NATIONAL HURRICANE CENTER ANNUAL SUMMARY

2014 ATLANTIC HURRICANE SEASON

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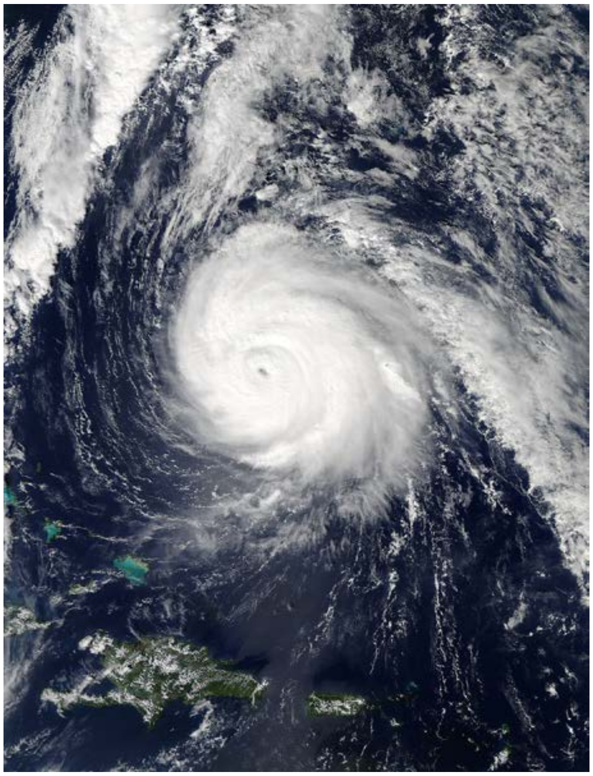

NASA MODIS VISIBLE IMAGE OF HURRICANE GONZALO AT 1745 UTC 16 OCTOBER 2014

ABSTRACT

The 2014 Atlantic hurricane season was below average in several respects. Although the number of hurricanes, six, equaled the long-term average, there were two major hurricanes (category 3 or higher intensity on the Saffir-Simpson Hurricane Wind Scale) and eight named storms, compared to the long-term averages of three and 12, respectively. The NOAA Accumulated Cyclone Energy (ACE) index, which is a measure of the strength and duration of (sub)tropical storms and hurricanes, was about 72% of the long-term median. Although most of the tropical cyclone activity occurred well east of the east coast of the United States, Hurricane Arthur made landfall on the North Carolina coast in July. Bermuda was hit by two hurricanes, Fay and Gonzalo, in less than a week's time in October.

OVERVIEW

Tropical cyclone activity was somewhat below average in the Atlantic basin during 2014. Eight tropical storms formed, of which six became hurricanes, and two intensified into major hurricanes. In comparison the long-term (1981-2010) averages are 12 named storms, 6 hurricanes, and 3 major hurricanes. The NOAA Accumulated Cyclone Energy (ACE) index for 2014 was 72% of the long-term median. While most land areas were spared from tropical cyclones in 2014, Hurricane Arthur made landfall on the North Carolina coast, and Bermuda was struck by Hurricanes Fay and Gonzalo within a six-day period. Gonzalo was the most intense Atlantic hurricane since Igor of 2010. There was also a tropical depression that did not intensify into a tropical storm.

Table 1 lists the tropical cyclones of the 2014 season, and the tracks of the season's (sub)tropical storms and hurricanes are shown in Figure 1. There was a dearth of tropical cyclone activity in the deep Tropics in 2014, with Gonzalo being the year's only low latitude (south of 20°N) hurricane. This lack of activity can be at least partially explained by some anomalous large-scale atmospheric features. Figure 2 depicts the anomalous vertical wind shear during August through October 2014. It can be seen that above-normal shear, which was hostile for tropical cyclone formation and intensification, prevailed over almost all of the Caribbean Sea and much of the tropical Atlantic. Interestingly, there was weaker shear near the northern Leeward Islands, which was the area where Hurricane Gonzalo formed. Another unfavorable environmental factor during the 2014 Atlantic hurricane season was the anomalous 200-mb velocity potential for August-October (Fig. 3), which featured a distinct pattern of anomalous upper-tropospheric convergence that dominated the Tropics. This pattern resulted in anomalous sinking motion at lower latitudes (not shown) that likely suppressed tropical cyclogenesis.

The following section summarizes the most significant tropical cyclones of 2014: Hurricanes Arthur, Fay, and Gonzalo. More detailed information on the tropical cyclones of 2014 can be found at http://www.nhc.noaa.gov/2014atlan.shtml .

SELECTED STORM SUMMARIES

Hurricane Arthur

Arthur was of non-tropical origin. An area of low pressure developed along a frontal boundary just off the coast of South Carolina on 28 June. The low moved generally southward for a couple of days, with the associated cloud pattern becoming more organized over the warm waters of the Gulf Stream east of Florida. Deep convection became sufficiently well organized and persistent for the low to be designated as a tropical depression at 0000 UTC 1 July about 70 n mi north of Freeport in the Bahamas. The depression drifted westward and gradually strengthened, becoming a tropical storm by 1200 UTC about 60 n mi east of Ft. Pierce, Florida.

Arthur was located in a region of weak mid-level steering, and the cyclone meandered east of Florida until early on 2 July. Later that day, a mid-level anticyclone began building over the western Atlantic, causing Arthur to accelerate toward the north. Light upper-level winds and warm ocean temperatures near 28°C allowed Arthur to gradually strengthen while east of Florida, although mid-level dry air in the vicinity of the cyclone limited the rate of intensification. Arthur continued northward and became a hurricane at 0000 UTC 3 July while centered 125 n mi east-southeast of Savannah, Georgia.

On 3 July, Arthur turned north-northeastward and continued to accelerate while it moved between the ridge over the western Atlantic and an approaching mid- to upper-level trough over the eastern United States. The hurricane continued to strengthen, passed to the east of Cape Fear, and reached its peak intensity of 85 kt at 0000 UTC 4 July just off of the coast of North Carolina. Coastal radar data and aircraft reconnaissance data indicate that Arthur turned northeastward and made landfall on Shackleford Banks, just west of Cape Lookout, North Carolina, a few hours later at 0315 UTC. Over the next 5 h or so, Arthur moved northeastward over Down East Carteret County and Pamlico Sound and crossed the Outer Banks just north of Oregon Inlet around 0800 UTC. Arthur is the earliest hurricane to make landfall in North Carolina since records began in 1851, surpassing the date when a hurricane made landfall between Kill Devil Hills and Kitty Hawk on 11 July 1901.

After crossing the Outer Banks, Arthur accelerated northeastward over the western Atlantic late on 4 July and early on 5 July. At the same time, strong upper-level winds and much colder sea surface temperatures caused Arthur to lose some strength and begin extratropical transition, and the cyclone weakened to a tropical storm at 0600 UTC 5 July while located about 115 n mi east of Provincetown, Massachusetts (Cape Cod). Arthur became an extratropical cyclone 6 h later while over the Bay of Fundy just west of Nova Scotia.

The extratropical low continued generally northeastward toward the Gulf of St. Lawrence through 6 July, producing gale-force winds and heavy rain over portions of Nova Scotia, Prince Edward Island, and New Brunswick. The low then reached eastern Labrador late on 6 July and crossed into the far northwestern Atlantic over the Labrador Sea on 7 July. Over the next couple of days, the extratropical low's winds decreased below gale force, and the system dissipated off the eastern coast of Labrador by 0000 UTC 10 July.

Sustained category 1 winds occurred across portions of extreme eastern North Carolina, especially the Outer Banks, while sustained category 2 winds were limited to marine areas of Pamlico Sound and offshore of the North Carolina coast. The highest sustained winds measured by surface stations were 1-min winds of 74 kt by a Weatherflow station in Pamlico Sound at 0554 UTC, 72 kt by a Weatherflow station in Salvo at 0753 UTC 4 July and, and a 2-min wind of 67 kt by the C-MAN station at Cape Lookout at 0220 UTC. The highest measured wind gust was 88 kt at Cape Lookout, while the Weatherflow stations in Pamlico Sound and on Ocracoke Island each measured gusts to 86 kt.

There were no reports of casualties associated with Arthur. The United States was generally spared from significant damage, and the Property Claim Services determined that Arthur did not meet their $25 million threshold in claims to be considered a "catastrophe". Despite the relatively modest damage, one of the hardest hit areas was Dare County, North Carolina, which includes the Outer Banks. A report from the Dare County damage assessment officer indicated that most of the damage in the county was the result of sound-side storm surge flooding, but strong winds also downed trees and caused damage to shingles, siding, and roofs. The worst damage occurred south of Oregon Inlet on Hatteras Island, especially in the Rodanthe, Salvo, and Waves areas, where wind and water damaged numerous residences, businesses, and campgrounds. More significant damage also occurred in Manteo, where sound-side flooding inundated businesses in the downtown area. Immediately after the storm, Dare County reported that total property damage in the county was just under $2 million. Duke Energy estimated that about 83,400 customers in North Carolina were without power at some point during the hurricane. Some parts of North Carolina Highway 12 were covered by sand due to storm surge, and the highway buckled near the Pea Island Bridge on Hatteras Island where the barrier island was breached during Hurricane Irene in 2011.

In New England, heavy rainfall caused flooding in parts of southeastern Massachusetts. Numerous roads were impassible and covered by up to a foot of water. A little more than 10,000 customers lost power, especially on Cape Cod. In Maine, strong winds and heavy rain helped to topple numerous large trees and power lines, causing extensive damage and knocking out power for about 20,000 customers. During its post-tropical stage, Arthur knocked down numerous large trees and caused extensive power outages across Atlantic Canada due to strong winds.

Hurricane Fay

An upper-level low formed several hundred n mi southeast of Bermuda on 8 October and induced the development of a surface trough. Southwesterly shear delayed any further organization of the low-level disturbance during the next day or so. When the upper low became nearly situated over the disturbance on 9 October, the shear relaxed, and a comma-shaped cloud developed. Scatterometer data early on 10 October indicated a large area of 25 to 30 kt winds, with the strongest winds about 120 to 140 n mi from the center of a well-defined surface low pressure system. The convective organization of the low continued to increase, and the system became a subtropical storm about 535 n mi south of Bermuda at 0600 UTC 10 October.

The storm moved north-northwestward around the western periphery of a mid-level ridge over the central Atlantic, while maintaining a large and asymmetric mass of convection on the northwestern side of a partially exposed low-level circulation center. The shear increased when the cyclone moved away from the protective cover provided by the nearby upper low, and the convection persisted and contributed to middle- and upper-tropospheric warming by 11 October. The first reconnaissance mission into the storm late on 10 October found that the radius of maximum winds had decreased to about 40 n mi, which was consistent with a concentration of convection closer to the center and increased banding, and Fay became a tropical cyclone by 0600 UTC 11 October. While the evolution to a tropical cyclone was taking place, strong upper-level divergence may have contributed to Fay intensifying from a 40- to a 55-kt tropical storm, even in the presence of high vertical shear.

Fay turned northward and then north-northeastward while accelerating as it moved north of the mid-level ridge axis. Additional strengthening occurred in spite of even stronger south-southwesterly 850-200 mb shear of nearly 35 kt, and Fay reached hurricane strength while it approached Bermuda around 0600 UTC 12 October. Aircraft and satellite data showed that Fay continued to possess an asymmetric cloud pattern and wind distribution, with the deepest convection and strongest winds located in a large band over the western and southwestern part of the circulation when Fay passed over the island around 0800 UTC that day. Strong winds and heavy rains in that band buffeted Bermuda a couple of hours after Fay made landfall.

Fay then turned sharply toward the east-northeast and accelerated in response to a shortwave trough moving through Atlantic Canada. Strong southwesterly vertical wind shear associated with this upper-level trough began to affect Fay, and satellite data showed that the separation between the low- and mid-level centers was rapidly increasing. Fay weakened to a tropical storm by 1800 UTC 12 October, with the surface circulation quickly becoming elongated while the cyclone's forward speed increased to greater than 20 kt. Additional weakening occurred, and Fay degenerated into an open trough by 0600 UTC 13 October before regenerating as a frontal cyclone over the northeastern Atlantic later that day. The frontal cyclone sped eastward and then east-southeastward well southwest of the Azores by late on 14 October and lost its identity along the front over the northeastern Atlantic on 15 October.

A maximum 10-min wind of 53 kt was measured at the official site at the Bermuda Airport (TXKF), with winds 20-40% higher reported elsewhere on the island at elevations well above the standard 10-m elevation. The application of a gust factor to the TXKF wind observation yields an estimated peak 1-min wind of 59 kt. A Weather Underground site at Smith's Parish reported a 70-kt 1-min wind at a height of 40 m, which corresponds to about 62 kt at 10 m. A 76-kt 10-min sustained wind was measured atop Commissioner's Point at an elevation of about 46 m above ground level, yielding a peak 1-min wind of 74 kt at 10 m (although the siting of the Commissioner's Point observations makes its representativeness uncertain). Wind gusts over hurricane force were commonplace throughout the island, with over 100-kt gusts reported at elevated locations.

The lowest observed pressure on Bermuda (984.5 mb) was measured in Smith's Parish near Flatt's Village at 0810 UTC. Another notable minimum pressure of 985.1 mb was measured at TXKF at 0820 UTC, when the station was reporting very light northerly winds. A rainfall total of 1.87 inches was measured at TXKF, but the funnel to the rain gauge was apparently carried away by the wind before the height of the storm. An unofficial total of 3.70 inches of rain was recorded by a member of the public on the west end of the island, but the gauge was tipped over at an angle by the gusty winds. A storm surge of 1.78 ft was measured by a NOAA tide gauge at St. George on the north coast of the island. Higher values could have occurred on the southern and western sides of the island, coincident with the strongest winds.

Fay's winds toppled utility poles, downed trees and street signs throughout Bermuda, with the damage likely exacerbated by saturated soils after nearly 14 inches of rain on the island in August and above normal rains in September. Nearly 27,000 customers were left without power. Isolated roof and vehicle damage was reported, though most of the damage was minor. Strong winds damaged the roof of the terminal building at the L.F. Wade International Airport, with several reports of severe flooding in that building. Several major roads were inundated, including Front Street in Hamilton. Large boats broke from their moorings and were pushed onshore, heavily damaged or destroyed.

There were no casualties due to Fay. One insurer on Bermuda preliminarily estimated their losses from Fay to be near $3.8 million. With several other insurers on the island, the total monetary losses are likely significantly higher, but there are no additional estimates at this time. Since Gonzalo affected Bermuda within six days of Fay's passage, it may be difficult to separate the impacts from the two storms.

Hurricane Gonzalo

Gonzalo originated from a tropical wave that moved off the west coast of Africa on 4 October. The wave eventually spawned a small low pressure area over the tropical Atlantic late on 11 October. Thunderstorm activity associated with the system increased in organization, and it is estimated that a tropical depression formed around 0000 UTC 12 October about 340 n mi east of the Leeward Islands. The depression moved westward through an environment of low vertical wind shear and warm waters, and strengthened into a tropical storm by 1200 UTC 12 October while located about 220 n mi east of Antigua. Gonzalo began to rapidly strengthen late on 12 October, and it became a hurricane around 1200 UTC 13 October when it was located just east-southeast of Antigua. Gonzalo turned west-northwestward and passed directly over that island a couple of hours later. The hurricane continued to strengthen while it passed through the northern Leeward Islands that afternoon. Gonzalo then turned northwestward before the southwestern portion of the eye moved over St. Barthélemy around 2000 UTC, with the center of the eye passing just north of the island about an hour later. Gonzalo made landfall on the island of St. Martin at about 2245 UTC with an estimated intensity of 75 kt, and passed over Anguilla about 45 minutes later. Shortly thereafter, Gonzalo moved over the Atlantic waters and strengthened to an intensity of 90 kt by 0600 UTC 14 October when it passed about 35 n mi northeast of Anegada, the northeastern-most of the British Virgin Islands.

The hurricane moved northwestward around the southwestern periphery of a deep-layer ridge over the central Atlantic during the next 24 to 36 h. Gonzalo rapidly intensified and became a major hurricane at 1800 UTC 14 October when it was located about 145 n mi north of San Juan, Puerto Rico. Gonzalo became a category 4 hurricane 6 h later with an estimated intensity of 115 kt. Over the next 12 to 18 h an eyewall replacement occurred, and Gonzalo weakened slightly. During this time, the hurricane began moving north-northwestward around the western portion of the ridge that was beginning to shift eastward. The eyewall cycle completed with the radius of maximum winds decreasing to less than 10 n mi by late on 15 October. The hurricane intensified again early the next day while it turned northward, and Gonzalo reached its estimated peak intensity of 125 kt at 1200 UTC 16 October, when it was centered about 460 n mi south-southwest of Bermuda. After that time, Gonzalo turned north-northeastward between the retreating ridge to its east and a mid- to upper-level trough that was located along the east coast of the United States.

Late on 16 October, the hurricane once again exhibited a double eyewall structure and began to weaken. The inner eyewall gradually eroded and the radius of maximum winds increased from about 10 n mi to 20-25 n mi by early on 17 October. Increasing southwesterly shear and slightly cooler sea surface temperatures caused Gonzalo to weaken to a category 3 hurricane by 1200 UTC 17 October when it was centered about 180 n mi south-southwest of Bermuda. Gonzalo’s maximum winds continued to decrease during the afternoon of 17 October while it moved north-northeastward toward Bermuda at about 15 kt. The hurricane made landfall on the southwestern coast of Bermuda with an estimated intensity of 95 kt shortly after 0000 UTC 18 October. Several observing sites on the island reported light winds and minimum pressures of around 952 mb between about 0020 and 0040 UTC as the center of the eye passed over the island.

After Gonzalo’s passage over Bermuda, the hurricane continued to accelerate north-northeastward, and by 1800 UTC 18 October its forward speed exceeded 30 kt. Increasing southwesterly vertical wind shear and cool waters caused additional weakening as Gonzalo's cloud pattern became less symmetric. The hurricane turned northeastward by early on 19 October and moved over much colder waters north of the Gulf Stream by 0600 UTC 19 October. A few hours later, the center of Gonzalo passed about 45 n mi southeast of the southeastern tip of the Avalon Peninsula of Newfoundland. Gonzalo became a 65-kt extratropical cyclone by 1800 UTC 19 October, while centered about 400 n mi northeast of Cape Race, Newfoundland. The extratropical cyclone turned east-northeastward and weakened before it was absorbed by a cold front several hundred n mi south-southwest of Iceland by 1200 UTC 20 October. The front and remnants of Gonzalo brought strong winds and heavy rains to the United Kingdom and portions of northern Europe the next day.

A 1-min sustained wind of 67 kt with a gust to 78 kt was observed at 1244 UTC on Antigua at V.C. Bird International Airport. Sustained hurricane-force winds were also reported on St. Barthélemy. A 1-minute sustained wind of 75 kt at an elevated observing site at Gustavia, and a private weather station reported winds of 66 kt with a gust to 94 kt at 1941 UTC. A minimum pressure of 984.1 mb was observed at the private weather station on Barthélemy at 2111 UTC. Sustained hurricane-force winds also likely occurred over portions of St. Martin and Anguilla. The official observing station in St. Martin reported winds of 55 kt with a gust to 69 kt around 0000 UTC 14 October, although higher winds could have occurred since the record for this station is incomplete. Tropical storm conditions were reported on Barbuda and likely occurred over portions of the northeastern British Virgin Islands. A storm surge of 1.08 ft was recorded at an NOS tide gauge on Barbuda during Gonzalo's passage on 13 October.

Bermuda experienced an extended period of tropical-storm-force winds or greater beginning around mid-day local time 17 October and ending after daybreak the following morning. Hurricane-force winds occurred over Bermuda for about 6 h from around 2300 UTC 17 October to 0500 UTC 18 October. The strongest sustained winds experienced on Bermuda were likely of category 2 intensity and occurred on the back side of the hurricane from a northwesterly direction in the southwestern eyewall. The highest (10-min) mean wind reported on the island was 94 kt with a gust to 113 kt at an elevated site at Commissioner's Point (~46 m) at 0250 UTC. An anemometer on the Bermuda Causeway (elevation ~12 m) measured a 10-min mean wind of 81 kt with a gust to 98 kt at 0250 UTC. The highest wind gust recorded on Bermuda was 125 kt at St. David's. During the passage of Gonzalo's eye over Bermuda around 0030 UTC 18 October, minimum pressures between 951.9 to 952.9 mb were reported at all of the available official and private weather observing sites. The Bermuda Institute of Ocean Sciences research ship, the *Atlantic Explorer*, sent hourly observations while in port at Bermuda. The ship reported peak winds of 56 kt at 2300 UTC 17 October and a minimum pressure of 951.2 mb around 0100 UTC 18 October. Gonzalo was the strongest hurricane to affect Bermuda since Hurricane Fabian in September 2003, and is the strongest October hurricane to make landfall on Bermuda since 1926.

A NOAA National Ocean Service (NOS) tide gauge at Esso Pier in the northern portion of Bermuda measured a storm surge of 2.54 ft. Coastal flooding on Bermuda was minimal since the hurricane made landfall around the time of low tide. The highest measured storm tide (combination of storm surge and the astronomical tide) was 3.25 ft above mean lower low water at Esso Pier.

Gonzalo is believed to be responsible for three direct deaths, all in the Leeward Islands. An 87-year-old man was killed on a boat that sank in the Simpson Bay Lagoon in St. Maarten.

French officials reported two others missing that were believed to be on boats, one on the French side of St. Martin and the other in St. Barthélemy. The whereabouts of these two individuals remain unknown and they are presumed to have been fatalities. No deaths or serious injuries were reported in Bermuda. After Gonzalo was no longer a tropical cyclone, its remnants caused two additional deaths and at least four injuries in Great Britain.

Media reports indicate that strong winds from Gonzalo caused numerous downed trees and utility lines in Anguilla, St. Barthélemy, both the French and Dutch sides of St. Martin, and Anguilla. Some roof and structural damage was also reported on these islands. The downed trees and power lines caused extensive power outages and made many roads impassable after the storm. There have been no monetary damage estimates received for any of the Leeward Islands. According to media reports, Gonzalo produced $200 to $400 million (USD) in insured losses on Bermuda. Strong winds downed numerous trees and utility poles, and also caused some structural damage including the loss of roofs and collapsed walls. Older structures fared worse than structures constructed under new building codes designed to withstand sustained winds up to about 95 kt. Most of the Bermuda was without electricity after the hurricane and it took more than two weeks to fully restore power on the island. A large number of boats were grounded and damage to marine vessels is not included in the aforementioned insured loss estimate. Minor damage to the Bermuda Causeway was also reported.

In the United Kingdom, strong winds caused widespread transportation delays, with trees falling on roadways and rail lines. More than 100 flights were cancelled at London's Heathrow airport and ferry service was also disrupted across the region.

FORECAST VERIFICATION

The 2014 Atlantic hurricane season had below-normal activity, with 159 official forecasts issued. The mean NHC official track forecast errors in the Atlantic basin were slightly smaller than the previous 5-yr means from 12 to 72 h, but higher than the 5-yr mean at 120 h. A record for accuracy was set from 24 to 72 h. The official track forecasts were highly skillful and performed close to the best-performing models. TVCA and HWFI had the highest skill and beat the official forecast at a few time periods. FSSE and EMXI were strong performers in the short term and EGRI was the best model at the longer range. GFSI and AEMI were fair performers while GHMI, CMCI, NVGI, and GFNI performed less well. The Government Performance and Results Act of 1993 (GPRA) track forecast goal was met.

Mean official intensity errors for the Atlantic basin in 2014 were below the 5-yr means at all lead times. Decay-SHIFOR errors in 2014 were also lower than their 5-yr means from 12 to 36 h and at 120 h, but larger than average at the other forecast times. The official forecasts beat all of the intensity guidance in 2014. Among the guidance, IVCN and DSHP were the best performers, followed by FSSE and LGEM. GHMI and HWFI were not skillful through 36 h, but were completive with the statistical and consensus aids at the longer range. The GPRA intensity forecast goal was met.

Table 1. 2014 Atlantic hurricane season statistics.

Storm Name	Class[a]	Dates[b]	Max. Winds (kt)	Min. Pressure (mb)	Deaths	U.S. Damage ($million)
Arthur	H	1 – 5 July	85	973		minor
Two	TD	21 – 23 July	30	1012		
Bertha	H	1 – 6 August	70	998	2	
Cristobal	H	23 – 29 August	75	965	7	
Dolly	TS	1 – 3 September	45	1000		
Edouard	MH	11 – 19 September	105	955		
Fay	H	10 – 13 October	70	983		
Gonzalo	MH	12 – 19 October	125	940	3	
Hanna	TS	22 – 28 October	35	1000		

[a] Tropical depression (TD), maximum sustained winds 33 kt or less; tropical storm (TS), winds 34-63 kt; hurricane (H), winds 64-95 kt; major hurricane (MH), winds 96 kt or higher.

[b] Dates begin at 0000 UTC and include all tropical and subtropical cyclone stages; non-tropical stages are excluded.

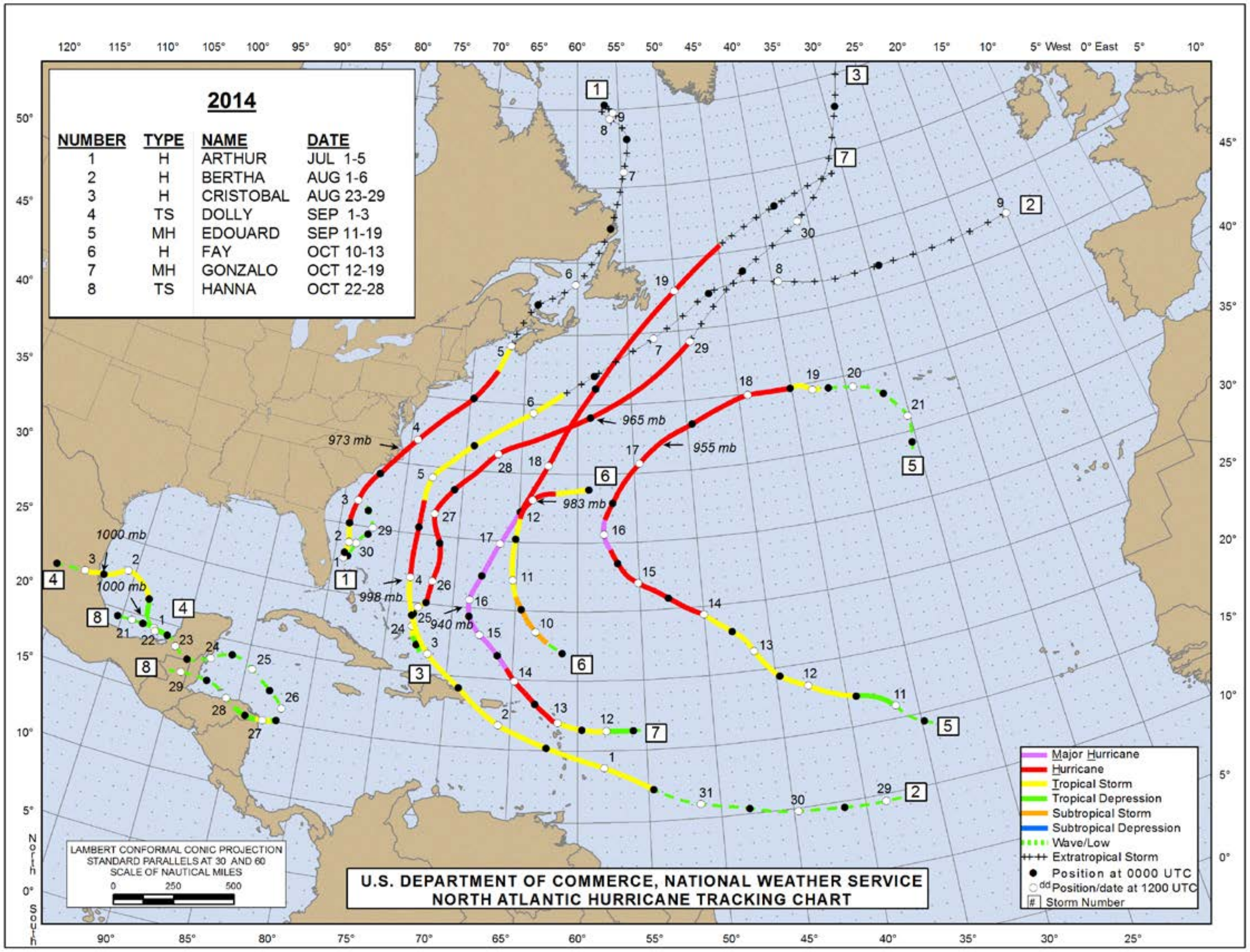

Figure 1: Tracks of the (sub)tropical storms and hurricanes of the 2014 Atlantic Hurricane Season.

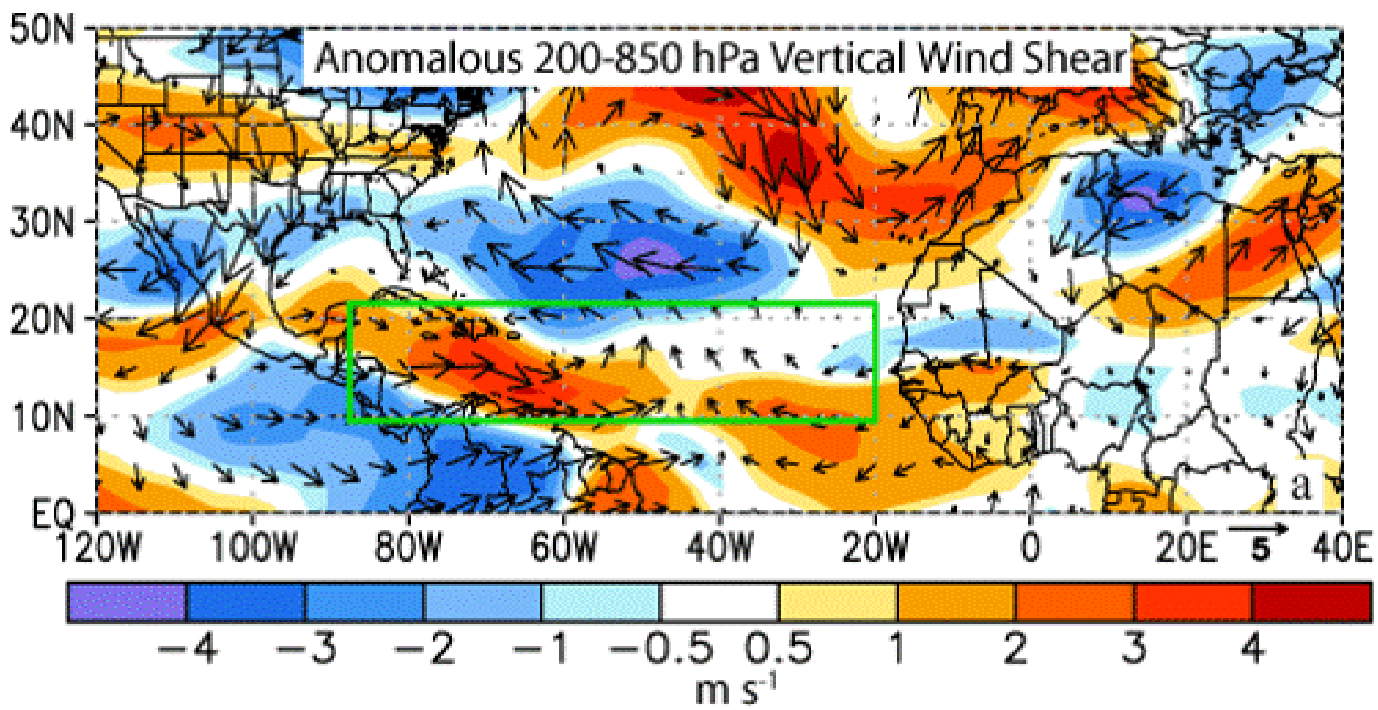

Figure 2: 200-850 mb anomalous magnitude of vertical wind shear and anomalous shear vector (m s^{-1}) for August through October of 2014. The green box indicates the Main Development Region. Anomalies are based on the 1981-2010 climatology. Figure courtesy of Gerry Bell (Climate Prediction Center).

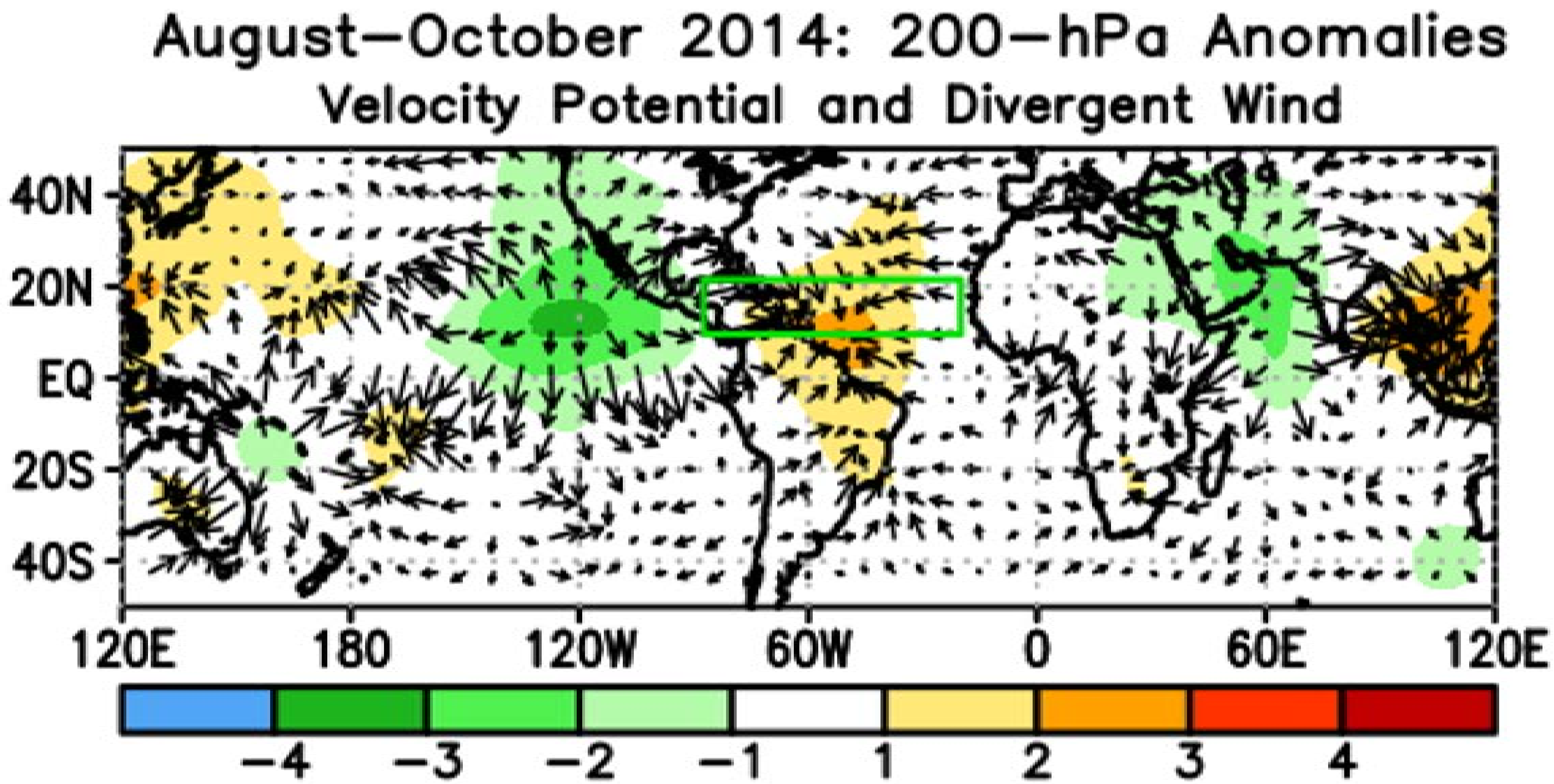

Figure 3: 200 mb anomalous velocity potential (10^6 m^2 s^{-1}) and divergent wind for August through October of 2014. The green box indicates the Main Development Region. Anomalies are based on the 1981-2010 climatology. Figure courtesy of Gerry Bell (Climate Prediction Center).