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QUARTERMASTER RESEARCH & ENGINEERING COMMAND
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TECHNICAL REPORT
EP-90

Canal Zone Analogs III

ANALOGS OF CANAL ZONE CLIMATE IN EAST CENTRAL AFRICA

QUARTERMASTER RESEARCH & ENGINEERING CENTER
ENVIRONMENTAL PROTECTION RESEARCH DIVISION

JUNE 1958

NATICK, MASSACHUSETTS

HEADQUARTERS
QUARTERMASTER RESEARCH & ENGINEERING COMMAND, US ARMY
OFFICE OF THE COMMANDING GENERAL
NATICK, MASSACHUSETTS

Major General Andrew T. McNamara
The Quartermaster General
Washington 25, D. C.

Dear General McNamara:

This report, "Analogs of Canal Zone Climate in East Central Africa", is the third of a series of tropical studies comparing the climates of tropical areas throughout the world with the climate of the Canal Zone. This report presents information for military planners and test personnel concerning the degree to which the climates of Balboa Heights and Cristobal in the Canal Zone resemble those of East Central Africa, and thus suggests the applicability to other regions of the results of equipment performance tested in the Canal Zone. Such information will also help those who plan, carry out, and appraise tests of Quartermaster clothing and equipment to select the proper time and place of testing.

Sincerely yours,

C. G. CALLOWAY
Major General, USA
Commanding

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EP-90

HEADQUARTERS QUARTERMASTER RESEARCH & ENGINEERING COMMAND, US ARMY
Quartermaster Research & Engineering Center
Natick, Massachusetts

ENVIRONMENTAL PROTECTION RESEARCH DIVISION

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ANALOGS OF CANAL ZONE CLIMATE IN EAST CENTRAL AFRICA

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Prepared for the Environmental Analogs Project (8-97-10-004)
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FOREWORD

A successful research, development, or training program requires a knowledge of the degree of environmental representativeness of test sites and training areas. The Quartermaster Corps, at the request of the Corps of Engineers, Waterways Experiment Station, under a directive from the U. S. Army General Staff, is developing a generalized, comparative, climatic picture of the wet tropics throughout the world by a series of tropical analog studies. The series parallels another already completed, which presented comparisons between Yuma, Arizona and the various desert regions of the Northern Hemisphere.

This is the third report of the tropical series. It compares the Canal Zone climate with that of East Central Africa, and by so doing provides a climatic reference for military planners and test personnel.

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ABSTRACT

The climate of East Central Africa is compared with that of Balboa Heights and Cristobal in the Canal Zone. Distributions of areas of analogy of pertinent climatic elements and combinations of these elements are shown on maps. Most of the study area is too hot and too dry for analogy with the tropical environment of the Canal Zone. No part of the study area has enough rainfall to be comparable with Cristobal. The one area that is closely analogous to Balboa Heights is in the Congo Basin, west of longitude 30° E and south of latitude 7° N. The amount of rainfall analogous to that of Balboa Heights is limited mostly to the southwestern part of the study area. Highlands in Kenya, Uganda, and Ethiopia are the only areas which are too cool for analogy with either Canal Zone station.

Relative humidities in most of the desert and interior regions are too low for analogy. However, some areas near the Gulf of Aden, Indian Ocean, Lake Victoria, and the Congo River, are either analogous or are too high for analogy. Areas with greatest mean monthly precipitation have mean cloudiness conditions nearly analogous to the Canal Zone. Analogy of mean wind speeds with those in the Canal Zone is erratically scattered throughout East Central Africa.

ANALOGS OF CANAL ZONE CLIMATE IN EAST CENTRAL AFRICA

1. Purpose and scope

This report is the third of a series comparing the climate of tropical regions with that of Cristobal and Balboa Heights, Canal Zone. These two stations were selected to represent the climates of the Atlantic and Pacific portions of the Canal Zone, respectively. The environment of Cristobal is described in a previous report (Wiley and others, 1955).

No attempt has been made to provide a regional climatology of East Central Africa. Instead, the method has been to select certain climatic elements that are considered particularly significant and, for each of these, to map the areas within the region considered closely analogous to either Balboa Heights or Cristobal. Some of the information presented on these maps of single climatic elements has been consolidated into two composite maps, one for each of the two Canal Zone stations, showing areas where there is a coincidence of analogy for several climatic elements.

2. Delimitation and geography of East Central Africa

For this study, East Central Africa includes all of Eritrea, Ethiopia, Sudan, French Somaliland, British Somaliland, and Somalia; parts of French Equatorial Africa, Egypt, and Libya; and the portions of the Belgian Congo, Kenya, and Uganda north of the Equator. (See Fig. 2)

Most of the area north and west of Khartoum, Sudan, consists of varying types of desert topography. The southwestern portion of the study area is dominated by the Congo Basin, containing tropical rain forest. There are two principal mountainous regions in the study area, the Ethiopian Massive, and the Kenya Highlands. In the Ethiopian Massive, the highest peak is Ras Dashan with an altitude of 15,154 feet. In the Kenya Highlands, Mt. Elgon, at 14,178 feet, is the highest point. Mt. Kenya, a higher peak in these highlands, is just outside the study area. Lago Assale in the Danakil Lowland is the lowest point in the study area; its surface is 380 feet below sea level. Parts of the Nile and Congo Rivers flow through the region. The major topographic regions shown in Figure 2 are described briefly in the following paragraphs.

The westernmost portion of this region, the Ubangi-Shari Upland, is a poorly-defined region occupying most of French Equatorial Africa included in this study. These uplands increase in elevation from west to east, with the highest point lying in the Marra Mountains (10,131 feet) in west central Sudan. The uplands are part of the transition zone between the deserts in the north and the equatorial rain forests of the Congo Basin in the south. A savanna type of climate prevails in the central part of the region, with long rainy and dry seasons.

The Kordofan Plateau, the Upper Nile Basin, and the Sudd are encompassed in one large region in the Sudan. The Kordofan Plateau, at elevations of 2,000 to 3,000 feet, occupies the western part of this region. There are no mountains or other outstanding relief features in this plateau.

The Upper Nile Basin and the Sudd lie to the south of the Kordofan Plateau; together they constitute a basin of low gradient in which the Nile and some of its major tributaries flow along meandering courses. In the center of this basin, masses of floating vegetation, or sudd, clog the courses of the rivers, creating a large marshy area. Most of this region is below 2,000 feet in elevation, although there are a few outliers of the Ethiopian Massive in the east.

In the northeastern portion of the study area, the Etbai Range fringes the western coast of the Red Sea as dissected mountains 3,000 to 7,500 feet high. Because of the scanty rainfall in this range, most of the streams are intermittent.

Separated from the Etbai Range by a valley south of Tokar, the Ethiopian Massive consists of a north-south core of mountainous territory extending from the edge of the Red Sea to the Eastern Rift depression at Lake Rudolf. Most of the region is higher than 6,500 feet, and some flat-topped mountains exceed 14,000 and 15,000 feet. The eastern segment of this region is treated as a part of the Somali Plateau and is separated from the greater massive by the trough of the Abyssinian Graben. The Ethiopian Massive has the most rugged topography of Africa. Many of the rivers have cut deep valleys in the plateau surface, which otherwise has the physical appearance of a level lowland.

Directly east of the narrowest part of the Abyssinian Graben lies the Somali Plateau which is a continuation of the Ethiopian Massive. This plateau graduates to lower elevations from northwest to southeast into the Somalia plains along the coast of the Indian Ocean. The Giuba and Shibeli Rivers drain the Somali Plateau to the south. Only in the western mountains and along the southern Somalia coast is the rainfall sufficient to prevent the region from being a desert.

Extending northeastward from Lake Rudolf through Ethiopia and including French Somaliland and parts of Eritrea and British Somaliland are the Abyssinian Graben and the Danakil Lowland. Both of these regions are a continuation of the Eastern Rift System. The graben is marked by a series of small deep lakes, through the southern block of the Ethiopian Massive, including Lakes Stefanie, Chamo, Abaya, and Zwai. In the broad northern stretches of the depression the Awash River drains into Lake Abbe in French Somaliland. The northern part of the graben widens, forming approaches to the Red Sea and the Gulf of Aden. North of the graben is the Danakil Lowland, with small intermittent streams terminating in several playa lakes. This lowland, 380 feet below sea level, is separated from the Red Sea by a low-lying hilly coastal plain.

The Eastern and Western Rift Belts terminate in southern Ethiopia, and southern Sudan, respectively. The interior lowland north of Lake Rudolf is the northern end of the Eastern Rift. The northern end of the Western Rift is near Torit, Sudan. Lake Albert, Lake Edward, and the Albert Nile River flow north into the Upper Nile and Sudd region from the floor of this rift. These two structural breaks in the highland areas have local climatic attributes which are incongruous with the surrounding regions.

The Interior Plateau, which comprises Uganda and a portion of Kenya, is part of the basin containing Lake Victoria. The mountains composing the edge of the Eastern Rift are volcanic cones, and lava extrusions are found here as in the Kenya Highlands. Most of the region is composed of rolling terrain 3,000 to 5,000 feet in elevation. Drainage from this plateau is into Lake Victoria or the Albert Nile. The land is higher in the south and west near the Western Rift.

The Central African Swell, a higher continuation of the Interior Plateau, lies west of the Western Rift. This region slopes westward and southward from the plateau into the Congo Basin. A mountain mass west of Lake Albert, 5,000 to 8,000 feet high, is the core of this region. West and north of this mass, the land is of moderate relief. A wide transitional plain lies between the mountains and the Congo Basin.

The Congo Basin, a part of which is in this study area, is characterized by the Congo River and its many tributaries. At Stanley Falls, just north of the Equator, the long north-flowing Congo turns westward. Most of the tributaries of the Congo in this region follow trellis drainage patterns across the wide, flat plain. This basin is old, and the course of the river falls only 246 feet in the 330 miles from Barumbu to Coquilhatville, Belgian Congo. The monotony of the landscape is characterized by tropical rain forest.

As East Central Africa has a greater relief than the rest of Africa, local variations in climate are more pronounced. The reliability of rainfall prediction in the desert areas is poor, some years having no rain and other years having several inches in one or two days. In the northern summer, wind from the southwest and west advances over the study area "distributing the summer rains of the Sudan and Ethiopia which feed the Nile flood; the aridity of Eritrea and Somaliland east of Ethiopia and the plateau on the south may be largely a rain-shadow effect" (Kendrew, 1953). In winter the northeast monsoon brings only slight precipitation to the windward heights. In the Ethiopian Massive, frequent violent thunderstorms swell the mountain streams and desert playas in the lowlands for brief periods. The wind system along the Indian Ocean shore is influenced by both the northeast monsoon and the southeast trades; the resultant winds are off-shore during the wet months and along-shore during the dry months. This produces either an evaporating effect or very little precipitation.

Vertical zonations of mountain climates are found in the areas of high elevations, with cool, moist conditions supporting "cloud forests" at some levels (6,500 to 9,000 feet). Field observers in this region report that neither the higher plateaus in Ethiopia nor the peaks of the Kenya Highlands are snow-capped all year.

3. Climatic summary of the Canal Zone

The Pacific portion of the Canal Zone, represented by Balboa Heights, has a moderately humid tropical climate with a four-month dry season (Fig. 1). The difference in mean monthly temperatures of the warmest and coldest months is only 2 F°, and the range from the highest mean daily maximum (March and April, 90°F) to the lowest mean daily minimum (February, 71°F) is only 19 F°. Precipitation, averaging 70 inches annually, is markedly seasonal. Two months, February and March, have less than 1 inch of rainfall, and five months have more than 8 inches. The dry season begins in December and ends in April. Rainfall in each of the remaining months is more than 7 inches; October and November both have more than 10 inches. Relative humidity is high from June through November. Cloudiness is at a maximum from May through November, coinciding with the wet season; sky coverage averages about 8 tenths at Balboa Heights at that season. Wind speed, however, is greatest during the dry season; winds average 9 to 10 mph at Balboa Heights from January through April, but only about 5 to 6 mph during the remainder of the year. Southeastward toward the coast, there is a slight decrease in rainfall and an increase in temperature, as elevation drops to sea level from 118 feet at Balboa Heights. Rainfall increases to the northwest, averaging 88 inches at Gamboa, 117 inches at Monte Lirio, and more than 130 inches at Cristobal.

The Atlantic portion of the Canal Zone, represented by Cristobal, has a wet tropical climate (Fig. 1). The difference in mean temperatures of the warmest and coolest months is only 2 F°, and the range from the highest mean daily maximum (April, May, June, September, and October, 86°F) to the lowest mean daily minimum (October and November, 75°F) is only 11 F°. The mean annual temperature of 81°F is typical of equatorial areas. Precipitation averages 130 inches a year, and the monthly distribution is uneven. Although no month can be considered really dry, two months have less than 2 inches of rainfall, while eight months have more than 11 inches. The drier season at Cristobal begins in January (3.4 inches) and ends in April (4.1 inches). During the remaining months, average rainfall ranges from about 12 to 22 inches. Mean relative humidity is high in all months; the lowest mean value, 77 percent, occurs in February and March. Cloud cover is greatest in July, 8 tenths, and least in February, 5.5 tenths. Mean wind speed is greatest in February and March (nearly 15 mph) and least in September (about 6 mph).

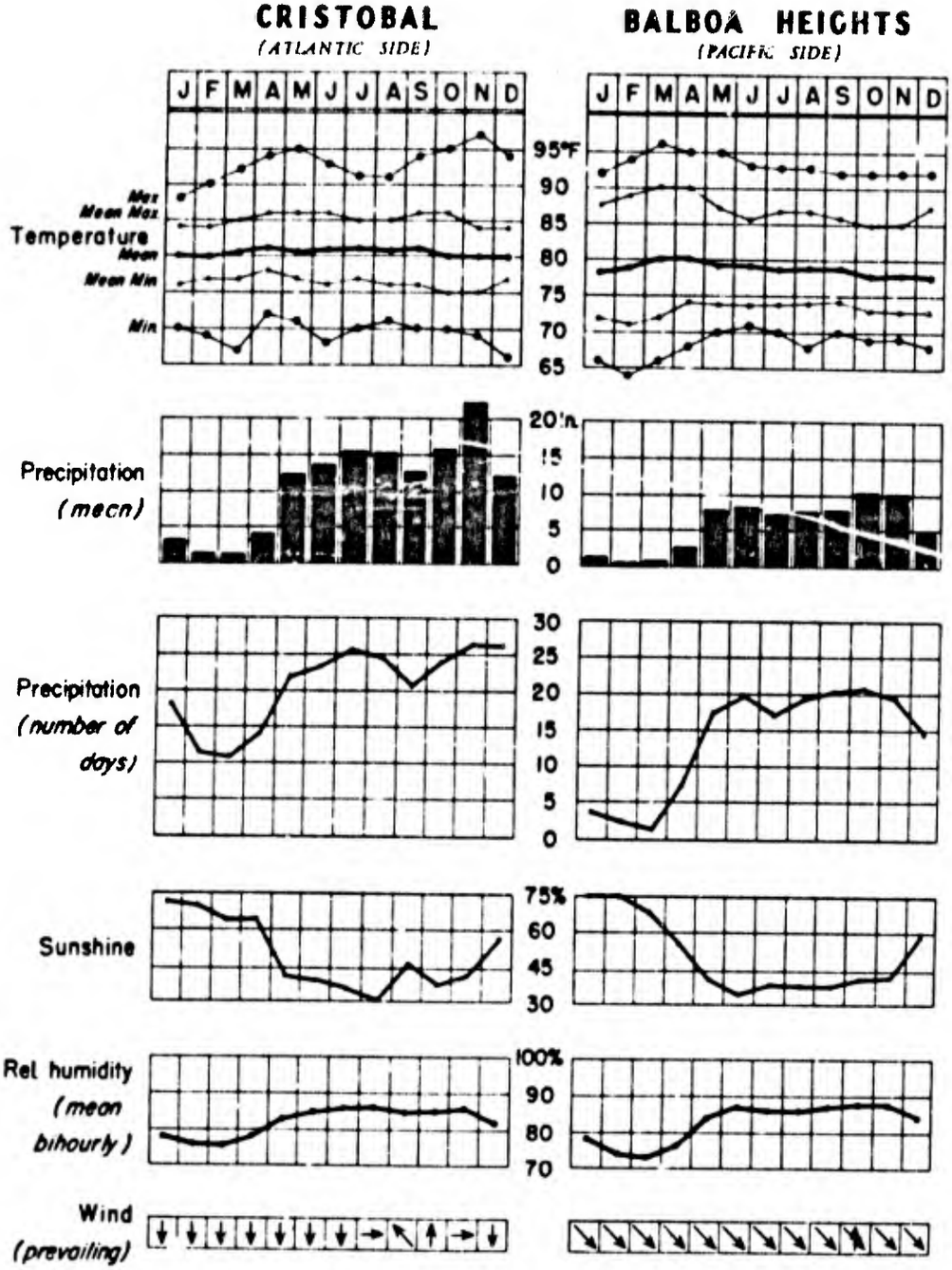

Figure 1. Climatic Summary of 2 Canal Zone stations

4. Criteria and methods

a. Climatic elements selected for study

As in the previous studies of this series, temperature, precipitation, humidity, cloud cover, and wind speed were the climatic elements considered most important to military activities. It was assumed that test authorities are more interested in stress periods (e.g., hottest and wettest) and in annual fluctuations than in the data for specific calendar months; accordingly, the warmest, coldest, wettest, and driest months of the year at each station were selected for study. The following specific climatic elements were studied:

(1) Mean temperature of the warmest month
(2) Mean daily maximum temperature of the warmest month
(3) Mean temperature of the coldest month
(4) Mean daily minimum temperature of the coldest month
(5) Mean daily temperature range of the warmest month
(6) Mean annual precipitation
(7) Mean precipitation of the wettest month
(8) Number of wet months
(9) Relative humidity of the driest month
(10) Mean cloud cover of the wettest month
(11) Mean wind speed of the wettest month

b. "Analogous" and "semianalogous" ranges defined

Classes were established defining the ranges of values considered to be closely analogous to those for Balboa Heights and Cristobal. Fairly narrow limits of analogy were used in order to keep comparisons closely representative of the two reference stations. Table I lists the classes of analogy and semianalogy selected for each element. For temperature, a departure of 4 degrees from the mean at the Canal Zone station was allowed for each analogy class (except where a mean was taken for the two reference stations), and an additional 4 degrees for semianalogy. As for precipitation: the mean annual rainfall of 70 inches at Balboa Heights is somewhat below that normally considered humid equatorial (supporting dense evergreen forest) for a locality with a dry season; therefore, in this tropical deciduous forest the limits of analogy were set at 55 to 85 inches, differentiating it from most of the evergreen rain forest areas, on the upper margin, and savanna areas, on the lower margin. Cristobal, which has a tropical evergreen rain forest type of climate, has a mean annual rainfall of 130 inches. A departure of up to 30 inches of mean annual rainfall was considered analogous to Cristobal, and an additional 30 inches was considered semianalogous. Departures of 5 percent in mean relative humidity, 1 tenth in amount of cloudiness, and 2 mph in wind speed were selected as ranges of analogy for these elements.

c. Explanation of maps

Values are shown for each station, with degree of analogy indicated by

a symbol. Isopleths were drawn to show zones of close analogy, and these zones are shaded. Areas of semianalogy were not shaded but were indicated by placing the appropriate symbol on the map and legend for stations having semianalogous conditions. From the separate maps showing analogous areas for each element, two composite maps were prepared, one for Balboa Heights and one for Cristobal, indicating regions where the following four single elements are analogous: mean temperature of the warmest month, mean temperature of the coldest month, mean annual precipitation, and number of wet months.

d. Limitations of data

The procedures as outlined have certain definite limitations in a climatic comparison of this sort. Foremost among these is the necessity, often encountered in climatology, of assuming climatic conditions in areas having few if any stations.

A second limitation is that some elements, such as dew point, solar radiation, and visibility, which would have proved valuable as indicators of climatic analogy, were not included in this study because of the limited amount of data available.

For certain elements the number of stations reporting does not provide a representative picture. Consequently, isopleths were not drawn for mean relative humidity for the driest month, mean cloudiness for the wettest month, or mean wind speed for the wettest month. The assumption has been made that Balboa Heights and Cristobal are representative of the Pacific and Atlantic portions of the Canal Zone.

Data from some African stations are not given in a form directly comparable to that for the Balboa Heights or Cristobal records. Where period of record, hours of observation, or manner of observation differed, station records had to be interperated in drawing the isopleths. Values outside the limits of analogy or semianalogy were not analyzed, nor were combinations of climatic elements other than those involved in computing number of wet months.

The method of recording temperatures varies from country to country. Mean temperatures are usually determined by averaging the daily maximum and minimum temperatures; however, at some stations in East Central Africa the means are obtained by averaging bi-hourly temperature observations as at Balboa Heights and Cristobal. Experience has shown that the difference between mean temperatures derived by these different ways is seldom more than 1 F^{o} (Contreras Arias, 1942). Hours of observation of relative humidity, wind speed, and cloudiness vary widely throughout the study area.

5. Analysis of single-element maps

Individual maps showing analogous areas have been prepared for the

climatic elements listed in paragraph 4a above, numbers 1 through 8. Maps of elements 9, 10, and 11 have been prepared showing only the values for individual stations, since the data were considered inadequate for delimiting analogous areas.

Much of the study area has been discussed previously in the Yuma analog series (Nelson, 1956), so there are but few stations shown in the deserts. The greatest densities of stations are located in Uganda, the western Congo Basin, along the Nile at the confluence of the Blue and White Niles, and in the highlands of Eritrea. The stations shown on the station location map have been selected from a larger number for greater clarity of the map.

a. Mean Temperature, Warmest Month (Fig. 3)

As Table I indicates, the analogous areas for both Balboa Heights and Cristobal for the mean temperature of the warmest month have values between 77°F and 85°F. The map shows that most of the area south of latitude 10° N is analogous to the Canal Zone stations, except for the highlands of the Ethiopian Massive and the Somali Plateau, most of the Interior Plateau, and the Kenya Highlands, all of which are too cool for analogy. In the Kenya Highlands region the weather station with the lowest mean temperature for the warmest month, 58.1°F, is at Equator, Kenya. In the north, temperatures are too high for analogy. A narrow belt of analogy circumscribes the Ethiopian Massive along the steep slopes, separating the cooler heights from the deserts at lower elevations. A major indentation of hotter-than-analogous temperatures penetrates as far south as latitude 5° N along the Sobat River lowland. To the east along the shore of the Indian Ocean are two areas of hotter temperatures. The highest mean temperature for the warmest month, 97°F, is recorded at Berbera, British Somaliland, in July and August.

b. Mean Daily Maximum Temperature, Warmest Month (Fig. 4)

At Balboa Heights, the mean daily maximum temperature for the warmest month is 90°F, whereas at Cristobal it is 86°F. As analogous temperatures for the two stations are respectively 86° to 94°F and 82° to 90°F, there is complete analogy for both stations when temperatures are from 86° to 90°F. Most of the area is hotter than the Canal Zone; the only areas of cooler daily temperatures are in the higher mountains of the Ethiopian Massive, the Interior Plateau, and the Kenya Highlands. The lowest mean daily maximum temperature for the warmest month, 66°F in June, is at Alomata, Ethiopia. La Regeau, in northern French Equatorial Africa, has the highest mean daily maximum temperature, 111.2°F, in May and June. Except for a small area around Mogadiscio in Somalia, the eastern Somali Plateau is too hot for analogy. The greatest area of complete analogy is within the Congo Basin. Smaller areas of complete analogy occur in Central Ethiopia and Southern Kenya. Cristobal, with lower temperatures, has less analogy than Balboa Heights.

c. Mean Temperature, Coldest Month (Fig. 5)

Analogy for both Canal Zone stations is 75° to 83°F for the mean temperature of the coldest month. Most of the western part of the area south of latitude 15° N and west of the Ethiopian Massive is analogous to this 8 F° range. Two other areas of analogy are the Danakil Lowland and the adjoining delta of the Abyssinian Graben in the north, and most of the Indian Ocean coast inland to the edge of the Somali Plateau. The only station that records a temperature in excess of analogy is Lugh Ferrandi, Somalia, which records a mean of 84.6°F in August. Three areas having temperatures too low for analogy appear within the western portion of the study area. The first, extending from Kafia Kingi southeastward along the southwestern Sudan border to Yubo, is a rolling upland above 3,000 feet in elevation. The second is Zeraf Cut in the Sudan, a valley location within the marshy delta of the Upper Nile Basin. The third area is the higher mountain range west of Lake Albert. The lowest mean temperature for the coldest month, 46°F. is at Adi Caieh, Eritrea.

d. Mean Daily Minimum Temperature, Coldest Month (Fig. 6)

For Balboa Heights analogy, the mean daily minimum temperature for the coldest month is 67° to 75°F, and for Cristobal it is 71° to 79°F. The areas of analogy are similar to those for the mean temperature of the coldest month, except that they are smaller, and all highlands above 3,000 feet are too cold for analogy. Only two stations in the entire region, Lugh Ferrandi and Brava, Somalia, have a coldest month mean daily minimum temperature as high (75°F) as that of Cristobal. Along the Indian Ocean, Gulf of Aden, and Red Sea coasts as far north as Massaua, Eritrea, analogous temperatures prevail. The lowest mean daily temperature for the coldest month, 38°F, is recorded in November and December at Dessie, north of Addis Ababa, Ethiopia.

e. Mean Daily Temperature Range, Warmest Month (Fig. 7)

A range from 4 F° to 20 F° constitutes analogy with one Canal Zone station or the other. For Cristobal, analogy is 4 F° to 12 F°; for Balboa Heights, analogy is 12 F° to 20 F°. In East Central Africa there are three major areas of analogy with Balboa Heights. One area follows closely the analogous area for the mean daily temperature of the coldest month (Fig. 6), along the Indian Ocean, Gulf of Aden, and bordering the Red Sea to Massaua, Eritrea. The other areas include the northwest shore of Lake Victoria and part of the Congo Basin. Only one station has a range small enough to be comparable with Cristobal; that is Brava, Somalia, where the mean daily range in April is 11 F°. On the other hand, Abeche, French Equatorial Africa, has an April and May range of 37.4 F°.

f. Mean Annual Precipitation (Fig. 8)

No station in East Central Africa records an annual precipitation heavy enough for analogy with Cristobal. The range of analogy for Balboa

Heights is 55 to 85 inches. Only in the southwest portion of the region, in the Congo Basin, is there any extensive area analogous to Balboa Heights. Smaller areas of analogy are along the northeastern shore of Lake Victoria and in three isolated mountain areas on the western escarpment of the Ethiopian Massive. It is within one of these three mountain areas, at Gore, Ethiopia, that the greatest mean rainfall occurs: the average is 79 inches per year over a 27-year period. Most of the precipitation reaching this area originates in the South Atlantic Ocean. During the period from April to October the southwesterly winds are under the influence of the summer low pressures of the Sahara and advance across the continent. However, some moisture is evaporated from the heart of the humid Congo Basin, and more is added from the great expanse of Lake Victoria. Thunderstorms produce the majority of the heavier rains in the higher elevations of the plateaus and in the Congo Basin. The driest areas are in the northwest Libyan Desert of French Equatorial Africa. For example, La Regeau has a mean of 0.5 inches (shown on the map as 1).

g. Mean Monthly Precipitation, Wettest Month (Fig. 9)

Analogy for precipitation of the wettest month is 8 to 14 inches for Balboa Heights and 15 to 29 inches for Cristobal. The analogous areas lie south of 15° N latitude and west of 40° E longitude. An area too dry for analogy separates the two largest areas of analogy along the lower Sudd, eastward past Lake Rudolf. The Ethiopian Massive because of higher altitudes has more rainfall than the surrounding low country. Included within a large area of Balboa Heights analogy are two areas of Cristobal analogy within the Massive. In northern Ethiopia, Selassie has the greatest mean monthly precipitation in the wettest month, 27.1 inches in July. Lake Tana, which is one of the sources of the Blue Nile, is surrounded by the other area of Cristobal analogy. To the south, northeast of Lake Victoria, an area of Balboa Heights analogy extends eastward for several hundred miles. In Somalia from the coast, through Balad, inland to Iscia Baidoa lies a small area analogous to Balboa Heights.

h. Number of Wet Months (Fig. 10)

In this series of analogs the term "wet month" is based on the Thornthwaite (1931) formula, having a base mean temperature of 68° and a mean monthly precipitation of 1.96 inches or more. Mean monthly precipitation for any given mean monthly temperature must be at least as high as the values indicated below in order to be called wet.

Mean monthly temperature (°F)	Mean monthly precipitation (in.)
95	2.88
90	2.71
85	2.54
80	2.37
75	2.20
70	2.03
68	1.96

Wet months with mean monthly temperatures below 68°F are excluded from consideration as being nontropical.

Using the above definition, the areas of analogy for wet months are 8 to 10 wet months for Balboa Heights and 9 to 11 wet months for Cristobal. There is only one area of such analogy in East Central Africa. It stretches over the Congo Basin, the Central African Swell, and past Lake Victoria to the peaks of the Kenya Highlands. The northernmost station exhibiting analogy is Bria, French Equatorial Africa, approximately 7° N latitude. On the southern border of this analogous zone is an area of 12 wet months; on the north there are too few wet months for analogy.

i. Relative Humidity, Driest Month (Fig. 11)

Relative humidities of the driest month of 70 to 80 percent and 72 to 82 percent are considered analogous for Balboa Heights and Cristobal respectively. Isopleths for this map were not drawn because of the inconsistency of records for this element. Roughly, there are three areas of probable analogy. One is the heart of the Congo Basin, the second includes French Somaliland, and the third is the shore of the Indian Ocean from the Gulf of Aden to the Equator. The highest mean relative humidity for the driest month, 87 percent in January, February and March, is recorded on the Indian Ocean coast at Mogadiscio, Somalia. The lowest mean relative humidity reported in this region, 18 percent in January, is at El Obeid and Kadugli, Sudan.

j. Mean Cloudiness, Wettest Month (Fig. 12)

Although there is a scarcity of data for mean cloudiness of the wettest month, and no isopleths were drawn, most of the Ethiopian Massive, and the Kenya Highlands are analogous to the Canal Zone. Sky cover of 7 to 8.9 tenths is considered analogous for both Canal Zone stations in the wettest month.

k. Mean Wind Speed, Wettest Month (Fig. 13)

Wind speed analogy of Balboa Heights for the wettest month is 4 to 8 mph, and that of Cristobal is 6 to 10 mph. With only 41 stations recording this element, and because of the differences of method and time,

no lines are drawn on this map. The Sudan and French Equatorial Africa have the most complete coverage of wind speed data.

6. Analysis of composite maps (Fig. 14, 15)

Two maps have been prepared which show composite analogous areas for Balboa Heights (Fig. 14) and Cristobal (Fig. 15). These composites consist of analogy of the following criteria for each Canal Zone station: mean temperature of the warmest month, mean temperature of the coldest month, and mean annual precipitation. Any area which is analogous with respect to these elements was then tested for complete analogy by plotting the analogous areas of the mean number of wet months. There is only one area of complete analogy with either Canal Zone station. A 200-mile wide belt of analogy to Balboa Heights, just north of the Congo River, extends from the western margin of the study area eastward to approximately 30° E. longitude. North of this belt there are too few wet months for analogy, and south of it there are too many wet months.

No area is analogous to Cristobal because of insufficient precipitation.

7. Tables of monthly values

Tables II through IX show the monthly and yearly means of the climatic elements for 22 East Central African key stations as well as the two Canal Zone stations. These stations were selected for length of reliable record and representativeness. No key stations are shown for the northern part of the region, which is largely desert. In each table the mean values for the stations reveal certain characteristics of climatic analogy which are not manifest in the maps. For example, a truer climatic picture is presented when one knows the length and frequency of the dry seasons.

TABLE I: CLIMATIC ELEMENTS AND CLASSES OF ANALOGY

Station index	Balboa Heights: Value of B.H. (mean)	Balboa Heights: Analogous (range)	Balboa Heights: Semianalogous (range)	Cristobal: Value at Cris. (mean)	Cristobal: Analogous (range)	Cristobal: Semianalogous (range)
TEMPERATURE (°F)						
Mean, warmest month*	80°F	77°-85°F	73°-76°F 86°-89°F	82°F	77°-85°F	73°-76°F 86°-89°F
Mean daily maximum, warmest month	90°F	86°-94°F	82°-85°F 95°-98°F	86°F	82°-90°F	78°-81°F 91°-94°F
Mean coldest month*	78°F	75°-83°F	71°-74°F 84°-87°F	80°F	75°-83°F	71°-74°F 84°-87°F
Mean daily minimum, coldest month	71°F	67°-75°F	63°-66°F 76°-79°F	75°F	71°-79°F	67°-70°F 80°-83°F
Mean daily range, warmest month	16F°	12F°-20F°	8F°-11F° 21F°-24F°	8F°	4F°-12F°	0F°-3F° 13F°-16F°
PRECIPITATION						
Mean annual (inches)	70	55-85	40-54 86-100	130	100-160	70-99 161-190
Mean, wettest month (inches)	11	8-14	5-7 15-17	22	15-29	8-14 30-36
Number of wet months	9	8-10	7 11	10	9-11	8 12
RELATIVE HUMIDITY (%)						
Mean, driest month	75%	70-80%	65-69% 81-85%	77%	72-82%	67-71% 83-87%
CLOUDINESS (tenths)						
Mean, wettest month	7.6	7.0-8.9	6.0-6.9 9.0-10.0	7.6	7.0-8.9	6.0-6.9 9.0-10.0
WIND SPEED(mph)						
Mean, wettest month	5.8	4-8	2-3 9-10	8	6-10	4-5 11-12

* See section 4b for explanation of ranges of analogy; sometimes a mean of the 2 reference stations is used.

TABLE II: STATIONS USED IN TABLES OF MONTHLY VALUES

Stations	Elev(ft)	Lat (N)	Long (E)	Period of Record (Yr) Temp.	Prec.	Other
Abeche (French Eq. Africa)	1,969	13°49'	20°47'	5	17	15
Addis Ababa (Ethiopia)	8,005	9°02'	38°45'	4	37	2
Asmara (Eritrea)	7,785	15°18'	38°56'	27	40	2
Bahar Dar (Ethiopia)	6,037	11°36'	37°25'	4	5	4-5
BALBOA HEIGHTS (Canal Zone)	118	8°58'	79°35'W	12-34	22-38	11-34
Bangassou (French Eq. Africa)	1,693	4°45'	22°50'	7	26	7
Bangui (French Eq. Africa)	1,296	4°22'	18°35'	22	21	21
CRISTOBAL (Canal Zone)	36	9°25'	79°52'W	7-32	8-60	3-41
Djibouti (French Somaliland)	20	11°35'	43°09'	30	34	30
Eldoret (Kenya)	6,863	0°32'	35°16'	15	15	15
El Fasher (Sudan)	2,395	13°38'	25°21'	17	17	17
Entebbe (Uganda)	3,842	0°05'	32°29'	26	50	26
Er Roseires (Sudan)	1,532	11°51'	34°23'	31	31	31
Ft Archambault (French Eq. Africa)	1,204	9°19'	18°24'	13	15	13
Gambela Post (Ethiopia)	1,345	8°15'	34°35'	26	30	26
Guardafui, Capo (Somalia)	262	11°44'	51°15'	3-5	1	1
Harar (Ethiopia)	6,071	9°42'	42°30'	10	14	1
Impfondo (Belgian Congo)	1,115	1°36'	18°04'	6	18	6
Khartoum (Sudan)	1,280	15°37'	32°33'	22	36	22
Lugh Ferrandi (Somalia)	535	3°47'	42°32'	13	16	13
Mogadiscio (Somalia)	39	2°01'	45°20'	15	15	4-5
Port Sudan (Sudan)	64	19°37'	37°13'	30	29	29
Stanleyville (Belgian Congo)	1,400	0°30'	25°11'	6	12	-
Yubo (Sudan)	1,968	5°24'	27°15'	7	7	7

TABLE III: MEAN MONTHLY TEMPERATURE (°F)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr
Abeche	81	82	88	92	92	91	85	80	84	87	84	80	86
Addis Ababa	62	59	64	61	63	59	57	59	58	60	61	60	60
Asmara	63	65	67	67	66	65	65	64	63	62	62	59	64
Bahar Dar	65	64	71	70	68	68	65	65	65	65	65	62	66
BALBOA HEIGHTS	78	79	80	80	79	79	79	79	79	78	78	78	79
Bangassou	79	81	81	81	80	79	78	77	78	78	79	78	79
Bangui	79	81	81	81	80	78	77	77	78	77	78	78	79
CRISTOBAL	80	80	81	82	81	81	81	81	81	80	80	80	81
Djibouti	78	79	81	84	88	93	96	94	90	85	81	79	86
Eldoret	63	64	64	65	63	61	60	60	61	63	63	62	62
El Fasher	69	72	78	83	86	87	83	81	82	82	75	69	79
Entebbe	72	72	72	71	71	70	69	69	70	71	71	71	71
Er Roseires	75	78	84	87	85	80	76	75	76	78	79	76	79
Ft. Archambault	80	83	88	89	86	83	79	78	80	82	82	80	82
Gambela Post	81	83	86	85	82	79	78	78	79	79	80	80	81
Guardafui, Capo	74	76	78	81	82	82	80	80	78	78	77	74	78
Harar	66	68	69	69	69	68	66	65	67	68	67	67	68
Impfondo	79	80	80	80	80	78	77	77	78	78	78	78	78
Khartoum	73	74	81	87	91	91	88	86	89	88	81	75	84
Lugh Ferrandi	89	92	93	91	88	87	85	85	87	88	88	89	88
Mogadiscio	81	83	83	84	82	81	79	79	80	81	82	81	81
Port Sudan	74	74	76	80	85	90	94	94	90	85	81	77	83
Stanleyville	78	78	78	78	79	77	76	76	76	77	77	77	77
Yubo	78	80	79	78	77	75	74	74	75	76	77	77	77

TABLE IV: MEAN DAILY MAXIMUM TEMPERATURE (°F)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr
Abeche	102	103	108	112	110	109	101	92	100	106	103	100	104
Addis Ababa	76	76	78	77	79	77	72	71	73	76	74	74	75
Asmara	76	76	76	78	79	79	80	73	74	72	71	72	75
Bahar Dar	82	83	86	83	80	79	74	74	76	79	78	79	79
BALBOA HEIGHTS	88	89	90	90	87	86	87	87	86	85	85	87	87
Bangassou	94	95	94	92	91	89	88	87	89	89	90	91	91
Bangui	91	93	92	91	89	88	86	86	87	87	88	89	89
CRISTOBAL	84	84	85	86	86	86	85	85	86	86	84	84	85
Djibouti	84	85	87	90	95	102	105	104	98	92	89	86	93
Eldoret	79	80	79	78	75	74	71	72	75	77	76	76	76
El Fasher	88	91	97	102	103	102	96	92	97	99	94	89	96
Entebbe	80	80	80	78	78	77	77	77	79	80	80	80	79
Er Roseires	98	100	103	105	102	95	90	89	92	97	99	98	97
Ft. Archambault	98	101	104	102	97	92	88	86	88	92	97	98	95
Gambela Post	98	100	101	98	93	89	87	87	89	92	94	96	94
Guardafui, Capo	80	82	83	87	89	88	88	87	84	85	83	81	85
Harar	77	78	80	80	80	78	75	74	76	78	78	78	78
Impfondo	88	90	91	91	90	87	85	86	87	87	87	88	88
Khartoum	88	90	98	104	106	105	101	97	101	102	96	89	98
Lugh Ferrandi	102	105	106	103	97	96	94	94	98	99	100	101	100
Mogadiscio	89	89	89	91	88	86	84	84	87	87	88	88	88
Port Sudan	81	81	84	89	95	102	106	105	100	93	88	83	92
Stanleyville	87	88	88	87	85	86	84	83	83	84	85	85	86
Yubo	91	92	90	88	86	84	82	82	84	86	88	90	87

TABLE V: MEAN DAILY MINIMUM TEMPERATURE (°F)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr
Abeche	59	61	68	72	75	74	69	68	68	67	64	59	67
Addis Ababa	45	47	50	50	49	50	50	50	50	47	44	44	48
Asmara	49	52	54	56	55	55	58	55	55	52	50	46	53
Bahar Dar	48	45	56	56	57	57	57	57	54	51	52	45	53
BALBOA HEIGHTS	72	71	72	74	74	74	74	74	74	73	73	73	73
Bangassou	65	66	68	69	69	69	68	67	67	68	67	65	67
Bangui	67	68	70	70	70	69	68	68	68	68	68	67	69
CRISTOBAL	76	77	77	78	77	76	77	76	76	75	76	77	76
Djibouti	72	74	75	78	80	84	86	84	82	78	74	72	78
Eldoret	47	48	50	51	51	48	49	48	47	49	50	49	49
El Fasher	50	52	58	64	69	71	70	69	68	64	56	50	62
Entebbe	63	64	64	64	64	63	62	61	62	63	63	63	62
Er Roseires	61	63	68	72	74	72	70	69	69	68	65	61	68
Ft. Archambault	62	66	72	76	75	72	71	70	71	71	67	62	69
Gambela Post	64	67	70	71	70	69	69	68	68	67	66	65	68
Guardafui,Capo	69	71	74	75	76	75	73	73	71	71	71	68	72
Harar	54	57	58	59	59	58	57	57	58	58	56	56	57
Impfondo	68	69	70	70	69	69	68	68	68	68	68	68	69
Khartoum	58	58	64	69	75	78	76	75	76	74	67	60	69
Lugh Ferrandi	75	79	80	79	79	77	76	75	76	76	76	74	77
Mogadiscio	74	78	76	77	76	75	74	73	73	75	76	74	75
Port Sudan	68	66	68	70	75	78	83	84	79	76	74	70	74
Stanleyville	68	69	69	70	69	68	68	67	68	69	68	68	68
Yubo	66	68	68	68	67	66	66	66	66	66	66	65	66

TABLE VI: MEAN MONTHLY PRECIPITATION (inches)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr
Abeche	0.0	0.0	T	T	0.9	0.9	5.0	9.1	2.9	0.6	0.0	0.0	19.3
Addis Ababa	0.5	1.5	2.6	3.4	3.4	5.4	11.0	11.8	7.2	0.8	0.6	0.2	48.7
Asmara	0.0	0.1	0.3	1.2	1.9	1.1	6.8	6.1	1.1	0.5	0.3	0.0	19.4
Bahar Dar	T	0.0	0.4	1.1	3.1	4.6	16.6	11.3	9.7	3.9	1.0	0.1	51.8
BALBOA HEIGHTS	1.0	0.6	0.7	2.9	8.0	8.4	7.3	7.8	8.2	10.2	10.5	4.7	70.3
Bangassou	1.2	1.7	4.4	5.7	8.9	7.8	7.7	8.2	7.8	10.6	3.9	1.4	70.6
Bangui	0.9	1.6	4.8	5.0	7.2	6.0	7.6	9.0	7.4	8.2	3.9	1.3	62.8
CRISTOBAL	3.4	1.5	1.5	4.1	12.5	13.9	15.6	15.3	12.8	15.8	22.3	11.7	130.4
Djibouti	0.4	0.7	0.8	0.5	0.2	0.0	0.2	0.5	0.3	0.3	0.6	0.6	5.7
Eldoret	0.7	1.9	2.2	4.5	4.8	4.2	7.3	7.6	3.1	1.2	1.8	1.0	40.4
El Fasher	0.0	0.0	T	T	0.4	0.8	4.5	5.4	1.2	0.2	0.0	0.0	12.4
Entebbe	2.6	3.6	6.1	10.2	9.3	4.9	3.1	2.8	3.0	3.9	5.1	4.6	59.3
Er Roseires	T	T	0.1	0.6	2.4	5.0	7.1	8.4	5.9	1.3	0.2	0.0	31.0
Ft. Archambault	0.0	T	0.4	1.1	4.2	5.6	9.4	12.2	10.2	3.6	0.1	0.0	46.9
Gambela Post	0.2	0.4	1.4	3.2	5.9	6.7	8.5	9.4	7.3	3.5	1.8	0.4	48.7
Guardafui,Capo	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.8
Harar	0.4	1.3	3.0	4.7	5.0	3.5	5.1	6.3	3.7	1.4	0.6	0.4	35.3
Impfondo	2.6	3.0	5.8	6.0	6.8	5.8	5.3	6.8	7.1	8.2	6.2	3.8	67.4
Khartoum	T	0.0	T	T	0.1	0.3	2.0	2.6	0.7	T	T	0.0	5.6
Lugh Ferrandi	0.1	0.2	1.0	4.2	2.2	0.0	0.1	T	0.1	2.8	2.7	0.6	14.0
Mogadiscio	0.0	0.0	0.0	2.6	2.8	3.7	2.8	2.1	1.4	1.2	1.7	0.7	19.0
Port Sudan	0.3	0.2	T	T	T	T	0.2	0.2	T	0.6	1.8	1.0	4.3
Stanleyville	2.2	3.5	6.0	6.4	5.9	4.5	4.8	5.5	7.7	8.0	7.8	4.0	66.3
Yubo	0.0	0.9	2.3	4.4	7.6	9.4	7.0	8.7	9.2	6.6	2.2	0.7	59.0

TABLE VII: MEAN CLOUDINESS (tenths of sky covered)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr
Abeche	2.5	3.7	3.7	3.6	3.3	3.9	5.3	6.6	5.7	4.0	1.8	3.1	3.9
Addis Ababa	2.7	4.4	4.7	7.0	3.7	6.0	8.4	7.5	5.7	2.8	2.1	2.5	4.8
Asmara	3.5	5.1	2.7	2.6	1.7	4.6	8.0	7.6	4.2	2.5	1.3	1.6	3.8
Bahar Dar	2.0	1.0	4.4	3.6	5.4	5.3	7.8	7.3	5.6	2.7	3.1	0.8	4.1
BALBOA HEIGHTS	4.8	4.8	5.0	6.3	7.6	8.0	7.6	7.7	7.7	7.7	7.6	6.3	6.8
Bangassou	5.1	5.4	6.3	6.2	6.5	6.6	*-	6.7	6.7	7.0	6.7	6.5	-*
Bangui	3.6	4.2	5.1	4.6	5.6	5.7	6.4	6.7	6.0	6.1	5.2	3.8	5.3
CRISTOBAL	5.9	5.5	5.8	6.4	7.8	7.9	8.0	7.6	7.1	7.4	7.6	6.8	7.0
Djibouti	2.5	3.8	2.2	2.0	1.0	1.2	2.2	1.1	1.3	1.6	1.4	1.9	1.8
Eldoret	4.3	4.9	5.1	5.7	5.4	5.8	6.8	6.0	5.1	5.0	5.6	4.8	5.4
El Fasher	0.9	0.9	1.2	1.3	2.2	2.7	4.0	3.9	2.7	1.6	0.6	0.6	1.9
Entebbe	5.4	5.9	6.3	7.1	6.3	5.8	5.9	5.7	5.8	6.1	6.3	6.2	6.1
Er Roseires	0.5	1.0	1.2	2.0	3.6	5.0	5.8	6.0	5.0	3.0	1.2	0.7	2.9
Ft. Archambault	2.2	2.4	3.4	3.3	5.1	5.4	6.3	6.5	6.0	5.0	3.1	2.2	4.2
Gamela Post	2.5	3.1	3.3	4.2	5.2	5.9	5.9	6.0	5.2	3.5	3.1	2.3	4.2
Guardafui,Capo*	-	-	-	-	-	-	-	-	-	-	-	-	-
Harar	3.1	1.0	4.4	4.2	6.7	6.9	8.9	9.1	7.7	4.8	2.2	1.3	5.0
Impfondo	5.0	5.3	6.0	5.9	6.3	6.0	6.6	6.4	6.7	6.4	6.5	6.1	6.1
Khartoum	0.7	0.8	0.8	0.9	1.8	2.1	3.1	3.5	2.5	1.2	0.5	0.6	1.5
Lugh Ferrandi	1.4	0.4	5.3	5.8	3.6	3.1	6.4	4.2	3.7	3.9	4.3	3.0	3.8
Mogadiscio	2.4	2.7	2.7	3.3	3.2	4.6	4.9	4.3	3.6	3.6	3.3	3.3	315
Port Sudan	3.6	3.0	2.0	1.4	1.6	1.4	2.3	2.2	1.4	1.7	3.0	3.4	2.2
Stanleyville	-	-	-	-	-	-	-	-	-	-	-	-	-
Yubo	2.2	3.4	4.9	5.6	5.2	4.4	5.7	5.5	4.7	4.4	3.7	2.4	4.3

* No data available

TABLE VIII: MEAN RELATIVE HUMIDITY (%)

Station	Time of Observ.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr
Abeche	07/13/19	32	28	25	26	37	42	59	77	64	37	32	31	41
Addis Ababa	08	52	61	58	69	55	74	86	86	78	56	51	55	65
Asmara	08	46	41	40	47	47	43	69	71	51	55	59	52	52
Bahar Dar	08	54	46	47	44	70	74	86	88	85	77	72	64	67
BALBOA HEIGHTS	hourly	78	75	75	77	85	87	86	87	87	88	88	84	83
Bangassou*		-	-	-	-	-	-	-	-	-	-	-	-	-
Bangui	07/13/19	70	67	71	76	80	83	84	85	83	83	80	73	78
CRISTOBAL	hourly	78	77	77	79	83	85	86	86	85	85	86	82	82
Djibouti	08	75	72	74	72	70	60	53	55	68	68	68	72	67
Eldoret	0830/1430	45	46	50	55	63	64	71	68	59	52	54	51	56
El Fasher	08/14/20	23	18	17	14	20	32	49	59	45	28	23	24	30
Entebbe	07/14/21	76	75	79	82	83	80	78	80	79	75	77	79	79
Er Roseires	08/14/20	40	35	29	31	46	64	76	82	81	71	54	44	54
Ft Archambault	06/12/18	36	29	35	48	61	72	81	85	83	77	60	42	59
Gambela Post	08	54	48	48	60	73	78	83	84	78	72	65	59	67
Guardafui, Capo	07/12	70	70	69	71	75	73	68	72	76	76	71	70	72
Harar	08	52	50	56	59	76	73	76	76	74	55	49	52	62
Impfondo	06/12/18	86	82	83	85	85	87	88	88	87	87	87	87	86
Khartoum	08	48	41	36	32	34	44	54	65	57	44	41	45	45
Lugh Ferrandi	08	40	36	38	52	53	52	55	51	49	55	51	46	48
Mogadiscio	08/14/19	87	86	88	89	91	90	92	92	91	88	87	88	89
Port Sudan	08/14/20	69	68	68	64	57	48	47	48	55	69	71	69	61
Stanleyville*		-	-	-	-	-	-	-	-	-	-	-	-	-
Yubo	08	60	65	74	83	87	89	90	90	87	87	80	65	80

*No data available

TABLE IX: MEAN WIND SPEED (mph)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr
Abechs*	-	-	-	-	-	-	-	-	-	-	-	-	-
Addis Ababa**	-	10	-	-	10	-	-	7	-	-	11	-	-
Asmara*	-	-	-	-	-	-	-	-	-	-	-	-	-
Bahar Dar	4	4	5	4	3	4	2	2	2	2	3	4	3
BALBOA HEIGHTS	9	10	10	9	6	5	6	6	6	6	6	6	7
Bangassou*	-	-	-	-	-	-	-	-	-	-	-	-	-
Bangui*	-	-	-	-	-	-	-	-	-	-	-	-	-
CRISTOBAL	14	15	15	12	8	7	8	8	6	7	8	12	10
Djibouti*	-	-	-	-	-	-	-	-	-	-	-	-	-
Eldoret*	-	-	-	-	-	-	-	-	-	-	-	-	-
El Fasher	4	4	4	5	5	5	5	4	4	4	3	4	4
Entebbe	3	3	4	3	3	3	3	3	4	4	3	3	3
Er Roseires	4	4	4	4	5	6	5	5	4	4	3	4	4
Ft Archambault*	-	-	-	-	-	-	-	-	-	-	-	-	-
Gambela Post	5	5	4	3	4	3	3	3	4	5	4	5	4
Guardafui, Capo*	-	-	-	-	-	-	-	-	-	-	-	-	-
Harar*	-	-	-	-	-	-	-	-	-	-	-	-	-
Impfondo*	-	-	-	-	-	-	-	-	-	-	-	-	-
Khartoum	7	7	7	7	7	9	8	7	6	5	8	9	7
Lugh Ferrandi*	-	-	-	-	-	-	-	-	-	-	-	-	-
Mogadiscio*	-	-	-	-	-	-	-	-	-	-	-	-	-
Port Sudan	10	11	10	8	7	7	8	7	6	6	9	9	7
Stanleyville*	-	-	-	-	-	-	-	-	-	-	-	-	-
Yubo	17	16	15	13	11	10	10	9	9	10	11	12	12

*No data available
** Only part of year available

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9. Acknowledgments

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10. Maps

Figure 2	Station Locations
Figure 3	Mean Temperature, Warmest Month
Figure 4	Mean Daily Maximum Temperature, Warmest Month
Figure 5	Mean Temperature, Coldest Month
Figure 6	Mean Daily Minimum Temperature, Coldest Month
Figure 7	Mean Daily Temperature Range, Warmest Month
Figure 8	Mean Annual Precipitation
Figure 9	Mean Monthly Precipitation, Wettest Month
Figure 10	Number of Wet Months
Figure 11	Relative Humidity, Driest Month
Figure 12	Mean Cloudiness, Wettest Month
Figure 13	Mean Wind Speed, Wettest Month
Figure 14	Composite of Analogous Areas - Balboa Heights
Figure 15	Composite of Analogous Areas - Cristobal

Note: Figure 2, "Middle Nile Basin" should be "Upper Nile Basin;" "La Rgeau" should be "La Regeau"

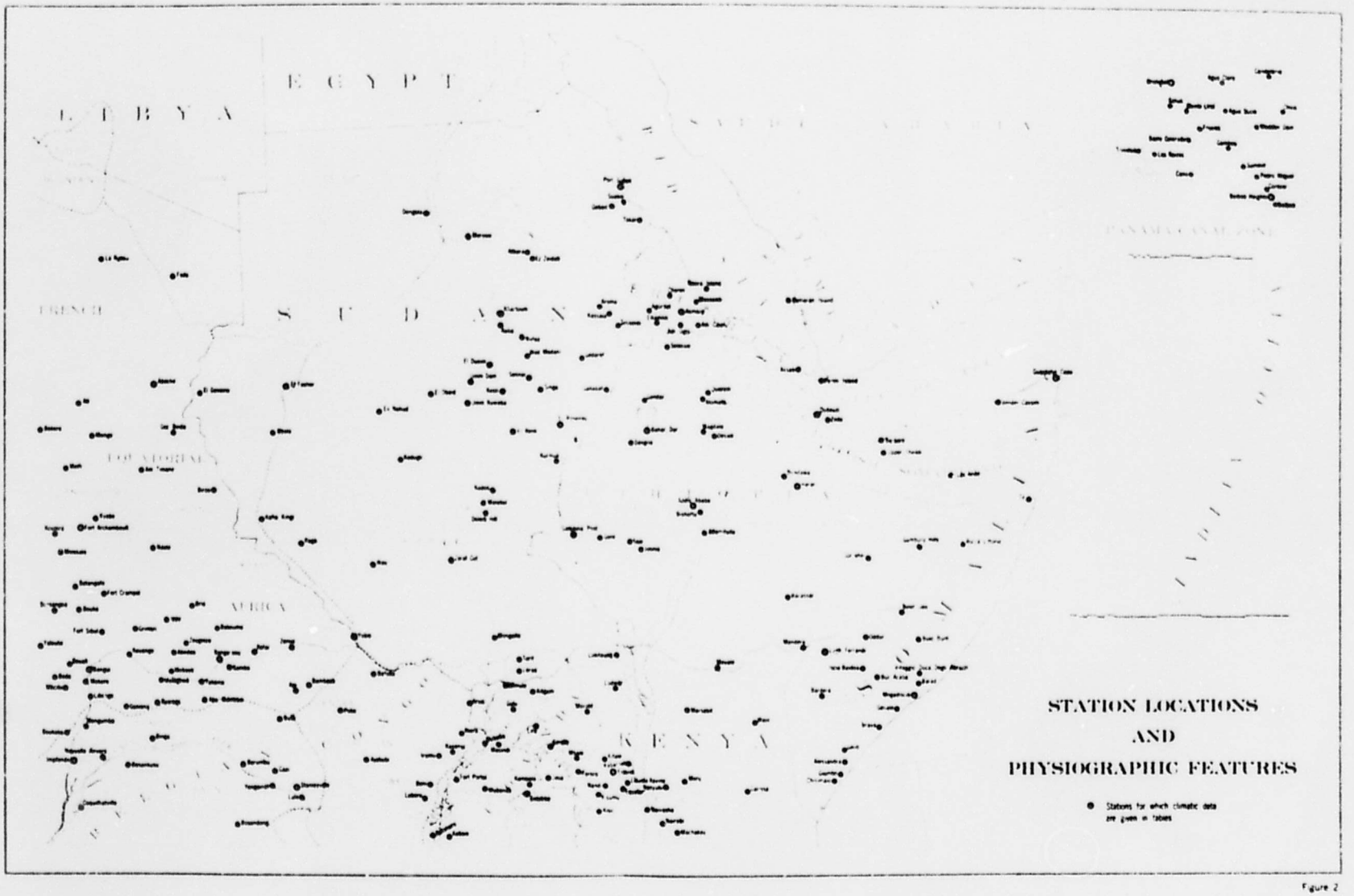
E G Y P T
L I B Y A
S U D A N
K E N Y A
STATION LOCATIONS
AND
PHYSIOGRAPHIC FEATURES
Stations for which climatic data are given in tables

Figure 2

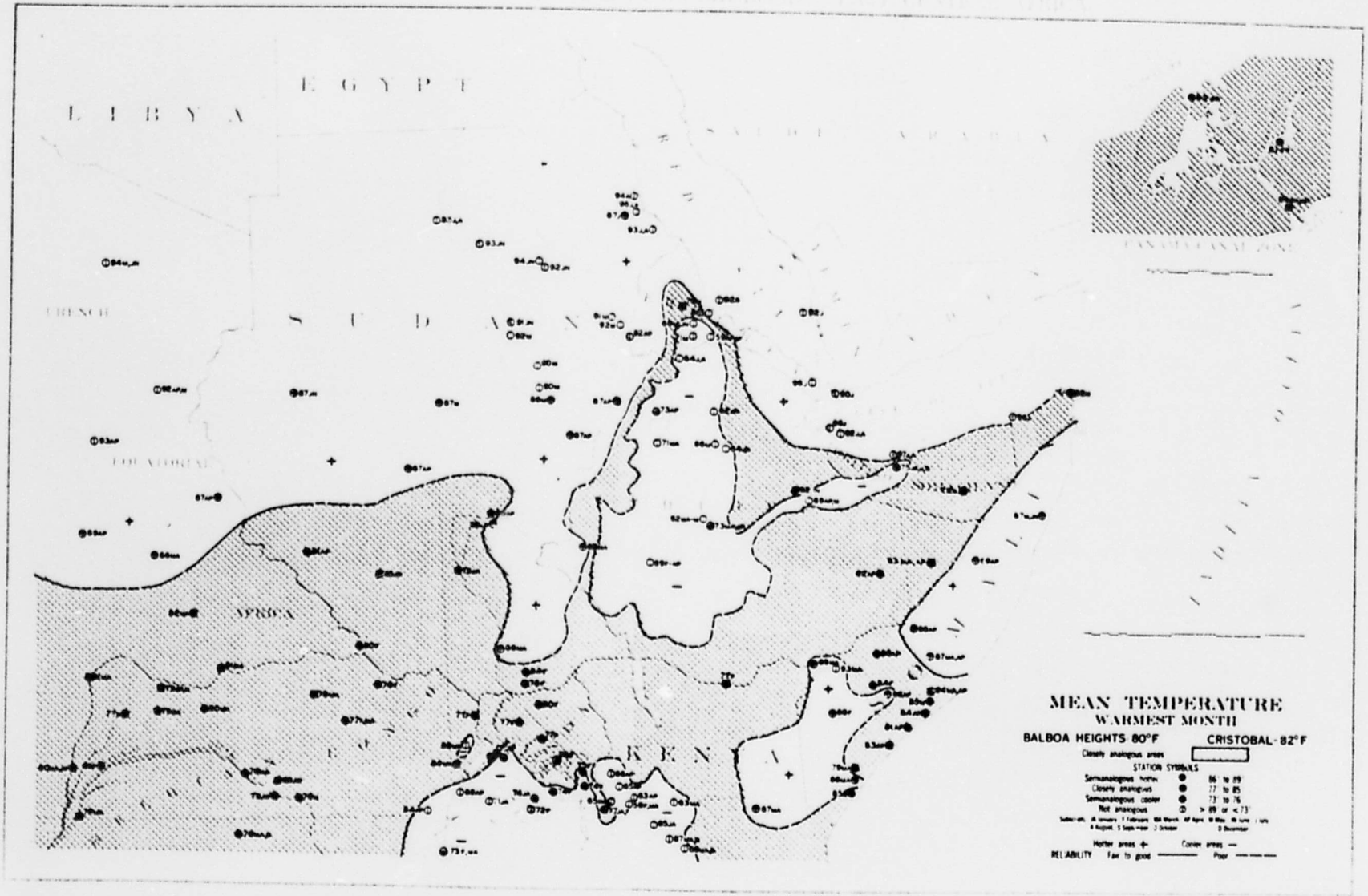
EGYPT
LIBYA
MEAN TEMPERATURE
WARMEST MONTH
BALBOA HEIGHTS 80°F
CRISTOBAL 82°F
Closely analogous areas
STATION SYMBOLS
Somewhat warmer
Closely analogous
Somewhat cooler
Not analogous
86 to 89
77 to 85
73 to 76
> 89 or < 73
Hotter areas
Cooler areas
RELIABILITY Fair to good
Poor

Figure 3

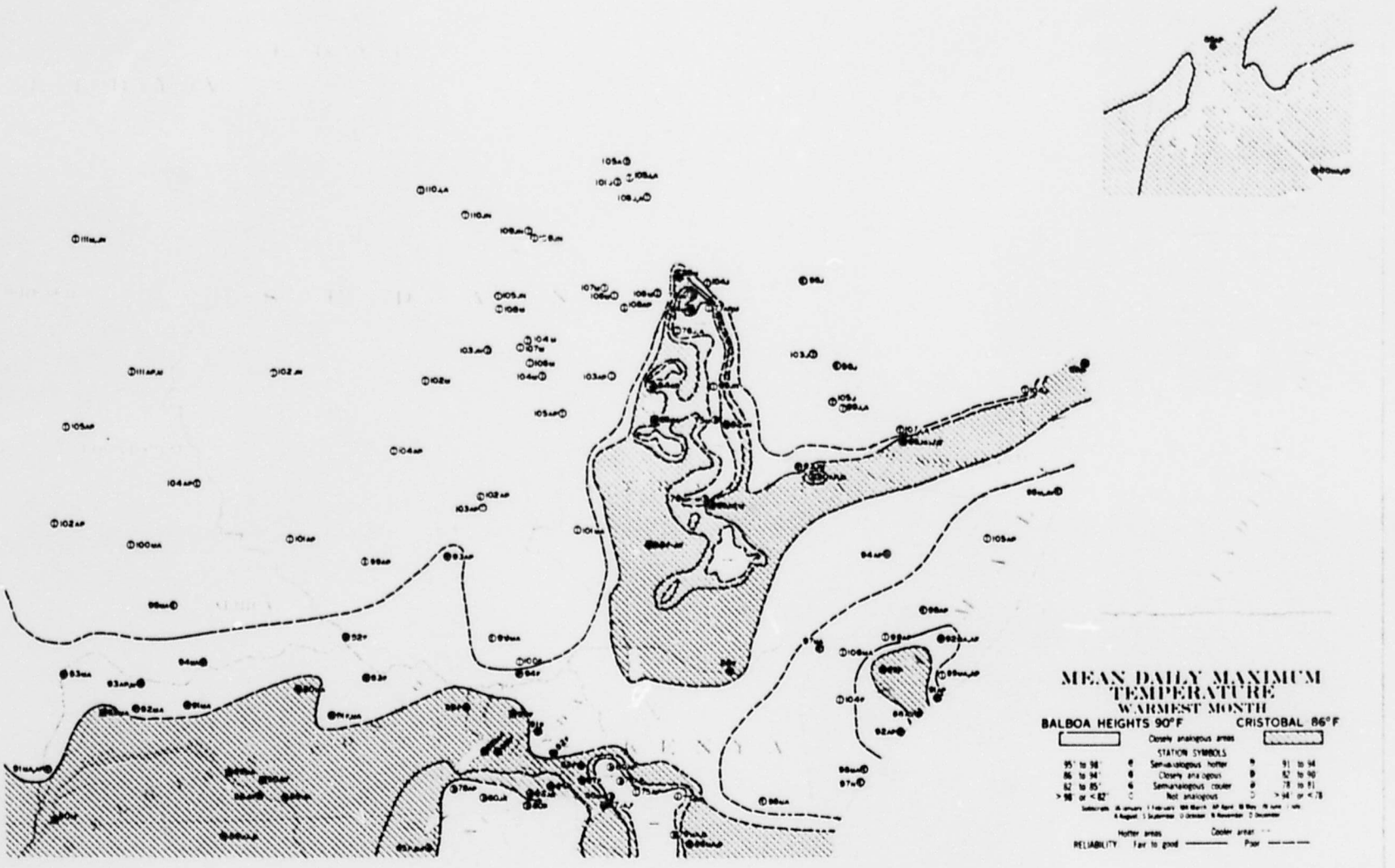
MEAN DAILY MAXIMUM TEMPERATURE
WARMEST MONTH
BALBOA HEIGHTS 90°F
CRISTOBAL 86°F
Closely analogous areas
STATION SYMBOLS
95° to 98°
86° to 94°
82° to 85°
> 98° or < 82°
Semi-analogous hotter
Closely analogous
Semi-analogous cooler
Not analogous
91° to 94°
82° to 90°
78° to 81°
> 94° or < 78°
Hotter areas
Cooler areas
RELIABILITY Fair to good
Poor

Figure 4

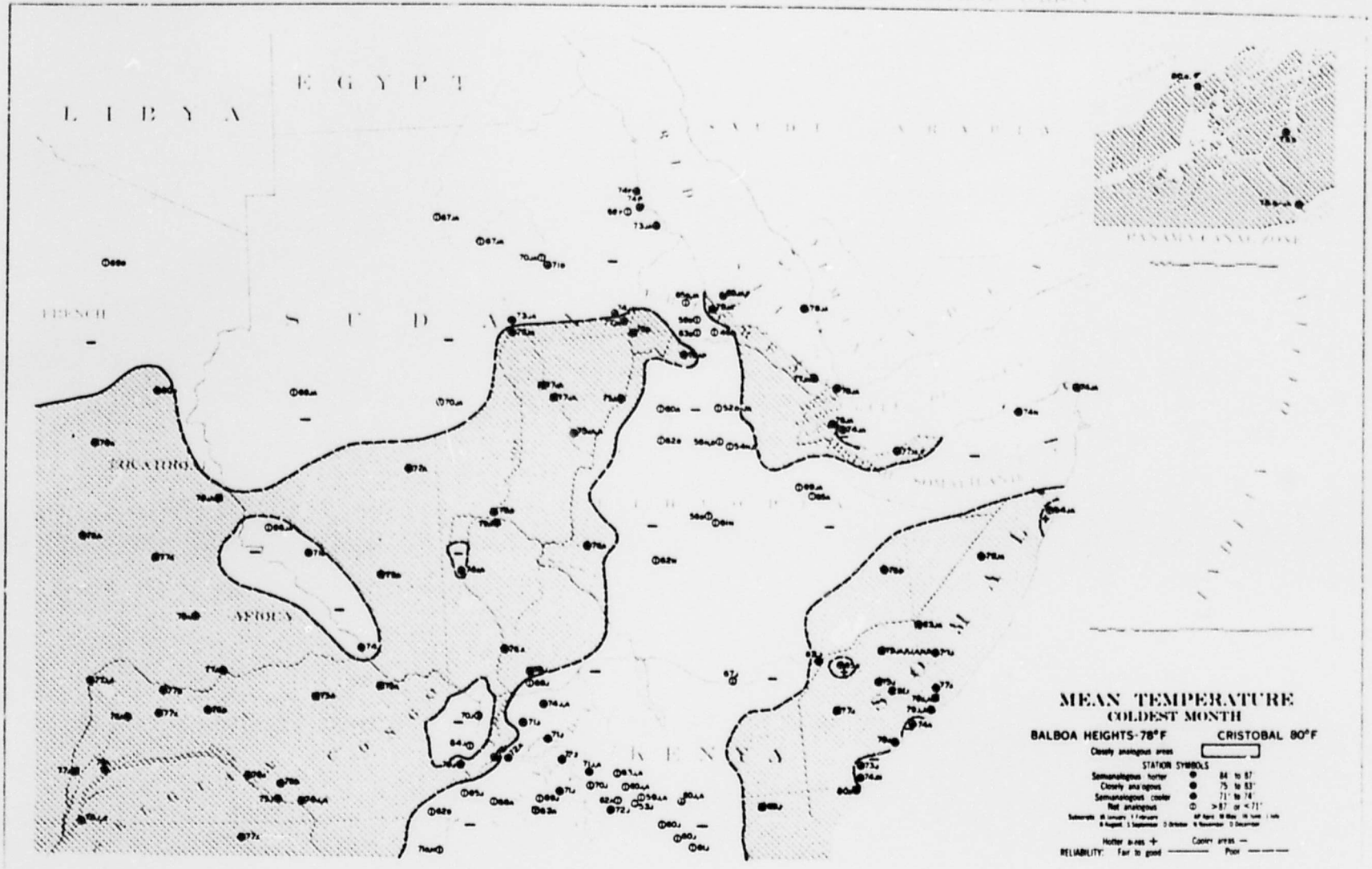
E G Y P T
L I B Y A
MEAN TEMPERATURE
COLDEST MONTH
BALBOA HEIGHTS-78°F
CRISTOBAL 80°F
Closely analogous areas
STATION SYMBOLS
Somewhat warmer
Closely analogous
Somewhat cooler
Not analogous
RELIABILITY: Fair to good
Poor

Figure 5

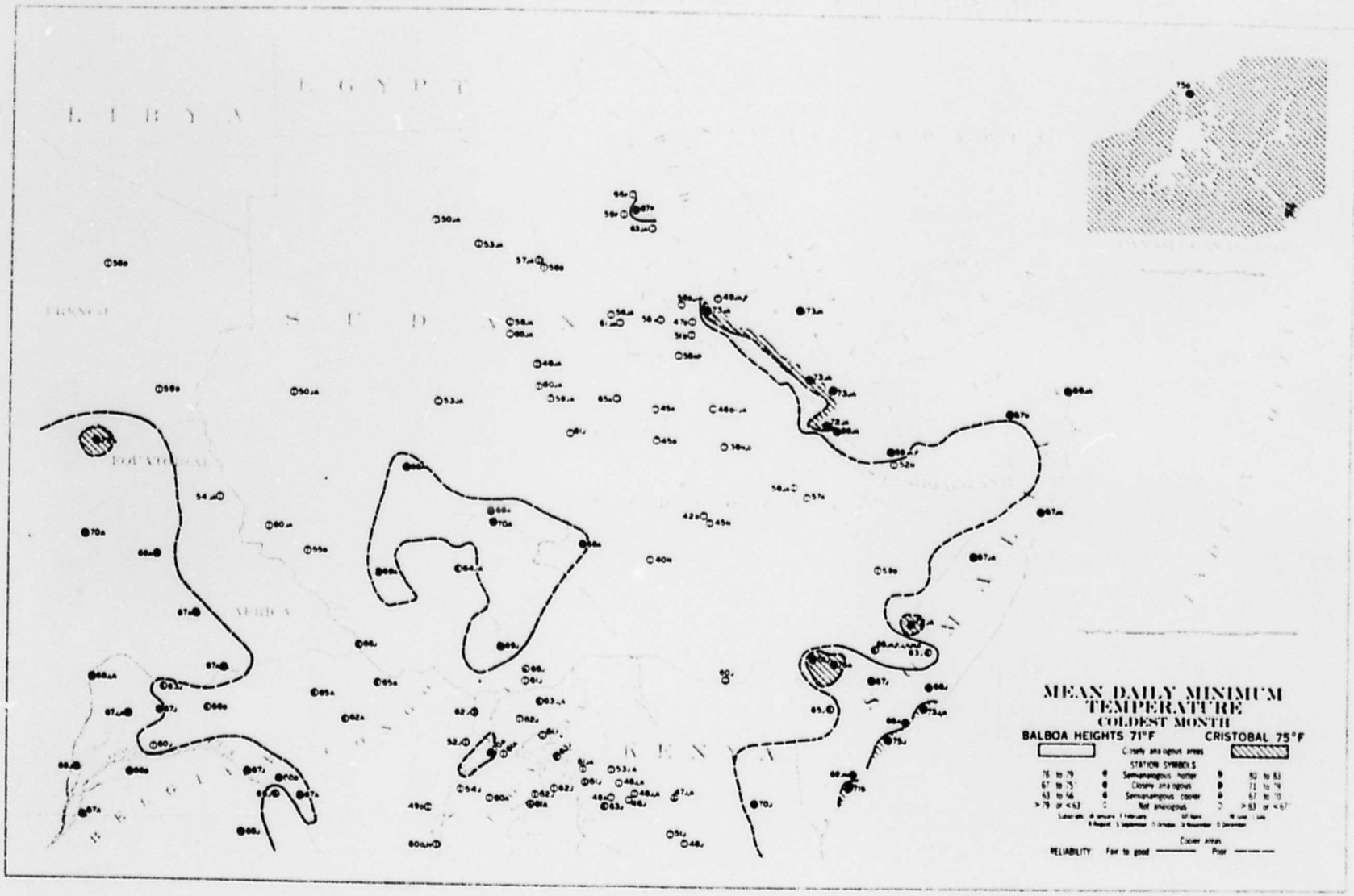
MEAN DAILY MINIMUM TEMPERATURE
COLDEST MONTH
BALBOA HEIGHTS 71°F
CRISTOBAL 75°F
Closely and copious areas
STATION SYMBOLS
Semianalogous hotter
Closely and copious
Semianalogous cooler
Not analogous
Cooler areas
RELIABILITY Fair to good
Poor

Figure 6

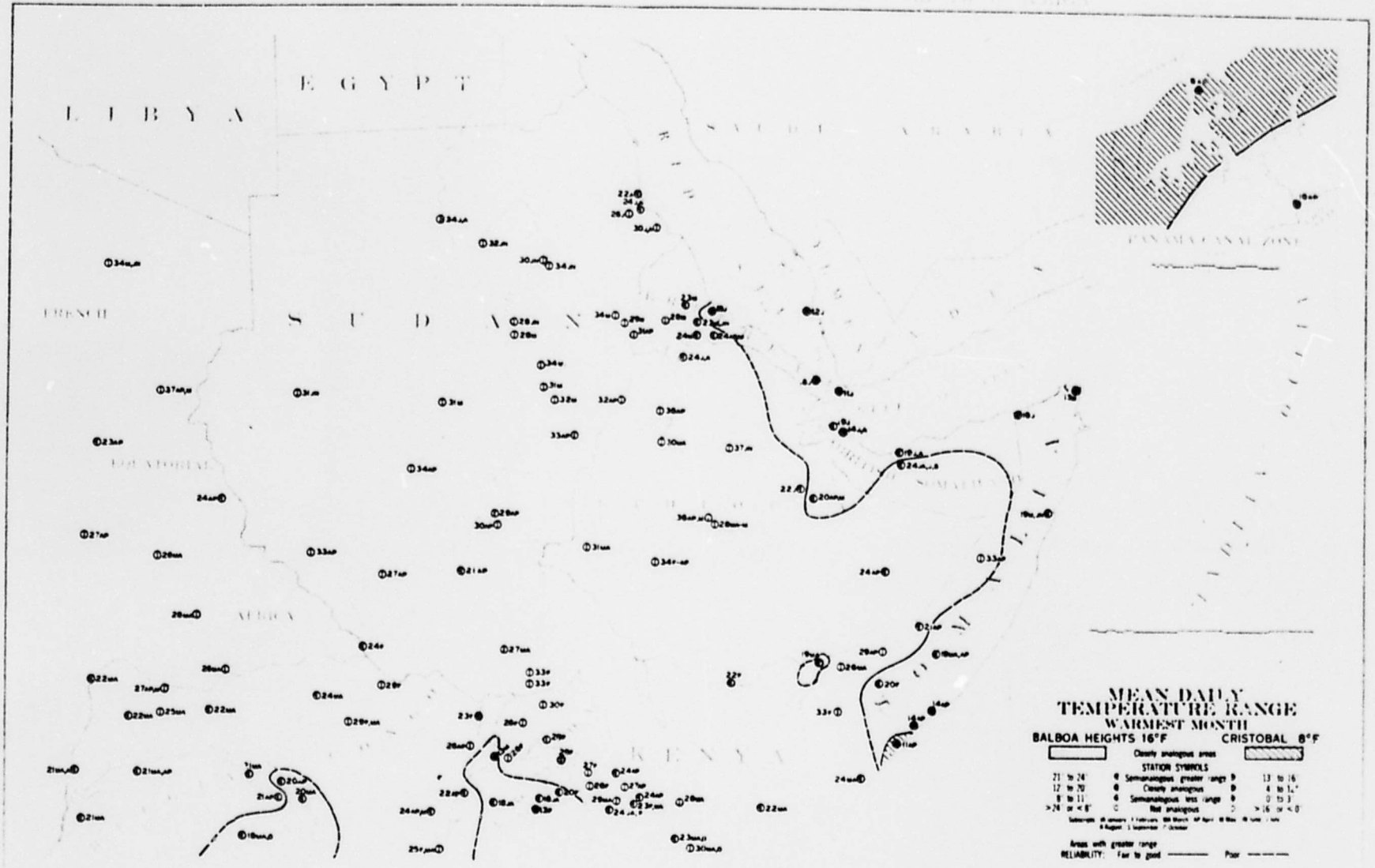
LIBYA
EGYPT
SUDAN
KENYA
PANAMA CANAL ZONE
MEAN DAILY
TEMPERATURE RANGE
WARMEST MONTH
BALBOA HEIGHTS 16°F
CRISTOBAL 8°F
Closely analogous areas
STATION SYMBOLS
21 to 24°
12 to 20
8 to 11
>24 or < 8°
13 to 16
4 to 1
0 to 3
> 16 or < 0
Areas with greater range
RELIABILITY: Fair to good
Poor

Figure 7

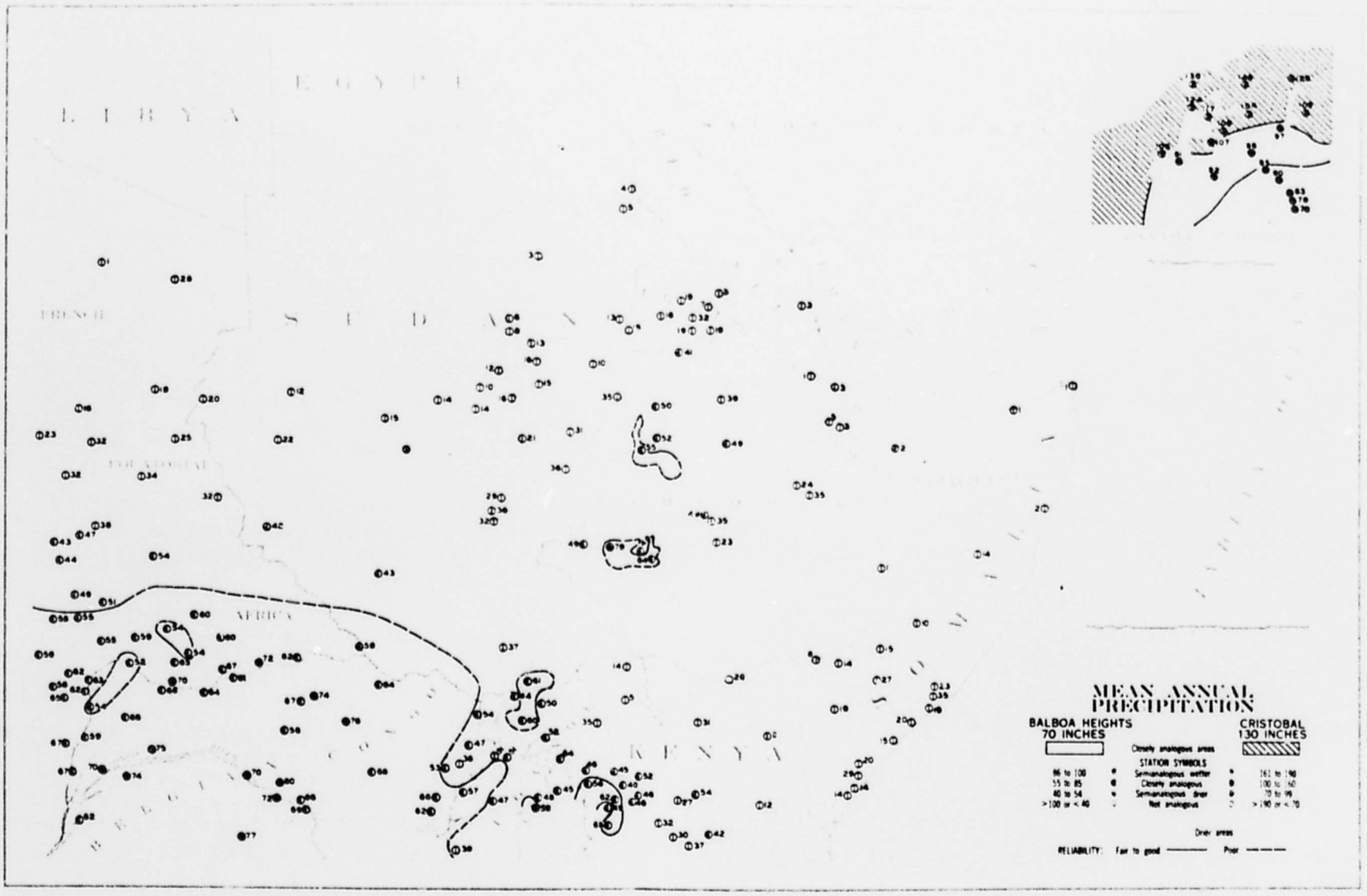
MEAN ANNUAL PRECIPITATION
BALBOA HEIGHTS
70 INCHES
CRISTOBAL
130 INCHES
Closely analogous areas
STATION SYMBOLS
86 to 100
55 to 85
40 to 54
>100 or < 40
Semianalogous wetter
Closely analogous
Semianalogous drier
Not analogous
161 to 190
100 to 160
70 to 99
>190 or < 70
Drier areas
RELIABILITY: Fair to good
Poor

Figure 8

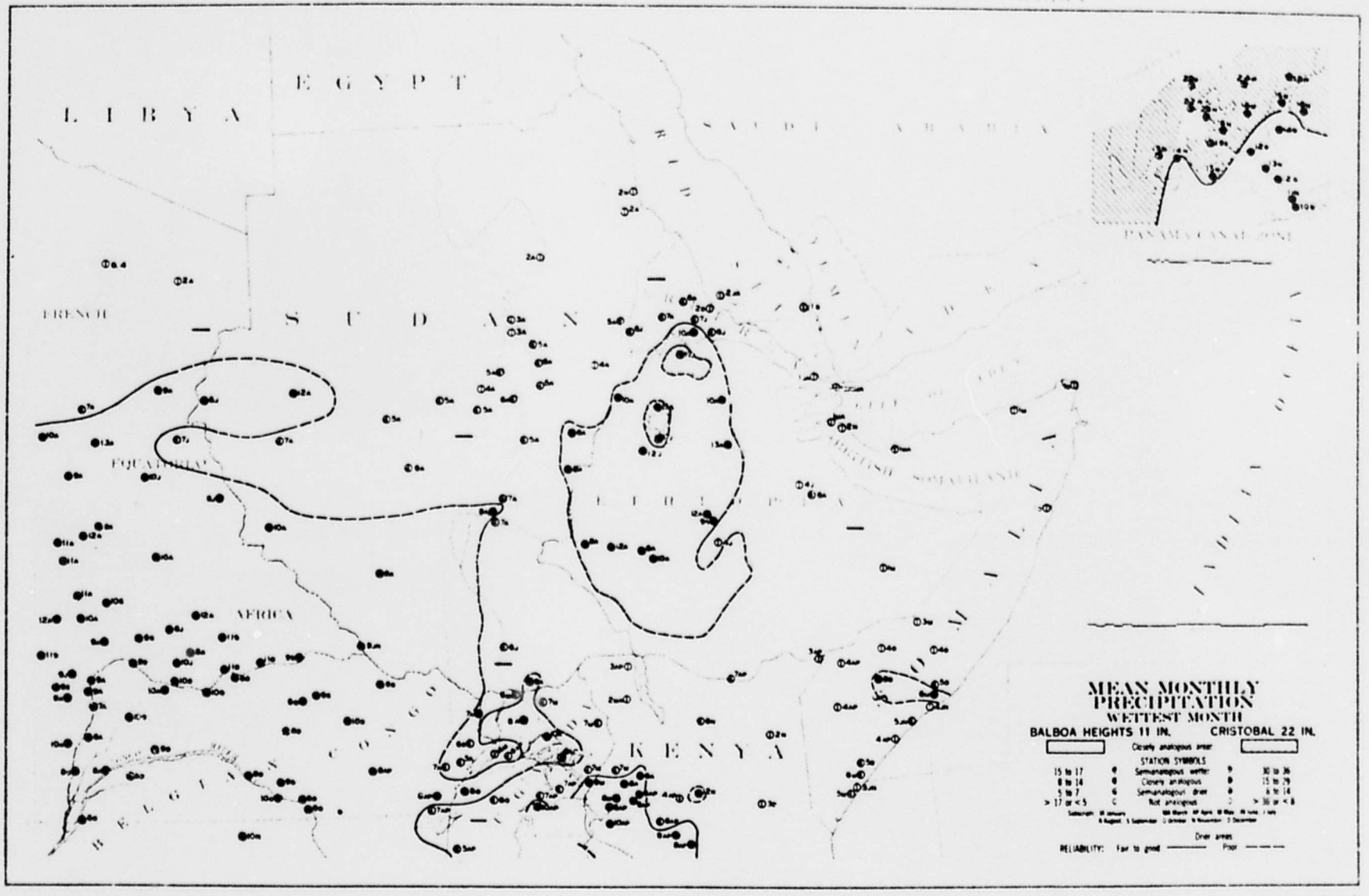
EGYPT
LIBYA
FRENCH
SUDAN
KENYA
PANAMA CANAL ZONE
MEAN MONTHLY PRECIPITATION
WETTEST MONTH
BALBOA HEIGHTS 11 IN.
CRISTOBAL 22 IN.
Closely analogous areas
STATION SYMBOLS
15 to 17
8 to 14
5 to 7
> 17 or < 5
Semianalogous wetter
Closely analogous
Semianalogous drier
Not analogous
30 to 36
15 to 29
4 to 14
> 36 or < 4
Drier areas
RELIABILITY: Fair to good
Poor

Figure 9

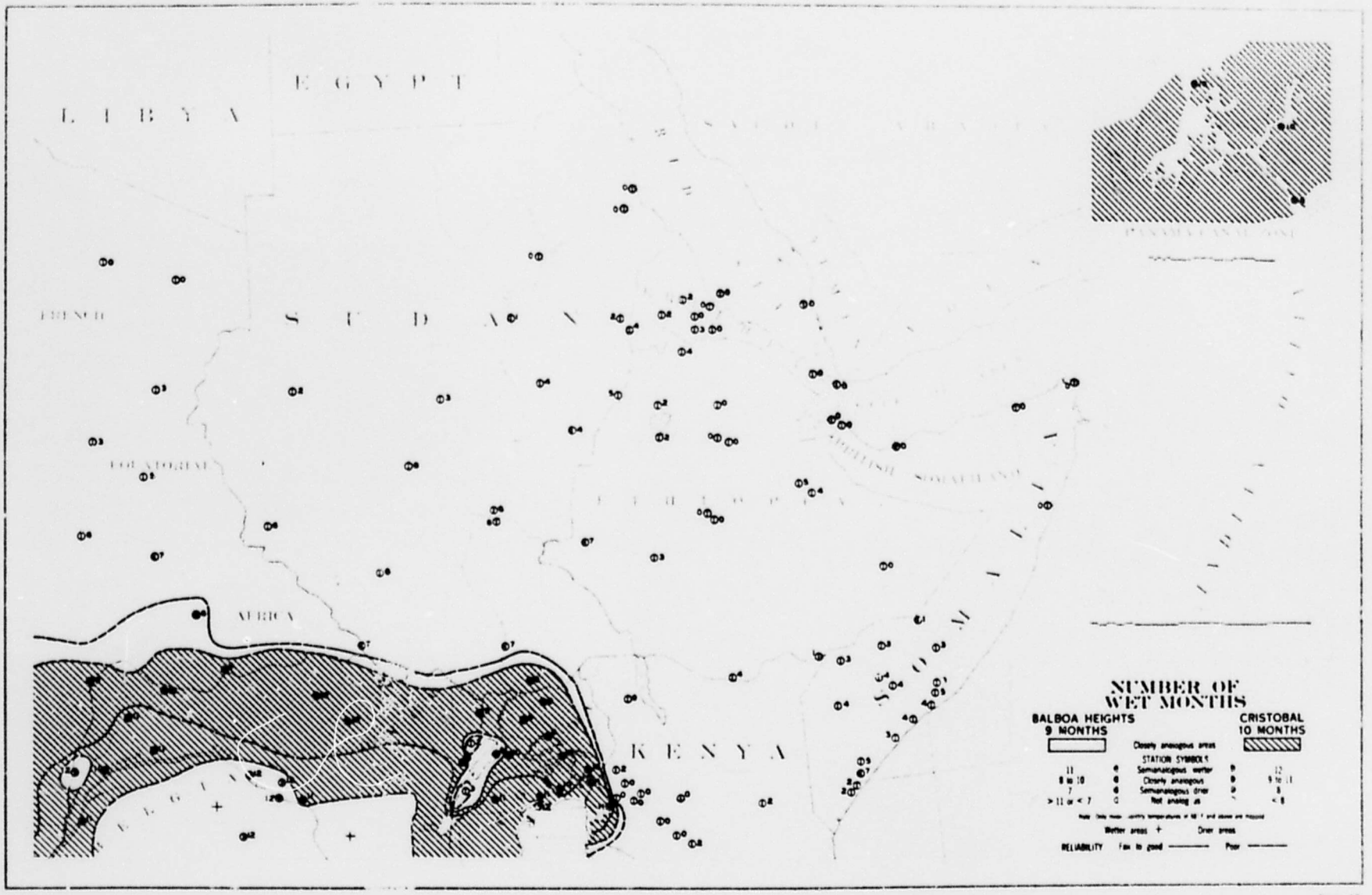
EGYPT
LIBYA
SAUDI ARABIA
FRENCH
SUDAN
ETHIOPIA
KENYA
NUMBER OF
WET MONTHS
BALBOA HEIGHTS
9 MONTHS
CRISTOBAL
10 MONTHS
Closely analogous areas
STATION SYMBOLS
11
8 to 10
7
> 11 or < 7
Semianalogous wetter
Closely analogous
Semianalogous drier
Not analog at all
12
9 to 11
8
< 8
Wetter areas +
Drier areas
RELIABILITY Fair to good
Poor

Figure 10

CLIMATIC ANALOGS OF PANAMA CANAL ZONE – EAST CENTRAL AFRICA

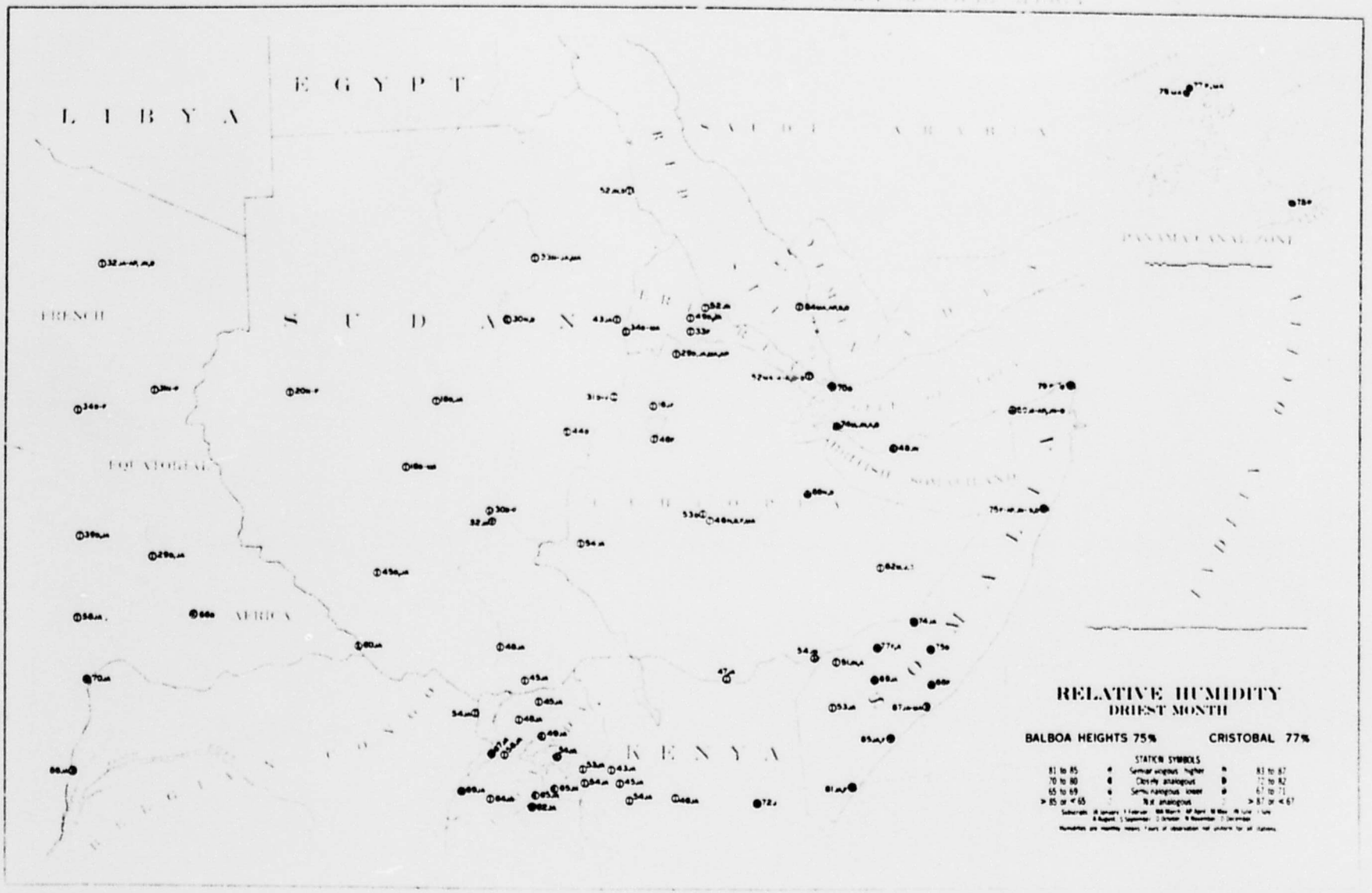

Figure 11

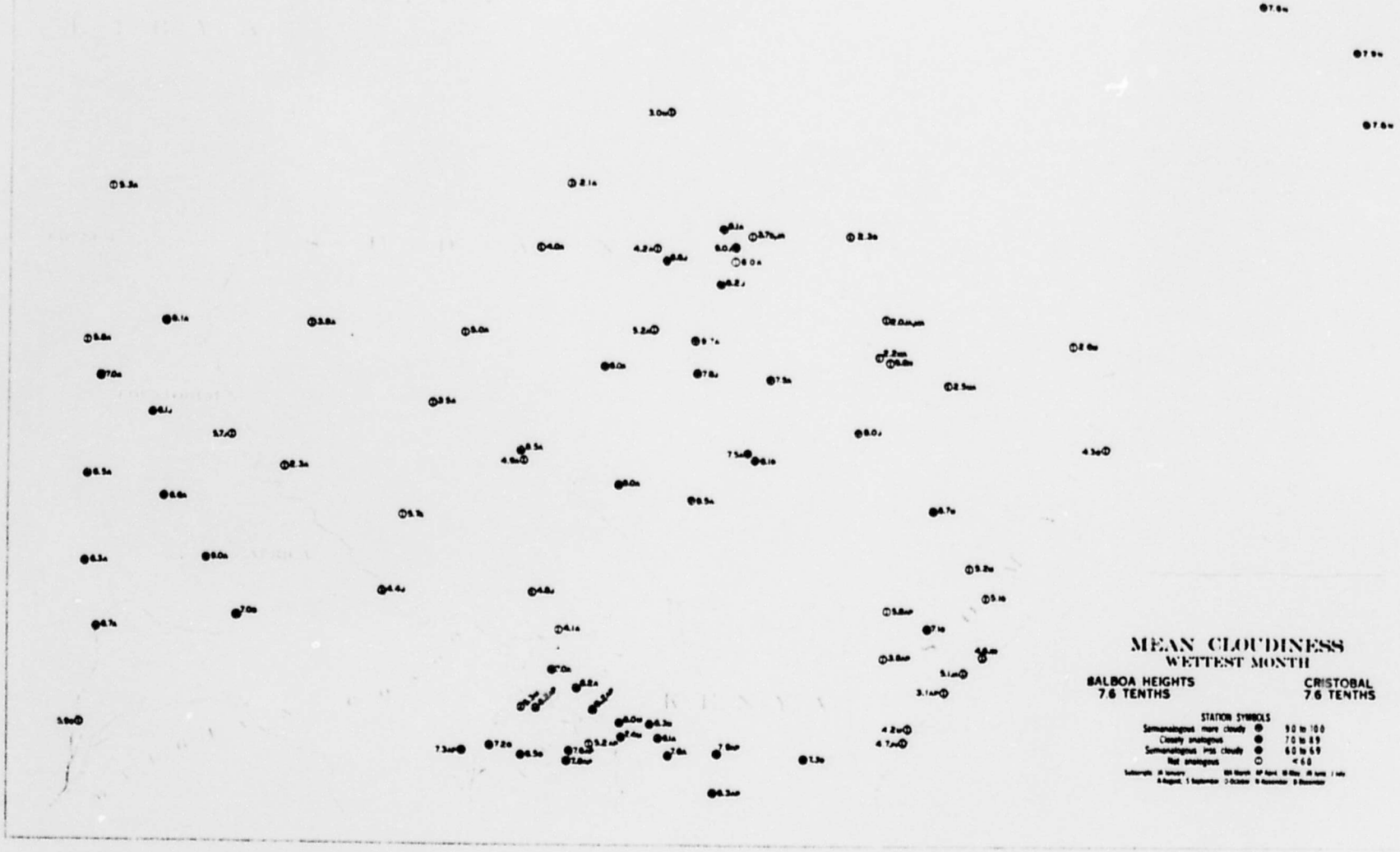
MEAN CLOUDINESS
WETTEST MONTH
BALBOA HEIGHTS
7.6 TENTHS
CRISTOBAL
7.6 TENTHS
STATION SYMBOLS
Somewhatgloomy more cloudy
Closely analogous
Somewhatgloomy less cloudy
Not analogous
90 to 100
70 to 89
60 to 69
< 60

Figure 12

CLIMATIC ANALOGS OF CANAL ZONE - EAST CENTRAL AFRICA

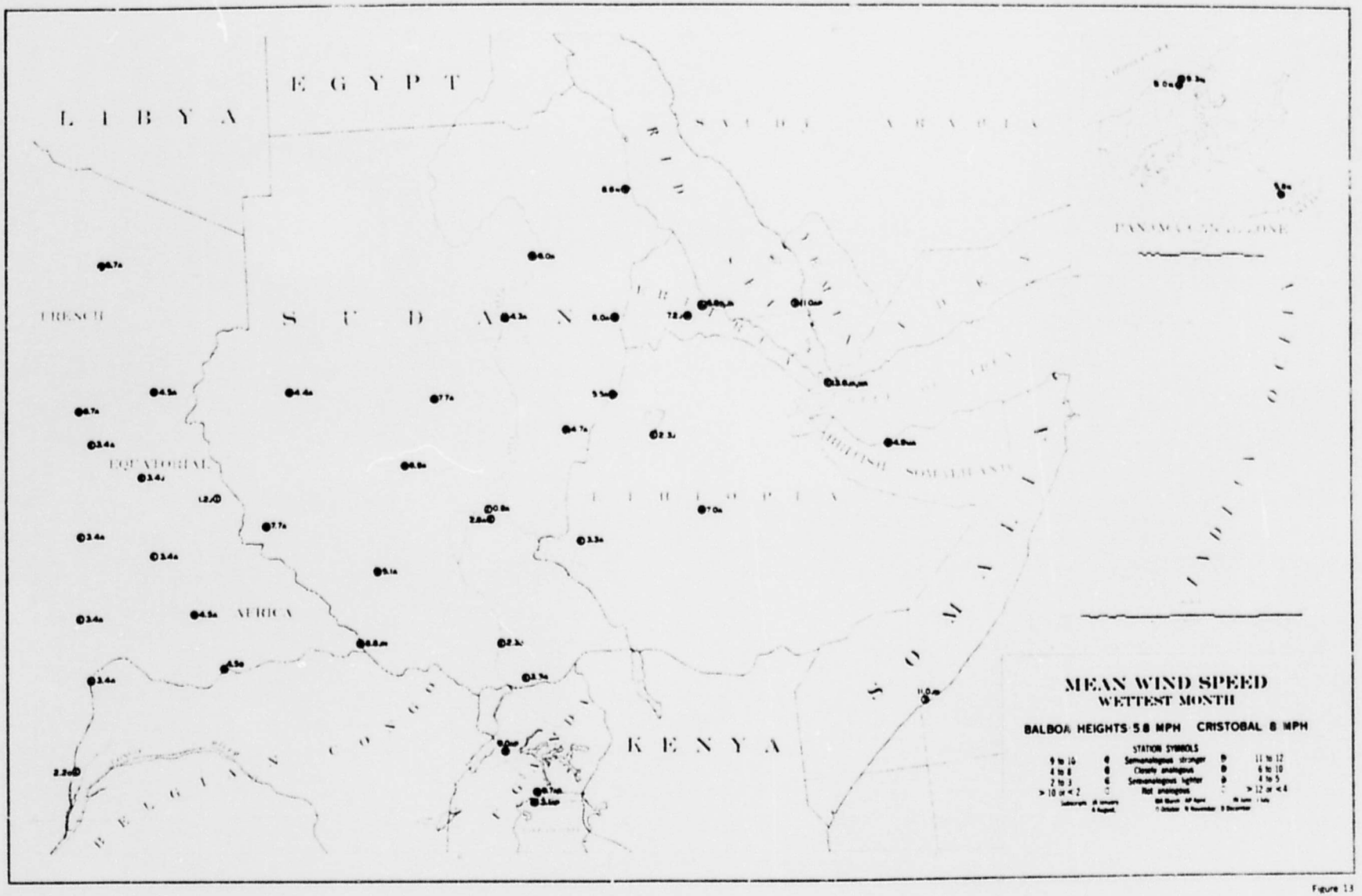

Figure 13

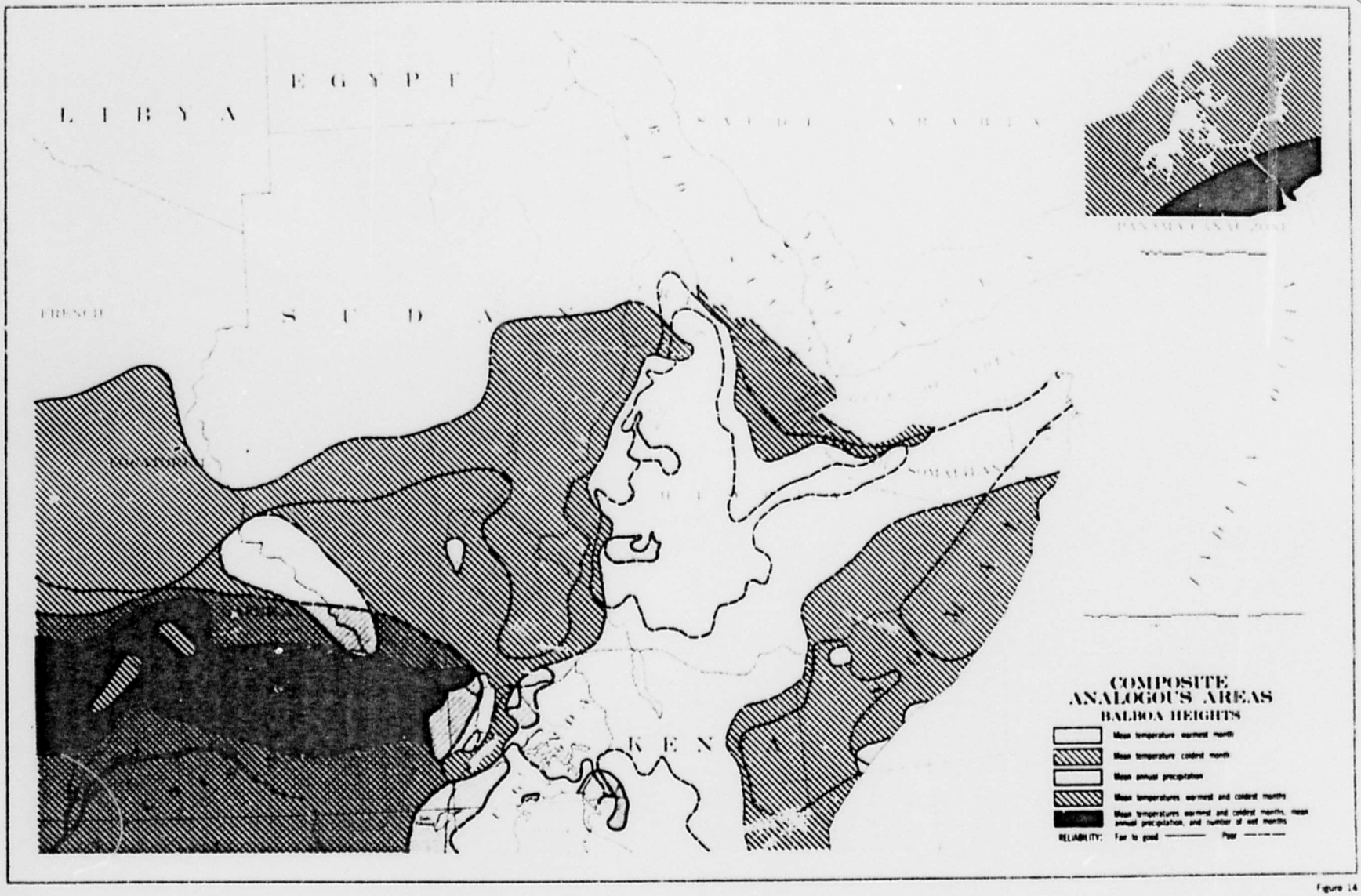
EGYPT
LIBYA
SAUDI ARABIA
SUDAN
KENYA
COMPOSITE
ANALOGOUS AREAS
BALBOA HEIGHTS
RELIABILITY: Fair to good ——— Poor - - - -

Figure 14

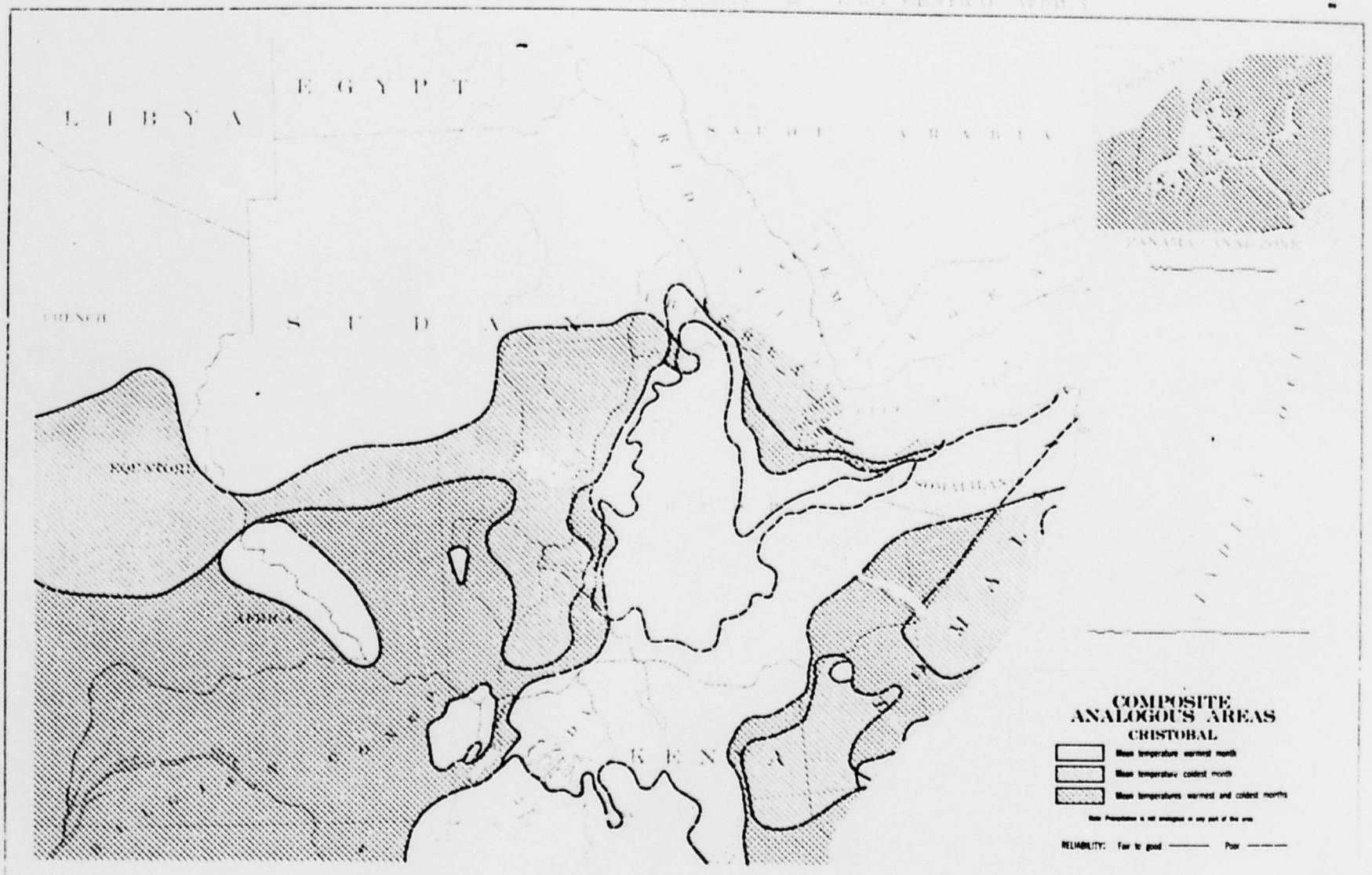
EGYPT
LIBYA
SAUDI ARABIA
SUDAN
ETHIOPIA
KENYA
SOMALIA
COMPOSITE
ANALOGOUS AREAS
CRISTOBAL
Mean temperature warmest month
Mean temperature coldest month
Mean temperatures warmest and coldest months
RELIABILITY: Fair to good ——— Poor ———

Figure 15