Met Office

Outlook

Verification of 2013 Seasonal Tropical Storm Forecasts for the North Atlantic

December 2013

Contents

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1. Executive summary

The 2013 hurricane season was one of the quietest seasons to be recorded in the past twenty years (CSU, 2013). Out of a total of 13 named storms, only 2 became hurricanes (winds >73 mph) and neither of these became major hurricanes (winds >110 mph). Despite the number of named storms being above average (12), 2013 recorded the fewest number of hurricanes since 1982 and is the first season since 1994 to record no major hurricanes. The long-term average number of hurricanes and major hurricanes is 6 and 3, respectively. The accumulated cyclone energy (ACE) index—a measure of the combined strength and duration of tropical storms during the season—was only 31[1]. This represents 30% of the 1981–2010 average of 104 and is the lowest ACE index observed since 1983.

Only one Tropical Storm (Andrea) made landfall in the United States; for the eighth year in a row there were no major hurricane landfalls. In contrast, Mexico was hit by eight storms: three from the Atlantic basin and five from the eastern North Pacific (NOAA 2013).

Monthly updated forecasts issued by the Met Office over the period April to September 2013 provided good guidance on the number of tropical storms, with observed values falling close to the forecast best-estimate. Observed numbers of hurricanes were also within the predicted range for all forecasts issued, apart from in May. However, values were at the extreme lower end of the range predicted. Forecasts of ACE index over-predicted observed activity with values falling outside the range predicted for all forecasts issued.

The 2013 hurricane season experienced below-average numbers of hurricanes and ACE index despite neutral conditions in the tropical Pacific Niño3.4 region and above-normal sea-surface-temperatures (SSTs) in the tropical Atlantic—a combination which typically favours an active hurricane season and were well predicted by the seasonal forecast. The low numbers are likely a result of exceptionally dry, sinking air and strong vertical wind shear over the Gulf of Mexico, Caribbean Sea and tropical Atlantic Ocean where the majority of hurricanes form (NOAA 2013).

2. The 2013 Atlantic hurricane season

A summary table of tropical storm activity during 2013 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 2013 hurricane season was joint 16th highest for named storms (13), but joint lowest for hurricanes (2) and major hurricanes (0) and 6th lowest for ACE index (31).

Tropical storm Andrea was the only named storm to make landfall in the United States. Andrea brought tornadoes, heavy rain and minor flooding to portions of Florida, eastern Georgia and eastern South Carolina, and caused one fatality (NOAA 2013). In comparison, Mexico was hit by eight storms, including three from the Atlantic basin (Barry, Fernand and Ingrid) and five from the eastern North Pacific. Of these eight landfalling systems, five struck as tropical storms and three as hurricanes (NOAA, 2013).

For the eighth year in a row, no major hurricanes made landfall in the United States. This is the first time since relatively reliable landfall data became available in 1878 that the US has had an eight-year period without a major hurricane landfall (CSU 2013). The low landfall activity in 2013 can be attributed to anomalous troughing over the East Coast of the US,

[1] Preliminary ACE index is from http://models.weatherbell.com/tropical.php. Final value likely to change in post-season analysis, which will determine whether the 2013 figure is the lowest since 1994 or 1983.

which has been present for the last few years (particularly in 2012). This causes storms to re-curve away from the US and back out into the Atlantic.

The 2013 season is only the third to experience below-average numbers of hurricanes since 1995, the start of the current era of high-activity in the Atlantic (NOAA 2013). The low numbers are likely a result of exceptionally dry, sinking air and strong vertical wind shear across much of the hurricane Main Development Region (MDR) — a region comprising the tropical Atlantic Ocean and Caribbean Sea where the majority of hurricanes form (Goldenberg et al 2001). In addition, there were also several strong outbreaks of dry and stable air that originated over Africa, which may have inhibited the genesis of tropical storms from African easterly waves (NOAA, 2013).

A feature of recent tropical storm seasons has been the contribution of short-lived storms, which reach tropical storm strength for only 2 days or less, to the total tropical storm count. During the 2013 season, only 2 out of 13 tropical storms were classified as short-lived (Andrea and Fernand). However, 10 of the remaining 11 storms were at tropical storm strength for a total of 4 days or less. Recent studies, such as Landsea *et al*. (2010), have examined the connection between tropical cyclone duration and annual storm counts. They found that the occurrence of short-lived storms in the Atlantic Hurricane Database (HURDAT, Jarvinen *et al*., 1984) has increased dramatically, from less than one per year in the late nineteenth–early twentieth century to about five per year since about 2000. The reason for the increase in short-lived storms is likely due to modern satellite technology and, in particular, continuous coverage of tropical storm activity in the eastern tropical Atlantic, without which many of the short-lived storms may have gone undetected.

3. Forecast verification

A summary of forecast numbers of tropical storms, hurricanes and ACE index issued by the Met Office from April to September 2013 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 ECMWF (European Centre for Medium Range Weather Forecasts) system 4—to create a ‘multi-model’ seasonal tropical storm forecast.

The 2013 season recorded 13 tropical storms (winds > 38 mph), 2 hurricanes and an ACE index of 31. Although the numbers of tropical storms were above the long-term 1980–2010 average of 12, the number of hurricanes and ACE index were below the average of 6 and 104, respectively.

Overall, forecasts of the number of tropical storms provided good guidance, with observed values falling within the predicted range for all forecasts issued. Observed numbers of hurricanes were also within the predicted range for all forecasts start dates apart from May, which over-predicted activity. It should be noted, however, that the observed number of hurricanes was at the extreme lower end of the predicted range in each forecast. Forecasts of ACE index over-estimated activity throughout the season resulting in observed values falling outside the predicted range for all forecasts issued.

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: the greatest skill for both numbers of hurricanes and ACE index is found for forecasts starting in June (linear correlations exceed 0.6); for tropical storms, the greatest skill is found for forecasts starting in August (0.55).

4. Evaluation of 2013 predictions

This year the observed ACE index fell outside the range predicted by the forecasts from all start times. In each case, the observed ACE was lower than predicted by the multi-model forecast (Table 1). It should first be highlighted that the observed ACE index in a given year is, by forecast definition, expected to lie within the 70% prediction interval approximately 7 out of 10 times. Thus in some years the observed number will lie outside of this range. However, in 2013, the observed ACE index fell outside the forecast range on all occasions. It is therefore of interest to consider reasons for the overall high bias in ACE index predicted this season.

First, the greatest influence on the ACE index forecasts would have been from the predicted neutral to neutral-cool phase of ENSO (El Niño-Southern Oscillation) during the hurricane season (see Figure 1). These conditions would have favoured enhanced tropical storm activity and ACE index in the Atlantic by creating more favourable conditions for storms to form (e.g. reduced vertical wind shear). In the event, SSTs in the Niño3.4 region were indeed neutral (i.e. tropical Pacific sea surface temperatures, sea level pressure, cloudiness and trade winds indicated that neither El Niño nor La Niña conditions were present; WMO 2013). Furthermore, cool SST anomalies were also present in the far eastern Pacific, although they were positioned too far to the east to be considered indicative of a basin-wide La Niña episode (WMO 2013). When combined, these conditions should favour an active hurricane season, such as that predicted; however, this was not observed. Therefore, the ENSO conditions experienced during 2013 are not likely to be the cause of the low hurricane numbers and ACE index observed in the Atlantic.

Second, SSTs in the tropical Atlantic were anomalously warm throughout the hurricane season. Thus, any storms which formed in the eastern tropical Atlantic would have been travelling over warm waters for long periods of time, allowing them to intensify into hurricanes. The predicted above-normal SSTs, combined with a neutral ENSO signal, would have further enhanced the potential for an active season and is likely another key factor resulting in a high hurricane and ACE index forecast in 2013.

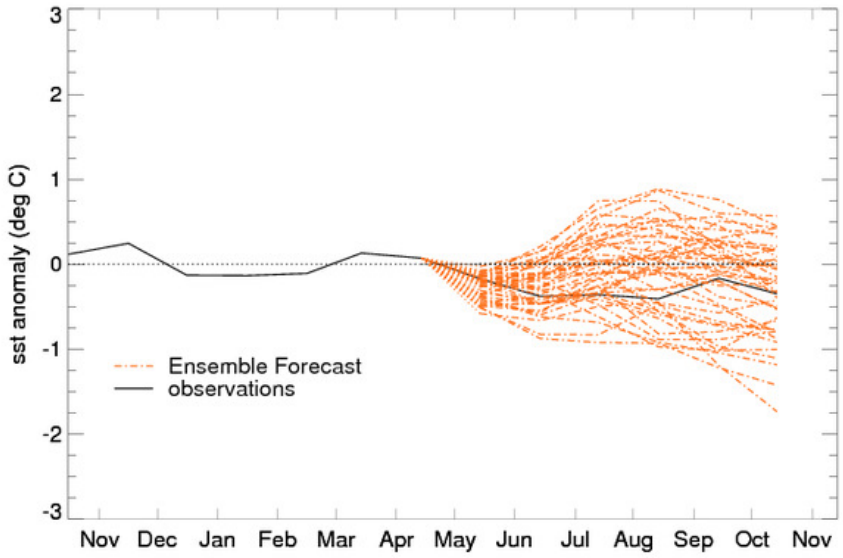

Figure 1. Met Office predicted Nino3.4 SST anomalies from 1 May. Orange lines show individual ensemble predictions; black line observations.

Despite warm tropical Atlantic SSTs and neutral ENSO conditions in the tropical Pacific, the Atlantic hurricane season experienced below-average numbers of hurricanes, major hurricanes and ACE index. In the event, very dry mid-level air combined with mid-level subsidence, strong vertical wind shear and stable lapse rates significantly suppressed the 2013 Atlantic hurricane season (CSU 2013).

4. Concluding Remarks

- Multi-model seasonal forecasts issued by the Met Office between April and September 2013 provided good guidance on the number of tropical storms throughout the season, with observed values falling within the predicted range for all forecasts issued.
- Forecasts of the number of hurricanes provided good guidance for all forecasts issued apart from May. However, observed values were at the lower end of the range predicted.
- ACE index forecasts performed poorly in 2013. On each occasion the observed value fell outside the forecast range.
- The 2013 Atlantic hurricane season experienced below-average numbers of hurricanes, major hurricanes and ACE index, despite warm tropical Atlantic SSTs and neutral ENSO conditions in the tropical Pacific – both of which were predicted by the seasonal forecast.
- The low level of hurricane activity is likely attributable to persistent, unfavourable atmospheric conditions as a result of high wind shear and several strong outbreaks of dry and stable air that originated over Africa, inhibiting the generation of storms from African easterly waves.

5. Future forecasts

The public forecast for the 2014 hurricane season will be released on the Met Office website in May 2014.

6. References

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Appendix

Storm name	Active dates	Category	Maximum wind speed (mph)	Minimum central pressure (hPa)	ACE index (10^4 kt^2)
Andrea	5–7 June	TS	65	992	1.58
Barry	17–20 June	TS	45	1003	0.57
Chantal	7–10 July	TS	65	1003	2.09
Dorian	23 July–3 August	TS	60	1002	2.62
Erin	15–18 August	TS	45	1006	1.10
Fernand	25–26 August	TS	60	1001	0.70
Gabrielle	4–13 September	TS	65	1003	1.92
Humberto	8–19 September	H1	85	980	8.76
Ingrid	12–17 September	H1	85	983	4.77
Jerry	September 29–3 October	TS	50	1005	1.54
Karen	3–6 October	TS	65	999	2.41
Lorenzo	21–24 October	TS	50	1003	1.62
Melissa	18–22 November	TS	65	980	1.46

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 2013. 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 from http://models.weatherbell.com/tropical.php.

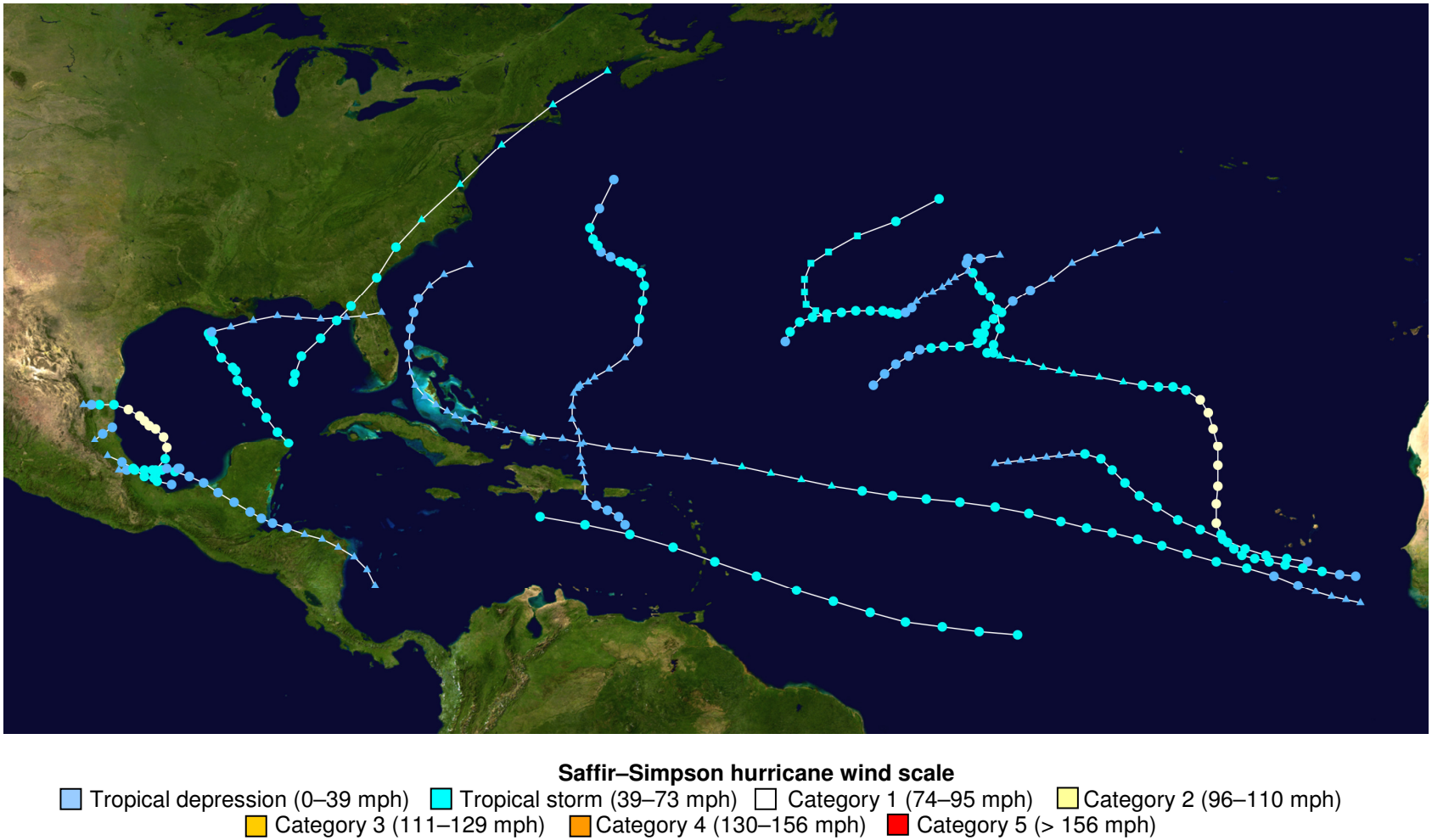

Figure 2. Tracks of all tropical depressions (wind speeds of approximately 30 mph) and named storms which occurred during the 2013 hurricane season. Colours refer to storm intensity (based on the Saffir–Simpson hurricane wind scale) at each 6 hour interval. Source: http://en.wikipedia.org/wiki/2013_Atlantic_hurricane_season.

Forecast	Period of forecast	Tropical storms		Hurricanes		ACE index	
		Forecast	Observed	Forecast	Observed	Forecast	Observed
April	May–October	12 (9-15)	12	7 (2-12)	2	101 (49-153)	29.7
May	June–November	14 (10-18)	13	9 (4-14)	2	131 (77-185)	31.1
June	July–November	12 (8-16)	11	8 (2-14)	2	109 (59-159)	29.0
July	August–November	10 (7-13)	9	7 (2-12)	2	90 (49-131)	24.3
August	September–November	8 (6-10)	7	5 (1-9)	2	67 (36-98)	22.5
September	October–November	3 (1-5)	3	1 (0-2)	0	19 (10-28)	5.49

Table 2. Observed and forecast numbers of tropical storms, hurricanes and ACE index issued monthly from April to September 2013. 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	0.31	0.39	0.33
May	June–November	0.41	0.42	0.42
June	July–November	0.31	0.65	0.62
July	August–November	0.43	0.48	0.61
August	September–November	0.55	0.40	0.51
September	October–November	0.30	0.00	0.23

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 2013. 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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