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Forecasting the Catalina Eddy

ARTHUR L. EICHELBERGER

Western Region

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A western Indian symbol for rain. It also symbolizes man's dependence on weather and environment in the West.

U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

NOAA Technical Memorandum NWSTM WR-62

FORECASTING THE CATALINA EDDY

Arthur L. Eichelberger
Weather Service Forecast Office
Los Angeles, California

WESTERN REGION
TECHNICAL MEMORANDUM NO. 62

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FORECASTING THE CATALINA EDDY

ABSTRACT

The Catalina Eddy, a small-scale vortex in the bight of southern California, has long been a serious problem for the forecaster. It disrupts the normal stratus pattern and can cause marked cooling in the southern California coastal area. The eddy is shown to result when an eastward-moving upper trough nears southern California, with strong northerly surface winds prevailing along the California coast.

An objective aid for predicting the eddy is presented. It was found that with a surface pressure gradient of five to ten millibars from 35N 125W to Los Angeles, positive vorticity advection resulting in vorticity values of seven to ten units (10^{-5} Sec^{-1}) at Los Angeles will generate the eddy.

Primitive equation prognostic vorticity charts are shown to be highly useful in forecasting development of the Catalina Eddy.

I. INTRODUCTION

The Catalina Eddy is a small-scale vortex in the marine layer generated in the bight of southern California. The eddy derives its name from the fact that the circulation center is usually located just southwest of Catalina Island.

On May 27 - 29, 1968, ESSA 2 and ESSA 6 weather satellites recorded a remarkable series of pictures of the life cycle of a Catalina Eddy. This series of photographs (Figures 1 - 4) is reproduced along with captions by Mr. Jay Rosenthal (1).

The Catalina Eddy's cyclonic circulation, as opposed to the normal westerly sea breeze, has a profound effect on the stratus pattern over the Los Angeles basin and nearby valleys. See Figure 5 for map of the basin and station locations.

With the normal westerly sea breeze, stratus ceilings in the Los Angeles basin are reported first by Los Angeles International Airport (LAX), followed in an hour or two by Long Beach (LGB). Then, if the marine layer is deep enough, stratus will be reported in the following two or three hours by Burbank (BUR) and Ontario (ONT).

When an eddy is developing, stratus will spread from the San Diego area northward into the southern portions of the basin, reaching LGB within an hour of the first report at Orange County Airport (SNA). The cloud layer usually reaches LAX and BUR nearly simultaneously an hour later and will frequently spread inland to ONT in an additional three hours. Continued expansion brings the cloud mass to Santa Barbara 85 miles northwest of LAX, blanketing all of the southern California coastal area. Visibility improves rapidly as the stagnant airmass which usually precedes the eddy is dispersed.

If the eddy is strong, the marine layer will deepen rapidly, obscuring coastal approaches to mountain passes around the basin and blanketing the entire basin with stratus within six hours of the time ceilings are first reported at SNA.

Effects of temperature depend largely on conditions preceding advent of the eddy. The average drop in maximum temperature at Los Angeles Civic Center from the day prior to eddy formation to the first day of the eddy, was two degrees for 55 eddies in the months of May through September. Drops of as much as 12 degrees were noted when the eddy followed a day with a very low inversion or no inversion. This effect is more pronounced over the higher coastal valleys. The average temperature drop was three degrees at March Air Force Base located at the 1500-foot level near Riverside. A drop of 15 degrees was noted at March AFB on one occasion. Clearly, the onset of a vigorous eddy will cause serious errors in forecasts predicated on no-eddy conditions.

Prior to development of the forecast system presented in this paper, no objective method of predicting the onset of the Catalina Eddy was available. Common practice at the Los Angeles Forecast Office was to wait until the eddy was evident before incorporating eddy effects into forecasts. The objective system described here is currently in use at the Los Angeles Forecast Office.

II. DEVELOPMENT OF THE OBJECTIVE FORECAST AID

Southerly winds at San Diego are so characteristically associated with the eddy that Meyer (2) defined the existence of the Catalina Eddy as: Surface wind at San Diego south-southeast through south-southwest five mph or more for at least four record observations between the hours of 1500 and 0300 PST. This association of the south wind at San Diego with the eddy was also demonstrated by Graham (3). The normal wind at San Diego in summer during these hours is slightly west of north.

It was determined that the necessary and sufficient conditions for eddy formation are the presence of strong northerly winds off the coast of California and positive vorticity advection (PVA) into the southern California coastal area. In this study, the north winds were measured by the sea level pressure gradient (ΔP) at 35N 125W minus LAX. Vorticity values at LAX were taken from the initial analysis on the 500-millibar four-panel prognostic charts. Twenty-four months of data, March 1968 through April 1970, were used in this study. (October and November 1969 were missing.) Vorticity values were taken from barotropic charts for the period March 1968 through March 1970, as these were the only charts available. Initial vorticity analyses on the primitive equation (PE) four-panel charts were used for April 1970 and the subsequent test period.

Sea-level pressure gradients and vorticity values were plotted against occurrence or nonoccurrence of eddies in the scatter diagram shown in Figure 6.

Days with a frontal passage or 500-mb trough passage, as well as second and third days of continuing eddies, were excluded. Only days with $0 \leq \Delta P < 15$ mb and vorticity increasing in a 12-hour period to a value of at least 4×10^{-5} sec^{-1} are plotted on the chart. (A no-eddy forecast is assumed on other days.) Data for days with no eddies were taken at 1600 PST. For days with eddies, surface data were taken immediately prior to eddy development, with vorticity values taken at the prior upper-air observation time (0400 or 1600 PST).

A primary eddy-forecast area (inner rectangle) was delineated on the chart (Figure 6). This area contained 59 eddies and 24 no-eddy days for 71% eddy occurrence. A secondary forecast area (surrounding the inner rectangle) contained 9 eddies and 13 no-eddy days for 41% occurrence. Two eddies fell well outside the above areas.

Table I includes results for the two years of development data. An eddy was considered to have been forecast if the data fell within either the primary or secondary forecast areas outlined in Figure 6.

TABLE I

VERIFICATION OF CATALINA EDDY FORECASTS MADE FROM DEPENDENT DATA

	Forecast		
Observed	Eddy	No Eddy	Totals
Eddy	68	2	70
No Eddy	37	502	539
TOTALS	105	504	609

PERCENT CORRECT (PC)	94%	THREAT SCORE (TS)	.64
PREFIGURANCE (PF)	.97	BIAS $\frac{\text{(No. Eddies fcst)}}{\text{(No. Eddies obsvd)}}$	1.50
POSTAGREEMENT (PA)	.65		

It can be seen that the objective system greatly overforecast eddy occurrences.

III. TEST OF THE FORECAST AID

Observed charts (perfect progs) for the period May 1 through July 31, 1970, were used to test the forecast aid. A scatter diagram (Figure 7) was constructed using the same tests for inclusion of data as for the development data.

Thirteen eddies occurred during this period. Only one fell outside the forecast area. Verification is shown in Table 2. Note the improvement in threat score, postagreement, and bias as compared to Table 1. This improvement is attributed to the superiority of the PE vorticity analyses used in the test over barotropic analyses, which were of necessity used in development of the aid.

TABLE 2

VERIFICATION OF CATALINA EDDY FORECASTS MADE FROM INDEPENDENT DATA

		Forecast	
Observed	Eddy	No Eddy	Totals
Eddy	12	1	13
No Eddy	3	66	69
TOTALS	15	67	82

PERCENT CORRECT	95%	THREAT SCORE	.75
PREFIGURANCE	.92	BIAS	1.15
POSTAGREEMENT	.80		

To assess usefulness of the aid based on NMC prognostic charts, forecasts of conditions favorable for eddy formation were made using PE four-panel progs for the period May 1 through July 31, 1970. An eddy was forecast to develop if the progs indicated PVA of one unit or more per 12 hours, provided that ΔP and LAX vorticity fell within the larger forecast rectangle in Figure 6, and PVA was forecast to continue for at least 12 hours. ΔP was considered to remain constant at the value observed when the PE prog package became available (approximately 1140 and 2340 PST). Cases when an eddy was in existence at the initial time of the prog package were not used. Onset time of the eddy was forecast to coincide with the beginning of PVA. An eddy forecast was considered a hit if an eddy formed within six hours of the time forecast. A no-eddy forecast was considered a miss if an eddy formed within 36 hours of the prog package initial time. Results are tabulated in Table 3:

TABLE 3

VERIFICATION OF CATALINA EDDY FORECASTS BASED ON NMC PROGNOSTIC CHARTS

	FORECAST		
	EDDY	NO EDDY	TOTALS
OBSERVED			
EDDY	14	8	22
NO EDDY	11	92	103
TOTALS	25	100	125

PERCENT CORRECT	84%	THREAT SCORE	.42
PREFIGURANCE	.64	BIAS	1.14
POSTAGREEMENT	.51		

Note the decrease in accuracy compared to forecasts based on observed charts, Tables 1 and 2. It is encouraging to note the small bias, however.

The objective aid can be used to forecast Catalina eddies, with probabilities of occurrence in the primary and secondary areas, as shown in Figure 8. Forecast the eddy to begin at the onset of PVA at Los Angeles as indicated on P.E. four-panel prognostic charts. PVA of one unit or more per 12 hours persisting for 12 hours or more is usually required to generate an eddy.

IV. DISCUSSION

The forecaster is cautioned that, as in all weather systems, strength of the Catalina Eddy is proportional to the forces causing it. Eddies included in this study ranged from those so weak that the only effects noticeable were a few hours of south winds at San Diego to eddies so strong that the marine layer deepened from a few hundred to 5000 feet in less than 24 hours. Although an eddy can develop with pressure gradients as small as 5 mb and vorticity values as low as 6 units, higher values are required to produce vigorous eddies.

In general, eddy strength is most sensitive to the value of the maximum vorticity measured at Los Angeles during the lifetime of the eddy. However, if the vorticity reaches 13 units or more at Los Angeles and higher values prevail inland, the eddy will be swept away in a strong general onshore flow.

Strongest eddy situations are those in which a decelerating frontal trough moves into southwestern United States, accompanied by vorticity maxima of 14 units or more in southern Nevada and 12 units at Los Angeles. Under these conditions, and given the necessary strong northerly winds along the coast, explosive deepening of the marine layer can be anticipated.

If a series of short wave troughs with half wave lengths of 600 miles or less are passing through the area, the eddy, if any, will be poorly organized and short lived; and there will be insufficient time for any significant changes in southern California coastal weather.

Once formed, an eddy will persist until either frontal passage occurs, a vorticity maximum passes, the marine layer deepens to 5000 feet and spills over the coastal mountain range, or vorticity values over coastal waters increase to 13 units or more and a general onshore flow ensues.

Eddies occur during the entire year but are primarily a warm season phenomenon. Fifty-five of the 70 eddies included in the dependent data sample developed in the months of May through September. This is to be expected, as the eastern Pacific high is in its more northerly position in summer; and the pressure over southern California has lowered in response to the interior thermal low. Normal sea level pressure gradient from 35N 125W to Los Angeles is 6 mb in July and 1 mb in January. Thus, northerly winds are usually present along the California coast in summer and upper troughs moving through the southwest are seldom strong, thus providing just the proper amount of PVA required to generate the Catalina Eddy.

V. ACKNOWLEDGMENTS

Credit is due present and past members of the Los Angeles forecast staff--especially Messrs. Brian Finke and Don Gales--whose comments were especially helpful in preparation of this paper. Appreciation is expressed to Scientific Services Division, WRH, for guidance received and for furnishing some of the data used.

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3. Graham, R. D., "The Effect of the Catalina Eddy on the Summer Wind at San Diego," Weather Service Forecast Office, Los Angeles, California - Manuscript 1955.

FIGURE 1. 27 May 1968 1728Z
ESSA 6 photo clearly showing Point Mugu, coastal southern California and adjacent waters free from stratus following offshore flow at the surface. Stratus is, however, present along Baja California coast.

FIGURE 2. 28 May 1968 1522Z
ESSA 2 photo showing early stages of Catalina Eddy. Note cyclonic spiral of stratus.

FIGURE 3. 28 May 1968 1821Z
ESSA 6 photo showing progression of stratus in cyclonic spiral of eddy. Note the isolation of clear, dry air.

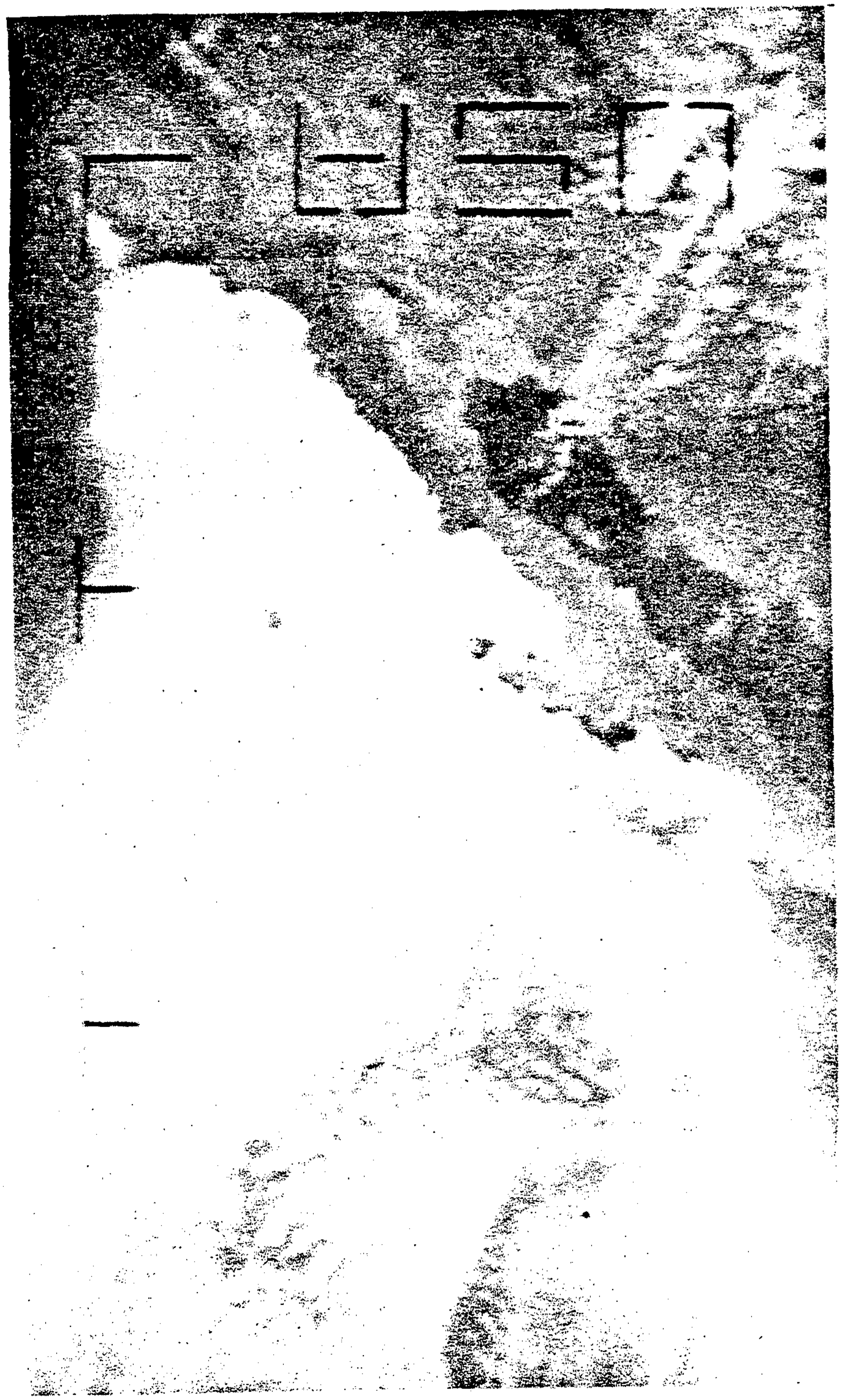

FIGURE 4. 29 May 1968 1717Z
ESSA 6 photo showing the complete envelopment of Point Mugu, coastal waters and region to the south by thick stratus. The clear, dry area has now been filled up by cloud from the dying eddy circulation.

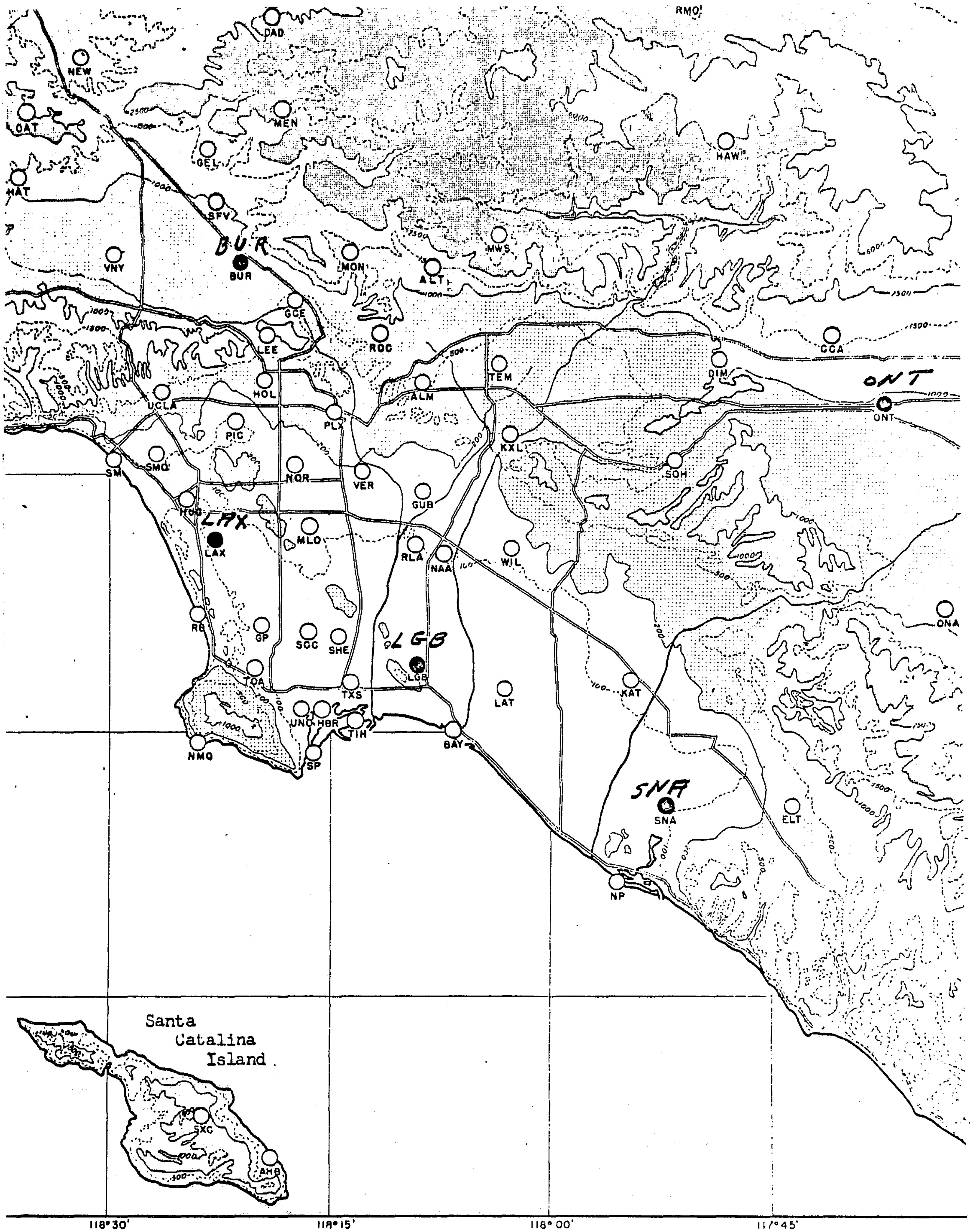

FIGURE 5. MAP OF THE LOS ANGELES AREA.

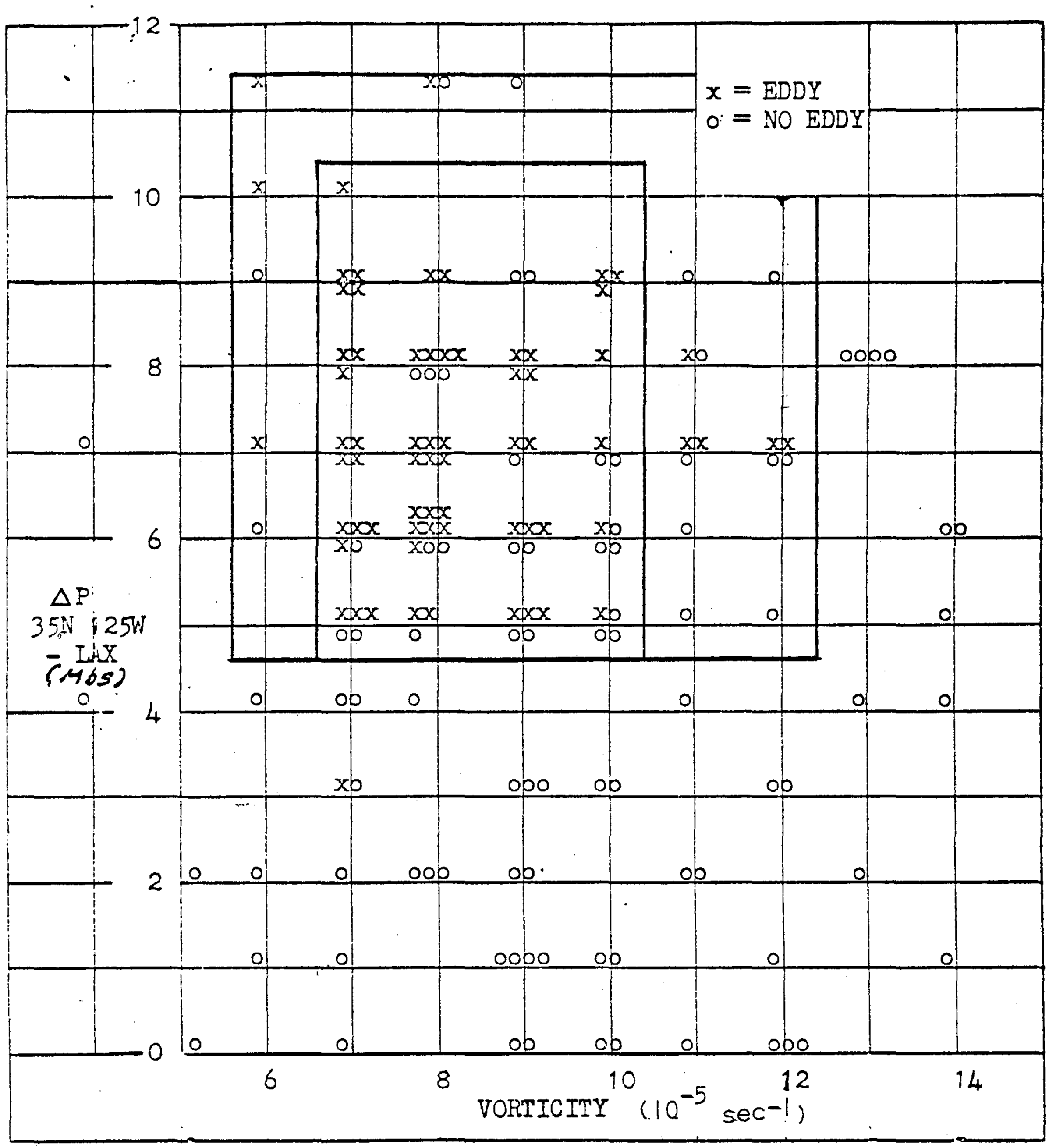

FIGURE 6. OCCURRENCES OF CATALINA EDDIES AS A FUNCTION OF SEA-LEVEL PRESSURE GRADIENT (35N 125W - LAX) AND VORTICITY AT LAX. DEPENDENT DATA.

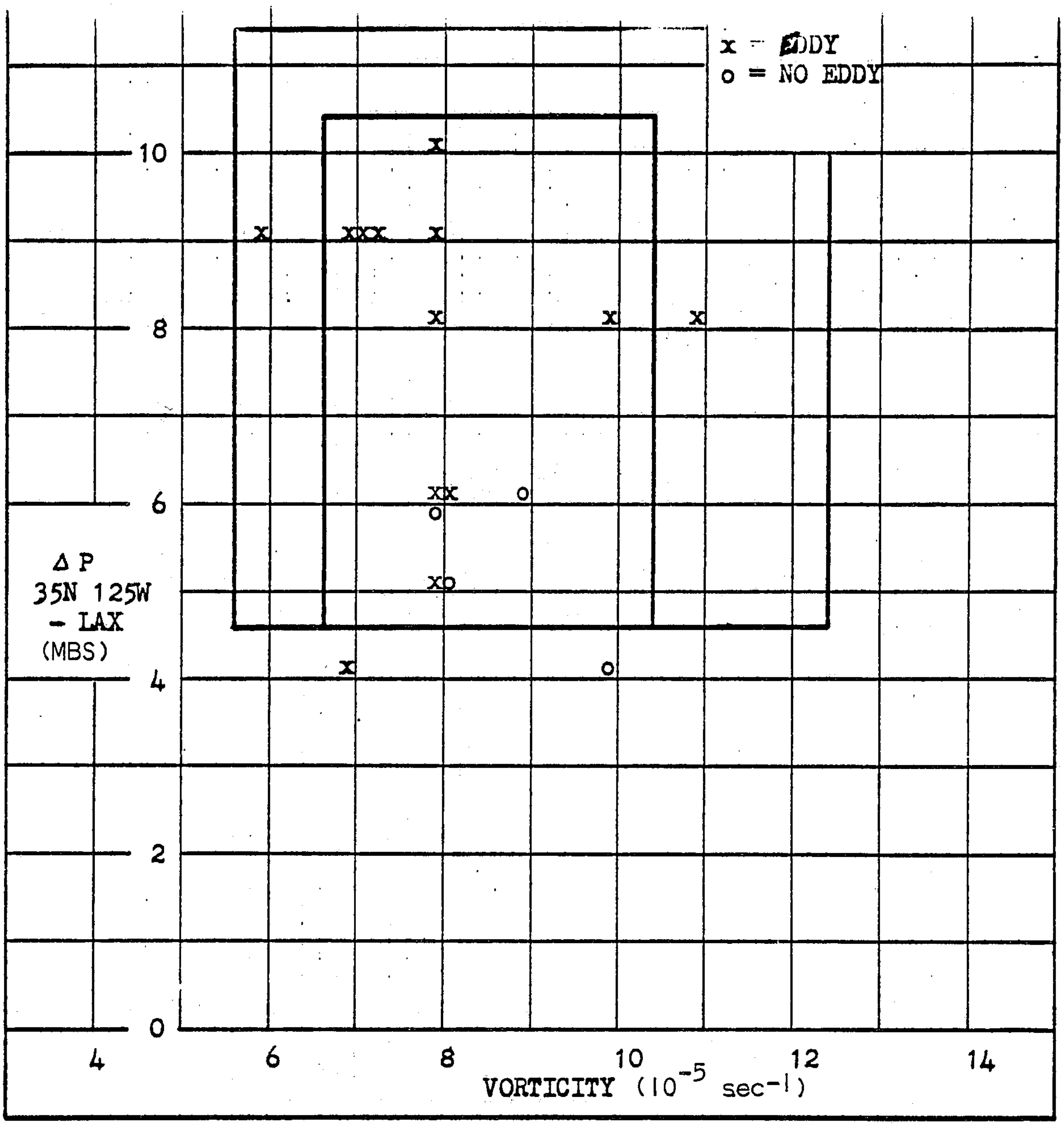

FIGURE 7. OCCURRENCES OF CATALINA EDDIES AS A FUNCTION OF SEA-LEVEL PRESSURE GRADIENT (35N 125W - LAX) AND VORTICITY AT LAX. INDEPENDENT DATA.

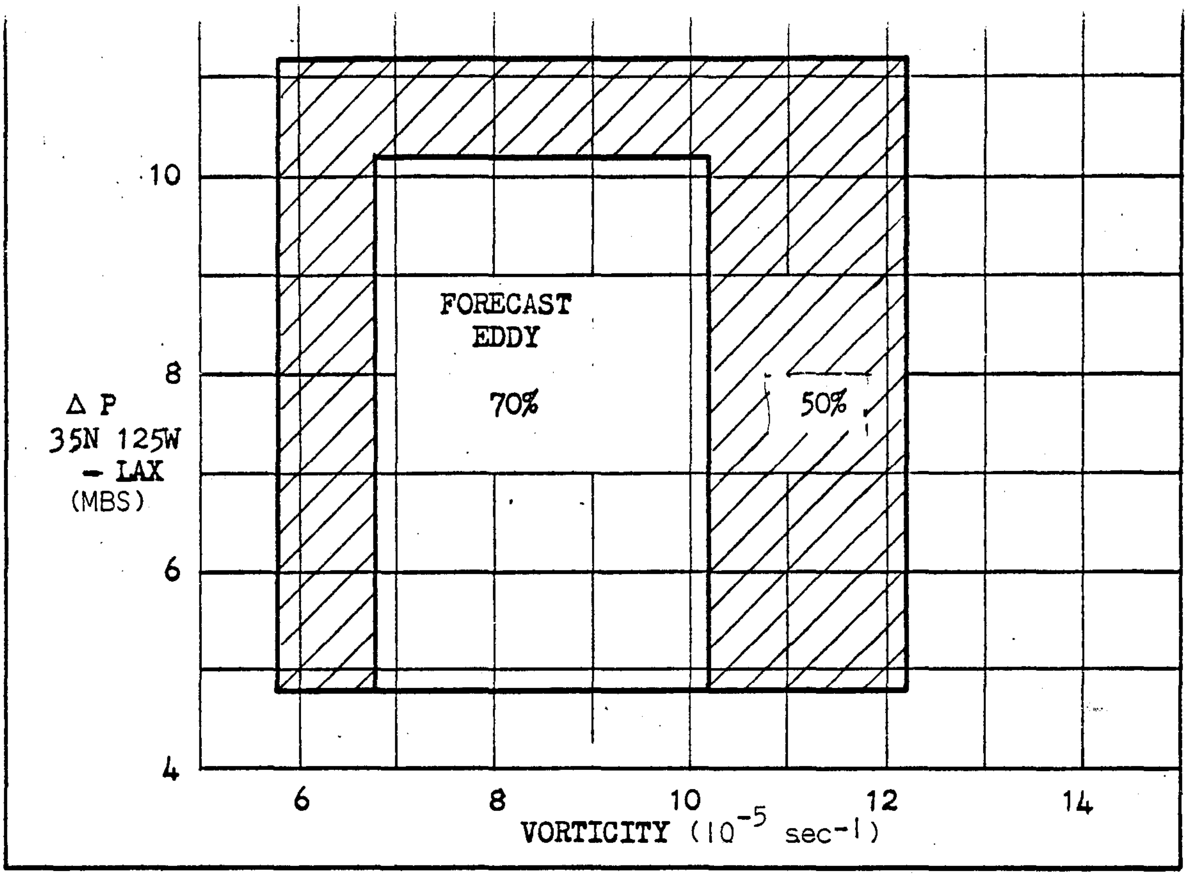

FIGURE 8. GRAPH FOR FORECASTING CATALINA EDDIES AS A FUNCTION OF SEA-LEVEL PRESSURE GRADIENT (ΔP) AND VORTICITY AT LAX.

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