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COST EFFECTIVENESS EVALUATION OF DROPSONDE DERIVED SEA LEVEL PRESSURES IN TROPICAL CYCLONES OF THE WESTERN NORTH PACIFIC

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DECEMBER 1974

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ABSTRACT

This study shows that Jordan's (1957) regression equation for calculating minimum sea level pressure from 700 mb height data can be used operationally for determining tropical cyclone intensity. By using Jordan's equation for minimum sea level pressure estimates, instead of dropsonde measured sea level pressure, a dollar savings of approximately $100,000 will be realized in the Western North Pacific each year.

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1. INTRODUCTION

From the earliest days of aircraft reconnaissance of tropical cyclones, dropsonde data taken in the cyclone centers showed a very high correlation between dropsonde measured surface pressure and aircraft measured 700 mb height. Jordan (1957) studied this correlation and derived a regression equation that has been used operationally for many years as an initial estimate of surface pressure by Joint Typhoon Warning Center (JTWC), Guam. Sea level pressure measurement is an important tool in deriving maximum surface wind speeds in tropical cyclones. In the light of present day forecasting techniques and every tightening budgetary constraints, this study was undertaken to determine the feasibility of relying solely on a regression equation to derive sea level pressure from aircraft measured 700 mb heights.

2. TYPHOON DATA FOR WESTERN PACIFIC

Data for this evaluation were coupled observations of 700 mb height and corresponding surface pressure. These data were extracted from JTWC's Annual Typhoon Reports for 1965 through 1973 and from Vortex Data Messages of Typhoons Carla, Dinah, Gilda, and Ivy of the 1974 season. All data used were collected by U.S. Air Force (USAF) WC-130 aircraft penetrating the tropical cyclone at the 700 mb level. The only criterion for inclusion of an observation in the sample was that at some time the particular tropical cyclone must have reached typhoon intensity. This criterion was applied for ease of data collection. All observations on these cyclones were included. These observations were not screened for transmission errors. Additionally, all stages of the cyclone's development, including the extratropical stage, were included. Because of this lack of data selectivity, it is assumed that the worst cases are included and resulting errors would be typical of those realized in routine operational application. Because of the large sample size (1,937 observations) the results are felt to be statistically significant.

The sample was divided into a dependent set (1965-1972 data) of 1,743 observations and an independent set of the remaining 194 observations (1973-74 data). This was done to develop a new regression equation and to compare it with Jordan's (1957) using the independent data sample.

3. RESULTS

A linear regression equation, (hereafter called the JTWC equation), was derived from the dependent data set and compared to the Jordan (1957) equation for dispersal characteristics on the independent data set. Correlation coefficients (r) were calculated for the JTWC and Jordan (1957) equations. The JTWC equation and the Jordan (1957) equations are:

JTWC equation $y = 651.6 + 0.112X$ N=1743
Jordan (1957) equation $y = 645.0 + 0.115X$ N=409
where:

y=Sea level pressure in millibars (SLP)
x=700 mb height in meters
N=Sample size for development of equation

The following statistics in Table 1 were derived by applying the JTWC and Jordan equations to the independent data. The mean of differences is the mean of differences between observed and calculated SLP's

	Mean of Differences	Standard Deviation	r
JTWC EQ	1.23	2.04	0.97
JORDAN EQ	-0.70	1.94	0.99

TABLE 1. Dispersal characteristics of JTWC equation and Jordan (1957) equation.

The frequency distributions of individual millibar differences between observed SLP's and calculated SLP's for both equations are shown in Figures 1 and 2. These figures show that 98.4% of Jordan's (1957) equation calculated SLP's and 94.8% of the JTWC equation calculated SLP's are within ± 5 mb of the observed SLP's.

Since the dispersal characteristics of Jordan's (1957) equation show better fit with the observed SLP's, Jordan's (1957) equation will be used hereafter.

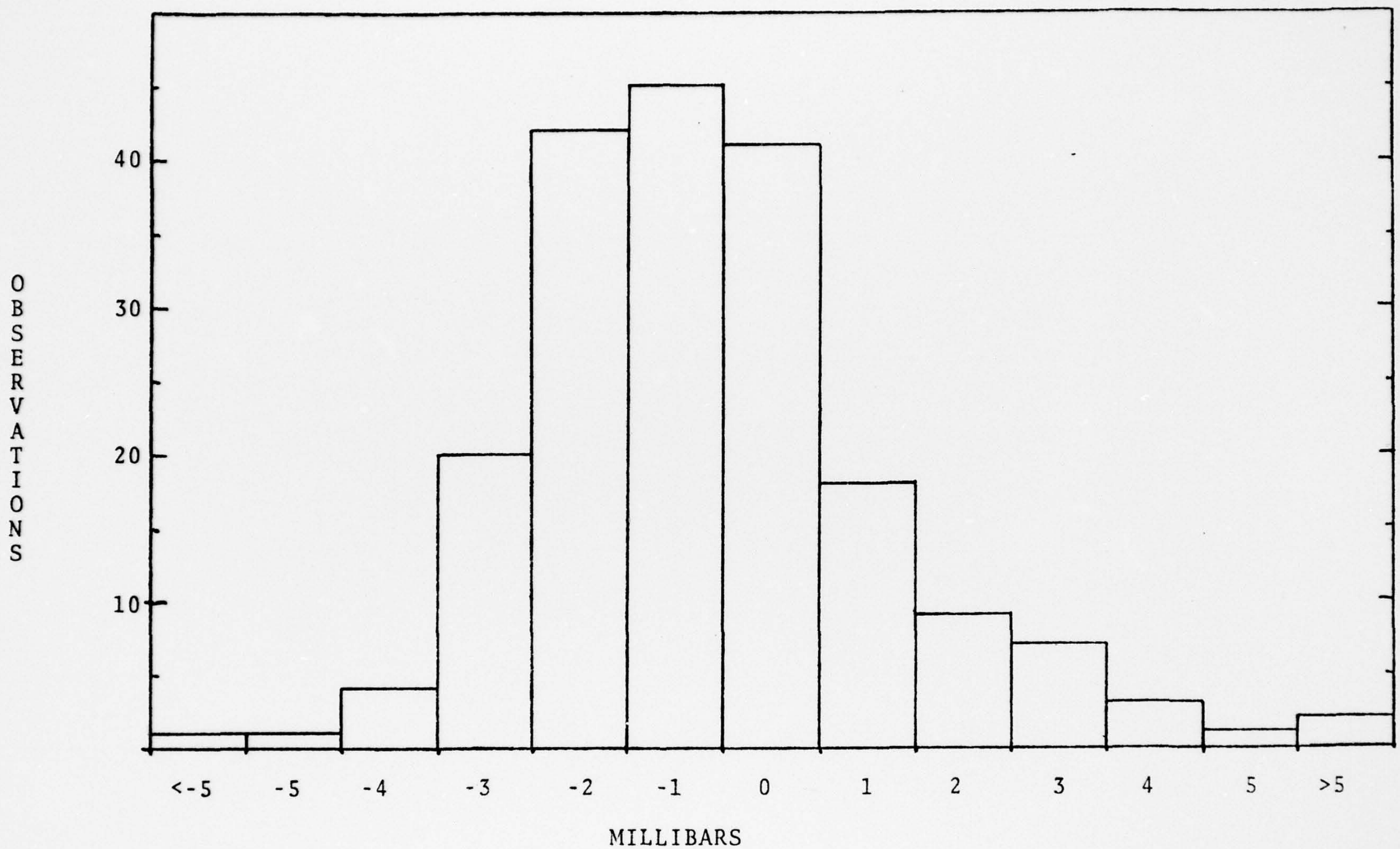

Figure 1. Histogram of differences between observed SLP and Jordan equation calculated SLP.

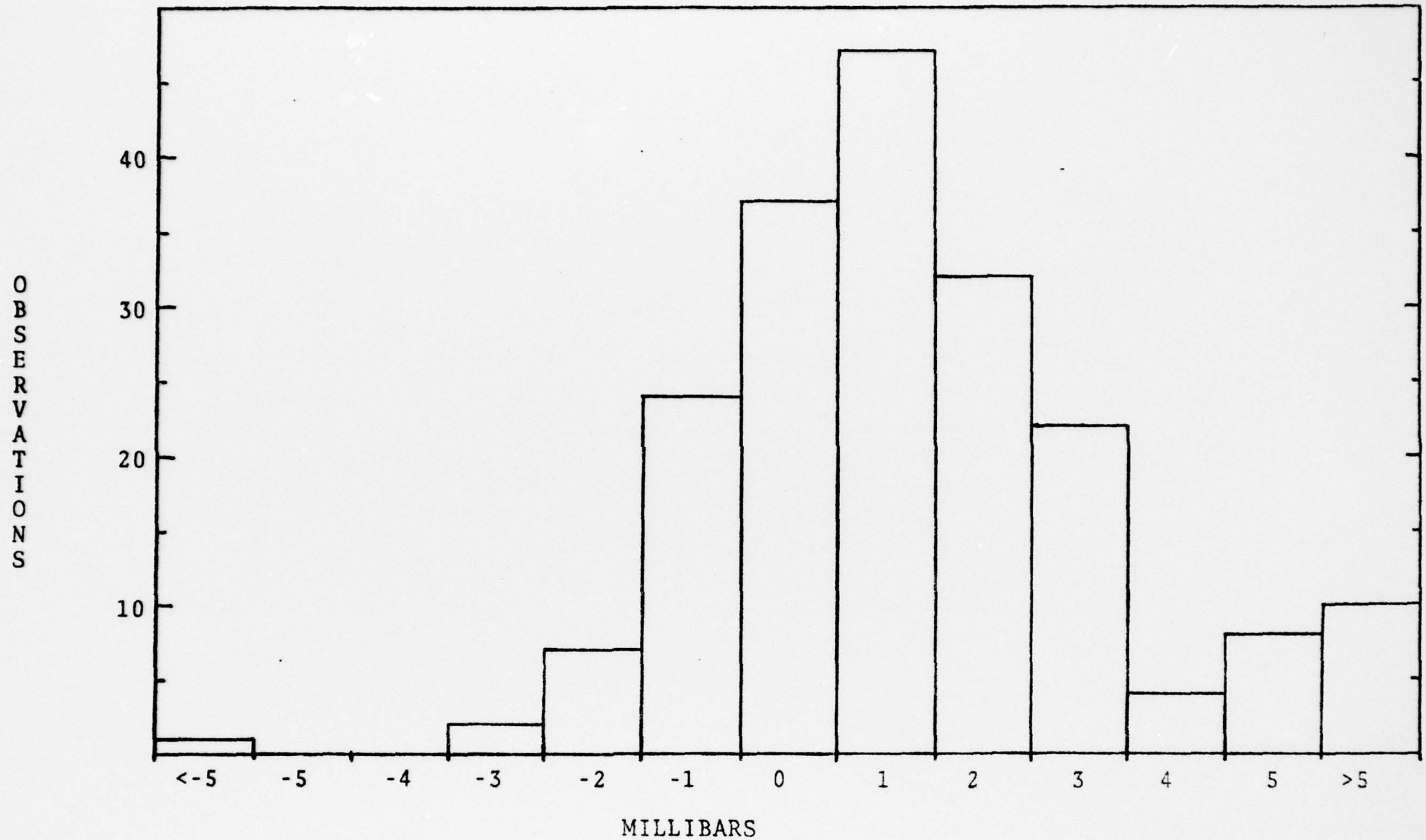

Figure 2. Histogram of differences between observed SLP and JTWC equation calculated SLP.

4. OPERATIONAL EVALUATION

The reconnaissance aircraft parameters used operationally at JTWC to estimate wind speed in tropical cyclones are the minimum sea level pressure (MSLP) and the wind speed observations. Wind speed observations include both directly measured flight level winds and the less reliable estimated surface wind speed.

There have been various relationships to estimate the maximum sustained surface wind speed in tropical cyclones from the MSLP. The Fujita (1971) relationship has been used by JTWC for the last two tropical cyclone seasons as an aid to deriving maximum surface wind speeds. In the Fujita (1971) relationship, a MSLP error of 8 mb corresponds to a wind speed error of approximately 10 knots. Another pressure/wind relationship derived by Atkinson and Holliday (1974) leads to a wind speed error of approximately 11 knots for a MSLP error of 9 mb. Thus, the few millibar error involved in estimating the MSLP from the 700 mb height data is insignificant for tropical cyclone forecasting purposes.

5. COST EFFECTIVENESS EVALUATION

The only real time data derived from dropsonde observations used in forecasting tropical cyclones is the MSLP. Although the complete dropsonde observation is transmitted as soon as the data is processed aboard the reconnaissance aircraft, this additional information is not useful for forecasting, but rather in post analysis and research. From a purely operational standpoint, it is clear that since dropsondes do not contribute to forecast improvement, the requirement to make a dropsonde measurement routinely should be eliminated. The dollar savings of eliminating these routine dropsonde observation requirements is illustrated below.

The AN/AMT-13 dropsondes used by the 54th Weather Reconnassance Squadron during the 1974 typhoon season in the Northwest Pacific cost $120 each. The AN/AMT-13A dropsonde which will replace the AN/AMT-13 dropsonde for use in the 1975 typhoon season cost $270 each. The cost of expending dropsondes for an average year (350-400 levied fixes) with the new dropsonde will be approximately $100,000.

Routine operational use of the Jordan (1957) regression equation for calculating MSLP's would result in a savings of this amount.

Two instances in which the Jordan equation produces somewhat less accurate results are in forming storms and in storms becoming extratropical. It should, however, be noted that the MSLP vs wind speed relationships are not valid in these instances either.

In developing storms where wind speeds are less than 50 kts, reconnaissance aircraft can be flown at the 1500 ft level. Accurately measured flight level wind speeds and extrapolated MSLP can be obtained directly from the aircraft and a dropsonde need not be dispensed. Surface wind speeds may be estimated from 700 mb winds in storms that are becoming extratropical by employing an empirical relationship derived from a study by Gray and Shea (1973).

An additional important benefit that would be realized by deleting the requirement for dropsonde observations in tropical cyclones is decreased loiter time in the eye. Important aspects of decreased loiter time include safety considerations and additional peripheral data gathering time.

6. CONCLUSION

Dropsonde data is not an operational necessity for tropical cyclone forecasting. Annual dollar savings of approximatley $100,000 in the western North Pacific area alone can be realized by deleting the dropsonde requirements on tropical cyclone reconnaissance missions.

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