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VERIFICATION OF AN OBJECTIVE METHOD TO FORECAST FRONTAL PASSAGES IN THE HAWAIIAN ISLANDS

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ABSTRACT

The University of Hawaii, under Techniques Development Laboratory sponsorship, has developed an objective technique to forecast the probability of frontal passage within 24 hours at four Hawaiian stations. 1271 forecasts of frontal passage within 24 hours at these stations were made from a synoptic surface chart series independent of the basic series used to derive the objective forecast technique. Results are shown and discussed. The system appears to forecast best the NO frontal passage contingency with very high reliability.

VERIFICATION OF AN OBJECTIVE TECHNIQUE TO FORECAST FRONTAL PASSAGES IN THE HAWAIIAN ISLANDS

I. DISCUSSION

An objective technique designed to provide a probabilistic forecast of frontal passage, within a 24-hour period, at four Weather Bureau first order stations in Hawaii has been developed by the University of Hawaii under sponsorship of the Techniques Development Laboratory, Systems Development Office.

Over 30 years of synoptic surface charts of the Northern Pacific provided the source of data needed to develop this objective forecast system. Details of the data acquisition are described by Worthley (1). Development of the resulting forecast technique is also described by Worthley (2). The collection of data used in development of the forecast technique ended with November 1967 surface charts.

The objective frontal passage forecast technique provides the forecaster with a set of templates scaled to fit a 1/20M Mercator projection -- a base map projection in common use in the Pacific by various weather service agencies. Examples of two of these templates are shown as figures 1 and 2. When using this technique the forecaster first determines if a front (nominally "cold") approaching the island chain is within one of the three areas shown in figure 3. If so, positions of the center of the following high, or the nearest frontal low in case there is no closely following high, are used to specify the probability of the approaching front passing one of four first order stations within the 24 hours following map time. The four first order stations for which forecasts are made are, from higher to lower latitude, Lihue, Kauai; Honolulu, Oahu; Kahului, Maui, and Hilo, Hawaii.

II. VERIFICATION

An excellent opportunity to make a partial verification of the objective technique arose when the Scientific Services Division, Pacific Region, obtained the services of Mr. Dennis Kamihara, a summer student assistant. Surface charts for the months of December 1967 through April 1968, and October 1968 through April 1969 were obtained from WBFO, Honolulu files. These charts encompass two winter seasons in Hawaii. During the winter season in Hawaii cold frontal passages occur with reasonable expectation, averaging 16 per year at Lihue [Worthley (1)].

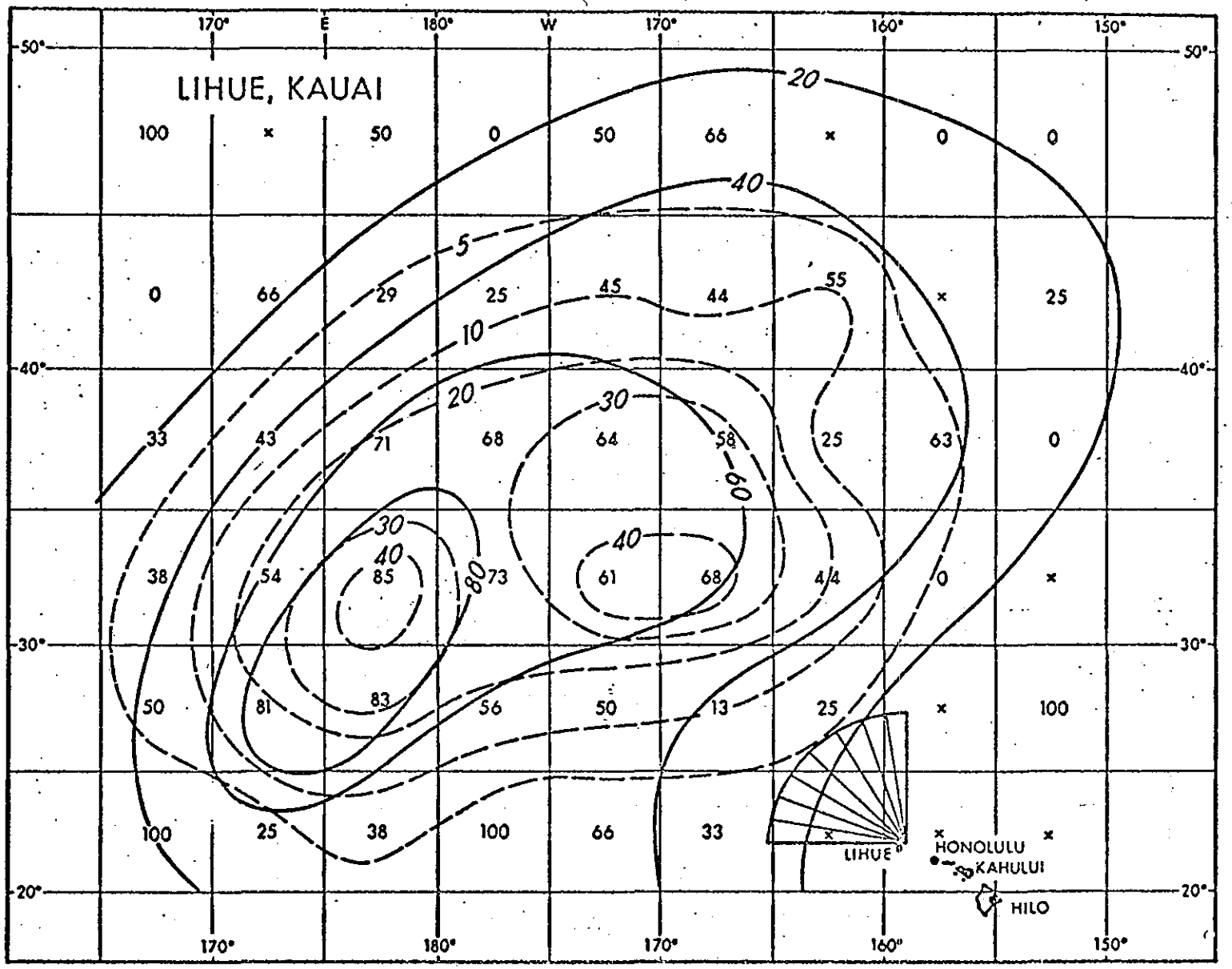

Figure 1. Probability of frontal passage at Lihue, Kauai, if front is in sector 2 and a high cell exists behind the front. Read percent probability at location of high cell center. Solid lines are isopleths of probability. The dashed lines are not used in applying this technique.

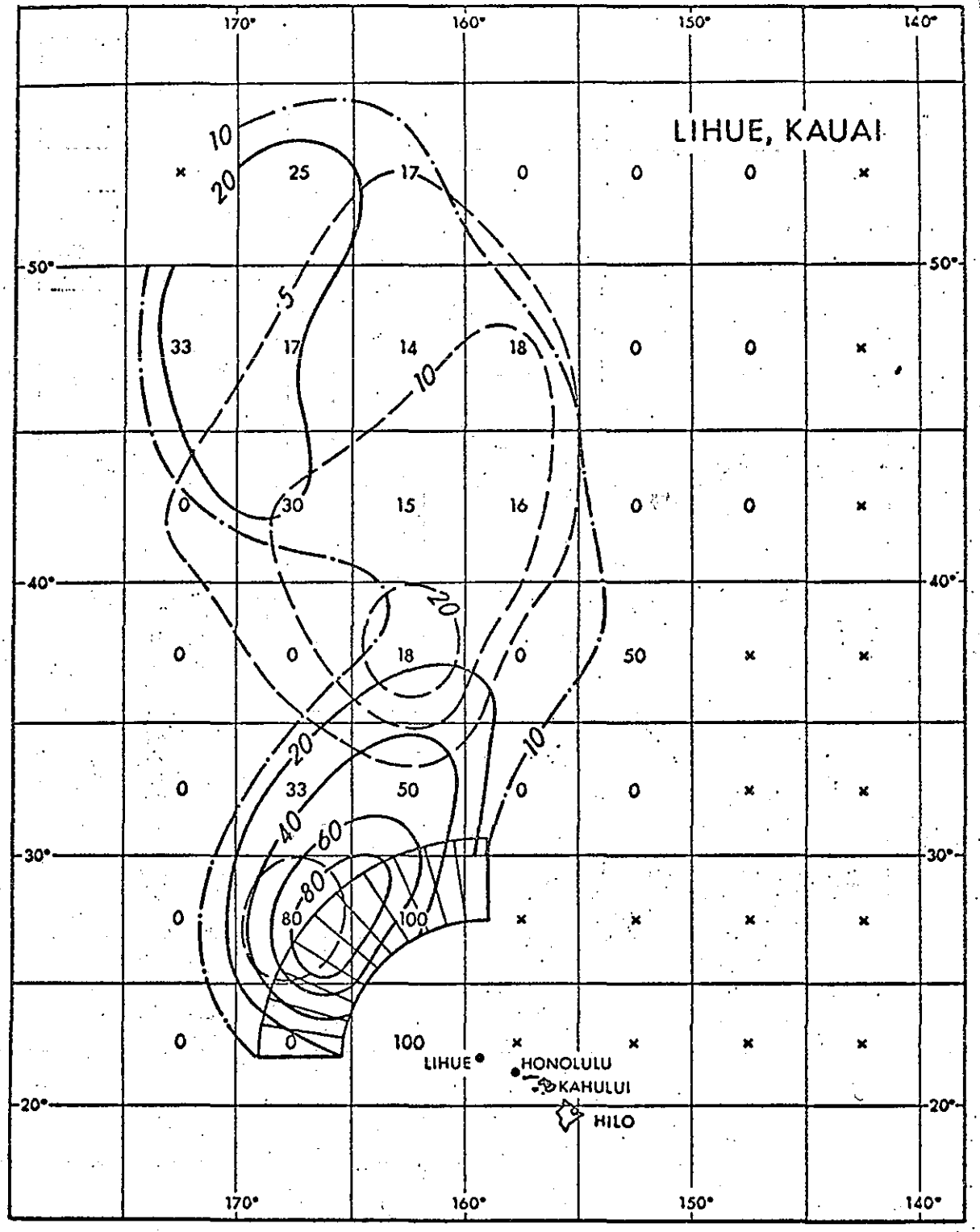

Fig. 2. Frequency of cold frontal passage within 24 hours of map time at Lihue, Kauai, with front in Area I and no high cell behind the front. Frequency is read for position of frontal low closest to Hawaii. Format same as Figure 1.

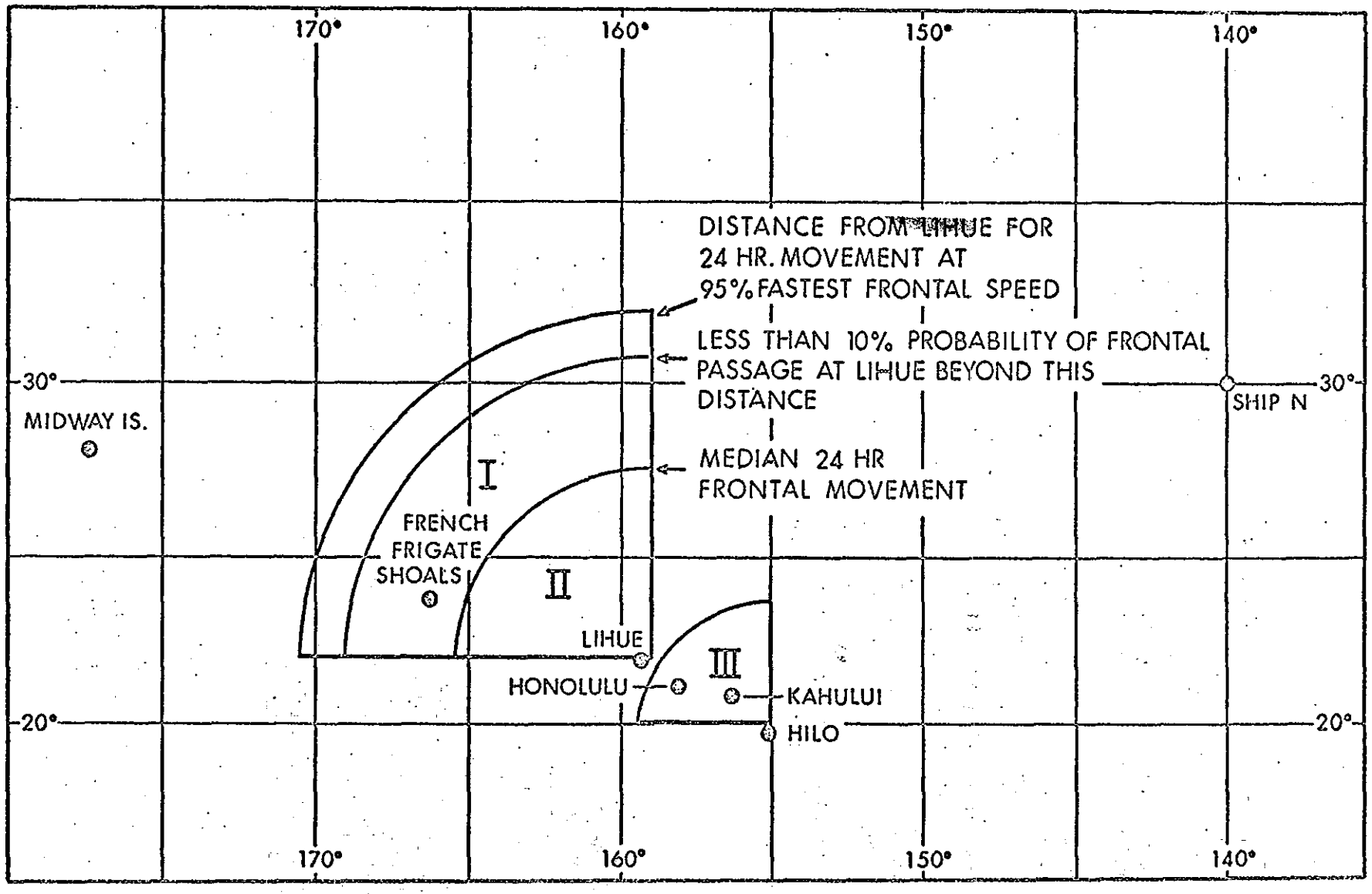

Fig. 3. Locator map showing areas of frontal position.

Charts for the month of March 1968 were not available. Surface analyses, for every six hours, were available.

Mr. Kamihara seemed ideal for the experiment. He had not taken any courses in or had any previous experience in synoptic meteorological analysis. It could be fairly said that he ought to be able to apply the objective technique with the least bias. He was given only the bare minimum of assistance in answering questions. For a working basis he was told to regard any blue line with pointed "teeth" on the chart and within an appropriate sector as a front for forecasting purposes.

Forecasts were made for the four stations every six hours. If no fronts were in any of the appropriate sectors, a forecast zero probability of passage was assigned for each station.

Results of this exercise were tabulated and stratified into 10% class intervals, beginning at 5% for each station. 0-5% was a special class. There are no data for the 95-100% as the system does permit 100% probability forecasts. Data results were further grouped by months, seasons, and finally combined for the two season period of the test.

Results of the final grouping are shown in figure 4 as graphs of forecast probability versus relative frequency of occurrence. Any class interval having 5 or less members is ignored.

III. RESULTS

Perhaps a period of only two seasons is too short for comprehensive verification, but it should be long enough to obtain a fair measure of technique utility. Discussion of results shown in figure 4 follow:

1. Lihue. More fronts pass this northernmost station than any other. The technique appears to fit well in the lower probabilities. The near zero probability case has the largest population and shows excellent reliability. The lack of high reliability in the higher forecast probabilities, especially when compared to Honolulu, may well reflect the uncertainty of frontal positions in the great oceanic spaces north of Kauai. Of course, we are now able to detect frontal positions through satellite imagery. This valuable analysis tool was not routinely available until 1966 and the lack of precision in locating fronts prior to 1966 may well have an effect on the basic statistics for Lihue.

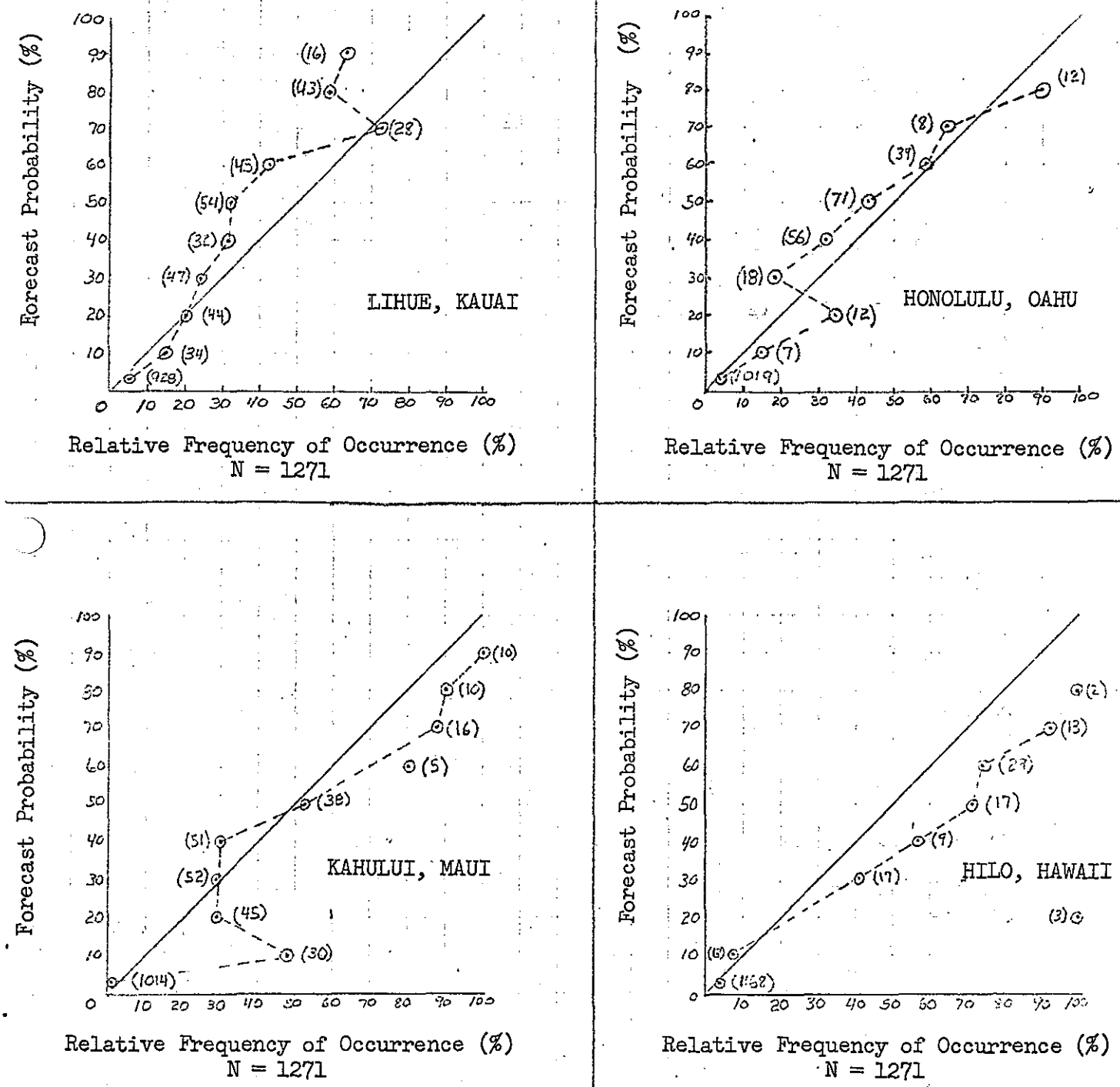

Figure 4. The forecast probability of frontal passage versus relative frequency of occurrence graphs for four Hawaiian stations. 1271 objective forecasts were made for the 1967-68 and 1968-69 winter seasons. Numbers in ( ) indicate the population in each class.

2. Honolulu. Honolulu shows the best forecast reliability of any of the stations tested. This may be because in the past 30 years the existence and position of a front was better known than in the Lihue case because of observed passage at Kauai. One interesting side benefit obtained here. During the experiment, sometimes the approaching front lay in the gap between sector II and Honolulu. In this instance the relative frequency of occurrence of frontal passage at Honolulu in 24 hours was 86%. We can use this to formulate a tentative probability rule to cover this circumstance as follows:

> "When a 'cold' front is between Lihue and Honolulu the probability of passage at Honolulu within the next 24 hours after map time is 86%."

3. Kahului. The lower frequency of frontal passage at more southerly stations is evident. The tendency shown by the system is to forecast frontal passage somewhat underconfidently when higher probabilities are indicated.

4. Hilo. Frontal passage at Hilo occurs much less often than at Lihue. In some categories, too few cases (≤ 5) existed to verify. Again, as at Kahului, the test showed a tendency to be underconfident when considering higher probabilities.

5. Chi Square Tests. Computation of a χ^2 statistic was made from the data distributions for each of the four stations. It was hoped that this statistic would confirm the hypothesis that the forecast and observed probabilities are reasonably from the same population. It was also intended to use this statistic to indicate a goodness of fit parameter. An impediment exists in that there is no long term climatology of frontal passage probability available, forcing us to derive "expected" frequencies from our test data. The statistic has the well known form:

$$\chi^2 = \sum_{i=1}^{10} \frac{(O_i - E_i)^2}{E_i}$$

where O_i is the observed number of frontal passages for a given probability category and E_i is the corresponding expected number of frontal passages from the test data. χ^2 values were obtained as follow:

Lihue	$\chi^2 = 13.35$
Honolulu	$\chi^2 = 2.05$
Kahului	$\chi^2 = 10.99$
Hilo	$\chi^2 = 7.98$

At nine degrees of freedom the approximate probability that $\chi^2 > \chi^2_o$ is as follows:

Lihue	15%
Honolulu	> 99%
Kahului	30%
Hilo	60%

Subjectively, one could say that the goodness of fit of the data at the four stations is: Lihue, poor; Honolulu, excellent; Kahului, fair; and Hilo, good.

IV. CONCLUSION

In our opinion, the best forecast of the system was the forecast of NO frontal passage. When the system indicated less than 5% probability of frontal passage, there were few "busts". Since this is by far the most common contingency, this objective technique can be a valuable assistant to the forecaster in initially segregating synoptic situations into categorical "YES/NO". If NO is indicated, he can accept this with a high degree of confidence.

There appears to be overconfidence in forecasting higher probabilities at Lihue and, to a lesser extent, at Honolulu. Conversely, there appears to be underconfidence in forecasting higher probabilities at Kahului and Hilo.

V. ACKNOWLEDGEMENTS

My thanks to Mr. Dennis Kamihara for his diligent efforts in making the large number of forecasts necessary to test the system. Also, thanks to Mr. Joseph Vederman for his comments and to Dr. Harry R. Glahn, TDL, for his general suggestions about verification procedures and especially for his suggestion about the χ^2 test.

VI. BIBLIOGRAPHY

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2. Worthley, L. E., 1968 "Forecasting Cold Frontal Passage Within 24 Hours of Map Time in Hawaii", HIG Report 68-5, University of Hawaii, pp. 19.