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TECHNICAL REPORT
EP-141

Canal Zone Analogs IX

ANALOGS OF CANAL ZONE CLIMATE IN THE FAR EAST

QUARTERMASTER RESEARCH & ENGINEERING CENTER
ENVIRONMENTAL PROTECTION RESEARCH DIVISION

OCTOBER 1960

NATICK, MASSACHUSETTS

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Natick, Massachusetts

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ANALOGS OF CANAL ZONE CLIMATE IN THE FAR EAST

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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 two series already completed, comparing Yuma, Arizona, with the various desert regions of the Northern Hemisphere, and Fort Greely, Alaska, and Fort Churchill, Canada, with the subarctic regions of North America and Eurasia.

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

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ABSTRACT

The climate of the Far East is compared with that of two locations in the Canal Zone: Balboa Heights, representing the drier, leeward, Pacific side of the Isthmus of Panama, and Cristobal, representing the wetter, windward, Atlantic side. Areas of analogy of pertinent climatic elements and combinations of these elements are shown on maps.

The Far East does not contain areas of complete climatic analogy to either Canal Zone station. Winter temperatures are too low in all parts of the study area to show coincidence with the three climatic elements normally used for comparison. Nearly all of the study area is comparable with the Canal Zone stations in respect to mean temperature of the warmest month. Much of the lowland area of Japan, Formosa, southern China and a small area in extreme southern Korea have mean annual precipitation analogous to Balboa Heights, but only five areas on the southeast coast of Japan have mean annual precipitation amounts which are analogous to Cristobal. Other climatic elements, such as mean daily maximum temperature for the warmest month, and number of wet months, show large areas with analogous, or greater than analogous, conditions. Much of Japan and southern China are analogous to Canal Zone stations in mean cloudiness of the wettest month and mean relative humidity of the driest month. Mean windspeeds in the warmest month, mean precipitation of the wettest month, and mean daily temperature range of the warmest month in nearly all of the lowland portions of the study area are analogous to Balboa Heights, but only small areas are analogous to Cristobal.

ANALOGS OF CANAL ZONE CLIMATE IN THE FAR EAST

1. Purpose and scope

This report is the ninth 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 the Far East. 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 the Far East

The area covered by this report includes those portions of China, Japan, and Korea generally south of 42°N latitude and east of 102°E longitude, and also Macao, Hong Kong, Okinawa (Ryukyu Archipelago), Formosa, and neighboring islands.

a. Topography

The Kwangsi-Kwangtung Lowland (in South China) is a broad, hilly region with little level land and few well-defined ranges. In the west the hills adjoin the Yunnan Plateau, and in the east they continue with slightly higher elevations as the Taiyun Shan and Wuyi Shan. This whole area is studded with steep limestone spires, some of which are over 4,000 feet high. Along the coast there are several small, level delta areas. In summer the southeastern monsoon brings considerable heat and moisture to this area; in winter the area is cool and dry. Due to irregular topography, many stations report high summer rainfall, and many other stations are in rain-shadow areas. The largest rain-shadow area in China is the Amoy coast northwest of Formosa. Here the Taiyun Shan, a few miles inland, receive much more rain than the coastal areas. Hainan Island is a southern extension of the low hilly topography of this large region.

The Yunnan Plateau (southwest China) is a spur of the Tibetan tableland, mostly over 6,000 feet in elevation. Although known as a plateau, this region is dissected by deep valleys, and is crossed by several high mountain ranges.

The Szechwan Basin (western border of China) is so-called largely because of the high encircling mountains, the Tsing Ling Shan, which rise to 13,658 feet in the north and the Liu Pen Shan in the south which rise to 9,186 feet in an eastern peak. It is a hilly amphitheater much higher than the Middle Yangtze Basins to the east, but considerably lower than the Tibetan tableland to the west. It is an area of rounded hilltops and narrow floodplains contained by steep-sided ridges. The high northern mountains are an effective barrier against the northwest monsoon of winter, and they catch some of the moisture carried inland by the summer (southeast) monsoon. The enclosed situation of the basin results in high humidities and considerable fogginess, even in winter.

The Middle Yangtze Basins are divided by low hills, which are deeply dissected, but whose summits are gently rounded. The central portion of this area has numerous small lakes and marshes bordering the Yangtze River. The Yangtze, which flows swiftly out of the Szechwan Basin in a narrow gorge, becomes broad and sluggish as it meanders across its nearly level middle course. This is an area of alternating drought and flood, depending on whether the summer (southeast) monsoons are strong or weak. Strong summer monsoons usually advance as far as the North China Plains, which then receive abundant precipitation, while the Yangtze basin areas suffer drought. Weak summer monsoons become stagnant over the Yangtze, resulting in a rainy year, while the North China area remains dry.

The North China Plains are sometimes called the Yellow River Plain. The deposition of the Yellow River (Hwang Ho), which in past centuries has emptied alternately on one side or the other of the Shantung Peninsula, has built up much of this area as delta and floodplain. The presently abandoned southerly course is called the Hwai Ho. The Yellow River flows in natural levees 10 to 20 feet above the plain, and quickly inundates large areas during periods of heavy rains. The rocky Shantung Peninsula was formerly separated from the mainland, but has become connected by fluvial deposition. The Shantung peaks, 3,700 to 4,700 feet in elevation, cause local orographic rainfall from the influx of moist summer air. This area has higher winds than the plains to the west, and slightly lower temperatures. The North China Plain experiences sharp seasonal temperature contrasts. The Great Plain of Manchuria to the northeast of this area is one of the coldest regions of China, and is not considered to be a part of this study area.

The lower Yangtze River plain may be regarded as a southeastern extension of the North China Plains. Only southwest of Nanking do hills separate the lower plains area from the Middle Yangtze Basins. Except

for occasional hilly sections, this plain is an alluvial lowland. It is dissected by a maze of canals and contains a large number of shallow lakes and ponds. After heavy rains the entire area around these lakes and ponds may be under water.

The western half of the Korean Peninsula is a highly irregular lowland consisting of low hills interlaced by short, swift streams. The eastern portion is mountainous. Precipitation in Korea varies mainly with orographic position (i.e., according to the location in relation to the mountains); the highest amounts occur on the middle slopes of the mountains. Sharp seasonal contrasts in both temperature and precipitation, comparable to those of the North China Plains, are characteristic of the lowlands of the peninsula.

Japan is both insular and mountainous. Four large islands make up Japan proper (one of these, Hokkaido, is outside the area of this report); each of these is surrounded by hundreds of smaller islands. Complex mountain ridges form the backbone of the larger islands and tend to characterize their climate. Slopes are unusually steep and summits are jagged. There is very little low, level land in Japan. Lowland climates in southern Japan are modified by the warm Japanese Current which flows northward on both sides of the islands. High mountain areas escape much of the high humidity, copious precipitation, and relatively high temperatures which characterize the lowland areas in summer months. In winter the mountains serve as a barrier for southern Japan against the snow and cold air of the northwest monsoon, but the northwestern and northern coasts receive heavy snowfalls.

The general configuration of Formosa is that of a tilted fault block, sloping to the west (Formosa Plain), from a range of 2-mile-high mountains (Chung Yang Shan) along its eastern side. The highest summit on the island is 14,501 feet high. While winter weather in the mountains is similar to that of northern China, winters in the lowlands are comparable to those in the Kwangsi-Kwangtung Lowland. Occasional summer typhoons bring concentrations of rainfall to the abrupt eastern slopes of the island. One mountain station, Kashoryo, has reported a maximum annual rainfall of 289 inches. The warm Japanese current flows on both sides of the island, causing relatively high temperatures in summer in the coastal lowlands.

b. Major climatic controls

The summer and winter monsoons are the major controls in the climate of the Far East. Other controls are: (1) the position of mountain barriers, (2) location of the region in the southeastern quarter of the continent, (3) nearness to the tropical seas, and (4) the warm Japanese Current.

The summer monsoon is a causal factor in the occurrence of tropical climates in the Far East. It lasts from May to September in southern China, but occurs only in July and August in the north. In May, deep masses of hot, moist, tropical air move into southern China directly from the Philippine and South China Seas and give heavy rain along the sluggish northern frontal systems, particularly on the sea-facing slopes of the Nan Ling Shan, Wuyi Shan, and Taiyun Shan. This early summer maximum of rainfall is augmented in June by a continuation of the Indian monsoon which moves across Burma, Thailand, Laos, and Viet Nam into southern China. This is a typically tropical period with high humidity, massive low clouds, light winds, and relatively high temperatures.

These tropical conditions gradually move north during the summer. The basins along the Yangtze River receive the effects of orographic rain from the high mountainous areas to the west, and the cloudiness and humidity conditions are similar to those on the south coast. In northern China, where the rainiest months are July and August, the air is drier, winds are stronger, and the frontal systems are more active. Most of the precipitation falls during short thunderstorms. By mid-September the monsoon changes from the summer (southerly) direction to the reverse winter (northerly) direction.

The winter monsoon brings cold climatic conditions into the study area. This factor clearly separates the climate of this area from that of the wet tropical areas of Southeast Asia. Cold winds blow throughout China in winter, even as far south as Canton and Hong Kong; they cross the Japan Sea accumulating moisture which is dropped as heavy snow in western Honshu. Mountain ranges protect southern China, eastern Korea, and southern Japan from some of the severest winter conditions, but these areas are markedly colder in winter than are the tropical areas.

In winter the islands (those off the coast of China, Hainan, Formosa, the Ryukyu and Japanese Islands) are not as cold and dry as China itself. The insularity and mountainous terrain of these islands modify the monsoonal influences on their climate. The summer monsoon, consisting largely of light southerly winds, moves along the Pacific side of the islands from south to north before heading toward the continent, and the heaviest rain from the moist air masses brought by these winds is recorded on south-facing mountain slopes and coastal promontories.

In both summer and winter the warm Japanese Current, which flows north along both sides of Formosa, Okinawa, and the Japanese islands, is a causal factor in climatic modification. Because of the warm water, the summers in Japan are similar to those in southern China, and winters are mild. Warm, moisture-laden air masses follow the Japanese Current throughout the year, but are more pronounced in June, July, and August. Stagnation of these air masses, particularly in late summer, causes long periods of light to moderate rainfall in central and southern Japan.

Mountainous areas tend to compartmentalize the various regions in this study area. Most of the highlands in the Far East are climatically distinct from neighboring lowlands. Generally, temperatures in highland areas are lower, cloudiness and windspeeds are greater, and precipitation may be much higher, especially on middle slopes exposed to the summer monsoon.

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. Windspeed, 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 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 windspeed is greatest in February and March (nearly 15 mph) and least in September (about 6 mph).

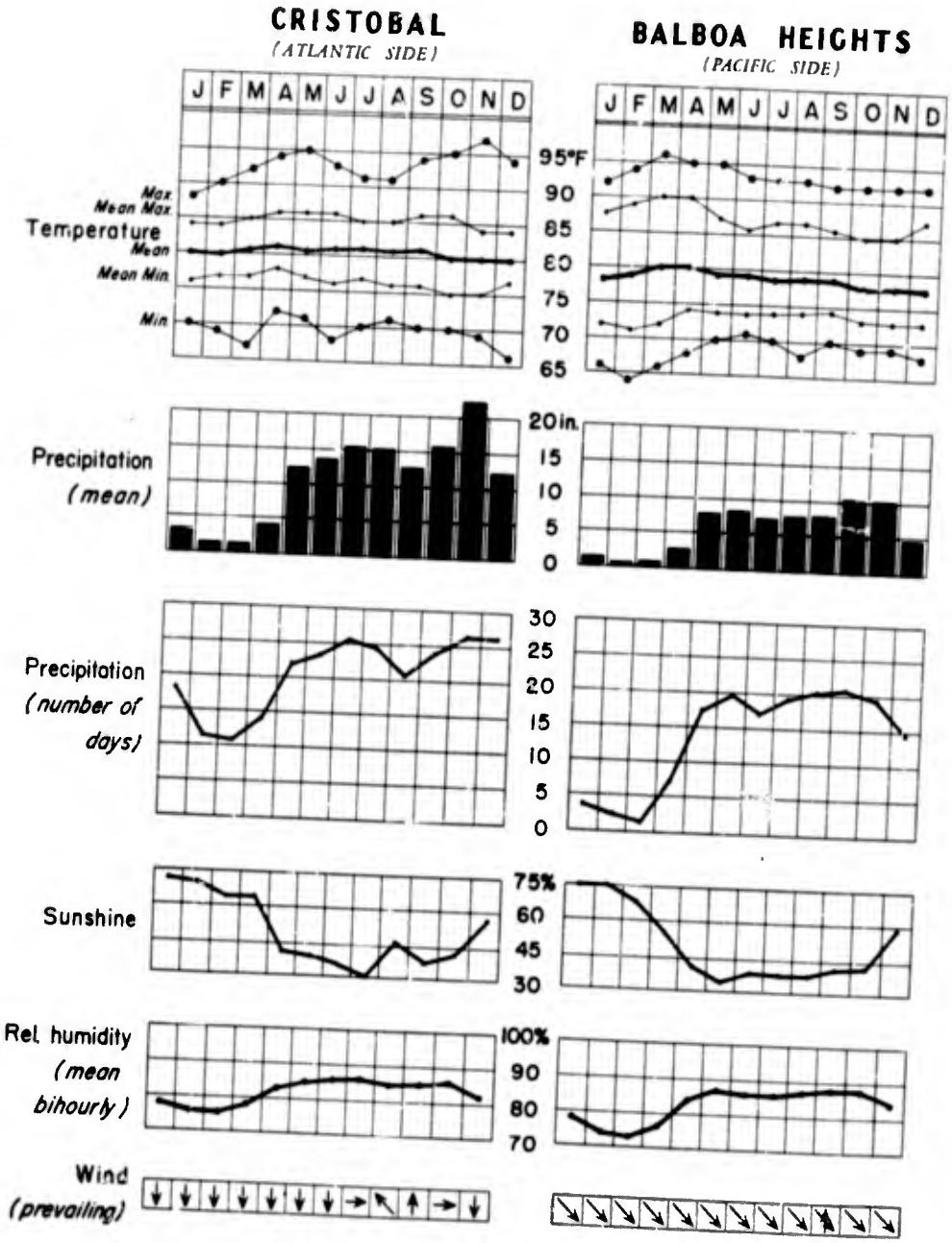

Figure 1. Climatic Summary of 2 Canal Zone stations

4. Criteria and methods

a. Climatic elements selected for study

As in the previous studies of this series, temperature, precipitation, humidity, cloud cover, and windspeed 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 windspeed 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 windspeed were selected as ranges of analogy for these elements.

*All tables are given in par. 7

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. In the Far East only the mean temperature of the warmest month and the mean annual precipitation are analogous. (See Figure 2 for station locations.)

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. Isopleths were drawn according to available station data. Data for additional stations may require minor revisions of these lines in future investigations. 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 Far East 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 interpolated 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 the Far East 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°. Hours of observation of relative humidity, windspeed, 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.

a. Mean temperature, warmest month (Fig. 3)

Balboa Heights (March and April, 80°F) and Cristobal (April, 82°F) have nearly the same mean temperature for the warmest month. For the purpose of this study, to show the analogous area of this climatic element, a range of 4 F° on either side of 81°F is used. Areas falling within this range are shown on the map by a blue and yellow pattern. An additional 4 F° above 85°F and below 77°F is considered semianalogous. Stations having semianalogous conditions are designated on the map by an appropriate symbol ("+" for hotter, "-" for cooler), but the areas that are so represented are not shaded.

Except for northern Japan, Manchuria, Mongolia, and northern Korea, nearly all of the lowlands in this study area are analogous to both Canal Zone stations. Areas too cool for analogy are found in the highlands throughout the study area. Three areas with warmest-month temperatures too high for analogy are found in the Middle Yangtze Basins and the Kwangsi-Kwangtung Lowland and Hainan.

The highest mean temperature for the warmest month is 93°F at Huangchinfu in the Middle Yangtze Basins, the lowest is 69°F at Dolonnor on the edge of the Gobi Desert. The months of June, July, and August in most of the Far East have mean temperatures similar to those for the hottest month in the Canal Zone.

b. Mean daily maximum temperature, warmest month (Fig. 4)

At Balboa Heights, the mean daily maximum temperature for the warmest month is 90°F; at Cristobal, which has a shorter and less pronounced dry season, the corresponding temperature is 86°F. Analogous areas are those which have temperatures within 4 F° of these means. The 82° to 90°F range is analogous to Cristobal, the 86° to 94°F range is analogous to Balboa Heights, the 86° to 90°F range is analogous to both.

In terms of this element the entire study area is analogous to either one or both of the Canal Zone stations, except for comparatively small areas in the extreme northern portions of Japan and Korea and in the high mountain areas. Dual analogy occurs in the lower slopes of the mountains of China and along most of the coastal lowlands of China, Hainan, Formosa, Okinawa, southwestern Japan, and Korea, and the southern portions of the Great Plain of Manchuria.

Areas either analogous to or hotter than Balboa Heights extend throughout the interior lowlands of China, including the upper Yangtze River valley and the Szechwan Basin. This analogous area reaches the Chinese coast in six places. A small area around Taihoku in northern Formosa is also analogous only to Balboa Heights. Within these areas only two stations (Tatung and Taming in north-central China) report mean daily maximum temperatures too high for analogy: 100°F in both cases.

The areas analogous only to Cristobal are found in the highlands of Formosa and Hainan, the high mountainous border of western and northern China, the Shantung Peninsula, southern Manchuria and Mongolia, nearly all of northern Japan and Korea, and in the mountains of southern Japan and Korea. Areas too cool for analogy are mostly in the high mountains. The lowest mean daily maximum temperature in this study area (76°F in July and August) was reported at Pungsan in northern Korea.

c. Mean temperature, coldest month (Fig. 5)

Balboa Heights and Cristobal have nearly the same mean temperature for the coldest month, 78° and 80°F respectively. A range of 4 F° above and below 79°F (75° to 83°F) is considered analogous, giving a single analogous area for both Canal Zone stations for this climatic element. A map of the mean temperature for the coldest month is a significant indication of true wet tropical conditions throughout the year. Not a single station in the entire study area is warm enough to be considered analogous (however, their warm season temperatures and rainfall are comparable to the Canal Zone stations). Even Basco Island, a northern extension of the Philippines, is only semianalogous, reporting 72°F means for January and February. Mean temperatures as low as -6°F for January are reported from Tyukotin in northern Korea.

d. Mean daily minimum temperature, coldest month (Fig. 6)

At Balboa Heights the mean daily minimum temperature for the coldest month (February) is 71°F; at Cristobal it is 75°F (October). Closely analogous areas are those with temperatures that fall within 4 F° of the above two means. The extremely low mean daily minimum temperatures of the study area rule out any analogy with the Canal Zone for this climatic element, and indicate that wet tropical climates per se are found only equatorward. A mean daily minimum temperature of -20°F for January was reported at Tyukotin in northern Korea.

e. Mean daily temperature range, warmest month (Fig. 7)

At Balboa Heights the mean daily temperature range for the warmest month is 16 F°; at Cristobal, directly exposed to the trade winds from the Caribbean Sea, it is only 8 F°. For Balboa Heights, analogy is 12 F° to 20 F°; for Cristobal, analogy is 4 F° to 12 F°.

The mean daily temperature ranges of the warmest month in nearly all of the lowland portions of the study area are analogous to Balboa Heights. The hilly and mountainous areas have temperature ranges greater than those considered to be analogous. Tatung in north-central China reports a mean daily temperature range of 47 F° in July, higher than that of any other station in the study area.

Analogy with Cristobal is limited to the southern lowlands and southeast coastal area of China and most of Hainan, the Ryukyus, and to a few points of land along the coasts of Japan, northern China, and Korea where temperatures are modified by marine conditions.

f. Mean annual precipitation (Fig. 8)

At Balboa Heights the mean annual precipitation is 70 inches; at Cristobal it is 130 inches. A range of 15 inches on either side of the mean is considered analogous to Balboa Heights; a 30-inch range is analogous to Cristobal. Most of the coastal areas of Japan, Formosa, southern Korea, and southeastern China are analogous to Balboa Heights. The major exception is the Amoy coast of China, where annual precipitation means are below the requirements for Balboa Heights analogy. A few scattered inland stations report analogous rainfall conditions, usually where mountain peaks cause monsoonal air to be lifted. Only five small areas in southern Japan have mean annual precipitation analogous to Cristobal. Takeda, a station on the west coast of Honshu, reports a mean annual precipitation of 112 inches, which is within the range of analogy for Cristobal. This high figure is due largely to heavy winter snowfall.

The unofficial greatest mean annual precipitation reported in this study area is 289 inches in a small, isolated valley in the highlands of Formosa. Naze, in the Ryukyu Archipelago, is the lowland station with the highest rainfall, 124 inches. While these amounts compare favorably with other tropical regions, this area of occurrence is quite small. The smallest annual rainfall figure, 12 inches, was recorded at Yangkao, northwest of Peiping, in the interior of China. Such low rainfall is typical of much of the interior of northern China, and is one of the major causes of non-analogy in many parts of this study area.

g Mean precipitation, wettest month (Fig. 9)

The wettest month is a time of maximum stress in wet tropical climates; therefore, a separate analysis was made of mean precipitation for that month. At Balboa Heights the mean precipitation for the wettest month (November) is 11 inches; at Cristobal it is 22 inches (November). At Balboa Heights, 3 inches on either side of the mean is considered to be analogous; at Cristobal 7 inches on either side of the mean is considered to be analogous.

The area of analogy in the Far East is greater for this climatic element (mean precipitation, wettest month) than for mean annual precipitation.

Nearly all of the southeastern lowland areas of China, as well as most of the lowlands of Japan, Formosa, Hainan, the Ryukyus and Korea have wettest month rainfall values which are analogous to Balboa Heights. Scattered areas of analogy with Cristobal are found on the middle slopes of the highlands of Korea, Honshu, and Hainan. The southern coasts and adjacent highlands of Shikoku, Kyushu, Formosa, Hong Kong, and a few points on the South China coast are also analogous to Cristobal. Nearly all of northern China, Manchuria, Mongolia, and the western mountainous portions of the study area are non-analogous to either Canal Zone station.

The greatest precipitation for the wettest month in China, 20 inches (July), was recorded at Peihai on the southern coast. Another station, Takeda in western Honshu, Japan, also reports 20 inches of precipitation, but this is due mostly to heavy snowfall in December. In north-central China at least two stations report wettest month rain totals of only 3 inches (July).

h. Number of wet months (Fig. 10)

The wetness or dryness of a month has been determined on the basis of Thornthwaite's 1931 temperature-precipitation formula. Selected values based on this formula are given below. A month is considered "wet" if its mean monthly precipitation equals or exceeds the amount given opposite its mean monthly temperature in the following tabulation:

Mean monthly temperature (°F)	Mean monthly precipitation (in.)	Mean monthly temperature (°F)	Mean monthly precipitation (in.)
95	2.88	55	1.52
90	2.71	50	1.35
85	2.54	45	1.18
80	2.37	40	1.02
75	2.20	35	.85
70	2.03	30	.68
65	1.86	25	.62
60	1.69	20	.62

Balboa Heights has an average of 9 wet months according to this formula, Cristobal has 10. Areas having a wet period 1 month longer or shorter than these means are considered analogous. A station with 8 wet months is thus analogous to Balboa Heights, one with 9 or 10 wet months is analogous to both Canal Zone stations, and one with 11 wet months is analogous to Cristobal.

In China only a narrow strip including portions of the Kwangsi-Kwangtung Lowland, the lower slopes of the Liu Pen Shan and the Kwai Ho (a tributary of the Yellow River) plains is analogous to either Canal Zone station. In Formosa a small area of analogy to both Canal Zone

stations can be found in the central part of the island; the southwestern portion is too dry, and the northeastern portion is too wet, for analogy. In Korea the west coast lowland, the Yalu River borderlands and a small piedmont area in southern Korea are analogous to Cristobal. A large area of southeast China, central Korea, as well as all of Japan, is too wet for analogy with 12 wet months. The arid northern and western portions of China are too dry for analogy.

i. Relative humidity, driest month (Fig. 11)

The relative humidity in February, the month of least rainfall at Balboa Heights, is 75 percent. The corresponding figure for Cristobal is 77 percent in February and March. Analogous stations are those at which the driest month has a mean relative humidity within 5 percent of one or the other of these means. Balboa Heights analogy thus extends from 70 to 80 percent and Cristobal from 72 to 82 percent.

Areas with mean relative humidities analogous to Balboa Heights include the middle slopes of the highland areas throughout the southeastern quarter of China, the middle slopes of eastern Japan, two coastal areas in northern and western Japan, and two coastal areas in western Korea. Areas analogous to Cristobal include two small areas in the Szechwan Basin, the middle and lower Yangtze valleys, two coastal areas in south China, the lowlands of Hainan, the highlands and northern coasts of Formosa, and the highlands of Kyushu and Honshu. Areas analagous to both Canal Zone stations include the southeast coast of China, Szechwan Basin and the lower slopes of the highlands of southeastern China, and east and west coasts of Formosa, the Ryukyus, the east and west coasts of Kyushu, the middle slopes of the Honshu Sanmyaku, and the central Yalu valley. The highest mean relative humidity for a dry month in the study area is 88 percent (January) at Yuehyang in the Middle Yangtze Basins. The lowest mean relative humidity reported is 49 percent (February) at Chihfeng in southern Manchuria, on the edge of the Great Plain of Manchuria.

j. Mean cloudiness, wettest month (Fig. 12)

At both Balboa Heights and Cristobal the mean cloudiness for the wettest month (November) is 7.6 tenths of sky coverage. Sky cover from 7.0 to 8.9 tenths is considered analogous to both Canal Zone stations. Dual analogy for mean cloudiness is found in the mountains of western China, throughout southern China, except for two small pockets, in all of Korea, all of Japan except for a small area near Shionomisaki in southern Honshu, and in the mountains of Hainan and Formosa. In addition, there are a few scattered analogies in mountain, coastal, and island stations in the northern part of the study area. The cloudiest station is Puchen, in the Wuyi Shan; 8.6 tenths of the sky is covered in June.

k. Mean windspeed, wettest month (Fig. 13)

The mean windspeed of the wettest month at Balboa Heights is 5.8 mph; at Cristobal it is 8 mph. A range of 2 mph on each side of each mean is considered analogous. Balboa Heights analogy thus extends from 4 to 8 mph and Cristobal analogy extends from 6 to 10 mph. Analogy with Balboa Heights extends over nearly all of the lowland portions of the study area. Dual analogy occurs in scattered localities around coasts of Japan, the southern coast of Korea, south coast of Formosa, the Ryukyus, the northeast China coast, and two areas on the south coast of China. The only significant area of analogy with Cristobal alone is along the northeast coast of China between the Shantung Peninsula and Shanghai. Even here, windspeeds too great for analogy are found at many coastal stations and points of land jutting into the Yellow Sea, e.g., a mean windspeed of 13.5 mph is reported for June at Tungtai. Although the lowest windspeed figures are shown for mountainous areas, these are usually reported from protected valley stations and are not representative of summits or exposed ridges.

6. Analysis of composite maps (Figs. 14 and 15)

Two maps, Figure 14 for Balboa Heights and Figure 15 for Cristobal, are included to show the extent within the study area of composite analogy of the more important elements presented singly elsewhere. The elements for which areas of analogy are fully plotted on the composite maps are (1) the mean temperature of the warmest month, (2) mean temperature of the coldest month, and (3) mean annual precipitation.

Neither of these maps for the Far East shows more than the coincident areas of mean temperature of the warmest month and mean annual precipitation. The absence of analogy with either Canal Zone station for the mean temperature of the coldest month precludes the completion of these maps. Based solely on the two elements mapped, it is apparent that climatic conditions in large areas of the lowlands of Japan and southern China are comparable in the warm season with conditions at Balboa Heights. Only five tiny island and coastal areas in southern Japan have climates which are analogous in summer to the conditions at Cristobal.

7. Tables of monthly values

Tables II through IX show the monthly and yearly means of the climatic elements for 20 key stations as well as for the two Canal Zone stations. The stations were selected for length of reliable record and representativeness. Key stations are not shown for the extreme northwestern 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 more complete climatic picture is presented when one knows the length and intensity of the rainy periods.

The key stations and the regions they represent are listed below:

Region	Key Station
Formosa Plain	Taihoku (Taipei)
Great Plain of Manchuria	Mukden
Honshu Plains	Tokyo, Sendai
Hsingan Shan	Dolonnor
Korean Peninsula Lowland	Pusan, Seoul
Kwangsi-Kwangtung Lowland	Canton, Peihai
Kyushu Lowland	Miyazaki
Middle Yangtze Basins	Hankow
North China Plains	Peiping (Peking)
Ryukyu Archipelago	Naze
Shantung Peninsula Lowland	Tsingtao (Ching-tao)
Southern Honshu	Kobe
Szechwan Basin	Chungking (Chung-ching)
Tai Hang Shan	Yangku (Yang-chu)
Tsing Ling Shan	Changan (Sian)
Yangtze Lowland	Shanghai
Yunnan Plateau	Kunming

TABLE I: CLIMATIC ELEMENTS AND CLASSES OF ANALOGY

Station index	Balboa Heights: Value at 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	77-85	73-76 86-89	82	77-85	73-76 86-89
Mean daily maximum, warmest month	90	86-94	82-85 95-98	86	82-90	78-81 91-94
Mean, coldest month*	78	75-83	71-74 84-87	80	75-83	71-74 84-87
Mean daily minimum, coldest month	71	67-75	63-66 76-79	75	71-79	67-70 80-83
Mean daily range, warmest month	16	12-20	8-11 21-24	8	4-12	0- 3 13-16
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
WINDSPEED (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 (Yrs) Temp.	Precip.
BALBOA HEIGHTS, C.Z.	118	8°58'	78°35'(W)	12-34	22-38
Canton, China	43	23°08'	113°17'	22	18
Changan, China	1,296	34°15'	108°55'	4	9
Chungking, China	712	29°34'	106°31	25	50
CRISTOBAL, C.Z.	36	9°25'	79°52'(W)	7-32	8-60
Dolonnor, China	3,975	42°15'	116°13'	4	8
Hankow, China	128	30°35'	114°17'	29	55
Kobe, Japan	191	34°41'	135°11'	30	30
Kunming, China	6,213	25°04'	102°40'	40	40
Miyazaki, Japan	28	31°55'	131°26'	30	30
Mukden, China	143	41°48'	123°23'	23	23
Naze, Japan	14	28°23	129°30'	30	30
Peihai, China	16	21°28'	109°05'	34	53
Peiping, China	171	39°54'	116°28'	7-34	75
Pusan, Korea	41	35°06'	129°01'	24	24
Sendai, Japan	127	38°16'	140°54'	2	2
Seoul, Korea	96	37°34'	126°59'	21	21
Shanghai, China	23	31°12'	121°26'	23	50
Taihoku, Formosa	31	25°02'	121°31'	30	30
Tokyo, Japan	19	35°41'	139°46	30	30
Tsingtao, China	258	36°04'	120°19'	20	36
Yangku, China	2,641	37°54'	112°31'	4	8

TABLE III

MEAN MONTHLY TEMPERATURE (°F)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
BALBOA HEIGHTS	78	79	80	80	79	79	79	79	79	78	78	78	79
Canton	56	52	63	71	78	81	83	83	80	75	68	60	71
Changan	28	36	46	57	69	79	83	79	69	56	43	33	57
Chungking	48	50	58	67	74	79	84	84	76	67	59	50	66
CRISTOBAL	80	80	81	82	81	81	81	81	81	80	80	80	81
Dolonnor	1	9	23	41	50	60	69	66	45	40	21	6	36
Hankow	40	43	50	62	71	80	85	85	77	67	55	45	63
Kobe	40	42	45	56	64	70	78	80	74	63	53	44	59
Kunming	48	50	60	68	70	72	72	70	66	63	56	50	62
Miyazaki	45	46	52	60	66	72	79	80	75	65	56	44	62
Mukden	9	16	30	48	61	71	77	75	62	48	30	14	45
Naze	58	58	61	67	71	78	81	82	79	73	67	61	69
Peihai	60	58	65	74	82	82	84	83	82	78	69	62	73
Peiping	25	29	41	56	69	76	80	78	70	56	38	29	54
Pusan	36	37	45	54	61	68	75	78	71	61	50	39	56
Sendai	31	31	37	48	56	63	73	75	67	57	47	37	52
Seoul	24	28	38	51	61	70	76	78	68	56	41	28	52
Shanghai	40	41	48	58	67	75	82	83	75	65	54	44	61
Taihoku	60	58	63	69	75	80	83	82	79	73	67	62	71
Tokyo	37	39	44	55	62	69	75	78	71	61	51	41	57
Tsingtao	31	33	40	51	61	68	74	77	70	61	47	34	54
Yangku	18	27	40	54	67	73	79	73	64	51	35	24	51

TABLE IV

MEAN DAILY MAXIMUM TEMPERATURE (°F)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
BALBOA HEIGHTS	88	89	90	90	87	86	87	87	86	85	85	87	87
Canton	64	62	67	76	83	88	89	90	87	83	74	65	77
Changan	39	47	58	68	82	93	93	88	79	68	54	41	68
Chungking	53	56	64	74	81	86	92	92	82	72	64	55	73
CRISTOBAL	84	84	85	86	86	86	85	85	86	86	84	84	85
Dolonnor	13	23	36	55	64	73	78	76	63	54	34	19	49
Hankow	46	50	50	69	79	87	92	92	84	74	62	51	70
Kobe	48	48	54	65	73	78	86	89	82	71	61	52	67
Kunming	62	64	71	75	77	78	77	77	75	69	65	62	71
Miyazaki	55	55	61	68	74	79	86	87	82	74	66	58	70
Mukden	20	28	41	60	73	83	87	85	75	61	40	25	57
Naze	64	63	67	73	78	84	88	88	86	80	74	67	76
Peihai	65	64	70	80	85	87	90	88	88	84	76	68	79
Peiping	34	39	52	67	81	87	90	87	81	69	50	38	65
Pusan	44	45	53	62	69	75	81	85	78	70	59	47	64
Sendai	40	39	47	58	65	71	80	83	75	67	57	46	61
Seoul	32	37	48	62	72	81	84	87	78	67	51	37	61
Shanghai	48	48	56	60	76	83	90	91	83	75	63	52	69
Taihoku	66	65	70	77	83	89	92	91	88	81	74	69	79
Tokyo	47	48	53	63	70	76	83	85	78	69	60	51	65
Tsingtao	36	39	47	58	68	74	80	83	77	68	54	41	60
Yangku	31	39	53	66	78	85	88	83	76	64	49	35	62

TABLE V

MEAN DAILY MINIMUM TEMPERATURE (°F)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
BALBOA HEIGHTS	72	71	72	74	74	74	74	74	74	73	73	73	73
Canton	51	51	58	67	73	78	79	79	76	70	60	52	66
Changan	20	27	34	46	56	66	73	69	60	47	37	26	47
Chungking	44	44	51	60	66	72	76	76	70	62	54	46	60
CRISTOBAL	76	77	77	78	77	76	77	76	76	75	76	77	77
Dolonnor	-10	- 4	11	28	36	47	60	56	38	26	8	- 6	24
Hankow	34	36	43	54	64	73	78	78	69	60	48	38	56
Kobe	34	34	38	48	56	64	72	74	68	57	47	38	53
Kunming	37	39	44	51	57	62	62	61	59	53	45	38	51
Miyazaki	35	36	42	51	58	66	72	73	68	57	46	37	53
Mukden	- 2	4	20	36	49	60	68	66	52	38	20	4	35
Naze	52	52	56	61	65	72	76	76	73	67	61	55	64
Peihai	55	53	60	69	76	77	79	78	76	71	63	56	68
Peiping	14	19	29	43	56	64	71	68	58	43	28	19	43
Pusan	29	30	37	47	54	62	70	73	65	54	43	32	50
Sendai	24	24	29	39	48	56	67	69	61	49	39	30	45
Seoul	15	20	29	41	51	61	70	71	59	45	32	20	43
Shanghai	32	34	39	49	58	67	74	74	67	56	45	35	53
Taihoku	54	53	57	63	69	73	76	75	73	68	62	57	65
Tokyo	30	31	36	46	54	62	69	72	65	54	43	33	50
Tsingtao	24	26	34	45	54	63	70	72	64	54	40	29	48
Yangku	8	15	23	42	53	61	68	64	52	38	24	15	39

TABLE VI

MEAN MONTHLY PRECIPITATION (inches)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
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
Canton	0.9	1.9	4.2	6.8	10.6	10.6	8.1	8.5	6.5	3.4	1.2	0.9	63.6
Changan	0.1	0.1	0.7	1.6	2.3	2.5	2.9	4.0	3.5	2.0	0.3	0.1	20.1
Chungking	0.7	0.8	1.5	3.8	5.6	7.0	5.6	4.8	5.8	4.3	1.8	0.8	42.5
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
Dolonnor	T	T	0.4	0.2	1.6	2.3	9.0	4.6	2.2	1.1	T	T	22.0
Hankow	1.8	1.9	3.6	5.8	7.0	9.0	7.1	4.1	3.0	3.1	1.9	1.2	49.5
Kobe	1.9	2.1	3.6	5.0	4.9	8.2	5.9	4.6	7.7	4.8	2.5	1.8	53.0
Kunming	0.5	0.4	0.4	0.7	3.6	6.2	9.9	9.2	5.2	3.8	2.0	0.6	42.5
Miyazaki	2.8	4.3	7.5	9.0	9.5	15.5	11.9	11.3	11.6	8.7	5.0	2.7	99.8
Mukden	0.2	0.2	0.7	1.0	2.3	3.4	6.4	5.9	3.0	1.5	0.9	0.3	25.8
Naze	7.8	8.3	8.3	10.2	12.5	15.9	9.6	13.0	10.5	12.0	9.0	6.9	124.0
Peihai	1.2	1.5	2.9	4.2	6.3	11.6	19.7	19.0	10.7	3.5	1.5	1.9	84.0
Peiping	0.2	0.2	0.4	0.6	1.3	3.2	10.0	5.7	2.2	0.7	0.3	0.1	24.9
Pusan	2.0	1.5	2.4	5.7	4.8	7.8	11.9	7.1	6.6	2.6	1.7	1.1	55.2
Sendai	1.2	1.2	2.3	6.0	5.3	3.9	3.5	4.4	5.9	5.6	2.6	2.0	43.9
Seoul	1.1	0.8	1.5	2.9	3.2	5.0	14.8	10.5	4.6	1.5	1.7	1.0	48.6
Shanghai	1.9	2.3	3.3	3.6	3.7	7.1	5.8	5.7	5.0	2.9	2.0	1.4	44.7
Taihoku	3.4	5.3	6.6	6.4	8.9	11.1	8.2	11.8	10.1	5.2	2.6	3.0	82.6
Tokyo	2.3	3.0	4.2	5.2	5.9	6.7	5.6	7.0	10.0	7.9	3.4	2.2	63.4
Tsingtao	0.4	0.3	0.7	1.2	1.7	3.5	5.8	6.0	3.4	1.4	0.8	0.7	25.9
Yangku	0.2	0.1	0.5	0.6	0.9	1.7	4.2	3.8	2.0	0.6	0.2	0.2	15.0

T - Trace

TABLE VII

MEAN CLOUDINESS (tenths of sky covered)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
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
Canton	5.1	8.3	7.7	8.5	6.9	7.5	6.5	6.1	7.5	5.2	4.9	6.2	6.7
Changan	5.4	5.6	6.3	6.9	6.4	6.0	5.9	5.9	5.7	6.1	5.5	5.4	5.9
Chungking	8.4	8.5	7.5	7.4	7.2	6.6	5.6	6.0	6.8	8.2	8.3	8.4	7.4
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
Dolonnor	2.4	3.7	4.7	4.4	6.5	6.5	7.1	5.7	4.5	3.7	3.1	2.8	4.6
Hankow	5.9	7.1	7.0	6.9	6.7	6.8	6.2	4.8	5.8	5.8	5.3	5.4	6.1
Kobe	5.4	5.8	6.1	6.4	6.6	7.7	7.1	6.0	6.9	5.9	5.1	4.8	6.2
Kunming	3.8	3.9	3.7	4.5	5.6	7.3	7.2	7.1	6.9	6.2	5.1	5.8	5.6
Miyazaki	4.2	5.1	5.9	6.7	6.9	8.0	6.6	5.8	6.5	5.8	4.8	3.9	5.9
Mukden	2.6	3.0	4.0	4.8	5.4	5.9	6.6	5.8	4.5	3.7	3.5	2.9	4.4
Naze	8.1	8.5	8.1	8.0	8.1	8.2	6.9	6.7	6.6	7.2	7.8	7.9	7.7
Peihai	8.0	5.3	5.7	5.0	5.0	6.0	5.0	4.7	4.0	4.0	4.3	4.3	5.1
Peiping	2.0	2.4	3.3	3.9	4.0	4.6	5.4	4.7	3.8	2.4	2.3	1.8	3.4
Pusan	3.7	4.3	5.1	5.7	5.9	7.2	7.0	5.9	6.5	4.4	3.9	3.4	5.3
Sendai	5.8	5.4	6.2	6.7	7.4	7.8	8.2	7.6	7.7	6.4	5.9	6.1	6.8
Seoul	4.4	4.4	5.1	5.7	6.1	6.7	7.6	6.6	5.8	4.4	4.4	4.4	5.5
Shanghai	6.1	6.8	6.8	6.9	7.0	7.7	6.4	5.8	6.4	5.7	5.2	5.0	6.3
Taihoku	7.8	8.1	8.1	7.8	7.4	7.2	5.7	5.8	5.6	6.8	7.4	7.7	7.1
Tokyo	4.3	5.1	5.9	6.8	7.1	8.1	7.5	6.8	7.5	6.7	5.1	4.1	6.3
Tsingtao	4.2	5.0	5.4	5.5	6.1	6.6	7.7	6.2	5.1	3.7	3.9	4.3	5.3
Yangku	2.0	2.5	2.5	2.3	2.3	3.2	3.9	3.9	2.4	2.1	1.3	2.1	2.5

TABLE VIII

MEAN RELATIVE HUMIDITY (percent)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
BALBOA HEIGHTS	78	75	73	77	85	87	86	87	87	88	88	84	83
Canton	73	81	84	84	84	84	81	80	76	72	70	72	78
Changan	72	69	62	64	64	58	69	79	78	75	76	72	70
Chungking	82	81	79	79	79	82	81	80	83	86	84	84	82
CRISTOBAL	78	77	77	79	83	85	86	86	85	85	86	82	82
Dolonnor	79	71	66	49	57	63	78	74	67	67	67	69	67
Hankow	75	77	77	77	76	79	78	75	74	74	75	74	76
Kobe	67	66	67	68	70	76	77	73	74	71	70	67	71
Kunming	67	63	58	58	68	80	81	84	81	80	78	74	73
Miyazaki	72	71	74	78	79	84	84	84	84	80	78	74	79
Mukden	64	60	55	51	57	62	74	77	72	68	63	64	64
Naze	73	73	73	76	77	79	79	80	79	75	73	71	76
Peihai	76	81	85	82	77	79	79	82	79	74	76	76	79
Peiping	62	56	52	48	51	59	76	78	71	66	60	62	62
Pusan	51	51	57	66	71	78	83	78	72	64	58	52	65
Sendai	75	70	70	72	78	82	86	83	83	79	75	73	77
Seoul	67	63	62	65	69	71	80	76	73	71	70	67	69
Shanghai	78	79	78	79	79	84	84	84	83	79	78	76	80
Taihoku	83	84	84	83	81	80	77	78	79	81	81	82	81
Tokyo	64	62	66	72	76	81	83	81	82	79	73	67	74
Tsingtao	69	68	70	71	73	82	89	84	74	67	65	65	73
Yangku	84	79	73	73	76	80	80	83	87	82	79	80	80

TABLE IX

MEAN WINDSPEED (miles per hour)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
BALBOA HEIGHTS	8.8	10.1	10.3	8.8	6.1	5.4	5.9	5.9	5.6	6.3	5.8	6.4	7.1
Canton	4.4	4.4	3.6	3.3	3.3	2.7	3.0	3.0	3.6	4.2	4.2	4.2	3.7
Changan	5.6	5.8	4.5	5.1	4.7	5.8	6.0	6.5	6.3	4.9	6.0	6.0	5.6
Chungking	3.0	3.0	4.0	4.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	3.0	3.3
CRISTOBAL	14.1	14.8	14.8	12.5	8.0	6.6	8.1	7.9	6.1	6.6	8.0	11.8	9.9
Dolonnor	7.0	5.0	7.0	9.0	9.0	9.0	5.0	5.0	9.0	7.0	11.0	11.0	7.8
Hankow	4.0	4.0	4.0	4.0	4.0	3.0	4.0	4.0	5.0	4.0	4.0	4.0	4.0
Kobe	5 8	5.8	5.8	5.6	5.4	5.1	5.1	5.6	5.6	5.4	5.6	6.3	5.6
Kunming	7.0	8.0	8.0	8.0	7.0	5.0	4.0	4.0	5.0	5.0	6.0	5.0	6.0
Miyazaki	6.0	6.3	6.0	5.6	5.6	5.1	5.6	5.6	4.9	4.7	4.9	5.6	5.5
Mukden	5.1	5.8	7.2	8.1	7.6	6.3	5.1	4.3	4.5	5.6	6.0	5.4	5.9
Naze	9.2	9.4	8.5	7.2	5.8	5.6	5.6	6.3	6.5	7.4	8.3	8.9	7.4
Peihai	9.6	9.3	7.5	6.0	6.0	5.7	5.7	5.4	7.2	8.4	8.4	9.3	7.4
Peiping	7.6	7.2	8.9	9.4	9.4	8.3	6.0	5.4	7.2	8.9	9.4	7.2	7.9
Pusan	9.8	9.6	8.7	7.6	6.5	5.8	6.7	6.5	6.9	6.9	8.1	9.6	7.7
Sendai	3.8	4.7	4.5	4.0	3.4	2.7	2.5	3.1	2.7	2.5	3.4	3.8	3.4
Seoul	3.8	4.5	5.1	4.9	4.7	4.5	4.5	4.0	3.6	2.9	3.6	3.6	4.1
Shanghai	12.0	12.0	12.0	12.0	12.0	11.0	12.0	12.0	11.0	10.0	11.0	12.0	12.0
Taihoku	7.8	7.4	8.1	7.2	6.5	4.9	5.6	6.5	6.9	8.3	8.9	8.3	7.2
Tokyo	6.0	6.7	6.9	6.7	6.5	5.8	5.8	5.8	5.8	5.4	5.4	5.6	6.0
Tsingtao	16.6	16.1	16.6	18.1	17.2	16.3	15.9	12.3	12.3	15.0	15.9	17.9	15.9
Yangku	3.4	4.0	6.3	6.5	4.7	4.7	3.4	2.7	3.8	3.1	4.0	3.1	4.0

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9. Acknowledgments

The final maps were drafted and printed at the Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi, from fair sheets prepared by the author.

10. Maps

Figure

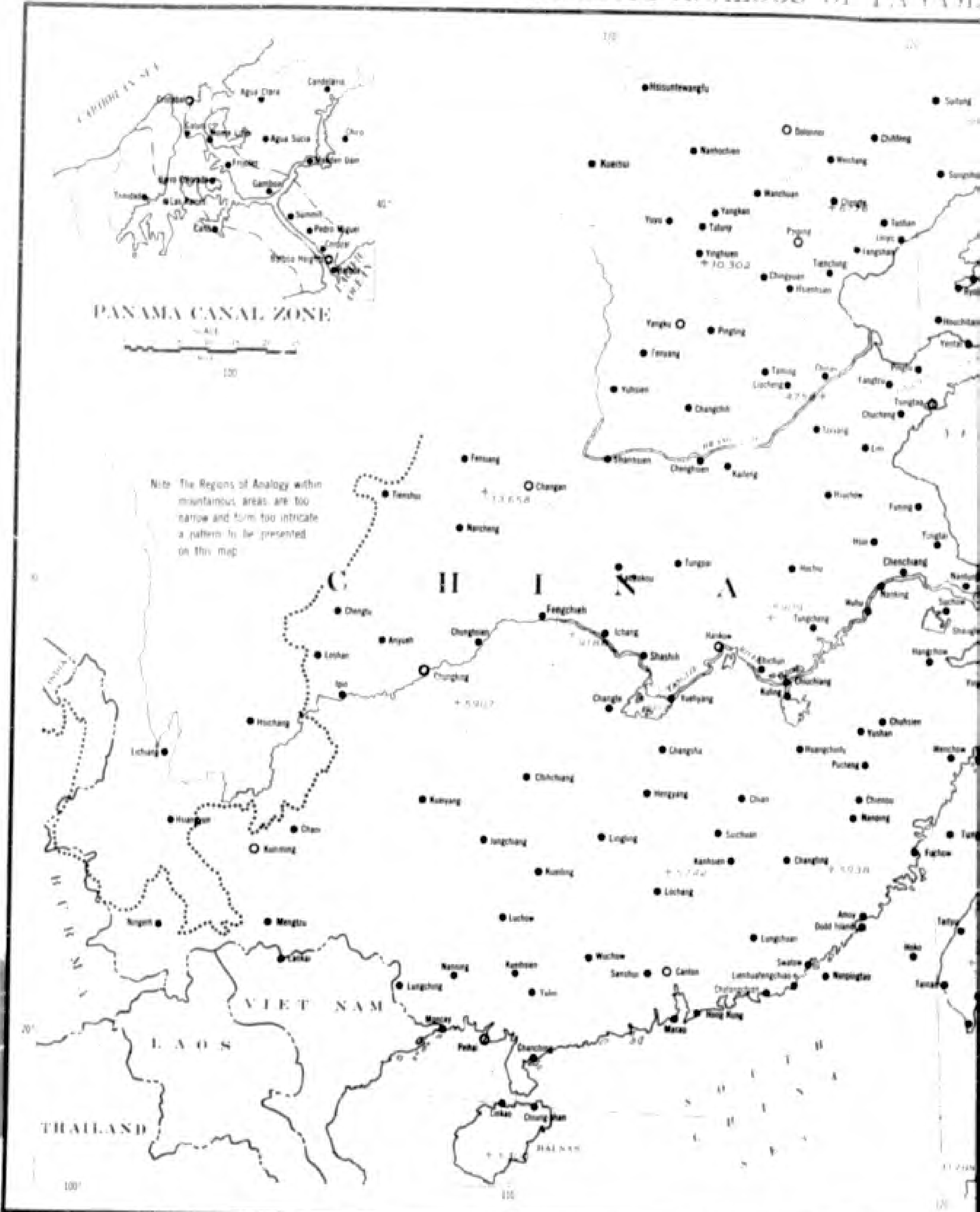
2. Station locations and physiographic features
3. Mean temperature, warmest month
4. Mean daily maximum temperature, warmest month
5. Mean temperature, coldest month
6. Mean daily minimum temperature, coldest month
7. Mean daily temperature range, warmest month
8. Mean annual precipitation
9. Mean precipitation, wettest month
10. Number of wet months
11. Relative humidity, driest month
12. Mean cloudiness, wettest month
13. Mean windspeed, wettest month
14. Composite of analogous areas - Balboa Heights
15. Composite of analogous areas - Cristobal

NOTE: In Figure 2 read

Shikoku for Skikoku
Tyukotin for Tyokotin

In Figure 2 mountainous areas are shown by yellow shading

CLIMATIC ANALOGS OF PANAM



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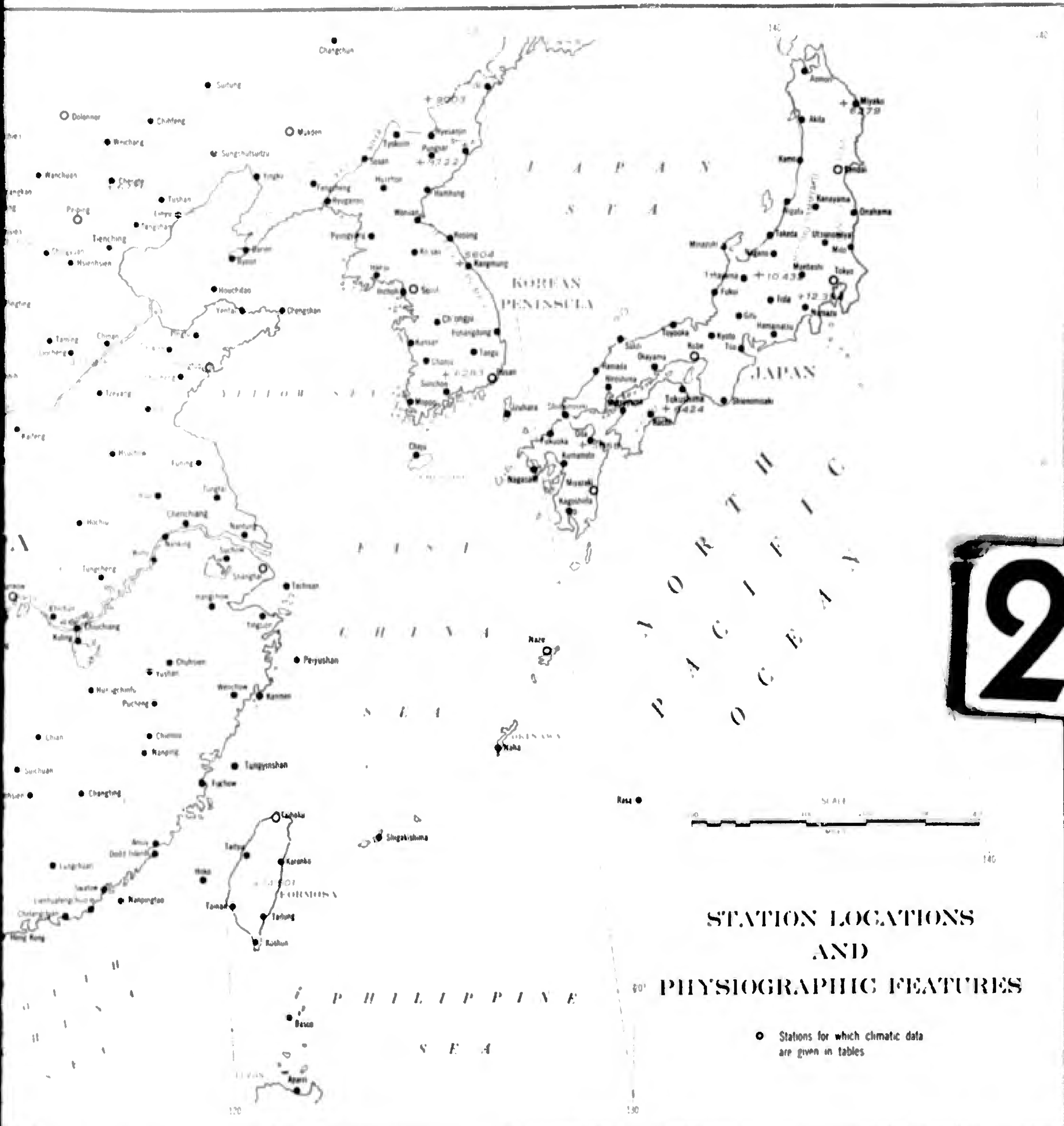
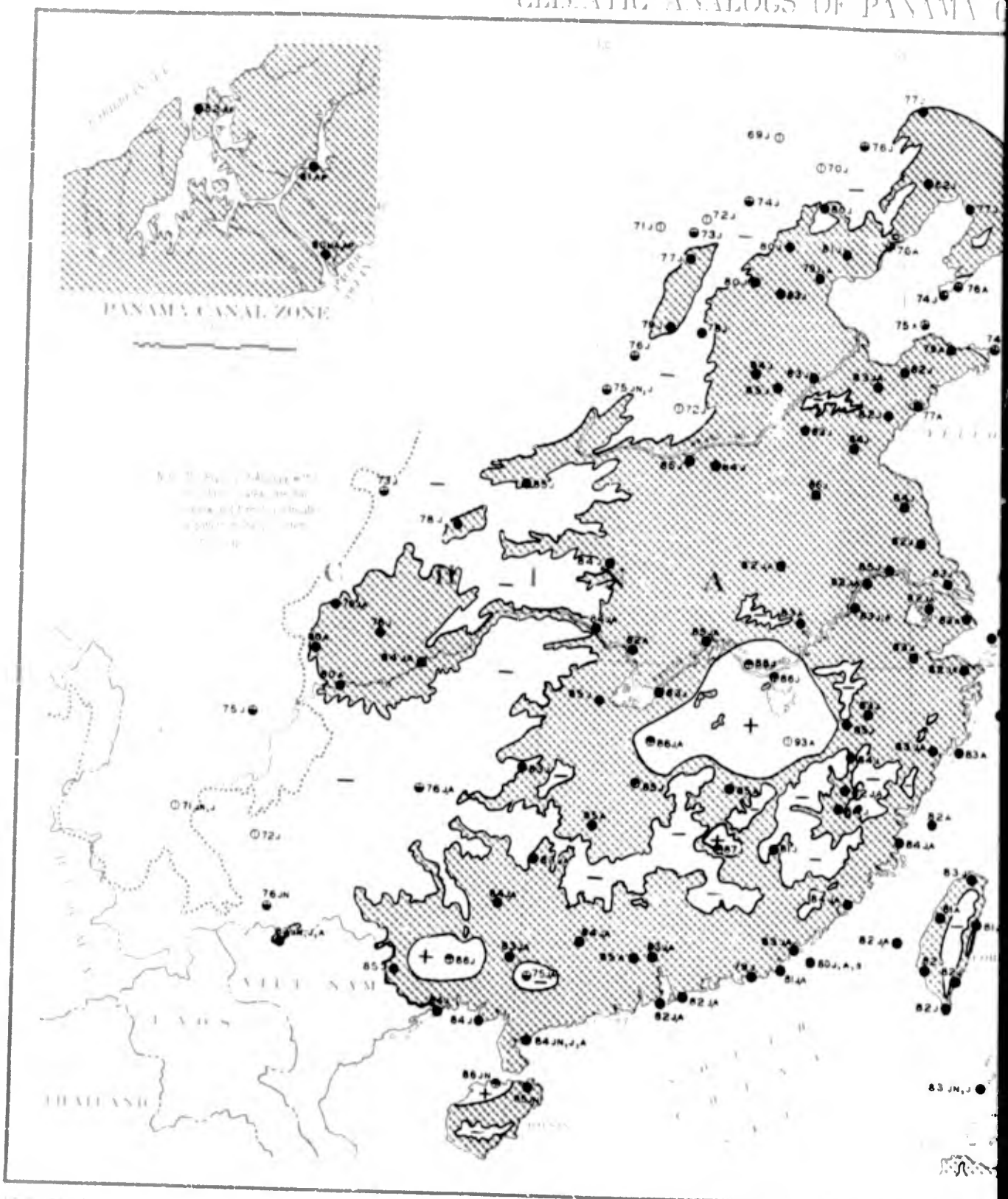
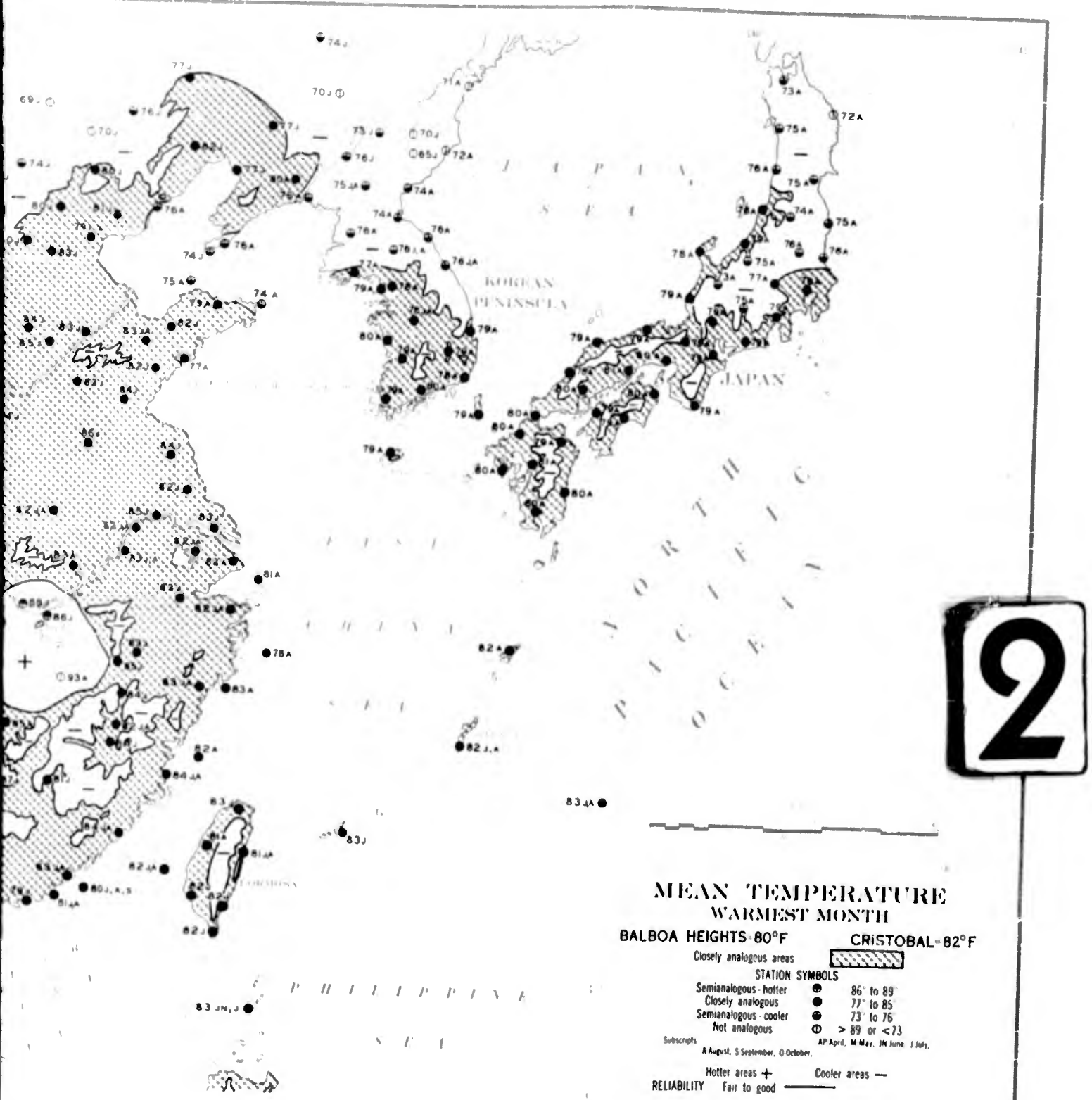

JAPAN SEA
KOREAN PENINSULA
JAPAN
EAST CHINA SEA
NORTH PACIFIC OCEAN
PHILIPPINE SEA
FORMOSA
OKINAWA
Seoul
Tokyo
Naha
Naze
Mukden
Dolonnor
Sendai
Kagoshima
Nagasaki
Shigakishima
Tungyinshan
Peiyushan
Hong Kong
STATION LOCATIONS
AND
PHYSIOGRAPHIC FEATURES
Stations for which climatic data are given in tables

2

Figure 2

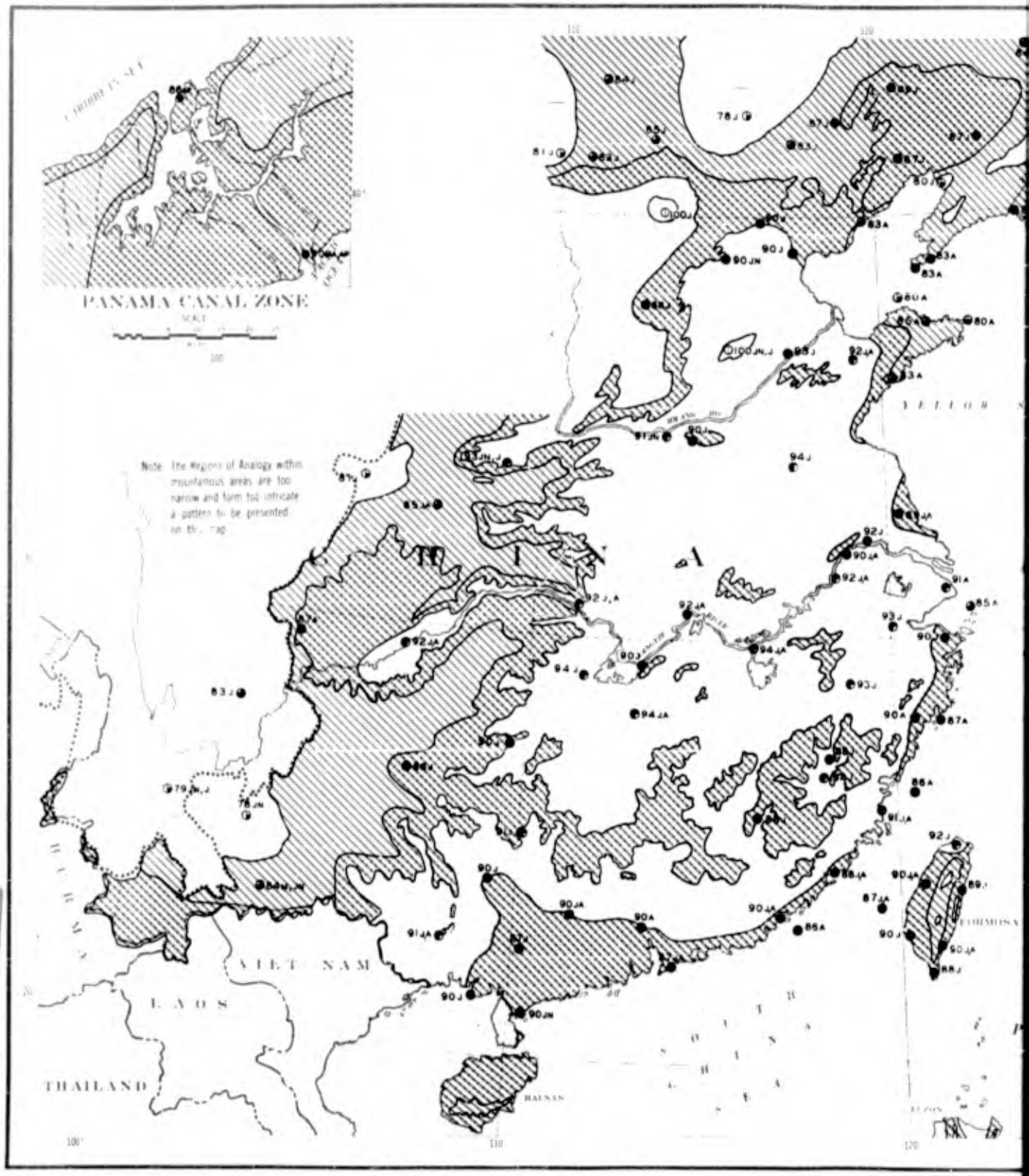


1


KOREAN PENINSULA
JAPAN
PACIFIC OCEAN
PHILIPPINES
MEAN TEMPERATURE
WARMEST MONTH
BALBOA HEIGHTS-80°F
CRISTOBAL-82°F
Closely analogous areas
STATION SYMBOLS
Semianalogous - hotter 86° to 89°
Closely analogous 77° to 85°
Semianalogous - cooler 73° to 76°
Not analogous > 89 or < 73
Subscripts
A August, S September, O October,
AP April, M May, JN June, J July,
Hotter areas +
Cooler areas —
RELIABILITY Fair to good

2

Figure 3

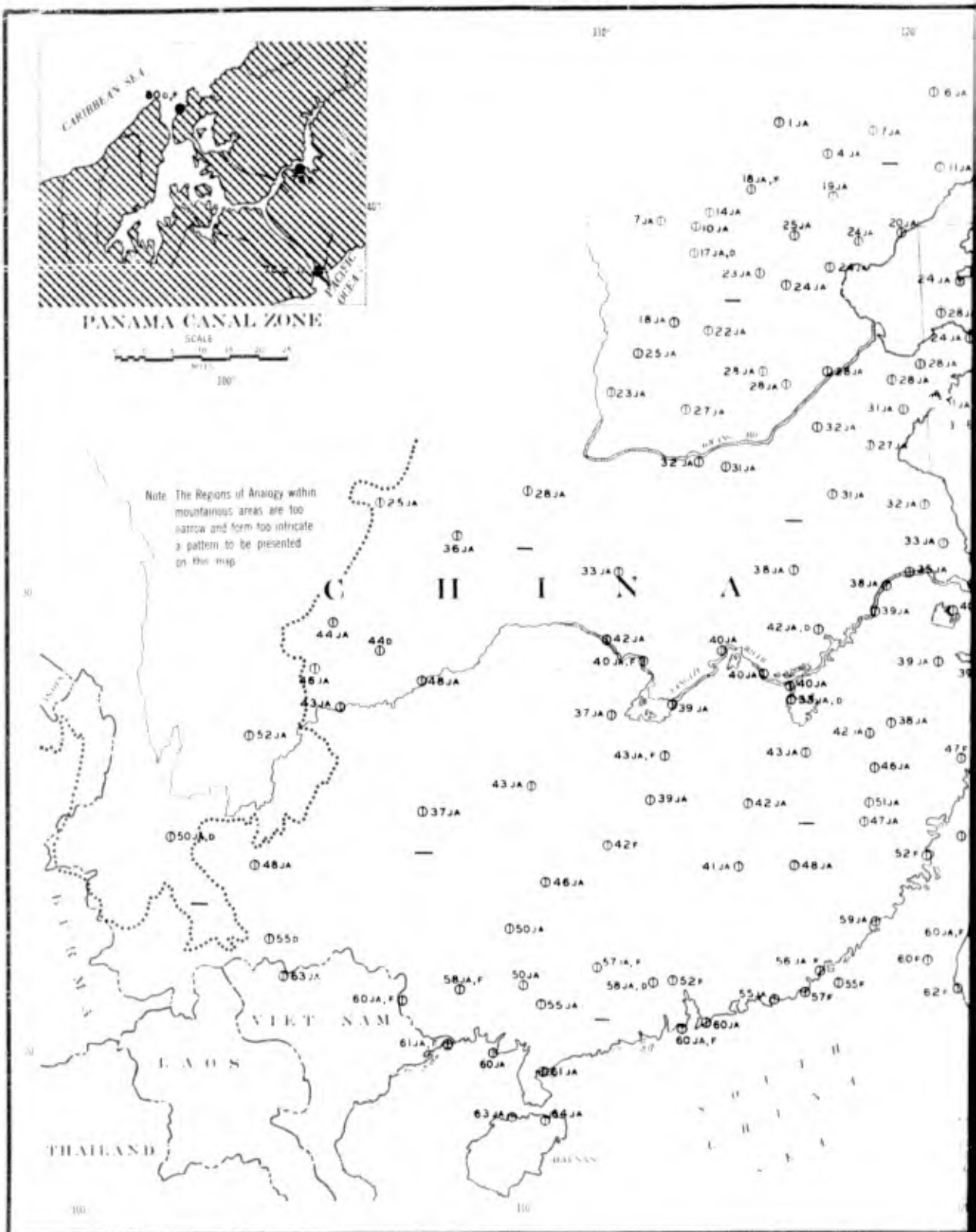

PANAMA CANAL ZONE
Note: The regions of Analogy within mountainous areas are too narrow and form too intricate a pattern to be presented on this map
VIET NAM
LAOS
THAILAND
BALNAN

1


JAPAN SEA
KOREAN PENINSULA
JAPAN
EAST CHINA SEA
PHILIPPINE SEA
NORTH PACIFIC OCEAN
FORMOSA
2
MEAN DAILY MAXIMUM TEMPERATURE
WARMEST MONTH
BALBOA HEIGHTS 90°F
CRISTOBAL 86°F
Closely analogous areas
STATION SYMBOLS
95° to 98° e
86° to 94° d
82° to 85° c
>98° or <82° a
Semianalogous - hotter
Closely analogous
Semianalogous - cooler
Not analogous
91° to 94°
82° to 90°
78° to 81°
>94° or <78°
Subscripts: A August, MA March, AP April, M May, JN June, J July,
Hotter areas
Cooler areas
RELIABILITY: Fair to good

Figure 4

CLIMATIC ANALOGS OF PANAM



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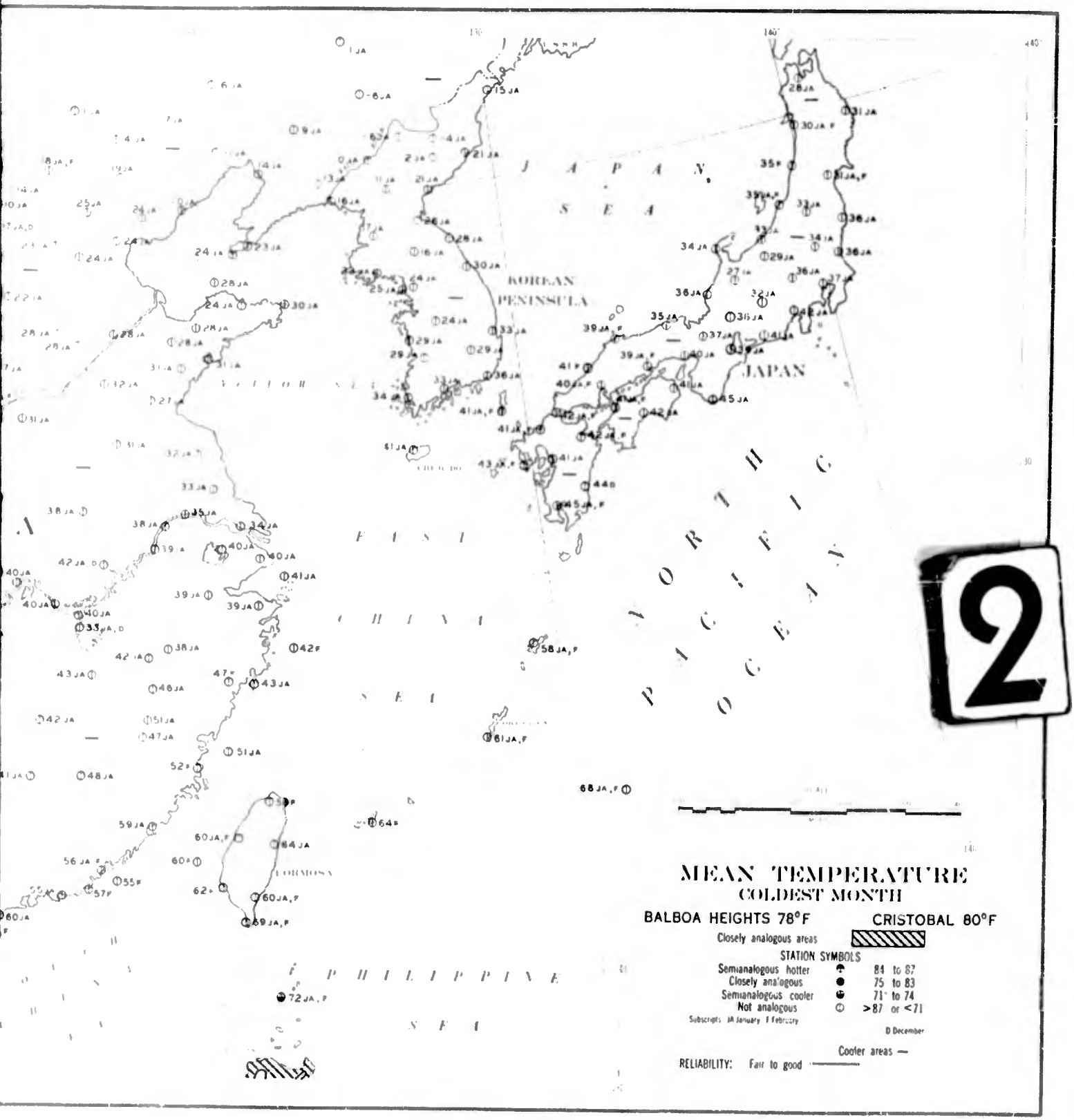
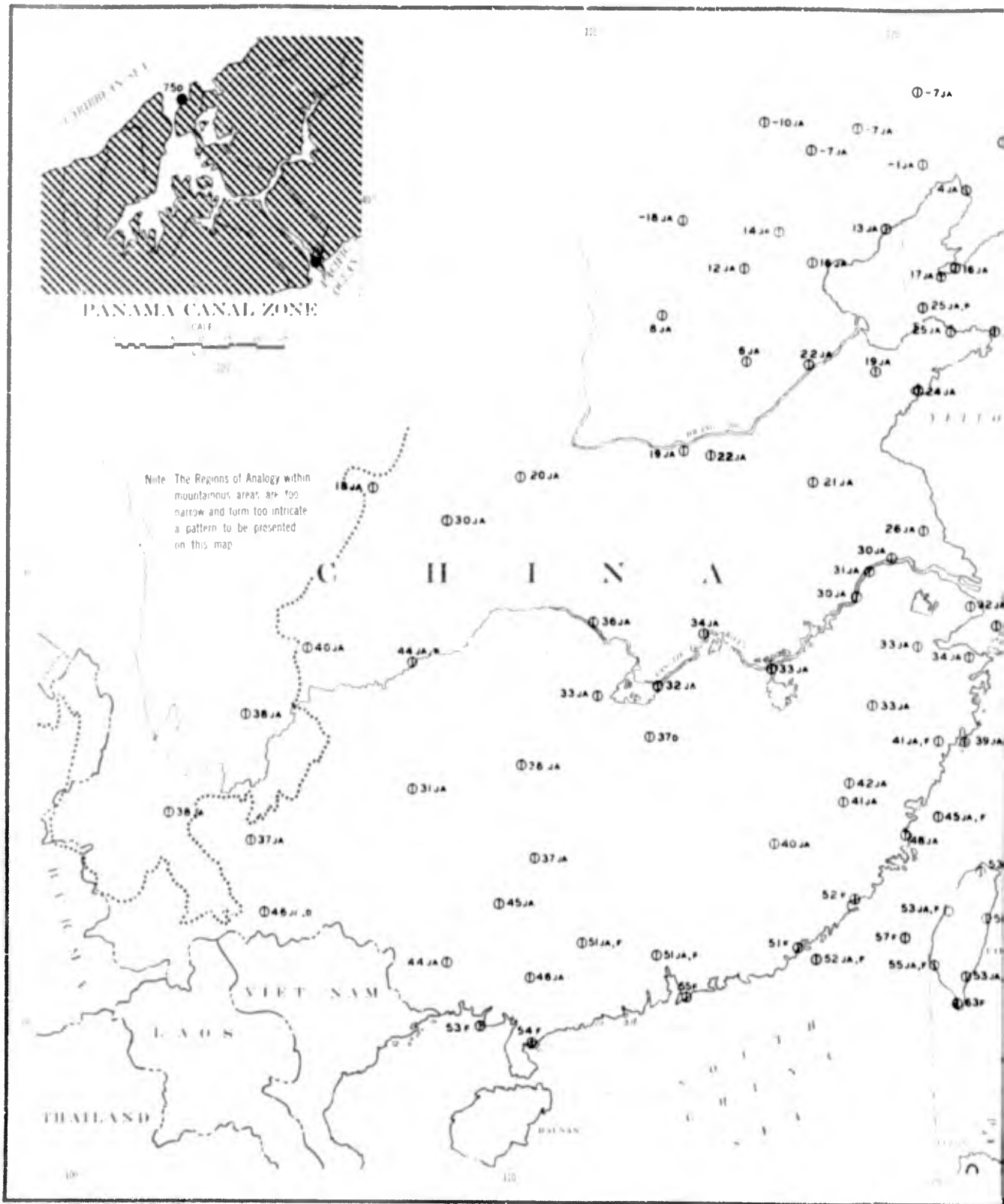

JAPAN
SEA
KOREAN
PENINSULA
JAPAN
NORTH
PACIFIC
OCEAN
CHINA
SEA
PHILIPPINE
SEA
FORMOSA
MEAN TEMPERATURE
COLDEST MONTH
BALBOA HEIGHTS 78°F
CRISTOBAL 80°F
Closely analogous areas
STATION SYMBOLS
Semianalogous hotter 84 to 87
Closely analogous 75 to 83
Semianalogous cooler 71° to 74
Not analogous >87 or <71
Subscripts JA January F February
D December
Cooler areas —
RELIABILITY: Fair to good

2

Figure 5


PANAMA CANAL ZONE
Note The Regions of Analogy within mountainous areas are too narrow and form too intricate a pattern to be presented on this map
CHINA
VIET NAM
LAOS
THAILAND

1

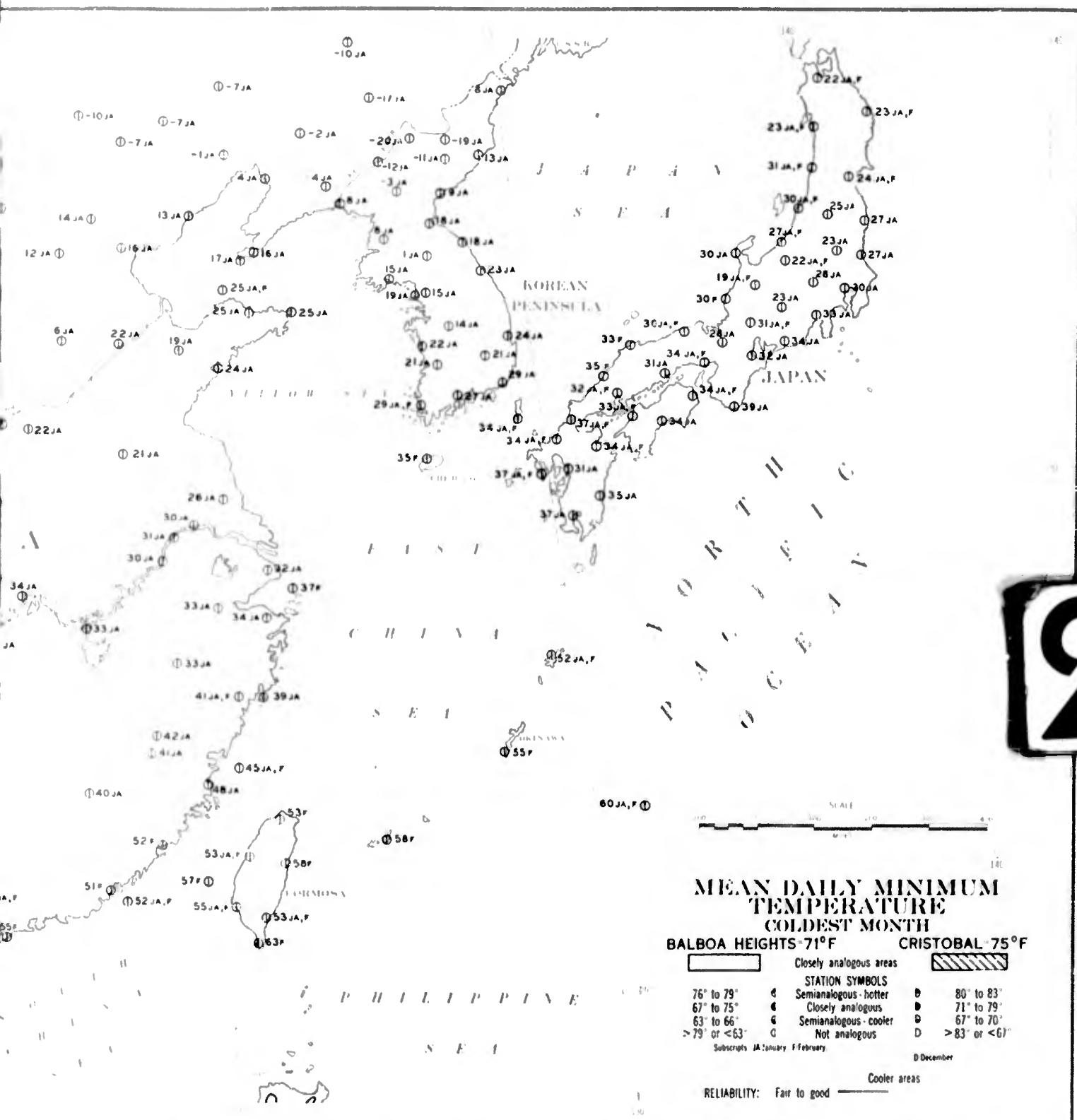
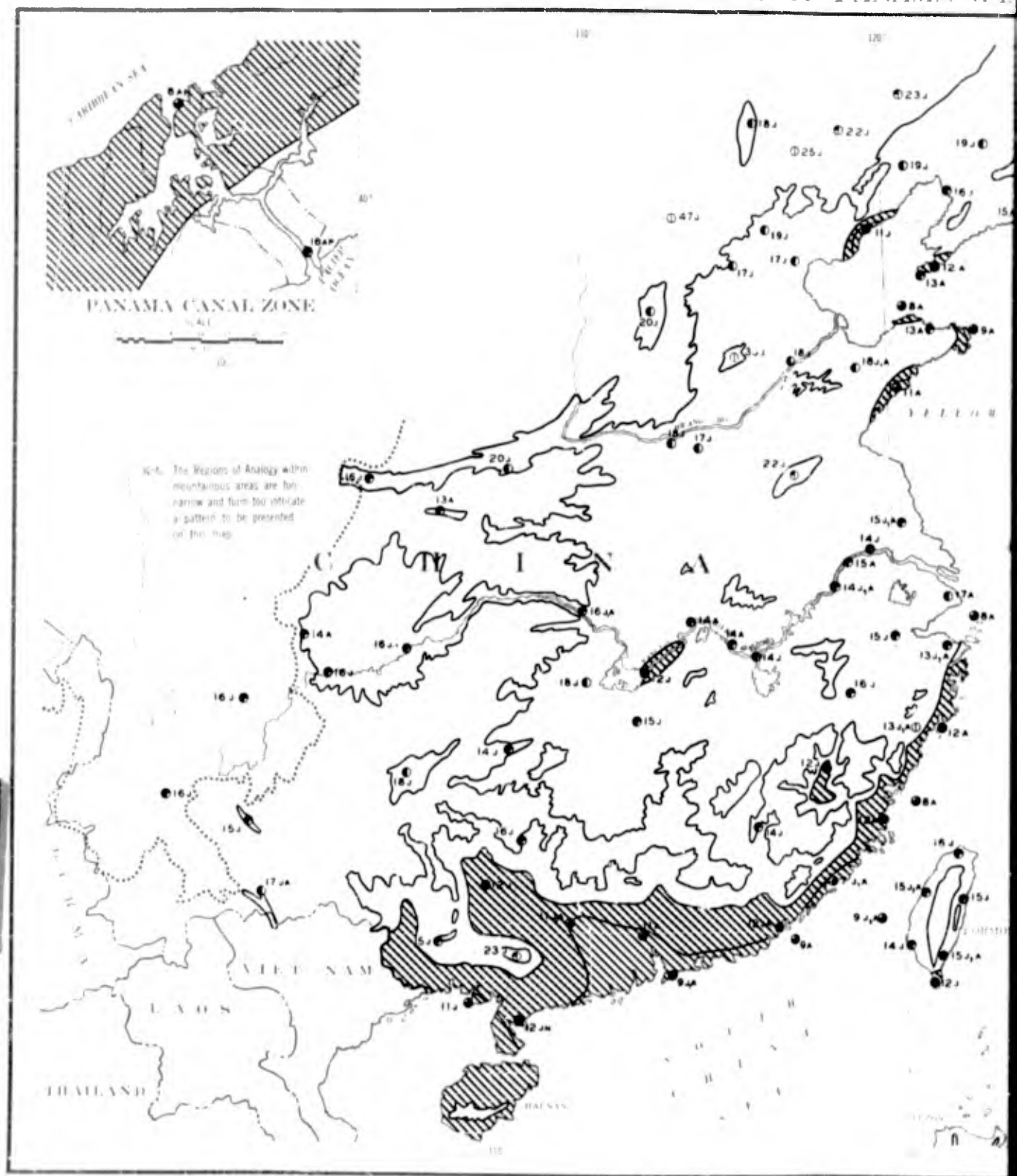
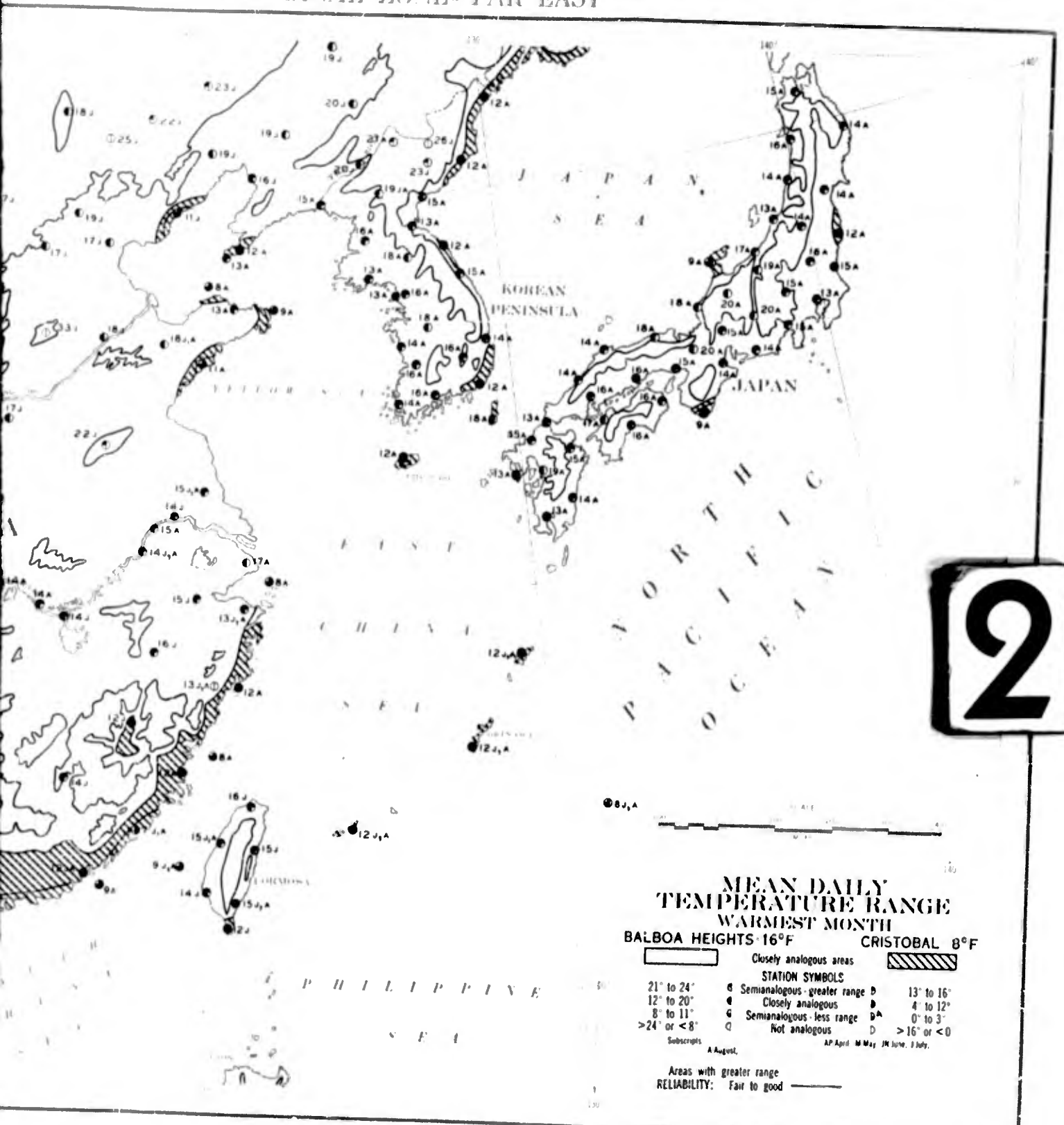

JAPAN SEA
KOREAN PENINSULA
JAPAN
PACIFIC OCEAN
CHINA SEA
PHILIPPINE SEA
TAIWAN
OKINAWA
MEAN DAILY MINIMUM TEMPERATURE
COLDEST MONTH
BALBOA HEIGHTS 71°F
CRISTOBAL 75°F
Closely analogous areas
STATION SYMBOLS
76° to 79° G Semianalogous - hotter B 80° to 83°
67° to 75° G Closely analogous B 71° to 79°
63° to 66° G Semianalogous - cooler B 67° to 70°
>79° or <63° G Not analogous D >83° or <67°
Subscripts JA January F February D December
Cooler areas
RELIABILITY: Fair to good

Figure 6

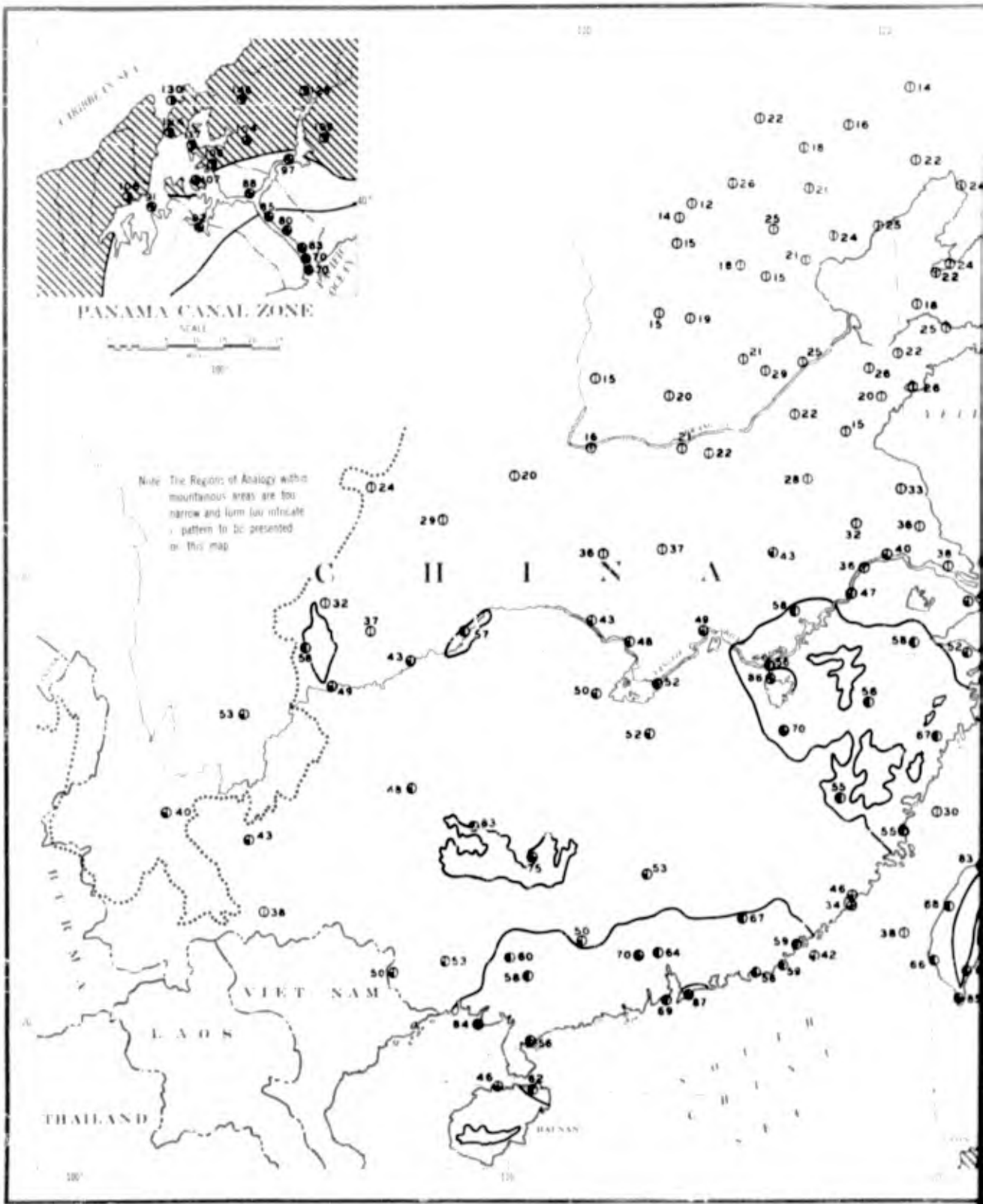

PANAMA CANAL ZONE
CARIBBEAN SEA
PACIFIC OCEAN
VIET NAM
LAOS
THAILAND

1

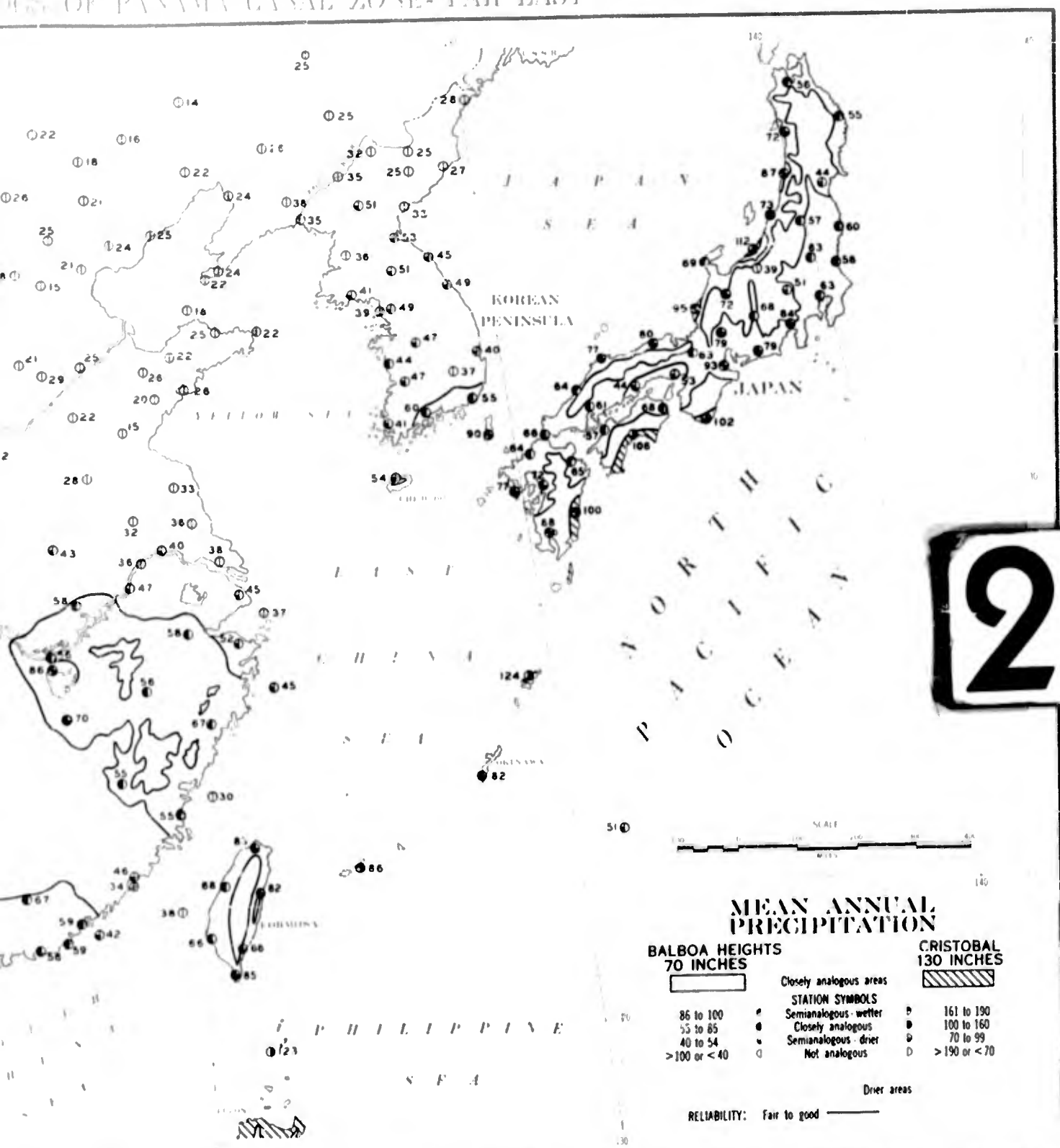

JAPAN SEA
KOREAN PENINSULA
JAPAN
NORTH PACIFIC OCEAN
EAST CHINA SEA
PHILIPPINE SEA
MEAN DAILY TEMPERATURE RANGE
WARMEST MONTH
BALBOA HEIGHTS 16°F
CRISTOBAL 8°F
Closely analogous areas
STATION SYMBOLS
21° to 24°
12° to 20°
8° to 11°
>24° or <8°
Semianalogous - greater range
Closely analogous
Semianalogous - less range
Not analogous
13° to 16°
4° to 12°
0° to 3°
>16° or <0
Areas with greater range
RELIABILITY: Fair to good

2

Figure 7


PANAMA CANAL ZONE
SCALE
Note: The Regions of Analogy within mountainous areas are too narrow and form too intricate a pattern to be presented on this map
C H I N A
VIET NAM
LAOS
THAILAND
BURMA
HAINAN

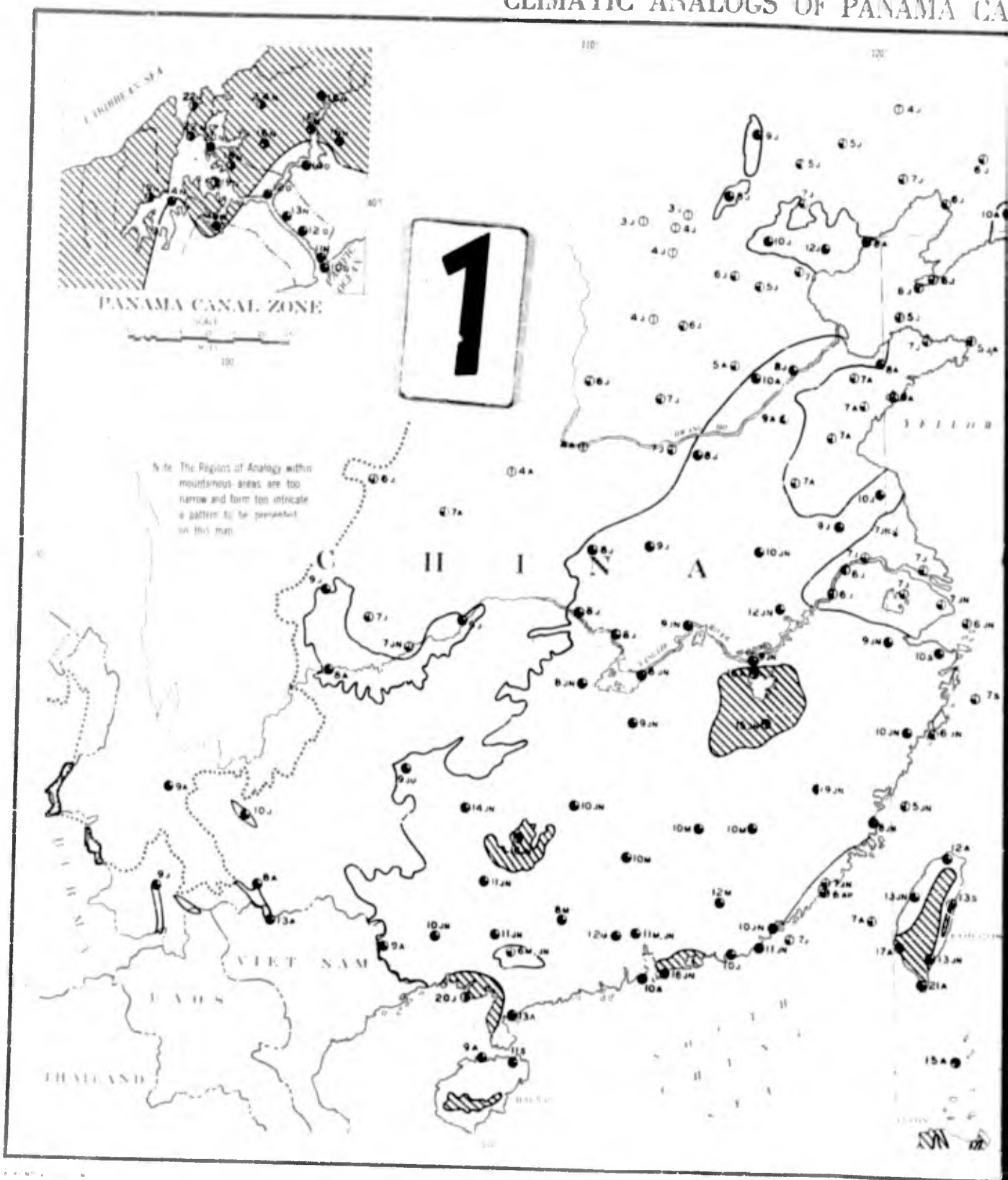
1


KOREAN PENINSULA
JAPAN
SEA OF JAPAN
PACIFIC OCEAN
PHILIPPINE SEA
SCALE
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

2

Figure 8

CLIMATIC ANALOGS OF PANAMA CA



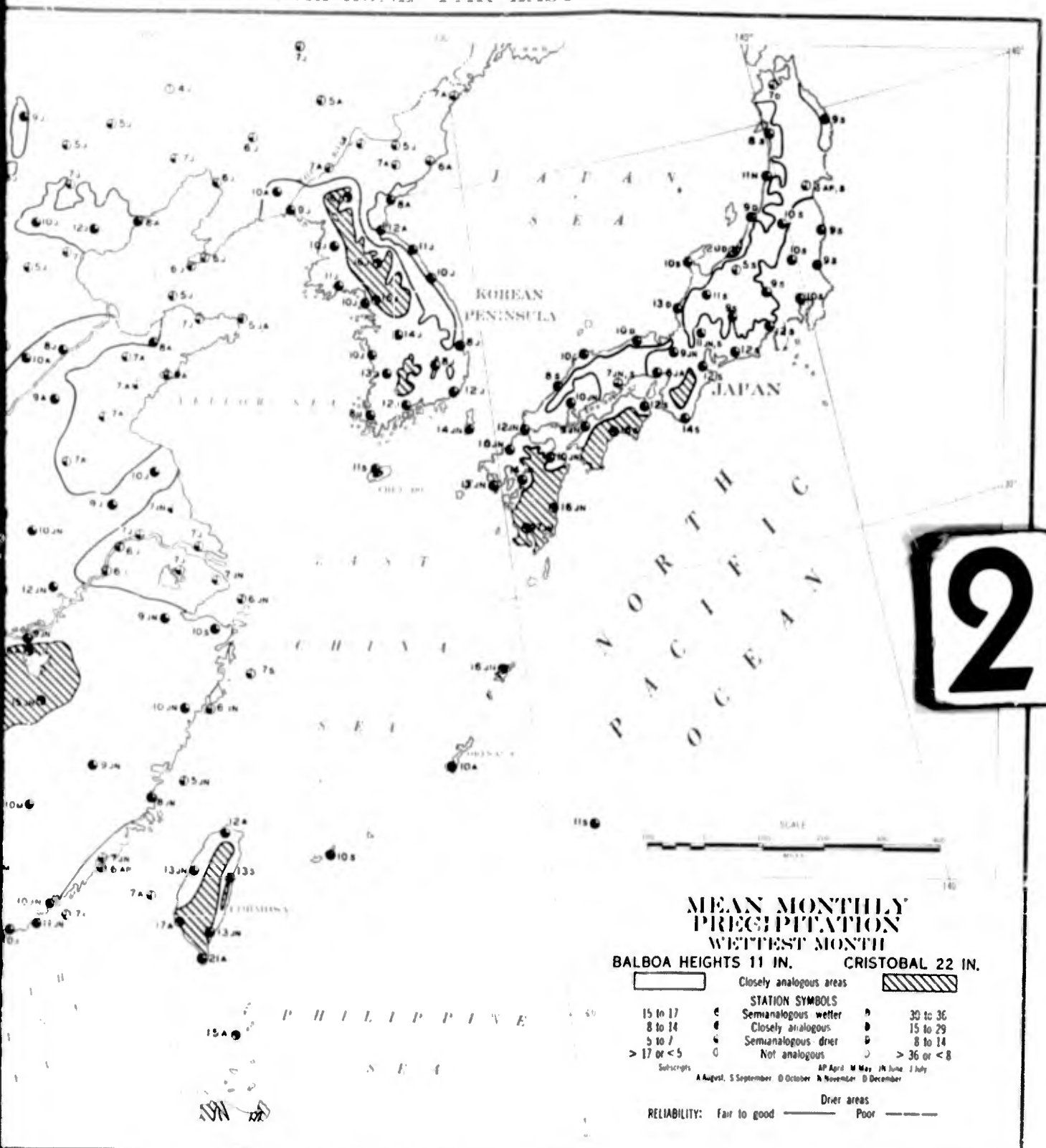
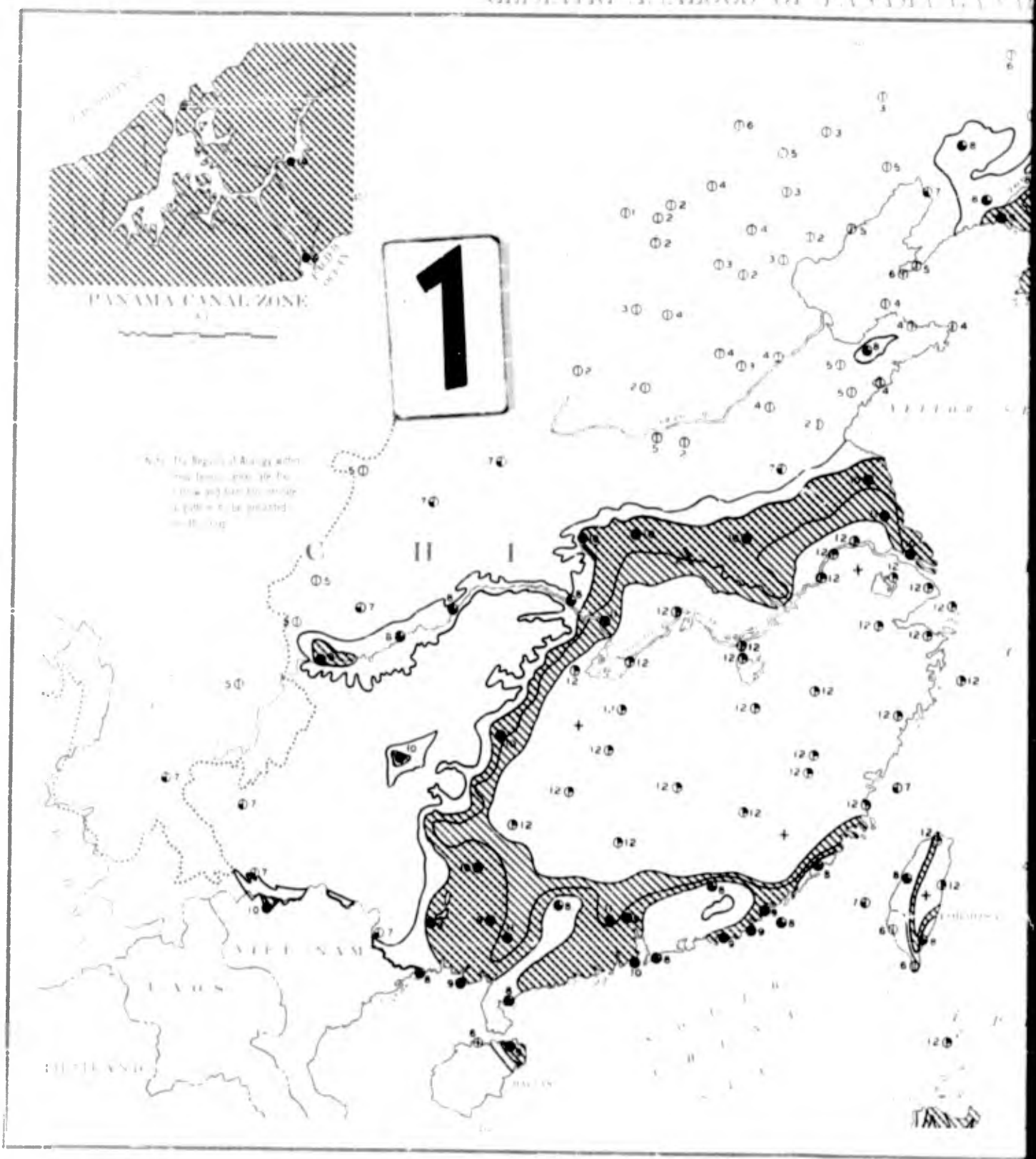
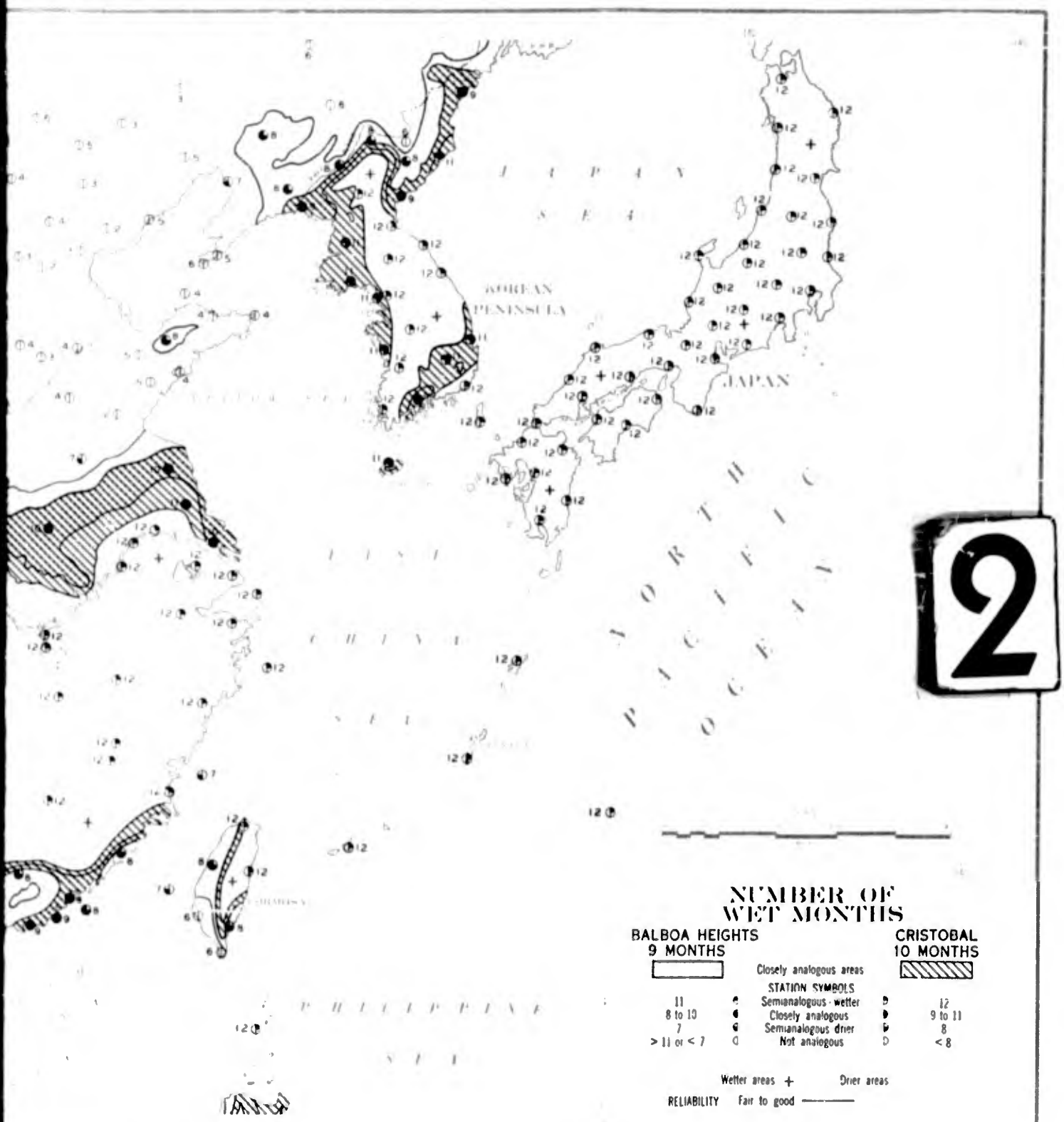

JAPAN SEA
KOREAN PENINSULA
JAPAN
EAST CHINA SEA
NORTH PACIFIC OCEAN
PHILIPPINE SEA
MEAN MONTHLY PRECIPITATION
WETTEST MONTH
BALBOA HEIGHTS 11 IN.
CRISTOBAL 22 IN.
Closely analogous areas
STATION SYMBOLS
15 to 17
8 to 14
5 to 7
> 17 or < 5
Semanalogous wetter
Closely analogous
Semanalogous drier
Not analogous
30 to 36
15 to 29
8 to 14
> 36 or < 8
Subscripts
A August, S September, O October, N November, D December
Drier areas
RELIABILITY: Fair to good
Poor

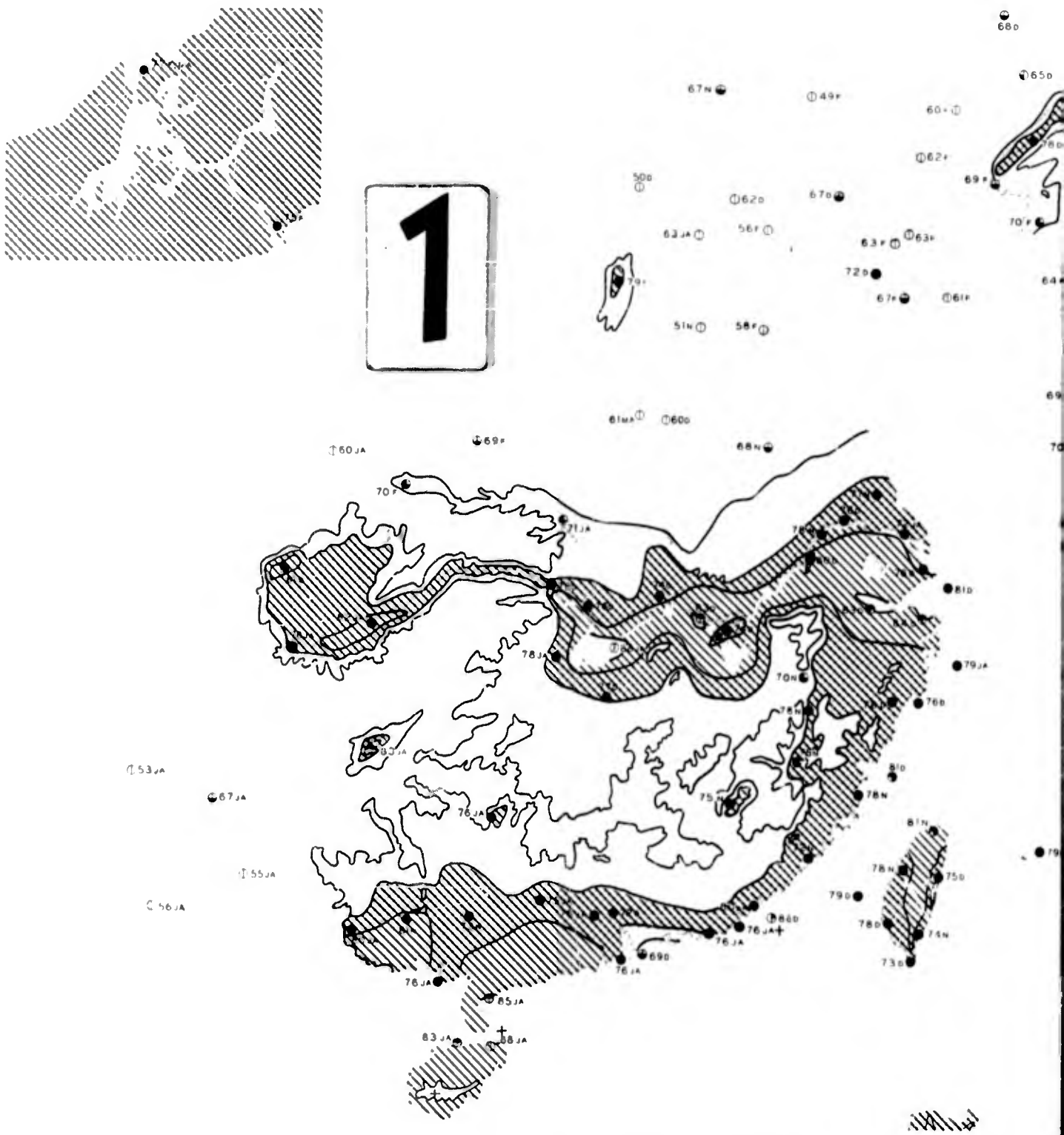
Figure 9


PANAMA CANAL ZONE
1


KOREAN PENINSULA
JAPAN
NORTH PACIFIC OCEAN
PHILIPPINE SEA
NUMBER OF WET MONTHS
BALBOA HEIGHTS 9 MONTHS
CRISTOBAL 10 MONTHS
Closely analogous areas
STATION SYMBOLS
11 Semianalogous - wetter 12
8 to 10 Closely analogous 9 to 11
7 Semianalogous drier 8
> 11 or < 7 Not analogous < 8
Wetter areas + Drier areas
RELIABILITY Fair to good

2

Figure 10


1

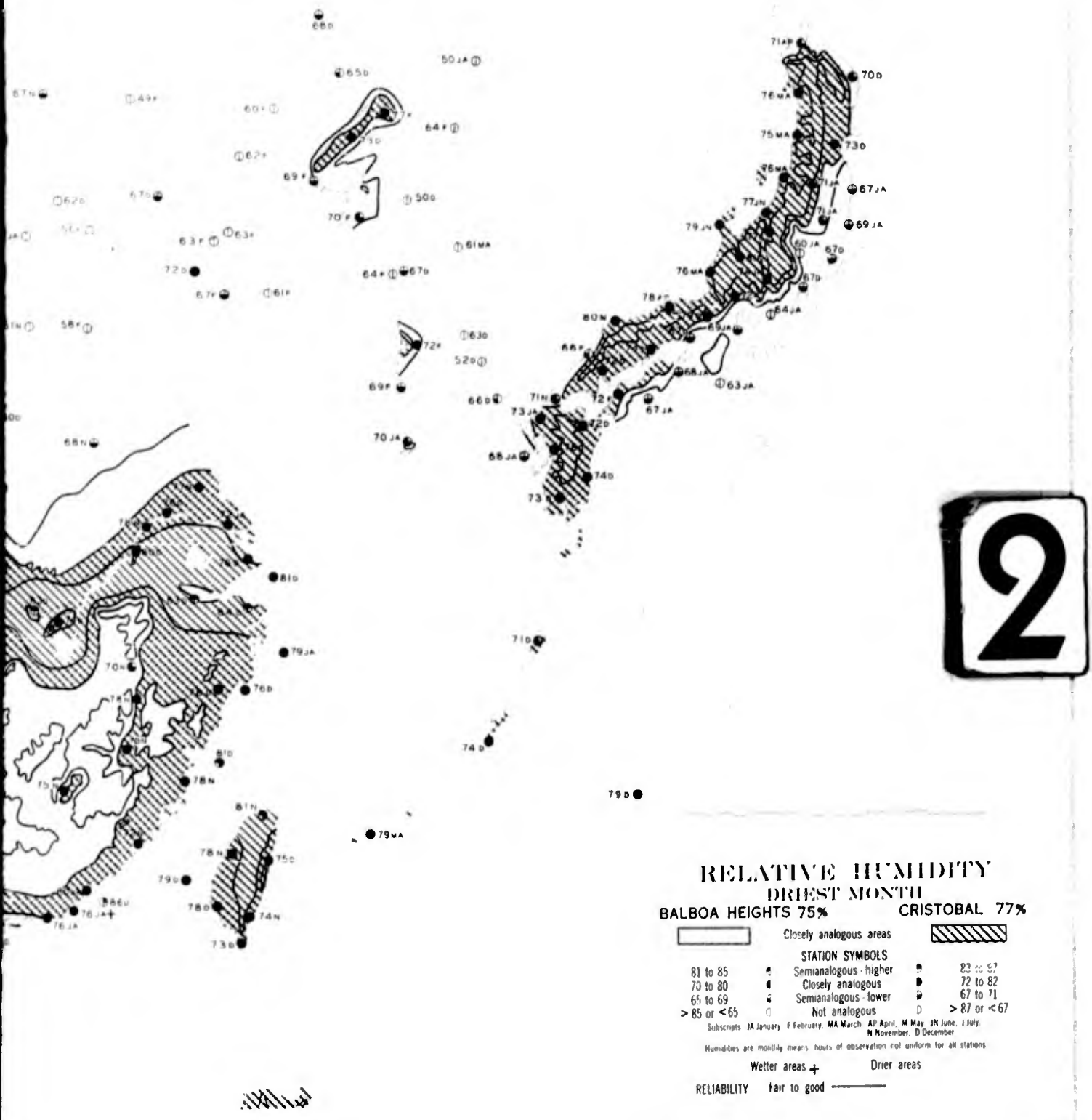
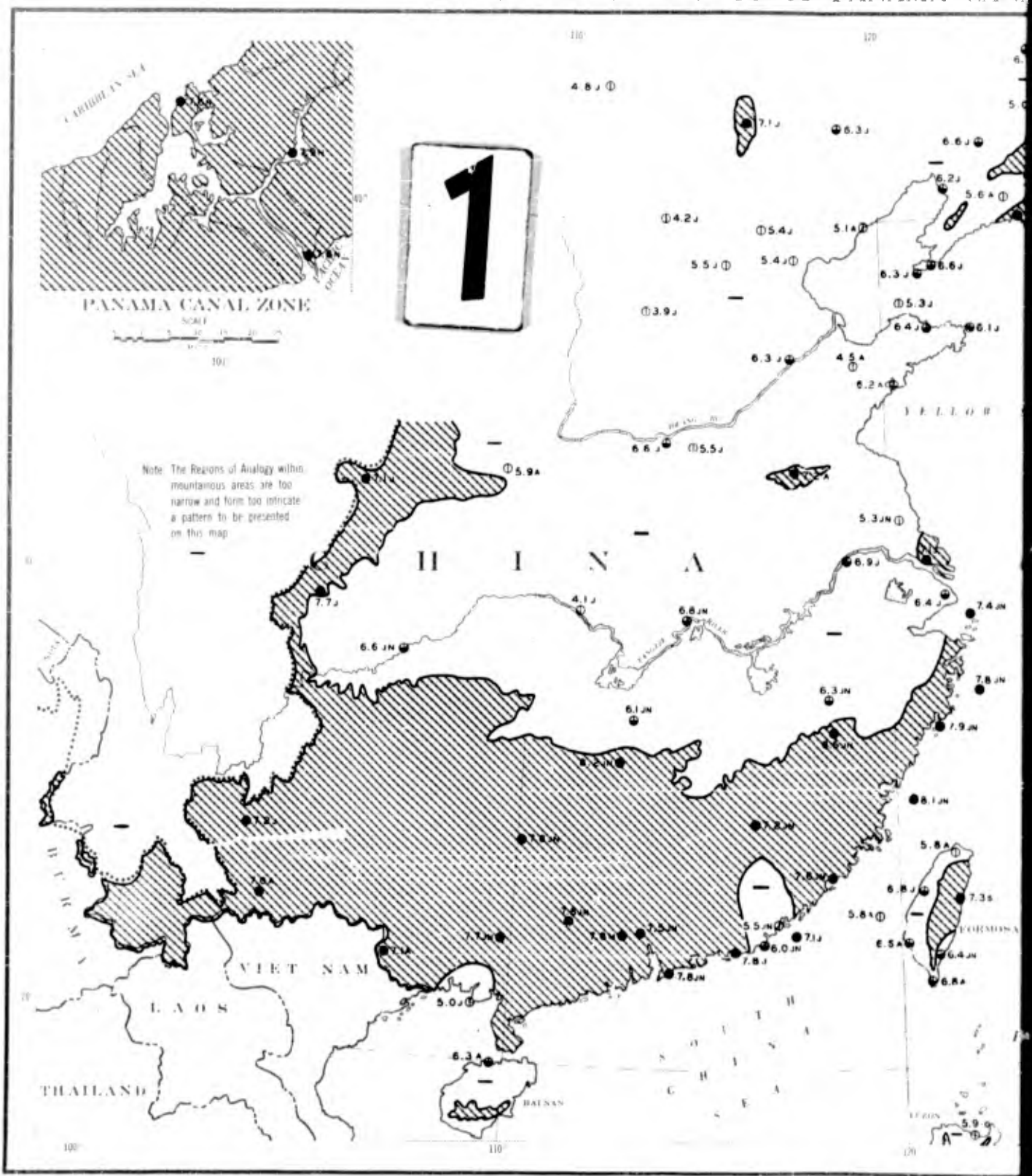

2
RELATIVE HUMIDITY
DRIEST MONTH
BALBOA HEIGHTS 75%
CRISTOBAL 77%
Closely analogous areas
STATION SYMBOLS
81 to 85 Semianalogous - higher 83 to 87
70 to 80 Closely analogous 72 to 82
65 to 69 Semianalogous - lower 67 to 71
> 85 or < 65 Not analogous > 87 or < 67
Subscripts JA January F February MA March AP April M May JN June J July
N November D December
Humidities are monthly means hours of observation not uniform for all stations
Wetter areas +
Drier areas
RELIABILITY fair to good

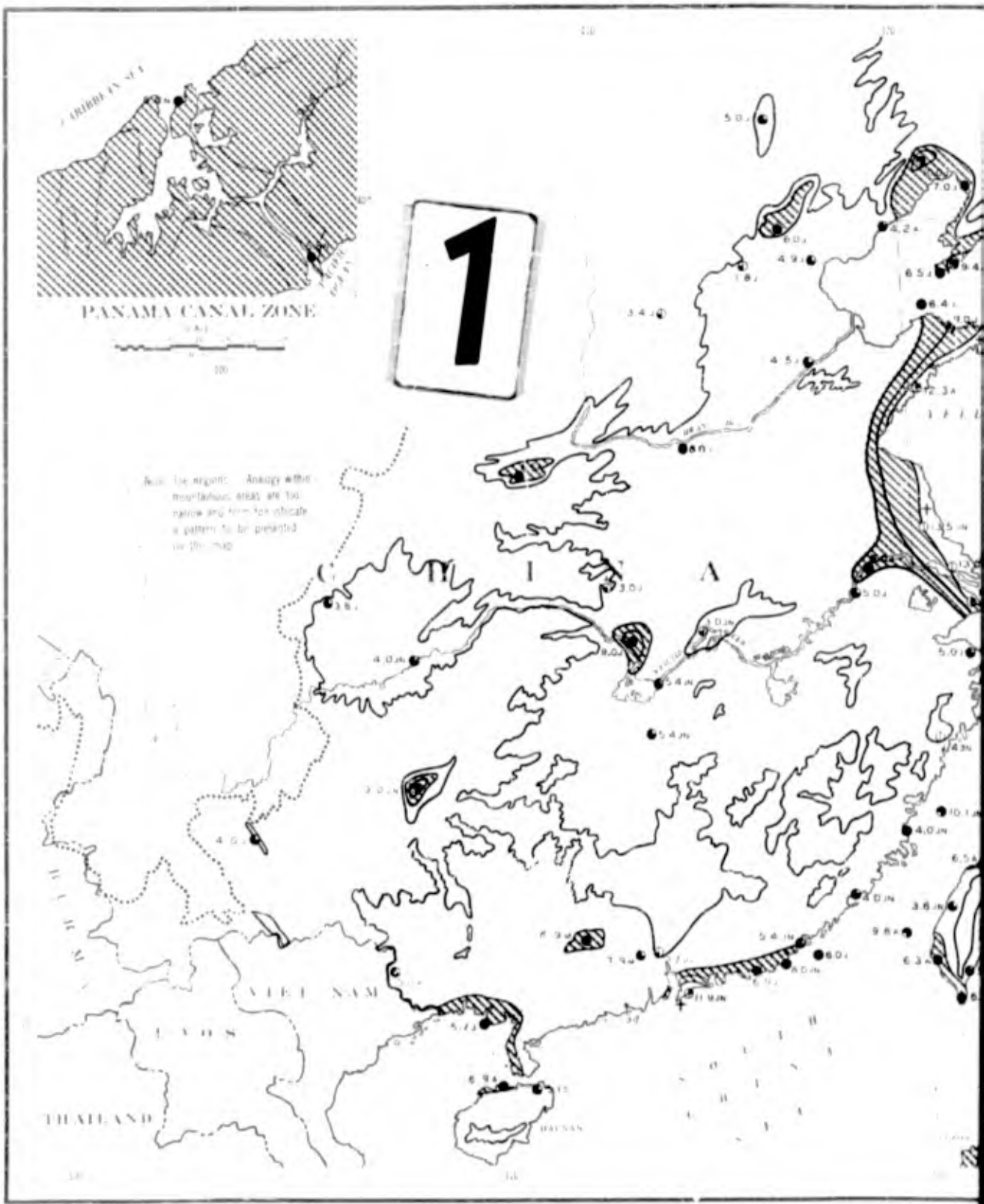
Figure 11


1
PANAMA CANAL ZONE
SCALE
Note: The Regions of Analogy within mountainous areas are too narrow and form too intricate a pattern to be presented on this map
CHINA
VIET NAM
LAOS
THAILAND
TAIWAN
FORMOSA
LUZON
BALNAN


JAPAN SEA
KOREAN PENINSULA
JAPAN
CHINA SEA
PHILIPPINE SEA
NORTH PACIFIC OCEAN
2
MEAN CLOUDINESS
WETTEST MONTH
BALBOA HEIGHTS
7.6 TENTHS
CRISTOBAL
7.6 TENTHS
Closely analogous areas
STATION SYMBOLS
Semianalogous more cloudy 9.0 to 10.0
Closely analogous 7.0 to 8.9
Semianalogous less cloudy 6.0 to 6.9
Not analogous <6.0
Subscripts
M May, JN June, J July
A August, S September O October N November D December
Less cloudy areas
RELIABILITY Fair to good

Figure 12

CLIMATIC ANALOGS OF PANAMA



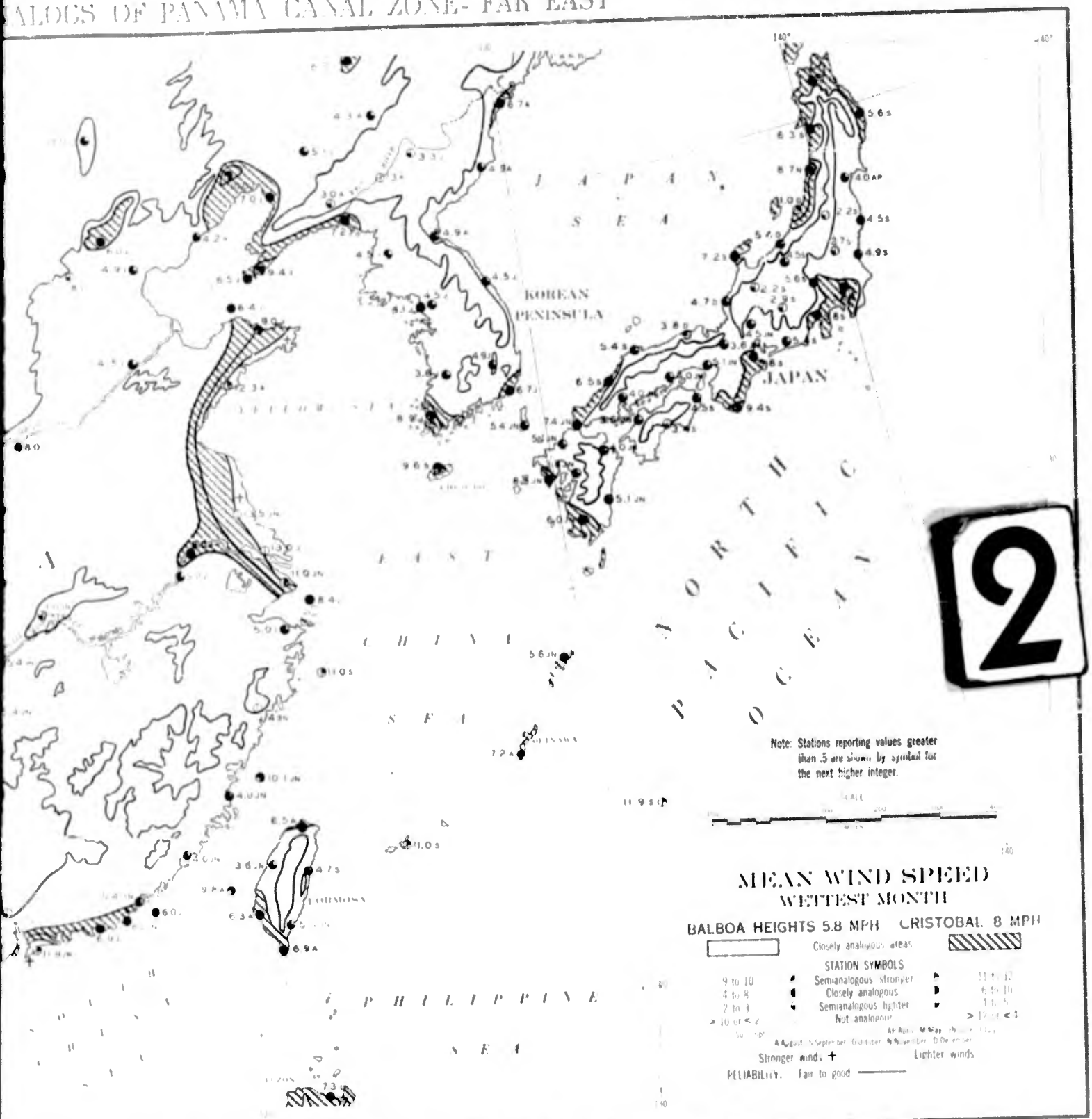
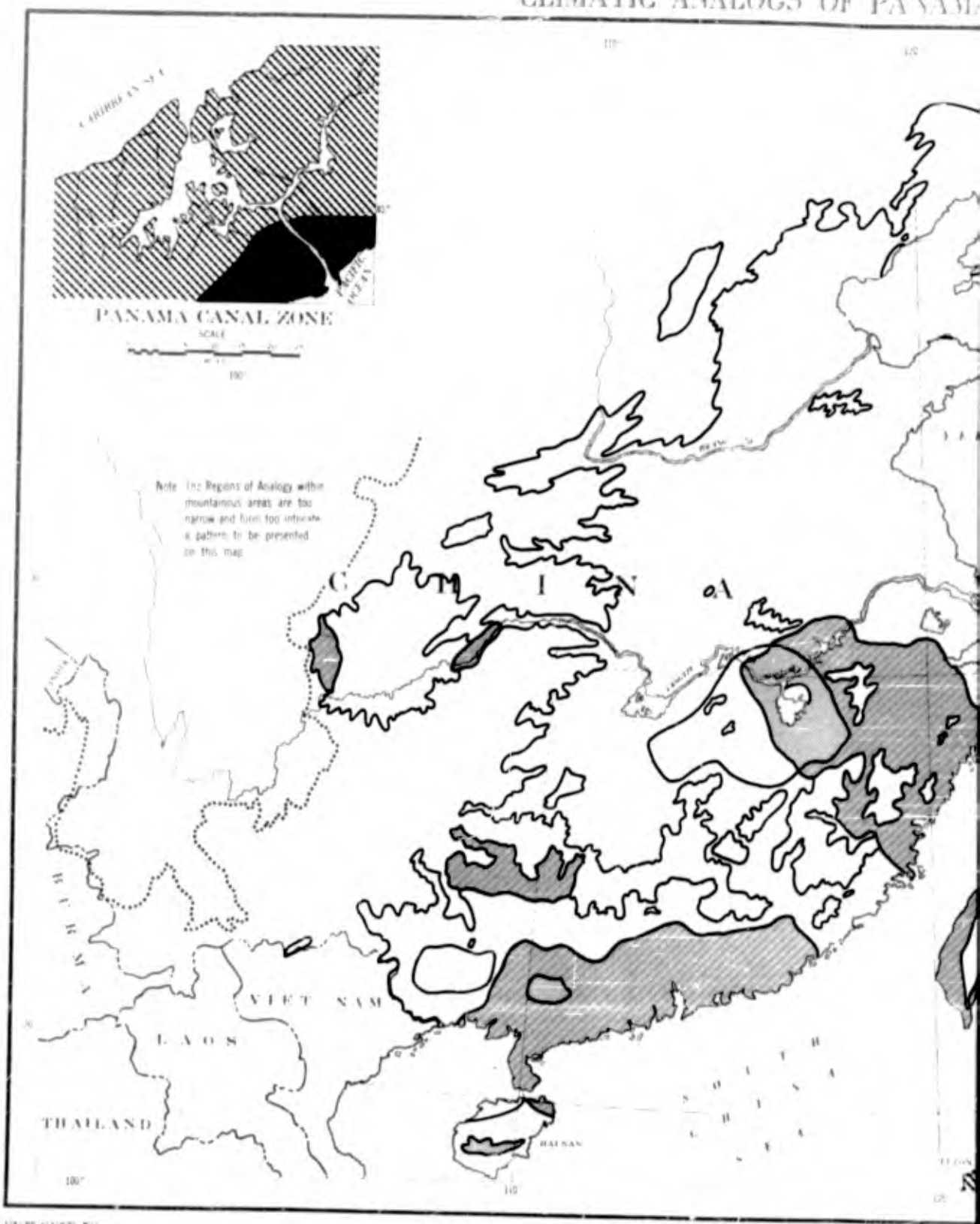

JAPAN SEA
KOREAN PENINSULA
JAPAN
EAST CHINA SEA
PHILIPPINE SEA
NORTH PACIFIC OCEAN
TAIWAN
Note: Stations reporting values greater than .5 are shown by symbol for the next higher integer.
MEAN WIND SPEED
WETTEST MONTH
BALBOA HEIGHTS 5.8 MPH
CRISTOBAL 8 MPH
Closely analogous areas
STATION SYMBOLS
9 to 10
4 to 8
2 to 3
> 10 or < 2
Semianalogous stronger
Closely analogous
Semianalogous lighter
Not analogous
Stronger winds +
Lighter winds
RELIABILITY. Fair to good

Figure 13

CLIMATIC ANALOGS OF PANAMA

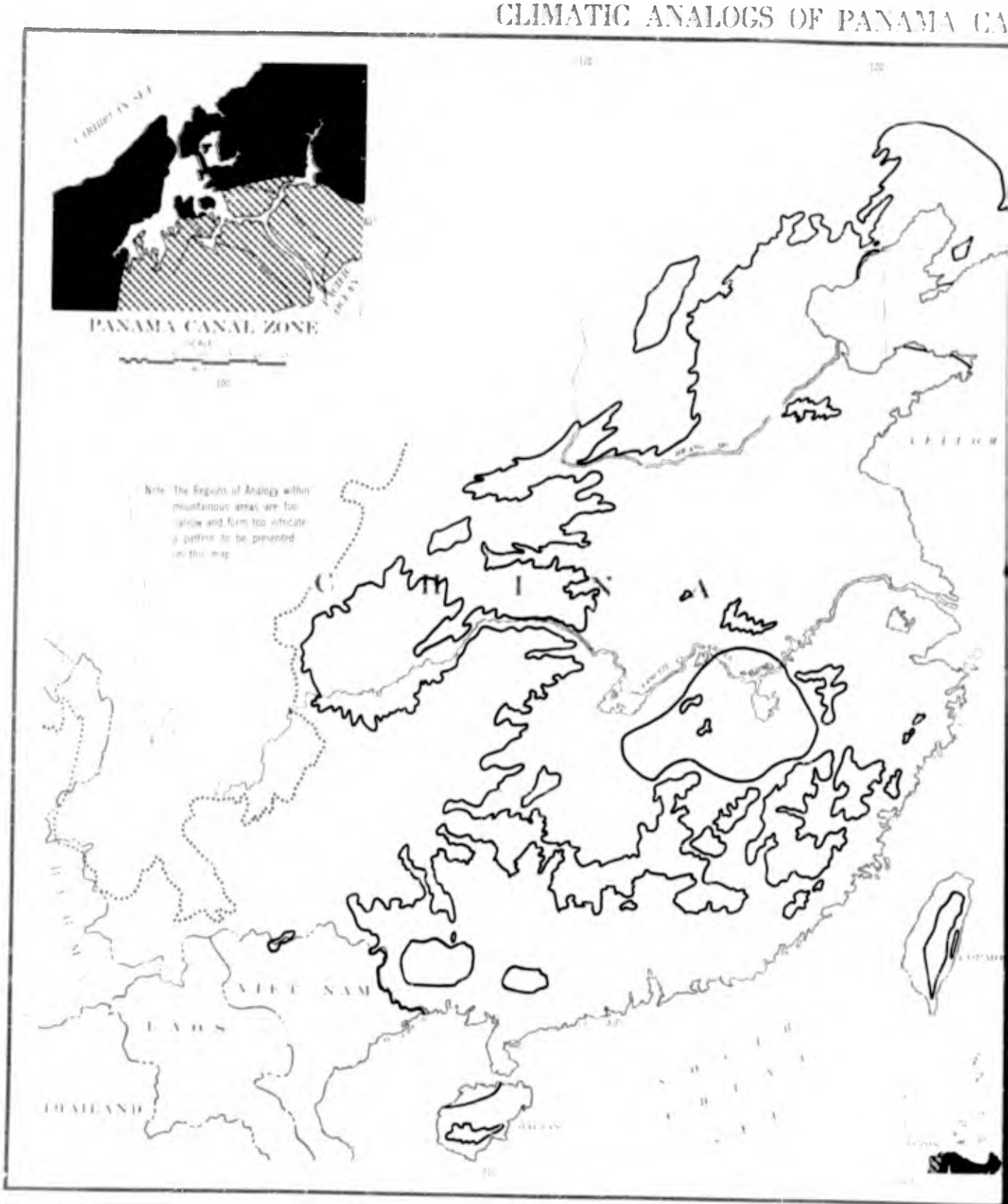


1


JAPAN SEA
KOREAN PENINSULA
JAPAN
NORTH PACIFIC OCEAN
CHINA SEA
PHILIPPINE SEA
2
COMPOSITE ANALOGOUS AREAS
BALBOA HEIGHTS
Mean temperature - warmest month
Mean temperature - coldest month
Mean annual precipitation
Mean temperatures - warmest and coldest months
Mean temperatures - warmest and coldest months, mean annual precipitation, and number of wet months
RELIABILITY: Fair to good

Figure 14

CLIMATIC ANALOGS OF PANAMA CA



1

ANALOGS OF PANAMA CANAL ZONE- FAR EAST

2

Figure 15

UNCLASSIFIED