

UNCLASSIFIED

AD NUMBER

ADB970345

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

FROM:

**Distribution authorized to U.S. Gov't. agencies and their contractors;
Administrative/Operational Use; MAR 1962. Other requests shall be referred to Central Intelligence Agency, Washington, DC 20505.**

AUTHORITY

CIA review dtd 5 Sep 1998

THIS PAGE IS UNCLASSIFIED

UNANNOUNCED

LOAN DOCUMENT

PHOTOGRAPH THIS SHEET

AD-B970 345



DTIC ACCESSION NUMBER

LEVEL

INVENTORY

NIS 448

DOCUMENT IDENTIFICATION

Mar 62

DISTRIBUTION STATEMENT

UNANNOUNCED	
NTIS	GRAM
DTIC	TRAC
UNANNOUNCED JUSTIFICATION	
BY	
DISTRIBUTION/	
AVAILABILITY CODES	
DISTRIBUTION	AVAILABILITY AND/OR SPECIAL
12	

DISTRIBUTION STAMP

DATE RECEIVED IN DTIC

98 3 2 009

DATE RECEIVED IN DTIC



DATE ACCESSIONED

DATE RETURNED

93-04333



REGISTERED OR CERTIFIED NUMBER

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-FDAC

DTIC FORM 70A JUN 88

DOCUMENT PROCESSING SHEET
LOAN DOCUMENT

PREVIOUS EDITIONS MAY BE USED UNTIL STOCK IS EXHAUSTED.

H
A
N
D
L
E

W
I
T
H

C
A
R
E

NATIONAL INTELLIGENCE SURVEY

BRITISH BORNEO

SECTION 23

WEATHER AND CLIMATE

Section 23 on NIS 44B is issued under the NIS maintenance program. It and Section 23 on NIS 44A supersede the original Section 23 on NIS 44, dated February 1952, copies of which should be destroyed.

CENTRAL INTELLIGENCE AGENCY

Washington, D. C.

ER II

NOT RELEASABLE TO FOREIGN NATIONALS

5562-500e

62-1929

BRITISH BORNEO

--- INTERNATIONAL BOUNDARY

/////// NIS AREA BOUNDARY

0 50 100 200 Statute Miles

0 50 100 200 Kilometers

CONFIDENTIAL

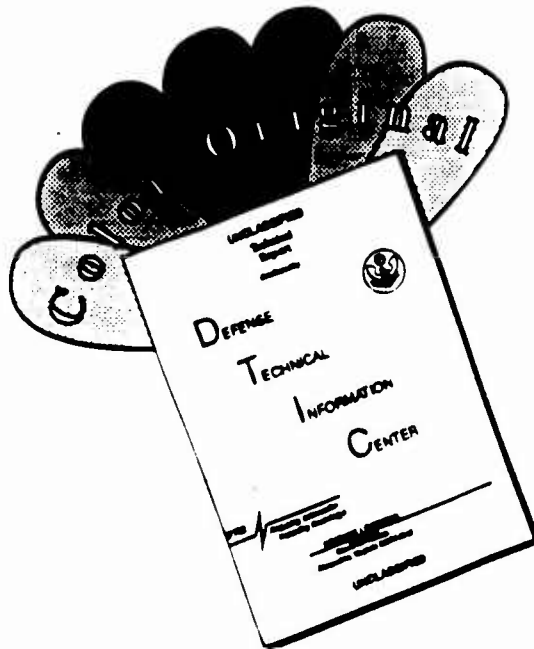


WARNING

This material contains information which is exempt from release under the provisions of the United States Code of Federal Regulations, Title 18, USC, Secs. 793 and 794, the transmission or disclosure of which in any manner to an unauthorized person is prohibited by law.

GROUP 1 Excluded from automatic downgrading and declassification

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF COLOR PAGES WHICH DO NOT REPRODUCE LEGIBLY ON BLACK AND WHITE MICROFICHE.



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR WEATHER SERVICE (MAC)
SCOTT AIR FORCE BASE, ILLINOIS 62225

16 MAR 1983

REPLY TO
ATTN OF

DNTS (Mr. Taniguchi, 4741)

SUBJECT

Declassification of National Intelligence Surveys (NIS)

TO 1 WW/DN 2 WW/DN 3 WW/DN 5 WW/DN 7 WW/DN
AFGWC/DO USAFETAC/DO 2 WS/DN

1. Reference 25 Feb 1983 letter from the Central Intelligence Agency in response to our letter requesting review for declassification of 46 NISs. CIA has declassified 23 of the 46 NISs. It is anticipated that another nine will be declassified by the end of summer. Fourteen will remain classified.

2. Attached is a copy of the CIA letter, with a list of the 23 declassified NISs. Please take necessary action to declassify them, using the CIA letter as the authority.

3. The list of nine will be released to you when we receive word from CIA that they have been declassified.

FOR THE COMMANDER

Allan C Ramsay
ALLAN C. RAMSAY, Colonel USAF
DCS/Aerospace Sciences

1 Atch
CIA Ltr, 25 Feb 83, w/Atch A Only

Cy to MAC/IN
AFGWC/TS
USAFETAC/TSK

*DNC JS (23)
yr action
Do others in
the Wing.
have these?
If yes we
need to pass the
word.*



CENTRAL INTELLIGENCE AGENCY
WASHINGTON, D.C. 20505

25 FEB 1983

Allan C. Ramsay, Colonel, USAF
DCS/Aerospace Sciences
Headquarters, Air Weather Service (MAC)
Scott Air Force Base, Illinois 62225

Attn: Mr. Taniguchi (AWS/DNTS)

Dear Colonel Ramsay:

This is in reply to your letter of 22 December 1982 which requested declassification of 46 National Intelligence Surveys which are held in the Air Weather Service Technical Library and several other AWS organizations.

Under the systematic review provisions of Executive Order 12065 the Central Intelligence Agency, in August-November 1980, reviewed all 46 of these documents. We recommended that 32 of these documents be declassified. Since several agencies collaborated in preparing these documents it was necessary to get their concurrence in the declassification action. We have received concurrences in the declassification of 23 of the documents from the other contributing agencies. These 23 NISs are listed in Attachment A, and the AWS copies of them may be marked declassified giving this letter as the authority.

The remaining nine NISs, which we recommended for declassification, are listed in Attachment B. We are still awaiting concurrences from the Defense Intelligence Agency, the responsible contributing agency, before we can take any further action on their declassification. Major Dempsey of DIA, with whom you coordinated this request, has informed us that DIA hopes to have their review of these NISs concluded by the end of this summer.

The remaining 14 NISs, listed in Attachment C, remain classified. CIA did not recommend their declassification as their release to the public could possibly reveal certain intelligence sources and methods under exemption of Section 1.3 (a)(4) of Executive Order 12356.

dtb

Since all Section 23S's (meteorological organizations) were less than twenty years old at the time of the CIA systematic review, none were examined or declassified.

Sincerely,

Allen R. Elkins

Allen R. Elkins
Director of Information Services
Directorate of Administration

Attachments:
As Stated

cc: Commander, DIA

DECLASSIFIED

<u>NIS NUMBER</u>	<u>SECTION NUMBER</u>	<u>COUNTRY</u>	<u>SUBJECT</u>	<u>DATE DECLASSIFIED</u>
12	24	Finland	Topography	22 August 1980
36	24	Pakistan	Topography	23 September 1980
✓44B	23	British Borneo	Weather & Climate	14 October 1980
104, Part I	1	Western North Atlantic	Marine Climate	14 November 1980
104, Part II	1	Northern North Atlantic	Marine Climate	14 November 1980
104, Part III	1	E-Central North Atlantic	Marine Climate	14 November 1980
104, Part IV	1	Equatorial Atlantic	Marine Climate	14 November 1980
✓104, Part V	1-3	Central South Atlantic	Marine Climate & Oceanog.	14 November 1980
✓104, Part IX	1	Med & Black Seas	Marine Climate	14 November 1980
104, Part X	1	NE North Atlantic	Marine Climate	17 November 1980
✓104, Part X	2	NE North Atlantic	Oceanography	17 November 1980
✓104, Part XI	1	Norwegian, Greenland & Barents Seas	Marine Climate	17 November 1980
✓105, Part I	1 (Rev)	Northeastern North Pacific	Marine Climate	17 November 1980
✓105, Part III	1	NE South Pacific	Marine Climate	17 November 1980
✓105, Part IV	1	South Central South Pacific	Marine Climate	17 November 1980



DECLASSIFIED Cont.

<u>NIS NUMBER</u>	<u>SECTION NUMBER</u>	<u>COUNTRY</u>	<u>SUBJECT</u>	<u>DATE DECLASSIFIED</u>
✓ 105, Part V	1	North Central South Pacific	Marine Climate	18 November 1980
✓ 105, Part VI	1 (Rev.)	South Central North Pacific	Marine Climate	17 November 1980
✓ 105, Part VII	1 (Rev.)	North Central North Pacific	Marine Climate	17 November 1980
105, Part VIII & Part IX	1 (Rev.)	Western & Northwestern North Pacific	Marine Climate	18 November 1980
✓ 105, Part X	1	Southwestern North Pacific	Marine Climate	18 November 1980
✓ 105, Part XII	1-3	Western South Pacific	Marine Climate & Oceanography	18 November 1980
✓ 106, Part III	1	SW Indian Ocean	Marine Climate &	18 November 1980
✓ 106, Part IV	1	NW Indian Ocean	Marine Climate	18 November 1980

TABLE OF CONTENTS FOR SECTION 23

	<i>Page</i>
A. General weather and climatic conditions	23- 1
1. Introduction	23- 1
2. Climatic controls	23- 2
a. General circulation and air masses	23- 2
(1) Northeast monsoon	23- 2
(2) Southwest monsoon	23- 3
(3) Intermonsoon seasons	23- 4
b. Migratory pressure systems	23- 4
c. Topographic influence	23- 4
d. Latitudinal and oceanic influences	23- 4
3. Special phenomena	23- 4
B. Weather and military operations	23- 5
1. Air operations	23- 5
a. Cloudiness	23- 5
(1) Southwest Coast	23- 5
(2) Northwest Coast	23- 6
(3) Northeast Coast	23- 7
(4) Interior Highlands	23- 7
b. Thunderstorms and turbulence	23- 7
c. Upper-air winds	23- 9
d. Upper-air temperatures and aircraft icing	23- 9
2. Air-ground operations	23-14
a. Low cloudiness and ceilings	23-14
b. Visibility	23-15
c. Combined ceiling and visibility	23-17
d. Surface winds	23-17
e. Stability and low-level temperature inversions	23-18
3. Ground surface operations	23-18
a. Temperature	23-18
b. Relative humidity	23-21
c. Precipitation	23-22
d. Overall effect of surface weather on clothing, storage, and shelter	23-23
(1) Clothing	23-23
(2) Storage	23-25
(3) Shelter	23-26
4. Amphibious operations	23-26
C. Meteorological facilities and organization	23-27
1. History and organization	23-27
2. Evaluation of the services	23-27
3. Weather observing and forecasting facilities	23-27
4. Training and educational level of meteorologists	23-28
5. Research and development progress	23-28
D. Climatic data tables	23-28
E. Comments on principal sources	23-43

LIST OF FIGURES

			<i>Page</i>
Fig. 23-1	Map	Surface airflow and intertropical convergence zone, January	23- 3
Fig. 23-2	Map	Surface airflow and intertropical convergence zone, April	23- 3
Fig. 23-3	Map	Surface airflow and intertropical convergence zone, July	23- 3
Fig. 23-4	Map	Surface airflow and intertropical convergence zone, October	23- 3
Fig. 23-5	Map	Mean cloudiness in afternoon	23- 6
Fig. 23-6	Map	Clear, partly cloudy, and cloudy days in afternoon	23- 7
Fig. 23-7	Map	Days with thunderstorms	23- 8
Fig. 23-8	Diag.	Upper-air wind roses, Bintulu	23-10
Fig. 23-9	Diag.	Upper-air wind roses, Kuching	23-11
Fig. 23-10	Diag.	Upper-air wind roses, Sandakan	23-12
Fig. 23-11	Diag.	Upper-air wind roses, Victoria	23-13
Fig. 23-12	Map	Frequency of specified ceiling ranges at specified hours	23-15
Fig. 23-13	Map	Frequency of specified visibility ranges at specified hours	23-16
Fig. 23-14	Map	Temperatures	23-19
Fig. 23-15	Map	Mean relative humidity in morning and afternoon	23-21
Fig. 23-16	Map	Mean precipitation	23-23
Fig. 23-17	Map	Days with precipitation ≥ 0.01 inch	23-24
Fig. 23-18	Table	Mean cloudiness	23-28
Fig. 23-19	Table	Mean cloudiness at specified hours	23-29
Fig. 23-20	Table	Clear days at specified hours	23-29
Fig. 23-21	Table	Cloudy days at specified hours	23-30
Fig. 23-22	Table	Days with thunderstorms	23-30
Fig. 23-23	Table	Frequency of specified ceiling ranges at specified hours	23-31
Fig. 23-24	Table	Frequency of specified visibility ranges at specified hours	23-32
Fig. 23-25	Table	Frequency of specified ceiling and visibility combinations at specified hours	23-33
Fig. 23-26	Table	Days with total cloud cover ≥ 2 -eighths with visibility $\geq 2\frac{1}{2}$ miles at specified hours	23-34
Fig. 23-27	Table	Days with surface wind ≥ 16 knots and no precipitation occurring at specified hours	23-34
Fig. 23-28	Table	Days with surface wind 3 to 10 knots, temperature $> 32^{\circ}$ F. but $< 90^{\circ}$ F., and no precipitation occurring at specified hours	23-35
Fig. 23-29	Table	Days with ceiling $\leq 1,000$ feet, visibility $\geq 2\frac{1}{2}$ miles, and surface wind ≥ 10 knots at specified hours	23-35
Fig. 23-30	Table	Mean daily maximum and minimum temperatures	23-36
Fig. 23-31	Table	Absolute maximum and minimum temperatures	23-36
Fig. 23-32	Table	Days with maximum temperature $\geq 90^{\circ}$ F.	23-37
Fig. 23-33	Table	Mean relative humidity at specified hours	23-37
Fig. 23-34	Table	Mean precipitation	23-38
Fig. 23-35	Table	Greatest and least precipitation	23-39

28 JUL 1992

AWS TECHNICAL LIBRARY

FL 4414

SCOTT 4414 8222

			<i>Page</i>
Fig. 23-36	Table	Maximum 24-hour precipitation	23-40
Fig. 23-37	Table	Days with specified precipitation amounts	23-41
Fig. 23-38A	Maps	Surface wind roses, January	<i>follows</i> 23-43
Fig. 23-38B	Maps	Surface wind roses, July	do
Fig. 23-39	Map	Station locations	do

This Section was prepared for the NIS under the general supervision of the Assistant Chief of Staff, Intelligence, USAF, by the Air Weather Service, with contributions on clothing, storage, and shelter from the Office of the Quartermaster General, Department of the Army, and on amphibious operations from the Naval Weather Service Division.

23. Weather and Climate

The user can supplement the information in this Section by referring to Section 20 for an evaluative summary of the Area's external geographic relationships and its significant internal geographic characteristics, including internal routes, barriers, and strategic areas. Topical treatment of Coasts and Landing Beaches, including some aspects of weather in amphibious operations, is given in Section 22; Topography, including State of the Ground in Section 24; and Urban Areas in Section 25. Integrated analysis of key military aspects of these topical Sections by regions is presented in Section 21.

A. General weather and climatic conditions

1. Introduction

The climate of British Borneo is typically equatorial, with most climatic elements exhibiting a monotonous uniformity throughout the year. Unknown in this NIS Area are seasons as we know them in midlatitudes. Instead, the climate is dominated by a true monsoon circulation, with two great airstreams—the northeast and southwest monsoons. These airstreams are separated by the intertropical convergence zone, which migrates northward and southward with the changing seasons. Both airstreams undergo sufficiently long journeys over tropical waters to be warm and moist when they arrive over the Area. Consequently the climate is hot and humid throughout the year. Mountain locations are somewhat cooler than the lowlands but are equally humid. Although rainfall is plentiful everywhere, it varies considerably from place to place and from season to season, depending on local topography and the direction of the monsoonal flow. Most of the rainfall is in the form of rather heavy showers—often thunderstorms. Cloudiness is generally widespread throughout the Area, especially during the day, and most often consists of convective type clouds. Low ceilings and visibilities do not normally hamper air operations except below cumulonimbus clouds, which for the most part can be avoided, and along the windward slopes of the mountains. Tropical storms are rare and typhoons usually pass north of the Area.

British Borneo occupies the northern part of the island of Borneo; it is bordered on the northwest by the South China Sea, on the northeast by the Sulu Sea, on the east by the Celebes Sea, and on

the south by Indonesian Borneo. The Area is approximately 700 miles long and extends southward to within 60 miles of the Equator. Its maximum width is about 200 miles. British Borneo consists of high, rugged, densely forested mountains bordered by discontinuous coastal lowlands and interrupted by a few small interior valley plains. Hills and mountains comprise about two-thirds of the country; the mountains consist of broken lines of high ranges and isolated peaks and are crossed by many low passes. There are a few summits over 7,000 feet, and the highest mountain peak, located in the northern part of the Area, reaches well over 13,000 feet. Streams are numerous throughout the Area, and coastal swamps are extensive.

For discussion purposes British Borneo has been divided into four regions (FIGURE 23-39): 1) Southwest Coast, 2) Northwest Coast, 3) Northeast Coast, and 4) Interior Highlands.

The Southwest Coast Region consists partly of swampy coastal plains extending in places to nearly 50 miles inland and partly of lowlands with scattered hills and mountains rising to about 3,000 feet. Also included in this region are a few offshore islands. Temperatures are high and vary little from place to place and from month to month because of the moderating oceanic influence. Rainfall is abundant, with all stations receiving more than 100 inches annually. The humidity is persistently high; the mean relative humidity in the Southwest Coast Region exceeds that in other regions slightly.

The Northwest Coast Region consists of a relatively narrow lowland strip and several offshore islands. It is predominantly level to gently rolling alluvial coastal and river plain, interrupted in places by mountain spurs, hills, and ridges. Temperatures are high with very little monthly variation. Precipitation is plentiful throughout the region, although mean annual precipitation varies considerably from station to station. Humidity is constantly high.

NOTE Requests for solutions to specific problems involving the interpretation of the weather factor in the user's unique operational terms should be directed to the Director, Climatic Center, USAF, Annex 2, 225 D Street, S.E., Washington 25, D.C.

The Northeast Coast Region is mostly swampy lowland along the coast. In some places the lowland is backed by nearly level or gently rolling terrain with scattered hills and ridges, and in other places by hills and mountains which are mostly steep and rugged. The region also includes several offshore islands. The climate here is characterized by copious rainfall, although many locations, notably in the southeast, receive considerably less annual precipitation than do other parts of the Area. Temperatures are high the year round and vary little from those of the other regions. Humidity is consistently high with only slight monthly variations.

The Interior Highlands Region includes most of the hills and mountains of British Borneo and is by far the largest of the four discussion regions. The principal ranges lie along the southeastern boundary of the Area and extend northeastward to the extremities of the Interior Highlands Region. In general, the highlands are characterized by relative coolness and by heavy and persistent rainfall along exposed slopes. Mean annual rainfall varies widely from place to place because of differences in elevation and location.

The climatic seasons in this NIS Area are based on the two major wind systems, the northeast and southwest monsoons, because neither temperature nor rainfall provides clear-cut seasons as we know them in midlatitudes. Four seasons can be identified, although the time occurrence of each may vary slightly from year to year and from region to region. The northeast monsoon is associated roughly with the Northern Hemisphere winter and occurs in November to mid-March. The southwest monsoon corresponds roughly to the Northern Hemisphere summer and extends from mid-May through September. Mid-March to mid-May is a transitional period in which the predominant northeast flow gives way to the southwest monsoon. This period is referred to as the spring intermonsoon season. A second transitional period, normally the month of October, is termed the autumn intermonsoon season.

2. Climatic controls

The climate of British Borneo is primarily determined by the position of the large semipermanent high-pressure and low-pressure centers in the temperate regions of the Northern and Southern Hemispheres. Other significant climatic controls are the location of the Area within extensive warm oceanic waters, its location with respect to latitude, and the topography both within and without the Area. Air masses, migratory pressure systems, and lines of convergence also affect the climate.

a. GENERAL CIRCULATION AND AIR MASSES — Over British Borneo the general circulation pattern is dominated by two great monsoons, the northeast and the southwest. Both are closely related to the high-pressure and low-pressure centers of Asia, Australia, and the neighboring oceans. In November to mid-March the air flows southwestward across British Borneo from the Siberian and North Pacific *highs* toward the equatorial low-pressure belt. From mid-May through September a reversal in pressure prevails, resulting in a flow of air northeastward from the Southern Hemisphere *highs* across the Area to the low-pressure region over interior Asia. The boundary zone between these two flows is called the intertropical convergence zone (ICZ). Widespread convergence within the ICZ usually brings heavy cloudiness, showers, and thunderstorms to British Borneo; weak, nearly parallel flows, on the other hand, may result in only light cumulus formation and scattered showers in the ICZ. The ICZ migrates annually across the Area during the short transitional seasons, when winds are, for the most part, light and variable. In this part of the world the position of the ICZ varies greatly from month to month and from year to year (FIGURES 23-1 through 23-4).

(1) *Northeast monsoon* — The air masses that comprise the northeast monsoon originate in the Siberian *high* and the North Pacific *high*. The cold, dry polar continental (*cP*) air that accumulates over Asia periodically spills out of the continent onto the warmer neighboring oceans. The cold air is gradually heated by contact with the warmer China coast and ocean waters and becomes quite moist and unstable to considerable heights. At the same time, tropical maritime (*mT*) air from the western Pacific flows southward and westward toward the Area, producing the airflow often known as the northeast trade winds. This *mT* air, greatly heated and moistened as it flows over equatorial waters, merges over the South China Sea with the much-modified air masses from Asia. After this long overwater trajectory toward the equatorial low-pressure trough, the currents of the northeast monsoon arrive over British Borneo as convectively unstable, warm, and humid tropical maritime (*mT*) air. Consequently much convective cloudiness and local rain showers are frequent throughout the Area, particularly on the windward mountain slopes. FIGURE 23-1 shows the generalized surface airflow pattern over the Area and the mean position of the ICZ south of the Area during January, a typical month of the northeast monsoon season. Local variations resulting from land and sea breezes and from terrain features are necessarily disregarded.

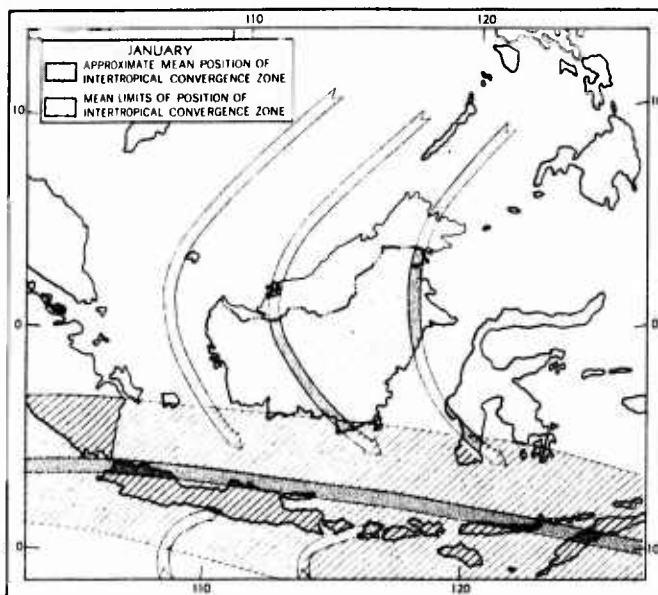


FIGURE 23-1. GENERALIZED SURFACE AIRFLOW AND INTERTROPICAL CONVERGENCE ZONE, JANUARY

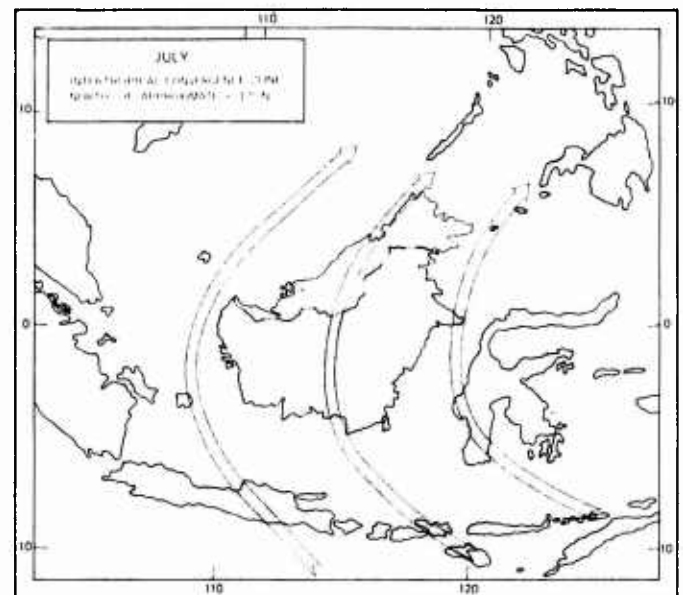


FIGURE 23-3. GENERALIZED SURFACE AIRFLOW AND INTERTROPICAL CONVERGENCE ZONE, JULY

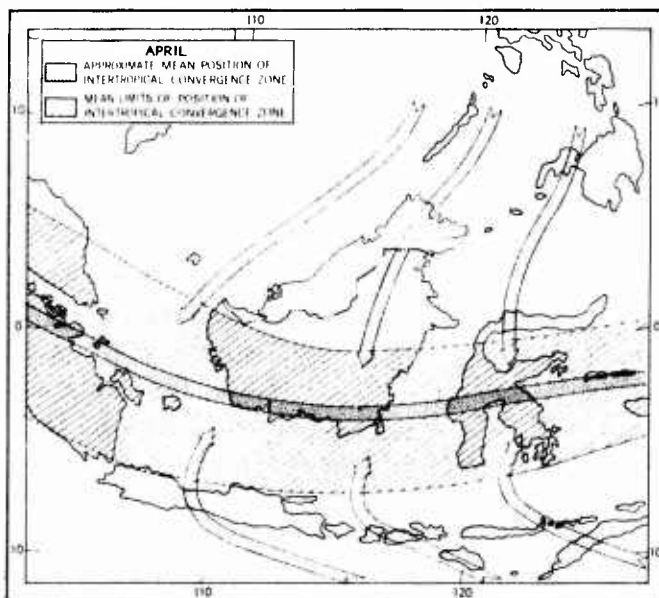


FIGURE 23-2. GENERALIZED SURFACE AIRFLOW AND INTERTROPICAL CONVERGENCE ZONE, APRIL

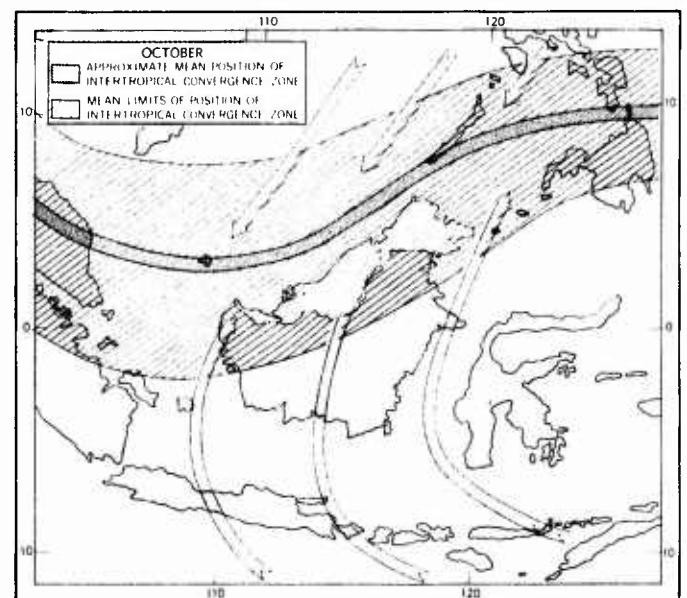


FIGURE 23-4. GENERALIZED SURFACE AIRFLOW AND INTERTROPICAL CONVERGENCE ZONE, OCTOBER

(2) *Southwest monsoon* — The air currents that comprise the southwest monsoon, which is dominant over the Area from mid-May through September, originate in the semipermanent belt of high pressure over Australia and the neighboring oceans. This airflow results from the dynamic balance between these Southern Hemisphere high-pressure cells and the semipermanent Asiatic low. Part of the airstream originates over Australia as a warm, dry, and stable southeast current. It is rapidly modified in its long passage over warm equatorial waters, and after merging south of Borneo with the flow from the Indian Ocean, it is very moist and unstable in the lower layers. The airstream recurves north of the

Equator and arrives over British Borneo as a southwest flow of air which is distinctly tropical maritime (*mT*) in nature. In this season also, cloudiness and rainfall are plentiful over the Area, especially on the windward slopes. However, many parts of British Borneo experience a period of minimum rainfall during this season, because of the passage of the southwest airstream over the mountains of central Borneo. The generalized surface airflow pattern for July, a typical month of the southwest monsoon, is given in FIGURE 23-3. This airflow pattern does not show the effects of local circulations such as land and sea breezes or mountain and valley winds. The

ICZ is north of approximately 12°N. in July and does not affect the Area.

(3) *Intermonsoon seasons* — The transitional seasons are relatively short periods between the northeast and southwest monsoons, when a reversal of atmospheric pressure takes place within the semipermanent pressure systems of both hemispheres. It is during these periods that the ICZ is active over the Area.

The spring intermonsoon season normally extends from mid-March to mid-May, as the northeast monsoon gives way to the advancing southwest monsoon. FIGURE 23-2 shows the generalized surface airflow and mean location of the ICZ in April. The ICZ usually passes over the Area in late April or early May, bringing an increase in cloudiness, precipitation, and thunderstorm activity as it moves northward, followed closely by the southwest monsoon.

The autumn intermonsoon season, shortest of the four seasons, normally occurs in October as the southwest monsoon is replaced by the northeast monsoon. FIGURE 23-4 gives the generalized surface airflow and mean position of the ICZ in October. Winds are usually light and variable and there is a general increase in cloudiness, showers, and thunderstorms as the ICZ passes over the Area in its southward migration.

b. *MIGRATORY PRESSURE SYSTEMS* — British Borneo lies too far south to be affected by migratory cyclones and associated frontal systems characteristic of midlatitudes. Typhoons and other tropical storms which endanger the coastal regions of Vietnam and southern China normally pass north of this NIS Area. Although there is no available record of such an occurrence, it is possible that tropical storms moving from east to west across the Celebes Sea or the South China Sea may occasionally affect the northeast coast of British Borneo.

The Area is at times affected by weak tropical disturbances moving from east to west along the ICZ. These disturbances, principally a feature of the autumn intermonsoon season, are usually marked by an increase in shower and thunderstorm activity. Easterly waves may also affect the Area during the northeast monsoon. The easterly wave is a trough line of low pressure imbedded within the easterly or northeasterly current. Convergent air motion is found toward the rear of the wave and is often associated with shower and thunderstorm activity. Unusually fine weather is sometimes found well ahead of the wave and is a result of the divergent air motion toward the front of the wave.

c. *TOPOGRAPHIC INFLUENCE* — The ruggedness of the topography of Borneo and the surrounding islands is a dominant characteristic influencing the climate of the Area. Since marked convective instability, high moisture content, and high temperature are all properties of the air mass over the Area, very little lift is needed to produce considerable cloudiness and rainfall.

Thick cloud banks are produced on the windward slopes and often over the peaks of mountain ridges that lie in the path of the monsoonal flow, especially during the northeast monsoon. Conversely, downslope airflow produces a clearing tendency on the leeward slopes. Therefore, in many parts of the Area, there is a marked difference in cloudiness and rainfall at stations only a short distance apart but located so that they are strongly affected by the upslope and downslope motion of the monsoonal flow.

Topography also influences the extent of local winds such as land and sea breezes and mountain and valley winds which are usually welcomed for the relief they bring from the constantly high temperatures in the lowlands. Since temperatures decrease about 3 Fahrenheit degrees per thousand feet increase in elevation, temperatures on the higher mountains are noticeably cooler than in the lowlands.

d. *LATITUDINAL AND OCEANIC INFLUENCES* — British Borneo extends from about 1°N. to 7°N. latitude, so that, strong solar heating of the Area continues throughout the year. Temperatures are persistently high, therefore, except at high elevations. The surrounding ocean waters also influence the climate of the Area. In addition to being the principal moisture source of the monsoonal currents, these warm ocean waters serve as a distinct stabilizing influence on the climate. The surface water temperature varies little during the year, remaining near 80° F. This extreme equability strongly affects the adjacent land areas, helping to maintain consistently high temperatures and humidities over most of the Area the year round.

3. Special phenomena

Tornadoes or similar destructive storms characteristic of midlatitudes are virtually unknown in this part of the world. Frequent local thunderstorms with accompanying lightning, occasional strong winds, and heavy rainfall are usually the most severe weather phenomena experienced in British Borneo. Heavy showers, becoming torrential at times in almost every month, often result in flooding. Consequently, loss of life and prop-

erty may occur, especially in the steep headwaters of the many rivers throughout the Area. Severe droughts are comparatively rare. Hail occurs rarely at the surface and infrequently in the upper-air, in spite of frequent large development of cumulonimbus clouds. Higher mountain stations probably experience a slightly higher frequency of hail than do the lowlands. Water-spouts and small whirlwinds are occasionally reported but seldom cause appreciable damage. Mirages are sometimes observed in the afternoon.

B. Weather and military operations

This Subsection is concerned with the effects of the meteorological elements upon military operations, which are here divided into four basic groups: air, air-ground, ground surface, and amphibious. Under each group are discussed the weather elements primarily relevant to the operations in that group. However, weather elements which are considered most applicable to one basic group may also affect operations in others. In such cases, reference should be made to the appropriate Subsection. The meteorological information contained herein is organized to highlight conditions that may be pertinent factors in planning. Discussion of the effects of weather on specific operations is not attempted since the weather factor in an operation is subject to change with the changing requirements of the operation itself.

1. Air operations

a. CLOUDINESS — British Borneo, like other countries in this part of the world, experiences considerable cloudiness throughout the year (FIGURE 23-18). Because the Area is almost continually dominated by warm, moist tropical maritime air, variations in mean cloudiness from season to season and from region to region are small and often irregular. The cloudiest months usually occur from late in the southwest monsoon season to late in the northeast monsoon season over most of the Area. Mean monthly cloud cover during this period varies from about 75% to 85% at most stations. A lack of cloud data in the southeastern part of the Northeast Coast Region precludes thorough analysis. However, available precipitation data, which are somewhat analogous

NOTE Air operations are defined as those operations taking place primarily above the frictional influence of the surface terrain on atmospheric circulation. The meteorological elements discussed in this Subsection are those which are of primary importance to such operations as high-level visual bombing, radar bombing, aerial photography, most types of aerial reconnaissance, and fighter support and interception.

to cloud data, indicate that the cloudiest months occur during the southwest monsoon when this part of the region is exposed to the southwest monsoonal flow. The months of minimum cloudiness are most frequently observed from late in the northeast monsoon season to early in the southwest monsoon season, when mean monthly cloud amounts usually vary from about 65% to 80%.

Mean annual cloudiness varies between about 75% and 85%, with the greater amounts recorded over the Southwest Coast Region. Although no cloud data are available for the Interior Highlands, other indications show that mean annual cloudiness may vary considerably, depending on location, elevation and exposure to the moist, unstable monsoonal flow.

The most common cloud type over British Borneo is cumulus, which often develops in the afternoon into towering cumulonimbus with shower and thunderstorm activity. Cirrus, cirrostratus, altostratus, and altocumulus also occur almost every day, but are much less significant than cumulus.

The diurnal cloud pattern over most of the Area occurs with notable regularity. Sheets of thin stratus and light fog often form after midnight over swampy valleys, sometimes covering the lower mountain slopes, but usually dissipate by midmorning. Convective activity causes cumulus clouds to start forming soon after sunrise over the interior, particularly on windward mountain slopes, and slightly later near the coast. Between late morning and early afternoon, cumulus clouds increase rapidly and cover most of the sky (FIGURE 23-5). During the afternoon the cumulus often develops into towering cumulonimbus extending to 20,000 or 30,000 feet or more. Shortly after sunset, the cumulus and cumulonimbus flatten out into shapeless masses and dissipate. However, convective clouds may remain throughout the night over windward slopes and ridges. Also, onshore winds may bring low clouds inland during the night. Data showing the diurnal variation of mean cloudiness are given in FIGURE 23-19. The frequencies of clear, partly cloudy, and cloudy days are shown graphically in FIGURE 23-6. Tabular data showing clear and cloudy days are presented in FIGURES 23-20 and 23-21.

(1) *Southwest Coast* — Diurnal variations in mean cloudiness throughout this region are remarkably small. Mean cloudiness is most frequently greatest during morning or early afternoon throughout the year, ranging between about 75% and 90%. Some months show lowest mean values during the afternoon, while other

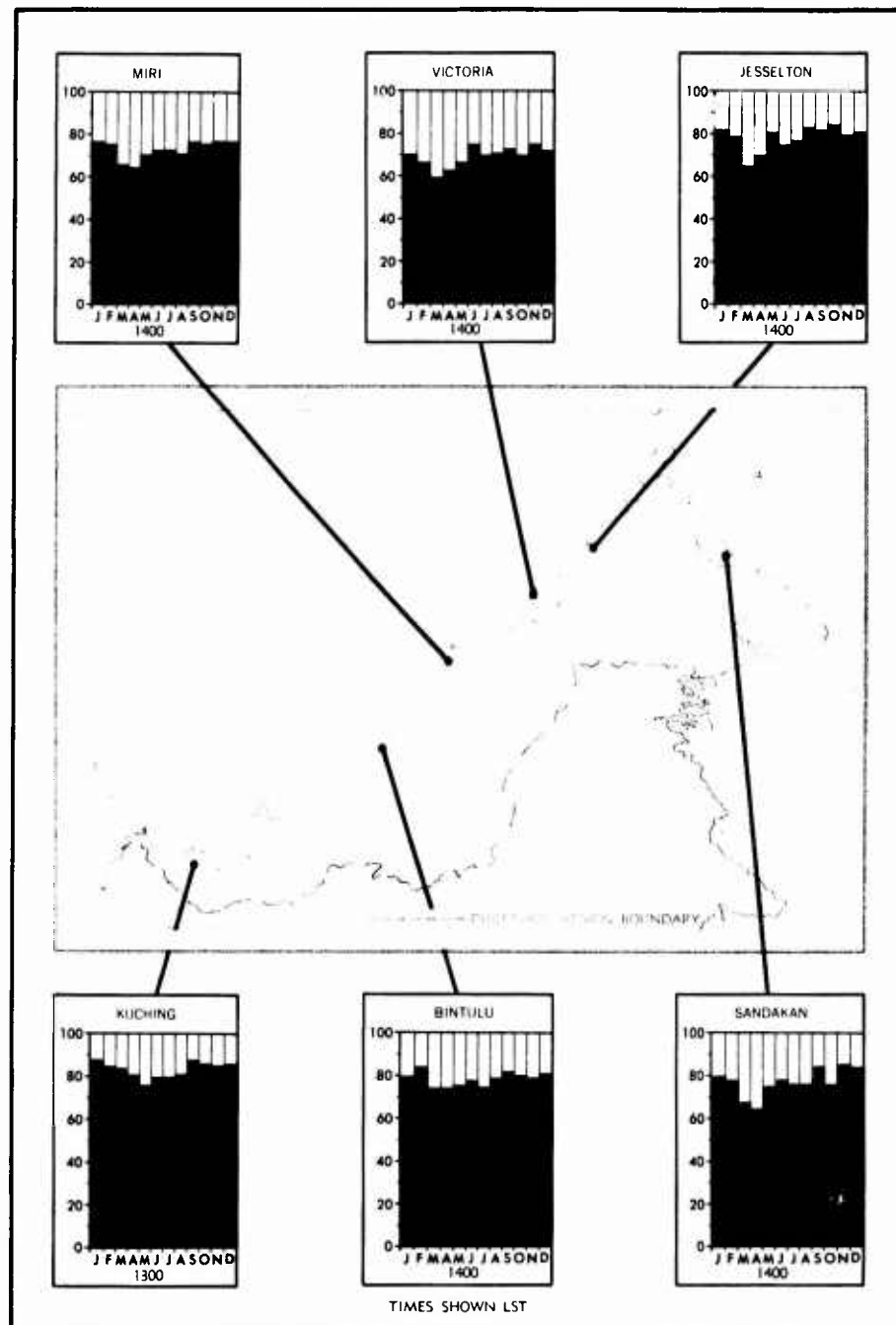


FIGURE 23-5. MEAN CLOUDINESS (%) IN AFTERNOON. (For tabular data see FIGURE 23-19.)

months show a minimum as low as about 70% in the evening. Clear days (cloud cover equal to or less than 2-eighths) are few, up to about 5 per month from March to July inclusive and 2 or less in each of the remaining months. Clear conditions are most probable in the middle night hours. There are usually 20 to 30 cloudy days (cloud cover equal to or greater than 6-eighths) per month the year round.

(2) *Northwest Coast* — This region also displays only a small diurnal variation in mean cloudiness. The greatest amounts of mean cloudiness may occur in either morning, early after-

noon, or evening, depending on location and exposure; amounts also vary from station to station and from season to season and generally range from about 65% to 85%. The diurnal pattern of lowest mean cloud amounts is also quite changeable; the lowest mean cloud amounts range from about 50% to 65%. During daytime hours, there are usually 3 to 7 clear days per month from January through April inclusive and up to 3 clear days in each remaining month; clear conditions are more probable in the night hours. Normally about 15 to 25 cloudy days per month occur during the year.

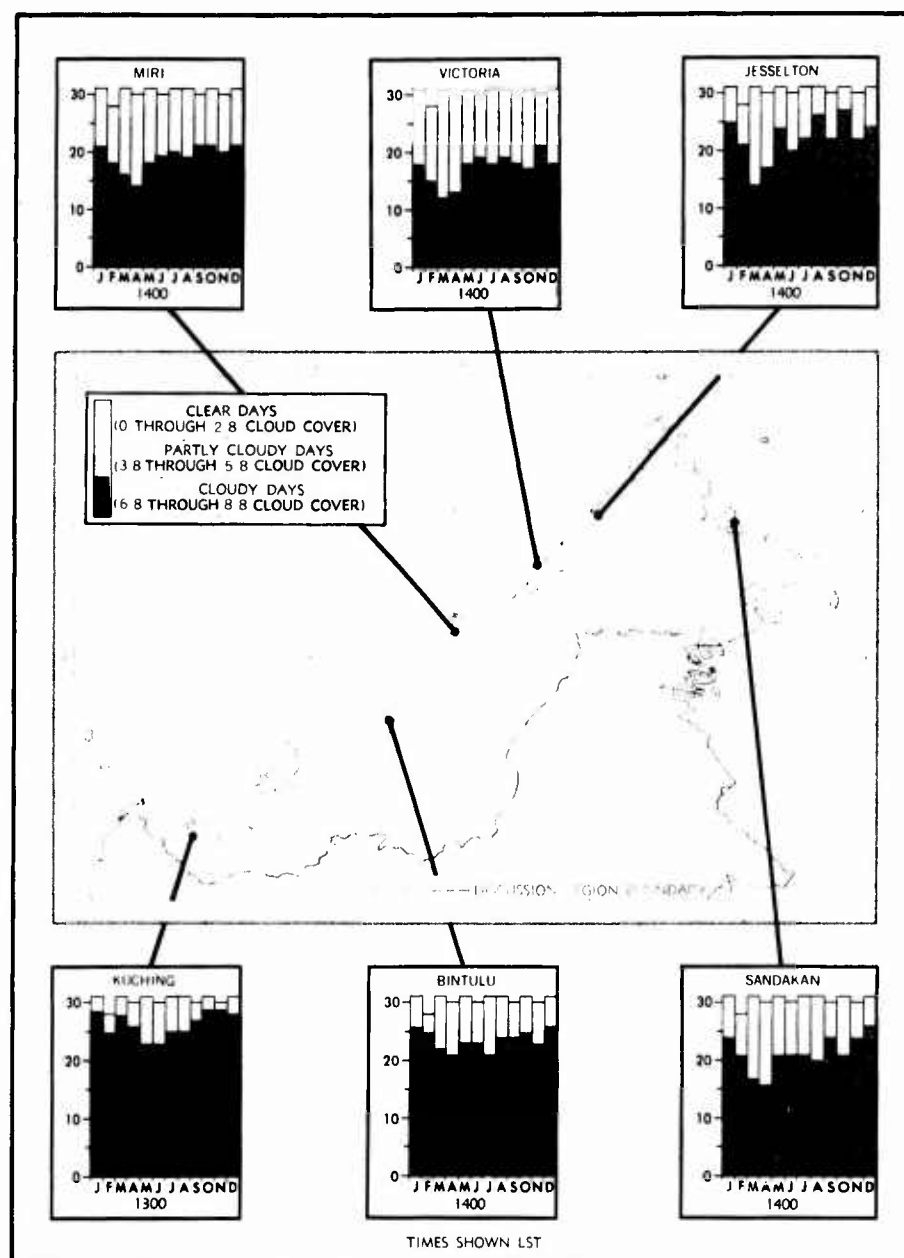


FIGURE 23-6. MEAN NUMBER OF CLEAR, PARTLY CLOUDY, AND CLOUDY DAYS IN AFTER-NOON. (For tabular data see FIGURES 23-20 and 23-21.)

(3) *Northeast Coast* — Over this region, mean cloudiness most often reaches a maximum in the morning or early afternoon with values varying between about 65% and 85%. Normally the lowest values are reported in the evenings; mean cloud amounts slightly below 60% have been recorded for the night hours. There are usually less than 3 clear days and about 15 to 25 cloudy days per month throughout the year, with little seasonal variation. Clear conditions are most probable during middle night hours.

(4) *Interior Highlands* — Lack of cloud data makes it impossible to draw any definite conclusions concerning the diurnal variation in cloudiness and the number of clear and cloudy days in this region. However, some general con-

clusions based on other information are possible. Mean cloudiness is believed to be greatest during the time of maximum convective activity in the afternoon and least near midnight. The number of cloudy days in some parts of this region probably equal or exceed that of the coastal regions. Windward slopes of higher ridges are the cloudiest locations. It is reasonable also to assume that clear nights occur considerably more often in the Interior Highlands than in coastal regions.

b. **THUNDERSTORMS AND TURBULENCE** — The frequency of thunderstorms over British Borneo is rather high throughout the year. On rare occasions they may be associated with squall lines. Most of the time, however, thunderstorm activity is local in nature and short-lived. The time of

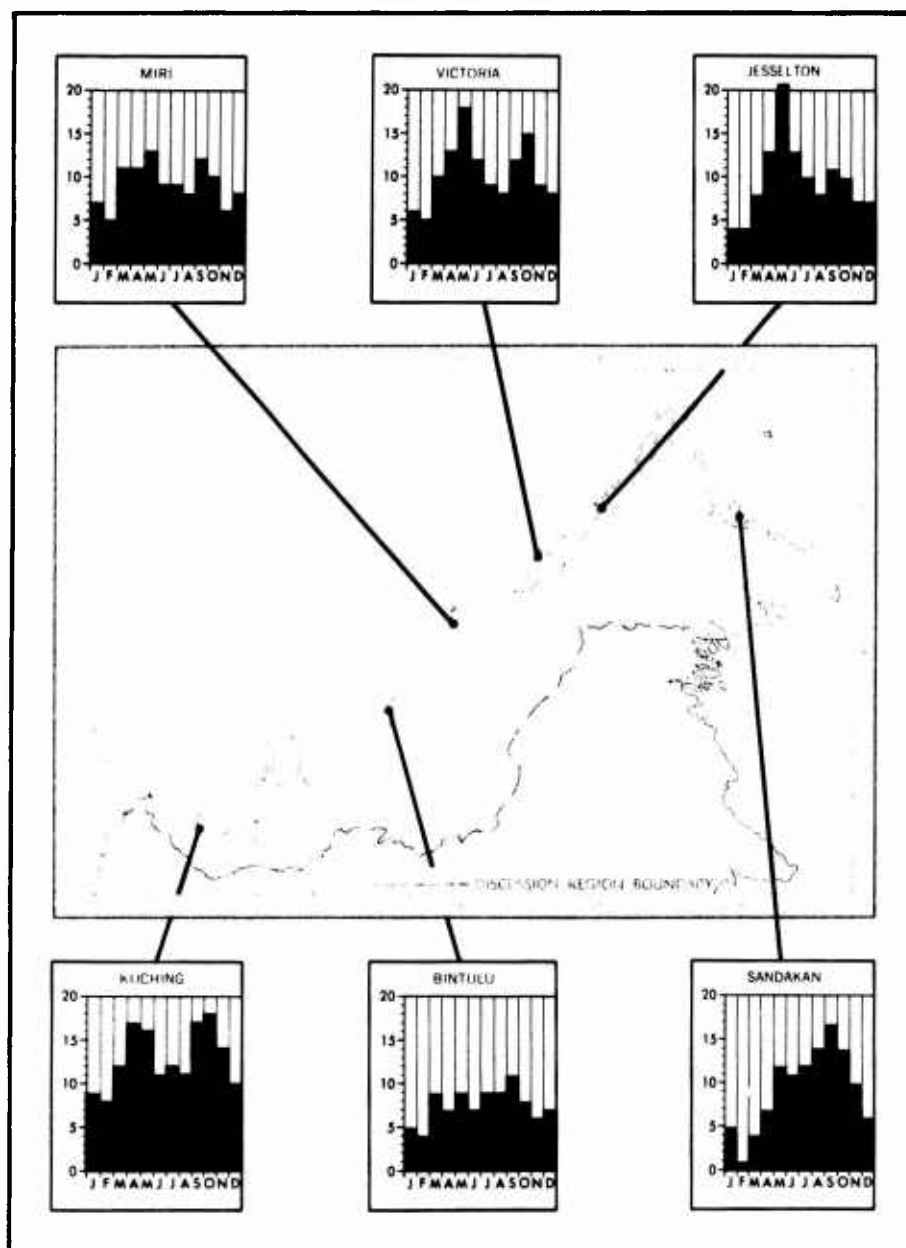


FIGURE 23-7. MEAN NUMBER OF DAYS WITH THUNDERSTORMS. (For tabular data see FIGURE 23-22.)

maximum activity over the interior and leeward coasts is normally during the afternoon when solar heating is greatest; sometimes the activity extends into early evening. Thunderstorms may occur at any time during day or night over windward coasts. Over the surrounding oceans thunderstorms are usually most common during the night, when the air in the lower layers becomes unstable because of heating from the warmer underlying water surfaces and cooling of the cloud tops by radiation.

While thunderstorms occur frequently throughout the year at most places, they are generally most common during the intermonsoon seasons when the ICZ passes over the Area. However, some stations may record highest frequencies

early and/or late in the southwest monsoon season. It is during this period that secondary maximums occur over much of the Area. Thunderstorms are generally least frequent during the northeast monsoon, particularly in January and February. FIGURES 23-7 and 23-22 show the mean number of days with thunderstorms over British Borneo.

In the Southwest Coast Region, thunderstorm occurrence ranges from a minimum of 4 days in February at Bintulu in the north to as many as 18 days in October at Kuching in the south. Over the Northwest Coast Region, May has the greatest number of thunderstorms, occurring on about one-half to two-thirds of the days. January or February usually has a minimum of 4 or 5 days.

Days with thunderstorms over the Northeast Coast Region vary from 17 in September to 1 in February at Sandakan. Although no thunderstorm data are available for other stations in the region, it is believed that the same pattern prevails except that minimum frequencies may range slightly higher. Thunderstorm data for the Interior Highlands are completely lacking; however, it is reasonable to assume that maximum frequencies occur very close to or during the intermonsoon seasons with the number of days equalling or exceeding that of the other regions.

In the tropics, vertical development of cumulonimbus clouds associated with thunderstorms often reaches 20,000 to 30,000 feet and sometimes extend to over 50,000 feet. Occasionally, gusty gale-force winds (28 knots or greater) accompany thunderstorms. In severe storms the surface winds may sometimes reach destructive force, causing local damage to housing and other facilities. Moderate or heavy rain may fall from well-developed cumulus clouds, but the heaviest rainfall usually occurs in thunderstorms and may become torrential at times.

Turbulence may be encountered in any season over British Borneo and is usually associated with thunderstorms, convection, and strong winds over the rough terrain. The turbulence starts during the morning as the surface of the ground is heated by the sun and convection begins. This turbulence gradually becomes moderate by noon-time as the cumulus clouds increase vertically. Thunderstorms often develop by afternoon with the associated turbulence becoming severe at times. Orographic turbulence may be encountered to some extent over the Interior Highlands, especially near the crest of ridges. However, the updrafts and downdrafts seldom reach velocities as great as those found in midlatitudes because of the prevailing moderate windflow over the Area.

c. UPPER-AIR WINDS — Adequate upper-air wind observations for British Borneo are restricted to the coastal regions and to heights up to 25,000 feet. These data are also reasonably representative, however, of upper-air winds over the Interior Highlands, where observations are unavailable. FIGURES 23-8 through 23-11 present seasonal upper-air wind roses for four coastal stations.

Over the Area, winds at about 5,000 feet are mostly from directions between north and east during December through May and between south and west during the remainder of the year. At this level there remains a close resemblance to the prevailing surface monsoonal flow as depicted in FIGURES 23-1 through 23-4. The southwest monsoonal flow remains evident over most of the Area

to about 15,000 feet from June to November, with wind directions most frequently from west to southwest. During the remaining months, winds at 10,000 and 15,000 feet over the southern part of the Southwest Coast Region are somewhat variable, blowing most often from the west. With increasing distance to the northeast, wind directions become predominantly easterly at these levels. Throughout most of the year, easterly winds prevail over the Area at 20,000 and 25,000 feet. Information from sources other than FIGURES 23-8 through 23-11 indicates that easterlies are prevalent at higher levels to about 50,000 feet the year round.

The flow at all levels is considerably weaker than in midlatitudes, with less day-to-day change. Most of the time, wind speeds between 5,000 and 25,000 feet are less than 20 knots and rarely exceed 50 knots. Mean wind speeds range from about 10 knots at 30,000 feet to 40 knots at 50,000 feet. Maximum speeds may exceed these values considerably.

Recent investigations of windflow between 50,000 and 100,000 feet over the Equator have shown the existence of an unexpected oscillation in wind direction, speed, and steadiness. The period of this oscillation is reported to range from 24 to 28 months, averaging 27 months over the west-central Pacific. A strong westerly current appears at the highest altitude and gradually subsides to lower altitudes and weakens. Then a strong easterly current appears at the highest level which also subsides and weakens. This process repeats systematically so that the mean monthly vertical profile for a given month is made up of strata of west and east currents with a smooth transition through zero between the maximum wind speed in each current. For each succeeding month the level of the core of each stratum is slightly lower, steadily descending 3,000 to 4,000 feet per month. This oscillation is most dominant over and within 10 degrees of the Equator.

d. UPPER-AIR TEMPERATURES AND AIRCRAFT ICING — Temperature gradients over the Area are rather small, particularly when compared to those of more northerly latitudes. The freezing level varies from a little more than 15,000 feet in October through January to about 16,000 feet in April through July. Diurnal variations from this mean probably do not exceed 1,000 feet. At about 25,000 feet, the temperature is near 0° F. (-18° C.) the year round and continues to decrease with increasing altitude to approximately 55,000 feet, where it averages around -75° C. A nearly constant temperature or a slight increase in temperature with height is observed at still

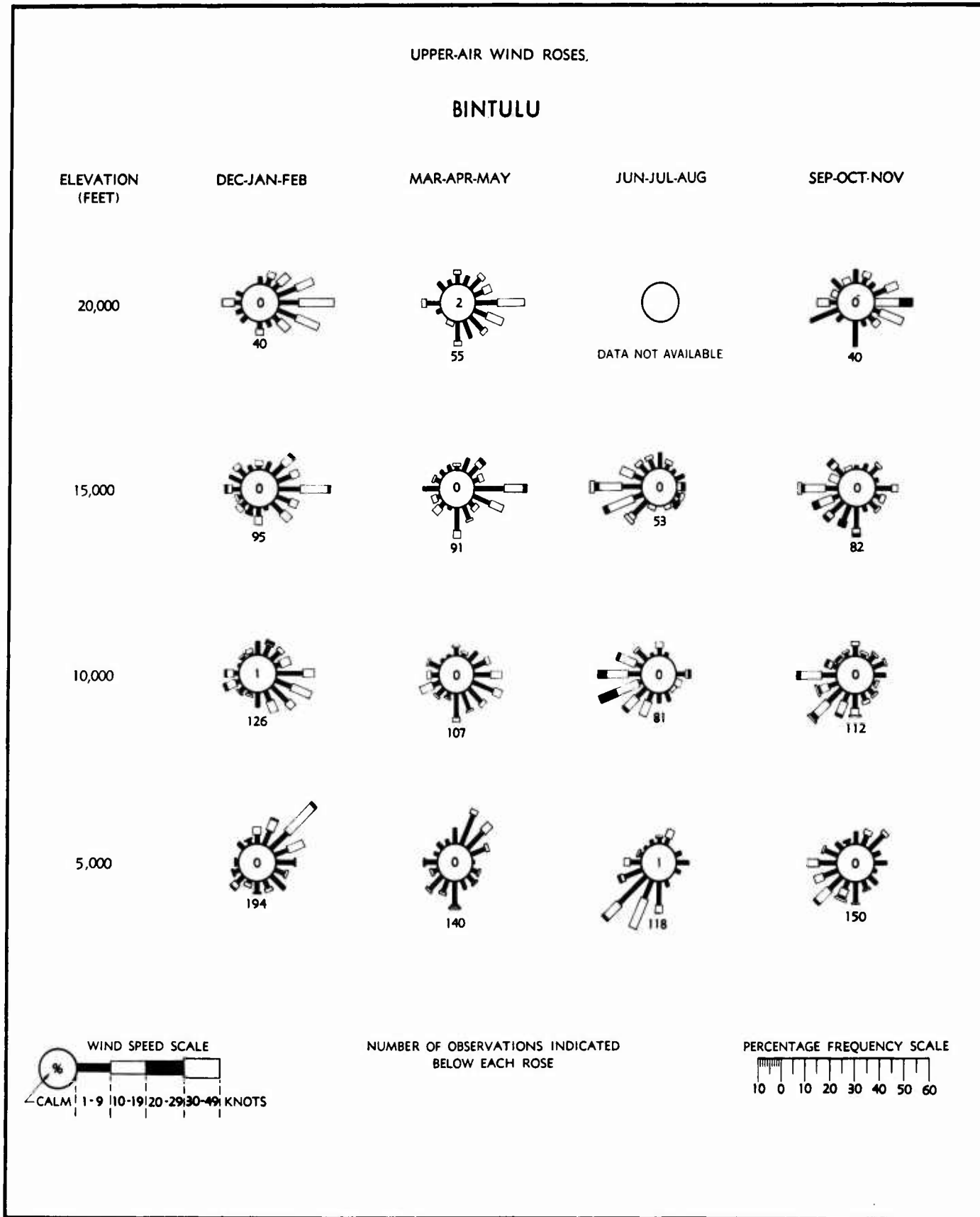


FIGURE 23-8. UPPER-AIR WIND ROSES, BINTULU

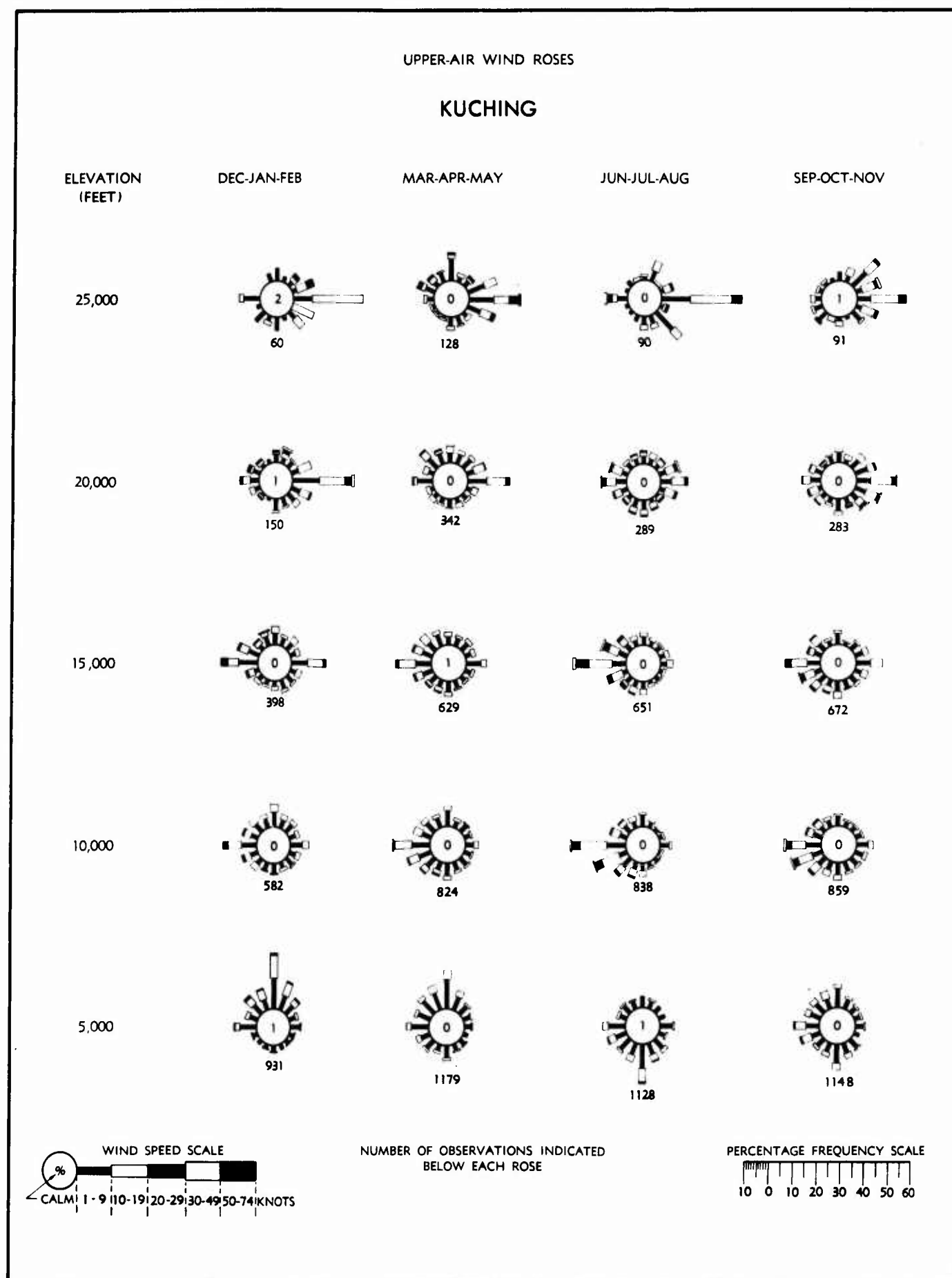


FIGURE 23-9. UPPER-AIR WIND ROSES, KUCHING

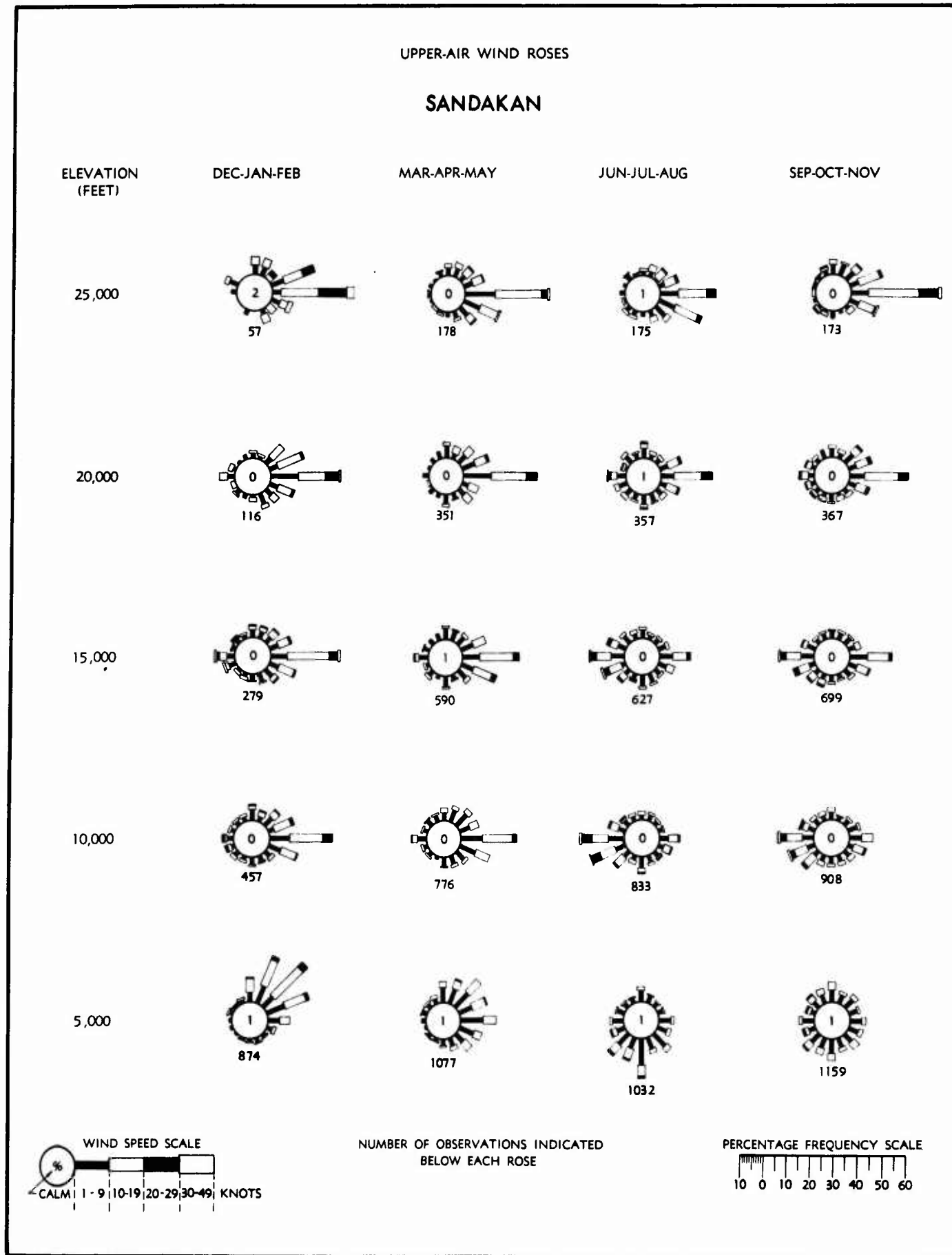


FIGURE 23-10. UPPER-AIR WIND ROSES, SANDAKAN

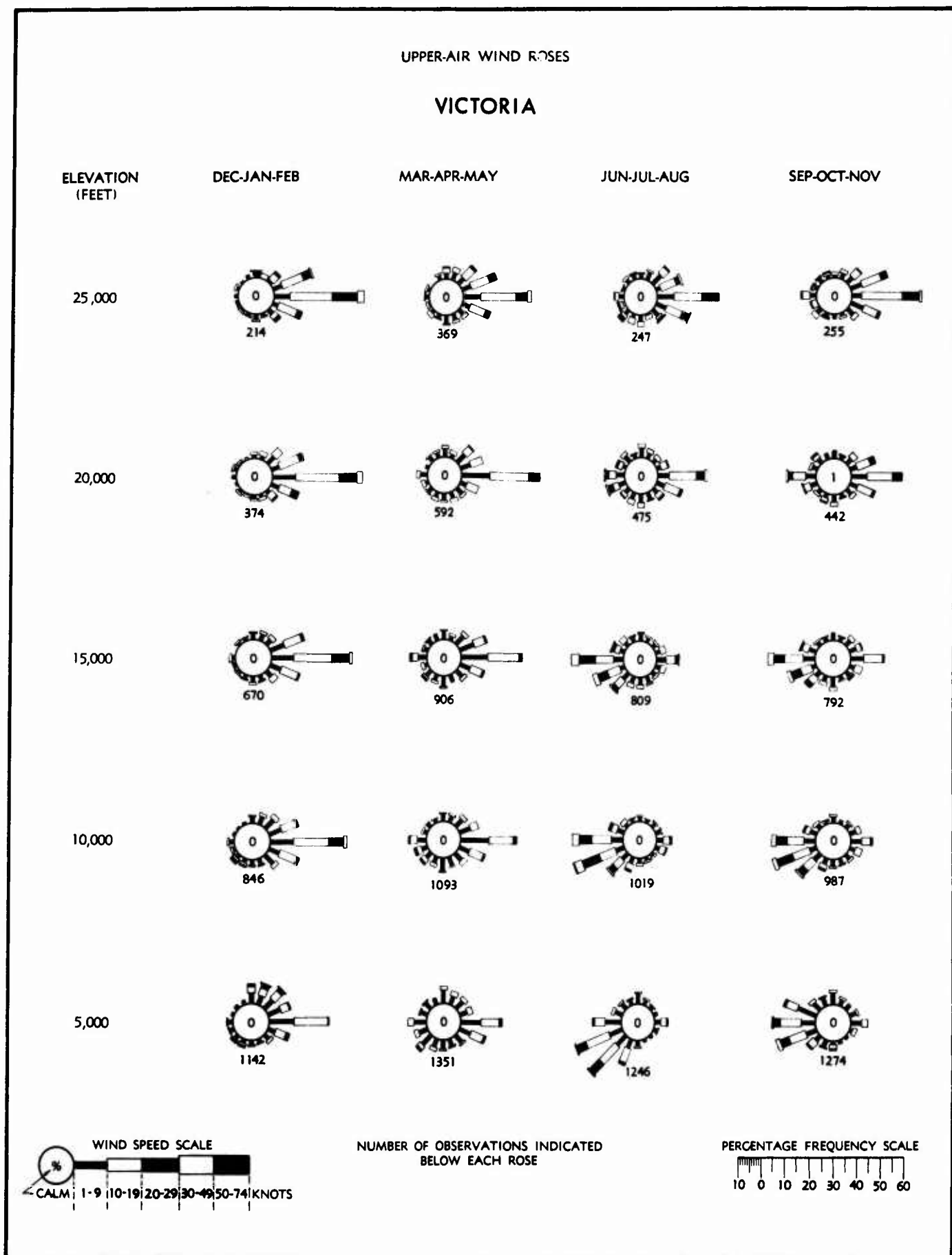


FIGURE 23-11. UPPER-AIR WIND ROSES, VICTORIA

higher altitudes. The tropopause is generally found at about 55,000 feet throughout the year.

The high elevation of the freezing level over equatorial regions generally precludes aircraft icing below about 14,000 feet; at higher levels, however, temperature and moisture conditions may be particularly conducive to the occurrence of such ice accretion. Heaviest icing is generally encountered in clouds or precipitation areas in which the temperature is at or slightly below freezing. The actual rate of ice accretion decreases with decreasing temperature. When air temperatures approach 0° F. (-18° C.), the icing rate usually becomes insignificant. Although aircraft icing over this NIS Area is a hazard in all seasons, the cloud conditions most likely to produce icing occur in April through October. During this time afternoon or evening cumulus and cumulonimbus clouds often extend to above the freezing level. The large masses of cumulonimbus associated with the intermonsoon seasons should be regarded as possible areas of particularly severe icing conditions. The vertical development of clouds is considerably reduced in November through March; consequently, convective clouds less frequently extend above the freezing level.

2. Air-ground operations

a. **LOW CLOUDINESS AND CEILINGS** — In aircraft operations within the friction layer, an important consideration is whether sufficient height above the terrain and below the clouds can be maintained to satisfactorily accomplish a mission. This factor may be of great importance when considering missions in and around the rough terrain of this NIS Area. Data on cloud ceiling heights are sparse and limited to the coastal regions. Although British Borneo has an abundance of cloudiness and precipitation, low ceiling heights are not frequent over the coastal regions, as shown in FIGURES 23-12 and 23-23. However, the frequency of low ceilings probably increases considerably over the highlands, especially on exposed slopes.

NOTE Air-ground operations are defined as those operations taking place within the friction layer above the earth's surface, or those primarily influenced by the meteorological conditions existing within that layer. The meteorological elements discussed in this Subsection are those which are of primary importance to such operations as parachute drops, chemical and biological warfare, tactical support, low-level reconnaissance, and air rescue. The success or failure of many of these operations may also depend to a large degree upon the behavior of elements above the friction layer or near the surface. A detailed discussion of such elements may be found in Subsections B, 1 and B, 3.

The Southwest Coast Region has a greater frequency of low clouds and low ceilings than the other coastal regions. Low ceilings are generally most frequent during the northeast monsoon and autumn intermonsoon seasons; ceiling heights about 600 feet or less occur 10% to 25% of the time in early morning during these seasons. Ceilings below about 5,000 feet have been observed as often as 40% of the time at midday in February and April. During most months of the southwest monsoon and spring intermonsoon seasons, less than 15% of the observations show ceilings of approximately 600 feet or below, and less than 35% show ceilings below about 5,000 feet. Diurnally, the lowest ceilings throughout the region are most frequent in the morning, with no significant variation between the afternoon and evening observations. The frequency of ceilings below about 5,000 feet reaches a maximum in the morning over the northern part of the Southwest Coast in most months and in the afternoon over the southern part in all months.

Over the Northwest Coast Region the frequency of low ceilings is much less than over the Southwest Coast Region. Ceilings about 600 feet or below occur no more than 10% of the time over the southern part of this region, with the maximum in September. Ceilings below about 5,000 feet are observed less than 20% of the time throughout the year. Farther north, ceilings near 600 feet or below are recorded on less than 2% of the observations, and ceilings below about 5,000 feet on less than 15% of the observations, with no significant seasonal variation. The diurnal variation over the region is slight, with maximum frequencies of all ceiling heights below about 5,000 feet alternating mostly between morning and evening.

The Northeast Coast Region has ceilings approximately 600 feet or below 1% or less of the time in October through April, and they occur with equal frequency in the morning, afternoon, and evening. During the remaining months such low ceilings do not normally occur. Ceilings below about 5,000 feet occur most often in the morning in August through March with a maximum frequency near 20% in January. During the remainder of the year ceilings below this level are usually most frequent in the evening when they are observed about 5% of the time or less.

Ceiling data for the Interior Highlands are not available. However, data on other elements and cloudiness variations in nearby countries provide some general conclusions. Ceilings below about 5,000 feet are probably most common during the afternoon, especially over the windward slopes. Afternoon cumulliform clouds are likely to form

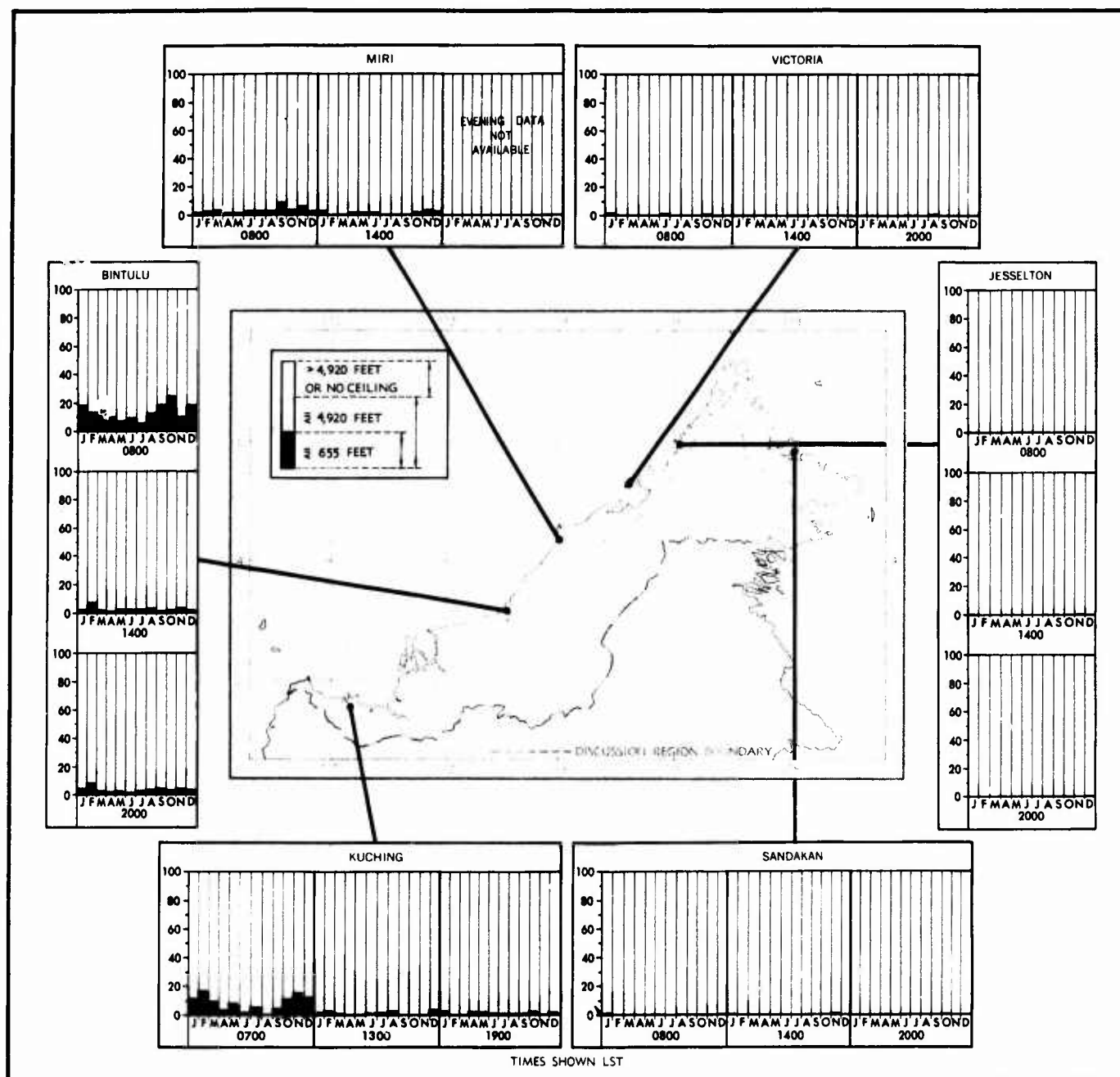


FIGURE 23-12. PERCENTAGE FREQUENCY OF SPECIFIED CEILING RANGES AT SPECIFIED HOURS. (For tabular data see FIGURE 23-23.)

ceilings of about 2,000 or 3,000 feet except in passing showers when ceilings may lower to less than 1,000 feet. However, ridges extending above about 3,000 feet may often penetrate the level of the afternoon convective cloud bases, as the clouds tend to form on the blocking windward slopes. The ridges will then be enveloped in fog, as the clouds intersect the ground. Radiational cooling after midnight often results in the formation of very low, thin stratus cloud over swampy valleys, sometimes covering the lower mountain slopes. Normally these stratus cloud bases do not exceed the higher treetops, and the vertical thickness of the clouds is less than 100 feet, with dissipation usually occurring by midmorning.

b. **VISIBILITY** — The visibility in British Borneo is not often greatly restricted, as shown in FIGURES 23-13 and 23-24. Variations in visibility from place to place are considerably greater than from month to month, especially in the mountains. Unfortunately data are too sparse to give more than a general idea of regional variations.

Over the Southwest Coast Region, very low visibilities, those less than 5-eighths of a mile, are reported less than 10% of the time during the northeast monsoon, the season of poorest visibility in this region. Visibilities this low are normally most frequent during the early morning. The frequency of visibilities less than 6 miles is considerably larger over the region. The maxi-

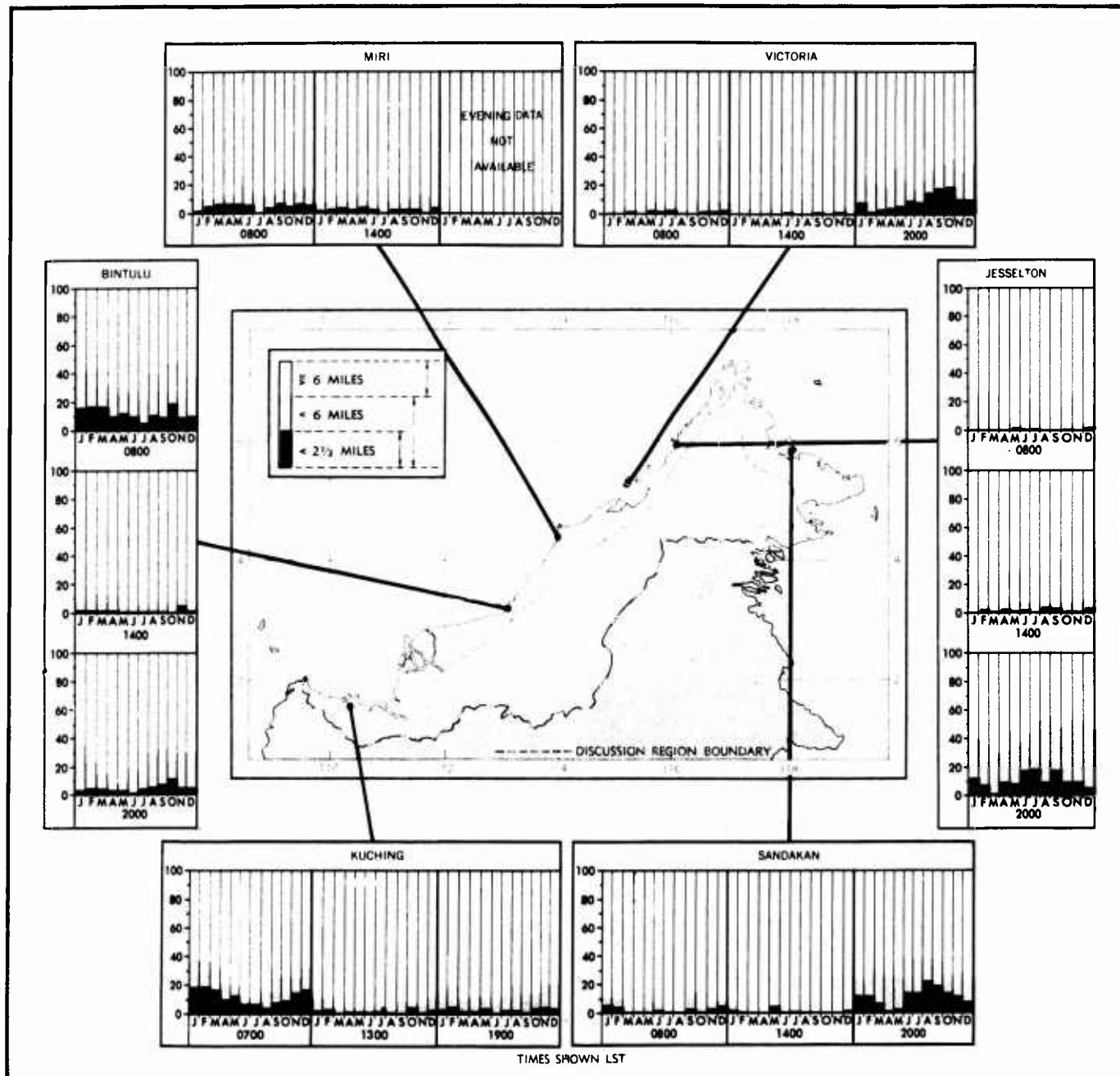


FIGURE 23-13. PERCENTAGE FREQUENCY OF SPECIFIED VISIBILITY RANGES AT SPECIFIED HOURS. (For tabular data see FIGURE 23-24.)

mum usually occurs in the early morning of either the northeast monsoon or the autumn intermonsoon season, but occurrences seldom exceed about 50% of the observations.

The Northwest Coast Region has visibilities less than 5-eighths of a mile most often during the late afternoon or early evening of the southwest monsoon season. Maximum occurrences are less than about 10% of the time. Visibility reduction to less than 6 miles occurs with a marked maximum during the late afternoon or early evening over the region. Seasonally, frequencies are usually highest from May to December inclusive, with maximums less than 55%.

Over the Northeast Coast Region, the data show that very low visibilities, less than 5-eighths of a mile, are infrequently observed, averaging only 2% of the time or less. Both seasonal and diurnal variations are insignificant. Visibilities of less than 6 miles may be observed at any time of the day or night in most months, but they have been reported most often in the late afternoon or evening during the southwest monsoon. However, the occurrences during this period do not exceed about 40% of the observations.

Tabular data on visibility are not available for the Interior Highlands. However, related information indicates frequent occurrence of fog and

low stratus over the swampy lowlands and river valleys of this region. Usually occurring between midnight and daybreak, this condition may frequently lower the visibility to less than 5-eighths of a mile. Afternoon convective cloud bases may often obscure mountain peaks and ridges, giving poor visibilities at mountain stations. These conditions may be highly variable, however, depending on the exposure of the station to the monsoonal flow.

The major restrictions to visibility over British Borneo are rain, haze, and fog, with rain by far the most important at most locations. Unfortunately tabular data giving the mean frequency of these obstructions are unavailable. Heavy rain showers may at any time reduce visibility considerably, sometimes to near zero conditions. These showers can generally be avoided by aircraft in flight, but they constitute a problem for aircraft landings and for many ground operations. Widespread rain sufficient to reduce visibilities greatly is not common. Haze often causes visibility to fall below 6 miles but probably seldom as low as 2½ miles. Haze conditions can normally be expected near sundown and especially during the southwest monsoon season when the land areas to the southwest have had an unusually dry year, and grass fires become prevalent. Although fog may occasionally form locally over parts of the coastal regions, its occurrence is confined mostly to the swampy river valleys of the Interior Highlands. Mirages may also affect the visibility to some extent since they cause objects to appear displaced from their true positions.

c. COMBINED CEILING AND VISIBILITY — The frequency of various combinations of ceiling and visibility are given in FIGURE 23-25. Ceiling and visibility conditions unfavorable for operations occur more often in the Southwest Coast Region than in other parts of the Area. Adverse conditions reach a maximum in the northeast monsoon and autumn intermonsoon seasons in this region. Over the other regions, there are no distinct seasonal variations; combined ceilings and visibilities are generally favorable for most operations throughout the year. The feasibility of air operations such as high-level bombing and aerial photography is also dependent upon cloud cover and visibility. FIGURE 23-26 gives the frequencies of one combination of these factors, 2-eighths or less cloud cover with visibility 2½ miles or more. There is no well defined favorable period during the year anywhere. Although these conditions occur at Jesselton on as many as 10 days during the morning hours in March, usually they are observed on less than 5 days in most months over the Area.

d. SURFACE WINDS — The surface winds over British Borneo are primarily controlled by two great airstreams, the northeast and southwest monsoons. These airstreams are interrupted when the ICZ moves northward and southward across the Area. FIGURES 23-38A and 23-38B present surface wind roses for the morning and afternoon hours of January and July, representative months of the northeast and southwest monsoon seasons, respectively. Wind directions given in the wind roses may differ considerably from the direction of the generalized surface airflow as shown in FIGURES 23-1 through 23-4. The wind roses show, in addition to the monsoonal flow, the local and diurnal effects such as those of terrain and the land and sea breezes. These effects are not included in the generalized surface airflow.

Over the northern half of the Southwest Coast Region, easterly winds prevail in the morning and northwesterly winds prevail in the afternoon the year round. Mean wind speeds usually vary from less than 5 knots in the morning to about 5 to 10 knots in the afternoon in all seasons. Gale-force winds (winds equal to or greater than 28 knots) are infrequent and confined mostly to the spring intermonsoon season. Calm conditions are observed less than 10% of the time. Wind directions over the southern half of the Southwest Coast are quite variable except in the afternoon during the northeast monsoon when the direction becomes predominantly north to northeast. Wind speeds over this part of the region usually average less than 5 knots in the morning and less than 10 knots in the afternoon throughout the year. Gales are limited mostly to an occasional occurrence during the spring intermonsoon season. Calms are observed about 60% to 65% of the time in the morning and about 10% to 20% of the time in the afternoon during the year.

In the Northwest Coast Region, morning winds blow mostly from the east or southeast except at the offshore island station of Victoria, where the diurnal changes caused by land and sea breezes are minimized. Morning winds here are similar to the average seasonal winds, with prevailing northeasterly winds during the northeast monsoon and southerly winds during the southwest monsoon. Wind directions in the afternoon over the Northwest Coast Region vary most frequently between north and west during the northeast monsoon and between south and west during the southwest monsoon. Mean wind speeds usually average between 5 and 15 knots over most of the region the year round. Gale-force winds blow infrequently during the year at most locations. Calms occur on about 5% to 30% of the observations in the morning and less than 5% in the afternoon in all seasons.

The Northeast Coast Region has southwesterly winds most often in the morning; however, the frequency of southwesterly winds is notably greater during the southwest monsoon season. North to northeast winds prevail during northeast monsoon in the afternoons. In the southwest monsoon season, afternoon winds are variable with maximum frequencies from the south or northeast. Mean wind speeds vary between about 5 and 10 knots most of the time. Gale-force winds are uncommon in any season. The frequency of calm winds in most months ranges from about 30% in the morning to about 10% in the afternoon.

A detailed discussion of surface winds over the Interior Highlands is impossible because of a complete lack of data; however, some generalizations can be made. The surface winds over most of the region are strongly affected by the rough terrain. Sheltered locations probably experience relatively light and variable winds, while exposed mountain stations feel most of the force of the monsoonal flow. Wind directions at higher elevations should be more consistent with the direction of the monsoonal winds than those at valley stations.

The effects of land and sea breezes over the coastal regions are readily apparent on surface wind roses (FIGURES 23-38A and 23-38B). At most coastal installations on the mainland, offshore winds prevail as late as 0800 LST in the morning as the cool land breeze continues to blow toward the warmer ocean waters. The strength of the sea breeze is also quite obvious along most of the coast. The sea breeze is usually strongest in the afternoon as the relatively cool air from the adjacent ocean waters blows toward the warmer land areas. Land and sea breezes are normally welcome for the relief they bring, particularly on the hot afternoons. They are fairly active most of the year, either opposing or strengthening the monsoonal flow. The sea breeze usually sets in about 1000 LST, increases until afternoon, and dies down shortly after sunset. The land breeze ordinarily rises about 2000 LST or later and may last until about 0900 LST.

Mountain winds and valley winds are most common in the Interior Highlands. The air over the highlands at night becomes colder and heavier than that of the underlying air and spills down the mountainsides and down the valleys. During the day, and especially in the afternoon, the underlying warmer, lighter air flows up the valleys and mountain slopes. The up-slope winds by day often assist in building cumulus clouds to high levels, while the down-slope winds at night tend to dissipate cloudiness.

Several types of air-ground operations are dependent upon combinations of climatic factors which include surface winds. The frequencies of three such combinations are given in FIGURES 23-27 through 23-29. These data are examples of data used to approximate the feasibility of some types of incendiary bombing, chemical warfare, and parachute operations, respectively.

e. STABILITY AND LOW-LEVEL TEMPERATURE INVERSIONS — Statistical data on low-level turbulence over British Borneo are not available. However, other information indicates that the atmosphere near the surface undergoes marked diurnal variations in stability. During the day, especially in the afternoon, the lower atmosphere becomes quite turbulent with strong vertical mixing because of the intense solar heating. Low flying aircraft would experience considerable bumpiness, particularly over the rough terrain of the Interior Highlands. At night, the lower air cools, vertical motion reaches a minimum, and the air becomes stable. Seasonal variations of low-level turbulence are slight compared to diurnal variations.

3. Ground surface operations

a. TEMPERATURE — British Borneo, located entirely within tropical latitudes, has high surface temperatures the year round at all but the mountain locations. The very warm temperatures, usually accompanied by high humidities, are at times very oppressive, especially to those who have lived for some time in temperate latitudes. Land and sea breezes offer some relief from the heat, particularly in the coastal regions.

Constancy characterizes the temperature regime in this NIS Area. The surface temperature of adjacent ocean waters is about the same throughout the year, and the influence of this nearly constant temperature is strongly imparted to the land areas. The mean annual temperature usually varies between 79° and 82° F. at low elevations and decreases about 3 Fahrenheit degrees for each 1,000 feet of increasing elevation. Mean temperature differences between the warmest and coolest months at most locations usually average only 2 Fahrenheit degrees and almost

NOTE Ground surface operations are defined as those operations taking place primarily at or very near the earth's surface. The meteorological elements discussed in this Subsection are those which are of primary importance to such operations as movement of troops and vehicles, selection of clothing and equipment, storage of supplies, and maintenance of armament and equipment. Some meteorological elements which may also have an effect upon this type of operation are discussed in Subsections B, 1 and B, 2.

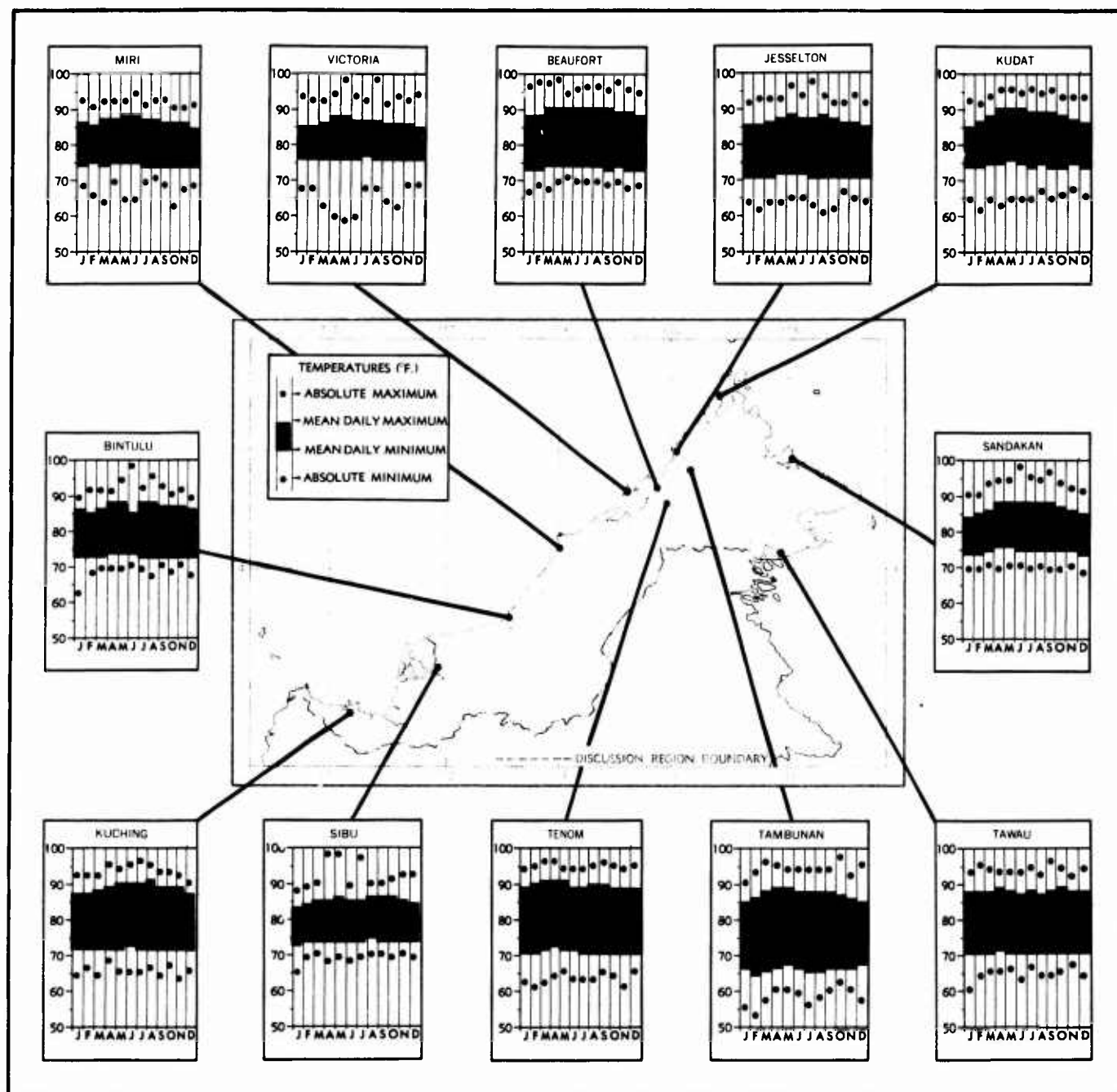


FIGURE 23-14. TEMPERATURES (°F.). (For tabular data see FIGURES 23-30 and 23-31.)

never exceed 4 degrees. These negligible monthly differences make it clear that no particular period can be defined as a cool season. The diurnal variations of mean temperature are of more concern, since they exceed the monthly changes by a considerable amount. Generally, the mean diurnal temperature range (difference between mean daily maximum and minimum temperatures) is greater over the inland regions, particularly in the highlands, than along the coast. Location within grassy or cultivated plots increases the diurnal variation while location in thick forests or near open waters normally decreases the diurnal range. FIGURE 23-14 shows temperature

regimes for selected stations in graphic form. Tabular listings of temperature data appear in FIGURES 23-30 through 23-32.

Over the Southwest Coast Region, mean daily maximum temperatures do not often exceed 90° F. Maximums above 90° F. are limited, for the most part, to the southwest monsoon season. The mean maximums are mostly in the mid to high 80's throughout the year. Mean daily minimum temperatures are usually in the low 70's, with no more than 3 Fahrenheit degrees difference from month to month and from station to station. The mean diurnal temperature range varies between about 10 and 20 Fahrenheit de-

grees over the region. The greatest range normally occurs during the southwest monsoon, although seasonal variations seldom exceed 4 Fahrenheit degrees. The highest absolute maximum temperatures in this region have been recorded during the spring intermonsoon or southwest monsoon seasons and everywhere are less than 100° F. Temperatures of 90° F. or higher occur in all months over most of the region; however, they are most frequent during the southwest monsoon season, when as many as 24 days with such temperatures have been recorded in June and August at Kuching. Considerably fewer days of 90° F. or higher temperatures are observed in the northeast monsoon season, sometimes less than 2 days per month. Absolute minimum temperatures are in the 60's or low 70's, with the lowest values recorded during the northeast monsoon season.

The Northwest Coast Region has mean daily maximum temperatures at most locations in the mid to high 80's. At Beaufort, an inland station, recorded mean daily maximums reach and exceed 90° F. but only by 1 degree. Although seasonal variations are small, the highest mean maximums usually occur during the spring intermonsoon or southwest monsoon seasons and the lowest values in the northeast monsoon season. Mean daily minimum temperatures are persistently in the 70's, with no significant seasonal variation. The mean diurnal temperature range varies between about 10 and 20 Fahrenheit degrees at most locations. The greatest range occurs during the spring intermonsoon or southwest monsoon seasons; at any location, however, the range seldom varies more than 3 Fahrenheit degrees during the year. Absolute maximum temperatures are in the 90's over most of the Area, although they have been as low as 89° F. at Brunei in October, November, and December. The highest extreme maximum temperatures have been observed from April through August in most places; however, values over 99° F. have not been recorded. Most stations record at least 1 day in each month when the temperature reaches 90° F. or higher. The highest frequencies, 9 to 11 days per month, usually occur in April, May, or June. Absolute minimum temperatures generally range in the 60's or low 70's. The lowest extreme minimum temperatures are not confined to any one period but vary from season to season and from place to place. The lowest temperature recorded within this region was 59° F., which occurred in May at Victoria.

Over the Northeast Coast Region, mean daily maximum temperatures range from 85° F. to 91° F. Northern stations usually record highest values in the spring intermonsoon or southwest

monsoon seasons and lowest values during the northeast monsoon. Seasonal changes are smaller along the southern coast, where mean maximum temperatures vary only 2 Fahrenheit degrees the year round. Mean minimum temperatures range between 74° F. and 76° F. during all seasons in the north and remain near 71° F. most of the year in the south. Generally, the region experiences a diurnal temperature range of about 10 to 20 Fahrenheit degrees. Seasonal variations are small; the greatest diurnal temperature ranges usually occur in the spring intermonsoon or southwest monsoon seasons in the north, while the south displays no particular seasonal pattern. Absolute maximum temperatures are in the 90's. The highest temperatures are observed in the spring intermonsoon or southwest monsoon seasons, but only in June at Sandakan has 99° F. been reached. Temperatures of 90° F. or more have been recorded in all months in the Northeast Coast Region and occur as often as 13 days per month in July at some places. Extreme minimums vary from the low 60's to the low 70's, and the lowest temperatures have always occurred in the northeast monsoon season.

Temperature data for the Interior Highlands are restricted to two stations, both located relatively close together in the northern part of the region. However, these data are believed to be fairly representative for stations below about 1,500 feet throughout most of the region. Mean daily maximum temperatures at low levels vary from the upper 80's to the low 90's, depending on elevation, location, and exposure. Mean maximum temperatures at higher elevations are probably much lower; over 8,000 feet, maximums probably fall to the 60's. Mean daily minimum temperatures at low levels range mostly from the mid 60's to the low 70's with no well defined seasonal variations; above 8,000 feet, they probably fall to the 40's. The mean diurnal temperature range is generally greater in the highlands than over the coastal regions, varying most often between about 20 and 25 Fahrenheit degrees. Even greater ranges most likely occur at higher elevations. Seasonal variations are insignificant. Extreme maximums at lower levels usually do not exceed 98° F. in the hottest month and usually average in the mid 90's most of the year. Days with temperature equal to or exceeding 90° F. appear to occur more often here than in the coastal regions, especially in the low valleys. Extreme minimum temperatures at low levels are in the 50's or 60's, with the lowest values usually recorded in the northeast monsoon season. It is believed that temperatures approaching freezing have occurred occasionally in the higher mountains.

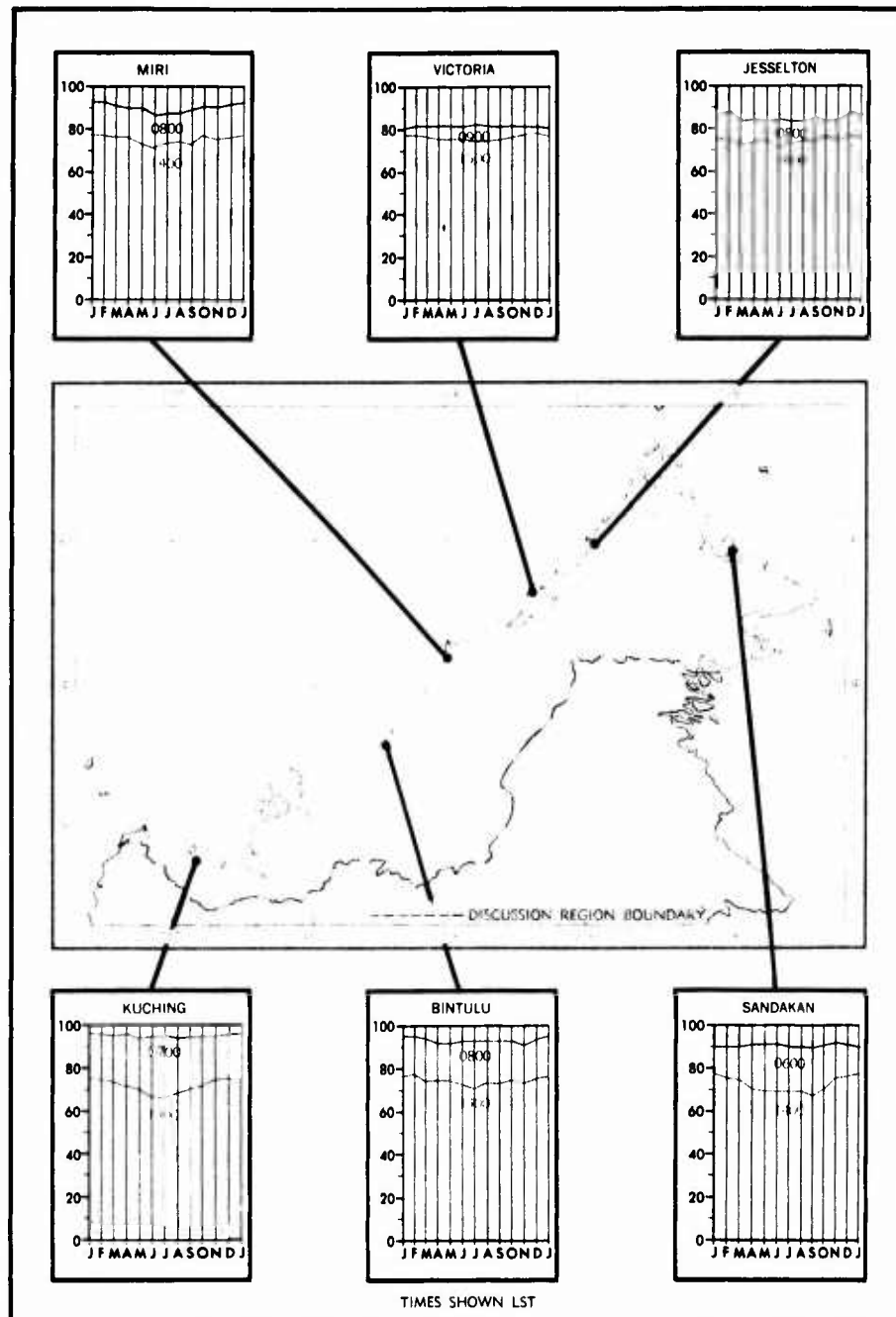


FIGURE 23-15. MEAN RELATIVE HUMIDITY (%) IN MORNING AND AFTERNOON. (For tabular data see FIGURE 23-33.)

b. **RELATIVE HUMIDITY** — Throughout British Borneo, the relative humidity is uncomfortably high in all months. The best available humidity data for the Area are presented in graphic form in FIGURE 23-15 and in tabular form in FIGURE 23-33. Although the seasonal variations are not great, the highest values usually occur during the northeast monsoon season or transitional seasons at most locations. Areal variations are also slight; however, on the average the moisture content of the air is slightly larger over the Southwest Coast than over the other regions. Over all the NIS Area, the diurnal variation of relative hu-

midity exceeds the seasonal variation by a considerable amount.

Recorded mean values in the Southwest Coast Region range from 54% in the afternoon at Sibul to 97% in the morning at Kuching. Most of the time, afternoon relative humidities vary between about 65% and 75%. In the Northwest Coast Region, mean values range from the 70's in the afternoon to the 80's or low 90's in the morning and evening. The Northeast Coast experiences mean relative humidities in the morning in the low 90's. Evening values are mostly in the 80's, while during the afternoon a low of 67% is re-

corded in September. Data for the Interior Highlands are not available. It is believed, however, that mean relative humidity may be equally high over much of the highlands, especially in swamps and dense forests. It is probable also that the diurnal range of mean relative humidity may be somewhat greater than over the coastal regions.

c. PRECIPITATION — Rainfall is everywhere abundant in this NIS Area. Frequent heavy rainfall is undoubtedly the most important climatic factor affecting operations, particularly ground surface operations. Mud may at times make many roads impassable. Roads, railroads, and other facilities are sometimes flooded or washed away, causing considerable interruption to normal operations. Most of the precipitation falls in the form of heavy showers. Mean annual amounts of precipitation vary from 68 inches at Tenom in the Interior Highlands to more than 200 inches at some locations, particularly those on exposed slopes. The majority of the rainfall measuring stations over the Area record more than 100 inches per year. FIGURE 23-16 presents mean precipitation in graphical form at selected stations. Tabular data for a more complete coverage of stations are given in FIGURE 23-34.

There is no part of the year in which excessive rainfall may not be experienced in any part of British Borneo. Consequently, the usual *wet* and *dry* seasons familiar to many midlatitude countries do not exist. Although mean monthly precipitation varies from place to place depending on location, elevation, and exposure, the wettest months occur most often during the northeast monsoon season. Regionally, precipitation amounts do not vary greatly, so that any one region cannot be designated as receiving the most rainfall. Over the Southwest Coast, mean annual amounts vary from about 110 to 160 inches and monthly amounts average between about 5 and 25 inches. The greatest mean monthly rainfall over this region always occurs during the northeast monsoon season. Mean annual rainfall along the Northwest Coast ranges from 86.6 inches at Kota Belud in the north to 200.9 inches at Labu in the central part of the region. On the average, most stations record from about 5 to 20 inches of rainfall monthly. The month with the greatest mean precipitation is in either the northeast monsoon or the autumn intermonsoon season. Mean annual rainfall over the Northeast Coast is on the whole slightly less than over the other regions. Average amounts in both the northern and southern parts of the region range between about 70 and 95 inches, while the central part measures about 120 to 125 inches. Precipita-

tion in most months averages about 5 to 20 inches. Although the wettest months are mostly in the northeast monsoon season, some locations along the south coast experience their heaviest falls during the southwest monsoon season. Rainfall in the Interior Highlands varies widely from place to place and from season to season; amounts are greatly influenced by exposure. Annually, mean precipitation ranges from 68.0 inches at Tenom to 227.8 inches at Long Akah. Monthly amounts at most places average between about 5 and 20 inches; however, Long Akah has recorded 29.4 inches in November. Any season may contain the wettest month.

The distribution of precipitation is often altered by topographical influences over British Borneo, especially in the Interior Highlands. The blocking mountain ridges of the highlands gives lift to the already moist, unstable monsoonal air. In addition, afternoon shower activity is considerably increased by the rough terrain of the highlands. Stations on windward mountain slopes may receive large amounts of rainfall, while sheltered stations only a few miles away in the lee of the mountain receive much reduced amounts.

Precipitation over the Area is quite erratic. Monthly and annual amounts received at a station may vary widely from year to year. One excellent example of this is Sandakan in the central part of the Northeast Coast Region where 61.1 inches was recorded in January of one year and only 1.4 inches in the same month of another year. The annual values at this same station have varied as much as 110 inches from one year to another. FIGURE 23-35 gives the greatest and least precipitation recorded at various stations throughout the Area.

Most of the rainfall over British Borneo is in the form of showers which are usually short-lived even during the wettest months. As in most tropical countries, the showers are frequent and usually heavy and may result in considerable flooding. Because of the high water vapor content of the air and the powerful ascending air currents, the rainfall of the tropics is more torrential than in temperate countries. Short thundershowers may occur in temperate latitudes with an intensity equal to that associated with thundershowers in the tropics, where as much as one-half inch of rain may fall in five minutes. However, these rates cannot be long maintained in temperate latitudes, because the water content of the air is soon exhausted. In contrast, rates of fall approaching this intensity may last for half an hour in British Borneo. In the course of 24 hours more than 10 inches of rain has fallen at several locations over the Area, as shown in FIGURE 23-36. Victoria in the Northwest Coast Region and San-

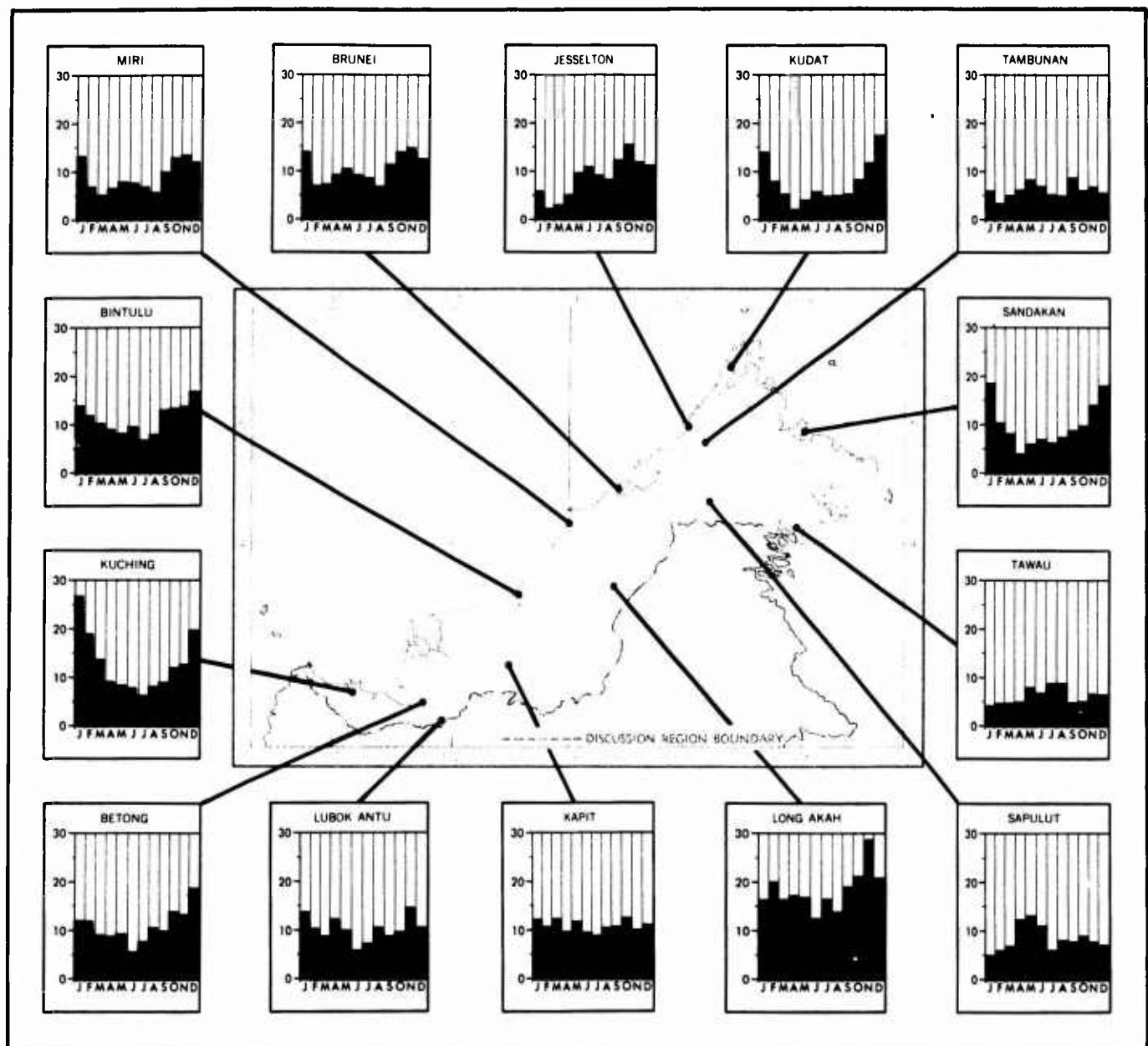


FIGURE 23-16. MEAN PRECIPITATION (INCHES). (For tabular data see FIGURE 23-34.)

dakan in the Northeast Coast Region have recorded as much as 14.5 inches in one day in September and January respectively.

Another indication of the frequent and plentiful rainfall of British Borneo is the number of days with measurable precipitation. These data are shown in graphic form in FIGURE 23-17 for selected stations. FIGURE 23-37 gives a more complete listing in tabular form of the mean number of days with specified precipitation amounts. The mean annual number of days with 0.01 inch or more of rainfall ranges from 117 at Lahad Datu along the Northeast Coast to 241 days at Long Akah in the Interior Highlands. In all regions the number of days per month with rain usually exceeds 5, even in the driest months, and ranges as high as 25 in December at Long Akah. How-

ever, most stations throughout the Area usually record between 10 and 20 rainy days in each month.

There is no record of snowfall occurring anywhere in British Borneo. It is very unlikely that snow would be encountered, even on the highest mountains, except possibly over the summit of Mount Kinabalu ($6^{\circ}05'N$, $116^{\circ}33'E$.) which rises to an elevation of more than 13,000 feet in the northern part of the Interior Highlands.

d. OVERALL EFFECT OF SURFACE WEATHER ON CLOTHING, STORAGE, AND SHELTER

(1) Clothing

(a) MAJOR INFLUENCES — Since British Borneo has a tropical rainforest climate, the determination of clothing requirements is based on

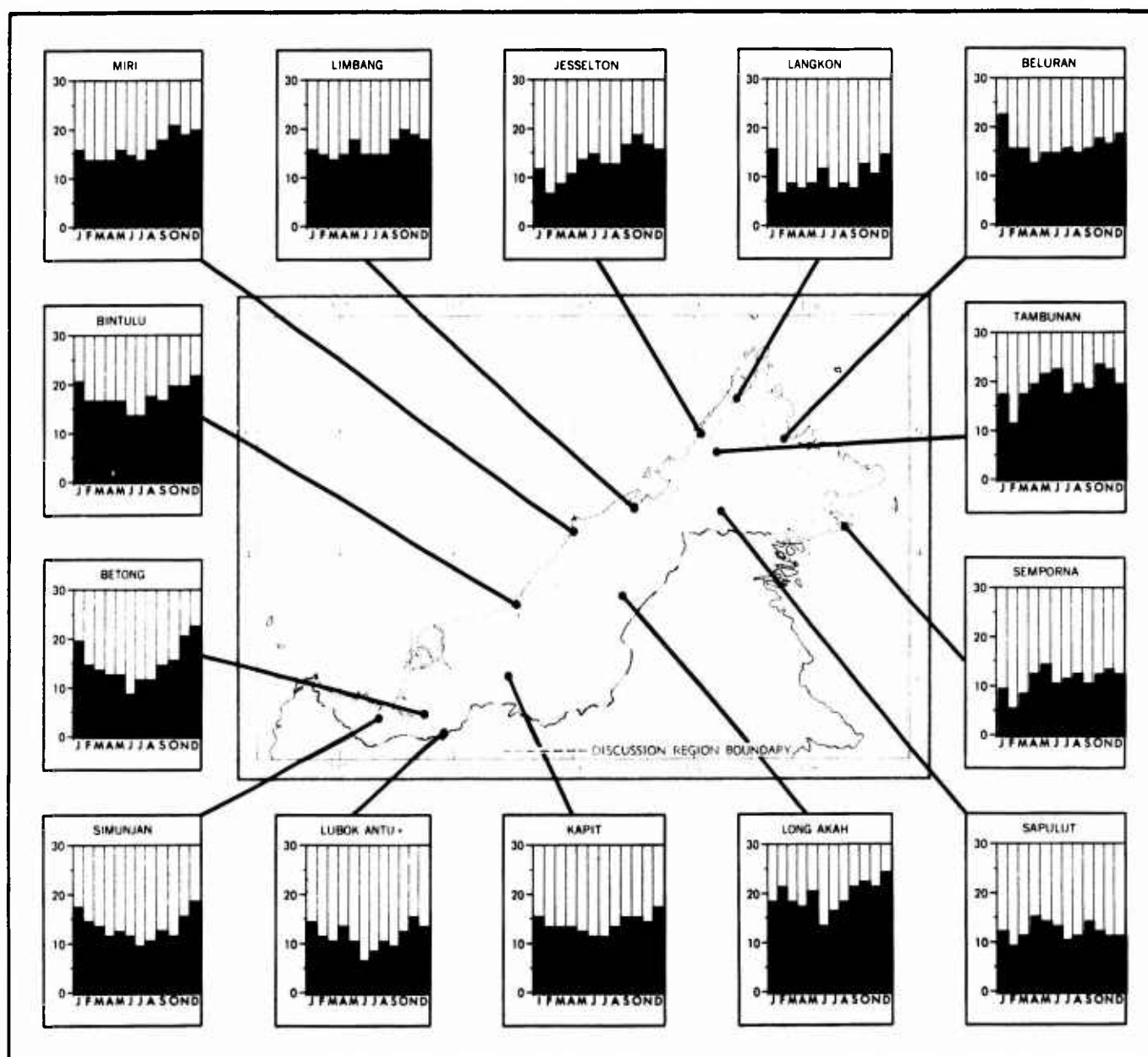


FIGURE 23-17. MEAN NUMBER OF DAYS WITH PRECIPITATION ≥ 0.01 INCH. (For tabular data see FIGURE 23-37.)

high temperature, high relative humidity, and excessive rainfall. This climatic regime is generally prevalent over the greatest part of the Area at all times of the year. Seasonal and diurnal temperature changes are insignificant at any one elevation. Monsoons influence the monthly range of precipitation; however, no seasonal modification of clothing assemblies is justified. Elevation rather than season provides the only temperature variation affecting a departure from a single clothing assembly. In addition, some special items of clothing and equipment are required as a protection against insects and water-borne organisms.

(b) REGIONAL REQUIREMENTS — In determining regional clothing requirements, there are two major divisions to be considered, the lowlands

and the highlands. The lowlands extend from the coast of North Borneo to the southern coast of Sarawak. Extensive lowlands are located in southern Sarawak and eastern North Borneo. The highlands, the most pronounced topographic feature, consist of hills, low ranges, and isolated peaks. The mean temperatures of 68° F. to 50° F. reached at higher elevations are the significant guides in the selection of clothing assemblies. It is estimated that these mean temperatures occur at about 4,000 feet and 10,000 feet, respectively. Less than about 15% of British Borneo is located above 4,000 feet, and only a very small portion exceeds 10,000 feet. These higher elevations are subjected to moderate winds. The combination of these winds, lower temperature, and high atmospheric humidity will have a chilling effect on the

body far below that indicated by a recorded temperature reading. This combination particularly affects troops manning installations on peaks and ridges.

Clothing requirements for this NIS Area are based on clothing assemblies that have been prescribed for world-wide use, depending upon the occurrence of mean monthly temperatures as follows:

CLOTHING ASSEMBLY	MEAN MONTHLY TEMPERATURE
Warm-weather	Above 68° F.
Cool-weather	50° to 68° F.
Cold-weather	14° to 50° F.

The warm-weather clothing assembly meets the requirements throughout the year for elevations below 4,000 feet, the cool-weather clothing assembly for elevations between 4,000 and 10,000 feet, and the cold-weather clothing assembly for elevations above 10,000 feet.

Appropriate service regulations list the exact nomenclature and the basis for issue of various components of these clothing assemblies. For planning purposes, however, the clothing assembly components are described in general terms. Also listed are special items which may be necessary because of varying climatic factors.

The warm-weather assembly suitable for this NIS Area is a cotton outfit (visored cap, lightweight jacket, trousers, and underwear). It also includes tropical combat boots and poncho. A woolen blanket is adequate sleeping equipment for use with this assembly.

The cool-weather assembly supplements the warm-weather assembly with a hooded water-repellent wind-resistant coat. Two woolen blankets or a lightweight sleeping bag are adequate sleeping equipment for use with this assembly.

The cold-weather clothing assembly consists of a wool shirt, wool trousers, wool and cotton underwear, wool cushion-sole socks, and leather combat boots. A coat liner is added to the coat used with the cool-weather assembly. A cotton cap or a field cap with wool pile lining is worn, depending upon the degree of coldness. Woolen glove inserts or woolen mitten inserts, worn with the appropriate leather shells, are also components of the cold-weather assembly. A mountain-type sleeping bag (down- and feather-filled) with a water-repellent case is adequate sleeping equipment for use with this assembly.

(c) EXCEPTIONS AND ADDITIONS FOR INDIVIDUALS IN A PROTECTED ENVIRONMENT — The clothing assemblies described above are based on the assumption that the individuals wearing them would be living in the open 24 hours a day. Clothing requirements at permanent installations may

be modified; for example, a raincoat might be more practical than a poncho, and blankets could be used in lieu of sleeping bags.

(d) SPECIAL REQUIREMENTS — Because of the frequent rainfall and high atmospheric humidity, individuals and equipment are constantly exposed to moisture. As a result, a greater than normal attrition in clothing, leather, and other items of equipment should be anticipated. Water-proofed covers, proper ventilation, and the use of fungus and rust preventatives are essential. In addition, routine and frequent sock changes and the use of foot powders are required.

Precautions should be taken against water-borne diseases. Disease-carrying insects are numerous in the many swampy locations in the coastal lowlands. A knee-length wading boot is a desirable item of protective footwear for this purpose. Over the remainder of the lowlands the tropical combat boot is adequate.

Headnets and mosquito bars are essential items for protection against insects throughout the Area. A finer mesh than normally used for mosquito netting is needed to combat sandflies. These potential disease carriers are nocturnal and the most annoying of all insects existing in this NIS Area. Troop instruction is required in methods of protection against disease-carrying ticks, e.g., buttoning sleeves at the wrists and tucking trousers in boots.

Boots that afford protection above the ankles are required for wear at all times, since snakes, scorpions, centipedes, and leeches are numerous in the grasslands and swamps. The tropical combat boot provides adequate protection for this purpose. In addition, routine examination of bedding, footwear, and clothing before use is required.

(2) Storage — High temperature and humidity, which prevail daily throughout the year, are the major environmental factors to be considered in the protection of items in both covered and open storage. Temperatures of over 90° F. occur frequently in the lowlands, decreasing slightly with elevation. Subsistence items generally susceptible to deterioration by consistently high temperature and humidity necessitate full utilization of cold storage facilities. When cold storage is not available, these items can be protected by being covered and well spaced for maximum ventilation. Although there is no record of frost, it probably could occur on the higher mountain peaks.

Protection from rainfall is required daily throughout the year. Although the monsoons influence seasonal precipitation, there is no part of the year free of possible heavy rainstorms.

High atmospheric humidity also occurs during the entire year in the Area, at high as well as at low elevations. Percentage figures for relative humidity do not convey the real effect moisture has on equipment. Protective measures against mildew should be routine. The amount of moisture in the air is such that canvas rots, clothing and leather items mildew, and maps, books, and painted surfaces are disfigured by mold. Dehumidifiers and chemicals should be used in covered storage locations to protect highly sensitive items, such as parachutes, instruments, and camera equipment. For open storage, covers and proper spacing are required. In addition, stored items should be uncovered during the rare periods of lower humidity to permit ventilation and drying.

Dunnage is required for all storage sites as protection from ground moisture. Timber is readily available; however, when possible, chemical treatment is required to discourage insect infestation when used for dunnage or in structures intended to be of a permanent nature.

The best storage sites are on high ground. Lowland regions, road cuts, and mountain trails are susceptible to flash flooding. Although records indicate no typhoon activity in this Area, measures are required to protect storage sites from moderate to high winds during local rainstorm periods.

(3) *Shelter* — Providing shelter protects against rainfall and the excessive number of annoying and disease-bearing insects in the Area. Tents developed by the U.S. Army for Temperate Zone operations, which are floored and screened with a fine mesh, provide adequate protection.

Camp sites located on high ground prevent damage from flooding. Extensive forests found throughout this NIS Area provide abundant timber for the construction of improvised shelter.

4. Amphibious operations

The climate along the coast of British Borneo is hot, wet, and humid, the coastal sections made endurable only by the moderating effect of the sea and the pronounced land and sea breezes. Tropical maritime air predominates throughout the

year. The usual monsoonal effects are experienced, but the winds are normally much weaker than they are over countries farther north.

In this Area, conditions would be favorable for amphibious operations more than 80% of the time, with conditions most favorable late in the spring intermonsoon season and during the southwest monsoon season. Marginal effects of typhoons which have swung exceptionally far south may be felt on rare occasions.

In general, surface winds are light in the Area. Surface winds over the coastal waters and beaches are less than 6 knots more than 60% of the time and greater than 16 knots only about 3% of the time. Gale-force winds are seldom experienced. Along the coast, land- and sea-breeze effects, felt up to 10 to 20 miles seaward, are frequently stronger than the monsoonal winds. Winds are normally light and variable near sunrise in most coastal regions, increasing to 12 to 16 knots with the onset of a sea-breeze effect in midafternoon. The direction of the wind is determined by the local land configuration and its effect on the sea-breeze as well as by the monsoonal influence. The monsoonal windflow influences the speed and direction of the wind caused by local effects.

Over coastal regions cloudiness is minimal at night and, under normal conditions, increases to a maximum in late afternoon or evening. Offshore the sequence is reversed. Cloud cover equal to or greater than 5-eighths is reported in 50% to 70% of the observations over coastal waters, except from Bintulu to Tanjong Datu, where it is reported in more than 70% of the observations. Cloudiness is quite uniform in all seasons, with only a slight increase in some months of the period August to February. Restrictions to visibility, other than those caused by precipitation, occur about once a month, with haze most likely in August and September. Visibility of less than 6 miles occurs about 15% of the time, and that less than a mile about 1% of the time.

Minimum monthly precipitation, averaging about 5 inches, occurs most frequently during the spring intermonsoon and southwest monsoon seasons; precipitation increases to about 25 inches at some locations during the northeast monsoon season. Convective thunderstorms are frequent throughout the year, with the greatest frequency usually in the intermonsoon seasons. Squalls accompanying the storms are occasionally quite severe. These storms occur over land in late afternoon or evening and offshore shortly before dawn; during the autumn intermonsoon season they occasionally appear as a squall line associated with the Intertropical Convergence Zone as it moves over the Area.

NOTE Amphibious operations are defined as those operations involving the movement of troops and equipment onto a beach and the associated protective measures. The meteorological elements discussed in this Subsection are those which are of primary importance to such operations as helicopter troop transport, waterborne troop and cargo landing, underwater demolition, air support, and naval gunfire support. Further discussion of some of the elements may be found in the Subsections on Air, Air-ground, and Ground Surface Operations.

The air temperature is quite uniform throughout the year, ranging from near 90° F. during the day to about 70° F. to 75° F. at night. The mean sea-water temperature averages 82° F. with extremes of 80° F. and 84° F. annually. Humidity is excessively high, averaging about 85% annually with a daily maximum of about 90% to 95% very common.

As a rule, the northeast winds are neither steady nor strong enough to cause much swell; however, along the northeast coast during the period December through March, swells higher than 6 feet are experienced about 15% of the time, and occasionally swells over 12 feet occur. During the remainder of the year, swells greater than 6 feet are experienced less than 10% of the time. Along the northwestern coast, swells higher than 6 feet are rare, except in December and January when they occur about 5% of the time. Heavy ground swells have occasionally been observed along the coast at all times of the year. Typhoons moving across the seas north of the Area may induce swells which reach the coast of British Borneo, mainly between Kudat and Brunei. Thus, all coasts may experience heavy surf during the main typhoon season, the period September through December.

C. Meteorological facilities and organization (as of December 1961)

1. History and organization

Meteorological service in the British Borneo Territories (Sarawak, North Borneo, and Brunei) is administered by the Malayan Meteorological Service, which is under the British Colonial Office and is responsible to the Governments of Malaya and Singapore. The Malayan Meteorological Service dates from about 1925. The Department of Civil Aviation and Meteorological Services, British Borneo Territories, was created in September 1955 and became the third department of the Governments of Sarawak, North Borneo, and Brunei to operate on a unified basis.

The Malayan Meteorological Service, under the direction of Mr. K. Regendrum (Ceylonese) has headquarters in the Fullerton Building, Singapore. The subordinate MMO at Paya Lebar Airport, Singapore, furnishes forecasts to British Borneo and is directed by Mr. T. S. H. Uang (Chinese).

The headquarters office of the Department of Civil Aviation and Meteorological Services of the British Borneo Territories is at Jesselton, North Borneo. Mr. R. L. Milton is director of the services. The Meteorological Division supervisor is Mr. Lee Kim Swee whose duties include supervision of me-

teorological stations, statistics, inspection and testing of equipment, and training of the meteorological staff.

Regular publications produced by the Jesselton office are Monthly Meteorological Abstract for Sarawak and North Borneo, Annual Climatological Summary for Sarawak and North Borneo, annual rainfall statistics summarized in monthly form for Sarawak and North Borneo and pictorially in rainfall maps, and pilot balloon data in monthly summary form. Weather records from the British Borneo observing and rainfall stations are checked, edited, and filed at Jesselton.

2. Evaluation of the services

Services provided by the British Borneo Department of Civil Aviation and Meteorological Services are limited to observing functions and climatological studies and are reasonably adequate. Lack of certain upper-air data (temperatures, humidities, pressures, and higher level winds) and daylight-only hours of operation are major deficiencies.

Forecasting and other technical support for British Borneo is provided by the Main Meteorological Offices (MMO), both civil and military, at Singapore. This service is generally good, especially considering the separate locations and the distance involved.

3. Weather observing and forecasting facilities

Limited information is available concerning weather equipment used throughout British Borneo. It is believed to be of British origin and similar to that used in Malaya. It should, therefore, be adequate and reliable for the limited observing services performed.

Seven observing stations comprise the British Borneo aviation weather network. These primary stations are well distributed along the northern coastal regions. Secondary stations (rainfall measuring) provide the only inland coverage in the Area. At least 43 stations in Sarawak and 73 in North Borneo take daily rainfall measurements.

Weather stations at airfields are located at Labuan (5°18'N., 115°15'E.), Kuching, Jesselton, Bintulu, Sandakan, and Sibü. Miri is the only weather station not located at an airfield. Pilot balloon (optical wind tracking) observations are taken at Kuching, Bintulu, Labuan, and Sandakan. There are no present or proposed radiosonde operations in British Borneo.

Surface synoptic observations are taken and reported daily by all stations at 0000, 0300, 0600, 0900, 1200, and 2100 GMT. Hourly observations are taken regularly at Labuan, Jesselton, and Sanda-

kan between the hours of 0000 and 0900 GMT. Kuching records hourly observations daily between 2100 and 0900 GMT. Kuching, Jesselton, and Sandakan also record significant weather changes. Upper-air observations are taken (weather permitting) at 0000, 0600, and 1200 GMT.

Observations are relayed to Labuan to meet requirements of the Borneo Flight Information Center and for transmission to the Singapore forecast office. British Borneo three-hourly synoptic and upper-air observations are included in the scheduled Singapore territorial weather broadcasts. Complete details on broadcast times, frequencies, station identifiers, and codes are contained in World Meteorological Organization Publication Number 9, Volume C, *Transmissions*, or the U.S. Navy Hydrographic Office Publication Number 118, *Radio Weather Aids*.

General area and civil aviation forecasts for British Borneo are prepared by the Malayan Meteorological Office, Paya Lebar Airport, Singapore. Forecasts for military operations at the Labuan R.A.F. staging posts are furnished by the British Air Ministry Meteorological Office, Changi, Singapore. Establishment of a forecast office at Labuan to provide forecasts for the British Borneo Territories and to work closely with the Flight Information Center is planned. It may be some time before this plan is realized, mainly because of delay in implementing a forecaster training program. Both the Malayan Meteorological Service and the British Air Ministry Meteorological Service can furnish British Borneo with short range forecasts for surface and for upper-air conditions to 55,000 feet. Accuracy of the forecasts is restricted by scarcity of basic data which is a common factor in equatorial regions. Competence of the forecasting staffs is considered good.

4. Training and educational level of meteorologists

Malayans, along with a few other Asians and Eurasians, comprise the forecasting staff of the MMO at Paya Lebar, Singapore. Their educational level is usually high and nearly all receive forecasting training in the United Kingdom.

Forecasters at the R.A.F. station, Changi, are well educated and trained in the United Kingdom. Observers operating the British Borneo weather stations receive their training locally under the direction of the Meteorological Supervisor. Since 1960 British Borneo has considered obtaining external assistance to help establish forecaster training for Asian university graduates. Little progress in this program has been noted.

5. Research and development progress

Research in British Borneo appears to be confined to a limited climatological program. There is no evidence of any new or unusual equipment being tested or in use.

D. Climatic data tables

Some of the data presented in tabular form in this Subsection are based, in part, on observations taken at primary stations along the coasts. Although these observations were taken as recently as 1960, the periods of record are rather short in many cases. The remainder of the data, primarily precipitation and temperature data, usually cover more years of record; in some instances the records began prior to 1940. For the most part, the precipitation and temperature data are based on observations taken at secondary stations, located on plantations or at small settlements, and give a more complete coverage of the NIS 44B Area. Consequently, tabular data of weather elements are generally representative of most of the coastal regions and, to a lesser extent, of the highlands. The lack of adequate coverage in the interior is one of the serious deficiencies in the available data covering the Area. In all cases the data presented are the best available and are considered to be reasonably reliable.

At the end of the Section, a map of station locations (FIGURE 23-39) appears, with a list showing latitude, longitude, and elevation of stations mentioned in Subsections A, B, and D. Annual values in some tables may differ slightly from the sums or means of the monthly values because of the rounding-off of fractions.

FIGURE 23-18. MEAN CLOUDINESS (%)

REGION AND STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:														
Bintulu.....	85	87	80	78	77	75	77	82	86	84	84	85	82	3-5
Kuching.....	89	86	80	78	75	79	79	84	85	85	85	86	83	3-6
Northwest Coast:														
Jesselton.....	74	77	59	67	79	79	80	83	83	80	80	79	77	2-6
Miri.....	76	75	66	65	72	76	76	74	77	76	78	78	74	3-5
Victoria.....	73	70	63	69	71	75	75	77	78	75	76	75	73	2-6
Northeast Coast:														
Sandakan.....	79	78	69	64	72	77	76	78	82	75	81	81	76	2-5

NOTE Means are based on 2 to 3 observations per day.

FIGURE 23-19. MEAN CLOUDINESS (%) AT SPECIFIED HOURS

REGION AND STATION	HOURL (LST)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:															
Bintulu.....	0800	90	89	85	86	78	79	81	86	89	88	88	89	86	3-5
	1400	80	84	74	74	76	78	75	79	82	80	79	81	79	3-4
	2000	85	89	80	75	78	69	76	82	86	85	84	86	81	3-5
Kuching.....	0700	92	88	81	78	76	78	80	84	85	85	85	86	83	3-5
	1300	88	85	84	81	76	80	80	81	88	86	85	86	83	3-5
	1900	85	85	75	76	72	75	78	86	82	84	86	86	81	4-6
Northwest Coast:															
Jesselton.....	0800	70	75	51	59	76	79	79	78	81	70	79	79	73	2-4
	1400	81	78	64	69	80	74	76	82	81	84	79	80	77	3-4
	2000	72	78	62	72	80	85	84	88	88	85	81	78	79	4-6
Miri.....	0800	76	75	66	66	74	79	79	78	78	76	79	79	75	3-5
	1400	76	75	65	64	70	72	72	70	76	75	76	76	72	3-4
Victoria.....	0800	78	72	65	70	72	80	80	81	84	72	81	76	76	2-3
	1400	70	66	59	62	66	74	69	70	72	69	74	71	69	2-4
	2000	70	71	64	74	74	72	75	79	79	84	72	79	74	3-6
Northeast Coast:															
Sandakan.....	0800	84	81	74	68	72	80	78	81	81	75	80	80	78	2-4
	1400	80	78	68	65	75	78	76	76	84	76	85	84	77	2-4
	2000	74	76	66	58	68	72	74	78	80	75	79	80	73	3-5

FIGURE 23-20. MEAN NUMBER OF CLEAR DAYS (≥ 2 -EIGHTHS CLOUD COVER) AT SPECIFIED HOURS

REGION AND STATION	HOURL (LST)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:															
Bintulu.....	0800	0	1	*	1	3	3	2	1	*	1	1	1	14	3-5
	1400	1	*	1	2	2	2	2	1	0	1	1	1	14	3-4
	2000	2	1	3	4	3	6	3	1	2	1	1	1	28	3-4
Kuching.....	0700	*	1	1	2	3	3	2	1	1	1	1	1	17	3-5
	1300	*	1	0	0	*	0	1	0	0	*	0	0	3	3-5
	1900	*	1	4	3	5	3	4	1	2	2	1	1	27	4-6
Northwest Coast:															
Jesselton.....	0800	5	3	10	7	1	2	2	2	2	3	3	*	40	2-4
	1400	*	1	5	3	1	3	3	1	*	1	2	1	22	2-4
	2000	4	3	7	4	2	2	2	2	1	1	2	3	33	4-6
Miri.....	0800	2	2	5	5	3	2	2	3	2	2	1	3	32	3-5
	1400	1	*	5	4	3	2	2	4	2	2	2	1	28	3-4
Victoria.....	0800	3	2	3	4	3	*	1	2	1	2	1	2	24	2-3
	1400	3	4	5	5	2	2	4	3	1	3	1	1	34	2-4
	2000	4	4	7	3	3	3	3	3	2	1	3	2	38	3-5
Northeast Coast:															
Sandakan.....	0800	*	2	2	3	2	3	2	1	2	2	2	1	23	2-4
	1400	*	1	2	3	2	1	1	1	1	*	*	0	13	2-4
	2000	1	1	1	2	2	1	*	0	*	*	*	*	9	3-5

* <0.5 day.

FIGURE 23-21. MEAN NUMBER OF CLOUDY DAYS (≥ 6 -EIGHTHS CLOUD COVER) AT SPECIFIED HOURS

REGION AND STATION	HOURL (LST)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:															
Bintulu.....	0800	29	25	27	26	23	22	25	28	27	27	26	28	313	3-5
	1400	26	25	22	21	23	23	21	24	24	25	23	26	283	3-4
	2000	26	25	24	21	22	19	22	24	26	26	25	27	287	3-4
Kuching.....	0700	29	26	24	20	21	22	25	25	24	26	26	27	295	3-5
	1300	29	25	28	26	23	23	25	25	27	29	29	28	317	3-5
	1900	25	23	22	21	20	21	24	26	23	24	25	26	280	4-6
Northwest Coast:															
Jesselton.....	0800	19	20	10	11	22	24	23	22	24	19	23	22	239	2-4
	1400	25	21	14	17	24	20	22	26	22	27	22	24	264	2-4
	2000	20	20	15	18	22	24	24	24	25	26	23	21	262	4-6
Miri.....	0800	23	19	17	15	20	21	23	23	20	21	22	22	246	3-5
	1400	21	18	16	14	18	19	20	19	21	21	20	21	228	3-4
Victoria.....	0800	22	18	15	17	20	23	24	24	24	20	23	21	251	2-3
	1400	18	15	12	13	18	19	18	19	18	17	21	18	206	2-4
	2000	17	17	15	20	20	18	20	21	21	25	19	22	235	3-5
Northeast Coast:															
Sandakan.....	0800	25	24	20	15	19	23	24	24	25	20	23	23	265	2-4
	1400	24	21	17	16	21	21	21	20	24	21	24	26	255	2-4
	2000	19	19	15	12	15	18	20	20	22	19	21	22	222	3-5

FIGURE 23-22. MEAN NUMBER OF DAYS WITH THUNDERSTORMS

REGION AND STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:														
Bintulu.....	5	4	9	7	9	7	9	9	11	8	6	7	91	6
Kuching.....	9	8	12	17	16	11	12	11	17	18	14	10	155	6
Northwest Coast:														
Jesselton.....	4	4	8	13	21	13	10	8	11	10	7	7	116	6
Miri.....	7	5	11	11	13	9	9	8	12	10	6	8	109	6
Victoria.....	6	5	10	13	18	12	9	8	12	15	9	8	125	6
Northeast Coast:														
Sandakan.....	5	1	4	7	12	11	12	14	17	14	10	6	113	6

FIGURE 23-23. PERCENTAGE FREQUENCY OF SPECIFIED CEILING* RANGES AT SPECIFIED HOURS

REGION AND STATION	HOUR (LST)	RANGE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
		<i>feet</i>														
Southwest Coast: Bintulu.....	0800	≧655	18	13	15	10	7	9	5	12	18	24	10	18	13	3-5
		≧983	19	19	15	15	10	11	8	12	21	25	13	20	16	3-5
		≧4,920	26	24	25	23	16	17	12	16	24	31	17	24	21	3-5
	1400	≧655	2	7	2	1	2	2	2	3	1	2	3	2	2	3-4
		≧983	6	11	2	4	3	3	2	4	7	5	6	3	5	3-4
		≧4,920	22	32	12	16	16	10	11	18	13	7	12	19	16	3-4
	2000	≧655	4	8	2	1	2	1	2	3	4	3	4	3	3	3-5
		≧983	10	15	4	3	3	2	2	7	9	7	5	7	6	3-5
		≧4,920	21	31	17	7	8	10	8	16	14	18	16	18	15	3-5
	0700	≧655	11	16	9	3	8	1	5	0	4	11	15	12	8	3-4
		≧983	13	18	9	6	8	2	5	0	7	12	16	13	9	3-4
		≧4,920	21	24	17	12	9	6	7	6	11	14	18	17	14	3-4
Kuching.....	1300	≧655	1	2	1	0	0	1	1	2	0	0	0	3	1	3-4
		≧983	4	4	6	2	2	1	1	4	3	5	2	7	3	3-4
		≧4,920	37	42	28	43	31	24	25	34	32	31	34	32	33	3-4
	1900	≧655	3	0	0	2	2	1	1	1	1	2	0	2	1	4-6
		≧983	5	3	1	4	3	3	3	2	2	4	3	5	3	4-6
		≧4,920	17	15	10	11	10	12	17	11	11	10	14	17	13	4-6
Northwest Coast: Jesselton.....	0800	≧655	0	0	0	0	0	0	0	0	0	0	0	0	0	2-4
		≧983	0	0	0	0	0	1	1	0	1	1	1	0	**	2-4
		≧4,920	3	8	4	4	8	3	7	1	6	2	5	2	4	2-4
	1400	≧655	0	0	0	0	0	0	0	0	0	0	1	0	**	2-4
		≧983	0	0	0	2	2	3	0	0	3	2	4	3	2	2-4
		≧4,920	4	0	3	5	5	4	1	5	5	8	6	5	4	2-4
	2000	≧655	0	0	0	0	0	0	0	0	0	1	0	1	**	4-6
		≧983	5	1	0	0	1	6	4	2	9	3	1	2	3	4-6
		≧4,920	10	6	3	5	4	10	8	6	14	9	5	9	7	4-6
	0800	≧655	1	2	3	1	1	2	2	2	8	3	6	2	3	3-5
		≧983	4	5	12	2	2	3	5	2	14	7	10	6	6	3-5
		≧4,920	12	15	11	6	10	7	10	10	18	12	15	13	12	3-5
Miri.....	1400	≧655	2	0	0	1	1	1	0	0	0	1	3	2	1	3-4
		≧983	5	6	2	5	3	3	4	1	5	8	8	6	5	3-4
		≧4,920	16	19	14	9	6	9	11	13	14	13	12	17	13	3-4
	0800	≧655	1	0	0	0	0	1	0	0	0	1	0	0	**	2-3
		≧983	2	0	2	0	0	5	2	0	2	3	2	7	2	2-3
		≧4,920	5	5	9	11	0	8	3	3	5	10	6	9	6	2-3
	1400	≧655	0	0	0	0	0	0	0	0	0	0	0	0	0	2-3
		≧983	0	1	0	0	0	1	0	0	0	1	2	0	**	2-3
		≧4,920	2	5	1	1	0	3	1	0	4	2	6	1	2	2-3
	2000	≧655	0	0	0	0	0	0	0	1	0	0	0	0	**	3-5
		≧983	1	2	0	1	1	1	4	1	1	1	1	3	1	3-5
		≧4,920	4	3	1	3	2	3	4	3	5	4	5	4	3	3-5
Northeast Coast: Sandakan.....	0800	≧655	1	0	0	0	0	0	0	0	0	0	0	1	**	2-4
		≧983	12	3	5	2	0	2	0	0	2	4	1	2	3	2-4
		≧4,920	22	16	16	2	2	4	0	5	5	6	8	10	8	2-4
	1400	≧655	1	0	0	0	0	0	0	0	0	0	1	0	**	2-4
		≧983	5	4	1	0	0	1	0	0	0	0	2	2	1	2-4
		≧4,920	17	12	11	2	3	2	1	4	4	2	5	9	6	2-4
	2000	≧655	0	0	0	1	0	0	0	0	0	1	0	0	**	3-5
		≧983	3	2	0	1	2	0	0	1	0	2	0	2	1	3-5
		≧4,920	13	10	5	2	4	6	4	3	3	3	4	7	5	3-5

* Ceiling herein is defined as ≧5-eighths cloud cover.

** <0.5%.

FIGURE 23-24. PERCENTAGE FREQUENCY OF SPECIFIED VISIBILITY RANGES AT SPECIFIED HOURS

REGION AND STATION	HOUR (LST)	RANGE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
		miles														
Southwest Coast: Bintulu.....	0800	< $\frac{5}{8}$	4	2	3	1	1	2	0	2	1	1	2	2	2	3-5
		< $2\frac{1}{2}$	16	17	17	10	12	10	5	11	9	19	9	10	12	3-5
		< 6	40	43	31	27	26	27	22	40	27	47	23	37	33	3-5
	1400	< $\frac{5}{8}$	0	0	1	1	0	0	0	0	1	0	0	0	*	3-4
		< $2\frac{1}{2}$	2	2	2	2	1	1	1	1	1	0	5	1	2	3-4
		< 6	7	13	7	12	2	4	3	4	7	5	10	5	7	3-4
	2000	< $\frac{5}{8}$	0	1	0	1	0	0	1	0	2	1	1	0	1	3-5
		< $2\frac{1}{2}$	3	4	4	3	3	1	4	5	7	11	5	5	5	3-5
		< 6	34	22	14	10	9	18	14	28	32	24	30	30	22	3-5
	Kuching.....	< $\frac{5}{8}$	5	7	6	2	5	4	2	1	2	5	4	3	4	3-4
		< $2\frac{1}{2}$	19	19	17	10	13	7	7	4	8	9	15	17	12	3-4
		< 6	38	37	32	21	19	9	12	16	25	27	25	32	24	3-4
Northwest Coast: Jesselton.....	0800	< $\frac{5}{8}$	0	0	0	0	2	0	0	0	0	0	0	0	*	2-4
		< $2\frac{1}{2}$	0	0	0	0	2	1	1	0	0	1	0	2	1	2-4
		< 6	3	3	2	4	3	5	1	0	1	2	4	4	3	2-4
	1400	< $\frac{5}{8}$	0	0	0	0	0	1	0	1	0	0	0	0	*	2-4
		< $2\frac{1}{2}$	0	2	1	2	1	2	0	4	3	1	1	3	2	2-4
		< 6	1	4	1	6	7	6	3	6	6	8	8	11	6	2-4
	2000	< $\frac{5}{8}$	4	2	0	3	3	8	7	0	1	1	1	1	3	4-6
		< $2\frac{1}{2}$	12	7	1	9	8	17	18	9	17	9	9	5	10	4-6
		< 6	39	35	30	44	37	42	52	54	47	52	51	46	44	4-6
	Miri.....	< $\frac{5}{8}$	1	1	1	0	1	2	0	1	4	0	2	0	1	3-5
		< $2\frac{1}{2}$	1	4	6	6	6	5	0	3	6	4	6	5	4	3-5
		< 6	9	9	11	12	19	14	12	16	14	18	15	13	13	3-5
Victoria.....	0800	< $\frac{5}{8}$	0	0	0	0	0	0	0	0	0	0	0	0	*	2-3
		< $2\frac{1}{2}$	0	0	1	0	2	1	2	0	0	1	1	2	1	2-3
		< 6	2	3	1	5	7	4	3	2	6	8	8	7	5	2-3
	1400	< $\frac{5}{8}$	0	0	0	0	0	1	0	0	0	0	0	0	*	2-3
		< $2\frac{1}{2}$	0	0	0	0	0	1	0	0	1	0	1	0	*	2-3
		< 6	0	3	0	3	1	2	1	2	1	2	3	1	2	2-3
	2000	< $\frac{5}{8}$	1	1	0	0	1	3	1	2	2	1	1	2	1	3-5
		< $2\frac{1}{2}$	8	1	3	4	5	9	8	15	18	19	10	10	9	3-5
		< 6	27	20	18	30	22	16	22	30	33	38	28	34	27	3-5
Northeast Coast: Sandakan.....	0800	< $\frac{5}{8}$	2	0	0	0	0	0	0	0	0	0	0	1	*	2-4
		< $2\frac{1}{2}$	6	4	0	0	0	2	0	0	3	1	3	5	2	2-4
		< 6	11	11	2	4	9	7	3	2	15	4	8	9	7	2-4
	1400	< $\frac{5}{8}$	0	0	0	0	1	0	0	0	0	0	0	0	*	2-4
		< $2\frac{1}{2}$	2	0	0	0	5	0	1	1	0	0	0	1	1	2-4
		< 6	6	2	1	0	5	3	1	2	0	1	0	2	2	2-4
	2000	< $\frac{5}{8}$	1	0	0	0	0	0	0	1	0	0	0	0	*	3-5
		< $2\frac{1}{2}$	12	12	7	1	3	14	14	22	19	14	12	8	12	3-5
		< 6	24	31	29	26	25	38	37	38	36	26	28	24	30	3-5

* < 0.5%.

FIGURE 23-25. PERCENTAGE FREQUENCY OF SPECIFIED CEILING* AND VISIBILITY COMBINATIONS AT SPECIFIED HOURS

REGION AND STATION	HOURLY (LST)	COMBINATION**	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast: Bintulu.....	0800	A	73	77	79	81	85	84	89	84	78	65	84	75	80	3-5
		B	4	8	3	6	7	3	5	2	4	8	5	6	5	3-5
		C	23	15	18	13	8	13	6	14	18	27	11	19	15	3-5
	1400	A	93	89	96	95	97	97	98	96	93	95	91	96	95	3-4
		B	5	4	1	4	1	1	0	1	6	3	5	2	3	3-4
		C	2	7	3	1	2	2	2	3	1	2	4	2	3	3-4
	2000	A	90	83	93	94	96	97	95	92	88	86	92	92	92	3-5
		B	6	7	5	4	2	2	2	5	5	10	4	5	5	3-5
		C	4	10	2	2	2	1	3	3	7	4	4	3	4	3-5
	0700	A	73	73	79	88	85	92	92	96	88	85	78	74	84	3-4
		B	7	6	6	7	5	4	1	3	6	2	4	10	5	3-4
		C	20	21	15	5	10	4	7	1	6	13	18	16	11	3-4
Kuching.....	1300	A	95	94	99	97	97	99	99	96	97	91	97	91	96	3-4
		B	4	4	0	2	2	0	0	2	3	5	2	4	2	3-4
		C	1	2	1	1	1	1	1	2	0	4	1	5	2	3-4
	1900	A	93	92	97	95	94	97	94	96	97	93	94	92	94	4-6
		B	4	7	2	3	3	2	3	2	2	4	5	6	4	4-6
		C	3	1	1	2	3	1	3	2	1	3	1	2	2	4-6
Northwest Coast: Jesselton.....	0800	A	100	100	100	100	98	99	98	100	99	98	99	98	99	2-4
		B	0	0	0	0	0	0	1	0	1	2	1	1	1	2-4
		C	0	0	0	0	2	1	1	0	0	0	0	1	***	2-4
	1400	A	100	98	99	97	96	96	100	97	95	98	96	95	97	2-4
		B	0	1	1	3	4	2	0	2	5	2	3	5	2	2-4
		C	0	1	0	0	0	2	0	1	0	0	1	0	***	2-4
	2000	A	87	92	98	91	92	82	81	90	80	89	90	94	89	4-6
		B	6	4	1	3	4	6	7	5	11	6	5	2	5	4-6
		C	7	4	1	6	4	12	12	5	9	5	5	4	6	4-6
Miri.....	0800	A	96	92	93	93	93	94	95	96	84	91	87	91	92	3-5
		B	3	5	2	5	5	2	3	1	7	6	6	6	4	3-5
		C	1	3	5	2	2	4	2	3	9	3	7	3	4	3-5
	1400	A	94	93	97	94	95	96	96	98	93	91	92	93	94	3-4
		B	4	6	2	4	3	3	4	1	6	8	5	5	4	3-4
		C	2	1	1	2	2	1	0	1	1	1	3	2	1	3-4
	0800	A	98	100	97	100	98	93	97	100	98	97	98	92	97	2-3
		B	1	0	3	0	2	4	3	0	2	0	2	8	2	2-3
		C	1	0	0	0	0	3	0	0	0	3	0	0	1	2-3
Victoria.....	1400	A	100	99	100	100	100	98	100	100	99	99	98	100	99	2-3
		B	0	1	0	0	0	1	0	0	0	1	2	0	***	2-3
		C	0	0	0	0	0	1	0	0	1	0	0	0	***	2-3
	2000	A	92	97	97	95	95	92	90	85	83	81	89	89	90	3-5
		B	6	2	3	4	3	4	5	8	6	8	5	5	5	3-5
		C	2	1	0	1	2	4	5	7	11	11	6	6	5	3-5
Northeast Coast: Sandakan.....	0800	A	85	95	95	98	100	97	100	100	97	96	96	93	96	2-4
		B	12	4	5	2	0	3	0	0	0	3	3	4	3	2-4
		C	3	1	0	0	0	0	0	0	3	1	1	3	1	2-4
	1400	A	93	96	99	100	95	99	98	99	100	100	98	97	98	2-4
		B	4	4	1	0	4	1	2	1	0	0	1	2	2	2-4
		C	3	0	0	0	1	0	0	0	0	0	1	1	1	2-4
	2000	A	86	87	92	98	95	86	86	78	81	86	88	91	88	3-5
		B	7	8	6	0	4	7	9	17	13	6	7	5	7	3-5
		C	7	5	2	2	1	7	5	5	6	8	5	4	5	3-5

* Ceiling herein is defined as ≥ 5 -eighths cloud cover.

** Combination:

A—Ceiling ≥ 984 feet with visibility $\geq 2\frac{1}{2}$ miles.B—Ceiling 656 to 983 feet with visibility $\geq 1\frac{1}{4}$ miles and/or visibility $\geq 1\frac{1}{4}$ miles but $< 2\frac{1}{2}$ miles with ceiling ≥ 656 feet.C—Ceiling < 656 feet and/or visibility $< 1\frac{1}{4}$ miles.*** $< 0.5\%$.

FIGURE 23-26. MEAN NUMBER OF DAYS WITH TOTAL CLOUD COVER ≥ 2 -EIGHTHS WITH VISIBILITY $\geq 2\frac{1}{2}$ MILES AT SPECIFIED HOURS

REGION AND STATION	HOURL (LST)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:															
Bintulu.....	0800	0	1	1	1	3	3	2	1	*	1	1	1	15	3-5
	1400	1	0	1	3	2	2	2	1	0	1	1	1	15	3-4
	2000	2	1	3	4	3	6	3	1	2	1	1	1	28	3-4
Kuching.....	0700	1	1	1	2	3	3	2	1	1	1	1	1	18	3-5
	1300	*	1	0	0	*	0	1	0	0	*	0	0	2	3-5
	1900	*	1	4	3	5	3	4	1	2	2	1	1	27	4-6
Northwest Coast:															
Jesselton.....	0800	5	3	10	7	1	2	2	2	2	3	3	*	40	1-4
	1400	*	1	5	3	1	3	3	*	*	1	2	1	21	2-4
	2000	4	3	7	4	2	1	2	2	1	1	2	3	32	4-6
Miri.....	0800	2	2	6	5	3	2	2	3	2	2	1	3	33	3-5
	1400	1	*	5	4	3	2	2	3	2	2	2	1	27	3-4
Victoria.....	0800	3	2	3	4	3	*	1	2	5	2	1	2	28	2-3
	1400	3	4	4	5	3	2	4	3	1	3	1	1	34	2-4
	2000	4	4	7	3	3	3	3	2	2	1	3	2	37	4-6
Northeast Coast:															
Sandakan.....	0800	*	2	3	3	2	3	2	1	2	2	2	1	23	2-4
	1400	*	1	2	3	2	1	1	1	1	*	*	0	13	2-4
	2000	2	2	2	7	3	3	2	1	1	2	2	1	28	3-5

* <0.5 day.

FIGURE 23-27. MEAN NUMBER OF DAYS WITH SURFACE WIND ≥ 16 KNOTS AND NO PRECIPITATION OCCURRING AT SPECIFIED HOURS

REGION AND STATION	HOURL (LST)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:															
Bintulu.....	0800	*	*	*	0	0	0	0	0	0	0	*	0	1	3-5
	1400	*	0	*	0	0	0	0	0	0	0	1	1	2	3-4
	2000	0	0	*	1	*	0	0	0	0	0	0	1	2	3-4
Kuching.....	0700	*	0	0	*	0	*	0	0	0	0	0	*	1	3-5
	1300	0	0	*	0	*	*	0	1	*	*	0	*	2	3-4
	1900	0	0	*	0	0	0	0	0	0	0	0	*	*	4-6
Northwest Coast:															
Jesselton.....	0800	*	0	0	1	0	0	0	0	*	1	0	0	2	2-4
	1400	2	2	*	1	1	0	2	0	1	*	1	1	11	2-4
	2000	*	2	0	*	*	0	*	*	*	0	0	0	3	3-6
Miri.....	0800	*	0	0	0	*	0	0	0	0	0	0	*	1	3-5
	1400	2	1	1	*	1	0	*	1	1	1	1	1	10	3-4
Victoria.....	0800	0	1	0	0	0	*	1	0	0	0	0	0	2	2-3
	1400	0	2	1	*	0	1	1	1	*	1	*	1	9	2-4
	2000	2	1	2	*	0	0	0	*	1	1	*	1	8	3-6
Northeast Coast:															
Sandakan.....	0800	*	0	0	0	0	0	0	0	0	*	0	*	1	1-4
	1400	*	1	*	0	*	*	0	*	0	*	1	1	5	2-4
	2000	1	0	0	1	0	*	0	*	0	0	0	*	3	3-5

* <0.5 day.

FIGURE 23-28. MEAN NUMBER OF DAYS WITH SURFACE WIND 3 TO 10 KNOTS, TEMPERATURE $>32^{\circ}$ F. BUT $<90^{\circ}$ F., AND NO PRECIPITATION OCCURRING AT SPECIFIED HOURS

REGION AND STATION	HOURL (LST)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:															
Bintulu.....	0800	3	2	4	4	5	4	7	7	5	3	6	5	55	3-5
	1400	19	17	23	16	11	16	15	12	17	20	15	19	200	3-4
	2000	10	9	9	5	3	4	5	5	4	6	3	6	69	3-4
Kuching.....	0700	1	1	1	1	1	2	*	1	1	2	2	1	14	3-5
	1300	16	14	13	10	7	7	10	7	10	9	14	13	130	3-4
	1900	1	2	4	4	2	4	6	3	5	5	5	3	44	4-6
Northwest Coast:															
Jesselton.....	0800	11	9	12	13	12	13	19	19	14	15	16	13	166	2-4
	1400	18	16	22	16	16	18	20	18	20	21	21	20	226	2-4
	2000	9	8	10	10	11	10	8	10	9	10	10	12	117	4-6
Miri.....	0800	9	6	5	10	8	8	15	11	10	13	10	11	116	2-5
	1400	18	18	19	19	16	16	16	14	18	16	15	17	202	3-4
Victoria.....	0800	14	11	15	13	17	14	17	16	15	16	14	13	175	2-3
	1400	21	16	22	19	21	19	23	21	22	23	19	20	246	2-3
	2000	14	11	14	11	9	6	8	8	6	8	9	10	114	3-5
Northeast Coast:															
Sandakan.....	0800	12	10	12	12	6	8	12	11	8	8	8	11	118	2-4
	1400	18	17	26	22	19	16	19	16	17	18	21	21	230	2-4
	2000	13	14	15	15	7	4	6	6	6	6	7	11	110	3-5

* <0.5 day.FIGURE 23-29. MEAN NUMBER OF DAYS WITH CEILING* $\leq 1,000$ FEET, VISIBILITY $\geq 2\frac{1}{2}$ MILES, AND SURFACE WIND ≤ 10 KNOTS AT SPECIFIED HOURS

REGION AND STATION	HOURL (LST)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:															
Bintulu.....	0800	22	20	25	24	26	25	27	26	23	21	24	23	286	3-4
	1400	27	24	28	28	30	29	30	29	27	28	26	29	335	3-4
	2000	28	23	29	27	30	29	29	28	26	26	28	28	331	3-5
Kuching.....	0700	22	21	25	26	26	27	29	30	26	26	23	23	304	3-4
	1300	28	25	29	29	29	28	31	29	29	27	27	27	338	3-4
	1900	29	26	29	29	28	29	29	29	29	29	28	28	342	4-6
Northwest Coast:															
Jesselton.....	0800	30	28	31	29	31	29	29	31	29	29	30	29	355	2-4
	1400	23	19	25	20	25	26	26	24	25	27	24	24	288	2-4
	2000	26	23	30	26	28	24	24	27	23	26	27	28	312	3-5
Miri.....	0800	29	26	29	28	28	28	28	27	25	28	25	27	328	3-5
	1400	24	21	24	24	26	25	25	23	25	22	24	26	289	3-4
Victoria.....	0800	30	27	30	30	30	27	27	31	28	27	27	27	341	2-3
	1400	25	20	26	27	30	24	27	26	28	28	25	25	311	2-4
	2000	20	18	24	26	29	26	27	25	24	23	26	23	291	3-5
Northeast Coast:															
Sandakan.....	0800	25	26	30	29	31	29	31	31	29	29	29	28	347	2-4
	1400	23	20	27	26	28	27	28	29	28	27	27	27	317	2-4
	2000	24	23	27	29	29	25	27	24	23	27	26	27	311	3-5

* Ceiling herein is defined as ≥ 5 -eighths cloud cover.

FIGURE 23-30. MEAN DAILY MAXIMUM AND MINIMUM TEMPERATURES (°F.)

REGION AND STATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:															
Bintulu.....	Max	87	86	87	89	89	86	89	89	88	88	88	87	88	7-10
	Min	73	73	73	74	74	74	73	73	73	73	73	73	73	7-10
Kuching.....	Max	88	88	89	90	91	91	91	92	90	90	90	88	90	11
	Min	72	72	72	72	72	73	72	72	72	72	72	72	72	11
Sibu.....	Max	84	85	86	86	87	86	86	87	87	87	86	85	86	5
	Min	73	74	74	74	74	74	74	75	74	74	74	74	74	5
Northwest Coast:															
Beaufort.....	Max	89	89	91	91	91	91	91	91	91	90	90	89	90	13
	Min	73	73	74	74	74	74	74	74	73	74	73	73	74	13
Brunei.....	Max	85	85	86	87	87	87	87	87	87	86	86	86	86	5
	Min	76	76	76	77	77	77	76	76	77	77	77	77	77	5
Jesselton.....	Max	86	86	87	88	89	88	88	89	88	87	87	86	87	20
	Min	71	71	71	72	72	72	71	71	71	71	71	71	71	20
Miri.....	Max	87	86	88	88	89	89	88	88	87	87	87	85	87	7-10
	Min	74	75	74	75	75	75	74	74	74	74	74	74	74	7-10
Victoria.....	Max	86	86	87	89	89	88	88	88	87	87	87	86	87	21
	Min	76	76	76	76	76	76	77	76	76	76	76	76	76	21
Northeast Coast:															
Kudat.....	Max	86	87	89	91	91	91	90	90	90	89	88	87	89	13-15
	Min	74	74	75	75	76	75	74	75	74	74	75	74	75	11-13
Sandakan.....	Max	85	86	87	89	89	89	89	89	89	88	87	86	88	45
	Min	74	74	75	76	76	75	75	75	75	75	75	74	75	45
Tawau.....	Max	89	89	89	90	89	88	89	88	89	90	89	89	89	13
	Min	71	71	71	72	71	71	71	71	71	71	71	71	71	13
Interior Highlands:															
Tambunan.....	Max	86	87	89	90	90	89	89	89	89	88	87	86	88	9-10
	Min	67	65	66	67	68	67	66	66	67	67	67	68	67	9-10
Tenom.....	Max	90	91	92	92	92	90	90	91	91	90	90	90	91	12
	Min	71	71	72	73	72	72	71	71	71	71	71	71	71	13

FIGURE 23-31. ABSOLUTE MAXIMUM AND MINIMUM TEMPERATURES (°F.)

REGION AND STATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:															
Bintulu.....	Max	90	92	92	92	95	99	93	96	93	91	92	90	99	5-6
	Min	63	69	70	70	70	71	70	68	71	69	71	68	63	5-7
Kuching.....	Max	93	93	93	96	95	96	97	96	94	94	93	91	97	9-12
	Min	65	67	65	69	66	66	66	67	65	68	64	66	64	11
Sibu.....	Max	89	90	91	99	99	90	98	91	91	92	93	93	99	5
	Min	66	70	71	69	70	69	70	71	71	70	71	70	66	5
Northwest Coast:															
Beaufort.....	Max	97	98	98	99	95	96	97	97	96	98	96	95	99	12
	Min	67	69	68	70	71	70	70	70	69	70	68	69	67	12
Brunei.....	Max	92	90	91	92	92	92	92	92	91	89	89	89	92	5
	Min	72	71	70	72	70	72	72	73	74	73	74	72	70	5
Jesselton.....	Max	92	93	93	93	97	94	98	94	92	92	94	92	98	23
	Min	64	62	64	64	65	65	63	61	62	67	65	64	61	23
Miri.....	Max	93	91	93	93	93	95	92	93	93	91	91	92	95	7-10
	Min	69	66	64	70	65	65	70	71	69	63	68	69	63	7-11
Victoria.....	Max	94	93	93	95	99	94	93	99	92	94	93	95	99	22
	Min	68	68	63	60	59	60	68	68	64	63	69	69	59	22
Northeast Coast:															
Kudat.....	Max	93	92	94	96	96	95	96	95	96	94	94	94	96	12-14
	Min	65	62	65	63	65	65	65	67	65	66	68	66	62	10-13
Sandakan.....	Max	91	91	94	95	95	99	96	95	97	94	93	92	99	34
	Min	70	70	71	70	71	71	70	71	70	70	71	69	69	34
Tawau.....	Max	94	96	95	94	94	94	95	93	97	95	93	95	97	12
	Min	61	65	66	66	67	64	67	65	65	66	68	65	61	12
Interior Highlands:															
Tambunan.....	Max	91	94	97	96	95	95	95	95	95	98	93	96	98	10
	Min	56	54	58	61	61	60	57	59	61	63	61	58	54	10
Tenom.....	Max	95	96	97	97	95	95	95	96	97	96	95	96	97	11
	Min	63	62	63	65	66	64	64	64	66	65	62	66	62	13

FIGURE 23-32. MEAN NUMBER OF DAYS WITH MAXIMUM TEMPERATURE $\geq 90^{\circ}$ F.

REGION AND STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:														
Bintulu.....	6	2	4	8	9	15	9	16	7	3	7	*	86	2
Kuching.....	3	4	9	15	20	24	18	24	17	16	6	3	159	2
Northwest Coast:														
Jesselton.....	*	2	3	10	9	11	3	5	2	1	2	1	49	2
Victoria.....	2	3	4	9	9	5	3	4	5	3	*	1	48	2
Northeast Coast:														
Sandakan.....	*	*	1	2	12	11	13	12	5	8	3	*	67	2

* <0.5 day.

FIGURE 23-33. MEAN RELATIVE HUMIDITY (%) AT SPECIFIED HOURS

REGION AND STATION	HOURL (LST)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:															
Bintulu.....	0800	96	96	95	93	93	94	94	94	94	94	92	95	94	3-5
	1400	76	77	74	74	74	72	70	73	73	74	73	75	74	3-4
	2000	89	89	87	89	89	88	87	89	89	89	91	91	89	3-4
Kuching.....	0700	97	97	96	97	95	96	96	95	96	96	96	97	96	3-5
	1400	75	74	73	71	70	66	66	68	70	71	74	75	71	7
	1900	90	90	88	90	89	88	87	87	89	91	93	93	90	4-6
Sibu.....	1400	71	69	68	65	63	64	60	65	64	54	67	70	65	2
Northwest Coast:															
Jesselton.....	0800	87	88	84	85	84	85	84	84	86	84	85	88	85	2-4
	1400	74	73	71	72	73	70	71	73	72	75	73	75	73	2-4
	2000	90	89	88	89	90	89	88	89	91	92	91	91	90	3-5
Miri.....	0800	93	93	91	90	90	87	88	88	90	91	91	92	90	3-5
	1400	76	76	75	75	72	70	72	73	72	76	74	75	74	3-4
Victoria.....	0900	81	82	82	82	82	82	83	82	82	82	82	82	82	16-17
	1500	76	76	75	74	74	74	73	73	74	75	76	77	75	16-17
	2000	86	87	86	85	85	85	85	85	83	87	87	86	86	4-5
Northeast Coast:															
Sandakan.....	0600	91	91	91	92	92	92	91	91	91	92	93	92	92	9
	1400	77	75	74	70	69	69	69	69	67	70	75	76	72	9
	2000	86	84	83	84	88	88	87	87	88	89	89	87	87	3-5

FIGURE 23-34. MEAN PRECIPITATION (INCHES)

REGION AND STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:														
Betong.....	12.5	12.4	9.8	9.6	9.9	6.0	8.3	11.4	10.7	14.7	14.0	19.2	138.5	6-10
Bintulu.....	14.7	12.4	10.8	9.5	8.7	10.0	7.4	8.4	13.5	13.9	14.1	17.1	140.5	10-12
Kuching.....	27.1	19.7	14.2	9.7	9.0	8.5	6.9	8.8	9.5	12.6	13.1	20.1	159.2	43
Lundu.....	21.7	16.0	9.6	6.7	8.4	5.1	4.4	4.9	7.5	5.7	8.2	10.6	108.8	7-9
Matu.....	16.2	11.6	6.1	5.5	7.4	6.4	8.1	9.0	12.1	9.2	11.8	17.8	121.2	6-10
Mukah.....	21.9	18.0	12.2	4.0	6.6	6.4	4.8	6.0	12.6	11.3	9.2	19.2	132.2	7-11
Selalang.....	14.2	12.2	9.0	7.7	7.6	5.8	5.9	6.7	9.4	9.7	13.2	14.7	116.1	7-10
Sibul.....	15.2	10.9	11.2	8.1	9.0	7.3	7.0	6.3	10.9	9.2	10.2	12.2	117.5	7-9
Simunjan.....	23.9	15.7	13.7	8.6	11.6	7.4	7.6	8.1	11.1	13.4	12.5	21.5	155.1	3-5
Northwest Coast:														
Beaufort.....	13.2	9.2	10.0	13.8	14.7	11.8	11.6	11.1	15.3	16.4	14.3	13.2	154.6	12
Brunei.....	14.6	7.6	7.8	9.8	10.9	9.5	9.0	7.3	11.8	14.5	15.2	13.0	131.0	12
Jesselton.....	6.3	2.8	3.4	5.7	10.0	11.3	9.7	8.8	12.7	15.9	12.2	11.5	110.3	20
Kota Belud.....	6.3	3.2	5.0	5.4	7.9	8.7	6.2	6.5	7.8	10.9	8.9	9.8	86.6	26
Labu.....	22.1	10.3	15.3	16.0	16.3	16.0	12.2	10.6	18.1	22.0	23.8	18.2	200.9	12
Limbang.....	9.8	11.6	9.0	11.9	12.5	10.6	8.6	10.8	12.5	11.6	12.1	12.8	133.8	8-11
Marudi.....	8.1	9.0	8.8	7.8	9.0	8.8	6.7	7.1	8.6	9.8	11.8	11.3	106.8	6-11
Miri.....	13.7	7.2	5.5	6.9	8.1	8.0	7.2	6.0	10.2	13.4	13.9	12.1	112.2	9-12
Victoria.....	4.4	4.6	5.9	11.7	13.6	13.8	12.5	11.7	16.4	18.3	16.5	11.2	140.6	14
Northeast Coast:														
Beluran.....	14.4	11.5	9.0	5.8	7.3	9.9	10.8	10.8	10.9	9.8	10.7	8.4	119.3	14-15
Kudat.....	14.4	8.3	5.8	2.5	4.6	6.1	5.2	5.3	5.6	8.9	12.1	17.9	96.7	15
Lahad Datu.....	8.9	5.0	5.5	3.9	6.7	6.4	5.5	3.3	5.9	6.6	6.6	8.6	72.9	11
Lamag.....	24.2	7.9	8.8	5.3	8.6	9.1	8.7	10.3	10.8	9.7	10.9	12.5	126.8	14
Langkon.....	16.9	5.0	6.4	4.9	5.5	6.6	4.0	4.7	4.6	6.2	6.8	13.5	85.1	9-10
Sandakan.....	19.0	10.9	8.6	4.5	6.2	7.4	6.7	7.9	9.3	10.2	14.5	18.5	123.7	46
Semporna.....	5.8	3.7	5.3	7.0	6.7	5.6	8.7	6.1	7.0	7.5	6.4	6.1	75.9	5
Tawau.....	4.9	5.2	5.3	5.7	8.6	7.7	9.2	9.2	5.6	5.8	7.2	7.1	81.5	11
Interior Highlands:														
Kanowit.....	10.7	15.0	8.4	9.6	12.4	6.3	9.8	10.9	11.7	12.6	12.6	11.7	131.7	6-9
Kapit.....	12.9	11.2	12.9	10.0	12.1	10.1	9.7	11.2	11.3	13.1	10.8	11.9	137.2	7-11
Kemabong.....	7.7	5.3	7.2	8.2	7.9	5.0	4.8	6.4	5.0	6.8	7.5	5.9	77.7	15
Long Akah.....	17.0	20.9	17.0	17.9	17.7	13.2	17.2	14.8	19.5	21.9	29.4	21.3	227.8	3-8
Longnawan*.....	12.5	10.9	14.0	16.4	15.0	10.6	10.2	11.1	15.4	16.1	16.5	12.1	160.8	24
Longpudjungan*.....	8.8	6.4	7.1	11.2	12.0	11.5	8.7	6.5	10.3	9.6	11.1	9.8	113.0	15
Lubok Antu.....	14.1	11.0	9.3	13.0	10.9	6.4	7.9	11.2	9.3	10.4	15.2	11.0	129.7	5-8
Pensiangan.....	8.0	6.1	8.8	13.5	15.3	12.7	7.6	8.3	9.9	11.4	9.0	7.7	118.3	9-10
Putussibau*.....	15.3	14.6	14.8	17.0	13.9	10.7	8.6	10.4	11.7	17.6	19.0	17.3	170.9	40
Ranau.....	11.5	4.6	5.3	5.0	9.5	7.3	5.1	6.6	7.4	6.2	7.1	9.0	84.6	4
Rundum.....	12.7	7.1	8.7	9.5	12.2	10.9	7.6	10.6	8.9	9.2	8.4	8.4	114.2	4
Sapong.....	6.5	5.5	7.0	7.4	7.7	8.0	4.5	6.7	6.0	7.4	6.4	7.4	80.5	9-10
Sapulut.....	5.7	6.5	7.5	12.9	13.8	11.7	6.7	8.3	8.2	9.5	8.1	7.6	106.5	9-10
Tambunan.....	6.1	3.9	5.4	6.4	8.7	7.4	5.7	5.5	9.2	6.7	7.2	6.0	78.2	21
Tenom.....	7.4	4.4	6.6	6.4	5.9	5.5	3.5	4.1	6.8	6.4	5.4	5.6	68.0	10

* Near but outside NIS 44B Area.

FIGURE 23-35. GREATEST AND LEAST PRECIPITATION (INCHES)

REGION AND STATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:															
Betong.....	Greatest	17.9	19.7	13.5	12.9	21.8	11.4	13.6	21.8	14.9	19.1	17.6	28.8	169.1	6-10
	Least	7.0	3.3	8.1	5.6	4.5	2.5	2.9	5.7	6.4	10.1	9.9	14.2	125.4	6-10
Kuching.....	Greatest	62.3	42.0	21.0	17.4	17.1	13.8	14.0	12.6	15.9	19.5	19.3	29.5	220.2	18
	Least	9.8	6.7	4.0	6.1	4.0	3.6	4.5	1.9	2.2	4.6	6.9	9.1	109.1	18
Matu.....	Greatest	25.3	26.5	9.2	12.9	11.1	12.9	18.7	14.2	18.2	14.9	22.4	23.5	115.9	6-11
	Least	0.7	4.1	3.3	0.7	2.9	3.4	1.4	7.3	1.8	0.8	4.3	0.5	92.0	6-11
Mukah.....	Greatest	47.2	30.2	23.1	8.8	11.4	17.2	8.4	8.9	30.7	15.2	15.7	35.0	184.0	7-11
	Least	5.8	5.9	5.5	1.7	1.0	3.2	1.2	3.4	4.3	6.3	2.8	11.2	122.3	7-11
Selalang.....	Greatest	19.8	22.5	14.7	13.5	10.9	10.5	9.4	12.2	17.2	12.7	18.8	22.2	145.3	7-10
	Least	9.9	3.9	4.6	3.4	3.9	4.0	1.6	2.2	2.5	7.3	10.6	3.5	119.3	7-10
Simunjan.....	Greatest	30.1	22.5	19.5	12.3	12.0	12.3	14.5	10.9	12.4	16.8	17.0	27.2	na	3-5
	Least	14.1	13.5	6.5	6.1	8.0	5.9	1.6	5.0	6.3	9.7	9.0	10.3	na	3-5
Northwest Coast:															
Jesselton*.....	Greatest	16	10	14	10	16	18	24	26	22	27	18	22	141	26
	Least	1	0	0	0	3	4	3	2	7	7	4	2	76	26
Kota Belud.....	Greatest	16.7	8.3	13.5	11.6	16.6	23.8	12.3	15.4	15.8	24.1	18.0	23.0	129.8	14-15
	Least	0.7	**	0.5	0.0	1.1	1.1	1.4	1.3	2.5	4.4	6.0	1.4	58.9	14-15
Limbang.....	Greatest	16.0	30.3	13.0	22.9	18.1	17.8	12.5	15.9	17.2	15.7	19.1	17.4	181.0	8-11
	Least	0.2	3.4	5.5	4.1	6.1	5.3	4.9	4.6	5.0	7.2	5.0	5.2	130.3	8-11
Marudi.....	Greatest	13.6	13.7	13.9	14.9	14.2	15.3	9.2	10.8	12.8	13.3	16.2	13.4	134.9	7-11
	Least	2.6	4.1	4.1	0.0	6.3	3.7	5.2	3.8	6.2	6.6	7.1	6.6	91.3	7-11
Northeast Coast:															
Beluran.....	Greatest	40.3	22.9	18.3	15.2	13.3	19.0	25.2	22.0	19.4	18.7	17.3	23.0	167.6	14-15
	Least	6.7	3.2	4.0	1.2	3.1	5.2	4.1	1.3	3.9	2.3	5.1	5.2	92.4	14-15
Kudat*.....	Greatest	36	21	19	11	9	7	8	15	11	15	19	41	132	20
	Least	5	0	0	0	0	1	0	0	1	3	5	7	57	20
Lahad Datu.....	Greatest	13.6	14.0	8.8	7.4	19.2	11.4	8.5	9.2	8.4	12.1	8.3	22.8	92.4	9-10
	Least	3.4	1.4	1.6	1.2	2.5	2.9	3.2	1.1	1.1	3.1	4.7	3.2	61.4	9-10
Lamag.....	Greatest	31.2	14.6	19.4	14.4	19.8	15.3	17.2	30.1	28.9	12.4	19.1	31.8	168.7	9-10
	Least	6.1	3.0	3.4	2.2	4.0	3.8	5.2	0.8	4.1	1.0	6.7	5.7	91.1	9-10
Langkon.....	Greatest	36.4	8.8	11.7	9.2	10.7	11.8	8.8	12.9	8.5	8.9	12.6	33.4	120.4	9-10
	Least	5.1	0.8	1.6	0.8	0.6	2.6	0.9	1.1	1.8	2.2	2.2	5.0	60.7	9-10
Sandakan.....	Greatest	61.1	34.5	24.9	10.6	16.7	17.1	11.9	17.9	20.4	18.1	31.4	43.9	177.6	52
	Least	1.4	0.0	0.0	0.5	1.0	2.5	2.7	2.0	2.1	2.3	3.8	5.8	67.2	52
Semporna.....	Greatest	12.8	5.7	8.4	13.4	9.2	7.5	19.8	9.3	10.6	11.7	7.6	10.1	103.4	15
	Least	2.1	0.9	1.2	2.8	4.1	4.7	2.4	4.6	3.5	4.5	4.5	3.5	51.6	15
Tawau*.....	Greatest	13	10	9	11	18	18	17	15	12	13	13	11	96	20
	Least	1	0	1	1	3	2	4	3	2	1	1	3	58	20
Interior Highlands:															
Kanowit.....	Greatest	16.3	17.0	14.4	17.8	21.2	11.5	14.7	14.2	14.9	15.2	18.5	18.5	151.6	6-9
	Least	3.5	13.1	4.6	5.0	4.2	2.5	3.7	6.7	6.5	10.2	9.1	6.2	111.3	6-9
Kapit.....	Greatest	20.6	15.7	18.1	16.6	17.4	15.4	14.2	14.6	20.3	16.3	14.5	15.6	148.1	7-11
	Least	7.3	5.2	9.1	6.0	8.5	4.2	5.9	8.0	7.0	9.1	5.4	8.8	121.2	7-11
Kemabong.....	Greatest	10.8	10.1	13.0	13.4	13.0	10.0	9.4	11.9	11.2	10.9	11.6	9.6	86.2	9-10
	Least	2.4	1.6	2.7	5.1	2.5	1.2	2.9	2.5	1.5	2.1	3.2	0.7	54.4	9-10
Long Akah.....	Greatest	23.9	24.6	29.4	24.0	21.6	20.3	18.7	23.5	26.0	29.9	33.1	23.9	257.4	3-8
	Least	7.1	12.1	7.3	13.0	13.0	6.3	16.0	7.2	9.9	16.0	22.3	19.1	214.0	3-8
Lubok Antu.....	Greatest	21.4	15.4	12.0	17.4	17.3	12.5	15.4	18.5	11.0	14.9	18.9	14.6	138.4	5-8
	Least	6.5	4.6	8.2	7.7	4.3	2.8	3.3	5.2	6.7	5.8	10.2	6.1	122.5	5-8
Pensiangan.....	Greatest	17.5	14.7	16.3	18.9	23.6	21.5	17.1	13.3	17.5	19.1	19.3	13.4	141.8	9-10
	Least	4.8	2.6	6.4	7.6	9.1	6.6	2.5	5.6	5.5	5.0	5.6	2.3	90.8	9-10
Putussibau* ***.....	Greatest	26	29	23	38	28	21	24	26	41	39	31	24	130	31
	Least	3	5	4	4	1	1	2	2	3	5	7	4	na	31
Sapong.....	Greatest	11.5	15.2	14.4	14.0	12.3	12.7	7.1	11.7	8.4	11.5	14.0	15.0	103.1	9-10
	Least	1.4	1.3	1.8	3.4	2.5	3.4	1.2	2.6	2.2	3.0	2.6	1.7	57.3	9-10
Sapulut.....	Greatest	8.7	17.1	12.1	22.7	22.4	18.2	11.0	13.5	16.4	16.3	11.4	14.6	119.4	9-10
	Least	2.2	1.2	1.9	6.2	5.3	5.7	2.4	2.1	5.4	3.0	2.6	3.0	83.6	9-10
Tambunan.....	Greatest	11.3	18.1	12.2	11.7	12.9	11.3	13.8	8.8	9.6	10.3	11.4	10.3	98.6	15
	Least	0.7	0.6	1.8	1.6	3.0	3.9	2.2	2.9	2.1	3.7	3.8	2.8	59.3	15

na Data not available.

* Data rounded to nearest whole number.

** <0.05 inch.

*** Near but outside NIS 44B Area.

FIGURE 23-36. MAXIMUM 24-HOUR PRECIPITATION (INCHES)

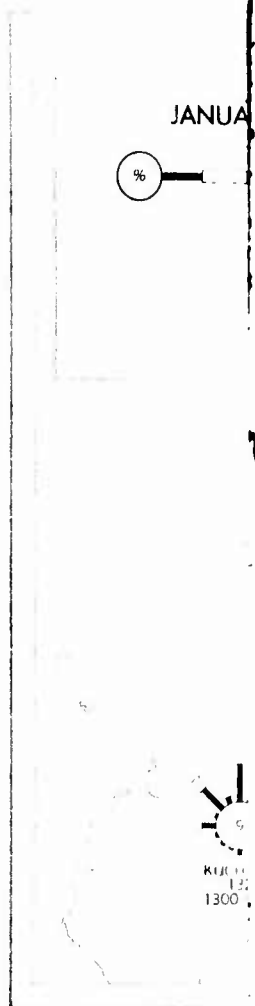
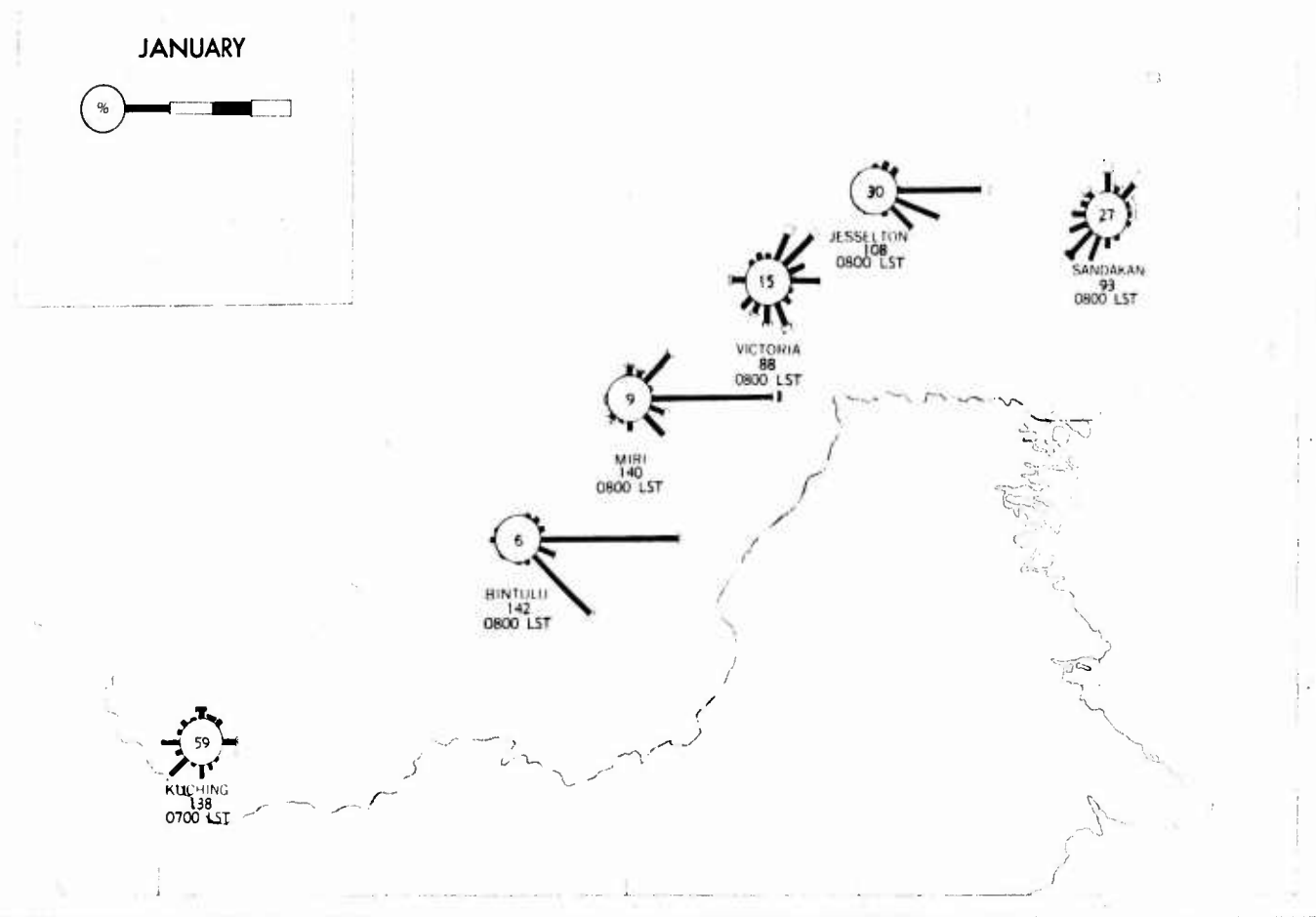
REGION AND STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
Southwest Coast:														
Betong.....	4.2	4.7	7.0	4.0	5.0	4.0	2.3	4.6	3.6	3.2	3.8	3.6	7.0	5-12
Bintulu.....	6.2	6.8	5.0	4.8	4.2	6.7	4.9	4.2	4.6	3.9	6.3	6.5	6.8	11-14
Kuching.....	12.5	10.1	8.3	4.3	4.1	3.9	3.9	4.3	4.1	4.5	10.6	7.3	12.5	27
Matu.....	5.8	3.9	2.9	2.9	5.3	3.0	5.8	5.8	5.8	5.8	7.7	6.8	7.7	4-9
Mukah.....	7.8	8.5	7.3	2.4	3.5	6.5	2.6	2.6	4.9	4.8	3.3	6.1	8.5	7-11
Selalang.....	4.7	3.6	5.1	5.7	3.0	2.5	3.7	4.3	3.3	3.5	5.3	4.3	5.7	5-11
Sibu.....	4.7	5.5	4.6	5.5	3.4	3.3	2.3	6.4	4.9	4.2	4.3	3.7	6.4	9-12
Simunjan.....	6.4	7.1	4.5	2.5	2.8	5.1	6.0	4.3	3.9	5.0	2.8	7.4	7.4	3-5
Northwest Coast:														
Beaufort.....	8.3	9.8	3.8	4.2	5.1	5.5	4.0	4.1	4.9	4.3	7.0	4.1	9.8	12
Jesselton.....	4.5	2.8	2.3	3.5	4.8	5.6	3.6	11.7	6.0	7.0	5.6	5.7	11.7	12-14
Limbang.....	3.2	13.0	3.4	4.6	3.1	5.8	3.2	5.3	3.7	3.7	3.3	4.5	13.0	7-10
Marudi.....	4.5	2.8	3.7	2.7	3.0	5.6	2.9	2.5	3.1	3.0	6.6	3.6	6.6	6-9
Miri.....	7.2	7.4	3.6	3.5	4.2	9.2	5.7	6.3	7.7	4.9	9.0	6.1	9.2	11-14
Victoria.....	5.1	12.4	3.6	5.7	6.5	8.0	6.9	5.0	14.5	6.3	10.6	4.9	14.5	21
Northeast Coast:														
Kudat.....	7.1	4.7	4.0	2.1	3.2	2.0	3.6	4.0	2.4	3.4	3.8	7.6	7.6	11
Sandakan.....	14.5	7.8	6.6	4.5	5.5	4.7	3.5	3.9	4.8	5.6	5.1	12.5	14.5	28
Tawau.....	2.3	2.8	2.6	5.0	4.5	5.5	4.4	4.8	3.0	2.5	2.9	3.5	5.5	11
Interior Highlands:														
Kanowit.....	2.9	3.6	6.0	3.5	5.9	2.9	4.6	4.7	7.4	3.4	3.6	3.3	7.4	5-7
Kapit.....	3.8	3.0	4.0	5.1	3.6	3.1	2.4	2.9	3.2	3.2	4.4	2.9	5.1	7-11
Long Akah.....	3.9	6.5	5.6	4.1	3.9	5.5	6.3	2.3	6.5	5.0	5.6	4.2	6.5	3-7
Lubok Antu.....	4.8	4.6	2.0	3.9	4.7	2.4	1.7	2.9	3.5	2.8	4.2	2.5	4.8	3-6
Tambunan.....	3.1	2.3	3.8	2.3	2.1	2.3	2.2	2.0	2.7	2.2	2.2	2.4	3.8	10
Tenom.....	2.4	3.4	6.3	2.4	2.2	2.2	3.1	2.2	2.1	2.6	3.2	4.8	6.3	10

FIGURE 23-37. MEAN NUMBER OF DAYS WITH SPECIFIED PRECIPITATION AMOUNTS

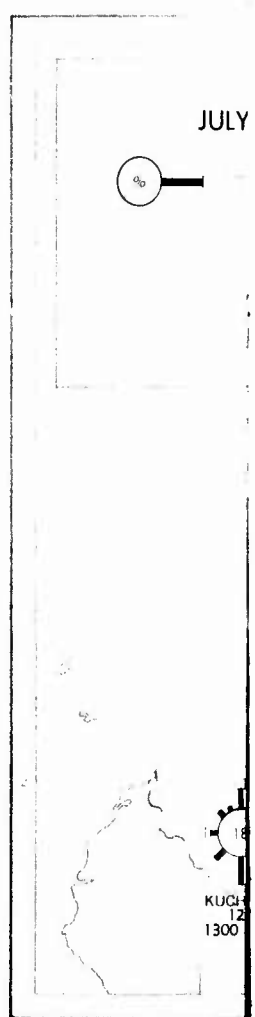
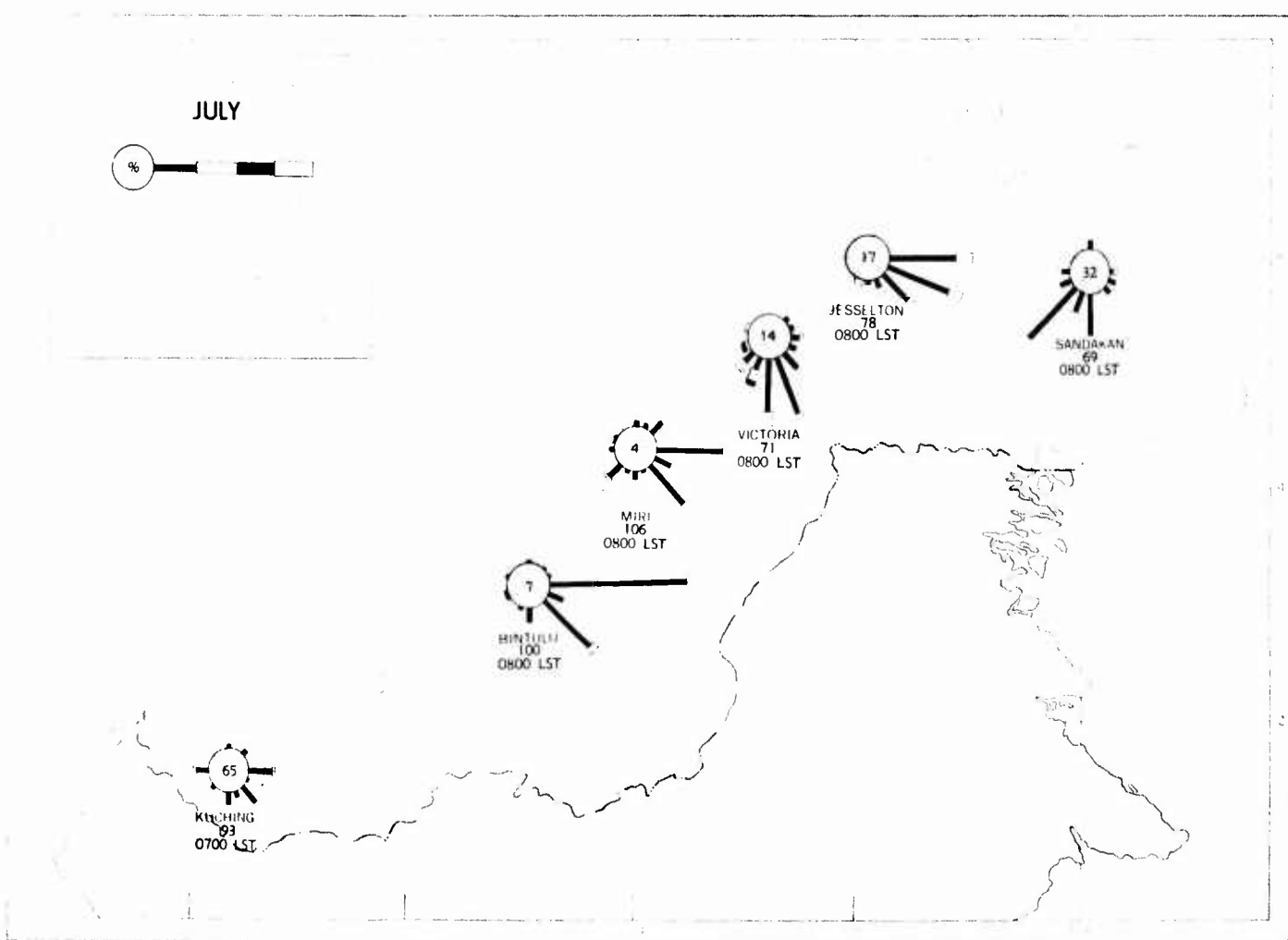
REGION AND STATION	AMOUNT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	YRS REC
	<i>inches</i>														
Southwest Coast:															
Betong.....	≥ 0.01	20	15	14	13	13	9	12	12	15	16	21	23	183	5-10
Bintulu.....	≥ 0.01	21	17	17	17	17	14	14	18	17	20	20	22	214	11-14
Kuching.....	≥ 0.04	22	18	18	16	16	13	13	13	16	19	20	23	207	18
Matu.....	≥ 0.01	14	10	8	7	8	7	7	7	9	14	15	17	123	6-10
Mukah.....	≥ 0.01	21	16	12	9	10	10	9	11	14	16	17	22	167	7-11
Selalang.....	≥ 0.01	17	14	16	12	12	10	9	10	13	16	18	17	164	6-10
Sibu.....	≥ 0.01	22	17	17	17	17	13	14	14	16	19	18	22	206	8-12
Simunjan.....	≥ 0.01	18	15	14	12	13	12	10	11	13	12	16	19	165	3-5
Northwest Coast:															
Beaufort.....	≥ 0.04	16	11	13	16	15	12	13	14	18	19	17	17	181	12
Jesselton.....	≥ 0.01	12	7	9	11	14	15	13	13	17	19	17	16	163	21
Kota Belud.....	≥ 0.01	12	5	9	11	13	14	11	11	13	17	14	15	145	9-10
Limbang.....	≥ 0.01	16	15	14	15	18	15	15	15	18	20	19	18	198	7-11
Marudi.....	≥ 0.01	16	18	17	14	18	14	16	12	18	19	21	20	203	6-11
Miri.....	≥ 0.01	16	14	14	14	16	15	14	16	18	21	19	20	197	11-14
Victoria.....	≥ 0.01	9	11	10	15	19	16	15	17	18	21	21	19	191	14
Northeast Coast:															
Beluran.....	≥ 0.01	23	16	16	13	15	15	16	15	16	18	17	19	199	9-10
Kudat.....	≥ 0.04	18	11	11	8	8	9	8	10	12	15	16	19	145	10-11
Lahad Datu.....	≥ 0.01	13	8	10	7	11	11	9	7	8	10	11	12	117	4-5
Lamag.....	≥ 0.01	17	13	12	11	13	15	14	12	14	15	17	19	172	9-10
Langkon.....	≥ 0.01	16	7	9	8	9	12	8	9	8	13	11	15	125	8-10
Sandakan.....	≥ 0.04	19	13	13	11	10	14	14	12	15	18	19	20	178	9
Semporna.....	≥ 0.01	10	6	9	13	15	11	12	13	11	13	14	13	140	5-6
Tawau.....	≥ 0.04	11	8	11	9	11	11	12	12	10	11	10	11	127	11
Interior Highlands:															
Kanowit.....	≥ 0.01	20	19	15	15	19	12	17	16	16	19	19	21	208	5-9
Kapit.....	≥ 0.01	16	14	14	14	13	12	12	14	16	16	15	18	174	7-11
Kemabong.....	≥ 0.01	14	10	14	16	18	17	12	15	14	19	15	15	179	9-10
Long Akah.....	≥ 0.01	19	22	19	18	21	14	17	19	22	23	22	25	241	3-8
Longnawan*	> 0.02	20	17	22	22	22	18	17	18	22	22	24	21	245	24
Longpudjungan*	> 0.02	13	10	13	13	17	16	14	12	14	14	15	14	165	15
Lubok Antu.....	≥ 0.01	15	12	11	14	11	7	9	11	10	13	16	14	143	3-8
Pensiangan.....	≥ 0.01	15	12	17	18	18	18	14	14	16	15	17	14	188	9-10
Putussibau*	> 0.02	18	14	16	16	15	12	10	12	13	17	20	19	182	40
Sapong.....	≥ 0.01	17	10	14	15	19	19	15	18	15	21	17	15	195	9-10
Sapulut.....	≥ 0.01	13	10	12	16	15	14	11	12	15	13	12	12	155	9-10
Tambunan.....	≥ 0.01	18	12	18	20	22	23	18	20	19	24	23	20	237	9-10
Tenom.....	≥ 0.01	16	11	14	14	17	17	14	16	15	18	17	16	185	10

* Near but outside NIS 44B Area.

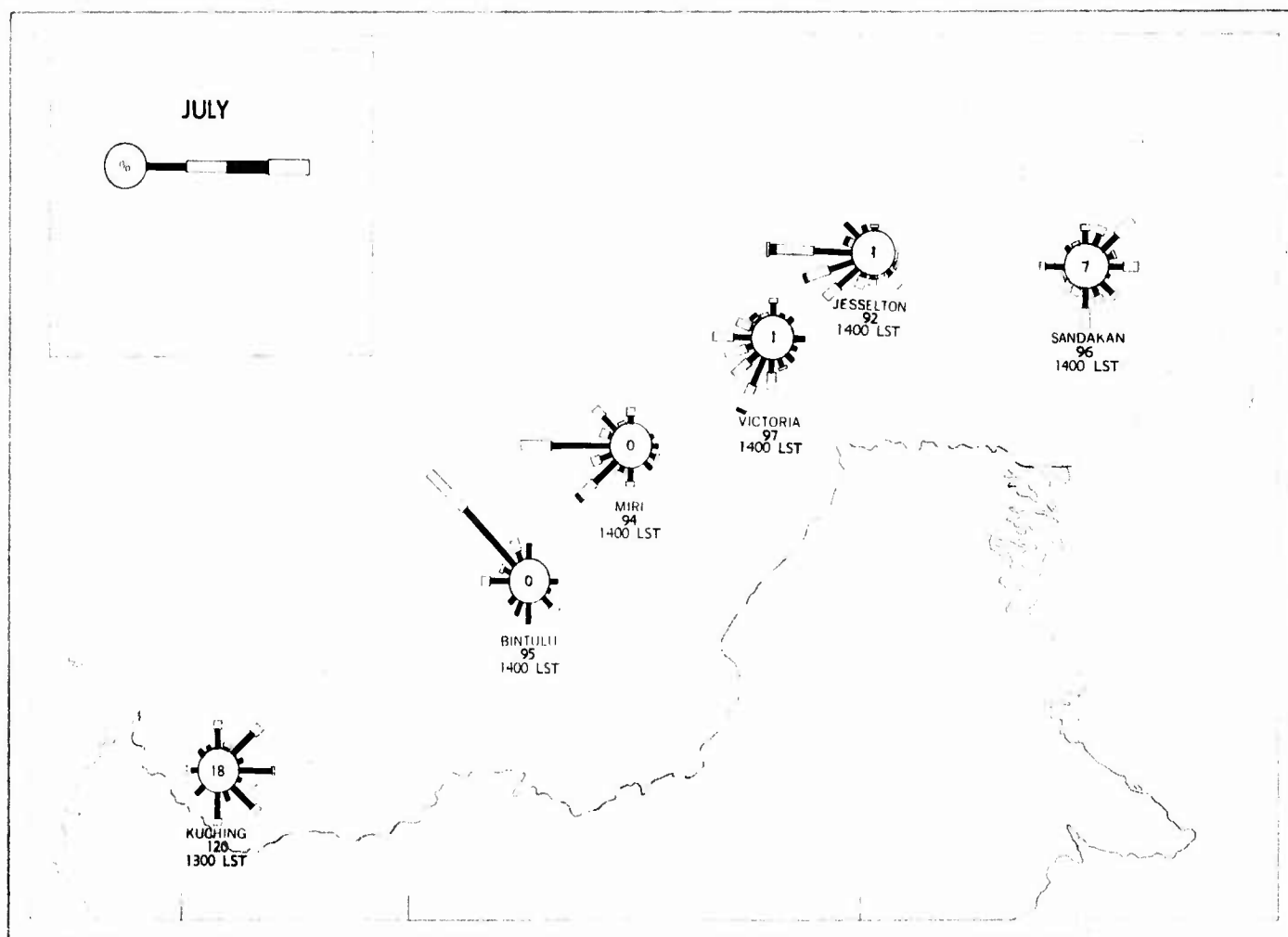
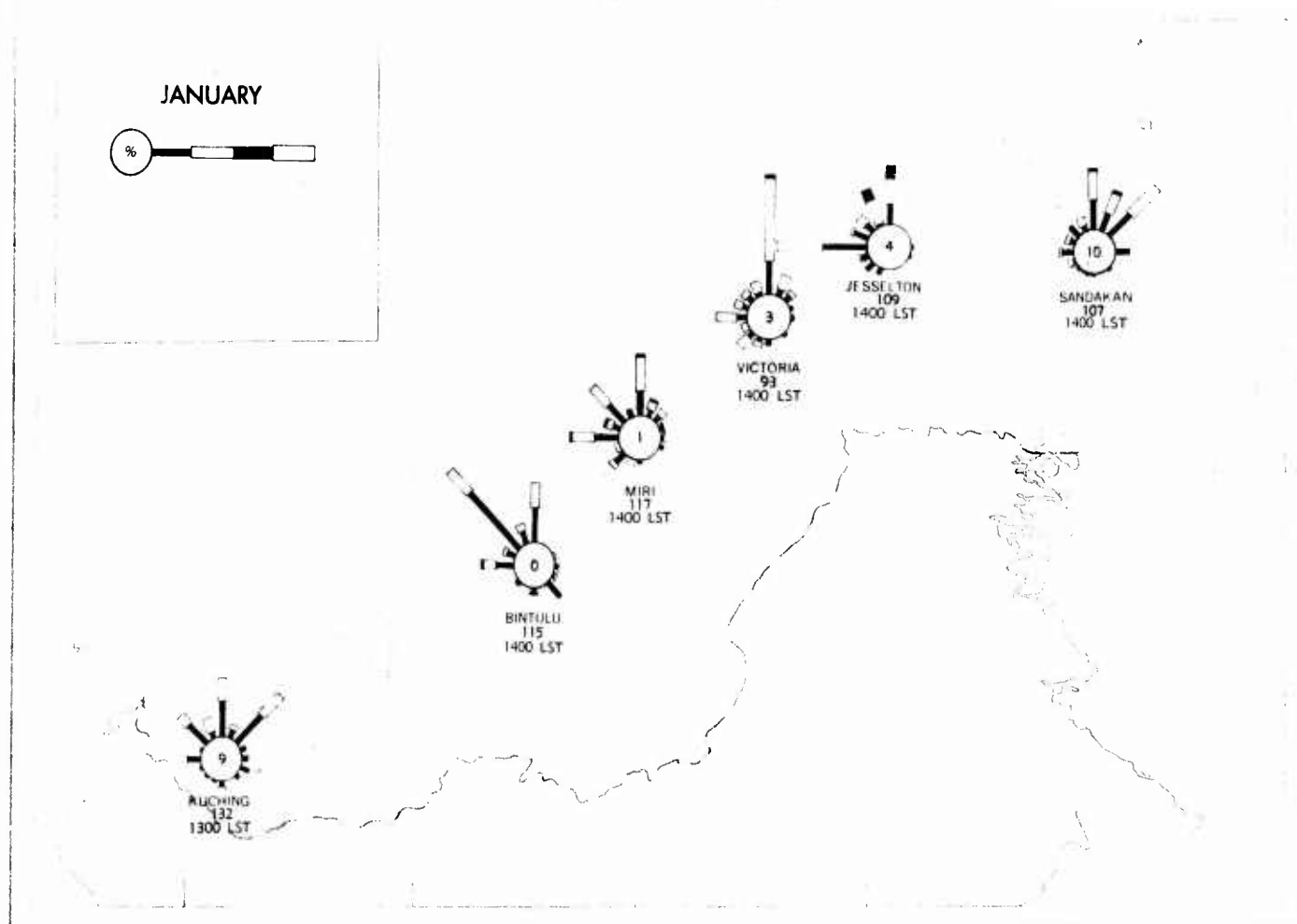
(B L A N K)



A. SURFACE WIND ROSES IN MORNING AND AFTERNOON JANUARY



B. SURFACE WIND ROSES IN MORNING AND AFTERNOON JULY



LIST OF STATIONS

REGION AND STATION	LATI- TUDE*	LONGI- TUDE*	ELEVA- TION
	° 'N.	° 'E.	feet
SOUTHWEST COAST:			
Betong.....	1 25	111 31	279
Bintulu.....	3 10	113 02	10
Kuching.....	1 33	110 21	43
Lundu.....	1 40	109 50	450
Matu.....	2 40	111 31	**10
Mukah.....	2 54	112 06	**20
Selalang.....	2 02	111 19	**100
Sibu.....	2 17	111 49	**200
Simunjan.....	1 20	110 43	**300
NORTHWEST COAST:			
Beaufort.....	5 20	115 45	**675
Brunei.....	4 53	114 56	**50
Jesselton.....	5 58	116 04	9
Kota Belud.....	6 21	116 26	**75
Labu.....	4 45	115 11	**300
Limbang.....	4 44	115 00	644
Marudi.....	4 10	114 19	**600
Miri.....	4 23	113 59	12
Victoria.....	5 17	115 16	58
NORTHEAST COAST:			
Beluran.....	5 54	117 33	**20
Kudat.....	6 53	116 50	**10
Lahad Datu.....	5 02	118 19	**25
Lamag.....	5 29	117 49	**700
Langkon.....	6 32	116 42	**350
Sandakan.....	5 52	118 06	38
Semporna.....	4 28	118 36	**15
Tawau.....	4 14	117 54	**10
INTERIOR HIGHLANDS:			
Kanowit.....	2 06	112 09	**250
Kapit.....	2 00	112 56	**300
Kemabong.....	4 55	115 56	**650
Long Akah.....	3 19	114 47	**325
Longnawan***	1 54	114 53	1,640
Longpudjungan***	2 34	115 40	715
Lubok Antu.....	1 03	111 50	**700
Pensiangan.....	4 33	116 19	**550
Putussibau***	0 50	112 56	164
Ranau.....	5 58	116 41	**1,600
Rundum.....	4 45	116 06	**2,200
Sapong.....	4 59	115 57	**675
Sapulut.....	4 42	116 27	**650
Tambunan.....	5 40	116 22	**1,200
Tenom.....	5 07	115 57	**600

* Coordinates give locations of weather stations and do not necessarily correspond to those for populated places.

** Approximate elevation.

*** Near but outside NIS 44B Area.

GENERAL BASIC INFORMATION

- — — — — International boundary
- — — — — Division, district, or residency boundary
- ⊙ Colony or protectorate capital
- Sandakan Division, district, or residency administrative seat
- — — — — Railroad
- — — — — Road
- 2740 Spot height (in feet)

1

109 110 111 112

8
7
6
5
4
3

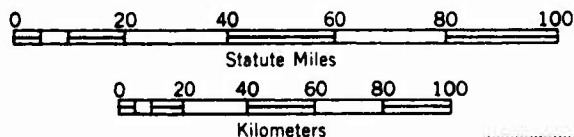
BRITISH INDONESIA BRITISH BORNEO STATION LOCATIONS

● METEOROLOGICAL STATION

Locations are shown only for stations for which data are presented in text or tables.

DISCUSSION REGION BOUNDARY

- I SOUTHWEST COAST
- II NORTHWEST COAST
- III NORTHEAST COAST
- IV INTERIOR HIGHLANDS



NIS Area boundary

GLOSSARY

batang river
kampong village
kuala river mouth
pulau island
sungai river
sungei river
tanjong point

SOUTH CHINA

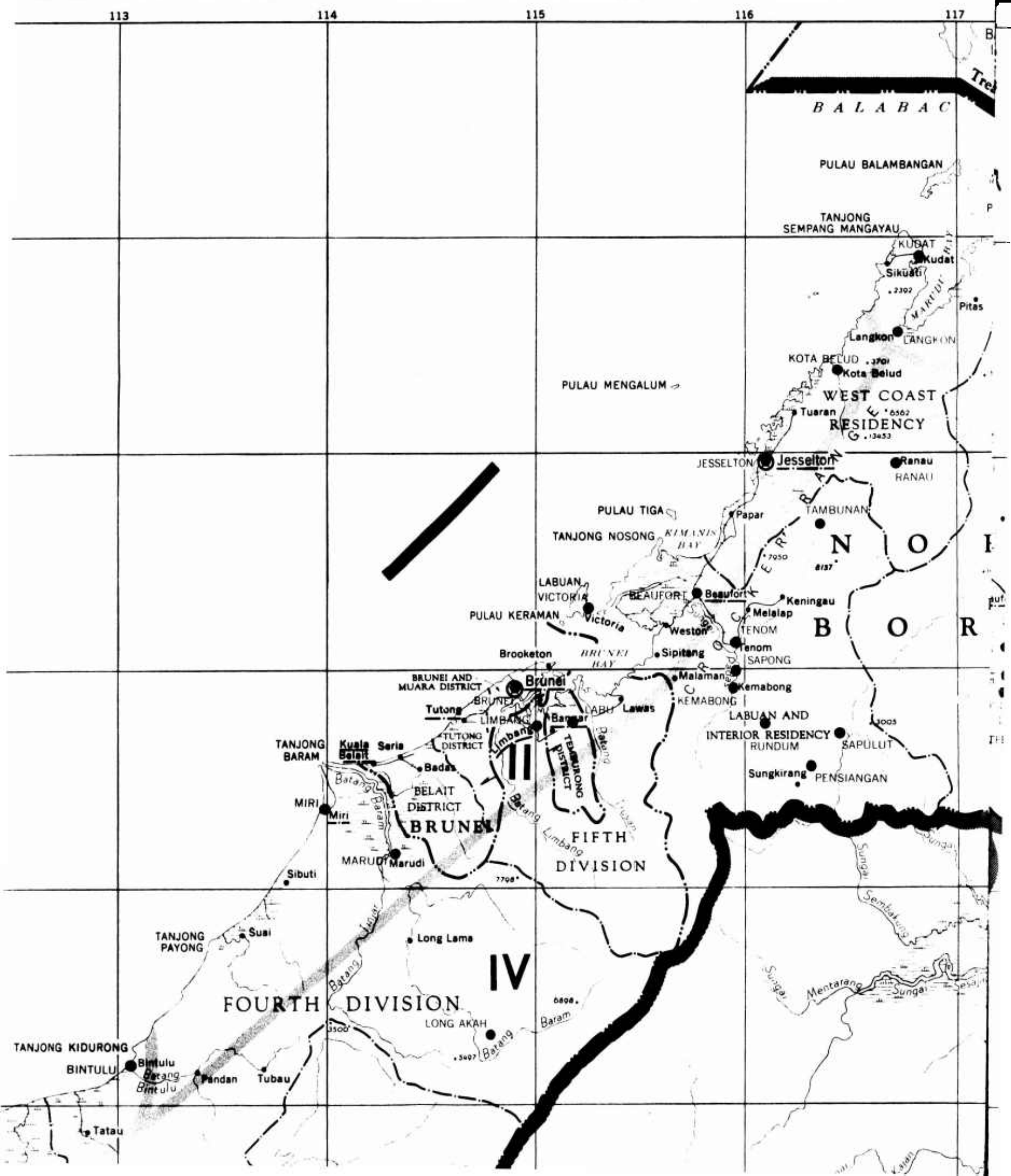
SEA

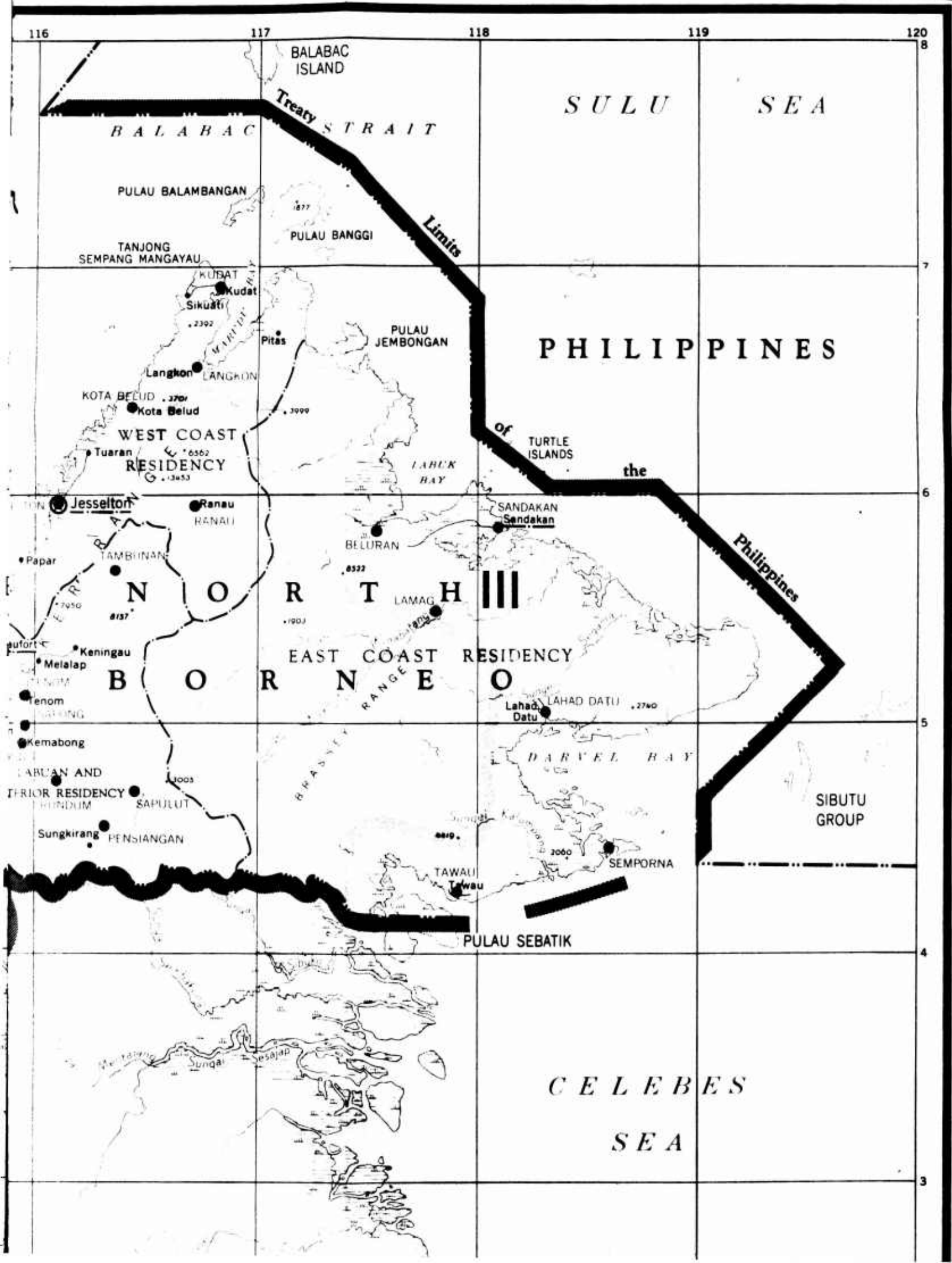
TANJONG

SOUTH

TANJONG SIRIK

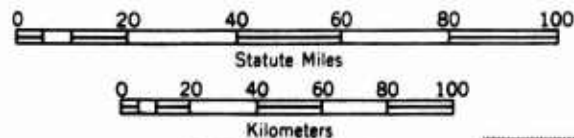






III NORTHEAST COAST

IV INTERIOR HIGHLANDS



NIS Area boundary

GLOSSARY

batang river
kampong village
kuala river mouth
pulau island
sungai river
sungei river
tanjong point

SOUTH CHINA

SEA

*SOUTH
NATUNA ISLANDS*

TANJONG KID
BIR

MUKAH

TANJONG SIRIK

MATU
Kuala Matu

Dalat

SIBU

Sibu

KANOWIT

Kanowit

Batang Rajang

SARAI

SELANG

Saratok

BETONG

Betong

Simunjan

Simunjan

Engkilil

LUBOK ANTU

UPPER

Sungai Embai

THIRD D

3170

2600

2750

2750

2750

TANJONG DATU

SISO

Lundu

LUNDU

Kuching

Kuching

Kampong Kandis

Simunjan

Simunjan

Serian

2750

2750

2750

2750

2750

The transportation shown on this map is generalized and for orientation purposes only.

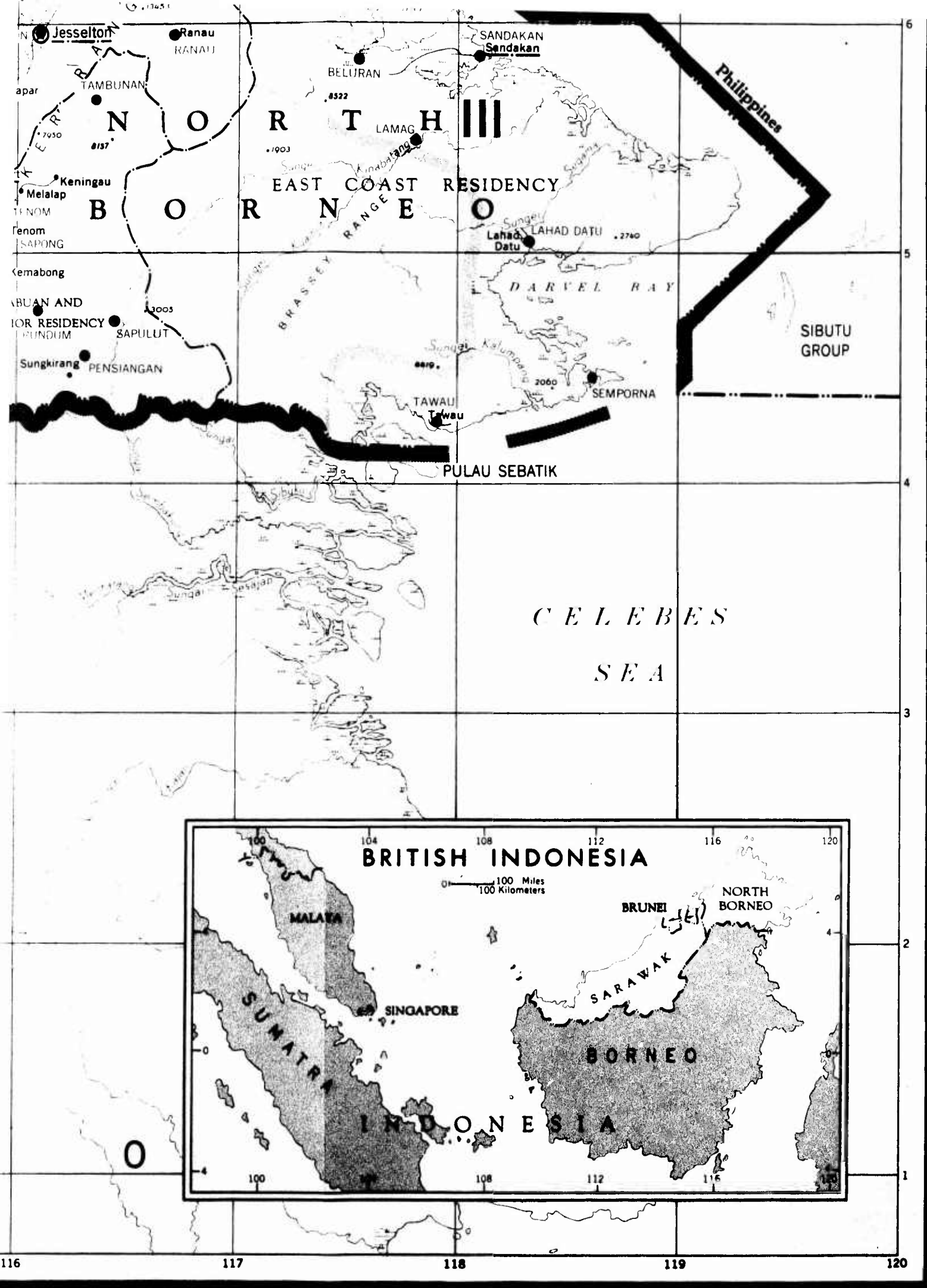
109

110

111

112

22074, AWS



STATION LOCATIONS FIGURE 23-39