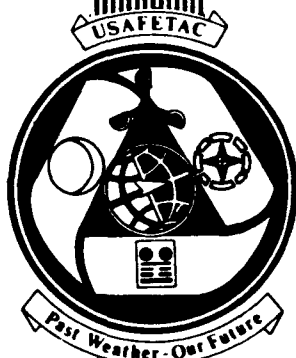
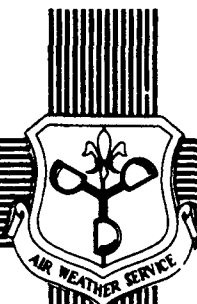


AD-A260 152

USAFETAC/TN--92/006

②



CLIMATE AND WEATHER

of the

HORN OF AFRICA

=EXECUTIVE SUMMARY=

by

Kenneth R. Walters, Sr
Capt Richard D. Arnold

DECEMBER 1992

DTIC
ELECTE
JAN 29 1993
S E D

Approved for public release;
distribution is unlimited.

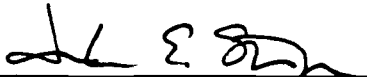
93-01693

USAF
ENVIRONMENTAL TECHNICAL
APPLICATIONS CENTER

Scott Air Force Base, Illinois, 62225-5116

REVIEW AND APPROVAL STATEMENT

USAFETAC/TN--92/006, *Horn of Africa Climate and Weather--Executive Summary*, December 1992, has been reviewed and is approved for public release. There is no objection to unlimited distribution of this document to the public at large, or by the Defense Technical Information Center (DTIC) to the National Technical Information Service (NTIS).



JUDSON E. STAILEY, Lt Col, USAF
Commander



KENNETH R. WALTERS, Sr
Lead Writer



WALTER S. BURGMANN
Scientific and Technical Information
Program Manager
24 December 1992

REPORT DOCUMENTATION PAGE

2. Report Date: December 1992
3. Report Type: Technical Note
4. Title: Horn of Africa Climate and Weather--Executive Summary
6. Author: Kenneth R. Walters, Sr., Capt Richard D. Arnold
7. Performing Organization Name and Address: USAF Environmental Technical Applications Center (USAFETAC), Building 859 Buchanan Street, Scott Air Force Base, Illinois 62225-5116
8. Performing Organization Report Number: USAFETAC/TN--92/006
12. Distribution/Availability Statement: Approved for public release; distribution is unlimited.
13. Abstract: Provides a brief executive summary of annual weather and climatology for the region generally known as the "Horn of Africa," an area that comprises Somalia, Yemen, Djibouti, Ethiopia, Sudan, and Kenya.
14. Subject Terms: CLIMATOLOGY, WEATHER, SUMMARY, HORN OF AFRICA, SOMALIA, YEMEN, DJIBOUTI, ETHIOPIA, SUDAN, KENYA
15. Number of Pages: 36
17. Security Classification of Report: Unclassified
18. Security Classification of this Page: Unclassified
19. Security Classification of Abstract: Unclassified
20. Limitation of Abstract: UL

PREFACE

This summary was requested by the U.S. Transportation Command (USTRANSCOM) staff to assist in planning for Operation RESTORE HOPE, which began on 9 December 1992. The study begins with a general summary of climate and weather across the entire Horn of Africa, then provides a similar summary for each of the countries it comprises. Most of the information in this summary was extracted from USAFETAC/TN--90/004, *SWANEA (Southwest Asia--Northeast Africa)--A Climatological Study, Volume 1--The Horn of Africa*, supplemented with more up-to-date information recently available. The lead writer is Chief of the USAF Environmental Technical Applications Center's Readiness Support Branch, USAFETAC/DOJ.

Accession For	
NTIS CRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and/or Special
A-1	

DTIC QUALITY INSPECTED 3

CONTENTS

HORN OF AFRICA CLIMATE AND WEATHER	1
CLIMATE CONTROLS	2
SIGNIFICANT WEATHER	3
SOMALIA CLIMATE AND WEATHER	11
SOMALIA GENERAL WEATHER.	11
Storms and Frontal Weather	11
Hazardous Weather.	12
Tides.	13
Currents.	13
SOMALIA SEASONAL WEATHER.	13
The Northeast Monsoon	13
The Spring Transition	14
The Southwest Monsoon	14
The Fall Transition	15
YEMEN CLIMATE AND WEATHER	16
YEMEN GENERAL WEATHER	16
The Northeast Monsoon	17
The Spring Transition	17
The Southwest Monsoon	17
The Fall Transition	18
DJIBOUTI CLIMATE AND WEATHER	19
DJIBOUTI GENERAL WEATHER	19
DJIBOUTI SEASONAL WEATHER	19
The Northeast Monsoon	19
The Spring Transition	20
The Southwest Monsoon	20
The Fall Transition	20
ETHIOPIA CLIMATE AND WEATHER	21
ETHIOPIA GENERAL WEATHER	21
ETHIOPIA SEASONAL WEATHER	21
The Northeast Monsoon (December-March)	22
Spring Transition (April-May)	22
Southwest Monsoon (June-September)	22
Fall Transition (October-November)	22

SUDAN CLIMATE AND WEATHER	23
SUDAN GENERAL WEATHER.	23
SUDAN SEASONAL WEATHER.	24
Dry Season (Mid-November-February)	24
Spring Transition (March-May)	24
Wet Season (June-September)	24
Fall Transition (October-mid November)	25
 KENYA CLIMATE AND WEATHER	26
KENYA GENERAL WEATHER	26
KENYA SEASONAL WEATHER	26
The Northeast Monsoon (Late December-February)	27
The Spring ("Long") Rains (March-July)	27
The Southeast Monsoon (August-mid October)	27
The Fall ("Short") Rains (Late October-mid December)	27

FIGURES

Figure 1. The region generally known as the "Horn of Africa" comprises the countries of Somalia, Yemen, Djibouti, Ethiopia, Sudan, and Kenya	1
Figure 2. Mean January Position of the NET and Associated Thunderstorms.	4
Figure 3. Mean February Position of the NET and Associated Thunderstorms.	4
Figure 4. Mean March Position of the NET and Associated Thunderstorms.	5
Figure 5. Mean April Position of the NET and Associated Thunderstorms.	5
Figure 6. Mean May Position of the NET and Associated Thunderstorms.	6
Figure 7. Mean June Position of the NET and Associated Thunderstorms.	6
Figure 8. Mean July Position of the NET and Associated Thunderstorms.	7
Figure 9. Mean August Position of the NET and Associated Thunderstorms.	7
Figure 10. Mean September Position of the NET and Associated Thunderstorms.	8
Figure 11. Mean October Position of the NET and Associated Thunderstorms.	8
Figure 12. Mean November Position of the NET and Associated Thunderstorms.	9
Figure 13. Mean December Position of the NET and Associated Thunderstorms.	9
Figure 14. Mean early August 3,000-foot (900-meter) Flow.	10
Figure 15. Maximum Observed Wind Speeds Associated with the Somali Jet.	10
Figure 16. Somalia Country Map.	11
Figure 17. The Somalia Low-Level Jet Stream.	12
Figure 18. Yemen country map.	16
Figure 19. Djibouti country map.	19
Figure 20. Ethiopia country map.	21
Figure 21. Sudan country map.	23
Figure 22. Kenya country map.	26

HORN OF AFRICA CLIMATE AND WEATHER

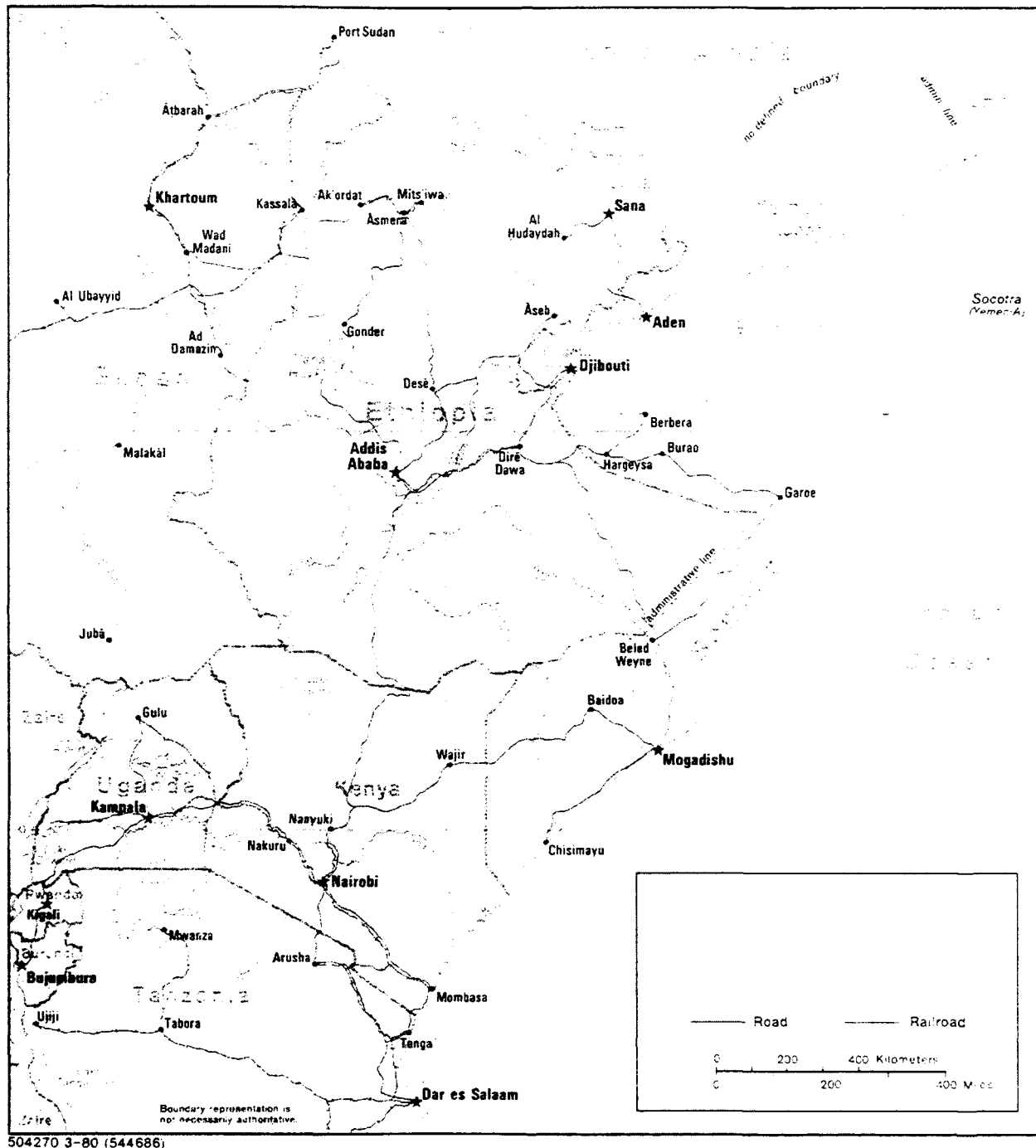


Figure 1. The region generally known as the "Horn of Africa" comprises the countries of Somalia, Yemen, Djibouti, Ethiopia, Sudan, and Kenya (map courtesy Central Intelligence Agency).

CLIMATE CONTROLS

Weather across the Horn of Africa is controlled by the north-south oscillation of the Near Equatorial Trough (NET), which is also known as the Intertropical Convergence Zone (ITCZ) or Monsoon Trough. Figures 2-13 show the *mean* monthly positions of the NET and associated thunderstorm activity. NET passage (either north or south) at any given location varies markedly from year to year. As a result, the frequency of shower or thundershower activity also varies greatly from one year to another. Additionally, orographic lifting of moist Indian Ocean air may cause isolated thunderstorms or showers to begin or persist well after the rest of an area has lost its shower activity. The hills northwest of Baidoa, Somalia, and the Kenyan highlands--especially in the higher mountains--are two known examples of such regions. Lake Victoria's "lake breeze" causes almost year-round thunderstorm and shower activity over an area just east and northeast of the lake.

- In January, only Sudan and northern Ethiopia are affected by northern hemisphere frontal systems; precipitation--mostly heavy showers or thundershowers--falls in northern Ethiopia and, because of forced lift, over the mountains along the southern shore of the Gulf of Aden and over the Kenyan highlands.. The rest of the region, under the influence of the Northeast Monsoon until late February or early March, is hot and dry.
- Between March and April, the NET moves rapidly northward, reaching southern Sudan and extreme northern Kenya by 1 April. By 1 May, it has reached a line that lies across central Sudan, northeast Ethiopia, and northern Somalia. By 1 July, the NET lies across extreme northern Sudan and northern Yemen.
- Onset of the Somali Jet occurs over Kenya in April after northward NET passage. This low-level, high-speed band of southern hemisphere air streams north, then northeast, across eastern Kenya, Somalia, and offshore southeast of Yemen and the Arabian Peninsula. It is a dominant feature of the Southwest Monsoon. It is strongest in July and August, but weakens by mid-September and disappears in late October as the NET moves south into central Somalia.
- In early September, the NET reverses direction and begins to move south, cutting off the moist southern hemisphere air that fuels extensive rainshowers and thunderstorms south of the NET. By about 1 November, the NET reaches southern Sudan, Southern Ethiopia, and central Somalia. It passes southward out of the area by mid-December to complete the annual cycle.

- The northerly to northeasterly low-level winds following the NET as it moves south bring good weather within 2 to 3 weeks of its passage. There is an exception: In Kenya just east of Lake Victoria, thunderstorms form year-round because of a complex lake breeze (similar to the sea breeze in coastal areas) that forces warm moist air up the mountains of western Kenya.

SIGNIFICANT WEATHER

- Air operations in Kenya and Somalia are temporarily restricted in Somalia and Kenya from a month before to a month after NET passage. They are also restricted over the southwestern half of Ethiopia and the southern half of Sudan from late April through October.
- Mogadishu has patchy night and morning low cloudiness during the Southwest Monsoon; there are isolated rain showers and an occasional thundershower during June and July. Late night and early morning low clouds are common at mountain airfields during both rainy seasons.
- Thunderstorm activity throughout the year is shown in Figures 2-13.
- Land transportation over unpaved roads is difficult during rainy seasons.
- Sea transport can be hazardous in the northern Arabian Sea and off the Somali and Kenyan coasts from June through September due to strong surface winds and high seas associated with the Somalia Jet, which routinely produces strong low-level wind shear and moderate turbulence or greater over eastern Kenya and the northern Arabian Sea. The jet also produces surface winds in excess of 25 knots over the northwestern Arabian Sea. The jet's position and wind speeds in early August are shown in Figure 14; Figure 15 shows the strongest known winds.
- Favored tracks for rare tropical storms are east of Madagascar. Isolated storms may enter the northern Mozambique channel in April and May and from September through December. They recurve and move southeast south of Madagascar, producing high seas and waves along the Kenyan coast.

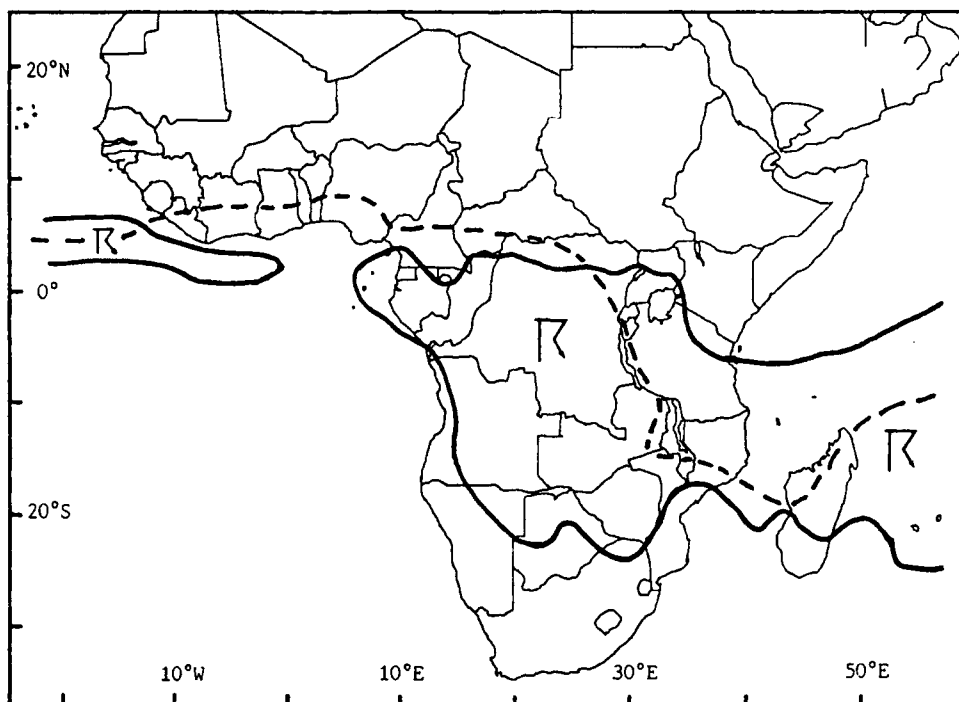


Figure 2. Mean January Position of the NET and Associated Thunderstorms. Thunderstorms are confined to Lake Victoria and the area around it.

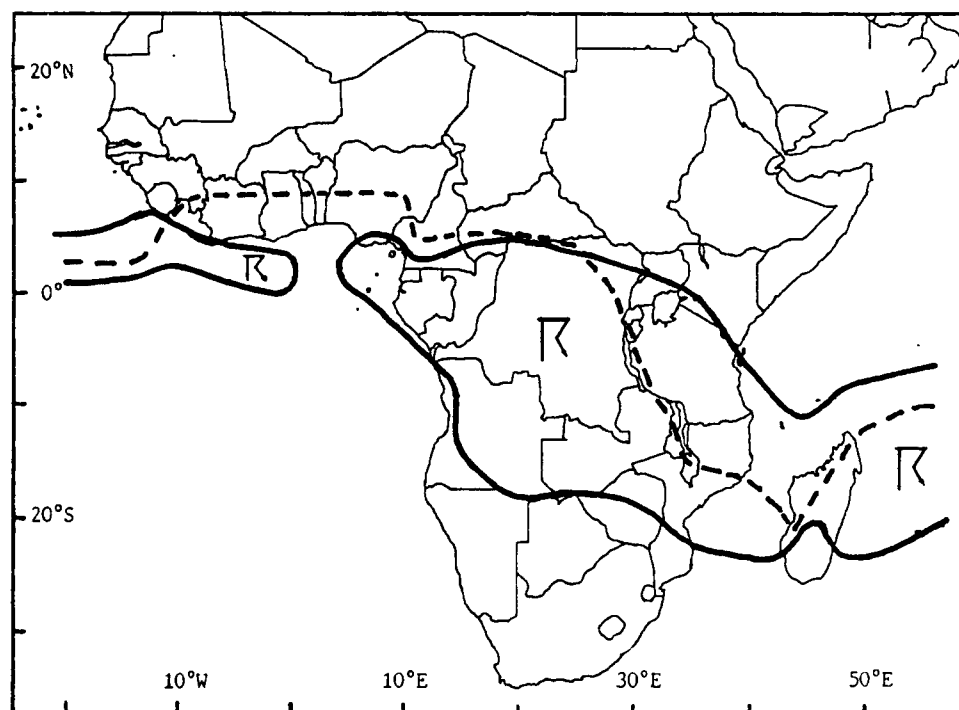


Figure 3. Mean February Position of the NET and Associated Thunderstorms. Thunderstorms have spread northeast into extreme southwestern Kenya.

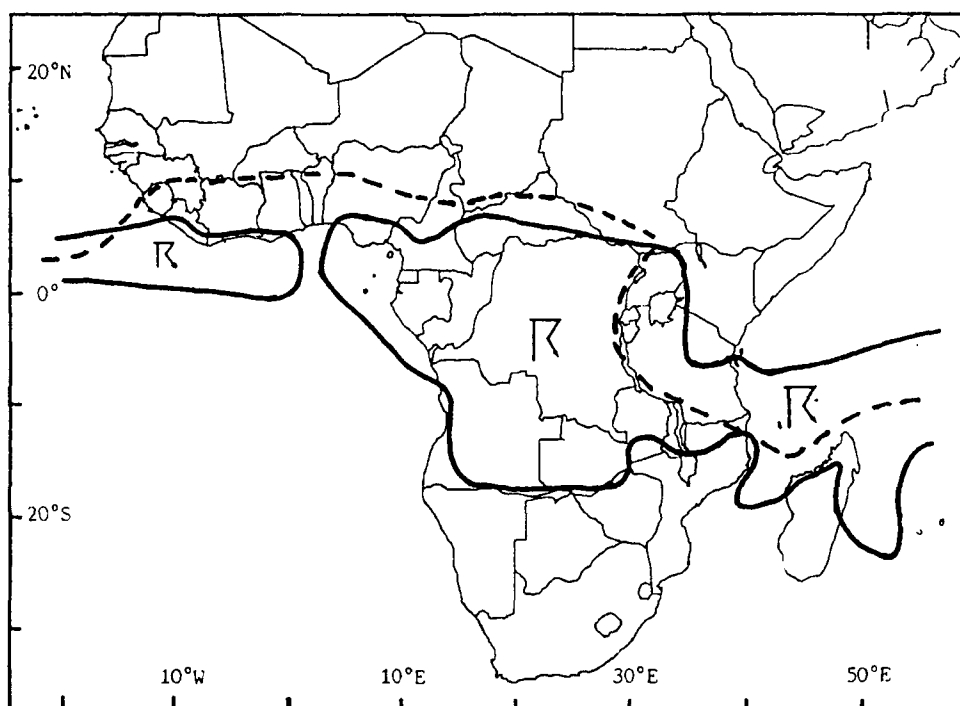


Figure 4. Mean March Position of the NET and Associated Thunderstorms. Thunderstorms are still confined to western Kenya.

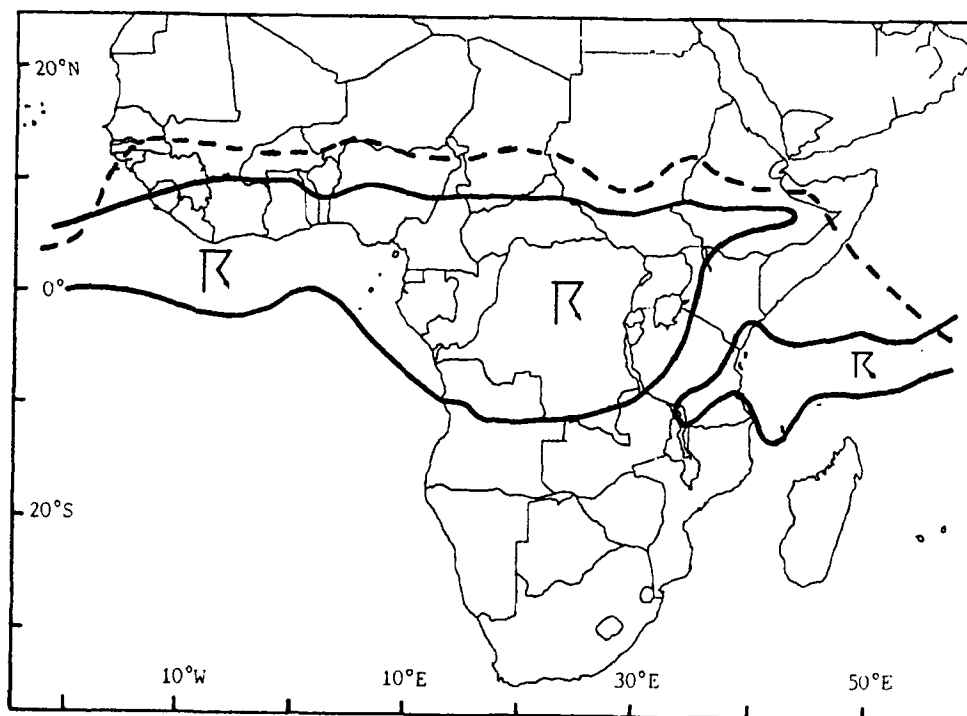


Figure 5. Mean April Position of the NET and Associated Thunderstorms. Thunderstorms have now spread into southern Sudan, southwestern Ethiopia, and southwestern Kenya.

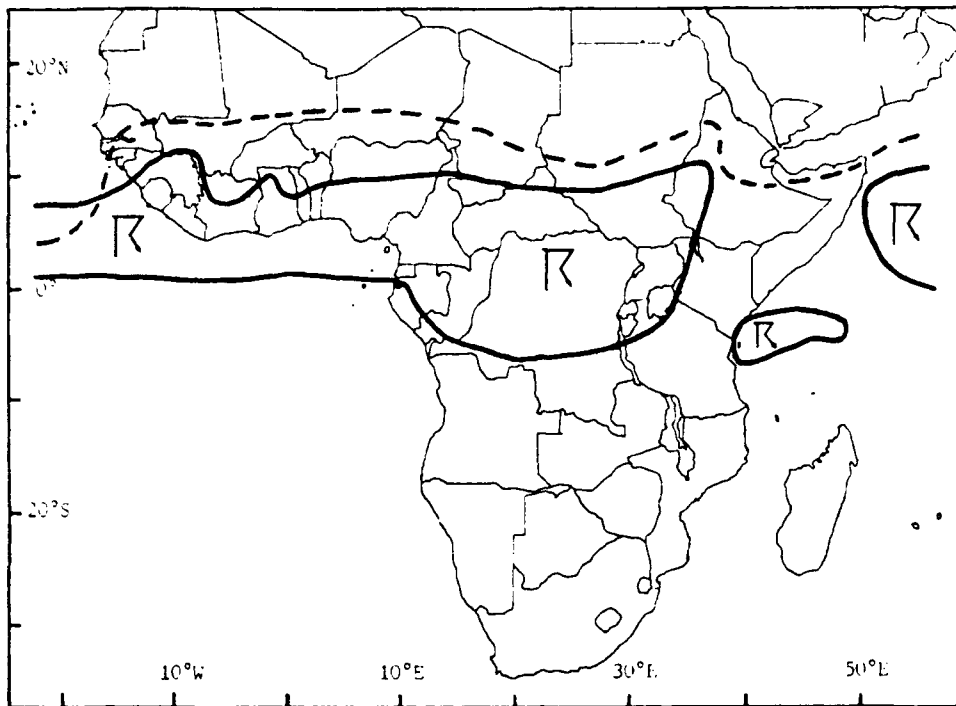


Figure 6. Mean May Position of the NET and Associated Thunderstorms. Thunderstorms are now common off the Kenyan coast, as well as in southern Sudan and southern Ethiopia.

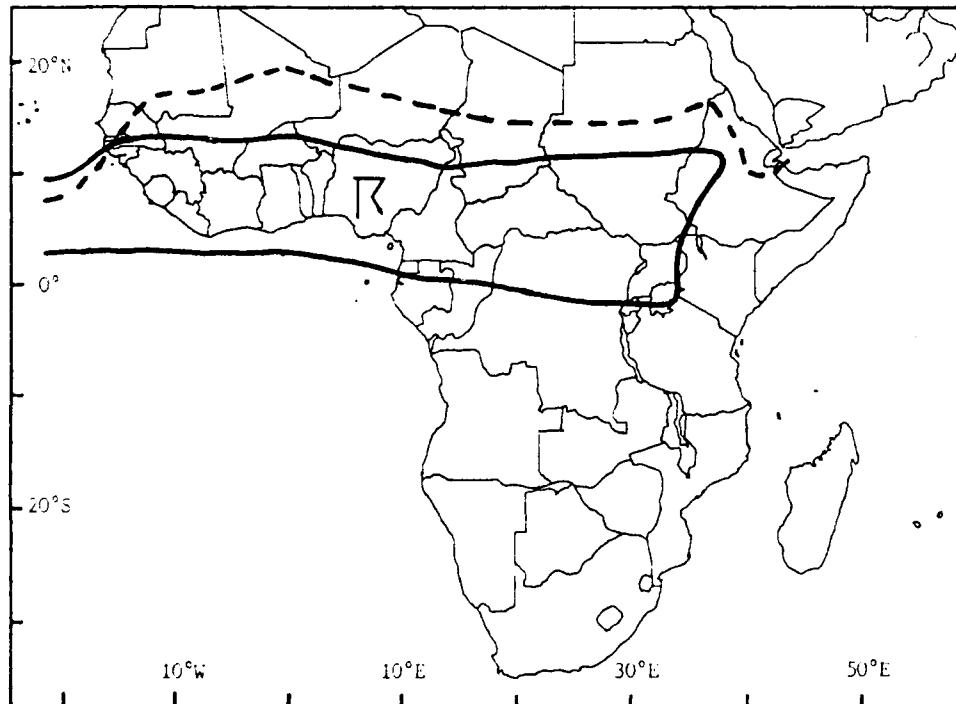


Figure 7. Mean June Position of the NET and Associated Thunderstorms. Thunderstorms are still common over southern Sudan and southwestern Ethiopia.

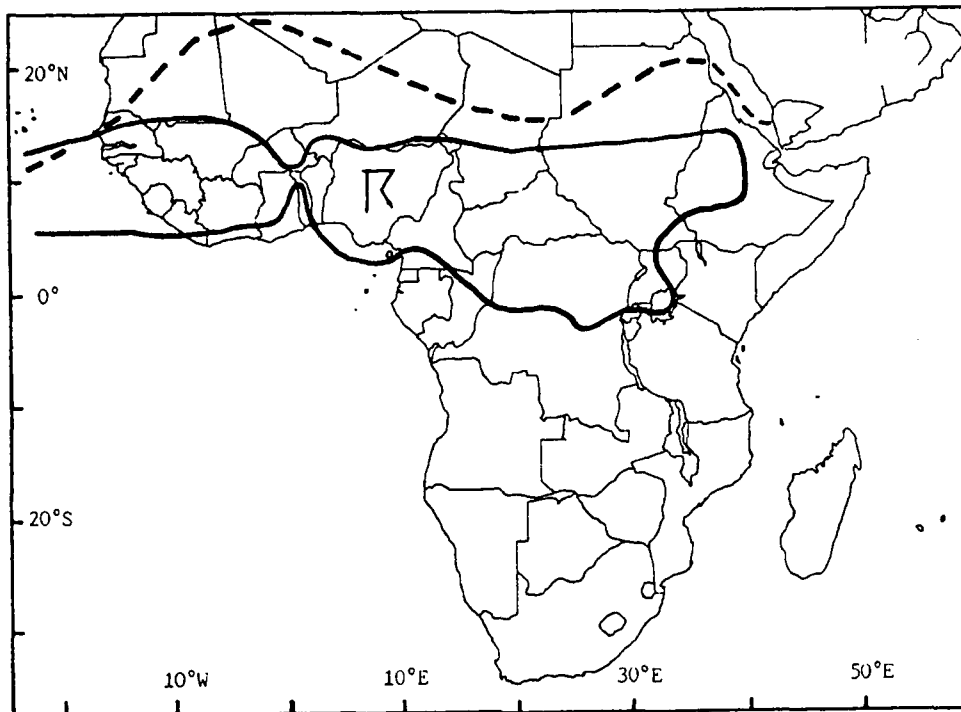


Figure 8. Mean July Position of the NET and Associated Thunderstorms. Thunderstorms remain common over southern Sudan and western Ethiopia.

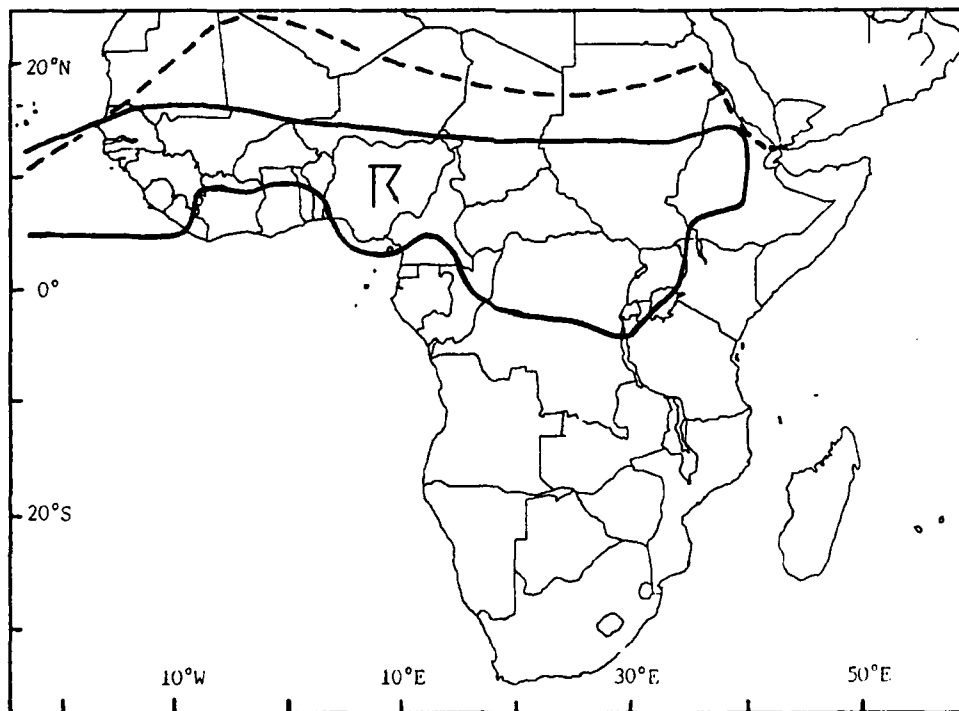


Figure 9. Mean August Position of the NET and Associated Thunderstorms. Thunderstorms still occur over southern Sudan and western Ethiopia.

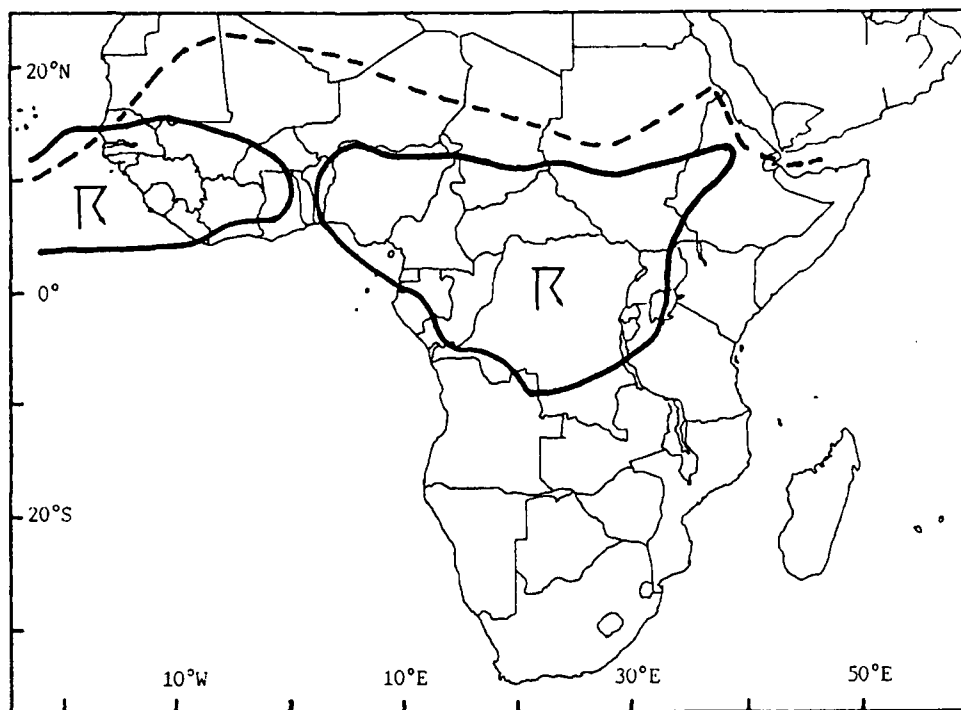


Figure 10. Mean September Position of the NET and Associated Thunderstorms. Thunderstorms slowly begin to recede south and west over Sudan and Ethiopia.

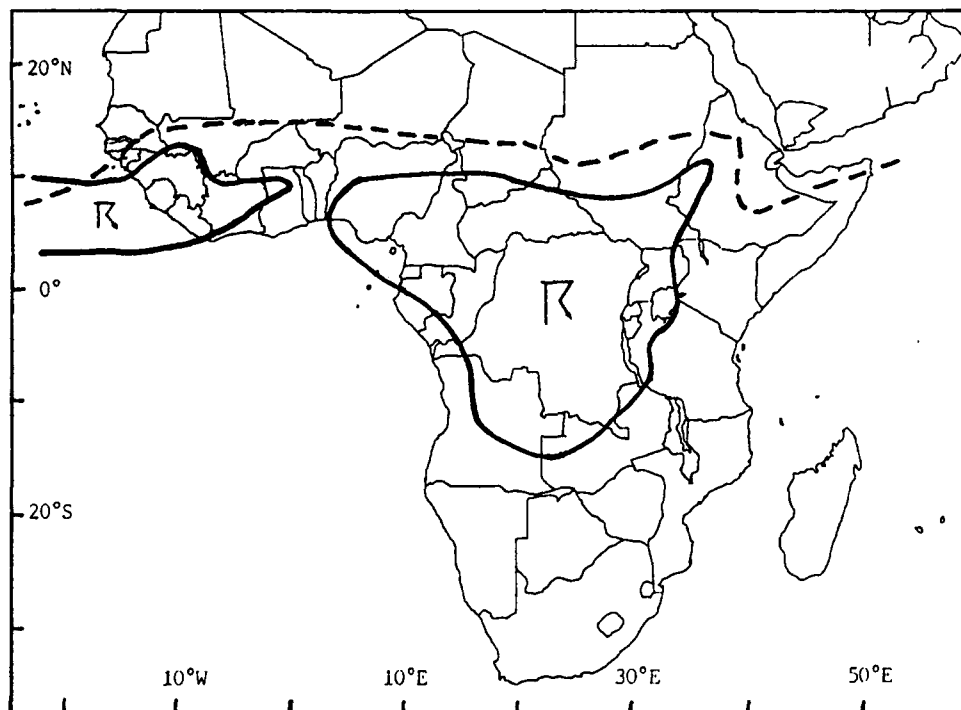


Figure 11. Mean October Position of the NET and Associated Thunderstorms. Only extreme western Ethiopia and the southern quarter of Sudan still have thunderstorms.

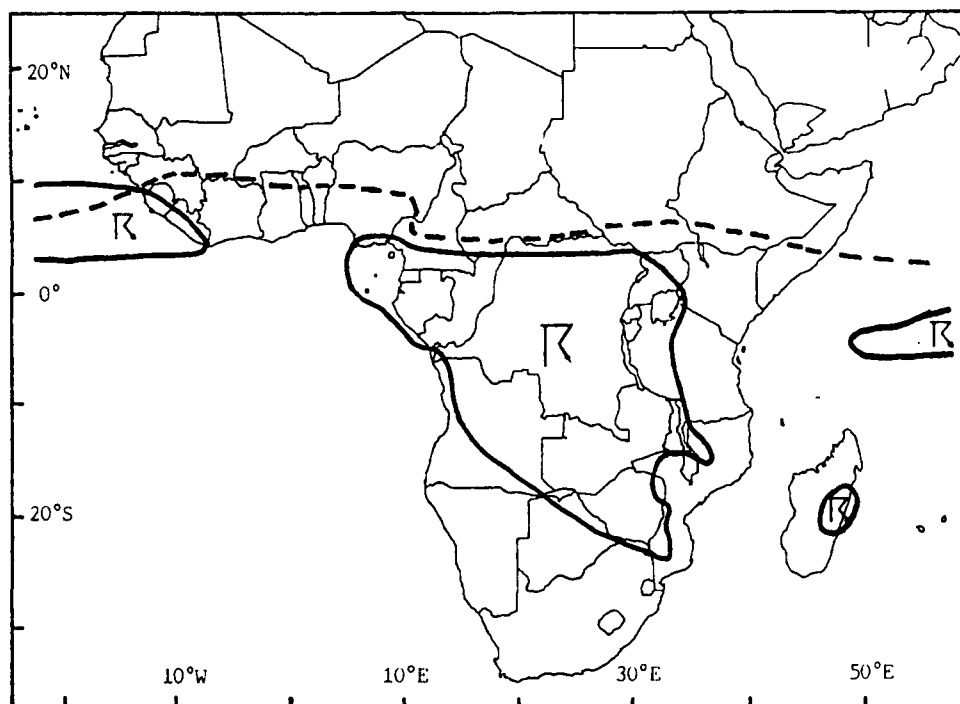


Figure 12. Mean November Position of the NET and Associated Thunderstorms. Widespread thunderstorms are confined to extreme southwestern Kenya.

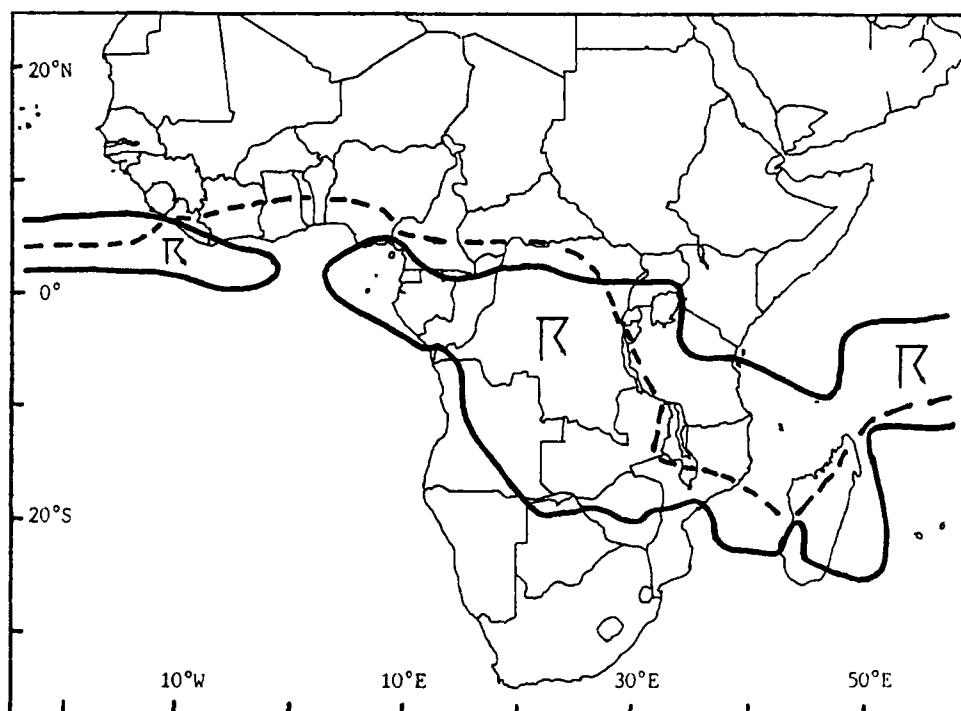


Figure 13. Mean December Position of the NET and Associated Thunderstorms. Thunderstorms remain confined to the Lake Victoria region.

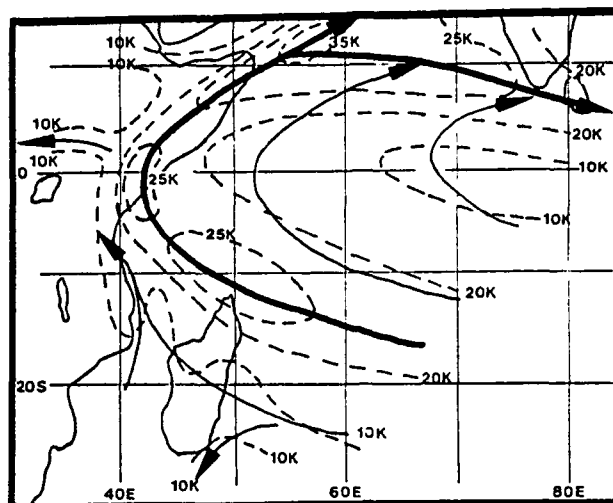


Figure 14. Mean early August 3,000-foot (900-meter) Flow. Solid Lines are streamlines; the thicker line indicates the Somali Jet core. Dashed lines are isotachs in knots.

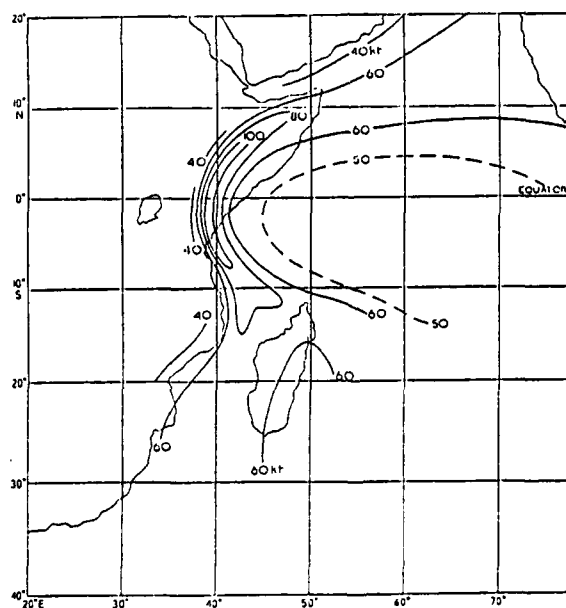


Figure 15. Maximum Observed Wind Speeds Associated with the Somali Jet. The highest speeds are found between 2,000 and 8,000 feet (600 and 2,400 meters).

SOMALIA CLIMATE AND WEATHER

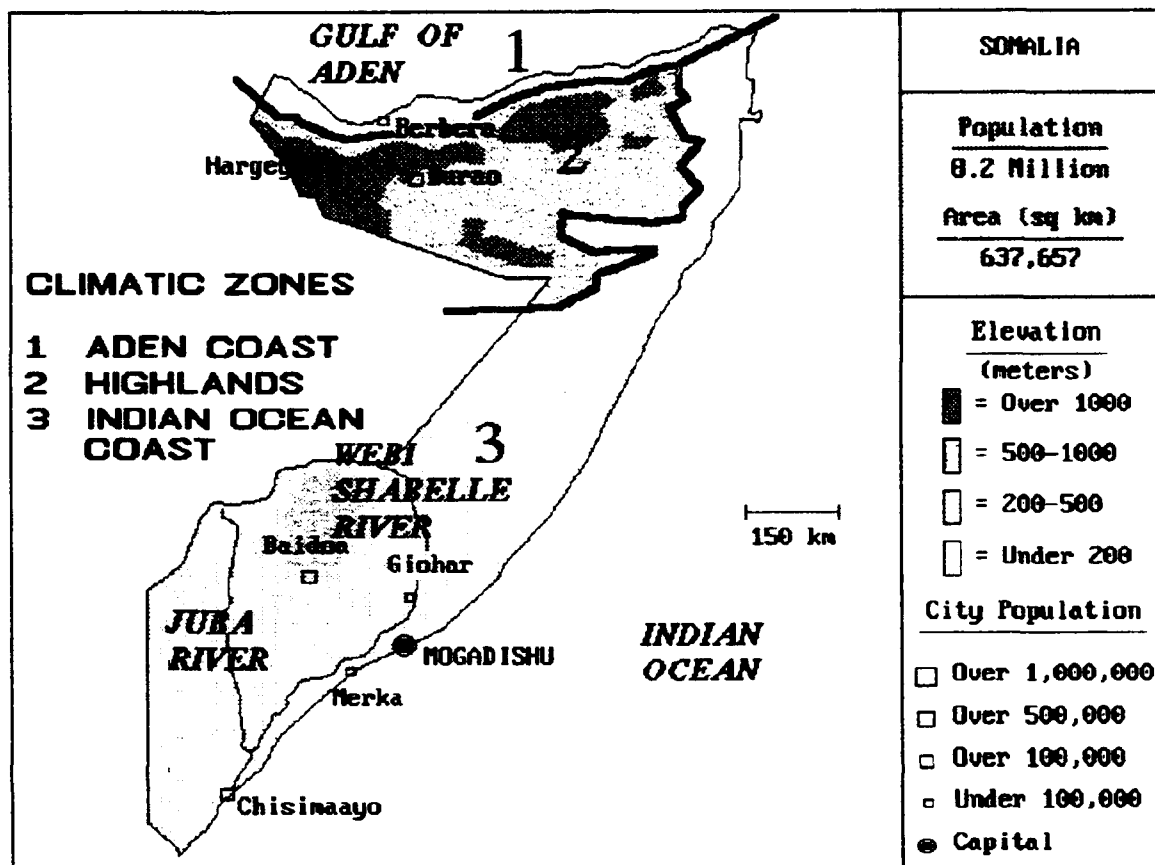


Figure 16. Somalia Country Map. The only high terrain is along the Gulf of Aden coast. Isolated peaks--the highest being Surad Ad east of Berbera--reach above 7,000 feet. Note the division of the country into three "zones of climatic commonality." These are the Gulf of Aden Coast, the Highlands, and the Indian Ocean Coast.

SOMALIA GENERAL WEATHER. The NET's north-south oscillation results in two main seasons and two transitions--see "Seasonal Weather." The showers and thundershowers produced by the NET drive most weather along the eastern African coast. Precipitation generally falls within 150 miles north and 250 miles south of the NET as it oscillates north and south.

Storms and Frontal Weather. Although frontal weather and tropical storms are almost unknown in Somalia, a very rare (but very strong) southern hemisphere cold front may push northward along the Kenyan coast during July and August before dissipating. Similarly, very strong northern hemisphere cold fronts may push southward into the Red Sea and

across Arabia, then dissipate. South Indian Ocean tropical storms cross Madagascar with some frequency, but none have ever recurved northward into Somalia. Similarly, no Arabian Sea tropical storms have so far reached the Indian ocean Coast of Somalia. However, such storms are known to have entered the Gulf of Aden in the past 150 years before dissipating; one may have made landfall during the late 19th century on the extreme northwestern Somali Gulf of Aden coast.

Hazardous Weather. Although heavy showers and thundershowers occur during the two rainy seasons, most hazardous weather is associated with the Somali Jet during the Southwest Monsoon. Persistent airborne dust and haze occur over most of Somalia during the Southwest Monsoon under and east of the Somali Jet. Patchy dense fog forms in July and August from the strong cold upwelling caused by the Somali Jet off the extreme northeast Indian Ocean Coast, especially northeast of Cape Guardafui. Visibilities are normally 4 to 6 miles during late morning and afternoon. Night and morning low clouds are also common along the coast and up to 50 miles inland, but they usually dissipate by mid-morning. Patchy low ceilings form along and east of the jet axis; bases range from 1,500 to 2,500 feet above ground level (AGL) and can cause problems for operations at fields without instrument landing aids--see Figure 17.

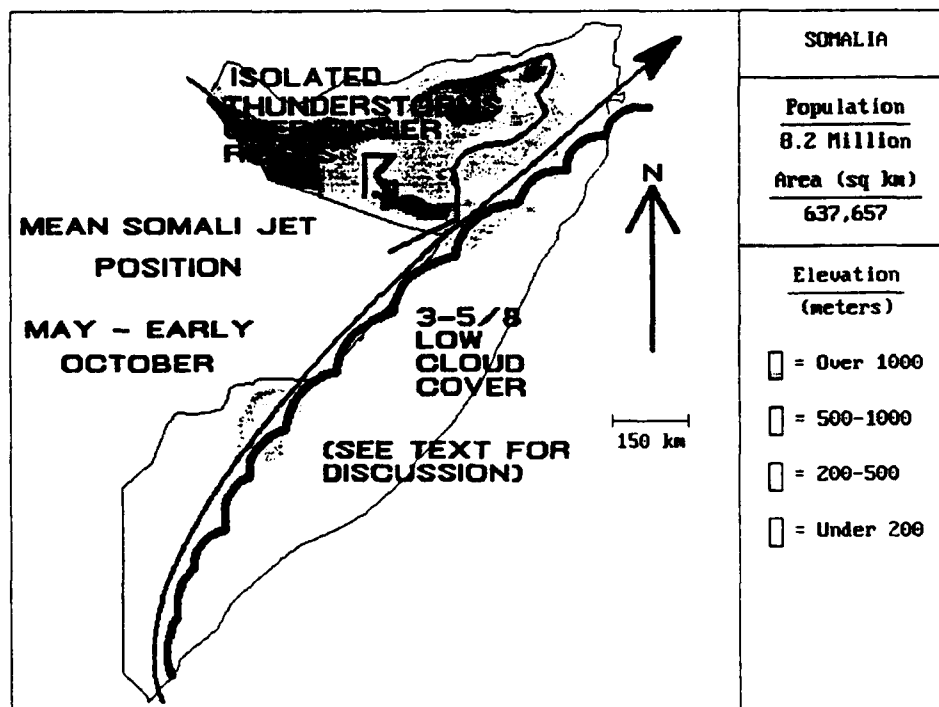


Figure 17. The Somalia Low-Level Jet Stream. Note the area of isolated thunderstorms in the highlands and the patchy low cloud cover on the southeast side of the jet-stream axis.

The Somali Jet produces strong low-level winds and associated turbulence, particularly over the Indian Ocean coastal interior, the eastern Highlands, and the eastern Gulf of Aden Coast. Surface wind speeds below the Somali Jet core are highest (40 knots or more) between local midnight and dawn. Afternoon gusts reach 20-25 knots. In the jet core, normally found between 3,000 and 5,000 feet (900 and 1,545 meters) MSL, speeds can reach 80 knots. Moderate to severe low-level turbulence occurs within 50 to 100 miles of the jet core from the surface to 7,000 feet (2,135 meters) MSL. A complex low-level eddy forms along the coast just east of Cape Guardafui on the extreme northeastern tip of Somalia. Low-level winds about 75 miles east of the Cape are strong, with variable directions. They pose operational problems for both aircraft and ships. Seas can be rough and erratic, with steep swells.

Tides. Tides along both the Gulf of Aden and Indian Ocean Coasts are diurnal. Mean Gulf of Aden tides are about 3 1/2 feet, with extremes reaching nearly 7 feet. Those along the Indian Ocean Coast are from 4 feet along the north coast to almost 7 feet at the Juba River bar; extremes are nearly 12 feet.

Currents. Offshore ocean currents during the northeast monsoon are northeasterly at 1 to 3 knots. During the southwest monsoon, they become southwesterly at 2 to 4 knots. Surfs are high only when a tropical cyclone passing well offshore recurves toward the southwest and the northern Mozambique Channel. Such rare conditions are most likely in April, May or November.

SOMALIA SEASONAL WEATHER. Rainfall in Somalia varies dramatically from one year to the next; it is important to remember note that all rainfall values discussed here are *averages*, in both duration and amount. Some years' rainfall may be two to three times the average, while in other years, there may be none. Somalia is divided into three climatological regions: The Gulf of Aden Coast, the Highlands, and the Indian Ocean Coast. Seasonal variations among these regions are discussed below.

The Northeast Monsoon (known locally as "Gilal") lasts from December through March. Precipitation is confined to mountain slopes that face north and northeast. Northeast Monsoon weather is generally good, but isolated showers and thundershowers fall over the western Highlands and northward-facing slopes of the Highlands immediately inland from the Gulf of Aden Coast. Isolated showers and thundershowers also fall over higher terrain north of Baidoa. Seasonal precipitation averages just over 4 inches south of the Gulf of Aden Coast and near 2.5 inches north of Baidoa. Elsewhere, the average is less than 1 inch. In December and March, night

and early morning patchy fog and low cloud form along the coast south of Mogadishu and over the marshes of the Juba and Webi Shabelle Rivers north and northeast of Chisimaayo. High temperatures range from the low 80s in the Highlands to the middle 90s (° F) over the Indian Ocean Coast, rising to slightly over 100 in the southern Indian Ocean coastal interior. Wet-bulb globe temperatures--used by the U.S. Army to evaluate temperature and humidity effects on troops--range from 80 to 85.

The Spring Transition ("Gu"--also known as the "long rains") occurs in April and May as the NET moves north toward its summer position across northern Ethiopia, Yemen, and southeastern Saudi Arabia. General raininess--mostly showers and thundershowers--accompanies the NET as it moves north. The NET often oscillates southward during this period; as a result, rains last longer and are more widespread than those of the Fall Transition. Surface transport over unpaved roads can be difficult; some flash flooding may occur. Ceilings are below 3,000 feet above ground level (AGL) more than half the time over the Indian Ocean Coast and the Highlands. Only the Gulf of Aden Coast has good weather, but even there occasional showers move off the Highlands over the coast. Fog and low clouds are common along the coast south of Mogadishu and over the marshes of the Juba and Webi Shabelle Rivers north and northeast of Chisimaayo. Seasonal precipitation ranges from less than 0.5 inch over the eastern Gulf of Aden Coast, to more than 2 inches over the Highlands. Average rainfall over the Indian Ocean Coast increases dramatically toward the south, rising to more 10 inches south of Chisimaayo. Temperatures drop as the rains and cloud cover move north. Highs over the Gulf of Aden Coast and the Highlands are from the mid 90s (° F) to the mid 100s. On the southern Indian Ocean Coast proper, temperatures decrease to the low 80s by the end of the season. Lows are in the mid 70s except over the Highlands, where they drop to the low 60s. Wet-bulb globe temperatures remain in the high 80s.

The Southwest Monsoon (known locally as "Hagai") lasts from late May through September. It is marked by sustained southwesterly winds below 7,000 to 10,000 feet MSL. The core of these winds--the Somali Jet--persists from May through early October. Figure 14 showed its mean August position. Core altitude is about 4,000 feet MSL; core speeds can exceed 80 knots, as was shown in Figure 15; Figure 16 showed its mean position from May through early October and its general effects on Somalia weather. Scattered showers fall over the southern half of Somalia. Isolated thunderstorms form over the western and central Highlands. Other weather during the Southwest Monsoon is directly related to the Somali Jet; see discussions under "General Weather." Seasonal precipitation ranges from near 5 inches along the coast south of Mogadishu and more than 10 inches

in the highlands to less than 0.5 inch over the central and northern Indian Ocean Coasts. High temperatures along the Indian Ocean Coast are in the low 80s (° F) south to the low 90s north; interior temperatures are from the mid 90s to the low 100s. Maximum temperatures in the highlands drop into the mid 70s or low 80s; Gulf of Aden coastal highs reach the middle 100s. Most low temperatures throughout the country are in the upper 70s to low 80s; in the highlands, the low to mid 60s. Wet-bulb globe temperatures range from the middle 80s in the south to over 90 along the Gulf of Aden Coast.

The Fall Transition ("Der"--also called "the short rains") lasts 30 days or less; its onset varies from late September to late October as the NET moves southward more rapidly than during the Spring Transition. Showers and thundershowers are as strong as during the Spring Transition, but don't last as long. Some flooding follows the heavier showers and thundershowers. General weather is similar to that of the Spring Transition, but because of the steady southward movement of the NET, it is neither as bad nor as long-lasting. Seasonal precipitation exceeds 5 inches near Baidoa and close to 3 inches over the central Indian Ocean Coast. Other areas receive less than 1.5 inches. High temperatures along the Indian Ocean Coast proper and over the highlands reach the middle to upper 80s (° F); other areas rise into the mid 90s. Lows in the highlands drop into the mid 60s; the rest of the country is in the upper 60s or low 70s. Wet-bulb globe temperatures range from the lows 80s near the Kenyan border to slightly over 90 along the Gulf of Aden Coast.

YEMEN CLIMATE AND WEATHER

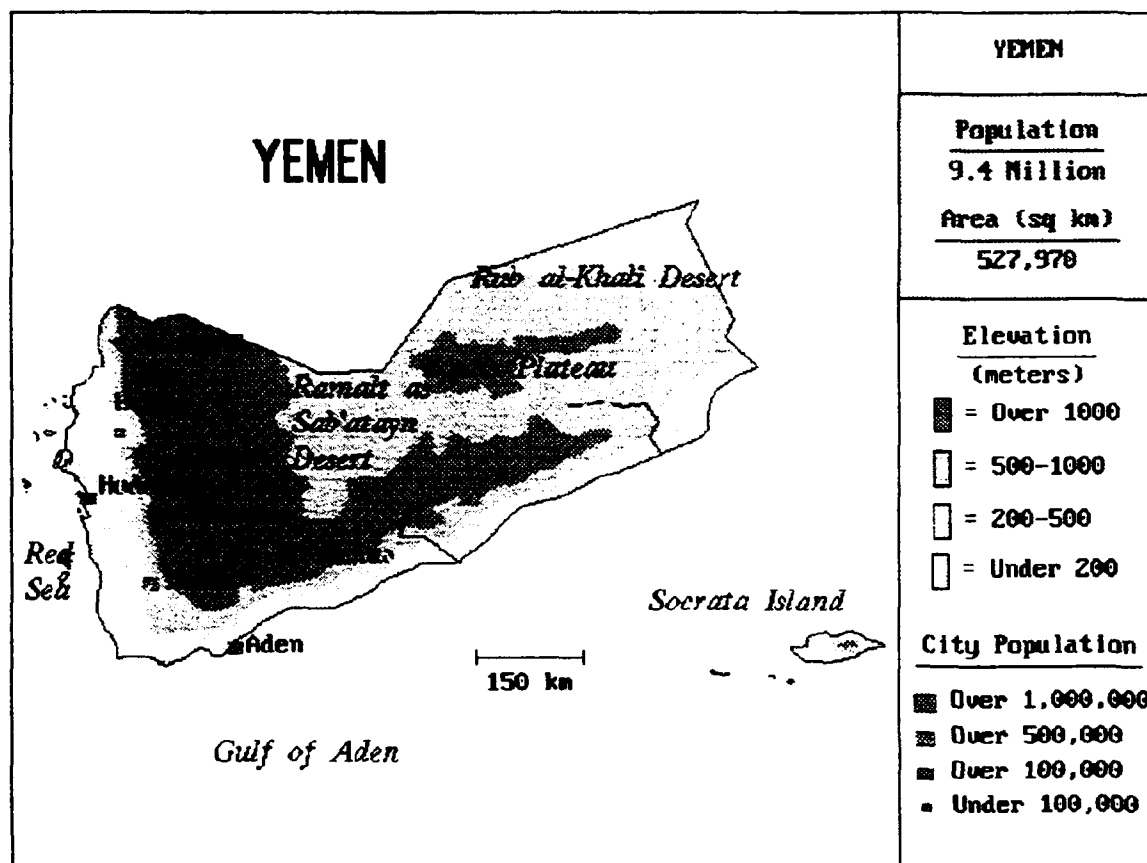


Figure 18. Yemen country map.

YEMEN GENERAL WEATHER. Cloud cover and precipitation over the highlands vary from one year to the next, but coastal weather is relatively constant--hot and humid with little rainfall, especially along the Gulf of Aden. Showers and thundershowers fall over the highlands during the Northeast Monsoon and over the higher mountains during the Southwest Monsoon. The NET lies across the Yemeni highlands only during the Southwest Monsoon. Morning fog occasionally forms along coasts, which are generally dry.

Land/sea breezes affect coastal areas and the lower foothills. Sea breezes at 6-10 knots normally last from mid-morning to early afternoon; they produce rainshowers and thunderstorms along the mountains, where winds are usually from the N or NE at 5 to 7 knots. Nighttime winds are generally light and variable. Frontal weather and tropical storms are rare. A strong Mediterranean cold front may push southward into the Red Sea

and across Arabia before dissipating. Only three Arabian Sea tropical storms have entered the Gulf of Aden before dissipating; one may have made landfall on the extreme northwestern Somali Gulf of Aden coast during the late 19th century.

YEMEN SEASONAL WEATHER.

The Northeast Monsoon (known locally as "Gilal") lasts from December through March. Isolated showers and thundershowers fall over the Highlands. Extremely strong Mediterranean cold fronts can reach the area. Weather is generally dry along the coast. Sea breezes produce rainshowers and thunderstorms along the mountains. By December, a cold front crosses the area every 5 to 10 days bringing light precipitation and increased mid- and upper-level clouds. Occasional 1,000-2,000 foot ceilings become scattered in the afternoon. Where Inland mountains face the coast, clouds are likely to form between 0900 and 1800 LST. Frontal passages in December bring primarily middle and upper clouds, with rain showers over the Highlands. Showers and thundershowers bring as much as 5 inches of rain a season to the higher mountains. Snow falls above 10,000 feet (3,050 meters). Mean daily highs are in the low 70s (° F) to low 90s; mean daily lows range from the low 50s to mid 70s. The Highlands are considerably cooler--Sa'na has dropped to 22° F in December.

The Spring Transition ("Gu") occurs in late April and May as the NET moves northward into its summer position across northern Ethiopia, Yemen, and southeastern Saudi Arabia. Isolated showers and thundershowers accompany it over the Highlands. Coastal areas remain hot, humid, and dry. Patchy low clouds cause occasional, mostly morning 2,000- to 3,000-foot (600- to 900-meter) ceilings at Aden. Isolated showers fall in May as the NET moves through the Gulf of Aden. Afternoon showers and thundershowers become more frequent over the southwestern Highlands. Coastal high temperatures range from the mid to low 90s (° F), with lows in the mid-60s. In the cooler highlands, temperatures are from the mid-70s to the low 80s, with lows in the low 40s. Surface transport over unpaved roads can be difficult; flash flooding may occur.

The Southwest Monsoon ("Hagai") lasts from late May through September. It is marked by routine showers over the Highlands. Early morning low clouds occasionally form ceilings below 1,000 feet (300 meters) that move onshore along the Gulf of Aden coast and dissipate by mid-morning. Isolated afternoon and evening thundershowers develop along the inland coastal mountains. Some persist until near midnight in the Aden area, but most dissipate after sunset. Late afternoon showers and thundershowers are common over the southwestern Highlands; isolated

severe thunderstorms have been reported. Dust and haze restrict visibilities to 3 miles on many afternoons. Coastal high temperatures reach the mid-90s (° F); lows are in the upper 70s or low 80s. Highland temperatures are 10 to 15 degrees cooler.

The Fall Transition ("Der") is the driest time of the year. It lasts 30 days or less, but onset varies from late September to late October as the NET moves southward rapidly. Once the NET has moved south into Somalia, precipitation decreases rapidly. Skies are generally clear, except for afternoon clouds over the higher peaks. Only widely isolated showers fall over the highest terrain. Even the southwestern highlands get only isolated showers. Snow falls above 10,000 feet (3,050 meters) as the first of the Mediterranean cold fronts arrives in late November, bringing extensive middle and high cloudiness. Coastal temperatures reach the low 90s (° F) and fall into to the low 70s; Highland highs range from the middle 50s to the low 70s, depending on elevation. Lows in the interior can go below freezing, but rarely.

DJIBOUTI CLIMATE AND WEATHER

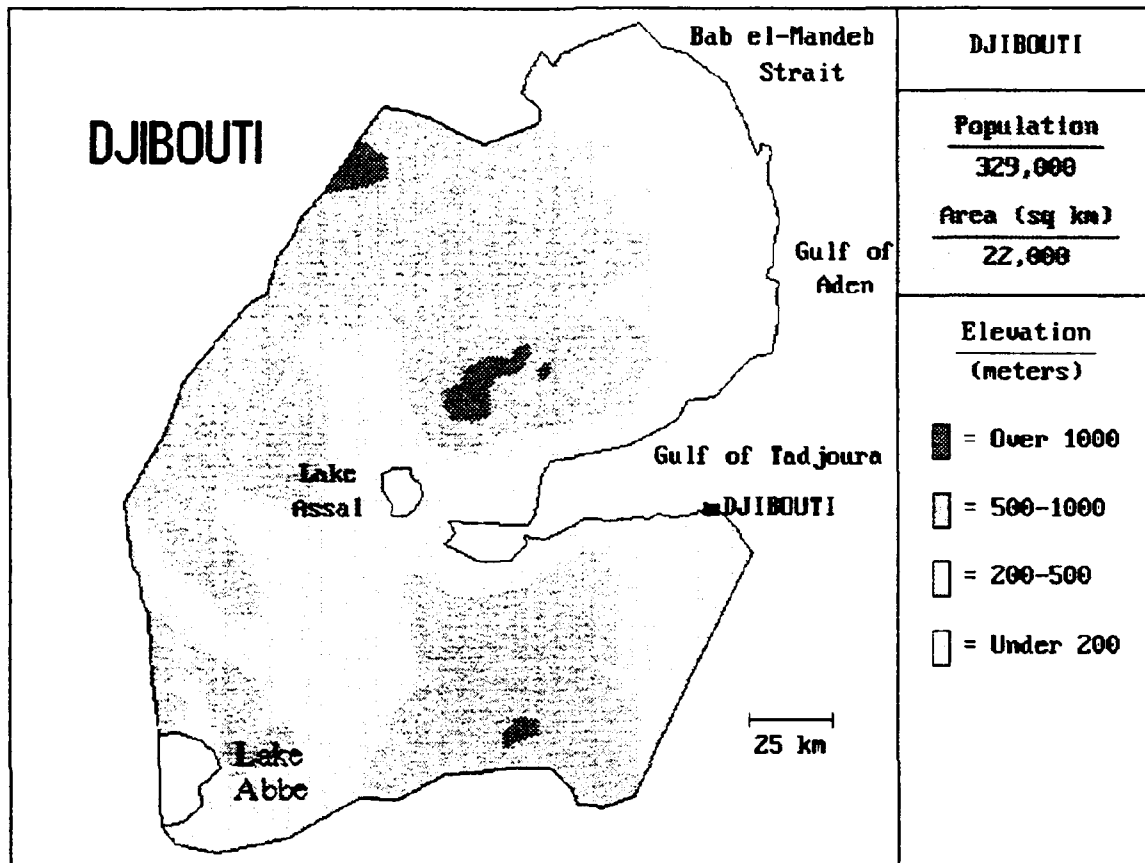


Figure 19. Djibouti country map.

DJIBOUTI GENERAL WEATHER. Fair weather dominates, but isolated showers or dust haze are possible, as discussed in "Seasonal Weather." For example, rare showers and isolated thundershowers fall over Djibouti during the Northeast Monsoon. Cloudiness and precipitation at other times of the year are almost non-existent. Land and sea breezes affect coastal areas and the lower foothills. Sea breezes normally last from mid-morning to early afternoon, with speeds of 6-10 knots. Nighttime winds are generally light and variable.

DJIBOUTI SEASONAL WEATHER.

The Northeast Monsoon (known locally as "Gilal") lasts from December through March. Isolated showers and thundershowers fall as the exception to the rest of the year. Night and morning low clouds occasionally form ceiling as low as 2,000 to 3,000 feet (600 to 900 meters). Afternoons

usually have only patchy low clouds. Isolated showers occur in the afternoons. Winds reflect a strong land/sea breeze; dust is most common in the afternoon. High temperatures are in the mid 80s (° F); lows are in the mid 70s.

The Spring Transition ("Gu") occurs in late April and May as the NET moves northward into its summer position across northern Ethiopia, Yemen, and southeastern Saudi Arabia. Extremely heavy showers and thunderstorms are possible; a 24-hour rainfall of over 7 inches (175 mm) has been recorded. Showers and thundershowers become increasingly rare as prevailing wind directions become southwesterly. Dust raised by the persistent southwesterly winds, however, becomes a problem. Once the NET moves into Yemen, winds become almost exclusively the product of the land/sea breeze; offshore at night, onshore during the day. High temperatures rise into the low 90s (° F); lows are in the low 80s.

The Southwest Monsoon ("Hagai") lasts from late May through September. Dust continues to be raised by the persistent southwesterly to westerly winds. Skies are almost clear; there are only patchy early morning low clouds and a very rare afternoon shower. High temperatures climb to over 100 (° F); lows are in the high 80s.

The Fall Transition ("Der") lasts 30 days or less, but onset varies from late September to late October. The NET moves southward rapidly. Skies are generally clear, except for patchy mid-morning clouds. By late October, isolated rain showers fall. Patchy night and early morning low clouds again appear. Winds come under the control of the land/sea breeze. High temperatures are only in the upper 80s; lows, in the upper 70s.

ETHIOPIA CLIMATE AND WEATHER

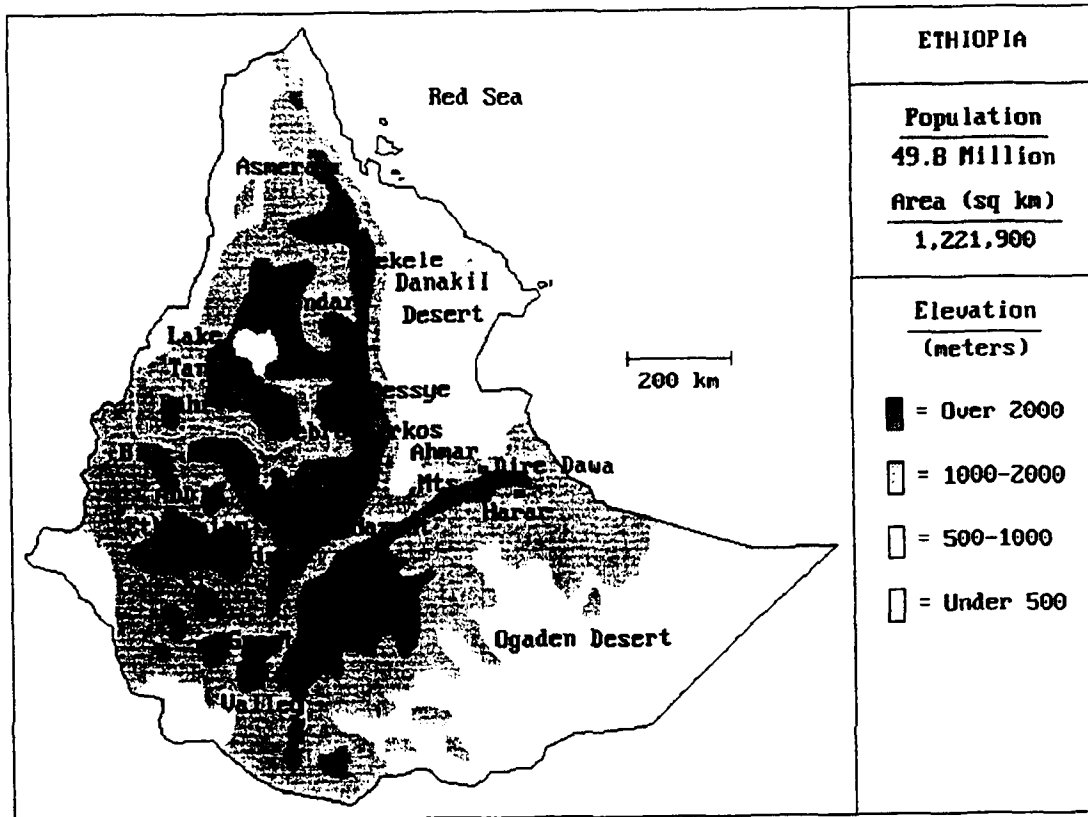


Figure 20. Ethiopia country map.

ETHIOPIA GENERAL WEATHER. Terrain plays a key role in Ethiopian weather. Widespread showers and thunderstorms form over the western highlands and the mountains of the eastern highlands from April through September. The showers end in October and good weather dominates most of Ethiopia from November through March. Showers, however, fall in the far southwestern mountains all year.

ETHIOPIA SEASONAL WEATHER. Mountain weather is notoriously variable; what occurs on one side of a ridge may not happen across the ridge crest. The higher mountains in the southwest have showers and thundershowers all year. Mountain valleys often have low overcast night and morning cloudiness, especially if showers have fallen late the previous afternoon. Wind patterns are caused by a complex series of terrain-controlled airflows. Temperatures are a function of elevation.

The Northeast Monsoon (December-March). Weather is generally good, except for extensive showers and isolated thundershowers along the western slopes of the central mountains. Occasional Mediterranean cold fronts moving south through the Red Sea cause isolated showers along the coast east of Asmara. Snow falls in the highest mountains. Mid-morning low cloud ceilings form in the east and southeast, but dissipate by late morning. Winds are variable, flowing down valleys at night and up valleys during the day. High temperatures are in the 80s (° F) between 3,300 and 6,600 feet (1,000 and 2,000 meters); lows reach into the 40s. Above 7,000 feet (2,300 meters), temperatures fall below freezing.

Spring Transition (April-May). General cloud cover increases as the NET moves north and increasing flow from the Atlantic and the Indian Ocean reaches the mountains. Showers, cloud cover, and thunderstorms move north and east. Low clouds, showers, and thundershowers begin to affect mountain airfields and obscure ridges. Airfields in mountain valleys often have extensive low cloudiness until early afternoon. Showers, cloud cover, and thunderstorms increase and move north and east. Only the eastern areas are relatively cloud-free. By late May, clouds are common over all but the northeastern third of Ethiopia. Winds remain a function of mountain-valley influences. High temperatures range from the middle 70s (° F) in the southwest to the low 90s in the northeast; lows range from slightly over 50 to near 70.

Southwest Monsoon (June-September). Extensive low cloud cover, thunderstorms, and almost daily showers affect the southwestern two-thirds of the country, while the northeastern third is relatively cloud-free. Most mountain ridges are obscured by late morning. Precipitation can be heavy, with resultant flash flooding. Temperatures range from the low 70s (° F) in the southwest to the mid 90s along the Djibouti border; lows, from the low 50s to the upper 60s.

Fall Transition (October-November). Conditions improve as the NET moves south. Showers and thunderstorms decrease as the moist southwesterly flow ends and the NET moves south out of the country. By late November, showers and thundershowers are confined to the far southwestern mountains. Temperatures over cloud-free areas rise despite the poleward movement of the Sun. Average highs range from the upper 70s (° F) in the southwest to near 90 along the Djibouti border. Lows drop into the upper 40s in the mountains; valley temperatures range from the upper 50s to the low 60s.

SUDAN CLIMATE AND WEATHER

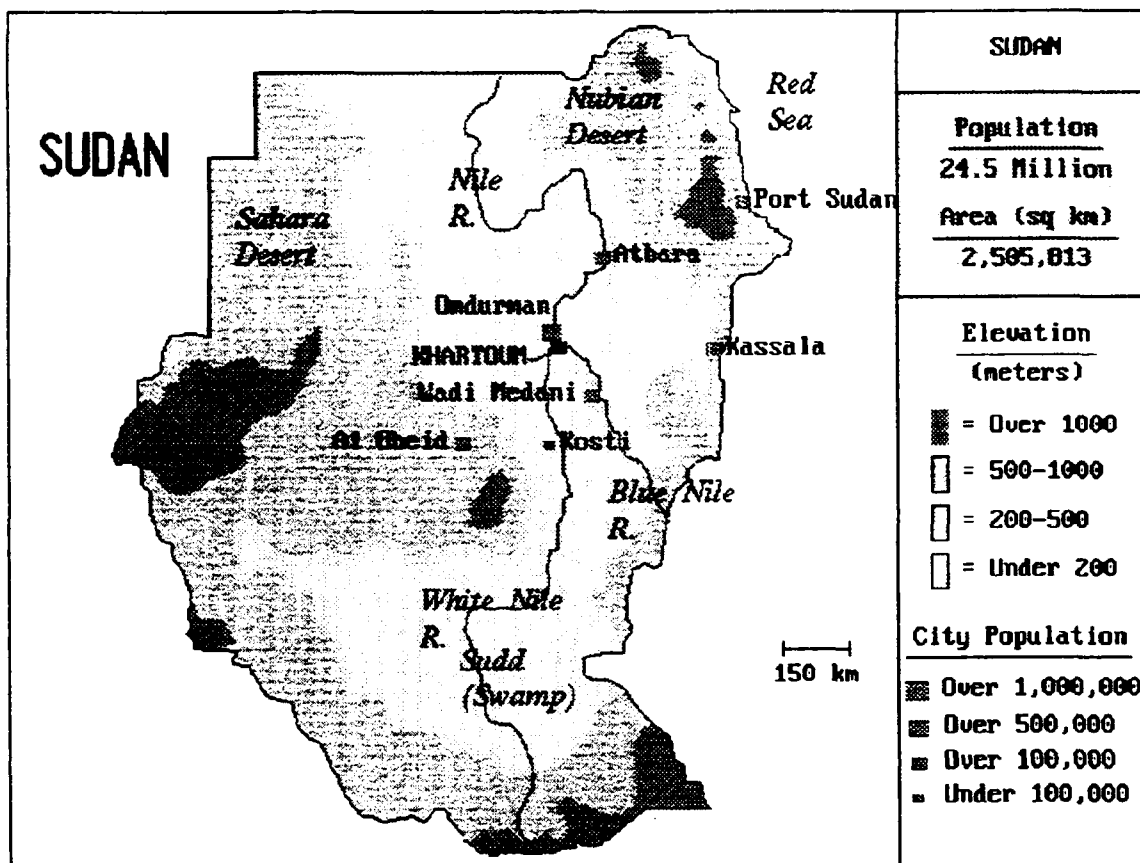


Figure 21. Sudan country map.

SUDAN GENERAL WEATHER. Two climatic regimes dominate Sudan. North of 16° N, the climate is semi-arid steppe that turns rapidly into desert as one moves north and northwest. South of 16°, summer rains associated with the NET produce a very different climate. A recurring problem associated with thunderstorms or any strong winds is blowing dust occurring north of 10° N. Even during the wet season, thunderstorms and showers are not continuous. Once the fine soil dries, initial thunderstorm winds cause the infamous "haboob," or fast-moving duststorm in which visibilities drop to less than 100 feet (30 meters); a wall of dust rises to several thousand feet above the ground. Conditions gradually improve over several hours as the dust settles back to the ground.

SUDAN SEASONAL WEATHER.

Dry Season (Mid-November-February). The NET has moved south of Sudan, but Mediterranean frontal systems crossing the area produce blowing dust. Only in the extreme south do occasional northward surges of the NET produce very isolated showers. Skies are almost clear below 20,000 feet except in the extreme south where isolated afternoon showers occur. Isolated showers also fall over the mountains bordering Ethiopia; snow has been briefly observed above 10,000 feet (3,050 meters). Winds ahead of frontal systems pick up dust--a persistent "dust haze" restricts visibilities in the northern half of Sudan to less than 6 miles much of the time, and visibilities drop well below 3 miles 1 day in 10. The lowest visibilities occur when a frontal system penetrates well south into Sudan, or when a major storm moves across northern Libya and Egypt. High temperatures are over 100 (° F); lows drop to near freezing over the Sahara.

Spring Transition (March-May). As the NET moves north (to about 15° N) by the end of May, summer rainshowers and thunderstorms begin to the south; they normally lag the NET by about 150 miles. The NET does not move continuously northward, but advances and retreats (or "surges") in response to storm systems developing in Algeria that move east along the coast into northern Egypt. Periods of showers and thundershowers alternate with periods of dry northerly winds. By late May, thunderstorms are occurring south of 14°. "Haboobs" are common with the strong winds associated with isolated thunderstorms occurring between the NET and the general area of rains 100 to 150 miles south of the NET. By late May, high temperatures range from near 100 (° F) in the south to over 105° in the dry air north of the NET.

Wet Season (June-September). The NET oscillates between 17° and 20° N during the wet season, but it has reached 25° N. From 100 miles south of the NET southward, extensive low ceilings and poor visibilities are common with showers and thundershowers. "Haboobs" are associated with the strong (over 50 knots in some cases) winds of the isolated thunderstorms just south of the NET where general rains are not occurring. Extensive squall lines form between 15° and 30° W south of 15° N and move westward from late June through mid-September. Seasonal rains total over 10 inches south of Khartoum, but exceed 38 inches in the extreme southwest. Flooding is common. High temperatures north of 15° N average near 110° F; south of 15° N, they are in the high 80s to low 90s. Low temperatures drop to the upper 70s in the north and to the upper 60s south.

Fall Transition (October-mid November). The NET moves steadily southward, reaching extreme southern Sudan by mid-November. Unlike the spring transition, "surges" are rare. NET passage southward marks the start of the dry season, with its northerly winds and blowing dust. Precipitation and associated cloudiness recede southward rapidly as the NET moves south. Weather north of the NET rapidly reverts to the dry, dusty conditions of winter (the dry season). Temperatures range from highs of 95 to 100° F, with lows in the upper 60s to low 80s.

KENYA CLIMATE AND WEATHER

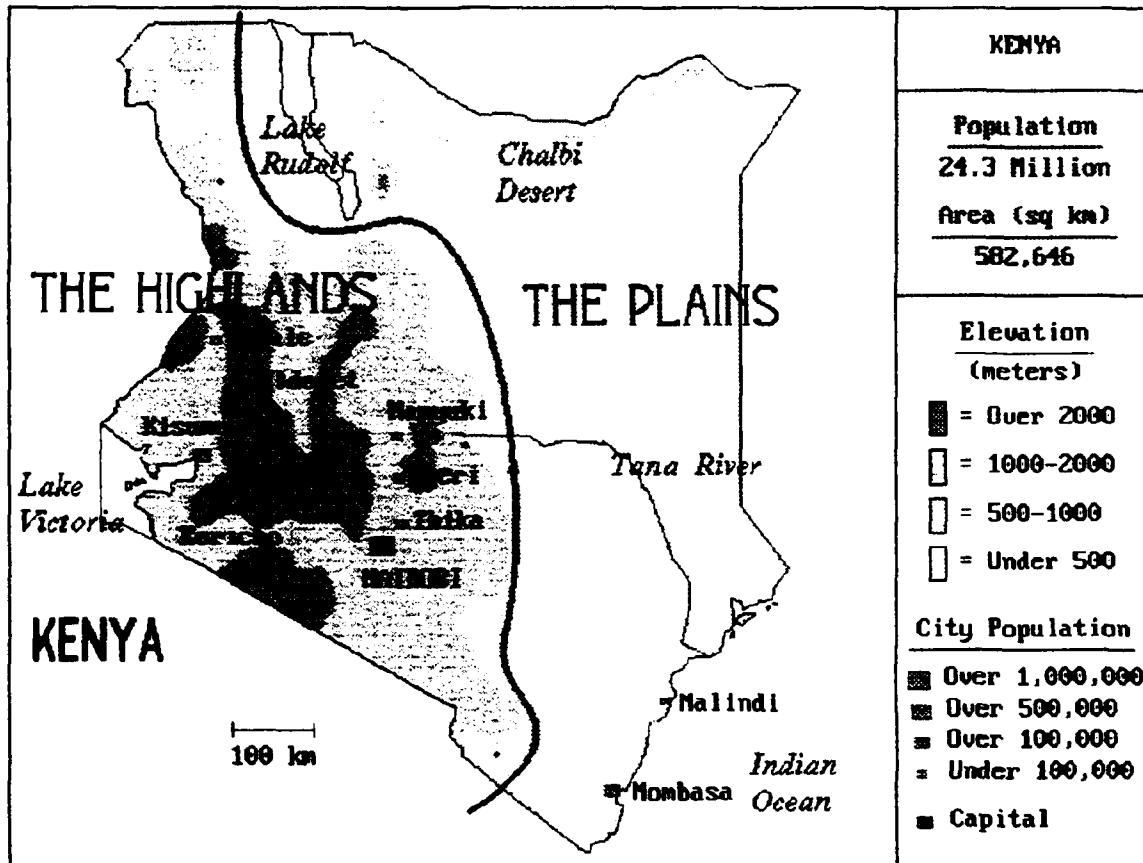


Figure 22. Kenya country map. Kenya is divided into two climatic regions, as shown. These regions reflect the combined influences of the dual passage of the NET, the rising terrain westward, and the effects of the Indian Ocean.

KENYA GENERAL WEATHER. Night and morning low clouds form 1,500 to 2,500 foot (400 to 600 meter) ceilings all year. Nocturnal fog and fog banks along the coast and near rivers routinely reduce visibilities to less than 3 miles. Ceilings in showers and thundershowers may go as low as 100 feet (30 meters) and 1/4 mile (400 meters).

KENYA SEASONAL WEATHER. Highland locations and Lake Victoria do not necessarily conform to the seasonal regimes discussed below because of rainfall enhancement from moist Indian Ocean Air lifted over ridges. The Central Mountains have the wettest season during northern hemisphere summer, but the extreme north is wettest in March and April. Lake Victoria has no dry season; a complex series of airflow interactions ensures that

showers and thundershowers--many producing hail--occur all year long on the Kenyan side of the lake. Late December through February and August through mid-October are "drier" seasons between the two primary wet seasons on the plains. During the spring and fall wet seasons, showers and thundershowers become widespread, especially in the afternoons and at night. The spring wet season has the most rainfall over the northeastern plains, but by the end of the fall rains, most falls over the southwestern plains. Onset, strength, and duration of these rains are extremely variable from one year to the next. Flash flooding is a particular problem during the two rainy seasons, when thunderstorm tops can reach 50,000 feet MSL.

The Northeast Monsoon (Late December-February). The NET lies south of Kenya. Drier, more stable, air is brought inland by northeasterly winds. Only widely isolated afternoon showers, and an occasional thundershower, form over higher terrain; otherwise, showers are rare. High temperatures range from the mid 80s (° F) to the mid 90s; lows are in the mid 60s or low 70s.

The Spring ("Long") Rains (March-July). Showers and thundershowers are widespread as the NET moves slowly northward; north-south oscillations are common. The Somali low-level jet forms over extreme eastern Kenya by late April and persists through July. The wind speed core altitude ranges from 3,000 to 7,000 feet; peak speeds are above 50 knots. Moderate to severe turbulence occurs within 35 to 50 miles horizontally and 2,000 to 6,000 vertically of the core. High temperatures are in the mid 80s (° F); lows are in the low 70s.

The Southeast Monsoon (August-mid October). The Somali low-level jet persists until late September. Showers and thundershowers decrease in coverage and frequency, but both increase in mid to late October as the NET moves far enough south to affect Kenya. High temperatures drop to near 80° F; lows are in the upper 60s.

The Fall ("Short") Rains (Late October-mid December). The NET moves across Kenya into Tanzania by late December. Unlike the Spring Rains, north-south oscillations are rare. Actual rainy season length on the plains is between 4 and 6 weeks at any one spot. High temperatures are in the upper 80s (° F); lows are near 70.

DISTRIBUTION

HQ AF/XOW, Pentagon, Washington, DC 20301	1
HQ USAF/XOOOW, Rm BD927, Washington, DC 20330-5054	1
OSAF/SS, Rm 4C1052, Pentagon, Attn: Weather, Washington, DC 20330-6560	1
USTC J3/J4-OW, Scott Dr., Bldg 1900, Scott AFB, IL 62225-7001	3
AWS/XTX/DO/XT, Losey St., Bldg 1521, Scott AFB, IL 62225-5008	1
Det 4, AWS, Bldg 91027, Hurlburt Fld, FL 32544-5000	1
Det 5, HQ AWS, Keesler AFB, MS 39534-5000	1
HQ AFGWC/DOM/SY/RM, MBB39, 106 Peacekeeper Dr., Ste 2N3, Offutt AFB, NE 68113-4039	1
AFSFC/DON, Stop 82, Bldg 715, Patrick Ave., Falcon AFB, CO 80912-5000	1
USAFETAC, Scott AFB, IL 62225-5000	6
OL-A, USAFETAC, Federal Building, Rm 305, Asheville, NC 28801-2723	1
NCDC Library (D542X2), Federal Building, Asheville, NC 28801-2723 (2 copies of SCSs)	1
AFSPACECOM/DOWA, Bldg 1, Stop 7, Peterson Rd., Peterson AFB, CO 80914-5001	1
AFTAC/DOW, Patrick AFB, FL 32925-5000	1
USAICS, Attn: ATSI-CDW, Ft Huachuca, AZ 85613-6000	1
AFMC(I)/DOW, Bldg 266, Post 108P Chidlaw Rd., Wright-Patterson AFB, OH 45433-5000	1
FASTC/TAW, 4115 Hebble Creek Rd., Ste 33, Wright-Patterson AFB, OH 45433-5637	1
ASD/WE, Bldg 91, 3rd St, Wright-Patterson AFB, OH 45433-6503	1
AFIT/CIR, Wright-Patterson AFB, OH 45433-6583	1
WL/DOA, Wright-Patterson AFB, OH 45433-6543	1
WL/DOW, Wright Patterson AFB, OH 45433-6543	1
FASTC/TAW, Wright-Patterson AFB, OH 45433-6543	1
PL/WE, Kirtland AFB, NM 87117-5000	1
HQ AFOTEC/WE, Kirtland AFB, NM 87117-7001	1
RL/WE, Griffiss AFB, NY 13441-5700	1
RL/SUL, Corridor W, Ste 262, 26 Electronic Pkwy, Griffiss AFB, NY 13441-4514	1
AFCESA/WE, Tyndall AFB, FL 32403-5000	1
AFCES/RDXT, Bldg 1120, Stop 21, Tyndall AFB, FL 32403-5000	1
ESD/WE, Vandenberg Dr., Bldg 1624, Hanscom AFB, MA 01731-5000	1
PL/TSM, Research Library, Hanscom AFB, MA 01731-5000	1
PLJGP, Hanscom AFB, MA 01731-5000	1
AFFTC/WE, Edwards AFB, CA 93523-5000	1
UTTR/WE, Hill AFB, UT 84056-5000	1
USCENTCOM/CCJ3-W, Bldg 540, MacDill Blvd, MacDill AFB, FL 33608-7001	1
HQ AFTAC/TNK, 1030 Highway A1A, Patrick AFB, FL 32925-5000	1
ESMC/WE, Patrick AFB, FL 32925-5000	1
OL-A, AFCOS, Site R, Fort Ritchie, MD 21719-5010	1
USAFALCENT RA, Pope AFB, NC 28308-5000	1
CCSO/FL, Tinker AFB, OK 73145-6340	1
AFOSR/NL, Bolling AFB, DC 20332-5000	1
TFWC/WE, Nellis AFB, NV 89191-5000	1
SMC, Det 2/TDO, Onizuka AFB CA 94088-3430	1
AL/OEBE, 2402 East Drive, Brooks AFB, TX 78235-5114	1
AMC/XOWR, Bldg P40 N, Martin Ave, Scott AFB, IL 62225-5000	3
AMC/TACC, Bldg P40 N, Martin Ave, Scott AFB, IL 62225-5000	1
AFSOC/DOW, Bldg 1, Hurlburt FLD, FL 32544-5000	1
ATC/DOTW, 244 F Street East, Suite #3, Randolph AFB, TX 78150-4325	1
502 OSS/OSW, Bldg 844, Rm 117, Maxwell AFB, AL 36112-5000	1
CFA, C-2/SWO, APO AP 96258-0210	1
603 ACCS/WE, Unit 2051, APO AP 96278-5000	1
8OSS/WX, APO AP 96264-5000	1
PACAF/DOW, Bldg 1102, Hickam AFB, HI 96853-5000	1
Det 1, HQ PACAF, COMNAVMAR, PSC 489, Box 20, FPO AP 96540-0051	1
11OPG/WE, 6900 9th Ste 205, Elmendorf AFB, AK 99506-5000	1
11WS, 1215 Flightline Ave, Ste 2, Eielson AFB, AK 99702-1520	1
15WS, Hickam AFB, HI 96353-5000	1
USSTRATCOM/J3615, Rm L127, Bldg 522, 901 SAC Blvd, Offutt AFB, NE 68113-5000	1
ACC/DOW, Bldg 21, 30 Elm St, Ste 215, Langley AFB, VA 23655-2093	5
12AOG/AOSW, E Ave., Bldg 2900, Bergstrom AFB, TX 78743-5000	1
USCENTCOM/CCJ3-W, MacDill AFB, FL 33608-7001	5

USSOCENT/SCJ2-SWO, MacDill AFB, FL 33608-7001	1
USSOCOM/SOJ3-W, MacDill AFB, FL 33608-6001	1
1WG, Bldg 168, Hardee St., Ft McPherson, GA 30300-5000	3
OL-A, 5WS, AFZJ/SWO, Ft Irwin, CA 92310-3000	1
OL-B, Det 2, 5WS, Ft Indiantown GAP, PA 17003-5002	1
CDR USASOC, Attn: AOIN-ST, Ft Bragg, NC 28307-5200	1
JSOC/Weather, P.O. Box 70239, Ft Bragg, NC 28307-5000	1
Det 4/WXG, Hangar Access Dr., Bldg 2065, Ft Drum, NY 13602-5042	1
Det 58, 1WXG, Bldg 9601, Butts AAF, Ft Carson, CO 80913-6403	1
HQ 5th U.S. Army, AFKB-OP (SWO), Ft Sam Houston, TX 78234-7001	1
USAFE/DOW, Unit 3050, Box 15, APO AE 09094-5000	1
USAFE/DOWO, Unit 3050, Box 500, APO AE 09094-5000	1
17AF/DOW, Unit 4065, APO AE 09136-5000	1
HQ USEUCOM ECJ3, Unit 30400, Box 1000, APO AE 09128-4209	1
7WS, CINCUSAREUR/AREAWX, APO AE 09403-5000	1
7WS, Unit 29351, APO AE 09014-5000	1
16AF/SWO, Unit 6365, APO AE 09641-5000	1
COMNAVOCEANCOM, Code N312, Stennis Space Ctr, MS 39529-5000	1
COMNAVOCEANCOM (Capt Brown, Code N332), Stennis Space Ctr, MS 39529-5001	1
NAVOCEANO (Rusty Russum), Bldg 8100, Rm 203D, Stennis Space Ctr, MS 39522-5001	1
NAVOCEANO, Code 9220 (Tony Ortolano), Stennis Space Ctr, MS 39529-5001	1
Maury Oceanographic Library, Naval Oceanography Office, Stennis Space Ctr, MS 39522-5001	1
Naval Research Laboratory, Monterey, CA 93943-5006	1
Naval Research Laboratory, Code 4323, Washington, DC 20375	1
Naval Postgraduate School, Chmn, Dept of Meteorology, Code 63, Monterey, CA 93943-5000	1
Naval Air Warfare Center-Weapons Division, Geophysical Sciences Branch, Code 3254, Point Mugu, CA 93042-5001	1
Armed Forces Medical Intelligence Center, Information Services Division, Bldg 1607, Ft Detrick, Frederick, MD 21702-5004	1
Chief, APG Met Team, Bldg 1134, Attn: AMSTE-TC-AM CAB, Aberdeen Proving Ground, MD 21005-5001	1
Atmospheric Sciences Laboratory (SLCAS-AS-I 3 10-2c), White Sands Missile Range, NM 88002-5501	1
TECOM Atmos Sci Div, AMSTE-TC-AA (MacBlain), White Sands Missile Range, NM 88002-5504	1
White Sands Met Team, AMSTE-TC-AM (WS), White Sands Missile Range, NM 88002-5501	1
USA TECOM, ATTN: AMSTE-TC-AM (RE) TECOM Met Team, Redstone Arsenal, AL 35898-8052	1
Director, U.S.A.-CETEC, Attn: GL-AE (Whitmarsh), Fort Belvoir, VA 22060-5546	1
Technical Library, Dugway Proving Ground, Dugway, UT 84022-5000	1
HQ NATO Staff Meteorological Officer IMS/OPS APO AE 09724	1
NOAA/MASC Library MC5, 325 Broadway, Boulder, CO 80303-3328	2
NOAA Library-EOC4W5C4, Attn: ACQ, 6009 Executive Blvd, Rockville, MD 20852	1
NOAA/NESDIS (Attn: Nancy Everson, E/RA22), World Weather Bldg, Rm 703, Washington, DC 20233	1
NGDC, NOAA, Mail Code E/GC4, 325 Broadway, Boulder, CO 80333-3328	1
NWS Training Center, 617 Hardesty, Kansas City, MO 64124	1
NIST Pubs Production, Rm A635, Admin Bldg, Gaithersburg, MD 20899	1
DTIC-FDAC, Cameron Station, Alexandria, VA 22304-6145	2
AUL/LSE, Maxwell AFB, AL 36112-5564	1
AWSTL, Scott AFB, IL 62225-5438	100