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# STATE OF THE CLIMATE IN 2024

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# STATE OF THE CLIMATE IN 2024

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### *c. Central America and the Caribbean*

—A. Arguez, Ed.

#### 1. CENTRAL AMERICA

—H. G. Hidalgo, J. A. Amador, E. J. Alfaro, B. Calderón, and N. Mora

Nine stations were analyzed across Central America (see Fig. 7.10 for stations and specific data sources). The station distribution is representative of the relevant seasonal and intraseasonal regimes of precipitation (Amador 1998; Magaña et al. 1999; Amador et al. 2016a,b), wind (Amador 2008), and temperature (Hidalgo et al. 2019) on the Caribbean and Pacific slopes of Central America (CA). Precipitation and temperature data were provided either by Central America National Weather Services (CA-NWS), NOAA, or the University of Costa Rica; however, in some cases, missing 2024 daily precipitation data were filled in with the nearest grid point data from the Climate Hazards and Infrared Precipitation (CHIRPs; Funk et al. 2015). Anomalies are reported using a 1991–2020 base period and were calculated from CA-NWS data. The methodologies used for all variables are described by Amador et al. (2011).

*(i) Temperature*

The year 2024 was warmer than normal (relative to the 1991–2020 base period) across most of Central America, with the most notable high annual temperature anomalies (Tm; °C) in Guatemala, Belize, and the Caribbean coast of Costa Rica. The stations of Phillip Goldson International Airport (PGIA; Tm1; +0.92°C), Puerto Barrios (Tm2; +1.09°C), Limón (Tm4; +0.72°C), and Montufar (Tm9; +1.79°C) had mean annual temperatures that were statistically significantly ($p \leq 0.05$) higher than the climatology. The Liberia Airport station was the only station analyzed to have a below-normal annual temperature (not significant). The five-day average temperature (Tm; °C) frequency distributions in 2024, as well as the climatology, for all stations analyzed are shown in Fig. 7.10. Annual temperature anomalies for each station are shown in Table 7.1.

**Table 7.1. Annual temperature and precipitation anomalies for 2024 with respect to the 1991–2020 averages (normals), calculated from monthly means and accumulations, respectively. Anomalies in the 95% tails of the 1991–2020 (two-tailed) statistical distributions are marked with a star icon (★). Only annual anomalies are presented; seasonal anomalies are not considered as the typical trimester seasons used in mid- and high latitudes are not representative for the tropics.**

| Station | 2024 Annual Temperature Anomaly (°C) | 1991–2020 Annual Temperature Normal (°C) | 2024 Annual Precipitation Anomaly (mm) | 1991–2020 Annual Precipitation Normal (mm) |
|---|---|---|---|---|
| Phillip Goldson International Airport (PGIA), Belize | +0.92 ★ | 26.9 | +548.7 | 1963 |
| Puerto Barrios, Guatemala | +1.09 ★ | 26.6 | –483.8 | 3331 |
| Lempira, Honduras | +1.03 | 26.7 | –1093.5 ★ | 2699 |
| Limón, Costa Rica | +0.72 ★ | 25.4 | –404.17 | 3687 |
| Tocumen Airport, Panama | +0.45 | 27.2 | +754.8 | 1760 |
| David, Panama | +0.19 | 28.0 | +608.6 | 2196 |
| Liberia Airport, Costa Rica | –0.42 | 27.1 | +660.7 | 1735 |
| Choluteca, Honduras | +0.48 | 29.8 | +870.8 | 1963 |
| Montufar, Guatemala | +1.79 ★ | 27.8 | +478.4 | 1689 |

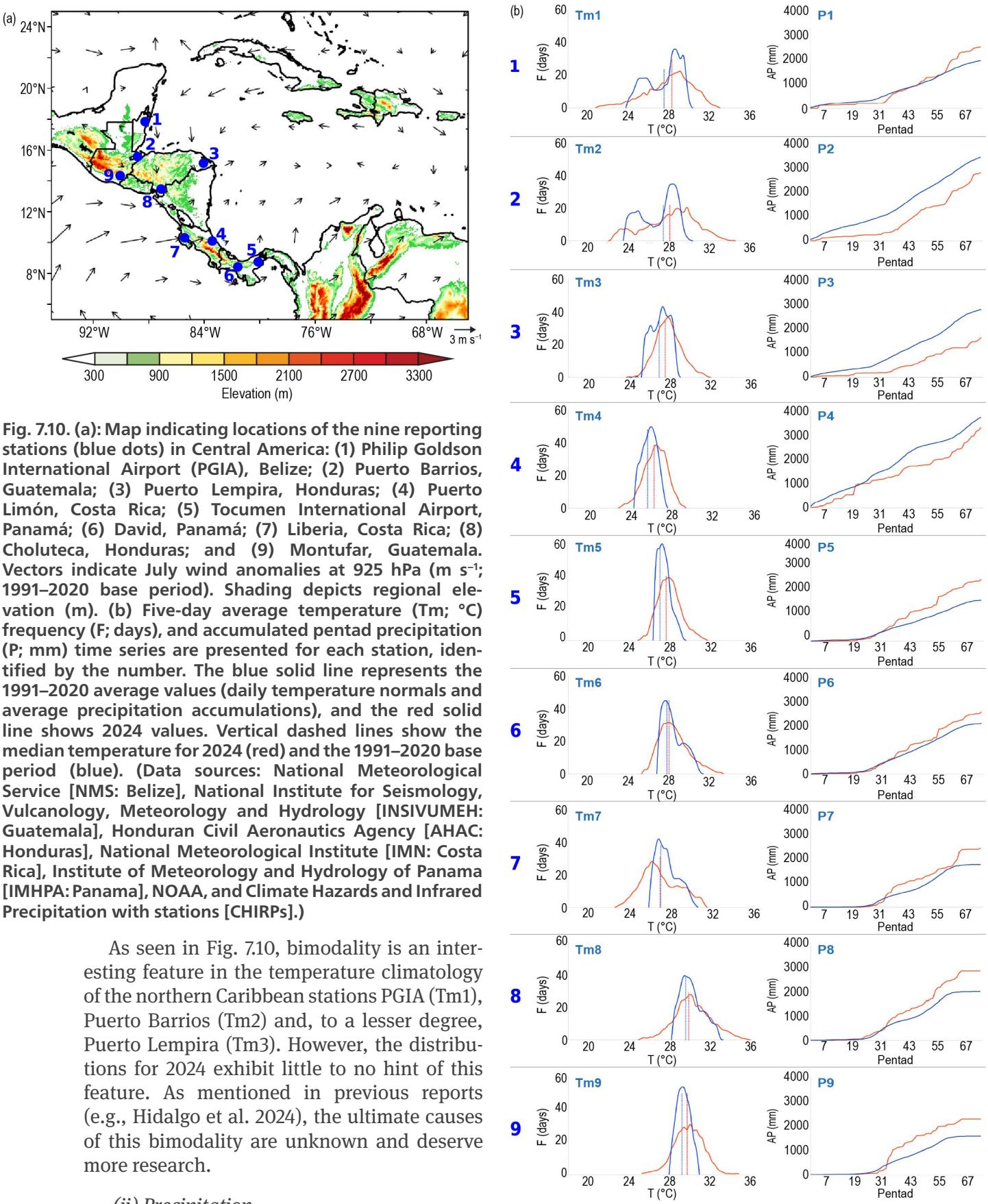


**Fig. 7.10. (a): Map indicating locations of the nine reporting stations (blue dots) in Central America: (1) Philip Goldson International Airport (PGIA), Belize; (2) Puerto Barrios, Guatemala; (3) Puerto Lempira, Honduras; (4) Puerto Limón, Costa Rica; (5) Tocumen International Airport, Panamá; (6) David, Panamá; (7) Liberia, Costa Rica; (8) Choluteca, Honduras; and (9) Montufar, Guatemala. Vectors indicate July wind anomalies at 925 hPa (m s$^{-1}$; 1991–2020 base period). Shading depicts regional elevation (m). (b) Five-day average temperature (Tm; °C) frequency (F; days), and accumulated pentad precipitation (P; mm) time series are presented for each station, identified by the number. The blue solid line represents the 1991–2020 average values (daily temperature normals and average precipitation accumulations), and the red solid line shows 2024 values. Vertical dashed lines show the median temperature for 2024 (red) and the 1991–2020 base period (blue). (Data sources: National Meteorological Service [NMS: Belize], National Institute for Seismology, Vulcanology, Meteorology and Hydrology [INSIVUMEH: Guatemala], Honduran Civil Aeronautics Agency [AHAC: Honduras], National Meteorological Institute [IMN: Costa Rica], Institute of Meteorology and Hydrology of Panama [IMHPA: Panama], NOAA, and Climate Hazards and Infrared Precipitation with stations [CHIRPs].)**

As seen in Fig. 7.10, bimodality is an interesting feature in the temperature climatology of the northern Caribbean stations PGIA (Tm1), Puerto Barrios (Tm2) and, to a lesser degree, Puerto Lempira (Tm3). However, the distributions for 2024 exhibit little to no hint of this feature. As mentioned in previous reports (e.g., Hidalgo et al. 2024), the ultimate causes of this bimodality are unknown and deserve more research.

*(ii) Precipitation*

The annual precipitation accumulations (P; mm) showed statistically significant ($p \leq 0.05$) drier-than-normal conditions in Puerto Lempira (P3; –1093.5mm). The remainder of the stations reported positive anomalies that were not statistically significant, except for Puerto Barrios (P2) and Puerto Limon (P4), which reported non-significant below-normal conditions. The lack of statistically significant annual precipitation accumulations across the Pacific slopes of

Central America coincided with relatively low tropical cyclone activity in the Pacific oceanic basin during 2024. Dry conditions along the central Caribbean coast of Central America, with wetter-than-normal precipitation over the Pacific slope, is a weather pattern typically associated with La Niña and above-normal sea surface temperature anomalies in the Caribbean/Atlantic oceanic basin indexed by the Tropical Northern Atlantic index (TNA; not shown) in a dipole fashion. Such climate teleconnections are referenced in other studies (e.g., Enfield and Alfaro 1999; Durán-Quesada et al. 2020). It is important to note that negative Oceanic Niño Index values were not reported until the July–September trimester of 2024, and that the negative values in the latter half of 2024 were not sufficiently negative or persistent enough to be characterized as a La Niña event (see section 4b for details). However, the TNA was indeed consistently positive throughout 2024 (https://psl.noaa.gov/data/correlation/tna.data), which could suggest that the expected significantly above-normal precipitation pattern was not clearly developed over the Pacific slope. The high-Pacific versus low-Caribbean pressure gradient that produces anomalous westerly flow (shown in the wind anomaly pattern of Fig. 7.10a) is coherent with the aforementioned SST dipole conditions and generally consistent with the above-normal (below-normal) annual precipitation accumulations in the Pacific (Caribbean) slopes observed across Central America in 2024. Annual precipitation anomalies for each station are listed in Table 7.1.

*(iii) Notable events and impacts*

The 2024 Atlantic tropical cyclone activity was considered to be an above-average season (see section 4g2). In contrast, the eastern tropical Pacific region showed relatively less activity (see section 4g3), with most tropical cyclones developing in the northern part, resulting in relatively low socioeconomic impacts for Central America. There were 96 fatalities due to hydrometeorological events (extreme rainfall and compounding impacts such as winds, mudslides, landslides, floods) in the region for 2024, excluding 26 fatalities due to tropical cyclones and another 26 attributed to lightning strikes (Table 7.2). Hurricane Rafael and Tropical Storm Sara both formed in the Caribbean Sea in November. Rafael caused indirect effects over the southernmost part of the region, leading to five deaths in Panama and two in Costa Rica. Sara caused landslides and floods across most countries in the region and contributed to 19 fatalities (Table 7.2). Due to their broad areas of impact, these two tropical cyclones accounted for most of the socioeconomic impacts in the region in 2024.

**Table 7.2. Number of fatalities in several Central American countries due to hydrometeorological events, specific tropical cyclones (Hurricane Rafael and Tropical Storm Sara), and lightning strikes. Data sources: Central American national weather services, regional newspapers, and national emergency committees, including: the National Civil Protection System (SINAPROC; Panama), the National Commission for Risk Prevention and Emergency Response (CNE; Costa Rica), the National System for Civil Protection, Disaster Prevention and Mitigation (El Salvador), the Permanent Contingency Commission of Honduras (COPECO; Honduras), the National Coordination for Disaster Reduction (CONRED; Guatemala), and El Diario de Hoy (Nicaragua).**

| Country | Hydrometeorological Events | Rafael | Sara | Lightning Strikes |
|---|---|---|---|---|
| Panamá | 7 | 5 | 6 | 12 |
| Costa Rica | 5 | 2 | 4 | 1 |
| Nicaragua | 16 | 0 | 2 | 5 |
| El Salvador | 24 | 0 | 0 | 2 |
| Honduras | 12 | 0 | 7 | 3 |
| Guatemala | 32 | 0 | 0 | 3 |
| TOTAL | 96 | 7 | 19 | 26 |

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