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ABSTRACT—J. BLUNDEN AND D. S. ARNDT

In 2013, the vast majority of the monitored climate variables reported here maintained trends established in recent decades. ENSO was in a neutral state during the entire year, remaining mostly on the cool side of neutral with modest impacts on regional weather patterns around the world. This follows several years dominated by the effects of either La Niña or El Niño events.

According to several independent analyses, 2013 was again among the 10 warmest years on record at the global scale, both at the Earth's surface and through the troposphere. Some regions in the Southern Hemisphere had record or near-record high temperatures for the year. Australia observed its hottest year on record, while Argentina and New Zealand reported their second and third hottest years, respectively. In Antarctica, Amundsen-Scott South Pole Station reported its highest annual temperature since records began in 1957. At the opposite pole, the Arctic observed its seventh warmest year since records began in the early 20th century. At 20-m depth, record high temperatures were measured at some permafrost stations on the North Slope of Alaska and in the Brooks Range. In the Northern Hemisphere extratropics, anomalous meridional atmospheric circulation occurred throughout much of the year, leading to marked regional extremes of both temperature and precipitation. Cold temperature anomalies during winter across Eurasia were followed by warm spring temperature anomalies, which were linked to a new record low Eurasian snow cover extent in May.

Minimum sea ice extent in the Arctic was the sixth lowest since satellite observations began in 1979. Including 2013, all seven lowest extents on record have occurred in the past seven years. Antarctica, on the other hand, had above-average sea ice extent throughout 2013, with 116 days of new daily high extent records, including a new daily maximum sea ice area of 19.57 million km^2 reached on 1 October.

ENSO-neutral conditions in the eastern central Pacific Ocean and a negative Pacific decadal oscillation pattern in the North Pacific had the largest impacts on the global sea surface temperature in 2013. The North Pacific reached a historic high temperature in 2013 and on balance the globally-averaged sea surface temperature was among the 10 highest on record. Overall, the salt content in near-surface ocean waters increased while in intermediate waters it decreased. Global mean sea level continued to rise during 2013, on pace with a trend of 3.2 mm yr^{-1} over the past two decades. A portion of this trend (0.5 mm yr^{-1}) has been attributed to natural variability associated with the Pacific decadal oscillation as well as to ongoing contributions from the melting of glaciers and ice sheets and ocean warming.

Global tropical cyclone frequency during 2013 was slightly above average with a total of 94 storms, although the North Atlantic Basin had its quietest hurricane season since 1994. In the Western North Pacific Basin, Super Typhoon Haiyan, the deadliest tropical cyclone of 2013, had 1-minute sustained winds estimated to be 170 kt (87.5 m s^{-1}) on 7 November, the highest wind speed ever assigned to a tropical cyclone. High storm surge was also associated with Haiyan as it made landfall over the central Philippines, an area where sea level is currently at historic highs, increasing by 200 mm since 1970.

In the atmosphere, carbon dioxide, methane, and nitrous oxide all continued to increase in 2013. As in previous years, each of these major greenhouse gases once again reached historic high concentrations. In the Arctic, carbon dioxide and methane increased at the same rate as the global increase. These increases are likely due to export from lower latitudes rather than a consequence of increases in Arctic sources, such as thawing permafrost. At Mauna Loa, Hawaii, for the first time since measurements began in 1958, the daily average mixing ratio of carbon dioxide exceeded 400 ppm on 9 May.

The state of these variables, along with dozens of others, and the 2013 climate conditions of regions around the world are discussed in further detail in this 24th edition of the *State of the Climate* series.

Tropical Storms Barry and Lorena, and Tropical Depression Number Eight all brought heavy rainfall to various regions across Mexico.

(iii) Notable events

Two tropical cyclones arrived simultaneously on Mexico's coasts (Pacific and Atlantic) in September. Hurricane Ingrid (12–17 September) formed in the Gulf of Mexico, near northern Tabasco and made landfall between Tamaulipas and Veracruz. Southern Tamaulipas received half of its mean annual rainfall in just six days, while northern Veracruz received one-third of its mean annual during the same period. At the same time, Hurricane Manuel made landfall twice on the Pacific coast, with the rainfall contributing over 60% of the mean annual precipitation in parts of Guerrero; Michoacan, Colima, and Jalisco were also impacted. During 17–19 September, northern Sinaloa received 40%–60% of its mean annual rainfall. Manuel caused flooding and severe damage to infrastructure, but also helped to improve soil moisture and recharge aquifers and reservoirs. The last time two tropical cyclones impacted Mexico simultaneously was in 1958 when tropical storms Alma in the Atlantic and Number Two in the Pacific made landfall between 13 and 16 June.

Nine winter storms impacted the country this year, four of them between January and March and five from November to December. The mountains of Baja California, Sonora, Chihuahua, Coahuila, Durango, and Zacatecas were most affected by these with low temperature and snowfalls. The last winter storm in late December was the heaviest, causing sleet and snowfall over Chihuahua, Nuevo León, Durango, and Tamaulipas.

c. Central America and the Caribbean

1) Central America—J. A. Amador, E. J. Alfaro, H. G. Hidalgo, A. M. Durán-Quesada, B. Calderón, I. L. Rivera, and C. Vega

For this region, nine stations from five countries were examined. The stations located on the Caribbean slope are: Philip Goldson International Airport, Belize; Puerto Barrios, Guatemala; Puerto Lempira, Honduras; and Puerto Limón, Costa Rica. On the Pacific slope: Tocumen International Airport and David, Panamá; Liberia, Costa Rica; Choluteca, Honduras; and San José, Guatemala. Procedures follow Amador et al. (2011) for all variables, except that the base period used to compute anomalies was 1981–2010. Liberia showed abnormal precipitation values on 22 May, 30 May, and 7 June 2013; the corresponding corrections were made using precipitation observed at a nearby meteorological station from the Costa Rica National Meteorological Institute (CRNMI).

(i) Temperature

Mean temperature (T_m) distributions for all stations are shown in Fig. 7.9. Most stations experienced a slightly warmer-than-average year. Similar to previous years, the negative skewness in T_m at Philip Goldson and Puerto Barrios on the Caribbean slope, in both the climatology and for 2013, is most likely a result of frequent cold surges from the north during the winter months. The T_m patterns suggest a near-normal year in northern Central America. The negative skewness in T_m is rarely observed in Puerto Lempira and Puerto Limón, indicating that cold fronts reaching these station latitudes, in the mean, rapidly lose their thermal properties. On the Pacific slope, most stations recorded a higher frequency of warmer T_m values during 2013 with less variability and lighter tails (indicating less frequent extremes).

(ii) Precipitation

For this section, "significant" probability (p) implies $0.05 < p < 0.10$, and "very significant" probability implies $p < 0.05$. Tocumen was not considered in this analysis because of missing data during 2013. The start of the rainy season is identified as two consecutive days with at least 25 mm of precipitation followed by a third day with measurable precipitation. A similar approach was used to compute the end of the rainy season, but from the end of the year backwards.

Compared with the 1981–2010 period, 2013 was a near-normal year in terms of starting and ending dates of the rainy season for the Central American stations, with the exception of Liberia and Philip Goldson International Airport, which observed early starting dates of the rainy season. Liberia experienced a wet year during 2013, including significantly late ending dates of the rainy season. It was the only station with a very significantly above-normal maximum 5-day wet-period accumulation, and a significantly below-normal number of dry pentads. In addition, Liberia and Philip Goldson International Airport showed significantly above-normal precipitation interquartile ranges, indicating great variability in contrast to the climatology, and an above-normal number of extreme wet outliers (precipitation above the 90th percentile). Other stations with an above-normal number of wet outliers were San José, Belize, and Puerto Barrios, Guatemala. Choluteca was the only station that showed above-normal maximum

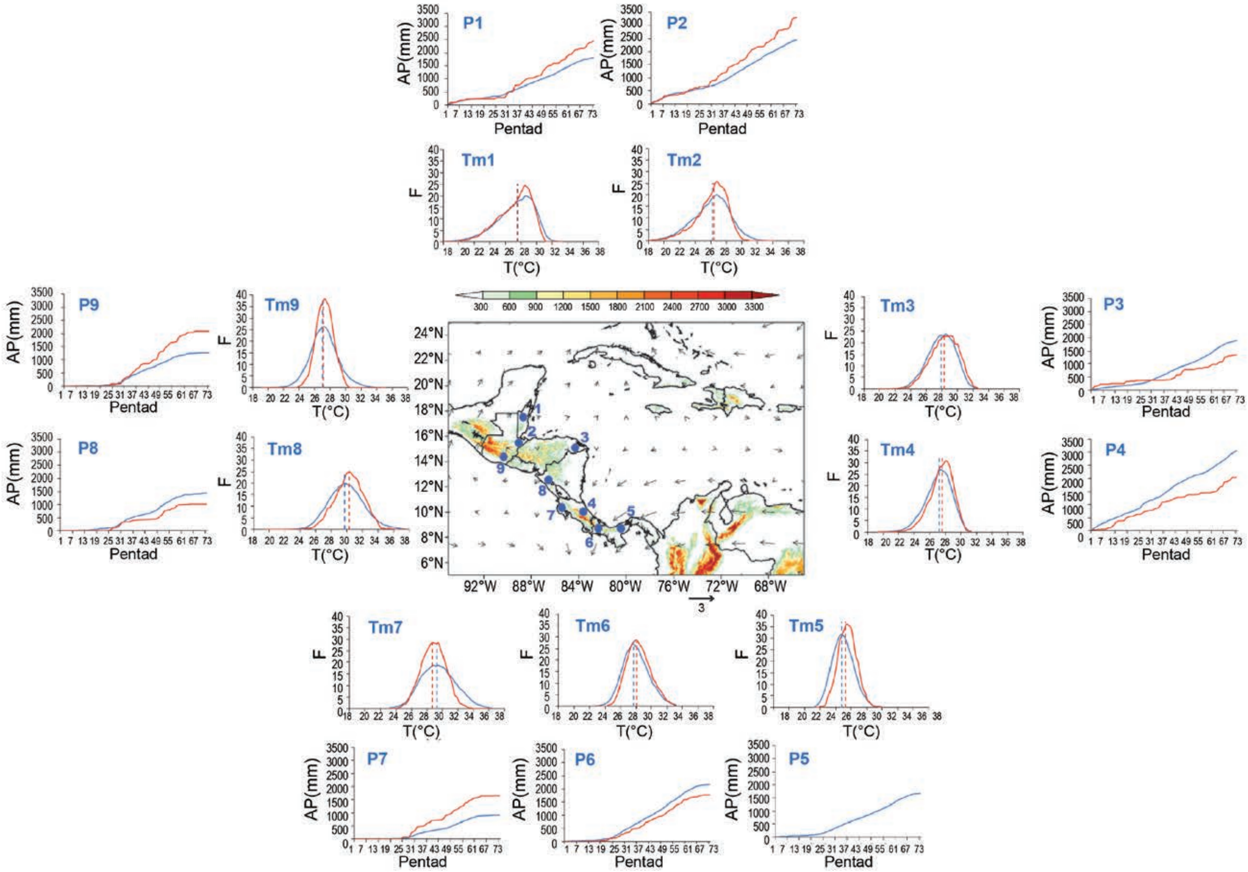


Fig. 7.9. Mean surface temperature (T_m, °C) frequency (F) and accumulated pentad precipitation (AP, mm) time series are shown for nine stations (blue dots) in Central America: (1) Philip Goldson International Airport, Belize; (2) Puerto Barrios, Guatemala; (3) Puerto Lempira, Honduras; (4) Puerto Limón, Costa Rica; (5) Tocumen International Airport, Panamá; (6) David, Panamá; (7) Liberia, Costa Rica; (8) Choluteca, Honduras; and (9) San José, Guatemala. The blue solid line represents the 1981–2010 average values and the red solid line shows 2013 values. Vertical dashed lines depict the mean temperature for 2013 (red) and the 1981–2010 period (blue). Tocumen (station 5) does not display 2013 precipitation due to missing data. Vectors indicate Jul wind anomalies at 925 hPa (1981–2010 base period). Shading depicts regional elevation (m). (Source: NOAA/NCDC.)

number of dry-pentads, and Puerto Limón had significant above-normal number of extreme dry outliers.

Moisture transport from both the Caribbean and the eastern tropical Pacific followed the mean annual cycle with deviations in intensity from the 1980–2013 period. A decrease in moisture transport from the Caribbean was observed during January and February. This is likely related to a cooler-than-normal SST and associated reduction in evaporation. The start of the 2013 rainy season coincided with a marked increase in the transport of moisture from the Caribbean in April (of the order of 4 mm day^{-1}). A reduction of transport from the Caribbean is observed from reanalysis data during the second half of the year, which may be linked with a decrease of the cyclone activity in 2013. Moisture transport from the eastern tropical Pacific was greater than normal, indicating an intensification of evaporation (Leduc et al. 2007).

(iii) Notable events

The region was under the influence of neutral ENSO conditions (see section 4b) and stronger-than-average 925-hPa winds during July (vectors in Fig. 7.9), a condition unfavorable for tropical cyclone formation (Amador et al. 2006). Indeed, 2013 was a below-average year for tropical storms in the Caribbean basin (6°–24°N, 92°–60°W). For the first time since 1986 there were only two named storms and no hurricanes in the region (Table 7.1).

During the first half of the rainy season (May–June), strong convective storms brought heavy rains that triggered landslides, claiming two lives in Panamá and three in Guatemala. During 3–13 September, several intense rainfall events and flash floods affected the Pacific slope and the populated areas of the Costa Rica's Central Valley, according to the CRNMI. The second half of the rainy season

Table 7.1. Number of named storms (NS) for years with zero, one, and two NS in the Caribbean basin (6°–24°N, 92°–60°W) for 1948–2013. Named storms that reached hurricane (H) or tropical storm (TS) strength are shown in parenthesis after the year with the maximum Saffir-Simpson category hurricane strength (Cat) also indicated. (Source: HURDAT 2, http://www.aoml.noaa.gov/hrd/hurdat/Data_Storm.html.)

Number of Named Storms (NS)	Years
0	**1983**
1	**1962** (TS Daisy), **1965** (H Betsy Cat 3), **1972** (H Agnes Cat 1), **1976** (TS Emmy), **1991** (TS Fabian), **1992** (TS Andre)
2	**1968** (TS Abby, H Gladys Cat 1), **1975** (H Eloise, H Gladys both Cat 1), **1977** (H Anita Cat 4, TS Freda), **1986** (TS Danielle, TS Frances), **1987** (H Emily Cat 3, TS Floyd), **1997** (H Ericka Cat 3, TS Grace), **2002** (H Lili, H Isidore, both Cat 3), **2013** (TS Chantal, TS Grabiele)

(August–November) wreaked havoc across Central America, claiming more than 41 lives (28 in Honduras and at least 13 in Nicaragua) due to intense rains, landslides, and river floods.

2) The Caribbean—T. S. Stephenson, M. A. Taylor, A. R. Trotman, A. O. Porter, I. T. Gonzalez, J. M. Spence, N. McLean, J. D. Campbell, G. Brown, M. Butler, R. C. Blenman, A. P. Aaron-Morrison, and V. Marcellin-Honore'

The Caribbeans climate was influenced by neutral ENSO conditions, an anomalously warm tropical North Atlantic in the latter half of the year, and below-normal hurricane activity. Annual temperatures were near normal (Fig. 7.10a). Normal to above-normal annual rainfall occurred over most eastern Caribbean islands, Puerto Rico, eastern Jamaica, and eastern Cuba (Fig. 7.10b). Unless otherwise specified, comparisons are to the 1981–2010 base period. Records set for the following territories are with respect to the year in parenthesis: Dominica (1982), Puerto Rico (1898), St. Croix (1972), St. Thomas (1953), Trinidad and Tobago (1946 and 1969, respectively).

(i) Temperature

Annual temperatures over the Caribbean were generally normal relative to 1981–2010 (Fig. 7.10a). Barbados recorded monthly maximum temperatures near or below the climatological means, except in March. The Cayman Islands reported warmer- (cooler-) than-normal monthly maximum (minimum) temperatures throughout the year. Monthly average temperatures were above normal across Trinidad, Tobago, and Puerto Rico, with San Juan recording its second warmest December (26.8°C). Other top 10 temperatures recorded for San Juan include the ninth warmest March (26.4°C) and the fifth warmest April, (27.1°C), fifth warmest April, September, and October (29.1° and 28.8°C, respectively). St. Croix experienced its tenth coolest March and May (25.1° and 26.8°C, respectively) and second warmest October (28.6°C). Near-normal temperatures were recorded over Cuba, excluding March and October where above- and below-normal temperatures were

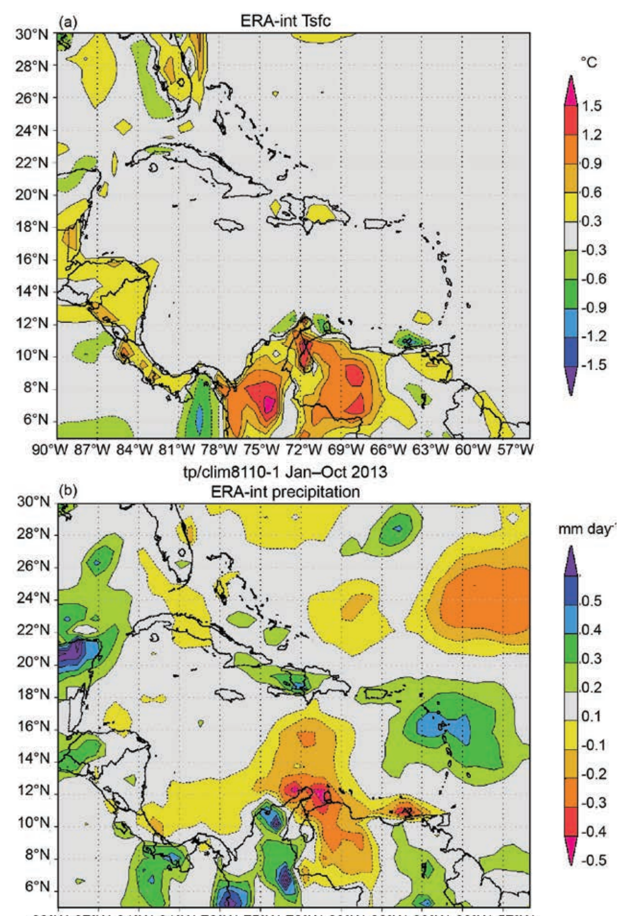
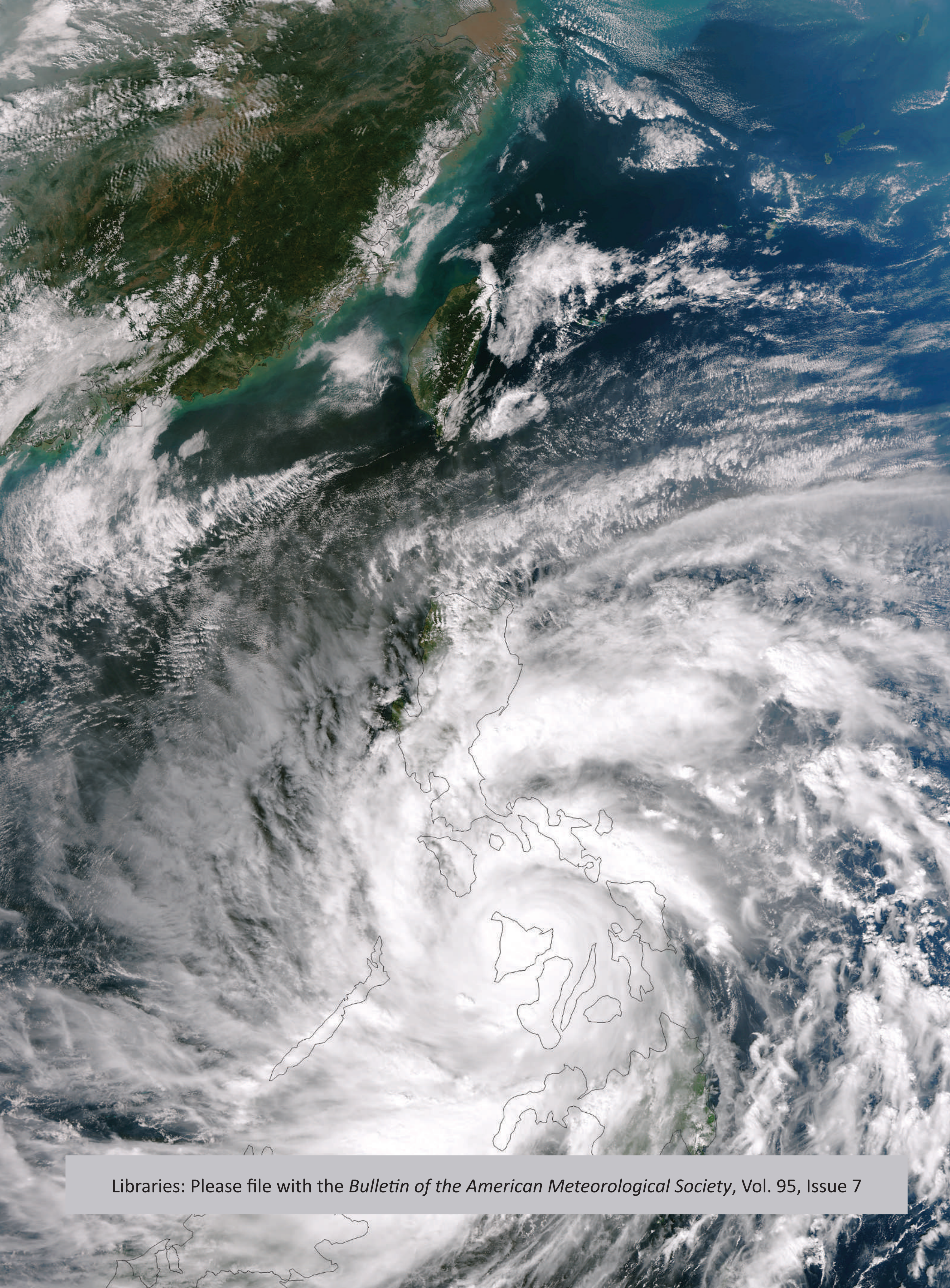


Fig. 7.10. (a) Temperature (°C) and (b) rainfall (mm day^{-1}) anomalies for Jan–Oct 2013 across the Caribbean basin (with respect to the 1981–2010 mean). (Source: ERA-Interim.)



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