The 2007 North Atlantic Hurricane Season
A Climate Perspective

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1. Overview

The 2007 Atlantic hurricane season produced 15 named storms (NS), six hurricanes (H) and two major hurricanes (MH) (Fig. 1). The long-term averages are 11 NS, 6 H, and 2 MH. For 2007 the National Oceanic and Atmospheric Administration (NOAA) Accumulated Cyclone Energy (ACE) index (Bell et al. 2000), a measure of the season's overall activity, was 84% of the 1950-2000 median (87.5×10^4 kt^2) (Fig. 2). This value is in the near-normal range, and reflects fewer and generally shorter-lived hurricanes and major hurricanes compared to recent seasons.

During 2007, storms first named in the Main hurricane development region [MDR, spanning the tropical Atlantic and Caribbean Sea between 9.5N-21.5N (Goldenberg and Shapiro

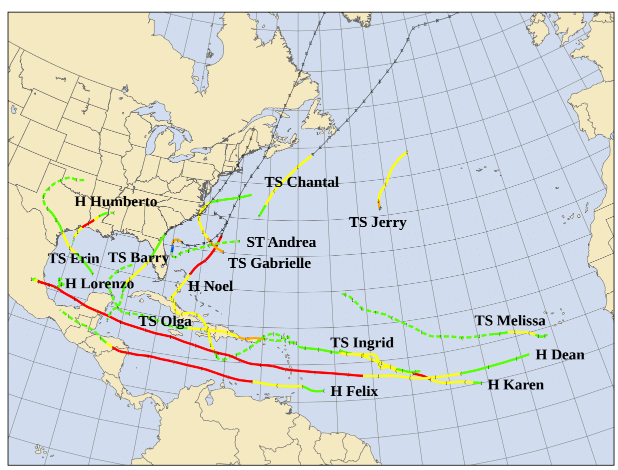


Fig. 1. Atlantic named storm tracks during 2007. Shading corresponds to strength, with green indicating tropical depression intensity, yellow indicating tropical storm intensity, and red indicating hurricane intensity.

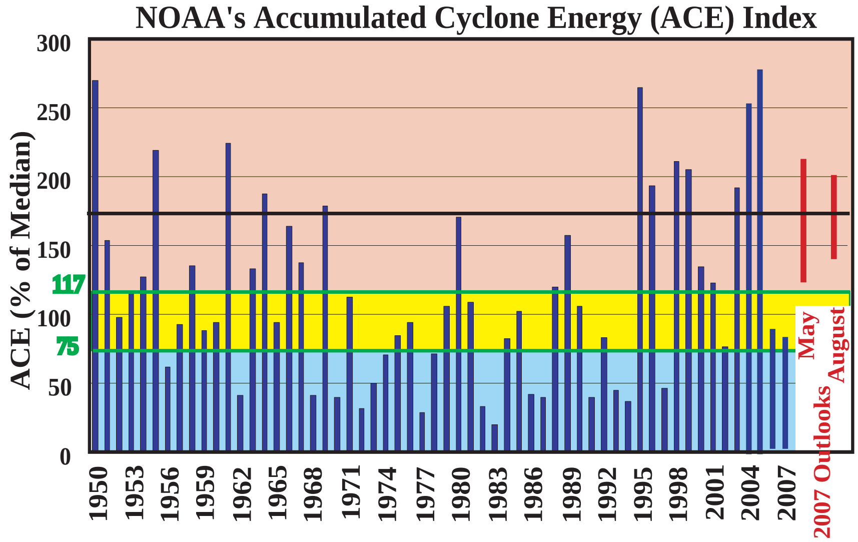


Fig. 2. NOAA's Accumulated Cyclone Energy (ACE) index expressed as percent of the 1951-2000 median value (87.5 x 10^4 kt^2). ACE is a wind energy index that measures the combined strength and duration of the named storms. ACE is calculated by summing the squares of the 6-hourly maximum sustained wind speed in knots (Vmax2) for all periods while the system is a tropical storm, subtropical storm, or hurricane. Pink, yellow, and blue shading shows NOAA's classifications for above-, near-, and below-normal seasons, respectively. The thick black line indicates the threshold (175%) for a hyperactive season. Green lines show boundaries for near-normal season. NOAA's forecasts issued in May and August 2007 are indicated by red bars at right.

1996) accounted for most of the seasonal ACE, but produced only 74% of the median. This is well below the average seasonal contribution during the current active era (1995-present) of 130%. Also, four named storms formed over the extratropical Atlantic (north of 21.5N) during 2007, but none were long-lived or became hurricanes. These systems produced an ACE of only 4% of the median, which is the fifth lowest since 1950 and well below the average seasonal contribution of 20%-35%. Therefore, the reduced 2007 activity was evident in both the MDR and the extratropics.

Two hurricanes made landfall in the Atlantic Basin at category-5 strength. Hurricane Dean struck the Yucatan Peninsula near Costa Maya on August 21 with 175 mph sustained winds. Hurricane Felix then made landfall near Punta Gorda, Nicaragua on September 2 with 160 mph sustained winds In addition, several other tropical storms and hurricanes struck the region around the Caribbean Sea.The United States was struck by one hurricane, one tropical storm, and three tropical depressions.

The occurrence of La Niña during an active hurricane era greatly increases the likelihood of an above normal Atlantic hurricane season, in part because this combination typically produces a weaker Tropical Upper Tropospheric Trough (TUTT) (also referred to as a mid-oceanic trough) and decreased vertical wind shear across the MDR. NOAA predicted a high likelihood of an above-normal season based on this expected combination of conditions.

However, although La Niña developed during August, there was an absence of a La Niña signal in the upper-level winds across the subtropical North Pacific Ocean and western MDR during the peak August-October (ASO) months of the season. This may be related to anomalous tropical convection throughout southeastern Asia, the Indian Ocean, and Indonesia, which was more typical of El Niño than La Niña, and which reached record strength during ASO. Thus, the above-normal Atlantic hurricane activity did not materialize as expected.

During August and September, the reduced hurricane activity was also partly linked to a strong upper-level ridge over the eastern United States, which contributed to the overall strength of the downstream TUTT, and to anomalous descending motion upstream of the TUTT axis. As a result, extensive areas of strong vertical wind shear and anomalous sinking motion suppressed hurricane formation and intensification. During October, the activity was also lower than expected over the Caribbean Sea, in association with a mixed set of atmospheric conditions having no obvious larger-scale climate links.

2. Atlantic atmospheric and oceanic conditions

a. *Upper-tropospheric circulation*

The peak months (ASO) of the 2007 season featured a strong and persistent upper-tropospheric trough (i.e. TUTT) over the central North Atlantic and central MDR (indicated by green box), as well as a strong and persistent ridge over eastern North America (Figs. 3a, b). During August and September, this anomalous circulation suppressed hurricane formation and intensification by producing extensive areas with enhanced vertical wind shear (blue shading, Figs. 4a, c) and anomalous sinking motion (blued shading, Figs. 4b, d).

For example, in August this circulation produced an extensive area of increased vertical wind shear across the central MDR, western North Atlantic, and the Gulf of Mexico (Fig. 4a).

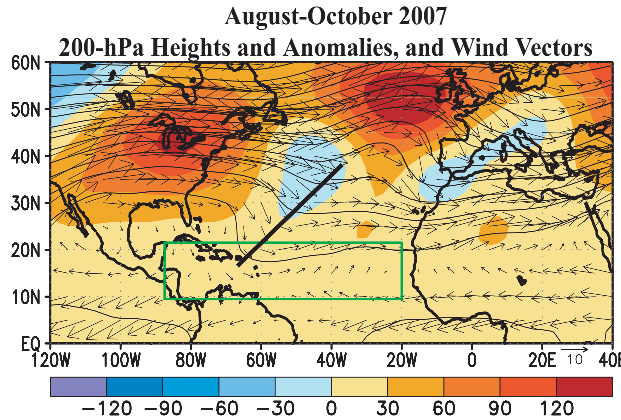


Fig. 3. August-October 2007: 200-hPa heights (solid contours, m), height anomalies (shaded), and vector winds. Thick solid line indicates the trough (TUTT) axis. Green box denotes the Main Development Region (MDR). Anomalies are departures from the 1971-2000 period monthly means.

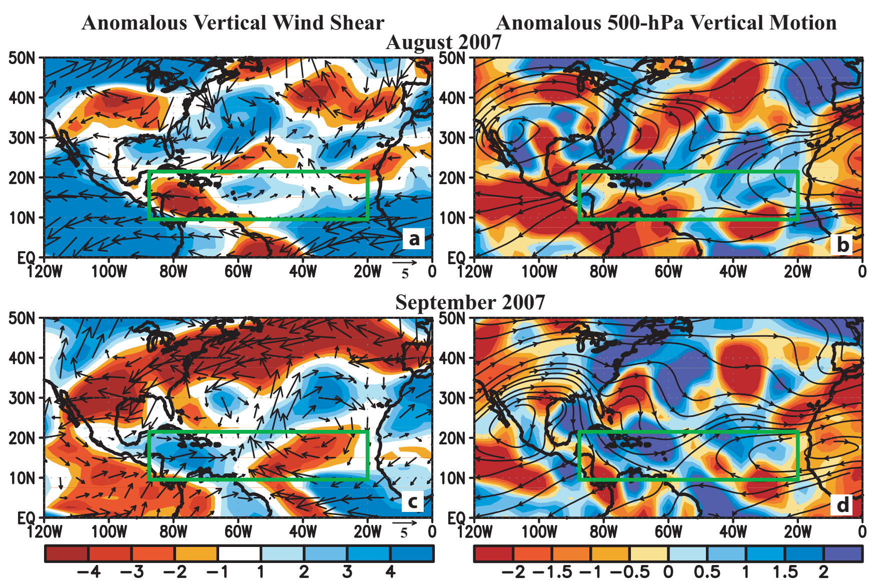


Fig. 4. Left panels (a, c) show the anomalous 200-850 hPa vertical wind shear strength (m s^{-1}) and vectors during (a) August and (c) September 2007. Red (blue) shading indicates below- (above-) average strength. Right panels (b, d) show the total 200-hPa streamlines and anomalous 500-hPa vertical motion (shaded) during (b) August and (d) September 2007. Red (blue) indicates anomalous ascent (descent). Green box denotes the Main Development Region (MDR). Anomalies are departures from the 1971-2000 period monthly means.

Large portions of the region also experienced anomalous sinking motion at 500-hP between the ridge and trough axes (Fig. 4b). In September the TUTT was broader and shifted westward toward the Caribbean Sea, resulting in increased vertical wind shear throughout that region (Fig 4c). Anomalous mid-level sinking motion was again evident between the mean ridge and trough axes, this time throughout the Gulf of Mexico and western half of the MDR (Fig. 4d). As a result, there was a notable lack of tropical storm and hurricane activity throughout the entire TUTT region.

For the entire ASO period, the main area of weak vertical wind shear (less than 8 m s^{-1}) was confined mainly to the extreme southern MDR and western Caribbean Sea (shaded regions, Fig. 5a). This pattern was especially pronounced in August, when Category-5 hurricanes Dean and Felix developed. Interestingly, the mean ASO vertical wind shear was below average across much of the MDR, which would normally suggest an above-normal season (Fig. 5b). However, for the eastern half of the MDR, most of the contribution to the negative anomalies came from October, a month when the total vertical shear is too strong to support tropical storm formation.

b. Low-level winds and African Easterly Waves (AEW)

During ASO 2007, the vertical structure of the low-level winds over the eastern MDR was not typical of an above-normal season. At 1000-hPa, enhanced northeasterly trade winds were associated with an area of below-average surface pressure over the extreme southeastern MDR (blue shading, Fig. 6). These conditions are not consistent with either the ongoing active hurricane era or the enhanced West African monsoon system (refer ahead to Fig.

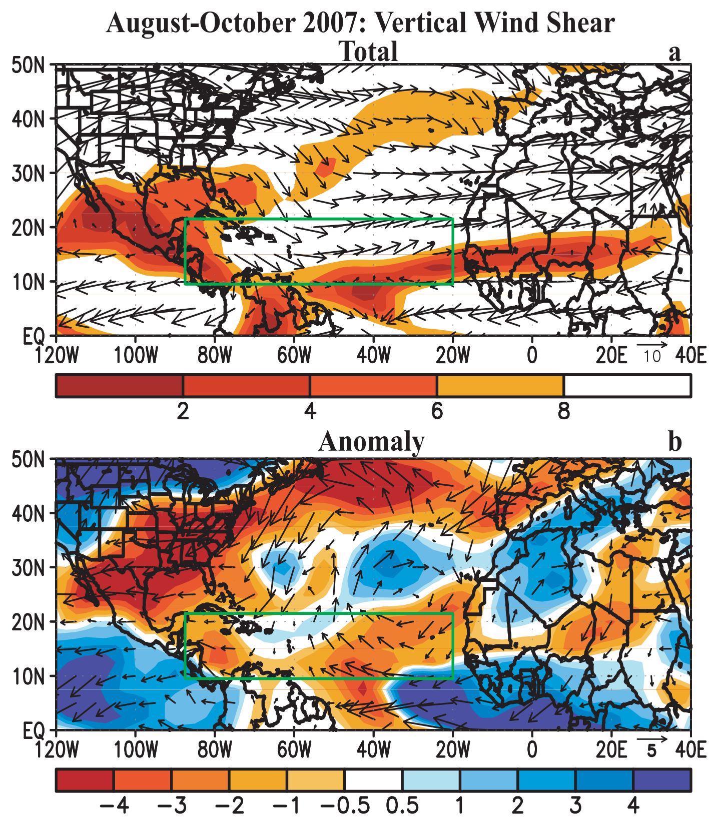


Fig. 5. August-October 2007: 200-850 hPa vertical wind shear magnitude (m s^{-1}) and vectors (a) total and (b) anomalies. In (a), shading indicates vertical wind shear below 8 ms^{-1}. In (b) red (blue) shading indicates below-(above-) average vertical shear. Vector scale is shown at bottom right. Green box denotes the Main Development Region (MDR). Anomalies are departures from the 1971-2000 period monthly means.

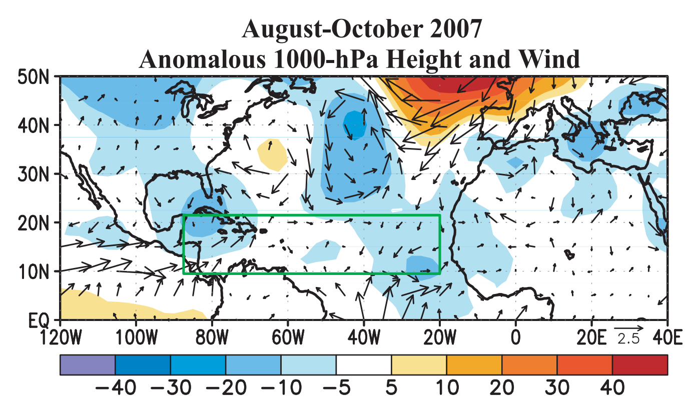


Fig. 6. August-October 2007: Anomalous 1000-hPa heights (m) and wind vectors (m s^{-1}). Vector scale is shown at bottom right. Green box denotes the Main Development Region (MDR). Anomalies are departures from the 1971-2000 period monthly means.

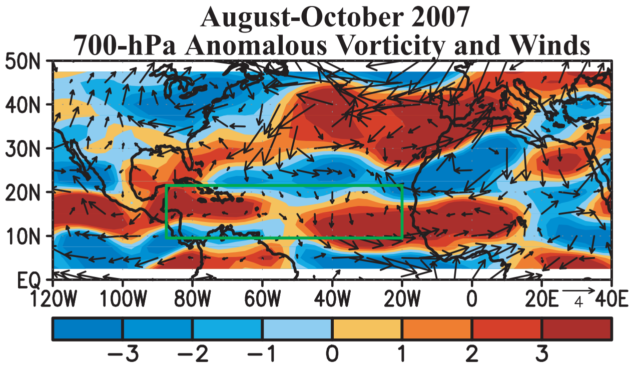


Fig. 7. August-October 2007: Anomalous 700-hPa wind vectors (m s^{-1}) and horizontal shear of the zonal wind (x 10^{-6} s^{-1}). Cyclonic anomalies are shaded red, and anticyclonic anomalies are shaded blue. Vector scale is shown at bottom right. Green box denotes the Main Development Region (MDR). Anomalies are departures from the 1971-2000 period monthly means.

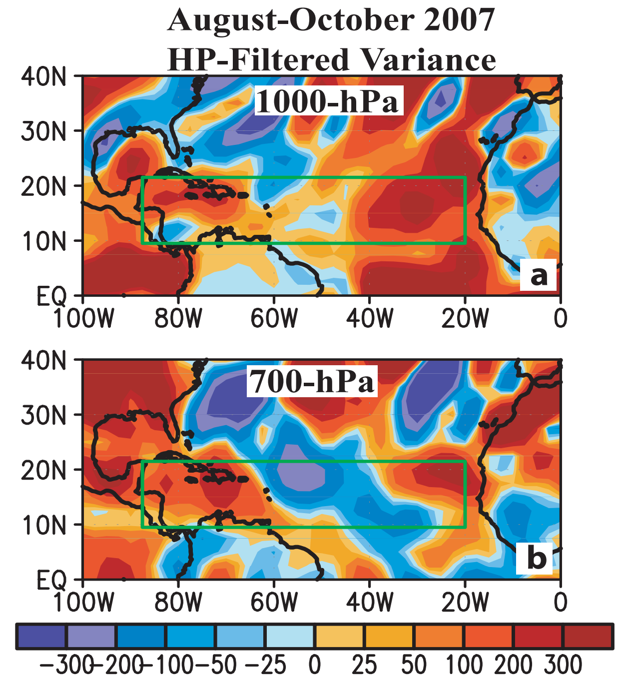


Fig. 8. August-October 2007: Anomalous 10-day high-pass (HP) filtered variance (m^2) of the meridional wind at (a) 1000-hPa and (b) 700-hPa. Green box denotes the Main Development Region (MDR). Anomalies are departures from the 1971-2000 period monthly means.

17). Conversely, at 700-hPa anomalous westerly winds and enhanced cyclonic vorticity (red shading, Fig. 7) in these regions along the equatorward flank of the African Easterly Jet (AEJ) were consistent with these climate features.

One can examine the collective African Easterly Wave (AEW) activity by looking at the high-pass (HP) filtered variance of the daily winds, as is often done to assess mid-latitude storm variability. The HP filtered variance (Duchon 1979) of the meridional wind is used there to examine the AEW activity. During ASO 2007, above average variance at 1000-hPa across the southern MDR (red shading, Fig. 8a) indicates substantial AEW activity near the surface. However, in the eastern MDR, below-average variance at 700-hPa (blue shading, Fig. 8b) suggests the AEWs were weaker at the level of the AEJ, and therefore less vertically developed than normal .

Nonetheless, given the strong vertical wind shear and anomalous sinking motion in the MDR, these conditions do not appear to be a main reason for the reduced Atlantic hurricane activity. Several named storms indeed formed from AEWs in the eastern MDR, but the strong vertical wind shear was often sufficient to suppress hurricane activity regardless of AEW strength.

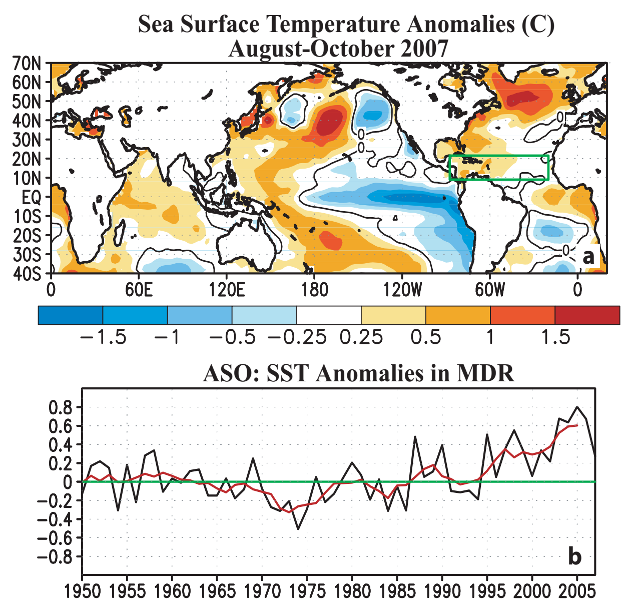


Fig. 9. (a) Sea-surface temperature (SST) anomalies (°C) during August-October 2007. Panel (b) shows consecutive ASO values of SST anomalies in the MDR. Red line shows the corresponding 5-yr running mean. Green box in (a) denotes the Main Development Region (MDR). Anomalies are departures from the 1971-2000 period monthly means.

c. Sea-surface temperatures

During ASO 2007, sea-surface temperatures were above average (+0.27°C) in the MDR (Fig. 9). This ongoing warmth is consistent with two inter-related sets of climate conditions that began in 1995: the warm phase of the Atlantic Multi-decadal Oscillation (AMO) (Enfield and Mestas-Nuñez 1999) and the active Atlantic phase of the tropical multi-decadal signal (Bell and Chelliah, 2006). Some of this persistent warmth has also been linked to increasing global temperatures over the last 100 years (Santer et al. 2006).

The above average SSTs during ASO 2007 were concentrated in the western half of the MDR, where departures averaged +0.47°C. The reduced hurricane activity in these regions is not consistent with the ongoing warmth, and instead reflects the dominant role played by the atmospheric anomalies in controlling Atlantic hurricane activity (Shapiro and Goldenberg 1998).

In the eastern MDR, SSTs cooled to near normal during ASO, following record levels during the previous three hurricane seasons. However, these cooler SSTs cannot account for any of the following key aspects of the season that suppressed hurricane activity: the strong TUTT and upstream ridge during August and September, the lack of a La Niña signal in the upper-level winds across the tropical North Pacific and MDR during ASO (section 3), and the reduced hurricane activity over the Caribbean Sea during October (section 2d).

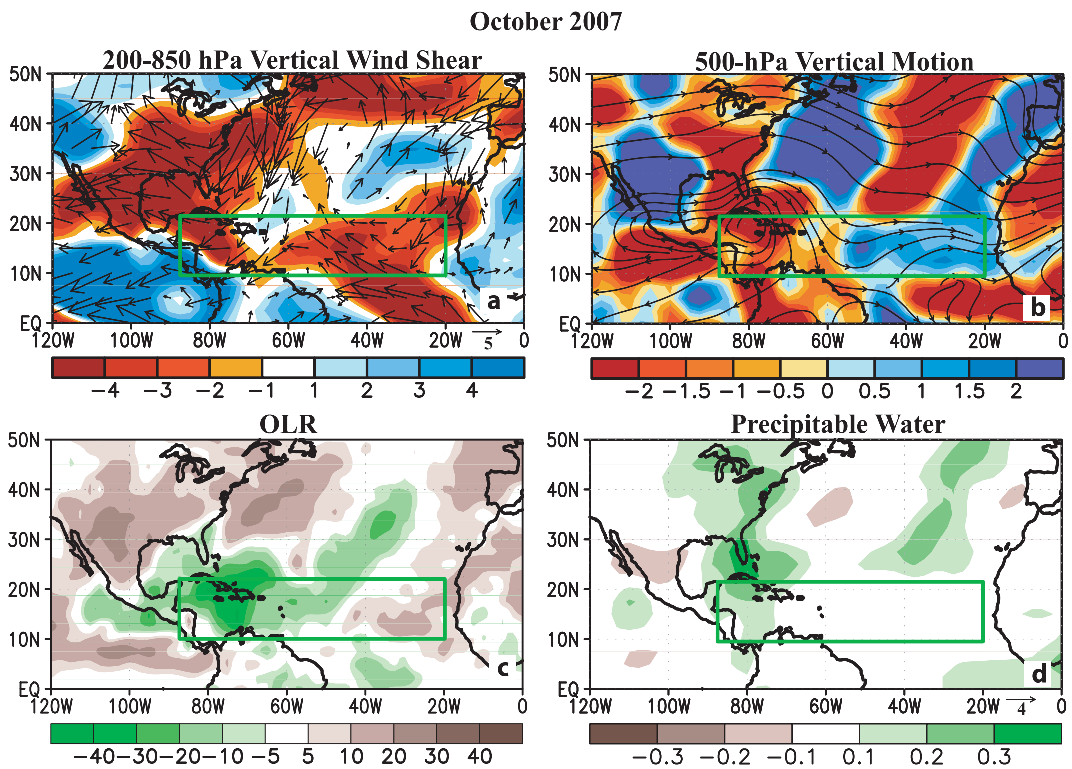


Fig. 10: October 2007atmospheric conditions : (a) Anomalous 200-850 hPa vertical wind shear magnitude ($m\ s^{-1}$) and vectors, with red (blue) shading indicating below- (above-) average strength of the vertical shear. (b) Total 200-hPa streamlines and anomalous 500-hPa vertical motion (shaded), with red (blue) shading indicating anomalous ascent (descent). (c) Anomalous Outgoing Longwave Radiation (OLR, $W\ m^{-2}$), with green shading in MDR indicating enhanced tropical convection. (d) Anomalous precipitable water (inches), with green shading indicating increased tropospheric moisture. Green box in all panels denotes the Main Development Region (MDR). Anomalies in panels (a, b, d) are departures from the 1971-2000 period monthly means. OLR anomalies (c) are departures from the 1979-2000 period monthly means.

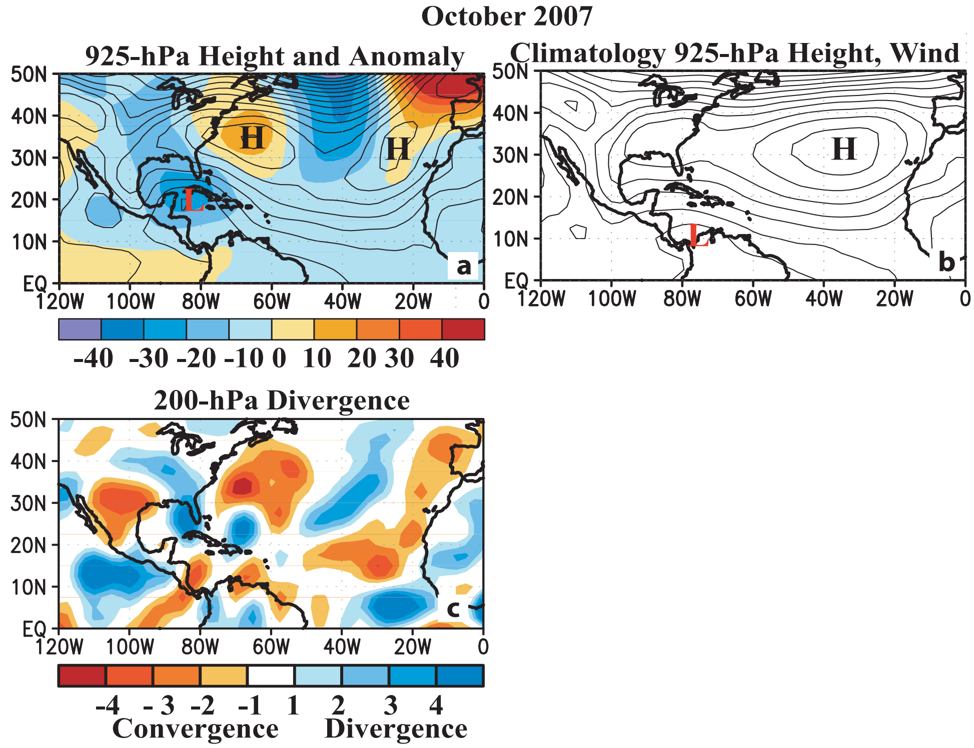


Fig. 11: October 2007 atmospheric conditions: (a) 925-hPa heights (solid contours, m) and anomalies (shaded), (b) Climatological mean 925-hPa heights, and (c) anomalous 200-hPa divergence, with blue (red) shading indicating anomalous divergence (convergence). Anomalies are departures from the 1971-2000 period monthly means.

d. Reduced activity in October

The Caribbean Sea is a preferred region for tropical cyclone formation in October, especially during above-normal seasons. Those seasons average 2-3 NS, 2 H, and 1 MH over the Caribbean Sea in October, which produce an average ACE value of 31% of the median. During October 2007, a sole Caribbean storm (H Noel) produced an ACE value of 6.4%. NOAA's prediction for an above-normal season implicitly suggested more Caribbean activity than was observed.

Specific reasons for this reduced activity remain unclear, since many of the atmospheric and oceanic anomalies were conducive to increased activity, including 1) below average vertical wind shear (Fig. 10a) and anomalous ascending motion at 500-hPa (Fig. 10b) in association with a strong upper-level ridge, 2) above average SSTs, 3) enhanced convection indicated by negative Outgoing Longwave Radiation (OLR) anomalies (Fig. 10c) and 4) above-normal precipitable water (Fig. 10d).

In contrast, the main area of low-pressure was located well north of normal over the northwestern Caribbean Sea and Central America, with much of the circulation located over land (Figs. 11a, b). These conditions were not particularly conducive to hurricane formation, esepcially over the southern Caribbean Sea where the normal core of low surface pressure was completely absent. This area also experienced anomalous upper-level convergence (Fig. 11c), sinking motion, and drier-than-average conditions between 300-400 hPa (not shown).

3. Prevailing Global Climate Patterns

El Niño and La Niña reflect opposite phases of the El Niño/ Southern Oscillation (ENSO), and both modulate seasonal Atlantic hurricane activity (Gray 1984). The occurrence of La Niña during an active hurricane era significantly increases the probability of an above-normal season, in part because this combination produces a weaker TUTT and an extensive region of reduced vertical wind shear in the MDR (Bell and Chelliah 2006). This expected combination of climate factors was the main reason behind NOAA's prediction of an above-normal season.

a. La Niña

La Niña refers to a periodic cooling of the SSTs across the central and east-central equatorial Pacific. This cooling results in a disappearance of equatorial convection between the date line and the west coast of South America, and also acts to retract the equatorial convection westward toward Indonesia and the eastern Indian Ocean. The result is a large-scale pattern of anomalous convection extending more than half the distance around the globe. La Niña's impacts on the upper tropospheric circulation are strongly related to this anomalous convection.

During ASO 2007, SSTs were below average as expected across the central and east-central equatorial Pacific (Fig. 9a). The value of the Niño 3.4 index was -0.8, and well within NOAA's threshold for a weak La Niña (-0.5 to -1.0). The Niño 3.4 index then dropped to –1.1 during September-November, indicating a moderate-strength La Niña during the latter portion of the season.

A time-longitude section shows this cooling was associated with suppressed convection over the central equatorial Pacific near 180° (Fig. 12a). However, over Indonesia and the eastern tropical Indian Ocean, the typical La Niña-related pattern of enhanced convection (Rivu and Baohua 2005) was absent, and the region instead experienced below average convection (black box, Fig. 12b). This observation suggests the La Niña forcing onto the upper-tropospheric circulation was weaker than would normally be expected for the observed SST anomalies.

The 200-hPa velocity potential is related to the divergent circulation associated with tropical

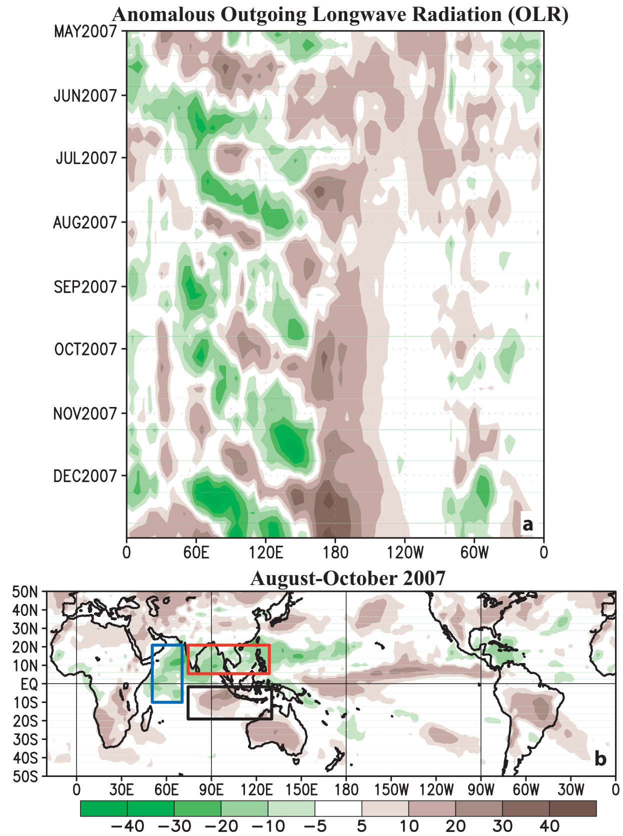


Fig. 12. Outgoing Longwave Radiation (OLR, W m^{-2}): (a) Time-longitude section of pentad anomalies between 5°N-5°S, and (b) August-October 2007 seasonal anomalies. Green shading indicates enhanced convection, and brown shading indicates suppressed convection. Boxes in panel (b) indicate averaging regions for time series shown in Fig. 15. Anomalies are departures from the 1979-2000 period means.

convection. For La Niña, the typical velocity potential pattern features 1) positive anomalies near the date line in association with suppressed convection and upper-level convergence, and 2) negative anomlaies over Indonesia and the eastern Indian Ocean in association with enhanced convection and upper-level divergence (Bell and Chelliah 2006). Especially noteworthy is a lack of persistent positive anomalies near the date line during ASO 2007 (Fig. 13), suggesting the suppressed convection in this region was not a dominant feature of the upper-level divergent circulation as would be expected for La Niña.

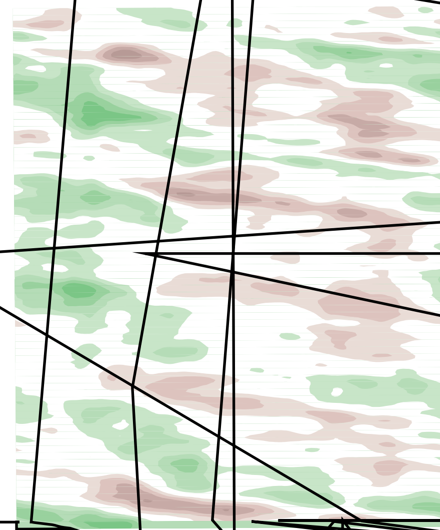
The 200-hPa streamfunction field captures the strength and position of the ridges and troughs, and is often useful in assessing changes in these features related to anomalous tropical convection. La Niña typically produces 1) enhanced troughs across the central and eastern subtropical Pacific in both hemispheres, which flank the region of suppressed equatorial convection, and 2) enhanced ridges over the western subtropical Pacific in both hemispheres, which flank the enhanced equatorial convection over Indonesia and the eastern Indian Ocean. The resulting anomalous wave pattern favors a weaker-than average-TUTT in the MDR.

During ASO 2007, the 200-hPa streamfunction anomalies over the subtropical North Pacific were not consistent with a typical La Niña. The anomalies were weak and the expected core of negative anomalies near the date line was absent (Fig.14). In contrast, there was good consistency between the negative streamfunction anomalies (indicating a weaker upper-level ridge) across the western subtropical North Pacific and the suppressed convection over Indonesia, both of which are opposite to the normal La Niña signal. As a result, the downstream TUTT exhibited no connection to La Nina.

Therefore, although the La Niña-related patterns of below-average SSTs and suppressed tropical convection were prominent east of the date line, there is no indication these conditions were dominating the upper-tropospheric circulation anomalies across the tropical North Pacific and North Atlantic Oceans. One likely reason is the highly anomalous convection over Indonesia and the eastern Indian Ocean, which was more typical of conditions during El Niño (section 3b).

b. Anomalous convection over Indonesia, southeastern Asia, and the Indian Ocean

During ASO 2007, the pattern of tropical OLR anomalies reflected anomalous convection in three very large regions encompassing the Indian Ocean, Indonesia, and southeastern Asia (Fig. 12b). Enhanced convection occurred over the western equatorial Indian Ocean, and across the India and the Southeast Asian monsoon regions, and suppressed convection covered the eastern Indian Ocean and Indonesia. The OLR anomalies for these combined regions were the strongest in the historical record dating back to 1979 (Fig. 15a). This pattern is more typical of El Niño, as was seen in 2006.



Within this pattern, the north-south dipole of anomalies between the Indian/Southeast Asian monsoon regions and the eastern Indian Ocean/ Indonesia was the strongest in the record (Fig. 15b), surpassing the previous record set in 2006. Also, the Indian Ocean (IO) dipole (Saji et al. 1999, Saji and Yamagata 2003a, b) was comparable to the strongest events in the record (Fig. 15c). This positive phase is also more typical of El Niño (Behera et al. 2006), with the strongest events occurring during the El Niño years of 1982-83, 1994, 1997, and 2006.

The amplitude and persistence of the above anomalies during both 2006 and 2007 indicates some independence from ENSO, as was also noted by Saji et al. (1999) and Saji and Yamagata (2003b). The observations suggest this climate signal may have overwhelmed the upper-tropospheric circulation anomalies normally associated with La Niña, thus negating La Niña's normally enhancing influence on the 2007 Atlantic hurricane season. Conversely, this same pattern may have enhanced El Niño's suppressing influence on the 2006 Atlantic hurricane season (Bell et al. 2007). How and why this pattern was so strong and persistent is unresolved.

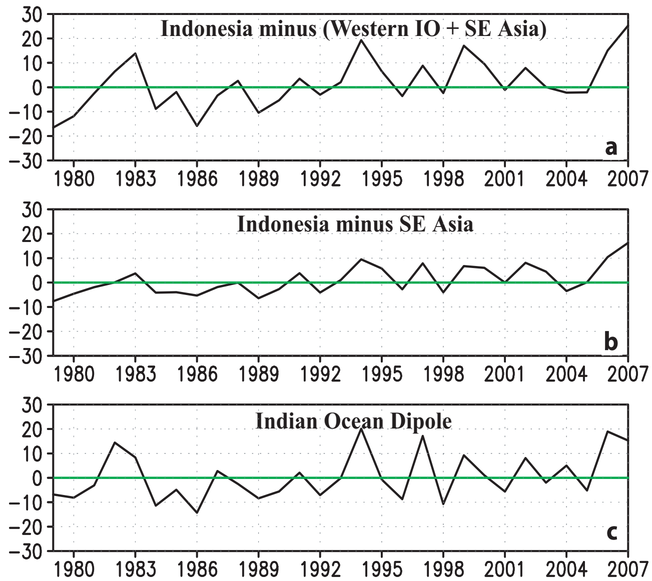


Fig. 15. August-October time series' of Outgoing Longwave Radiation (OLR, W m^{-2}) anomalies averaged over the boxed regions in Fig. 12b; (a) Indonesia (black box) minus Western Indian Ocean (blue box) minus southeastern Asia (red box); (b) Indonesia minus southeastern Asia; and (c) the Indian Ocean dipole (Indonesia minus Western Indian Ocean). Anomalies are departures from the 1979-2000 period monthly means.

c. Ongoing active Atlantic hurricane era

Historically, approximately 55% of Atlantic hurricanes and 80% of Atlantic major hurricanes develop from tropical storms first named in the MDR. These systems account for almost 95% of the difference in the seasonal ACE index between above-normal and below-normal hurricane eras (Bell and Chelliah, 2006), and for nearly all the difference in the number of hurricanes and major hurricanes (Goldenberg et al. 2001).

Since 1995, hurricane seasons have averaged 14.5 named storms, 8 hurricanes, and 3.8 major hurricanes, with an average ACE index of 165% of the median (Fig. 2). NOAA classifies nine of the last thirteen hurricane seasons as above normal, with seven being hyperactive (ACE > 175% of the median). Only four seasons since 1995 have not produced above normal activity. Three of these are the El Niño years of 1997, 2002, and 2006.

Although 2007 was one of the least active years since 1995, it was still more active than most seasons of the below-normal era 1971-1994. Those seasons averaged 8.5 named storms, 5 hurricanes, 1.5 major hurricanes, and an ACE index of only 75% of the median. One-half of these seasons were below normal, only three were above normal (1980, 1988, 1989), and none were hyperactive. Time series' of key atmospheric wind parameters (Fig. 16) highlight the dramatic differences between these above-normal and below-normal hurricane eras.

A main contributing factor to the current active era is the tropical multi-decadal signal, which reflects the leading modes of tropical convective rainfall variability occurring on multi-decadal time scales (Bell and Chelliah 2006). A phase change in the tropical multi-decadal signal corresponds with the dramatic transition in1995 from the inactive hurricane era (1971-1994) to the active era (Bell et al. 2007).

One key aspect of the current active hurricane era is an east-west see-saw in anomalous tropical convection between the West African monsoon region and the Amazon Basin, signaling an enhanced West African monsoon system (see also Landsea and Gray 1992) and suppressed convection in the Amazon Basin. This feature was again prominent during 2007 (Fig. 17). A second aspect of the tropical multi-decadal signal is ongoing above average SSTs in the North Atlantic, consistent with the warm phase of the Atlantic multi-decadal mode (Goldenberg et al. 2001).

As shown by Bell and Chelliah (2006), the tropical multi-decadal signal is associated with an inter-related set of atmospheric anomalies known to favor active hurricane seasons. Many of these anomalies were again in place during 2007, including (1) enhanced upper tropospheric (200-hPa) ridges in both hemispheres over the Atlantic Ocean (Fig. 14), (2) an enhanced tropical easterly jet and a westward expansion of the area of anomalous easterly winds at 200-hPa, and (3) reduced tropical easterlies at 700-hPa across the central and eastern Atlantic (Fig. 16b), and (4) enhanced cyclonic relative vorticity along the equatorward flank of the African Easterly Jet (Fig. 16c). In light of these ongoing conditions,

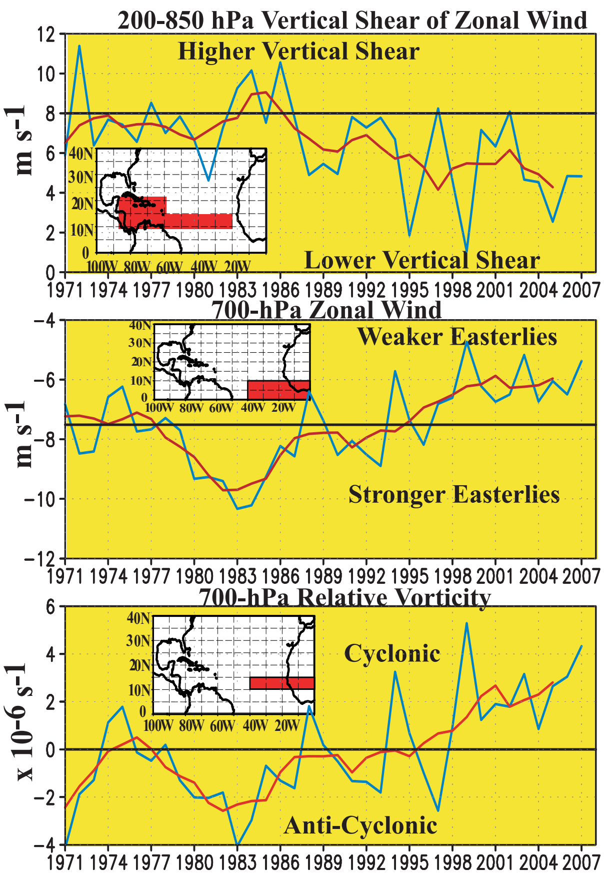


Fig. 16. August-October time series' showing area-averaged values of (a) 200-850 hPa vertical shear of the zonal wind (m s^{-1}), (b) 700-hPa zonal wind (m s^{-1}) and (c) 700-Pa relative vorticity (x 10^{-6} s^{-1}). Blue curve shows unsmoothed three-month values, and red curve shows a 5-pt running mean of the time series. Averaging regions are shown in the insets.

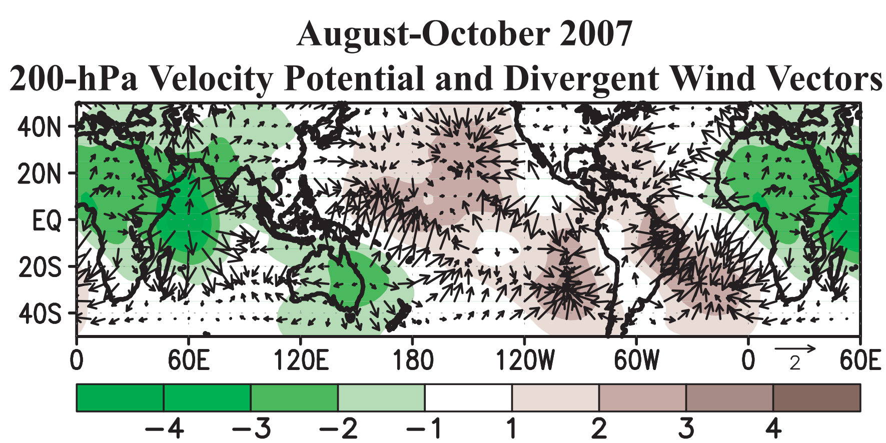


Fig. 17. August-October 2007: Anomalous 200-hpa velocity potential (x 10^6 m^2 s^{-1}) and divergent wind vectors (m s^{-1}). Vector scale is shown at bottom right. Anomalies are departures from the 1971-2000 period daily means.

there is no indication the current active hurricane era has ended.

4. NOAA's Seasonal Hurricane Outlooks

NOAA's seasonal Atlantic hurricane outlooks (issued in both May and early August) were based on the expected occurrence of La Niña during an active Atlantic hurricane era, which greatly increases the probability of an above-normal season. The May outlook called for a 75% chance of an above-normal season, with a likely range of 13-17 named storms, 7-10 hurricanes, 3-5 major hurricanes, and an ACE range of 125%-210% of the median. The August outlook called an 85% chance of an above-normal season, with a likely range of 13-16 named storms, 7-9 hurricanes, 3-5 major hurricanes, and an ACE range of 140%-200% of the median.

The observed number of named storms was well within NOAA's predicted range, and the observed numbers of hurricanes and major hurricanes were each one below the predicted range. However, the combined intensity and duration of the hurricanes and major hurricanes, as measured by the ACE index, was far below expectations.

Improvements in tools such as Quikscat, AMSU, cyclone phase space, and the unique use of aircraft observations, has likely led to more tropical storms and subtropical storms being identified now compared to a generation ago (Landsea 2007). For this reason, NOAA's seasonal forecasts include an average of two additional named storms. For 2007, it is estimated that four tropical storms, Andrea, Chantal, Jerry, and Melissa, may not have been named a generation ago.

5. Summary

During August and September, a strong tropical upper-level trough (TUTT) combined with a strong ridge over the eastern United States to produce above-average vertical wind shear and anomalous mid-level sinking motion across the western half of the MDR, Gulf of Mexico, and western and central subtropical North Atlantic Ocean. These conditions limited hurricane formation, intensity, and duration in both the tropics and extratropics. During October, a mixed set of atmospheric conditions with no obvious climate links led to below-average activity over the Caribbean Sea. The resulting seasonal activity was in lower portion of the near-normal range.

NOAA's prediction for an above-normal season was based on the expected occurrence of La Niña during an active hurricane era. This combination is very conducive to an active hurricane season, in part because it typically contributes to a weaker TUTT and decreased vertical wind shear across the MDR. During 2007, La Niña developed in August and then reached moderate strength (as measured by the sea-surface temperature anomalies) during September-November. NOAA's over-prediction of the 2007 activity resulted in part from the absence of a La Niña signature on the upper-tropospheric circulation across the tropical North Pacific and western MDR during the peak of the season.

One plausible explanation is that although convection was suppressed across the central and east-central equatorial Pacific as expected for La Niña, it was also suppressed over Indonesia and the eastern tropical Indian Ocean. Therefore, the total La Niña forcing onto the upper-level atmospheric winds was weaker than would normally be expected for the observed equatorial Pacific SST anomalies.

In addition, the La Niña signal may have been overwhelmed by the persistent and record strength pattern of anomalous convection, characterized by enhanced convection across the western equatorial Indian Ocean and across the India and the Southeast Asian monsoon regions, and suppressed convection over the eastern Indian Ocean and Indonesia. This overall pattern is more typical of El Niño.

Although ASO 2006 and ASO 2007 featured opposite phases of ENSO, the anomalous convection in the above regions was similar between the two seasons. This climate signal may have reinforced El Niño's impacts on the upper-tropospheric circulation during ASO 2006. Conversely, it may have negated La Niña's impacts during ASO 2007. How and why this pattern was so strong and persistent is unresolved.

It is important to note that key atmospheric anomalies known to be associated with the current active hurricane era were in place dueing 2007 as predicted. A nearly identical set of conditions has been described by these same authors for every Atlantic hurricane season since 1998 (Bell et al. 2000-2007). Therefore, although the activity was reduced for a second straight season, there is no indication the current active hurricane era has ended.

6. References

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