



Met Office

Verification

Verification of 2014 Seasonal Tropical Storm
Forecasts for the North Atlantic

December 2014



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1. Executive summary

The 2014 hurricane season recorded only 8 tropical storms (winds \geq 39 mph), making it one of the quietest seasons in the past twenty years. Out of 8 storms, 6 became hurricanes (winds \geq 74 mph) and 2 of these reached major hurricane strength (winds \geq 111 mph). The accumulated cyclone energy (ACE) index—a measure of the combined strength and duration of tropical storms during the season—was 65.1¹. This represents around 63% of the 1980–2010 average ACE index of 104 and is the 4th lowest ACE index since 1995, the start of the current era of high activity in the North Atlantic. The low number of tropical storms in 2014 was due in part to strong vertical wind shear and mid-level subsidence over the tropical Atlantic and Caribbean Sea (CSU 2014), which created unfavourable conditions for tropical storm development and intensification.

One hurricane (Arthur) made landfall in the United States; for the ninth year in a row the United States experienced no major hurricane landfalls. The Caribbean was hit by three storms (Bertha, Gonzalo and Hanna); Mexico and Central America were impacted by two Atlantic tropical storms as well as several Pacific tropical storms.

Monthly updated forecasts issued by the Met Office over the period April to September 2014 provided good guidance on the number of tropical storms and hurricanes, with observed values falling within the predicted range for all forecasts issued. Forecasts of ACE index also performed well with observed values falling within the predicted range for all forecasts issued apart from August. Forecasts of major hurricane numbers are currently not issued.

2. The 2014 Atlantic hurricane season

A summary table of tropical storm activity during 2014 and a corresponding plot of storm tracks are provided in Table 1 and Figure 1 of the Appendix, respectively. Based on historical records since 1944 the 2014 hurricane season was joint 14th lowest for named storms (8), joint 32nd lowest for hurricanes (6), joint 15th lowest for major hurricanes (2) and 22nd lowest for ACE index (65.1).

Only one hurricane (Arthur) made landfall in the United States, causing power outages to around 20,000 people in North Carolina (BBC 2014). The Caribbean was impacted by three storms (Bertha, Gonzalo and Hanna); Mexico and Central America were impacted by two Atlantic tropical storms (Hanna and Dolly) as well as several Pacific tropical storms. Gonzalo was the strongest storm of the season with peak winds of 145 mph. The remnants of Gonzalo later impacted parts of the UK with heavy rain and winds of up to 70 mph (Met Office 2014).

For the ninth year in a row, no major hurricanes made landfall in the United States. This is the longest time that the U.S. has gone without a major hurricane landfall since relatively reliable landfall data became available in 1878 (the previous record was eight years 1861–1868; CSU 2014). The last major hurricane to make landfall in the U.S. was Wilma in October 2005. The low landfall activity in 2014 can be attributed to anomalous troughing over the U.S. East Coast, which has been present for the last few years (particularly in 2012 and 2013). This causes storms to re-curve away from the U.S. and back out into the Atlantic.

The 2014 season recorded below-average numbers of tropical storms and the 4th lowest ACE index since 1995, the start of the current era of high-activity in the Atlantic. The low numbers of tropical storms can be attributed to strong vertical wind shear across the tropical Atlantic and Caribbean Sea (CSU 2014), which acted to suppress tropical storm activity in a

¹ Based on preliminary ACE index values from <http://models.weatherbell.com/tropical.php>

region where the majority of hurricanes typically form. During July–September the average vertical wind shear in the Caribbean was the highest recorded since 1986 (CSU 2014). In addition, there was strong mid-level subsidence over the tropical Atlantic and Caribbean Sea, which would have further suppressed tropical storm activity (CSU 2014). As a result, the majority of hurricanes that formed in 2014 reached their maximum intensity outside the tropics where conditions were generally more favourable for intensification.

3. Forecast verification

A summary of forecast numbers of tropical storms, hurricanes and ACE index issued by the Met Office from April to September 2014 is provided, alongside corresponding observations, in Table 2 of the Appendix. Each forecast is based on combined output from two world leading seasonal forecasting systems—the Met Office ‘GloSea’ system 5 and the European Centre for Medium Range Weather Forecasts (ECMWF) system 4—to create a ‘multi-model’ seasonal tropical storm forecast with a total of 93 ensemble members. The public forecast, released 16 May 2014, was made available on the Met Office website².

The 2014 season recorded 8 tropical storms (of which 6 reached hurricane strength) and an ACE index of 65.1. The number of tropical storms and ACE index were below the long-term 1980–2010 average of 12 and 104, respectively. The number of hurricanes was equal to the long-term average.

Forecasts of the number of tropical storms and hurricanes provided good guidance during 2014, with observed values falling within the predicted range for all forecasts issued. Forecasts of ACE index also performed well, with observed values falling inside the predicted range for all forecasts issued apart from August.

The performance of the multi-model forecasting system, as measured by the long-term skill of retrospective forecasts (or hindcasts) for the period 1996–2009, is provided in Table 3 of the Appendix. Linear correlations between observed and predicted values of tropical storms, hurricanes and ACE index are positive for all forecast lead times apart from for predictions of hurricane numbers issued in September. The greatest skill for both numbers of hurricanes and ACE index is found for forecasts starting in June (linear correlations of 0.68 and 0.59, respectively); for tropical storms, the greatest skill is found for forecasts starting in August (0.59).

² Met Office seasonal tropical storm forecast for the 2014 Atlantic hurricane season <http://www.metoffice.gov.uk/weather/tropicalcyclone/seasonal/northatlantic2014>.

4. Concluding Remarks

- Multi-model seasonal forecasts issued by the Met Office between April and September 2014 provided good guidance on the number of tropical storms and hurricanes throughout the season, with observed values falling within the predicted range for all forecasts issued.
- Forecasts of ACE index also performed well with observed values falling inside the predicted range for all forecasts issued apart from August.
- The 2014 Atlantic hurricane season experienced below-average numbers of tropical storms and ACE index (relative to 1980–2010), although the number of hurricanes and major hurricanes were near the long-term average. The low numbers of tropical storms and ACE index were due to strong vertical wind shear and mid-level subsidence, which suppressed the generation and intensification of storms in the tropical North Atlantic and Caribbean Sea.

5. Future forecasts

The public forecast for the 2015 hurricane season will be released on the Met Office website in May 2015.

6. References

BBC (2014). Hurricane Arthur loses strength. <http://www.bbc.co.uk/news/world-us-canada-28144335>

CSU (2014). Summary of 2014 Atlantic tropical cyclone activity and verification of author's seasonal and two-week forecasts.

<http://tropical.atmos.colostate.edu/Forecasts/2014/nov2014/nov2014.pdf>

Goldenberg, S.B., Landsea, C.W., Mestas-Nuñez, A.M., and Gray W.M. (2001). The recent increase in Atlantic hurricane activity: Causes and implications. *Science*, **293**, 474–479.

Jarvinen, B. R., Neumann, C. J., Davis, M. A. S. (1984). A tropical cyclone data tape for the North Atlantic Basin, 1886–1983: Contents, limitations, and uses. NOAA Tech. Memo. NWS NHC 22, Coral Gables, FL, 21 pp. Available online at <http://www.nhc.noaa.gov/pdf/NWS-NHC-1988-22.pdf>.

Landsea, C. W., Vecchi, G. A., Bengtsson, L., Knutson, T. R. (2010). Impact of duration thresholds on Atlantic tropical cyclone counts. *J. Climate*, **23**, 2508–2519.

Met Office (2014): Top UK wind speeds as Gonzalo's remnants felt.

<http://metofficenews.wordpress.com/2014/10/21/top-uk-wind-speeds-as-gonzalos-remnants-felt/>

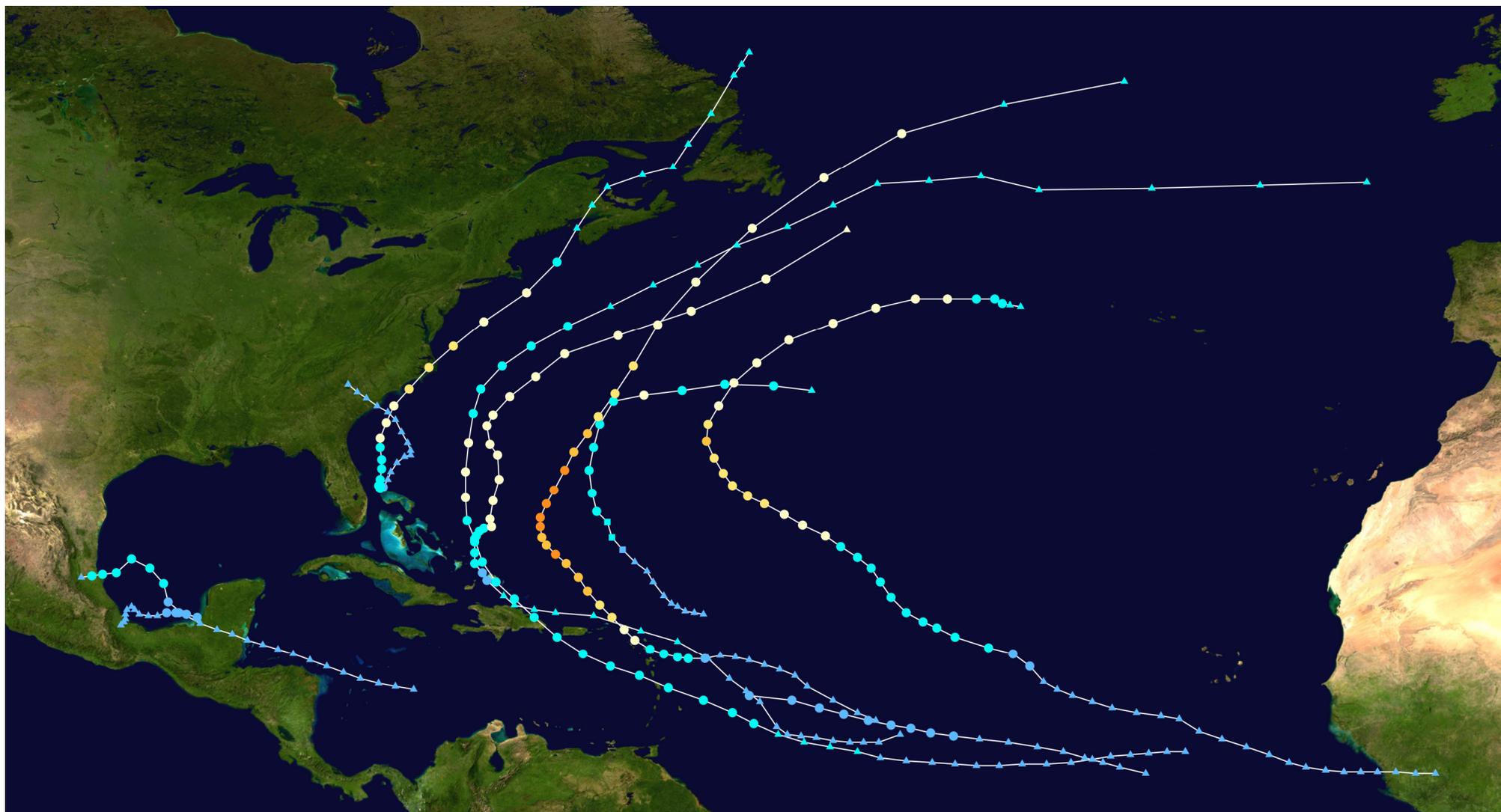
Appendix

Storm name	Active dates	Lifetime (days)	Category	Maximum wind speed (mph)	Minimum central pressure (hPa)	ACE index (10^4 kt^2)
Arthur	1–5 July	4	2	100	973	6.8
Bertha	1–6 August	5	1	80	998	5.2
Cristobal	23–29 August	6	1	85	970	7.6
Dolly	1–3 September	2	TS	50	1002	0.9
Edouard	11–19 September	8	3	115	955	15.4
Fay	10–13 October	3	1	75	986	3.4
Gonzalo	12–19 October	7	4	145	940	25.4
Hanna	22–28 October	6	TS	40	1000	0.4

Saffir–Simpson hurricane wind scale

■ Tropical depression (0–39 mph)
 ■ Tropical storm (39–73 mph)
 ■ Category 1 (74–95 mph)
 ■ Category 2 (96–110 mph)
■ Category 3 (111–129 mph)
 ■ Category 4 (130–156 mph)
 ■ Category 5 (> 156 mph)

Table 1. Summary of tropical storm activity during 2014. Note that final details may change during post-analysis of the season and details of tropical depressions (wind speeds of approximately 30 mph) have been excluded. Colours refer to maximum storm intensity (based on the Saffir–Simpson hurricane wind scale). ACE index values are rounded from <http://models.weatherbell.com/tropical.php>.



Saffir–Simpson hurricane wind scale

- Tropical depression (0–39 mph)
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- Category 1 (74–95 mph)
- Category 2 (96–110 mph)
- Category 3 (111–129 mph)
- Category 4 (130–156 mph)
- Category 5 (> 156 mph)

Figure 2. Tracks of all tropical depressions (wind speeds of approximately 30 mph) and named storms which occurred during the 2014 hurricane season. Colours refer to storm intensity (based on the Saffir–Simpson hurricane wind scale) at each 6 hour interval. Source: http://en.wikipedia.org/wiki/2014_Atlantic_hurricane_season.

Forecast	Period of forecast	Tropical storms		Hurricanes		ACE index	
		Forecast	Observed	Forecast	Observed	Forecast	Observed
April	May–October	9 (6-12)	8	5 (2-8)	6	61 (29-93)	65.1
May	June–November	10 (7-13)	8	6 (3-9)	6	84 (47-121)	65.1
June	July–November	10 (7-13)	8	5 (2-8)	6	74 (37-111)	65.1
July	August–November	9 (6-12)	7	5 (2-8)	5	72 (40-104)	51.5
August	September–November	7 (4-10)	5	4 (1-7)	3	66 (34-98)	31.1
September	October–November	3 (2-4)	3	1 (0-2)	2	14 (7-21)	14.8

Table 2. Observed and forecast numbers of tropical storms, hurricanes and ACE index issued monthly from April to September 2014. Forecast best-estimates are calculated from the mean of the combined 93-member Met Office GloSea5 and ECMWF ensemble. Values in brackets represent ± 1 standard deviation about the ensemble mean. Colours refer to forecast verification: green - observed values were within the predicted range, amber - observed values were outside the predicted range.

Forecast	Period of forecast	Forecast skill (linear correlation)		
		Tropical storms	Hurricanes	ACE index
April	May–October	0.44	0.36	0.22
May	June–November	0.47	0.46	0.43
June	July–November	0.37	0.68	0.59
July	August–November	0.48	0.45	0.57
August	September–November	0.59	0.38	0.50
September	October–November	0.32	-0.71	0.26

Table 3. Forecast skill (Pearson's linear correlation) of Met Office GloSea5–ECMWF multi-model tropical storm, hurricane and ACE index forecasts issued monthly from April to September 2014. Skill is measured over the corresponding forecast period using hindcasts for 1996–2009. Perfect forecasts would have a skill of 1.0. Historical observations are obtained from the Atlantic hurricane database (HURDAT2).

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