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DECEMBER 1979

NASA

NASA Reference Publication 1044

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NASA
National Aeronautics
and Space Administration

**Scientific and Technical
Information Branch**

1979

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SUMMARY

A study of upper winds ranging from 100 mb to 25 mb pressure altitude has been performed to define the mission operating altitudes for purposes of high altitude platform design. Four areas of interest have been investigated: the contiguous United States to address the National Aeronautics and Space Administration (NASA)/Wallops Flight Center High Altitude Powered Platform (HAPP) requirements; and the Norwegian area, the Mediterranean area, and the Pacific area from Alaska to Japan with surrounding areas for addressing the Navy's high altitude platform (HI SPOT) concepts. A preliminary study conducted using wind data at Wallops Flight Center established guidelines for this study. The National Oceanic and Atmospheric Administration's (NOAA) National Climatic Center was contracted for quality, site selection and representation of compiled data as specified by the NASA Wallops Flight Center Lighter-Than-Air Program Office.

Sites were selected by the National Climatic Center, based on adequate rawinsonde coverage, geographic dispersion and climate characteristics, to best represent each of the four area's conditions. Several years of rawinsonde data were compiled and presented in the following formats: wind profiles from surface to 10 mb pressure altitude (31 km); and maps of the four geographical areas depicting mean scalar speeds, standard deviation, sample size, and wind roses presenting wind directions and mean speed per direction. In addition, the data were provided in maps unique for design purposes depicting the frequency of wind speeds occurring less than predetermined design speeds of 30, 40, 50, and 75 knots.

The results of this study show that high altitude winds are at a minimum between the altitudes of 18 and 22 km dependent on time of year. For these altitudes, based on a 95 percent statistical occurrence, results show that in the United States annual wind speeds are less than 50 knots with the exception of the winter period; for the winter the winds are less than 50 knots at 86 percent of the sites. The foreign areas studied appear to be more seasonably limited. Wind speeds are less than 50 knots greater than 80 percent of the time during the non-winter months and 45 percent of the time during the winter months. Conditions can be improved with a change in altitude, latitude, or season.

INTRODUCTION

A study has been conducted to characterize upper winds - primarily magnitudes - for use as guidelines in high altitude platform design. This effort addresses the probabilities for flight operation at the potential mission operating altitudes for assumed design speeds on a seasonal basis. NASA/Wallops Flight Center has been investigating the feasibility of a HAPP concept - a long duration, remotely piloted, geostationary platform - with power supplied by microwave transmission. Both heavier-than-air and lighter-than-air concepts exist for use as communication, surveillance, remote sensing, and in situ measurement platforms. Preliminary studies (refs. 1 and 2) have indicated the potential feasibility of the HAPP concept; however, further environmental definition of the winds has been stressed due to the criticalness of power plant and platform design. The dependency upon transmitted power from a ground fixed beam source requires station keeping capabilities, and since the propulsion (power) requirements for stationary operation increase as a cube of the wind velocity, the definition of winds for altitudes of minimum conditions is essential to the success of HAPP concepts. In addition to NASA's HAPP concept requirements the needs for the Navy's high altitude platform (HI SPOT) concept - a long duration, remotely piloted, solar power system - have been addressed at the Navy's request due to their similar dependency on upper winds for design.

NASA's Wallops Flight Center contracted with NOAA's National Climatic Center to provide qualified site selection and to compile and present data in a prescribed method. All available rawinsonde data from these selected sites (from the surface to 10 mb altitude) were compiled and analyzed to characterize the horizontal wind field. The following geographical areas of interest were investigated: the contiguous United States for NASA HAPP activities; and both the European area, including the Norwegian and Mediterranean Seas, and the Pacific area from Alaska to Japan with surrounding areas for the Navy's HI SPOT concepts. The results of this effort are presented here including site selection and its basis, wind profiles for sites, maps detailing various statistical parameters, discussions of the data's validity, and conclusions regarding the expected wind environment for both the NASA and Navy high altitude platform concepts.

APPROACH

Wallops Flight Center conducted a preliminary in-house study to provide detailed information on the upper winds at Wallops Flight Center. The data were provided using a standard winds aloft format (ref. 3) including percentage of winds per direction, percentage of winds per speed group (1-9 knots, 10-19 knots, etc.), and statistical information (mean, std. deviation, etc.) for nine years of daily measurements at established standard altitudes ranging from surface to a pressure altitude of 4 mb. Based upon this

initial effort, the NASA/Wallops Flight Center Lighter-Than-Air Program Office developed a working plan which provided guidelines for a follow-on effort to include the United States and foreign areas of interest. The major components of the study were: site selection, data compilation, presentation, and qualification.

A large coverage was desired; therefore, site selection was of extreme importance as resources limited the number of locations which could be investigated. To this end the study guidelines required sites to be selected based on the upper wind characteristics for the following four geographical areas of interest: the United States (including Alaska); the Pacific area (including the Sea of Japan and Sea of Okhotsk); the Norwegian Sea with immediate surroundings; and the Mediterranean Sea with immediate surroundings. The number of sites selected for each area was dependent only on fulfillment of requirements to represent the upper wind conditions per geographical area. Other possible site selection method alternatives were considered including: selection based on potential use per site; using an array of sites which provides overall high altitude platform coverage per locales of interest; or use of all wind reporting stations. The selection based on potential use per site was not used since these sites have not yet been defined. Using the array format was not acceptable as it would not necessarily represent the desired unique wind condition expectations in a geographical area but might instead provide a number of sites with similar conditions. Using all reporting stations was rejected due to being impractical on a cost and time basis.

Winds aloft summaries, consisting of several years (approximately twenty years dependent on site) of twice daily rawinsonde soundings, were used for the data base. Since the primary purpose of this wind study was to establish the minimum speed operating altitudes and design requirements for high altitude platforms, all maps and profiles were developed to support this; primary interest was placed on wind magnitudes from the surface to 31 km with directional information being only minimally addressed.

To define the potential mission operating altitudes for high altitude vehicles, wind profiles were desired consisting of mean wind speed and expected theoretical standard deviations versus altitude. Based on these wind profiles from surface to 31 km for all selected sites, a definition of the potential operating regime would be established with respect to seasons and further emphasis would be placed on this regime. The remainder of the study would consist of representation of the wind data in map form. Maps, representing the operating regime for the separate areas of interest and providing a breakdown of the annual conditions, would include the following: mean wind speed, wind roses representing directions, and the proportion of occurrences below predetermined operating speeds. The maps would provide contours of constant parameters depicting probable conditions in the areas of interest based on the selected sites. Potential design operating speeds of 30, 40, 50, and 75 knots were selected for parametric analysis of upper wind operating conditions. The analysis provides proportions of historical occurrence of

winds less than the established value (30, 40, 50, and 75 knots) as well as theoretical confidence intervals providing reliability of these proportions. Wind direction data would be presented in the form of wind roses indicating the historical occurrence from each direction and the respective mean speed.

The National Climatic Center, based on their expertise and experience, was contracted to perform this study task as directed by NASA/Wallops Flight Center. The National Climatic Center records and archives data for all meteorological stations including information from the U. S. Weather Service, Navy, Air Force, plus foreign operated sites, and its climatology experience would provide the basis for reliable site selection.

Upon completion of the site selection and data representation by the National Climatic Center, Wallops Flight Center would provide conclusions pertaining to the potential mission operating environment for high altitude platform concepts.

SITE SELECTION

Using the mean scalar wind chart for the winter season, as described in reference 4, the National Climatic Center selected sites based on: (1) adequate sampling of upper winds per site; (2) dispersion of sites throughout the geographical area of interest; and (3) representation of the unique upper winds per geographical area.

TABLE I.-UNITED STATES SITE SELECTION

		Data Period		
Number	Name and Location	Start	Stop	Total Sample (50 mb)
1.	*Albuquerque, NM	1/48	12/71	9704
2.	Bismarck, ND	1/48	8/64	4619
3.	Boothville, LA	8/50	12/71	8056
4.	*Cape Kennedy, FL	2/50	5/70	16424
5.	*Charleston, SC	1/48	12/71	11795
6.	Columbia, MO	1/48	8/64	6567
7.	*Dayton, OH	12/51	12/71	13268
8.	*Denver, CO	10/48	12/69	12636
9.	*Eglin, FL	1/49	5/70	20823
10.	Fort Worth, TX	1/49	9/60	5856
11.	Great Falls, MT	1/48	12/66	7168
12.	*International Falls, MN	1/48	9/72	11211
13.	Lake Charles, LA	1/48	9/72	9297
14.	Miami, FL	1/48	12/71	10007
15.	Medford, OR	1/50	12/70	8633
16.	*Oakland, CA	1/50	12/70	10771
17.	*Omaha, NE	1/48	12/72	11860
18.	*Portland, ME	1/48	9/72	10483
19.	Quillayute, WA	1/50	12/70	9615
20.	Salt Lake City, UT	2/50	10/69	11573
21.	*Spokane, WA	1/50	12/70	11144
22.	*Tucson, AZ	3/56	12/70	10752
23.	*Vandenberg, CA	7/58	5/70	11933
24.	Victoria, TX	7/66	12/71	3680
25.	*Washington, DC	10/60	12/71	13439

* Prime Site

During this selection the National Climatic Center determined that the Norwegian Sea and Mediterranean areas should be combined due to high altitude climatological similarities. For similar reasons Alaskan sites were added to the Pacific area. Data were provided in existing winds aloft summaries; the tables provide a listing of data periods as well as the total recorded sample size for the 50 mb level. Tables I, II, and III provide a listing of all stations selected for the United States, European and Pacific locales respectively. Initially 14 U. S. sites, 15 European sites, and 11 Pacific sites were selected as prime sites. However, during data compilation and map analysis, additional sites were required due to the discontinuity of the data of one or more of the selected prime sites when compared with the overall pattern described by the network of prime sites. The National Climatic Center, based on experience of expected climatological conditions, determined that these discontinuities could result from sampling size, instrumentation, data reduction efforts, or data transmission errors. Supplemental sites in the vicinity of the questionable stations were added to support the analysis. A total of 25 U. S. sites, 21 European sites, and 23 Pacific sites were used in the compilation of the results.

TABLE II.-EUROPEAN SITE SELECTION

		Data Period		
Number	Name and Location	Start	Stop	Total Sample (50 mb)
1.	Apeppo, Syria	7/57	6/67	396
2.	*Alger, Algeria	1/49	8/67	904
3.	*Bet Dagan, Israel	2/56	2/67	653
4.	*Brindisi, Italy	1/64	2/71	5216
5.	Chaumont, France	7/53	8/59	3306
6.	*Essen, Germany	7/65	10/71	3341
7.	Iraklion, Greece	1/64	12/72	3656
8.	*Izmir, Turkey	1/61	12/67	136
9.	Jan Mayen, Norway	1/64	12/72	3656
10.	*Jokioinen, Finland	1/49	11/63	2554
11.	*Keflavik, Iceland	10/51	9/61	8942
12.	*Kobenhavn, Denmark	.0/49	10/71	6110
13.	Lvov, USSR	2/47	9/67	1122
14.	*Matruh, Egypt	2/55	6/66	68
15.	*Milano, Italy	7/57	2/71	5866
16.	Nicosia, Cyprus	1/56	12/67	1252
17.	*Odessa, USSR	12/46	9/67	1228
18.	*Thorshavn, Faeroe Islands	11/49	10/71	2432
19.	*Tripoli, Libya	4/49	7/63	6516
20.	*Valentia, Ireland	1/60	10/71	1345
21.	*Yerevan, USSR	2/49	12/67	414

* Prime Site

TABLE III.-PACIFIC SITE SELECTION

Number	Name and Location	Data Period		Total Sample (50 mb)
		Start	Stop	
1.	Adak, Alaska	1/46	2/64	3581
2.	Akita, Japan	1/56	12/65	4794
3.	*Aleksandrovsk, USSR	9/51	12/65	371
4.	*Anchorage, Alaska	1/48	10/72	11200
5.	*Ayan, USSR	8/50	12/65	126
6.	Barrow, Alaska	1/62	12/66	2192
7.	Barter, Alaska	1/68	12/72	2194
8.	Buhta Ugolnaja, USSR	4/55	12/65	None
9.	Fairbanks, Alaska	1/48	6/70	9713
10.	Kodiak, Alaska	1/46	8/62	4335
11.	*Korf, USSR	1/52	12/65	1141
12.	Mosulpo, Korea	7/54	12/70	7855
13.	*Mys Vasilyeva, USSR	7/53	12/65	30
14.	Nagayevo, USSR	3/50	12/65	278
15.	Nikol Skoye, USSR	8/57	12/65	429
16.	*Nome, Alaska	1/48	4/69	8766
17.	*Osan, Korea	10/50	12/70	17230
18.	*Sapporo, Japan	1/56	12/65	4846
19.	*Shemya, Alaska	6/46	2/64	3821
20.	Shionomisaki, Japan	1/56	12/65	4986
21.	*Vladivostok, USSR	10/46	6/71	3024
22.	Wakkanai, Japan	1/56	12/65	4399
23.	*Wajima, Japan	1/56	12/65	4711

* Prime Site

DATA PRESENTATION

The data are presented in three separate parts: Section A (beginning on page 17) presents the U. S. area; Section B (page 144) presents the European area; and Section C (page 216) presents the Pacific area. Each section consists of the following identical subsets: (1) wind profiles - selected prime sites only; (2) sample count ("N" count on maps); (3) mean speed and standard deviation (maps with constant mean speed contours); (4) wind roses (maps indicating speed and direction); (5) proportion of winds < 30 knots (maps with constant percentage contours); (6) proportions < 40 knots; (7) proportions < 50 knots; and (8) proportions < 75 knots.

The study is presented in a seasonal format such that December, January, and February are presented by winter; March, April, and May are represented by spring; etc. Wind profiles (subsets A-1, B-1, and C-1) - provided for the prime sites only - present the mean speed, the mean speed plus and minus one standard deviation, the 95 percentile, and the 99 percentile at all standard pressure altitude levels recorded from surface to 10 mb. The Appendix is provided as easy reference for conversion of the standard pressure level to geopotential altitude in meters and feet. Foreign sites contained a fewer number of data levels due to differences in data collection procedures. The parameters, based on the assumption that the data is normally distributed, were computed as follows:

mean speed: $$\bar{V} = \left[\frac{\Sigma V}{n} \right]_{\text{LEVEL}}$$

standard deviation:
(for mean speed $\pm$ 1 σ) $$\sigma = \left[\sqrt{\frac{\Sigma (V-\bar{V})^2}{n-1}} \right]_{\text{LEVEL}}$$

95 percentile: $$95 \text{ percent value} = (\bar{V} + 1.645\ \sigma)_{\text{LEVEL}}$$

99 percentile: $$99 \text{ percent value} = (\bar{V} + 2.326\ \sigma)_{\text{LEVEL}}$$

where:

$\bar{V}$ = mean speed (= V in profiles).
n = sample size (= N in profiles).
σ = standard deviation (= S in profiles).

The profiles may be interpreted as describing the number of occurrences of wind magnitudes less than the established percent contour. For example, theoretically 99 percent of all recorded wind values are less than the values indicated on the 99 percentile profile. In addition, empirical 84.13 percent values (shown as asterisks on profiles) calculated from the recorded data in the wind summaries are presented in the pressure altitude regime 100 to 25 mb. The wind summaries used contained percent of occurrence for the following speed classes: 1-9 knots, 10-19 knots, 20-29 knots. 30-39 knots, 40-49 knots, 50-59 knots, 60-74 knots, 75-99 knots, 100-149 knots, 150-199 knots, and $\geq$ 200 knots. The empirical 84.13 percent values were computed by summing the percent values in these speed class intervals and interpolating for 84.13 percent if required. Since in theory $\bar{V} + \sigma$ = 84.13 percent, the normality assumption can be validated by comparing the empirical 84.13 percent values with the mean speed plus 1 σ profile. NASA selected the regime from 100 to 25 mb pressure altitude to be closely examined as a result of the indicated lull in winds shown on the profiles. Eight altitude levels - 100, 80, 70, 60, 50, 40, 30, and 25 mb - were used for the United States; foreign sites included the levels of 100, 70, 50, and 30 mb because of differences in established record keeping procedures.

All maps provide information for a particular locale (U. S., Europe, Pacific) for one season and one altitude. The first maps of each section (subsets A-2, B-2, and C-2) contain sample count values for all selected sites. The sample counts in many cases support the need for the additional sites (indicated by smaller characters on the maps) to supplement the prime sites. The next series of maps (subsets A-3, B-3, and C-3)

characterize the mean speed for each area. Isotachs (contours of constant speed) were constructed by using the site to site values and interpolating between sites where necessary. As the study progressed support sites were added as required because of the discontinuity of some prime site data to other prime site data; the contours do not reflect the discontinuous data. The contours provide a geographic breakdown for each map of the conditions to be expected. Contours for standard deviation are not presented; however, the computed standard deviation is indicated below the mean value for each site. Maps containing 16 point wind roses for the prime sites indicate percent occurrence per direction and the mean speed for that direction. These maps are located in subset 4 of sections A, B, and C. The length of the line indicates the percentage of historical occurrence of the direction the winds came from; and the numerical values associated with each of the 16 compass points indicate the mean speed of occurrences for only that direction.

The remainder of the maps (subsets 5, 6, 7, and 8) for each section provide contours of constant proportions (presented as percentages) of wind magnitudes less than predetermined values. The proportions were based on actual occurrence of wind magnitudes less than 30, 40, 50 and 75 knots. These values were selected by Wallops Flight Center to best represent an envelope of possible operating speed for the high altitude platform concepts. Values less than 30 knots (10 and 20 knots) were not used since proportions would be extremely low and non-representative for high altitude vehicle design. Values greater than 75 knots were not selected since design speeds of that order were deemed unrealistic. Confidence intervals of 95 percent and 99 percent for the proportions were computed based on the assumption of a normal data distribution. These confidence intervals provide a measure of estimating how accurate the sample proportion is to the true proportion. Assuming a normal distribution of data, these intervals were calculated as follows:

confidence interval: $$P_a = \pm Z_a \sqrt{\frac{p(1-p)}{n}}$$

where $Z_a = 1.96$ for 95%; $Z_a = 2.58$ for 99 percent.

P_a = theoretical true proportion.

p = observed proportion.

n = sample size.

These intervals are interpreted such that:

$$p - Z_a \sqrt{\frac{p(1-p)}{n}} < P_a < p + Z_a \sqrt{\frac{p(1-p)}{n}}$$

In words, a confidence interval is a statistical measure of the true proportion based on: (1) normal distribution, (2) sample size, and (3) observed proportion.

To simplify interpretation of these maps, only contours of constant theoretical proportion were prepared. The plus/minus values for the 95 percent and 99 percent confidence intervals are tabulated on the maps below the associated observed proportions for each site.

QUALIFICATION OF DATA

Areas of immediate concern are assumption of normality, validity of represented data, and quality of rawinsonde techniques. As previously reported, theoretical and actual observed values for mean speed plus one standard deviation (84.13 percent) were compared to provide a measure of the validity of the normality assumption. In addition, theoretical 95 percent and 99 percent values have been compared to the actual 95 percent and 99 percent values. Results of the comparisons are: (1) approximately 10 percent difference (average value) between the theoretical and actual values for the 95 percent profiles; and (2) approximately 35 percent difference between theoretical and actual profiles in the extremes (99 percent). In most cases the actual values were greater than the theoretical values. Contributing factors to the deviations observed are: (1) few wind magnitudes recorded at extremes; (2) large recording intervals of data (10 knot intervals - 0 to 60 knots, 50 knot intervals - 100 to 200 knots); and (3) linear interpolation of the actual 84.13 percent, 95 percent, and 99 percent values. For example, at Albuquerque, New Mexico (50 mb pressure altitude level-winter season), based on the mean speed and standard deviation the 84.13 percent, 95 percent, and 99 percent values are 26.4, 33, and 40 knots, respectively. However, the values as determined by linearly interpolating the recorded data are 25.6, 37, and 58 knots for 84.13, 95, and 99 percent, respectively. In some cases these deviations can be theoretically justified by relating the sample count to the comparison. Questionable site data were qualified in this study by the addition of sites in the general vicinity of the site in question.

Other available formats of wind data exist which include: the serially complete data, which includes basic rawinsonde data as presented in this study but completed by the theoretical addition of missing samples; and grid point data, which is map form, computer enhanced rawinsonde data presented in an array format using latitude and longitude as coordinates. However, since this study was conducted on a seasonal and not a daily basis, it was felt that the basic rawinsonde data would be adequate.

The quality of rawinsonde data has been questioned and reviewed. The National Climatic Center indicates that problems existing with basic rawinsonde data are: (1) missing data; (2) addition of standard pressure levels (different sample sizes); and (3) accuracy of the ground meteorological detector (GMD) measurement system. Missing

data results from: (1) transmission problems from rawinsonde to GMD; (2) transmission problems from site to record center; (3) failure in rawinsonde; and (4) rawinsonde forced out of the GMD receiving range. The addition of standard pressure levels results in a discontinuity of data resulting from sample size. The 70 mb pressure altitude level was added as a standard recording level several years after the others had been established. A slight discontinuity due to sample size is reflected on some profiles presented in this report. Independent tests (refs. 5 and 6) have been conducted comparing GMD measurements to radar trackings. These tests show that wind speeds obtained using the GMD are slower on the average by 2-4 knots than radar outside the jet stream region.

CONCLUSIONS

Analysis of this data has been performed to determine the wind environmental impact upon the design of the high altitude platforms. Seasonal and altitude variations have been analyzed. The results for all areas will be presented as follows: (1) geographical area coverage; (2) site operation; (3) maximum and minimum wind speeds (for seasonal operation); (4) average wind speeds; and (5) the operating altitude regime. These conclusions only address the wind magnitudes; the maps with wind roses, located in subset 4 of sections A, B, and C, provide direction data for informational purposes only.

The conclusions concerning site operation and maximum and minimum wind speeds (2 and 3 above) are presented as an alternate method of analyzing the rawinsonde data to determine the potential for operating at mission altitudes; these conclusions were determined from direct analysis of the prime site wind summaries. However, sites added to support questionable prime sites are not reflected in these conclusions. Therefore, the percent of platform operation based on geographical area is better since the questionable prime site data was omitted in the contours as justified by the added support sites. In the United States, platform operation based on 100 percent of site operation is similar to the platform operation based on 100 percent geographical area since the added sites verified the questionable prime sites. However, as seen in the following conclusions, the foreign areas do not reflect this agreement between percent of operation based on geographical area and the percent of prime site operation due to the support sites substantiating the discontinuity.

Geographical Area Coverage

The percent of platform operation (time) for 100 percent geographical area coverage has been determined using the maps (subsets 5, 6, 7, and 8) of proportions of winds less than 30, 40, 50, and 75 knots for the pressure altitude levels 100 to 25 mb. These maps

were analyzed per season and geographical area, and the altitude of minimum wind conditions was determined; at this altitude the proportion contour with the lowest value (worst case) which described any part of the geographical area (United States, etc.) of interest was used as the basis for the conclusions regarding the percent of operation for 100 percent geographical area coverage.

In cases where the contour fully describes the worst case for the altitude of minimum wind conditions, the value of that contour was recorded. However, in cases where a sizable portion of geographical area extends beyond this contour the particular situation was assessed based on the presented wind conditions. These results are presented in Table IV. The altitudes of minimum wind conditions will be discussed in a separate section.

Significant findings for mission altitude operation are:

United States:

- 98 percent (or higher) non-winter operation; 85 percent winter operation for a design speed of 50 knots.
- 95 percent non-winter operation; 75 percent winter operation for a design speed of 40 knots.

European Area:

- 85 percent (or higher) non-winter operation; 45 percent winter operation for a design speed of 50 knots (Norwegian Sea area).
- 95 percent (or higher) non-winter operation; 80 percent winter operation for a design speed of 50 knots (Mediterranean Sea area).

TABLE IV.-PERCENT OF OPERATION FOR 100% GEOGRAPHICAL AREA COVERAGE

Design Speed	Season	Percent of Time Per Area				
		U.S.	Norwegian Sea	Mediterranean Sea	Sea of Japan	Sea of Okhotsk
30 knots	Winter	60	20	50	30	10
	Spring	90	60	80	80	80
	Summer	98	90	85	95	98
	Fall	90	55	80	70	50
40 knots	Winter	75	30	70	50	40
	Spring	95	70	90	90	90
	Summer	99.6	95	95	98	98
	Fall	95	75	90	70	70
50 knots	Winter	85	45	80	70	60
	Spring	98	85	95	90	95
	Summer	99.6	98	98	99	99
	Fall	98	90	95	90	80
75 knots	Winter	95	90	98	90	90
	Spring	99.5	95	99	98	98
	Summer	99.7	99	99	99	99
	Fall	99.5	98	99	99	99

Pacific Area:

- 90 percent (or higher) non-winter operation; 70 percent winter operation for a design speed of 50 knots (Sea of Japan area).
- 80 percent (or higher) non-winter operation; 60 percent winter operation for a design speed of 50 knots (Sea of Okhotsk area).

Table V presents the percent of platform operation at design speed of 30 and 50 knots for a percent of geographical area in the United States. These conclusions were obtained by examining the proportion maps (only subsets 5 and 7 of Section A) as done for the preceding conclusions regarding 100 percent geographical area but measuring the percent of geographical area for various percents of operation.

TABLE V.-PERCENT OF OPERATION FOR PERCENT OF U.S. AREA COVERAGE

Design Speed	Season	Approximate Percent of Geographical Area	Percent of Time
30 knots	Winter	80	70
		50	80
		20	90
	Spring	65	95
		10	97.5
	Summer	90	98.5
		80	99.5
	Fall	75	95
		20	97.5
50 knots	Winter	99	85
		80	90
		55	95
		35	97.5
	Spring	99	98
		65	99
	Summer	45	100
	Fall	99	98
		75	99
		35	99.5

Site Operation

All of the selected prime sites were used to determine the percent of annual site operation per geographical area. Significant findings, based on a 95 percent theoretical occurrence, are as follows:

United States:

- 100 percent non-winter operation; 86 percent winter operation for a design speed of 50 knots.
- 100 percent non-winter operation; 43 percent winter operation for a design speed of 40 knots.

European Area:

- 100 percent non-winter operation; 85 percent winter operation for a design speed of 80 knots.

Pacific Area:

- 100 percent non-winter operation; 80 percent winter operation for a design speed of 75 knots.

Based on a 99 percent theoretical occurrence a design speed of 55 knots would provide 100 percent non-winter operation and 50 percent winter operation for the United States. As mentioned this data does reflect the discontinuities particularly in foreign areas and therefore should not be considered as representative as the area coverage results.

Maximum and Minimum Wind Speeds

All of the prime sites used in the United States, European area, and the Pacific area have been analyzed at all potential mission operating altitudes to determine the maximum and minimum 95 percentile wind speeds (plus 99 percentile for the U. S.) at the altitude of the minimum wind conditions per season. The maximum and minimum values represent the range of the sites with the largest value to the smallest value per geographical area. These results reflect all prime site data including those sites determined to be discontinuous; therefore, the maximums indicated - especially in the foreign areas - are higher than the more realistic values provided by the analyzed maps (Table IV). Table VI provides this seasonal maximum and minimum information.

TABLE VI.-PRIME SITE MAXIMUM AND MINIMUM WIND SPEEDS FOR MINIMUM WIND SPEED ALTITUDE

Season	United States				Pacific Area		European Area	
	95 *		99 *		95 *		95 *	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Winter	66	30	81	34	86	50	94	38
Spring	34	21	42	26	45	20	68	25
Summer	32	14	37	17	32	15	68	14
Fall	35	21	42	25	72	26	76	23
Annual	66	30	81	34	86	50	94	38

* Refers to theoretical occurrences.

Average Wind Speeds

The maps of mean speeds - subset 3 of Sections A, B, and C - were used to determine the seasonal maximum averages per 100 percent geographical area. These values were determined by surveying the maps for the altitude of minimum winds per season; the contour with the highest value (worst case) which described any part of the geographical

area was recorded. However, in cases where a sizable portion of geographical area extends beyond this contour, the situation was assessed based on the presented conditions. Table VII provides a complete seasonal and area breakdown.

TABLE VII.-AVERAGE WIND SPEEDS (MAXIMUM PER AREA)

Season	United States	Pacific Area (Total)	Norwegian Sea	Mediterranean Sea
Winter	30	50	45	30
Spring	15	20	30	15
Summer	25	15	15	20
Fall	15	30	30	20

Operating Altitude Regime

The minimum wind speed altitude per site is dependent on its geographic location. The altitudes indicated below represent a majority of the sites per geographical area; however, at some locations a higher altitude (30 mb pressure altitude level) for non-summer applications or a lower (100 mb pressure altitude level) for summer applications will provide a small improvement for the wind speed conditions. As seen by the wind profiles, the minimum wind altitudes vary from site to site and season to season; in general, the range of the minimum wind altitudes involves more than one pressure altitude level. A change in latitude will also improve conditions. For example, minimum conditions for the United States change such that the low latitude provides minimum winds in the winter and the high latitude provides minimum winds in the summer. In general, the wind speed altitudes are as follows:

- 40 mb to 50 mb (21 km to 22 km) for non-summer applications.
- 60 mb to 80 mb (18 km to 19 km) for summer applications.

This study has presented an analysis of the upper air winds to provide probabilities for high altitude platform operation at mission altitudes on a seasonal basis. This effort has therefore only addressed the long term overall sizing issue and not the finer definition of the wind structure needed for answering the mission operating issues. A follow-on effort would be to define the operating scenarios from the surface to mission operating altitudes. This effort should take into consideration the deployment and retrieval requirements (launch, ascent, recovery) as well as the short term finer effects of the winds on the on-station requirements for HAPP operation. The previously mentioned serially complete and grid data could be used since the scenarios would require a finer analysis of the winds with respect to short periods of time (days/hours as compared to seasons). In addition to the operational issues, the follow-on effort would provide data for support of the wind study presented in this report, and together would provide the total wind environment influencing high altitude platform operation.

APPENDIX

STANDARD ALTITUDES

Pressure (Millibars)	Geopotential (Meters)	(Feet)
SFC	0	0
1000	111	364
950	540	1773
900	988	3243
850	1457	4781
800	1949	6394
750	2466	8091
700	3012	9882
650	3590	11780
600	4207	13801
550	4865	15962
500	5574	18289
450	6344	20812
400	7185	23574
350	8117	26631
300	9164	30065
250	10363	33999
200	11784	38662
175	12631	41440
150	13608	44647
125	14675	48440
100	16180	53083
80	17595	57726
70	18442	60504
60	19437	63711
50	20576	67507
40	22000	72177
30	23849	78244
25	25029	82115
20	26481	86881
15	28368	92071
10	31055	101885

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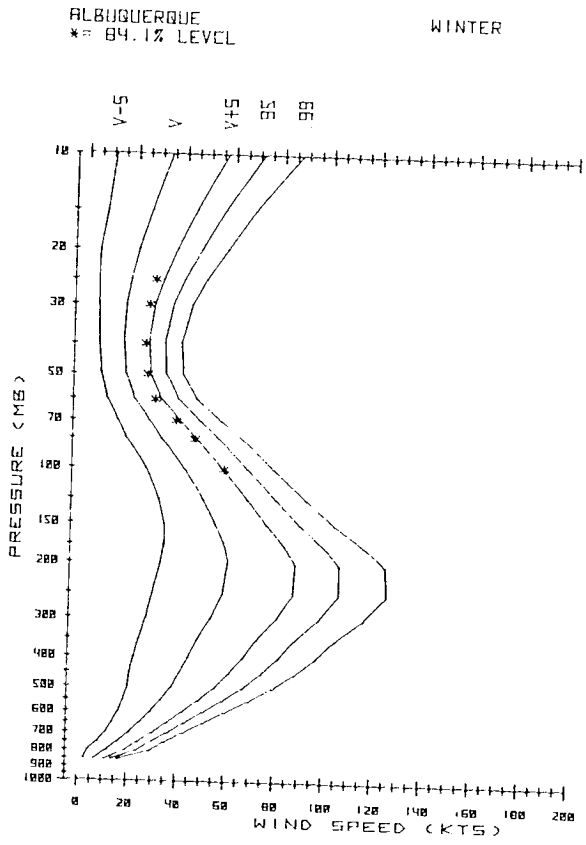
SECTION A

UNITED STATES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V
V+S
SS
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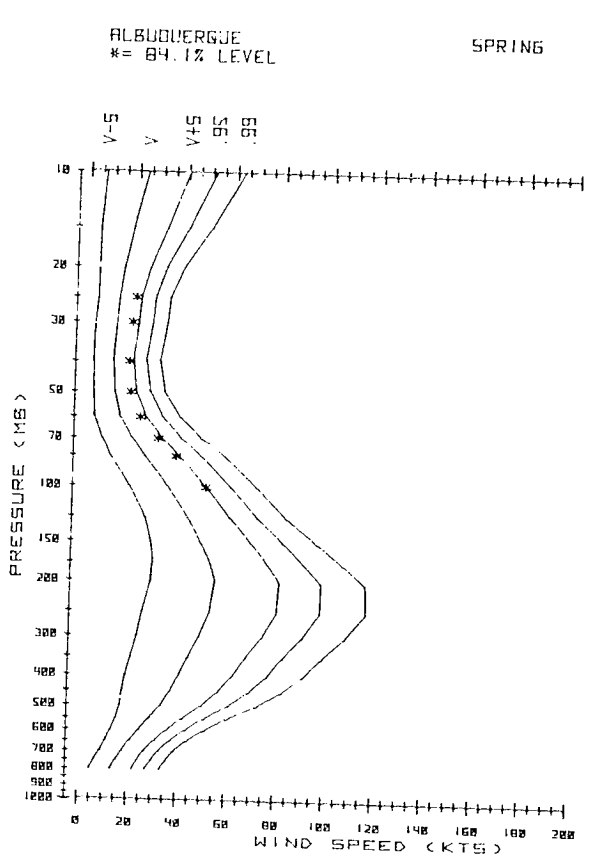
WIND SPEED (KTS)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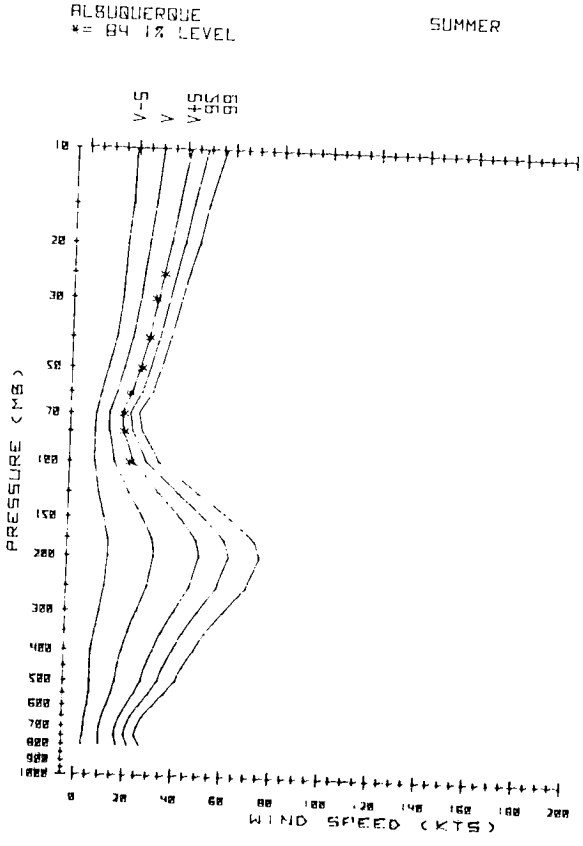
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V
V+S
SS
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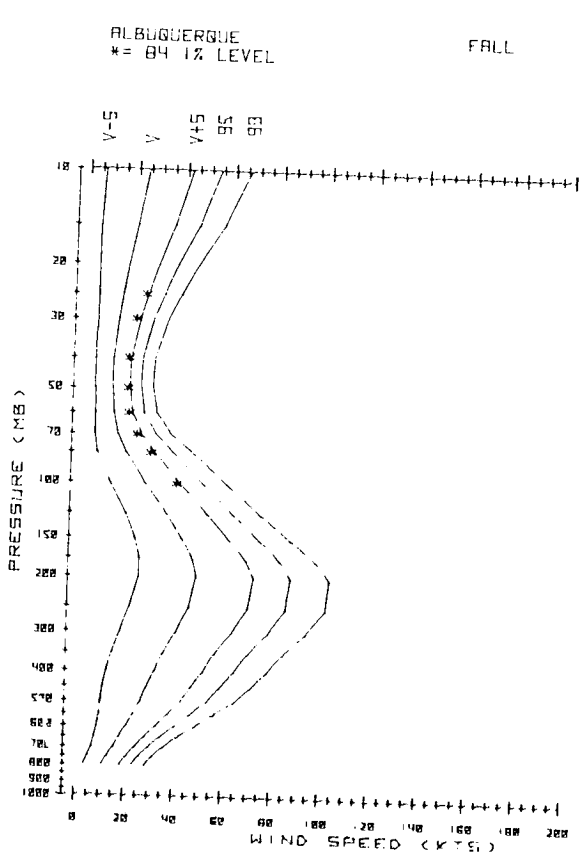
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V-S
V
V+S
SS
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PRESSURE (MB)
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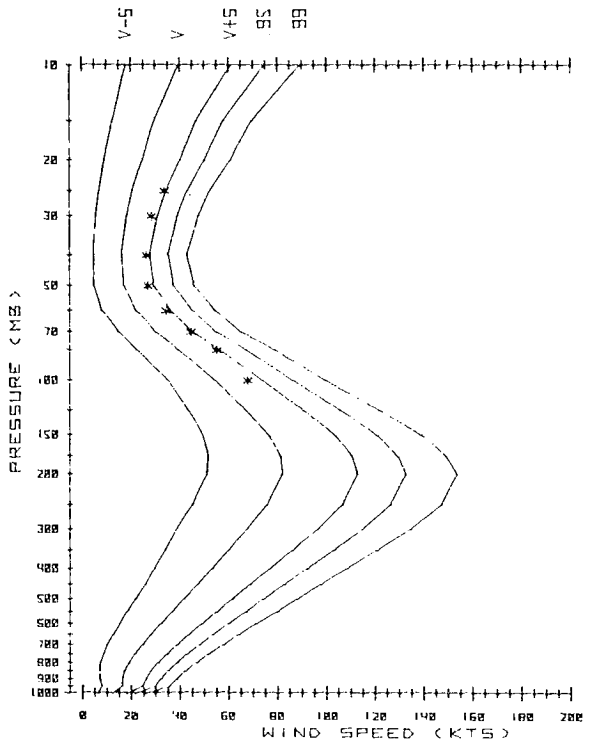

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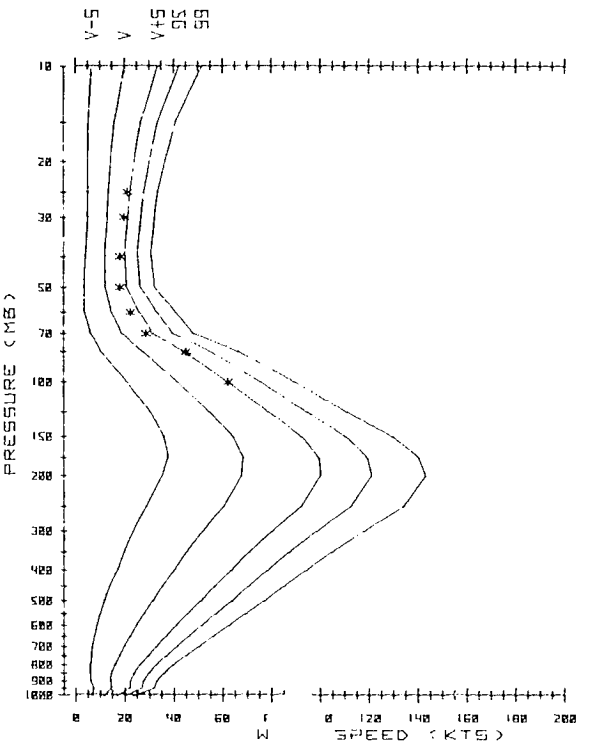

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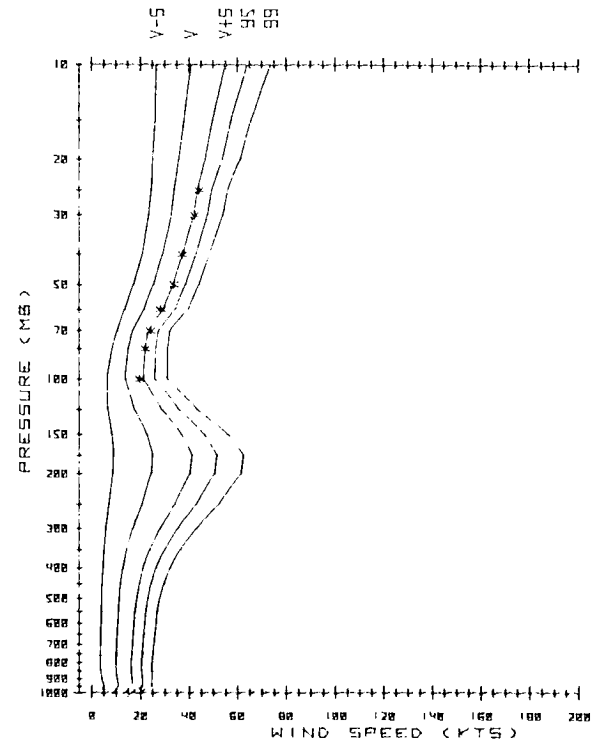

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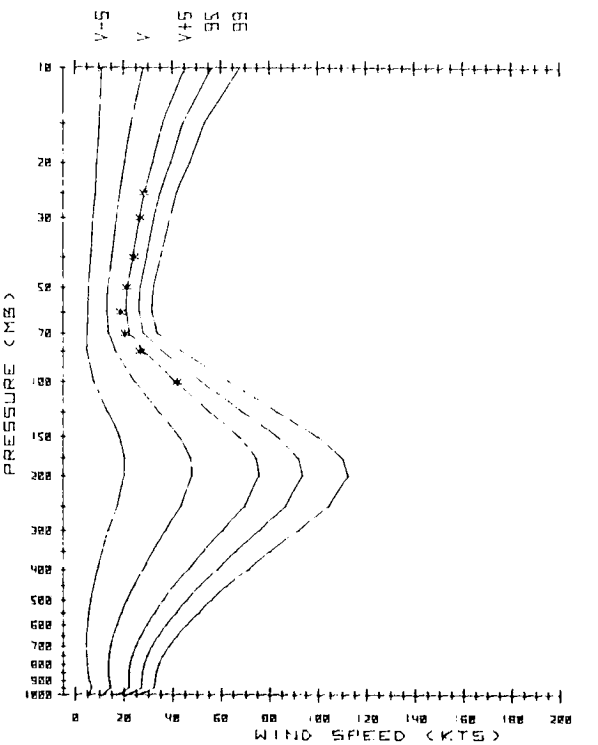

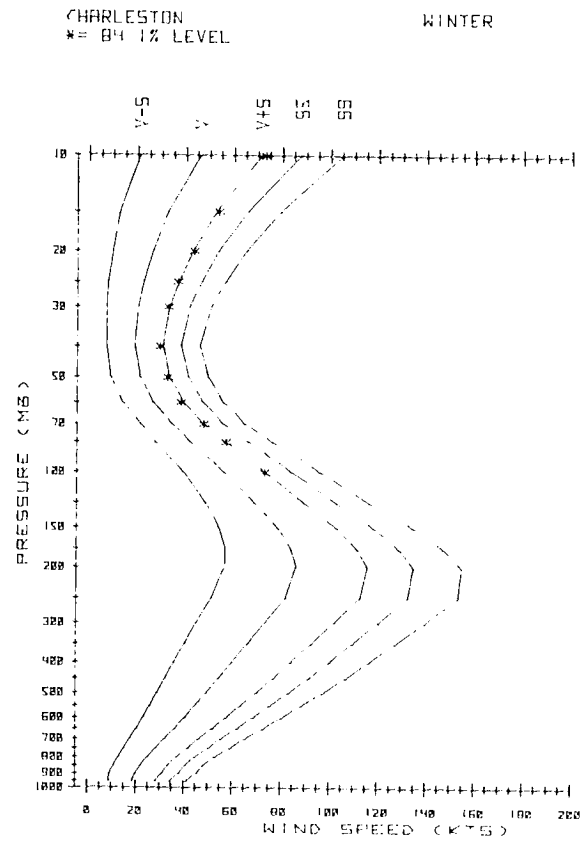
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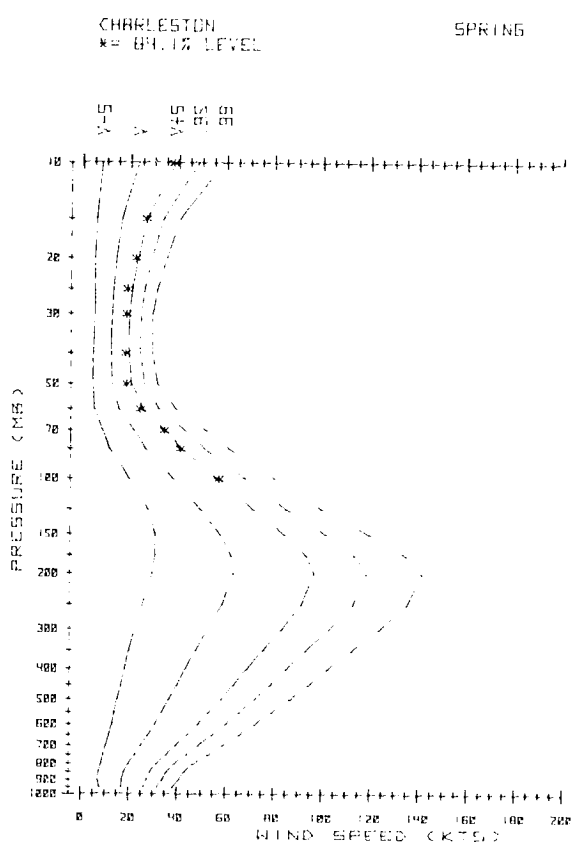
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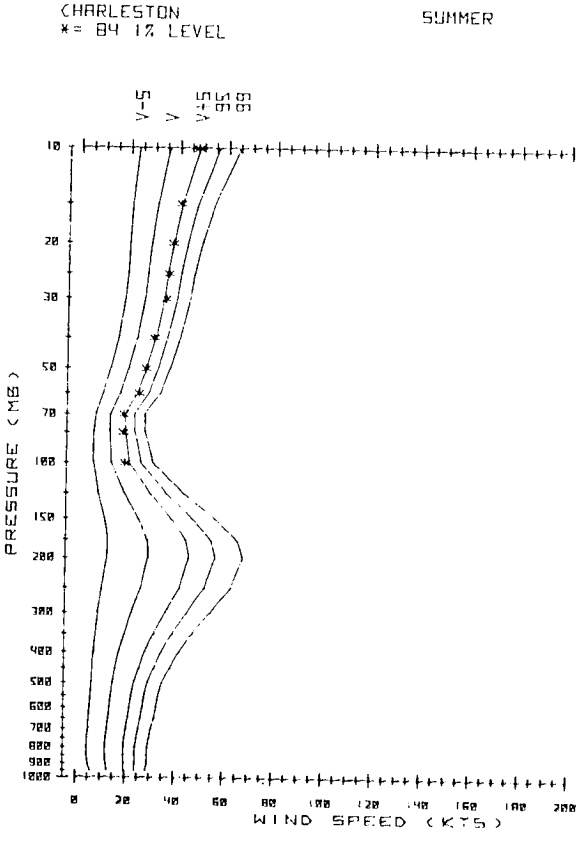
WIND SPEED (KTS)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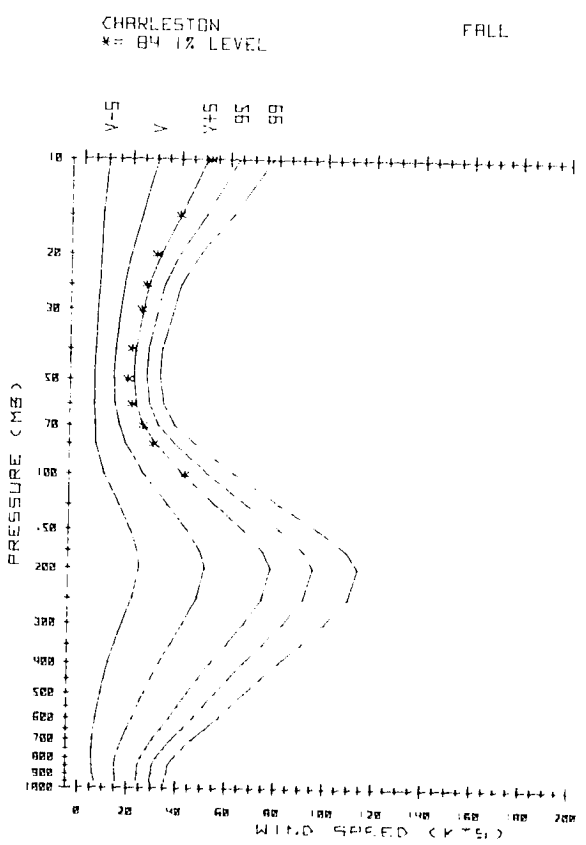
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WIND SPEED (KTS)

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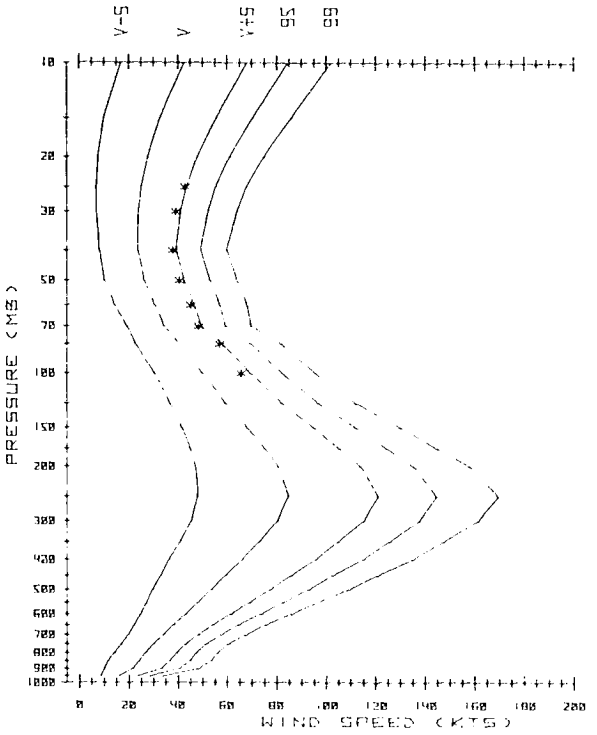

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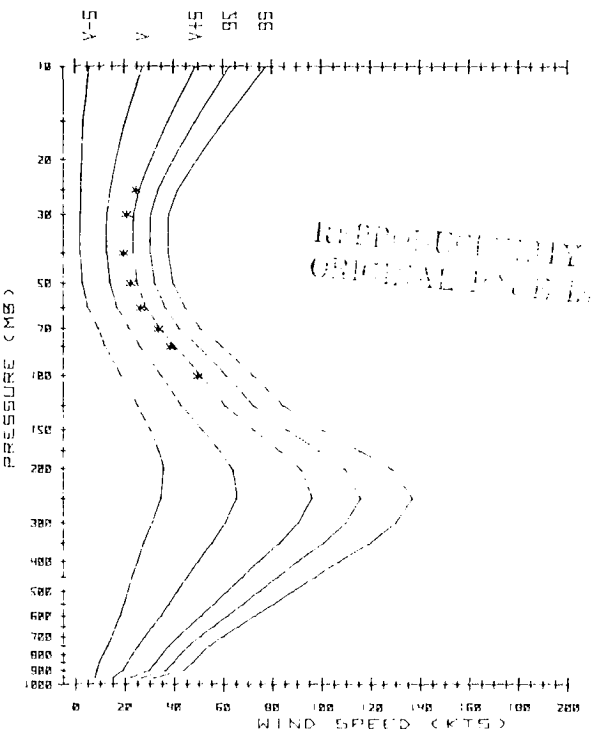

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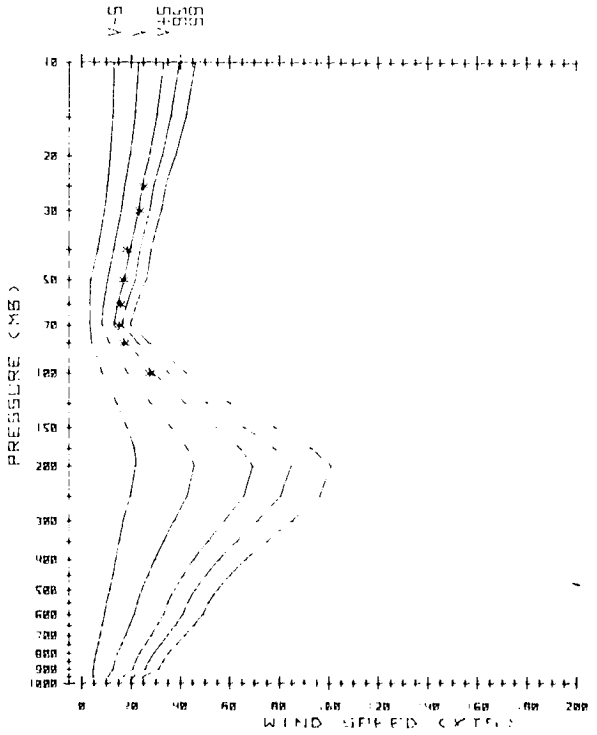

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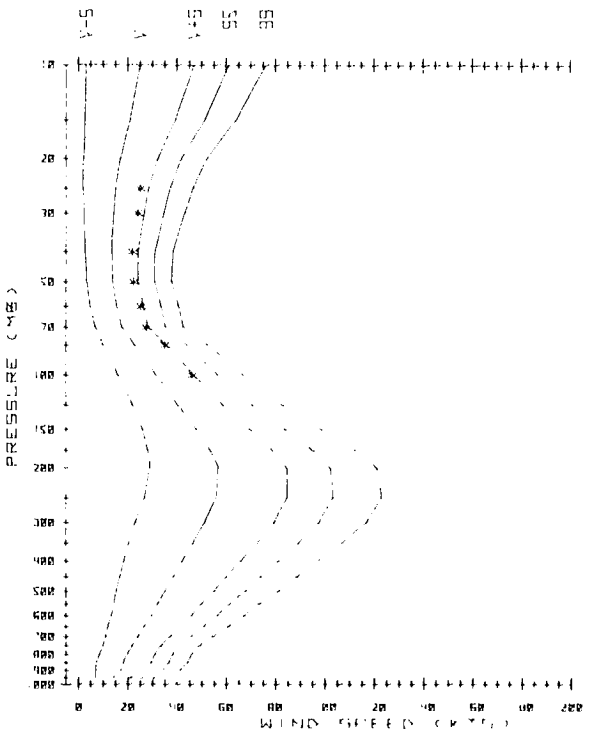

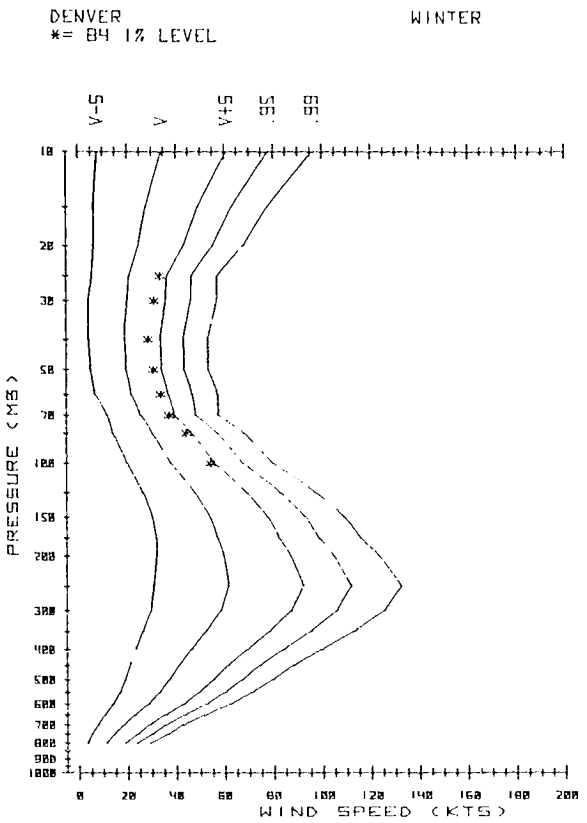
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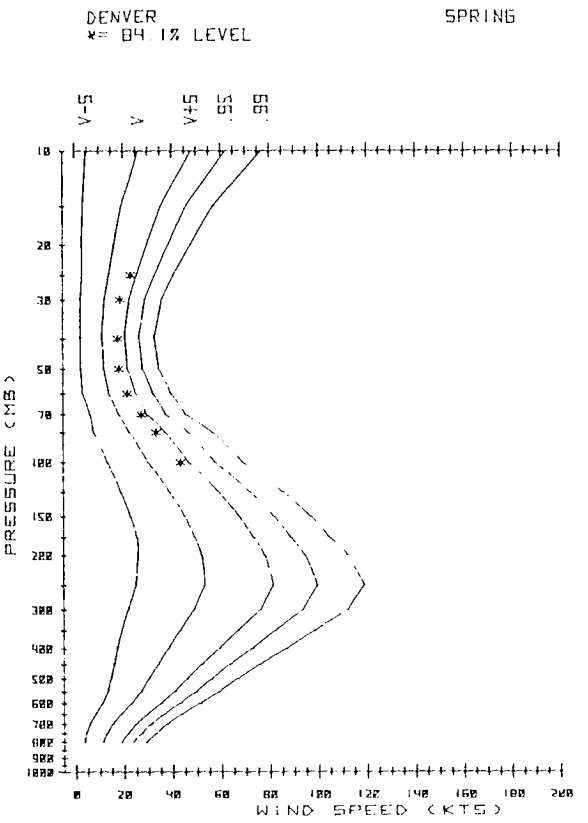
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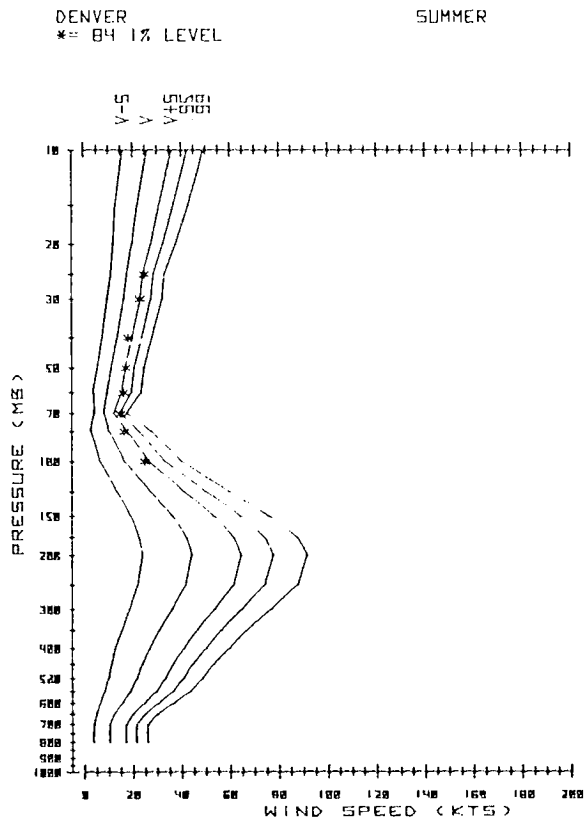
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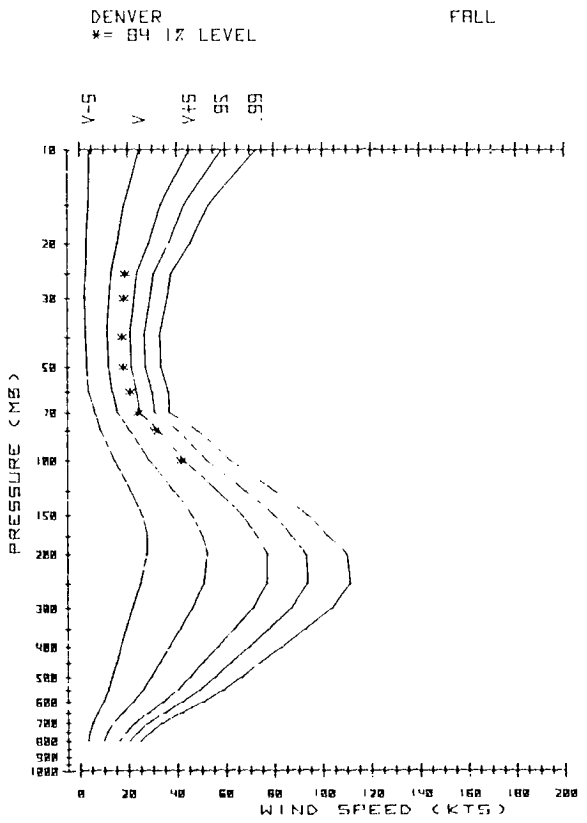
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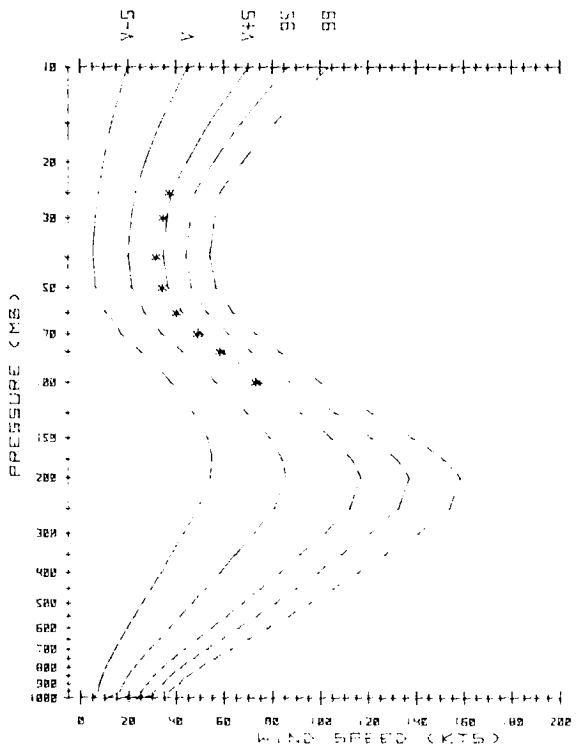

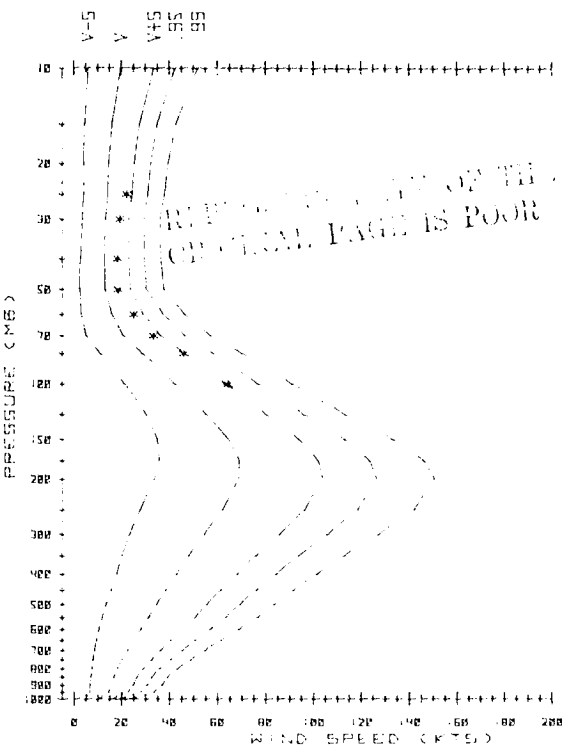

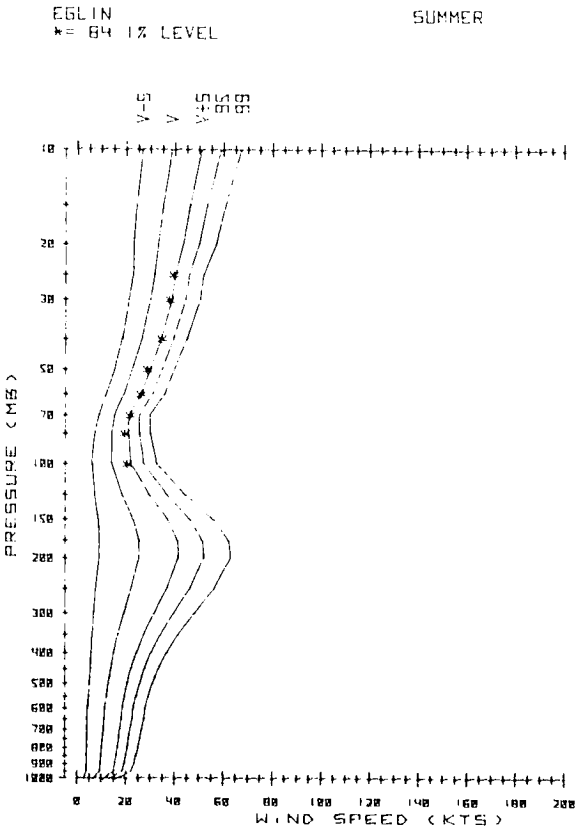

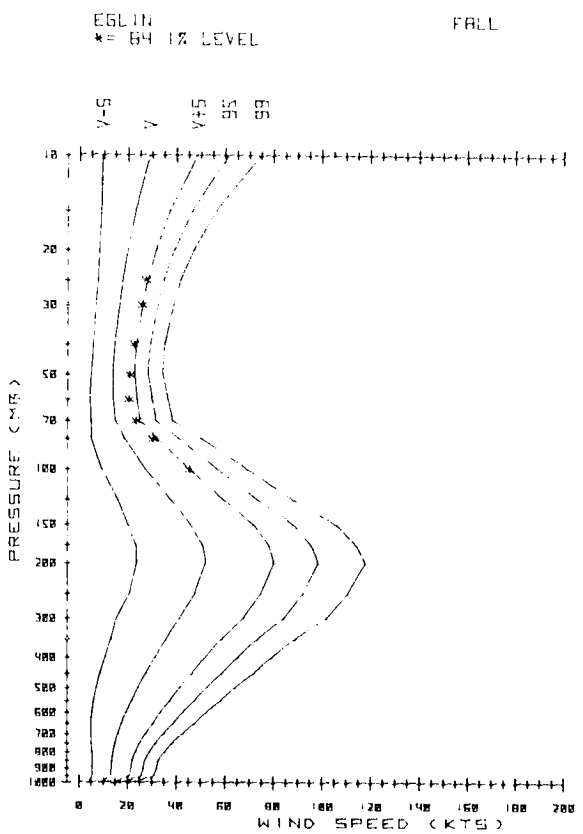

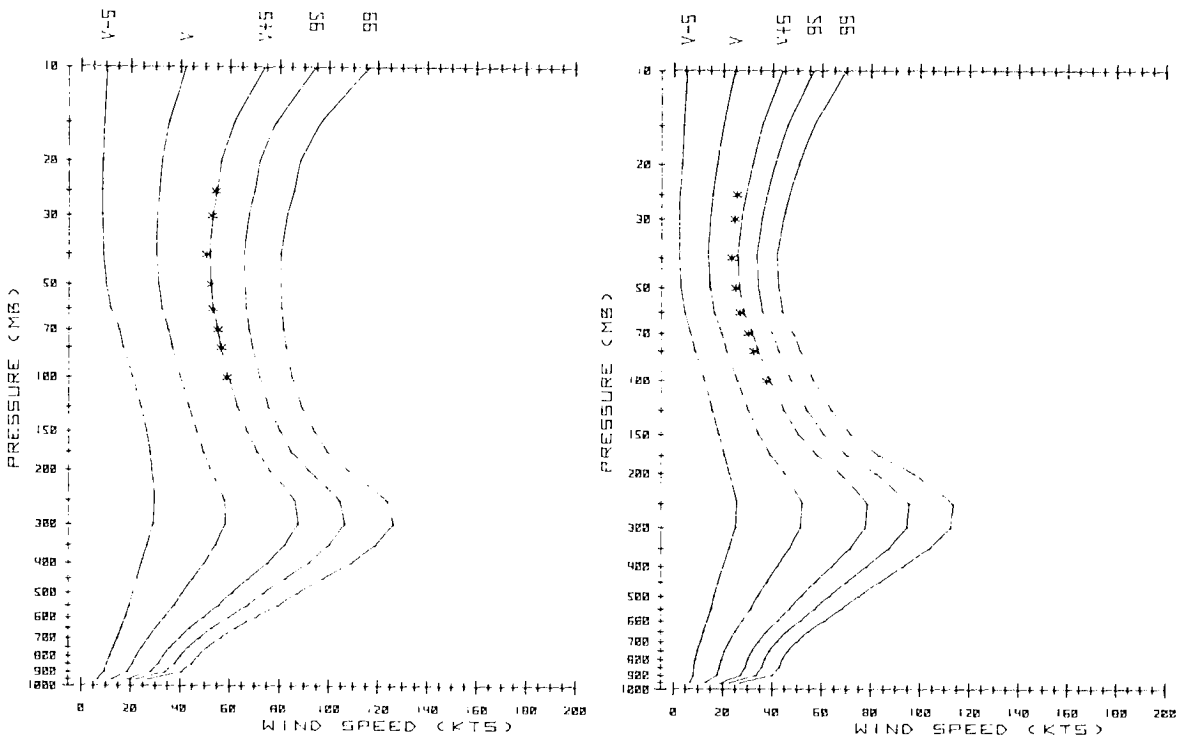
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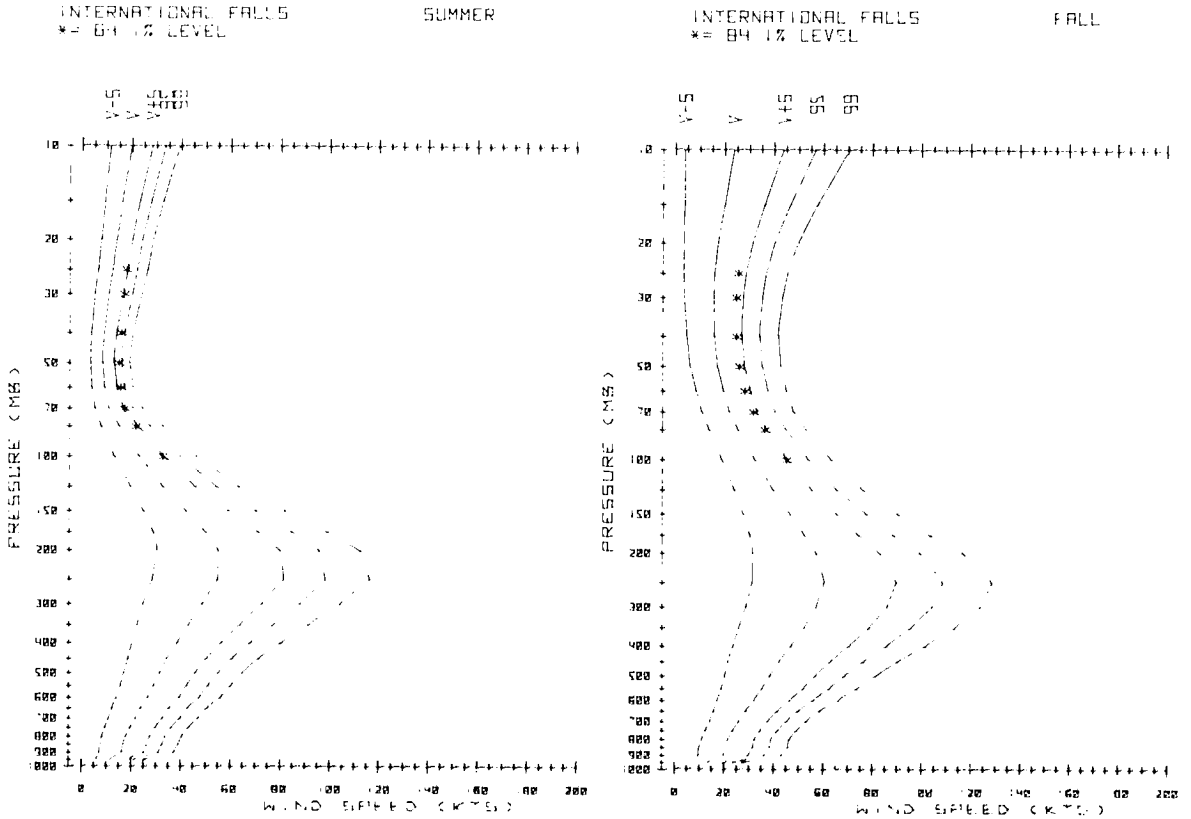
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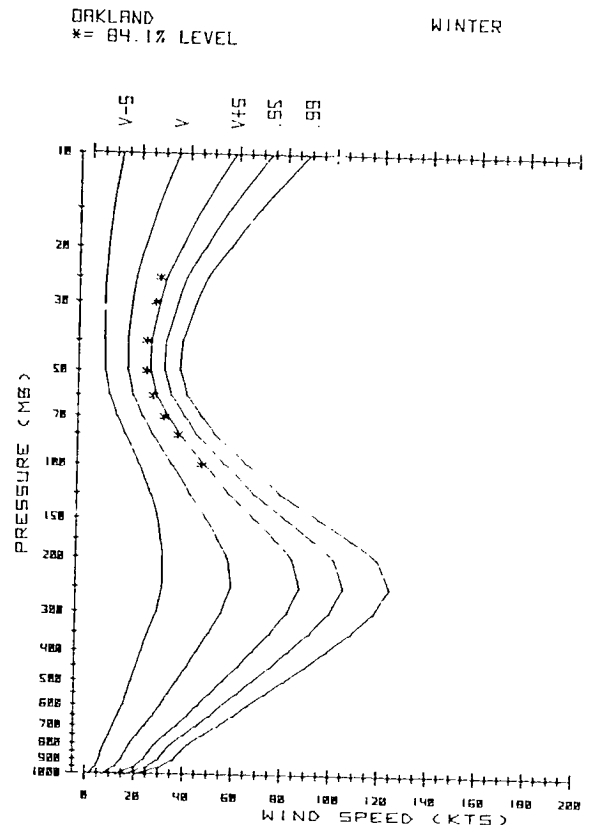

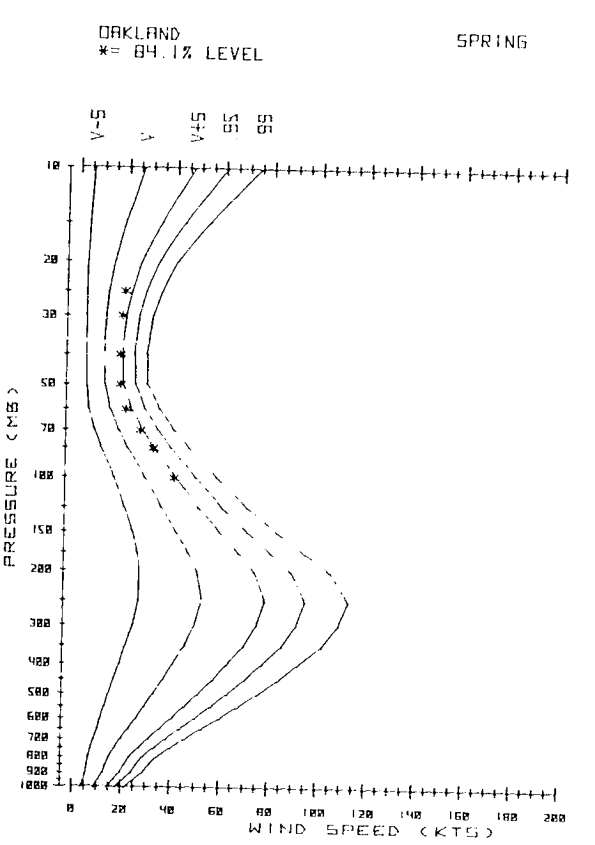

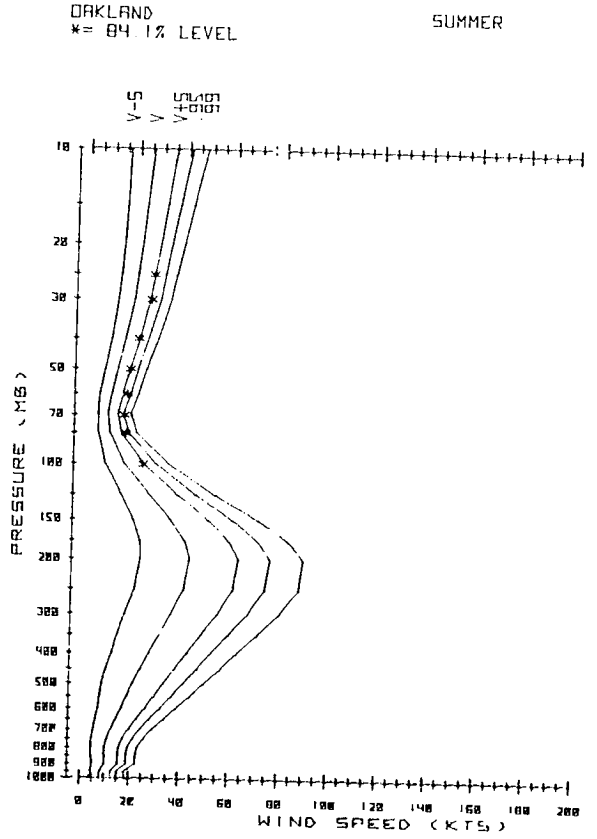

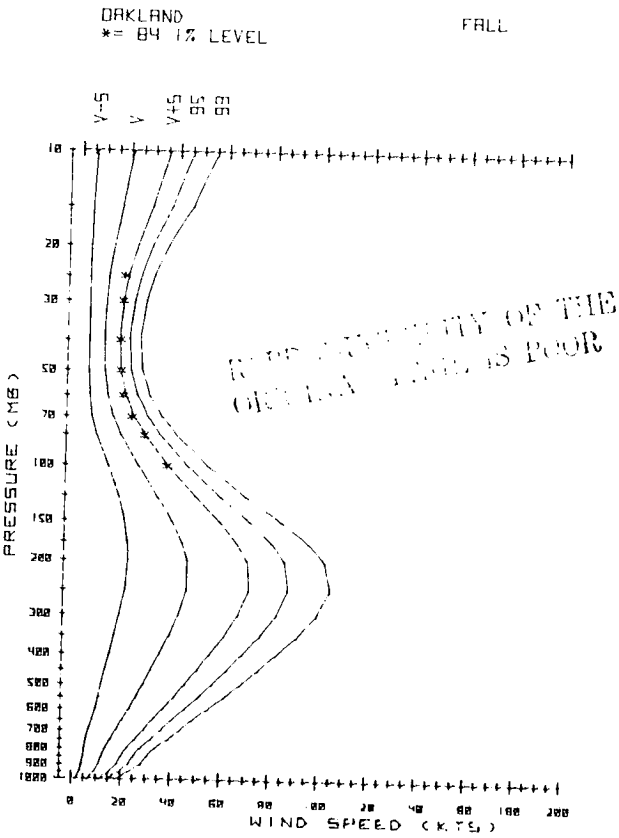

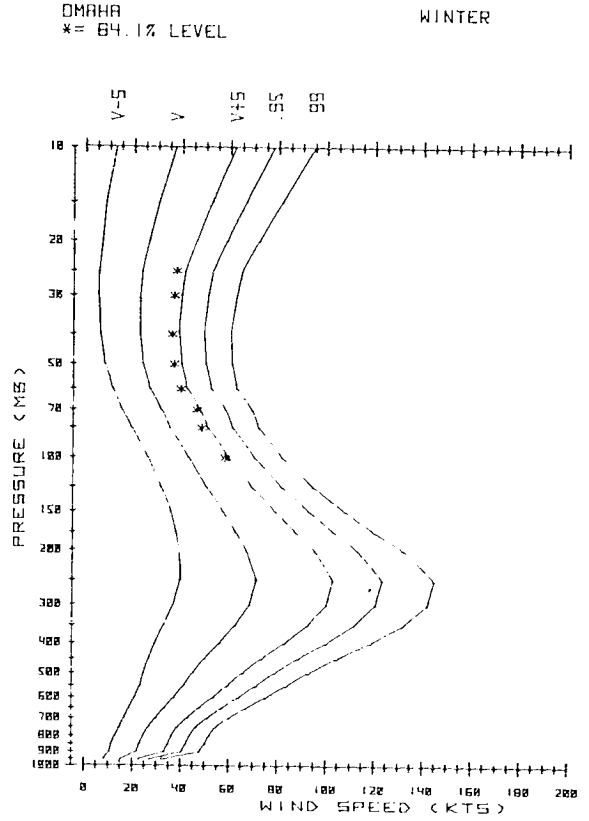
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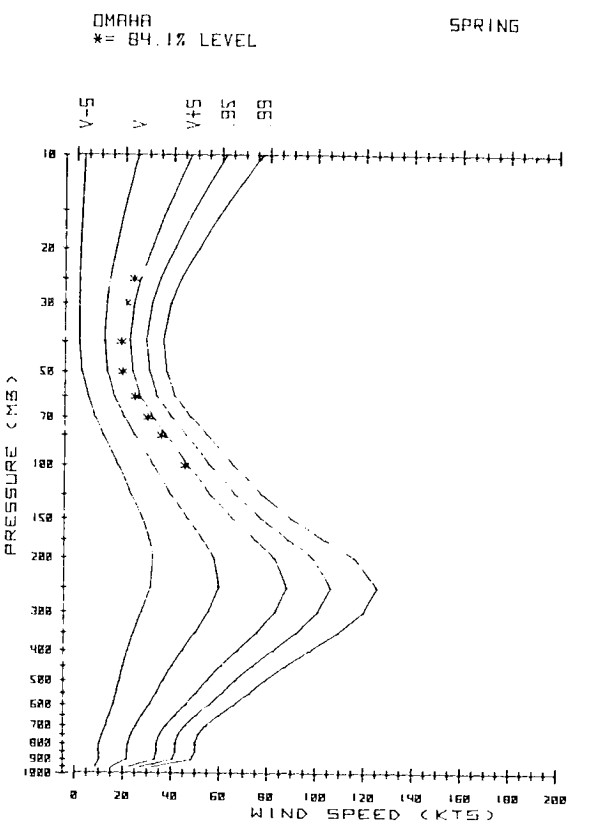
V
V+5
95
99
PRESSURE (MB)
WIND SPEED (KTS)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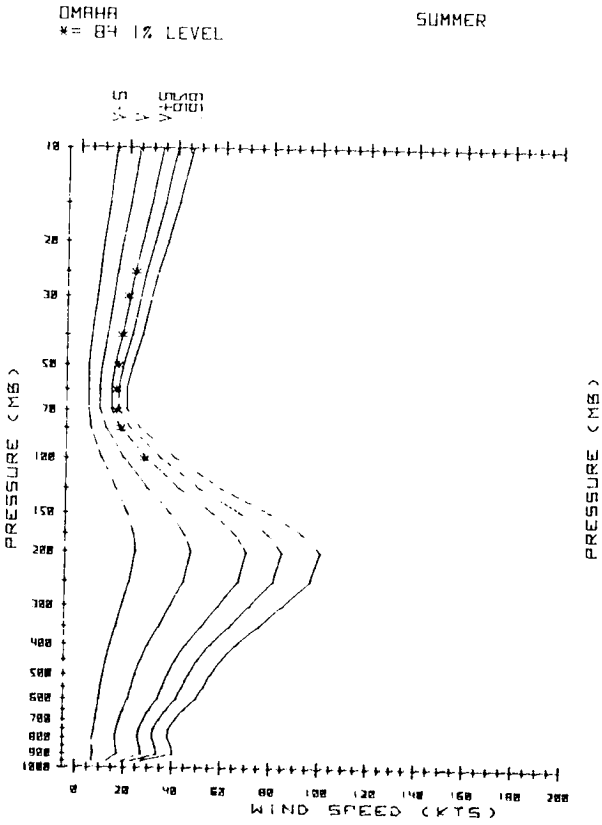
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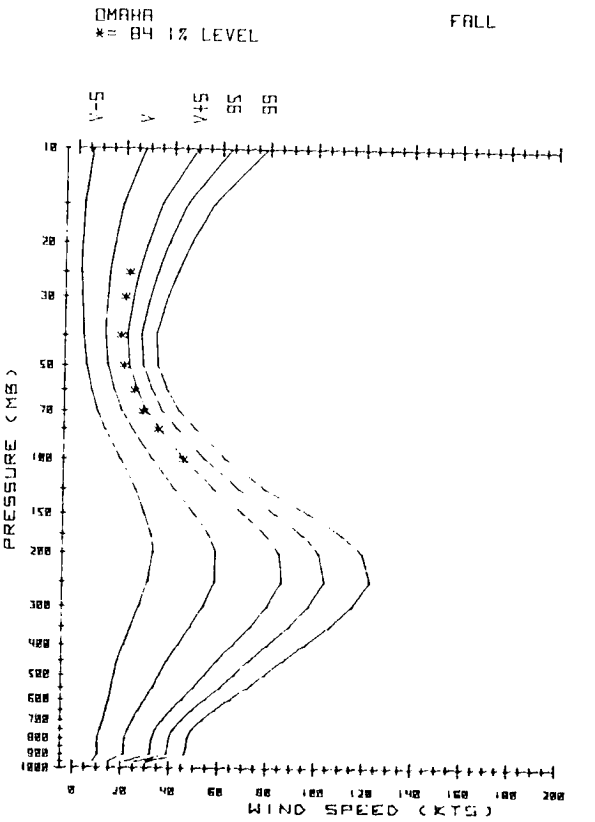
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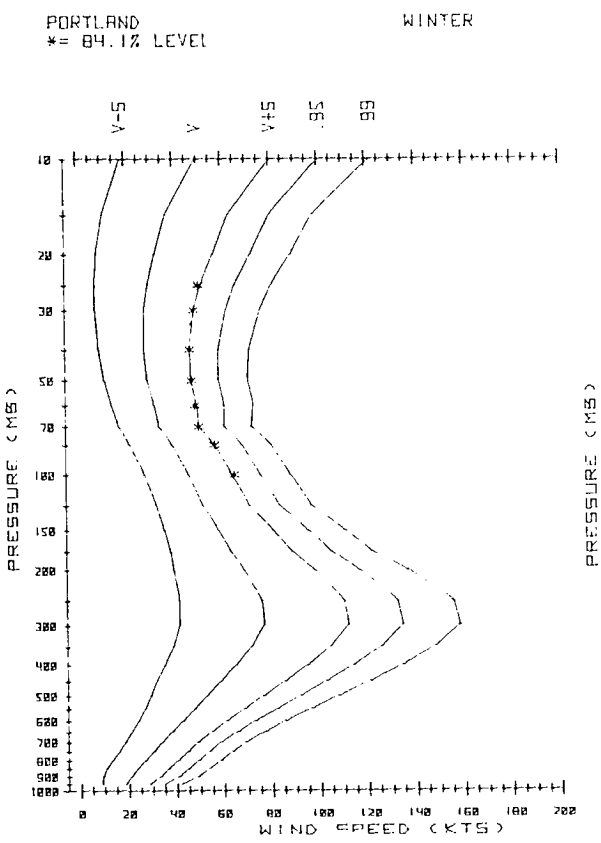
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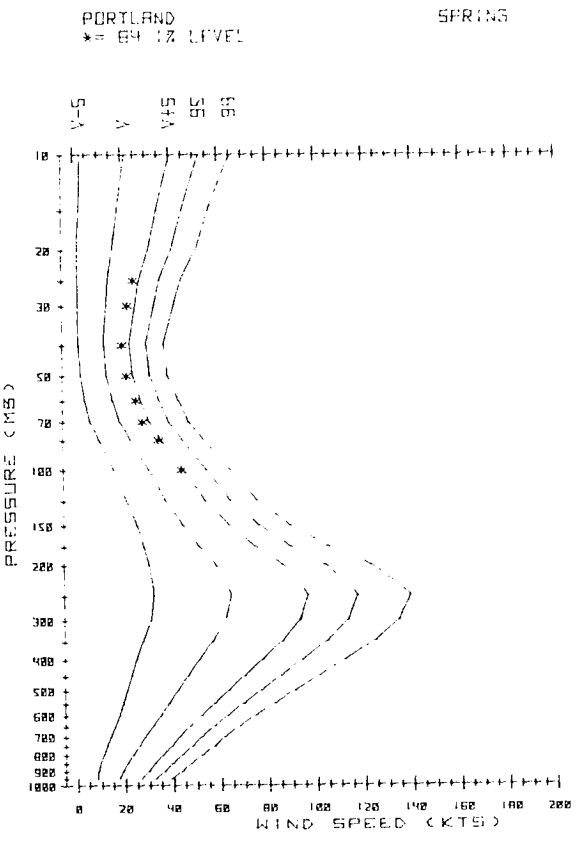
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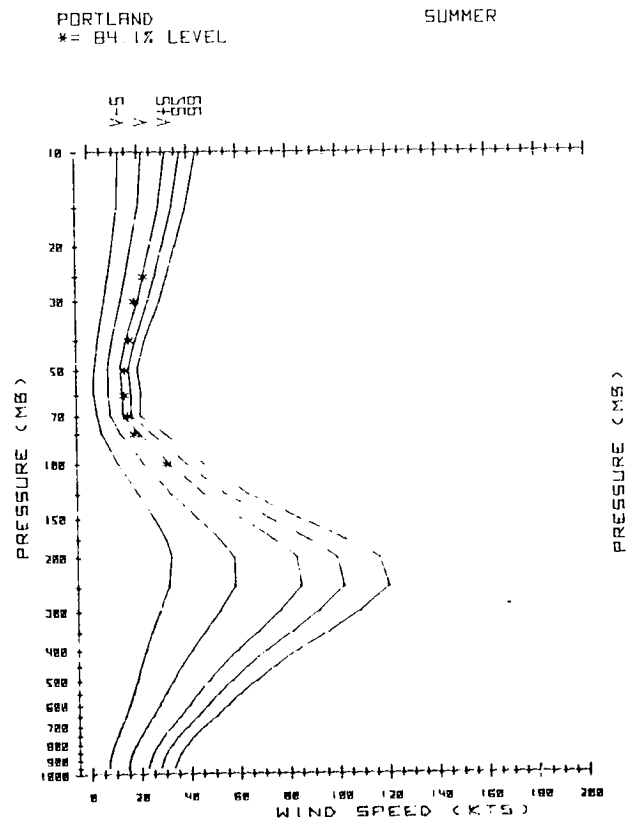
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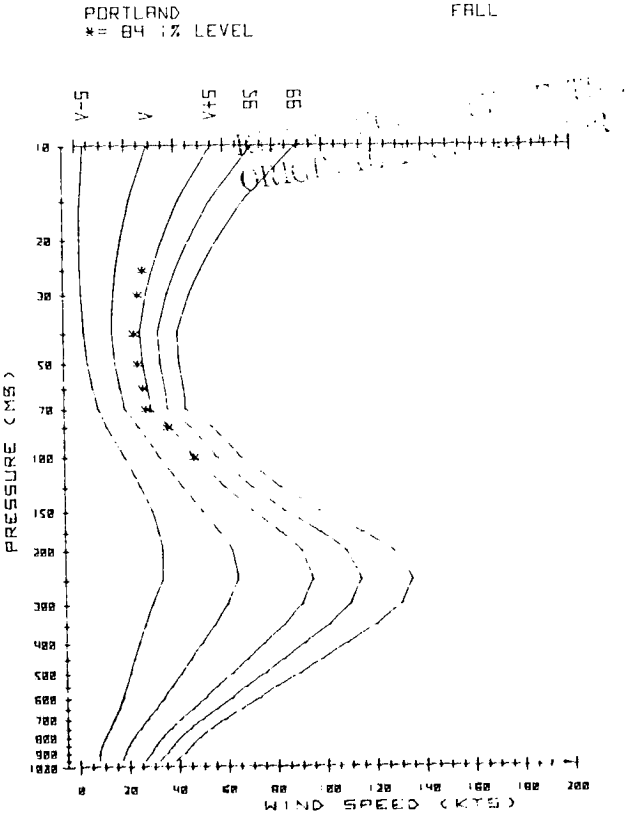
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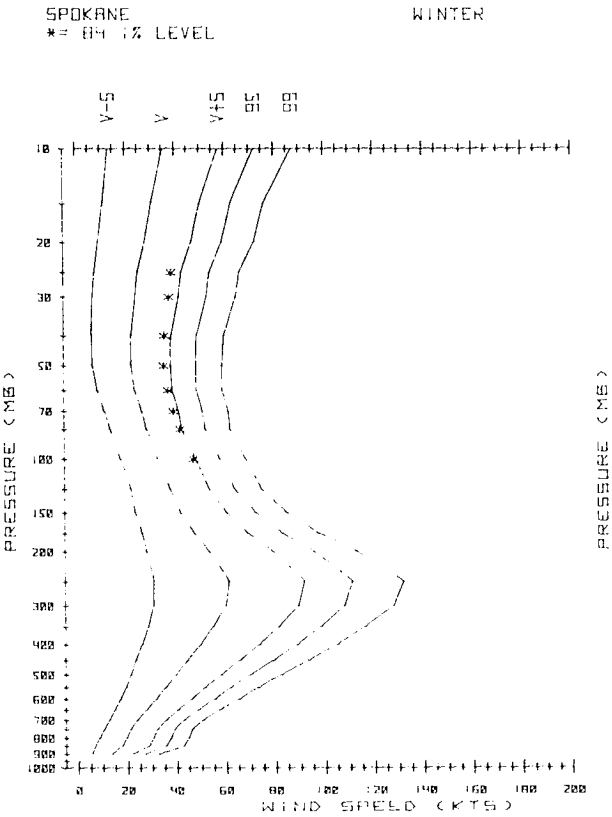
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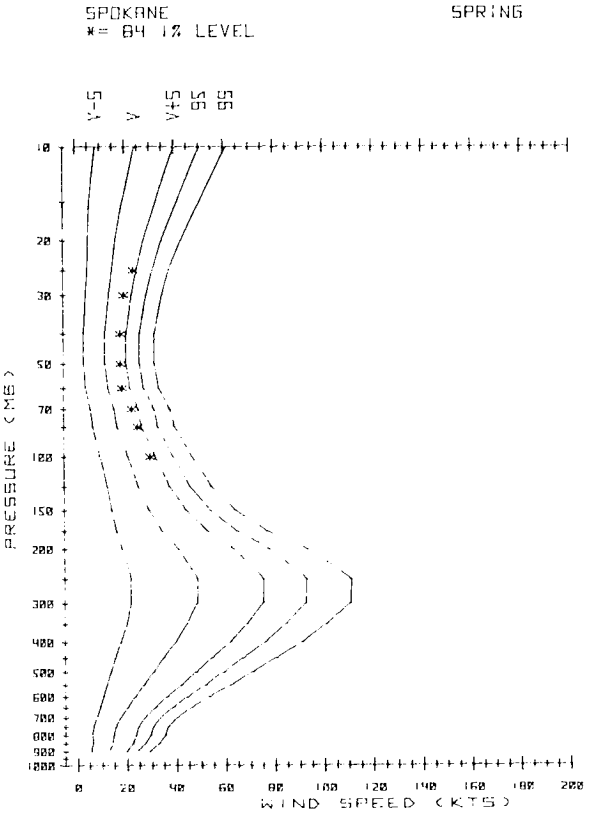
WIND SPEED (KTS)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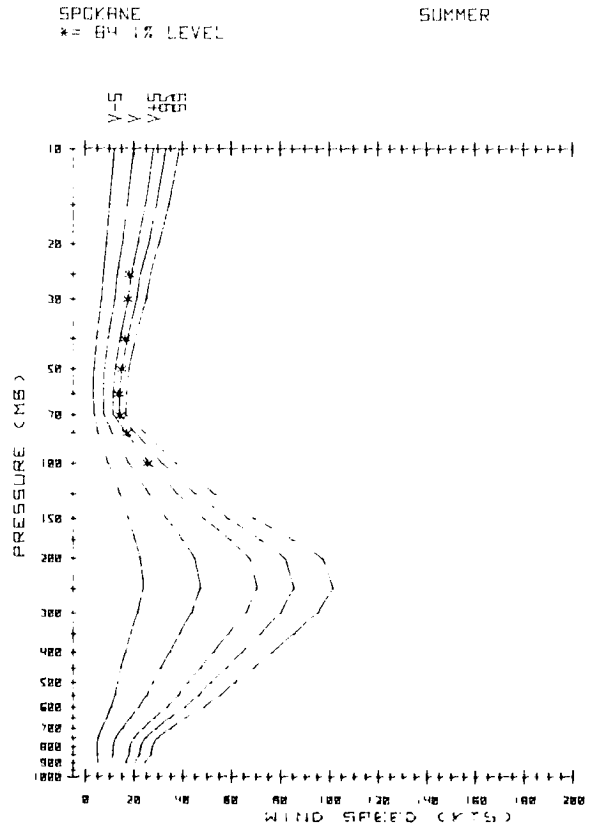
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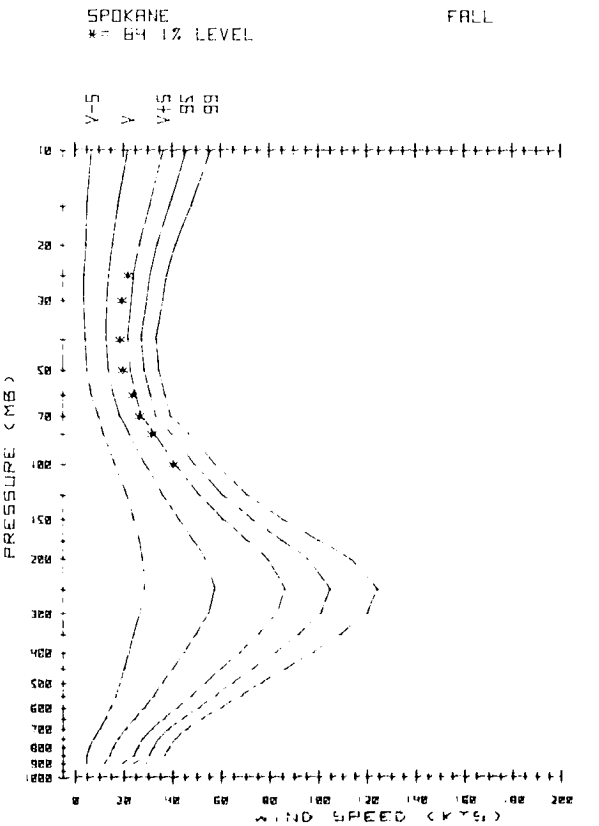
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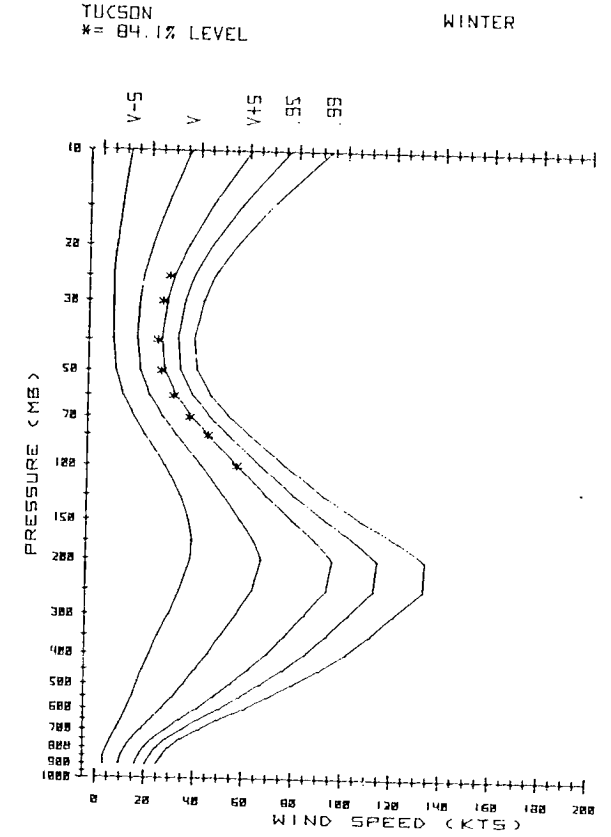
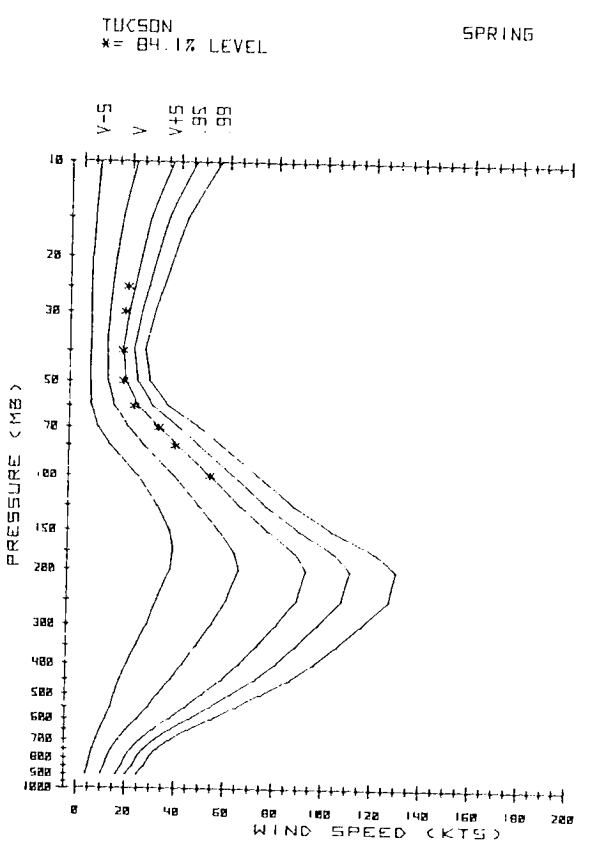
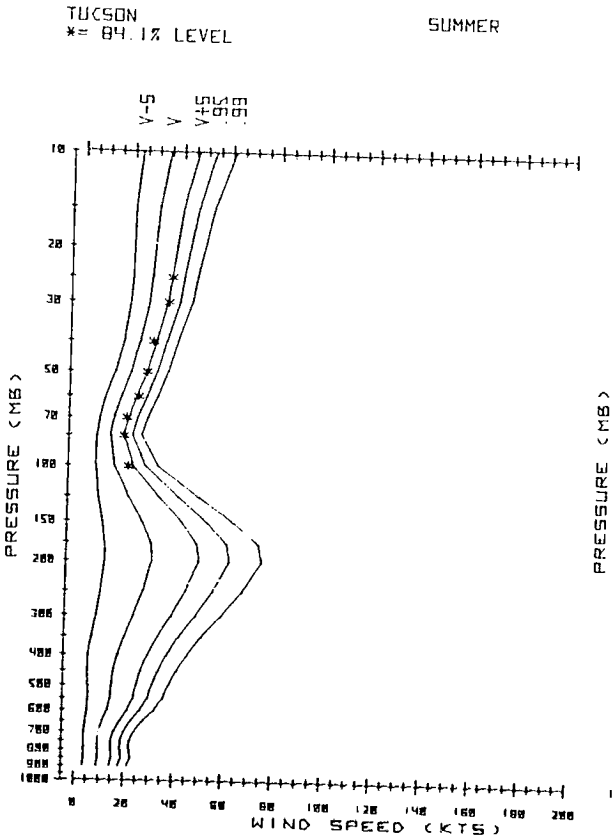
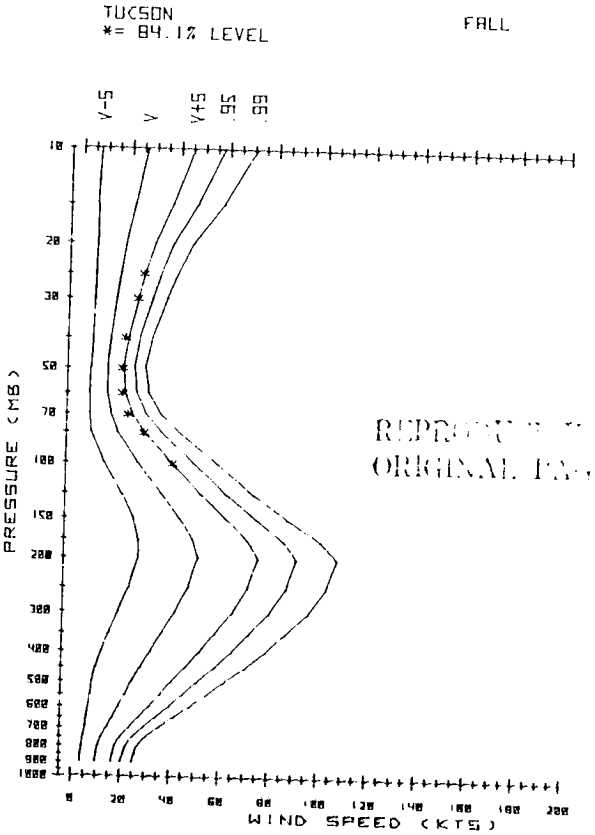
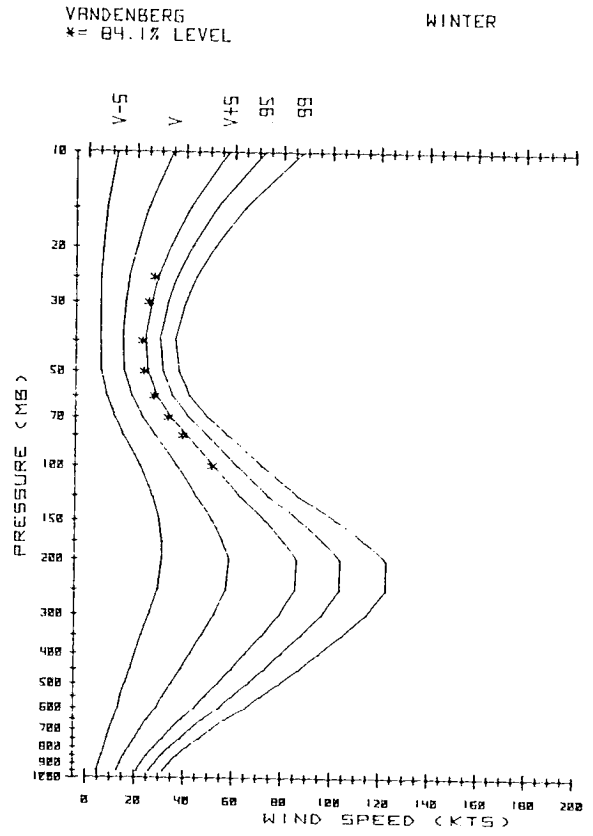
WIND SPEED (KTS)

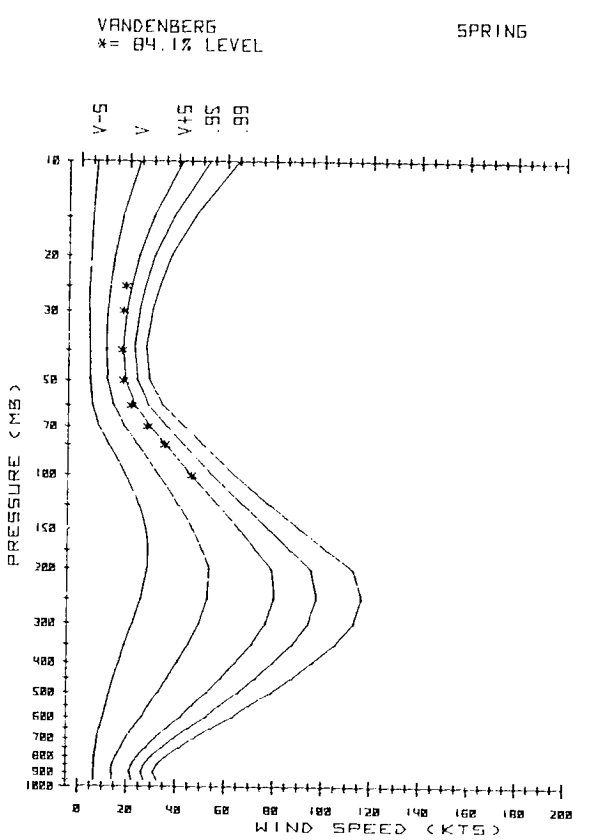


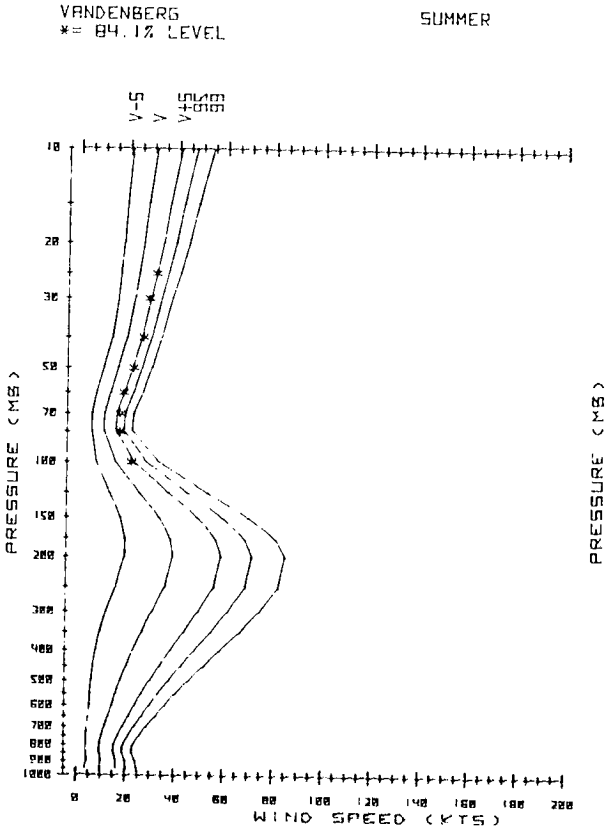


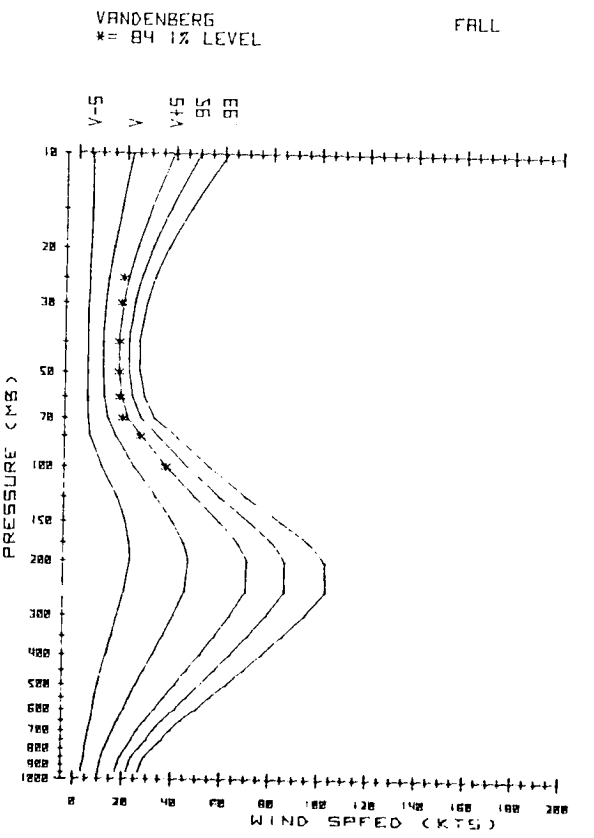




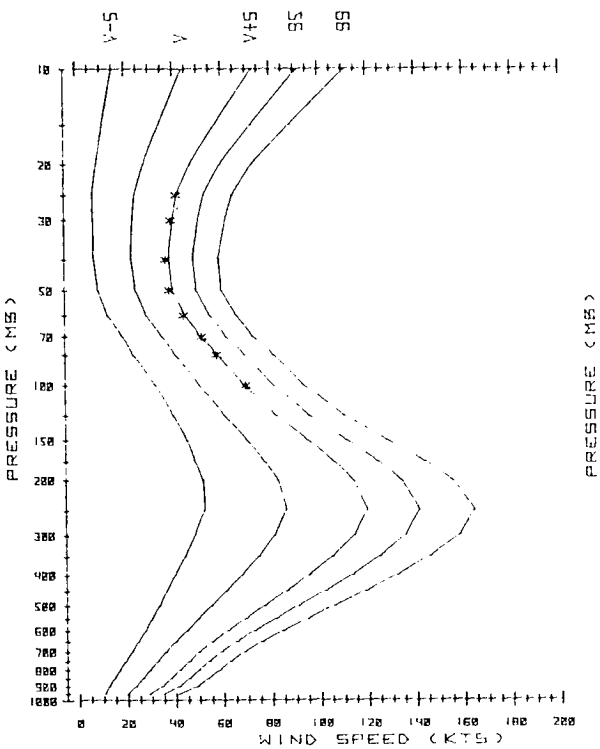

VANDENBERG
*= 84.1% LEVEL
WINTER
V-S
V
V+S
PRESSURE (MB)
WIND SPEED (KTS)


VANDENBERG
*= 84.1% LEVEL
SPRING
V-S
V
V+S
PRESSURE (MB)
WIND SPEED (KTS)

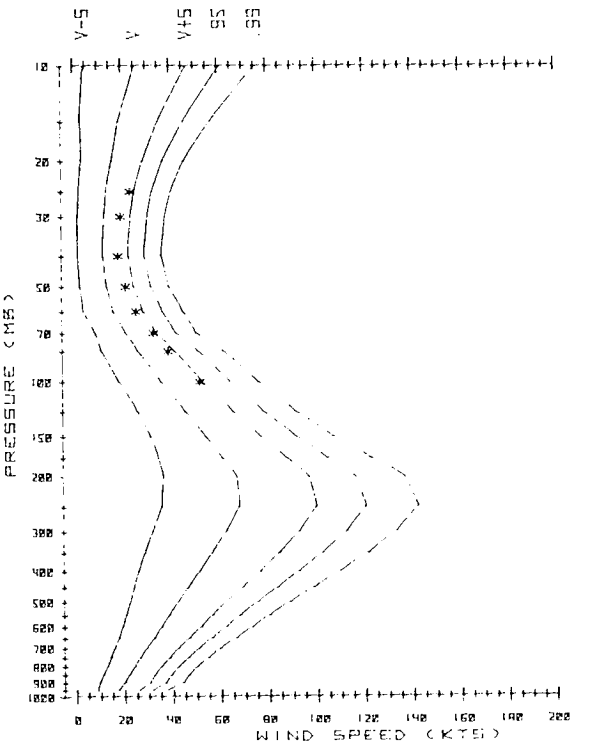

VANDENBERG
*= 84.1% LEVEL
SUMMER
V-S
V
V+S
PRESSURE (MB)
WIND SPEED (KTS)


VANDENBERG
*= 84.1% LEVEL
FALL
V-S
V
V+S
PRESSURE (MB)
WIND SPEED (KTS)

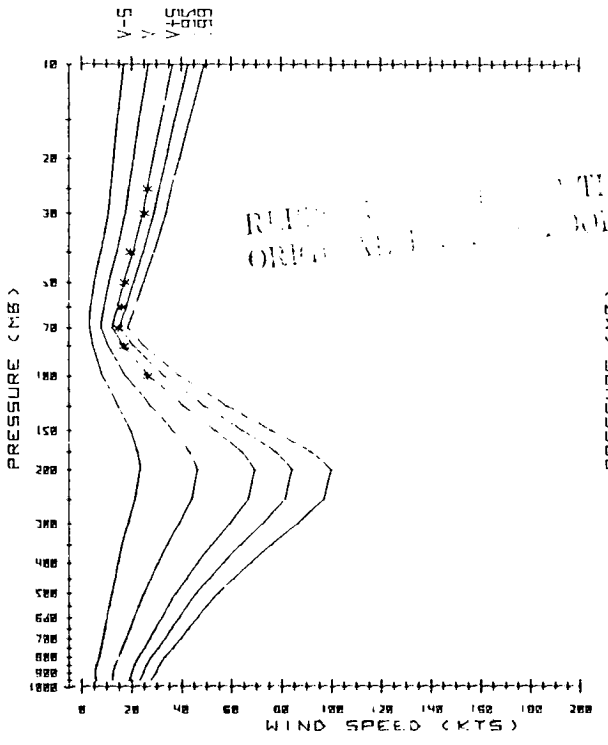
WASHINGTON WINTER
*= 84.1% LEVEL



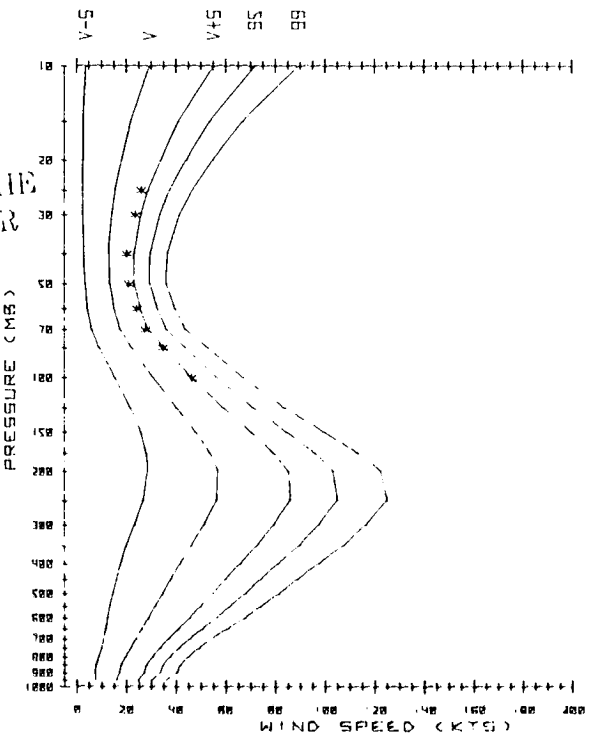
WASHINGTON SPRING
*= 84.1% LEVEL

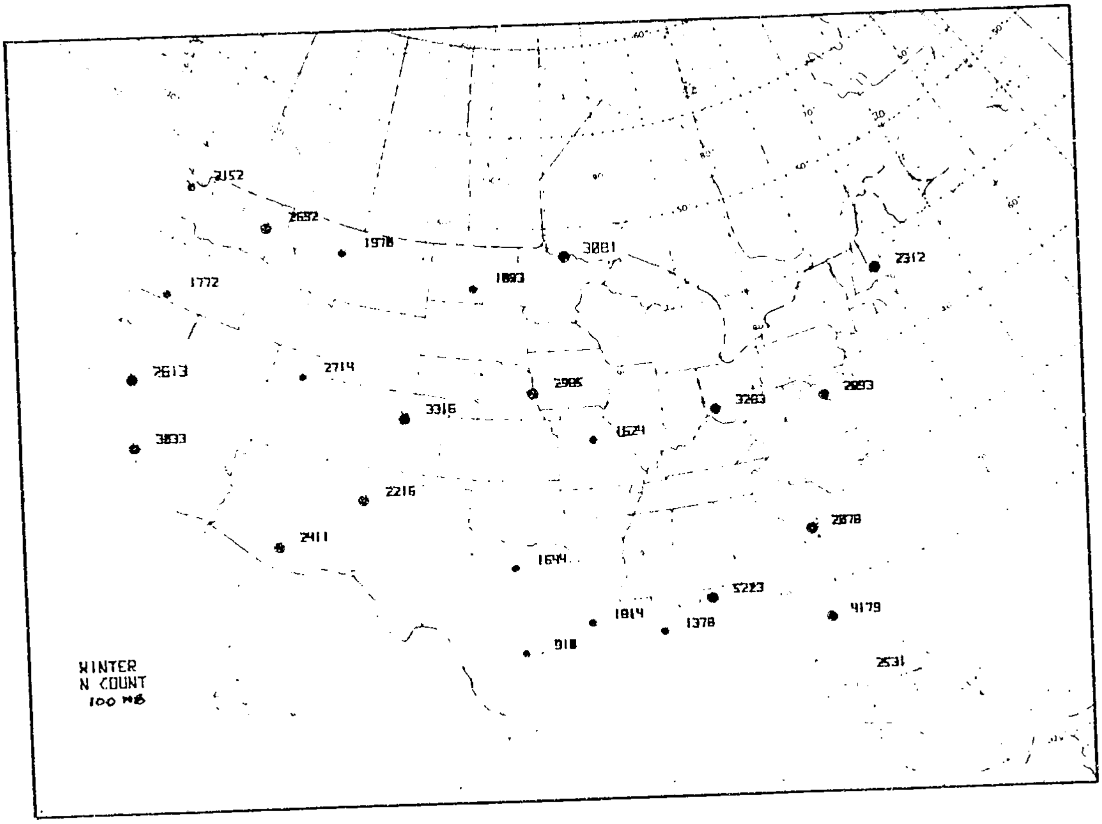


WASHINGTON SUMMER
*= 84.1% LEVEL



WASHINGTON FALL
*= 84.1% LEVEL




WINTER
N COUNT
100 MB
2152
2692
1978
3081
2312
1772
1893
2613
2714
2985
3283
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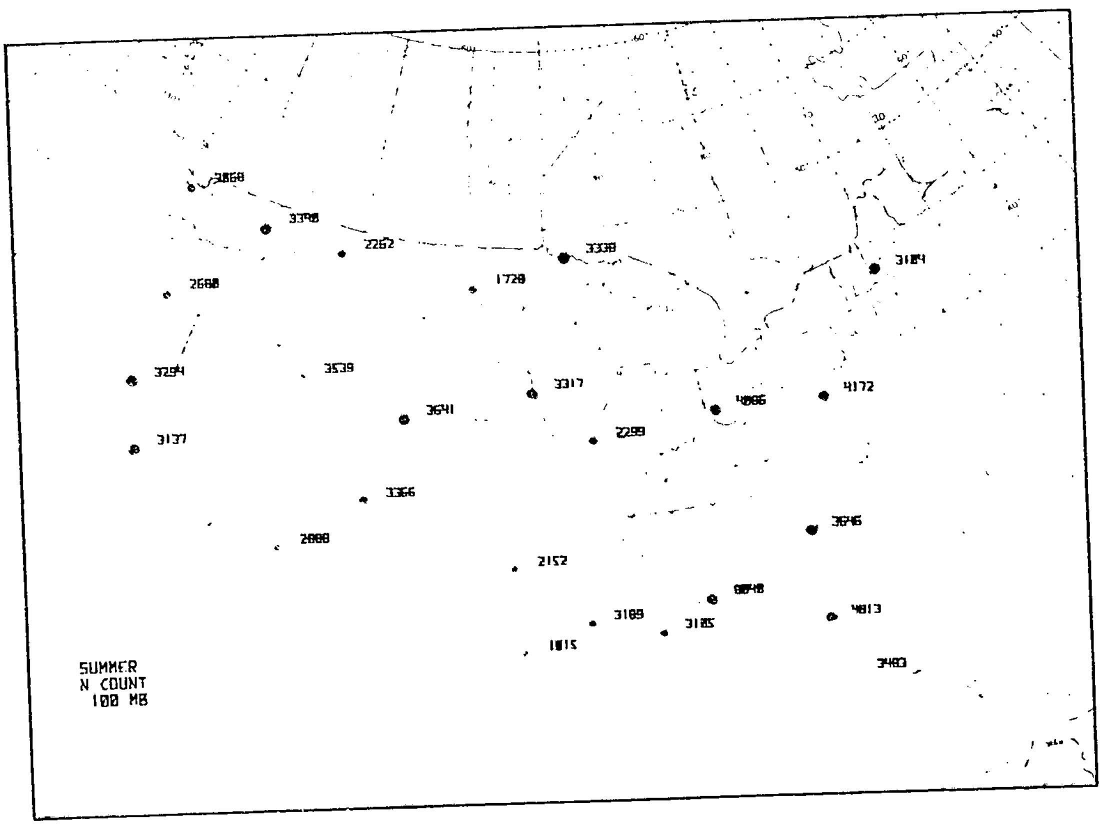
4179
918
2531


SUMMER
N COUNT
100 MB
3868
3398
2262
3338
3184
2668
1728
3294
3539
3317
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3641
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2299
3137
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3185
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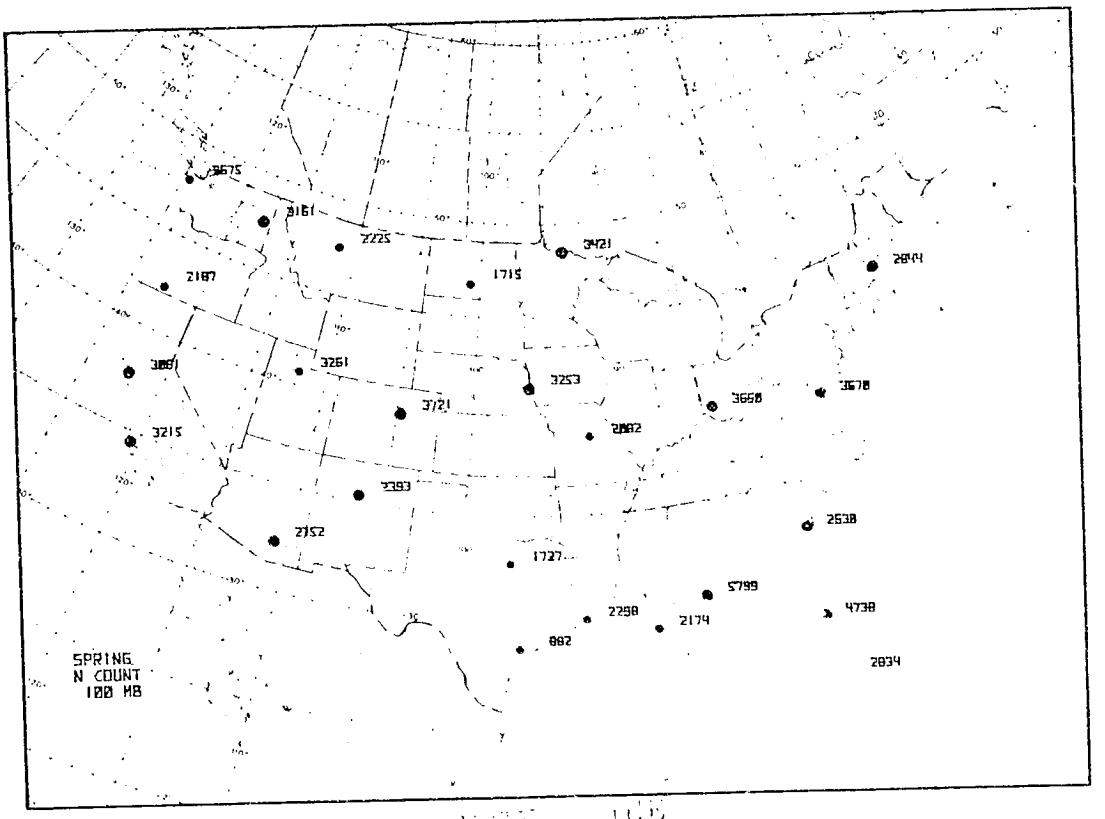
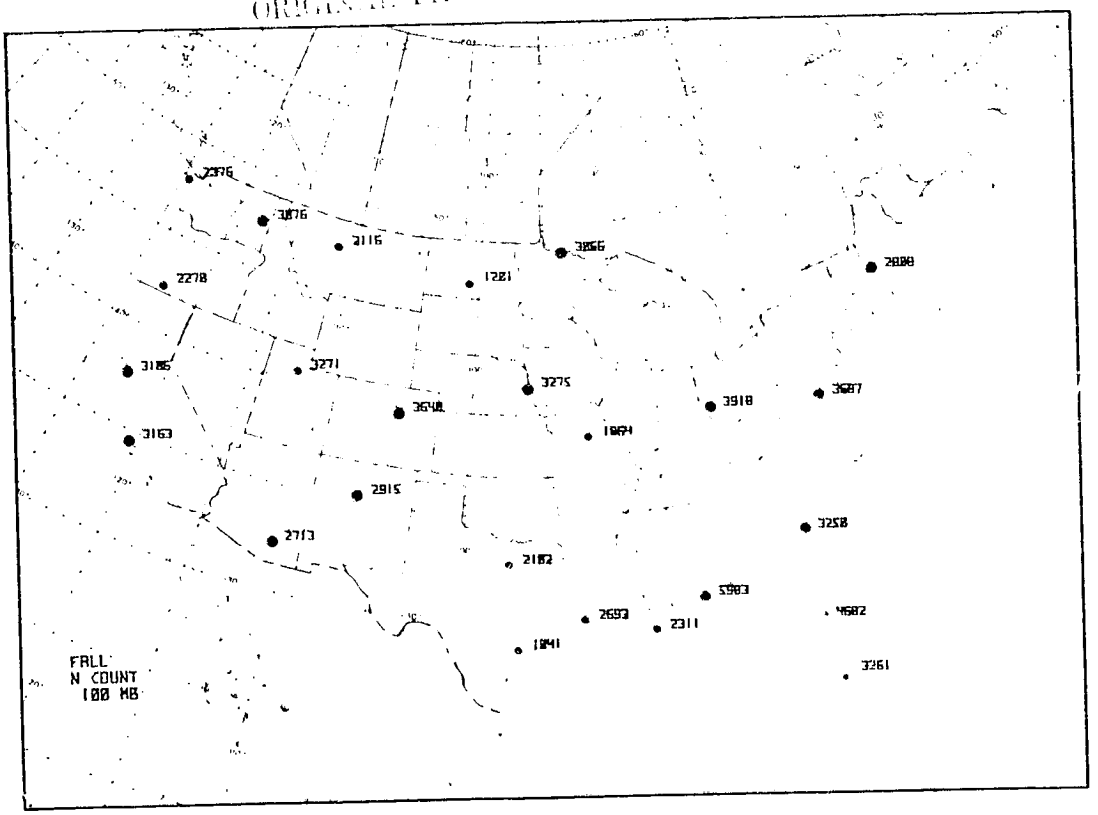
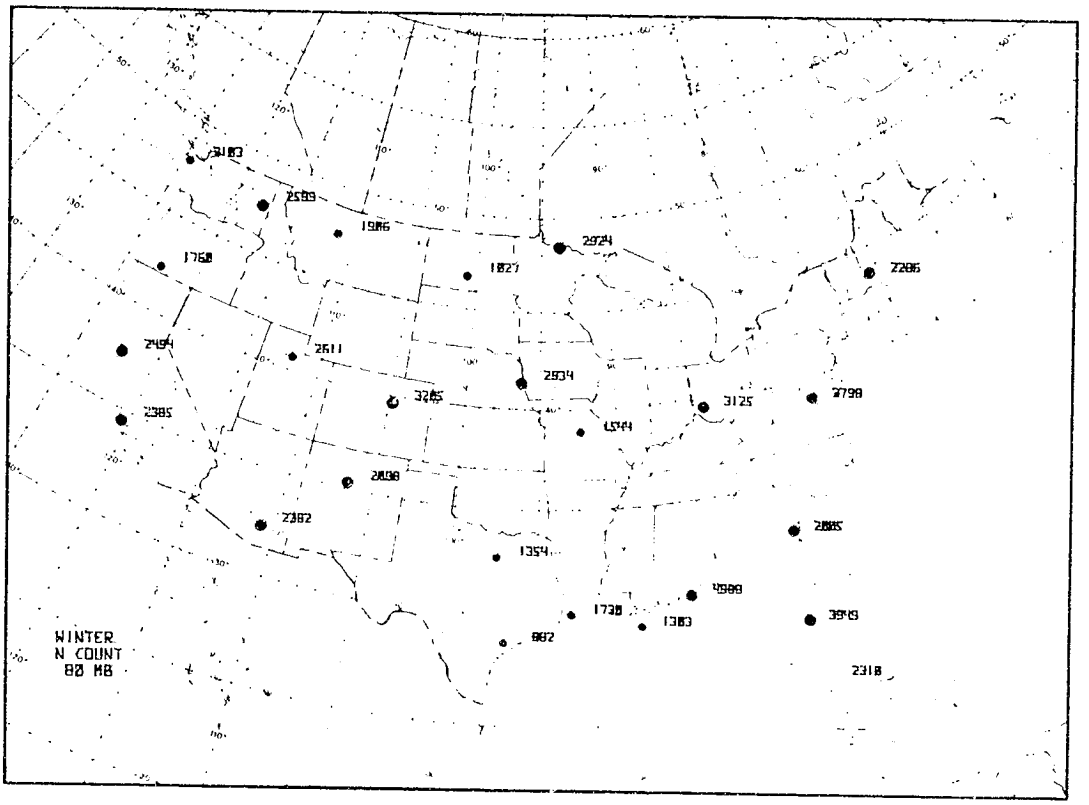
1815
3483






WINTER
N COUNT
80 MB
3183
2589
1986
2924
1760
1827
2286
2494
2611
2934
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2385
4544
2838
2382
2885
1354
4988
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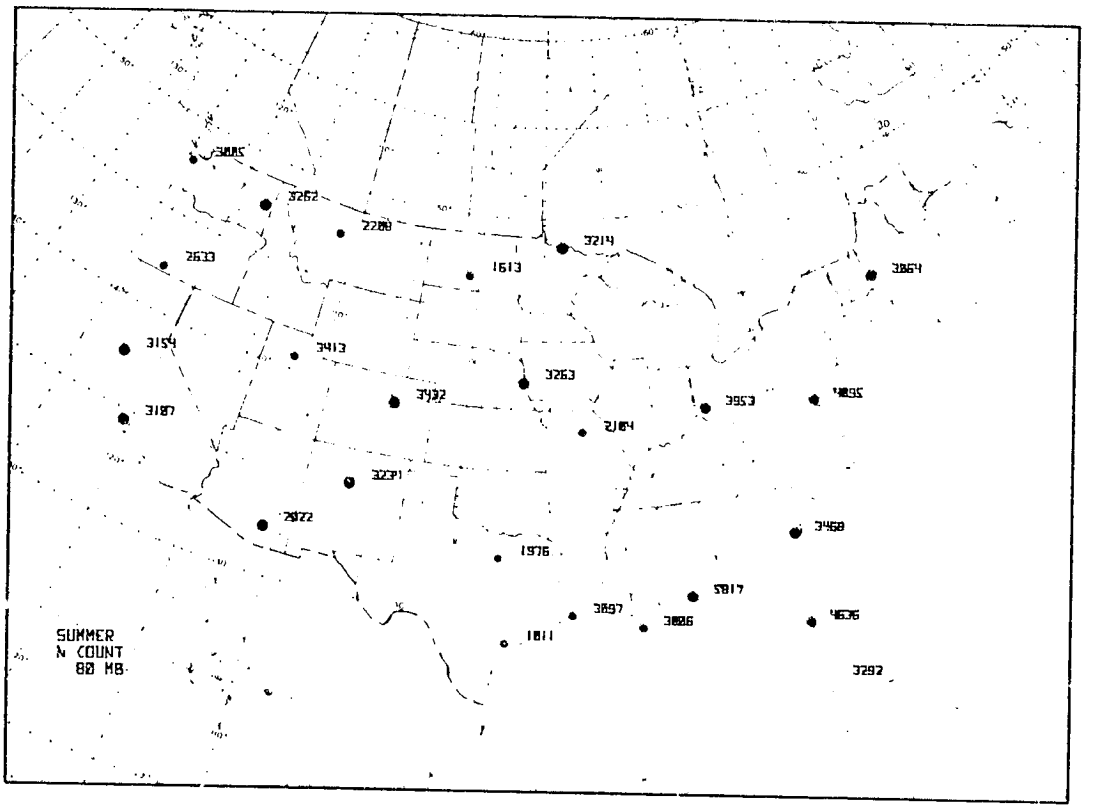
1383
3949
882
2318


SUMMER
N COUNT
80 MB
3885
3262
2280
3214
2633
1613
3864
3154
3413
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2972
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1976
5817
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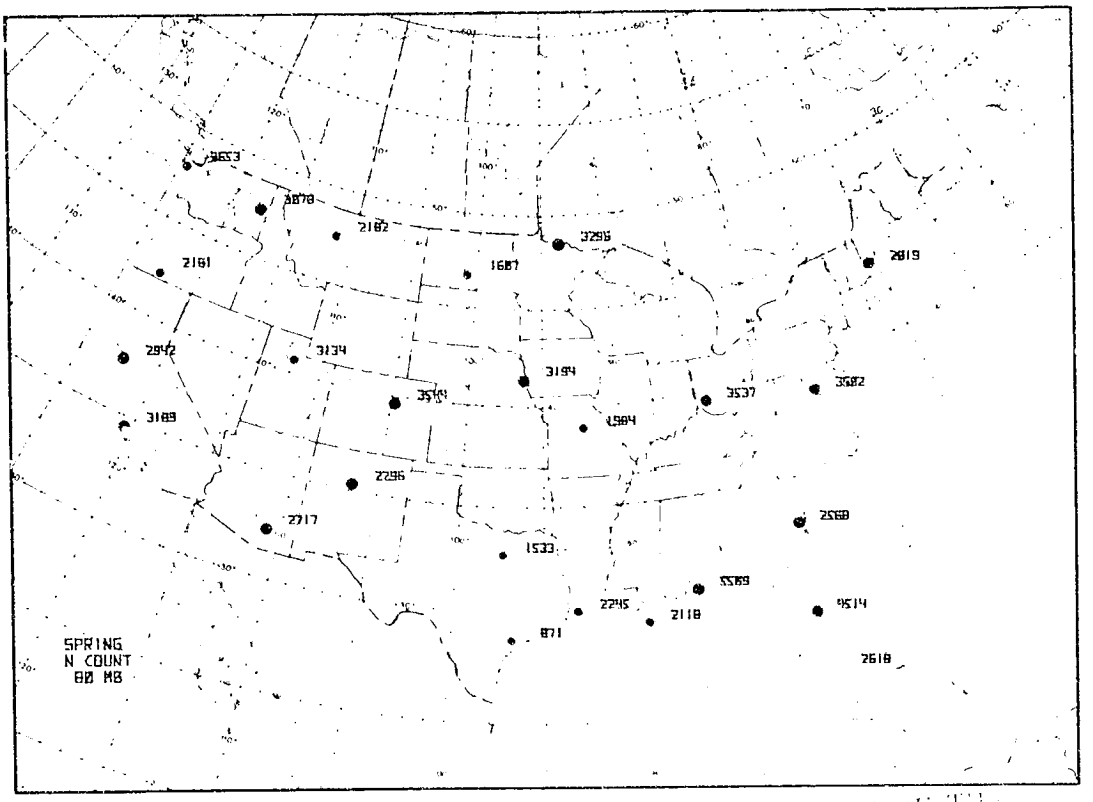
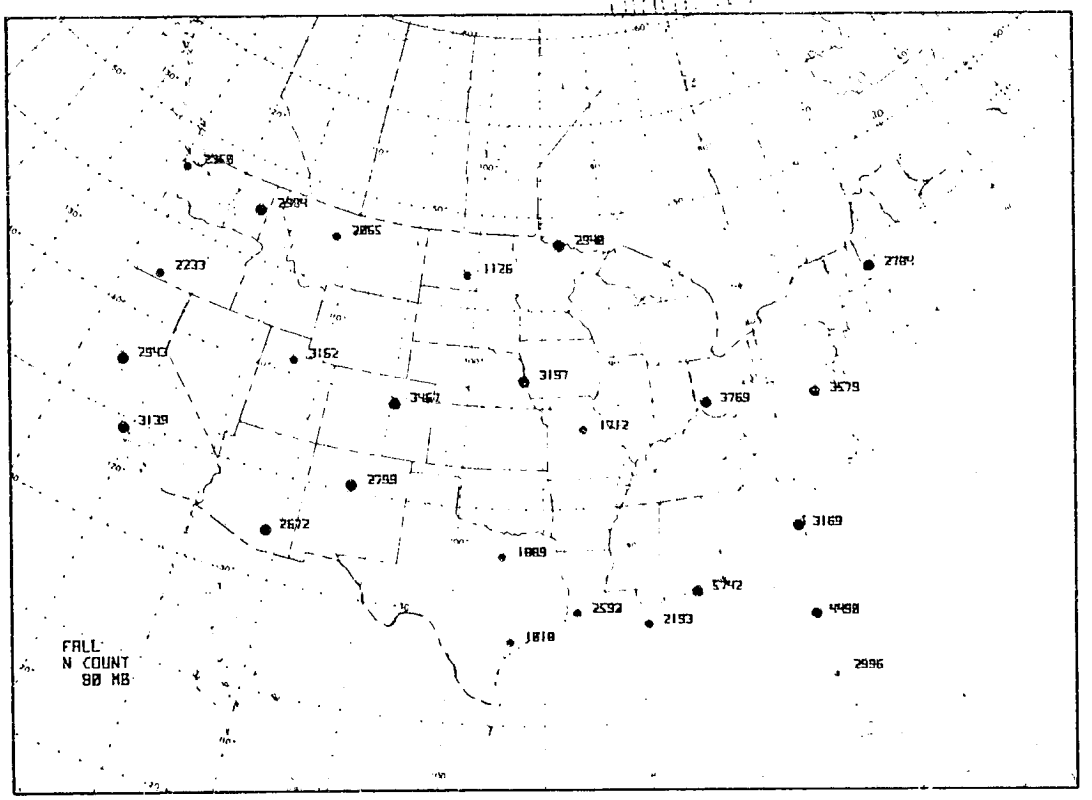
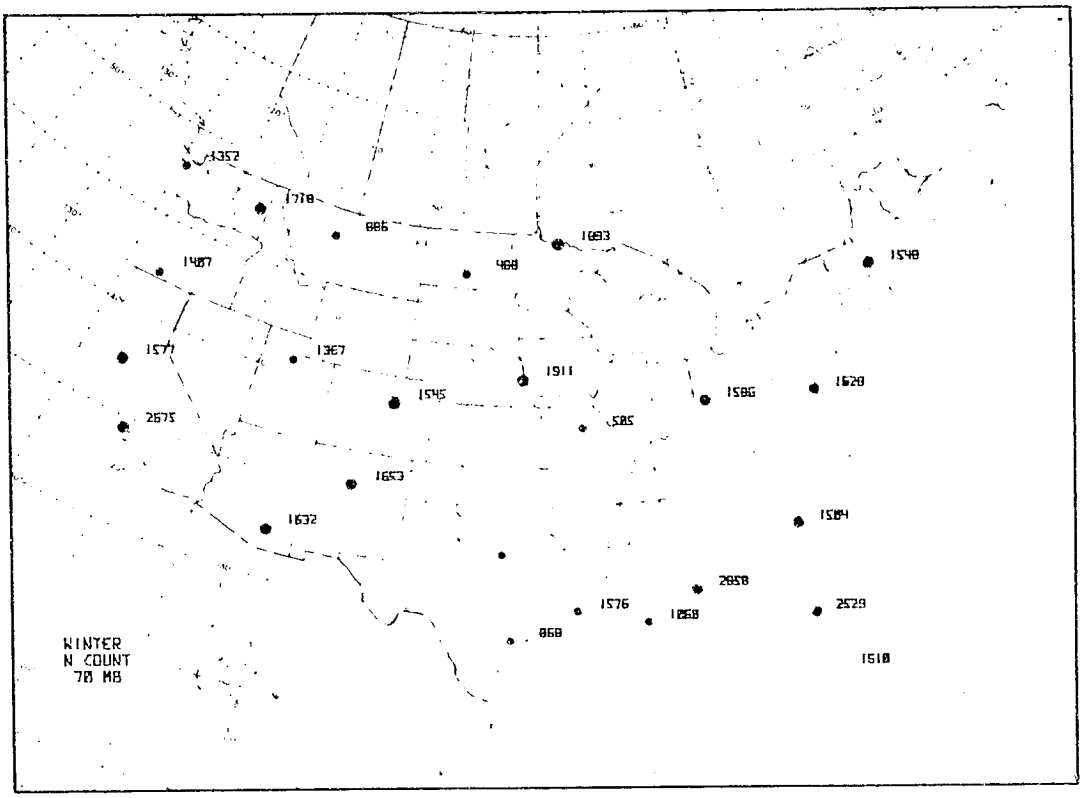
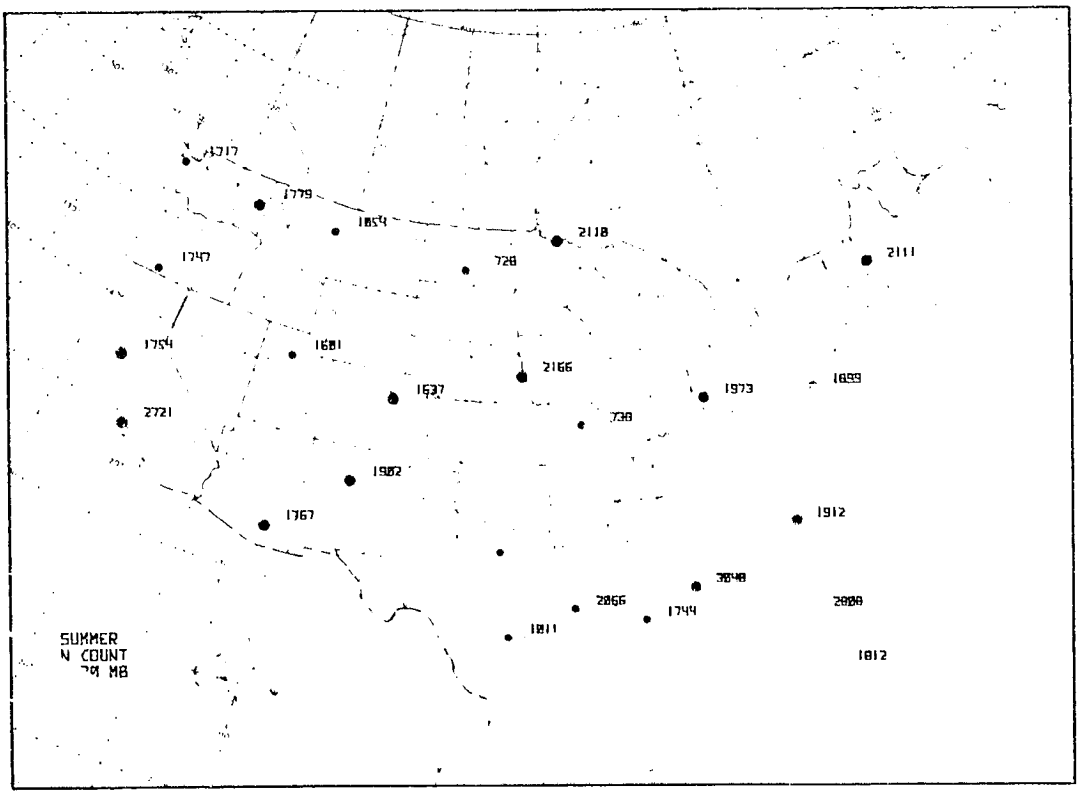
3826
4636
1811
3292






4352
1778
886
1883
1487
488
1548
1577
1367
1911
1545
1586
1620
2675
585
1653
1632
1584
2858
1576
1868
2529
868
1510
WINTER
N COUNT
70 MB


1717
1779
1854
2118
2111
1747
728
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1681
2166
1637
1973
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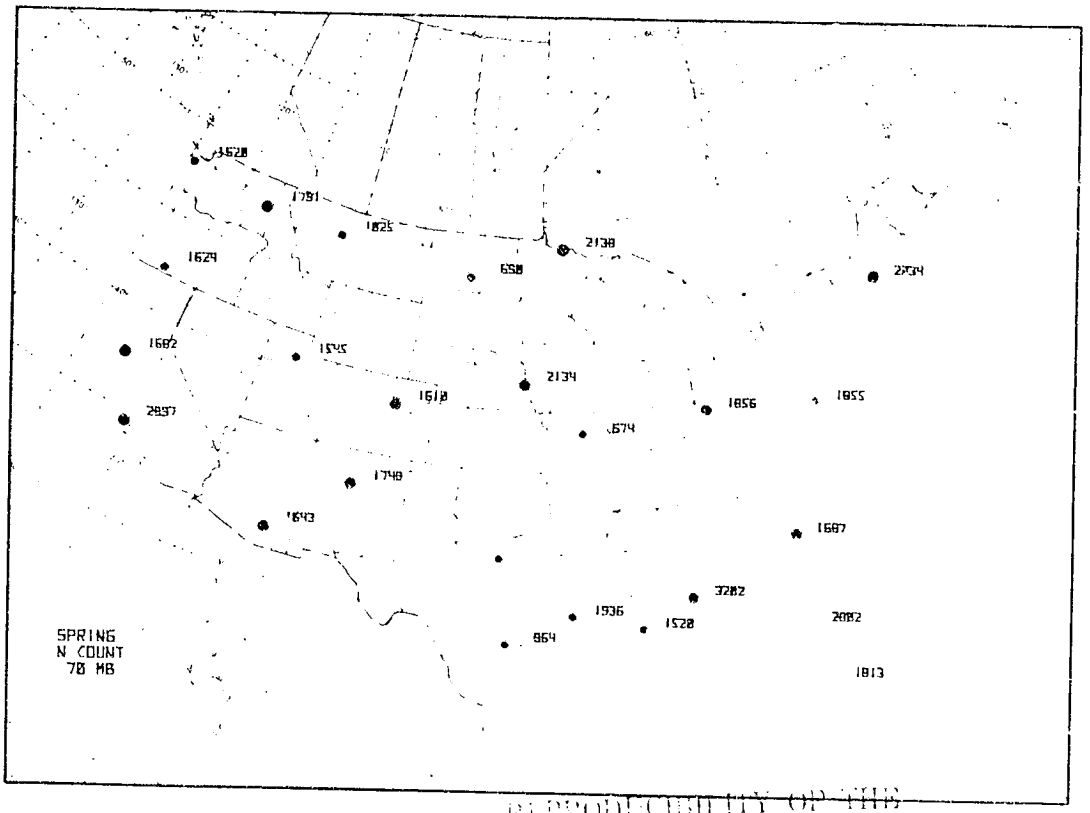
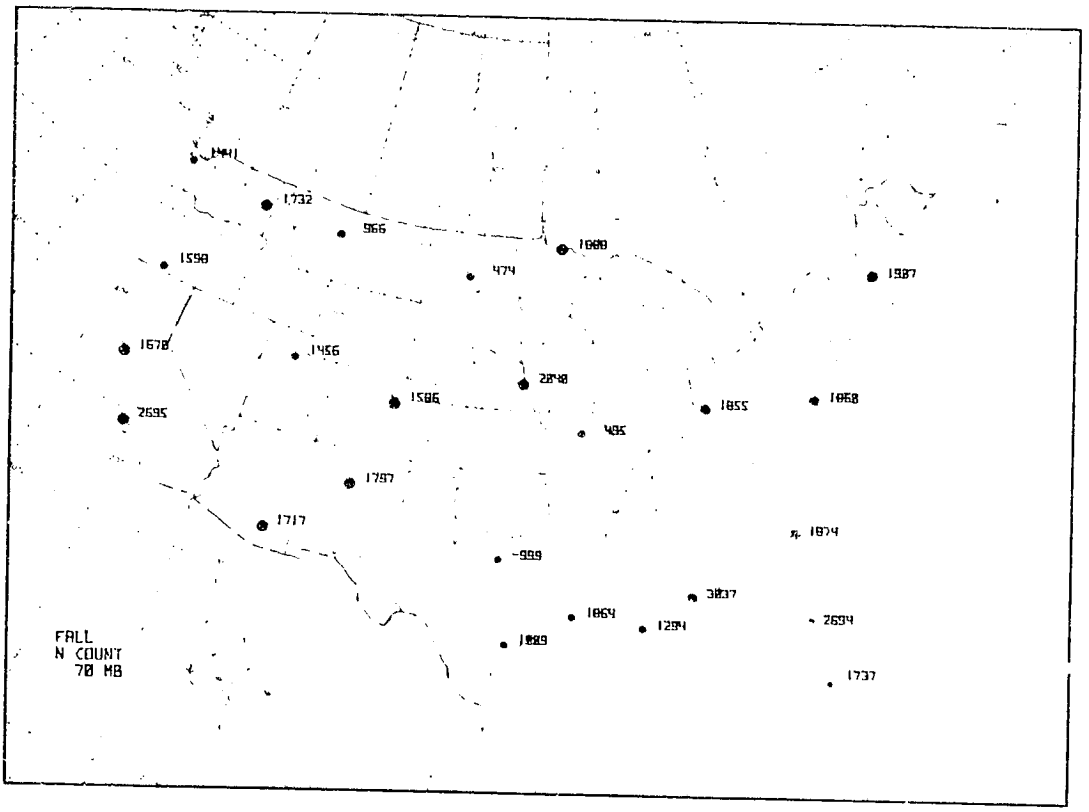
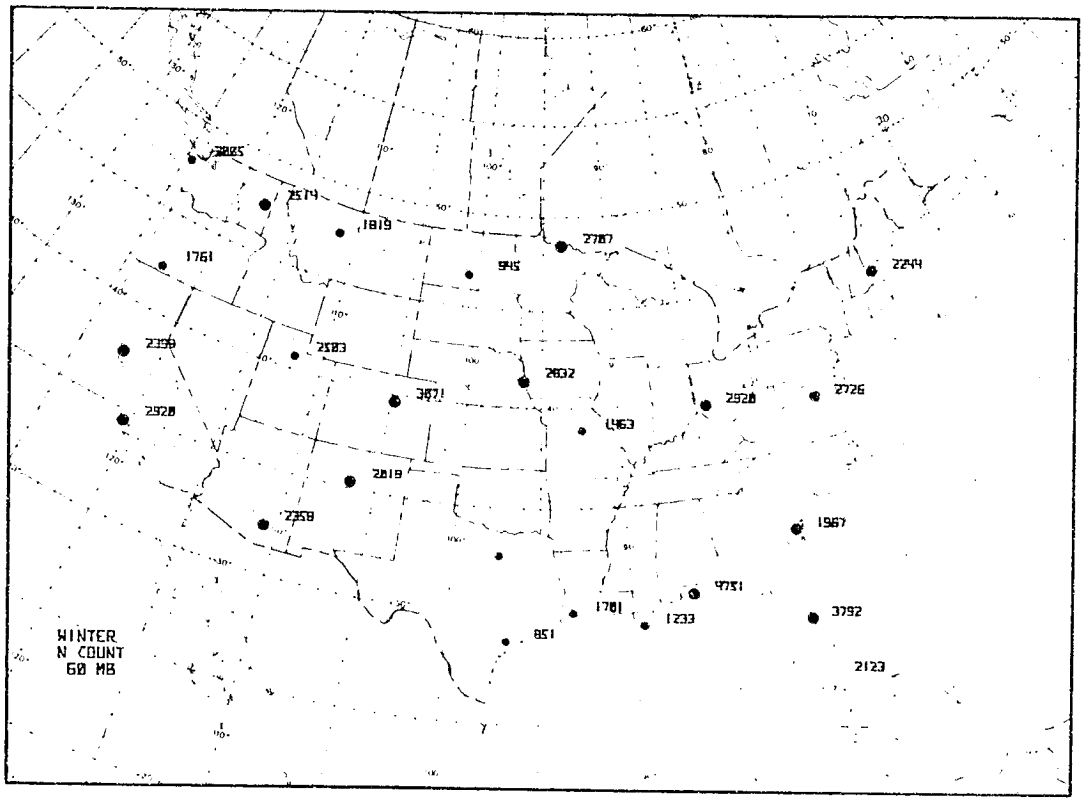
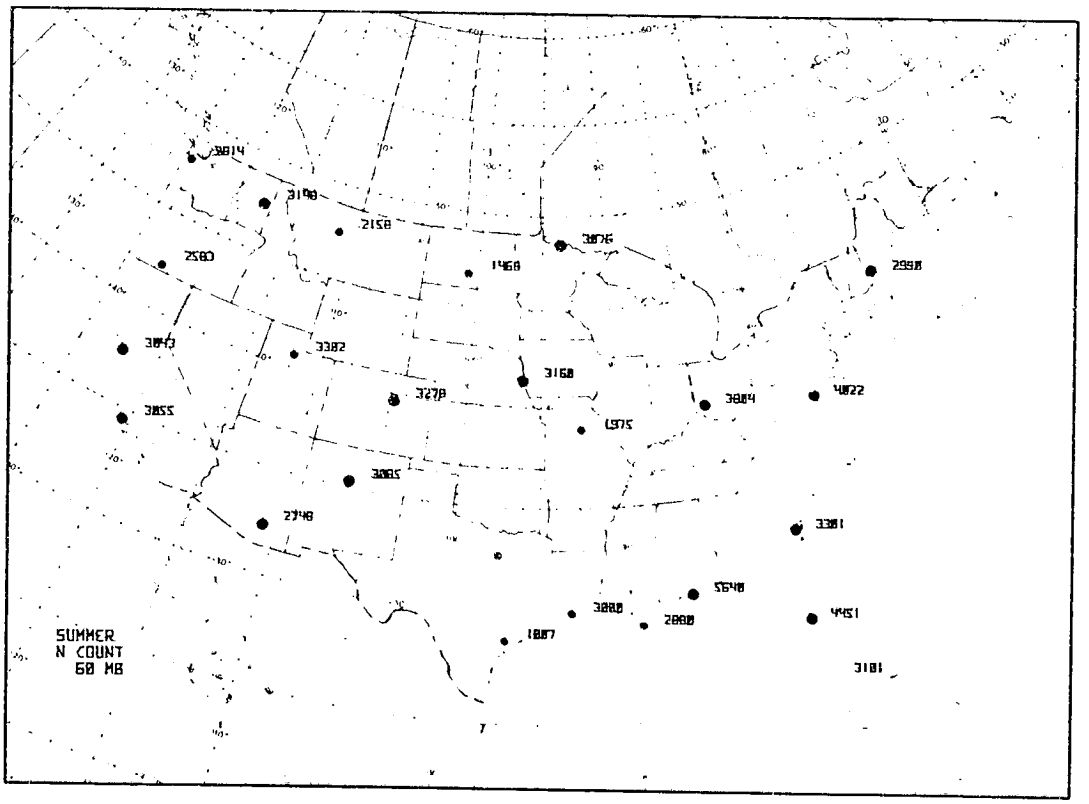
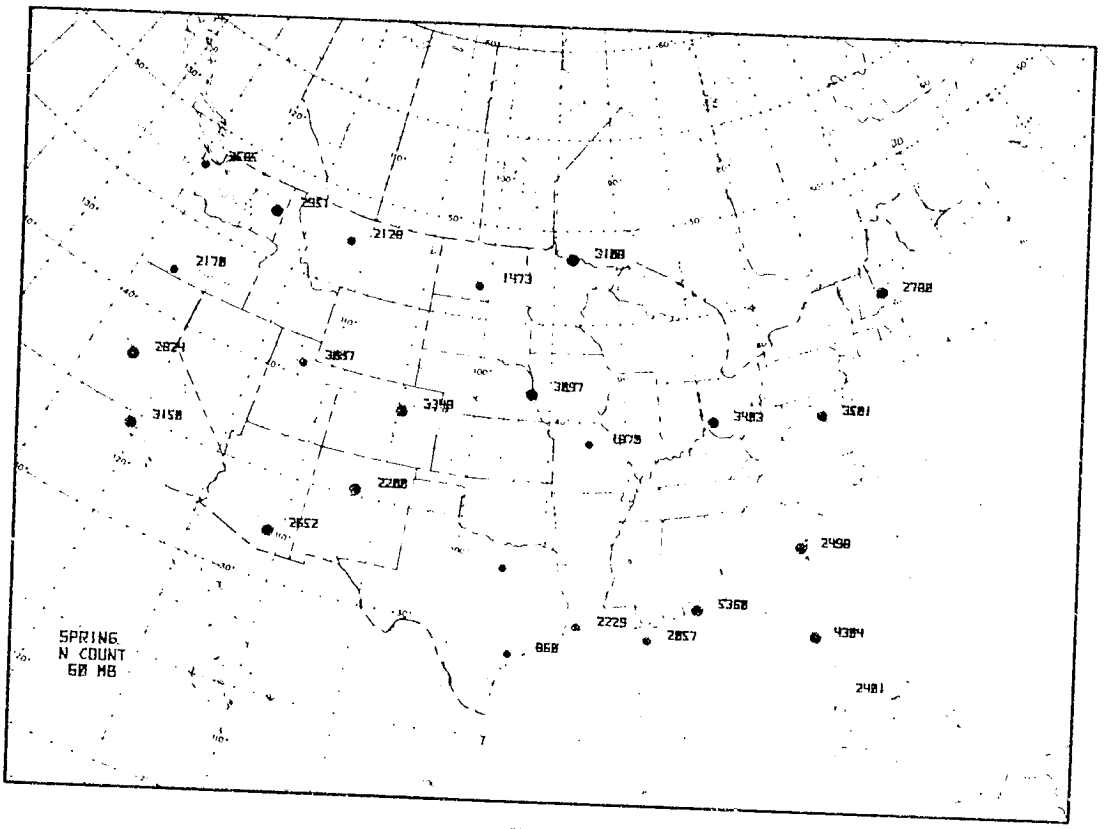
1982
1767
1912
3048
2866
1744
2888
1811
1812
SUMMER
N COUNT
70 MB

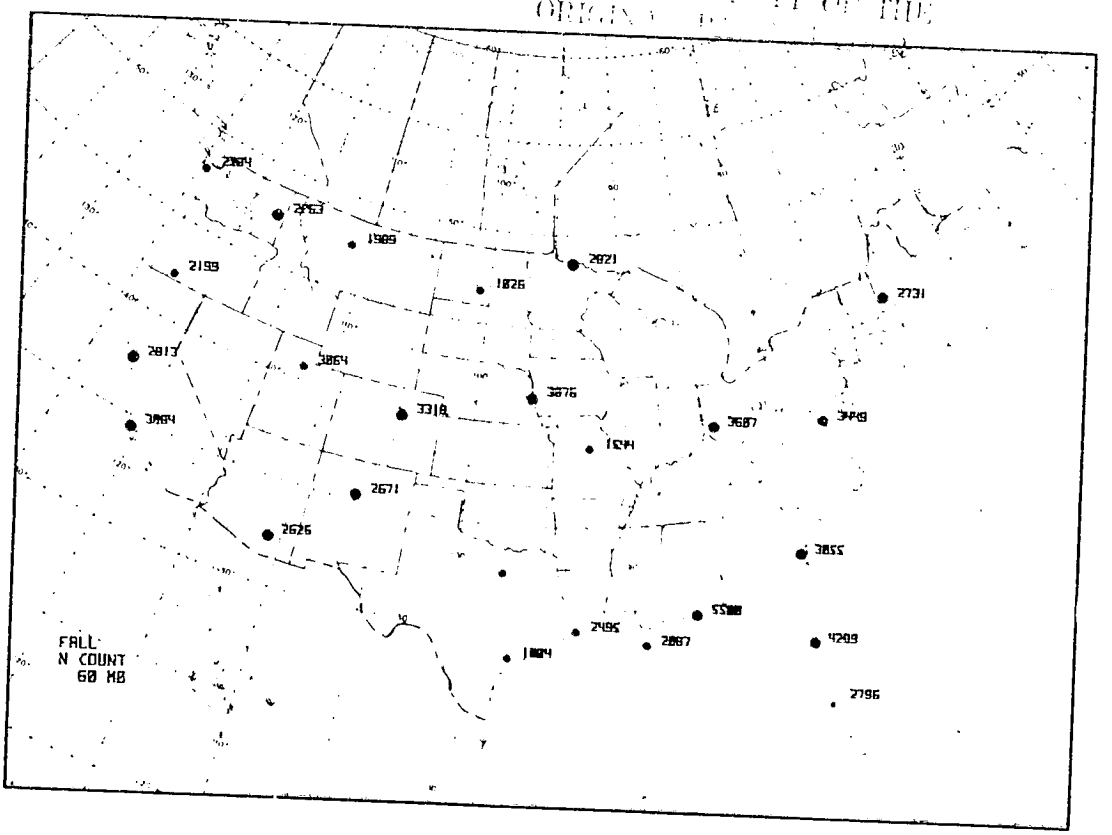


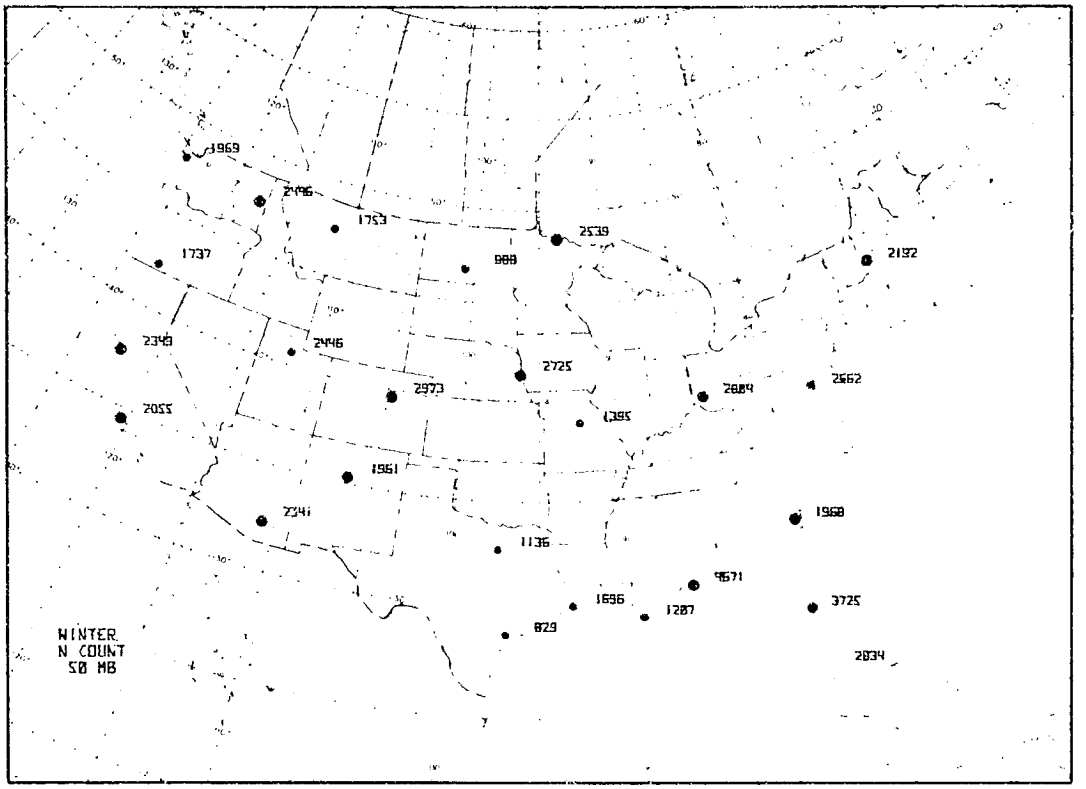



WINTER
N COUNT
60 MB


SUMMER
N COUNT
60 MB






1969
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1737
988
2192
2349
2446
2725
2973
2684
2662
2055
1395
1961
2347
1968
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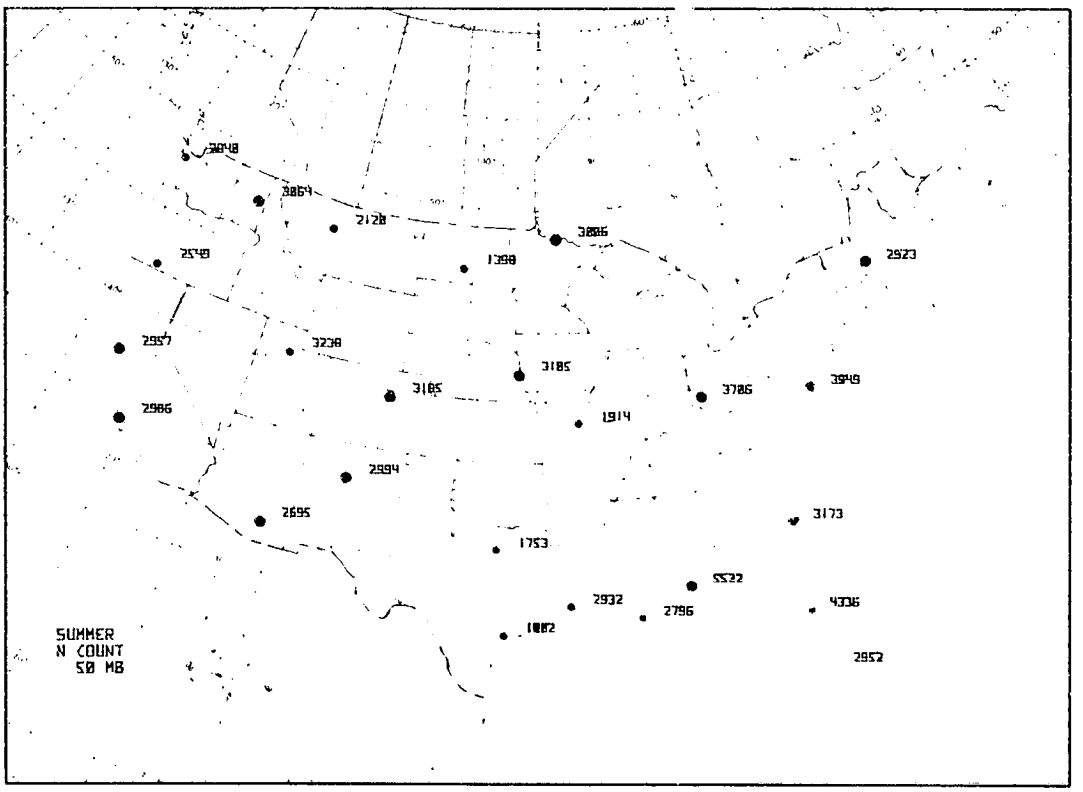
9671
1696
1287
3725
829
2834
WINTER
N COUNT
50 MB


3048
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3886
2923
2549
1398
2957
3238
3185
3185
3786
3949
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1914
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2695
3173
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5532
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2796
4336
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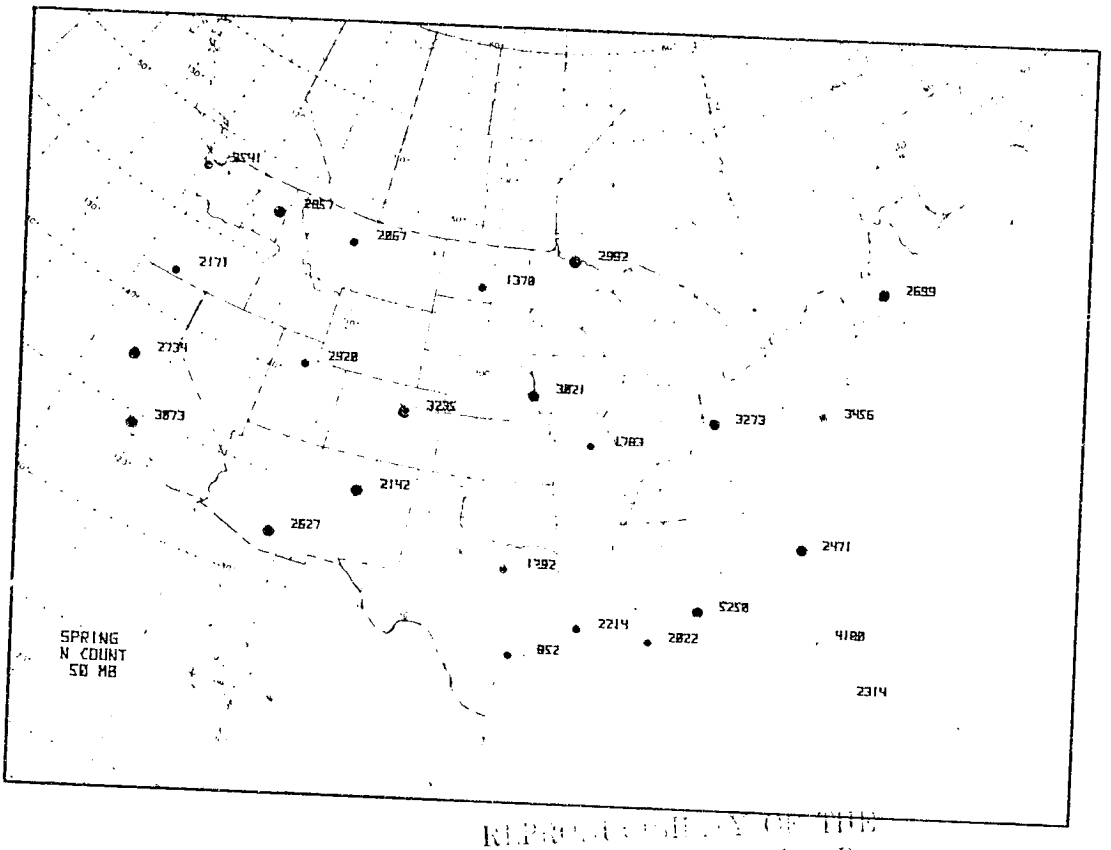
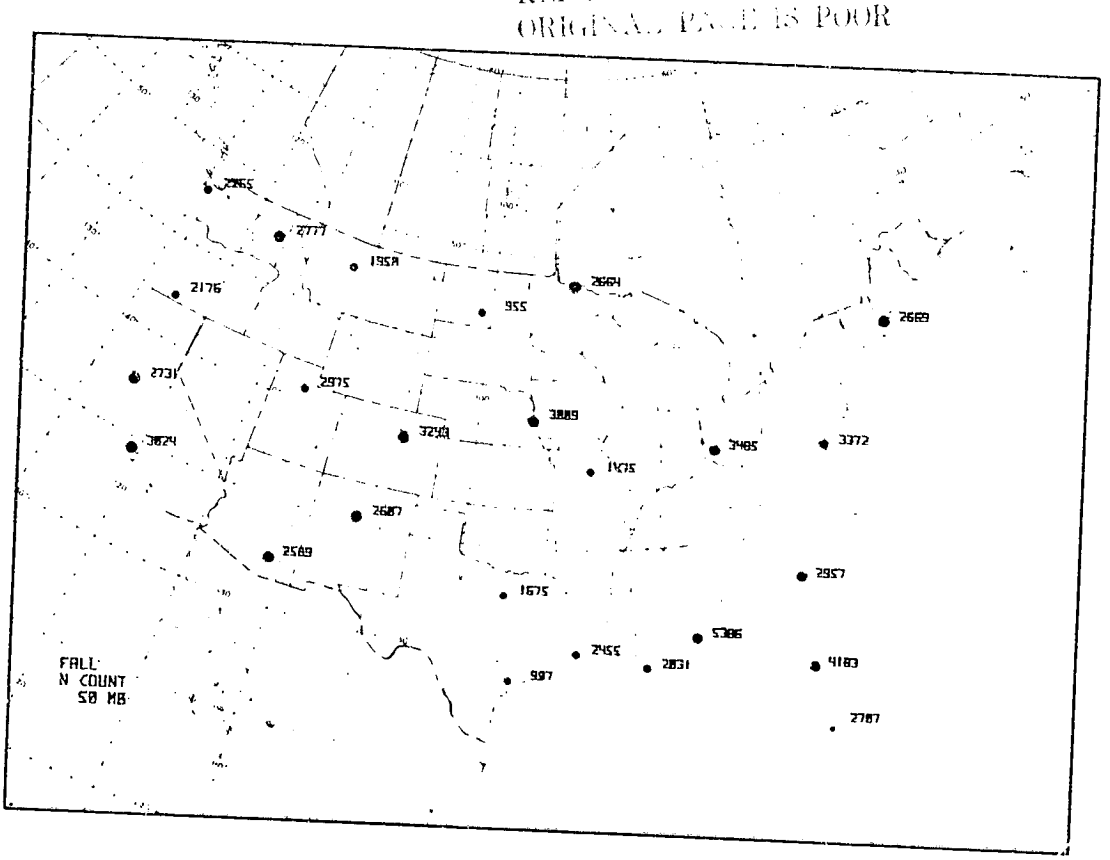
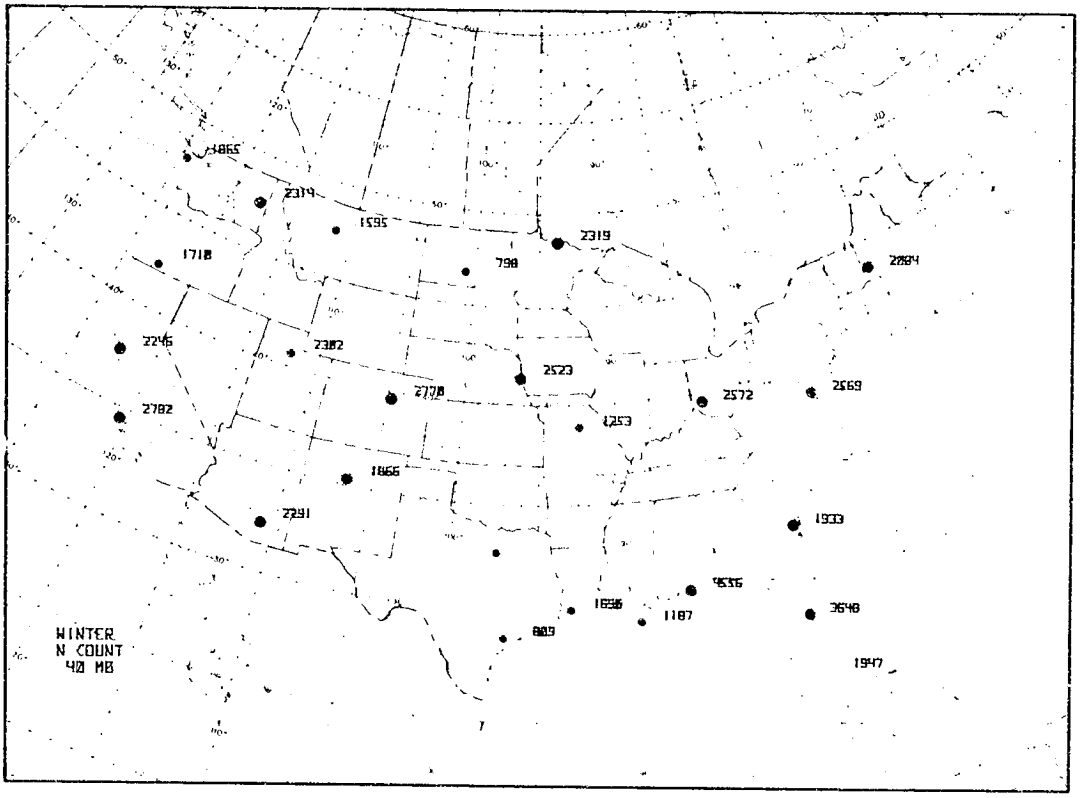
2852
SUMMER
N COUNT
50 MB






1865
2314
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2319
1718
798
2884
2246
2382
2523
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1253
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2291
1933
1656
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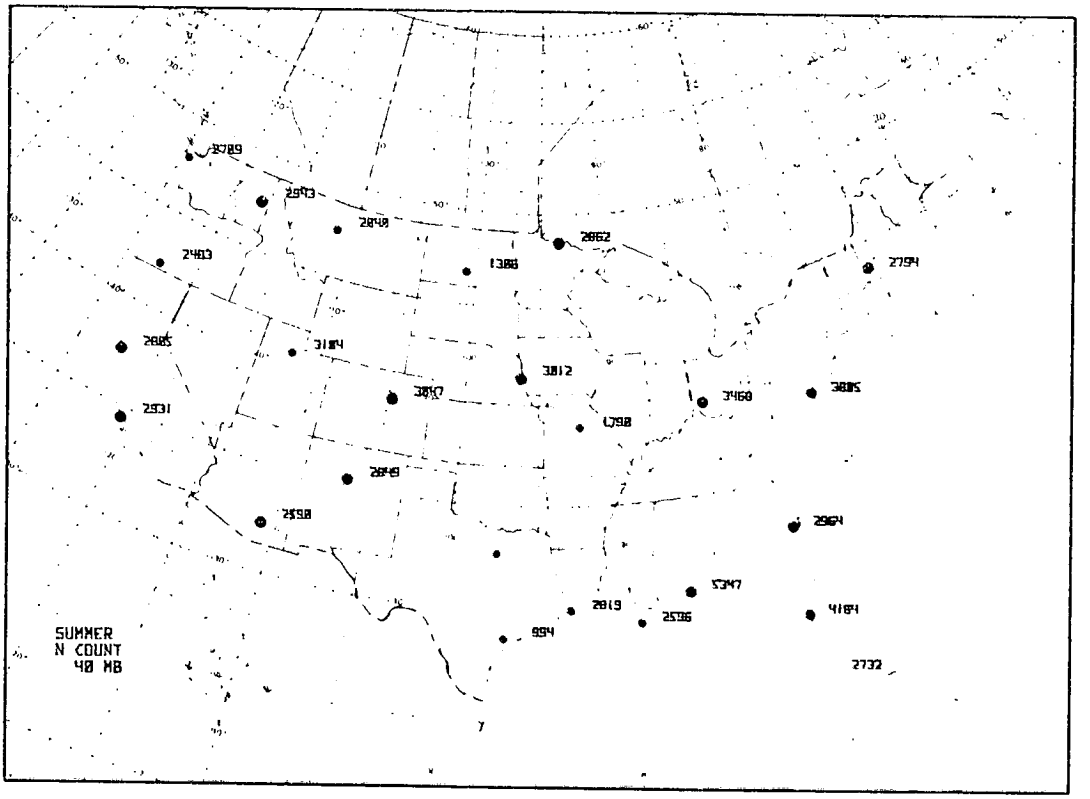
3648
809
1947
WINTER
N COUNT
40 MB


3789
2943
2840
2862
2403
1388
2754
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3184
3812
3847
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4184
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2732
SUMMER
N COUNT
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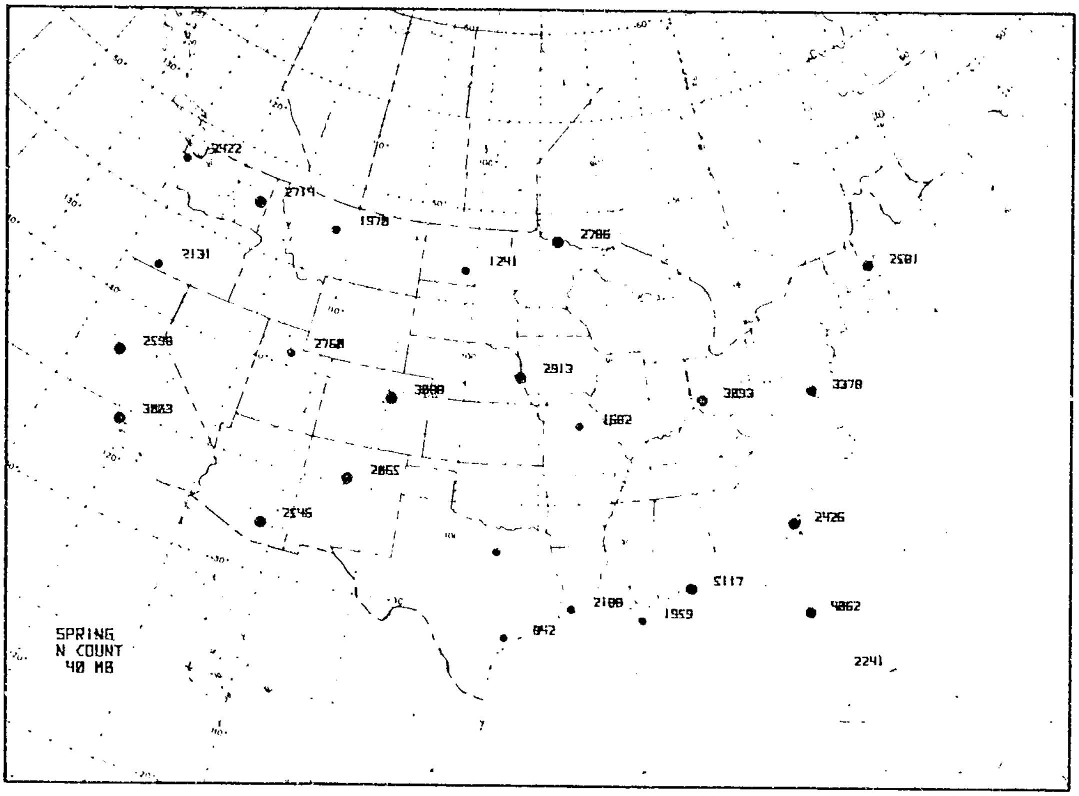
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2768
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4862
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2241
SPRING
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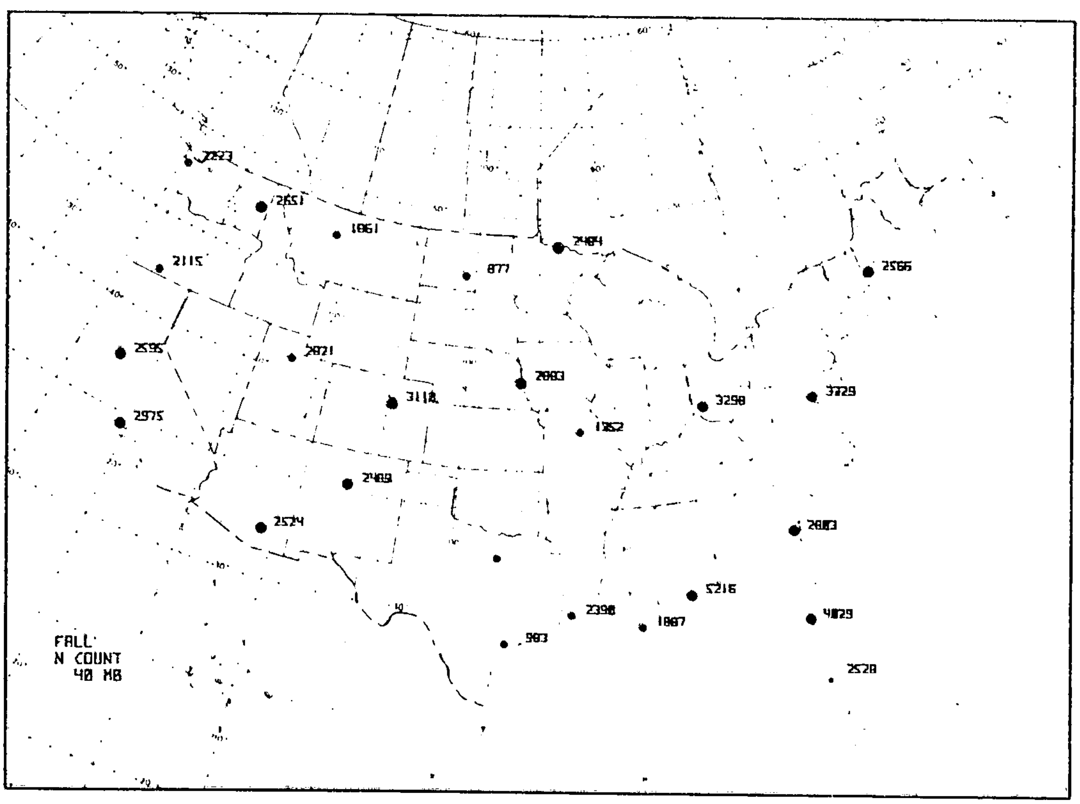
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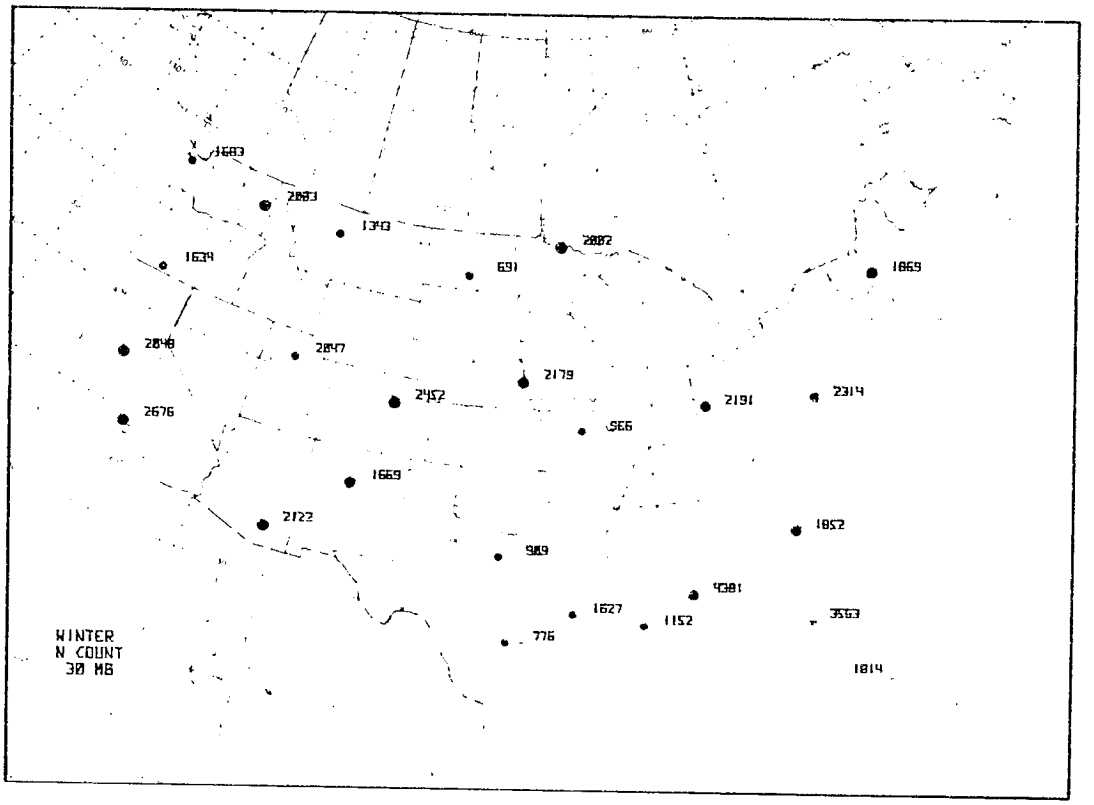
4829
983
2528
FALL
N COUNT
40 MB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2882
1634
691
1869
2848
2847
2179
2452
2191
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989
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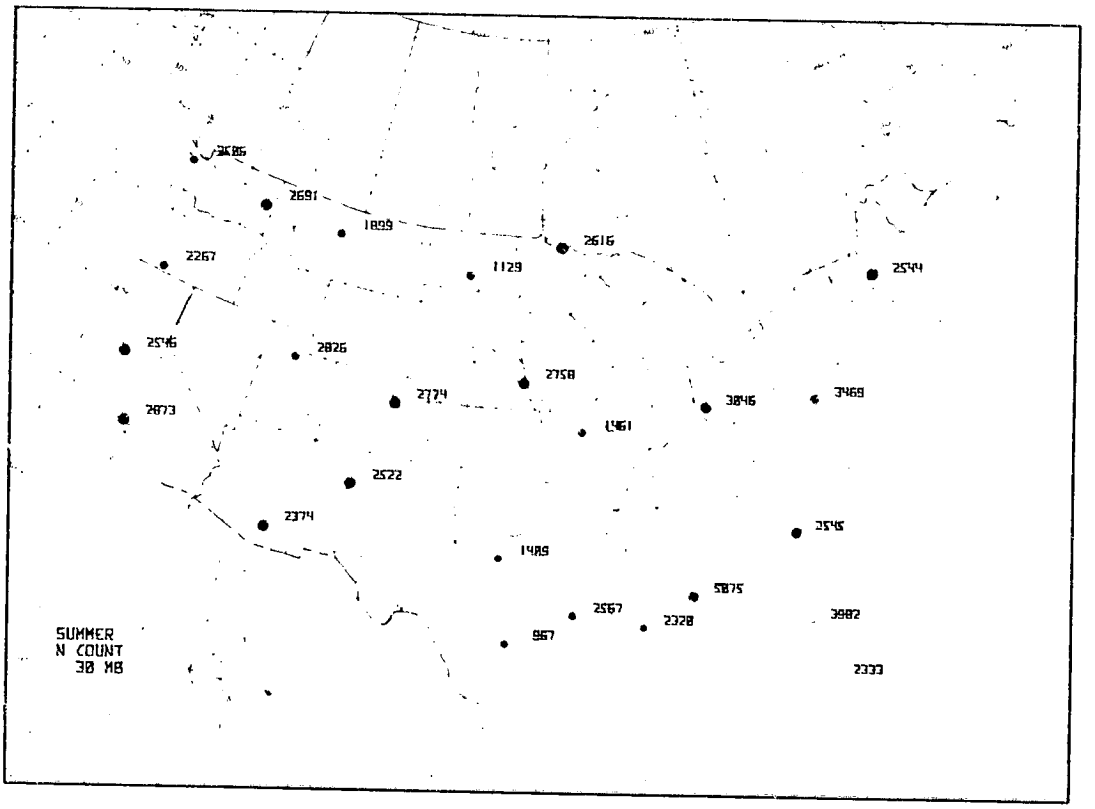
1152
3563
776
1814
WINTER
N COUNT
30 MB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1899
2616
2267
1129
2544
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2826
2758
2774
3846
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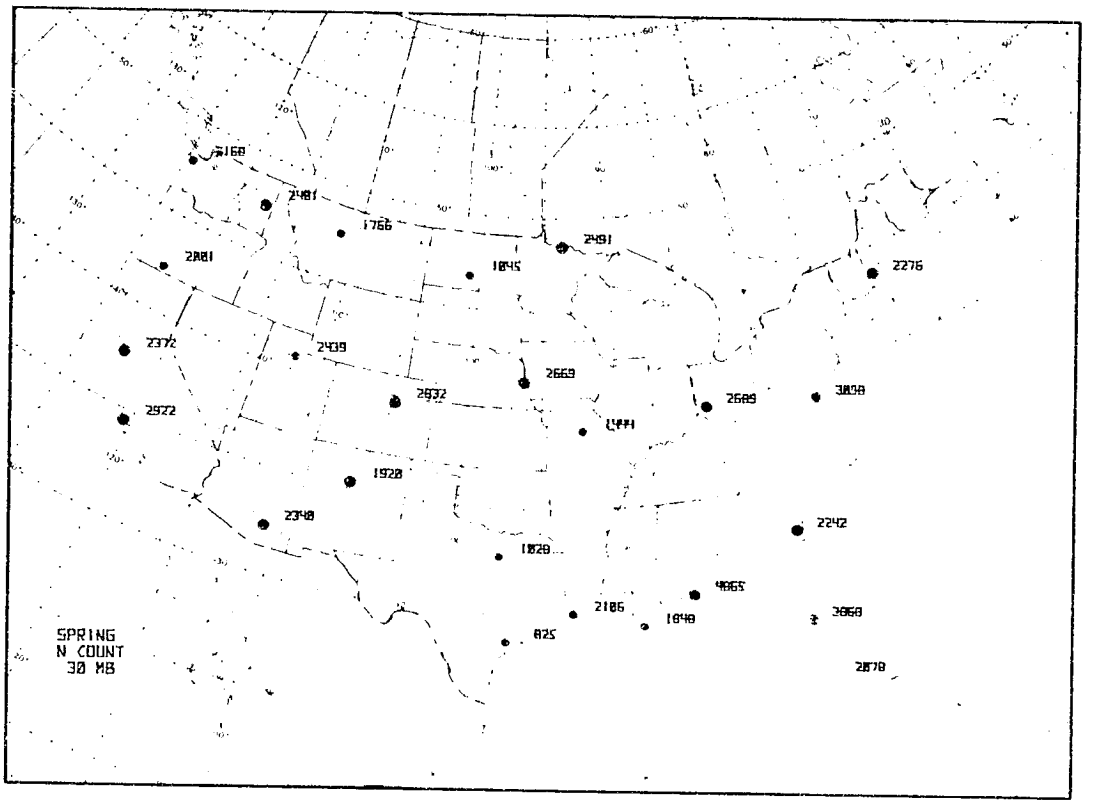
1489
5875
2567
2328
3982
967
2333
SUMMER
N COUNT
30 MB


SPRING
N COUNT
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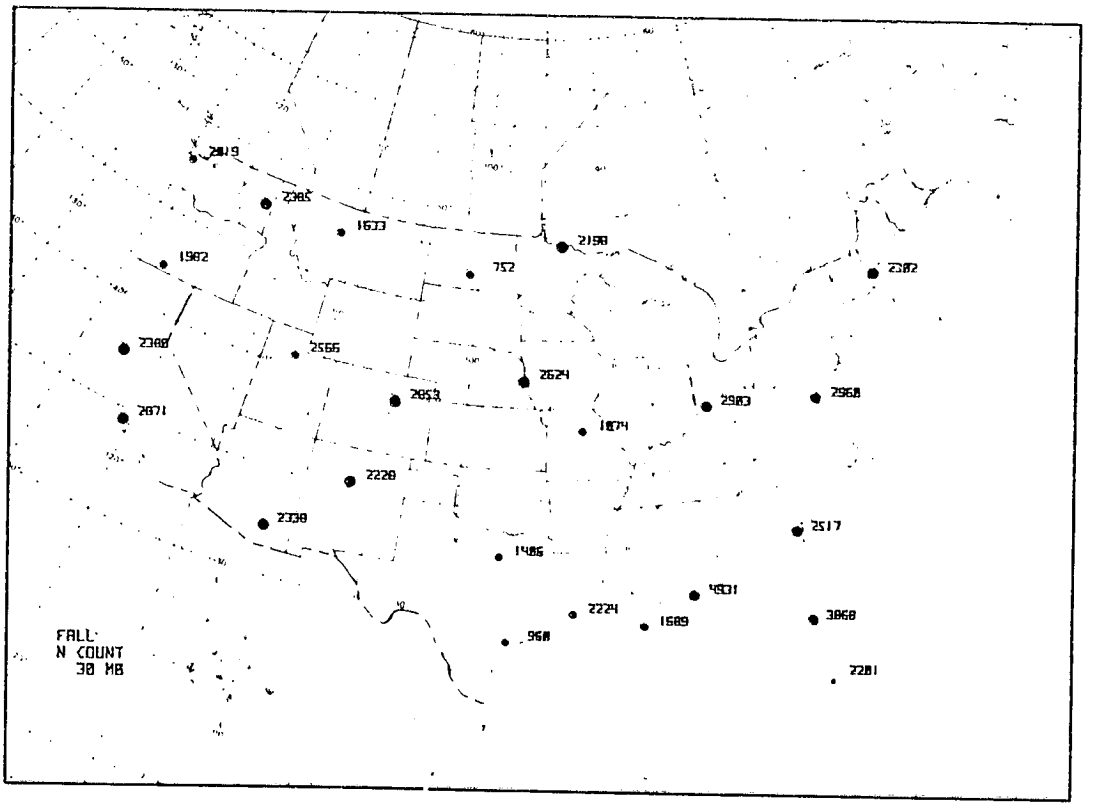
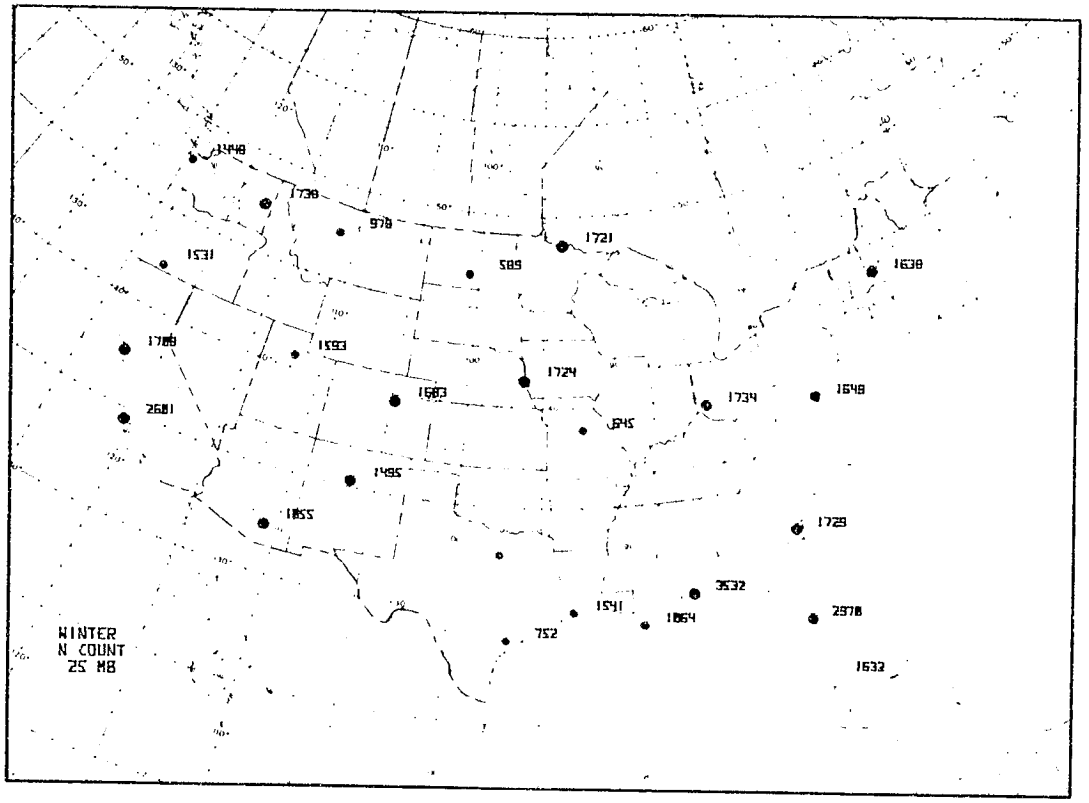

FALL
N COUNT
30 MB


WINTER
N COUNT
25 MB
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1738
978
1721
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589
1638
1788
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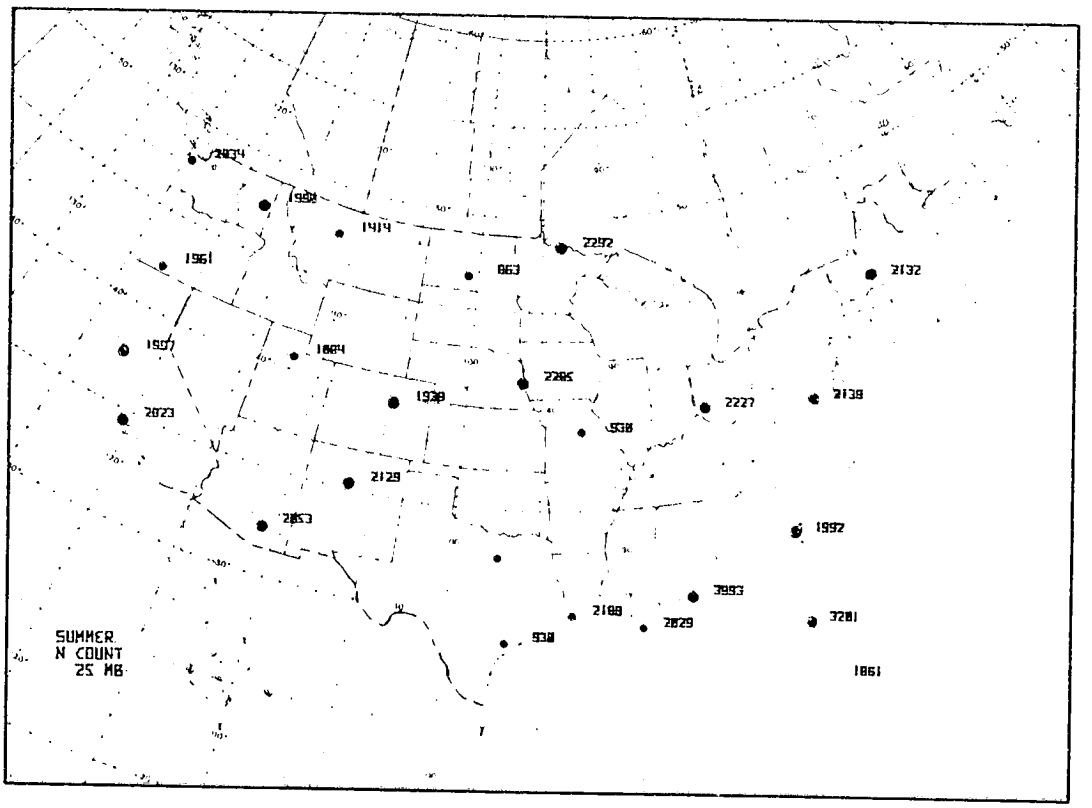
752
1632


SUMMER
N COUNT
25 MB
2434
1980
1414
2292
1961
863
2132
1997
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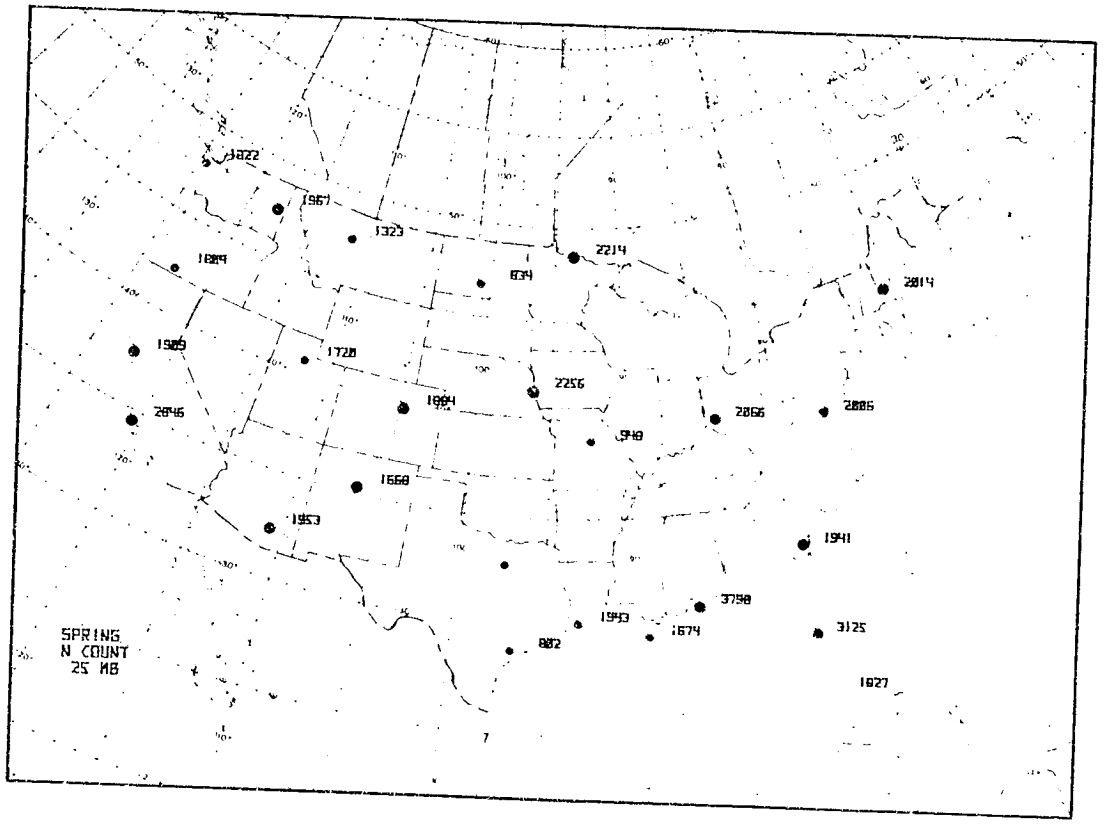
SPRING
N COUNT
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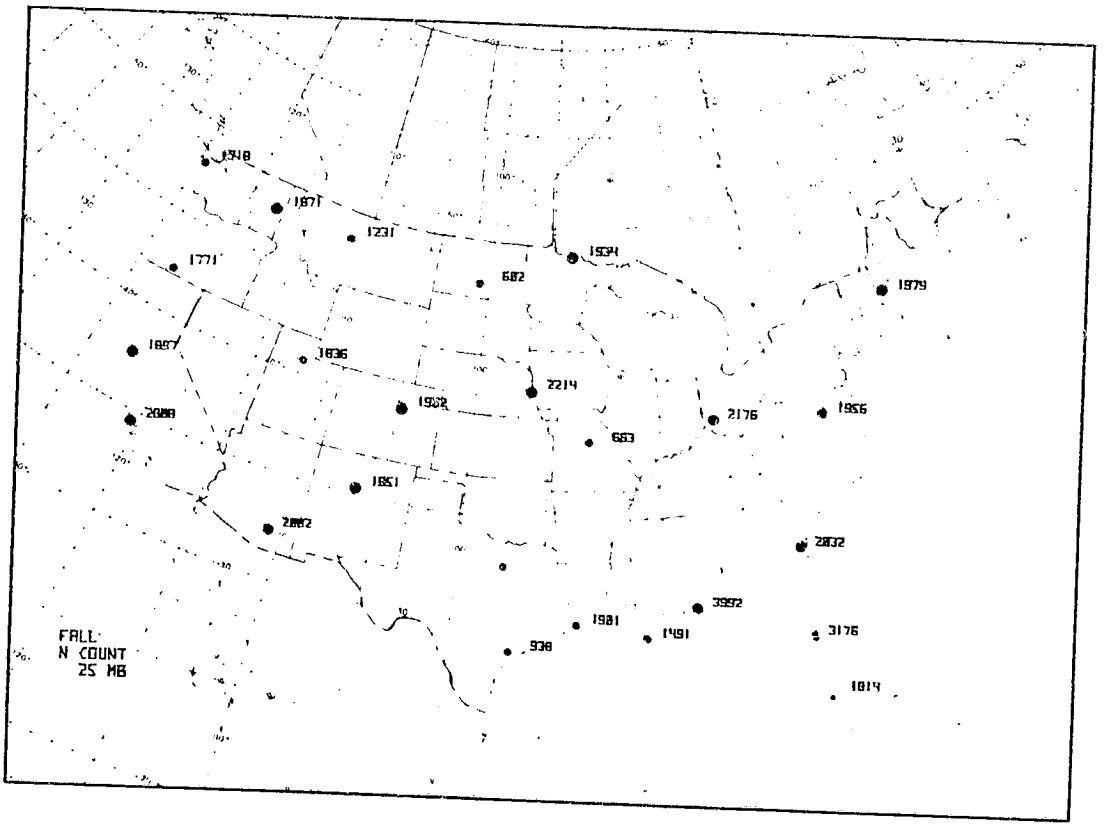
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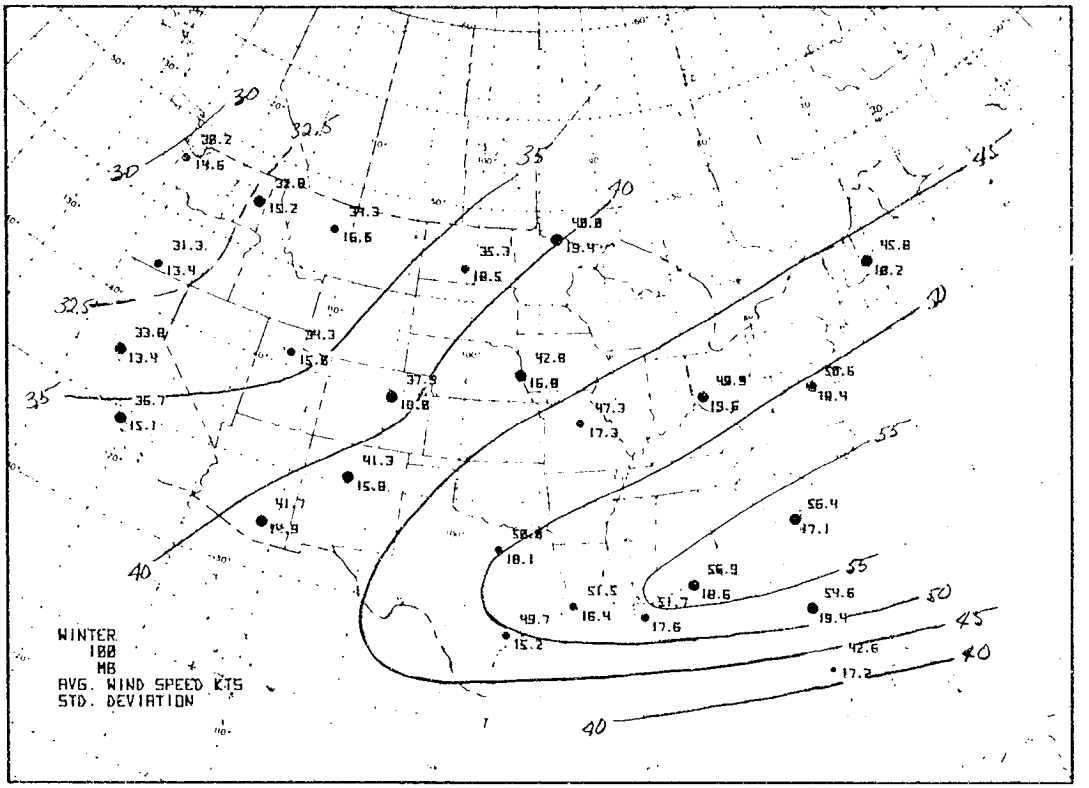
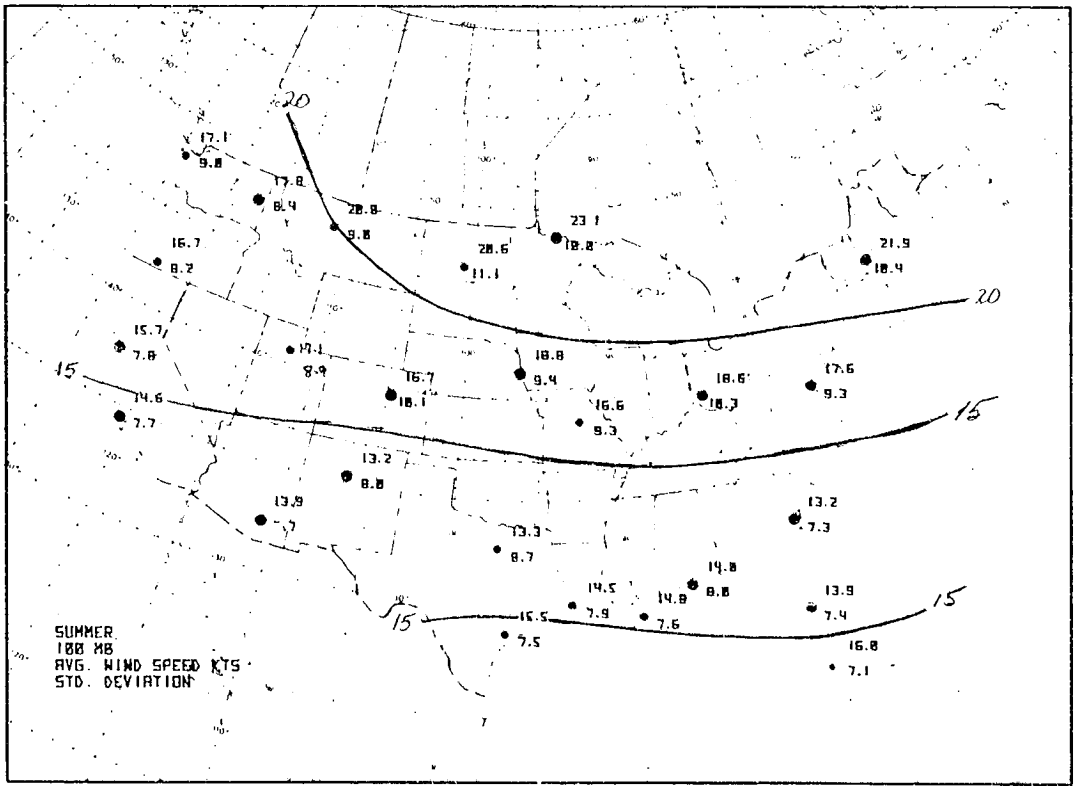
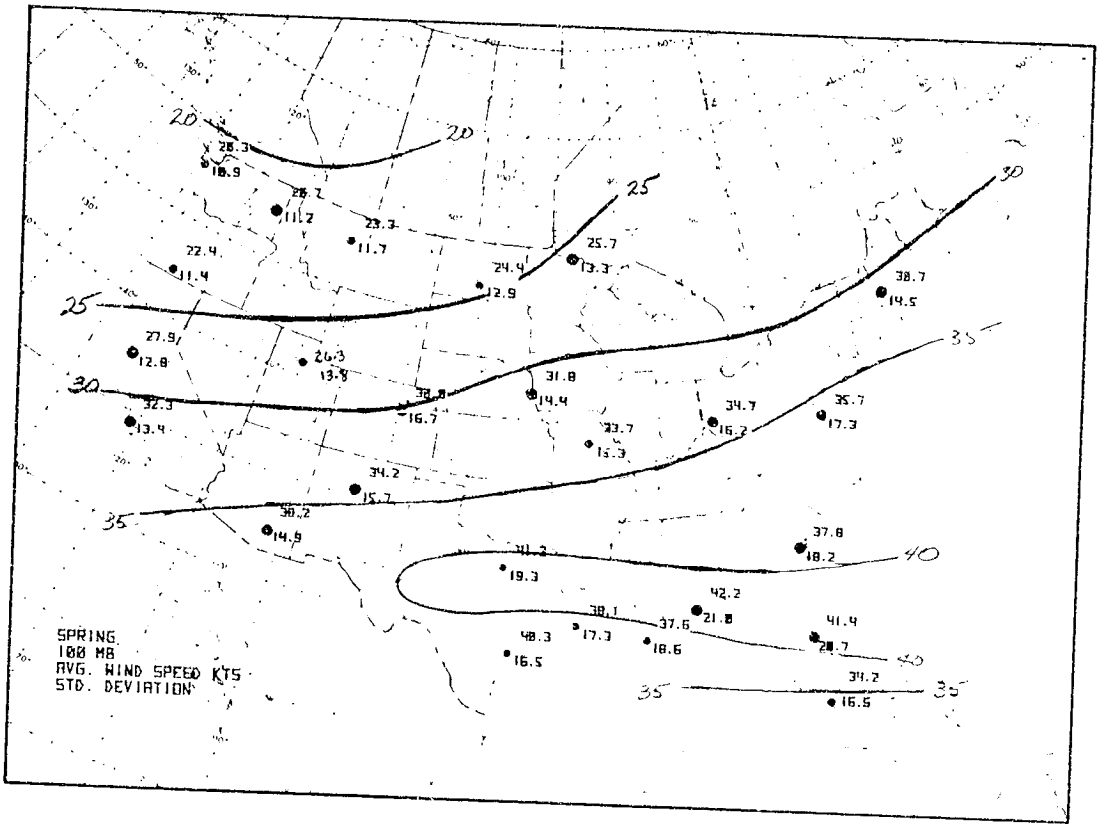
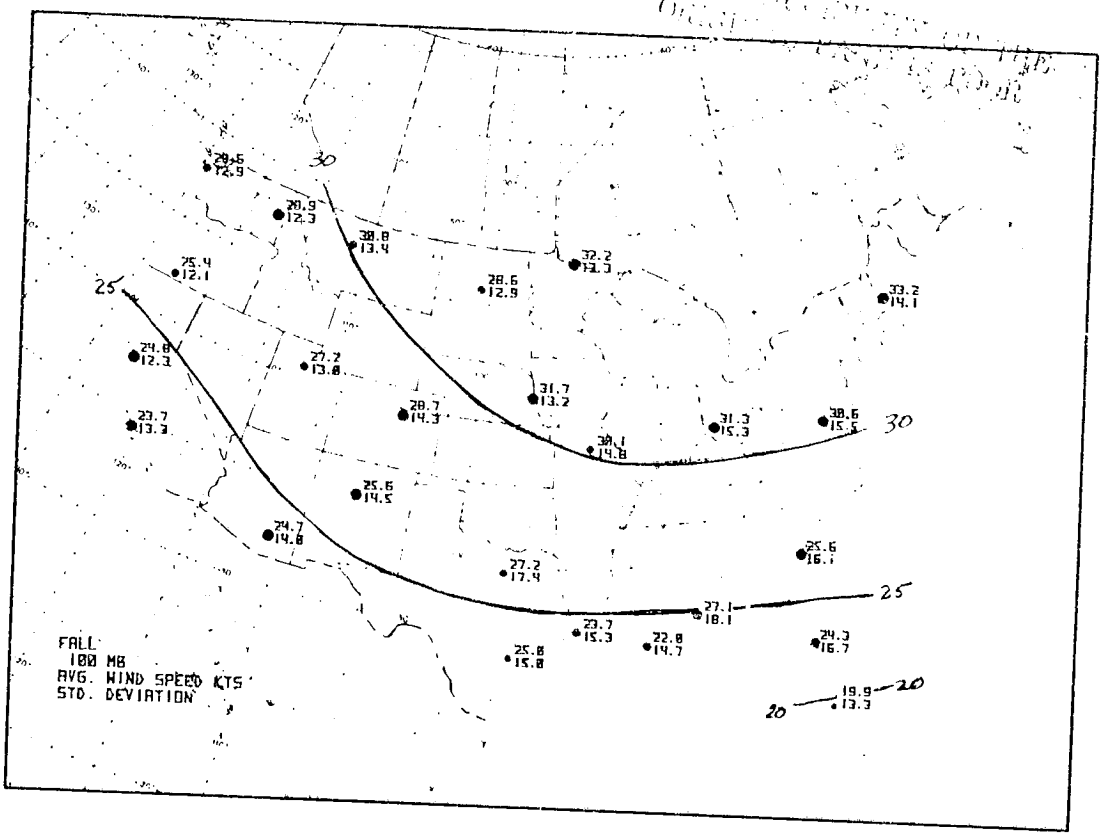
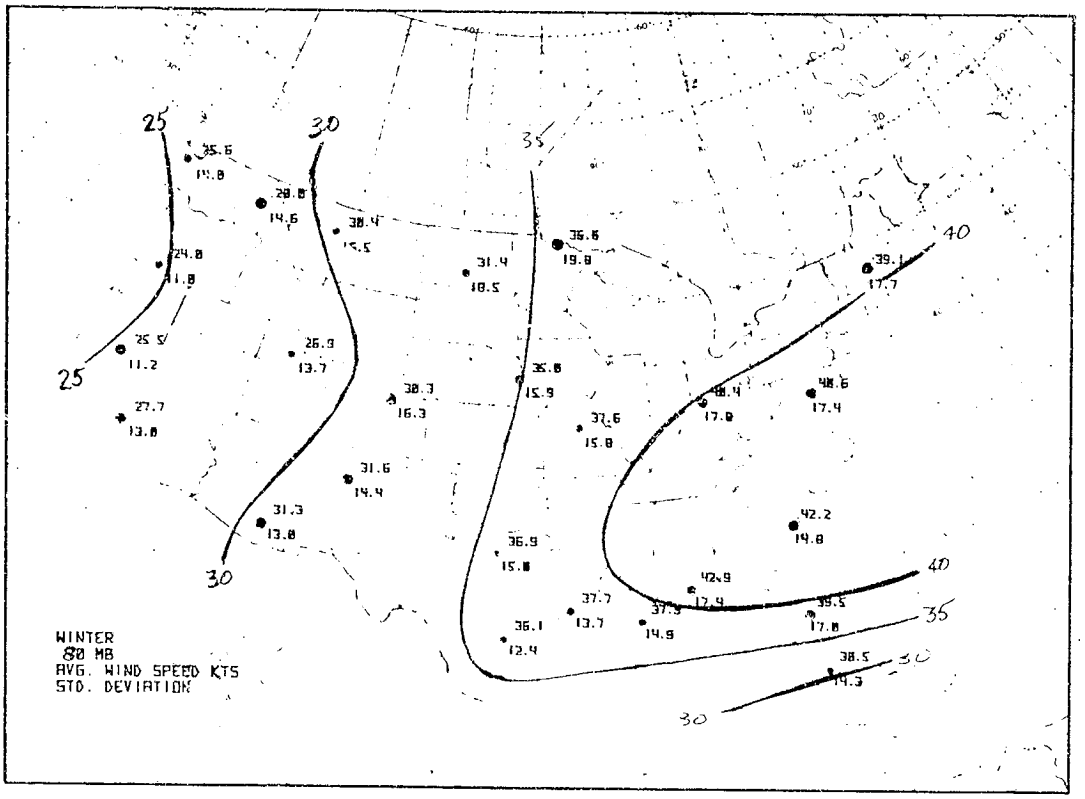
N COUNT
25 MB

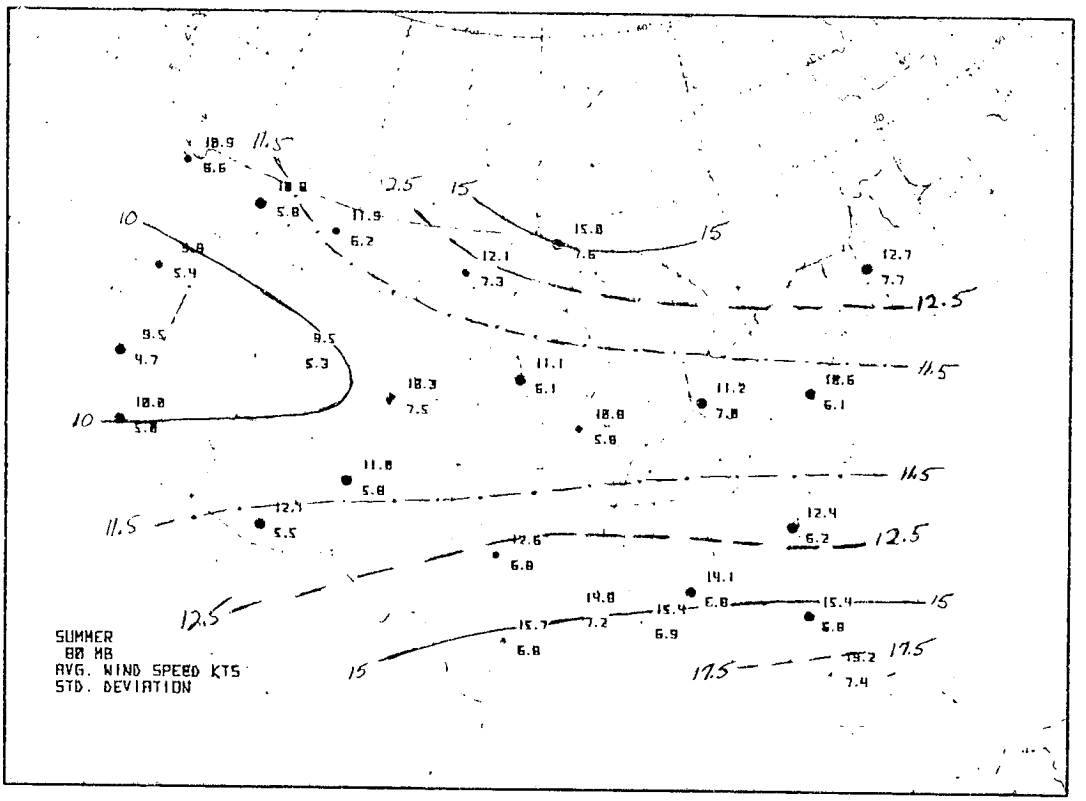

WINTER
100
MB
AVG. WIND SPEED KTS
STD. DEVIATION


SUMMER
100 MB
AVG. WIND SPEED KTS
STD. DEVIATION


SPRING
100 MB
AVG. WIND SPEED KTS
STD. DEVIATION


FALL
100 MB
AVG. WIND SPEED KTS
STD. DEVIATION


WINTER
80 MB
AVG. WIND SPEED KTS
STD. DEVIATION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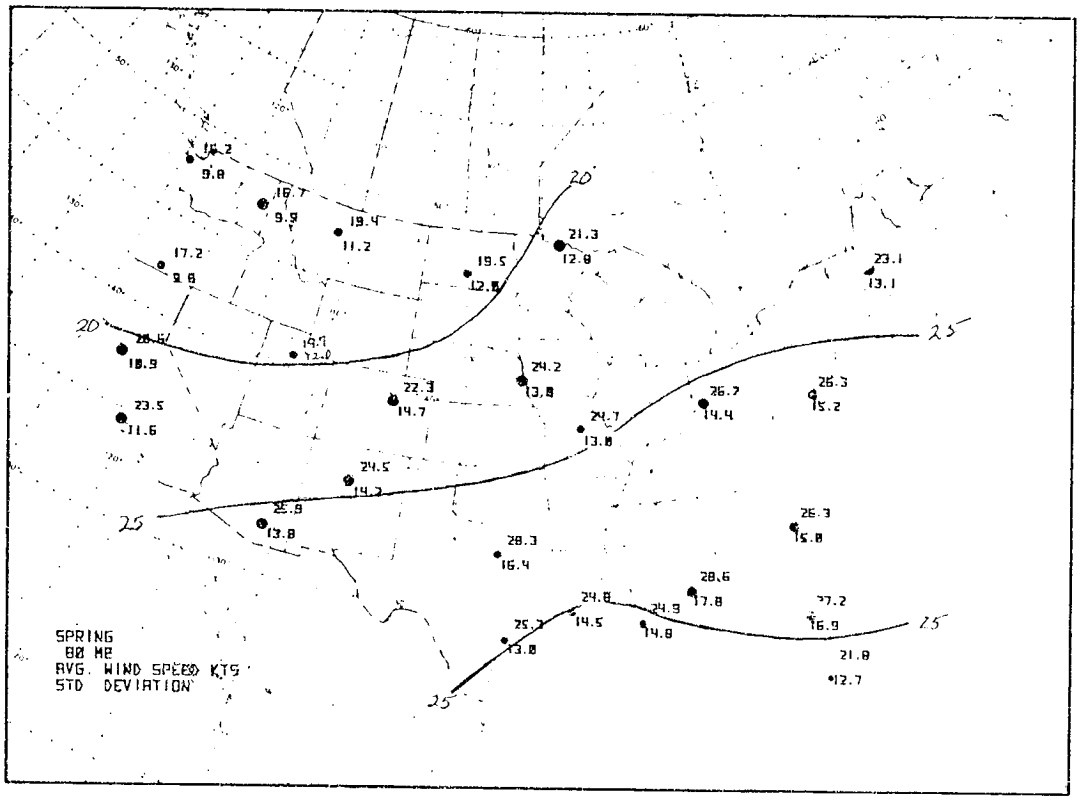
STD. DEVIATION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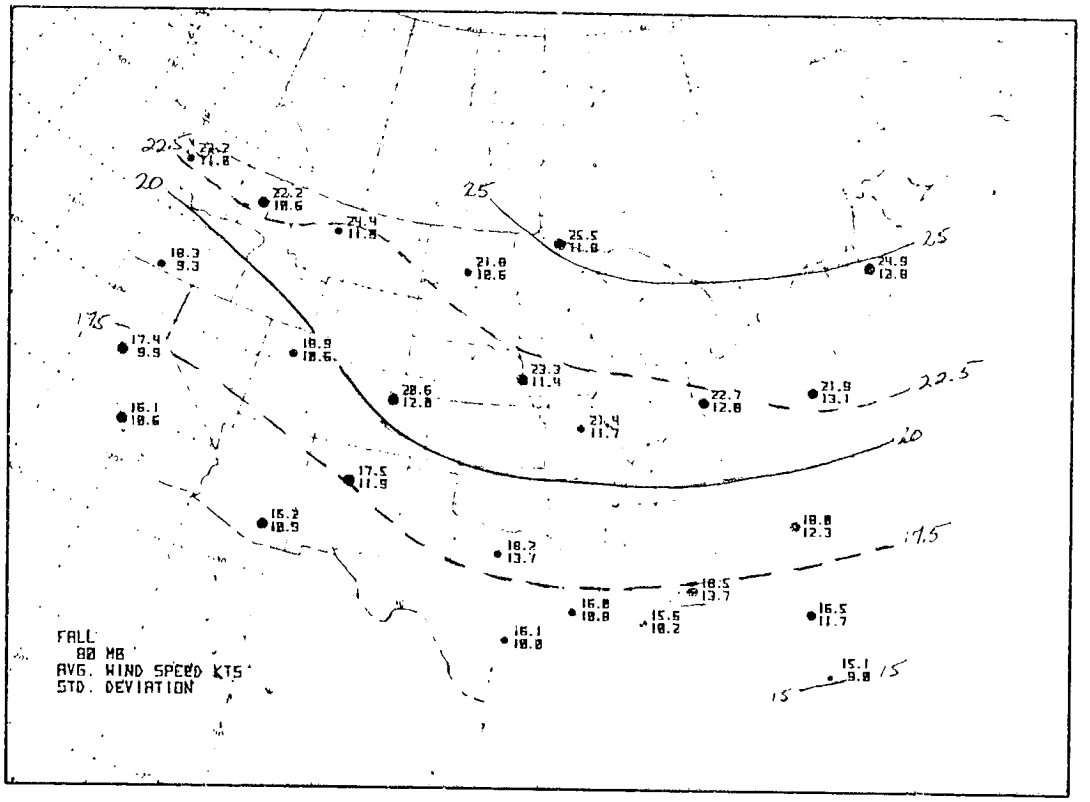
STD DEVIATION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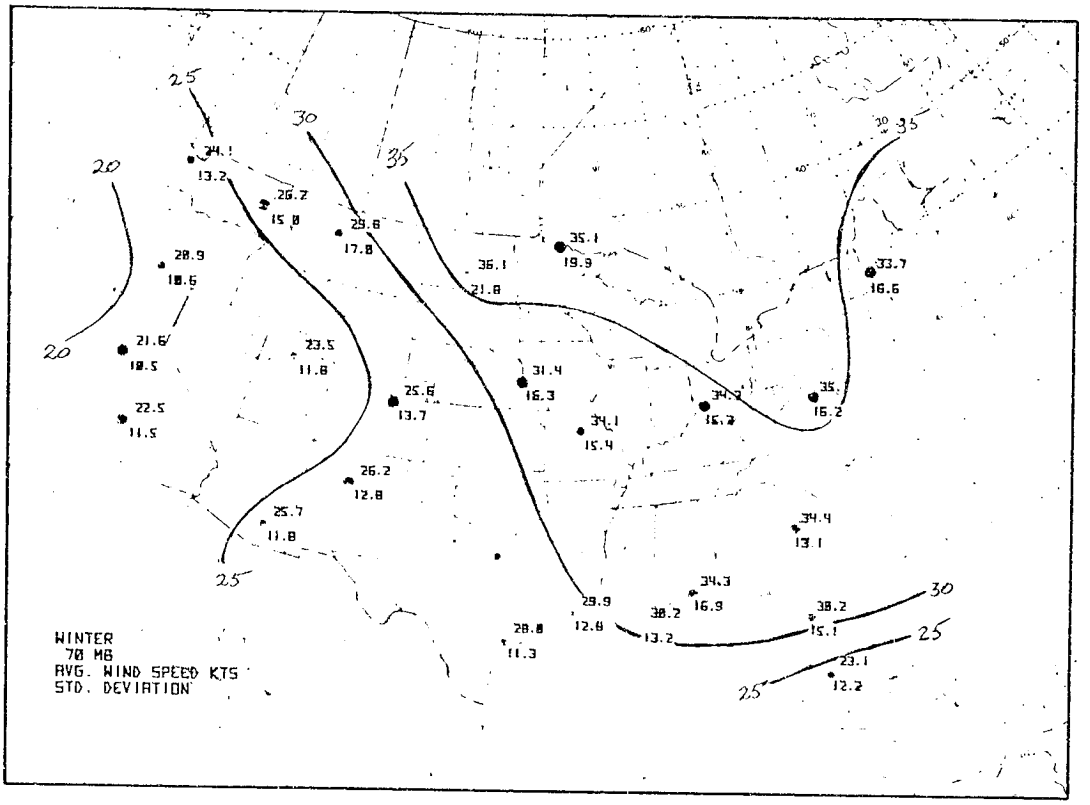
STD. DEVIATION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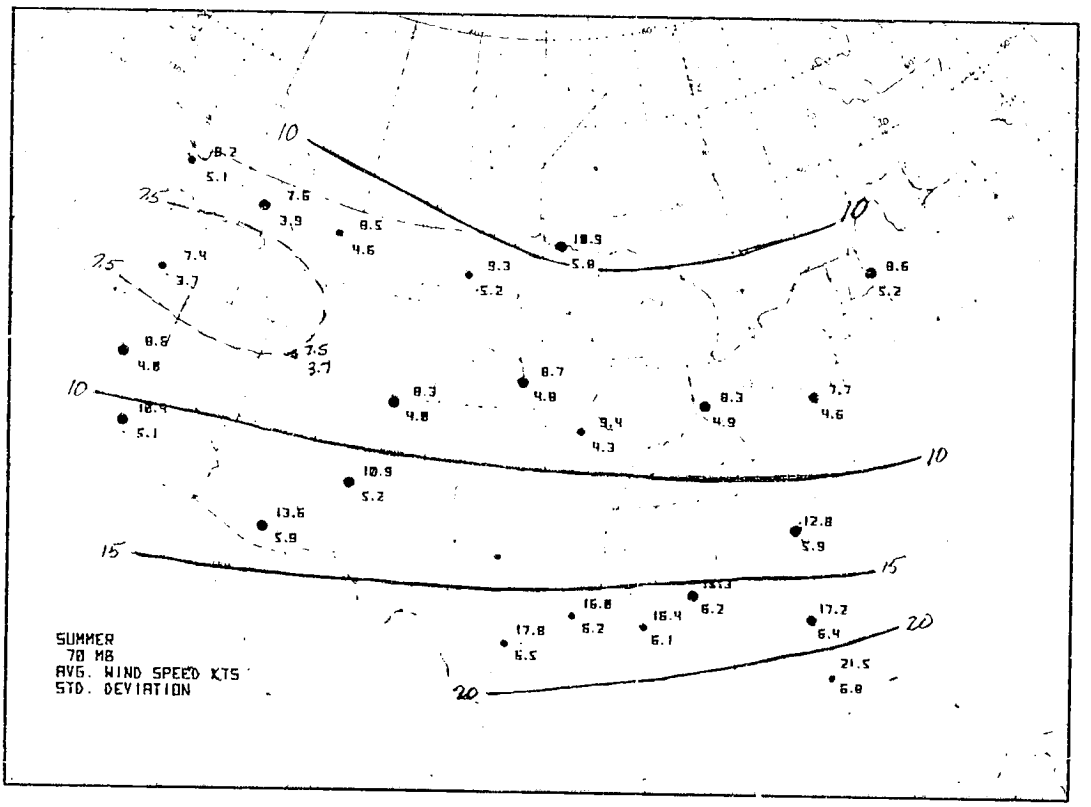
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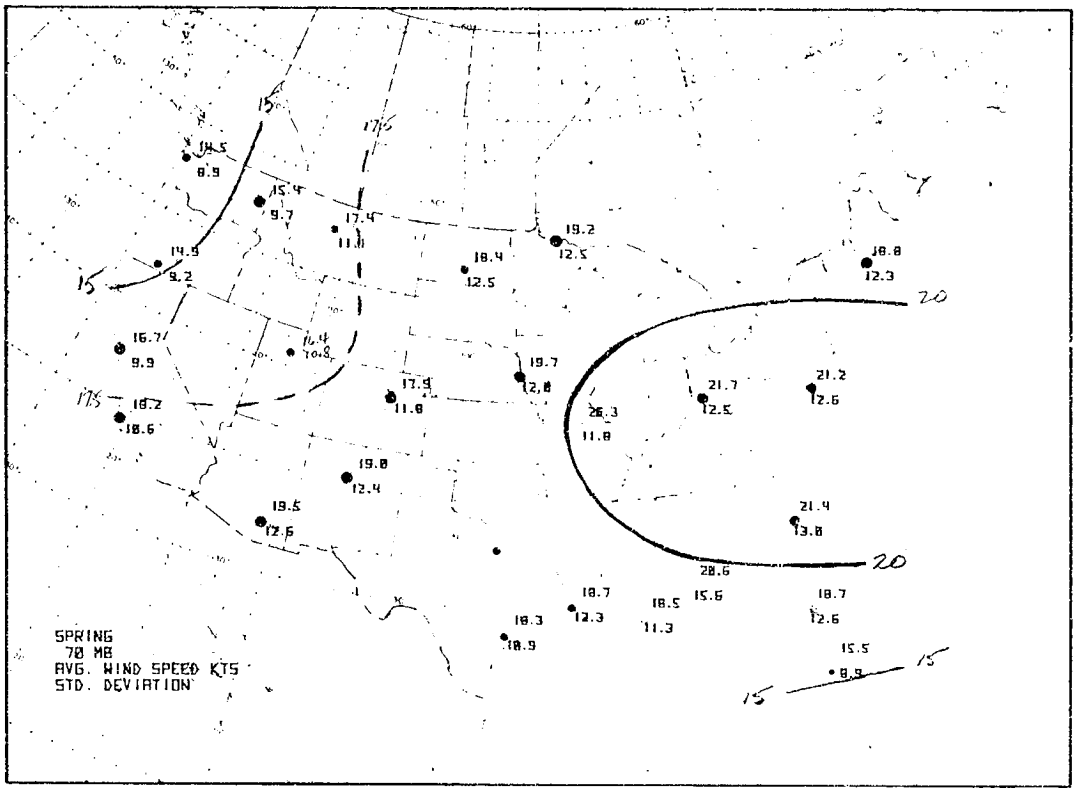
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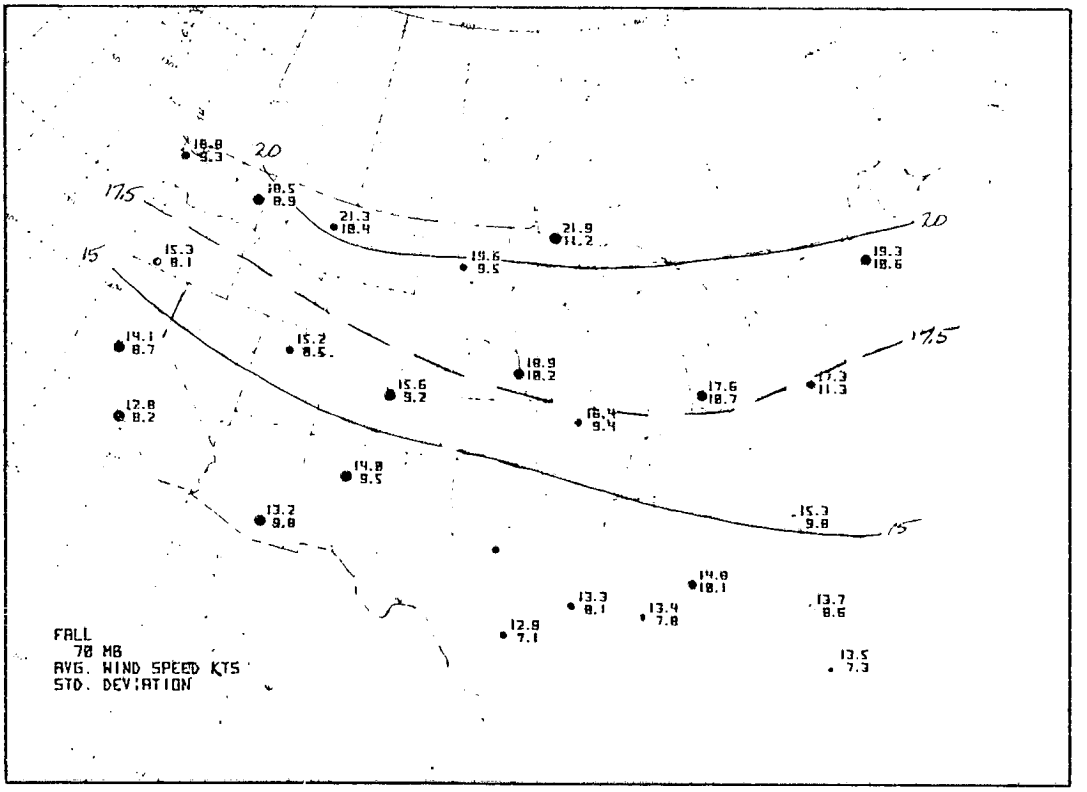
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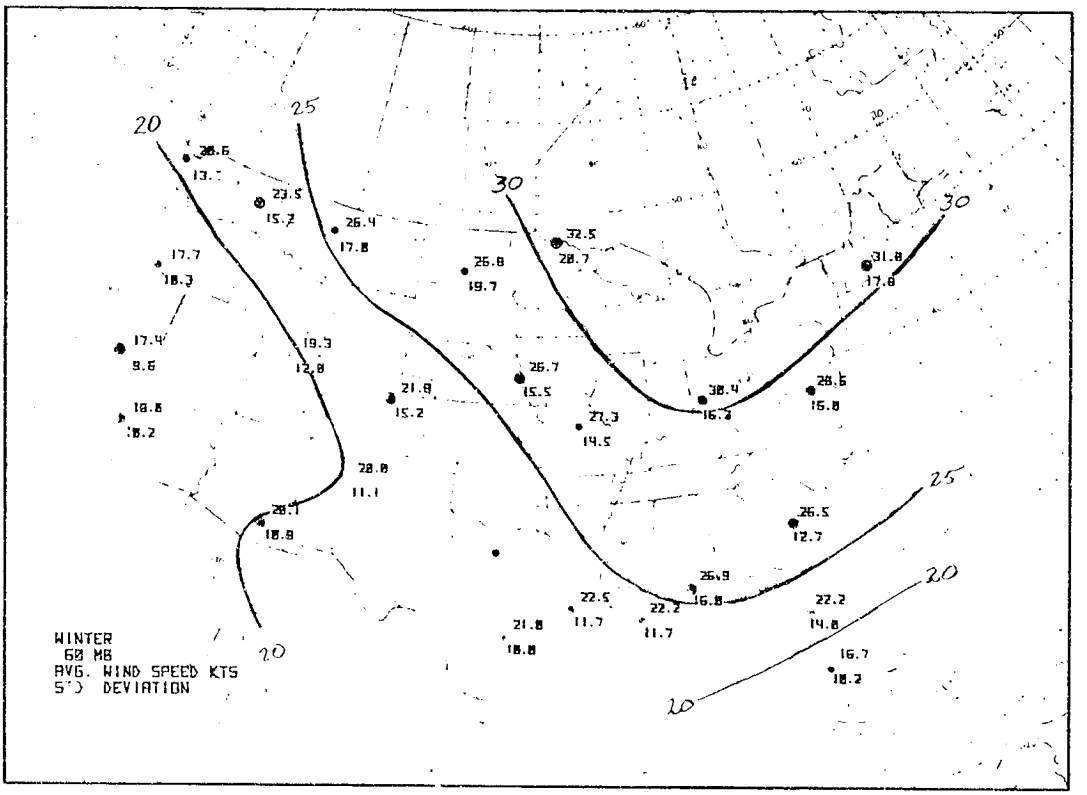
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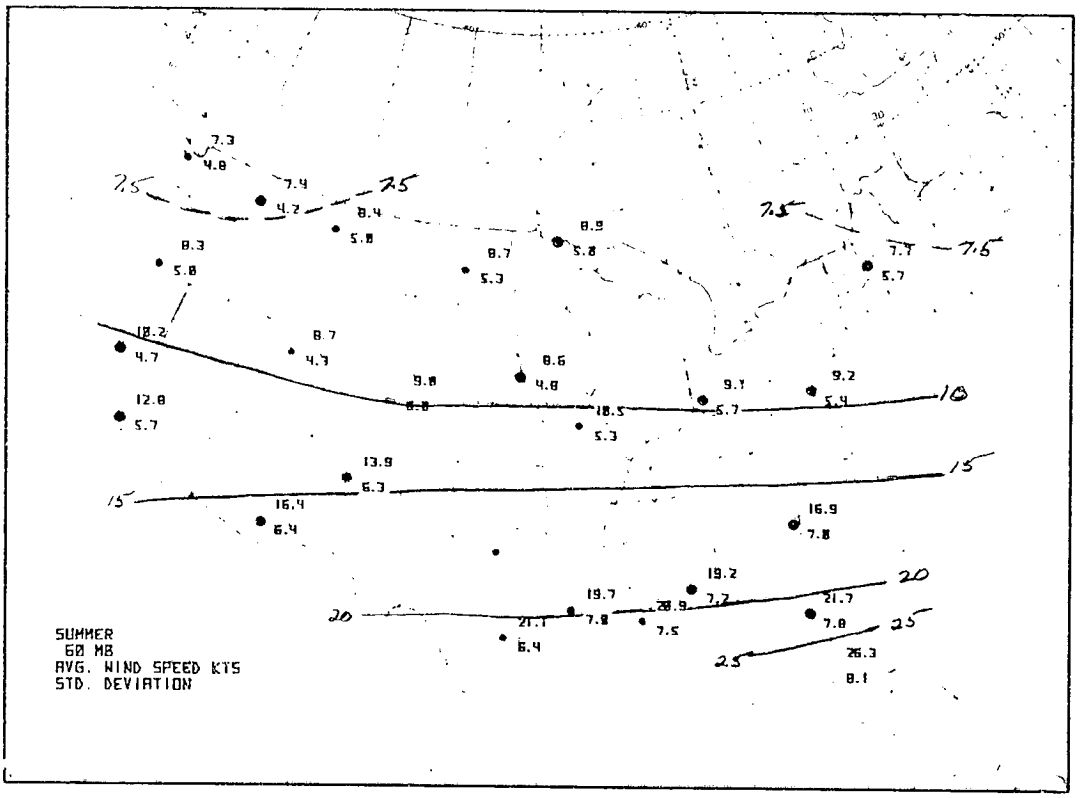
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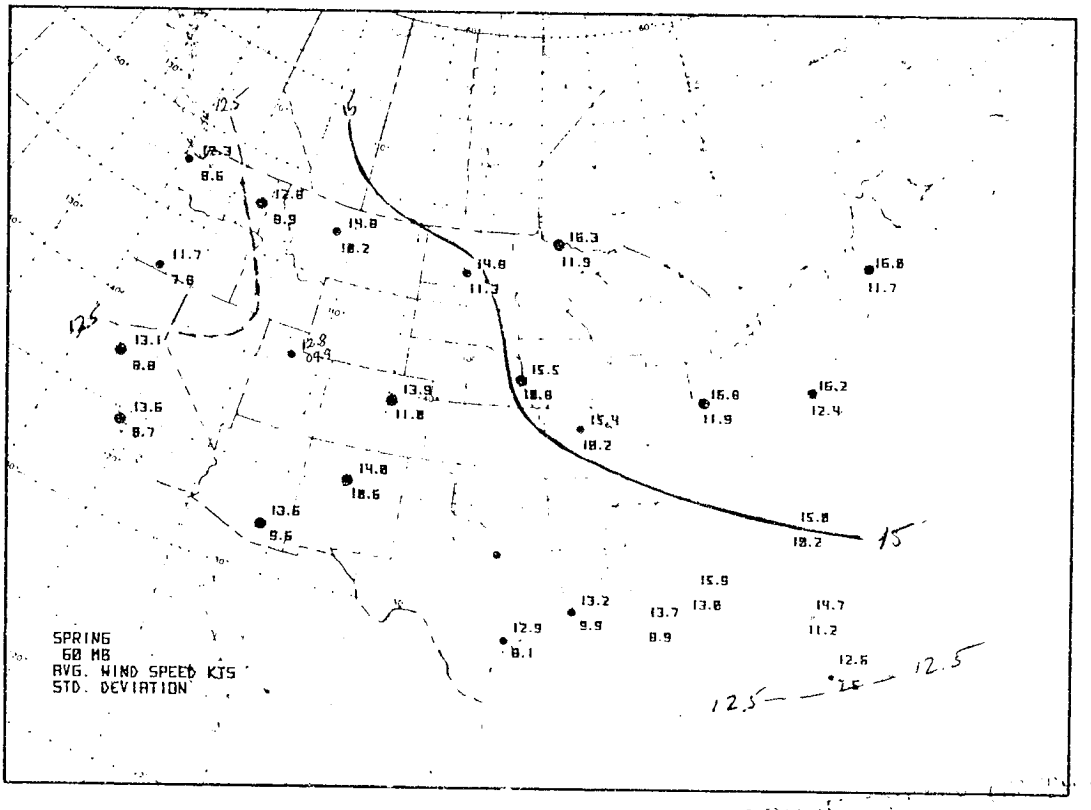
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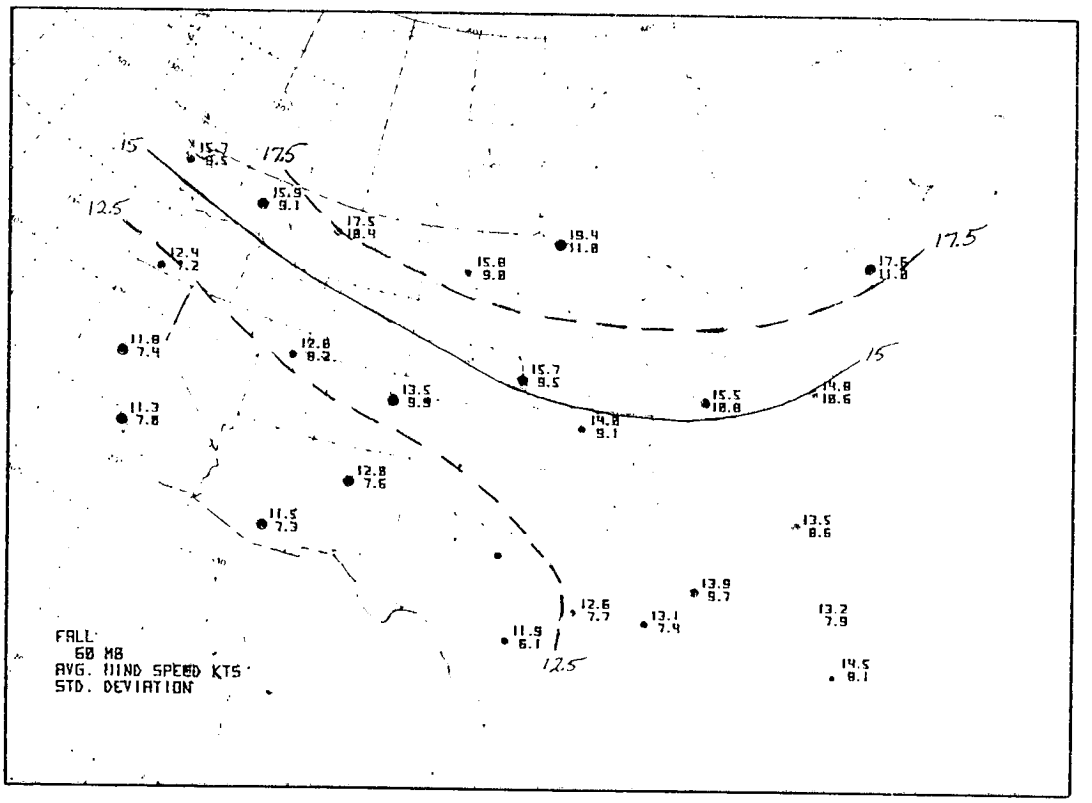
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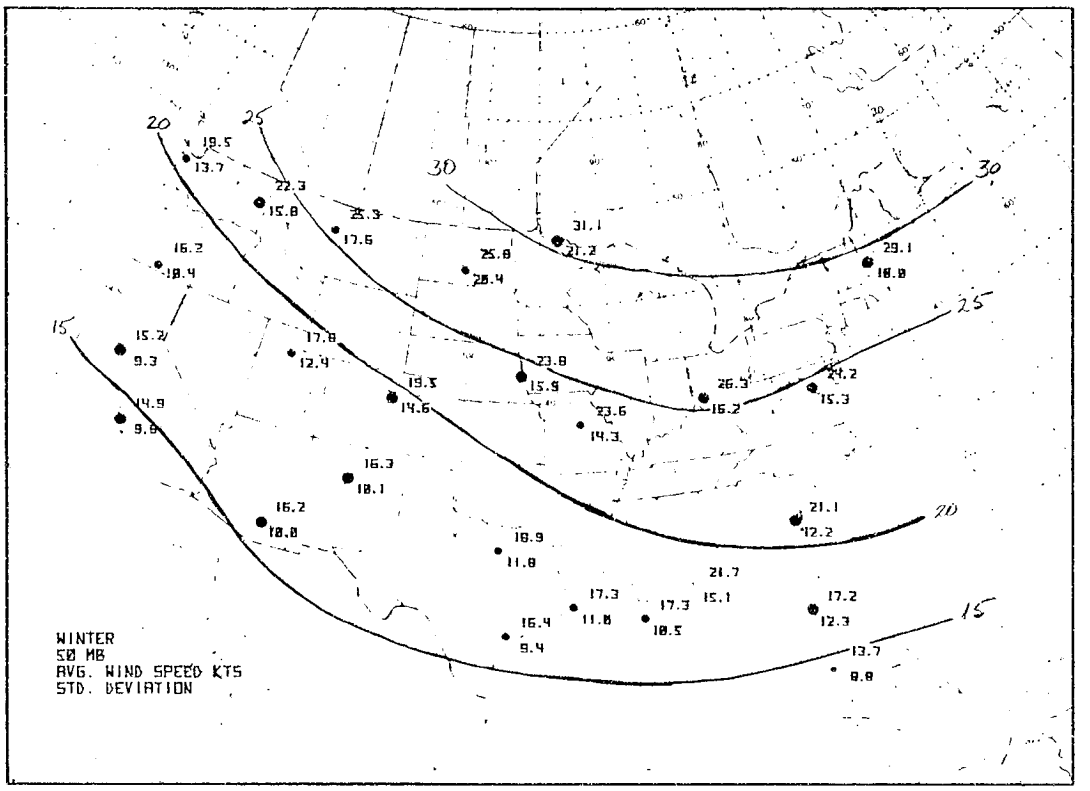
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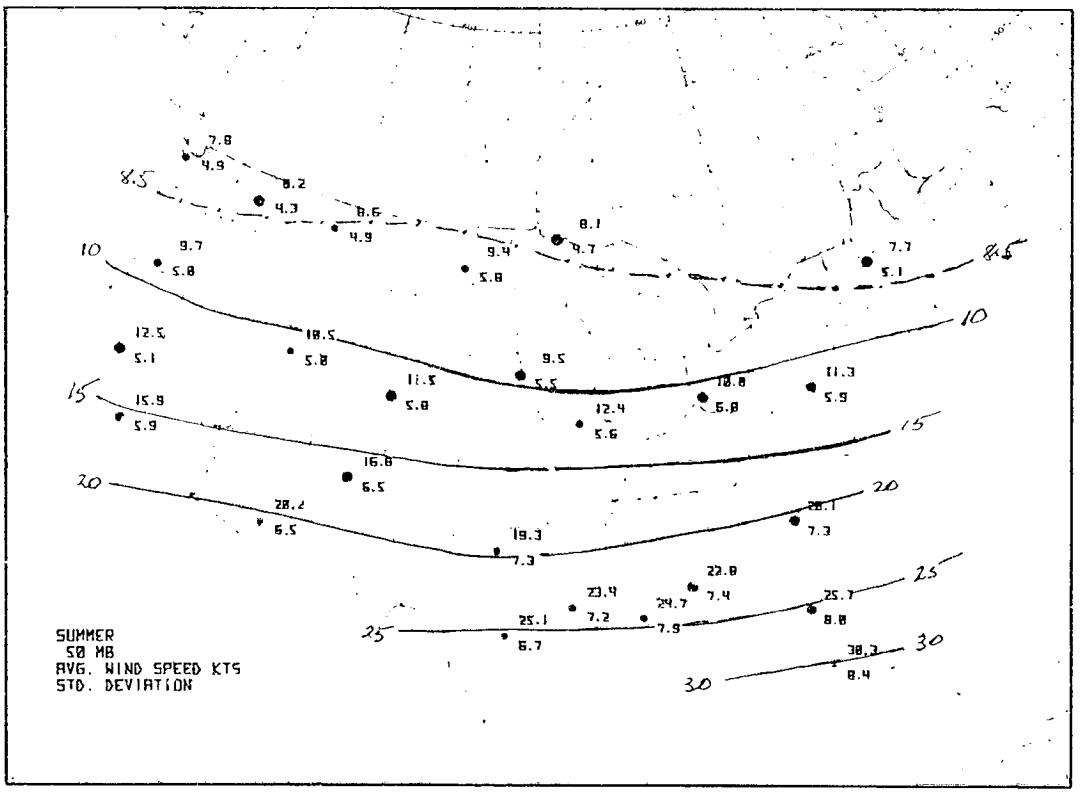
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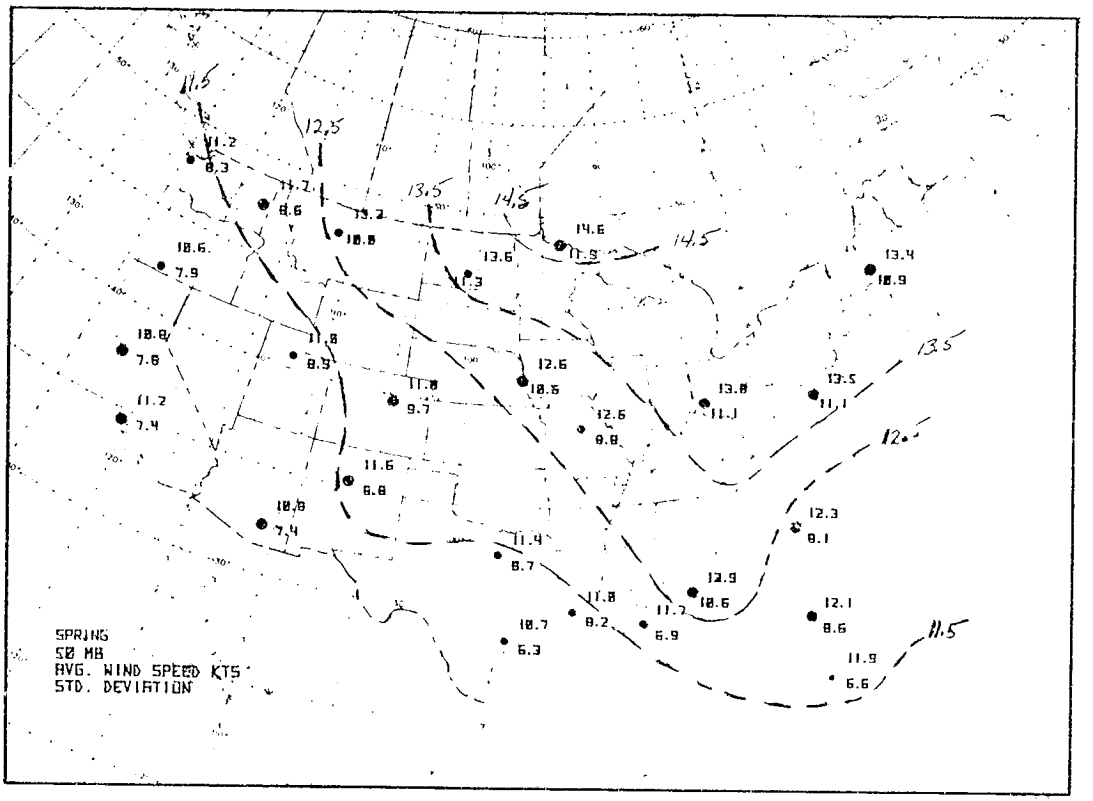
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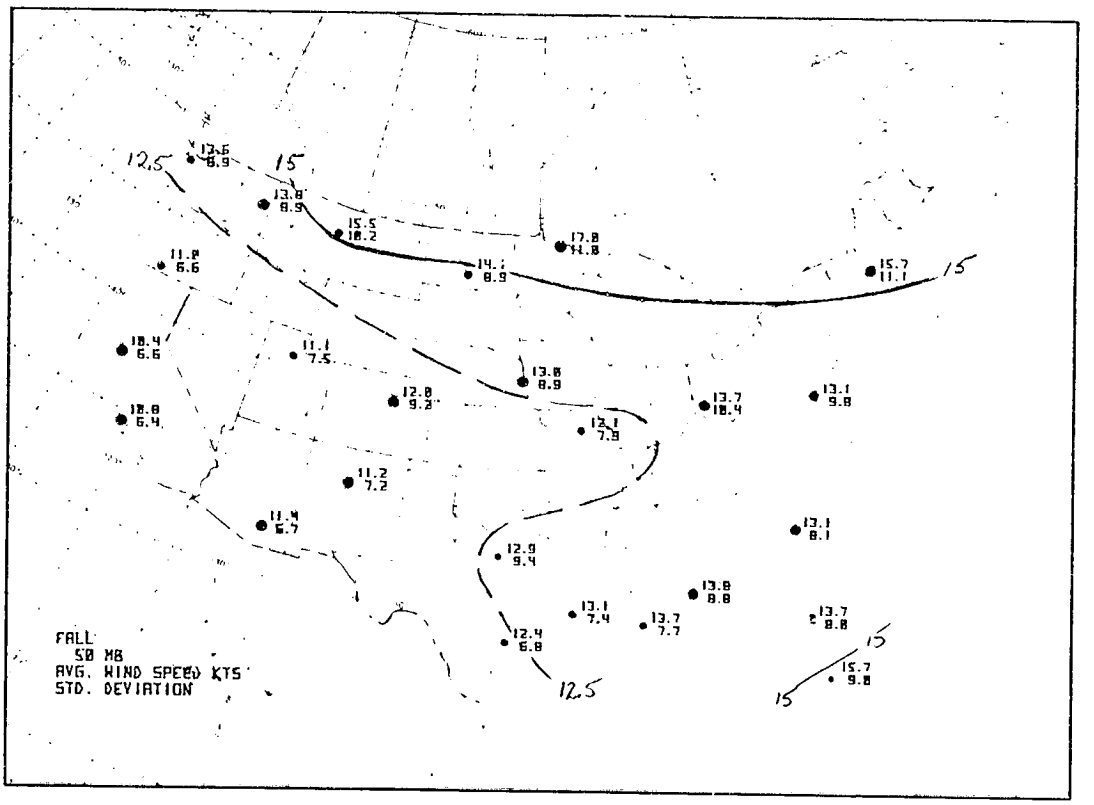
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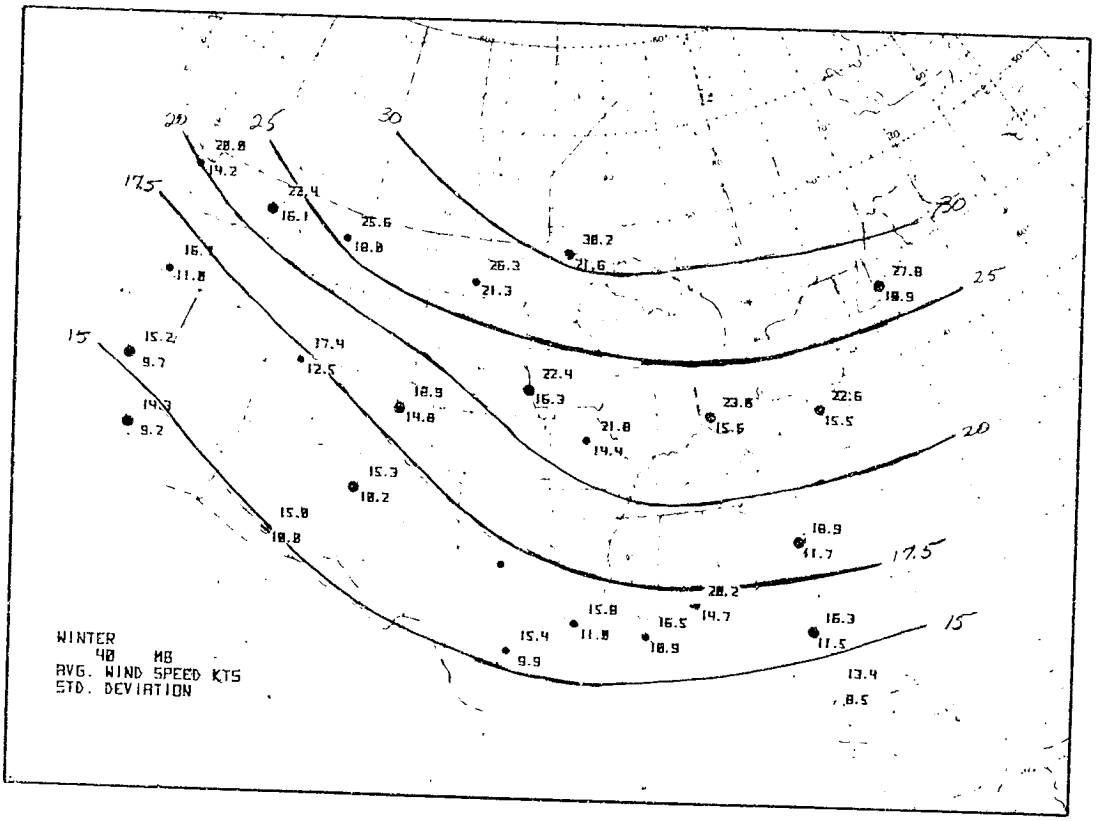
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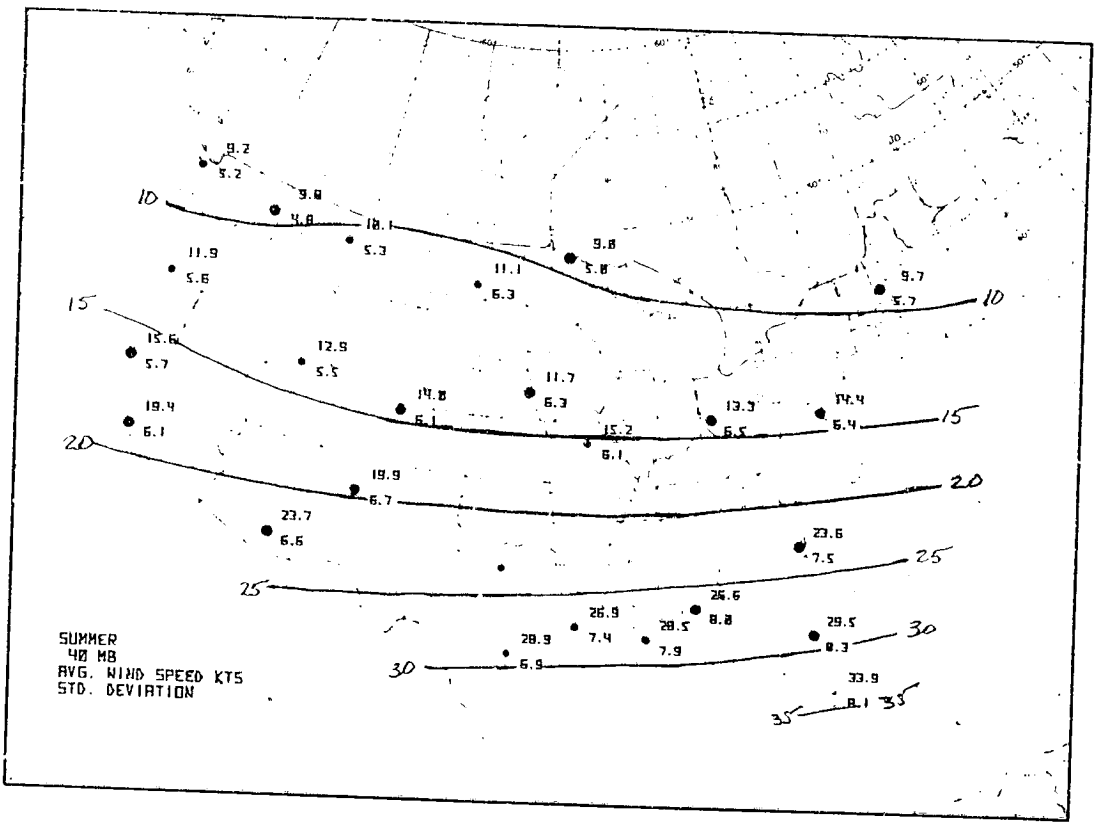
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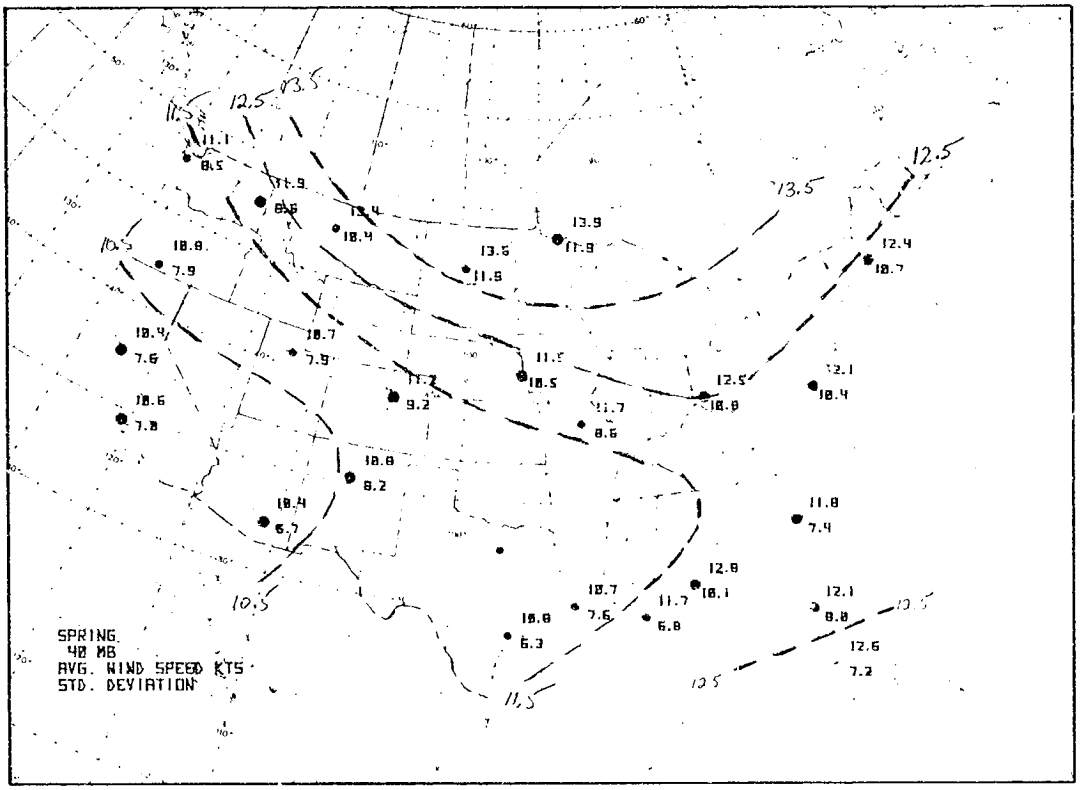
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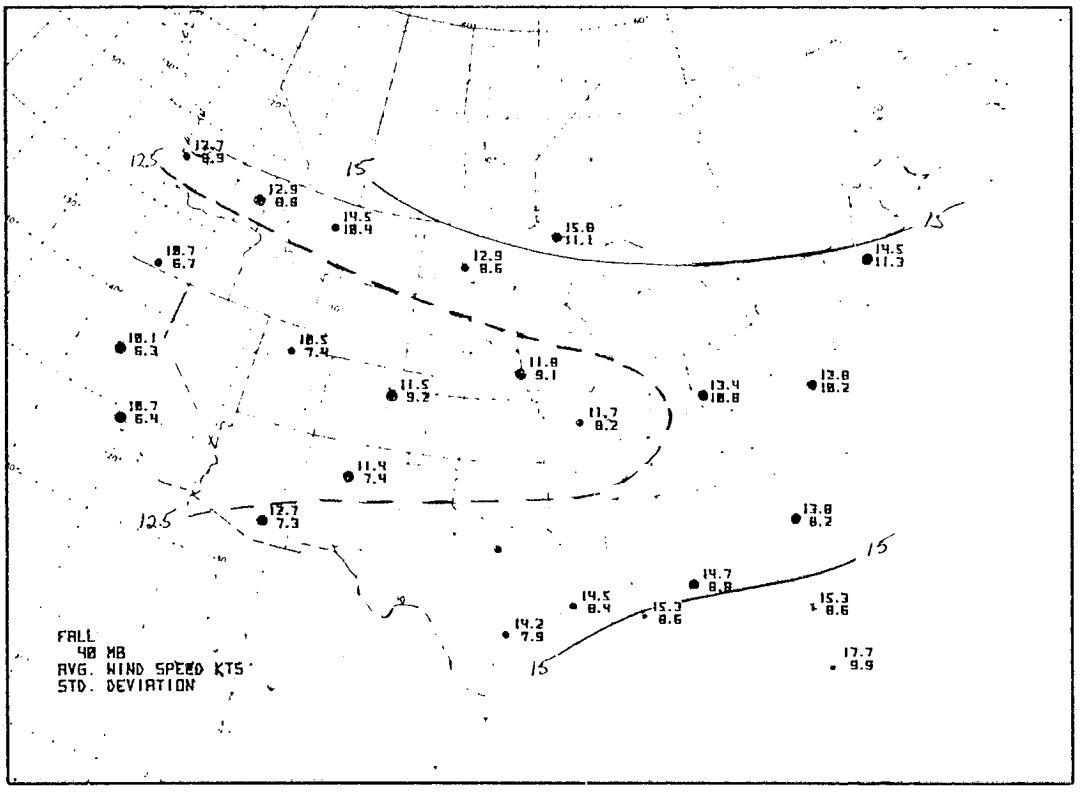
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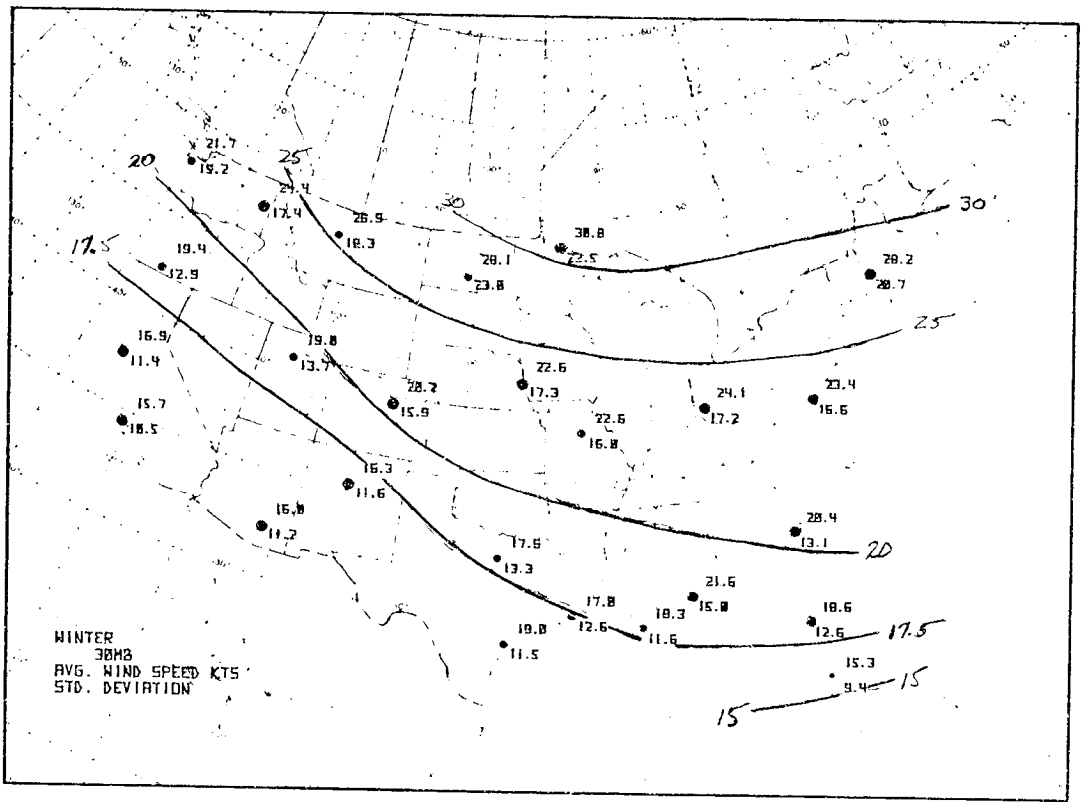
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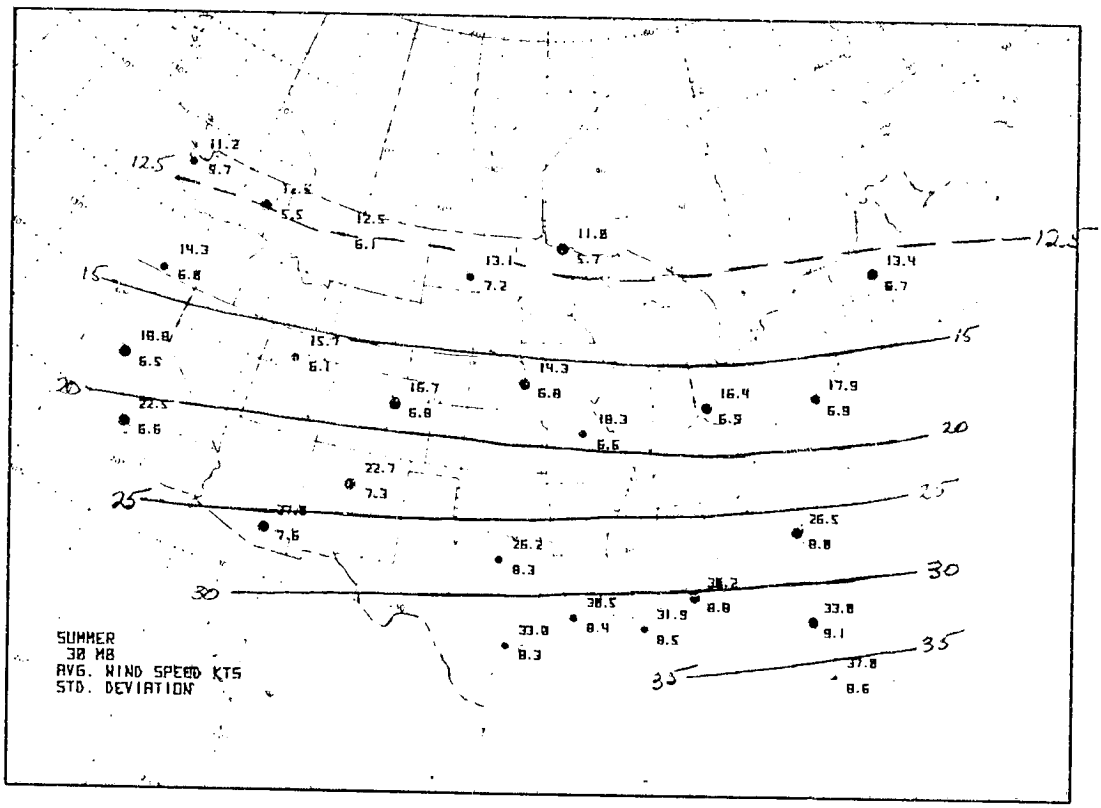
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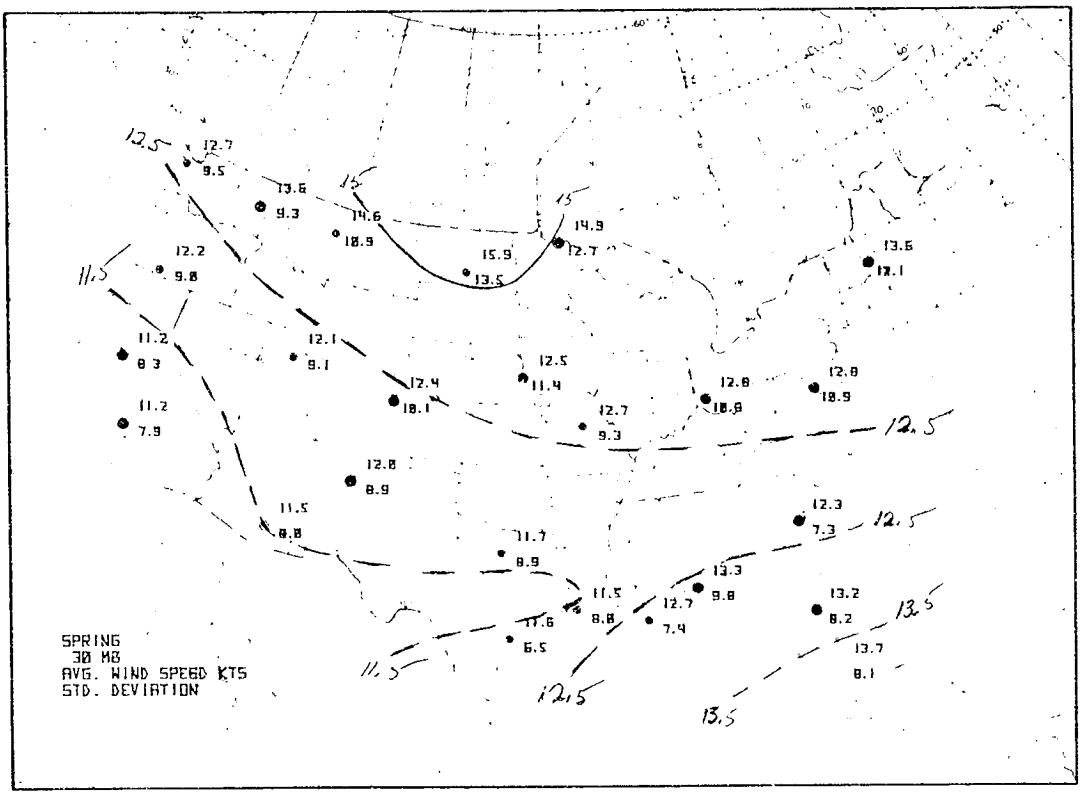
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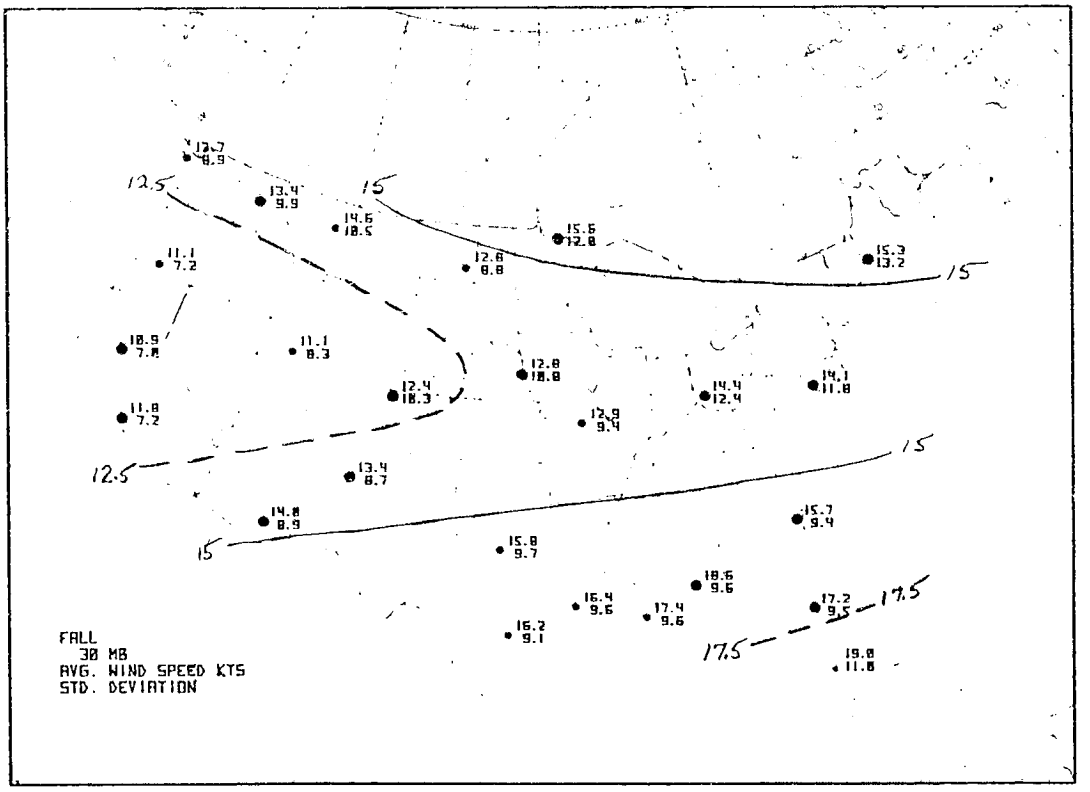
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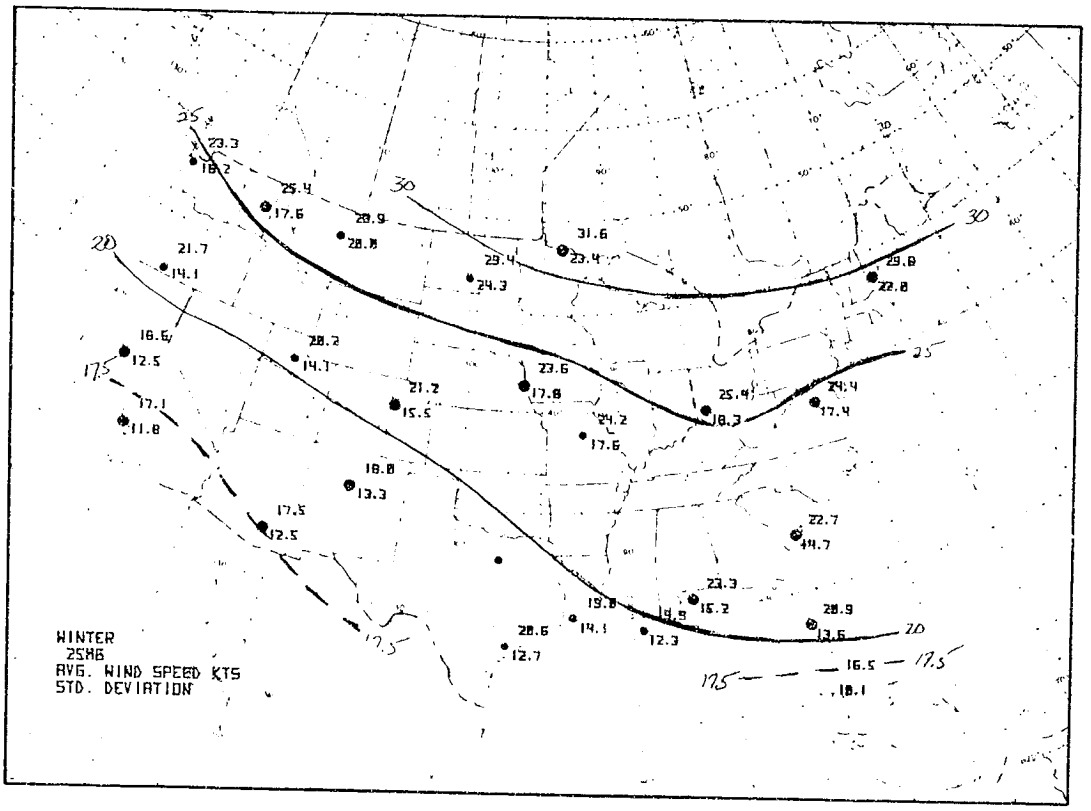
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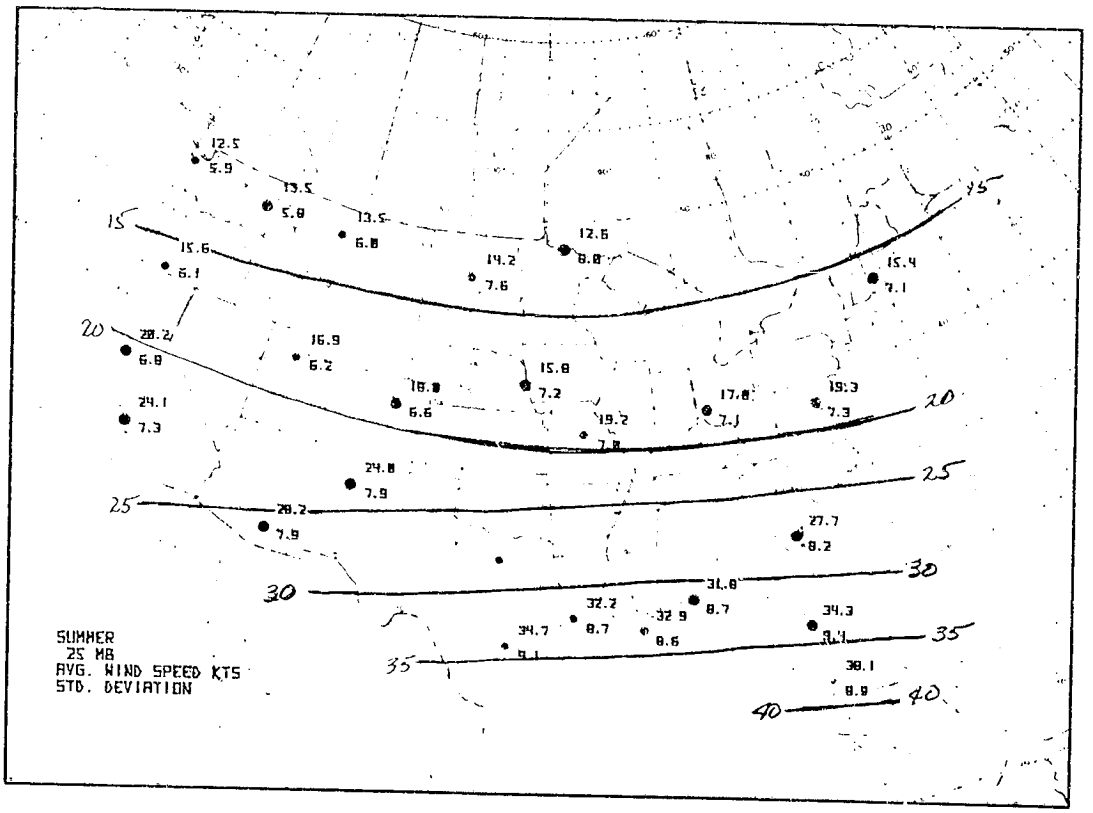
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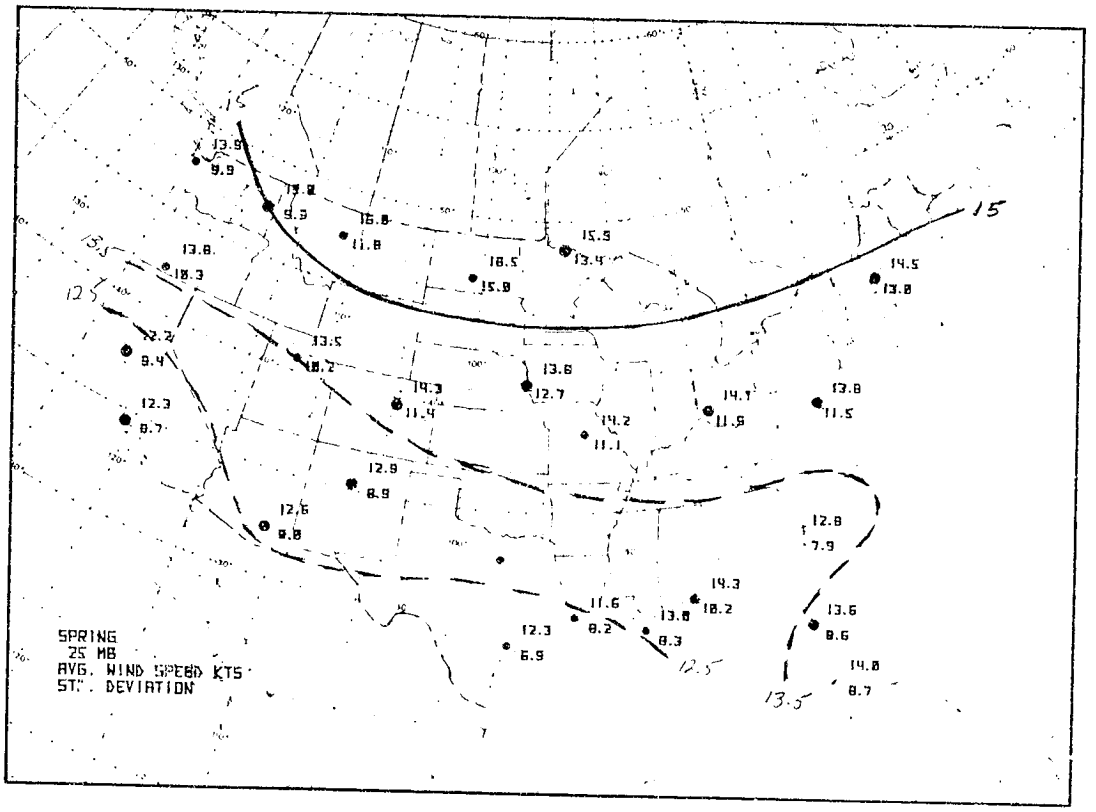
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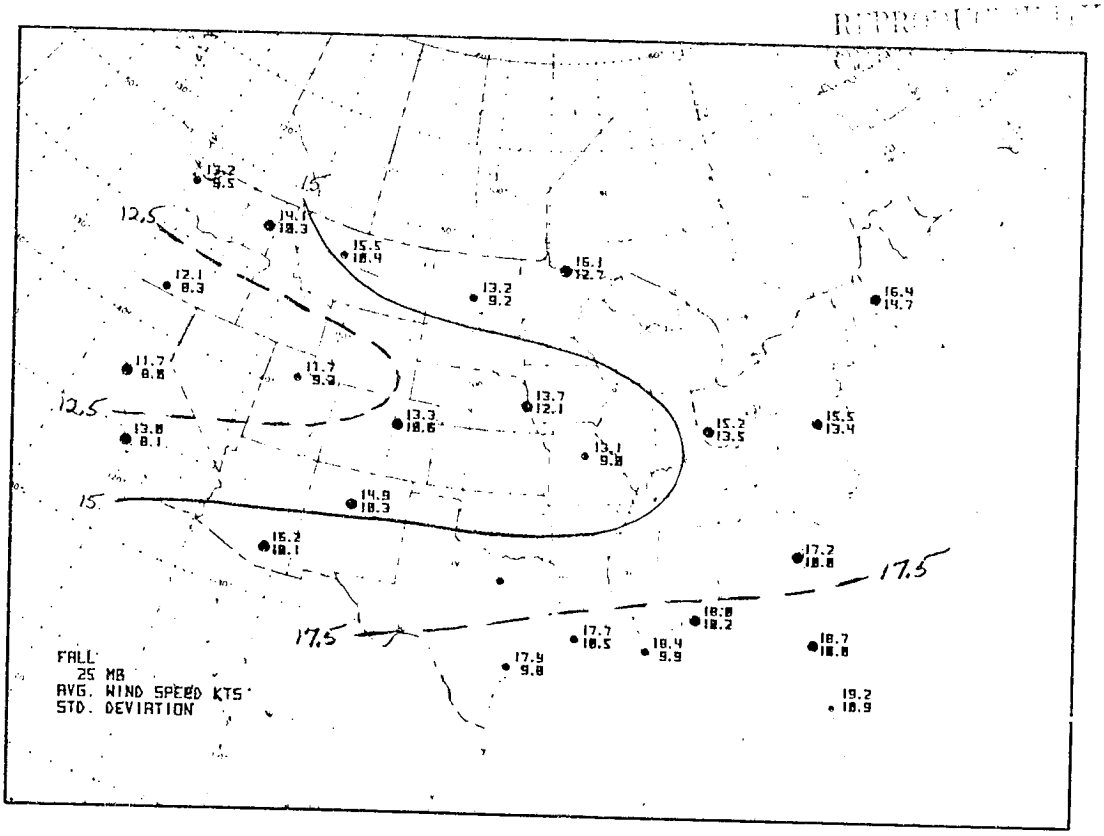
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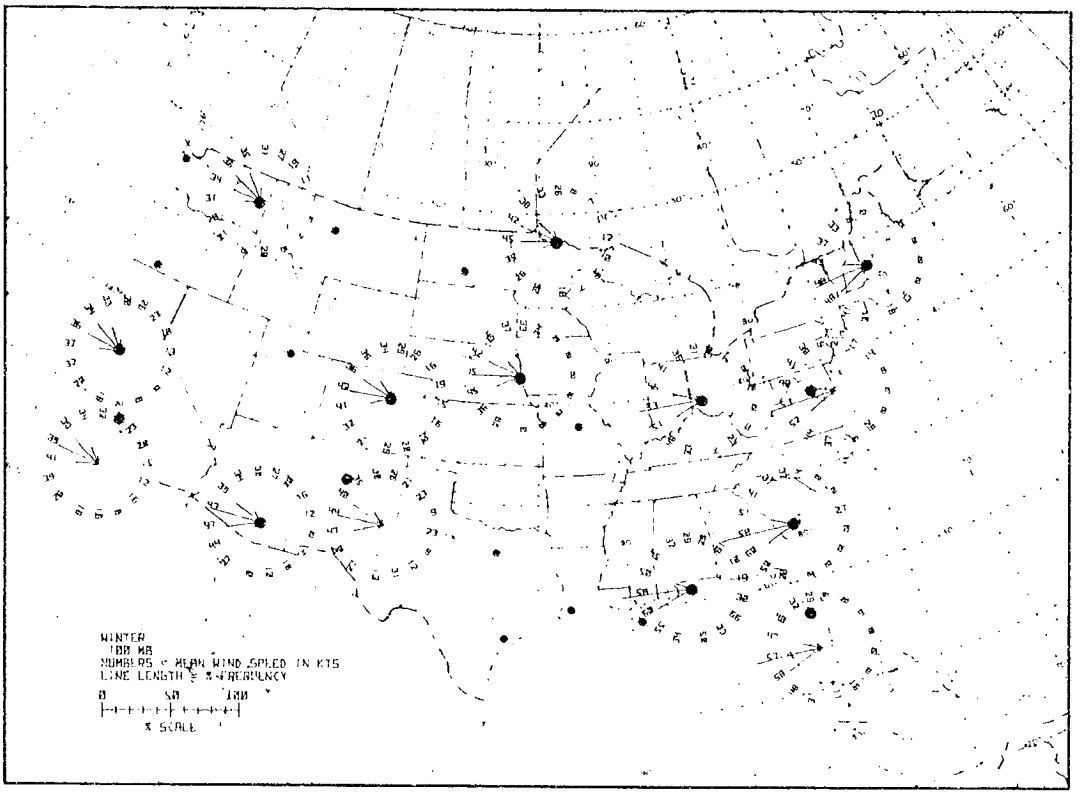
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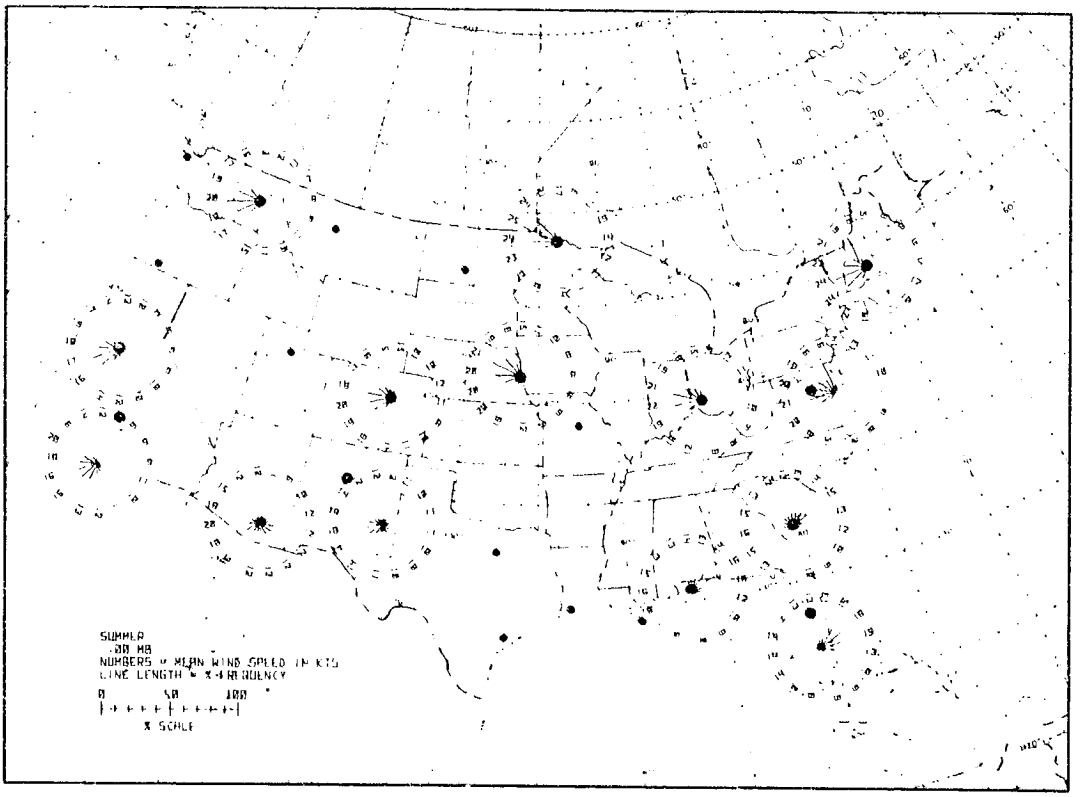
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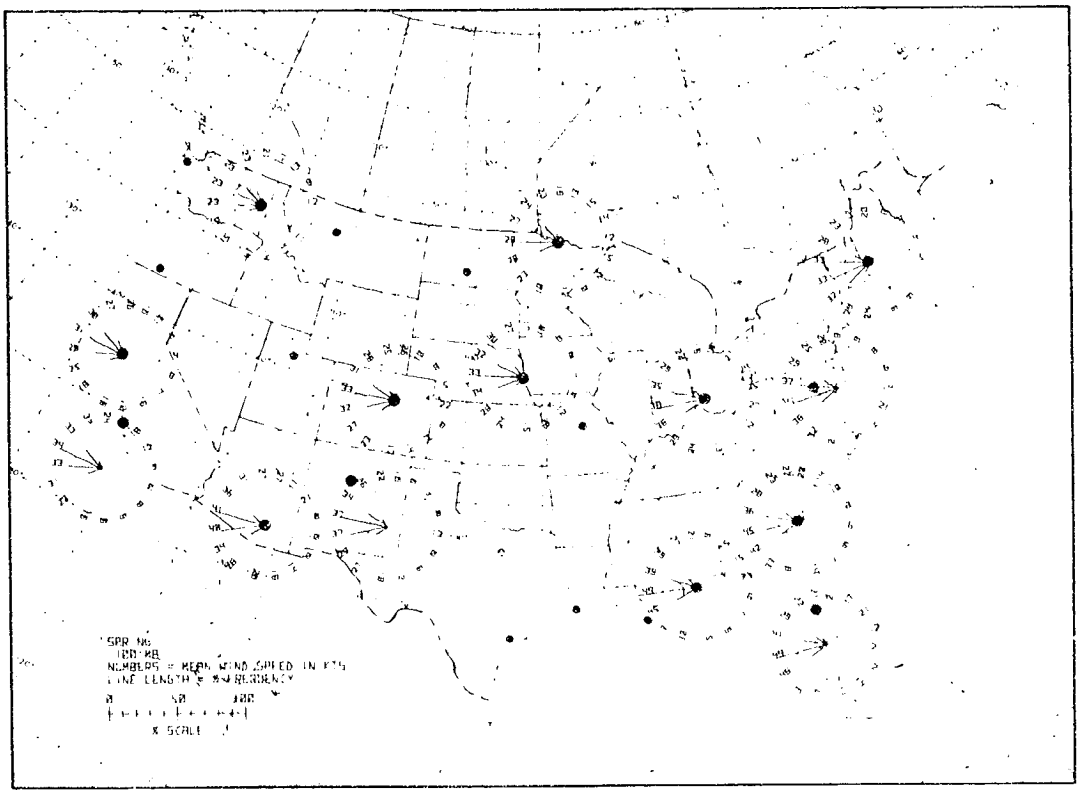
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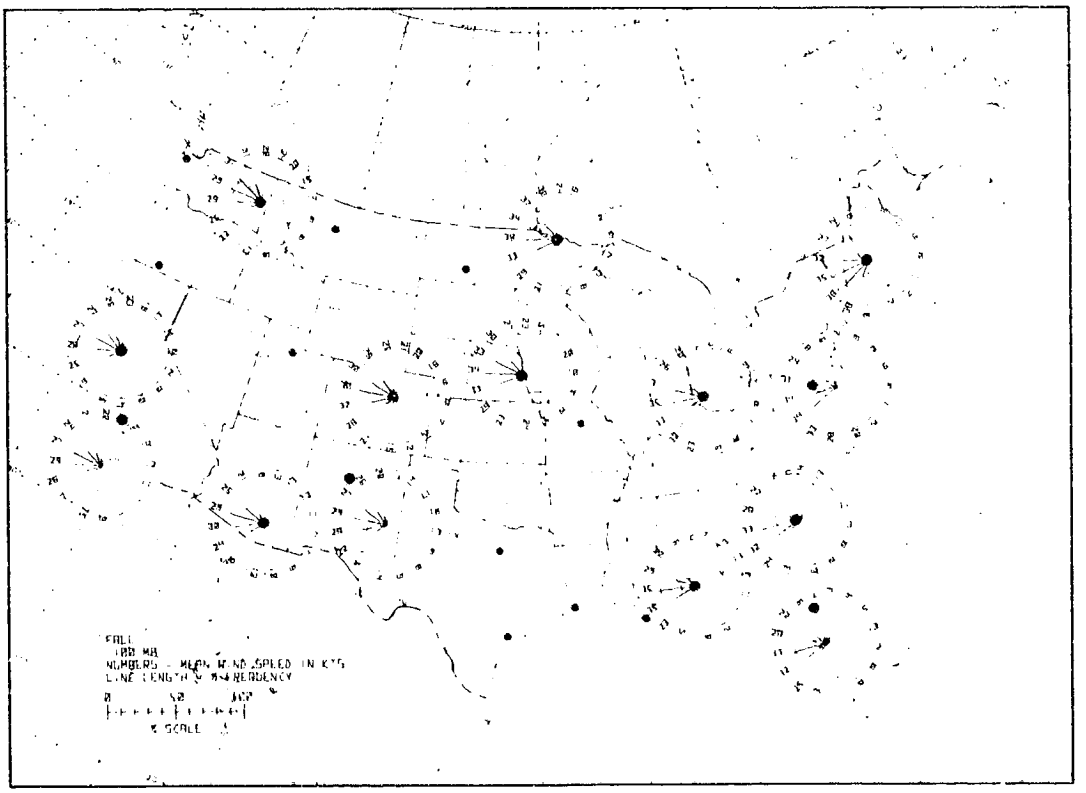
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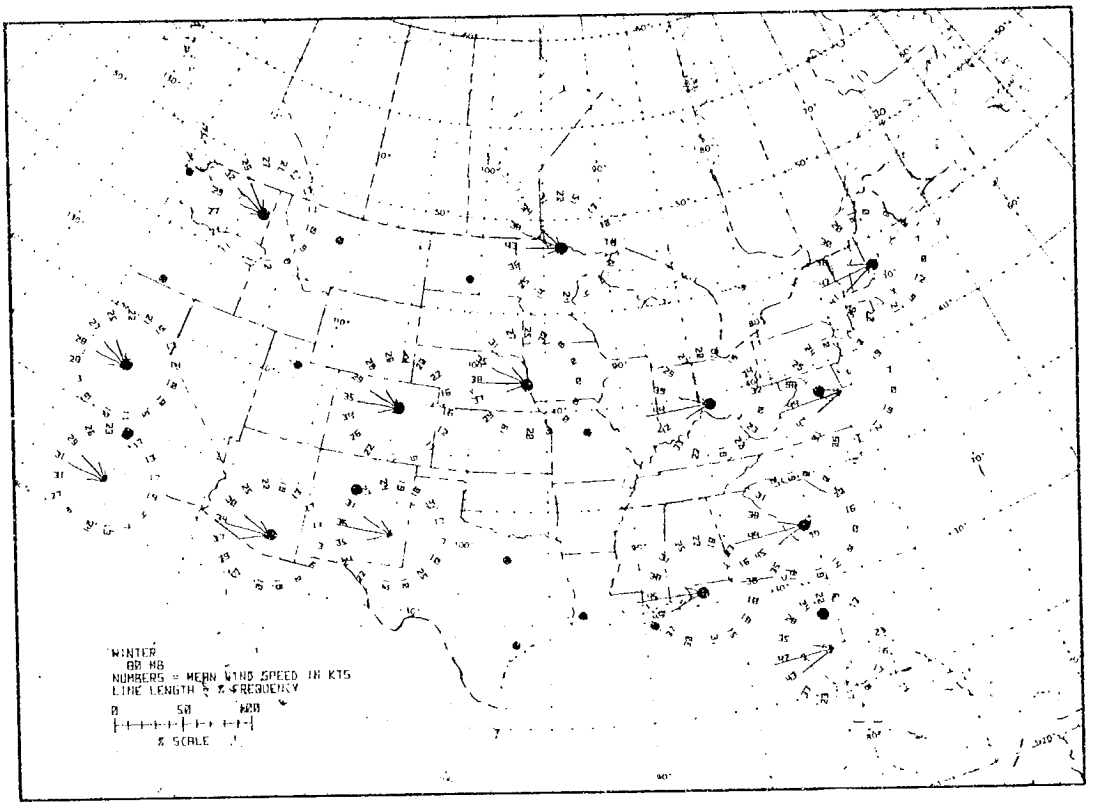
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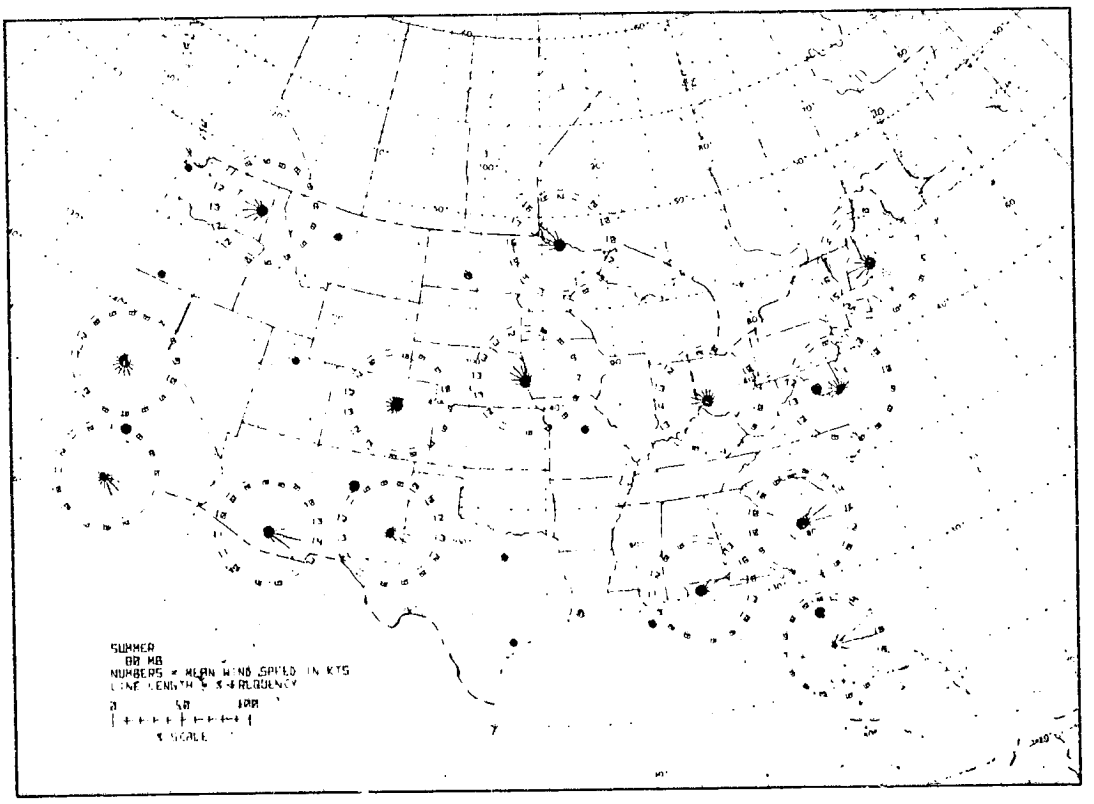
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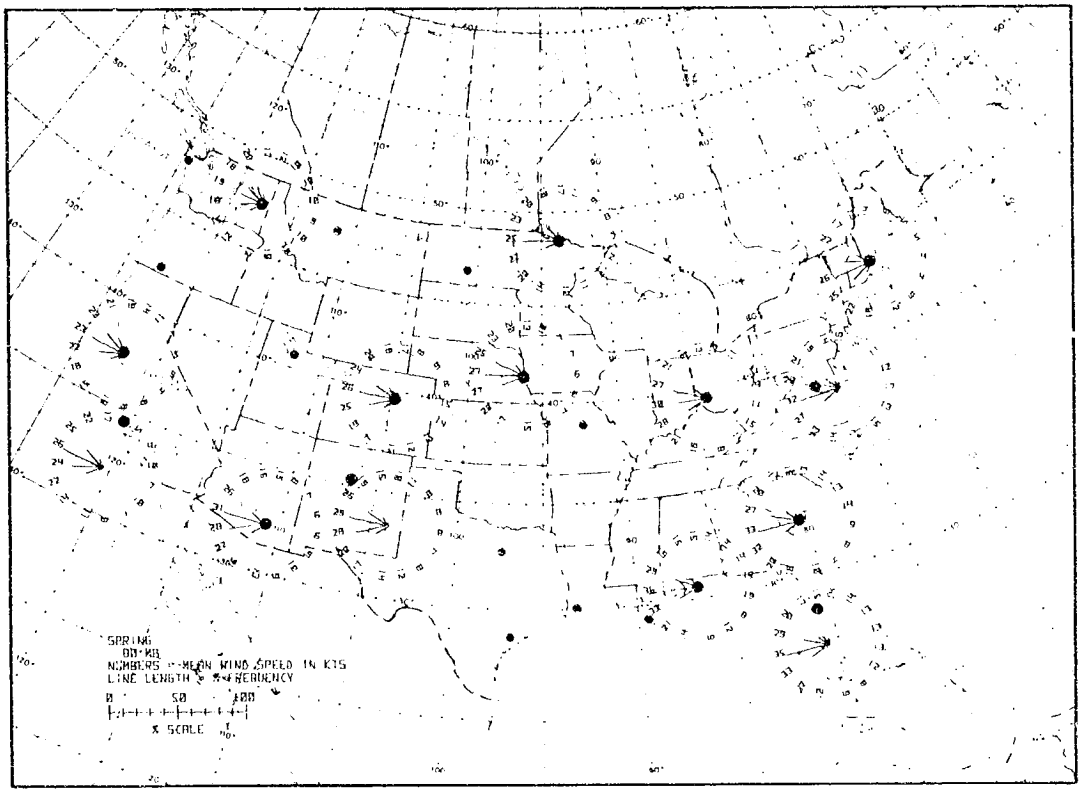
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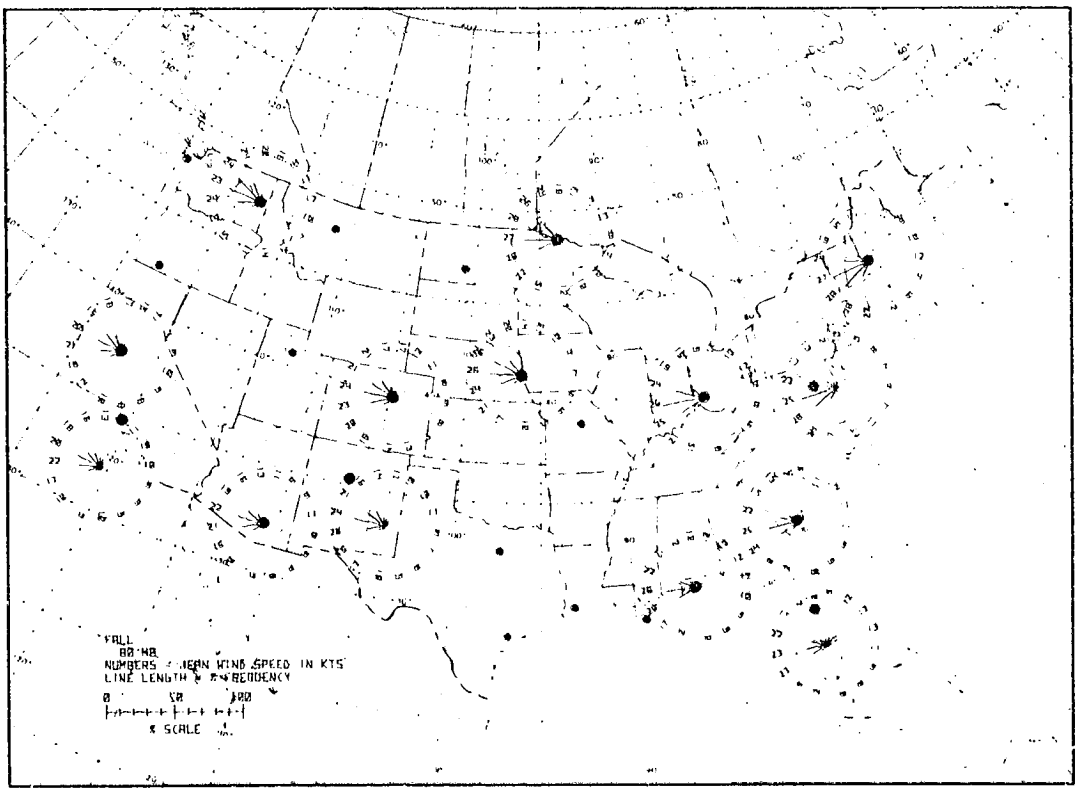
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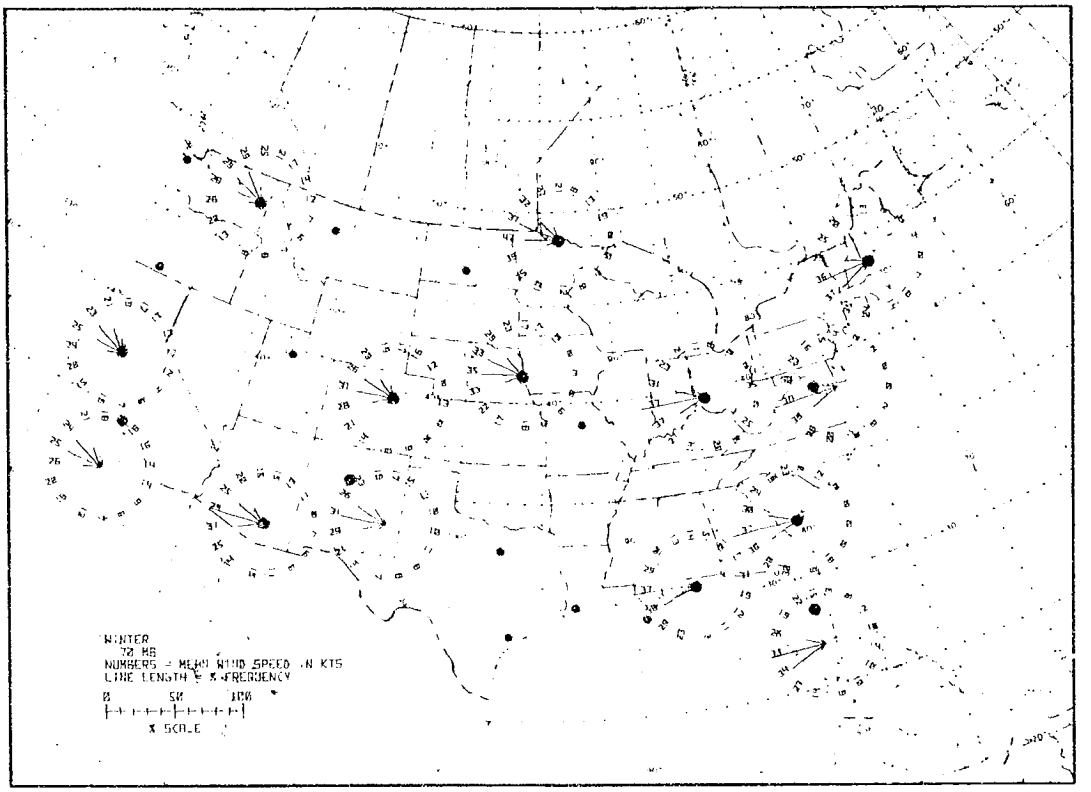
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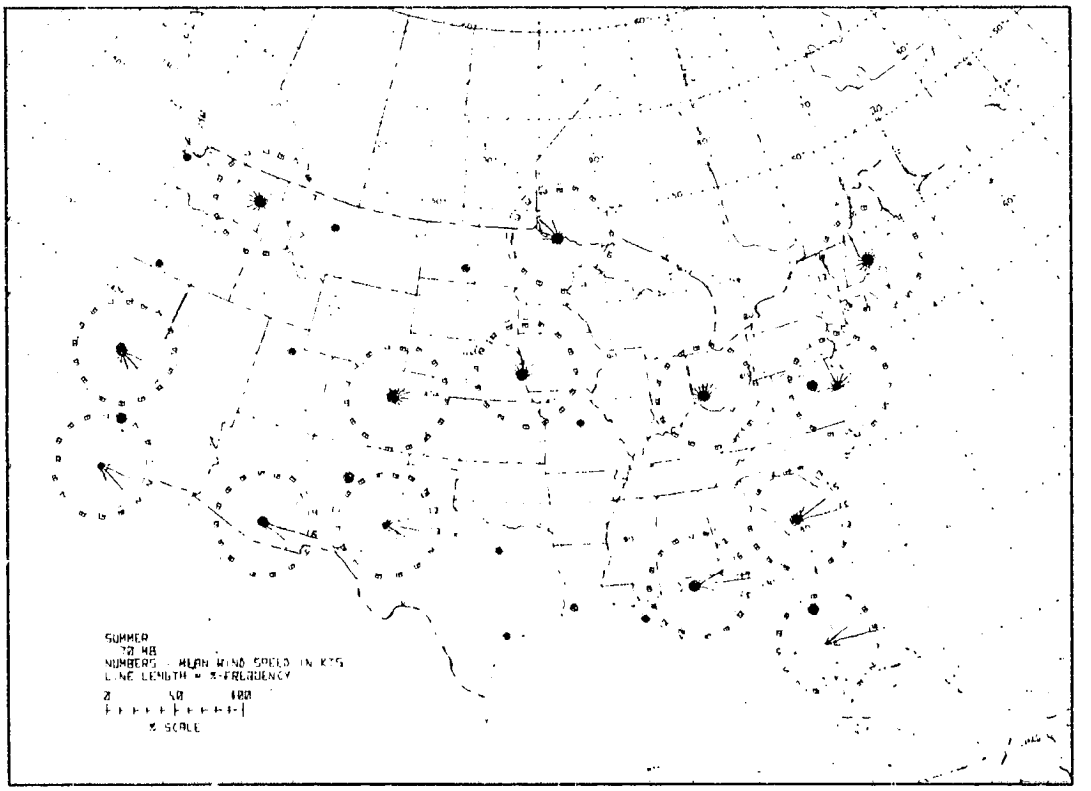
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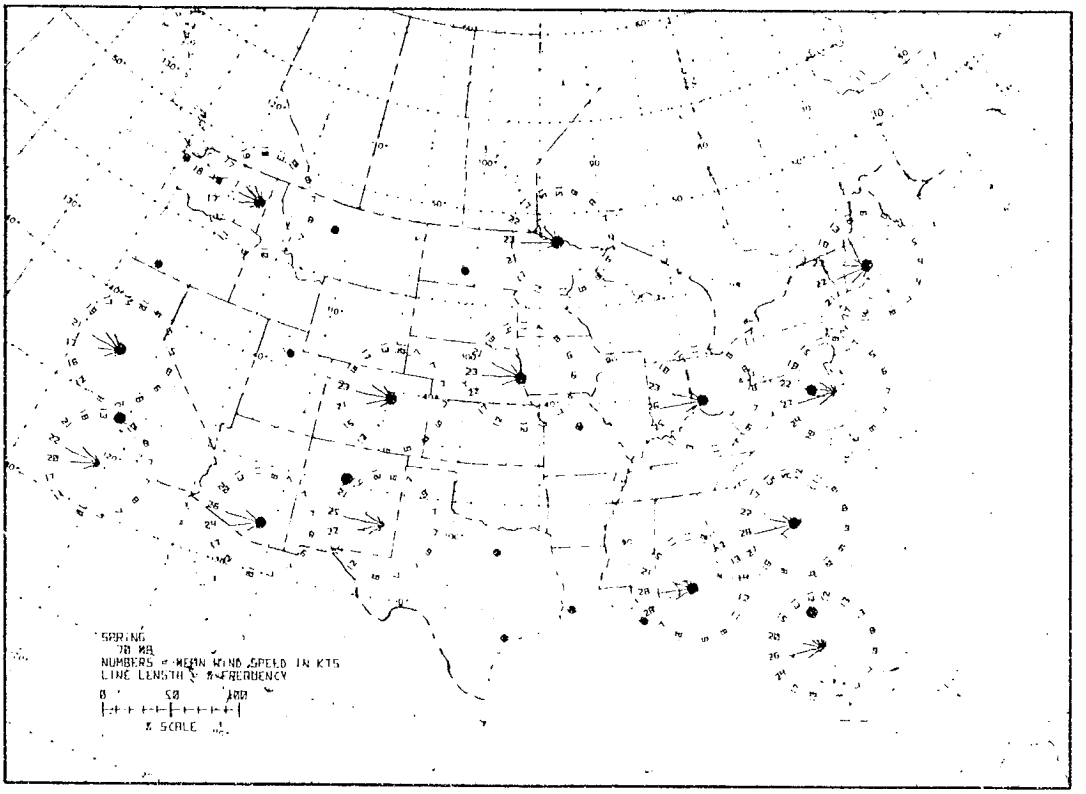
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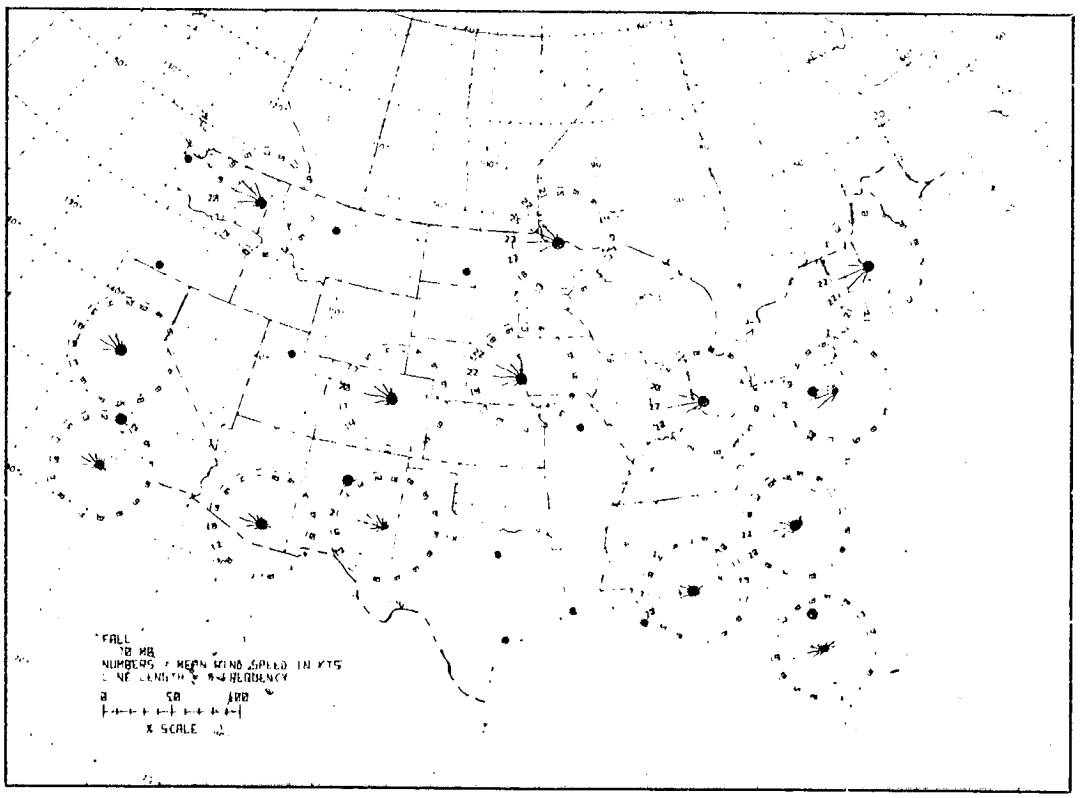
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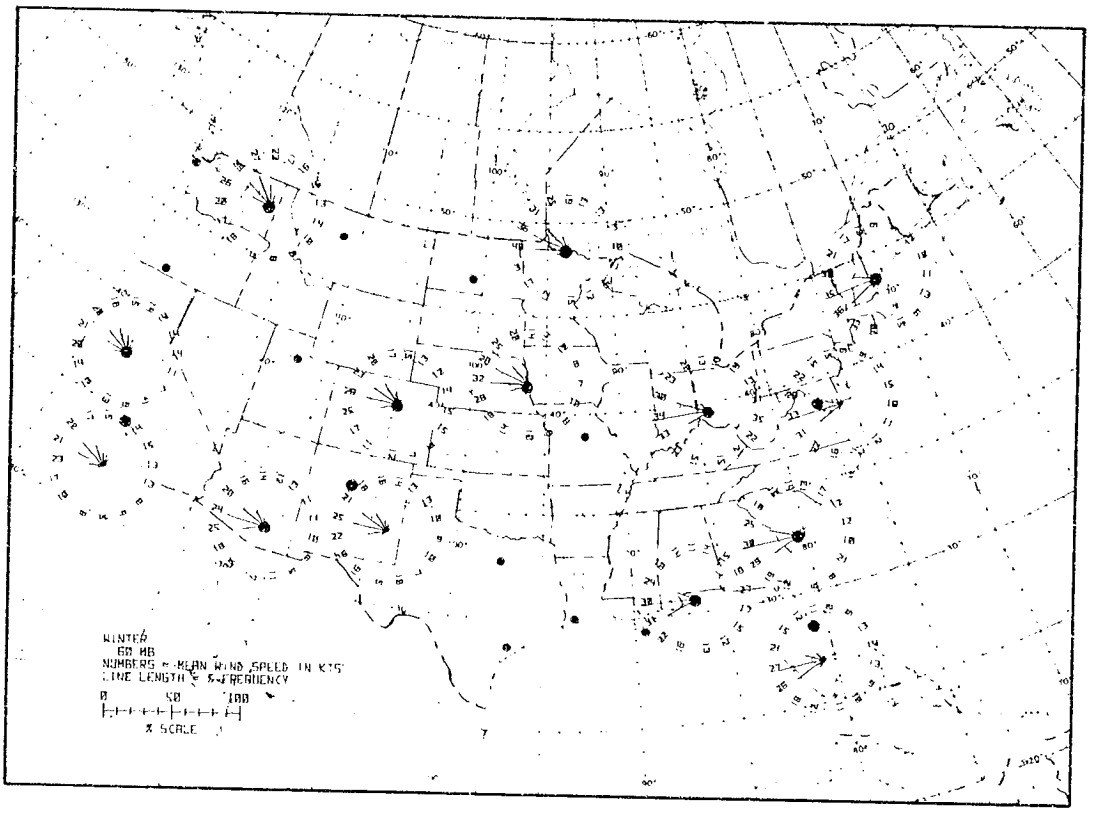
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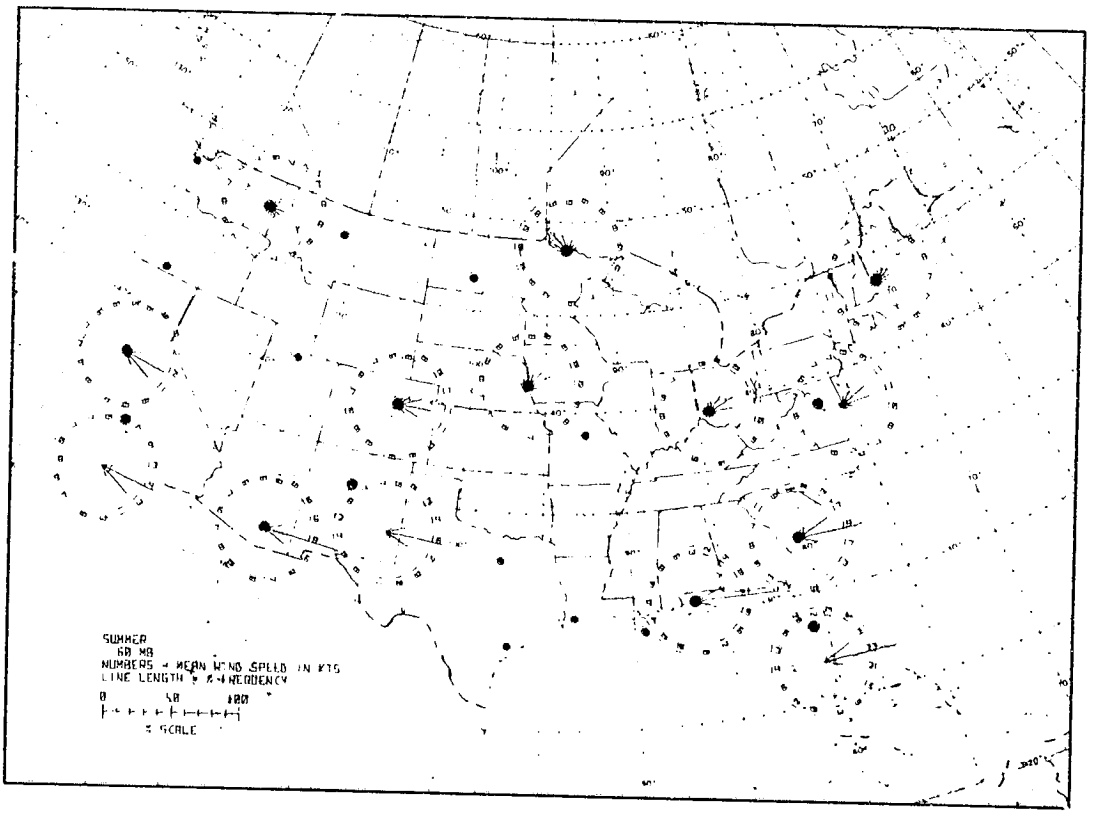
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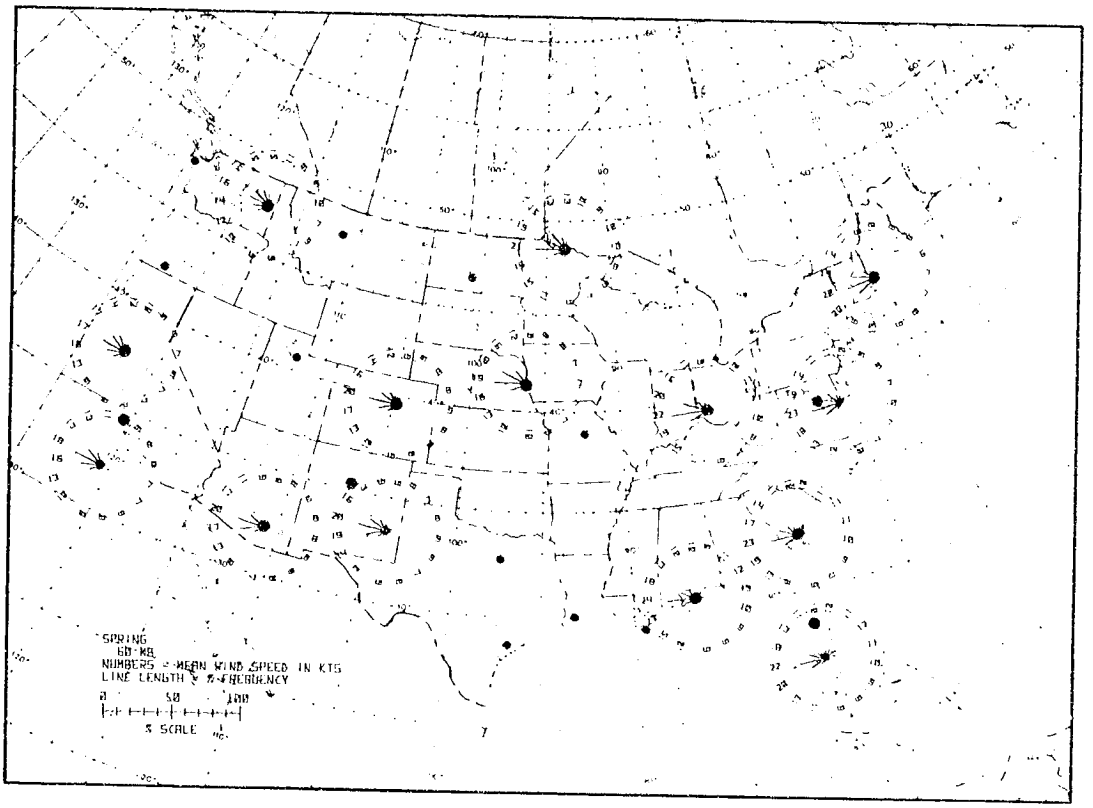
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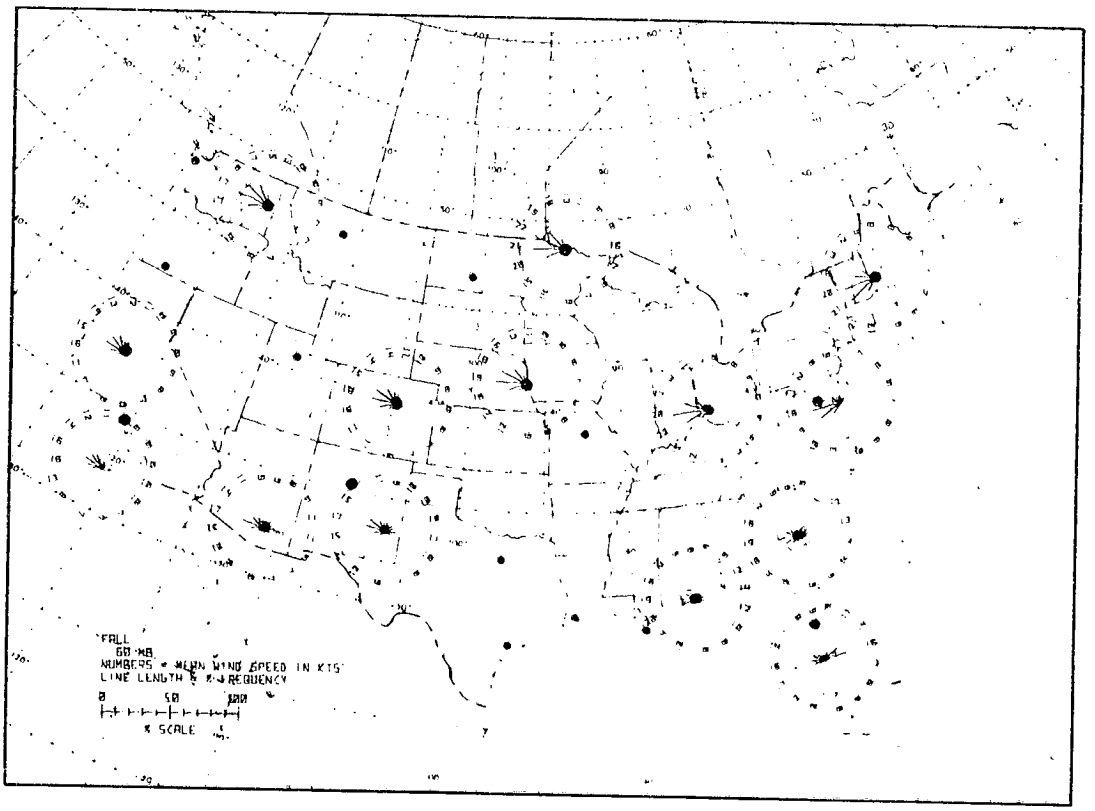
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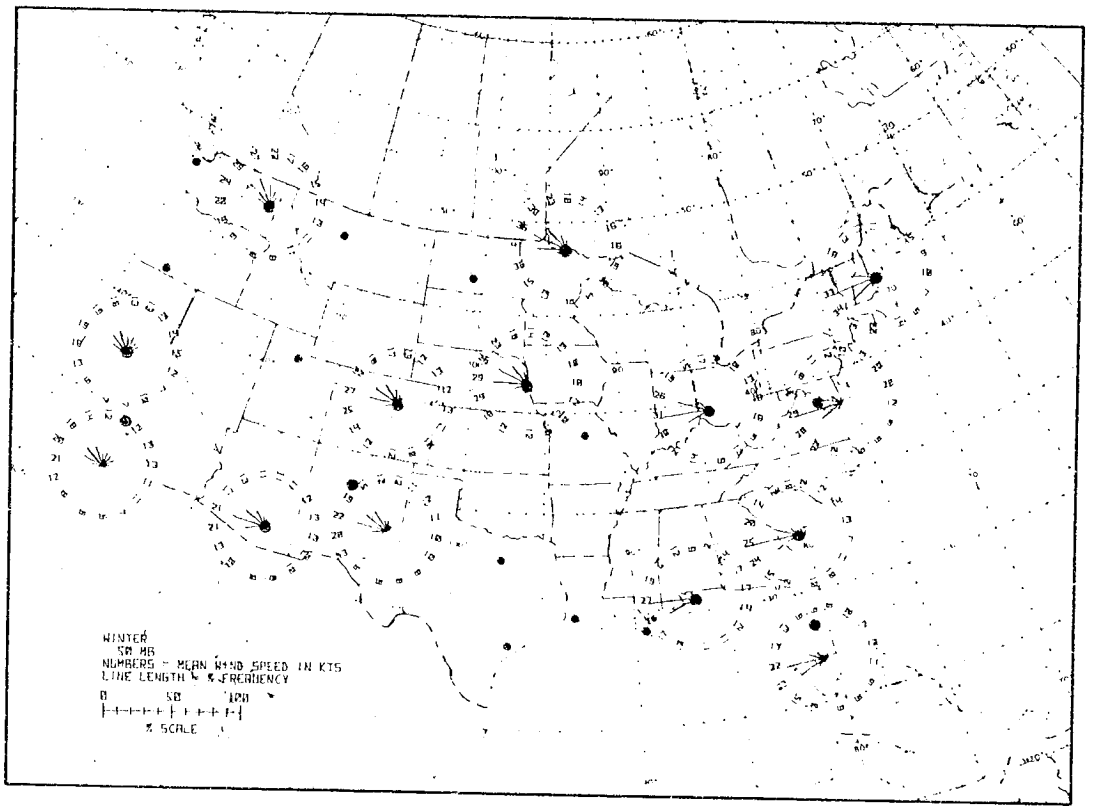
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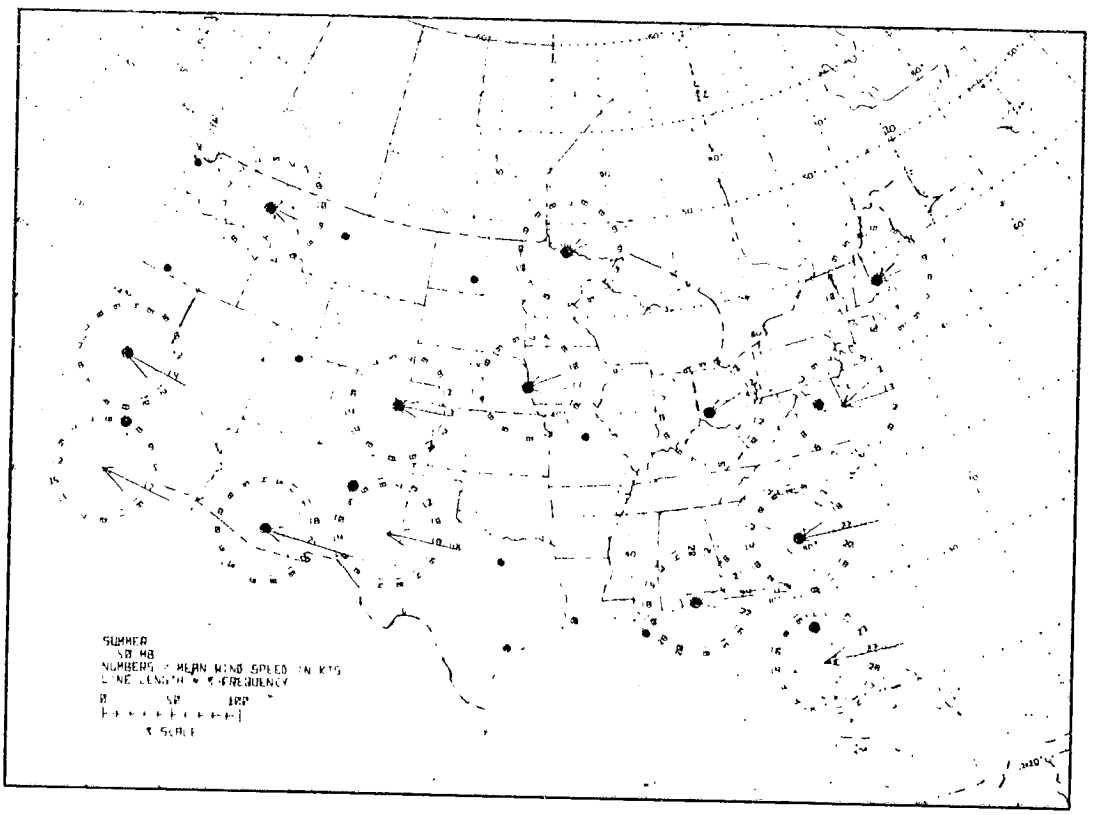
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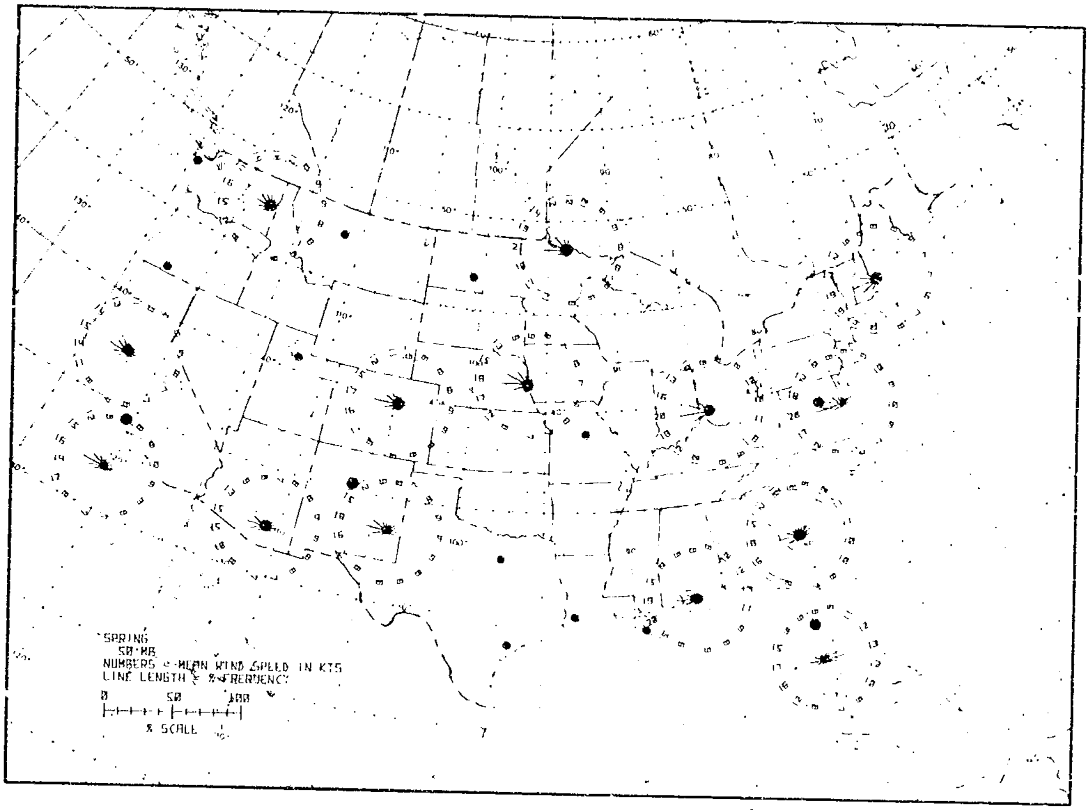
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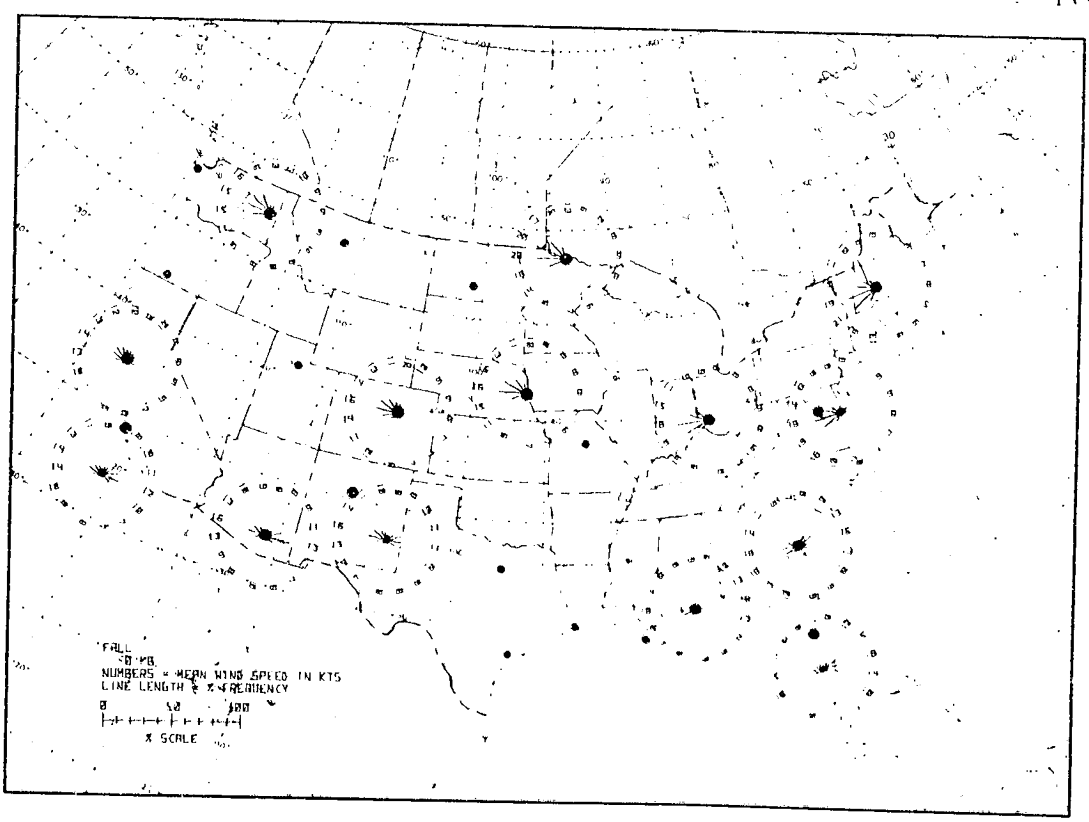
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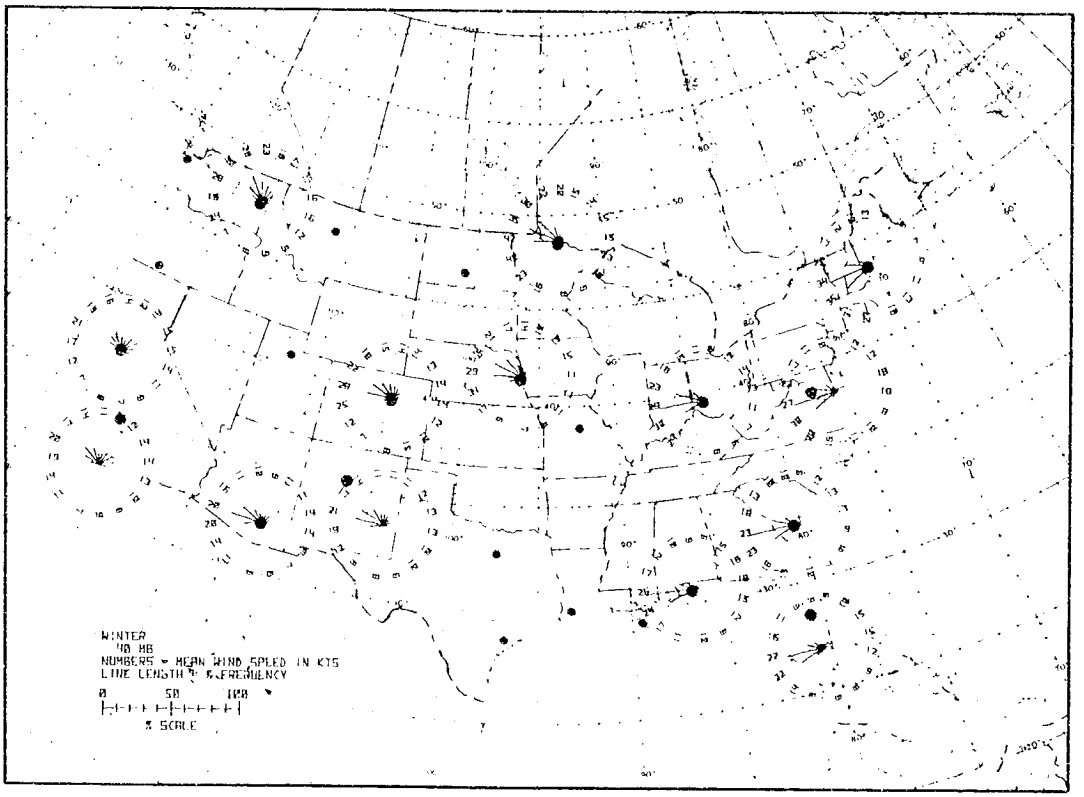
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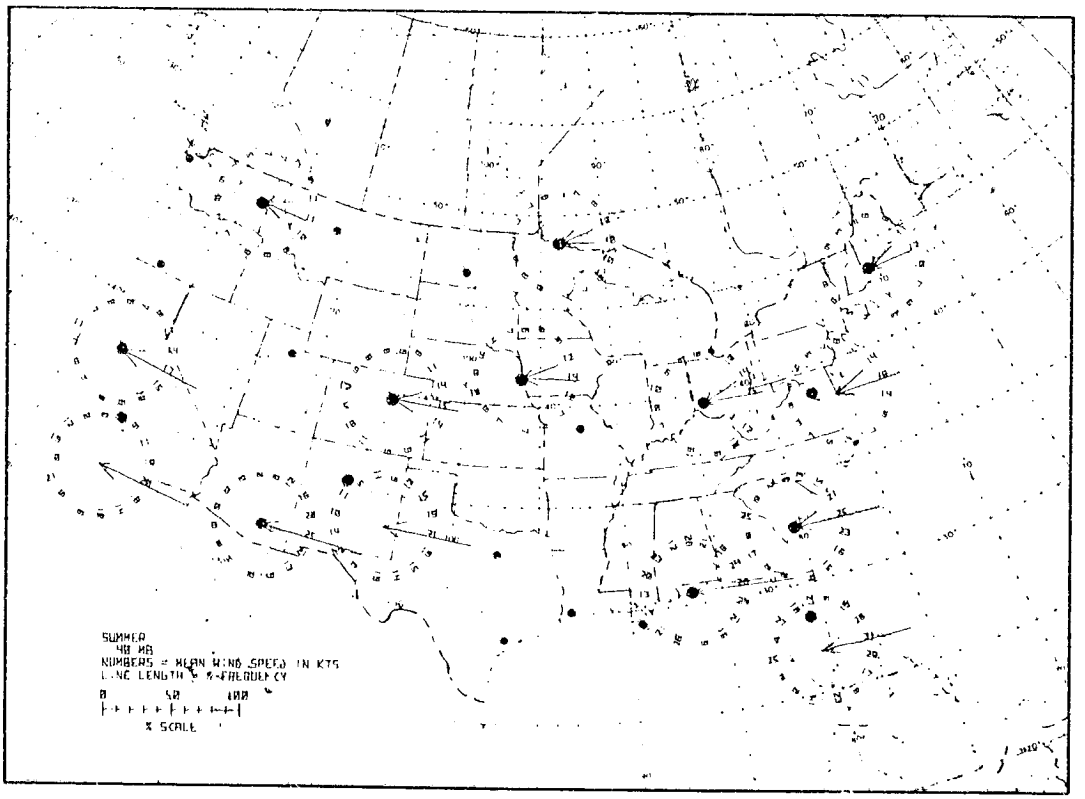
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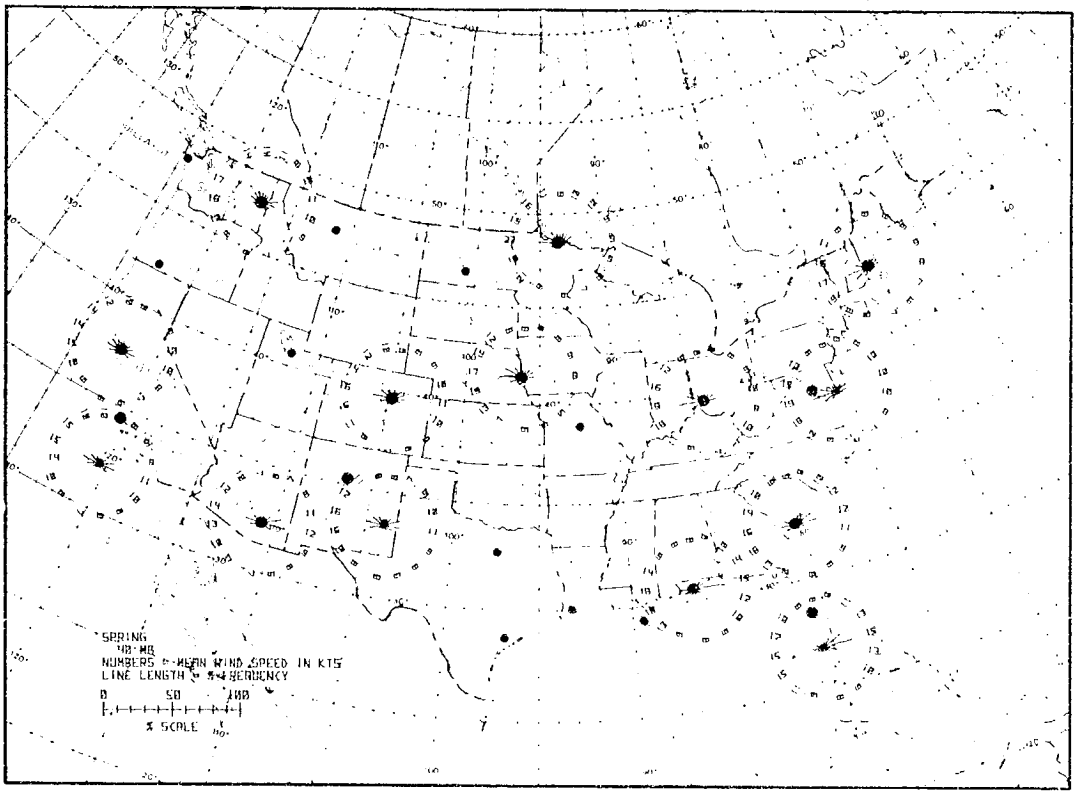
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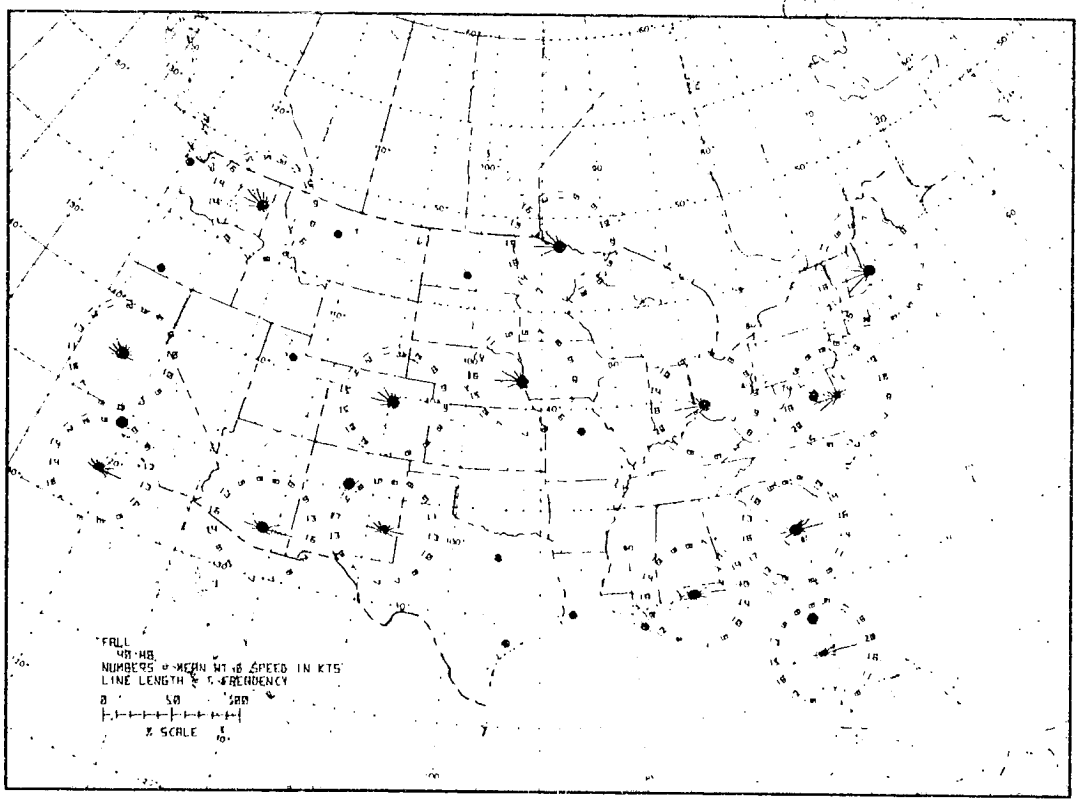
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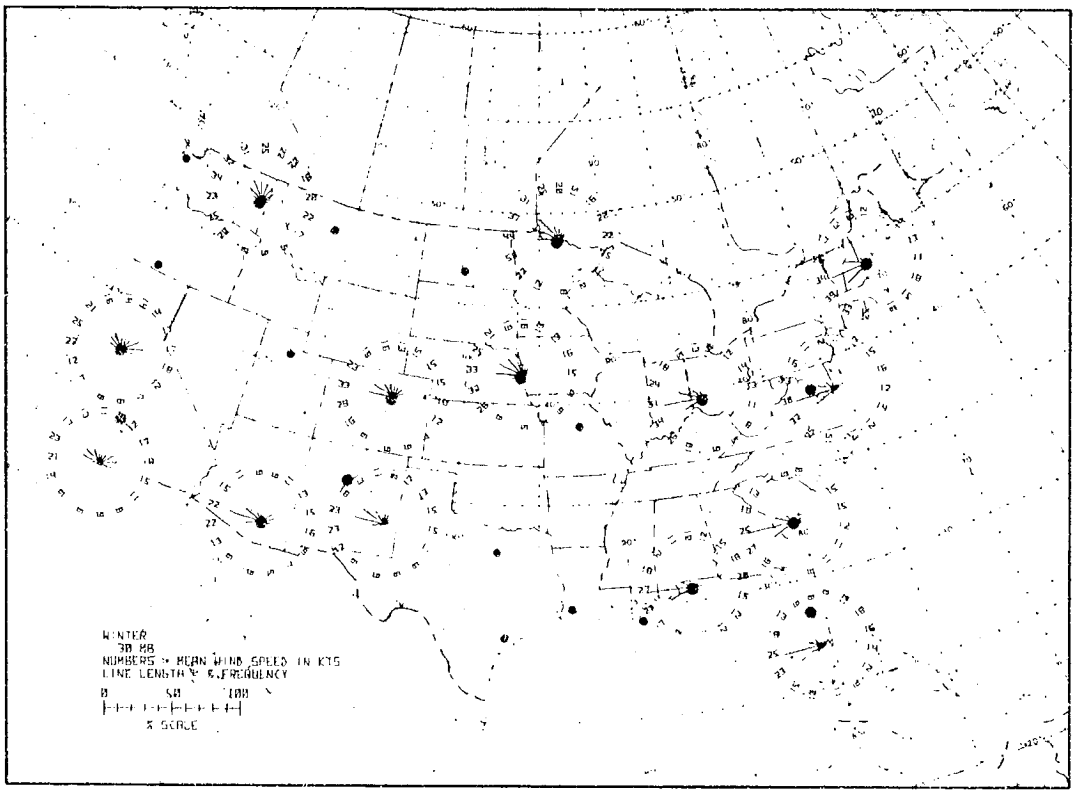
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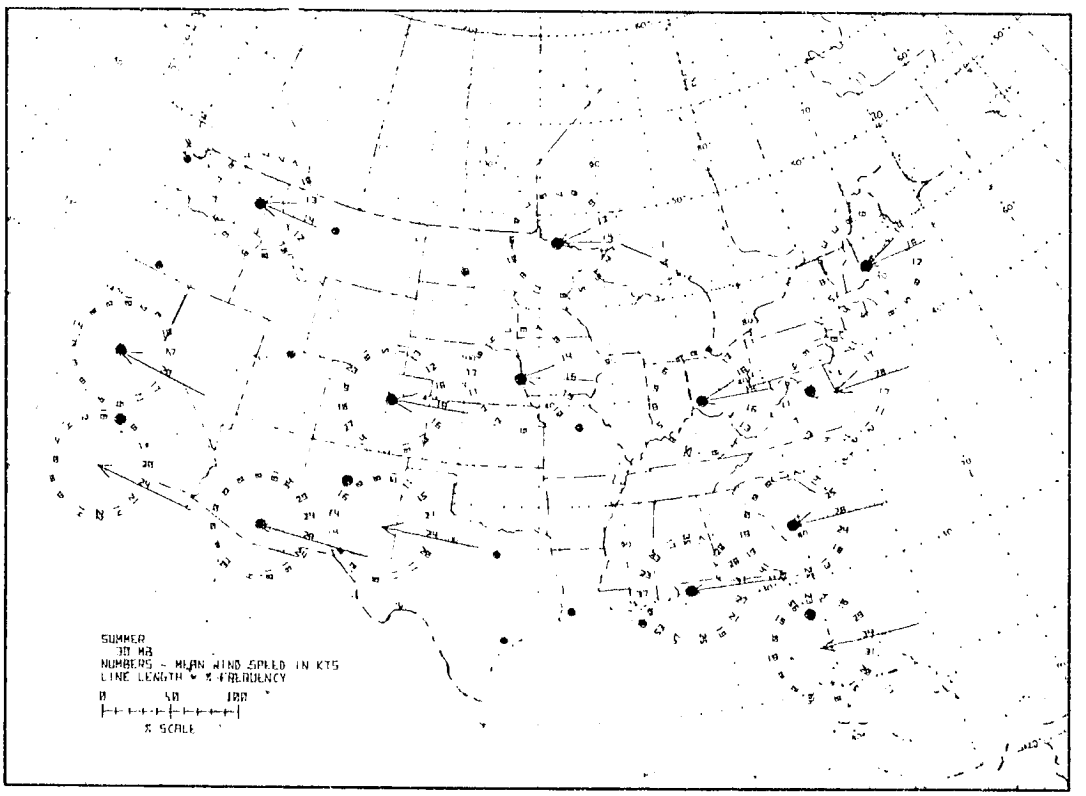
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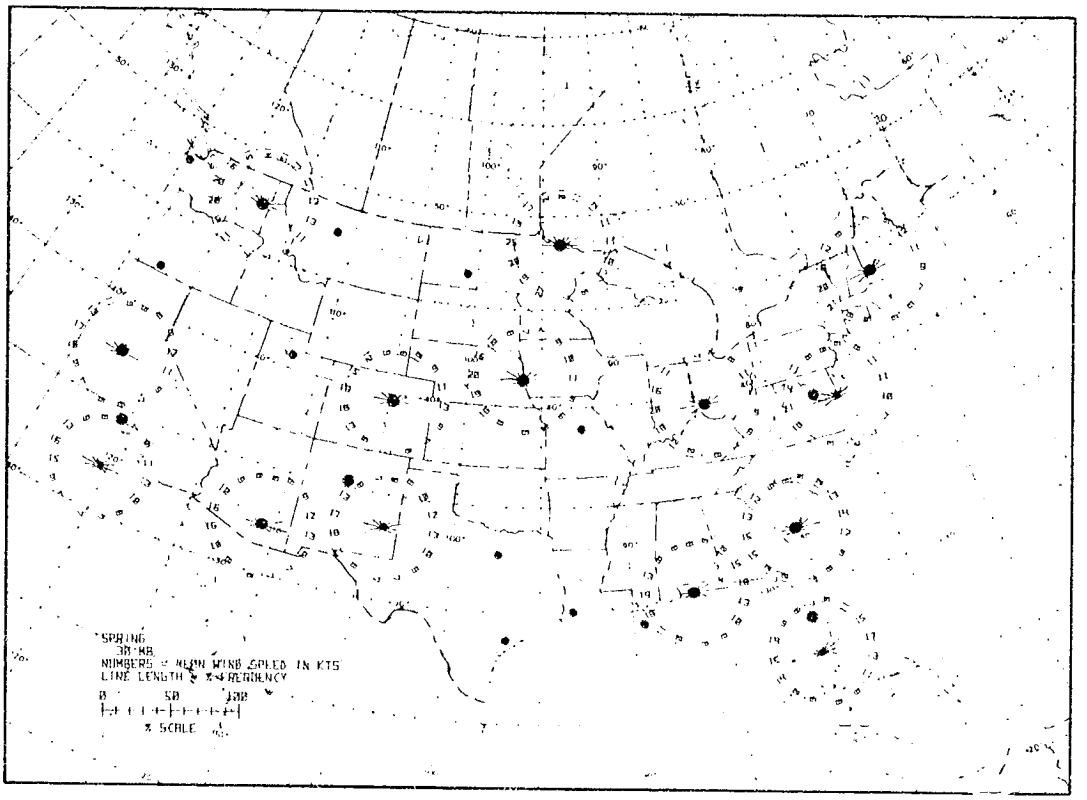

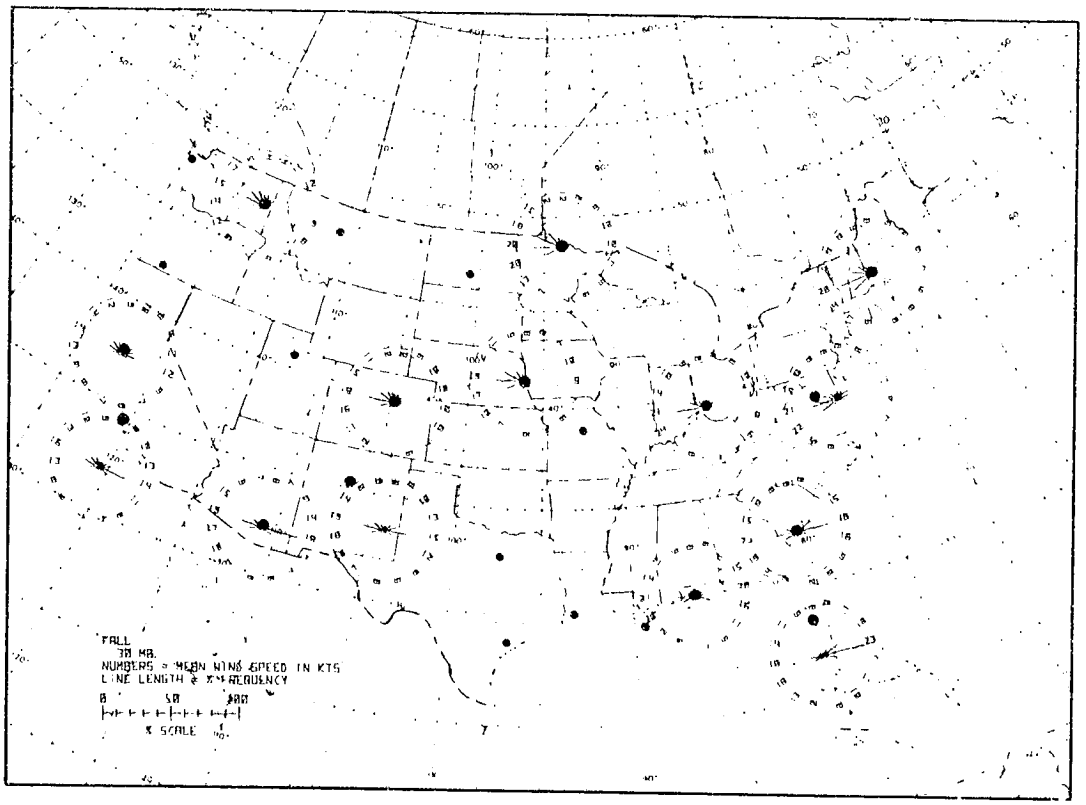

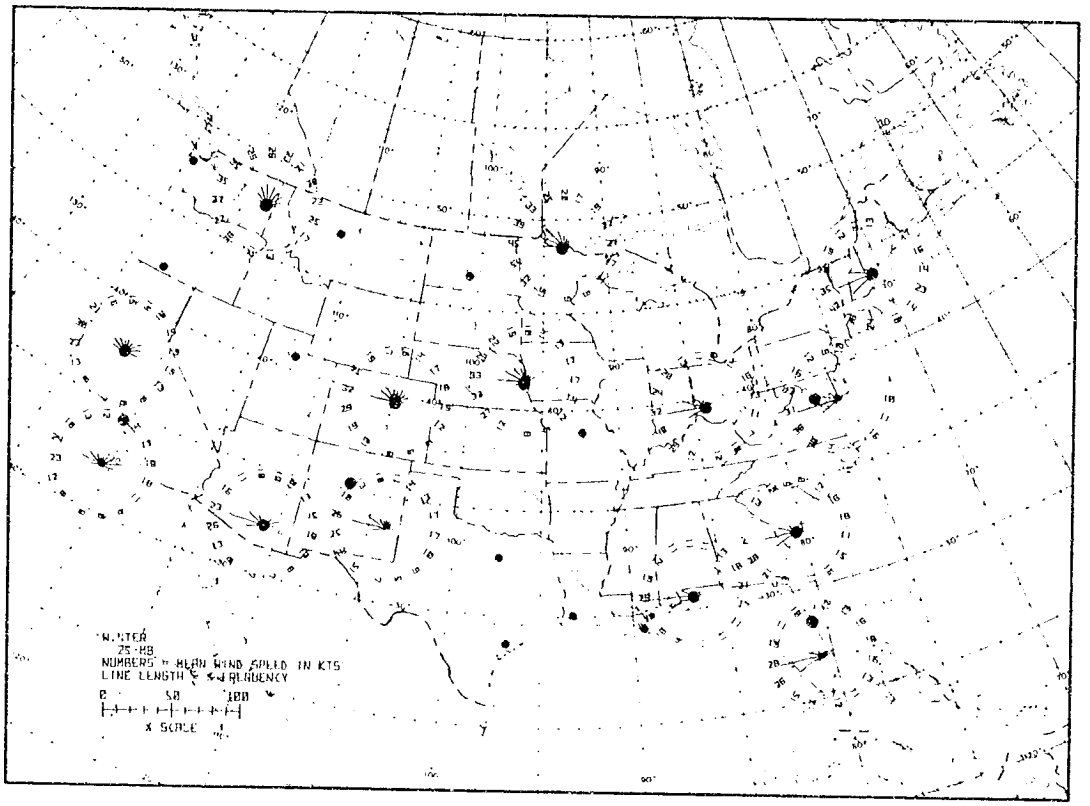
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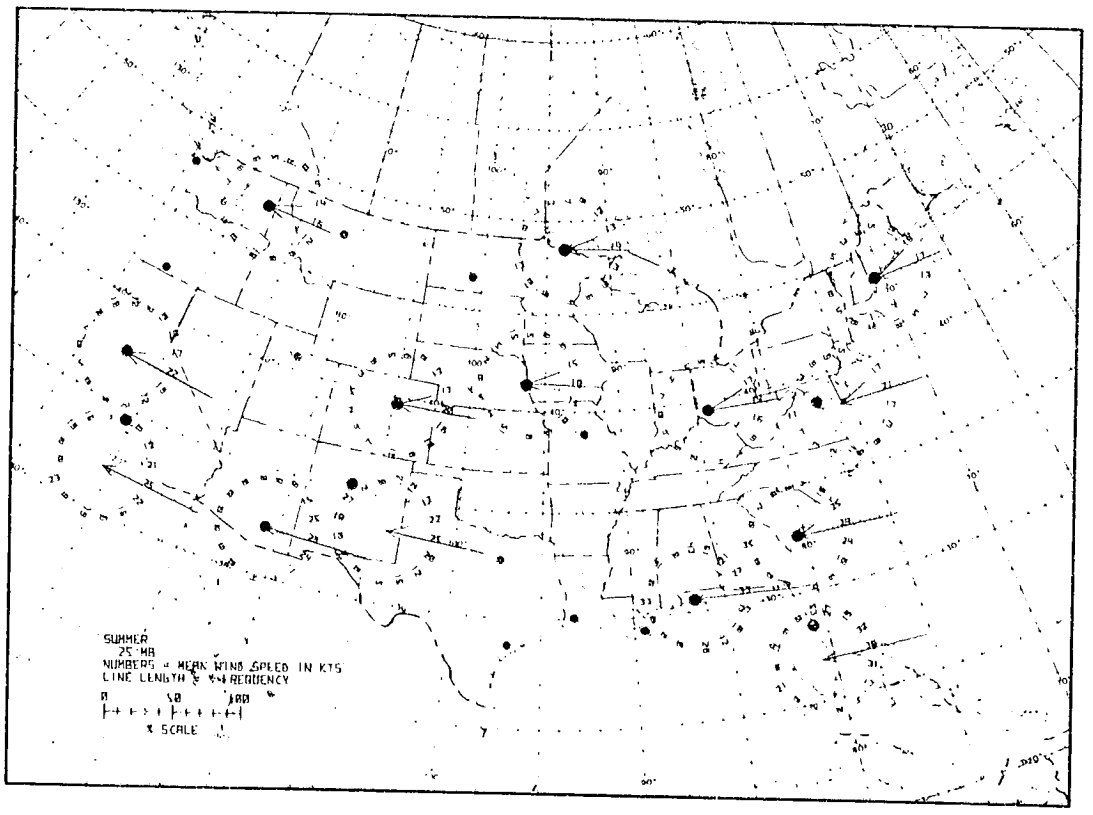
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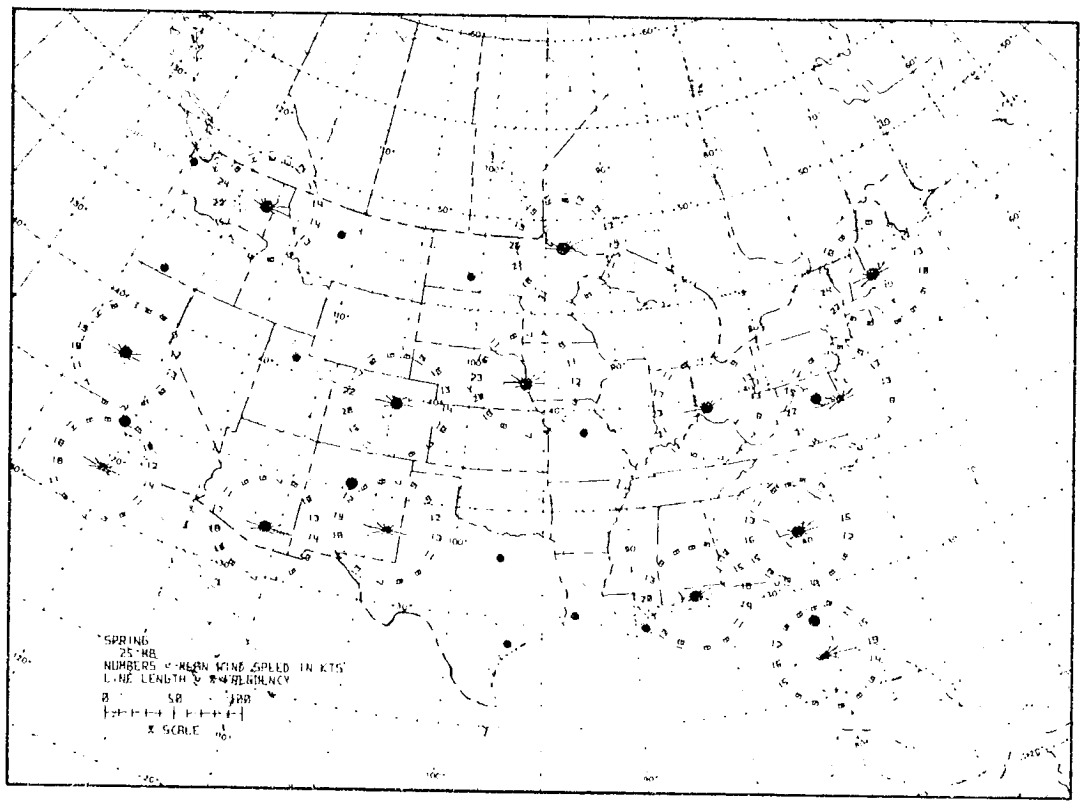
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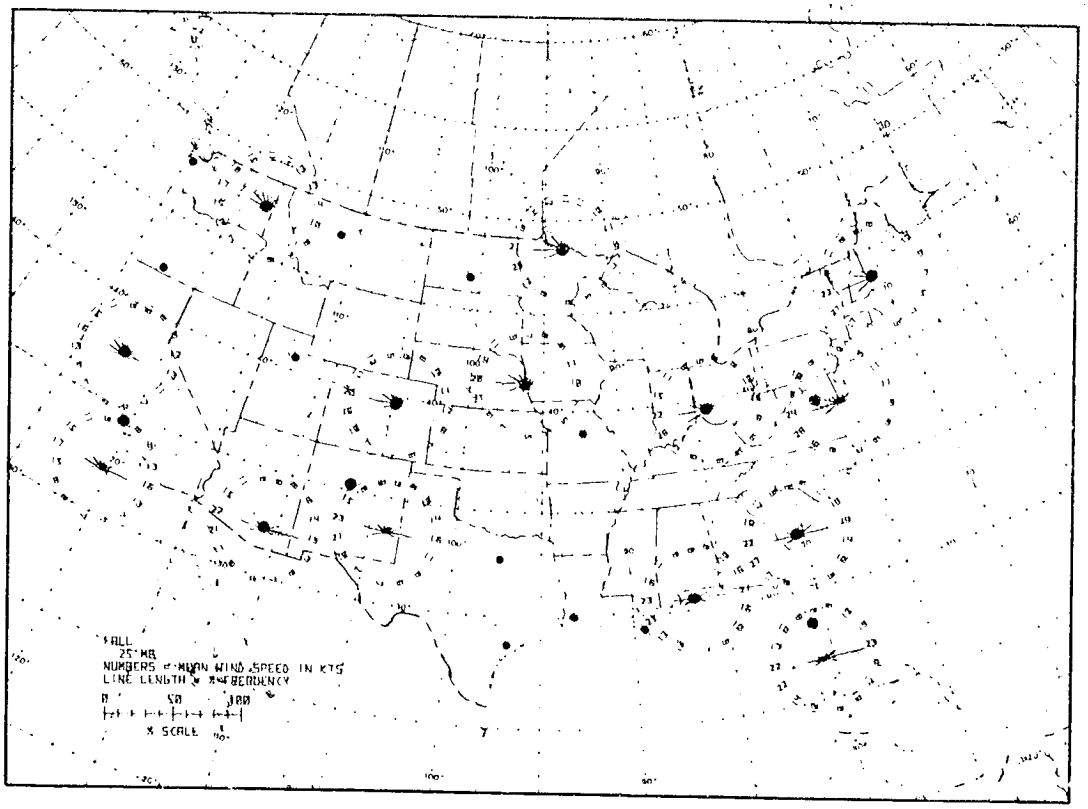
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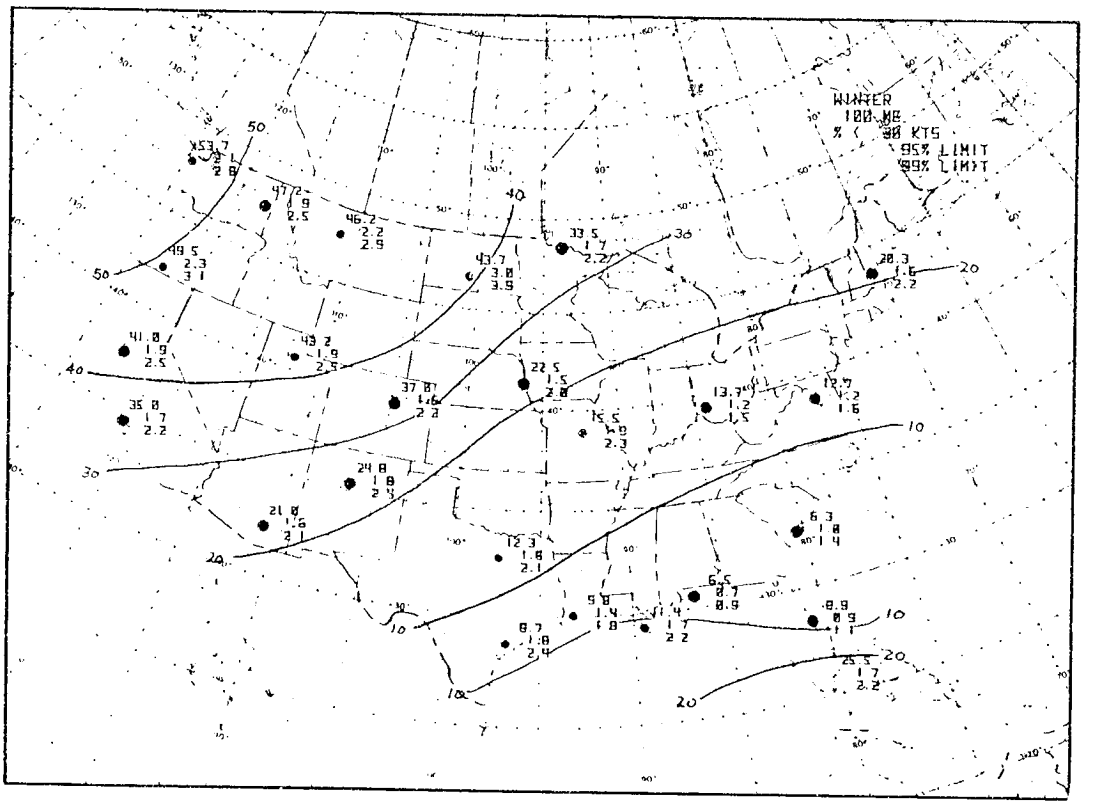
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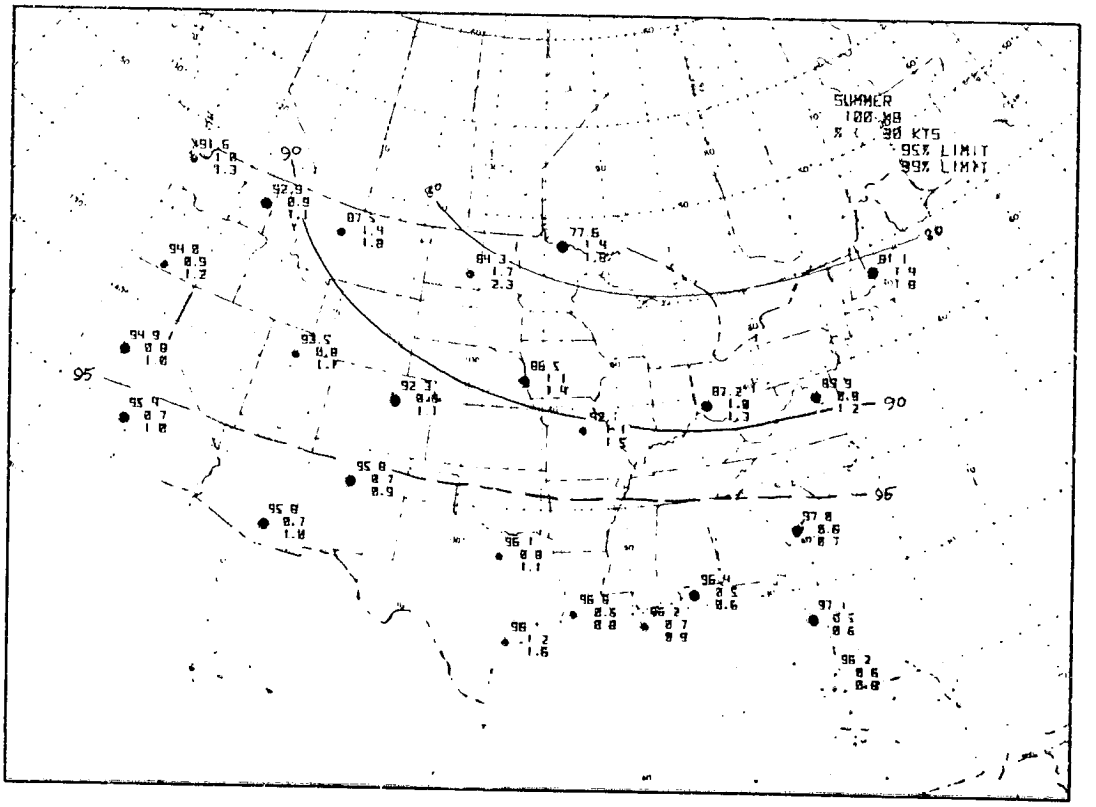
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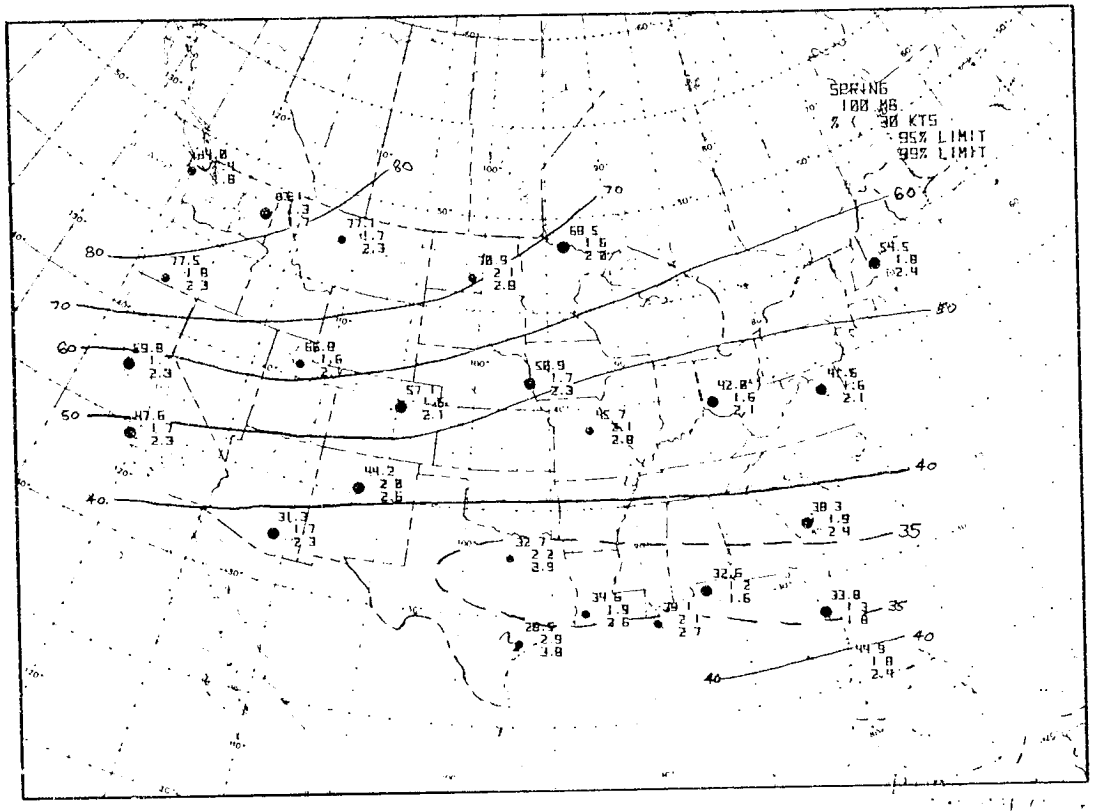
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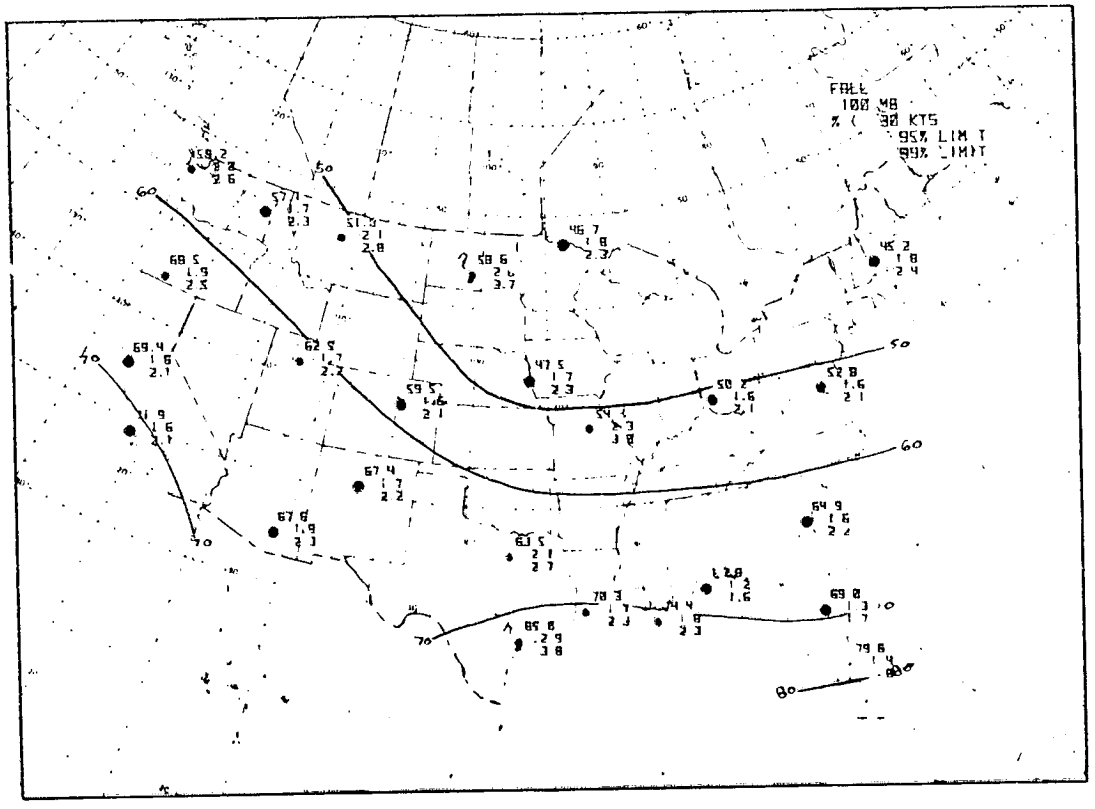
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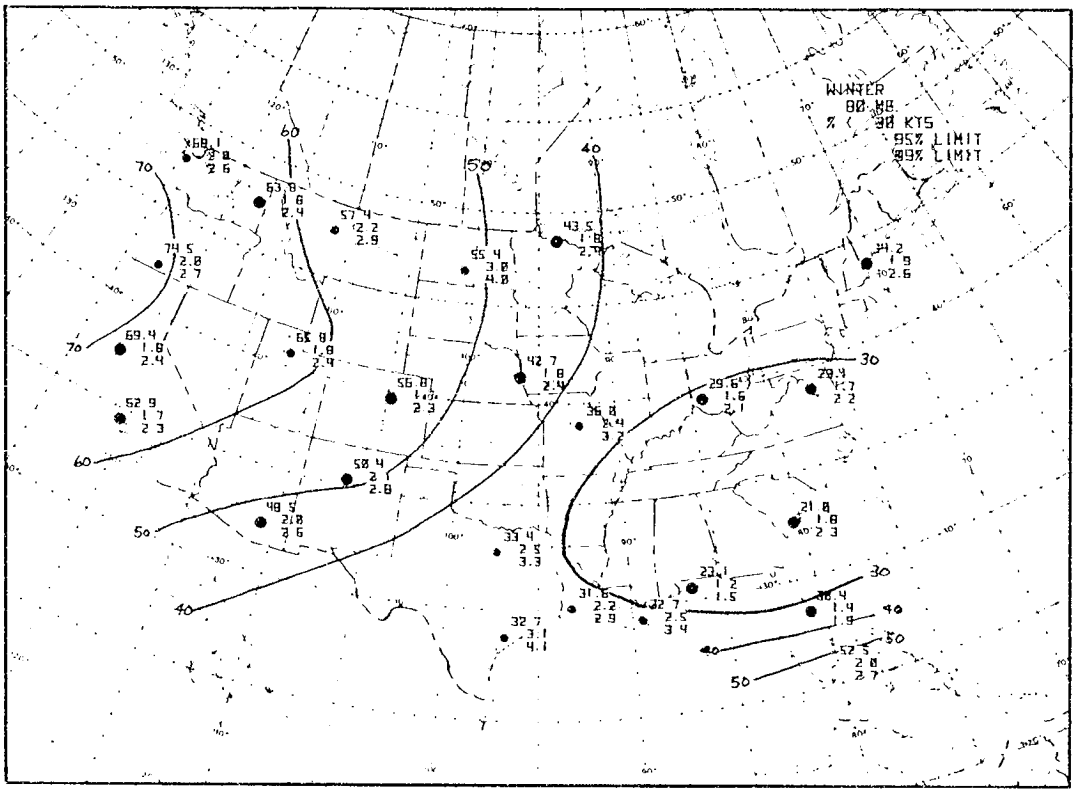
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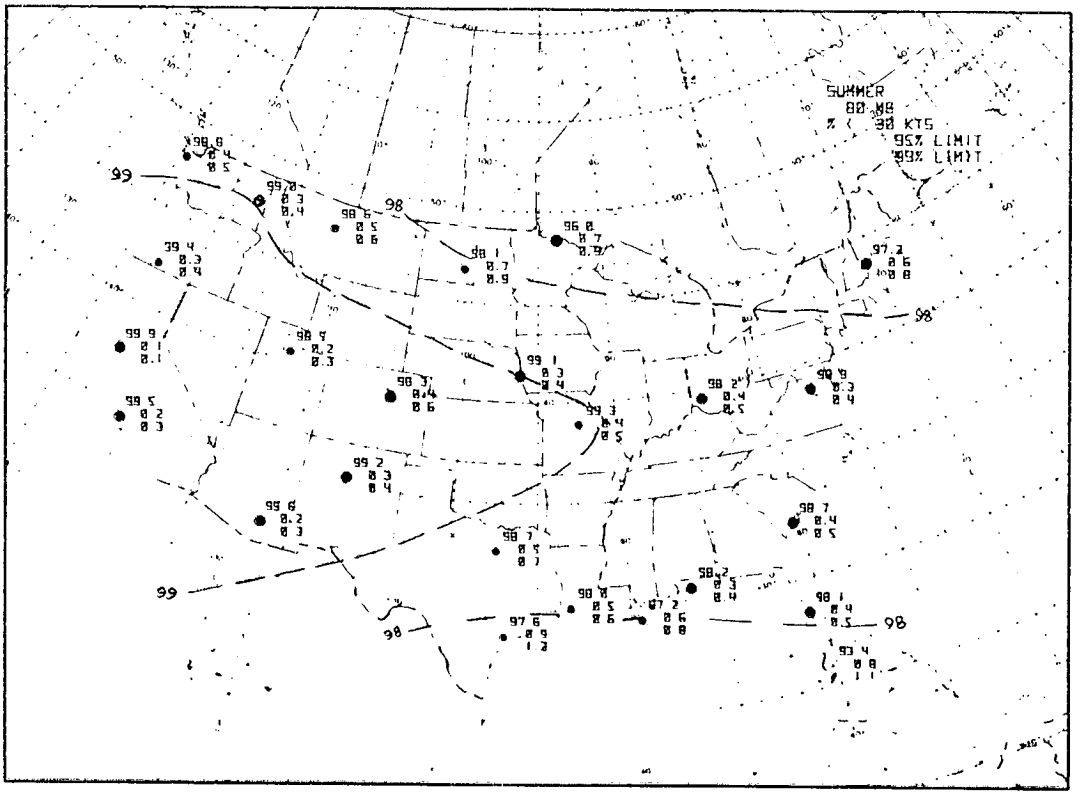
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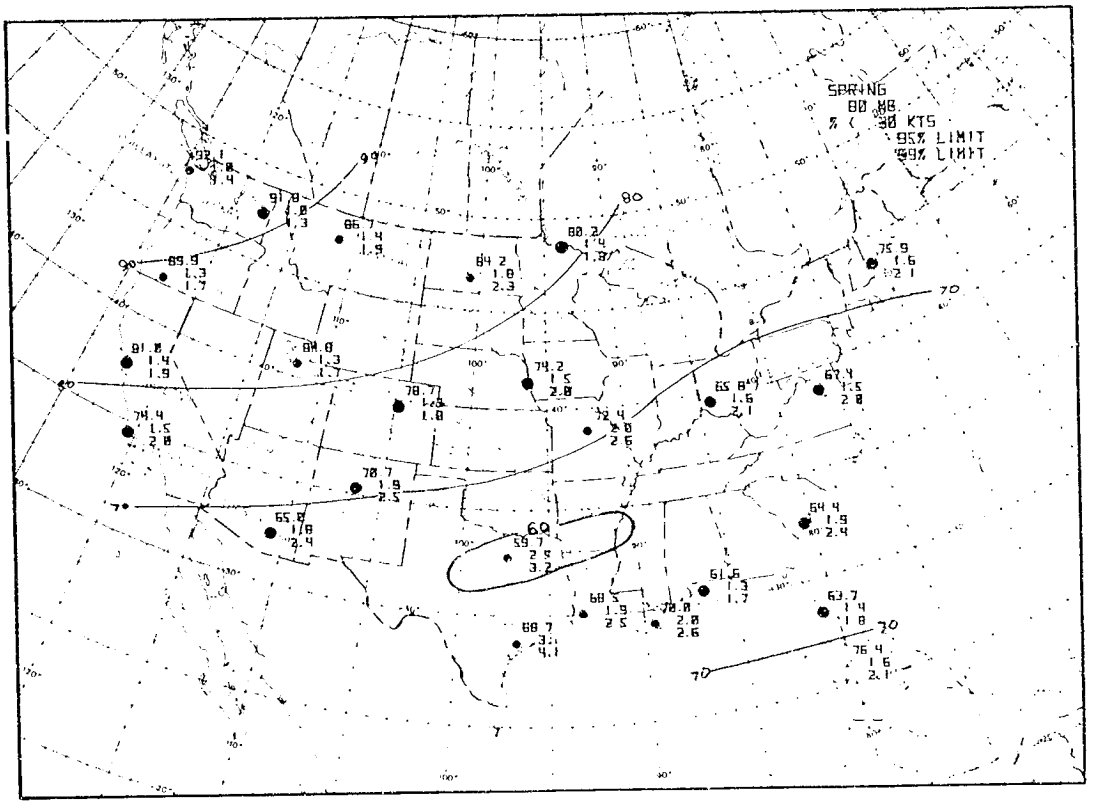
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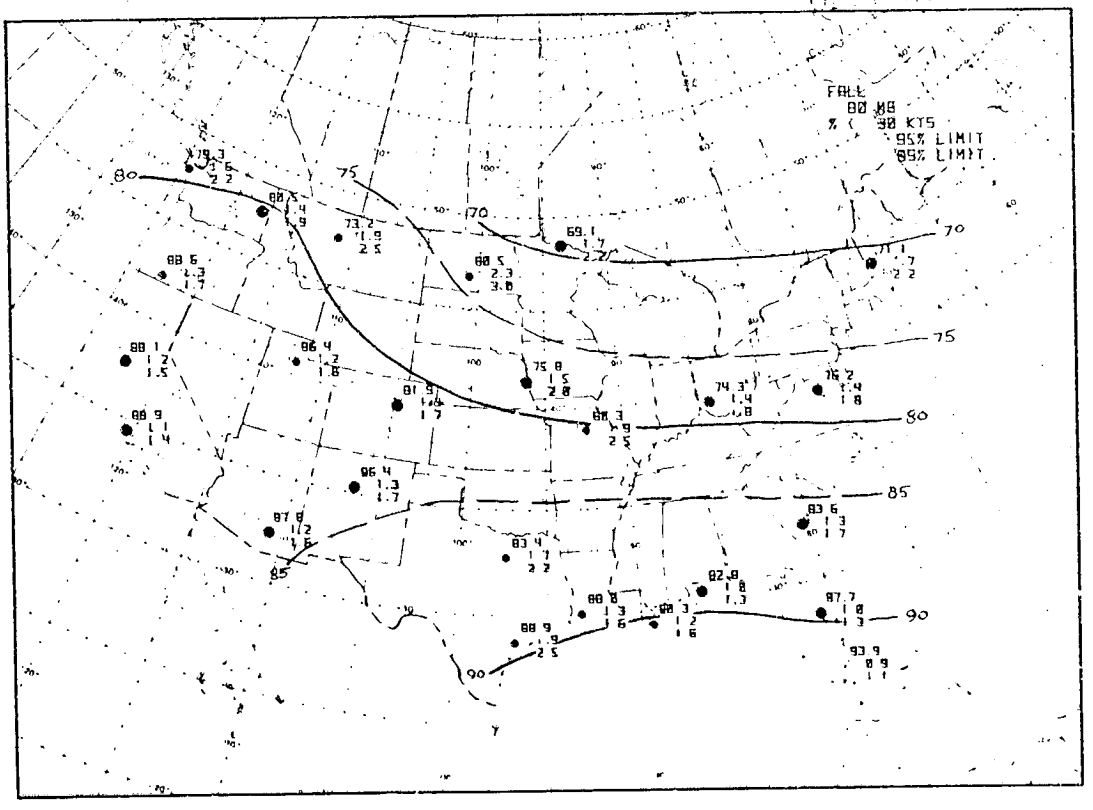
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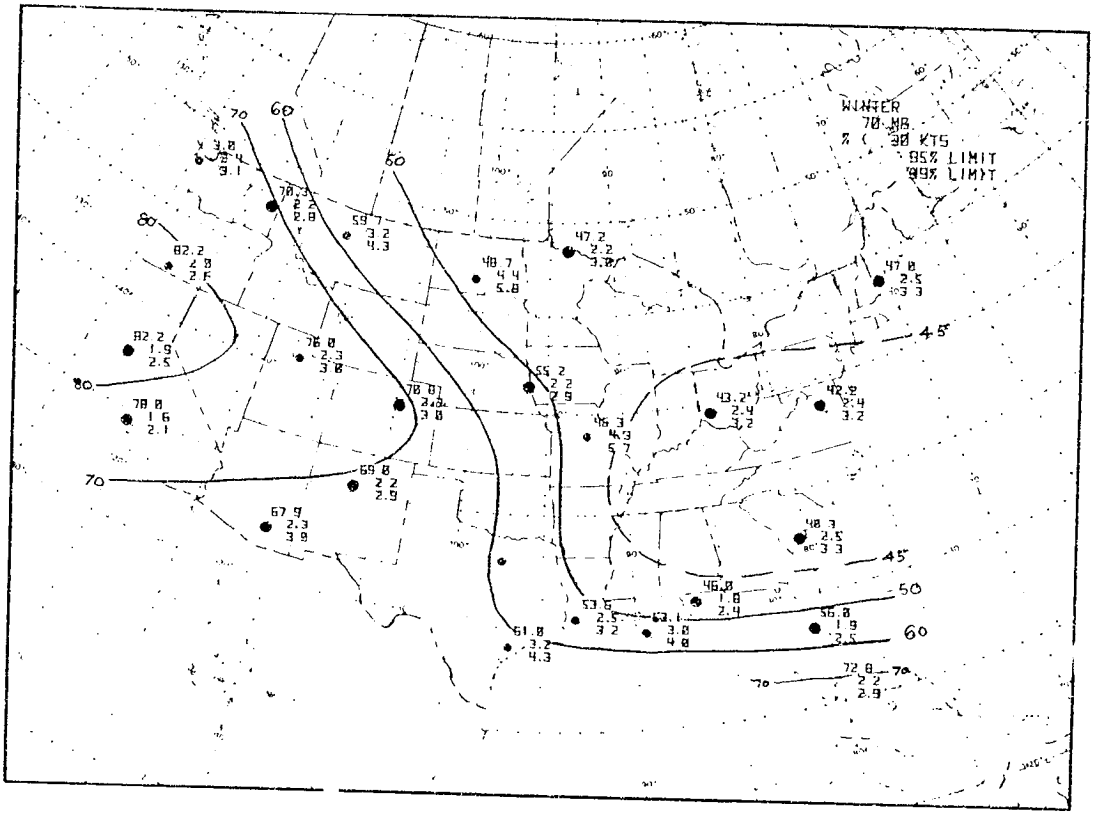
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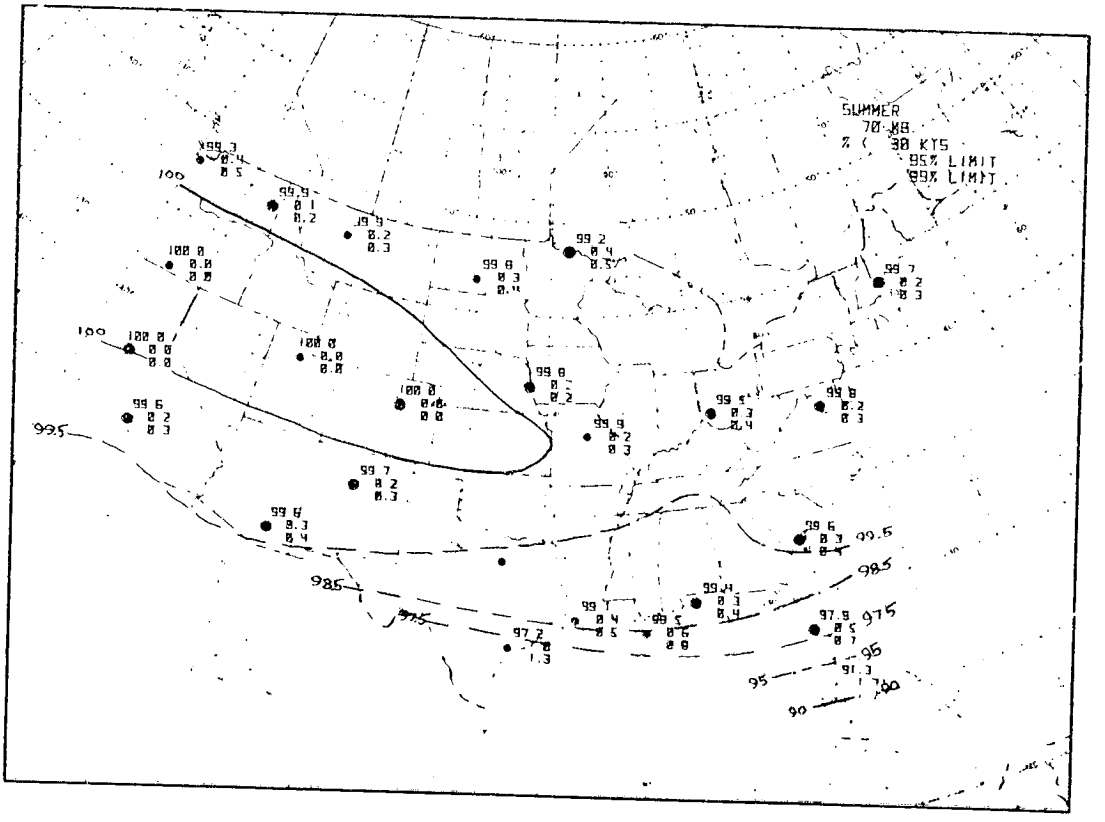
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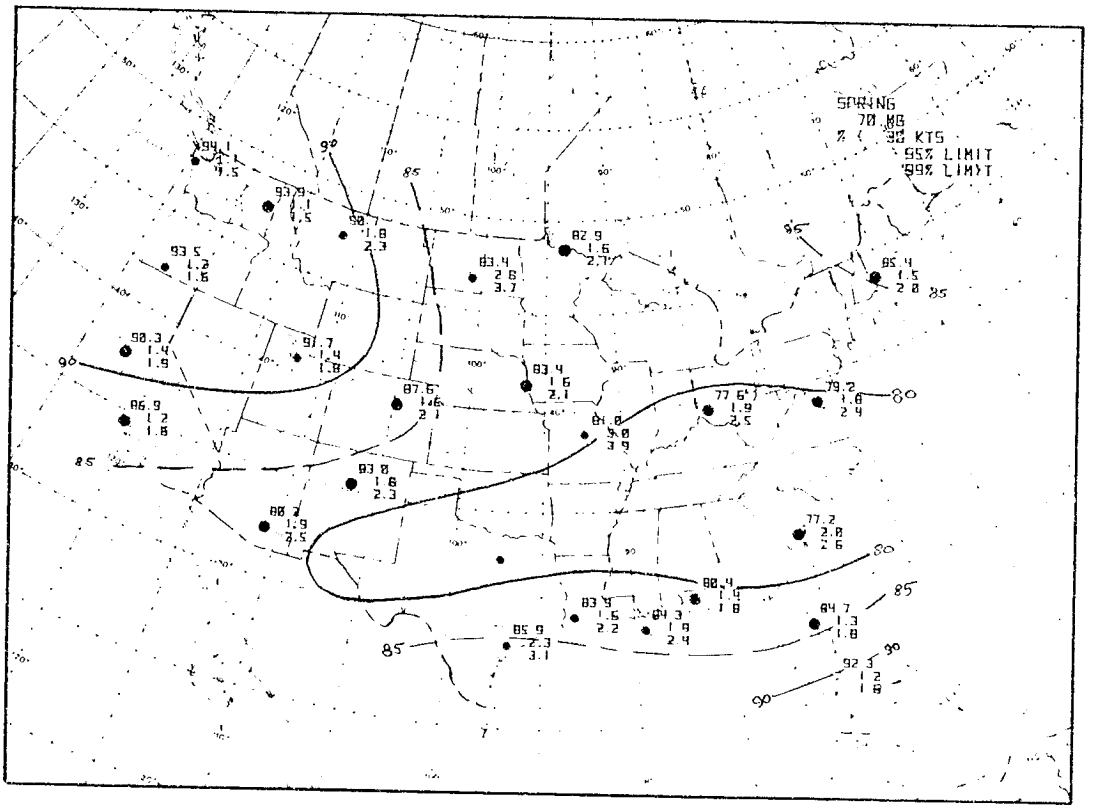
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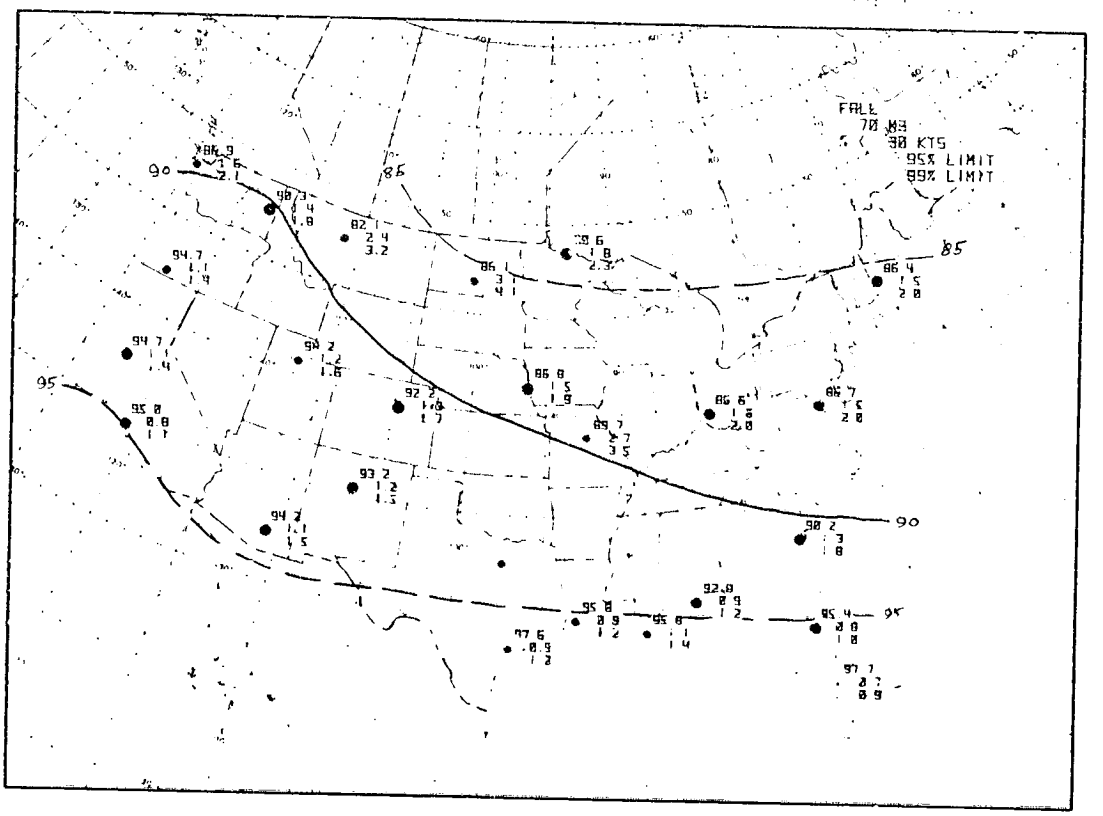
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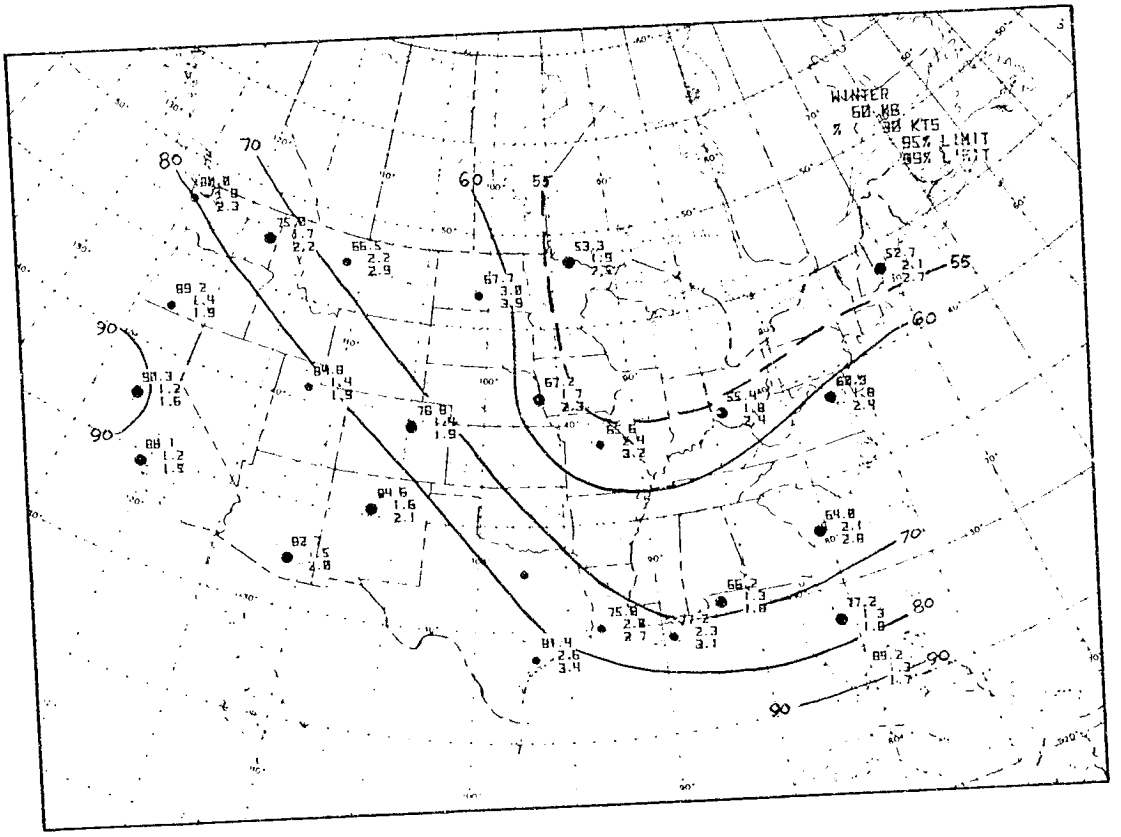
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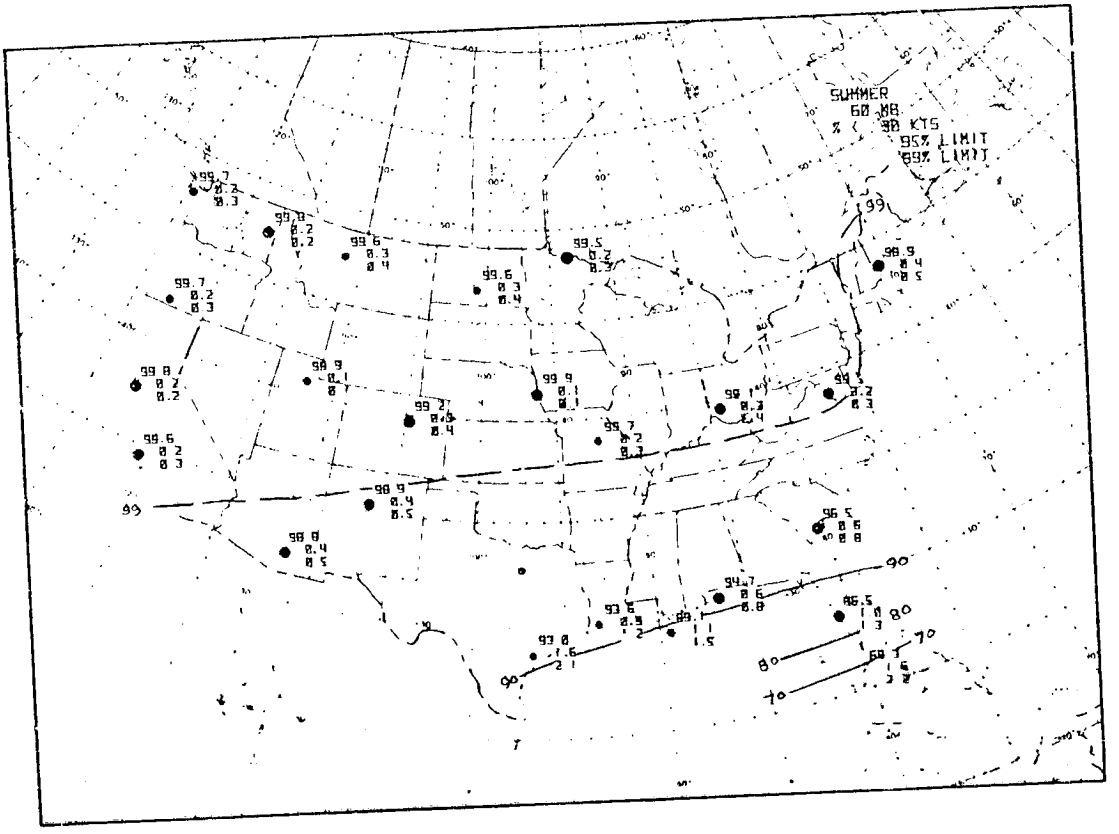
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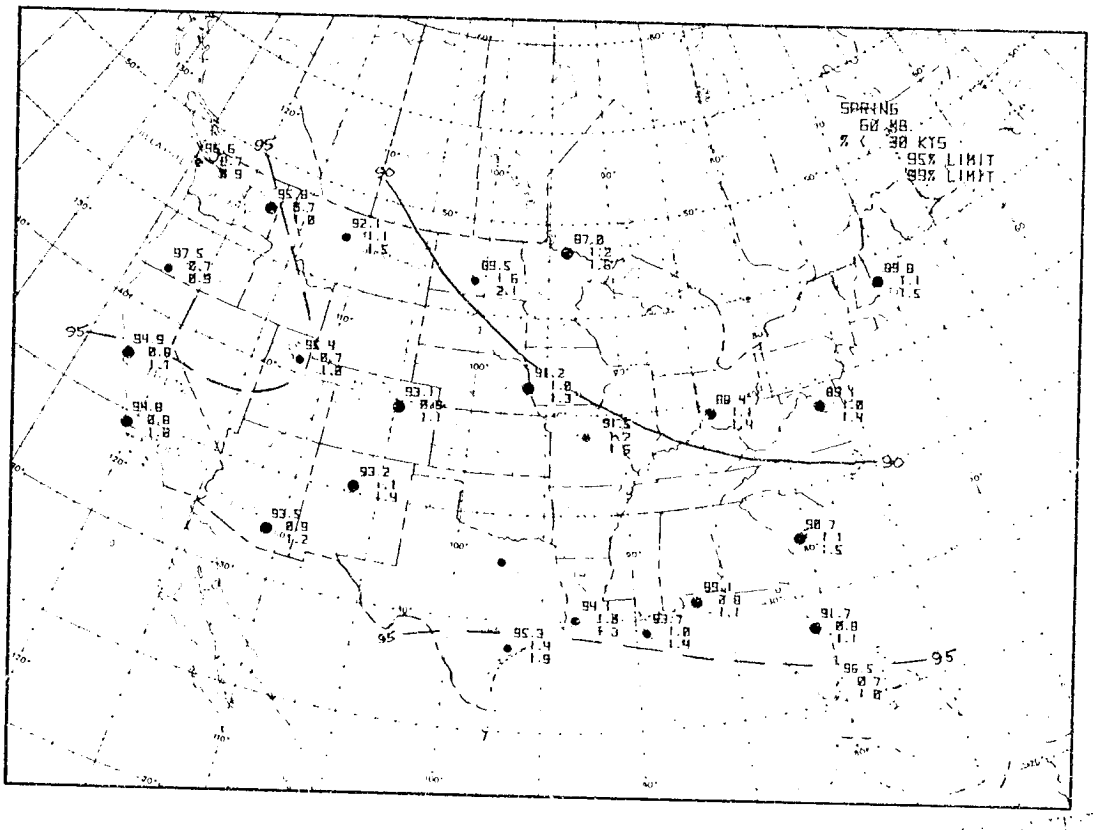
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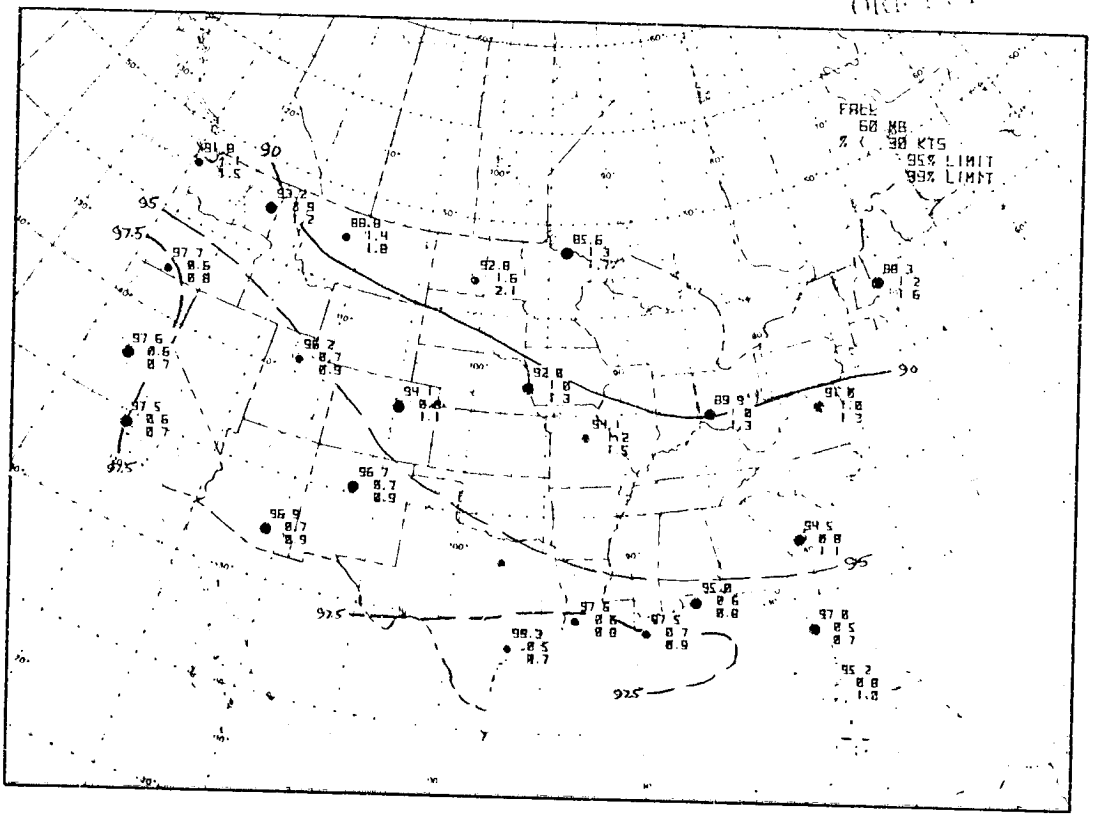
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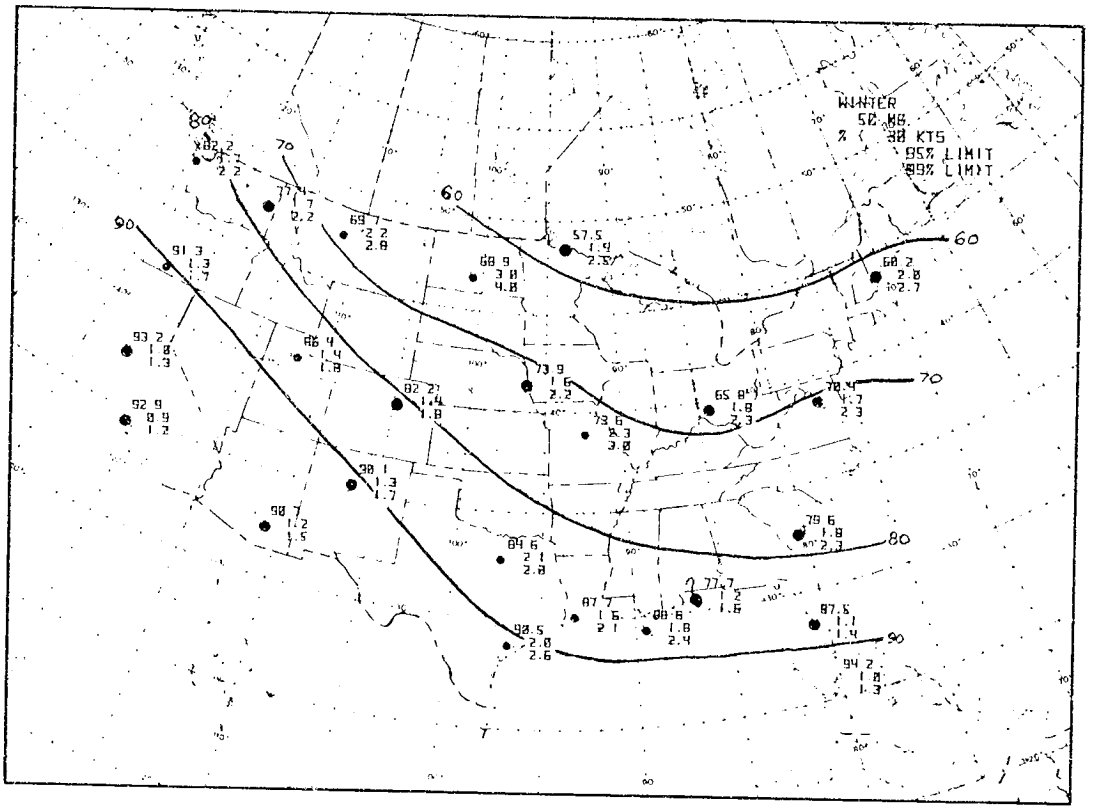
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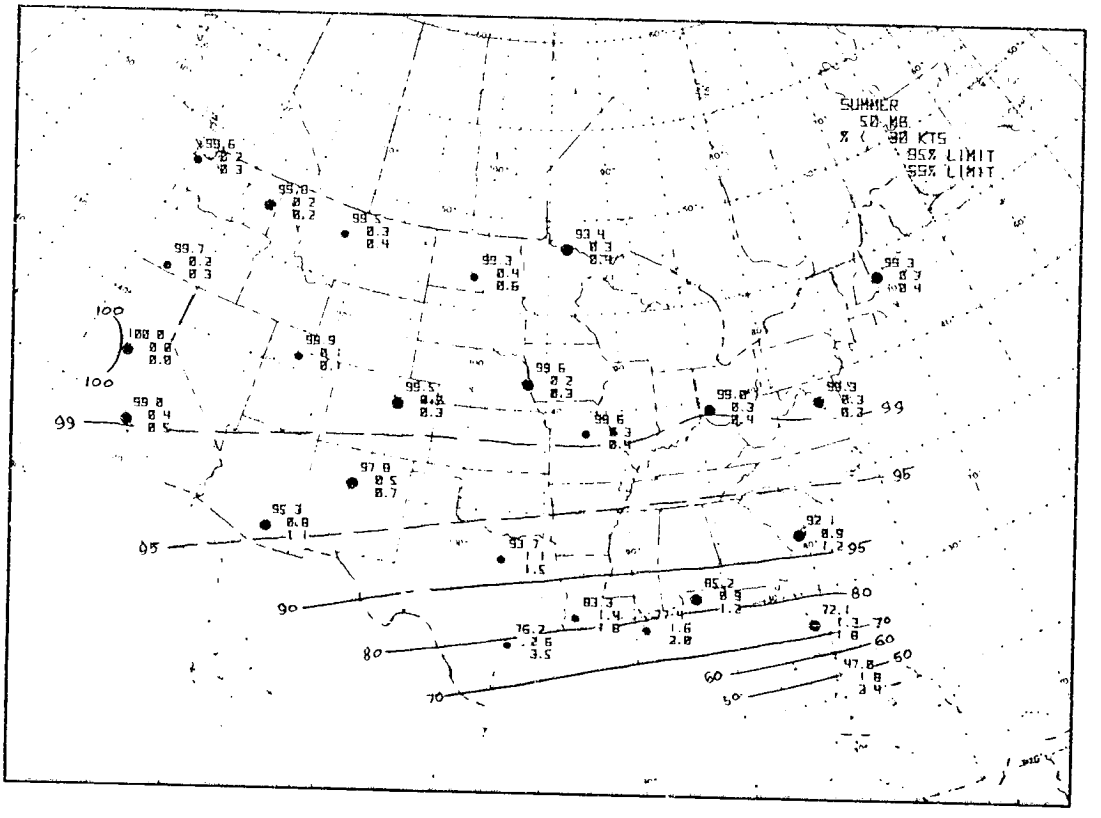
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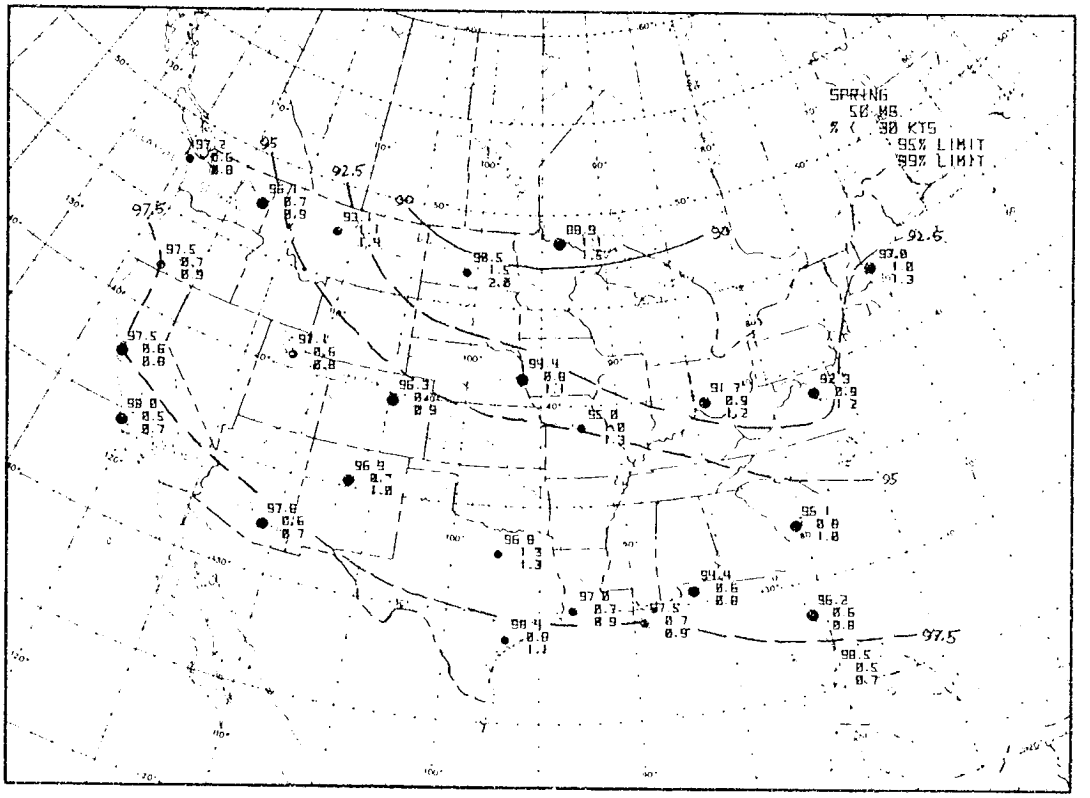

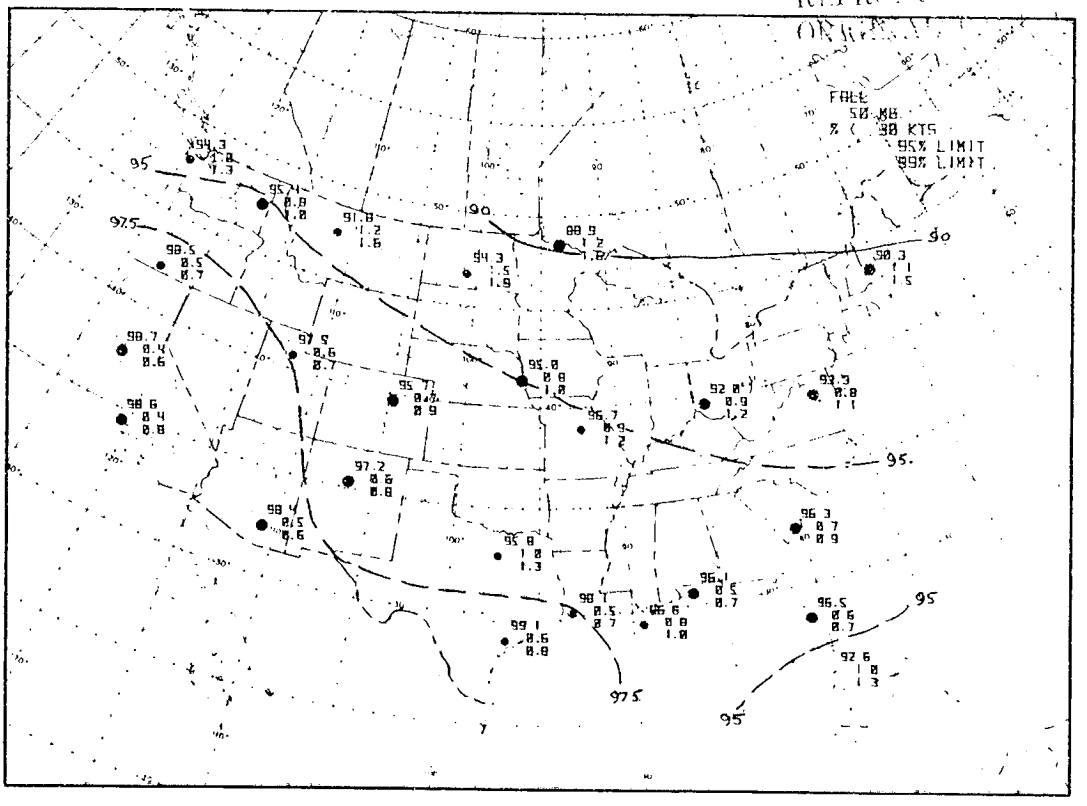

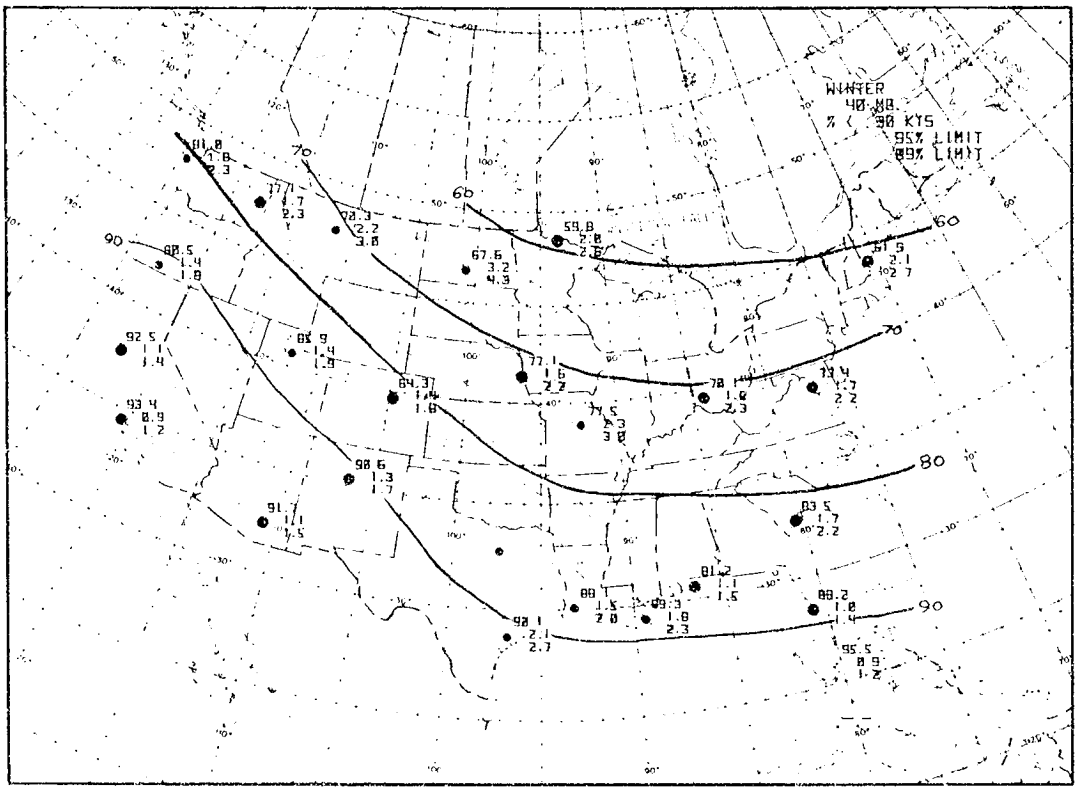
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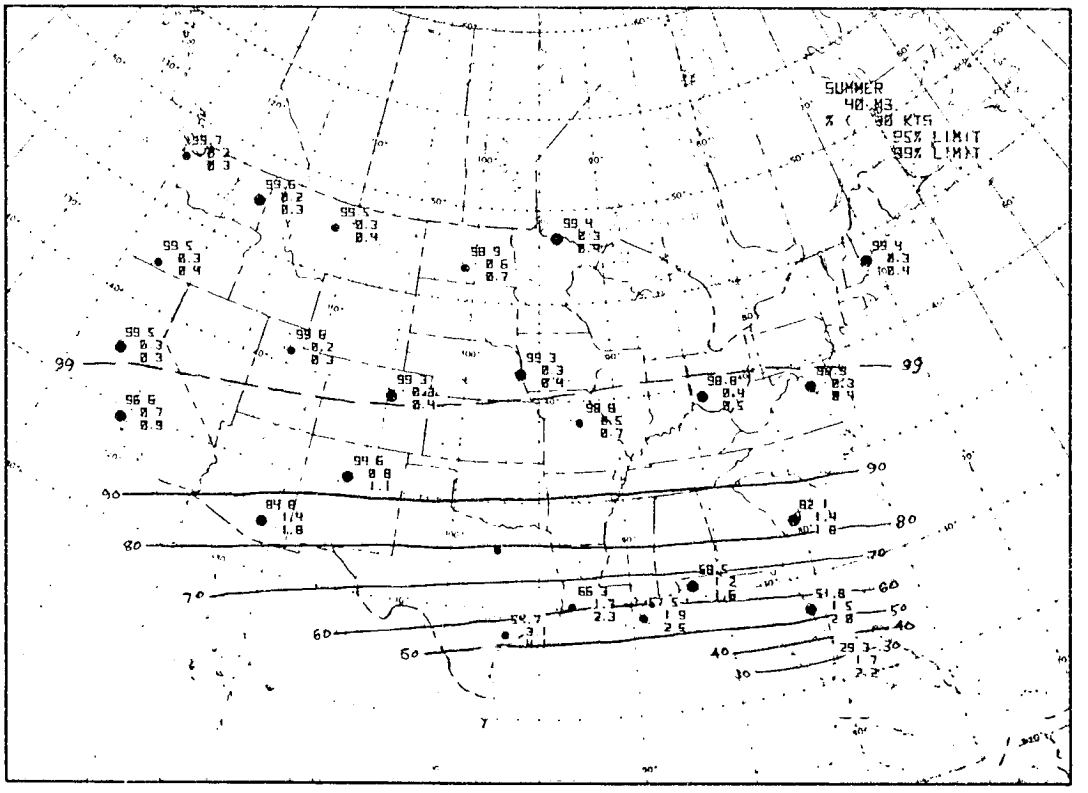
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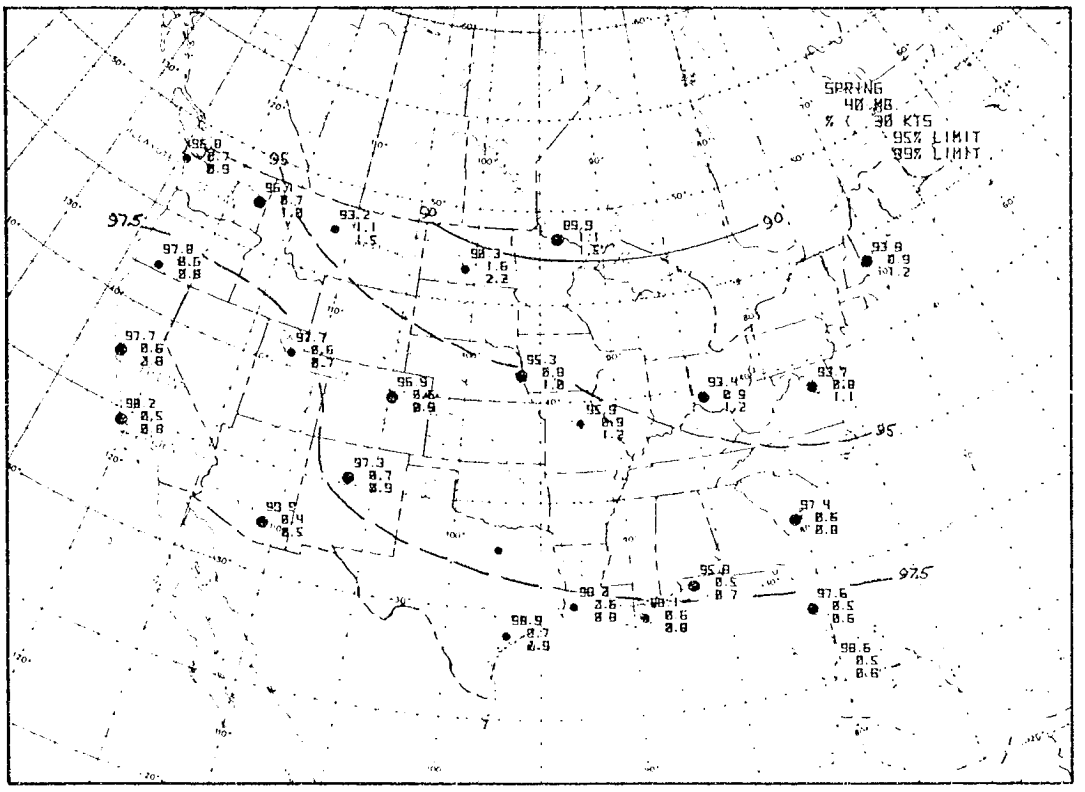
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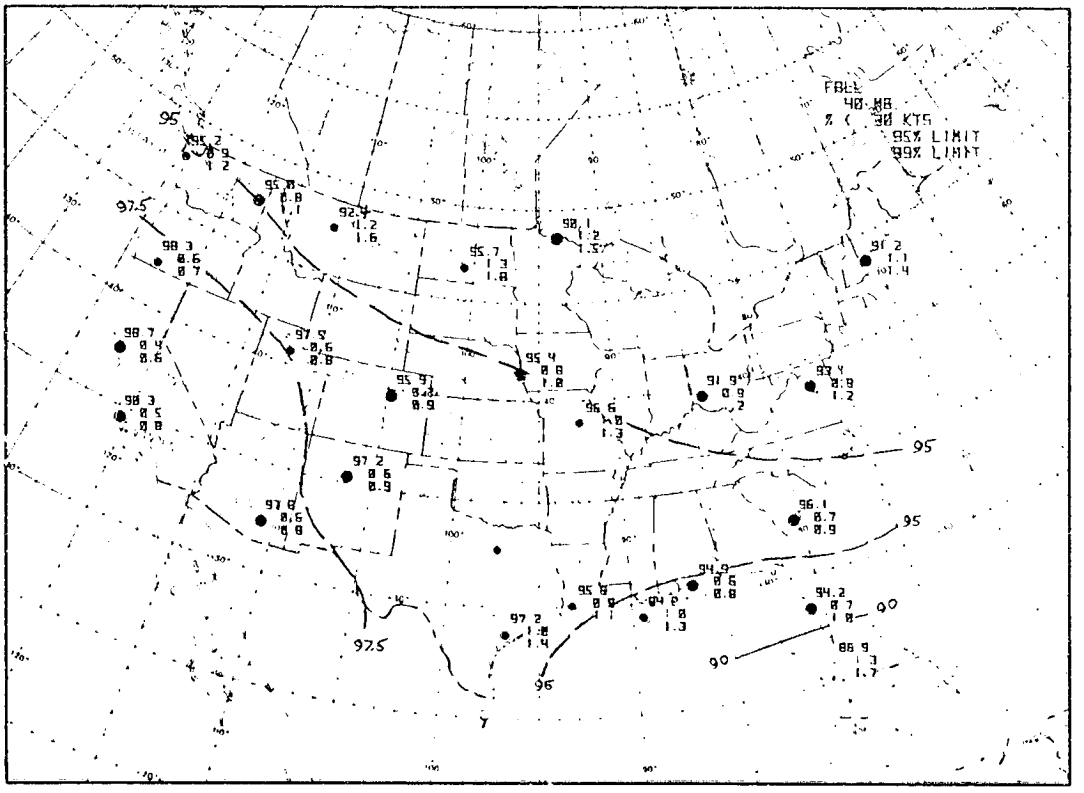
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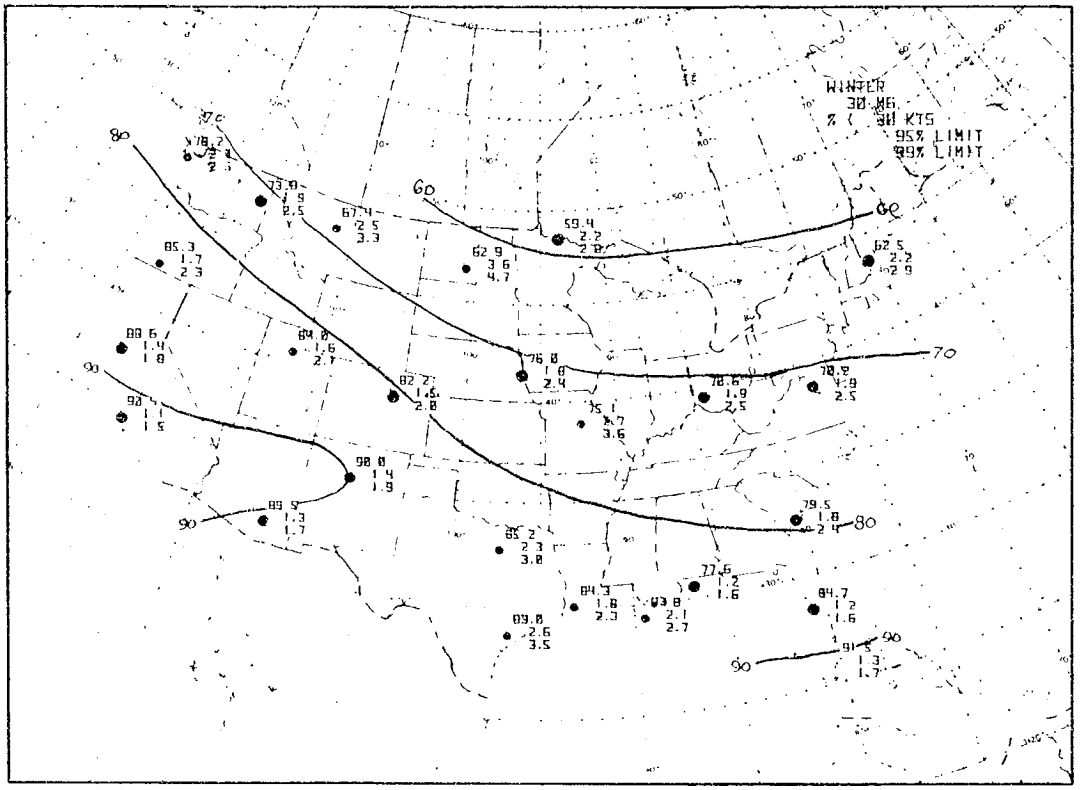
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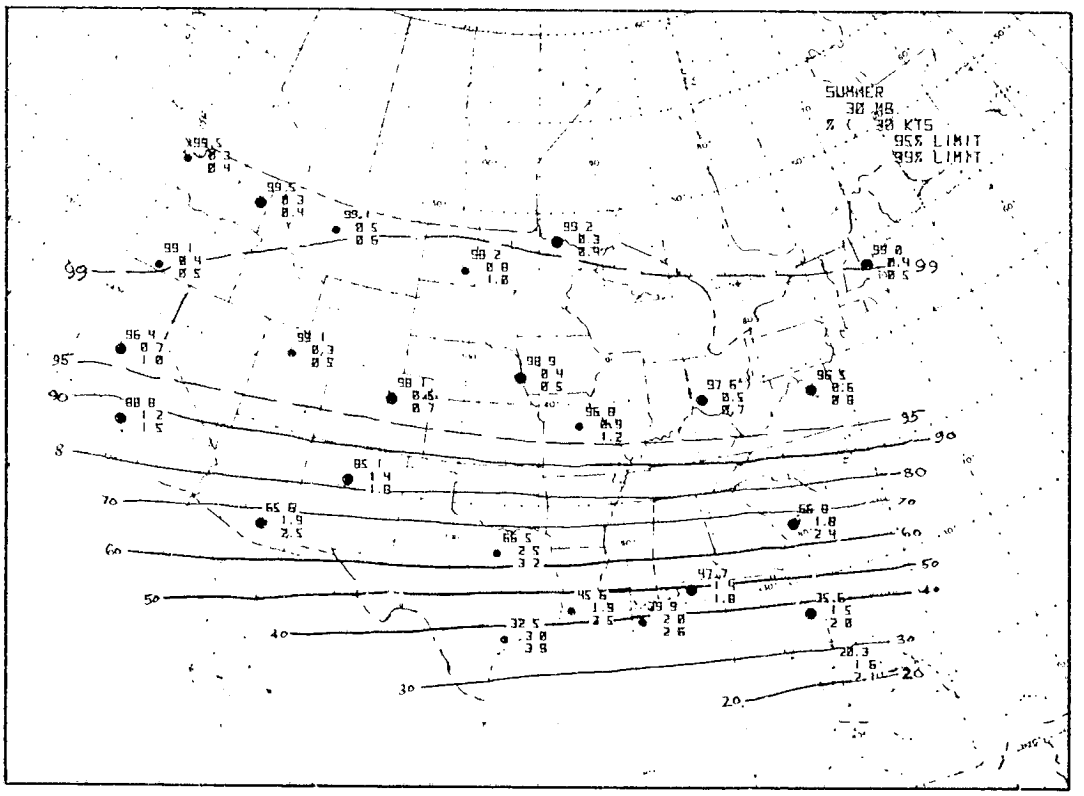
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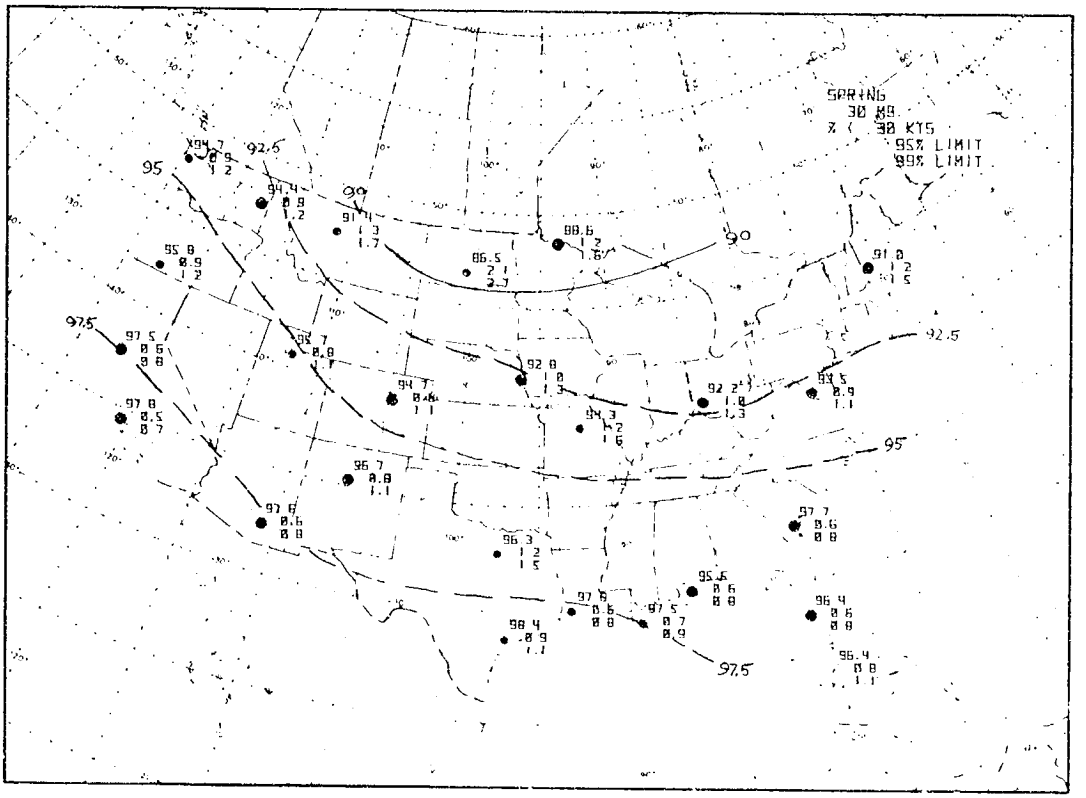
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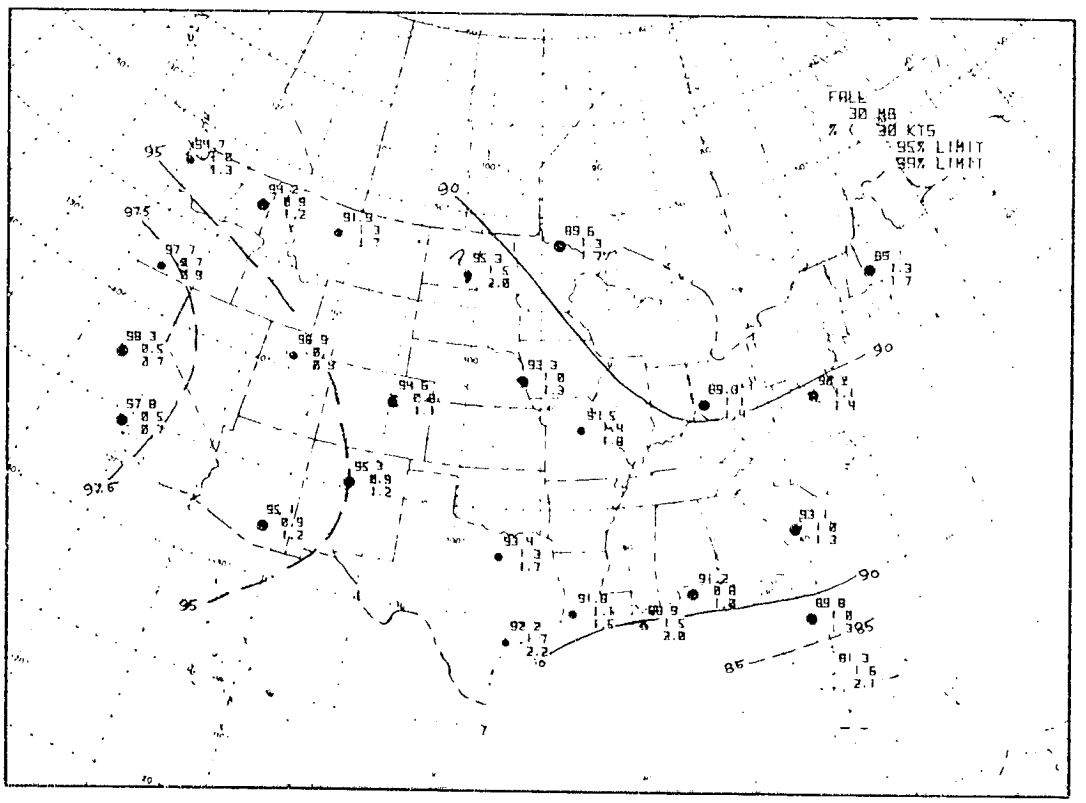
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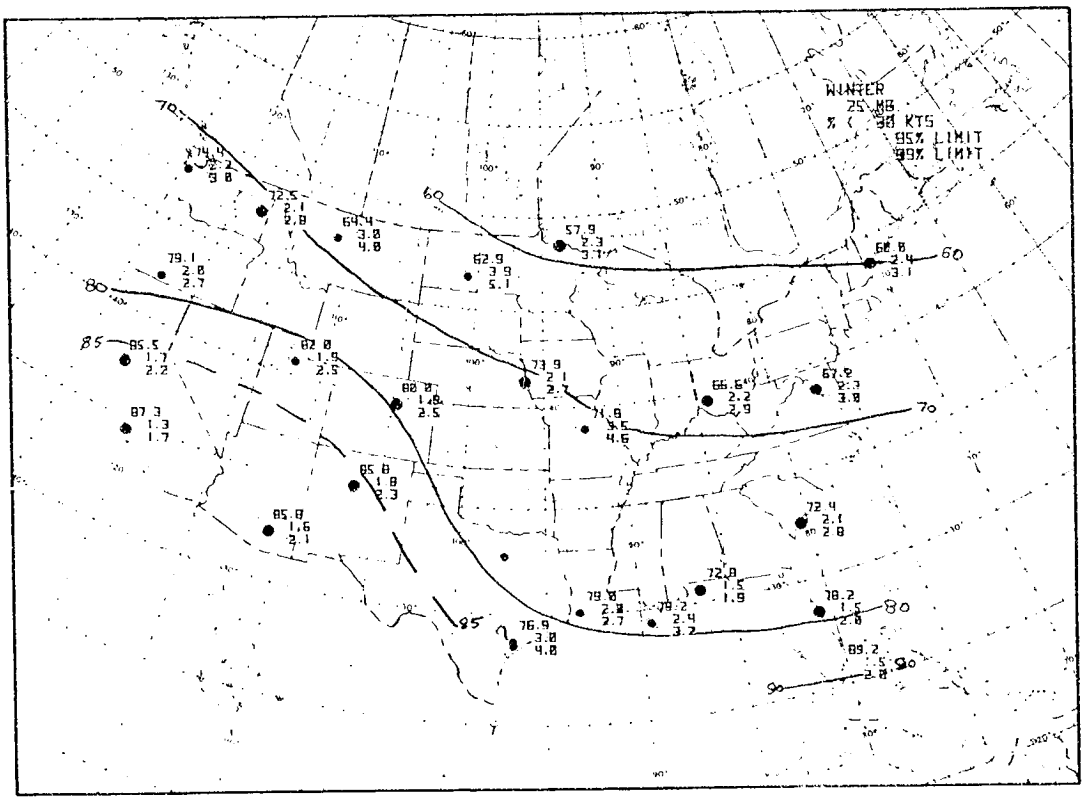
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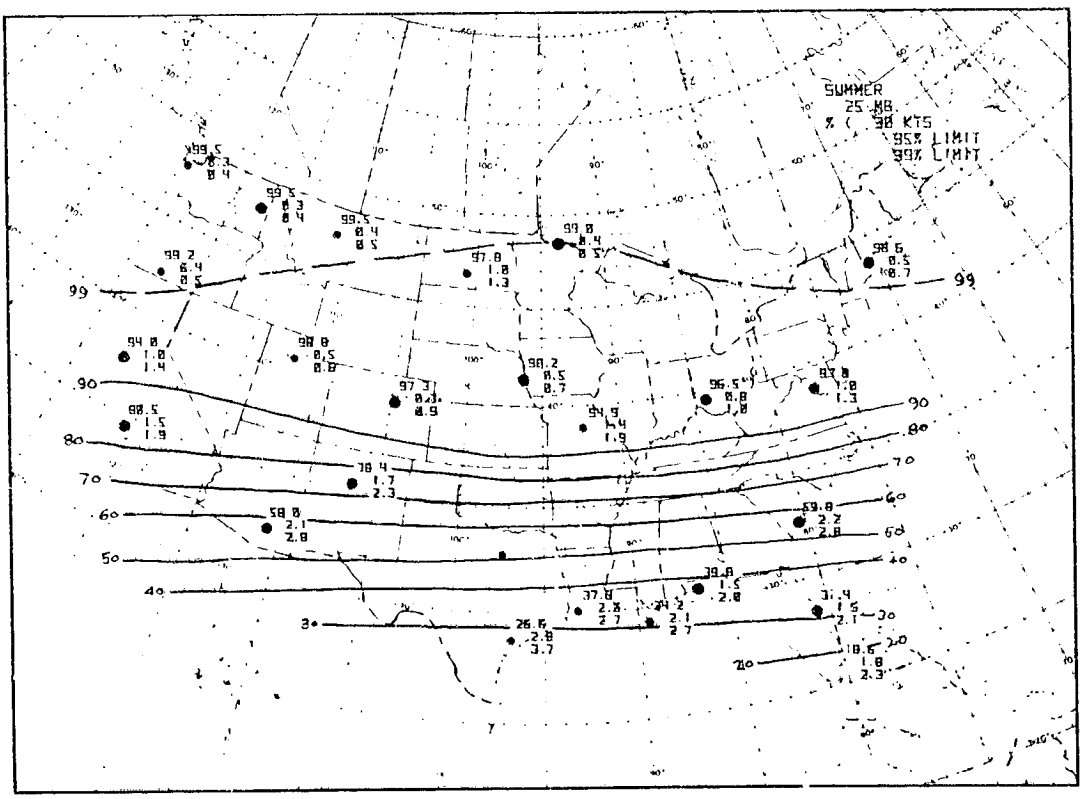
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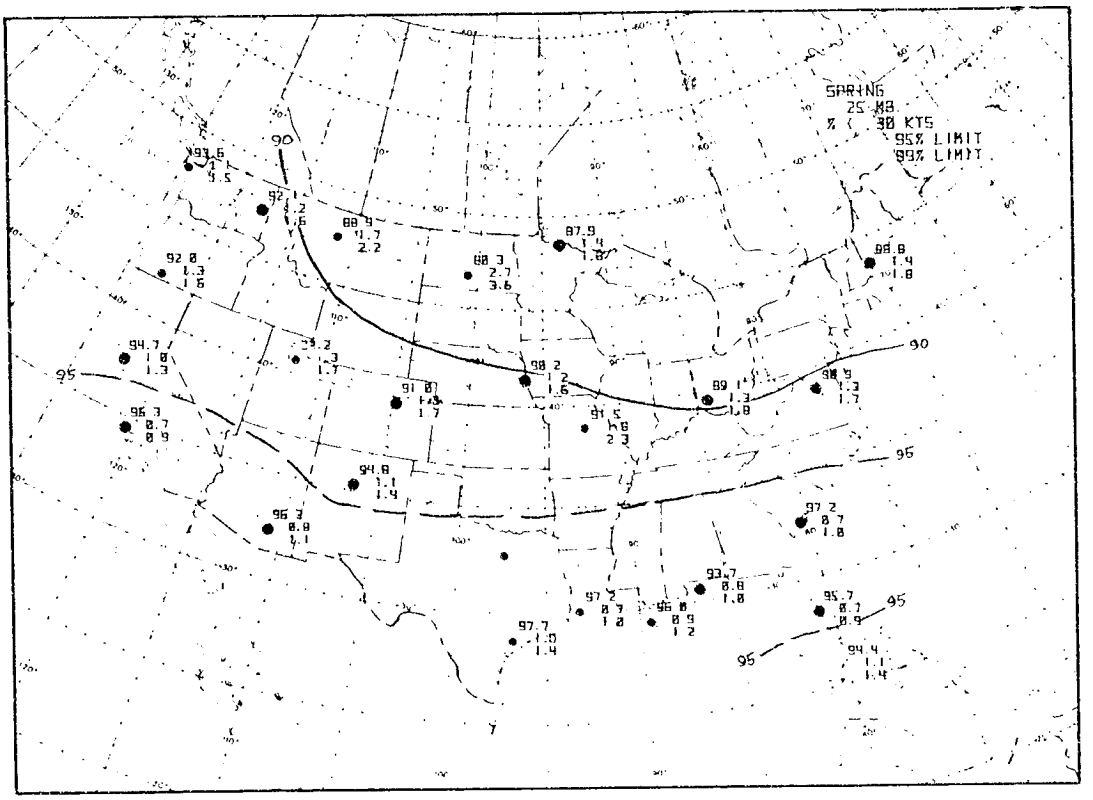
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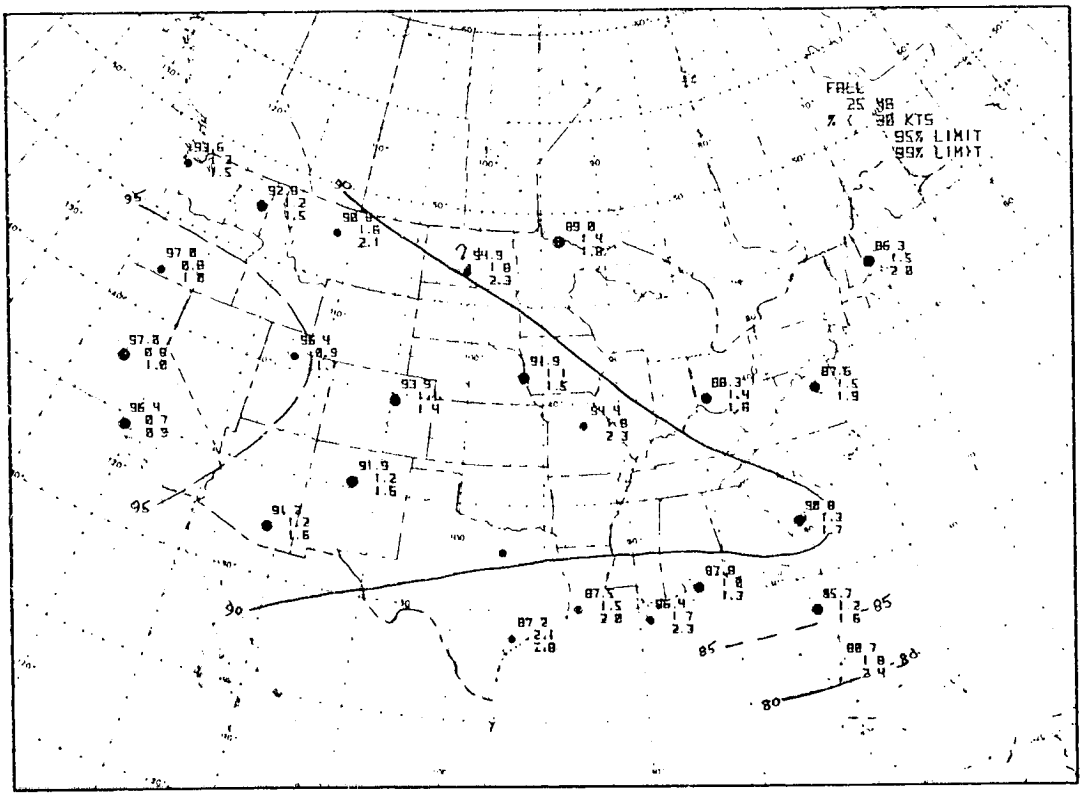
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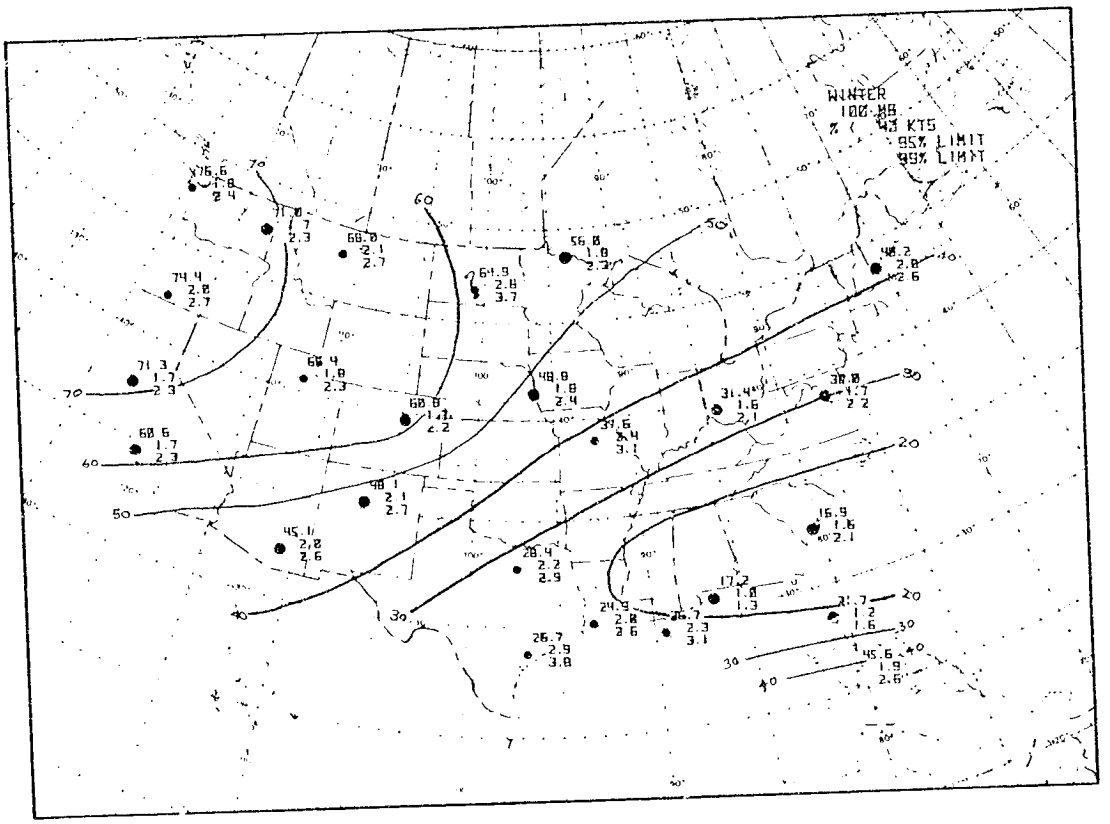
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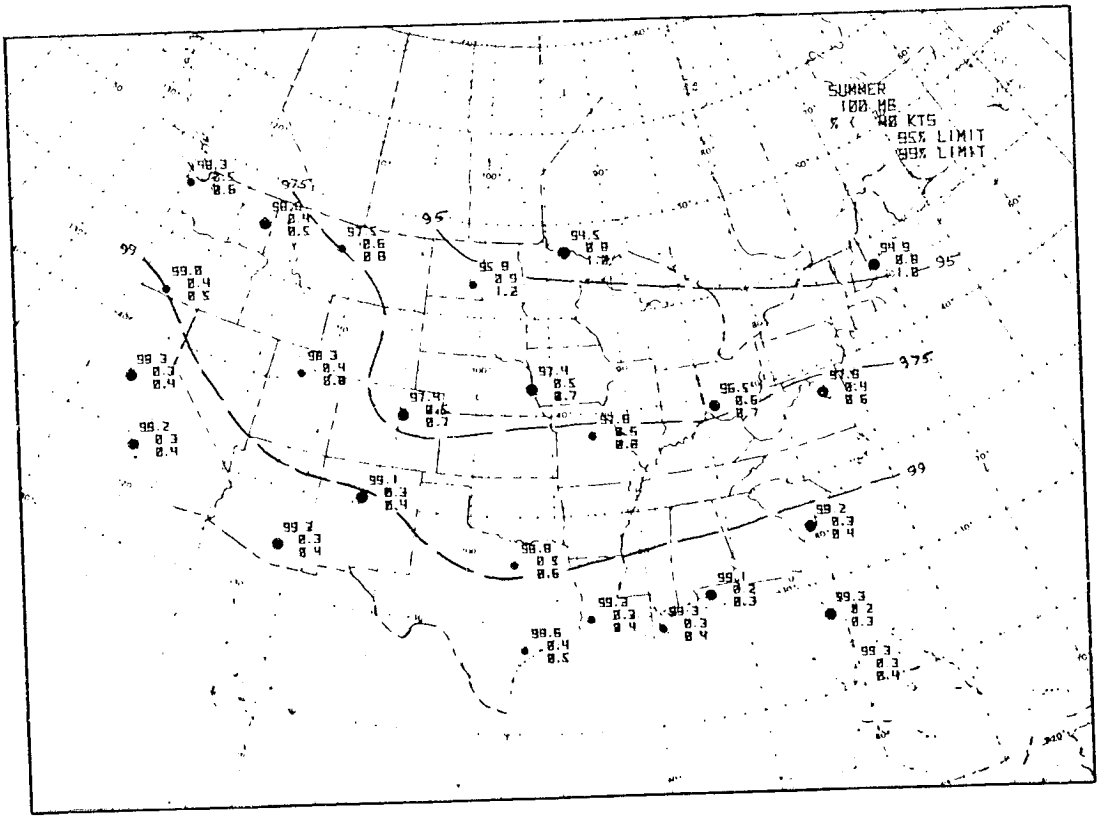
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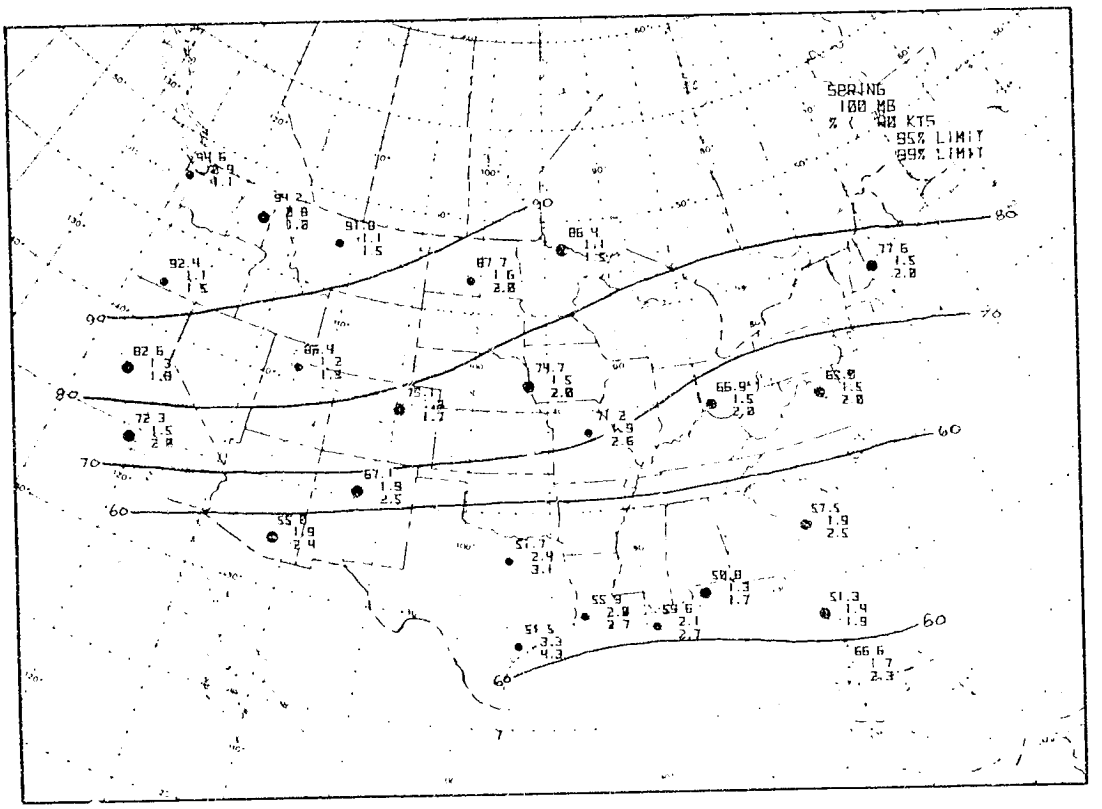
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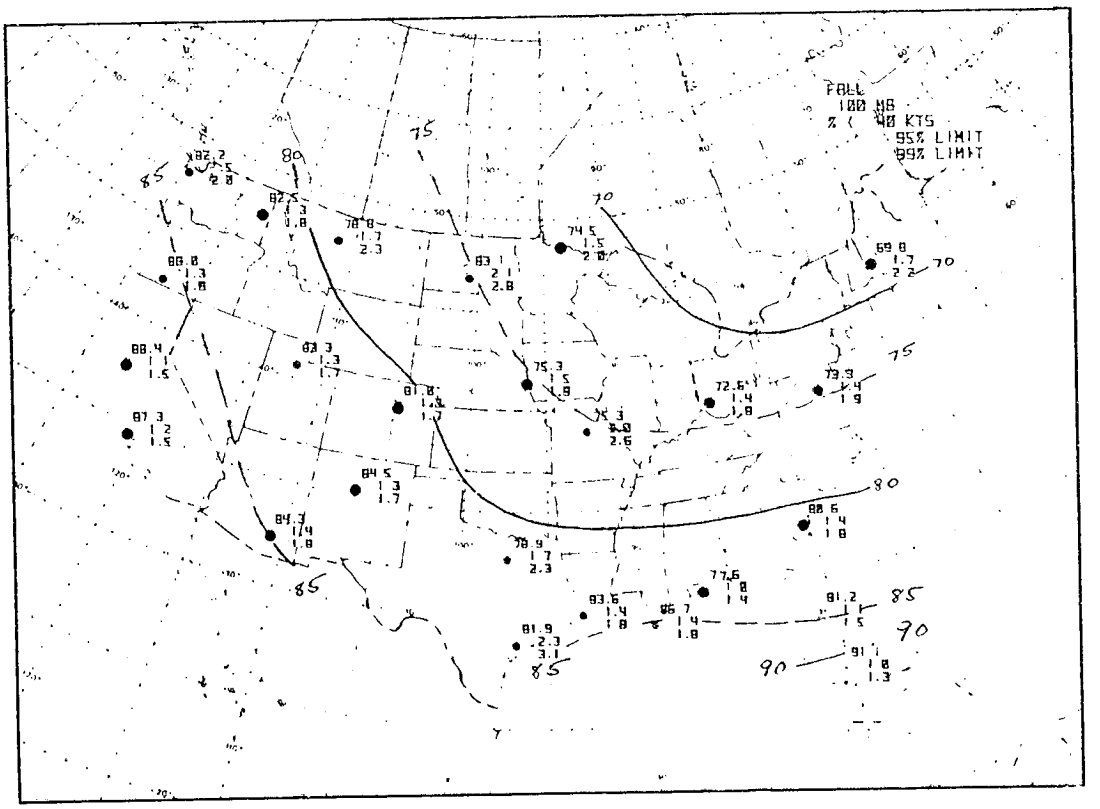
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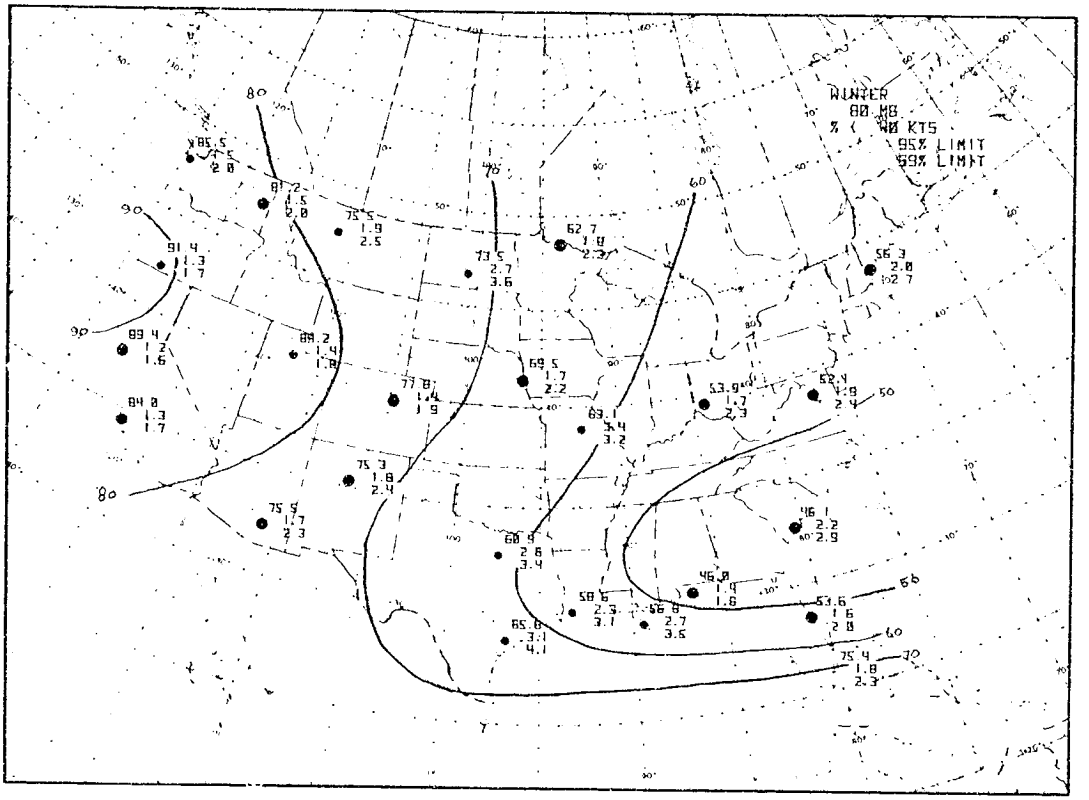
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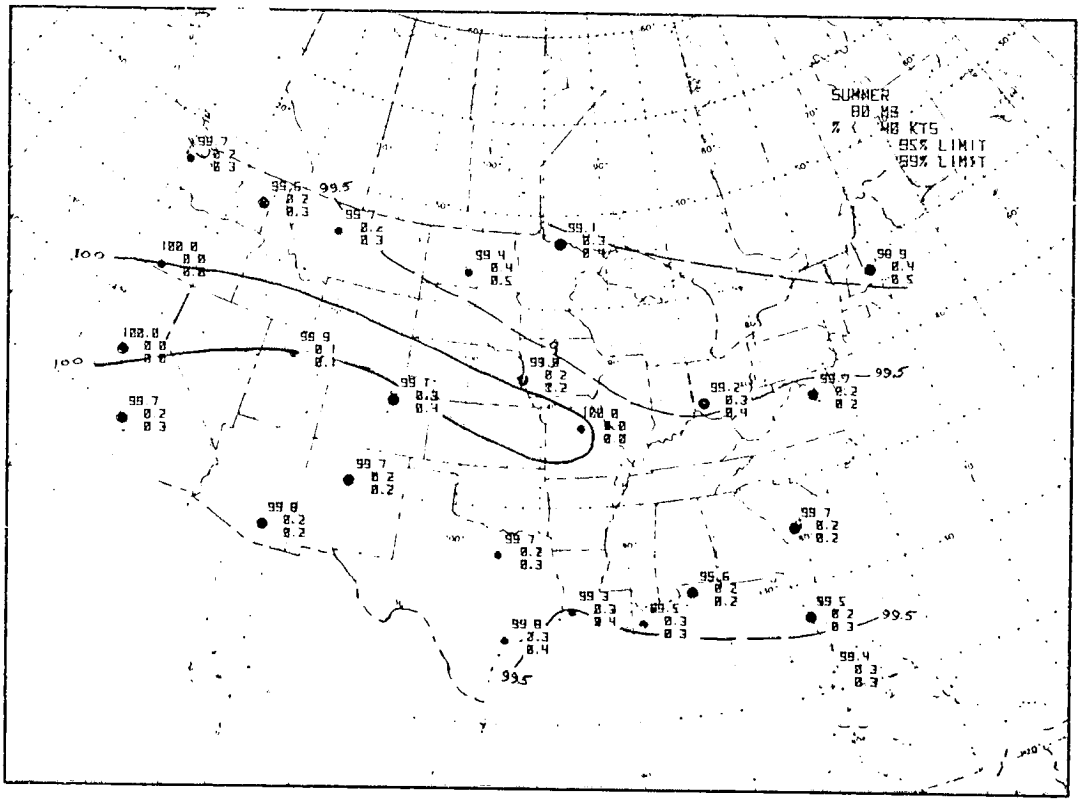
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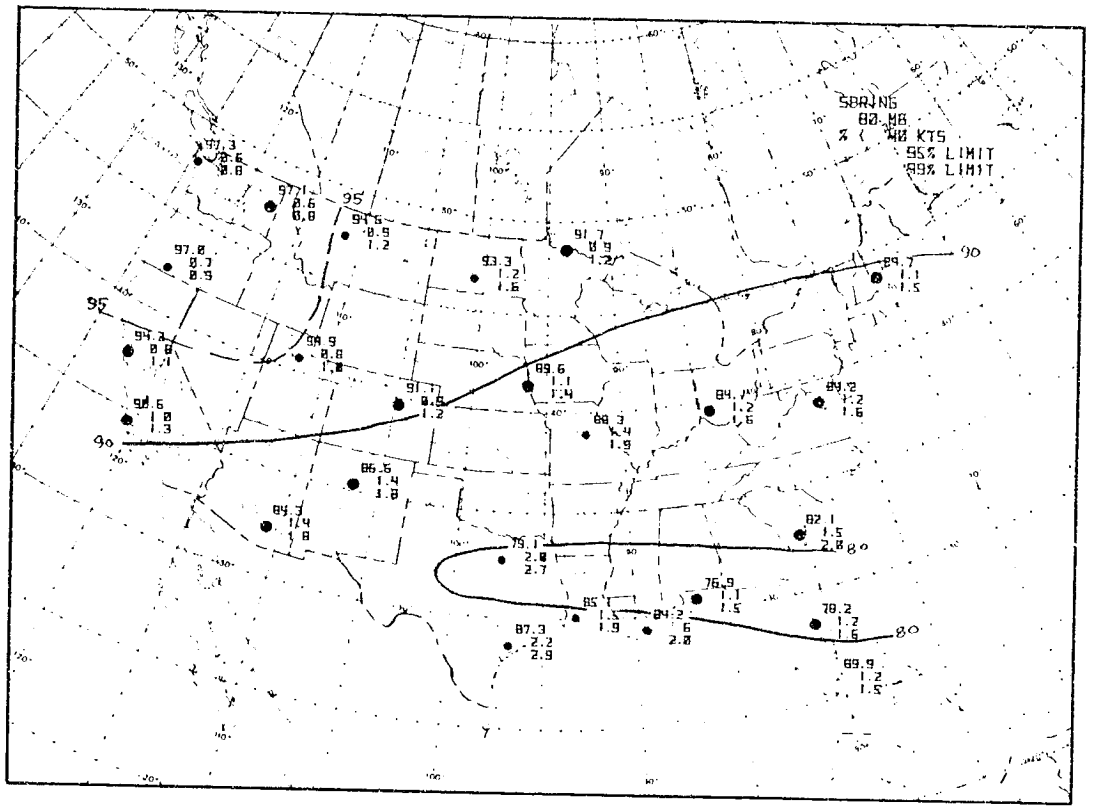
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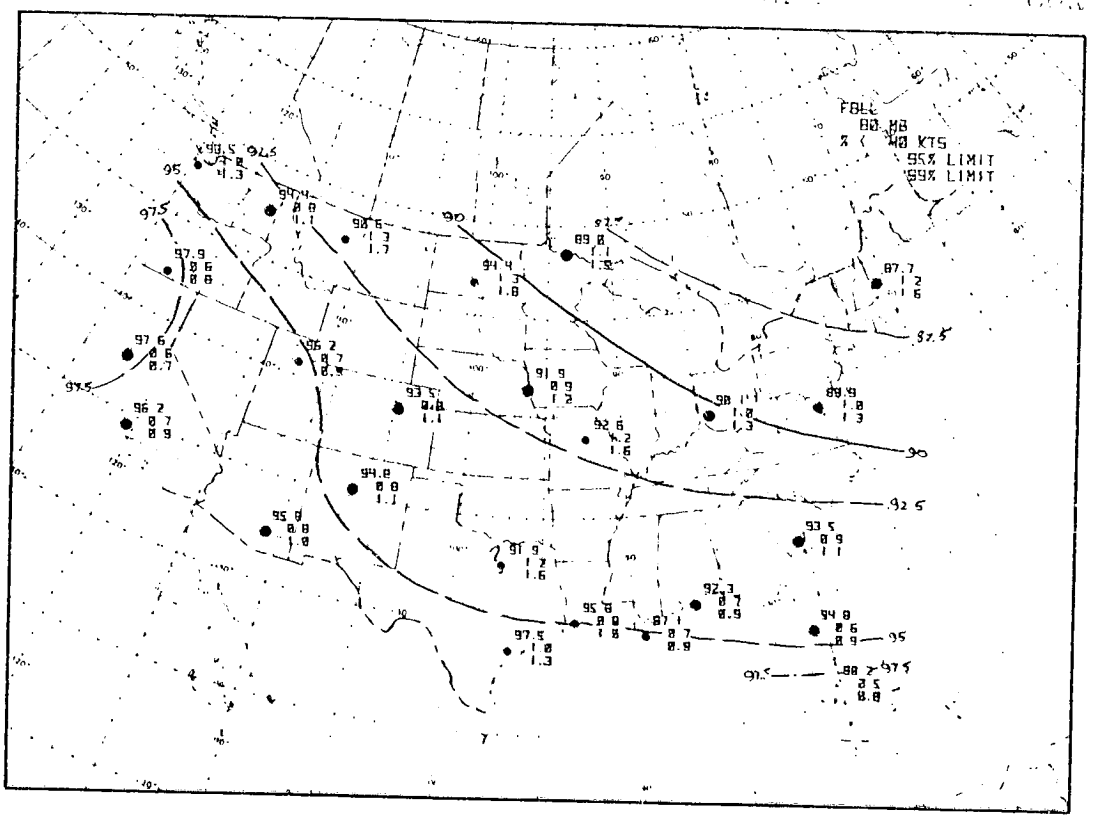
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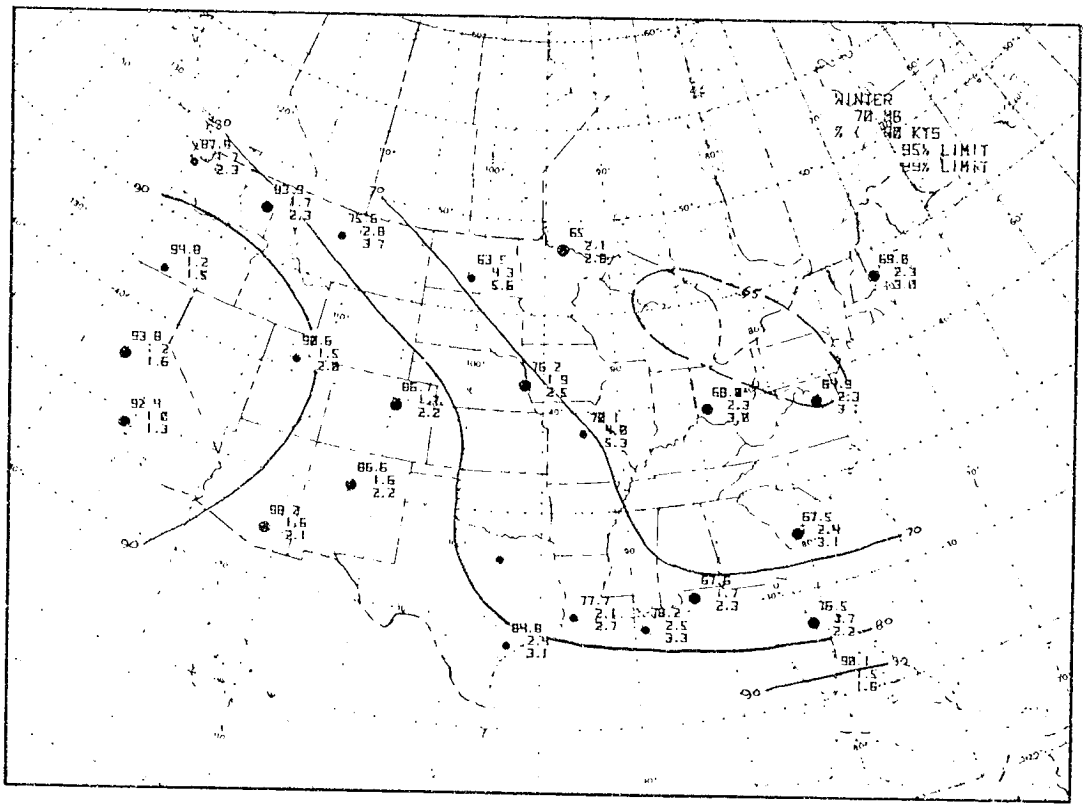
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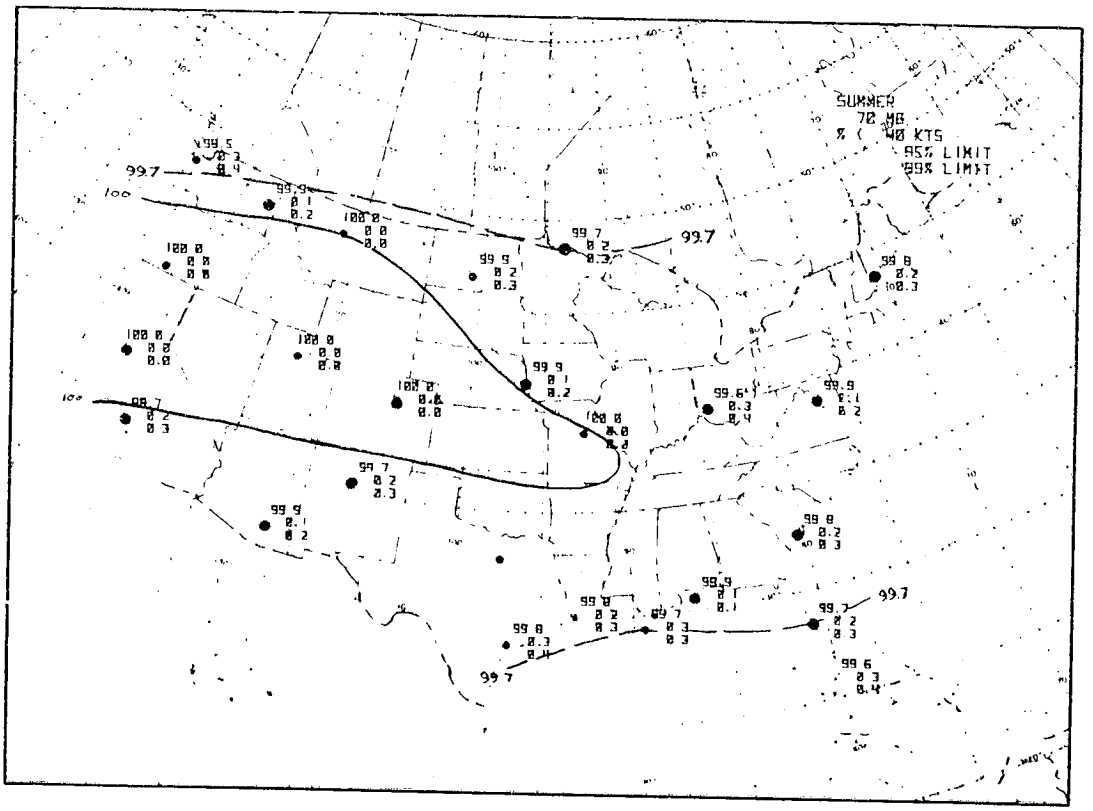
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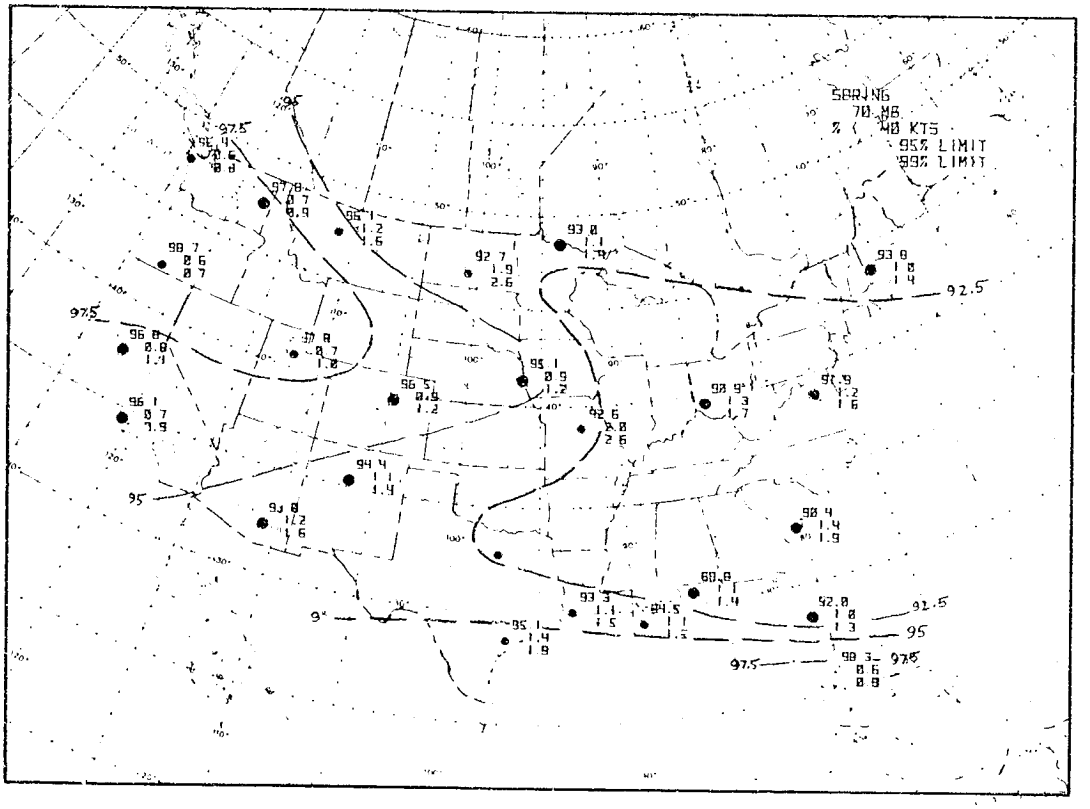
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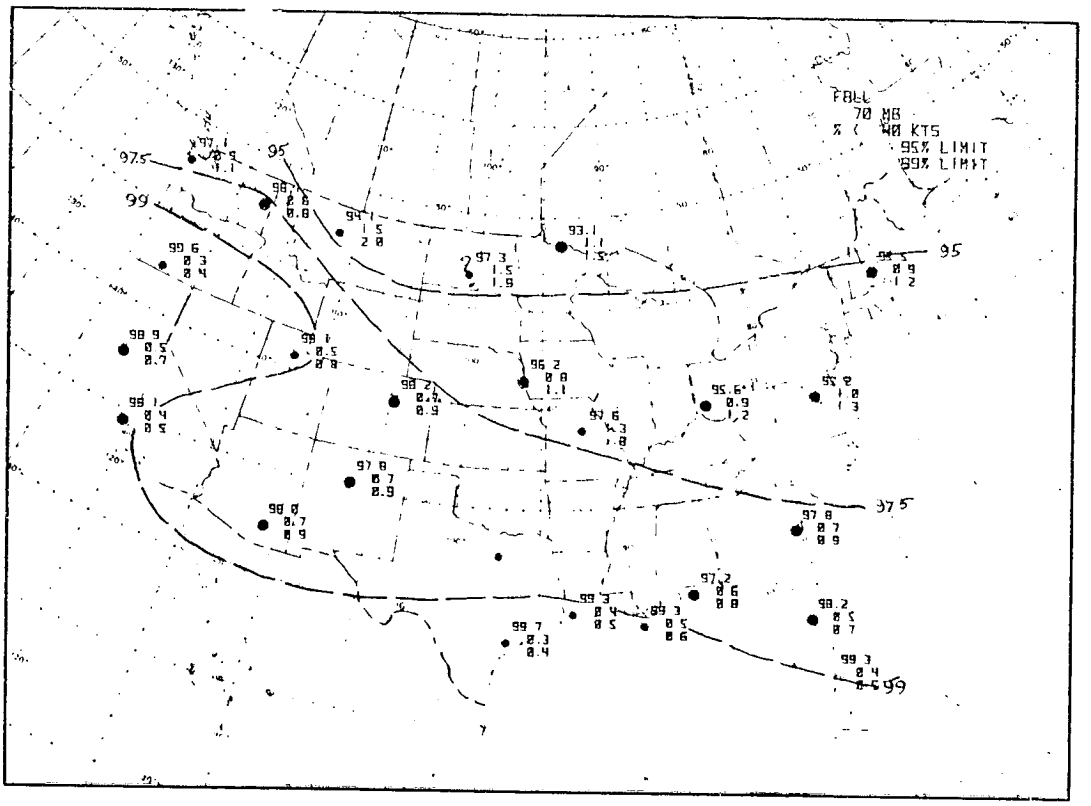
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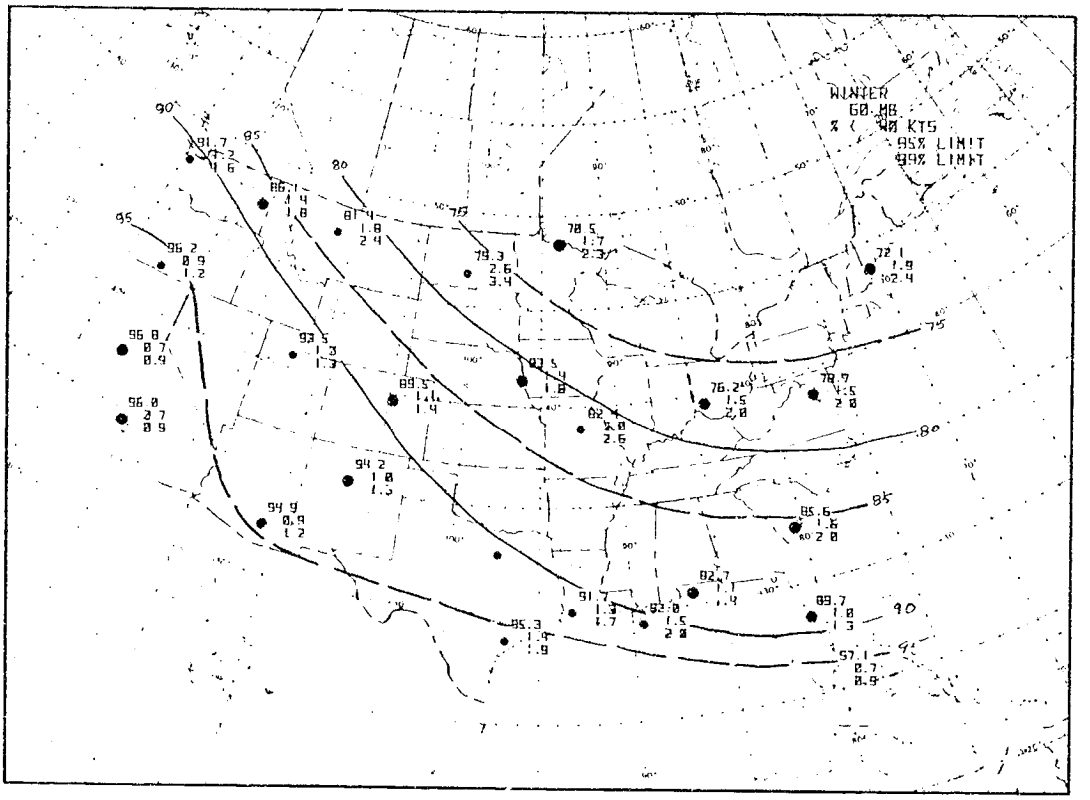
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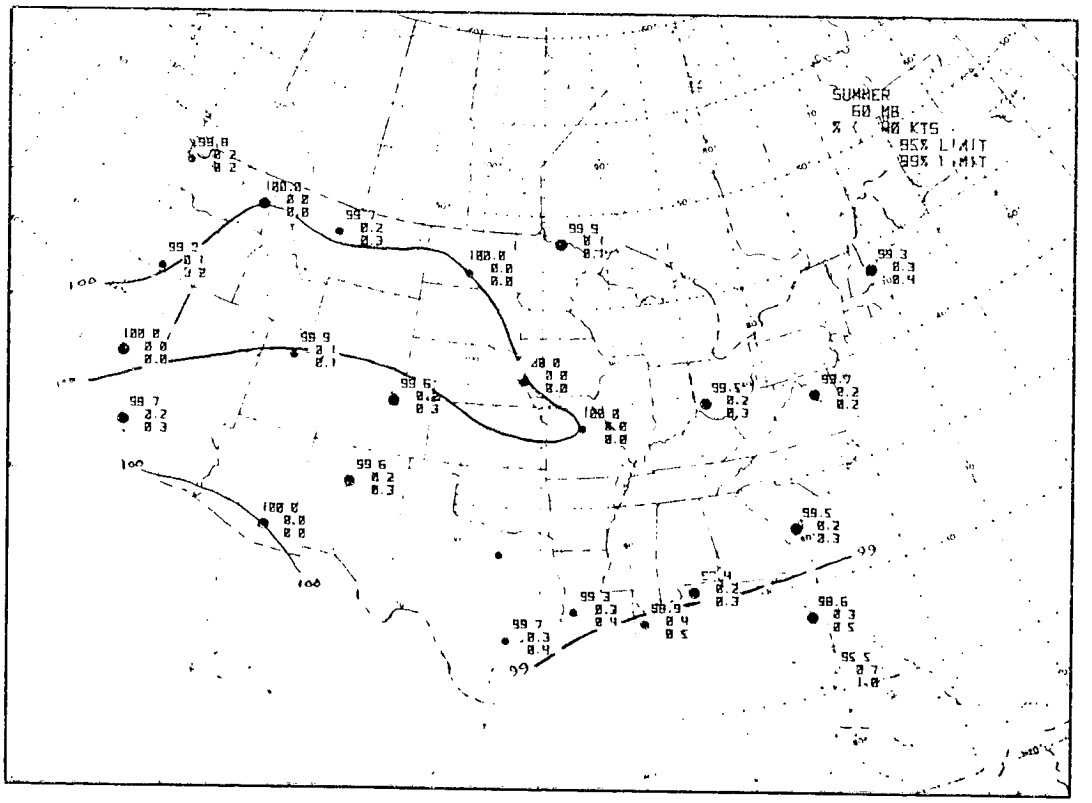
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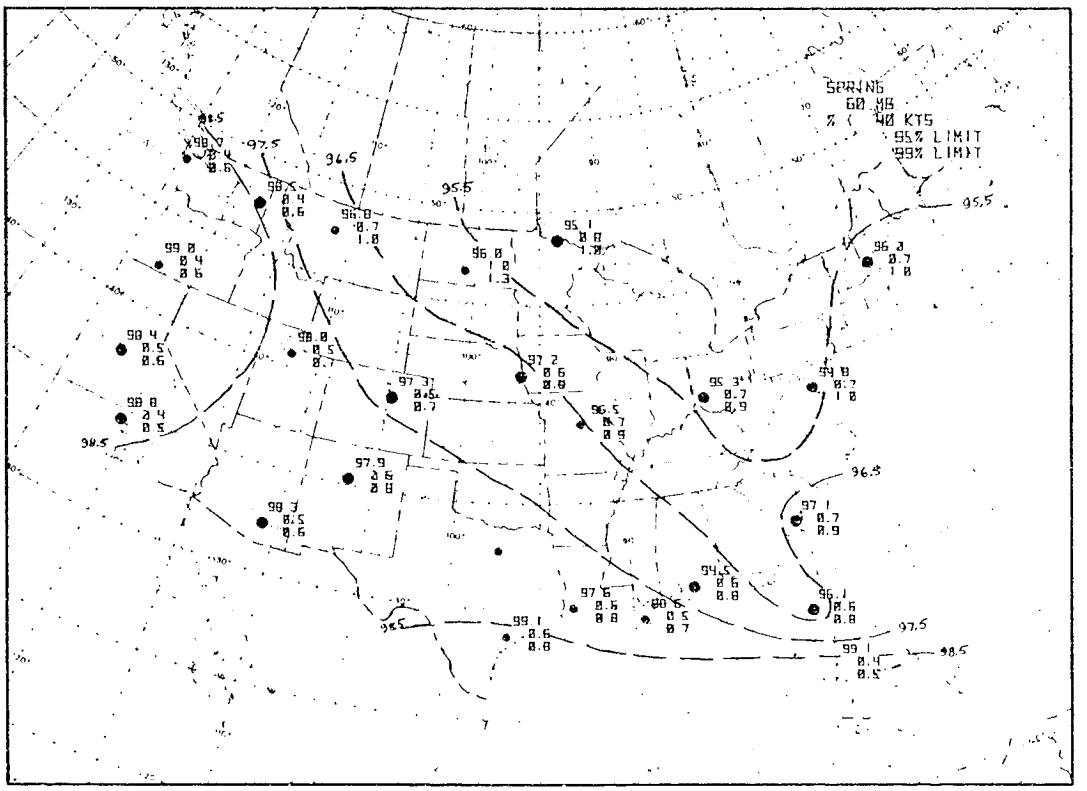
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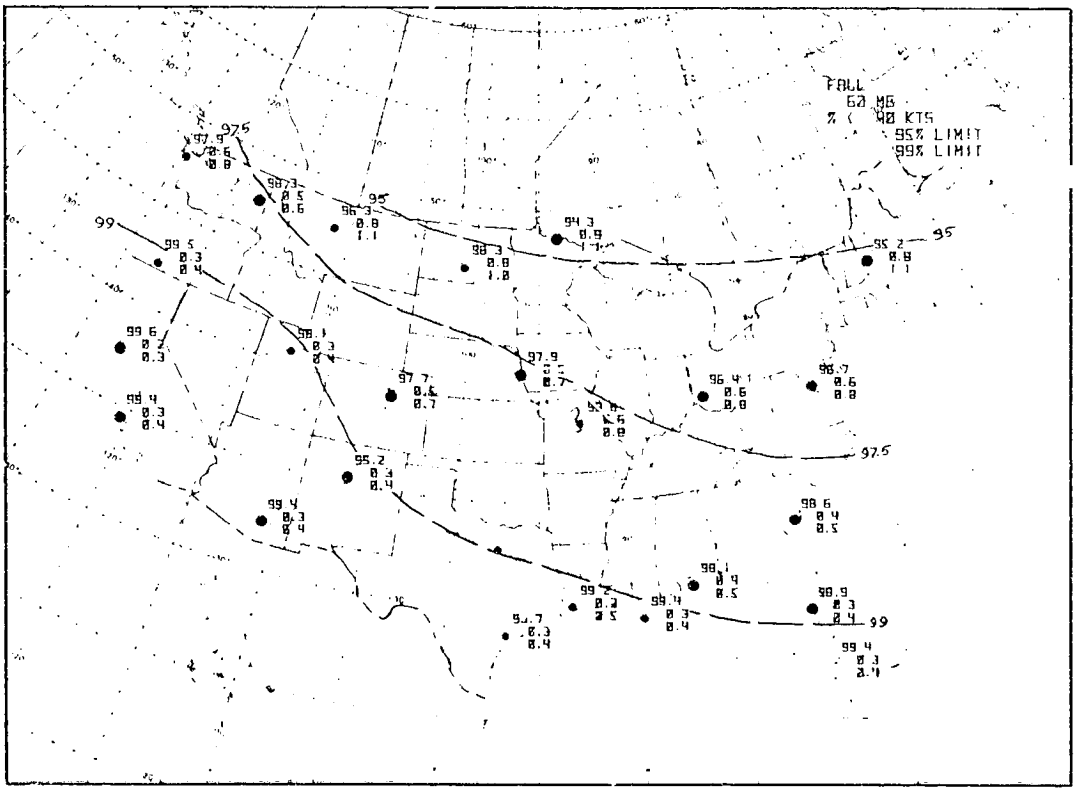
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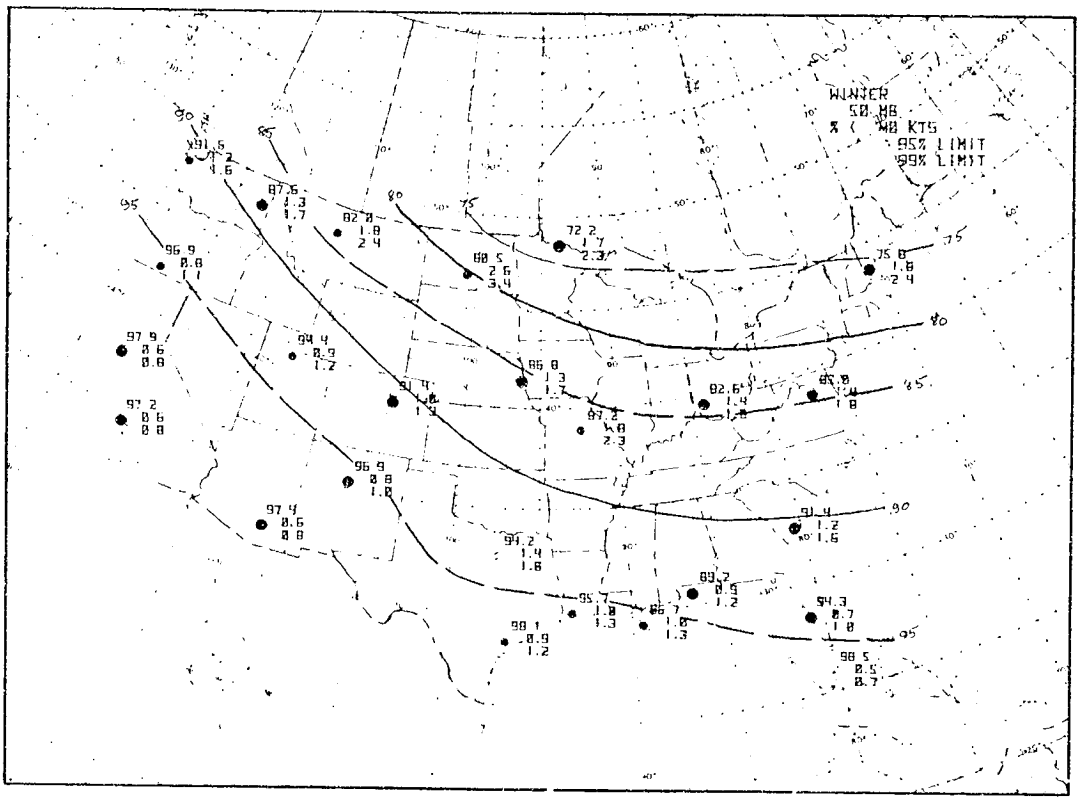
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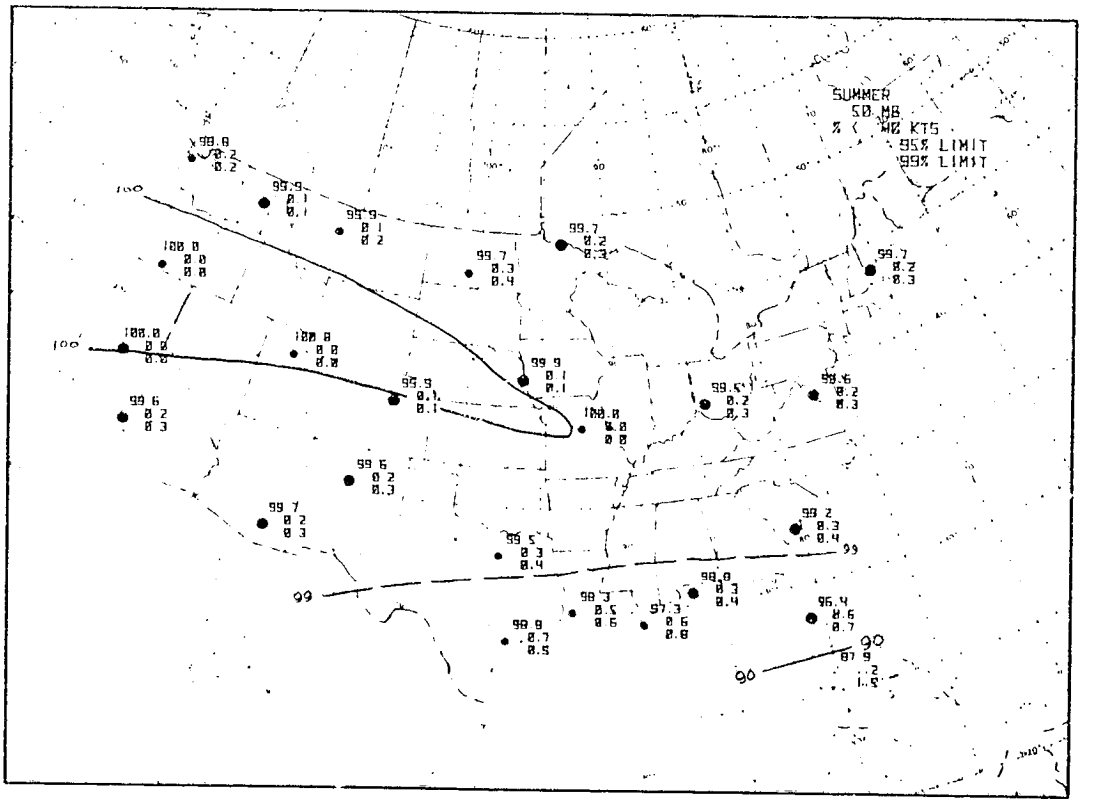
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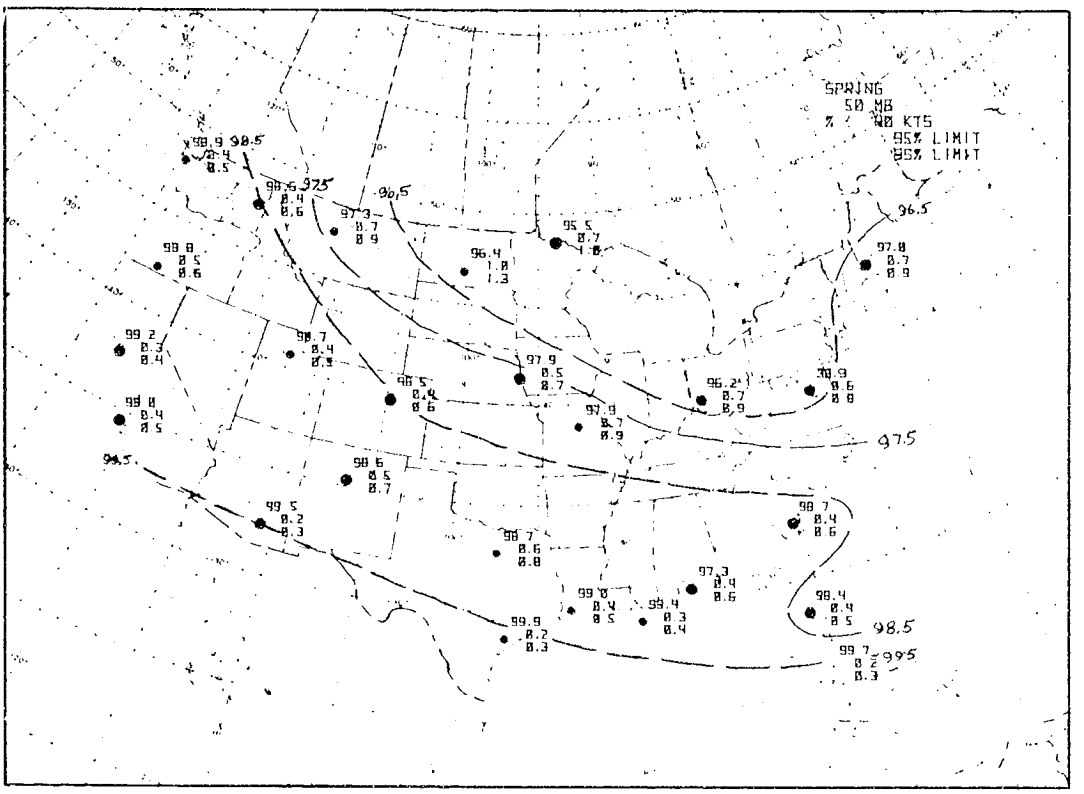
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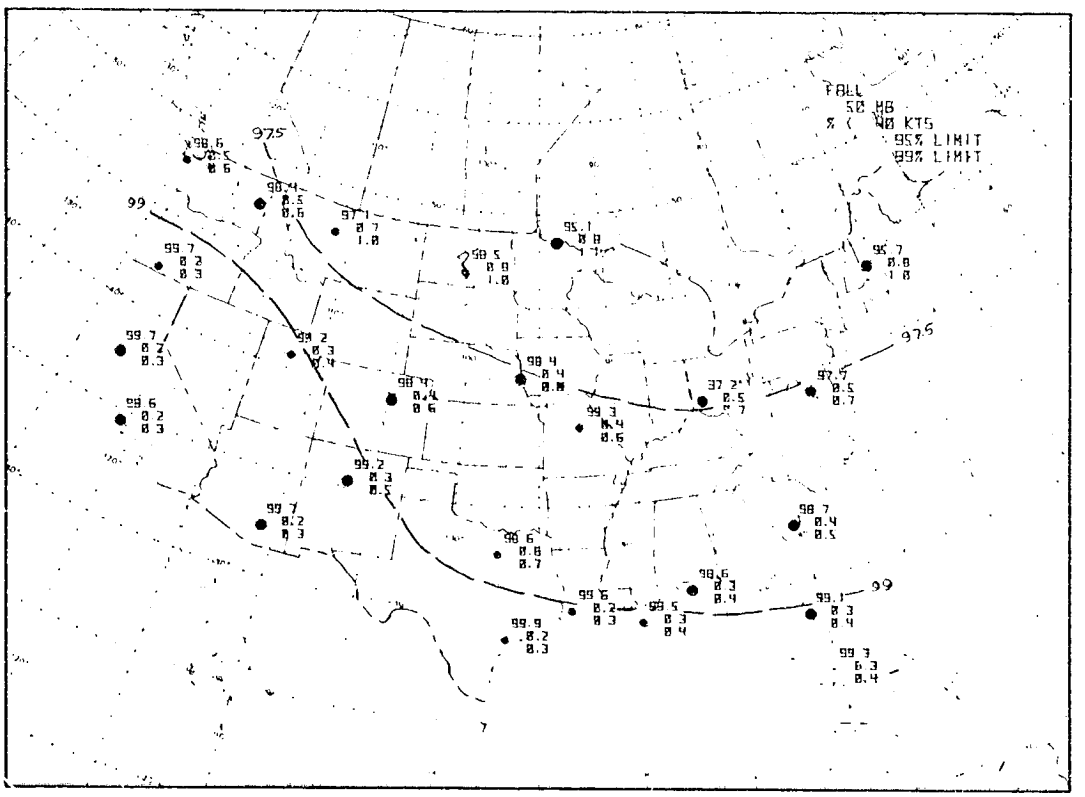
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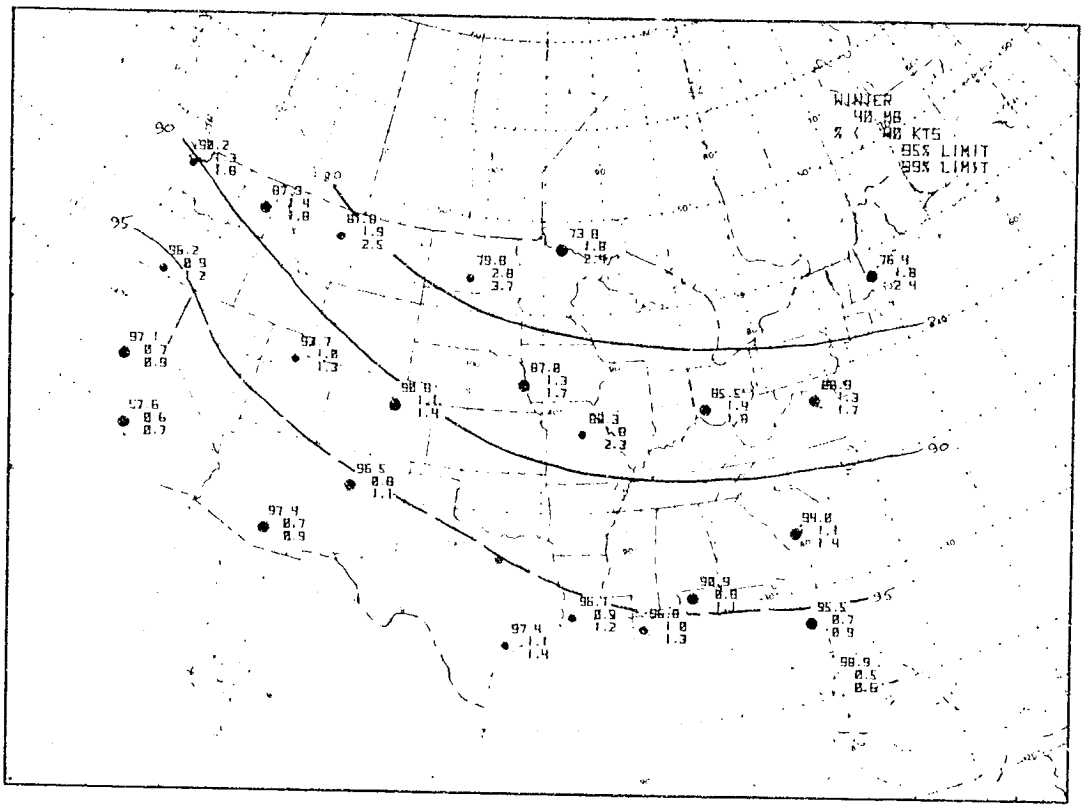
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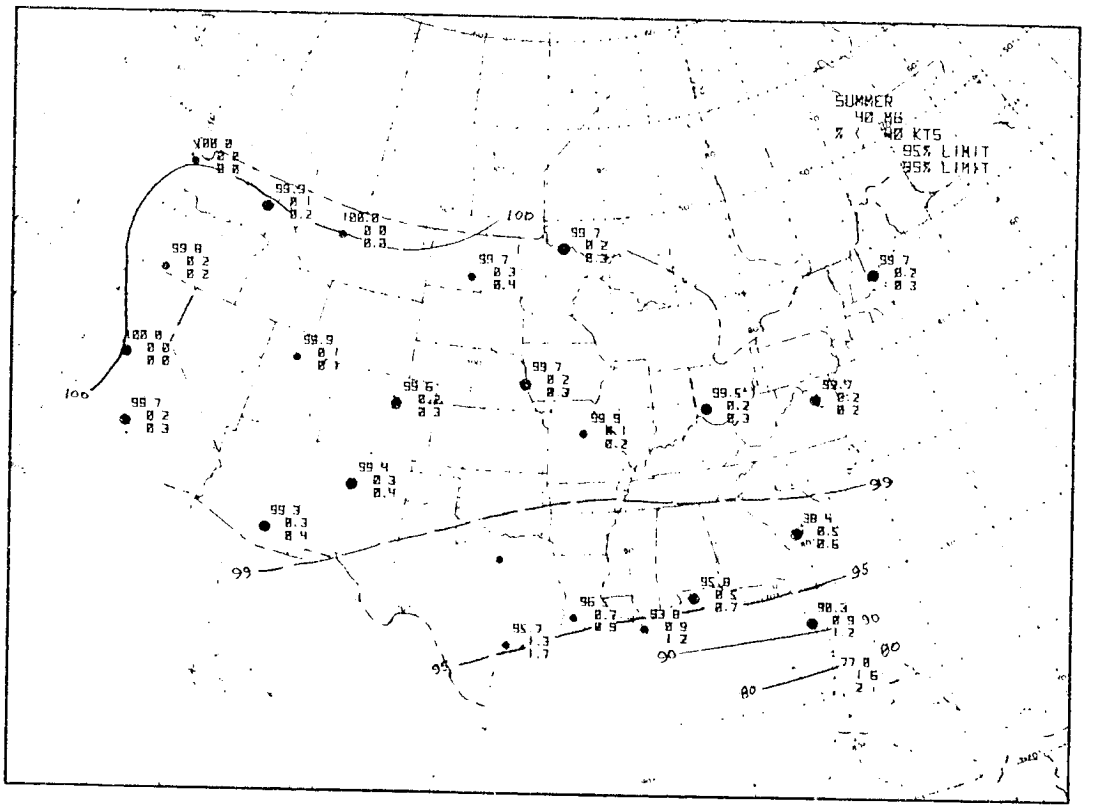
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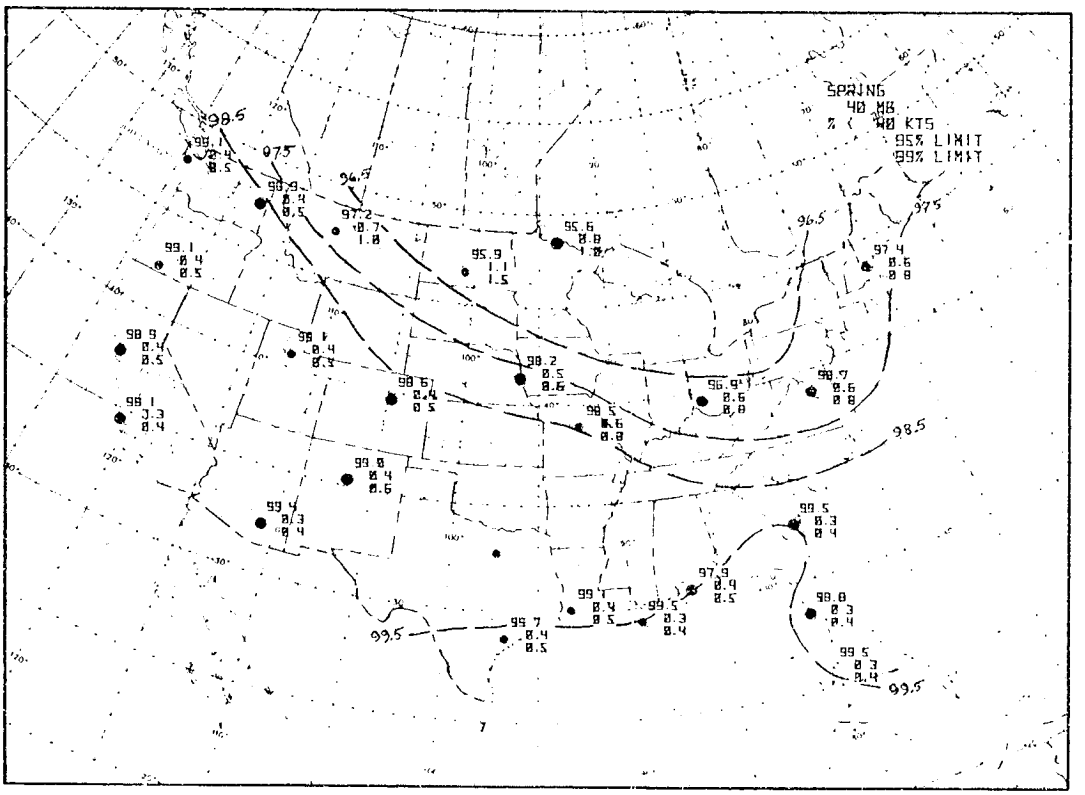
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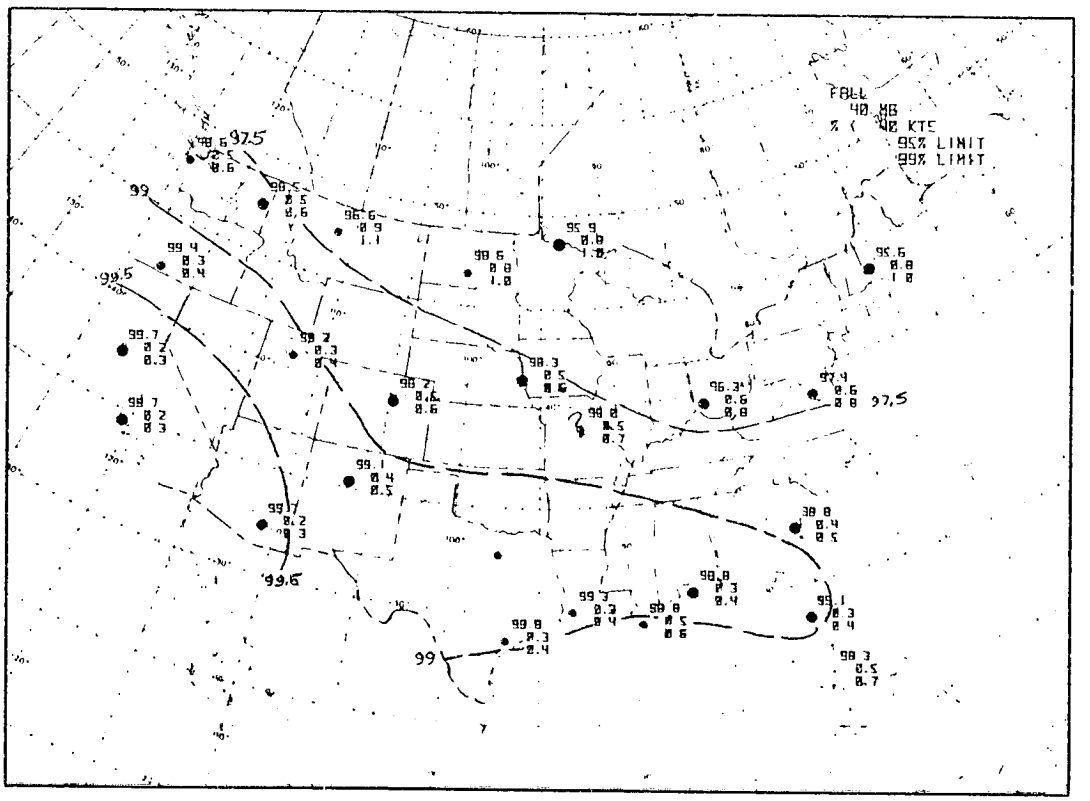
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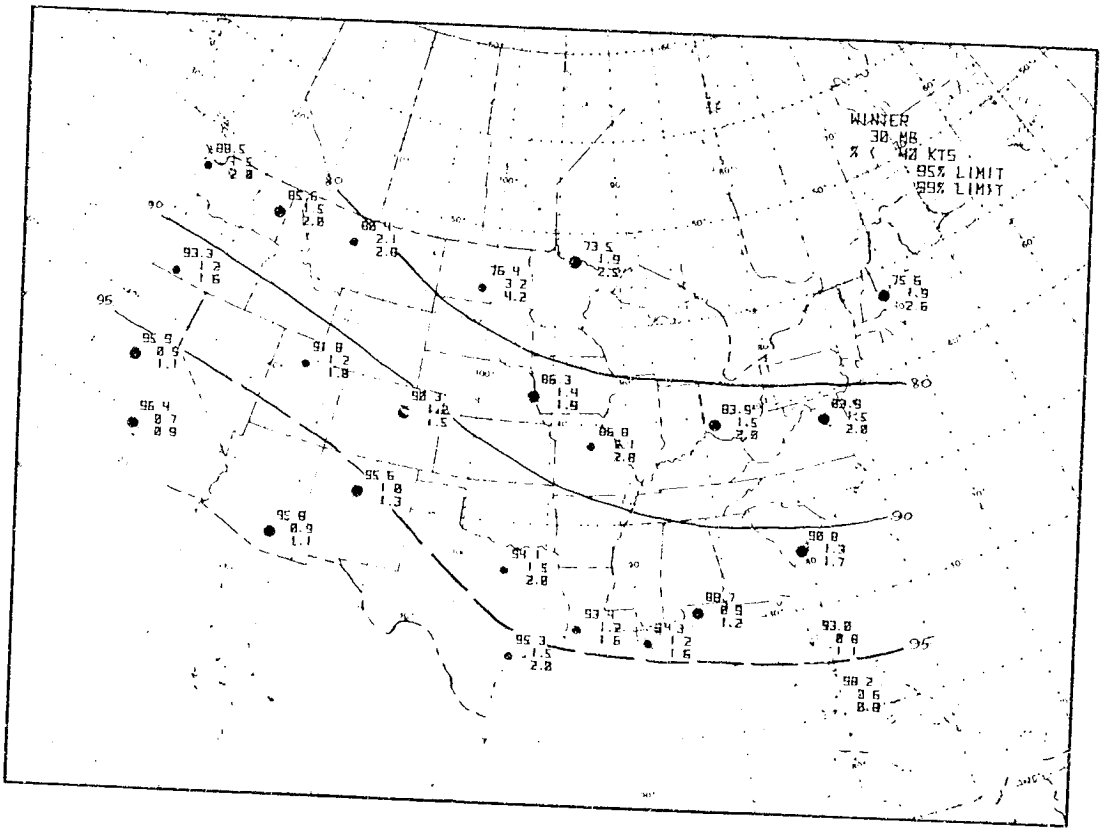
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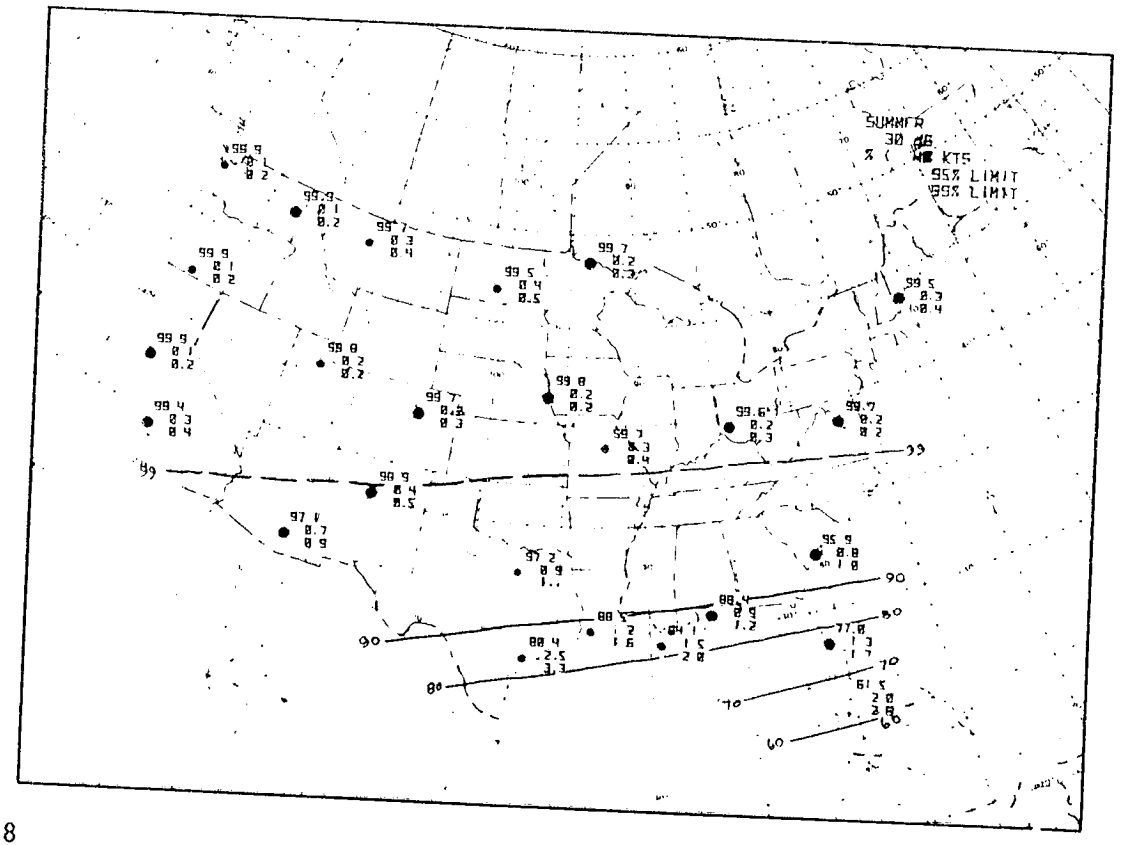
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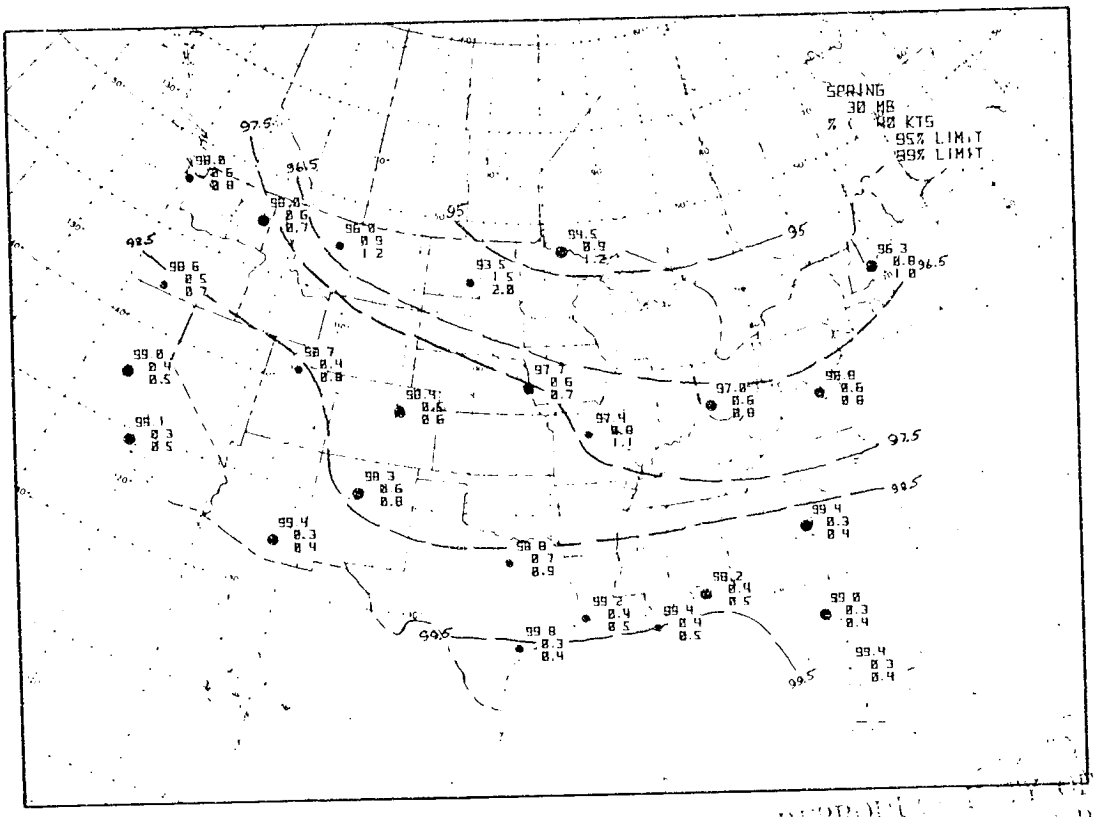

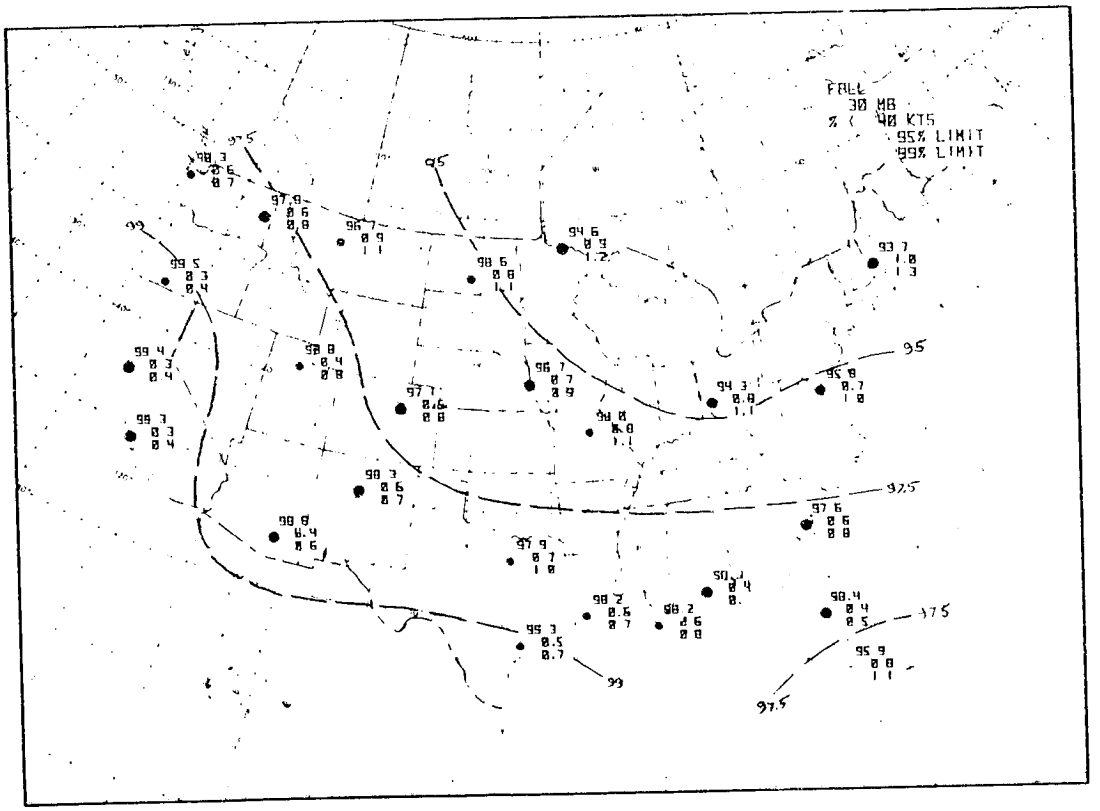

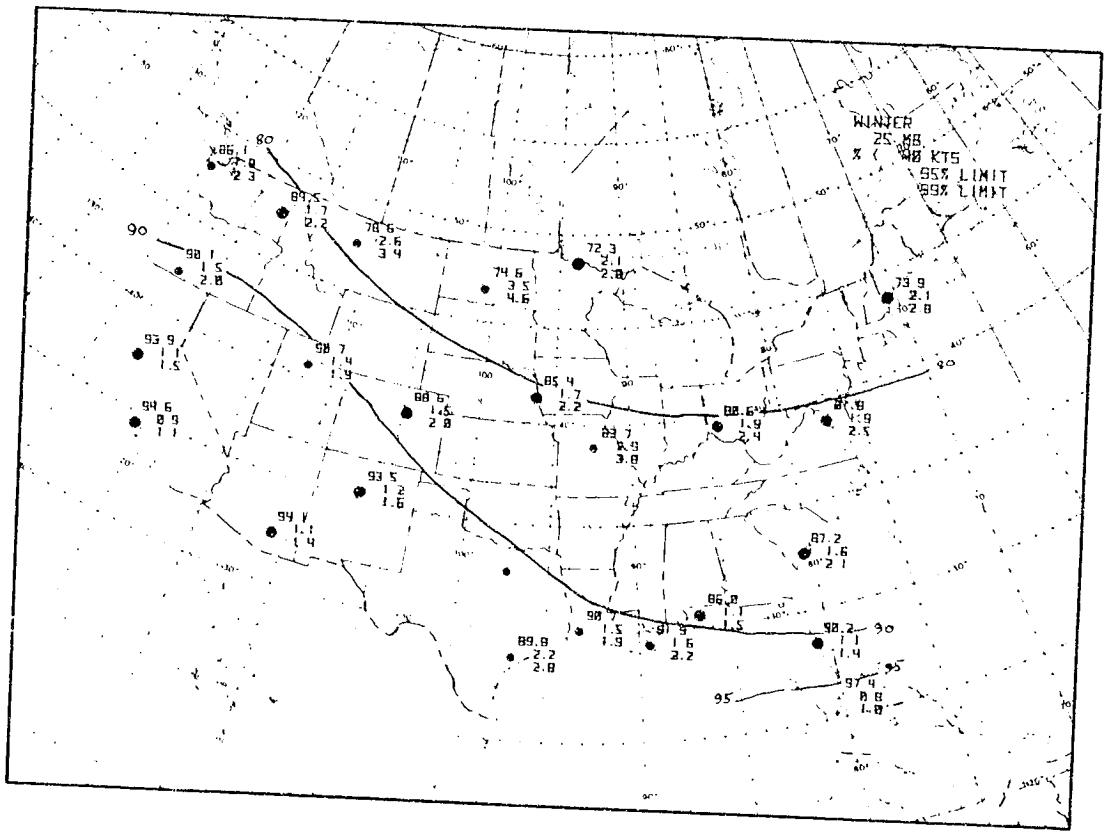
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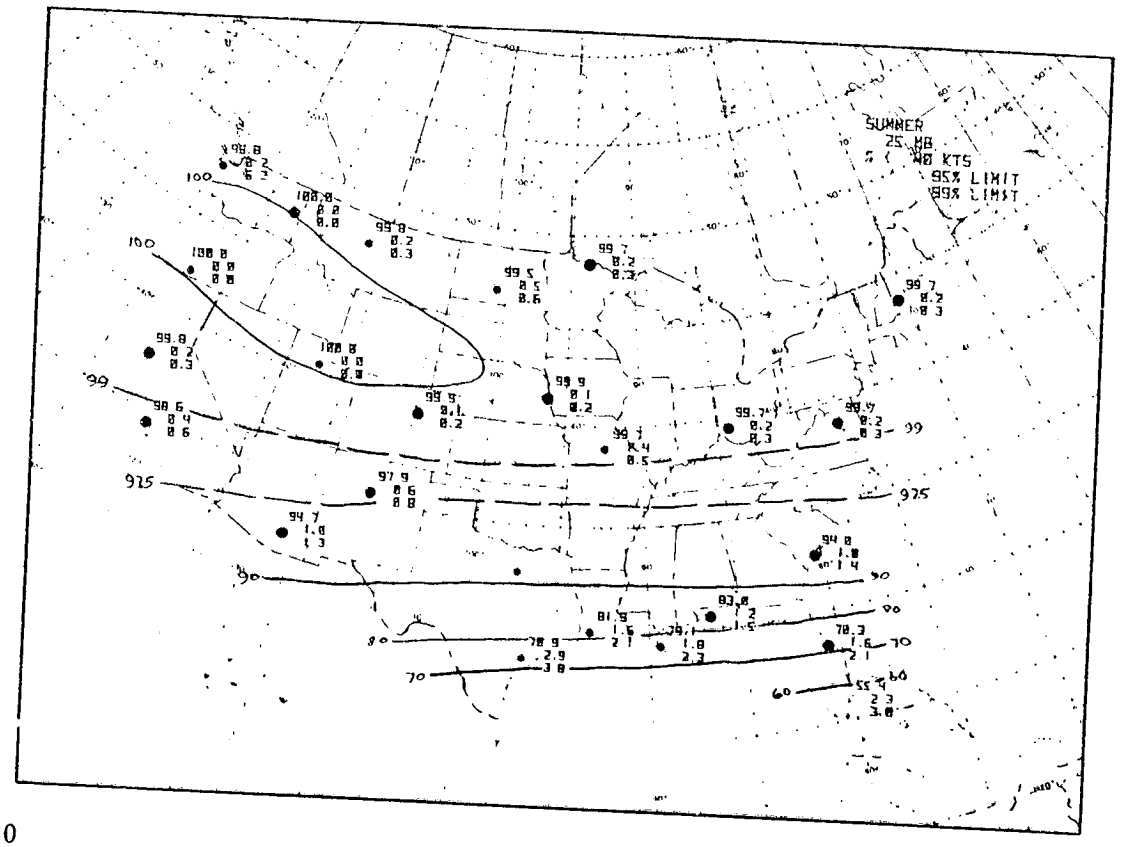
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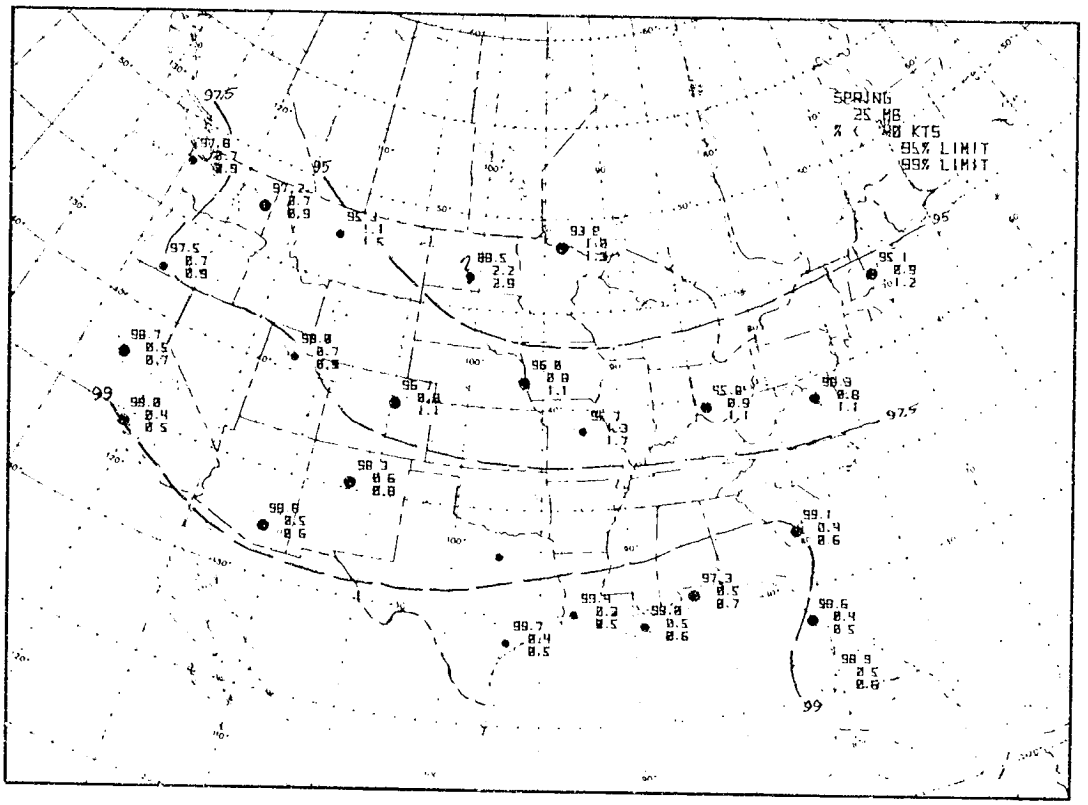
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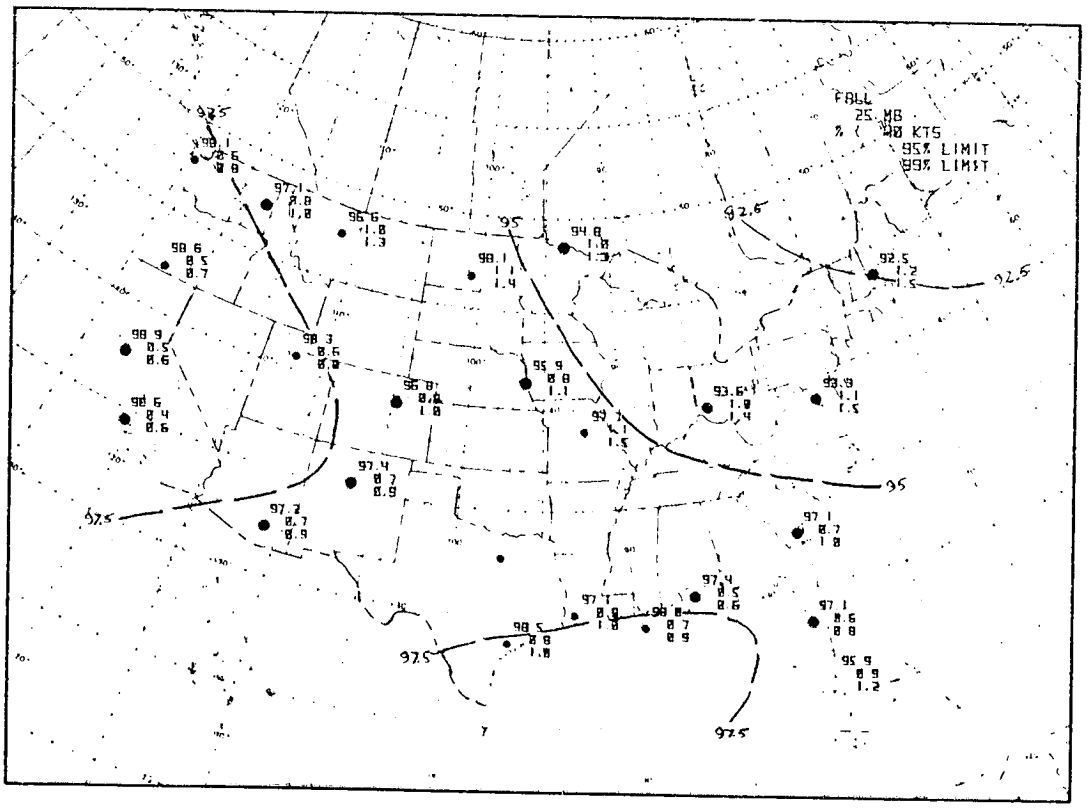
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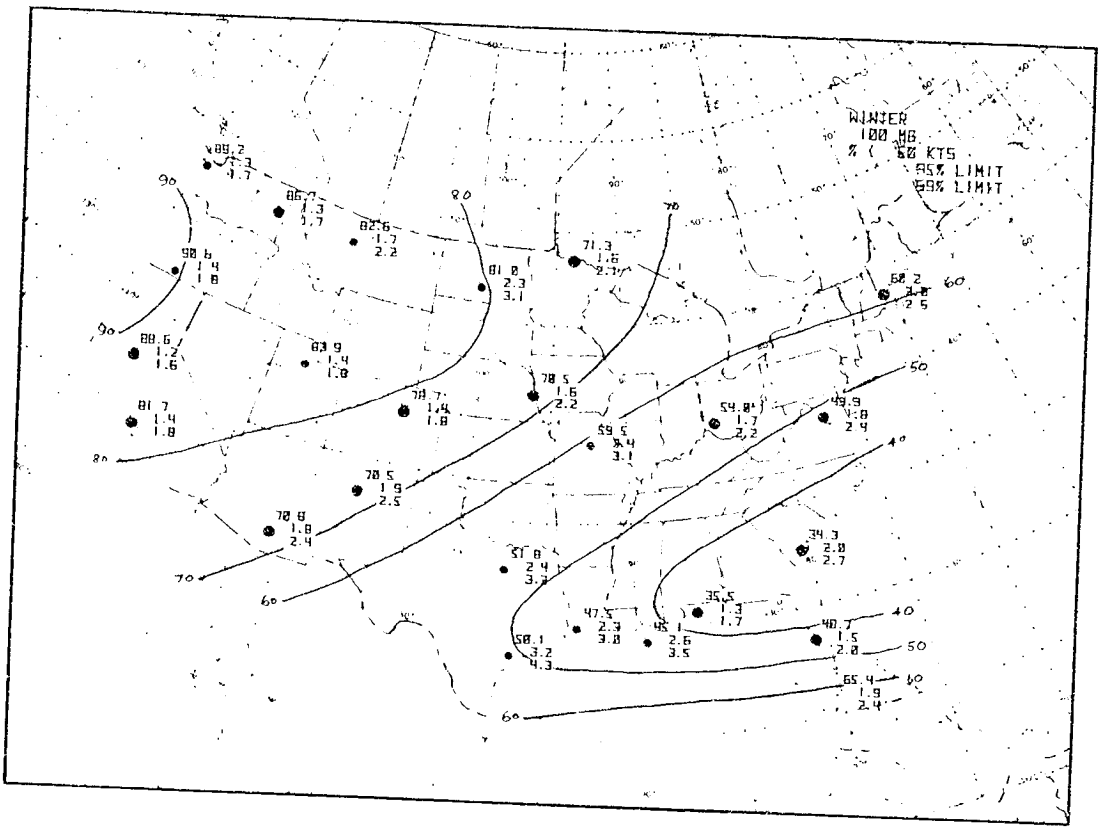
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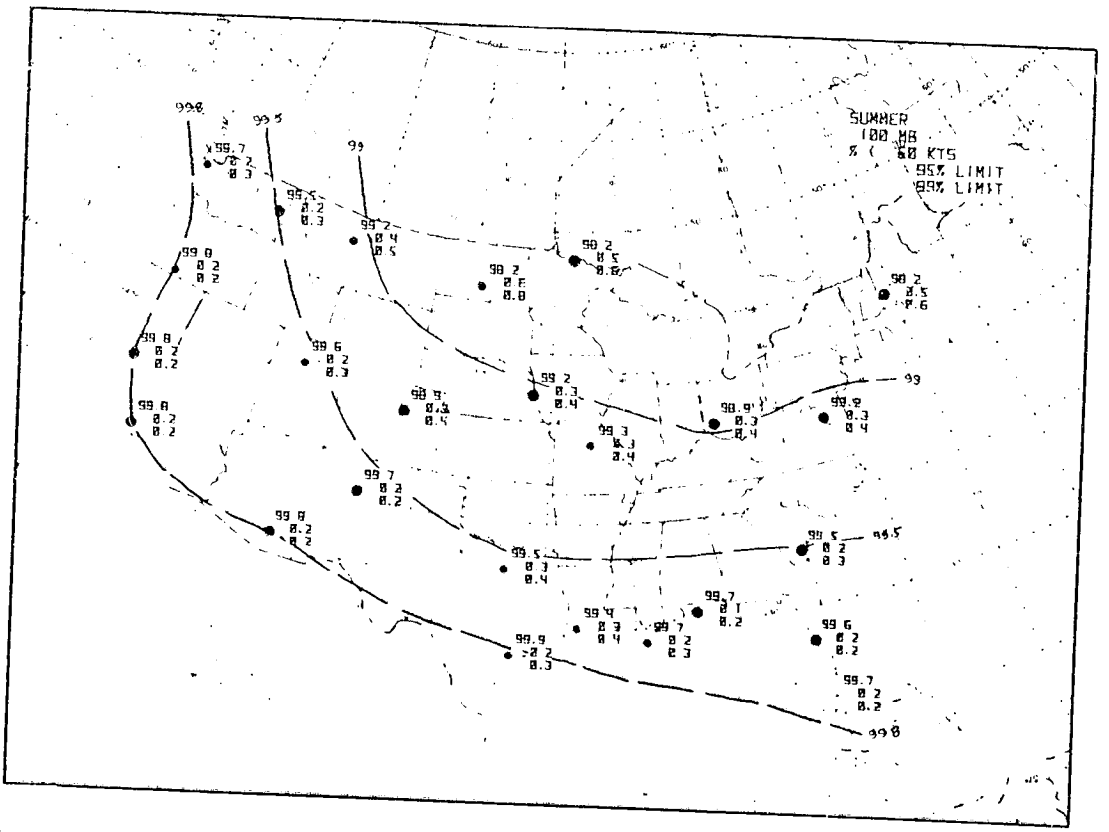
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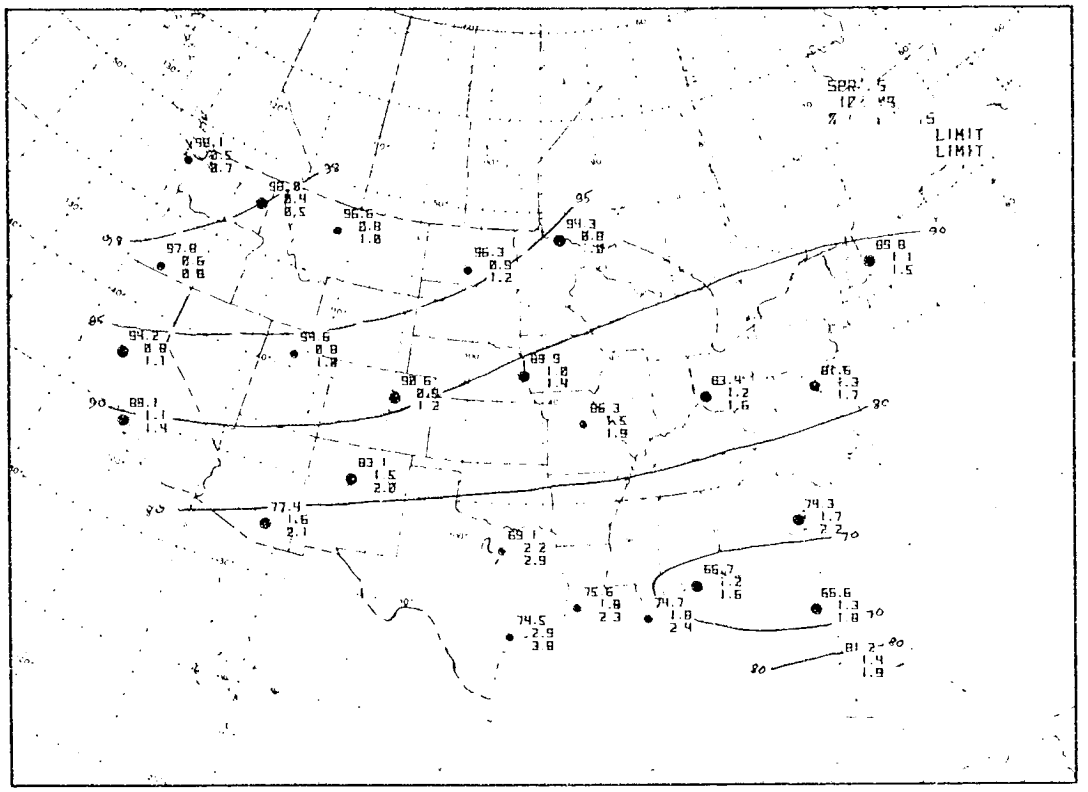
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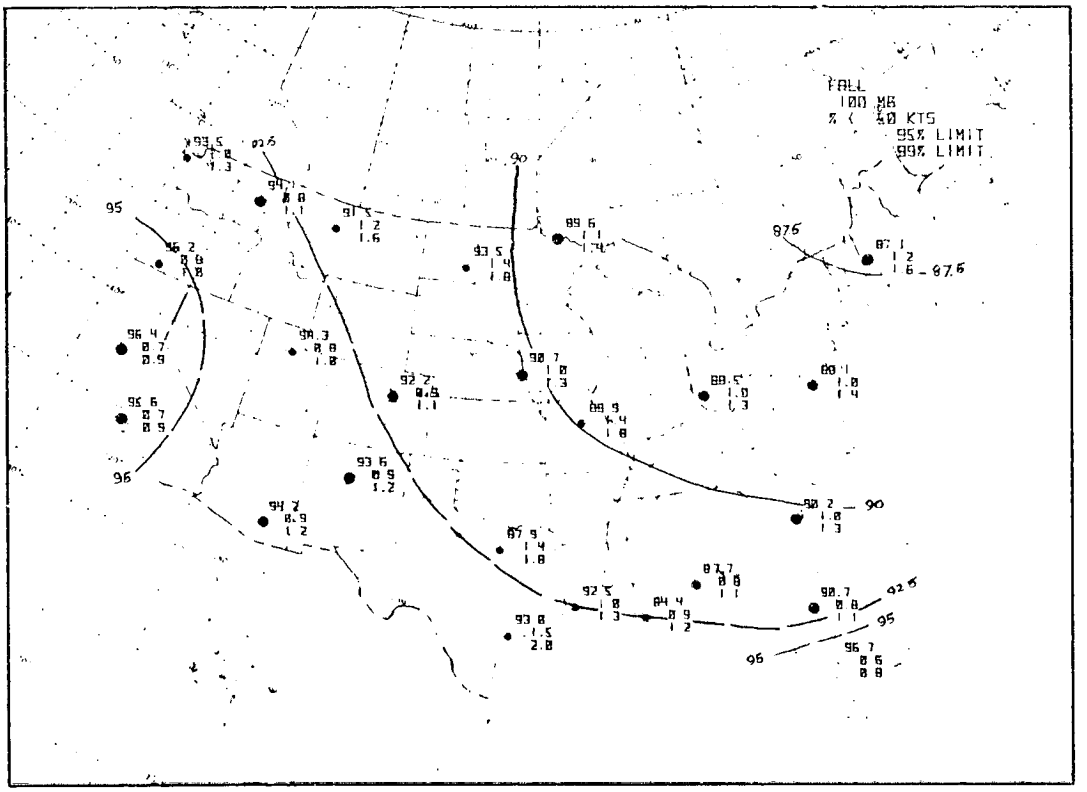
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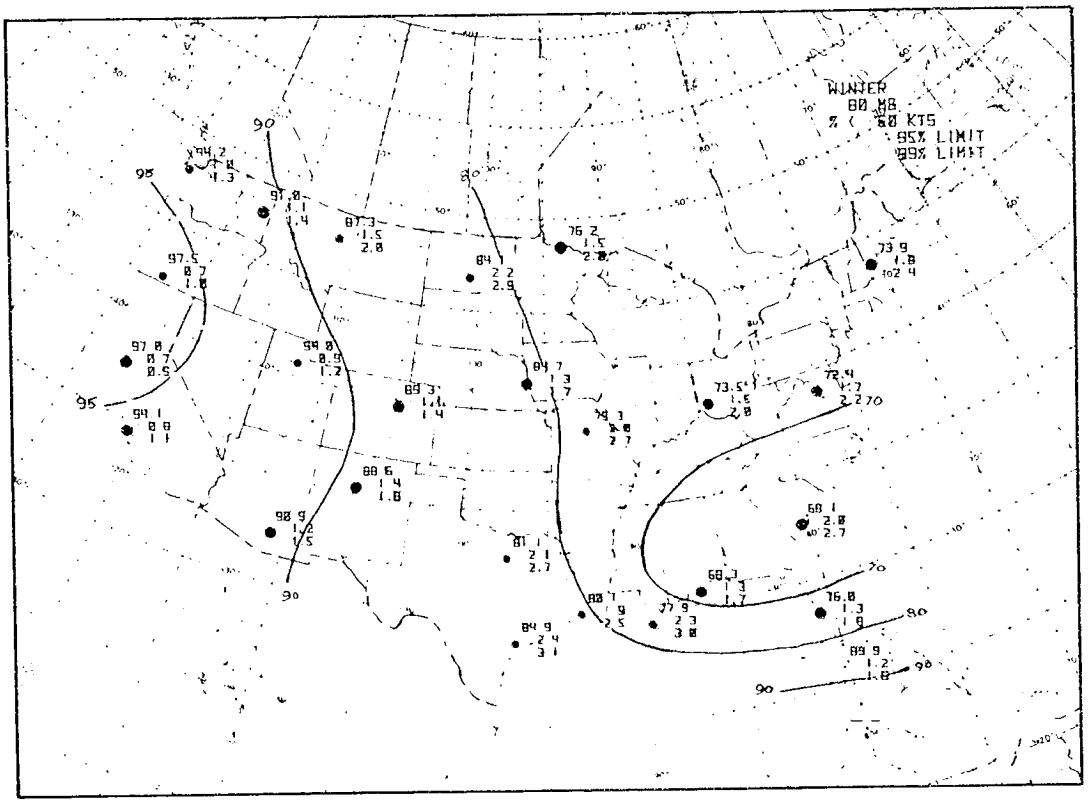
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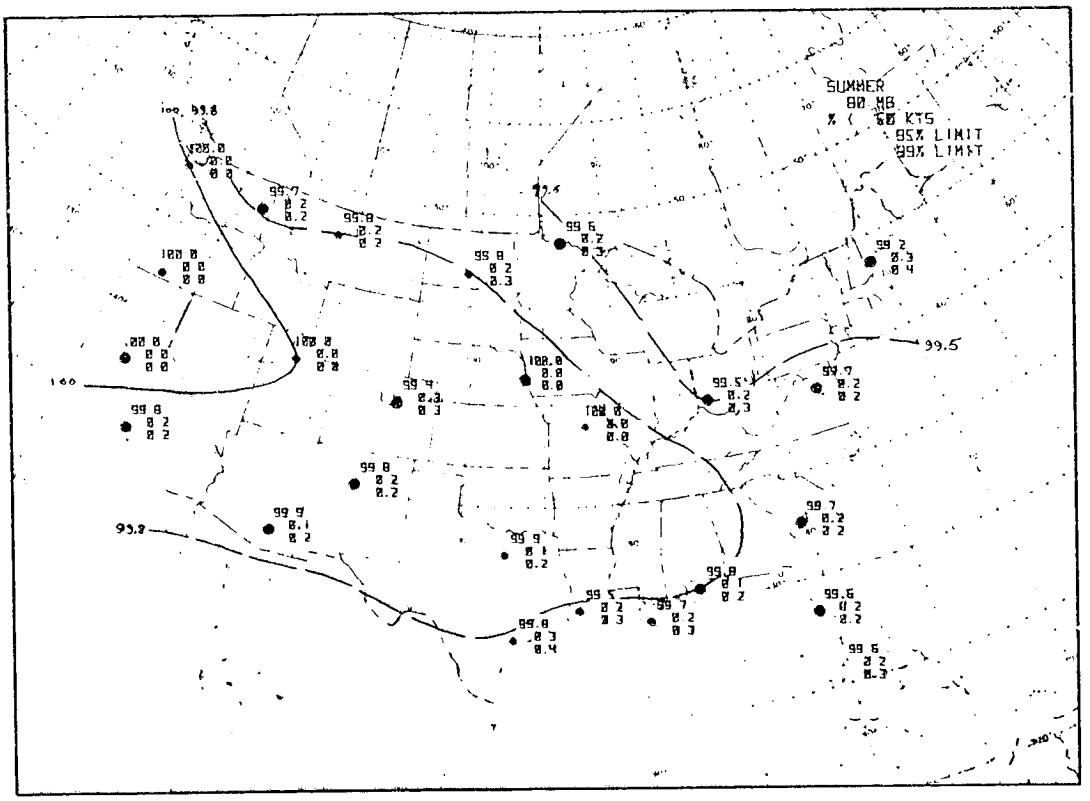
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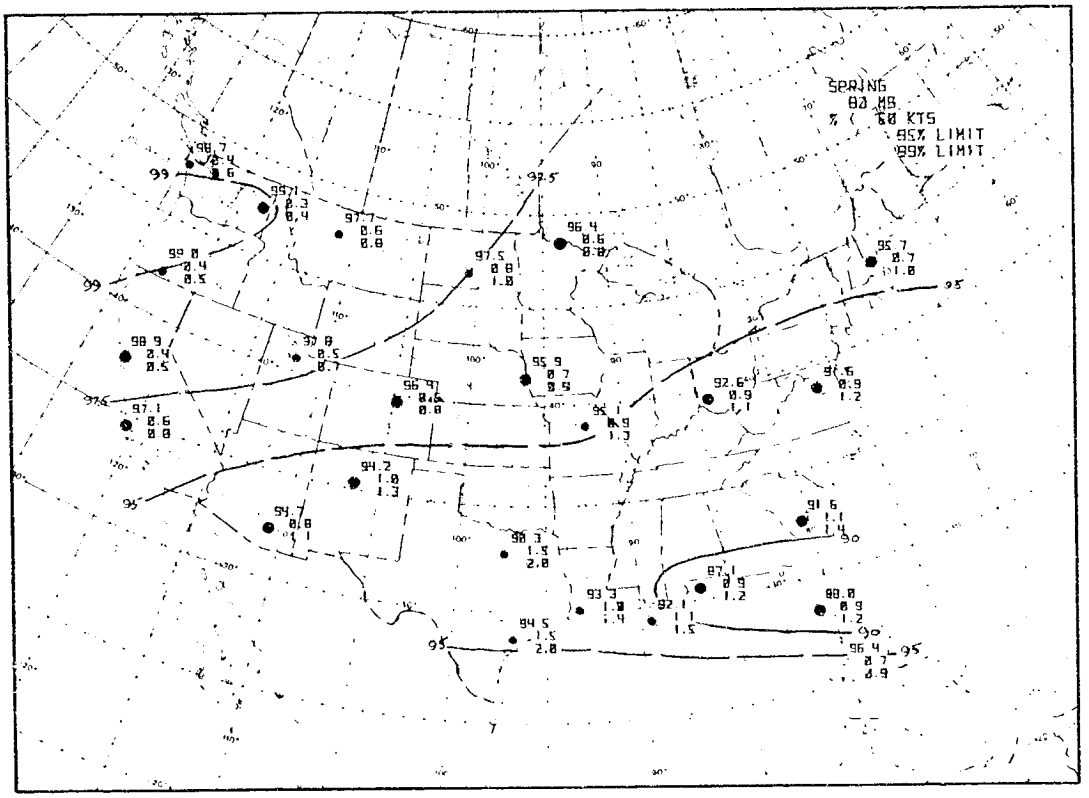
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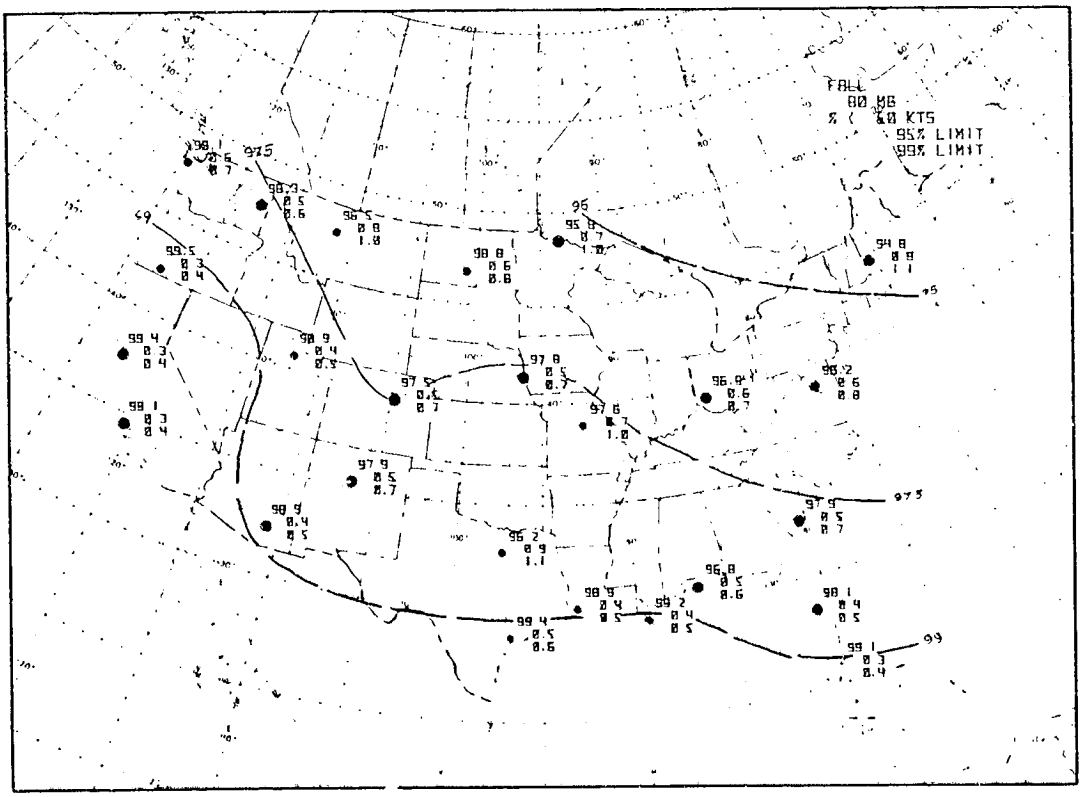
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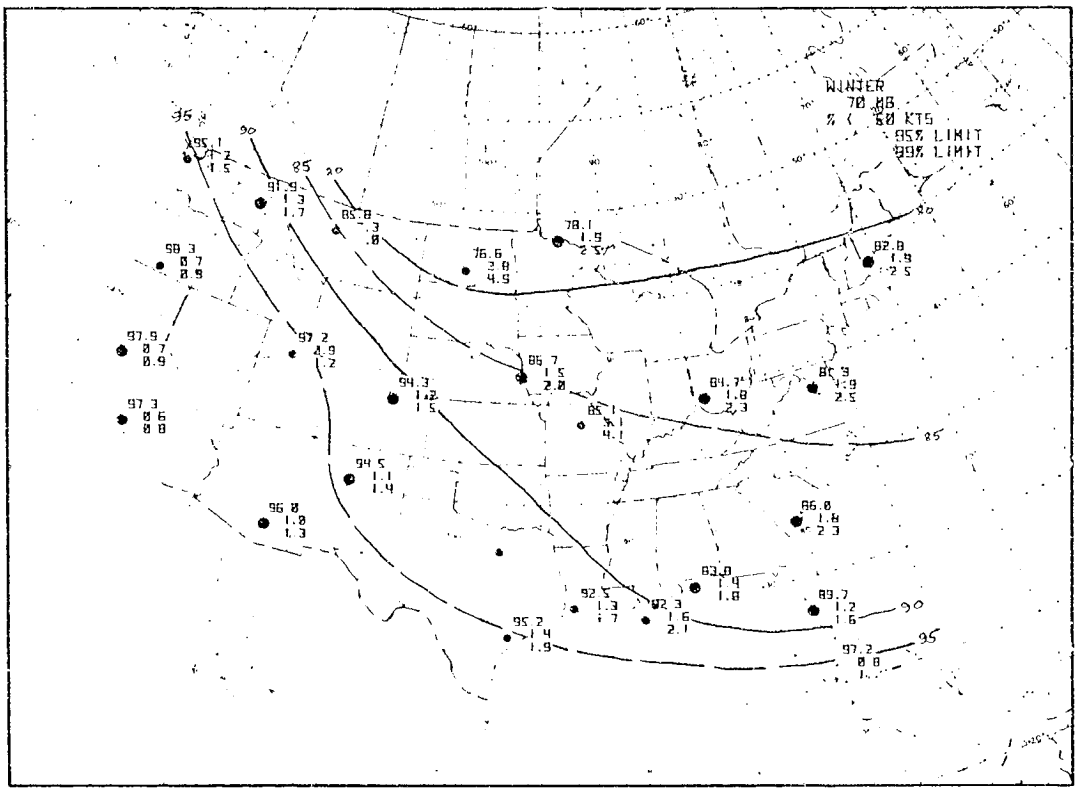
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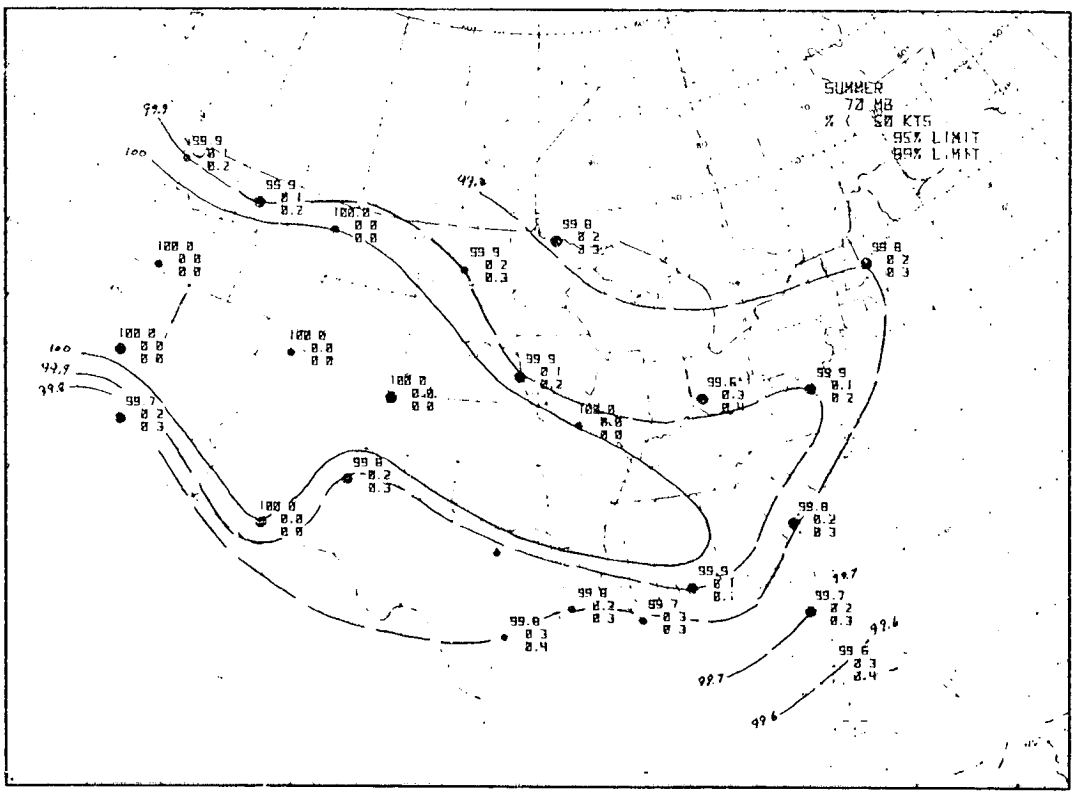
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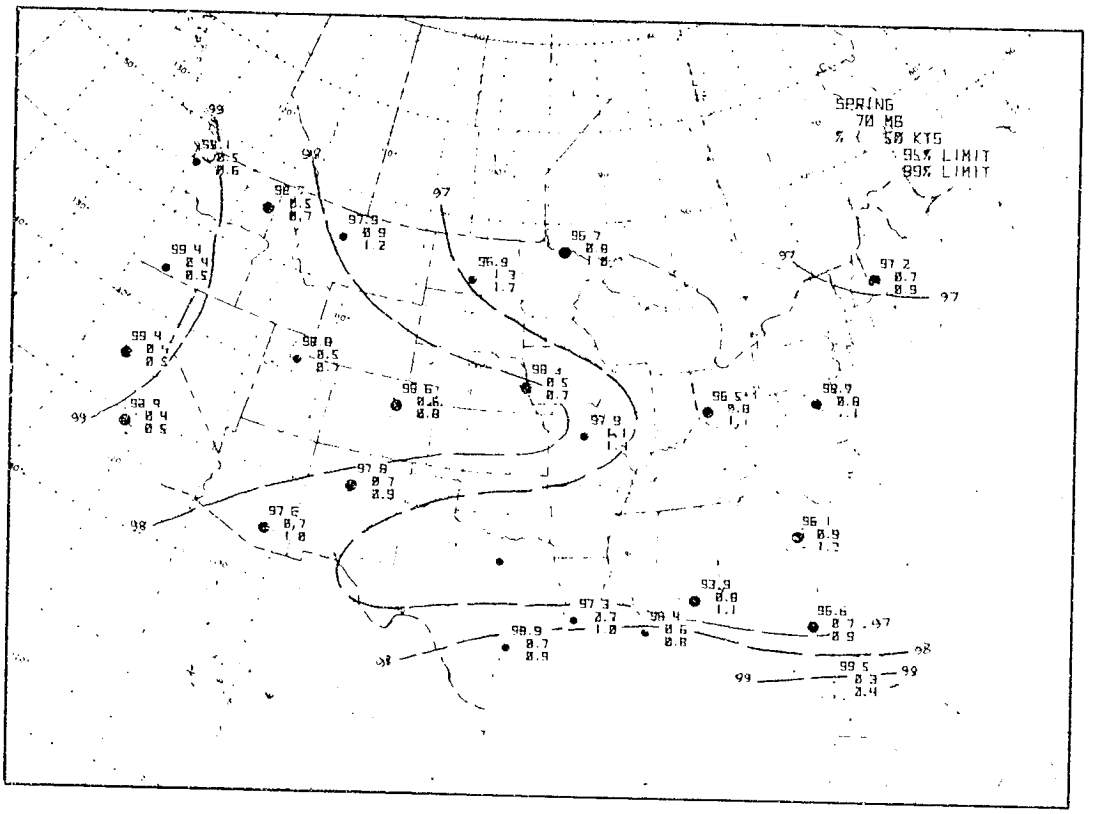

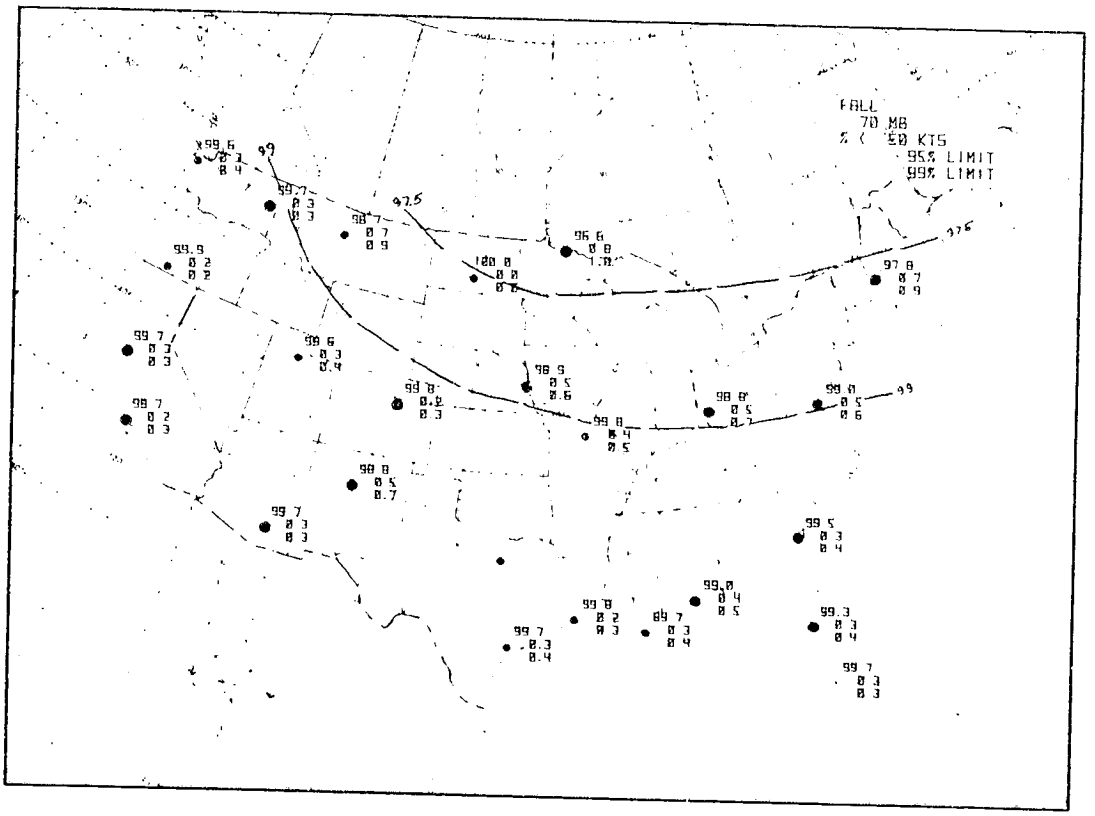

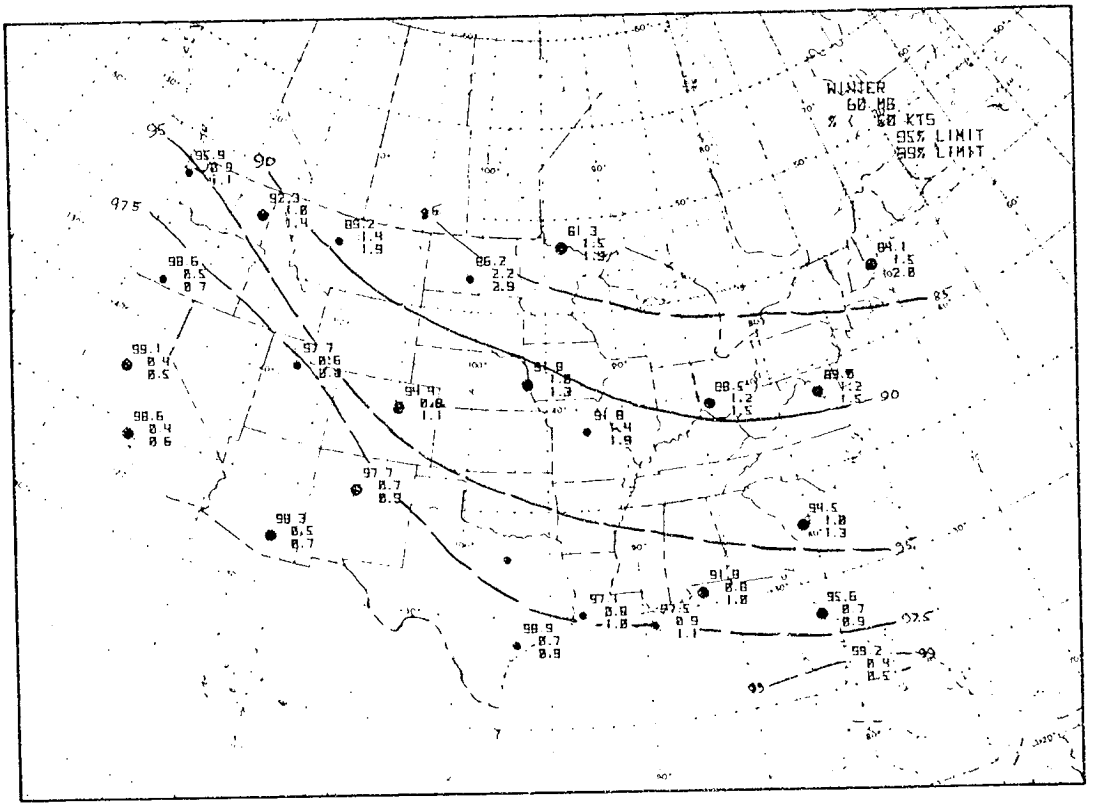
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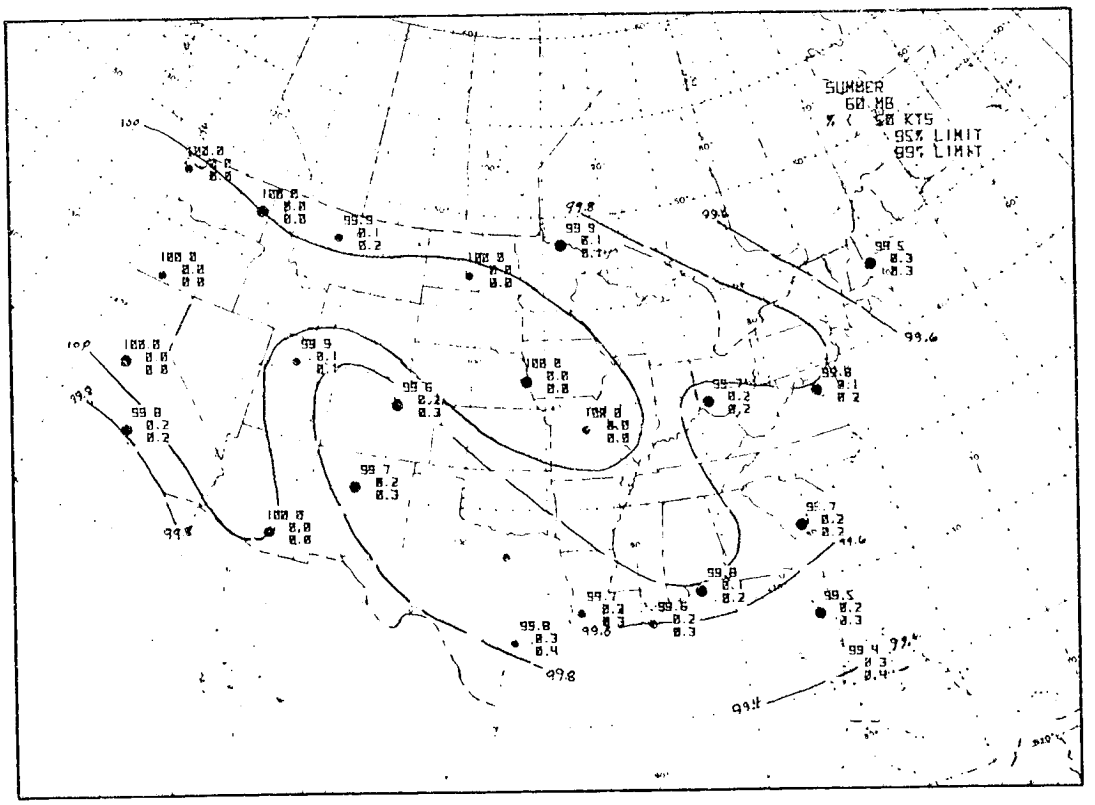
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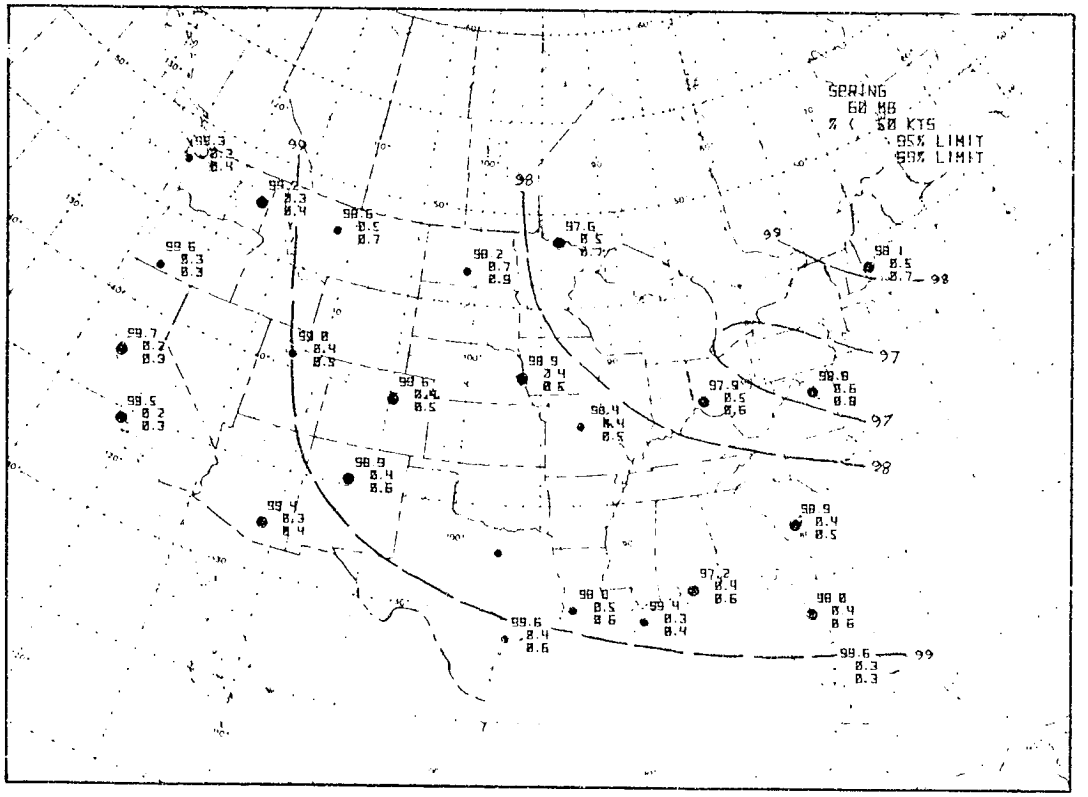
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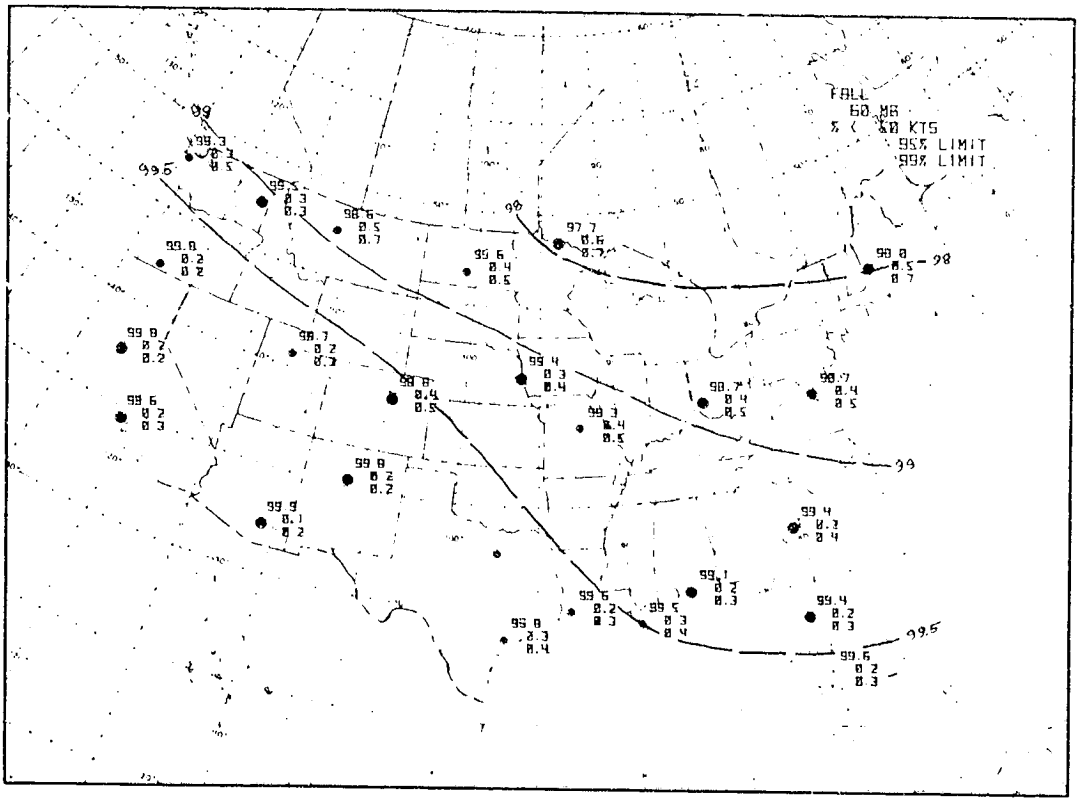
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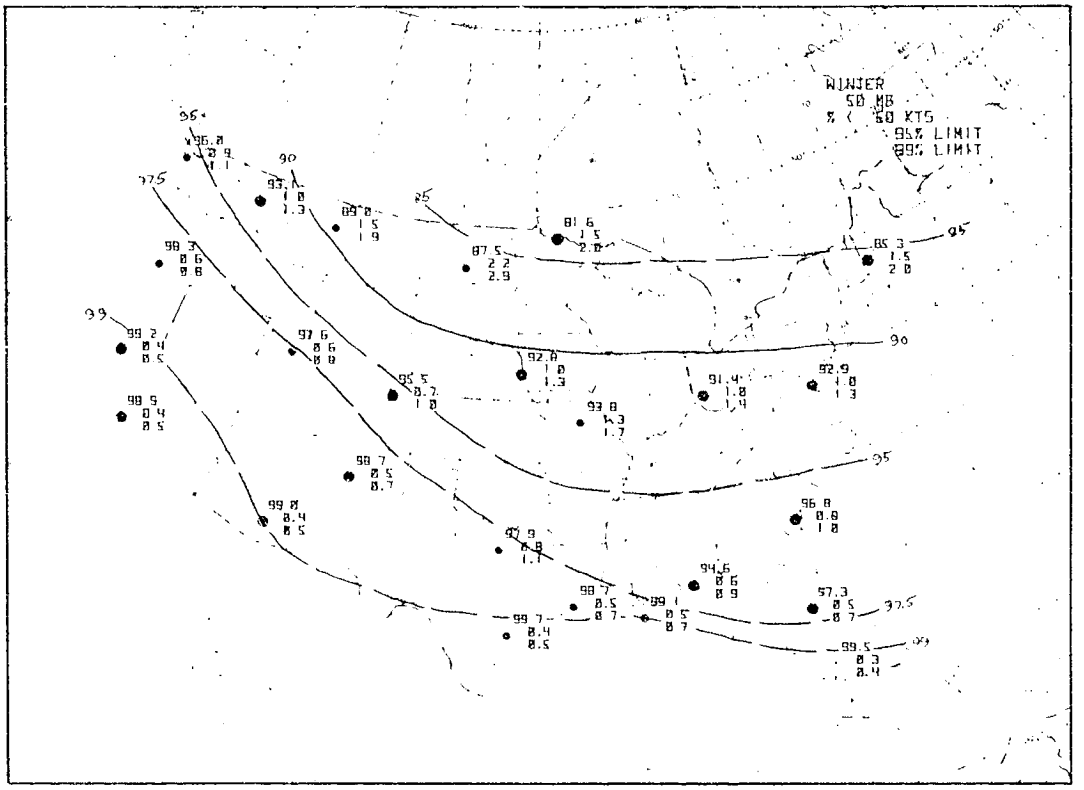
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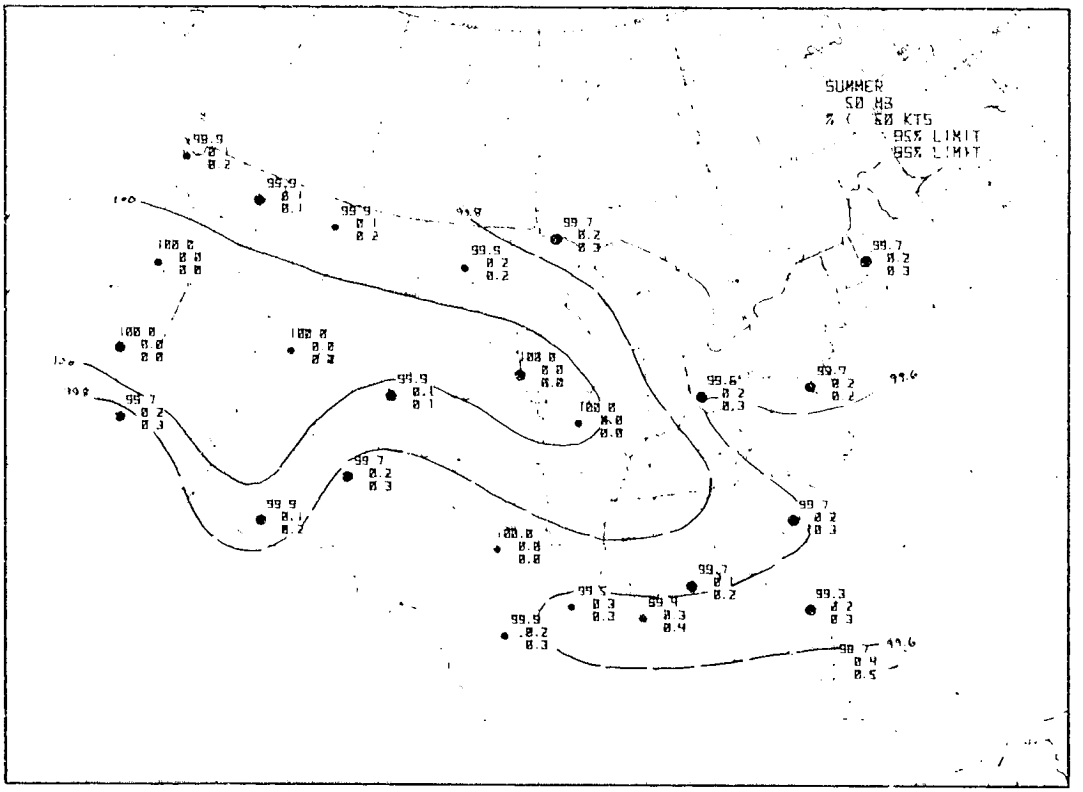
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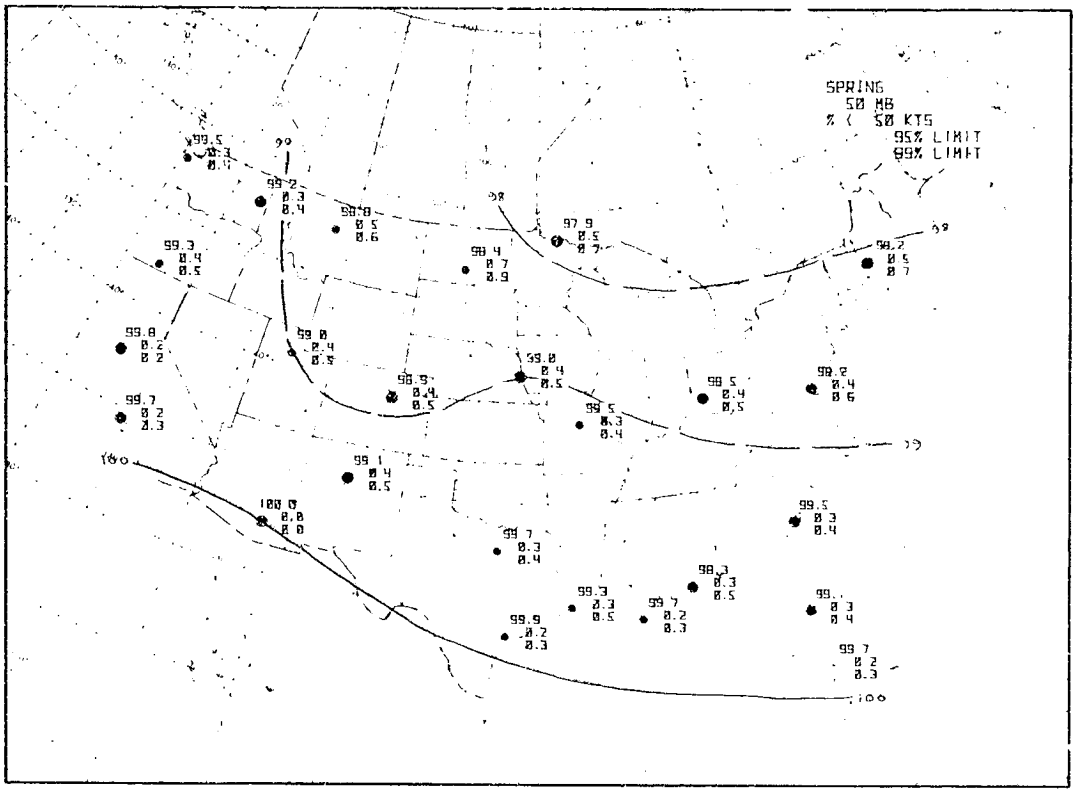
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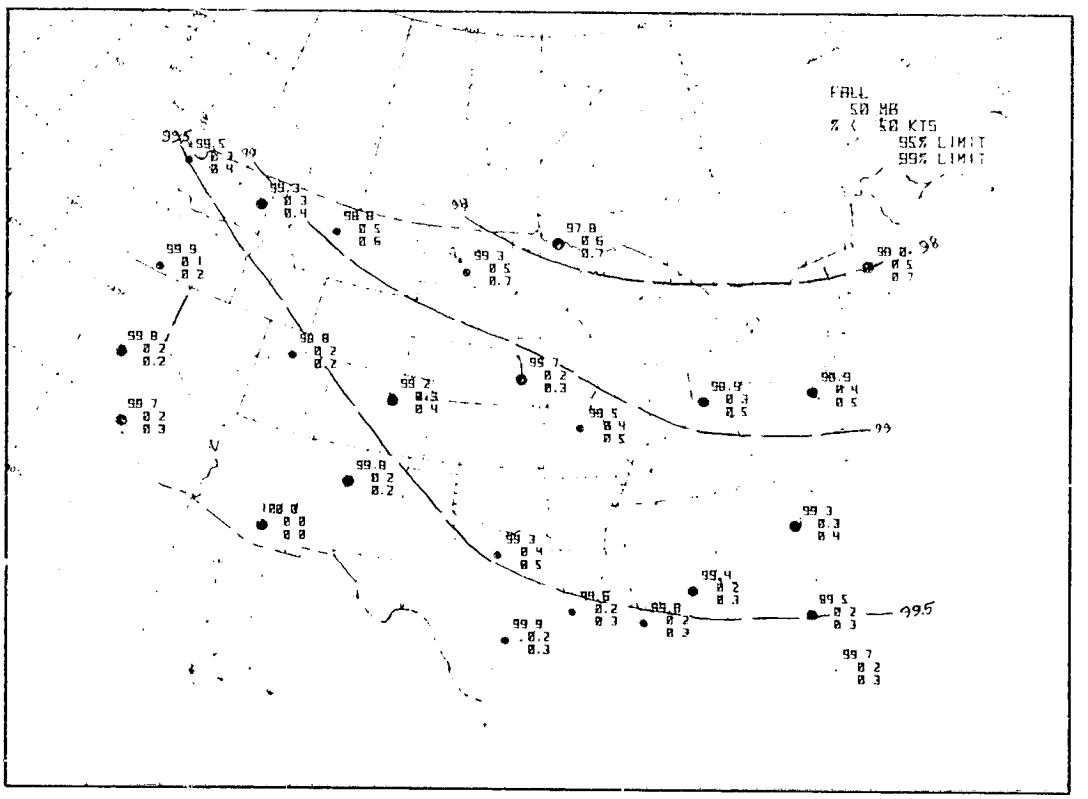
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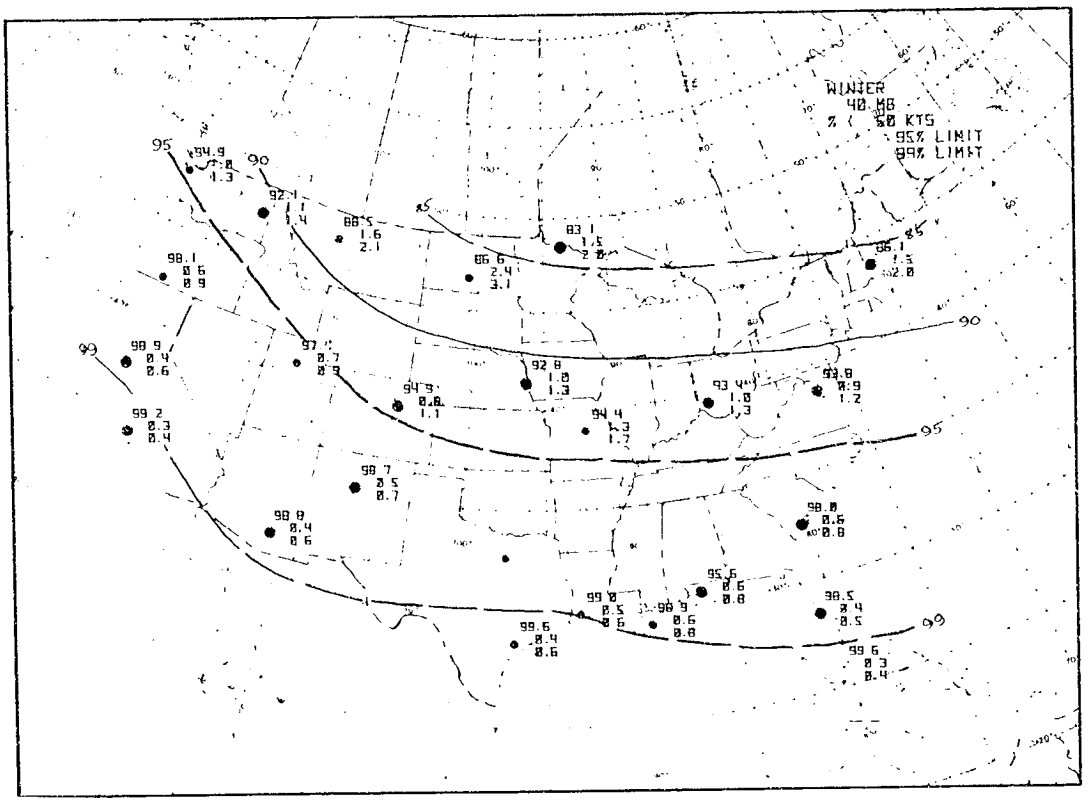
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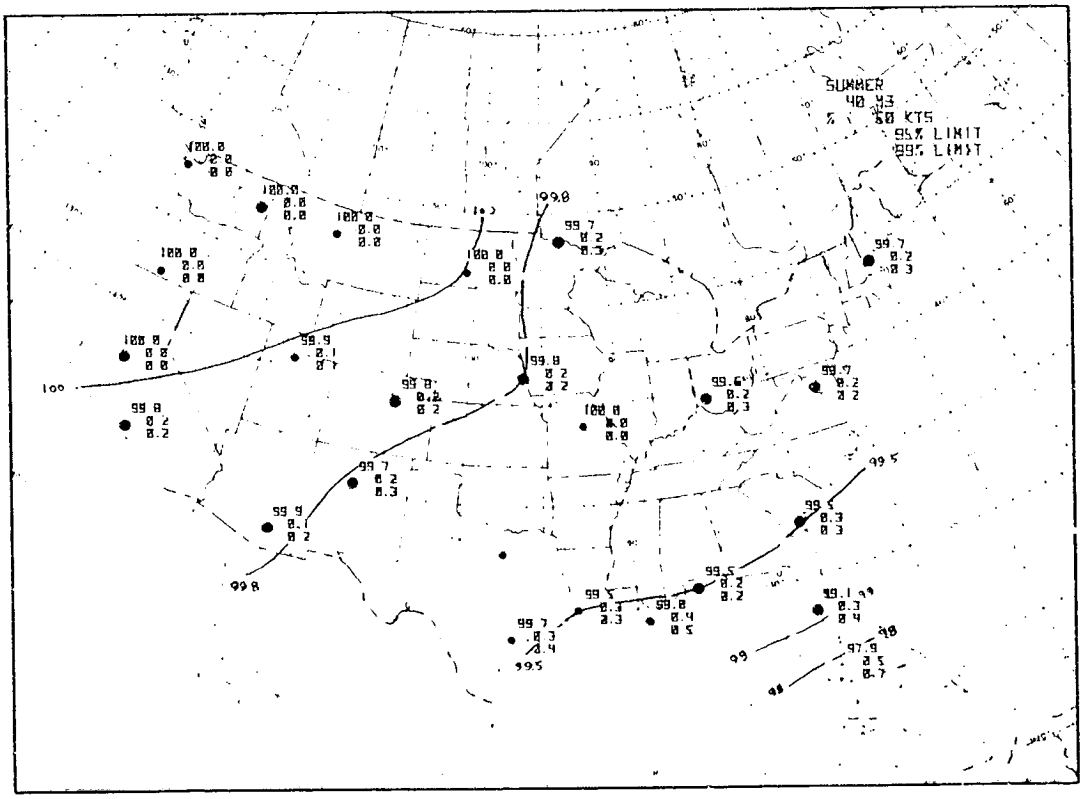
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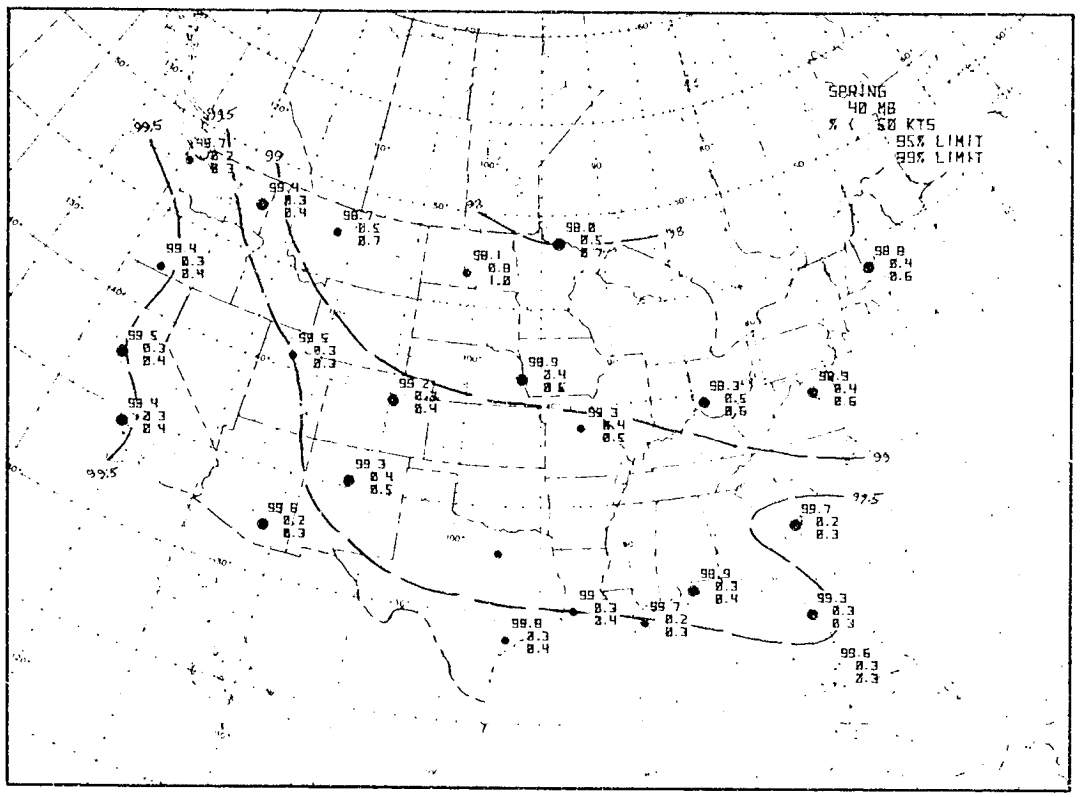
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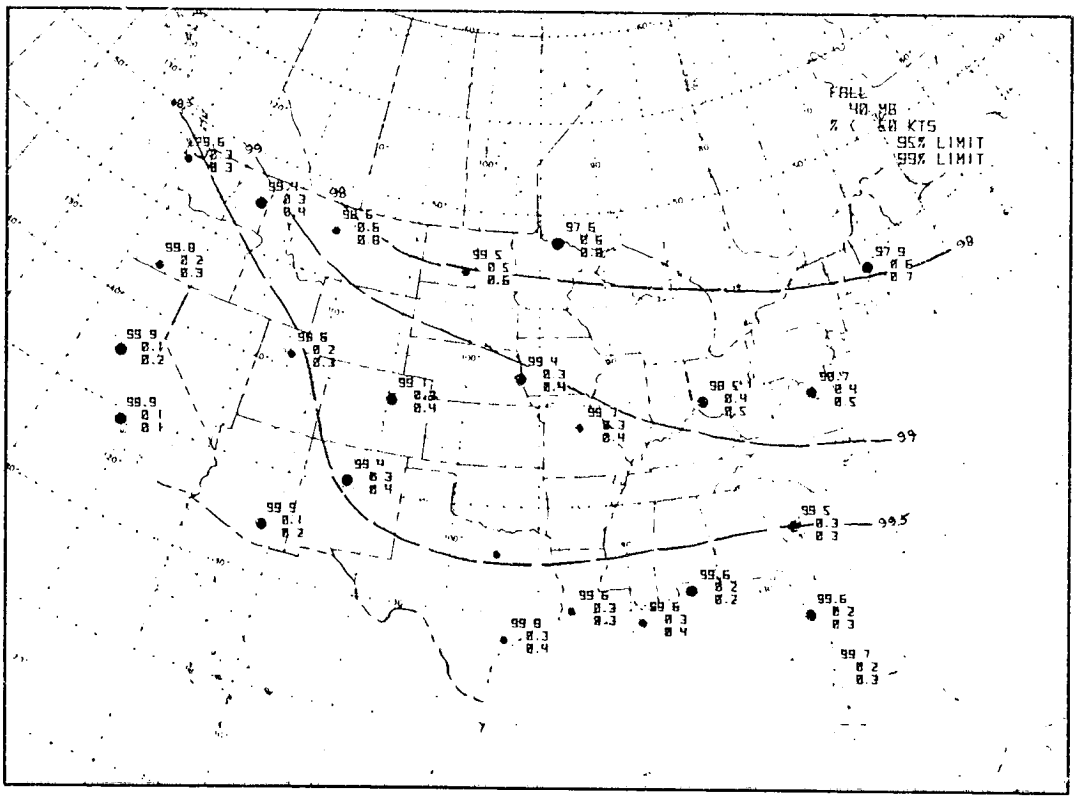
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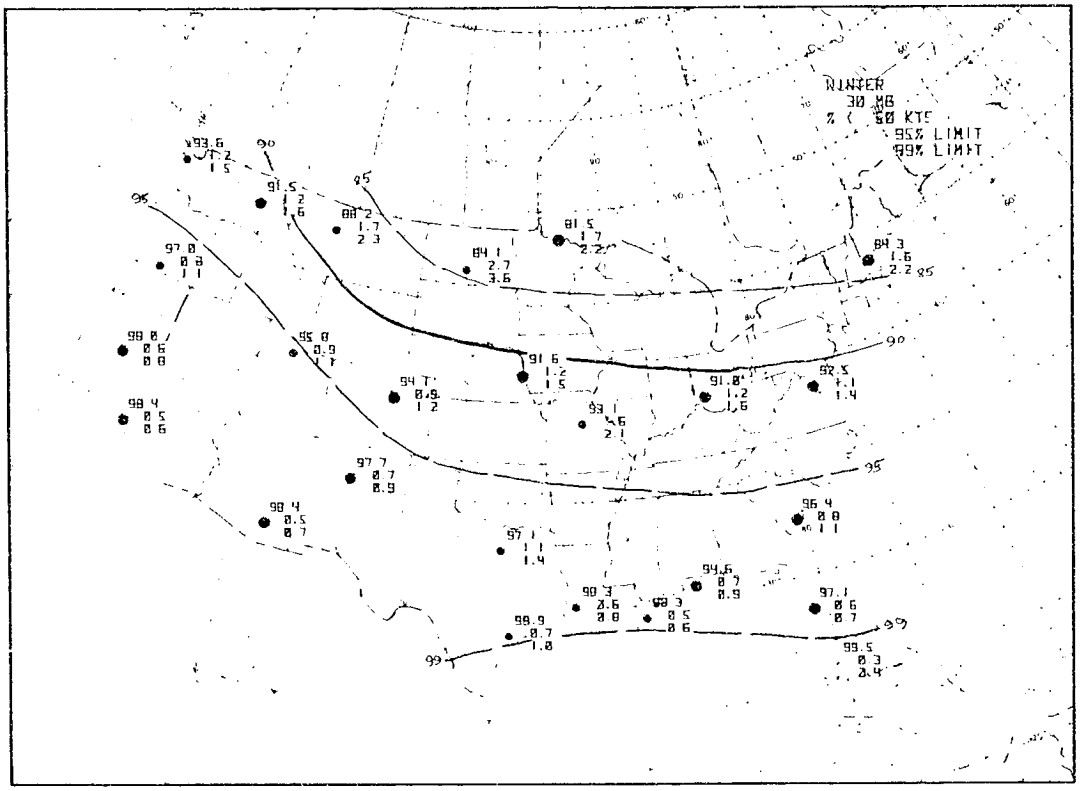
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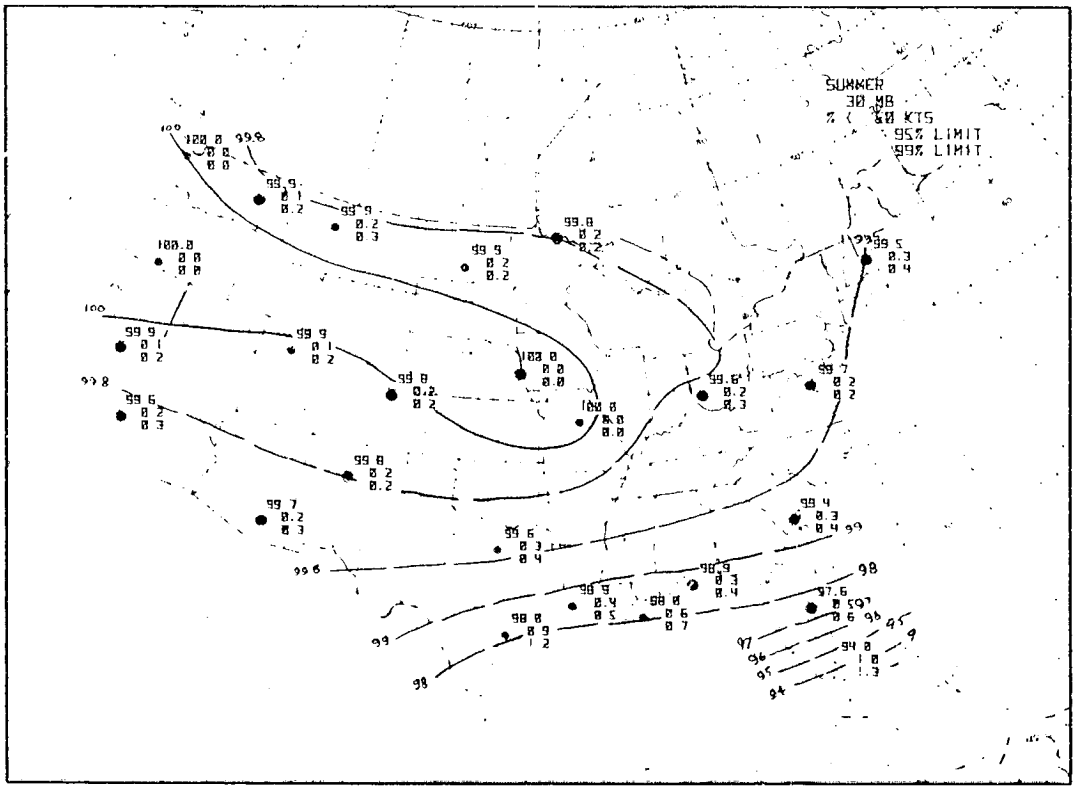
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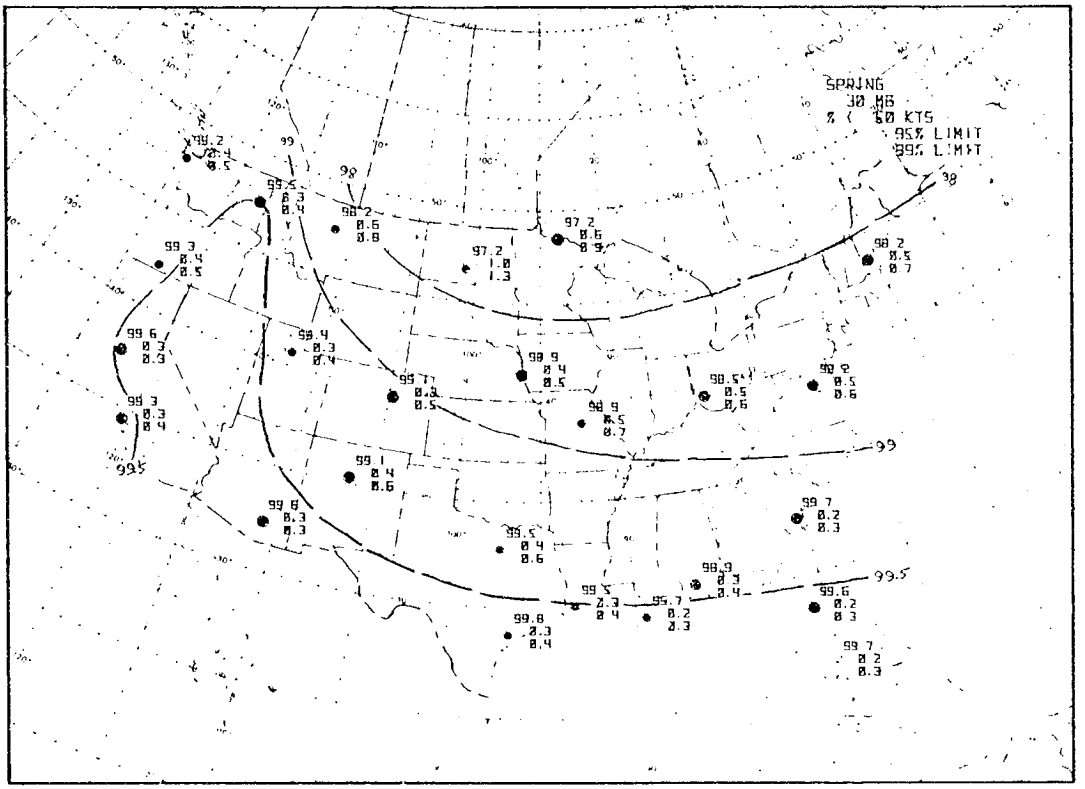
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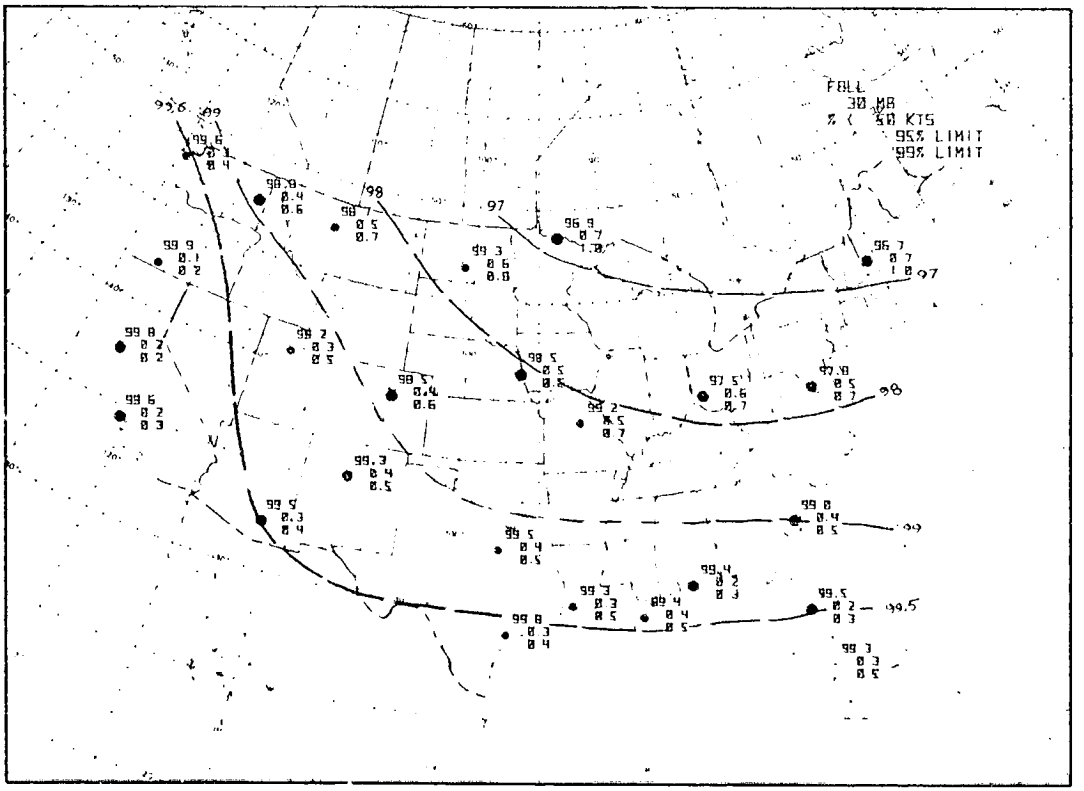
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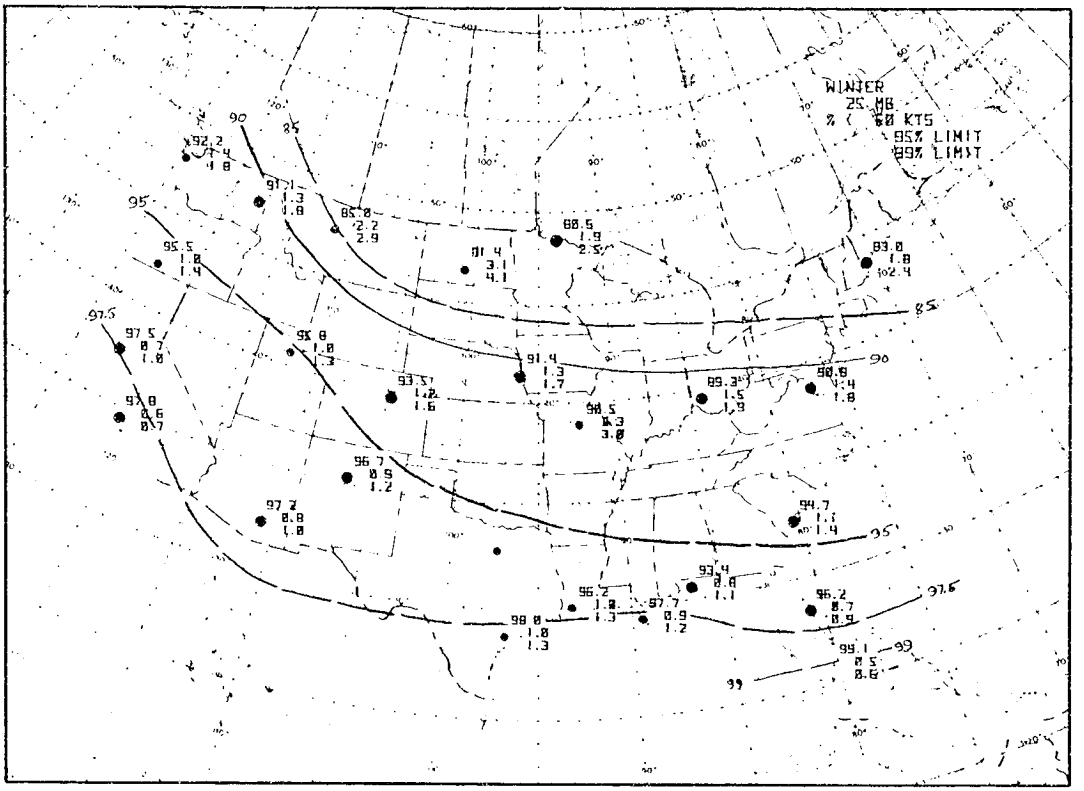
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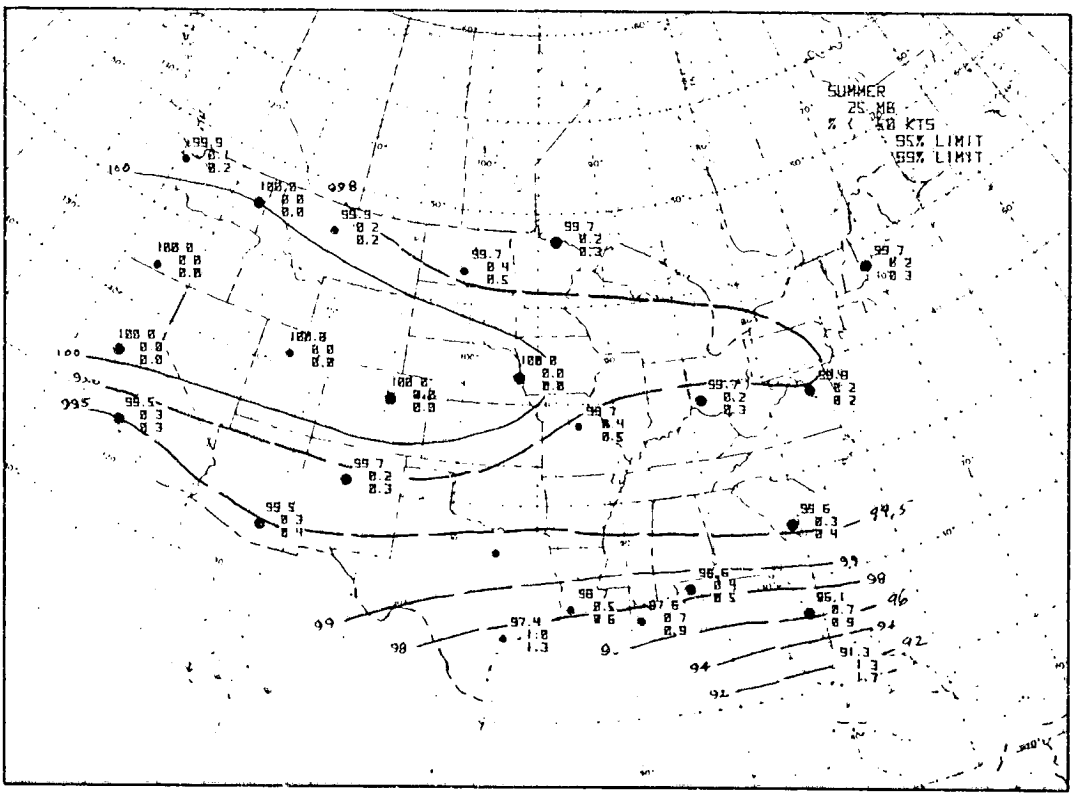
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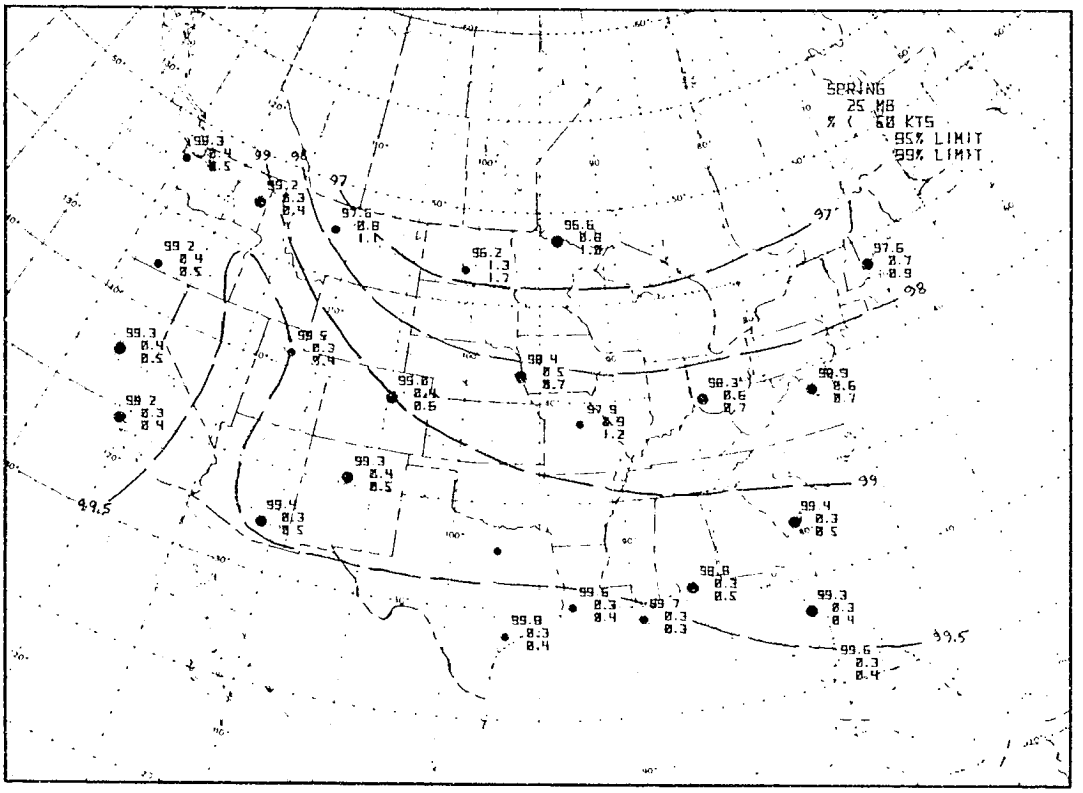

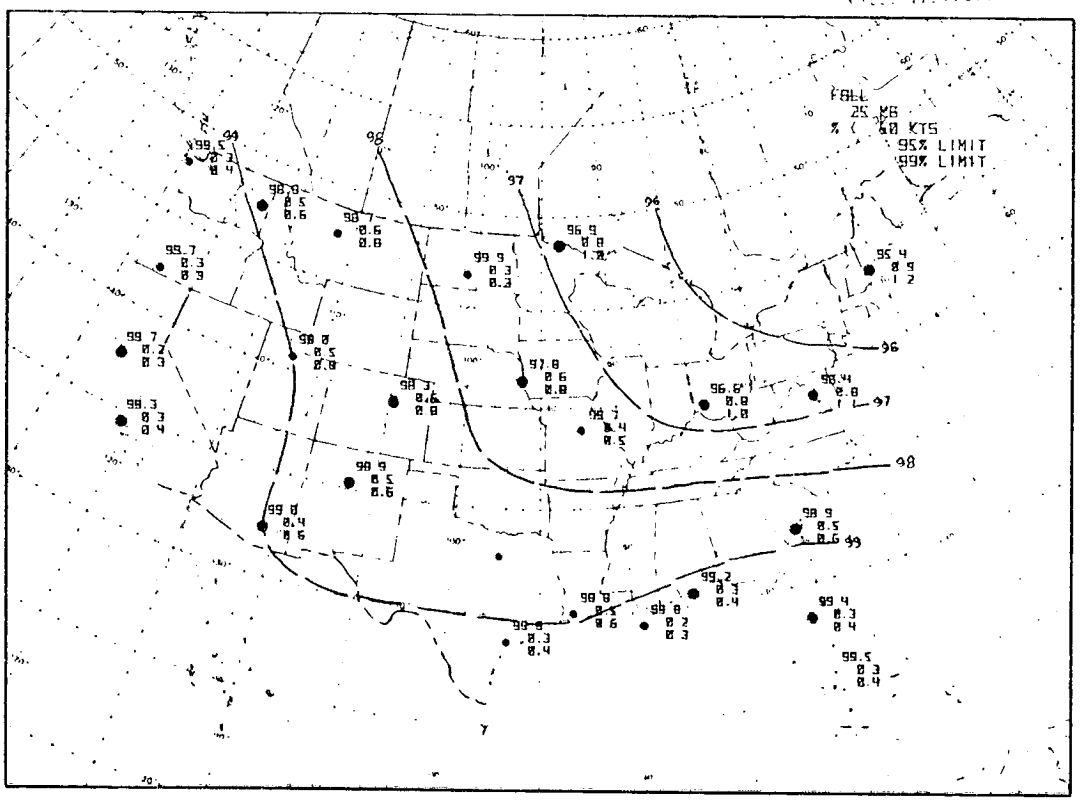

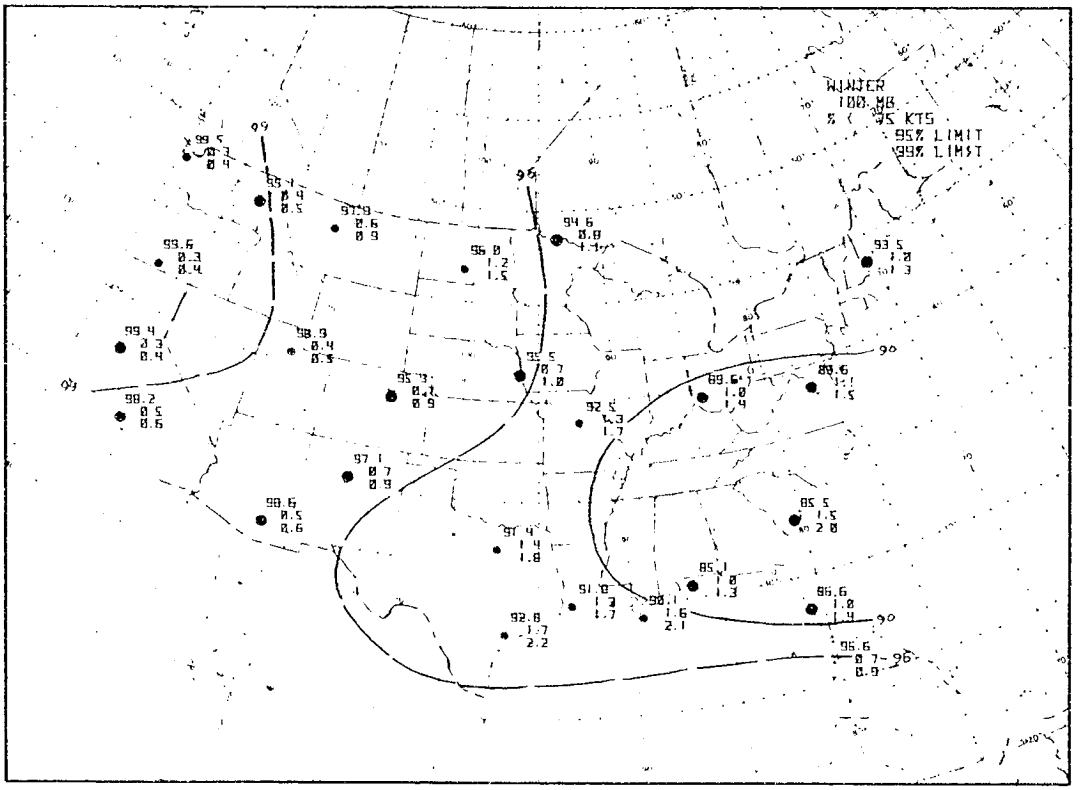
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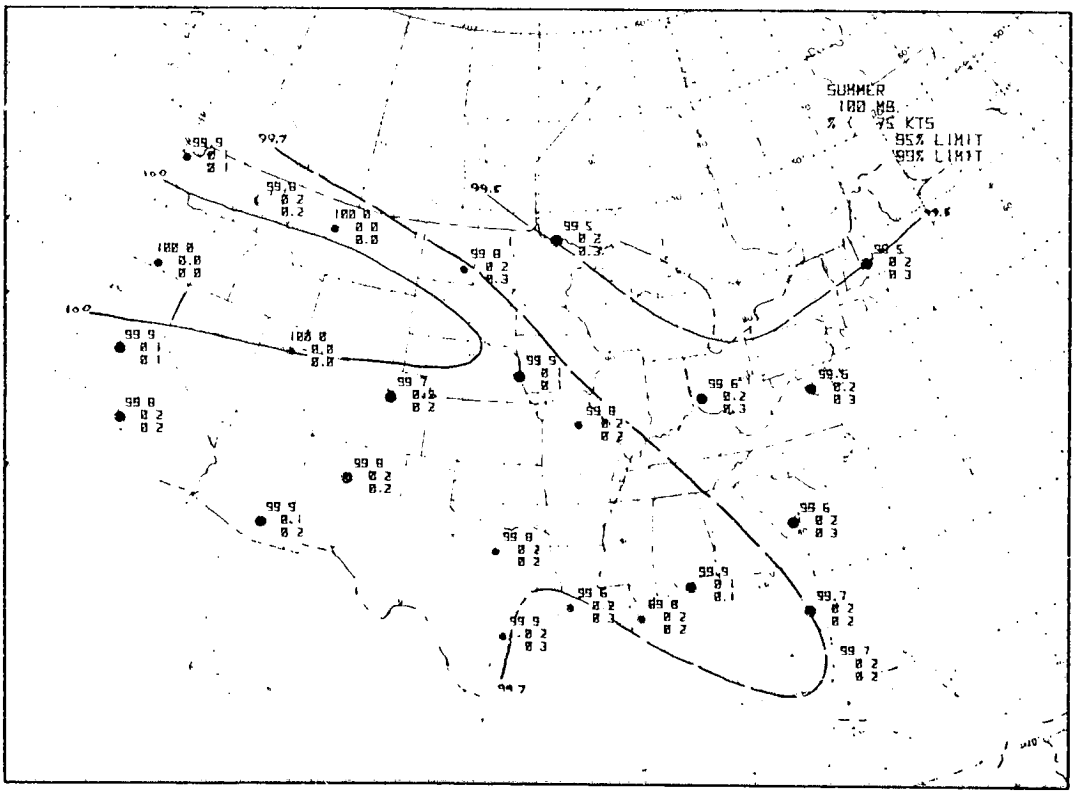
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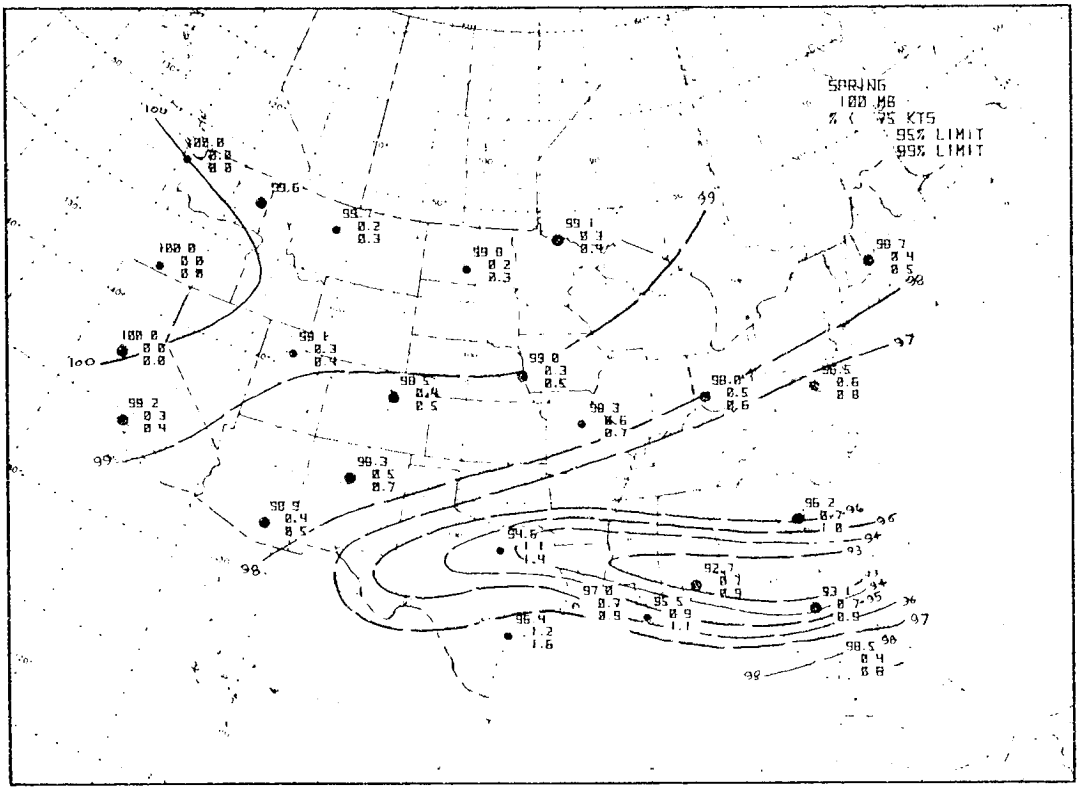
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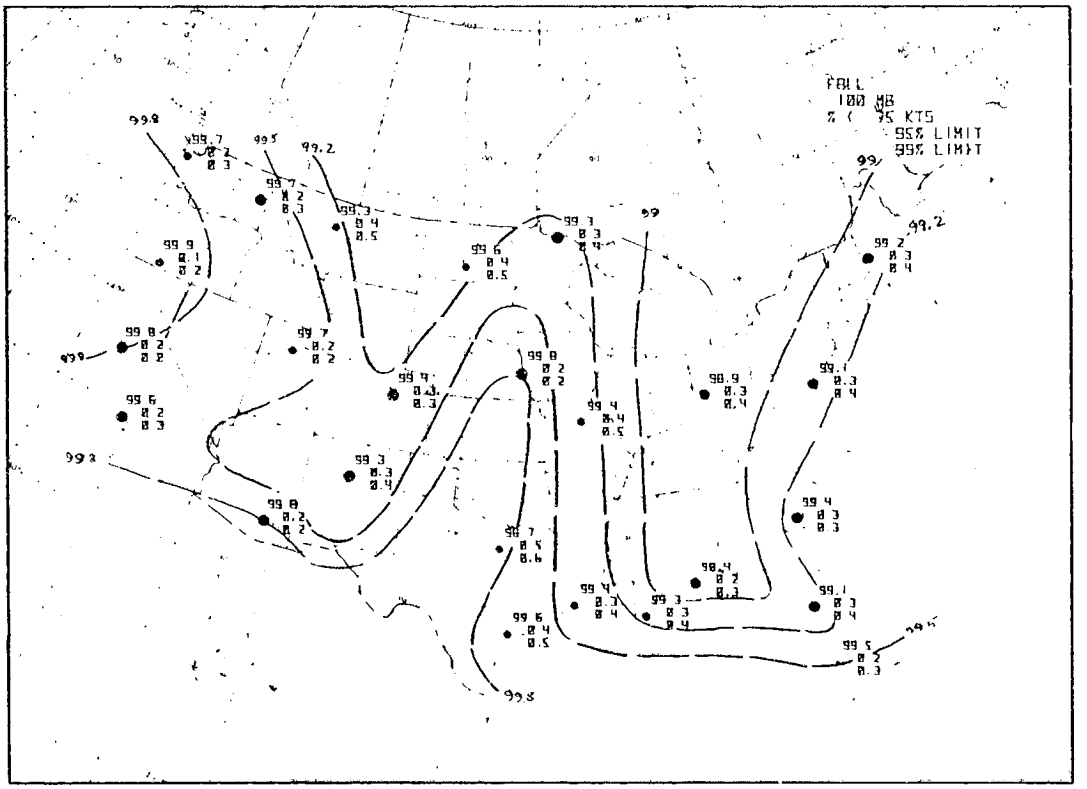
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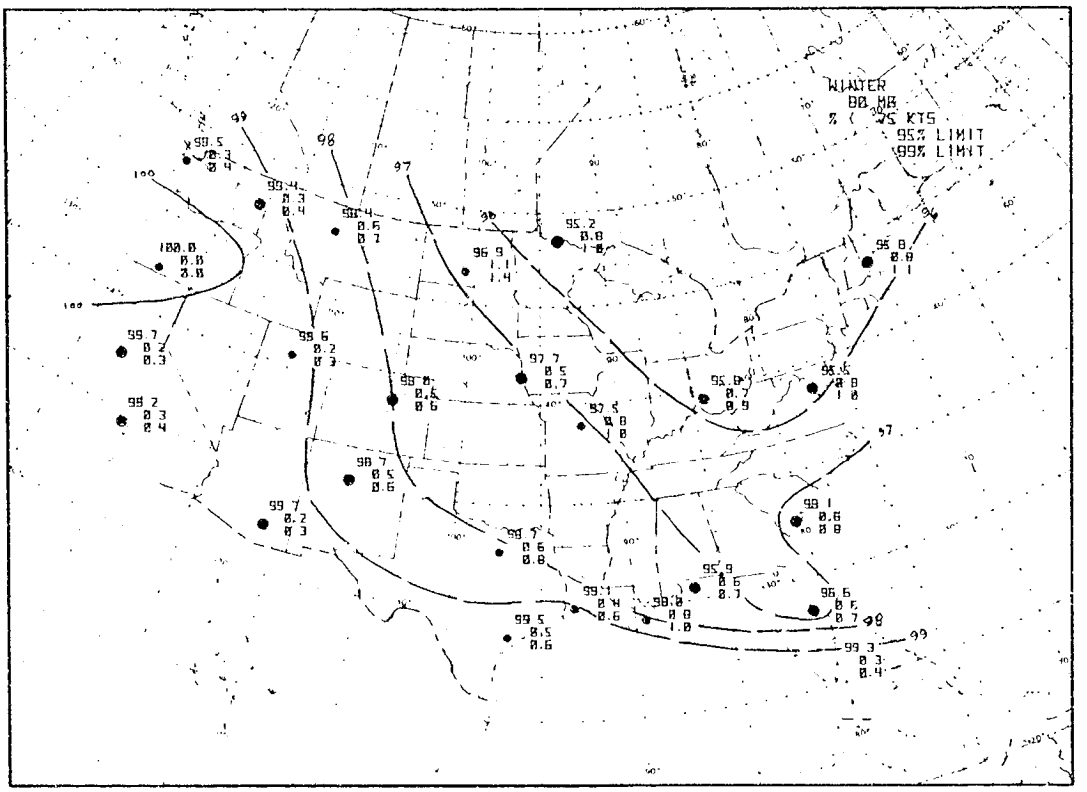
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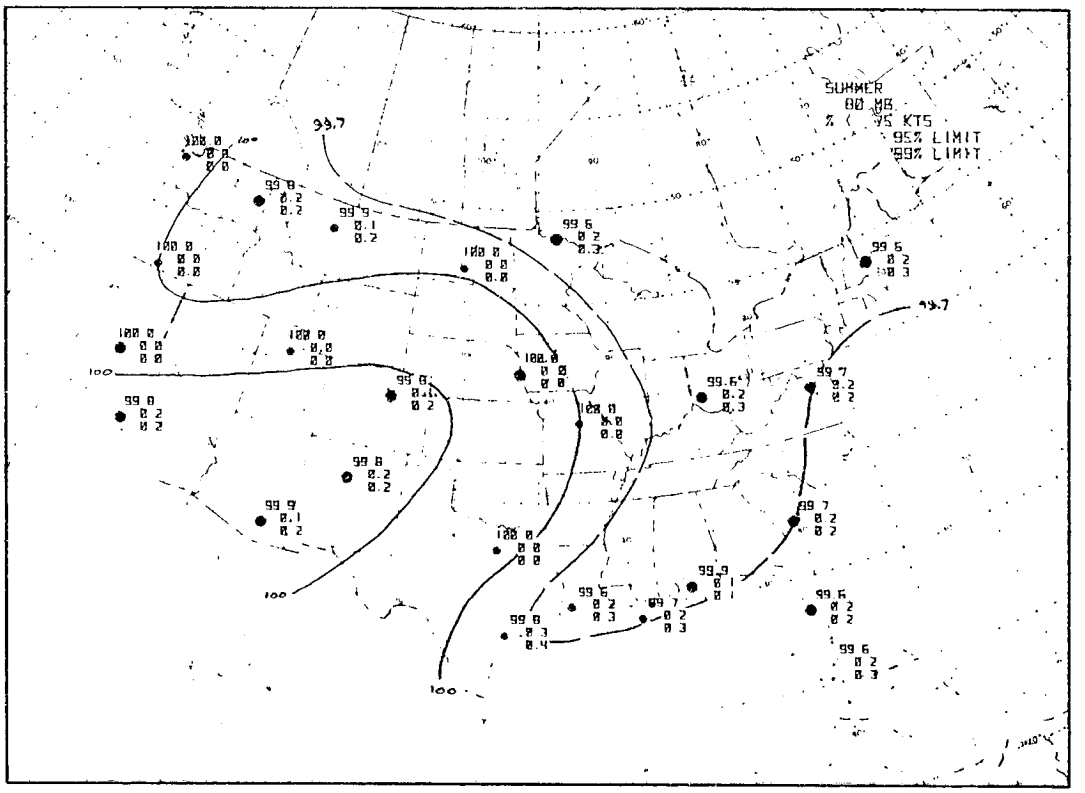
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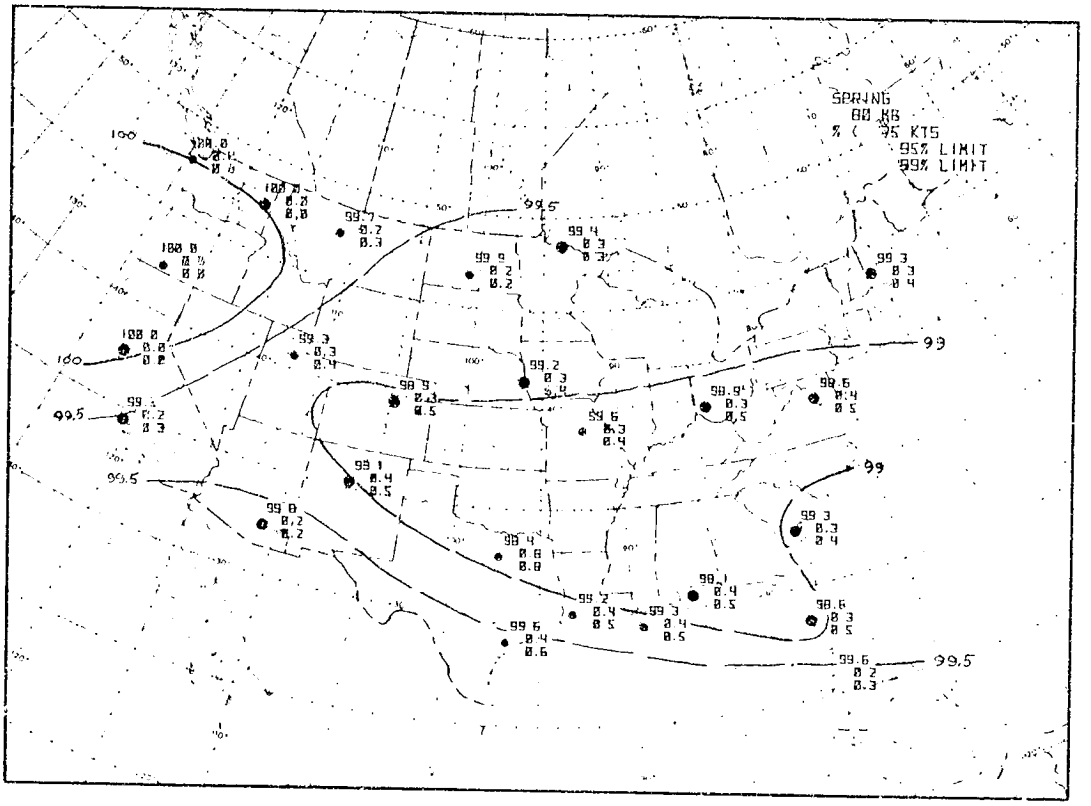
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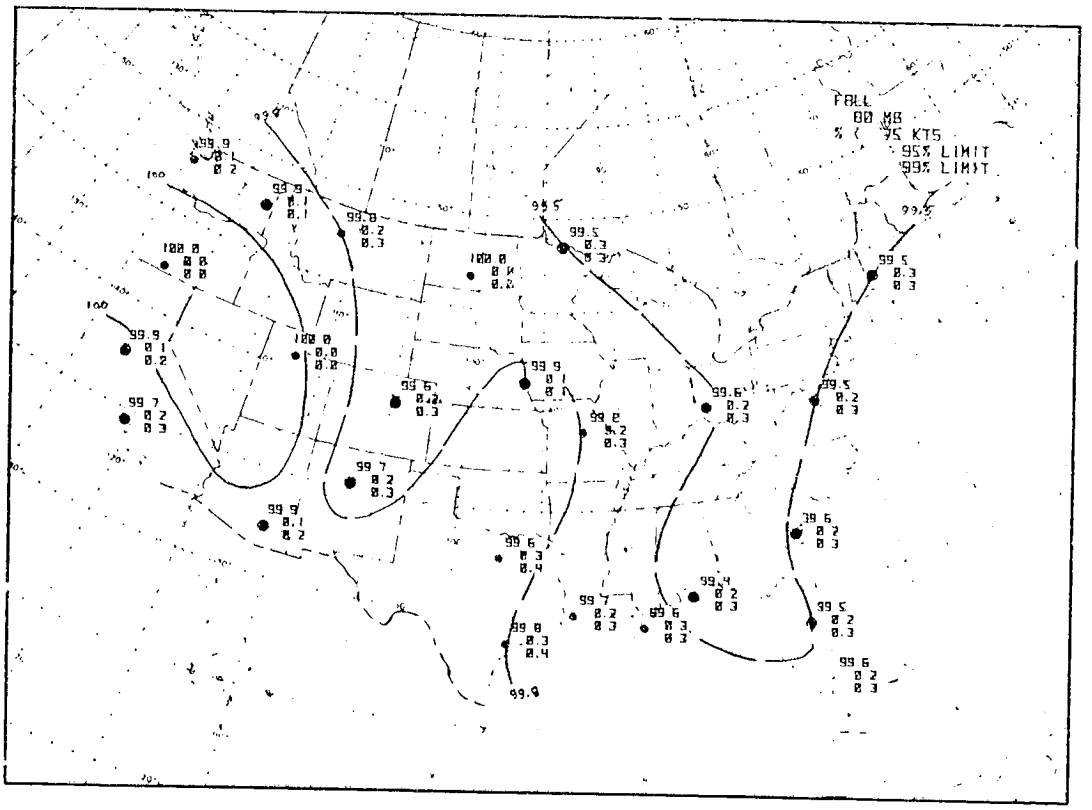
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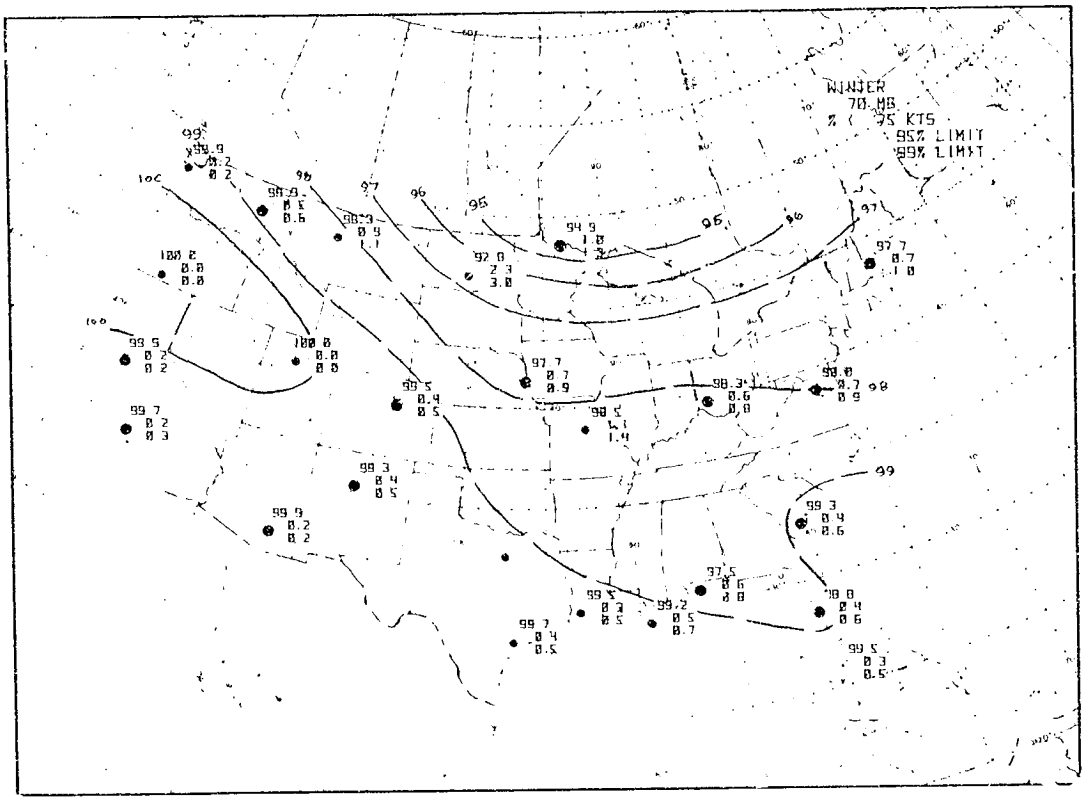
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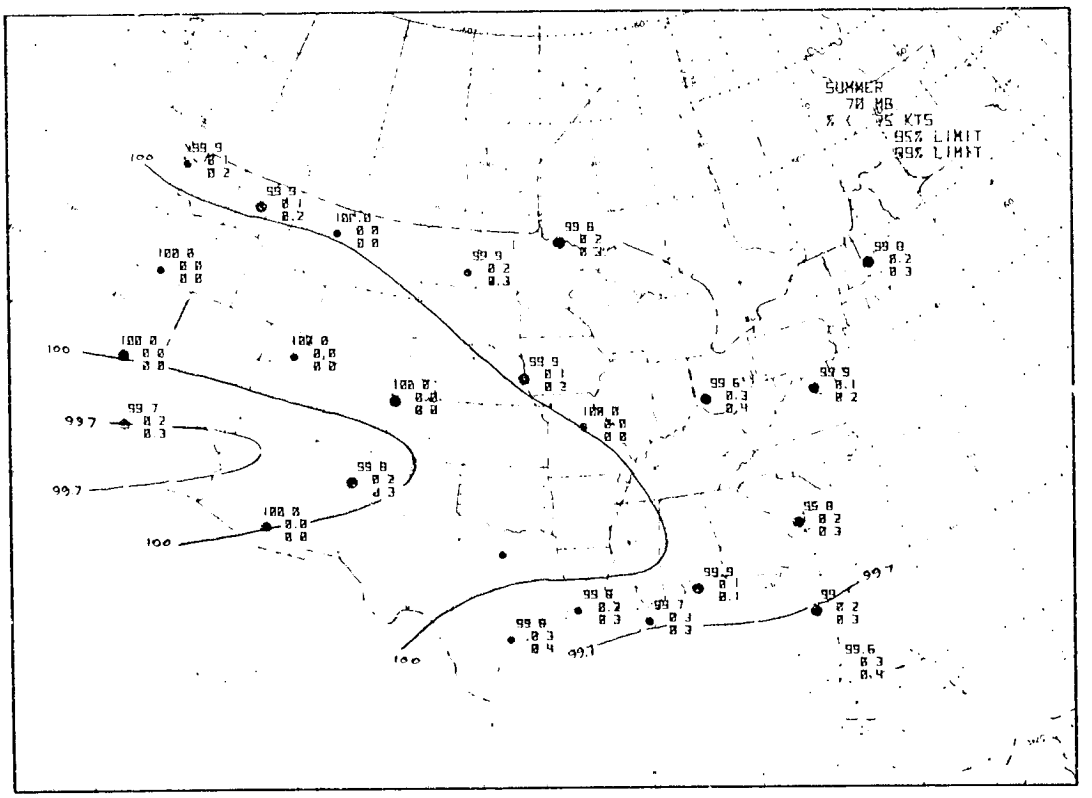
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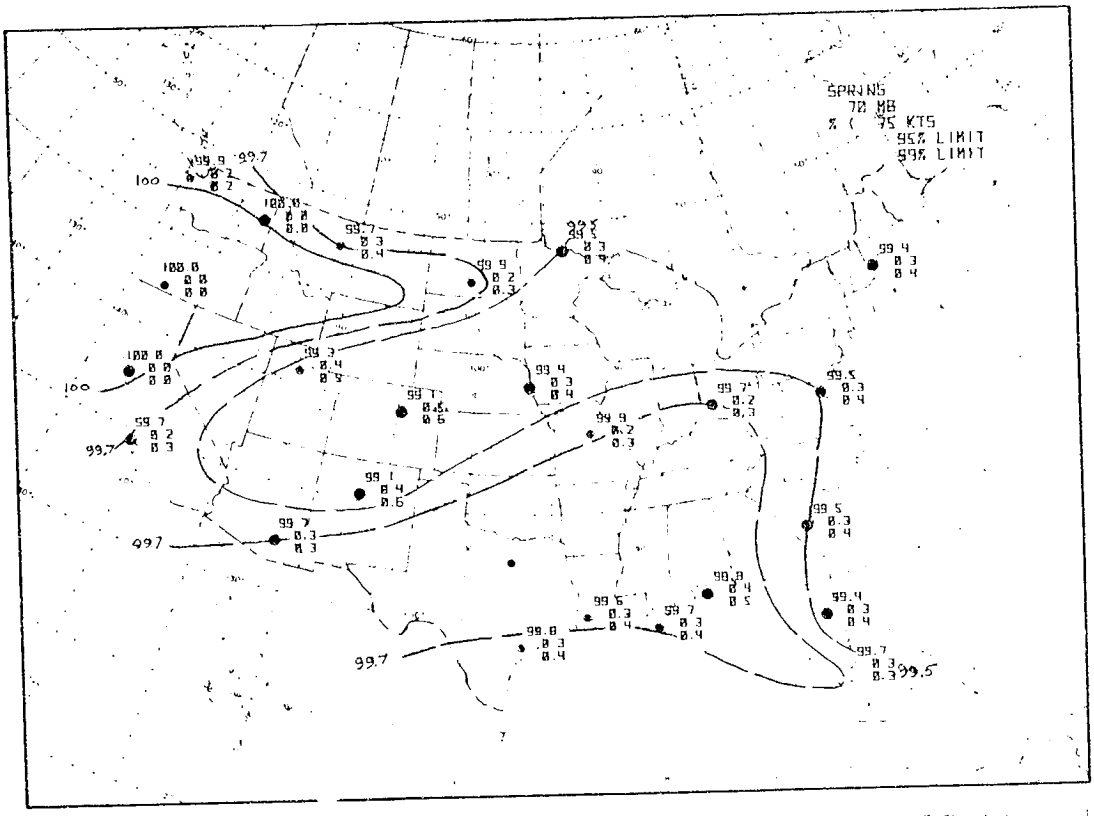

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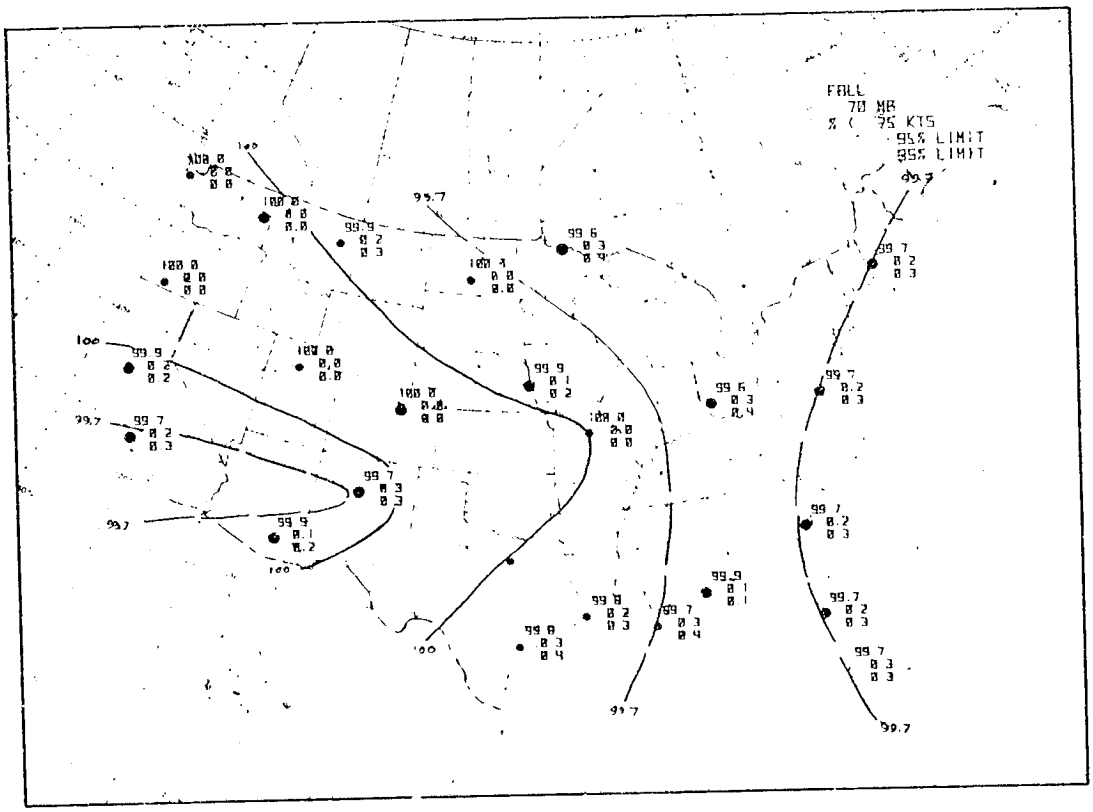

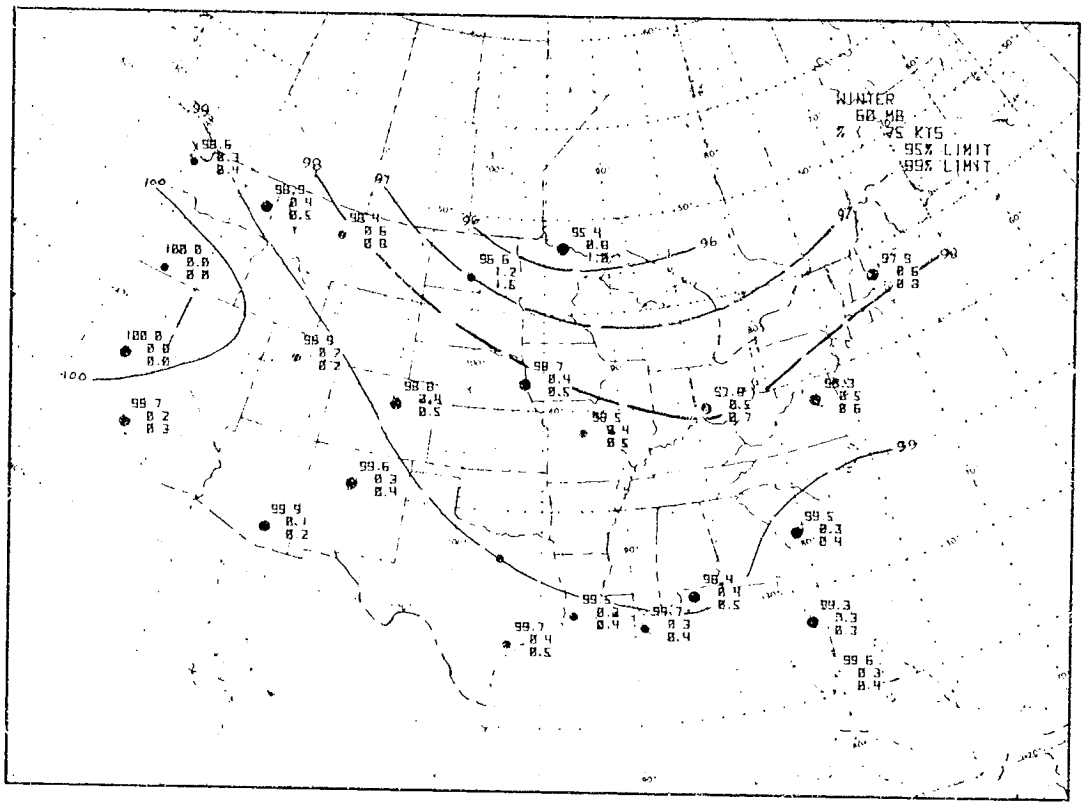
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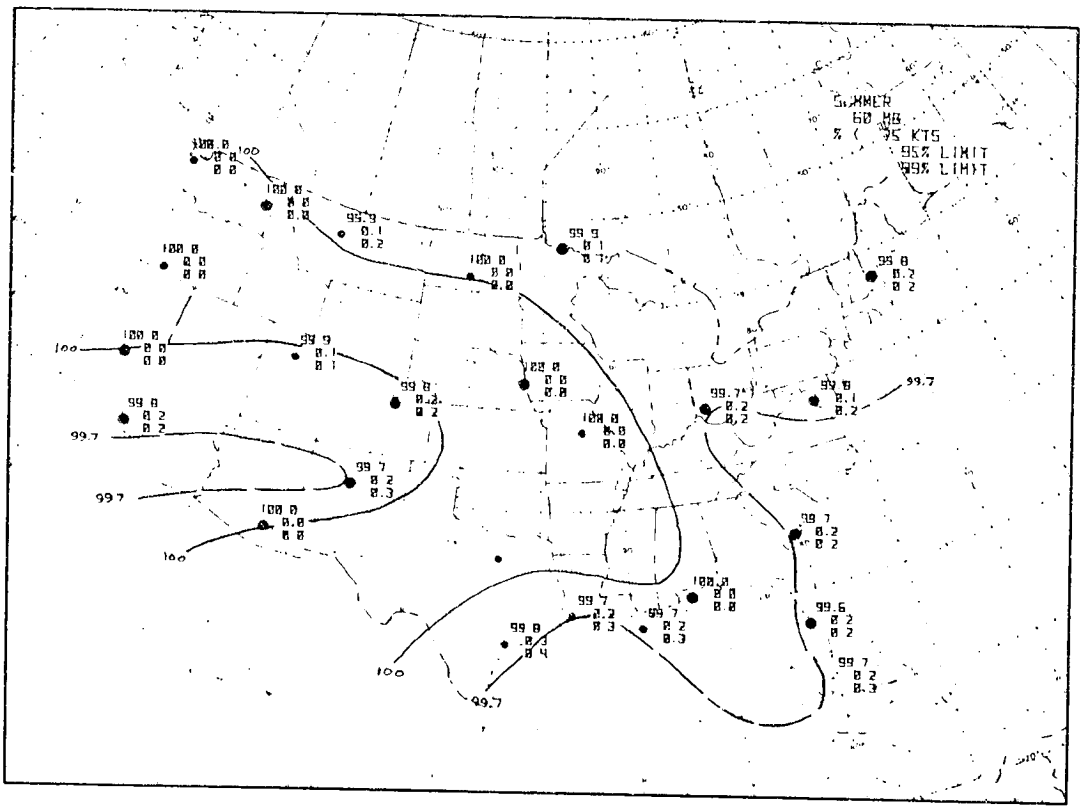
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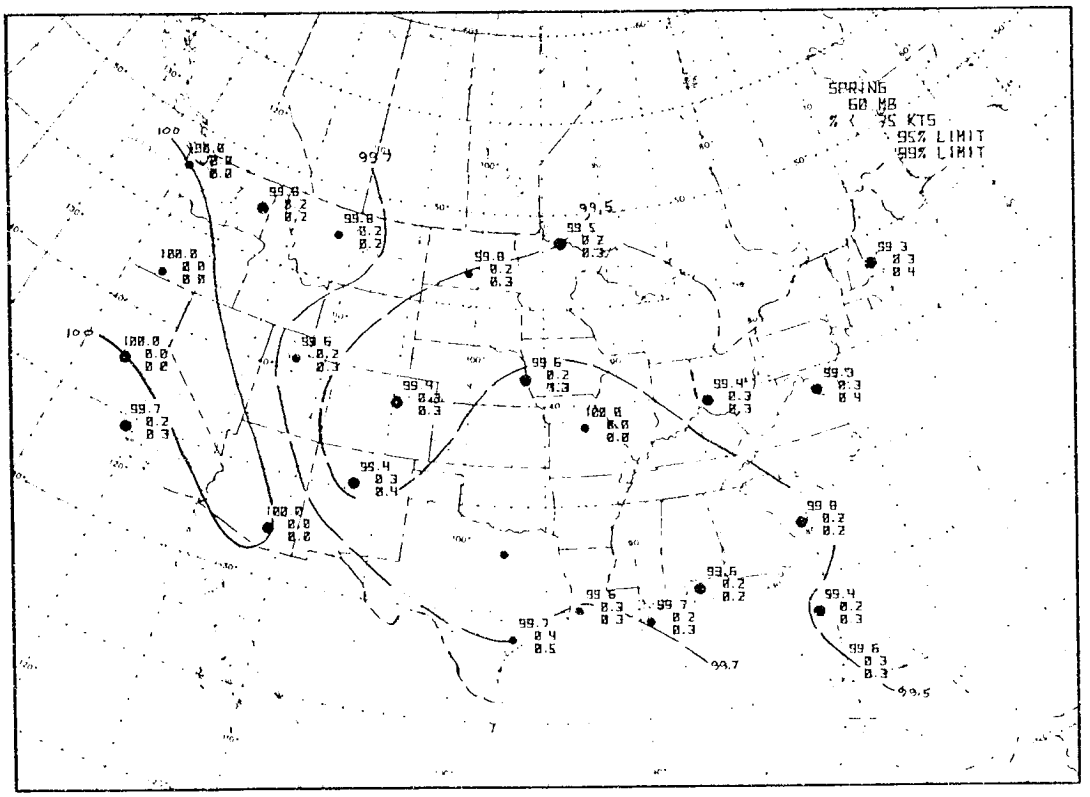
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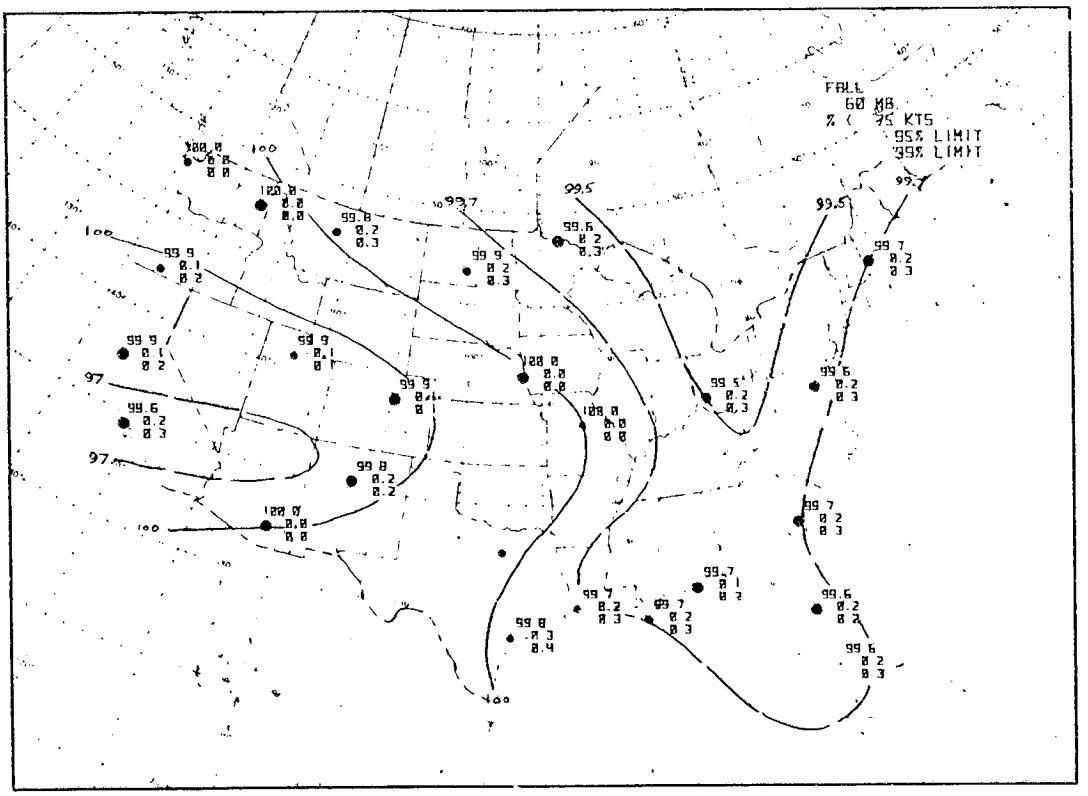
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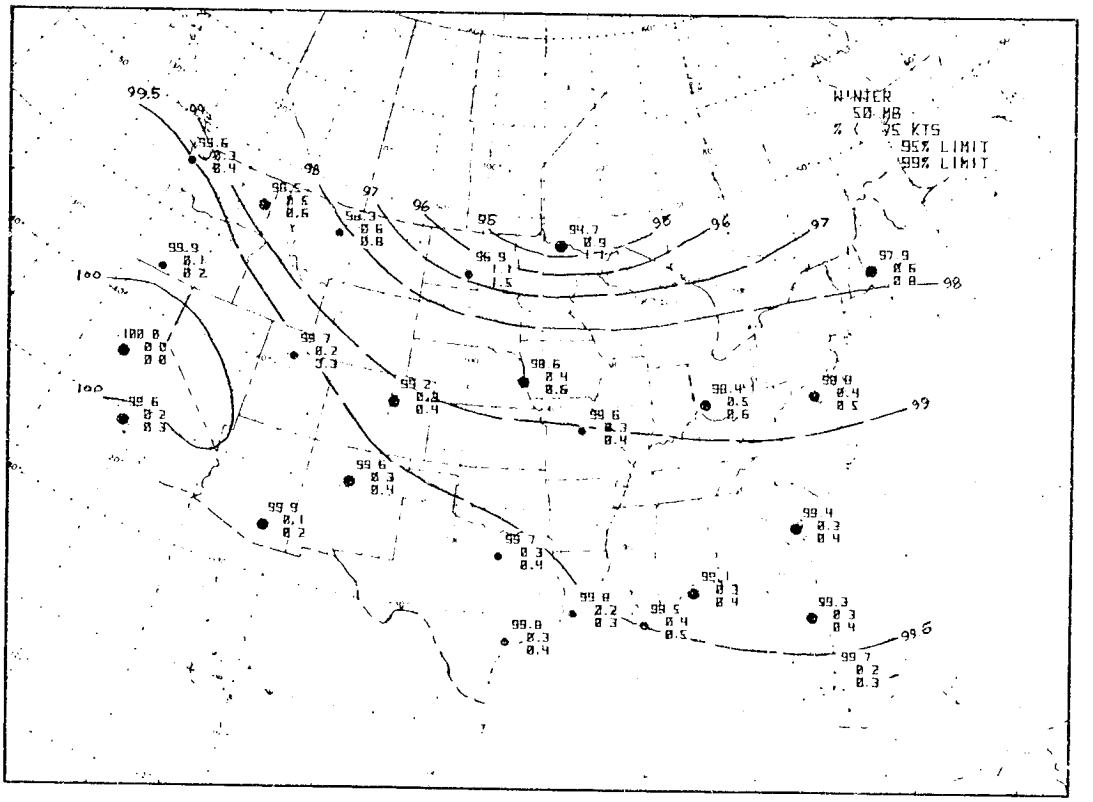
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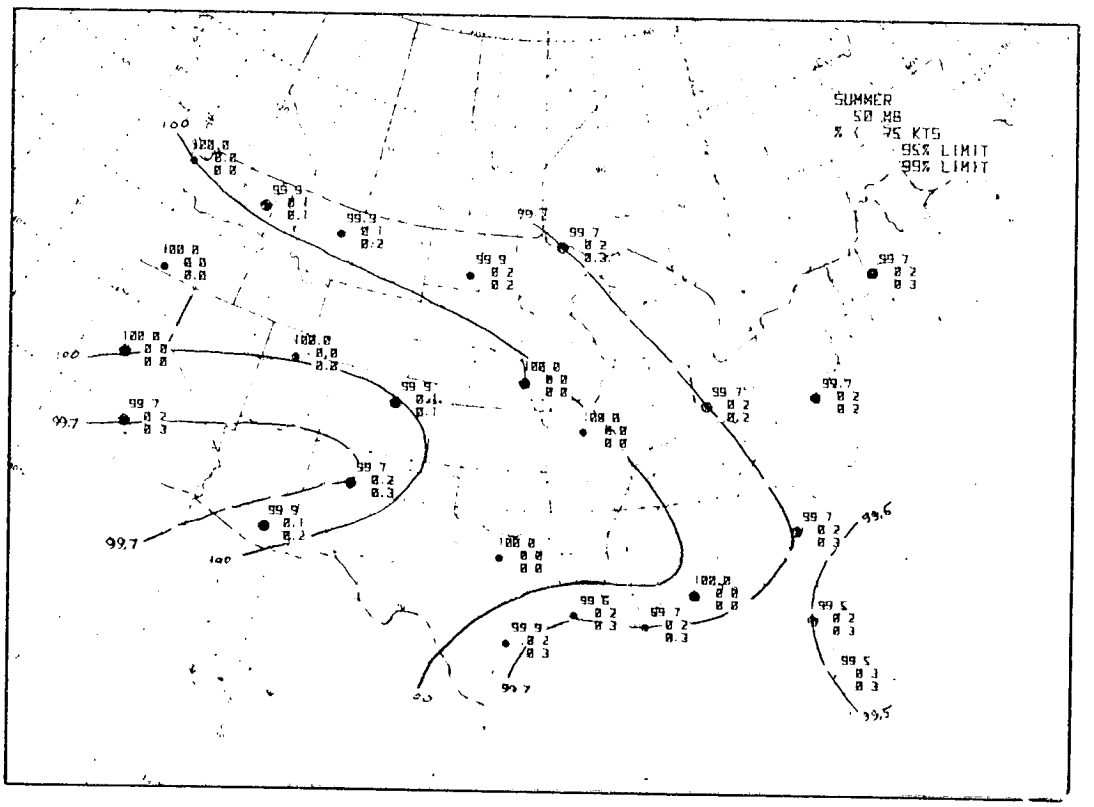
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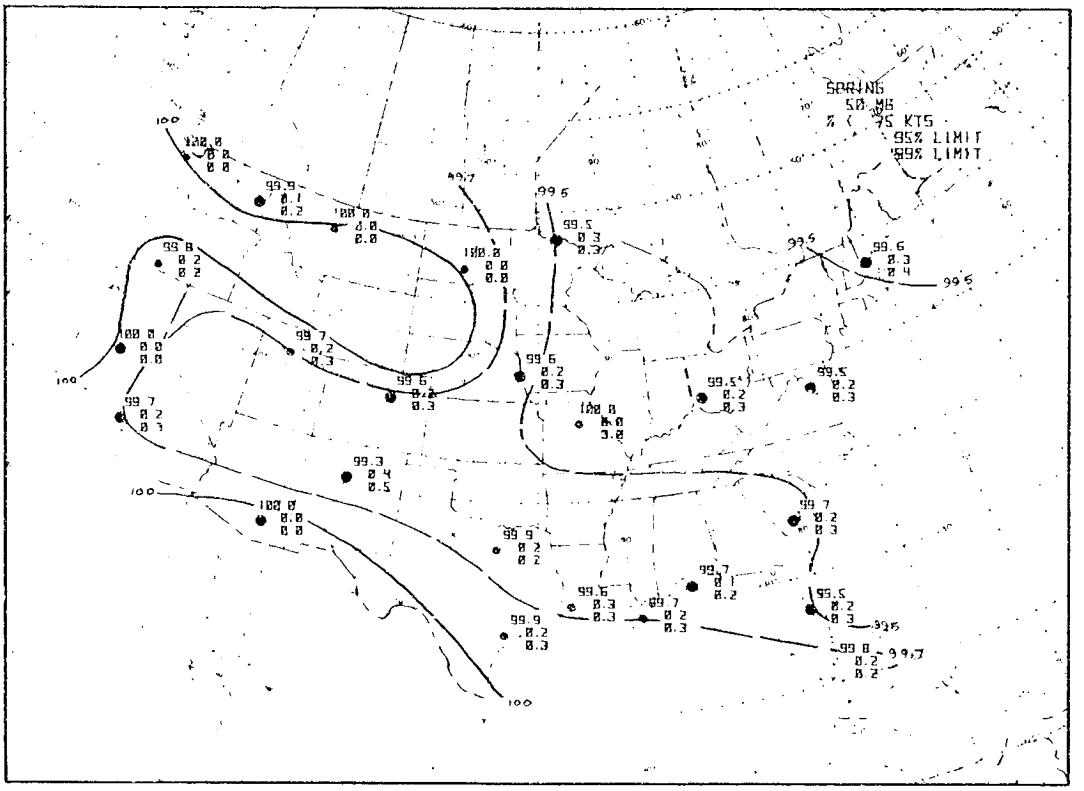
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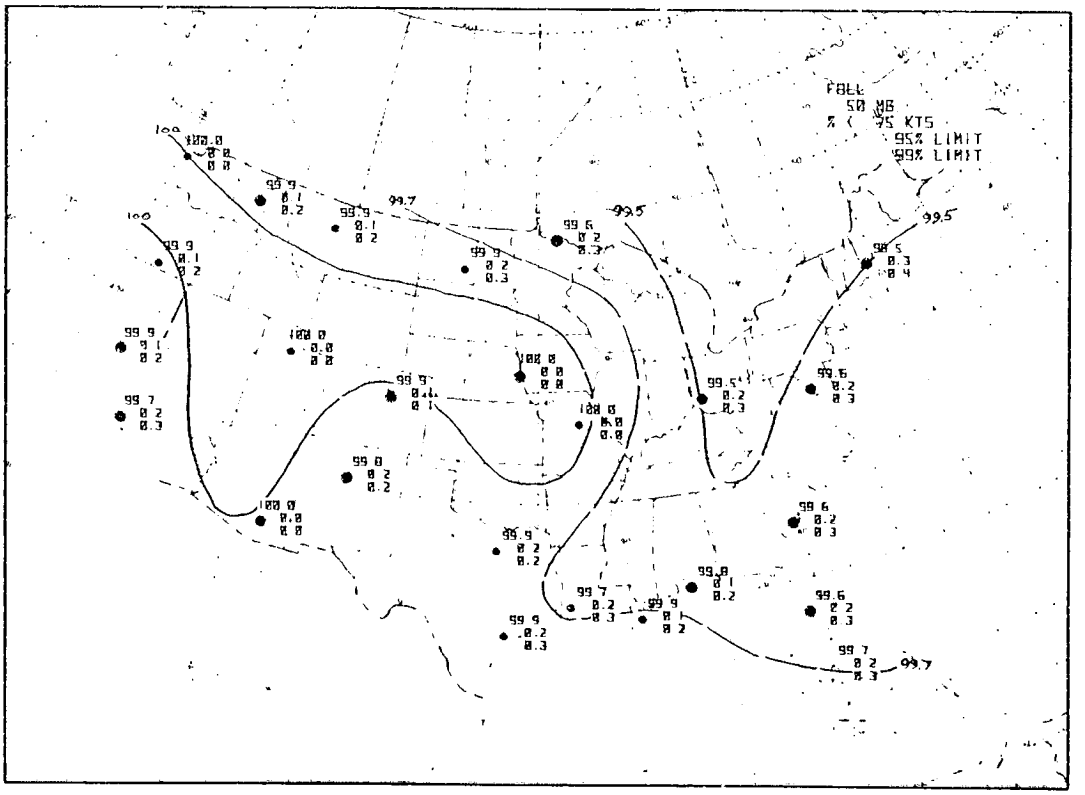
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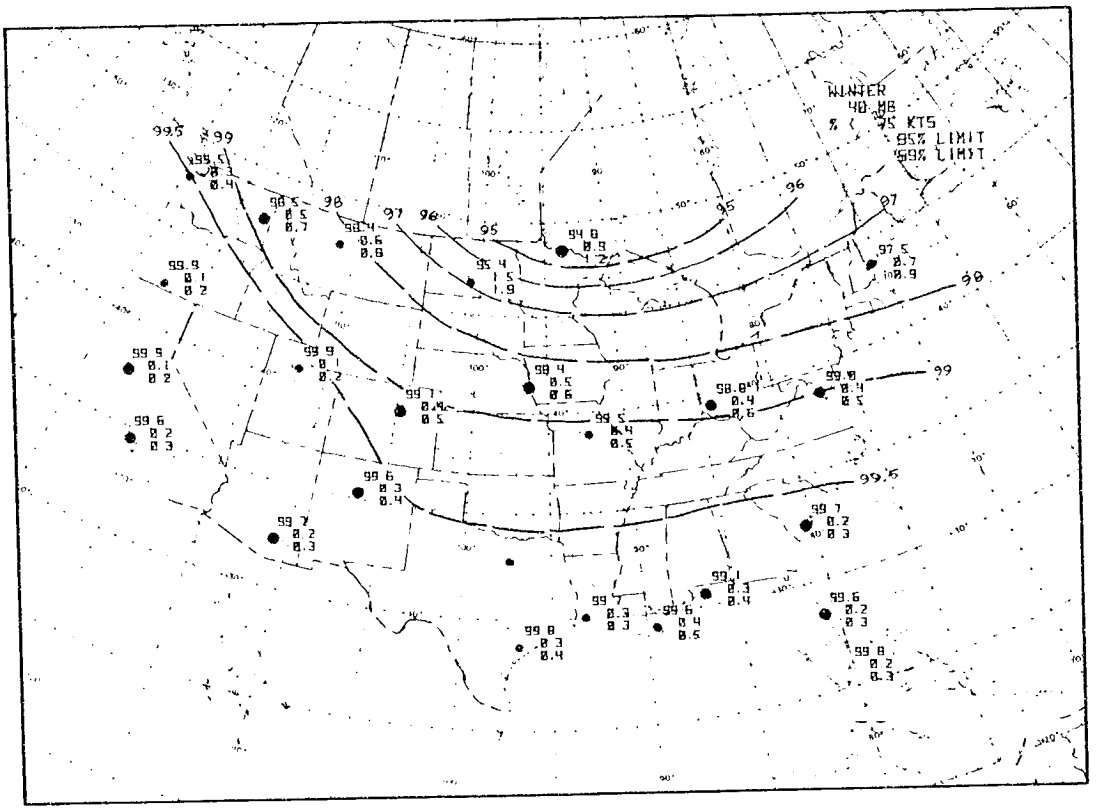
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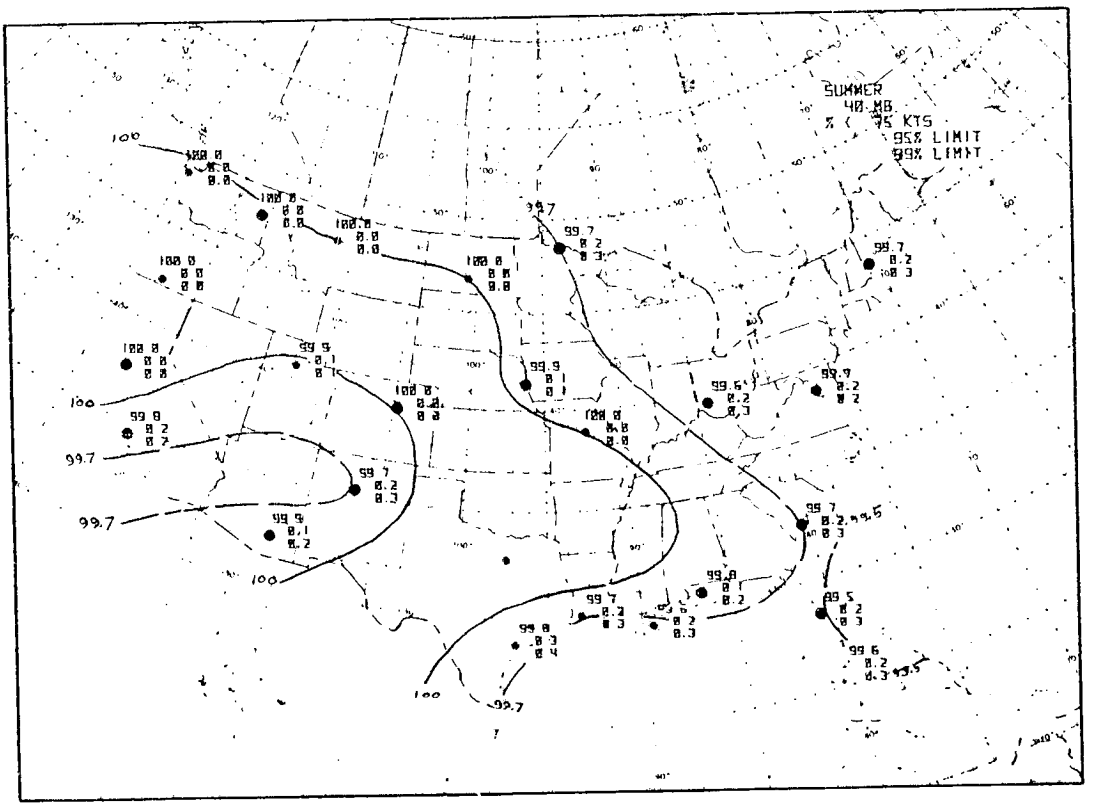
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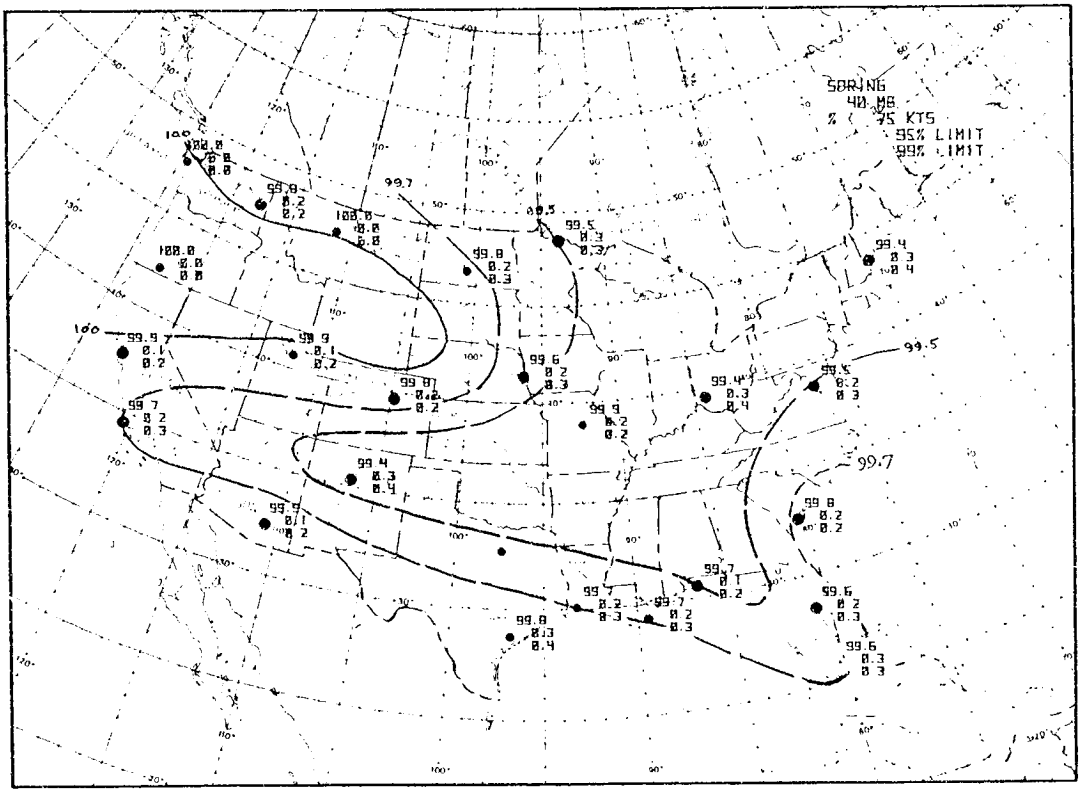
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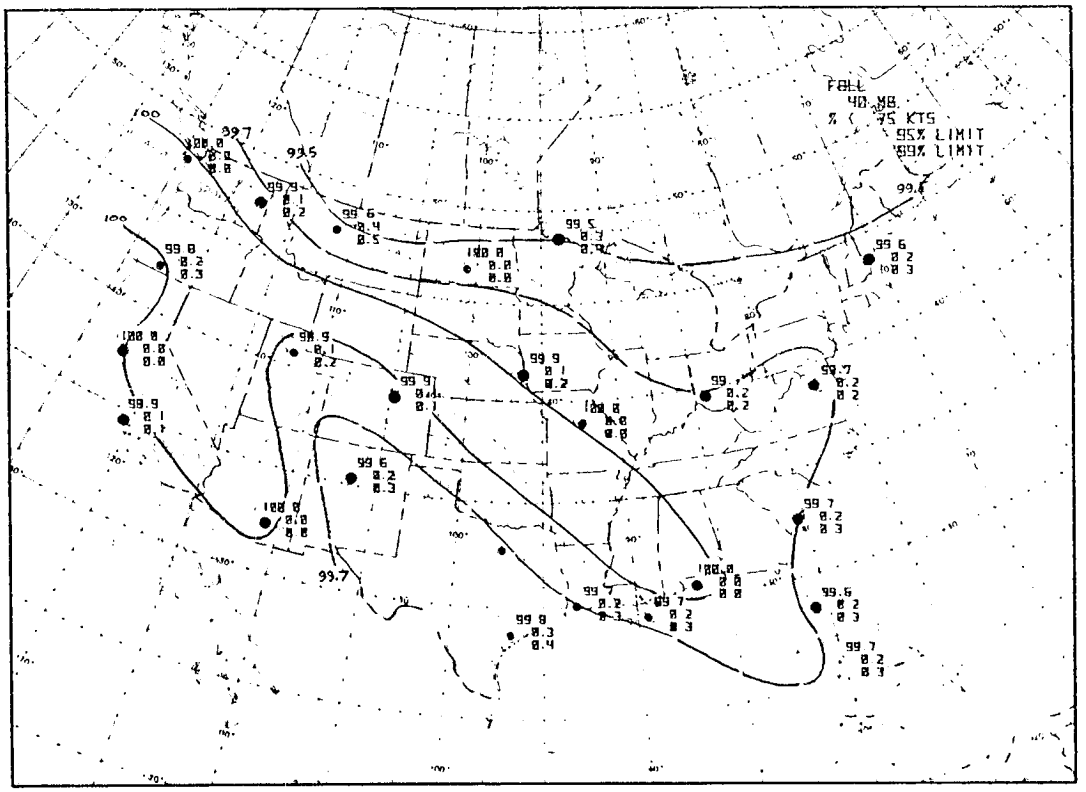
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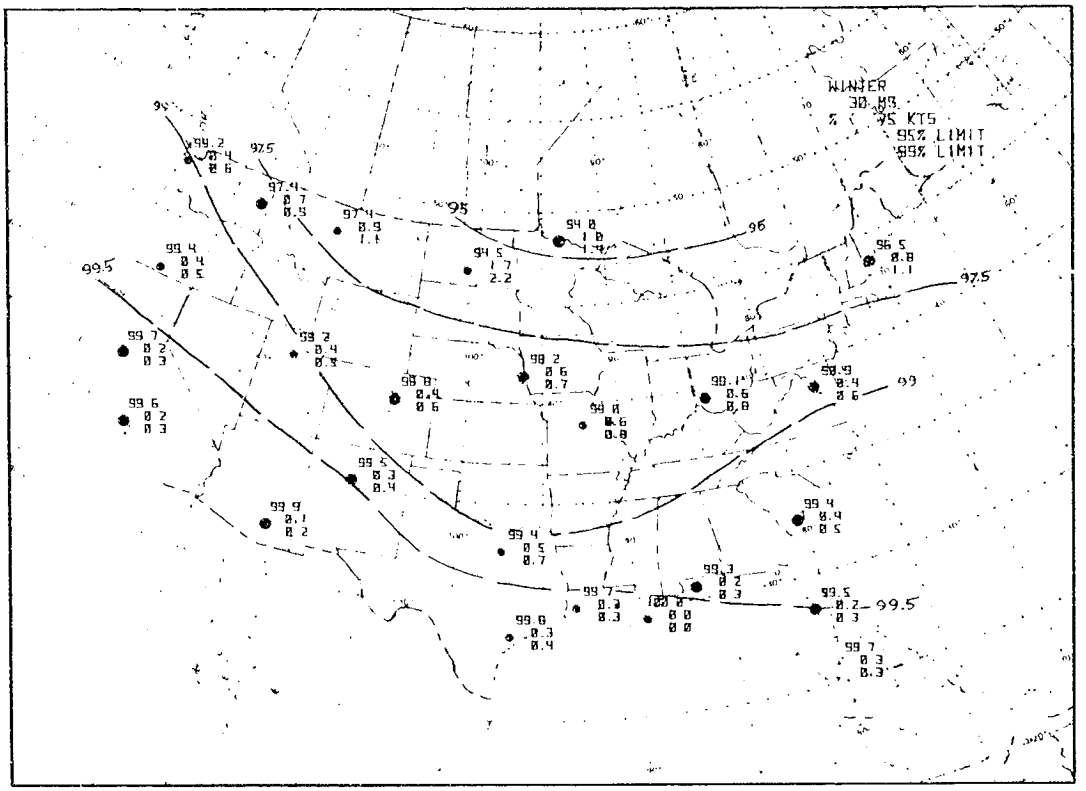
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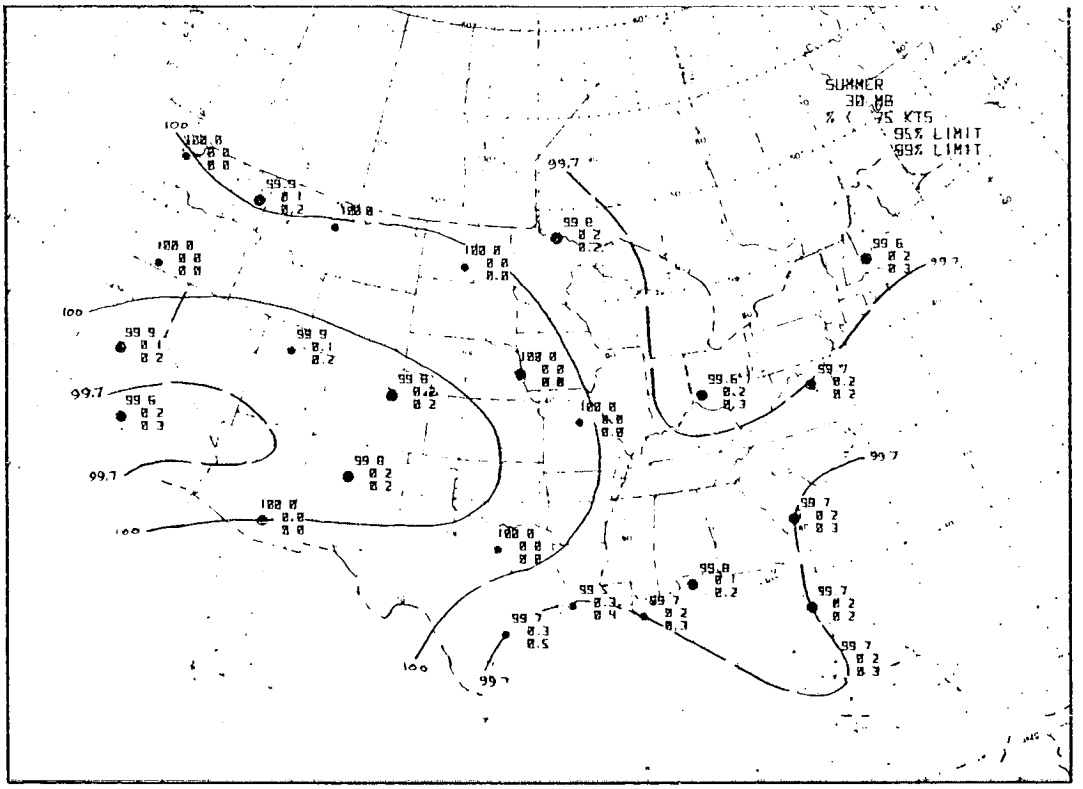
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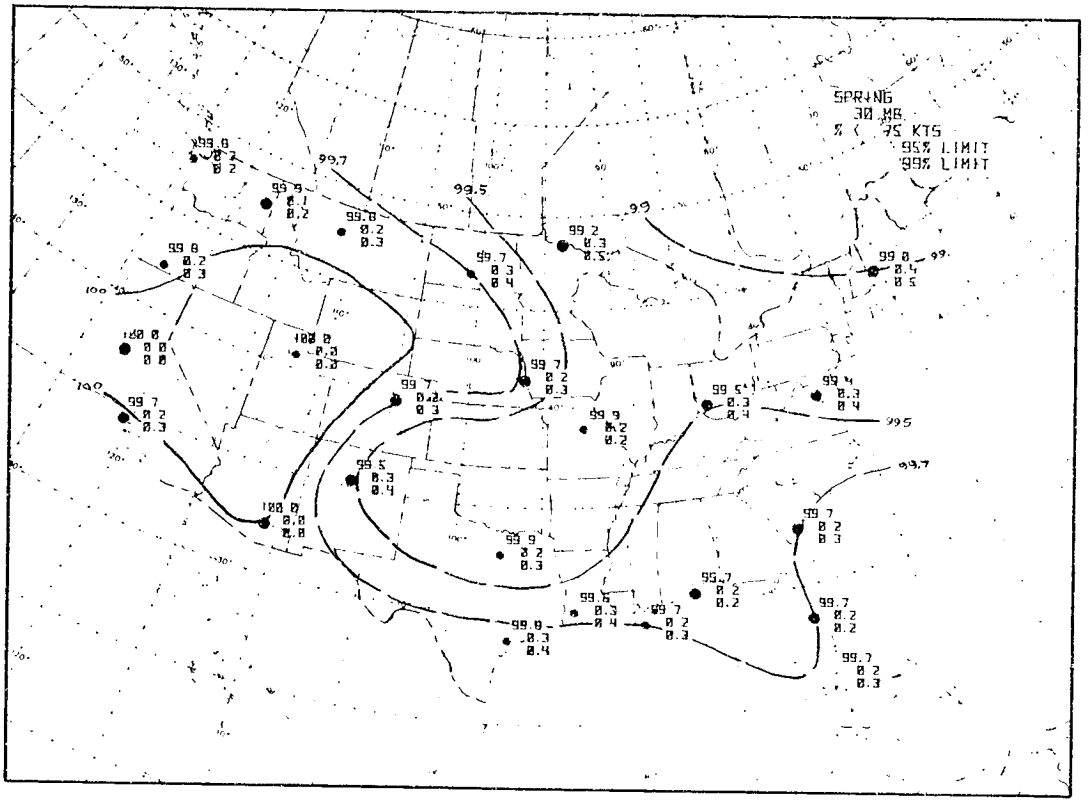
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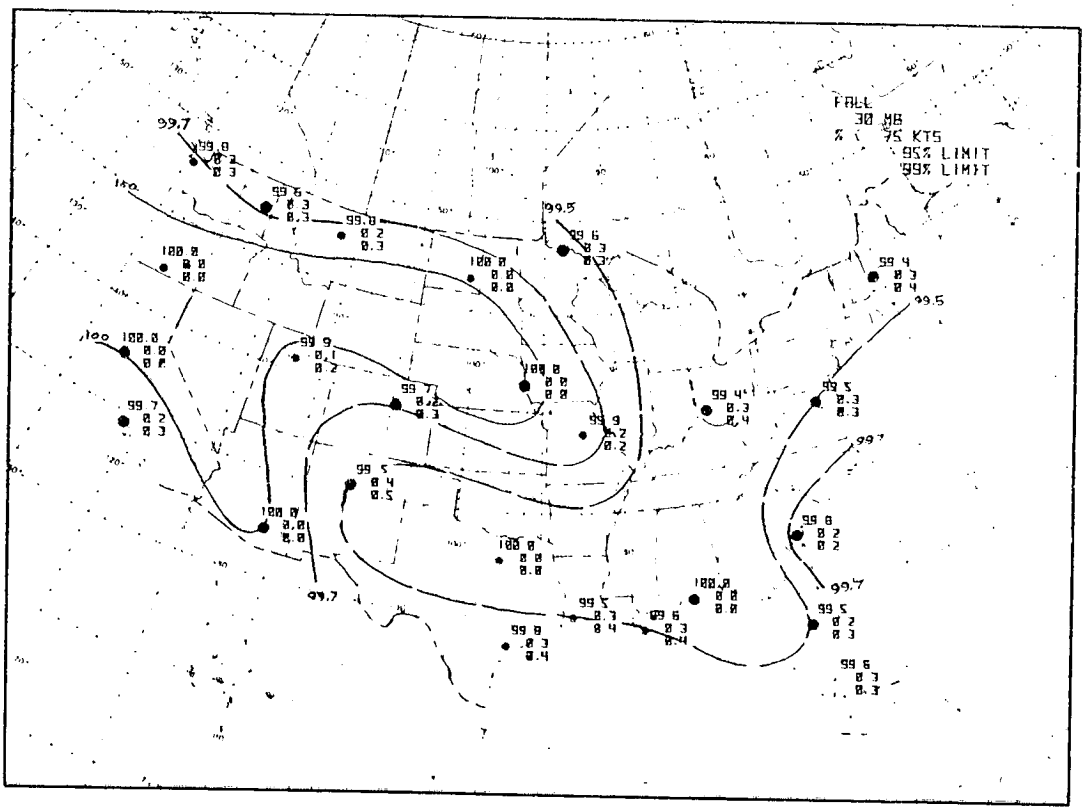
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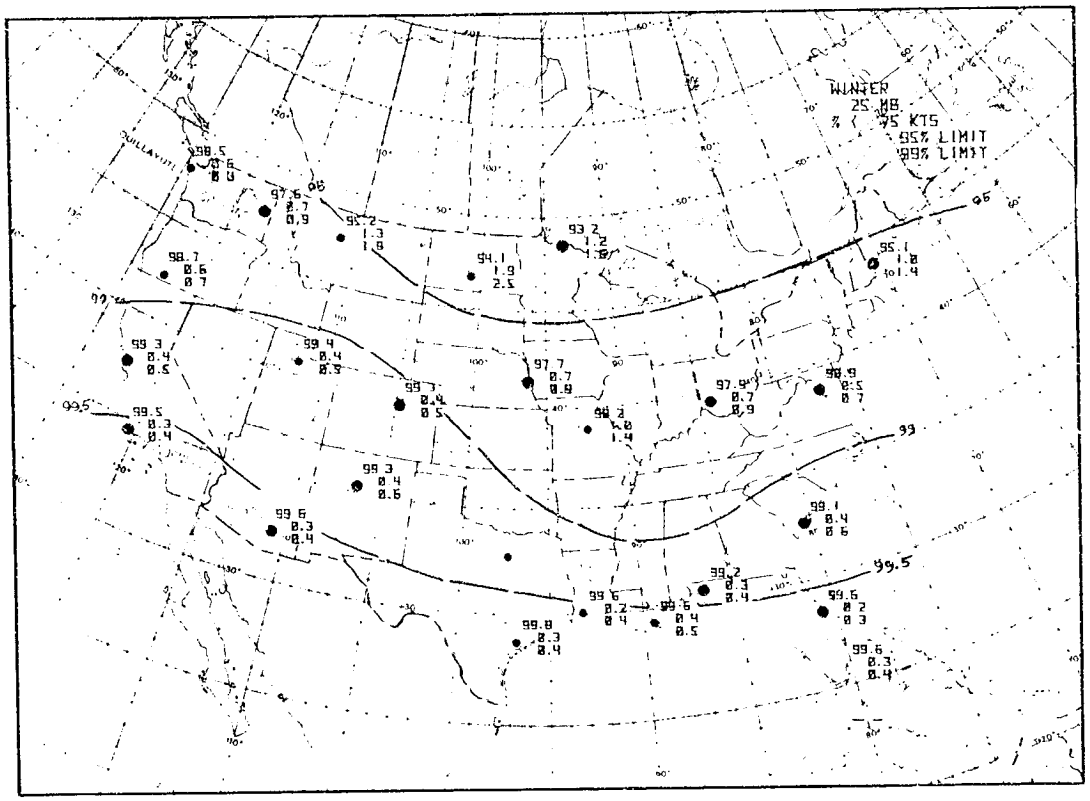
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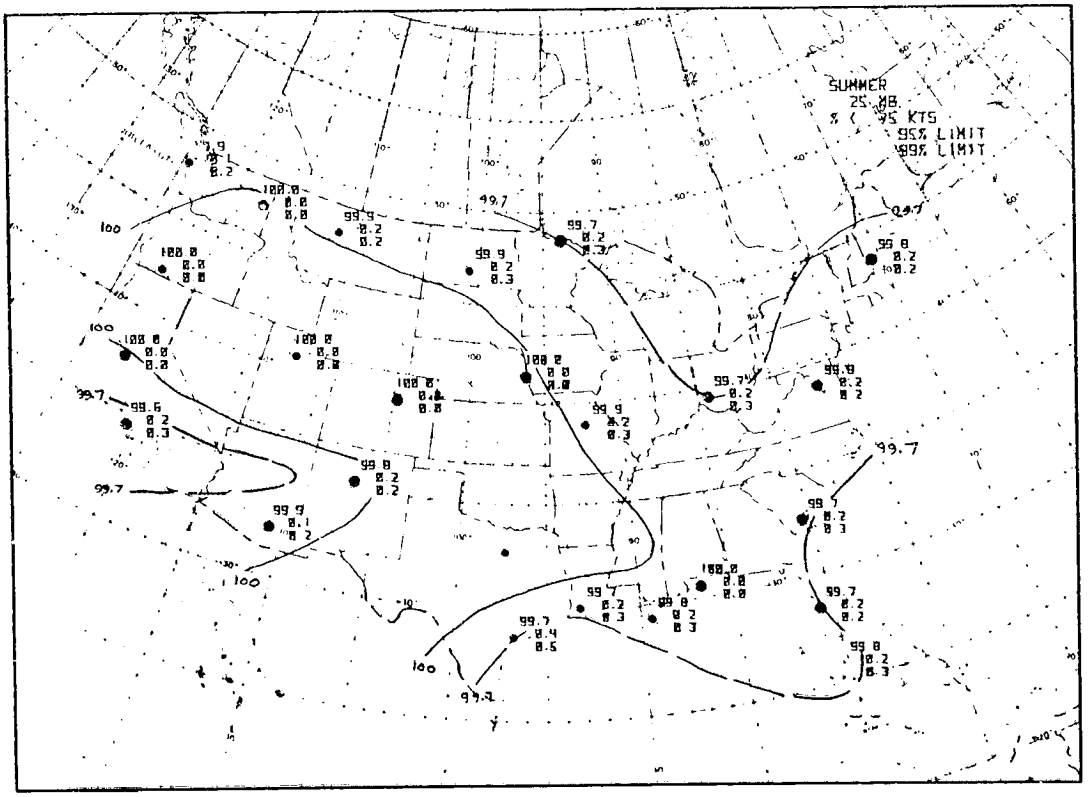
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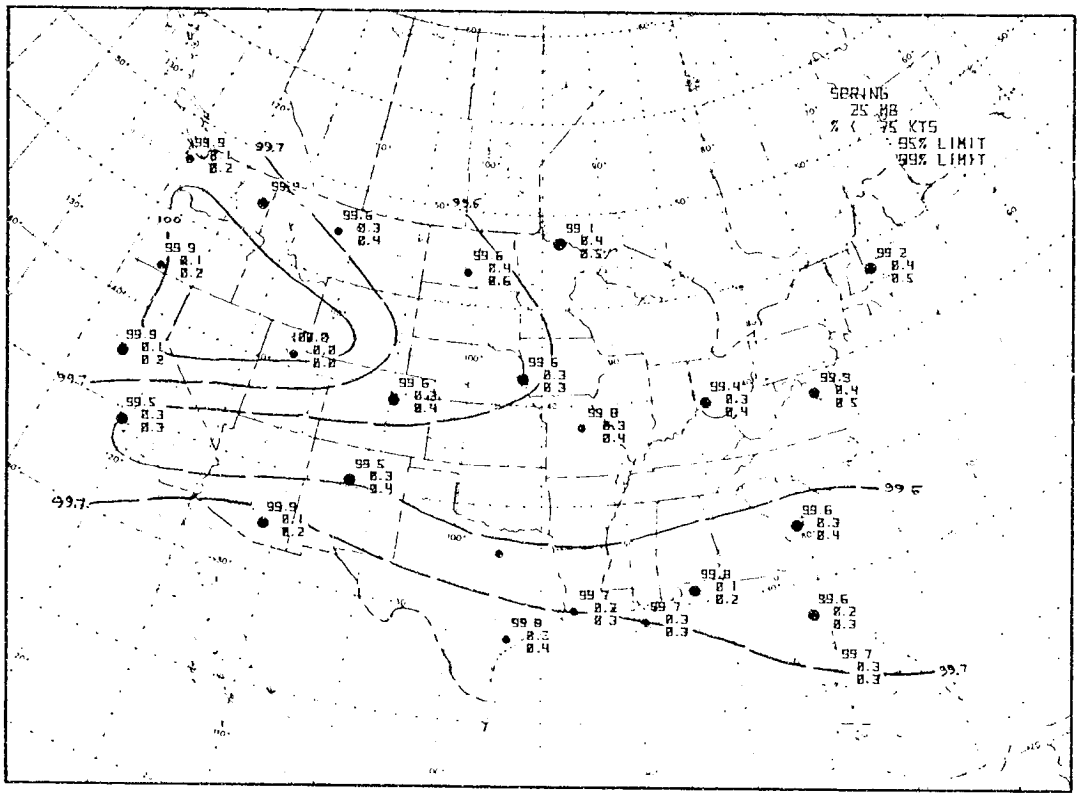
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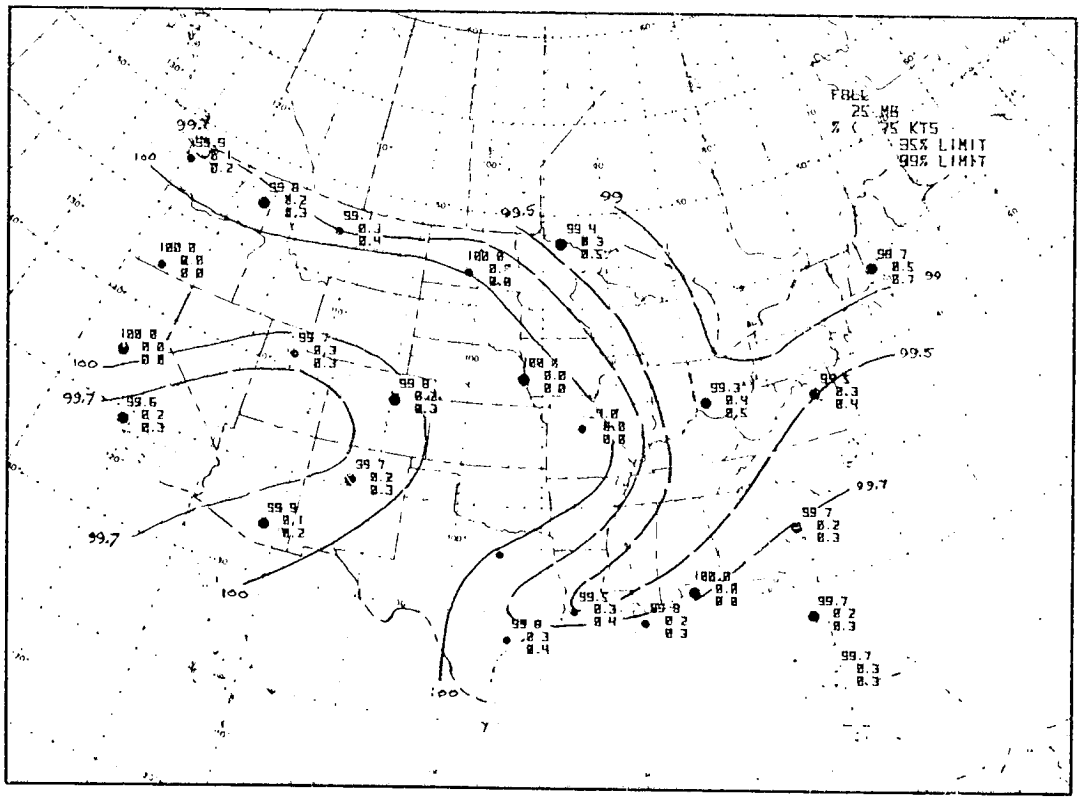
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SECTION B

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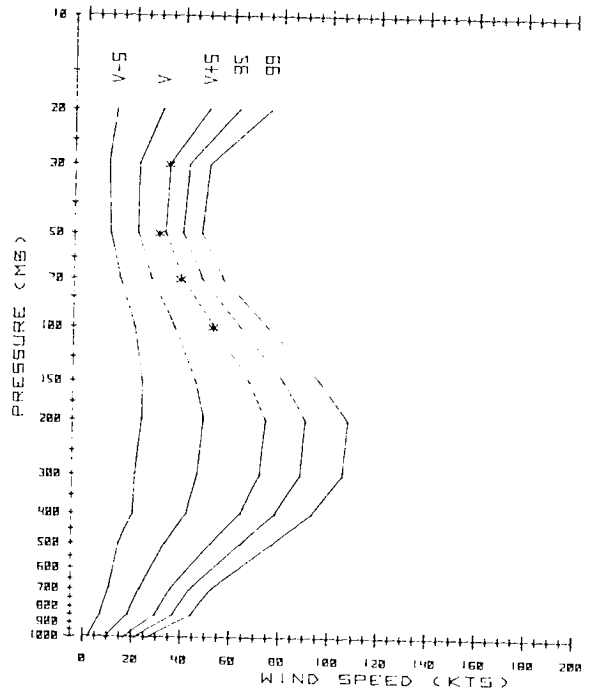

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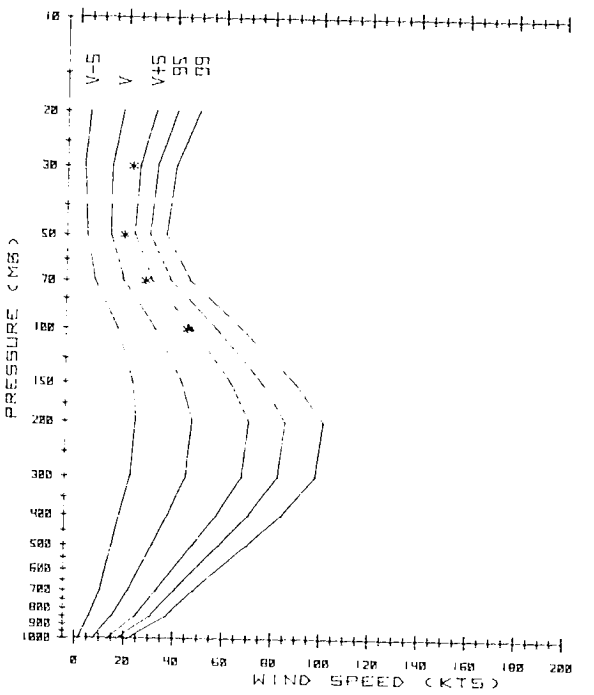

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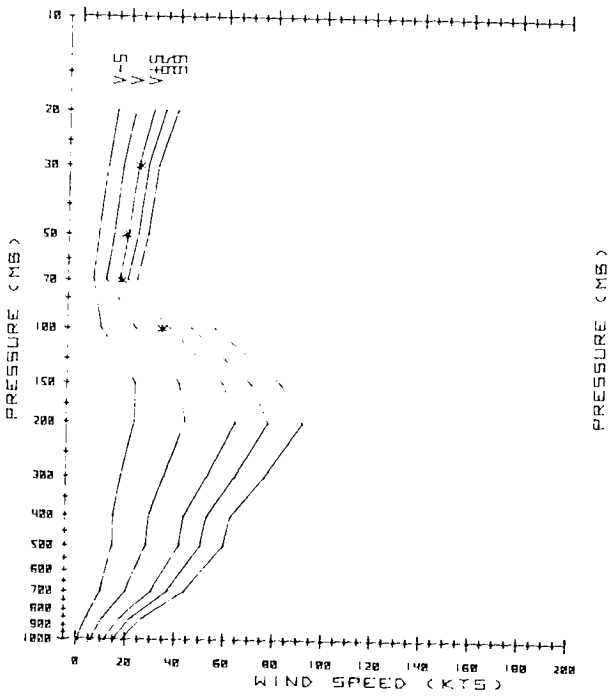

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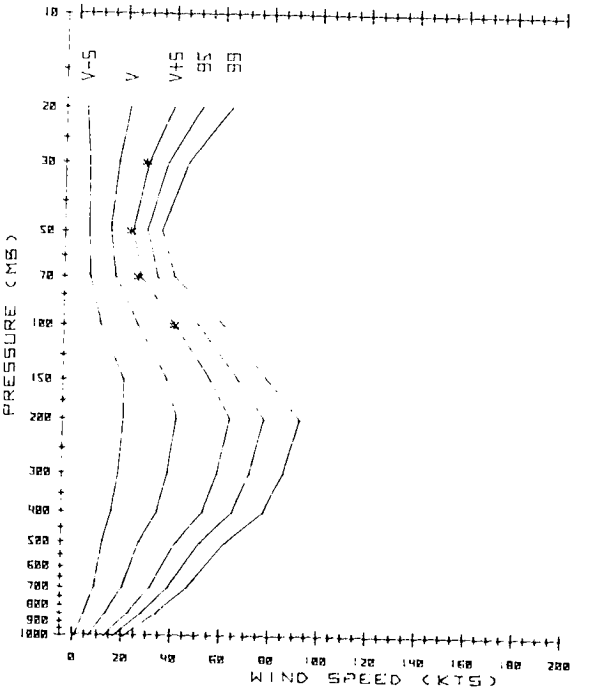

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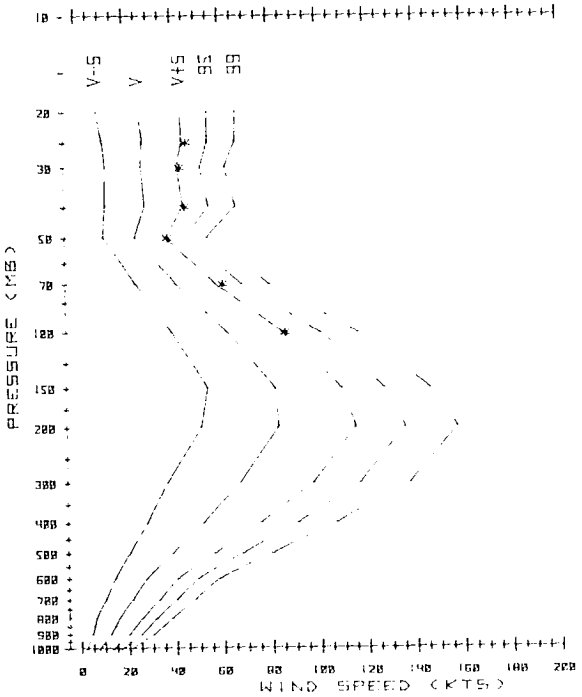

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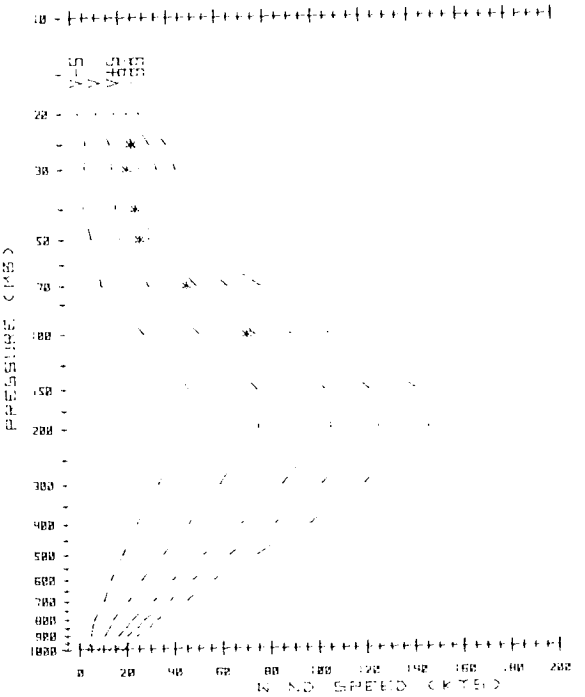

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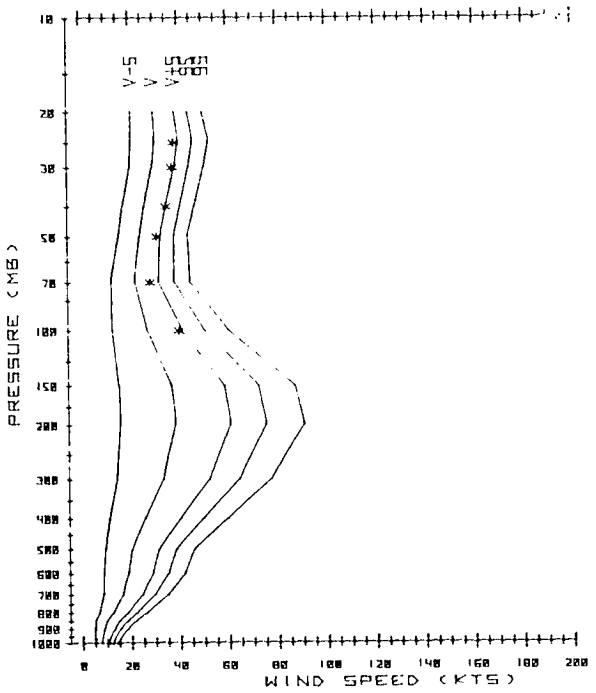

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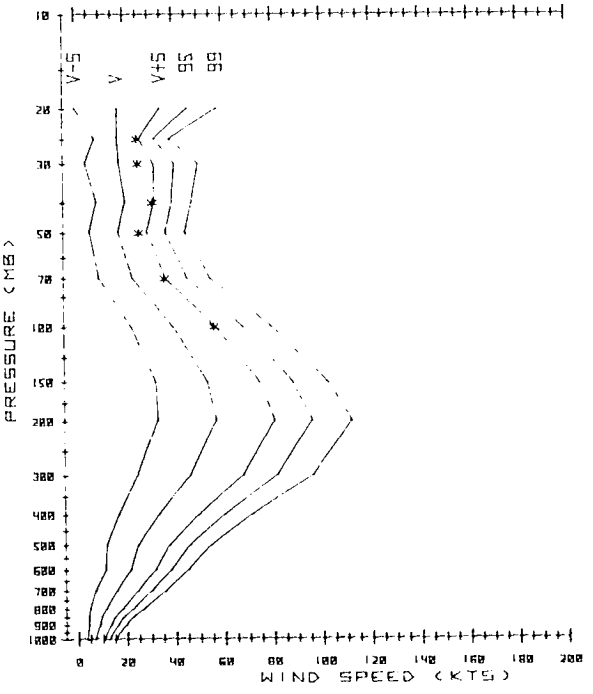

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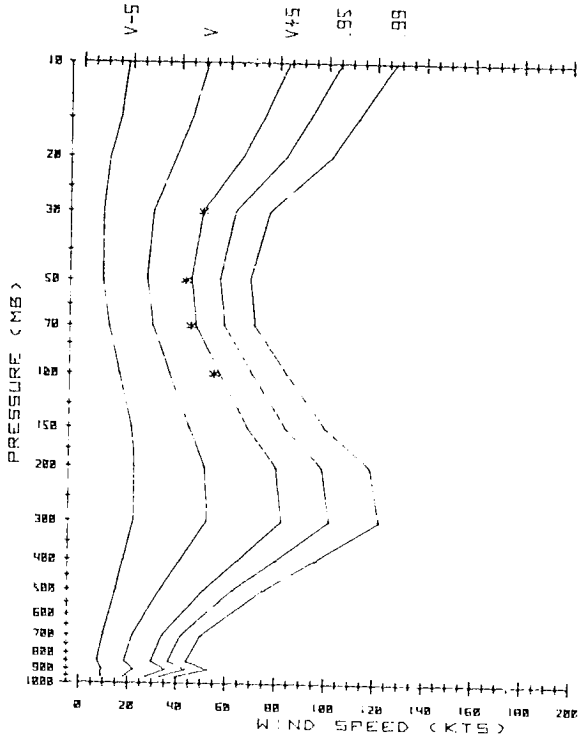

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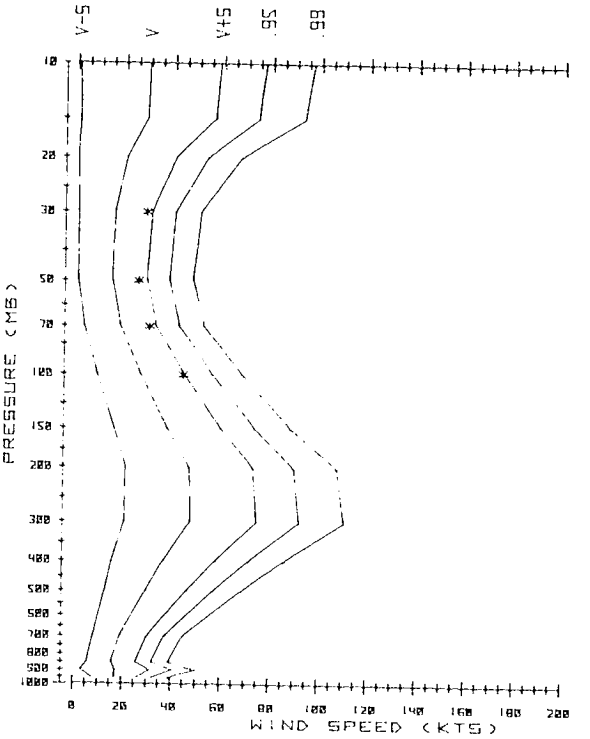

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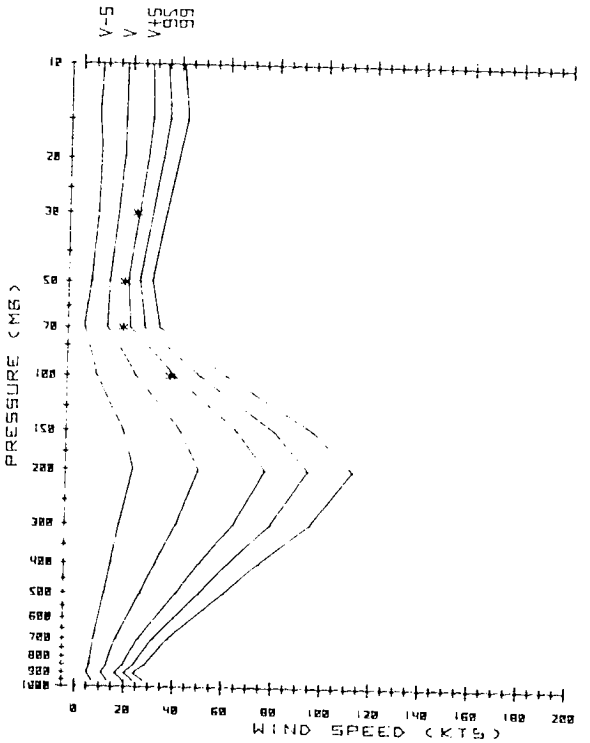

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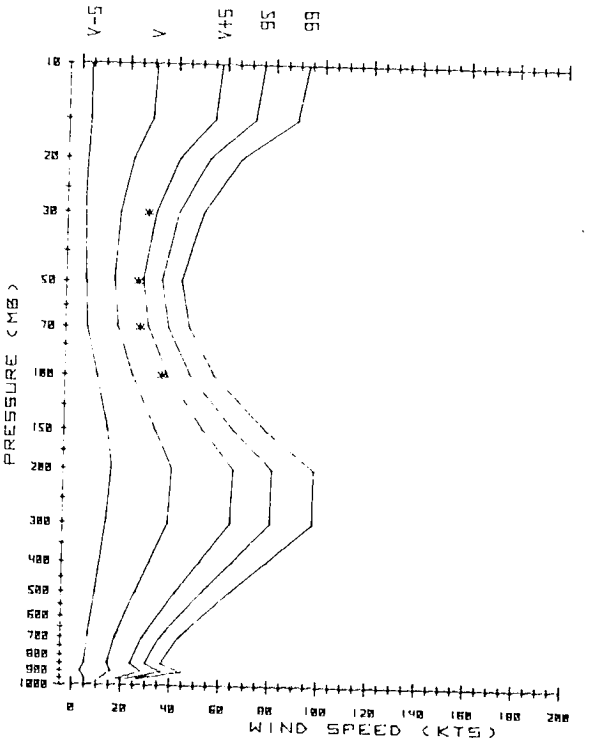

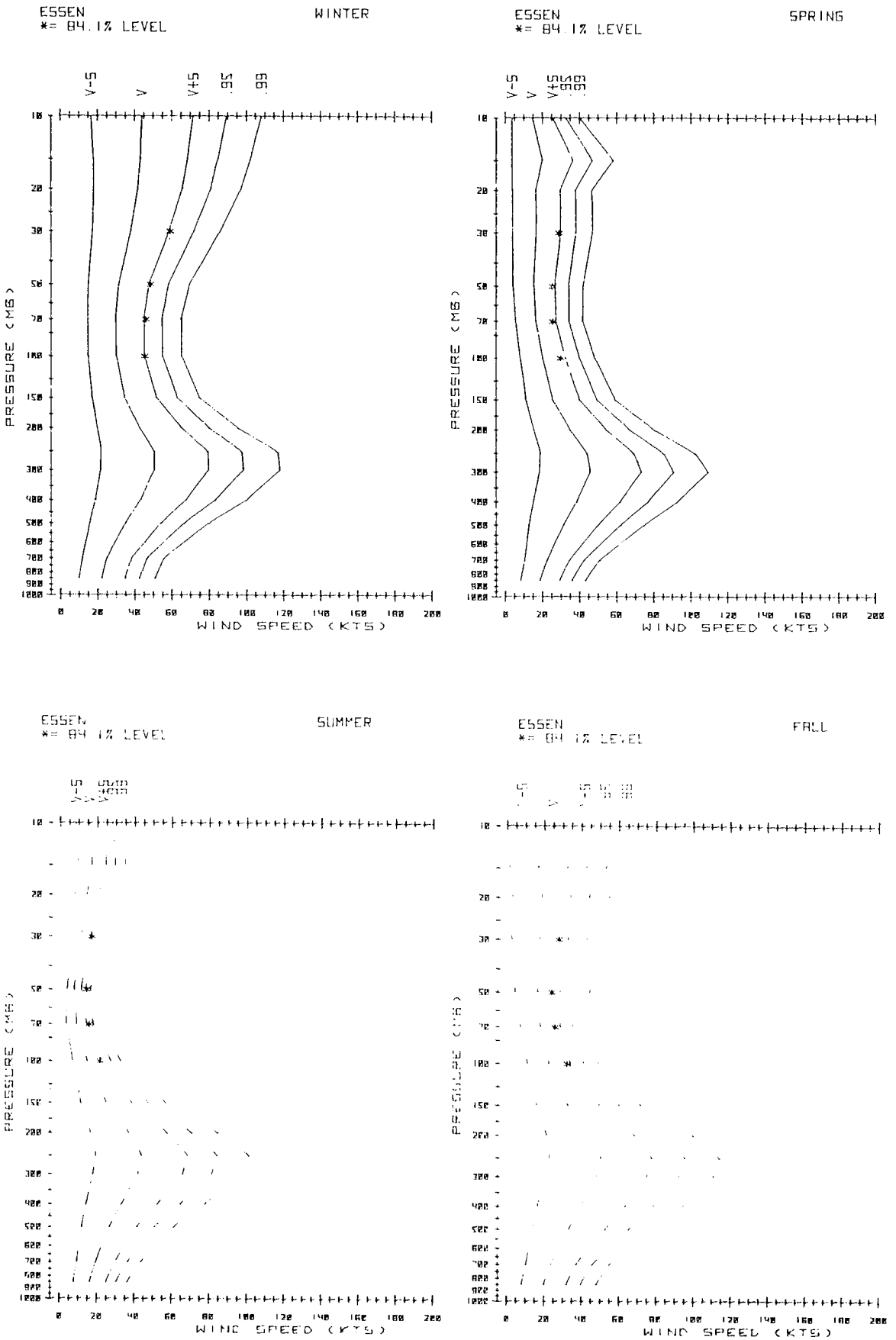
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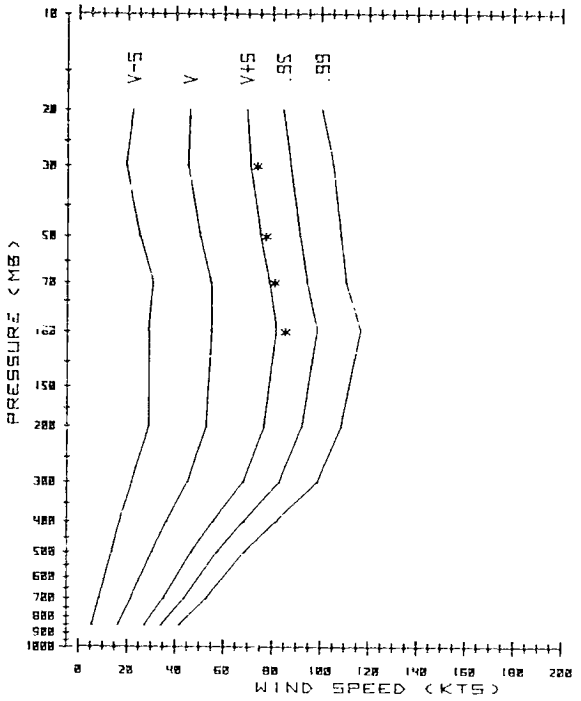

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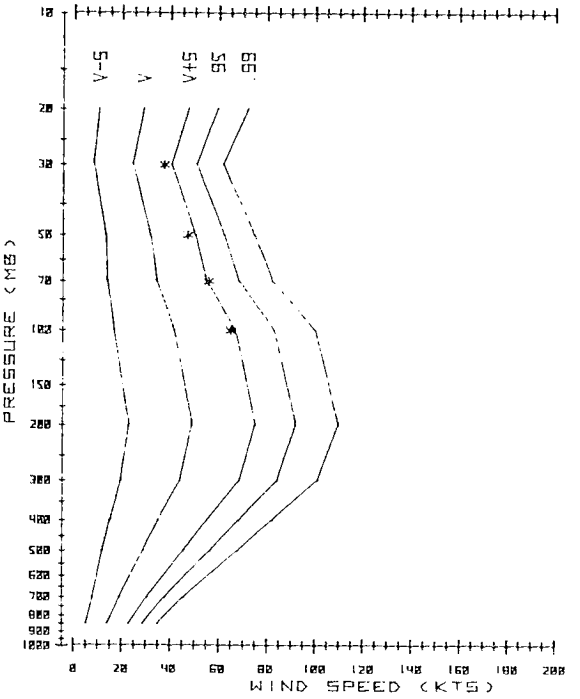

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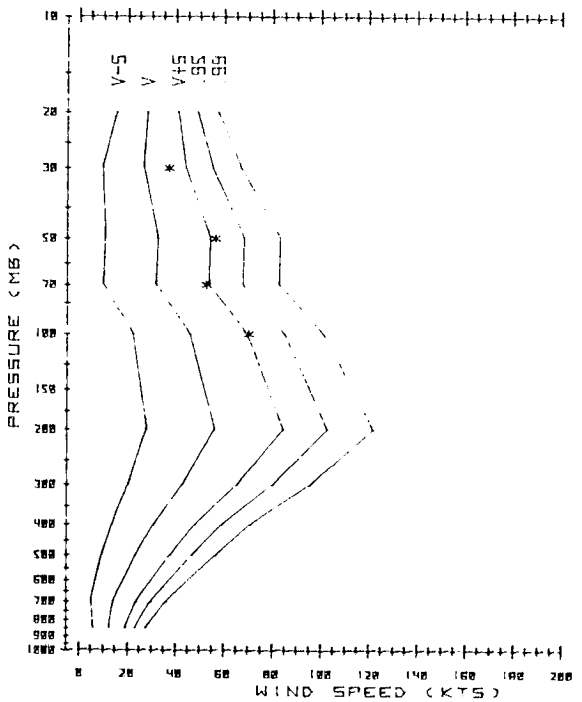

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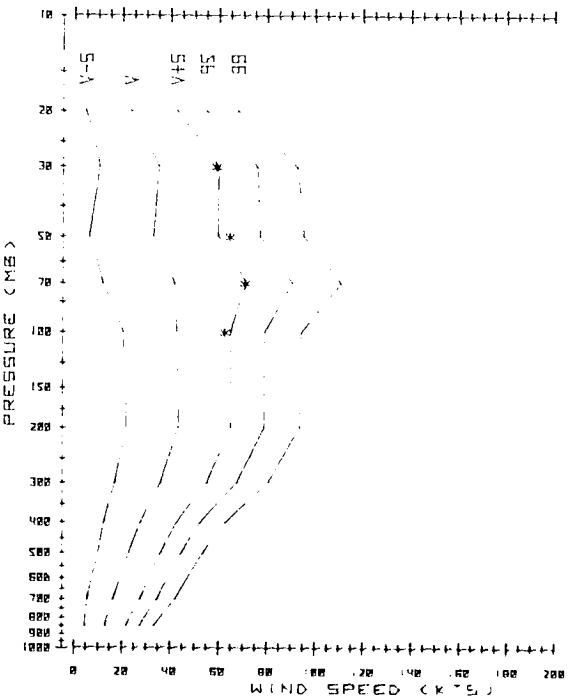

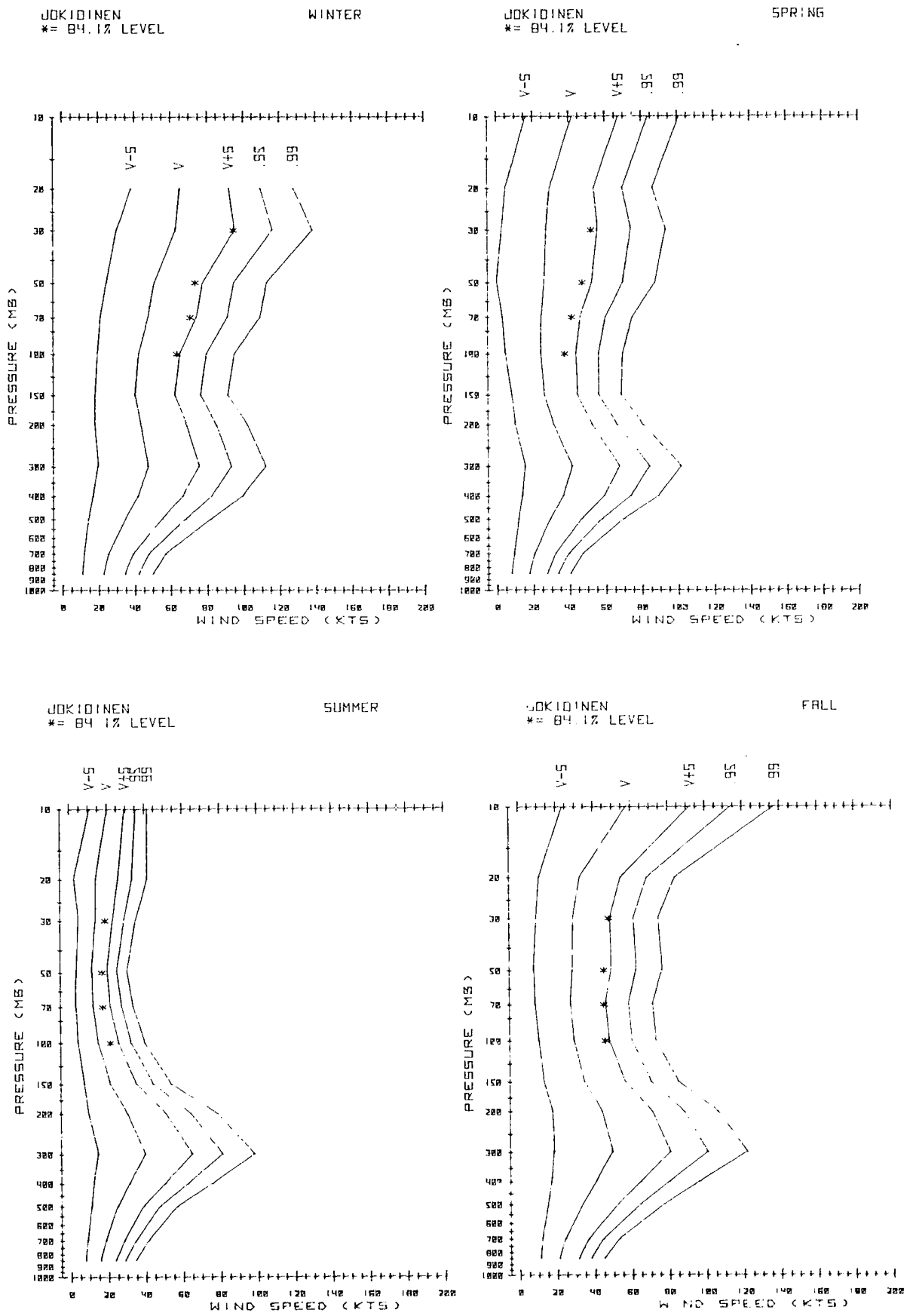
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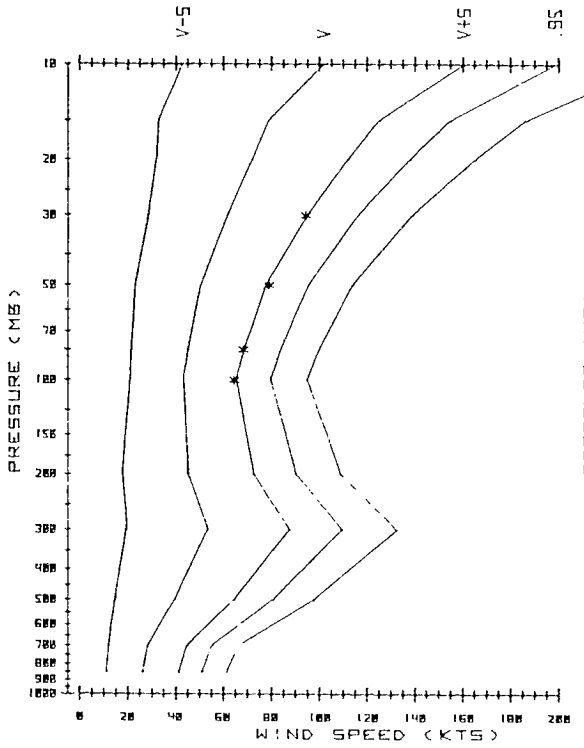

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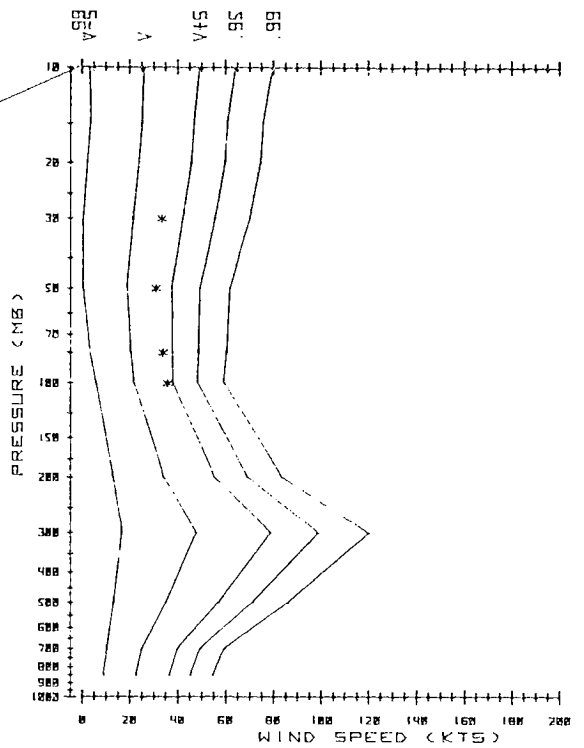

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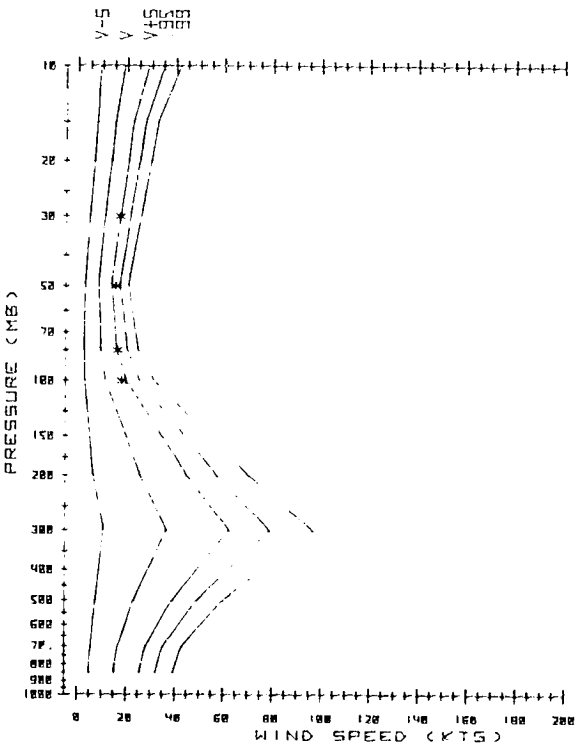

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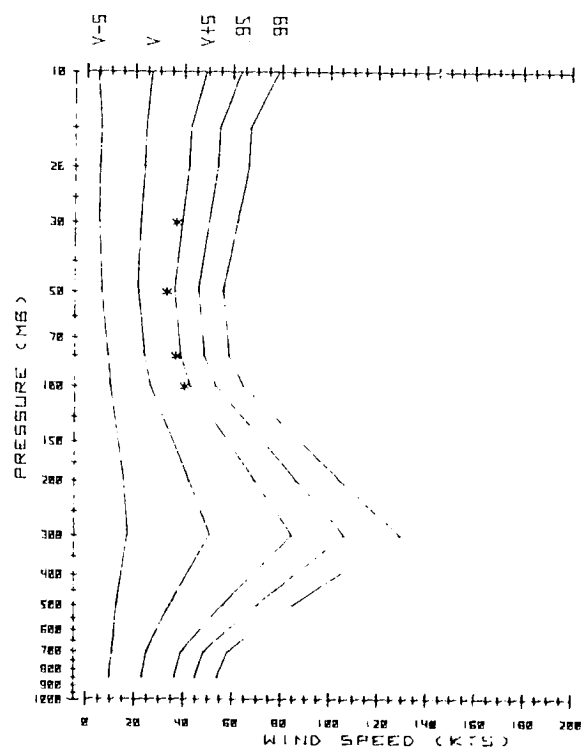

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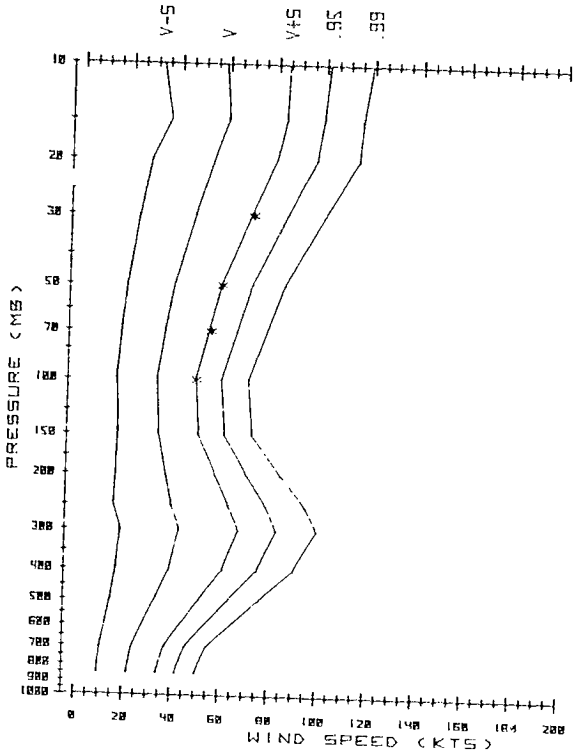

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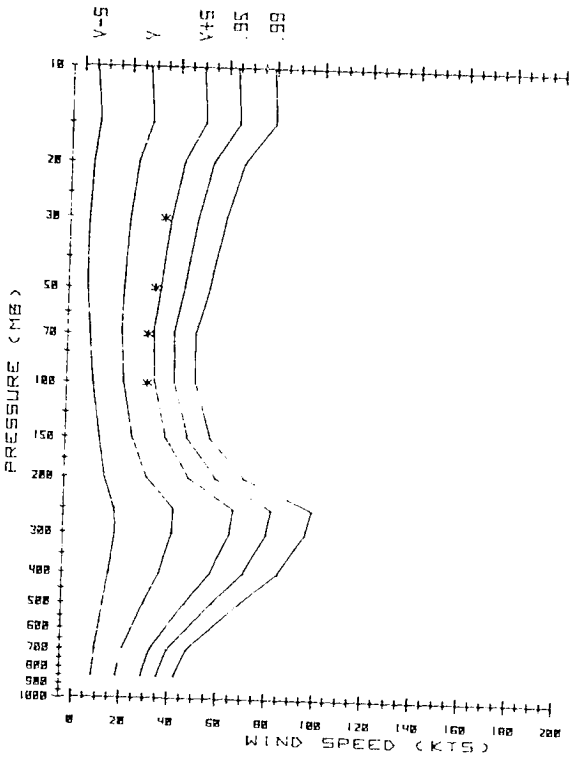

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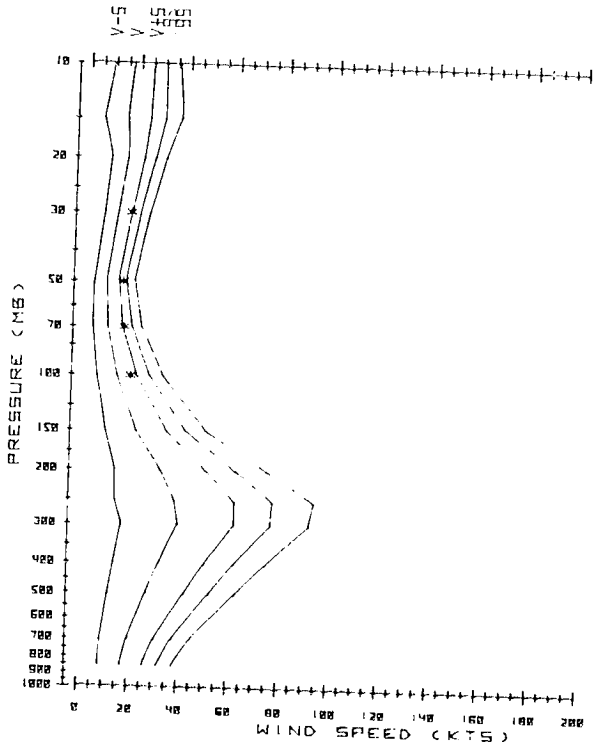
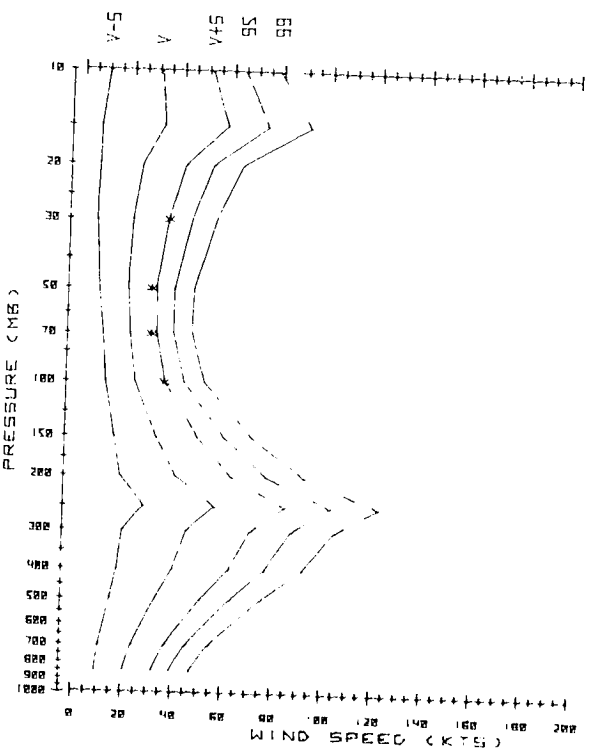
SUMMER



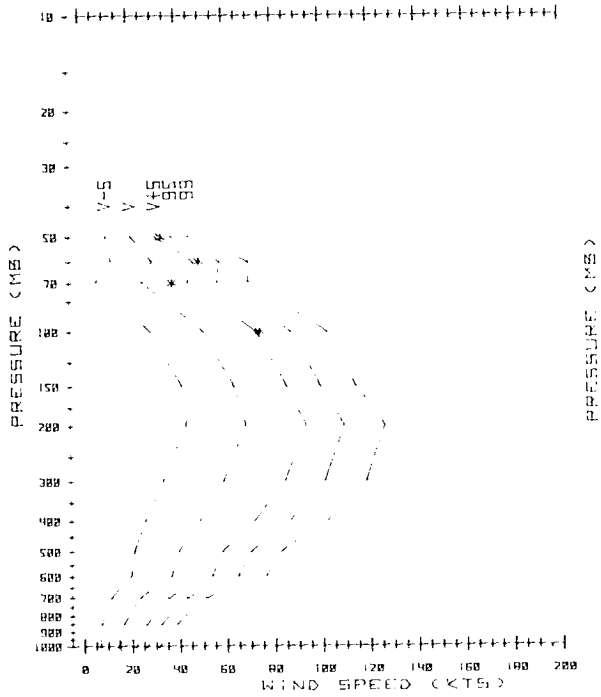
KOBENHAVN
*= 84.1% LEVEL

FALL



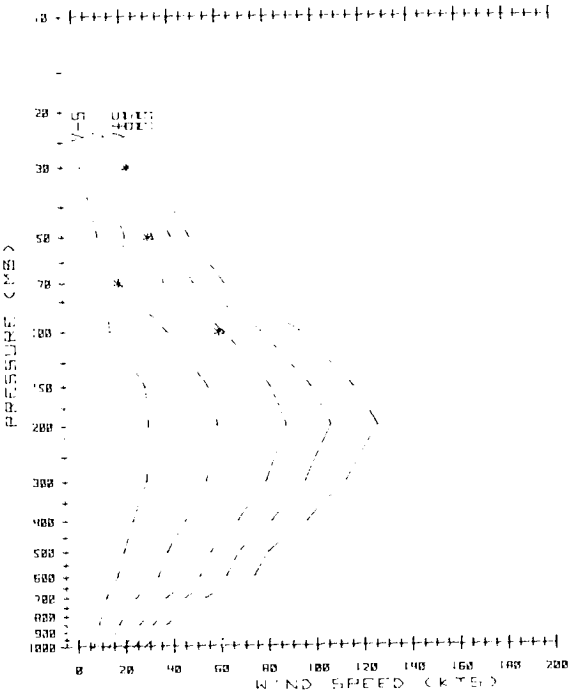
MATRUH
*= 84.1% LEVEL

WINTER



MATRUH
*= 84.1% LEVEL

SPRING



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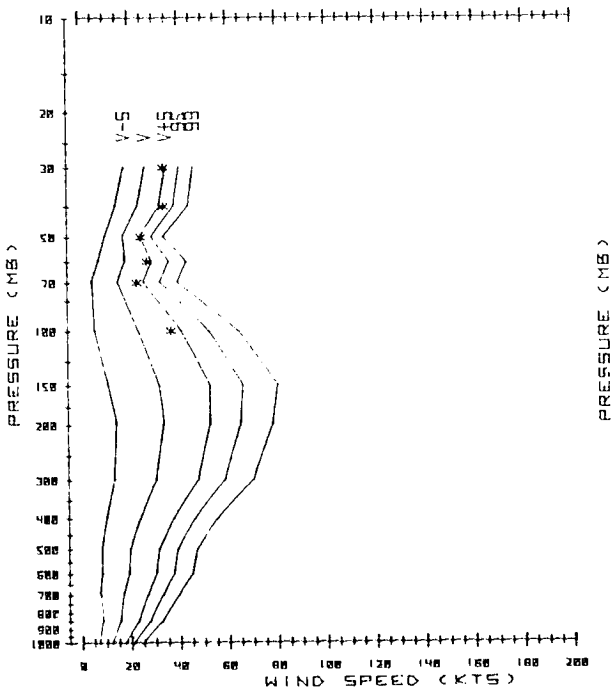
SUMMER



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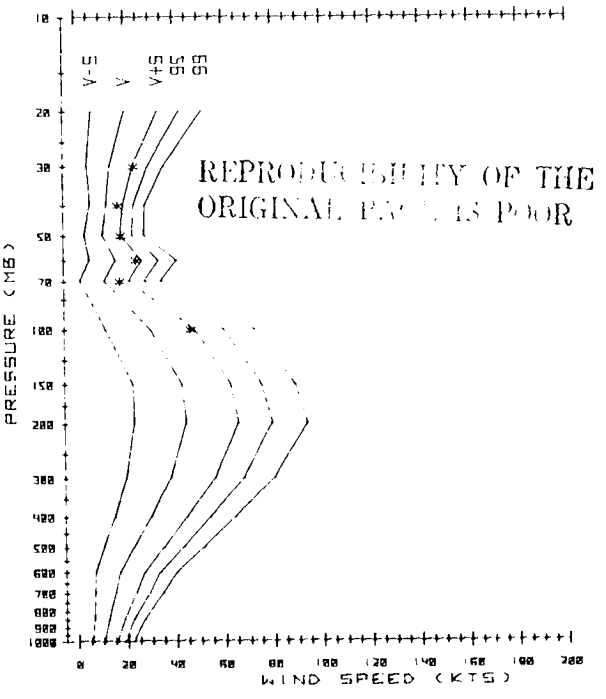
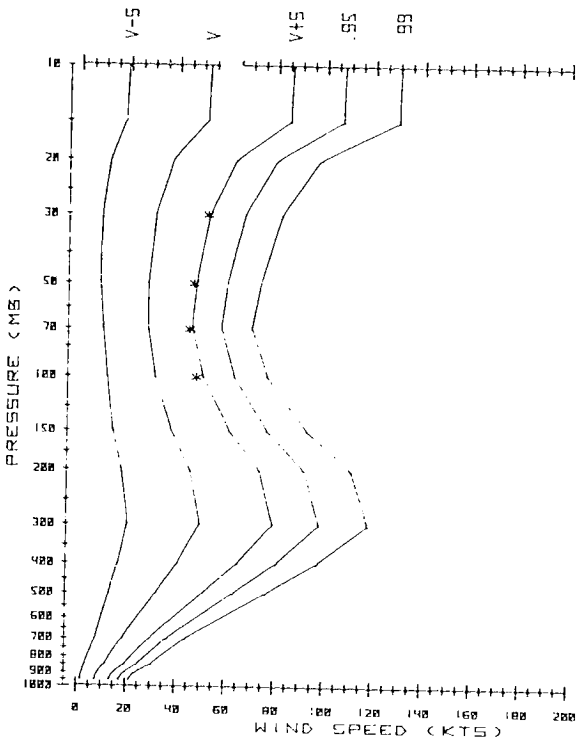
*= 84.1% LEVEL

FALL



MILAND
*= 84.1% LEVEL

WINTER



MILAND
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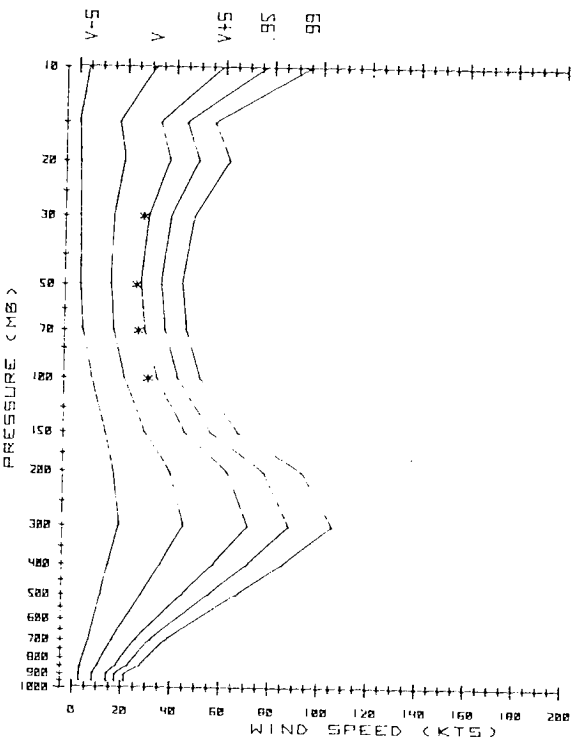
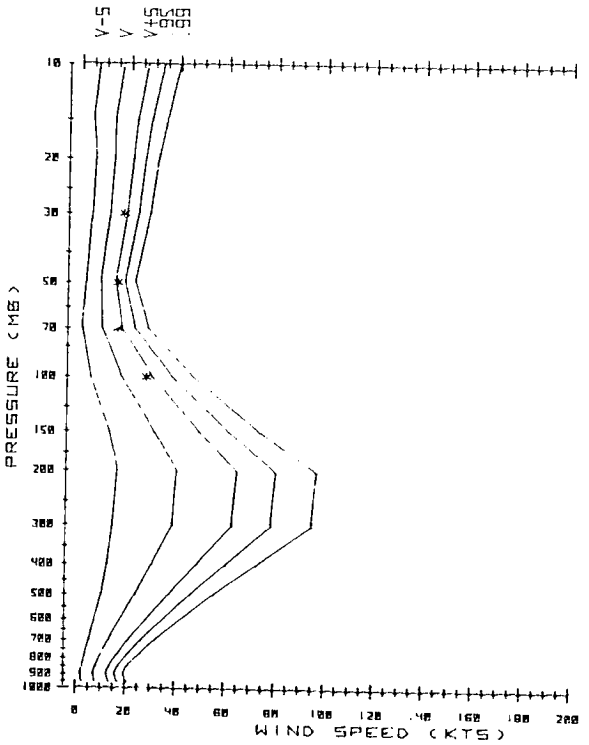
SPRING



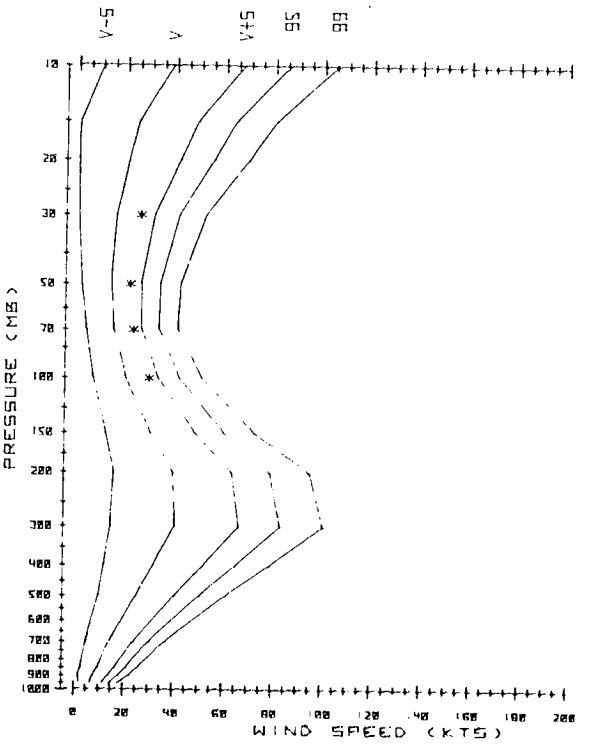
MILAND
*= 84.1% LEVEL

SUMMER

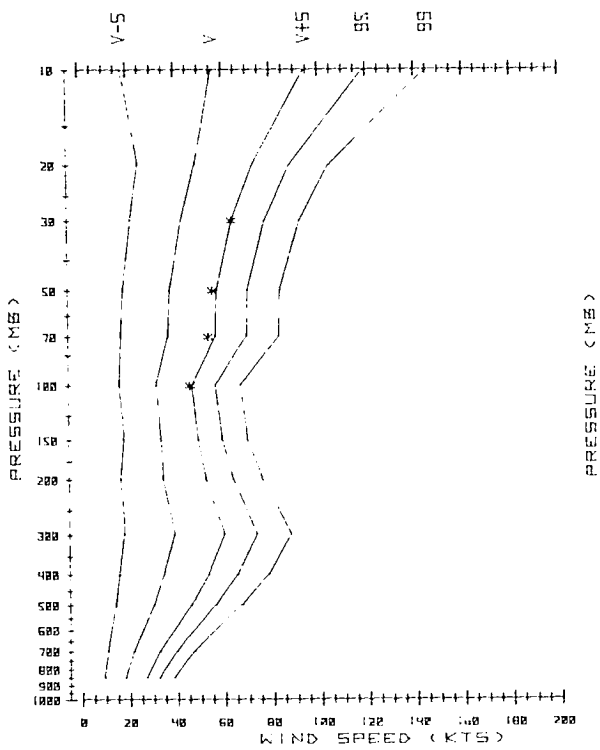


MILAND
*= 84.1% LEVEL

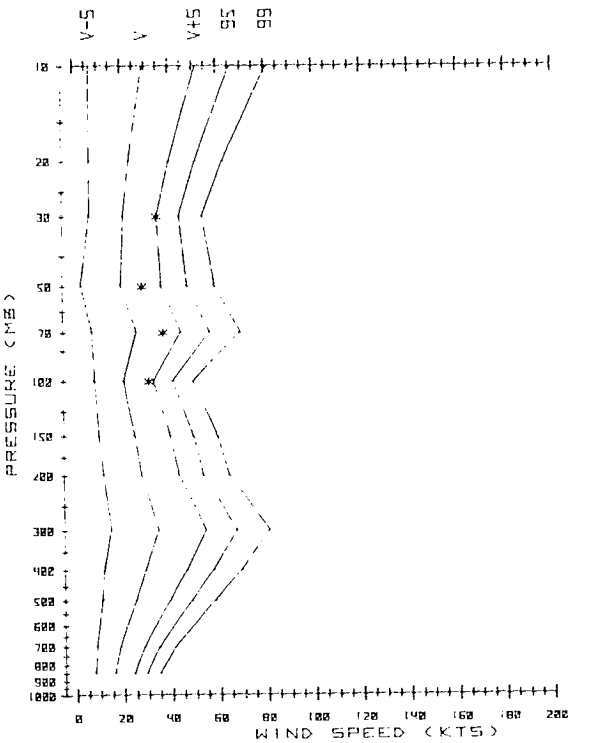
FALL



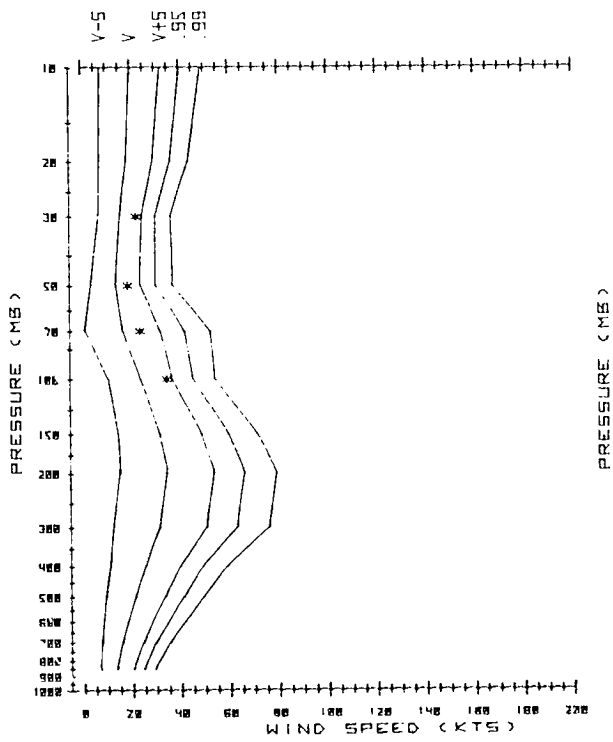
ODESSA WINTER
*= 84.1% LEVEL



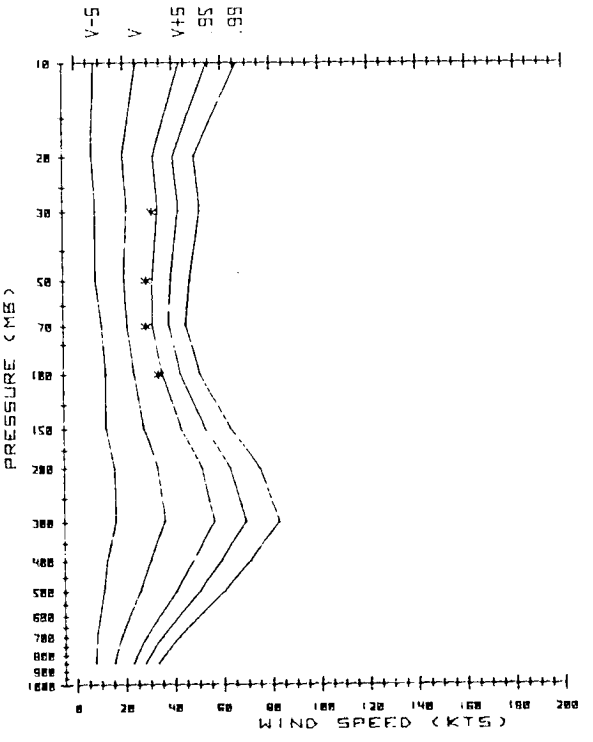
ODESSA SPRING
*= 84.1% LEVEL

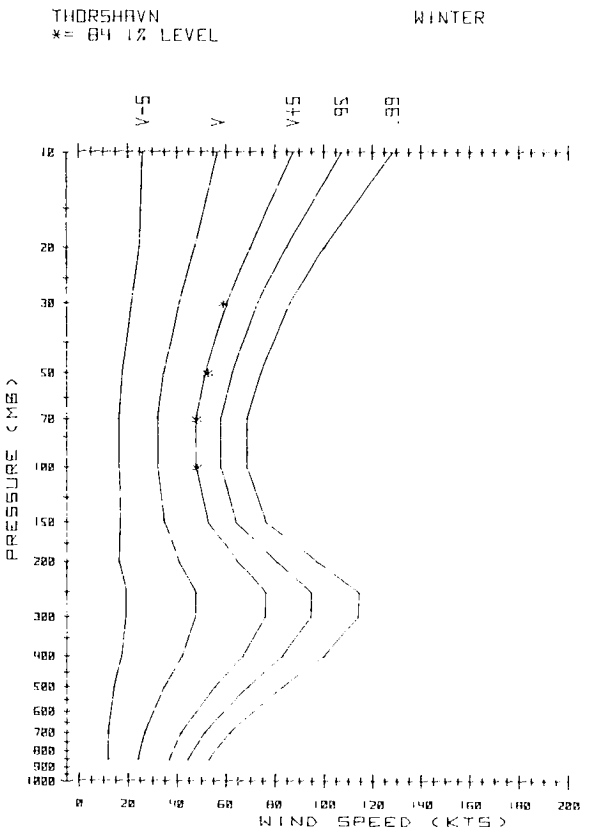


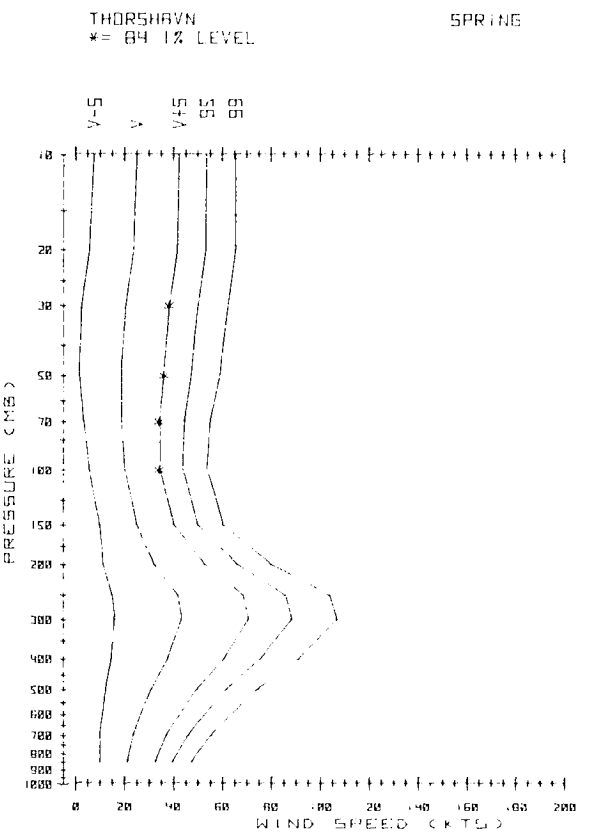
ODESSA SUMMER
*= 84.1% LEVEL

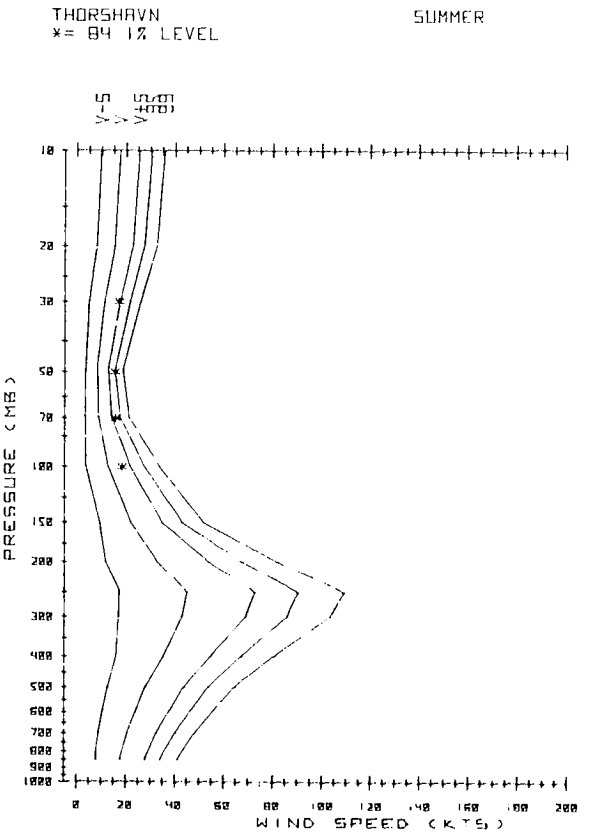


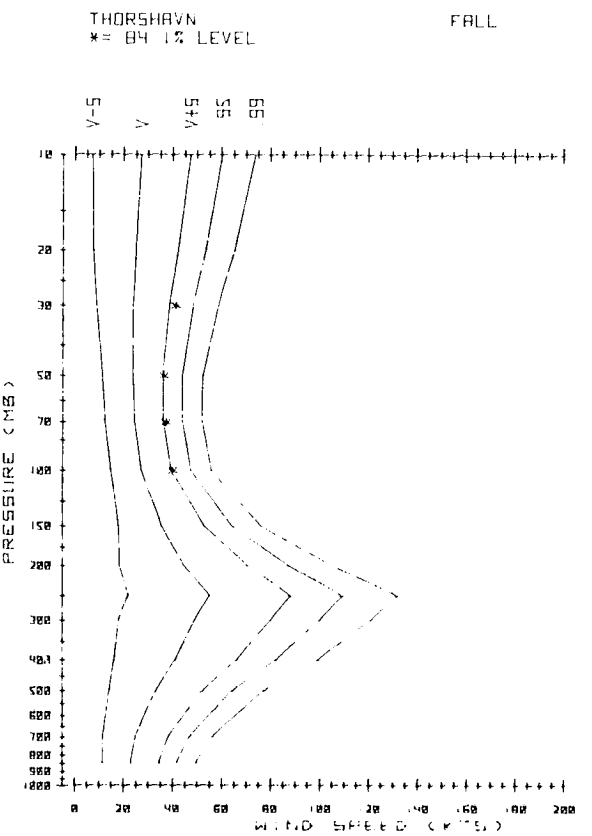
ODESSA FALL
*= 84.1% LEVEL



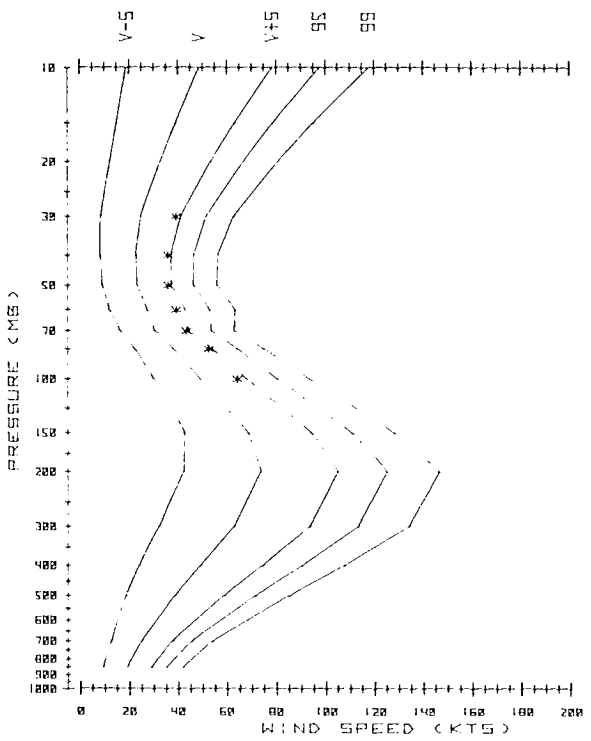

THORSHAVN
*= 84 1% LEVEL
WINTER
PRESSURE (MB)
WIND SPEED (KTS)


THORSHAVN
*= 84 1% LEVEL
SPRING
PRESSURE (MB)
WIND SPEED (KTS)

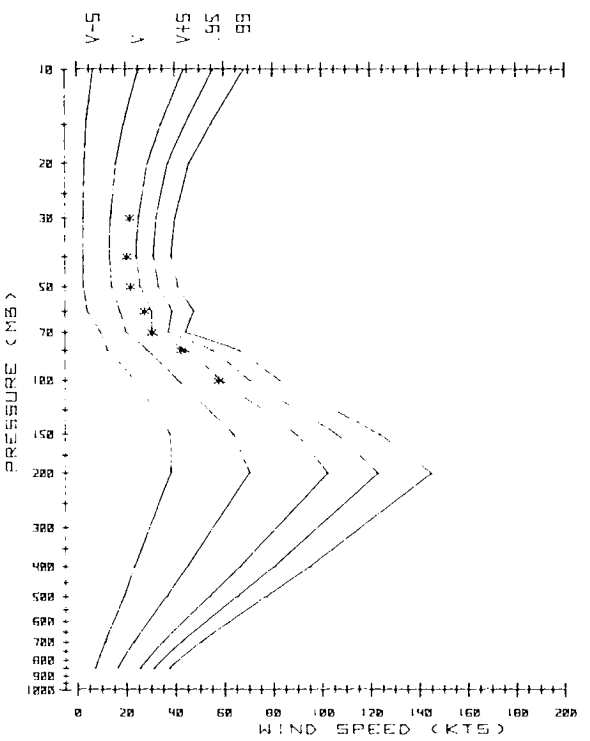

THORSHAVN
*= 84 1% LEVEL
SUMMER
PRESSURE (MB)
WIND SPEED (KTS)


THORSHAVN
*= 84 1% LEVEL
FALL
PRESSURE (MB)

TRIPOLI WINTER
*= 84.1% LEVEL



TRIPOLI SPRING
*= 84.1% LEVEL



TRIPOLI SUMMER
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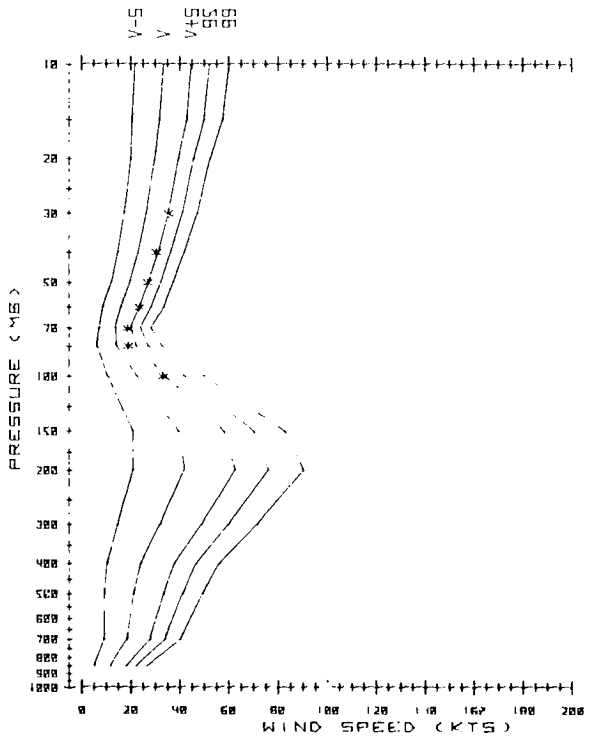
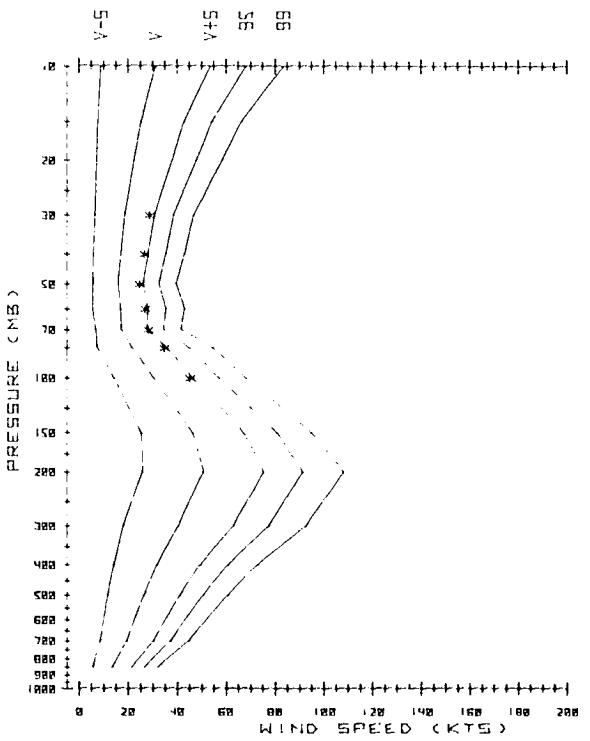
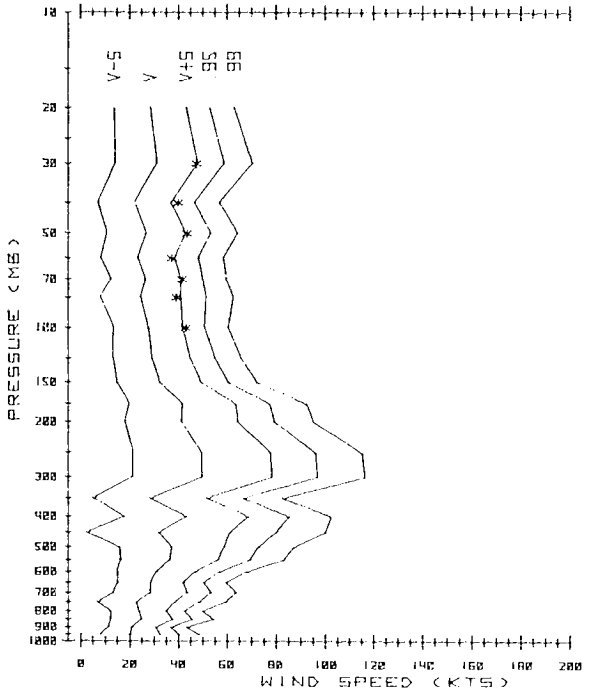


TRIPOLI FALL
*= 84.1% LEVEL



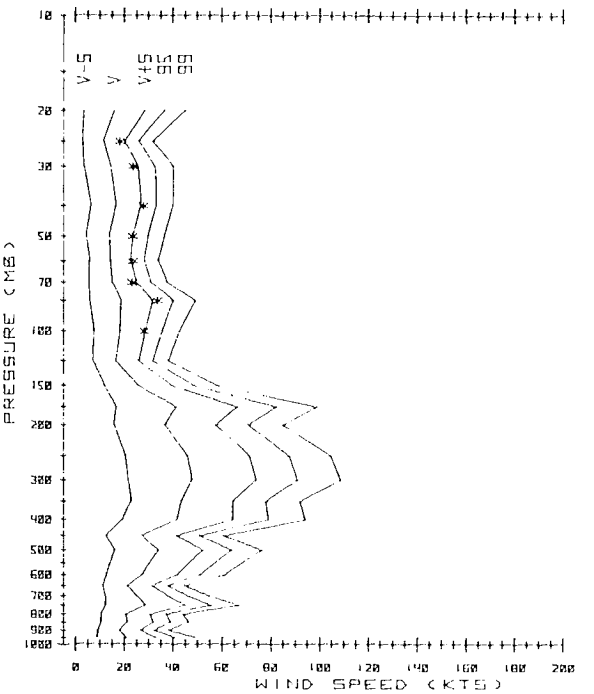
VALENTIA
*= 84.1% LEVEL

WINTER



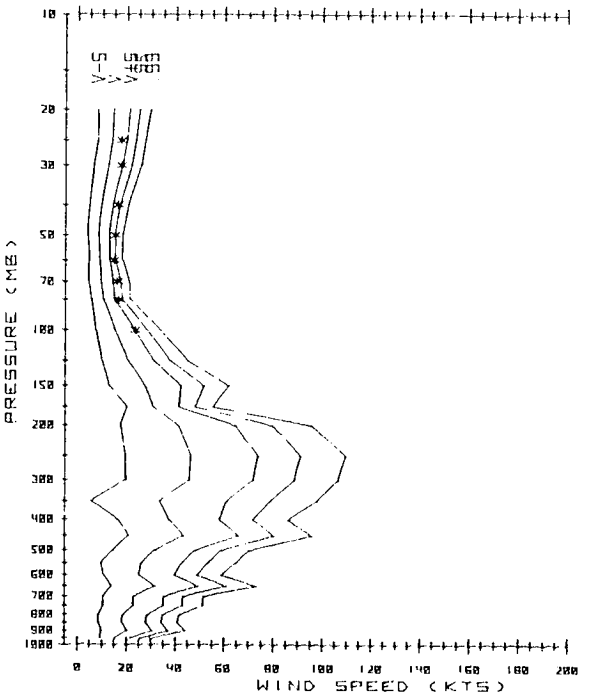
VALENTIA
*= 84.1% LEVEL

SPRING



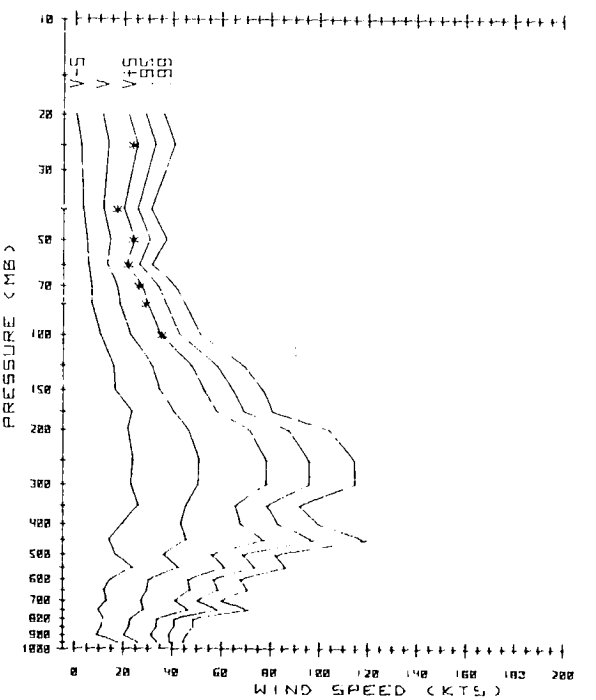
VALENTIA
*= 84.1% LEVEL

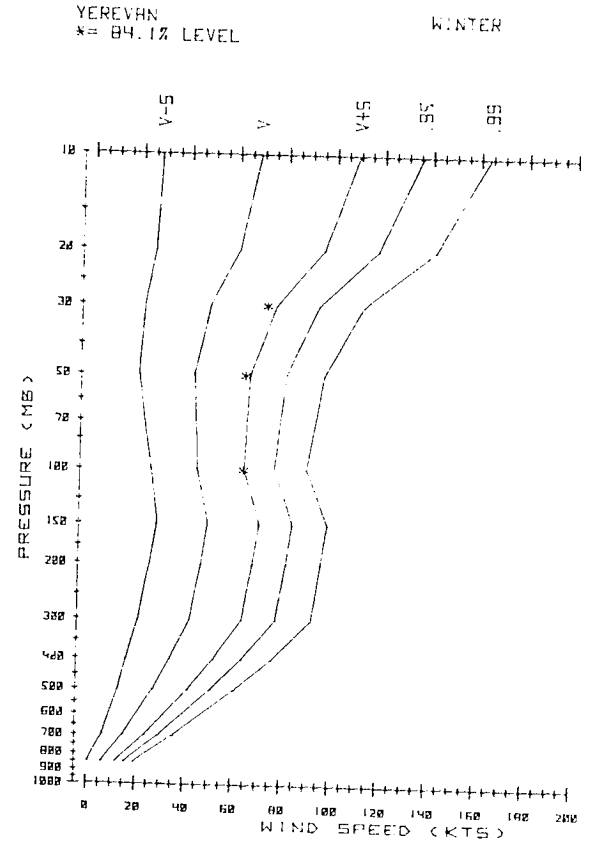
SUMMER

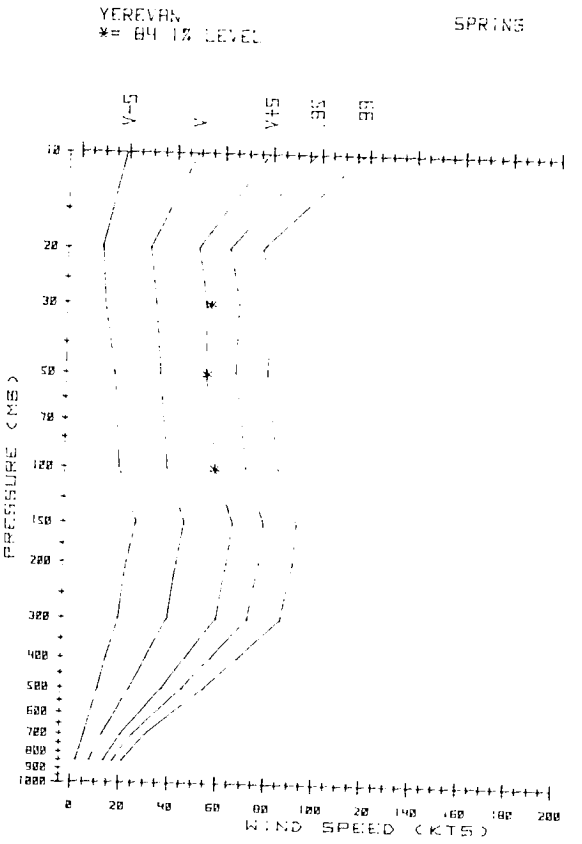


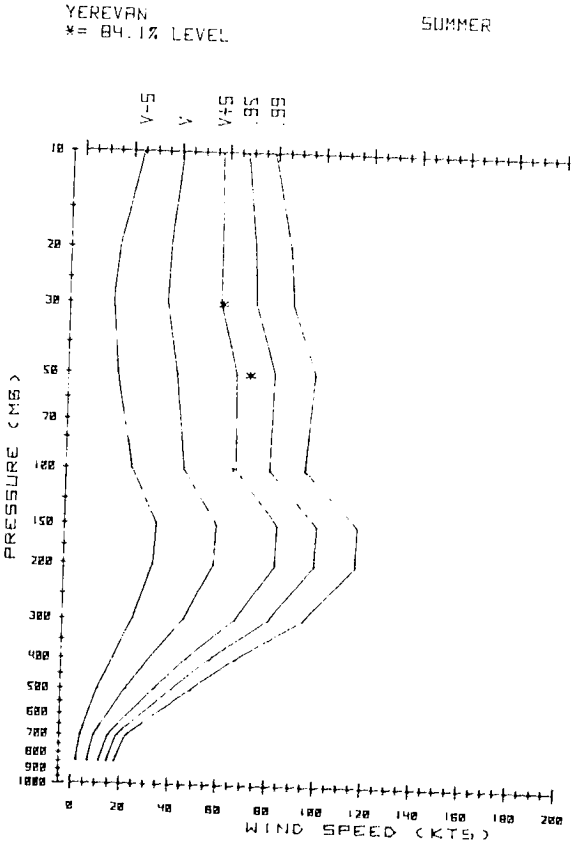
VALENTIA
*= 84.1% LEVEL

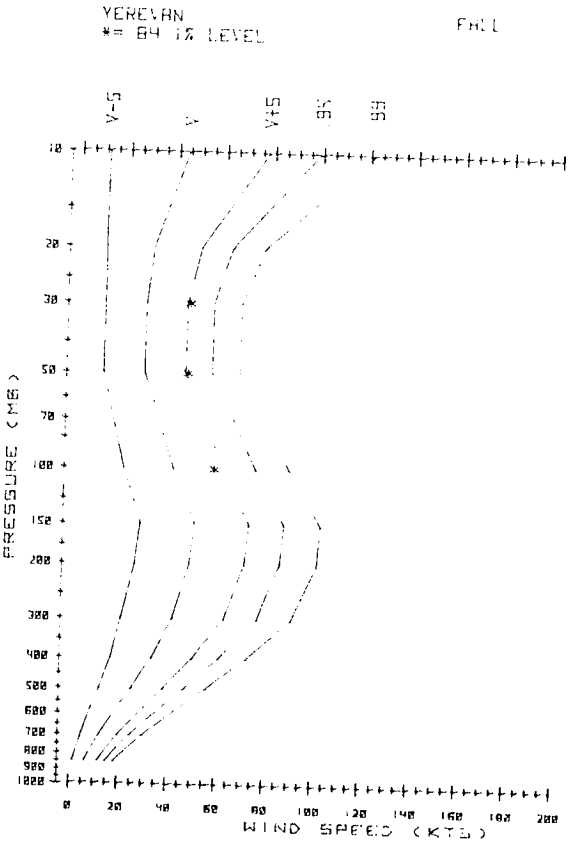
FALL

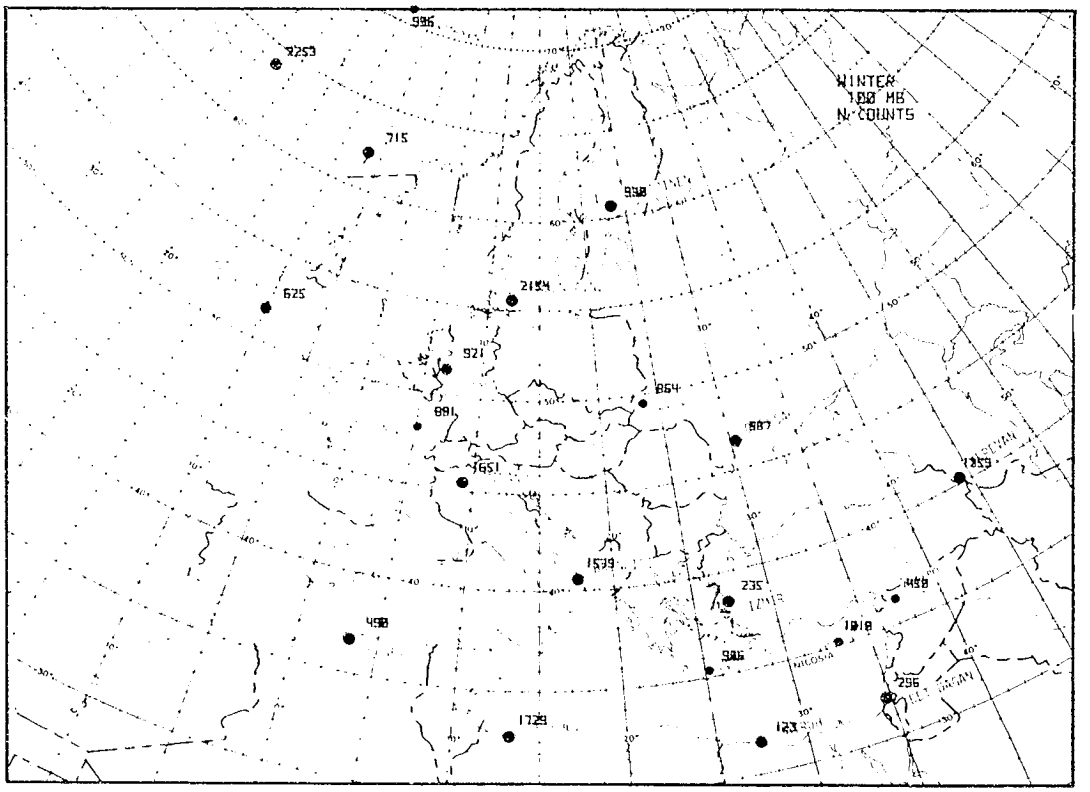


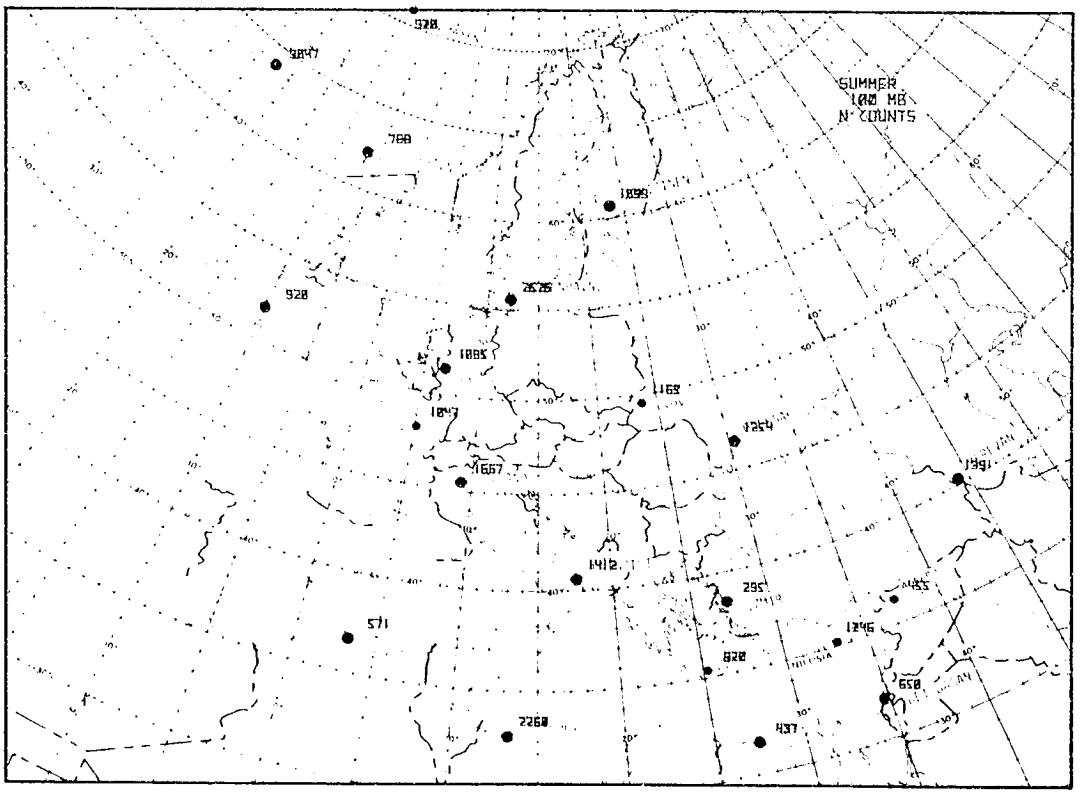

YEREVAN
*= 84.1% LEVEL
WINTER
V-5
V
V+5
95
99
PRESSURE (MB)
WIND SPEED (KTS)

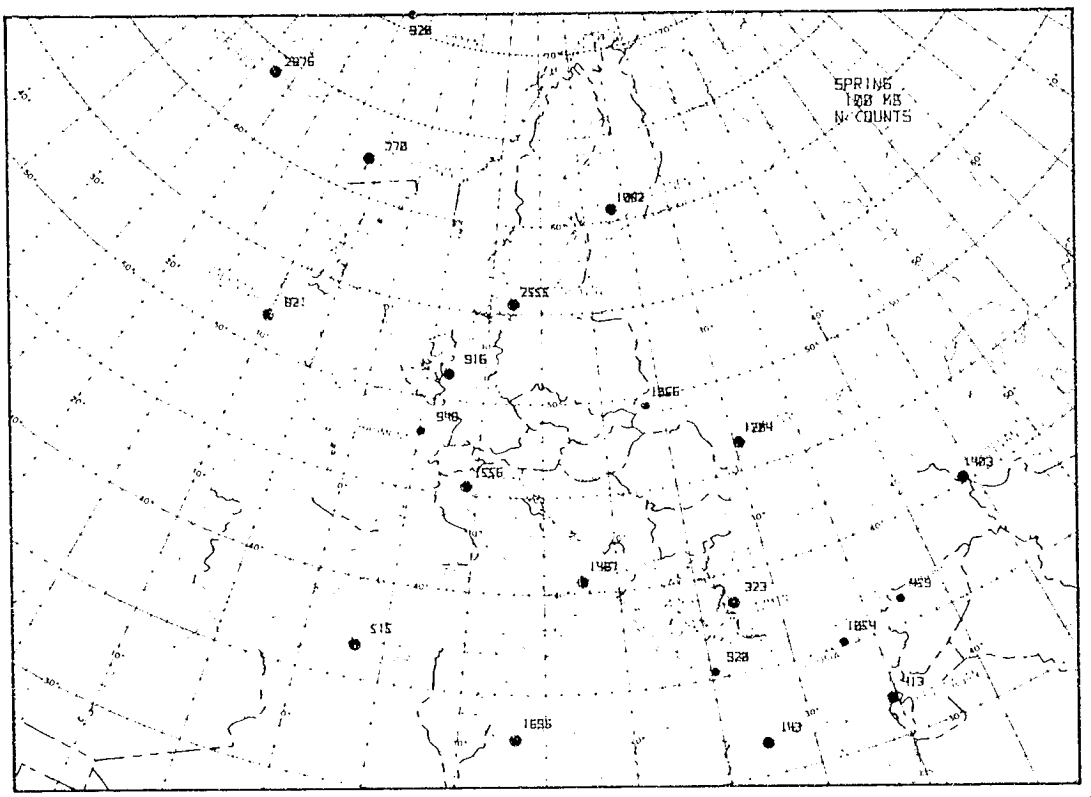

YEREVAN
*= 84.1% LEVEL
SPRING
V-5
V
V+5
95
99
PRESSURE (MB)
WIND SPEED (KTS)

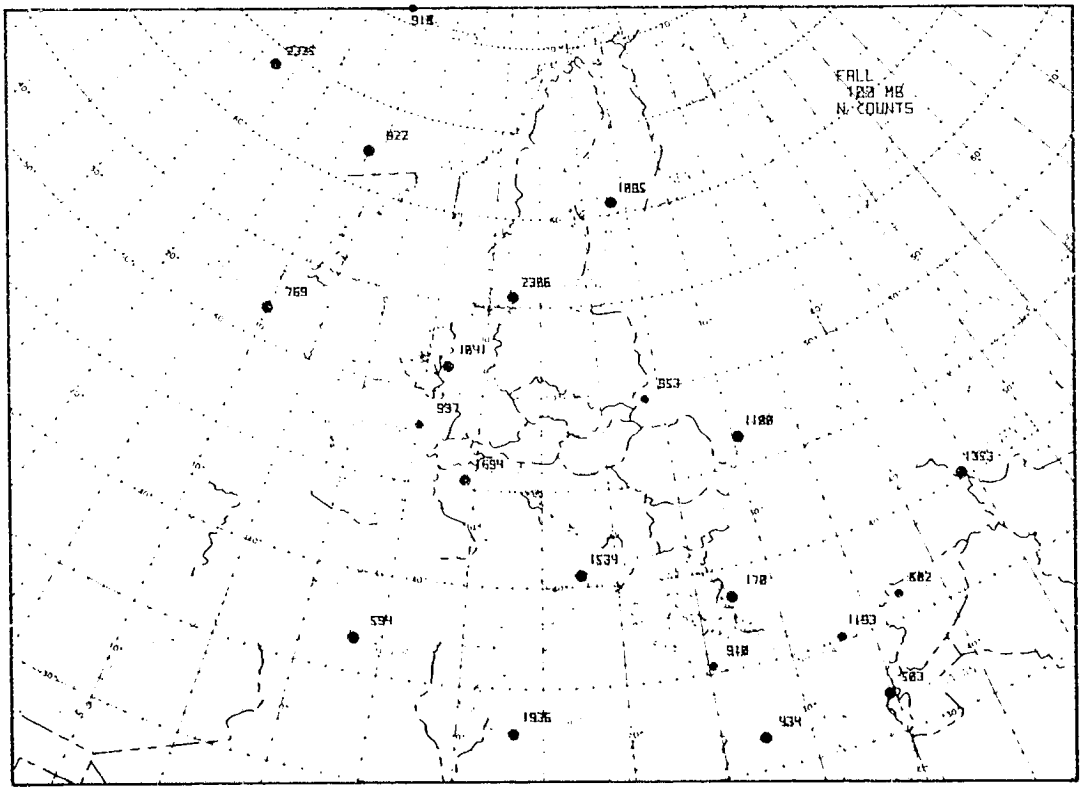

YEREVAN
*= 84.1% LEVEL
SUMMER
V-5
V
V+5
95
99
PRESSURE (MB)
WIND SPEED (KTS)

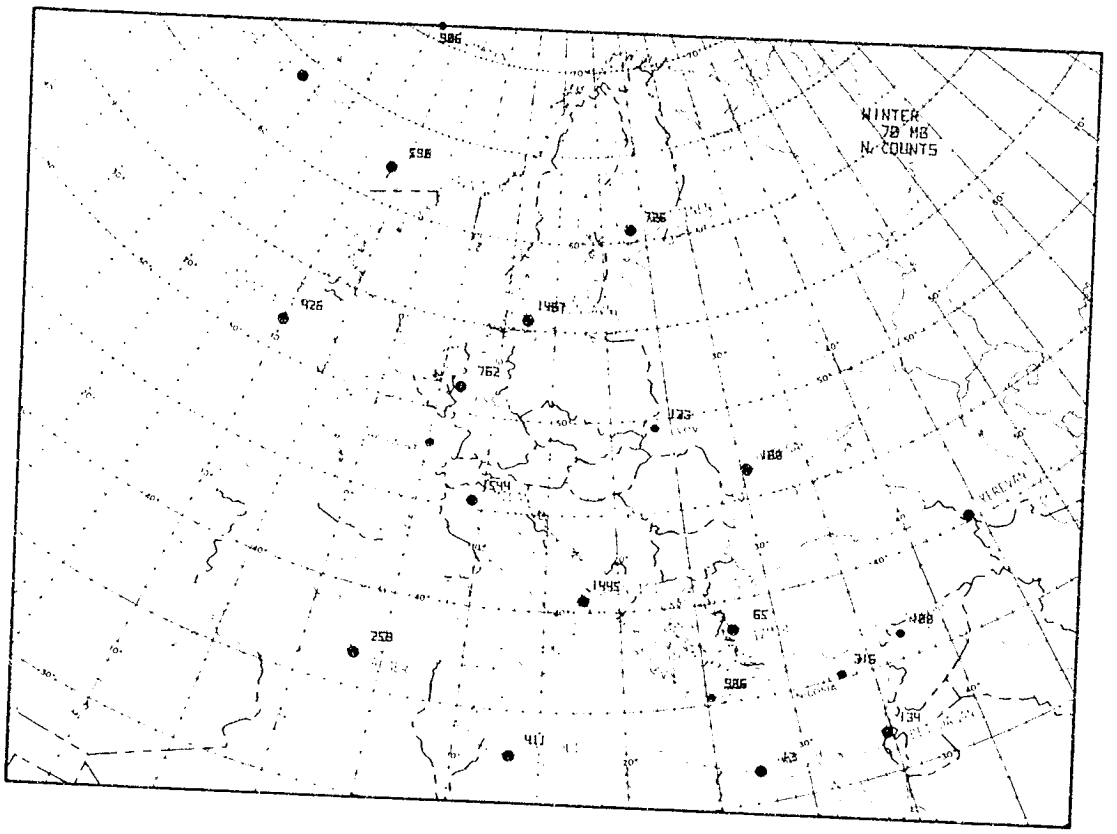

YEREVAN
*= 84.1% LEVEL
FALL
V-5
V
V+5
95
99
PRESSURE (MB)
WIND SPEED (KTS)


WINTER
100 MB
N. COUNTS


SUMMER
100 MB
N. COUNTS



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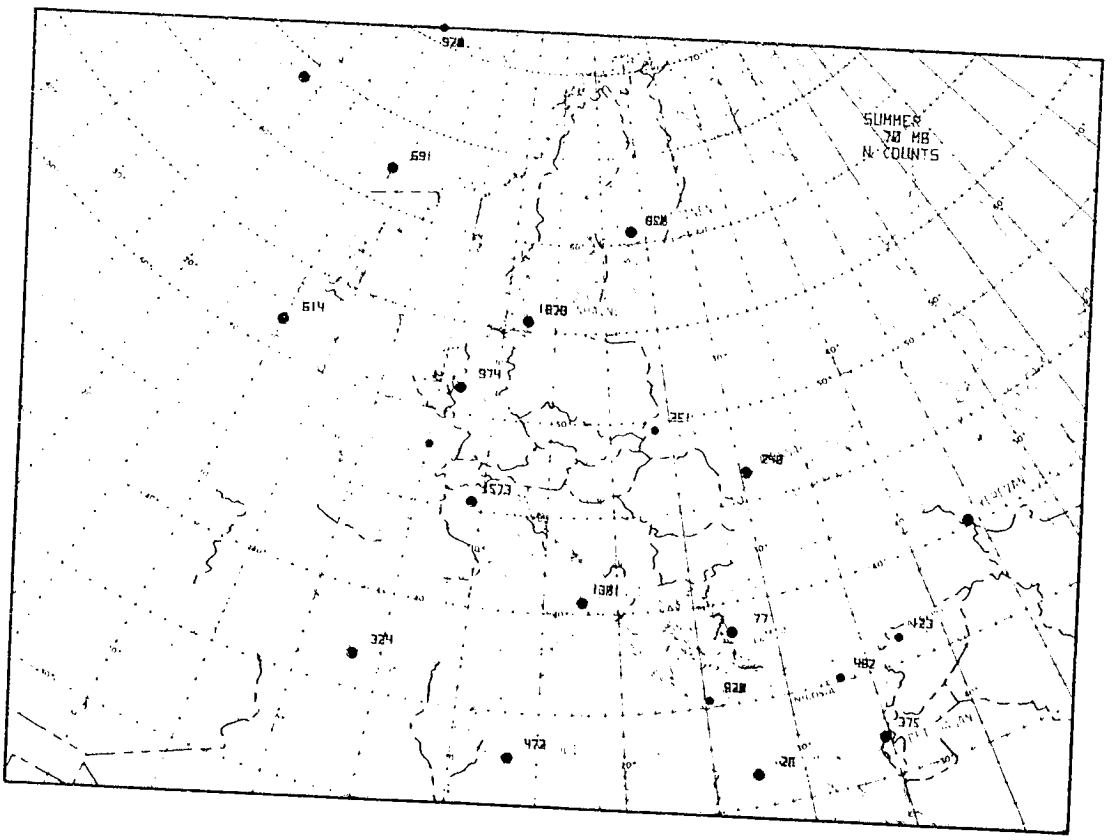
70 MB
N. COUNTS


SUMMER
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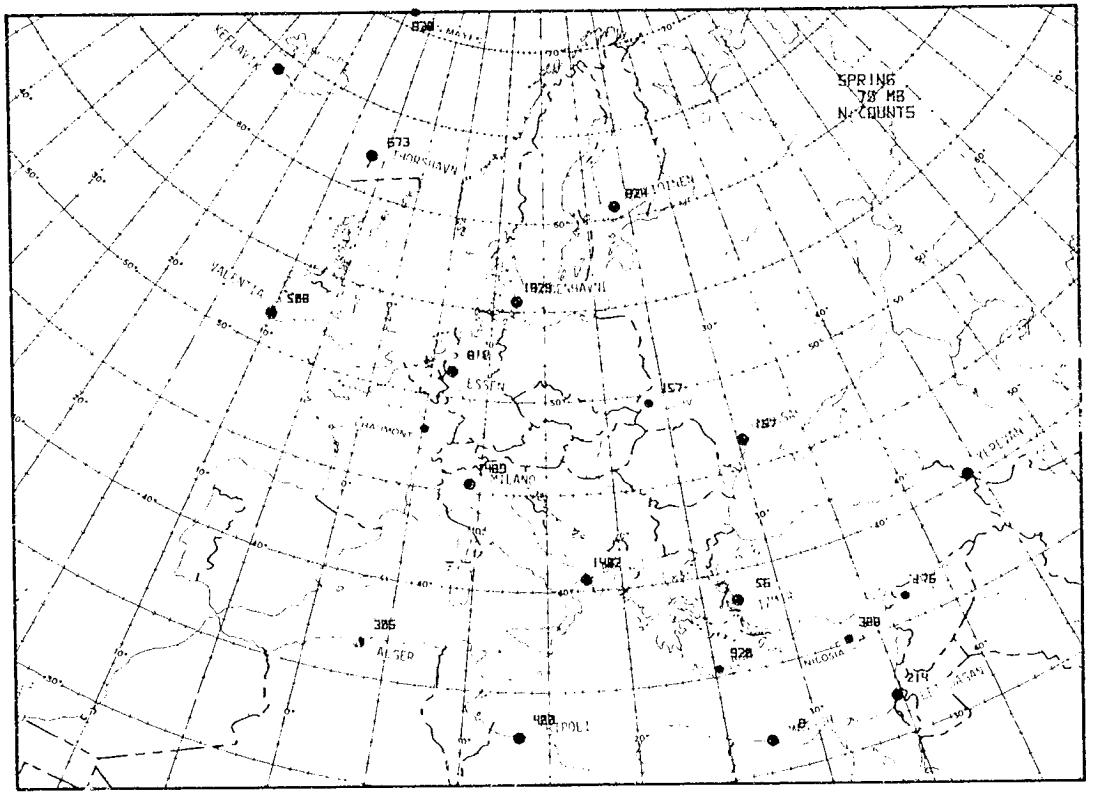
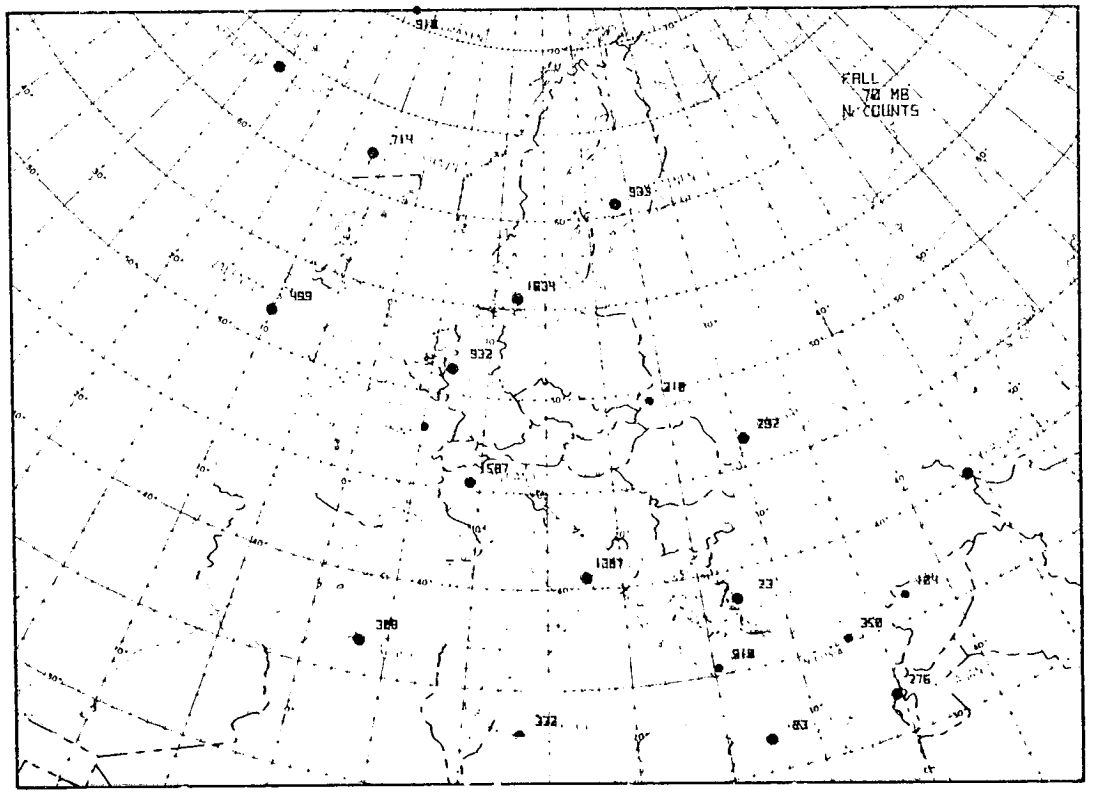
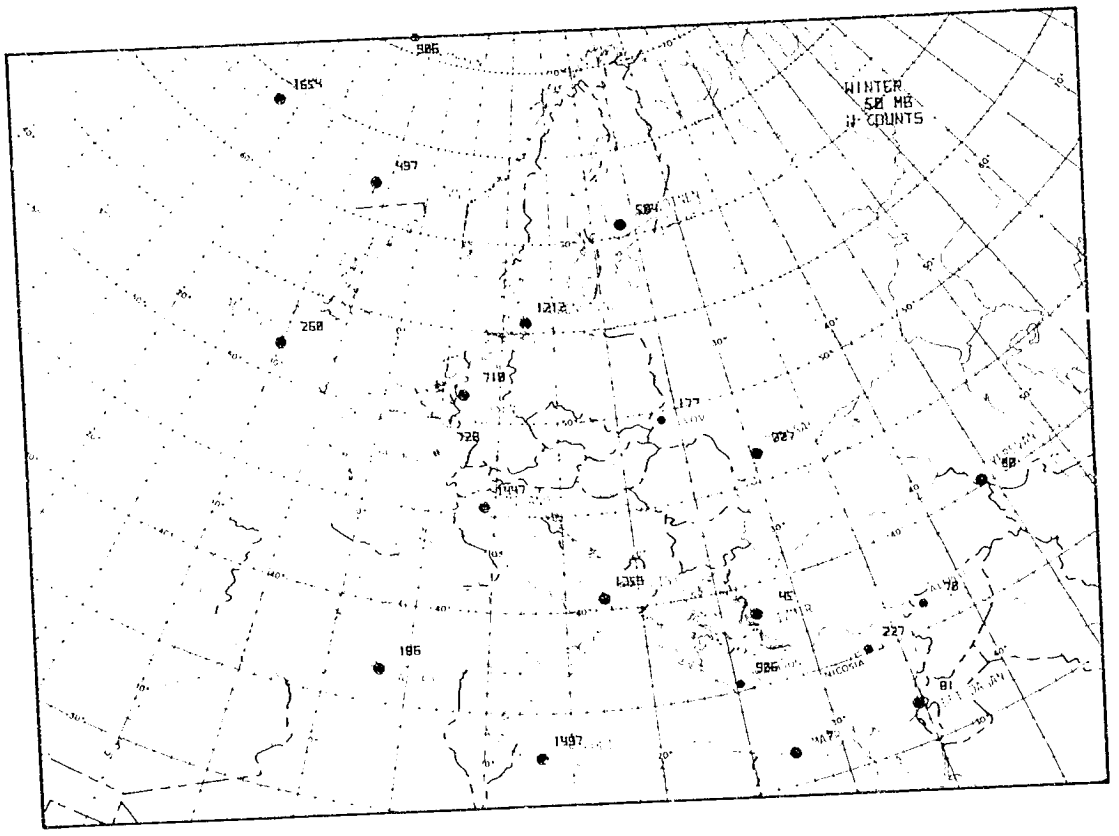
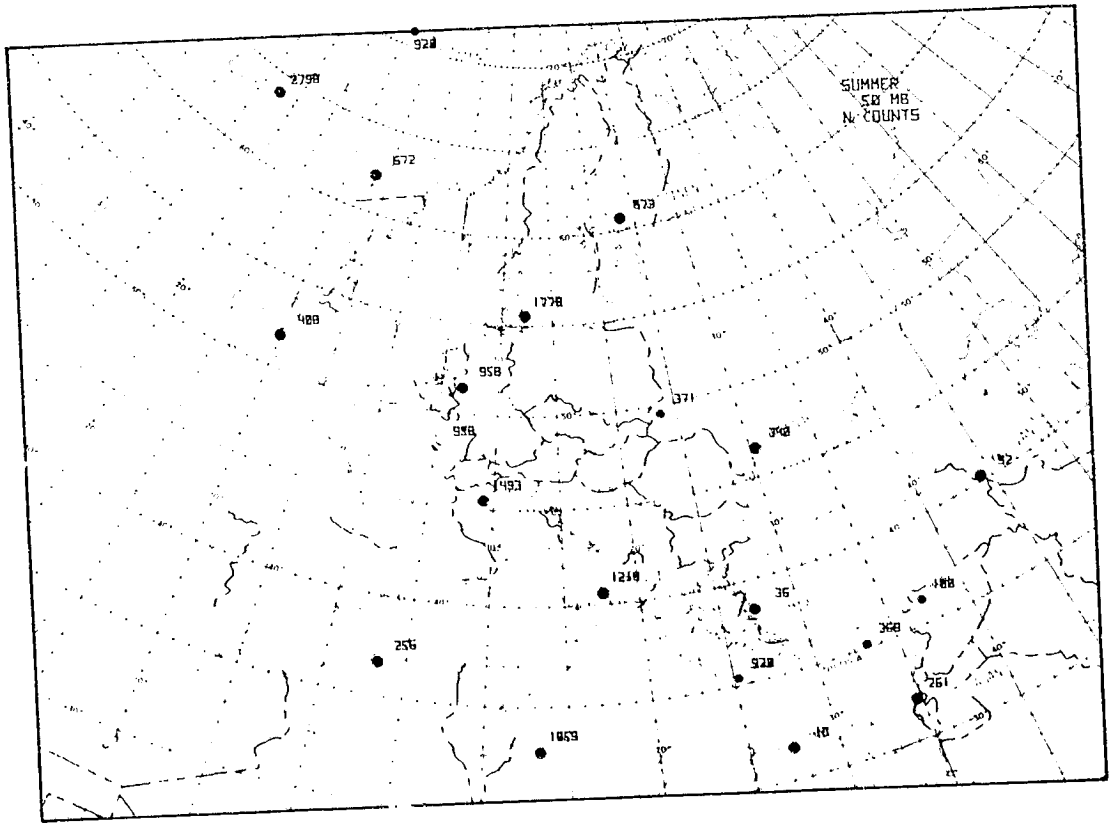
N. COUNTS


SPRING
78 MB
N. COUNTS


FALL
78 MB
N. COUNTS


WINTER
50 MB
N COUNTS


SUMMER
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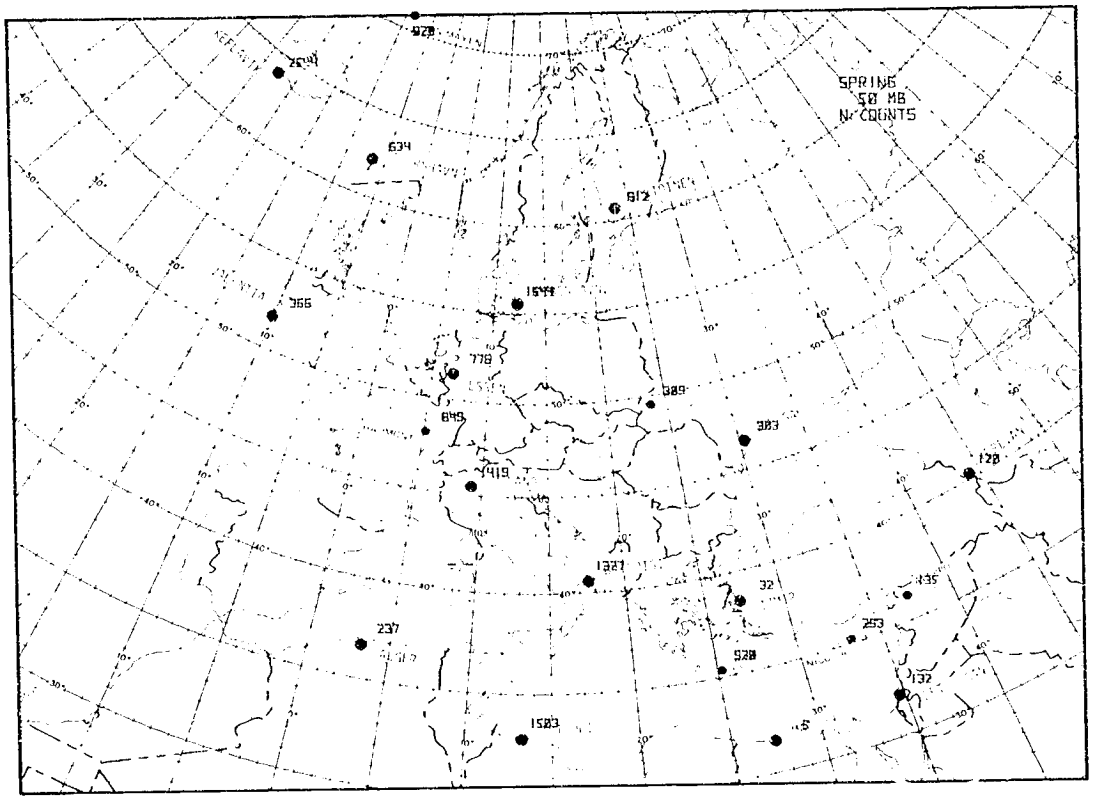
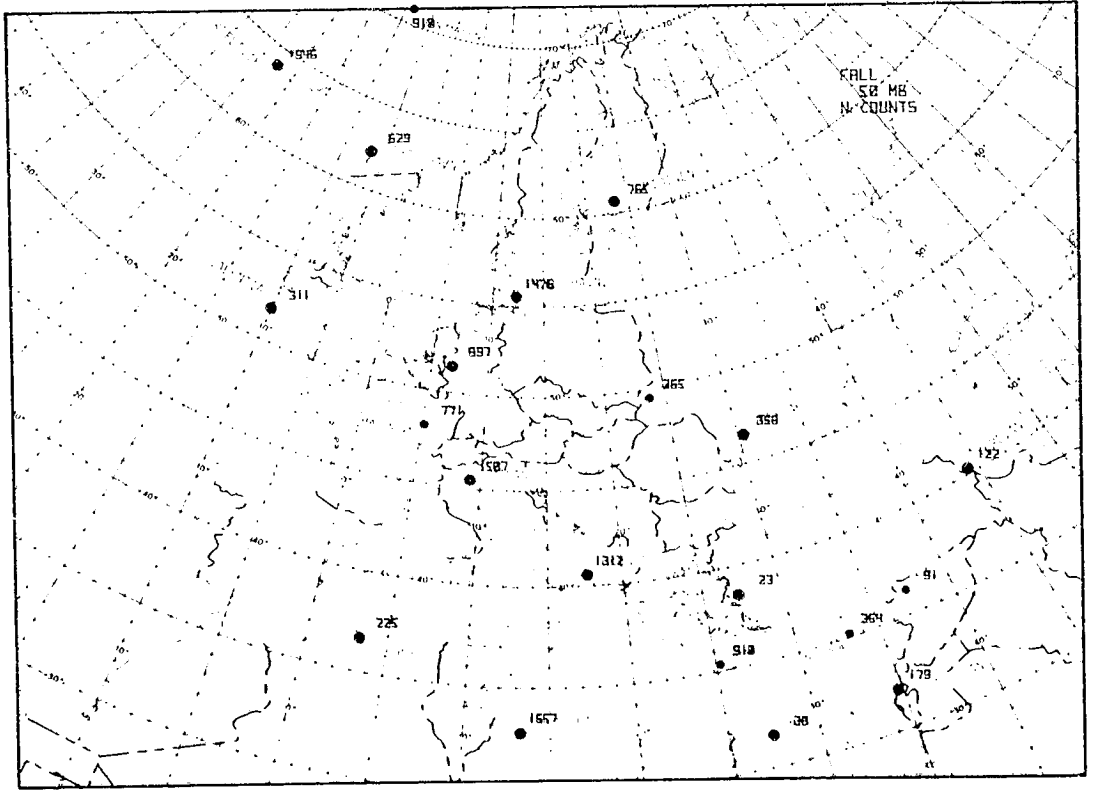
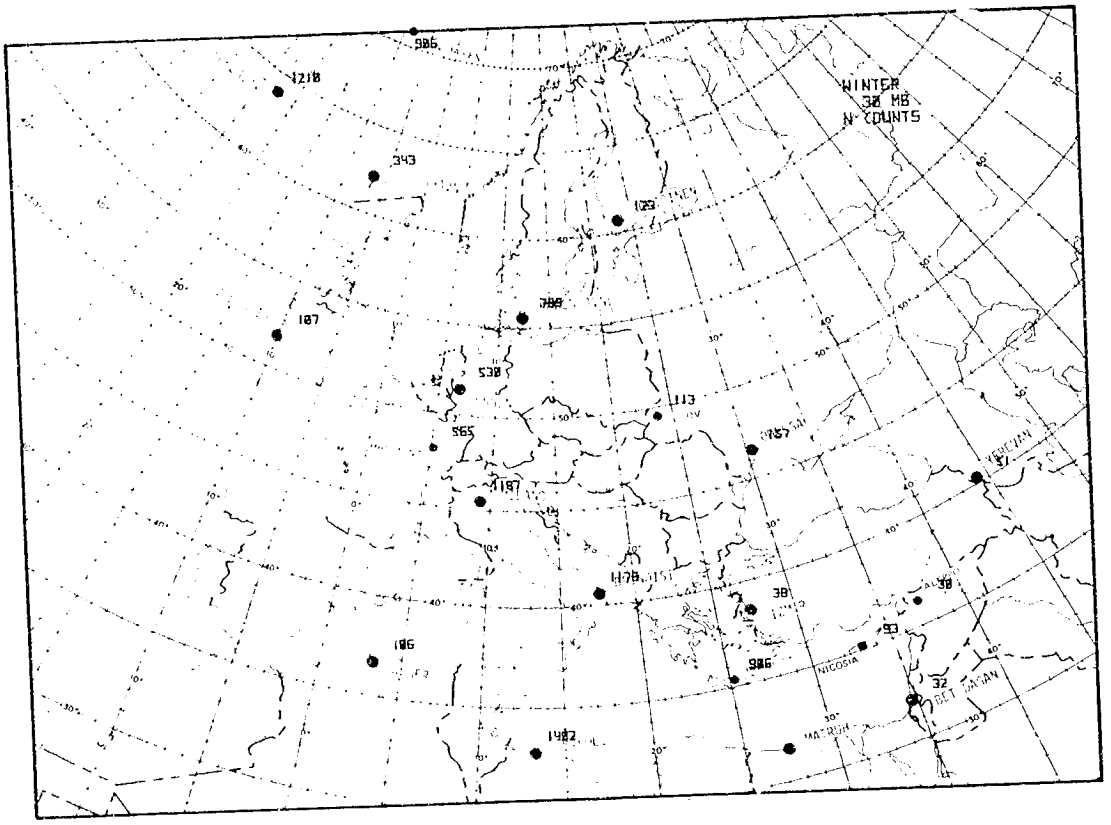
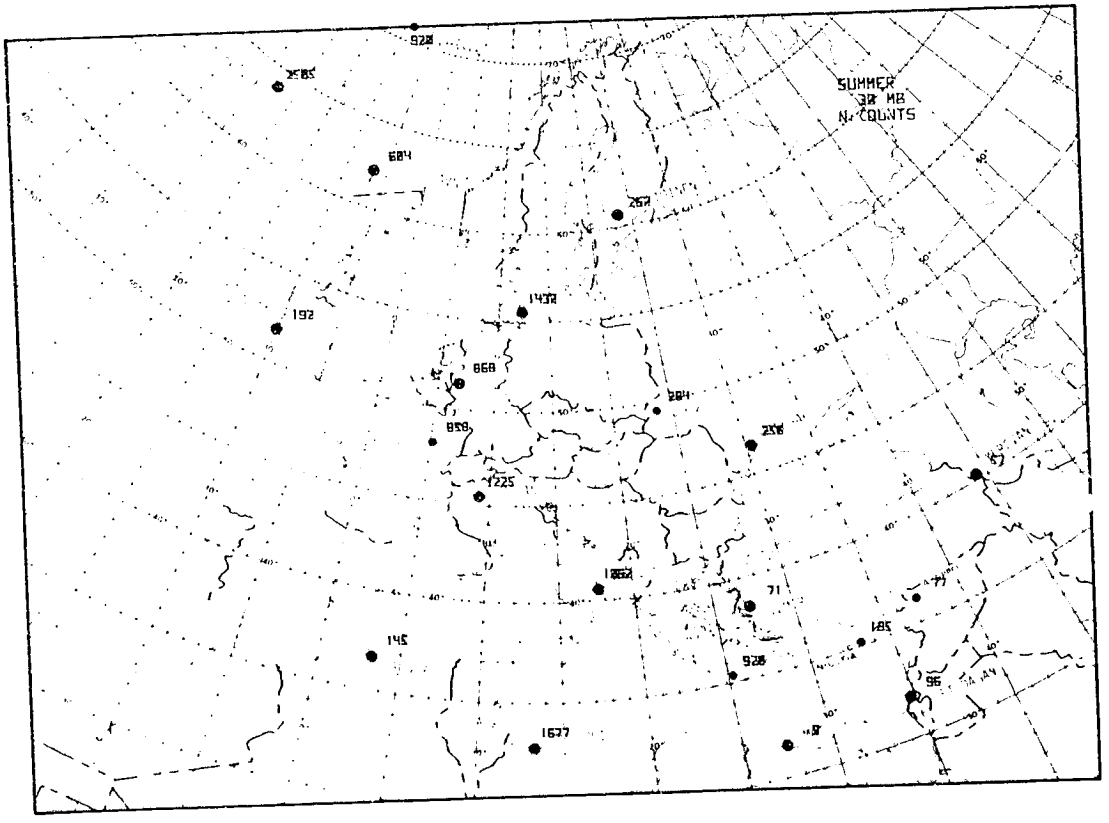
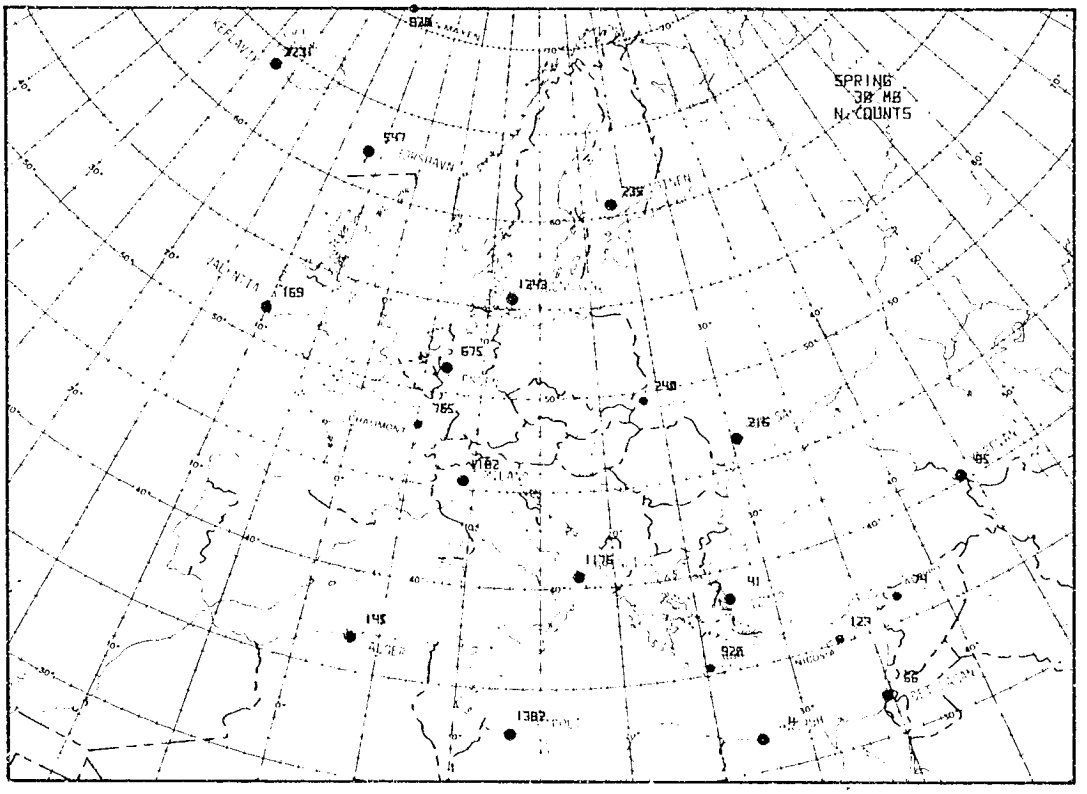
N COUNTS


SPRING
50 MB
N-COUNTS


FALL
50 MB
N-COUNTS


WINTER
32 MB
N COUNTS


SUMMER
32 MB
N COUNTS


SPRING
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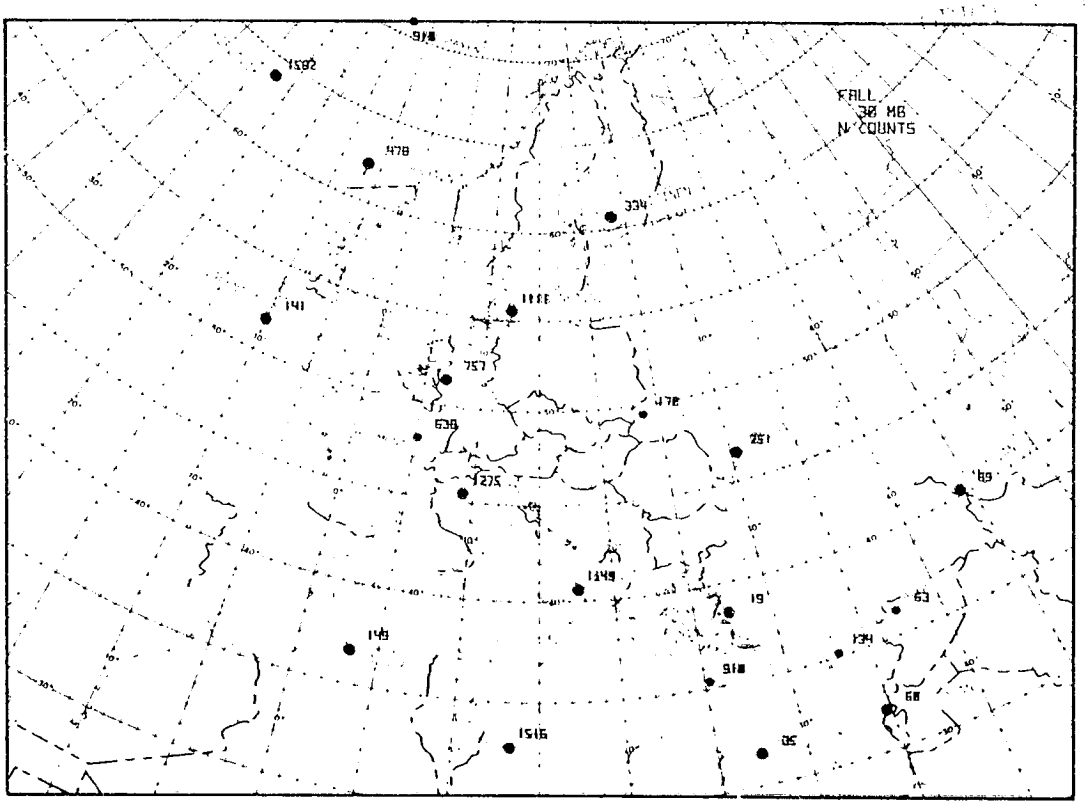
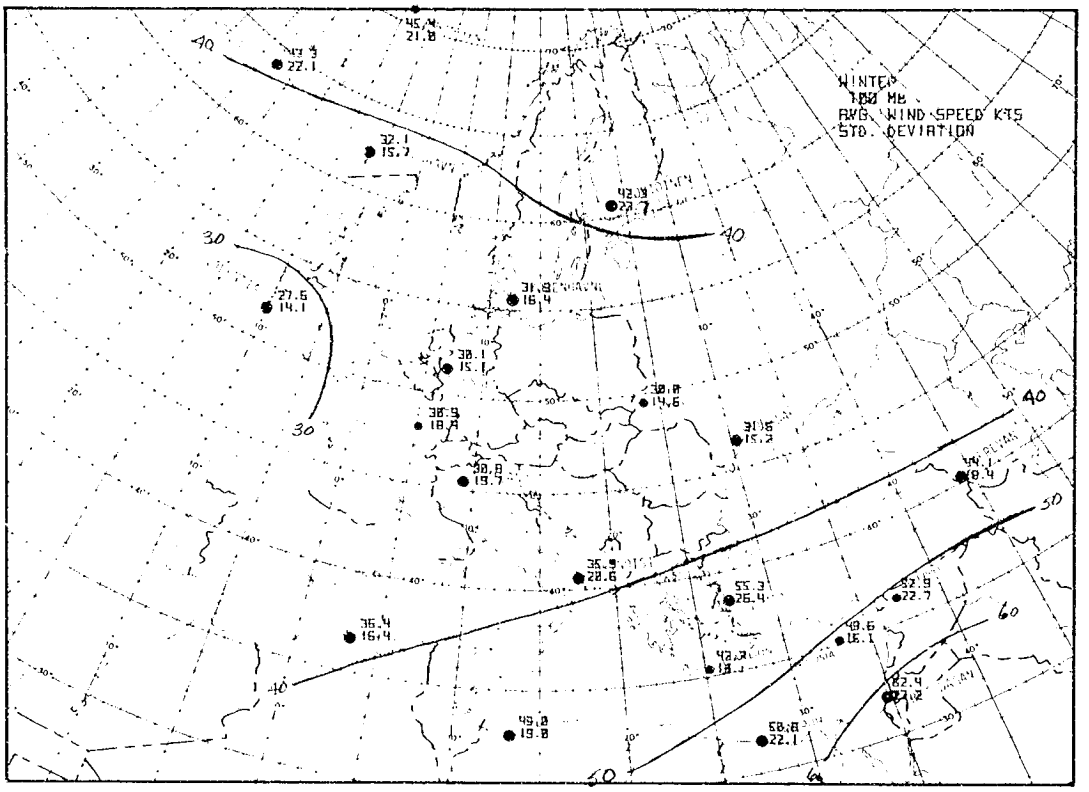
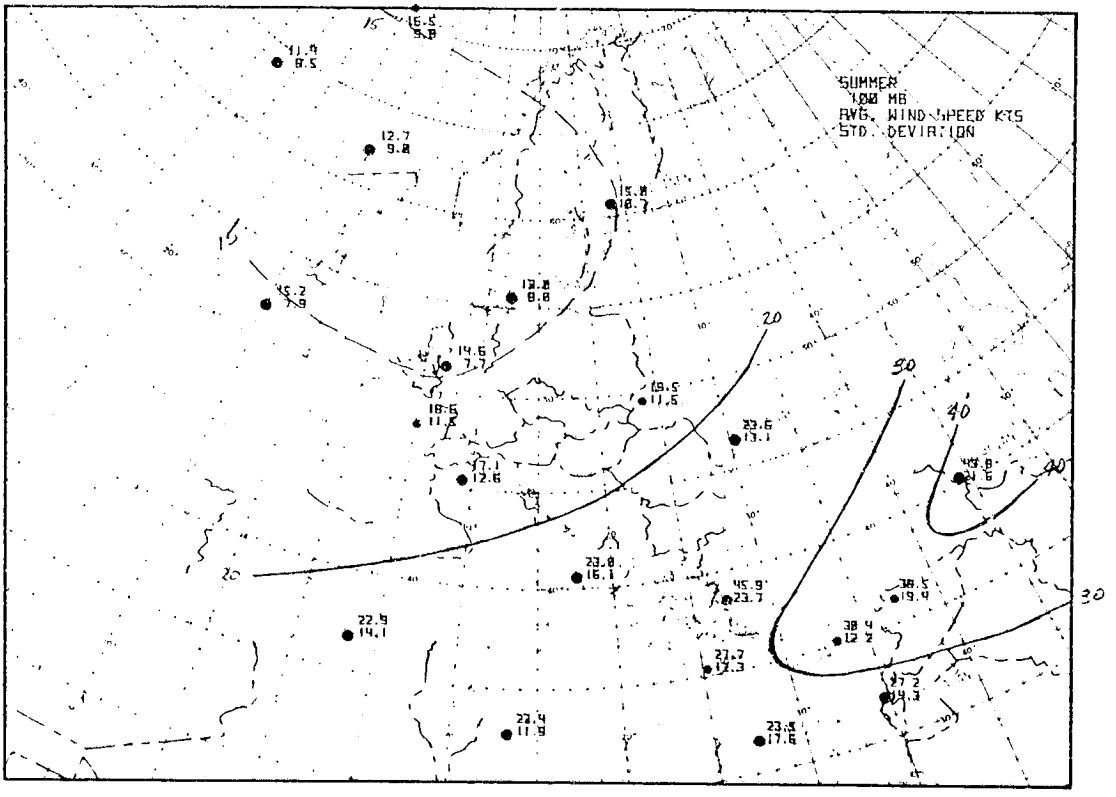
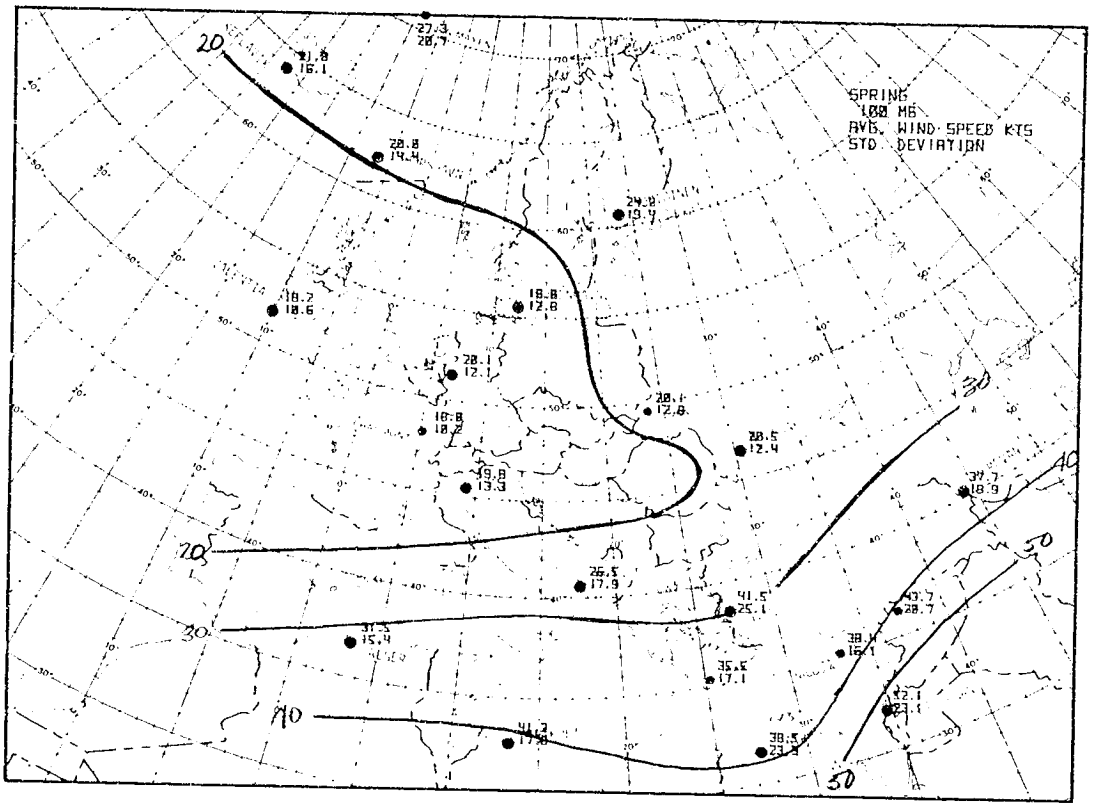
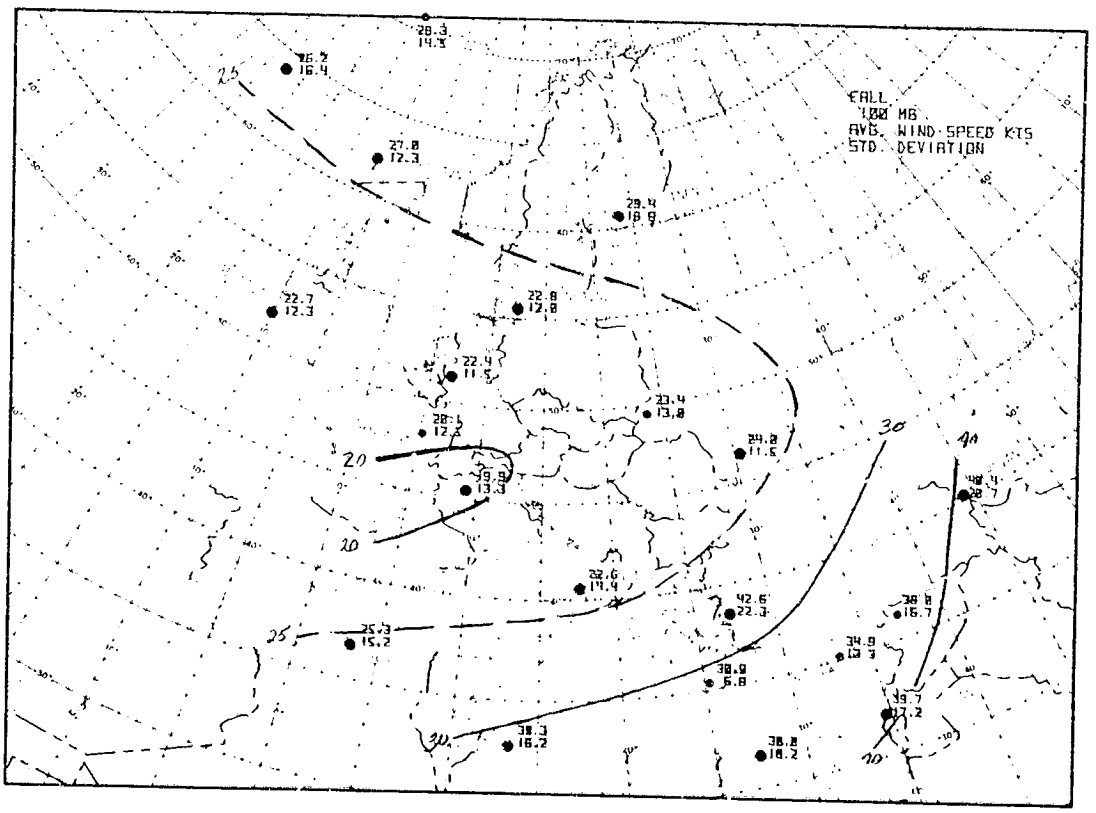
N. COUNTS


FALL
30 MB
N. COUNTS


WINTER
100 MB
AVG. WIND SPEED KTS
STD. DEVIATION


SUMMER
100 MB
AVG. WIND SPEED KTS
STD. DEVIATION


SPRING
1000 MB
AVG. WIND SPEED KTS
STD. DEVIATION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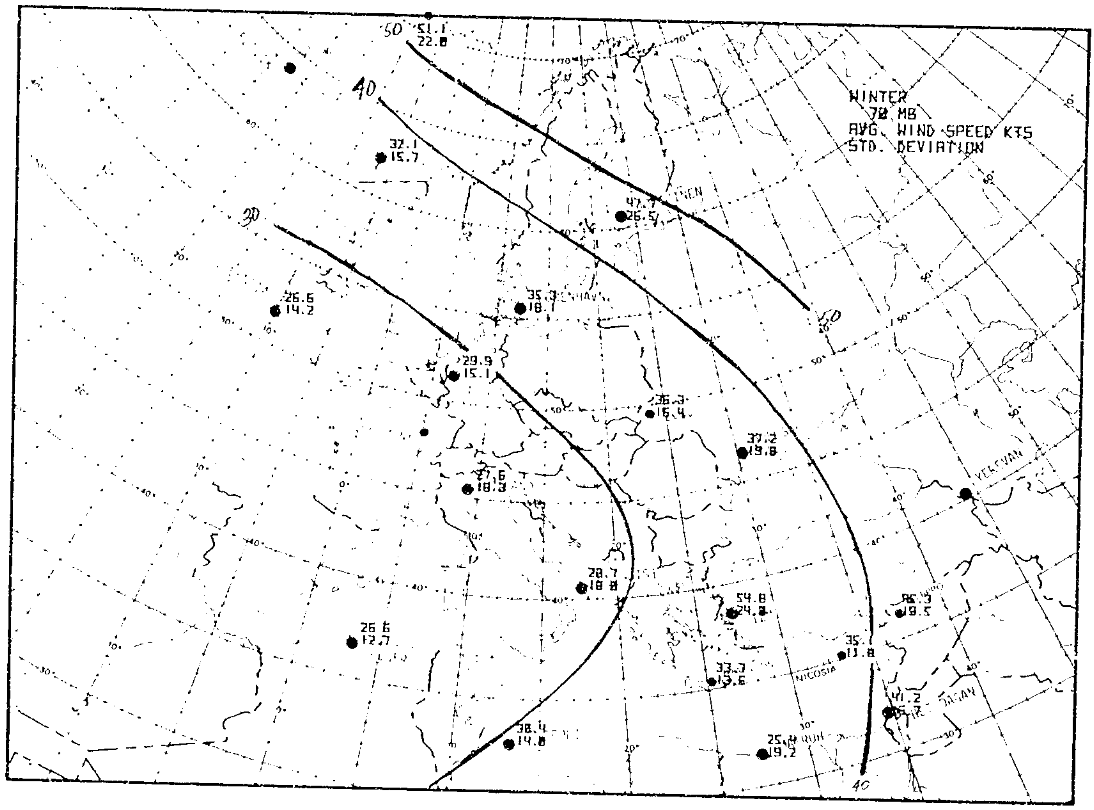
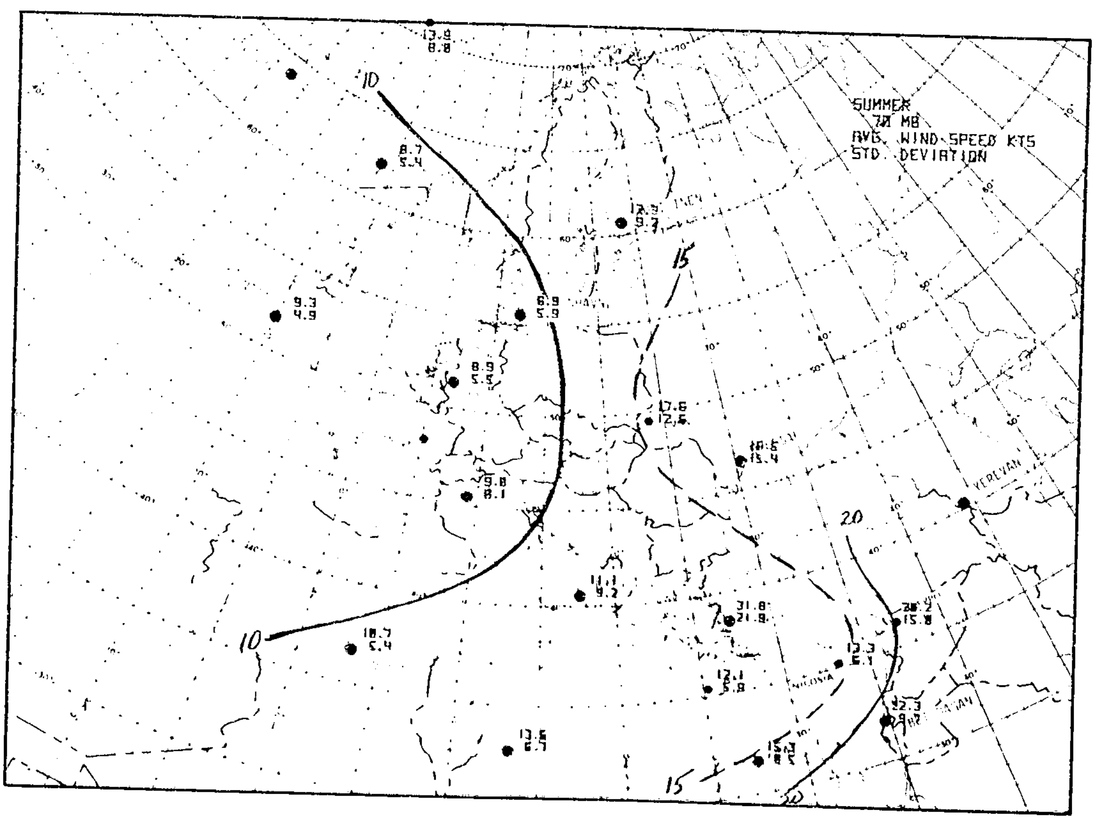
1000 MB
AVG. WIND SPEED KTS
STD. DEVIATION


WINTER
70 MB
AVG. WIND SPEED KTS
STD. DEVIATION
YEREVAN
NICOSIA


SUMMER
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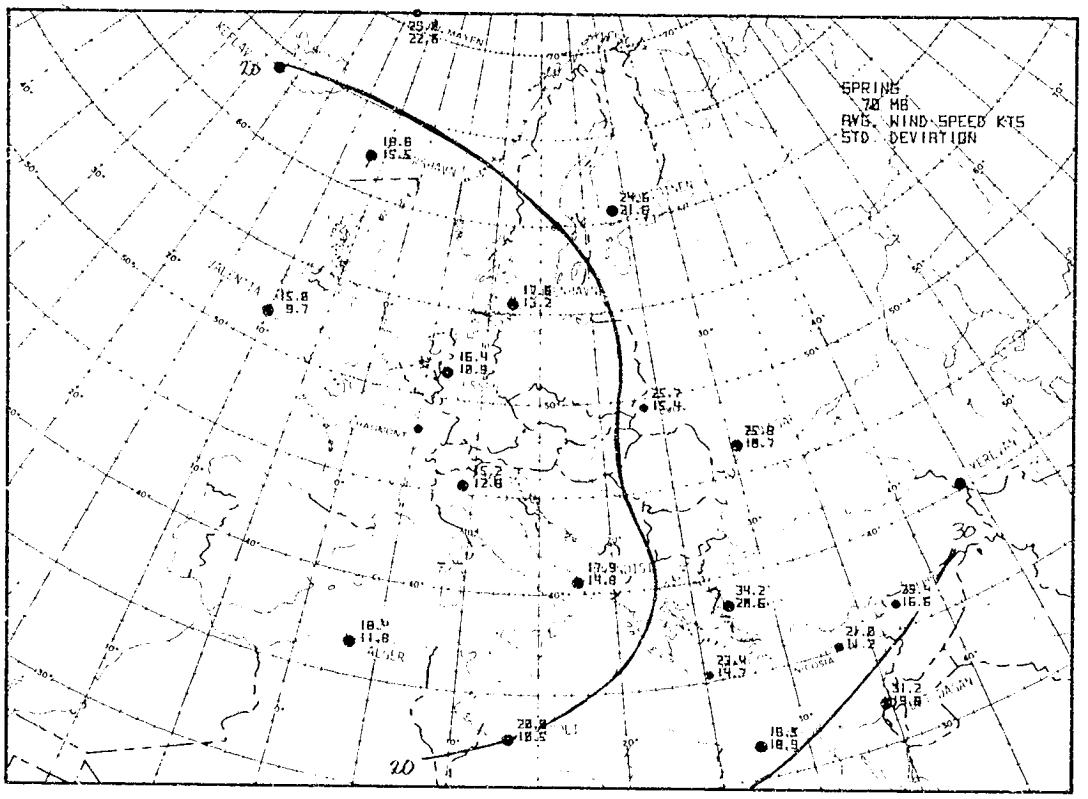
AVG. WIND SPEED KTS
STD. DEVIATION
YEREVAN
NICOSIA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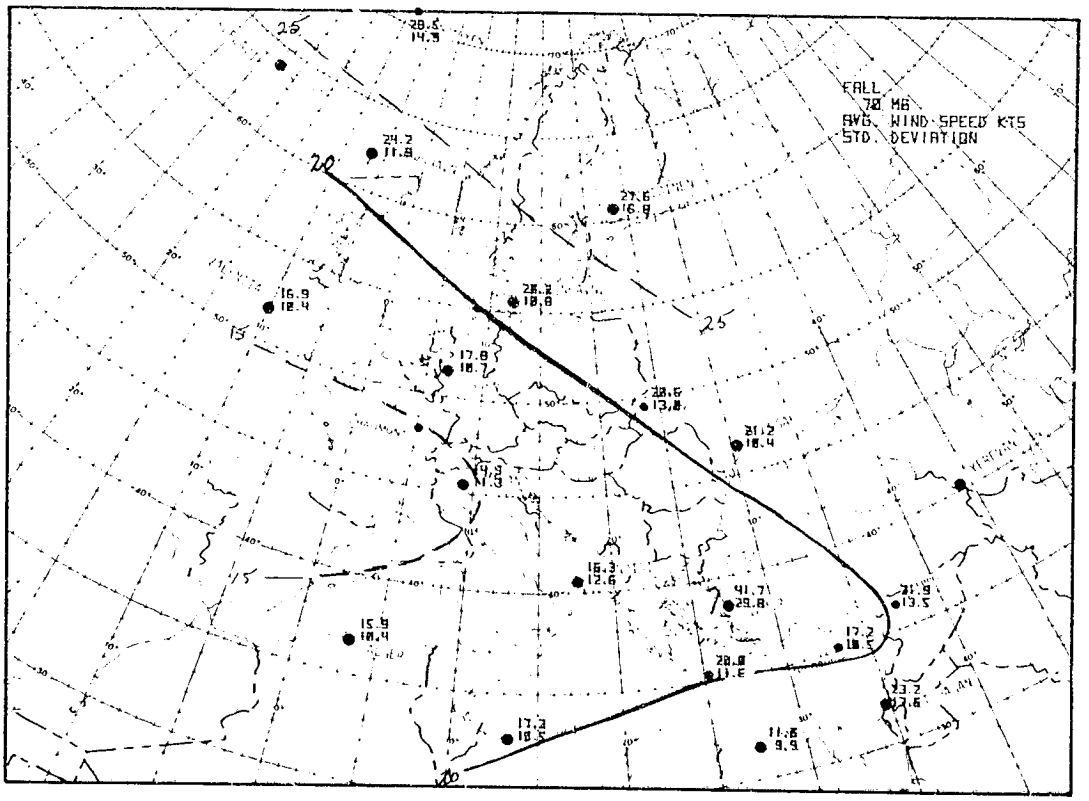
AVG. WIND SPEED KTS
STD. DEVIATION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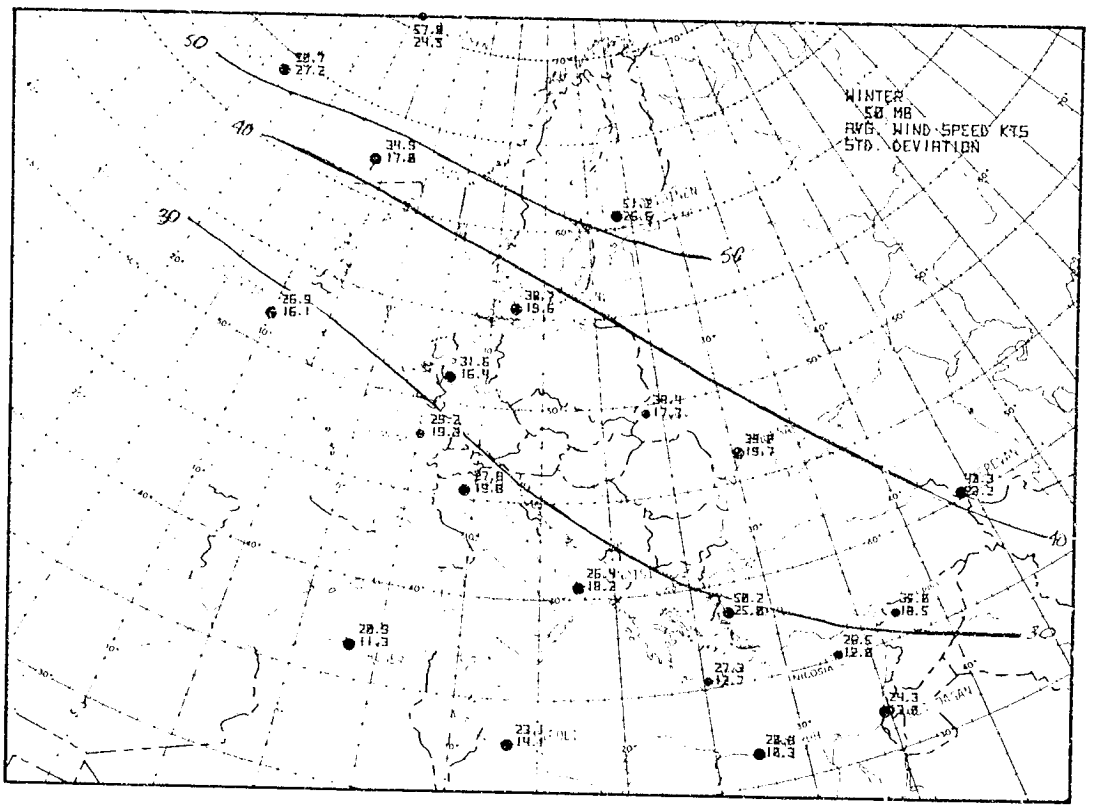
AVG. WIND SPEED KTS
STD. DEVIATION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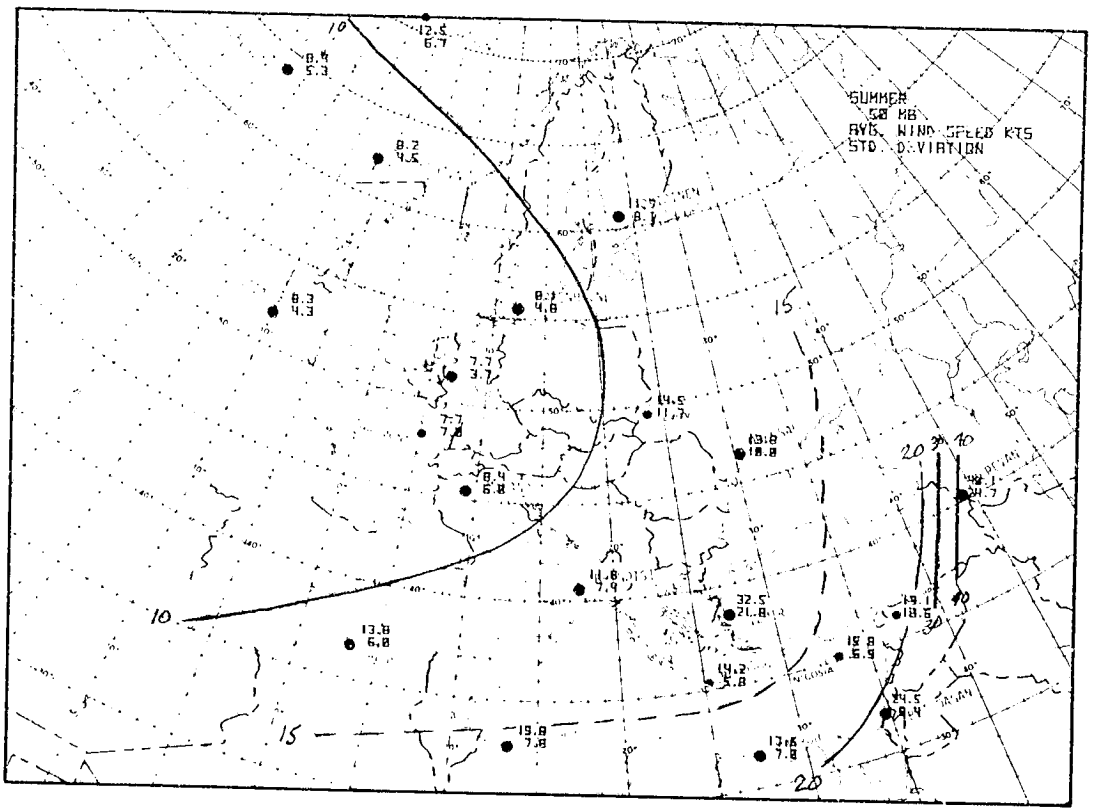
STD. DEVIATION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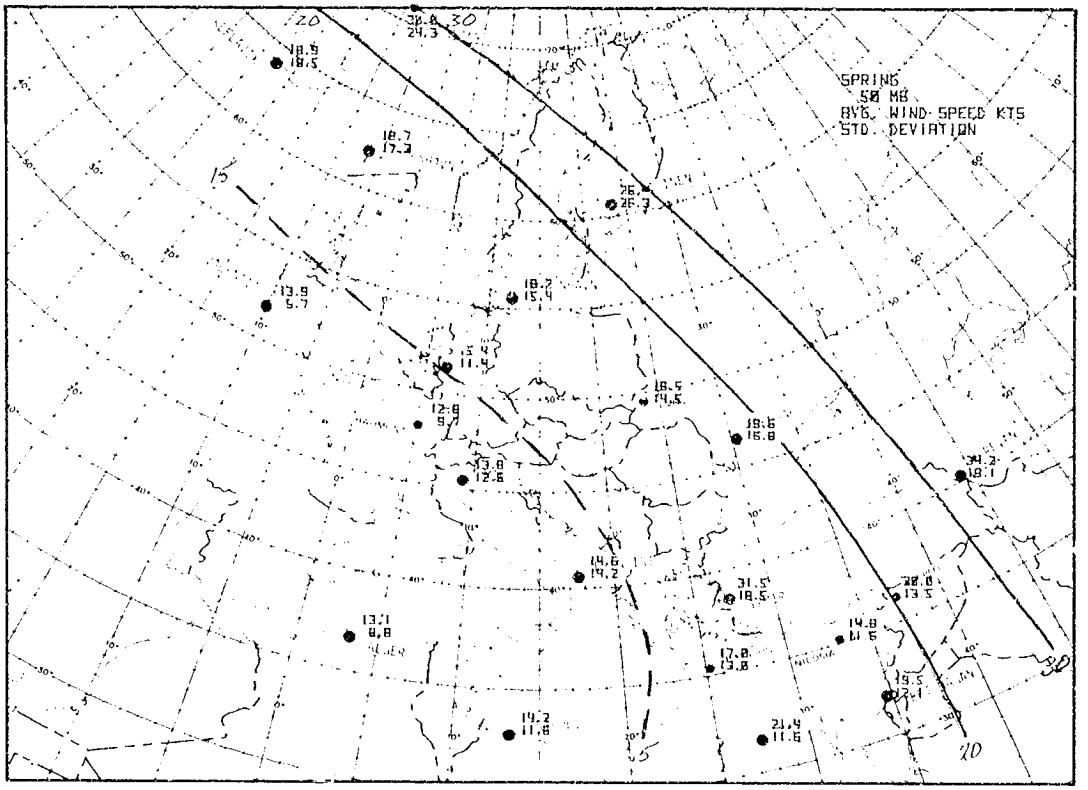

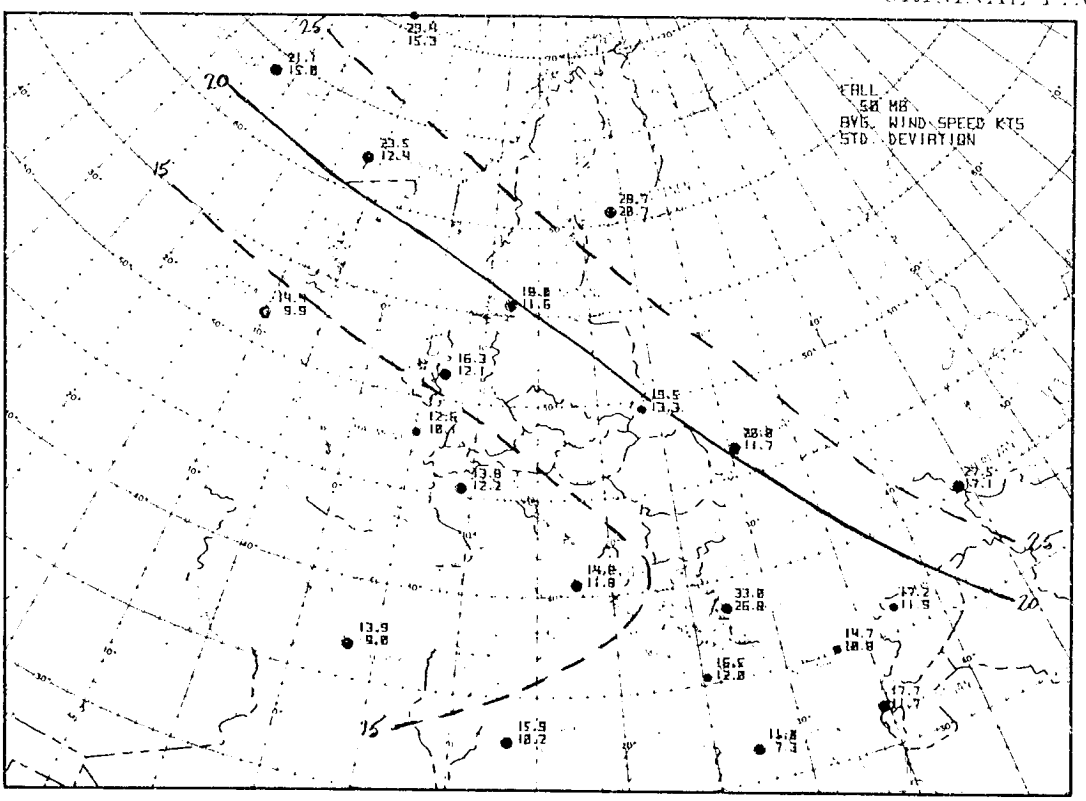

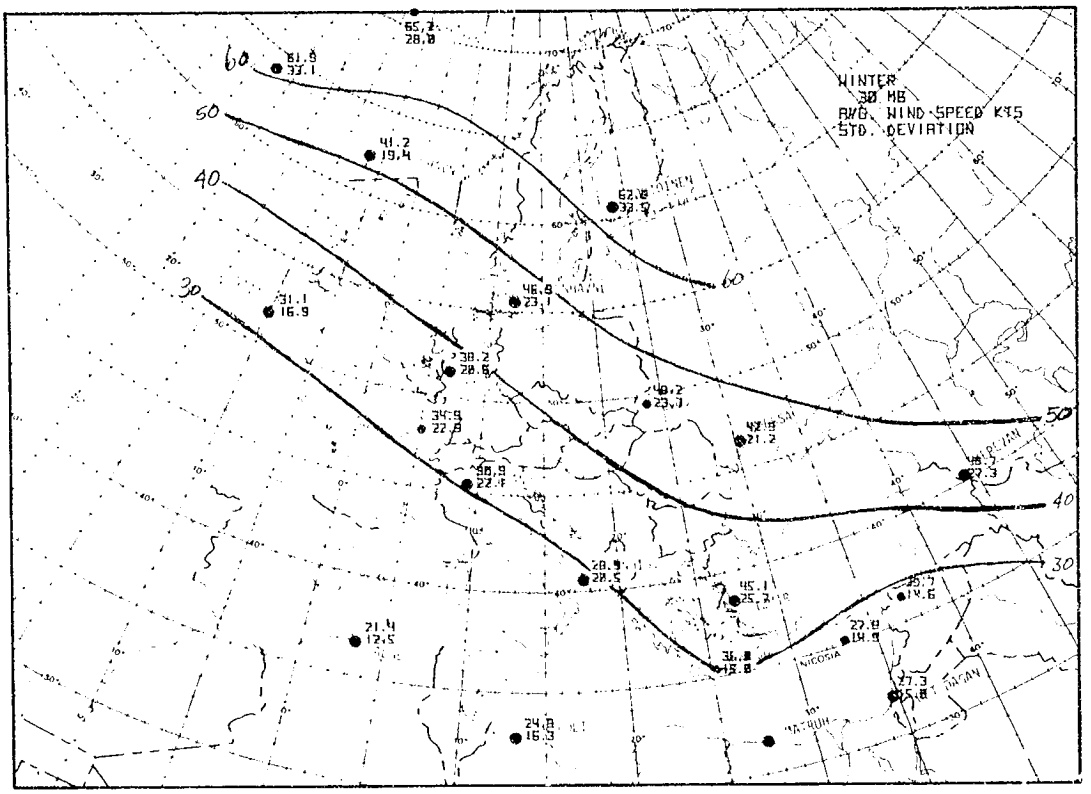
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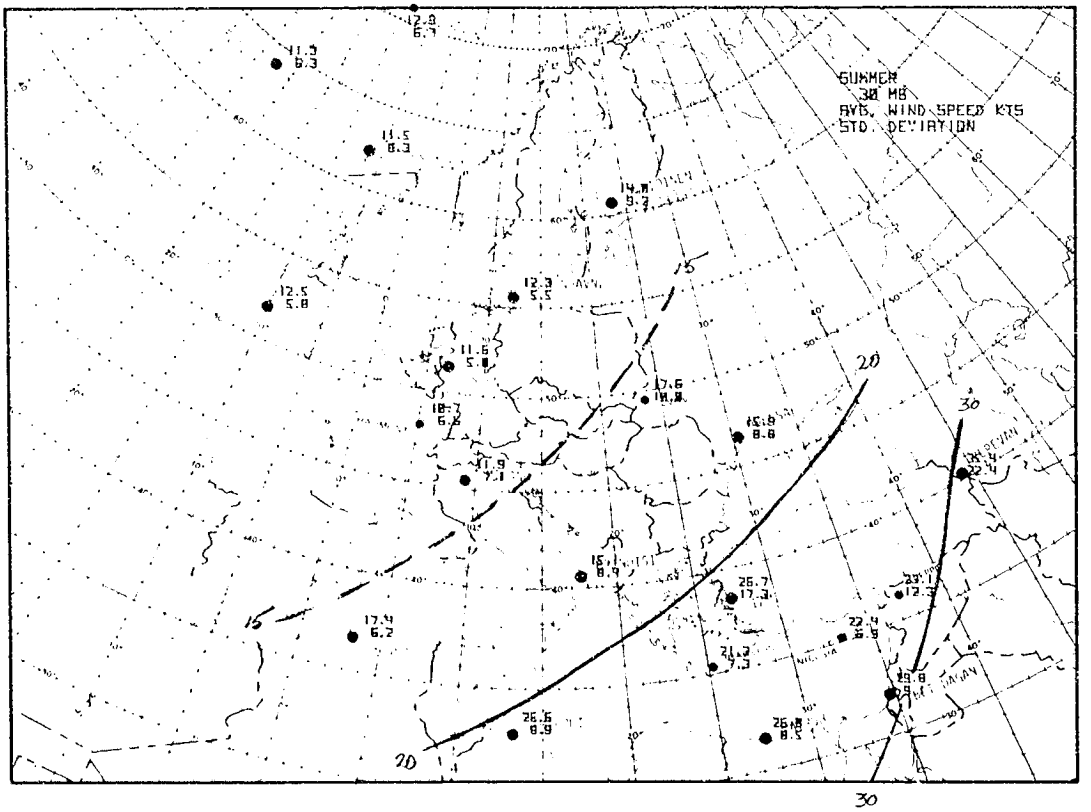
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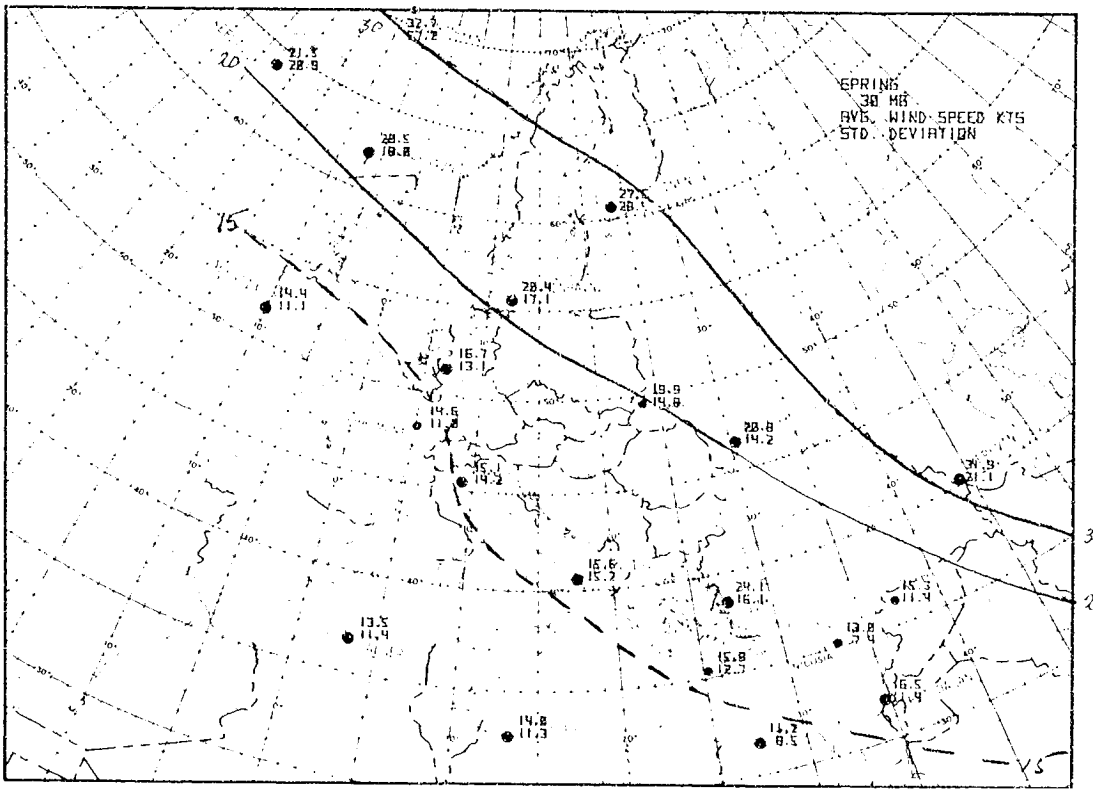
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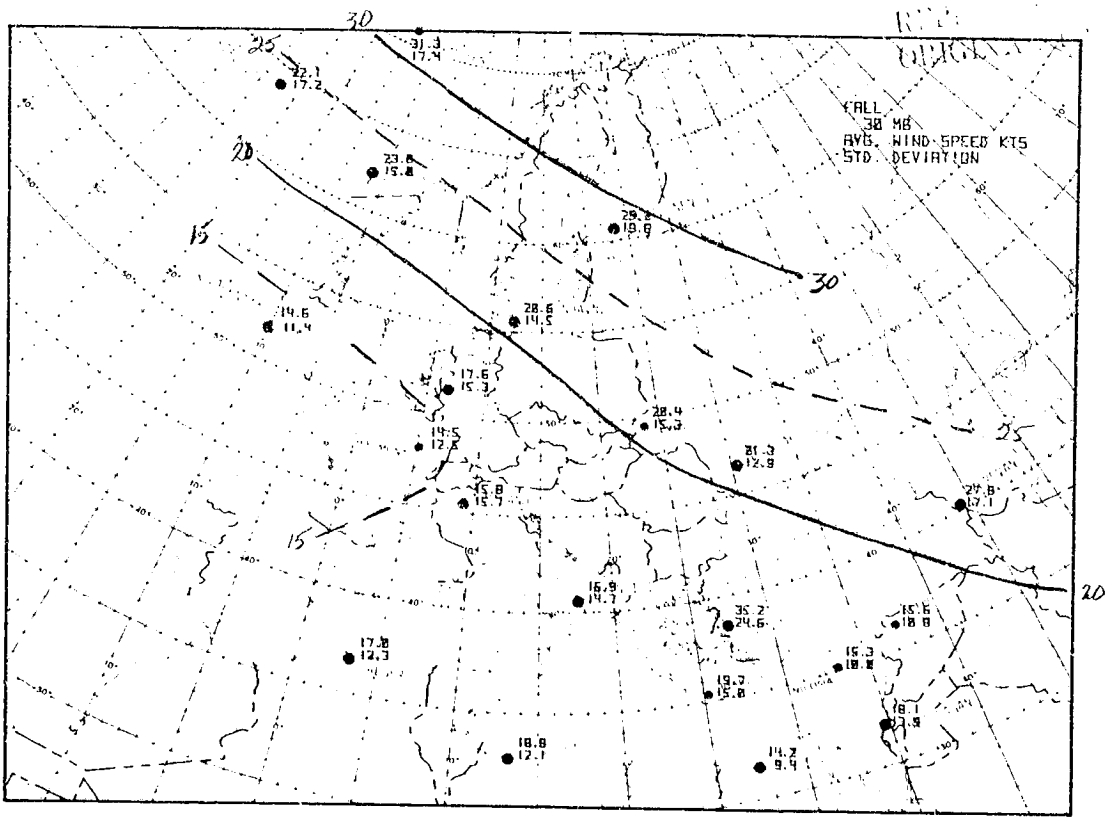
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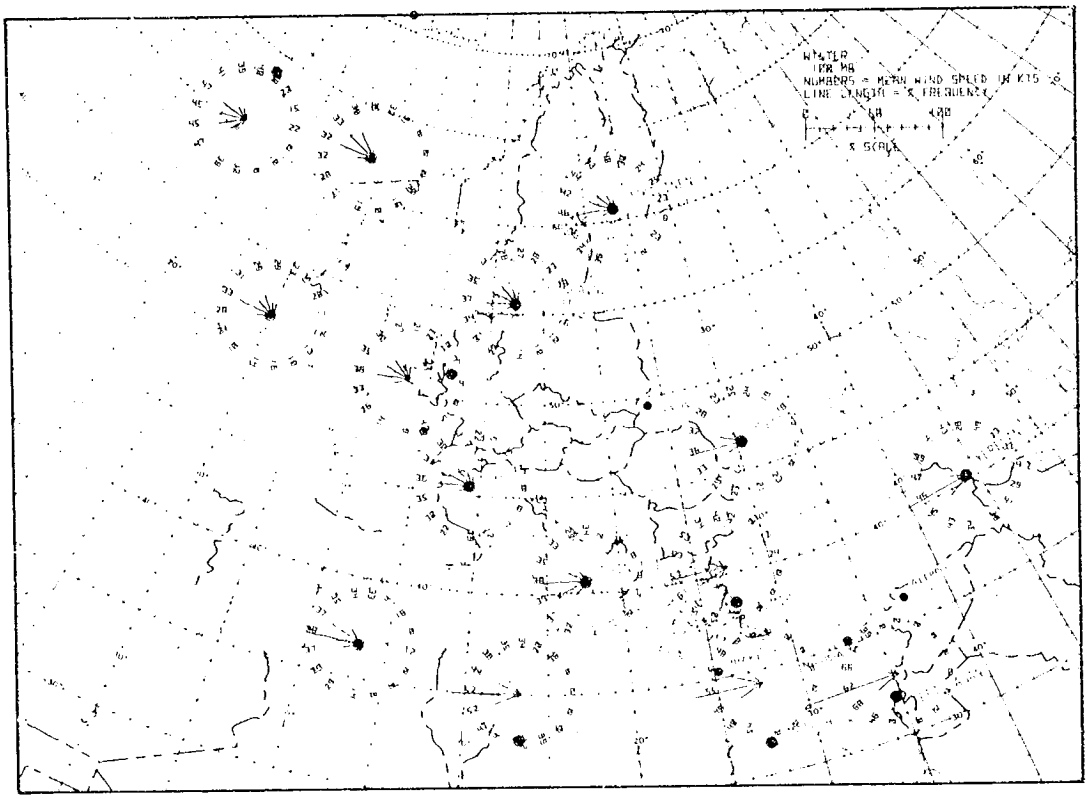
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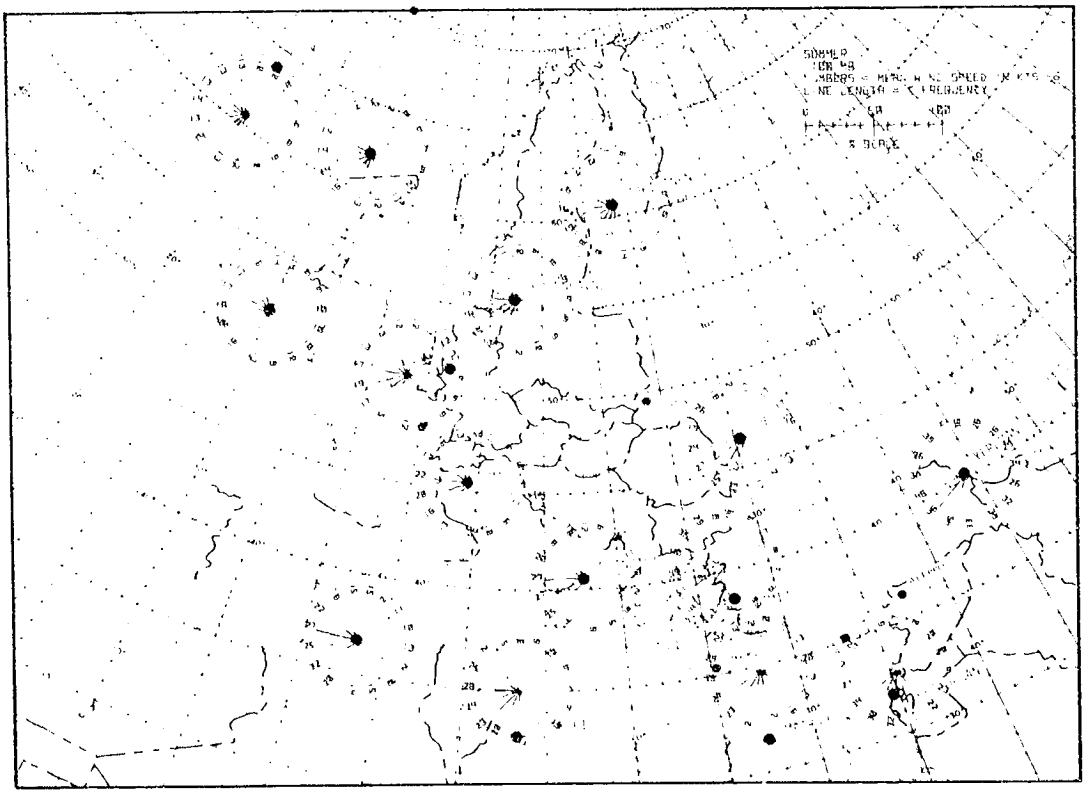
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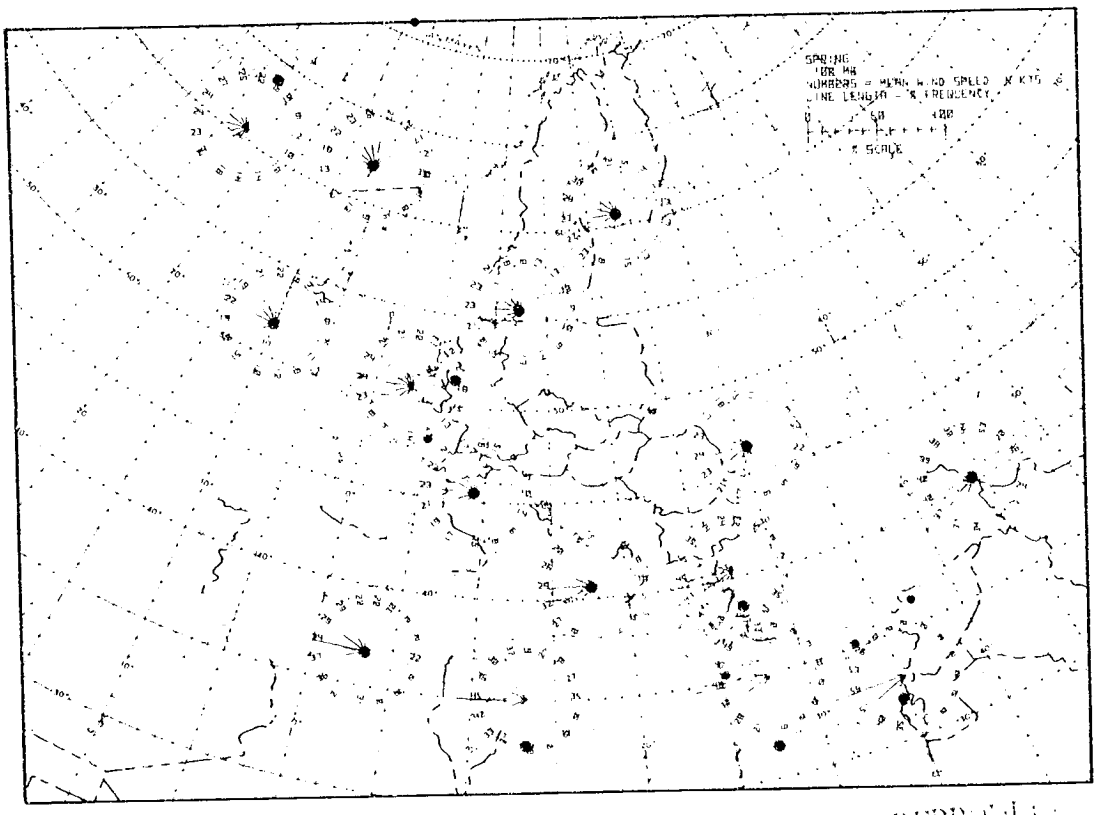

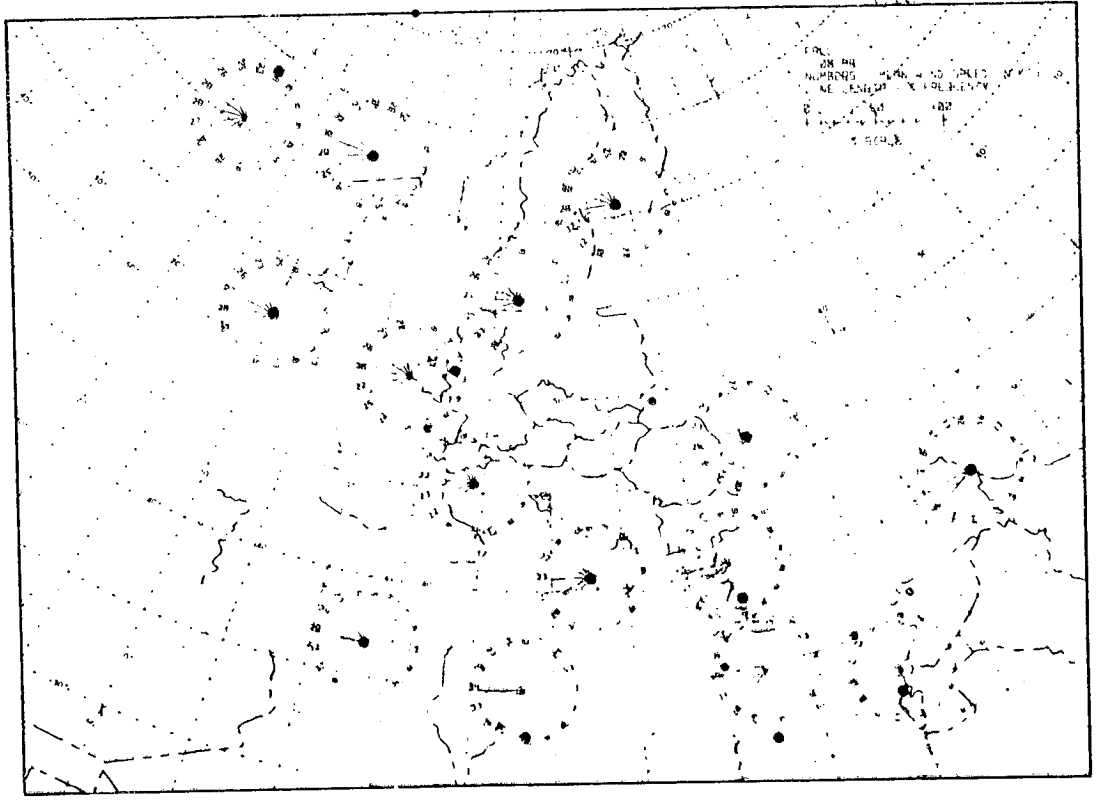

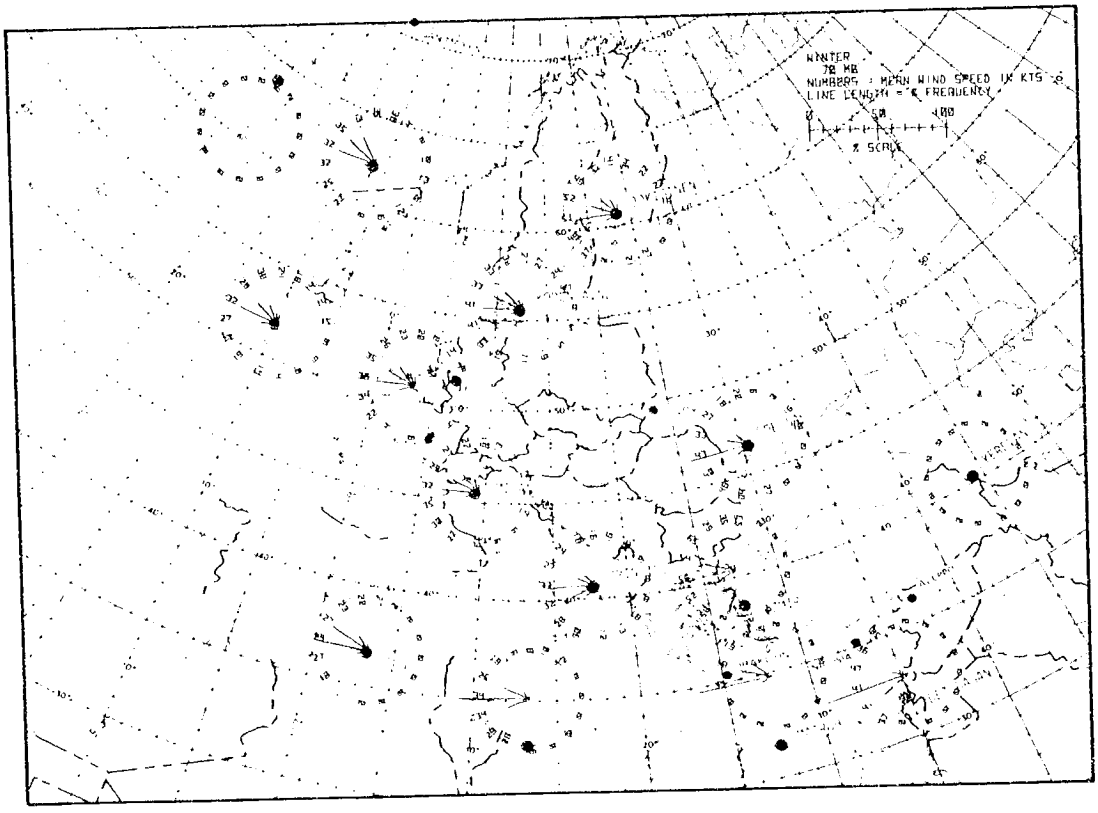
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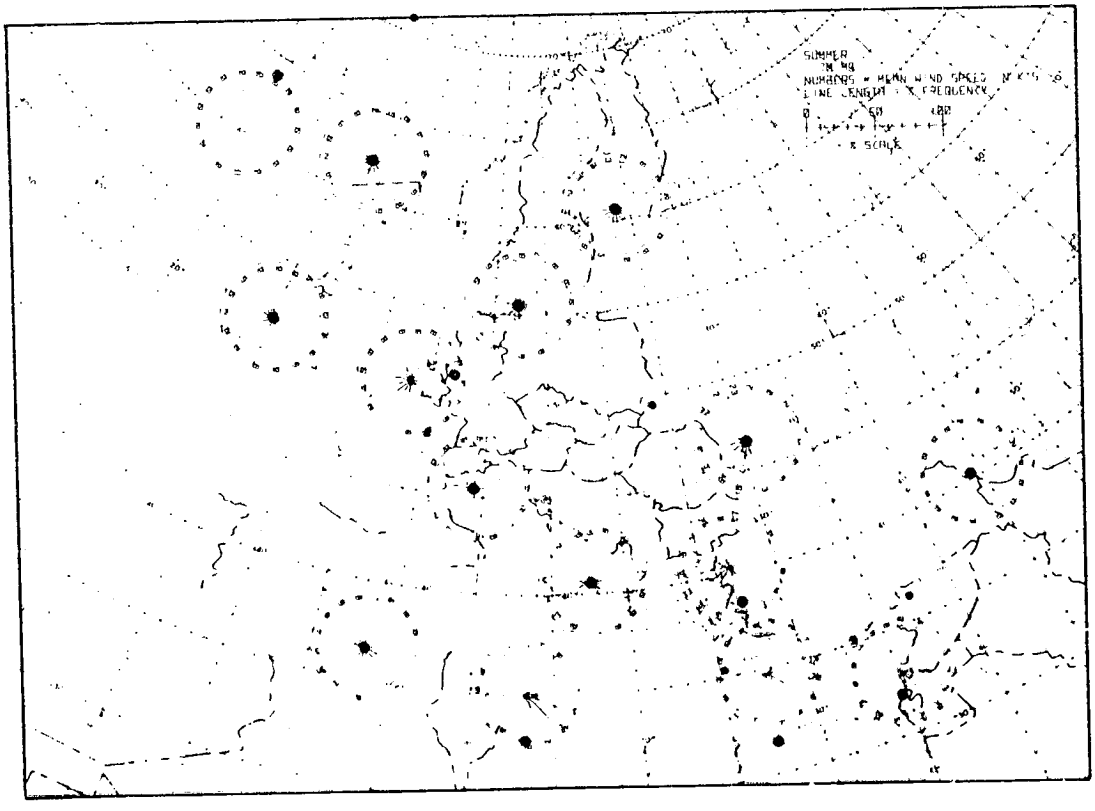
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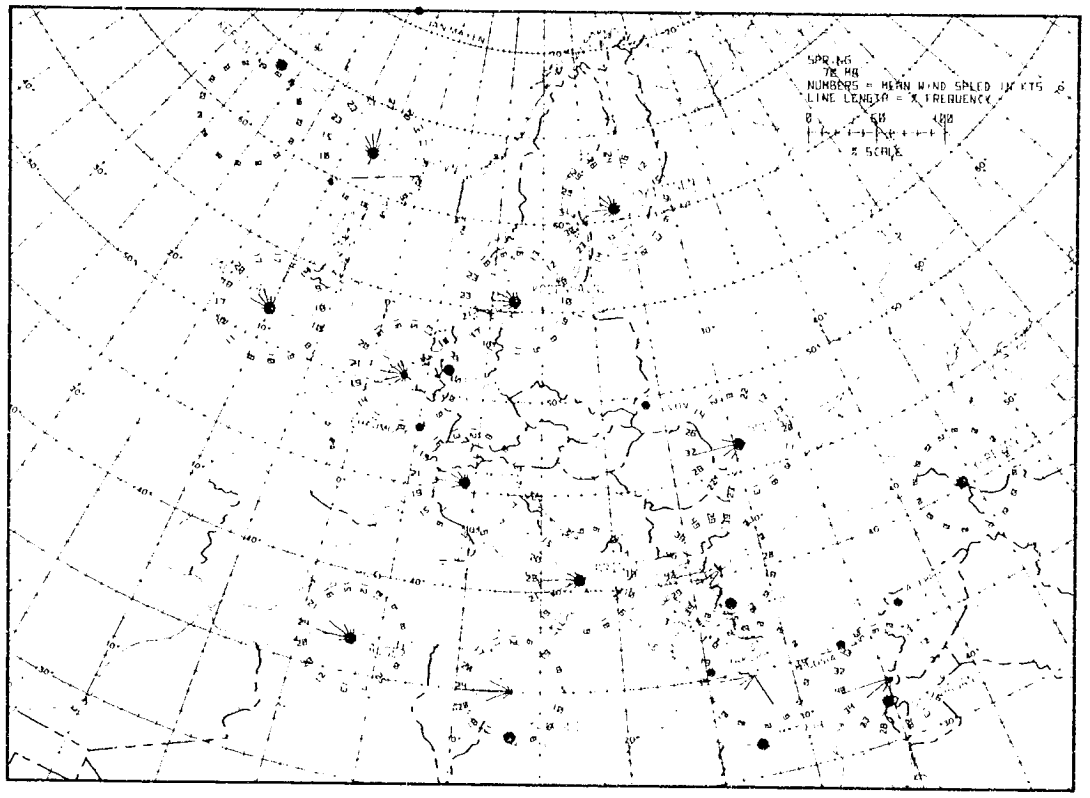
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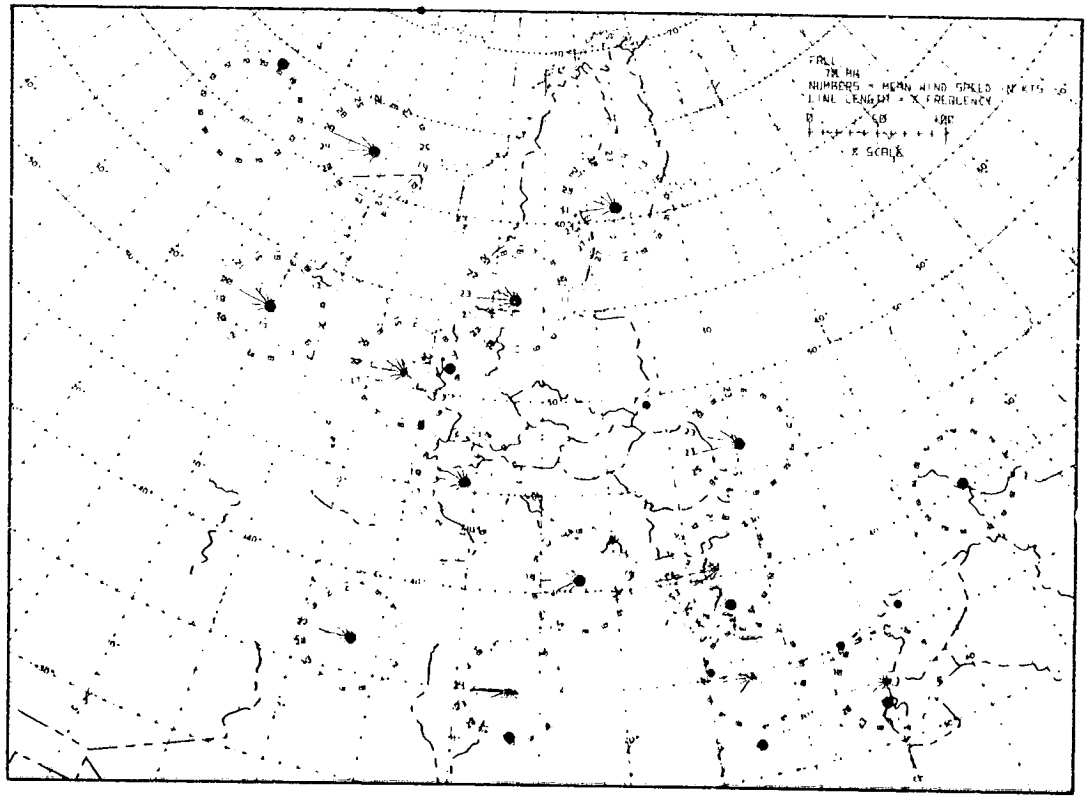
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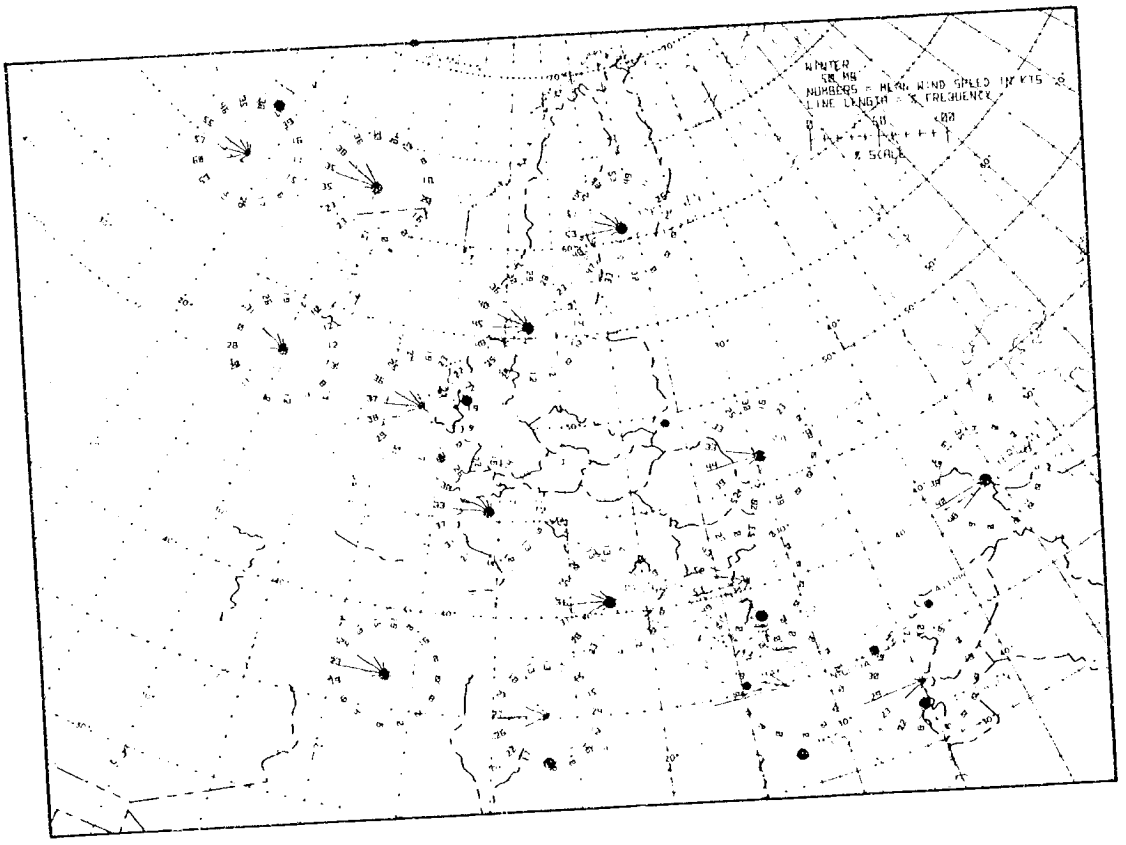
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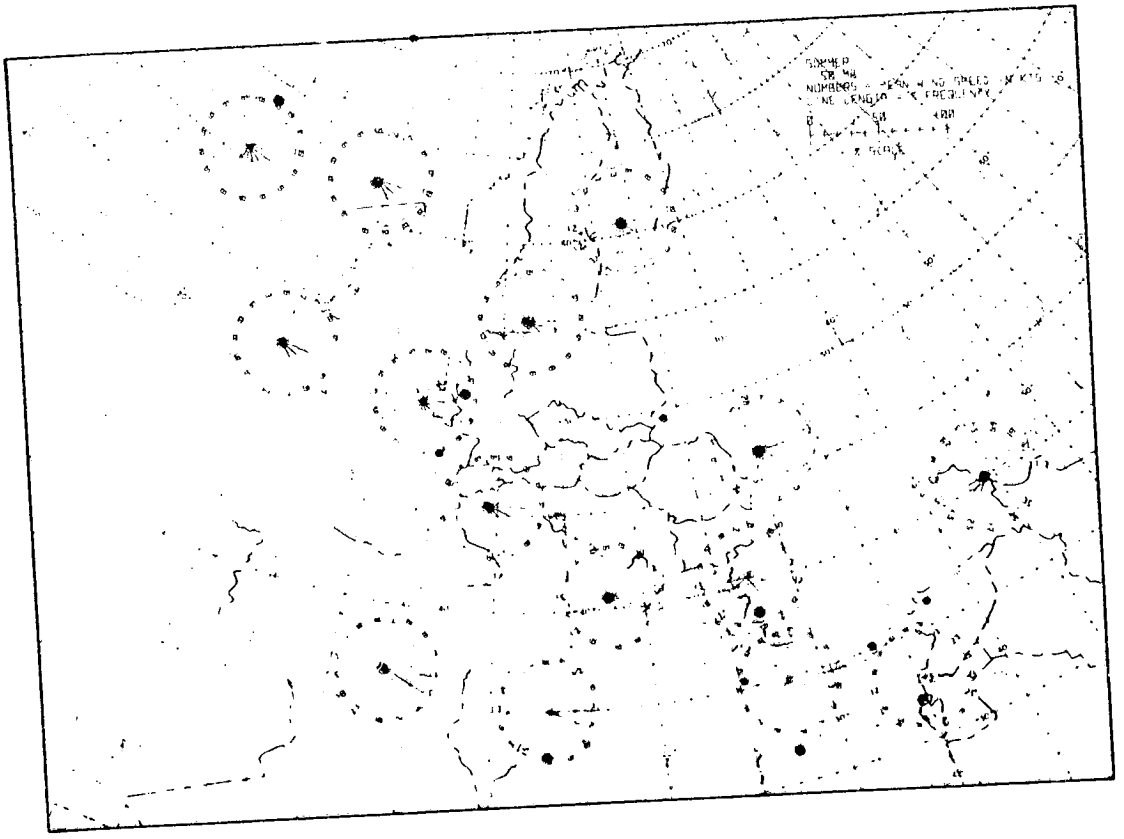

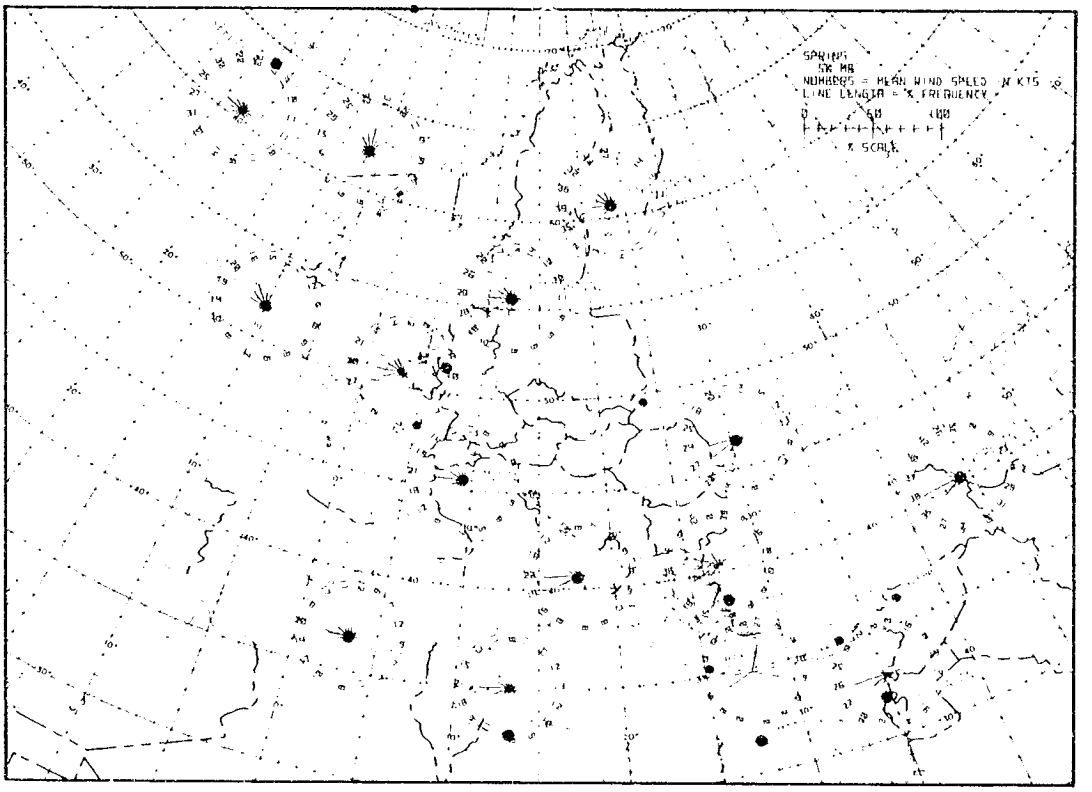
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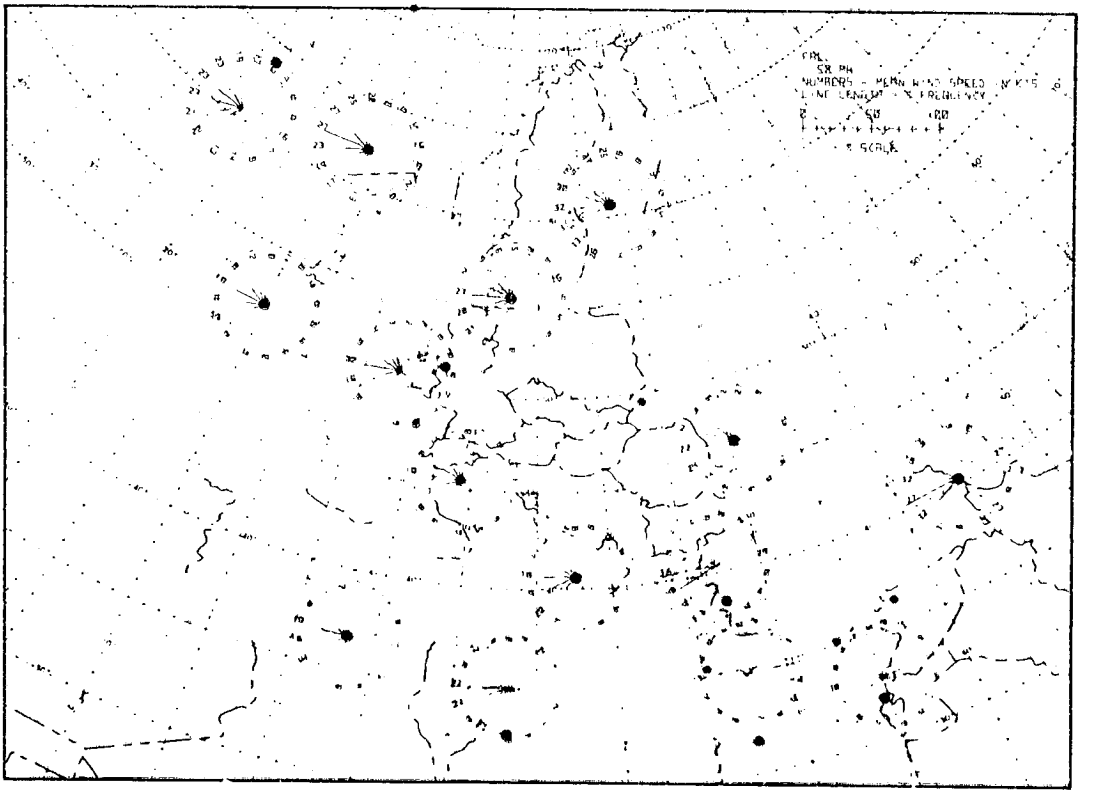
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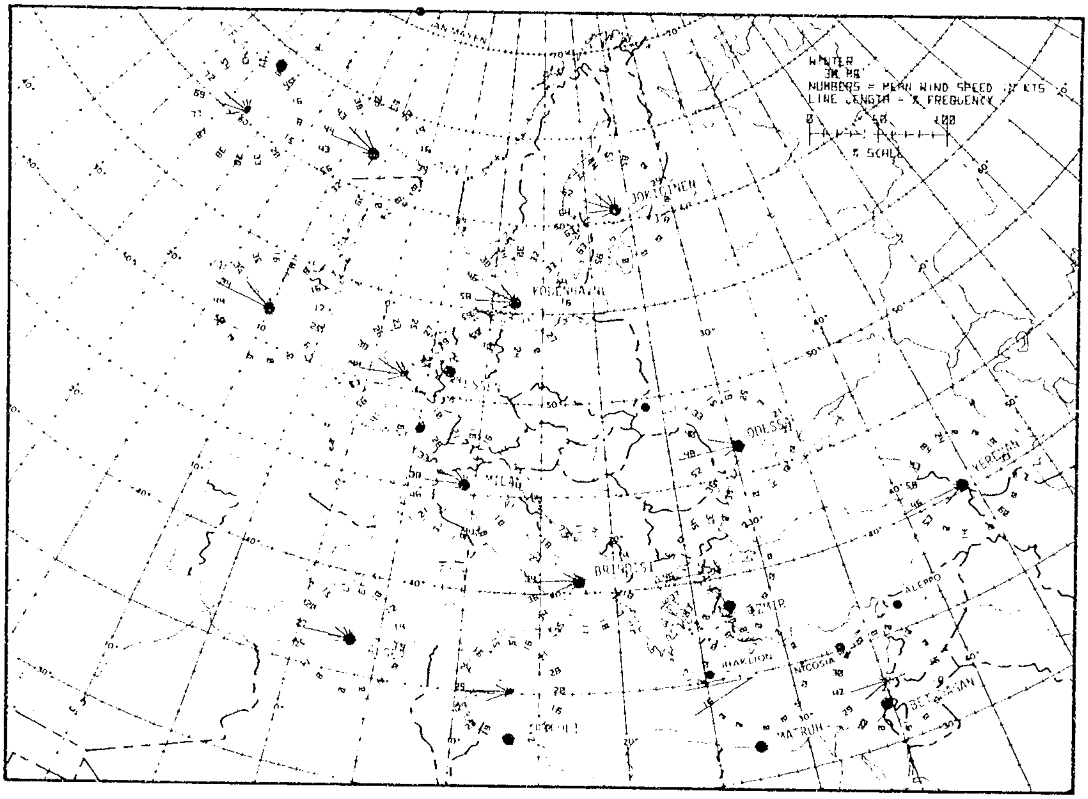
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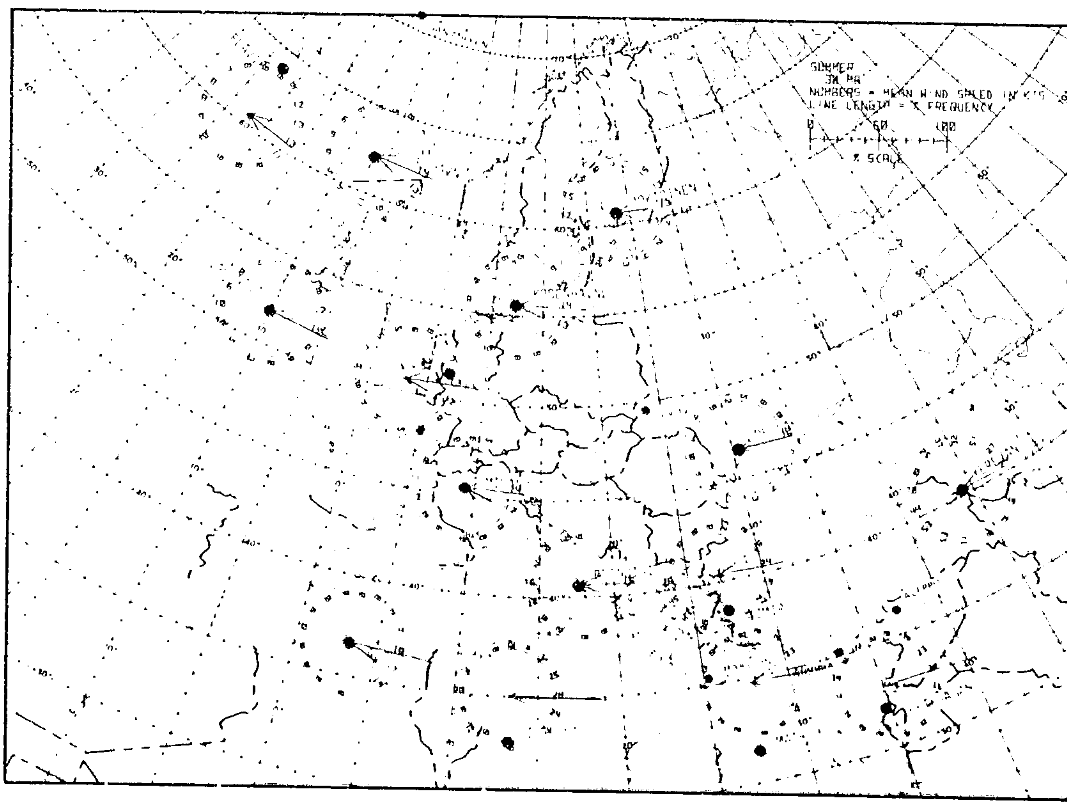
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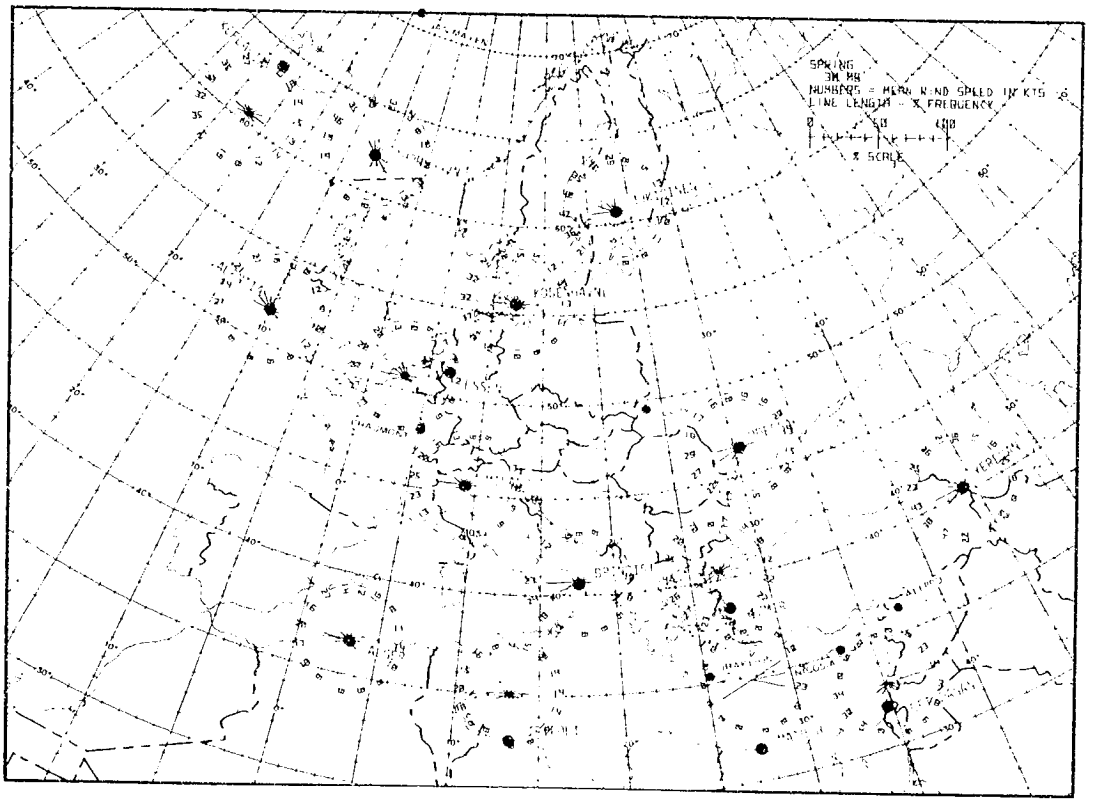
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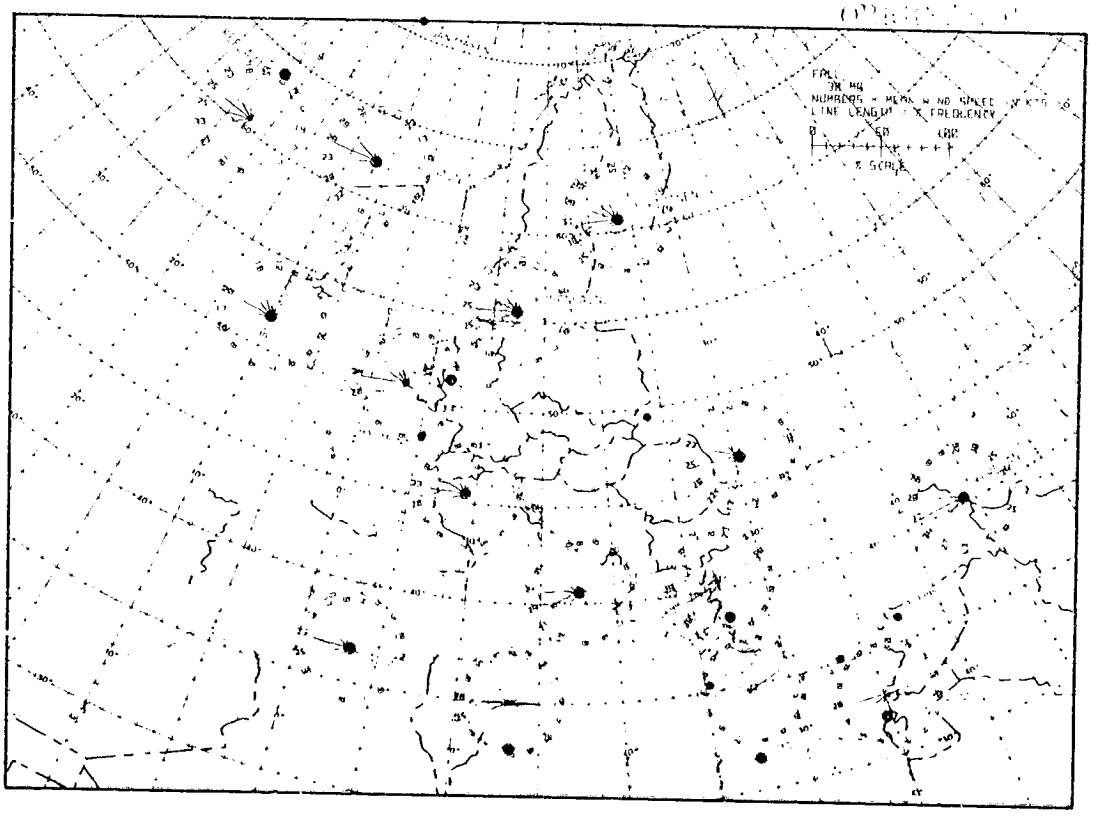
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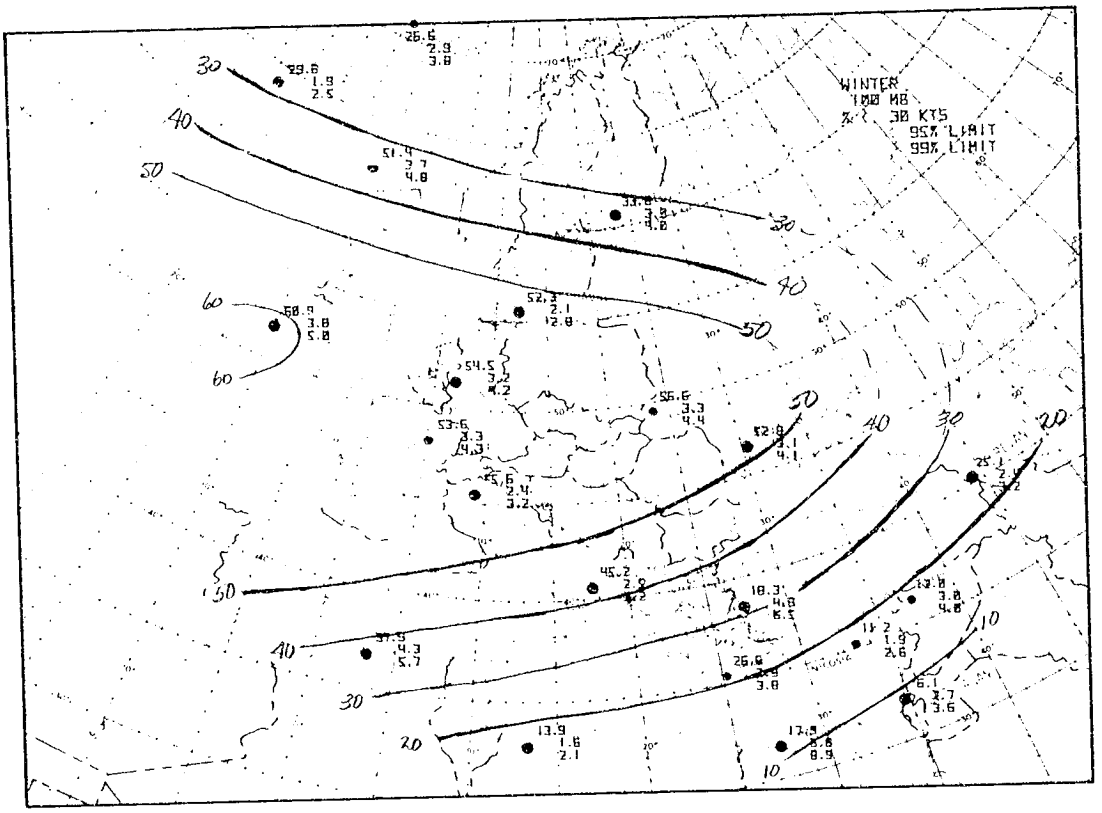
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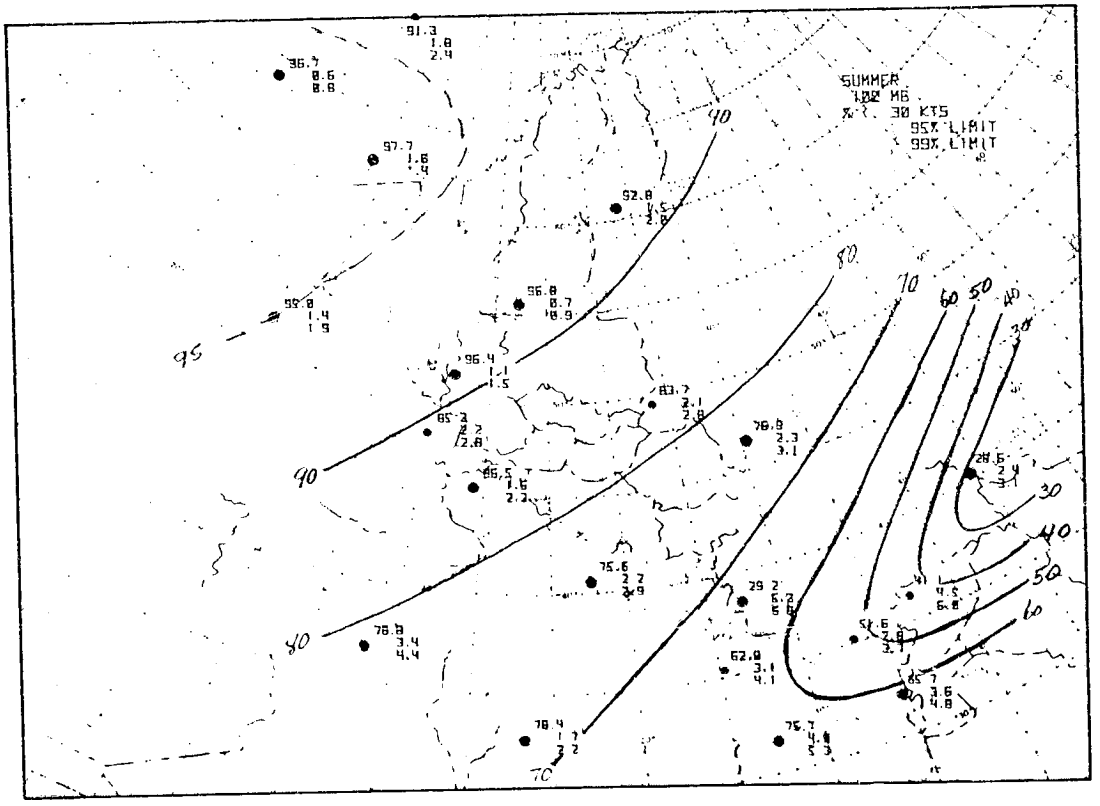
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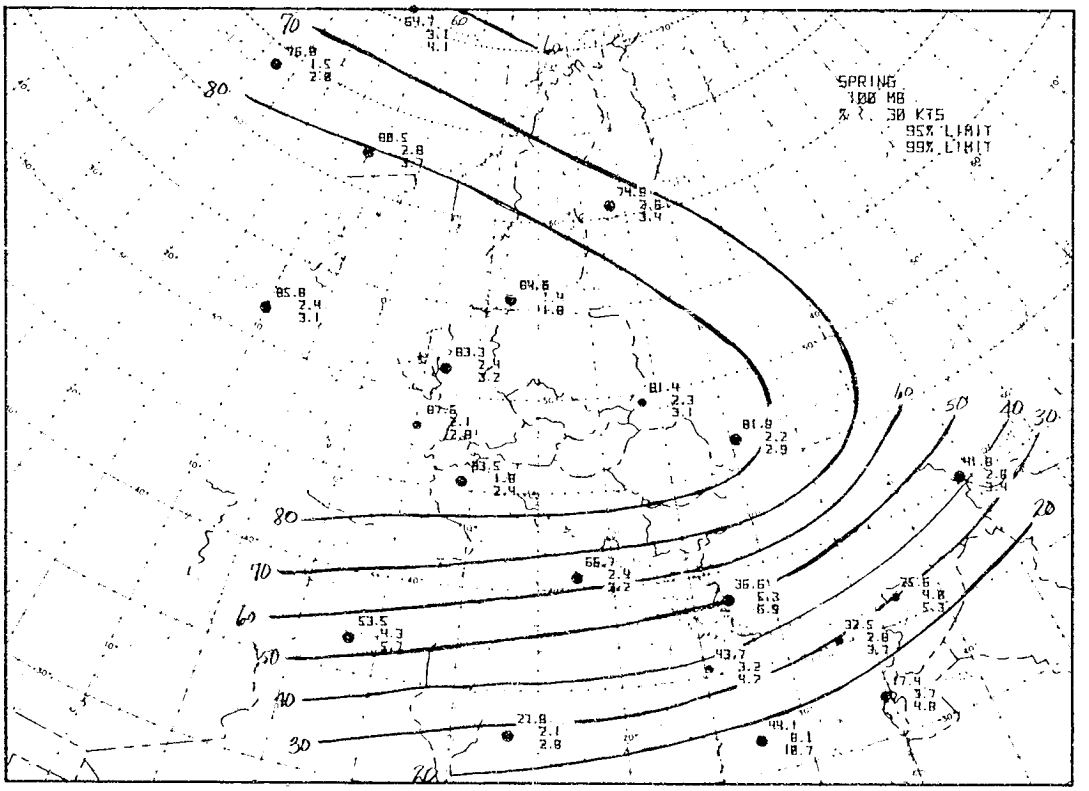
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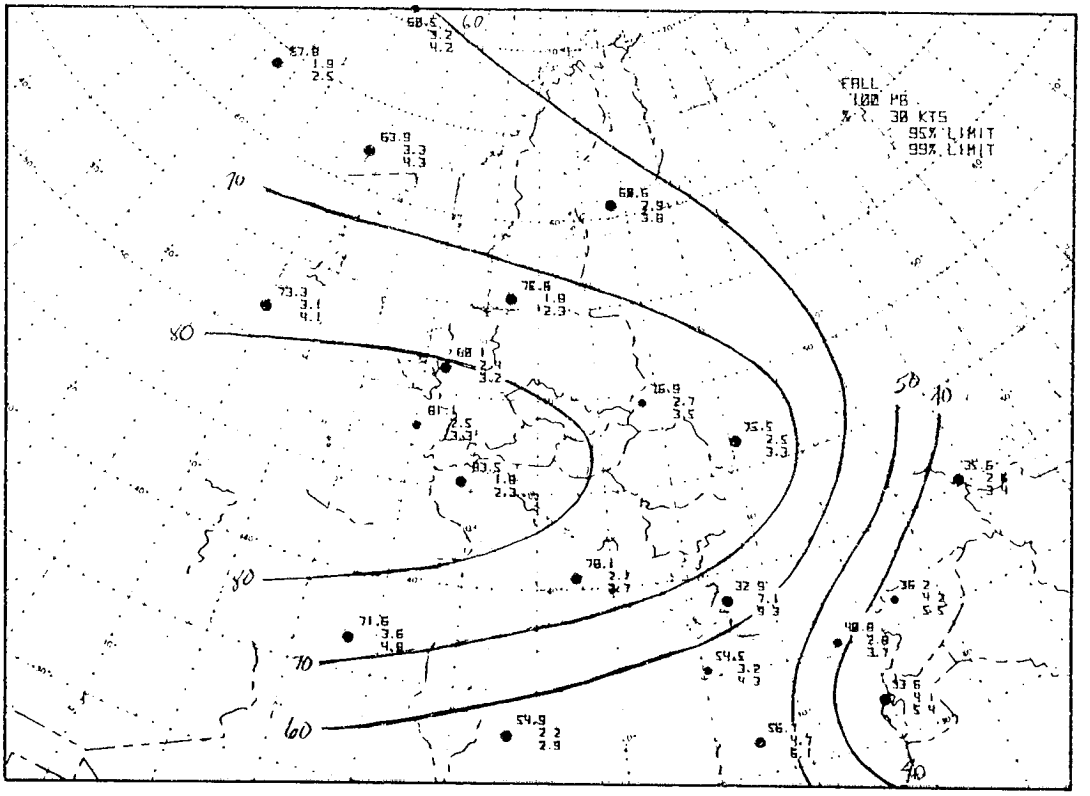
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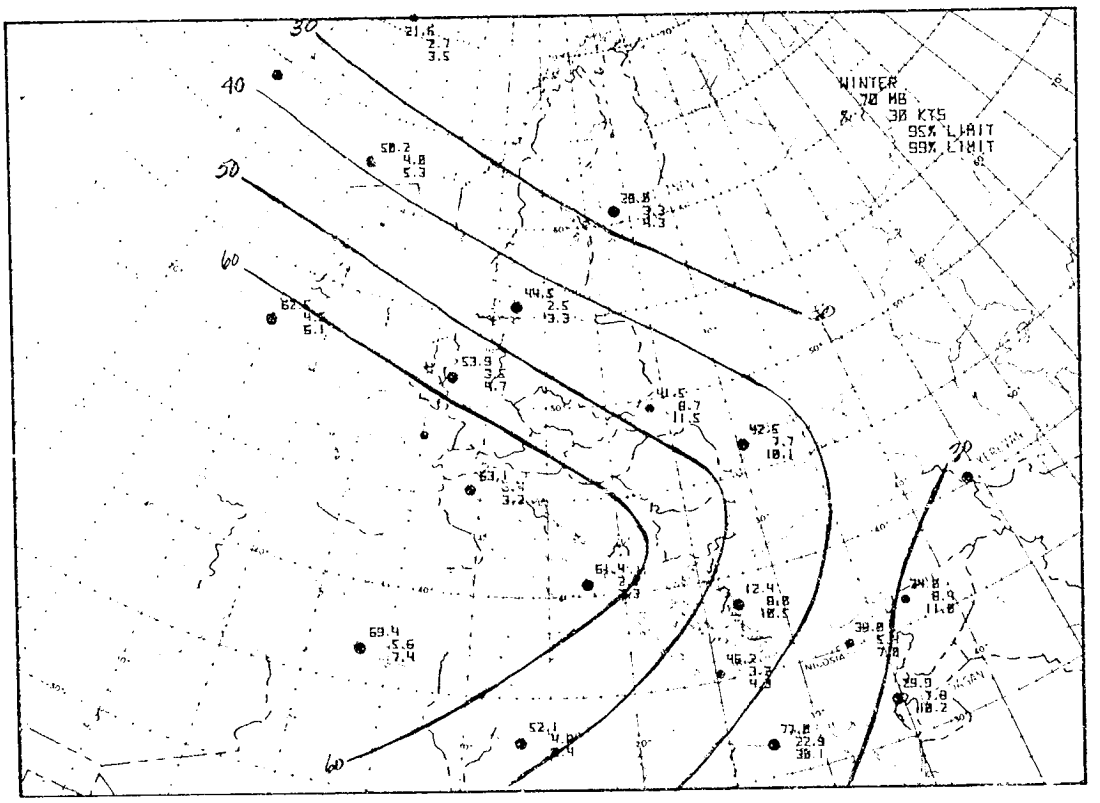
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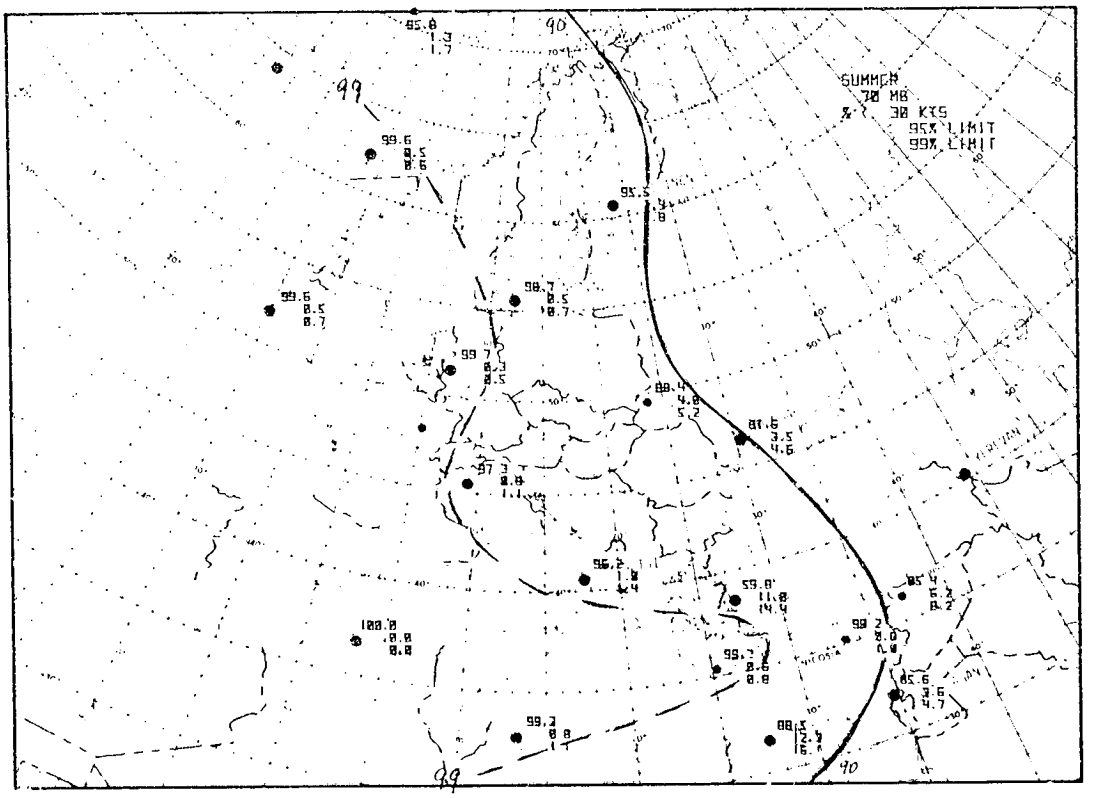
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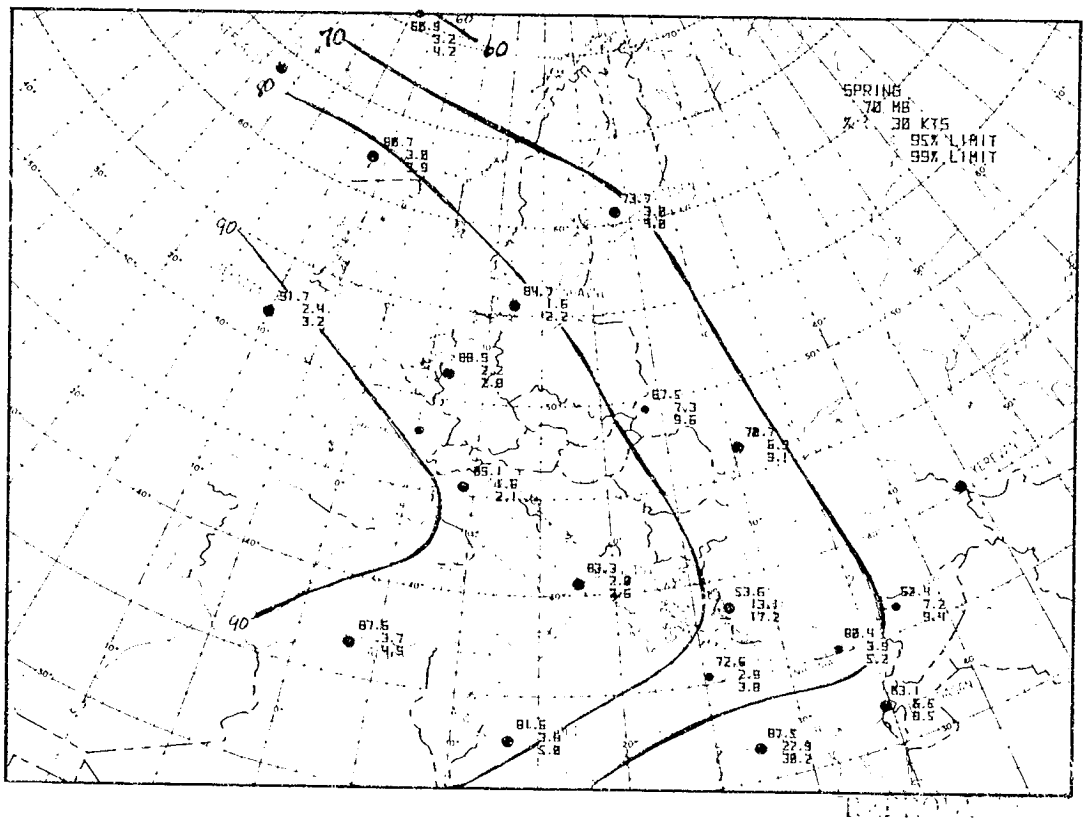
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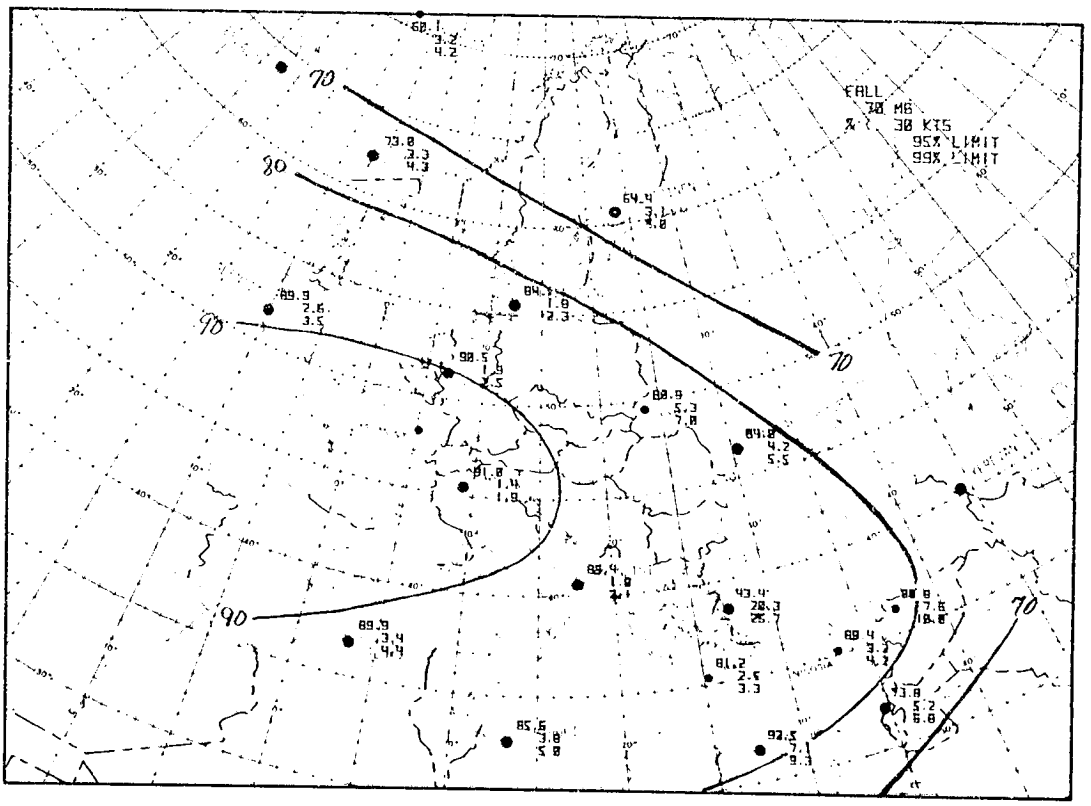
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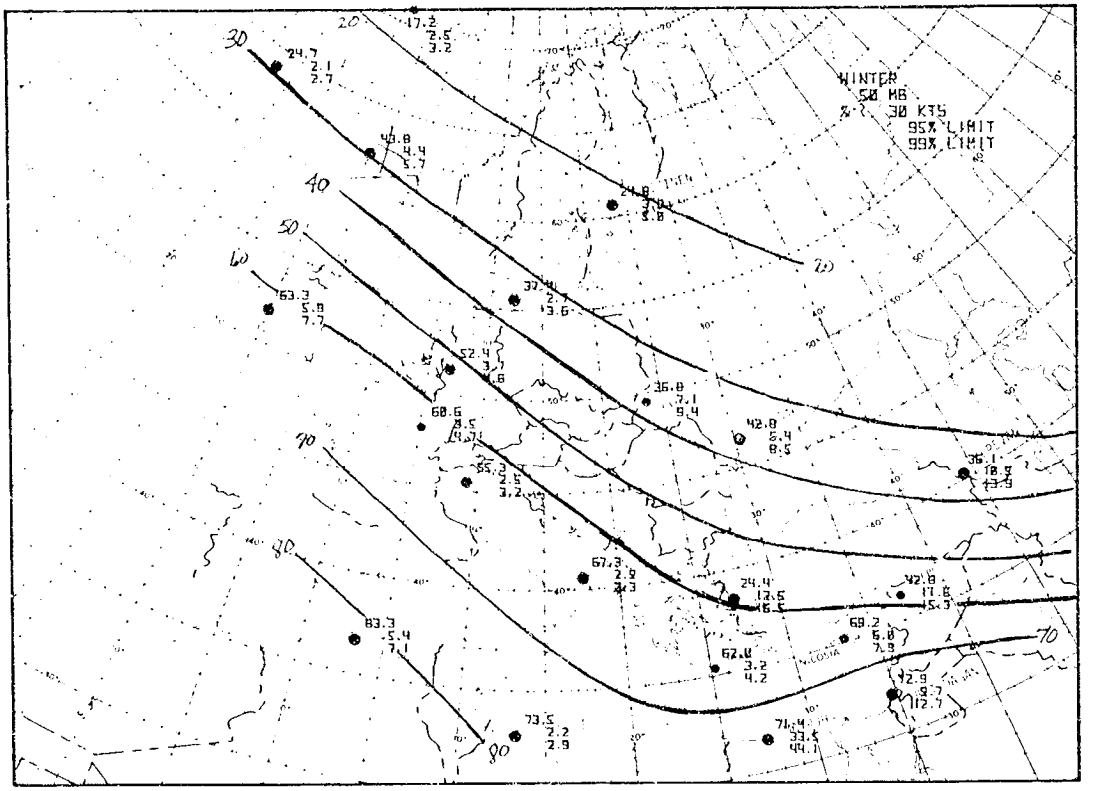
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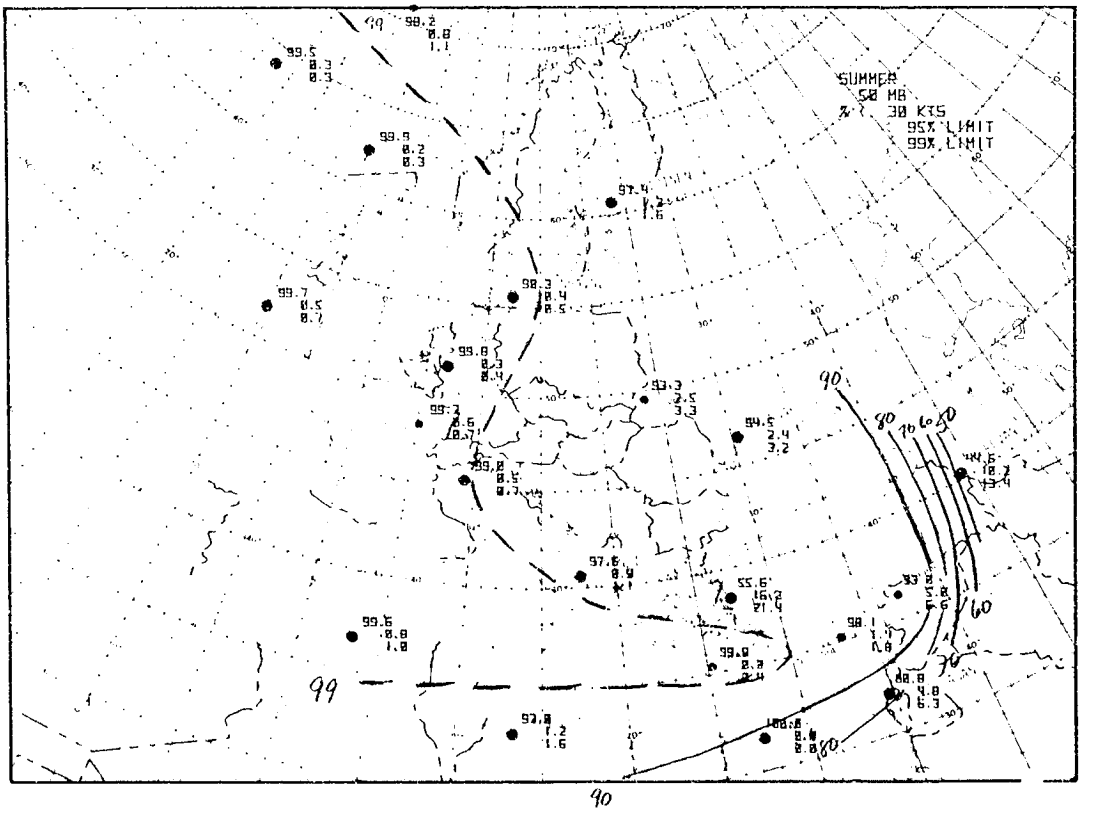
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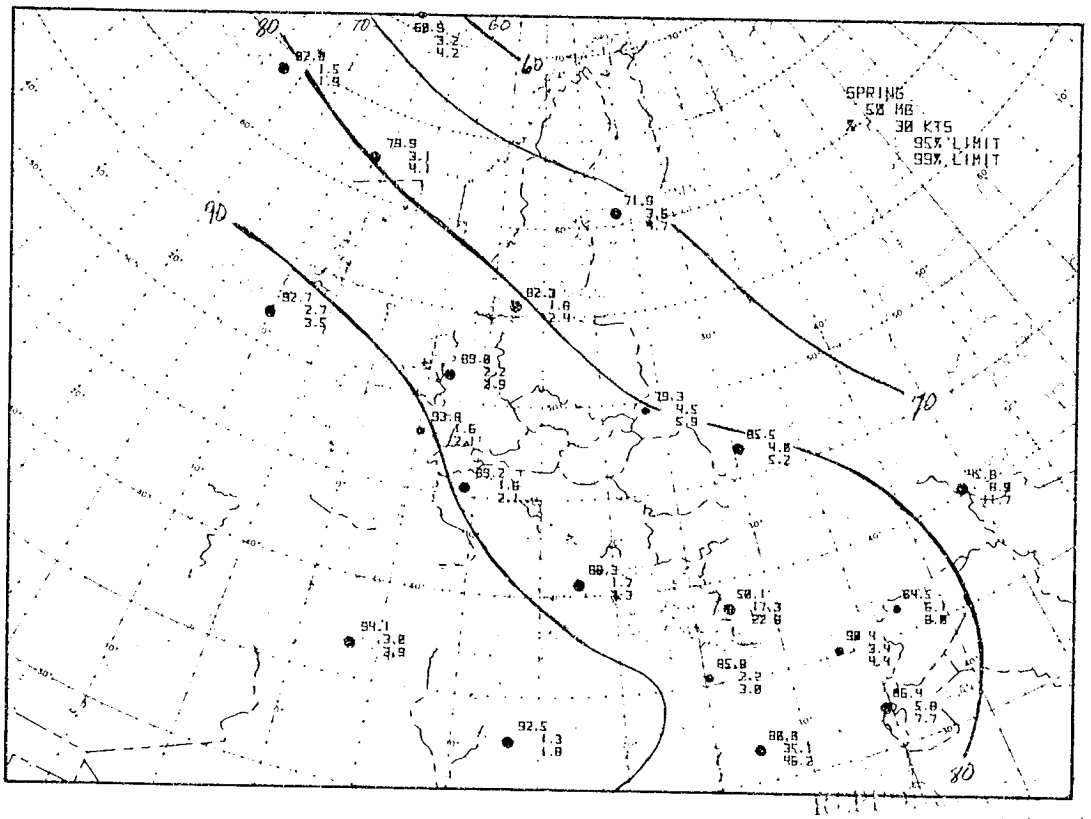
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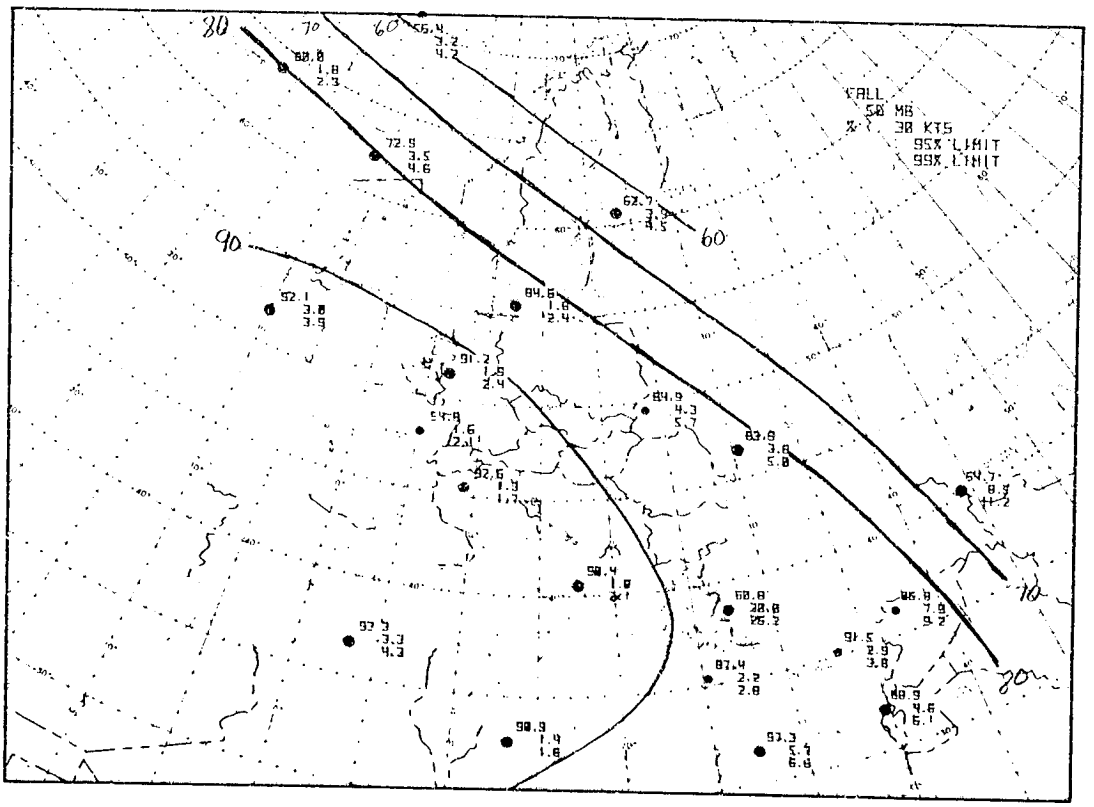
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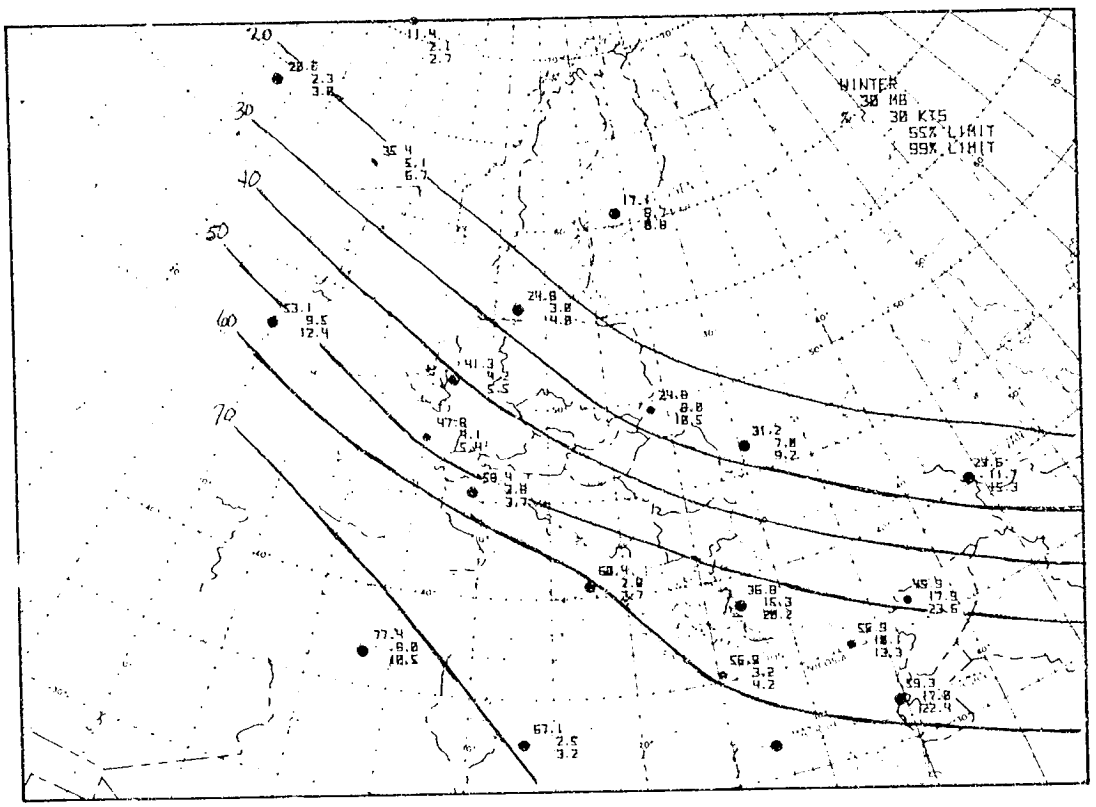
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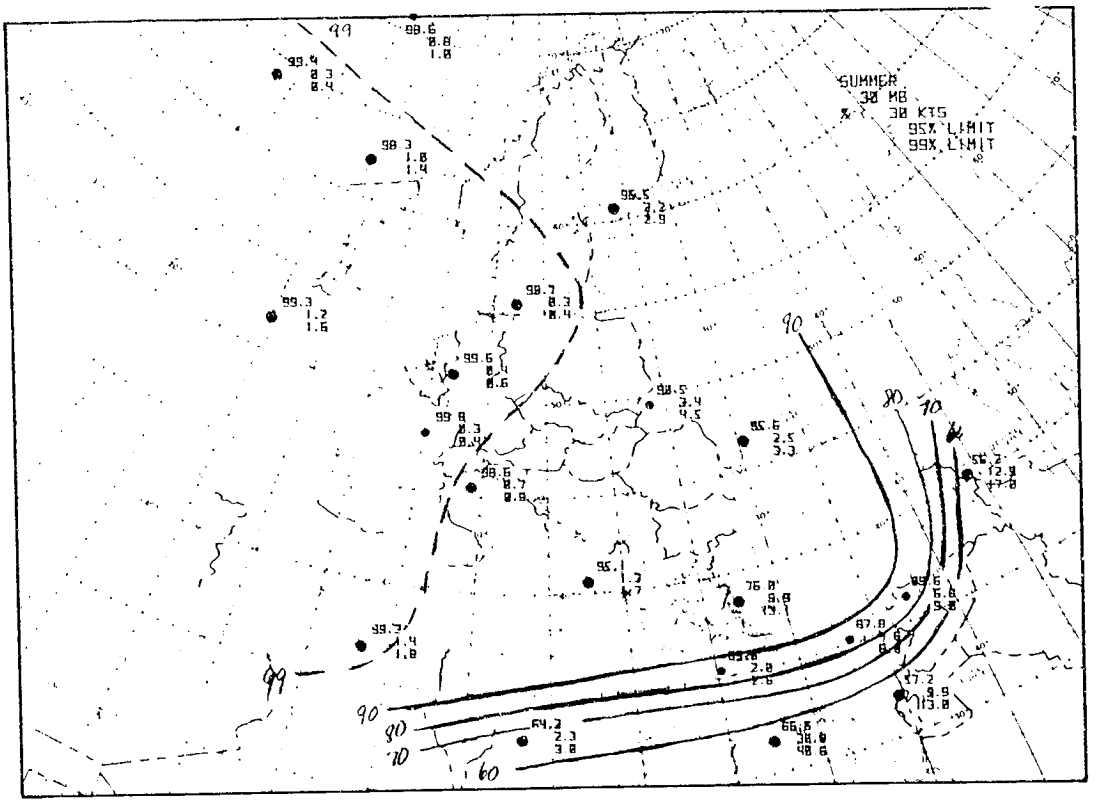
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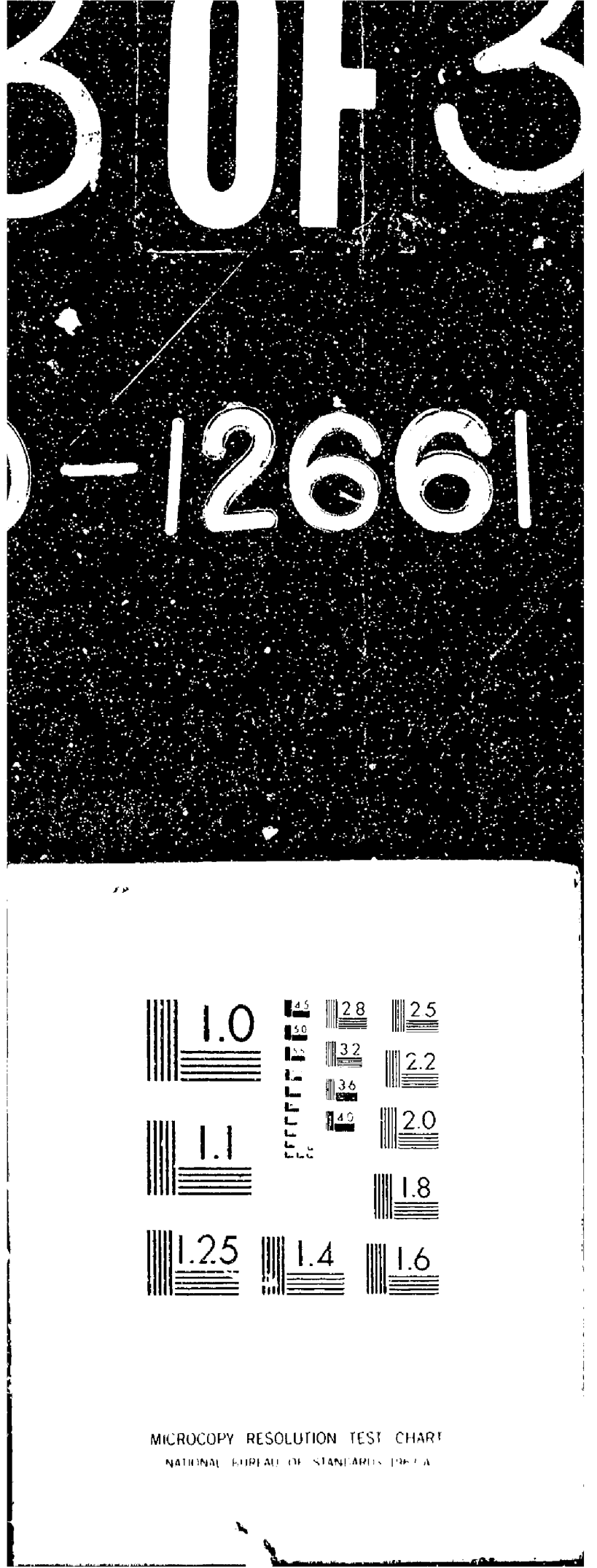
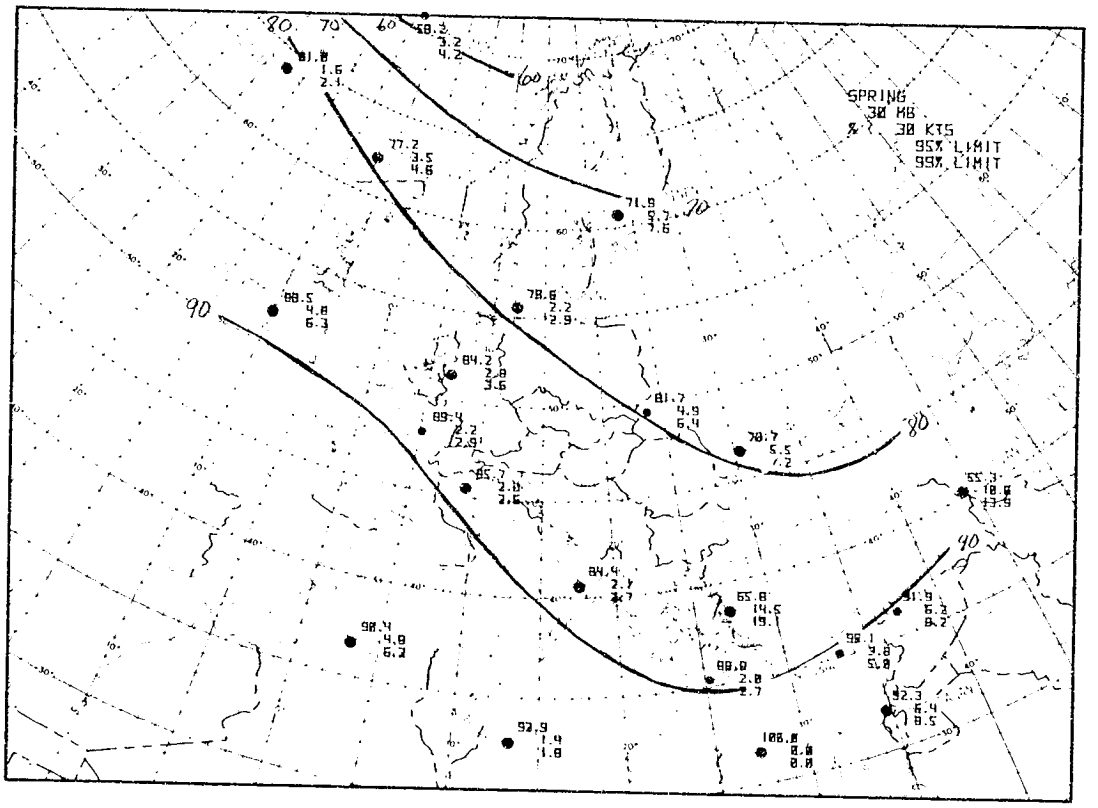


MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963-A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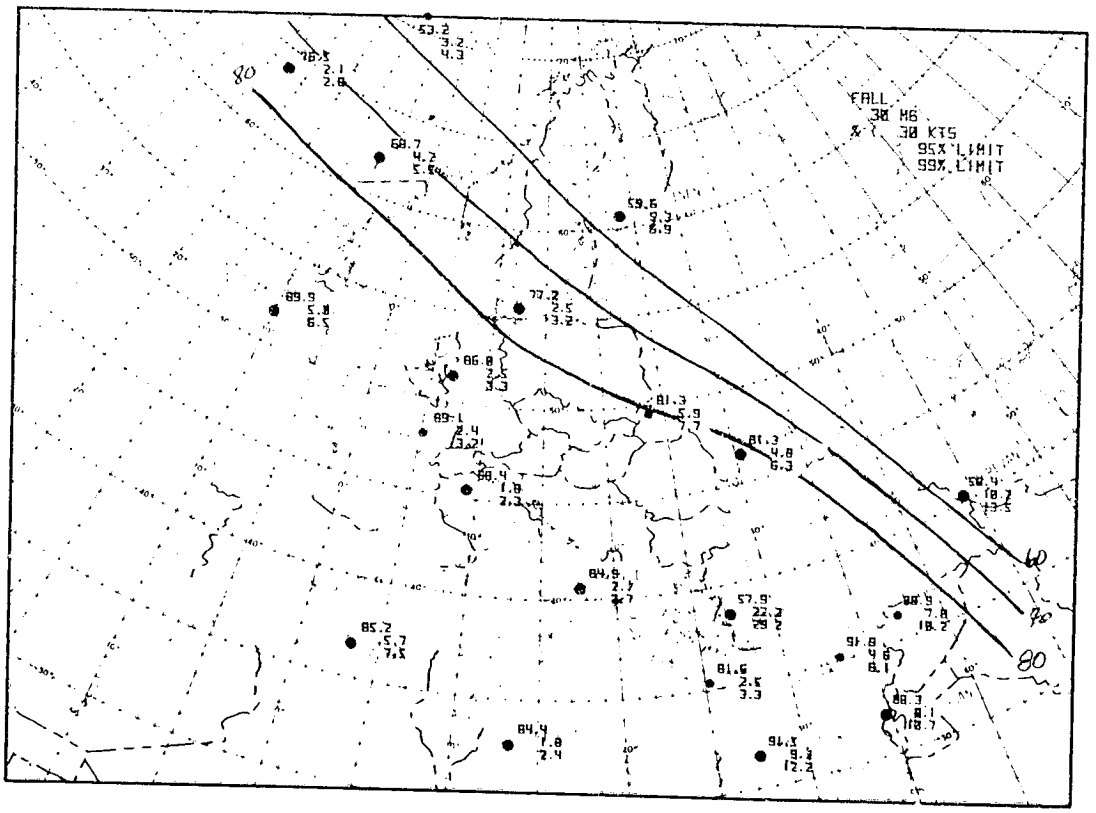
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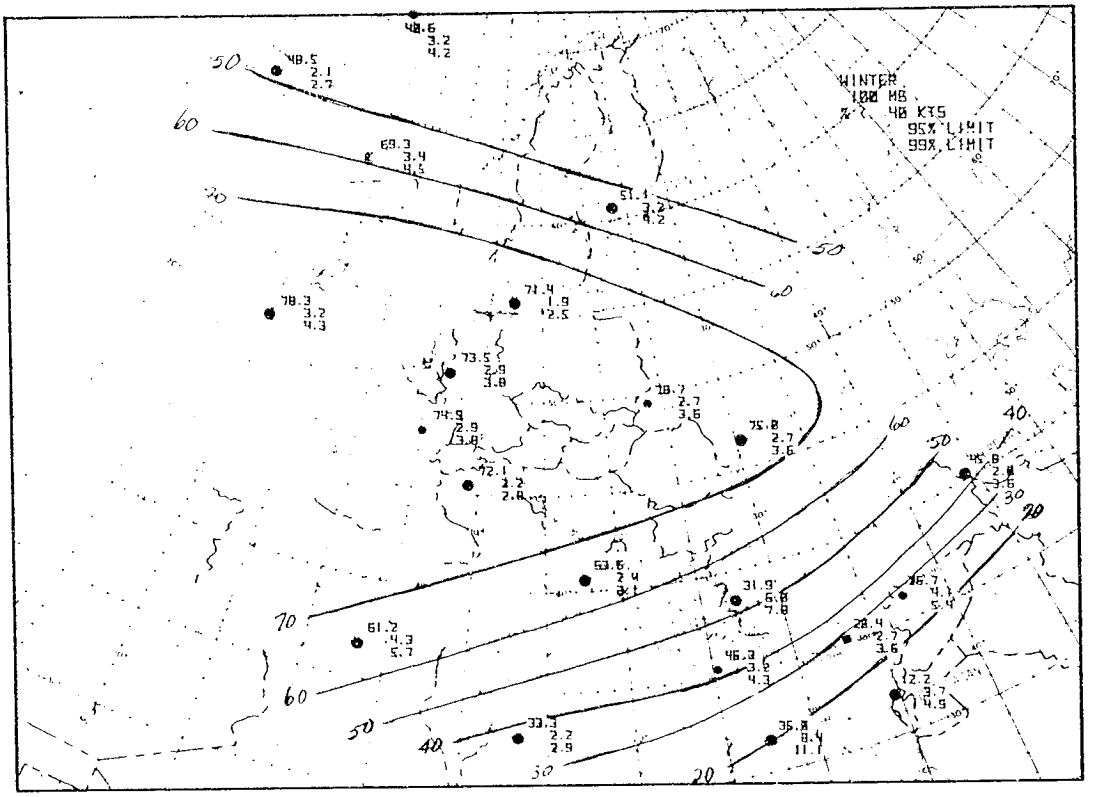
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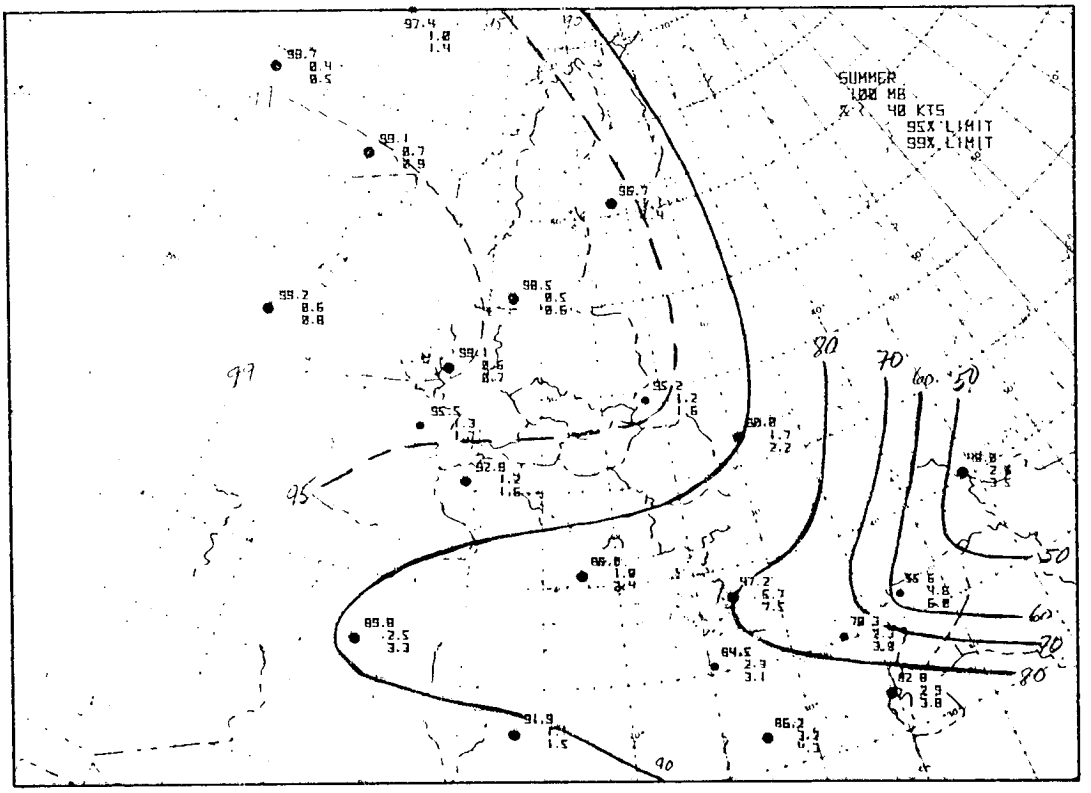
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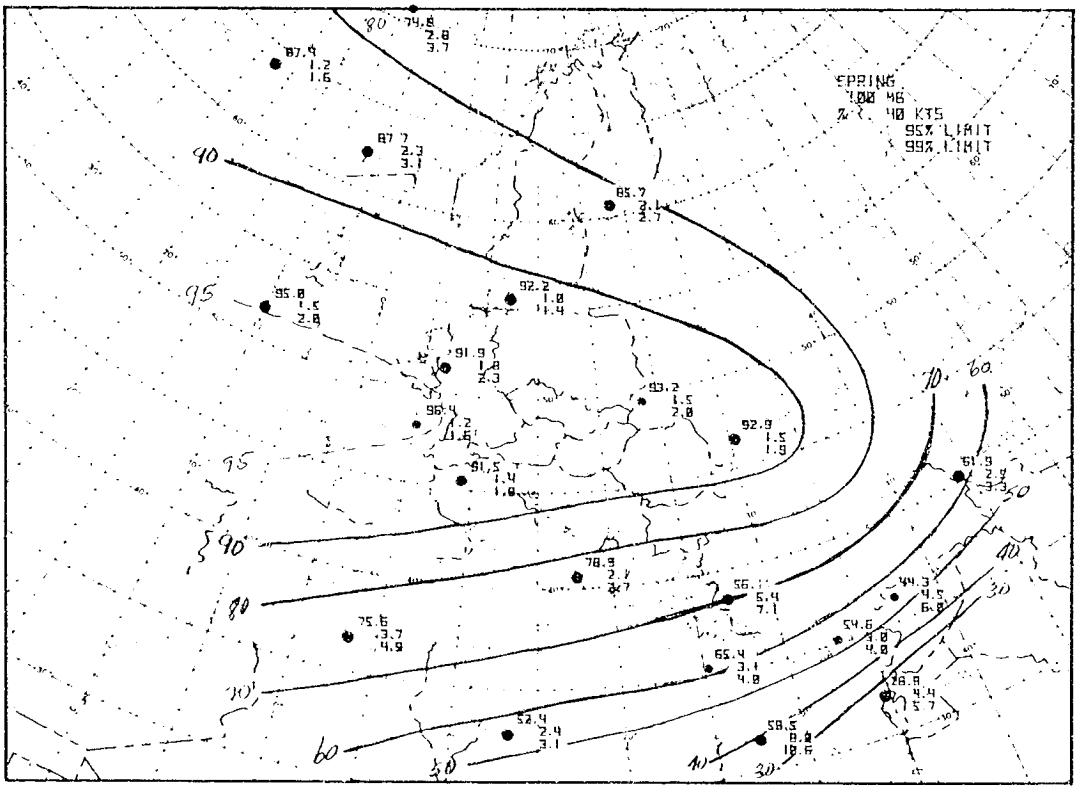
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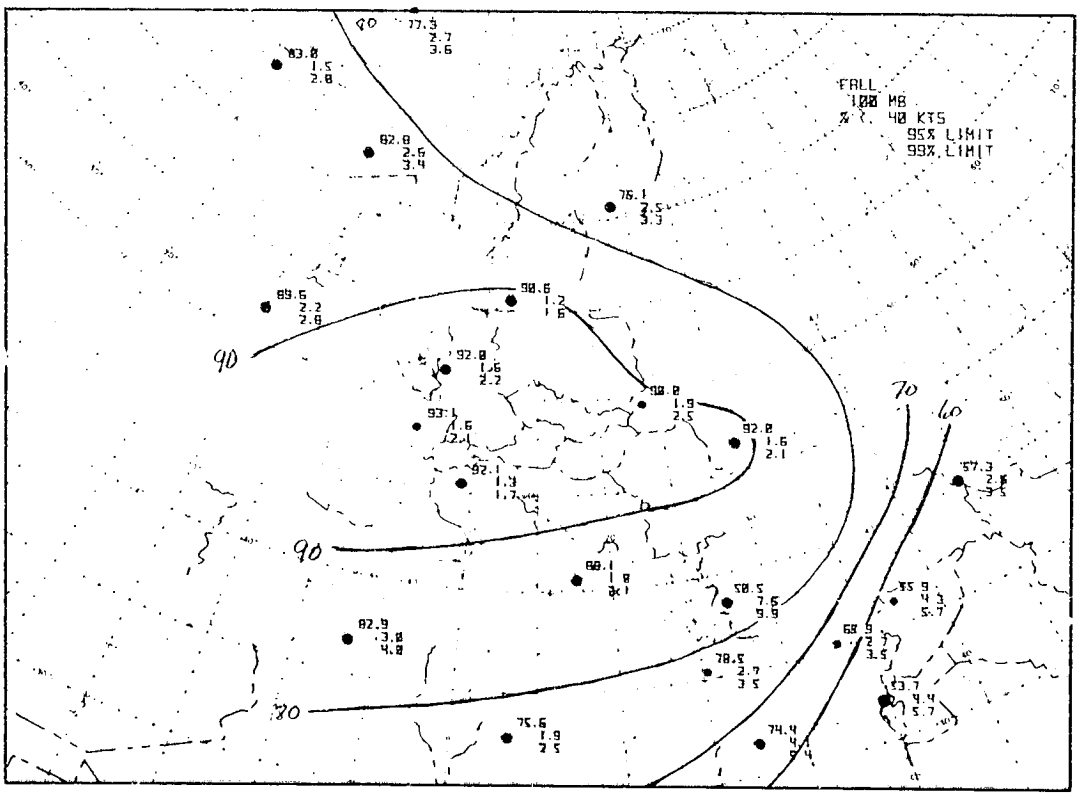
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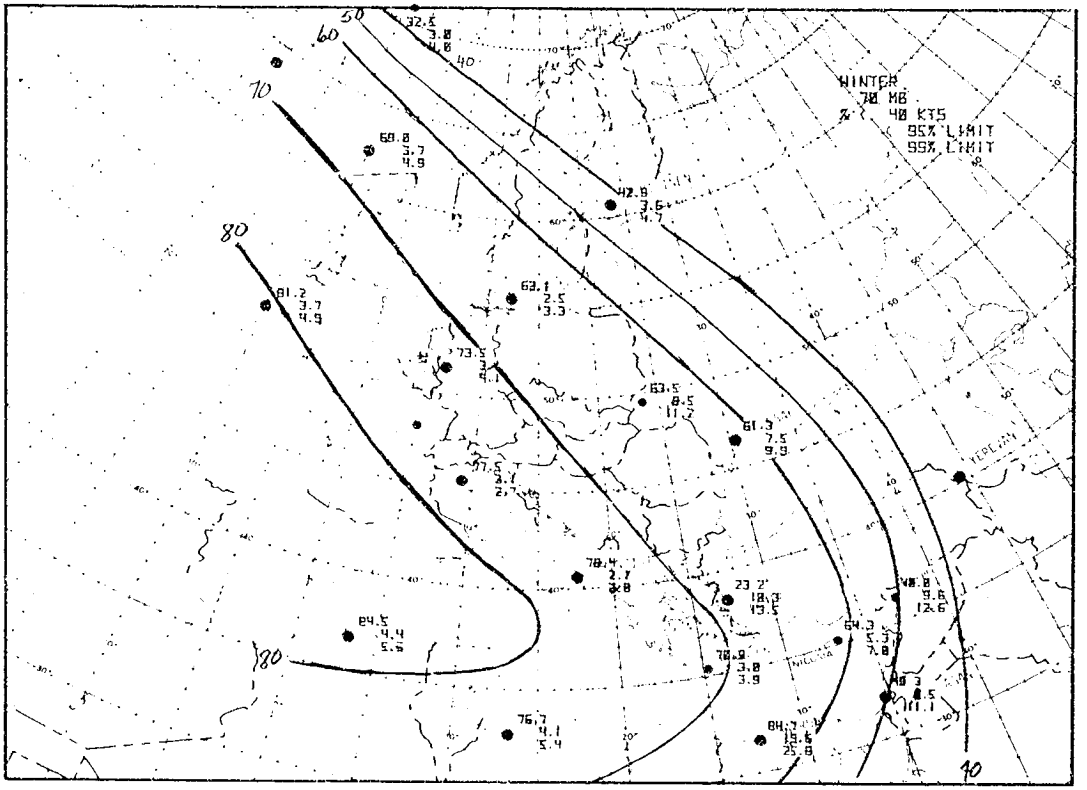
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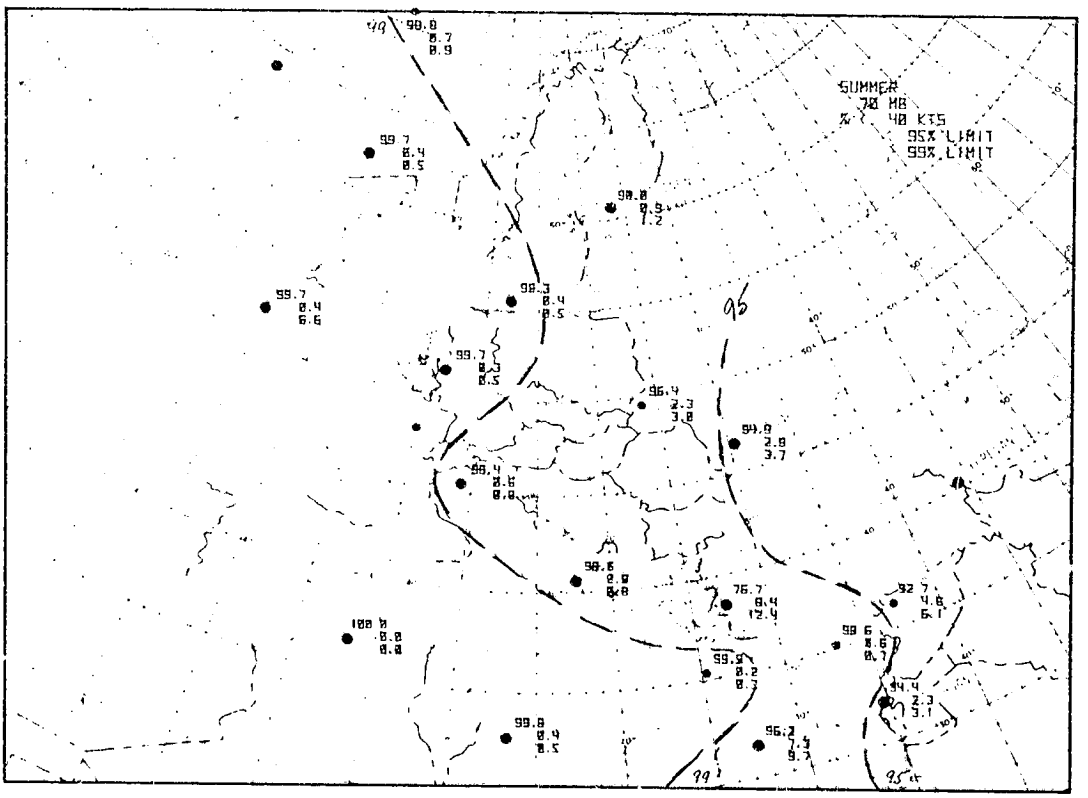
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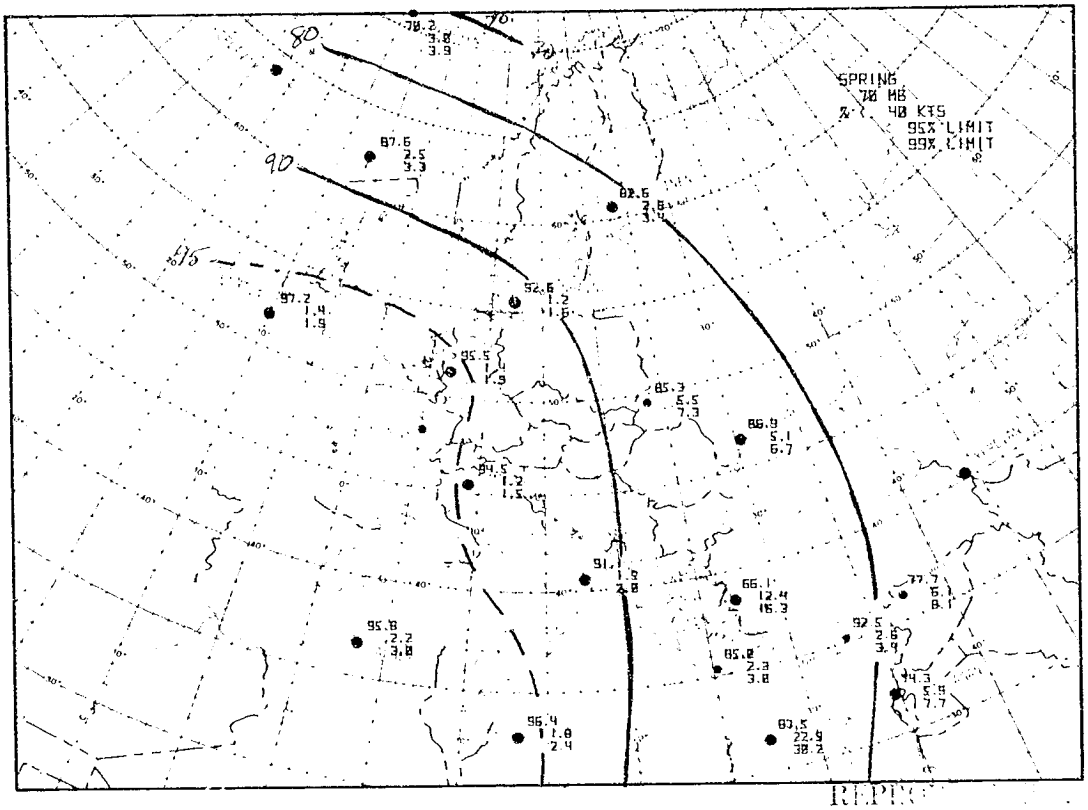

REPRODUCED FROM THE
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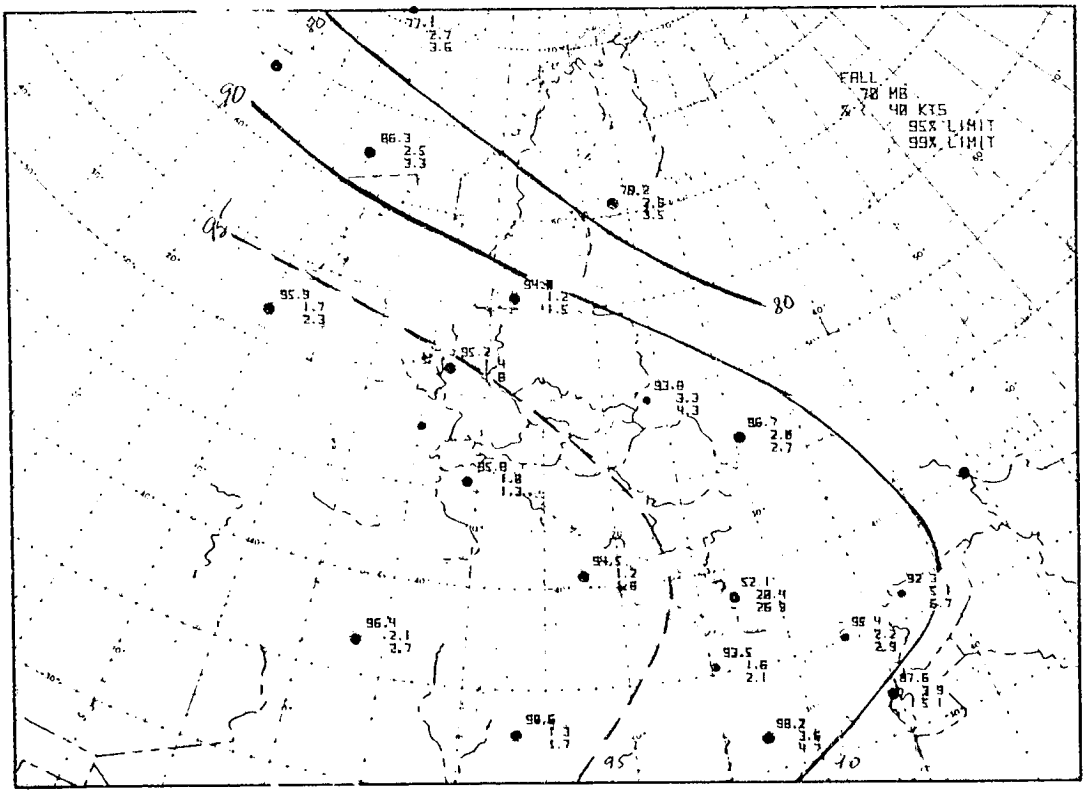

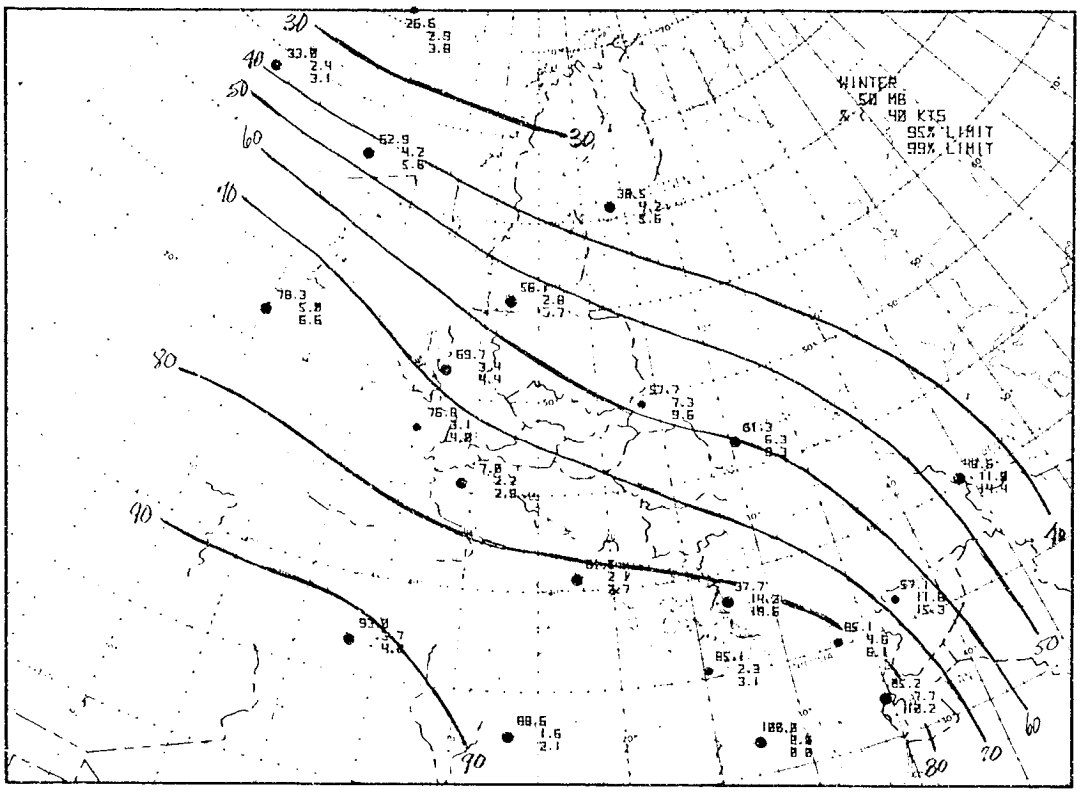
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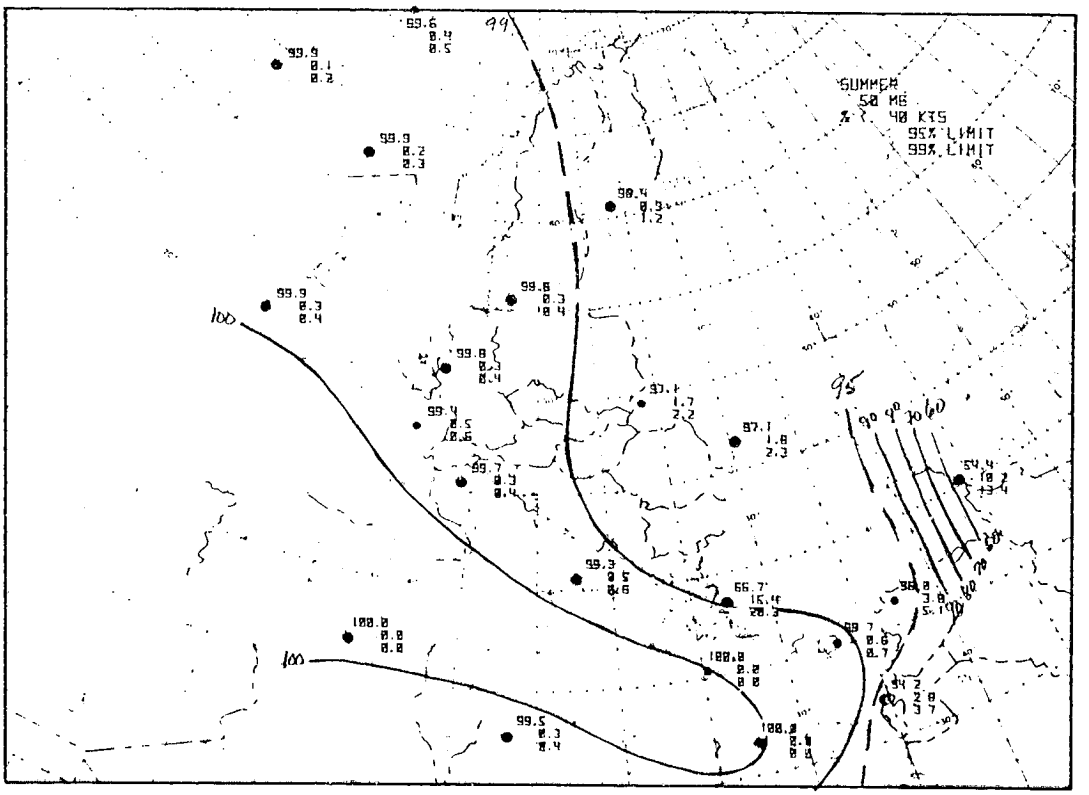
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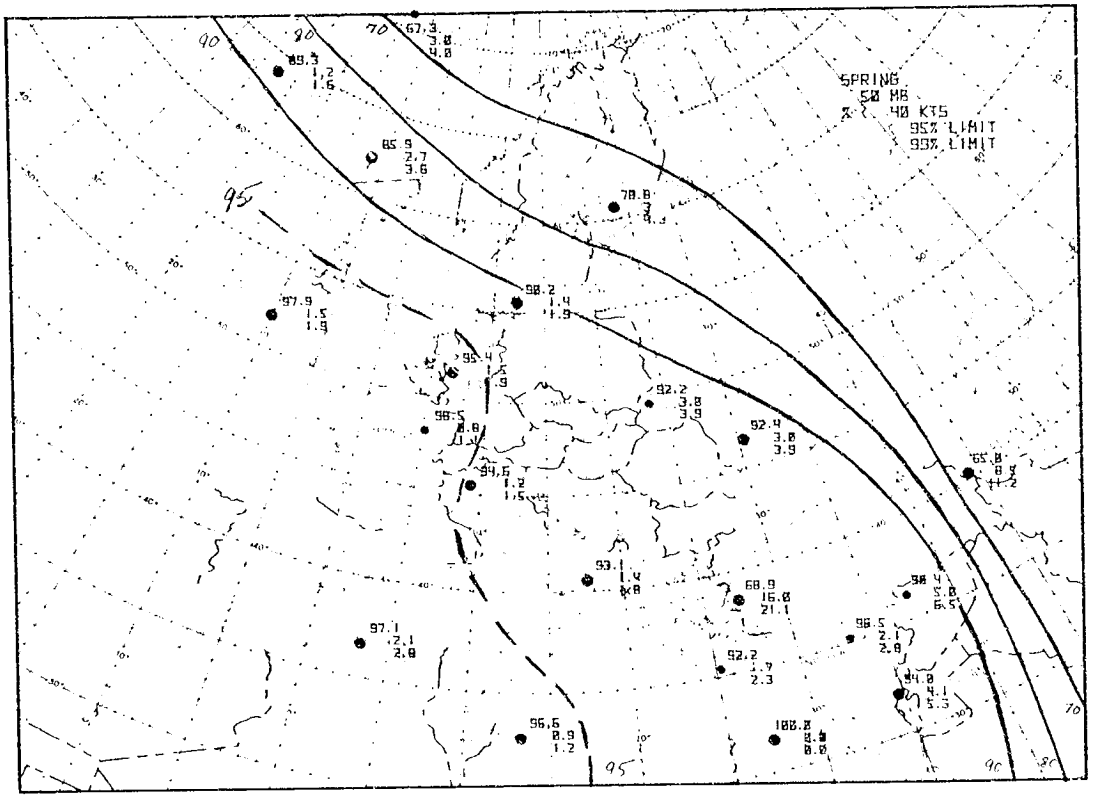
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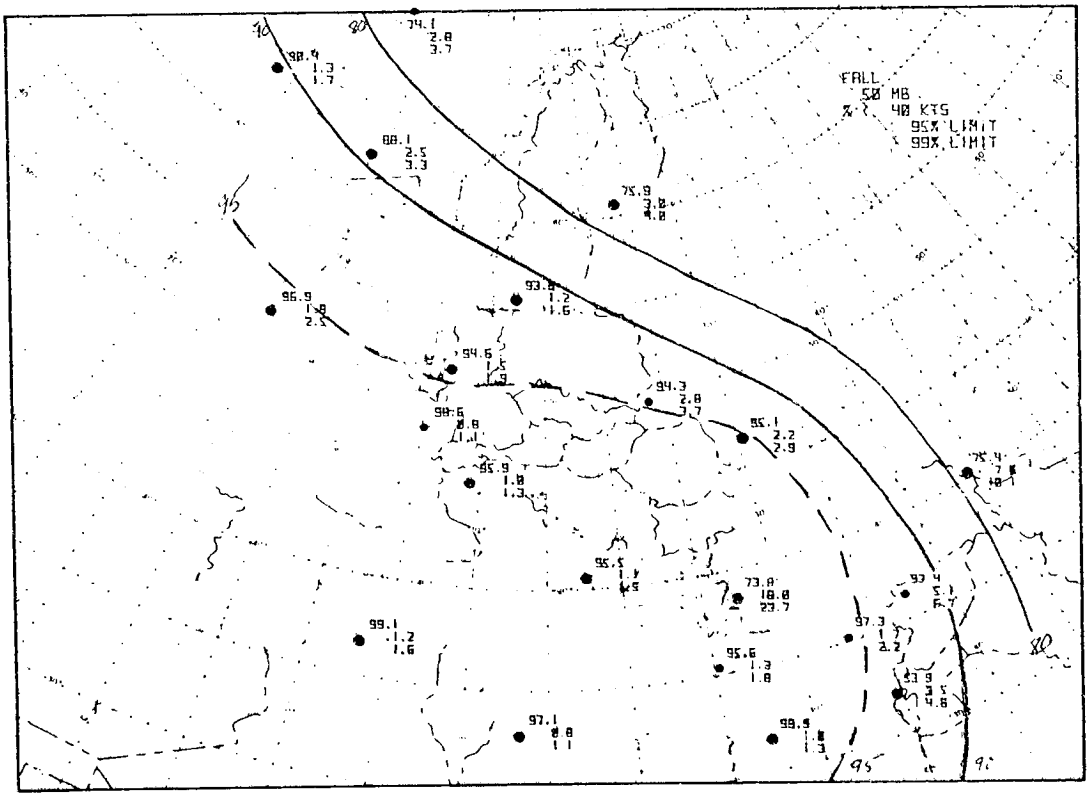
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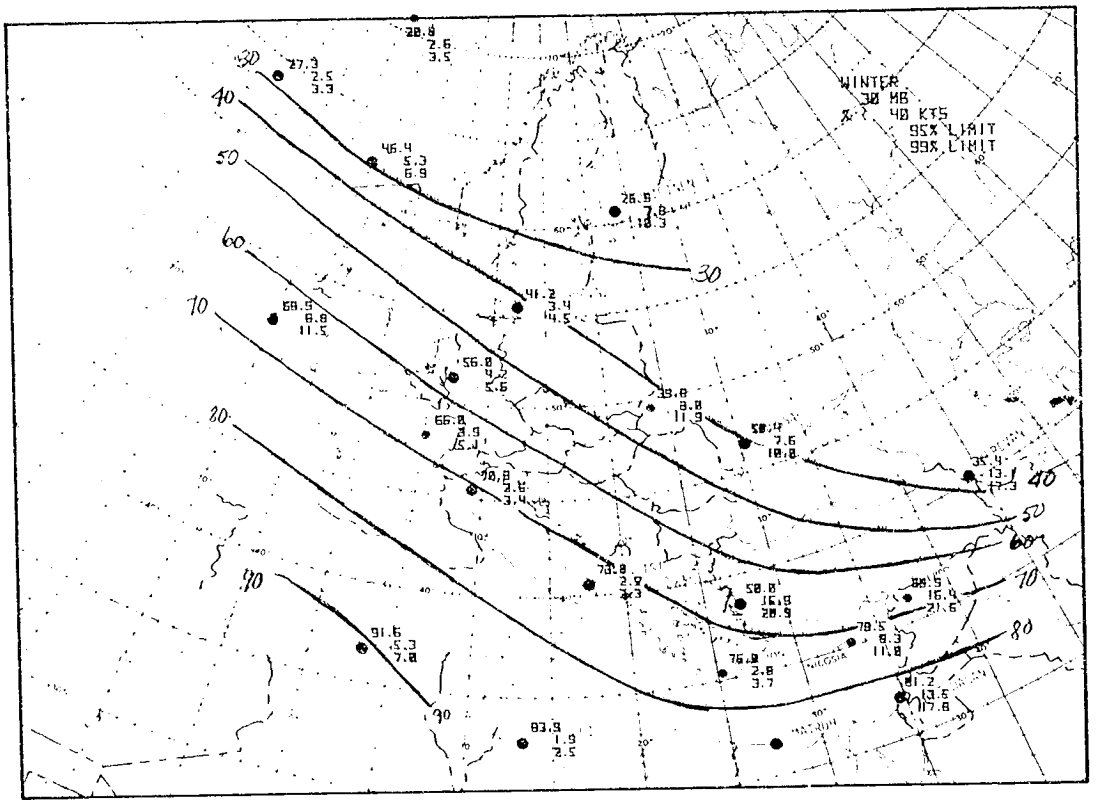
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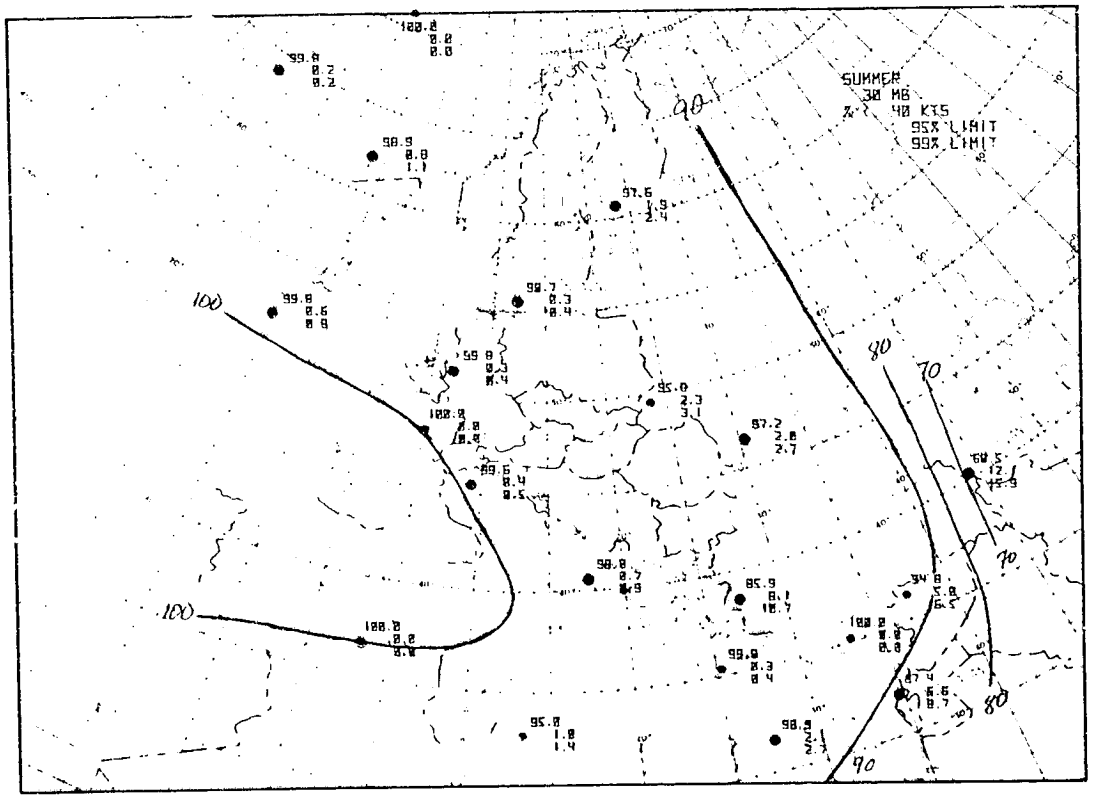
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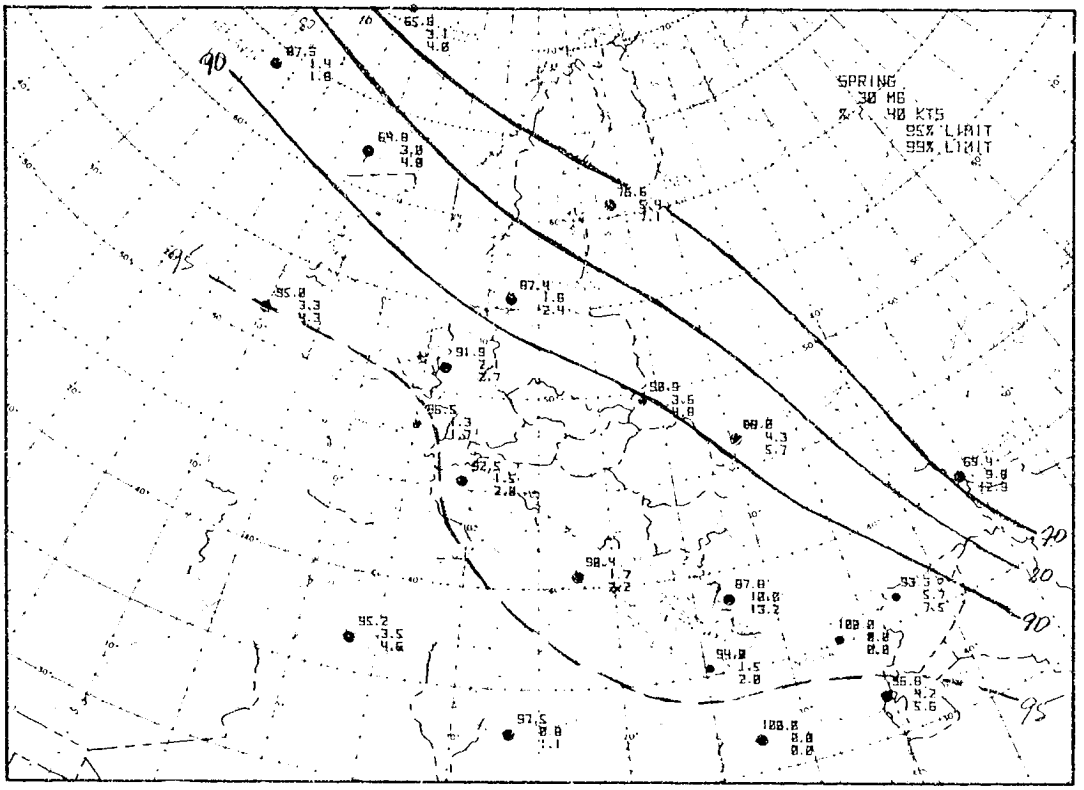
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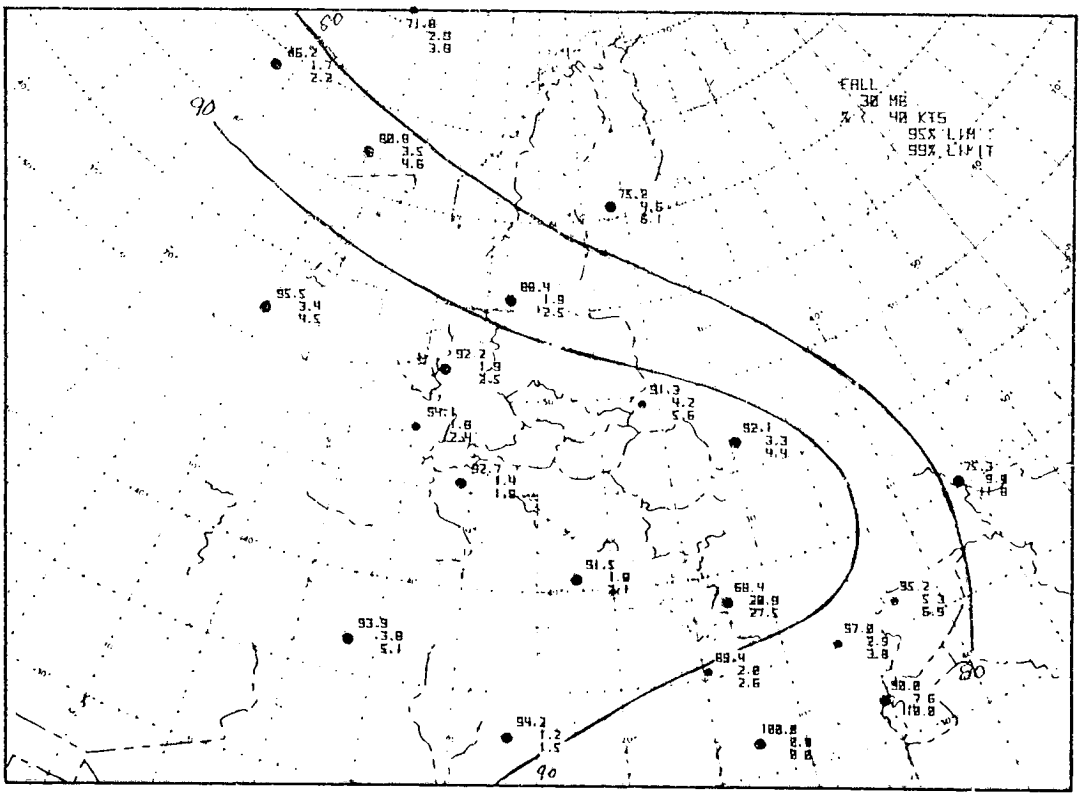
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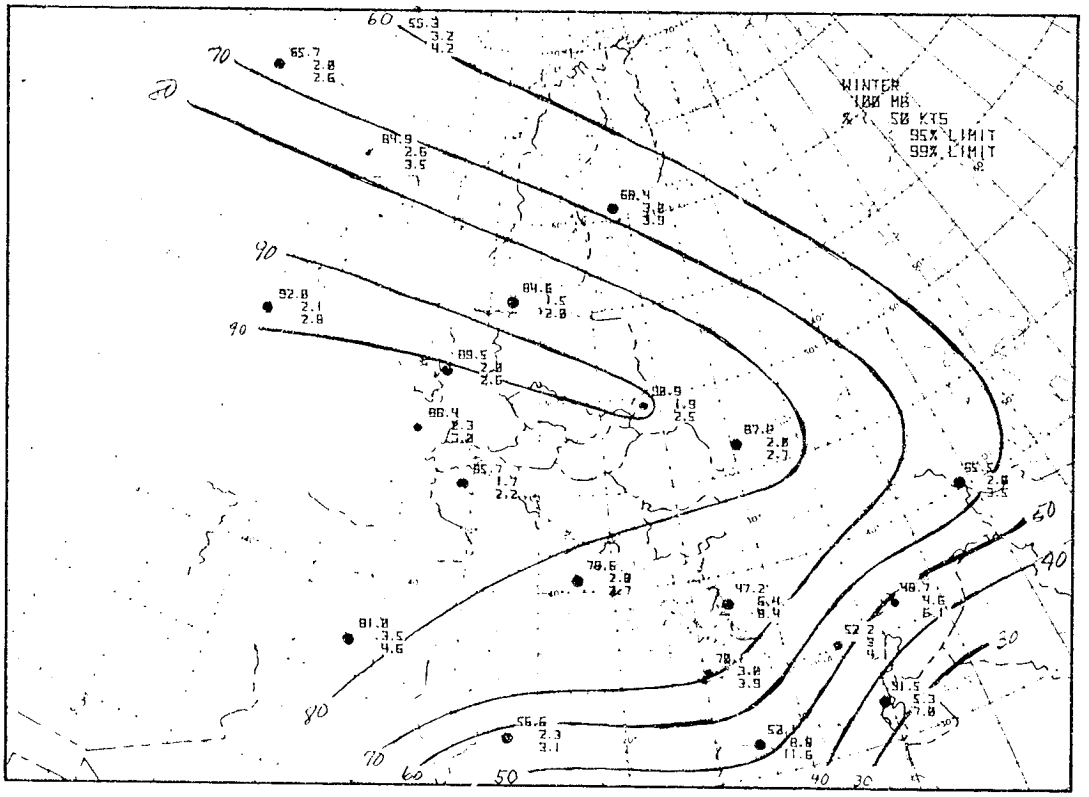
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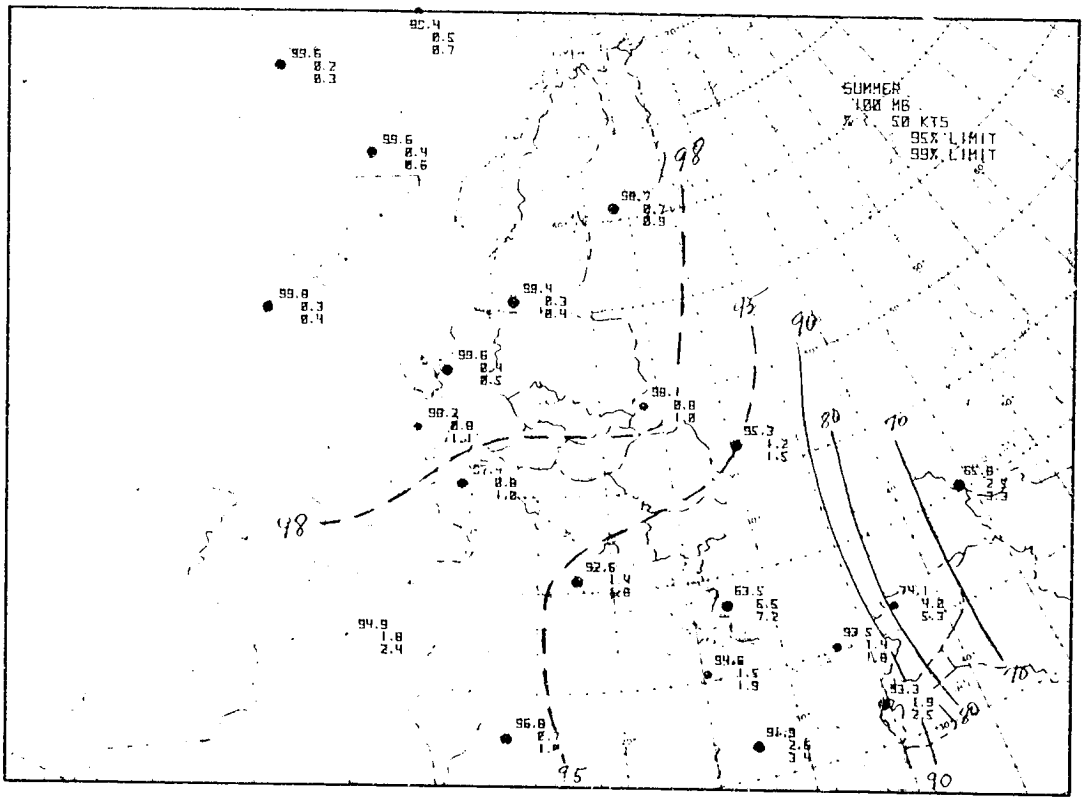
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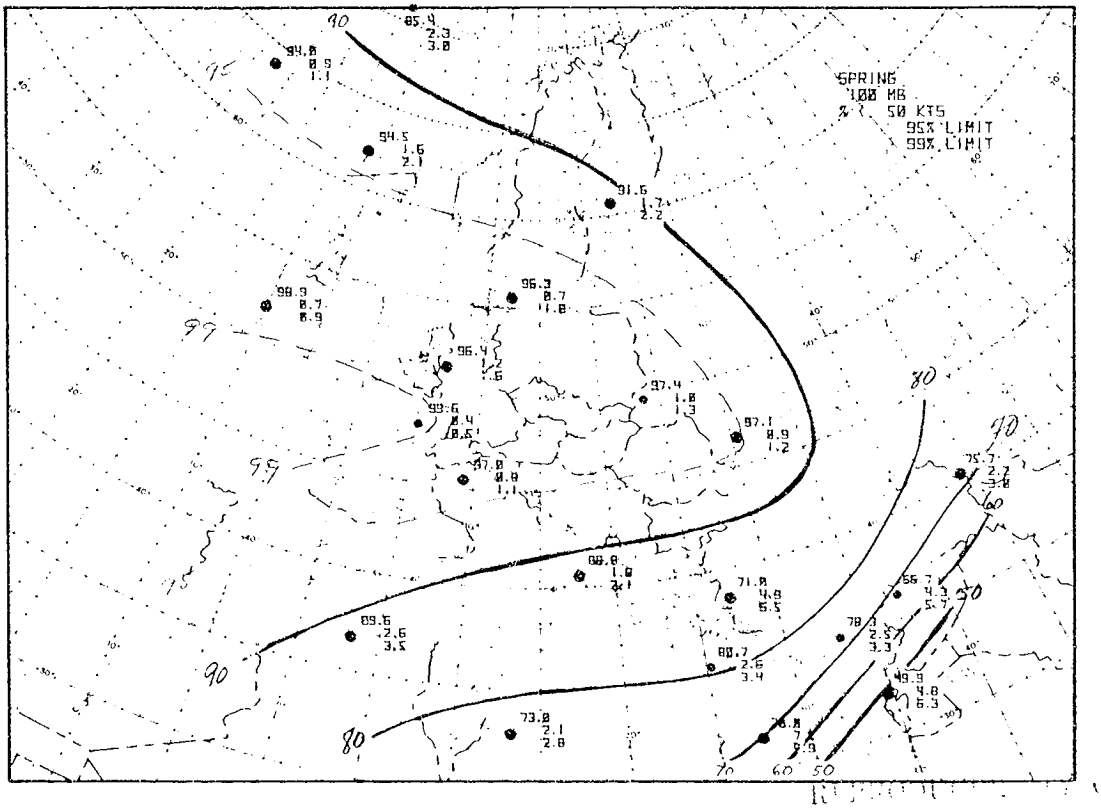
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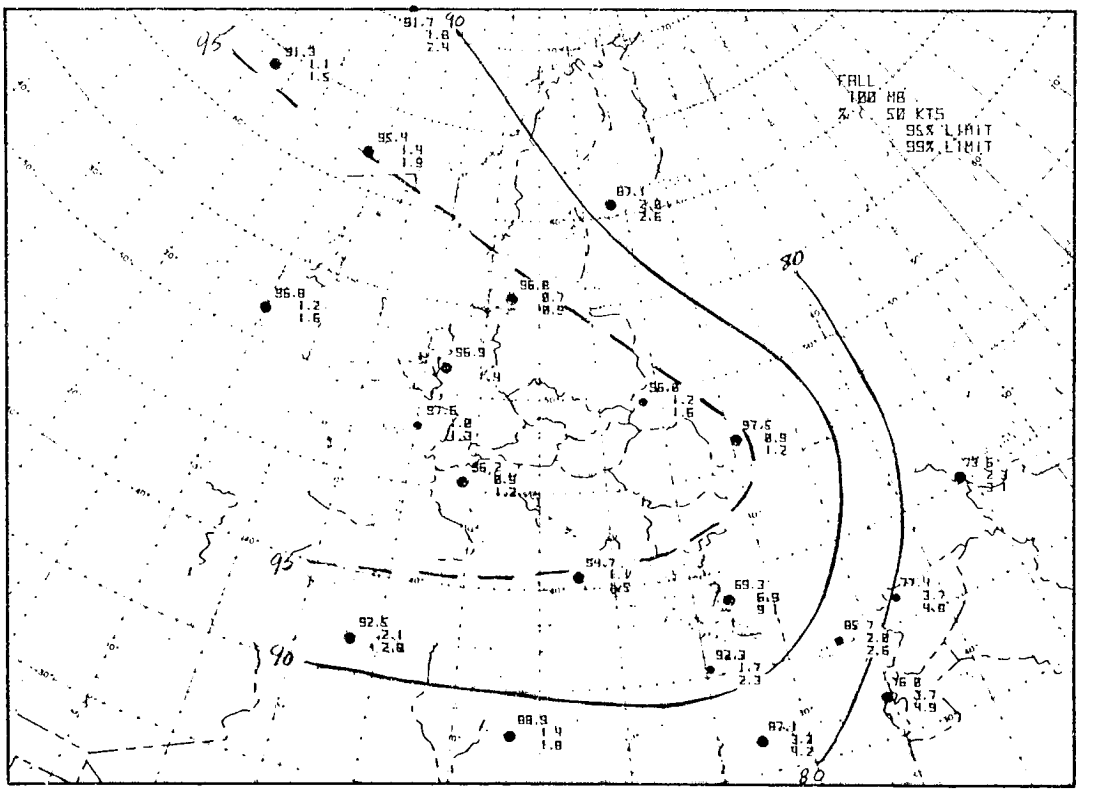
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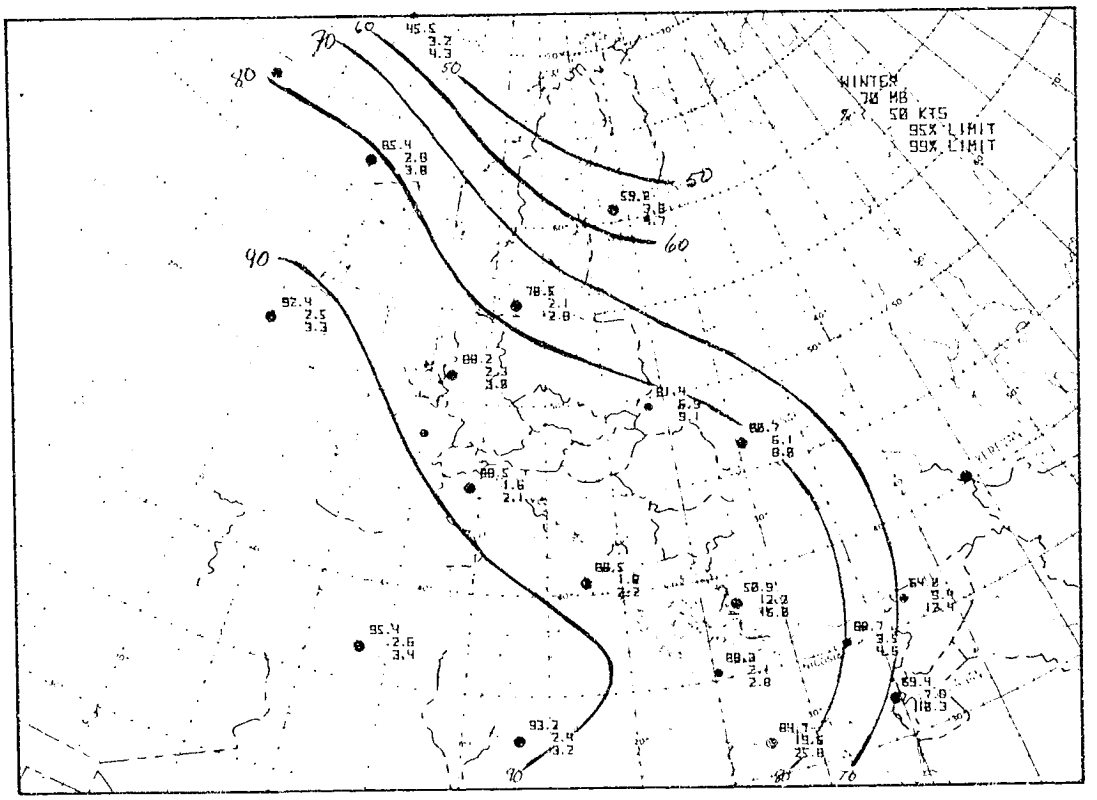
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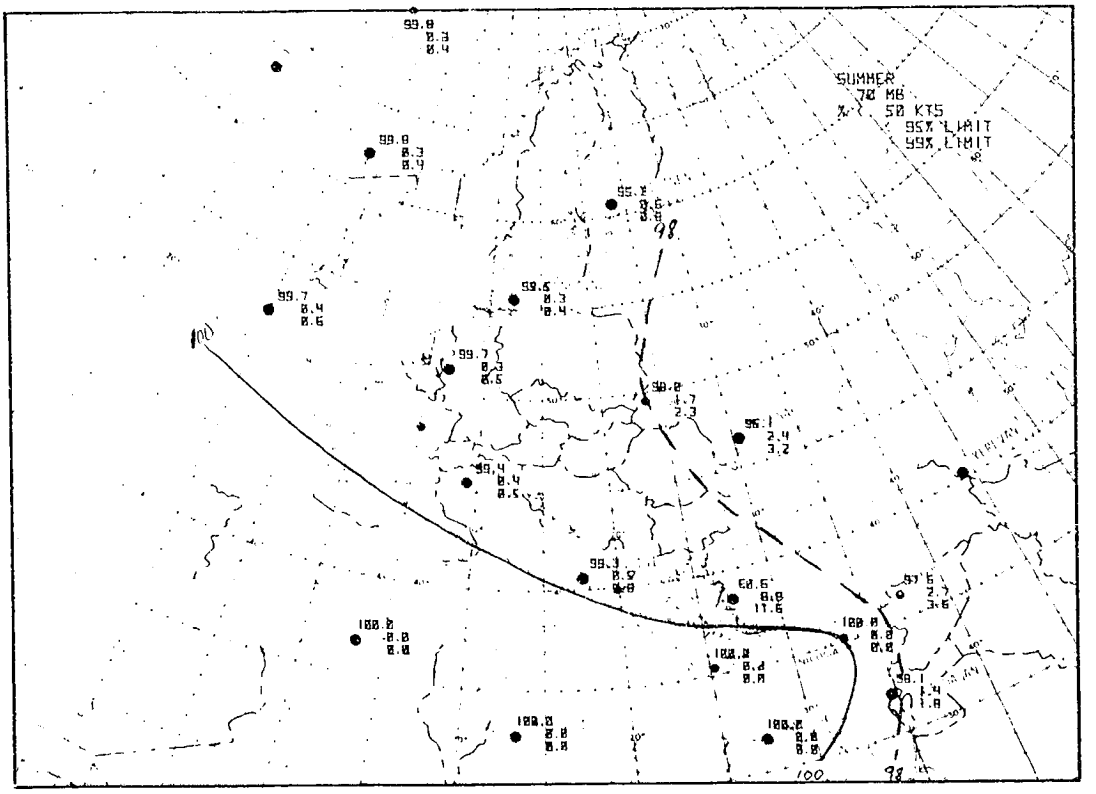
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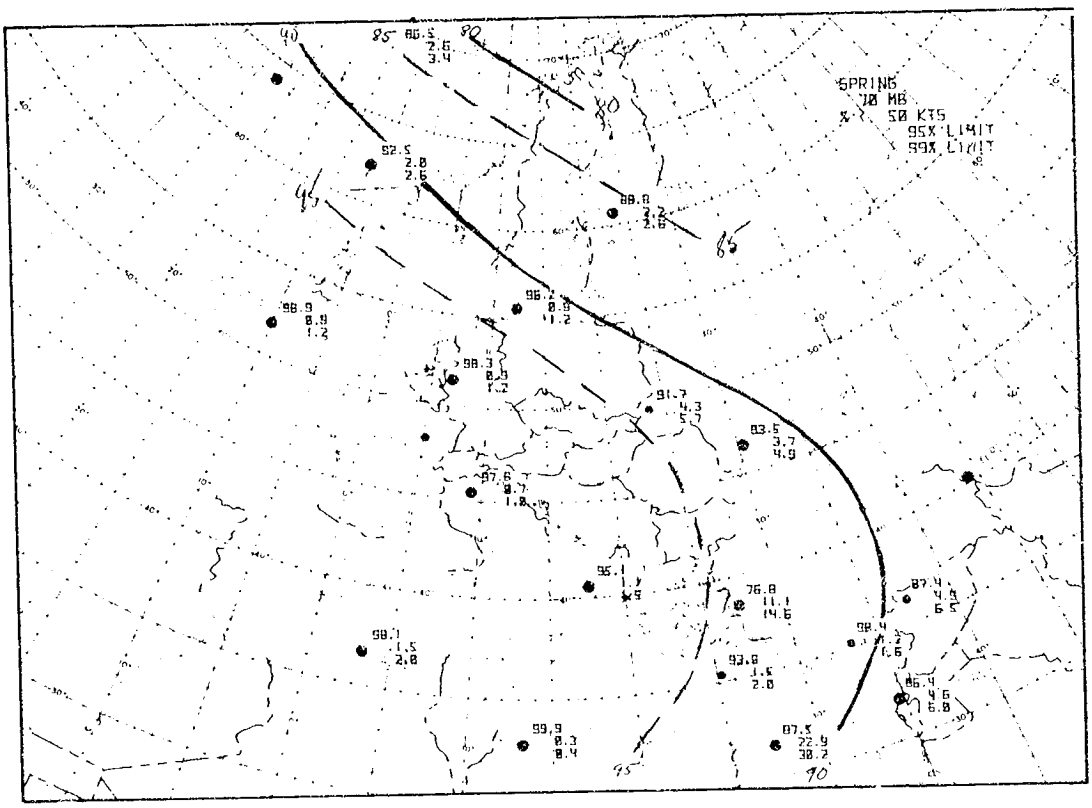
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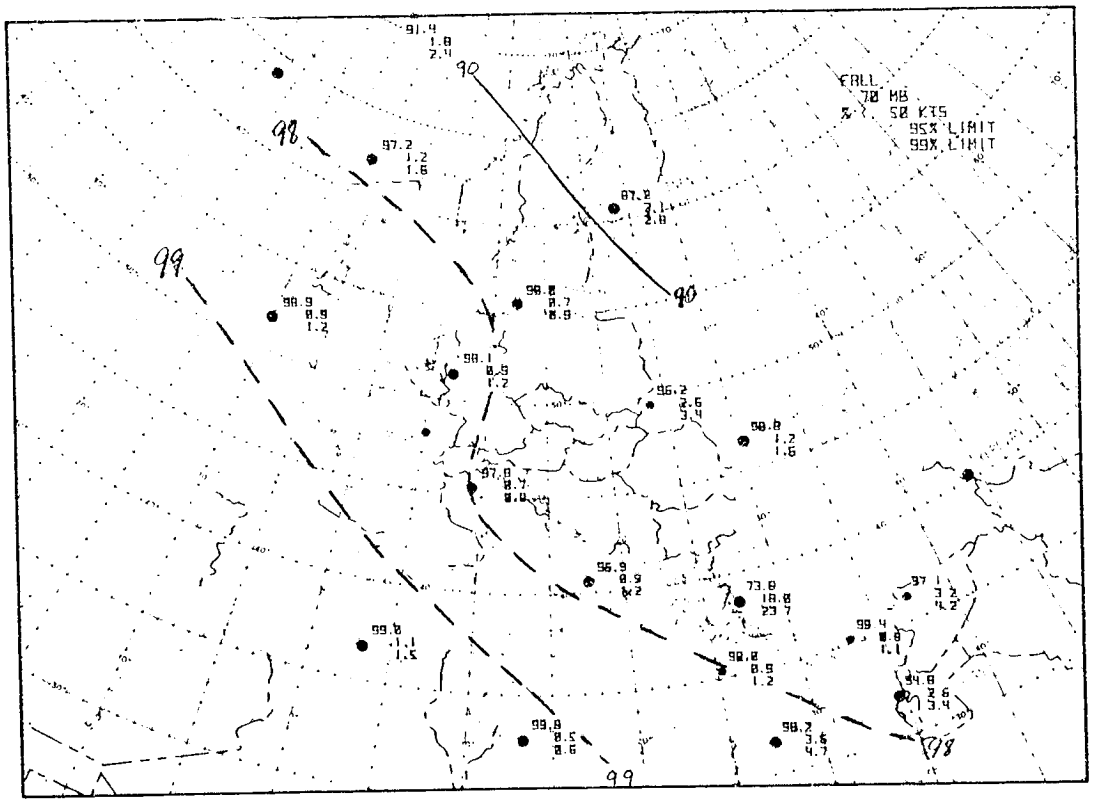
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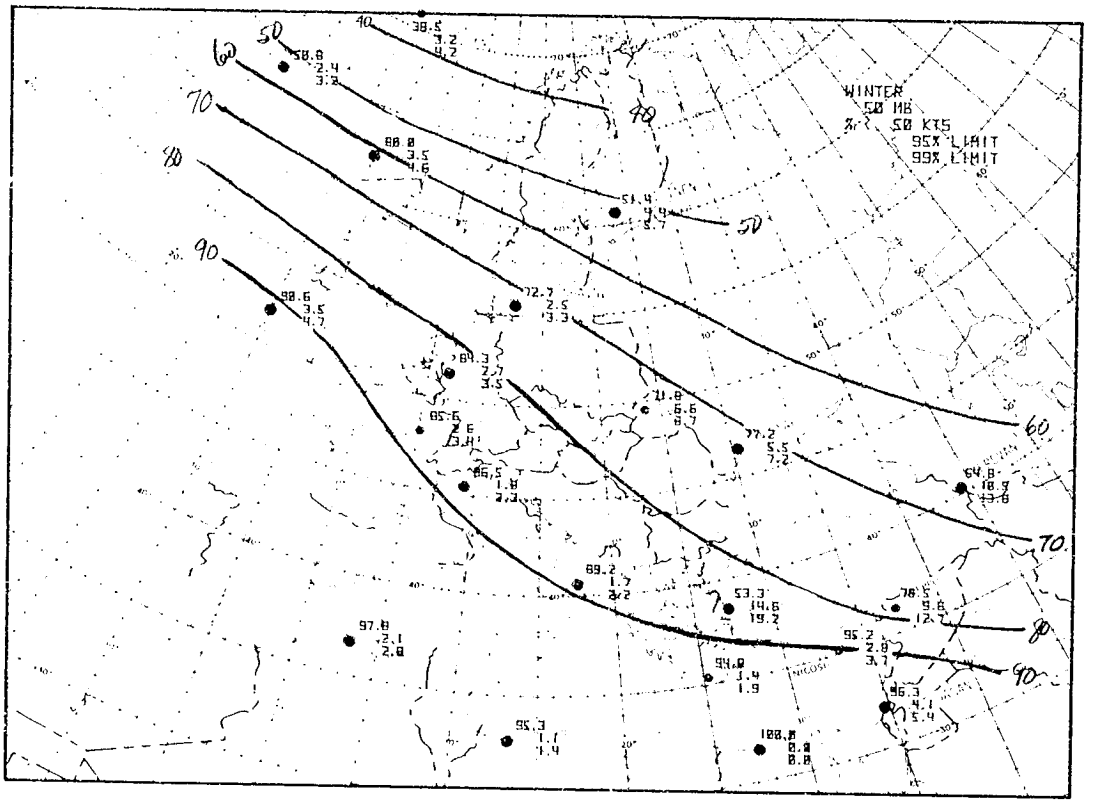
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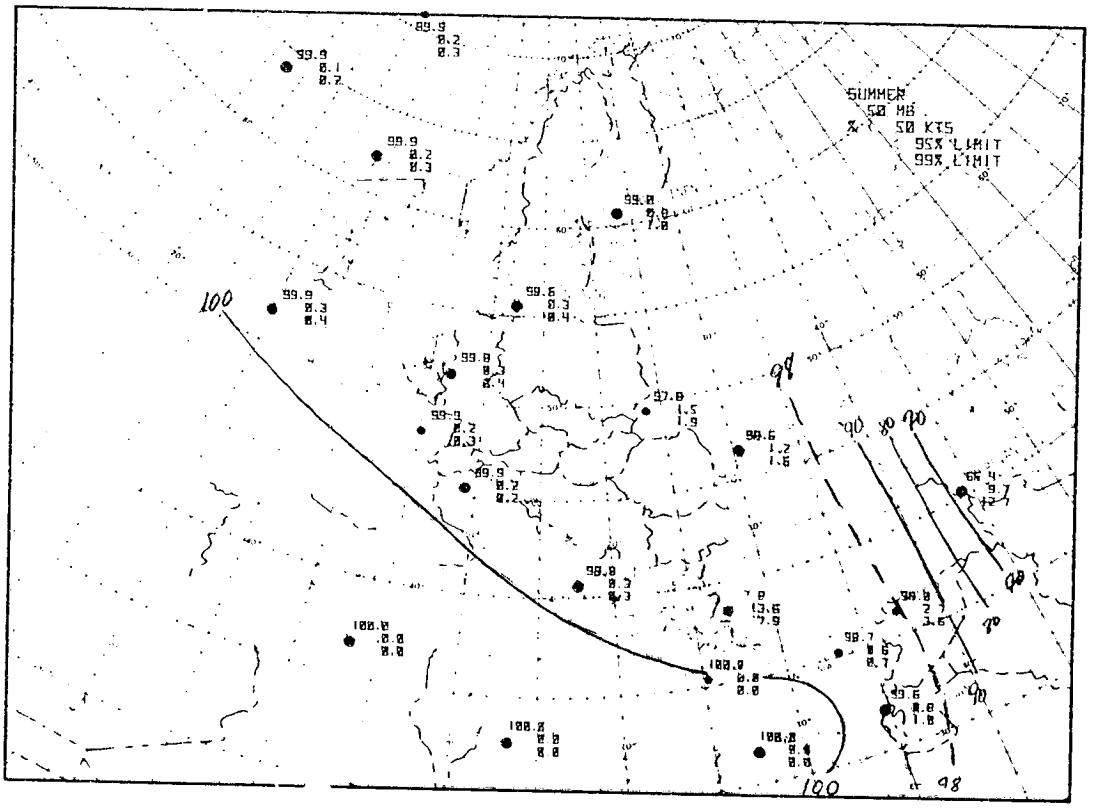
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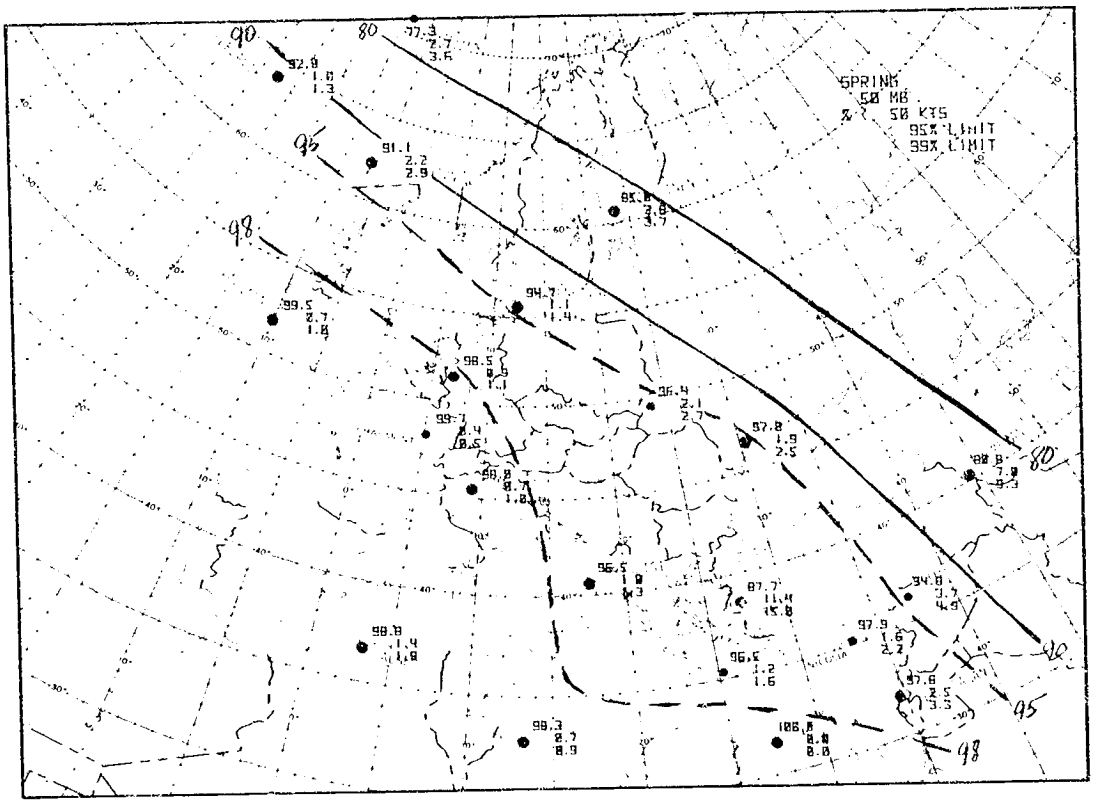
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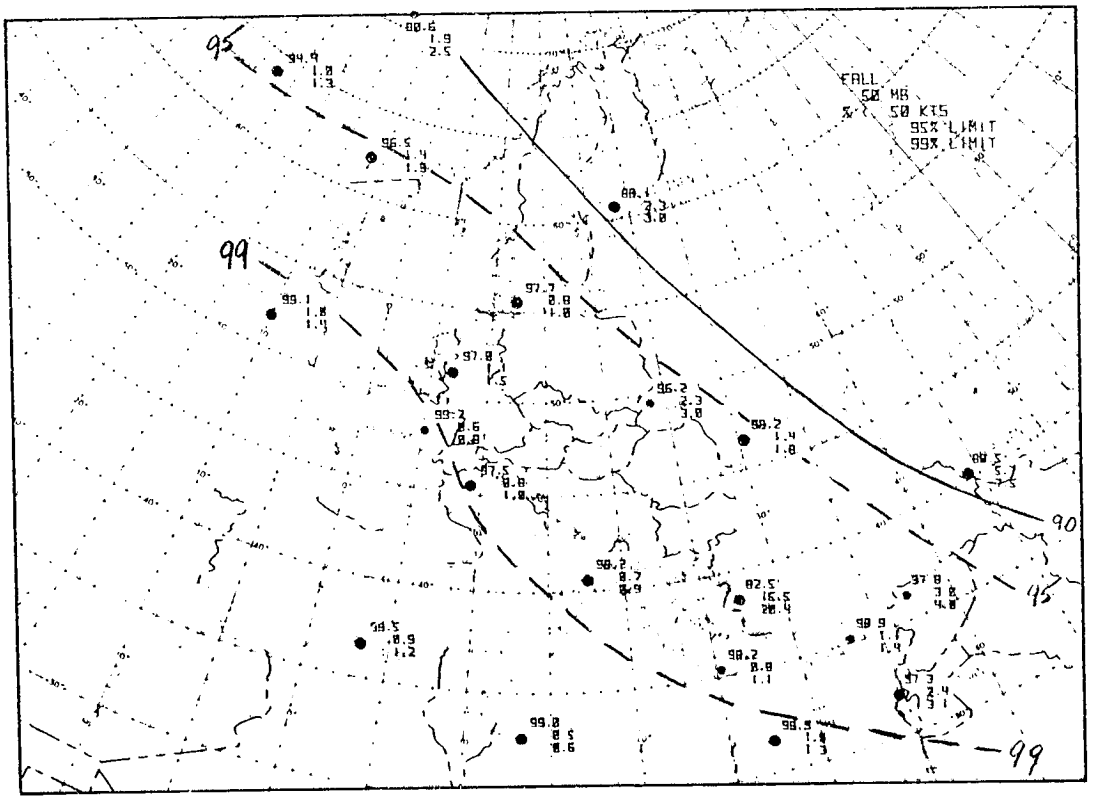
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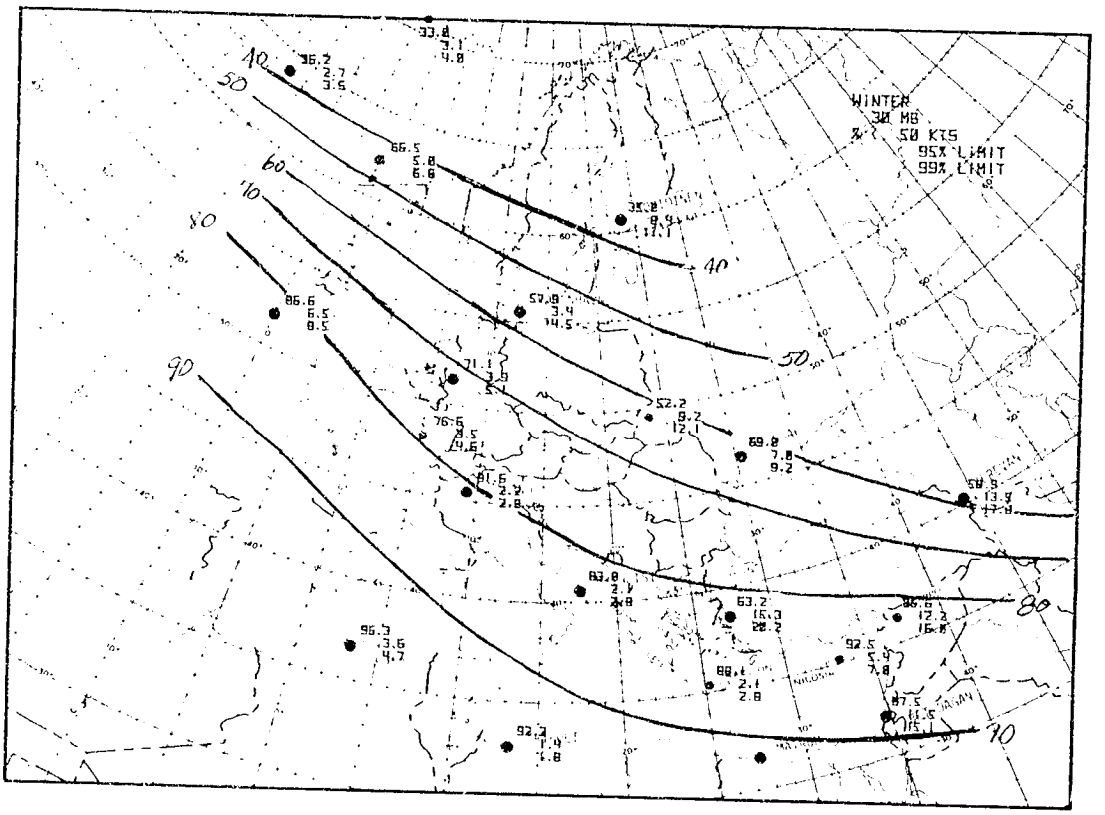
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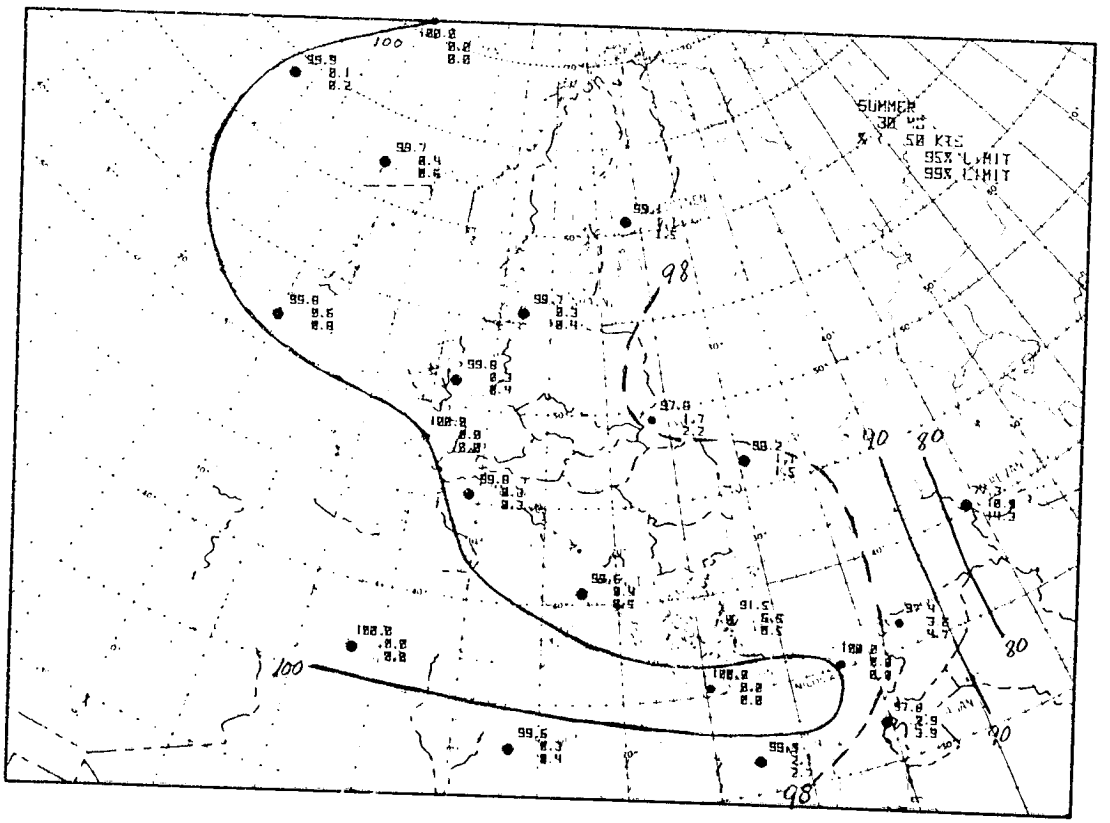
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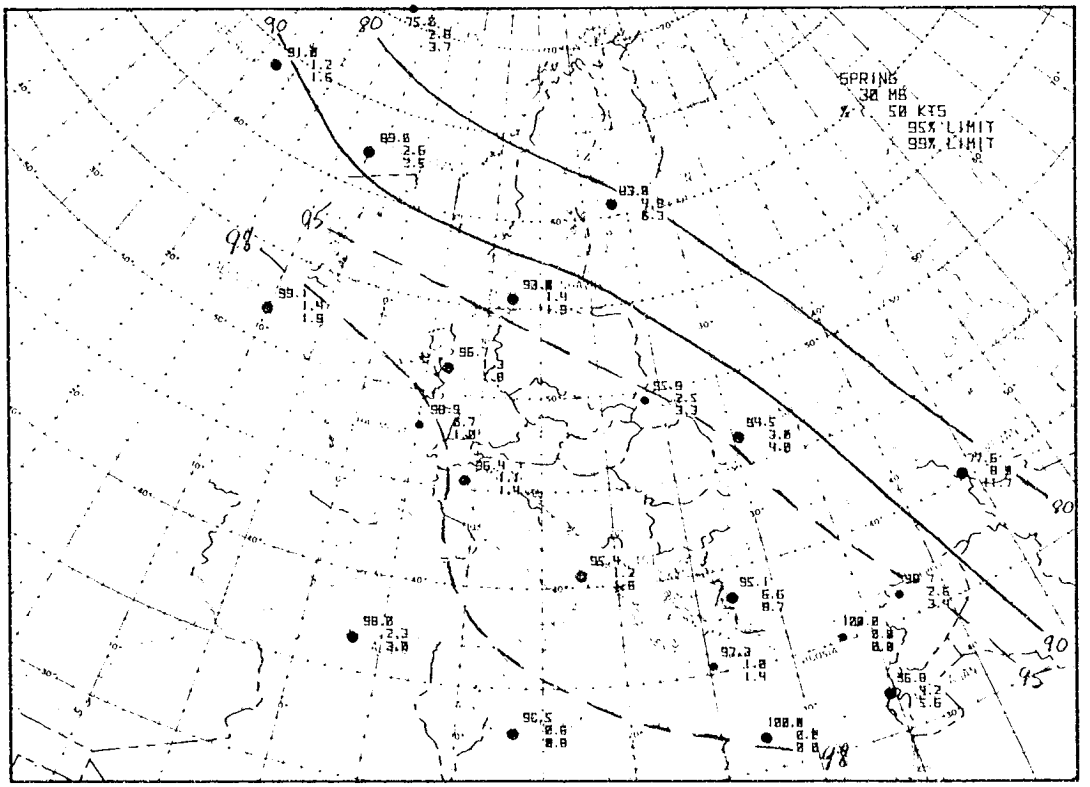

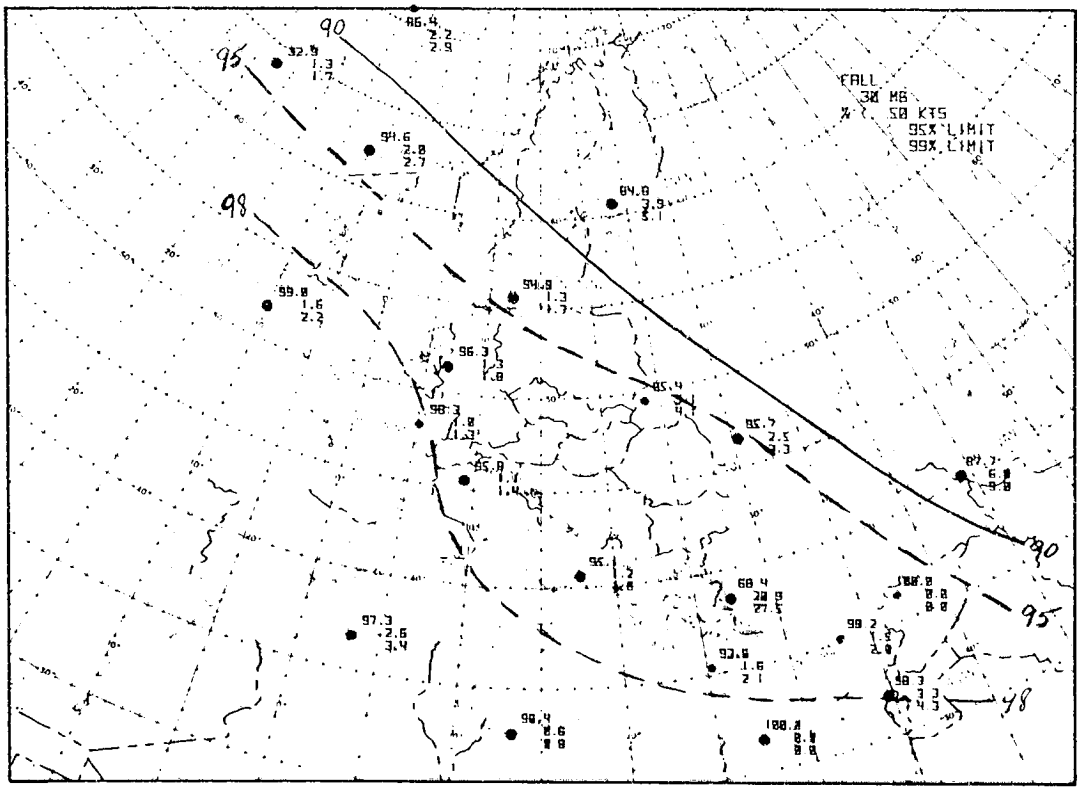

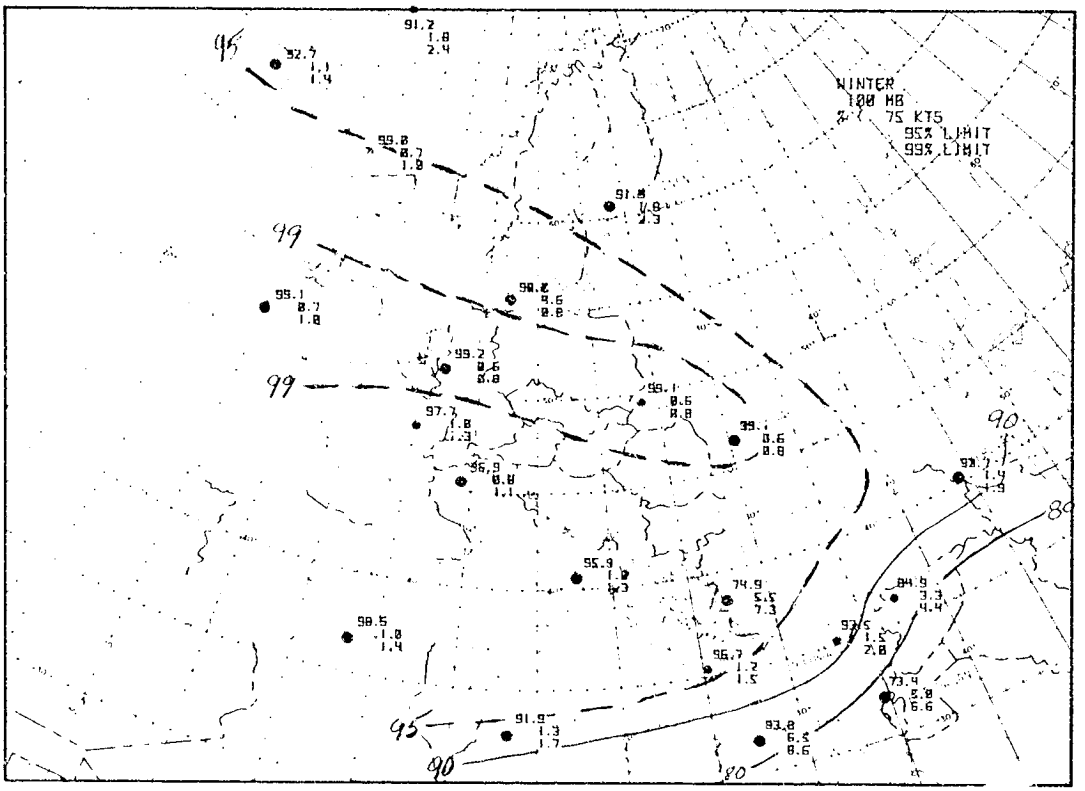
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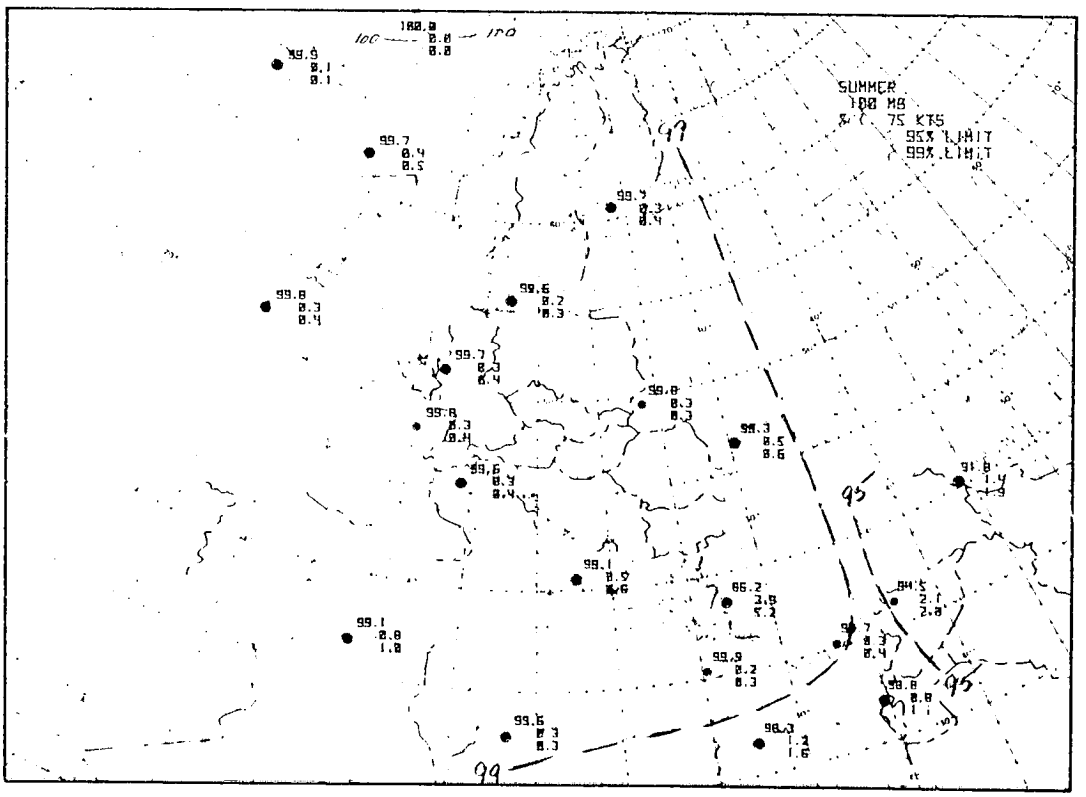
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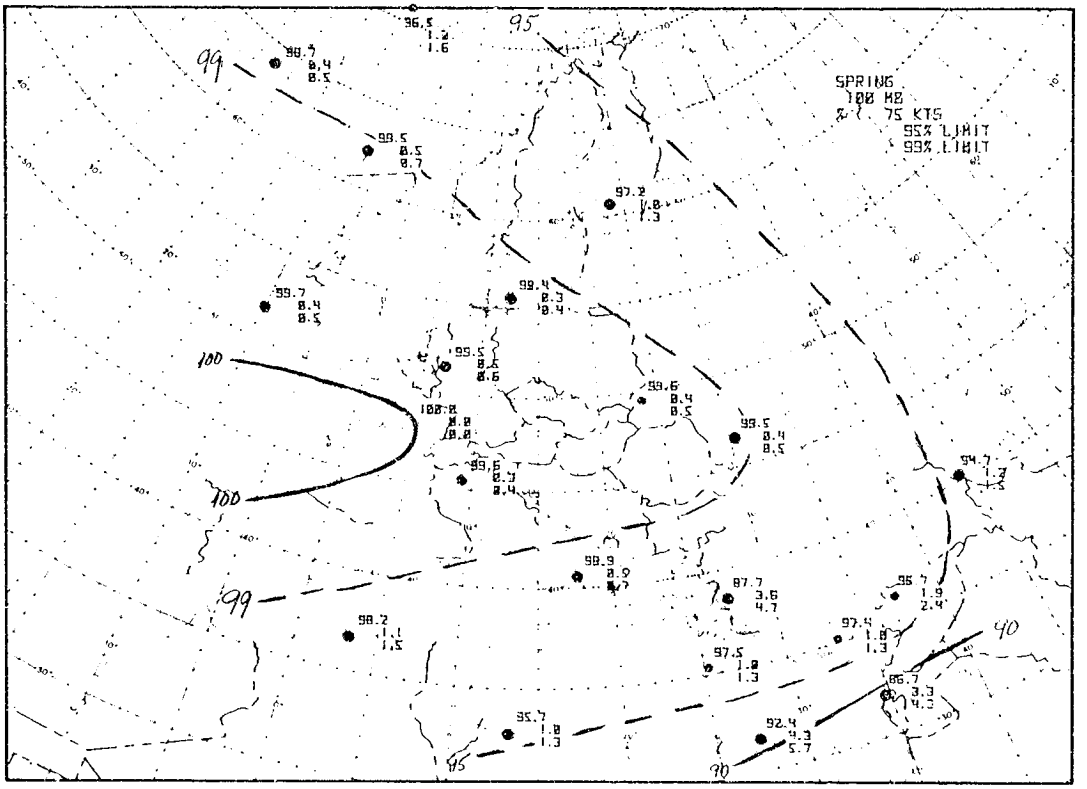
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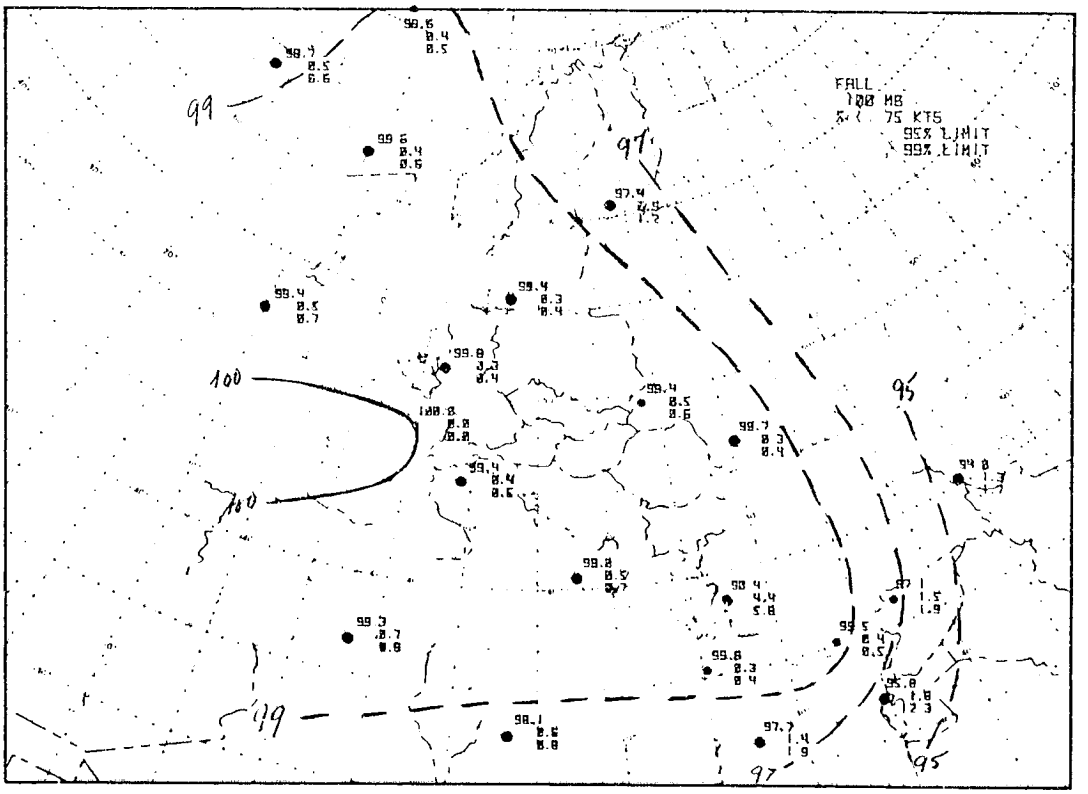
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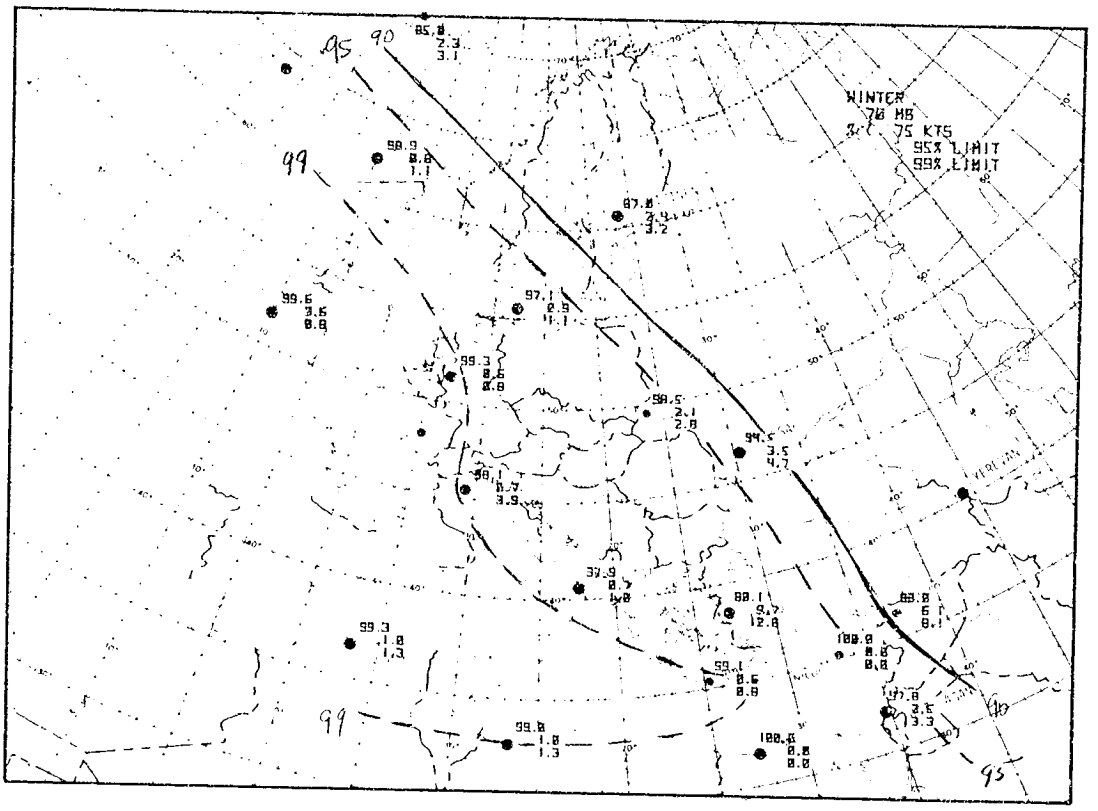
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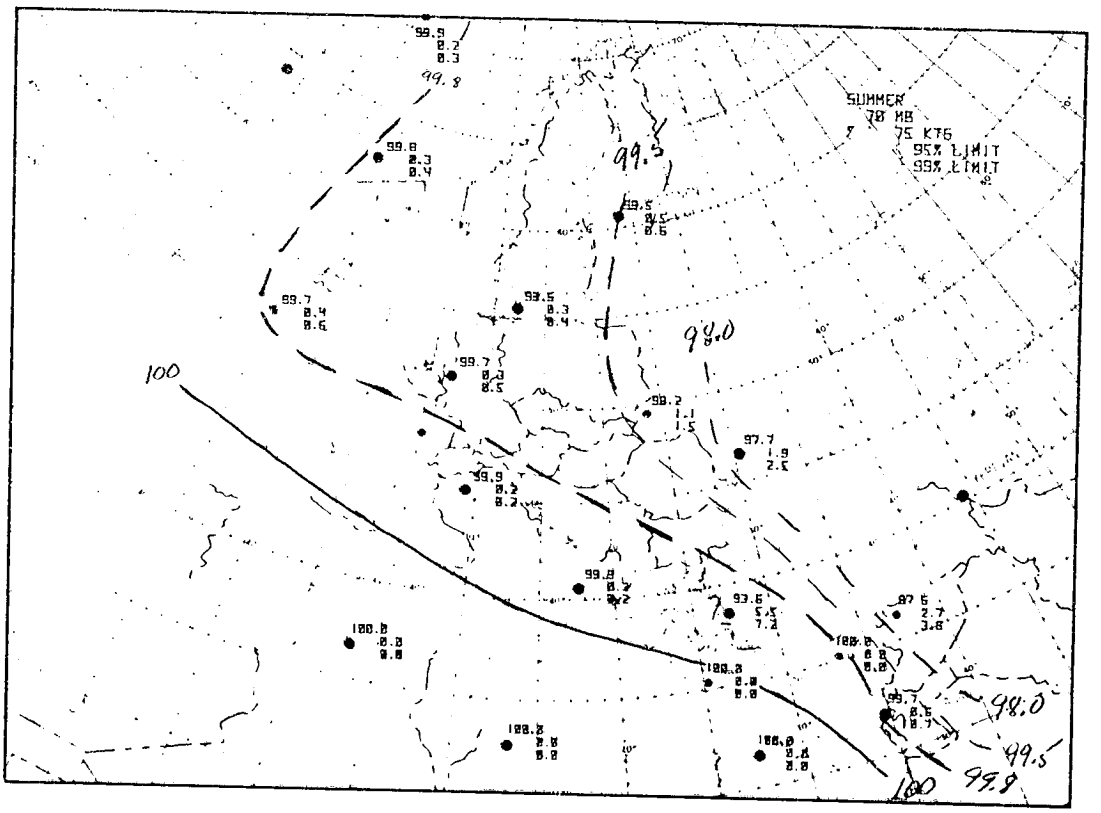
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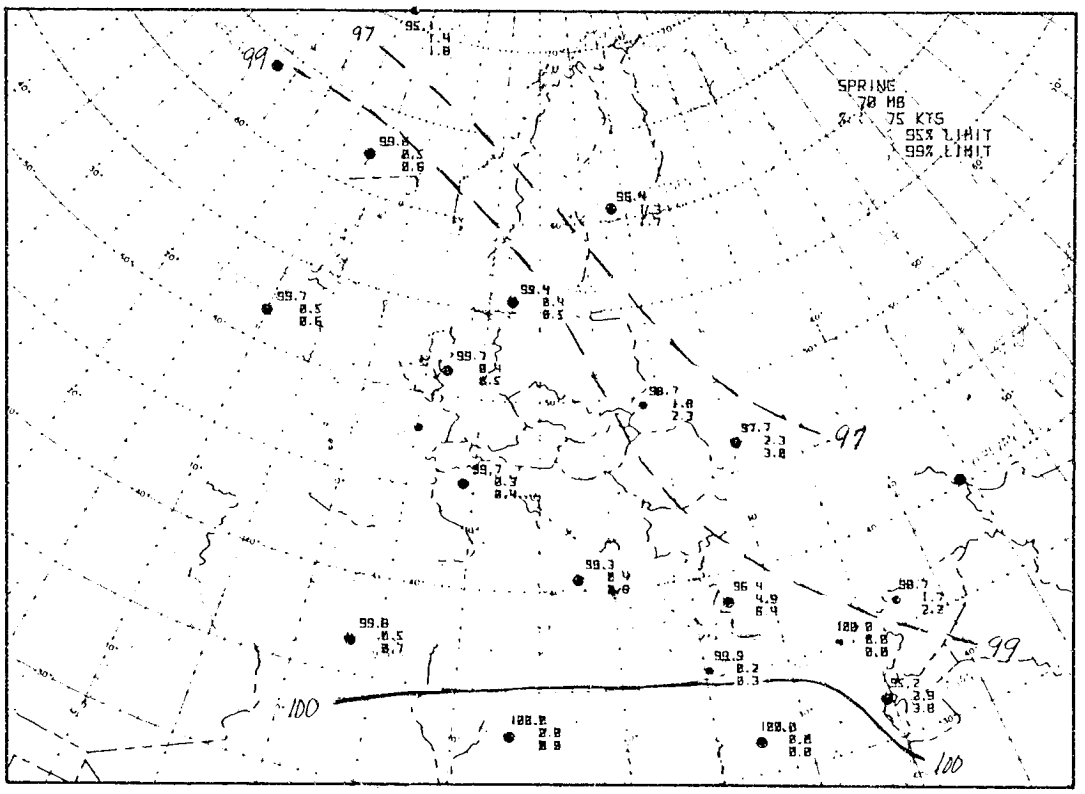
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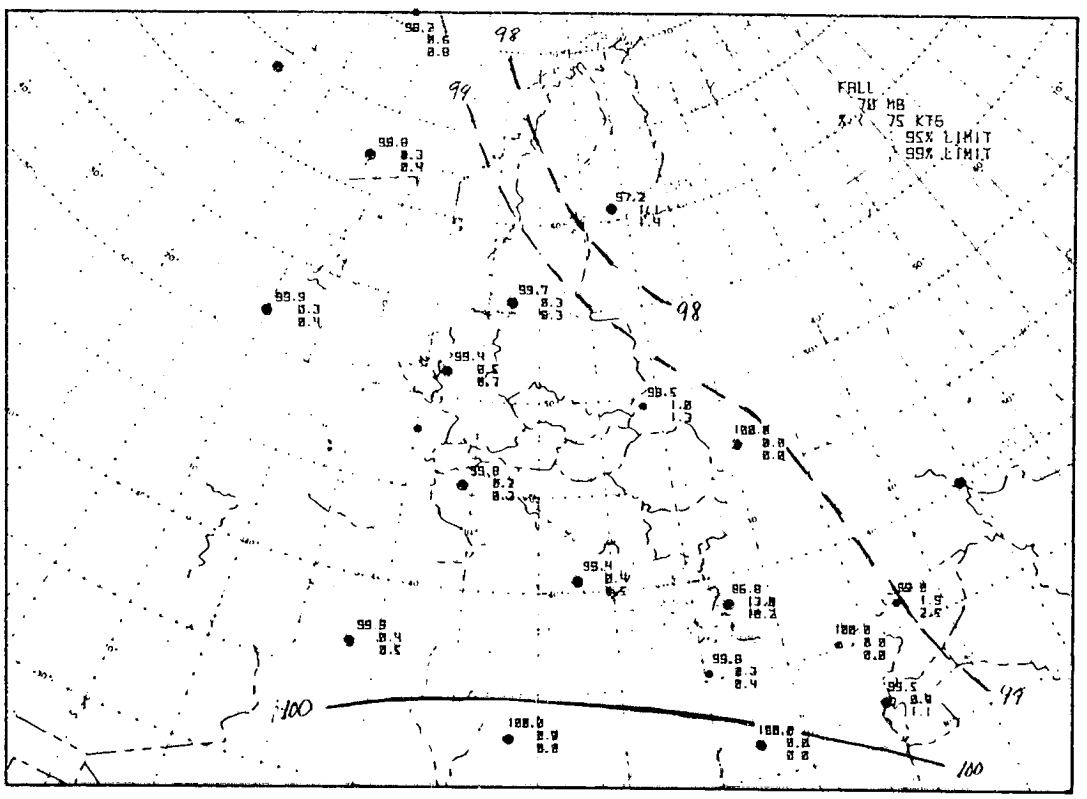
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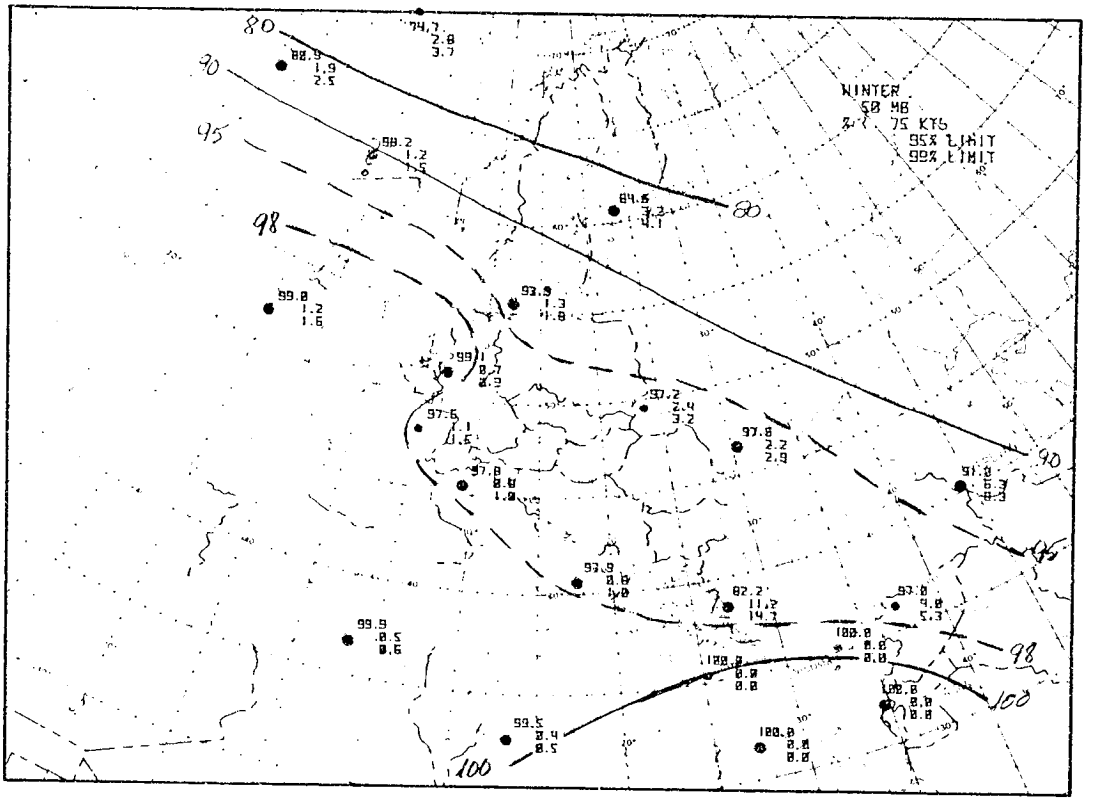
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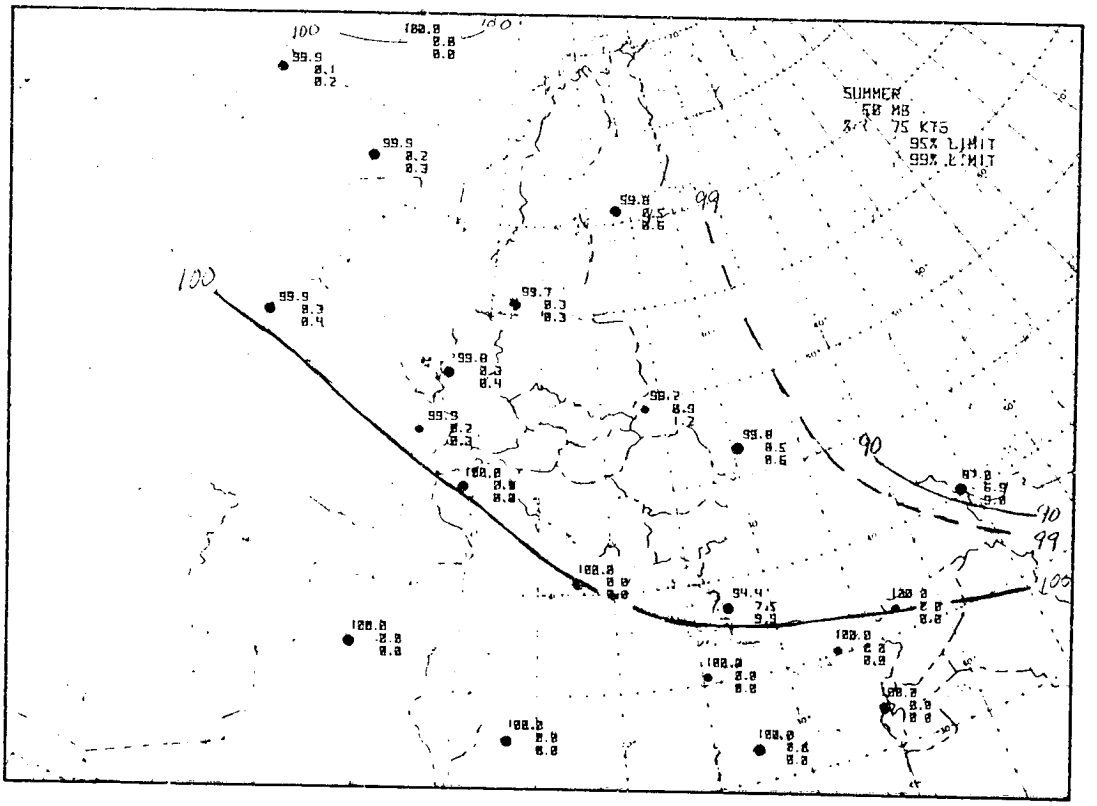
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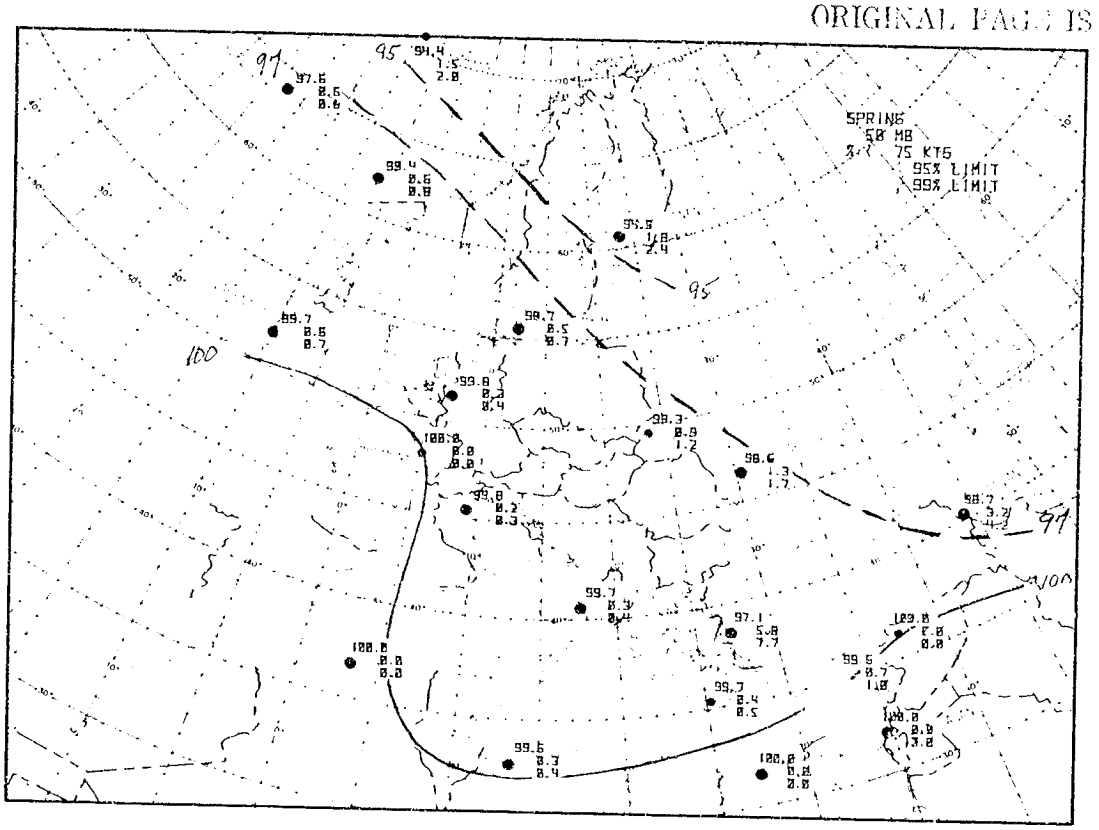

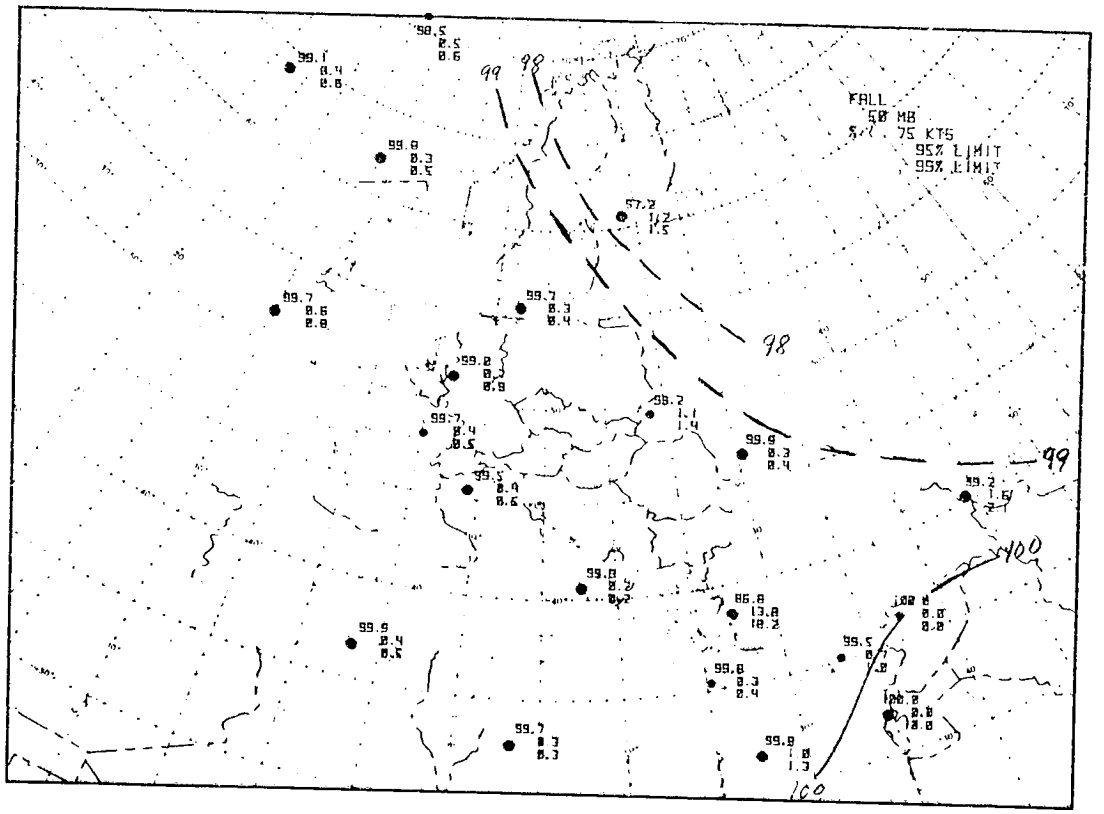

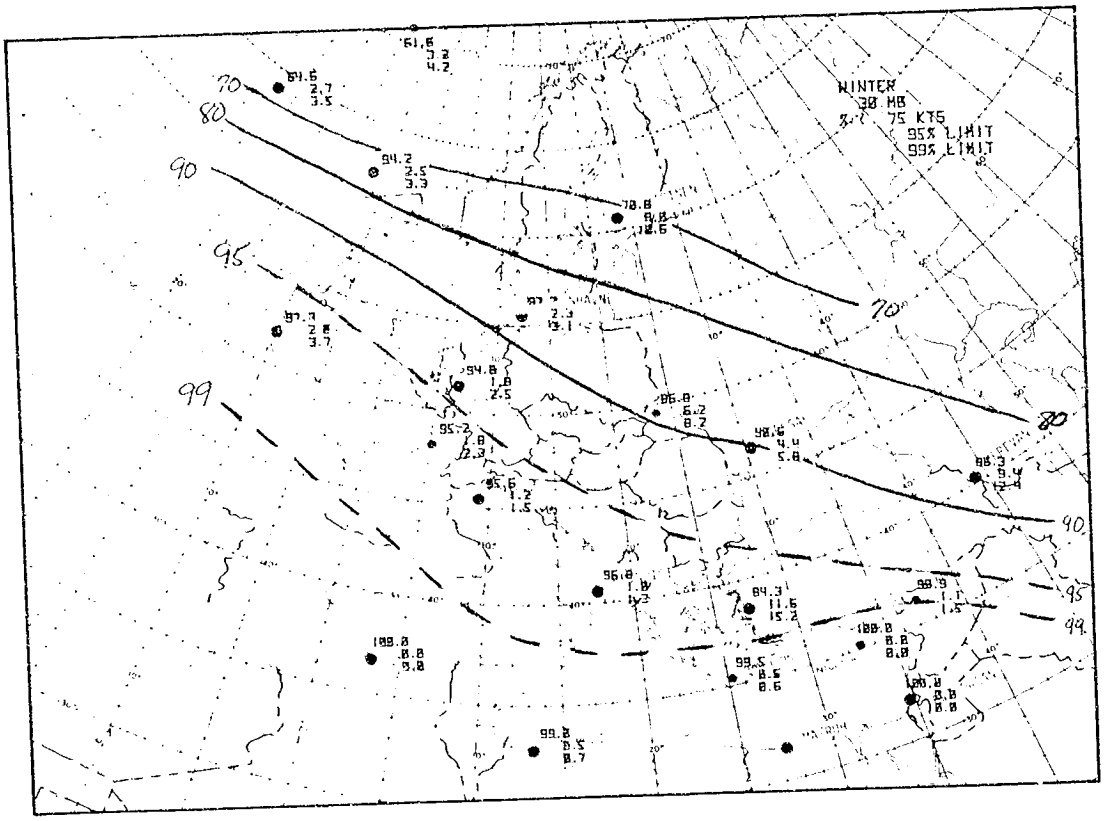
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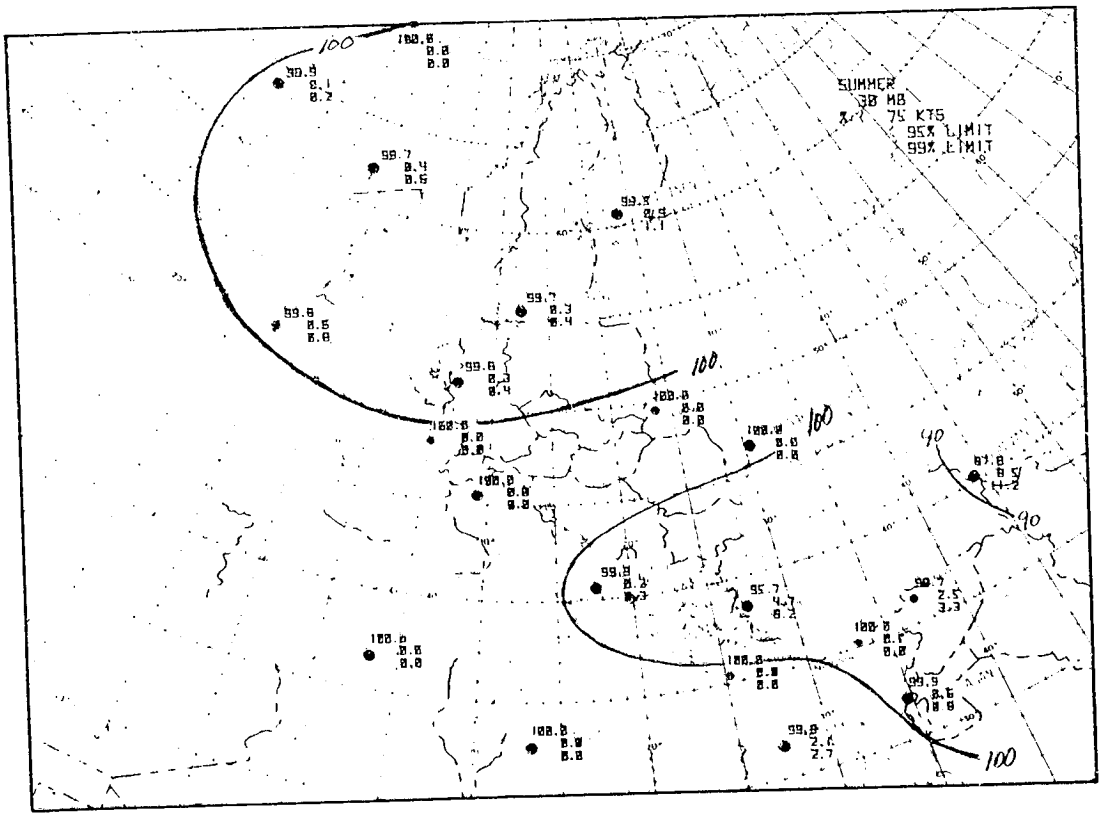
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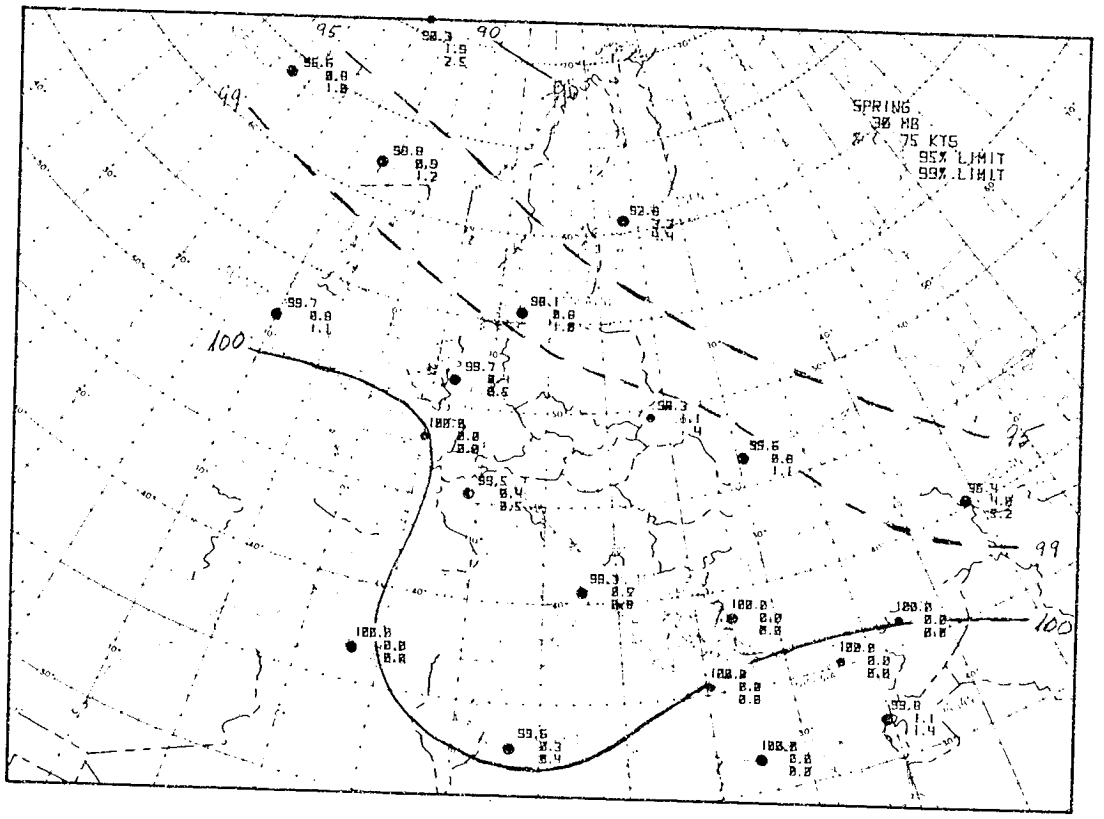
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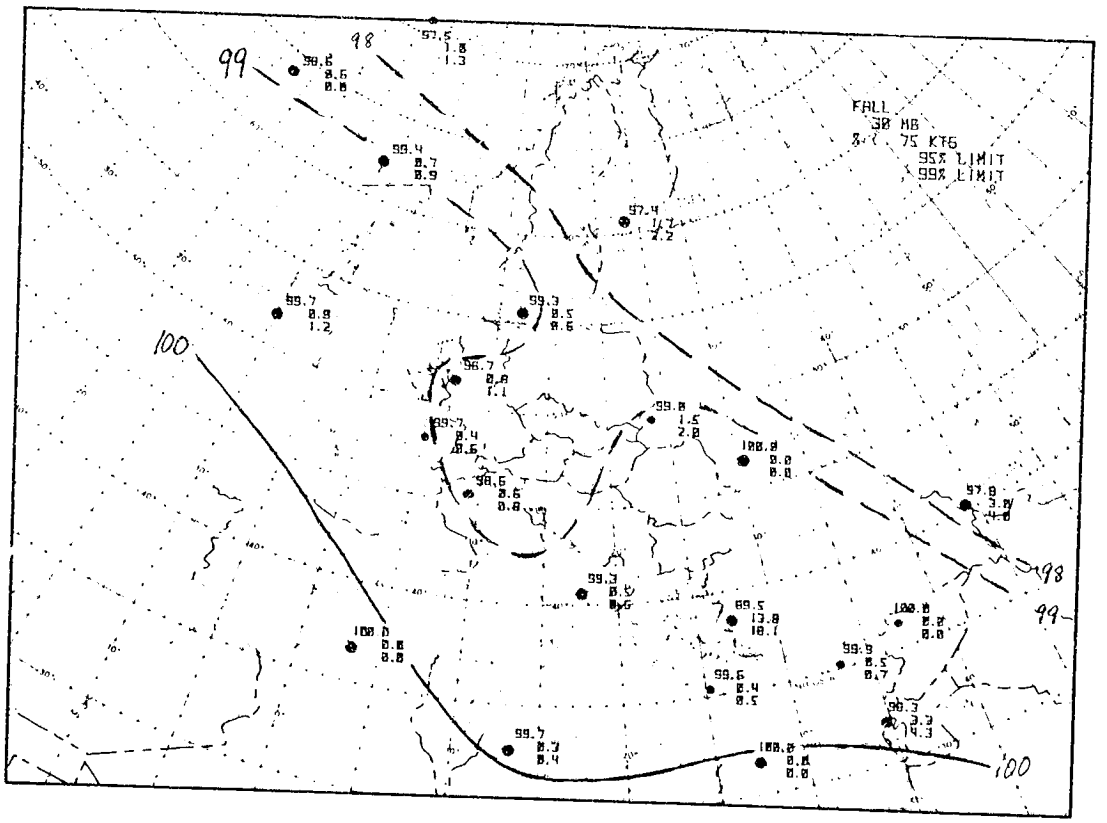
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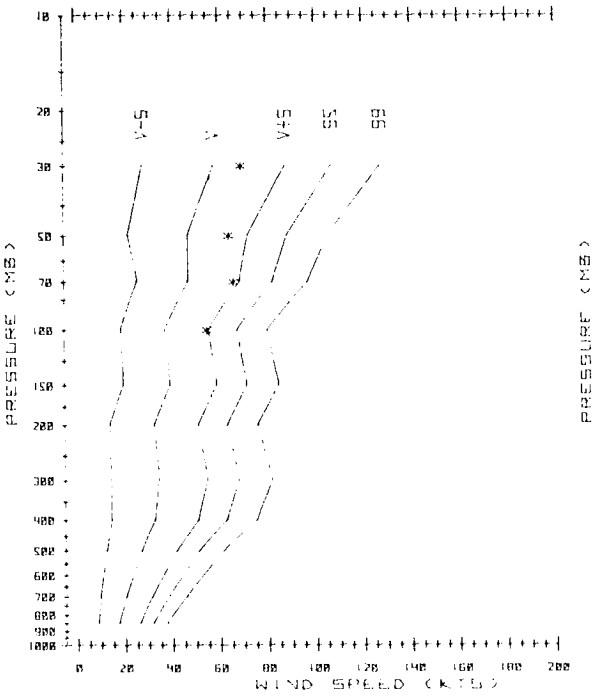
SECTION C

PACIFIC

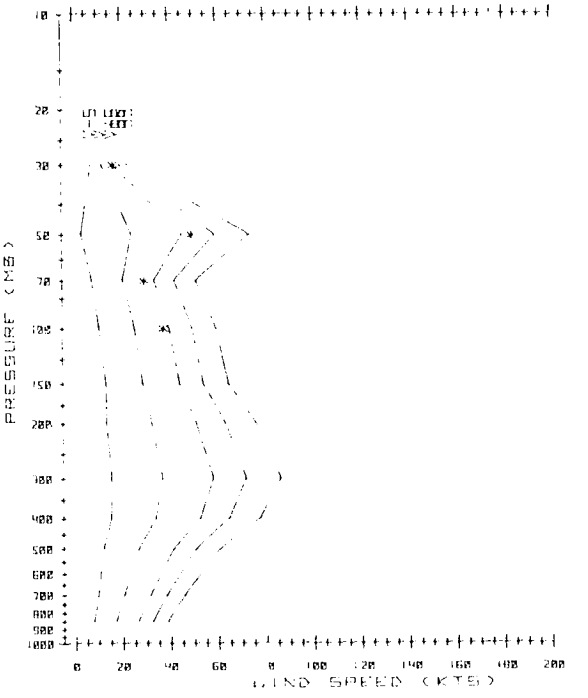
ALEKSANDROVSK
** 84 1% LEVEL

WINTER



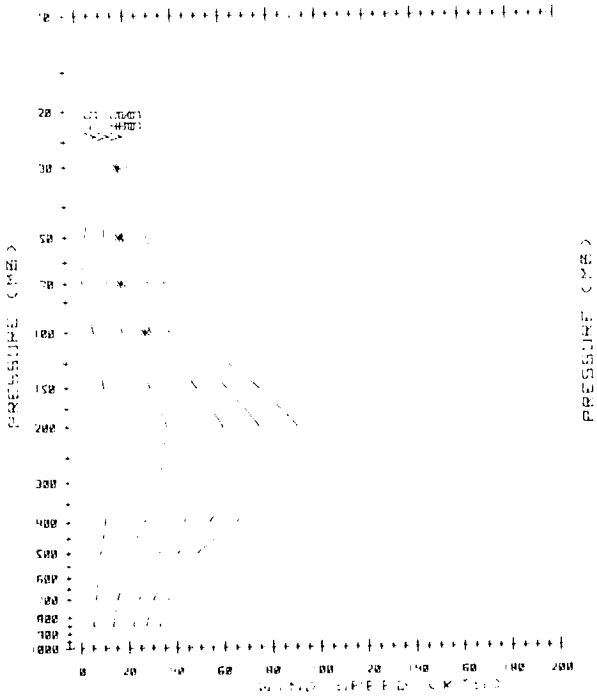
ALEKSANDROVSK
** 84 1% LEVEL

SPRING



ALEKSANDROVSK
** 84 1% LEVEL

SUMMER



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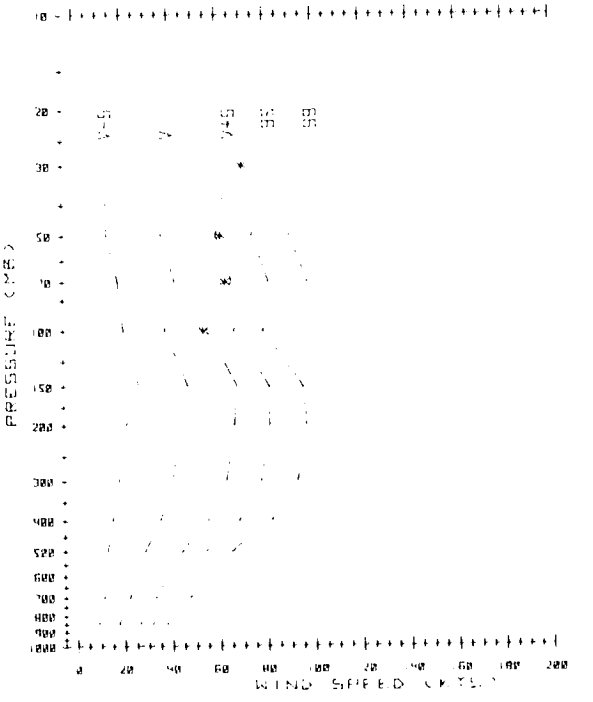

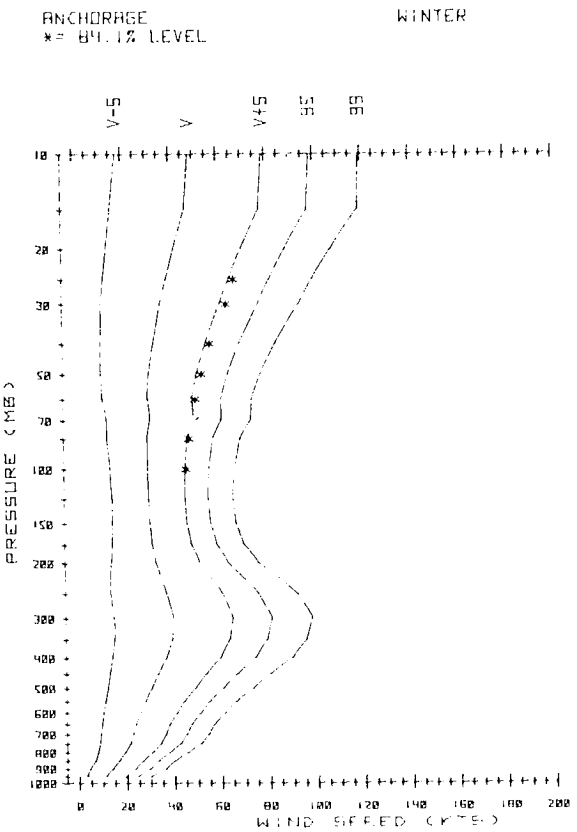
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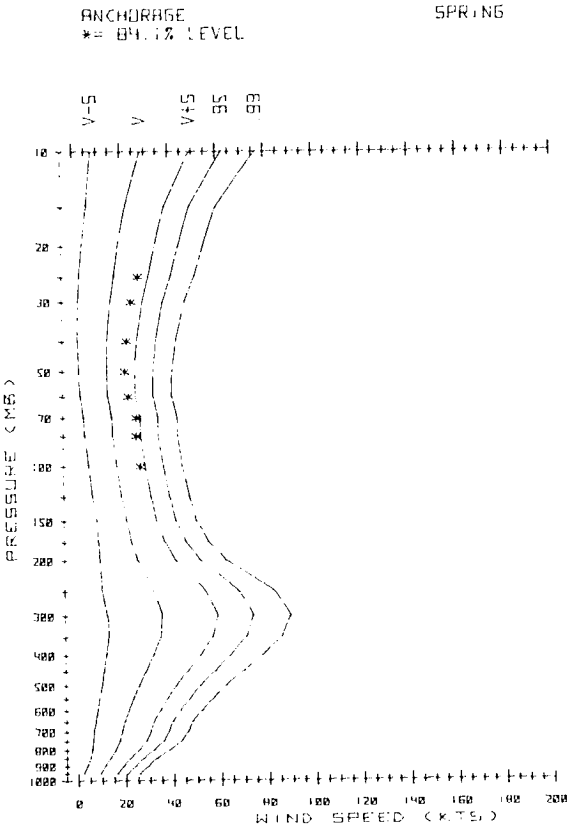
V
V+S
S5
S5
PRESSURE (MB)
WIND SPEED (KTS)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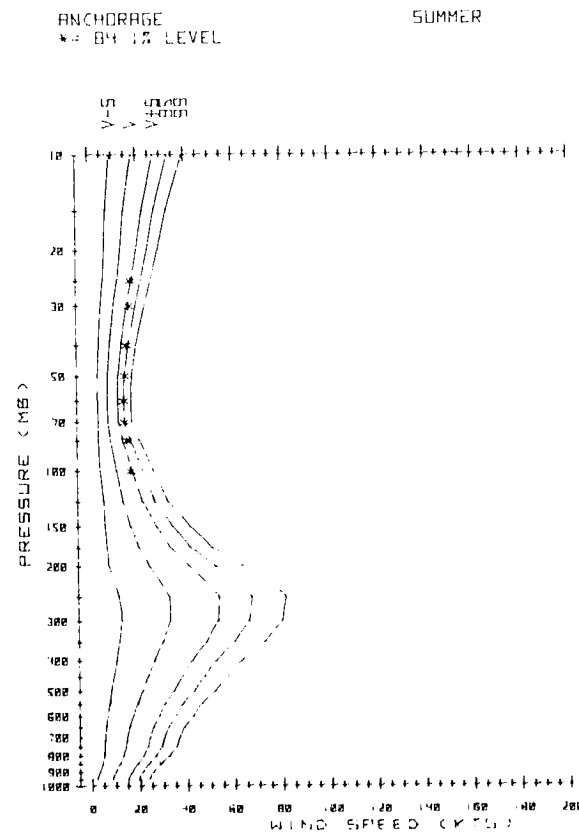
SPRING
V-S
V
V+S
S5
S5
PRESSURE (MB)
WIND SPEED (KTS)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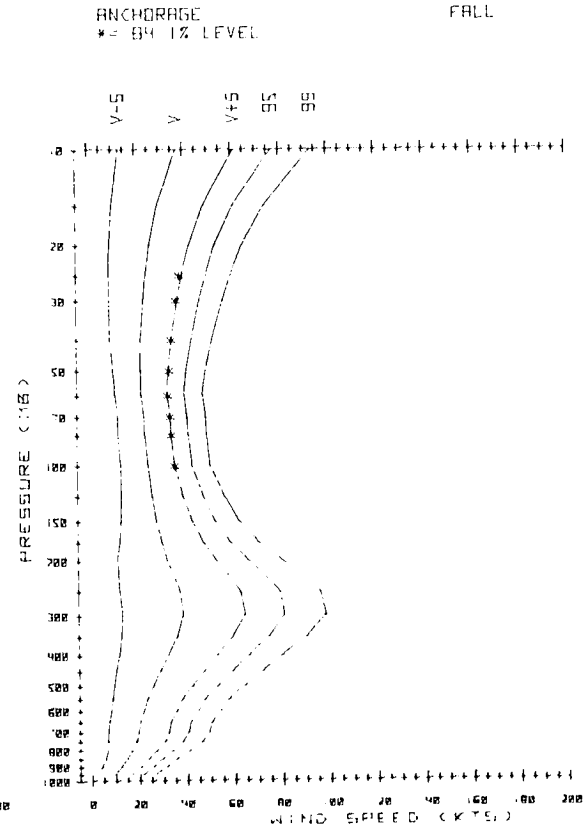
SUMMER
PRESSURE (MB)
WIND SPEED (KTS)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FALL
V-S
V
V+S
S5
S5
PRESSURE (MB)
WIND SPEED (KTS)

AYAN
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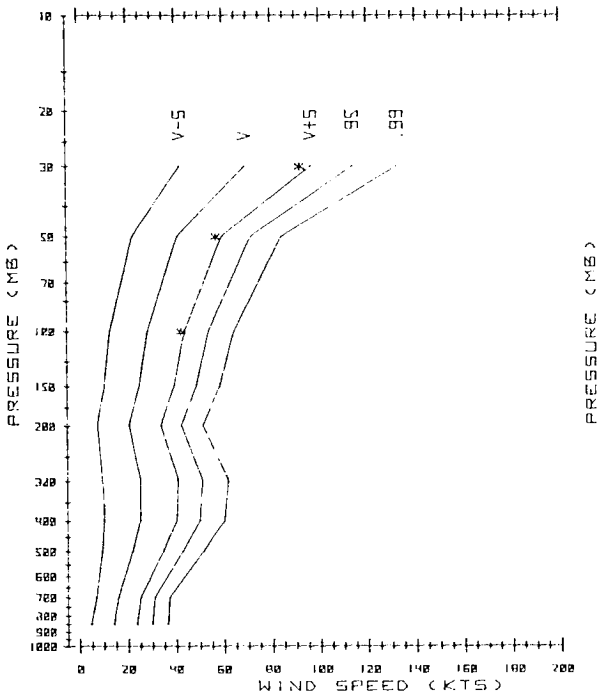
WINTER



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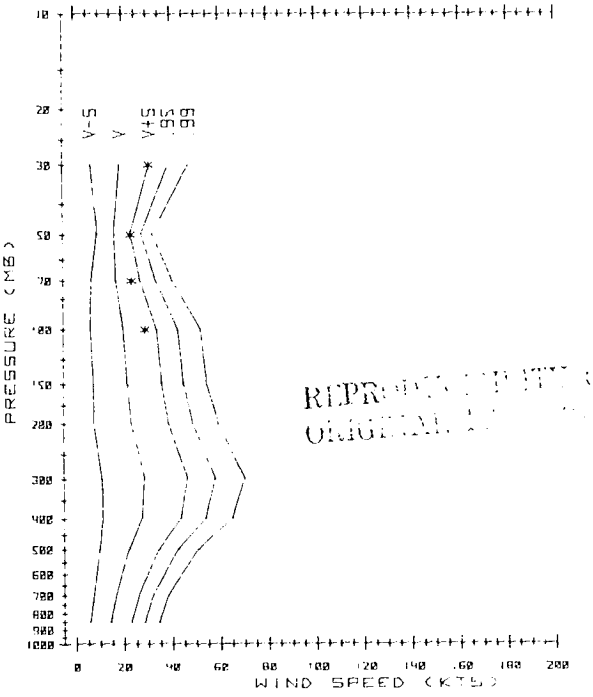

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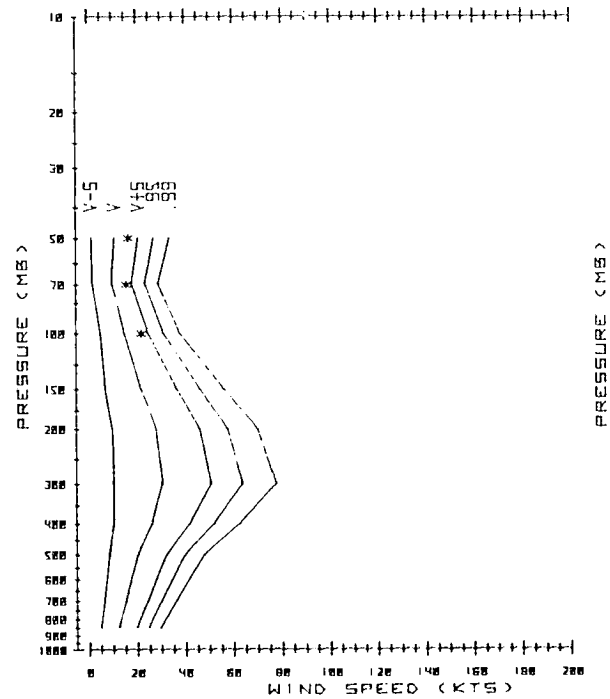
SUMMER



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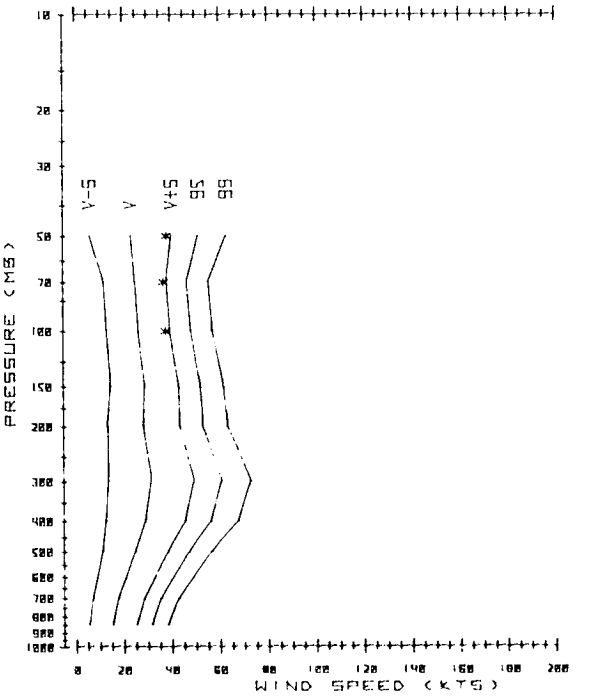
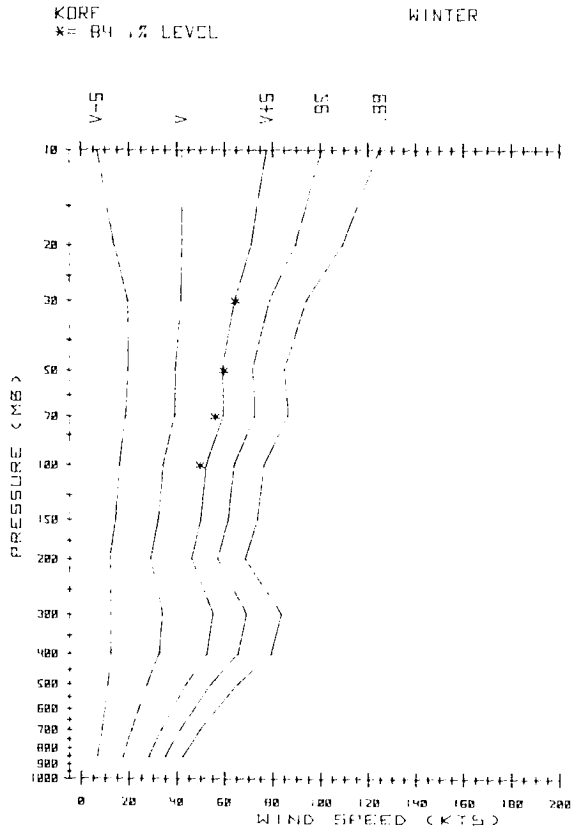
FALL

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WINTER
V-5
V
V+5
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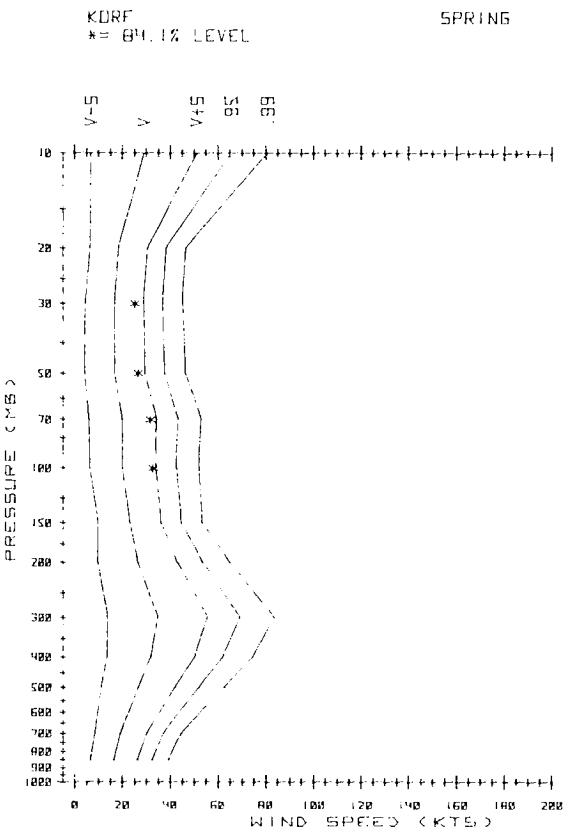
PRESSURE (MB)
WIND SPEED (KTS)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V
V+5
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PRESSURE (MB)
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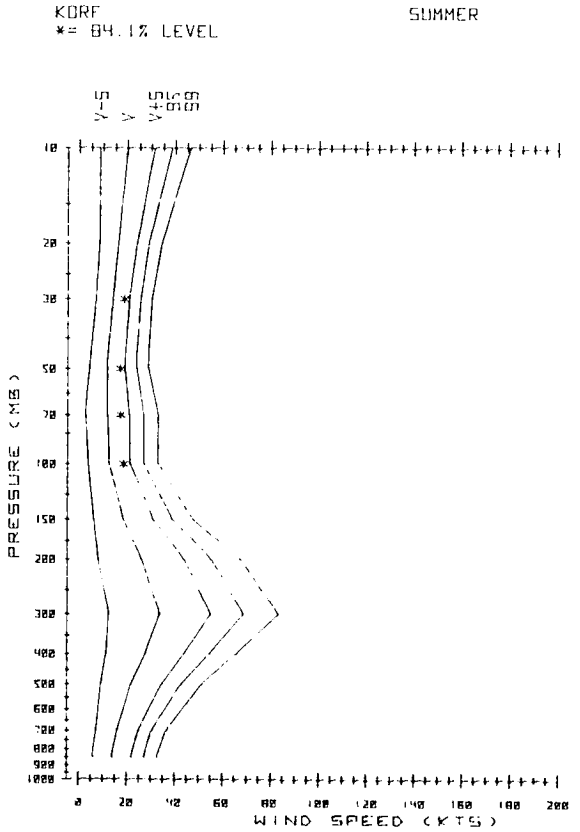
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SUMMER
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PRESSURE (MB)
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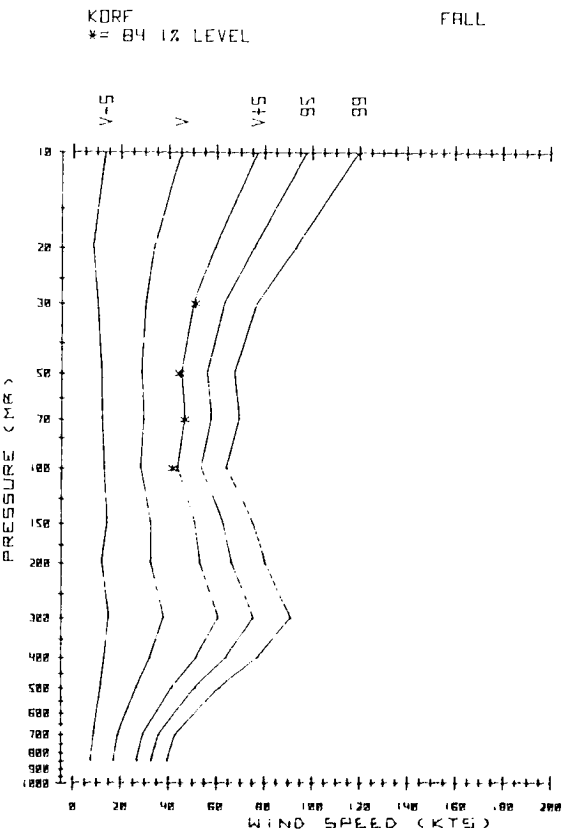
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FALL
V-5
V
V+5
50
90
PRESSURE (MB)
WIND SPEED (KTS)

MYS VASILYEVA
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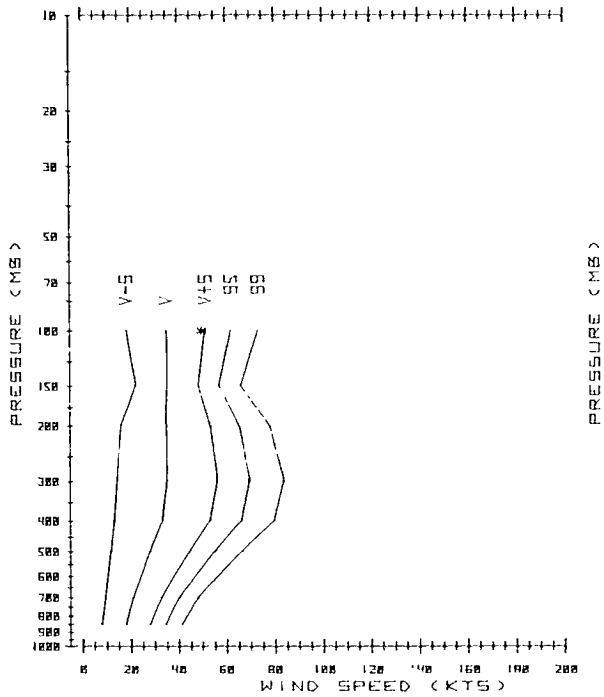
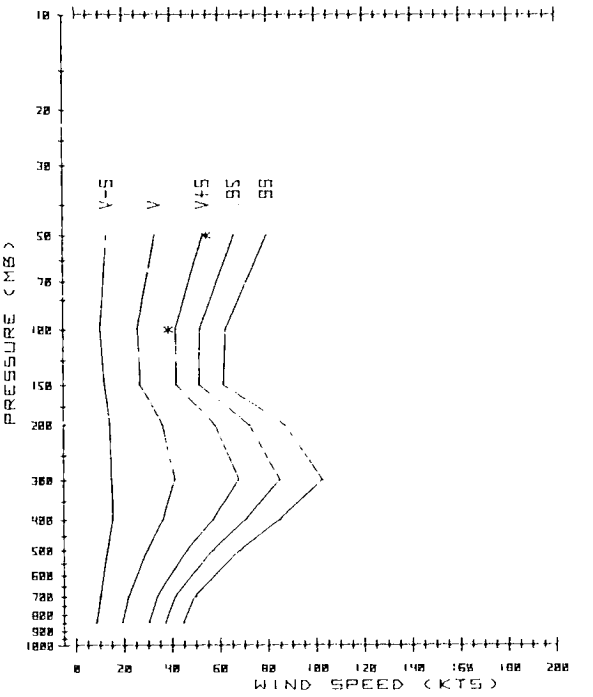
WINTER



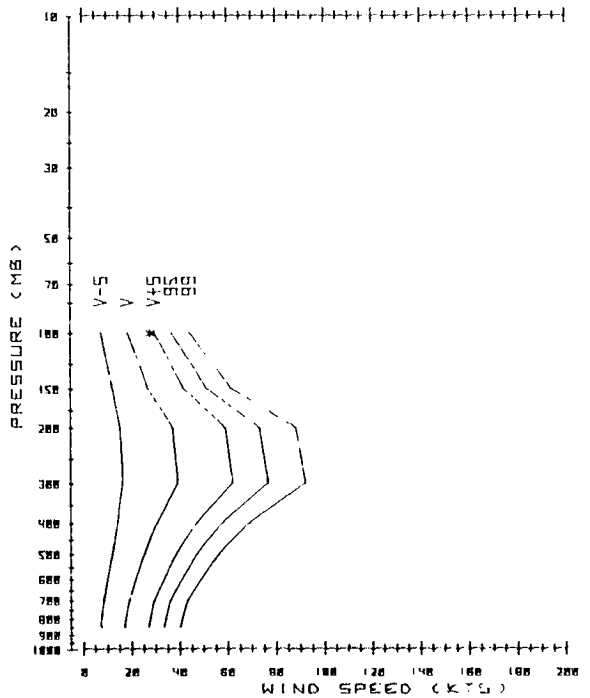
MYS VASILYEVA
*= 84 1% LEVEL

SPRING



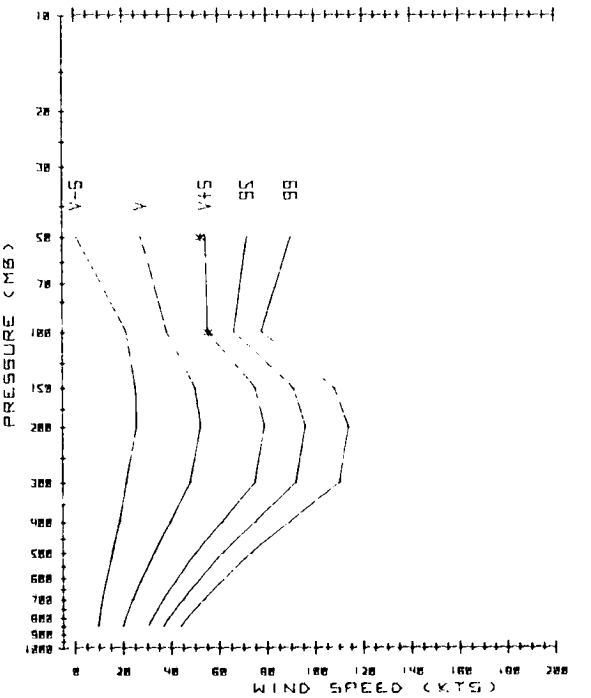
MYS VASILYEVA
*= 84 1% LEVEL

SUMMER

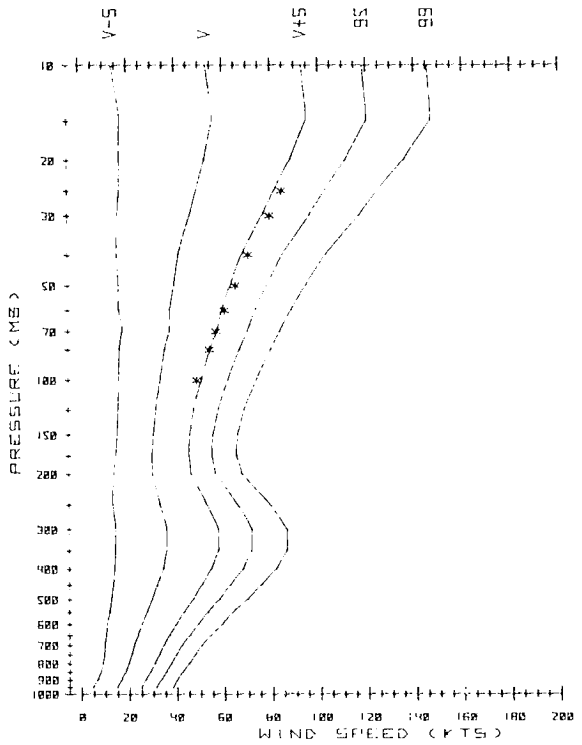


MYS VASILYEVA
*= 84 1% LEVEL

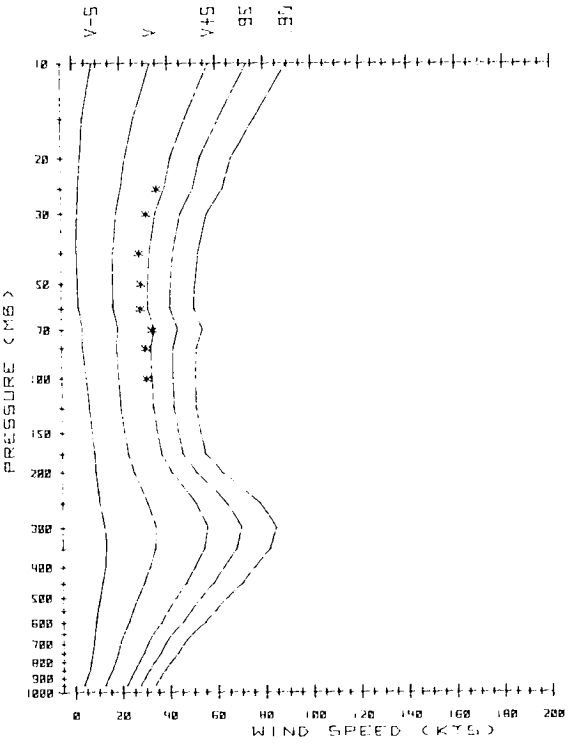
FALL



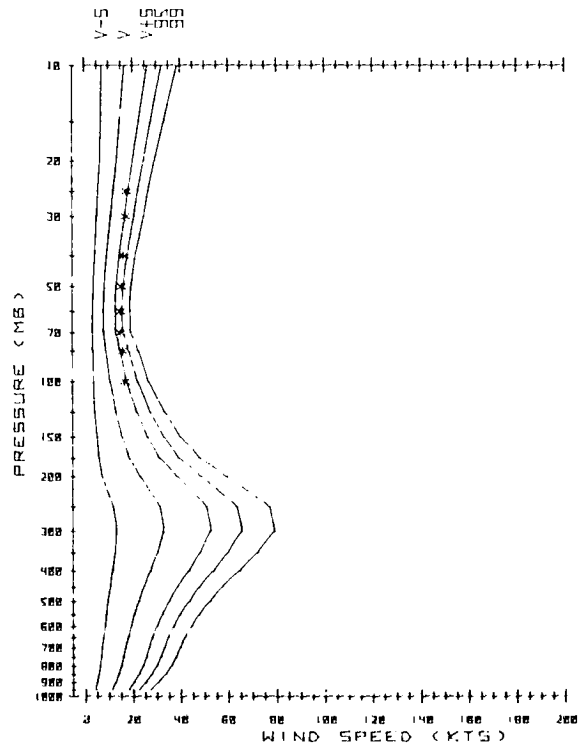
NOME WINTER
*= 84.1% LEVEL



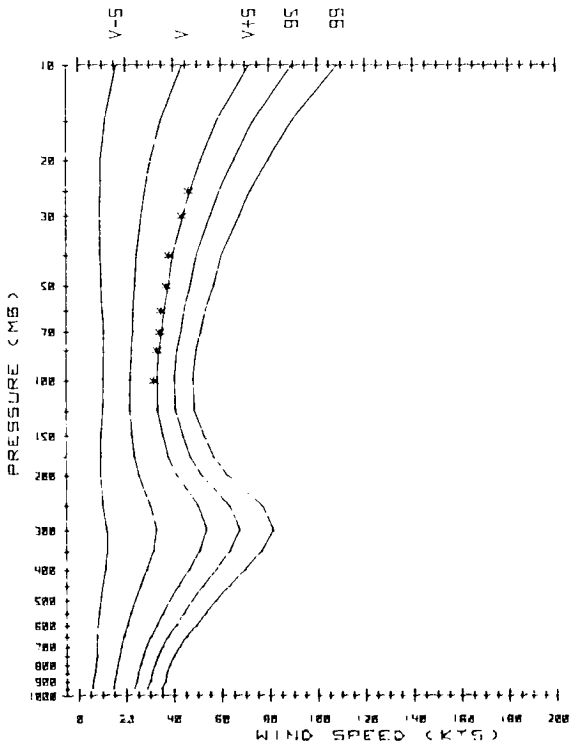
NOME SPRING
*= 84.1% LEVEL



NOME SUMMER
*= 84.1% LEVEL

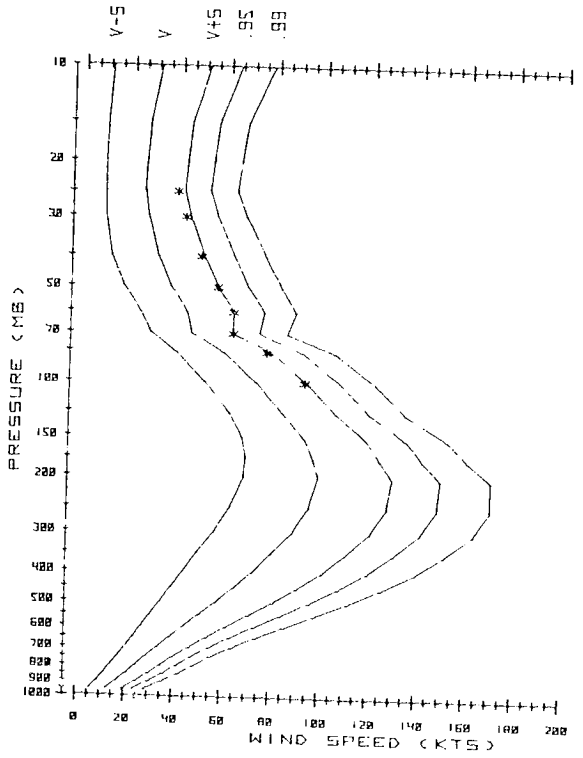


NOME FALL
*= 84.1% LEVEL



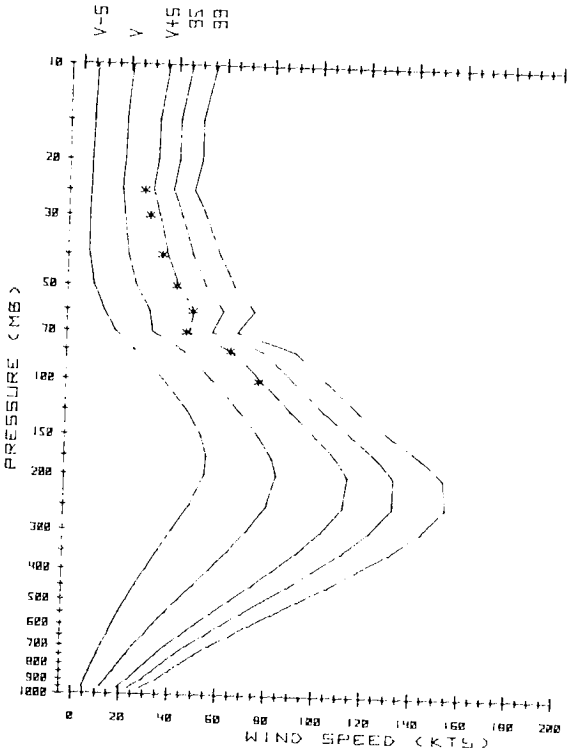
OSAN
*= 84.1% LEVEL

WINTER



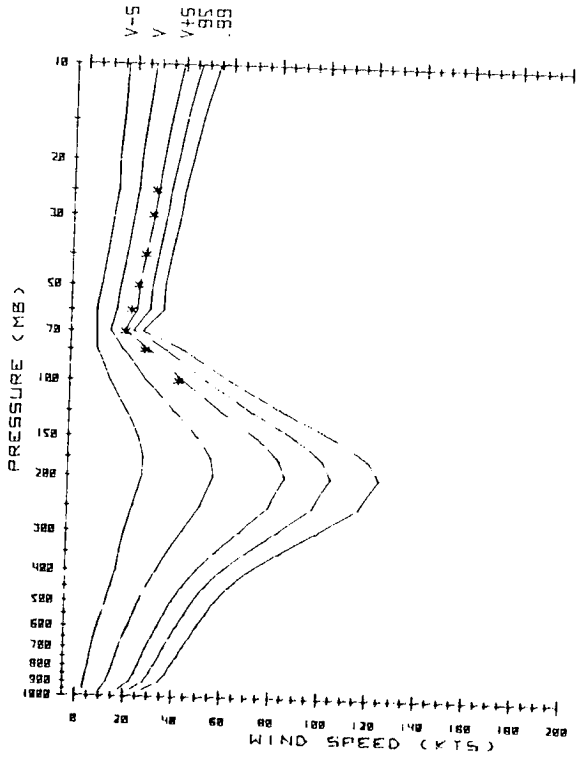
OSAN
*= 84.1% LEVEL

SPRING



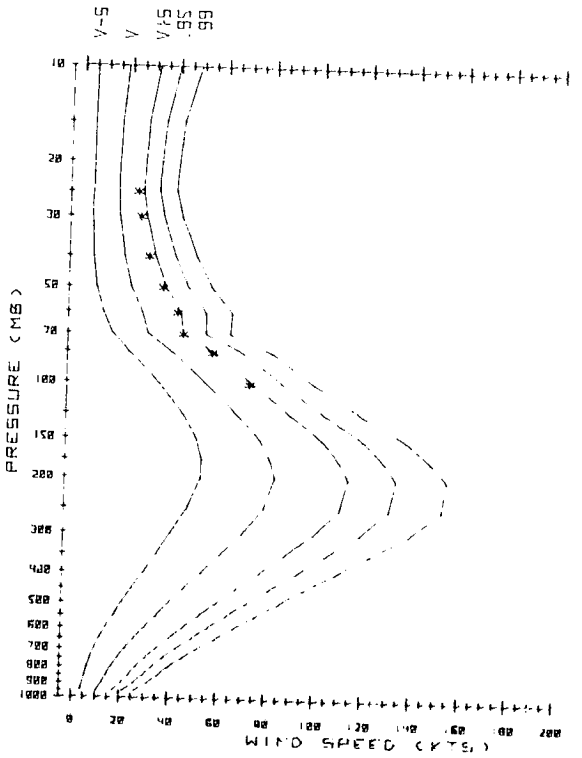
OSAN
*= 84.1% LEVEL

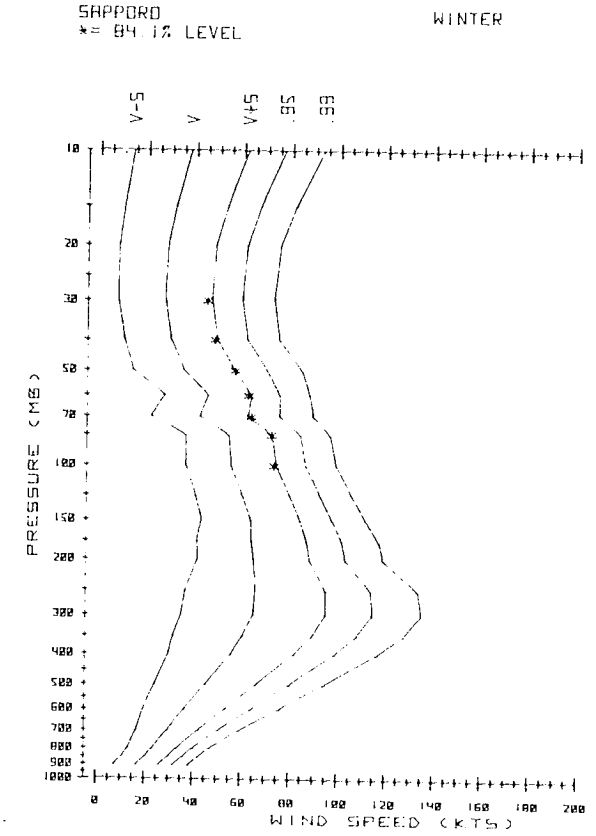
SUMMER

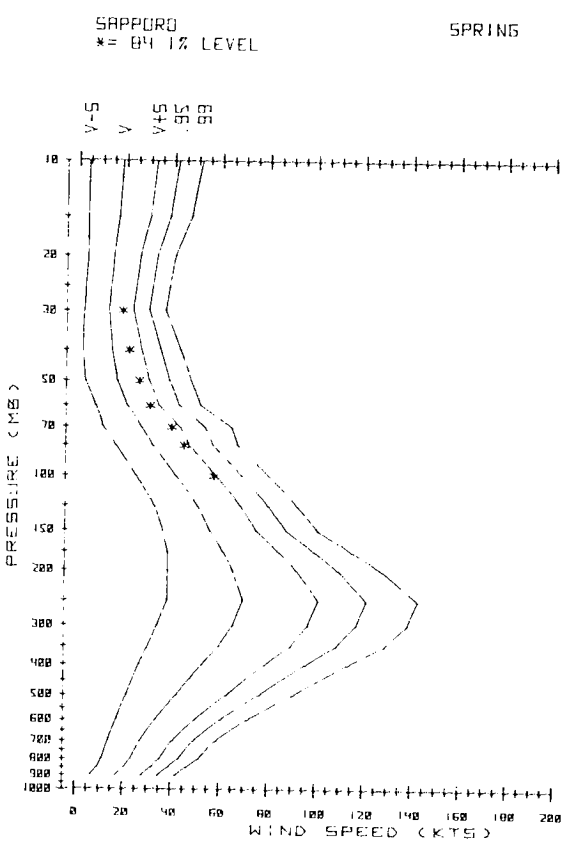


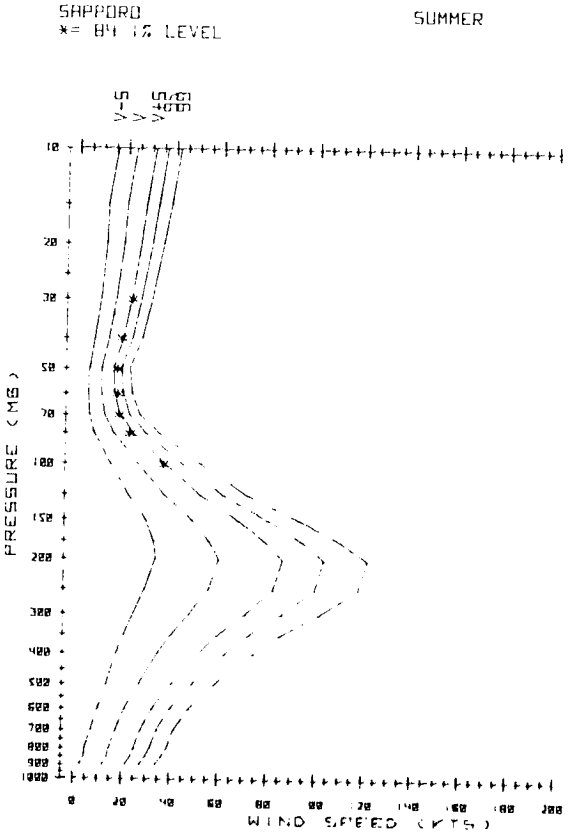
OSAN
*= 84.1% LEVEL

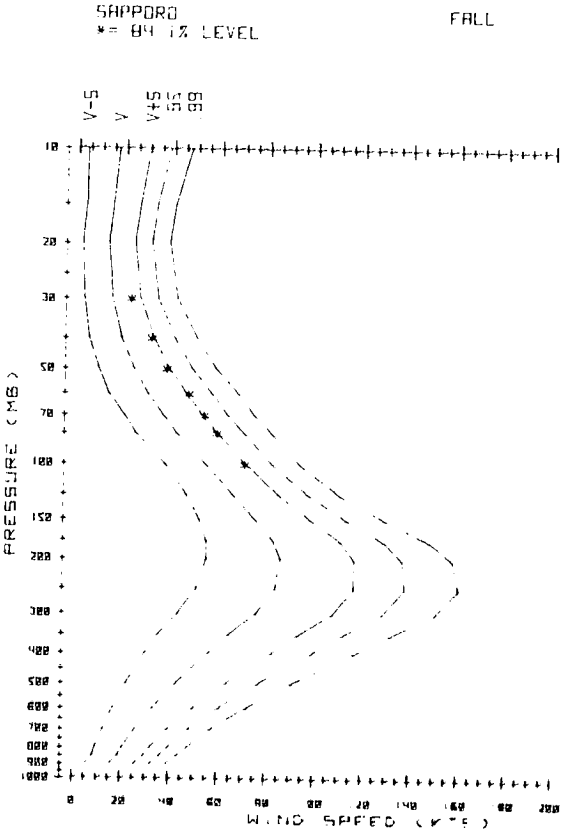
FALL



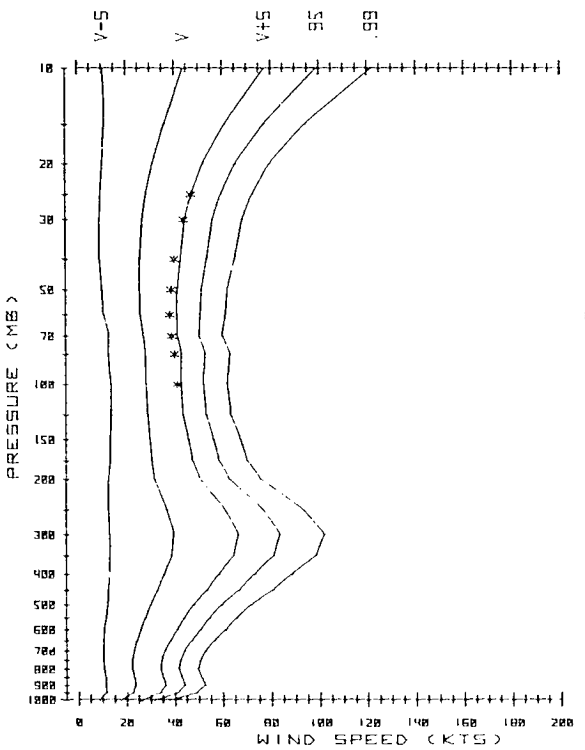

SAPPORO
*= 84 1% LEVEL
WINTER
V-S
V
V+S
PRESSURE (MB)
WIND SPEED (KTS)


SAPPORO
*= 84 1% LEVEL
SPRING
V-S
V
V+S
PRESSURE (MB)
WIND SPEED (KTS)

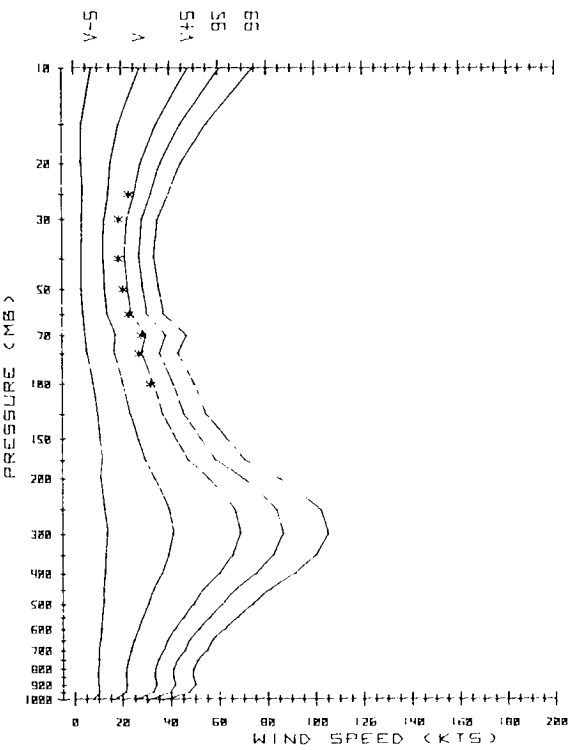

SAPPORO
*= 84 1% LEVEL
SUMMER
PRESSURE (MB)
WIND SPEED (KTS)


SAPPORO
*= 84 1% LEVEL
FALL
V-S
V
V+S
PRESSURE (MB)
WIND SPEED (KTS)

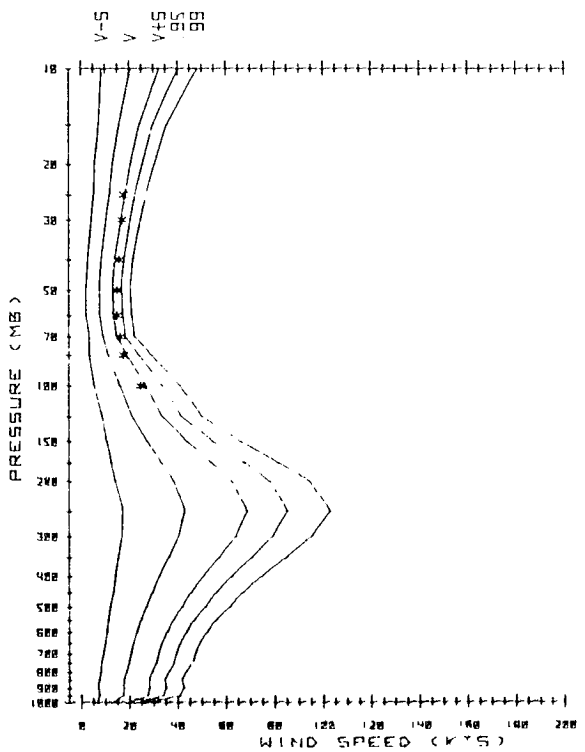
SHEMYA WINTER
*= 84.1% LEVEL



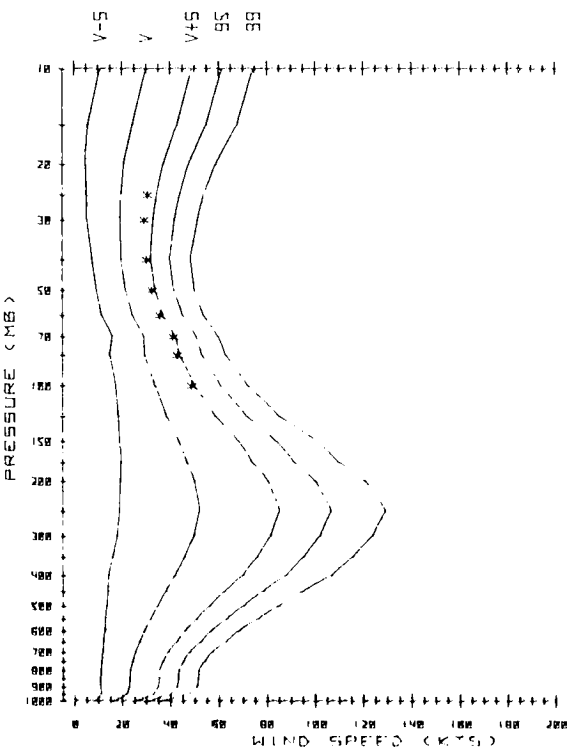
SHEMYA SPRING
*= 84.1% LEVEL



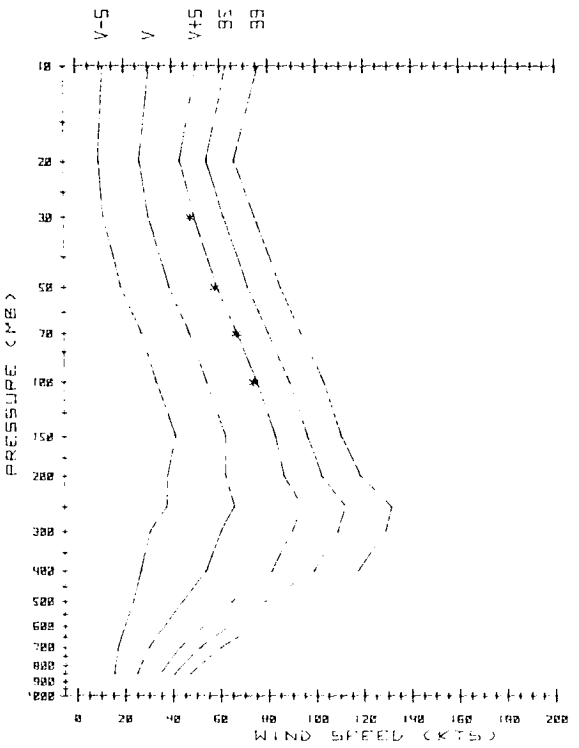
SHEMYA SUMMER
*= 84.1% LEVEL



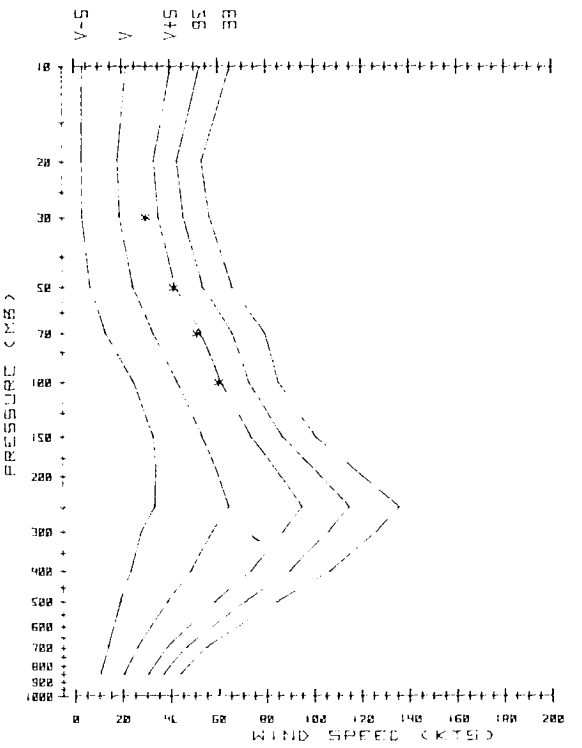
SHEMYA FALL
*= 84.1% LEVEL



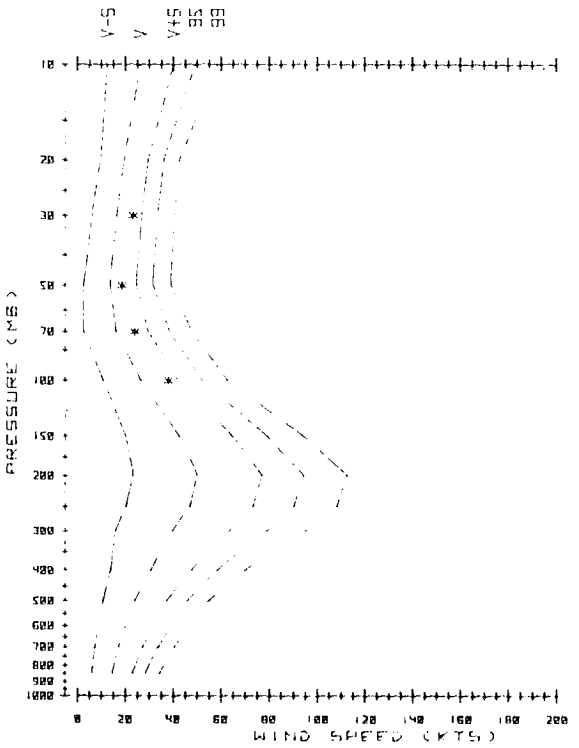
VLADIVOSTOK WINTER
*= 84.1% LEVEL



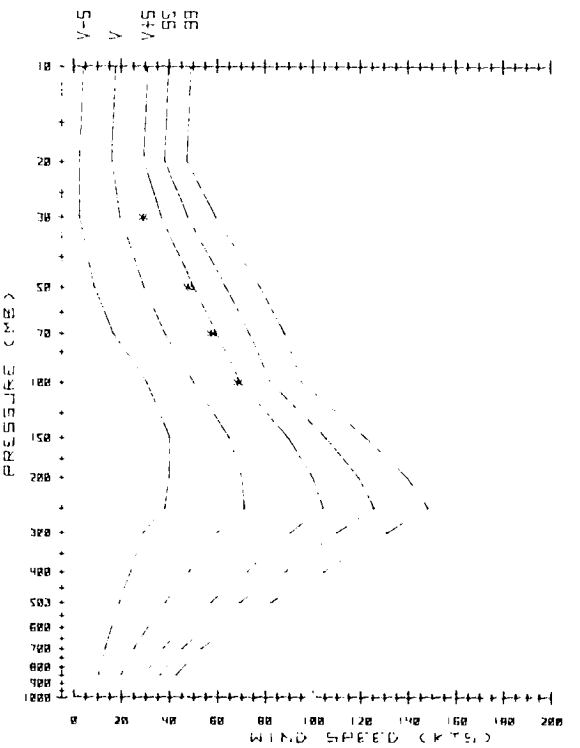
VLADIVOSTOK SPRING
*= 84.1% LEVEL



VLADIVOSTOK SUMMER
*= 84.1% LEVEL

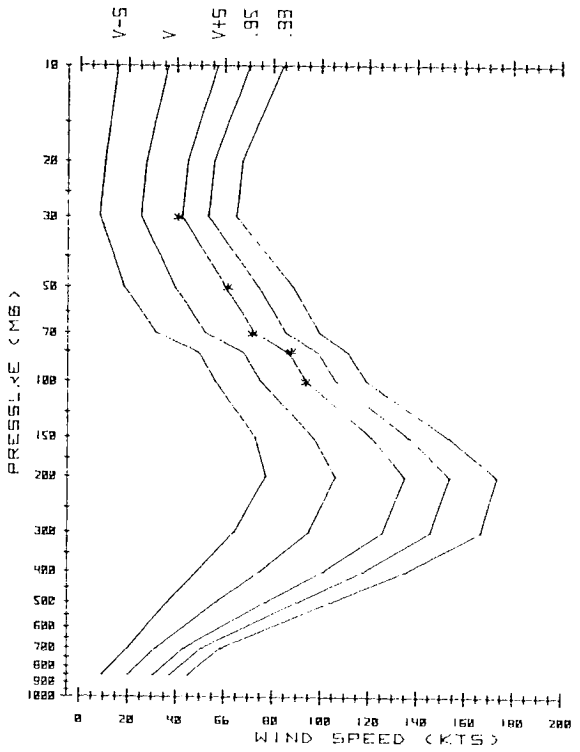


VLADIVOSTOK FALL
*= 84.1% LEVEL



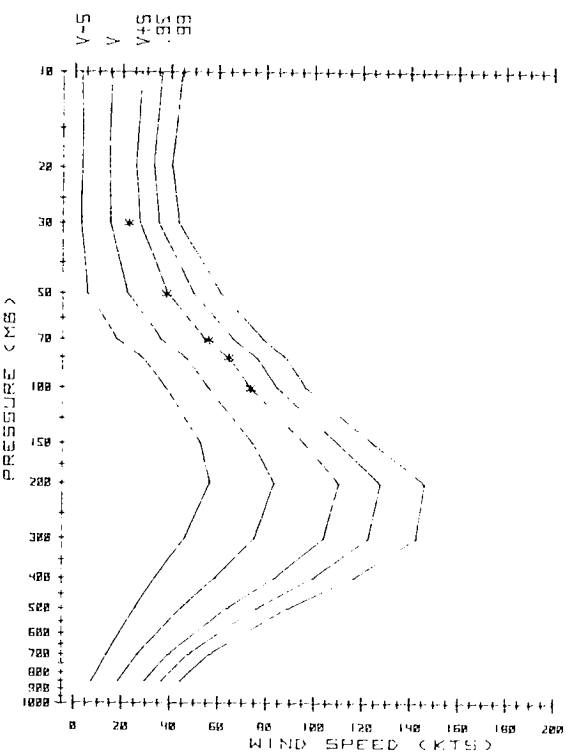
WAJIMA
*= 84.1% LEVEL

WINTER



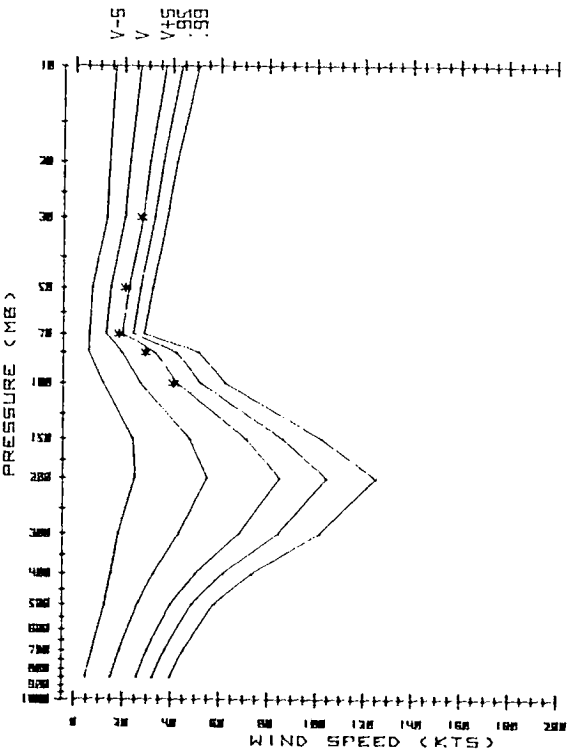
WAJIMA
*= 84.1% LEVEL

SPRING



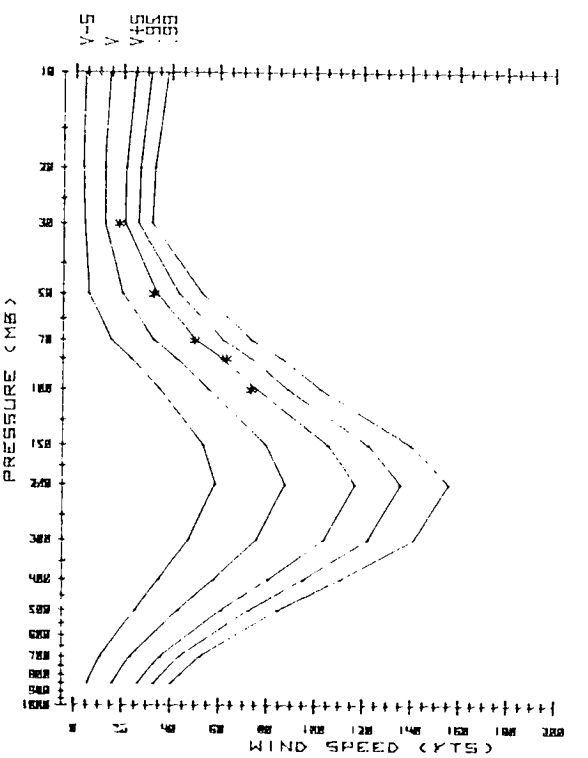
WAJIMA
*= 84.1% LEVEL

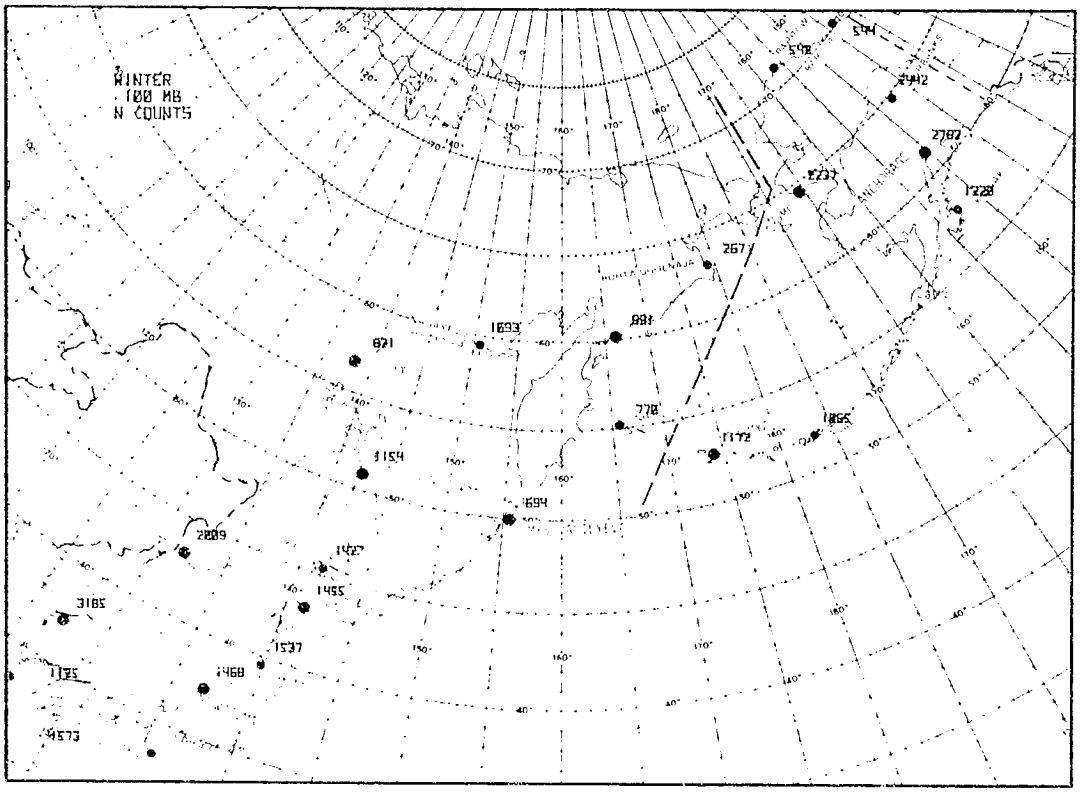
SUMMER

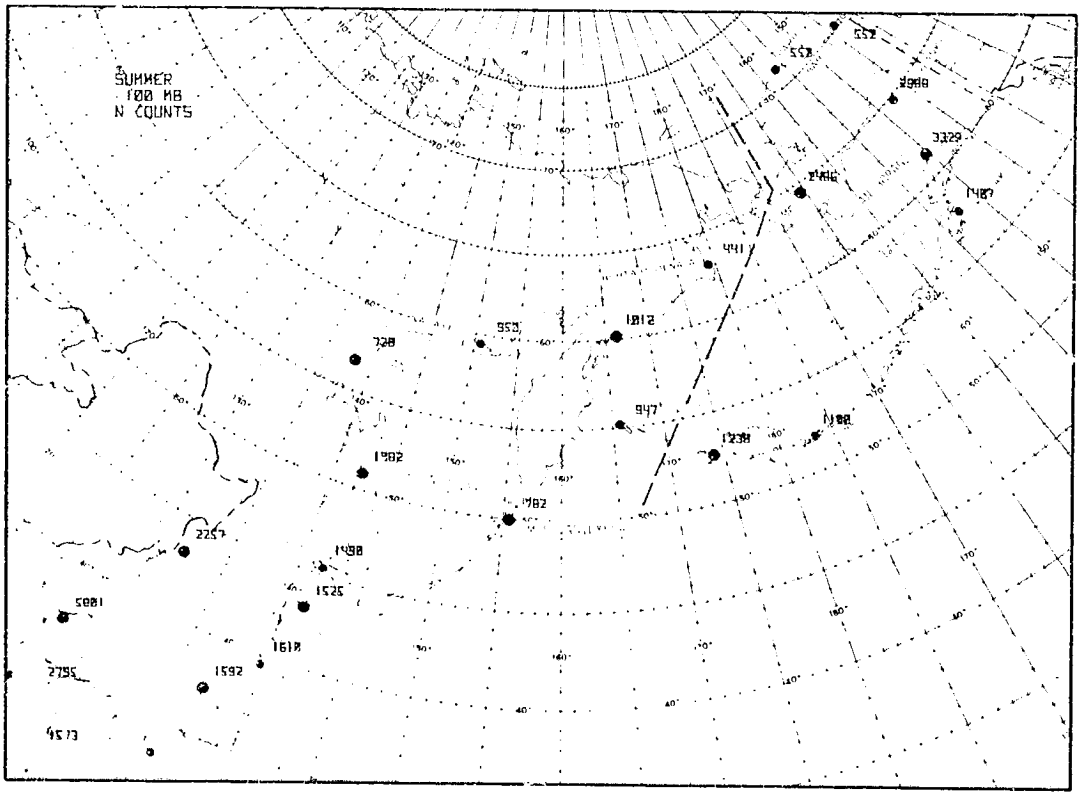


WAJIMA
*= 84.1% LEVEL

FALL




WINTER
100 MB
N COUNTS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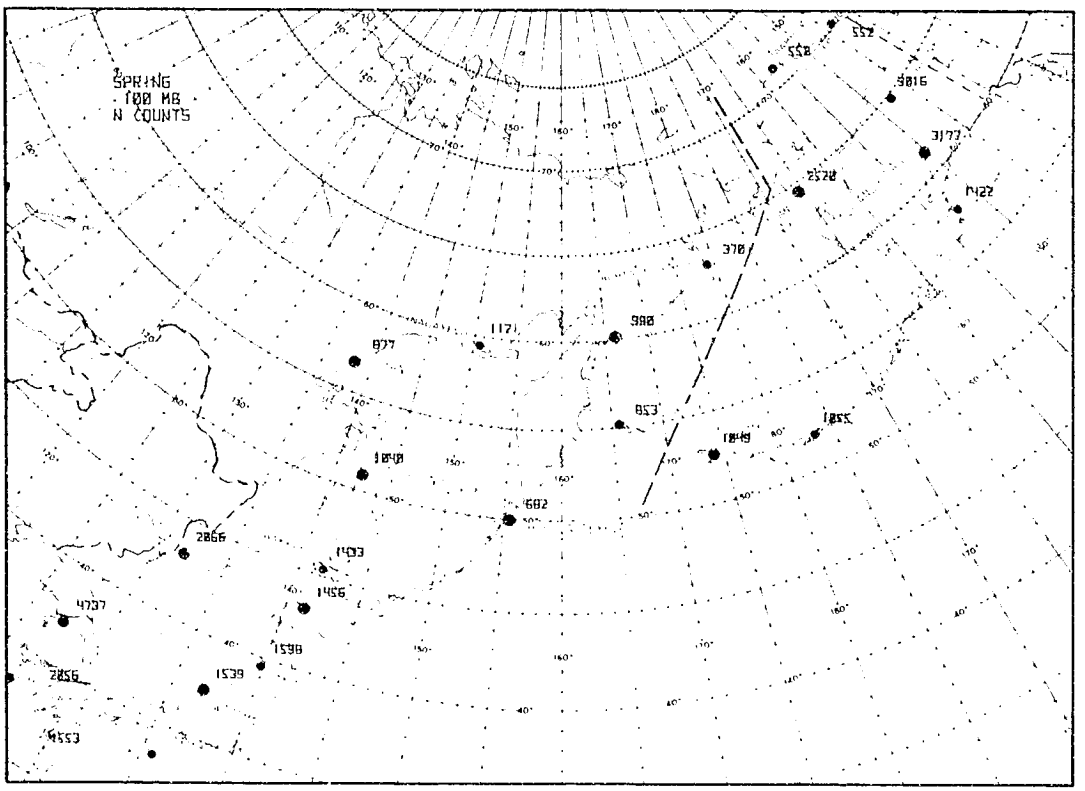
N COUNTS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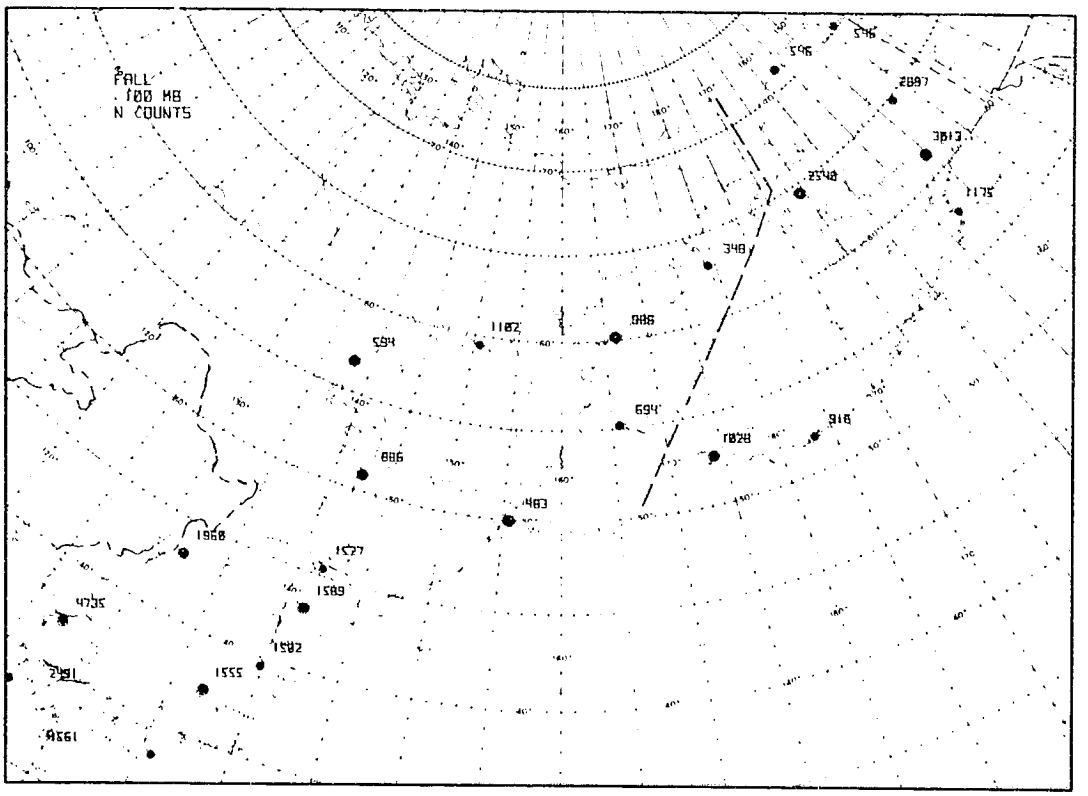
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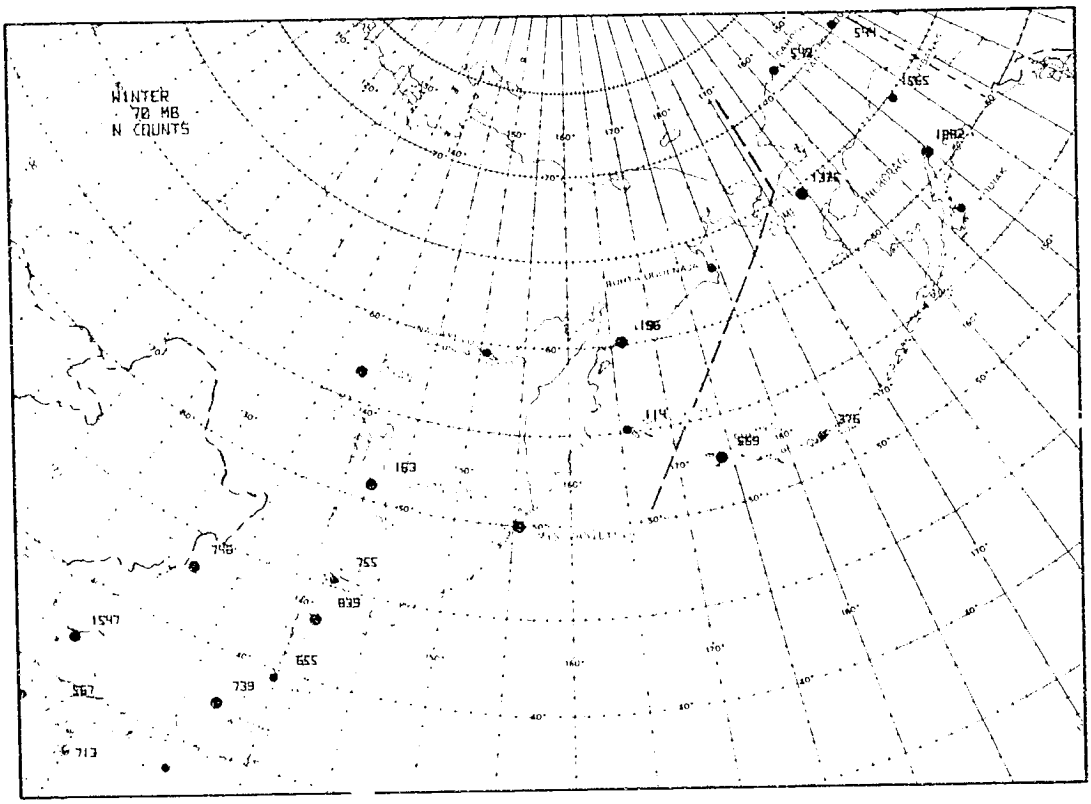
N COUNTS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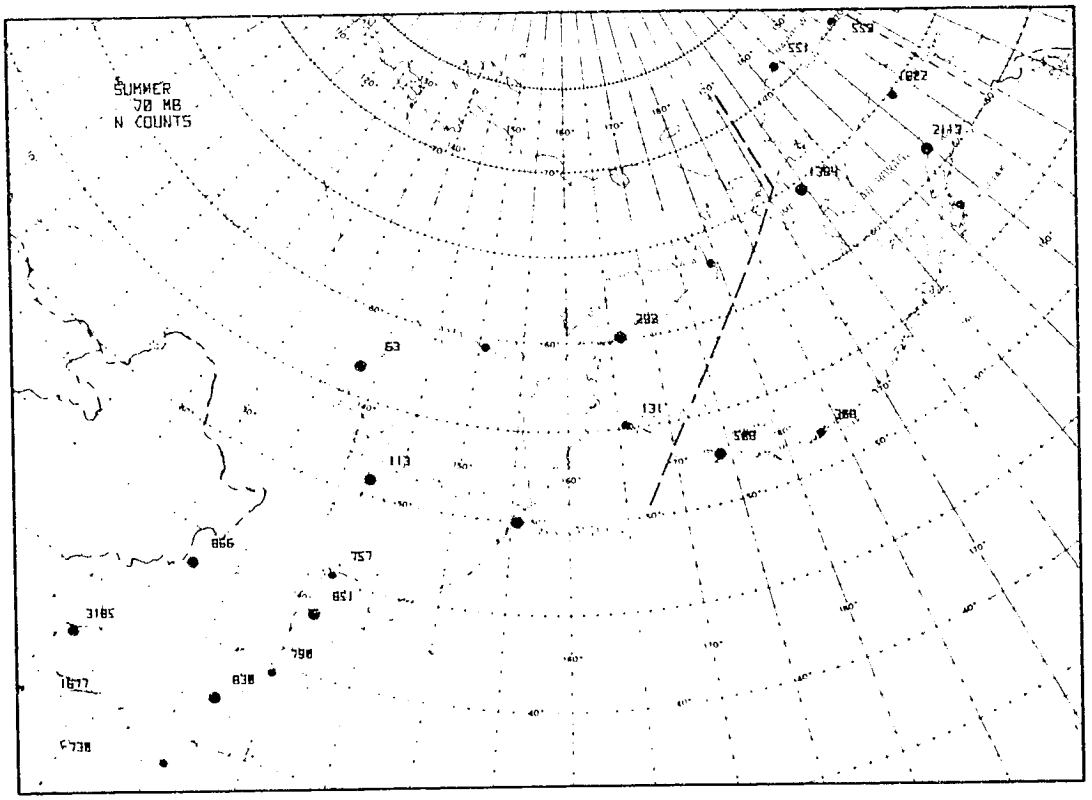
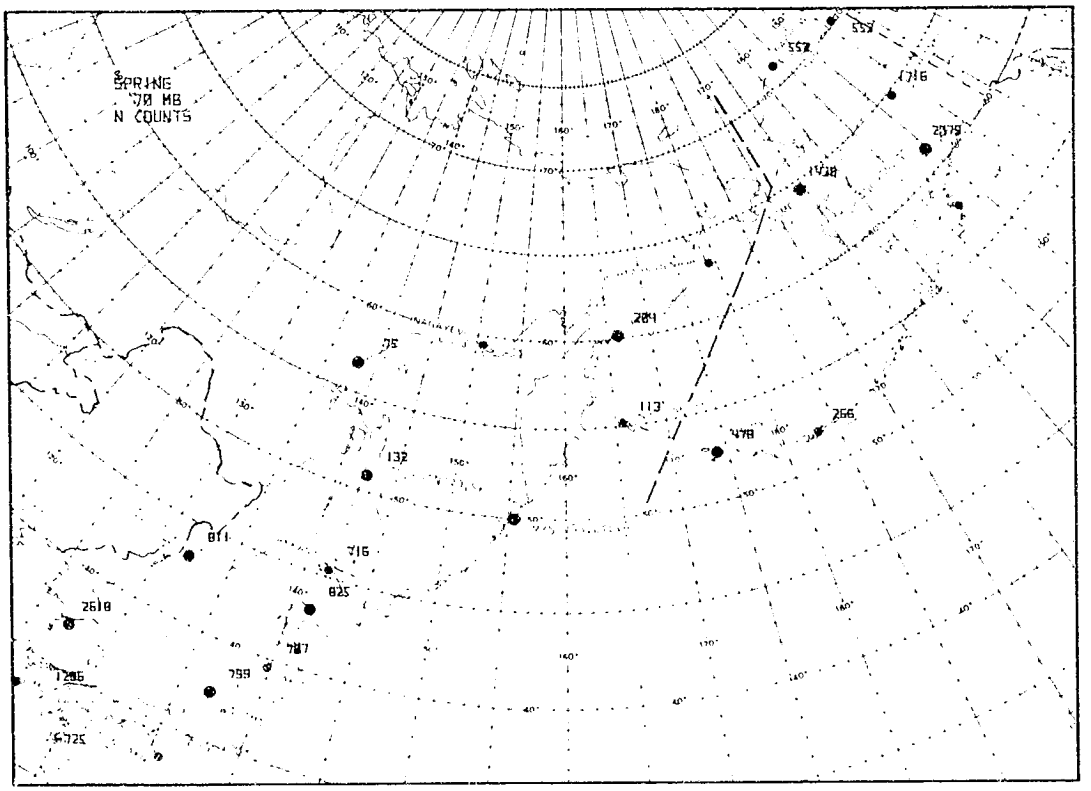
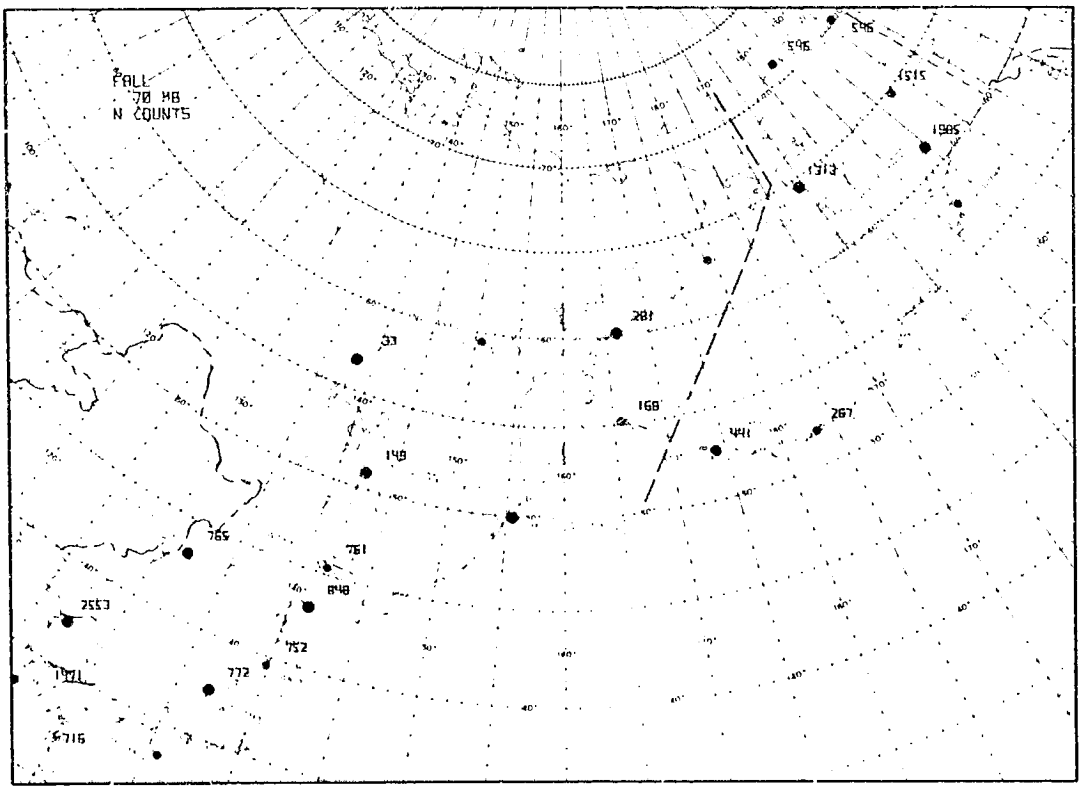
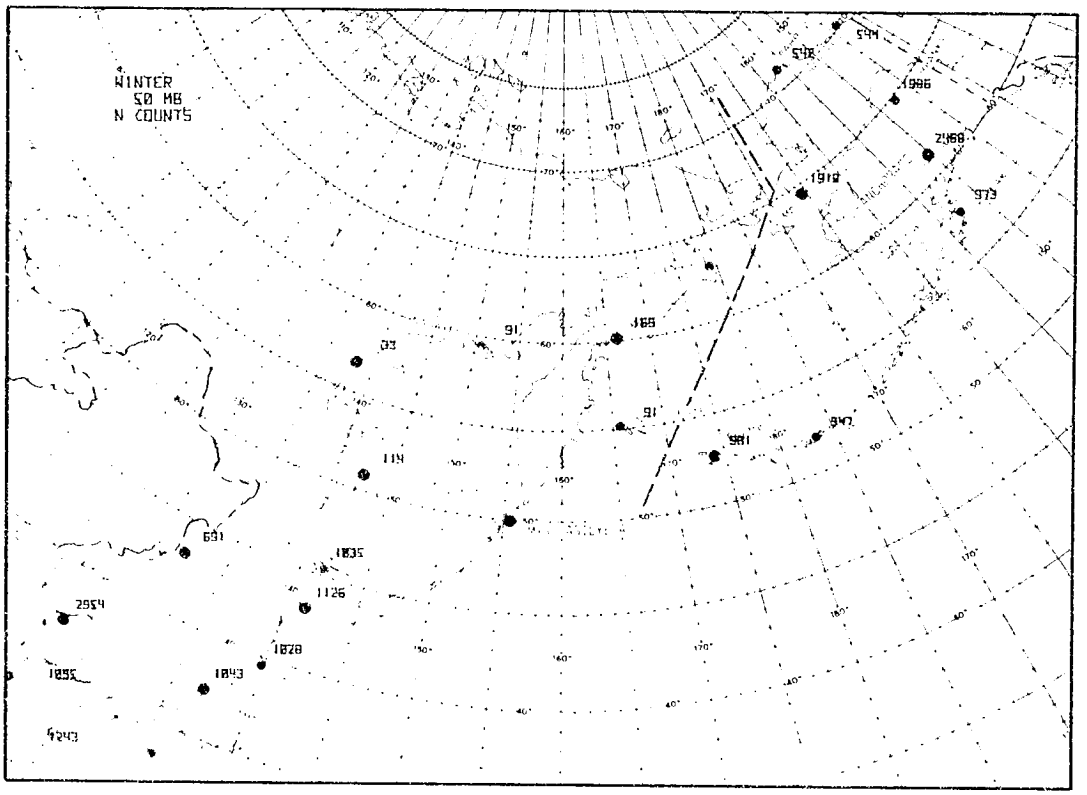
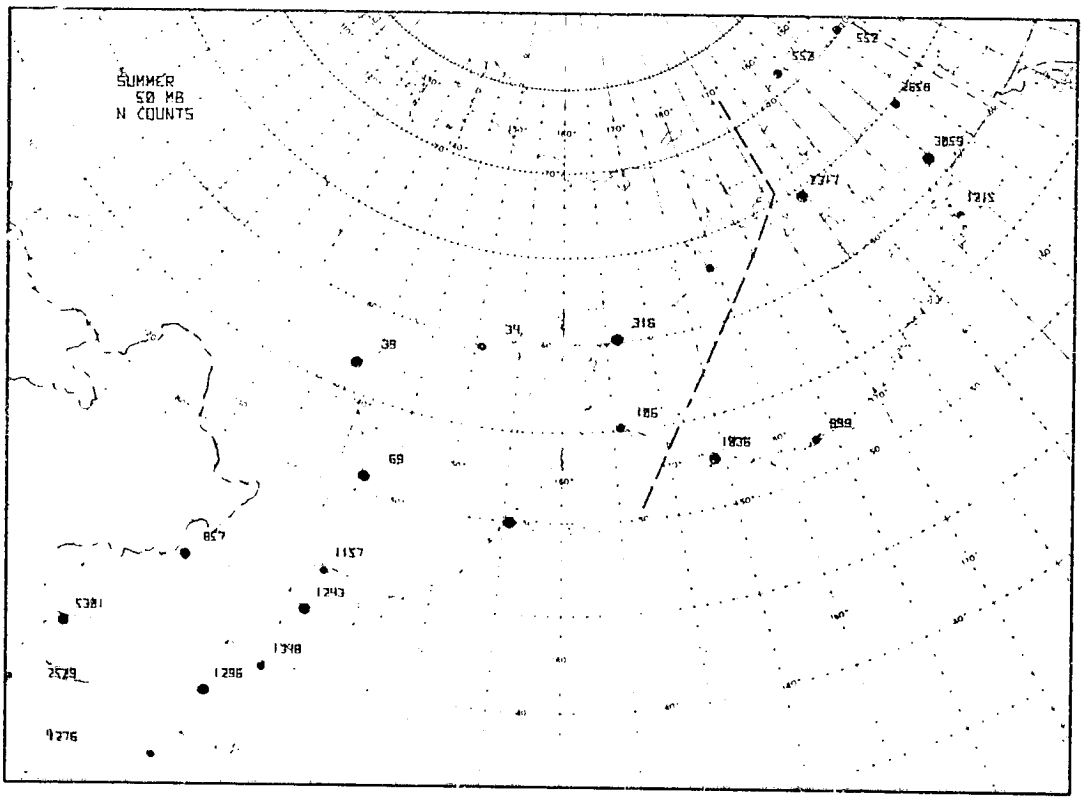
N COUNTS


SUMMER
70 MB
N COUNTS






WINTER
50 MB
N COUNTS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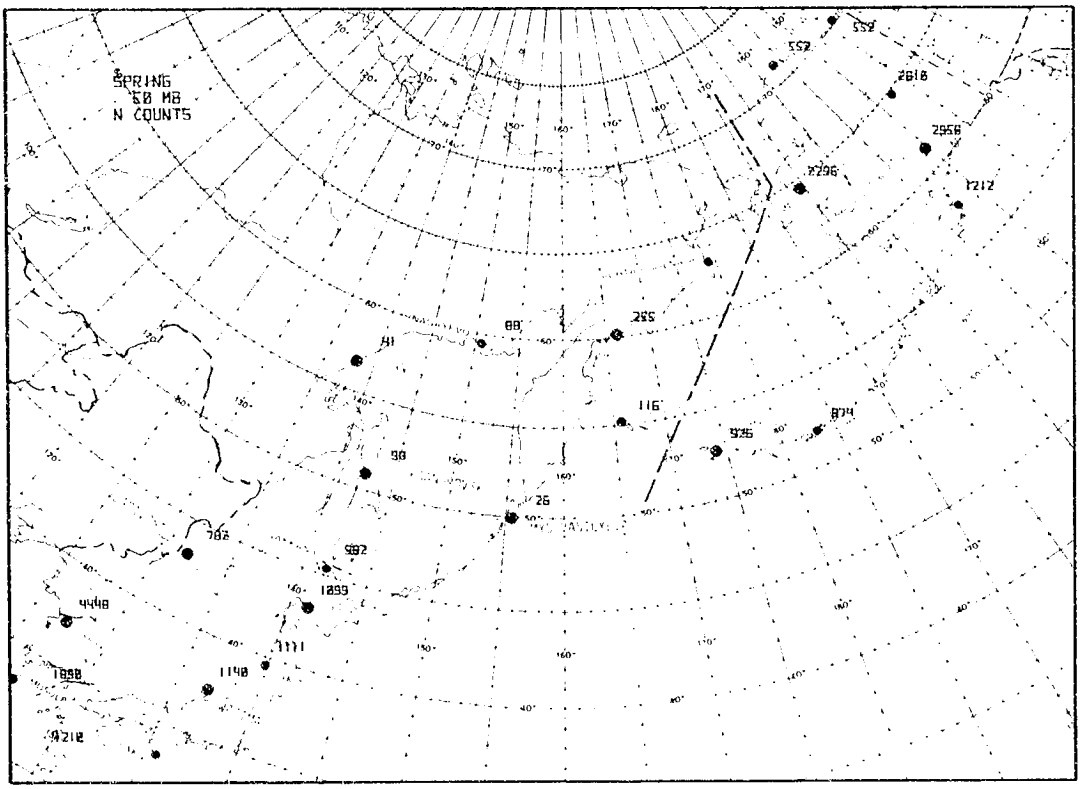
N COUNTS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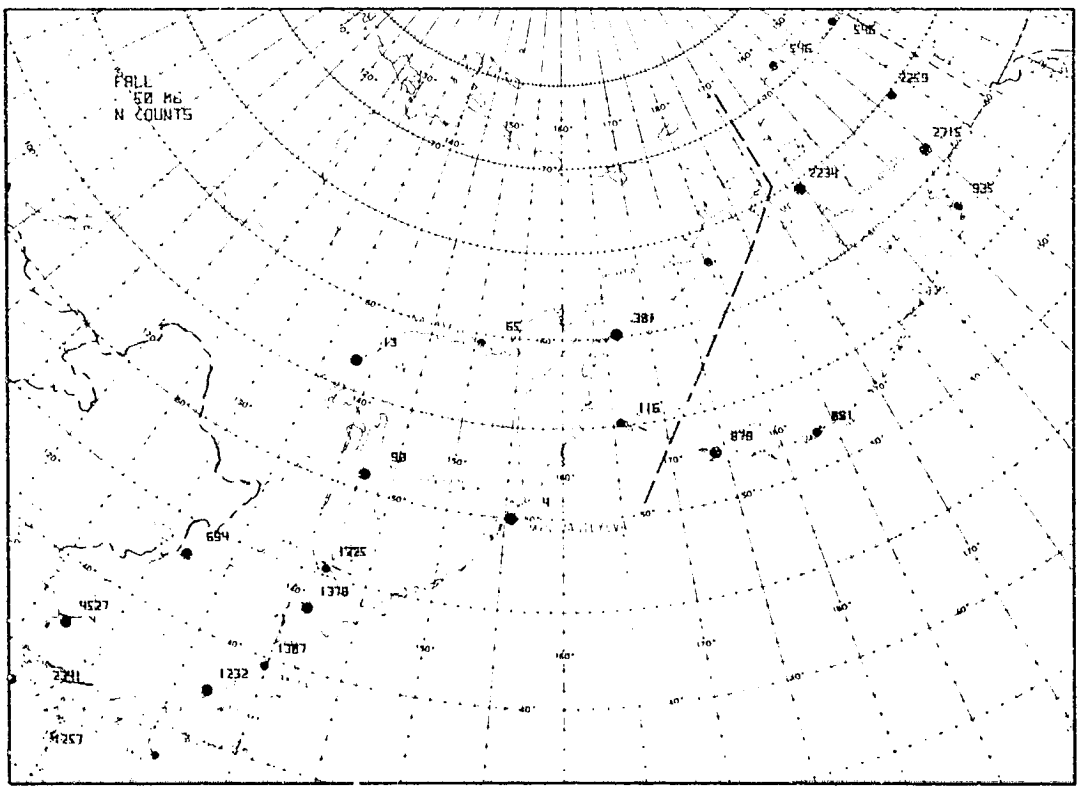
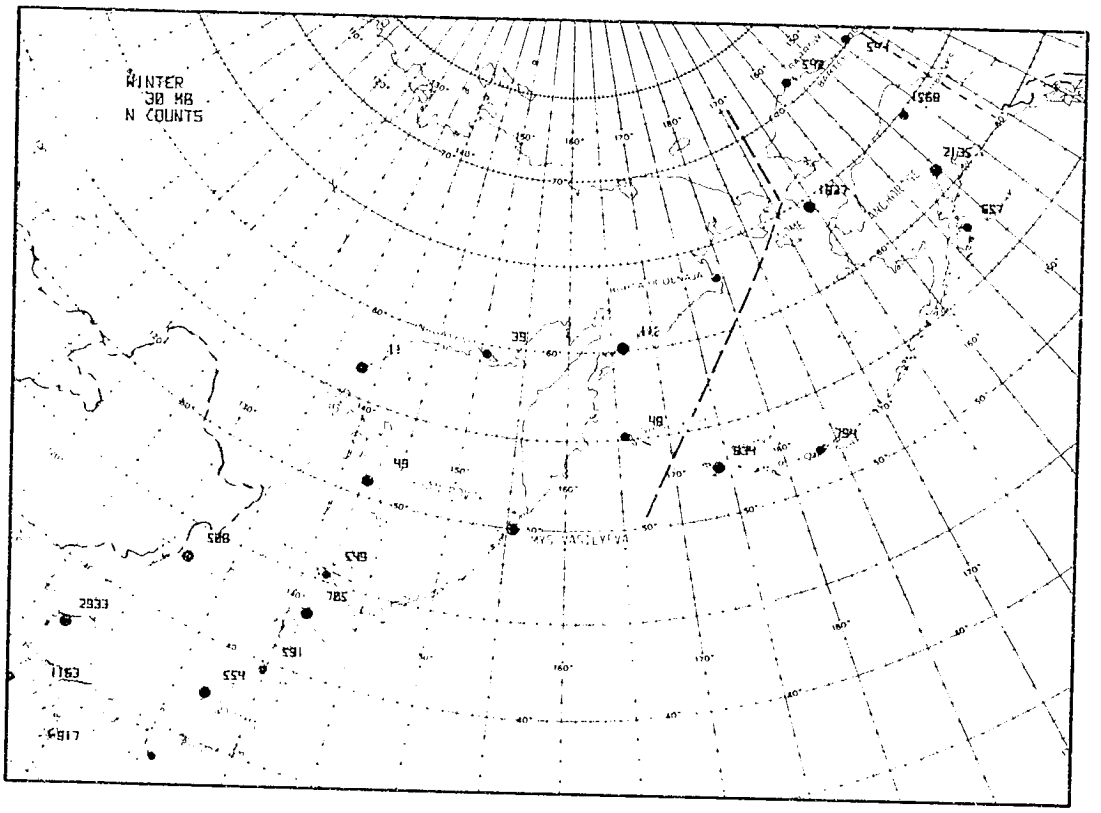
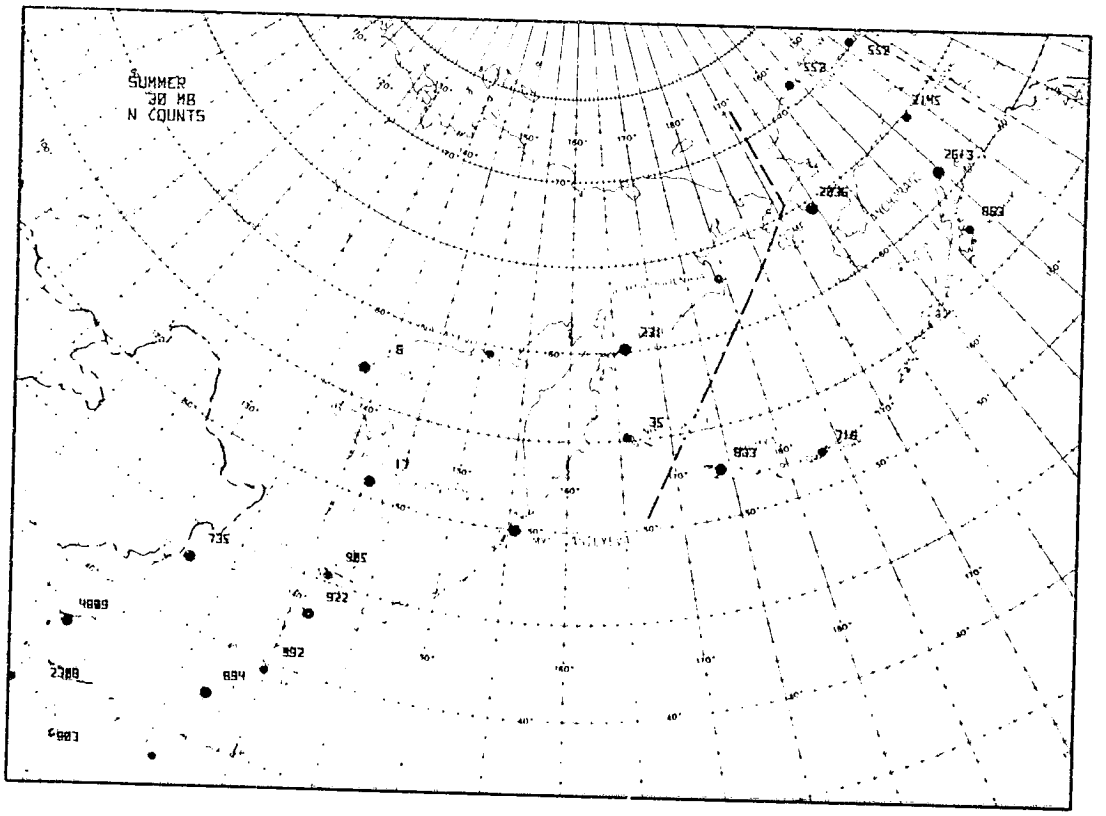

FALL
50 MB
N COUNTS


WINTER
30 MB
N COUNTS


SUMMER
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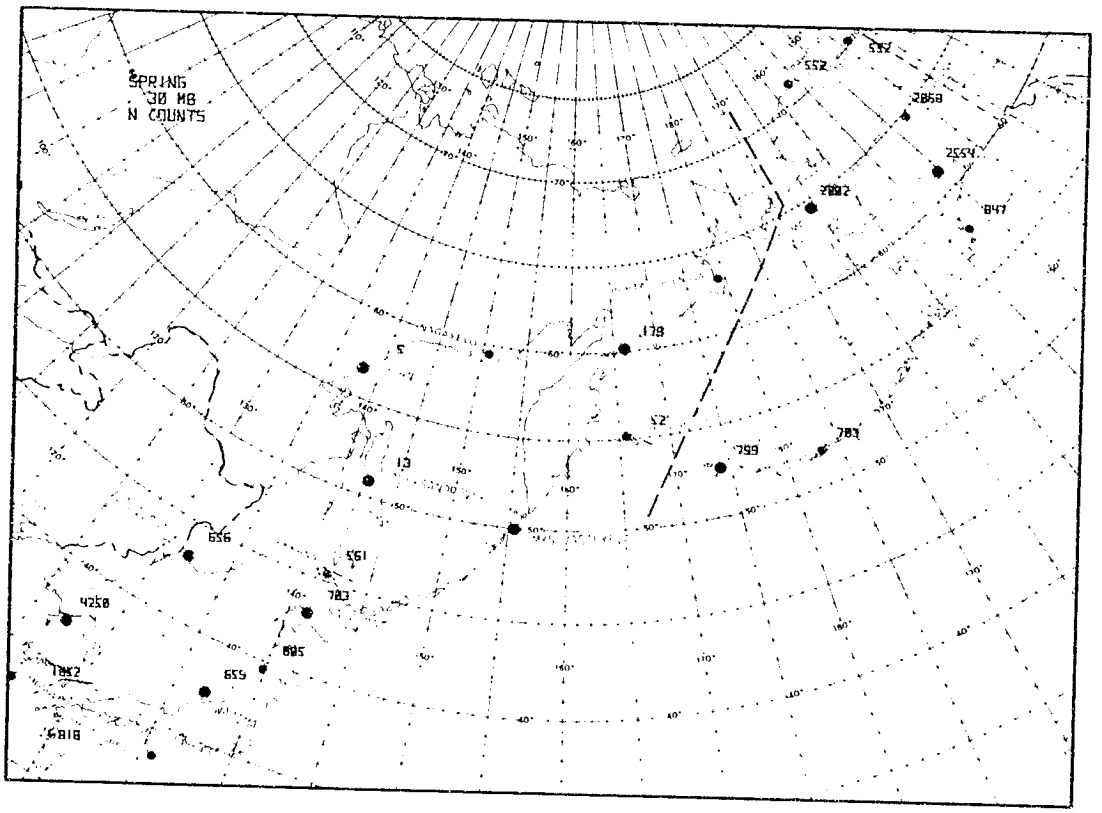
N COUNTS


SPRING
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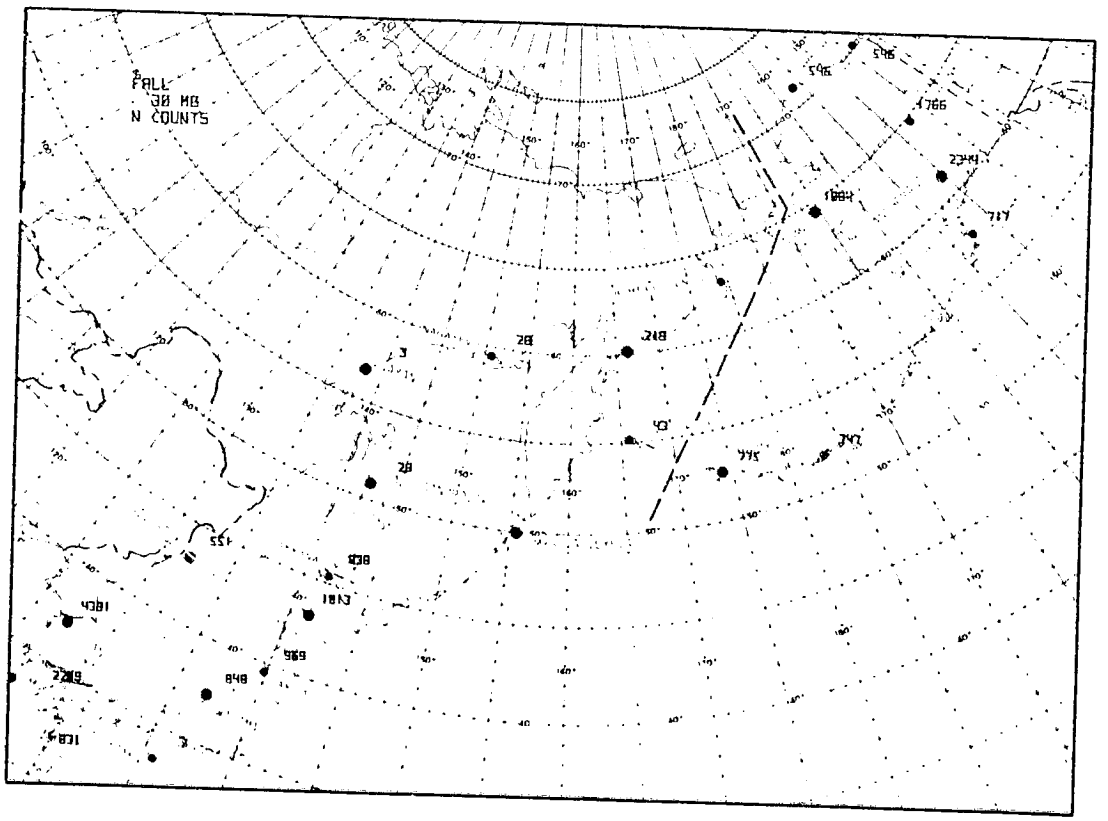
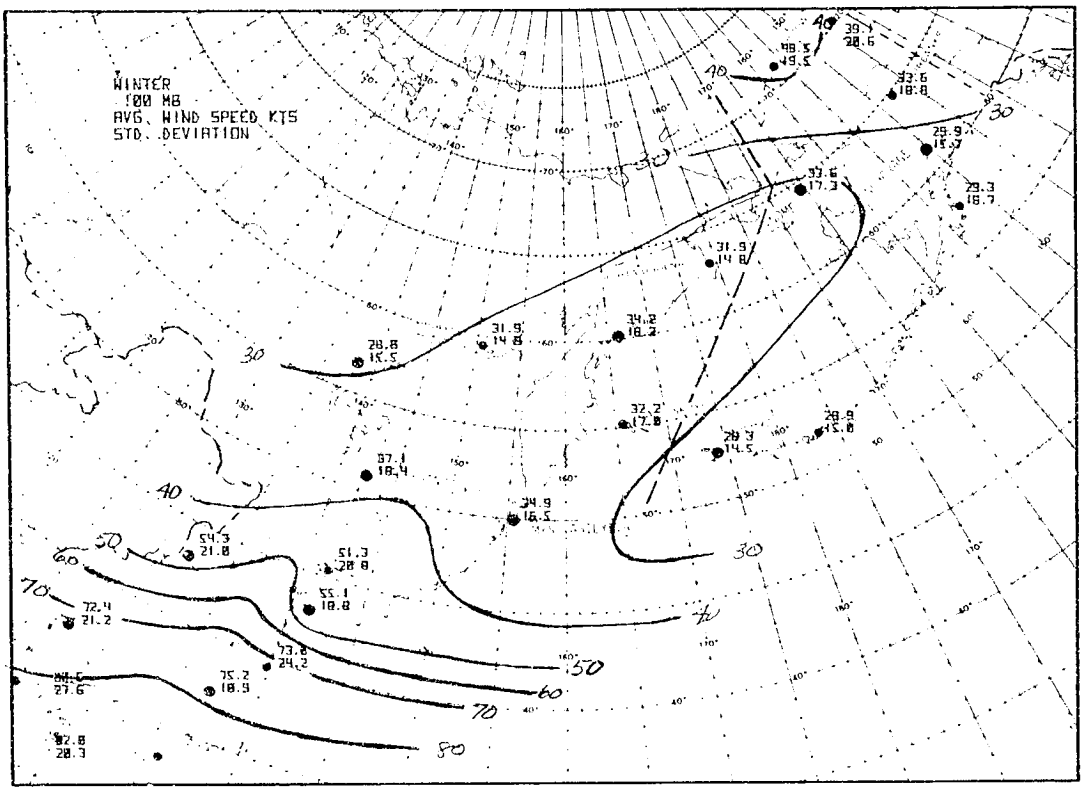
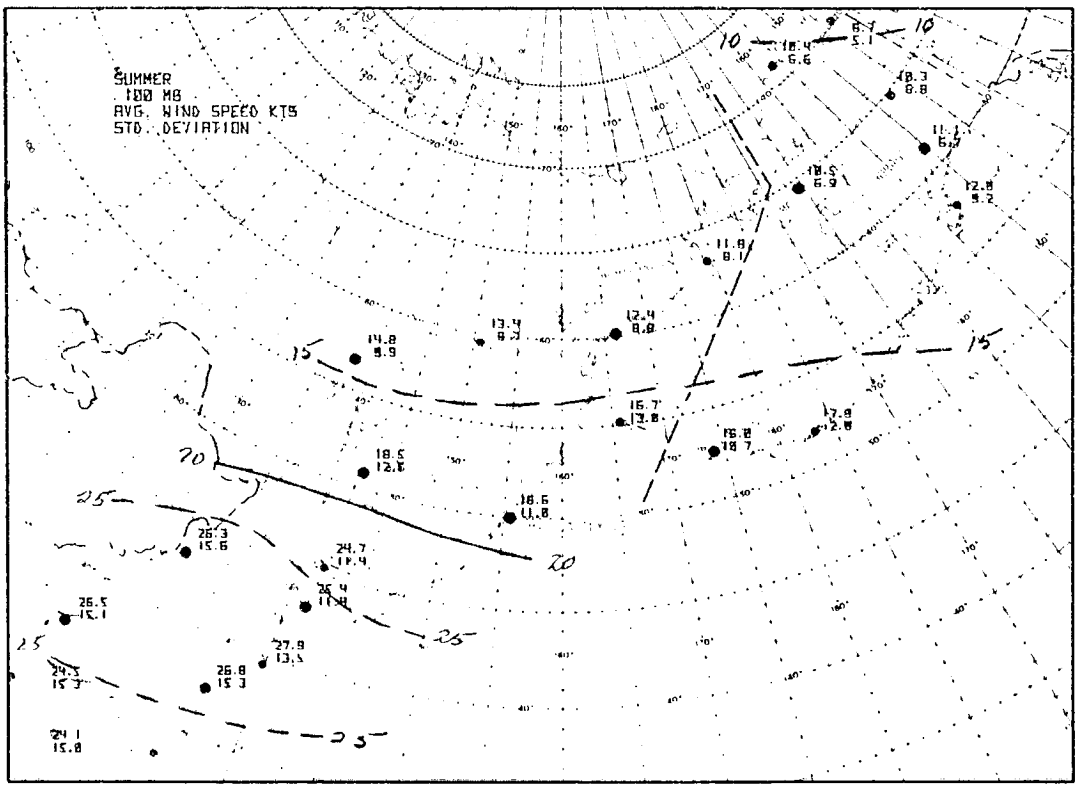
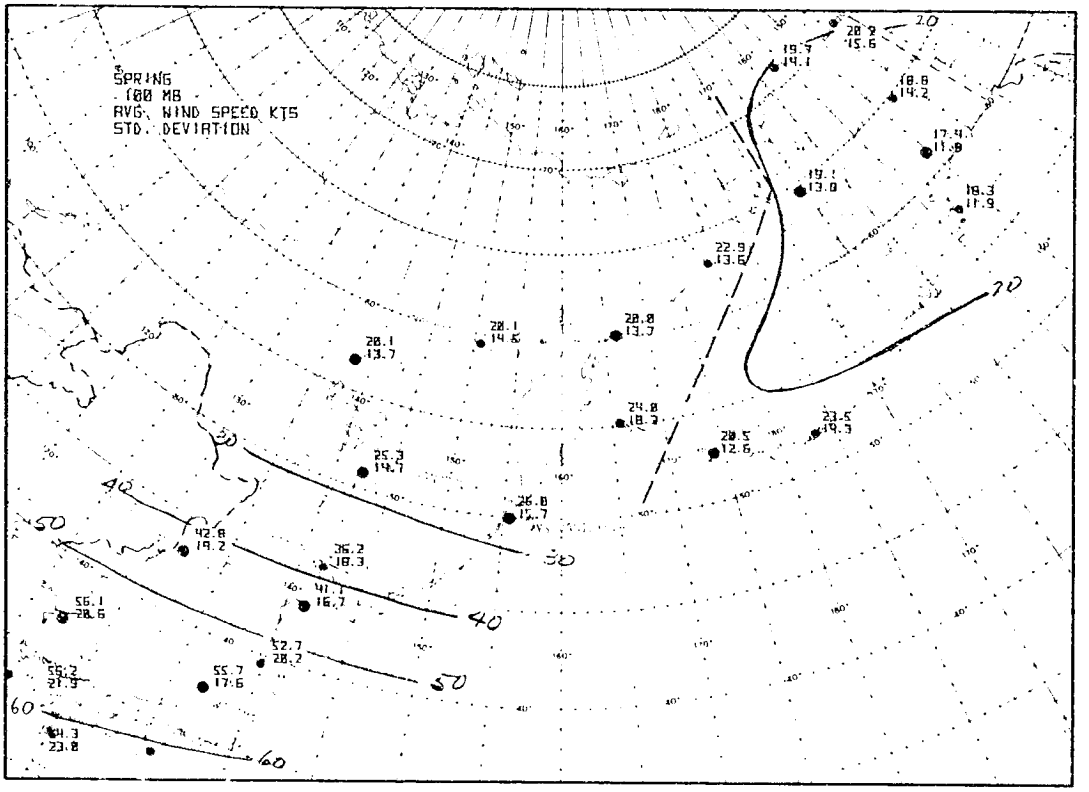
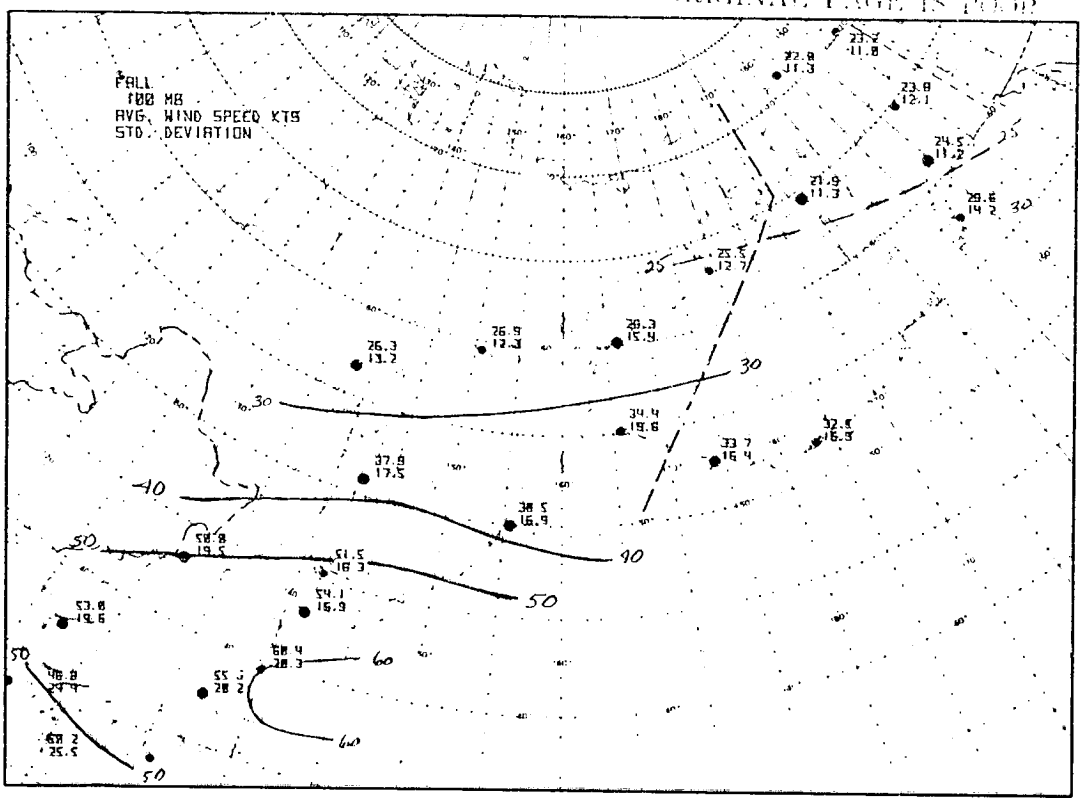
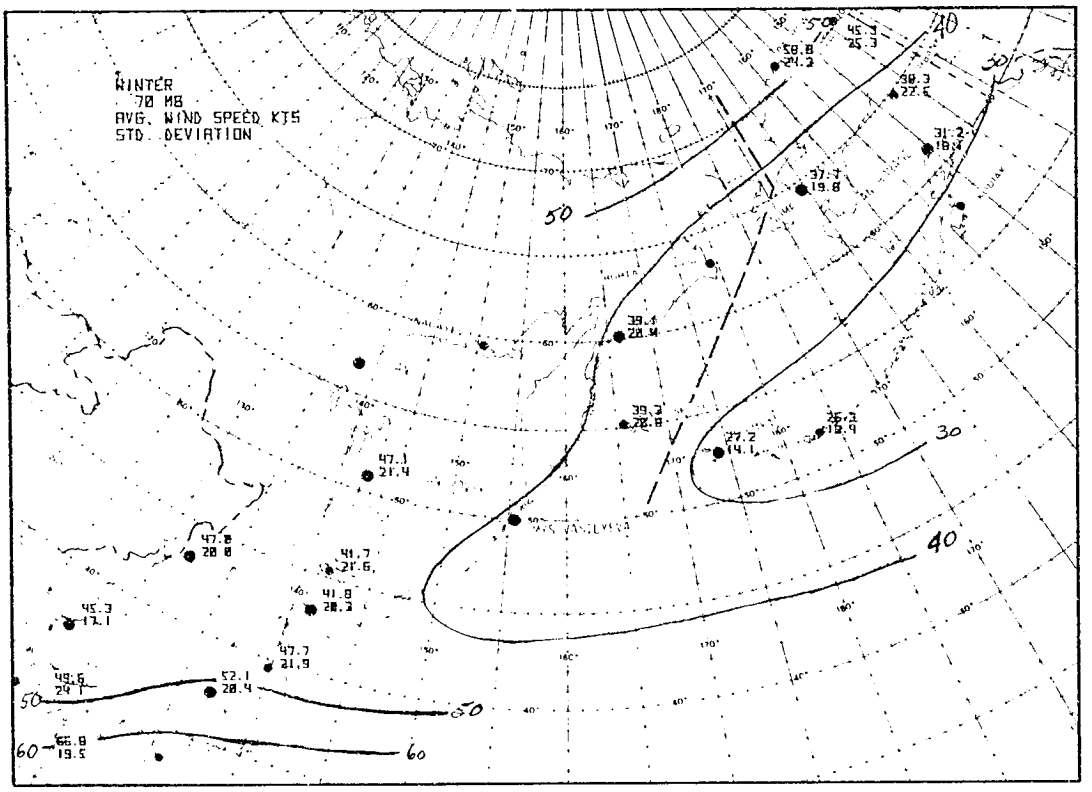

FALL
30 MB
N COUNTS

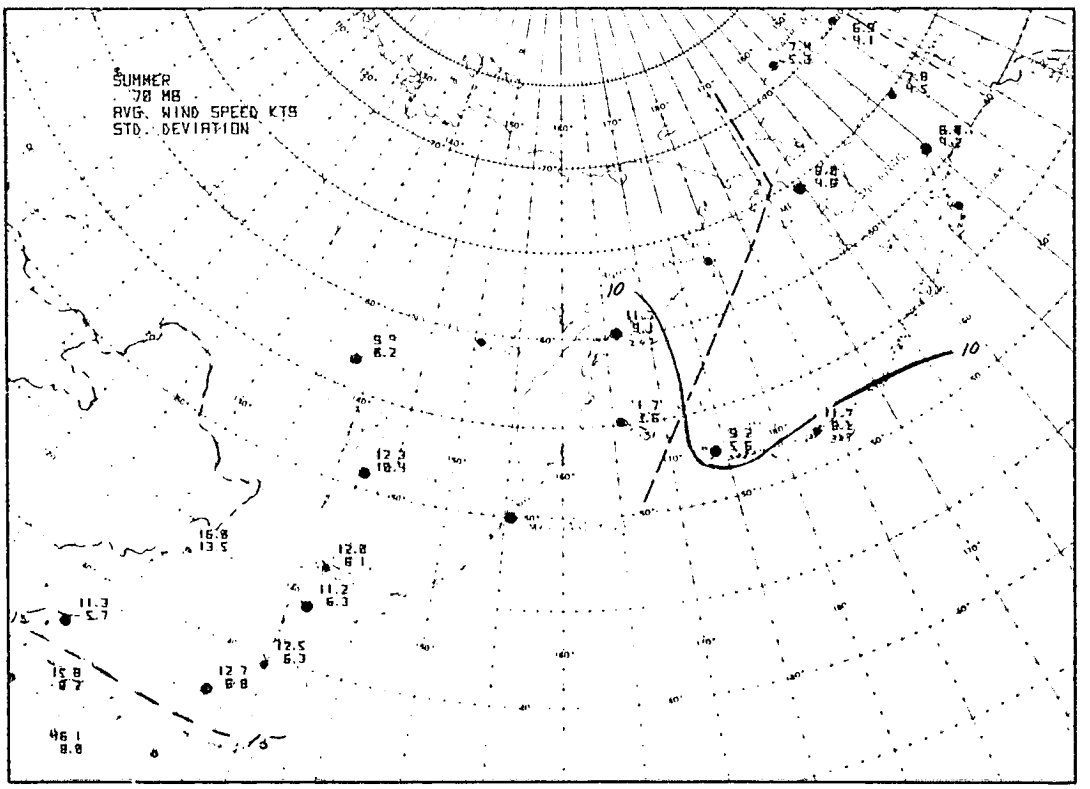

WINTER
100 MB
AVG. WIND SPEED KTS
STD. DEVIATION

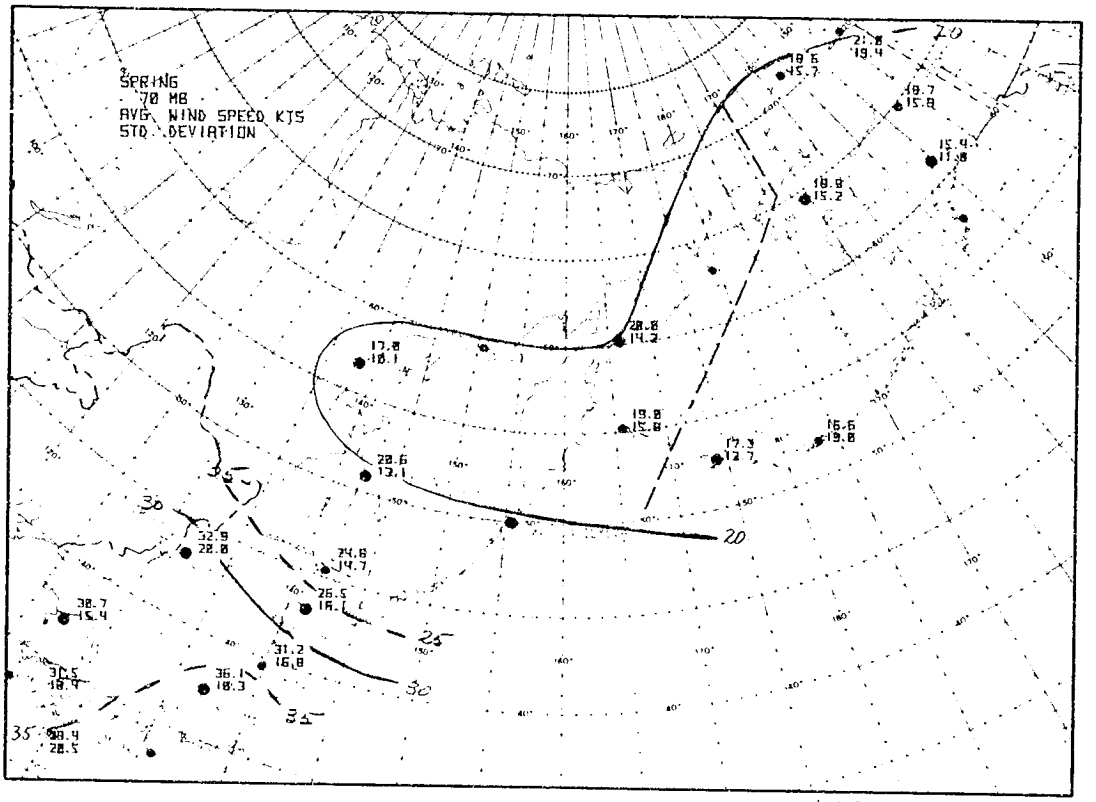

SUMMER
100 MB
AVG. WIND SPEED KTS
STD. DEVIATION






WINTER
70 MB
AVG. WIND SPEED KTS
STD. DEVIATION
50
40
30
60


SUMMER
70 MB
AVG. WIND SPEED KTS
STD. DEVIATION
10
15


SPRING
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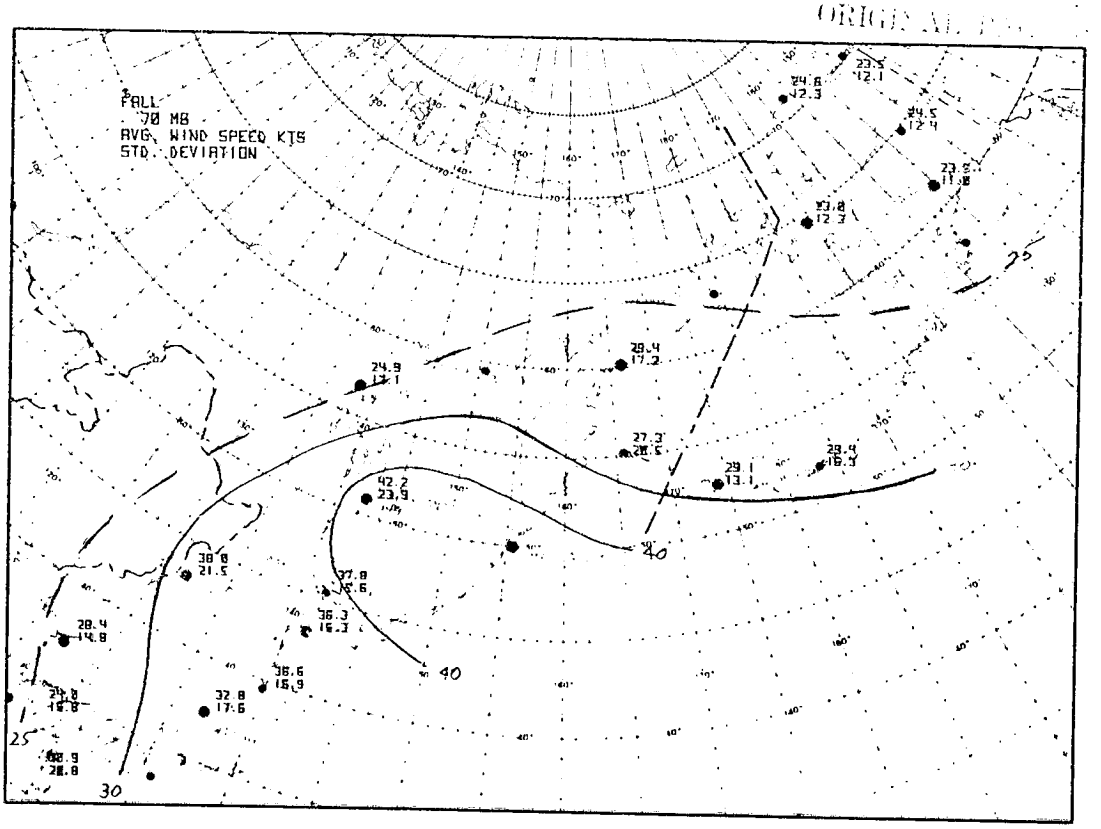
AVG. WIND SPEED KTS
STD. DEVIATION


FALL
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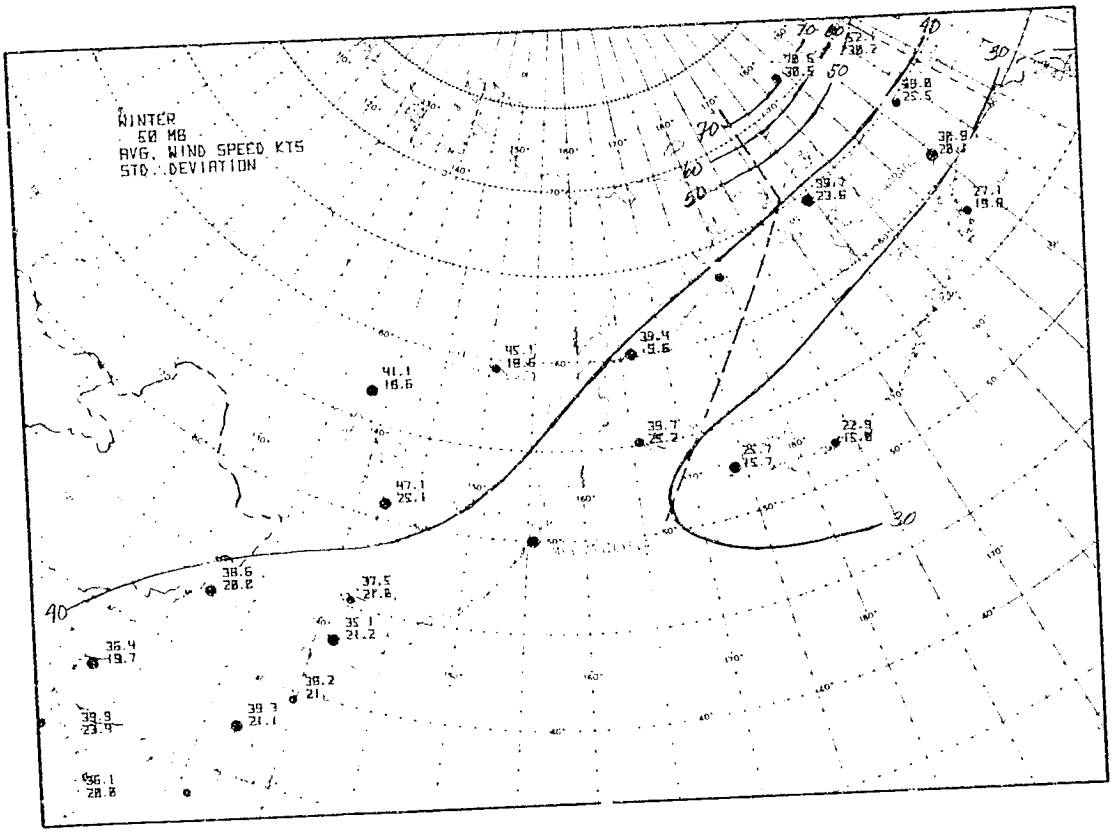
AVG. WIND SPEED KTS
STD. DEVIATION


WINTER
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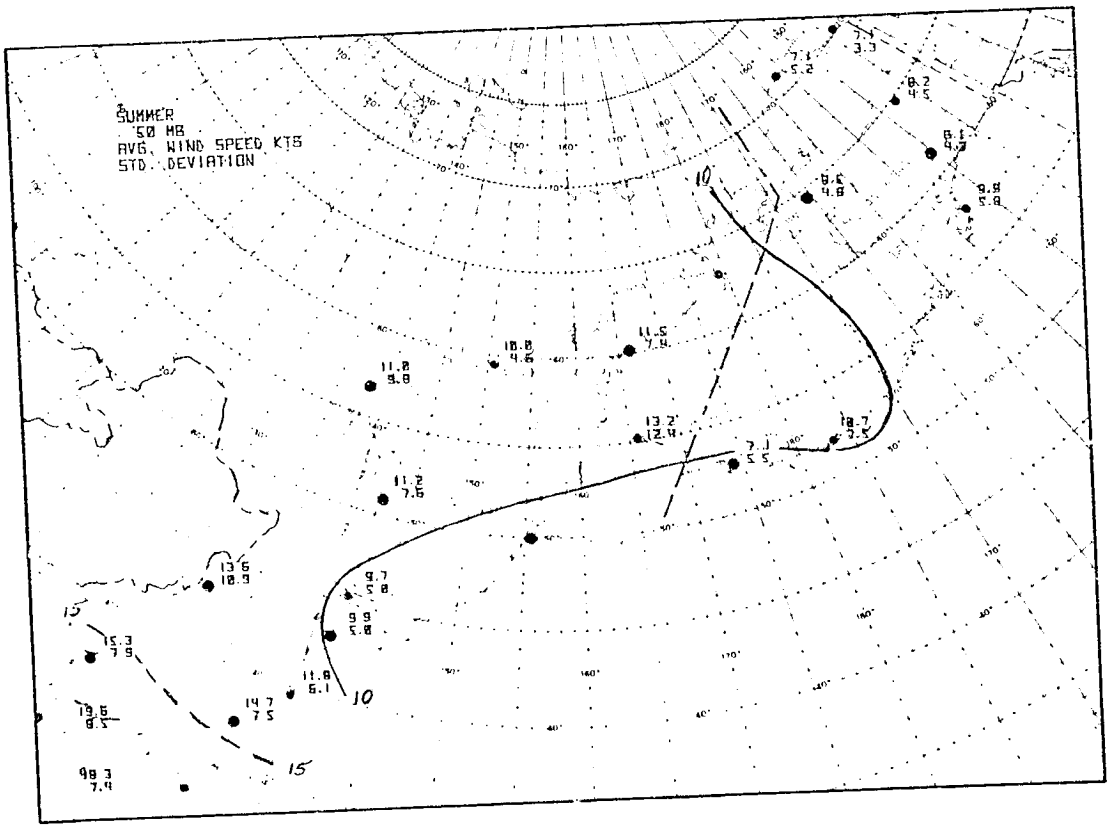
AVG. WIND SPEED KTS
STD. DEVIATION


SUMMER
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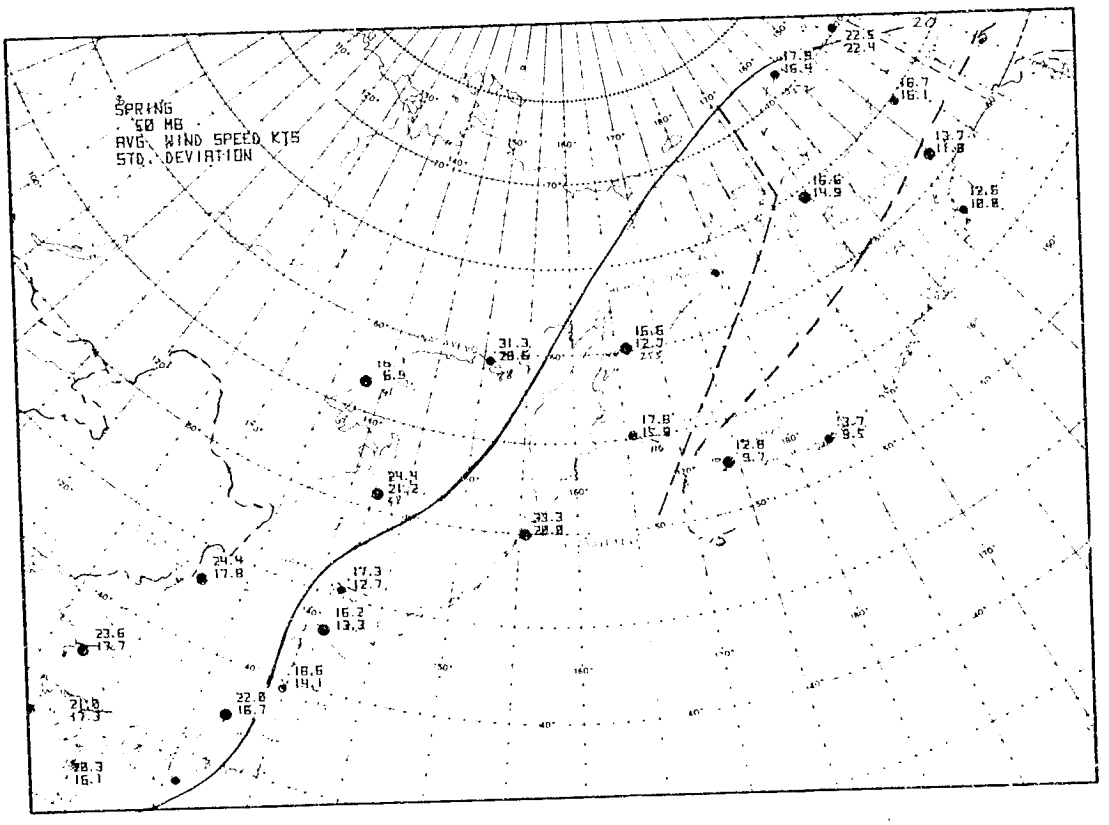
AVG. WIND SPEED KTS
STD. DEVIATION


SPRING
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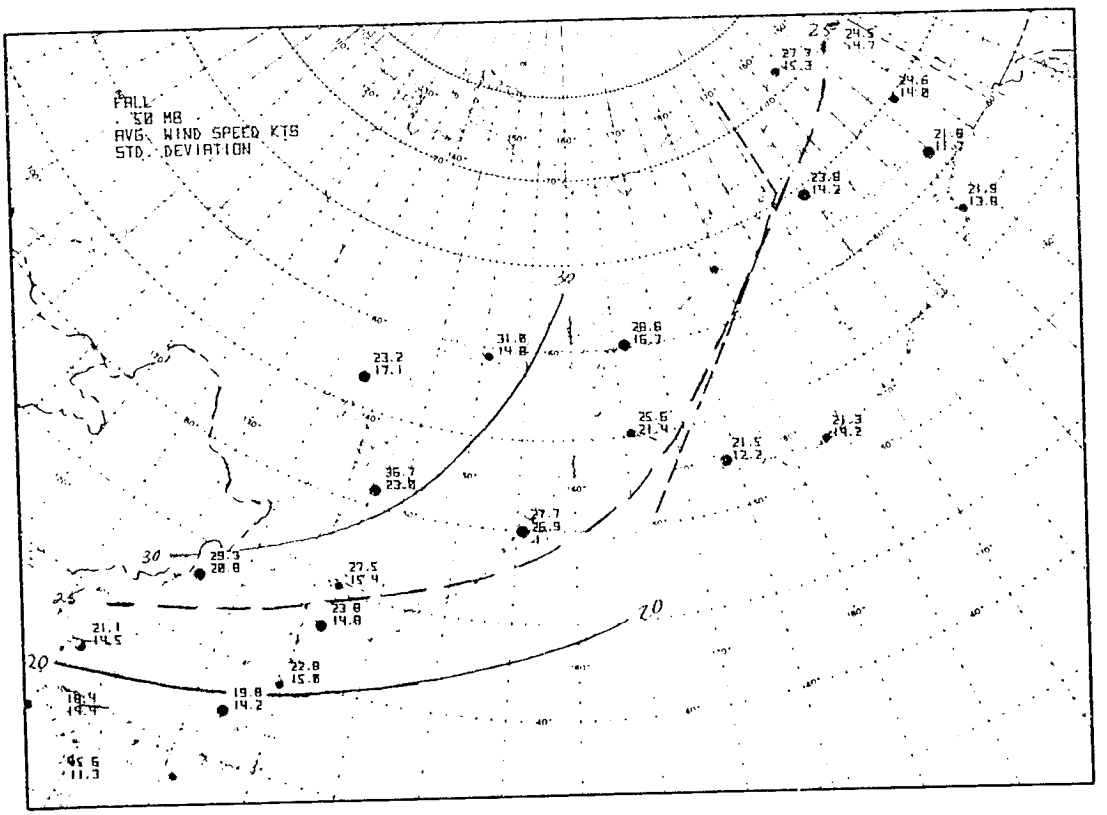
AVG. WIND SPEED KTS
STD. DEVIATION


FALL
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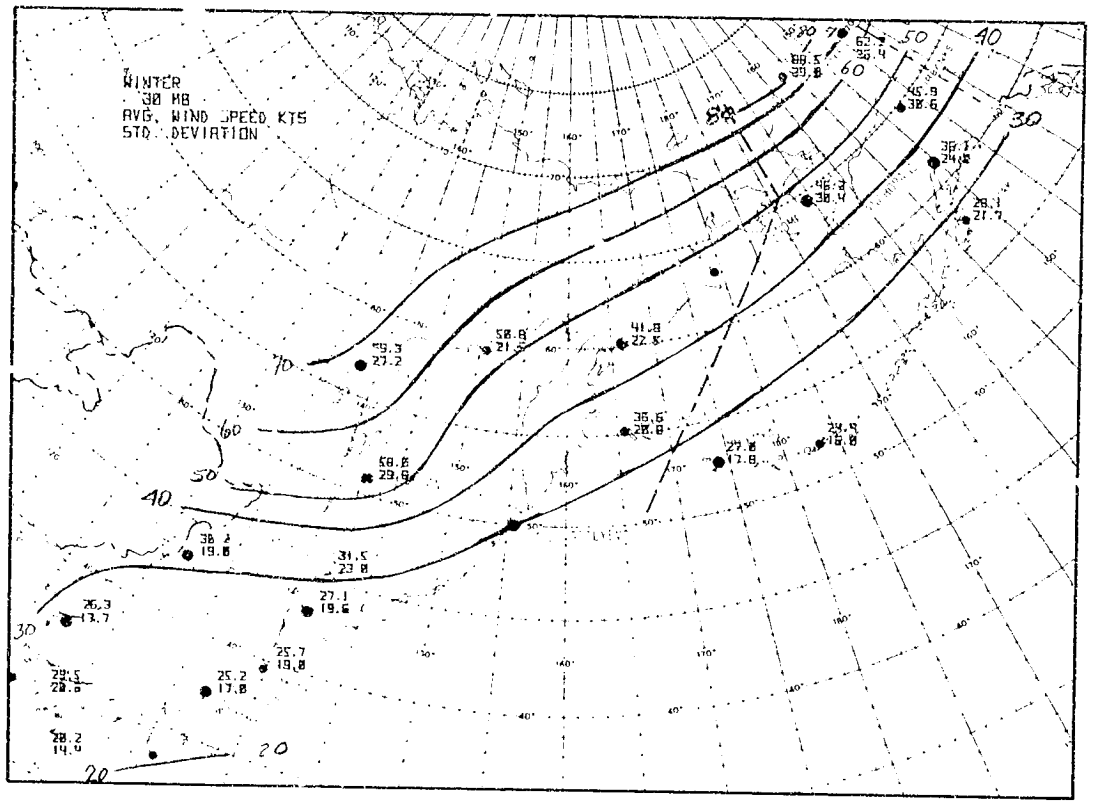
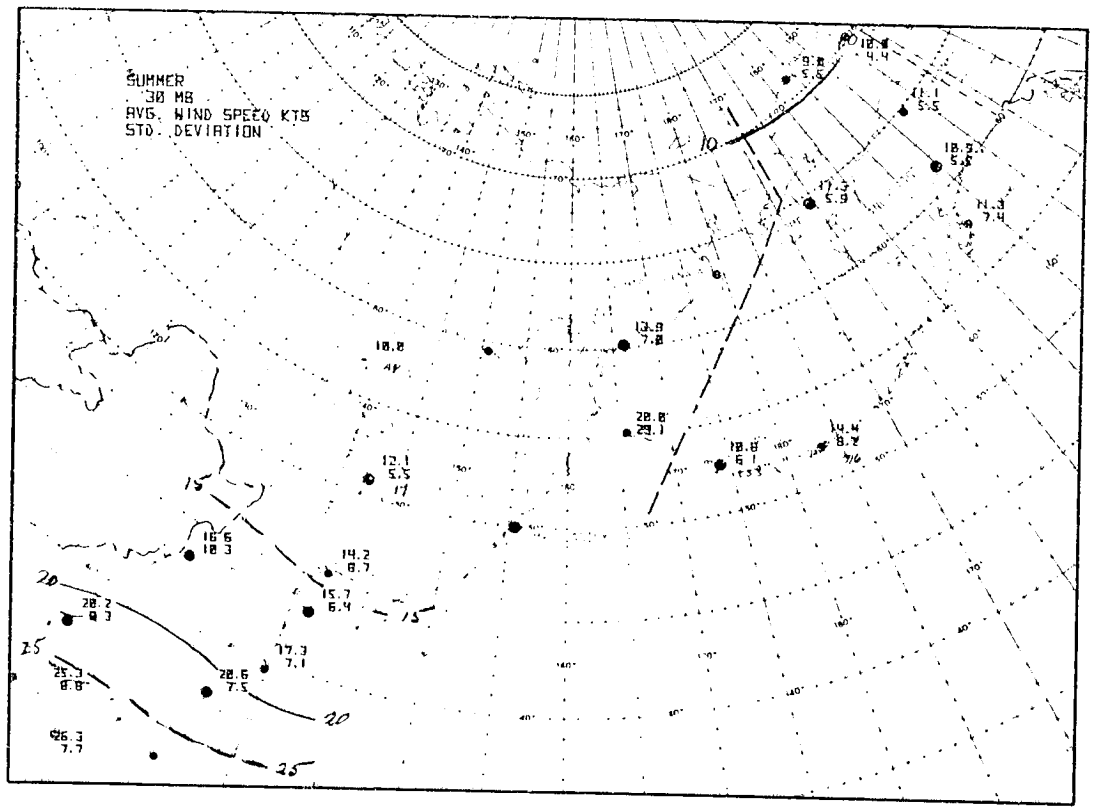
AVG. WIND SPEED KTS
STD. DEVIATION


WINTER
30 MB
AVG. WIND SPEED KTS
STD. DEVIATION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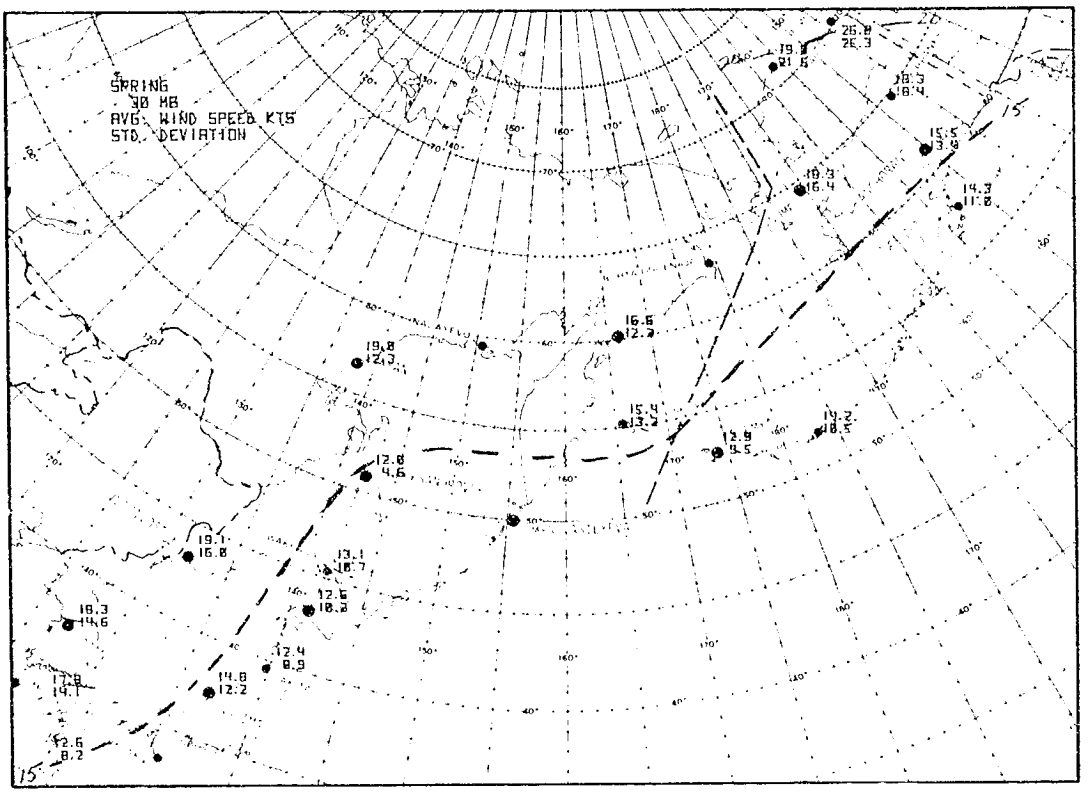
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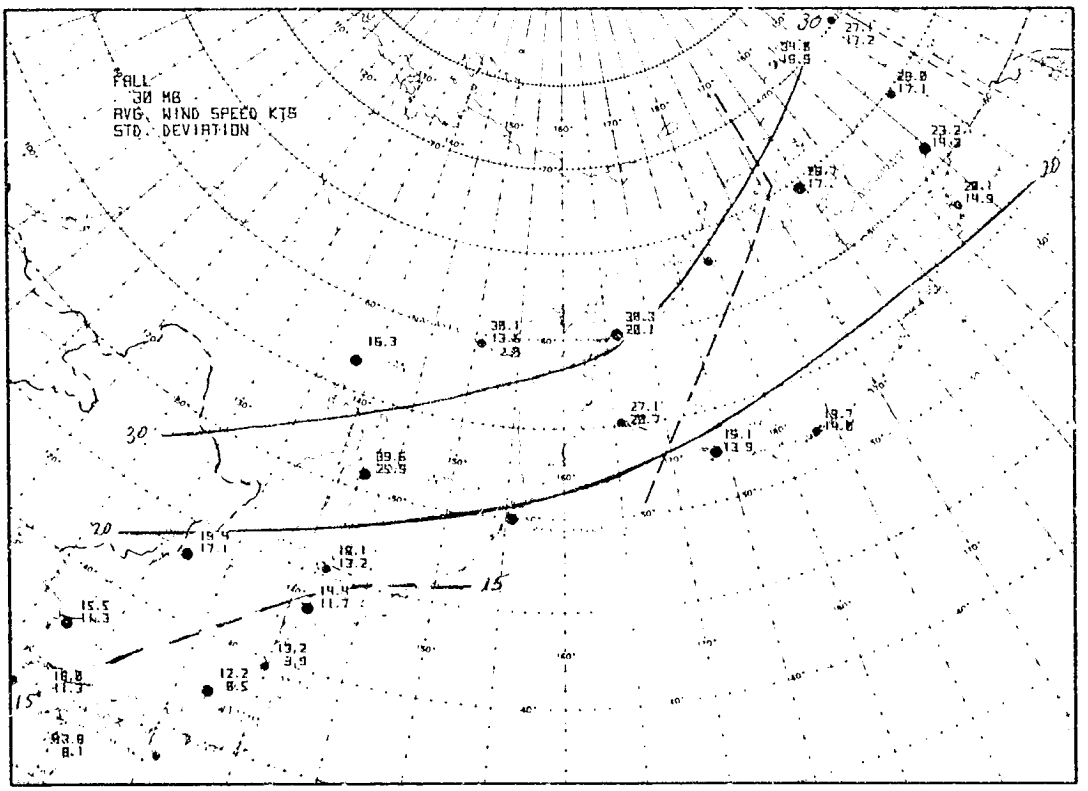
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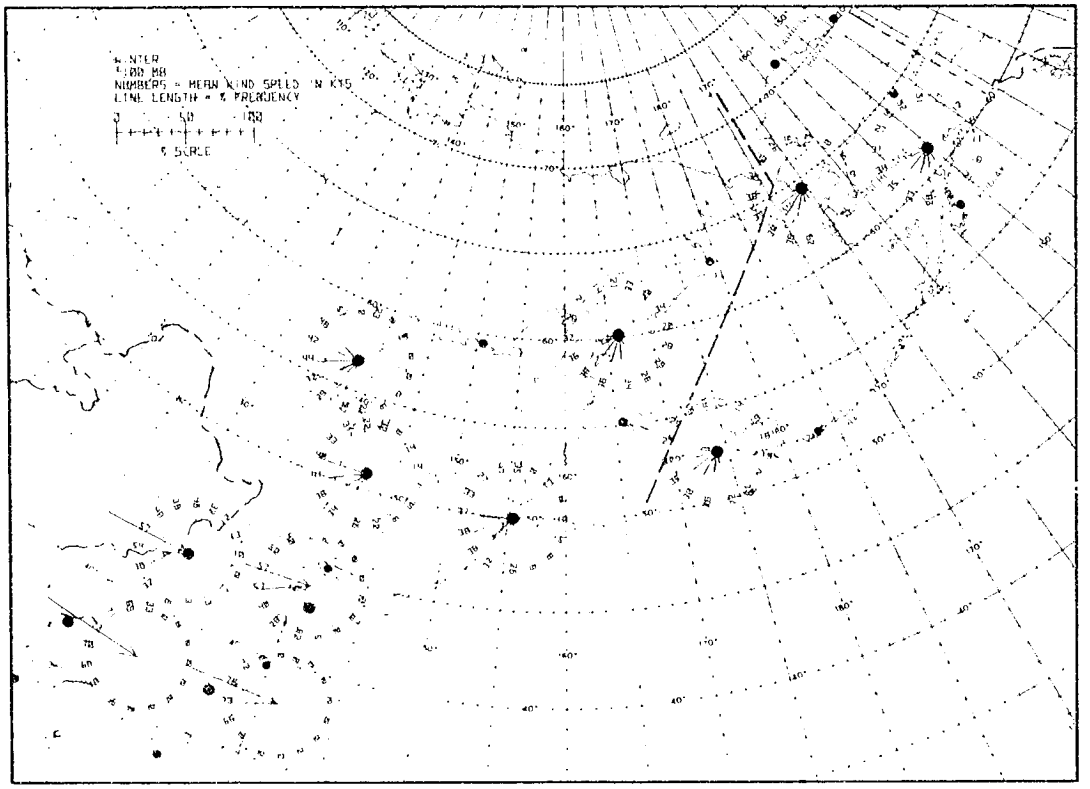
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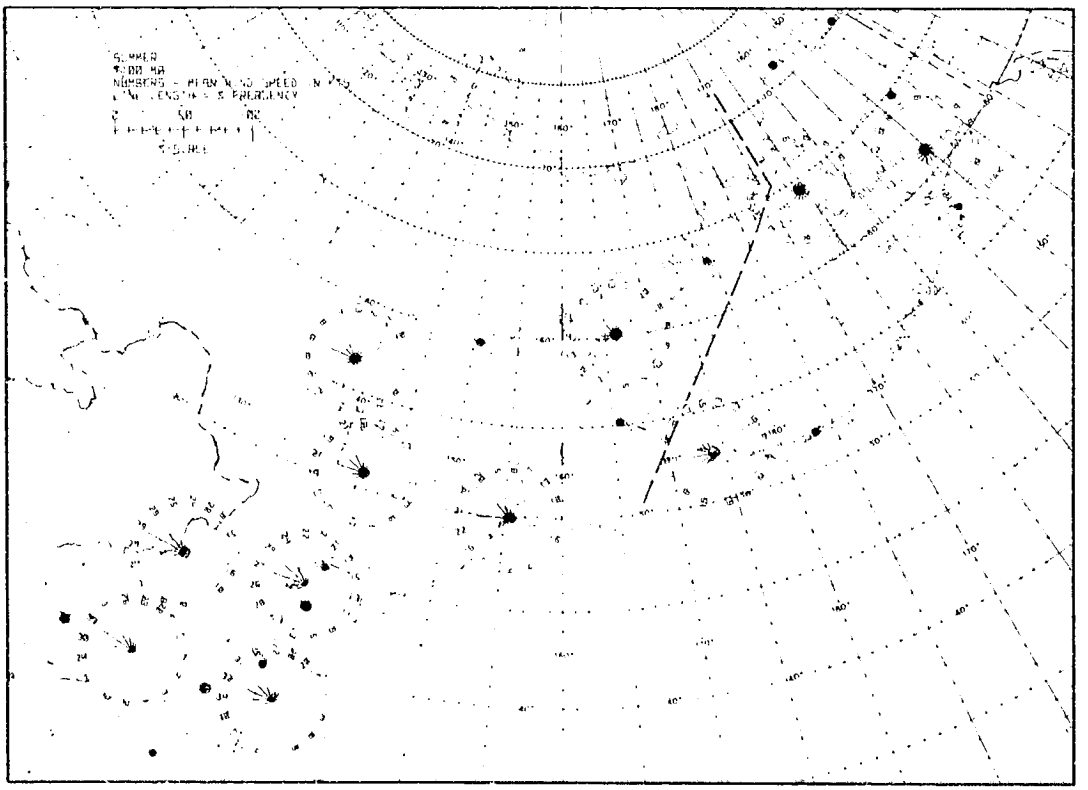
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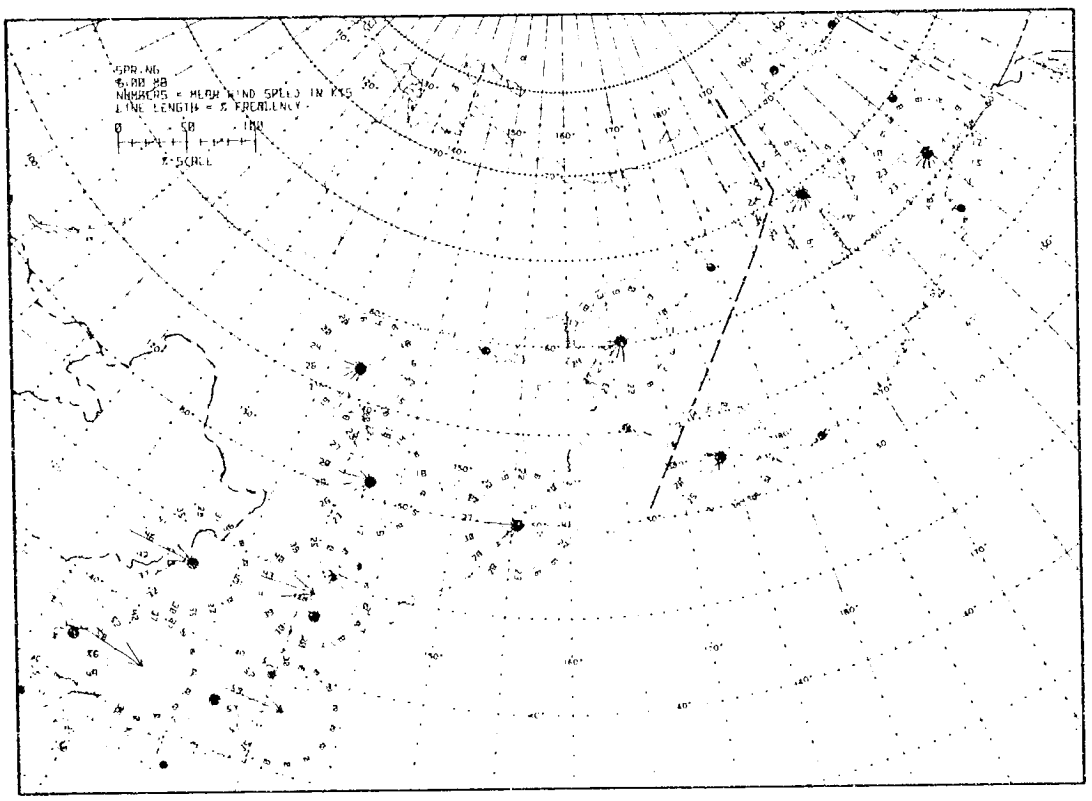
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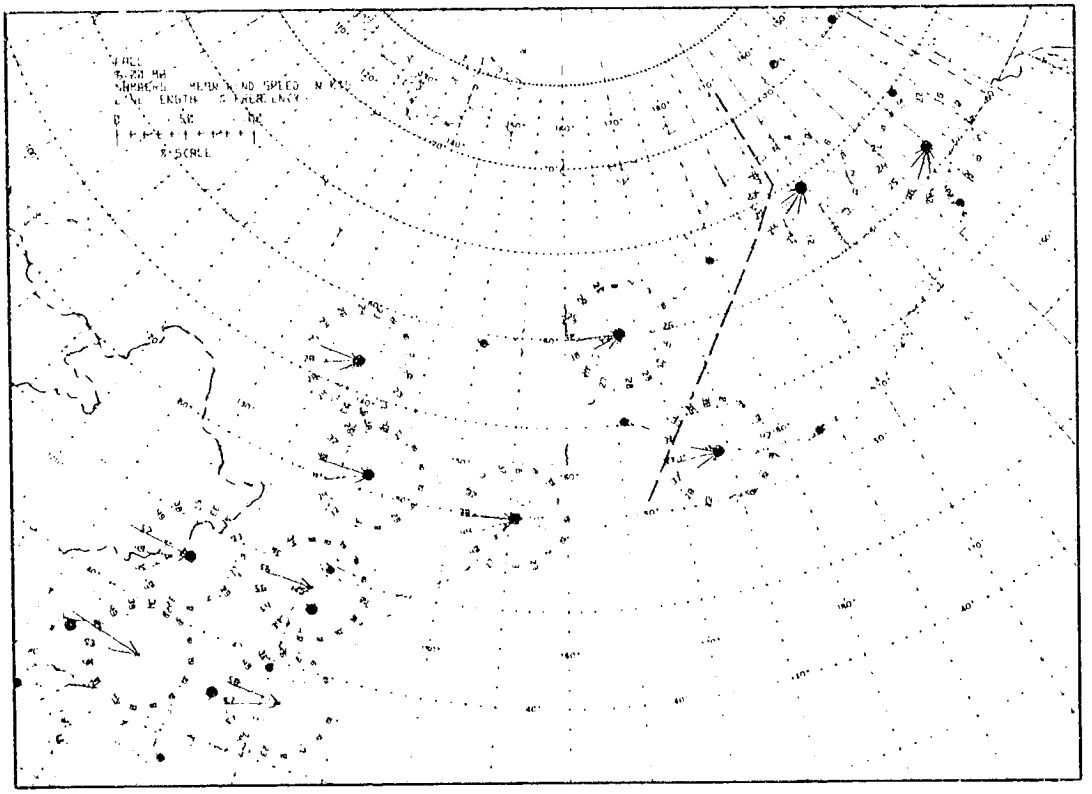
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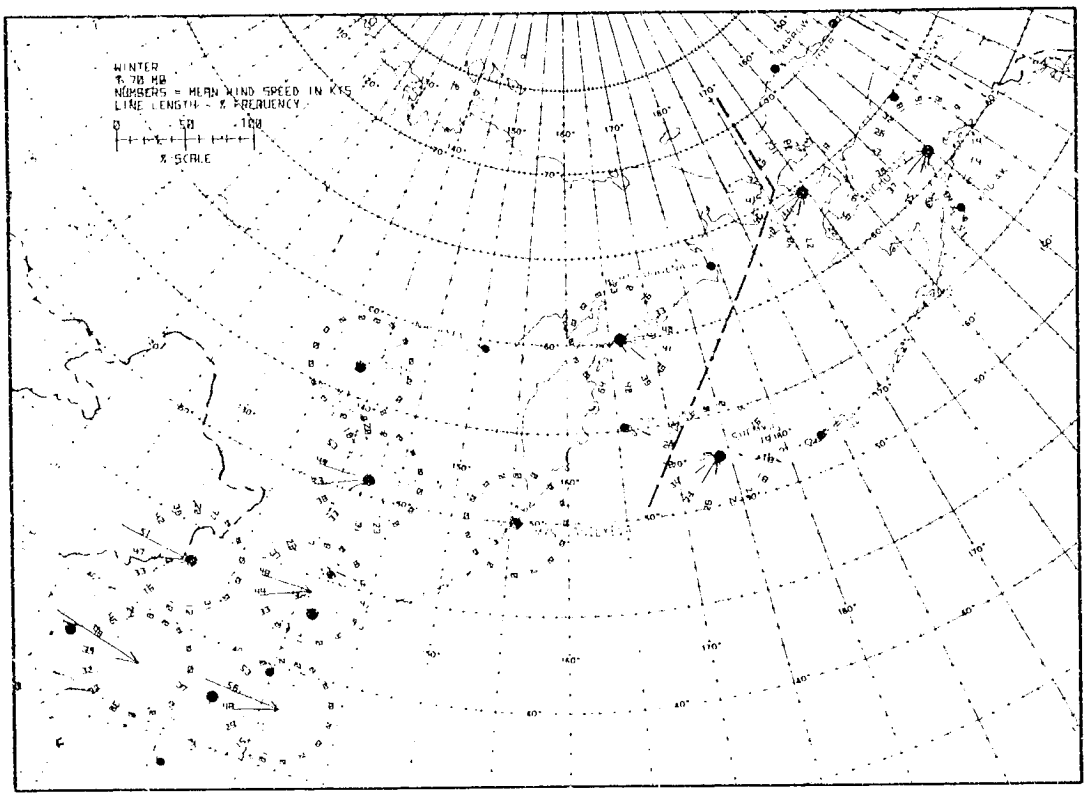
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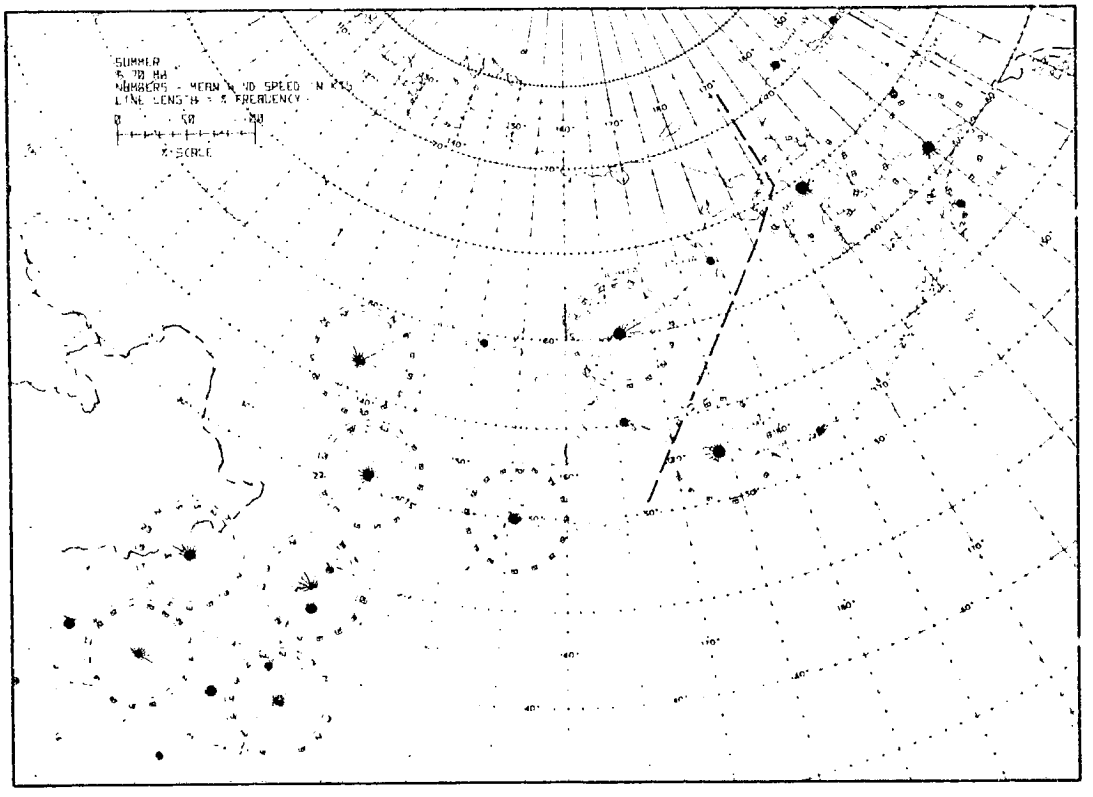
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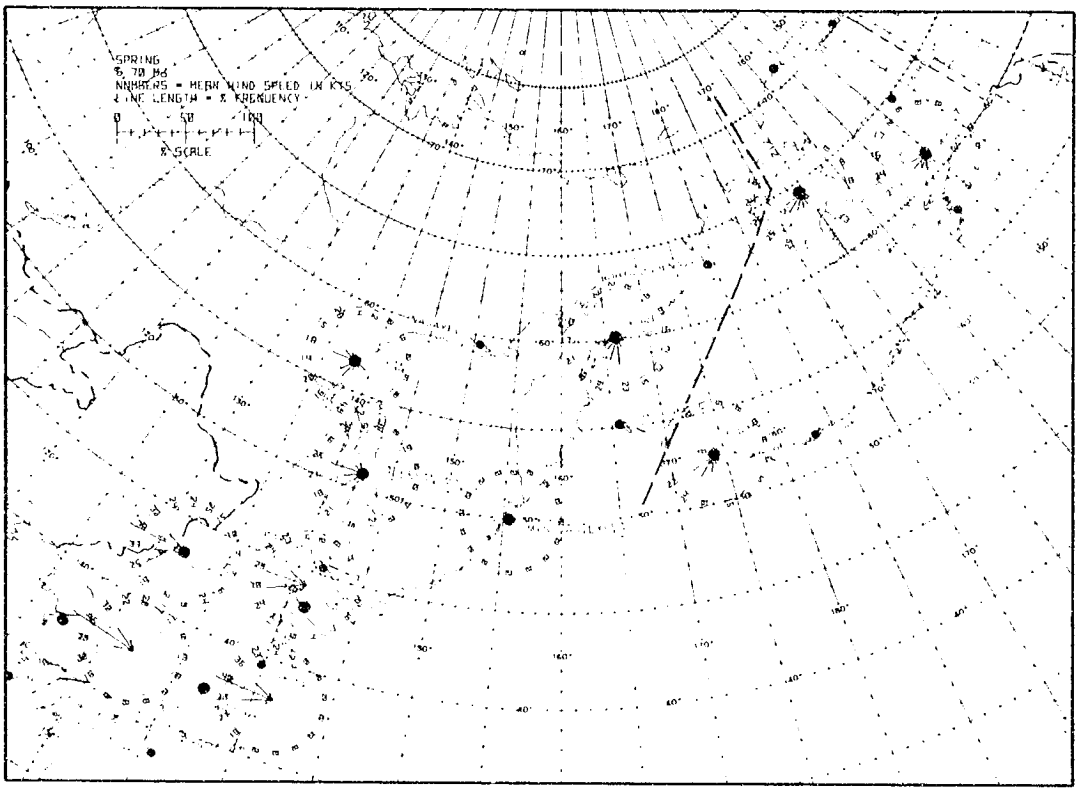
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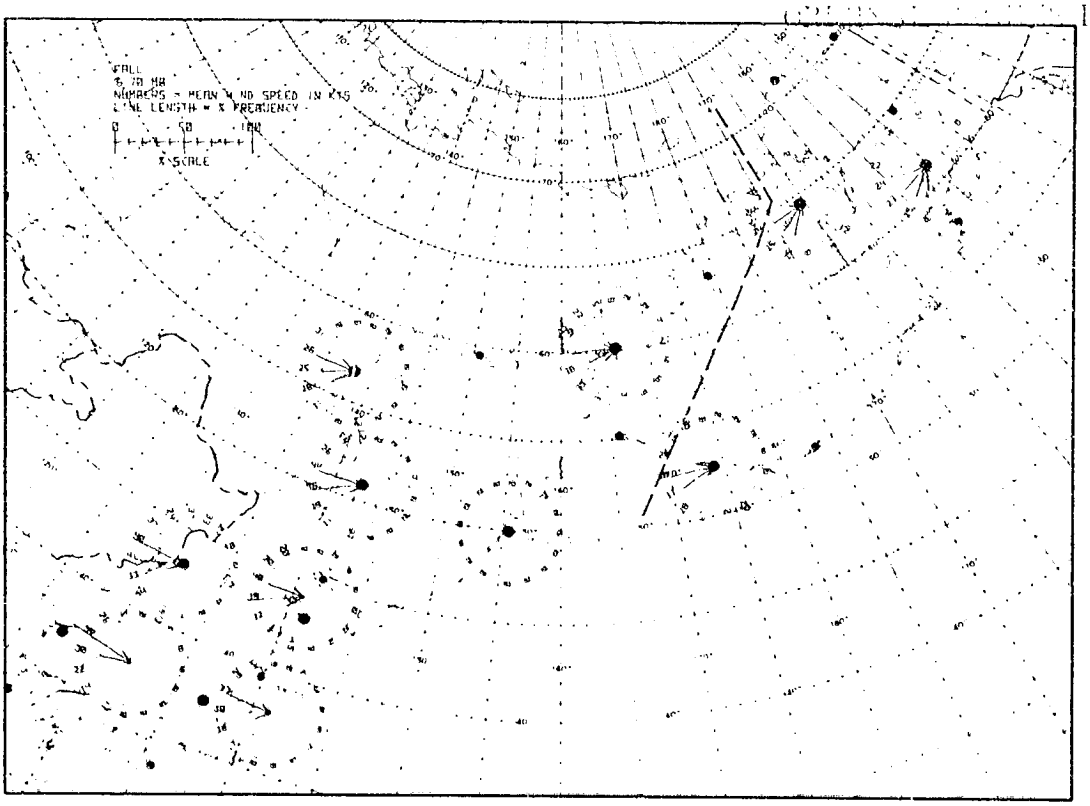
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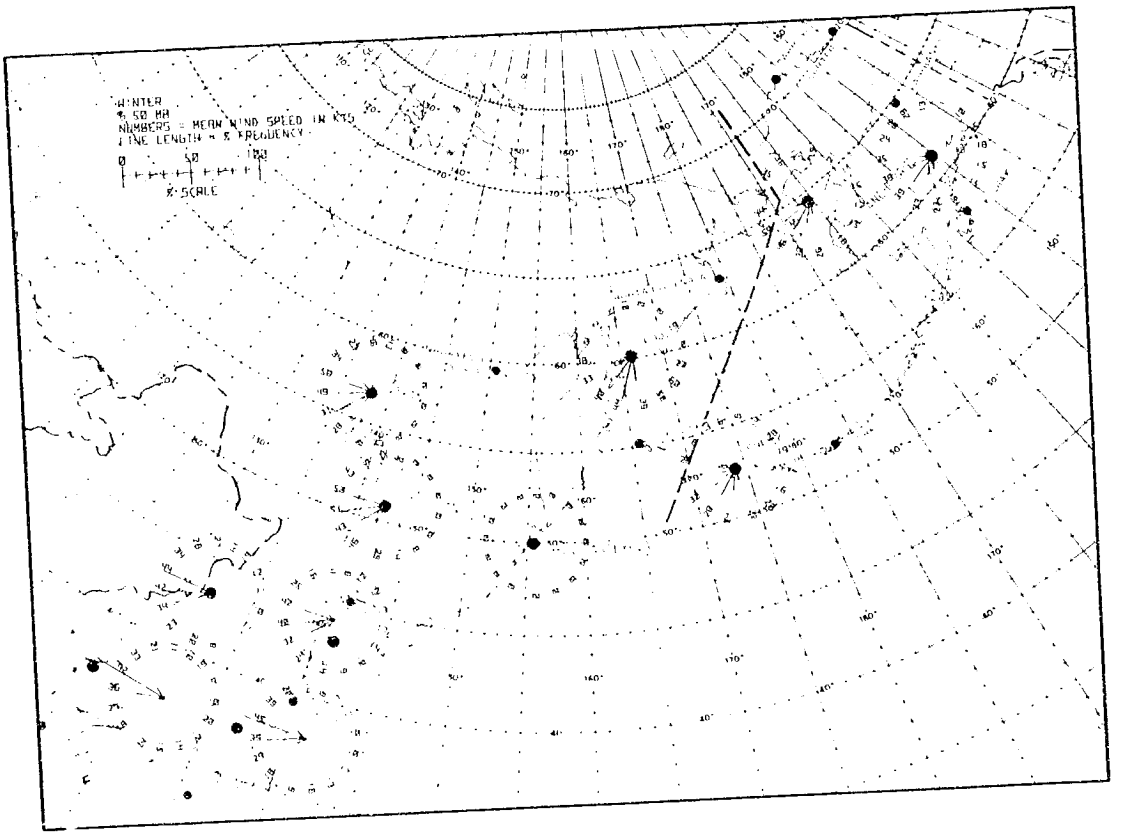
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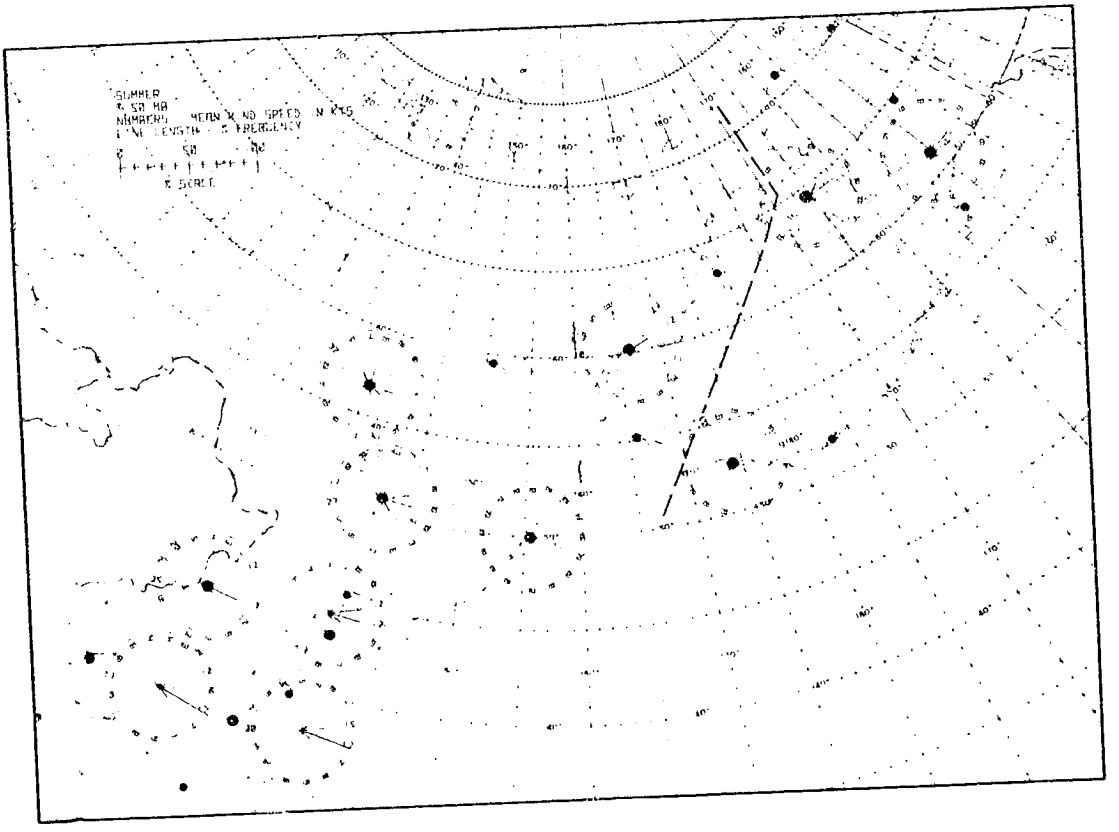
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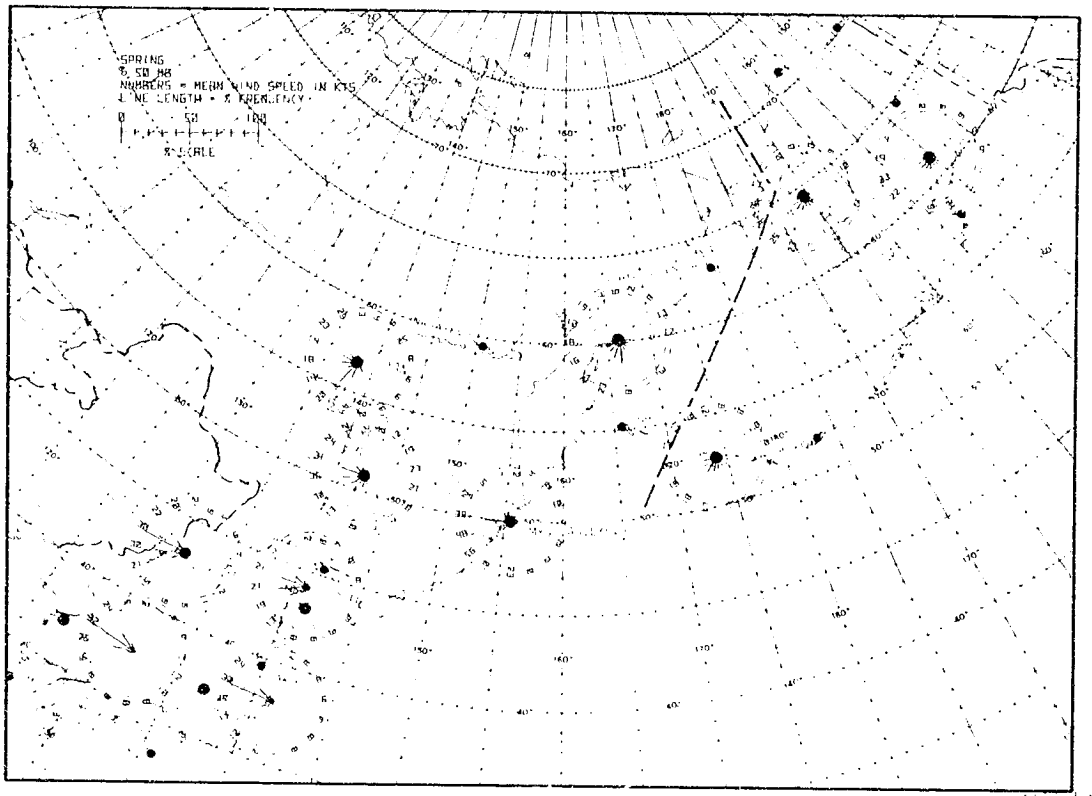

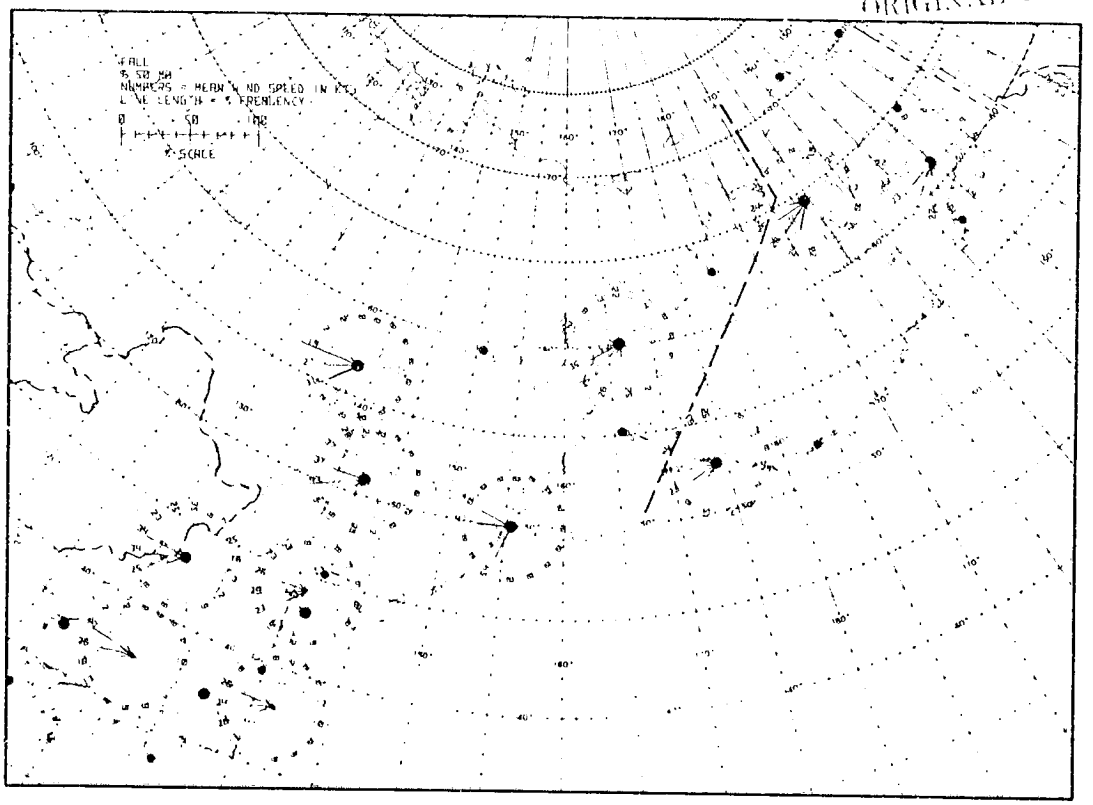

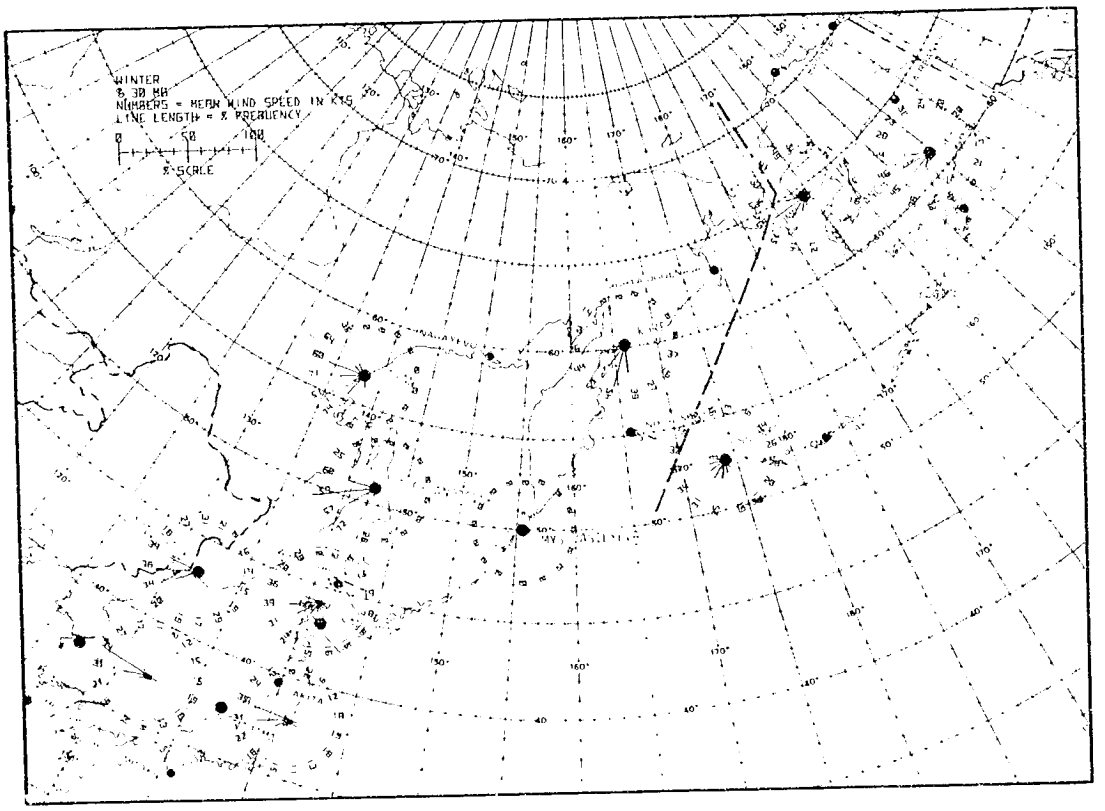
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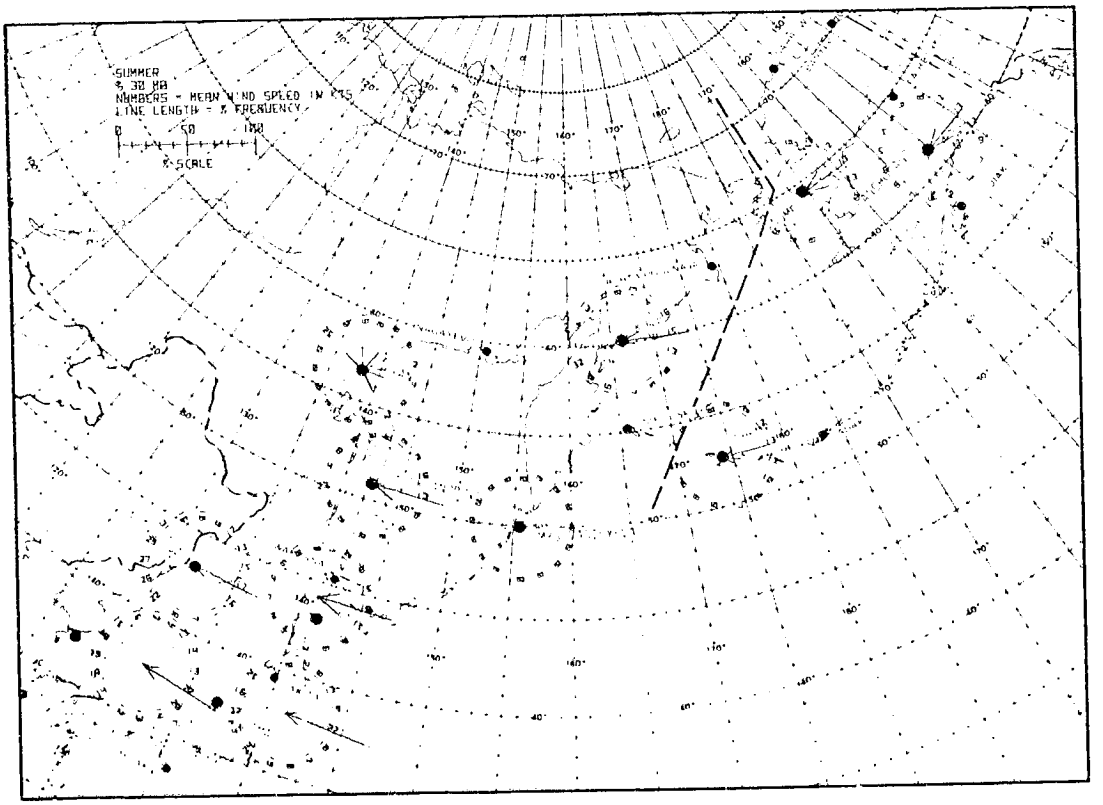
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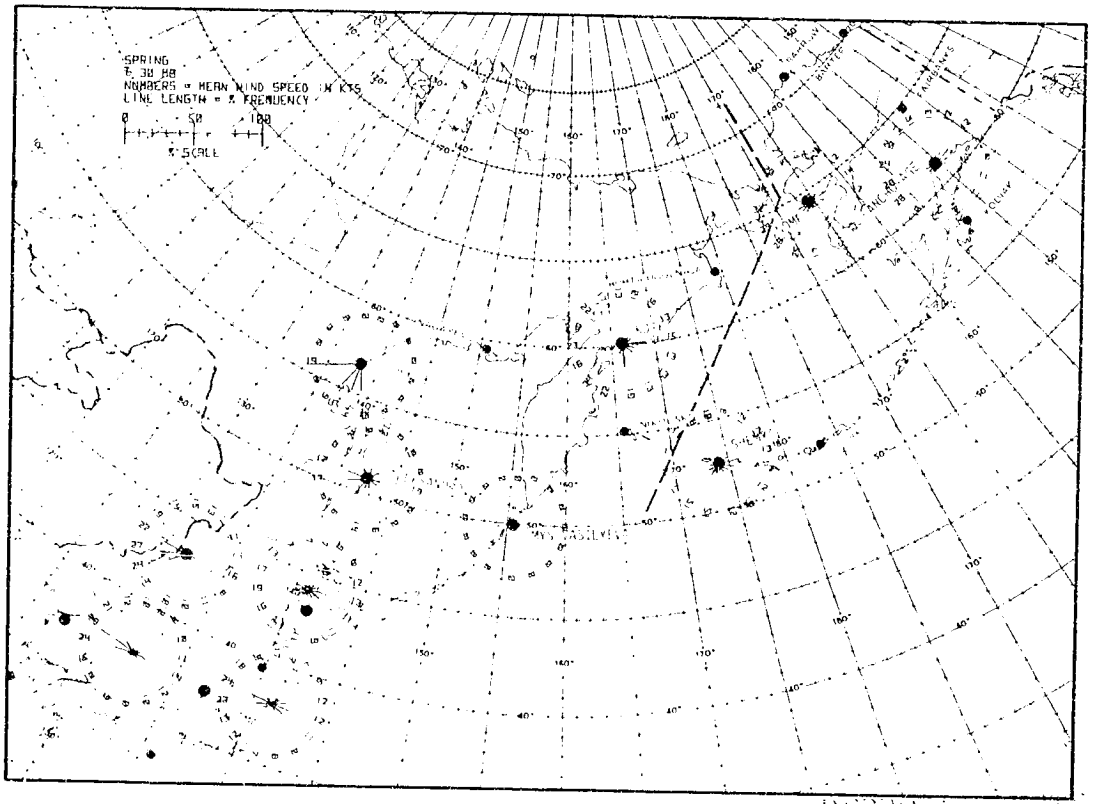

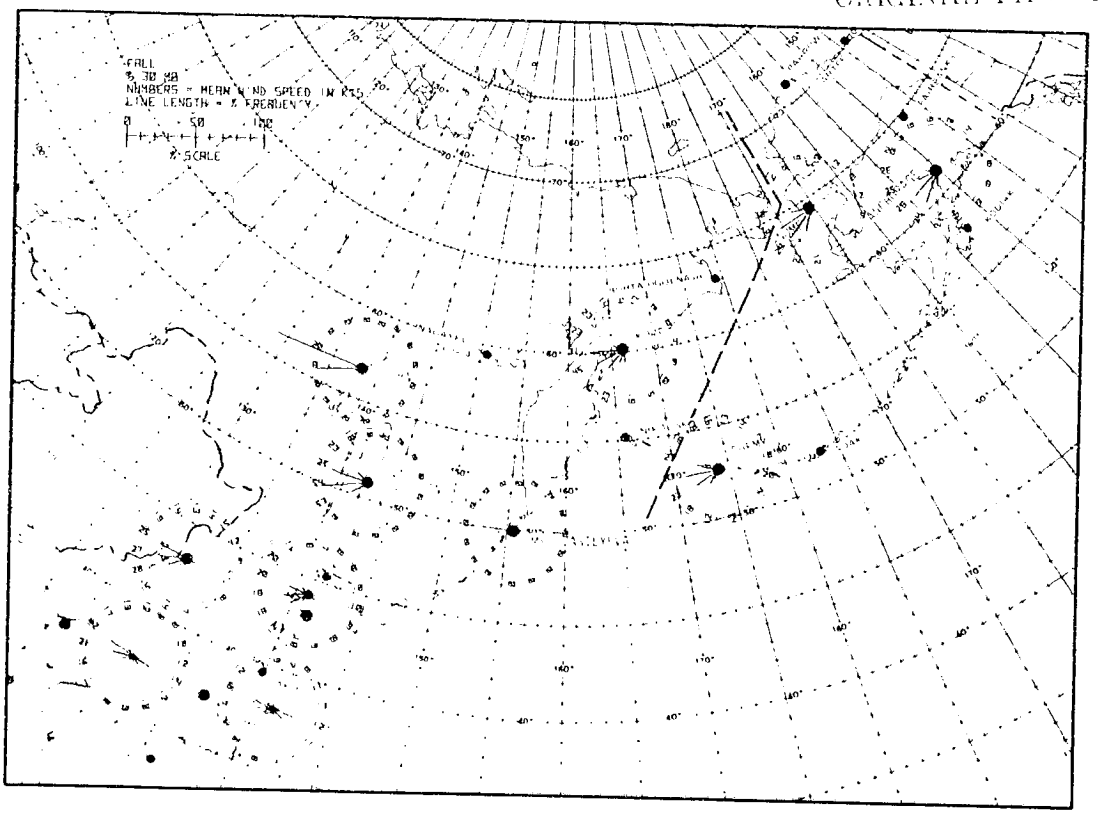

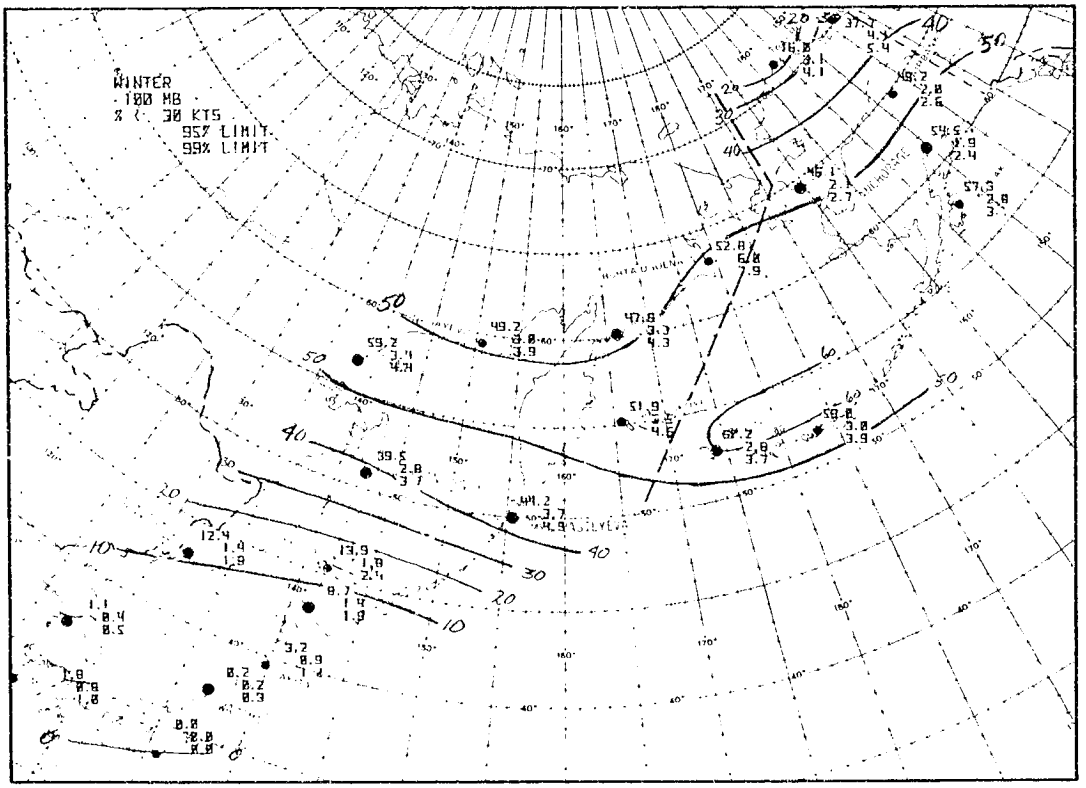
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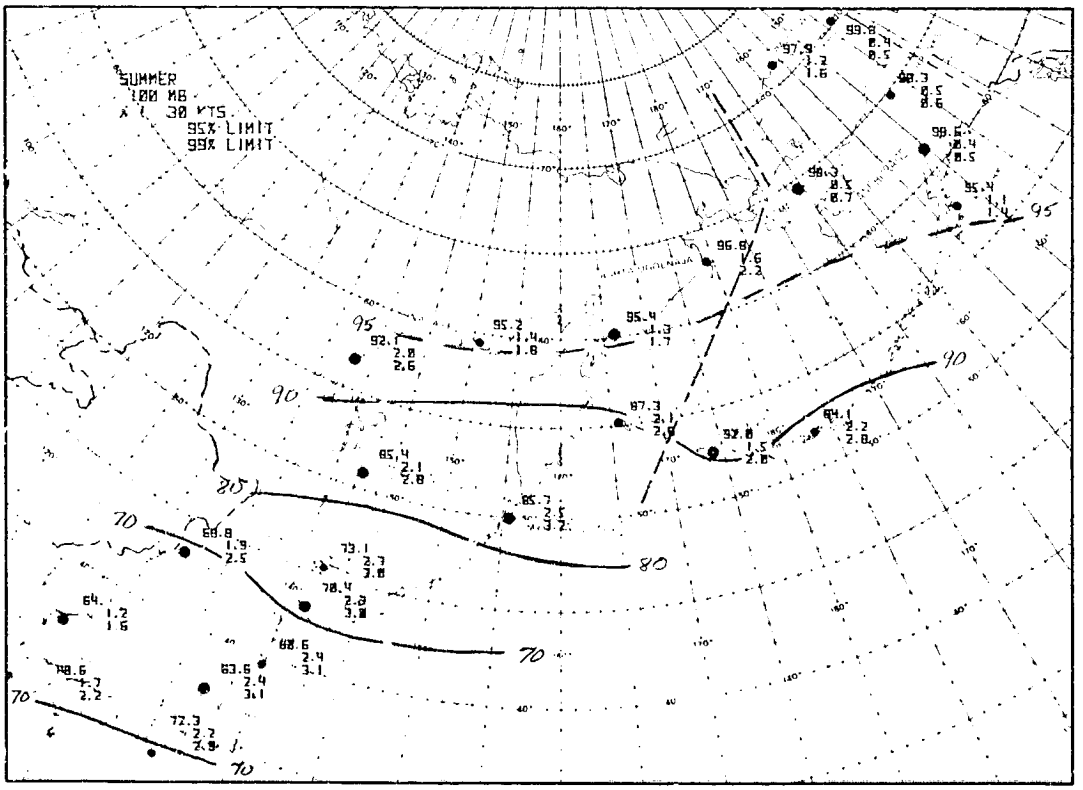
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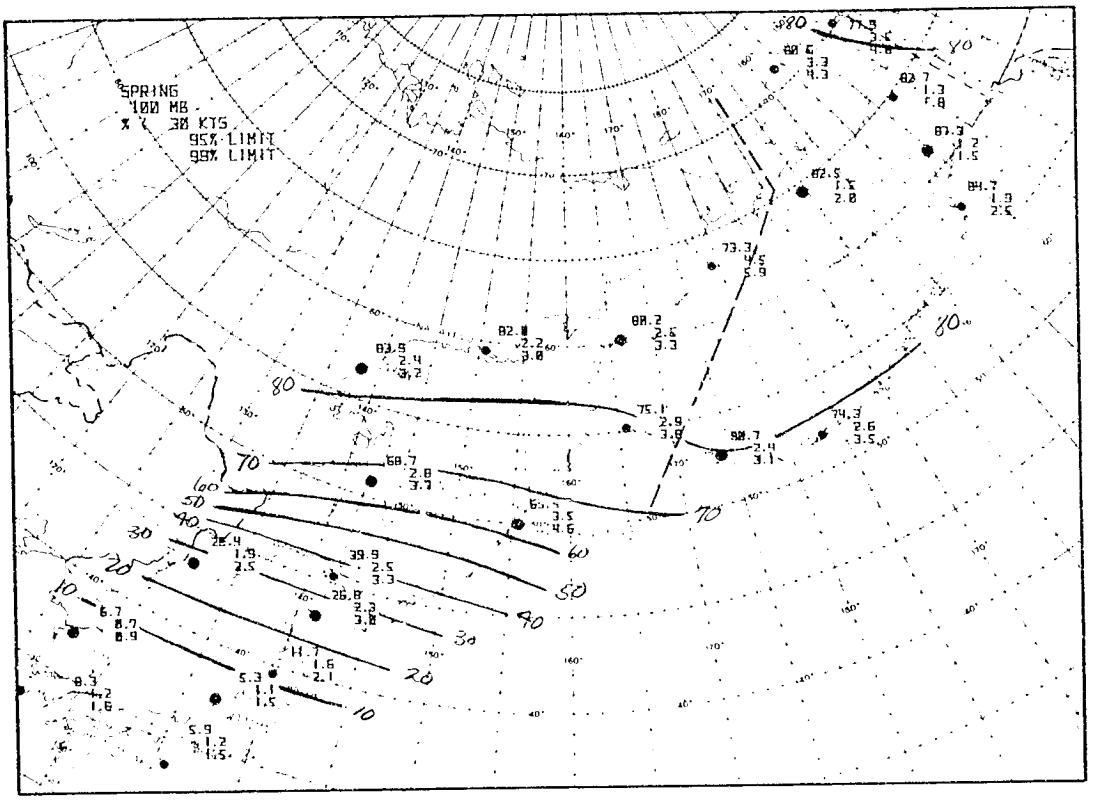
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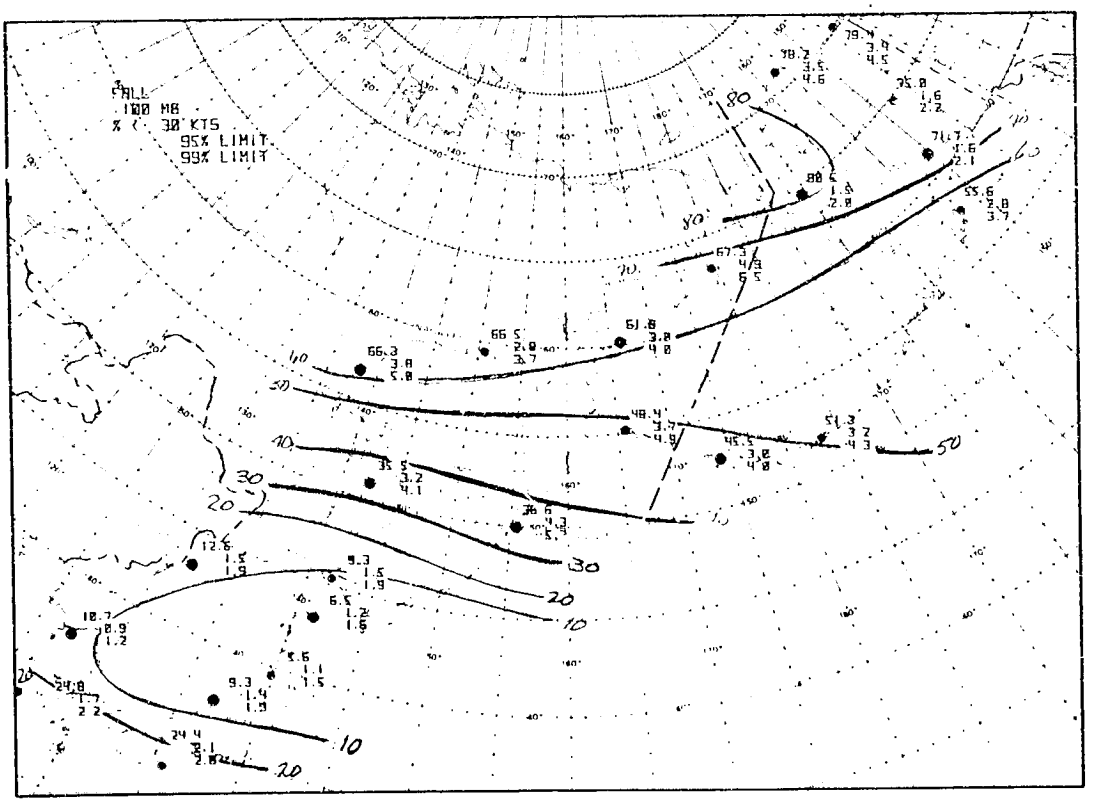
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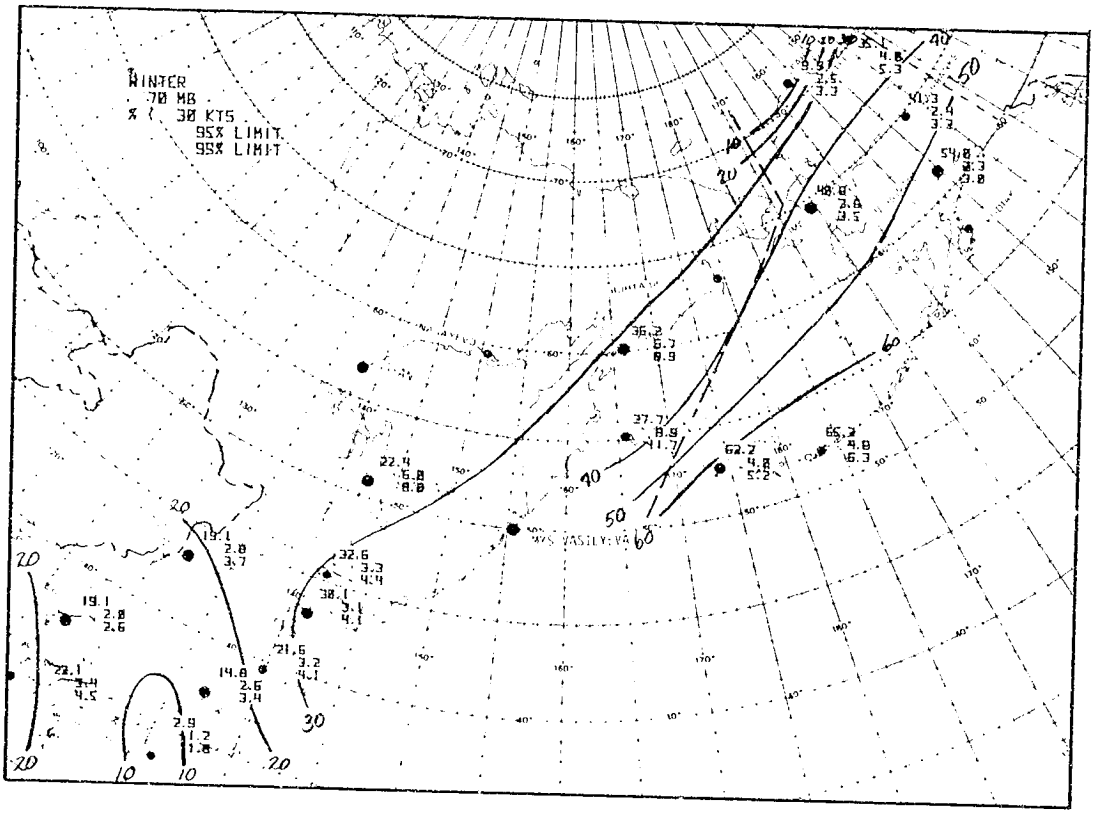
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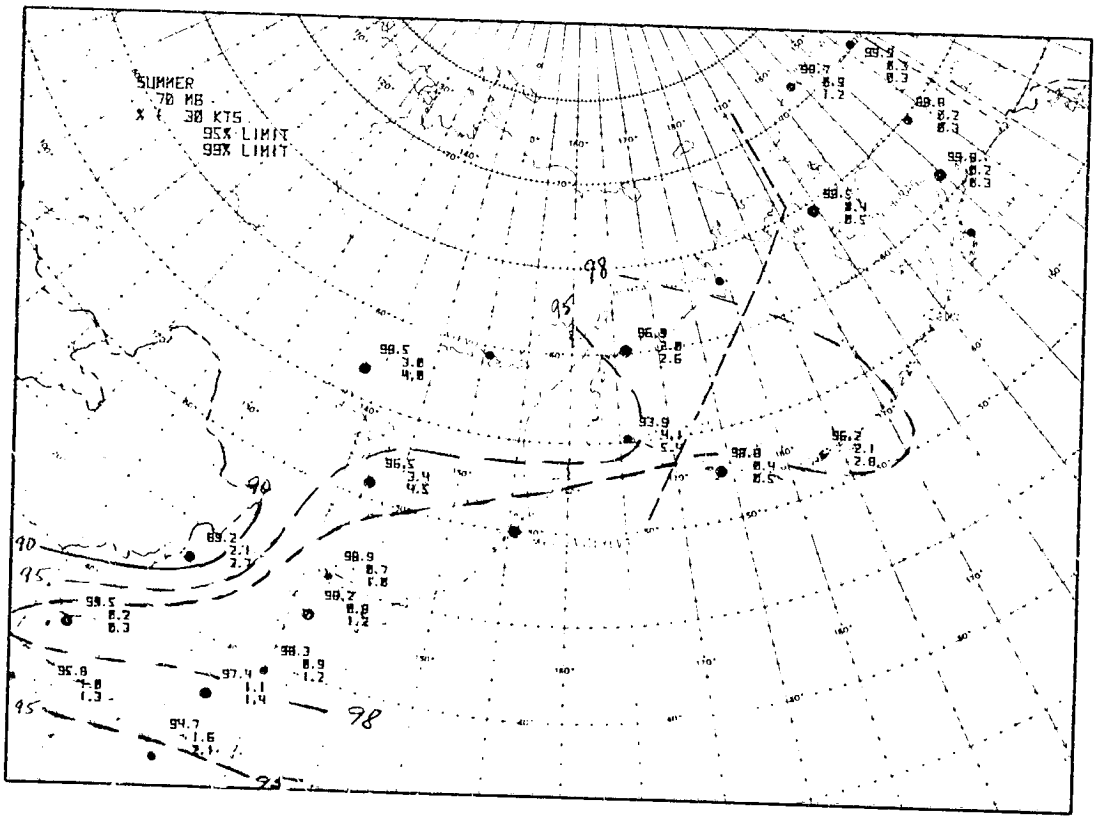
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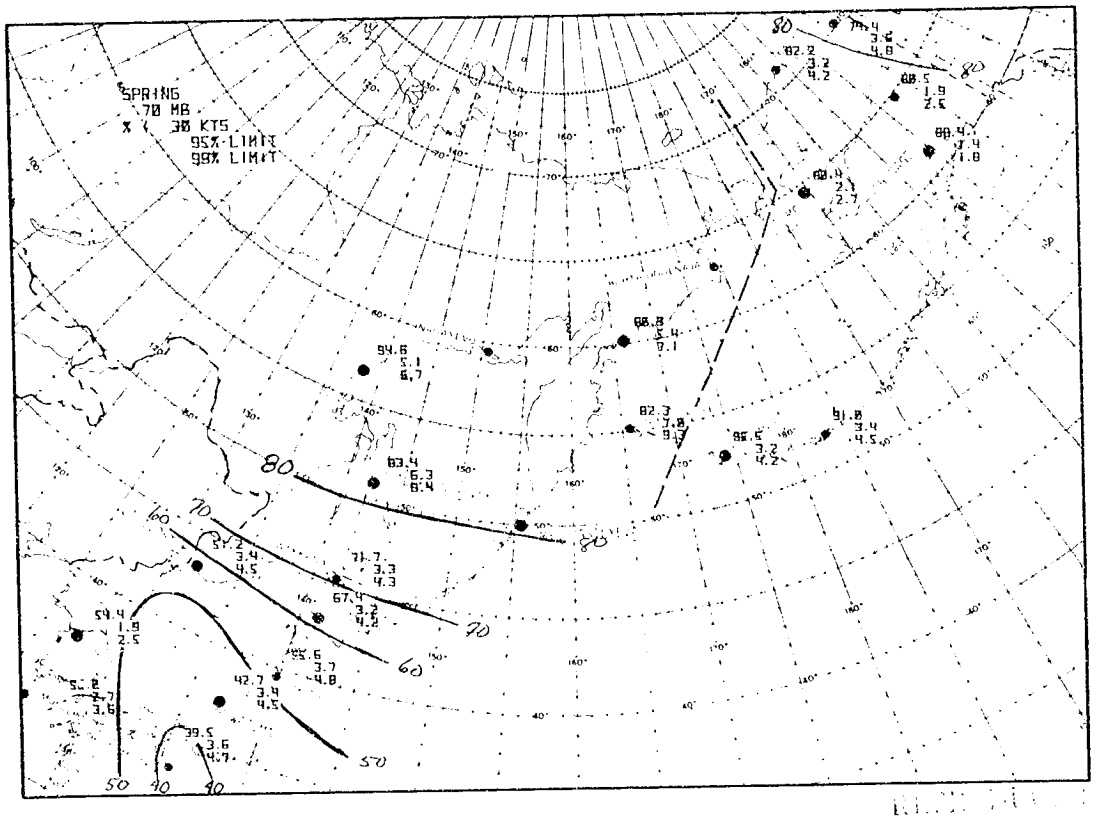

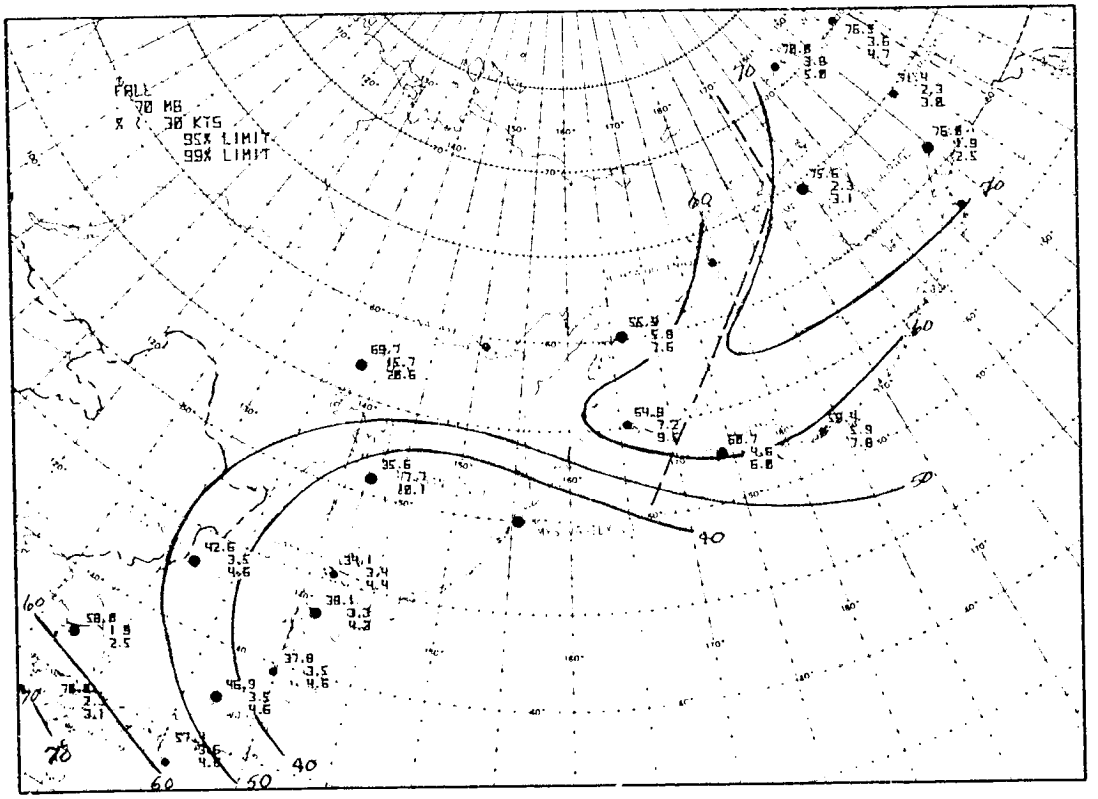

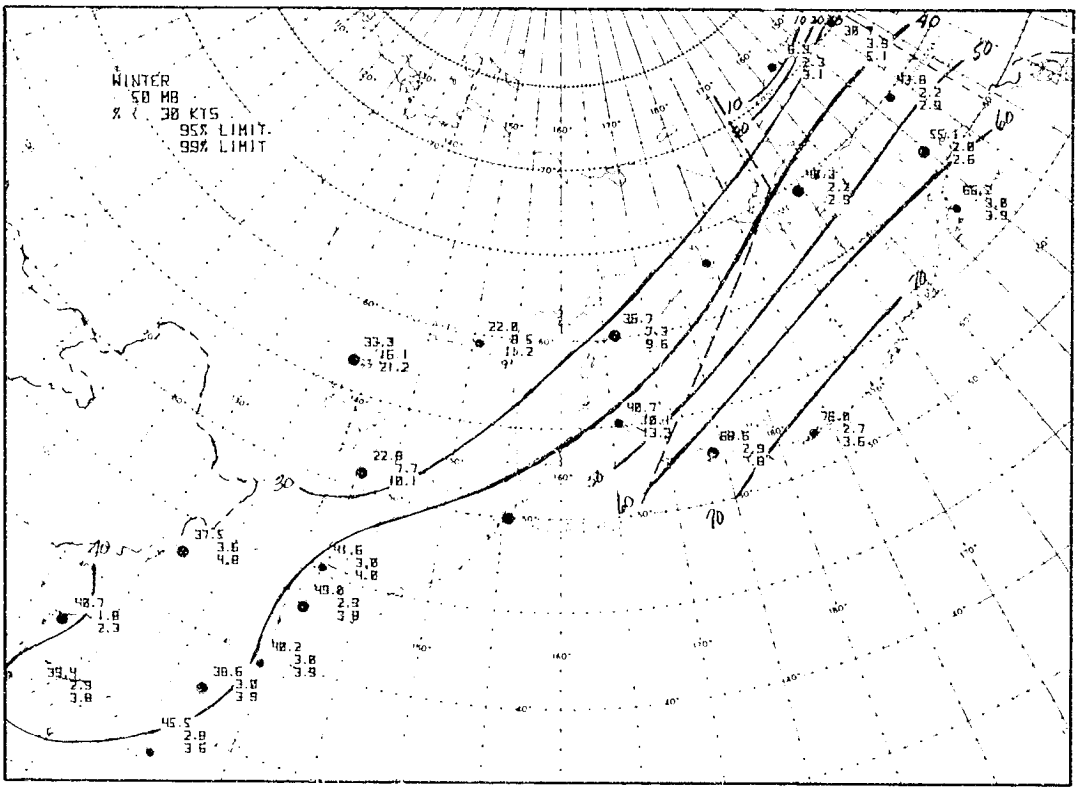
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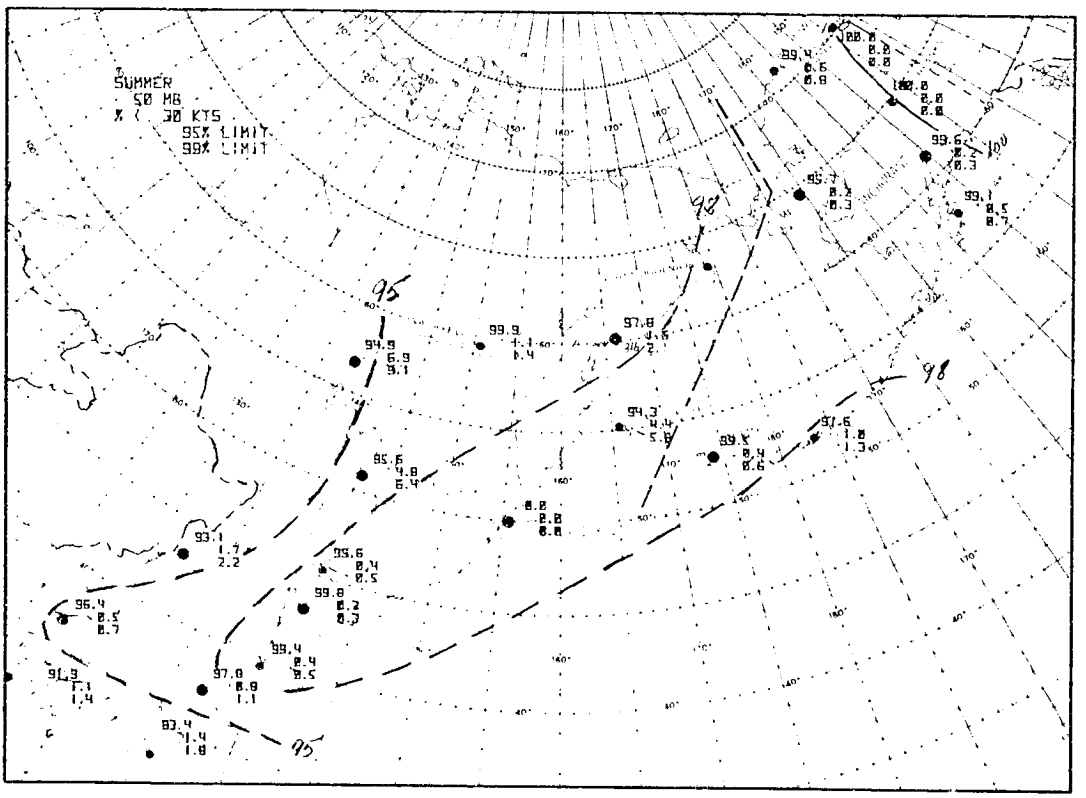
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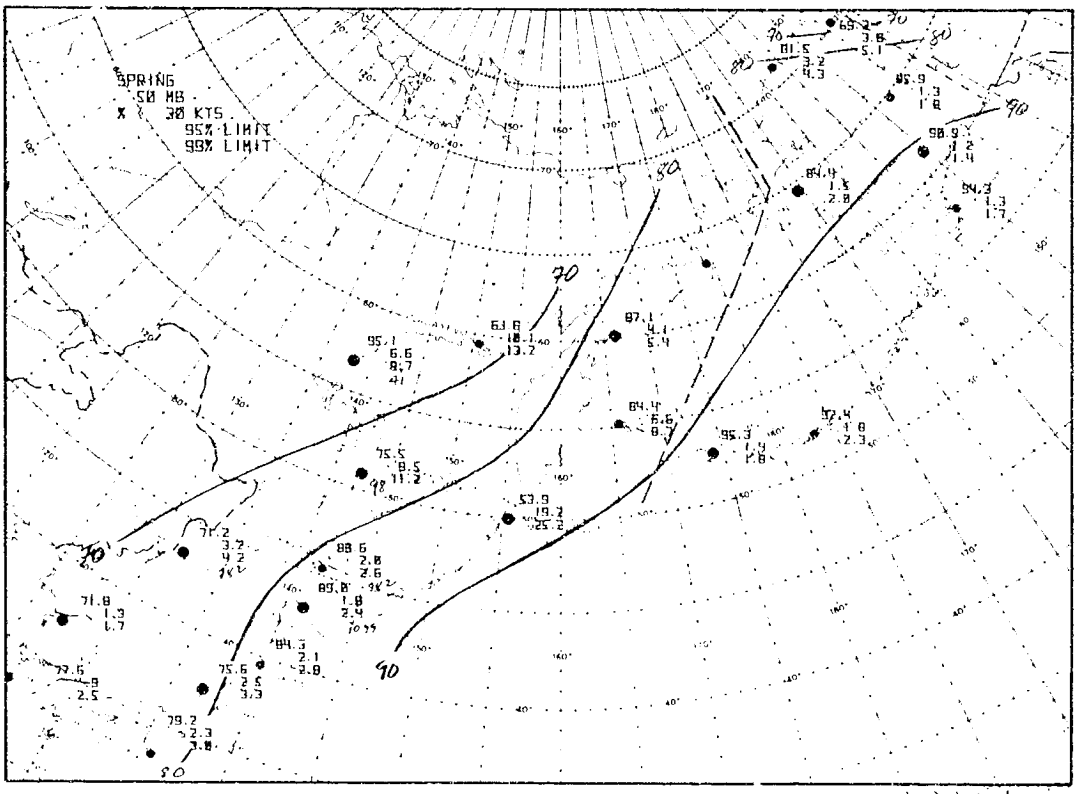

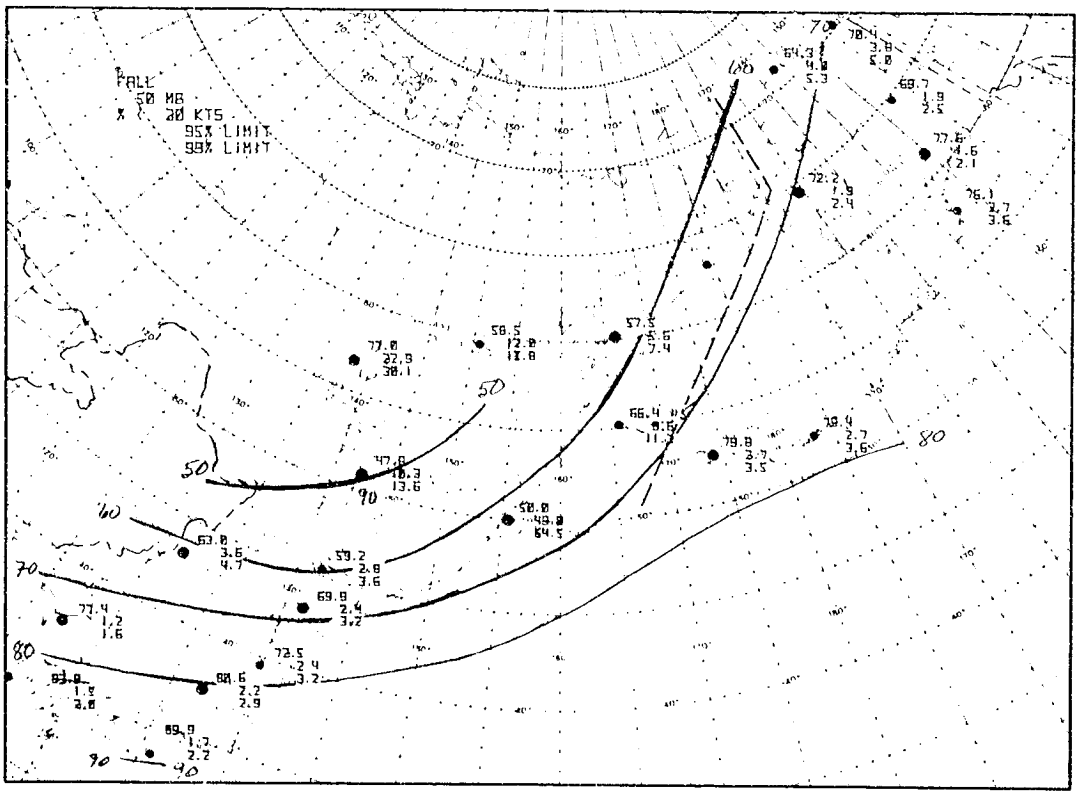

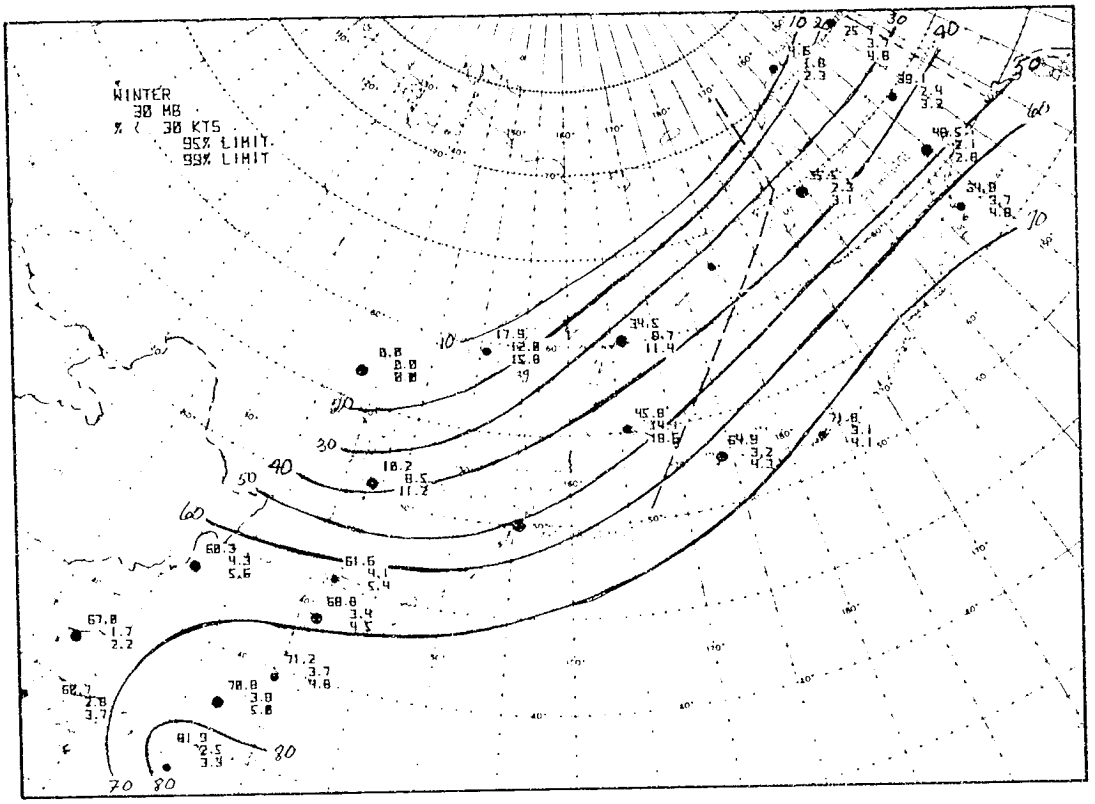
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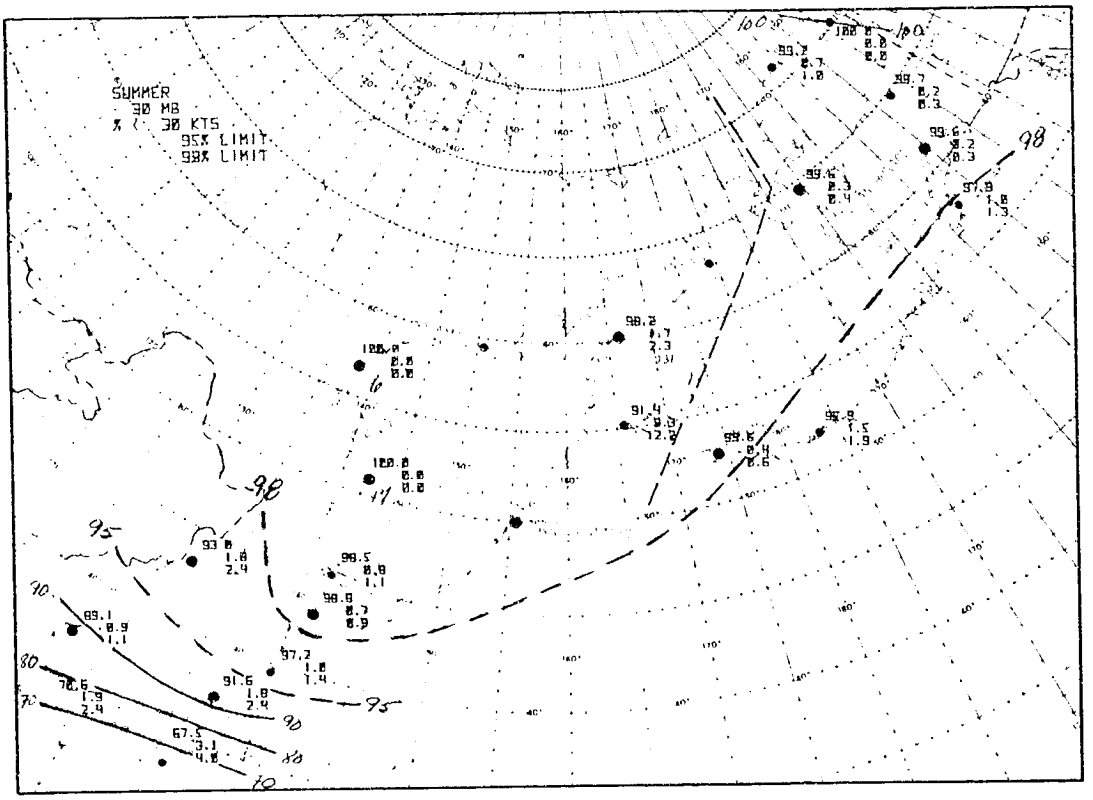
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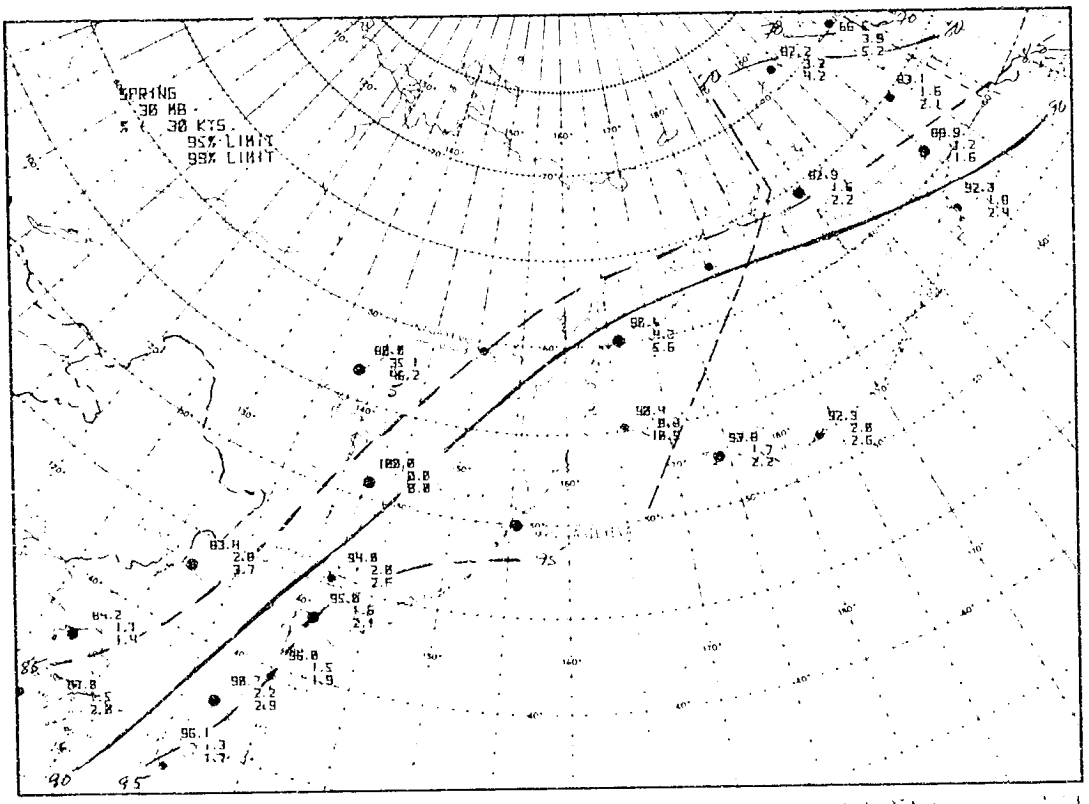

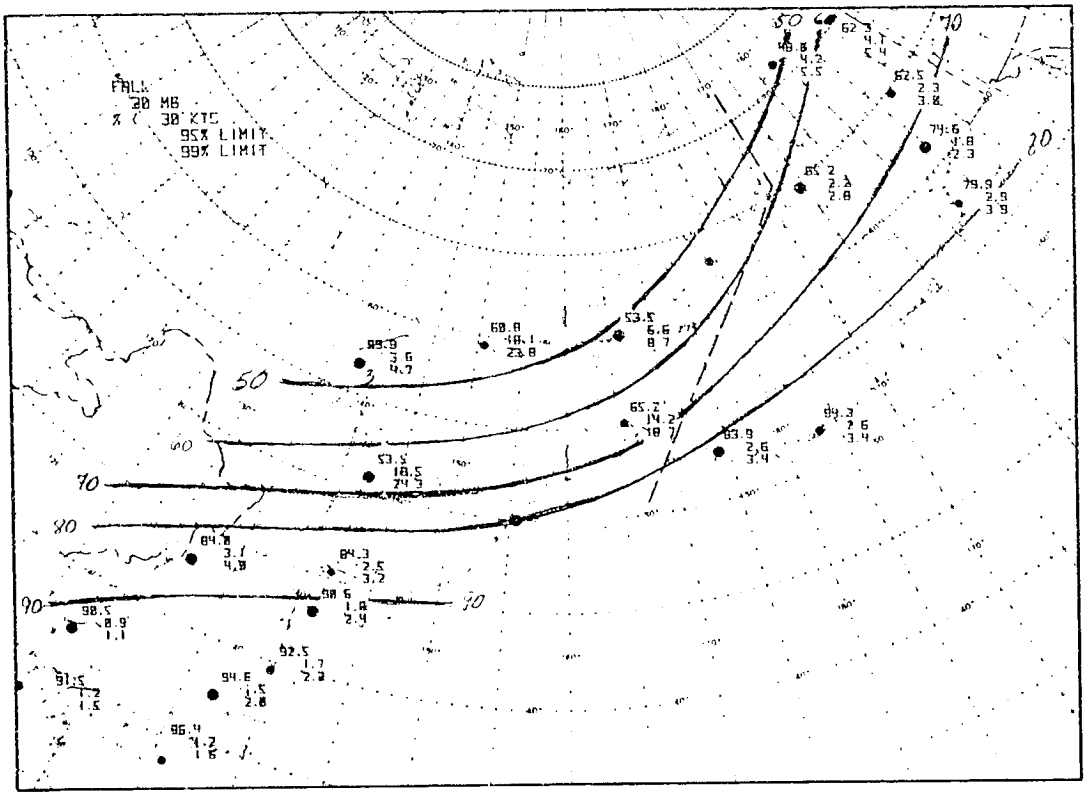

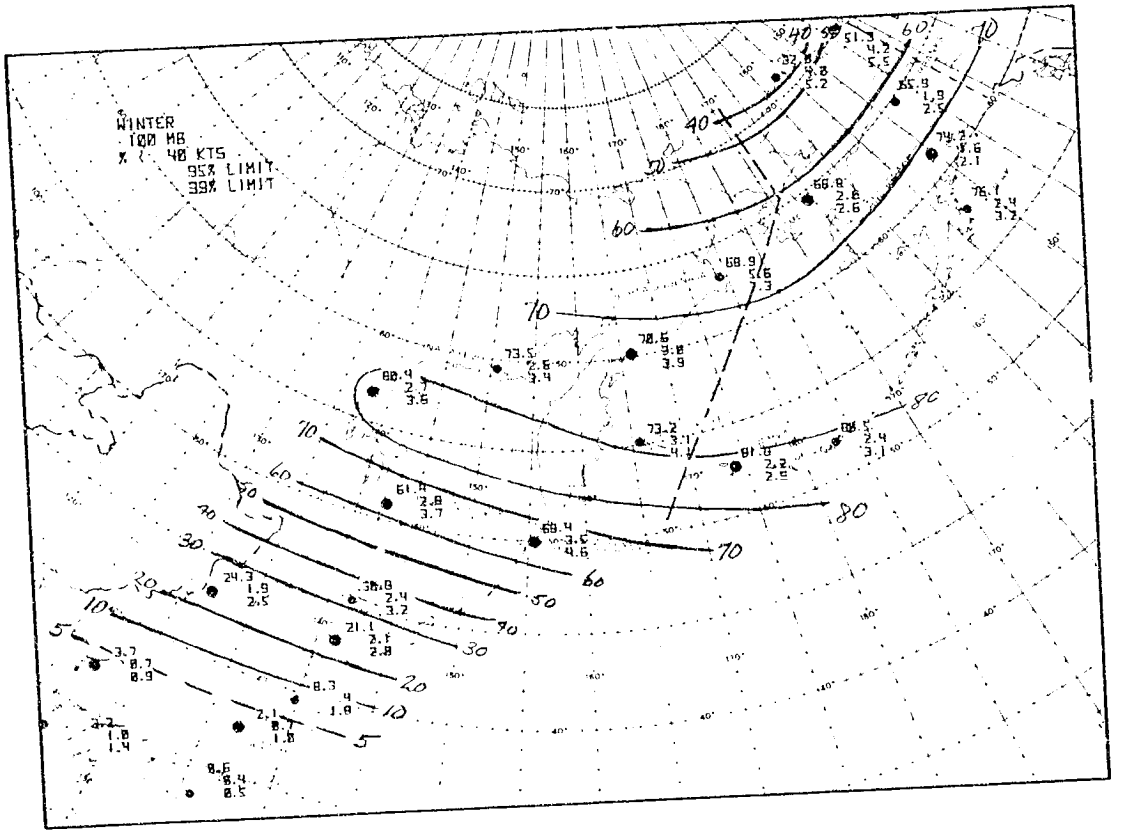
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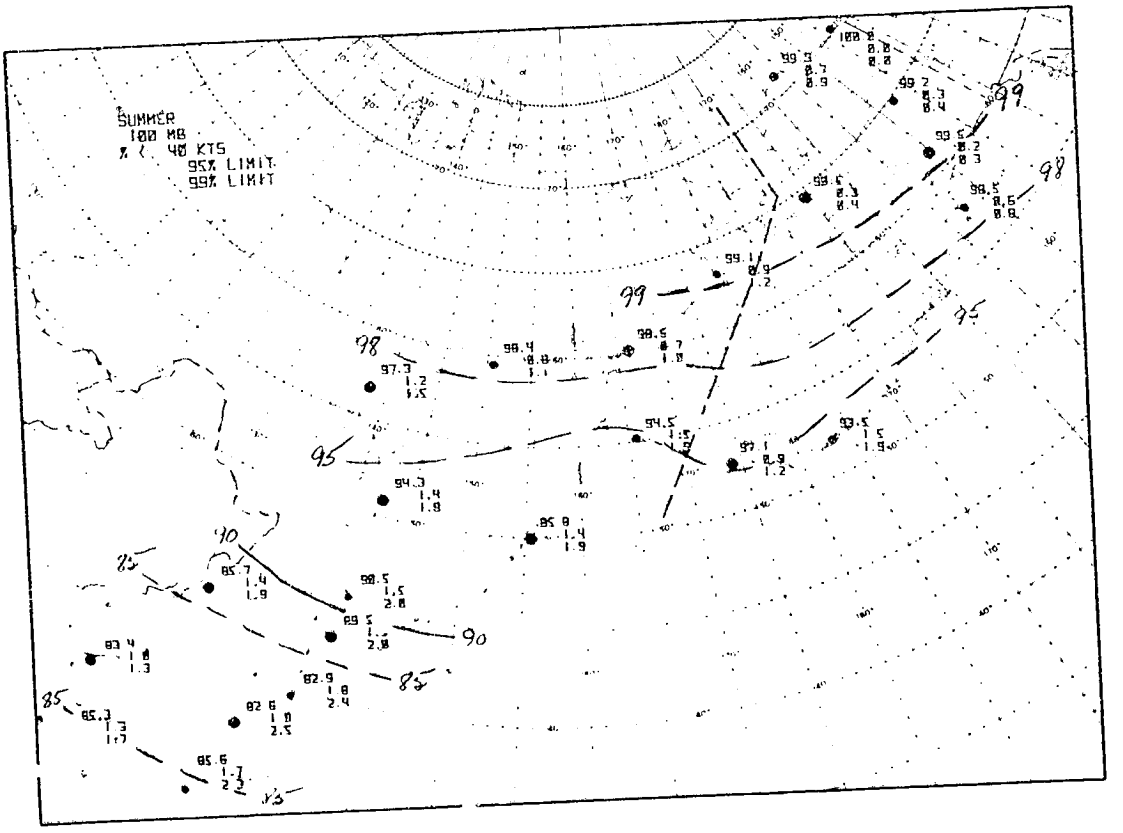
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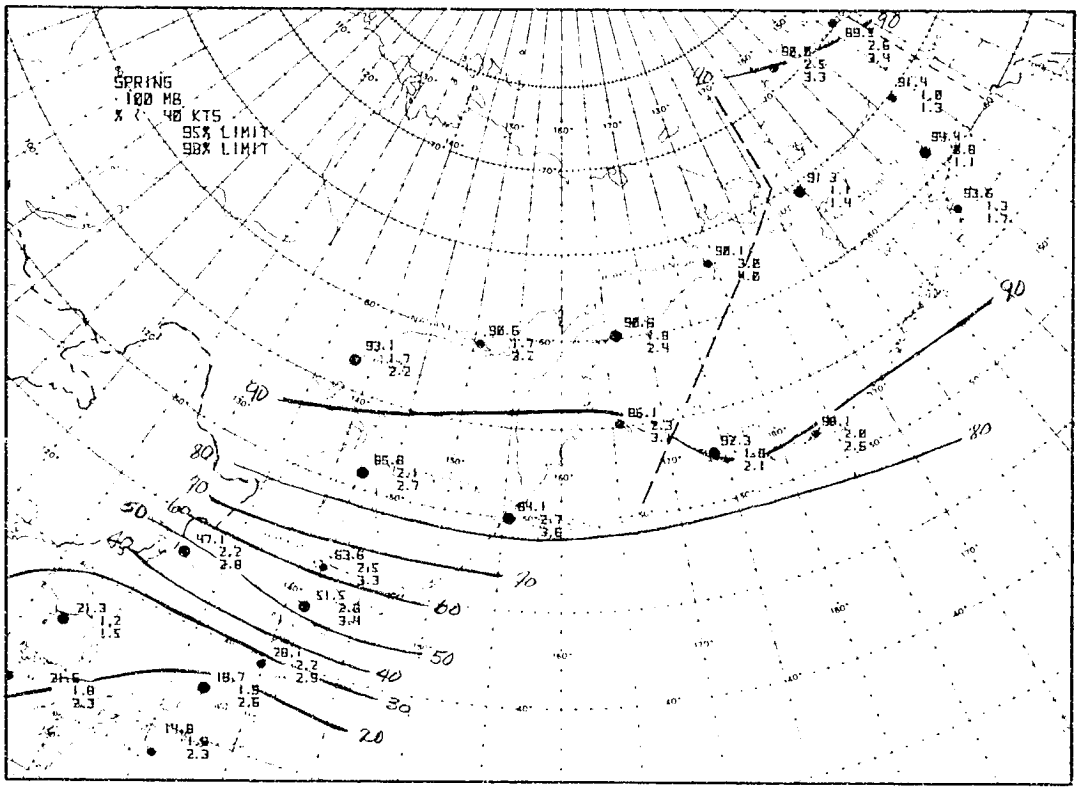

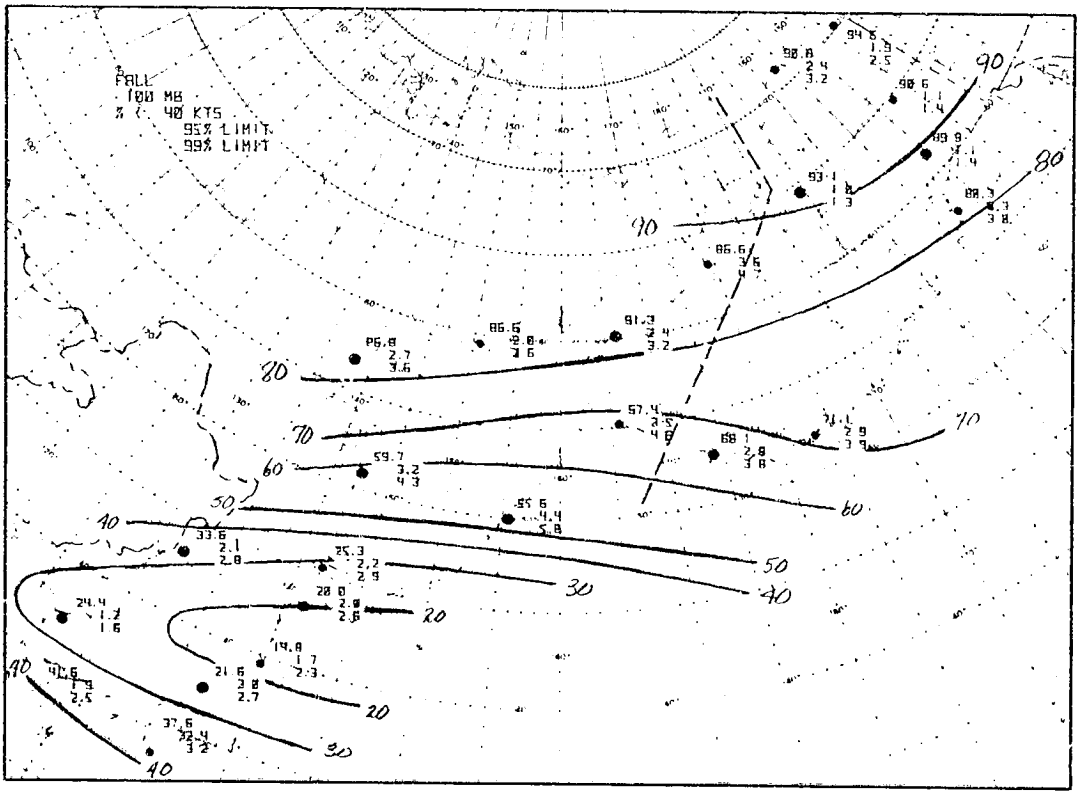

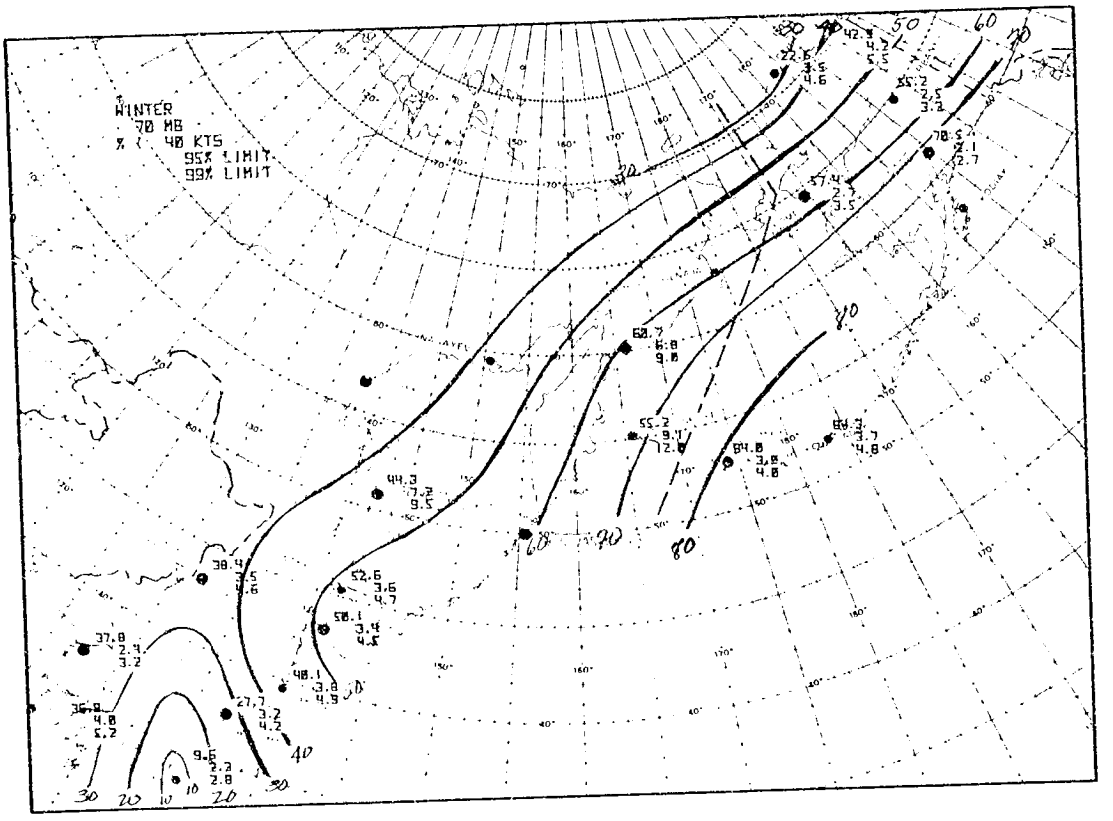
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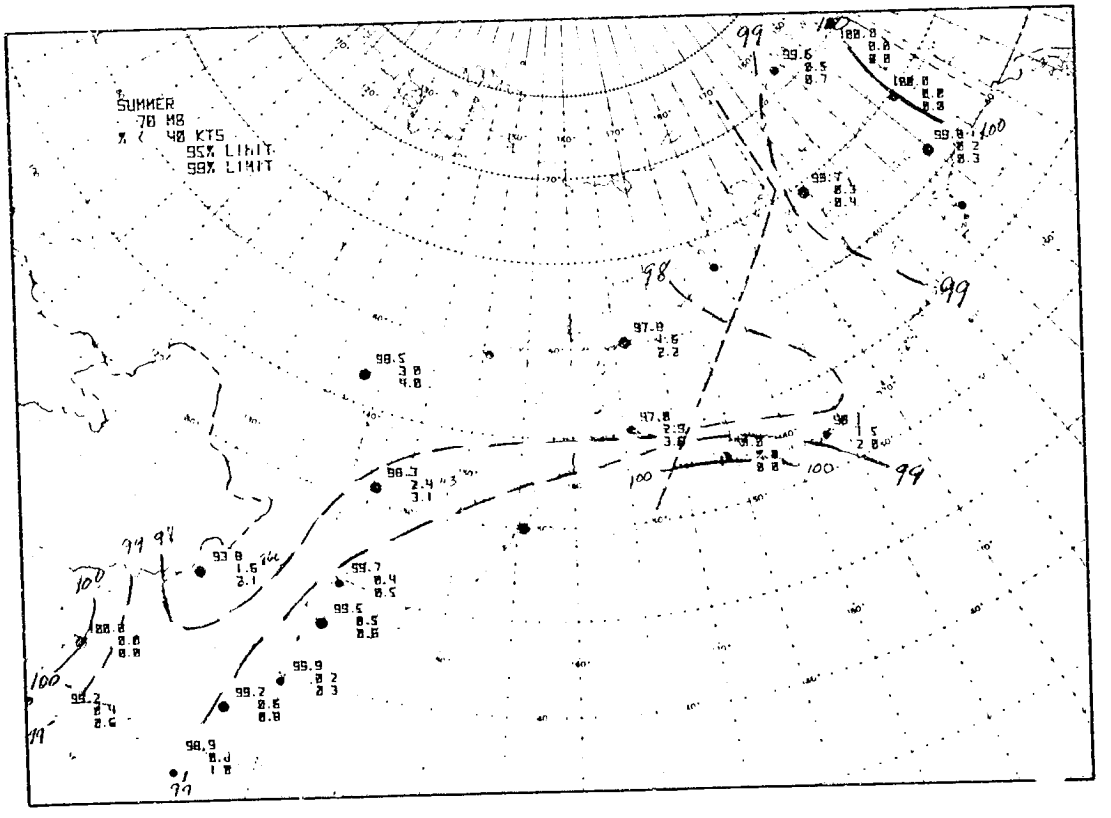
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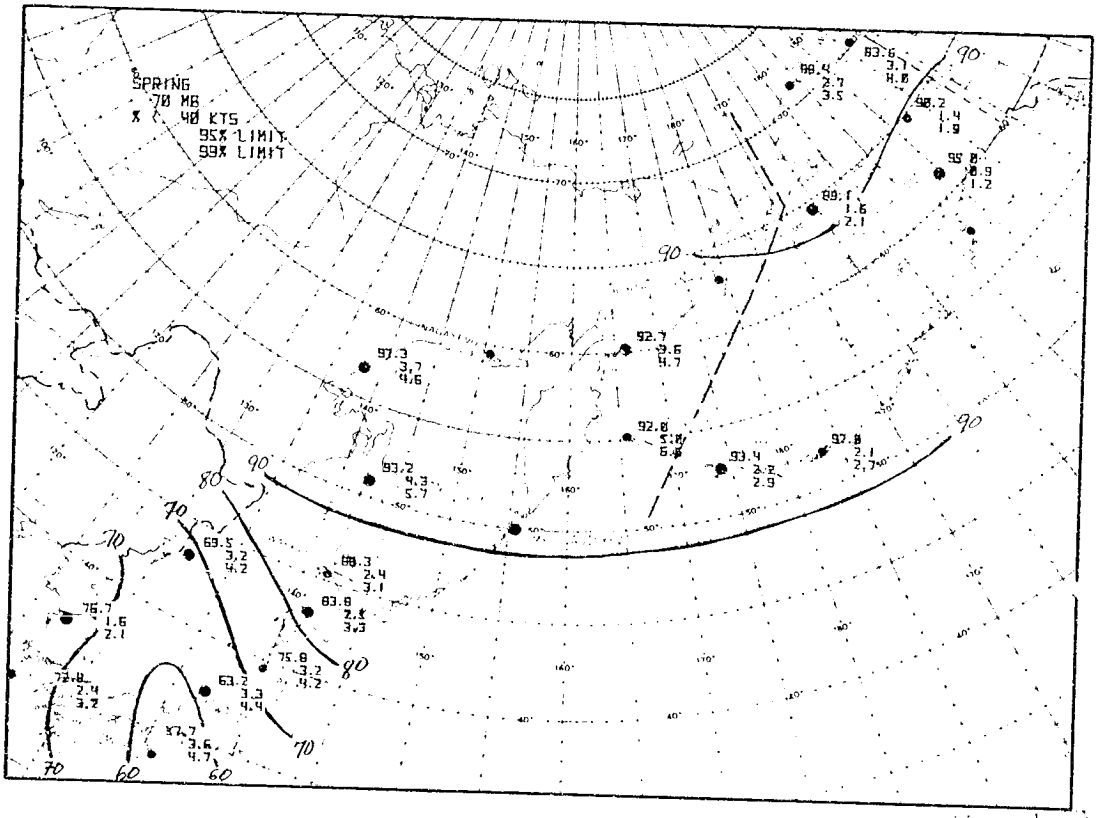

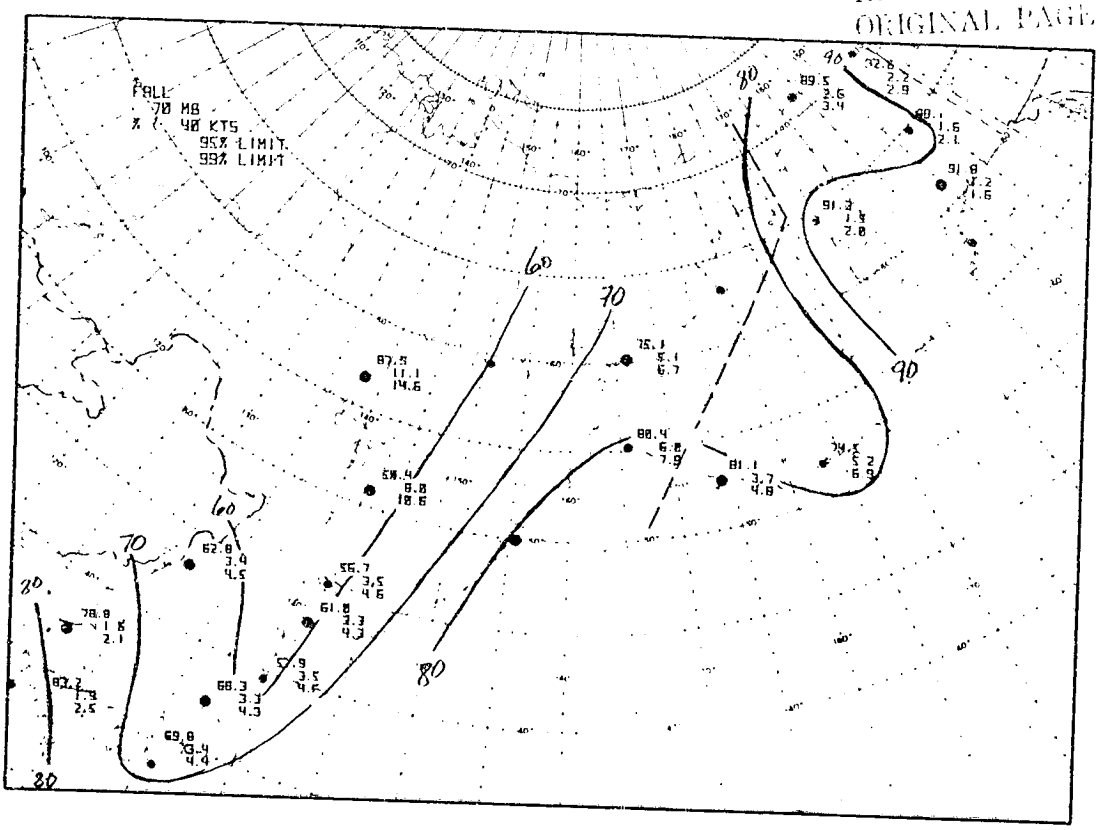

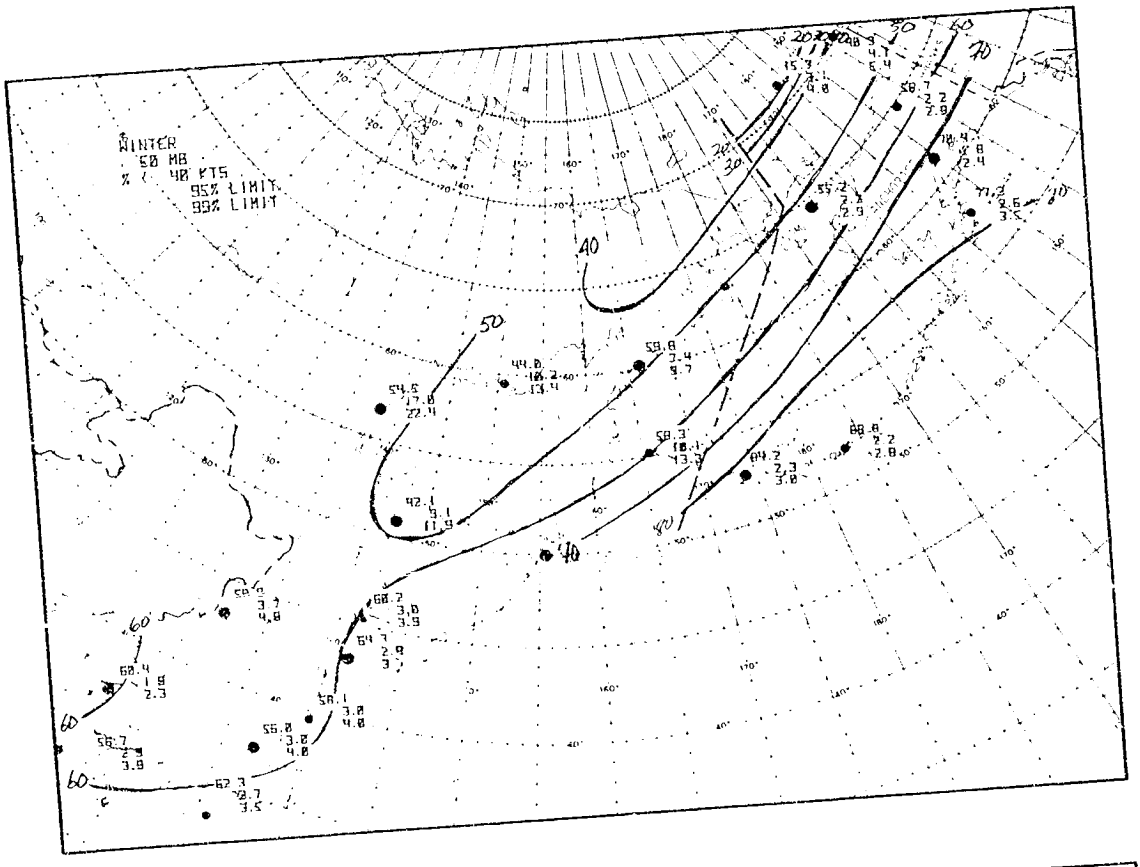
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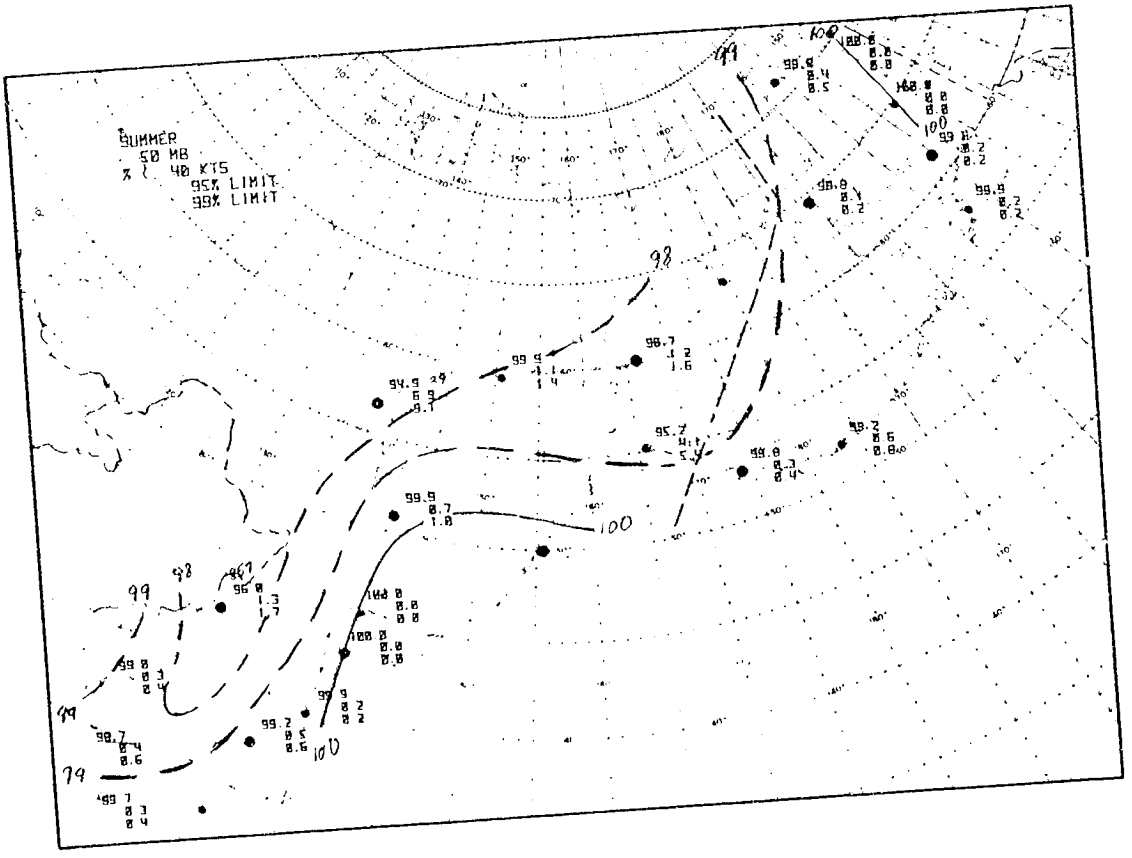
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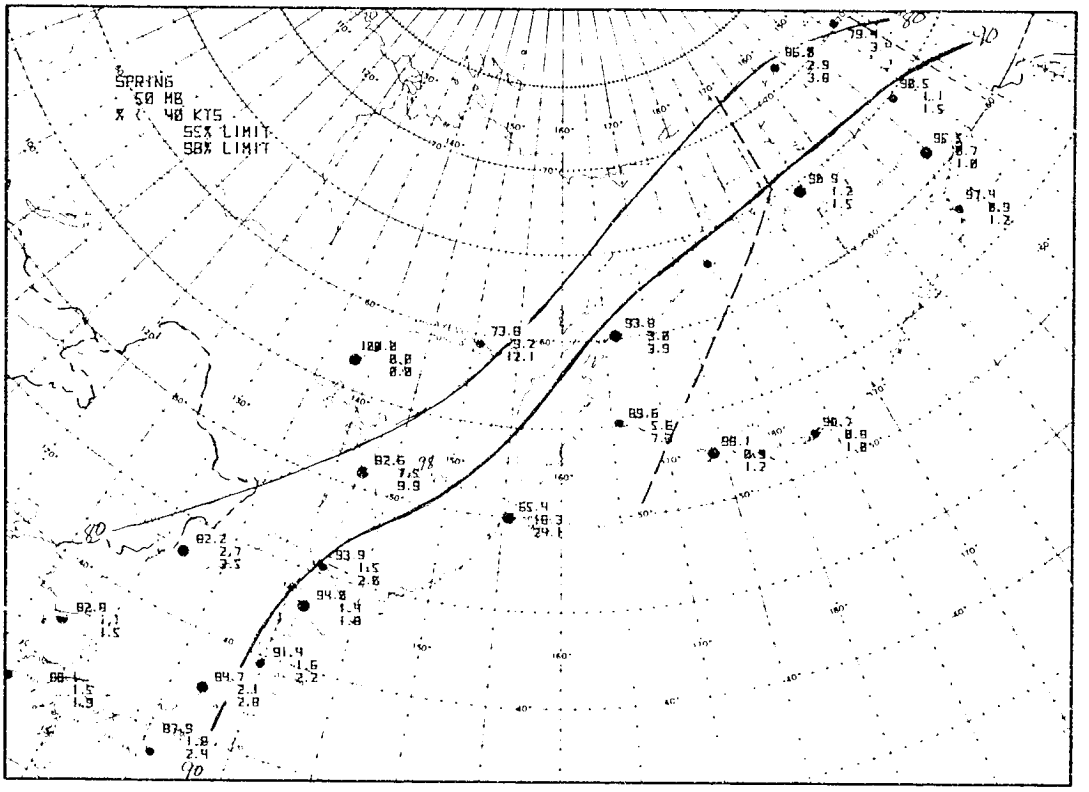

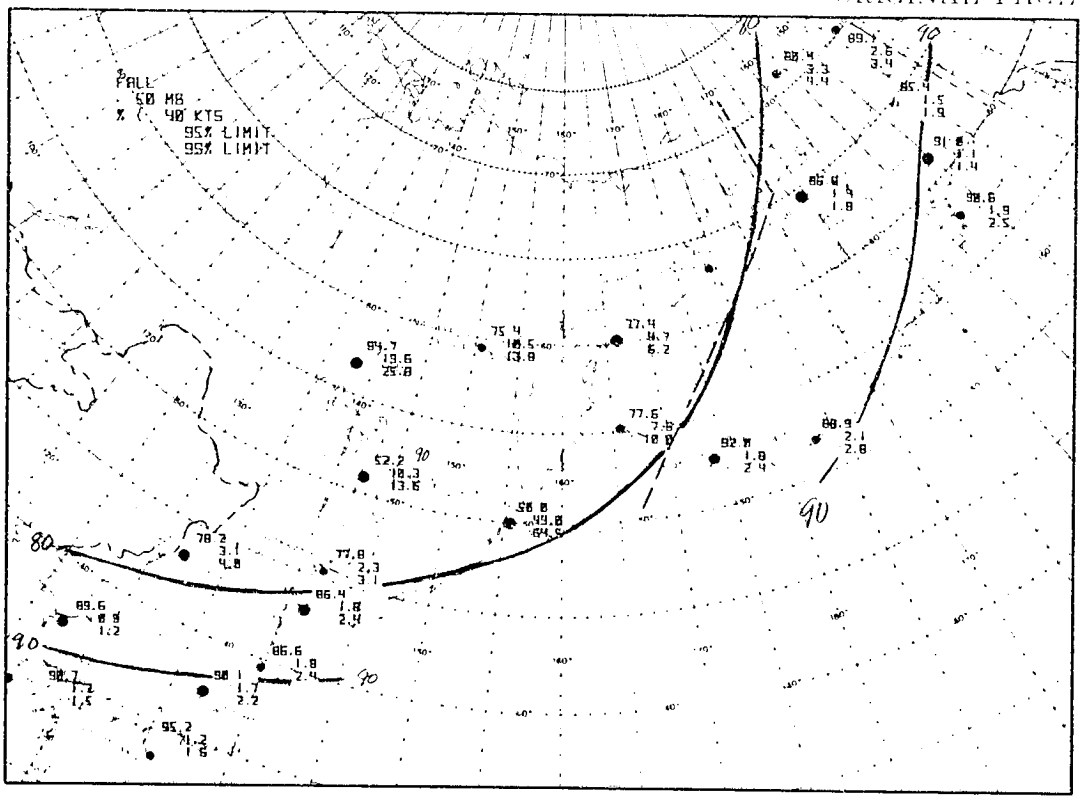

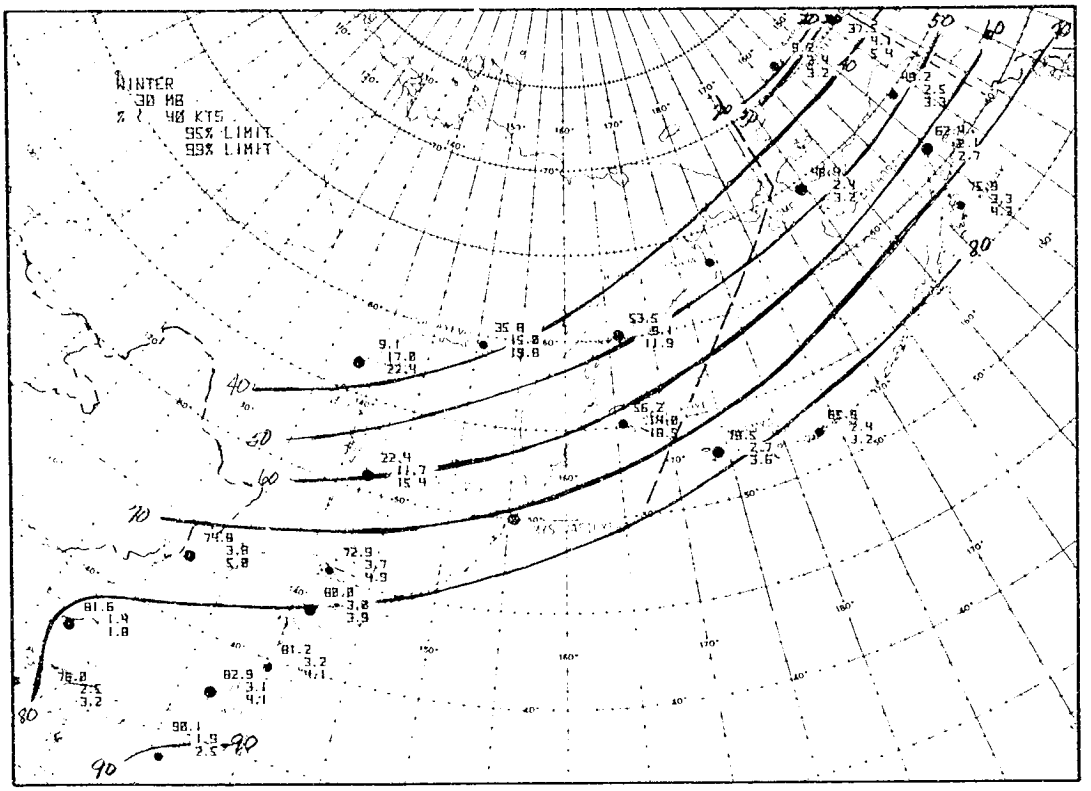
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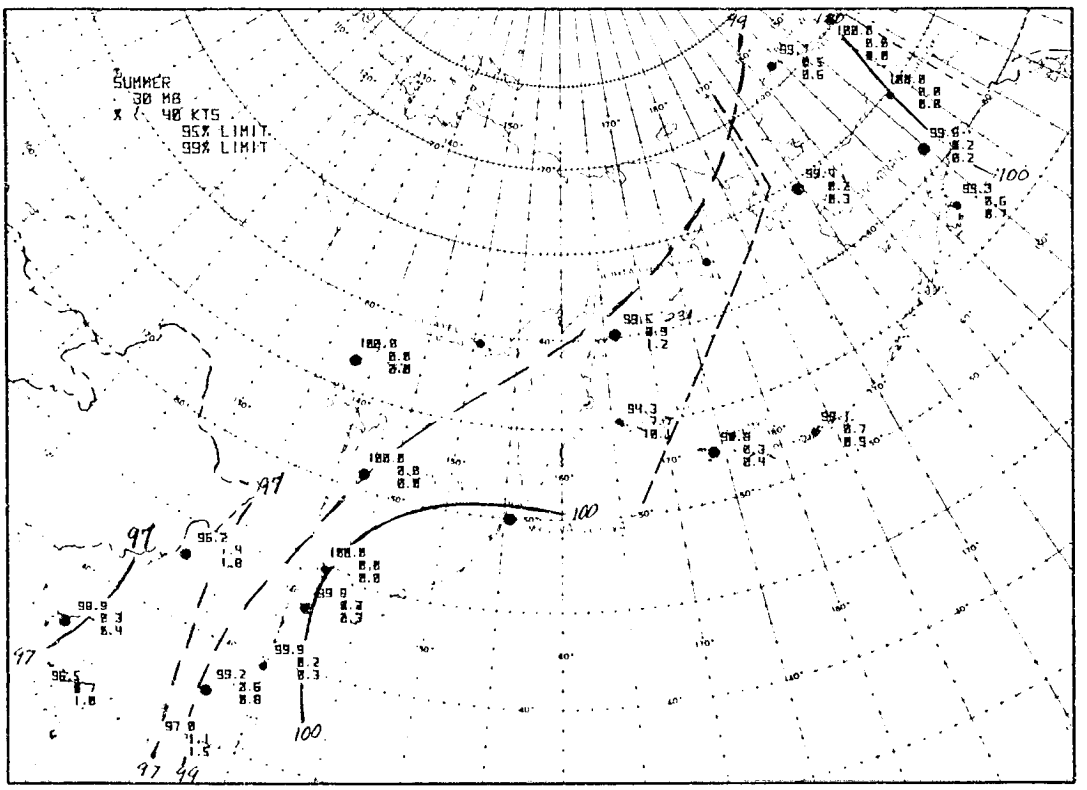
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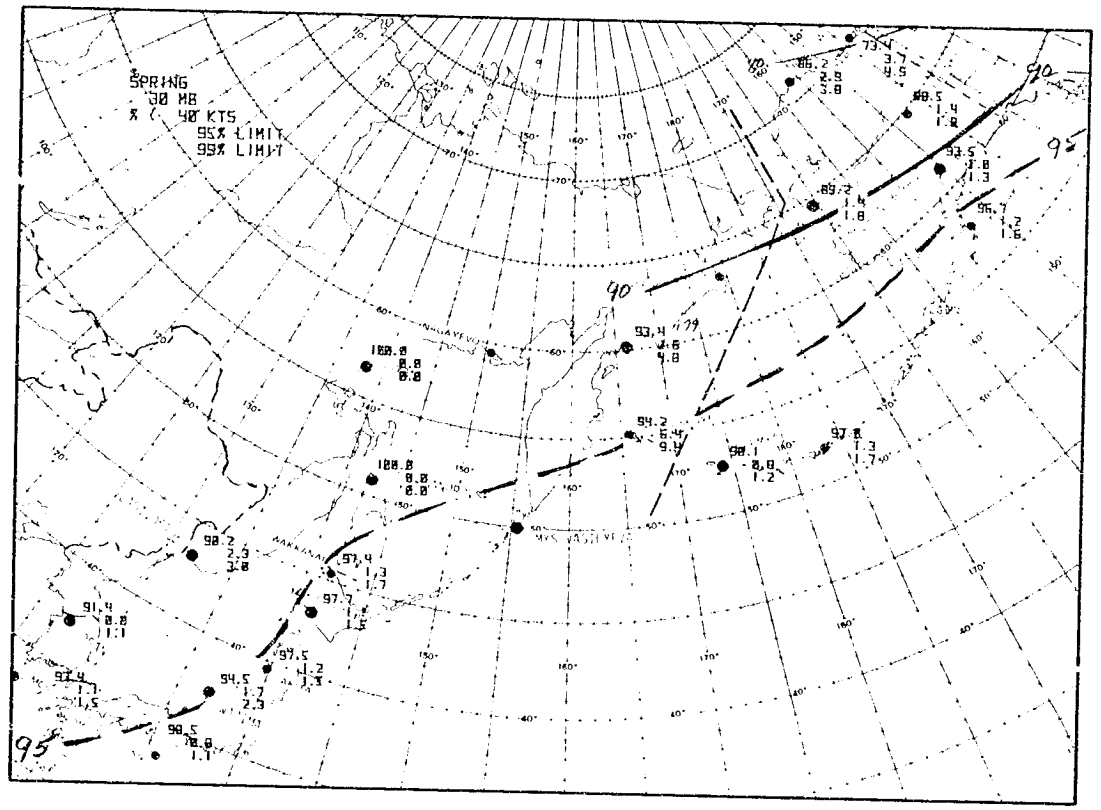

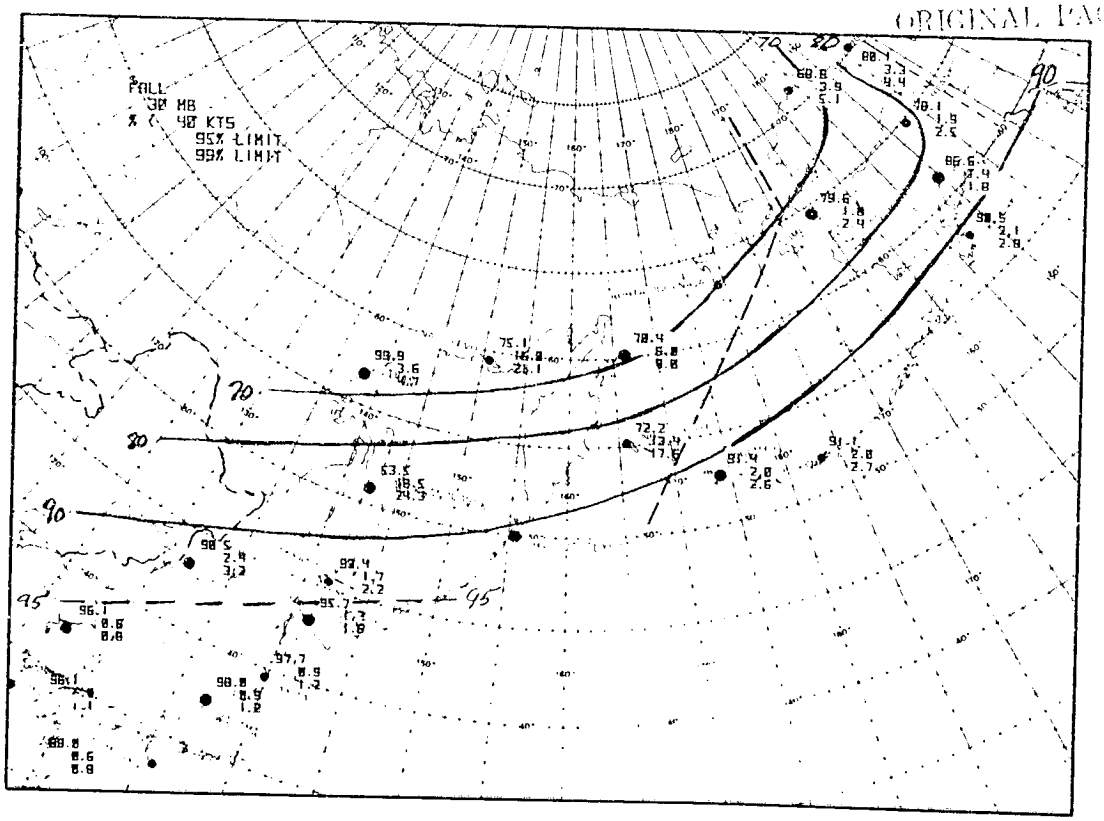

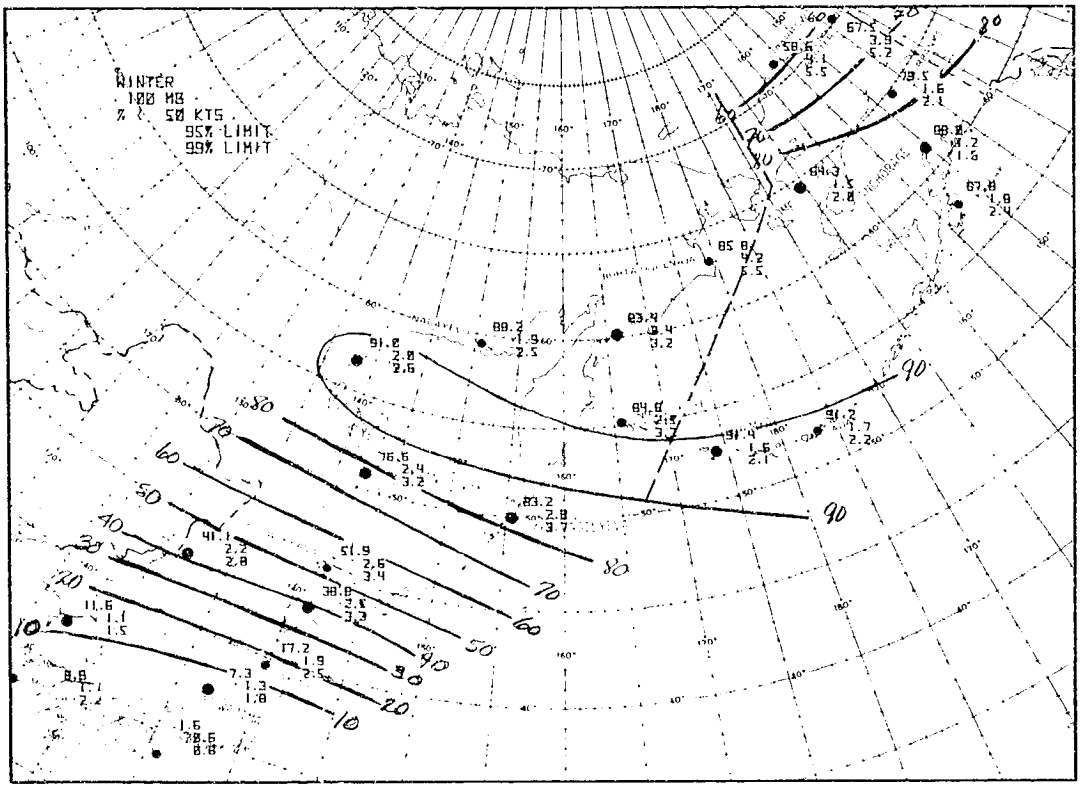
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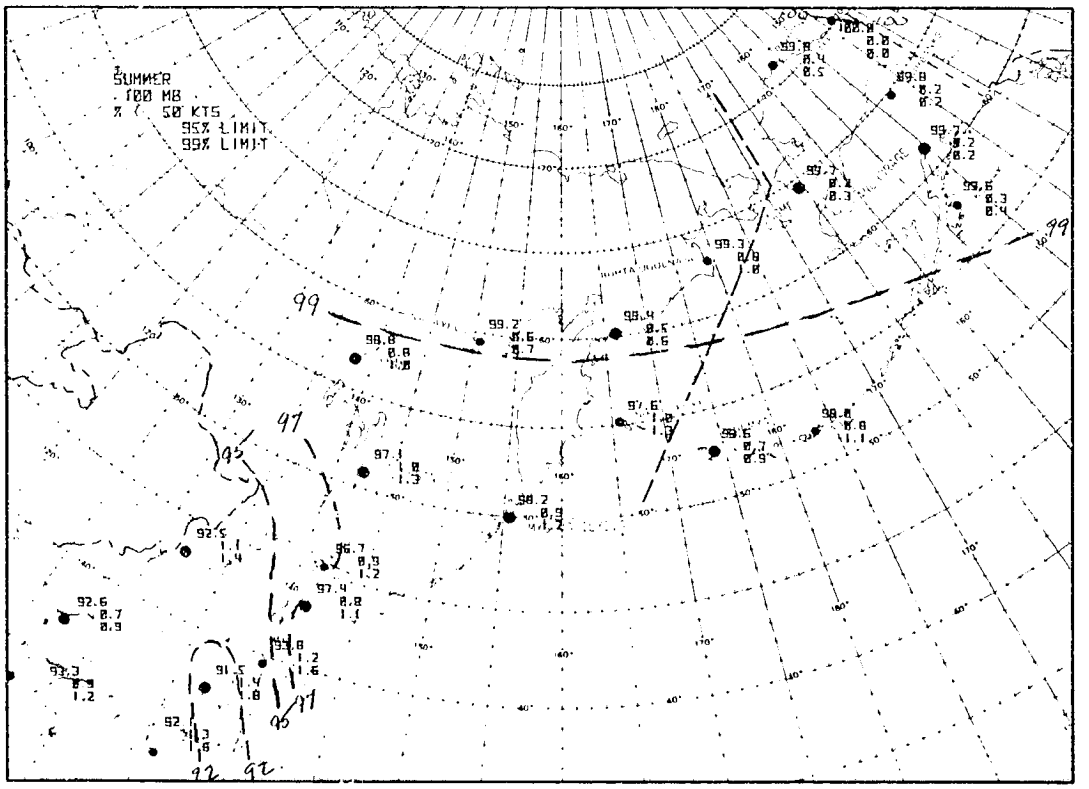
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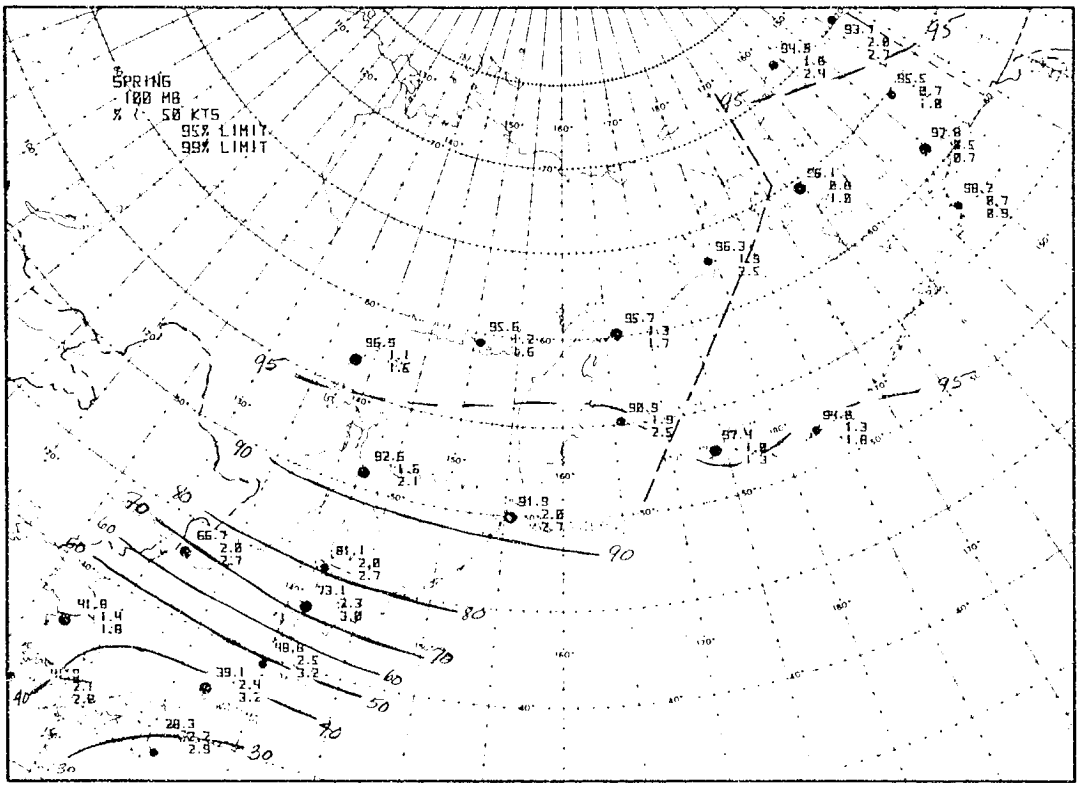

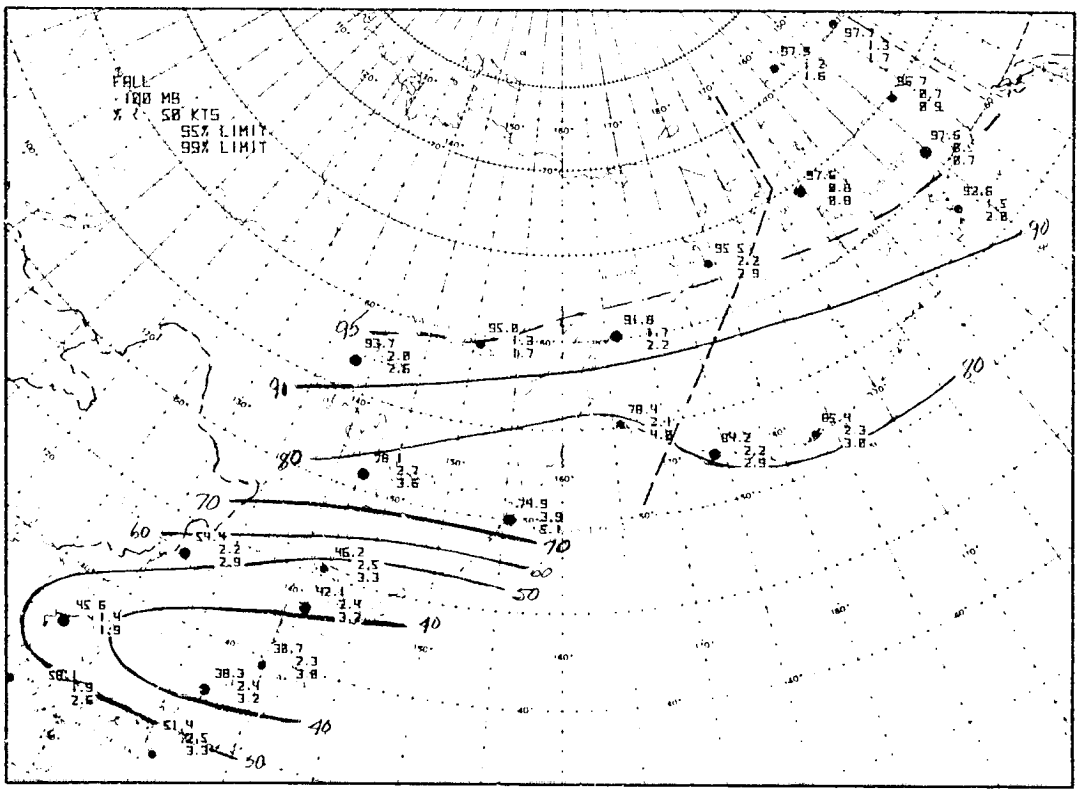

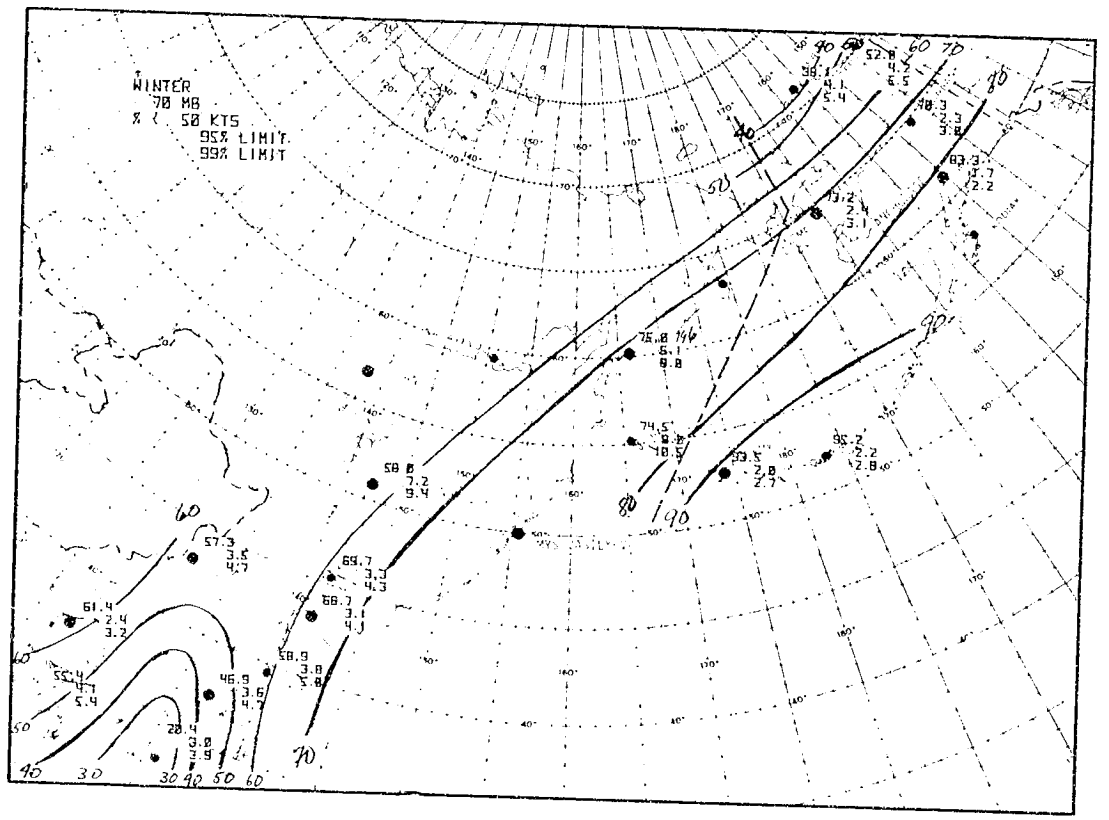
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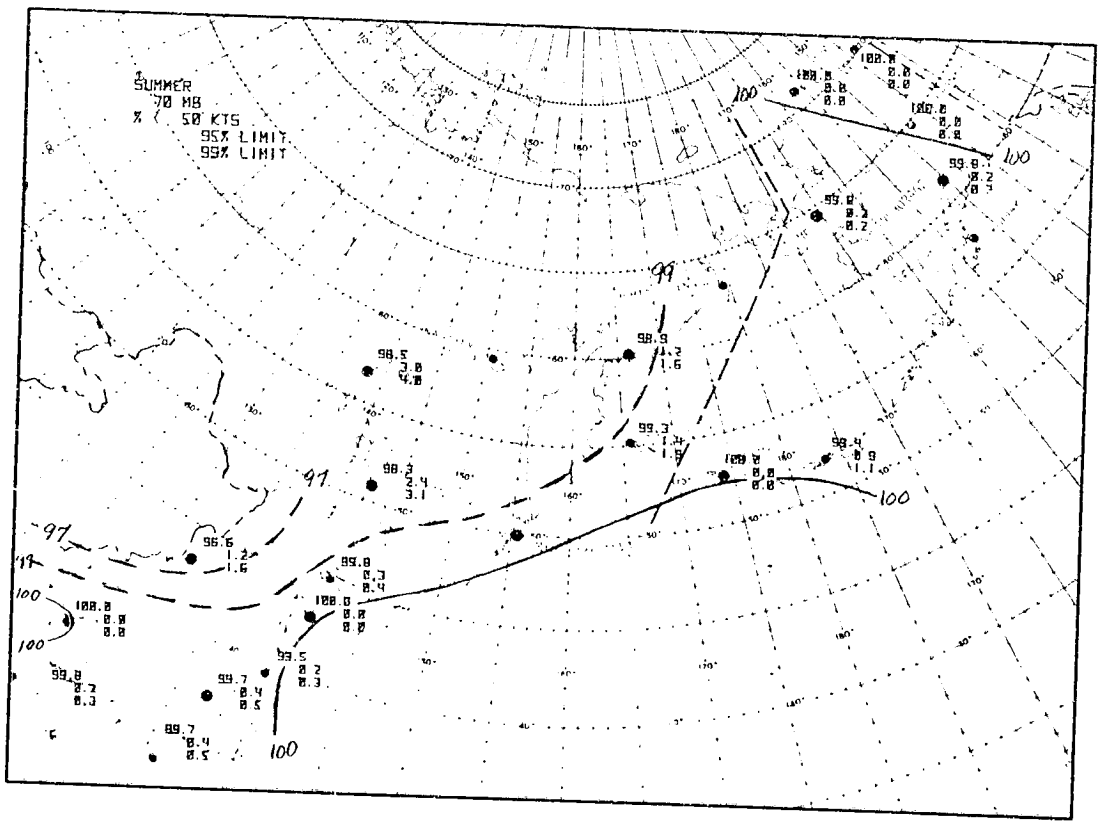
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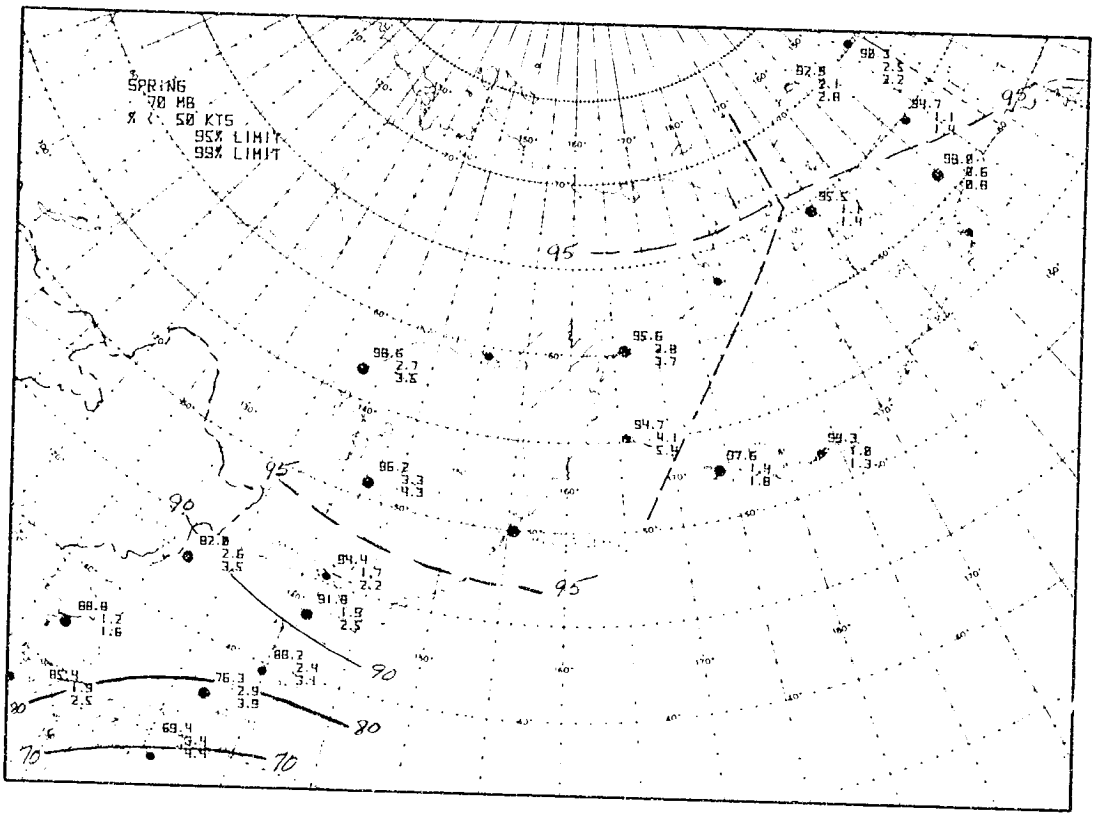
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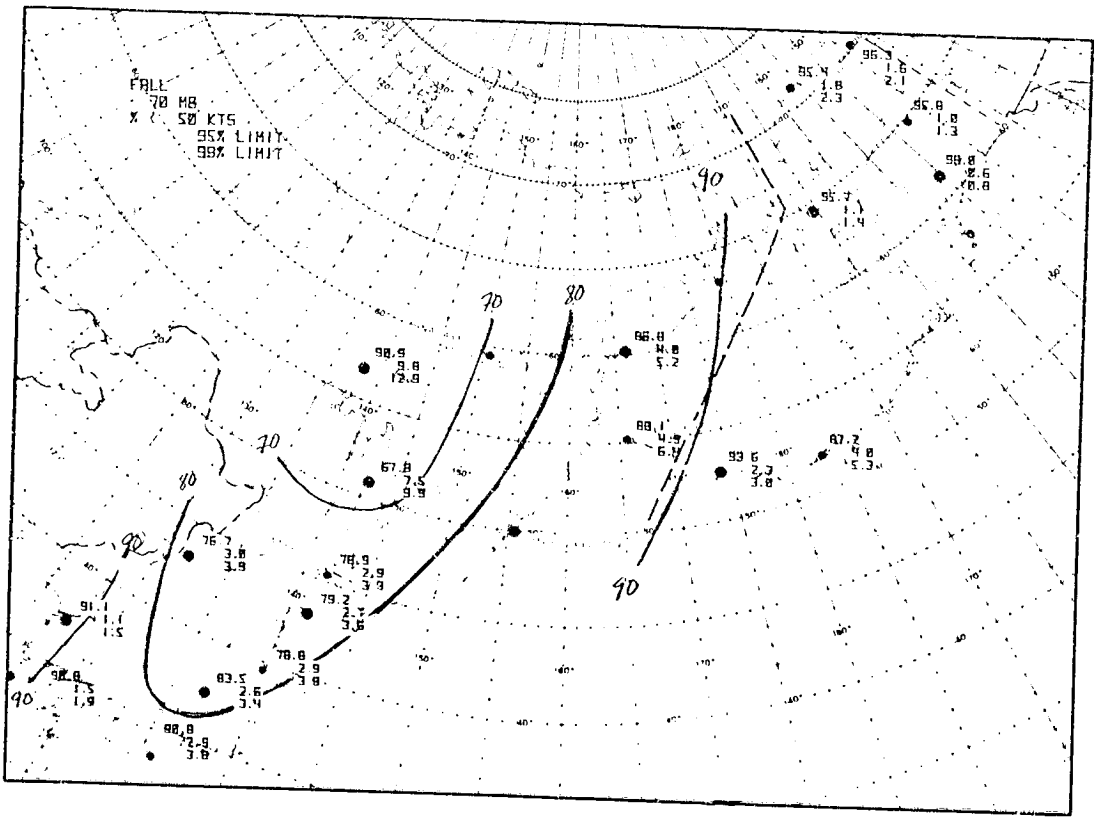
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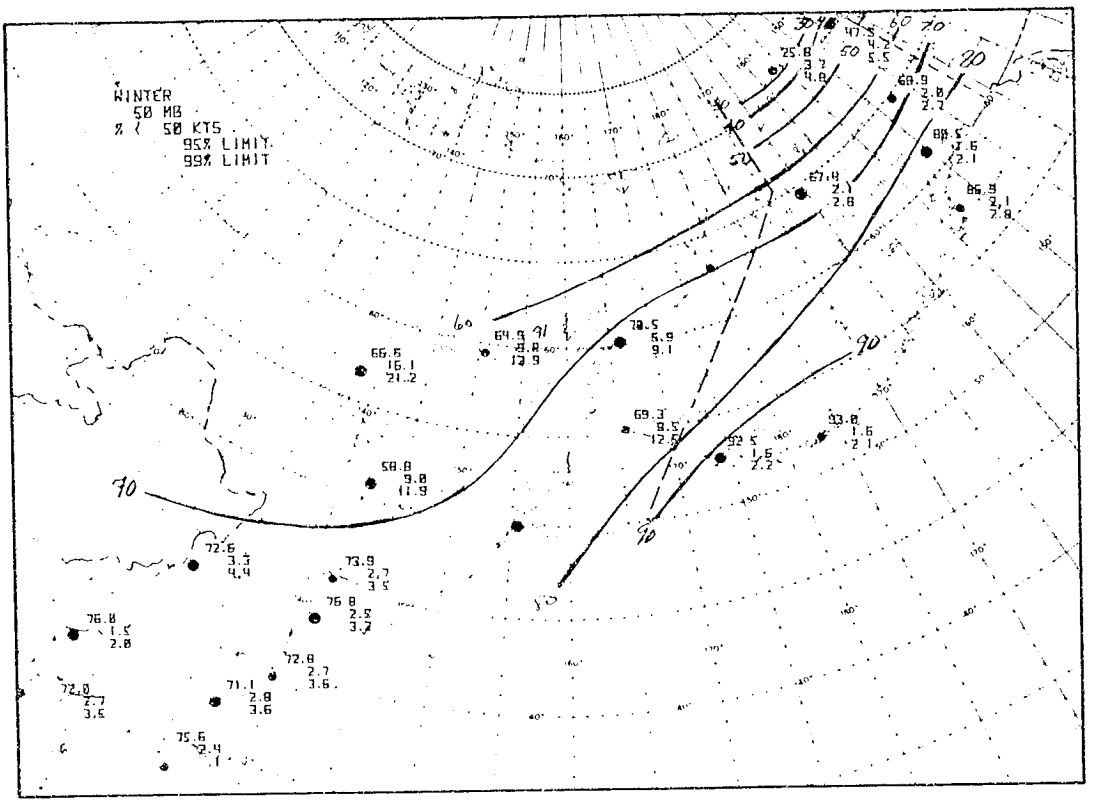
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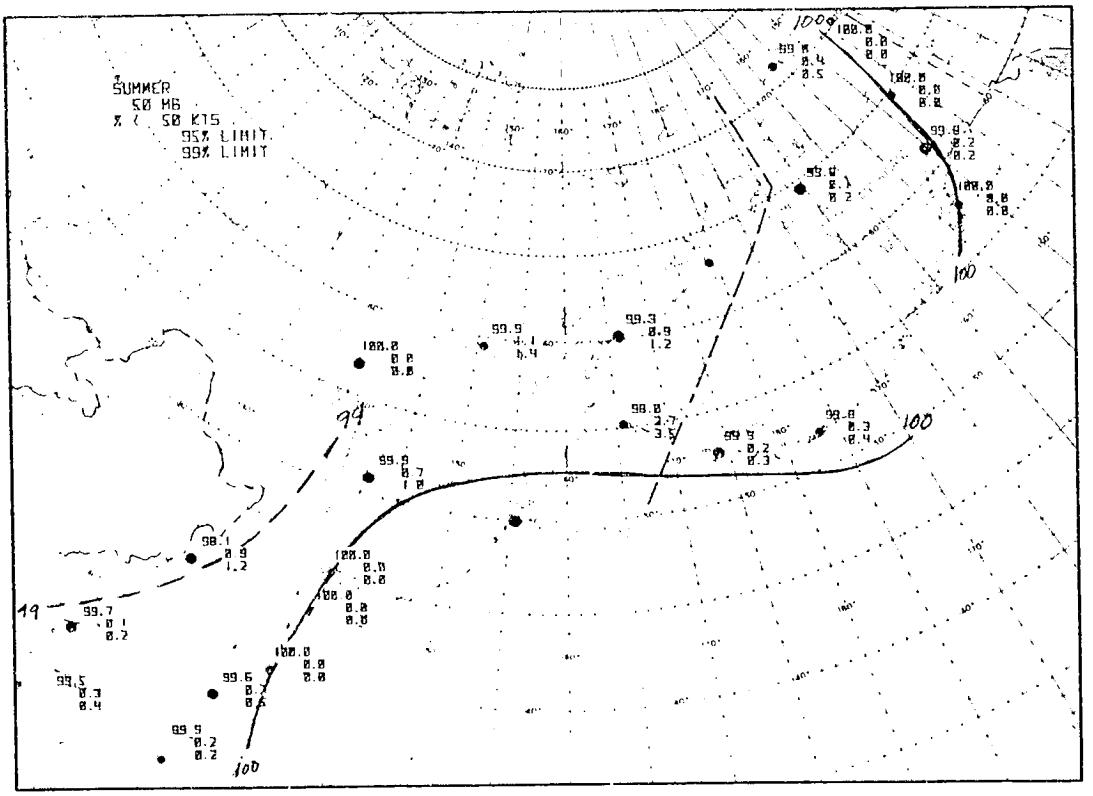
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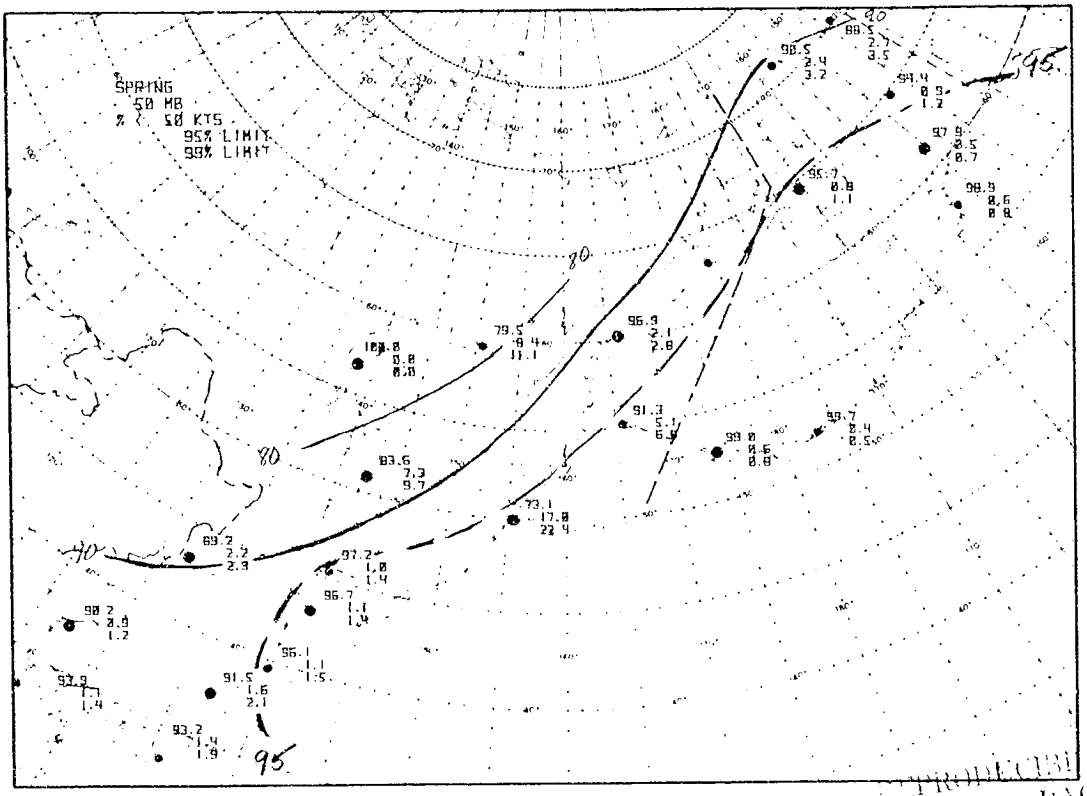

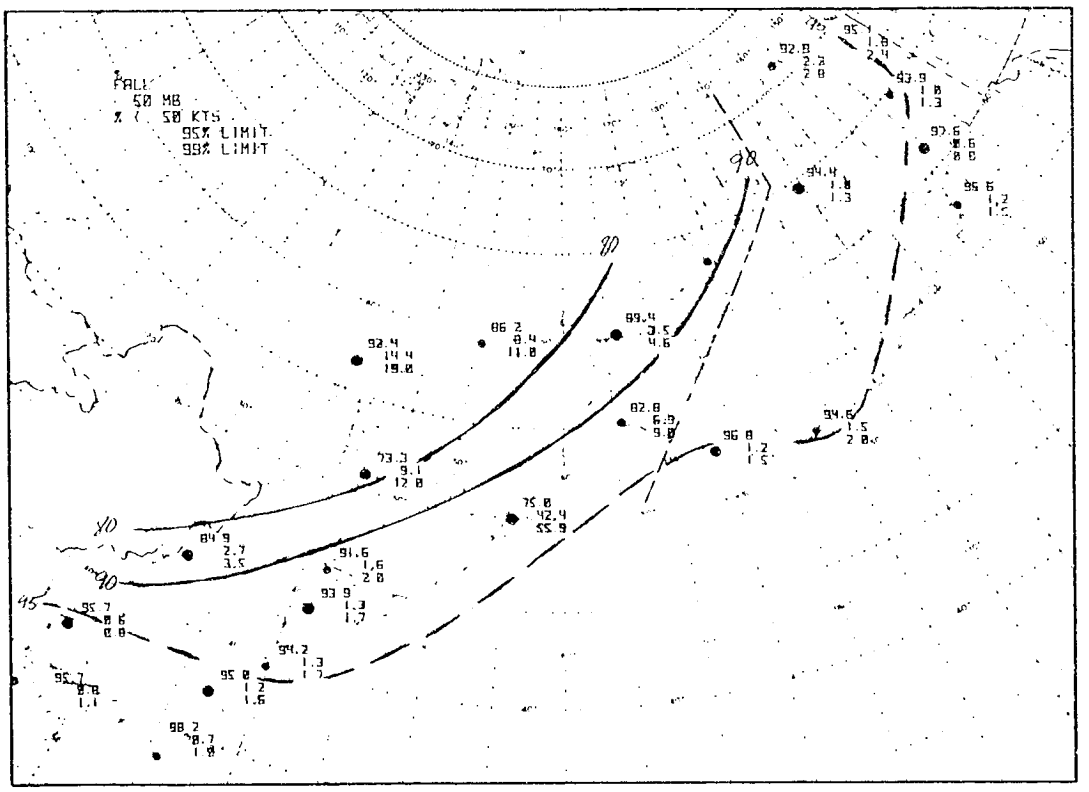

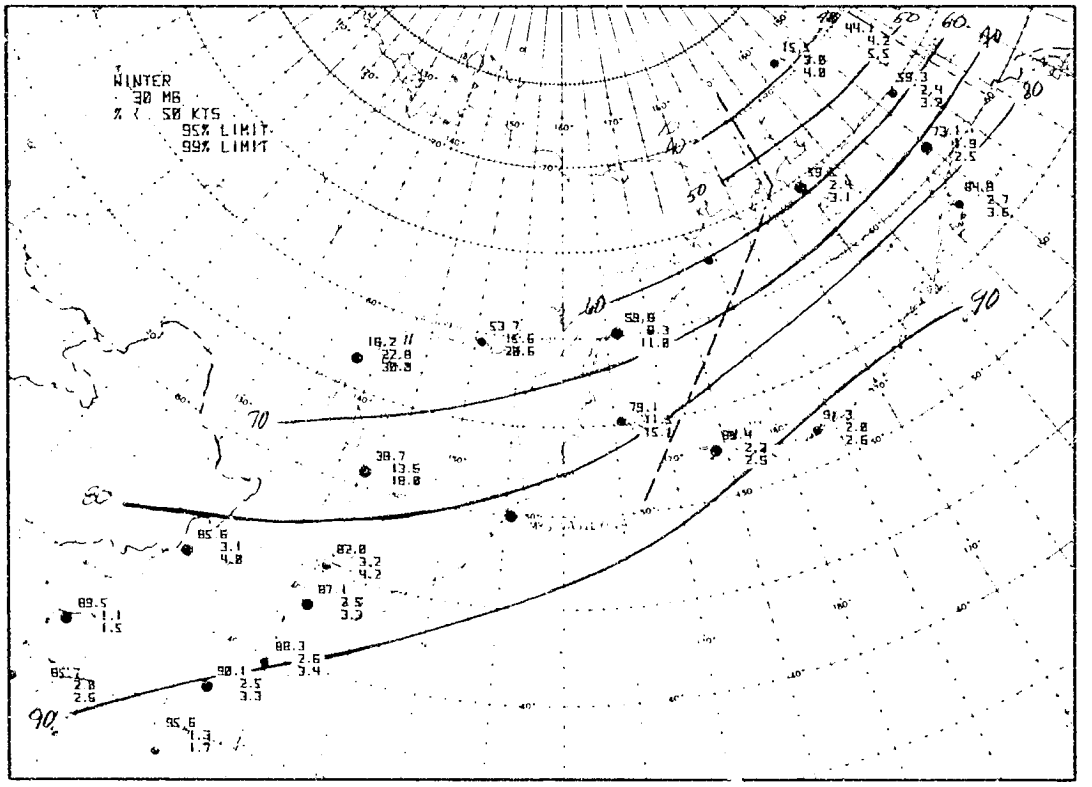
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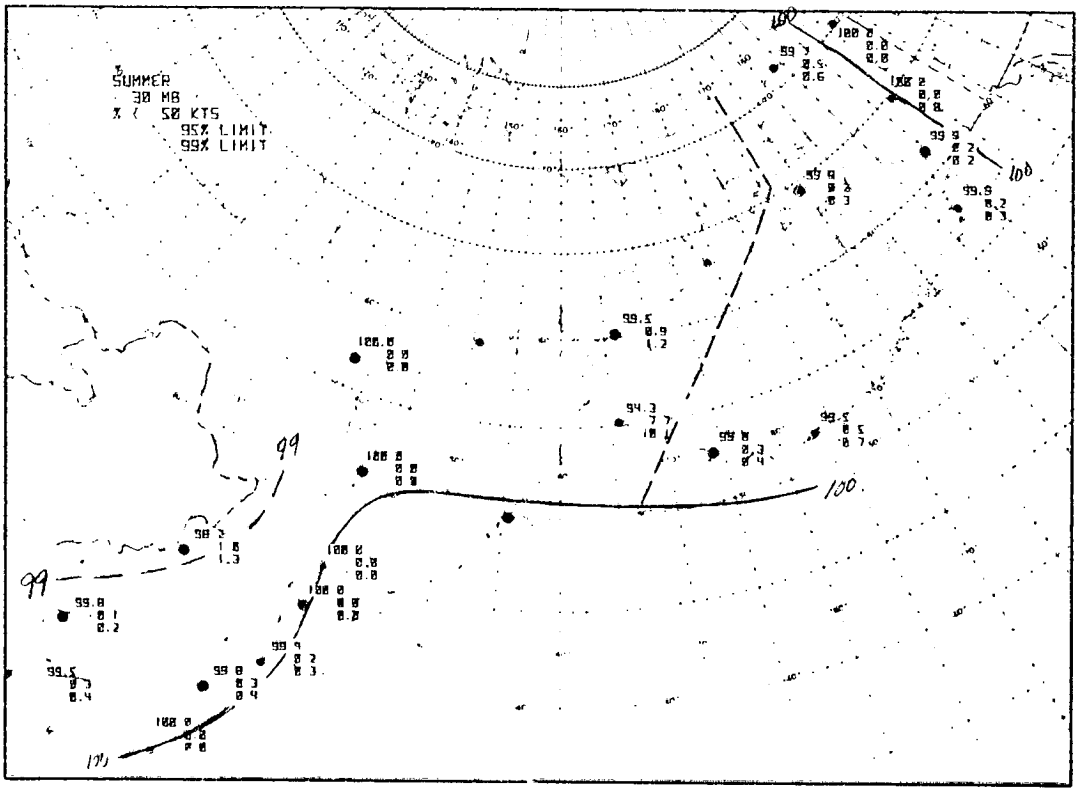
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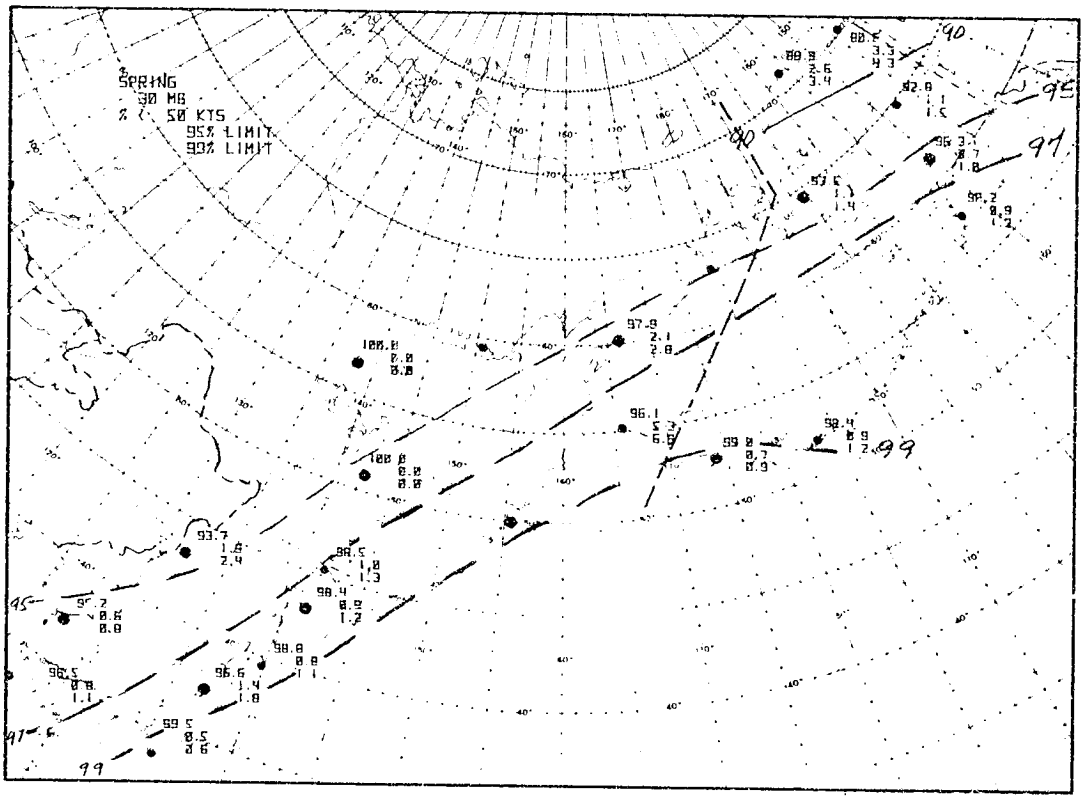
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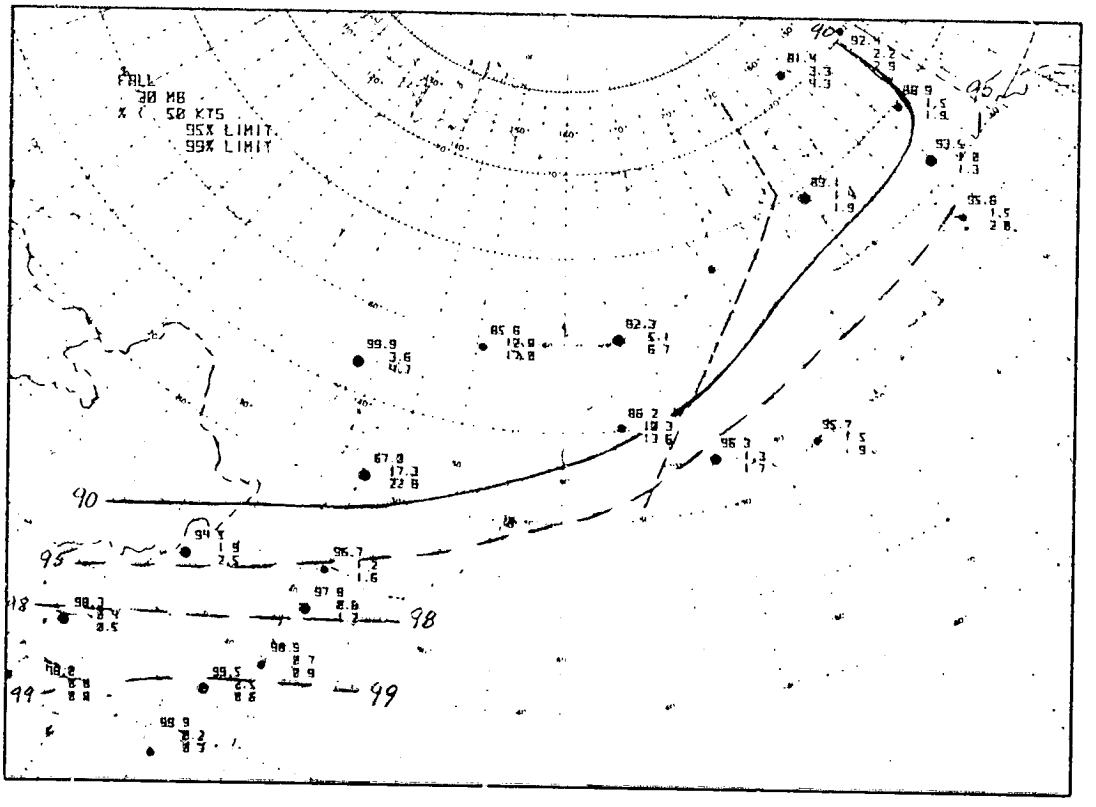
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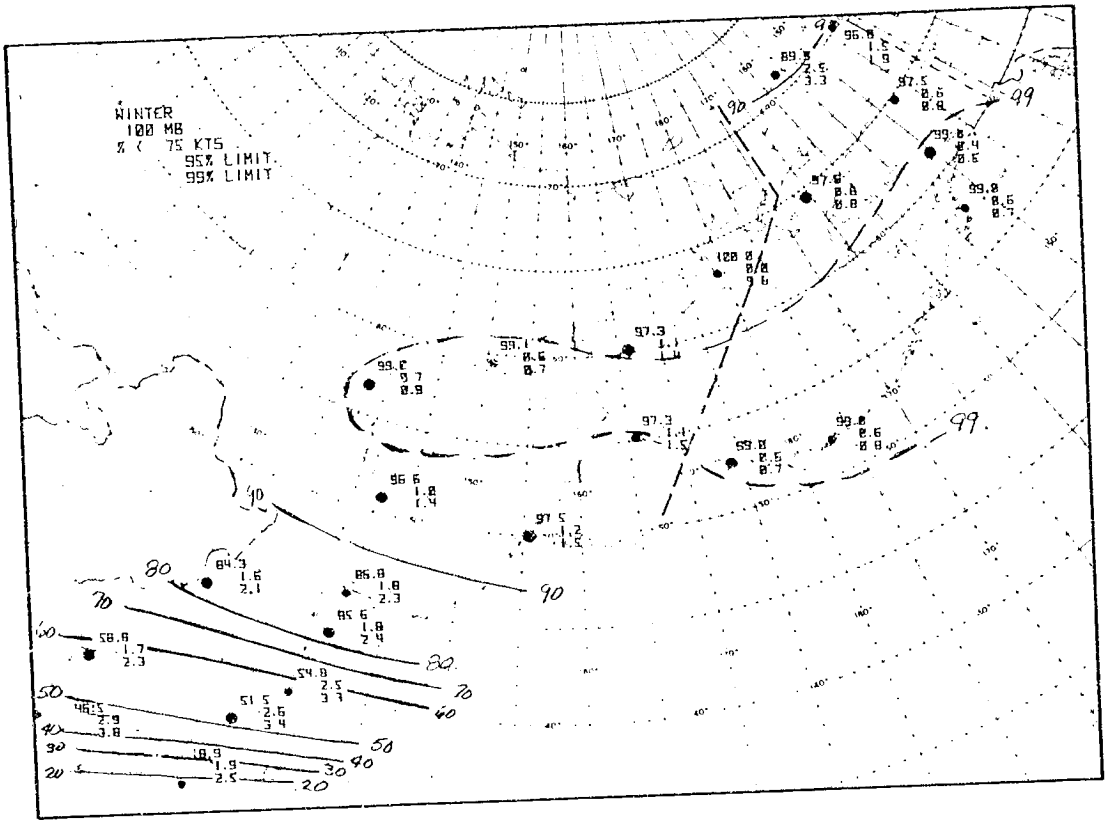
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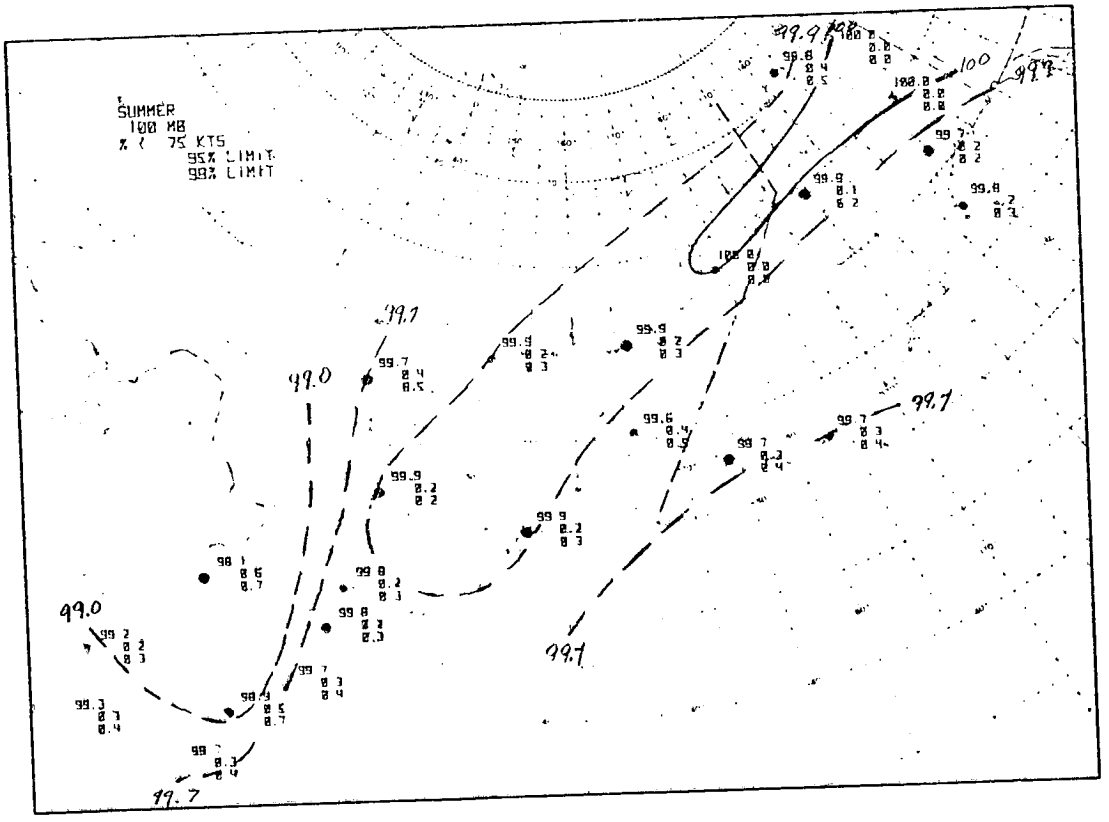
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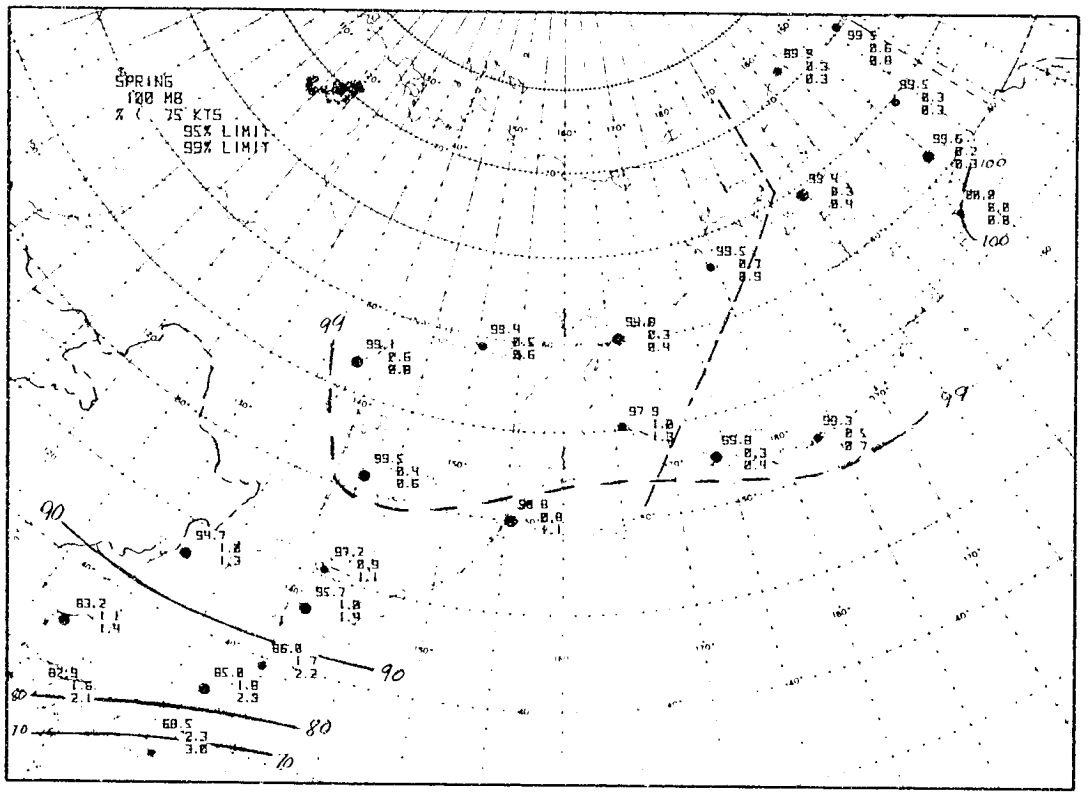
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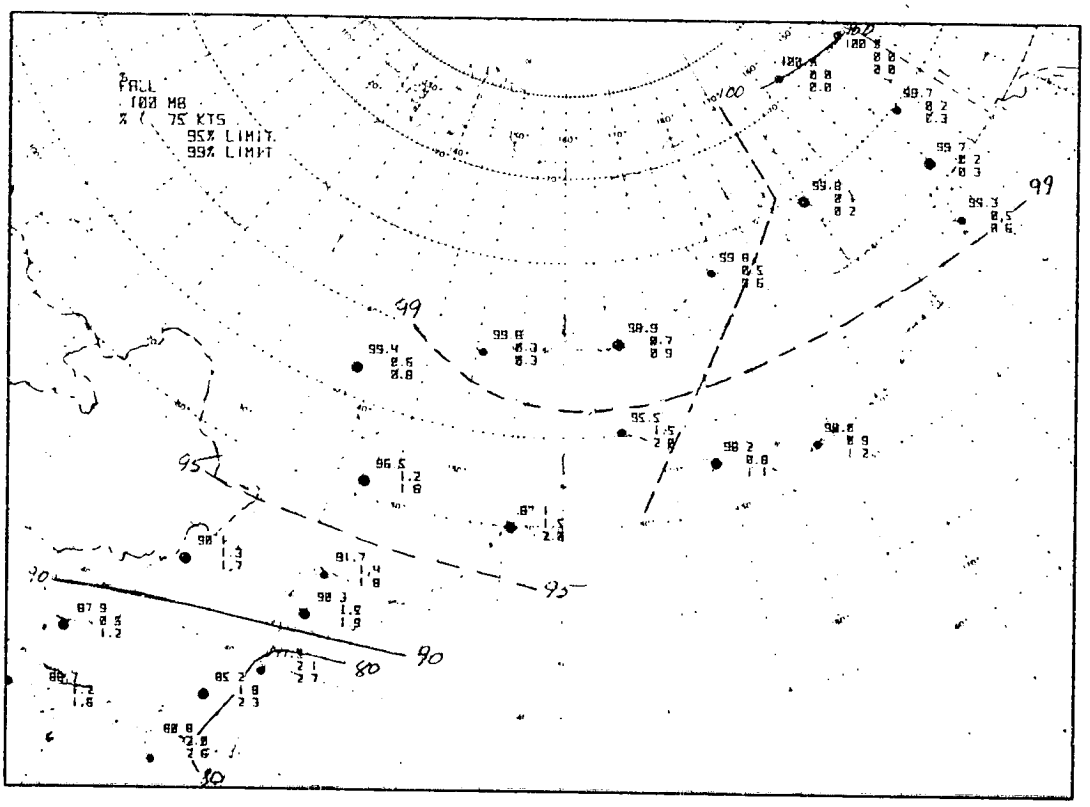
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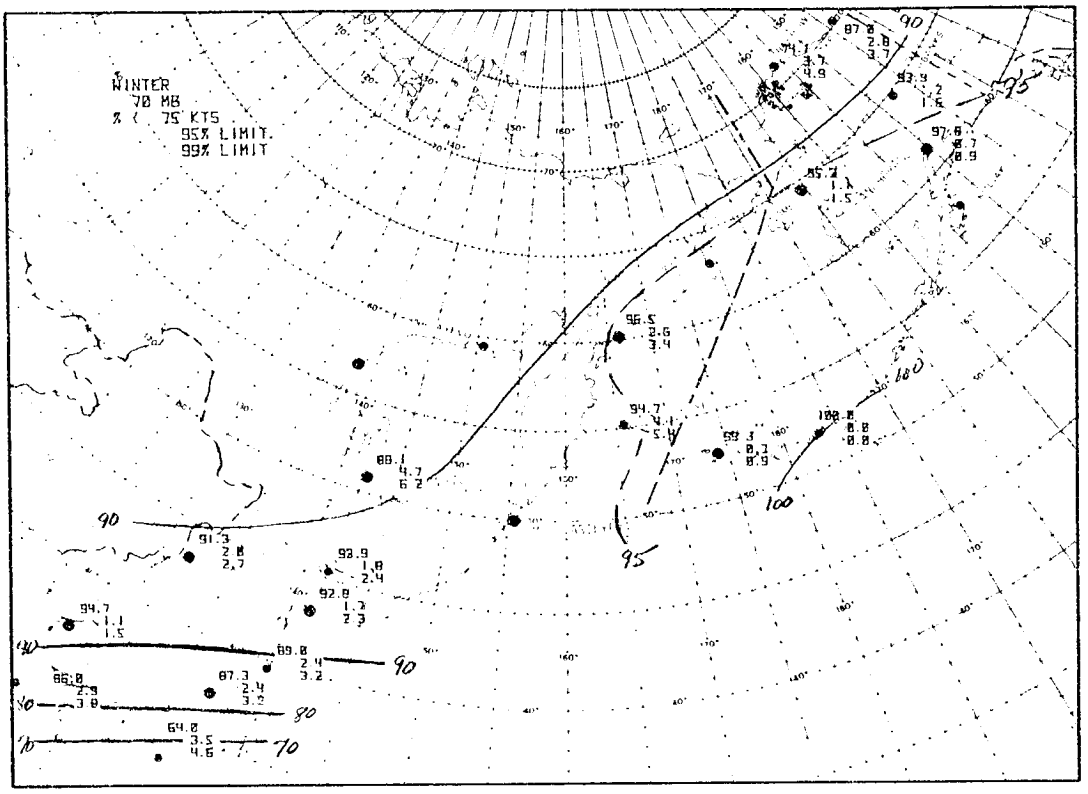
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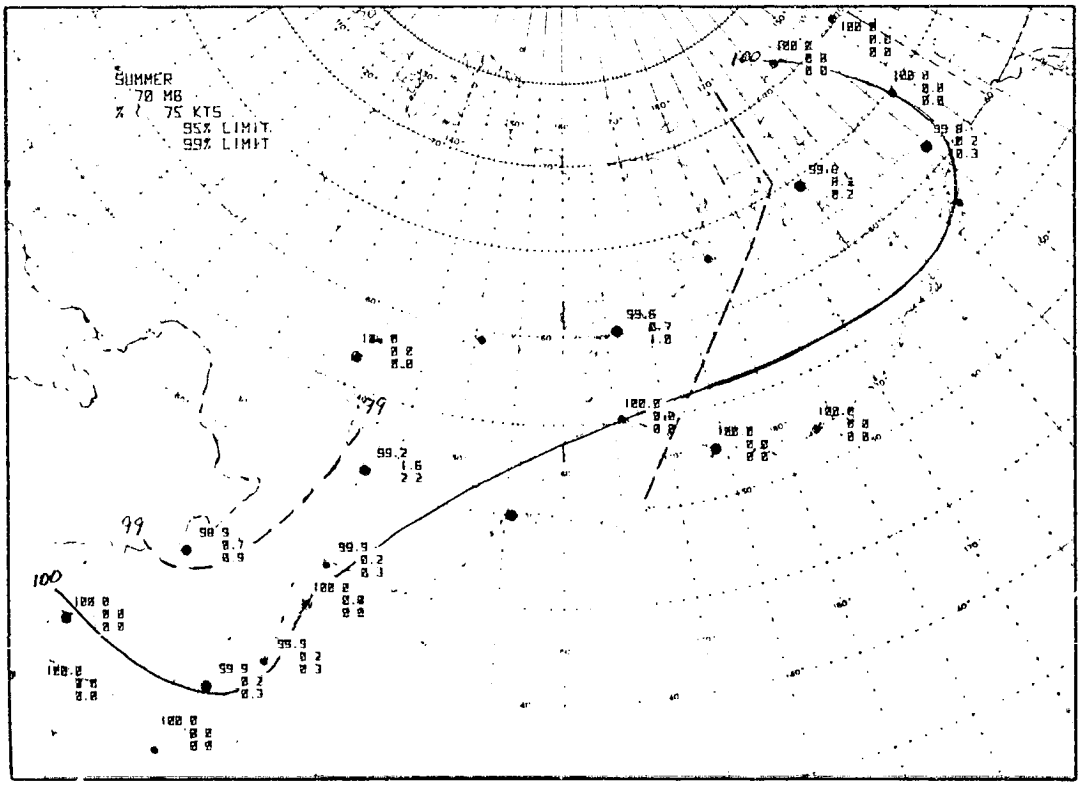
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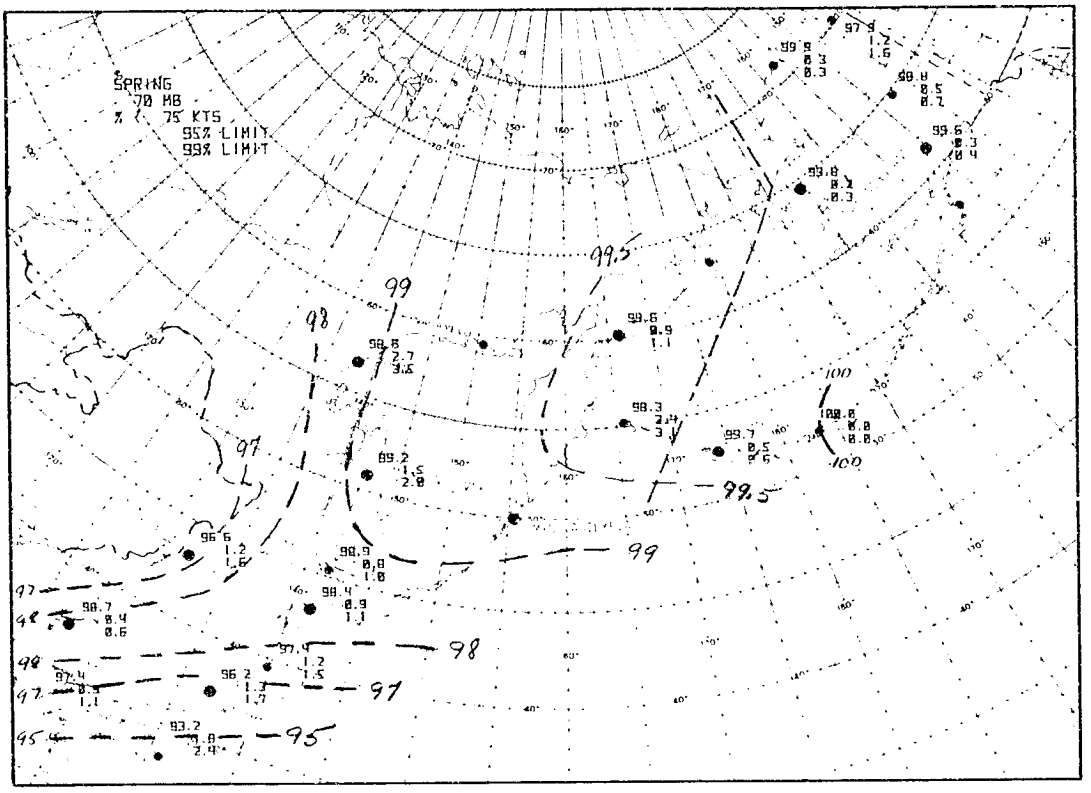
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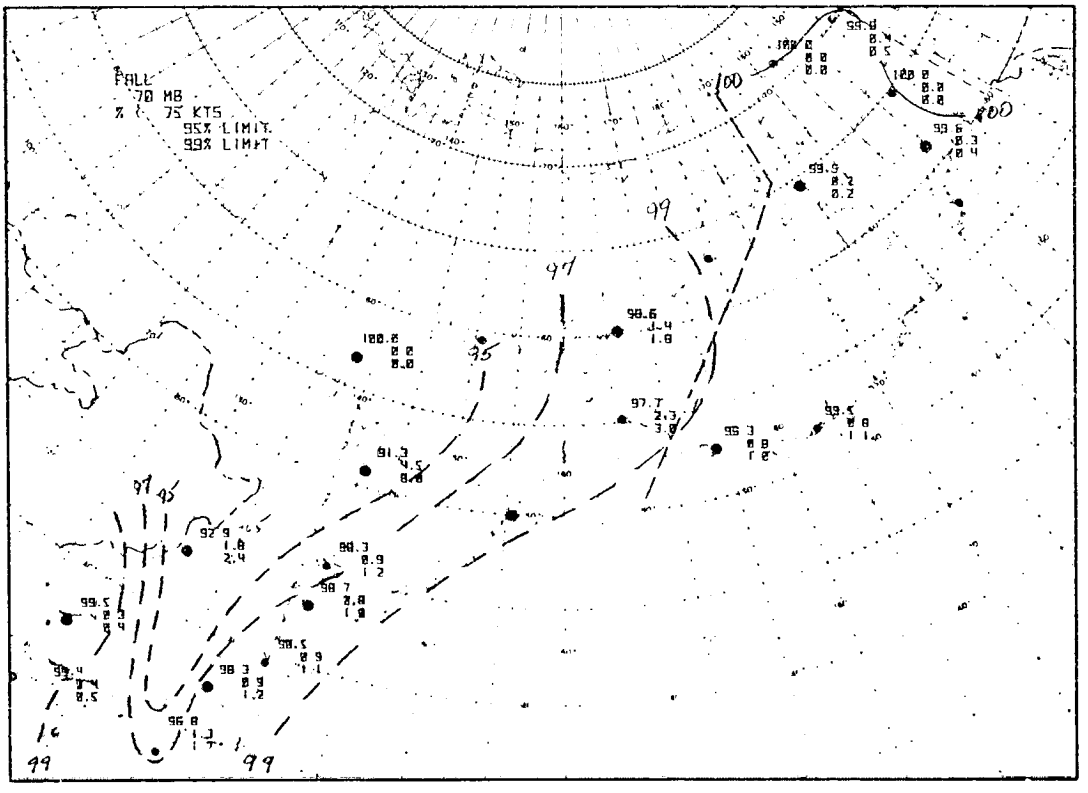
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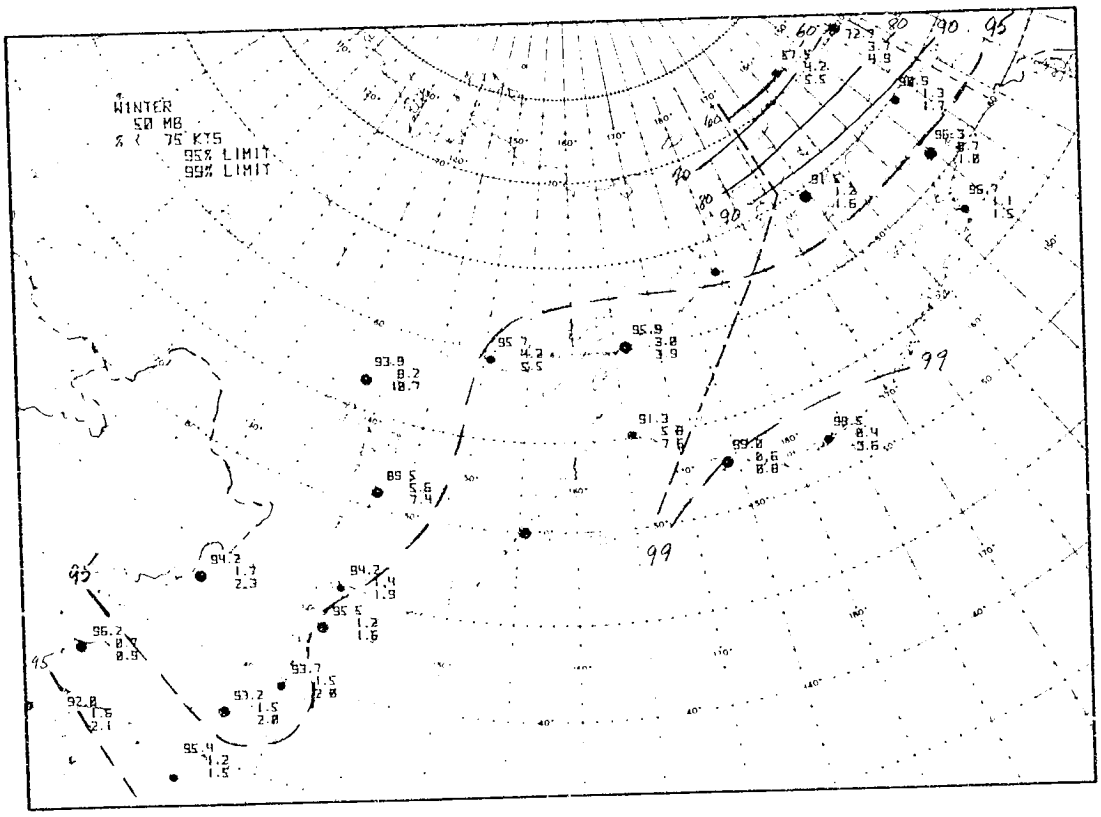
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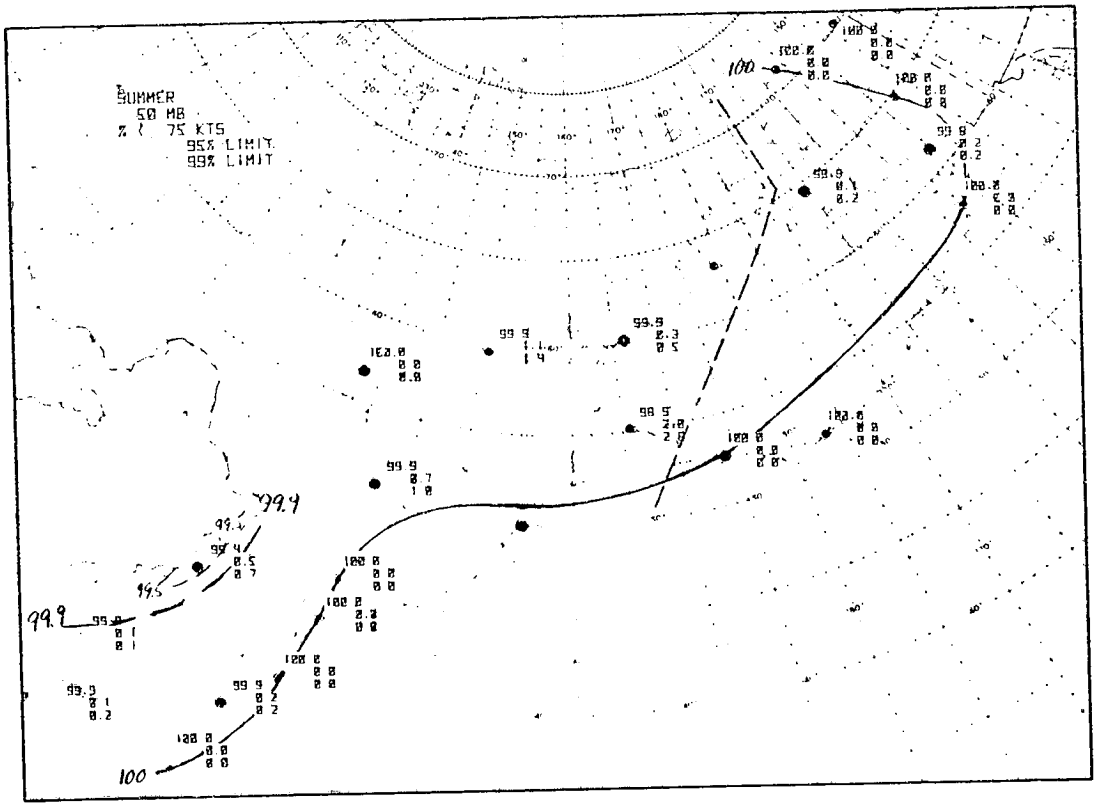
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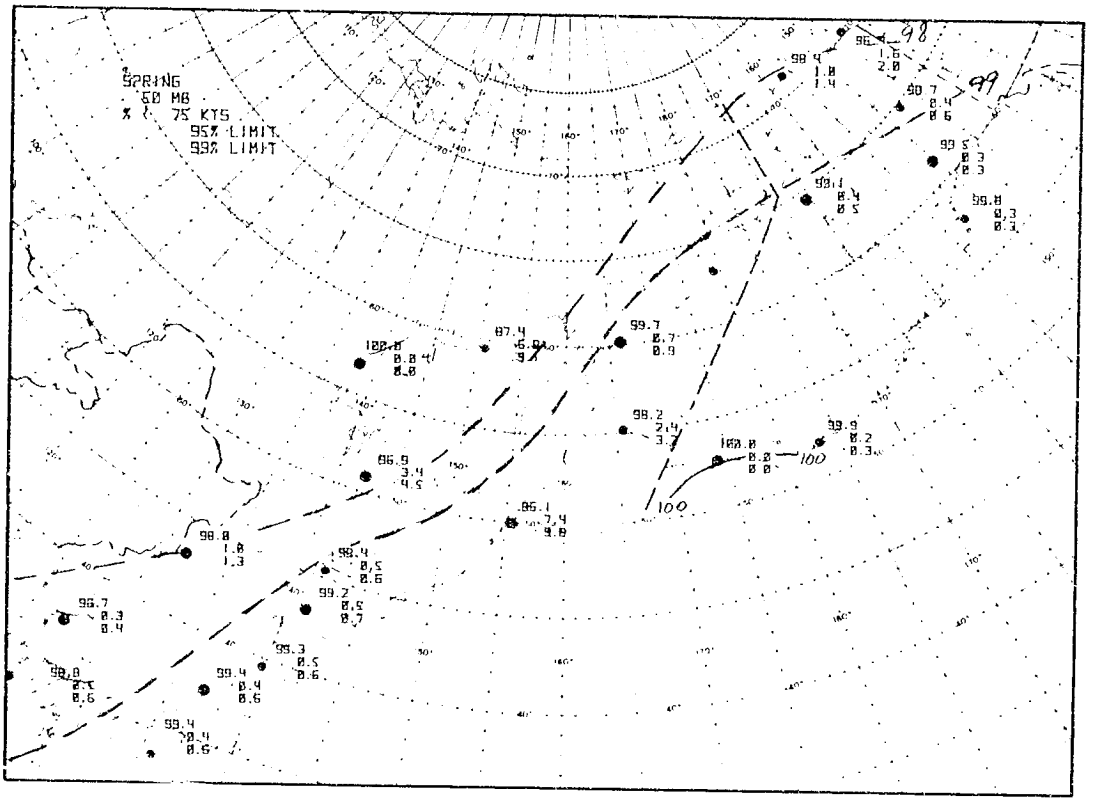
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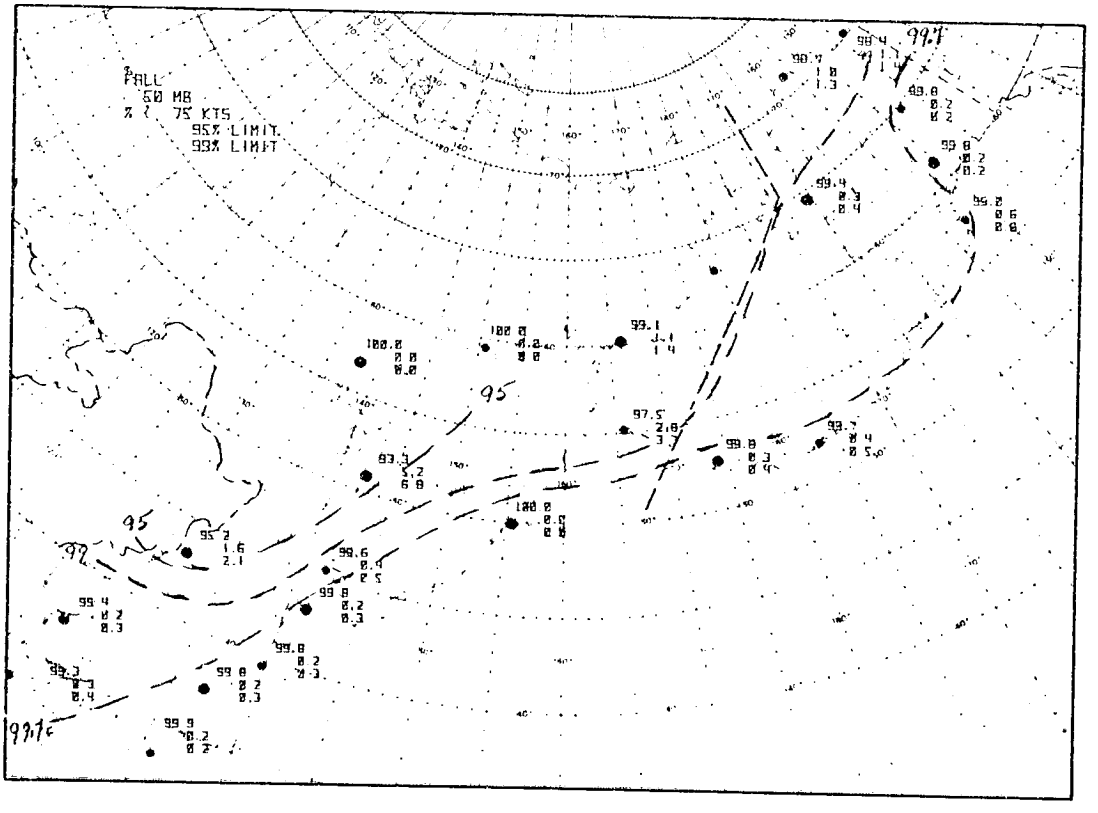
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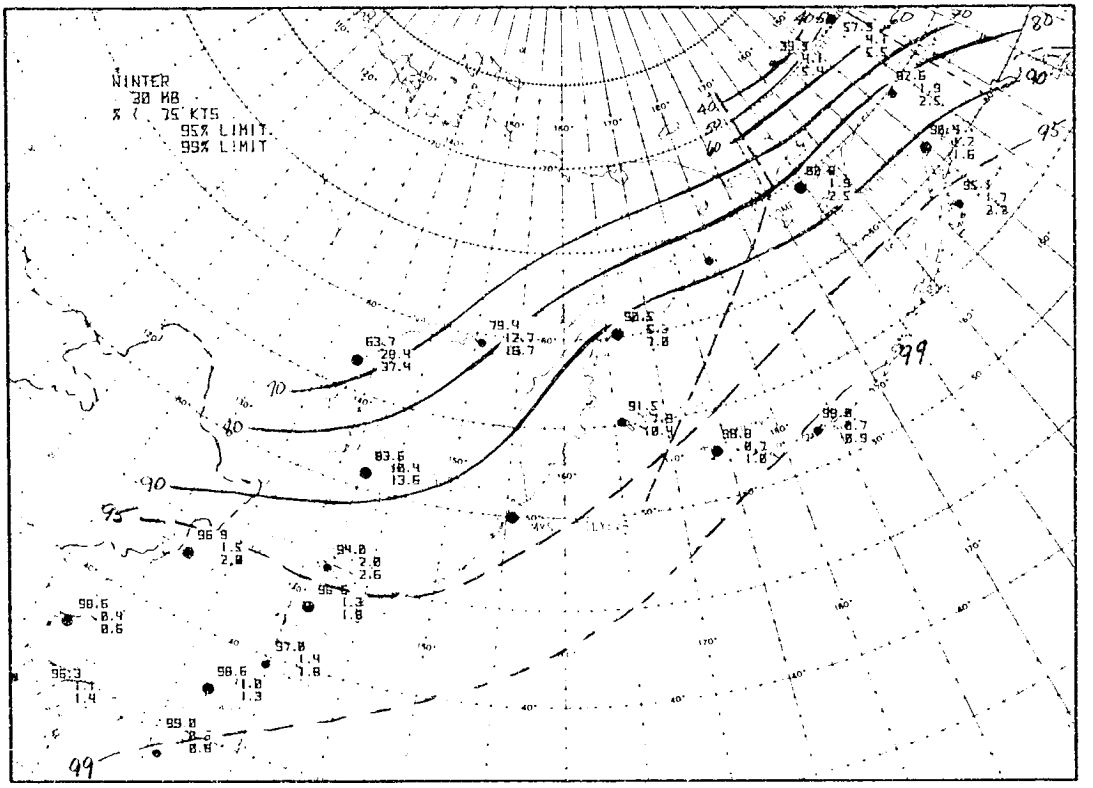
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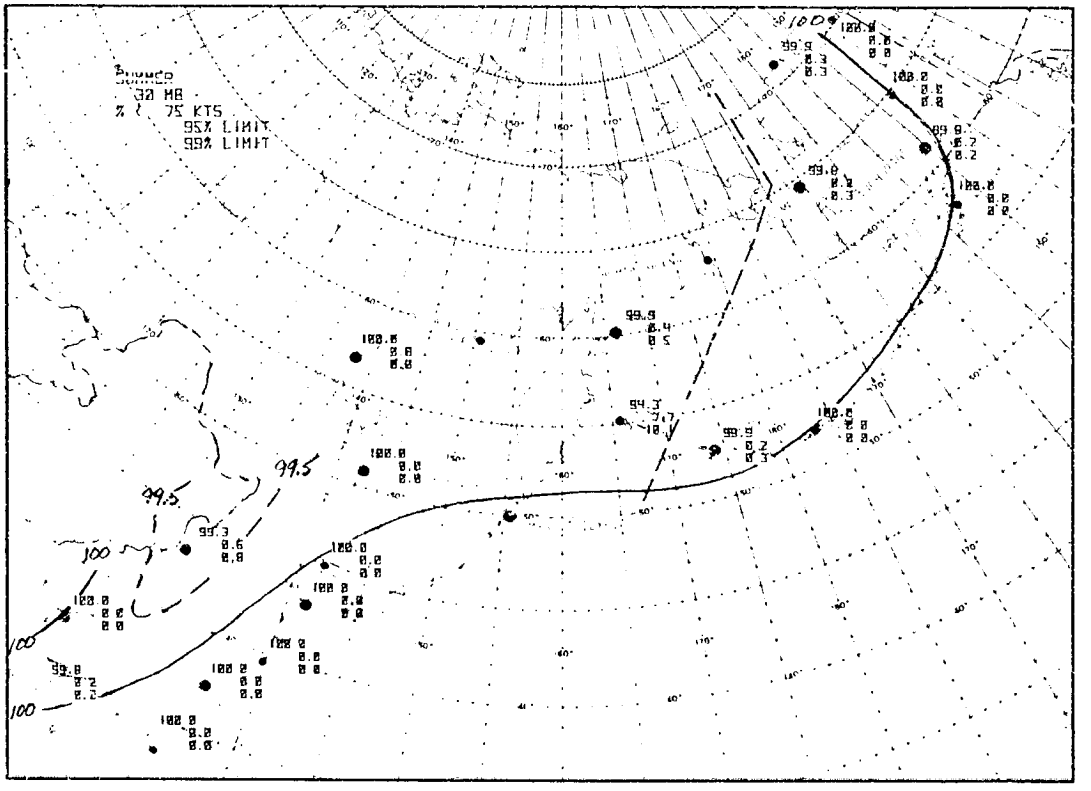
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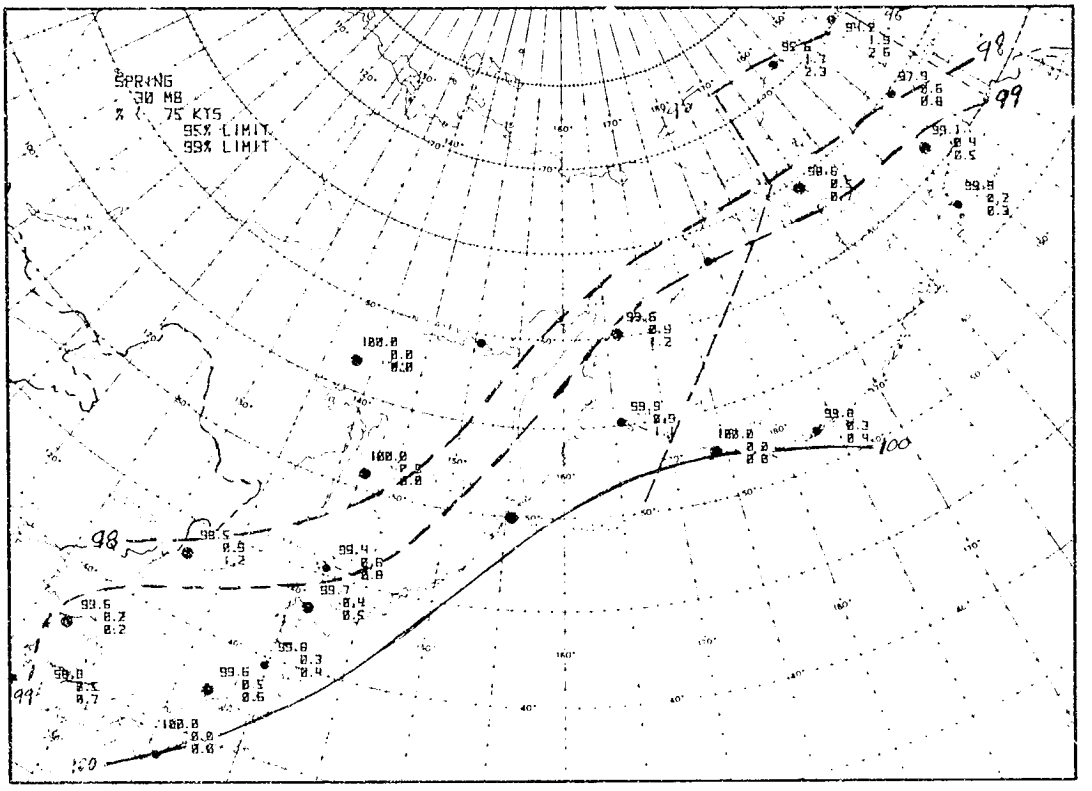
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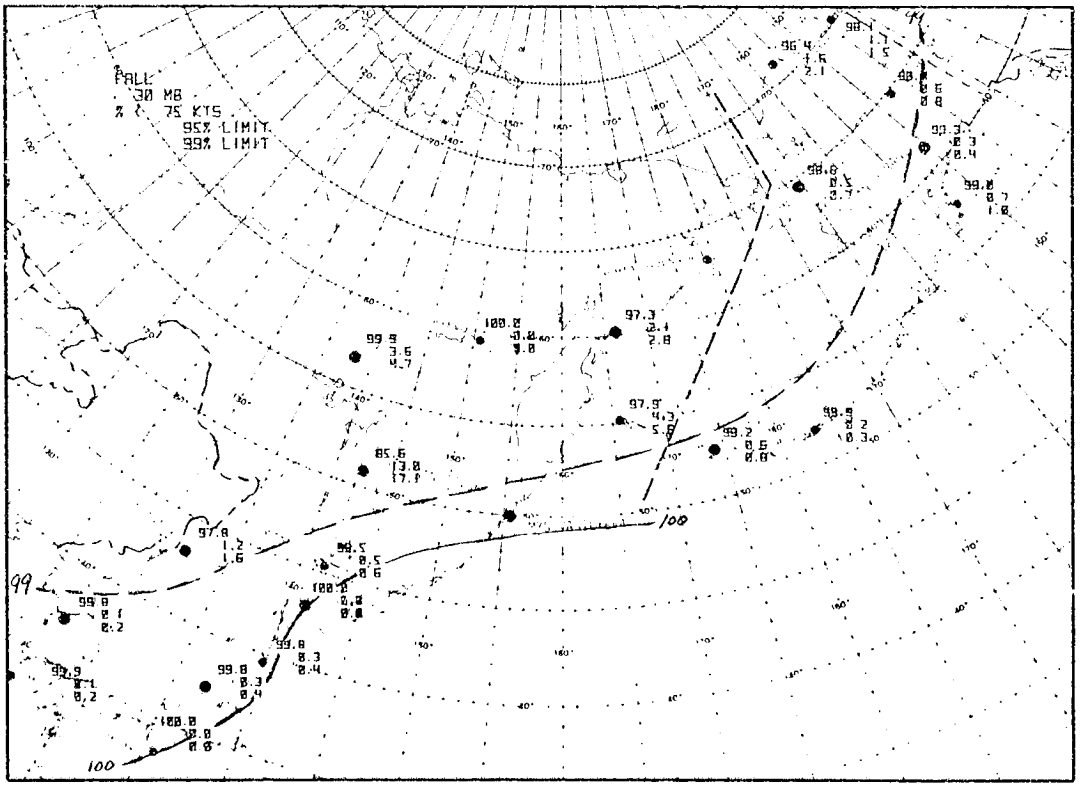
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1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA RP-1044		

4. Title and Subtitle	5. Report Date
WIND STUDY FOR HIGH ALTITUDE PLATFORM DESIGN	December 1979
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Thomas W. Strganac	10. Work Unit No.

9. Performing Organization Name and Address	11. Contract or Grant No.
Wallops Flight Center National Aeronautics and Space Administration Wallops Island, VA 23337	13. Type of Report and Period Covered Reference Publication

12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code
National Aeronautics and Space Administration Washington, DC 20546	

15. Supplementary Notes

16. Abstract

An analysis of upper air winds was performed to define the wind environment at potential operating altitudes for high altitude powered platform concepts. NASA's preliminary high altitude powered platform (HAPP) studies have indicated their feasibility but have also indicated the need for the definition of the potential operating environment for design. Expected wind conditions of the continental United States, Pacific area (Alaska to Sea of Japan), and European area (Norwegian and Mediterranean Sea) were obtained using a representative network of sites selected based upon adequate high altitude sampling, geographic dispersion, and observed upper wind patterns. A data base of twenty plus years of rawinsonde gathered wind information was used in the analysis. Annual variations from surface to 10 mb (approximately 31 km) pressure altitude were investigated to encompass the practical operating range for the platform concepts. Parametric analysis for the United States and foreign areas was performed to provide a basis for vehicle system design trade-offs. This analysis of wind magnitudes indicates the feasibility of annual operation at a majority of sites and more selective seasonal operation for the extreme conditions between the pressure altitudes of 100 to 25 mb based upon the assumed design speeds.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
High altitude powered platform studies High altitude winds High altitude vehicle design	Unclassified - unlimited STAR Category 47

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	288	$11.00

* For sale by the National Technical Information Service, Springfield, Virginia 22161

NASA-Langley, 1979