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DEVELOPMENT OF AN IMPROVED AUTOMATED SYSTEM FOR FORECASTING CLOUD AMOUNT, CEILING HEIGHT, VISIBILITY, AND OBSTRUCTIONS TO VISION IN ALASKA

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1. INTRODUCTION

An automated system for forecasting cloud amount, ceiling height, and visibility for the 26 Alaskan stations listed in column one of Table 1 became operational within the National Weather Service (NWS) in April 1979 (National Weather Service, 1979). Table 2 shows the categories for which cumulative probability equations were developed for all three weather elements. In operations, the probability forecasts are transformed to "best" category forecasts by use of a threshold technique. To develop the original prediction equations, we used the Model Output Statistics (MOS) technique (Glahn and Lowry, 1972) with output from the National Meteorological Center's (NMC's) Primitive Equation (PE) model (Shuman and Hovermale, 1968; National Weather Service, 1977a). On August 13, 1980, the PE model was replaced by the Spectral model (Sela, 1980; National Weather Service, 1980), so the Alaskan cloud amount, ceiling height, and visibility forecasts were then based on the output from this new model.

The conversion to the Spectral model led to a deterioration of the MOS guidance for Alaska. Tests performed for probability of precipitation (Maglaras, 1982) and temperature showed that forecasts from equations based on output from the Limited-area Fine Mesh (LFM) model (Newell and Deaven, 1981; National Weather Service, 1977b) were superior to the operational forecasts based on Spectral model output. We developed an experimental set of LFM-based cloud amount and ceiling height prediction equations for the winter (November-March) season for the 18-h projection from 0000 GMT using three seasons (1977-78 through 1979-80) of developmental data. Regionalized, cumulative category probability equations were developed for the 39 stations listed in Table 1 (see also Fig. 1) for each of the cloud amount and ceiling height categories shown in Table 2 by using the Regression Estimation of Event Probability (REEP) statistical model (Miller, 1964). On independent data (winter 1980-81), we compared the forecasts from the new experimental equations to the forecasts from the old operational equations. Table 3 shows the Brier scores (Brier, 1950) and the Heidke skill scores (Panofsky and Brier, 1965) for the experimental system and the old system. The results of this comparison indicated that forecasts from the LFM-based equations were superior to the operational forecasts from PE-based equations which used Spectral model output. Therefore, in an effort to improve the operational cloud amount, ceiling height, and visibility guidance, we developed new sets of equations from the LFM model output. In addition, we derived equations to forecast the occurrence of obstructions to vision.

New regionalized equations were developed with data from all 39 stations listed in Table 1 for four seasons: winter (November-March), spring (April-May), summer (June-August), and fall (September-October). Equations were derived for each of the cumulative categories shown in Table 4. Some changes were made to the original categories of ceiling and visibility in order to better account for the distribution of the frequency of occurrence of each element. The cloud amount categories were also changed because we presently archive cloud amount observations as opaque sky cover and total sky cover is no longer available.

2. DEVELOPMENT OF THE NEW SYSTEM

A. Potential Predictors

Table 5 shows the potential predictor variables used to develop the new equations for the four different weather elements for all four seasons. These included model output variables valid for 6-, 12-, 18-, 24-, 30-, 36-, 42-, and 48-h projections. The model output variables for the 6- and 12-h projections were unsmoothed; for the 18-, 24-, and 30-h projections, 5-point space-smoothed variables were used; and for the 36-, 42-, and 48-h projections, 9-point space-smoothed predictors were used. The observed predictor variables were from 0300 or 1500 GMT. Table 5 also gives the acronyms by which the various predictors will be referred to in this paper.

The CVRF constant predictors are derived from 12 year station climate records for the specific times of 0000, 0600, 1200, and 1800 GMT. These constants indicate the relative frequency of the combined occurrence of ceiling $\leq$ 1000 feet and visibility $\leq$ 3 miles for each station and time period.

B. Regions

Regionalization is desirable for the prediction of ceiling and visibility because occurrences of the lower categories for both elements are considered rare events in most locations and grouping stations increases the sample size used to develop equations. In the MOS system, stations are grouped into regions if they exhibit similar characteristics of the predictand in response to output from the numerical model. In particular, for each station we determined the observed relative frequency of various categories of the three elements for the 12-h projection after 0000 and 1200 GMT for all cases when the 12-h LFM forecast of MEAN RH was $\geq$ 0, 60, and 90%. The frequencies for each season were determined from developmental samples of: four winter seasons (1977-78 through 1980-81), five spring seasons (1978 through 1982), approximately five summer seasons (1978 through 1981, plus June and July, 1982), and five fall seasons (1977 through 1981). We chose MEAN RH because, from experience, we've found that this variable is generally the most important model predictor for forecasting ceiling, visibility, and cloud amount. Figs. 2, 3, 4, and 5 show the regions determined for the winter, spring, summer, and fall seasons, respectively. These regions were determined by combining stations with similar frequency values of ceiling, visibility, and cloud amount for the MEAN RH predictor. Also, the climatic frequency of each of the three elements for the development sample and geographic boundaries played an important role in determining the regions when it was not clear in which region the station belonged.

Examination of the regions indicates that regional boundaries are not necessarily consistent with geographic boundaries. This is not unusual since the purpose of regionalizing is to group together stations which exhibit similar statistical characteristics based on output from the LFM rather than solely from geographical patterns.

C. Development of the Equations

We combined the data from all stations within a region and developed equations to forecast the probability of occurrence of several categories of cloud amount, ceiling height, visibility, and obstructions to vision. We did this for each season for the 6-, 12-, 18-, 24-, 30-, 36-, 42-, 48-, 54-, and 60-h projections from both 0000 and 1200 GMT using the REEP screening procedure. Except for the winter season, we used the same data samples that were used to develop the regions. For the winter season, an additional partial season of data, November 1981 through January 1982, was used.

In the REEP screening procedure, a subset of effective predictors for use in linear-regression equations is objectively selected from a larger set of potential predictors. The equations developed give estimates of the probabilities of occurrence for a given set of binary-type predictands (categories) as shown in Table 4. The predictands are called binary because in the developmental phase each predictand category was assigned a value of either 1 or 0 in a given case depending on whether or not the observed value of the element fell within that category. The potential predictors were either in binary or continuous form. The use of binary predictors helps to account for possible non-linear relationships between the predictand and predictor. A good description of the REEP screening procedure can be found in Glahn and Lowry (1972).

In order to provide more consistent cloud amount and ceiling height forecasts, and also visibility and obstructions to vision forecasts, the equations for each pair of weather elements were derived simultaneously. With this procedure, all 11 equations for cloud amount and ceiling, and all nine equations for visibility and obstructions to vision, contain the same predictors, but, of course, the individual regression coefficients differ. For each equation, the REEP screening process was continued until a maximum of 20 terms had been selected.

For all four elements and seasons, the equations for the projections of 6 to 48 hours contain surface weather elements observed at 0300 or 1500 GMT as predictors. In addition to these "primary" sets of equations, we also developed "backup" equations which don't include observed predictors.

Tables 6 and 7 list the 20 most important predictors as given by the REEP screening procedure for the 6-, 12-, 24-, 36-, and 48-h projections from 0000 GMT for the cloud amount and ceiling height, and for the visibility and obstructions to vision equations, respectively, for the winter season. These rankings were determined by both frequency and order of selection; for this purpose, all projections, smoothings, and binary limits were combined for each type of variable. The numbers in parentheses are the total points accumulated by the predictor for that projection and was used to determine the order of the ranking. Table 6 shows that in the shorter range projections the OBS CIG and OBS CLDS are by far the most important predictors used to predict cloud amount and ceiling, and all other predictors are of minor importance. As the time of the projection increases, the observed predictors become less important and are replaced by the MEAN RH, CVRF, 850 T-DP, STA LONG, 850 VV, and P AMT as the main predictors. Table 7 shows that for the shorter range projections OBS VIS and OBS OBSTVIS are by far the most important predictors used to predict visibility and obstructions to vision. Also of importance is OBS CIG. As the time of the projection increases, the observed predictors are replaced as the main predictors by the MEAN and BL RH, CVRF, and P AMT.

Table 8 shows the winter season, 0000 GMT cycle, 12-h cumulative reductions of variance and equation coefficients for three categories of cloud amount for region 7 (see Fig. 2). Here, the 12-h LFM MEAN RH forecast was the first term selected by the regression procedure. This predictor reduced the variance by 39%, 40%, and 36% for the clear, scattered, and broken categories, respectively. The equation for the overcast category is not shown because it is never needed since the categories are cumulative. Other predictors chosen included OBS CIG and OBS CLDS from the surface observation taken at 0300 GMT, several variables from the LFM model, and CVRF and STA LAT. LFM variables with valid times during and after the predictand valid time appear in these equations. The predictors are in both continuous and binary form. A binary predictor, such as the MEAN RH, is given a value of 1 if it is less than or equal to a particular threshold value (e.g., 50%); otherwise, the value of the predictor is set to 0.

D. Threshold Probabilities

In order to convert probability forecasts to categorical forecasts for each element, we use the threshold probability technique to obtain the "best" category. For cloud amount, ceiling height, visibility, and obstructions to vision forecasting in Alaska, this procedure is used to compare the cumulative probability forecast to the critical threshold value which has been established. A set of threshold probability values was determined for each element and category for each region, season, forecast cycle and projection for both the primary and backup equations.

The threshold probability values were determined by using the beta classification model (Miller and Best, 1981). The many possible combinations of the predictors in each equation produce a range of probability values that can be forecast for each category of each weather element. These values can be grouped according to the occurrence or non-occurrence of that category (event) and examined through the use of frequency distribution plots. An example of such a frequency distribution is shown in Fig. 6. The area under the solid curve, X, is the probability distribution of the occurrence of a particular event and the area under the dashed curve, Y, is the probability distribution of the non-occurrence of the same event. From these curves, a threshold probability value to forecast this category is usually chosen somewhere inside the probability range where the two curves overlap (P_1 to P_3).

The exact value of the threshold probability may be related to desired characteristics of the categorical forecasts. For example, a threshold probability equal to P_3 means that every time the event is forecast, it will occur; however, many times the event will occur even though it was not forecast (underforecasting). Conversely, with a threshold probability equal to P_1, every time the event is forecast, it will occur; however, it will be forecast many times when it does not occur (overforecasting). The beta model can be used to group the dependent data sample into curves similar to those shown in Fig. 6 and select a threshold value for each category and element. For forecasting cloud amount, ceiling height, visibility, and obstructions to vision in Alaska, we applied the beta model in such a manner that the threshold probability values produced categorical forecasts with a unit bias.[1]

For the contingency table included in Fig. 6, a unit bias is achieved when C=D. The positions in the contingency table labeled A, B, C, and D have their corresponding areas under the curves X and Y labeled A, B, C, and D respectively. The total area of A also includes D, and the total area of B also includes that part of C below the curve X. To achieve a unit bias for the example given in Fig. 6, the beta model would be used to choose a threshold probability value equal to P_2 in order to insure that the areas C and D were equal.

3. SUMMARY

A system for forecasting cloud amount, ceiling height, and visibility became operational within the National Weather Service in April 1979. That system was developed with the MOS technique and output from the PE model. In an effort to improve these forecasts, and also to make forecasts of obstructions to vision, we developed new sets of equations to predict all four weather elements. This new system is based on LFM model output.

We derived the equation sets for cloud amount and ceiling height, and for visibility and obstructions to vision, simultaneously in order to produce more consistent forecasts between each pair of elements. Separate sets of equations were derived for both forecast cycles (0000 and 1200 GMT) for the winter, spring, summer, and fall seasons. Probability threshold values used to convert the probability forecasts to categorical forecasts were derived with the beta classification model.

These new equations were implemented operationally in September of 1982. Cloud amount forecasts based on the new equations are being disseminated as guidance to NWS forecasters in Alaska via the FMAK1 teletype bulletin (National Weather Service, 1983). Forecasts for all four weather elements are being disseminated as guidance to United States Air Force forecasters via the FXUS teletype bulletin. Although the development was for cumulative categories, exclusive categories are forecast operationally.

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[1]Bias is the ratio of the number of forecasts of an event to the number of observations of that event. A unit bias is achieved when this ratio is equal to one.

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Table 1. Developmental data stations used in the operational and the new systems (see Fig. 1).

Stations used by the old and new systems		Additional stations used by only the new system	
Anchorage	ANC	Bettles	BTT
Anchorage Elmendorf	PAED	Cordova	CDV
Annette Island	ANN	Dillingham	DLG
Barrow	BRW	Gulkana	GKN
Barter Island	BTI	Homer	HOM
Bethel	BET	Kenai	ENA
Big Delta	BIG	Northway	ORT
Cape Lisburne	PALU	Petersburg	PSG
Cape Newenham	PAEH	Sitka	SIT
Cape Romanzof	PACZ	Skagway	SGY
Cold Bay	CDB	Talkeetna	TKA
Fairbanks	FAI	Tanana	TAL
Fairbanks Eielson	PAEI	Valdez	VDZ
Galena	PAGA		
Indian Mountain	PAIM		
Juneau	JNU		
King Salmon	AKN		
Kodiak Island	ADQ		
Kotzebue	OTZ		
McGrath	MCG		
Nome	OME		
Sparrevohn	PASV		
St. Paul Island	SNP		
Tatalina	PATL		
Tin City	PATC		
Yakutat	YAK		

Table 2. Definitions of cumulative categories used for the development of prediction equations for the old operational system. The scattered category of cloud amount also includes thin scattered, thin broken, and thin overcast.

Category	Ceiling Height (ft)	Visibility (mi)	Cloud Amount (total sky cover)
1	<200	<1/2	clear
2	200-400	1/2-7/8	scattered
3	500-900	1-2 1/2	broken
4	1000-2900	3-4	overcast, obscured
5	3000-7500	5-6	
6	>7500	>6	

Table 3. Brier-scores and Heidke skill scores for the old operational and the new experimental winter season cloud amount and ceiling forecasts for the 18-h projection from 0000 GMT. The sample consisted of independent data combined from 25 stations (all stations in column 1 of Table 1 except Big Delta) for the 1980-81 winter season.

Forecast Element	Type of Forecast	Brier Score	Improvement over Operational (%)	Heidke Skill Score	Improvement over Operational (%)	Number of Cases
Cloud Amt	Operational	.561	--	.365	--	2986
	Experimental	.540	3.74	.366	0.27	
Ceiling Hgt	Operational	.539	--	.329	--	3110
	Experimental	.526	2.41	.356	8.21	

Table 4. Definitions of categories used for the development of prediction equations for ceiling, visibility, cloud amount, and obstructions to vision for the new system. The blowing category of obstructions to vision includes blowing snow, dust, sand, and sea spray. The fog category also includes ice fog and ground fog.

Category	Ceiling (ft)	Visibility (mi)	Cloud Amount (opaque sky cover in tenths)	Obstructions to vision (caused by)
1	<400	<7/8	0-1	None
2	500-700	1/2-2 3/4	2-5	Smoke, Haze
3	800-900	3-4	6-9	Blowing
4	1000-2000	5-6	10	Fog
5	2100-3000	>6		
6	3100-3900			
7	4000-7500			
8	>7500			

Table 5. Potential predictors included in the development of the cloud amount, ceiling height, visibility, and obstructions to vision equations for all seasons.

Definition	Acronym	Levels
	a. Model Output Predictors	
Temperature	T	500 mb, 700 mb, 850 mb, 1000 mb
West wind component	U	200 mb, 500 mb, 700 mb, 850 mb, BL
South wind component	V	200 mb, 500 mb, 700 mb, 850 mb, BL
Wind speed	WNSPD	500 mb, 700 mb, 850 mb, BL
Mean relative humidity	MEAN RH	SFC-500 mb
Boundary layer relative humidity	BL RH	--
Constant pressure height	HGT	500 mb, 700 mb, 850 mb, 1000 mb
Vertical velocity	VV	500 mb, 700 mb, 850 mb, BL
Precipitable water	P WATER	SFC-500 mb
Precipitation amount	P AMT	--
Boundary layer potential temp.	BL POT T	--
Dew point	DP	500 mb, 700 mb, 850 mb, 1000 mb
	b. Model Output Derived Predictors	
Temperature-dew point depression	T-DP	500 mb, 700 mb, 850 mb
Temperature advection	T ADV	500 mb, 850 mb
Vorticity advection	ADVVOR	500 mb
Geostrophic vorticity advection	VORADV	500 mb
Geostrophic west wind component	GEO U	500 mb
Geostrophic south wind component	GEO V	500 mb
Geostrophic wind speed	GEO S	500 mb
Relative vorticity	R VOR	500 mb, 700 mb, 850 mb, BL
Wind divergence	WD DV	500 mb, BL
Moisture convergence	MCONV	850 mb, BL
K Index	K INDEX	
G Index	G INDEX	
Total-totals Index	TT INDEX	
	c. Observed and Geoclimatic Predictors	
Observed weather	OBS W	
Observed ceiling	OBS CIG	
Observed visibility	OBS VIS	
Observed obstruction to vision	OBS OBSTVIS	
Observed opaque sky cover	OBS CLDS	
Observed west wind component	OBS U	
Observed south wind component	OBS V	
Observed temperature	OBS T	
Observed dew point	OBS TD	
Sine of the day of the year	SIN DOY	
Cosine of the day of the year	COS DOY	
Station latitude	STA LAT	
Station longitude	STA LONG	
Station elevation	STA ELEV	
Ceiling and visibility climatic freq.	CVRF	

Table 6. The 20 most important predictors ranked according to the number of times they were chosen and by their position in the cloud amount and ceiling height forecast equations for the 0000 GMT winter season development. The values in parentheses indicate the number of points accumulated by the predictor with this ranking system.

Rank	Projection 6-h		12-h		24-h		36-h		48-h	
1	OBS CIG	(1157)	OBS CIG	(673)	MEAN RH	(264)	MEAN RH	(280)	MEAN RH	(165)
2	OBS CLDS	(617)	OBS CLDS	(367)	OBS CIG	(197)	CVRF	(124)	850 T-TD	(137)
3	MEAN RH	(98)	MEAN RH	(316)	OBS CLDS	(162)	850 VV	(122)	STA LONG	(131)
4	OBS OBSTVIS	(46)	P WATER	(74)	P AMT	(160)	OBS CLDS	(120)	CVRF	(128)
5	OBS T-TD	(35)	P AMT	(65)	STA LONG	(119)	OBS CIG	(100)	500 GEO V	(113)
6	CVRF	(26)	CVRF	(57)	700 T-DP	(99)	STA LAT	(97)	700 V	(107)
7	OBS W	(25)	BL MCONV	(55)	STA ELEV	(89)	STA LONG	(96)	1000 HGT	(98)
8	BL MCONV	(21)	700 T-DP	(55)	CVRF	(79)	STA ELEV	(88)	STA ELEV	(85)
9	P AMT	(16)	OBS TD	(45)	850 VV	(59)	K INDEX	(83)	OBS CLDS	(73)
10	BL WD DV	(15)	STA LONG	(43)	850 T-DP	(59)	500 U	(77)	SIN DOY	(64)
11	500 T-DP	(12)	850 VV	(41)	500 T-DP	(59)	850 T-DP	(74)	STA LAT	(61)
12	500 DP	(11)	STA ELEV	(38)	500 V	(56)	500 T	(67)	K INDEX	(59)
13	STA LAT	(10)	700 VV	(34)	STA LAT	(54)	P AMT	(60)	OBS T-TD	(53)
14	850 U	(9)	850 R VOR	(31)	K INDEX	(52)	850 HGT	(60)	OBS CIG	(53)
15	200 V	(8)	BL R VOR	(26)	OBS T-TD	(48)	BL RH	(57)	500 U	(51)
16	BL U	(7)	BL U	(25)	G INDEX	(46)	700 V	(56)	850 VV	(47)
17	1000 DP	(7)	850 T	(21)	700 V	(45)	1000 HGT	(40)	1000 DP	(47)
18	BL RH	(6)	1000 T	(21)	TT INDEX	(39)	500 V	(40)	700 VV	(46)
19	STA LONG	(6)	OBS OBSTVIS	(19)	BL RH	(39)	850 U	(38)	700 T-TD	(45)
20	700 VV	(6)	850 WNSPD	(19)	700 VV	(36)	200 V	(36)	BL V	(41)

Table 7. Same as Table 6 except for visibility and obstructions to vision forecast equations.

Rank	Projection 6-h		12-h		24-h		36-h		48-h	
1	OBS VIS	(885)	OBS OBSTVIS	(440)	BL RH	(201)	BL RH	(210)	BL RH	(266)
2	OBS OBSTVIS	(479)	OBS VIS	(369)	MEAN RH	(196)	OBS OBSTVIS	(161)	CVRF	(201)
3	OBS CIG	(208)	MEAN RH	(175)	OBS OBSTVIS	(168)	CVRF	(148)	STA LONG	(125)
4	OBS CLDS	(74)	OBS CIG	(106)	CVRF	(151)	MEAN RH	(135)	COS DOY	(122)
5	P AMT	(65)	CVRF	(98)	OBS VIS	(137)	BL WNSPD	(131)	850 DP	(106)
6	CVRF	(59)	P AMT	(86)	P AMT	(115)	OBS VIS	(106)	OBS VIS	(102)
7	BL RH	(57)	BL RH	(71)	STA LONG	(88)	G INDEX	(86)	500 HGT	(97)
8	MEAN RH	(44)	850 VV	(70)	BL R VOR	(88)	COS DOY	(84)	850 VV	(77)
9	OBS W	(35)	BL MCONV	(64)	850 DP	(86)	850 VV	(74)	500 U	(63)
10	BL MCONV	(35)	850 DP	(49)	BL MCONV	(74)	P AMT	(58)	BL WNSPD	(59)
11	OBS V WIND	(33)	1000 T	(47)	BL U	(74)	1000 DP	(54)	P AMT	(58)
12	850 VV	(30)	OBS T-DP	(41)	BL WNSPD	(73)	STA LAT	(52)	1000 HGT	(58)
13	OBS T-DP	(26)	BL R VOR	(39)	P WATER	(69)	P WATER	(50)	1000 DP	(55)
14	OBS WNSPD	(19)	10-5 TH	(38)	OBS T	(55)	BL R VOR	(49)	OBS OBSTVIS	(52)
15	200 U	(17)	850 U	(36)	500 VV	(55)	500 U	(49)	850 T ADV	(52)
16	STA LONG	(16)	BL POT T	(34)	K INDEX	(47)	10-8.5 TH	(48)	10-8.5 TH	(52)
17	700 DP	(15)	OBS V	(33)	850 VV	(42)	OBS CIG	(47)	700 R VOR	(50)
18	10-8.5 TH	(13)	700 VV	(31)	STA ELEV	(42)	500 GEO U	(47)	200 U	(49)
19	850 R VOR	(13)	BL V	(28)	10-8.5 TH	(41)	700 HGT	(44)	BL VV	(48)
20	850 U	(11)	STA ELEV	(27)	OBS T-DP	(36)	BL V	(41)	STA ELEV	(45)

Table 8. The cumulative reductions of variance and equation coefficients for estimating the 12-h cloud amount (0000 GMT) for region 7 (see Fig. 2) during the winter season months of November through March. Predictor acronyms are defined in Table 5.

Predictor (Units)	Projection (h)	Cumulative Reduction of Variance			Coefficients			Binary Threshold
		CAT1	CAT2	CAT3	CAT1	CAT2	CAT3	
MEAN RH (%)	12	0.388	0.400	0.362	0.0006	0.0001	-0.0016	Continuous
OBS CIG (ft x 100)	03	0.025	0.027	0.017	0.0254	0.0053	0.0159	≤39.5
OBS CLDS (tenths)	03	0.041	0.016	0.005	0.1904	0.1131	0.0640	≤2.5
CVRF (06Z) (%)	00	0.001	0.001	0.001	-0.0011	-0.0011	-0.0006	Continuous
BL MCONV (sec^{-1} x 10^{-8})	12	0.000	0.001	0.001	0.0008	0.0018	0.0025	Continuous
OBS CIG (ft x 100)	03	0.000	0.001	0.000	0.0519	0.0542	0.0485	≤4.5
750 VV (mb/sec)	12	0.018	0.016	0.010	-0.1138	-0.1265	-0.1043	≤-.0003
OBS CLDS (tenths)	03	0.010	0.014	0.015	0.1113	0.1510	0.1628	≤9.5
OBS CIG (ft x 100)	03	0.001	0.001	0.001	-0.0208	-0.0202	-0.0283	≤20.5
850 VV (mb/sec)	12	0.006	0.006	0.006	43.0300	48.1400	50.7300	Continuous
TT INDEX (°F)	12	0.001	0.006	0.001	0.0028	0.0056	0.0080	Continuous
MEAN RH (%)	12	0.011	0.005	0.002	0.1761	0.1363	0.0735	≤50
STA LAT	--	0.001	0.000	0.001	0.0030	0.0003	-0.0023	Continuous
OBS CIG (ft x 100)	03	0.000	0.000	0.001	-0.0163	0.0045	0.0206	≤9.5
MEAN RH (%)	18	0.005	0.006	0.007	-0.0043	-0.0052	-0.0057	Continuous
OBS CIG (ft x 100)	03	0.004	0.003	0.002	-0.1157	-0.1039	-0.0811	≤75.5
BL V (m/sec)	12	0.002	0.002	0.001	0.0053	0.0059	0.0058	Continuous
BL RH (%)	12	0.000	0.001	0.001	-0.0002	-0.0009	-0.0014	Continuous
P AMT (m)	12	0.001	0.000	0.001	-0.0262	-0.0103	-0.0219	≤.0006
OBS T-TD (°F)	03	0.001	0.001	0.001	0.0220	0.0176	0.0082	≤4.5
		Regression Constant			0.2939	0.5782	0.8469	
		Total Standard Error of Estimate			0.3054	0.3330	0.3679	

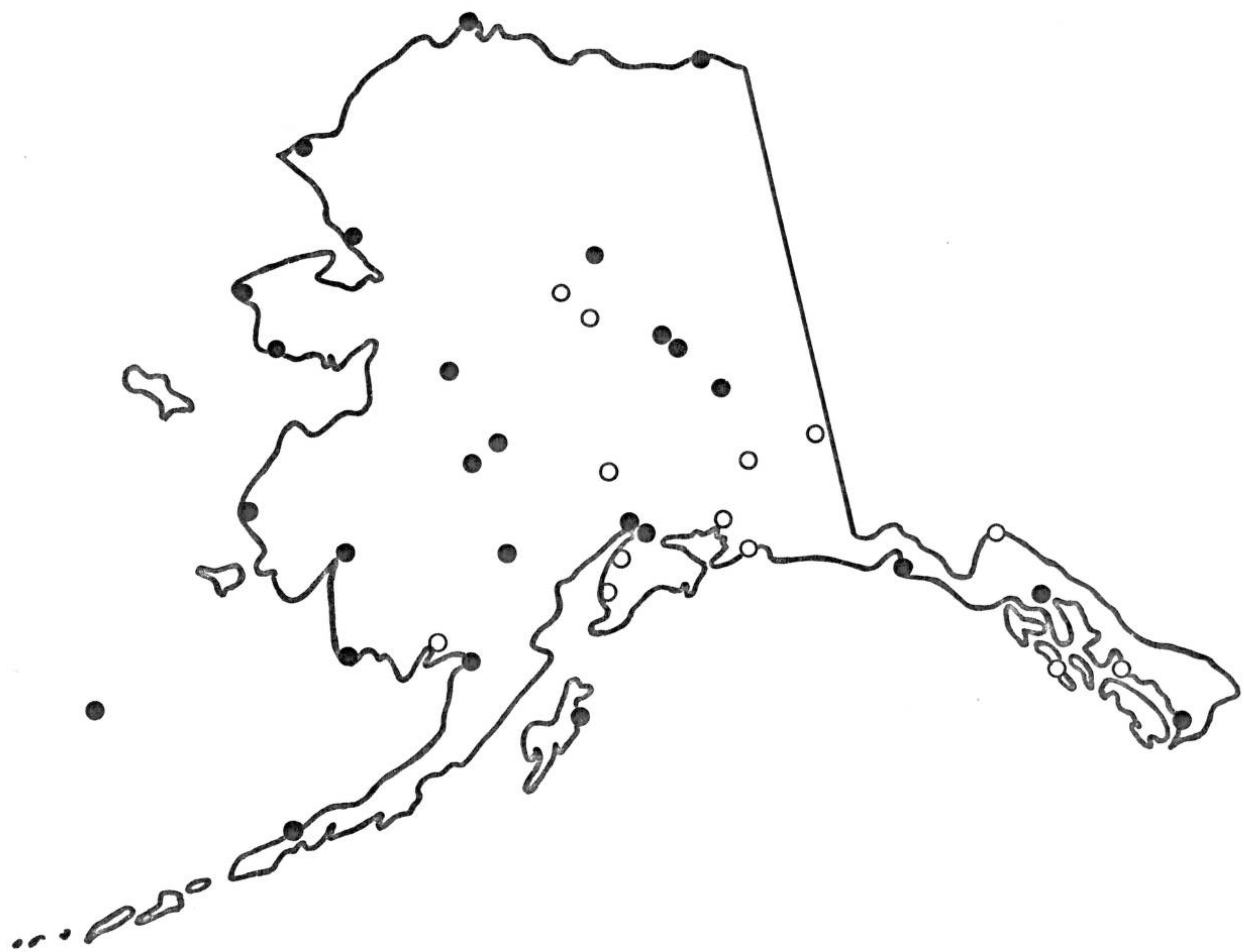

Figure 1. Stations used to develop the new system. Stations designated by closed circles comprised the old operational system.

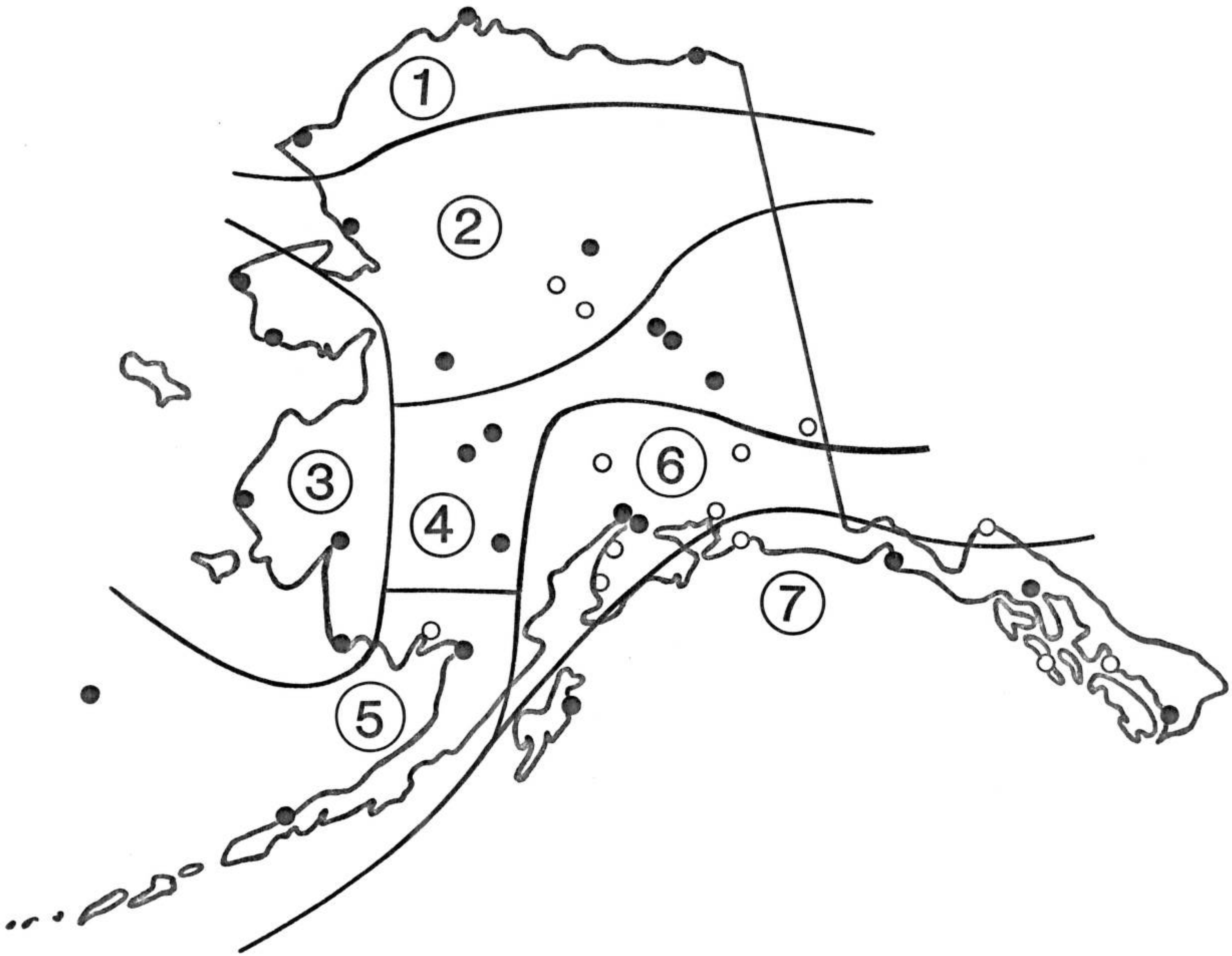

Figure 2. Regions used to develop cloud amount, ceiling height, visibility, and obstructions to vision equations for Alaska for the winter season.

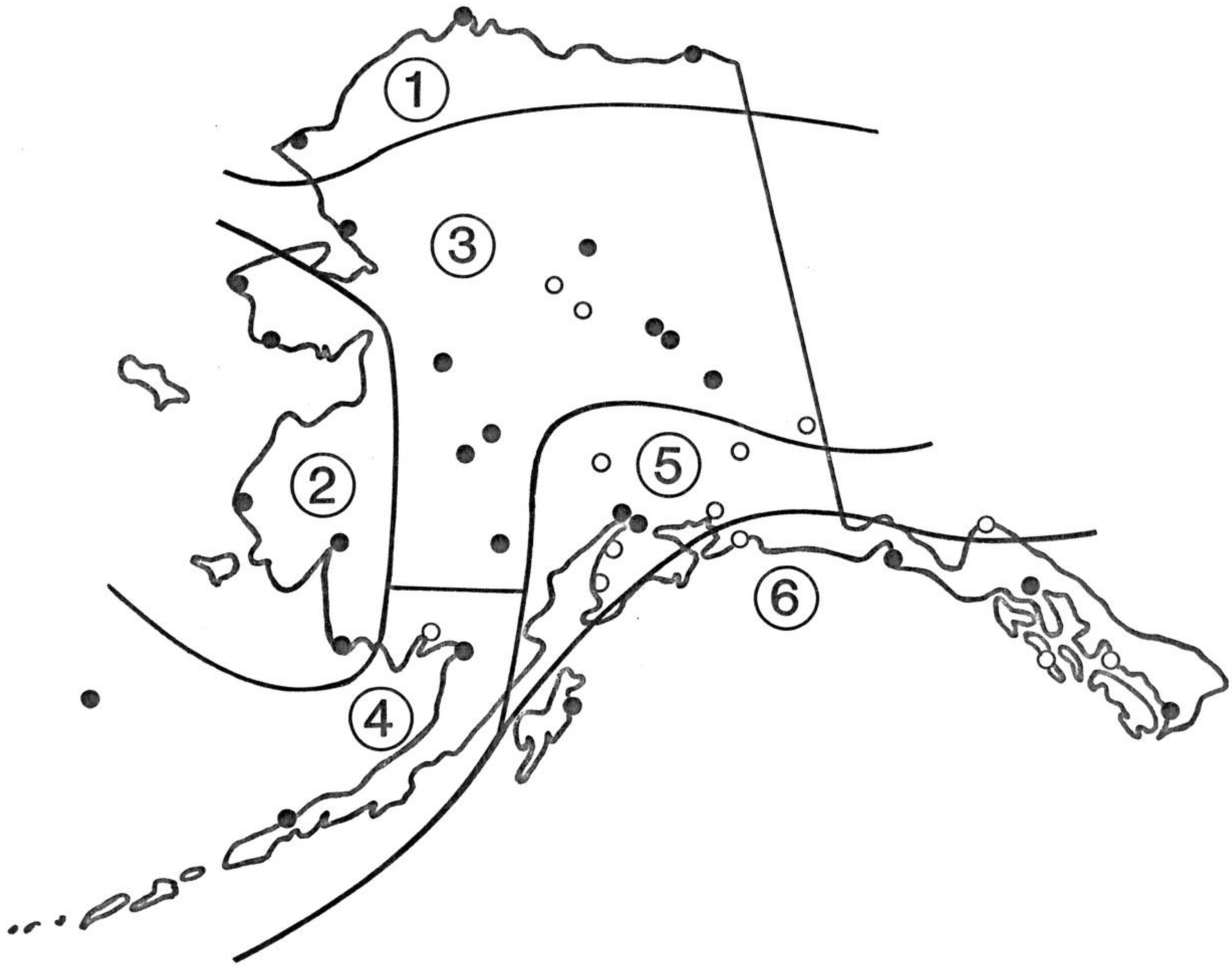

Figure 3. Same as Fig. 2 except for the spring season.

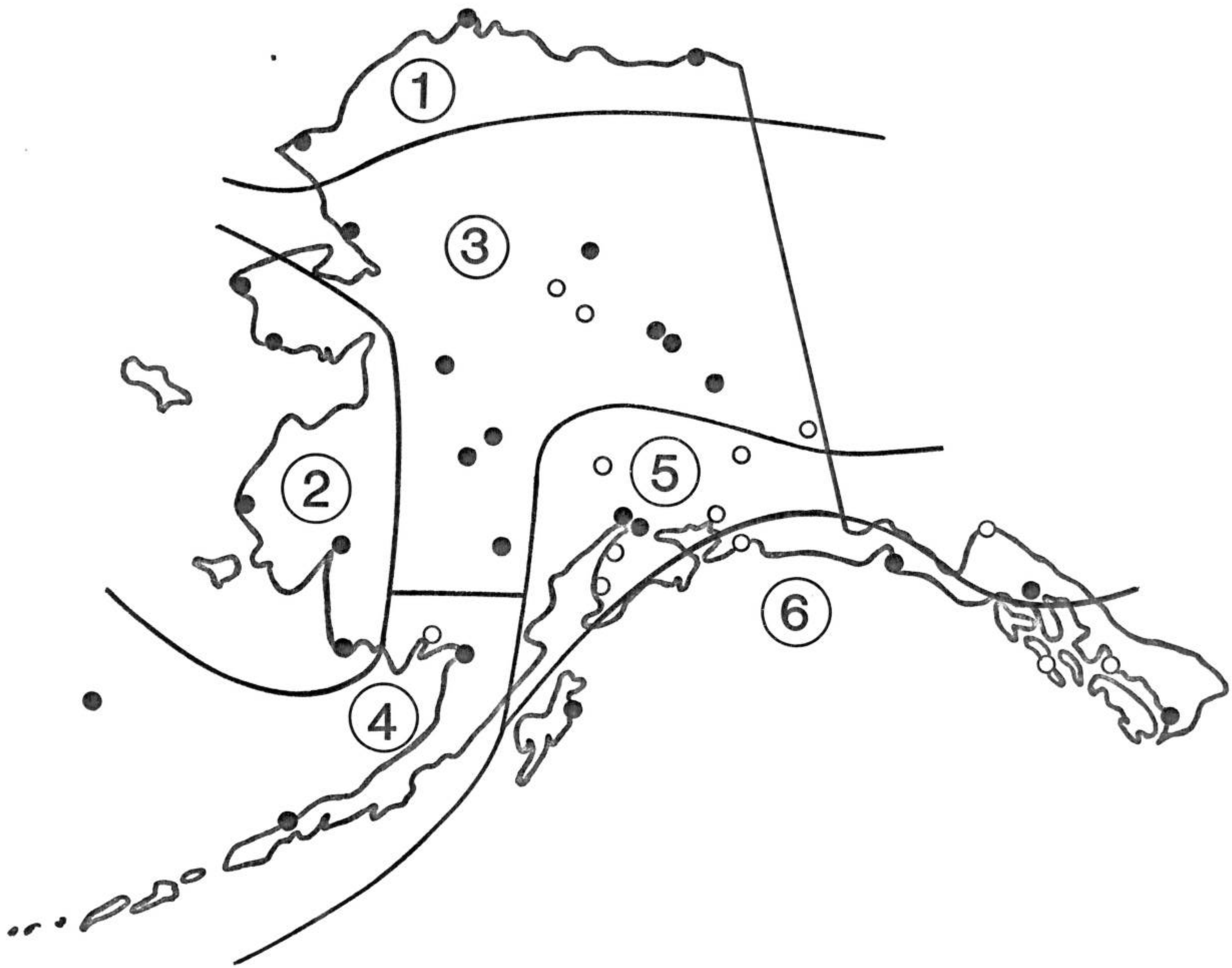

Figure 4. Same as Fig. 2 except for the summer season.

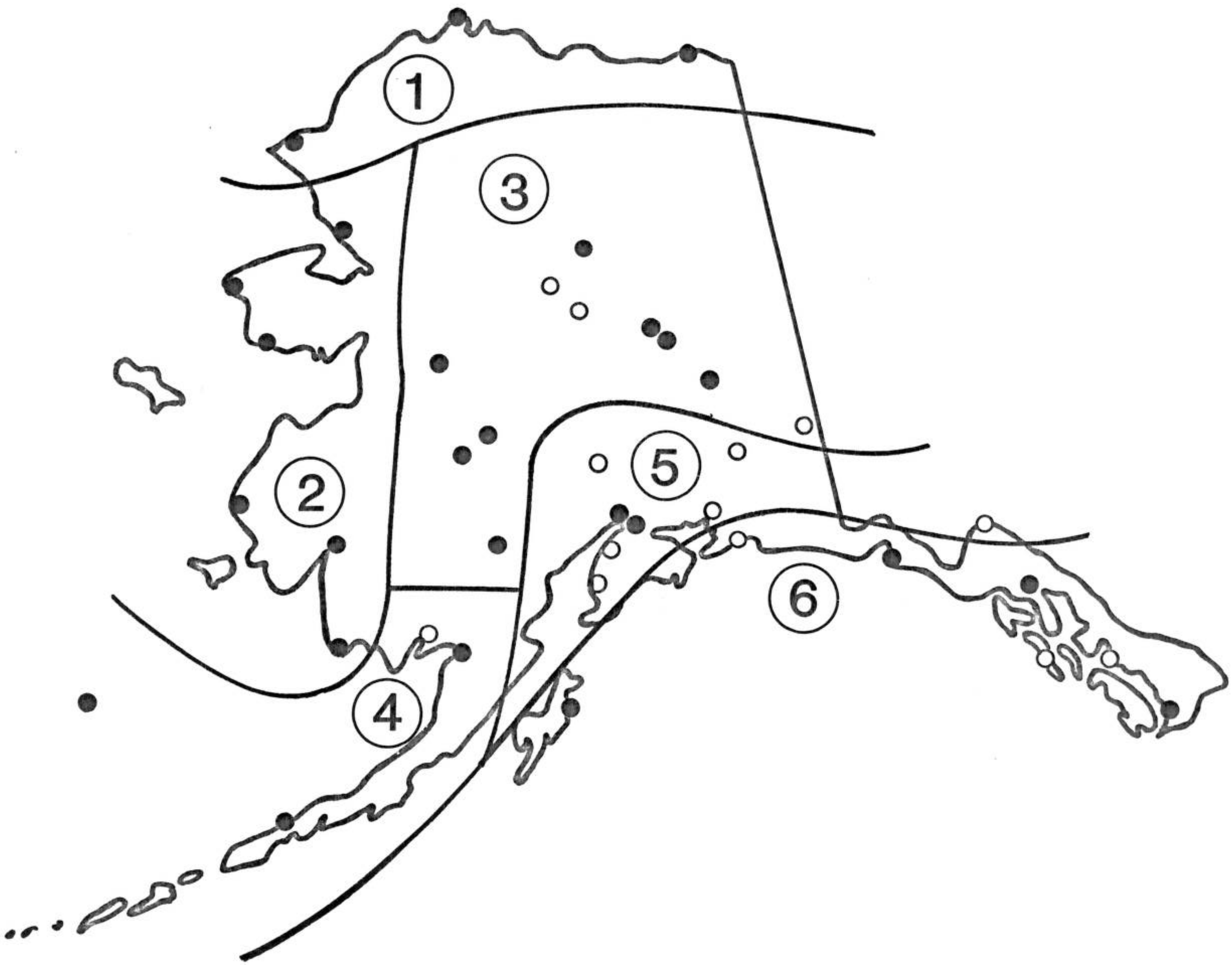

Figure 5. Same as Fig. 2 except for the fall season.

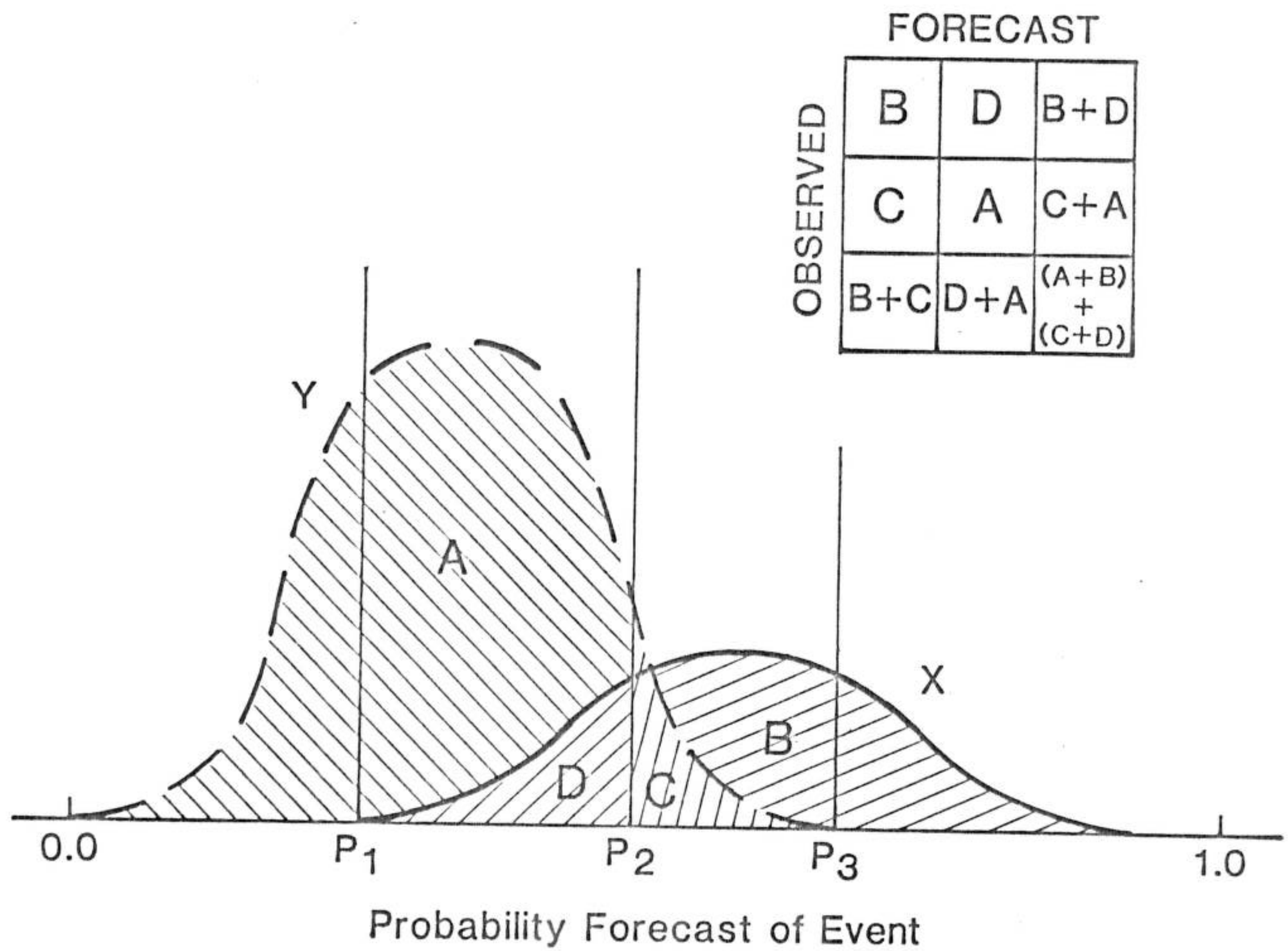

Figure 6. Example frequency distribution of the occurrence (curve X) of an event and the non-occurrence (curve Y) of an event. The labeled areas under the curves have had their values placed where they belong in the contingency table. The total area of A also includes D, and the total area of B also includes that part of C below the curve X.