6. TROPICAL CYCLONE SUPPORT SUMMARY

TROPICAL CYCLONES AFFECTING THE PHILIPPINE ISLANDS

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Two early 1970's studies on the climatology of tropical cyclones striking the Philippine Islands have been updated. The previous studies involved manual interpretation of a small data base; now, with computer processing, a much larger data base is used. The computer study provides quantitative output, including standard deviations. This study looks at tropical cyclone intensity change, track change, occurrence climatology, and various other parameters. It allows the typhoon forecaster to more accurately anticipate changes in intensity and motion of tropical cyclones interacting with the Philippine Islands.

DVORAK FORECAST INTENSITY STUDY

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A study to compare forecast intensity (FI) to the actual JTWC best track verification showed that some minor modifications to the Dvorak model would make FI more accurate. These modifications were incorporated into a flow chart the analysts now use to determine FI. Improvements include the ability to lower FI if a peaking day is determined, the ability to more accurately reflect FI when the forecast track brings the system over land, and the ability to keep the FI stable when short-term fluctuations to the Dvorak T-number occur.

DVORAK INTENSITY ANALYSIS OVER LAND STUDY

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A recent paper, Improved Utilization of Satellite Imagery in Tropical Cyclone Analysis (Takemura, 1989), addressed tropical cyclone intensity estimation over land. In its current state, the Dvorak analysis scheme does not allow analysis overland. Thus, when a tropical cyclone moves back over water there is a break in the intensity trend. A local study was initiated using satellite images of tropical cyclones over land. Analysts were required to derive a Dvorak T-number for the cloud systems while they were over land. Compilation of results showed that all intensity analyses from Detachment 1 satellite analysts were within an acceptable error margin of 0.5 T-number establishing that analysts could derive with consistent T-numbers for tropical cyclones over land. The next part of this study will associate the T-number over land with actual tropical cyclone intensities. This will allow satellite analysts to provide over-land current intensity numbers to JTWC.

SOUTHERN HEMISPHERE TROPICAL CYCLONE CLIMATOLOGY

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Detachment 1 expanded its interactive tropical cyclone climatology data base (currently complete for the western North Pacific) to include the Southern Hemisphere. Data includes position, intensity, speed, intensity change and speed change. The Bay of Bengal and the Arabian Sea will be included in the next data base expansion.

NOGAPS STEERING MODEL (NSM)

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Since May 1990, JTWC has been developing and testing a locally run steering model known as the NOGAPS Steering Model (NSM). It is designed to replace the CYCLone Operational Prediction System (CYCLOPS) and to overcome a number of weaknesses inherent in that model. These include i) use of NOGAPS 500- and 700-mb wind fields to compute steering directly, whereas CYCLOPS uses height fields to compute steering geostrophically, and ii) steering from unsmoothed NOGAPS data over an annular region around the tropical cyclone, whereas CYCLOPS uses the heavily smoothed SR height fields that tend to miss weak synoptic features that nevertheless affect storm motion. Although it has been tested for only portions of the 1990 Northwest Pacific tropical cyclone season, NSM has shown skill in forecasting movement of small cyclones and in detecting sudden turns (NSM uses no persistence). The model performs poorly on large tropical cyclones, presumably due to misplaced vortex effects and annulus size. NSM will be modified in 1991 to include an additional, larger steering flow annulus to better determine the environmental steering around large systems.

TROPICAL CYCLONE MOTION FIELD EXPERIMENT

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The Tropical Cyclone Motion (TCM-90) field experiment was conducted in the Northwest Pacific during August and September 1990. TCM-90 was the culmination of a five-year Accelerated Research Initiative of the Office of Naval Research Marine Meteorology Program (Dr. Robert Abbey, Jr., Program Director). The TCM-90 field experiment was coincident in time with three other separate field experiments, which made this effort one of the largest experiments on typhoons ever attempted. The World Meteorological Organization Typhoon Committee sponsored a real-time prediction experiment called SPECTRUM (SPecial Experiment Concerning Typhoon Recurvature and Unusual Motion). A USSR oceanographic expedition called TYPHOON-90 provided meteorological observations over the Philippine Sea. Finally, the Taiwan Area Typhoon Experiment (TATEX) studied the interaction of typhoons with the Taiwan orography.

TCM-90 was organized around Intensive Observing Periods (IOP) of 36-48 hours duration when 6-hour rawinsondes were launched and other special observations were collected. Seven IOP'S involving six typhoons were conducted, and will provide data sets to test several hypotheses that were developed during the research phase leading to TCM-90. Complex interactions with the subtropical ridge occurred during all seven IOP's. Documentation of the physical mechanisms by which the typhoon can affect the adjacent ridge, and thus affect the track, is expected to be one of the major results of the research initiative.

Perhaps the most impressive early result of TCM-90 was the detailed documentation of the complexity of the environmental flow fields observed in the western North Pacific. Interactions with the monsoon trough, midlatitude troughs and Tropical Upper Tropospheric Trough (TUTT) cells were observed in various IOP's. In some cases, the troughs changed the typhoon track. In other cases, the typhoon continued to track steadily along. Documenting these effects, and when they occur, should provide a solid scientific result that will also contribute to improvements in forecasting.

Five other tropical cyclones occurred during August and September that were not the subject of an IOP due to timing or location. These cases will provide additional examples for study. Comparisons of track predictions during these storms will indicate the benefits of the additional observations collected during the TCM-90 IOP's. Other data sensitivity studies (withholding certain sites or data types from the complete set) should indicate the crucial locations for observations to improve track predictions.

TROPICAL CYCLONE FORECASTER'S REFERENCE GUIDE

Miller, R.J., J-H. Chu, and C.R. Sampson
NOARL West
Monterey, California

Development of a Tropical Cyclone Forecaster's Reference Guide continues. The reference guide will contain a section covering tropical meteorology in general, as well as the formation, motion, structure, and dissipation of tropical cyclones. Satellite case studies and descriptions of forecast aids will also be included. Future plans are to put the guide on a computer as an information management system.

AUTOMATED TROPICAL CYCLONE FORECASTING SYSTEM (ATCF) UPGRADE

Roesser, D. M., R. J. Miller, and C. R. Sampson
NOARL West
Monterey, California

The ATCF has been operational at JTWC since August 1988. The system runs on an IBM-AT compatible machine using the MS-DOS operation system. This current configuration limits the capabilities of the ATCF. For this reason, NOARL is currently adapting the ATCF software to a UNIX environment. UNIX advantages include more power, multi-tasking, and portability. The X-Windows/Motif system will serve as the user interface, allowing the user to run all ATCF functions in a windows environment.

TROPICAL CYCLONE EXPERT SYSTEM

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NOARL West
Monterey, California

NOARL is developing an expert system for tropical cyclone forecasting. Using forecasting thumb rules and research results such as objective technique error statistics, the expert system will objectively weigh the information based upon the current forecast situation and assist the forecaster in making decisions.

PC-BASED TROPICAL CYCLONE TRACK CLIMATOLOGY FORECAST AID

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The traditional climatology track forecast aid has been developed for use on a desktop PC. The aid uses a global climatology data base from 1945 to present. New best track information can easily be added to the data base. A graphical display shows the past positions used in formulating the forecast. This facilitates evaluation of the fit of the climatology to the forecast track.

TROPICAL CYCLONES AFFECTING TAIWAN

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Joint Typhoon Warning Center

The study done by Brand and Blelloch in 1973 on the climatology of tropical cyclones affecting Taiwan has been updated using computer processing and a significantly larger data set. It examines tropical cyclone intensity change, speed of movement change, tracks, and occurrence. It provides a guide to the satellite analysts and typhoon forecasters for forecasting changes in intensity and motion of tropical cyclones interacting with Taiwan.

NEW METHODS IN FORECASTING INTENSITY OF TROPICAL CYCLONES

Capt. Bruce Thompson, USAF
Joint Typhoon Warning Center

New methods have been developed to assist typhoon forecasters with intensity forecasts using the NOGAPS 200-mb prognostic charts and intensity climatology. The 200-mb NOGAPS charts are used to assess the synoptic pattern and determine if the tropical cyclone will move into a favorable or unfavorable area for intensification within the next 72 hours. The assessment generally considers the amount of vertical shear and outflow channel(s). In addition, a tropical cyclone climatology data base is used to develop a specially tailored intensity climatology for a specific tropical cyclone. The intensity climatology can be stratified by time of year, latitude, longitude, intensity trend, and a number of other parameters. Using the 200-mb NOGAPS prognostic charts and the intensity climatology, the "normal" one T-number per day intensification scheme developed by Dvorak (1984) can be modified to produce a customized intensity forecast.

A CLIMATOLOGY OF VERY INTENSE TYPHOONS: OR WHERE HAVE ALL THE SUPER TYPHOONS GONE?

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Introduction. The term super typhoon is a classification applied to tropical cyclones that reach 130 kt sustained one-minute average wind speed. The term is not a World Meteorological Organization (WMO) standard, but is used by JTWC. A Climatological Study of Super Typhoons was published in the 1970 Annual Typhoon Report (ATR, the predecessor of the ATCR) (JTWC, 1970), and included the years 1959-1970. Figures from that climatological study have been republished in various individual storm write-ups in succeeding ATR's/ATCR's and the study is frequently used in intensity forecasting. This article provides a long-needed update to the earlier study.

At the outset such an update seemed fairly simple. By using an interactive climatology of tropical cyclones of the western North Pacific developed by the Technique Development Group, Detachment 1, First Weather Wing, all tropical cyclones meeting the 130-kt criterion from 1971 through 1988 where identified. The 1970 Study identified 70 super typhoons during the period 1959-1970 for an average of 5.8 per year. The 1989 climatological search identified 48 for the period 1971-1988 for an average of 2.7 - less than half the number for the earlier period. Where had all the super typhoons gone?

Background. The 1970 Study identified super typhoons by applying the equation developed by Fletcher (1955) which correlated maximum sustained winds with recorded minimum sea-level pressure. The equation gives 944 mb as the equivalent sea-level pressure corresponding to 130 kt. Since aircraft estimates of surface wind speeds in excess of 100 kt are subjective, the conservative nature of sea-level pressure makes it the optimum parameter to use in classifying super typhoons.

The most often cited part of the 1970 Study is the figure depicting 5°x 5° squares containing the frequency of first occurrence of first super typhoon intensity (Figure 6-1). The 1970 Study found two maxima between the Philippine and the northern Mariana Islands. The super typhoon maxima were downstream from the minimum sea-level pressure double maxima found by Fung (1970). The 1970 Study also showed that super typhoon occurrence was normally distributed about the peak reached in September.

Subsequently Atkinson and Holliday (1975) developed a relationship between tropical cyclone minimum sea-level pressure and maximum sustained winds. That relationship (reinforced by the results of (Lubeck and Shewchuck (1980))has become the standard relationship used by JTWC since. That relationship equates 130 kt with approximately 910 mb.

Pressure was routinely available because of the availability of aircraft reconnaissance. Gradually satellite surveillance augmented, and ultimately, replaced aircraft reconnaissance in 1987. Subsequent determinations of intensity have been made either by satellite imagery using the procedures of Dvorak (1973, 1984), or by the occasional surface observation. Because pressure was no longer measured, intensities where determined from the Dvorak scale and then converted to pressure using the Atkinson-Holliday relationship.

Methodology. Because of the advantage of using sea-level pressure cited by the 1970 Study, this study also used sea-level pressure to determine intensity. The Atkinson-Holliday threshold of 910 mb was used as the criterion for selecting super typhoons. However, because the term super typhoon is based on intensities of at least 130 kt, the term - Very Intense Typhoons (VIT) will be used in this study to indicate the use of pressure vice wind criteria.

Aircraft reconnaissance and satellite surveillance data were extracted from the Individual and Consolidated Typhoon Reports from 1950 through 1958 and the ATR's and ATCR's thereafter. Each instance of a tropical cyclone reaching a central pressure of 910 mb was classified as a VIT. No attempt was made to determine the location of the first occurrence of 910 mb to other than 5°x 5° square unless fix data crossed square boundaries. In those cases the fix data were linearly interpolated to locate the appropriate square. If only aircraft fix data were available, either the measured central pressure from dropsonde data, or a derived-pressure obtained from the relationship:

$$SLP = 645 + .115\,x$$
$$x = 700 \text{ mb height in meters}$$

was used. When aircraft data became scarce, the first occurence of super typhoon intensity was equated to 910 mb using satellite derived intensities and the Atkinson-Holliday relationship.

Results. By using the more restrictive criterion of 910 mb, 83 tropical cyclones were classified as VIT's for the period 1950 through

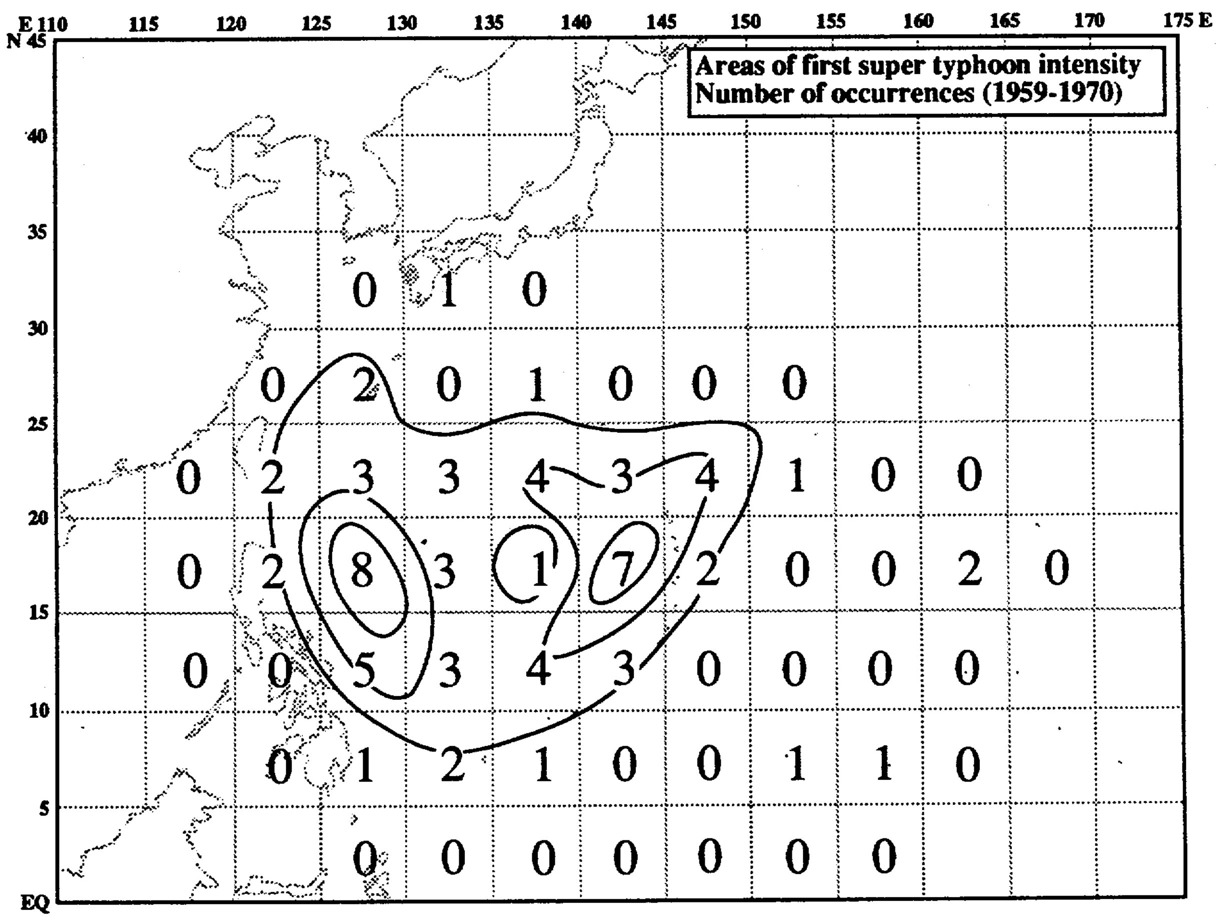

Figure 6 - 1

1989. This is an average of 2.2 per year. While the double maxima is no longer evident (Figure 6-2), an axis of maximum occurrence remains between 15°- 20° north latitudes. The primary area is west of 135°. The axis of maximum occurrence corresponds to the axis of the Sub-Equatorial Ridge (SER) and is east of the East Asian Trough (EAT) (Guard, 1977).

The 1970 Study had found super typhoons normally distributed about a peak in September. The peak in VIT occurrence is in October (Figures 6-3 and 6-4).

There appears to be some consistency in the VIT classification. Despite the changing fix platforms and procedures, the decadal average of VIT's remains relatively constant with the 60's being a below average decade and the 80's an above average decade and the 50's and 70's near average (Figure 6-5). However, since 1975 at least one VIT has occurred every year. This may be attributable to the the advent of the operational availability of satellite derived intensities (Dvorak, 1973).

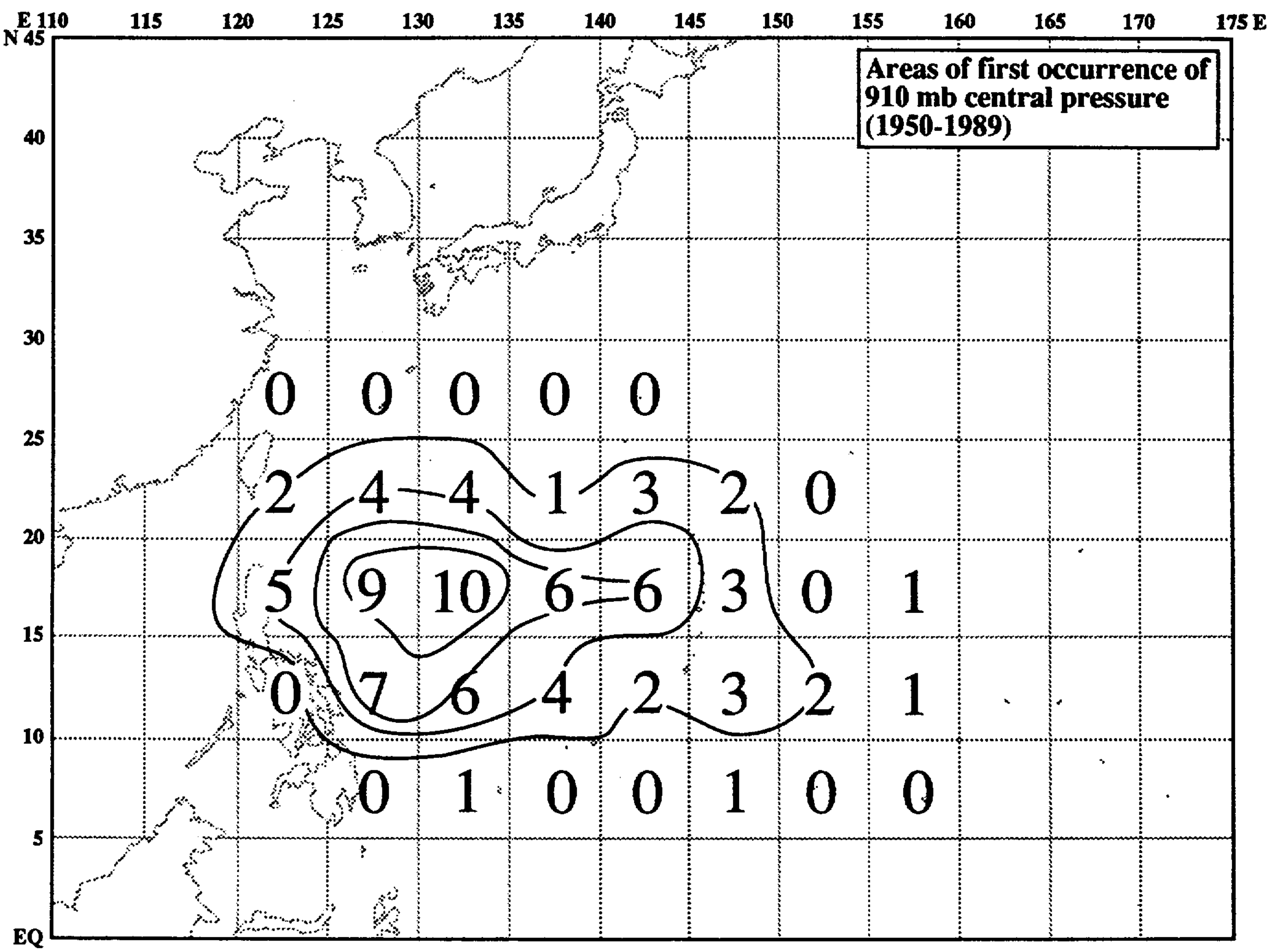

Figure 6 - 2

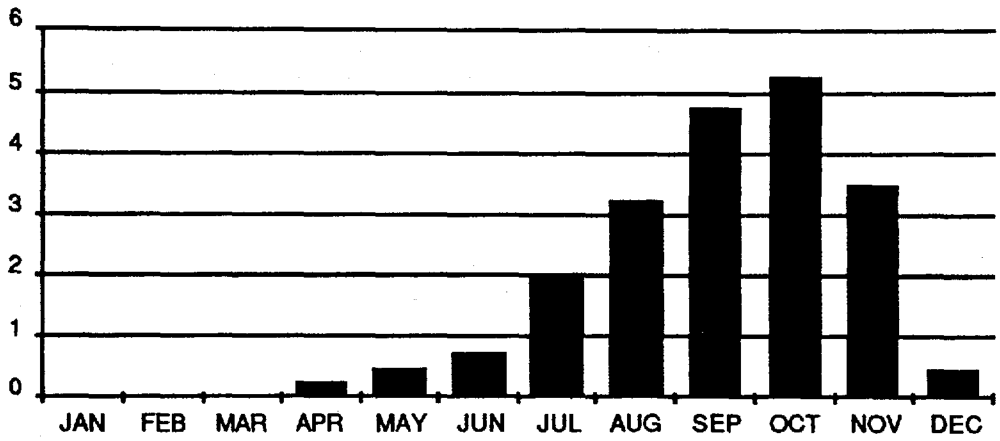

Figure 6 - 3

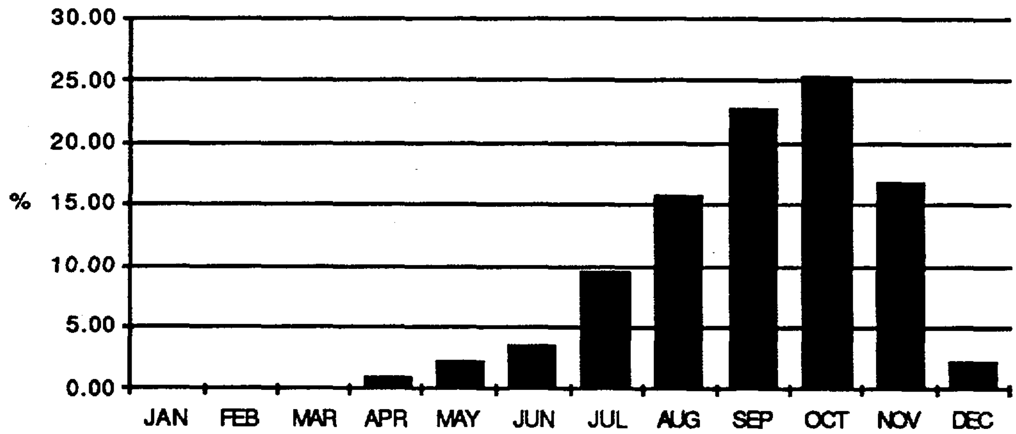

Figure 6 - 4

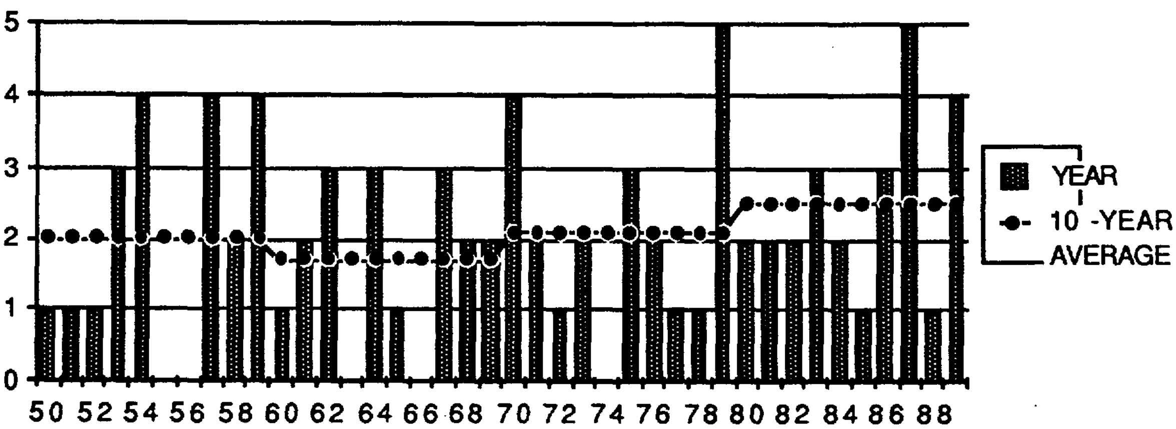

Figure 6 - 5

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