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An Evaluation of the CMC 36-Hour Prognostic 500 mb Height at 5 West Coast Upper Air Stations

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INTRODUCTION

This Technical Note evaluates the performance of the CMC 36-hour prognostic height at 5 West Coast upper air stations. A previous Technical Note, 82-025, compared the CMC 36-hour prognostic 500 mb height before and after ship PAPA's removal. This note deals more specifically with the spatial distribution of the CMC 36-hour performance versus height tendencies.

1 - METHODOLOGY

A) Data

Five upper air stations representative of B.C. weather were chosen. They were; from north to south: Annette (ANN), Port Hardy (YZT), and Quillayute (UIL) on the coast; Prince George (YXS) and Vernon (WVK) in the interior.

The CMC 36-hour height values at the 5 West Coast upper air stations were abstracted from the CMC charts and tabulated against the 500 mb height values recorded by their respective radiosondes. The errors in the prognostic height (ΔZ) for each valid period, both 00Z and 12Z, were tabulated over a full year, 1982.

B) Height Tendency (definition)

The synoptic situations were classified in terms of the 500$_{mb}$ height tendencies. These tendencies were determined over a 24 hour period, using the height values 12 hours prior and 12 hours after the valid time of the prognostic.

The following defines the tendencies:

- / : Height has risen by 4 dm or more in 12 hours.
- — : Height hasn't risen or dropped by 4 dm or more in 12 hours.
- \ : Height has dropped by 4 dm or more in 12 hours.

These are then combined to form a 24 hour tendency. e.g. \/

For every height tendency category, a frequency distribution of the height error (ΔZ) was plotted for each upper air station (Figures 1-3). All distributions were smoothed by a method which averages the fluctuations of high frequencies. Finally, each frequency distribution was put in percent. More details on the equations used are available in Appendix I.

2 - FREQUENCY DISTRIBUTION OF HEIGHT TENDENCIES

Table I shows that the frequency distribution is similar for all upper air stations. As expected, the category representing the very slowly changing synoptic patterns (--) contained the highest number of cases (34%). Only 22% of all cases are found in the categories representative of the fast changing synoptic situations (/ , /\, \/, \ ).

The table also shows that the standard deviation, except for a few exceptions, slowly increases as the amount of data decreases with most values between 3.5 to 5.5. However, there is no evident relation of the standard deviation versus upper air stations.

3 - SYNOPTIC SITUATIONS (based on height tendencies)

A) Situations of significant rising height in the first 12 hours: (/ , /‾ , /\).

In these categories, Figure 1 shows that the average error is mainly negative. If the error is generally slight in the (/) category (-1.5 to +0.4), the underestimation of the CMC model is more pronounced in the (/‾) category (-2.5 to -0.4) and becomes really significant in the (/\ ) category (-4.0 to -1.5).

Geographically, Figure 1A shows that the underestimation becomes more pronounced as one travels southeastward from the northern B.C. coast. On Figure 1B, a ridge of average error is observed from central B.C. southeastward. On Figure 1C, a stronger ridge from the southern B.C. coast northeastward takes place.

B) Situations of steady height in the first 12 hours: (_/ ,--, ‾\).

Figure 2 shows that the model significantly overestimates the height in the (_/) category (+1.5 to +3.2). The trend is less pronounced in the (—) category (+0.5 to +1.9) becomes almost inexistent in the (‾\) category (-0.6 to +0.7).

Geographically, Figure 2A shows a ridge of average error from the central B.C. coast towards southeastern B.C. On Figure 2B, the ridge is weaker and oriented northeastward. On Figure 2C, the positive values over northwestern B.C. become negative in southeastern B.C.

C) Categories of significant dropping height in the first 12 hours: (\/ ,_, \ ).

As Figure 3 shows, the poorest performance of the CMC model is seen in the (\/) category (+4.3 to +10.1) with a systematic average error of the order of 5-10 dm. A strong average overestimation of the order of 3-5 dm is also observed in the (_) category (+2.3 to 4.3). A still significant positive average error in the 2-4 dm range is shown in the (\ ) category (+0.9 to +3.7).

Figure 3A shows an average error ridge of approximately 10-12 dm off the central B.C. coast extending east-southeastward. Figure 3B shows that the overestimation becomes less pronounced as you travel northeastward from the southern B.C. coast. Figure 3C shows a ridge extending eastward from the central B.C. coast.

CONCLUSION

A) Height Tendency

Figures 1, 2, & 3 are summarized in Table II. Three main conclusions can be seen from Table II:

1. On overall average, the CMC 36-hour slightly overestimates the height by 1-2 dm.

2. Looking at the height tendencies during the first 12 hours, the average error always increases in relative values as you move from the rising (/) to the dropping categories (\ ).

3. Looking at the height tendencies during the last 12 hours, the average error always decreases in relative values as you move from the rising (/) to the dropping (\ ) categories.

With respect to these conclusions, all compiled results show a rather poor performance from the model when falling, then rising heights (\/) occurred as would be expected in shortwave and frontal passages. Significant overestimation of the order of 2-4 dm are systematically observed in the (_/ , _, \ ) categories. The (/\ ) category also presents a significant bias towards underestimation. Table I-II shows that the CMC model performs within an acceptable range of $\pm$ 2 dm about 60% of the time.

B) Geographical peculiarities

The highest relative error values are usually found just off the central B.C. coast. Future studies would be necessary to relate the different patterns observed in Figure 1A-B-C, 2A-B-C, and 3A-B-C in relation to the height tendency categories. The probable step would be to look at the frequency distribution of the upper air flow directions versus height tendency categories.

REFERENCES

Poirier, D., "Comparison of CMC 36-Hour Prognostic 500 mb Height Before and After Ship PAPA's Removal", Pacific Region Technical Note 82-025.

APPENDIX I

ΔZ	Error on height.
j	Subscript for height error values where $Z \equiv j$, $(-15 \leq j \leq +15)$.
s	Subscript for upper air stations where $s \in$ [ANN, YZT, UIL, YXS, WVK].
c	Subscript for height tendency categories where $c \in$ [/, ⌜, ∧, ⌟, −, ¬, ∨, ⌞, \].
N(j)	Number of cases where $\Delta Z \equiv j$.
Ncs(j)	N(j) versus station/category.
N'cs(j)	Ncs(j) smoothed and put in percent.
$Ncs \equiv N$	Total number of cases versus station/category.
$Ns \equiv \sum_c Ncs$	Total number of cases over all categories for a station.
$Nc \equiv \sum_s Ncs$	Total number of cases over all stations for a category.
$N \equiv \sum_c \sum_s Ncs$	Total number of cases.
$\bar{X}cs \equiv \bar{X}$	Average error in height derived form a station/category distribution.
$\bar{X}c \equiv \sum_s \bar{X}cs$	Approximation of the average error over all stations for a category.
$[\bar{X}cs]c$	Minimum and maximum average error for a category.
$\sigma cs \equiv \sigma$	Standard deviation derived from a station/category distribution.
$\sigma c \equiv \sum_s \sigma cs$	Approximation of the standard deviation over all stations for a category.
$[\sigma cs]c$	Minimum and maximum standard deviation for a category.
$[\sigma cs]s$	Minimum and maximum standard deviation for a station.

$$\Delta Z = Z \text{ (CMC PROG)} - Z \text{ (RADIOSONDE)} \equiv j$$

$$N'cs(j) = \left\{ [N_{cs}(j-1) + 2N_{cs}(j) + N_{cs}(j+1)]/4N_{cs} \right\} \%$$

$$\bar{X} \equiv \bar{X}cs = \sum_j [N'cs(j) * j/100]$$

$$\sigma \equiv \sigma cs = \left\{ \sum_j [N'cs(j) * (j-Xcs)^2/(100-1)] \right\}^{\frac{1}{2}}$$

TABLE I

Frequency Distribution of Height Tendency Categories

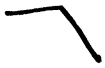
Stations (c) (s) Categories	ANN	YZT	UIL	YXS	WVK	$N_c \equiv \sum_s N_{cs}$ (%)	$\sigma_c \equiv \sum_s N_{cs}$ $[\sigma_{cs}]_c$ RANGE
	59 9%	66 10%	48 8%	40 6%	54 8%	267 (8%)	4.0 (3.8-4.2)
	78 12%	70 10%	73 12%	80 12%	93 14%	394 (12%)	3.8 (3.6-3.9)
	18 3%	20 3%	16 3%	13 2%	20 3%	87 (3%)	5.0 (4.0-6.7)
	74 11%	67 10%	69 12%	80 12%	85 12%	375 (11%)	3.9 (3.7-4.5)
	213 32%	217 32%	191 32%	293 43%	199 29%	1113 (34%)	4.0 (3.7-4.6)
	70 11%	88 13%	72 12%	63 9%	82 12%	375 (11%)	4.4 (4.0-4.6)
	28 4%	29 4%	24 4%	15 2%	27 4%	123 (4%)	5.2 (4.4-5.8)
	68 10%	75 11%	61 10%	61 9%	75 11%	340 (10%)	4.7 (4.1-5.6)
	49 7%	49 7%	43 7%	41 6%	50 7%	232 (7%)	4.7 (4.1-5.2)
$\sum_c N_{cs} \equiv N_s$ (%)	657 (99%)	681 (100%)	597 (100%)	686 (101%)	685 (100%)	3306 (100%)	$N_{cs} \equiv N$ (%)
$[\sigma_{cs}]_s$ RANGE	(3.7-6.7)	(3.9-5.4)	(3.8-4.7)	(3.7-5.3)	(3.6-5.0)		

TABLE II

Average Errors Versus Height Tendency Categories

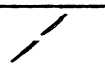
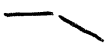
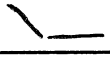
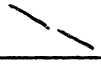
Height Tendency			
$\sum_s \overline{X}_{cs} \equiv \overline{X}_c$ $[\overline{x}_{cs}]_c$ RANGE	-0.5 (-1.5/+0.4)	-1.6 (-2.5/-0.4)	-2.7 (-4.0/-1.5)
Height Tendency			
$\sum_s \overline{X}_{cs} \equiv \overline{X}_c$ $[\overline{x}_{cs}]_c$ RANGE	+2.2 (+1.5/+3.2)	+1.0 (+0.5/+1.9)	+0.1 (-0.6/+0.7)
Height Tendency			
$\sum_s \overline{X}_{cs} \equiv \overline{X}_c$ $[\overline{x}_{cs}]_c$ RANGE	+6.5 (+4.3/+10.1)	+3.5 (+2.3/+4.3)	+2.4 (+0.9/+3.7)

FIGURE 1.

FREQUENCY DISTRIBUTION OF CMC 500MB 36HR FORECAST HEIGHT ERRORS VERSUS SYNOPTIC PATTERNS AT 5 WEST COAST UPPER AIR STATIONS.
(SYNOPTIC PATTERNS BASED ON 500MB HEIGHT TENDENCIES)

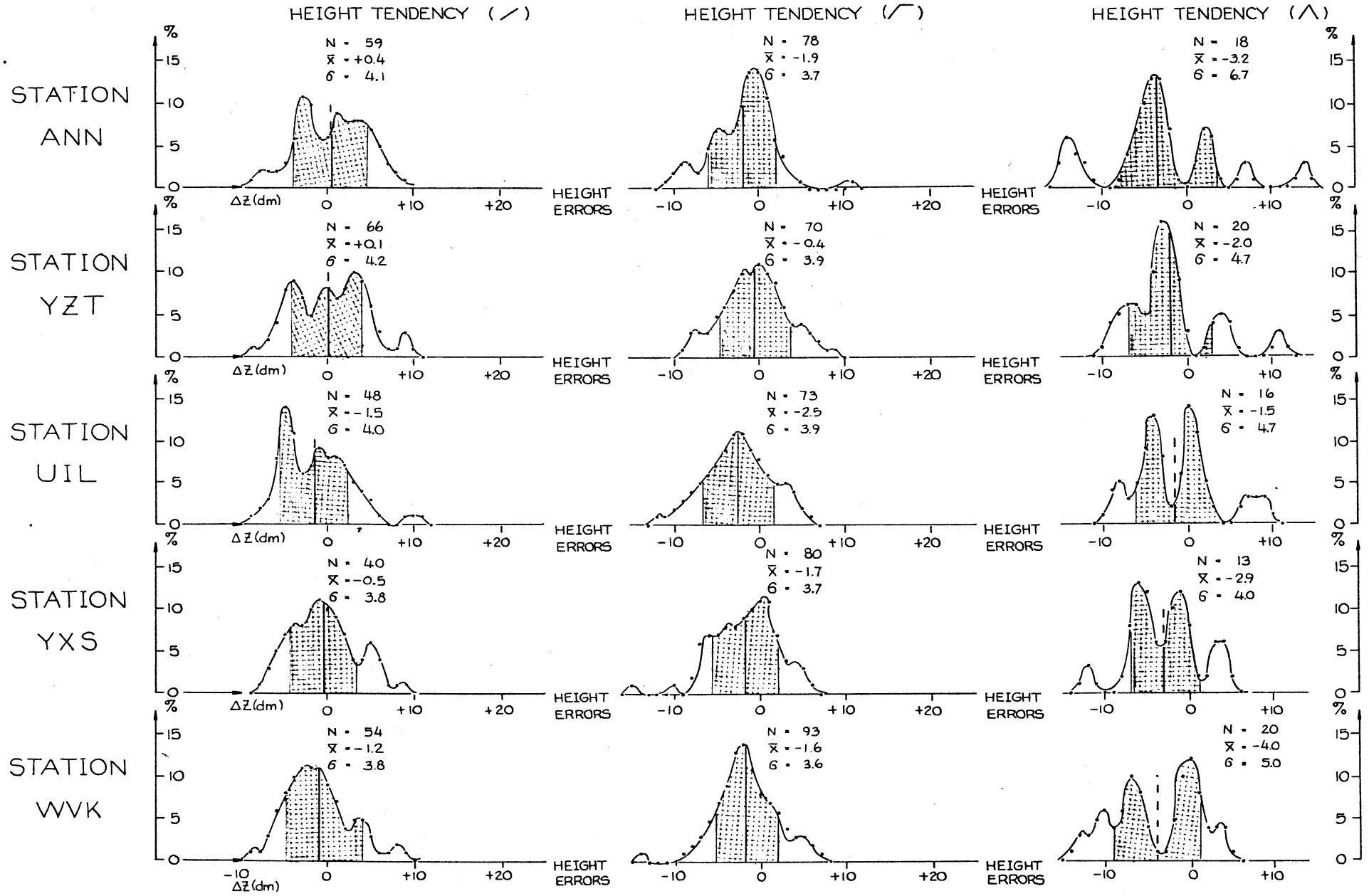


FIGURE 2.

FREQUENCY DISTRIBUTION OF CMC 500MB 36HR FORECAST HEIGHT ERRORS VERSUS SYNOPTIC PATTERNS AT 5 WEST COAST UPPER AIR STATIONS.
(SYNOPTIC PATTERNS BASED ON 500MB HEIGHT TENDENCIES)

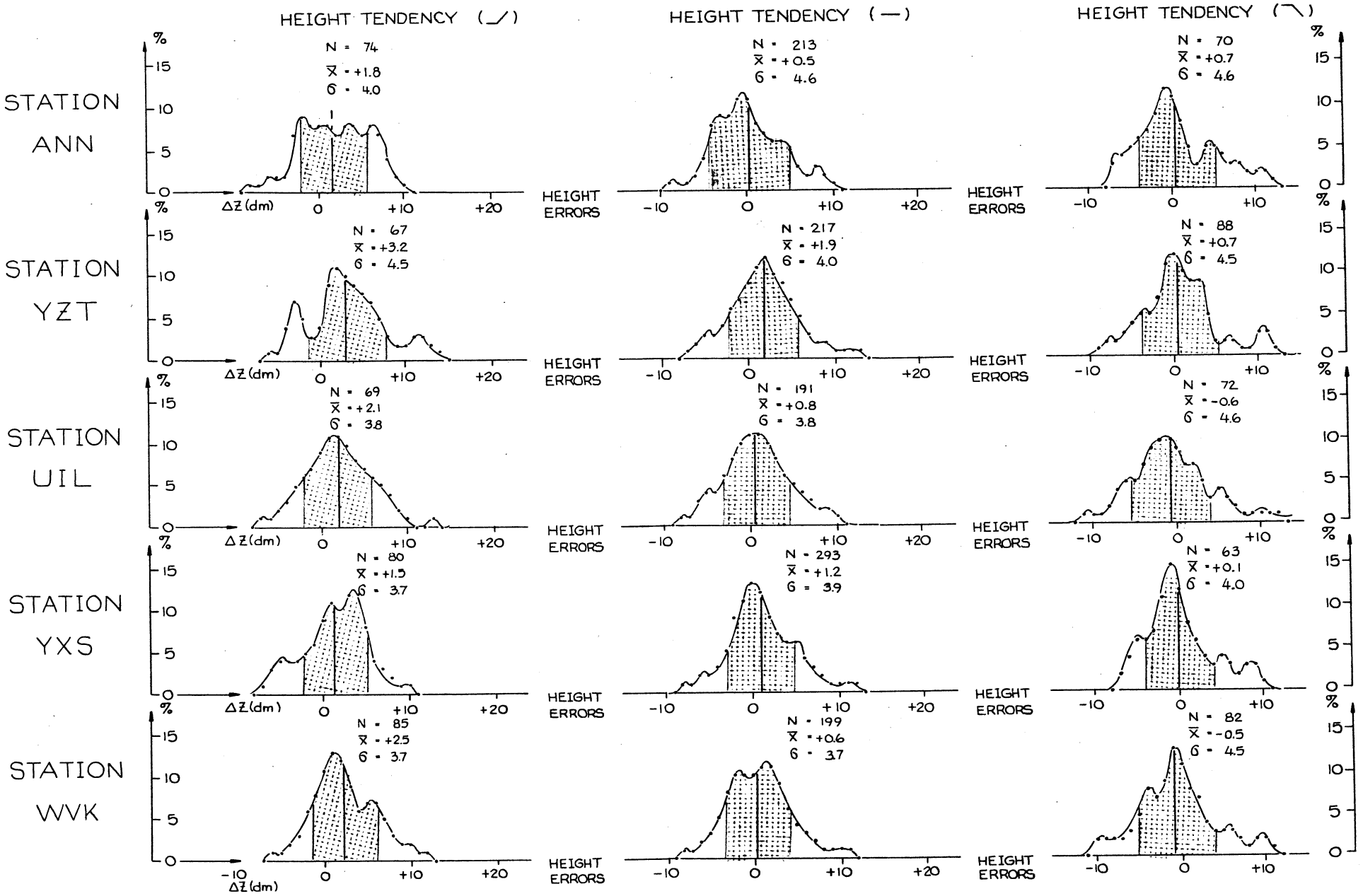
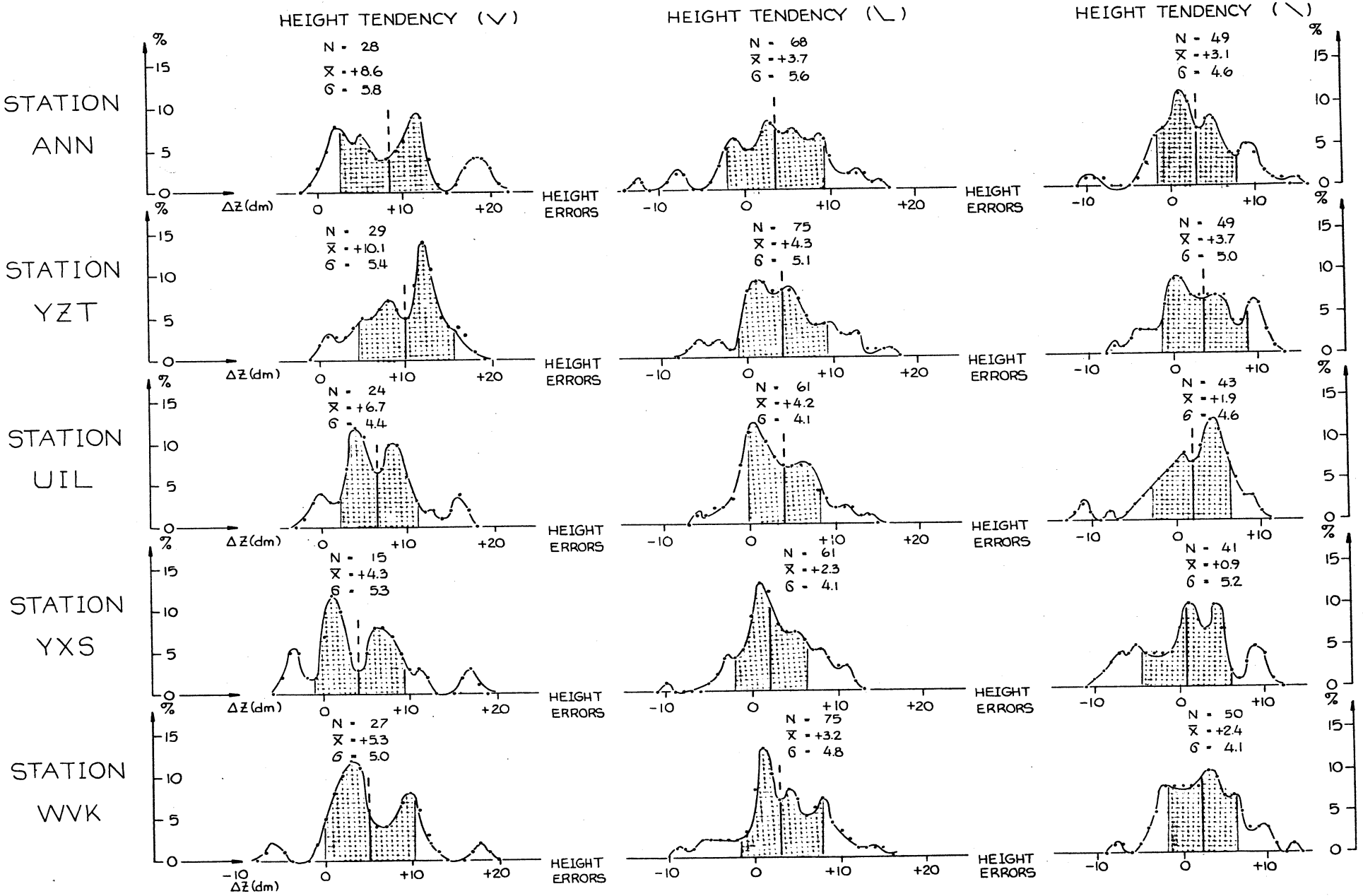


FIGURE 3.

FREQUENCY DISTRIBUTION OF CMC 500MB 36HR FORECAST HEIGHT ERRORS VERSUS SYNOPTIC PATTERNS AT 5 WEST COAST UPPER AIR STATIONS.

(SYNOPTIC PATTERNS BASED ON 500MB HEIGHT TENDENCIES)



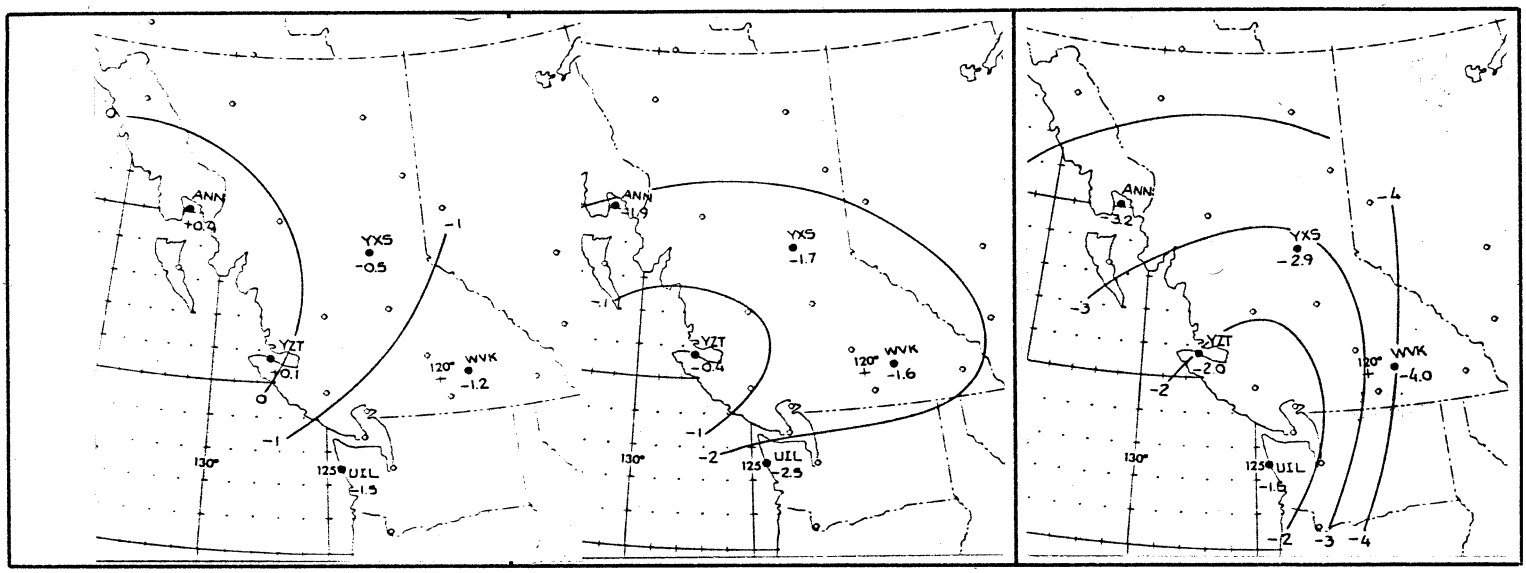


FIGURE 1A FIGURE 1B FIGURE 1C

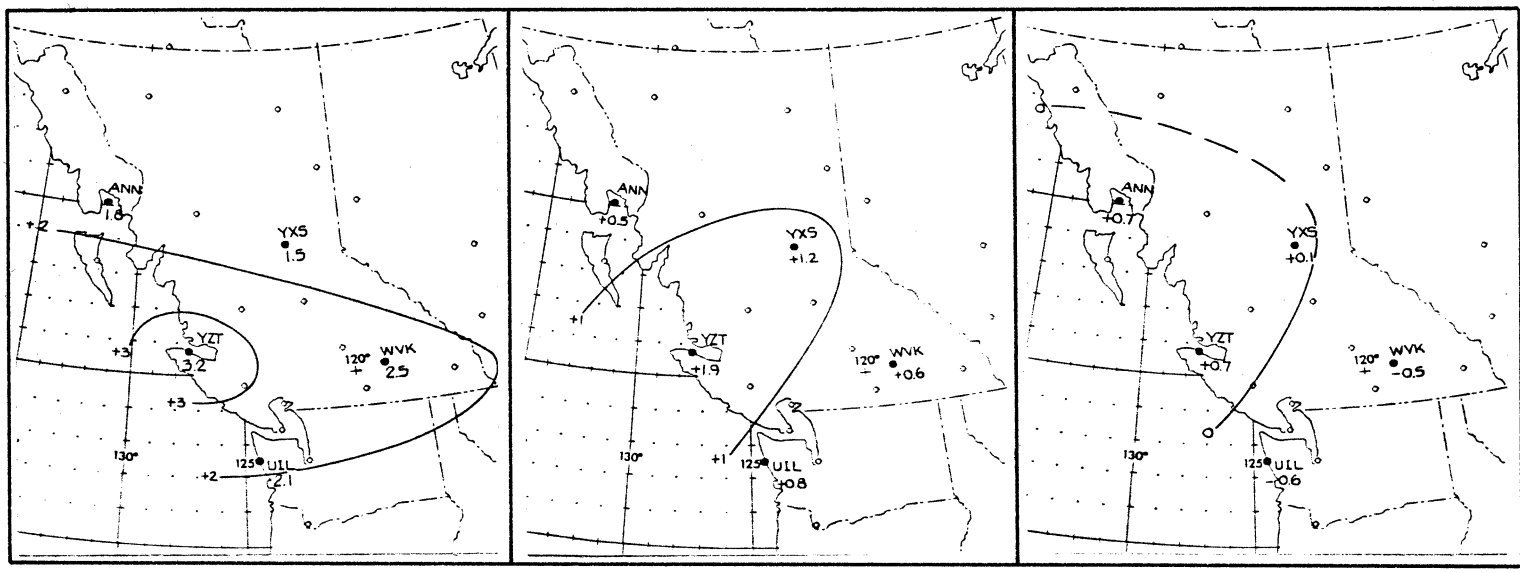


FIGURE 2A FIGURE 2B FIGURE 2C

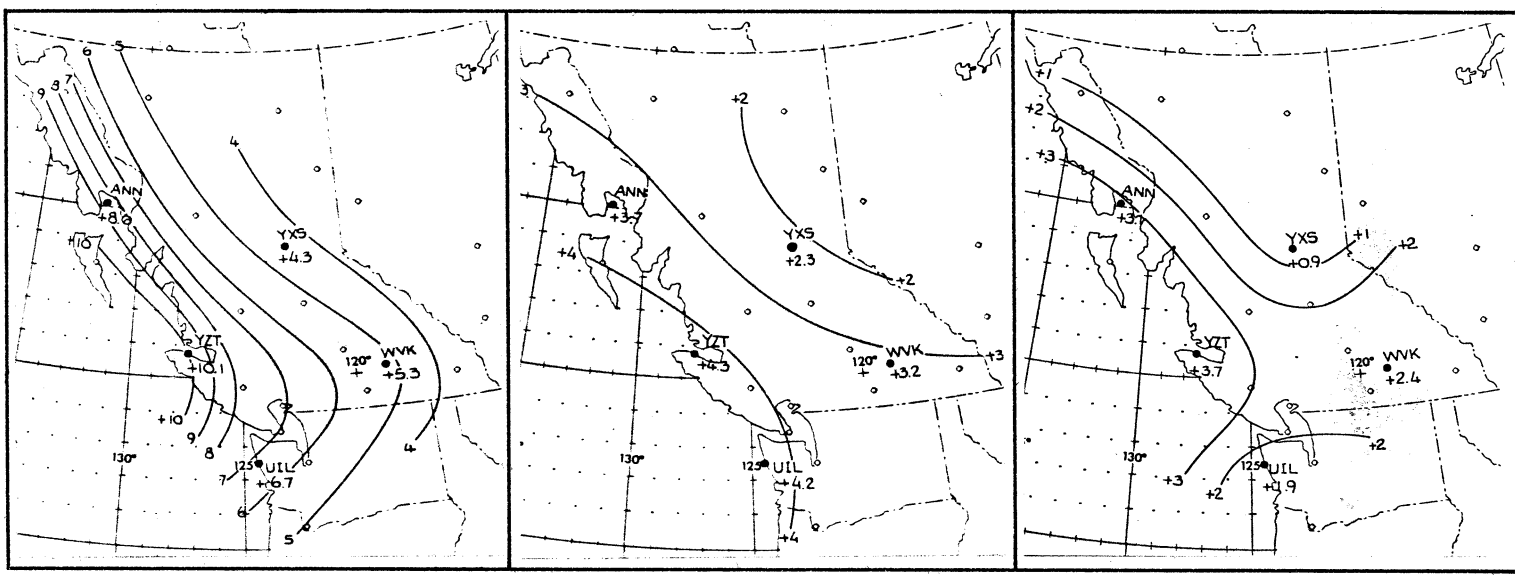


FIGURE 3A FIGURE 3B FIGURE 3C