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An Evaluation of CMC's Forecast Guidance for Heavy Rainfall at Vancouver

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INTRODUCTION

Probability of Precipitation Amount (POPA) forecasts have been produced by the Canadian Meteorological Centre (CMC) and transmitted to operational forecast offices since December, 1980. As well, a Quantitative Precipitation Forecast (QPF) based on spectral model output has been provided to forecasters for selected stations. Since the Weather Forecast Research Section at AES Headquarters has begun a project to verify the POPA forecasts, it was suggested that an evaluation of CMC guidance for particular Vancouver rainstorms would complement their project. In this note four rainstorms, one for each season of the year which gave heavy rainfall at Vancouver Airport are examined.

POPA

CMC transmits a POPA forecast for British Columbia (e.g. Figure 1) twice daily. A Multiple Discriminant Analysis (MDA) method is used for 0-12, 12-24, and 24-36 hour forecast periods and a Regression Estimate of Event Probability (REEP) method is used for the 36-48 and 48-60 hour forecast periods. A set of 5 or more predictors were selected for the 00-12Z and 12-24Z periods for each of the four seasons of the year. The spring season is March-May; summer June-August; fall September-November, and winter is December-February. The predictor sets for Vancouver are listed in PWC Technical Information #25, January 29, 1981.

Spectral Model Output QPF

Twice daily, CMC transmits QPF information for Vancouver as part of the spectral model output package (Figure 2). The precipitation amounts forecast for the 12 hour periods from T + 12 to T + 60 were compared with the POPA forecasts for the rainstorms studied.

CASE STUDIES

Precipitation records for Vancouver Airport were examined for the past two years to find rainstorms in which at least 10 mm of rain fell in a 12 hour period. This corresponds to category 4 precipitation, commonly referred to in verification of POPA. One storm was selected for each of the seasons. A brief synoptic summary and an evaluation of CMC precipitation forecast guidance will be included for each case study.

Spring - April 3, 1982

Figure 3 is the surface map for 1200Z, April 3, 1982. It shows a filling low pressure system tracking toward Vancouver Island and a trowal from eastern Idaho into the southern interior of B.C. Precipitation at Vancouver resulted from frontal lift ahead of the trowal and from orographic/ convergent effects in the unstable airmass behind the trowal. Table 1 summarizes rainfall amounts and CMC guidance for the storm. Looking at the POPA figures for amounts greater than 10 mm, only the 24 hour forecast for the 00-12Z period gave a probability greater than 50%. The 36 hour forecast probability for this period was also largest for the greater than 10 mm category. Several observations can be made about the POPA output in this case. Rather surprisingly, the 12 hour POPA was poorer than the 24 and 36 hour POPA for the 00-12Z period. Also of note is the rapid drop in probabilities between the 36 and 48 hour forecasts. This falloff in probabilities at 48 hours was likely due to the change from the MDA to the REEP methods of calculating. The REEP method notoriously underforecasts category 4 precipitation amounts. Another observation was the much lower probabilities forecast for the 12-24Z period compared to the 00-12Z period for forecasts out to 36 hours. This will be discussed later in this study since it appears to be a reoccurring anomaly.

The precipitation amounts forecast by the model verified best for the short range forecasts in this case. The forecasts identified the correct periods which would receive the heaviest amounts when the forecasts the day before and after the April 3, 1982 storm were examined. However, all forecast amounts were too low.

Summer Case - July 15, 1982

Almost 30 mm of rain fell at Vancouver Airport in the 24 hour period ending 0000Z, July 16, 1982 (Table 1). The surface map for 1200Z, July 15, 1982 (Figure 4) shows a surface low in western Alberta and an area of precipitation covering most of southern B.C. This low was the surface portion of an intense cold low system which was in the process of crossing southern British Columbia.

The POPA forecasts were very poor for this storm. For category 4 precipitation, the largest POPA was 8%. These poor results are partially due to poor spectral model performance since QPF figures were in the range of zero to 5 mm. Possibly another reason for the performance of MDA in this case was due to a poor predictor set because of the limited sample of category 4 precipitation events in summer. Examining forecast precipitation amounts as the upper low crossed southern B.C., the spectral model tended to forecast category 2 (0.2-2 mm) or 3 (2-10 mm) amounts in B.C. but increased the amounts to category 3 and 4 east of the Rockies.

Fall Case - October 31, 1981

This storm, also referred to as the Halloween Weekend storm (reference Horita, PRTN 81-024), dumped 61 mm of rain at Vancouver Airport for the 24 hour period ending 0000Z November 1, 1981. The surface map for 0000Z, November 1, 1981 (Figure 5) is typical for a heavy rain situation. A front lies on a northeast-southwest orientation just to the north of Vancouver with a strong southwesterly flow at all levels.

The POPA forecasts (Table 1) were generally reasonable for this storm, particularly for the short-range ones. The 12 hour POPA for category 4 precipitation was 65% for 00-12Z, October 31 and both 24 hour forecasts were just under 50%. The QPF forecasts were also fairly good although underforecasting amounts. Category 4 precipitation was forecast out to 36 hours so the spectral model appeared to be performing well.

Winter Case - December 3, 1982

The December 3, 1982 storm in which over 37 mm of rain fell at the Vancouver Airport was another typical heavy rain producing weather regime. The 1200Z surface map for December 3, 1982 (Figure 6) shows a frontal wave and low pressure system just off northern Vancouver Island with a front lying to the southwest. A very strong southwesterly flow crosses the southwestern B.C. coast.

The POPA forecasts (Table 1) for category 4 precipitation were relatively good for the 00-12Z period with the highest probabilities for the 12 and 24 hour forecasts. For the 12-24Z period POPA dropped off below 20% for all forecasts although more than 12 mm of rain fell in this period. As for the spring case the rapid falloff in POPA for category 4 precipitation from the 00-12Z to 12-24Z appears to be more than just poor spectral model performance. For 12 hour forecasts, the QPF was 10 mm for the the 00-12Z period and 18 mm for the 12-24Z period, yet the POPA of category 4 dropped from 75% to 11%.

Summary of Observations

Of the four synoptic cases studied, the POPA forecasts for category 4 amounts were best for the typical fall/winter heavy rain situation. In these cases southwestern B.C. lies under a strong southwesterly flow pattern with a frontal zone lying through the region. Under this weather regime, CMC's QPF generally performed well. The CMC POPA and QPF guidance was poorest for the spring/summer rainstorms which involved upper lows.

The POPA forecasts derived by the MDA procedure from 12 to 36 hours appeared to be fairly reasonable although conservative. The 48 and 60 hour forecasts calculated using the REEP method appear to be of little use for forecasting category 4 amounts.

In the spring and winter storm case studies, there appeared to be an anomaly where POPA forecasts for category 4 precipitation were much greater for the 00-12Z period than for the succeeding 12-24Z period. Of interest may be some observations from a cursory examination of preliminary statistics from the Research Section's POPA Verification project. The POPA Verification Project covers POPA forecasts for 10 B.C. stations for 1981. Of these 10, 6 stations including Vancouver Airport show POPA figures for the 00-12Z period to be much higher (in most cases double) than those for the 12-24Z period for cases when category 4 precipitation is occurring. Reasons for this discrepancy are not readily apparent. A diurnal factor in the predictor set is a possible cause. However, since the statistics cover the whole year of 1981 and the six stations have different predictor sets, it is thought the problem lies elsewhere. Another possible reason is that there may have been a more limited sample of category 4 precipitation events for the 12-24Z period when the predictor sets were chosen.

CONCLUSIONS

The following conclusions should be treated as very tentative due to the small sample evaluated.

For rainstorms where more than 10 mm of rain fell in a 12 hour period at Vancouver Airport, the POPA forecasts appeared reasonable although conservative for all seasons except the summer months. POPA figures seldom exceed 75% for category 4 precipitation. A value of 20% probability or more is required to imply any likelihood of category 4 precipitation. Possibly due to the very small sample of summer storms, the POPA forecast of category 4 rainfall amounts was poor and will likely remain so for that season.

In the cases studied, there was some correlation between the POPA and QPF forecasts but not as much as expected. Since each is derived differently, this is not surprising.

The POPA forecasts for the first 36 hours were of some value but beyond that the value was negligible.

There appears to be an anomaly between POPA forecasts for the 00-12Z period and the 12-24Z period. POPA figures for the 00-12Z period were markedly higher than for the 12-24Z period for two of the storms studied. As well this anomaly appears in preliminary statistical summaries prepared by the Research Section. This possible discrepancy should be resolved.

VANCOUVER RAINSTORMS

Date	Period	Prec. Amount	POPA Forecast % (CMC's QPF mm) of 10 mm Precipitation				
			12	24	36	48	60
April 3, 1982	00-12Z	11 mm	29(6)	52(6)	49(5)	14(3)	13(2)
	12-24Z	10 mm	12(5)	13(4)	15(4)	10(4)	8(4)
July 15, 1982	00-12Z	17 mm	8(M)	8(0)	3(0)	3(0)	0(0)
	12-24Z	12 mm	1(5)	0(M)	0(3)	2(2)	0(2)
October 31, 1981	00-12Z	32 mm	65(17)	42(12)	12(6)	10(5)	17(8)
	12-24Z	29 mm	38(18)	49(17)	24(12)	10(6)	8(5)
December 3, 1982	00-12Z	25 mm	75(10)	68(M)	37(9)	21(10)	M(9)
	12-24Z	12 mm	11(18)	14(20)	18(M)	18(21)	19(18)

M = Missing

Table 1

List of 4 rainstorms where Vancouver Airport recorded 10 mm or more rain over 12 hours. Also included are the POPA values in percent and CMC's QPF values in mm for the forecast 12 hour periods ending at 12, 24, 36, 48, and 60 hours.

FXCN05 CWA05 211740

PROB OF PCPN IN 4 RANGES: OVER 0.2MM, 0.2-2MM, 2-10MM, OVER 10MM

	TODAY					TUESDAY						WEDNESDAY						
	12-24Z					00-12Z			12-24Z			00-12Z				12-24Z		
YVI	52	34	17	1/	72	32	37	3/ 87	33	45	9/ 70	24	36	10/ 53	31	17	5
YZT	48	28	19	1/	85	29	48	8/ 83	26	49	8/ 71	16	33	22/ 71	31	32	8
YXT	79	38	40	1/	92	51	37	4/ 79	37	40	2/ 78	36	31	11/ 65	33	32	0
YXS	38	33	5	0/	30	26	4	0/ 39	34	5	0/ 48	36	11	1/ 31	31	0	0
YVR	56	21	31	4/	93	24	58	11/ 90	30	47	13/ 90	27	46	17/ 62	39	21	2
YHE	26	17	9	0/	50	25	23	2/ 40	22	17	1/ 59	17	27	15/ 55	22	27	6
YYF	8	7	1	0/	23	20	3	0/ 7	6	1	0/ 35	25	10	0/ 15	12	3	0
YRV	69	38	30	1/	37	23	14	0/ 60	30	29	1/ 59	11	38	10/ 24	24	0	0
YYE	5	5	0	0/	3	3	0	0/ 17	15	2	0/ 43	35	8	0/ 34	22	12	0
YPR	85	22	53	10/	81	25	39	17/ 89	20	58	11/ 78	18	38	22/ 76	17	44	15

FIGURE 1.

FOCN02 CWA05 211620

STN : VR SPECTRAL DATA FROM FEB 21 83 12 0

	HOURS	0	6	12	18	24	36	48	60
THK	10-5	535	538	542	543	544	547	543	537
	8-5	404	407	410	411	411	414	411	405
	8-7	152	153	154	154	155	156	155	153
Z	500	553	556	560	558	557	559	553	550
PCP			0	1	2	3	4	9	6
T	850	-1	0	1	2	3	4	3	0
	700	-10	-9	-7	-5	-4	-2	-4	-8
DPD	1000	3	4	3	3	3	2	2	2
	850	3	4	3	3	3	3	2	2
	700	9	6	4	1	2	3	1	2
RH	850	78	75	80	79	82	83	89	85
*	700	48	62	72	90	87	80	91	86
KI		11	12	16	21	24	21	25	22
DIV	850		6	1	-3	-1	-2	0	0
	300		-5	2	9	1	1	14	6
W	850		-6	-8	-10	-6	-14	-9	2
	700		5	-6	-8	-10	-8	-12	-8
CLD	L		11	53	85	89	71	99	85
	MED		7	59	92	84	77	98	83
	HI		20	59	57	60	60	64	56
TMP	SFC	4	4	7	9	10	10	11	11	10	10	9	7
MSL		1022	1025	1022	1022	1022	1017	1018	1017	1016	1013	1011	1016
DIR	1000	202	205	133	144	157	164	176	179	180	154	191	201
SPD	1000	9	7	12	16	18	23	23	22	22	23	27	12

FIGURE 2.

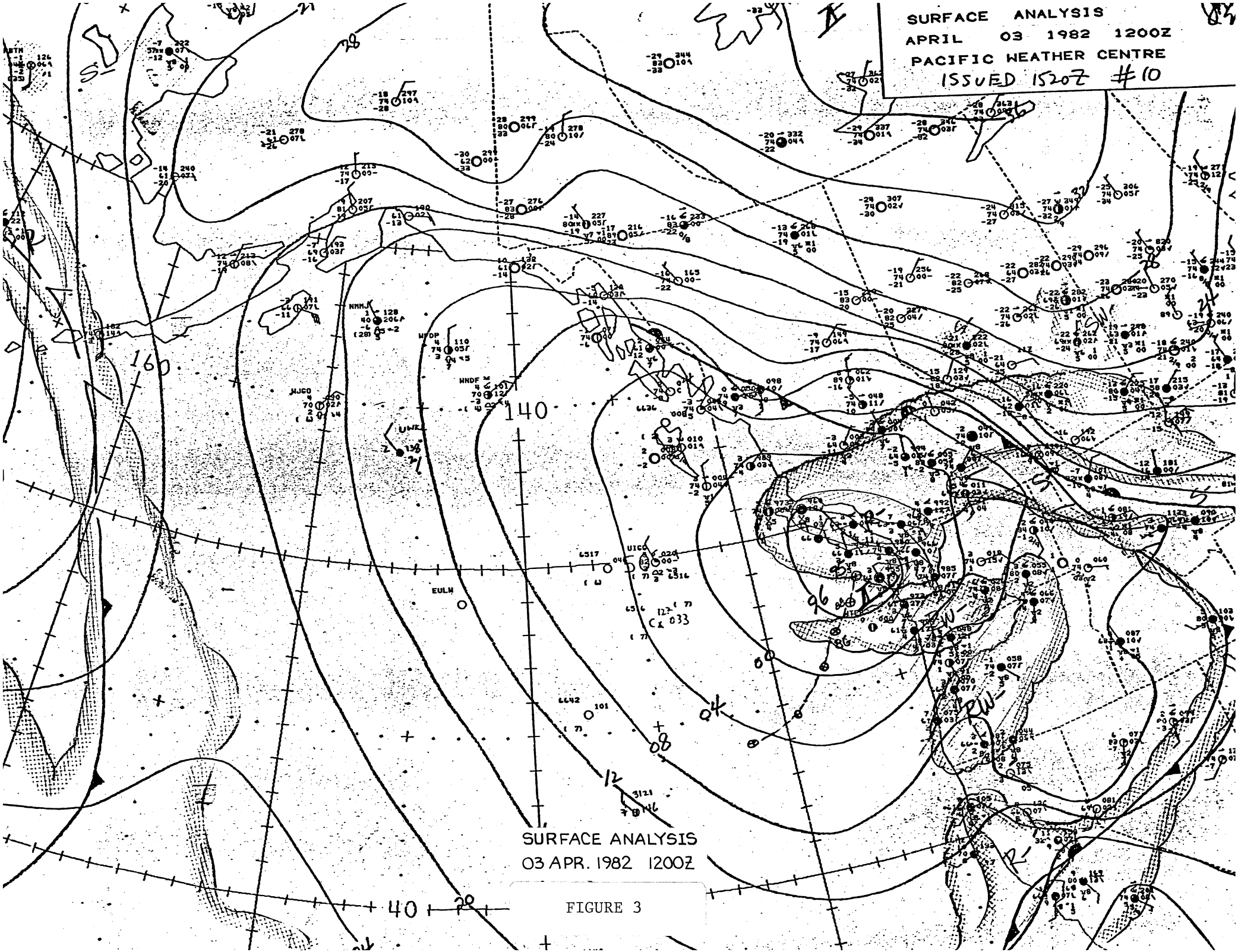
SURFACE ANALYSIS
APRIL 03 1982 1200Z
PACIFIC WEATHER CENTRE
ISSUED 1520Z #10
SURFACE ANALYSIS
03 APR. 1982 1200Z

FIGURE 3

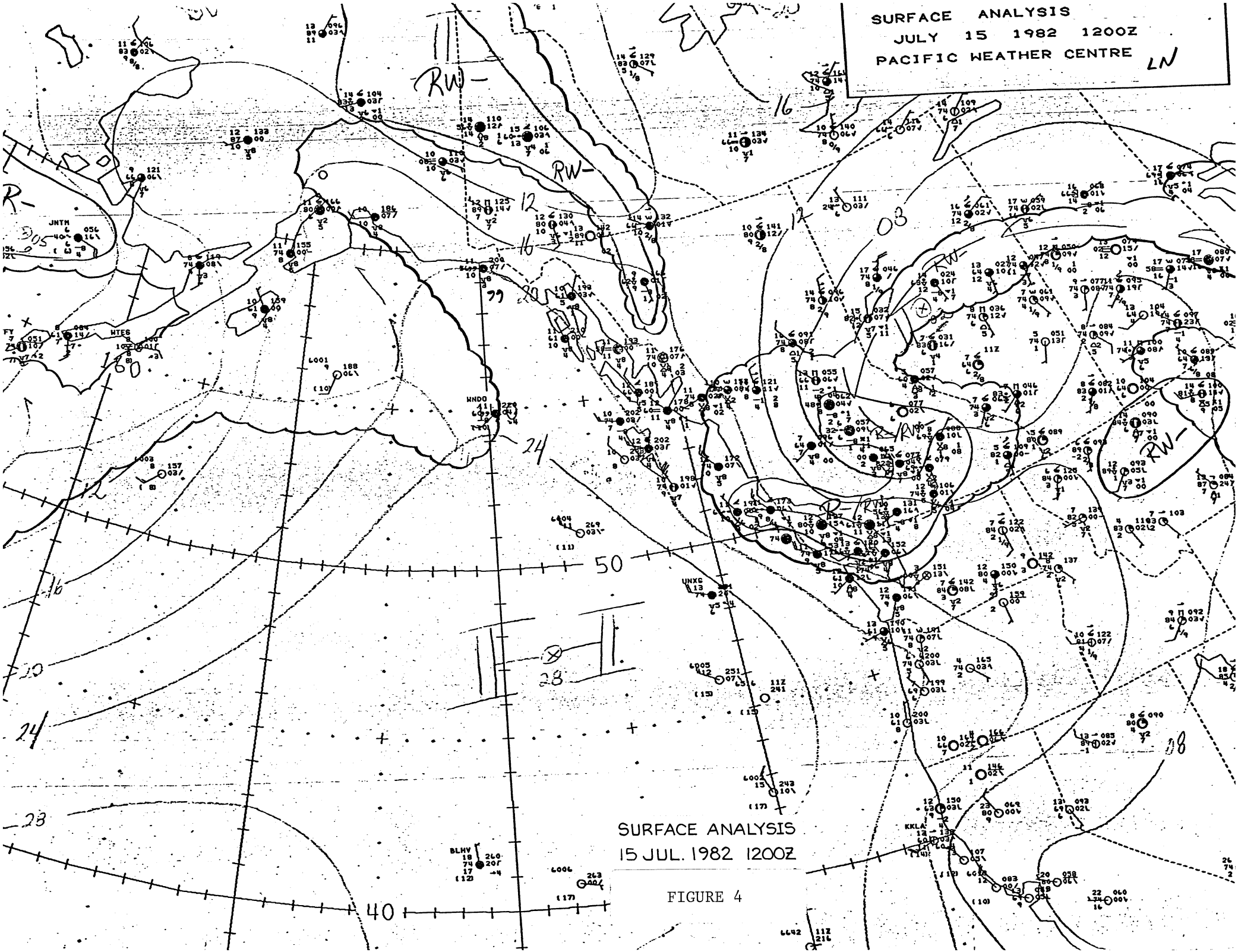
SURFACE ANALYSIS
JULY 15 1982 1200Z
PACIFIC WEATHER CENTRE
LN
SURFACE ANALYSIS
15 JUL. 1982 1200Z

FIGURE 4

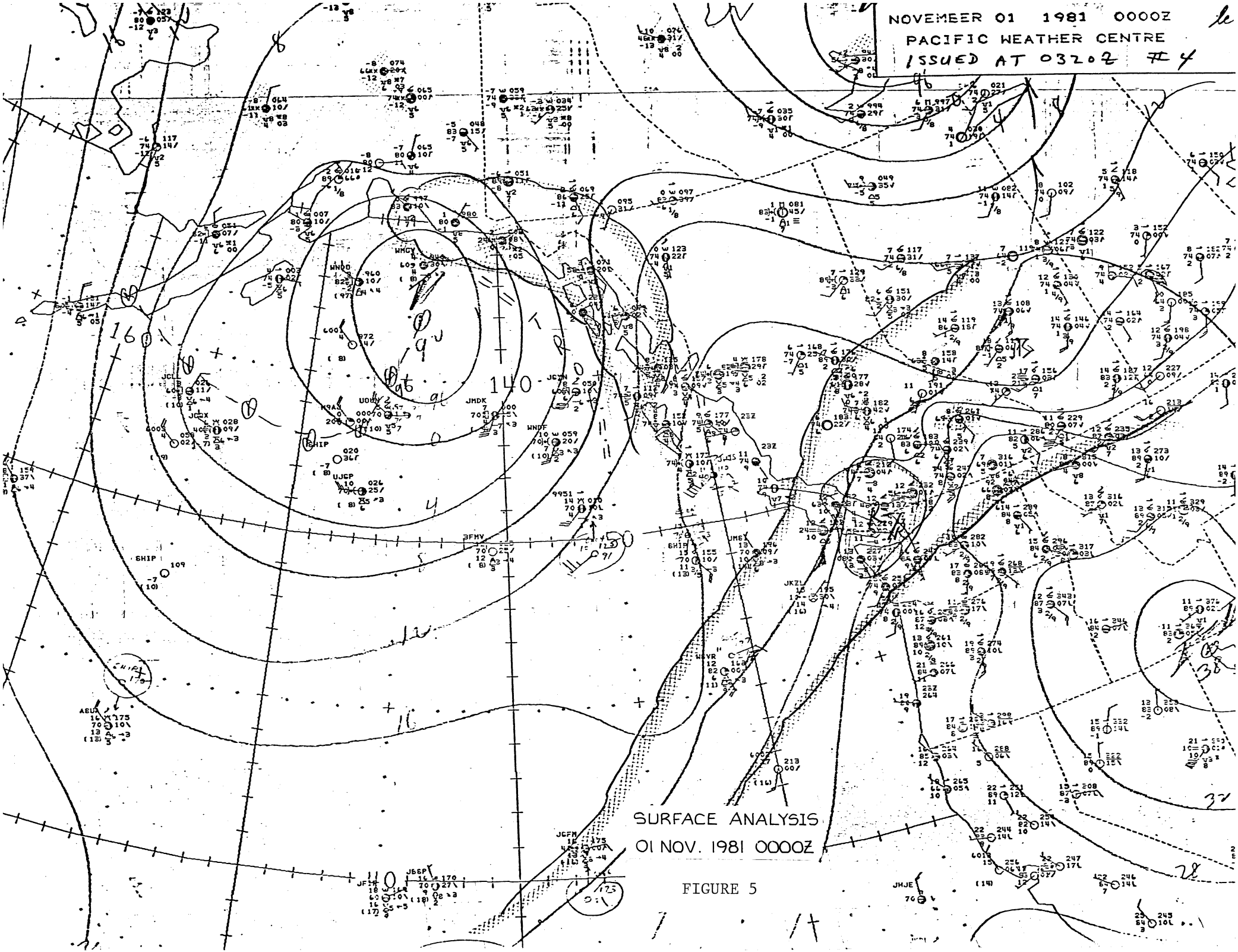
NOVEMBER 01 1981 0000Z
PACIFIC WEATHER CENTRE
ISSUED AT 0320Z #4
SURFACE ANALYSIS
01 NOV. 1981 0000Z

FIGURE 5

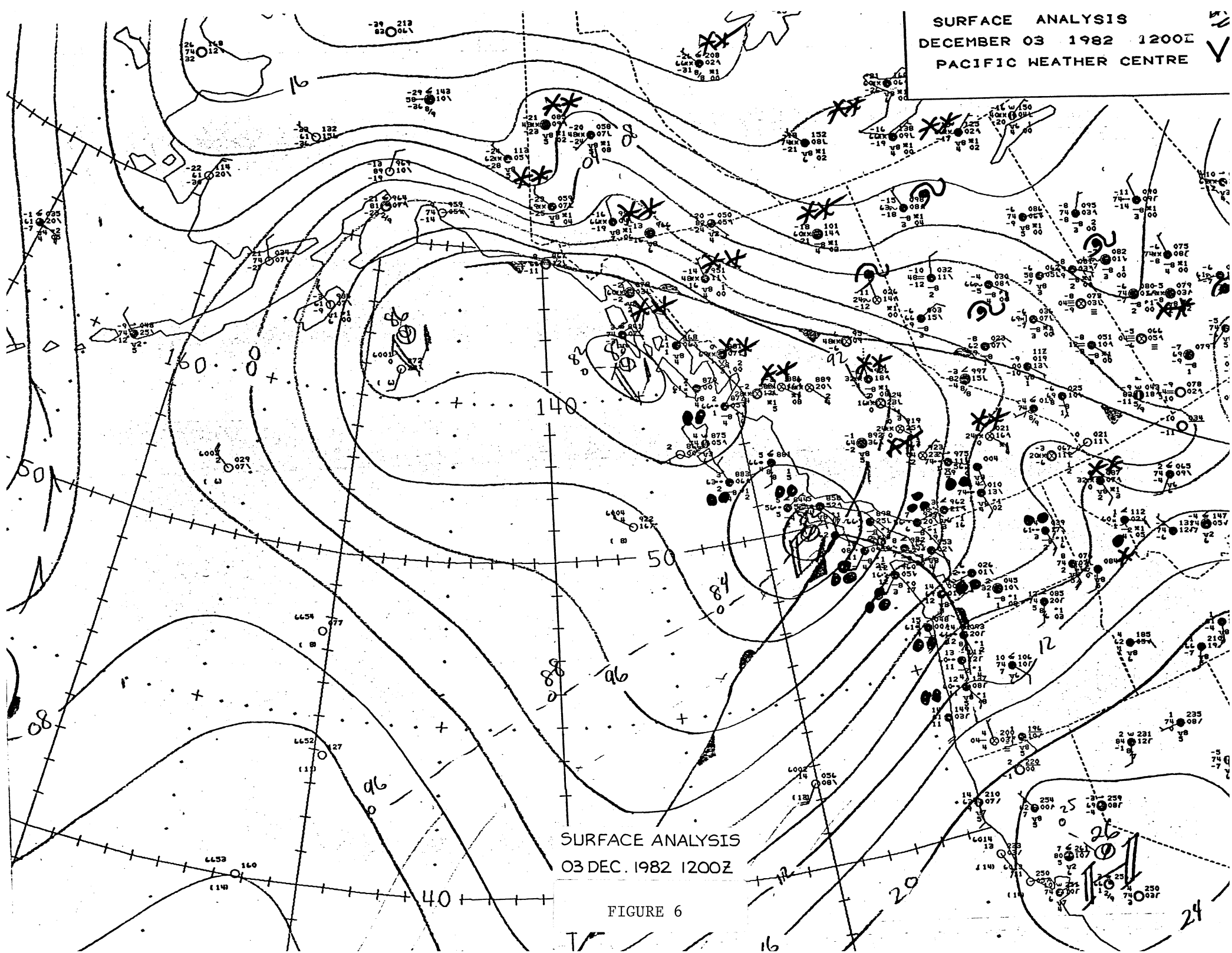
SURFACE ANALYSIS
DECEMBER 03 1982 1200Z
PACIFIC WEATHER CENTRE
SURFACE ANALYSIS
03 DEC. 1982 1200Z

FIGURE 6