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WORLD AREAS MORE HUMID THAN THE CANAL ZONE DURING THE WET SEASON

(Note 3 of "Studies to Aid TECOM in Analyses of Environmental Risks to Materiel")

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U.S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES
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The purpose of this study is to show the severity of humidity, expressed in terms of dewpoint, in the Canal Zone, site of the U.S. Army Tropic Test Center, in relation to other tropical areas. Extensive areas of the tropical and subtropical regions of the world experience a level of humidity stress during the month of highest mean dewpoint in excess of that reported at either Cristobal or Howard AFB, both in the Canal Zone, during the 7-month long wet season. Of these, southern Asia and the Amazon Basin of South America stand out as the most prominent areas of exceedance in terms

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of both extent and contiguous coverage. As shown on the maps, the areas of dewpoint exceedance are most widespread when determined by comparison with a mean dewpoint value of 74°F, the $\bar{T}_d$ at Howard AFB for all months of the wet season (May through November).

As a set, the three maps illustrating the study can aid in determining the validity of test results obtained at sites within or near Cristobal and Howard AFB.

PREFACE

This note is the third in the series "Studies to Aid TECOM in Analyses of Environmental Risks to Materiel." It was produced under DA Project IT 162112A528, Task 01 Work Unit 0003, Environmental Support to TECOM; and the work was conducted by the Geographic Sciences Laboratory, U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia.

In recent discussions with U.S. Army Test and Evaluation Command (TECOM) personnel, the point was made that, although the Army expends considerable funds and effort to test materiel at extreme levels of environmental stress at the various test sites of the Army, it is uncertain how representative of world climatic extremes these sites really are. Stated differently, TECOM would like to be assured that the materiel tests being conducted at the Tropic Test Center under natural hot-wet conditions, at the Yuma Proving Ground under natural hot-dry conditions, and at the Arctic Test Center under natural cold-dry conditions, truly represent levels of stress as severe as will be encountered anywhere during the service life of the materiel in question. Additionally, TECOM would like to know where its testing program needs improvement, and what parts thereof fall short of representing world extremes. The maps contained in this series should help to answer such questions by indicating the location and extent of areas subject to climatic severity in excess of that experienced at each test site in question.

It is pointed out, however, that these studies are not intended as arguments for or against retention of the environmental testing centers at their present sites. Other factors in addition to climate come into play in evaluating the suitability of each test site.

Neither should the inference be drawn from the studies that all Army materiel will fail in areas where the maps indicate more severe conditions than at the test sites. This depends on the design, purpose, and use made of individual items of equipment. For some items it makes little difference whether the operational environment is more or less severe than the test environment, since no climate-induced problems were ever envisioned for certain items subjected to testing, nor are any anticipated even under more rigorous conditions. However, in cases where the performance characteristics of materiel are indicated as marginal or substandard during testing and the environment is considered to be the cause, the maps can serve as indicators where such materiel may fail to perform adequately or may have a shortened service life.

CONTENTS

I. INTRODUCTION

This note is basically a map study of high humidity, expressed in terms of mean monthly dewpoints which exceed levels of the wet season regime of dewpoint at selected stations in the Canal Zone. Two of these, Cristobal, located on the wetter, more humid Caribbean coast, and Howard Air Force Base, located on the drier, less humid Pacific coast, are viewed as key stations to this analysis, providing, as they do, a means for measuring the dewpoint spread between the two coasts of the Canal Zone. Though actual differences in dewpoint between the coasts are not great, being about 2°F, they are significant, since saturation is reached much more readily and for longer durations at Cristobal than at Howard AFB. The November rainfall totals for the two sites, 22.3 inches and 9.8 inches, respectively, attest to such differences. The same relationships between Cristobal and Howard AFB hold as well for dewpoint and for rainfall during all other months of the wet season (herein defined as the period from May through November) with the difference in dewpoint being consistently 2°F and the difference in rainfall being about 50 percent.

The principal findings of the study are presented on three maps, Plates I, II, and III. Plate I shows the world distribution of those areas where mean dewpoint temperatures for the month of peak dewpoint value during the year are in excess of 76°F. the value for mean monthly dewpoint during May, June, July, and August at Cristobal. Plate II shows similar distributions drawn for a mean dewpoint temperature base of 75°F, the mean at Cristobal for the late season months of September, October, and November. Plate III is drawn to a base of 74°F, the mean dewpoint temperature at Howard AFB for each of the seven consecutive months, May through November inclusive, that constitute the wet season.

The maps are designed to aid TECOM personnel in assessing where in the world probabilities are highest for equipment and/or human failure in the field under conditions of high humidity duress or in rating the high humidity performance characteristics of Army materiel. In using the maps it should be noted that the maps were drawn to mean values of dewpoint. Actual values, as encountered in nature, can vary considerably from the mean. For example, at Cristobal during November, the wettest month, extremes of dewpoint ranged from a high of 83°F to a low of 66°F over an 8-year period. Within this range, however, more than 85 percent of the observations fall within 3 degrees of the mean, indicating a remarkable degree of consistency for dewpoint from day to day. This stability of dewpoint seems to be a universal characteristic of the hot-wet areas of the world.

II. EFFECTS OF DEWPOINT EXTREMES ON MEN AND MATERIEL

High humidity combined with high temperature reduces the soldier's capacity to perform work and to remain alert and perceptive. Work capacity and survival times are reduced, sweat rates accelerated, water requirements increased, and numerous other physiological variables are affected adversely in one way or another. For example, it has been shown that with air temperature at 85°F and the dewpoint at 71°F, nothing more than moderate work should be attempted on a sustained 8-hour basis; with the same air temperature and the dewpoint raised to 78°F, only light work should be attempted. However, such limitations do not preclude hard work for very short periods of time. Other manifestations of high humidity in combination with high temperature are chronic discomfort caused by sweating and subsequent distraction of the individual from his work, loss of sleep and a resulting increase of irritability, and the lowering of motivation in tasks requiring sustained mental concentration.

Materials subject to microbiological deterioration or damage due to oxidation become more vulnerable as dewpoints and temperatures rise. Actually, the degree of activity of such agents of destruction is determined by the interactions of at least five factors including temperature, the amount of condensation present, humidity, time, and, in the case of microbiological deterioration, the micro-organisms present (molds and other fungi). Microbiological activity is moderate at temperatures between 65°F and 75°F, and dewpoints about 5°F lower. However, at temperatures between 75°F and 90°F, with dewpoints again about 5°F lower, microbiological activity is sufficient to produce severe deterioration. Because different materials deteriorate at different rates, it is difficult to define the words "moderate" and "severe" in relation to material deterioration. For example, severe microbiological deterioration can damage leather goods within a period of 10 days, whereas, with tentage a period of 6 months is generally required to inflict serious damage. The oxidation (rust) rates of unprotected metals are closely attuned to microbiological deterioration rates with the oxidation rates increasing as temperatures and dewpoints rise. However, oxidation begins at much lower temperature levels, with considerable activity taking place even at the freezing point, the controlling factor seemingly being the presence of sufficient moisture.

III. EVALUATION OF DATA

The Glossary of Environmental Terms (Terrestrial)[1] defines mean monthly dewpoint as the "average of the mean dewpoints of each day (generally computed from observations taken at equal time periods of six hours or less apart) within a month, averaged over a period of years." When based on 10 or more years of record, the mean monthly dewpoint ($\bar{T}_d$) is generally a highly stable parameter, which maintains a nearly constant value as the base period of record increases.

In effect, the dewpoint temperature represents one tool to measure the degree of atmospheric saturation. Other terms commonly used as measures of "humidity" include absolute humidity, mixing ratio, relative humidity, saturation deficit, specific humidity, wet-bulb temperature, and vapor pressure. Few of these terms find as much favor with researchers as dewpoint - the temperature to which air must be cooled for saturation to occur. Some of the advantages inherent in the use of dewpoint as a medium for quantifying humidity include expressibility on all temperature scales, direct convertibility to vapor pressure, stability of value as air temperatures fluctuate, and accuracy as a gauge of the water-vapor content of the atmosphere. The stable properties of dewpoint are particularly important in research. Unlike relative humidity, which reacts immediately but inversely with changes in air temperature, the dewpoint temperature, for all practical purposes, remains unaffected by changing air temperature. Changes in the value of the dewpoint temperature occur only through processes that result in the addition or removal of moisture from the atmosphere. A sea breeze that brings moist air to coastal sites is one example of the types of phenomena that increase the moisture content of the air. Rain or snow exemplify phenomena that will remove moisture from the atmosphere.

The data on which the maps are based were taken principally from two Naval Weather Service reports, NAVAIR 50-1C-52[2] and

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[1] U.S. Department of Defense, Glossary of Environmental Terms (Terrestrial), MIL-STD-1165, 25 March 1968.

[2] H. L. Crutcher and J. M. Meserve, Selected Level Heights, Temperatures and Dewpoints for the Northern Hemisphere, NAVAIR-1C-52, Naval Weather Service Command, January 1970.

NAVAIR 50-1C-55.[3] These reports represent a consolidation of data from many different sources, which have been screened for validity, summarized and recompiled as average monthly dewpoint estimations, then plotted and mapped by degree square on a world basis. The data used for the two Canal Zone base stations are contained in separate sources; namely, U.S. Naval Weather Service World-Wide Airfield Summaries, Volume VII[4] for Howard AFB data, and specially processed psychrometric summaries[5] for the Cristobal data.

IV. SIGNIFICANCE OF MAPS TO RISK ANALYSIS

The maps (Plates I-III, folded into the rear of the study) are self-explanatory for the most part. In using the maps, however, it should be noted that the mean monthly dewpoint temperatures during the wet season at Cristobal and Howard AFB are being compared to their equivalents elsewhere for the most humid (highest mean monthly dewpoint) month of the year. The reason for this somewhat unorthodox procedure is that dewpoints are uniformly high throughout a lengthy wet season (seven months) in the Canal Zone; whereas in other parts of the world, high dewpoints frequently occur only in a short season, with average dewpoints at their summit during a single month. Therefore, the month-to-month consistency of high dewpoints is not necessarily duplicated in those areas mapped as being subject to levels of humidity duress equal to, or in excess of, those experienced at the Canal Zone stations. Neither do the maps indicate the days or weeks within the month when dewpoints will reach their peaks, nor can they be used as a basis for predicting the years when higher-than-average extremes will be experienced; at present valid predictions of such variables are beyond the state-of-the-art.

V. CONCLUSIONS

Extensive areas of the tropical and subtropical regions of the world experience a level of humidity duress during the month of highest mean dewpoint in excess of that reported at either

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[3] J.J. Taljaard H. VanLoon, H. L. Crutcher, and R. L. Jenne, Climate of the Upper Air, Part 1-Southern Hemisphere, Vol. 2, Temperatures, Dewpoints and Heights at Selected Pressure Levels, NAVAIR 50-1C-55, Naval Weather Service Command, September 1969

[4] U.S. Naval Weather Service World-Wide Airfield Summaries, Volume VII, Central America, February 1968

[5] Unpublished data tabulations entitled Psychrometric Summaries supplied by the Data Processing Division,ETAC, USAF,Asheville, NC (undated)

Cristobal or Howard AFB during the 7-month long wet season. Of these, southern Asia and the Amazon Basin of South America stand out as the most prominent areas of exceedance in terms of both extent and contiguous coverage. As shown on the maps, the areas of dewpoint exceedance are most widespread when determined by comparison with a mean dewpoint value of 74°F the $\bar{T}_d$ at Howard AFB for all months of the wet season (May through November). Constraints on areal distribution become slightly discernible when the areas of exceedance are determined on the basis of a slightly higher dewpoint level of 75°F, the $\bar{T}_d$ for each month of the period from September through November at Cristobal; and unmistakably evident when determined by comparison with a value of 76°F, the $\bar{T}_d$ for Cristobal for each month of the period from May through August.

As a set, the three maps illustrating the study can aid in determining the validity of test results obtained at test sites located within or near Cristobal, C.Z., and within or near Howard AFB, C. Z.

PLATE I

WORLD AREAS WHERE HIGHEST MEAN MONTHLY DEWPOINTS ARE IN EXCESS OF 76° F

76° F = the computed value for $\bar{T}_{dp}$ at Cristobal, located on the humid Caribbean coast of the Canal Zone, for the wet season months of MAY, JUNE, JULY, and AUGUST.

1000 0 1000 2000 3000 Miles

1000 0 1000 2000 3000 Kilometers

Approximate Scale (along Equator)

AITOFF'S EQUAL AREA PROJECTION Adapted by V. C. Finch

USAETL, Compiled November 1974

The representation of international boundaries on this map is not necessarily authoritative.

PLATE II

WORLD AREAS WHERE HIGHEST MEAN MONTHLY DEWPOINTS ARE IN EXCESS OF 75° F

75° F = the computed value for $\bar{T}_{dp}$ at Cristobal, located on the humid Caribbean coast of the Canal Zone, for the wet season months of SEPTEMBER, OCTOBER, AND NOVEMBER

1 000 0 1 000 2 000 3 000 Miles

1 000 0 1 000 2 000 3 000 Kilometers

Approximate Scale (along Equator)

AITOFF'S EQUAL AREA PROJECTION Adapted by V. C. Finch

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