

Influence of Tropical Easterly Waves on the ChocoJet during the 2019 OTREC Campaign

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ABSTRACT: This study investigates how convectively coupled tropical easterly waves (TEWs) affect the Choco low-level jet (ChocoJet) as they move across the western Caribbean. The ChocoJet is a low-level flow over the eastern Pacific (EPAC) that modulates precipitation patterns over the tropical eastern Pacific and northwestern South America. By combining data from the Organization of Tropical East Pacific Convection (OTREC; August–September 2019), ERA5 reanalysis products, and satellite data, we analyze precipitation and circulation patterns during convectively coupled and nonconvectively coupled TEWs, comparing them to non-TEW days. During convectively coupled TEWs days, the ChocoJet strengthens and becomes more southerly, while the ITCZ moves northward, leading to enhanced precipitation over the western Caribbean and drier conditions over the northern part of the Colombian Pacific. In contrast, nonconvectively coupled TEW days exhibit reduced precipitation and precipitable water over the Caribbean and far EPAC, with a layer of northeasterly flow centered at 850 hPa flowing over a shallower, weaker, and more westerly ChocoJet. Additionally, convectively coupled TEWs are associated with a weaker western Caribbean and far eastern Pacific pressure gradient compared to nonconvective TEWs. These observable and predictable synoptic-scale circulation–precipitation relationships contribute to a better understanding of hydrometeorological variability in the region.

SIGNIFICANCE STATEMENT: Tropical easterly waves and related convective organization traversing the Caribbean Sea are important sources of synoptic-scale precipitation–circulation variability in the far eastern Pacific and Colombian Pacific. This eastern tropical Pacific study aims to identify precipitation–circulation relationships that enhance the understanding of synoptic-scale meteorological phenomena.

KEYWORDS: Atmospheric waves; Jets; Synoptic-scale processes; Tropical cyclones; Hydrometeorology; Field experiments

1. Introduction

Tropical easterly waves (TEWs) are quasi-periodic wave disturbances embedded in the easterly trade winds during boreal summer and autumn (Nitta and Takayabu 1985; Lau and Lau 1992; Roundy and Frank 2004; Serra et al. 2010). They influence the circulation dynamics of tropical America at synoptic scales (Nitta and Takayabu 1985; Thorncroft and Hodges 2001; Cárdenas et al. 2017; Cornforth et al. 2017; Dominguez et al. 2020). TEWs have been related to convective precipitation (Thorncroft and Hodges 2001; Gomes et al. 2015) and contribute up to 50% of the seasonal precipitation (June–November) over northern South America (Dominguez et al. 2020), as well as up to 20% of the tropical intraseasonal precipitation (Lubis and Jacobi 2015). Additionally, TEWs can be convectively coupled (convective), but can also propagate without significant convection activity (nonconvective). Of the latter, nearly 50% have been related to environments with prevailing suppressed

convection over northern South America and the Caribbean (Giraldo-Cardenas et al. 2022).

The Choco low-level jet (ChocoJet) is a westerly branch of the eastern Pacific (EPAC) southwesterly cross-equatorial flow that facilitates moisture transport into the Colombian Pacific. It reaches the western range of the Andes and triggers orographic precipitation (Poveda and Mesa 2000), as well as the organization of convection into mesoscale convective systems (MCSs; Jaramillo et al. 2017; Mejía et al. 2021). The ChocoJet strengthens seasonally during September–November (SON) when the sea surface temperature (SST) gradient between the relatively cold Peruvian waters and the warmer waters of the Colombian Pacific increases (Poveda and Mesa 2000). Recently, Mejía et al. (2021) showed that northerly flow from the Caribbean low-level jet (CLLJ) can also interact with the ChocoJet, enhancing low-level confluence over the Pacific coast of Colombia and Panama (hereafter “far EPAC,” Fig. 1) and modulating the development of convection over this region.

Due to the large spatial and temporal variability of tropical convection, the far EPAC and western Colombia face significant challenges. They house the rainiest place in the world, with average annual precipitation ranging between 8000 and 13 000 mm yr^{−1} (Poveda and Mesa 2000; Jaramillo and Chaves

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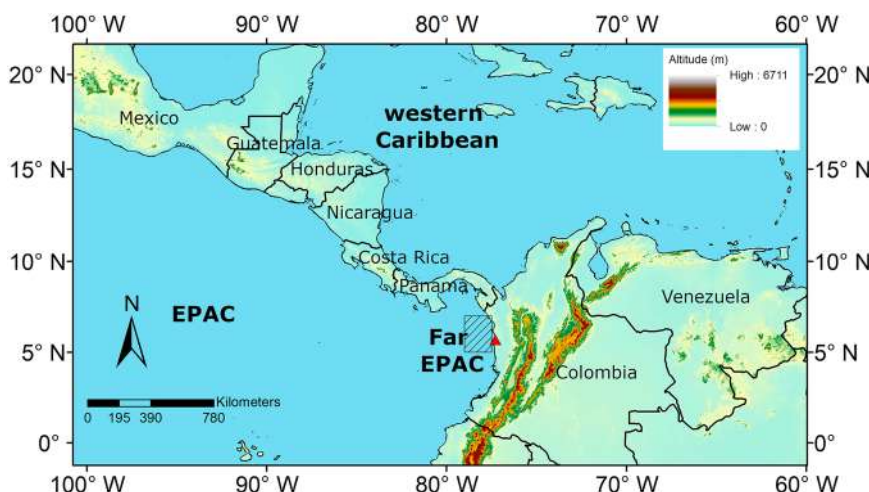


FIG. 1. Region of interest showing geographic features described in the text, as well as the Nuquí radiosonde site (red triangle) and domain for ERA5 spatial averages (hatched area).

2000; Warner et al. 2003; Poveda 2004; Mejía and Poveda 2005; Sakamoto et al. 2011; Poveda et al. 2014; Yepes et al. 2019, 2020; Mesa-Sánchez and Rojo-Hernández 2020; Mejía et al. 2021). While regional circulation patterns interacting with the topography are known to characterize the prevailing climate of the region (Poveda and Mesa 1999; Morales et al. 2021; Sierra et al. 2021; Mejía et al. 2021), some questions remain, particularly regarding the sources of synoptic-scale variability in precipitation and its relatively large maritime diurnal patterns (Zuluaga and Houze 2015; Jaramillo et al. 2017).

Previous studies have investigated the influence of TEWs on precipitation over EPAC (Huaman et al. 2021) and northern South America (Giraldo-Cardenas et al. 2022; Salas et al. 2022), but the mechanisms behind this interaction are not fully understood (Giraldo-Cardenas et al. 2022). We argue that a better understanding of the interaction of the TEWs with ChocoJet can help shed some light on the sources of synoptic-scale variability in the region. It is well known that TEWs have two differentiable regions in their structure: 1) the trough, associated with cyclonic vorticity and convective activity, and 2) the ridge, related to anticyclonic vorticity and inhibition of convection. In this study, we hypothesize that TEWs troughs crossing over the western Caribbean (around 80°W) increase the Caribbean–eastern Pacific pressure gradient during convective days in southwestern Caribbean, shifting the ChocoJet to a more northward orientation, which suppresses precipitation over western Colombia and the far EPAC. To our knowledge, this is the first attempt to relate the influence of TEWs to the better-understood relationships between precipitation and ChocoJet.

In this study, we investigate the influence of convective and nonconvective TEWs incursions over the western Caribbean to infer how they modulate ChocoJet during the Organization of the Tropical Convection of the East Pacific (OTREC) field campaign (Fuchs-Stone et al. 2020; Mejía et al. 2021). Specifically, we use OTREC Nuquí upper-air sounding, satellite, and

reanalysis data to examine the day-to-day variability of circulation and precipitation in the region. This work is organized as follows: section 2 describes the data and methodology; section 3 presents the results, and finally section 4 shows discussion and conclusions.

2. Data and methodology

a. OTREC catalog

OTREC Nuquí soundings were collected as part of the OTREC project (Fuchs-Stone et al. 2020; Mejía et al. 2021). A total of 140 Vaisala RS41-SG radiosondes were launched using TA200 balloons from 5 August to 25 September 2019 (hereafter “OTREC campaign”; Mejía and Poveda 2020). The launching site was located in the coastal town of Nuquí, Chocó (6°N, 77°W) (Fig. 1). The ground systems consisted of a Vaisala Digicor MW41 and a RI41 ground check device. Even though there were intensive observations every 6 h, in this study we only use those soundings from 0000 and 1200 UTC or 0700 and 1900 LT (UTC – 5 h).

b. GPM-IMERG

We used the Global Precipitation Measurement (GPM) mission (Huffman et al. 2020) precipitation products for the period 2000–19, which estimates precipitation as a function of microwave and infrared (IR) reflectivity bands, serving as a reference standard to unify precipitation measurements from a constellation of satellites. We used daily data at $0.1^\circ \times 0.1^\circ$ spatial grid size. GPM is an open-access dataset freely available on the web page <https://pmm.nasa.gov/GPM>.

c. Reanalysis

We used 950-, 850-, and 700-hPa pressure levels of wind; 600-, 700-, and 850-hPa relative vorticity; sea level pressure; and precipitable water fields from the European Centre for Medium-Range Weather Forecasts (ECMWF) reanalysis (ERA5; Hersbach et al. 2020). We initially downloaded

ERA5 hourly data with a grid size of $0.25^\circ \times 0.25^\circ$, and subsequently aggregated the dataset to a daily resolution. It is important to point out that OTREC upper-air observations were sent to the Global Transmission Systems in real time and most likely assimilated by ERA5. The ERA5 products are available at the European Copernicus Program on the website <https://www.copernicus.eu/>.

d. Convective and nonconvective TEWs chronology

We identified all TEWs that crossed the Atlantic Ocean and the Caribbean Sea during the OTREC campaign. TEWs were first tracked in real time using the NOAA Marine Tropical Surface Analysis from NOAA web services: <https://www.nhc.noaa.gov/marine/>. NOAA releases these analyses every 6 h with information related to the current state of the atmosphere, such as the sea level pressure field and any relevant synoptic surface features. Subsequently, we refined the TEW identification by relating them with 700-hPa filtered relative cyclonic vorticity features obtained from ERA5 (Serra et al. 2008, 2010; Whitaker and Maloney 2020). For this process, we use the fast Fourier transform (FFT; Kammler 2008) to analyze 2.5–12-days periodicity band (Rydbeck et al. 2017). To categorize the convection activity in our population of TEWs, we used outgoing longwave radiation (OLR) data from the Climate Prediction Center (CPC; Liebmann and Smith 1996) at a $2.5^\circ \times 2.5^\circ$ grid size and averaged from twice a day to daily time increments. OLR data are available from the International Research Institute Climate Data Library website (<https://iri.columbia.edu/>).

Figure 2 shows a longitudinal Hövmöller of OLR and 700 hPa filtered relative vorticity from ERA5 fields averaged between 10°N and 15°N during the OTREC campaign (5 August–25 September 2019). The TEWs chronologies were defined as the days when the positive filtered relative vorticity moved westward over 80°W . Changing the longitudinal locations of the TEW troughs by $\pm 3^\circ$ shows no significant impact on the results. By tracking areas of westward-moving features of filtered relative cyclonic vorticity, we identified 10 TEW days as 7, 11, 13, 16, 27, and 30 August, as well as 4 and 13 September. Otherwise, days are defined as days without TEWs in the region (hereafter “non-TEW”; 46 days). This TEW days chronology is robust upon examining relative vorticity fields at 600 and 850 hPa (not shown).

TEWs were categorized as convectively coupled (convective) if they were collocated to a convective structure with OLR below 240 W m^{-2} (Lau et al. 1997; Collimore et al. 2003), or defined as nonconvective otherwise. We used infrared *Geostationary Operational Environmental Satellite-16* (GOES-16; <https://catalog.eol.ucar.edu/otrec/satellite>) available at 15-min time increments and 6-km grid size to visually inspect and confirm the existence of organized convective structures during the TEWs days. This procedure resulted in 5 days with convective TEWs (7, 13, 16 August, and 4 and 13 September) (Fig. 2, dots over the 80°W line) and 3 days with nonconvective TEWs on 11, 27, and 30 August (Fig. 2, black crosses over the 80°W line). This TEW chronology closely agrees with those shown by Huaman et al. (2021), despite having Central America and the EPAC as their

focal area, who found two convective TEWs: 7 and 13 August and 13 September. Our chronology selection agrees with the dates proposed in Huaman et al. (2021) and the methodology suggested by Serra et al. (2008) for identifying tropical easterly waves (TEWs) based on the similarity between vorticity fields and the OLR analysis. However, one exception included the period 4–7 September, which is related to a rather weak relative vorticity signal and a less apparent westward propagation track.

e. Composite analysis

We use a composite analysis to examine the atmospheric differences between convective and nonconvective TEWs days (Terray et al. 2003; Boschat et al. 2016; Xie et al. 2017). Statistical significance of the differences between composites is estimated based on a *t* test (von Storch and Zwiers 1984) assuming double-sided distribution and a significance level above 95%. The same procedure was followed for the atmospheric profiles and pressure level fields. To address uncertainties related to the selection of the TEW chronology and to test the robustness of the statistics due to small sample sizes we also performed: 1) a bootstrapping with replacement whenever possible; 2) two filtering methodologies, the FFT (Kammler 2008) and the ensemble empirical mode decomposition (EEMD; Wu and Huang 2009), with periodicity bands of 3–10 days, 2.5–12 days, 2.5–15 days, 3–6 days, 4–12 days, and 3–15 days. When necessary, we discussed the sensitivities of the results to the TEW categorization and sample size (see Table A1 and Fig. A1 in the appendix).

3. Results

a. Precipitation and regional circulation

Figure 3 compares the mean precipitation and 950-hPa circulation patterns based on the long-term mean (August–September 2000–19) and the mean estimates during the OTREC campaign (August–September 2019). During the OTREC days (with respect to the climatology), over the Caribbean Sea, the easterlies from the CLLJ shift northerly and decrease over the Isthmus of Panama at 950 hPa. Simultaneously, over the far EPAC, the ChocoJet weakens. In this sense, Chelton et al. (2000) argues that the cross-isthmus pressure gradients can generate intense wind jets blowing through all three gaps and into the Pacific over the Gulfs of Tehuantepec, Papagayo, and Panama. These circulation patterns, along with the land influence of Central America and orographic interaction with the Andes over South America, contribute to the development of the far EPAC extension of the rather distorted ITCZ and the precipitation maximum just offshore the Colombian Pacific coast (Poveda and Mesa 1999; Yepes et al. 2019; Mejía et al. 2021). Of note is that during the OTREC campaign, the winds in the zone of influence of the CLLJ were anomalously stronger, whereas the ChocoJet was anomalously weaker over the EPAC ($3^\circ\text{--}6^\circ\text{N}$, $78^\circ\text{--}80^\circ\text{W}$, see Fig. 3c).

b. Precipitation and wind composites

Figure 4 shows GPM precipitation, ERA5 950-hPa wind, and 300-hPa divergence composites during the OTREC

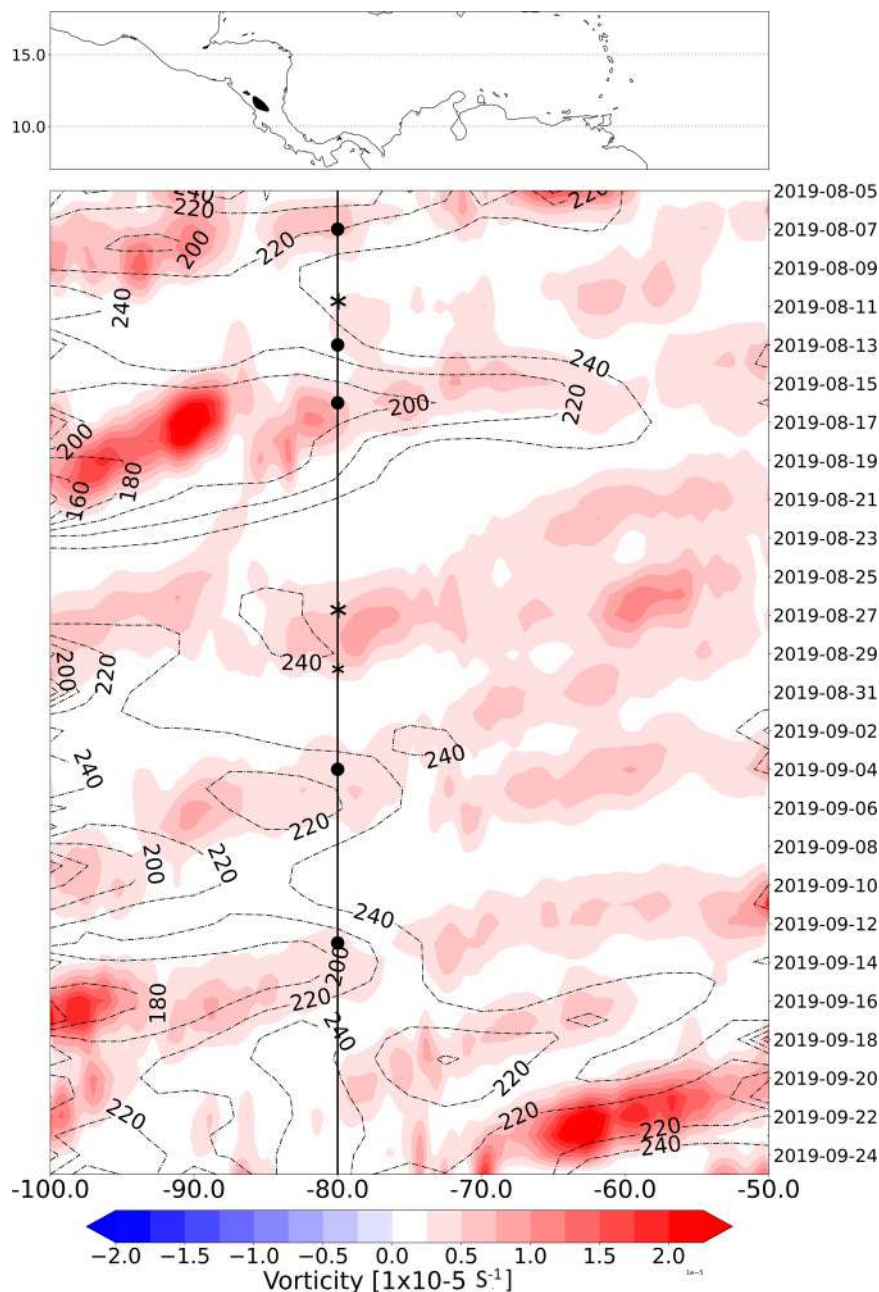


FIG. 2. ERA5 700-hPa filtered relative vorticity retaining the 2.5–12-days periodicity (shaded contours) and CPC OLR (black dashed–dotted contour lines) longitudinal Hovmöller diagram averaged from 10° to 15°N during the OTREC campaign. Dot and cross symbols over the 80°W meridian show TEWs days defined as convective and nonconvective, respectively. Negative vorticity is not included to emphasize cyclonic vorticity.

convective and nonconvective TEW events, as well as their respective differences relative to non-TEW days. Not surprisingly, convective TEWs exhibit more precipitation over the western Caribbean (80°W) as it is closely related to lower OLR (per construction of the convective TEW events). However, convective TEWs show that precipitation is enhanced in a coherent ITCZ-like pattern extending over the EPAC (Fig. 4e).

Conversely, nonconvective TEW days indicate suppressed precipitation in the region and a southerly ITCZ movement (Fig. 4f). In the subsequent analysis, we investigate observed large-scale environmental factors that contributed to convection invigoration on convective TEWs days. Figure 4 also reveals intriguing precipitation patterns over the region: 6°–9°N, 78°–80°W with suppressed precipitation during convective TEW days. We emphasize that

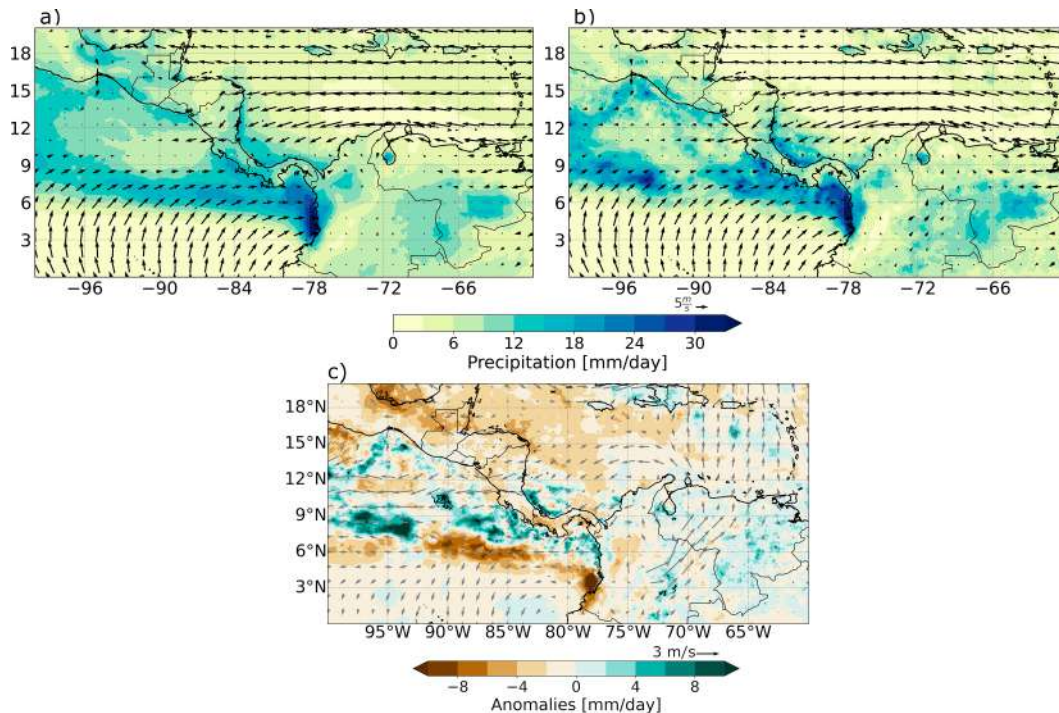


FIG. 3. Daily mean GPM precipitation (contours; mm day^{-1}) and ERA5 wind vectors at 950 hPa during August–September for (a) the long-term mean averaged in 2000–19, (b) the OTREC campaign period (2019), and (c) anomalies estimated as the difference between (b) minus (a). Black contour precipitation lines and bold wind vectors in (c) highlight differences that are statistically significant with a 95% confidence level.

these results are robust despite the relatively small sample of event days (per bootstrapping analysis with replacement, not shown). However, we are also cautious as some rather noisy composited precipitation patterns resulted from single-organized convective systems.

Low-level anomalies in wind fields exhibit striking differences between convective and nonconvective TEWs. On convective TEWs days, there is a significant enhancement of cross-equatorial and more meridional ChocoJet. Additionally, a noticeable cyclonic difference field related to the TEW troughs over the western Caribbean and Central America, favoring southerly wind differences over Panama and northwest Colombia. This seemingly enhanced low-level cyclonic rotation may favor convectively active TEWs, although none of the wave breaking or other factors leading to tropical cyclone formation were observed. In contrast, the nonconvective TEW days show difference fields with a stronger CLLJ and significantly weaker cross-equatorial ChocoJet. It is important to note that most of the outlined features are coherent in space but not statistically significant. This could be attributed to the relatively small sample sizes in this compositing approach. However, a bootstrapping analysis with replacement suggests that results are robust (not shown).

c. Wind and moisture flux patterns

Figure 5 presents the mean vertical profiles of wind components measured during OTREC (August–September 2019)

estimated using ERA5 data, and ERA5 multiyear means (August–September 1979–2019, sea spatial average domain in Fig. 1). Overall, the observations indicate that the ERA5 reanalysis adequately represents the main vertical patterns during OTREC, considering that this region is relatively unconstrained by upper-air observations. However, despite the assimilation of OTREC soundings into the Global Transmission System, some notable differences persisted. For instance, the level of maximum zonal wind associated with ChocoJet is observed at 950 hPa from the soundings and ERA5 during the campaigns period, while the ERA5 climatology (red line) shows a weaker and shallower maximum at 925 hPa. Nevertheless, the meridional wind profiles show relatively better agreement between the observations and reanalysis. Despite these low-level structural biases in the ERA5, spatial averaging and thermodynamic adjustments in this cloudy and active convection region can limit a more accurate comparison (Sentić et al. 2022). At midlevels and above 800 hPa, which is the characteristic level of the Andes mountains, there is a predominant easterly–southeasterly flow. Climatological studies investigating the sources of moisture have identified the Amazon region as a dominant source of moisture for northern South America during September–November (Hoyos et al. 2018).

Figure 6 displays the daily mean moisture flux vertical profiles from the OTREC soundings on days categorized as convective TEWs, nonconvective TEWs, and non-TEWs, aiming to examine the differences among these TEW categories. Despite the small sample size, distinct differences between convective and Nonconvective days are observed. At low levels

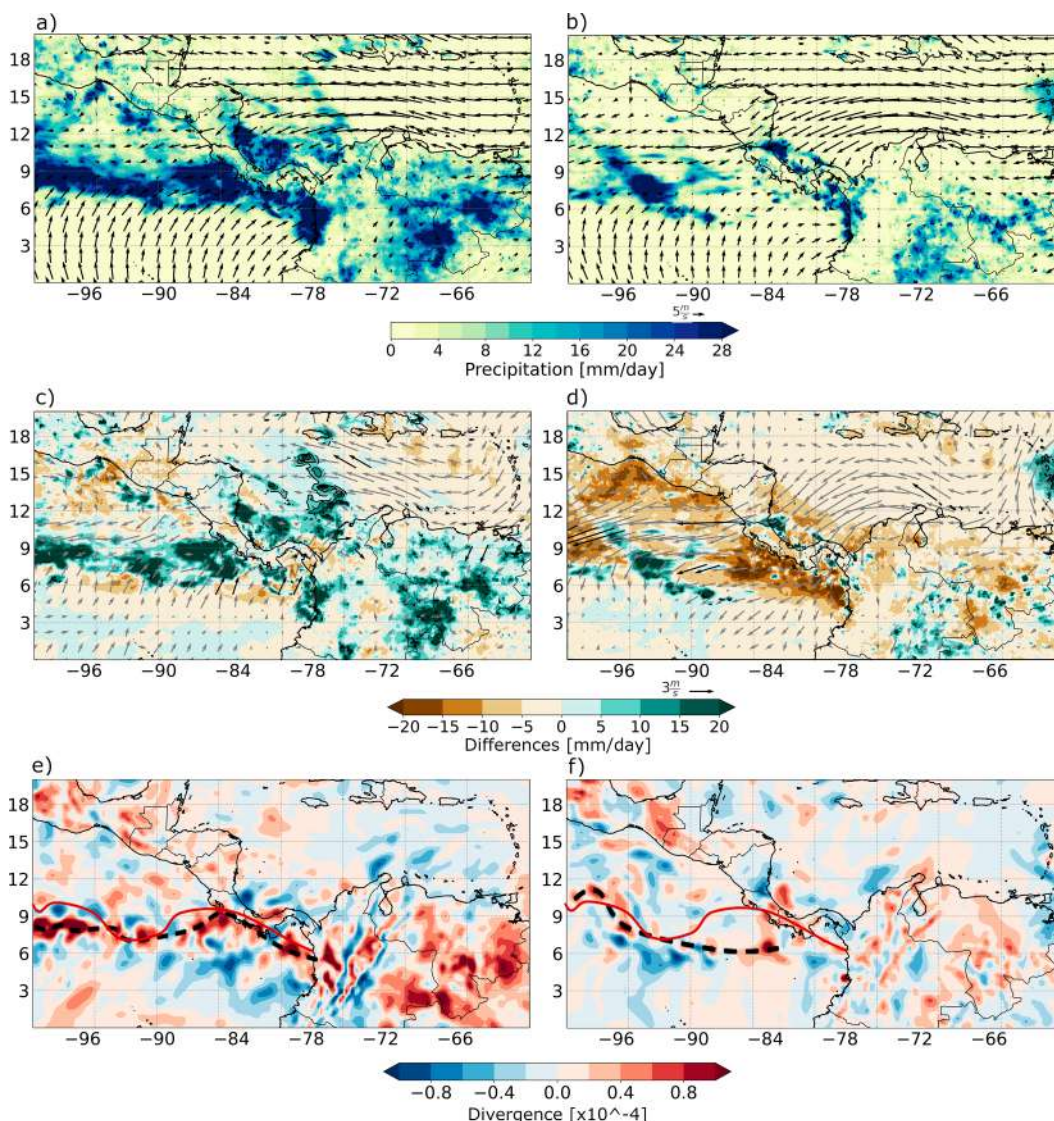


FIG. 4. GPM precipitation and ERA5 950-hPa wind vectors for (a) convective and (b) nonconvective TEWs. Differences fields for (c) convective and (d) nonconvective TEW days are estimated relative to non-TEW days. ERA5 300-hPa divergence for (e) convective TEWs and (f) nonconvective TEWs. The black line indicates the maximum divergence at 300 hPa for convective and nonconvective days in (e) and (f), respectively, and the red line indicates the observational maximum divergence at 300 hPa for non-TEWs days. Black contour lines of precipitation and bold wind vector differences highlight areas that are statistically significant with a 95% confidence level.

(1000–900 hPa), ChocoJet-related moisture flux tends to be more southwesterly during TEW days than all other days. Particularly, convective TEWs days display a more intense and deeper moisture flux. It is noteworthy that the outlined moisture flux differences relative to days with non-TEWs agree well with ERA5 circulation patterns shown at 950 hPa (Fig. 4). On convective TEW days, a coherent enhanced low-level southerly circulation is evident in the region, highlighting its synoptic nature. The nonconvective TEW days show a pronounced northerly to northeasterly moisture flux pattern between 900 and 800 hPa (Fig. 6b). To further analyze this feature, we examined regional sea level pressure, 850-hPa

wind vectors (Fig. 7), and precipitable water (Fig. 8) composite differences for convective and nonconvective TEW days compared to non-TEW days. The most noticeable feature is that the enhanced northerly wind component in Fig. 6b is part of a coherently enhanced northeasterly flow pattern to the west of the Andes (over the far EPAC and Panama). This feature is related to enhanced Caribbean–equatorial EPAC sea level pressure differences, further supporting the observation that the ITCZ trough weakens and shifts south during nonconvective TEW days (Fig. 4c). Additionally, it is noteworthy that the outlined flow pattern on nonconvective TEW days extends upstream of the trough axis over the Caribbean basin

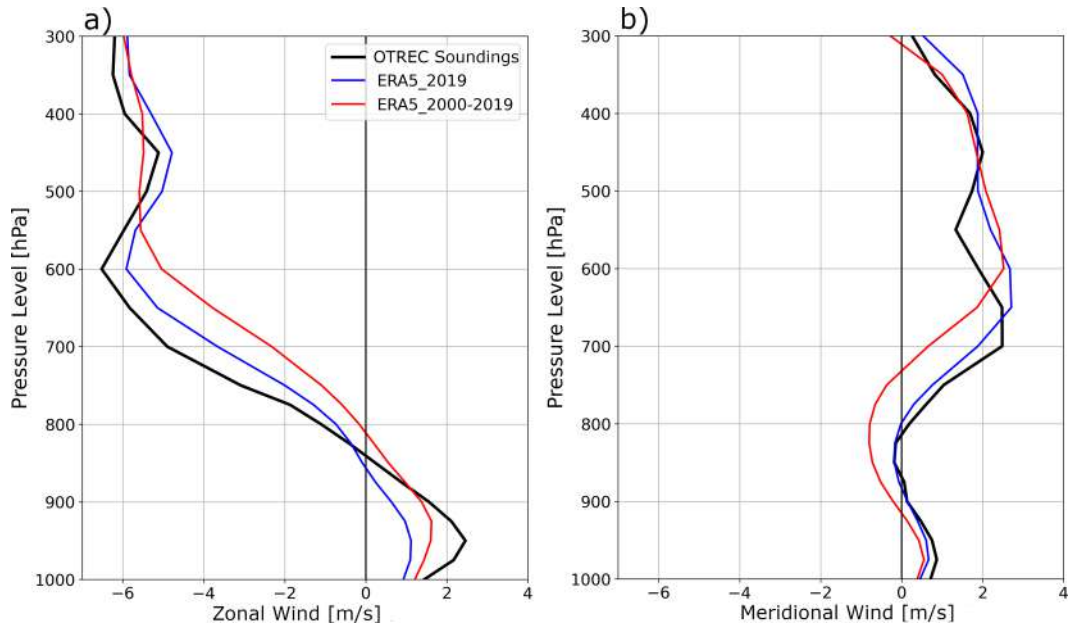


FIG. 5. (a) Zonal and (b) meridional wind vertical profiles based on (black lines) OTREC soundings and (blue lines) ERA5 reanalysis during August–September 2019, and (red lines) ERA5 multiyear mean for August–September in 2000–19.

(80°W, per construction of the TEW days chronology). This flow pattern connects with relatively drier air masses over the central and eastern Caribbean basin, which can suppress convection development over the western Caribbean.

4. Discussion and conclusions

This study examines the OTREC data from August to September 2019 and investigates how convectively coupled

tropical easterly waves (TEWs) traversing over the western Caribbean modulate the ChocoJet and precipitation over the tropical and northwestern South American regions. The co-occurrence of TEWs and convective activity was characterized using OLR and the 2.5–12-days filtered relative vorticity fields at 700 hPa.

Figure 9 presents a schematic diagram summarizing our findings. During convective TEW days, the ChocoJet turns more southerly, resulting from a weaker SLP gradient between western

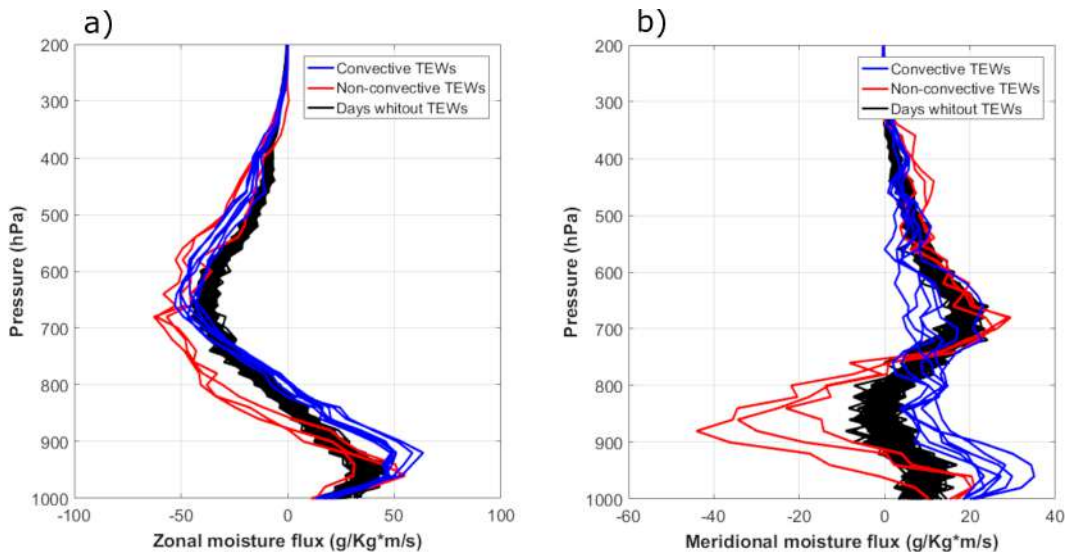


FIG. 6. Vertical profiles of (a) zonal and (b) meridional moisture flux using the OTREC Nuqui soundings during the days with convective TEWs (blue), nonconvective TEWs (red), and non-TEWs (black). Different profiles in each category were generated by bootstrapping with replacement.

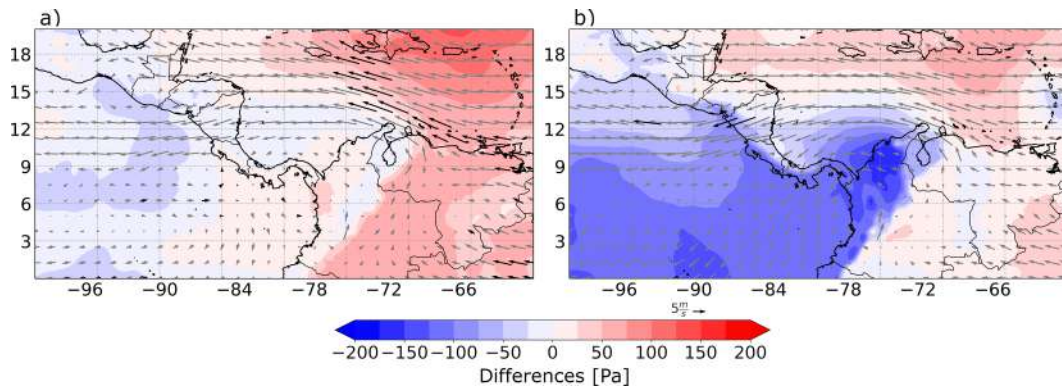


FIG. 7. Sea level pressure and 850-hPa wind vectors differences during (a) convective days and (b) nonconvective days relative to non-TEW days. Black contour lines and bold vectors denote locations where sea level pressure differences and winds, respectively, are significant with a 95% significance level.

Caribbean and the EPAC, while the ITCZ maintains its mean position, leading to wetter conditions over western Caribbean and drier conditions over the northern part of the Colombian Pacific (Poveda and Mesa 2000; Yepes et al. 2019; Mejía et al. 2021). Furthermore, during nonconvective TEWs days (Fig. 9b), the ChocoJet is a weaker southwesterly flow respect to the convective TEWs days, the Caribbean region exhibits drier than normal conditions, an enhanced Caribbean–tropical EPAC SLP gradient is observed, as well as the ITCZ exhibits a southerly movement. Moreover, an anomalous northerly flow at 850 hPa was identified by the observations and supported by the reanalysis as a regional feature. We hypothesize that this northerly flow induces strong vertical shear, limiting convection organization over the Caribbean.

Mejía et al. (2021) demonstrated that days with enhanced precipitation in the far EPAC and western Colombia are typically organized as mesoscale convective systems (MCSs) and are associated with enhanced ChocoJet. Our results corroborate their findings and further indicate that a portion of this variability is linked to westward-propagating tropical easterly waves (TEWs) over the western Caribbean region. However, it is important to note that convective and nonconvective

TEWs are somewhat influenced by the regional environment (Serra et al. 2010). In addition to TEWs, there are other sources of synoptic-scale variability in the region. For example, Velasco and Fritsch (1987) demonstrated that MCSs over the far EPAC can undergo growth and cyclogenesis, suggesting that internal variability partially explains the day-to-day precipitation–circulation relationships. Moreover, during the OTREC campaign, westerly zonal wind intraseasonal variability anomalies in the eastern Pacific could have perturbed the convective background environment (Mejía et al. 2021), suggesting that the convective structure of the TEWs can be related to larger-than-synoptic-scale forcings.

Although the OTREC period is rather short to draw more general and robust conclusions, the insights provided by the OTREC soundings helped us to postulate intriguing precipitation–circulation relationships.

The diagnosis and characterization of convective and nonconvective TEWs strongly depend on the wave-tracking procedure (Belanger et al. 2016). In the climatological study by Giraldo-Cardenas et al. (2022), the passage of TEWs was identified over the 70°–80°W and 5°–15°N region and showed that precipitation anomalies over the EPAC lagged +2 days with respect

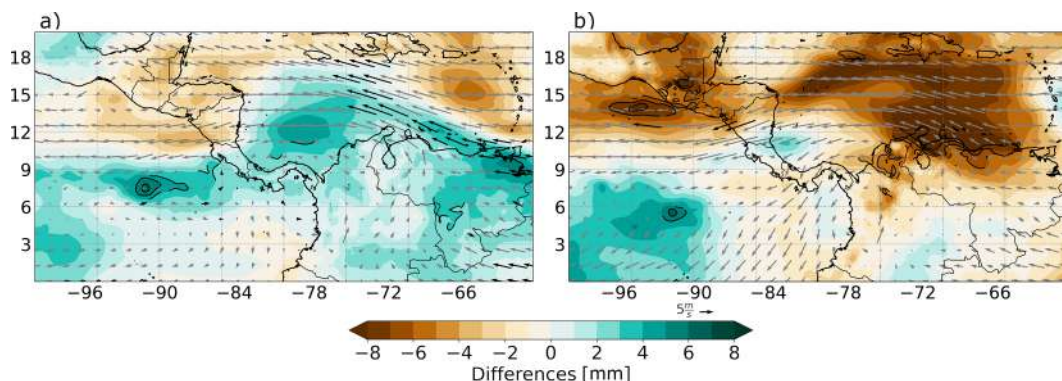


FIG. 8. Precipitable water and 850-hPa wind vectors differences during (a) convective days and (b) nonconvective days relative to non-TEWs. Black contour lines and bold vectors denote locations where precipitable water differences and winds, respectively, are significantly different with a 95% significance level.

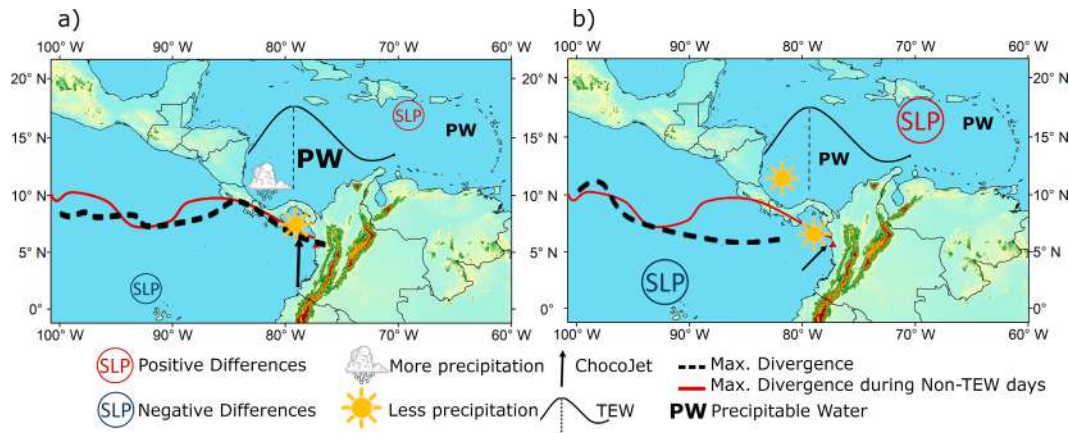


FIG. 9. Schematic representation of the postulated atmospheric conditions related to sea level pressure, 850-hPa precipitable water, precipitation, maximum upper-level divergence at 300 hPa, and the ChocoJet winds at 950 hPa during (a) convective TEWs days and (b) nonconvective TEWs days. Bigger (smaller) symbols indicate an increase (decrease) of variables in each condition.

to the passage of the wave, likely due to the broad longitudinal area of their TEW definition. In contrast, our study focuses on selecting chronology days of TEW passing 80°W parallel. Keeping these differences in mind, the anomalously dry Colombian Pacific–wet western Caribbean precipitation patterns (Fig. 2 in Giraldo-Cardenas et al. 2022) are consistent with this study.

The OTREC campaign helps fill the observation gap in the region. However, regular upper-air observation sites (and a dense network of meteorological stations) in the far EPAC can help provide observable and predictable information on the day-to-day variability of precipitation and convection organization. Some features that need further research include the following. Days with TEWs co-occurring with a southerly flow over the Colombia and Venezuela Llanos (located between 65° and 75°W from 10°N to 2°S) are probably related to the day-to-day variability of the Orinoco low-level jet (Torrealba and Amador 2010; Jiménez-Sánchez et al. 2020; Builes-Jaramillo et al. 2022). Thus, does the Orinoco low-level jet influence convective/nonconvective days over the Colombian Pacific? We also hypothesize that convectively coupled TEWs and ChocoJet interaction depends on the background environment, with convectively active TEWs related to weaker and moister CLLJ flow and stronger ChocoJet, resulting from a weaker Caribbean–EPAC pressure gradient.

This work revealed observable and predictable large-scale information to improve TEWs impacts forecast skill. This is of paramount importance given that TEWs are precursors of tropical cyclones (Serra et al. 2010), and that their contribution to seasonal precipitation is up 50% in the far eastern Pacific (Dominguez et al. 2020).

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Data availability statement. OTREC data are archived at NCAR/EOL under the sponsorship of the National Science Foundation and are publicly available (<https://data.eol.ucar.edu/project/OTREC>). In this work, we specifically used radiosondes from Nuquí (Mejia and Poveda 2020). Other data implemented in this research are the ERA5 products available in the ECMWF/Copernicus Climate Change Service (C3S) services at <https://cds.climate.copernicus.eu/>. Precipitation data are derived from the GPM-IMERG V06B (Huffman et al. 2018) available at <https://doi.org/10.5067/GPM/IMERG/3B-HH/06>.

APPENDIX

Filtering Methods for TEWs Classification

The appendix shows the results of the classification of convective and nonconvective TEWs using the fast Fourier transform and the ensemble empirical mode decomposition (EEMD) filtering methods (Fig. A1), with periodicity bands of 3–10 days, 2.5–12 days, 2.5–15 days, 3–6 days, 4–12 days, and 3–15 days (Table A1).

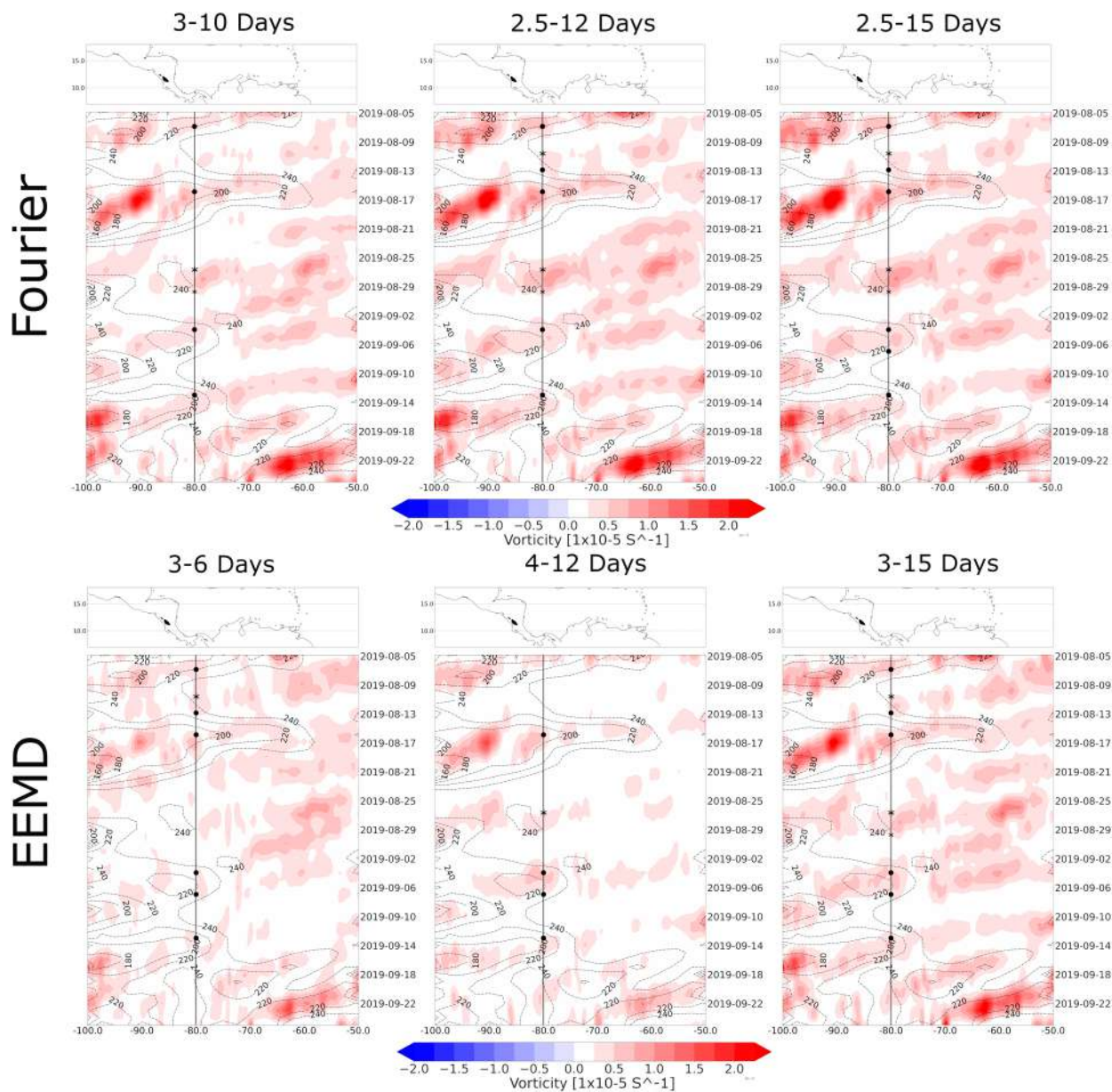


FIG. A1. ERA5 700-hPa filtered relative vorticity (shaded contours) based on the (top) fast Fourier transform (FFT) and (bottom) ensemble empirical mode decomposition (EEMD) methods. CPC OLR (black dashed-dotted contour lines) longitudinal Hovmöller diagrams averaged from 10° to 15°N during the OTREC campaign. Black dots and crosses over the 80°W meridian denote the TEWs days defined as convective and nonconvective, respectively. Negative vorticity is not included to emphasize cyclonic vorticity.

TABLE A1. Tropical easterly waves convective and nonconvective days chronology based on the fast Fourier transform and the ensemble empirical mode decomposition (EEMD) methods.

TEWs	Current methodology	Fourier			EEMD		
		3–10 days	2.5–12 days	2.5–15 days	3–6 days	4–12 days	3–15 days
Convective	7 Aug	7 Aug	7 Aug	7 Aug	7 Aug		7 Aug
	13 Aug		13 Aug	13 Aug	13 Aug		13 Aug
	16 Aug	16 Aug	16 Aug	16 Aug	16 Aug	16 Aug	16 Aug
	20 Aug						
	4 Sep	4 Sep	4 Sep	4 Sep	4 Sep	4 Sep	4 Sep
	7 Sep			7 Sep	7 Sep	7 Sep	7 Sep
	13 Sep	13 Sep	13 Sep	13 Sep		13 Sep	13 Sep
Nonconvective	11 Aug		11 Aug	11 Aug	11 Aug		11 Aug
	24 Aug						
	27 Aug	27 Aug	27 Aug	27 Aug		27 Aug	27 Aug
		30 Aug	30 Aug	30 Aug			30 Aug

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