.7	47.1	57.0	65.5	72.6	78.4	83.1	86.8	89.8	92.1	93.9	95.3	96.4	97.3	97.9	98.4	98.8	99.1
7	31.4	53.7	69.2	79.7	86.7	91.4	94.4	96.4	97.7	98.6	99.1	99.4	99.6	99.8	99.9	99.9	99.9	100.0	100.0	100.0
8	12.0	23.6	34.3	44.0	52.6	60.1	66.6	72.2	76.9	80.9	84.3	87.1	89.4	91.3	92.9	94.2	95.3	96.2	96.9	97.5
9	18.3	33.8	46.8	57.5	66.2	73.3	79.0	83.5	87.1	89.9	92.2	93.9	95.3	96.4	97.2	97.8	98.3	98.7	99.0	99.2
10	16.3	30.6	42.8	53.2	61.9	69.2	75.1	80.0	84.0	87.2	89.8	91.9	93.6	94.9	96.0	96.8	97.5	98.0	98.5	98.8
11	12.6	24.1	34.5	43.8	51.9	59.0	65.2	70.5	75.1	79.0	82.4	85.2	87.6	89.7	91.4	92.8	94.0	95.0	95.9	96.6
12	6.8	16.0	26.1	36.1	45.4	54.0	61.5	68.0	73.6	78.4	82.4	85.7	88.4	90.6	92.4	93.9	95.1	96.1	96.9	97.5
13	0.9	1.9	2.9	4.1	5.3	6.5	7.9	9.2	10.6	12.0	13.5	15.0	16.5	18.0	19.5	21.1	22.6	24.2	25.7	27.3
14	0.2	0.4	0.7	0.9	1.1	1.3	1.6	1.8	2.1	2.3	2.6	2.9	3.1	3.4	3.7	3.9	4.2	4.5	4.8	5.1
15	27.8	48.3	63.2	74.0	81.7	87.2	91.1	93.8	95.7	97.0	97.9	98.6	99.0	99.3	99.5	99.7	99.8	99.9	99.9	99.9
16	4.5	10.3	16.8	23.7	30.5	37.3	43.7	49.7	55.3	60.4	65.1	69.3	73.1	76.4	79.4	82.1	84.4	86.5	88.3	89.9
17	13.7	27.7	40.7	52.2	61.9	70.0	76.5	81.8	86.0	89.2	91.8	93.7	95.3	96.4	97.3	98.0	98.5	98.9	99.1	99.4
18	26.4	47.0	62.4	73.7	81.8	87.5	91.5	94.2	96.1	97.4	98.2	98.8	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0
19	15.5	29.3	41.2	51.4	60.0	67.3	73.3	78.3	82.4	85.8	88.6	90.8	92.6	94.1	95.3	96.2	97.0	97.6	98.1	98.5
20	4.7	9.8	15.3	20.8	26.4	31.9	37.2	42.3	47.1	51.7	56.0	59.9	63.6	67.1	70.2	73.1	75.7	78.2	80.3	82.3
21	0.9	1.8	2.8	3.9	5.1	6.3	7.5	8.8	10.1	11.5	12.9	14.3	15.7	17.2	18.7	20.1	21.6	23.1	24.6	26.1
22	1.2	2.6	4.2	5.9	7.7	9.5	11.5	13.5	15.6	17.7	19.8	21.9	24.1	26.2	28.4	30.5	32.6	34.7	36.8	38.8
23	0.4	0.9	1.3	1.8	2.3	2.8	3.4	3.9	4.5	5.0	5.6	6.2	6.8	7.5	8.1	8.7	9.4	10.0	10.7	11.4
24	8.8	17.2	25.2	32.6	39.5	45.9	51.7	57.0	61.8	66.1	70.0	73.5	76.6	79.4	81.9	84.1	86.0	87.7	89.2	90.6
25	0.1	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.5	1.6	1.8	1.9	2.0	2.2	2.3	2.5	2.6	2.8
26	0.4	0.8	1.2	1.6	2.0	2.5	2.9	3.4	3.9	4.4	4.9	5.4	5.9	6.5	7.0	7.5	8.1	8.7	9.2	9.8
27	32.3	55.4	71.1	81.6	88.4	92.7	95.5	97.2	98.3	99.0	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
28	31.4	53.6	68.9	79.4	86.4	91.1	94.2	96.3	97.6	98.5	99.0	99.4	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0
29	6.2	13.6	21.5	29.5	37.2	44.5	51.3	57.5	63.0	68.0	72.4	76.3	79.7	82.6	85.2	87.4	89.3	90.9	92.3	93.5

PROBABILITY OF SEEING 95. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 4 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	52.1	78.4	90.6	96.0	98.3	99.3	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	40.6	66.6	81.8	90.4	95.0	97.4	98.7	99.4	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	13.0	25.6	37.2	47.5	56.6	64.3	70.9	76.3	80.9	84.6	87.6	90.1	92.1	93.7	95.0	96.1	96.9	97.5	98.1	98.5
4	37.1	62.4	78.2	87.7	93.2	96.3	98.0	98.9	99.4	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	36.4	60.3	75.5	85.0	90.9	94.5	96.7	98.1	98.9	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
6	5.4	11.5	17.9	24.4	30.8	37.0	42.9	48.5	53.7	58.5	62.9	66.9	70.6	73.9	76.9	79.5	81.9	84.1	86.0	87.7
7	22.8	43.9	60.7	73.2	82.1	88.2	92.3	95.1	96.8	98.0	98.7	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0
8	21.9	40.0	54.4	65.8	74.5	81.1	86.1	89.9	92.6	94.6	96.1	97.2	98.0	98.6	99.0	99.3	99.5	99.6	99.7	99.8
9	21.5	38.8	52.6	63.5	72.0	78.6	83.7	87.6	90.6	92.9	94.7	96.0	97.0	97.7	98.3	98.7	99.1	99.3	99.5	99.6
10	24.0	42.9	57.4	68.5	76.9	83.1	87.7	91.1	93.6	95.4	96.7	97.6	98.3	98.8	99.1	99.4	99.6	99.7	99.8	99.8
11	24.2	43.2	57.8	68.9	77.3	83.5	88.0	91.4	93.8	95.6	96.8	97.7	98.4	98.9	99.2	99.4	99.6	99.7	99.8	99.9
12	6.3	12.8	19.3	25.7	31.9	37.8	43.5	48.7	53.6	58.2	62.3	66.2	69.7	72.8	75.7	78.3	80.7	82.8	84.7	86.4
13	2.4	4.8	7.2	9.6	12.0	14.4	16.8	19.2	21.5	23.8	26.1	28.3	30.5	32.7	34.8	36.9	38.9	40.9	42.9	44.8
14	1.7	3.5	5.3	7.2	9.2	11.1	13.1	15.1	17.2	19.2	21.2	23.2	25.2	27.2	29.2	31.2	33.1	35.0	36.9	38.7
15	29.8	51.5	66.9	77.6	85.0	90.0	93.4	95.6	97.1	98.1	98.8	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0	100.0
16	32.1	56.2	72.6	83.3	90.0	94.1	96.5	98.0	98.8	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
17	14.7	30.5	45.1	57.6	67.8	75.9	82.1	86.9	90.4	93.1	95.0	96.4	97.4	98.2	98.7	99.1	99.4	99.5	99.7	99.8
18	42.9	68.2	82.7	90.7	95.1	97.4	98.6	99.3	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	32.3	55.6	71.6	82.1	88.9	93.2	95.8	97.5	98.5	99.1	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
20	1.6	3.4	5.4	7.7	10.0	12.5	15.1	17.8	20.5	23.2	25.9	28.6	31.3	34.0	36.6	39.2	41.7	44.2	46.6	49.0
21	9.0	18.2	27.2	35.8	43.8	51.0	57.6	63.5	68.6	73.2	77.1	80.5	83.5	86.0	88.2	90.0	91.6	93.0	94.1	95.1
22	1.6	3.5	5.6	7.9	10.3	12.9	15.6	18.3	21.1	23.9	26.6	29.4	32.2	34.9	37.6	40.2	42.8	45.3	47.7	50.1
23	2.3	4.7	7.3	10.1	12.9	15.8	18.7	21.7	24.6	27.6	30.5	33.4	36.2	38.9	41.6	44.3	46.8	49.3	51.7	54.0
24	12.2	23.4	33.3	42.2	50.1	57.0	63.1	68.4	73.0	76.9	80.4	83.3	85.8	88.0	89.8	91.4	92.7	93.9	94.8	95.6
25	1.6	3.2	4.9	6.6	8.4	10.3	12.1	14.0	15.9	17.9	19.8	21.7	23.6	25.5	27.5	29.3	31.2	33.1	34.9	36.7
26	4.2	8.9	13.9	19.0	24.2	29.3	34.3	39.1	43.7	48.1	52.3	56.2	59.9	63.3	66.5	69.5	72.2	74.8	77.1	79.2
27	45.4	71.4	85.4	92.7	96.4	98.2	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	50.5	76.0	88.6	94.6	97.5	98.8	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
29	3.1	6.6	10.5	14.7	18.9	23.3	27.6	31.9	36.1	40.2	44.1	47.9	51.5	54.9	58.2	61.3	64.2	66.9	69.4	71.8

PROBABILITY OF SEEING 95. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 7 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	63.7	87.9	96.2	98.8	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	63.3	89.2	97.1	99.3	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	0.1	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.5	1.6	1.8	1.9	2.0	2.2	2.3	2.5	2.6	2.8
4	4.7	11.0	18.1	25.6	33.0	40.2	47.0	53.3	59.0	64.2	68.9	73.0	76.7	79.9	82.7	85.2	87.3	89.2	90.8	92.1
5	29.2	51.0	66.7	77.6	85.1	90.2	93.6	95.8	97.3	98.3	98.9	99.3	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0
6	25.3	50.1	68.7	81.1	88.9	93.6	96.4	98.0	98.9	99.4	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
7	6.3	12.6	18.8	24.9	30.8	36.3	41.6	46.6	51.3	55.7	59.7	63.4	66.9	70.0	72.9	75.6	78.0	80.2	82.2	84.0
8	45.7	73.5	87.8	94.6	97.7	99.0	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	13.5	26.4	38.1	48.5	57.5	65.2	71.7	77.0	81.5	85.1	88.1	90.5	92.4	94.0	95.2	96.2	97.0	97.7	98.2	98.6
10	5.3	10.7	16.3	21.9	27.4	32.7	37.8	42.7	47.3	51.7	55.8	59.6	63.1	66.4	69.5	72.3	74.9	77.2	79.4	81.4
11	13.7	26.8	38.8	49.4	58.6	66.3	72.8	78.1	82.5	86.1	88.9	91.2	93.1	94.6	95.7	96.7	97.4	98.0	98.4	98.8
12	0.7	1.5	2.3	3.2	4.1	5.0	6.0	7.0	8.1	9.2	10.3	11.4	12.6	13.7	14.9	16.1	17.3	18.5	19.7	20.9
13	2.7	6.0	9.6	13.5	17.5	21.7	25.8	30.0	34.1	38.0	41.9	45.6	49.2	52.7	55.9	59.0	61.9	64.7	67.3	69.7
14	0.3	0.6	1.0	1.3	1.7	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.7	6.1	6.6	7.0	7.5	7.9
15	7.4	15.1	22.7	30.1	37.2	43.8	49.9	55.6	60.7	65.4	69.5	73.3	76.6	79.6	82.2	84.5	86.5	88.3	89.9	91.2
16	0.4	0.8	1.2	1.6	2.0	2.5	2.9	3.4	3.9	4.4	4.9	5.4	5.9	6.5	7.0	7.5	8.1	8.7	9.2	9.8
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	55.6	81.6	92.7	97.2	98.9	99.6	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	13.3	27.2	40.2	51.8	61.6	69.7	76.4	81.7	85.9	89.2	91.8	93.7	95.3	96.4	97.3	98.0	98.5	98.9	99.2	99.4
20	2.9	6.7	11.1	15.9	21.0	26.1	31.3	36.3	41.2	45.8	50.3	54.5	58.4	62.1	65.5	68.7	71.6	74.3	76.8	79.0
21	4.2	9.6	15.5	21.8	28.2	34.4	40.5	46.2	51.6	56.6	61.2	65.5	69.3	72.8	75.9	78.8	81.3	83.5	85.5	87.3
22	2.1	4.8	7.8	11.1	14.6	18.3	22.0	25.8	29.6	33.3	36.9	40.5	43.9	47.3	50.5	53.6	56.5	59.3	62.0	64.5
23	0.6	1.2	1.9	2.6	3.4	4.2	5.0	5.8	6.7	7.6	8.5	9.4	10.3	11.3	12.2	13.2	14.2	15.2	16.2	17.2
24	41.5	66.5	81.1	89.4	94.2	96.8	98.3	99.1	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25	43.3	70.8	85.8	93.3	96.9	98.6	99.4	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
26	18.8	36.4	51.5	63.7	73.2	80.4	85.9	89.9	92.8	94.9	96.4	97.5	98.2	98.8	99.1	99.4	99.6	99.7	99.8	99.9
27	18.9	34.8	47.8	58.5	67.1	74.1	79.6	84.0	87.5	90.3	92.5	94.1	95.5	96.5	97.3	97.9	98.4	98.8	99.1	99.3
28	15.2	28.3	39.5	49.1	57.2	64.0	69.9	74.8	78.9	82.4	85.3	87.8	89.8	91.5	93.0	94.2	95.1	96.0	96.7	97.2
29	3.8	8.5	13.8	19.5	25.2	30.9	36.5	41.9	47.0	51.8	56.3	60.5	64.4	68.0	71.3	74.2	77.0	79.4	81.6	83.6

PROBABILITY OF SEEING 95. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 7 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	73.1	93.5	98.5	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	75.1	94.8	99.0	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	1.3	2.7	4.0	5.4	6.9	8.3	9.8	11.2	12.7	14.2	15.7	17.2	18.7	20.2	21.7	23.2	24.7	26.2	27.6	29.1
4	8.6	17.9	27.3	36.3	44.7	52.4	59.2	65.3	70.6	75.2	79.1	82.5	85.4	87.8	89.9	91.6	93.1	94.3	95.3	96.1
5	38.4	62.8	77.9	87.0	92.5	95.7	97.5	98.6	99.2	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	19.4	39.9	57.2	70.5	80.1	86.8	91.4	94.4	96.4	97.7	98.6	99.1	99.4	99.6	99.8	99.9	99.9	99.9	100.0	100.0
7	10.8	20.9	30.3	38.8	46.5	53.4	59.6	65.0	69.8	74.0	77.7	80.9	83.6	86.0	88.0	89.8	91.3	92.6	93.7	94.7
8	45.6	73.2	87.5	94.4	97.6	99.0	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	13.6	27.4	40.2	51.4	61.1	69.1	75.6	80.9	85.2	88.5	91.2	93.2	94.8	96.0	97.0	97.7	98.3	98.7	99.0	99.3
10	17.9	36.9	53.4	66.5	76.5	83.7	88.9	92.5	95.0	96.6	97.8	98.5	99.0	99.4	99.6	99.7	99.8	99.9	99.9	100.0
11	32.6	57.0	73.6	84.2	90.7	94.7	96.9	98.3	99.0	99.5	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	0.1	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.3	1.5	1.6	1.8	1.9	2.1	2.3	2.4	2.6	2.8	2.9	3.1
13	3.6	7.6	11.7	16.0	20.4	24.8	29.1	33.3	37.5	41.5	45.3	49.0	52.5	55.8	58.9	61.9	64.7	67.4	69.8	72.1
14	0.3	0.6	1.0	1.3	1.7	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.7	6.1	6.6	7.0	7.5	7.9
15	5.7	11.5	17.1	22.7	28.1	33.3	38.2	42.9	47.4	51.6	55.5	59.1	62.6	65.7	68.7	71.4	73.9	76.2	78.4	80.3
16	3.0	6.2	9.7	13.2	16.9	20.6	24.2	27.9	31.5	35.0	38.4	41.8	45.0	48.1	51.1	54.0	56.8	59.4	61.9	64.2
17	3.4	6.9	10.4	14.0	17.6	21.1	24.7	28.1	31.5	34.9	38.1	41.2	44.2	47.2	50.0	52.7	55.3	57.8	60.1	62.4
18	56.9	82.3	92.9	97.3	99.0	99.6	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	31.8	56.8	73.8	84.6	91.2	95.0	97.2	98.5	99.2	99.5	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	2.1	4.7	7.7	11.0	14.5	18.2	21.9	25.6	29.4	33.1	36.7	40.3	43.7	47.0	50.2	53.3	56.2	59.0	61.7	64.2
21	3.3	7.0	10.8	14.8	18.8	22.9	26.9	30.9	34.8	38.6	42.2	45.8	49.2	52.4	55.5	58.4	61.2	63.9	66.4	68.7
22	1.2	2.6	4.2	5.9	7.7	9.5	11.5	13.5	15.6	17.7	19.8	21.9	24.1	26.2	28.4	30.5	32.6	34.7	36.8	38.8
23	3.2	6.6	10.2	13.9	17.6	21.3	25.0	28.7	32.3	35.8	39.3	42.6	45.8	48.9	51.8	54.7	57.4	60.0	62.4	64.8
24	43.1	68.0	82.2	90.1	94.6	97.0	98.4	99.1	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25	65.0	89.2	96.9	99.2	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
26	53.7	82.5	93.9	98.0	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
27	29.6	51.3	66.8	77.6	85.0	90.0	93.4	95.7	97.2	98.2	98.8	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0	100.0
28	27.7	47.9	62.6	73.3	80.9	86.4	90.4	93.2	95.2	96.6	97.6	98.3	98.8	99.2	99.4	99.6	99.7	99.8	99.9	99.9
29	1.6	3.5	5.7	8.0	10.5	13.1	15.8	18.5	21.4	24.2	27.0	29.8	32.6	35.3	38.0	40.7	43.3	45.8	48.3	50.7

PROBABILITY OF SEEING 95. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 10 TIME 4

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	79.0	96.1	99.3	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	20.8	39.0	53.9	65.7	74.8	81.7	86.8	90.5	93.2	95.2	96.6	97.6	98.3	98.8	99.2	99.4	99.6	99.7	99.8	99.9
3	1.7	3.5	5.3	7.3	9.3	11.3	13.4	15.5	17.6	19.8	21.9	24.1	26.2	28.3	30.4	32.5	34.5	36.5	38.5	40.5
4	22.4	43.4	60.3	72.8	81.8	88.0	92.2	95.0	96.8	97.9	98.7	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0
5	29.2	51.0	66.7	77.6	85.1	90.2	93.6	95.8	97.3	98.3	98.9	99.3	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0
6	36.7	61.4	77.0	86.6	92.3	95.6	97.5	98.6	99.2	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	19.6	36.0	49.4	60.2	68.9	75.8	81.2	85.5	88.8	91.4	93.4	95.0	96.2	97.1	97.8	98.3	98.7	99.0	99.3	99.5
8	27.7	49.3	65.2	76.6	84.4	89.7	93.3	95.7	97.2	98.2	98.9	99.3	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0
9	10.0	19.1	27.3	34.8	41.5	47.6	53.1	58.1	62.5	66.5	70.1	73.4	76.3	78.9	81.2	83.3	85.1	86.8	88.2	89.6
10	21.3	39.8	54.9	66.7	75.8	82.5	87.5	91.1	93.7	95.6	96.9	97.9	98.5	99.0	99.3	99.5	99.7	99.8	99.8	99.9
11	30.5	53.0	68.9	79.7	86.9	91.7	94.7	96.7	97.9	98.7	99.2	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0
12	0.9	1.8	2.8	3.9	5.1	6.3	7.5	8.8	10.1	11.5	12.9	14.3	15.7	17.2	18.7	20.1	21.6	23.1	24.6	26.1
13	1.2	2.6	4.2	5.9	7.7	9.5	11.5	13.5	15.6	17.7	19.8	21.9	24.1	26.2	28.4	30.5	32.6	34.7	36.8	38.8
14	0.4	0.9	1.3	1.8	2.3	2.8	3.4	3.9	4.5	5.0	5.6	6.2	6.8	7.5	8.1	8.7	9.4	10.0	10.7	11.4
15	8.8	17.2	25.2	32.6	39.5	45.9	51.7	57.0	61.8	66.1	70.0	73.5	76.6	79.4	81.9	84.1	86.0	87.7	89.2	90.6
16	0.1	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.5	1.6	1.8	1.9	2.0	2.2	2.3	2.5	2.6	2.8
17	0.4	0.8	1.2	1.6	2.0	2.5	2.9	3.4	3.9	4.4	4.9	5.4	5.9	6.5	7.0	7.5	8.1	8.7	9.2	9.8
18	32.3	55.4	71.1	81.6	88.4	92.7	95.5	97.2	98.3	99.0	99.4	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
19	31.4	53.6	68.9	79.4	86.4	91.1	94.2	96.3	97.6	98.5	99.0	99.4	99.6	99.7	99.8	99.9	99.9	100.0	100.0	100.0
20	6.2	13.6	21.5	29.5	37.2	44.5	51.3	57.5	63.0	68.0	72.4	76.3	79.7	82.6	85.2	87.4	89.3	90.9	92.3	93.5
21	6.8	16.0	26.1	36.1	45.4	54.0	61.5	68.0	73.6	78.4	82.4	85.7	88.4	90.6	92.4	93.9	95.1	96.1	96.9	97.5
22	0.9	1.9	2.9	4.1	5.3	6.5	7.9	9.2	10.6	12.0	13.5	15.0	16.5	18.0	19.5	21.1	22.6	24.2	25.7	27.3
23	0.2	0.4	0.7	0.9	1.1	1.3	1.6	1.8	2.1	2.3	2.6	2.9	3.1	3.4	3.7	3.9	4.2	4.5	4.8	5.1
24	27.8	48.3	63.2	74.0	81.7	87.2	91.1	93.8	95.7	97.0	97.9	98.6	99.0	99.3	99.5	99.7	99.8	99.9	99.9	99.9
25	4.5	10.3	16.8	23.7	30.5	37.3	43.7	49.7	55.3	60.4	65.1	69.3	73.1	76.4	79.4	82.1	84.4	86.5	88.3	89.9
26	13.7	27.7	40.7	52.2	61.9	70.0	76.5	81.8	86.0	89.2	91.8	93.7	95.3	96.4	97.3	98.0	98.5	98.9	99.1	99.4
27	26.4	47.0	62.4	73.7	81.8	87.5	91.5	94.2	96.1	97.4	98.2	98.8	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0
28	15.5	29.3	41.2	51.4	60.0	67.3	73.3	78.3	82.4	85.8	88.6	90.8	92.6	94.1	95.3	96.2	97.0	97.6	98.1	98.5
29	4.7	9.8	15.3	20.8	26.4	31.9	37.2	42.3	47.1	51.7	56.0	59.9	63.6	67.1	70.2	73.1	75.7	78.2	80.3	82.3

PROBABILITY OF SEEING 95. PERCENT OR MORE OF AREAS IN ONE-OR TWO-LOOKS

MONTH 10 TIME 8

REGION	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12	N=13	N=14	N=15	N=16	N=17	N=18	N=19	N=20
1	85.6	98.2	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	38.1	63.5	79.2	88.4	93.6	96.6	98.2	99.0	99.5	99.7	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	2.6	5.4	8.2	11.2	14.2	17.2	20.2	23.2	26.2	29.2	32.1	35.0	37.8	40.5	43.2	45.8	48.3	50.7	53.1	55.3
4	38.4	64.5	80.3	89.4	94.4	97.1	98.5	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	40.7	65.5	80.2	88.7	93.6	96.4	98.0	98.9	99.4	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	21.3	39.7	54.8	66.6	75.7	82.4	87.4	91.1	93.7	95.6	96.9	97.8	98.5	99.0	99.3	99.5	99.7	99.8	99.8	99.9
7	16.8	32.4	46.1	57.6	67.0	74.6	80.5	85.2	88.8	91.6	93.7	95.3	96.5	97.4	98.1	98.6	99.0	99.2	99.4	99.6
8	41.8	67.5	82.4	90.6	95.1	97.5	98.7	99.3	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9	19.0	34.7	47.5	57.9	66.4	73.2	78.7	83.1	86.6	89.4	91.7	93.4	94.8	96.0	96.8	97.5	98.1	98.5	98.8	99.1
10	34.2	58.1	74.0	84.1	90.4	94.3	96.6	98.0	98.8	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
11	41.1	66.8	81.8	90.2	94.8	97.3	98.6	99.3	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	9.0	18.2	27.2	35.8	43.8	51.0	57.6	63.5	68.6	73.2	77.1	80.5	83.5	86.0	88.2	90.0	91.6	93.0	94.1	95.1
13	1.6	3.5	5.6	7.9	10.3	12.9	15.6	18.3	21.1	23.9	26.6	29.4	32.2	34.9	37.6	40.2	42.8	45.3	47.7	50.1
14	2.3	4.7	7.3	10.1	12.9	15.8	18.7	21.7	24.6	27.6	30.5	33.4	36.2	38.9	41.6	44.3	46.8	49.3	51.7	54.0
15	12.2	23.4	33.3	42.2	50.1	57.0	63.1	68.4	73.0	76.9	80.4	83.3	85.8	88.0	89.8	91.4	92.7	93.9	94.8	95.6
16	1.6	3.2	4.9	6.6	8.4	10.3	12.1	14.0	15.9	17.9	19.8	21.7	23.6	25.5	27.5	29.3	31.2	33.1	34.9	36.7
17	4.2	8.9	13.9	19.0	24.2	29.3	34.3	39.1	43.7	48.1	52.3	56.2	59.9	63.3	66.5	69.5	72.2	74.8	77.1	79.2
18	45.4	71.4	85.4	92.7	96.4	98.2	99.2	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19	50.5	76.0	88.6	94.6	97.5	98.8	99.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	3.1	6.6	10.5	14.7	18.9	23.3	27.6	31.9	36.1	40.2	44.1	47.9	51.5	54.9	58.2	61.3	64.2	66.9	69.4	71.8
21	6.3	12.8	19.3	25.7	31.9	37.8	43.5	48.7	53.6	58.2	62.3	66.2	69.7	72.8	75.7	78.3	80.7	82.8	84.7	86.4
22	2.4	4.8	7.2	9.6	12.0	14.4	16.8	19.2	21.5	23.8	26.1	28.3	30.5	32.7	34.8	36.9	38.9	40.9	42.9	44.8
23	1.7	3.5	5.3	7.2	9.2	11.1	13.1	15.1	17.2	19.2	21.2	23.2	25.2	27.2	29.2	31.2	33.1	35.0	36.9	38.7
24	29.8	51.5	66.9	77.6	85.0	90.0	93.4	95.6	97.1	98.1	98.8	99.2	99.5	99.7	99.8	99.9	99.9	99.9	100.0	100.0
25	32.1	56.2	72.6	83.3	90.0	94.1	96.5	98.0	98.8	99.3	99.6	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
26	14.7	30.5	45.1	57.6	67.8	75.9	82.1	86.9	90.4	93.1	95.0	96.4	97.4	98.2	98.7	99.1	99.4	99.5	99.7	99.8
27	42.9	68.2	82.7	90.7	95.1	97.4	98.6	99.3	99.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
28	32.3	55.6	71.6	82.1	88.9	93.2	95.8	97.5	98.5	99.1	99.5	99.7	99.8	99.9	99.9	100.0	100.0	100.0	100.0	100.0
29	1.6	3.4	5.4	7.7	10.0	12.5	15.1	17.8	20.5	23.2	25.9	28.6	31.3	34.0	36.6	39.2	41.7	44.2	46.6	49.0

APPENDIX E. CONTINUOUS VIEWING (MONTE CARLO) PROBABILITY OF SEEING RESULTS

SAMPLE OUTPUT

Perfect Resolution Probability of Seeing Computer Program

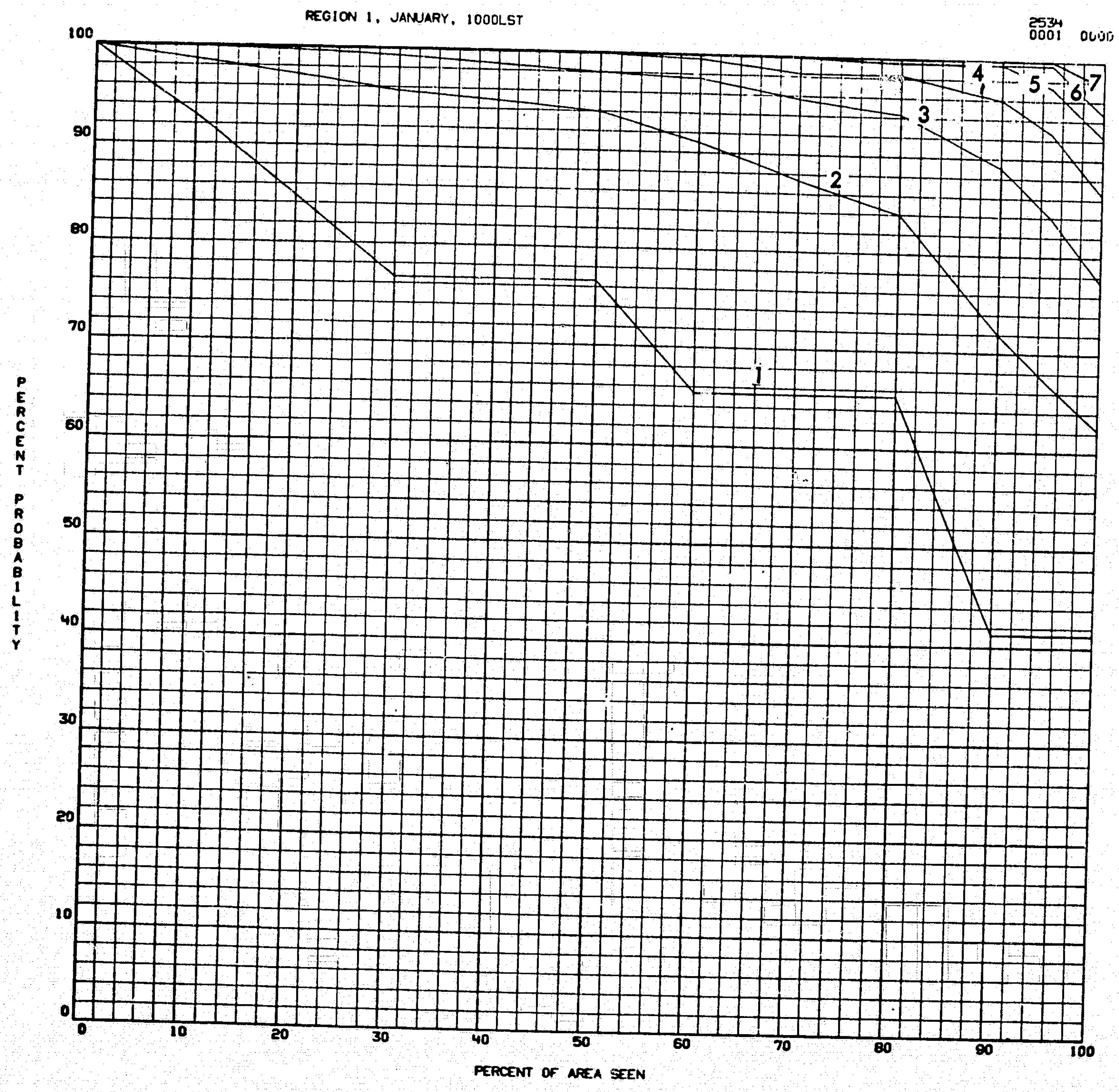
Subroutine: Continuous Viewing (Monte Carlo)

Cloud Statistics: Basic 30-nm FOV Enlarged for 100-nm FOV

Computed Relationship: The probability (percent) of seeing any selected percent or more of an area 100 n miles by 100 n miles in N independent passes. Continuous viewing is looking or photographing every pass over the area regardless of cloud cover. Independent passes are passes at least 24 hours apart.

Sample Output: Page E-2: Percent probability versus percent (or more) of area seen for N = 1, 2,. . . 8 for Region 1, January, 1000 LST.

Remaining Pages: Same as Page E-2 for Regions 1, 2, 8, 11, 18, 19, for each season mid-month (Jan, Apr, Jul, Oct), for 1000 LST, followed by similar data for special ERTS locations at Chesapeake Bay, Phoenix, and Feather River.


REGION 1, JANUARY, 1000LST
2534
0001 0000
PERCENT PROBABILITY
PERCENT OF AREA SEEN
100
90
80
70
60
50
40
30
20
10
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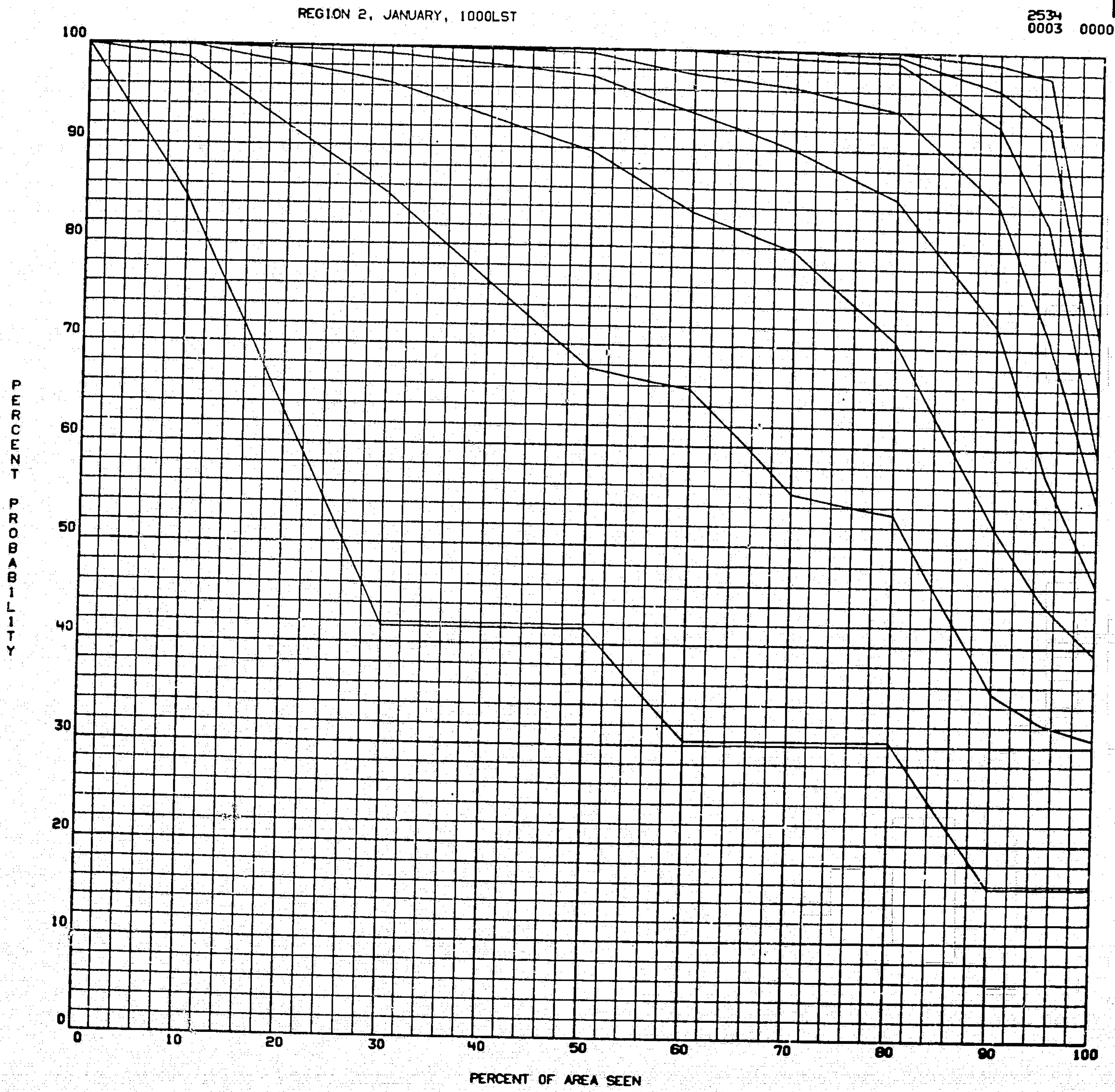
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7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2534
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PERCENT PROBABILITY
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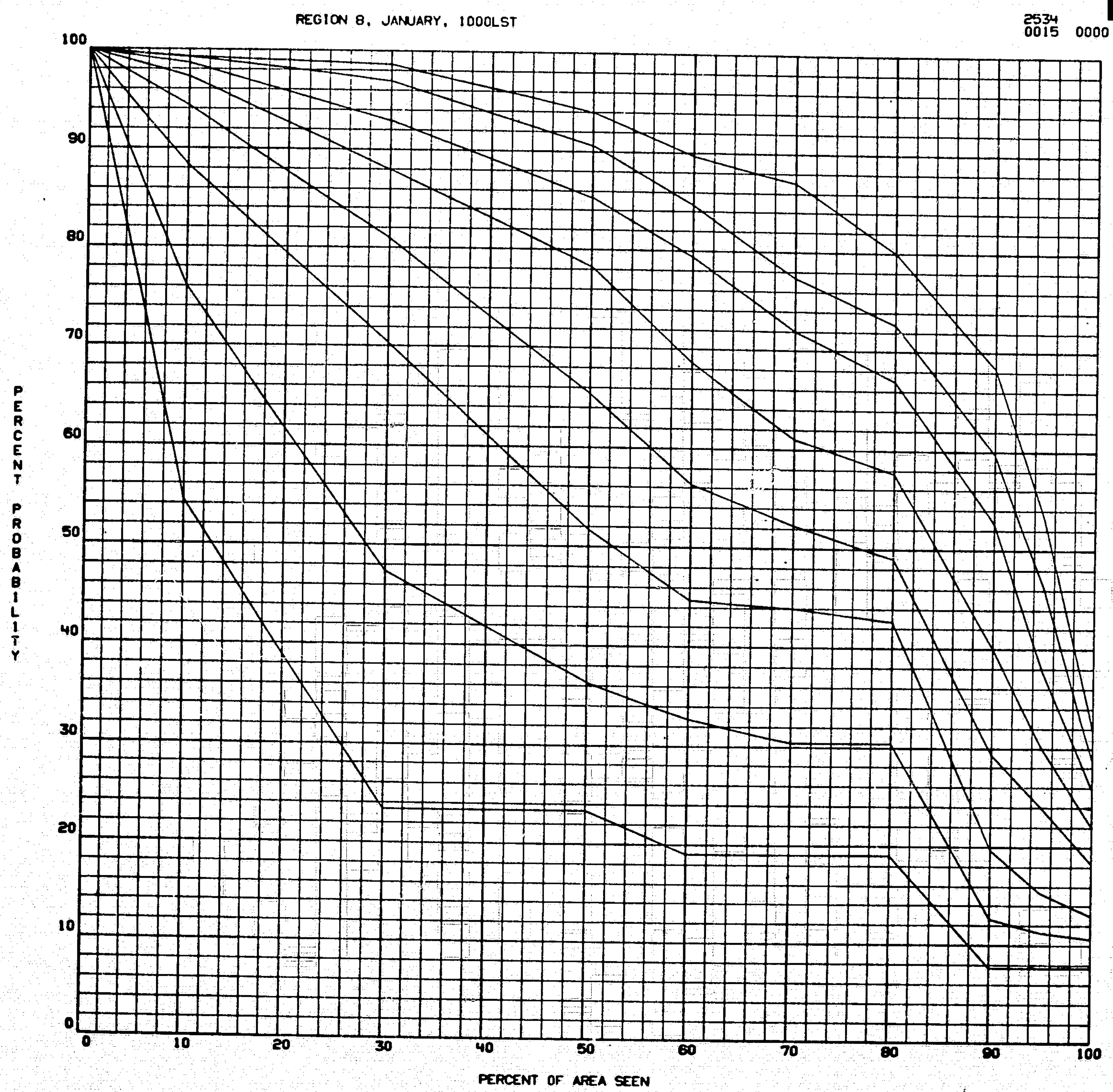
70
80
90
100
PERCENT OF AREA SEEN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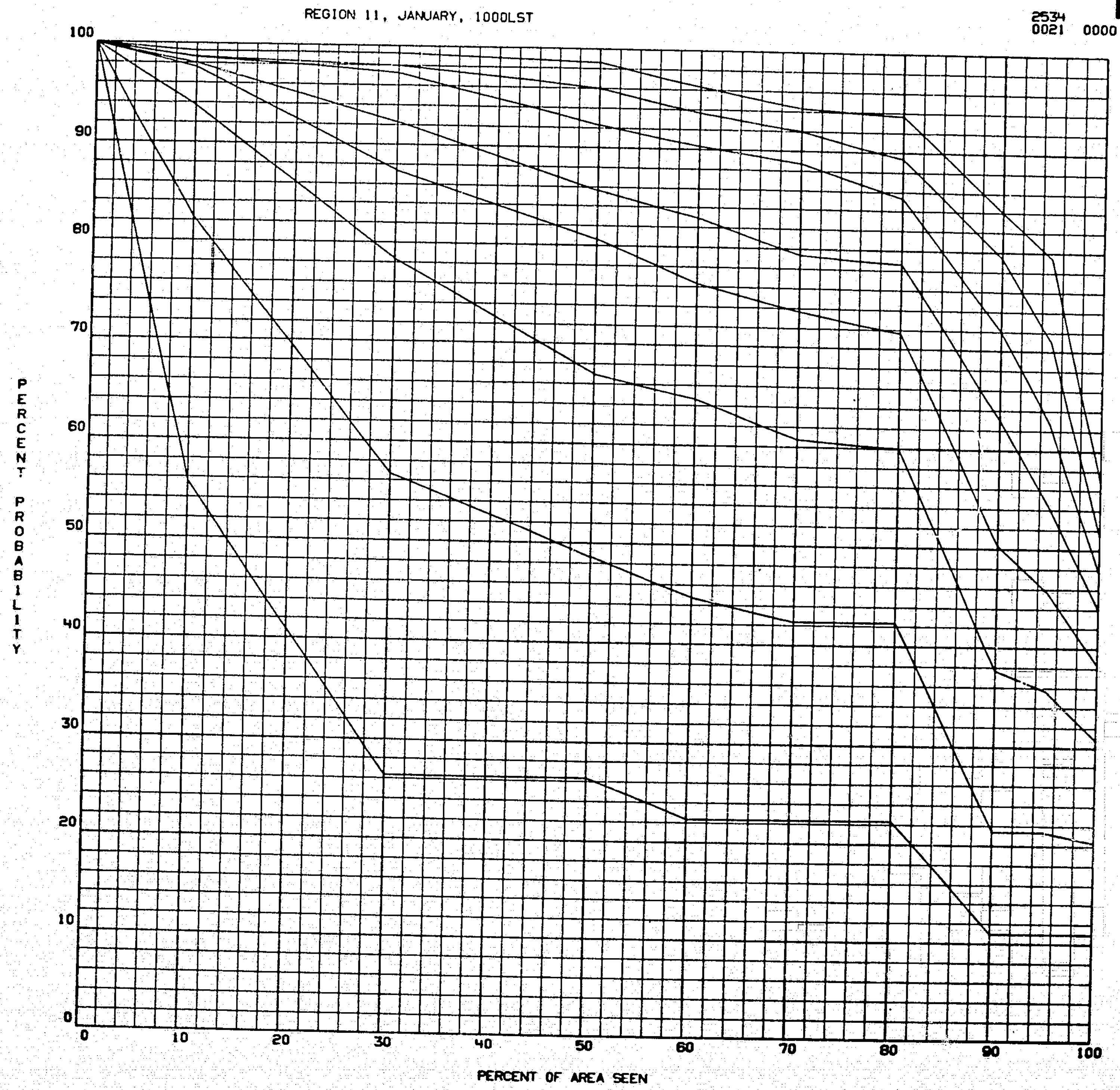
70
80
90
100
PERCENT OF AREA SEEN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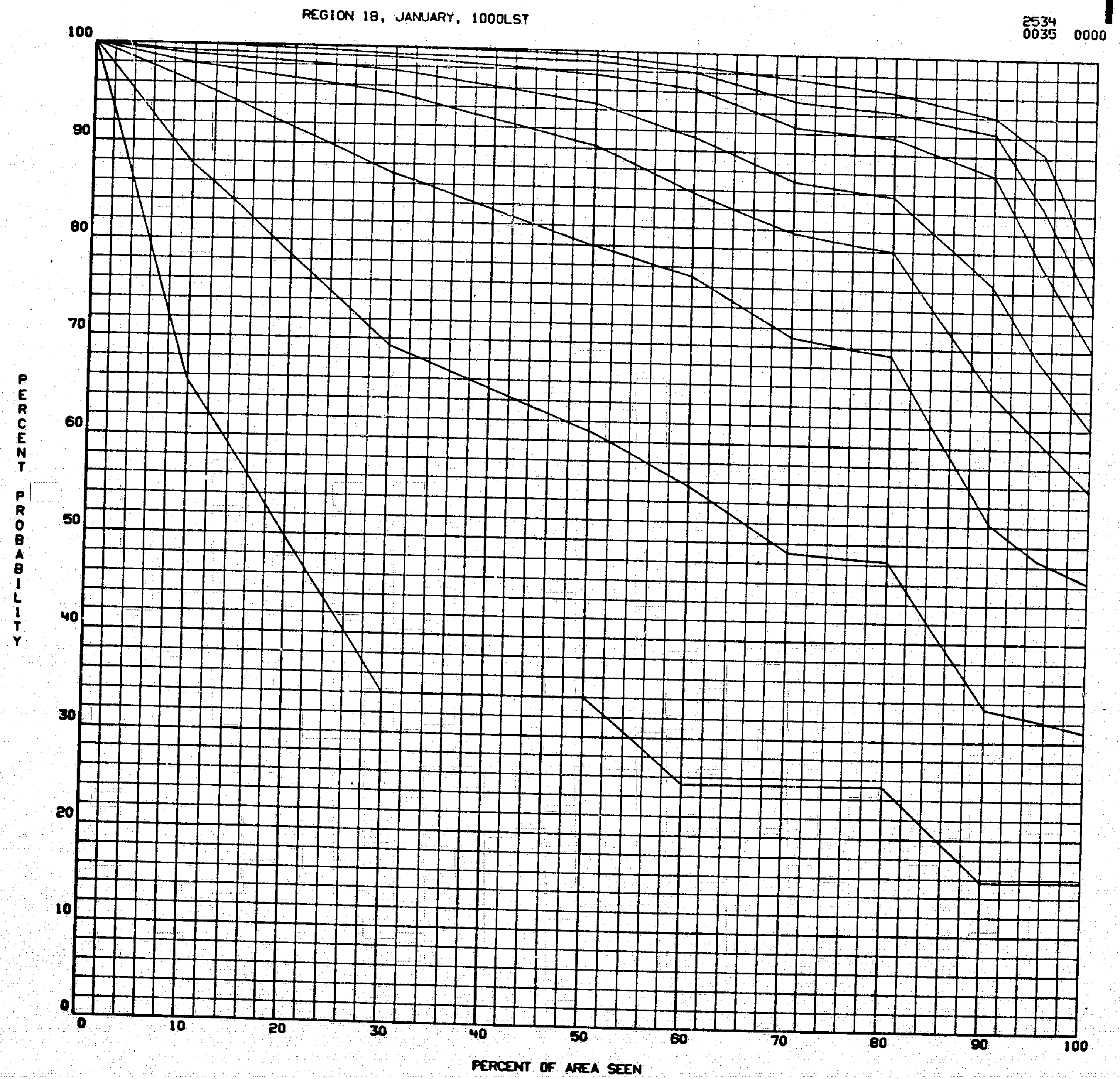
70
80
90
100
PERCENT OF AREA SEEN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2534
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60
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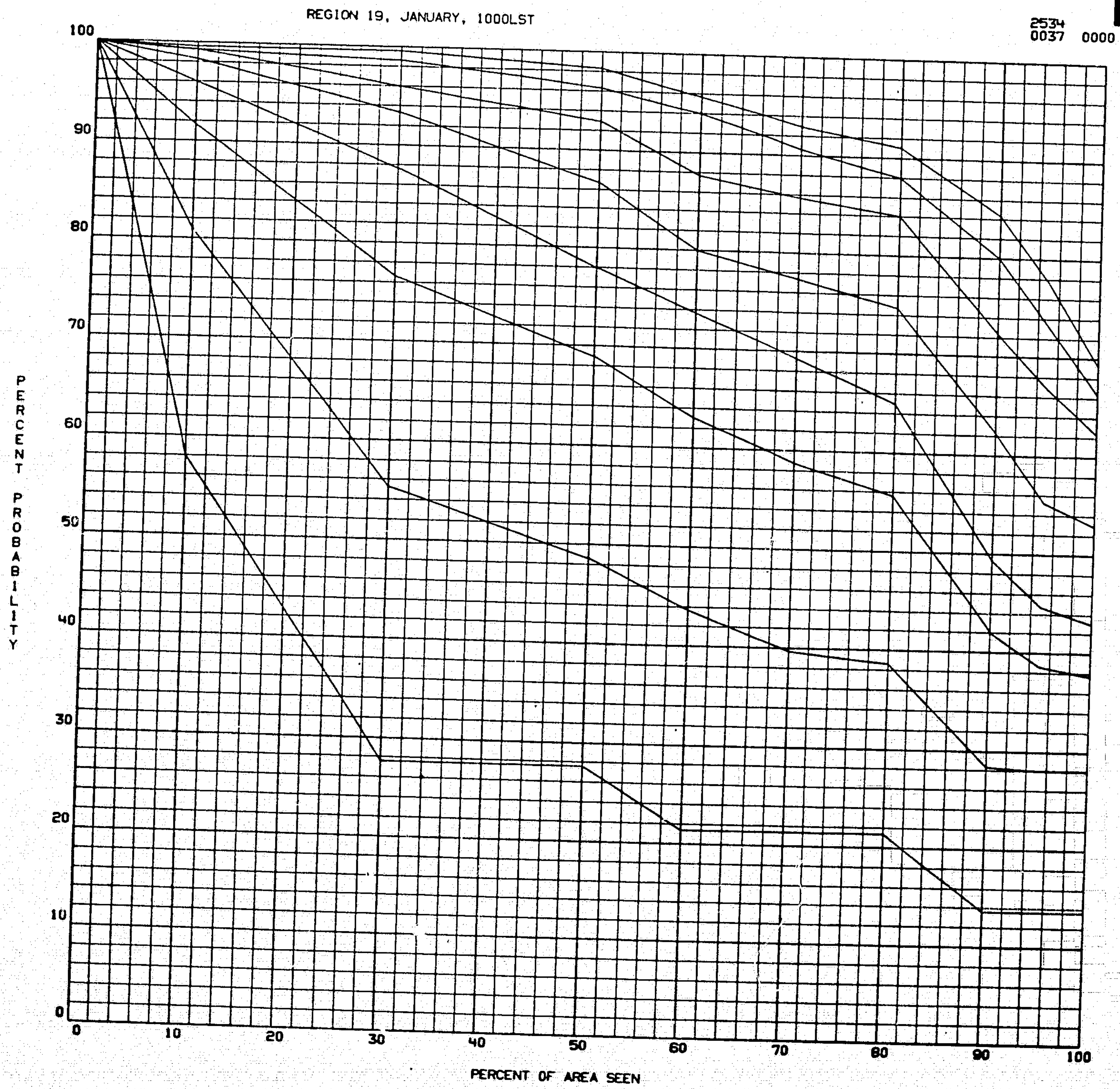
70
80
90
100
PERCENT OF AREA SEEN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PERCENT OF AREA SEEN
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80
90
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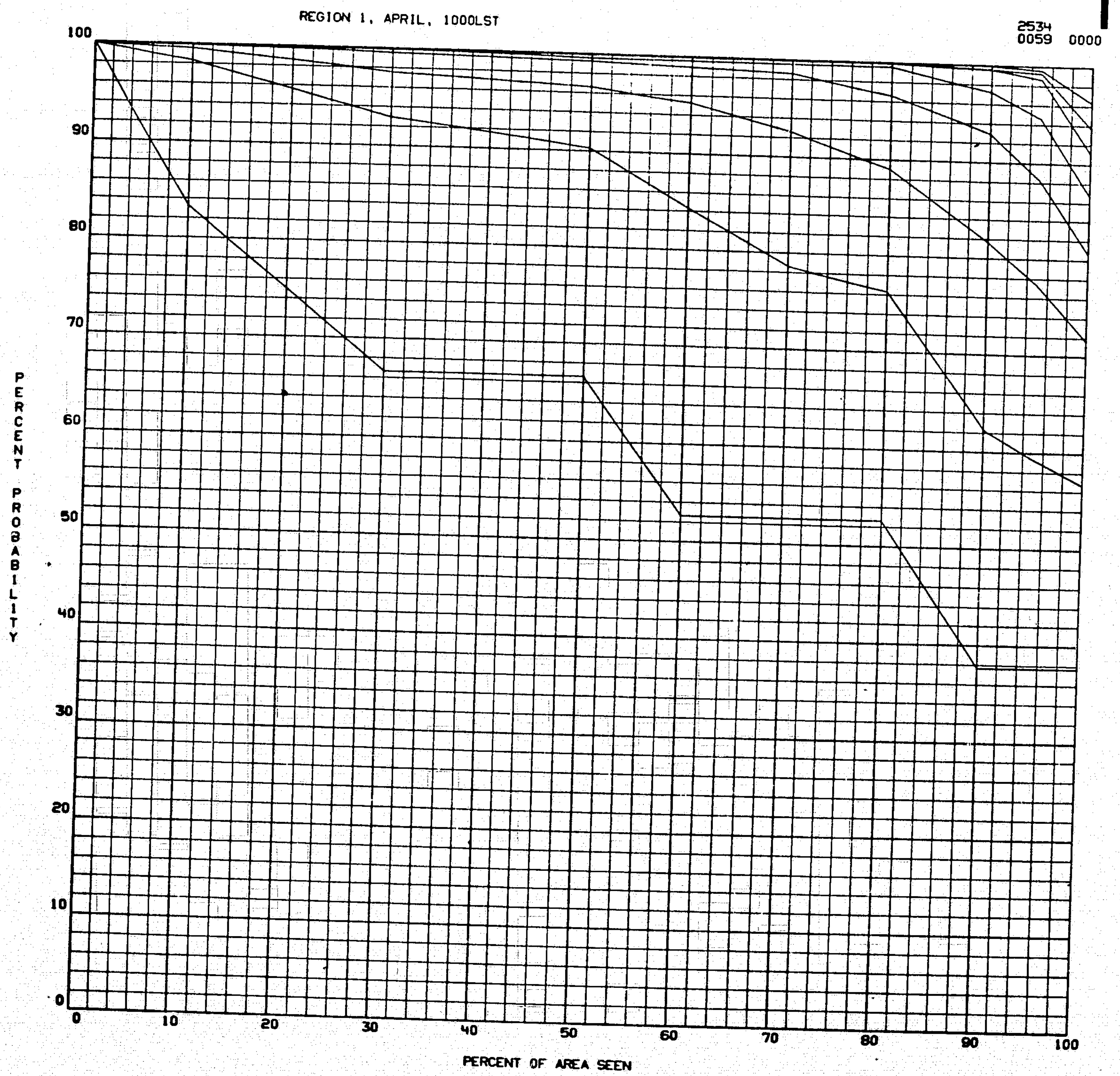
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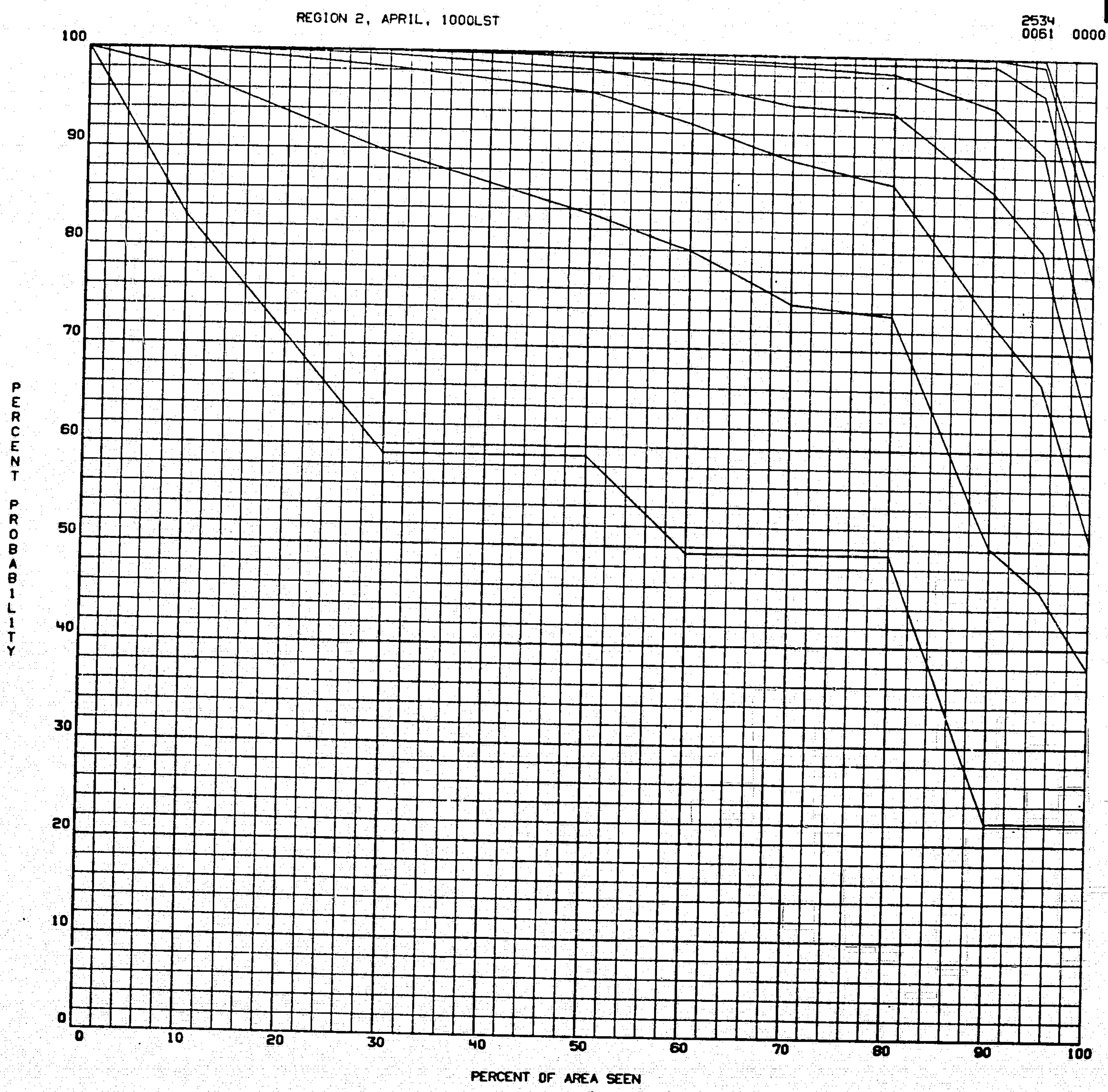
PERCENT OF AREA SEEN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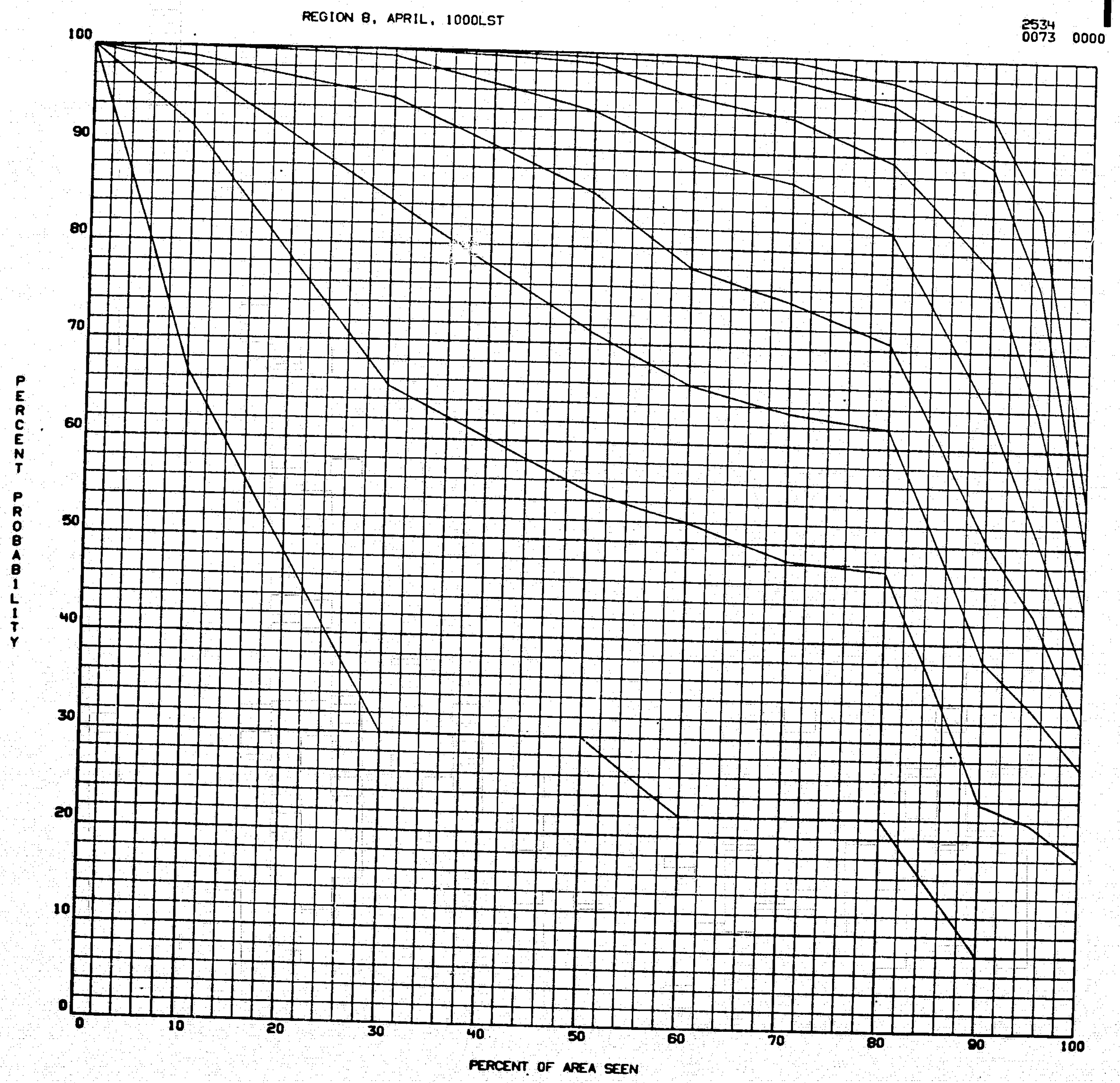
90
100
PERCENT OF AREA SEEN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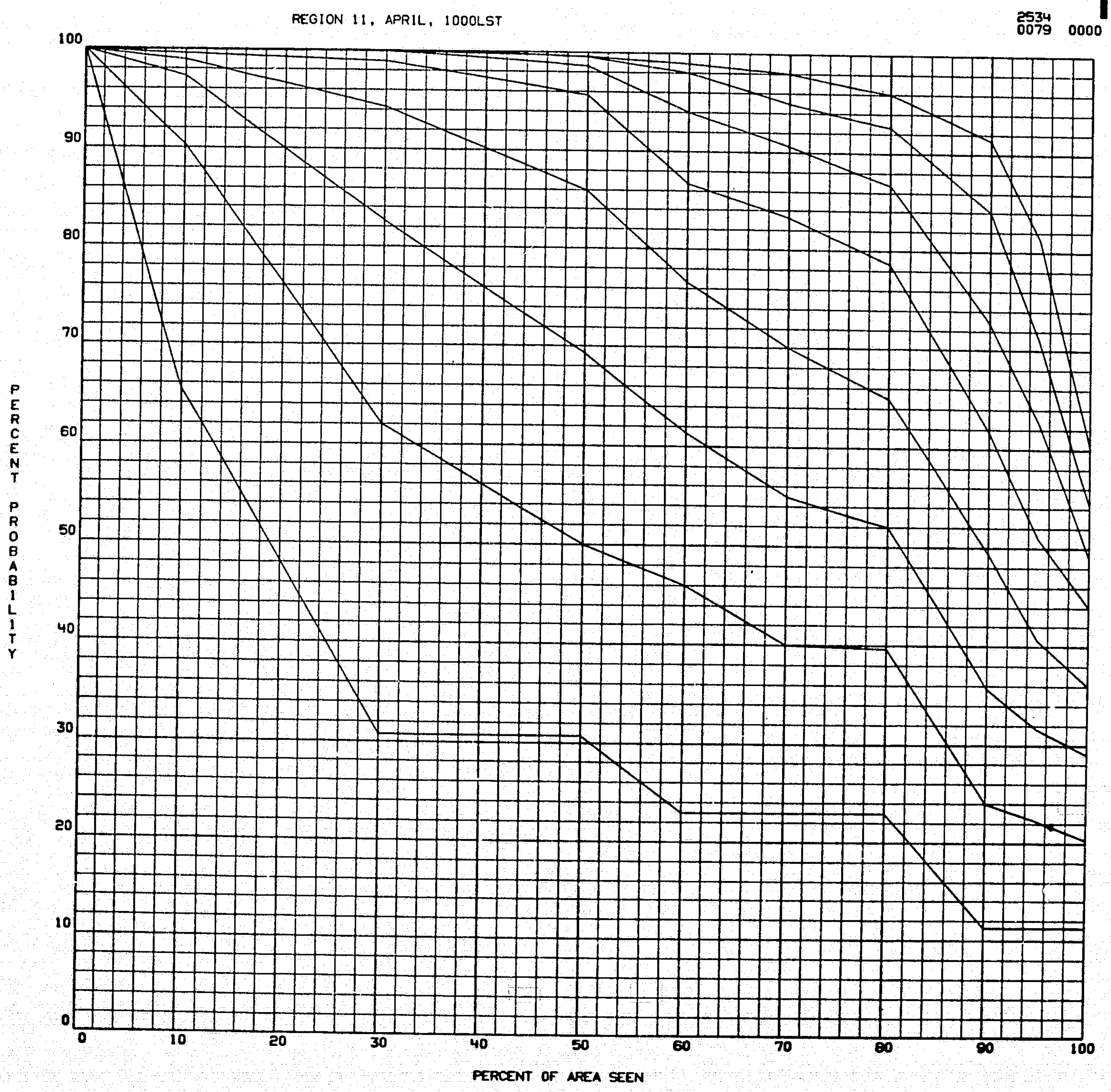
70
80
90
100
PERCENT OF AREA SEEN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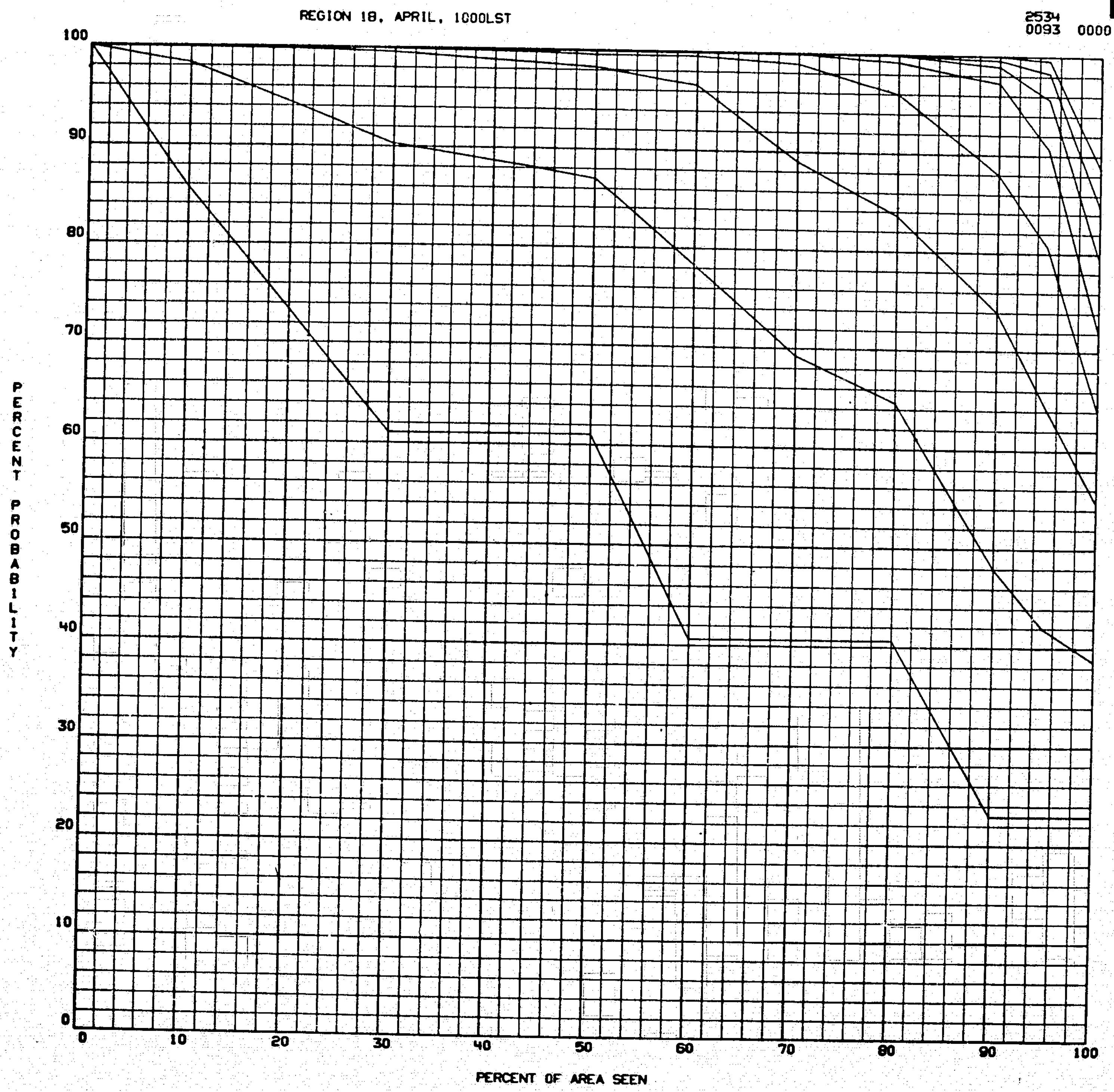
90
100
PERCENT OF AREA SEEN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0093 0000
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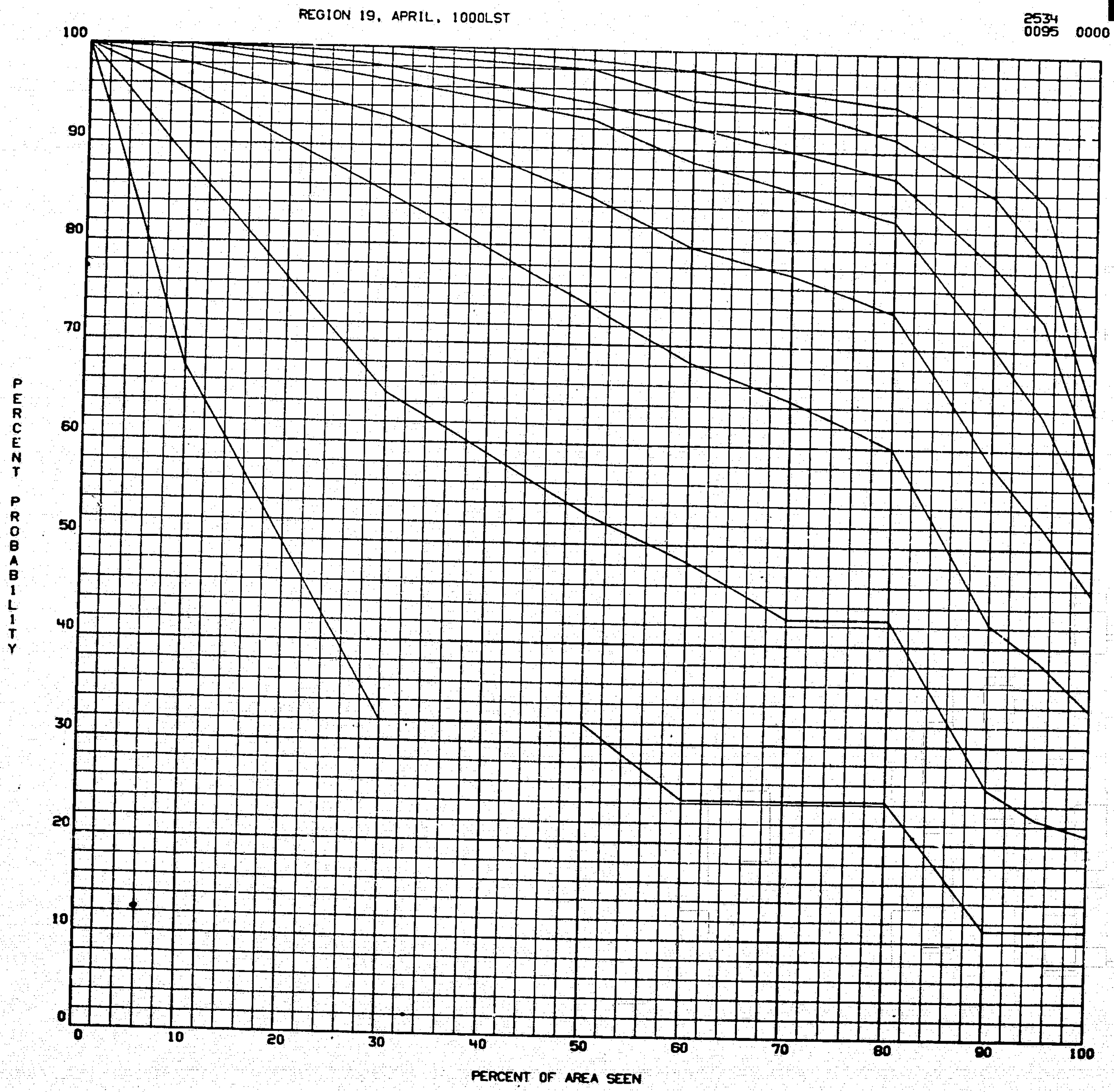
90
100
PERCENT OF AREA SEEN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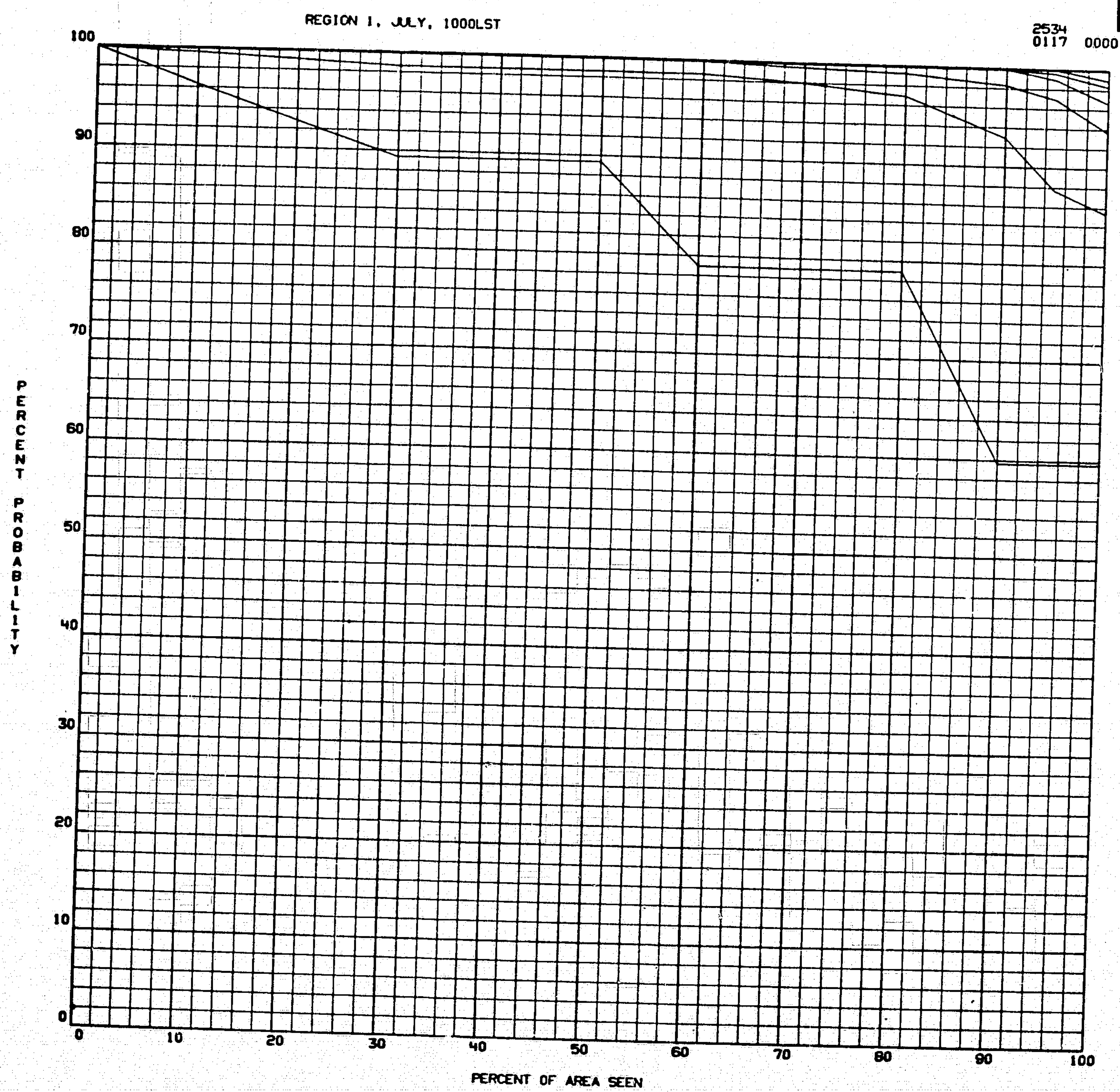
90
100
PERCENT OF AREA SEEN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2534
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PERCENT PROBABILITY
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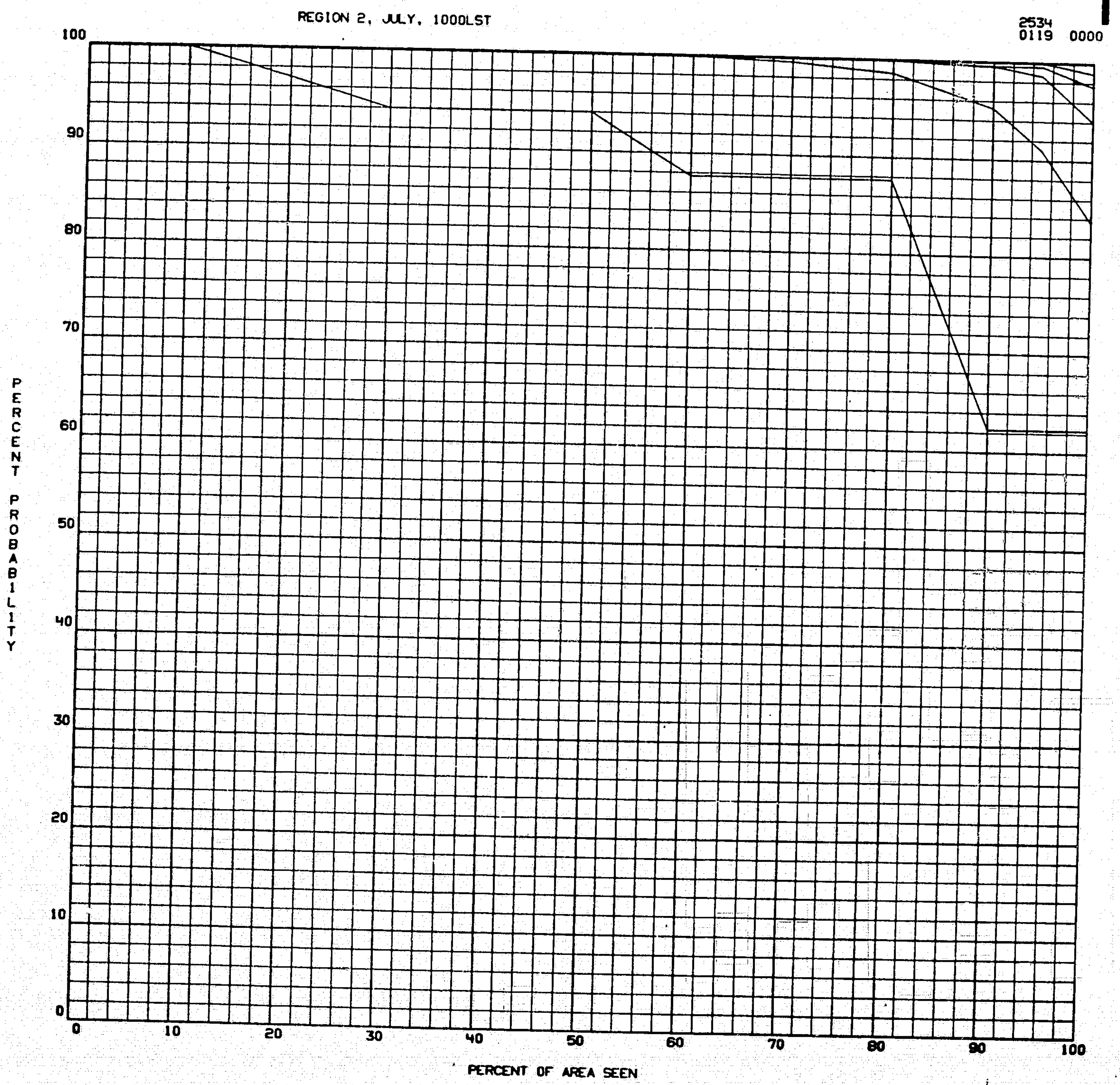
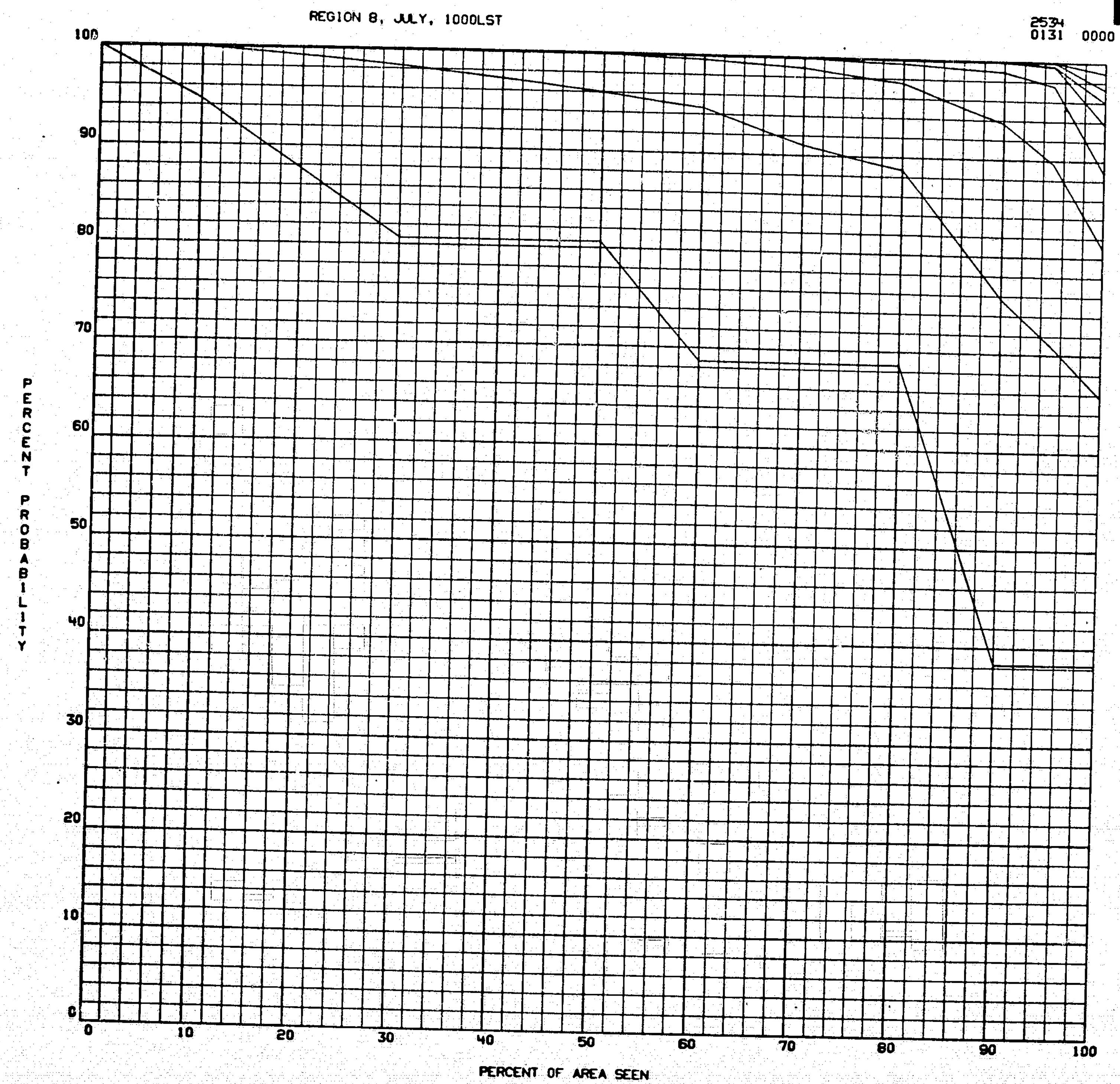
30
40
50
60
70
80
90
100
PERCENT OF AREA SEEN

Space Division
North American Rockwell

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30
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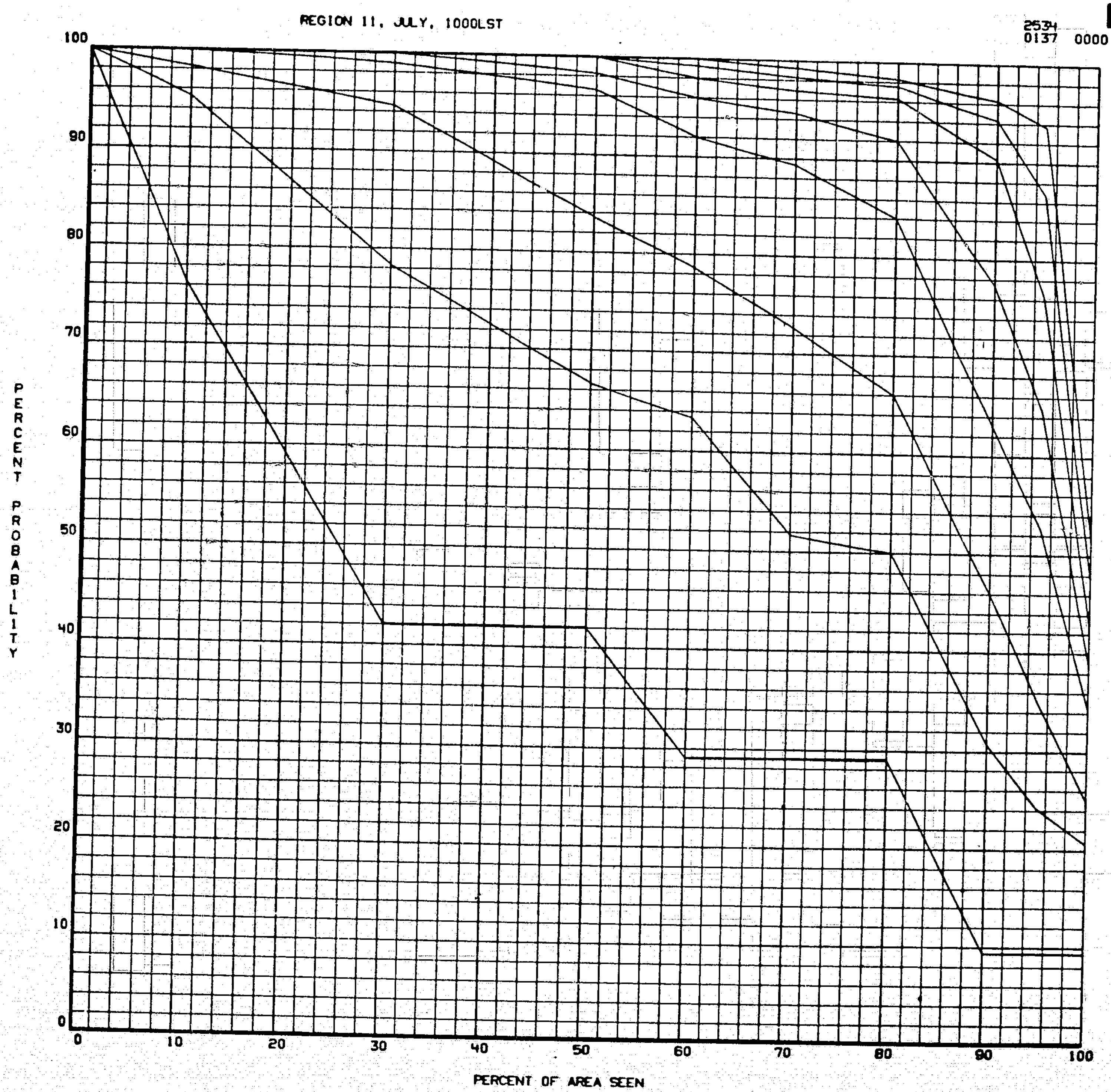
70
80
90
100
PERCENT OF AREA SEEN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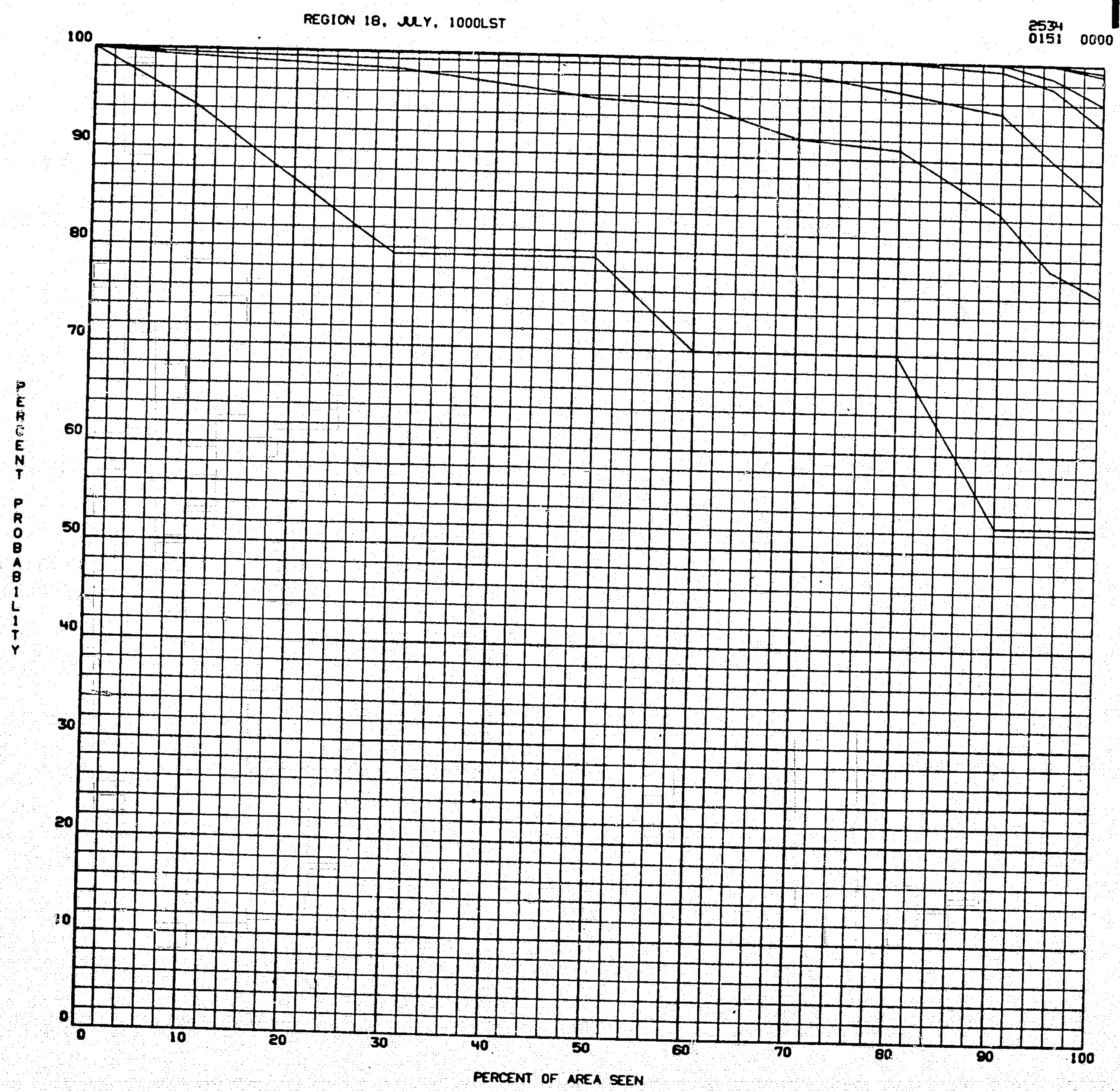
80
90
100
PERCENT OF AREA SEEN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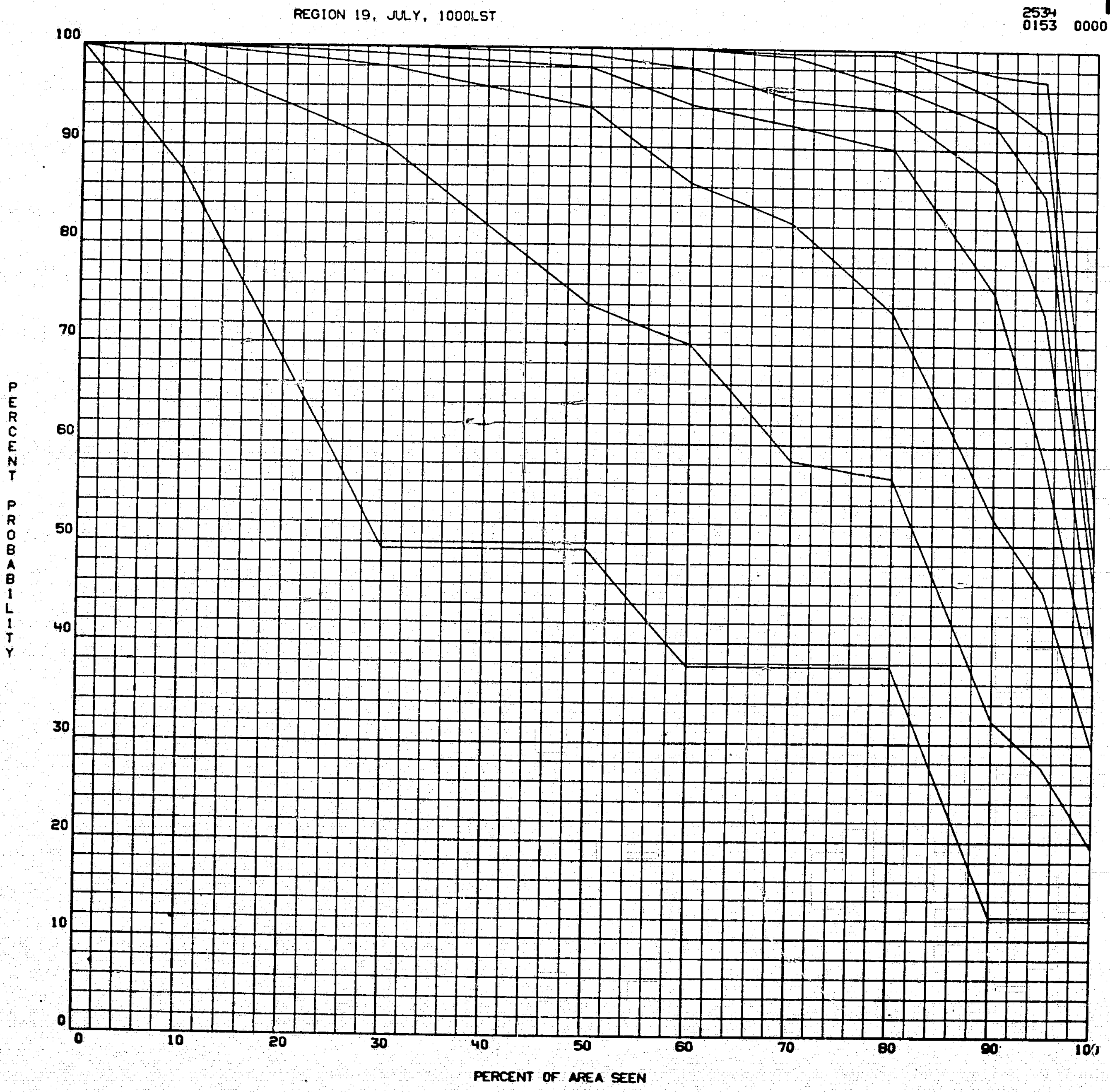
70
80
90
100
PERCENT OF AREA SEEN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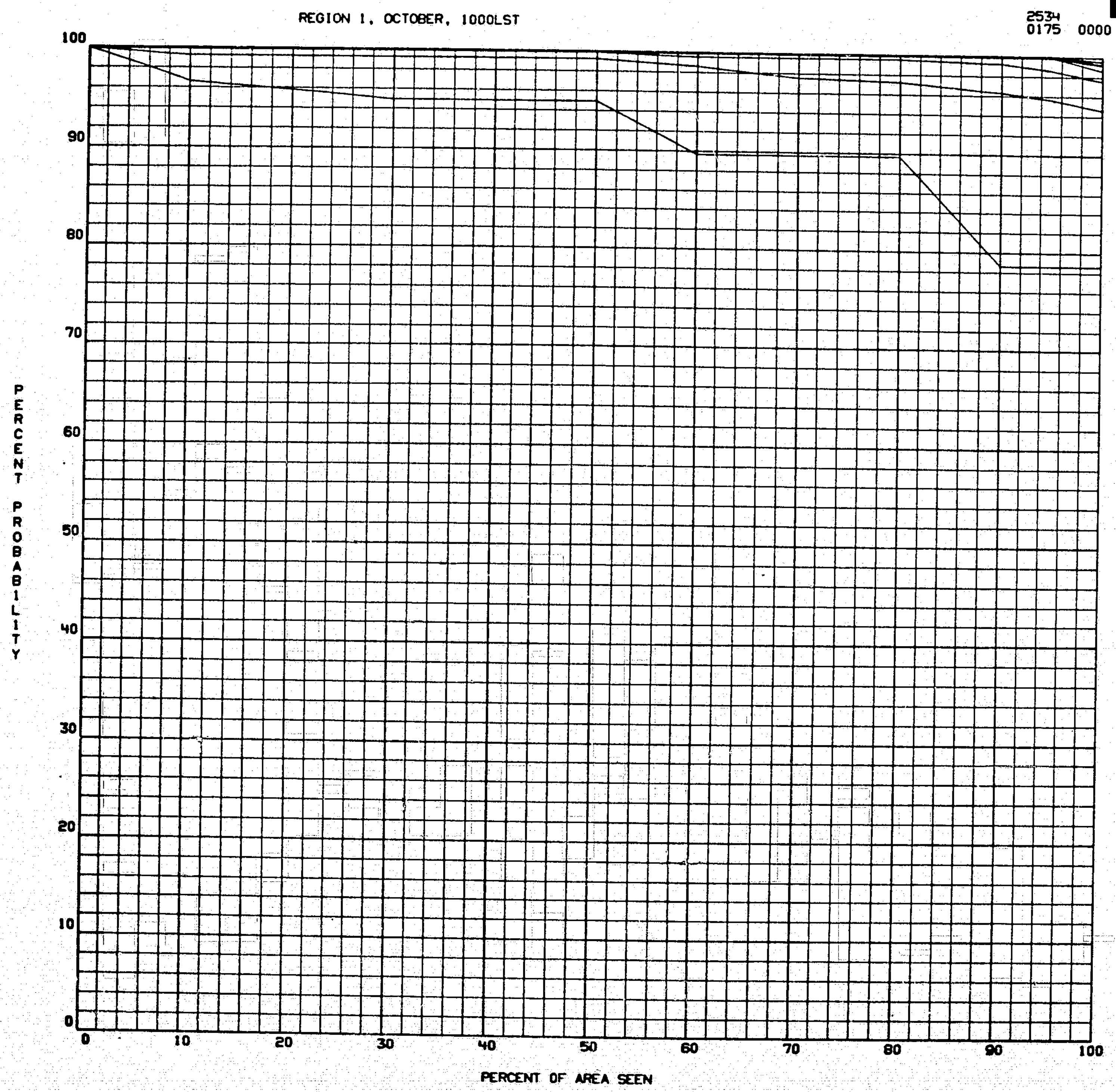
70
80
90
100
PERCENT OF AREA SEEN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2534
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PERCENT PROBABILITY
PERCENT OF AREA SEEN
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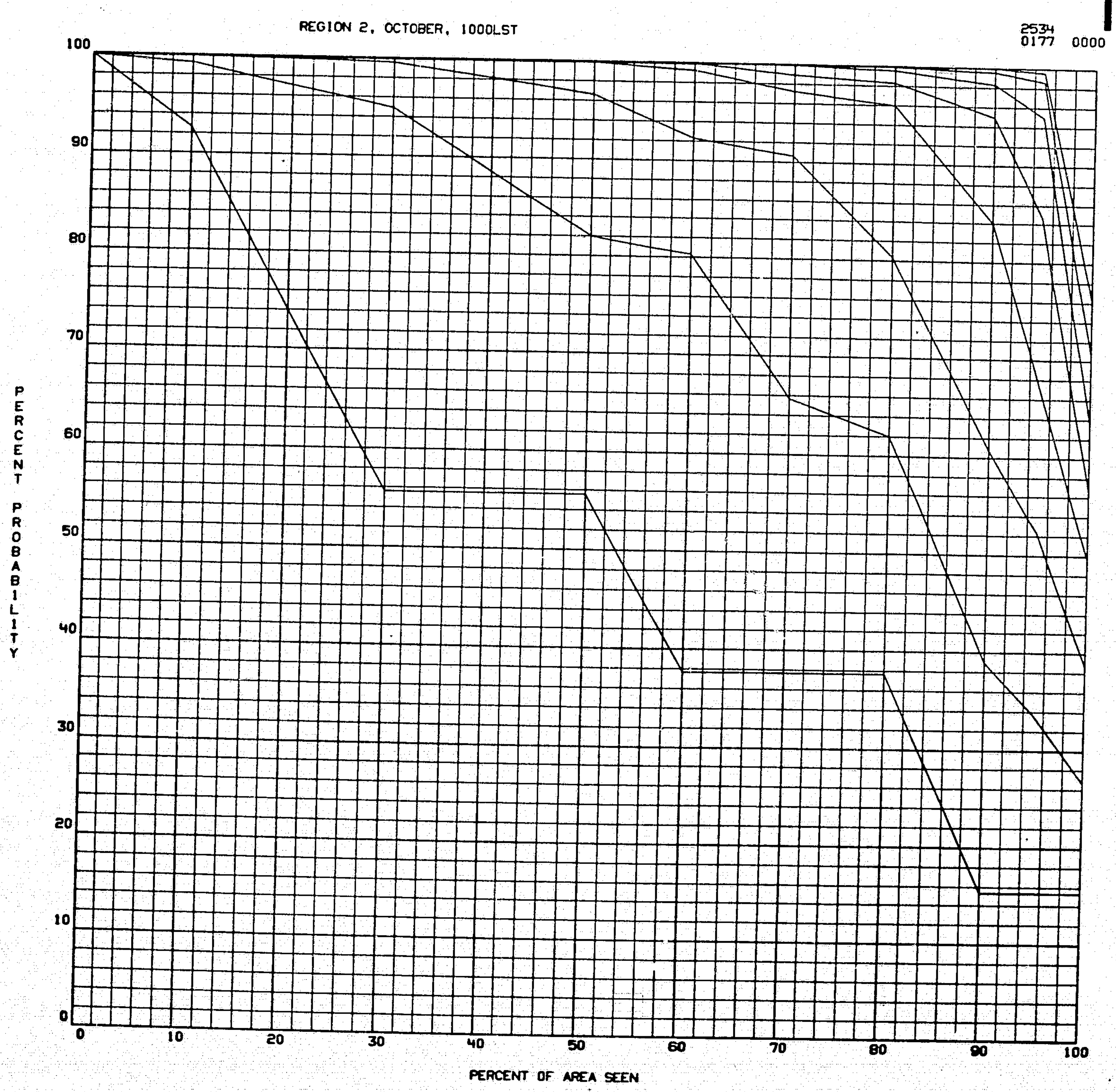
80
90
100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PERCENT PROBABILITY
PERCENT OF AREA SEEN
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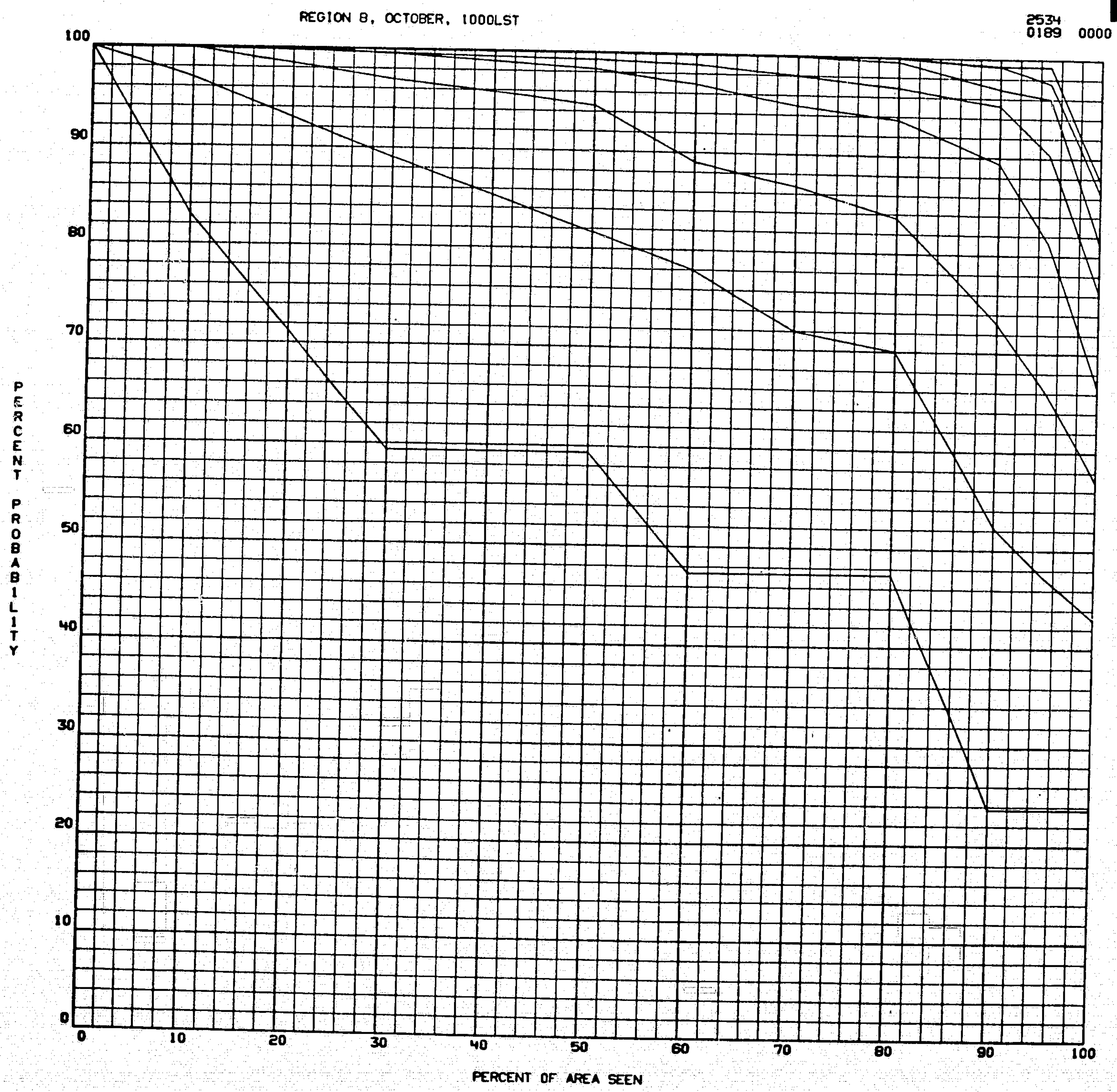
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2534
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70
60
50
40
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0
PERCENT PROBABILITY
0
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20
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40
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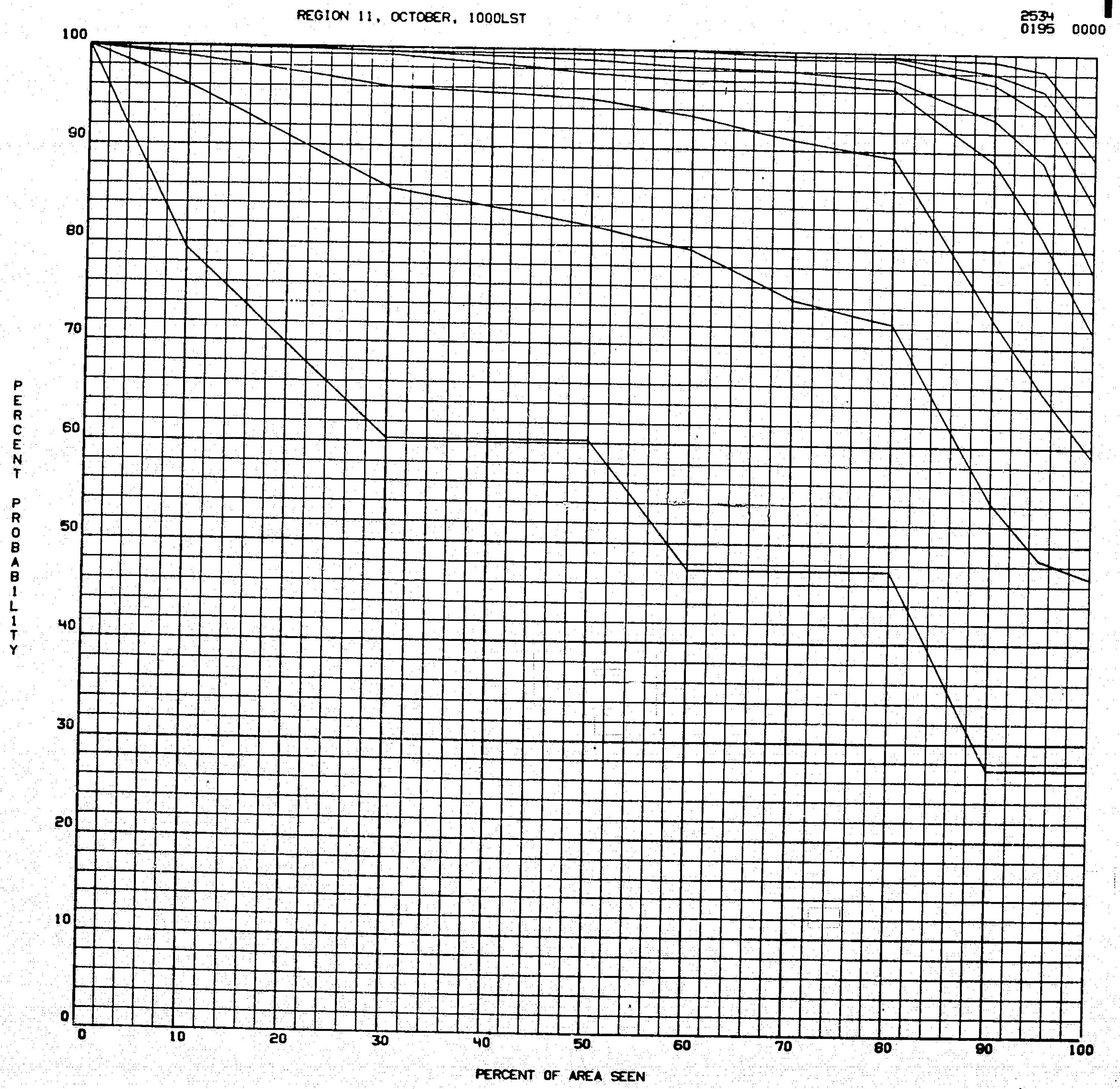
60
70
80
90
100
PERCENT OF AREA SEEN


REGION 11, OCTOBER, 1000LST
2534
0195 0000
PERCENT PROBABILITY
PERCENT OF AREA SEEN
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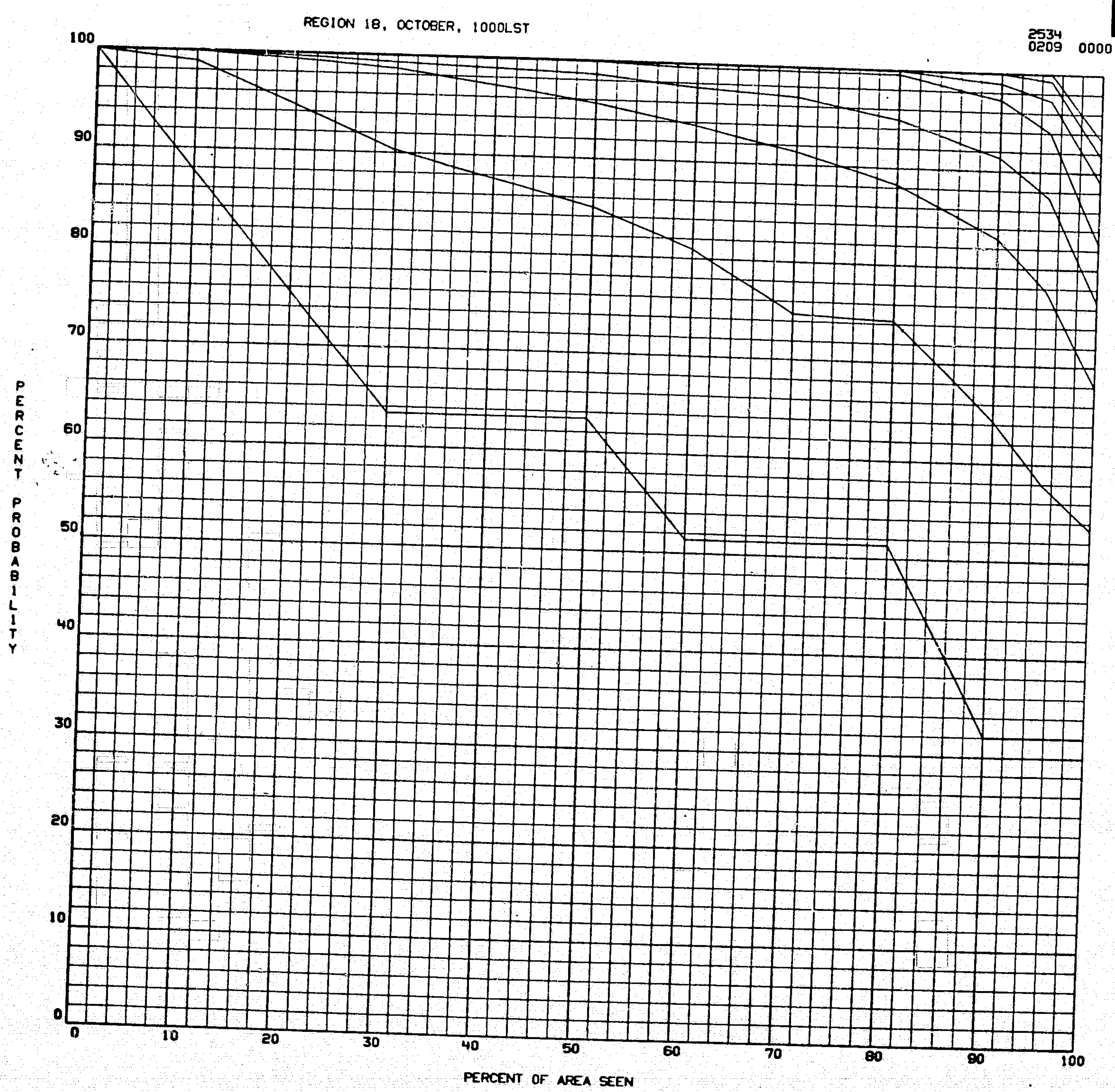
60
70
80
90
100


REGION 18, OCTOBER, 1000LST
2534
0209 0000
100
90
80
70
60
50
40
30
20
10
0
PERCENT PROBABILITY
0
10
20
30
40
50
60
70
80
90
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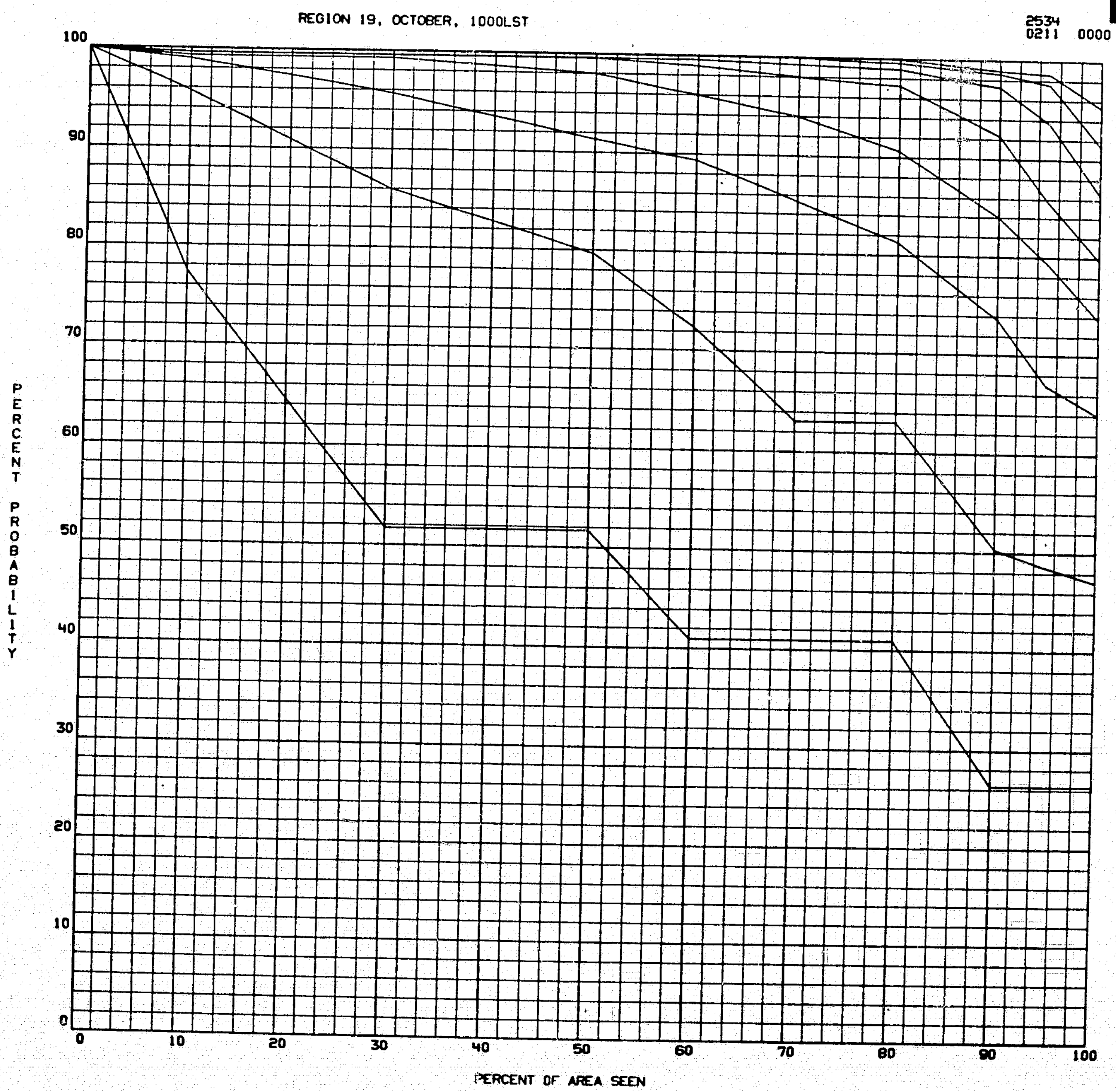
REGION 19, OCTOBER, 1000LST
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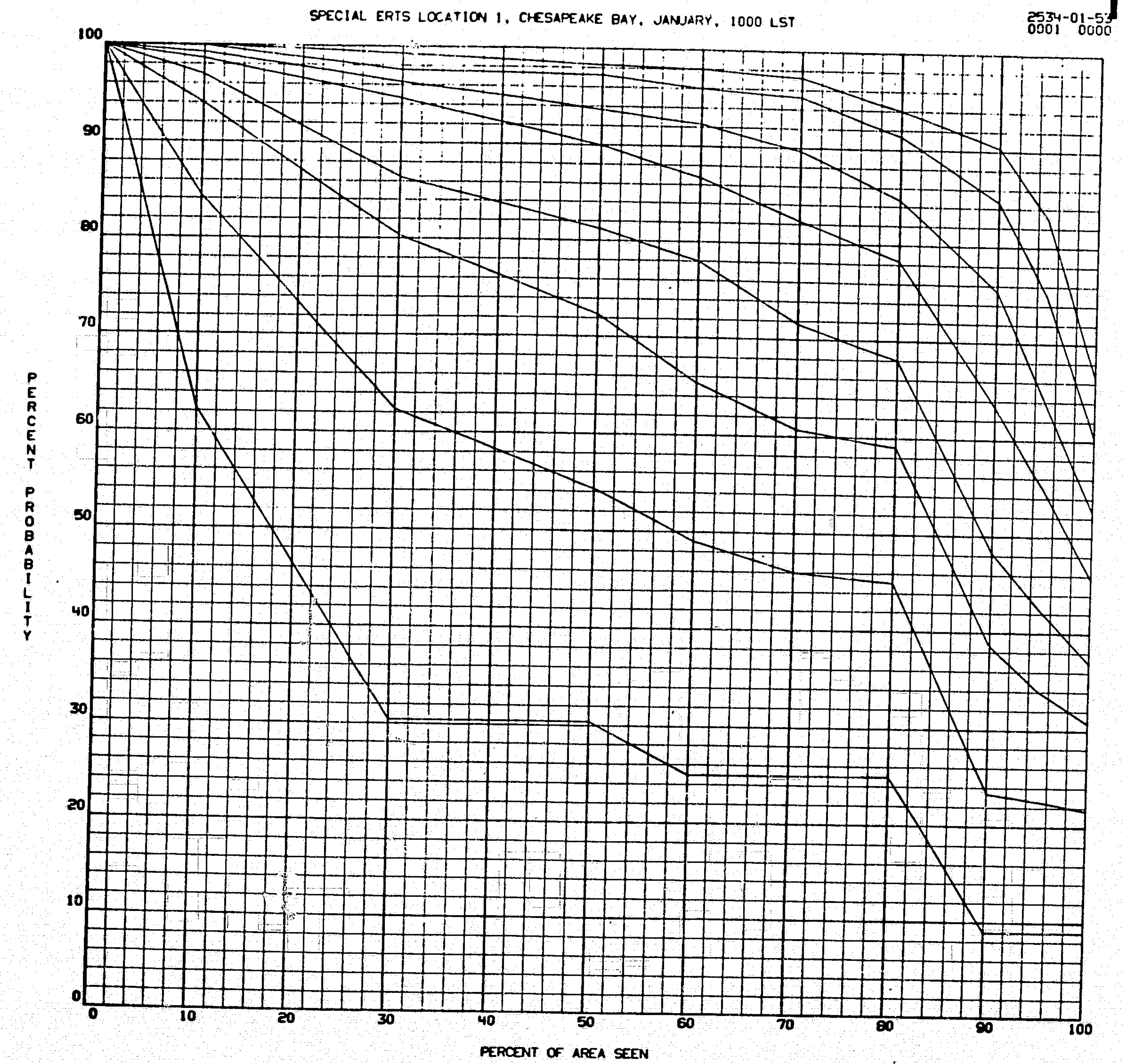
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0001 0000
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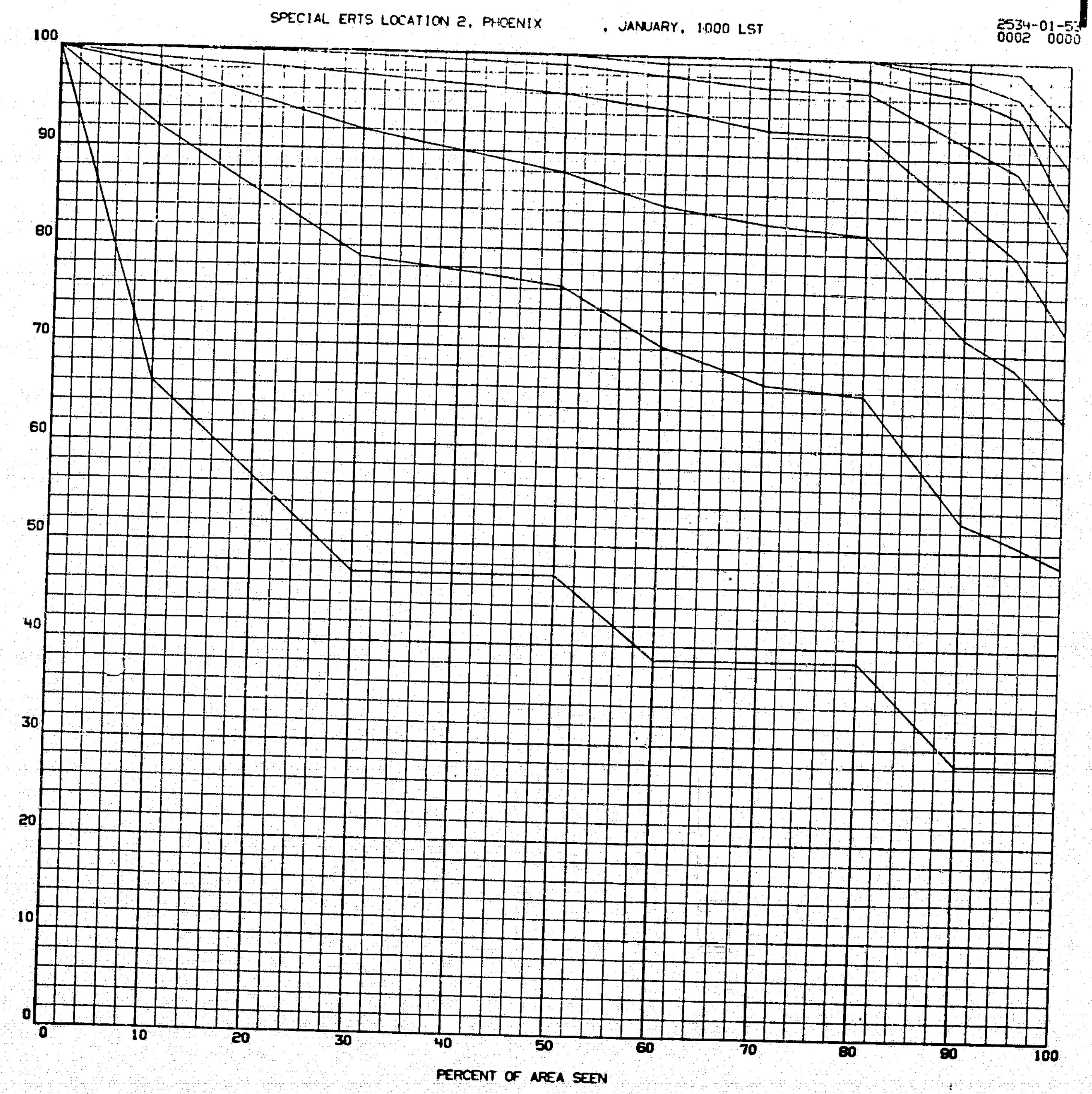
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0002 0000
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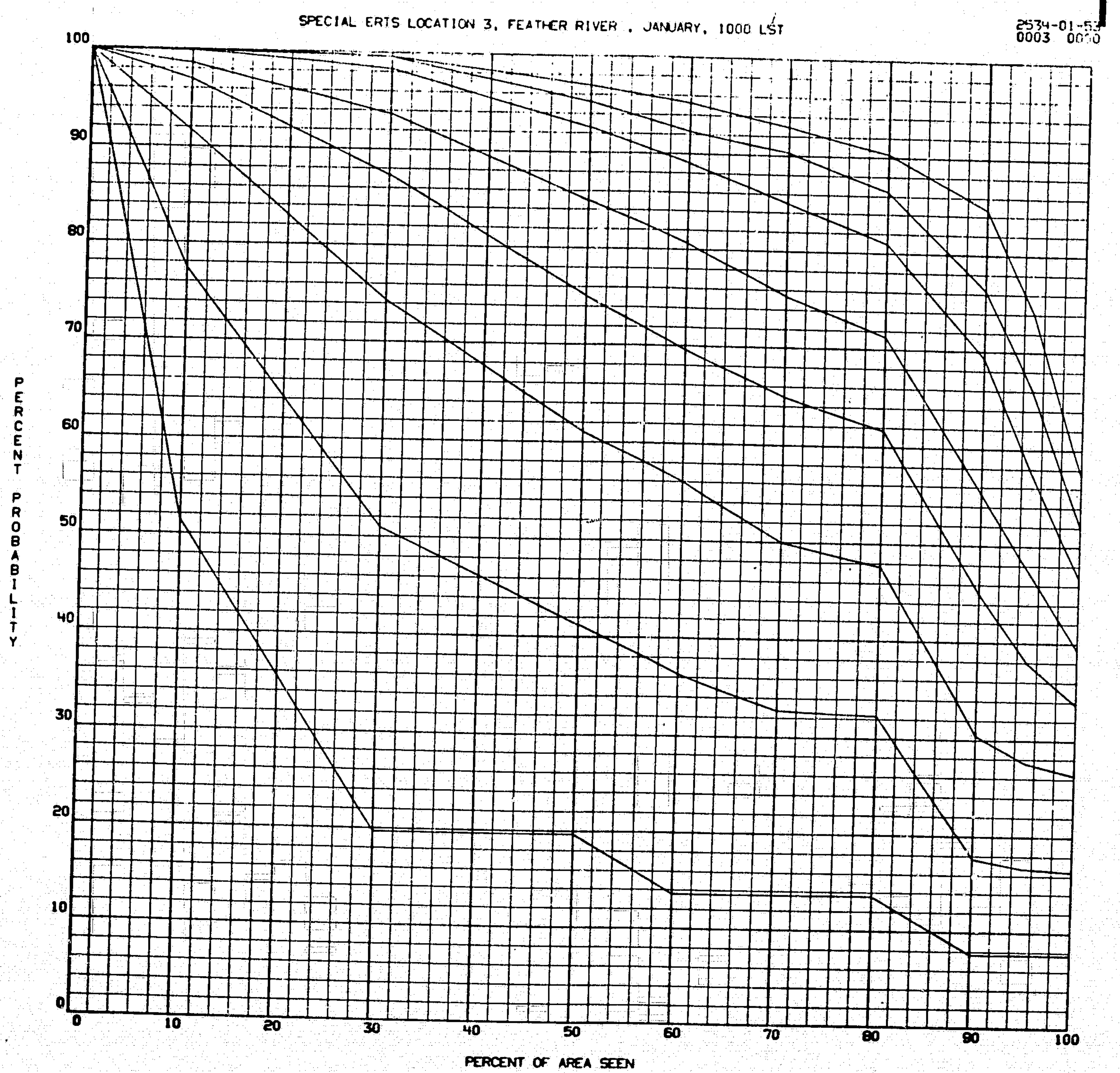
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0003 0000
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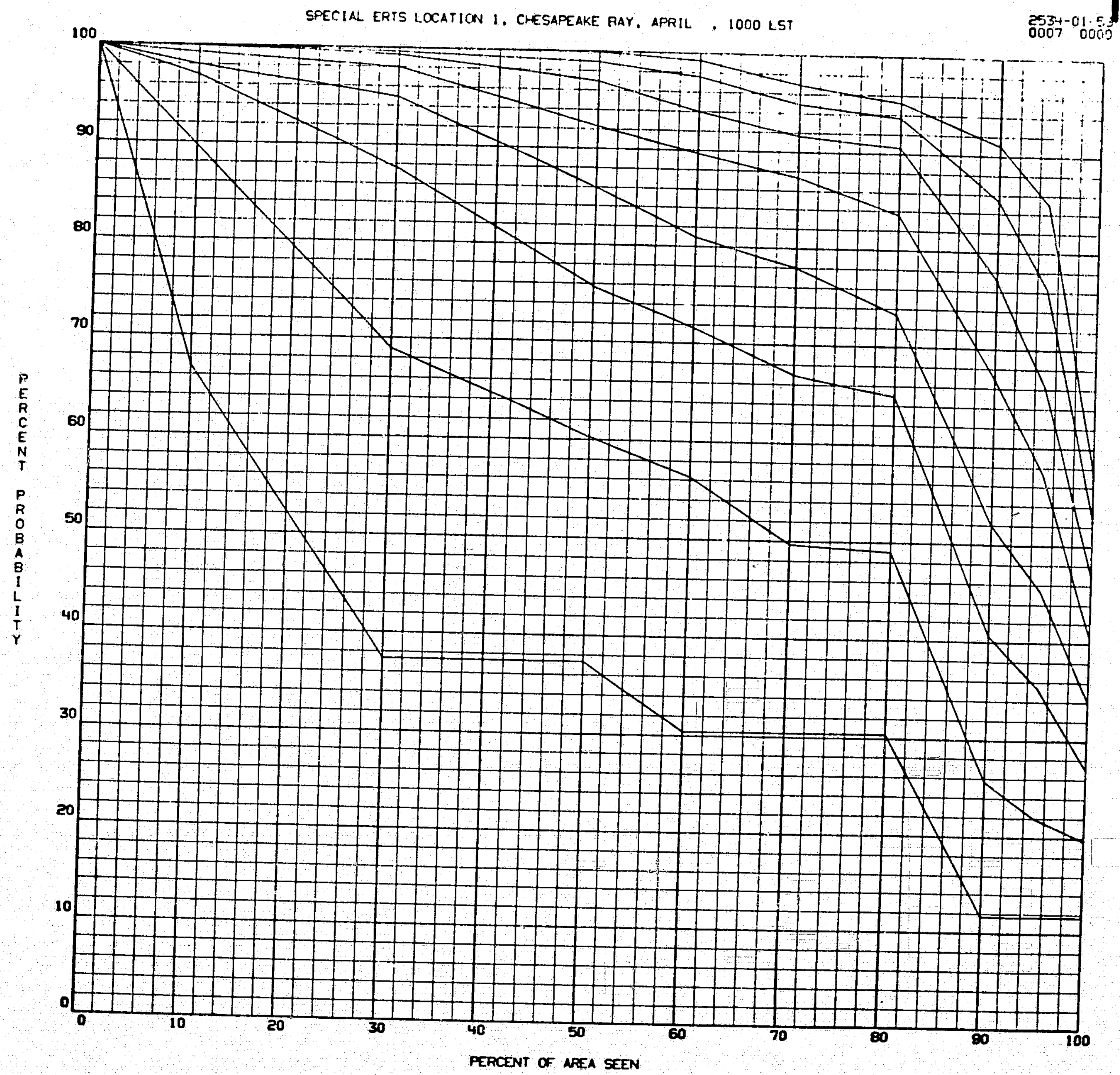
PERCENT OF AREA SEEN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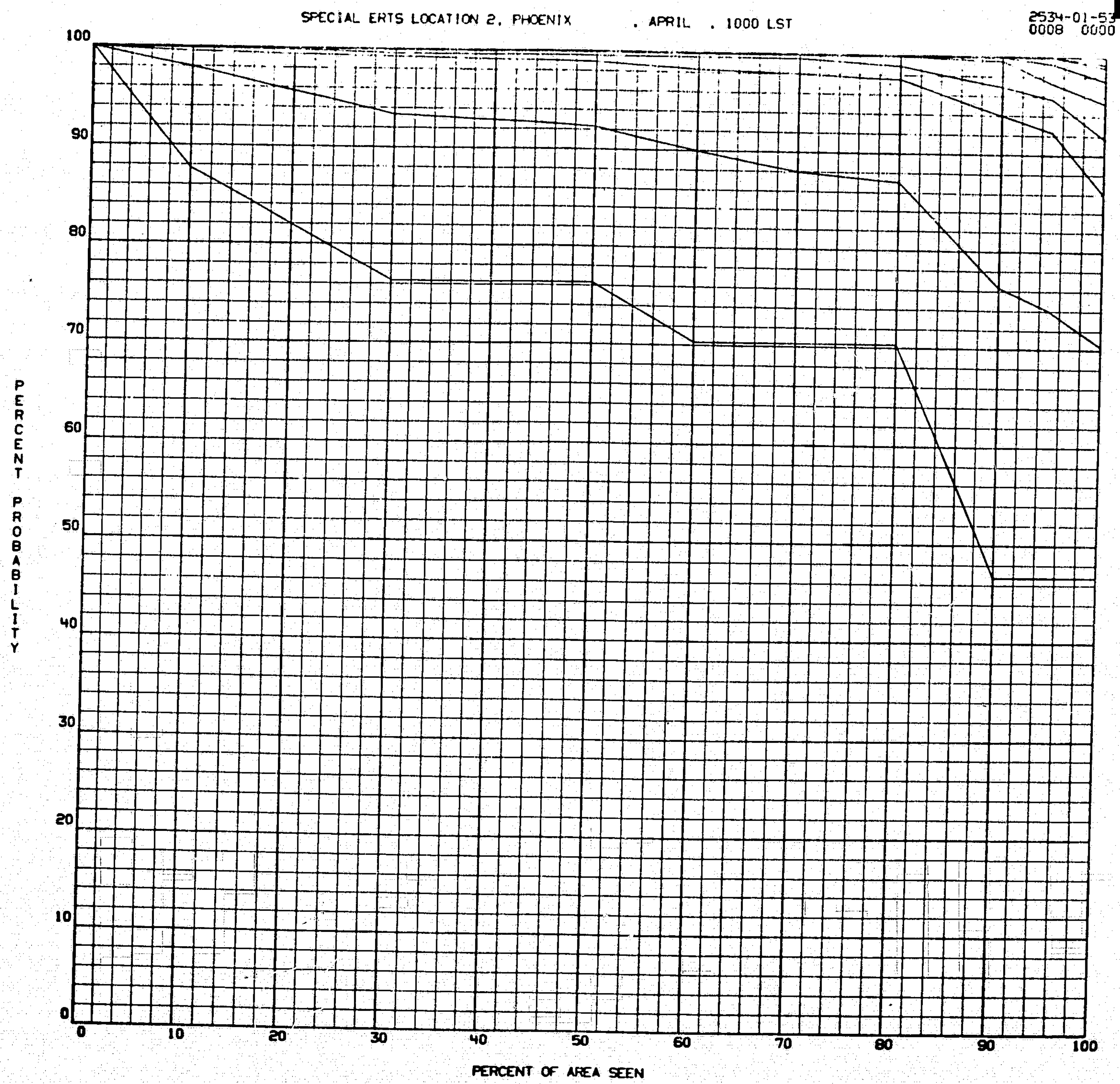
SPECIAL ERTS LOCATION 2, PHOENIX . APRIL . 1000 LST
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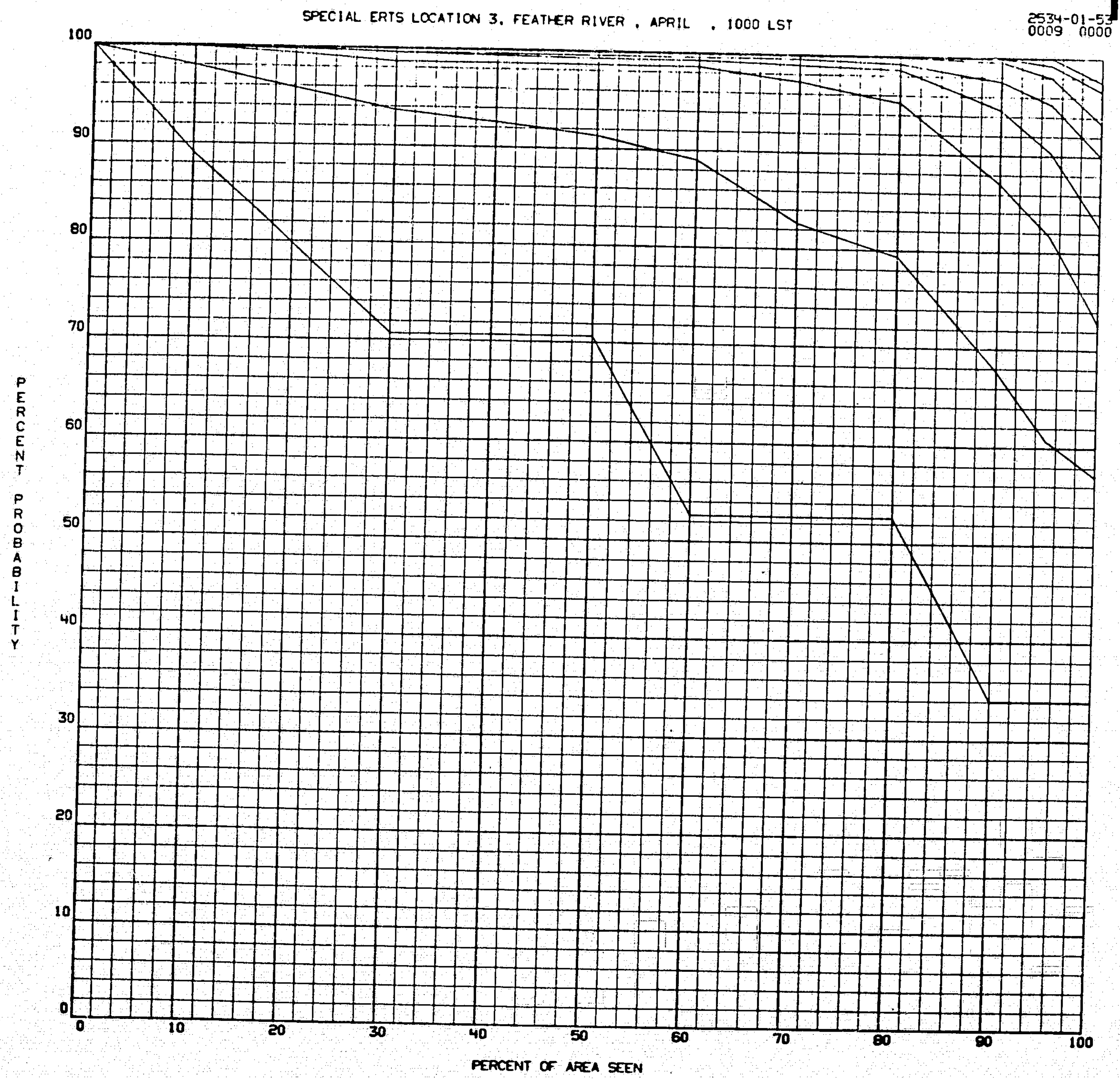
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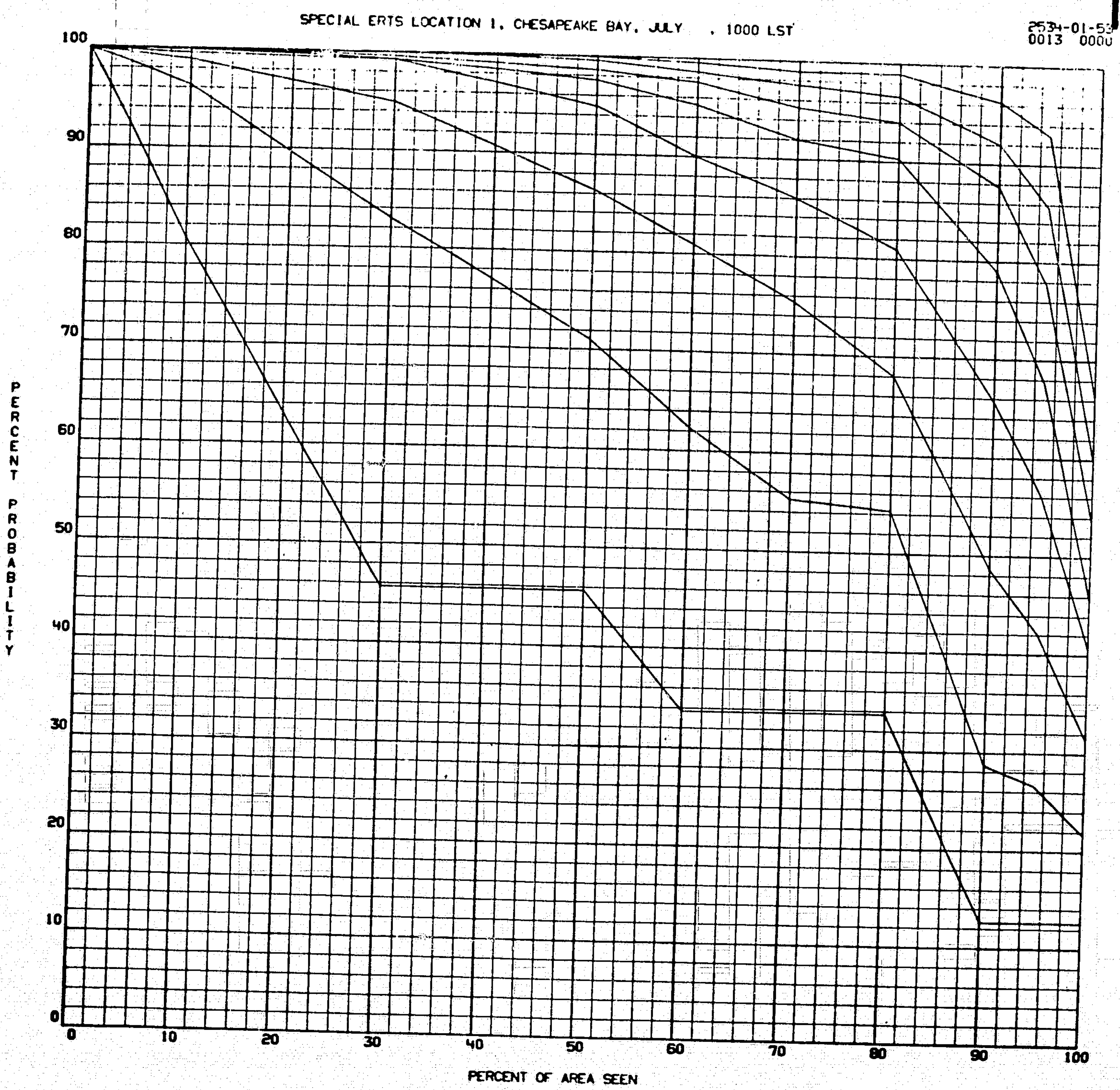
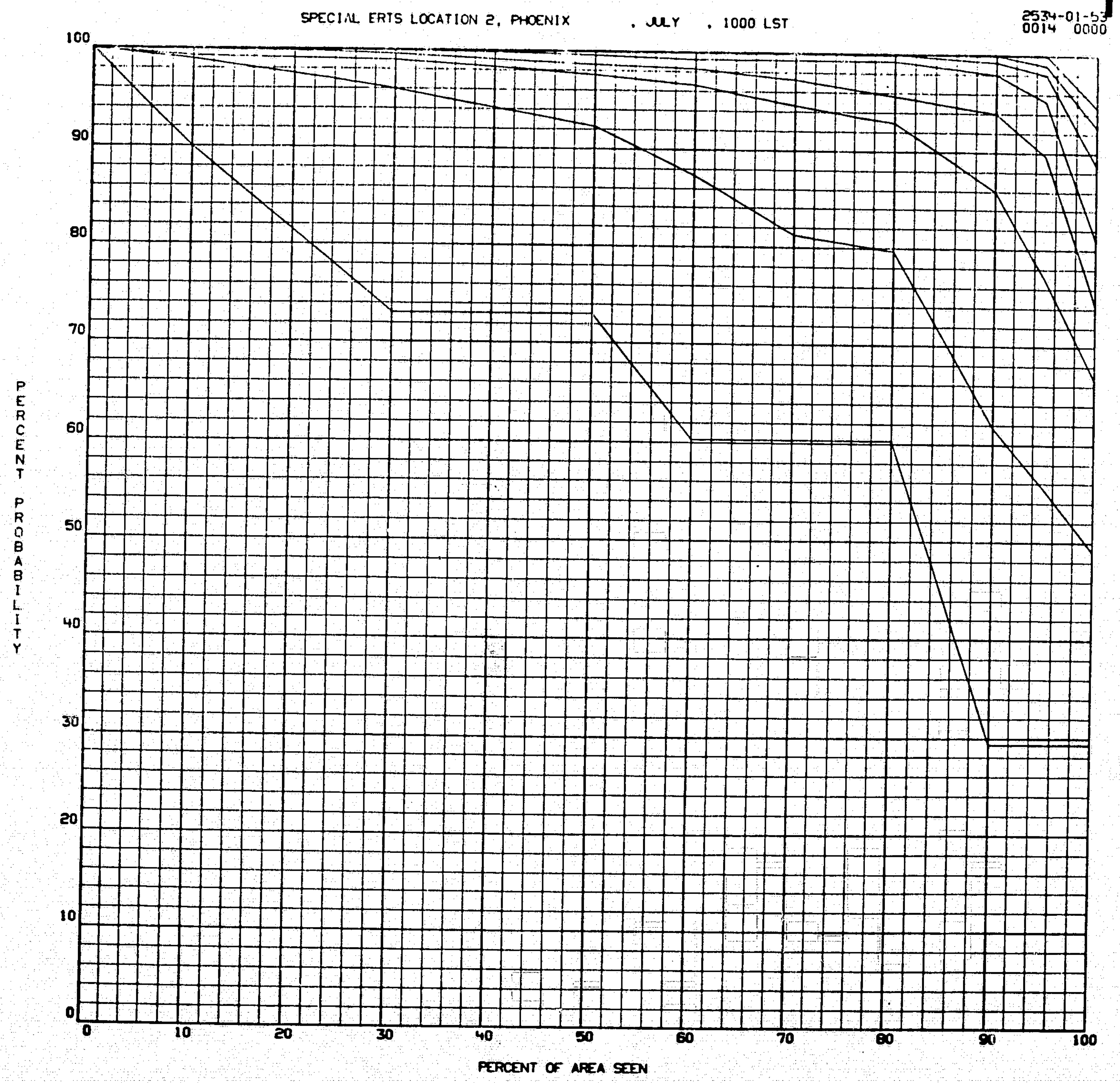
PERCENT OF AREA SEEN

Space Division
North American Rockwell




SPECIAL ERTS LOCATION 2, PHOENIX , JULY , 1000 LST
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0014 0000
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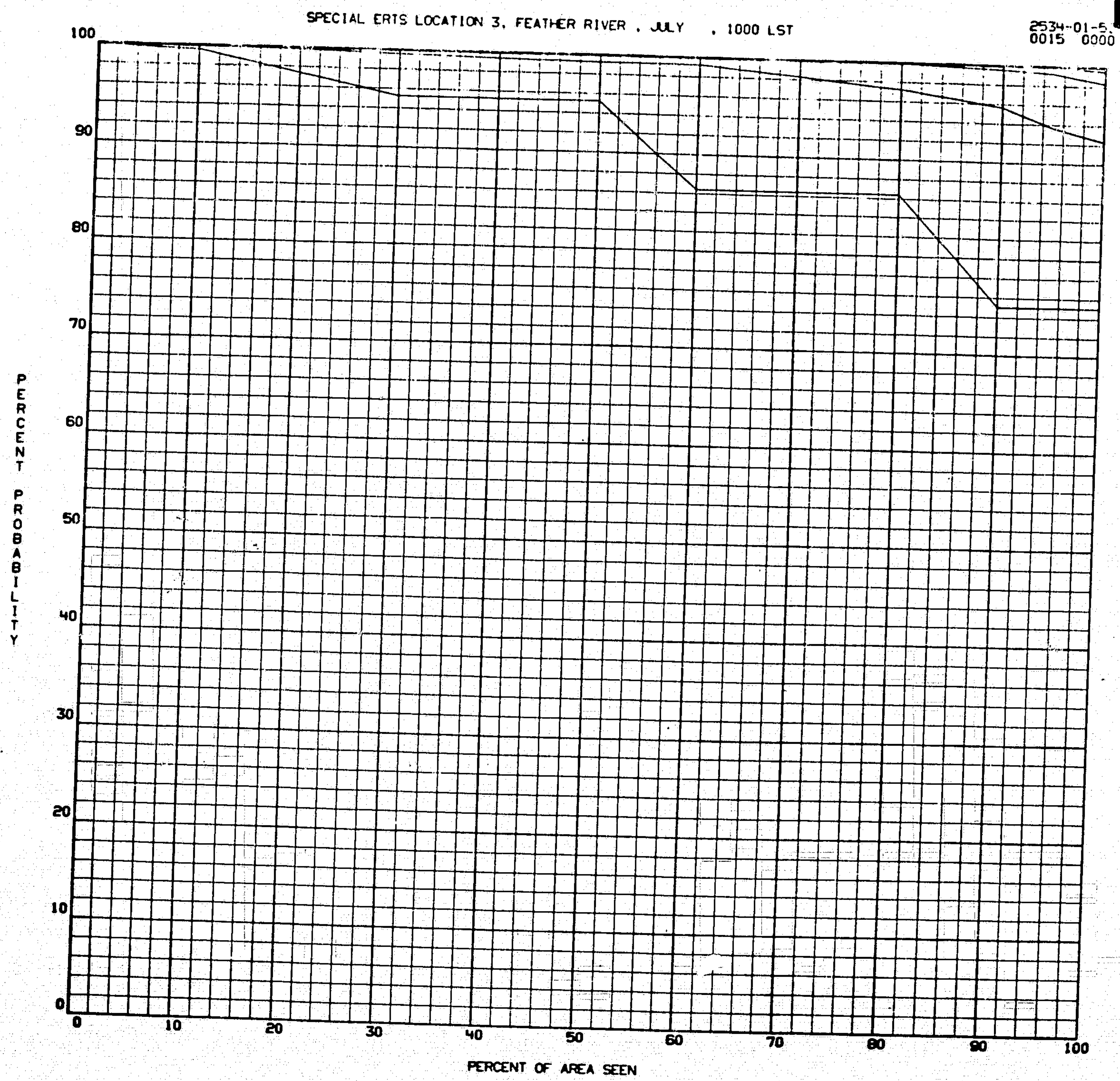
PERCENT OF AREA SEEN


SPECIAL ERTS LOCATION 3, FEATHER RIVER , JULY , 1000 LST
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0015 0000
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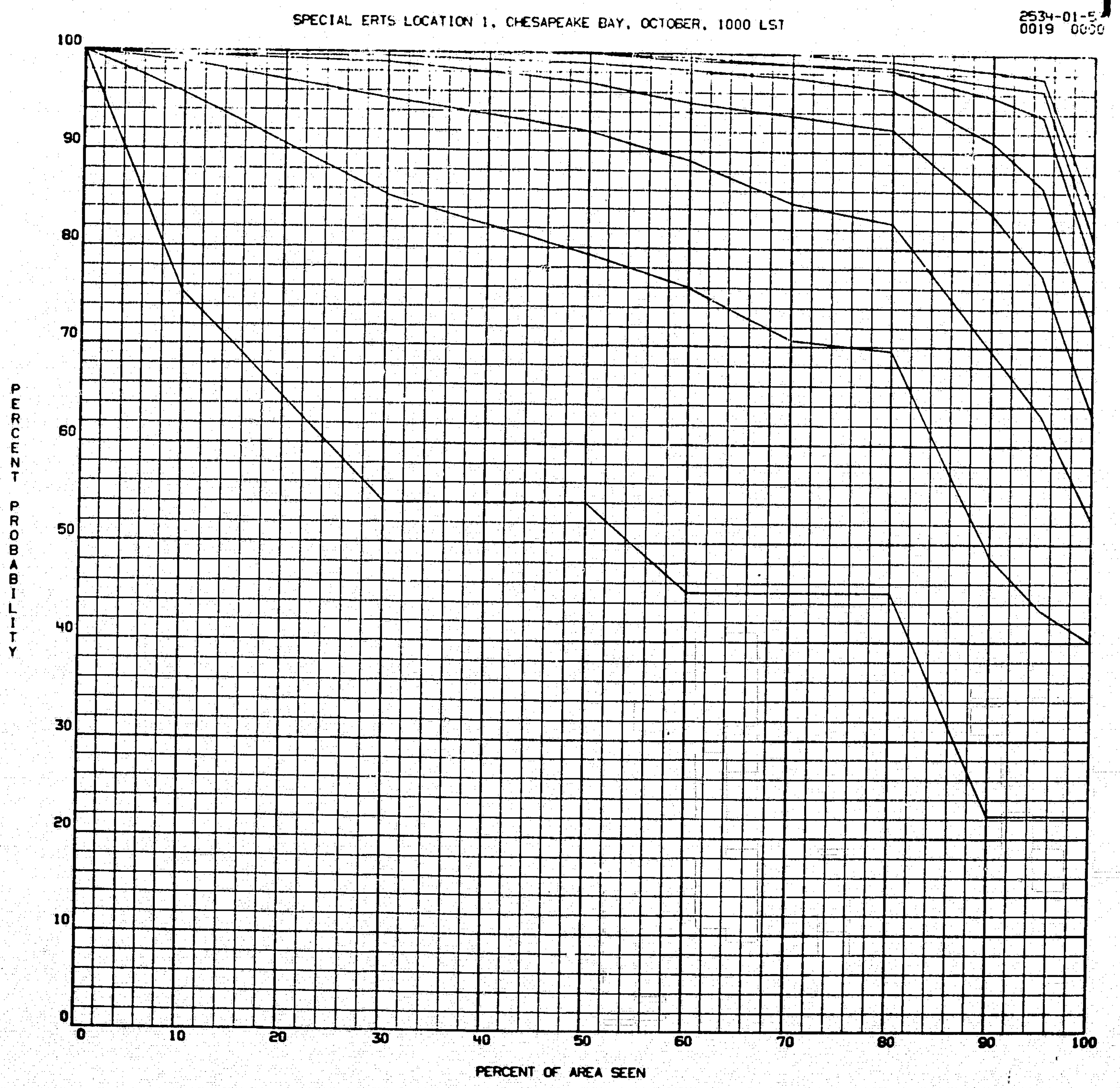
PERCENT OF AREA SEEN


SPECIAL ERTS LOCATION 1, CHESAPEAKE BAY, OCTOBER, 1000 LST
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0019 0050
PERCENT PROBABILITY
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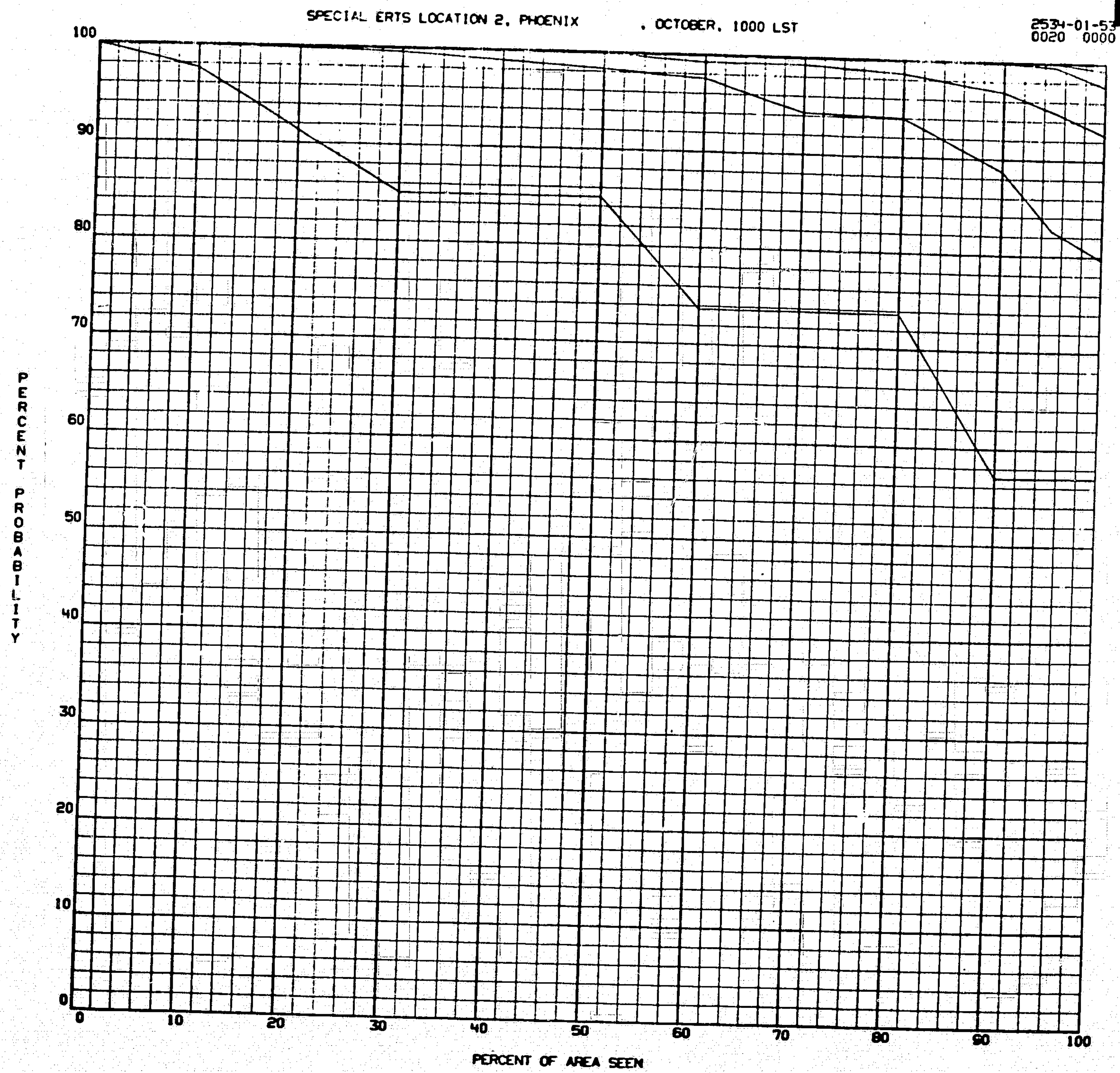
PERCENT OF AREA SEEN


SPECIAL ERTS LOCATION 2, PHOENIX , OCTOBER, 1000 LST
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PERCENT PROBABILITY
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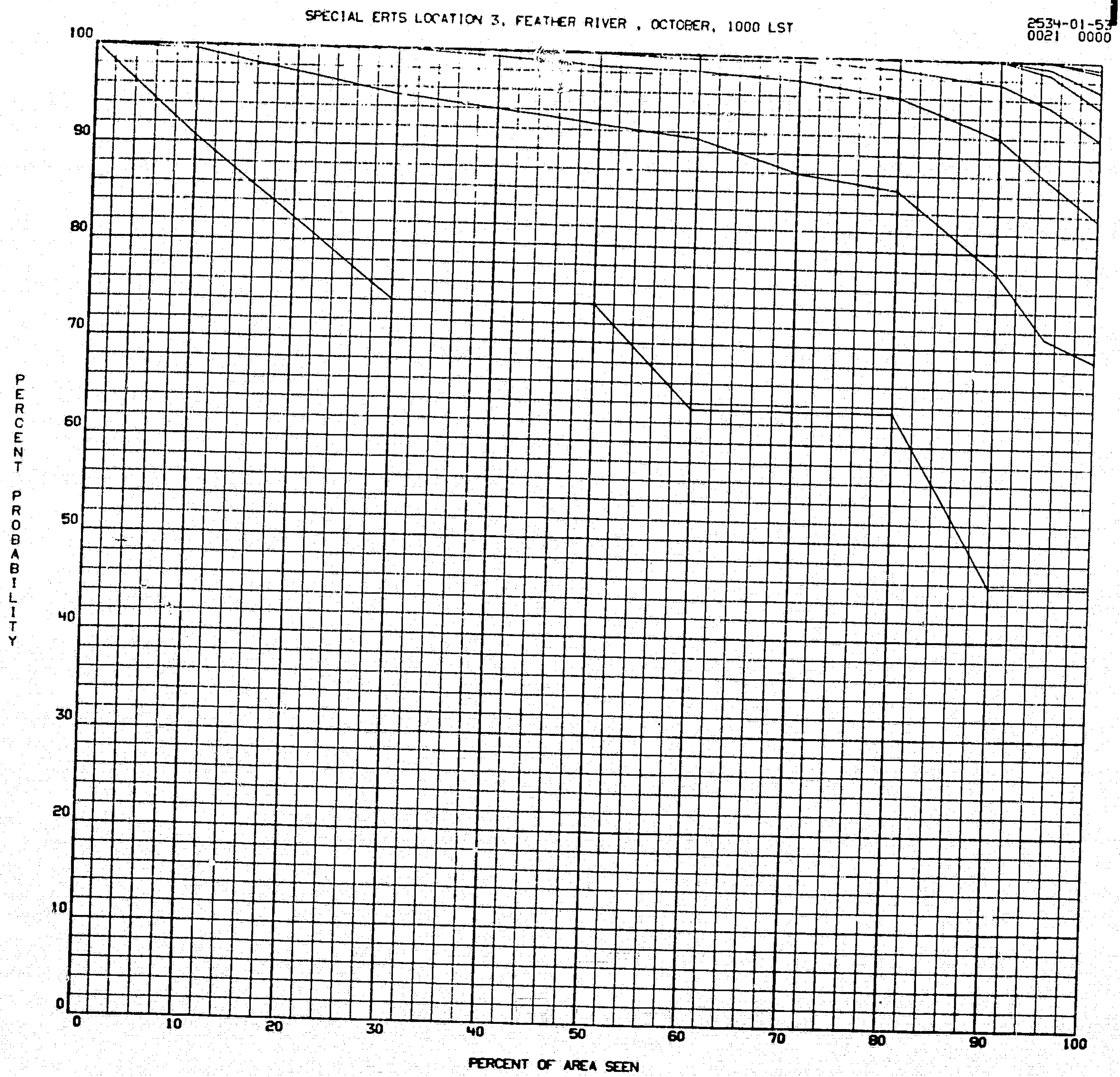
PERCENT OF AREA SEEN


SPECIAL ERTS LOCATION 3, FEATHER RIVER , OCTOBER, 1000 LST
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0021 0000
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PERCENT OF AREA SEEN