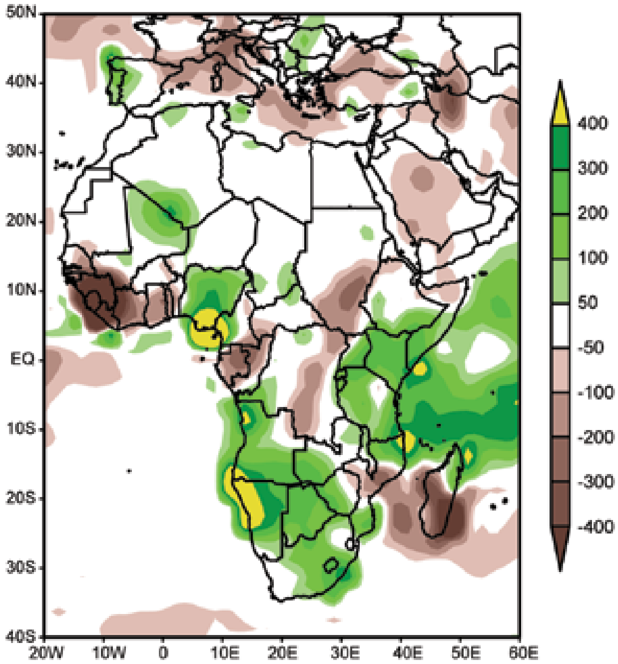

Fig. 6.1. African 2006 annual precipitation anomalies (mm; 1979–2000 base) from the CAMS-OPI dataset (Janowiak and Xie 1999). [Source: NOAA/NCDC.]

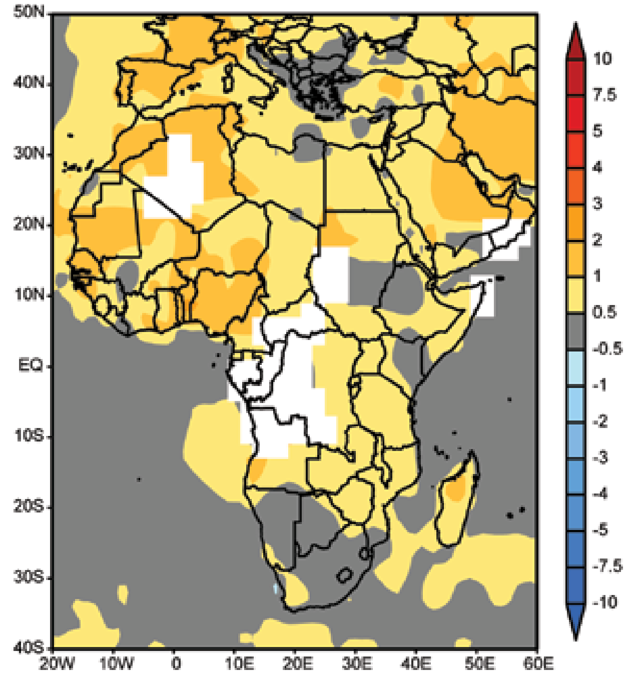

Fig. 6.2. African 2006 annual temperature anomalies (°C; 1971–2000 base) from CAMS-OPI.

decrease in Antarctic ozone depletion beginning around 2010, detectable at the 2σ level by 2023, and with a disappearance of the springtime ozone depletion phenomenon by 2070.

6. REGIONAL CLIMATES—A. Arguez, Ed.

a. Overview—A. Arguez

While a holistic (global) view of the 2006 state of the climate is a worthwhile vantage point, much can also be gleaned by analyzing individual continents, countries, and subregions. This section represents such a "downscaling" approach, as 2006 weather conditions over smaller geographic areas are not only described and put in a historical context, but international and interregional contrasts are also brought to light. The section is divided into seven sections: Africa, North America, Central America and the Caribbean, South America, Asia, Europe, and Oceania. These regions are further subdivided into practical climate divisions. Country and regional names utilized in this section do not, in any shape or form, reflect any political bias or sympathy. In addition, please note that varying base periods are often utilized for the computation of climate anomalies.

b. Africa—A. Arguez

Precipitation was generally above average over much of Sub-Saharan Africa in 2006 (Fig. 6.1). Several flood events and droughts occurred, causing substantial losses to human life and property. Most of Africa was slightly warmer than average for 2006 (Fig. 6.2). The following section discusses the state of the climate in four distinct regions: eastern Africa, northern Africa, southern Africa, and western Africa (including the Sahel).

1) Eastern Africa—M. Bell, C. Oludhe, P. Ambenje, L. Njau, Z. Mumba, and M. Kadi

The GHA countries have experienced heavy rainfall leading to severe flooding (the worst in the region for 50 years), causing loss of life and property in the region from October to November 2006. The worst hit were parts in Ethiopia, Somalia, and Kenya. Flood waters from the Juba River in Somalia and the Tana River in Kenya combined to inundate a large region of northeastern Kenya. Several rivers burst their banks, washing away roads and destroying bridges.

Climatologically, the timing of the rainy seasons in East Africa is governed by the meridional migration of the ITCZ through the course of the year. Although the complex orography and presence of the East African lakes make the climate of the region quite complicated, three general regimes can be delineated. In the southern sector, central and southern Tanzania has a unimodal rainfall regime, with precipitation primarily between December and April.

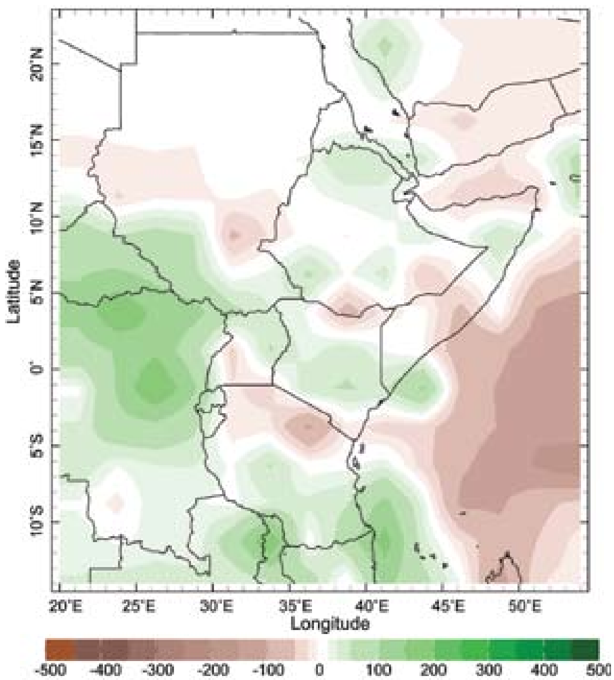

Fig. 6.3. March–May 2006 precipitation anomalies (mm; 1979–2000 base) for East Africa using CMAP (Xie and Arkin 1997), v0610. [Source: NOAA/CPC.]

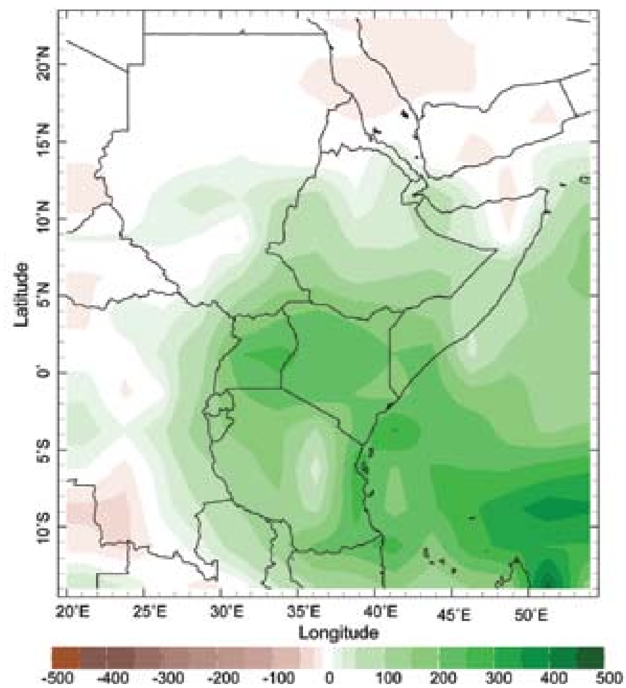

Fig. 6.4. October–December 2006 precipitation anomalies (mm; 1979–2000 base) for East Africa from CAMS-OPI.

Northern and northeastern Tanzania, most of Kenya, southern and eastern Ethiopia, and most of Somalia comprise the equatorial sector, which generally exhibits a bimodal rainfall regime, with the "long rains" during March–May and the "short rains" during October–December. In the northern sector, which includes much of central and western Ethiopia, western Eritrea, and much of Sudan, the major rainy season occurs during the months of June–September. In addition to a peak in rainfall centered on July and August, areas of north-central Ethiopia, eastern Eritrea, and Djibouti also experience a climatological rainfall maximum during March–May.

East Africa experienced a dramatic shift from terrible drought at the beginning of the year to generally abundant precipitation that was accompanied by destructive flooding throughout the region. Although the March–May long rains (Fig. 6.3) brought above-normal rainfall to parts of Kenya and southern Somalia, areas of northern Tanzania, and portions of northern Kenya, southern and eastern Ethiopia, and central Somalia continued to experience precipitation deficits. However, the October–December short rains (Fig. 6.4) produced above-normal rainfall throughout the region.

(i) Southern sector

By the early months of 2006, below-normal rainfall in Tanzania during the previous year was causing significant food security and power supply problems. Approximately two-thirds of Tanzania's electrical power is produced by hydropower. By February 2006, water levels in the country's hydropower reservoirs were nearly too low to continue producing electricity. After extremely dry conditions in January, rain finally began falling somewhat consistently in February and March in central and southern Tanzania, which constituted a delay of several weeks for the start of the rainy season there.

In the final quarter of 2006, some significant early rainy season precipitation fell in October and November in central and southern Tanzania, and rainfall in December was well above average throughout the country. The heavy rains caused flooding in the regions of Shinyanga and Kigoma in northwestern Tanzania. The paths of Tropical Storm Anita and Cyclone Bondo brought them into the northern end of the Mozambique Channel during December, providing an additional source of moisture and rainfall, though neither made landfall on the continent.

(ii) Equatorial sector

The extreme drought in East Africa, which became very severe by early 2006 with the nearly complete failure of the October–December 2005 short rains (Oludhe et al. 2006), was centered on the border region of northeastern Kenya, southeastern Ethiopia, and southern Somalia. Accumulated precipitation anomalies over the March–May 2006 long-rains season show near- to above-normal precipitation throughout much of Kenya, far southern Somalia, northeastern Uganda, and parts of southern Ethiopia. Below-normal precipitation is indicated in parts of north-central Kenya, southern Uganda, north-central Tanzania, eastern Ethiopia, and large parts of central and southern Somalia. Precipitation during the March–May long rains was only about 40%–70% of normal in these areas of Somalia (and in the neighboring Somali region of eastern Ethiopia, and parts of northern Kenya).

(iii) Northern sector

Rainfall in the highlands of central and western Ethiopia, much of Sudan, and western Eritrea started earlier than normal and remained plentiful throughout the June–September rainy season. In many areas of the northern sector, precipitation was more than 200% of normal. Heavy rainfall in July and August throughout most of Ethiopia resulted in deadly floods. In spite of some flood damage to crops, the above-normal June–September rainy season resulted in excellent crop production in Ethiopia and Sudan. A record cereal crop for 2006, estimated to be about 32% above the previous 5-year average, was forecast for Sudan.

2) Northern Africa—M. Bell

(i) Temperature

During 2006, annual mean temperature anomalies ranged from about 0.5° to 1.9°C above normal for most stations in North Africa. The warmest departures from the 1971–2000 mean were generally found along or just north of the Atlas Mountains across northern Morocco, Algeria, and Tunisia. Temperatures were generally cooler than normal in January and February 2006. Above-average temperatures returned to the region during March–May, but moderated somewhat during the course of the boreal summer through September. Above-normal temperatures again dominated in October and November.

(ii) Precipitation

The Mediterranean and Atlantic coastal area of North Africa receives the majority of its precipitation during October–April, largely from midlatitude cyclones and associated cold fronts. Mean annual rainfall totals decreased rapidly from about 700 mm at stations along the Mediterranean coast of Algeria and Tunisia to nearly zero in the interior of the Sahara Desert. In the Atlas Mountains of northern Morocco, Algeria, and Tunisia, cold-frontal passages can bring subfreezing temperatures and heavy rain or snow, occasionally causing floods and landslides.

For the year, annual precipitation amounts were above the 1971–2000 normal in a band extending just south of the Atlas Mountains from western Algeria northeastward into Tunisia, and at some locations along the Atlantic and Mediterranean coasts of Morocco and Algeria. Annual totals were generally below normal in Egypt, in interior Algeria, and in the Atlas Mountains of northern Algeria. Precipitation anomalies for the October 2005–April 2006 rainy season were above normal throughout the Canary Islands, Morocco, northern Algeria, northern Tunisia, and northwestern Libya. They were below normal in central Algeria, northwestern Libya, and northern Egypt

COUNTRY SPOTLIGHT: MOROCCO—K. Kabidi

During early 2006, Morocco recorded wet conditions with an average monthly rainfall much greater than the monthly long-term mean. Winter storm systems occurred during January and February, generating cold-air intrusion from the north and caused heavy rainfall that exceeded the monthly mean by more than 100%. For example, Rabat City recorded 173 mm during January, whereas the 1971–2000 monthly mean is only 82 mm. Several heat wave events occurred in late spring and during summer, punctuated by a +3°C temperature anomaly for the month of May in many parts of Morocco (Fig. 6.5). In addition, 2006 saw many Moroccan stations break wind speed records in summer, surpassing 100 km h^{-1} in some instances.

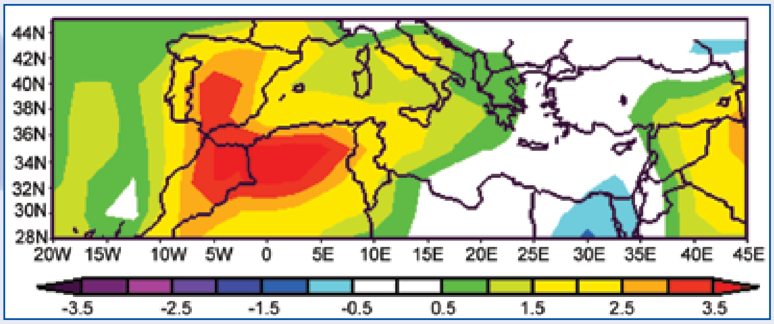

Fig. 6.5. May air temperature anomalies over northwest Africa (°C).

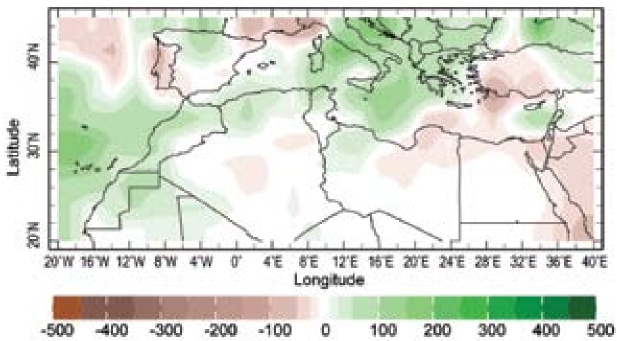

Fig. 6.6. October 2005–April 2006 precipitation anomalies (mm; 1979–2000 base) for North Africa from CMAP.

(Fig. 6.6). After generally near-normal precipitation during October–December 2005, several extratropical cyclones brought abundant rainfall to most of North Africa during the first two months of 2006. However, the months of March and April were quite dry throughout the region, particularly in northern Algeria and Tunisia. To start the 2006/07 boreal winter rainy season, precipitation deficits affected northern Morocco, Algeria, and Tunisia in October and November. Above-normal precipitation returned to northern Algeria and Tunisia in December.

(iii) Notable events

During 7–13 February, a slowly propagating extratropical cyclone tracked eastward across the Canary Islands and Morocco, and into western Algeria, producing unusually heavy rainfall and destructive flooding. The heavy rains at Las Palmas/Gando Station on the Canary Islands contributed significantly to an October 2005–April 2006 precipitation total that was approximately 200% of the median for the rainy season. The storm also contributed heavily to a February 2006 total of 81 mm of precipitation at Tindouf Station in western Algeria; mean and median rainfall for February are 2.7 and 0.6 mm, respectively.

3) Southern Africa—A. Kruger, W. Landman, and W. Thiaw

(i) Temperature

Annual mean temperatures over southern Africa were generally very close to the 1971–2000 mean in the southern parts, but about 0.5°–1.0°C above the 1979–2000 average in the north. In an area in the northern part of Madagascar, temperatures were between 1° and 2°C above normal (Fig. 6.2). The near-normal temperature conditions in the southern parts is reflected by the mean temperature anomalies of 28 South African climate stations, which show that temperatures in South Africa were about 0.27°C above the 1961–90 mean, making 2006 only the 15th warmest year since 1961.

(ii) Precipitation

Overall, southern Africa received mostly normal to above-normal rainfall during 2006. The Namibian northern coastal area and adjacent interior experienced very high rainfall, which is very uncharacteristic of the region. In contrast, below-normal rainfall was experienced in central Mozambique and central and southern Madagascar, where it was very dry in the east (Fig. 6.1).

The rainy season for most of southern Africa extends from October to April, with most rainfall usually from December to March. ENSO plays a significant role in the variability of rainfall, and for the most part causes drier conditions during warm episodes and wetter conditions during cold episodes. In the 2006 late-summer rainfall season, SSTs in the Niño-3.4 region were on average about −0.7°C below normal (base period 1971–2000), probably playing a role in the above-normal rainfall experienced over most of southern Africa during late summer.

A surface trough got established over southern Angola, Namibia, and South Africa. Associated with this system, upper-air (500 hPa) cyclonic circulation resulted in high rainfall totals during the austral summer and autumn over the southern parts, including South Africa, Namibia, Botswana, and Angola. Such wet conditions may have been associated with the La Niña conditions observed during early 2006. Well-established cloud bands were reported, contributing to large rainfall anomalies, particularly over Namibia. Easterly waves contributed to rainfall over the eastern regions including Kenia, Tanzania, Mozambique, and parts of South Africa. In late autumn, the surface circulation became anticyclonic, but with some frontal activity that contributed to anomalously wet conditions over parts of South Africa, including regions that are predominantly summer rainfall areas. During austral spring (SON), surface and associated upper-air trough systems developed once again over the west, leading to wet conditions over large areas of the region. However, these systems weakened during the month of December in association with the establishment of El Niño, associate with dryness over the south and wetter conditions over eastern equatorial Africa.

(iii) Circulation

The low-level atmospheric circulation associated

COUNTRY SPOTLIGHT: MOZAMBIQUE—D. Patricio

Mozambique is situated on the southern part of the East African coast, generally between 10° and 27°S and between 30° and 41°E. The country has a climate with tropical characteristics due to its location, with a hot rainy season generally from October to April, and a milder dry season from May to September.

In the southern part of Mozambique, the average monthly rainfall ranges from 23 mm in August to 152 mm in January. The annual average rainfall is about 857 mm. The monthly normal average air temperature ranges from 18.7°C in July to 26.3°C in February, with an annual average air temperature of 23.0°C. In 2006, the minimum monthly rainfall was observed in July (14.4 mm) and the maximum in March (289.0 mm), with an annual total of 1067.1 mm (24.5% above normal). Concerning the average air temperature, the smallest monthly average was 20.1°C in July and the largest was 27.8°C in February. The annual average value was 23.8°C, corresponding to 0.8°C above normal.

In central Mozambique, the monthly mean rainfall varies from 16 mm in September to 221 mm in February, with average annual rainfall of about 1191 mm (Fig. 8). The monthly average air temperature ranges from 20.2°C in July to 27.0°C in January; the annual average air temperature is 24.4°C. In the case of 2006, the minimum monthly rainfall was observed in July (5.4 mm) and the maximum in March (322.7 mm), with an annual value of 919.5 mm (22.8% below normal). With regard to the average air temperature, the monthly minimum value was registered as 21.1°C in July and the maximum was 29.2°C in December. The annual average value of 25.4°C corresponds to 1.0°C above normal.

In northern Mozambique, the monthly mean rainfall ranges from 4 mm in September to 196 mm in January; the annual average rainfall is about 1017 mm. The normal monthly average air temperature ranges from 19.4°C in July to 24.4°C in November; the annual average air temperature is 22.5°C. For 2006, the smallest monthly rainfall was observed in September (2.4 mm), while the maximum was reported in March (259.9 mm). The annual total was 1122.3 mm (10.4% above normal). The coldest (warmest) monthly average temperature was registered as 20.8°C (28.0) in July (November). The annual average temperature was 24.5°C (2.0°C above normal).

Figure 6.7 depicts the temporal distribution of monthly total rainfall and average air temperature for year 2006, as well as for the normal period (1961–90). In 2006, the weather was strongly influenced by the ITCZ during summer in the center and north. In the south, cold fronts played a dominant role. The southern and central parts of Mozambique were affected by a tropical depression in January, and by tropical cyclone Boloetse in February.

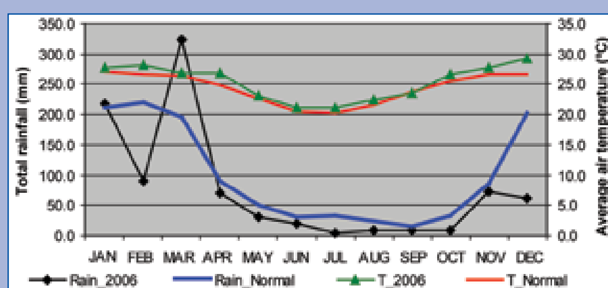

Fig. 6.7. Time Series of monthly total rainfall (mm) and average air temperature (°C) for Mozambique in 2006 and the normals for the 1961–90 base period.

with the 2005/06 rainy season featured easterly winds that averaged about 4–8 m s^{-1} from the east-central Indian Ocean westward into Madagascar and portions of interior southern Africa. This easterly flow was found along the equatorward flank of an enhanced Mascarene high pressure system and converged over interior southern Africa with a northeasterly flow that originated from the Bay of Bengal. The 500-hPa geopotential height exhibited strong intraseasonal variability in the circulation, but the presence of an anomalous trough was evident throughout the season. This anomalous trough was associated with a weak low-level anomalous cyclonic circulation across southern Africa and favored the intrusion of midlatitude disturbances. These contributed to higher-than-normal rainfall activity across southern Africa.

4) Western Africa—W. Thiaw

(i) Precipitation

The 2006 rainy season once again featured above-normal rainfall across most of the Sahel (Fig. 6.8). Rainfall totals were slightly less than those in 2005, but exceeded 100 mm above the average over portions of southwestern Senegal, southern and northern Burkina Faso, southern Niger, and central Chad. Overall, the 2006 rainy season was the fourth wettest since 1968. However, despite the wet conditions, the rainfall season was marked by a late onset. As of July, most areas in central Senegal, southern Mauritania, western Mali, and Niger reported rainfall deficits with amounts only 50%–70% of the long-term climatological mean. An abrupt northward jump of the ITCZ in mid-July marked the onset of the rains in most areas in the Sahel. As of August 2006, cu-

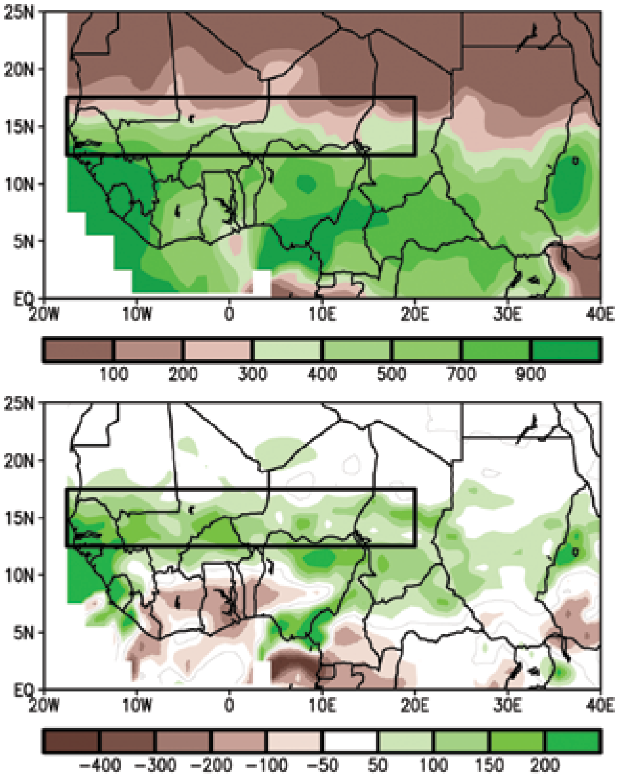

Fig. 6.8. June–September 2006 (a) total rainfall and (b) anomalies (mm; 1971–2000 base) for western Africa. The boxed region denotes the approximate boundaries of the Sahel.

mulative rainfall totals were near or above average across many areas in the Sahel. In the west, the formation of tropical depressions (some of them later developed into Atlantic tropical storms and hurricanes) along the coastlines of southern Senegal and Guinea, resulted in strong rainfall anomalies exceeding 200 mm. In contrast, seasonal rainfall totals across most of the Gulf of Guinea region were below normal. Rainfall deficits ranged between 100 and 300 mm across the central and southern areas of Benin, Togo, Ghana, most of the Cote d'Ivoire, and the eastern half of Guinea. The exceptions were the northern and southeastern areas of Nigeria, Liberia, and Sierra Leone, where rainfall totals exceeded 900 mm.

(ii) Atmospheric circulation

The above-average 2006 rainy season resulted from an enhanced West African monsoon in the latter part of the season. In August–September 2006, strong southwesterly winds at 925 hPa averaging 3–6 m s^{-1} extended well northward into the Sahel region. This enhanced monsoonal inflow was also evident at 850 hPa with Atlantic westerly wind anomalies exceeding 3 m s^{-1}, contributing to a deep penetration of moist, unstable air well into the Sahel region. The enhanced monsoon was also associated with an anomalous low-level cyclonic circulation across the northern and central Sahel, characterized by enhanced cyclonic shear along the equatorward flank of the AEJ. The mean position of the AEJ across the western Sahel was at about 15°N.

c. North America

1) Canada—R. Whitewood and D. Phillips

The climate of Canada in 2006 was characterized by near-record temperatures (Fig. 6.9) and near-normal precipitation relative to the 1951–80 base period (Fig. 6.10). Extreme weather took a toll this year with several deaths and millions of dollars in property damage. British Columbia suffered the most in 2006, starting the year with a near-record number of days with precipitation, experiencing drought-like conditions through the summer, and concluding with some of the most powerful storms ever to hit the province.

(i) Temperature

Canada, as a whole, experienced its second warmest year—2.4°C above normal (Fig. 6.11), with 1998 remaining the warmest at 2.5°C above normal—since reliable nationwide records started in 1948. Most of Canada had temperatures at least 2°C above normal, with the northern territories experiencing the greatest anomaly of about 4°C. Only an area in northern British Columbia had near-normal temperatures. This marks the 10th straight year of above-normal temperatures, with 6 of the warmest 10 years occurring in the last 10 years. Over the period of record (1948–2006) the national trend is +1.3°C.

Nine of the eleven Canadian climate regions had temperatures that ranked among the 10 warmest, with three climate regions having their warmest year: two covering Nunavut (+3.4° and +2.3°C), and one covering northern Ontario and Quebec (+2.3°C). Three other regions experienced their second warmest year: the region covering much of the Northwest Territories (+3.2°C), Atlantic Canada (+1.8°C), and southern Ontario and Quebec (+1.8°C). Over the 59 years of record, all the climate regions show a positive trend, with the region covering much of the Northwest Territories showing the largest trend of +2.2°C, and the Atlantic Canada region the smallest trend of +0.3°C.

(ii) Precipitation

Nationally, 2006 was unremarkable with regard to precipitation totals, ranking 21st wettest, out of