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Atlas of Simultaneous Occurrence of Different Cloud Types over Land

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PREFACE

This is the second of a series of atlases to be published as part of an extensive study of the global cloud climatology from ground-based observations. The first atlas, published as NCAR/TN-201+STR, described the observed simultaneous occurrence of different cloud types over the oceans. The present atlas covers a similar analysis of cloud observations over the land. The classification and grouping of cloud types, and the general methodology of determining different cloud type co-occurrences was discussed in the first atlas, and the reader is referred to that atlas for details of the procedures used. Additional discussion is contained in the present atlas to describe those cases where a different procedure was followed either as an improvement, or to fit the different circumstances under which land-based cloud observations are made.

The current cloud climatology study is part of the International Satellite Cloud Climatology Program (ISCCP) and will provide a complementary data set for evaluating and validating results from the First ISCCP Regional Experiment (FIRE) and subsequent field experiments.

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LIST OF CLOUD MAPS

The maps are contained in four separate sections by seasons: December, January, February (DJF); March, April, May (MAM); June, July, August (JJA); September, October, November (SON). Map numbers are consecutive within each section.

	Map numbers			
	DJF	**MAM**	**JJA**	**SON**
Number of synoptic cloud reports, in hundreds	I-1	II-1	III-1	IV-1
Number of observations of cloud types present, in hundreds				
Cirrus, Cirrostratus, Cirrocumulus (Ci/Cs/Cc)	I-2	II-2	III-2	IV-2
Altostratus, Altocumulus (As/Ac)	I-3	II-3	III-3	IV-3
Nimbostratus (Ns)	I-4	II-4	III-4	IV-4
Cumulus (Cu)	I-5	II-5	III-5	IV-5
Stratus, Stratocumulus (St/Sc)	I-6	II-6	III-6	IV-6
Cumulonimbus (Cb)	I-7	II-7	III-7	IV-7
Percent of land station reports contributing to statistics of upper cloud levels:				
High cloud level	I-8	II-8	III-8	IV-8
Middle cloud level	I-9	II-9	III-9	IV-9
Frequency of occurrence of:				
completely clear sky	I-10	II-10	III-10	IV-10
sky obscured due to fog	I-11	II-11	III-11	IV-11
different cloud types:				
Ci/Cs/Cc	I-12	II-12	III-12	IV-12
As/Ac	I-13	II-13	III-13	IV-13
Ns	I-14	II-14	III-14	IV-14
Cu	I-15	II-15	III-15	IV-15
St/Sc	I-16	II-16	III-16	IV-16
Cb	I-17	II-17	III-17	IV-17

List of cloud maps, (continued)

Contingency probabilities of the co-occurrence of coupled cloud types:

Season	**Given cloud type**	Probability that these are also present						
		Ci/Cs/Cc	**As/Ac**	**Ns**	**Cu**	**St/Sc**	**Cb**	**NO***
DJF			I-24	I-26	I-28	I-30	I-32	I-18
MAM	Ci/Cs/Cc		II-24	II-26	II-28	II-30	II-32	II-18
JJA			III-24	III-26	III-28	III-30	III-32	III-18
SON			IV-24	IV-26	IV-28	IV-30	IV-32	IV-18
DJF		I-25		I-34	I-36	I-38	I-40	I-19
MAM	As/Ac	II-25		II-34	II-36	II-38	II-40	II-19
JJA		III-25		III-34	III-36	III-38	III-40	III-19
SON		IV-25		IV-34	IV-36	IV-38	IV-40	IV-19
DJF		I-27	I-35		I-42	I-44	I-46	I-20
MAM	Ns	II-27	II-35		II-42	II-44	II-46	II-20
JJA		III-27	III-35		III-42	III-44	III-46	III-20
SON		IV-27	IV-35		IV-42	IV-44	IV-46	IV-20
DJF		I-29	I-37	I-43				I-21
MAM	Cu	II-29	II-37	II-43				II-21
JJA		III-29	III-37	III-43				III-21
SON		IV-29	IV-37	IV-43				IV-21
DJF		I-31	I-39	I-45				I-22
MAM	St/Sc	II-31	II-39	II-45				II-22
JJA		III-31	III-39	III-45				III-22
SON		IV-31	IV-39	IV-45				IV-22
DJF		I-33	I-41	I-47				I-23
MAM	Cb	II-33	II-41	II-47				II-23
JJA		III-33	III-41	III-47				III-23
SON		IV-33	IV-41	IV-47				IV-23

*NO = No Other Cloud

1. Introduction

Clouds are of primary importance in processes that produce the earth's climate system and thus constitute basic variables in describing and determining that system. Because of their solar and thermal-infrared radiation characteristics they strongly modify the earth's radiation budget. Clouds are affected, in turn, by various components of the earth's radiation field in addition to heat and moisture transport on different scales of atmospheric motion. They occur practically everywhere in the troposphere and are found in different sizes and shapes. However, particular cloud types are predominant under certain conditions. They tend to take on different forms depending on the nature of the underlying surface and physical factors contributing to their evolution.

Meteorological observations show that when clouds are reported it is usual for two or more cloud types to be present at the same time and frequently at different heights. However, when a multilayered cloud system exists, ground based observers cannot always identify the amount, or in some cases, even the presence of upper-layer clouds. An analogous situation applies for observations taken from platforms located above the top cloud layers (satellite observations). The mechanisms through which clouds interact with their physical environment are complex involving their horizontal and vertical geometry as well as their microphysical characteristics both of which are represented, in part, by their cloud type designation. It is thus useful, in considering the role of clouds as they effect climate and climate variations, to provide a description of the global distribution of various cloud types as well as of total cloud cover. The radiative inputs to the earth-atmosphere system are functions of the top and bottom boundary conditions of the cloud ensembles, and information contributing to correct inference relating the co-occurrence of different cloud types could improve the radiation calculations of climate prediction models. In addition, such information would provide data for cross-calibration of different observing techniques and constitute an important pragmatic guide for computation of the generation of clouds in numerical climate models.

Clouds have traditionally been reported from routine observations taken at land-based weather stations, on ships at sea or from aircraft. With the advent of satellites, an additional important mode of cloud observations became available. Satellite cloud observations have the distinct advantage of near global coverage with a high density of observations in time and space. Inference from these observations, however, cannot easily be made with regard to most cloud types, particularly when clouds are present at different atmospheric levels. Different cloud types can still best be identified by direct observations of well trained ground based observers.

This atlas is similar to one published earlier on the simultaneous occurrence of different cloud types over the oceans (Hahn et al., 1982). It is based exclusively on data reported from land station surface synoptic observations for the ten year period 1971-1980. We present below a set of maps which show, for each of the four seasons, the frequency of occurrence of each of six cloud types, of fog and of clear skies, in addition to the contingency probabilities $P(A \Rightarrow B)$ by which is meant: given the presence of type A, the probability that type B also occurs. This atlas, however, does not contain any information about cloud amounts. Such information will be published in later atlases along with analyses of the variability of total cloudiness and clouds of different types, both over the oceans and over the land.

The present atlas makes use of the same methodology as that used in the corresponding atlas for the oceans. The reader is referred to the text of that atlas for a discussion of the details of the method of analysis. Some additional information is provided here for those few cases where the procedure used for the land data was different.

The same quantities are mapped here as were mapped in the ocean atlas, and the order and numbering of the maps is the same. The maps for the land, however, are at 5° x 5° latitude-longitude resolution, instead of the 15° x 30° resolution used for the oceans. As mentioned above, the only source of data used here is the routine weather observations from land stations, coded by the observers into the WMO synoptic code (WMO, 1974). Therefore, although many of the 5° x 5° boxes contain some ocean area, the values plotted apply only to the land portion of the box.

2. Data Source

Synoptic reports from land stations were obtained on magnetic tape from the "SPOT" archive of the Fleet Numerical Oceanography Center (FNOC) in Monterey, California. The SPOT archive begins in October 1966, but for the years 1966-1970 there are many mislocated data and almost no observations from the Southern Hemisphere. In these early years the SPOT archive is also lacking the station identification numbers. Beginning in January 1971 the archive consists of high quality data with global coverage. Therefore, for this atlas we analyzed ten years of data, 1971-1980, a total of approximately 100 million observations. This is about ten times as many observations as were used for the ocean atlas. The observations are normally made every three hours, with somewhat more at GMT hours divisible by 6. Typically about 4100 stations appear in the archive at 0, 6, 12, 18 GMT and about 3000 stations at 3, 9,15, 21 GMT. About 20% of the stations do not make observations at night.

All observations were weighted equally, irrespective of year. No thorough study was made of the interannual variation of the contingency probabilities; however, three-year subsets of 15°-zonal means were examined for December-January-February. As long as the longitudinal coverage within the latitude zone was comparable in the different subsets, the computed values usually differed from each other by less than 1%.

3. Method of analysis

The grouping of the 27 standard cloud types into 6 types for this study is the same as that used in the ocean atlas, and is given in Table 1. This table is the same as that given in the ocean atlas except for some additions to clarify the specifications of nimbostratus and stratus. The detailed procedure for assigning types from a single observation is given in Figures 1-4. Abbreviations used in those figures (and in the text) are given in Table 2. Details of the procedures for computing the co-occurrence probabilities are not shown here; they are given in Sec. 4d of the ocean atlas.

The land data set also contains observations from a few automatic weather stations which were improperly coded into the archive. Reports from these stations should not contain any cloud information, so that the cloud fields should be coded as missing (unreported), but they appear instead as zeros in this data set. These observations were found (with one exception mentioned below) always to have the present weather coded as missing (ww = /), so we were able to discard them on that basis. This policy (shown in Fig. 1) causes us also to discard some valid cloud observations. However, less than 1% of the observations made by observers have ww = /, and these tend to be questionable observations in other respects, in that they are often internally inconsistent (e.g. $N_h > N$). Rejecting all observations which lack present weather should therefore not bias our analysis.

The tests shown in Fig. 1 weed out nearly all the inconsistent reports, even though they do not check for all possible inconsistencies, because the ones tested for are by far the most common.

The data sampling criteria used in this atlas are more stringent than those used in the ocean atlas. To compute a probability $P(A \Rightarrow B)$ for the ocean atlas, the requirement was as follows: Of the times that A was present in a given box and a given season, we required that in at least 50 individual observations it was possible to see whether B was also present. For the land we have changed this criterion from 50 to 200. This was done in order to reduce the number of inconsistencies in the land co-occurrence probabilities. For example, the sum $P(St \Rightarrow Ci) + P(St \Rightarrow As) + P(St \Rightarrow Ns) + P(St \Rightarrow NO)$ must be at least 1.0, where "NO" means "no other cloud". Because these probabilities are not all computed from the same populations, the sum may occasionally be less than 1.0, an inconsistency which indicates that the population was too small to give reliable statistics. This is only one of several such constraints on sums of probabilities. With the criterion set at 200, the total number of such inconsistencies was reduced to less than 2% of the total possible. A failure to meet this criterion is the reason for blank locations on the maps. We do not regard these blanks as a serious lack of information, since they occur in locations where the quantity plotted is of little importance: e.g. if cloud type A occurred so rarely that $P(A \Rightarrow B)$ could not be computed, then the actual value of this

Table 1.

Grouping of cloud types

cloud types used in this paper	shorthand notation	observer codes included in each type[1]
Ci/Cs/Cc	Ci	C_H 1-9
As/Ac	As	C_M 1,3,4,5,6,8,9; C_M 2,7 if not precipitating[3]
Ns[2]	Ns	If (precipitating)[3] and (C_M 2,7 or C_L 6,7)
Cu	Cu	C_L 1,2
St/Sc[4]	St	C_L 4,5,8; C_L 6,7 if not precipitating[3] or if C_M = 2,7, /
Cb[5]	Cb	C_L 3,9

[1] C_H = high cloud type; C_M = middle cloud type; C_L = low cloud type. The numbering scheme is defined in WMO (1956).
N=0 (clear) counts as a synoptic cloud report and is used in computing frequency of occurrence of cloud types but is not used in computation of contingency probabilities.

[2] Ns is also considered to be present when the cloud reports indicate "sky obscured" due to rain or snow (present weather code ww 50-89). Note that if the report has both (C_M = 2 or 7) *and* (C_L = 6 or 7) with precipitation, this is counted as a co-occurrence of Ns with St. The case C_M = / and C_L = St with precipitation is also considered to be a co-occurrence of Ns with St. The present weather codes are defined in WMO (1974).

[3] "Precipitating" means present weather code 50-89.

[4] reports of "sky obscured due to fog" are excluded in the co-occurrence statistics.

[5] Cb is also considered to be present when the cloud report indicates "sky obscured" and the present weather code is 90-99. This combination is quite rare.

Table 2. Symbols Used

N	total cloud cover
N_h	lower cloud amount
C_L	low cloud type
C_M	middle cloud type
C_H	high cloud type
/	not reported
ww	present weather
F	fog (ww 10-12, 40-49)
R	rain or snow (ww 50-89)
T	thunderstorm (ww 90-99)
LAT	latitude
LON	longitude
NCLR	number of reports of completely clear sky
NFOG	number of reports of sky obscured due to fog
NCLD	number of observations in which at least one cloud type is present
Ci	cirrus
Cs	cirrostratus
Cc	cirrocumulus
As	Altostratus
Ac	Altocumulus
Ns	Nimbostratus
Cu	Cumulus
St	Stratus
Sc	Stratocumulus
Cb	Cumulonimbus
NO	No Other cloud

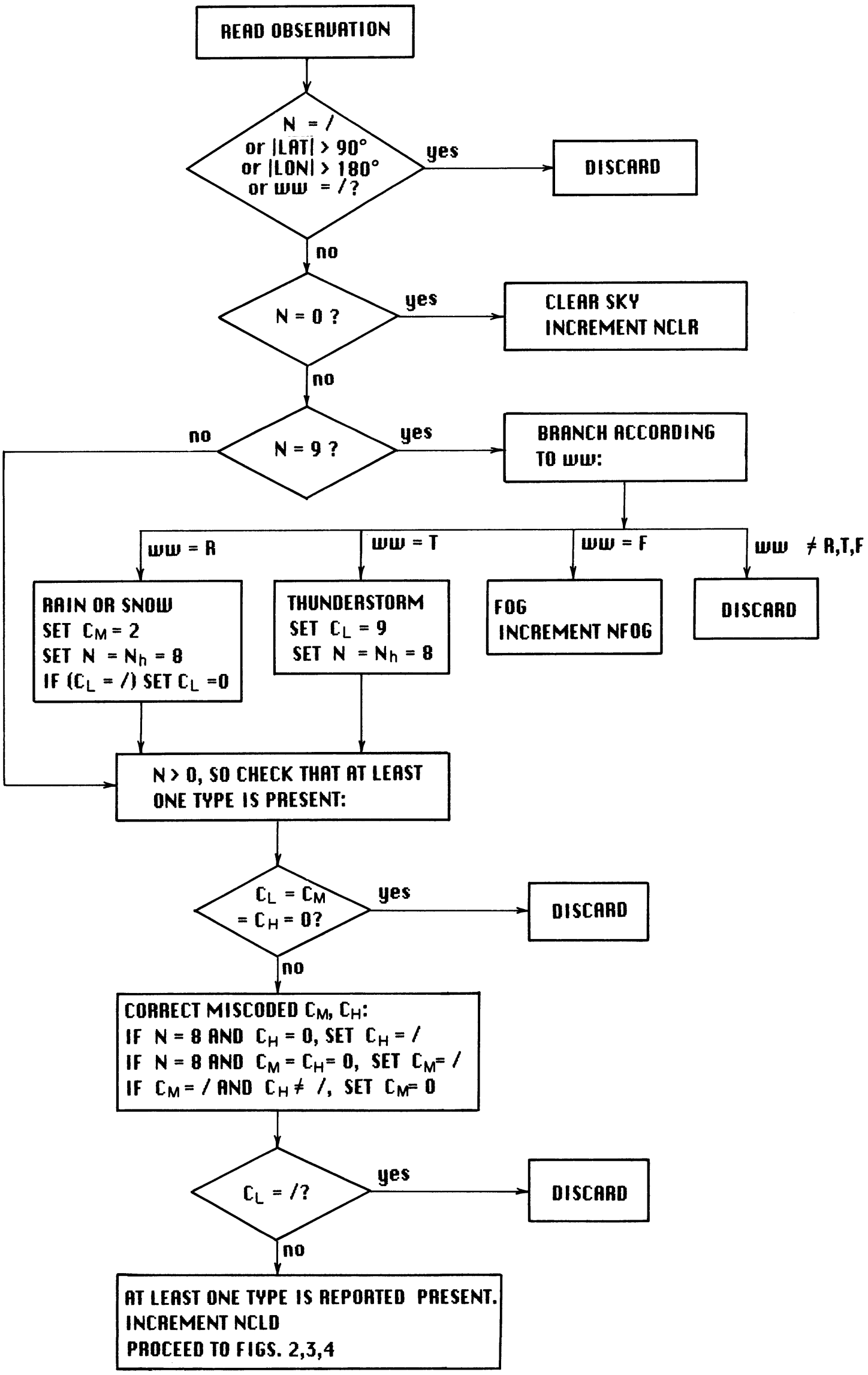


Figure 1. Data selection and checking.

Abbreviations used here are defined in Table 2. Observations with present-weather missing (ww = /) were discarded in order to exclude miscoded automatic-weather-station reports, as explained in the text. The check for clear sky (N = O) should properly be done *after* the test for discarding an observation because low cloud type was unreported (C_L=/), in processing data sets in which a significant fraction of the observations have C_L=/ e.g. ocean data prior to 1940. However, since 96% of the land observations used here include low cloud type, negligible change in f (clear) would result from reversing those tests.

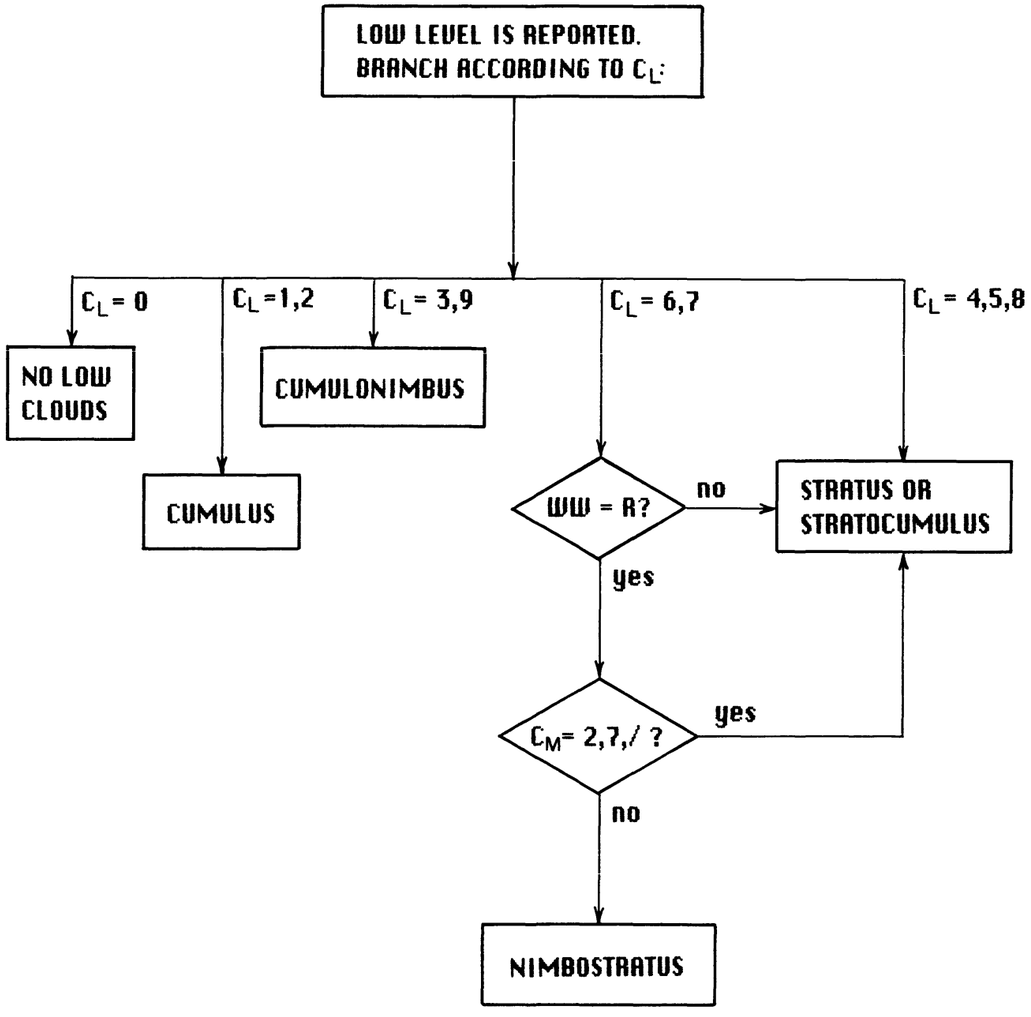
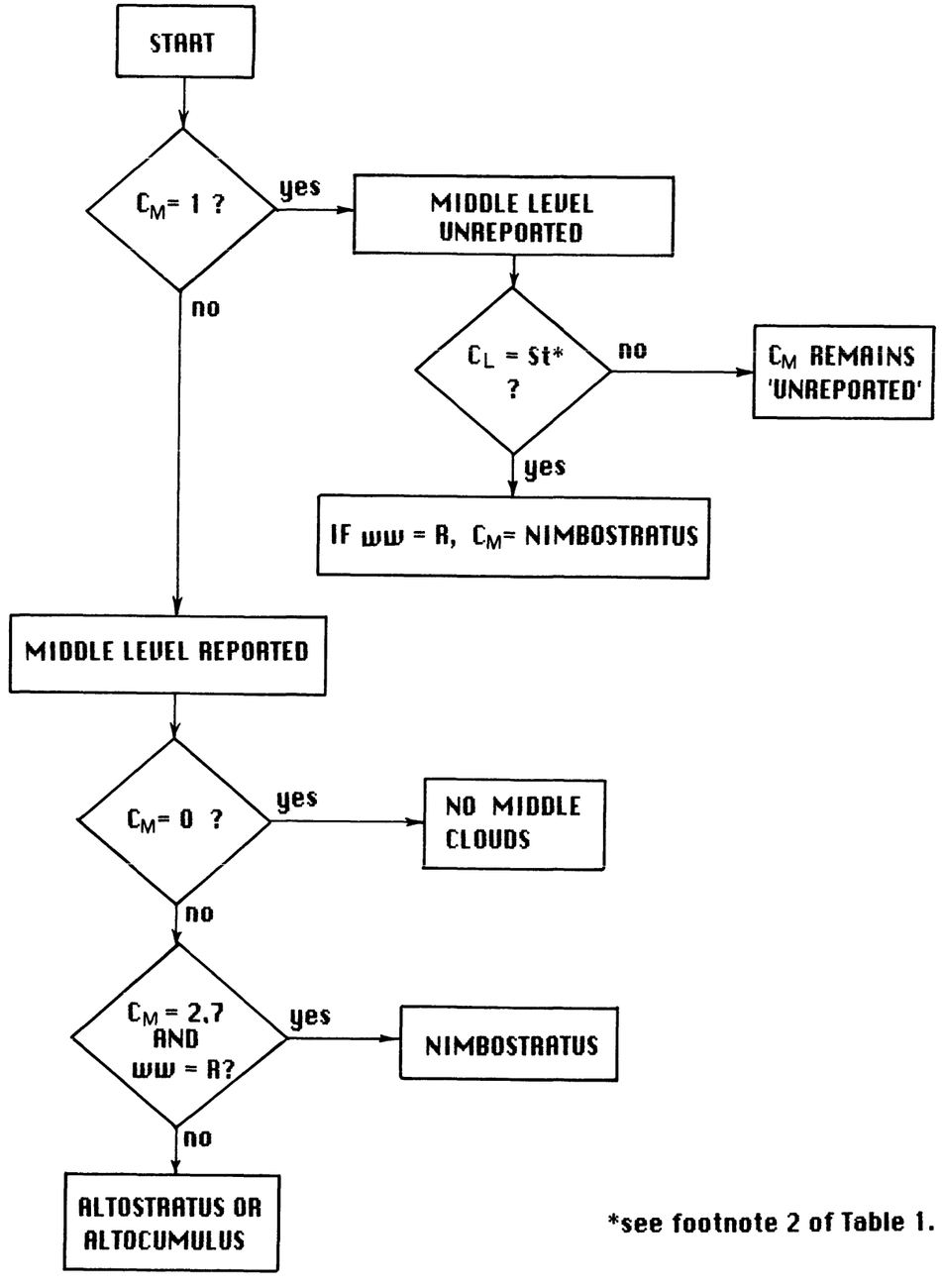


Figure 2. Low cloud type classification .



*see footnote 2 of Table 1.

Figure 3. Middle cloud type classification

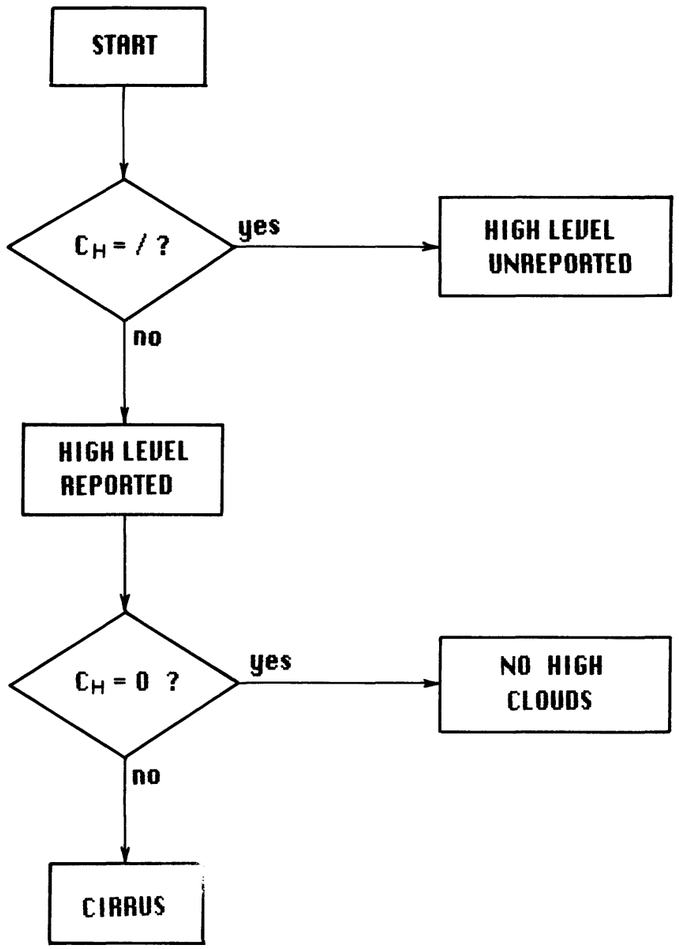


Figure 4. High cloud type classification.

probability is of minimal importance to climatic studies.

4. Biases and errors

The values of frequency and co-occurrence probabilities are subject to inaccuracy due to biases that are introduced either by the observers or by the analysis procedure, and also due to errors in the analysis procedure which were detected after completing the study.

Two types of bias were discussed in the ocean atlas and shown to be small: the tendency of ships to avoid storms ("fair-weather bias") and the inaccurate reporting of some cloud types by untrained volunteer observers on merchant ships ("observer bias"). Land stations are at fixed locations and routine synoptic observations are most often made by trained weather observers. Thus these two biases should be even less important for land data.

The bias with possibly the greatest influence on our results is the tendency of ground observers not to detect cirrus and altostratus when they are present at night (the "night-detection bias"). We have not yet analyzed for the diurnal cycles of cloud type frequencies over land. However, over the oceans the frequency of occurrence of cirrus, f(Ci), in the daytime averages about 1.3 times the diurnal-mean value. Because f(Ci) does not vary smoothly with time of day but instead shows a sharp increase at sunrise and decrease at sunset, we think that the diurnal variation is at least partly due to a night-detection bias rather than a true variation. The same pattern is found for As/Ac. Since both co-occurrence atlases were prepared with the use of all observations, it is suggested that the frequency of occurrence of cirrus and of As/Ac should be increased by a factor 1.3, if observations were distributed uniformly through day and night. But because of the greater number of daytime observations, the factor to be used is somewhat less, about 1.25. This would increase the global-land-average cirrus frequency from 40% to 50%. Application of such a correction factor assumes, of course, that the diurnal variation of f(Ci) in the observations is due entirely to the observer bias and not at all to a true diurnal variation of the clouds. Such a correction factor, if applied to f(Ci) and f(As), should also be applied to all probabilities of co-occurrence of these two types contingent on the presence of other clouds: $P(X \Rightarrow Ci)$ and $P(X \Rightarrow As)$. The results presented here and in the

ocean atlas are uncorrected.

Another important bias is the underestimation of frequency of upper clouds due to the possibility (pointed out in the ocean atlas) that an upper cloud is hidden behind a partial lower overcast yet *reported absent* because it does not intrude into the region of the sky which is visible through the lower layer. This "partial-undercast bias" has not been quantified. It results in a systematic underestimate of frequencies of upper clouds (Ci and As/Ac). The effect of this bias on f(Ci) increases as the amount of lower clouds increases, which may be responsible for the trend shown in Fig. 1 of the ocean atlas.

A bias which may lead to spurious geographical variation of Ci and As is the possible difference in observing practice among different observers or different countries with regard to the decision of whether to report higher cloud types. We have found that the frequency of $C_H = /$ (not reported) increases with lower cloud amount. This code sometimes is used even when the high level is visible, if the lower cloud covers most of the sky, leading to the "abstaining cirrus bias". For example, Map IV-27 shows that the probability of cirrus, given nimbostratus, is much higher north of the Black Sea than south of it. This could be explained if the reporting practice, when nimbostratus is nearly overcast ($N = N_h = 7$), is to code $C_H = 0$ in Turkey but $C_H = /$ in the USSR. A brief test only partially confirmed this hypothesis. This bias counteracts the 'partial-undercast' bias. The effects of both could be minimized by calculating Ci and As statistics only on the subset of observations for which $N_h \leqslant 6/8$.

All three of the biases just discussed illustrate that as expected, surface observations give less accurate information about high clouds than about low clouds.

It should be noted that some of the co-occurrence maps are of limited utility because of the arbitrary classification of types given in Table 1. In particular, the maps for P(As $\Rightarrow$ Ns) and P(Ns $\Rightarrow$ As) may not be very useful. Our classification allows them to occur together only under the special conditions that Ns is assigned from the low group while in the middle level As is reported present, whereas the observer may actually have seen both types when coding $C_M = 7$.

After completion of both co-occurrence atlases, we decided that our classification of the present-weather (ww) codes could be improved. We find that ww codes 80-89 are usually reported in the presence of convective low clouds. In the cases where we must decide the cloud type based on ww (Table 1), it therefore seems inappropriate to specify nimbostratus as present when ww is 80-89. This actually happened only rarely in our procedure. The effects of grouping ww 80-89 together with 90-99 (footnote 5 of Table 1) instead of with 50-79 would therefore generally be very small. The greatest change would occur in the regions where the frequencies of Cb and Ns are both large, e.g. at Bergen (Norway) in winter. A study was done on the single season DJF 1979 to estimate the maximum likely effects of this change at that station and globally. The result at Bergen was that f(Cb) increased from 16 to 17% and f(As) from 50 to 52%, both at the expense of f(Ns) which decreased from 13 to 10%. P(Cb $\Rightarrow$ As) increased from 69 to 75% and P(Cb $\Rightarrow$ Ns) decreased from 6 to 1%. The changes were smaller elsewhere on the globe, but the values on our maps of P(Cb $\Rightarrow$ Ns), which are very small numbers anyway, may be considered too large because of our classification. The global average changes were as follows: f(Cb) was unchanged at 5%; f(As) increased from 34 to 35%; f (Ns) decreased from 12 to 11%. P(Cb $\Rightarrow$ As) increased from 48 to 52%, and P(Cb $\Rightarrow$ Ns) decreased from 5 to 2%.

In summary, there are a number of biases and procedural decisions which can affect our results. Undoubtedly we have not discovered all the biases, but we think that the major ones have been identified. Most have very small effects on our results. The most significant bias is likely that due to the reduced detection of cirrus and altostratus at night.

5. Format of the maps

The atlas contains 47 maps for each of the four seasons. These maps show, for the land areas, the global distribution of the various quantities related to cloud types and co-occurrences, for the 10 year period 1971-1980.

The resolution of the maps is 5° latitude by 5° longitude, between 50°N and 50°S. At higher latitudes the size of the boxes is increased in longitude to maintain roughly equal area in

each box. The resolution is 5° x 10° for 50° – 70° latitude, 5° x 20° for 70° – 80° latitude, 5° x 40° for 80° – 85°, and 5° x 360° for 85° – 90°.

Each section of the atlas includes the following maps:

a) The total number of synoptic weather reports (in hundreds) which have information about cloud types, present or absent (Map 1). Such information may be an observation of a specific cloud type present (C_L,C_M,orC_H code 1-9) or a cloud type inferred when the sky is obscured consistent with the ww report as shown in Table 1, or an observation of clear sky.

b) The number (in hundreds) of times that each of the six cloud types was observed to be present (Maps 2-7).

c) The fraction of reports of cloud (in percent) contributing to the statistics of middle or high cloud levels (Maps 8 and 9). This is the number of synoptic reports in which the middle (or high) level was not coded with a slash, divided by the total number of reports in which *any* cloud was reported present.

d) The overall frequency of occurrence, f (percent), of each cloud type as well as of fog and clear sky (Maps 10-17). It is the number of times the particular type was reported present, divided by the number of synoptic weather reports which contain information about that cloud level, i.e. in which that level was not coded with a slash. (The fraction of times that the level was not coded with a slash is given in Map 8 or 9.) Values are tabulated for each box for which probabilities contingent on that cloud type were computable, i.e., whenever the particular cloud type was reported present at least 200 times.

e) The probability, P, given one of the six cloud types, that no other cloud is present (Maps 18-23);

f) The co-occurrence probabilities P for coupled cloud types (Maps 24-47). Some P-maps are absent simply due to the definitions of cloud types given in Table 1. For instance, Table 1 allows only one low cloud type to be reported in a single observation so the co-occurrence probabilities of Cu, Cb, and St with each other are zero by definition.

Zonal average values for only the land part of the zone are printed along the right side of the maps. These result from averaging the values of all 5° x 5° boxes in each zone, each box weighted by the the area of land it contains. The definition of land differs from that shown by the continental outlines on the maps in two respects: all lakes, as well as the Ross Ice Shelf and the Filchner-Ronne Ice Shelf, are counted as land. A zonal average is computed if at least one-third of the possible land boxes are represented in the zone. The fraction of each zone which is land is given in Table 3.

Blanks occur on the maps where there were insufficient observations in the 10 years to obtain a statistically significant co-occurrence probability. Normally, these are boxes with no reporting stations throughout the 10-year period. In these locations, one can either interpolate between the values in neighboring boxes, if they are represented, or else take the overall frequency of occurrence from the f-maps by default.

The numbers plotted on these maps are available on magnetic tape from the Data Support Section at NCAR.

6. Discussion

The number of synoptic cloud reports in a 5° x 5° box (Map 1) would be about 36 hundred if the box contained one station which made observations every 6 hours throughout the 10 years. Larger numbers are found where several stations contribute. In Europe and northern Asia, where the density of stations is high, the symbol ** is sometimes plotted to indicate a number greater than 100,000. Some regions of Africa and Australia are blank on all the cloud maps because of the absence of observing stations.

The maps showing the percentage of reports contributing to the statistics of middle or high cloud levels give an indication of the statistical reliability of the information presented on the co-occurrence probability maps. These values are less than 100% principally because of the presence of a lower overcast. For example, Map I-9 shows values close to 100% in eastern

Table 3. Zonal average land fractions (percent)

Zone	Northern Hemisphere	Southern Hemisphere
0-5°	22	26
5-10°	26	24
10-15	25	21
15-20	30	24
20-25	36	25
25-30	41	22
30-35	43	16
35-40	45	7
40-45	50	4
45-50	57	3
50-55	61	2
55-60	57	0
60-65	72	0
65-70	76	22
70-75	41	60
75-80	29	88
80-85	17	100
85-90	0	100

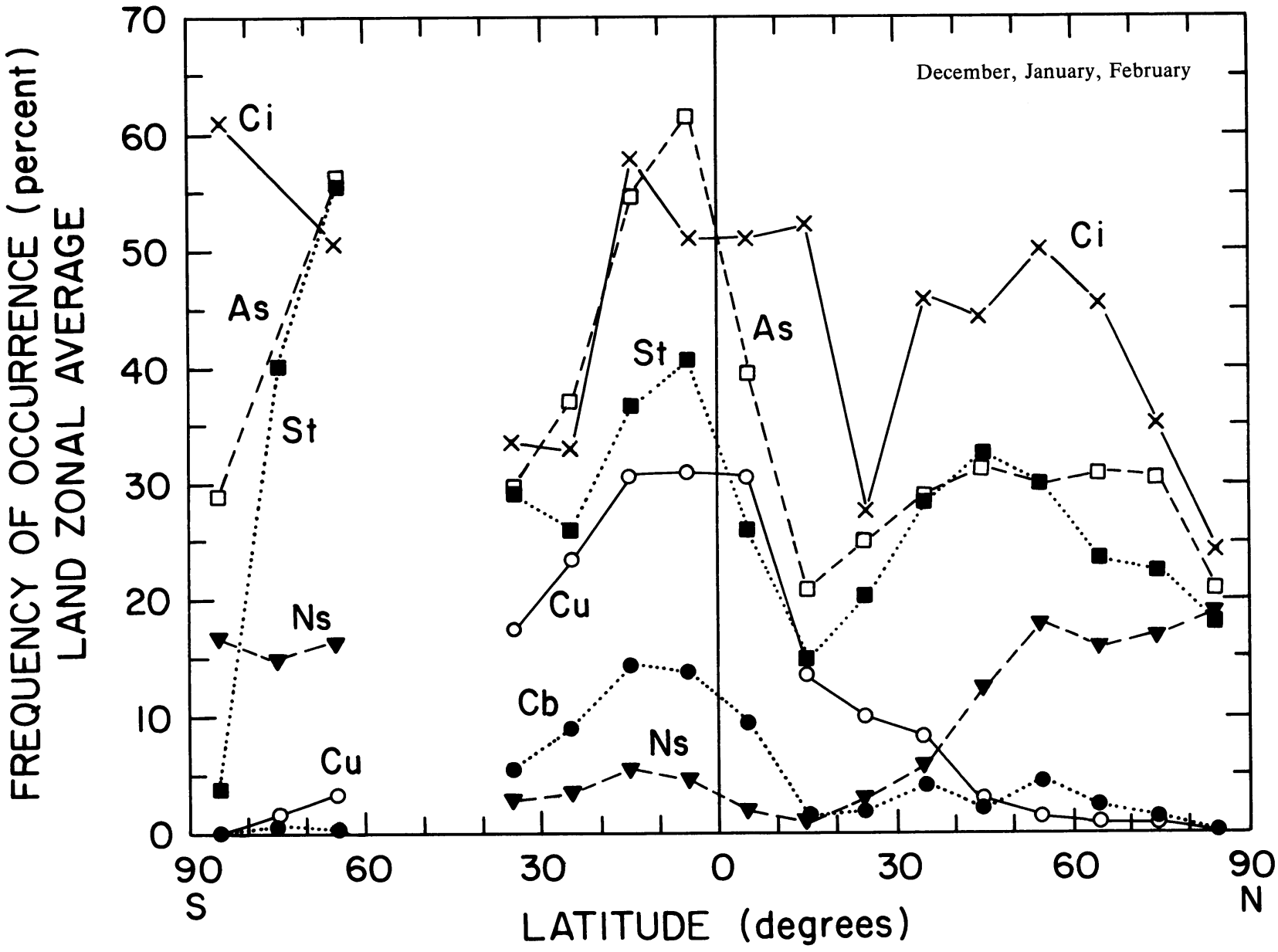
Siberia but much lower, close to 80%, in western Canada. The reason is the higher frequency of low overcast in Canada, consistent with Map I-16 showing f(St) near 30% in western Canada but less than 5% in eastern Siberia. The values average 87% for the middle level and 73% for the high level. The values are higher than those over the ocean because the land has generally fewer low overcast conditions than the ocean.

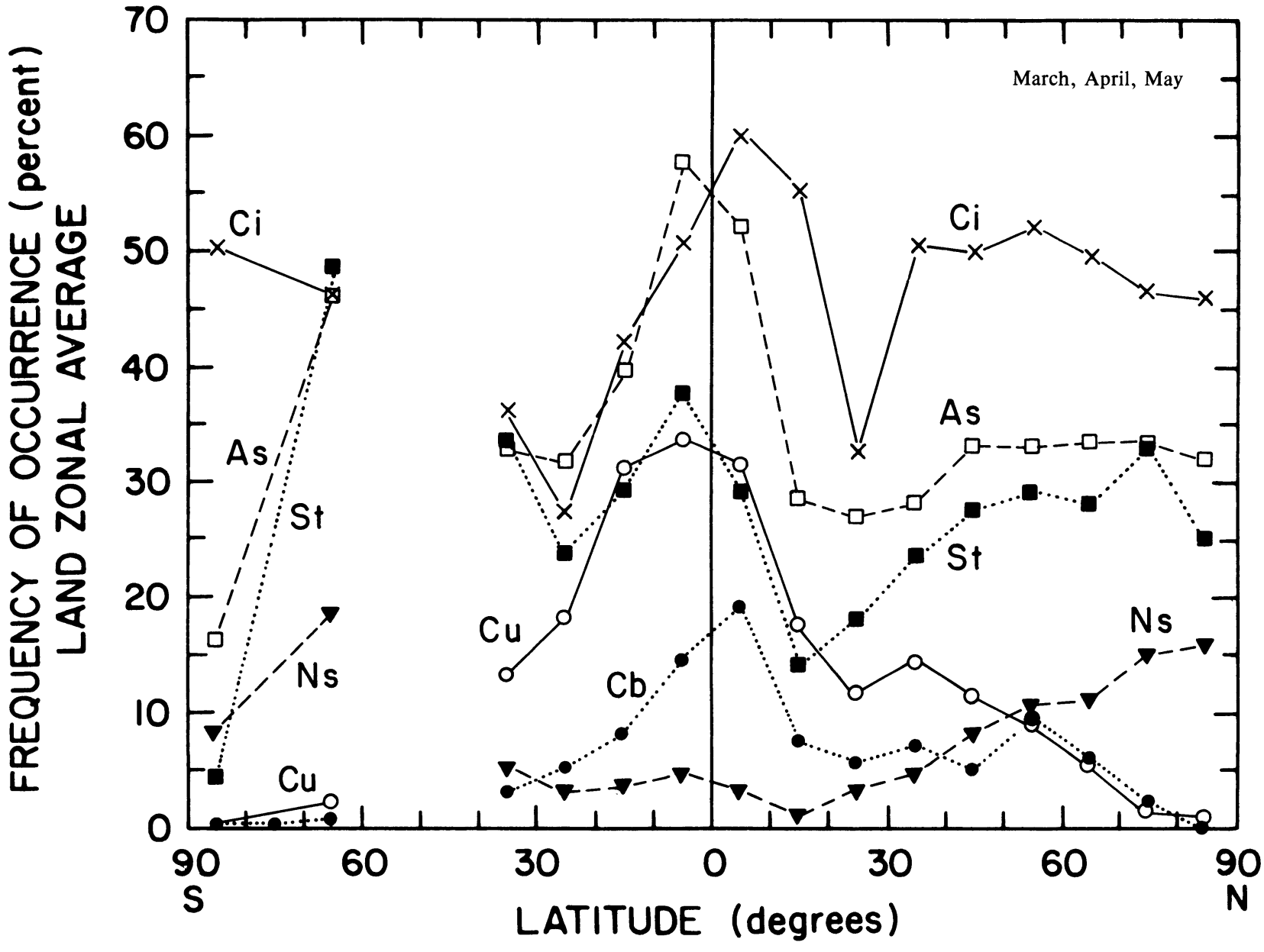
The frequency of clear sky (Map 10 for each season) is generally much larger over land than the 2-5% found over the open ocean, except in the tropical regions in local summer. Sky obscuration due to fog (Map 11) is very rare over land.

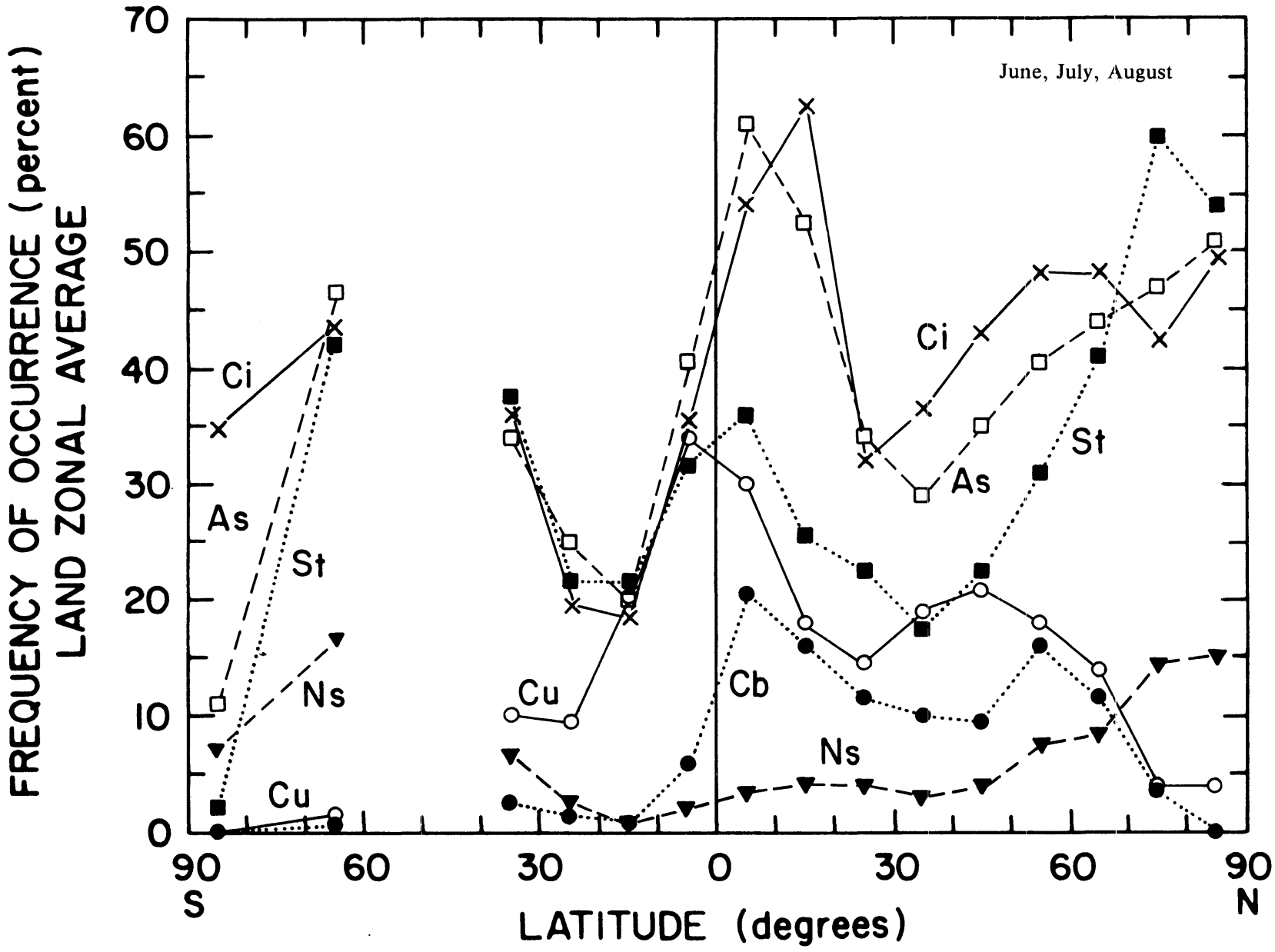
Maps of the frequency of occurrence, f, of each cloud type are presented so that they can be compared with the contingency probabilities of observed cloud-type couples. The zonal land average values of f shown along the right side of the maps were used to prepare the graphs of the average latitudinal variation of f shown in Fig. 5. Fig. 5 shows the values for 10-degree zones, except for 40°-60°S where the land fraction is less than 5%, for four seasons (5a-d).

The patterns in Fig. 5 are generally what one would expect for these types from synoptic experience and the observed large scale features of the general circulation. A pronounced peak is seen near the equator for almost all types. Even Ns exhibits a slight peak at low latitudes. These frequency peaks move north and south of the equator in response to the seasonal variations in the average position of the inter-tropical convergence zone (ITCZ) (see, for instance, Figs. 10.3 and 10.4 of Riehl, 1978). However, the cirrus maximum shifts from 15°S in DJF to 15°N in JJA, whereas the As maximum shifts only from 5°S to 5°N. Since low latitude cirrus is most often the result of spreading from the tops of cumulonimbus clouds, the latitudinal variation is enhanced by the northward extension of the upper branch of the Hadley circulation during JJA. The Cb maximum near the equator is a good indication of the zonal average location of the ITCZ over land. During most seasons this maximum occurs in the Northern Hemisphere.

In the Northern Hemisphere, the high latitude winter maximum in cirrus results from the extension of sub-polar frontal cloud systems. The summer cirrus maximum, however, is


December, January, February
FREQUENCY OF OCCURRENCE (percent)
LAND ZONAL AVERAGE
70
60
50
40
30
20
10
0
Ci
As
St
Ns
Cu
Cb
90
S
60
30
0
30
60
90
N
LATITUDE (degrees)


March, April, May
FREQUENCY OF OCCURRENCE (percent)
LAND ZONAL AVERAGE
70
60
50
40
30
20
10
0
Ci
As
St
Ns
Cu
Cb
90
S
60
30
0
30
60
90
N
LATITUDE (degrees)



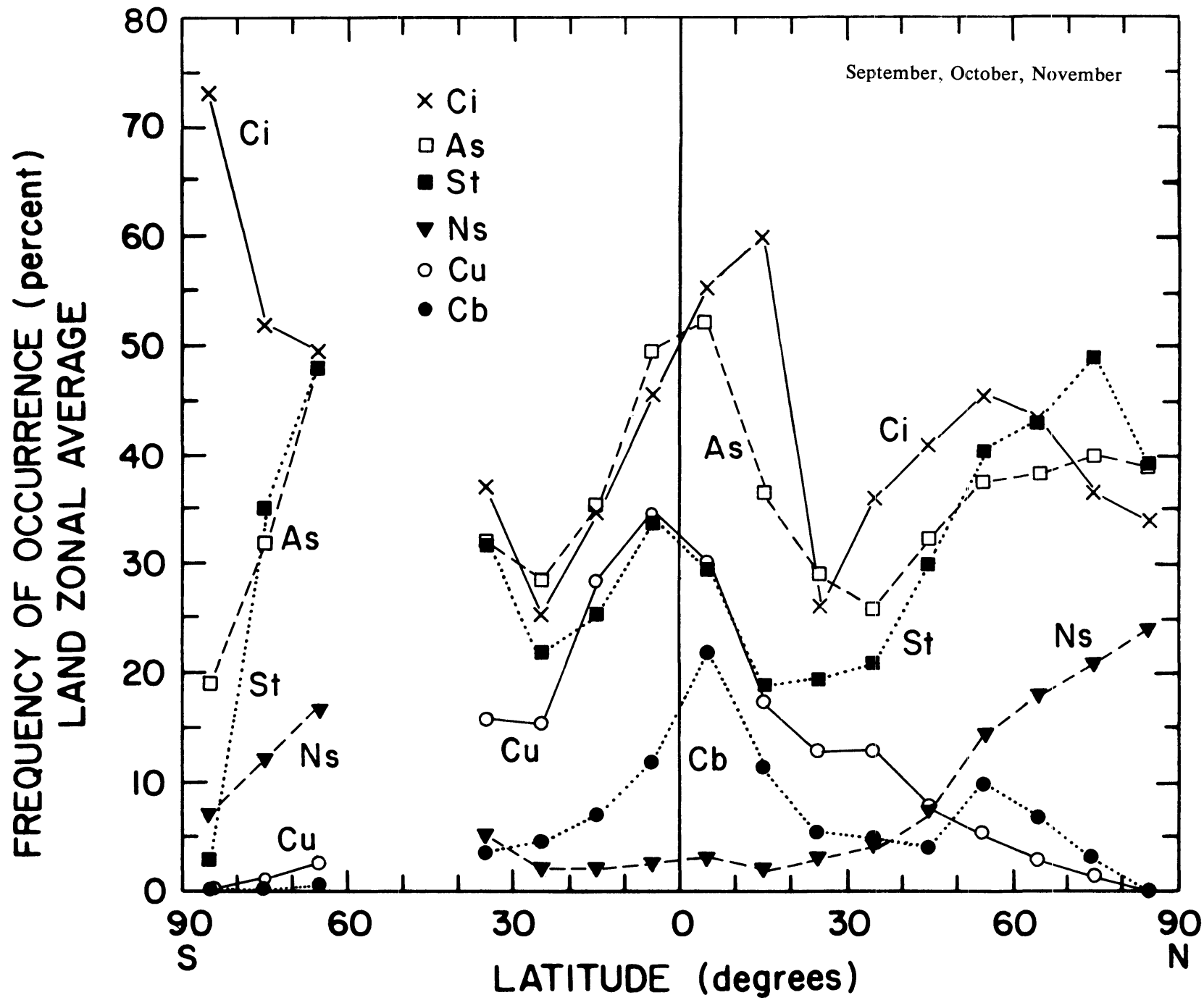


Figure 5. Frequency of occurrence of each cloud type over land as a function of latitude. The reason for the gap at 40°-60°S is that there is insufficient land to form zonal averages at these latitudes.

associated with strong convective clouds. Note, for instance, the related high latitude maxima in the Northern Hemisphere between Ci and the convective clouds (Cu and Cb) during JJA but not during DJF. Most cloud types show a strong minimum in the subtropical desert region at 20°-30° in each hemisphere, although this is less obvious in the Southern Hemisphere because the lack of land area south of 40°S precludes formation of zonal averages.

A sharp minimum in Cb frequency (~1%) is found in the region of the descending branch of the winter-hemisphere Hadley cell at 15°S in JJA and 15°N in DJF. Cb is mostly concentrated in the tropics, except in JJA when there is a double maximum in the Northern Hemisphere, one in the tropics and the other at sub-polar latitudes.

The seasonal and latitudinal changes in cumulus frequency are similar to the changes in Cb. However, except for DJF, the maximum of Cu is not at the ITCZ (Cb maximum) but rather somewhat upstream in the approach to the ITCZ. This has sometimes been identified as "trade-wind cumulus", found frequently over the tropical oceans.

The plots of the three most common cloud types (Ci, As, and St) are roughly parallel in all four seasons, with minima in both northern and southern subtropics in all seasons. The deeper of the two minima is at 20°S in JJA and at 20°N in DJF.

On the Antarctic continent cirrus is by far the most common cloud reported. In this region, Cu, Cb and St are very rare during all seasons. The temperatures over the Antarctic are sufficiently low that most stratiform clouds are composed of ice crystals and have the appearance of cirrus. This could account for the pronounced latitudinal variation of cirrus opposite that of altostratus and stratus as reported during all seasons poleward of 65°S. St becomes very common in the coastal regions of the continent (60° to 70°S). The maximum frequency of reported St is found in the sub-Antarctic, as compared to other latitudes, in all seasons except JJA at which time the Arctic summer stratus is at its peak. However, it is not only St that is common in the Arctic summer, but also As and Ci.

Nimbostratus behaves differently from all other types, with low frequency in the tropics, increasing toward the poles. The greatest frequency of Ns is found in the high northern latitudes in all seasons, reaching a peak of 24% in the Arctic autumn.

The prominent features in Fig. 5 are thus seen to be consistent with known patterns of the general circulation of the atmosphere.

Returning now to the discussion of the maps, we see that high and middle clouds are frequently observed alone over land (Maps 18, 19), in dramatic contrast to the situation over the ocean. P(Ci $\Rightarrow$ NO) averages 45% over land but only 9% over the ocean.

The frequency maps, as well as the co-occurrence maps, show geographical variations that are much less smooth than those shown in the ocean atlas. There are at least two reasons for this. One is that the surface conditions on land can exhibit great local variation, so that a station may not be representative of the total area of its box. Another is that differences in observing procedure among individual observers and among different countries, as shown below, can affect the land areas much more than the ocean areas, because each ocean grid box is sampled by many different ships.

In spite of the increased geographical variability over land, most of the quantities mapped do show rather smooth variations. There are, however, some strange values which need special explanation, that we single out for discussion here.

Very strange values in all seasons were exhibited by the box in the Arabian Peninsula at 15° – 20°N, 45° – 50° E. Only occasional reports came from this station, and they began in 1979. About 80% of the observations were of cumulonimbus, and about 20% of the present-weather reports were of snow. This station (Sharorah, Saudi Arabia) is listed by WMO (1979) as an automatic station (number 40571). We conclude that the reports were either transmitted or transcribed incorrectly, although they do not fit the pattern of incorrect reports from other automatic stations. Therefore all values computed for this box were deleted, and that location is blank on the maps. This is the only location which had to be artificially blanked. We subsequently learned that this automatic station was known to be malfunctioning in 1981 (Eric Smith, personal communication).

Two neighboring boxes in the Sahara, at 15 - 20 ° N, 5° – 15° E, represented by one station each, almost never report clear sky. These stations are Agadez and Bilma in northern Niger, each of which reports regularly. Nearly all the reports are of a partial cover of cirrus, usually alone. The occasional reports that differ from these are self-consistent. It seems strange that cirrus is so much more prevalent here than immediately to the east and west (Map 12), suggesting a possible difference among observing procedures in different countries.

Local differences in reporting of cirrus are also apparent in South America along the equator near 70°W, where the reason seems to be the difference (mentioned above) in deciding whether to report the high cloud level when the lower cloud is nearly overcast. The reports in box 0° – 5°N,70° – 75°W, which has a small f(Ci), often have $C_H = 0$, but never $C_H = /$, when $N_h = 7$. The neighboring box 0° – 5°S, 65° – 70°W, has a large f (Ci), mainly because the observers there usually coded $C_H = /$ whenever $N_h = 7$. This spurious variation could be avoided by computing frequency only from those reports which had $N_h < 7/8$.

Another dramatic local variation is seen in neighboring boxes at 0° – 5°N, 115° – 125°E. The two stations on the east coast of Borneo (Tawau and Tarakan) in the western box report cumulus most frequently, while at the same time the two stations in the north of Sulawesi (Menado and Gorontalo) in the eastern box tend to report St/Sc instead. Part of this difference is due to our grouping of the cloud types. Much of the "St/Sc" in Sulawesi comes from $C_L = 8$, which actually means that cumulus and stratocumulus were both present, but which we have grouped in Table 1 with St/Sc instead of with Cu. However, that can explain only part of the difference. The great differences in f(Cu) and f(St) between these locations is probably a result of local topographic influences, due to the mountainous terrain in these coastal regions.

Another example of correct reports showing large geographical variation due to local effects is the prevalence of cumulus at 20° – 25°N, 5° – 10°E. The station representing this box is Tamanrassett, whose clouds are influenced by the local mountains and therefore different from the surrounding lowland desert.

The results shown in the various contingency maps are summarized in Table 4 where the zonal average values of the contingency probabilities are shown for 15° latitude zones. For the different latitude zones, four numbers, corresponding to the four seasons as noted to the right, are given for each element of the table. The columns in the table give the probability of occurrence of a given cloud type together with other specified clouds. Also shown in the last column is the probability $P(A \Rightarrow NO)$, i.e., given cloud type A, the probability that no other cloud type is present. As discussed above, certain elements of the table are blank simply due to the definitions of cloud types given in Table 1, or where the number of observations was insufficient to satisfy the minimum criterion required for the contingency tabulation. (If the criterion was satisfied in less than one-third of the land boxes in the zone, a blank appears in Table 4, except that for 75°-90°S only 4 boxes were required to compute a zonal average.) The numbers in Table 4 are the result of averaging the values of all 5° x 5° boxes in the zone, each box weighted by the fraction of land it contains and by the latitude-dependent area of the box.

The contingency probabilities may be compared with the average overall frequency of occurrence of each cloud type (leftmost column). If the contingency probability $P(A \Rightarrow B)$ is equal to the overall frequency of occurrence of B, then one may say that the value derived for $P(A \Rightarrow B)$ could be due to chance and is probably not meteorologically associated, since, on average, B is no more or less likely when A is present than when it is not. However, if the contingency probability $P(A \Rightarrow B)$ is higher (or lower) than the frequency of occurrence of B, the two cloud types are positively (or negatively) correlated. Cirrus and altostratus, for example, are positively correlated, since $P(As \Rightarrow Ci)$ generally exceeds f(Ci). Altostratus and cumulus are generally negatively correlated. These same correlations were noted also in the ocean atlas.

Global average frequencies and co-occurrence probabilities for land are compared to the ocean values in Table 5. These are not true global averages, but are instead just the averages of those boxes which had sufficient observations to compute values for the maps. The "global average" probabilities contingent on Ns, for example, are therefore weighted toward the values for the regions where Ns is common. Ninety percent of the boxes contributed to the global

averages for Ci and As, 85% for St, 80% for Cu, and 60% for Cb and Ns.

Cumulus, stratus, and altostratus are more frequently observed over the ocean than over land, but the precipitating clouds Ns and Cb are about equally frequent over land as over ocean.

Cirrus is reported more frequently over land than ocean (global averages 44% land, 31% ocean). While some part of this difference could be due to the partial-undercast bias explained above (since stratus is more common over ocean), it is likely that in general this is a real difference between land and ocean. We can see this by comparing regions which have the same frequency of stratus. Comparing Map I-12 with its counterpart in the ocean atlas, we see that f(Ci) in the eastern US in DJF is about 50%, compared to 20-30% in the north Atlantic 0°-30°N, whereas f(St) is the same in both regions (Maps I-16).

The most dramatic difference between land and ocean is in P(Ci $\Rightarrow$ NO) and P (As $\Rightarrow$ NO). Ci and As are much more likely to be found alone over land than over ocean.

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Table 4a

75°-90°N LAND-AREA-WEIGHTED AVERAGE CONTINGENCY PROBABILITIES (PERCENT)*

Given cloud type	Frequency of occurrence (f)	Fraction of reports contributing to statistics of type (%)	Probability that these are also present							
			Ci	As	Ns	Cu	St	Cb	NO	
	31	65	-	23	-	1	16	1	64	DJF
	46	68	-	31	16	1	22	1	53	MAM
Ci	45	55	-	44	-	3	42	1	32	JJA
	38	54	-	36	-	1	36	1	42	SON
	26	82	28	-	1	1	22	2	59	DJF
	33	81	44	-	2	2	33	2	39	MAM
As	48	69	45	-	1	3	61	1	25	JJA
	39	70	35	-	1	1	46	2	43	SON
	16	99	-	2	-	0	44	1	-	DJF
	16	99	-	5	-	0	52	0	15	MAM
Ns	17	99	-	4	-	0	67	0	6	JJA
	22	99	-	3	-	0	66	0	16	SON
	5	100	-	-	-	-	-	-	-	DJF
	5	100	-	-	-	-	-	-	-	MAM
Cu	3	100	-	-	-	-	-	-	-	JJA
	2	100	-	-	-	-	-	-	-	SON
	24	100	22	26	39	-	-	-	31	DJF
	35	100	37	37	30	-	-	-	23	MAM
St	67	100	36	49	19	-	-	-	23	JJA
	50	100	28	39	31	-	-	-	25	SON
	12	100	-	-	-	-	-	-	-	DJF
	4	100	-	-	-	-	-	-	-	MAM
Cb	5	100	-	-	-	-	-	-	-	JJA
	5	100	-	-	-	-	-	-	-	SON
	0	-	-	-	-	-	-	-	-	DJF
Sky obscured	0	-	-	-	-	-	-	-	-	MAM
due to fog	5	-	-	-	-	-	-	-	-	JJA
	1	-	-	-	-	-	-	-	-	SON
	40	-	-	-	-	-	-	-	-	DJF
Clear	24	-	-	-	-	-	-	-	-	MAM
sky	8	-	-	-	-	-	-	-	-	JJA
	18	-	-	-	-	-	-	-	-	SON

*"Ci" = Ci + Cs + Cc
"As" = As + Ac
"St" = St + Sc
"NO" = No Other cloud

Table 4b

60°-75°N LAND-AREA-WEIGHTED AVERAGE CONTINGENCY PROBABILITIES (PERCENT)

Given cloud type	Frequency of occurrence (f)	Fraction of reports contributing to statistics of type (%)	Probability that these are also present							
			Ci	As	Ns	Cu	St	Cb	NO	
	45	60	-	31	18	1	15	2	59	DJF
	49	66	-	32	10	5	19	4	53	MAM
Ci	47	67	-	42	6	14	29	8	30	JJA
	43	53	-	37	21	3	29	4	40	SON
	31	84	48	-	1	1	23	3	41	DJF
	34	83	51	-	1	4	30	6	32	MAM
As	44	81	47	-	0	11	40	12	23	JJA
	39	74	45	-	1	3	41	7	32	SON
	16	98	51	2	-	0	34	1	16	DJF
	12	97	-	3	-	0	45	3	9	MAM
Ns	9	96	-	3	-	1	65	5	3	JJA
	19	96	54	3	-	0	51	2	7	SON
	2	100	-	-	-	-	-	-	-	DJF
	6	100	50	29	1	-	-	-	36	MAM
Cu	14	100	51	38	1	-	-	-	31	JJA
	3	100	48	37	2	-	-	-	33	SON
	24	100	35	35	32	-	-	-	23	DJF
	28	100	36	38	22	-	-	-	27	MAM
St	43	100	35	42	16	-	-	-	29	JJA
	44	100	30	37	25	-	-	-	28	SON
	6	100	39	39	10	-	-	-	34	DJF
	8	100	40	37	5	-	-	-	36	MAM
Cb	14	100	41	46	3	-	-	-	32	JJA
	11	100	29	38	5	-	-	-	42	SON
	0	-	-	-	-	-	-	-	-	DJF
sky obscured	1	-	-	-	-	-	-	-	-	MAM
due to fog	2	-	-	-	-	-	-	-	-	JJA
	1	-	-	-	-	-	-	-	-	SON
	28	-	-	-	-	-	-	-	-	DJF
clear	21	-	-	-	-	-	-	-	-	MAM
sky	7	-	-	-	-	-	-	-	-	JJA
	13	-	-	-	-	-	-	-	-	SON

Table 4c

45°-60°N LAND-AREA-WEIGHTED AVERAGE CONTINGENCY PROBABILITIES (PERCENT)

Given cloud type	Frequency of occurrence (f)	Fraction of reports contributing to statistics of type (%)	Probability that these are also present							
			Ci	As	Ns	Cu	St	Cb	NO	
	48	56	-	31	17	2	20	3	56	DJF
	50	66	-	34	9	10	19	7	48	MAM
Ci	46	75	-	40	5	20	21	13	30	JJA
	44	59	-	37	14	7	24	6	43	SON
	31	77	52	-	1	2	32	4	35	DJF
	33	82	53	-	0	8	31	10	28	MAM
As	39	85	49	-	0	15	29	17	24	JJA
	37	76	48	-	0	6	38	9	30	SON
	16	98	59	2	-	0	43	2	9	DJF
	10	97	65	2	-	1	54	5	4	MAM
Ns	7	96	-	2	-	2	64	11	2	JJA
	12	96	64	2	-	1	58	4	4	SON
	2	100	53	32	3	-	-	-	34	DJF
	10	100	48	25	1	-	-	-	40	MAM
Cu	19	100	48	31	1	-	-	-	38	JJA
	6	100	44	31	1	-	-	-	40	SON
	31	100	38	35	27	-	-	-	23	DJF
	29	100	37	38	20	-	-	-	27	MAM
St	29	100	36	42	14	-	-	-	30	JJA
	38	100	31	38	20	-	-	-	29	SON
	5	100	43	37	6	-	-	-	34	DJF
	9	100	46	40	4	-	-	-	32	MAM
Cb	14	100	47	50	3	-	-	-	27	JJA
	16	100	37	43	4	-	-	-	35	SON
	1	-	-	-	-	-	-	-	-	DJF
sky obscured	1	-	-	-	-	-	-	-	-	MAM
due to fog	1	-	-	-	-	-	-	-	-	JJA
	1	-	-	-	-	-	-	-	-	SON
	25	-	-	-	-	-	-	-	-	DJF
clear	19	-	-	-	-	-	-	-	-	MAM
sky	13	-	-	-	-	-	-	-	-	JJA
	18	-	-	-	-	-	-	-	-	SON

Table 4d

30°-45°N LAND-AREA-WEIGHTED AVERAGE CONTINGENCY PROBABILITIES (PERCENT)

Given cloud type	Frequency of occurrence (f)	Fraction of reports contributing to statistics of type (%)	Probability that these are also present							
			Ci	As	Ns	Cu	St	Cb	NO	
	46	67	-	33	7	7	21	3	53	DJF
	51	74	-	33	4	13	19	7	48	MAM
Ci	39	82	-	41	3	20	17	14	33	JJA
	38	75	-	36	4	12	19	6	46	SON
	29	83	56	-	0	8	36	4	25	DJF
	29	87	60	-	0	13	31	9	20	MAM
As	30	91	60	-	0	19	23	14	26	JJA
	28	87	51	-	0	13	30	8	26	SON
	9	98	-	2	-	2	55	2	4	DJF
	6	97	-	2	-	2	61	5	2	MAM
Ns	5	96	-	2	-	4	64	6	2	JJA
	6	97	-	2	-	2	63	4	2	SON
	8	100	44	30	1	-	-	-	41	DJF
	14	100	48	25	1	-	-	-	41	MAM
Cu	20	100	39	28	0	-	-	-	48	JJA
	12	100	38	30	1	-	-	-	46	SON
	30	100	38	38	17	-	-	-	27	DJF
	25	100	43	39	15	-	-	-	27	MAM
St	18	100	38	40	10	-	-	-	35	JJA
	23	100	34	40	14	-	-	-	32	SON
	5	100	39	42	5	-	-	-	31	DJF
	7	100	55	44	3	-	-	-	25	MAM
Cb	10	100	54	48	2	-	-	-	25	JJA
	5	100	48	48	3	-	-	-	27	SON
	1	-	-	-	-	-	-	-	-	DJF
sky obscured	1	-	-	-	-	-	-	-	-	MAM
due to fog	1	-	-	-	-	-	-	-	-	JJA
	1	-	-	-	-	-	-	-	-	SON
	26	-	-	-	-	-	-	-	-	DJF
clear	22	-	-	-	-	-	-	-	-	MAM
sky	30	-	-	-	-	-	-	-	-	JJA
	34	-	-	-	-	-	-	-	-	SON

Table 4e

15°-30°N LAND-AREA-WEIGHTED AVERAGE CONTINGENCY PROBABILITIES (PERCENT)

Given cloud type	Frequency of Occurrence (f)	Fraction of reports contributing to statistics of type (%)	Probability that these are also present							
			Ci	As	Ns	Cu	St	Cb	NO	
	33	83	-	29	2	11	17	3	55	DJF
	36	85	-	32	1	13	16	8	50	MAM
Ci	41	82	-	41	4	16	22	16	33	JJA
	34	84	-	36	3	14	19	11	43	SON
	25	91	40	-	0	12	29	4	34	DJF
	27	92	46	-	0	14	24	10	31	MAM
As	39	92	45	-	0	16	28	15	29	JJA
	31	92	41	-	0	15	27	11	32	SON
	8	99	-	-	-	-	-	-	-	DJF
	8	95	-	-	-	-	-	-	-	MAM
Ns	9	95	-	5	-	3	68	15	3	JJA
	6	97	-	4	-	3	70	12	2	SON
	14	100	29	29	0	-	-	-	52	DJF
	15	100	36	32	0	-	-	-	46	MAM
Cu	18	100	48	42	1	-	-	-	32	JJA
	16	100	36	35	1	-	-	-	45	SON
	25	100	26	41	7	-	-	-	38	DJF
	22	100	33	44	6	-	-	-	36	MAM
St	34	100	43	53	10	-	-	-	25	JJA
	24	100	32	47	8	-	-	-	34	SON
	3	100	41	50	4	-	-	-	28	DJF
	9	100	53	52	3	-	-	-	23	MAM
Cb	18	100	61	59	4	-	-	-	14	JJA
	12	100	57	56	4	-	-	-	18	SON
	1	-	-	-	-	-	-	-	-	DJF
sky obscured	0	-	-	-	-	-	-	-	-	MAM
due to fog	0	-	-	-	-	-	-	-	-	JJA
	0	-	-	-	-	-	-	-	-	SON
	38	-	-	-	-	-	-	-	-	DJF
clear	36	-	-	-	-	-	-	-	-	MAM
sky	31	-	-	-	-	-	-	-	-	JJA
	36	-	-	-	-	-	-	-	-	SON

Table 4f

0°-15°N LAND-AREA-WEIGHTED AVERAGE CONTINGENCY PROBABILITIES (PERCENT)

Given cloud type	Frequency of Occurrence (f)	Fraction of reports contributing to statistics of type (%)	Probability that these are also present							
			Ci	As	Ns	Cu	St	Cb	NO	
	55	87	-	33	2	23	21	8	42	DJF
	63	83	-	44	2	26	22	18	26	MAM
Ci	60	75	-	57	3	26	28	23	12	JJA
	61	81	-	47	3	25	23	23	21	SON
	33	95	58	-	0	23	30	11	16	DJF
	45	95	62	-	0	23	29	21	12	MAM
As	60	92	59	-	0	23	35	23	10	JJA
	48	94	60	-	0	23	31	25	10	SON
	4	99	-	-	-	-	-	-	-	DJF
	4	98	-	3	-	7	62	22	1	MAM
Ns	5	98	-	2	-	6	65	18	2	JJA
	4	98	-	3	-	6	67	17	2	SON
	29	100	50	33	0	-	-	-	36	DJF
	28	100	60	39	0	-	-	-	25	MAM
Cu	27	100	58	51	1	-	-	-	22	JJA
	27	100	58	43	1	-	-	-	25	SON
	27	100	50	50	5	-	-	-	27	DJF
	26	100	61	59	5	-	-	-	17	MAM
St	32	100	56	67	8	-	-	-	13	JJA
	26	100	59	62	7	-	-	-	15	SON
	9	100	69	61	3	-	-	-	14	DJF
	17	100	72	60	2	-	-	-	11	MAM
Cb	21	100	70	67	3	-	-	-	9	JJA
	20	100	70	62	3		-	-	11	SON
	0	-	-	-	-	-	-	-	-	DJF
sky obscured	0	-	-	-	-	-	-	-	-	MAM
due to fog	0	-	-	-	-	-	-	-	-	JJA
	0	-	-	-	-	-	-	-	-	SON
	18	-	-	-	-	-	-	-	-	DJF
clear	9	-	-	-	-	-	-	-	-	MAM
sky	3	-	-	-	-	-	-	-	-	JJA
	8	-	-	-	-	-	-	-	-	SON

Table 4g

0°-15°S LAND-AREA-WEIGHTED AVERAGE CONTINGENCY PROBABILITIES (PERCENT)

Given cloud type	Frequency of occurrence (f)	Fraction of reports contributing to statistics of type (%)	Probability that these are also present							
			Ci	As	Ns	Cu	St	Cb	NO	
Ci	54	65	-	57	4	32	36	15	10	DJF
	49	70	-	52	4	34	33	15	12	MAM
	32	78	-	38	3	32	27	6	30	JJA
	43	73	-	47	3	34	29	13	18	SON
As	61	89	52	-	0	28	44	15	9	DJF
	54	90	49	-	0	29	42	15	11	MAM
	37	89	35	-	0	29	39	7	22	JJA
	46	89	45	-	0	29	39	14	14	SON
Ns	6	98	-	4	-	7	73	9	-	DJF
	4	98	-	4	-	7	73	10	-	MAM
	4	99	-	-	-	-	-	-	-	JJA
	4	98	-	-	-	-	-	-	-	SON
Cu	32	100	53	53	1	-	-	-	22	DJF
	34	100	48	46	1	-	-	-	28	MAM
	32	100	30	31	0	-	-	-	51	JJA
	34	100	42	39	0	-	-	-	37	SON
St	40	100	50	68	10	-	-	-	14	DJF
	36	100	46	64	9	-	-	-	17	MAM
	31	100	31	50	4	-	-	-	36	JJA
	32	100	42	58	6	-	-	-	24	SON
Cb	18	100	62	66	3	-	-	-	14	DJF
	15	100	58	62	3	-	-	-	17	MAM
	8	100	46	58	2	-	-	-	26	JJA
	13	100	54	61	2	-	-	-	20	SON
sky obscured due to fog	0	-	-	-	-	-	-	-	-	DJF
	0	-	-	-	-	-	-	-	-	MAM
	1	-	-	-	-	-	-	-	-	JJA
	0	-	-	-	-	-	-	-	-	SON
clear sky	4	-	-	-	-	-	-	-	-	DJF
	6	-	-	-	-	-	-	-	-	MAM
	23	-	-	-	-	-	-	-	-	JJA
	11	-	-	-	-	-	-	-	-	SON

Table 4h

15°-30°S LAND-AREA-WEIGHTED AVERAGE CONTINGENCY PROBABILITIES (PERCENT)

Given cloud type	Frequency of occurrence (f)	Fraction of reports contributing to statistics of type (%)	Probability that these are also present							
			Ci	As	Ns	Cu	St	Cb	NO	
Ci	43	74	-	46	4	26	25	14	23	DJF
	31	78	-	40	4	22	21	9	35	MAM
	19	77	-	28	2	11	16	2	58	JJA
	28	76	-	38	3	20	19	8	39	SON
As	42	88	46	-	0	20	33	15	24	DJF
	33	88	38	-	0	18	32	9	32	MAM
	23	87	23	-	0	12	31	3	49	JJA
	30	88	35	-	0	17	30	9	36	SON
Ns	5	98	-	4	-	4	73	8	-	DJF
	4	99	-	4	-	4	75	5	-	MAM
	3	99	-	-	-	-	-	-	-	JJA
	4	98	-	4	-	3	72	5	-	SON
Cu	25	100	43	33	1	-	-	-	41	DJF
	22	100	31	28	0	-	-	-	52	MAM
	12	100	17	23	0	-	-	-	65	JJA
	20	100	29	27	0	-	-	-	54	SON
St	31	100	38	49	12	-	-	-	28	DJF
	26	100	28	43	9	-	-	-	37	MAM
	22	100	16	36	7	-	-	-	49	JJA
	24	100	25	42	7	-	-	-	40	SON
Cb	13	100	55	58	3	-	-	-	21	DJF
	7	100	49	58	3	-	-	-	23	MAM
	3	100	-	-	-	-	-	-	-	JJA
	6	100	49	60	3	-		-	22	SON
sky obscured due to fog	0	-	-	-	-	-	-	-	-	DJF
	0	-	-	-	-	-	-	-	-	MAM
	0	-	-	-	-	-	-	-	-	JJA
	0	-	-	-	-	-	-	-	-	SON
clear sky	16	-	-	-	-	-	-	-	-	DJF
	26	-	-	-	-	-	-	-	-	MAM
	46	-	-	-	-	-	-	-	-	JJA
	32	-	-	-	-	-	-	-	-	SON

Table 4i

30 °-45 °S LAND-AREA-WEIGHTED AVERAGE CONTINGENCY PROBABILITIES (PERCENT)

Given cloud type	Frequency of occurrence (f)	Fraction of reports contributing to statistics of type (%)	Probability that these are also present							
			Ci	As	Ns	Cu	St	Cb	NO	
	34	76	-	38	5	16	25	7	37	DJF
	36	72	-	40	5	12	26	3	40	MAM
Ci	36	67	-	40	6	9	27	3	43	JJA
	37	73	-	39	4	14	25	4	40	SON
	30	86	45	-	0	15	33	9	29	DJF
	32	84	47	-	0	11	37	6	30	MAM
As	33	81	45	-	0	9	38	4	34	JJA
	32	84	48	-	0	13	36	7	29	SON
	4	98	-	3	-	3	68	6	3	DJF
	5	98	-	3	-	2	68	3	3	MAM
Ns	7	98	-	2	-	2	67	2	3	JJA
	5	98	-	3	-	3	68	4	3	SON
	17	100	33	26	1	-	-	-	52	DJF
	13	100	33	27	1	-	-	-	53	MAM
Cu	10	100	29	27	1	-	-	-	55	JJA
	15	100	34	26	1	-	-	-	53	SON
	31	100	29	34	9	-	-	-	44	DJF
	34	100	29	36	10	-	-	-	42	MAM
St	38	100	27	35	13	-	-	-	41	JJA
	33	100	29	35	11	-	-	-	42	SON
	7	100	42	51	3	-	-	-	31	DJF
	4	100	40	54	4	-	-	-	31	MAM
Cb	4	100	36	51	5	-	-	-	31	JJA
	4	100	42	52	4	-	-	-	31	SON
	0	-	-	-	-	-	-	-	-	DJF
sky obscured	1	-	-	-	-	-	-	-	-	MAM
due to fog	1	-	-	-	-	-	-	-	-	JJA
	0	-	-	-	-	-	-	-	-	SON
	25	-	-	-	-	-	-	-	-	DJF
clear	24	-	-	-	-	-	-	-	-	MAM
sky	23	-	-	-	-	-	-	-	-	JJA
	23	-	-	-	-	-	-	-	-	SON

Table 4j

45 °-60 °S LAND-AREA-WEIGHTED AVERAGE CONTINGENCY PROBABILITIES (PERCENT)

Given cloud type	Frequency of occurrence (f)	Fraction of reports contributing to statistics of type (%)	Probability that these are also present							
			Ci	As	Ns	Cu	St	Cb	NO	
	48	69	-	52	-	17	41	4	18	DJF
	43	64	-	52	-	9	40	3	23	MAM
Ci	38	61	-	56	-	7	37	3	22	JJA
	44	67	-	56	-	14	40	4	18	SON
	46	81	58	-	0	15	50	5	14	DJF
	45	79	53	-	0	8	51	4	21	MAM
As	47	79	49	-	0	7	49	3	24	JJA
	47	80	56	-	0	12	50	4	17	SON
	9	96	-	4	-	2	66	4	2	DJF
	12	96	-	4	-	1	64	2	3	MAM
Ns	13	96	-	2	-	1	57	2	3	JJA
	10	96	-	3	-	1	60	4	4	SON
	18	100	47	36	1	-	-	-	38	DJF
	10	100	38	32	1	-	-	-	46	MAM
Cu	8	100	32	34	1	-	-	-	49	JJA
	15	100	41	34	1	-	-	-	44	SON
	50	100	43	47	14	-	-	-	27	DJF
	49	100	38	48	18	-	-	-	26	MAM
St	48	100	31	48	20	-	-	-	27	JJA
	48	100	39	49	15	-	-	-	27	SON
	6	100	32	33	5	-	-	-	47	DJF
	6	100	23	26	4	-	-	-	59	MAM
Cb	7	100	21	25	3	-	-	-	62	JJA
	6	100	30	31	6	-	-	-	51	SON
	0	-	-	-	-	-	-	-	-	DJF
sky obscured	0	-	-	-	-	-	-	-	-	MAM
due to fog	1	-	-	-	-	-	-	-	-	JJA
	0	-	-	-	-	-	-	-	-	SON
	6	-	-	-	-	-	-	-	-	DJF
clear	11	-	-	-	-	-	-	-	-	MAM
sky	12	-	-	-	-	-	-	-	-	JJA
	9	-	-	-	-	-	-	-	-	SON

Table 4k

60 °-75 °S LAND-AREA-WEIGHTED AVERAGE CONTINGENCY PROBABILITIES (PERCENT)

Given cloud type	Frequency of occurrence (f)	Fraction of reports contributing to statistics of type (%)	Probability that these are also present							
			Ci	As	Ns	Cu	St	Cb	NO	
	56	57	-	51	-	3	36	0	35	DJF
	50	52	-	52	-	1	31	1	38	MAM
Ci	51	53	-	47	-	1	22	1	45	JJA
	59	57	-	48	-	1	24	0	44	SON
	56	84	52	-	0	3	42	1	33	DJF
	54	84	50	-	0	1	40	1	39	MAM
As	48	87	51	-	0	1	27	1	40	JJA
	50	88	57	-	0	1	31	1	32	SON
	17	100	-	-	-	-	-	-	-	DJF
	20	99	-	-	-	-	-	-	-	MAM
Ns	20	100	-	-	-	-	-	-	-	JJA
	16	100	-	-	-	-	-	-	-	SON
	5	100	-	-	-	-	-	-	-	DJF
	3	100	-	-	-	-	-	-	-	MAM
Cu	2	100	-	-	-	-	-	-	-	JJA
	3	100	-	-	-	-	-	-	-	SON
	47	100	49	57	15	-	-	-	20	DJF
	35	100	-	52	14	-	-	-	25	MAM
St	33	100	-	-	16	-	-	-	-	JJA
	39	100	-	53	15	-	-	-	23	SON
	1	100	-	-	-	-	-	-	-	DJF
	0	-	-	-	-	-	-	-	-	MAM
Cb	0	-	-	-	-	-	-	-	-	JJA
	0	-	-	-	-	-	-	-	-	SON
	1	-	-	-	-	-	-	-	-	DJF
sky obscured	0	-	-	-	-	-	-	-	-	MAM
due to fog	0	-	-	-	-	-	-	-	-	JJA
	0	-	-	-	-	-	-	-	-	SON
	8	-	-	-	-	-	-	-	-	DJF
clear	12	-	-	-	-	-	-	-	-	MAM
sky	18	-	-	-	-	-	-	-	-	JJA
	14	-	-	-	-	-	-	-	-	SON

Table 4l

75 °-90 °S LAND-AREA-WEIGHTED AVERAGE CONTINGENCY PROBABILITIES (PERCENT)

Given cloud type	Frequency of occurrence (f)	Fraction of reports contributing to statistics of type (%)	Probability that these are also present							
			Ci	As	Ns	Cu	St	Cb	NO	
	57	71	-	26	-	1	14	1	58	DJF
	52	76	-	17	-	1	11	0	76	MAM
Ci	39	79	-	11	-	1	-	-	84	JJA
	68	82	-	21	-	1	10	0	73	SON
	35	93	43	-	1	2	21	1	46	DJF
	41	74	-	-	-	-	-	-	-	MAM
As	33	78	-	-	-	-	-	-	-	JJA
	23	95	59	-	0	1	17	0	34	SON
	16	100	-	2	-	0	17	1	-	DJF
	18	100	-	-	-	-	-	-	-	MAM
Ns	15	100	-	-	-	-	-	-	-	JJA
	14	100	-	-	-	-	-	-	-	SON
	5	100	-	-	-	-	-	-	-	DJF
	0	-	-	-	-	-	-	-	-	MAM
Cu	0	-	-	-	-	-	-	-	-	JJA
	0	-	-	-	-	-	-	-	-	SON
	48	100	-	-	20	-	-	-	21	DJF
	30	100	-	-	-	-	-	-	-	MAM
St	22	100	-	-	-	-	-	-	-	JJA
	37	100	-	-	17	-	-	-	-	SON
	0	-	-	-	-	-	-	-	-	DJF
	0	-	-	-	-	-	-	-	-	MAM
Cb	0	-	-	-	-	-	-	-	-	JJA
	0	-	-	-	-	-	-	-	-	SON
	1	-	-	-	-	-	-	-	-	DJF
sky obscured	1	-	-	-	-	-	-	-	-	MAM
due to fog	2	-	-	-	-	-	-	-	-	JJA
	1	-	-	-	-	-	-	-	-	SON
	17	-	-	-	-	-	-	-	-	DJF
clear	31	-	-	-	-	-	-	-	-	MAM
sky	43	-	-	-	-	-	-	-	-	JJA
	19	-	-	-	-	-	-	-	-	SON

Table 5

GLOBAL LAND/OCEAN AVERAGE CONTINGENCY PROBABILITIES (PERCENT)

Given cloud type	Frequency of occurrence (f)	Fraction of reports contributing to statistics of type(%)	Ci	As	Ns	Cu	St	Cb	NO	
	46/30	70/63	-	36/64	7/8	12/34	22/36	6/13	45/9	DJF
	47/32	74/66	-	37/63	5/6	16/35	21/34	9/14	41/10	MAM
Ci	41/31	76/65	-	41/65	4/6	19/33	23/35	12/15	33/9	JJA
	42/31	71/64	-	39/65	6/6	15/34	23/36	9/14	38/9	SON
	35/43	86/73	50/45	-	0/1	12/29	32/48	7/13	28/8	DJF
	35/42	88/75	52/47	-	0/1	14/30	31/45	11/14	25/8	MAM
As	39/44	88/74	45/45	-	0/1	17/29	32/47	13/15	26/7	JJA
	36/44	85/74	47/45	-	0/1	14/30	34/47	11/15	27/7	SON
	11/8	98/95	57/38	2/10	-	2/2	53/61	4/4	8/4*	DJF
	8/7	97/95	60/41	3/11	-	2/3	59/61	6/5	4/3	MAM
Ns	7/6	96/96	55/42	3/13	-	3/2	65/63	9/5	2/4	JJA
	10/6	97/96	60/41	3/12	-	2/2	62/64	6/5	4/4	SON
	16/36	100	45/28	34/37	1/1	-	-	-	38/50	DJF
	17/37	100	46/29	31/35	1/0	-	-	-	39/51	MAM
Cu	20/36	100	42/30	34/37	1/0	-	-	-	41/50	JJA
	16/37	100	42/29	34/37	1/0	-	-	-	41/51	SON
	30/43	100	38/29	43/52	17/12	-	-	-	26/30*	DJF
	28/40	100	40/30	45/52	13/12	-	-	-	27/31	MAM
St	30/42	100	37/29	46/53	11/11	-	-	-	31/31	JJA
	31/43	100	35/29	45/53	13/11	-	-	-	30/31	SON
	8/11	100	49/35	50/54	5/2	-	-	-	26/34	DJF
	10/12	100	53/37	49/54	3/2	-	-	-	24/33	MAM
Cb	14/12	100	52/37	53/56	3/2	-	-	-	23/32	JJA
	10/12	100	49/37	52/57	3/2	-	-	-	26/32	SON
	1/1	-	-	-	-	-	-	-	-	DJF
sky obscured	0/1	-	-	-	-	-	-	-	-	MAM
due to fog	1/2	-	-	-	-	-	-	-	-	JJA
	1/1	-	-	-	-	-	-	-	-	SON
	23/5	-	-	-	-	-	-	-	-	DJF
clear	21/6	-	-	-	-	-	-	-	-	MAM
sky	22/5	-	-	-	-	-	-	-	-	JJA
	22/5	-	-	-	-	-	-	-	-	SON

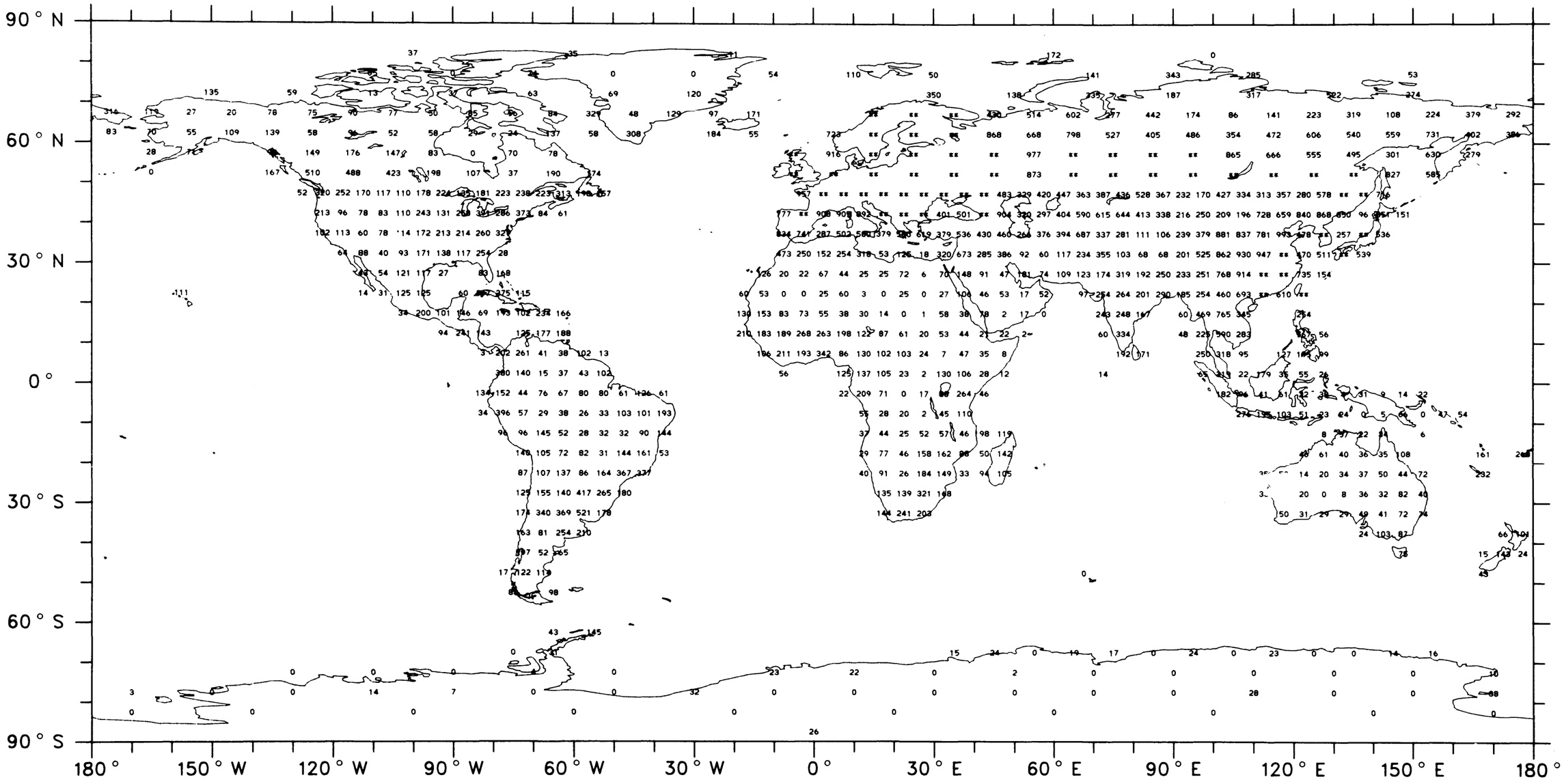
*For the computation of P(Ns $\Longrightarrow$ NO) and P(St $\Longrightarrow$ NO), the class of reports which were considered to contain a reliable indication of 'no other' was expanded for this atlas. Revised probabilities for the ocean are given here; they are lower than those given in the ocean atlas.

Map 1-1

Number of Synoptic Cloud Reports from Land Stations (in Hundreds)

December, January, February (1971-1980)

Land Areas Only

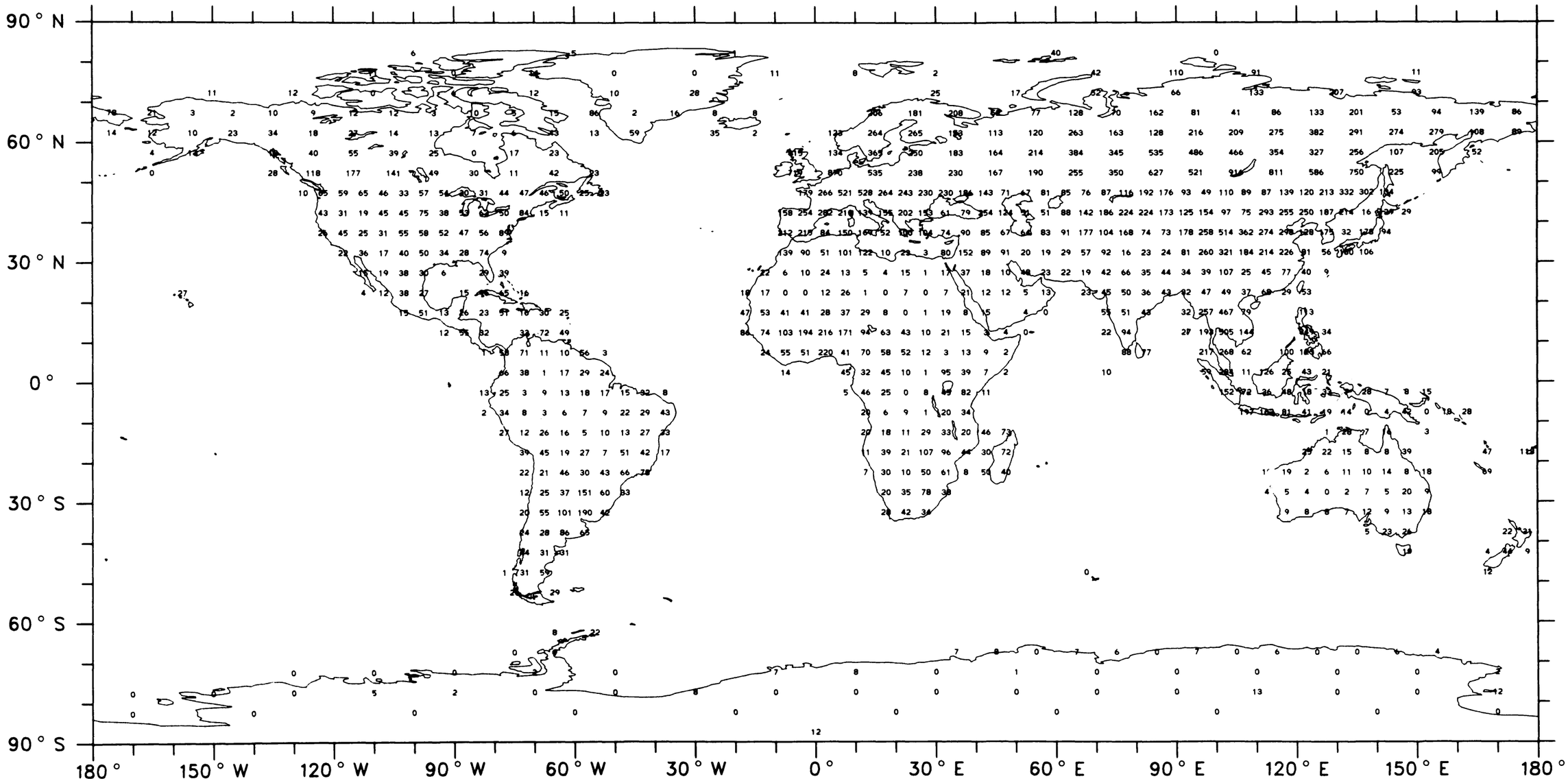


Map 1-2

Number of Observations of Cirrus, Cirrostratus, or Cirrocumulus (in Hundreds)

December, January, February (1971-1980)

Land Areas Only

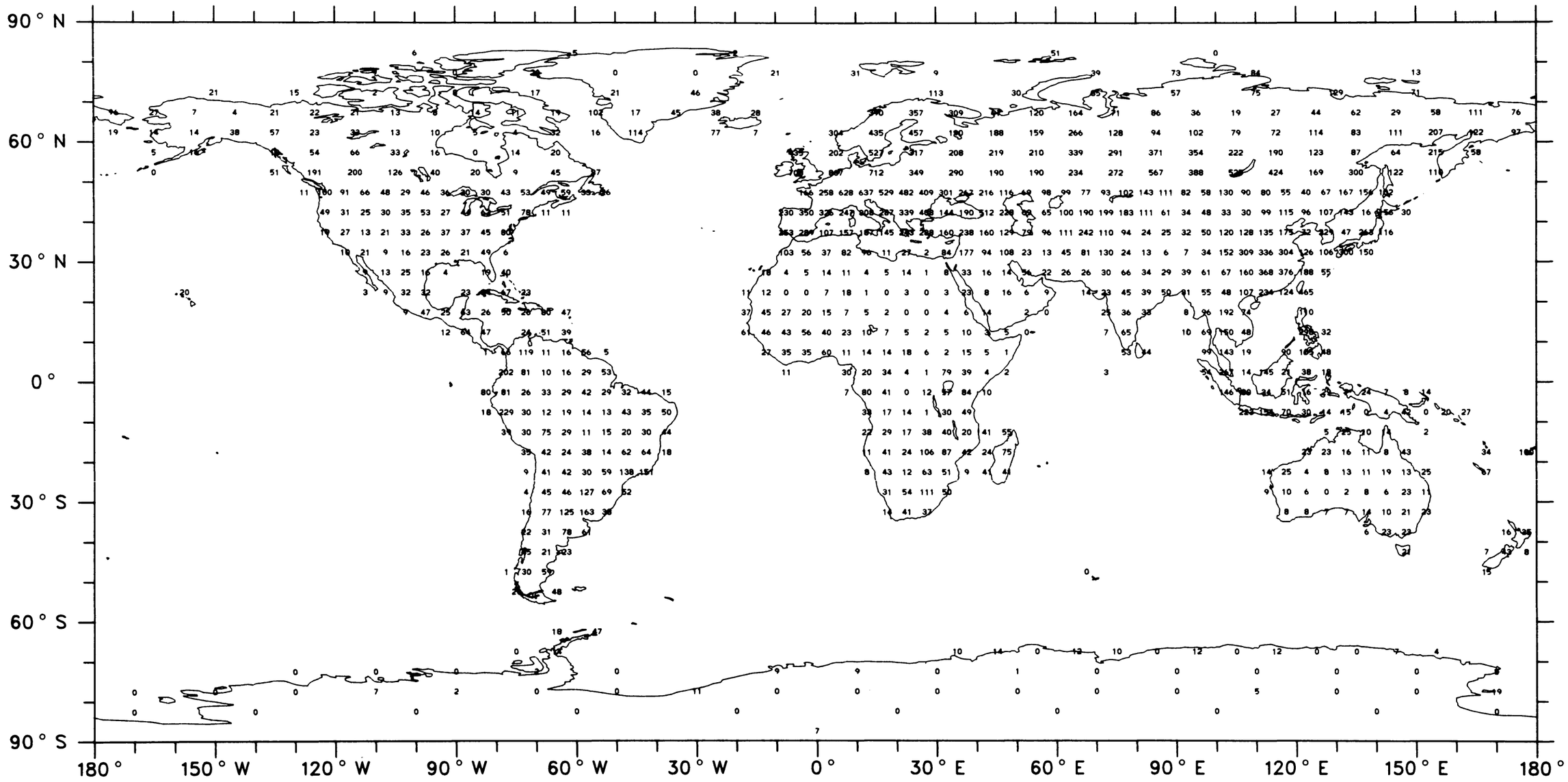


Map 1-3

Number of Observations of Altostratus or Altocumulus (in Hundreds)

December, January, February (1971-1980)

Land Areas Only

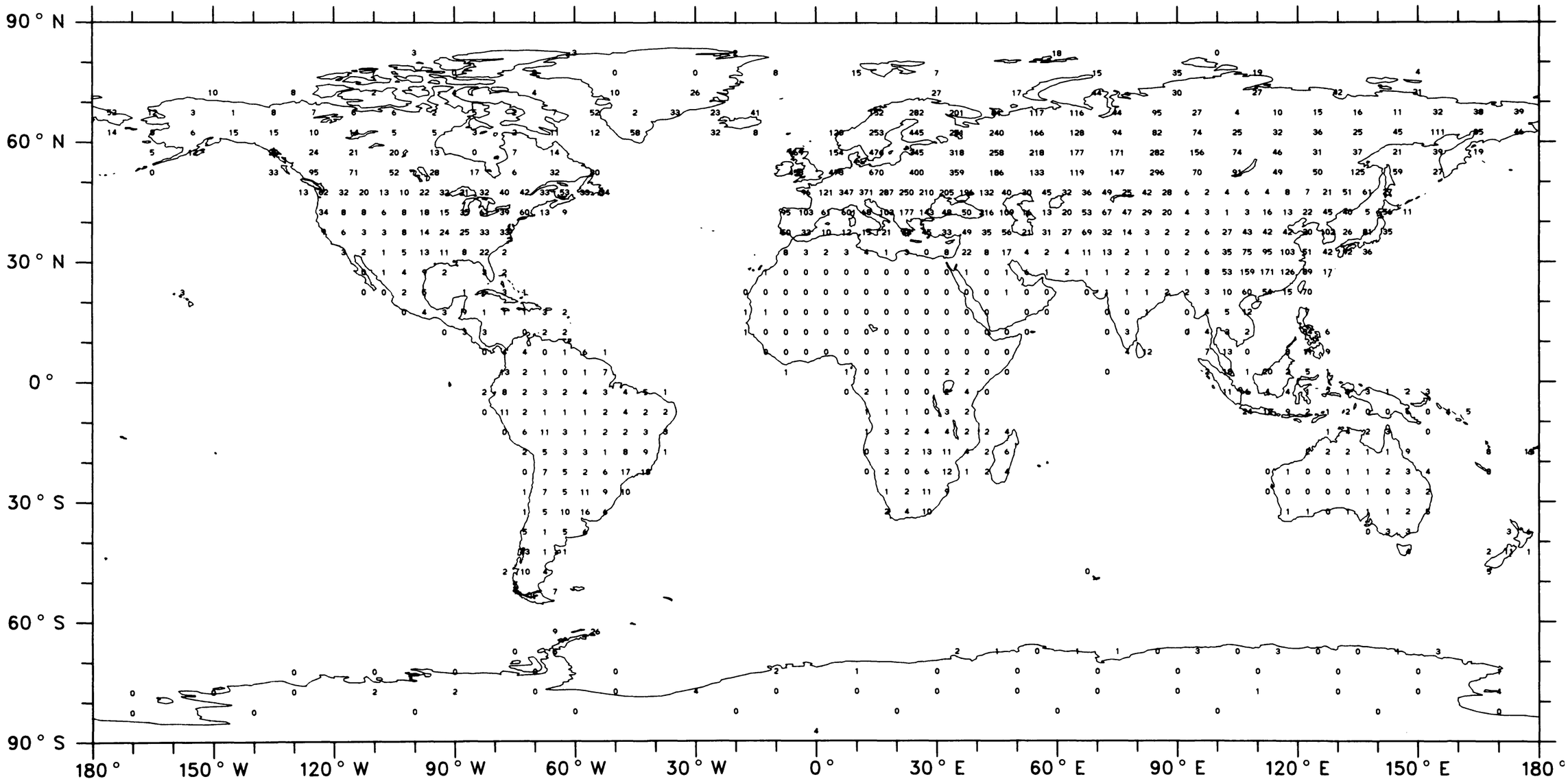


Map 1-4

Number of Observations of Nimbostratus (in Hundreds)

December, January, February (1971-1980)

Land Areas Only

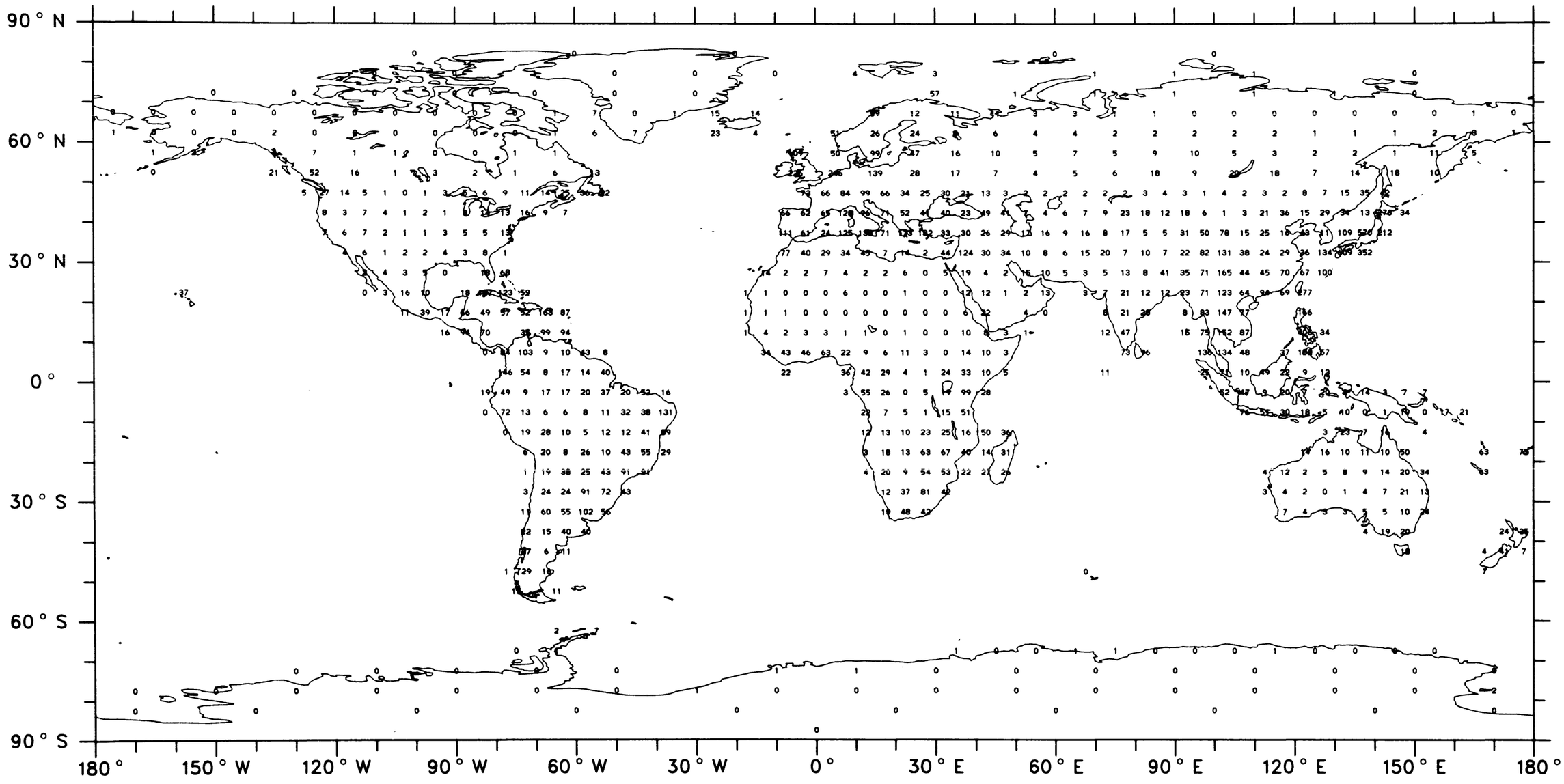


Map I-5

Number of Observations of Cumulus (in Hundreds)

December, January, February (1971-1980)

Land Areas Only

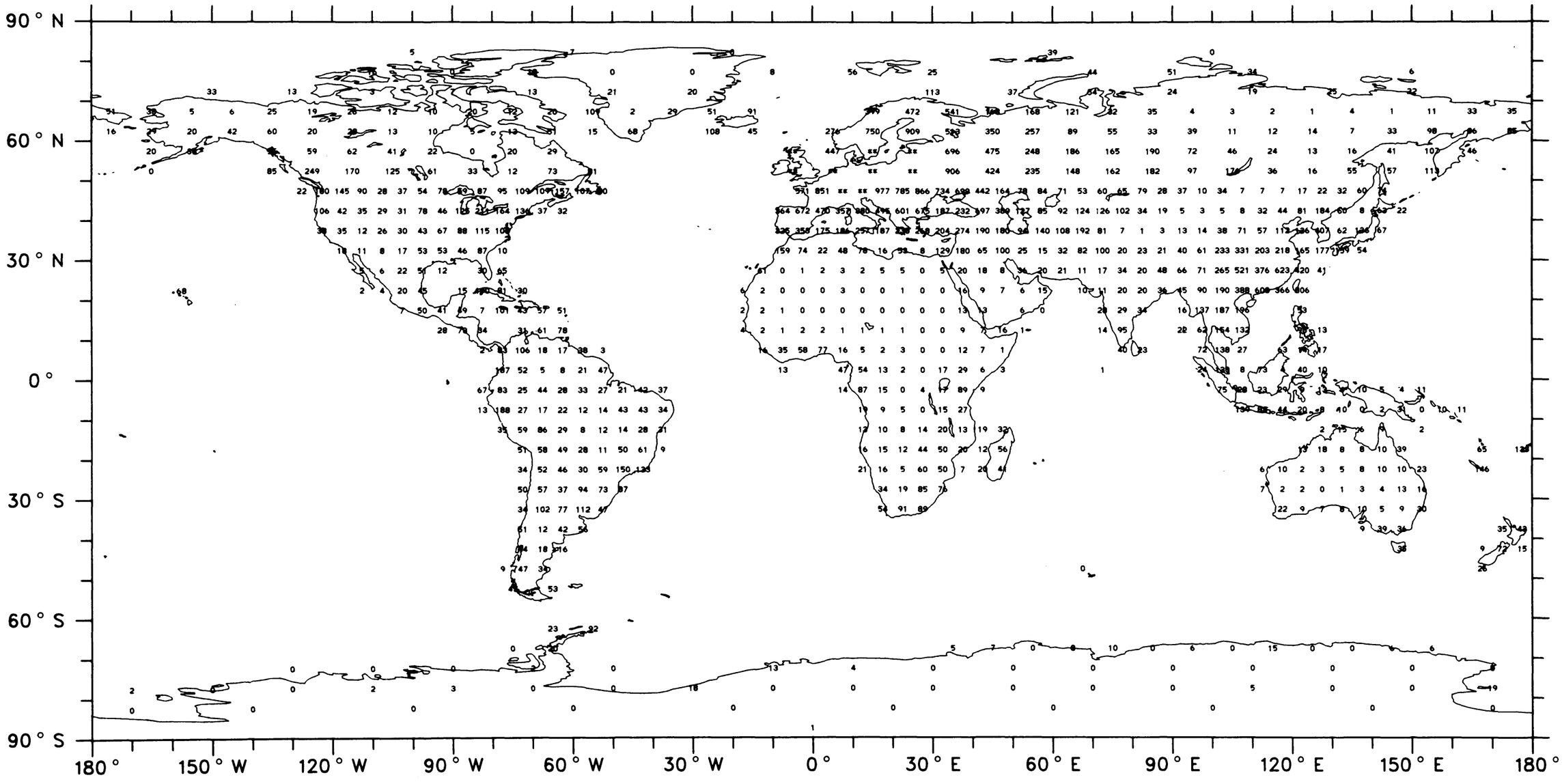


Map 1-6

Number of Observations of Stratus or Stratocumulus (in Hundreds)

December, January, February (1971-1980)

Land Areas Only

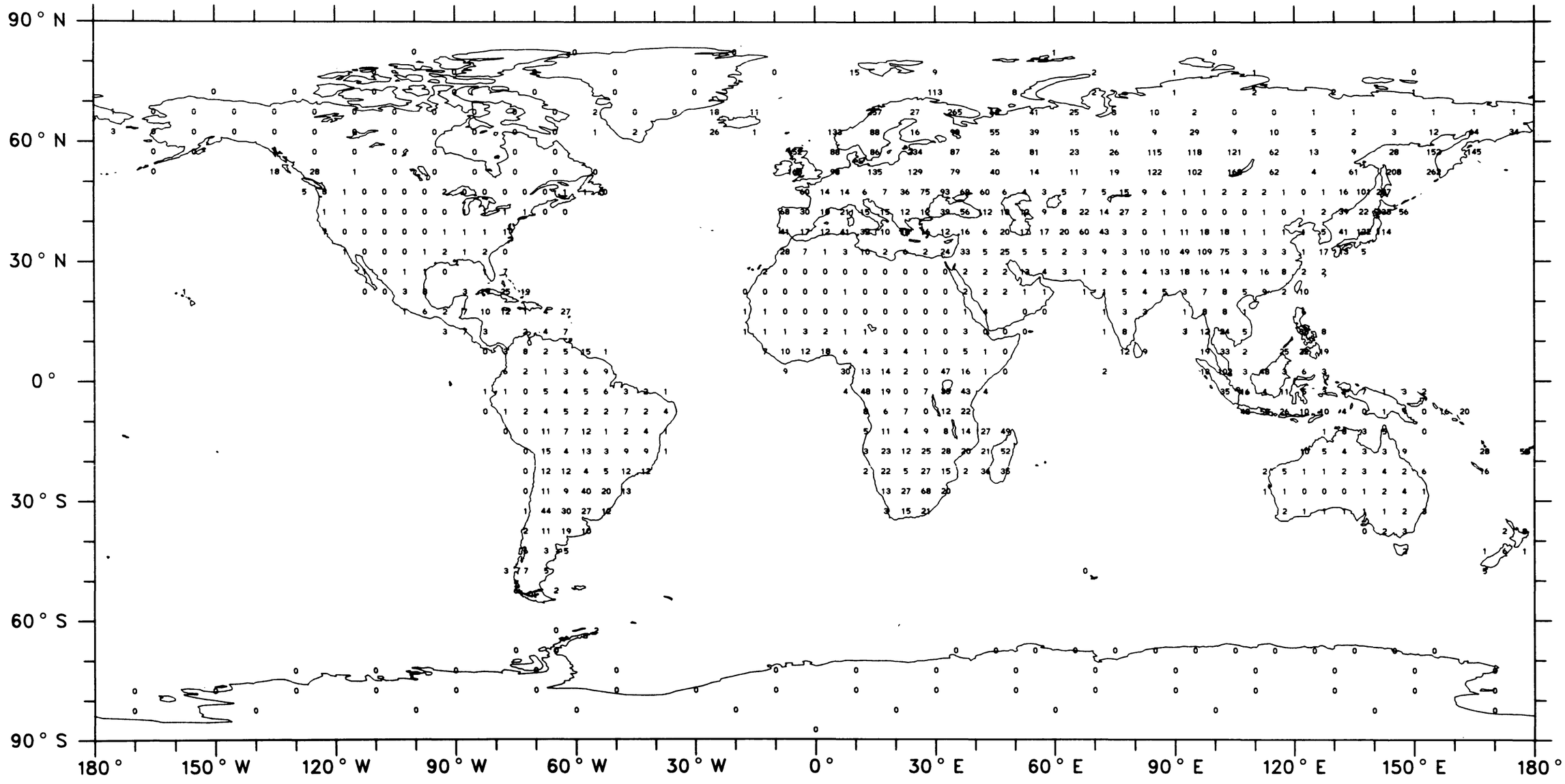


Map 1-7

Number of Observations of Cumulonimbus (in Hundreds)

December, January, February (1971-1980)

Land Areas Only

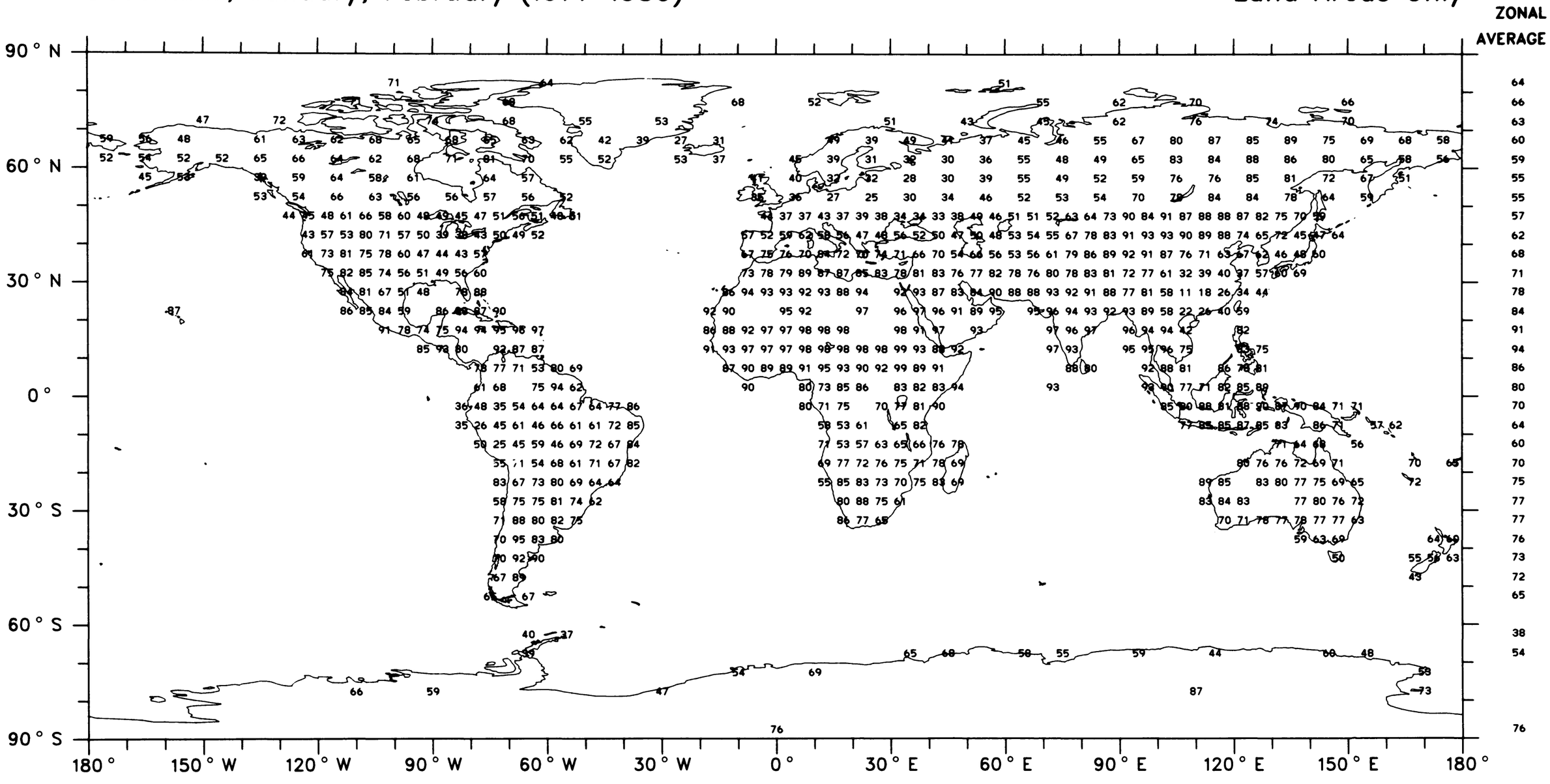


Map 1-8

Percent of Land Station Reports Contributing to Statistics of the High Cloud Level

December, January, February (1971-1980)

Land Areas Only

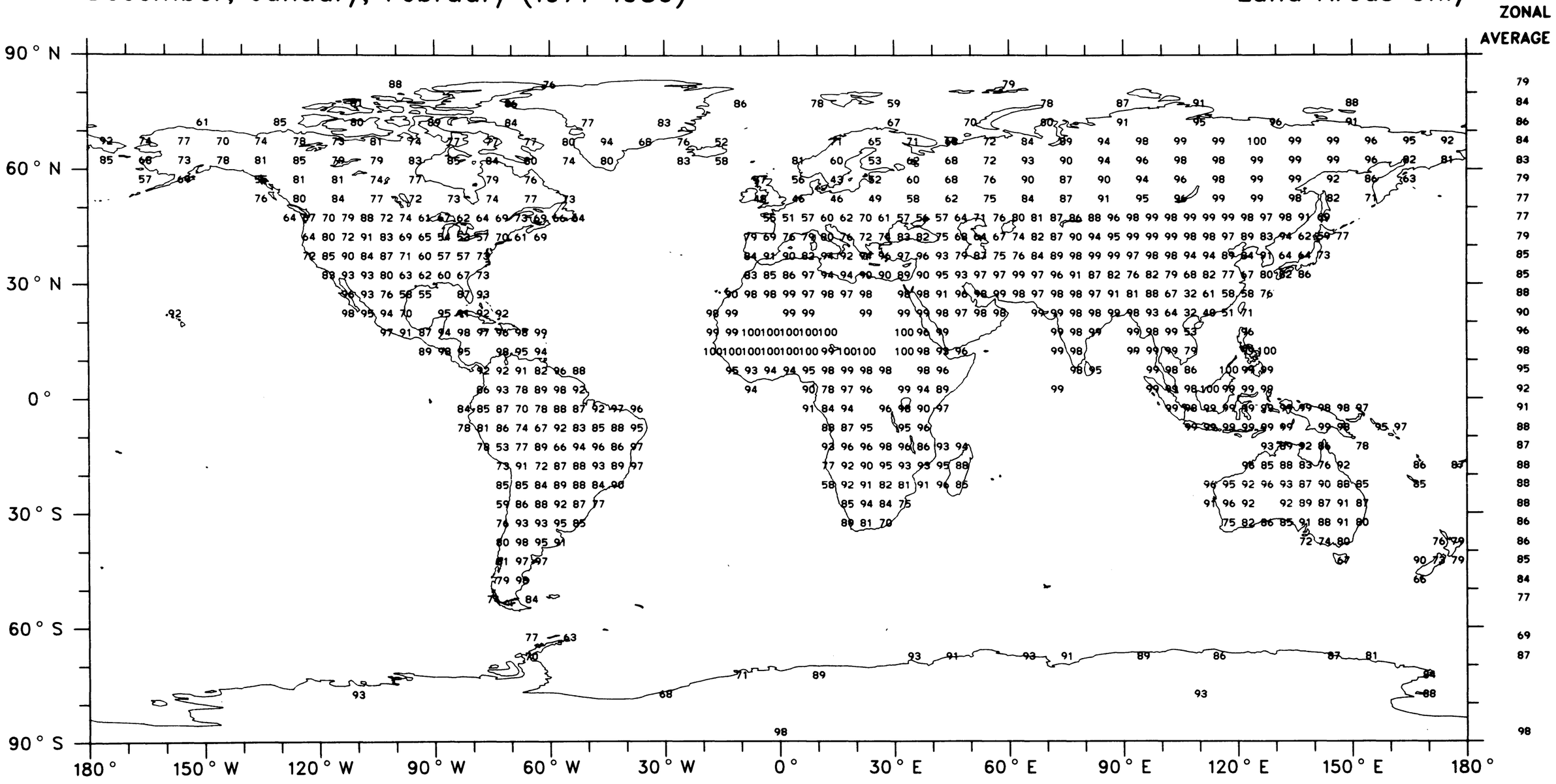


Map 1-9

Percent of Land Station Reports Contributing to Statistics of the Middle Cloud Level

December, January, February (1971-1980)

Land Areas Only

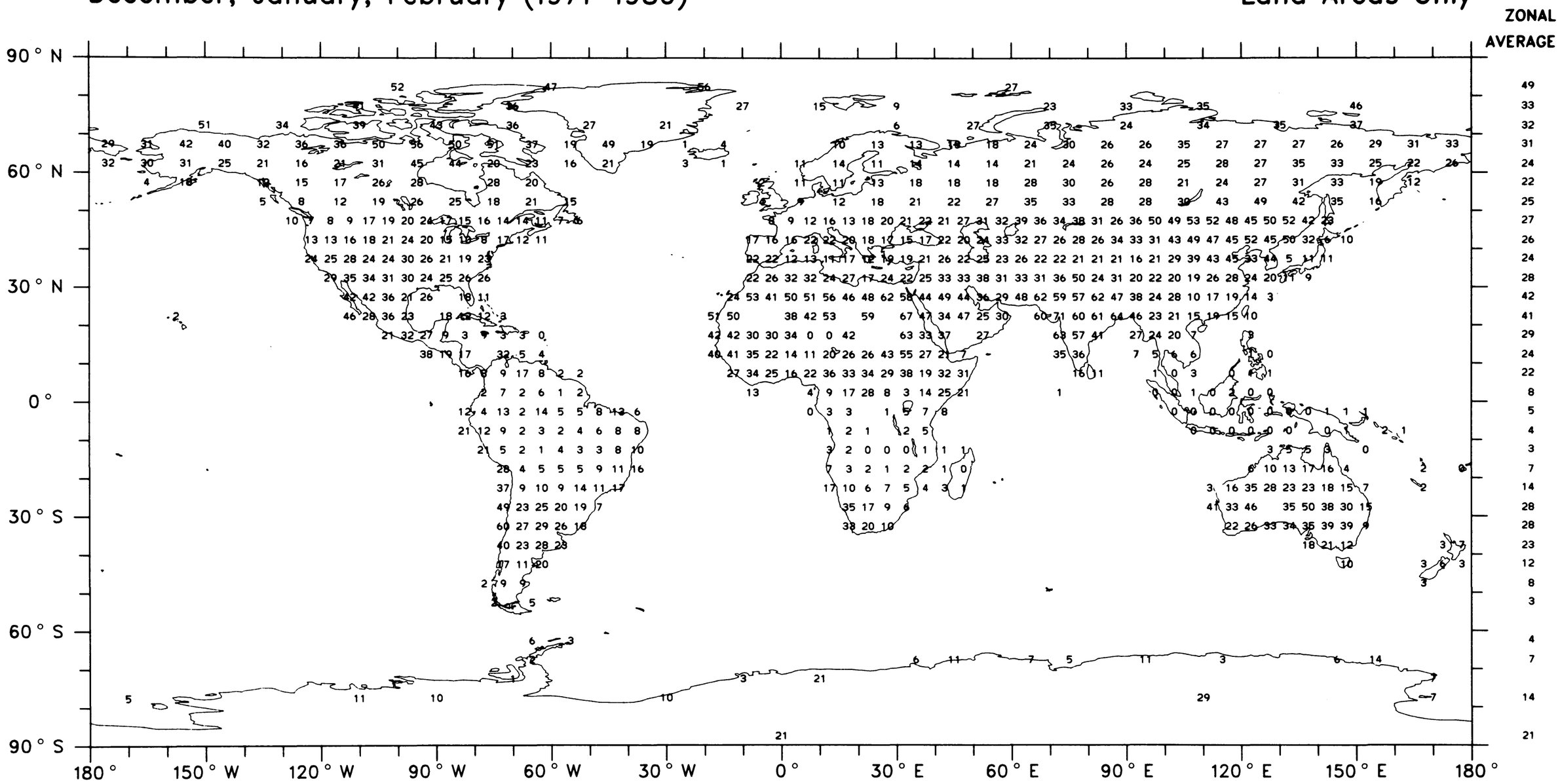


Map 1-10

Frequency of Occurrence (Percent) of Completely Clear Sky

December, January, February (1971-1980)

Land Areas Only

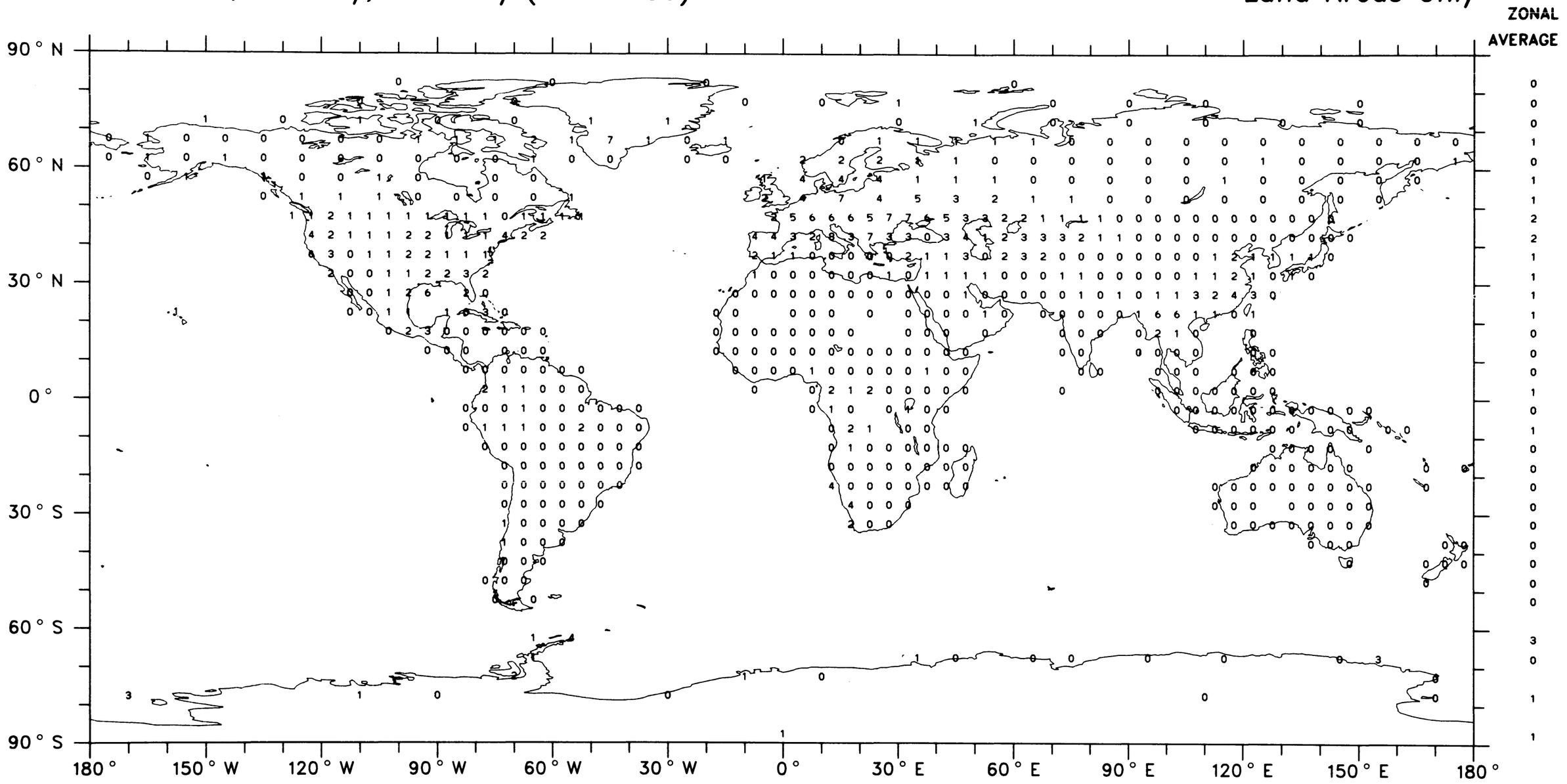


Map 1-11

Frequency of Occurrence (Percent) of Sky Obscured due to Fog

December, January, February (1971-1980)

Land Areas Only

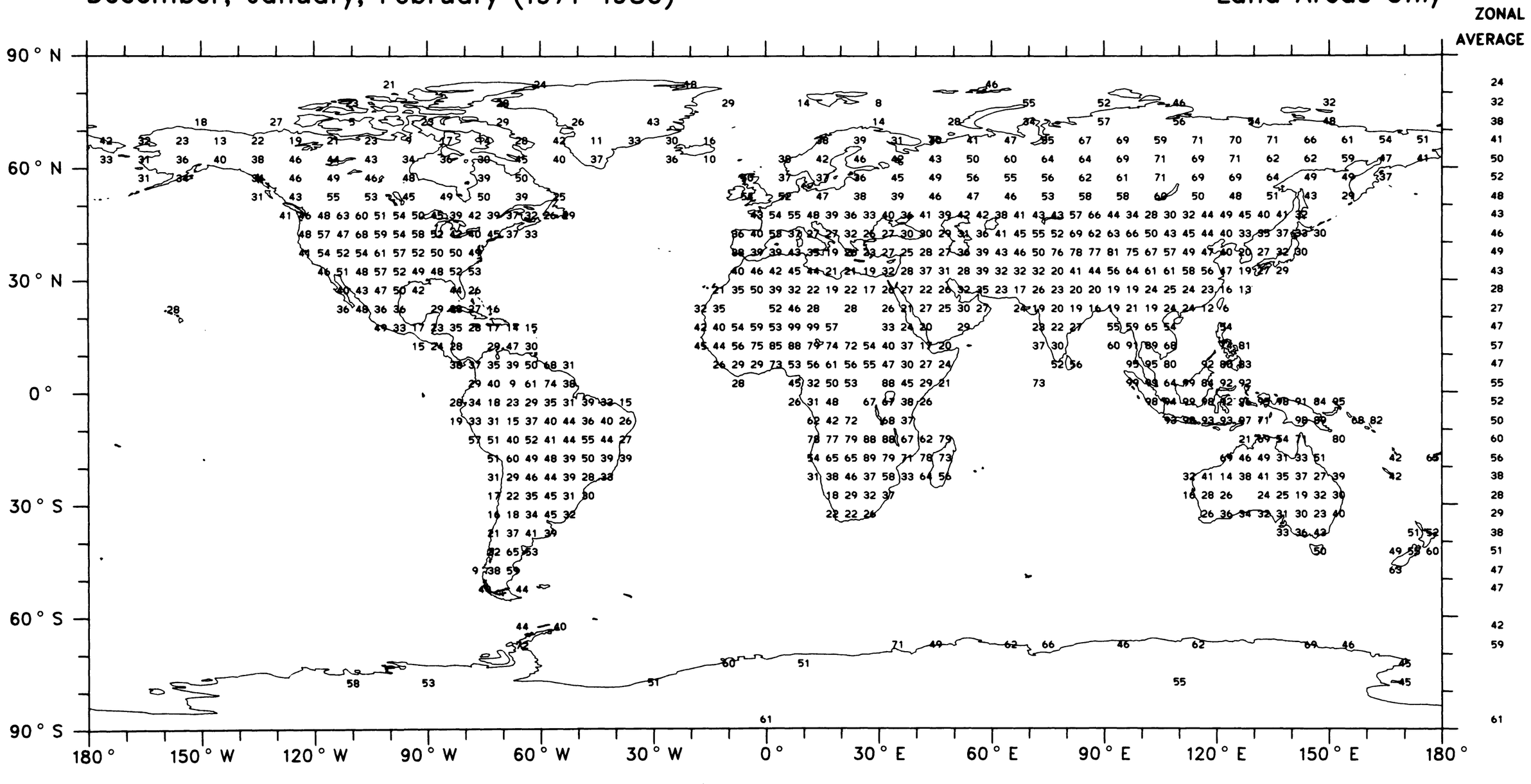


Map 1-12

Frequency of Occurrence (Percent) of Ci/Cs/Cc

December, January, February (1971-1980)

Land Areas Only

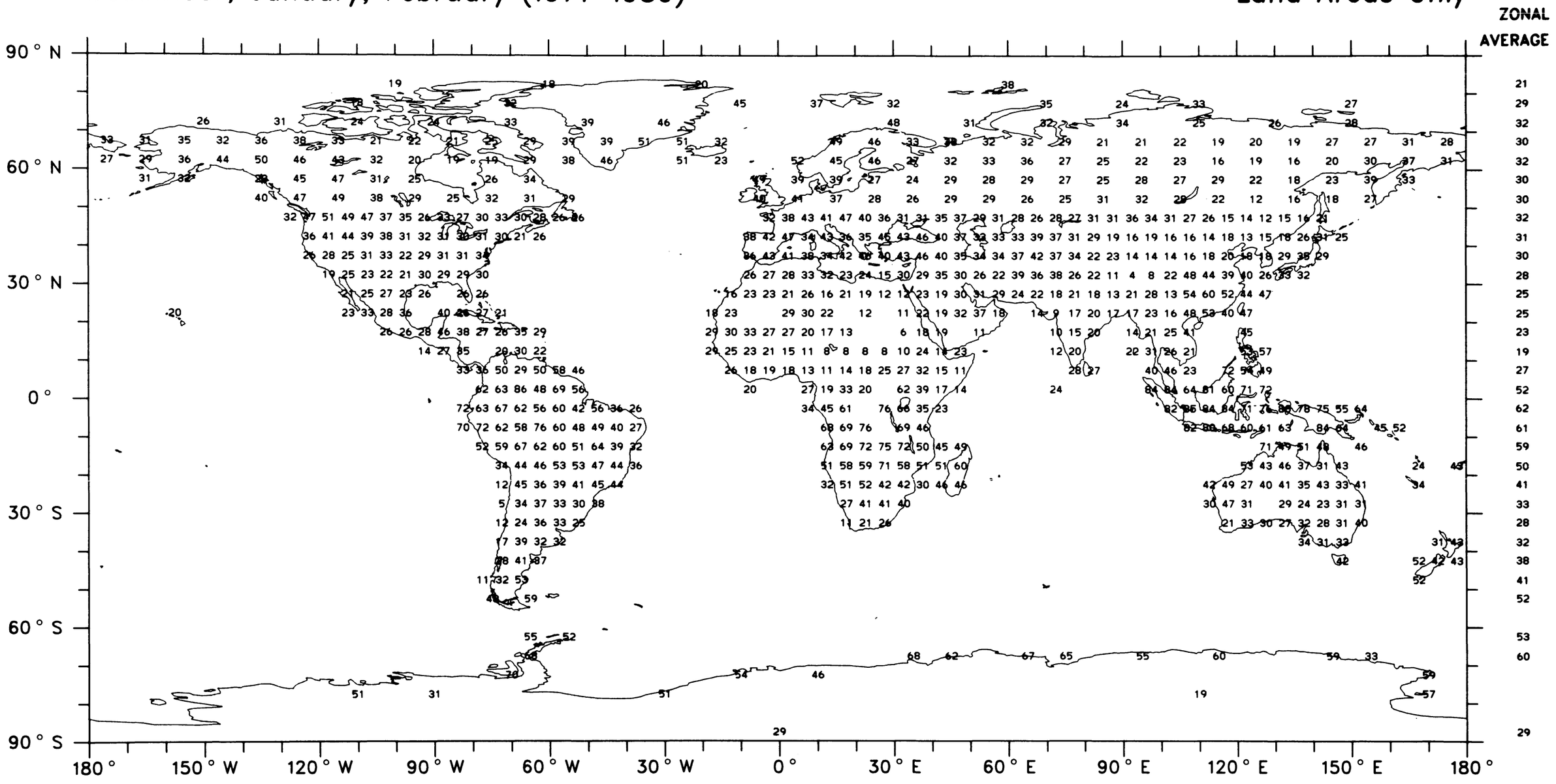


Map 1-13

Frequency of Occurrence (Percent) of As/Ac

December, January, February (1971-1980)

Land Areas Only

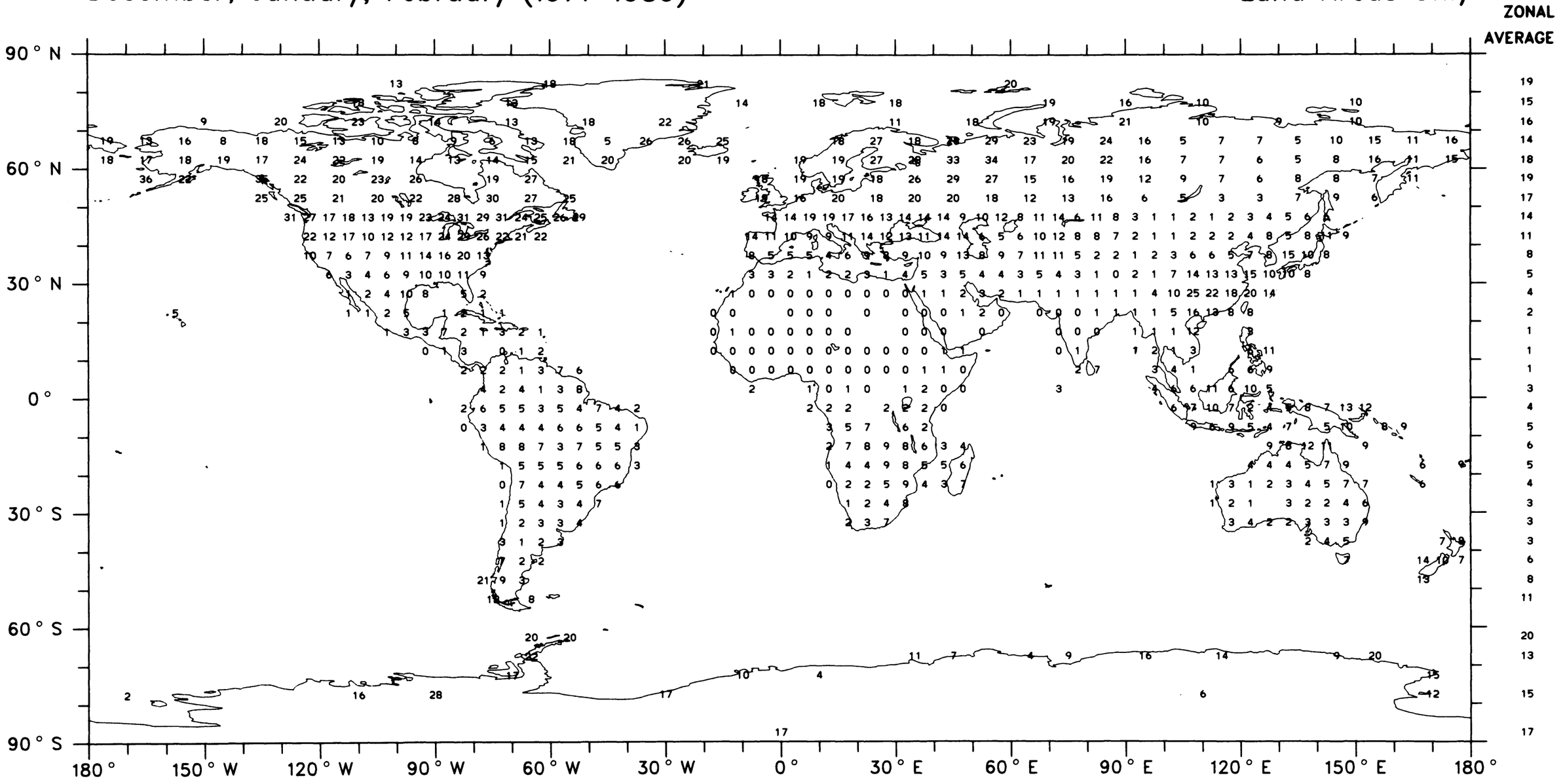


Map 1-14

Frequency of Occurrence (Percent) of Nimbostratus

December, January, February (1971-1980)

Land Areas Only

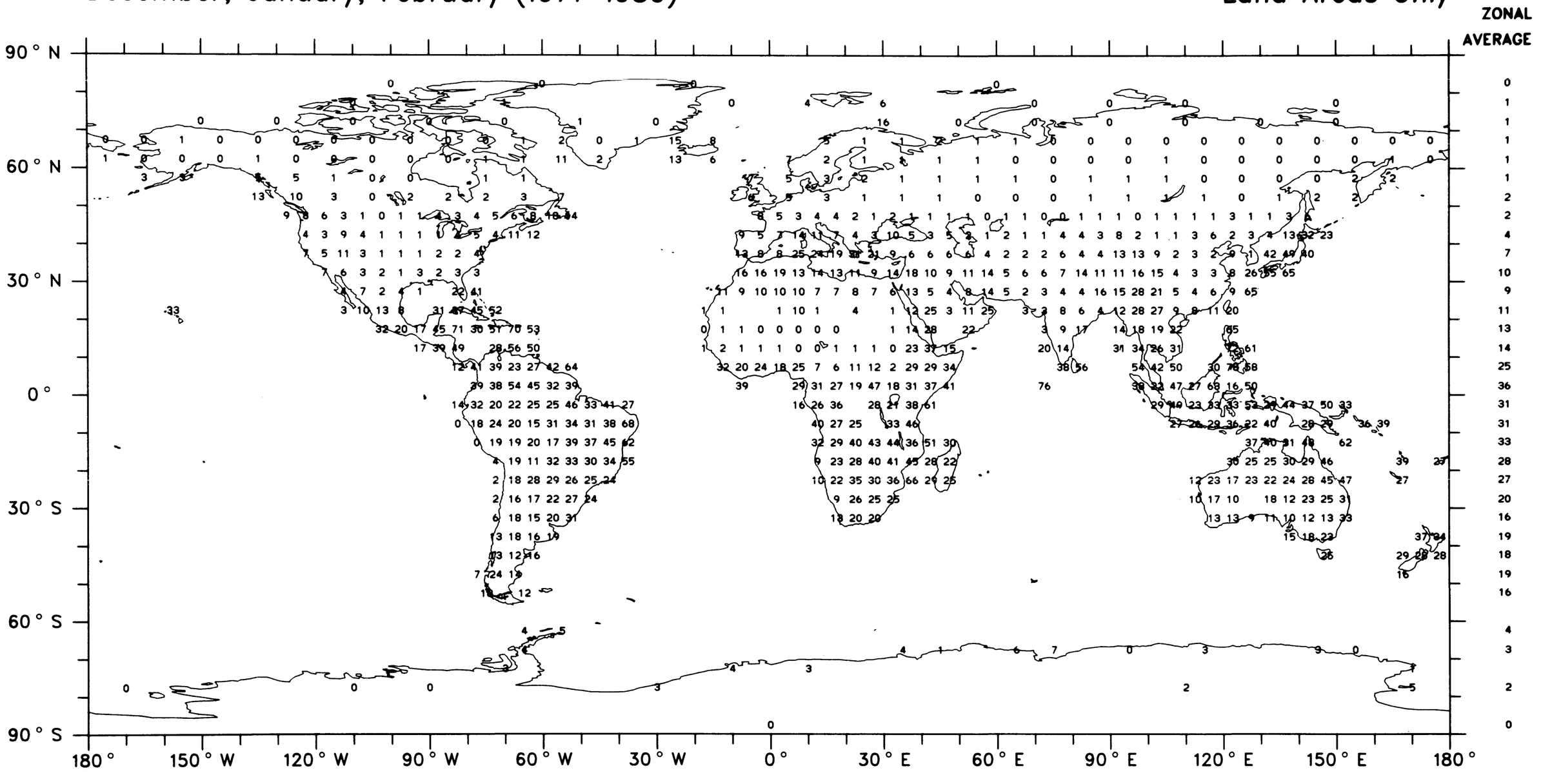


Map I-15

Frequency of Occurrence (Percent) of Cumulus

December, January, February (1971-1980)

Land Areas Only

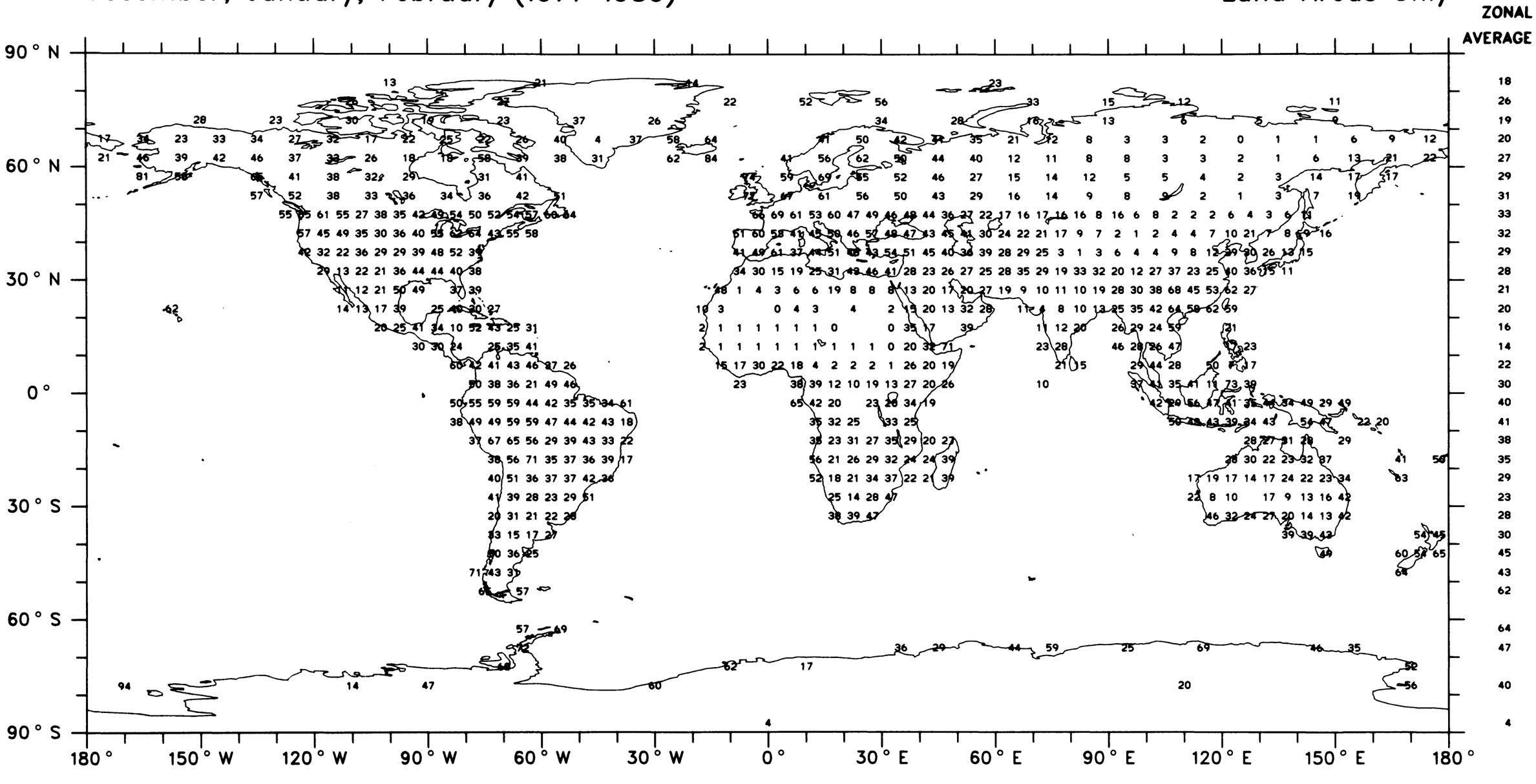


Map 1-16

Frequency of Occurrence (Percent) of St/Sc

December, January, February (1971-1980)

Land Areas Only

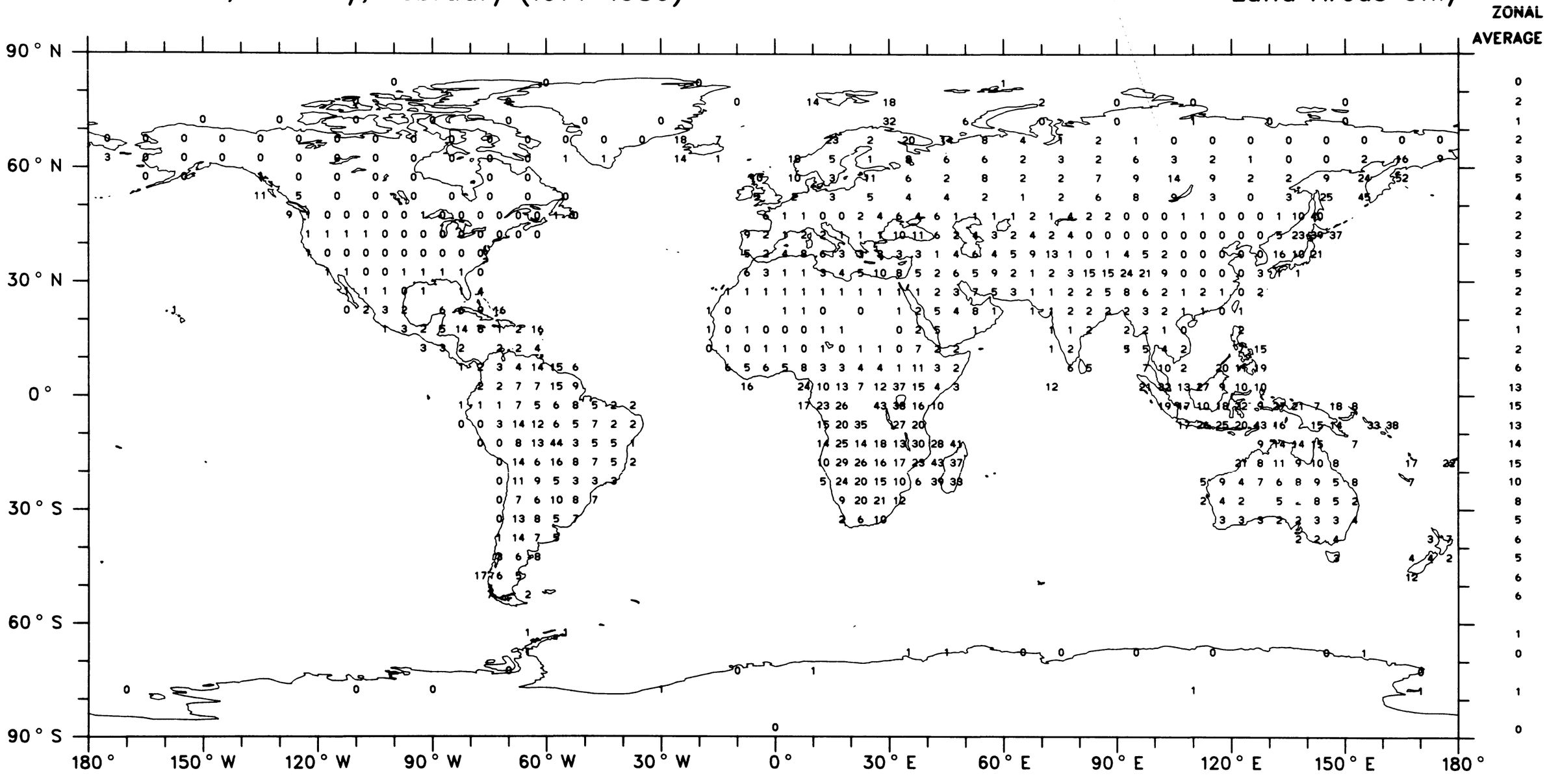


Map 1-17

Frequency of Occurrence (Percent) of Cumulonimbus

December, January, February (1971-1980)

Land Areas Only

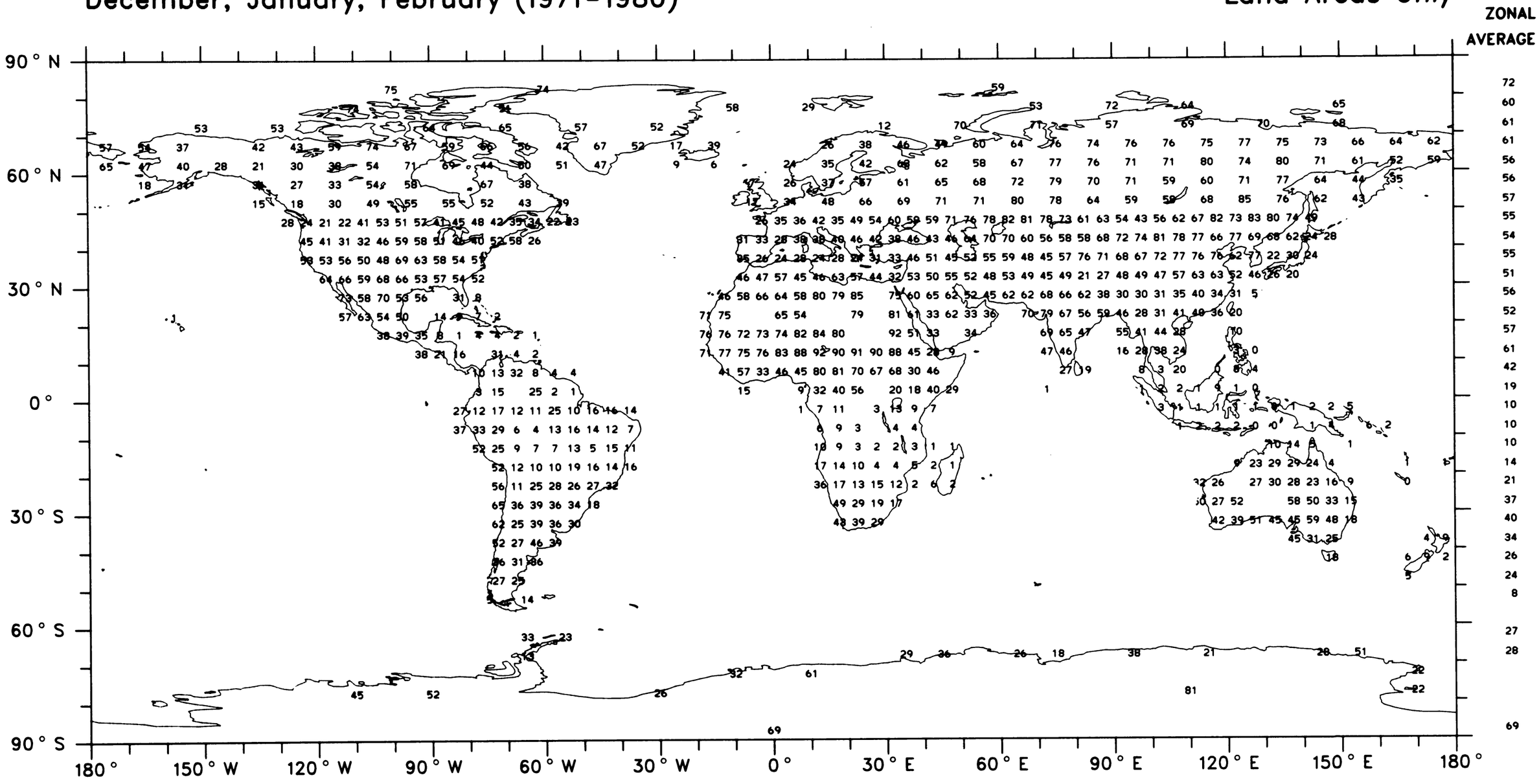


Map 1-18

Given Ci/Cs/Cc, Probability (Percent) That No Other Cloud Is Present

December, January, February (1971-1980)

Land Areas Only

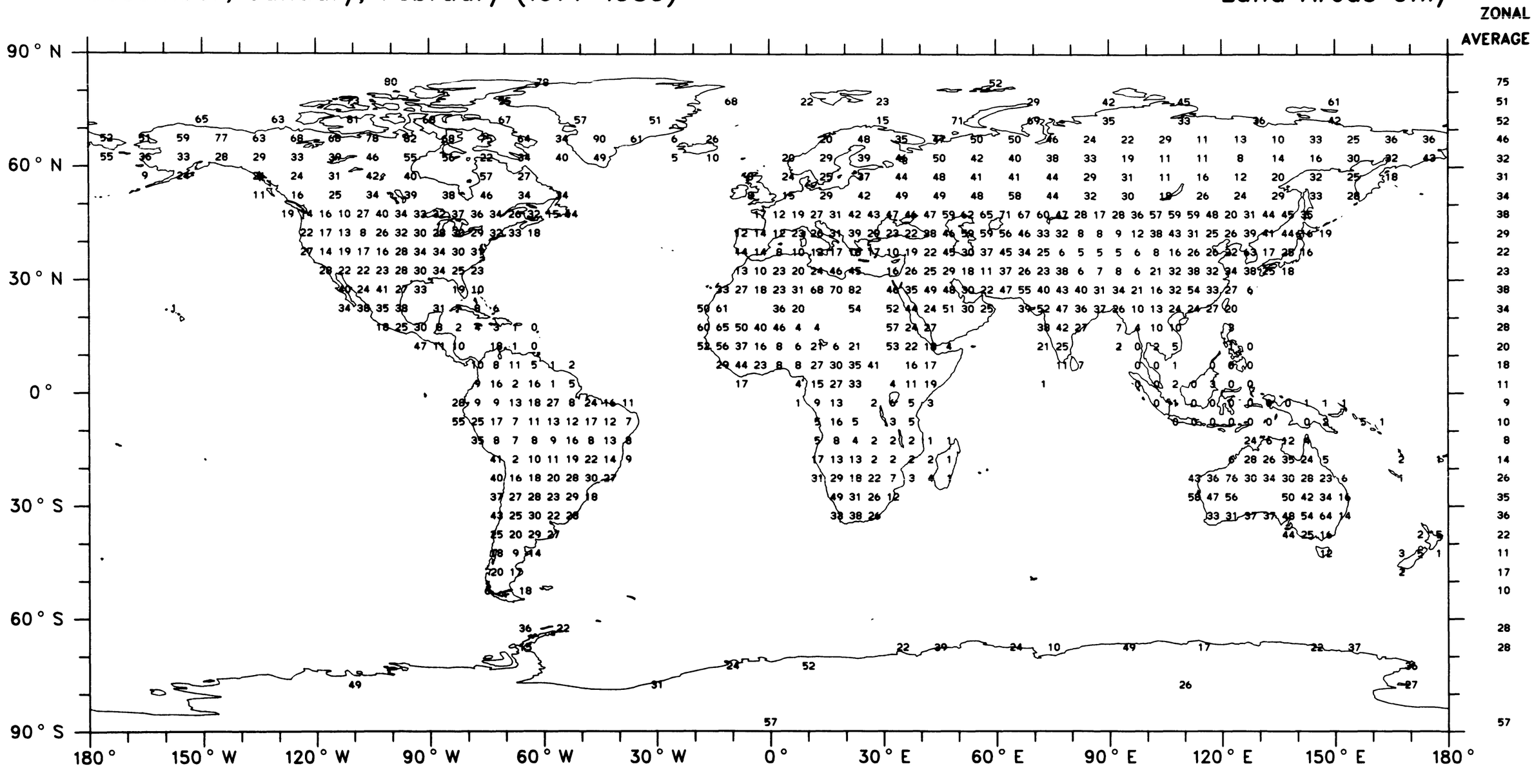


Map 1-19

Given As/Ac, Probability (Percent) That No Other Cloud Is Present

December, January, February (1971-1980)

Land Areas Only

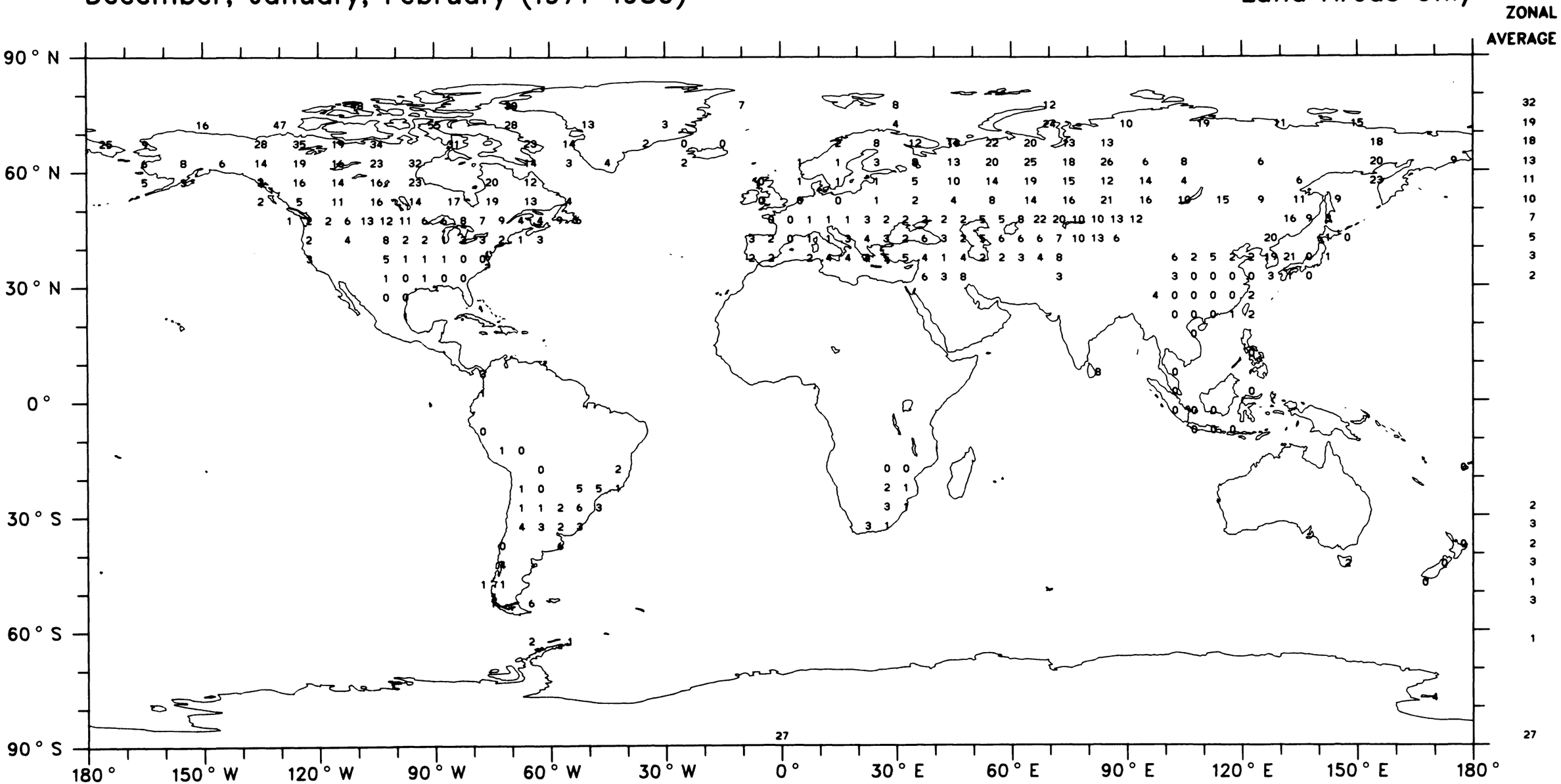


Map I-20

Given Nimbostratus, Probability (Percent) That No Other Cloud Is Present

December, January, February (1971-1980)

Land Areas Only

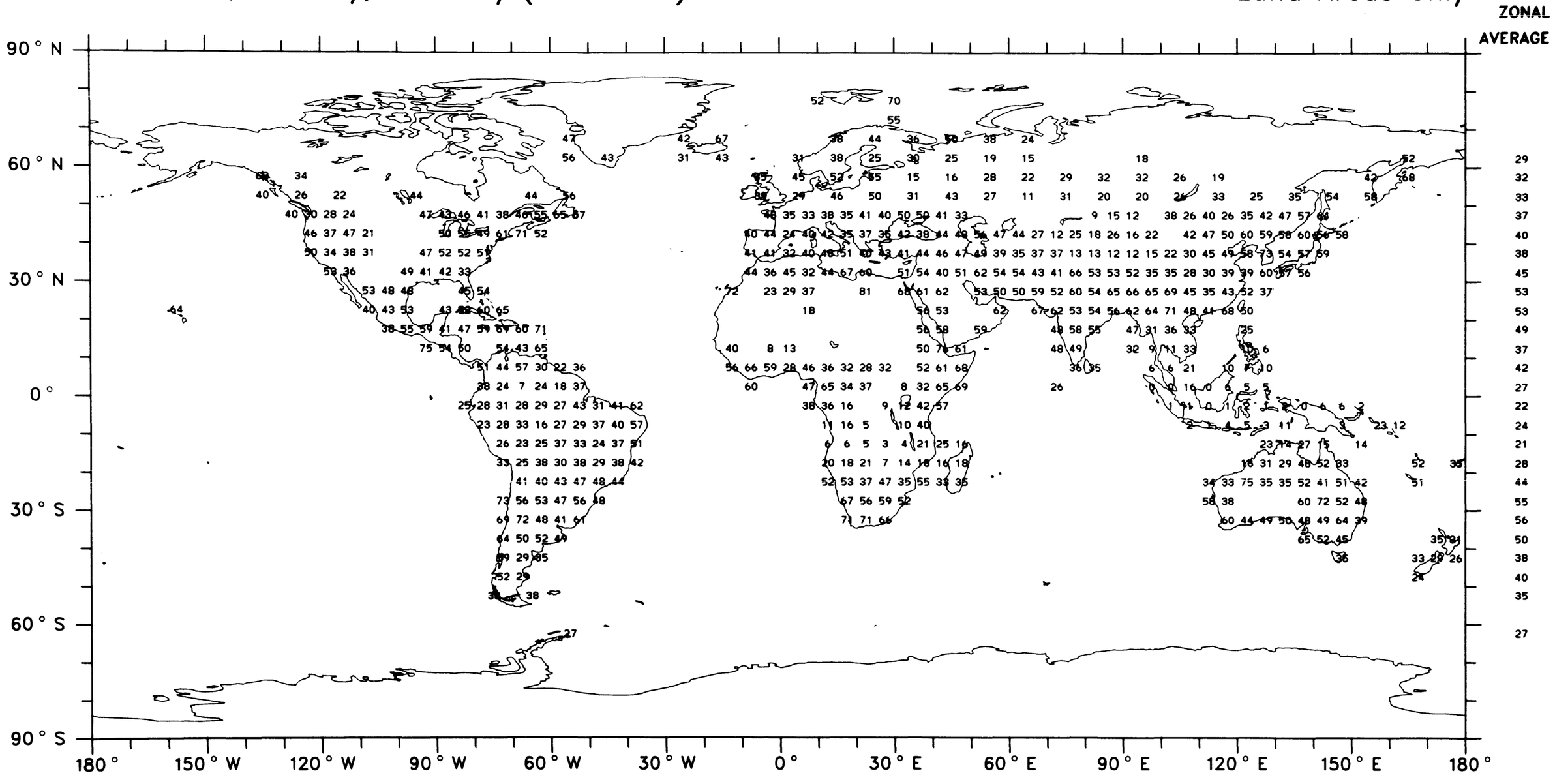


Map I-21

Given Cumulus, Probability (Percent) That No Other Cloud Is Present

December, January, February (1971-1980)

Land Areas Only

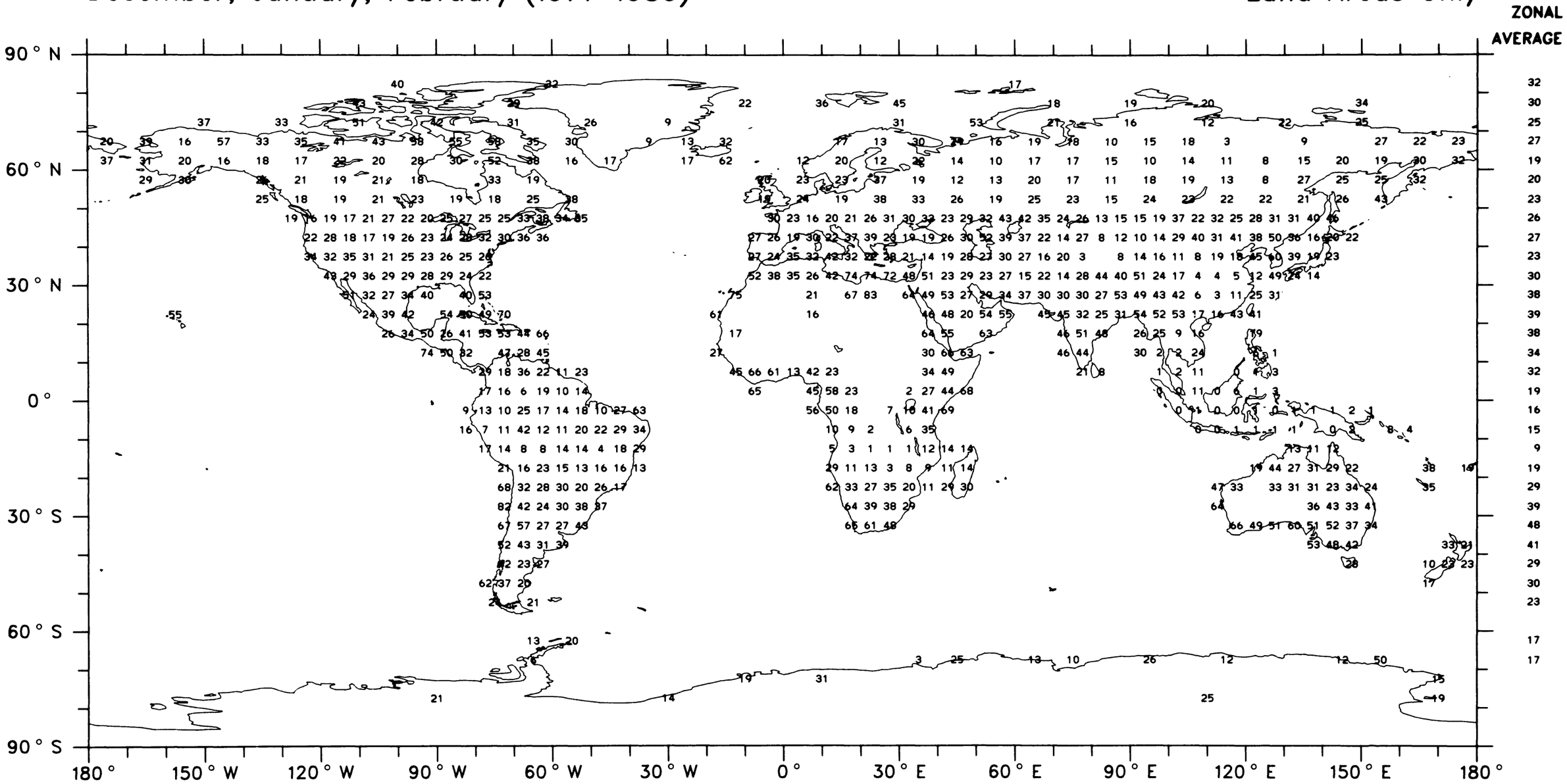


Map 1-22

Given St/Sc, Probability (Percent) That No Other Cloud Is Present

December, January, February (1971-1980)

Land Areas Only



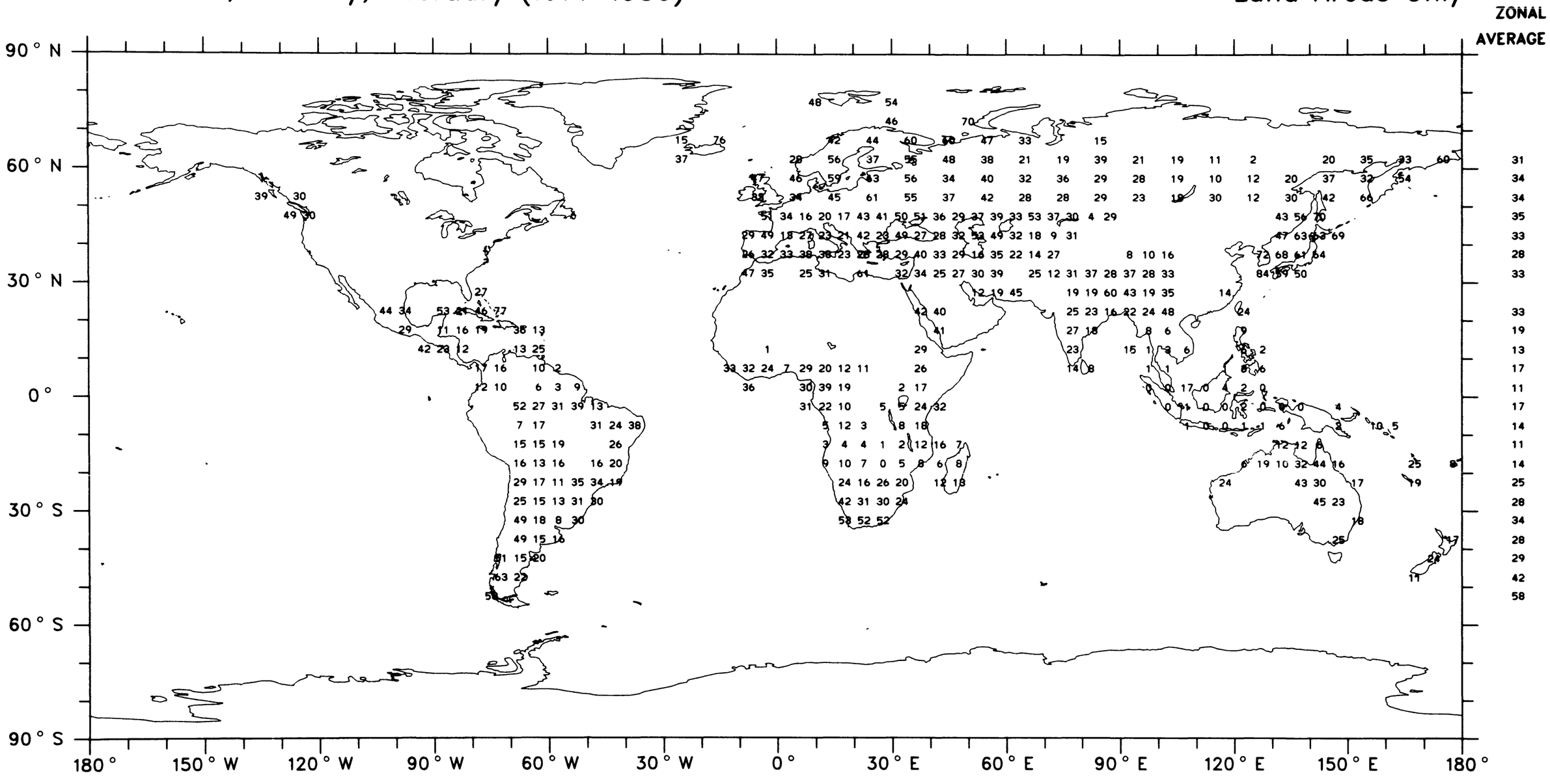
Map 1-23

Map 1-23

Given Cumulonimbus, Probability (Percent) That No Other Cloud Is Present

December, January, February (1971-1980)

Land Areas Only

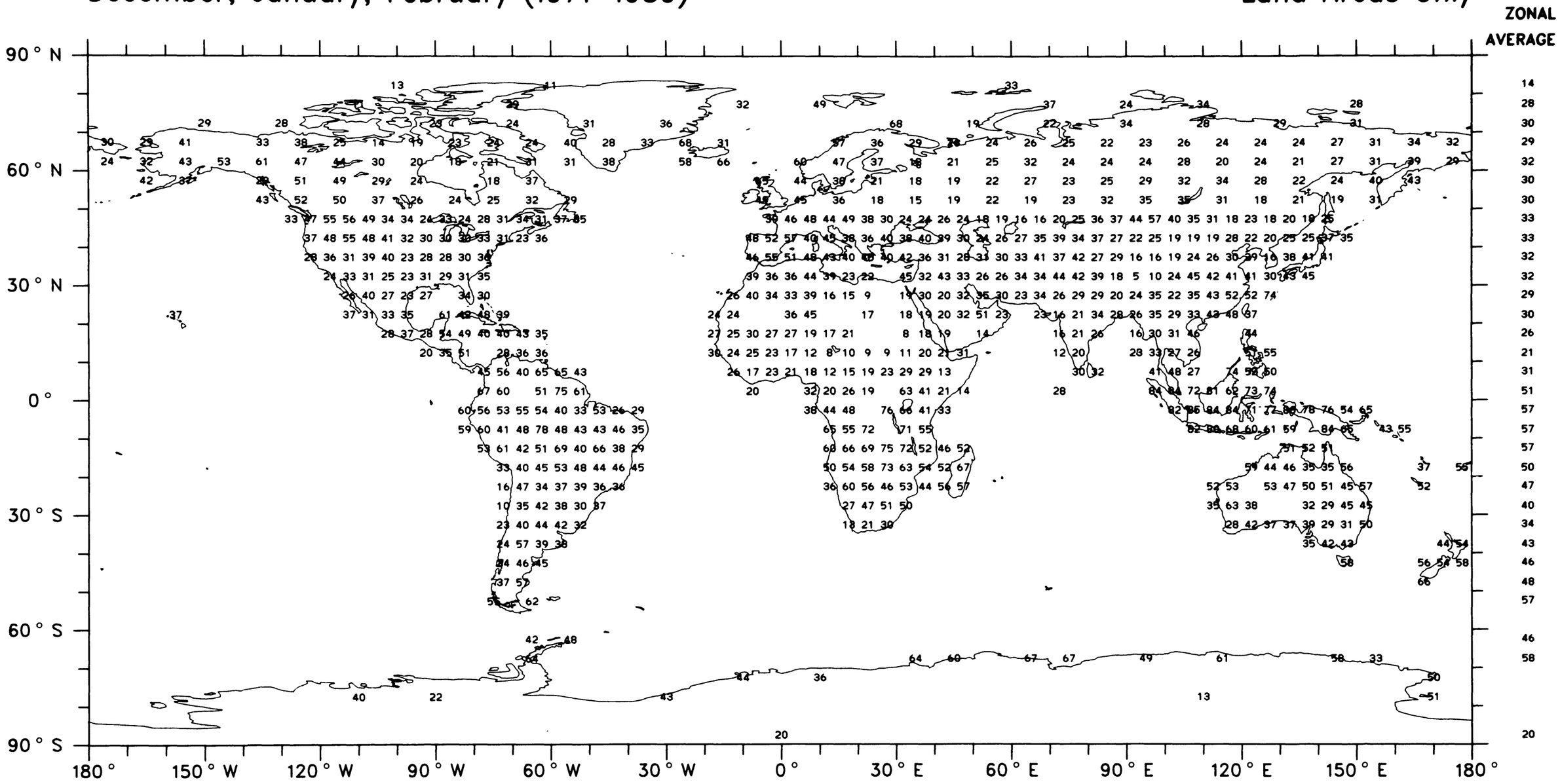


Map I-24

Given Ci/Cs/Cc, Probability (Percent) That As/Ac is Also Present

December, January, February (1971-1980)

Land Areas Only

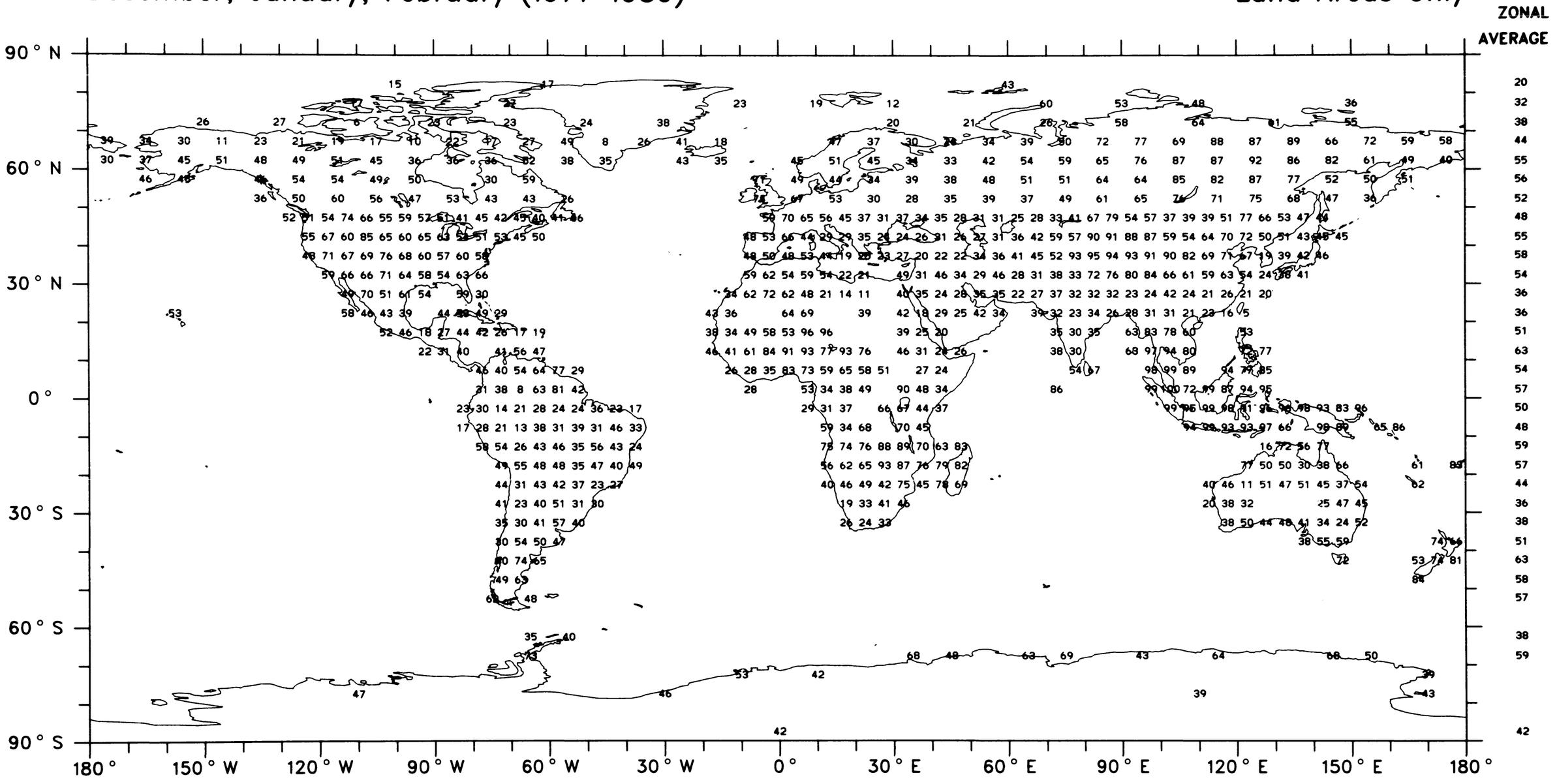


Map I-25

Given As/Ac, Probability (Percent) That Ci/Cs/Cc is Also Present

December, January, February (1971-1980)

Land Areas Only

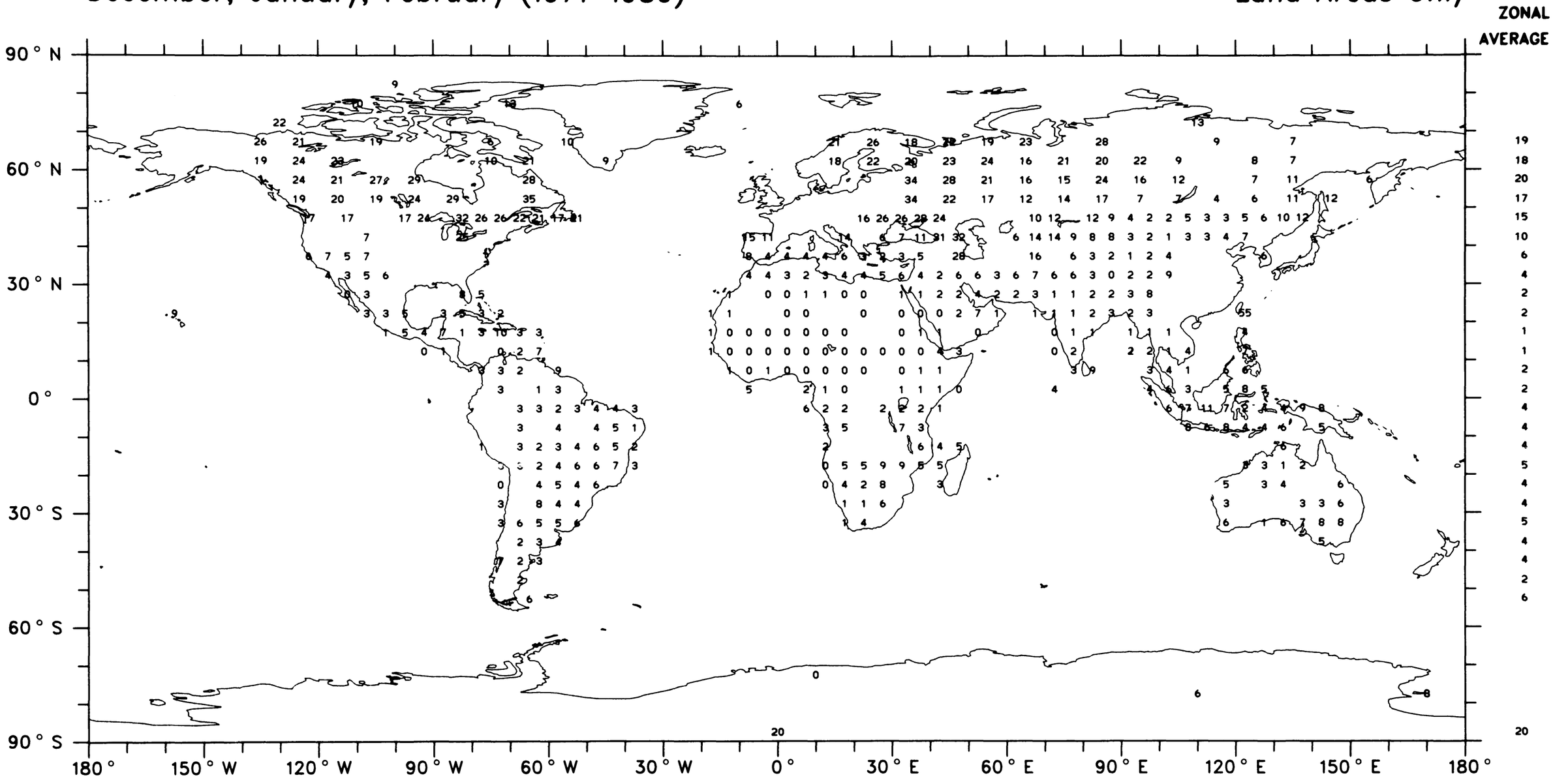


Map 1-26

Given Ci/Cs/Cc, Probability (Percent) That Nimbostratus is Also Present

December, January, February (1971-1980)

Land Areas Only

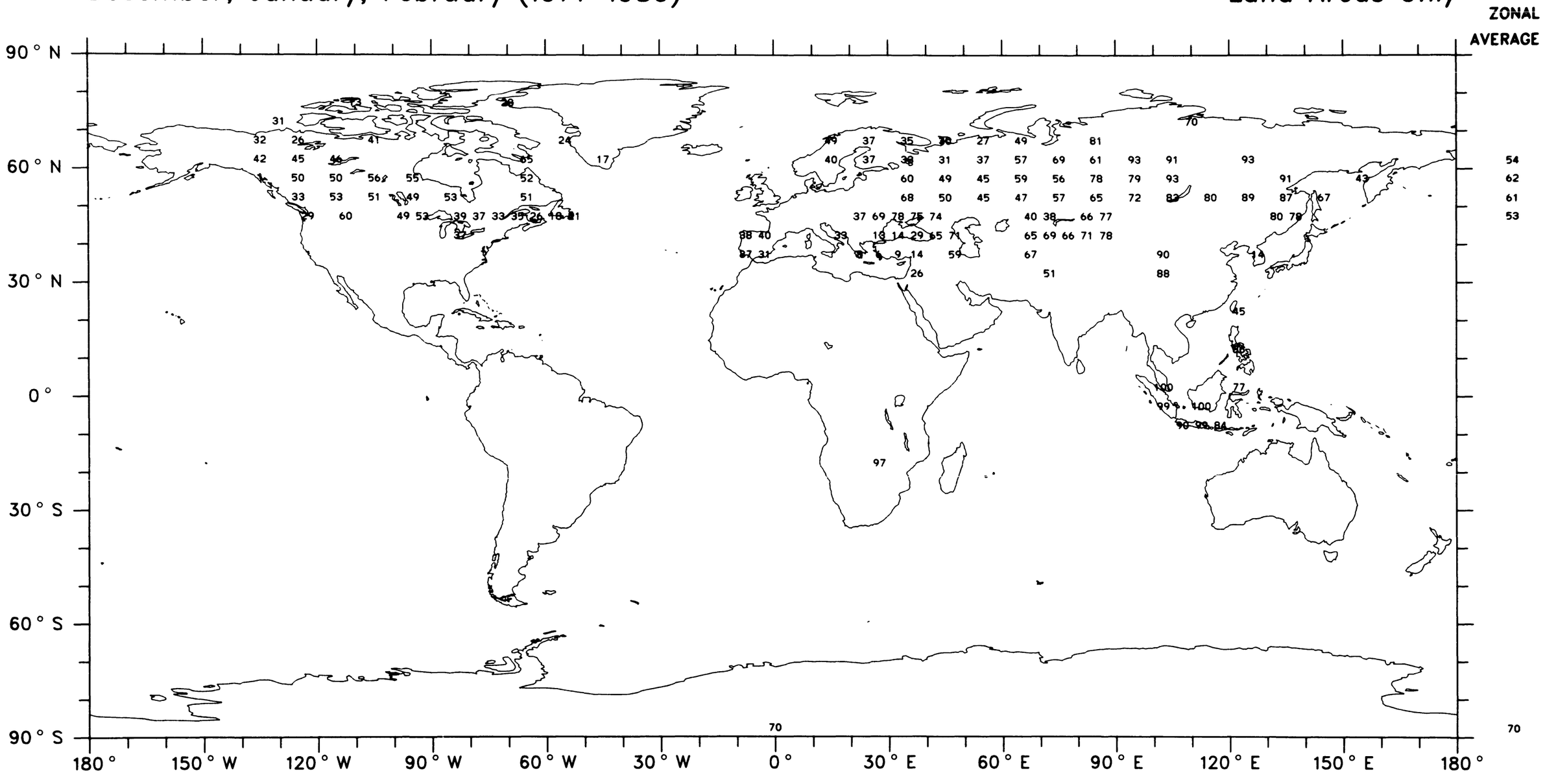


Map I-27

Given Nimbostratus, Probability (Percent) That Ci/Cs/Cc is Also Present

December, January, February (1971-1980)

Land Areas Only

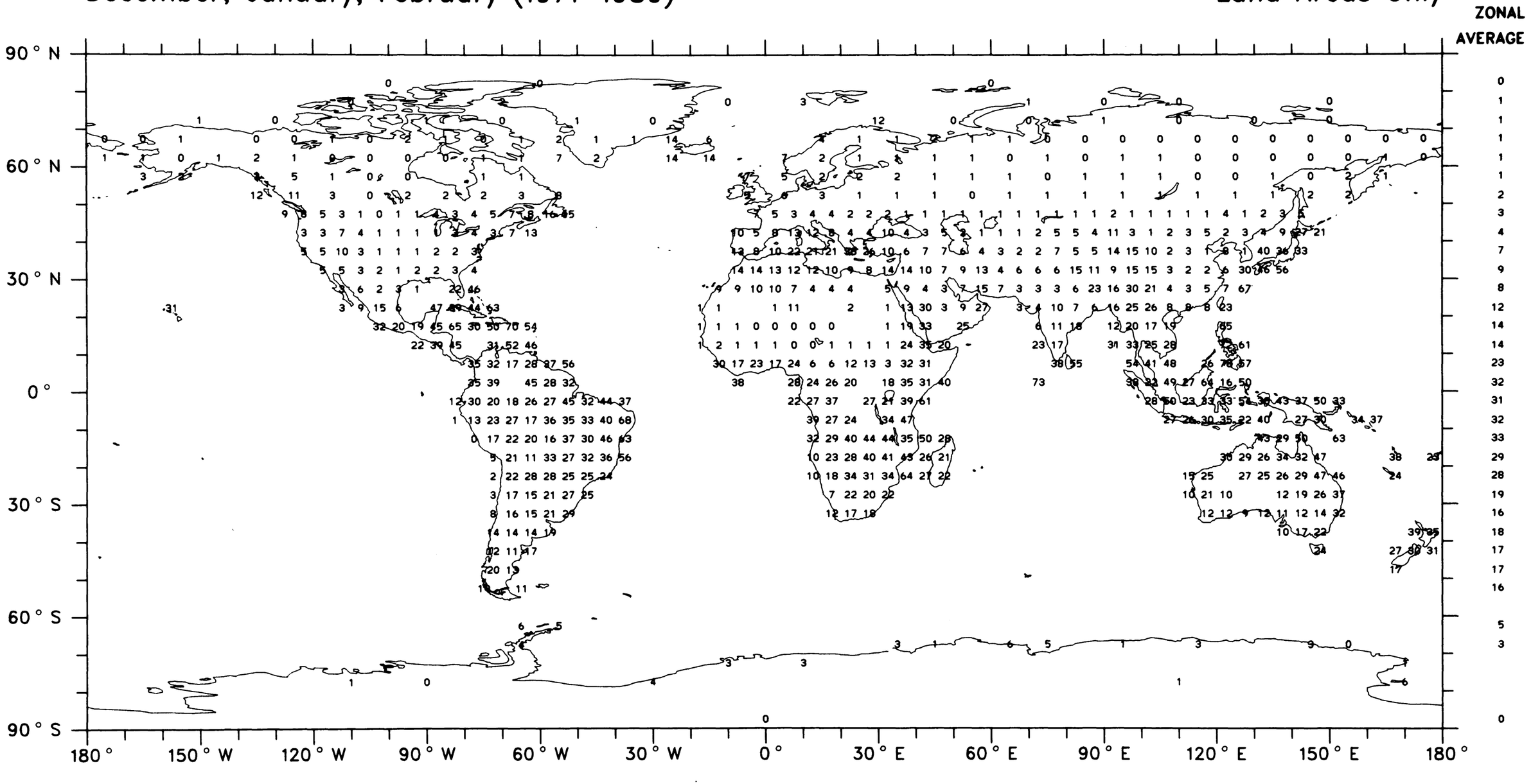


Map 1-28

Given Ci/Cs/Cc, Probability (Percent) That Cumulus is Also Present

December, January, February (1971-1980)

Land Areas Only

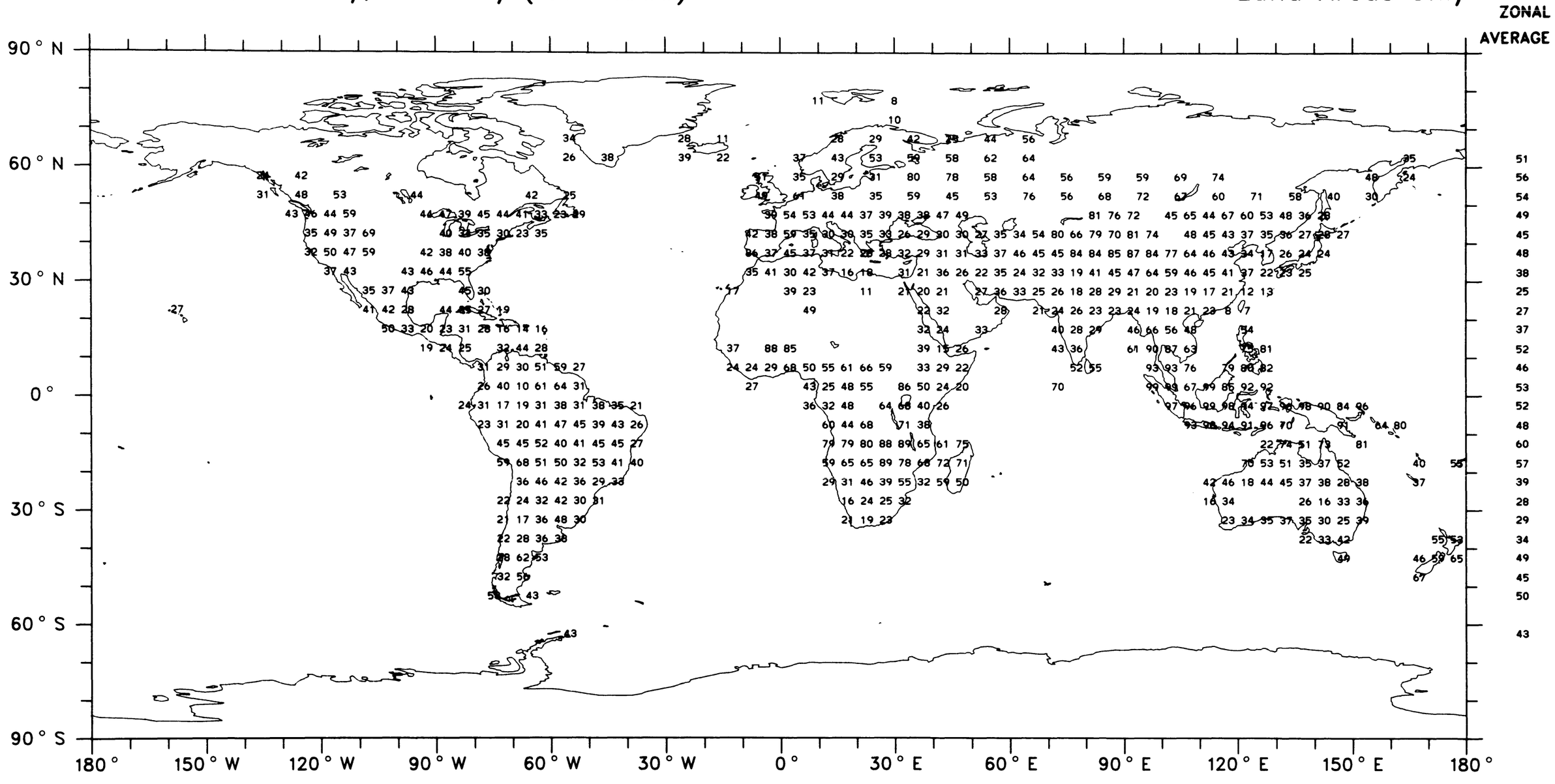


Map I-29

Given Cumulus, Probability (Percent) That Ci/Cs/Cc is Also Present

December, January, February (1971-1980)

Land Areas Only

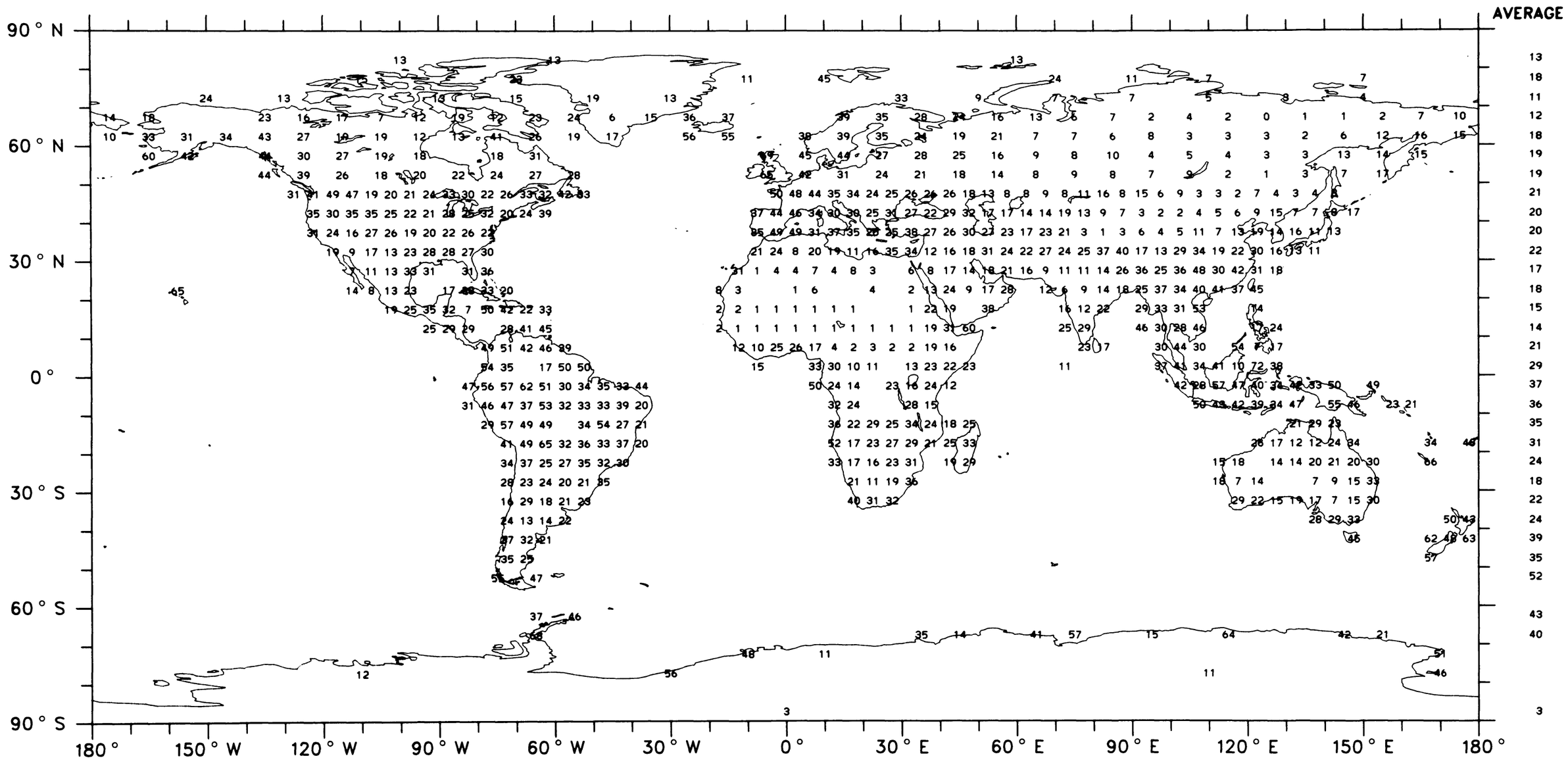


Map I-30

Given Ci/Cs/Cc, Probability (Percent) That St/Sc is Also Present

December, January, February (1971-1980)

Land Areas Only

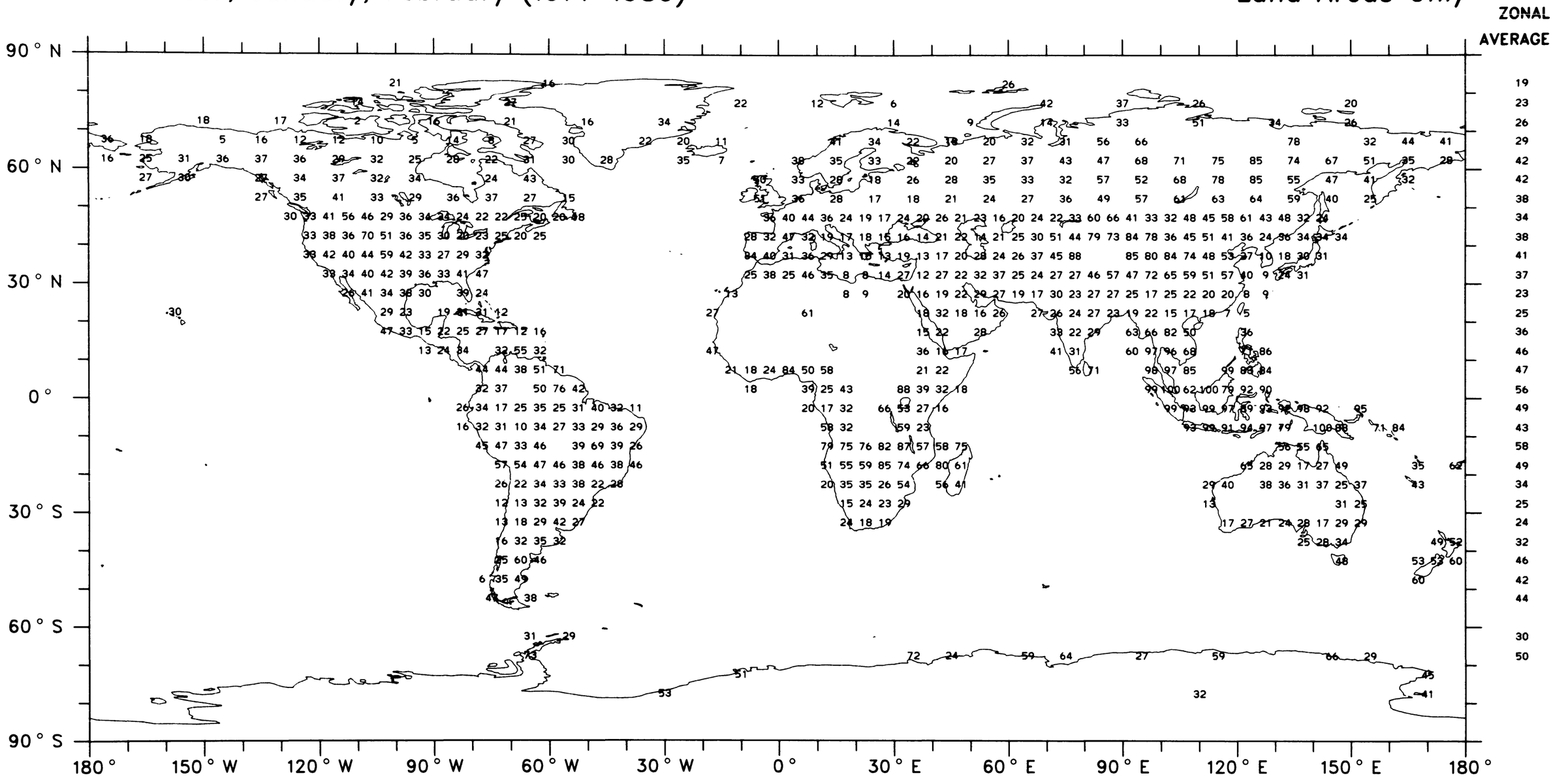


Map 1-31

Given St/Sc, Probability (Percent) That Ci/Cs/Cc is Also Present

December, January, February (1971-1980)

Land Areas Only

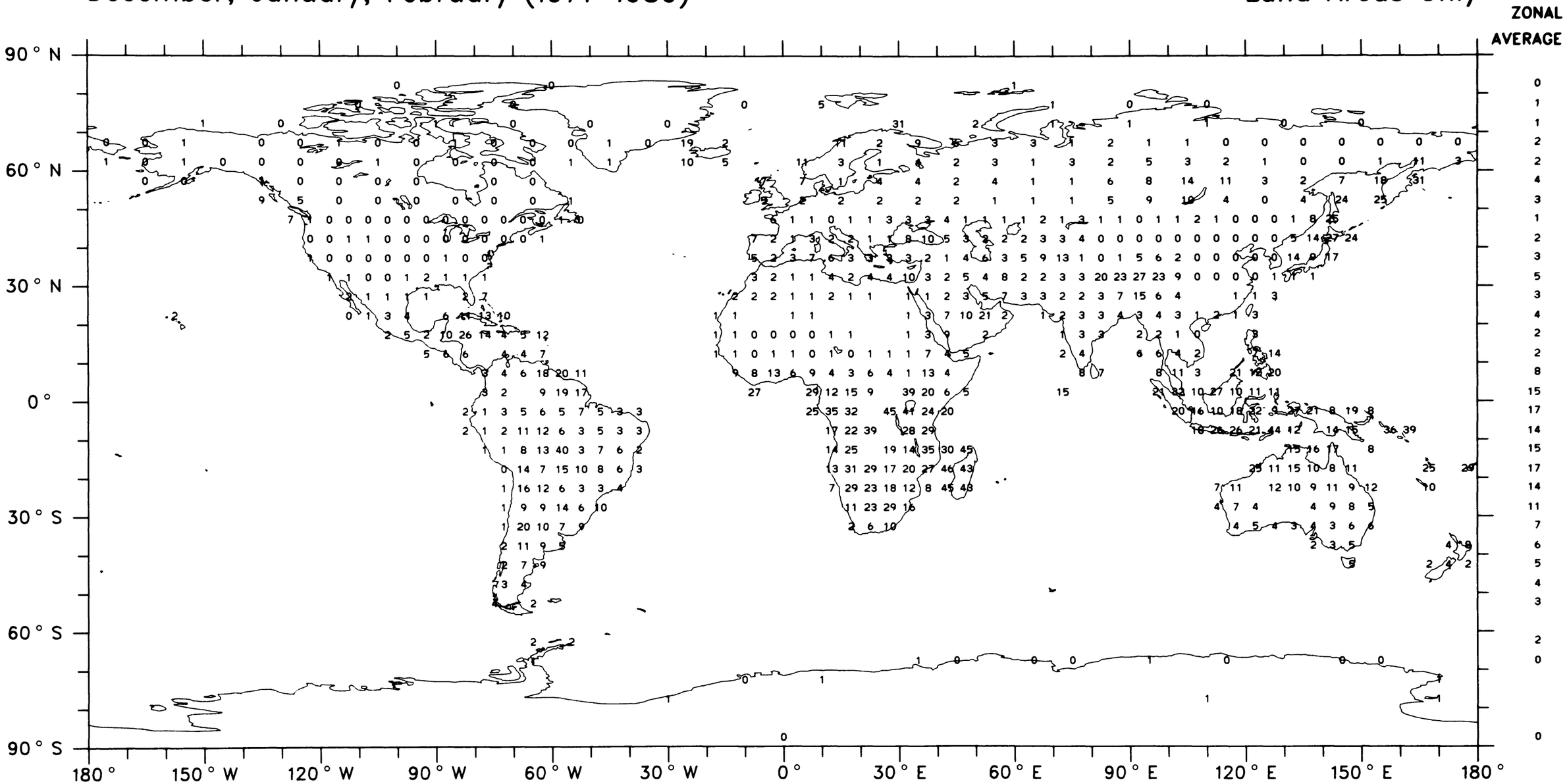


Map I-32

Given Ci/Cs/Cc, Probability (Percent) That Cumulonimbus is Also Present

December, January, February (1971-1980)

Land Areas Only

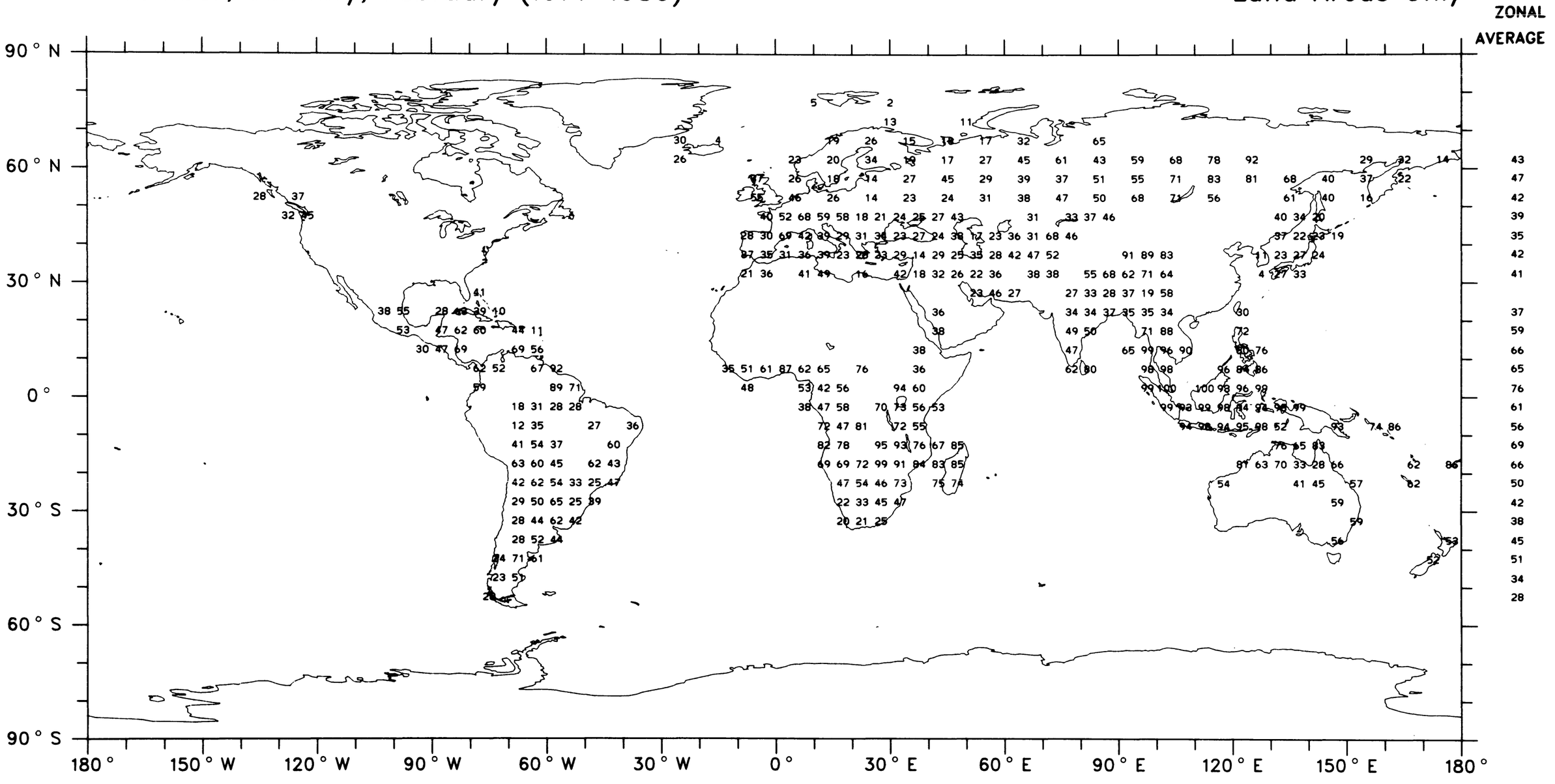


Map 1-33

Given Cumulonimbus, Probability (Percent) That Ci/Cs/Cc is Also Present

December, January, February (1971-1980)

Land Areas Only

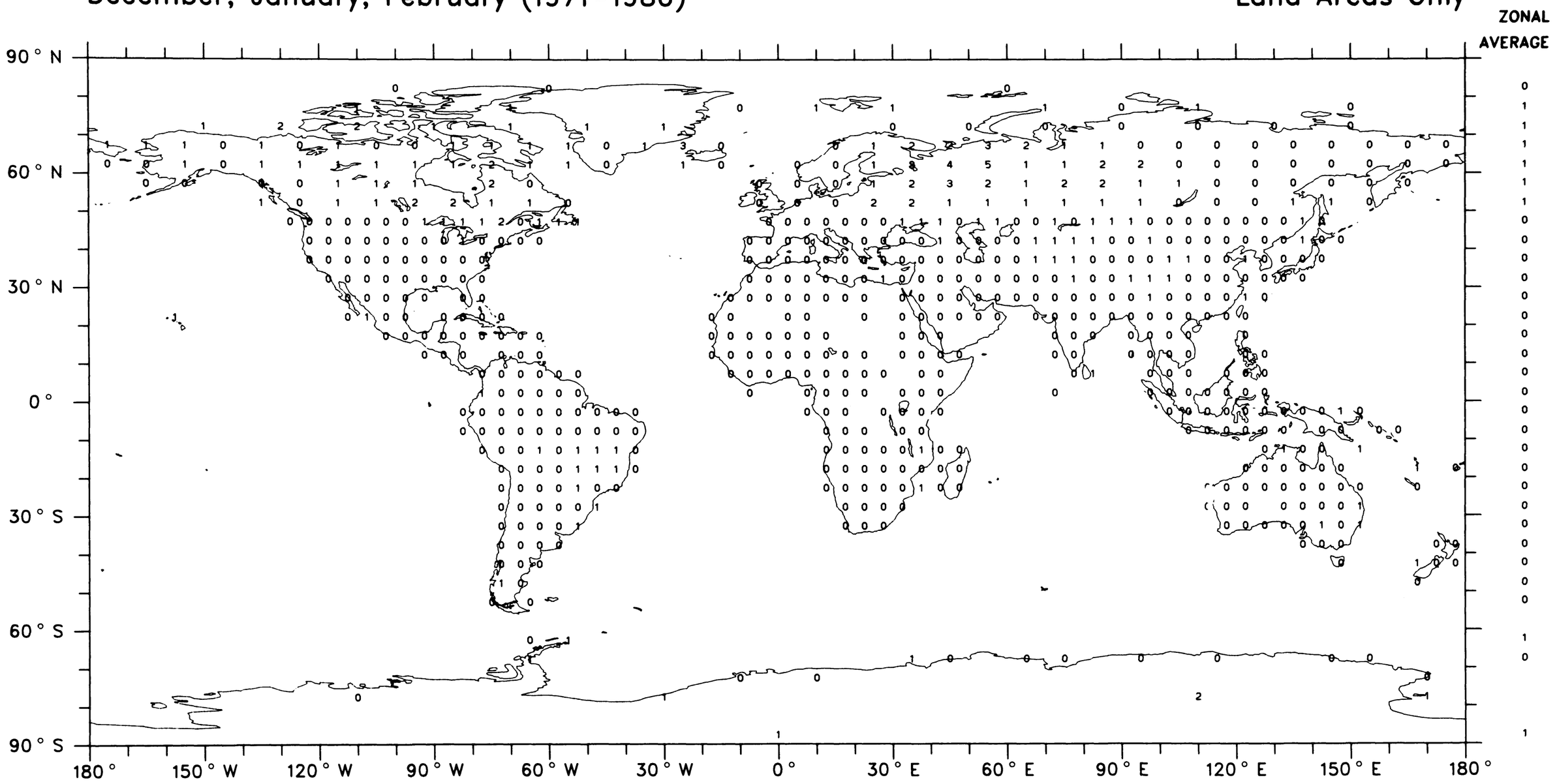


Map 1-34

Given As/Ac, Probability (Percent) That Nimbostratus is Also Present

December, January, February (1971-1980)

Land Areas Only

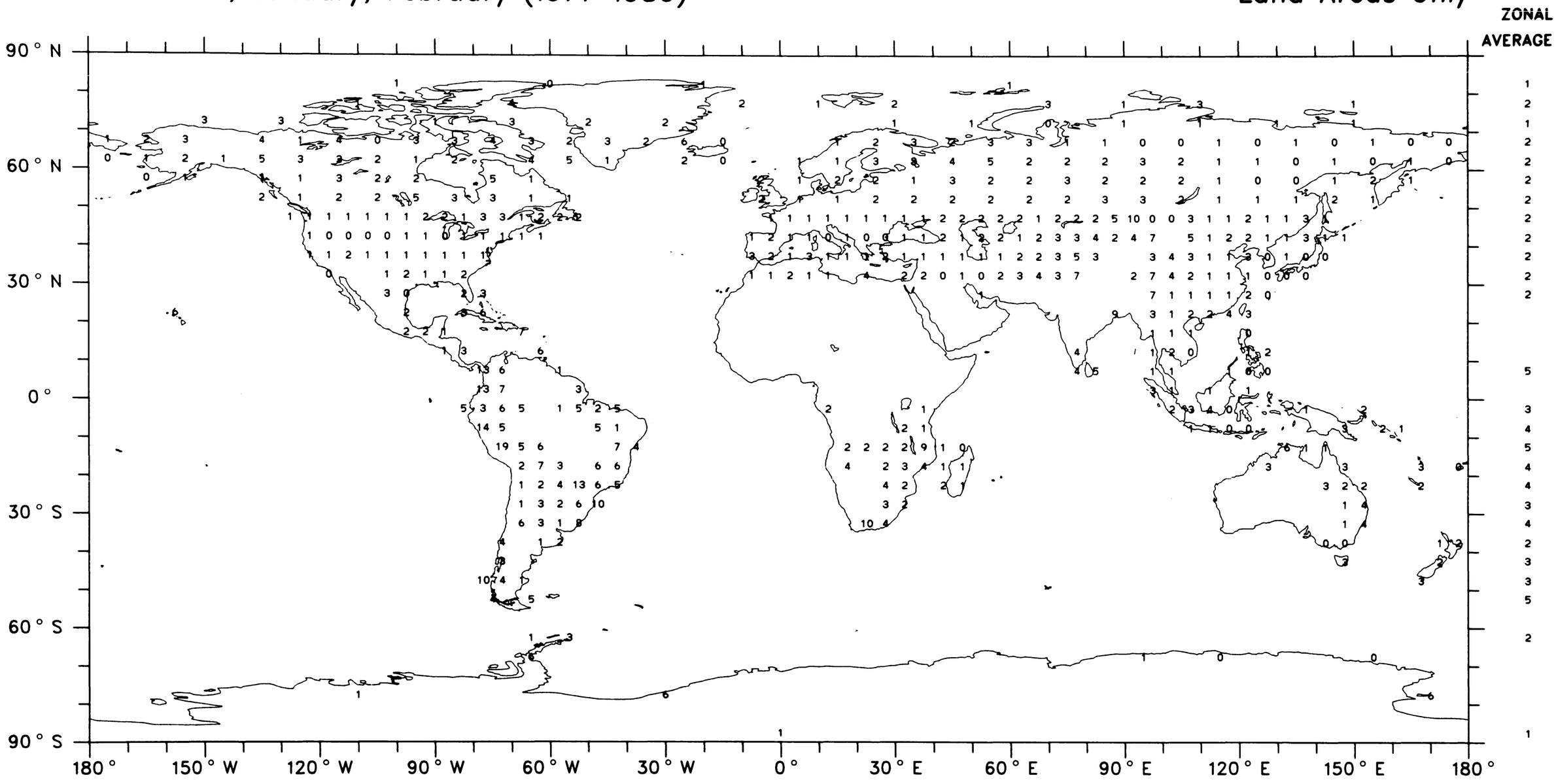


Map 1-35

Given Nimbostratus, Probability (Percent) That As/Ac is Also Present

December, January, February (1971-1980)

Land Areas Only

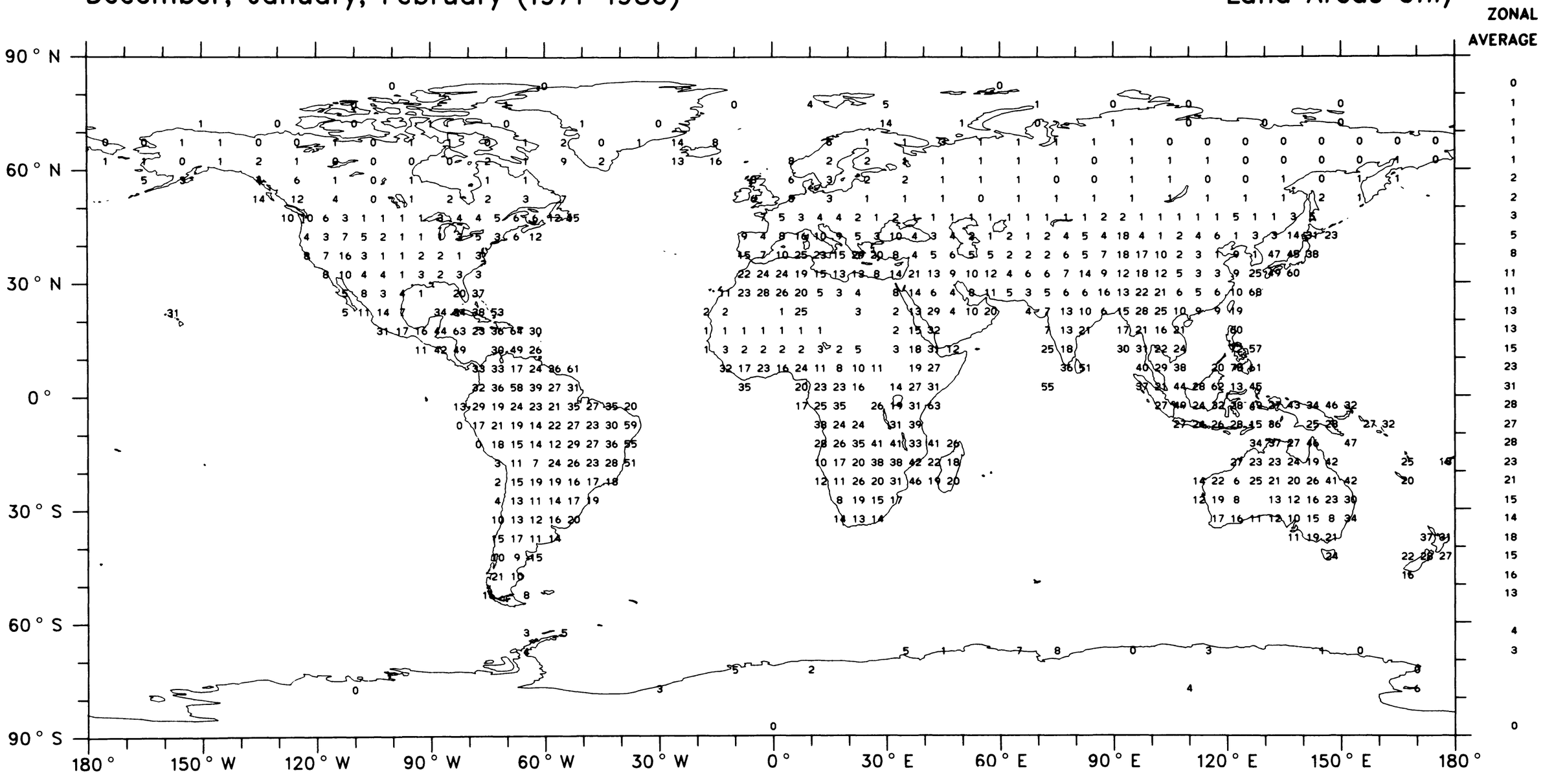


Map 1-36

Given As/Ac, Probability (Percent) That Cumulus is Also Present

December, January, February (1971-1980)

Land Areas Only

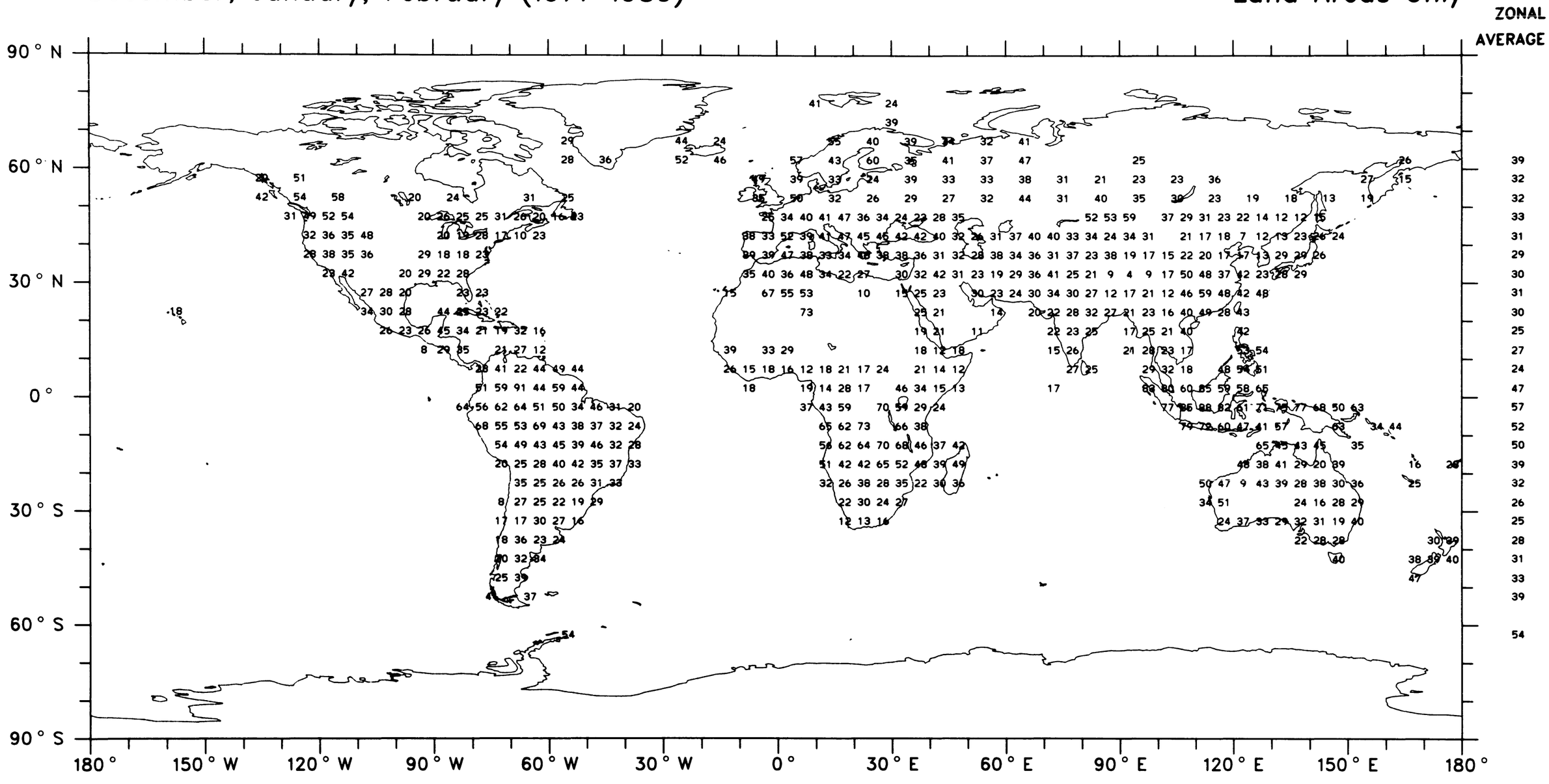


Map 1-37

Given Cumulus, Probability (Percent) That As/Ac is Also Present

December, January, February (1971-1980)

Land Areas Only

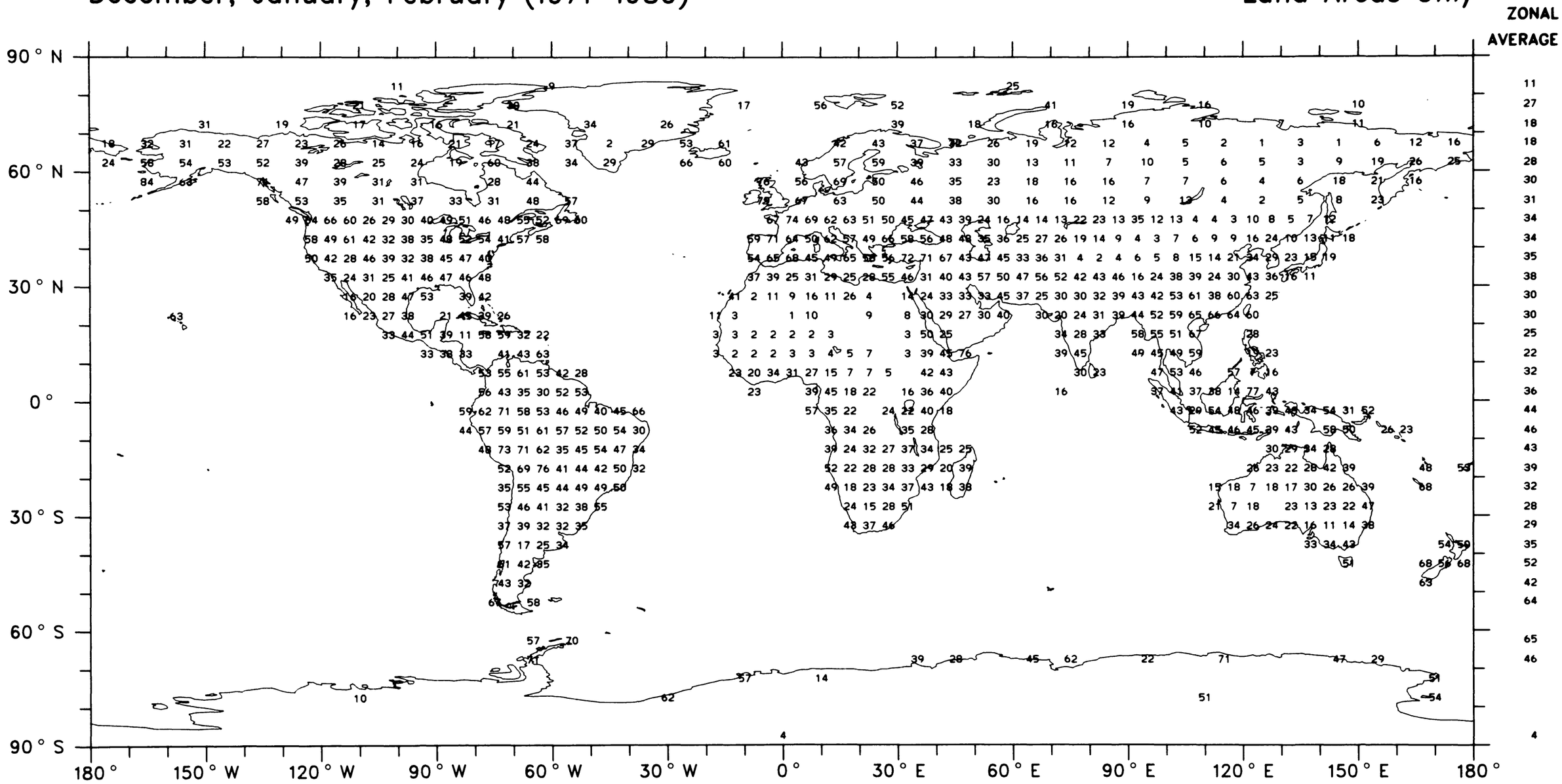


Map 1-38

Given As/Ac, Probability (Percent) That St/Sc is Also Present

December, January, February (1971-1980)

Land Areas Only

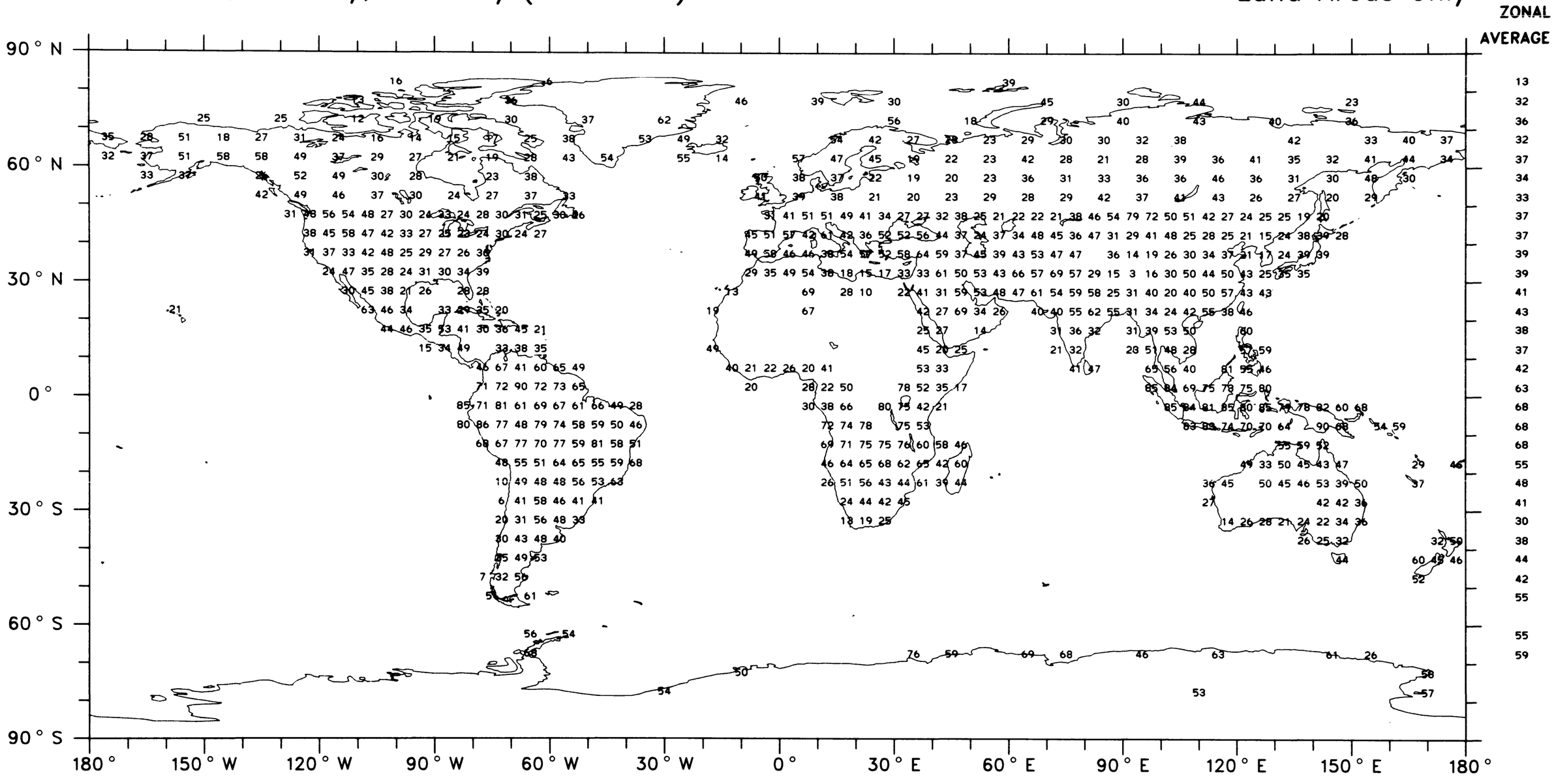


Map 1-39

Given St/Sc, Probability (Percent) That As/Ac is Also Present

December, January, February (1971-1980)

Land Areas Only

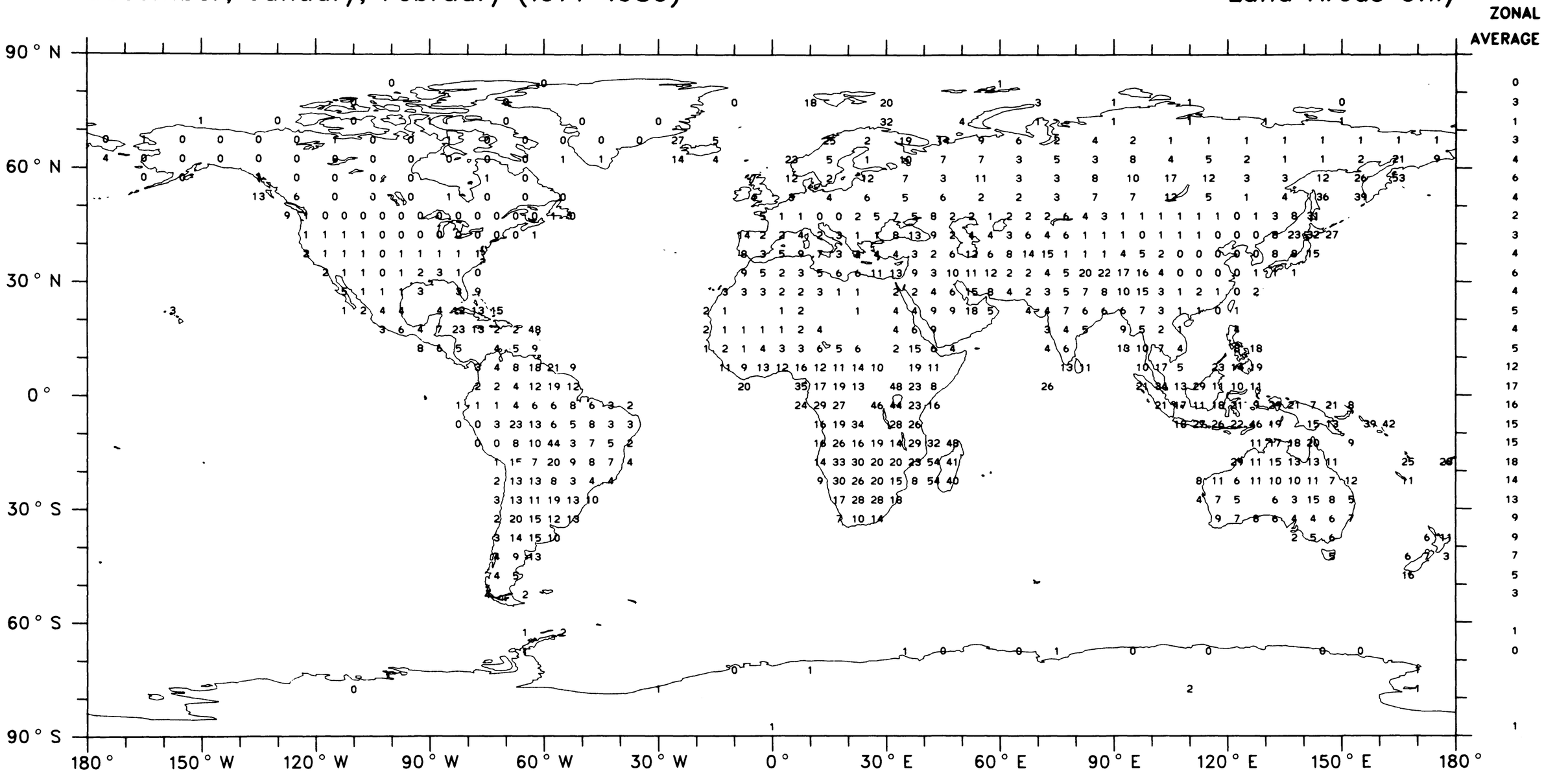


Map 1-40

Given As/Ac, Probability (Percent) That Cumulonimbus is Also Present

December, January, February (1971-1980)

Land Areas Only

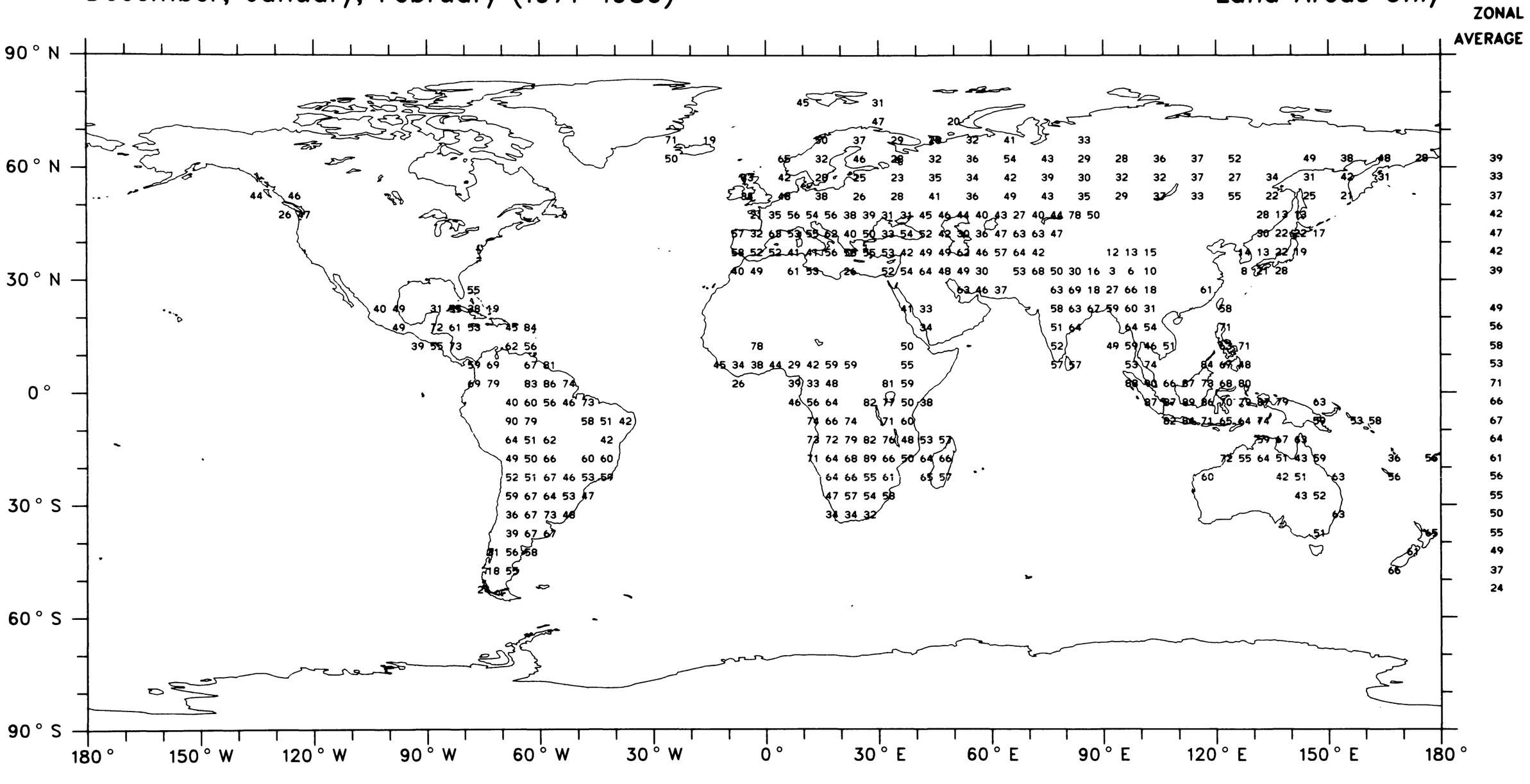


Map 1-41

Given Cumulonimbus, Probability (Percent) That As/Ac is Also Present

December, January, February (1971-1980)

Land Areas Only

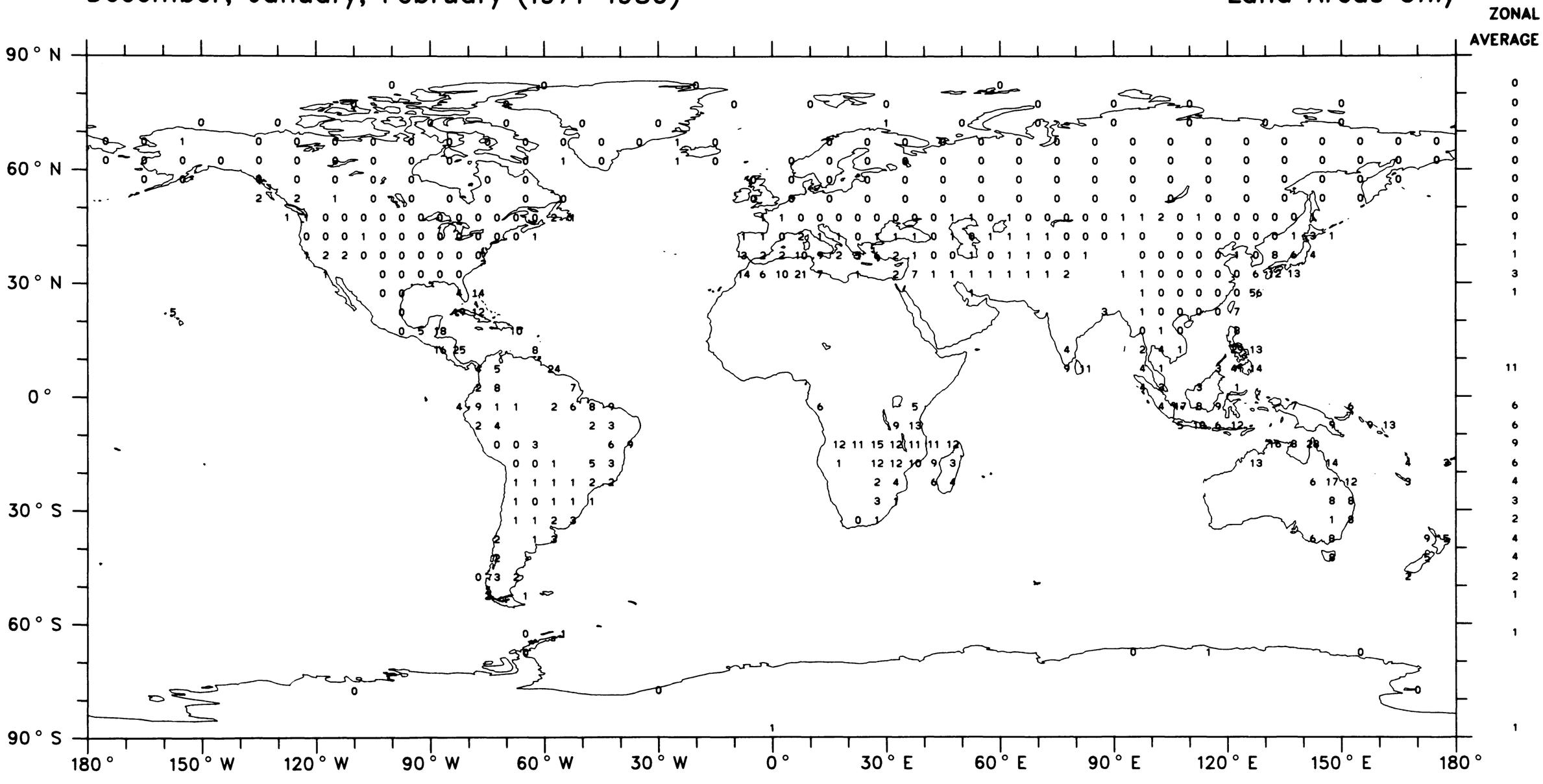


Map I-42

Given Nimbostratus, Probability (Percent) That Cumulus is Also Present

December, January, February (1971-1980)

Land Areas Only

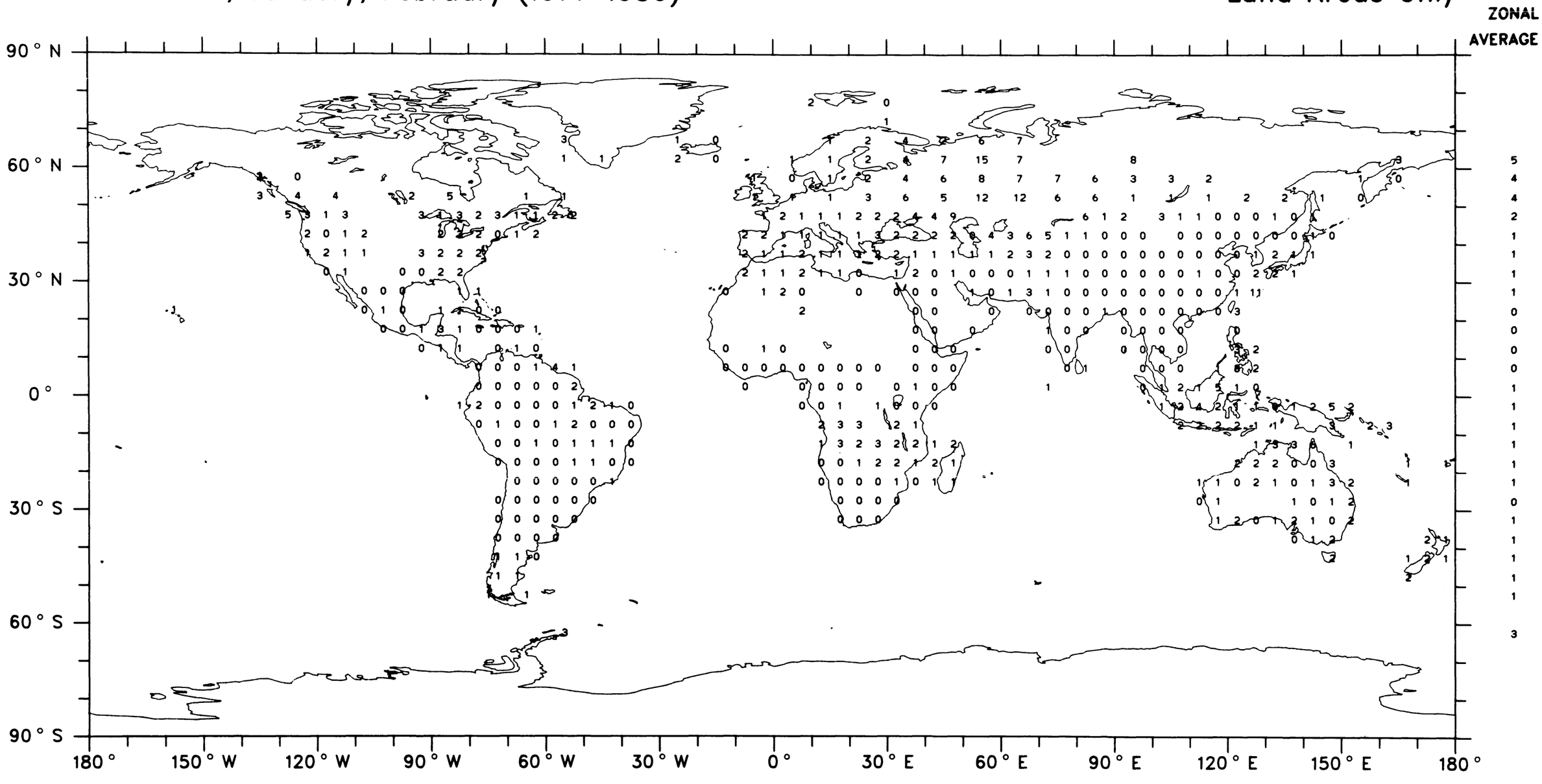


Map 1-43

Given Cumulus, Probability (Percent) That Nimbostratus is Also Present

December, January, February (1971-1980)

Land Areas Only

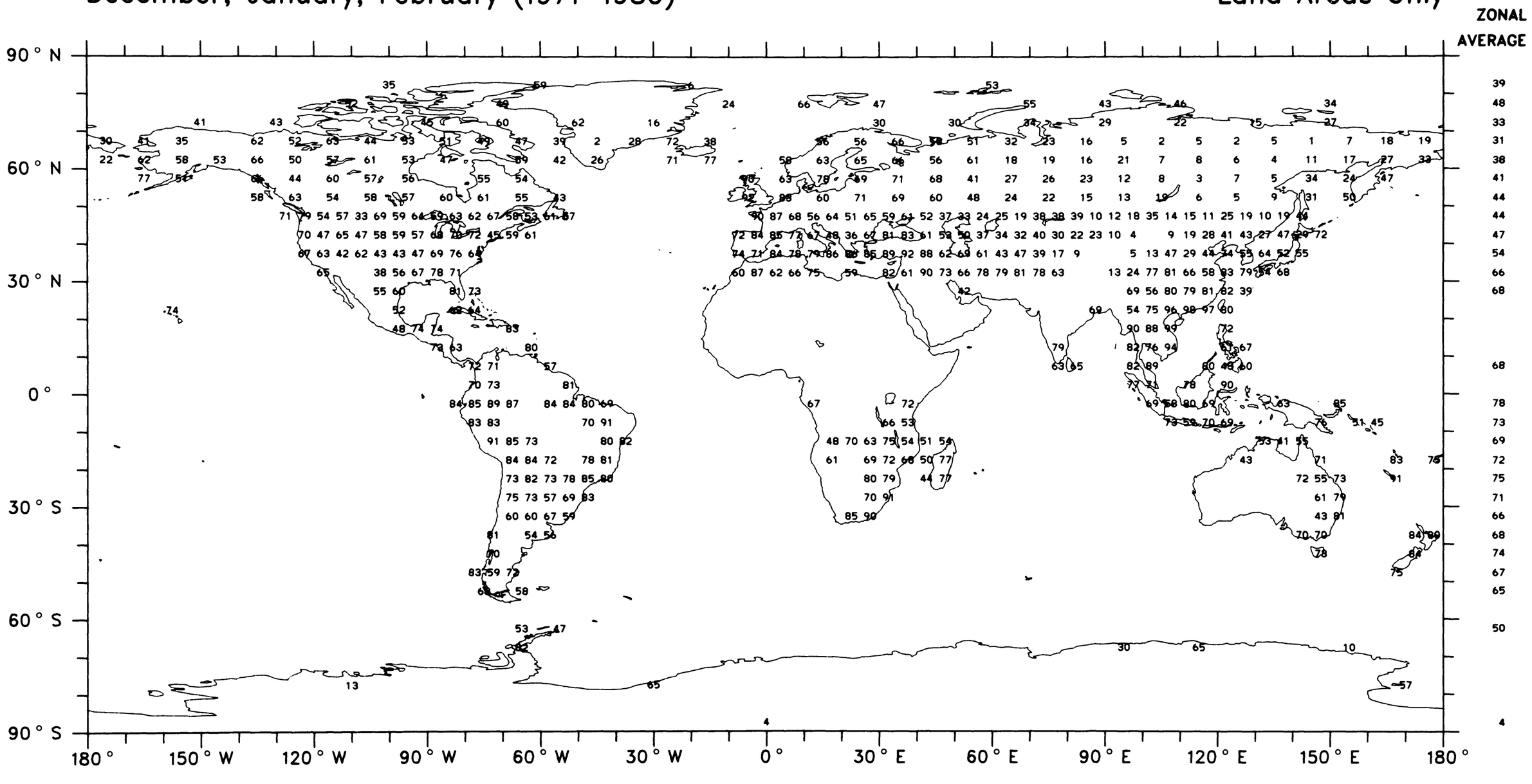


Map 1-44

Given Nimbostratus, Probability (Percent) That St/Sc is Also Present

December, January, February (1971-1980)

Land Areas Only

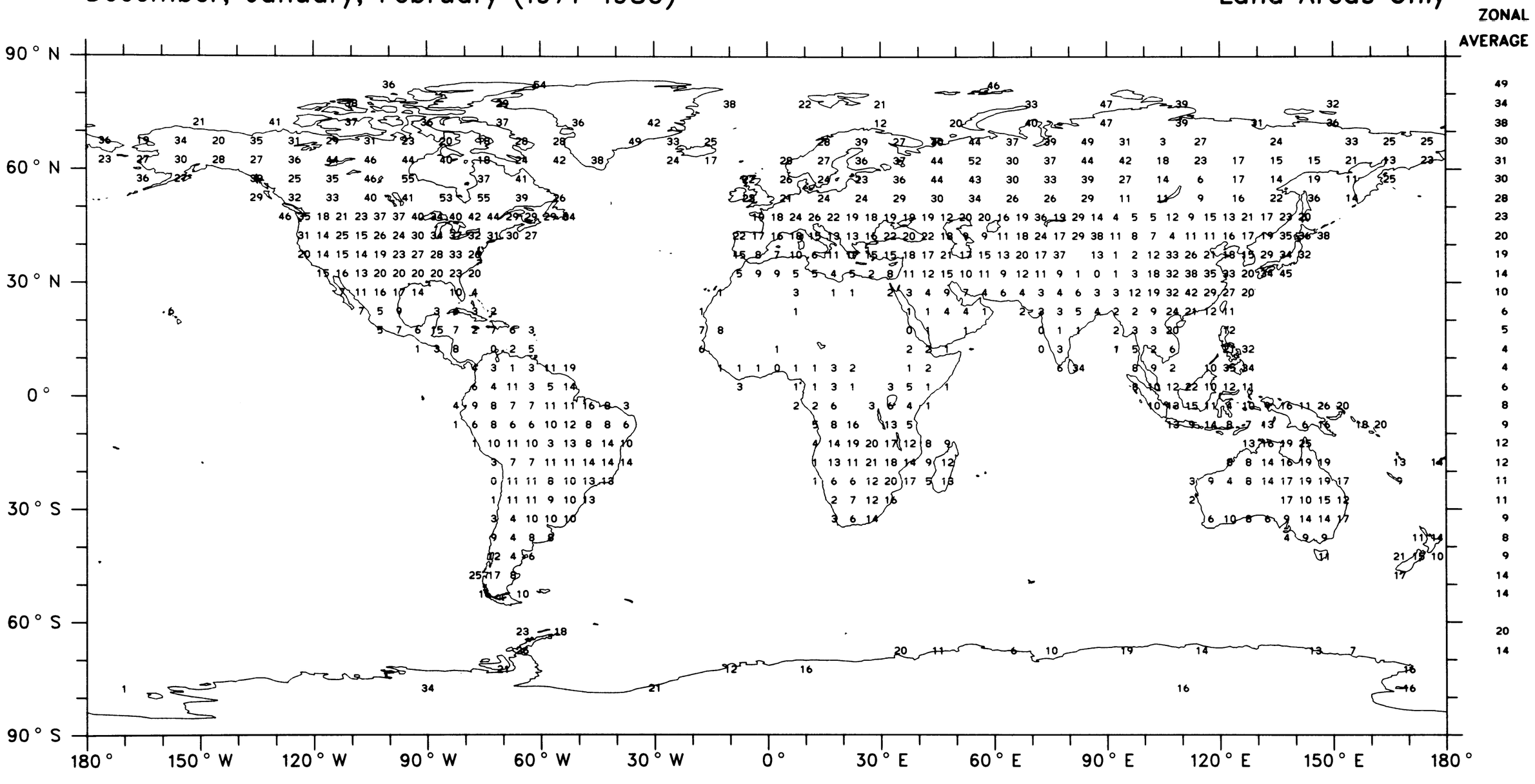


Map 1-45

Given St/Sc, Probability (Percent) That Nimbostratus is Also Present

December, January, February (1971-1980)

Land Areas Only

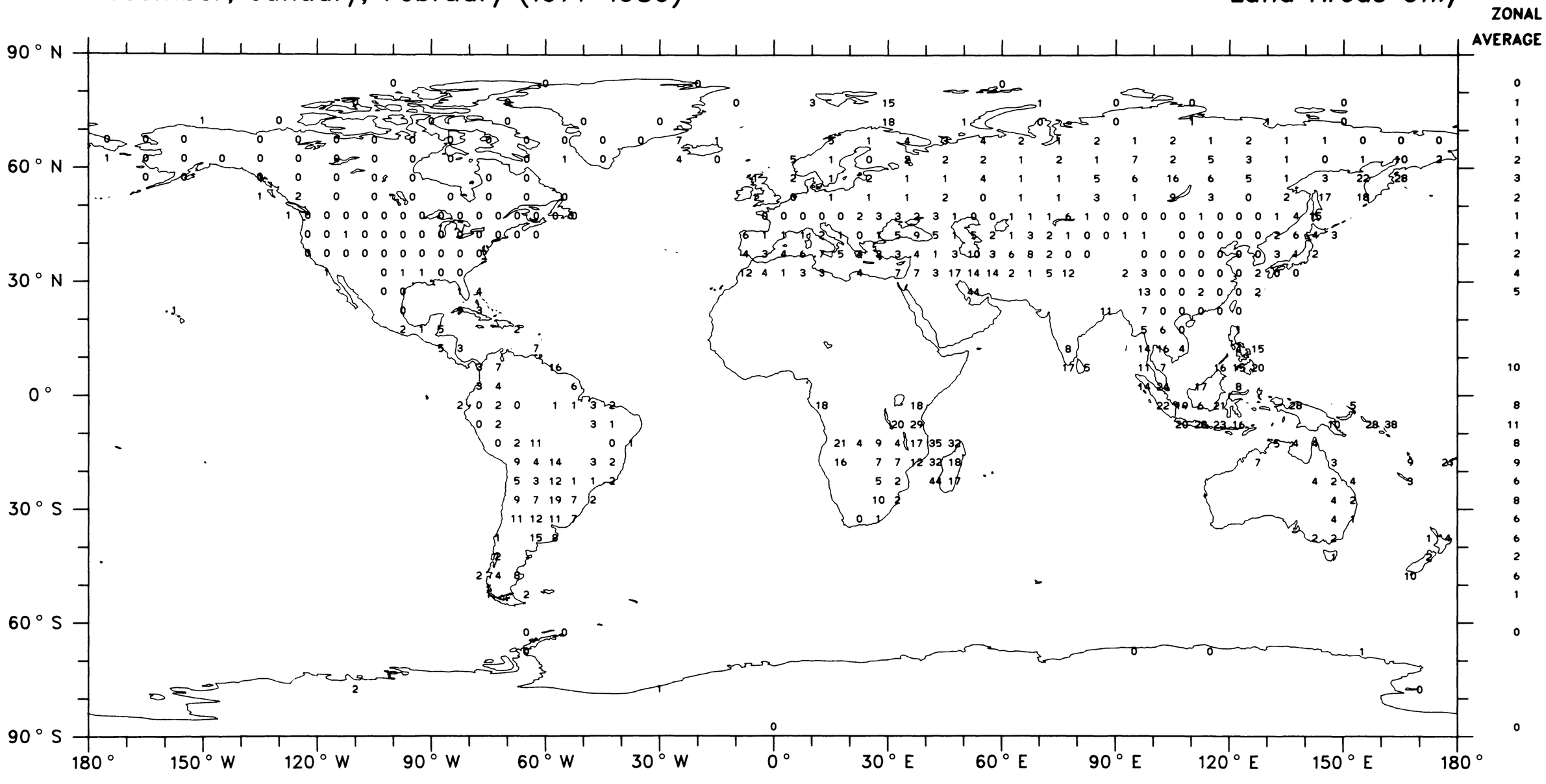


Map I-46

Given Nimbostratus, Probability (Percent) That Cumulonimbus is Also Present

December, January, February (1971-1980)

Land Areas Only

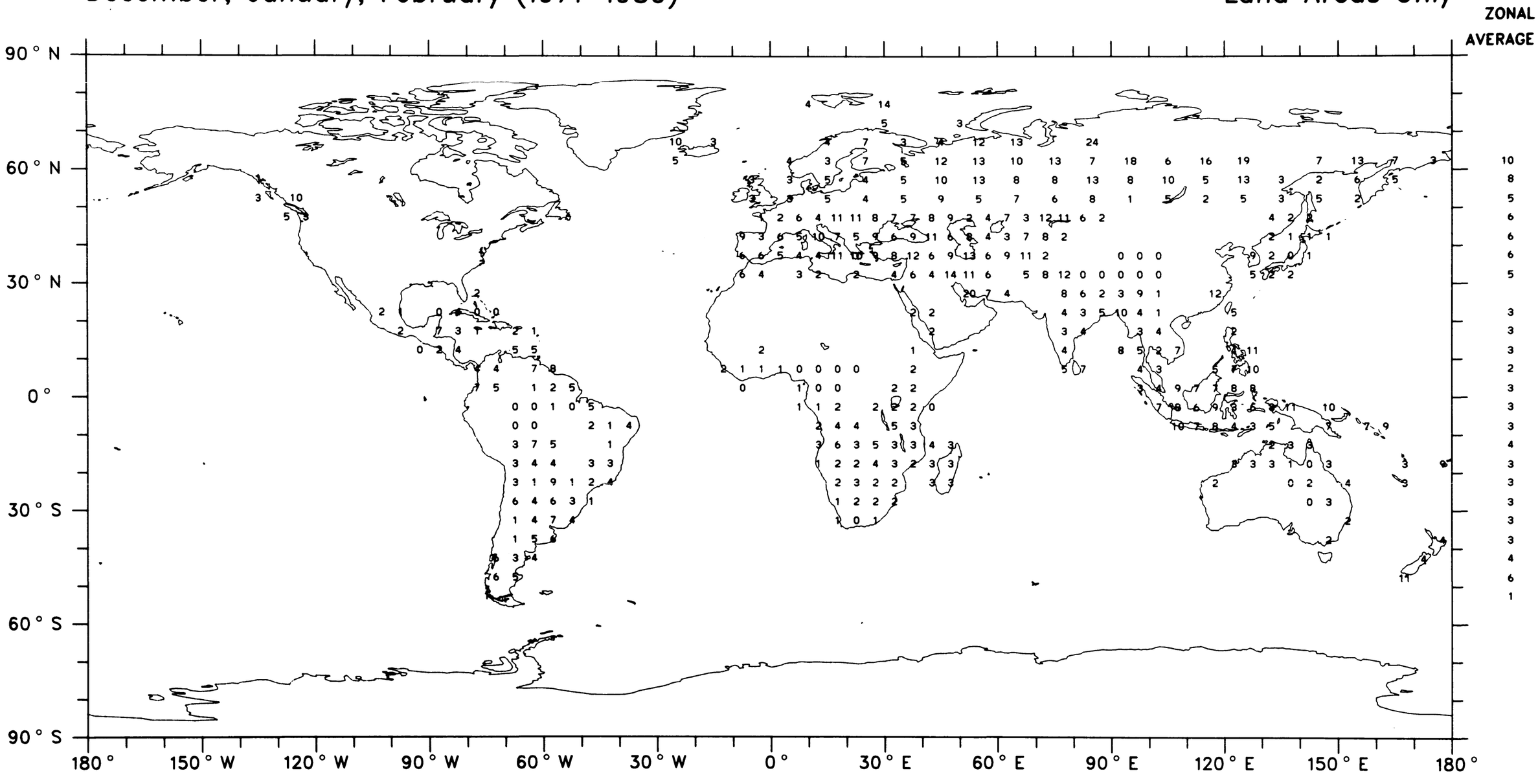


Map I-47

Given Cumulonimbus, Probability (Percent) That Nimbostratus is Also Present

December, January, February (1971-1980)

Land Areas Only

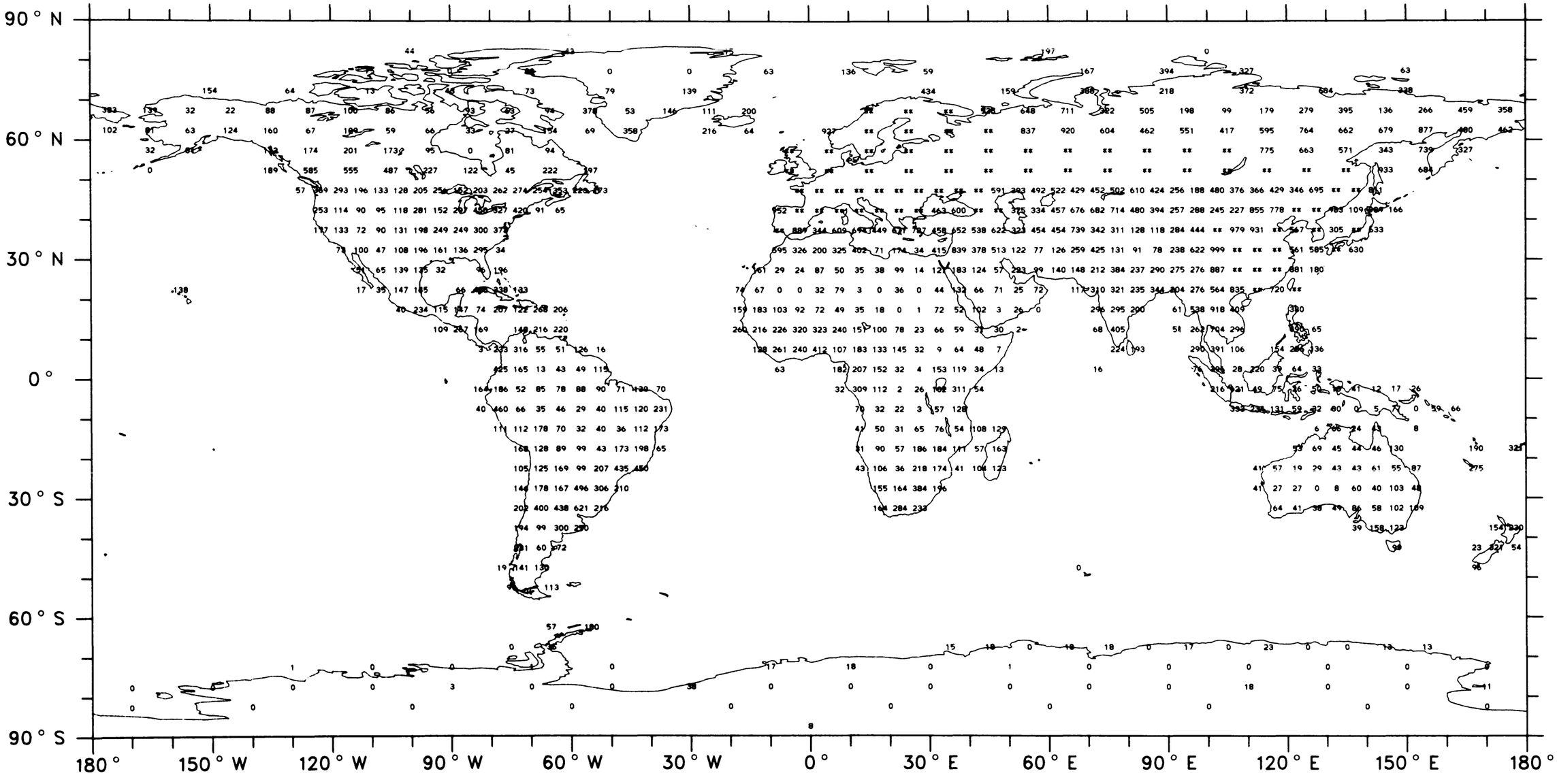


Map II-1

Number of Synoptic Cloud Reports from Land Stations (in Hundreds)

March, April, May (1971-1980)

Land Areas Only



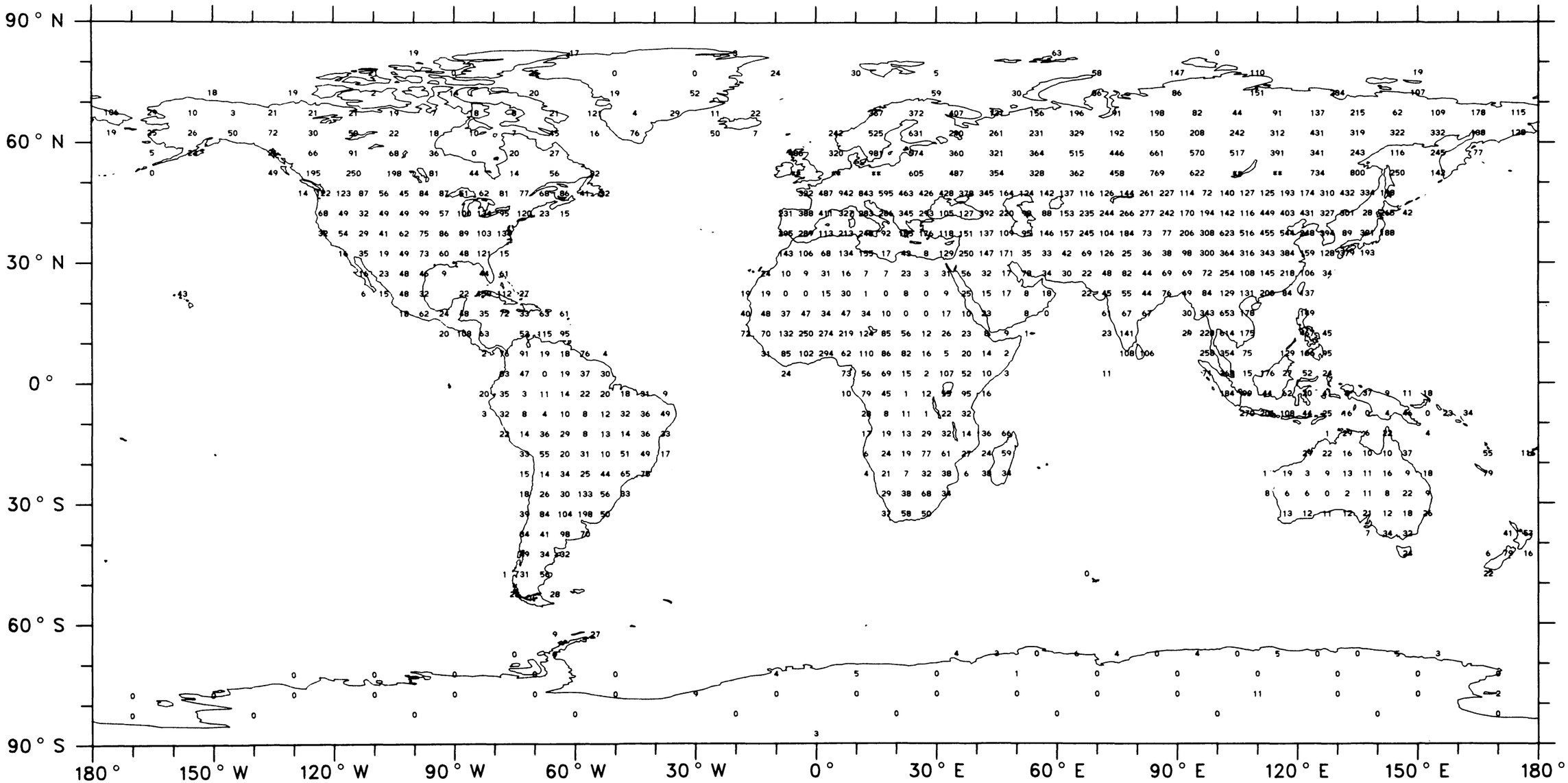
Map II-2

Map II-2

Number of Observations of Cirrus, Cirrostratus, or Cirrocumulus (in Hundreds)

March, April, May (1971-1980)

Land Areas Only



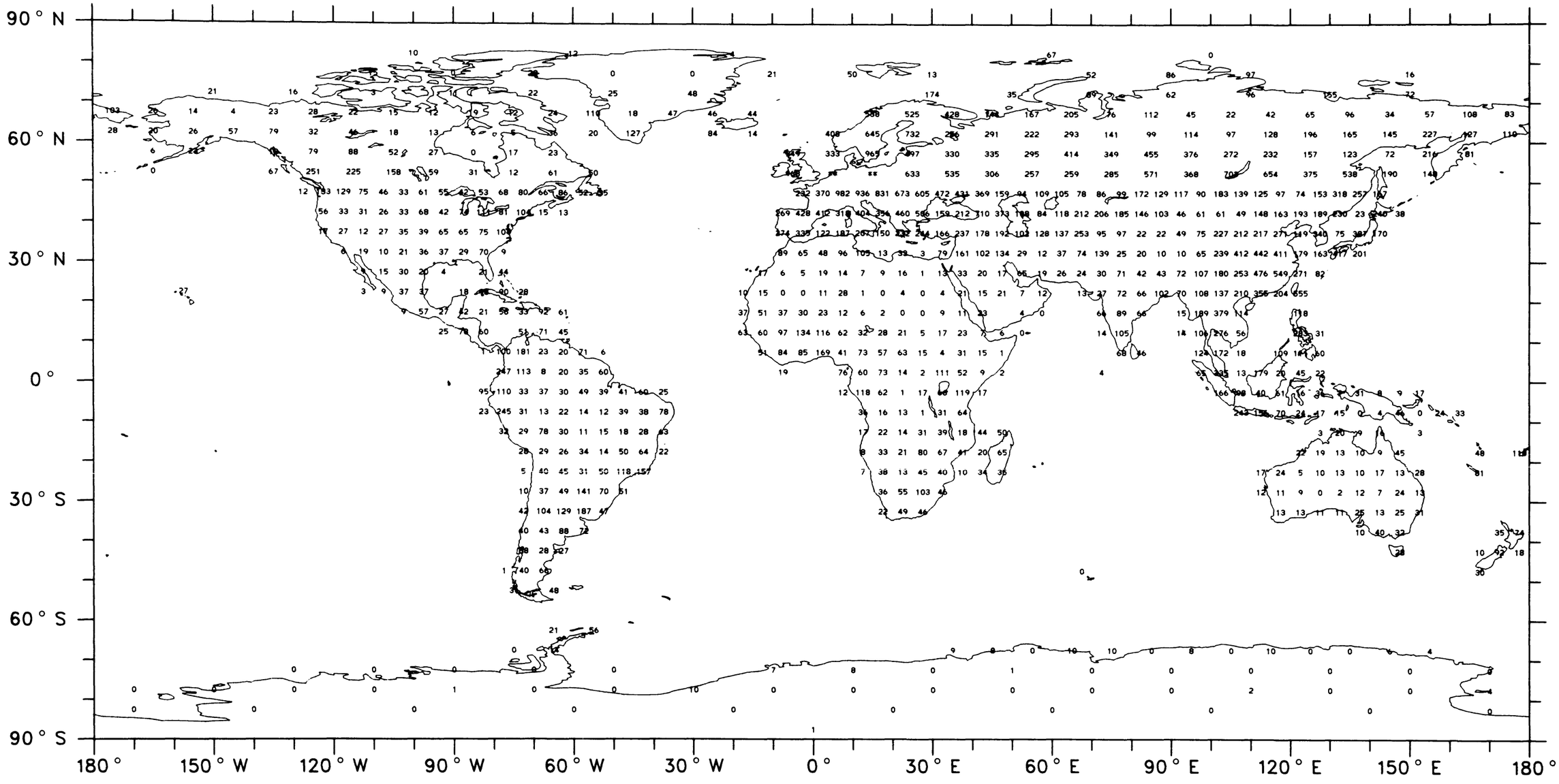
Map II-3

Map II-3

Number of Observations of Altostratus or Altocumulus (in Hundreds)

March, April, May (1971-1980)

Land Areas Only

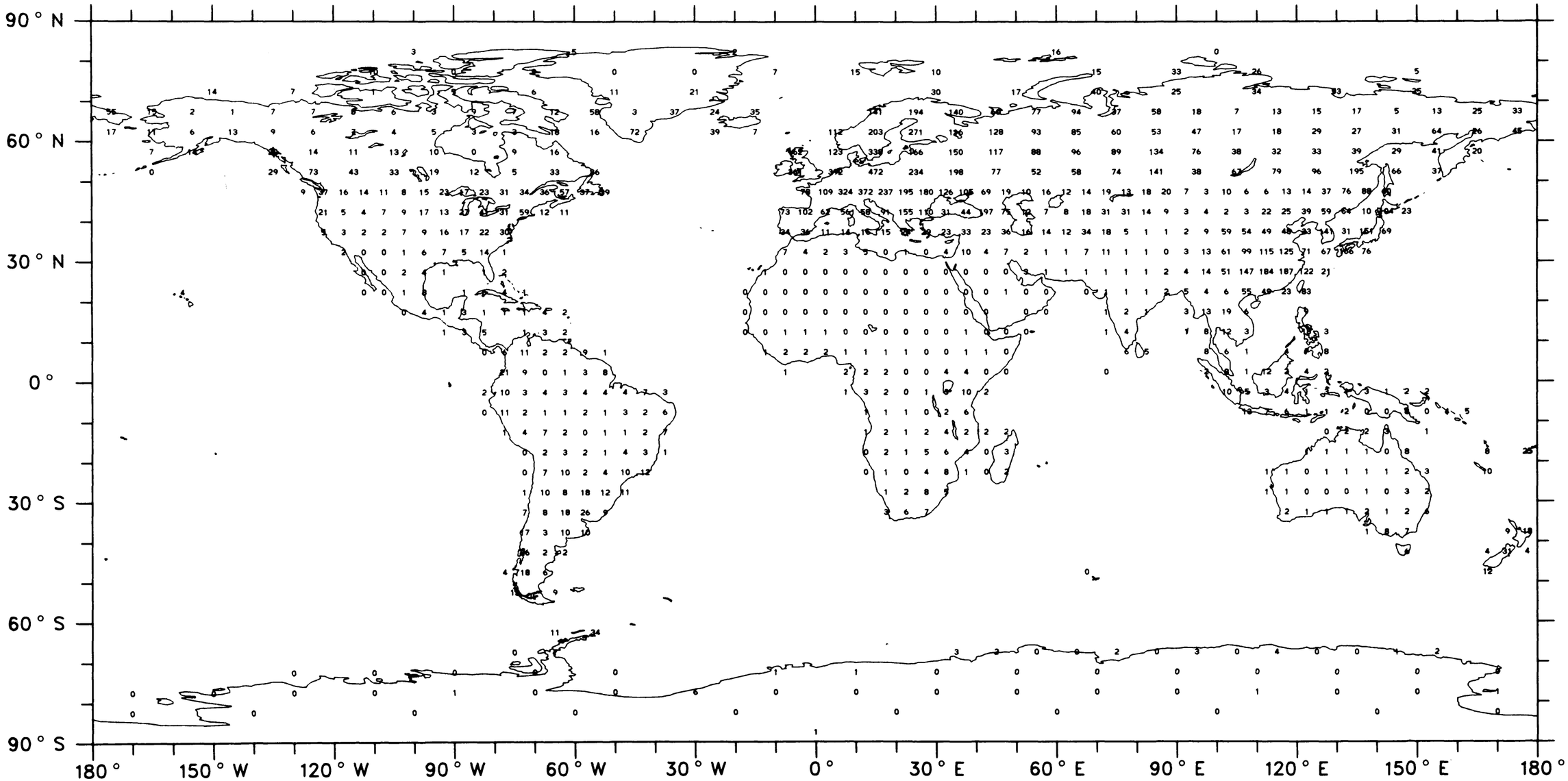


Map II-4

Number of Observations of Nimbostratus (in Hundreds)

March, April, May (1971-1980)

Land Areas Only



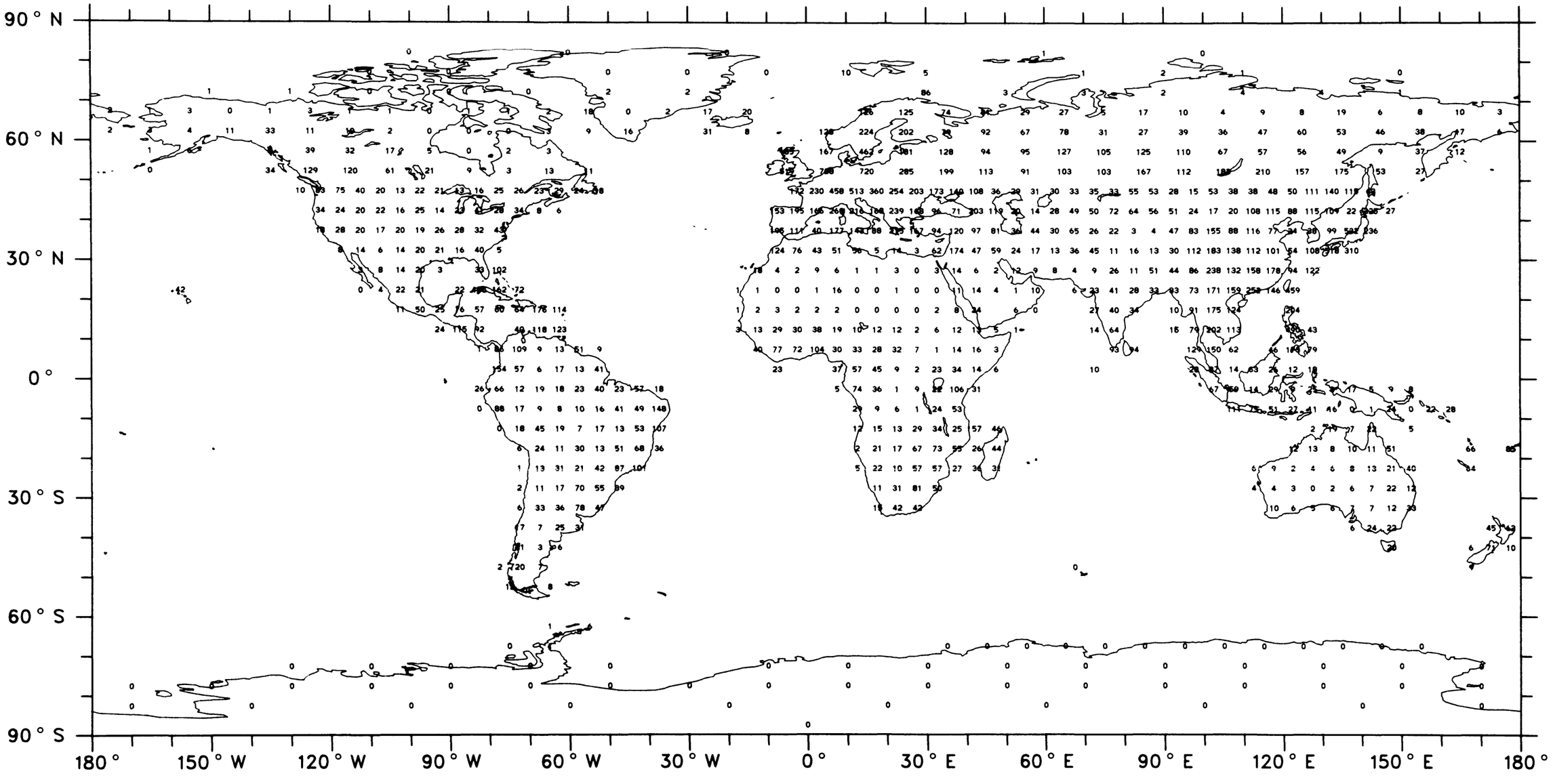
Map II-5

Map II-5

Number of Observations of Cumulus (in Hundreds)

March, April, May (1971-1980)

Land Areas Only

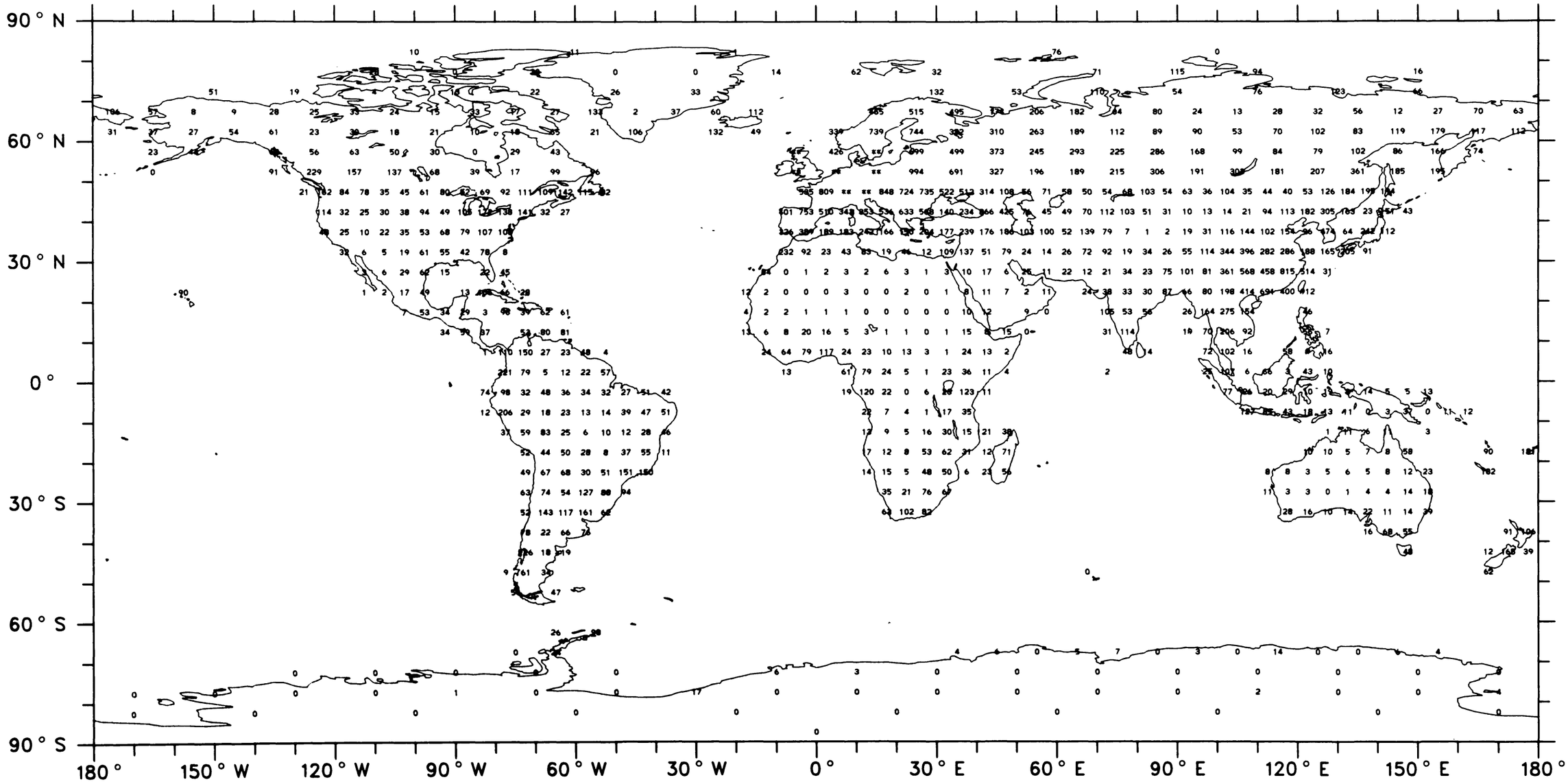


Map II-6

Number of Observations of Stratus or Stratocumulus (in Hundreds)

March, April, May (1971-1980)

Land Areas Only

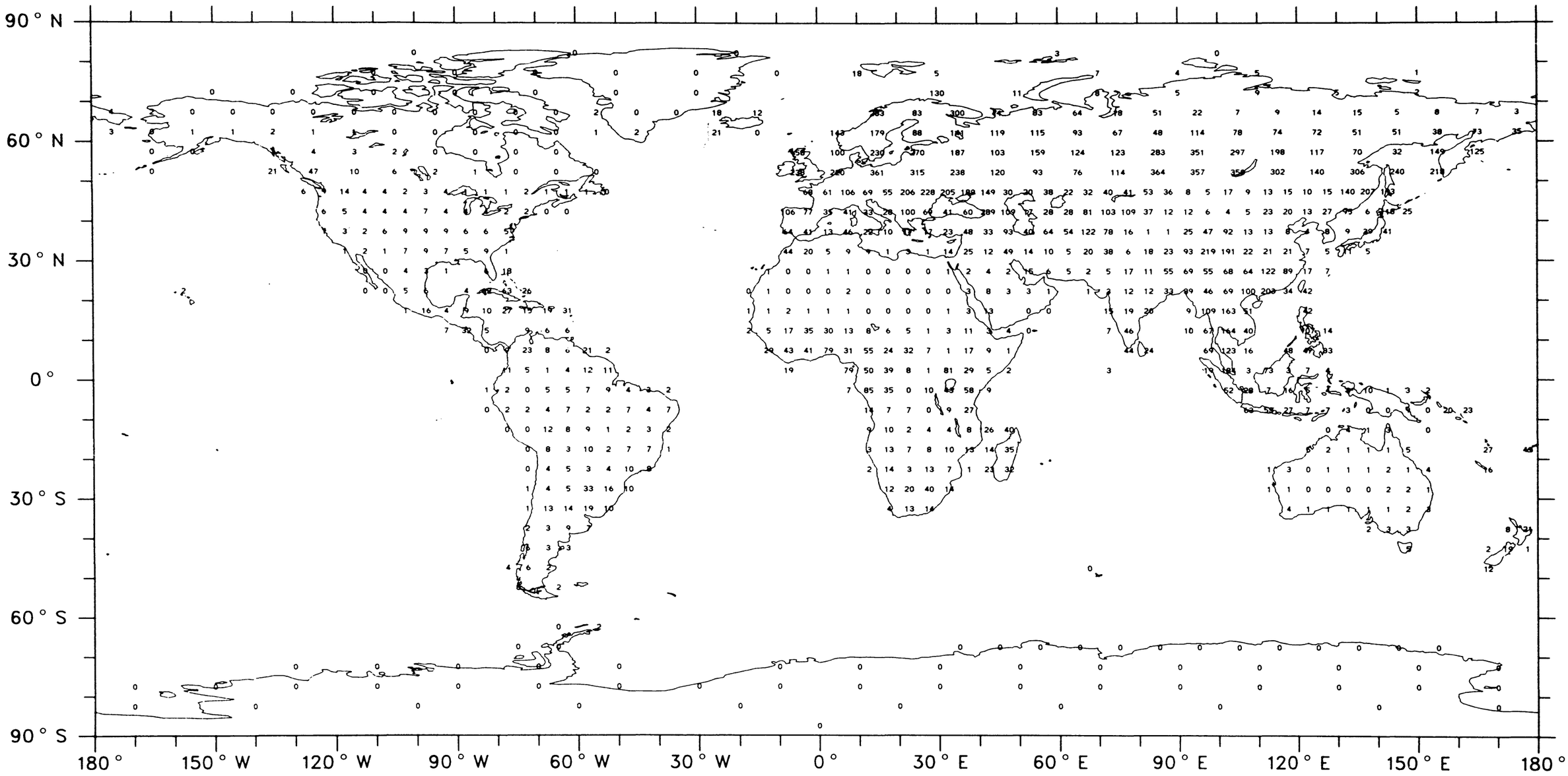


Map II-7

Number of Observations of Cumulonimbus (in Hundreds)

March, April, May (1971-1980)

Land Areas Only

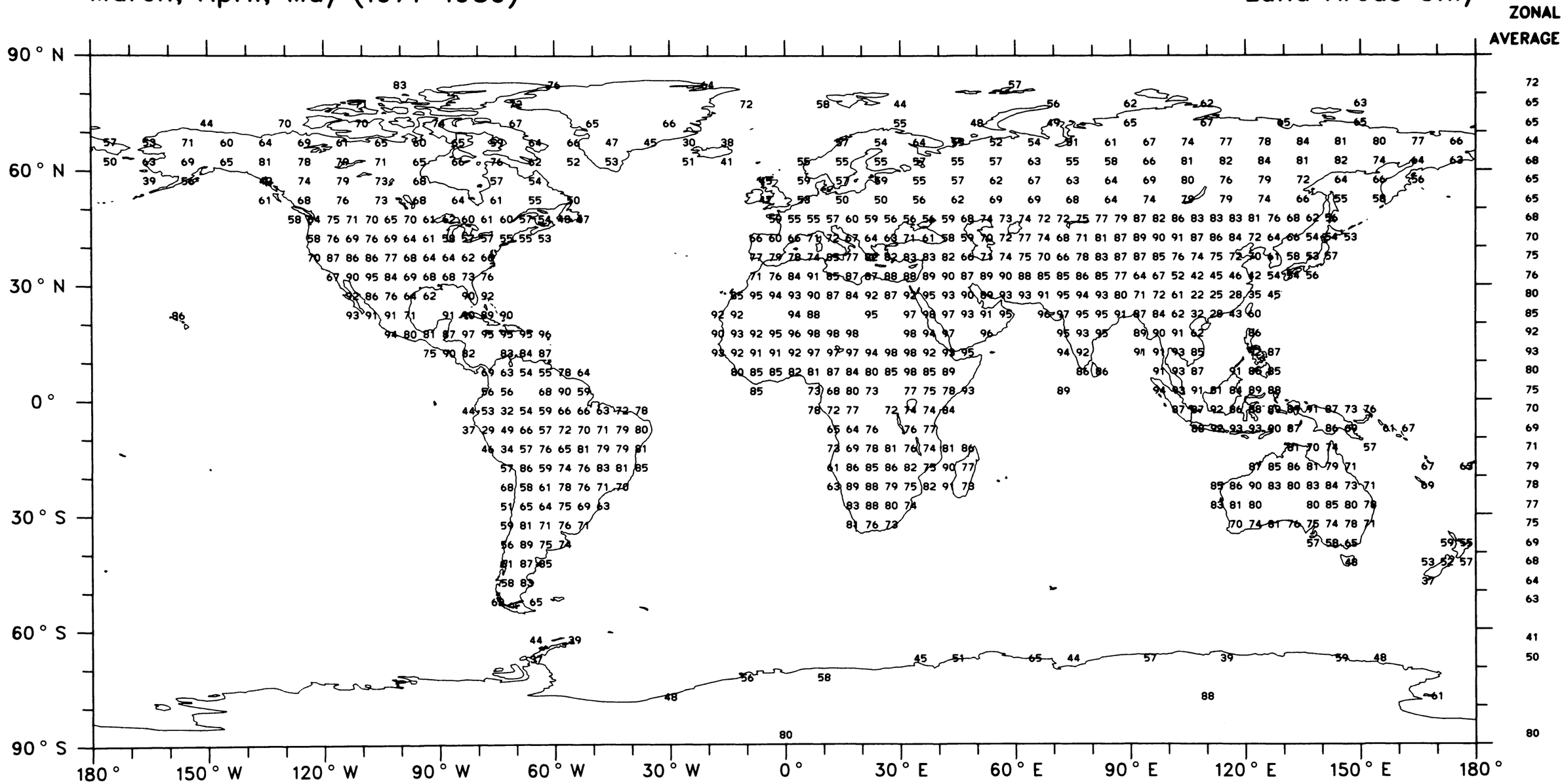


Map II-8

Percent of Land Station Reports Contributing to Statistics of the High Cloud Level

March, April, May (1971-1980)

Land Areas Only

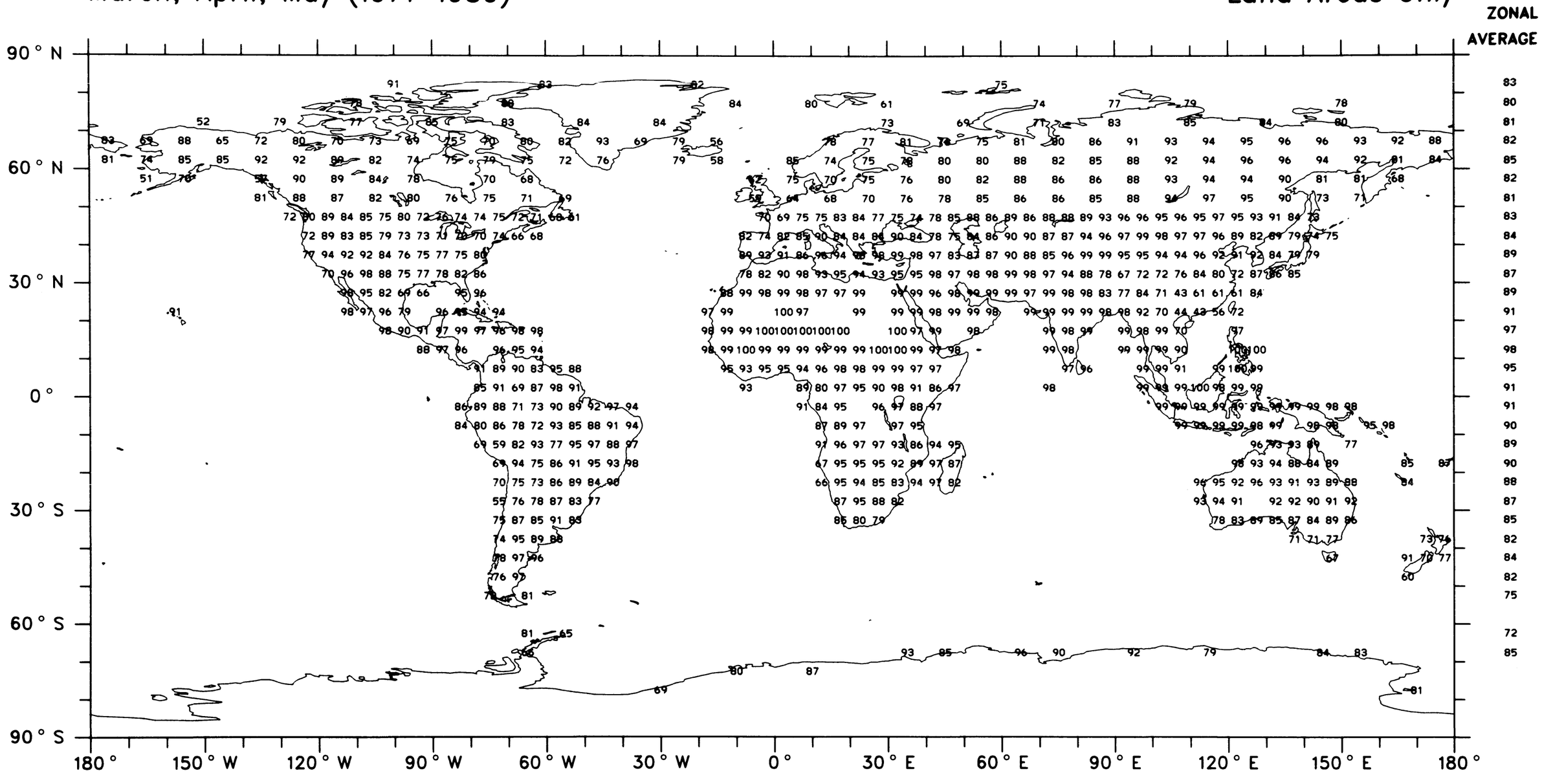


Map II-9

Percent of Land Station Reports Contributing to Statistics of the Middle Cloud Level

March, April, May (1971-1980)

Land Areas Only

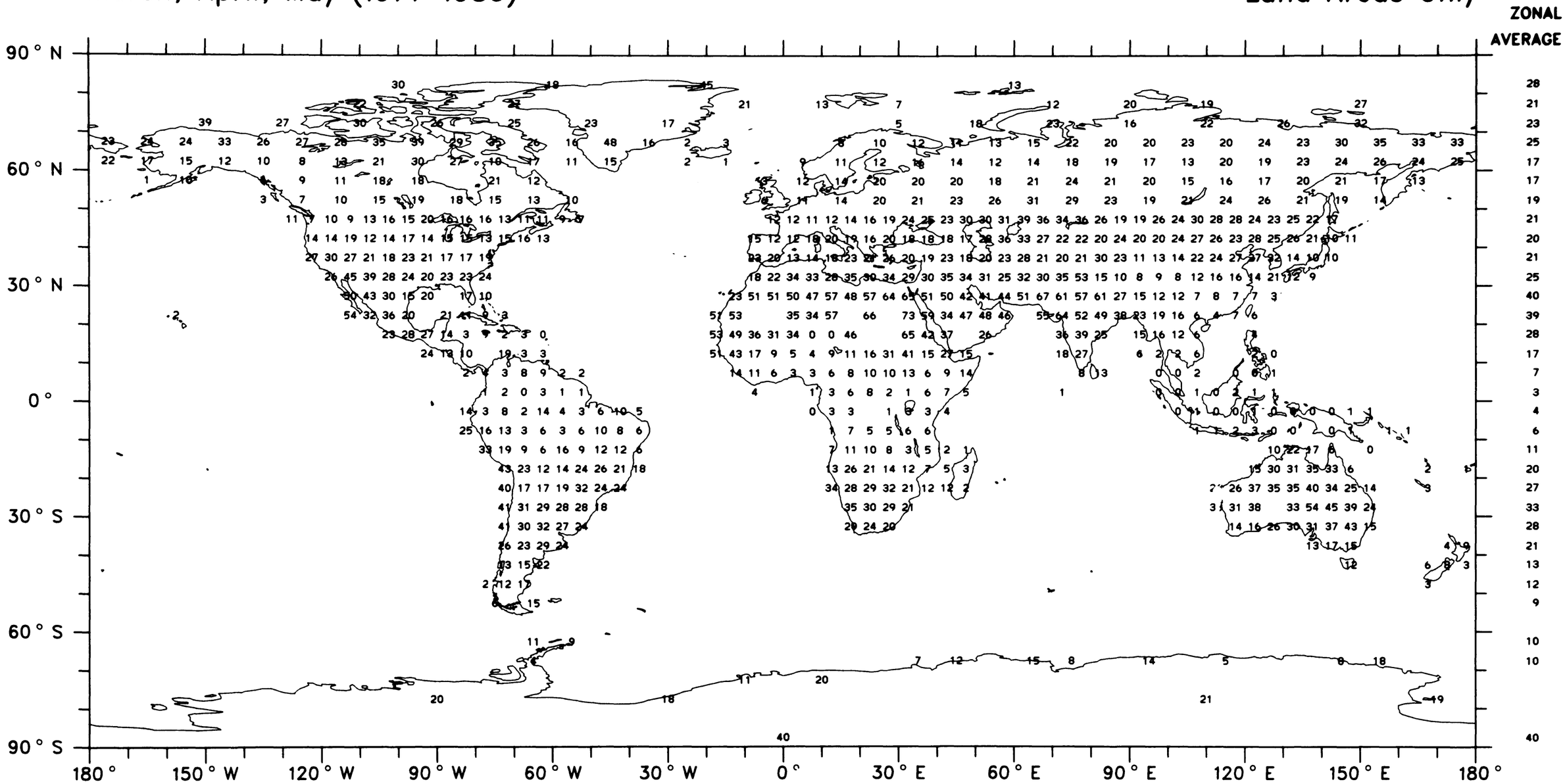


Map II-10

Frequency of Occurrence (Percent) of Completely Clear Sky

March, April, May (1971-1980)

Land Areas Only

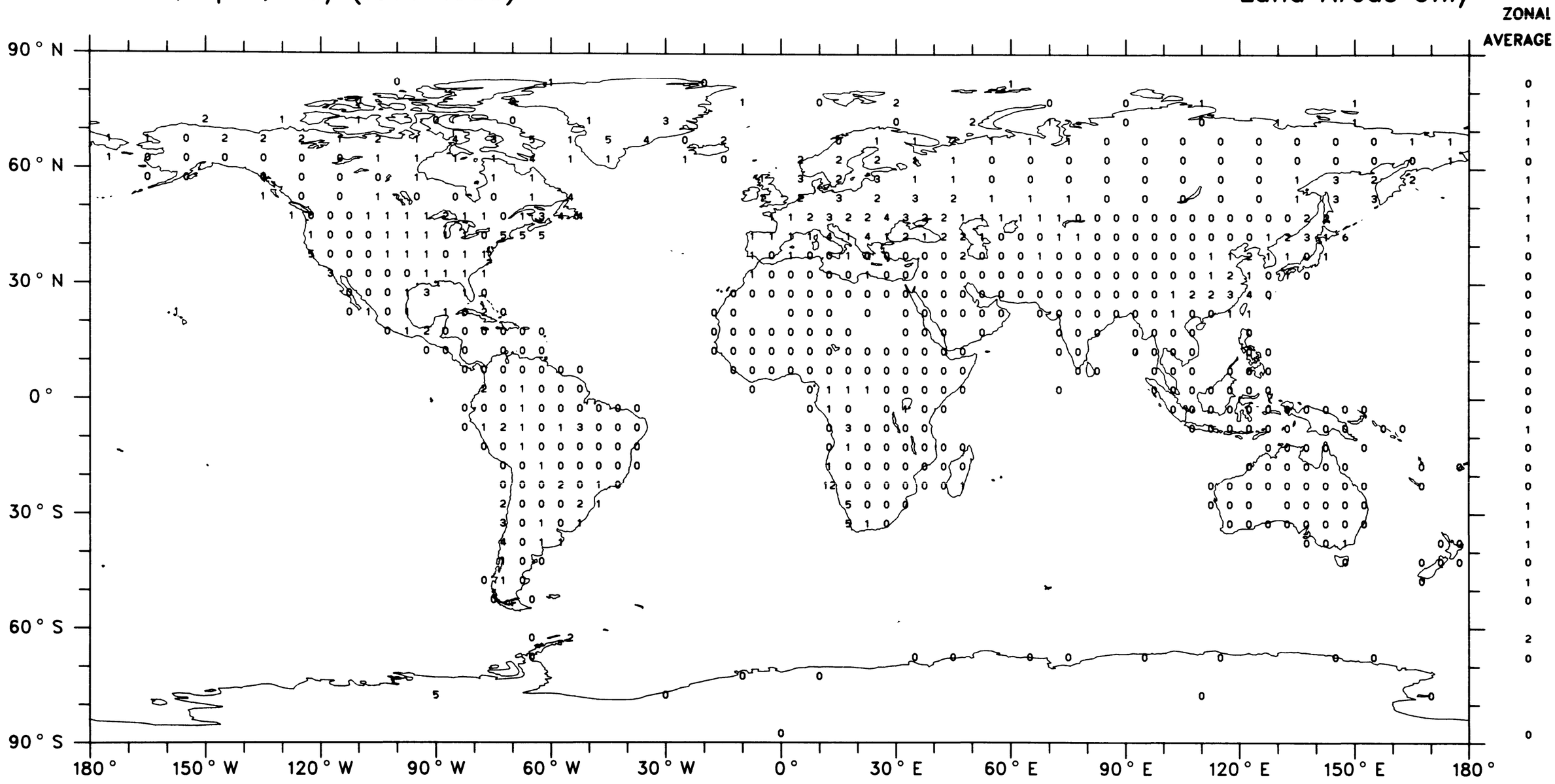


Map II-11

Frequency of Occurrence (Percent) of Sky Obscured due to Fog

March, April, May (1971-1980)

Land Areas Only

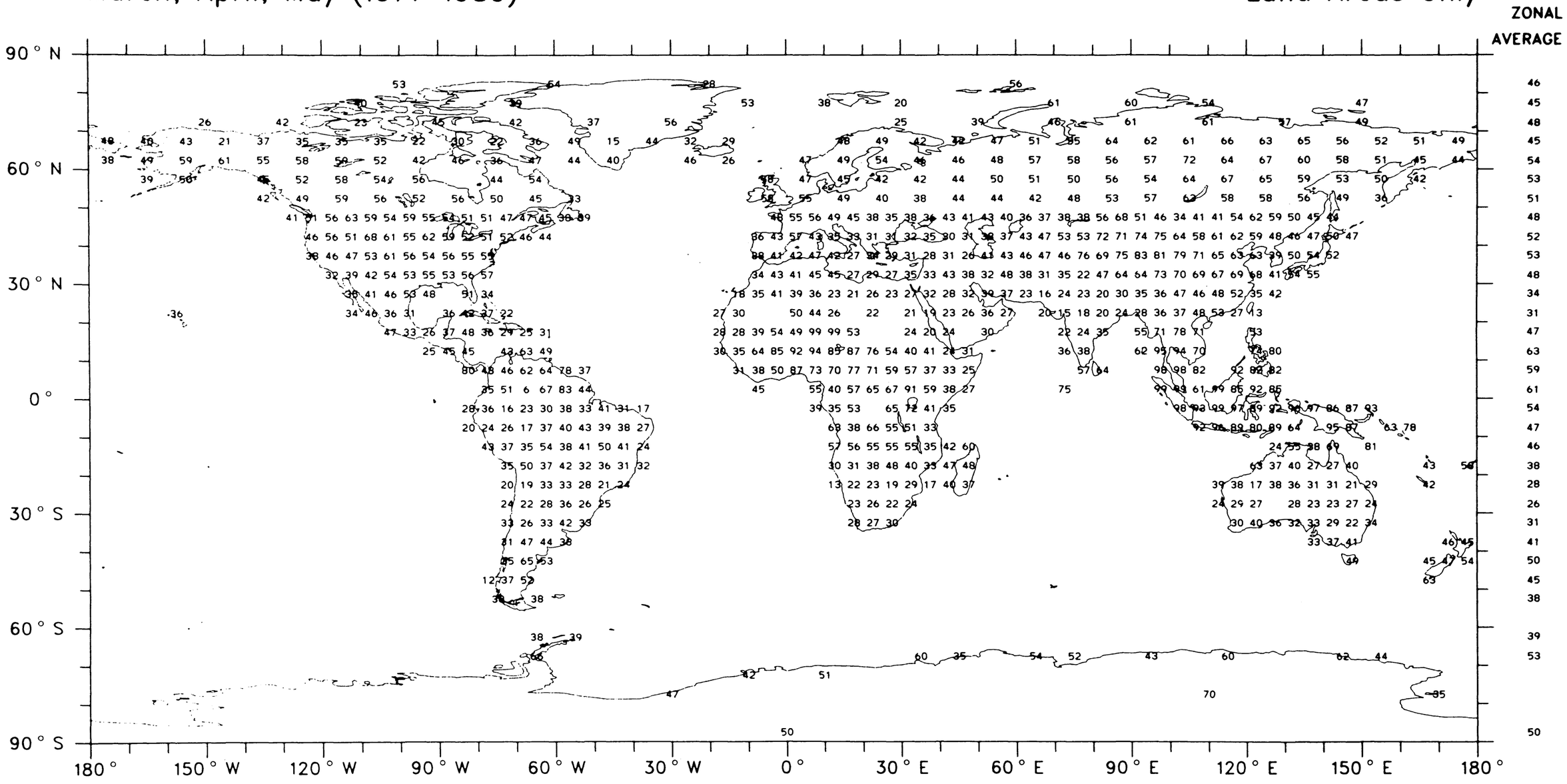


Map II-12

Frequency of Occurrence (Percent) of Ci/Cs/Cc

March, April, May (1971-1980)

Land Areas Only

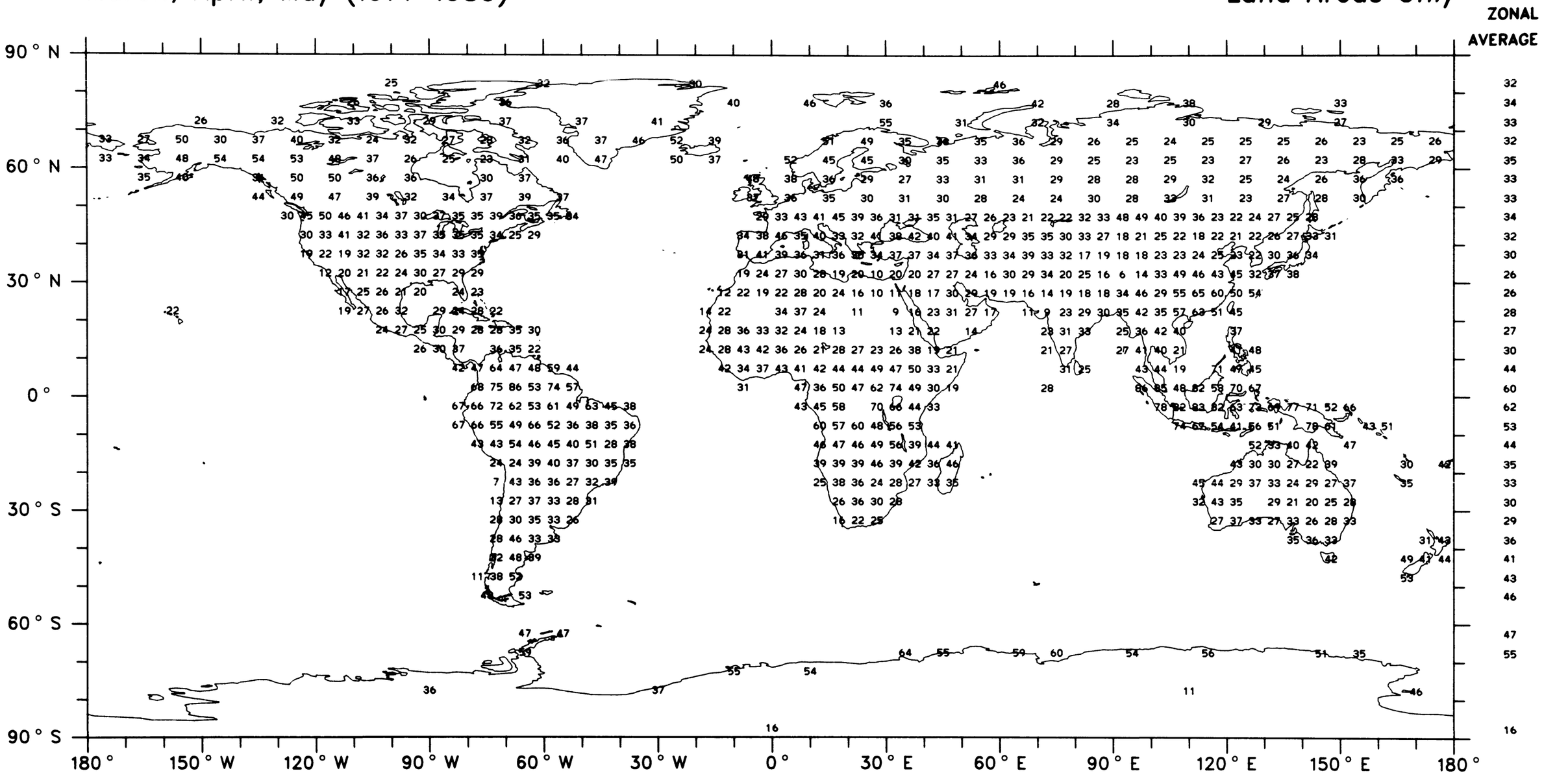


Map II-13

Frequency of Occurrence (Percent) of As/Ac

March, April, May (1971-1980)

Land Areas Only

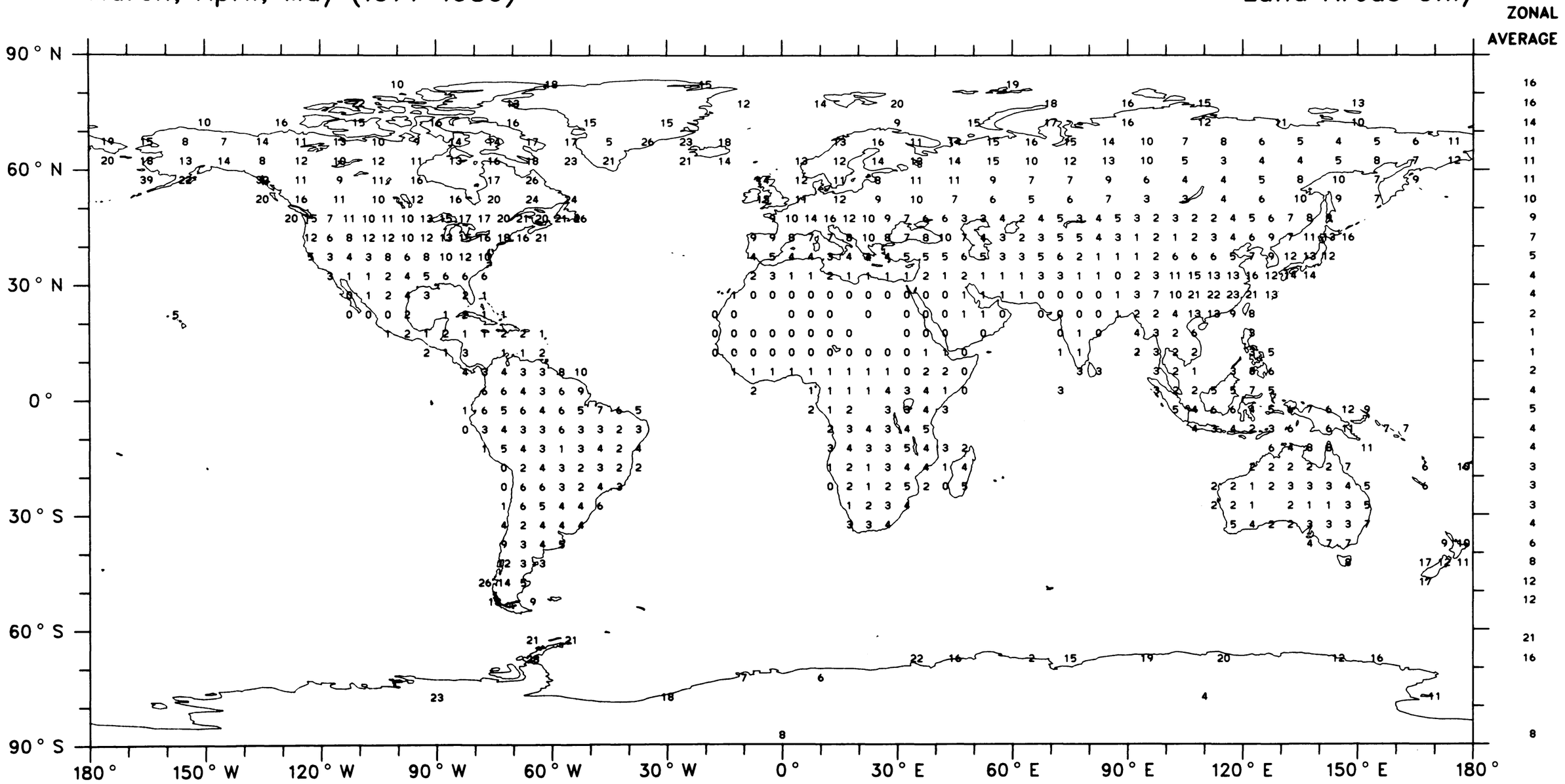


Map II-14

Frequency of Occurrence (Percent) of Nimbostratus

March, April, May (1971-1980)

Land Areas Only

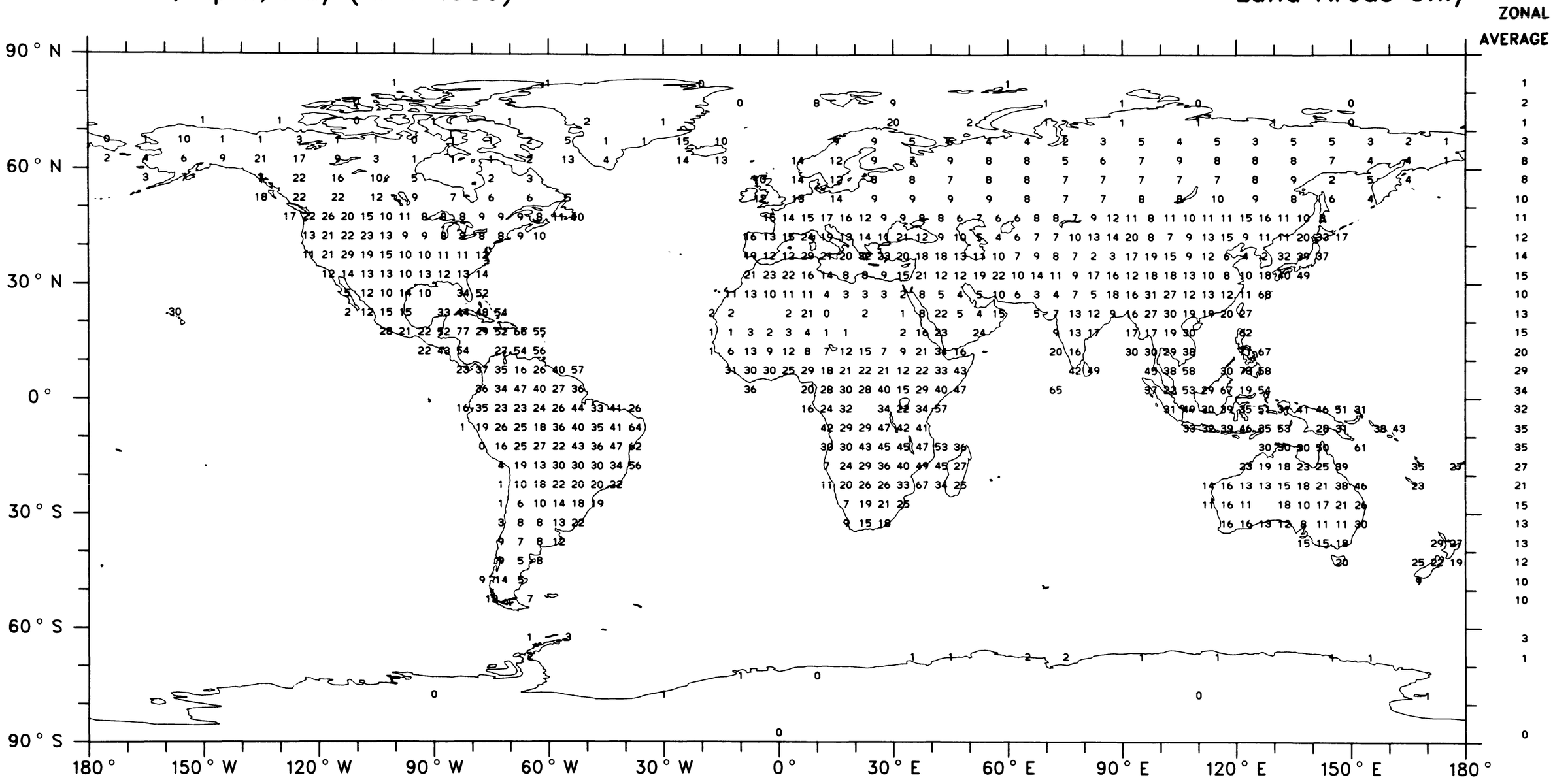


Map 11-15

Frequency of Occurrence (Percent) of Cumulus

March, April, May (1971-1980)

Land Areas Only

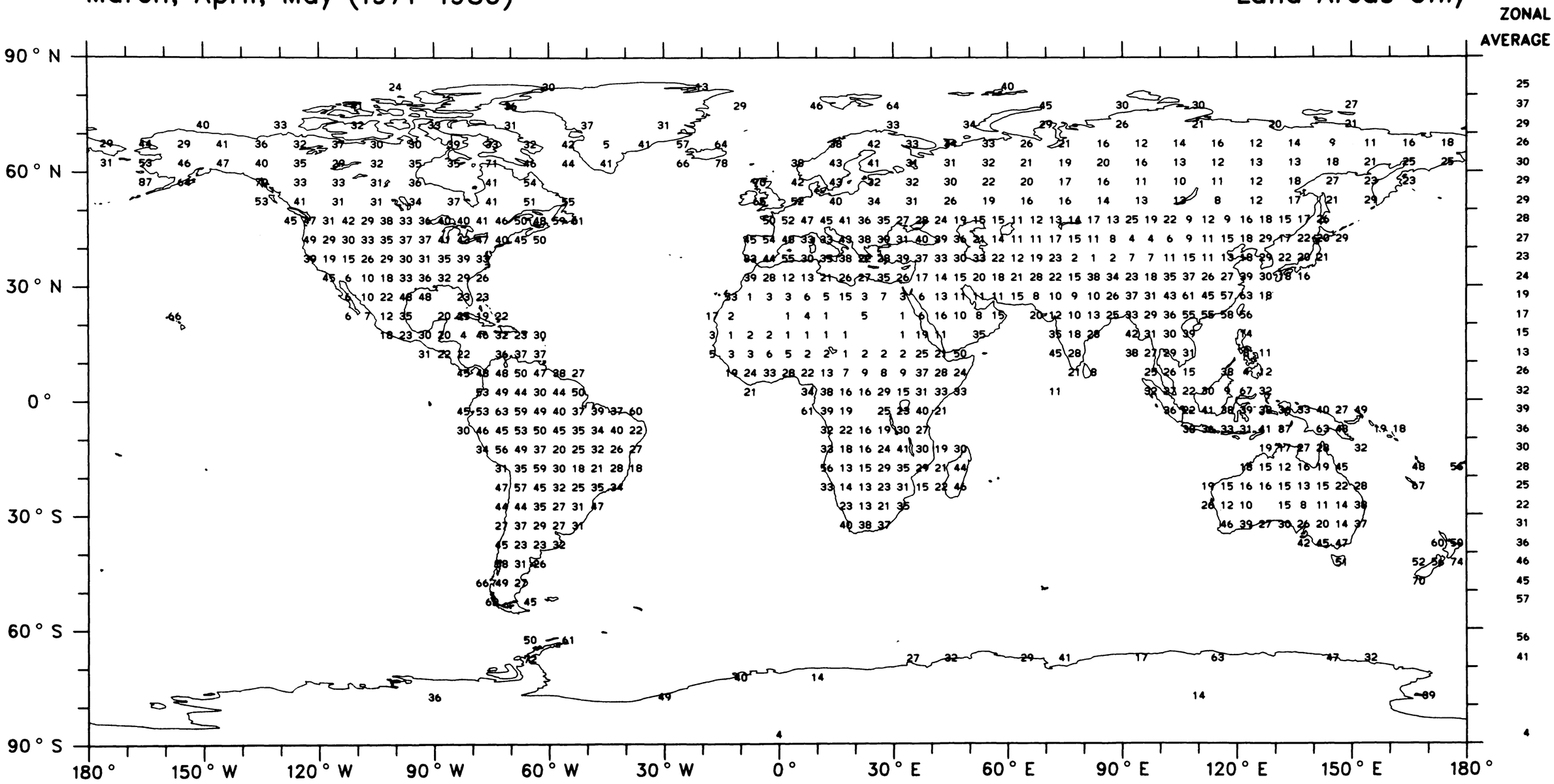


Map II-16

Frequency of Occurrence (Percent) of St/Sc

March, April, May (1971-1980)

Land Areas Only

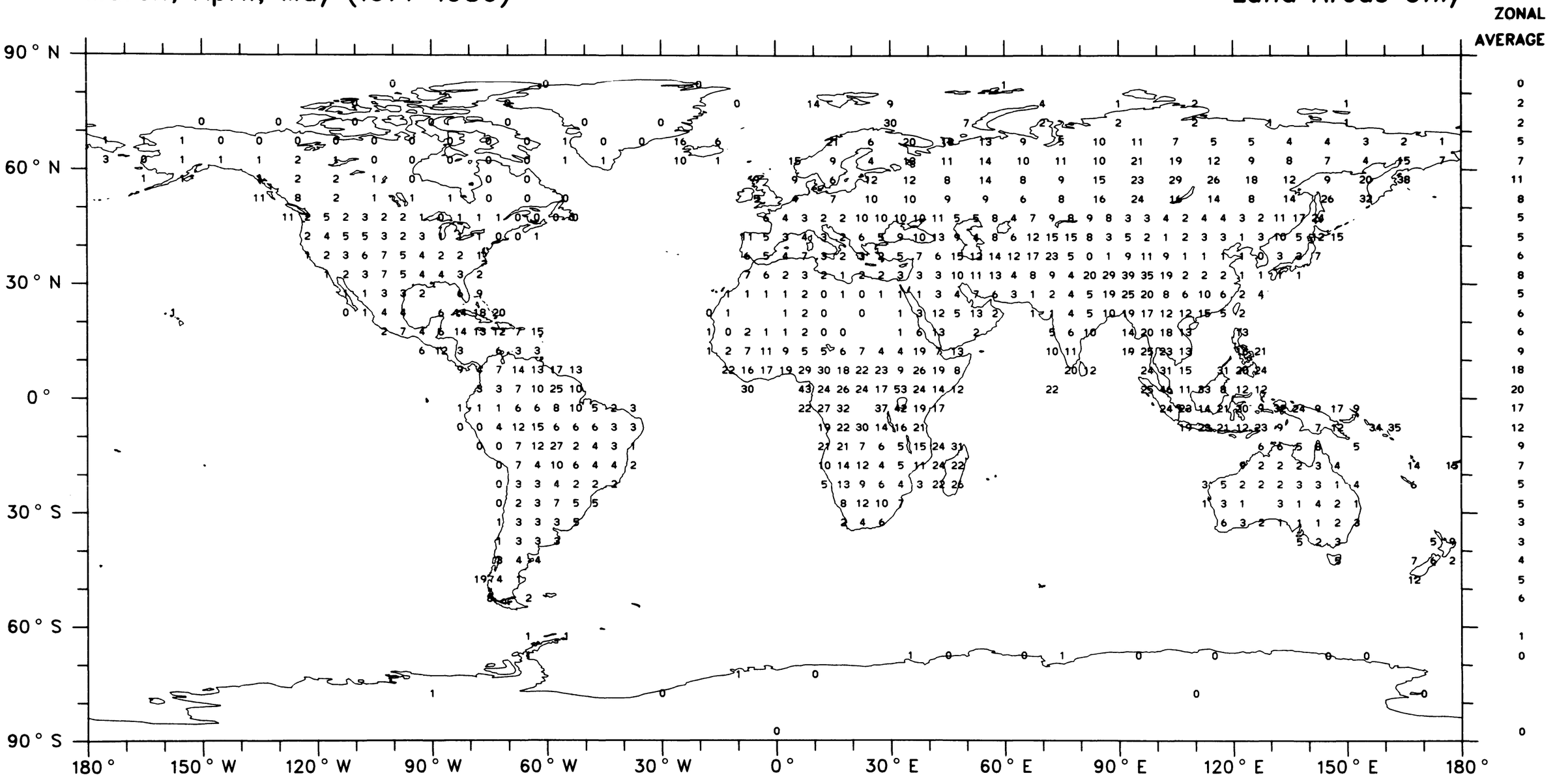


Map II-17

Frequency of Occurrence (Percent) of Cumulonimbus

March, April, May (1971-1980)

Land Areas Only

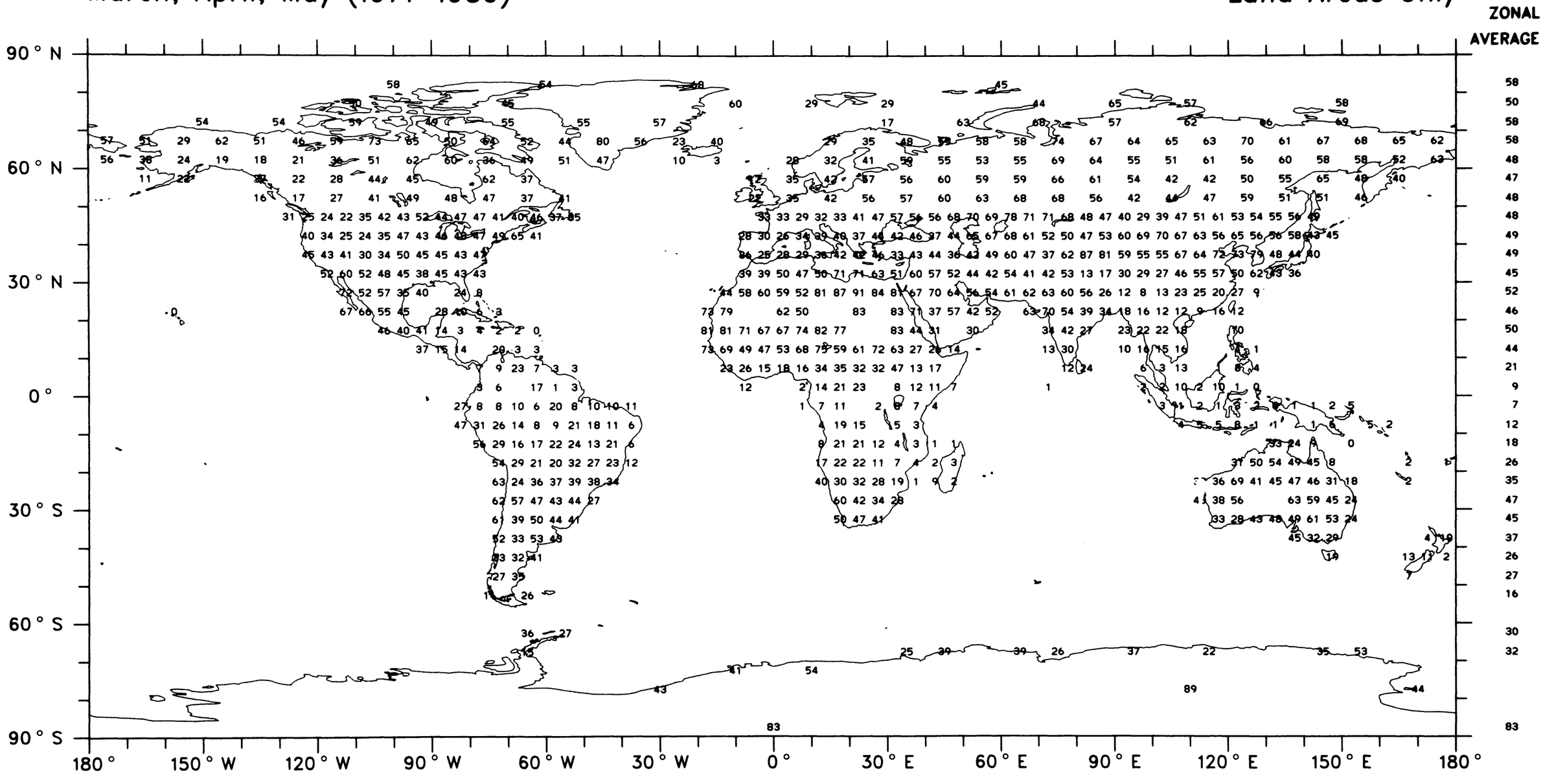


Map 11-18

Given Ci/Cs/Cc, Probability (Percent) That No Other Cloud Is Present

March, April, May (1971-1980)

Land Areas Only

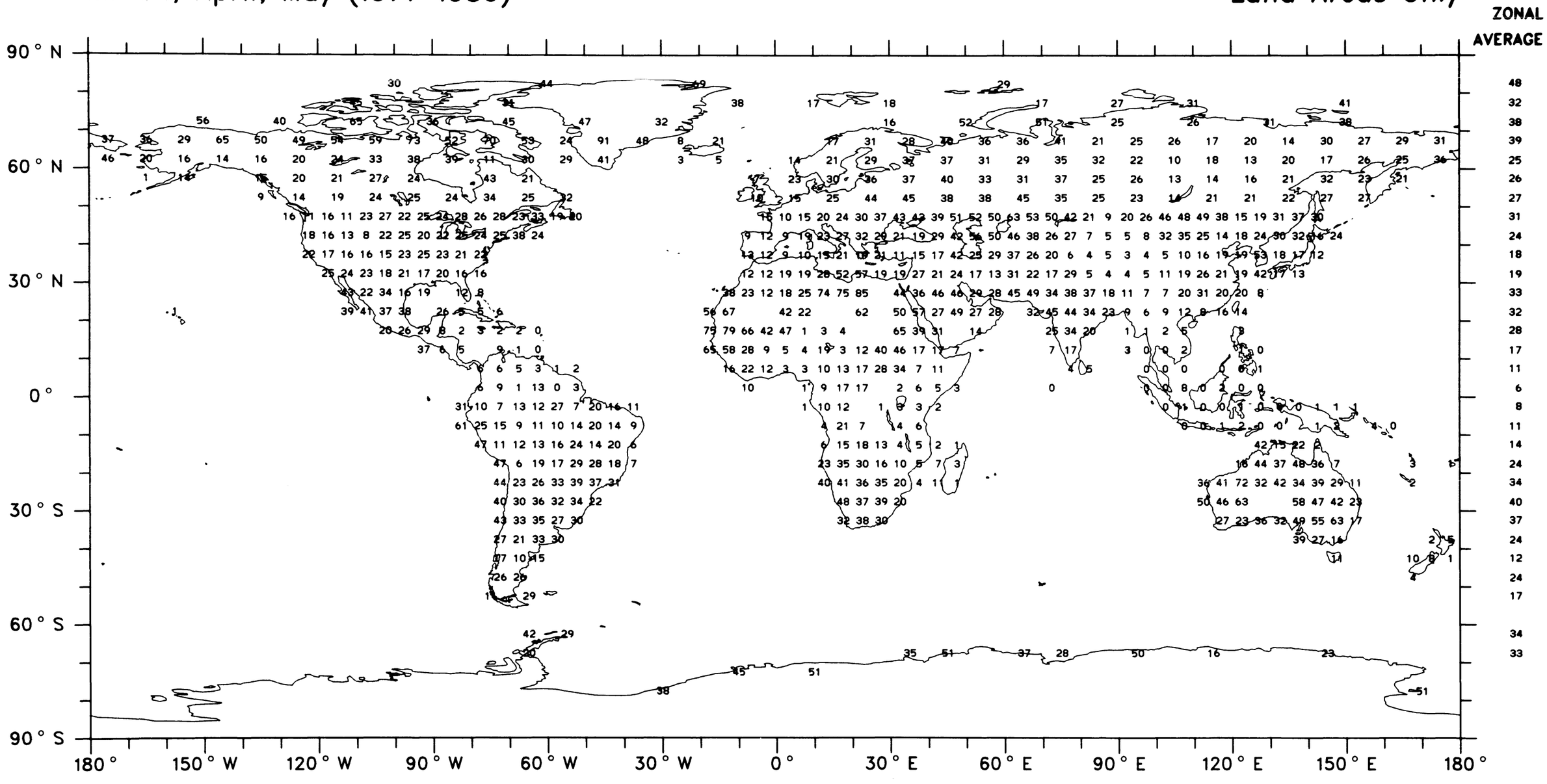


Map II-19

Given As/Ac, Probability (Percent) That No Other Cloud Is Present

March, April, May (1971-1980)

Land Areas Only

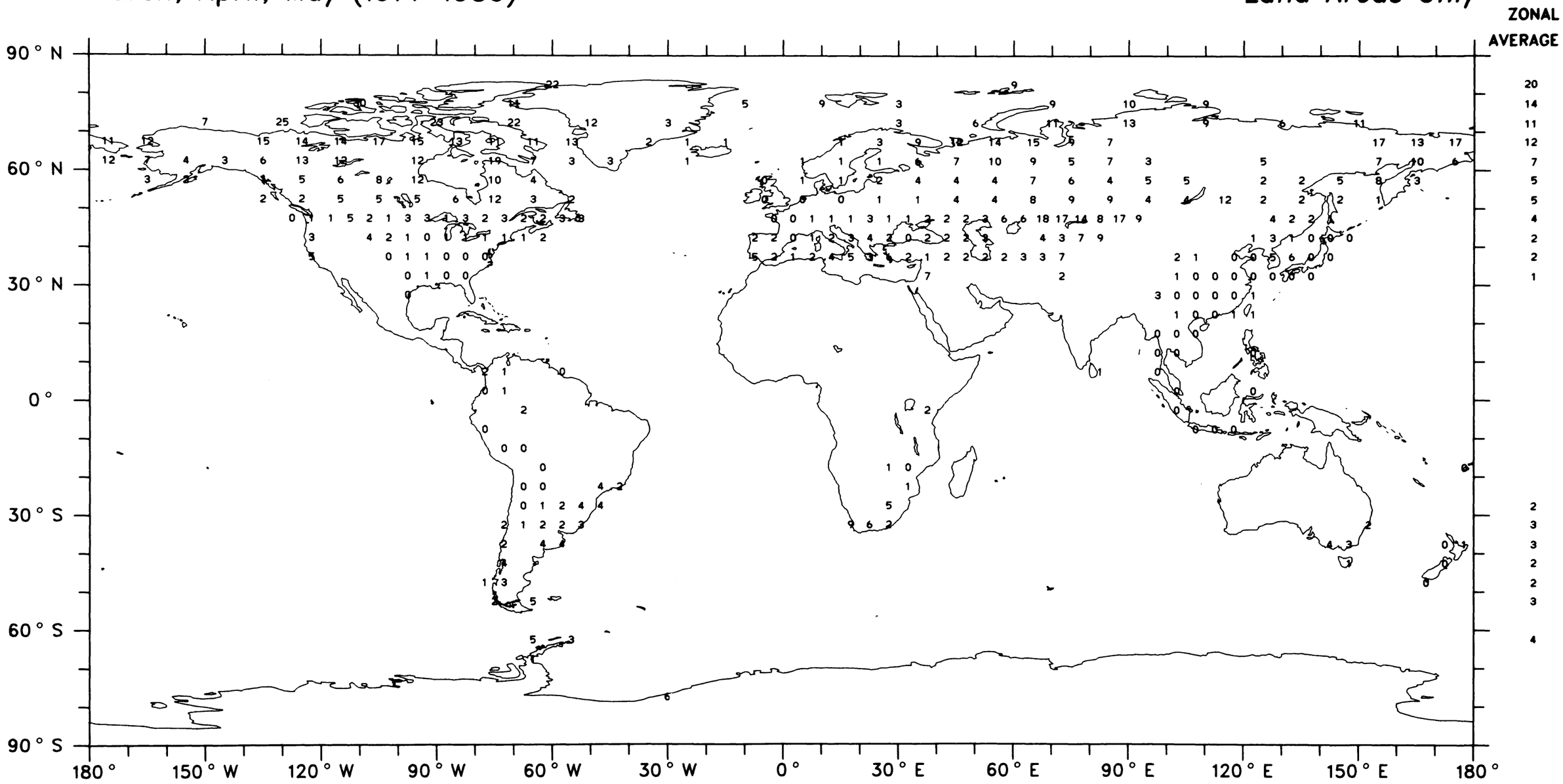


Map II-20

Given Nimbostratus, Probability (Percent) That No Other Cloud Is Present

March, April, May (1971-1980)

Land Areas Only

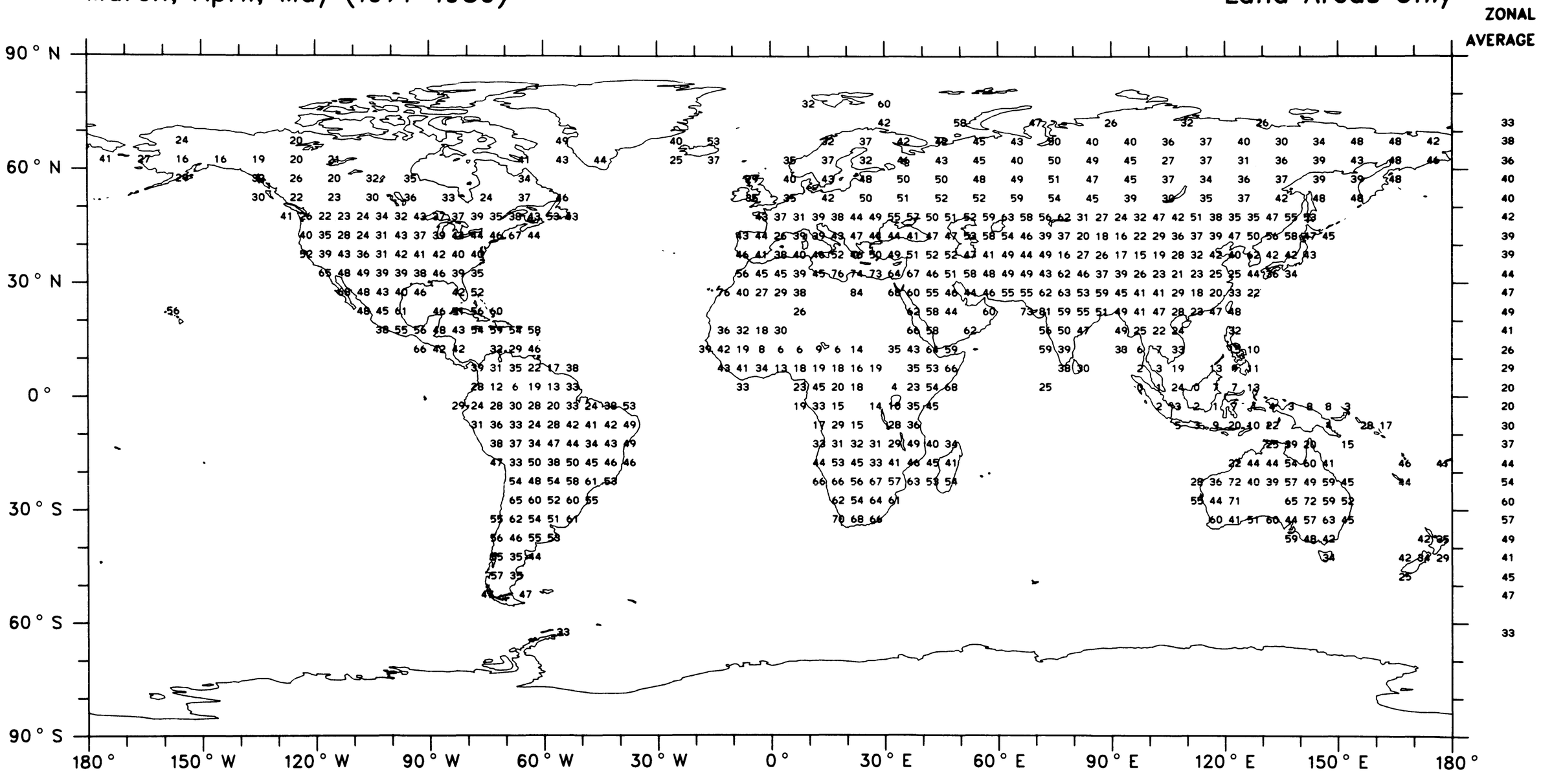


Map II-21

Given Cumulus, Probability (Percent) That No Other Cloud Is Present

March, April, May (1971-1980)

Land Areas Only

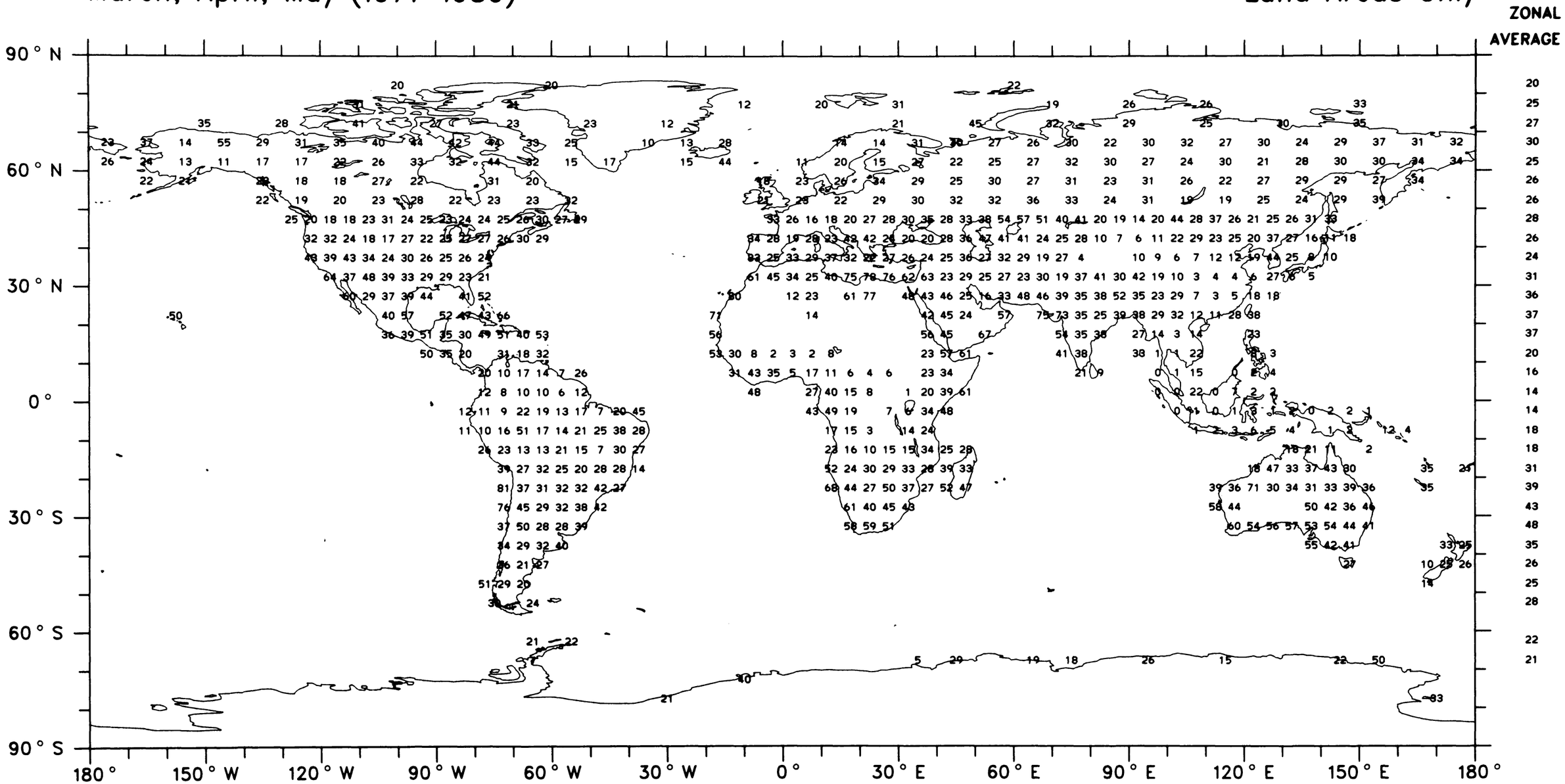


Map II-22

Given St/Sc, Probability (Percent) That No Other Cloud Is Present

March, April, May (1971-1980)

Land Areas Only

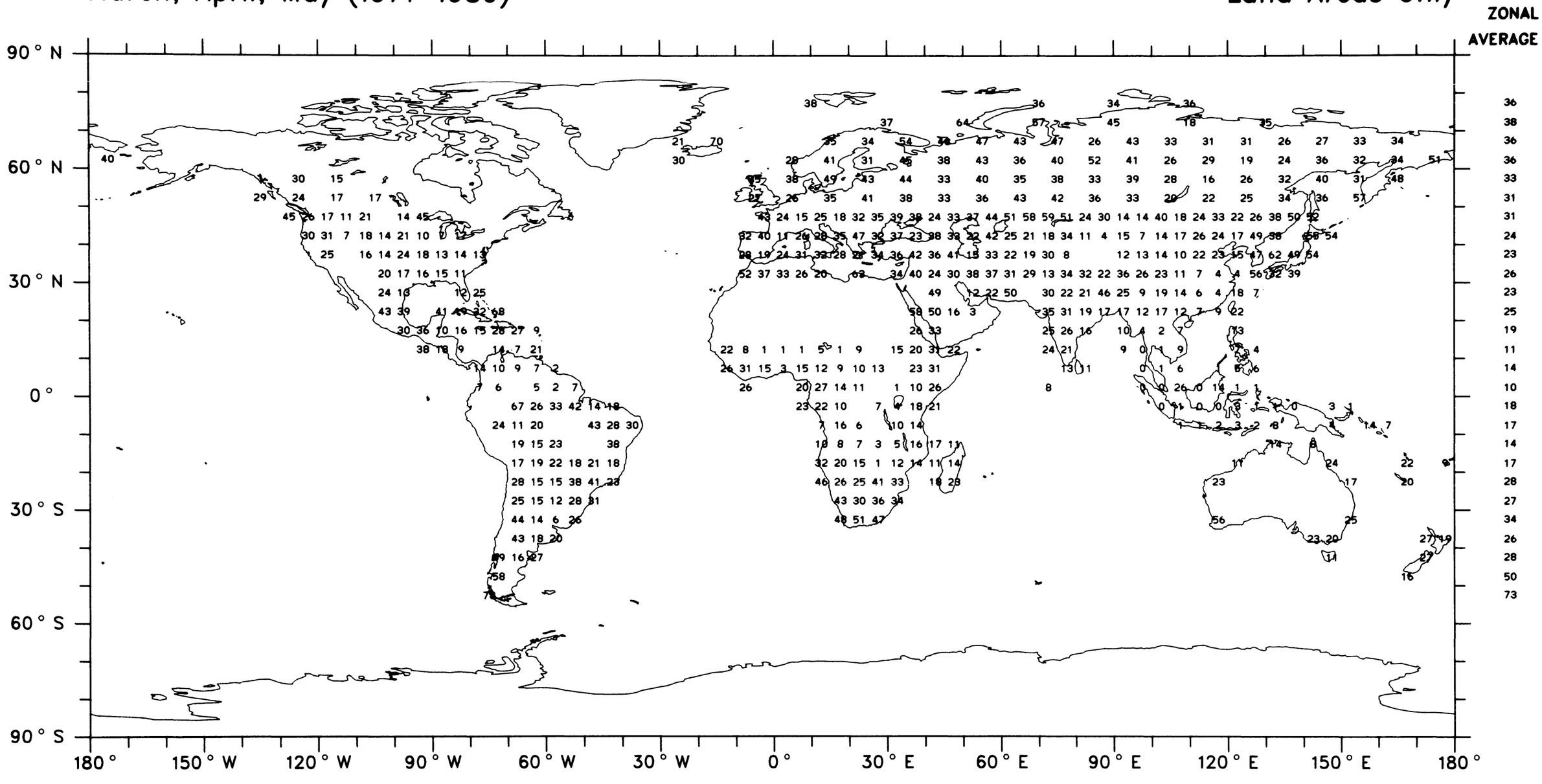


Map II-23

Given Cumulonimbus, Probability (Percent) That No Other Cloud Is Present

March, April, May (1971-1980)

Land Areas Only



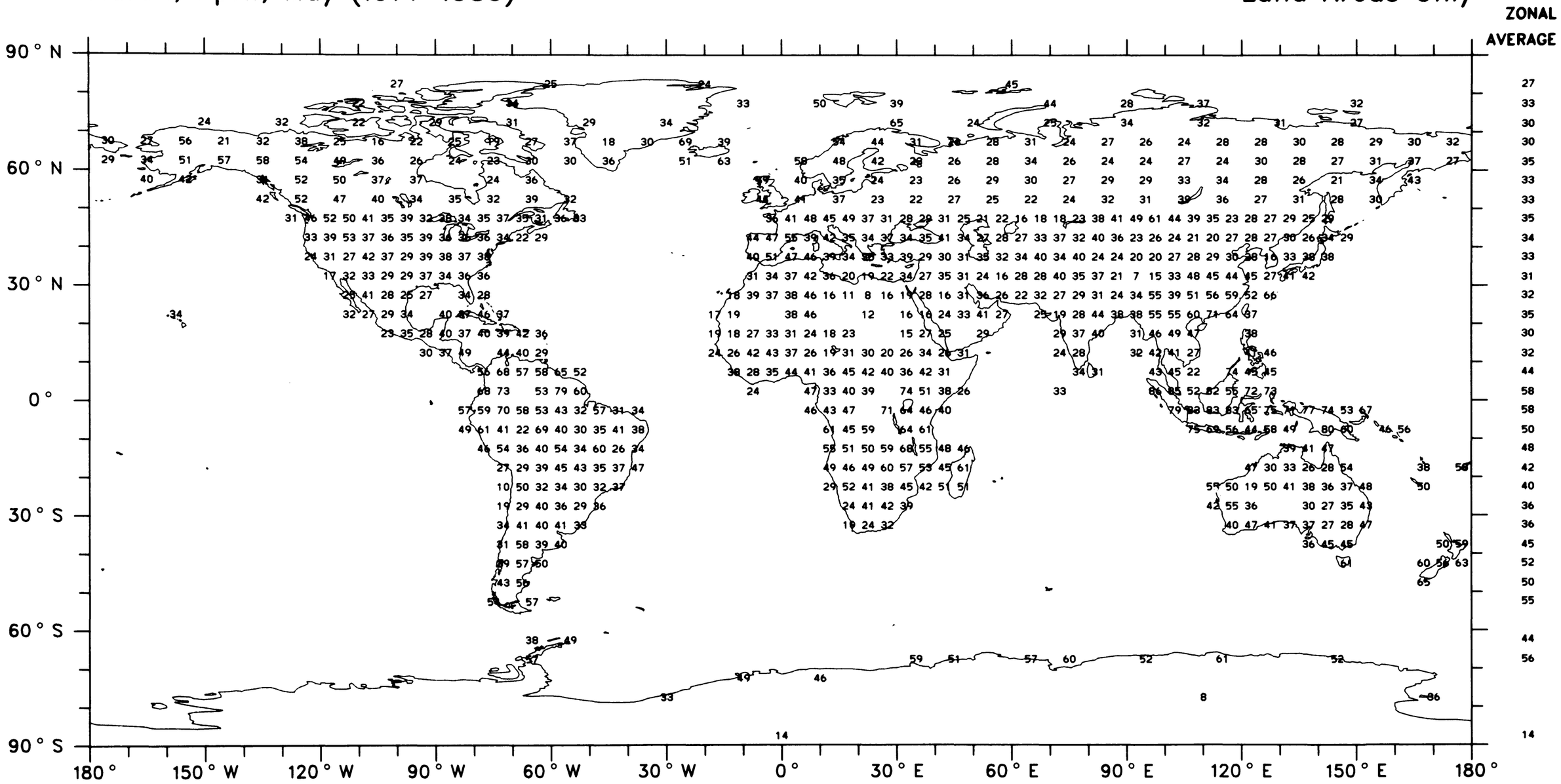
Map II-24

Map II-24

Given Ci/Cs/Cc, Probability (Percent) That As/Ac is Also Present

March, April, May (1971-1980)

Land Areas Only

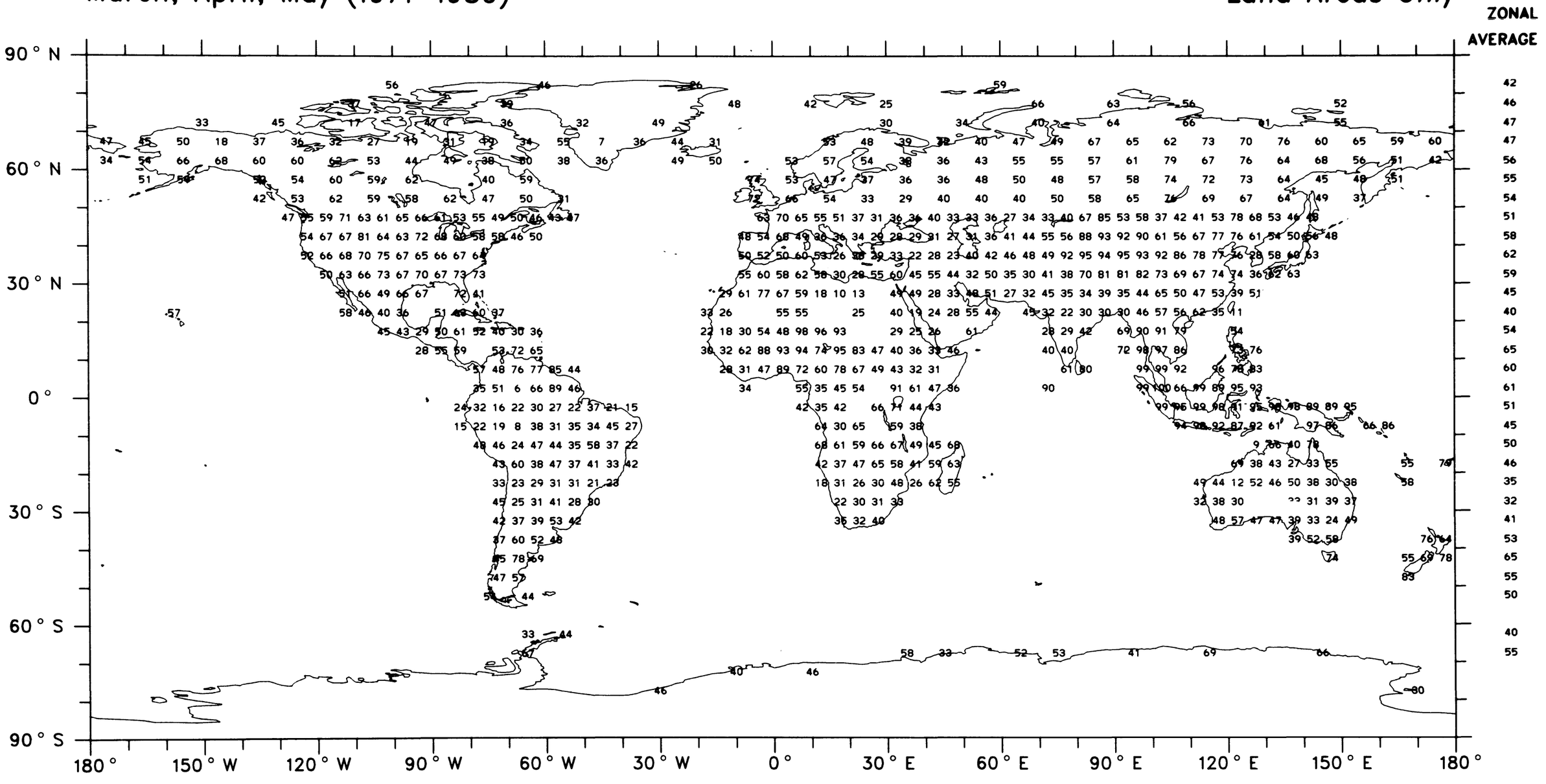


Map II-25

Given As/Ac, Probability (Percent) That Ci/Cs/Cc is Also Present

March, April, May (1971-1980)

Land Areas Only

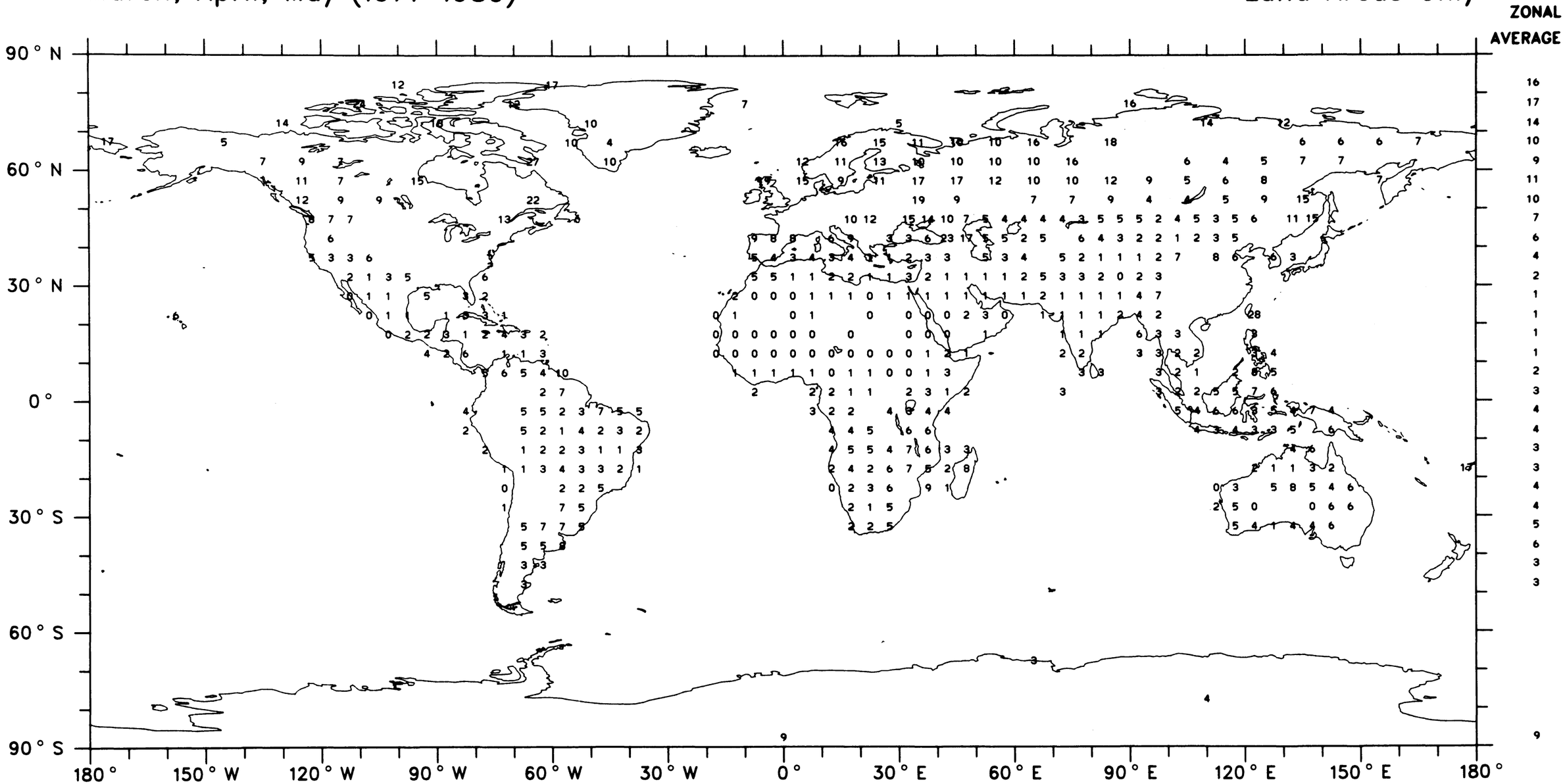


Map II-26

Given Ci/Cs/Cc, Probability (Percent) That Nimbostratus is Also Present

March, April, May (1971-1980)

Land Areas Only

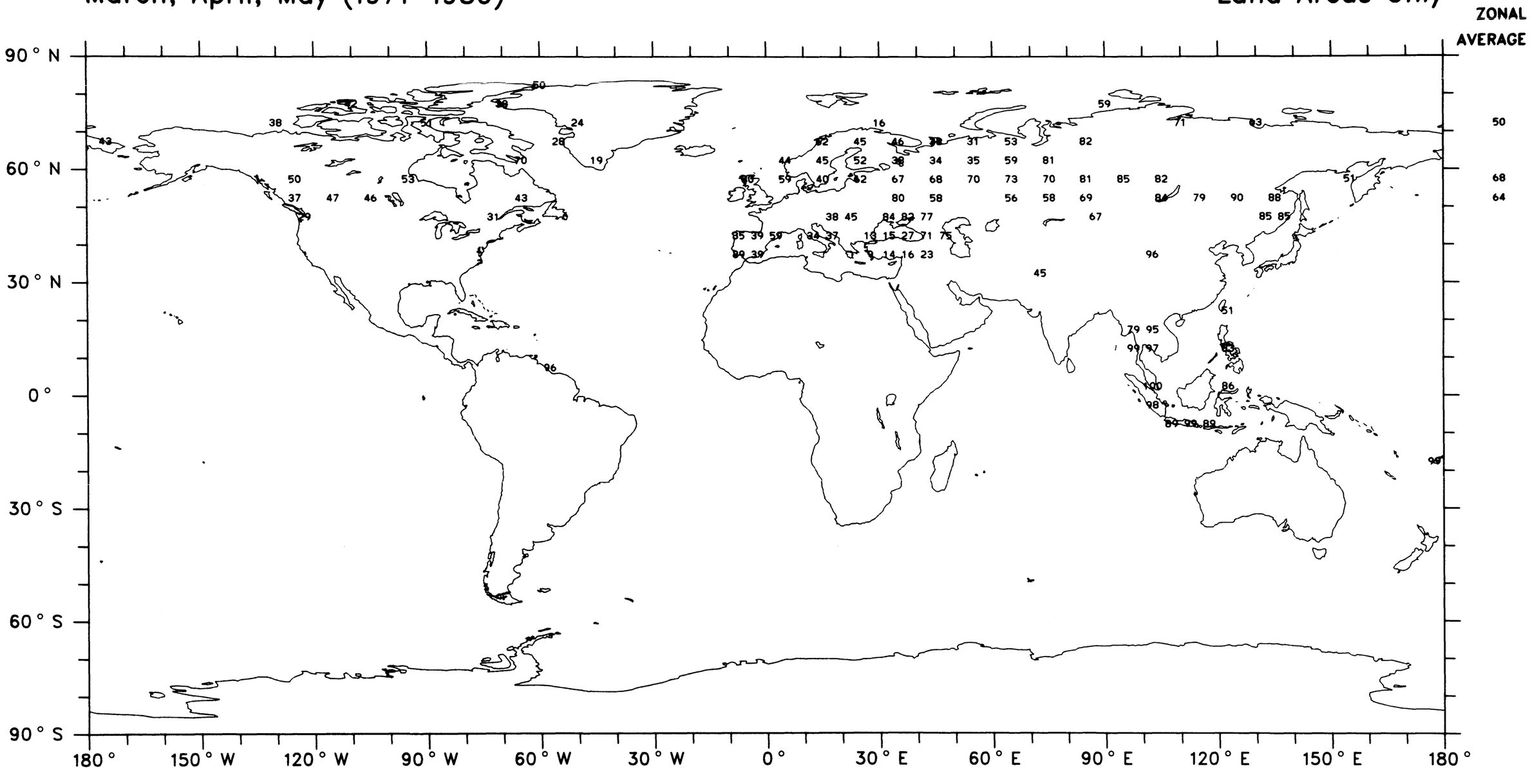


Map II-27

Given Nimbostratus, Probability (Percent) That Ci/Cs/Cc is Also Present

March, April, May (1971-1980)

Land Areas Only

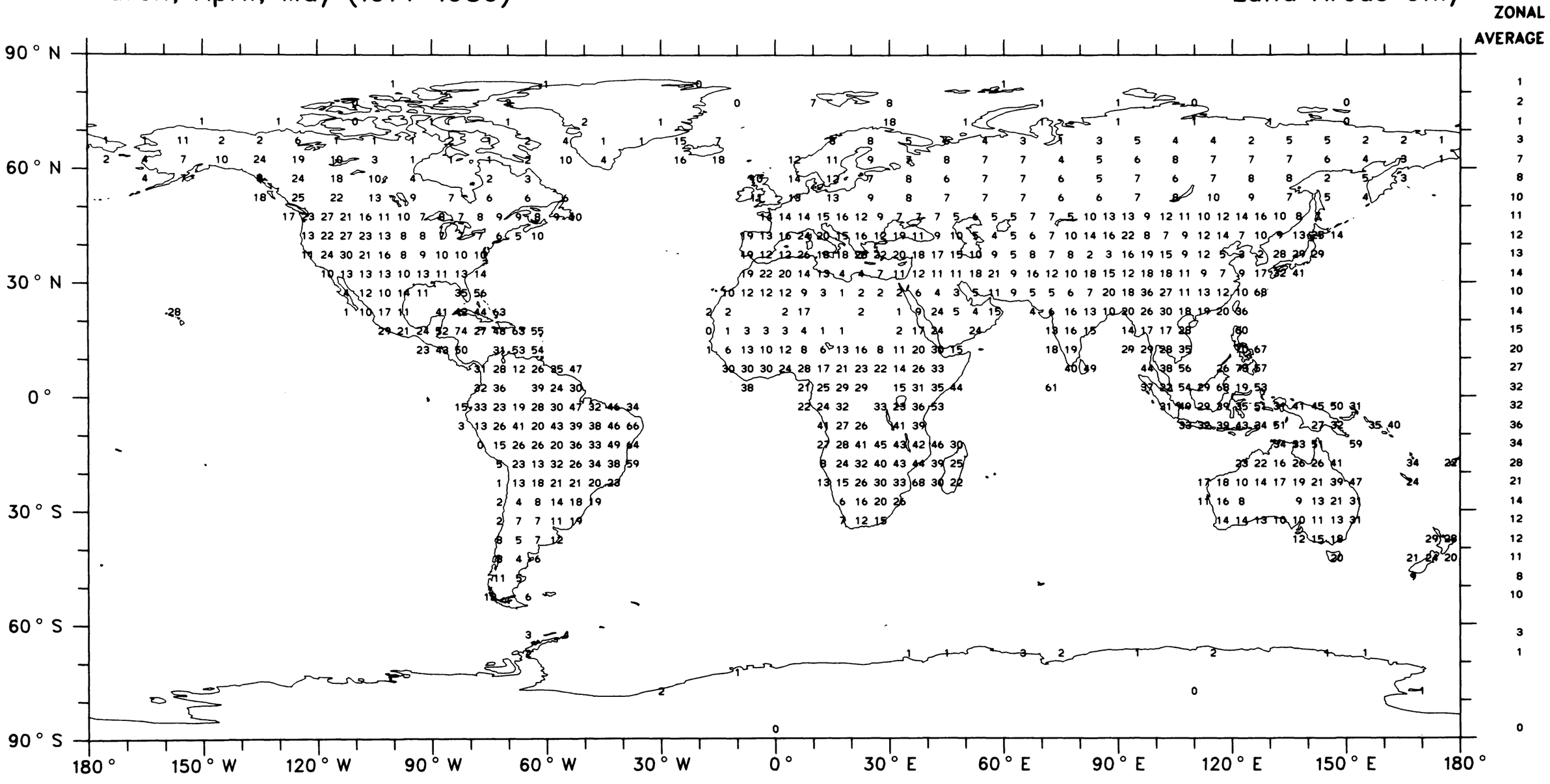


Map II-28

Given Ci/Cs/Cc, Probability (Percent) That Cumulus is Also Present

March, April, May (1971-1980)

Land Areas Only

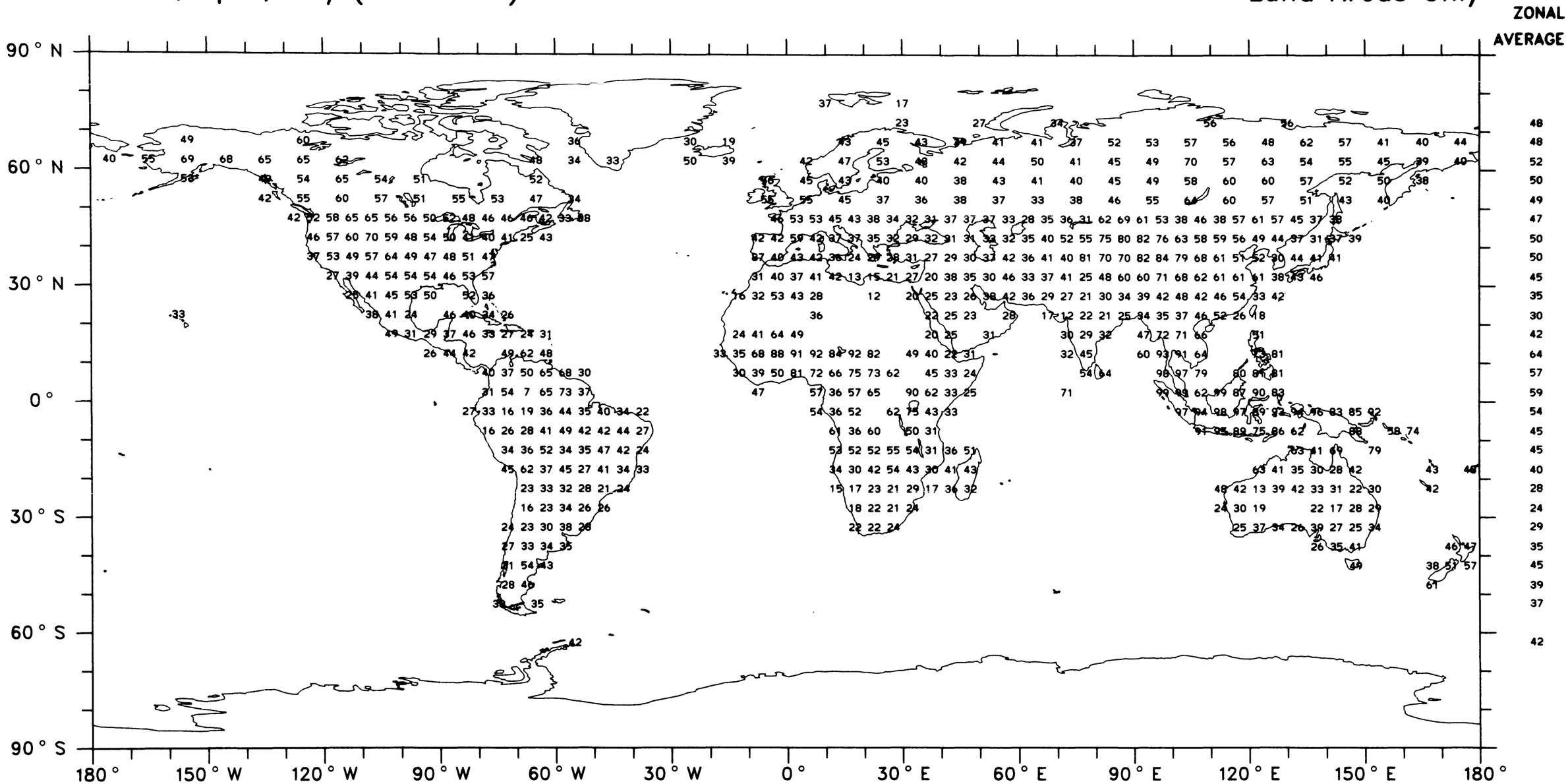


Map II-29

Given Cumulus, Probability (Percent) That Ci/Cs/Cc is Also Present

March, April, May (1971-1980)

Land Areas Only

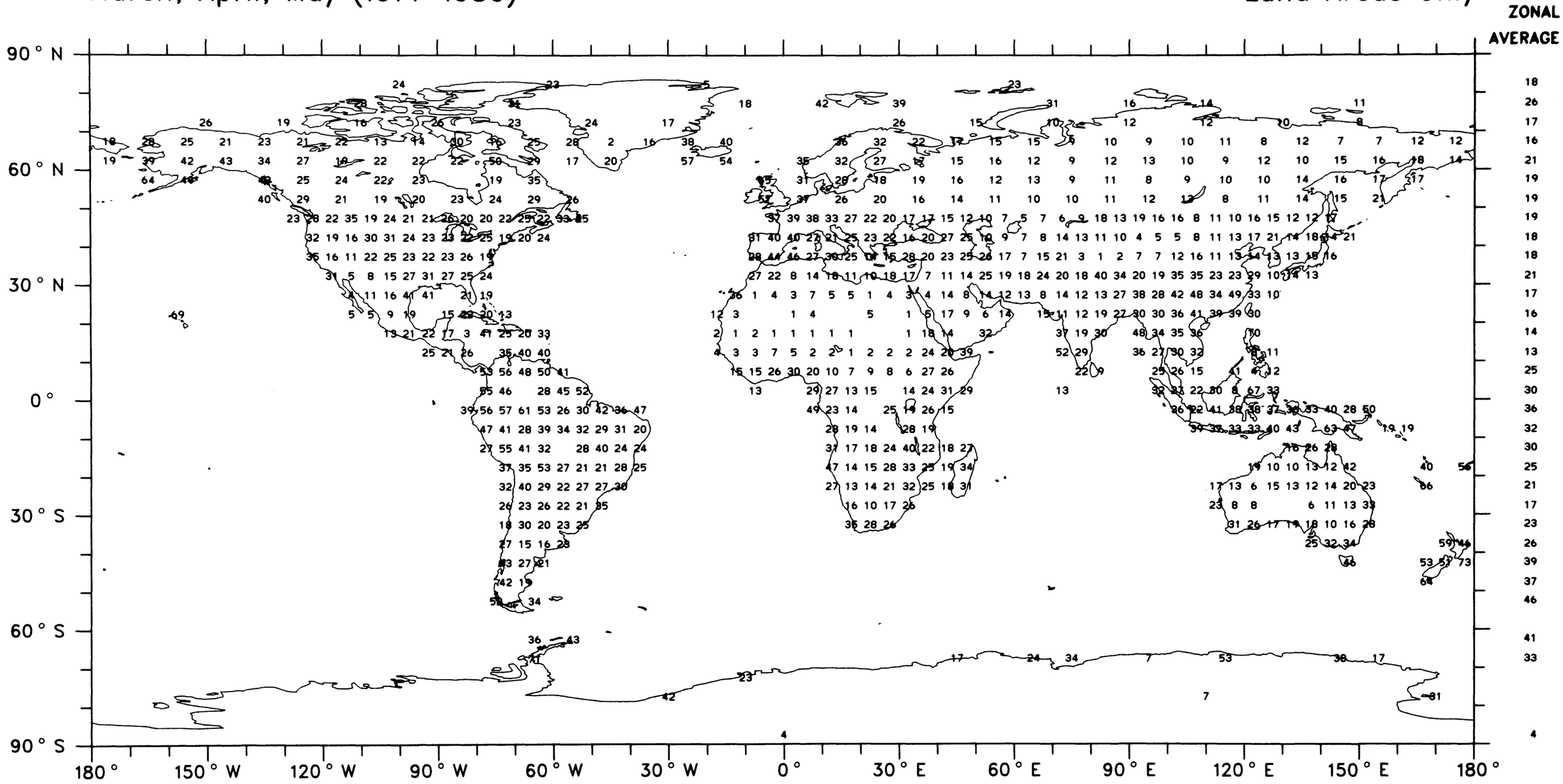


Map II-30

Given Ci/Cs/Cc, Probability (Percent) That St/Sc is Also Present

March, April, May (1971-1980)

Land Areas Only

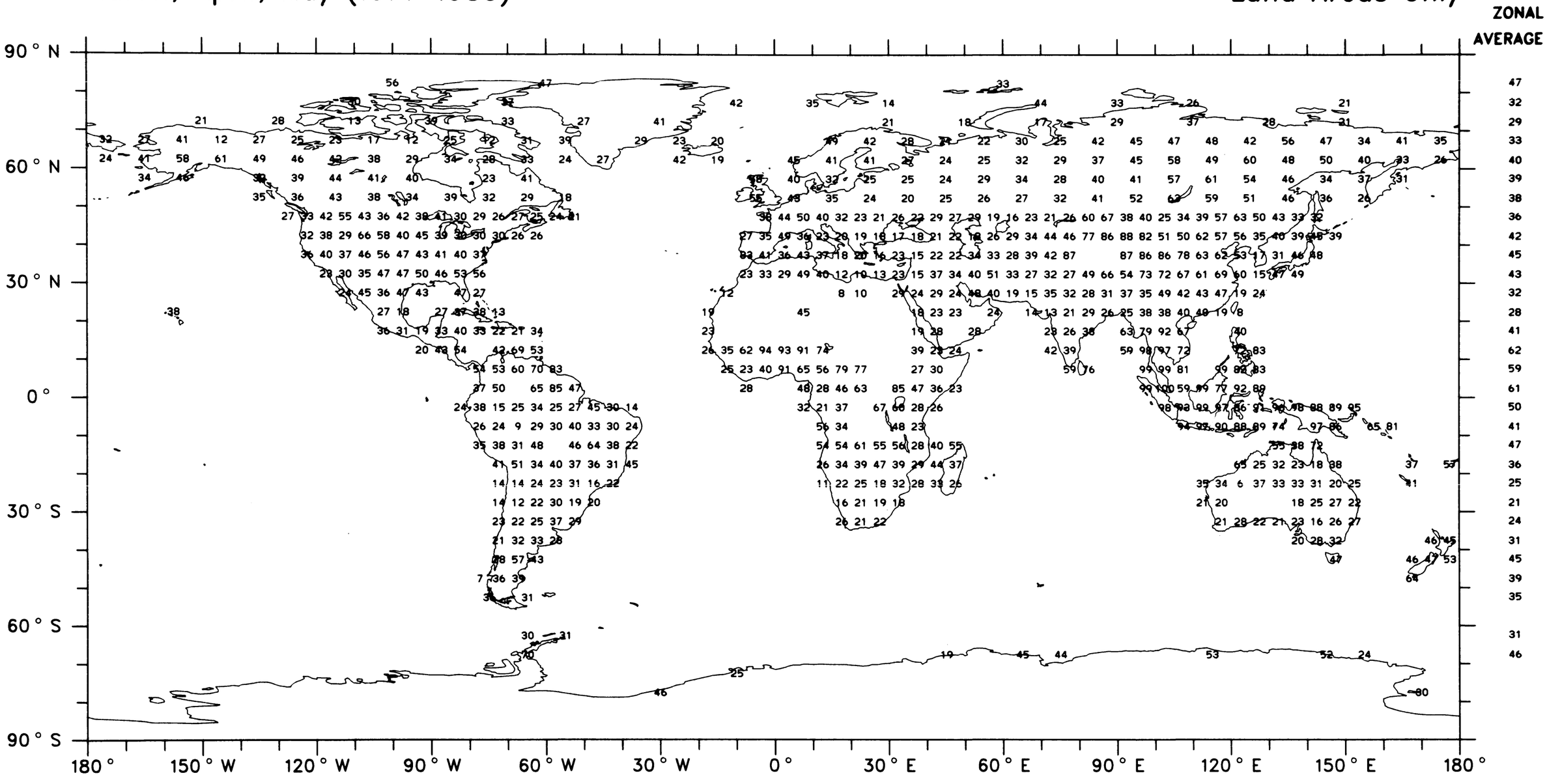


Map II-31

Given St/Sc, Probability (Percent) That Ci/Cs/Cc is Also Present

March, April, May (1971-1980)

Land Areas Only

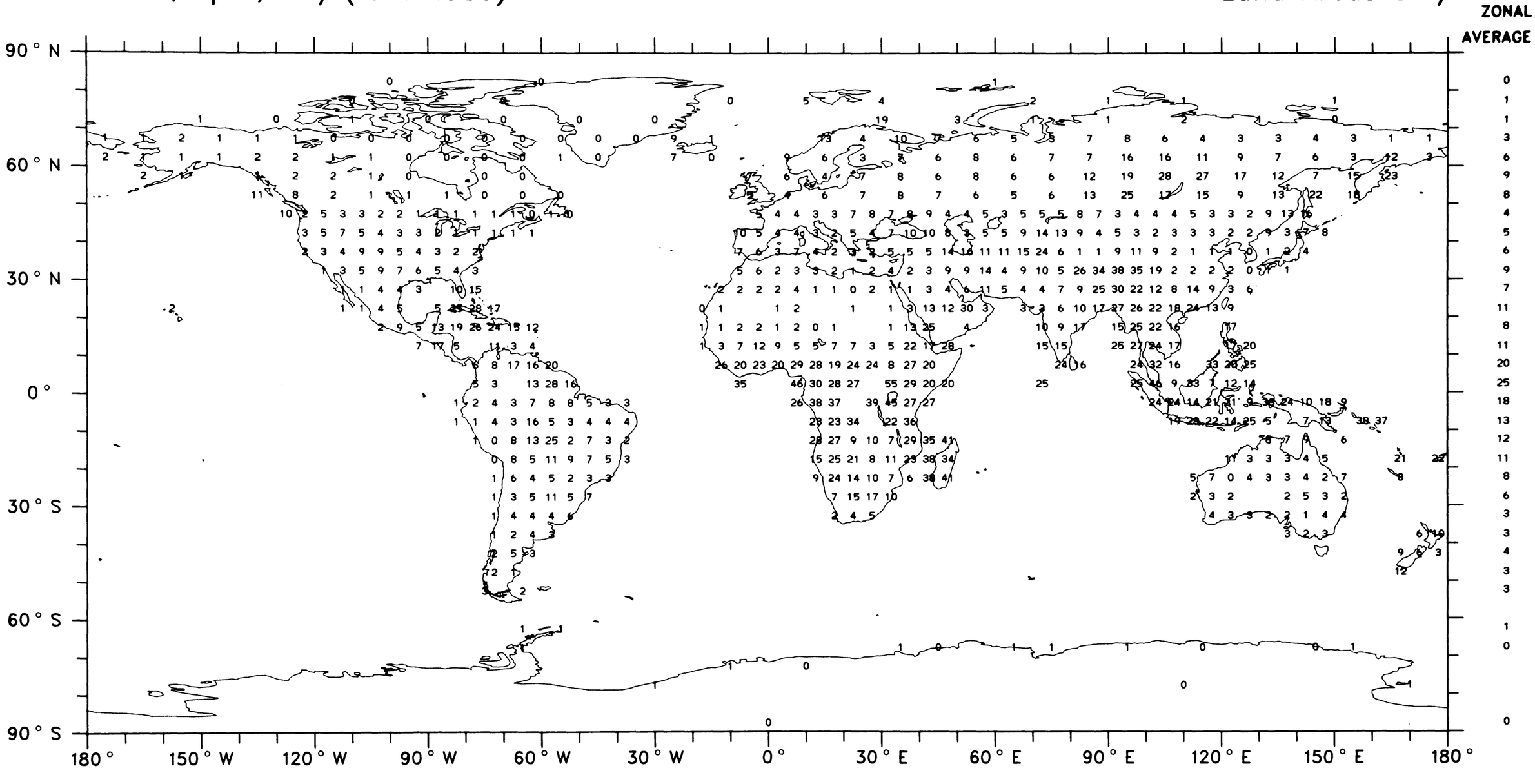


Map II-32

Given Ci/Cs/Cc, Probability (Percent) That Cumulonimbus is Also Present

March, April, May (1971-1980)

Land Areas Only



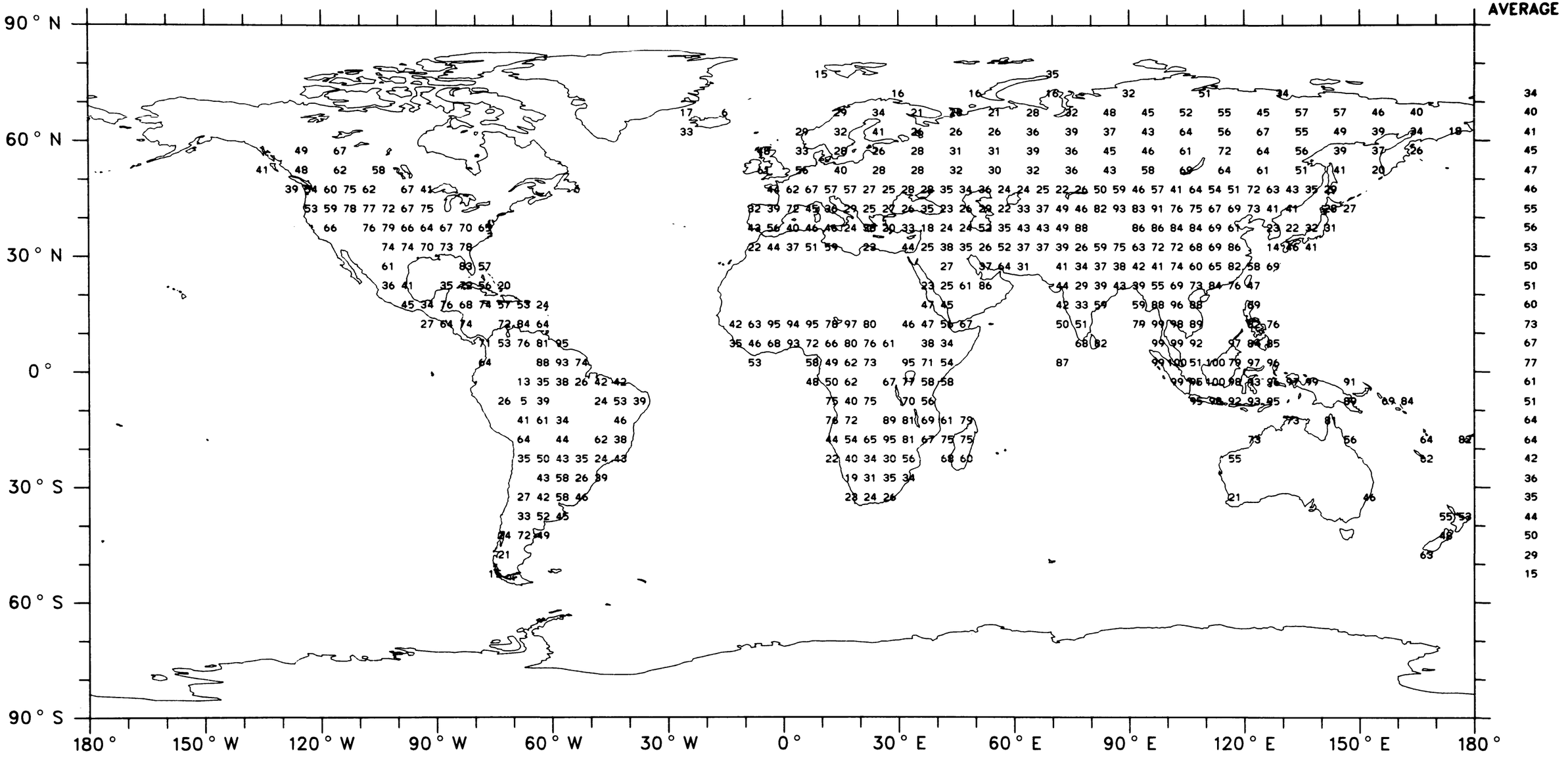
Map II-33

Map II-33

Given Cumulonimbus, Probability (Percent) That Ci/Cs/Cc is Also Present

March, April, May (1971-1980)

Land Areas Only

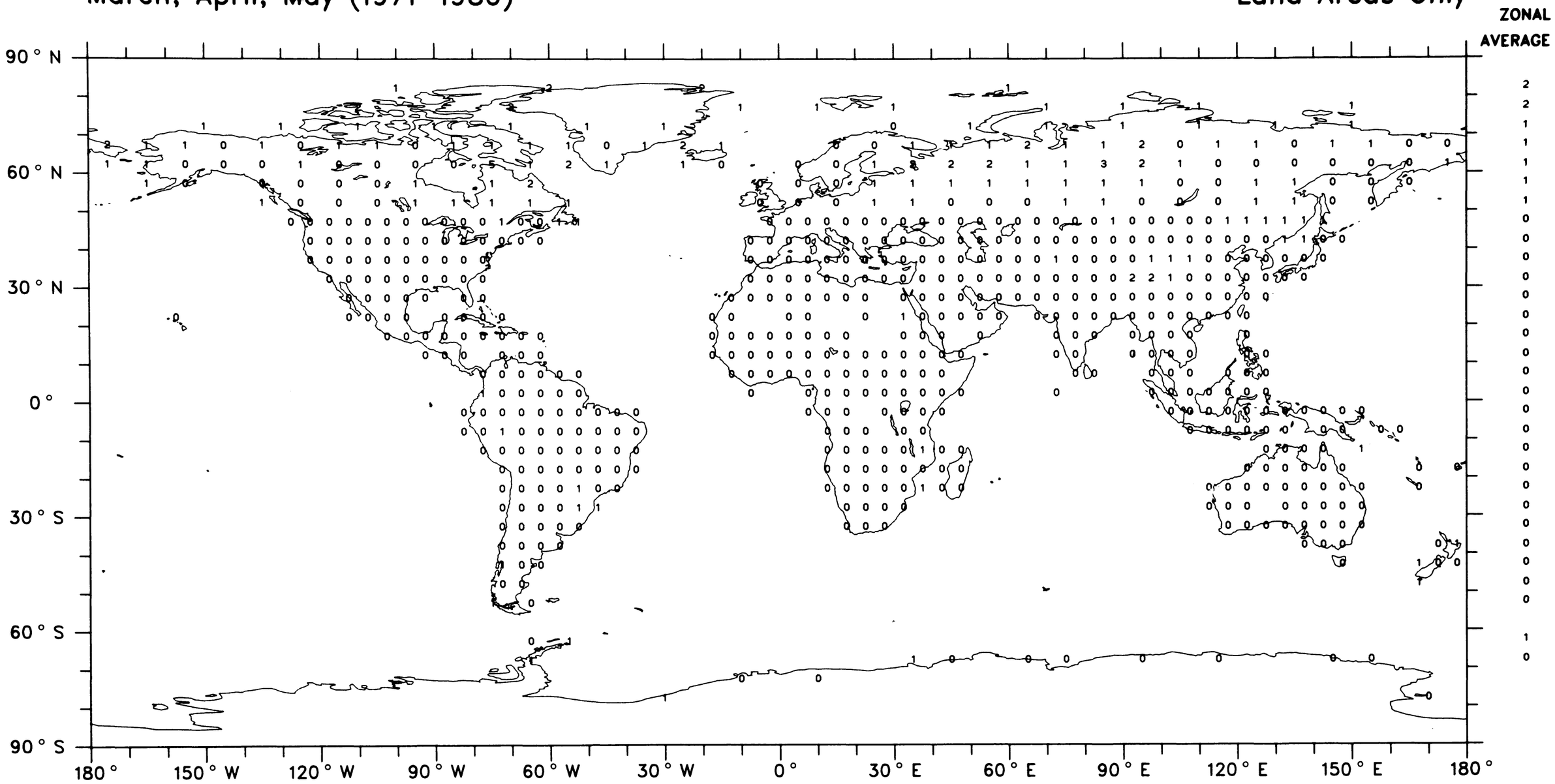


Map II-34

Given As/Ac, Probability (Percent) That Nimbostratus is Also Present

March, April, May (1971-1980)

Land Areas Only



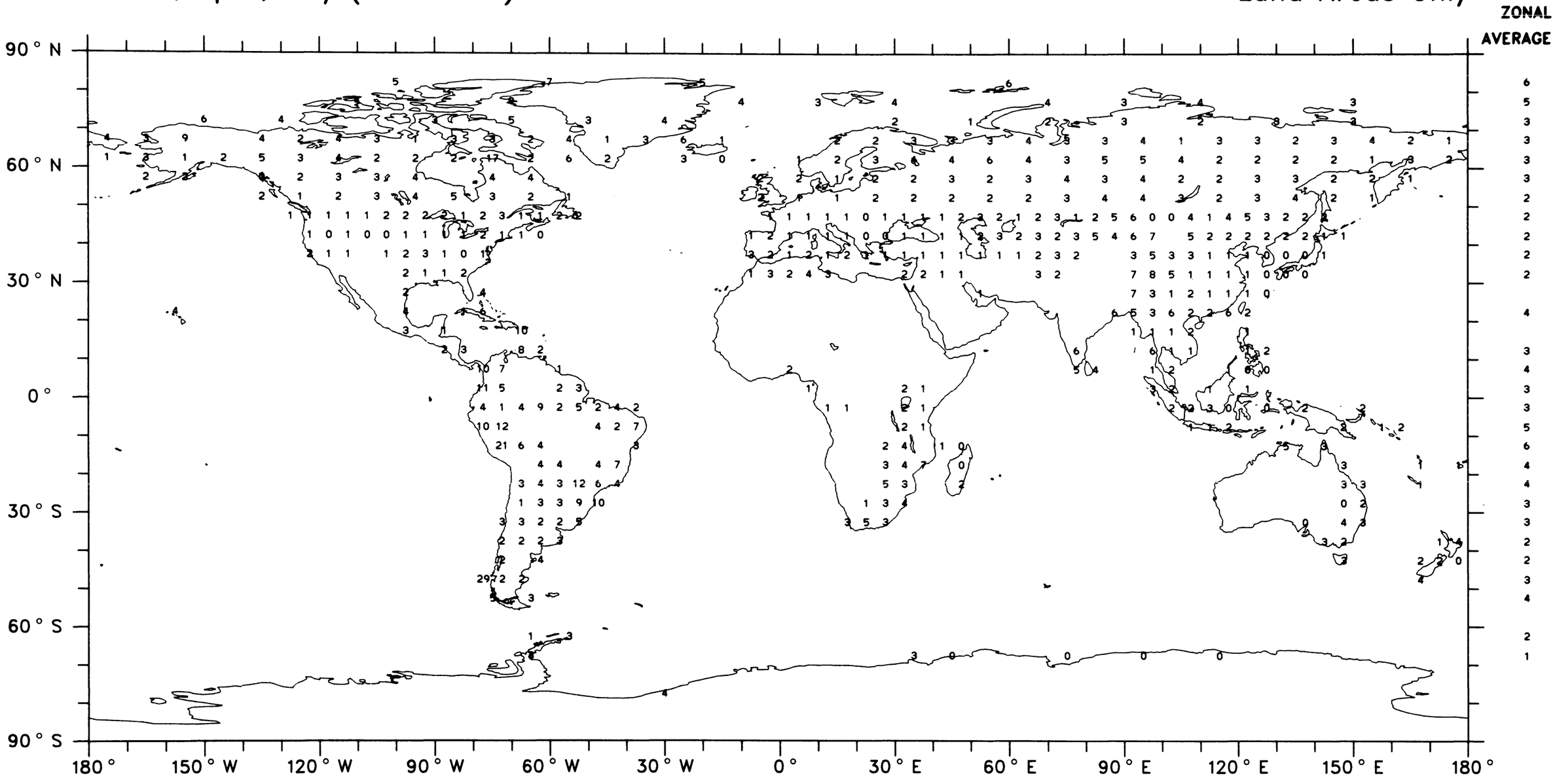
Map II-35

Map II-35

Given Nimbostratus, Probability (Percent) That As/Ac is Also Present

March, April, May (1971-1980)

Land Areas Only

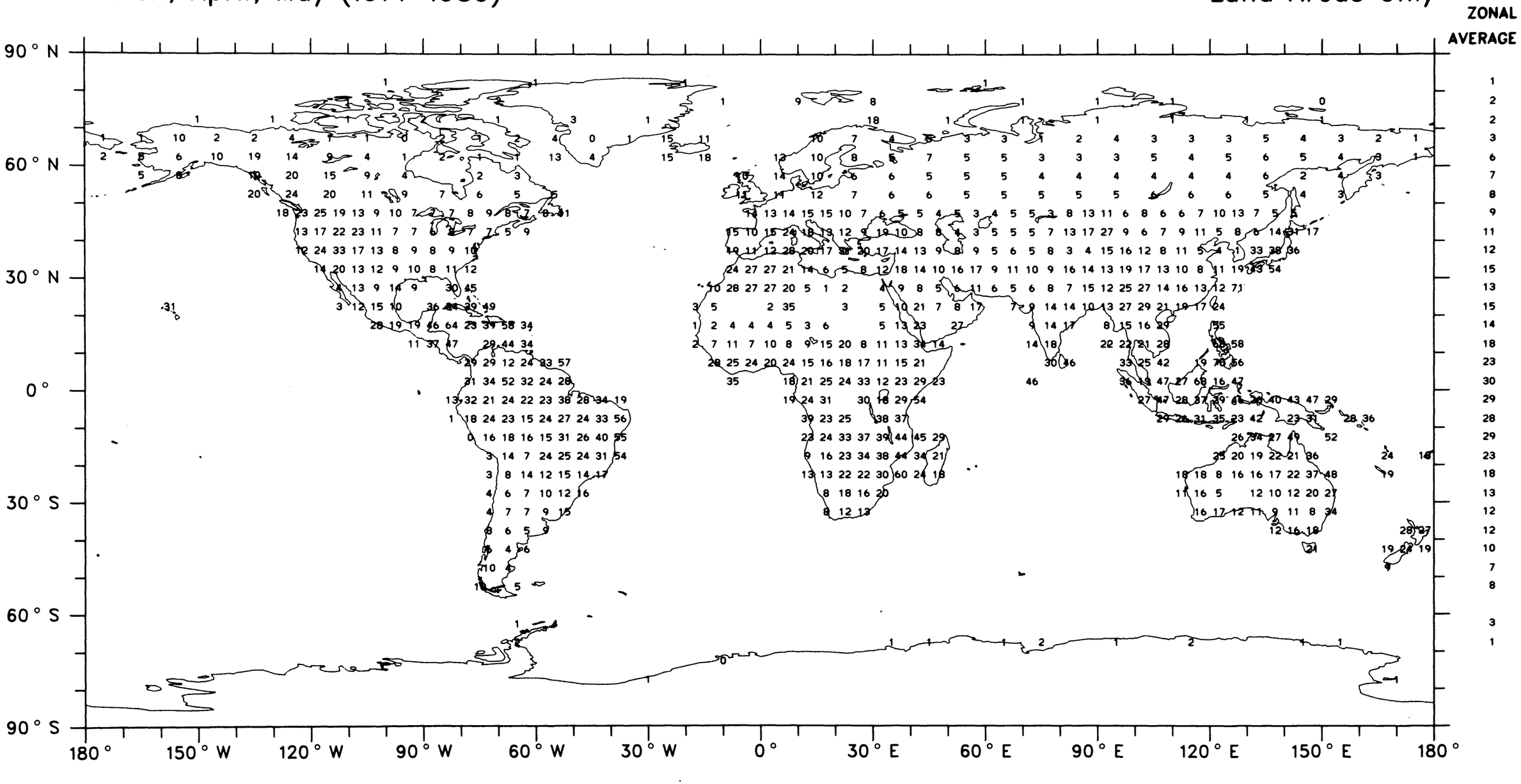


Map II-36

Given As/Ac, Probability (Percent) That Cumulus is Also Present

March, April, May (1971-1980)

Land Areas Only

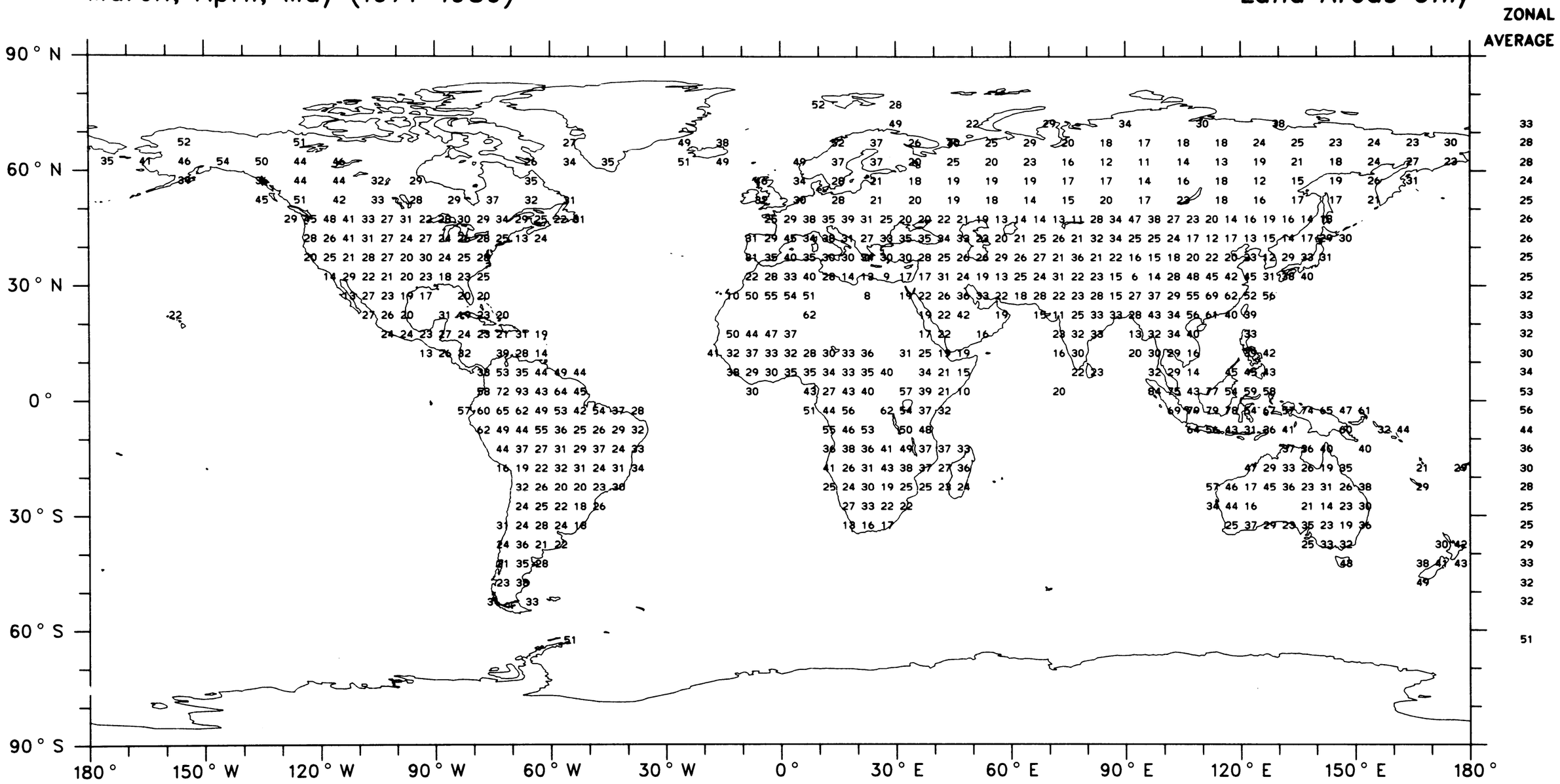


Map II-37

Given Cumulus, Probability (Percent) That As/Ac is Also Present

March, April, May (1971-1980)

Land Areas Only

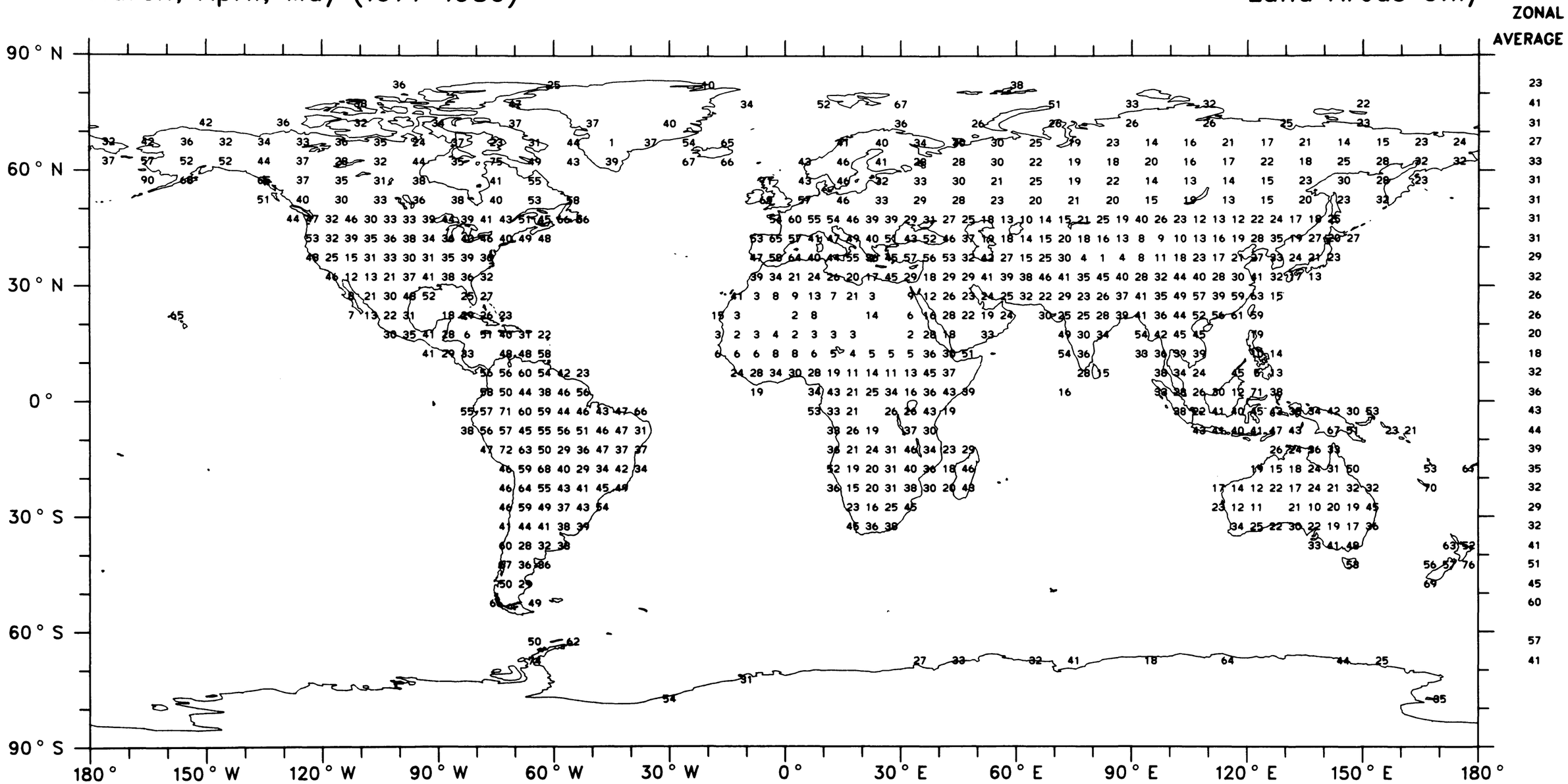


Map II-38

Given As/Ac, Probability (Percent) That St/Sc is Also Present

March, April, May (1971-1980)

Land Areas Only

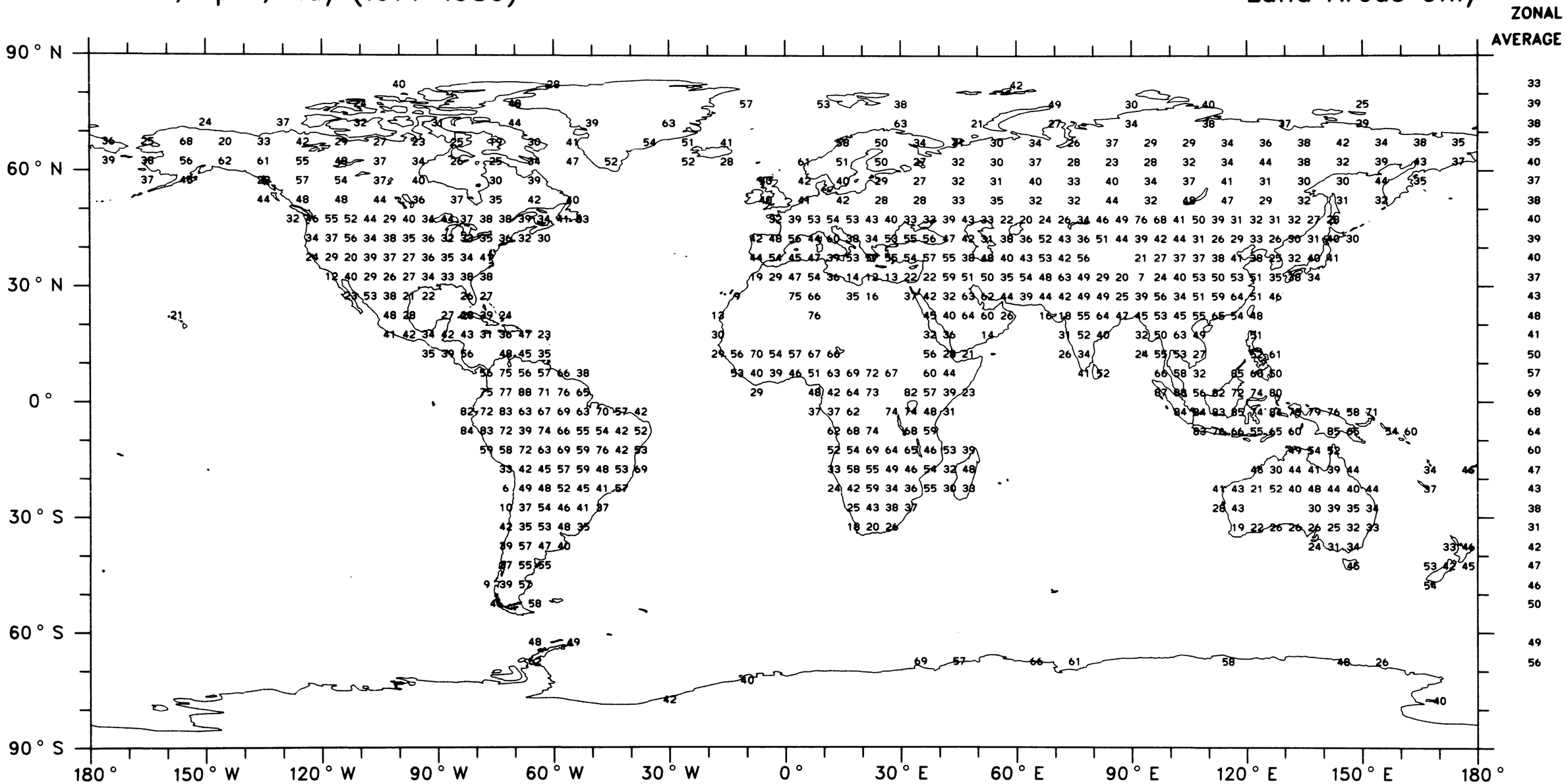


Map II-39

Given St/Sc, Probability (Percent) That As/Ac is Also Present

March, April, May (1971-1980)

Land Areas Only

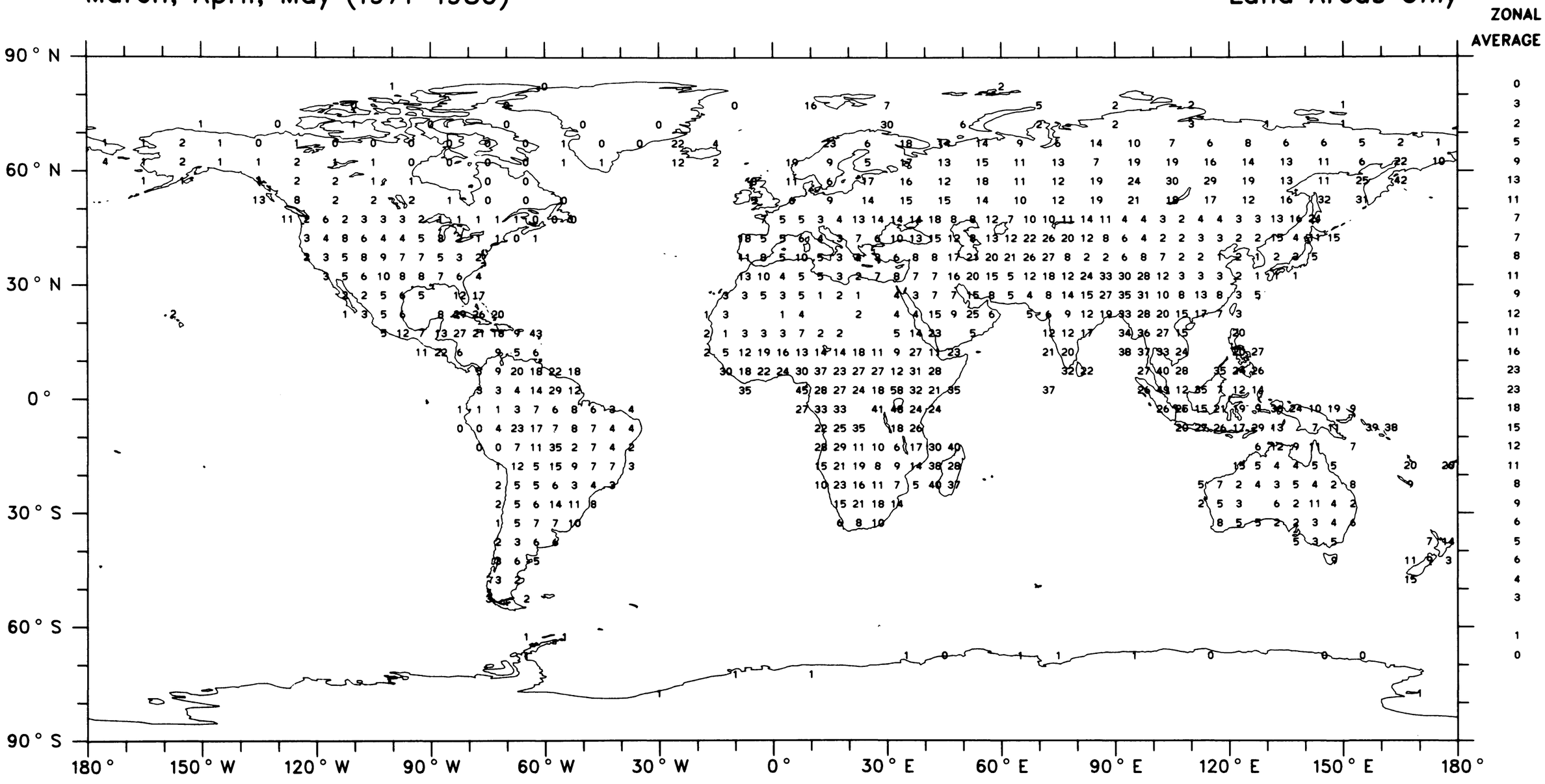


Map II-40

Given As/Ac, Probability (Percent) That Cumulonimbus is Also Present

March, April, May (1971-1980)

Land Areas Only



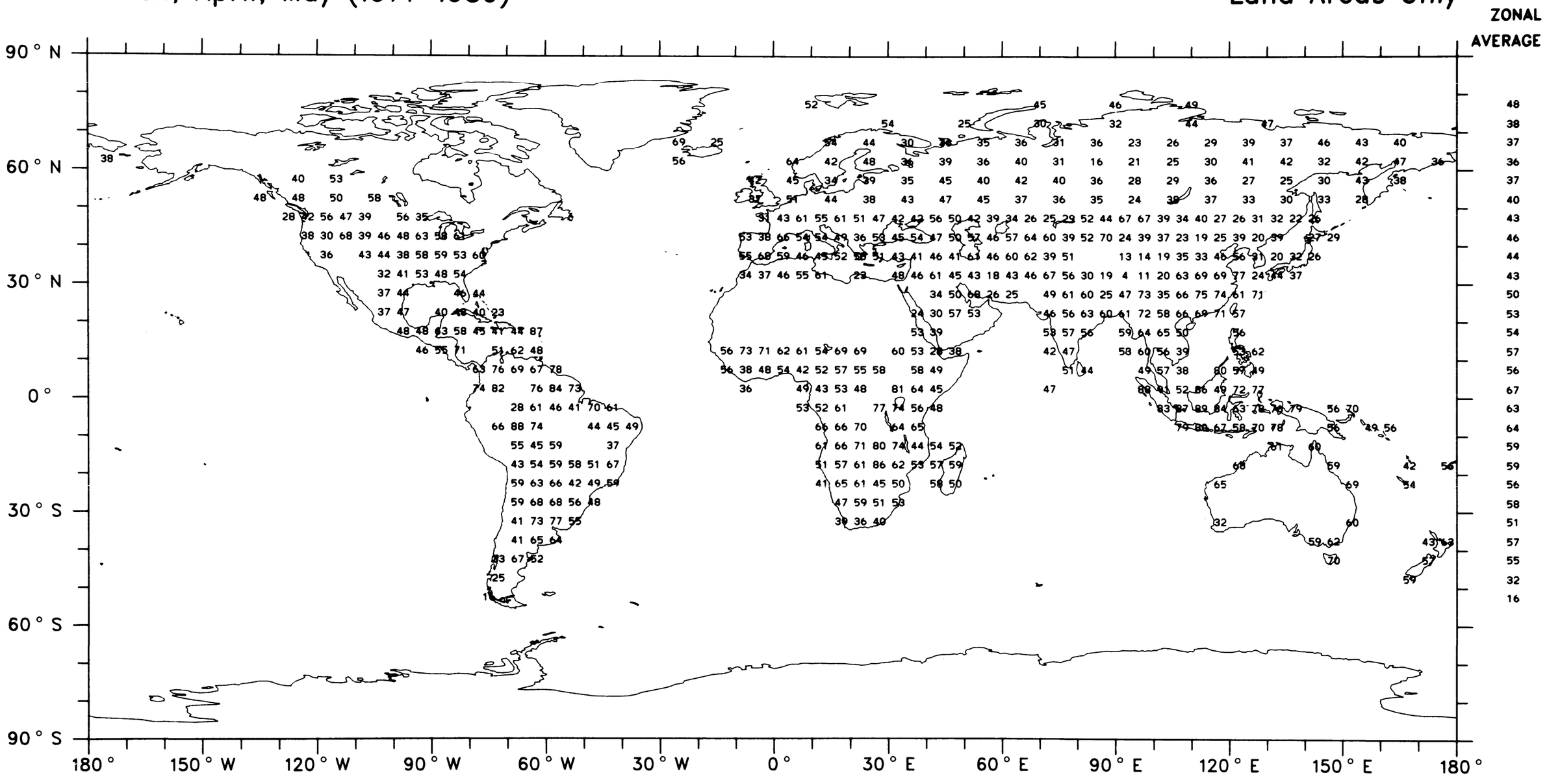
Map II-41

Map II-41

Given Cumulonimbus, Probability (Percent) That As/Ac is Also Present

March, April, May (1971-1980)

Land Areas Only

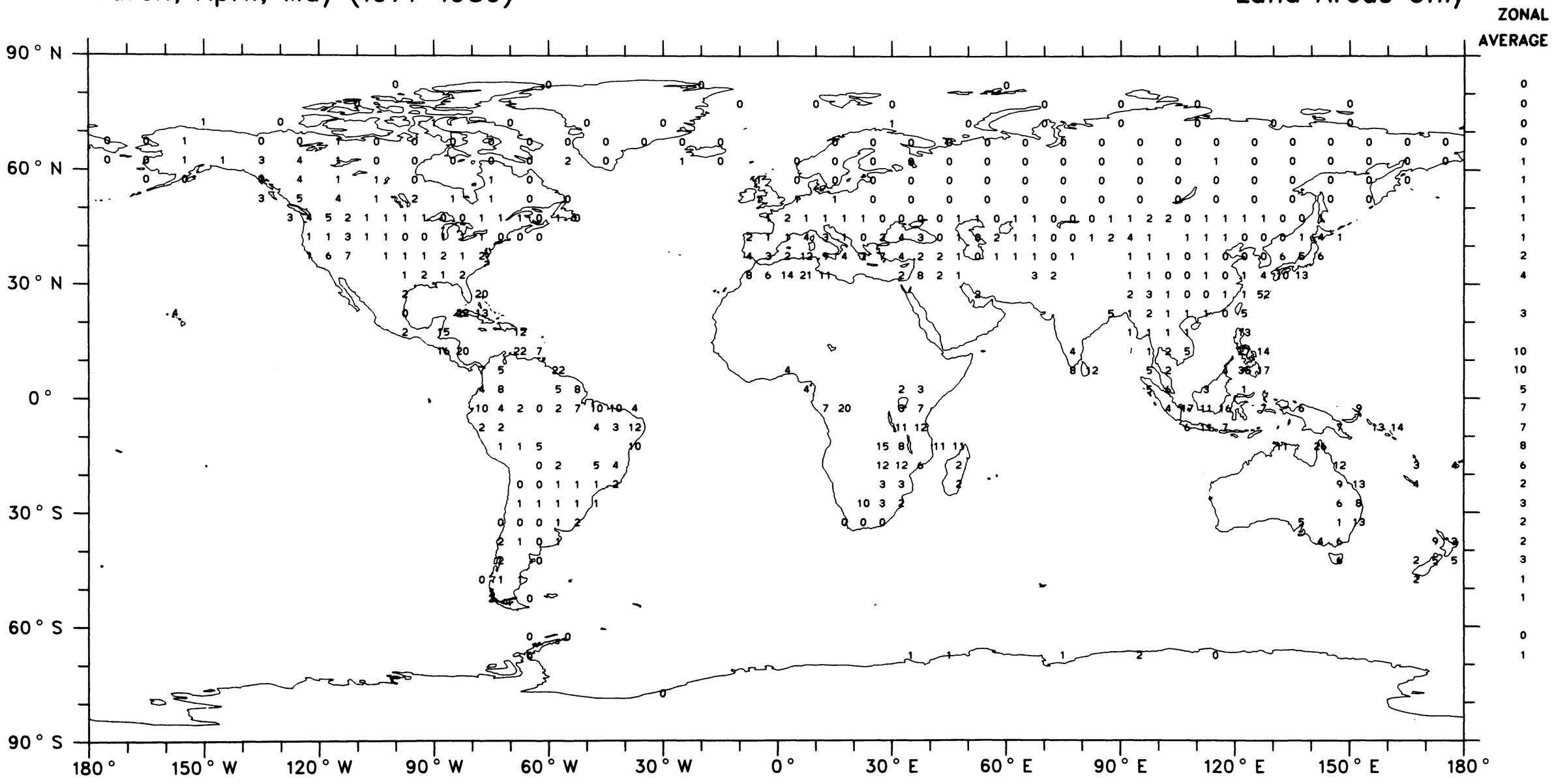


Map II-42

Given Nimbostratus, Probability (Percent) That Cumulus is Also Present

March, April, May (1971-1980)

Land Areas Only

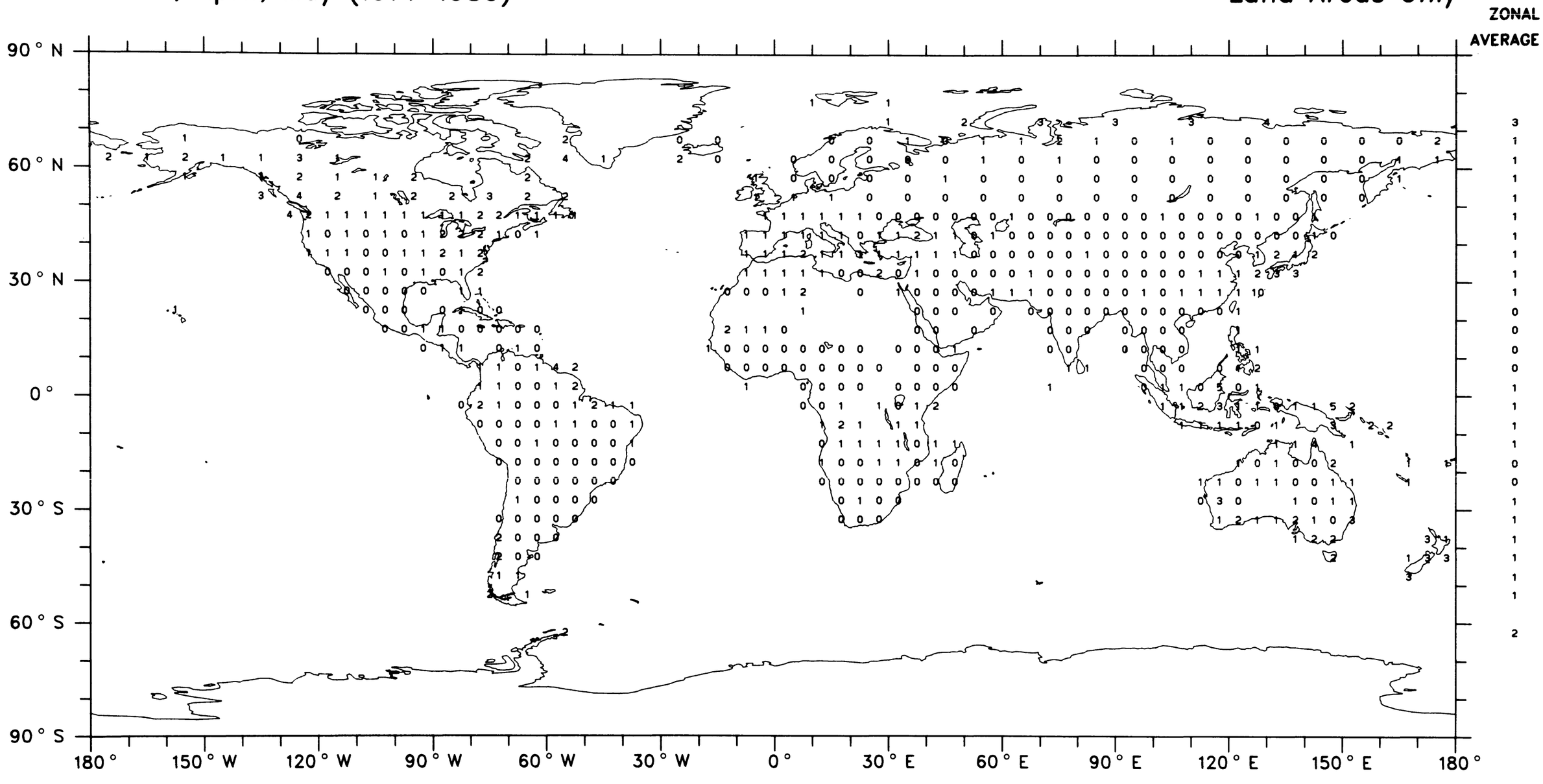


Map II-43

Given Cumulus, Probability (Percent) That Nimbostratus is Also Present

March, April, May (1971-1980)

Land Areas Only

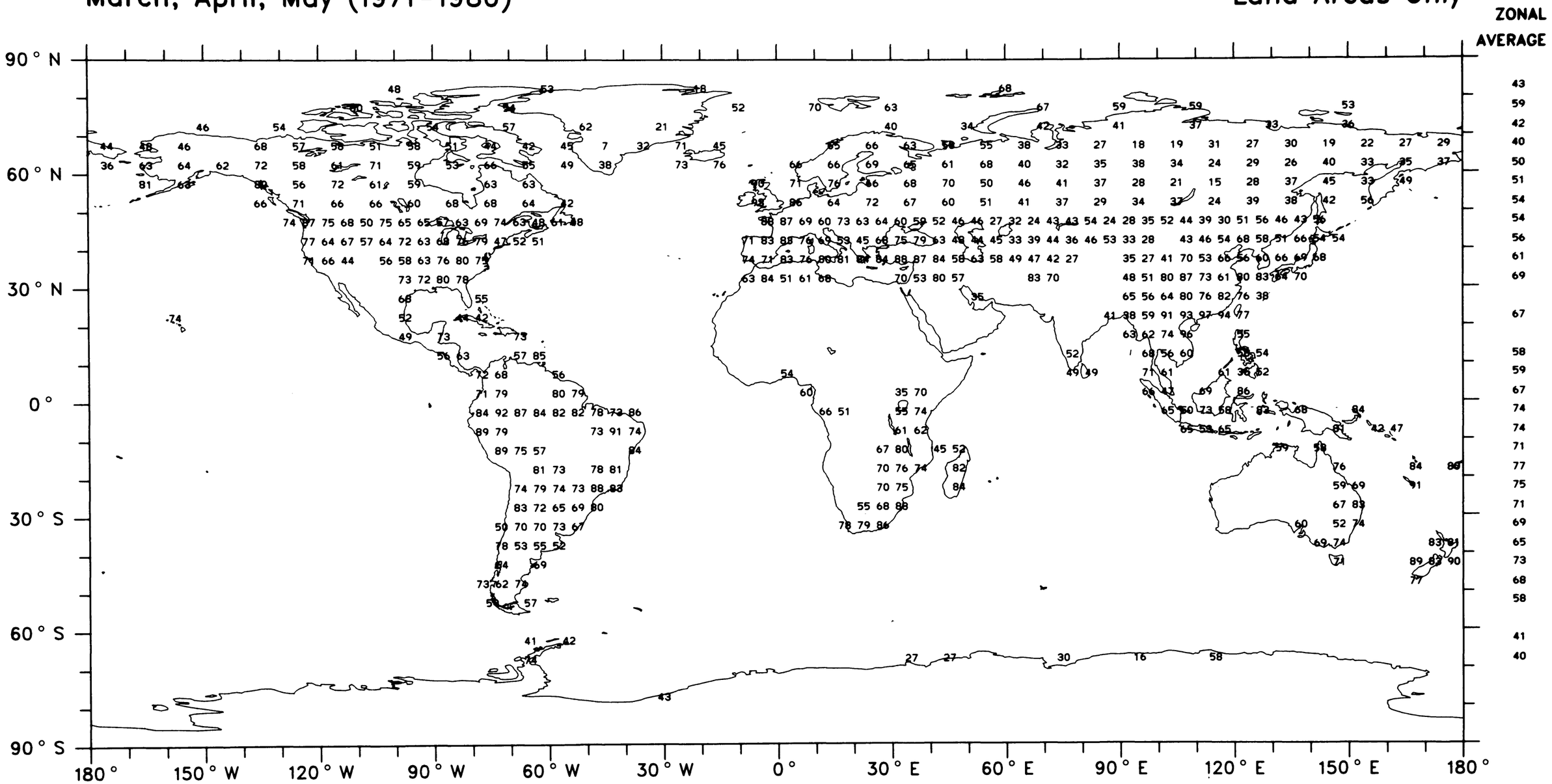


Map II-44

Given Nimbostratus, Probability (Percent) That St/Sc is Also Present

March, April, May (1971-1980)

Land Areas Only

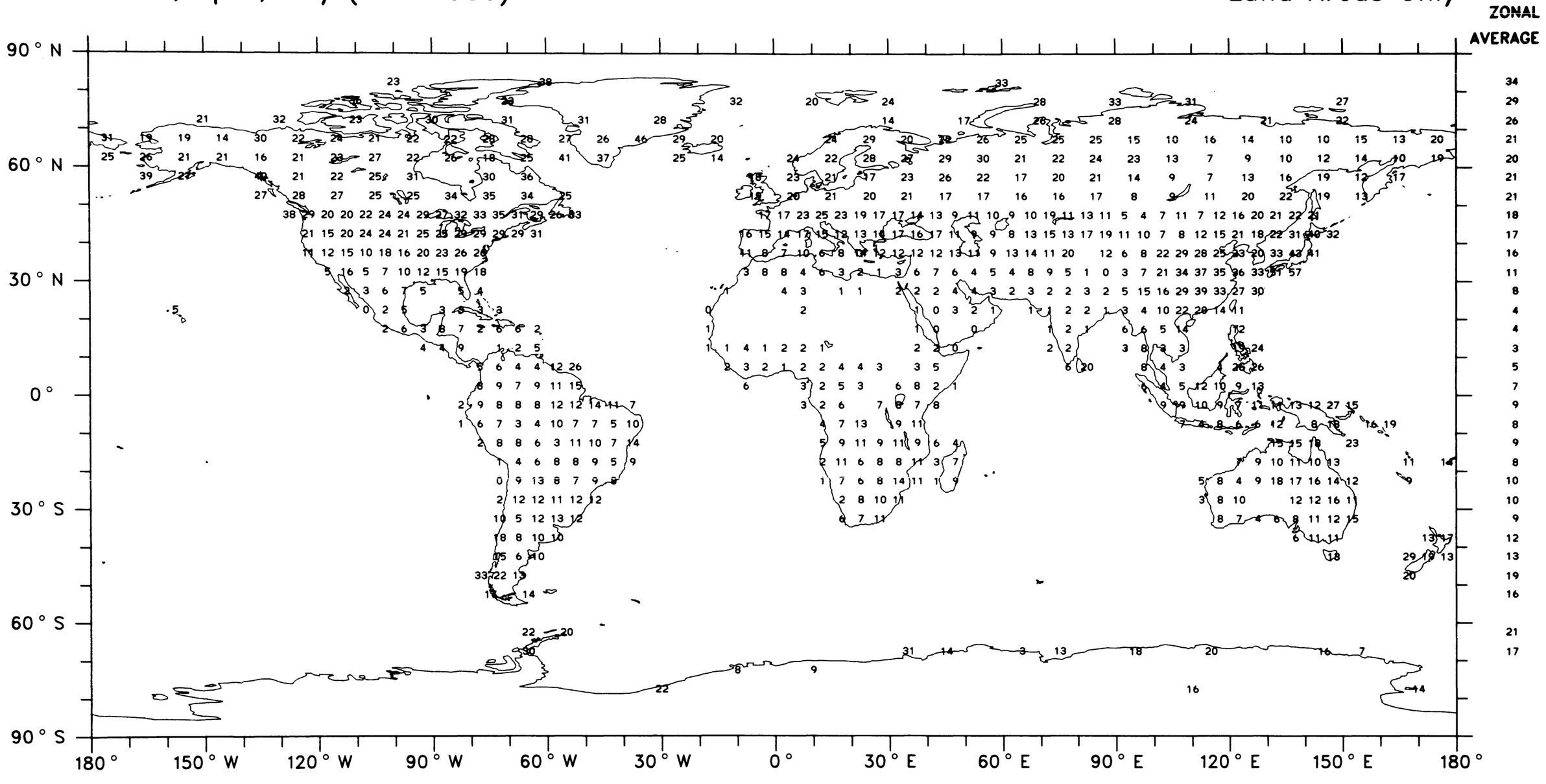


Map II-45

Given St/Sc, Probability (Percent) That Nimbostratus is Also Present

March, April, May (1971-1980)

Land Areas Only

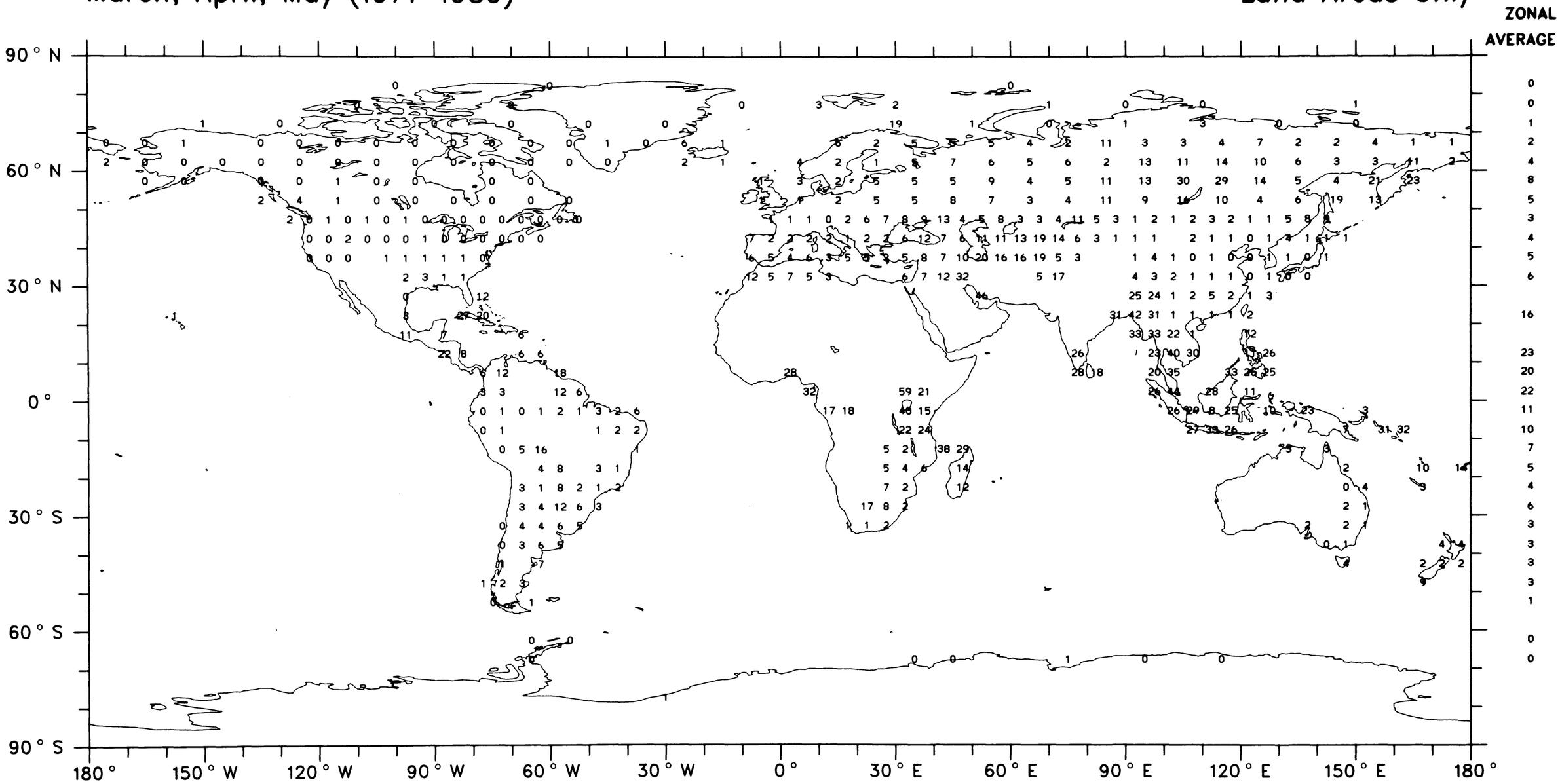


Map II-46

Given Nimbostratus, Probability (Percent) That Cumulonimbus is Also Present

March, April, May (1971-1980)

Land Areas Only

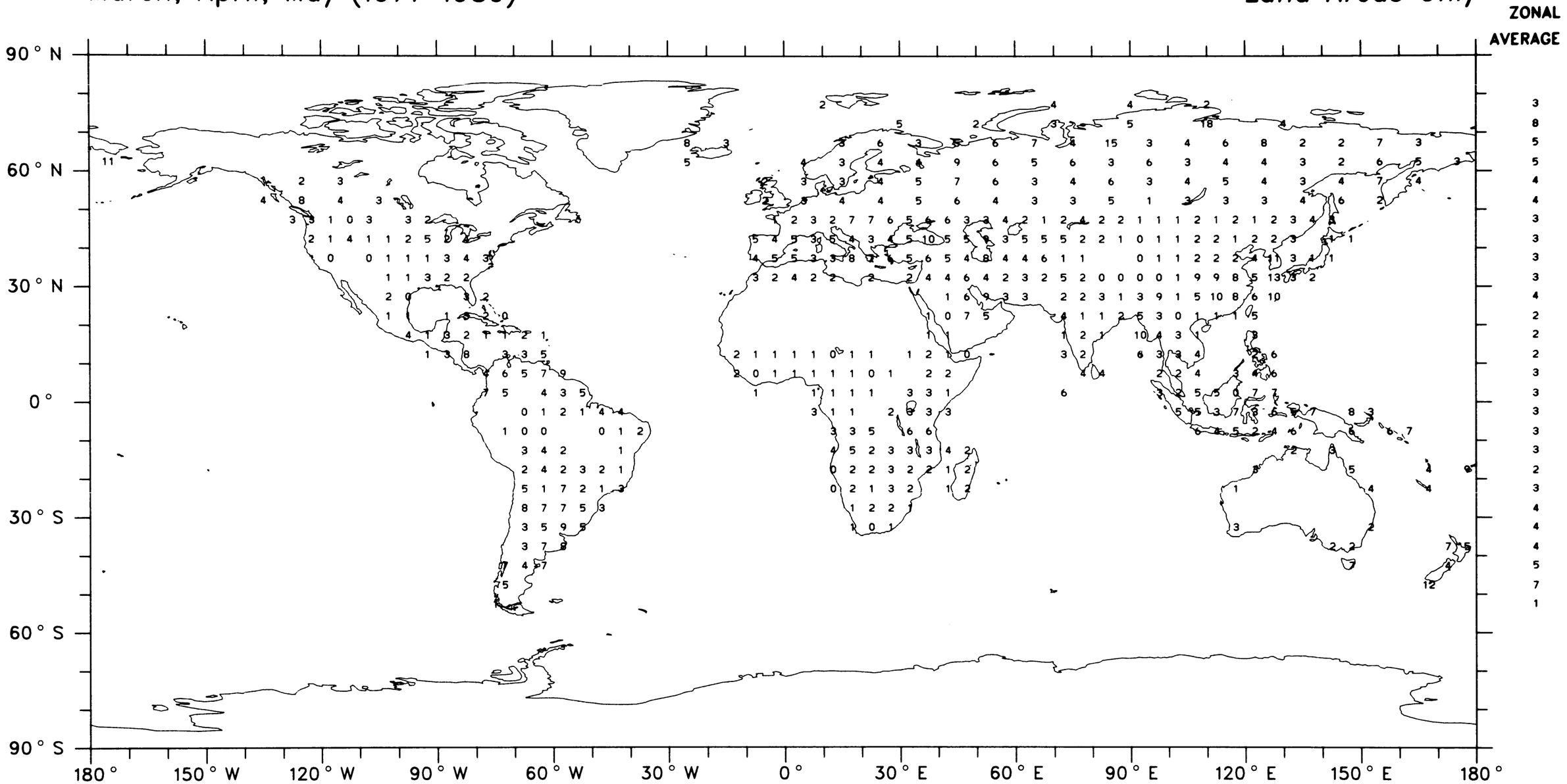


Map II-47

Given Cumulonimbus, Probability (Percent) That Nimbostratus is Also Present

March, April, May (1971-1980)

Land Areas Only

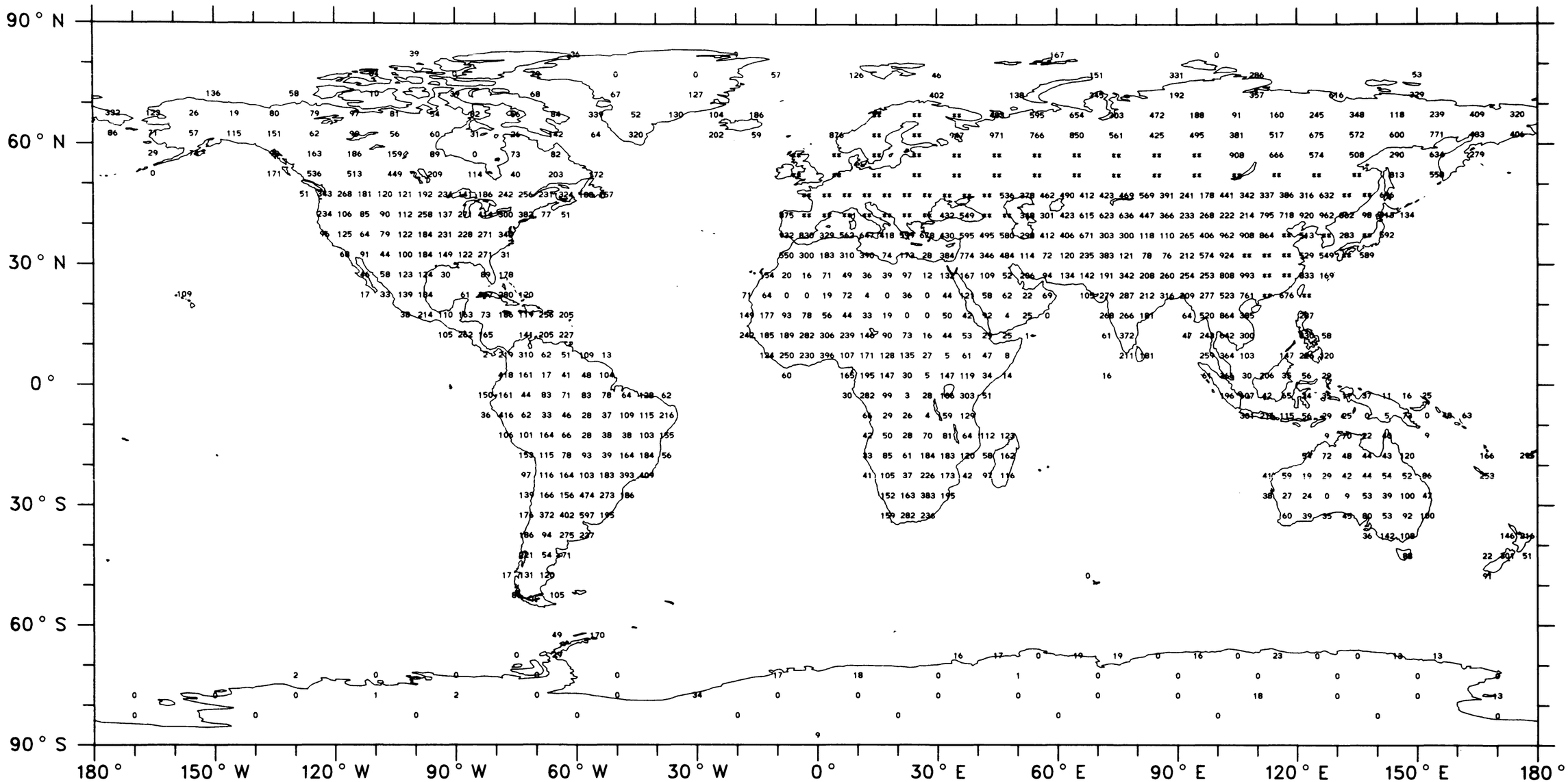


Map III-1

Number of Synoptic Cloud Reports from Land Stations (in Hundreds)

June, July, August (1971-1980)

Land Areas Only

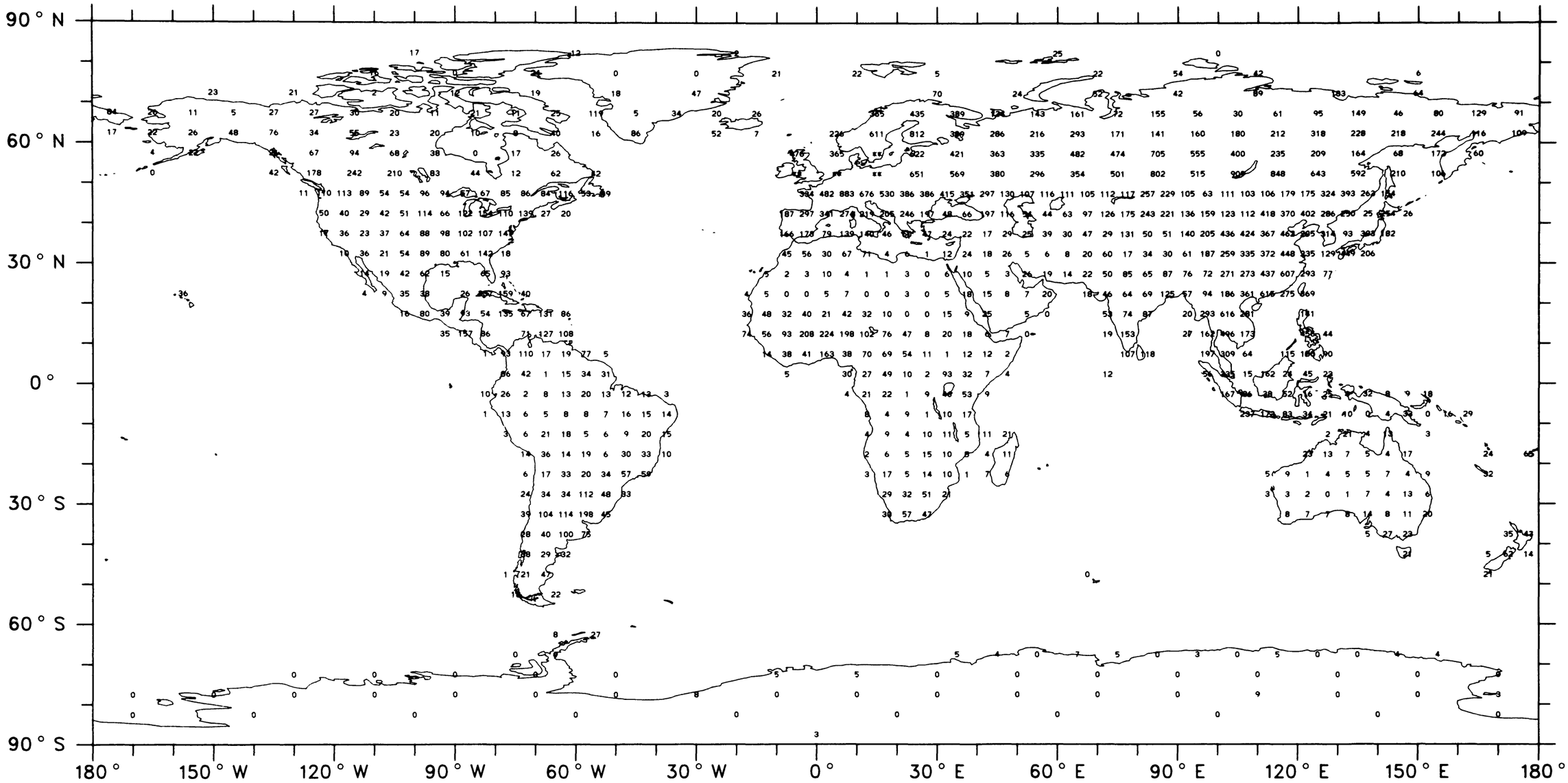


Map III-2

Number of Observations of Cirrus, Cirrostratus, or Cirrocumulus (in Hundreds)

June, July, August (1971-1980)

Land Areas Only

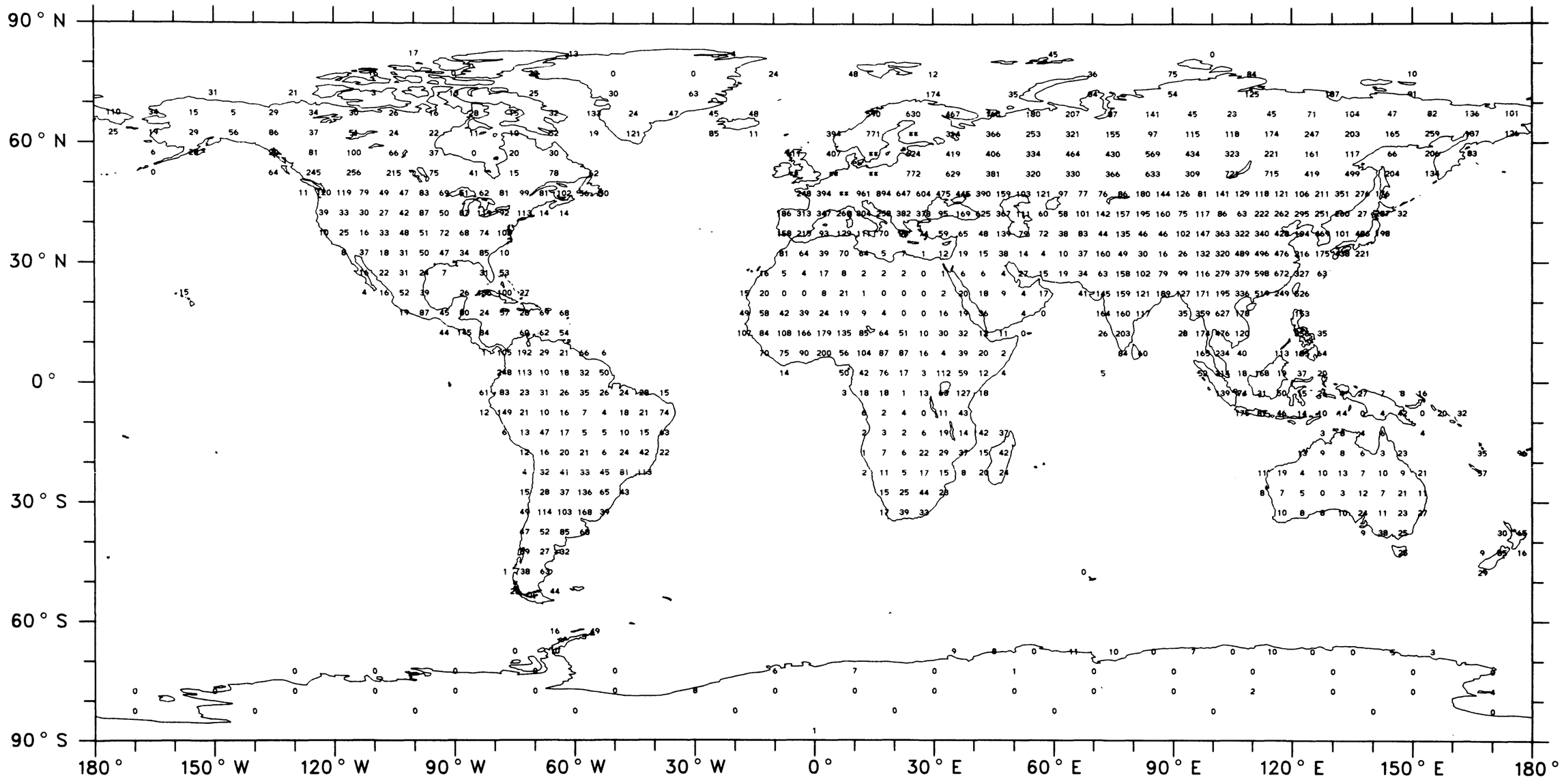


Map III-3

Number of Observations of Altostratus or Altocumulus (in Hundreds)

June, July, August (1971-1980)

Land Areas Only

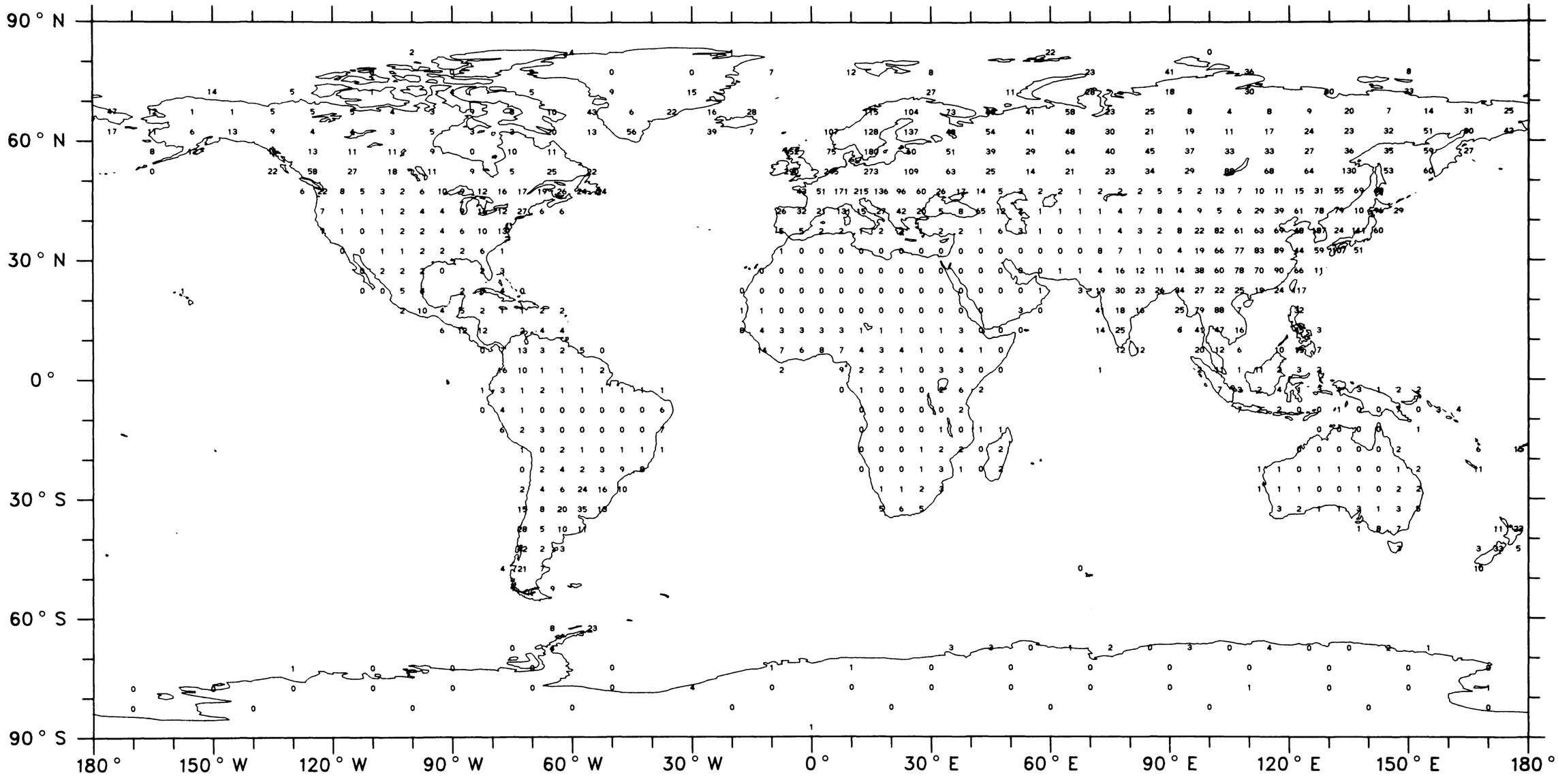


Map III-4

Number of Observations of Nimbostratus (in Hundreds)

June, July, August (1971-1980)

Land Areas Only

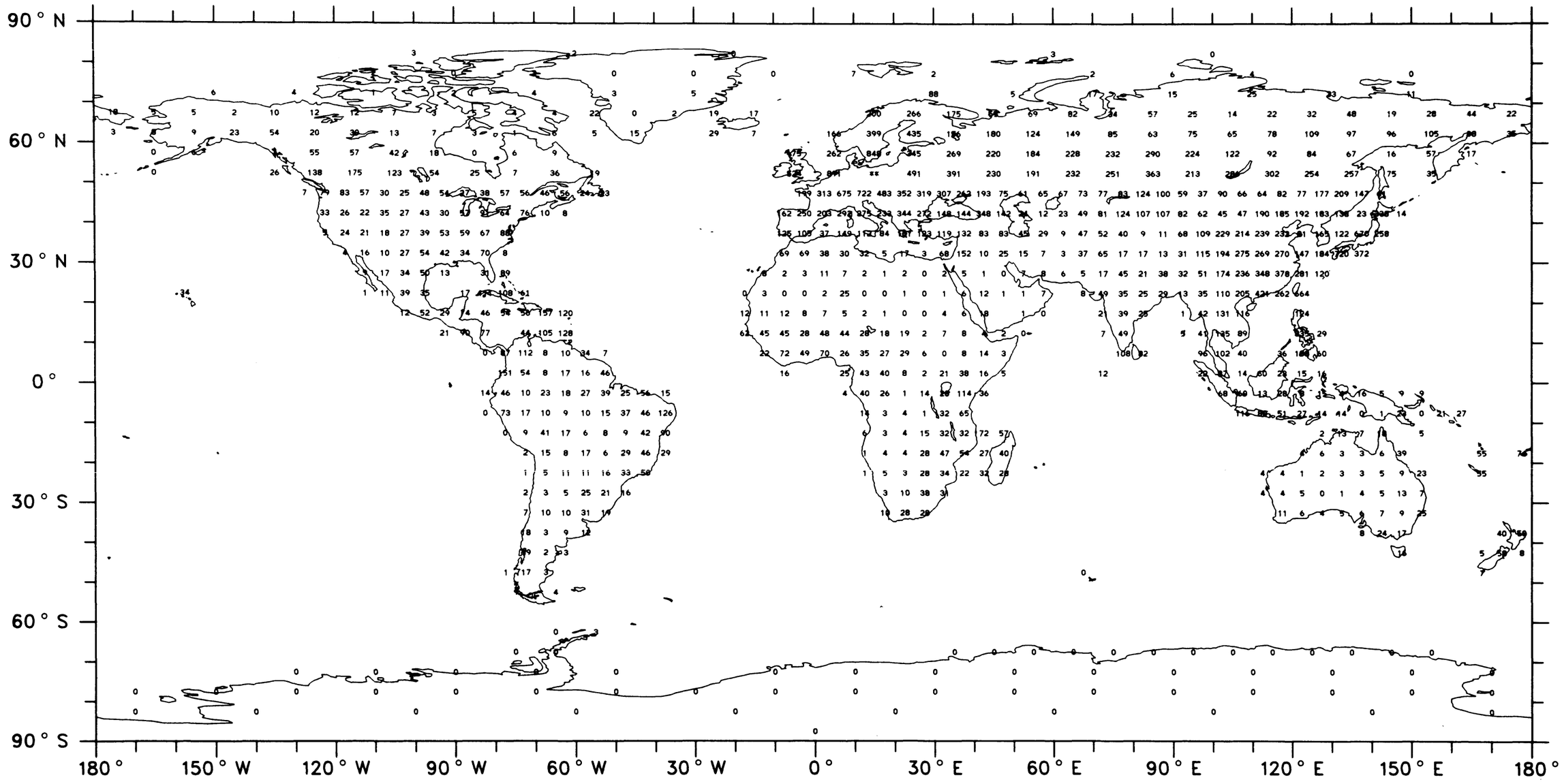


Map III-5

Number of Observations of Cumulus (in Hundreds)

June, July, August (1971-1980)

Land Areas Only

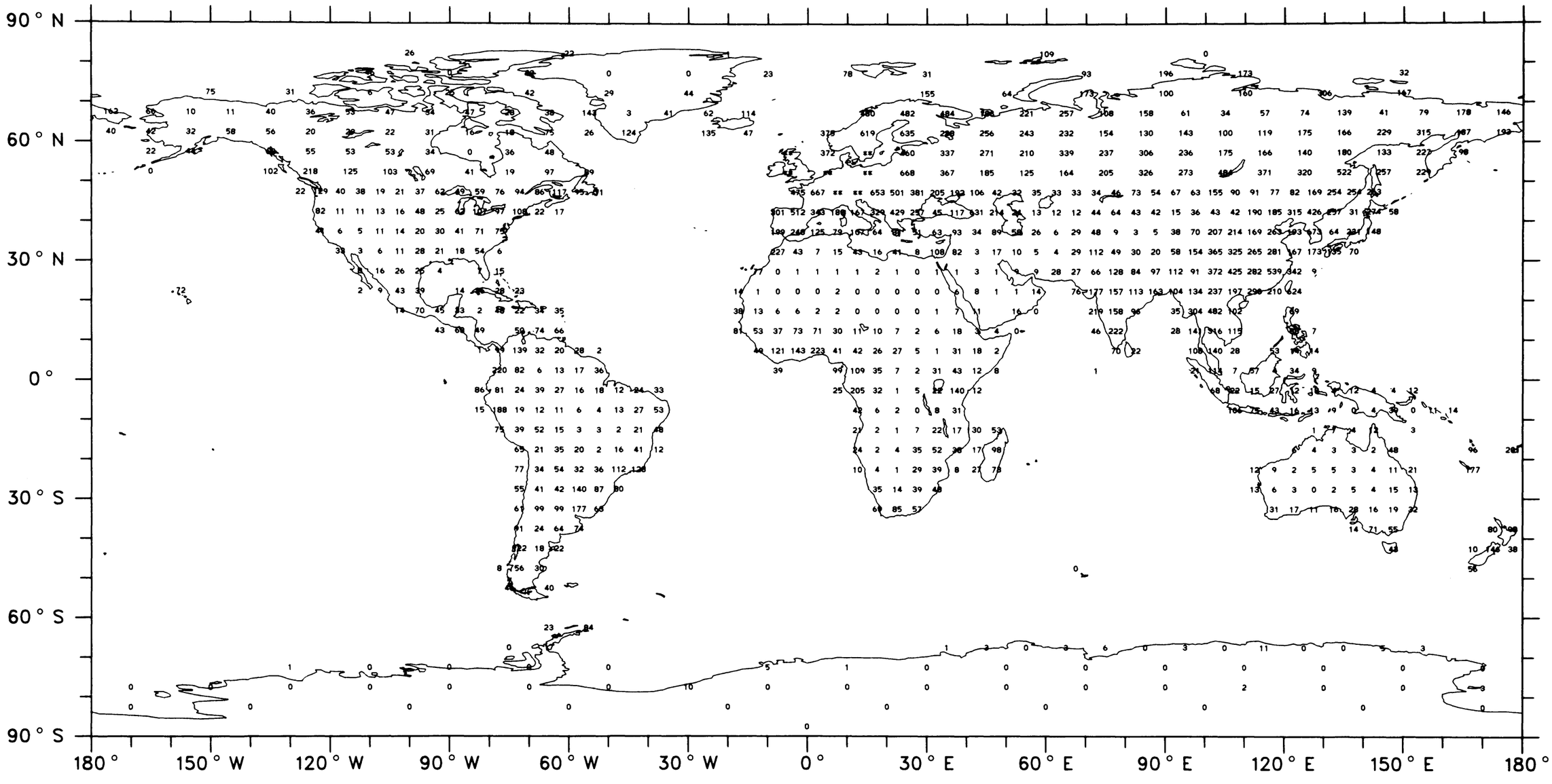


Map III-6

Number of Observations of Stratus or Stratocumulus (in Hundreds)

June, July, August (1971-1980)

Land Areas Only

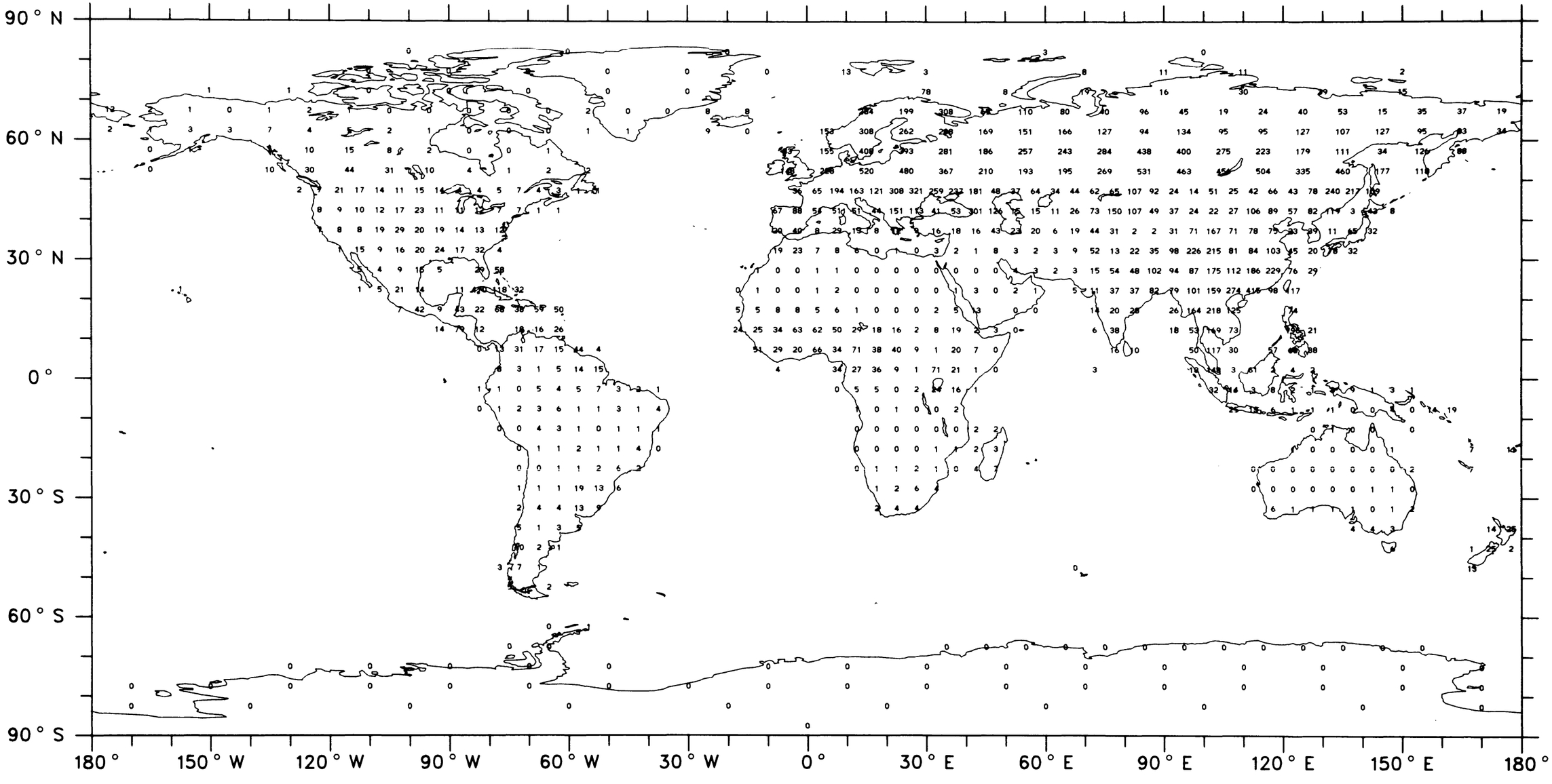


Map III-7

Number of Observations of Cumulonimbus (in Hundreds)

June, July, August (1971-1980)

Land Areas Only



Map III-8

Percent of Land Station Reports Contributing to Statistics of the High Cloud Level

June, July, August (1971-1980)

Land Areas Only

ZONAL AVERAGE

90 ° N
60 ° N
30 ° N
0 °
30 ° S
60 ° S
90 ° S

180 ° 150 ° W 120 ° W 90 ° W 60 ° W 30 ° W 0 ° 30 ° E 60 ° E 90 ° E 120 ° E 150 ° E 180 °

62 50 59 66 71 71 73 79 81 83 82 82 80 83 83 69 73 77 78 80 83 76 72 70 65 63 60 63 48 50 83

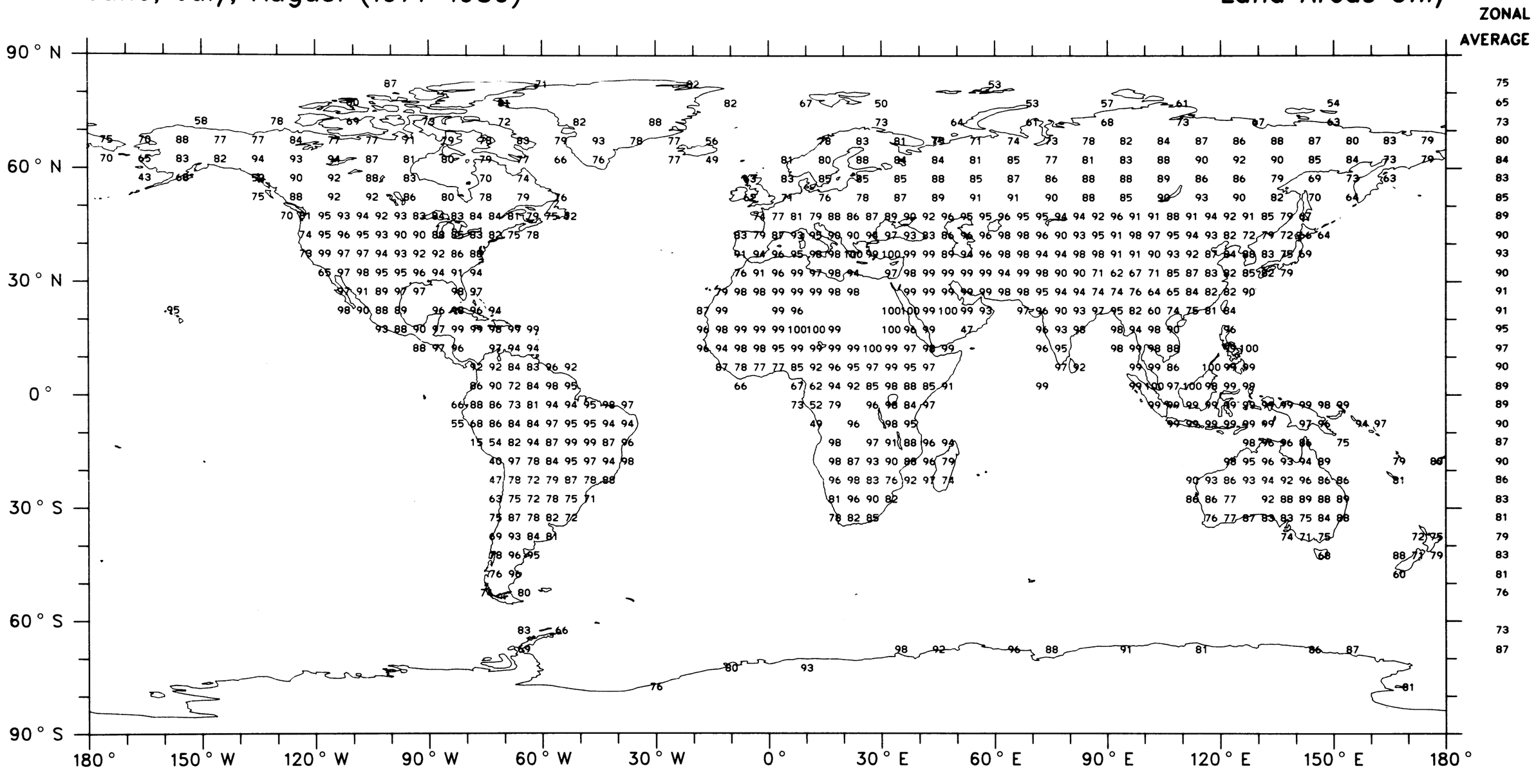
Map III-9

Map III-9

Percent of Land Station Reports Contributing to Statistics of the Middle Cloud Level

June, July, August (1971-1980)

Land Areas Only

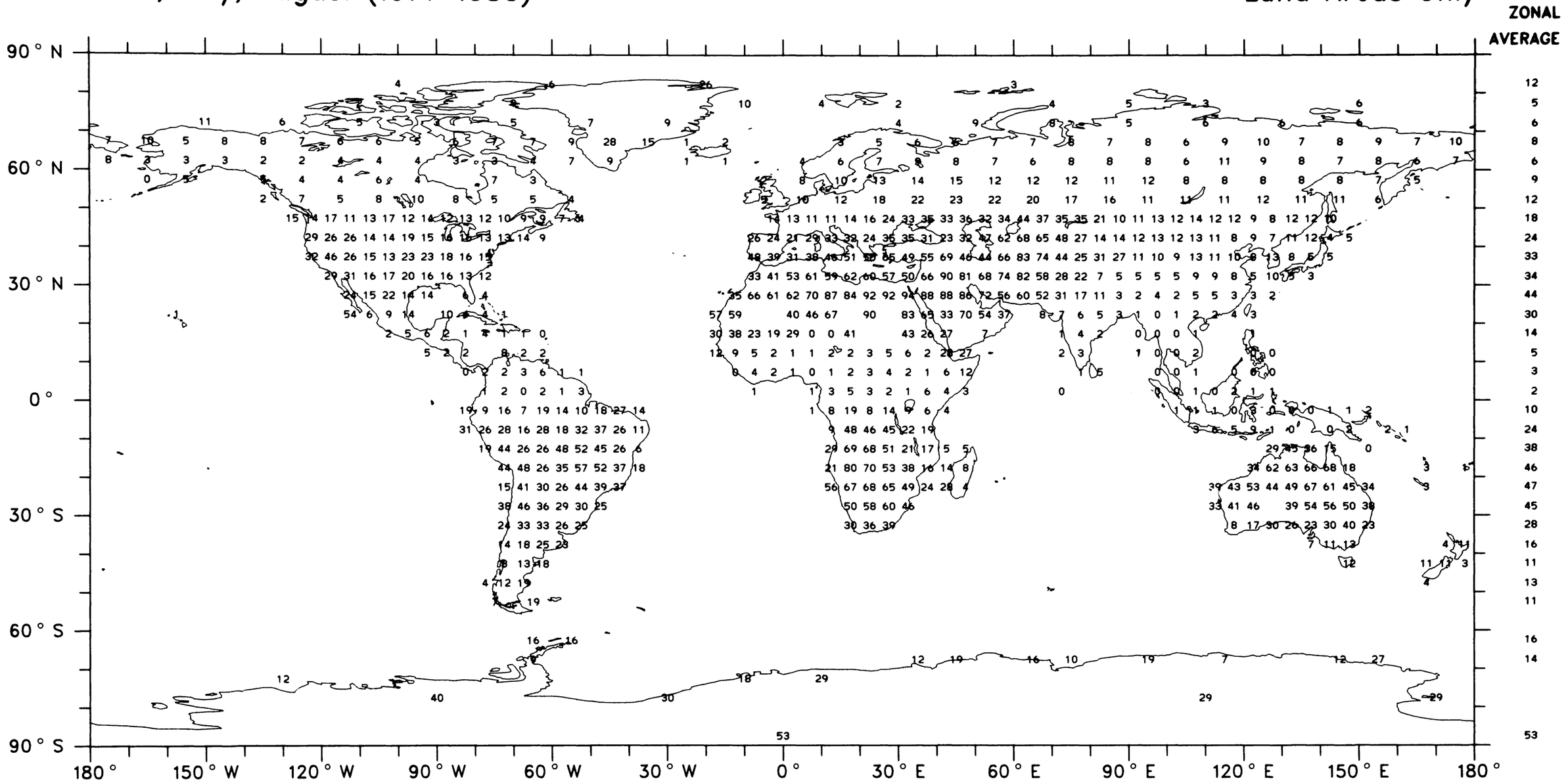


Map III-10

Frequency of Occurrence (Percent) of Completely Clear Sky

June, July, August (1971-1980)

Land Areas Only



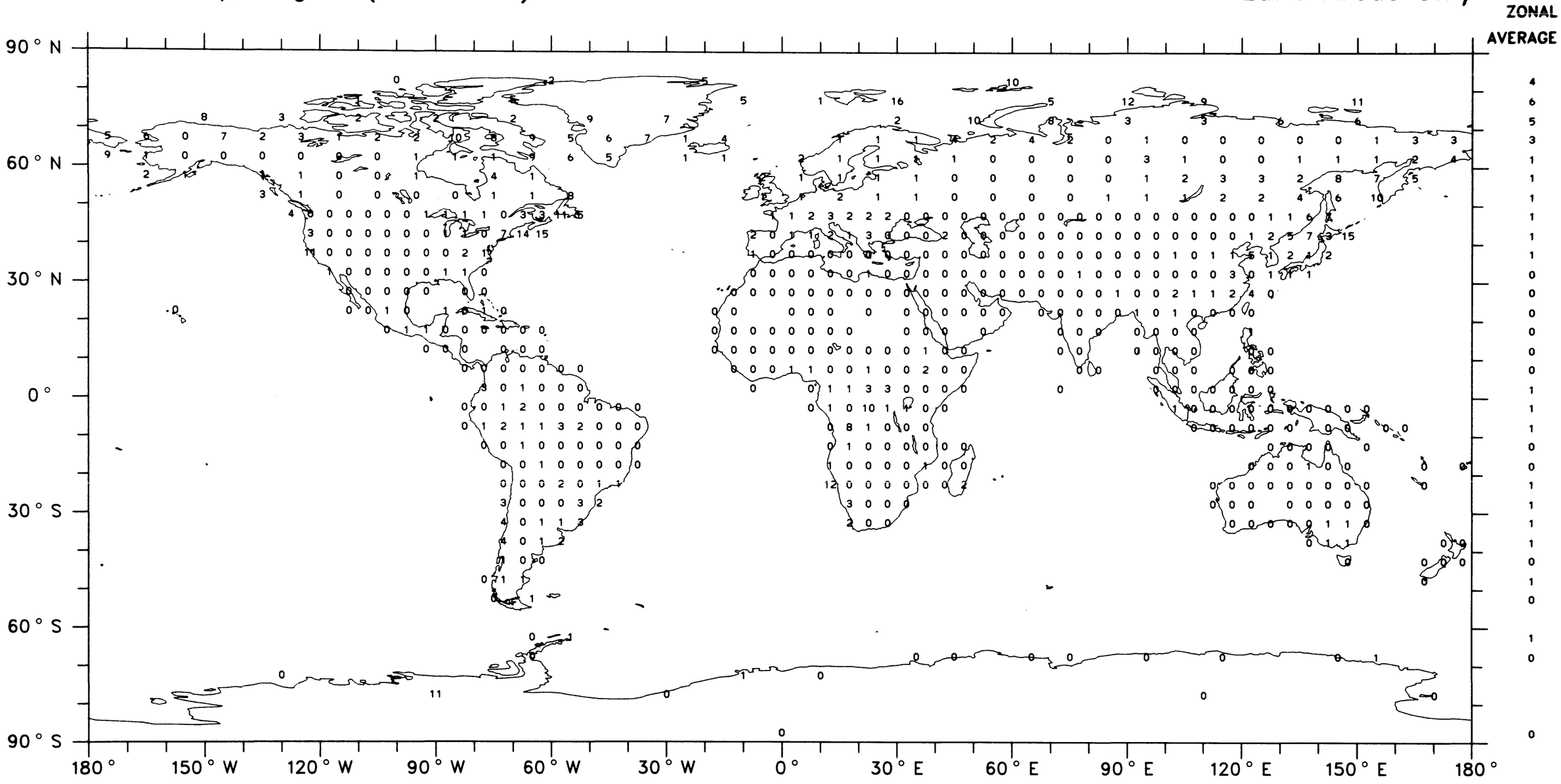
Map III-11

Map III-11

Frequency of Occurrence (Percent) of Sky Obscured due to Fog

June, July, August (1971-1980)

Land Areas Only

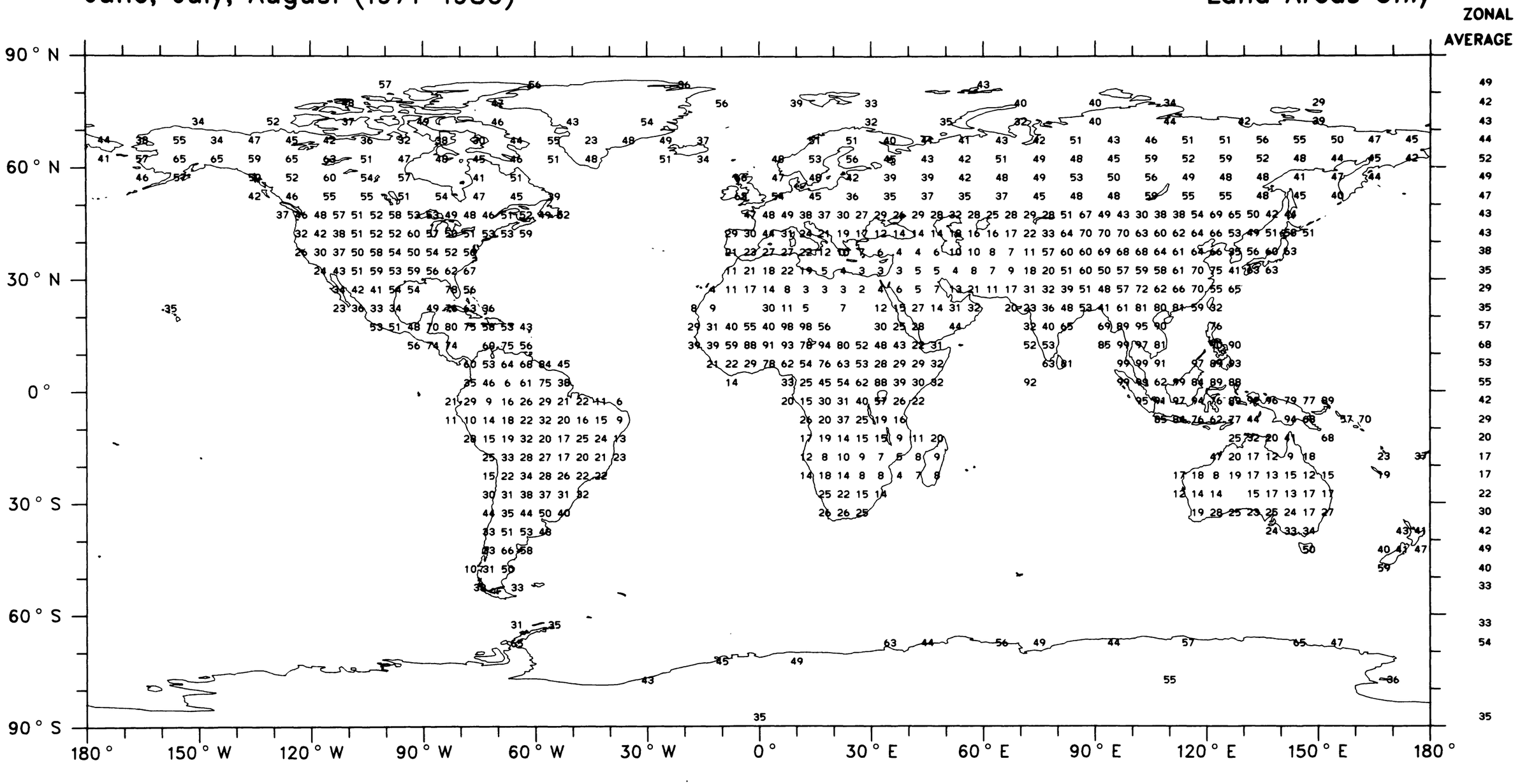


Map III-12

Frequency of Occurrence (Percent) of Ci/Cs/Cc

June, July, August (1971-1980)

Land Areas Only

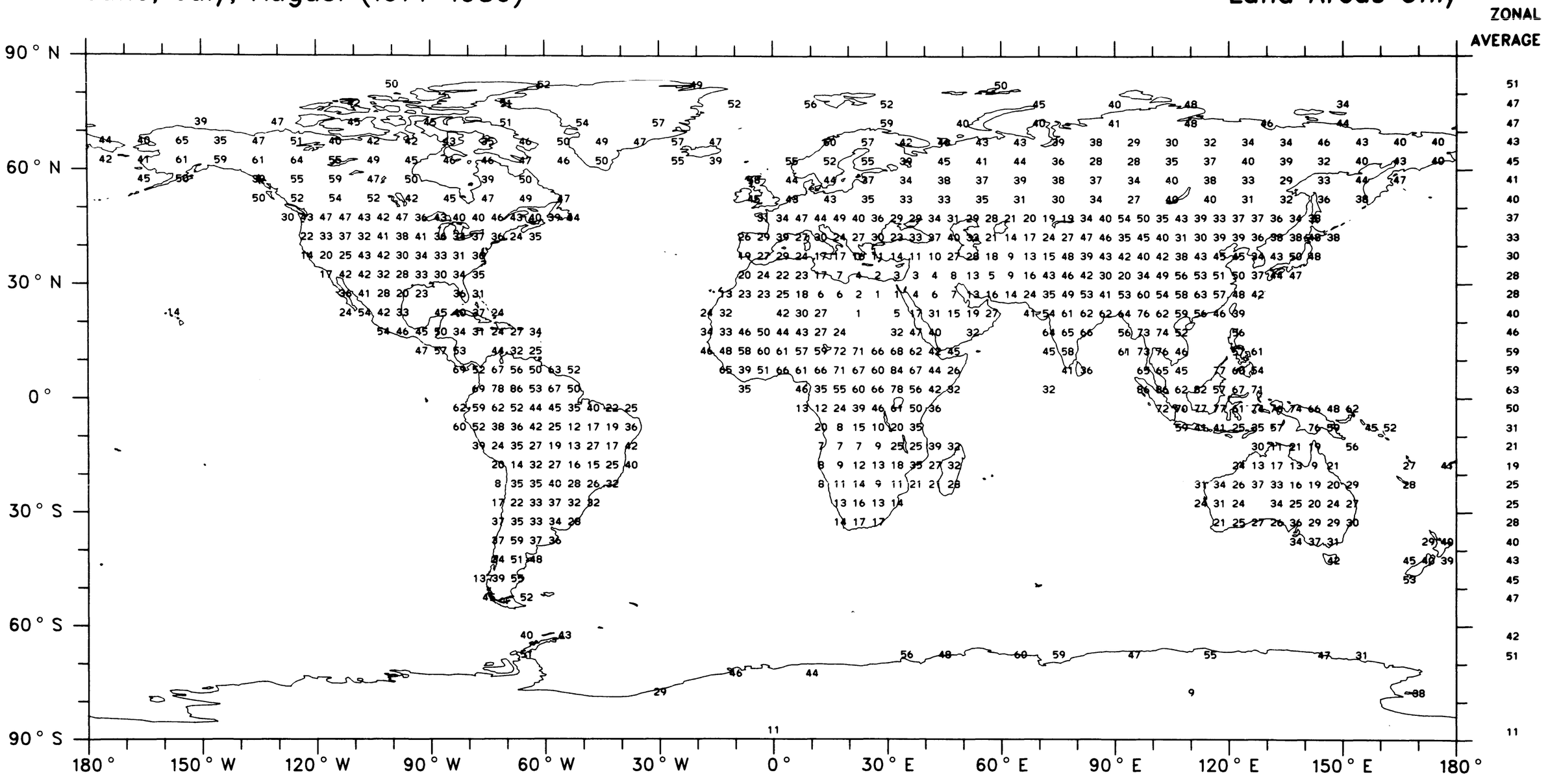


Map III-13

Frequency of Occurrence (Percent) of As/Ac

June, July, August (1971-1980)

Land Areas Only

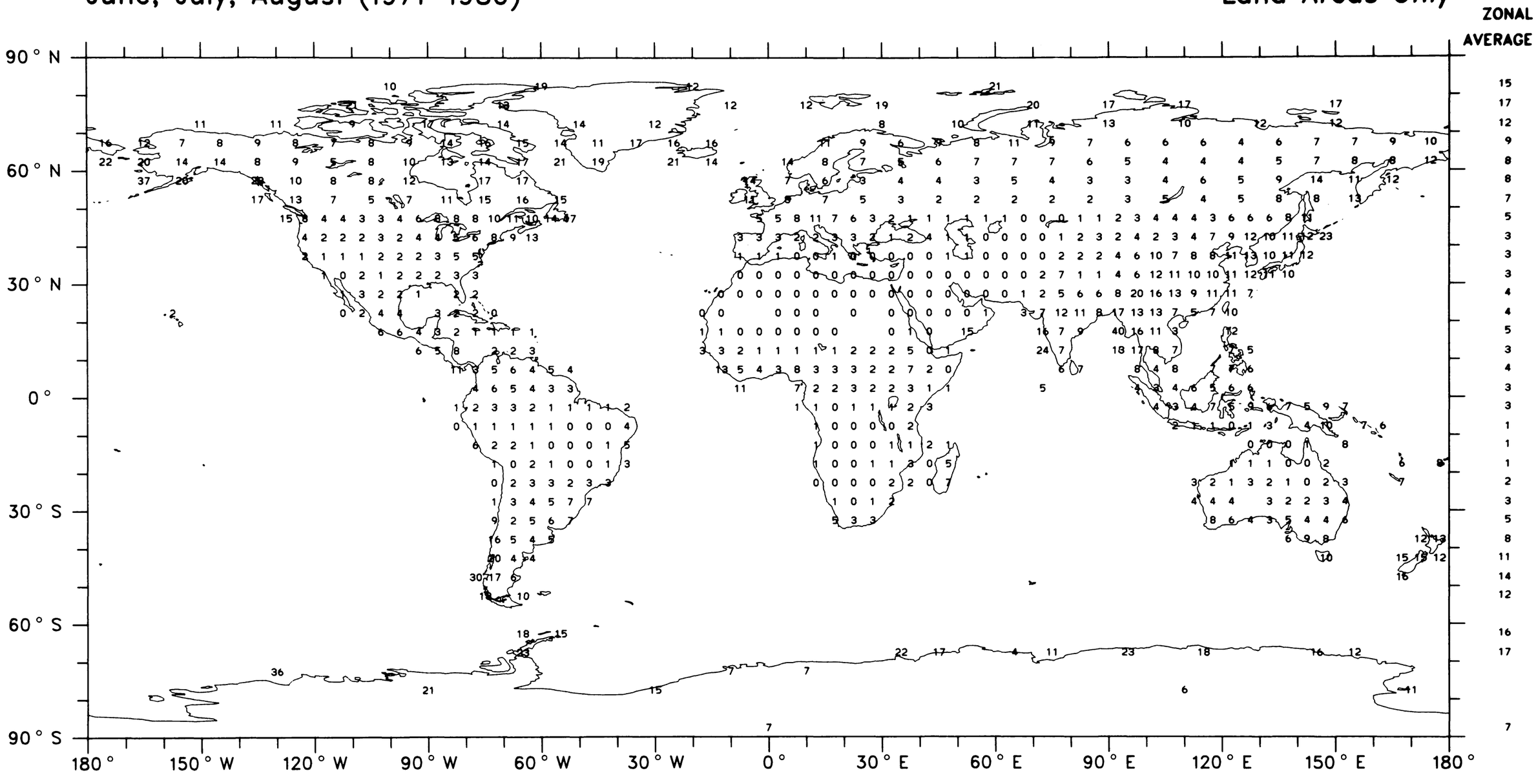


Map III-14

Frequency of Occurrence (Percent) of Nimbostratus

June, July, August (1971-1980)

Land Areas Only

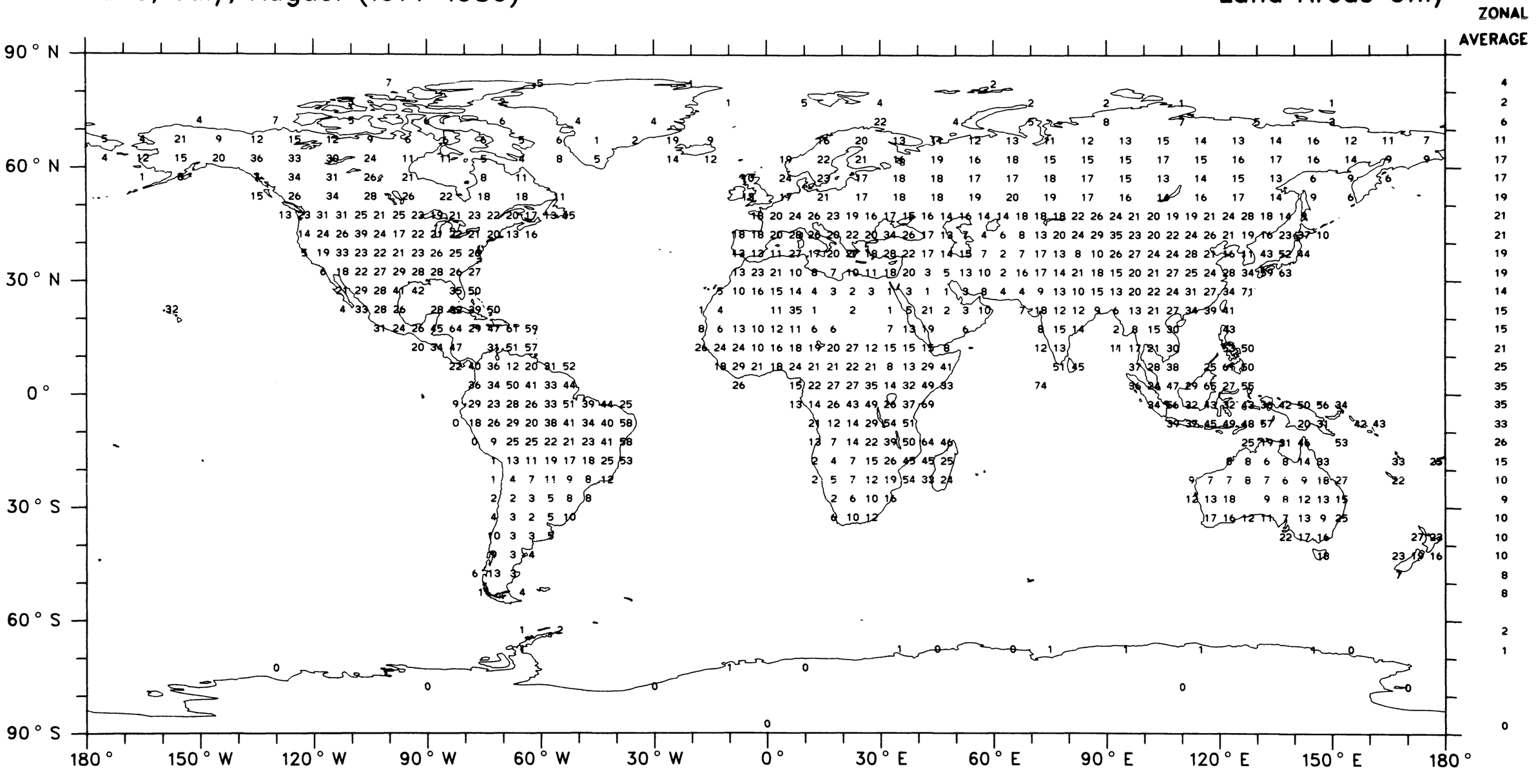


Map III-15

Frequency of Occurrence (Percent) of Cumulus

June, July, August (1971-1980)

Land Areas Only

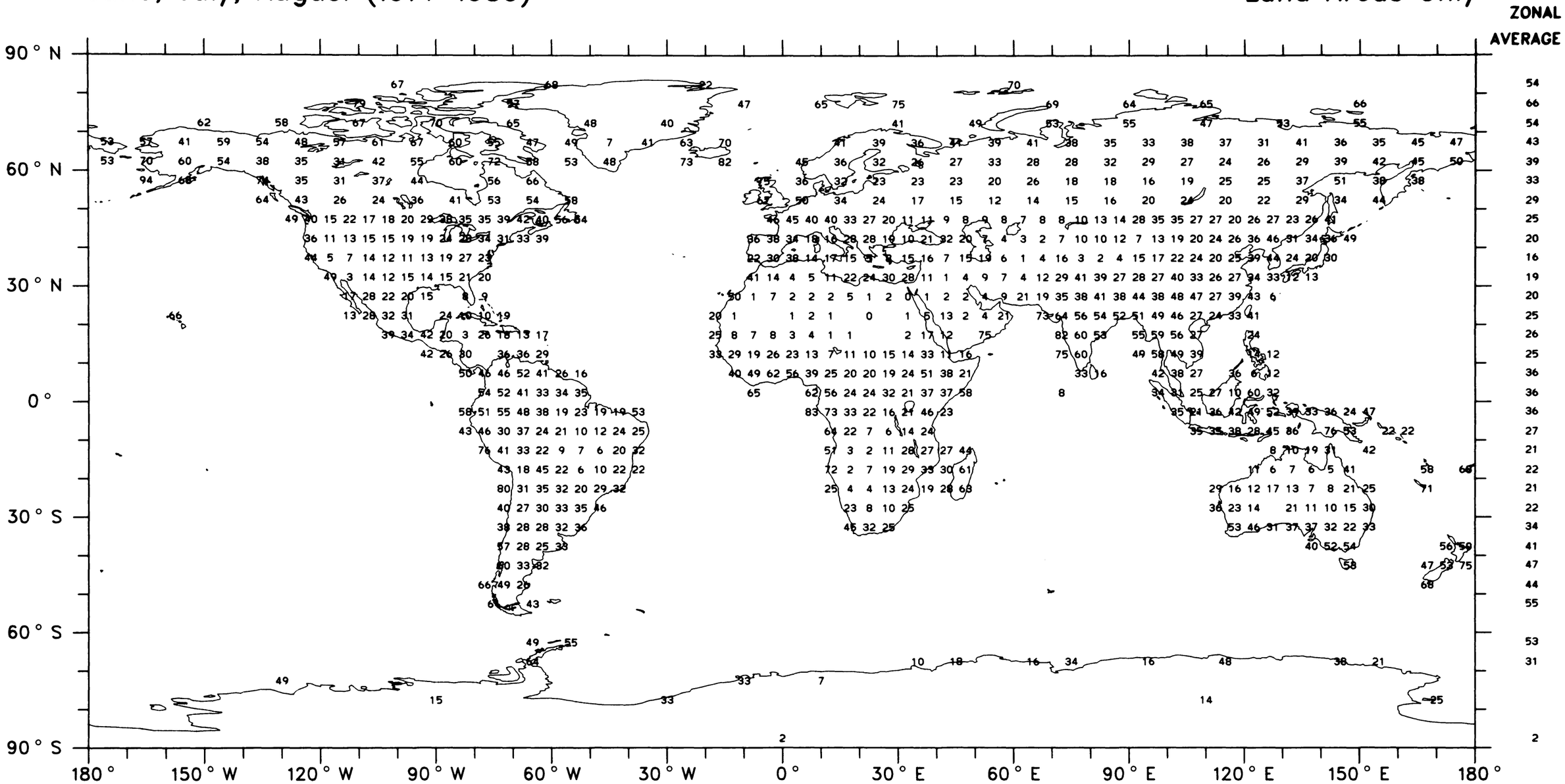


Map III-16

Frequency of Occurrence (Percent) of St/Sc

June, July, August (1971-1980)

Land Areas Only

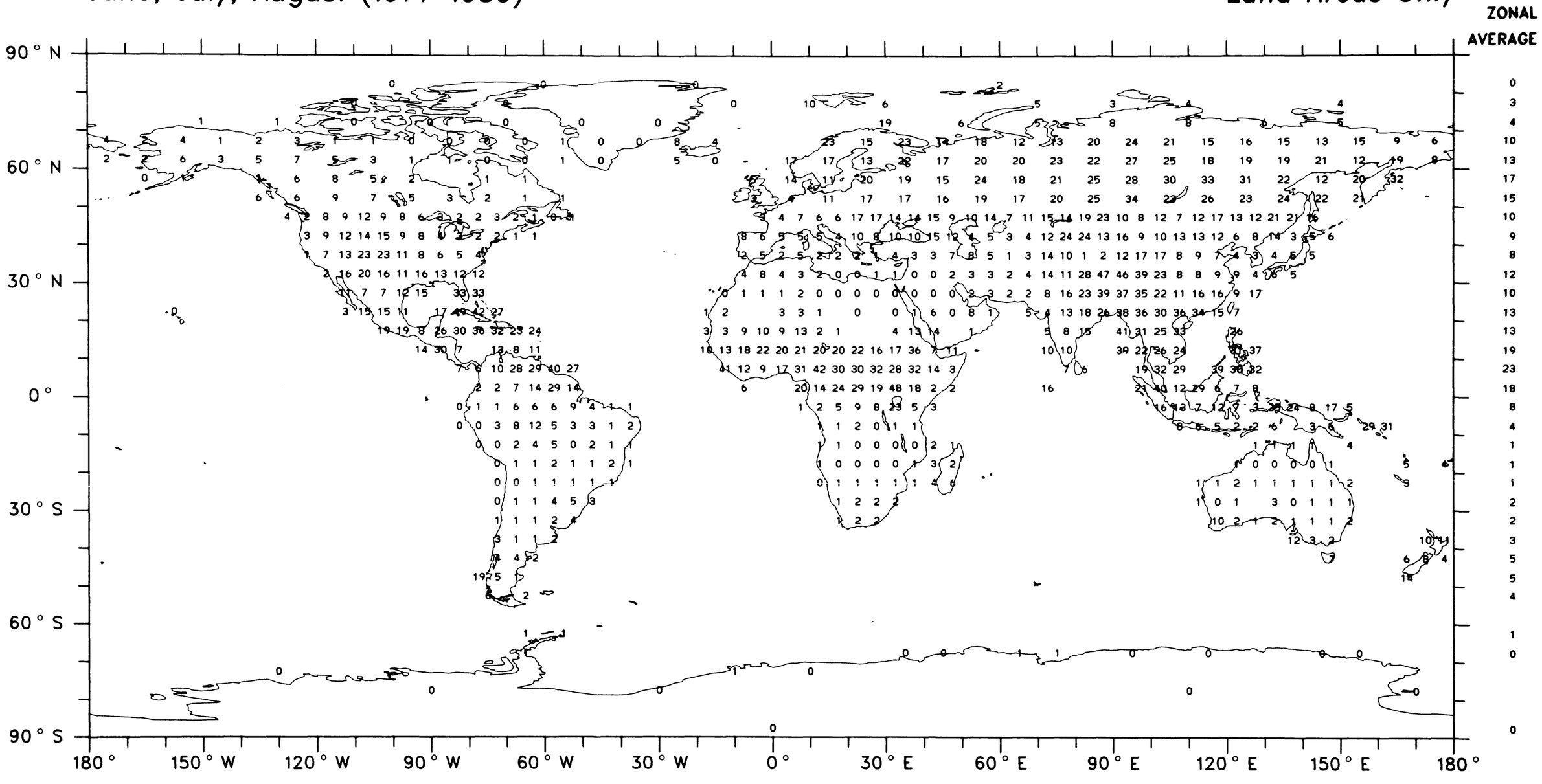


Map III-17

Frequency of Occurrence (Percent) of Cumulonimbus

June, July, August (1971-1980)

Land Areas Only

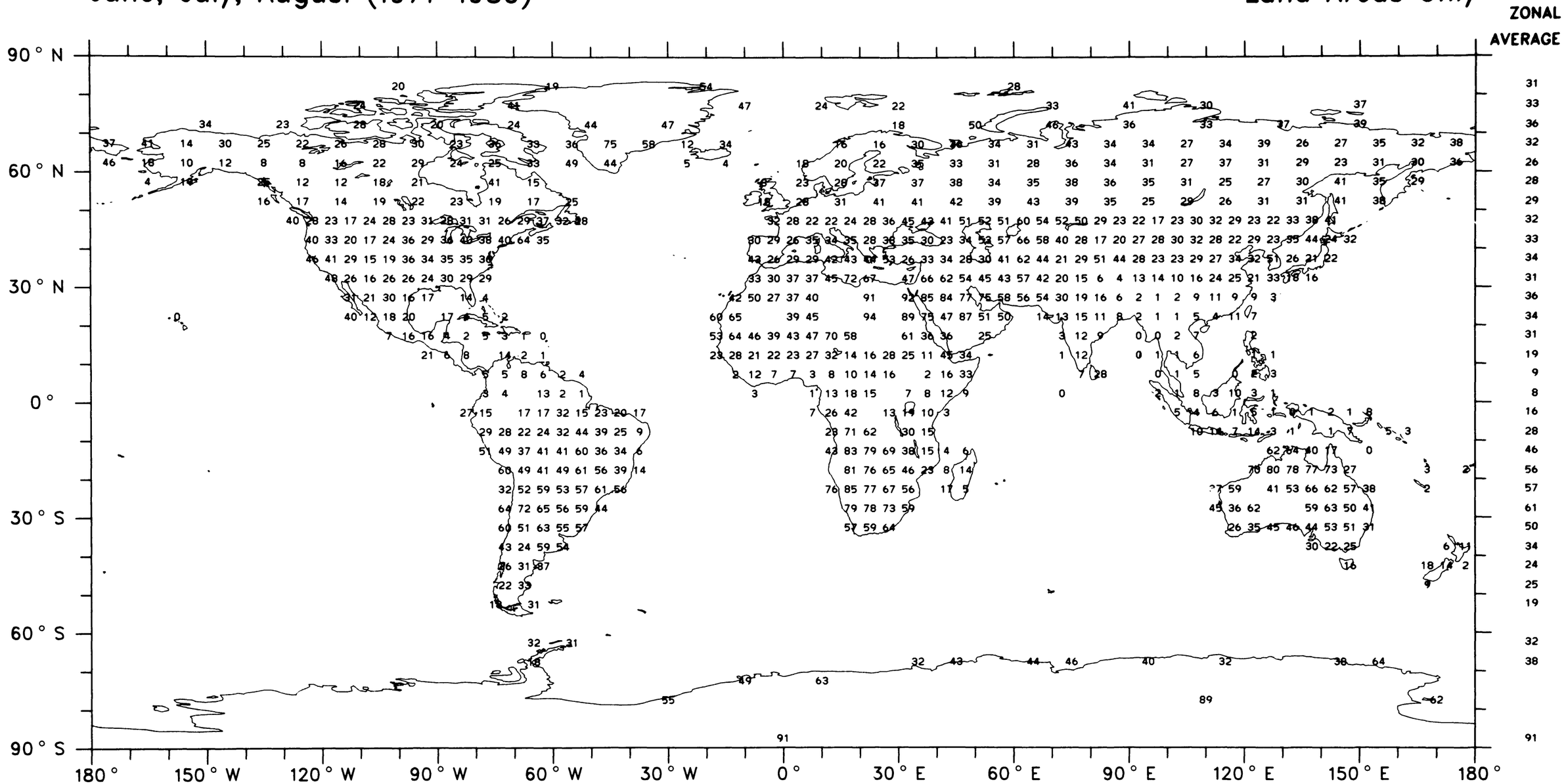


Map III-18

Given Ci/Cs/Cc, Probability (Percent) That No Other Cloud Is Present

June, July, August (1971-1980)

Land Areas Only

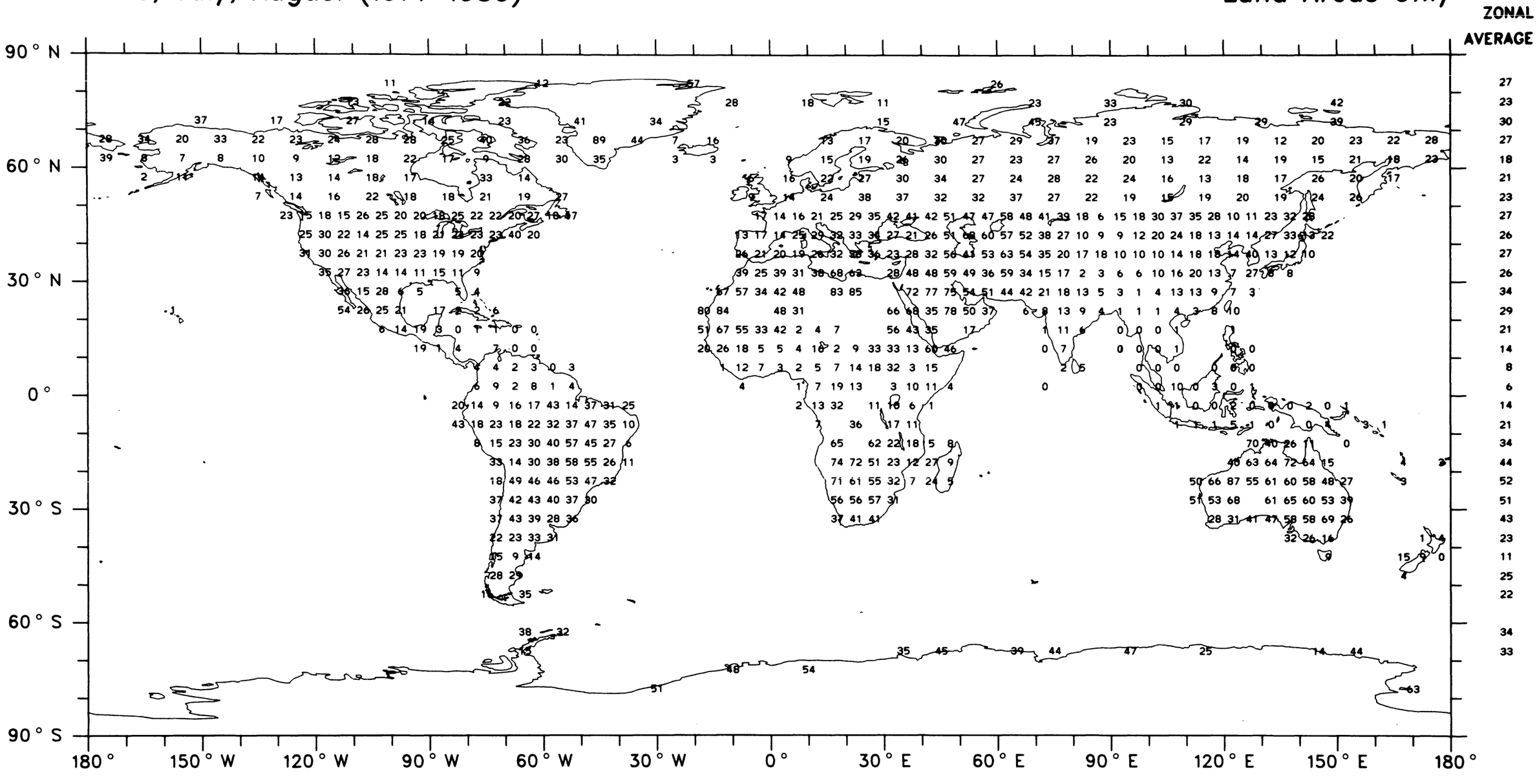


Map III-19

Given As/Ac, Probability (Percent) That No Other Cloud Is Present

June, July, August (1971-1980)

Land Areas Only

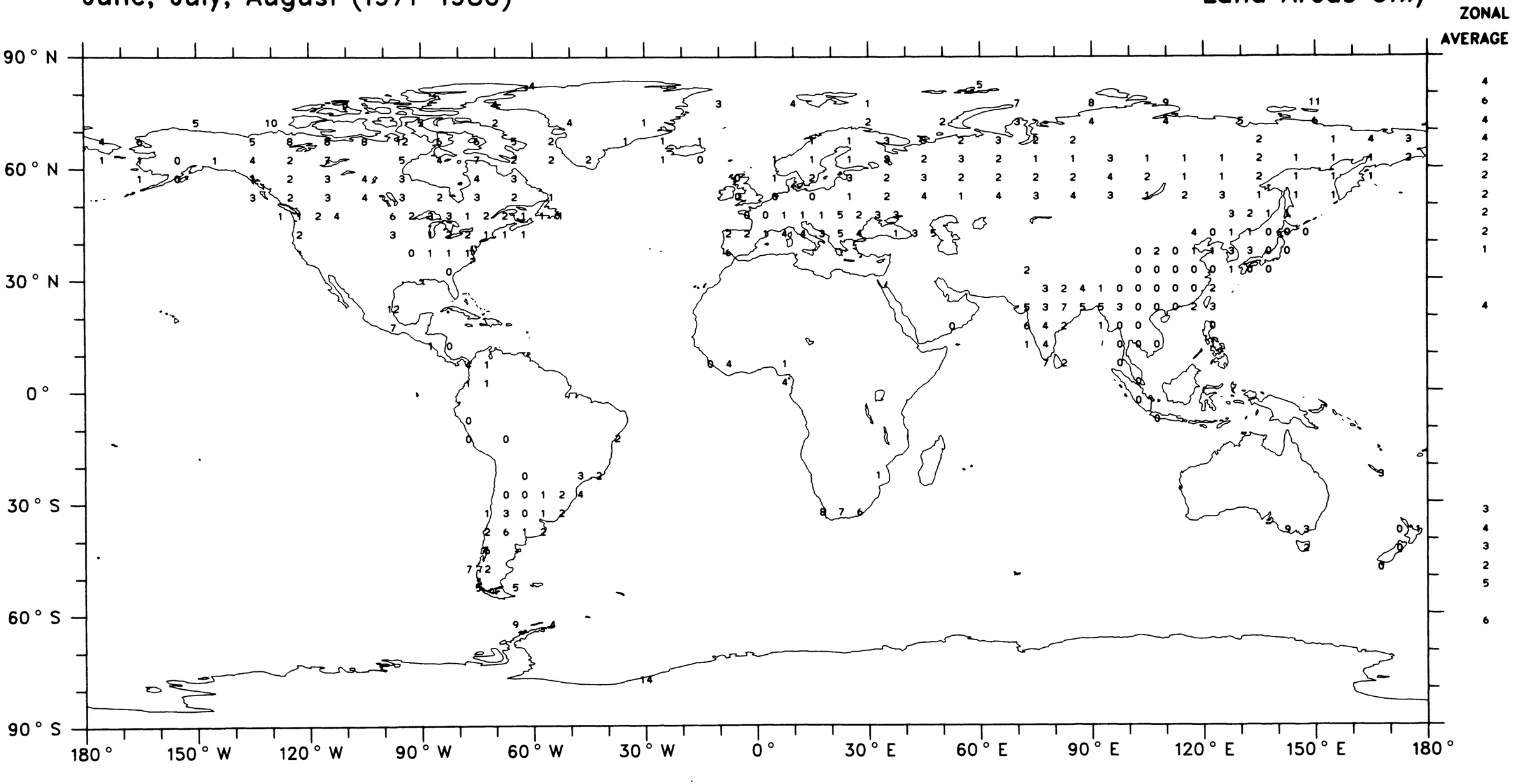


Map III-20

Given Nimbostratus, Probability (Percent) That No Other Cloud Is Present

June, July, August (1971-1980)

Land Areas Only

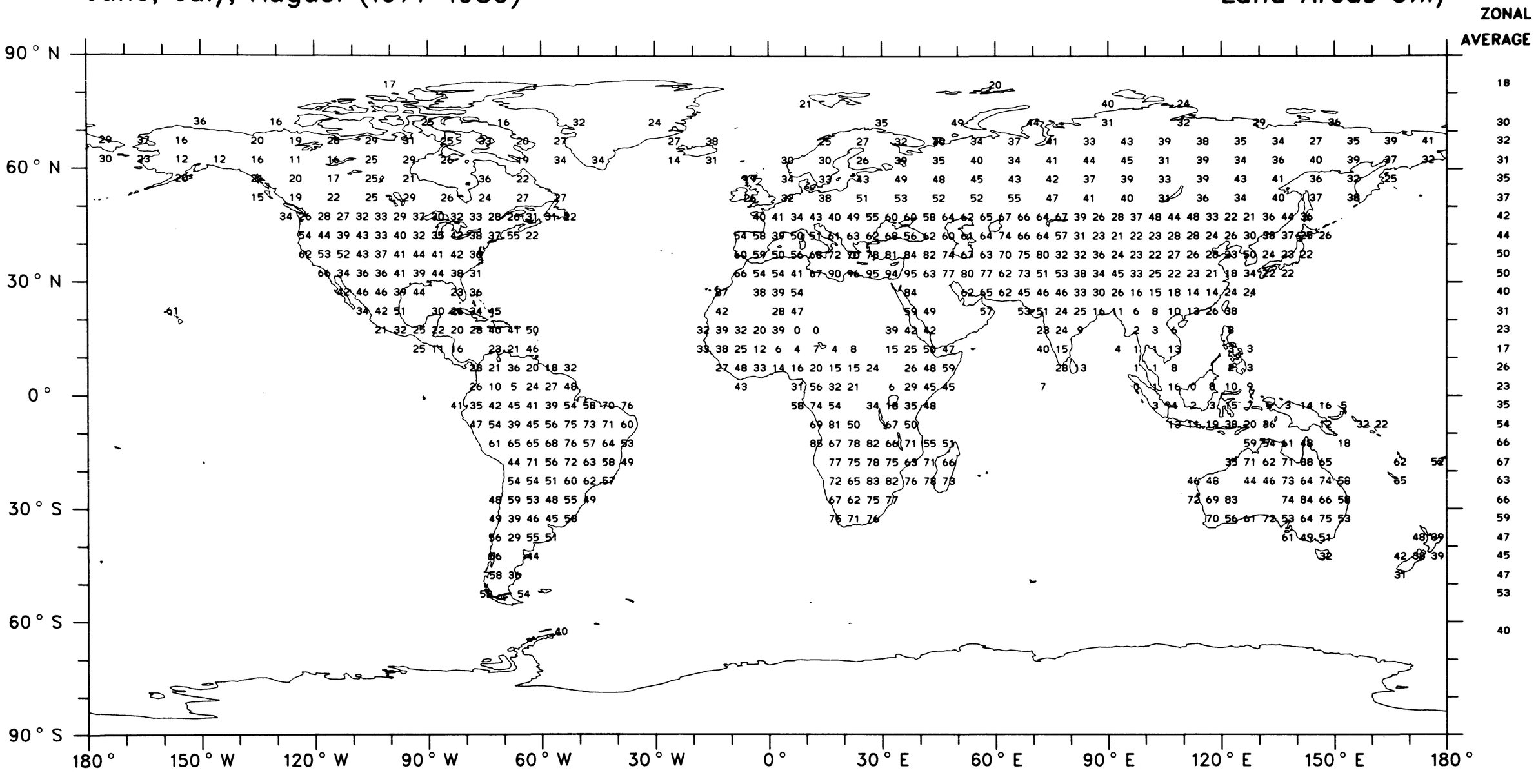


Map III-21

Given Cumulus, Probability (Percent) That No Other Cloud Is Present

June, July, August (1971-1980)

Land Areas Only

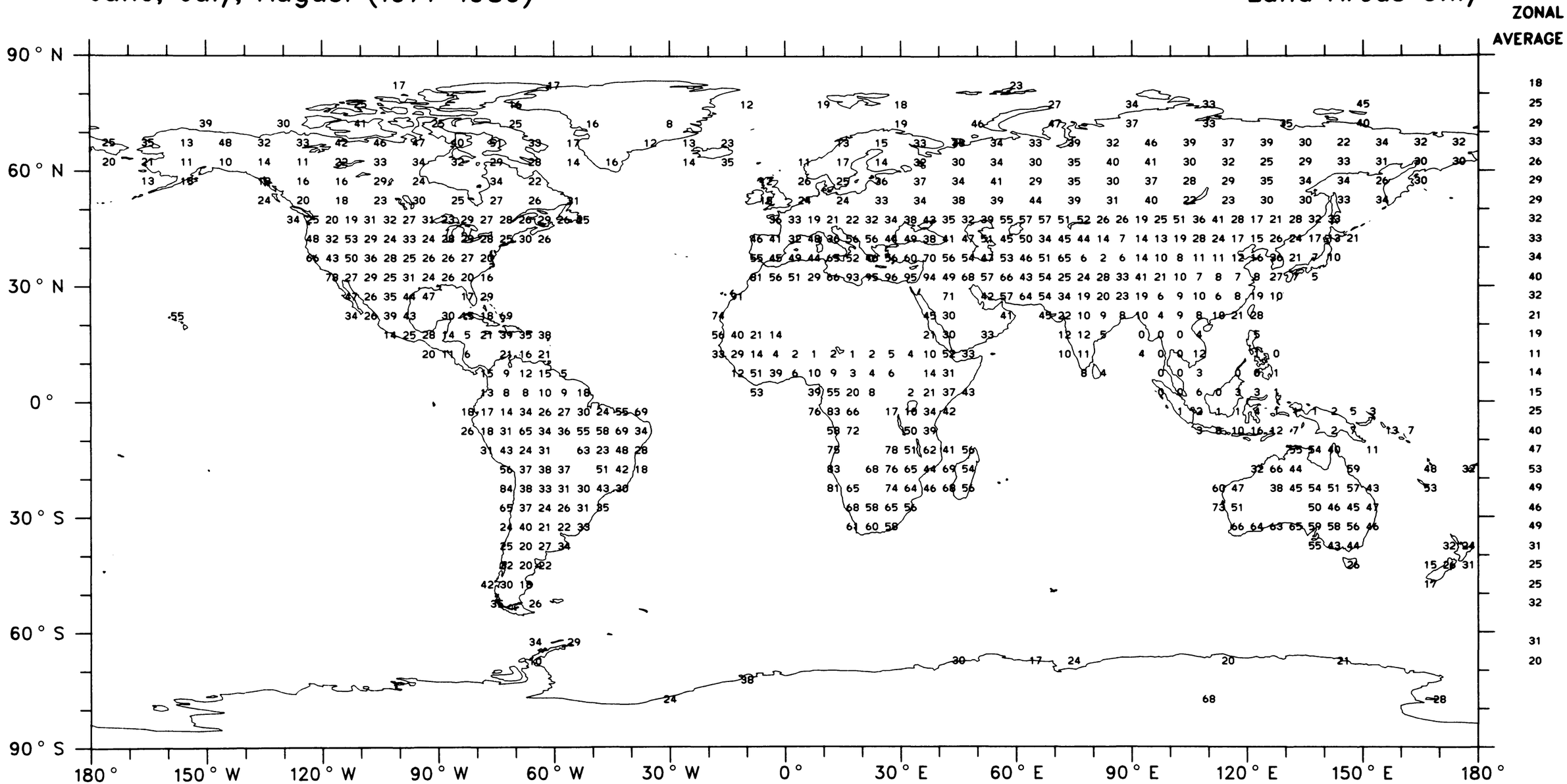


Map III-22

Given St/Sc, Probability (Percent) That No Other Cloud Is Present

June, July, August (1971-1980)

Land Areas Only



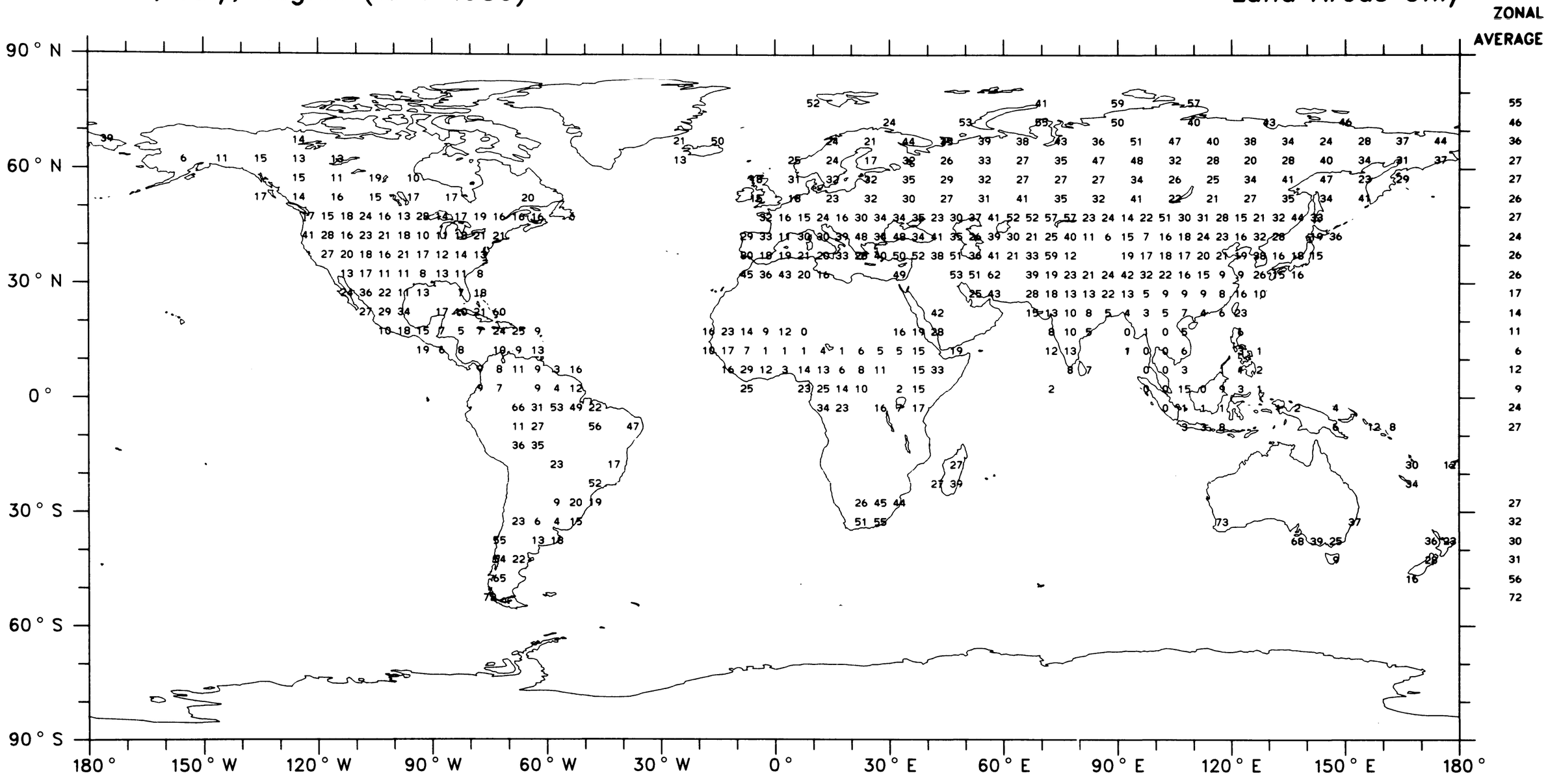
Map III-23

Map III-23

Given Cumulonimbus, Probability (Percent) That No Other Cloud Is Present

June, July, August (1971-1980)

Land Areas Only

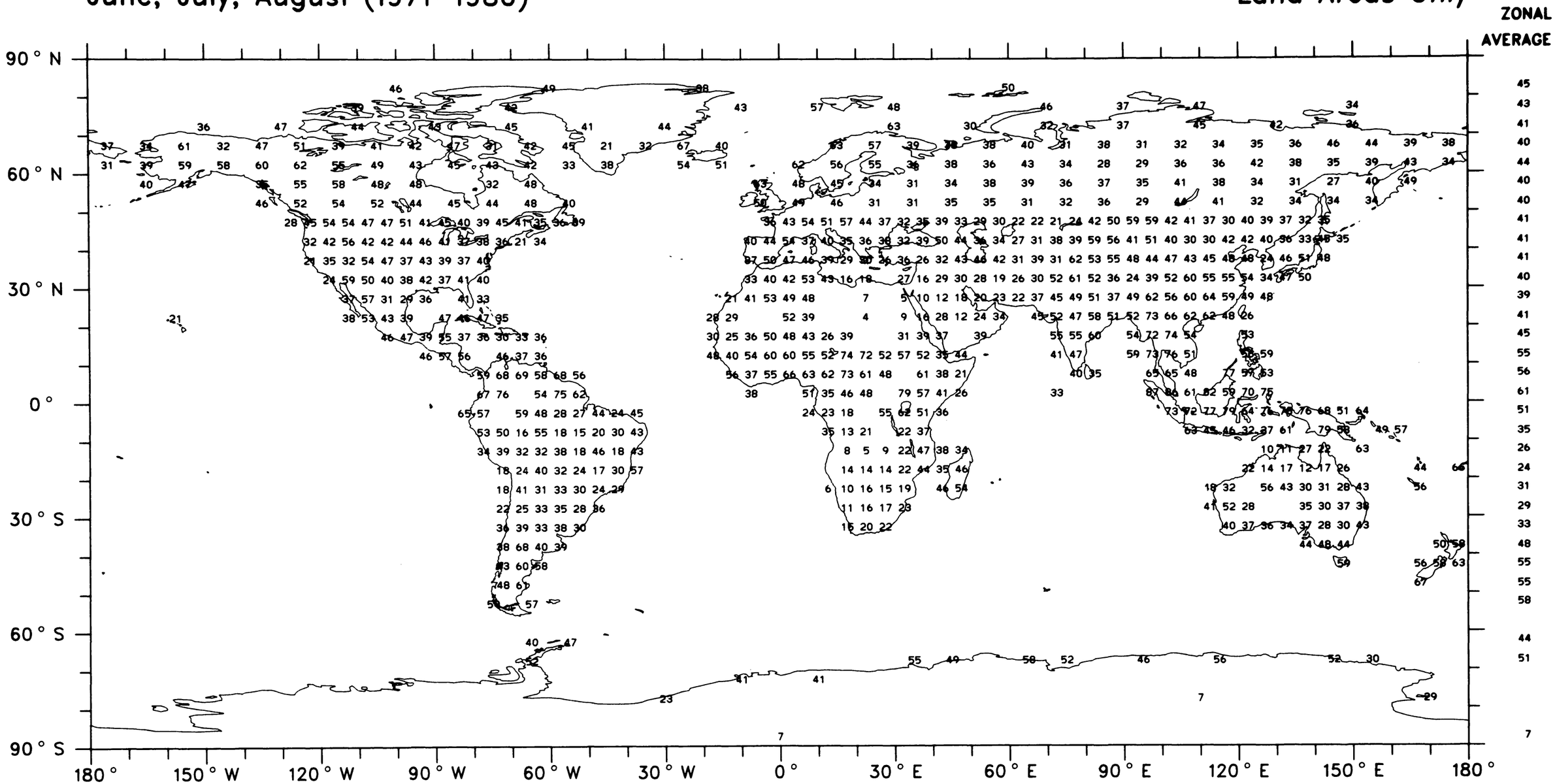


Map III-24

Given Ci/Cs/Cc, Probability (Percent) That As/Ac is Also Present

June, July, August (1971-1980)

Land Areas Only



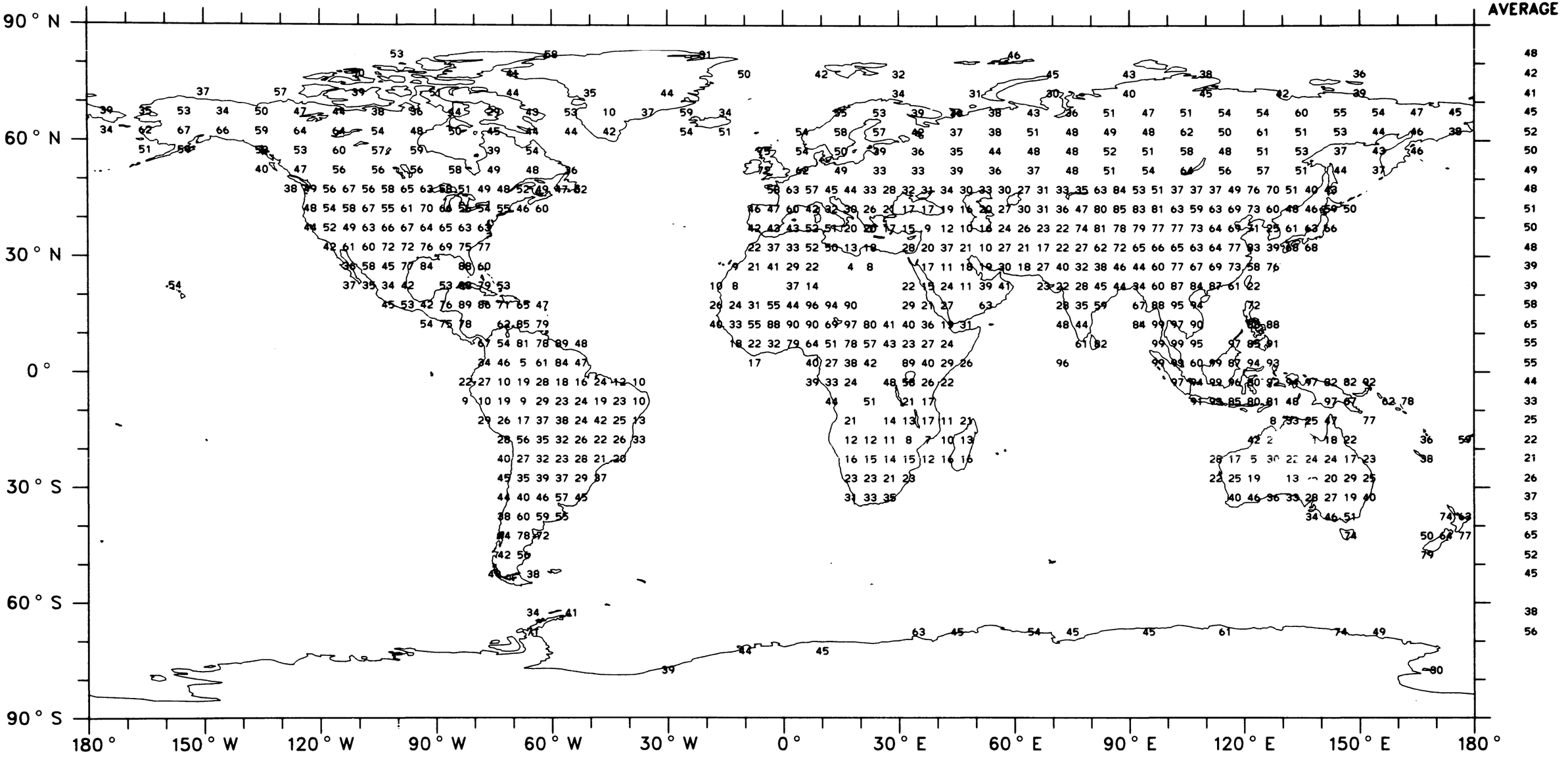
Map III-25

Map III-25

Given As/Ac, Probability (Percent) That Ci/Cs/Cc is Also Present

June, July, August (1971-1980)

Land Areas Only

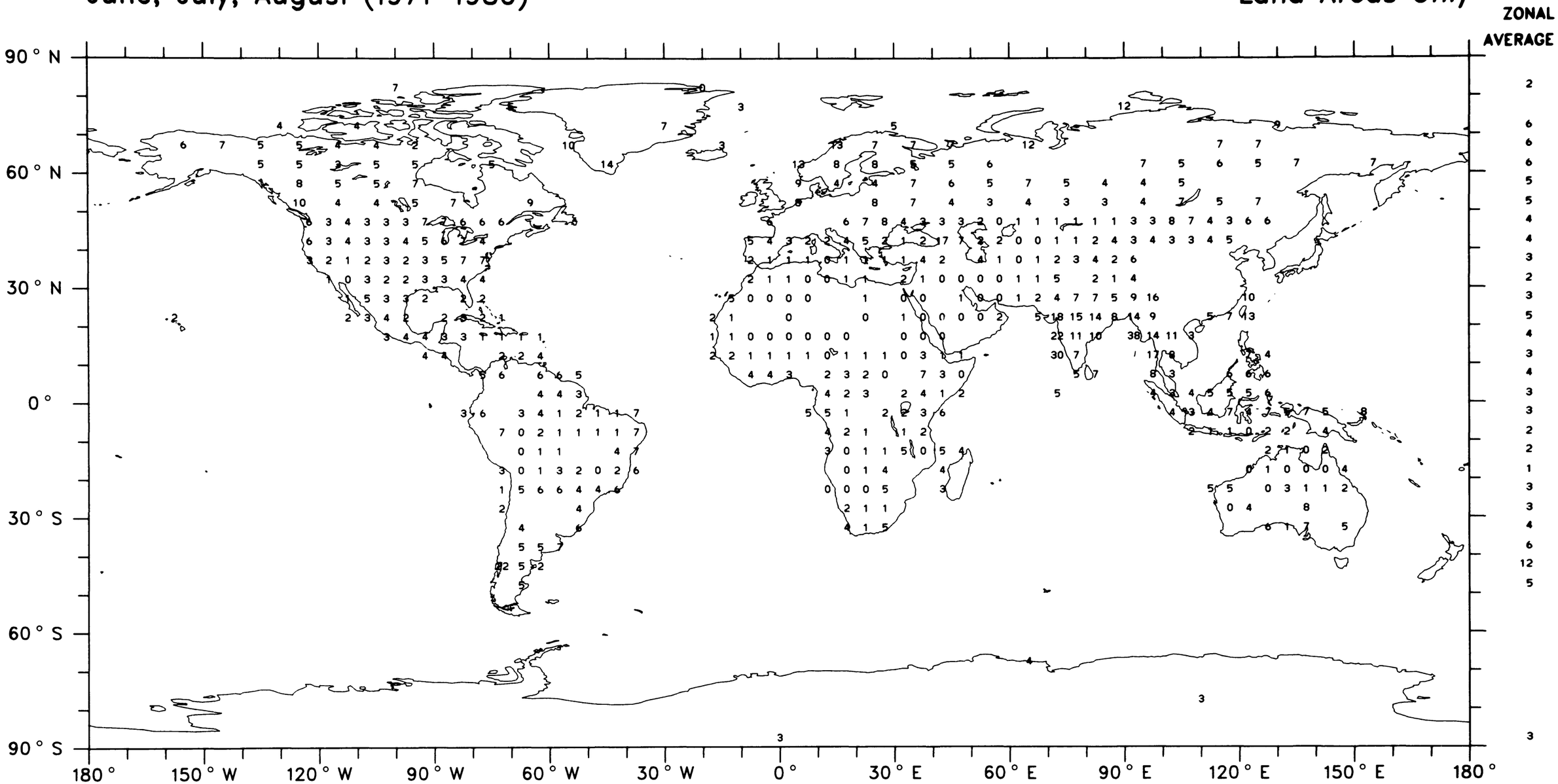


Map III-26

Given Ci/Cs/Cc, Probability (Percent) That Nimbostratus is Also Present

June, July, August (1971-1980)

Land Areas Only



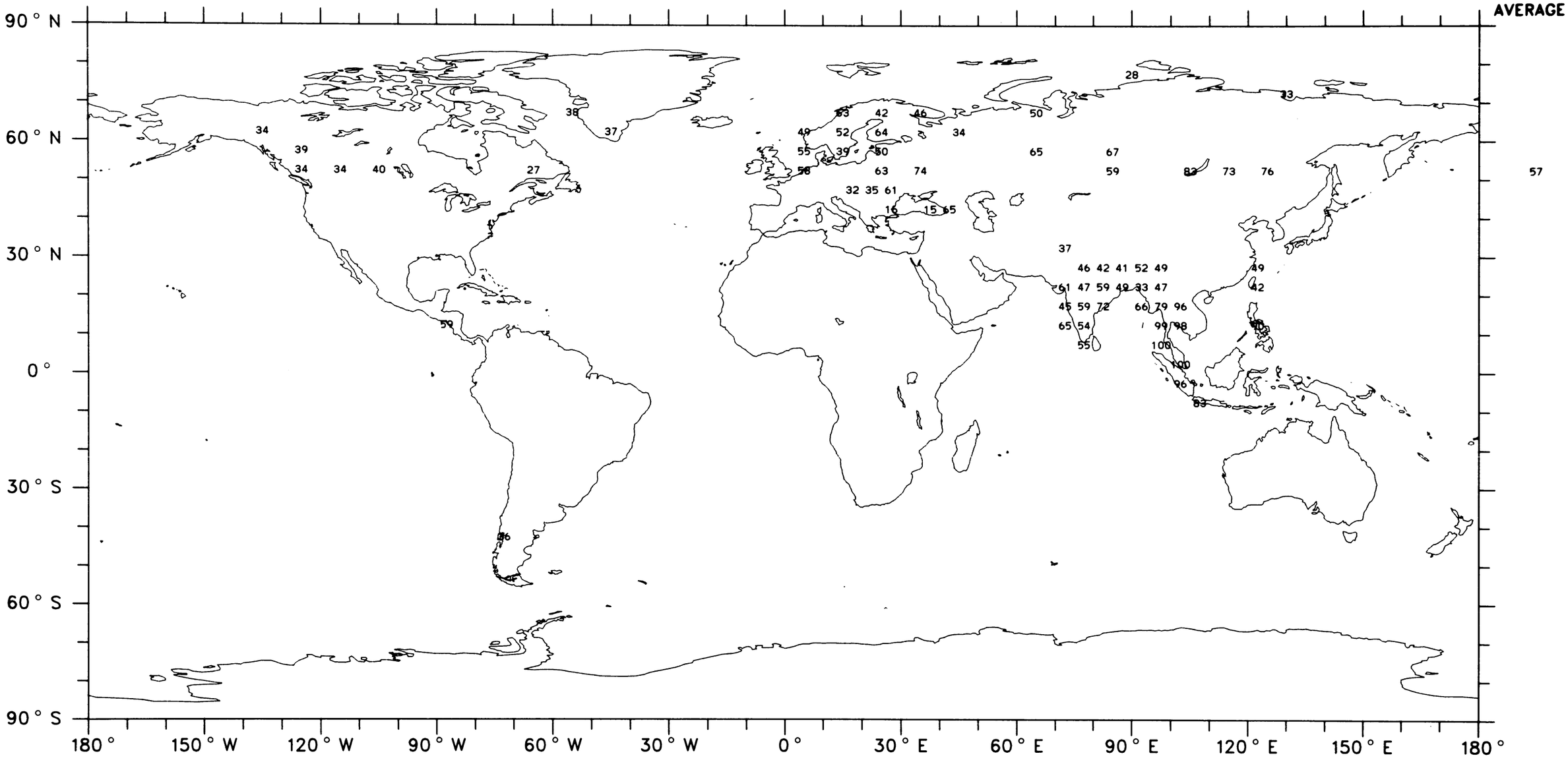
Map III-27

Map III-27

Given Nimbostratus, Probability (Percent) That Ci/Cs/Cc is Also Present

June, July, August (1971-1980)

Land Areas Only

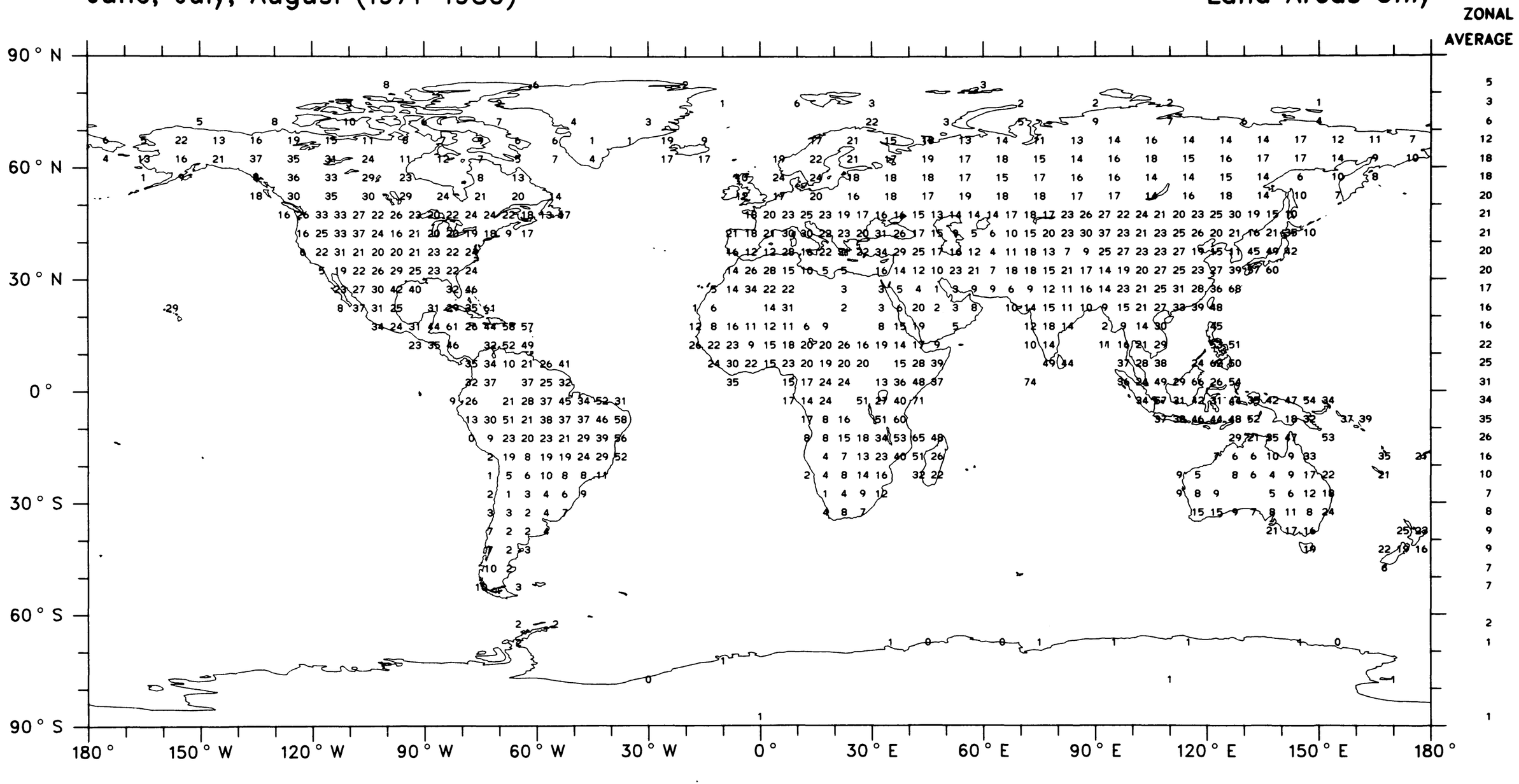


Map III-28

Given Ci/Cs/Cc, Probability (Percent) That Cumulus is Also Present

June, July, August (1971-1980)

Land Areas Only

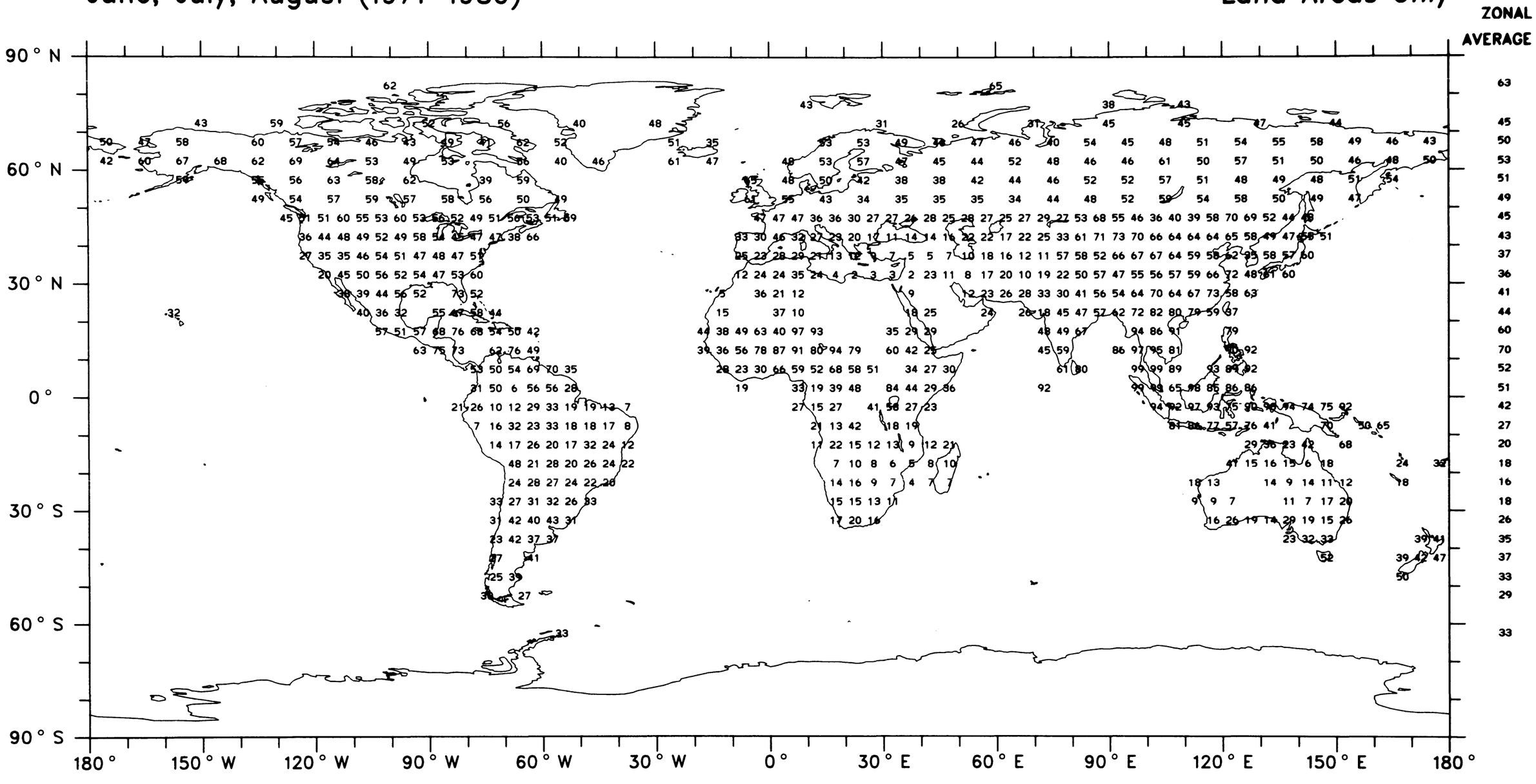


Map III-29

Given Cumulus, Probability (Percent) That Ci/Cs/Cc is Also Present

June, July, August (1971-1980)

Land Areas Only

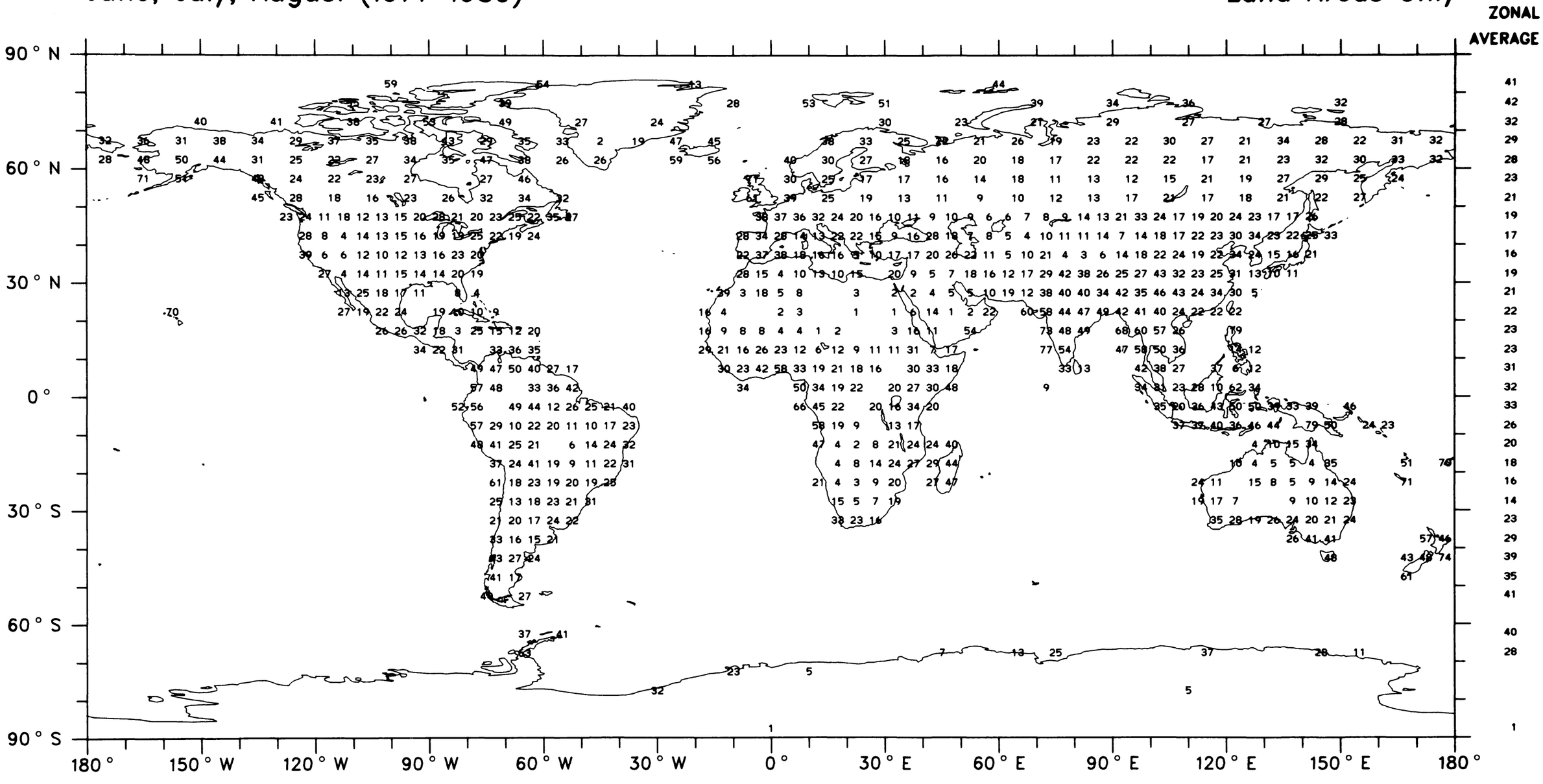


Map III-30

Given Ci/Cs/Cc, Probability (Percent) That St/Sc is Also Present

June, July, August (1971-1980)

Land Areas Only

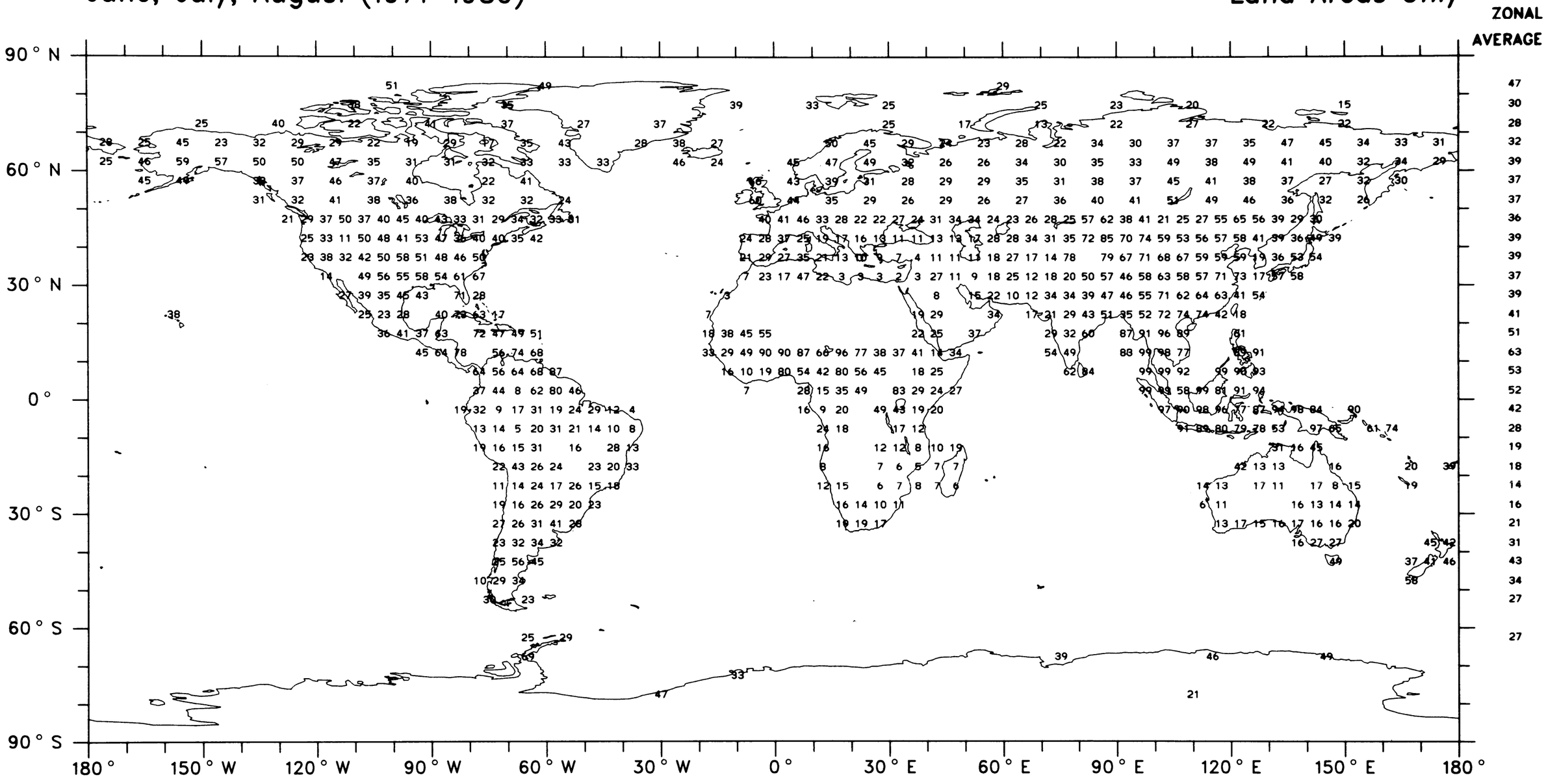


Map III-31

Given St/Sc, Probability (Percent) That Ci/Cs/Cc is Also Present

June, July, August (1971-1980)

Land Areas Only

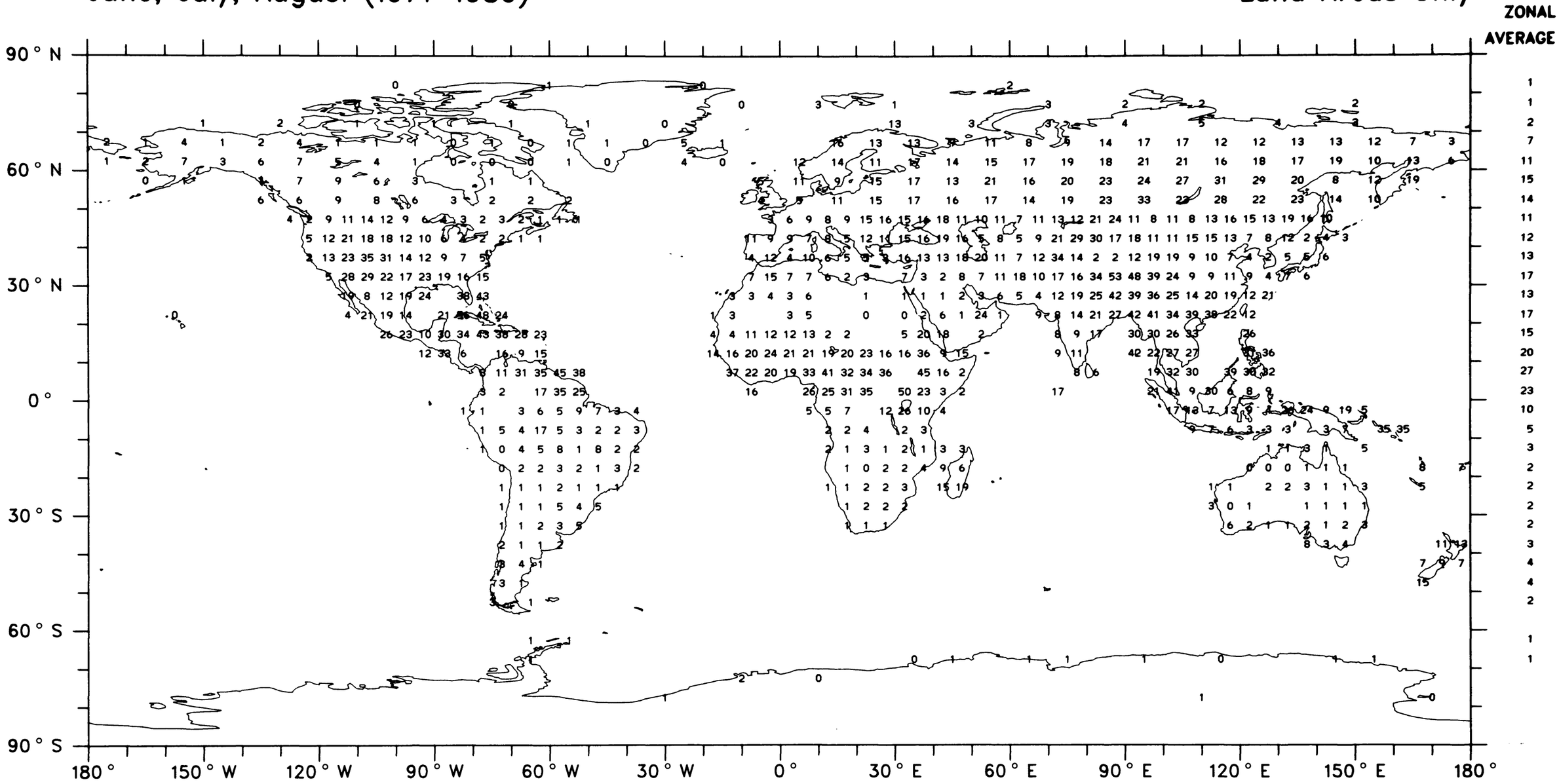


Map III-32

Given Ci/Cs/Cc, Probability (Percent) That Cumulonimbus is Also Present

June, July, August (1971-1980)

Land Areas Only

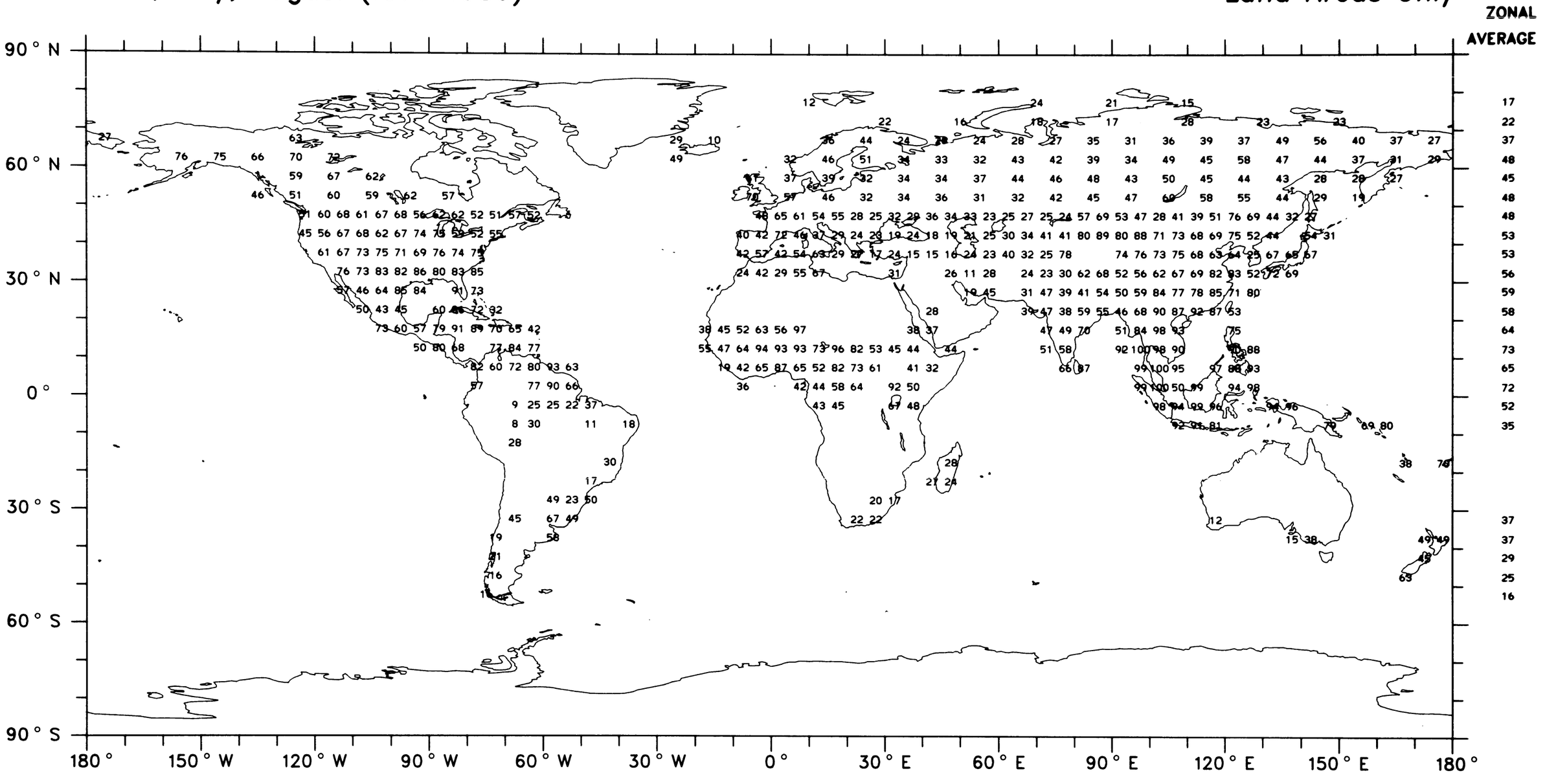


Map III-33

Given Cumulonimbus, Probability (Percent) That Ci/Cs/Cc is Also Present

June, July, August (1971-1980)

Land Areas Only

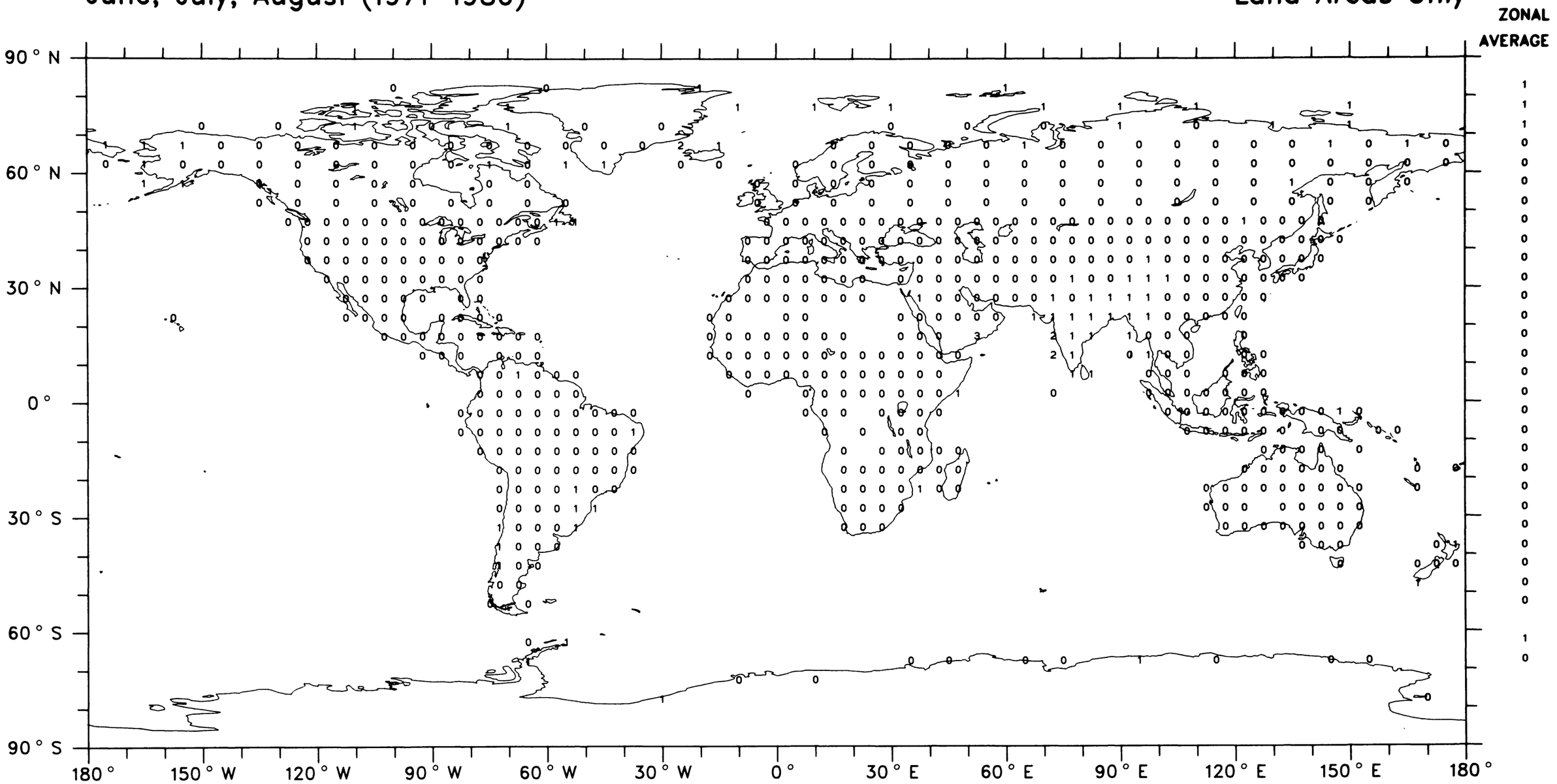


Map III-34

Given As/Ac, Probability (Percent) That Nimbostratus is Also Present

June, July, August (1971-1980)

Land Areas Only



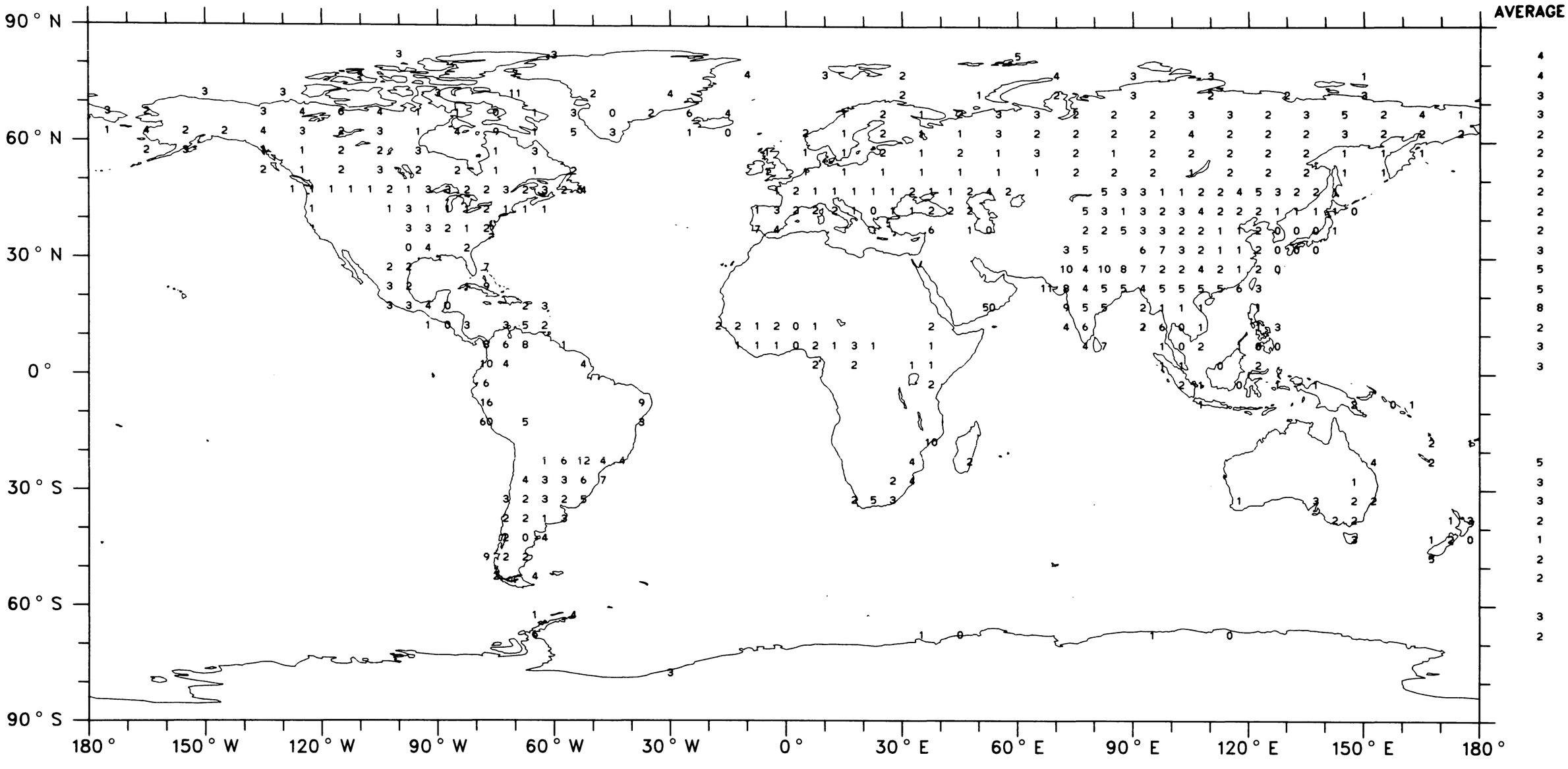
Map III-35

Map III-35

Given Nimbostratus, Probability (Percent) That As/Ac is Also Present

June, July, August (1971-1980)

Land Areas Only

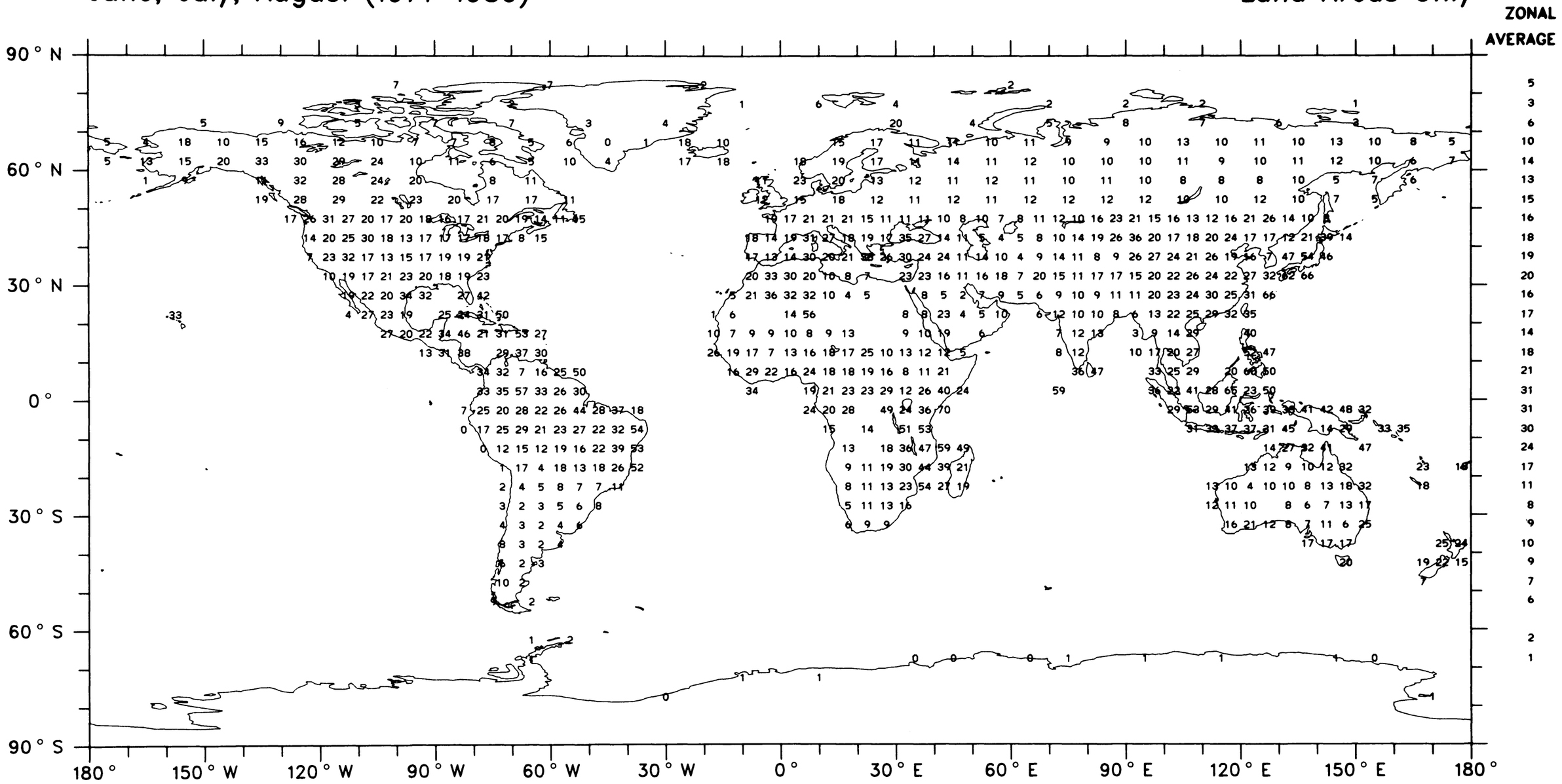


Map III-36

Given As/Ac, Probability (Percent) That Cumulus is Also Present

June, July, August (1971-1980)

Land Areas Only

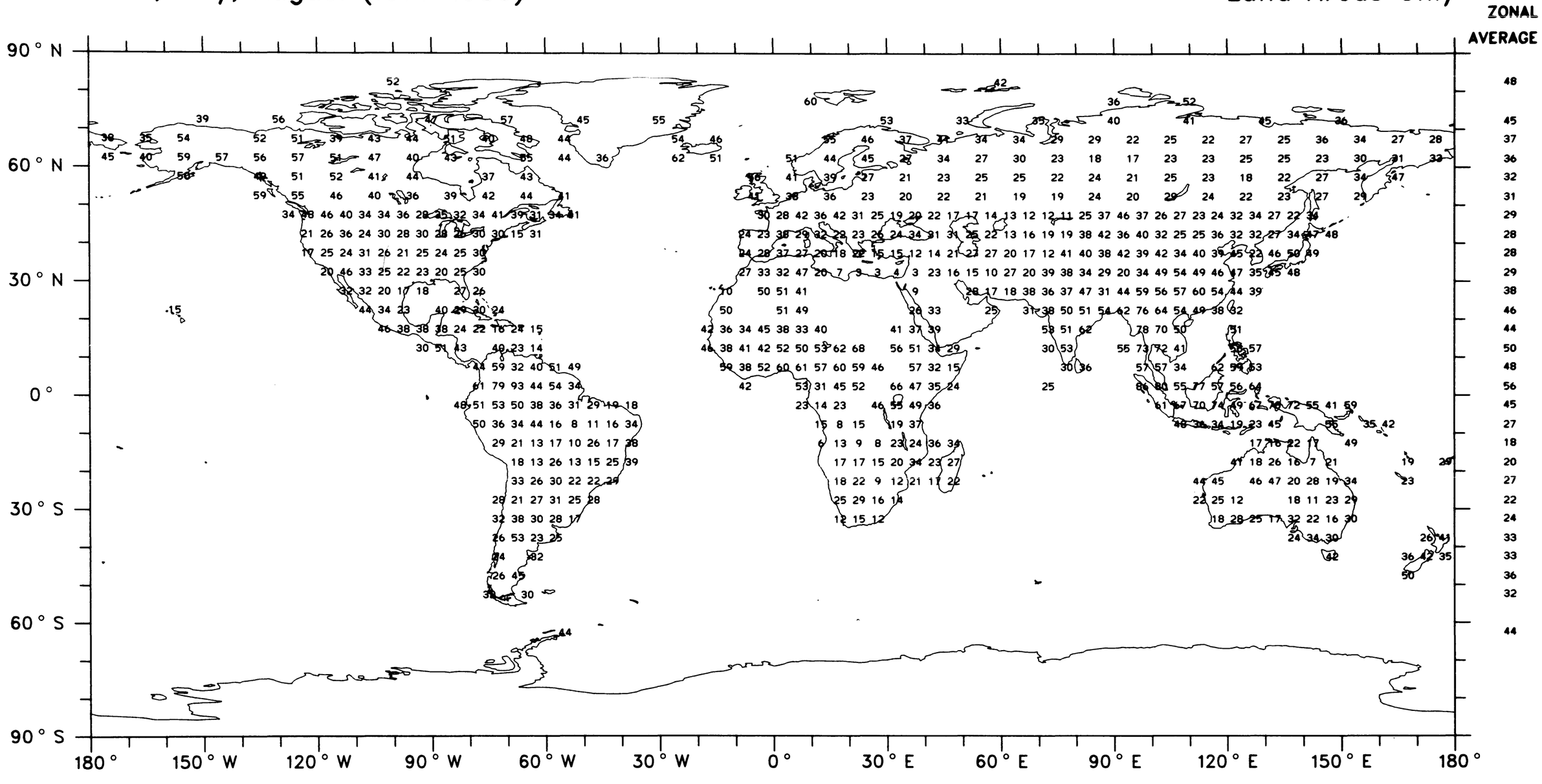


Map III-37

Given Cumulus, Probability (Percent) That As/Ac is Also Present

June, July, August (1971-1980)

Land Areas Only

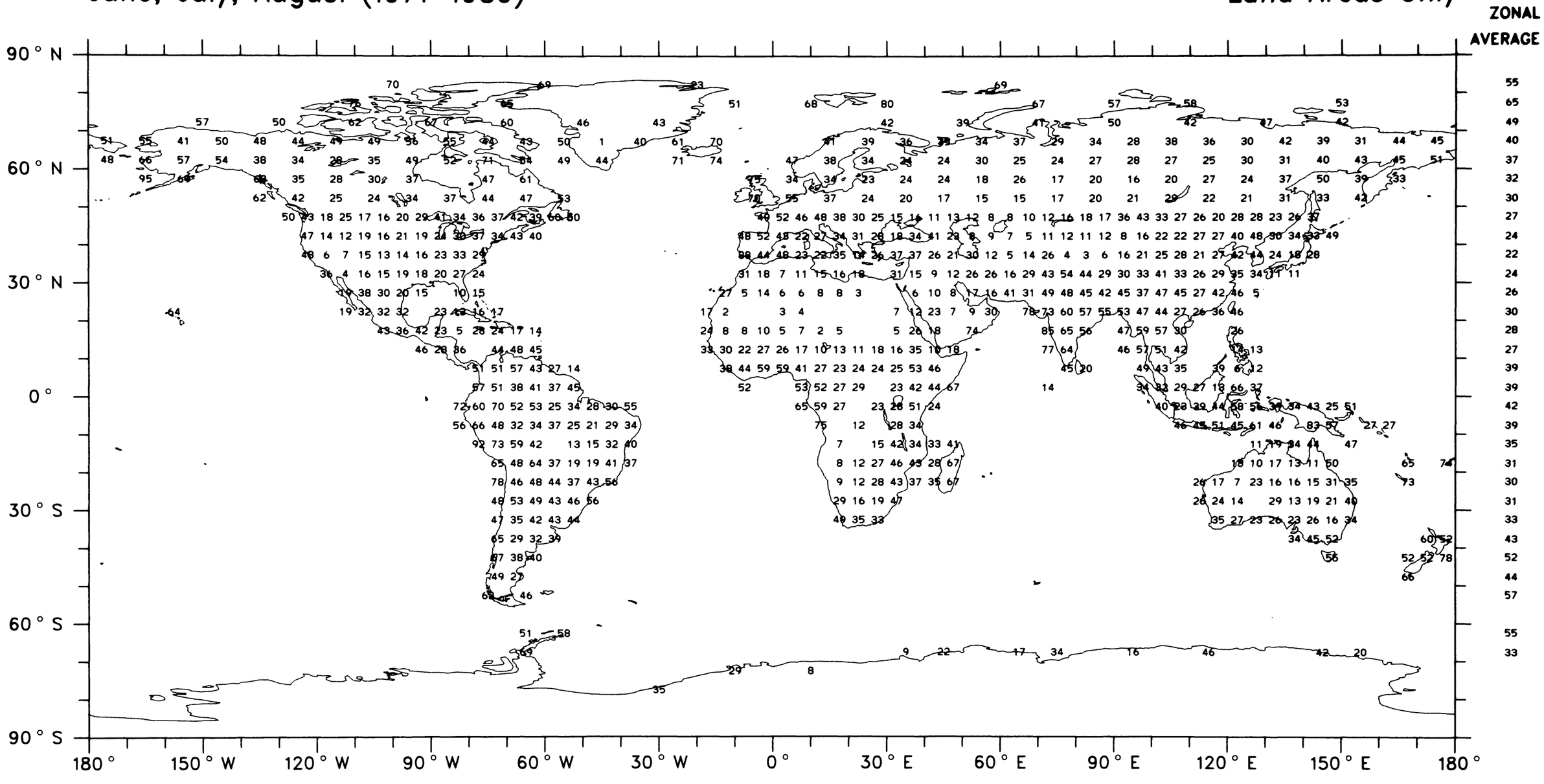


Map III-38

Given As/Ac, Probability (Percent) That St/Sc is Also Present

June, July, August (1971-1980)

Land Areas Only

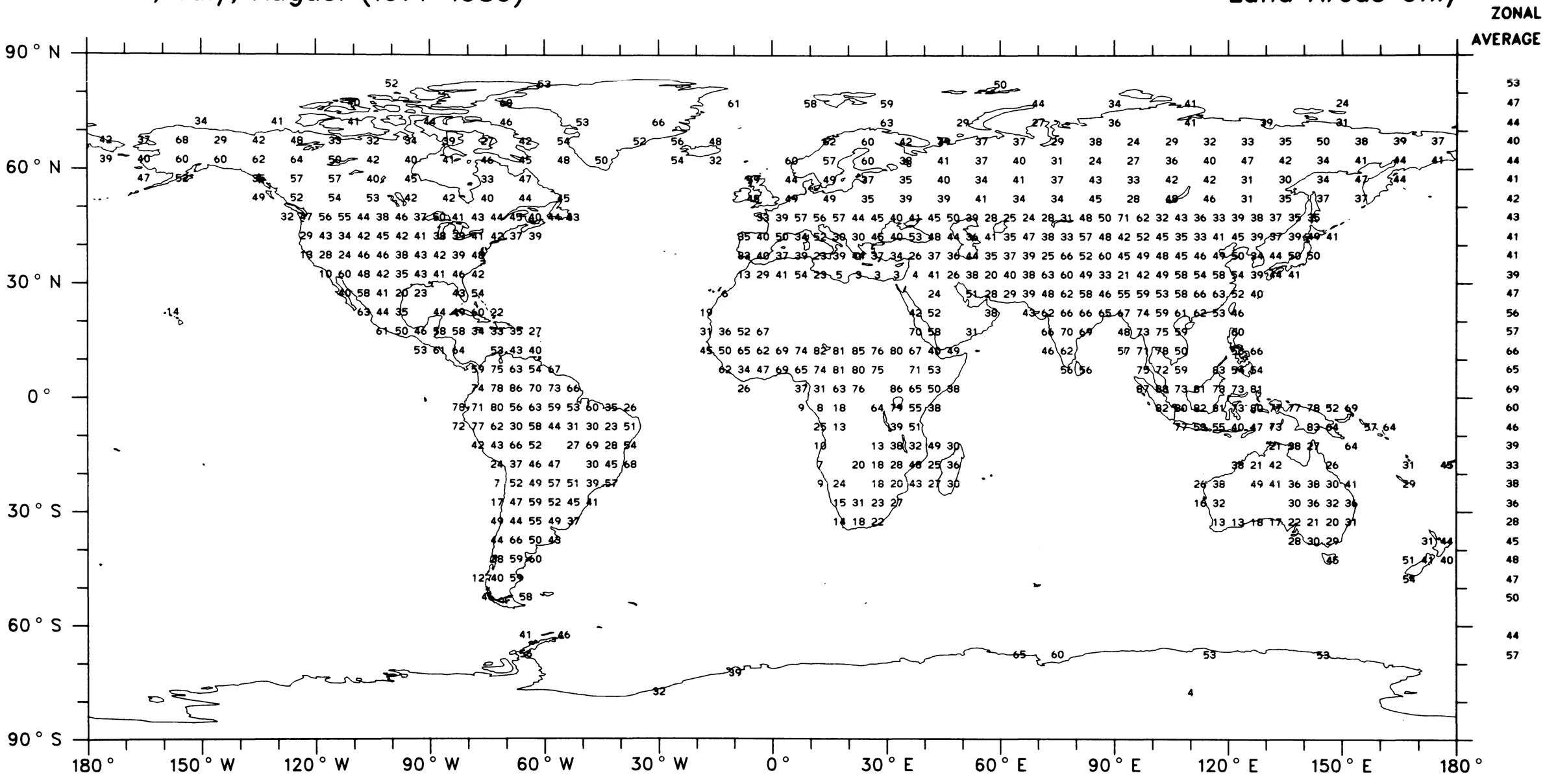


Map III-39

Given St/Sc, Probability (Percent) That As/Ac is Also Present

June, July, August (1971-1980)

Land Areas Only

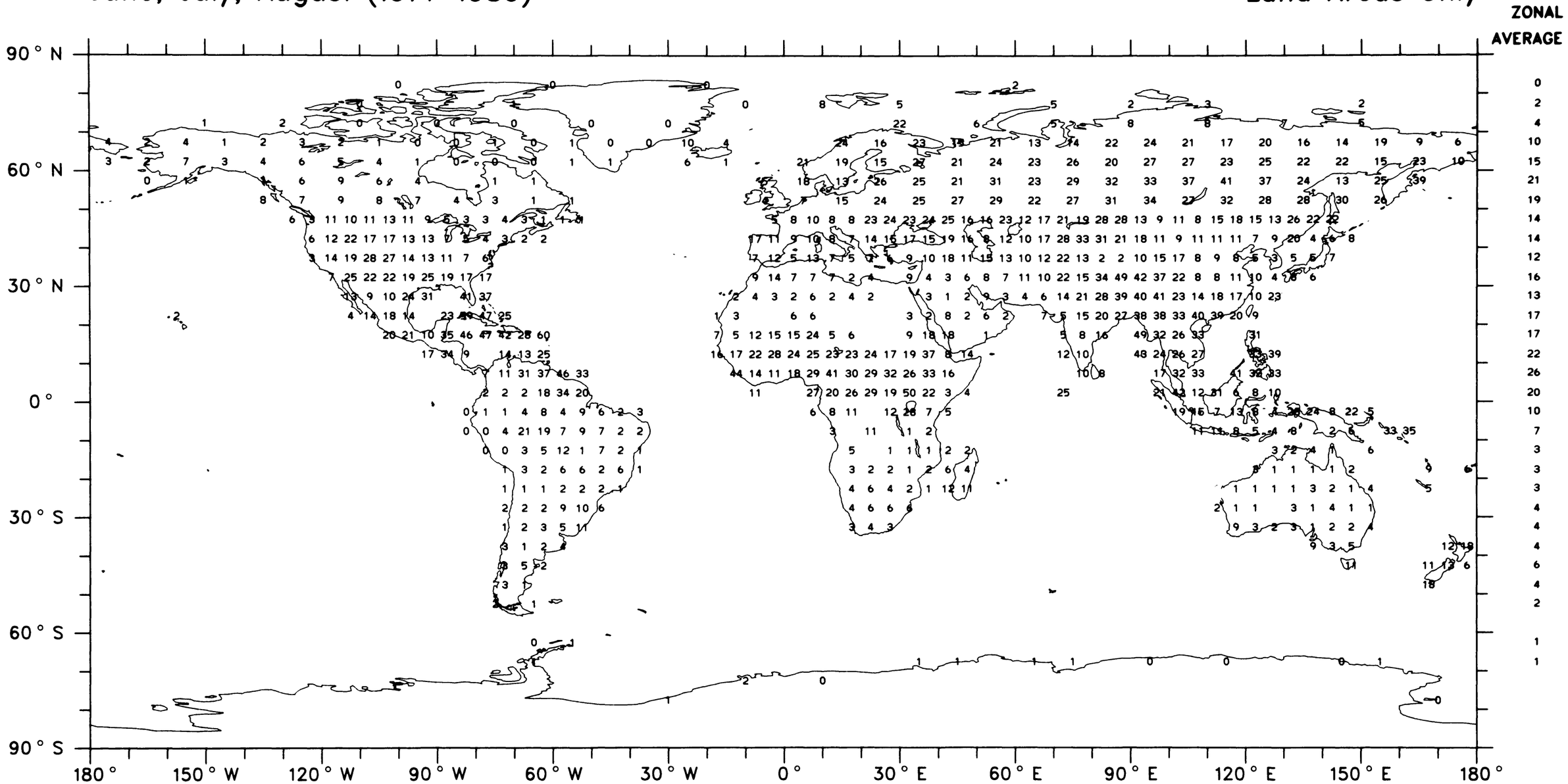


Map III-40

Given As/Ac, Probability (Percent) That Cumulonimbus is Also Present

June, July, August (1971-1980)

Land Areas Only

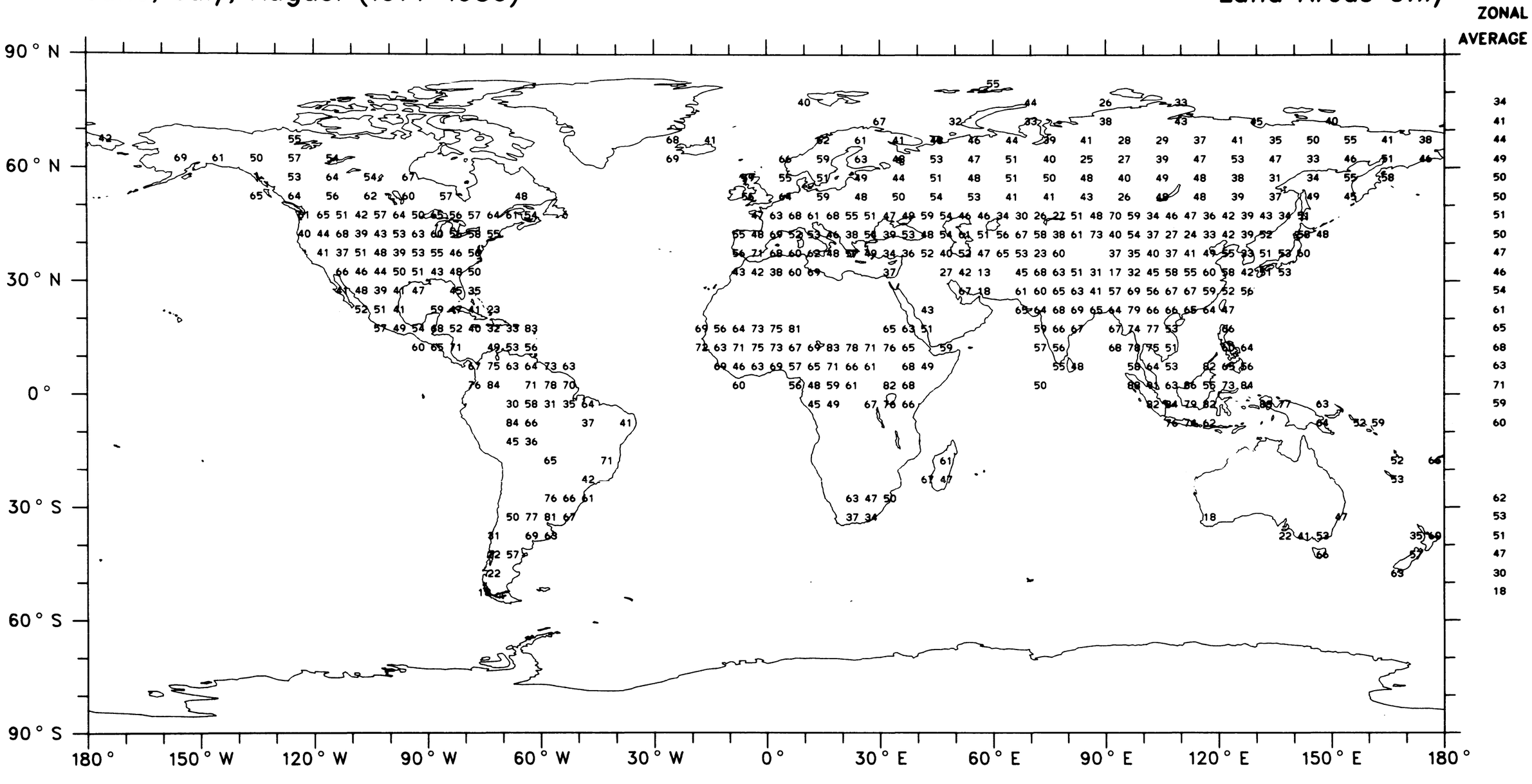


Map III-41

Given Cumulonimbus, Probability (Percent) That As/Ac is Also Present

June, July, August (1971-1980)

Land Areas Only



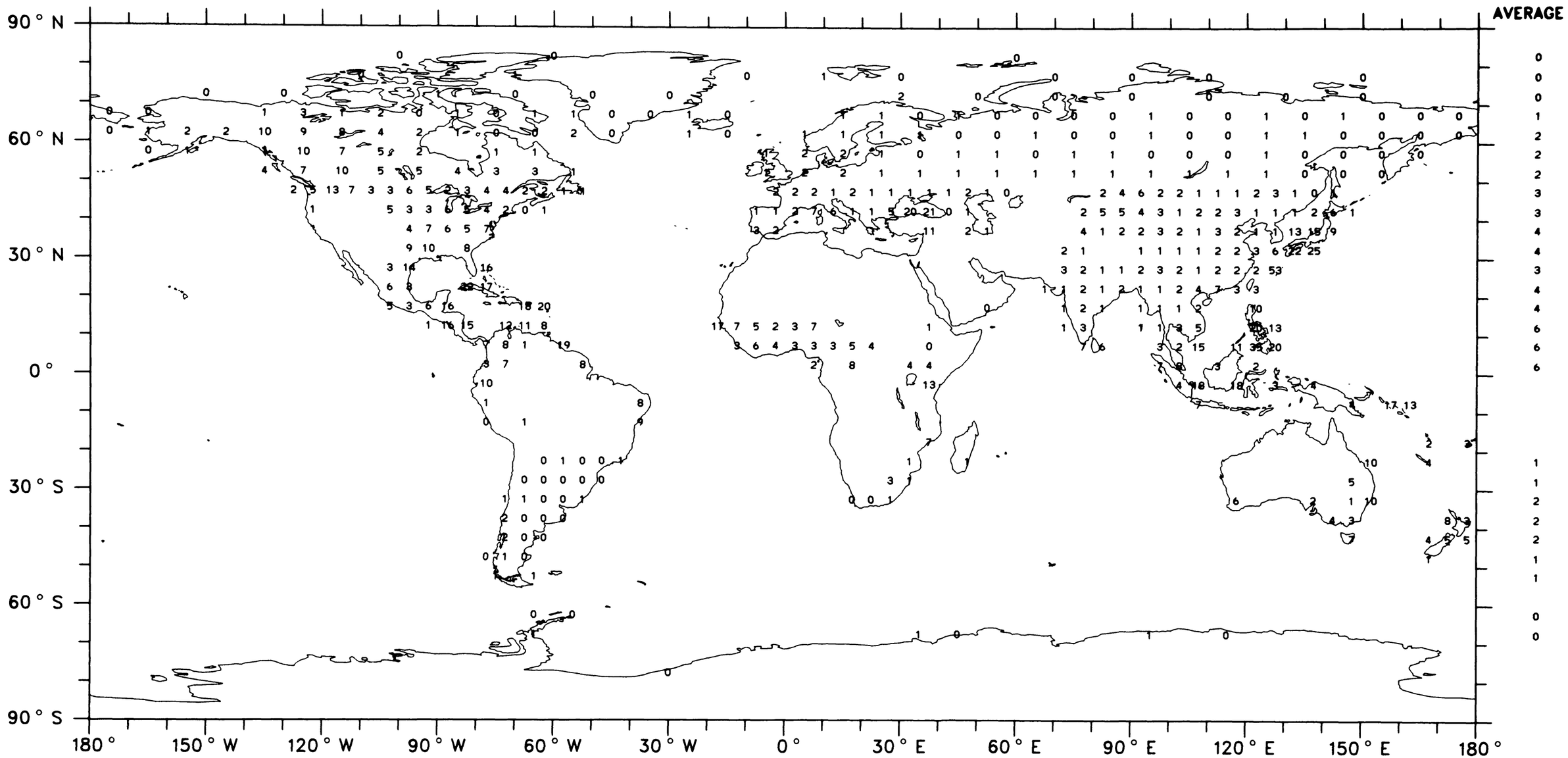
Map III-42

Map III-42

Given Nimbostratus, Probability (Percent) That Cumulus is Also Present

June, July, August (1971-1980)

Land Areas Only



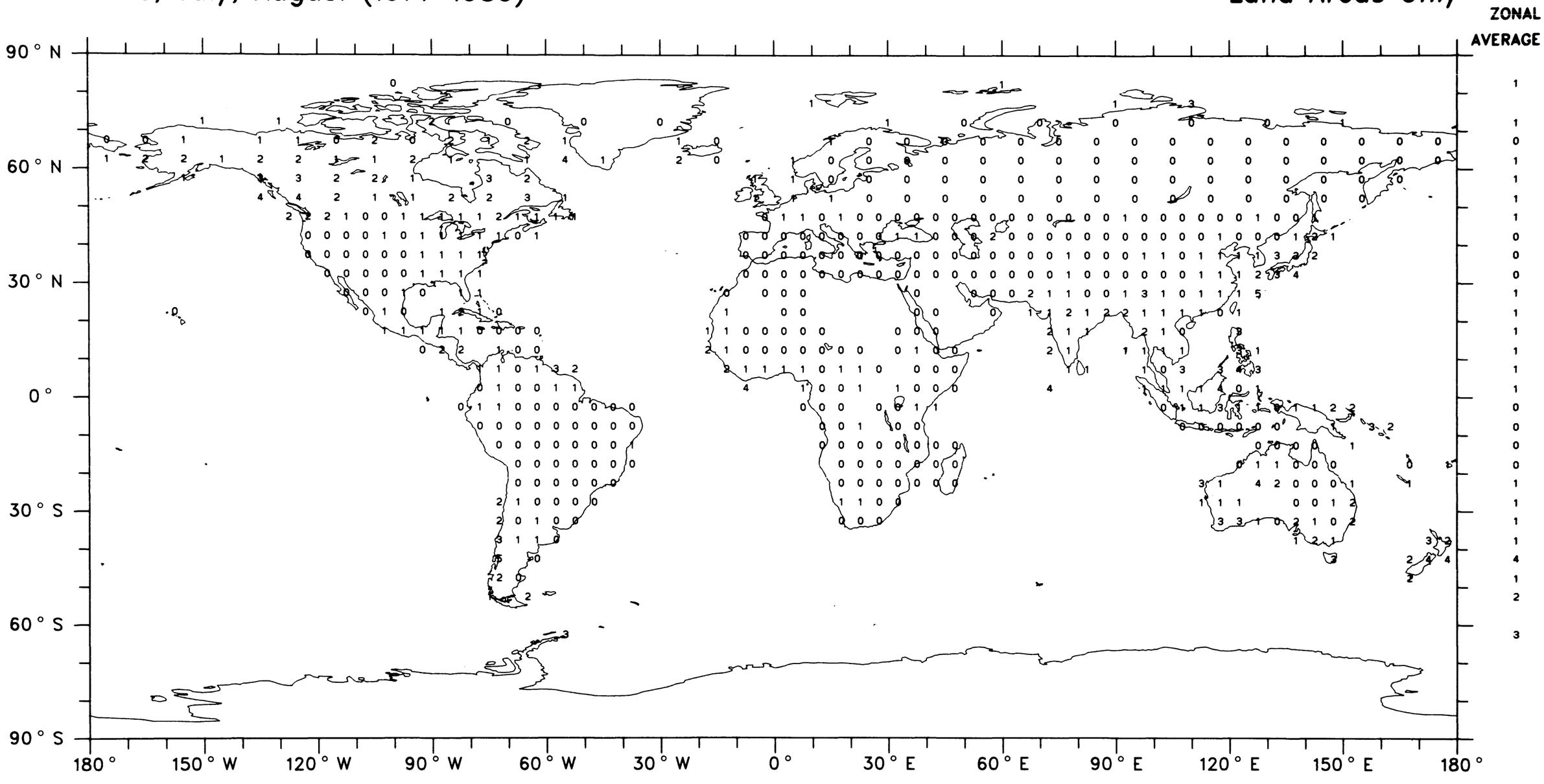
Map III-43

Map III-43

Given Cumulus, Probability (Percent) That Nimbostratus is Also Present

June, July, August (1971-1980)

Land Areas Only

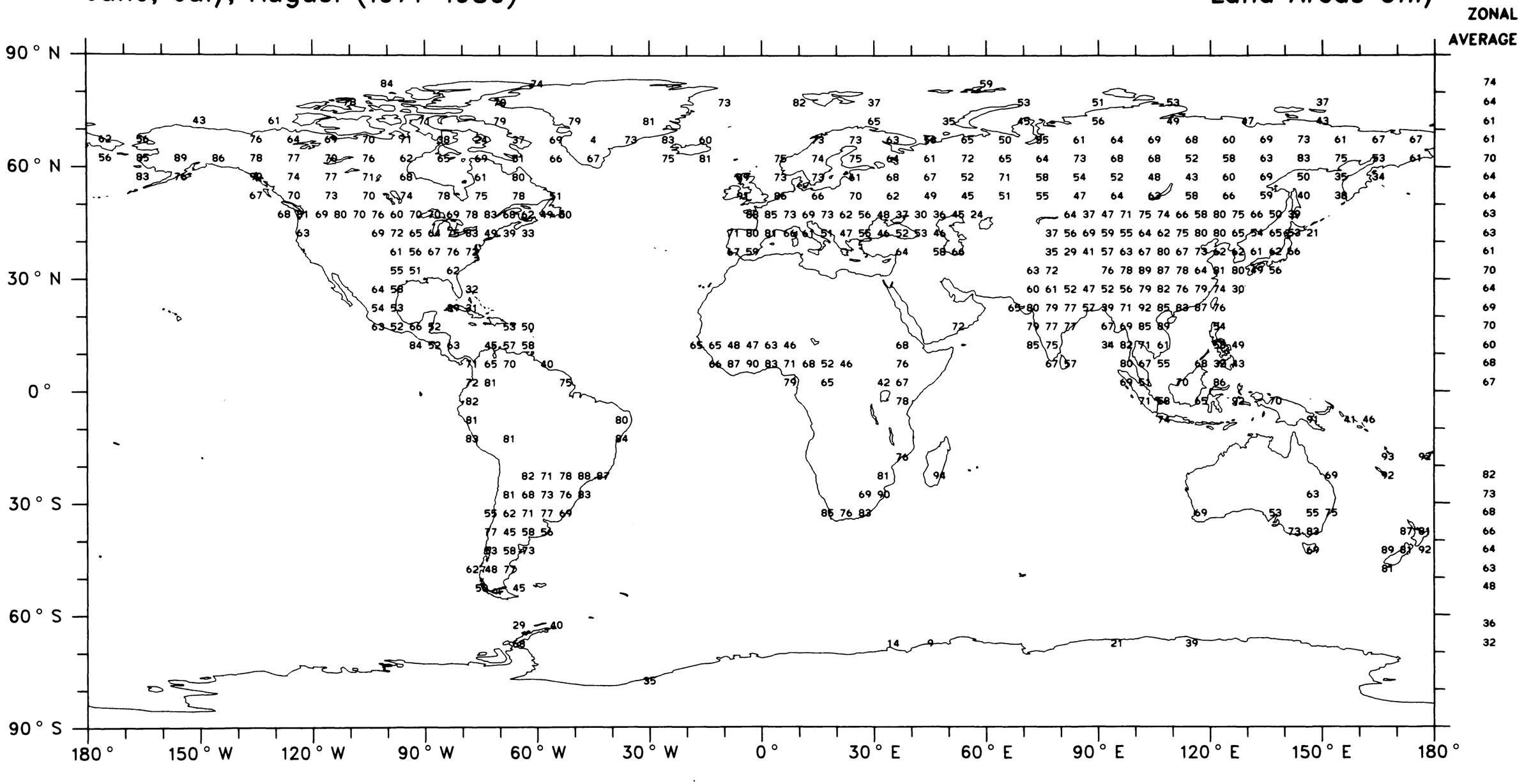


Map III-44

Given Nimbostratus, Probability (Percent) That St/Sc is Also Present

June, July, August (1971-1980)

Land Areas Only

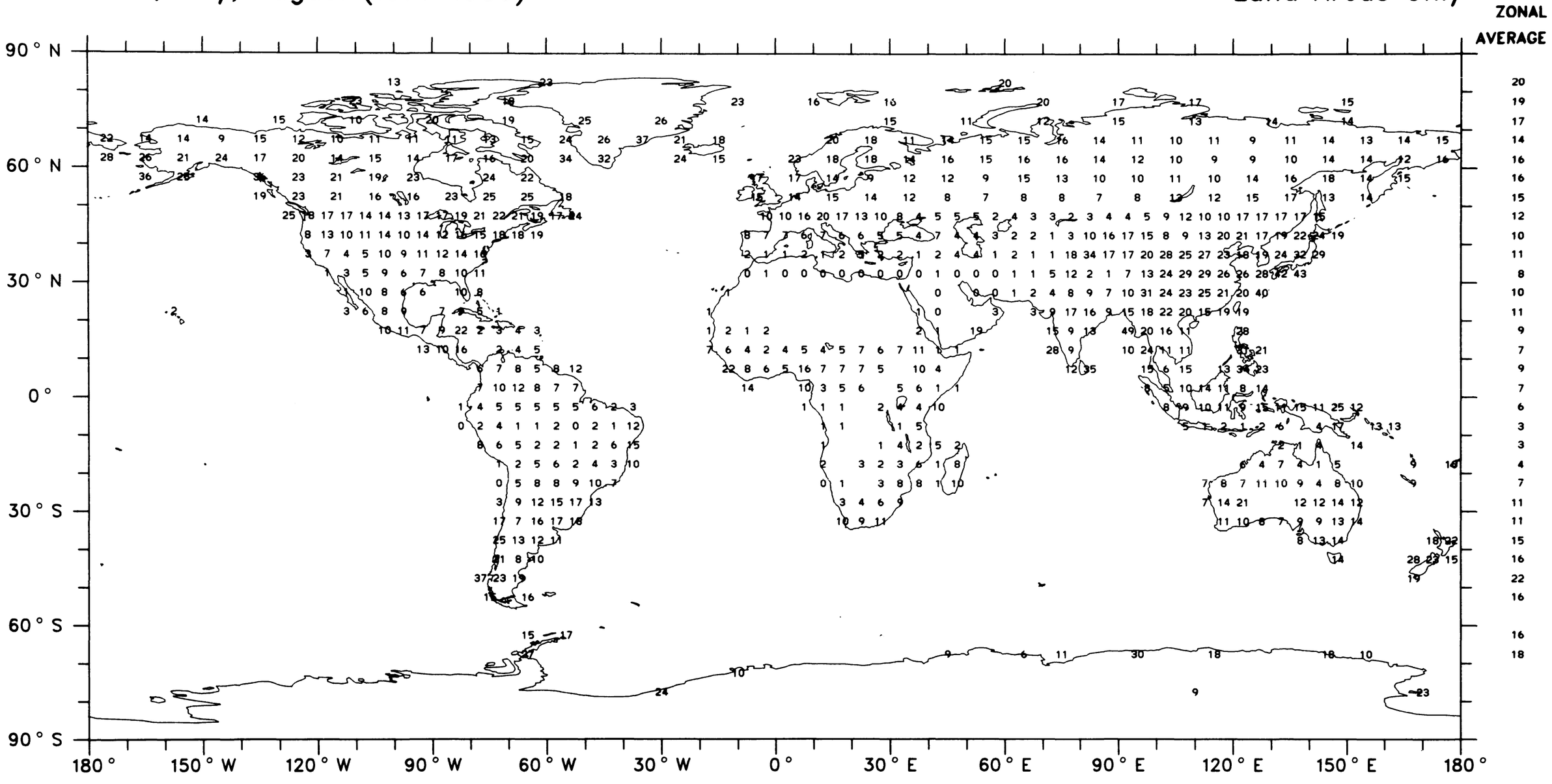


Map III-45

Given St/Sc, Probability (Percent) That Nimbostratus is Also Present

June, July, August (1971-1980)

Land Areas Only

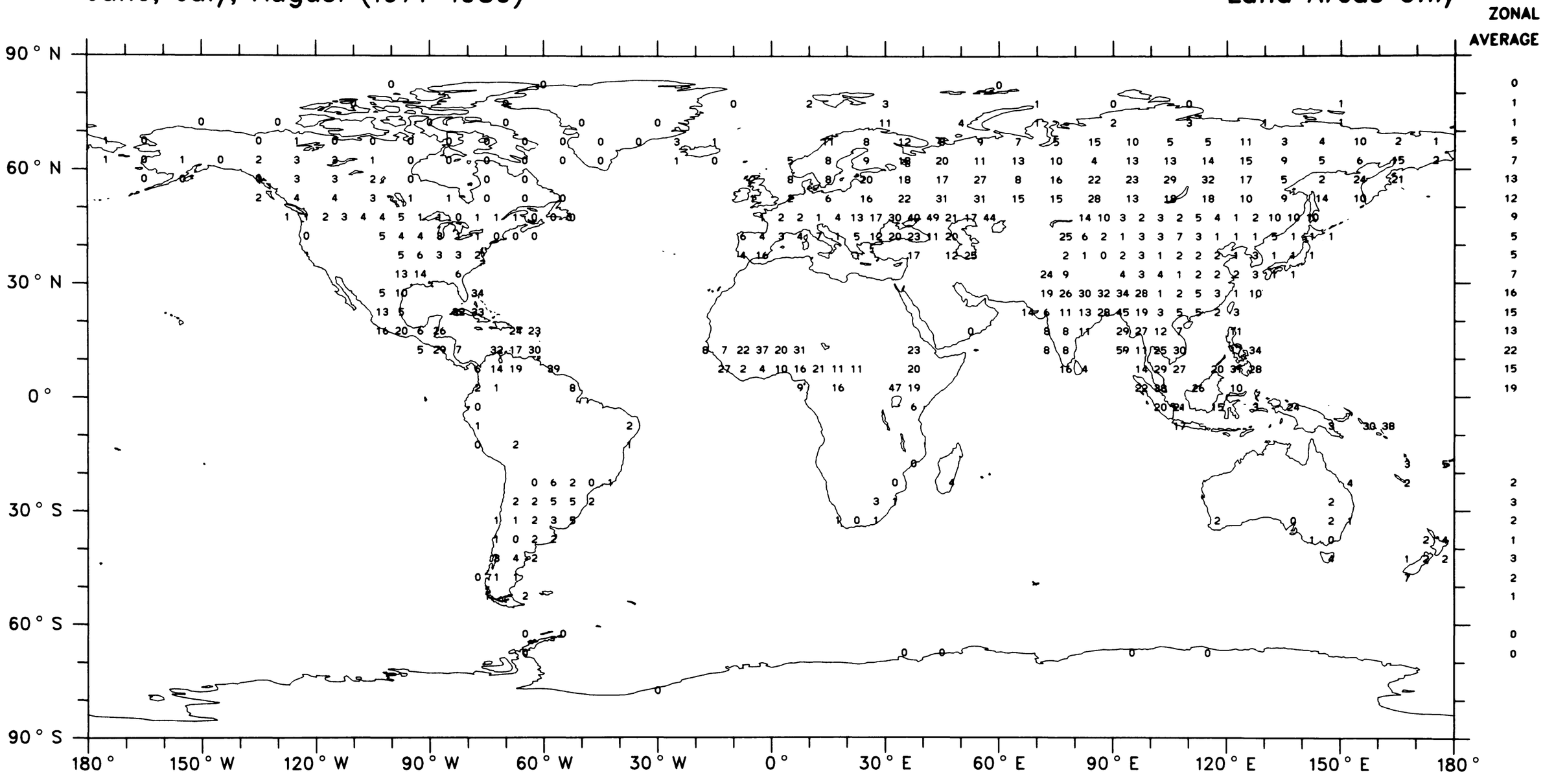


Map III-46

Given Nimbostratus, Probability (Percent) That Cumulonimbus is Also Present

June, July, August (1971-1980)

Land Areas Only

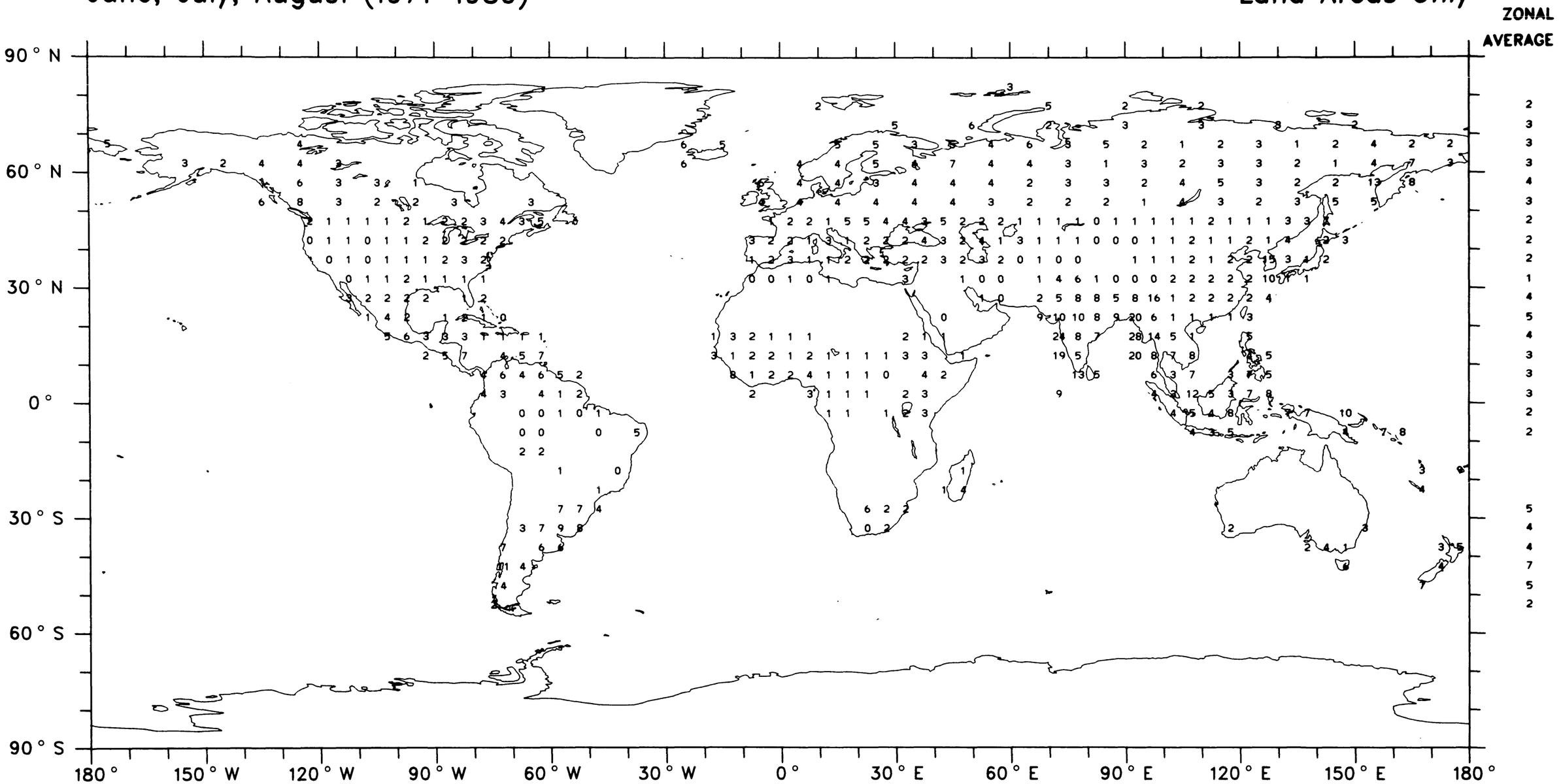


Map III-47

Given Cumulonimbus, Probability (Percent) That Nimbostratus is Also Present

June, July, August (1971-1980)

Land Areas Only

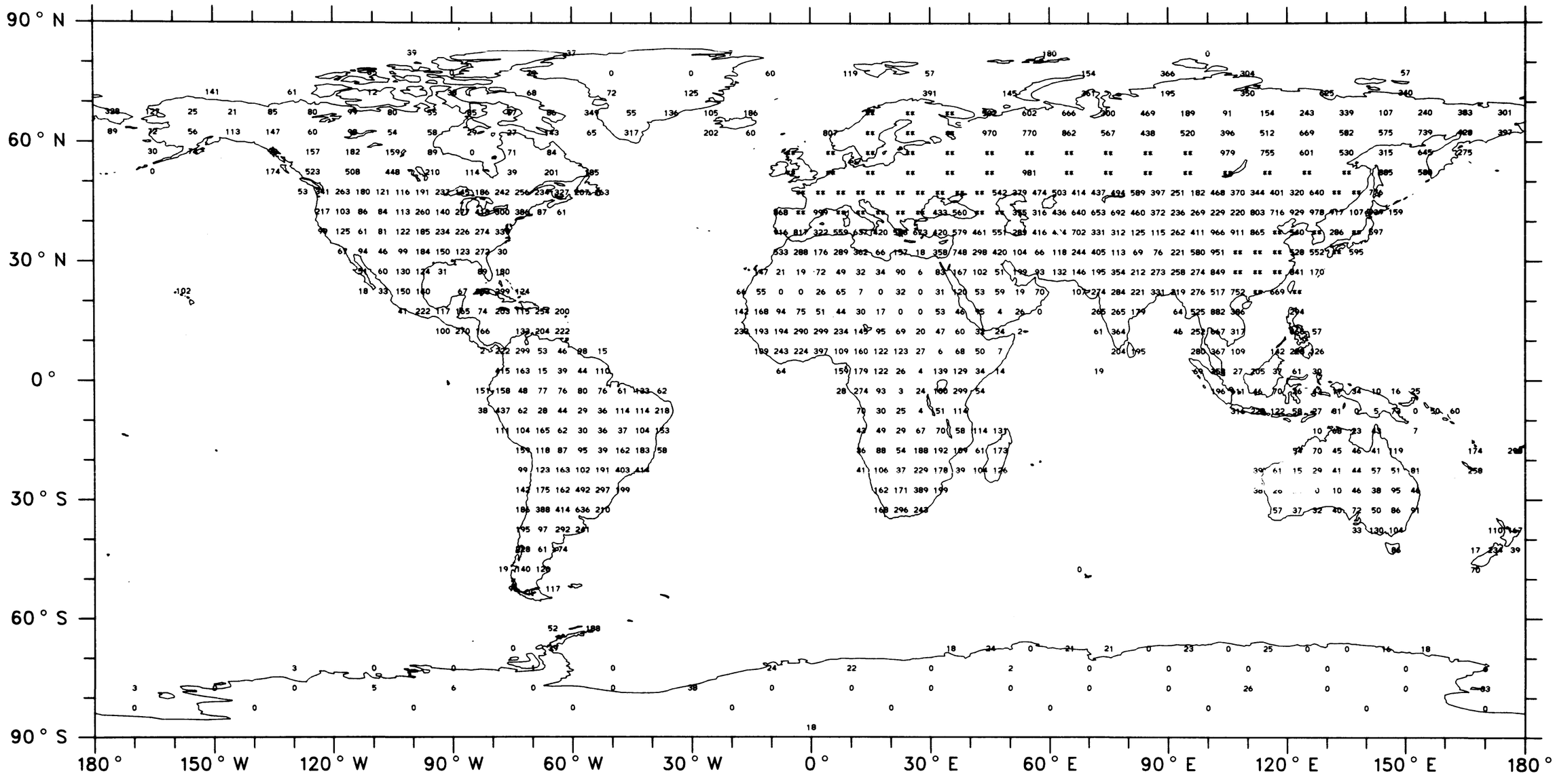


Map IV-1

Number of Synoptic Cloud Reports from Land Stations (in Hundreds)

September, October, November (1971-1980)

Land Areas Only

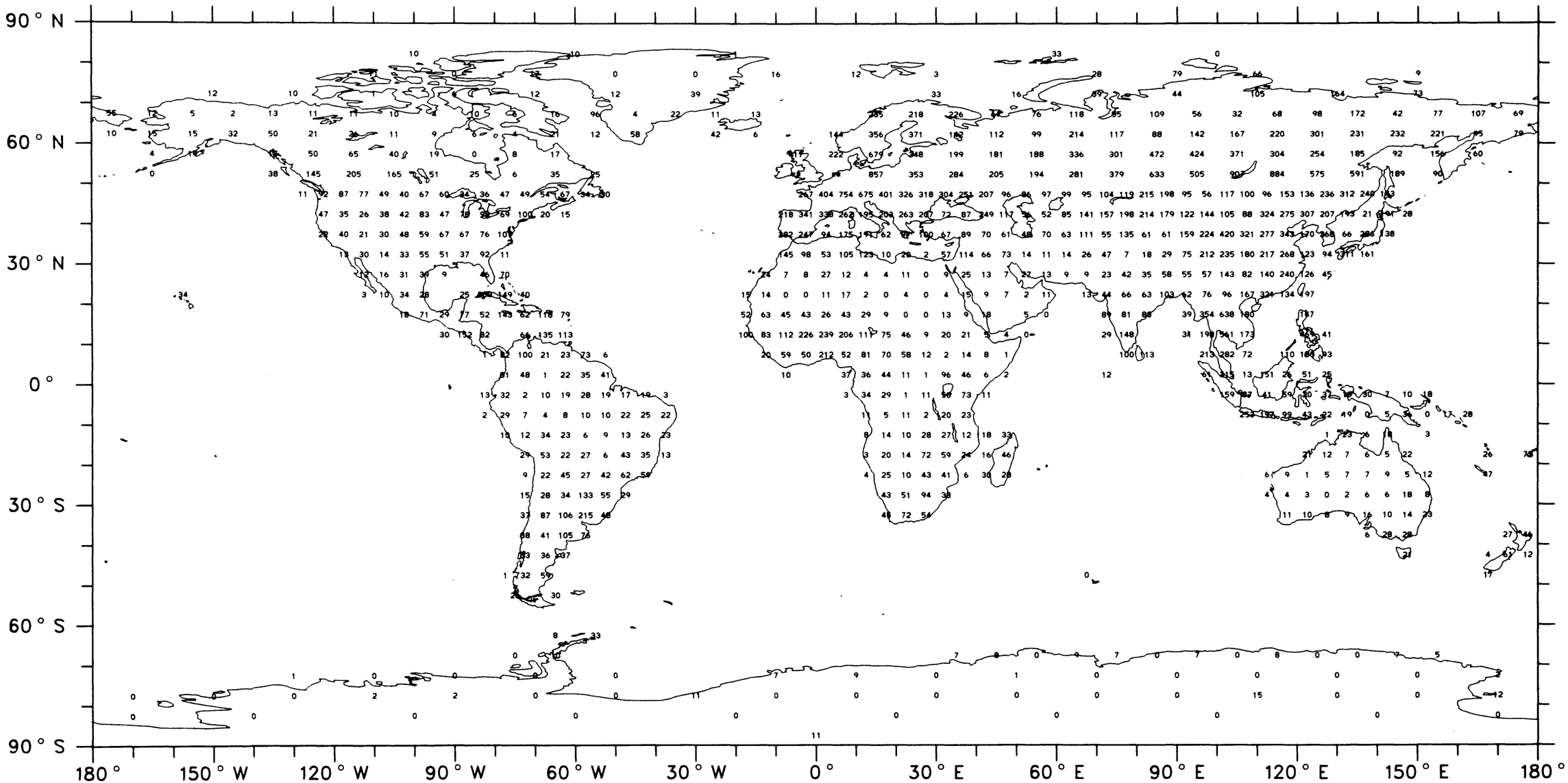


Map IV-2

Number of Observations of Cirrus, Cirrostratus, or Cirrocumulus (in Hundreds)

September, October, November (1971-1980)

Land Areas Only

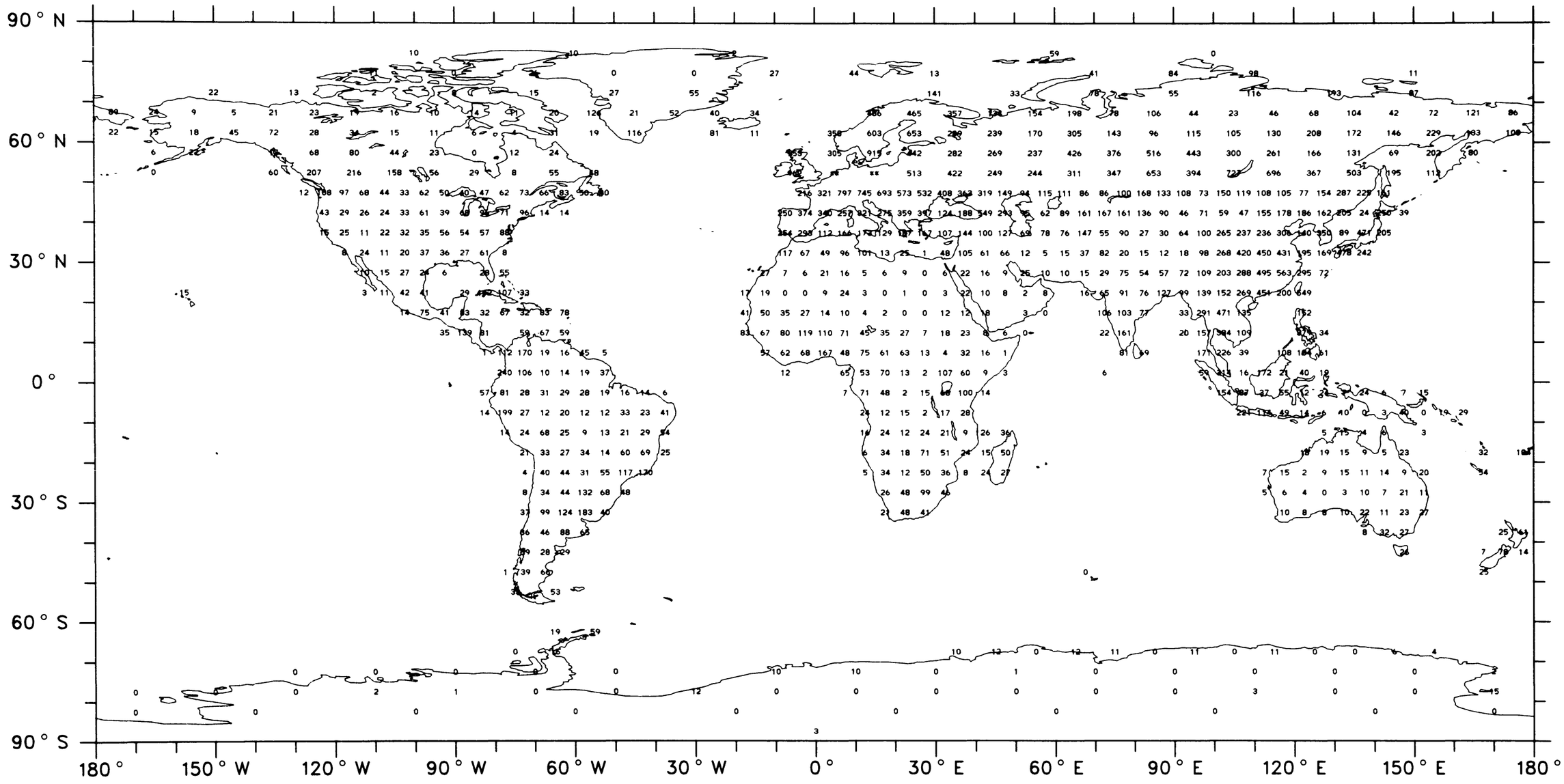


Map IV-3

Number of Observations of Altostratus or Altocumulus (in Hundreds)

September, October, November (1971-1980)

Land Areas Only

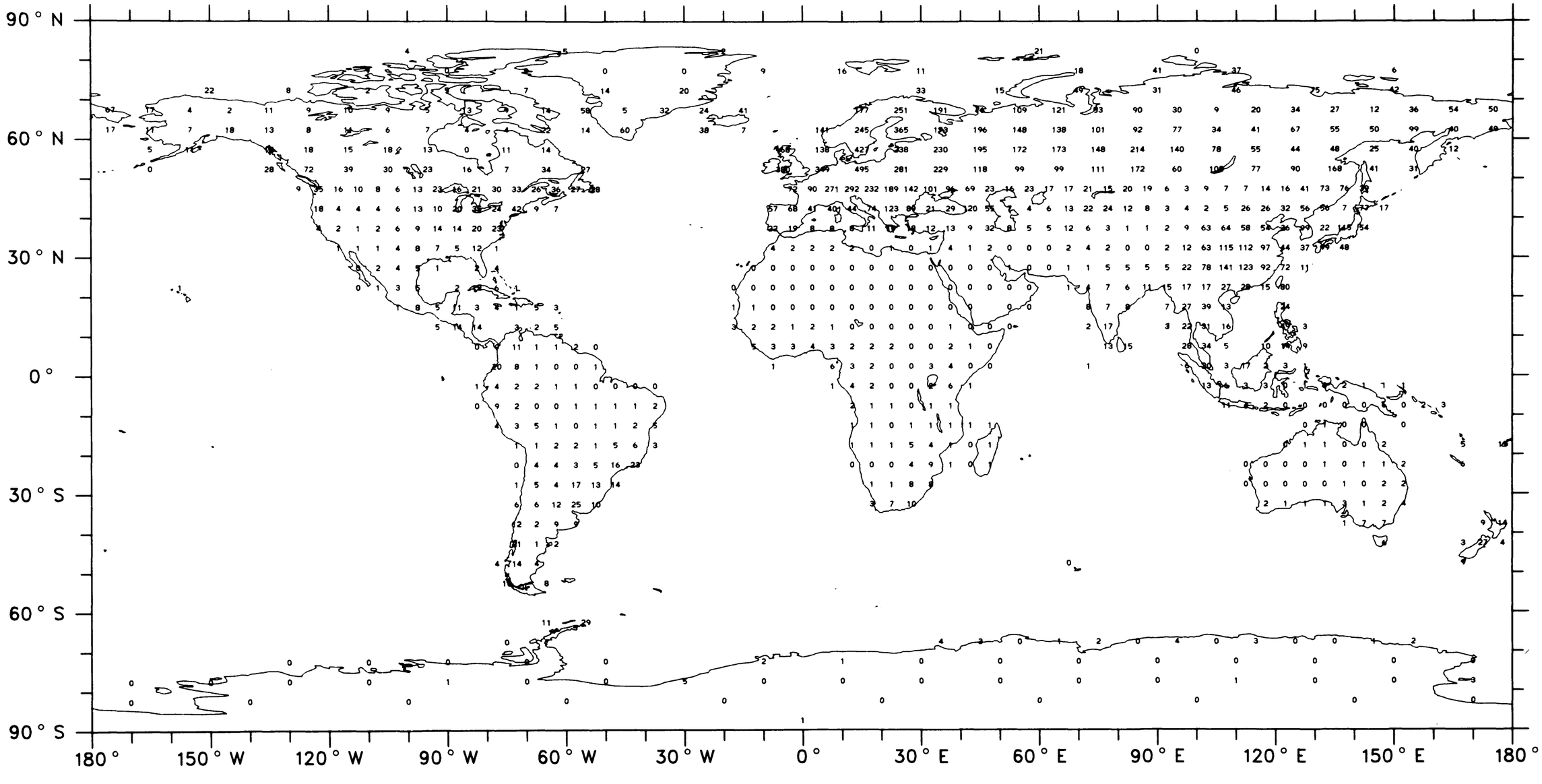


Map IV-4

Number of Observations of Nimbostratus (in Hundreds)

September, October, November (1971-1980)

Land Areas Only

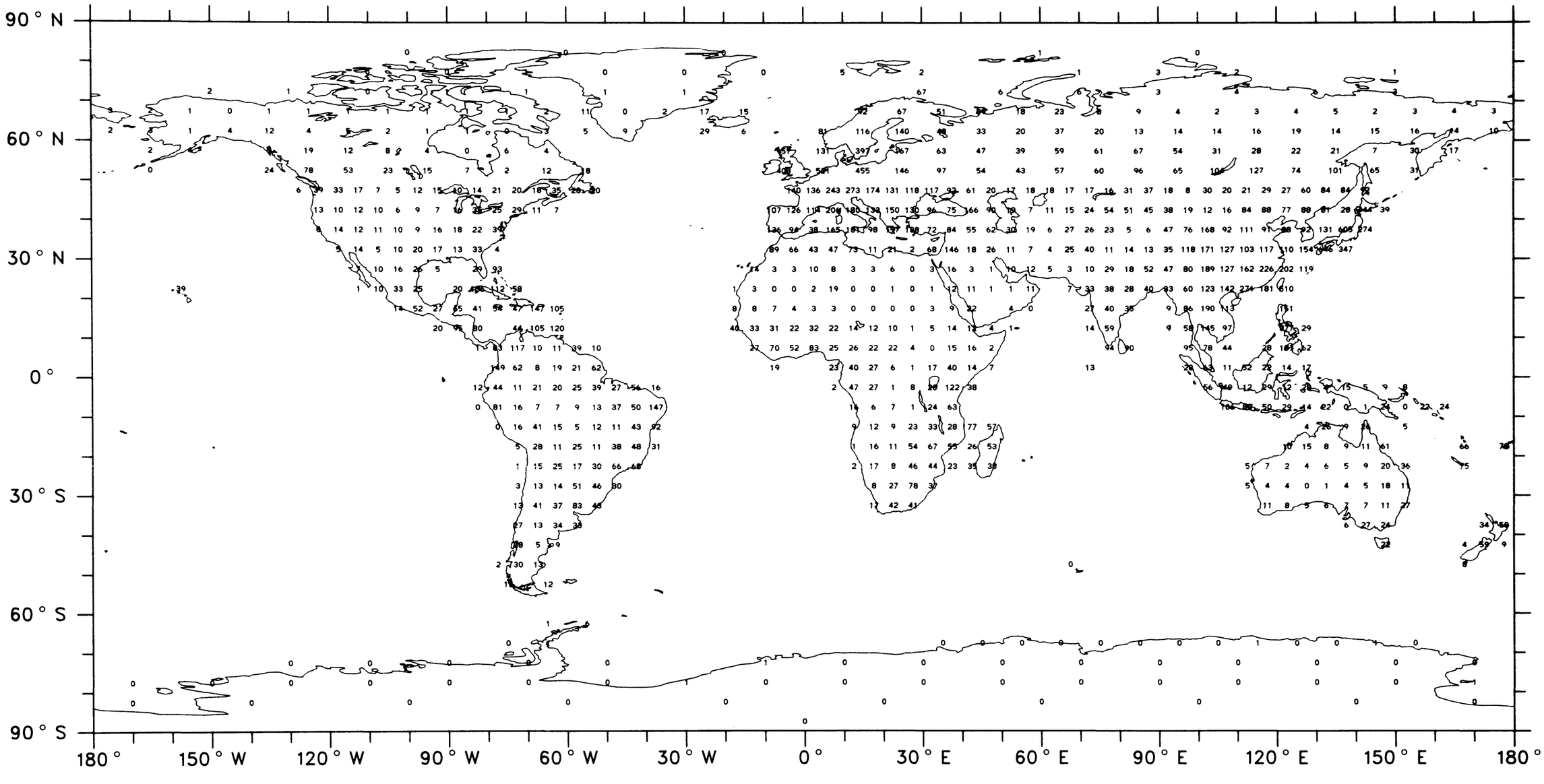


Map IV-5

Number of Observations of Cumulus (in Hundreds)

September, October, November (1971-1980)

Land Areas Only

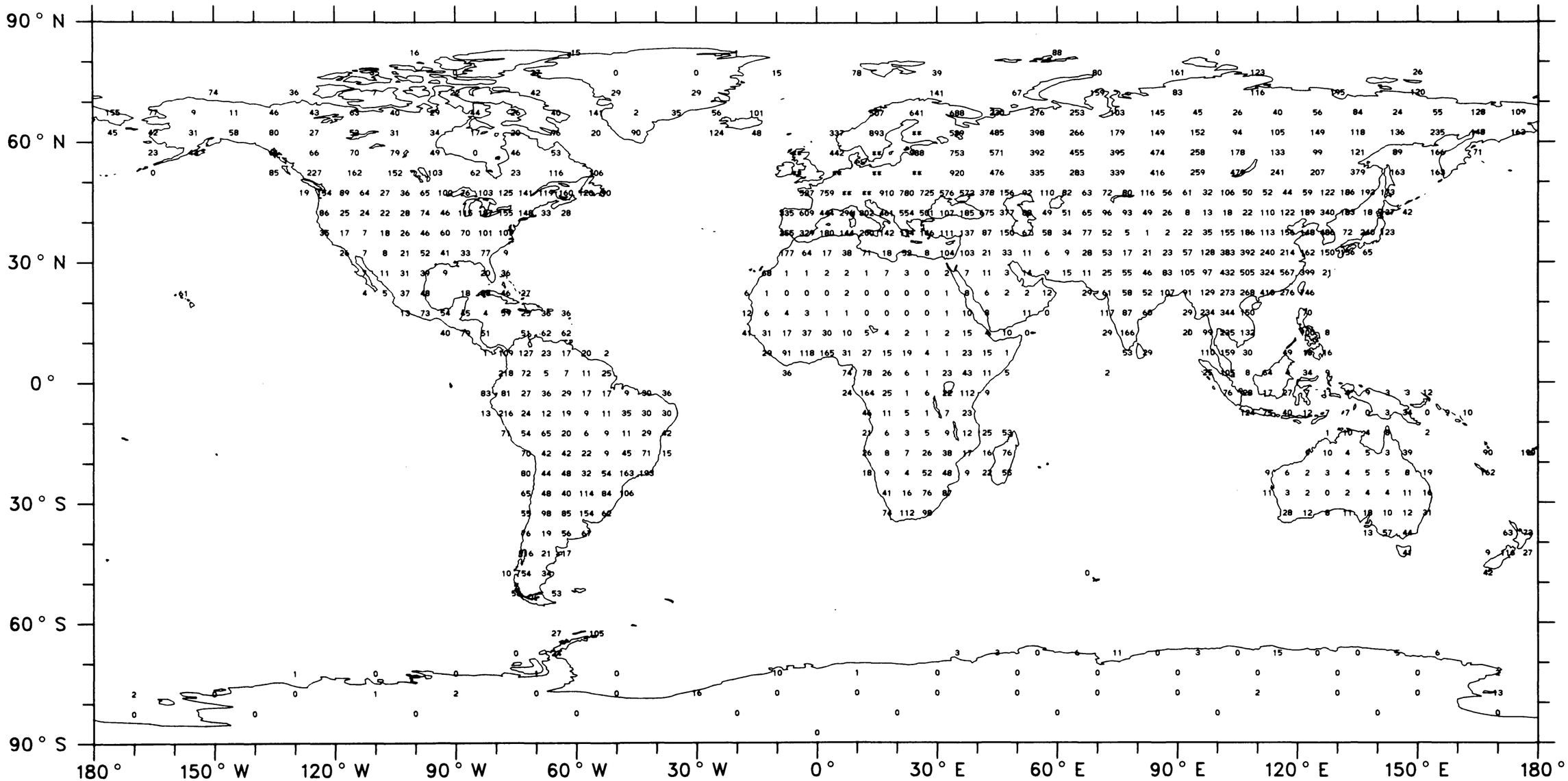


Map IV-6

Number of Observations of Stratus or Stratocumulus (in Hundreds)

September, October, November (1971-1980)

Land Areas Only

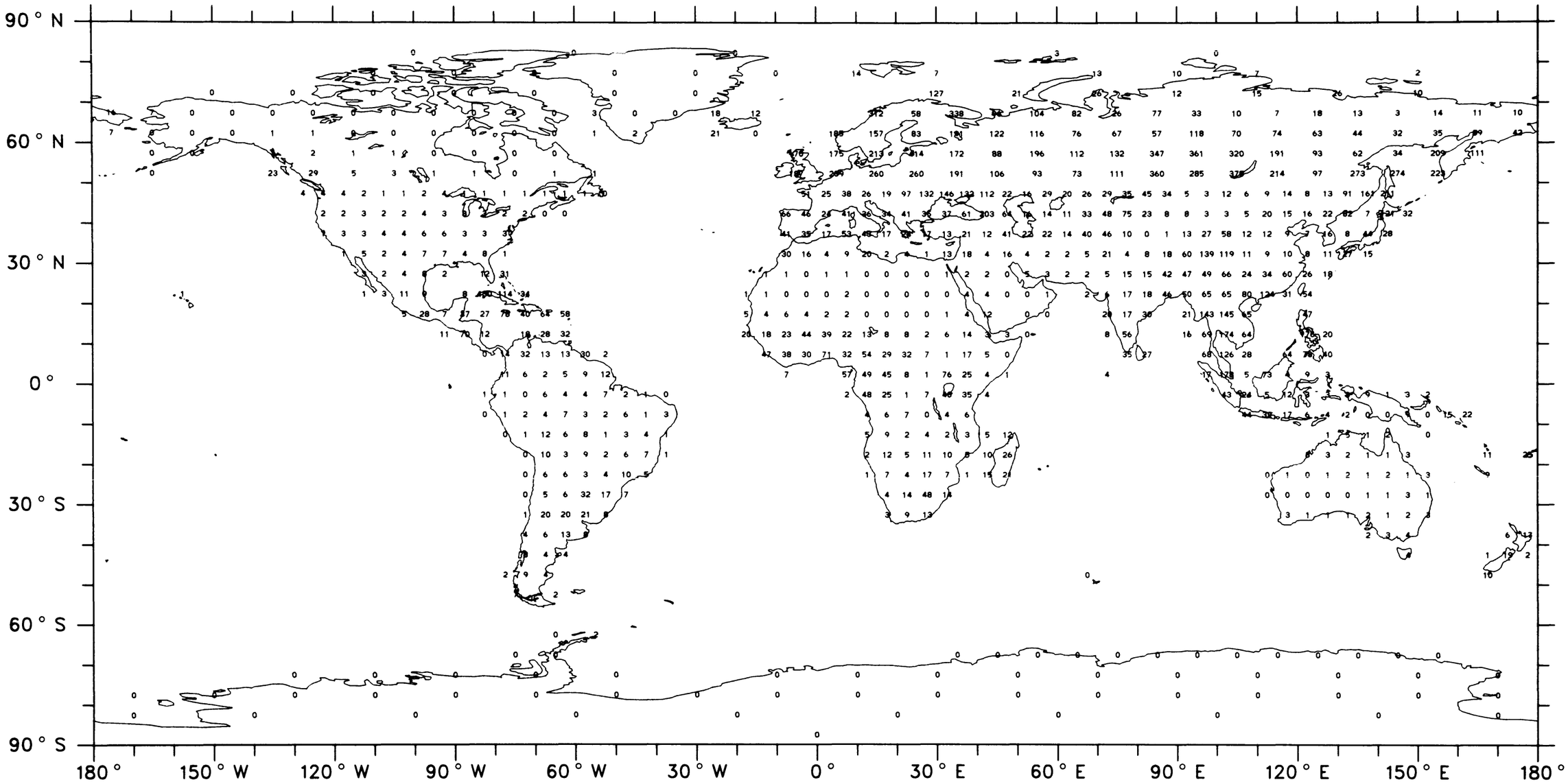


Map IV-7

Number of Observations of Cumulonimbus (in Hundreds)

September, October, November (1971-1980)

Land Areas Only

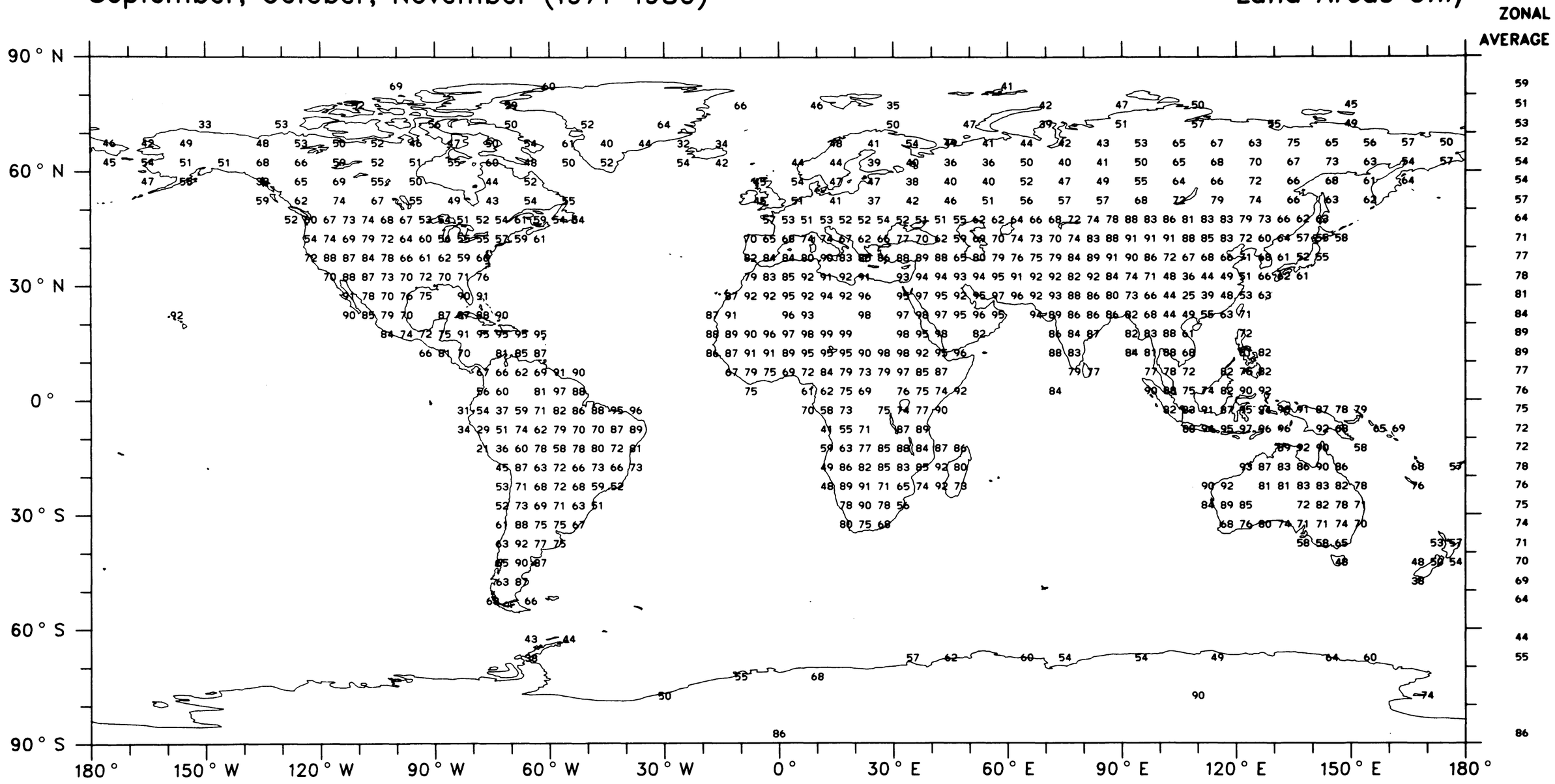


Map IV-8

Percent of Land Station Reports Contributing to Statistics of the High Cloud Level

September, October, November (1971-1980)

Land Areas Only



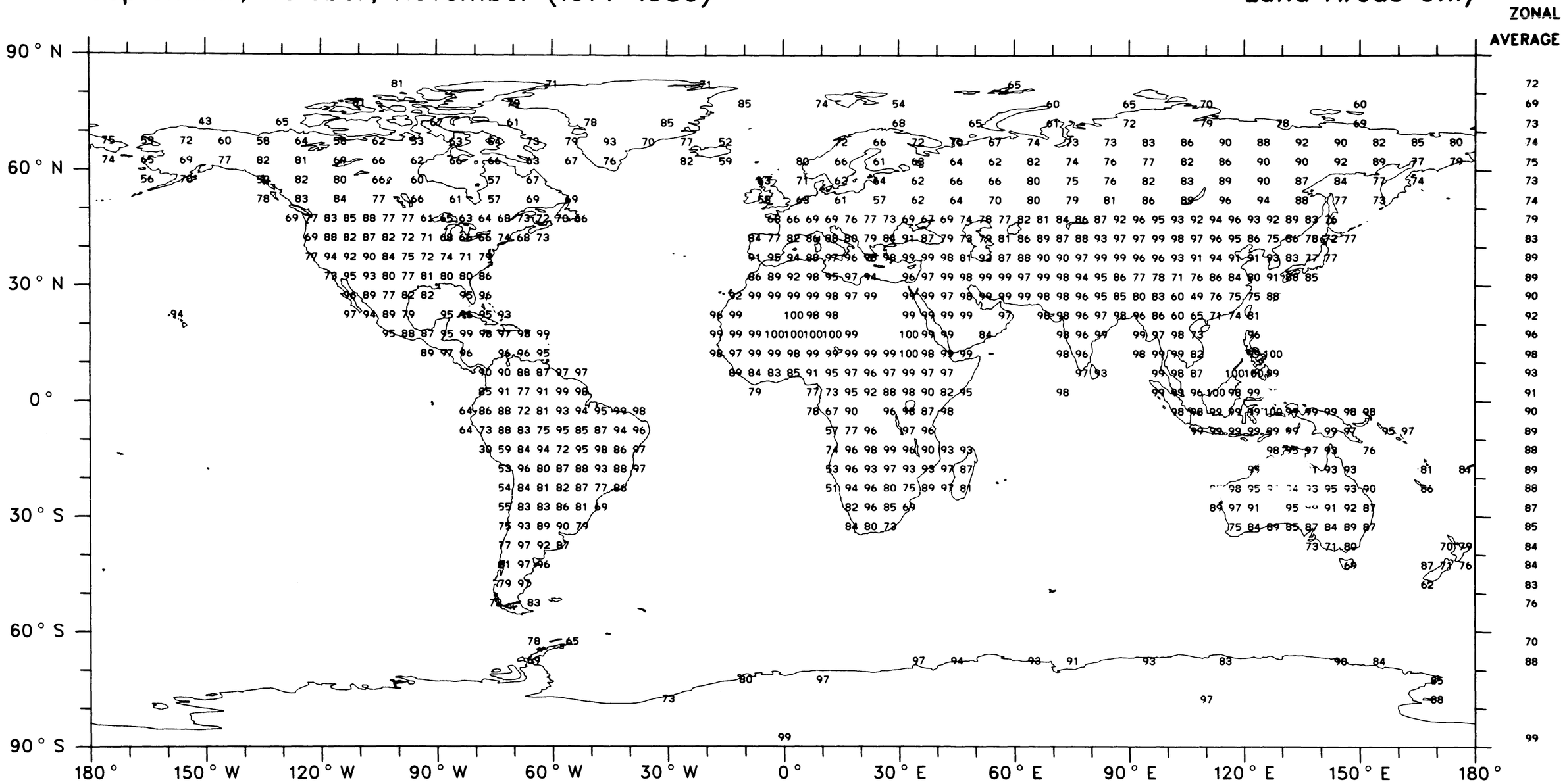
Map IV-9

Map IV-9

Percent of Land Station Reports Contributing to Statistics of the Middle Cloud Level

September, October, November (1971-1980)

Land Areas Only

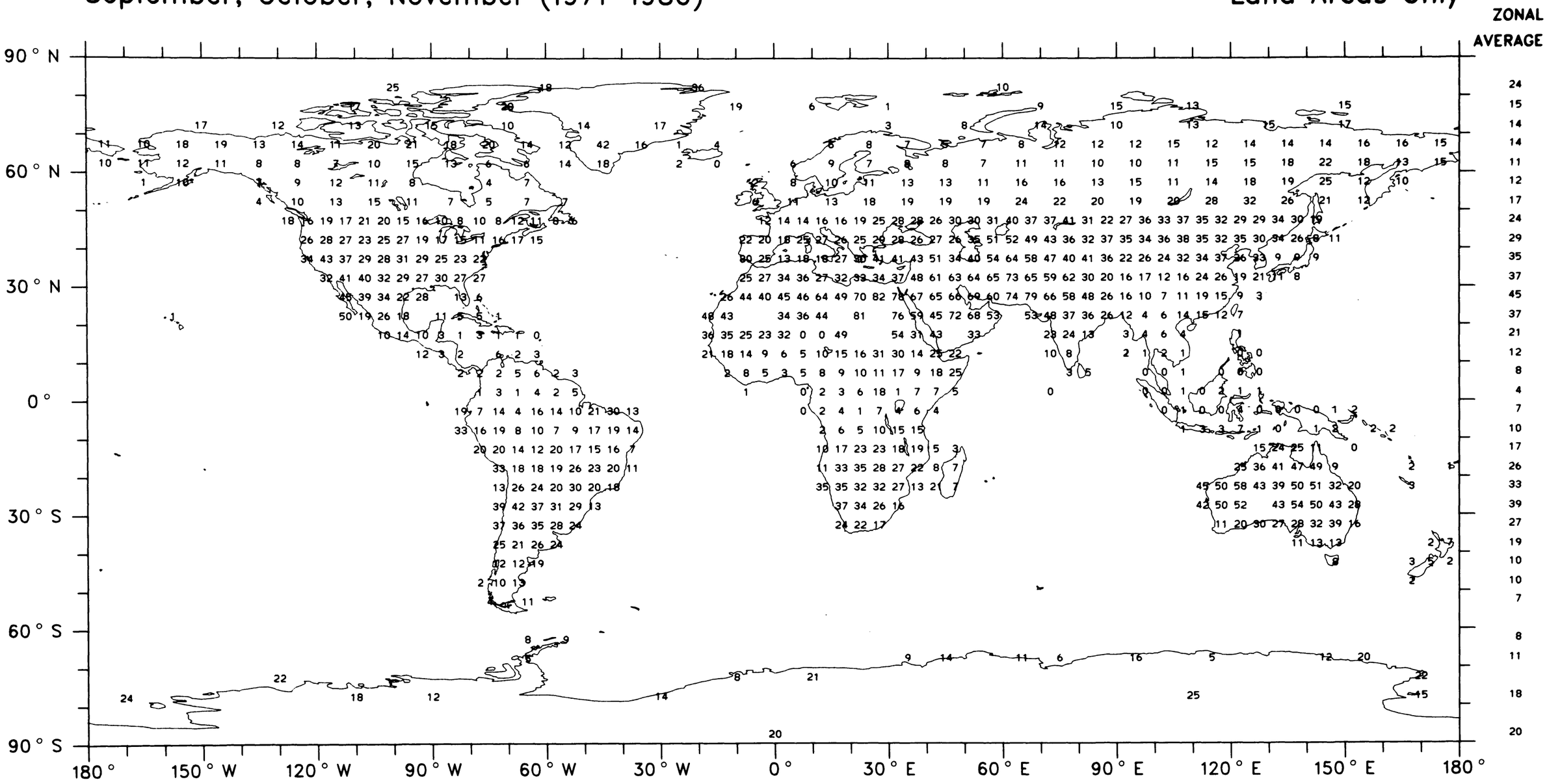


Map IV-10

Frequency of Occurrence (Percent) of Completely Clear Sky

September, October, November (1971-1980)

Land Areas Only

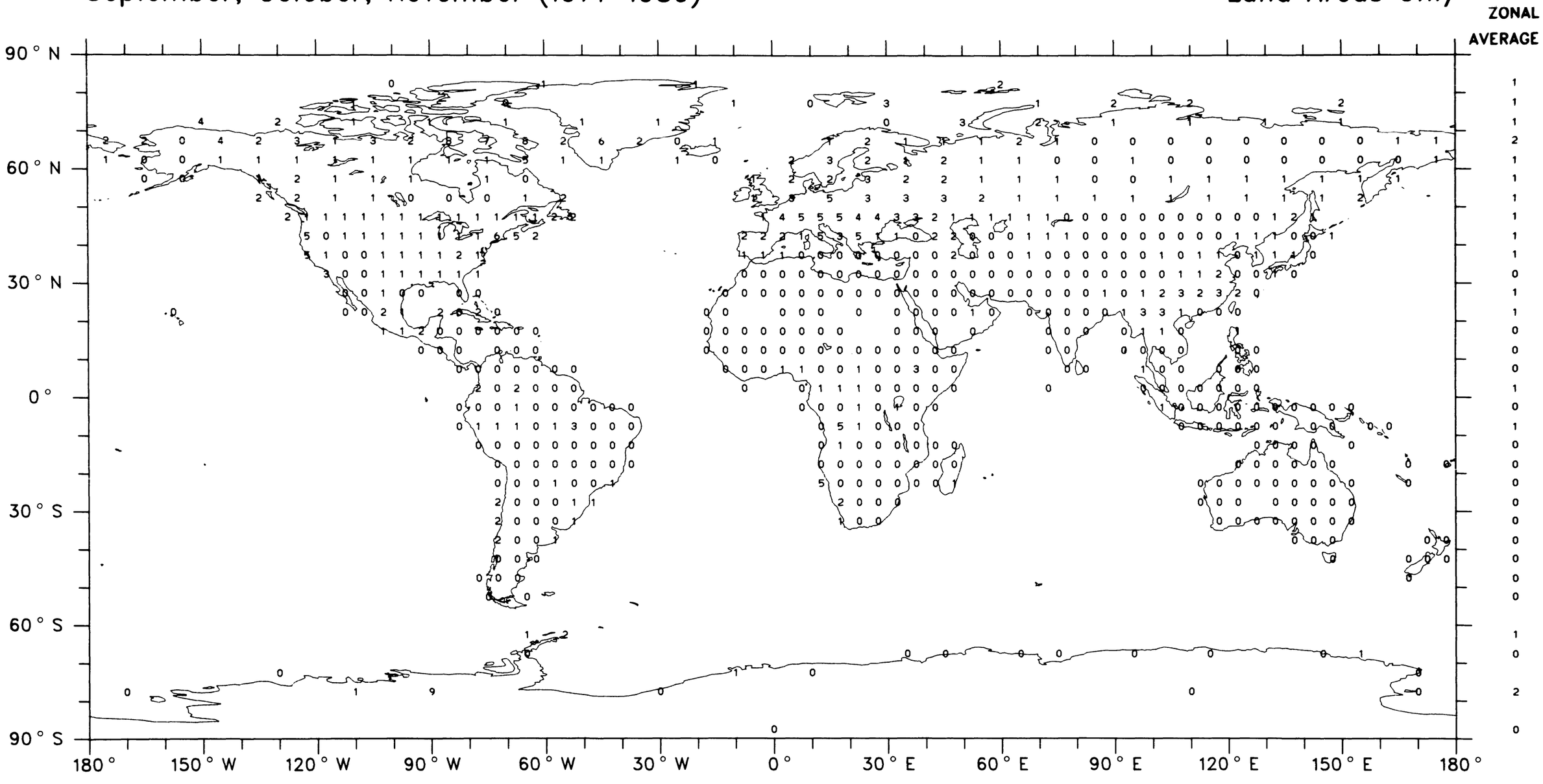


Map IV-11

Frequency of Occurrence (Percent) of Sky Obscured due to Fog

September, October, November (1971-1980)

Land Areas Only

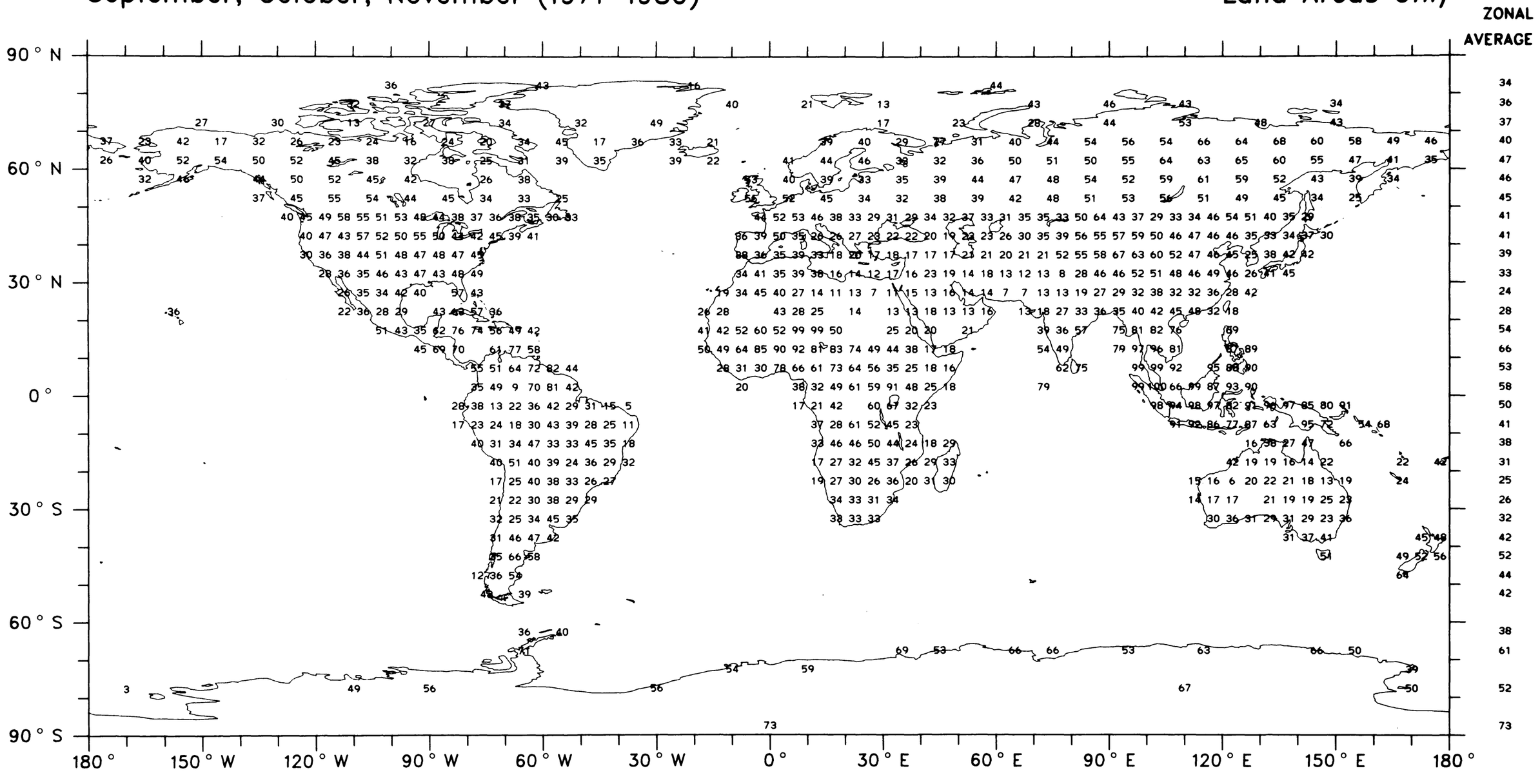


Map IV-12

Frequency of Occurrence (Percent) of Ci/Cs/Cc

September, October, November (1971-1980)

Land Areas Only



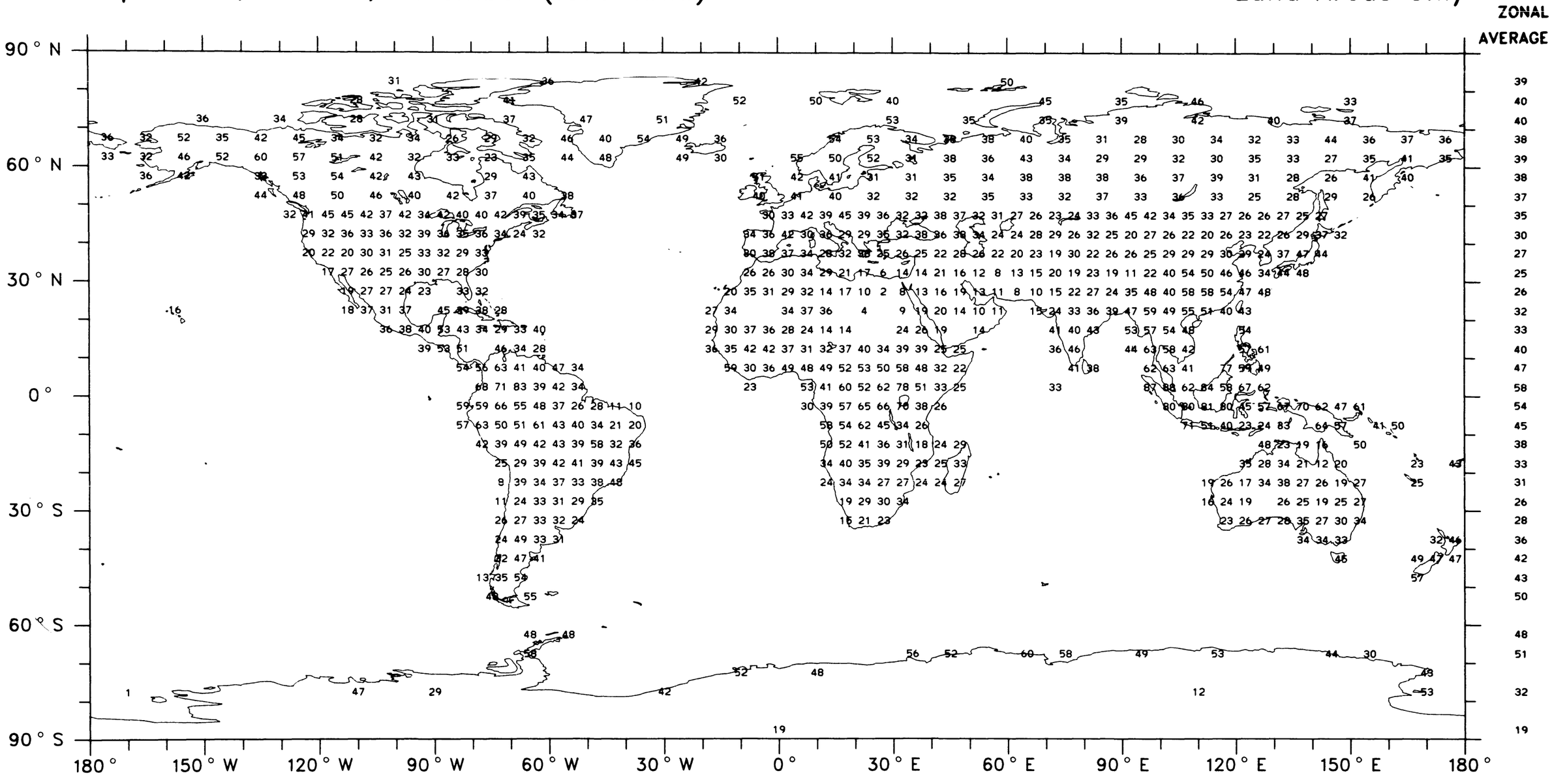
Map IV-13

Map IV-13

Frequency of Occurrence (Percent) of As/Ac

September, October, November (1971-1980)

Land Areas Only

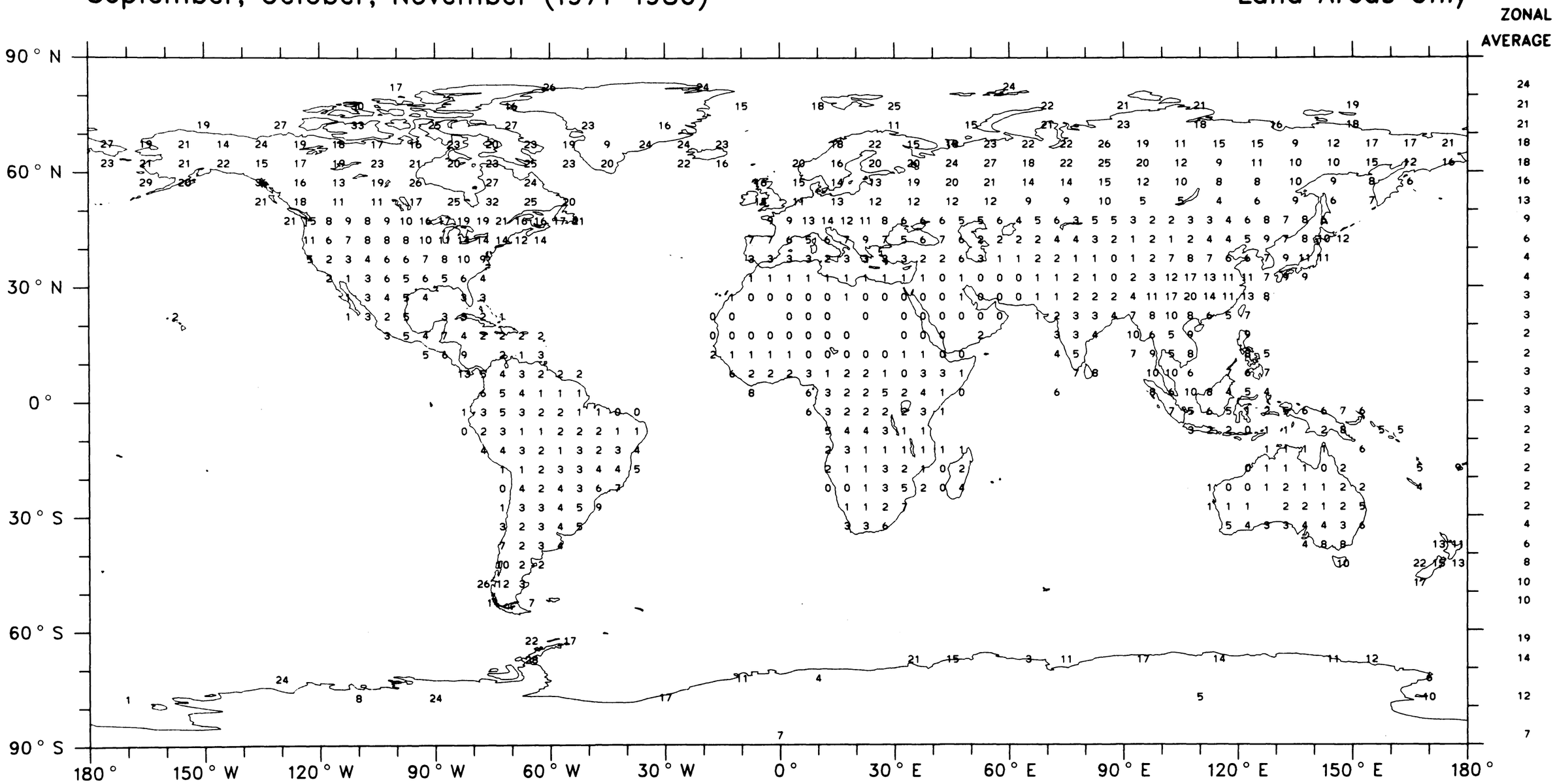


Map IV-14

Frequency of Occurrence (Percent) of Nimbostratus

September, October, November (1971-1980)

Land Areas Only

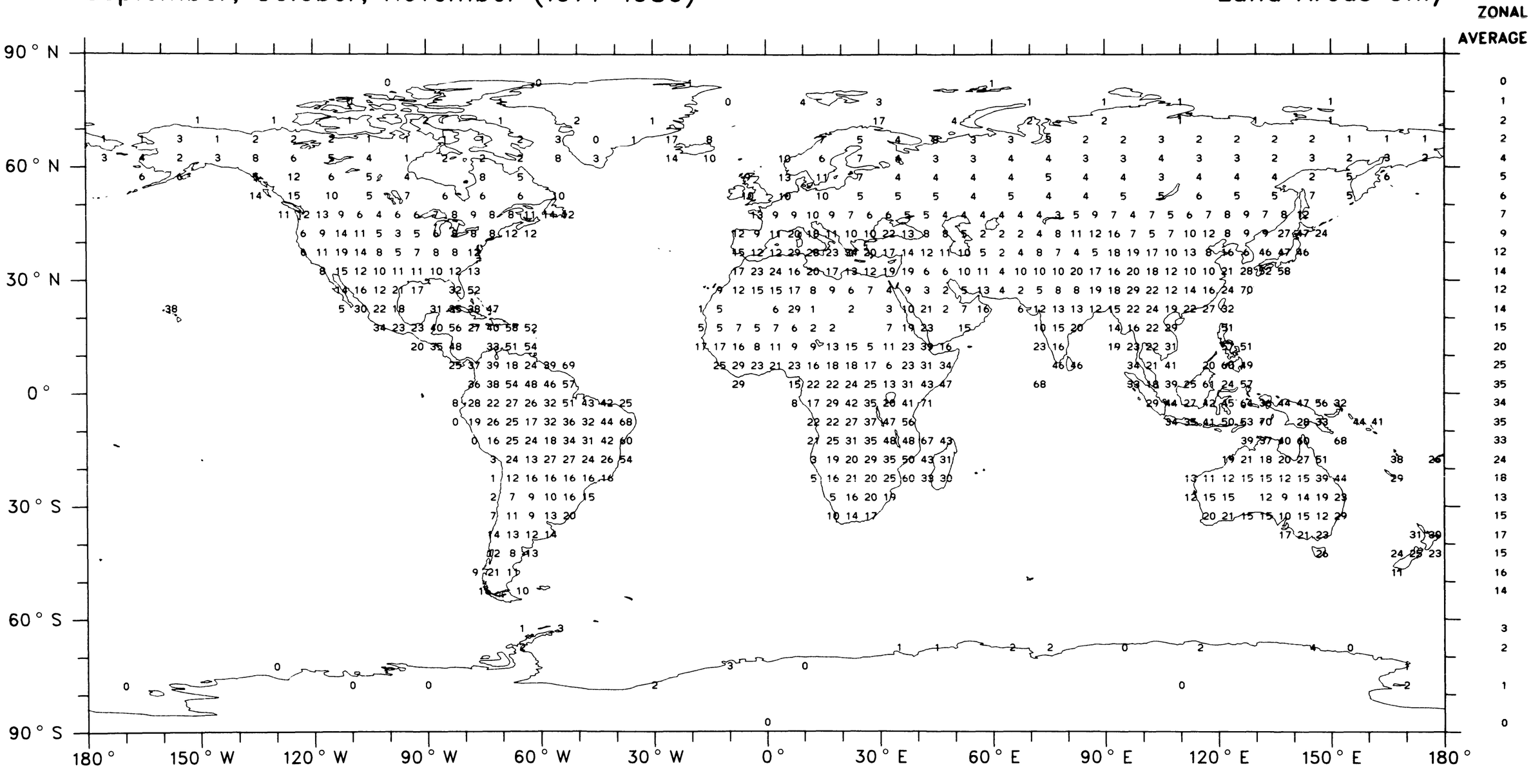


Map IV-15

Frequency of Occurrence (Percent) of Cumulus

September, October, November (1971-1980)

Land Areas Only

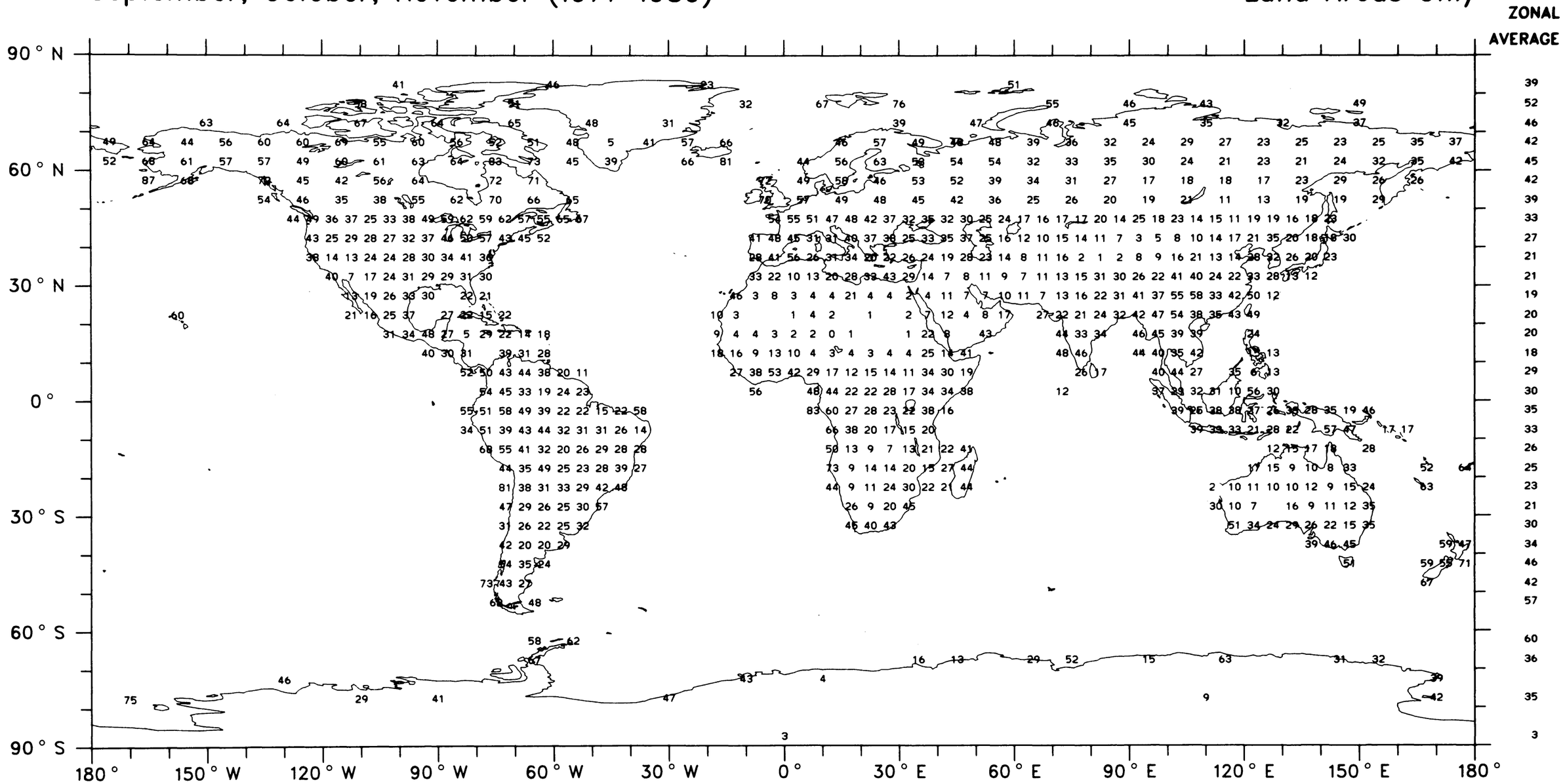


Map IV-16

Frequency of Occurrence (Percent) of St/Sc

September, October, November (1971-1980)

Land Areas Only

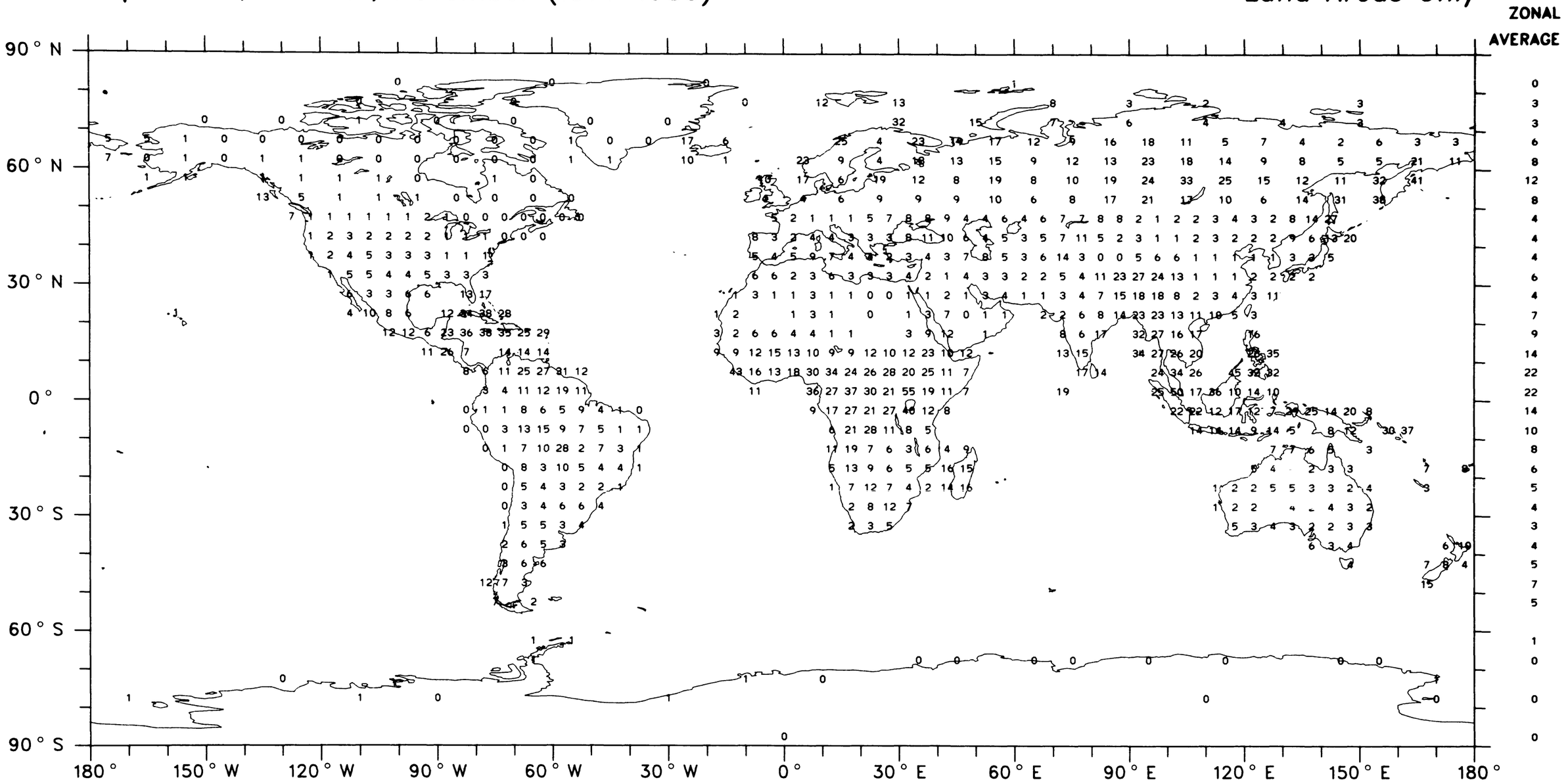


Map IV-17

Frequency of Occurrence (Percent) of Cumulonimbus

September, October, November (1971-1980)

Land Areas Only

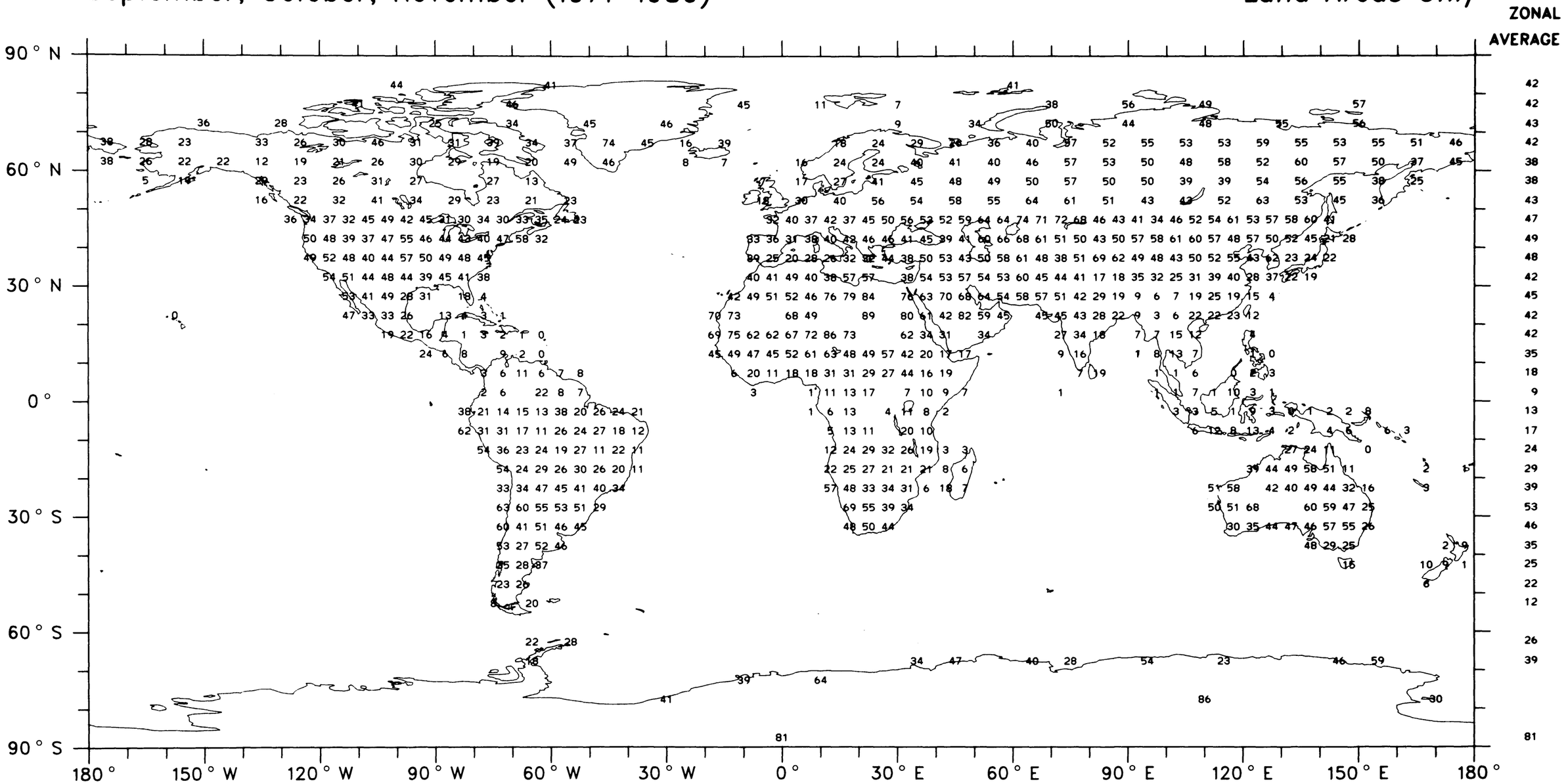


Map IV-18

Given Ci/Cs/Cc, Probability (Percent) That No Other Cloud Is Present

September, October, November (1971-1980)

Land Areas Only

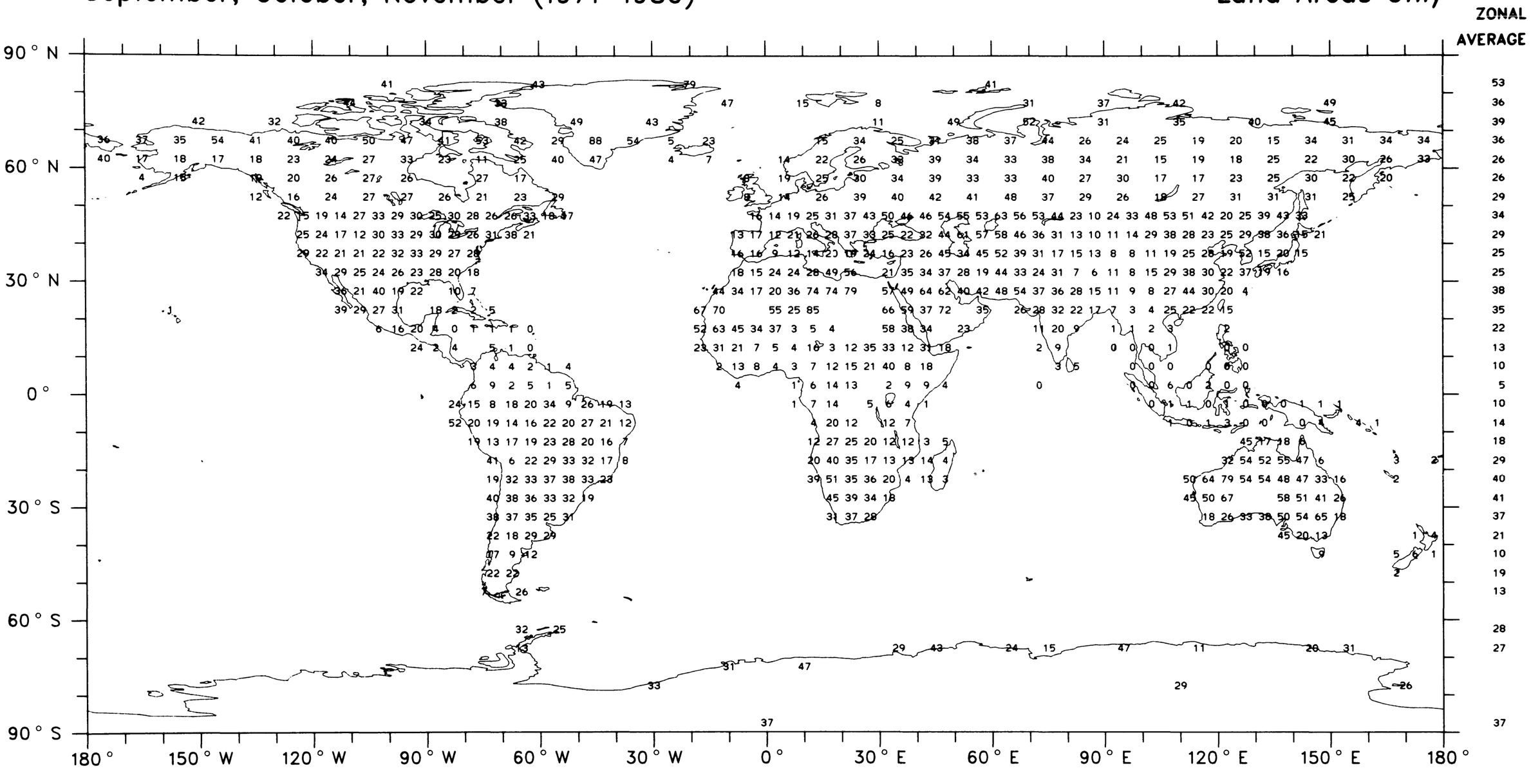


Map IV-19

Given As/Ac, Probability (Percent) That No Other Cloud Is Present

September, October, November (1971-1980)

Land Areas Only

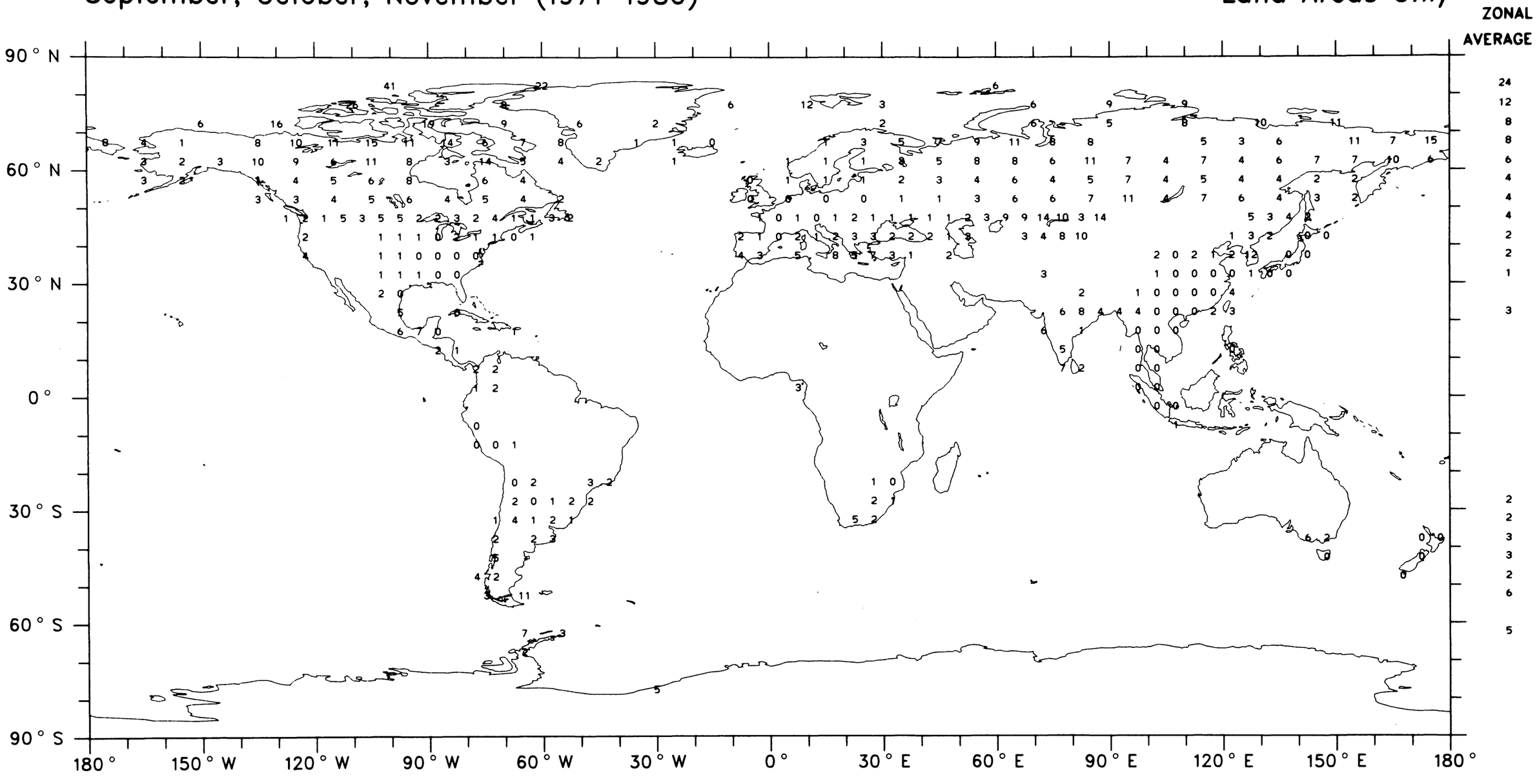


Map IV-20

Given Nimbostratus, Probability (Percent) That No Other Cloud Is Present

September, October, November (1971-1980)

Land Areas Only

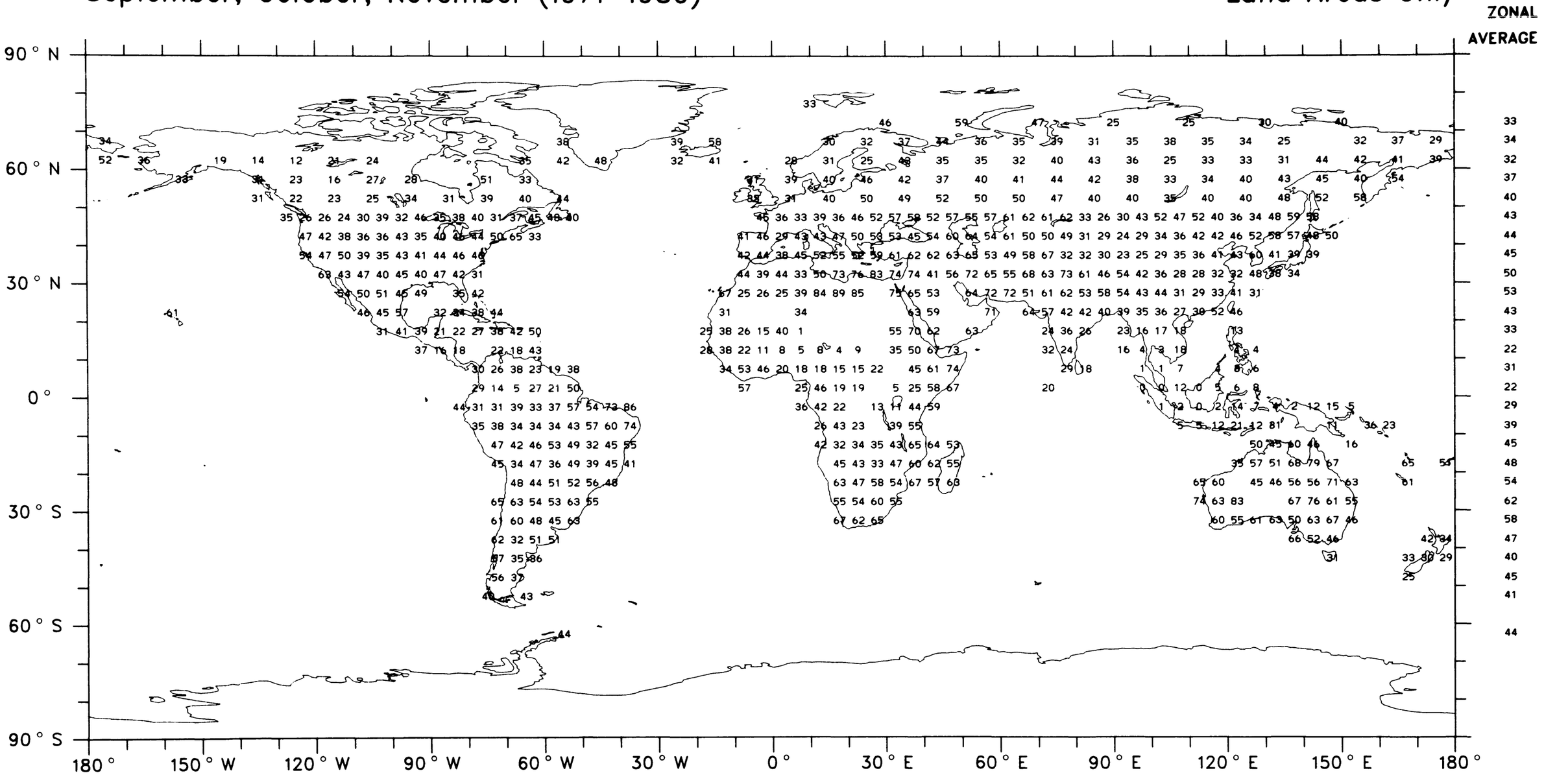


Map IV-21

Given Cumulus, Probability (Percent) That No Other Cloud Is Present

September, October, November (1971-1980)

Land Areas Only

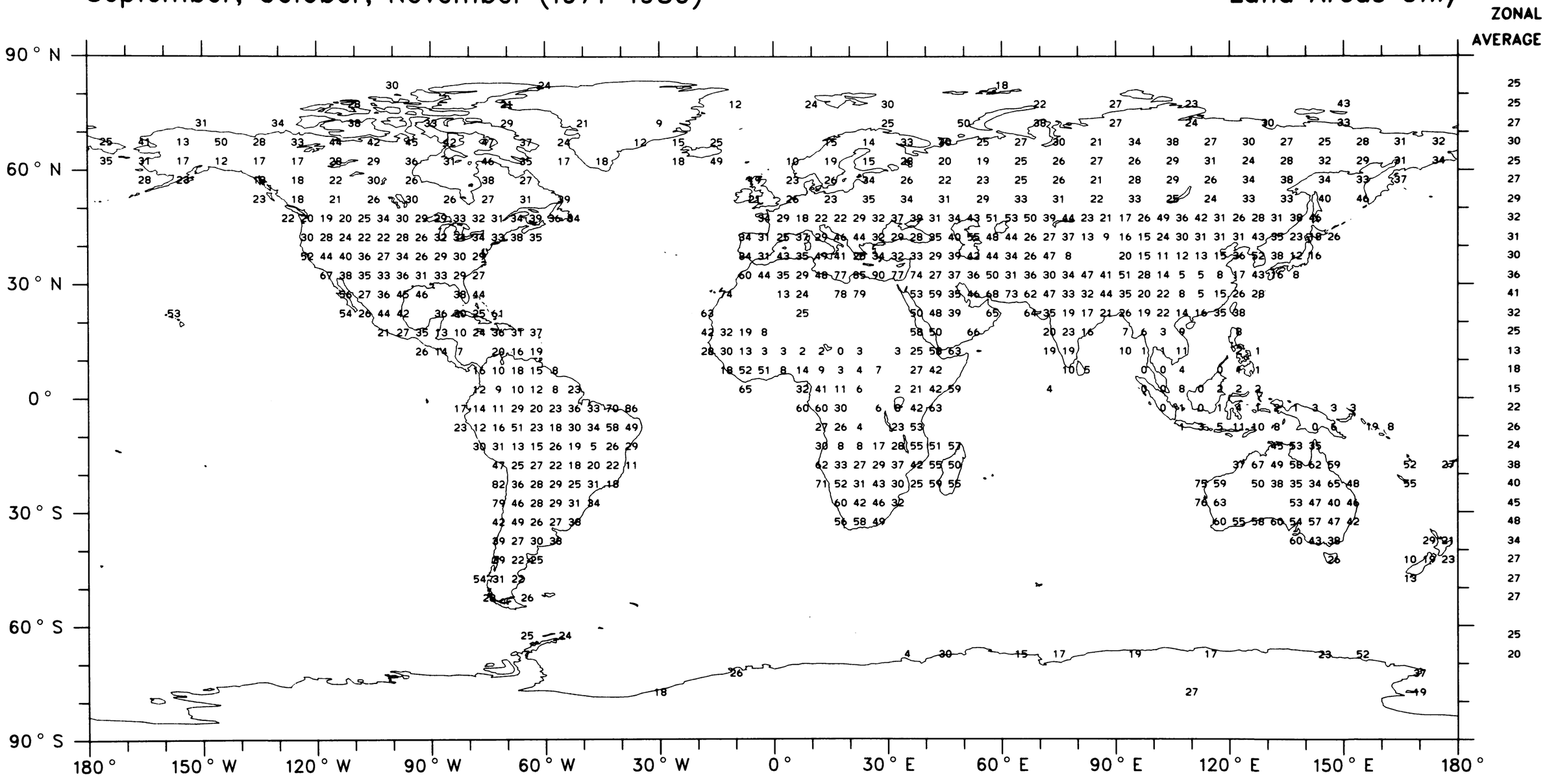


Map IV-22

Given St/Sc, Probability (Percent) That No Other Cloud Is Present

September, October, November (1971-1980)

Land Areas Only

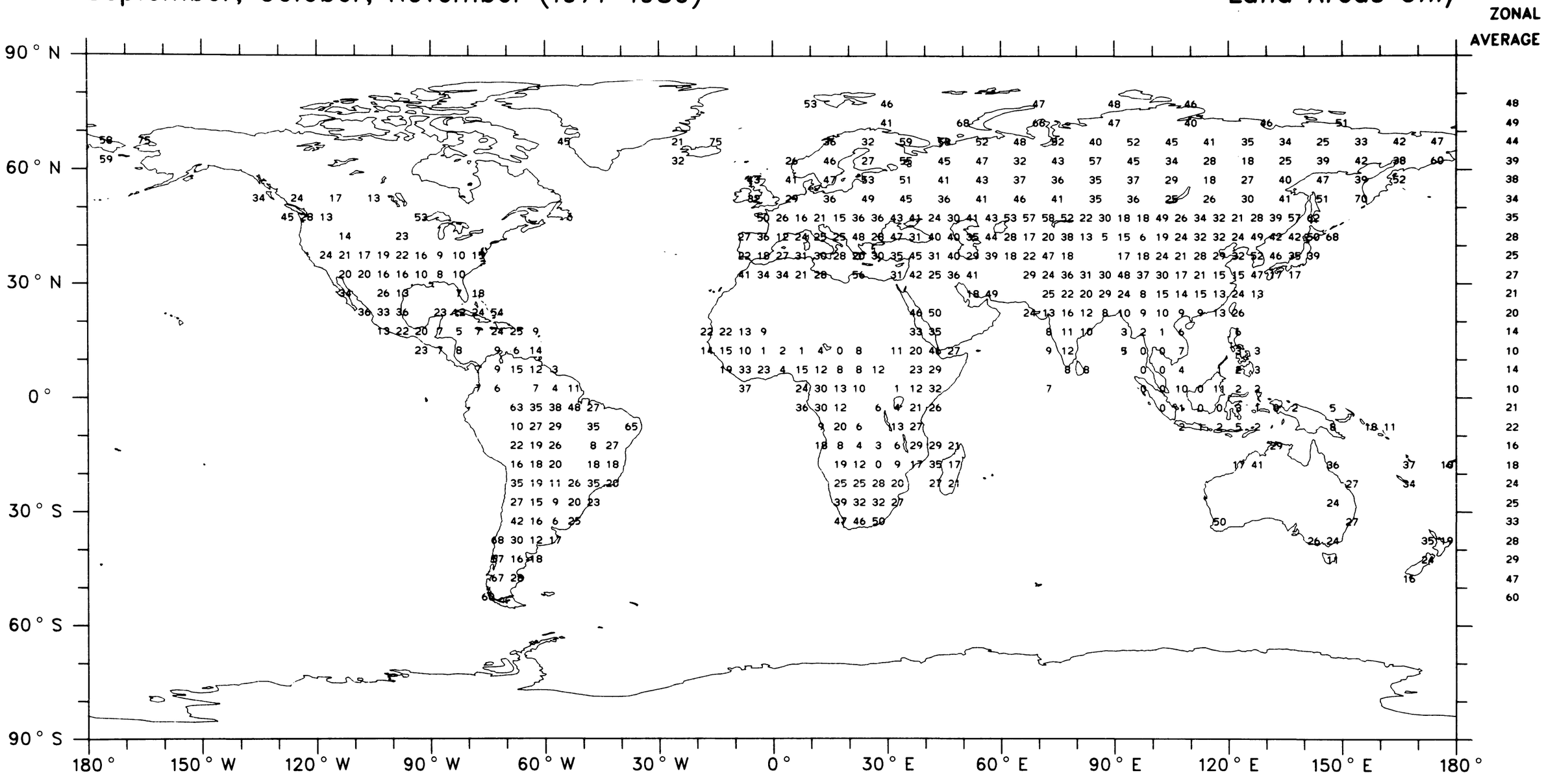


Map IV-23

Given Cumulonimbus, Probability (Percent) That No Other Cloud Is Present

September, October, November (1971-1980)

Land Areas Only

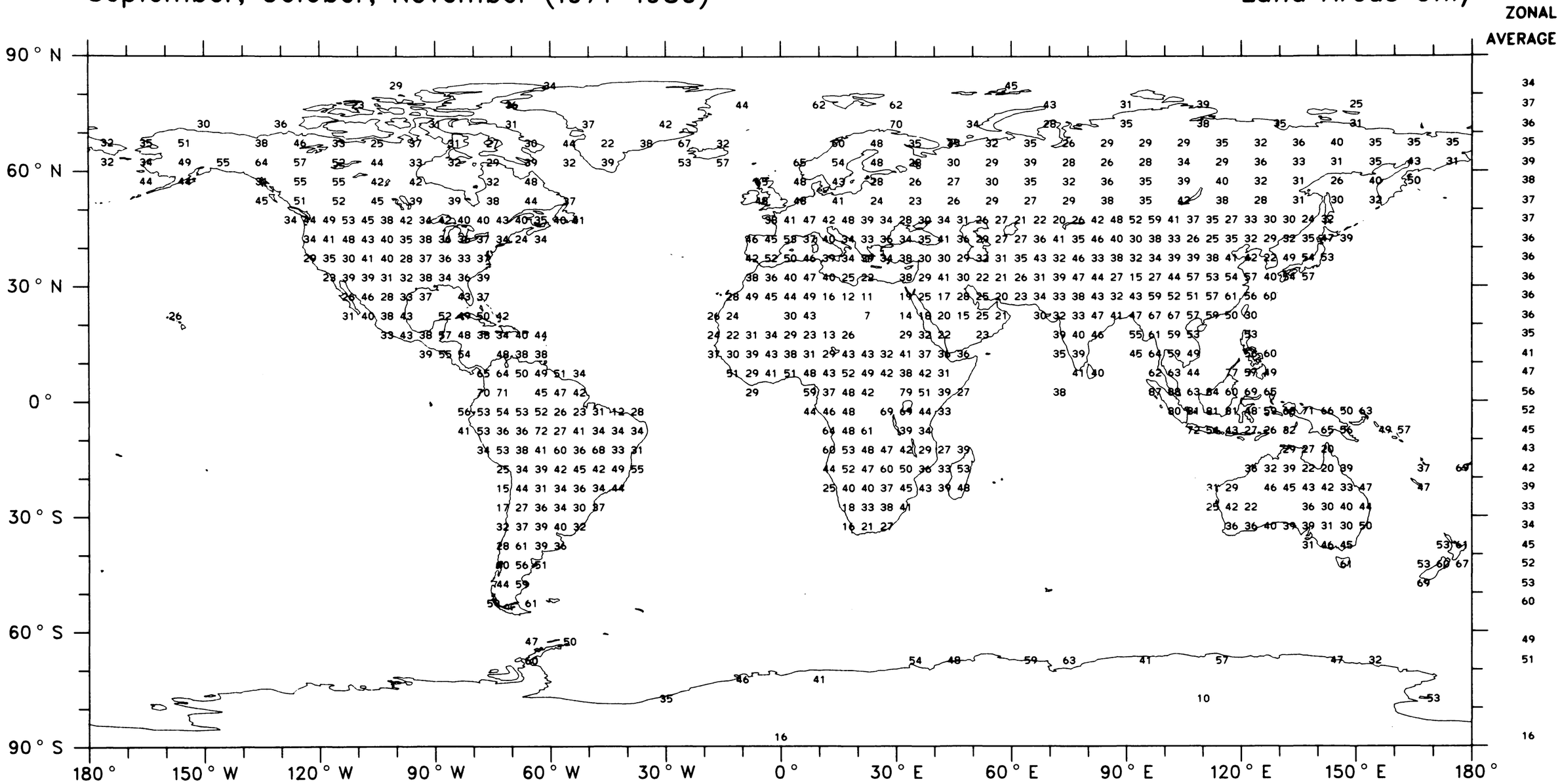


Map IV-24

Given Ci/Cs/Cc, Probability (Percent) That As/Ac is Also Present

September, October, November (1971-1980)

Land Areas Only



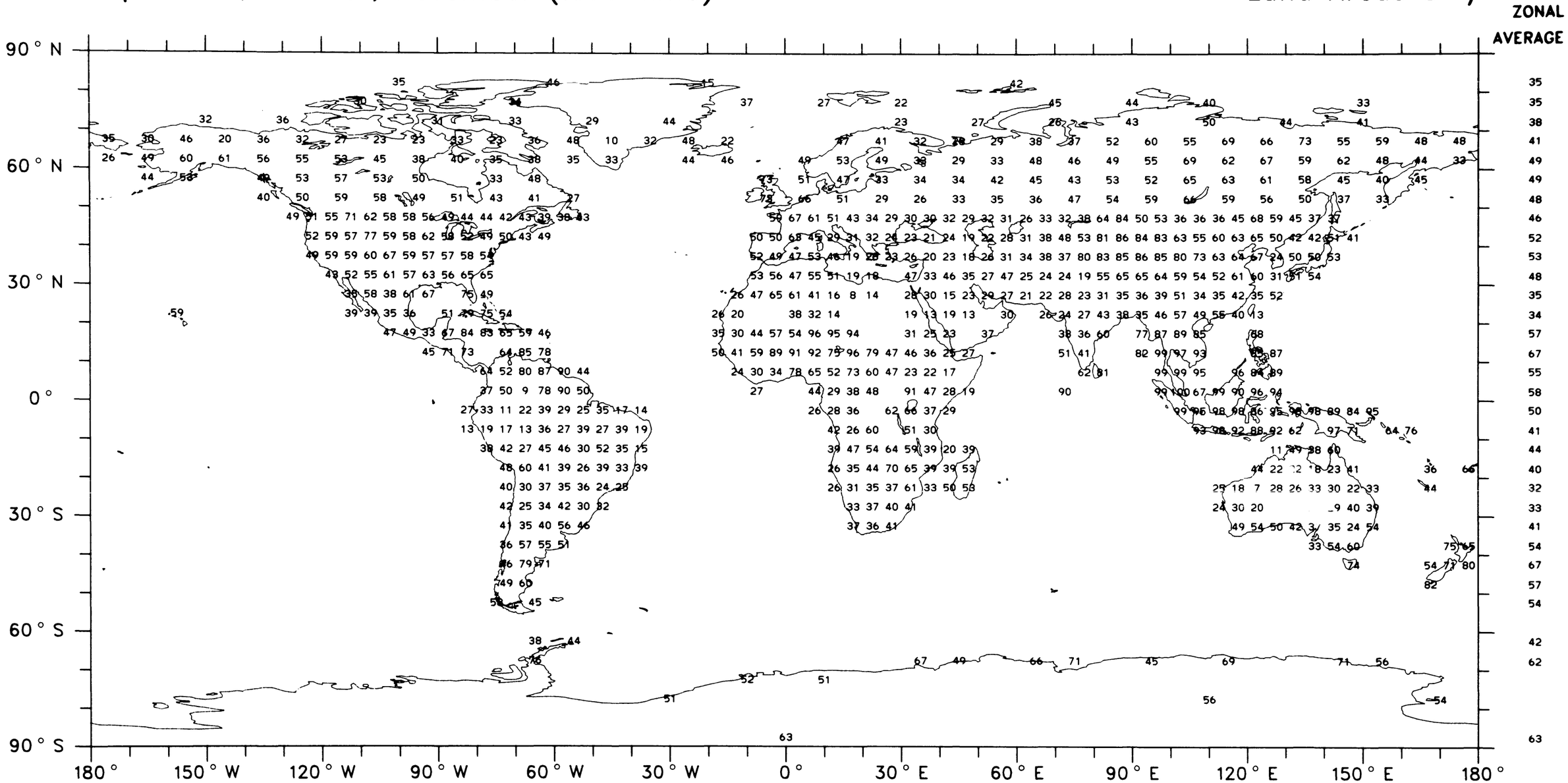
Map IV-25

Map IV-25

Given As/Ac, Probability (Percent) That Ci/Cs/Cc is Also Present

September, October, November (1971-1980)

Land Areas Only

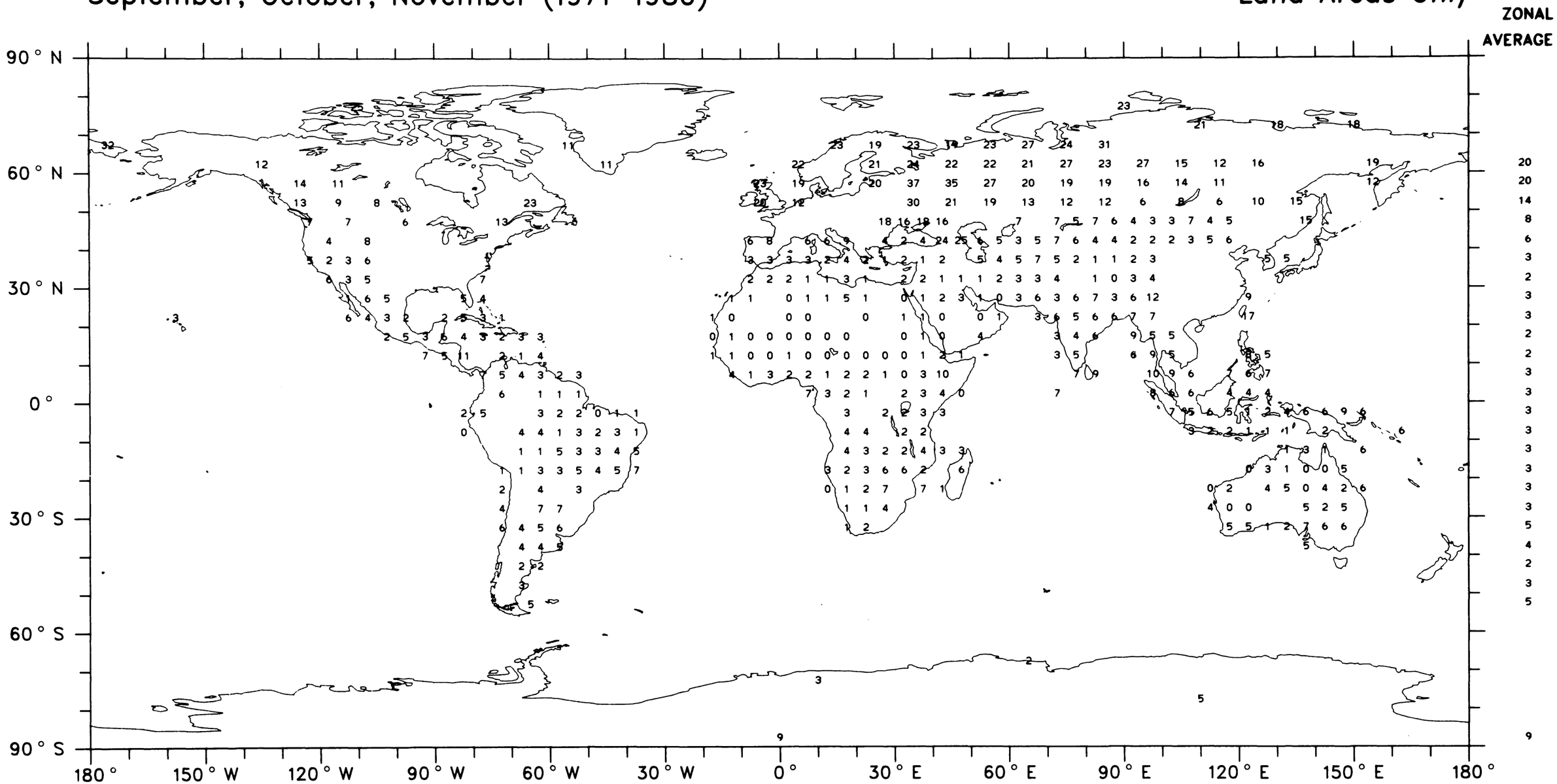


Map IV-26

Given Ci/Cs/Cc, Probability (Percent) That Nimbostratus is Also Present

September, October, November (1971-1980)

Land Areas Only



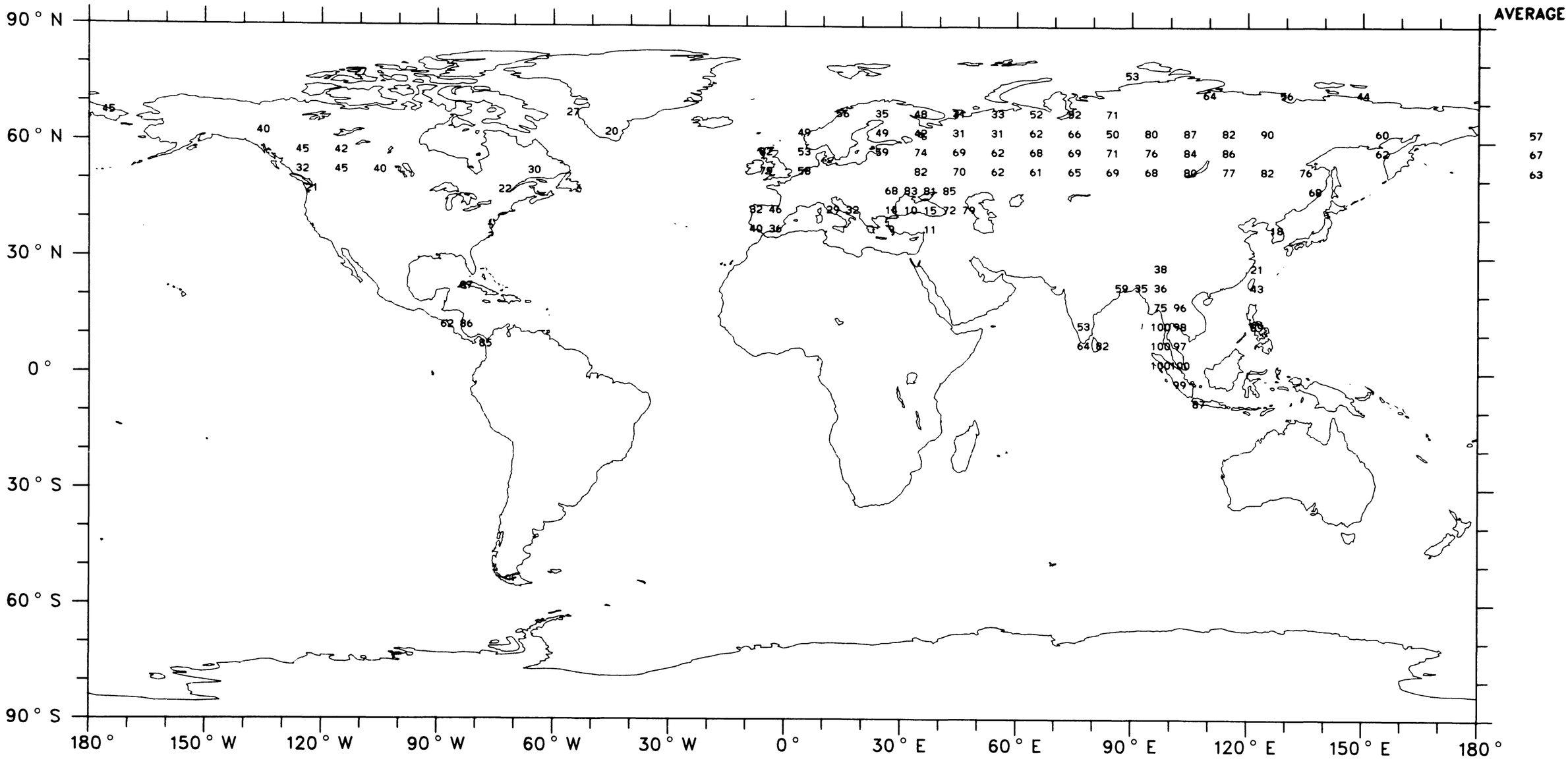
Map IV-27

Map IV-27

Given Nimbostratus, Probability (Percent) That Ci/Cs/Cc is Also Present

September, October, November (1971-1980)

Land Areas Only



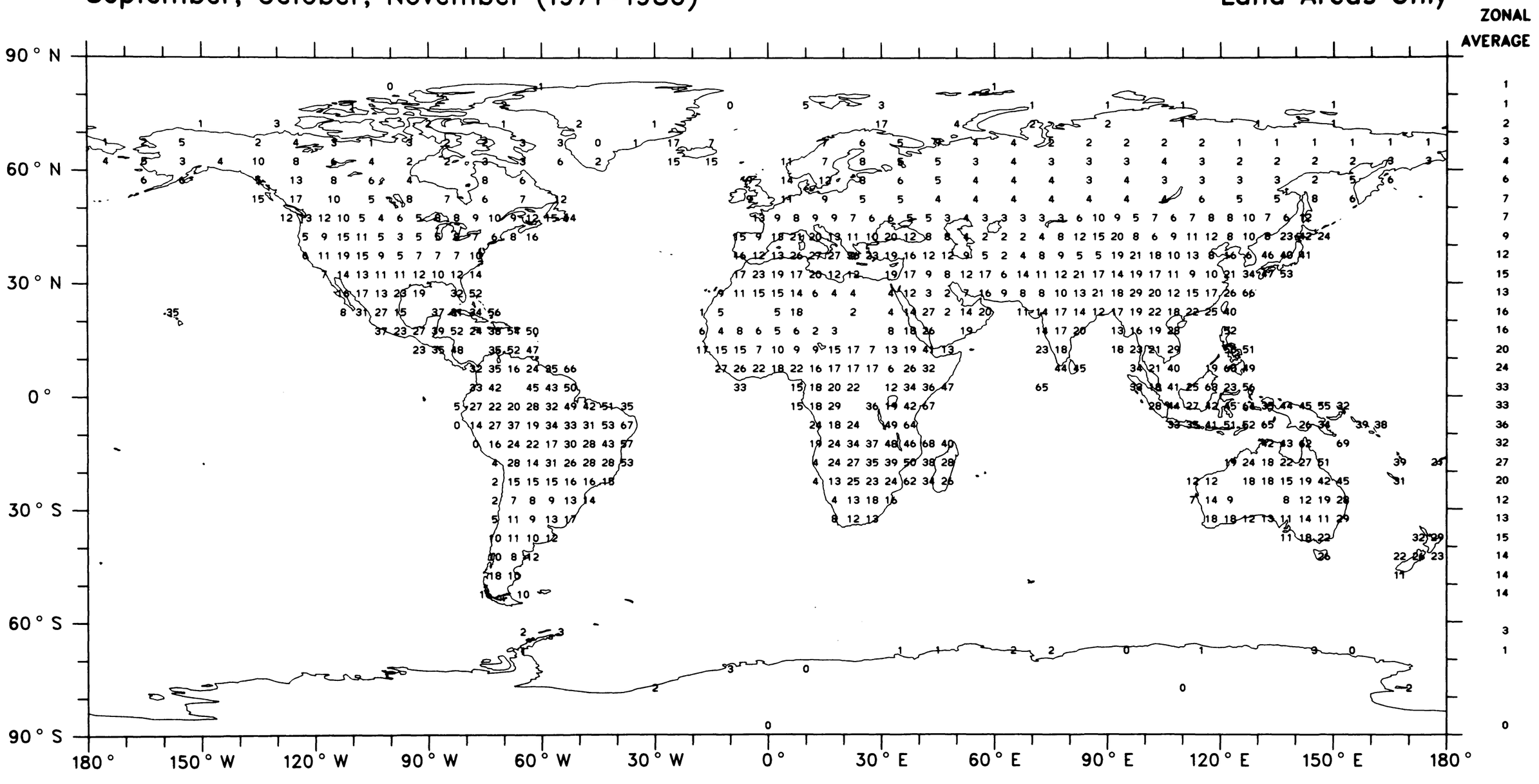
Map IV-28

Map IV-28

Given Ci/Cs/Cc, Probability (Percent) That Cumulus is Also Present

September, October, November (1971-1980)

Land Areas Only

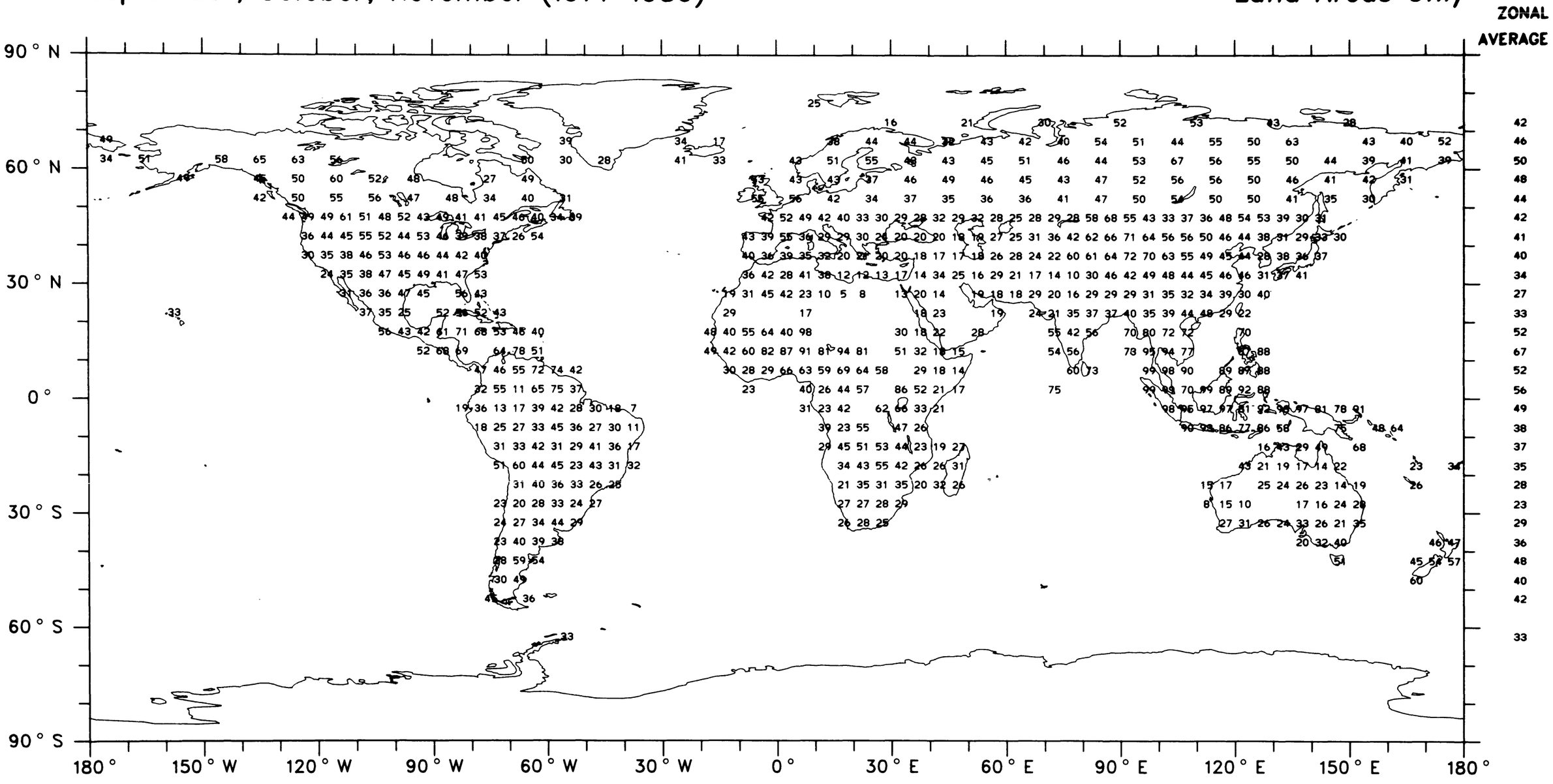


Map IV-29

Given Cumulus, Probability (Percent) That Ci/Cs/Cc is Also Present

September, October, November (1971-1980)

Land Areas Only

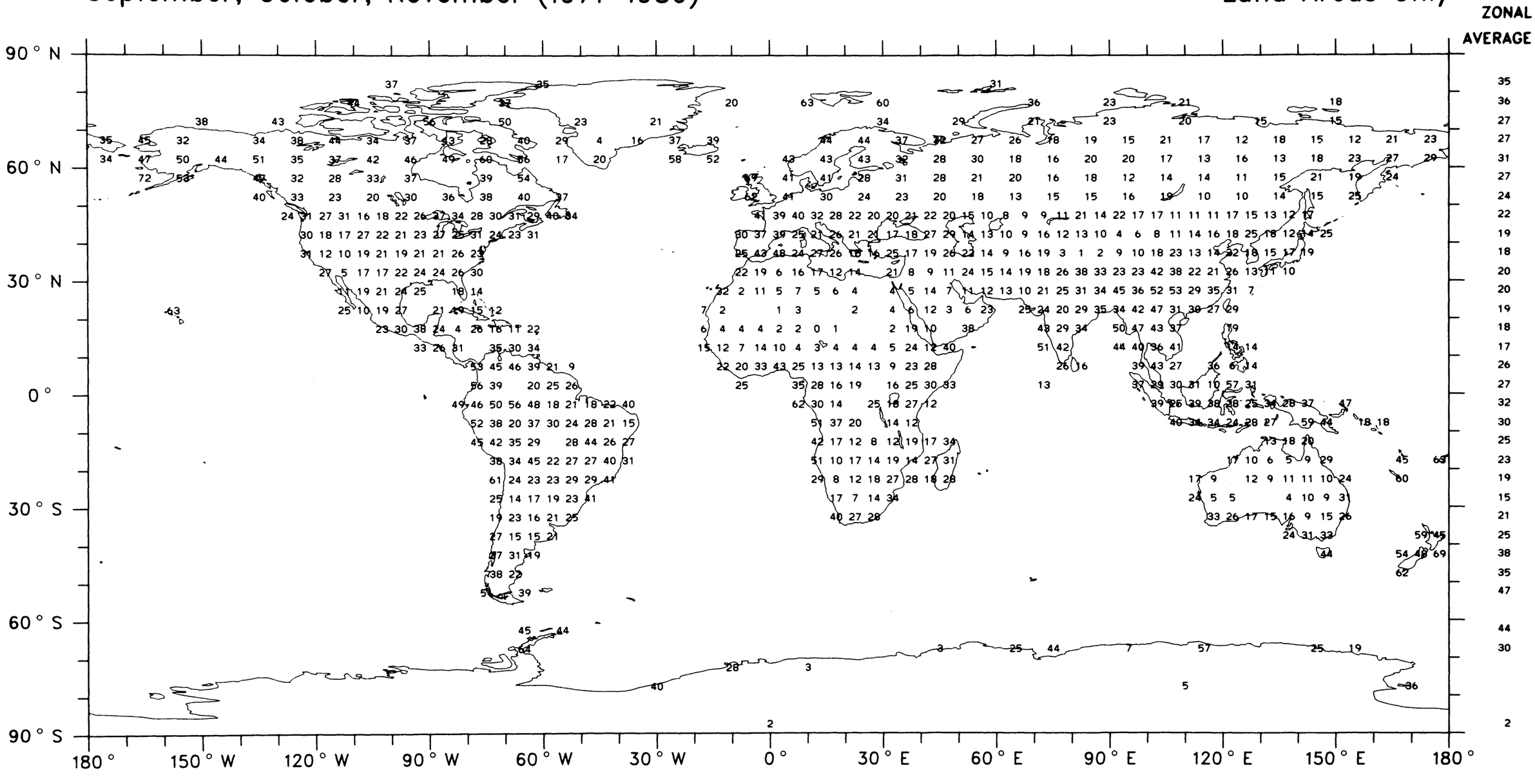


Map IV-30

Given Ci/Cs/Cc, Probability (Percent) That St/Sc is Also Present

September, October, November (1971-1980)

Land Areas Only

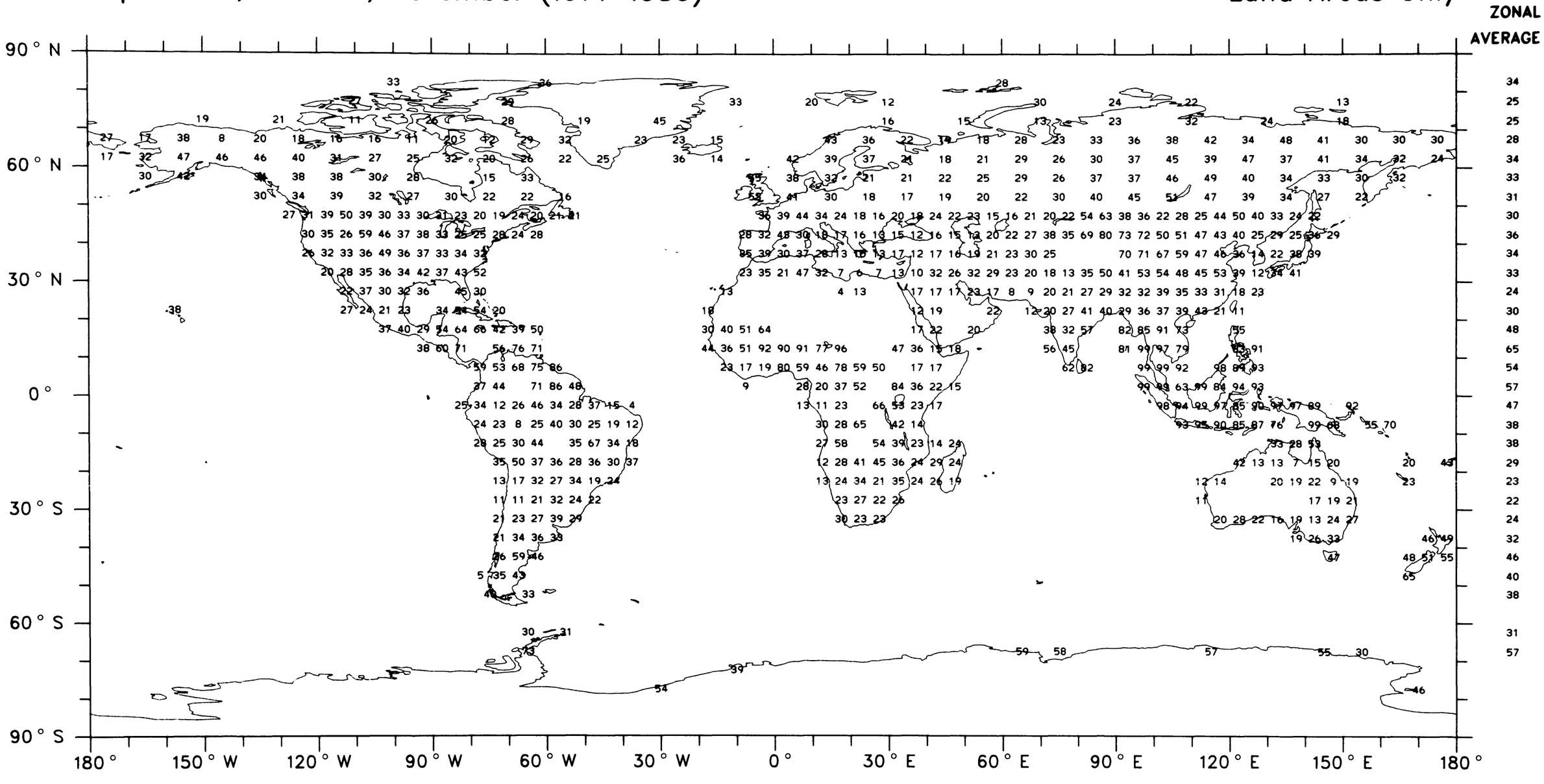


Map IV-31

Given St/Sc, Probability (Percent) That Ci/Cs/Cc is Also Present

September, October, November (1971-1980)

Land Areas Only

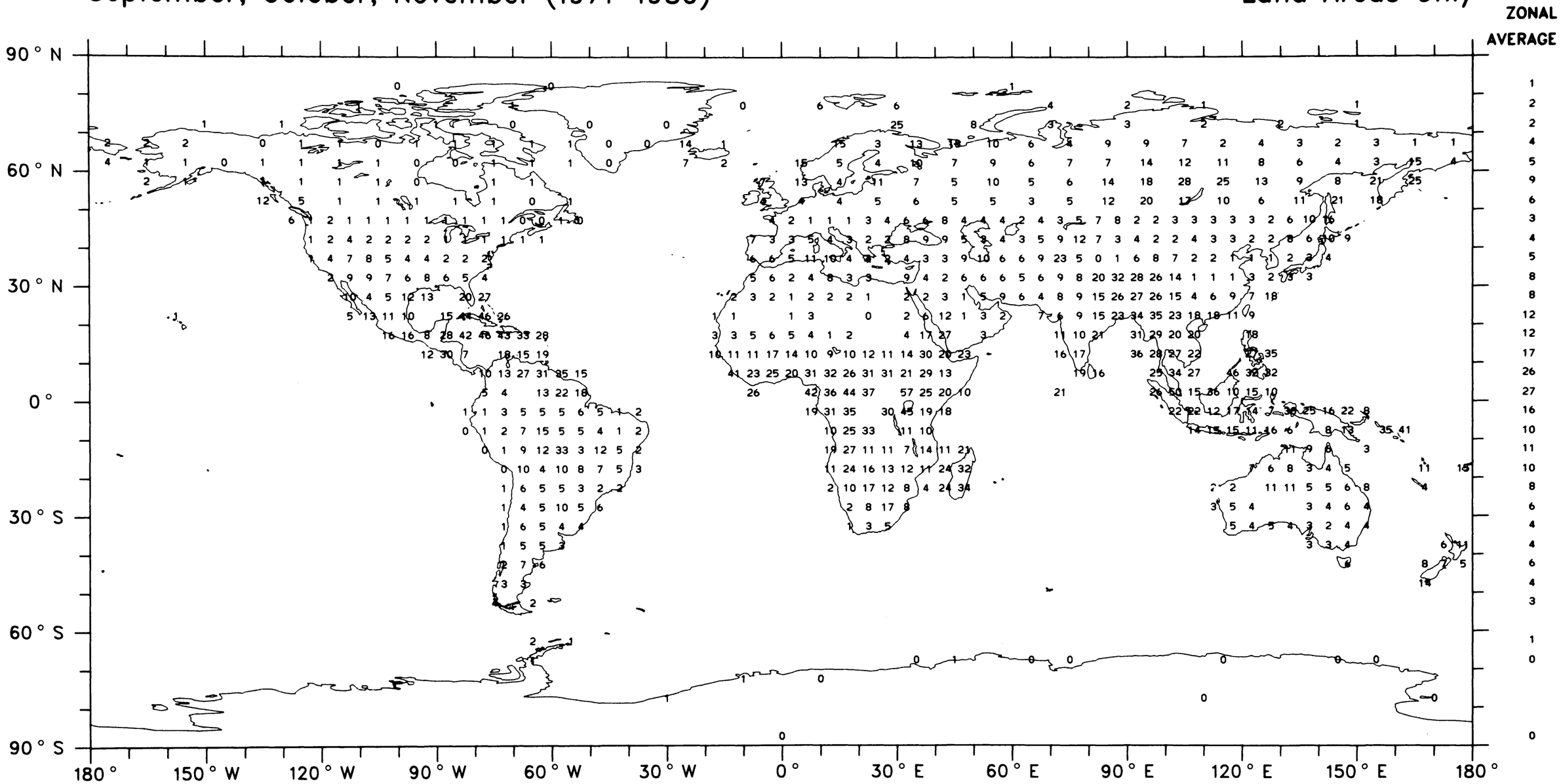


Map IV-32

Given Ci/Cs/Cc, Probability (Percent) That Cumulonimbus is Also Present

September, October, November (1971-1980)

Land Areas Only

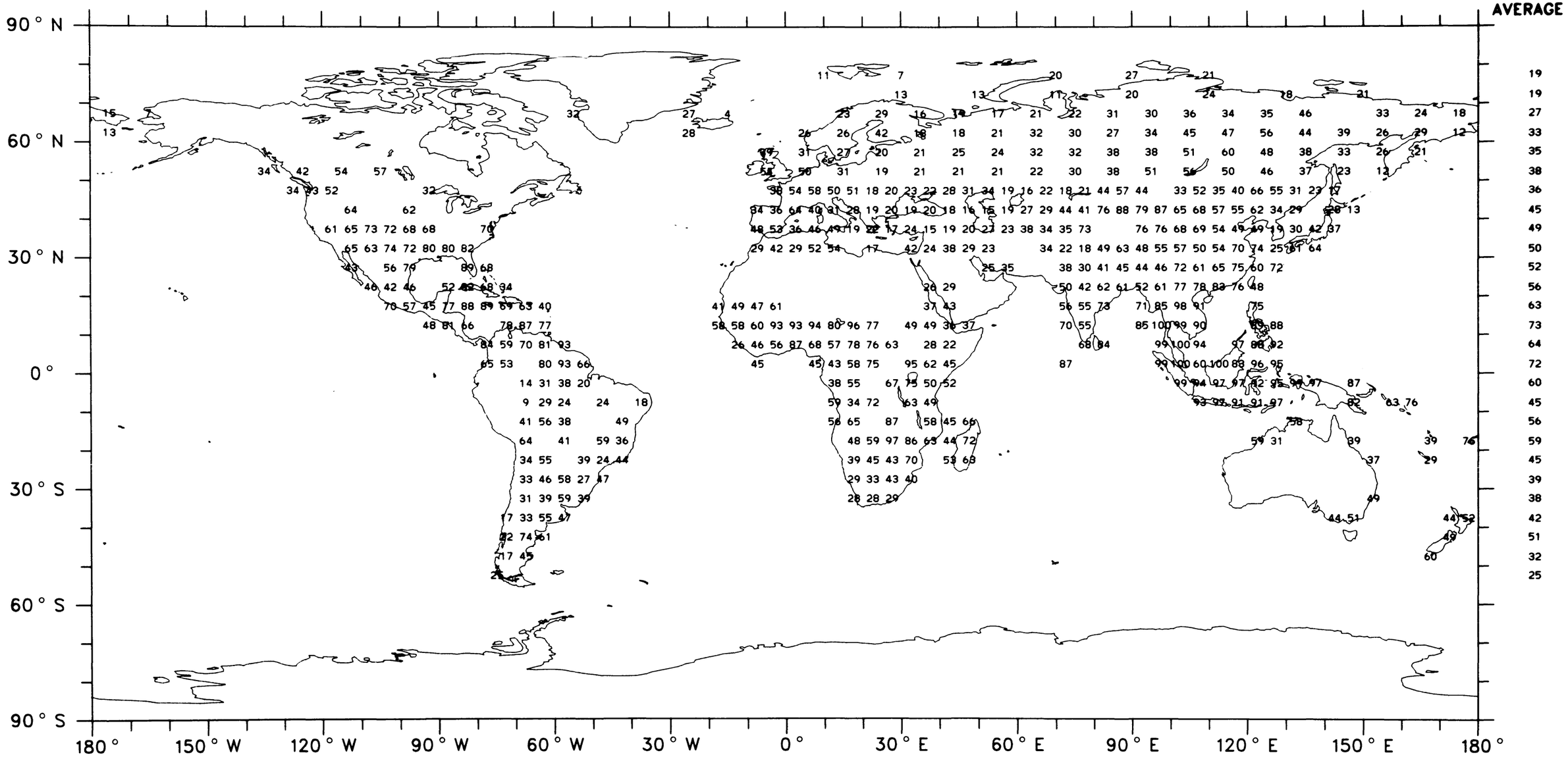


Map IV-33

Given Cumulonimbus, Probability (Percent) That Ci/Cs/Cc is Also Present

September, October, November (1971-1980)

Land Areas Only

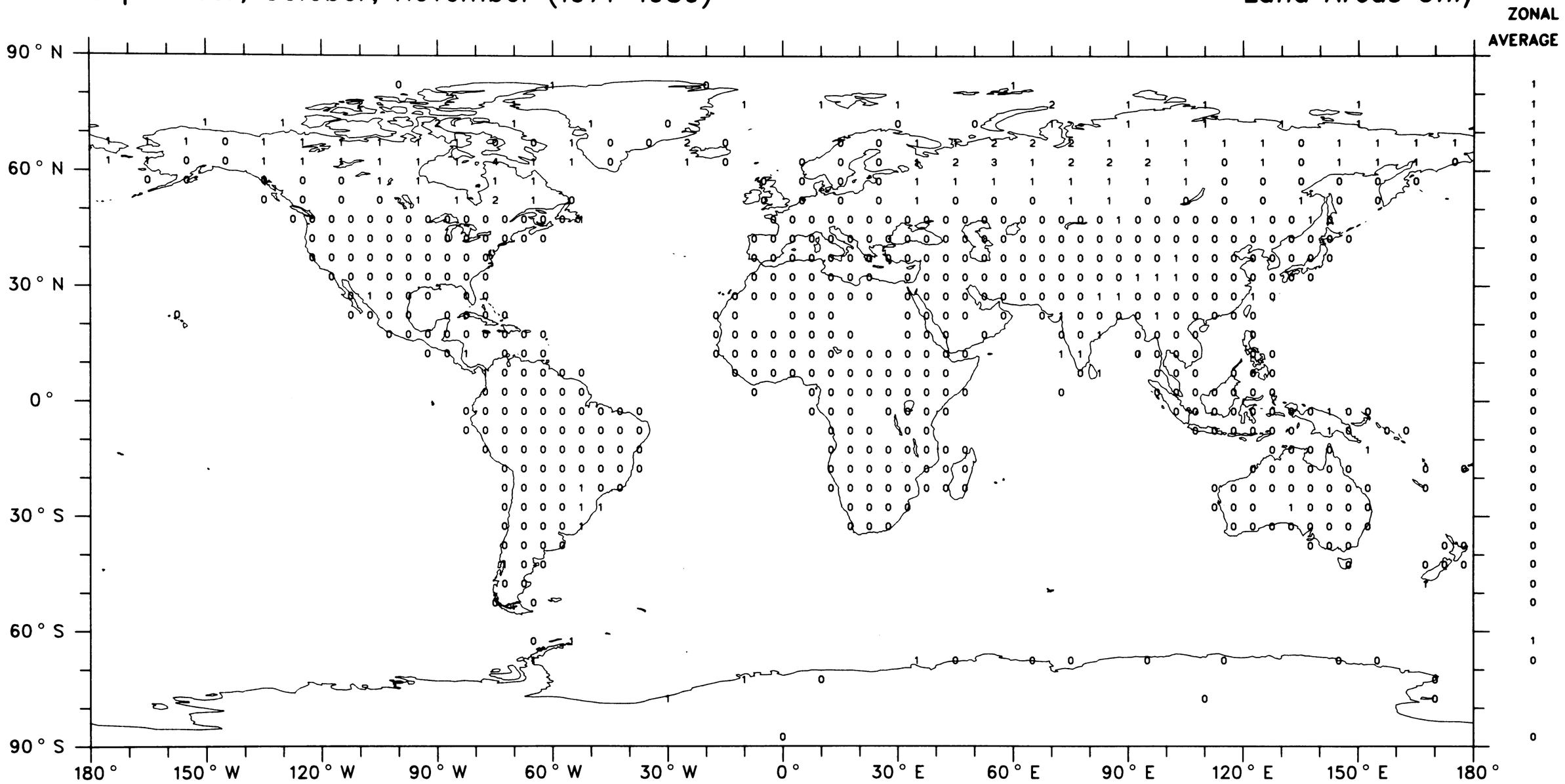


Map IV-34

Given As/Ac, Probability (Percent) That Nimbostratus is Also Present

September, October, November (1971-1980)

Land Areas Only



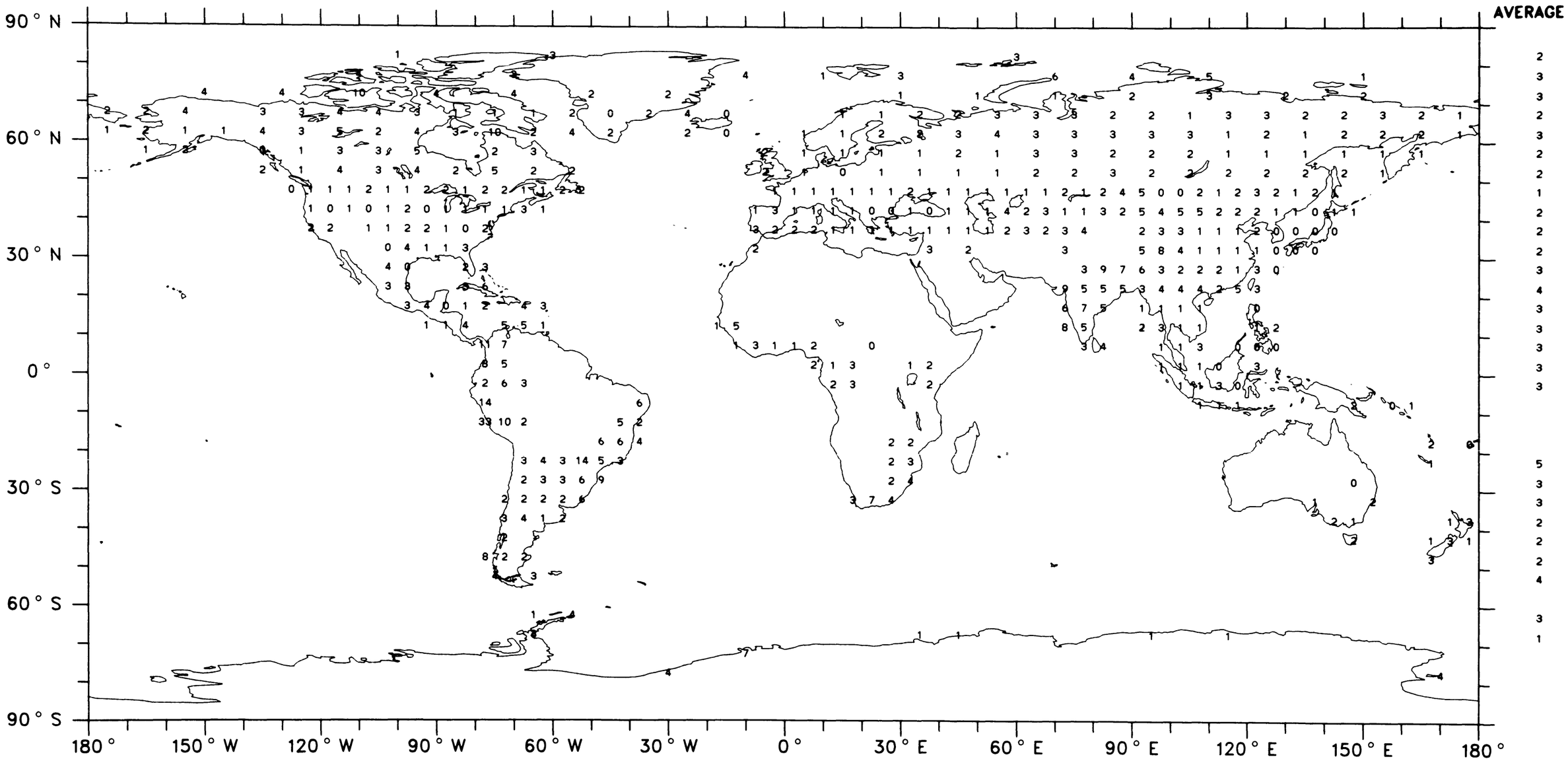
Map IV-35

Map IV-35

Given Nimbostratus, Probability (Percent) That As/Ac is Also Present

September, October, November (1971-1980)

Land Areas Only

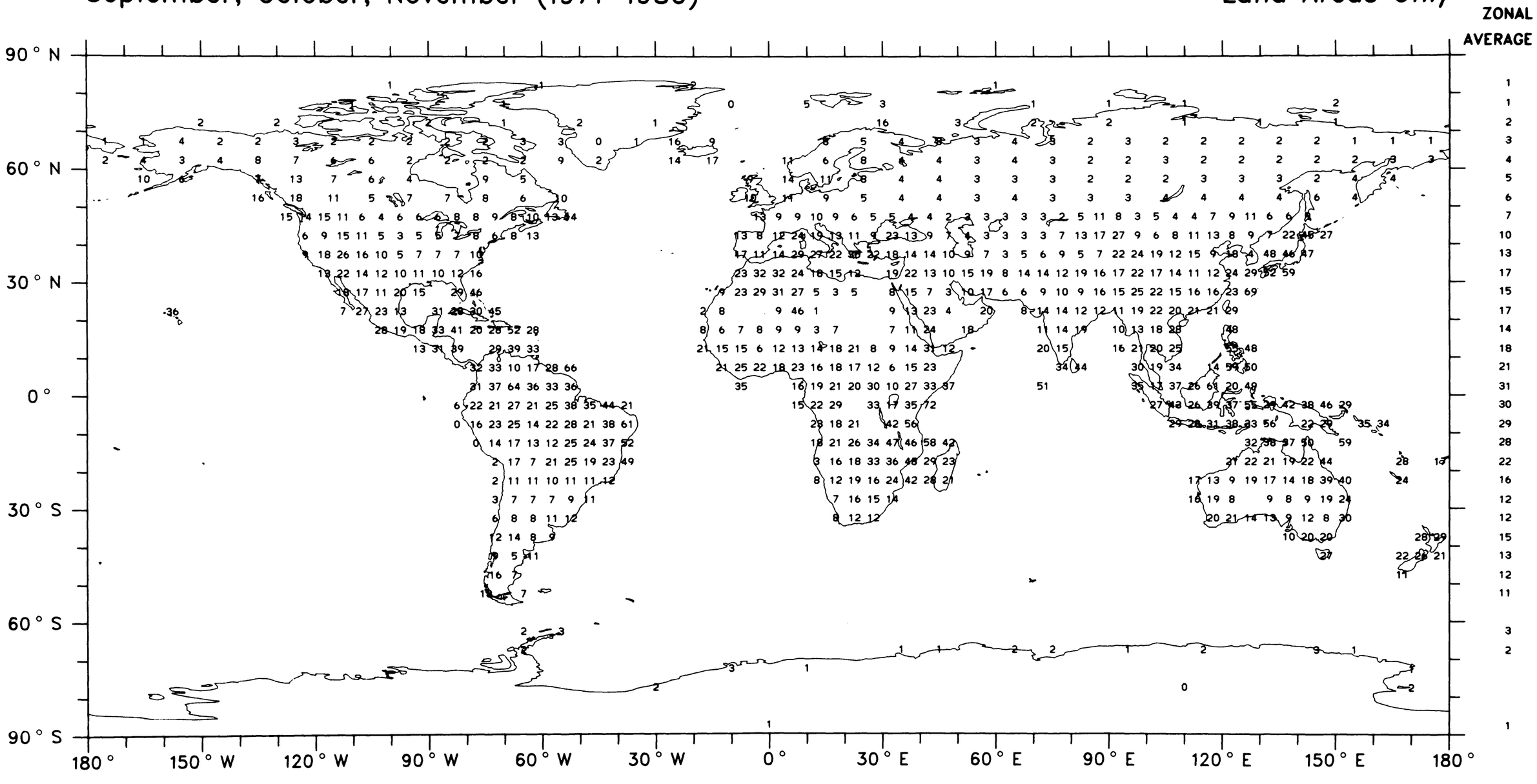


Map IV-36

Given As/Ac, Probability (Percent) That Cumulus is Also Present

September, October, November (1971-1980)

Land Areas Only

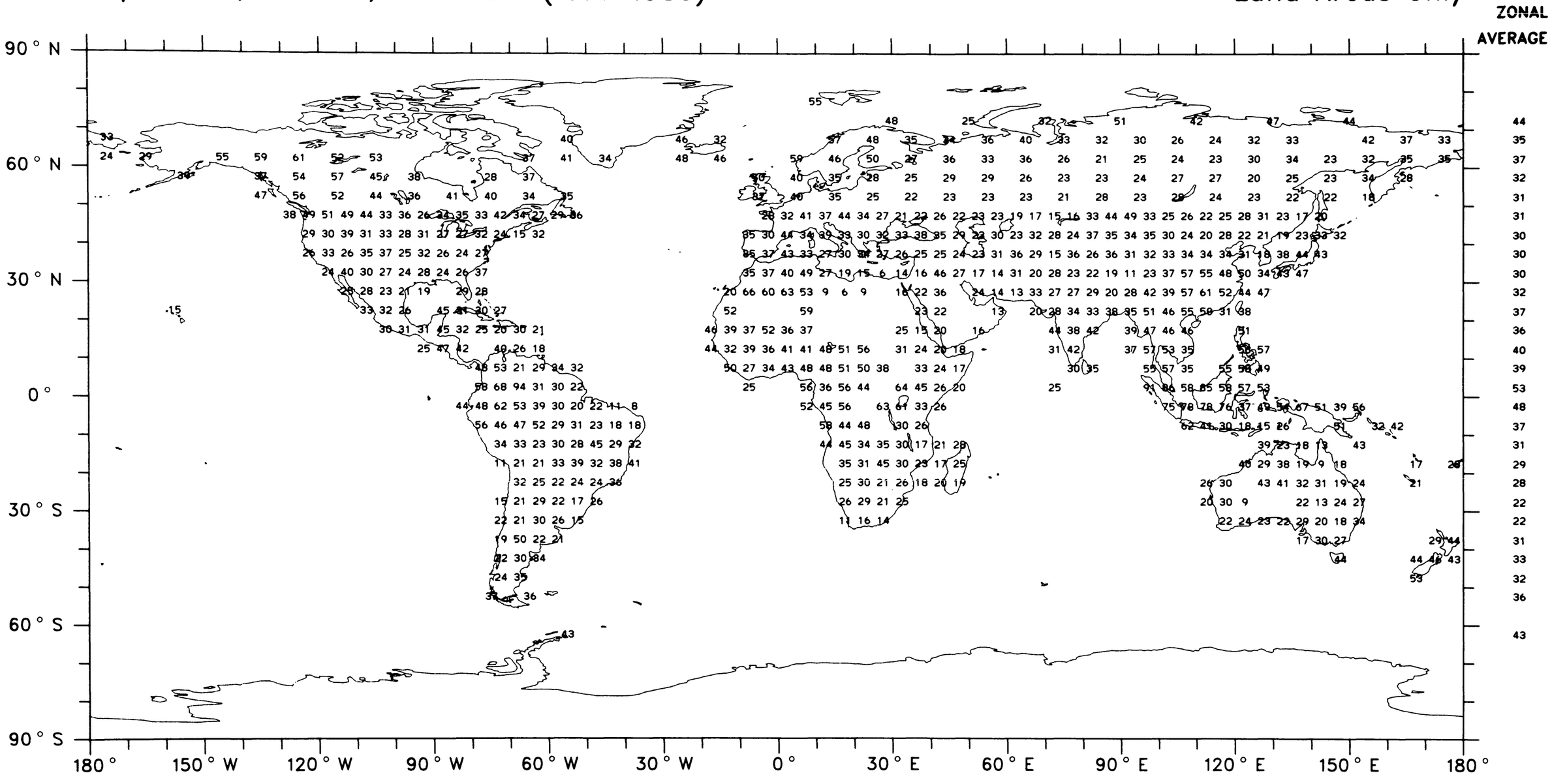


Map IV-37

Given Cumulus, Probability (Percent) That As/Ac is Also Present

September, October, November (1971-1980)

Land Areas Only

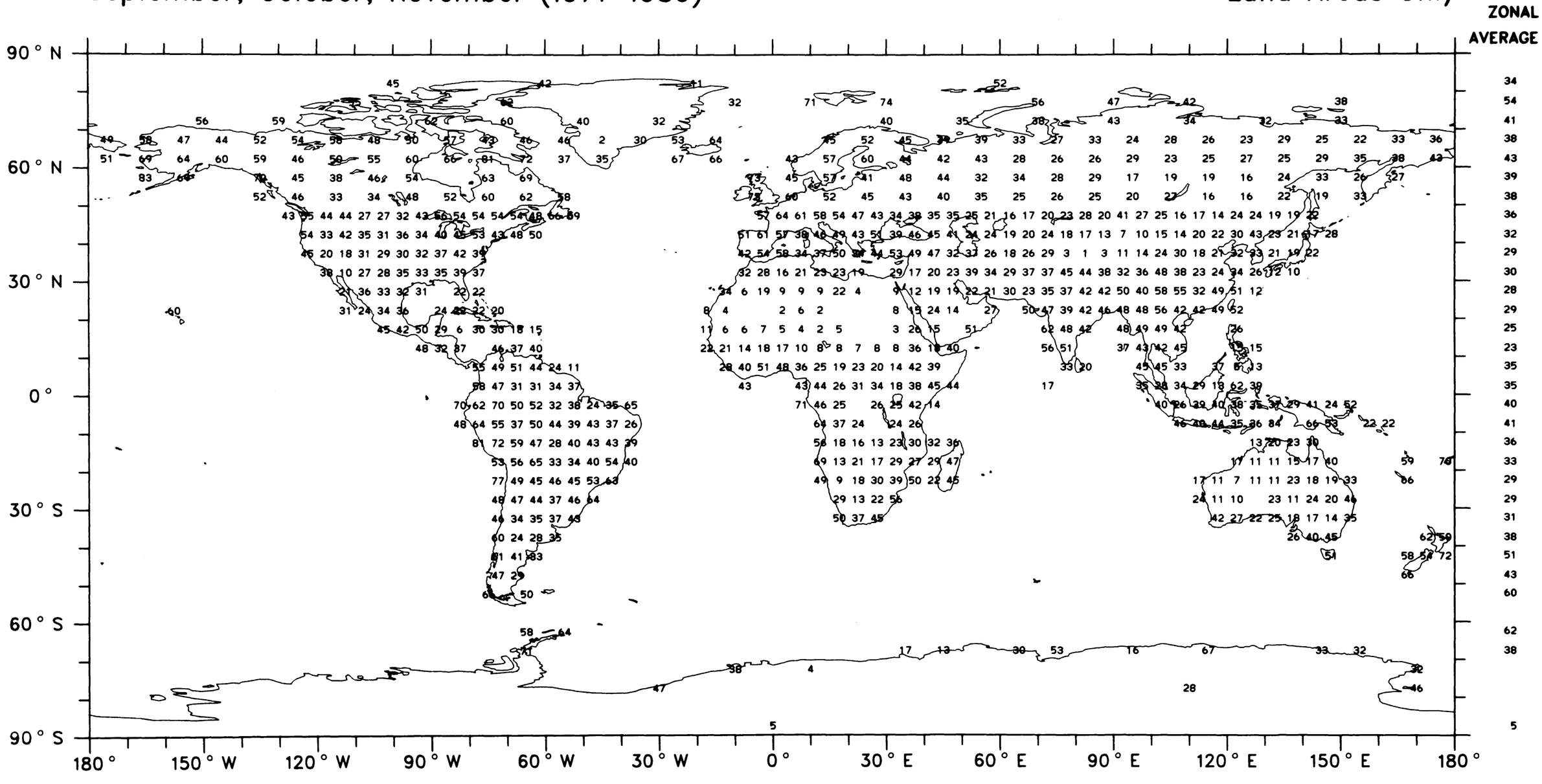


Map IV-38

Given As/Ac, Probability (Percent) That St/Sc is Also Present

September, October, November (1971-1980)

Land Areas Only

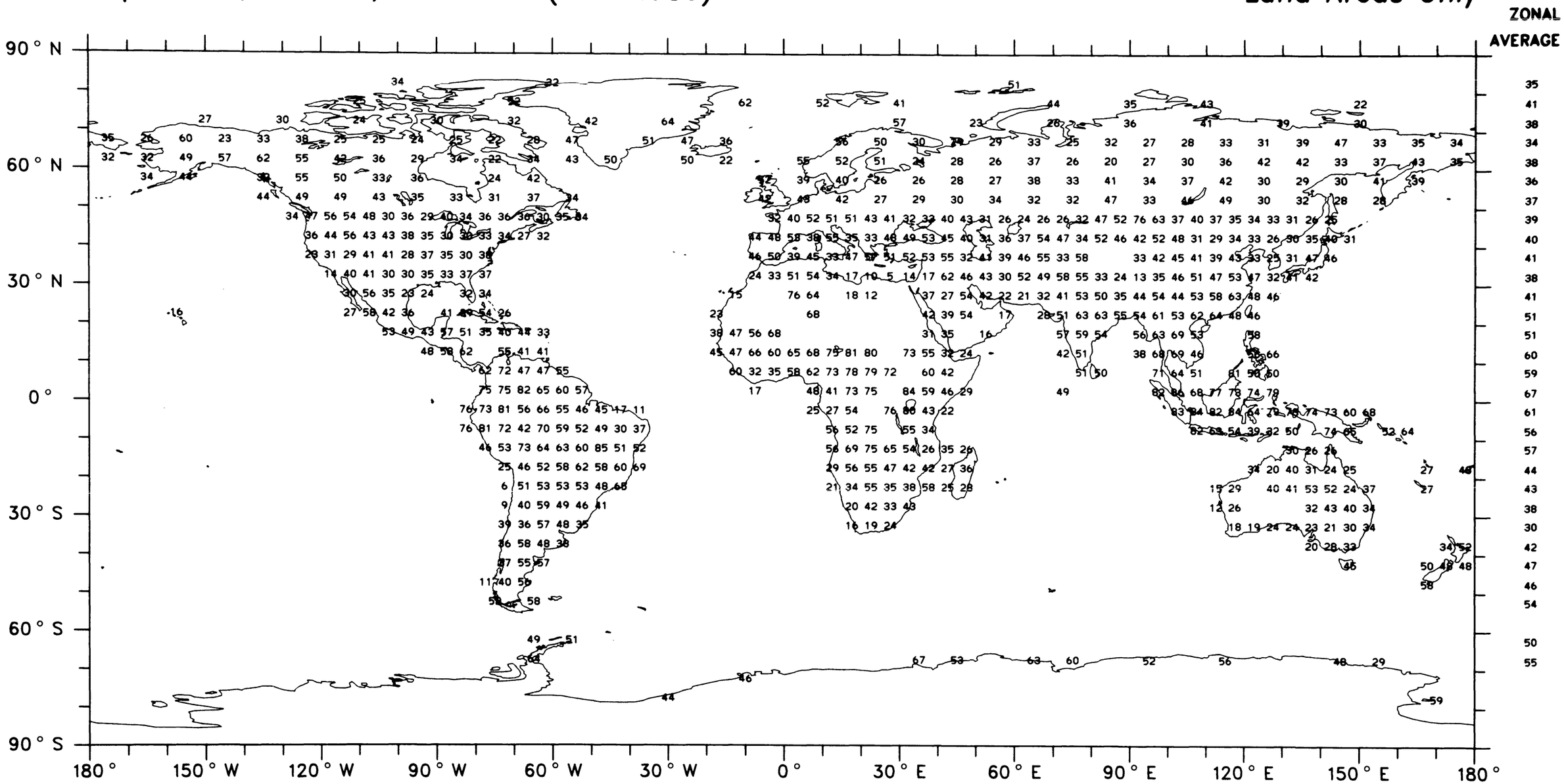


Map IV-39

Given St/Sc, Probability (Percent) That As/Ac is Also Present

September, October, November (1971-1980)

Land Areas Only

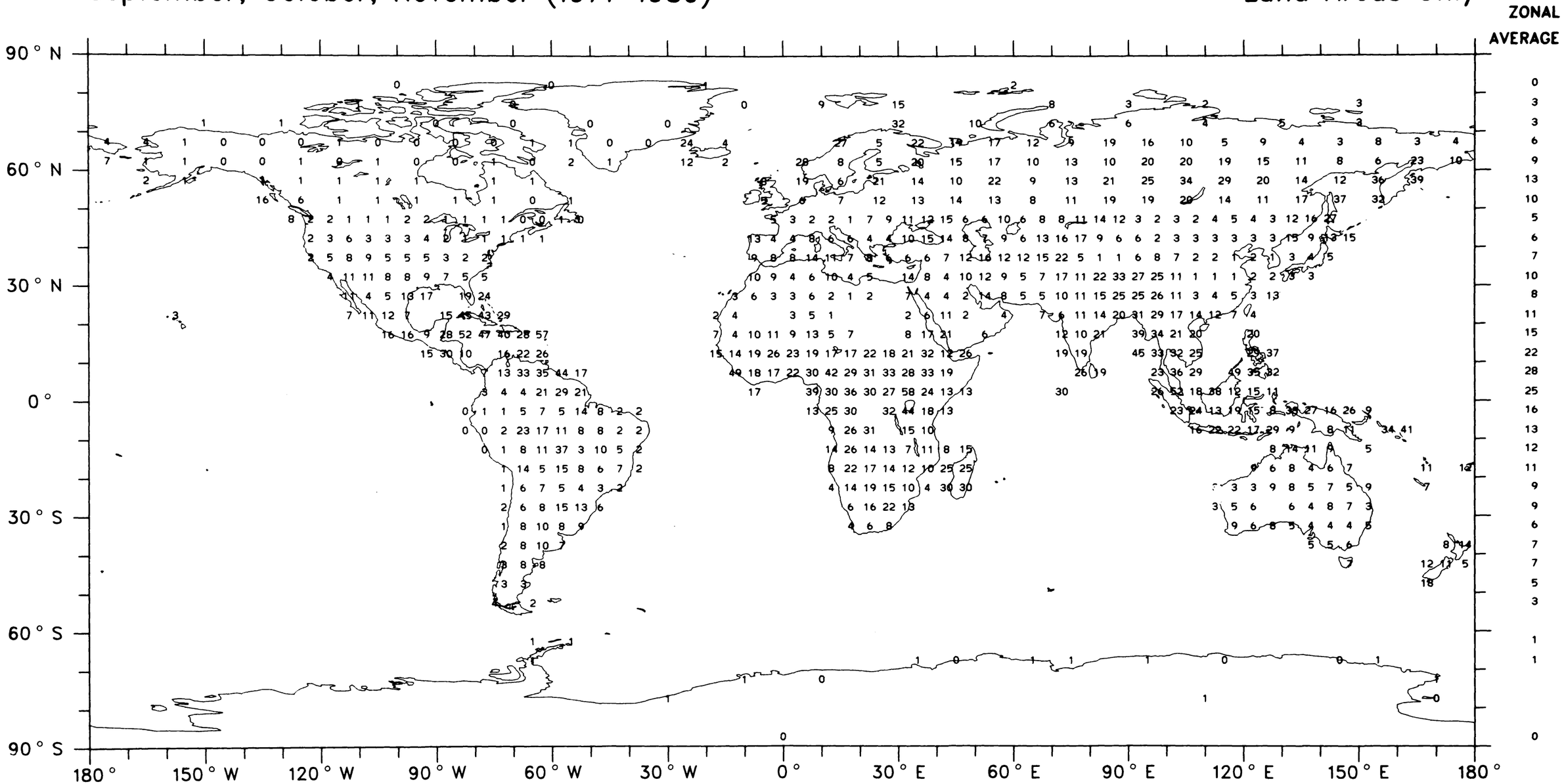


Map IV-40

Given As/Ac, Probability (Percent) That Cumulonimbus is Also Present

September, October, November (1971-1980)

Land Areas Only

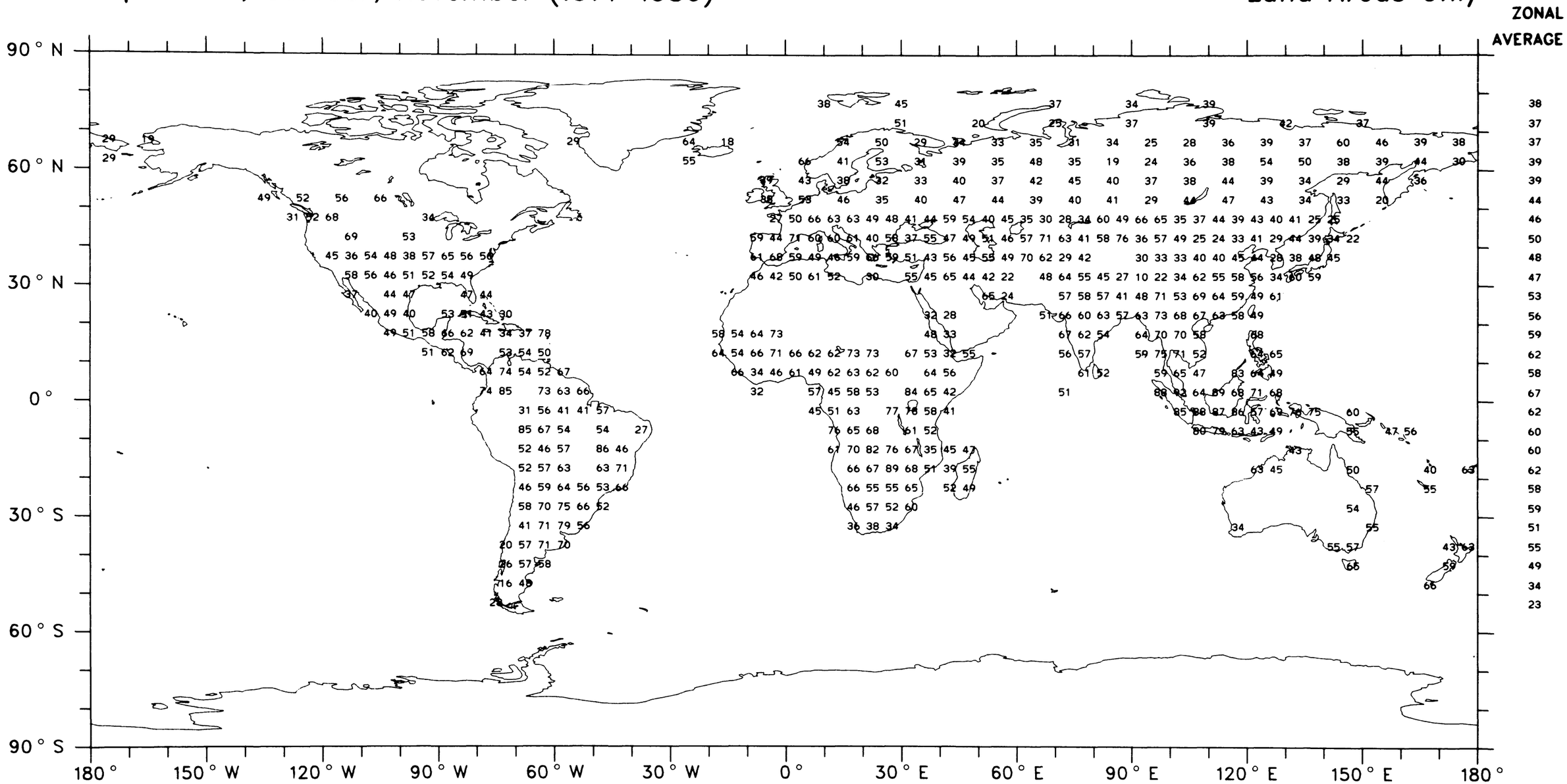


Map IV-41

Given Cumulonimbus, Probability (Percent) That As/Ac is Also Present

September, October, November (1971-1980)

Land Areas Only

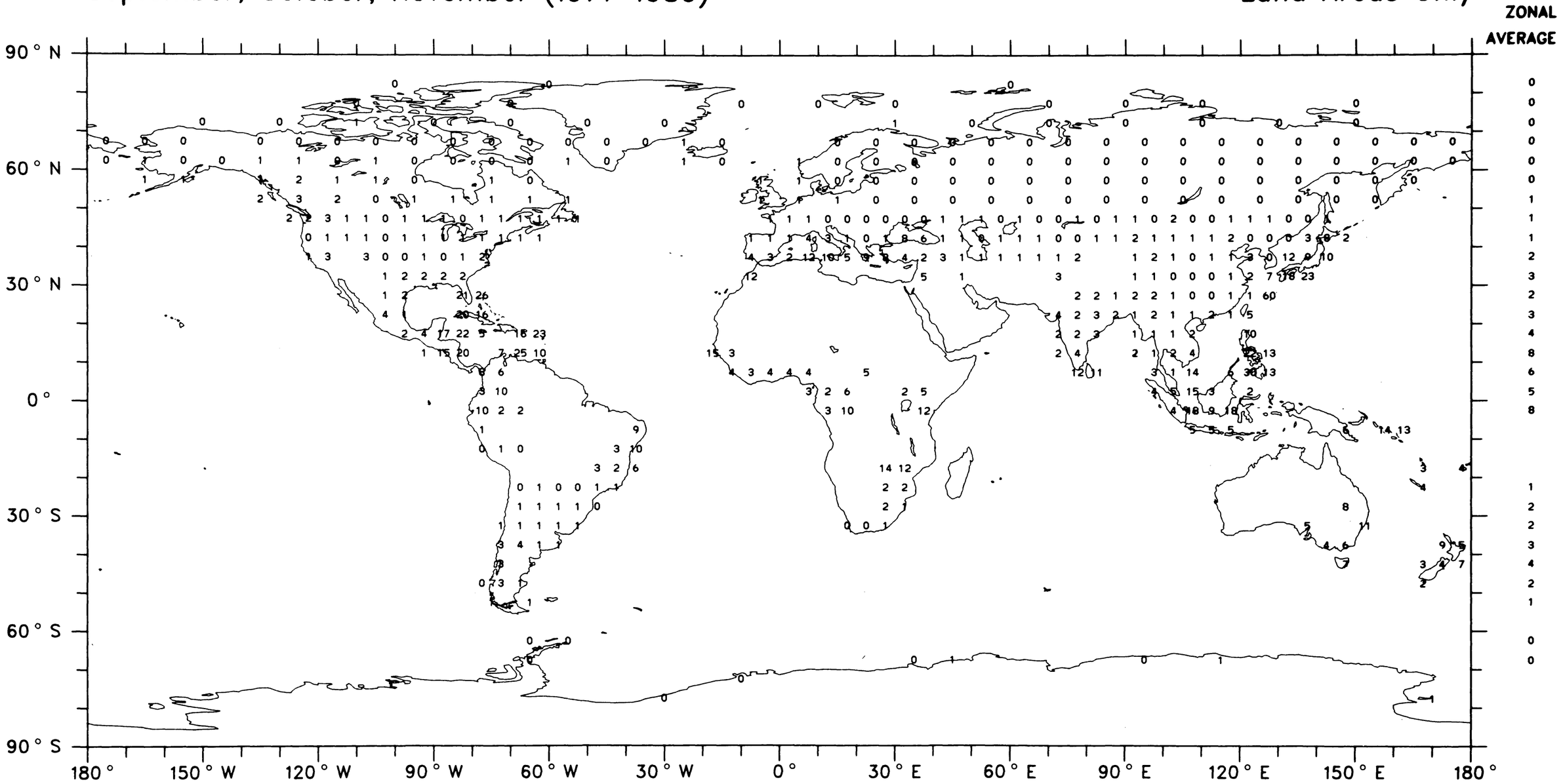


Map IV-42

Given Nimbostratus, Probability (Percent) That Cumulus is Also Present

September, October, November (1971-1980)

Land Areas Only



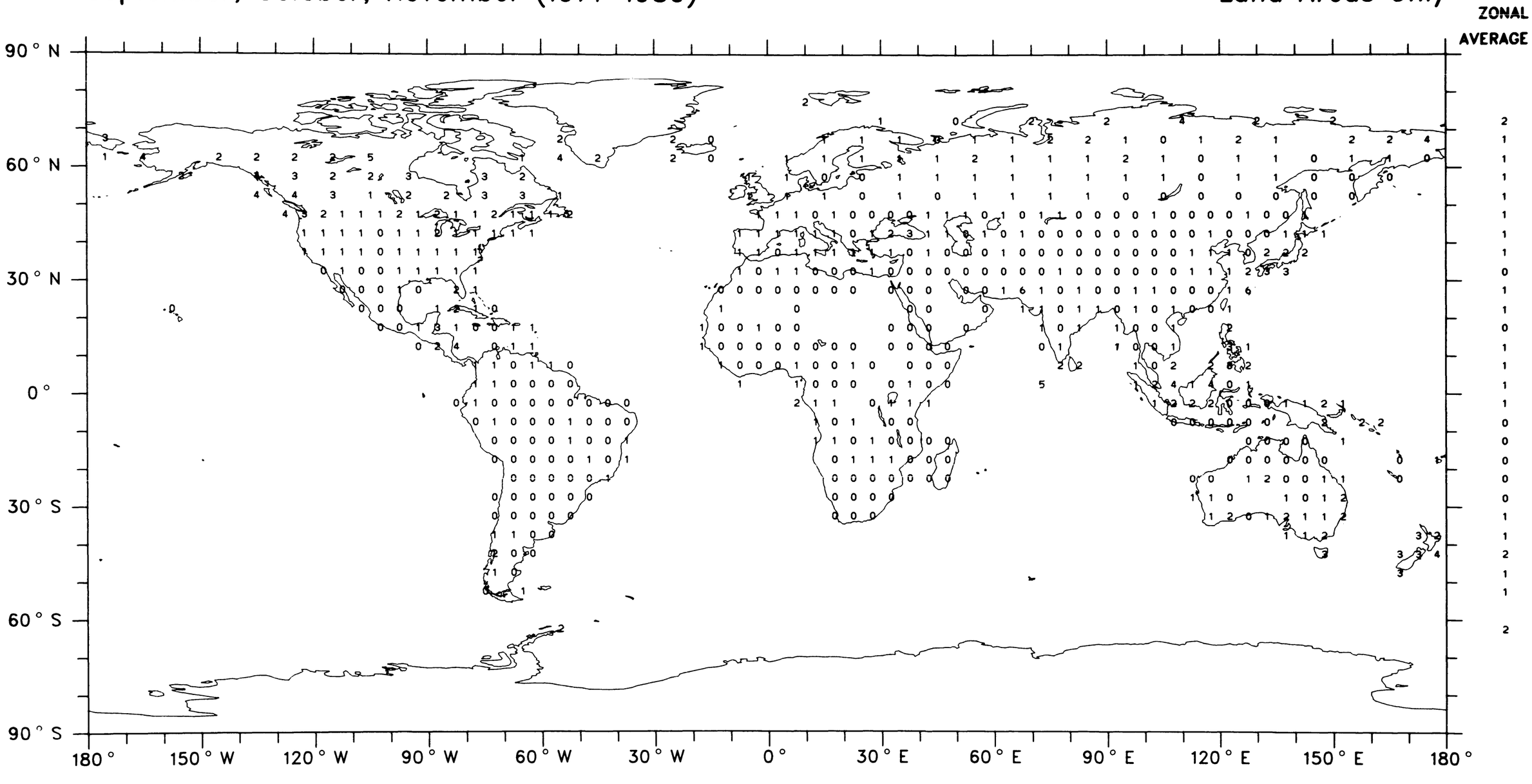
Map IV-43

Map IV-43

Given Cumulus, Probability (Percent) That Nimbostratus is Also Present

September, October, November (1971-1980)

Land Areas Only

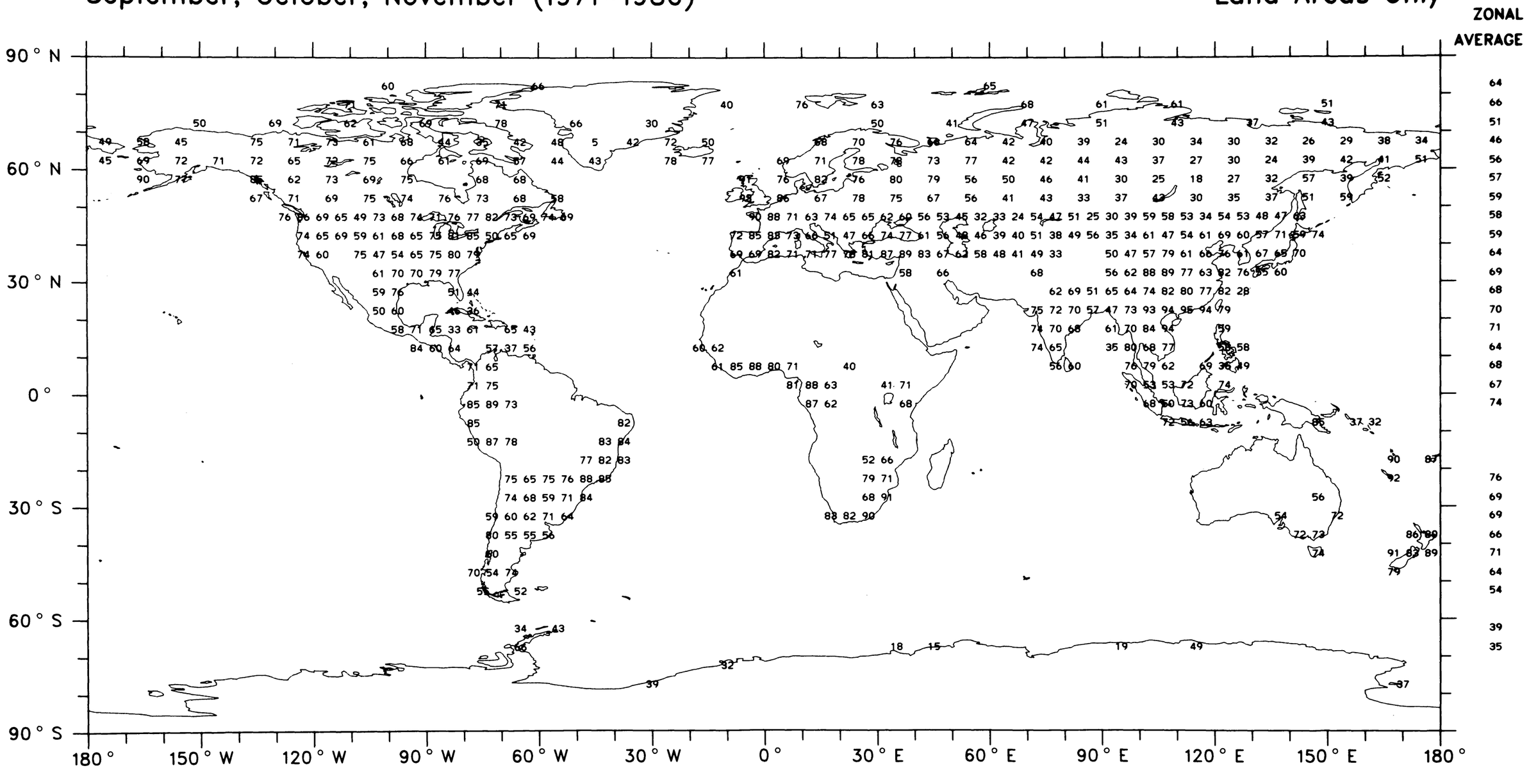


Map IV-44

Given Nimbostratus, Probability (Percent) That St/Sc is Also Present

September, October, November (1971-1980)

Land Areas Only

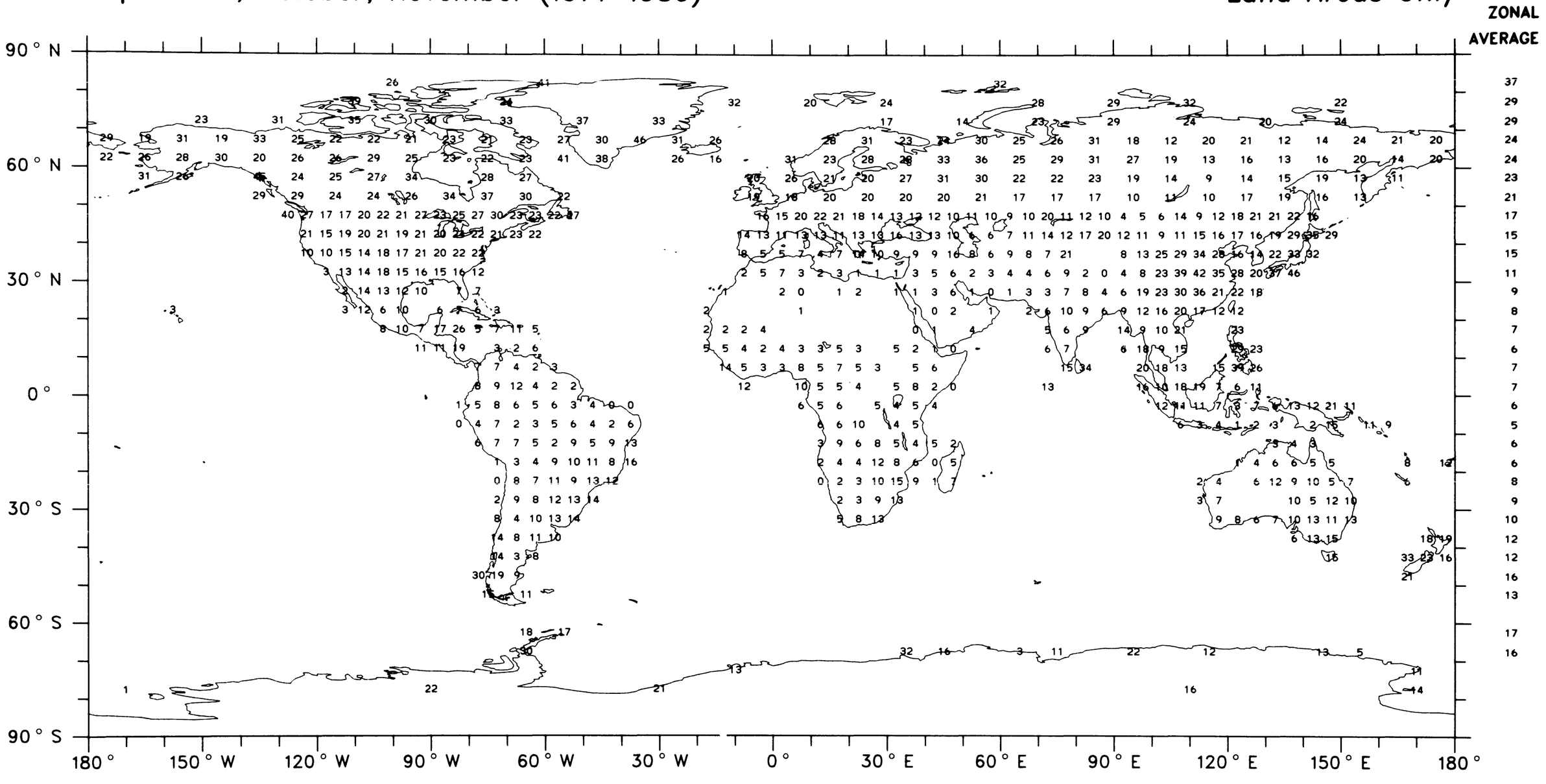


Map IV-45

Given St/Sc, Probability (Percent) That Nimbostratus is Also Present

September, October, November (1971-1980)

Land Areas Only

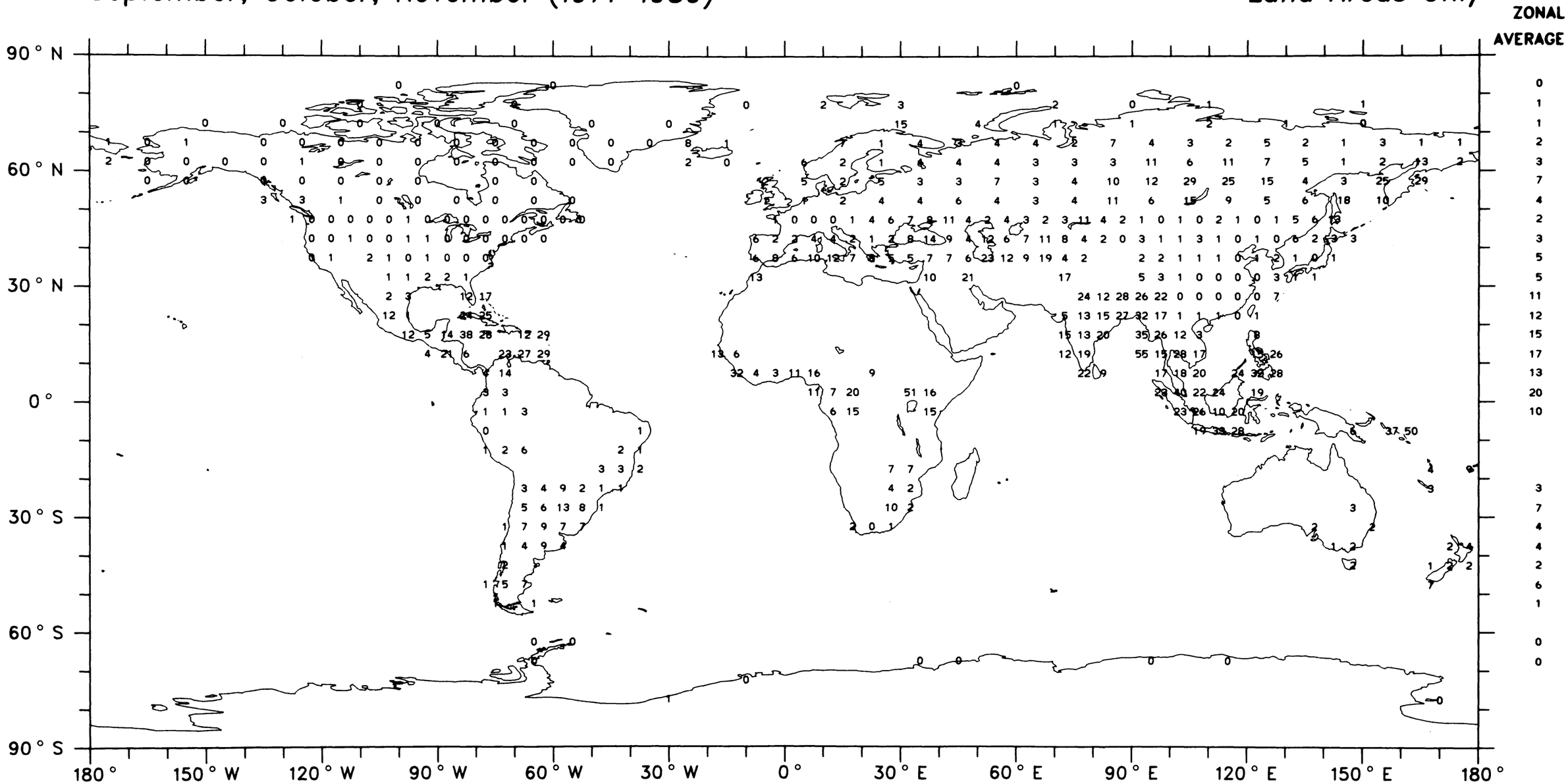


Map IV-46

Given Nimbostratus, Probability (Percent) That Cumulonimbus is Also Present

September, October, November (1971-1980)

Land Areas Only



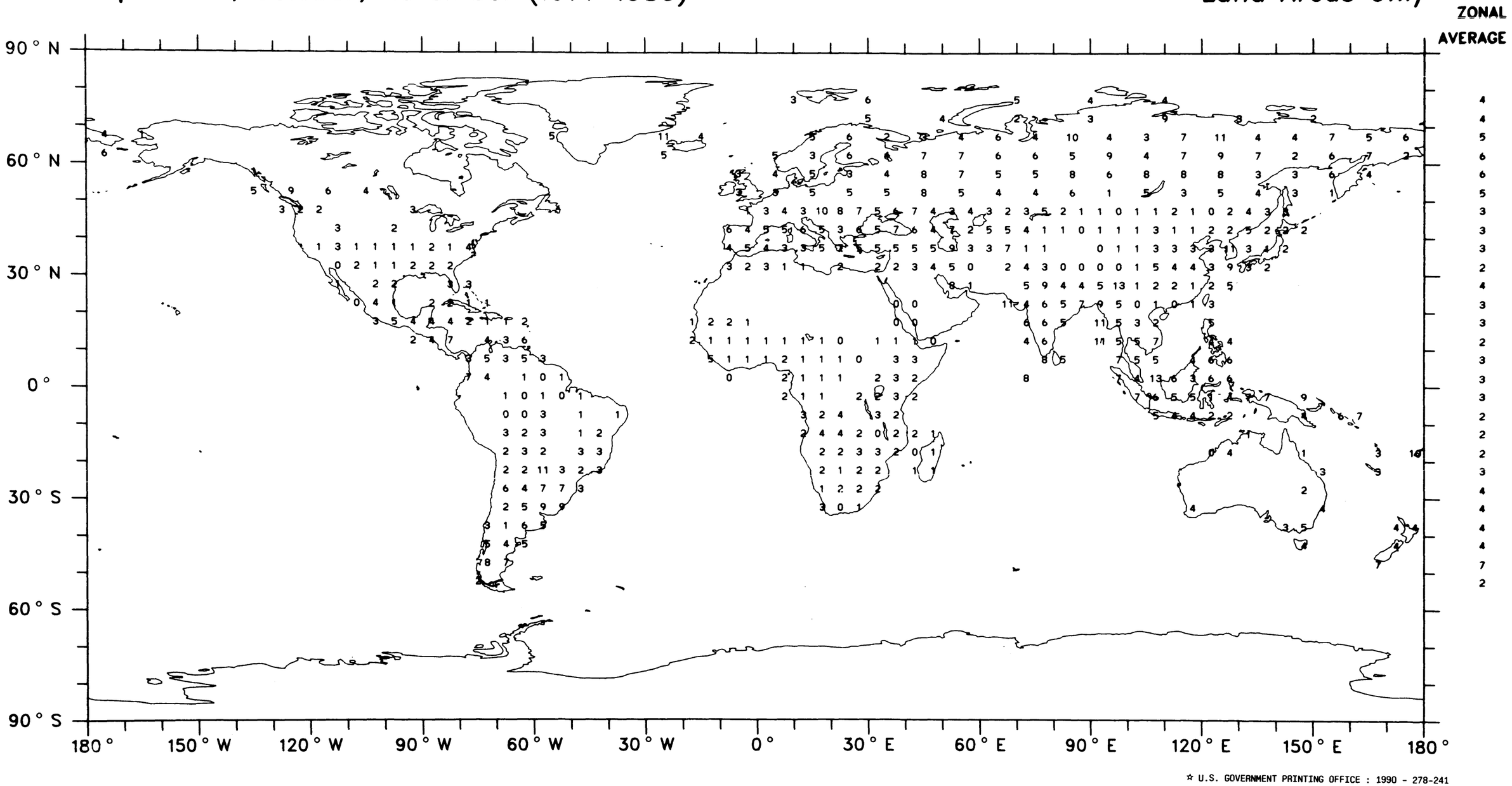
Map IV-47

Map IV-47

Given Cumulonimbus, Probability (Percent) That Nimbostratus is Also Present

September, October, November (1971-1980)

Land Areas Only



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