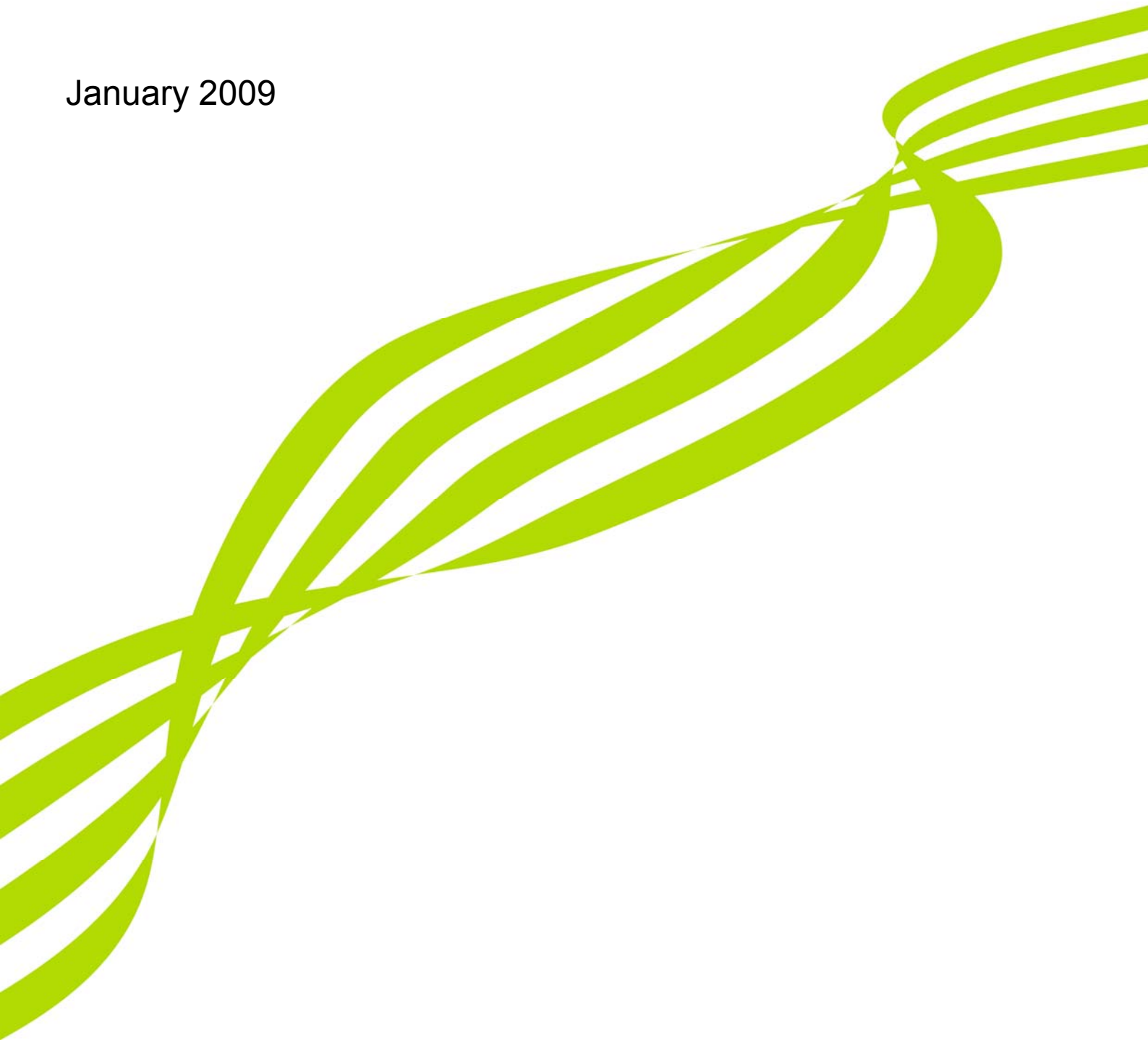
Met Office

2008 North Atlantic hurricane season: verification of the Met Office seasonal forecast

January 2009



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Executive summary

The 2008 North Atlantic hurricane season was the fourth most active season in terms of tropical storm numbers since 1944 (the start of reconnaissance aircraft in the region and therefore improved observation reliability), with activity greater than that observed in 2006 and 2007. The Met Office Hadley Centre dynamical seasonal forecast, issued on the Met Office website on 18th June 2008, gave accurate guidance on the number of tropical storms. A subsequent more detailed forecast report was later made available and gave accurate guidance on the Accumulated Cyclone Energy (ACE) index. Statistical forecasts from other centres also provided good guidance.

Introduction

The Met Office Hadley Centre has issued seasonal forecasts for the North Atlantic tropical storm season since 2007. The prediction tool used is the Met Office Global Seasonal forecasting system known as GloSea. GloSea uses a dynamical numerical model of the climate system with full interactive coupling between the ocean and atmosphere. The number of tropical storms developing in the GloSea seasonal predictions can be counted, and this forms the basis of the forecast. Importantly, GloSea is skilful in predicting the evolution of large-scale ocean-atmosphere processes and interactions that drive the degree of tropical storm activity, and this gives rise to skilful forecasts of tropical storm numbers. More details on the methodology may be found in the 2008 forecast report, available at http://www.metoffice.gov.uk/weather/tropicalcyclone/northatlantic.html. This verification report is best read together with the forecast report.

Use of dynamical prediction systems represents a new methodology in operational tropical storm forecasting. Traditionally such forecasts have been made using statistical prediction methods. Statistical methods do not model atmospheric processes, but rely on past relationships between storm numbers and preceding observed conditions (e.g. pre-season sea surface temperature (SST) patterns). Recent research has shown that the skill of dynamical systems (such as GloSea) for Atlantic tropical storm forecasting is now challenging, or even overtaking, that of some well-known statistical methods (Vitart, 2006 and Vitart et al., 2007).

Verification of the Met Office seasonal forecast for 2008

Two types of prediction were made. A deterministic 'best estimate' forecast and a more detailed forecast providing the probability of different activity ranges and thresholds.

	Predicted for July–November		
	Best estimate	Range	Observed
Number of storms	15	10–20	15
ACE index	147	122–172	141

Table 1: Deterministic forecast and verification.

Verification of the deterministic forecast is provided in Table 1. The forecast provided very accurate guidance. The best estimate for the number of storms for the July–November period was precisely the number observed (15). The best estimate forecast for ACE index (147) compared very well with the observed value of 141. Only one storm formed outside the July–November forecast period — tropical storm Arthur — and this contributed a negligible amount to the season's total ACE index.

The ranges of values provided with the best estimate forecast, for tropical storm numbers and for ACE index, are based on the assumption that potential outcomes follow a 'bell curve' (normal) distribution symmetrical around the best estimate. In practice, the distribution may be multi-modal rather than normal. For this reason, forecasts were made for the probability that the number of storms will lie in pre-defined ranges, or categories (e.g. 10 to 12 storms) and that a certain threshold of activity would be exceeded (e.g. more than 12 storms). A comparison of the observed outcomes with the outcomes predicted most likely by the probability forecast is provided in Table 2.

The probability forecast gave accurate guidance in favouring activity greater than the climate mode, both for tropical storm numbers and ACE index. However, the most likely category overestimated the observed activity, by one category for ACE index and by two categories for tropical storm numbers.

Climate mode	Outcome predicted most likely	Observed outcome
Number of storms in the range 10–12	Number of storms in the range 19–21	The observed number of storms was in the range 13–15
ACE index in the range <70	ACE index in the range 160–180	The observed ACE index was in the range 130–159

Table 2: Appraisal of the probability forecasts. The forecasts provided probabilities that the observed number of tropical storms would be in the ranges <7, 7–9, 10–12, 13–15, 16–18, 19–21 and >21 and probabilities that the observed ACE index would fall in the ranges <70, 70–99, 100–129, 130–159, 160–189, 190–219 and >219. Reference climatology used for the probability forecast was 1987–2007.

Predictions of tropical Pacific and North Atlantic SST

North Atlantic tropical storm activity is known to be positively correlated with anomalies in North Atlantic SST, and negatively correlated with tropical Pacific SST (e.g. El Niño favours the suppression of tropical storm numbers; Gray, 1984). During August–October 2008, North Atlantic SST anomalies were positive (up to 1ºC) over much of the main development region (MDR: 10º–20º N, 20º–60º W; figure 1). GloSea predicted anomalies were also positive over the MDR, mainly in the northern half of the region. The observed and predicted positive anomalies are consistent with observed and predicted above-normal activity.

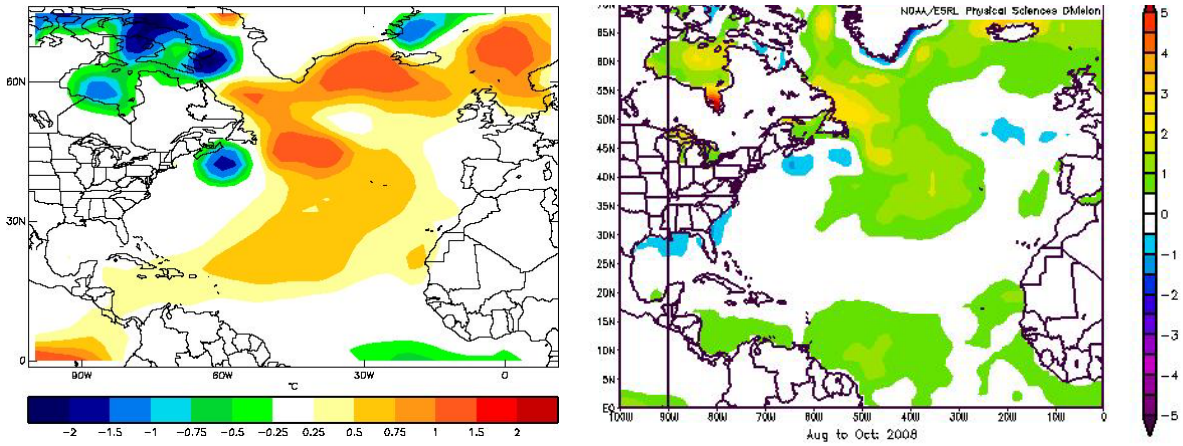

Figure 1: Met Office Hadley Centre ensemble-mean forecast SST anomaly for August-September-October 2008 (left) and the observed August-September-October SST anomaly (right). Predicted anomalies are expressed relative to the 1987–2001 average and observed anomalies to the 1971–2000 average. Observed anomalies are from NOAA's Earth System Research Laboratory.

In June 2008 GloSea predicted a strong warming in the tropical Pacific with the then-present La Niña conditions transitioning to El Niño conditions by September 2008 (figure 2). The GloSea predicted warming in the tropical Pacific was the likely cause of a predicted secondary probability peak for very low storm activity, and the relatively large uncertainty range (10–20) around the best estimate of 15 storms. It was noted, from consideration of other predictive information, that development of El Niño conditions was a low probability — but could not be ruled out. In fact, although some warming did take place, La Niña conditions persisted longer than expected, weakening to near-neutral anomalies for much of the season. Thus, the mechanism for suppression of activity associated El Niño was not initiated.

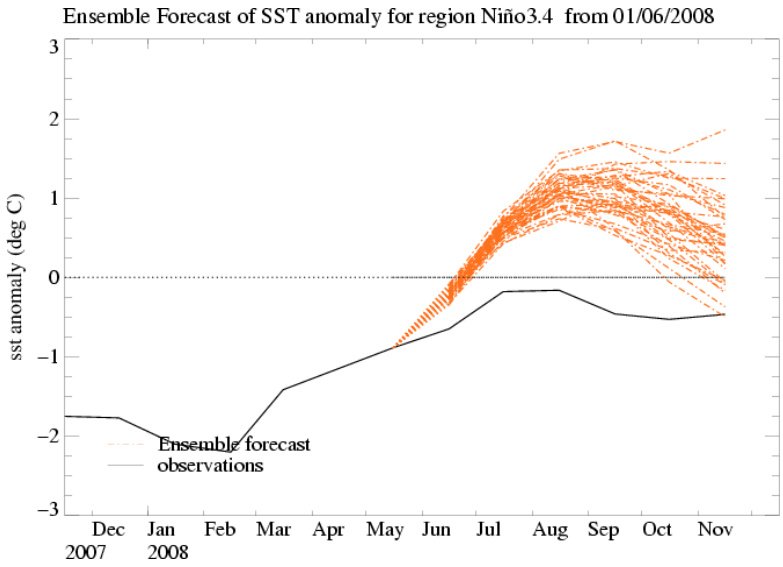

Figure 2: Observed (black) and predicted (41 members, red) SST anomalies for the Niño3.4 region in the Pacific Ocean. Anomalies are expressed relative to the 1987–2001 period.

2008 predictions from other centres

Predictions for the 2008 North Atlantic hurricane season from various forecast centres are shown in table 3.

Source	Date of issue	Tropical storms	ACE index
CSU	7th Dec 2007	13	115
TSR	10th Dec 2007	15.4 (±4.7)	149 (±66)
TSR	7th April 2008	14.8 (±4.1)	136 (±61)
CSU	9th April 2008	15	150
NOAA	22nd May 2008	12–16	109–184
CSU	3rd June 2008	15	150
TSR	5th June 2008	14.4 (±3.4)	131 (±52)
MOHC	18th June 2008	15*	147 (122–172)*
CSU	5th Aug 2008	17	175
NOAA	7th Aug 2008	14–18	150–220
Observed		16	141

Table 3: Comparison of 2008 tropical storm and ACE index forecasts for the North Atlantic sector, June–November 2008. Forecasts include those issued by Colorado State University (CSU), Tropical Storm Risk (TSR) and the National Oceanic and Atmospheric Administration (NOAA). The MOHC forecast is issued for the July–November period (shown by *). Observed values are for the entire season.

Observed 2008 North Atlantic activity

The 2008 North Atlantic hurricane season became the fourth most active season in terms of tropical storm numbers since 1944, when reliable records are generally considered to have started due to the advent of aircraft reconnaissance flights (e.g. Owens and Landsea, 2003 and references therein). Over the entire season, extending from 31st May to the 9th November (the dates of the first and last storms), a total of 16 tropical storms (winds ≥39 mph) were observed. Of these, 8 obtained hurricane strength (winds ≥74 mph) and 5 became intense hurricanes (category 3 or higher on the Saffir-Simpson hurricane scale — see http://www.nhc.noaa.gov/aboutsshs.shtml), with winds exceeding 111 mph. This represented above-normal tropical storm activity (relative to the 1990–2005 long-term average of 12.4) and higher activity compared to the previous two years: the 2006 (2007) season observing 9 (15) tropical storms, 5 (6) hurricanes and 2 (2) intense hurricanes, respectively. A total ACE index of 141 was accumulated for the entire 2008 season; this compares to an ACE index of 78 in 2006 and 68 in 2007. A

summary of observed tropical storm activity for the 2008 North Atlantic hurricane season is shown in table 4. Corresponding storm tracks are shown in figure 3.

Storm name	Active dates	Highest intensity	Max wind speed (mph)	Min pressure (mbar)	ACE index
Arthur	31st May–1st June	TS	40	1004	0.4
Bertha	3rd July–20th July	Cat. 3	120	948	28.4
Cristobal	19th July–23rd July	TS	65	1000	3.2
Dolly	20th July–24th July	Cat. 2	100	964	5.3
Edouard	3rd Aug–5th Aug	TS	65	997	1.5
Fay	15th Aug–24th Aug	TS	65	986	6.7
Gustav	25th Aug–2nd Sept	Cat. 4	150	941	18.5
Hanna	28th Aug–7th Sept	Cat. 1	80	978	10.5
Ike	1st Sept–14th Sept	Cat. 4	145	935	38.8
Josephine	2nd Sept–5th Sept	TS	65	994	2.8
Kyle	25th Sept–29th Sept	Cat. 1	80	984	4.7
Laura	29th Sept–1st Oct`	TS	60	993	2.3
Marco	6th Oct–7th Oct	TS	65	998	1.2
Nana	12th Oct–13th Oct	TS	40	1005	0.4
Omar	14th Oct–18th Oct	Cat. 3	125	959	6.7
Paloma	6th Nov–9th Nov	Cat. 4	145	943	9.9

Table 4: Observed 2008 tropical cyclone activity in the North Atlantic. The highest intensity attained is shown as either TS (tropical storm) or hurricane category (as defined by the Saffir-Simpson hurricane scale). Adapted from Klotzback (2008).

The 2008 season became the first year on record to observe the formation of one intense hurricane in each of five successive months: Bertha in July, Gustav in August, Ike in September, Omar in October and Paloma in November. Hurricane Bertha (3rd–20th July 2008) became the longest-lived storm formed in July, lasting a total of 17 days. Bertha formed further east than any other storm formed during July. Hurricane Gustav (25th August–2nd September) — the strongest hurricane of the season in terms wind speed (peak winds of 150 mph) — became the second hurricane to make landfall along the U.S. Gulf Coast, causing an estimated $8.3 billion worth of damage. Hurricane Ike (1st–14th September) was the strongest hurricane of the season in terms of central pressure (reaching a minimum of 935 mbar). Ike was the third and last hurricane of the season to make landfall along the U.S. Gulf Coast, and became the third most destructive hurricane on record, with an estimated $31.5 billion worth of damage. Hurricane Paloma (6th–9th November) was the second strongest hurricane, in terms of wind speed, to form in November since 1944 (peak winds of 145 mph).

During July to September, six consecutive storms made landfall along the U.S. coast (three tropical storms and three category 2 hurricanes): Dolly (Texas), Edouard (Texas), Fay (Florida), Gustav (Louisiana), Hanna (South Carolina), and Ike (Texas). Fay (15th–24th August) was the only storm on record to make landfall four times in Florida. Four of these hurricanes made landfall in Haiti (Fay, Gustav, Hanna, Ike), resulting in 800 fatalities. Hurricane Hanna (28th August–7th September) — the deadliest storm of the season — resulted in 529 of these fatalities alone (Klotzback, 2008). Three intense hurricanes (Gustav, Ike and Paloma) made landfall in Cuba. No intense hurricanes made landfall along the U.S. coast during 2008 and no category 5 hurricanes were observed.

Overall, the 2008 season was the fourth most active in terms of named storms and one of the most destructive seasons on record, with 831 direct fatalities and an estimated $54 billion in damage, according to NOAA's National Climatic Data Center (NCDC; http://www.ncdc.noaa.gov/oa/climate/research/2008/hurricanes08.html).

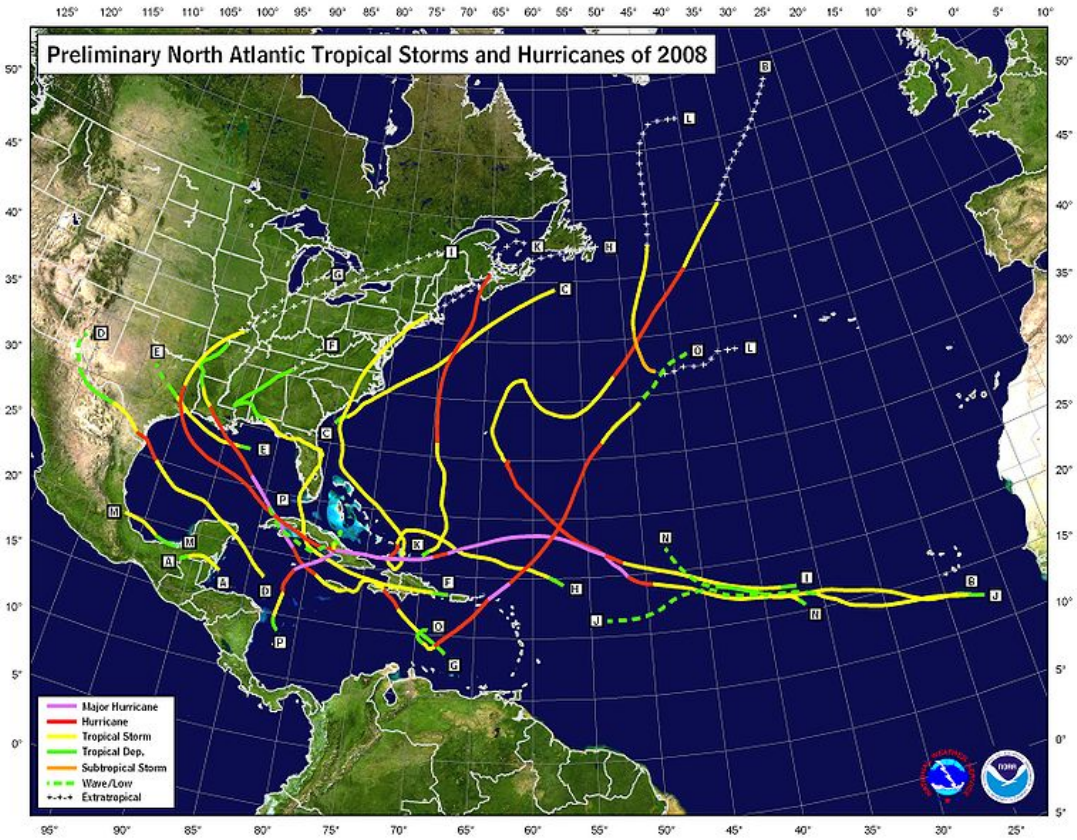

Figure 3: Observed tropical cyclone tracks for 2008. Tracks are shown for Arthur, Bertha, Cristobal, Dolly, Edouard, Fay, Gustav, Hanna, Ike, Josephine, Kyle, Laura, Marco, Nana, Omar and Paloma (http://www.nhc.noaa.gov/2008atlan.shtml).

Prediction skill measured using retrospective forecasts (hindcasts)

The skill of GloSea in predicting the numbers of tropical storms and ACE index using retrospective forecasts ('re-forecasts' or hindcasts) initialised in June 1987–2007 are shown in figure 2. Results are based on the mean of 15-member ensembles covering the July–November period. The cross-validation procedure has been employed in which no observed information for the year being predicted is used in the calibration process — in order that the hindcasts are consistent with the constraints of an operational environment. Forecast values are compared to corresponding observed values from NOAA's HURDAT "best track" re-analysis dataset — see http://www.aoml.noaa.gov/hrd/hurdat/ and the following paper for details on the dataset http://www.aoml.noaa.gov/hrd/hurdat/Documentation.html.

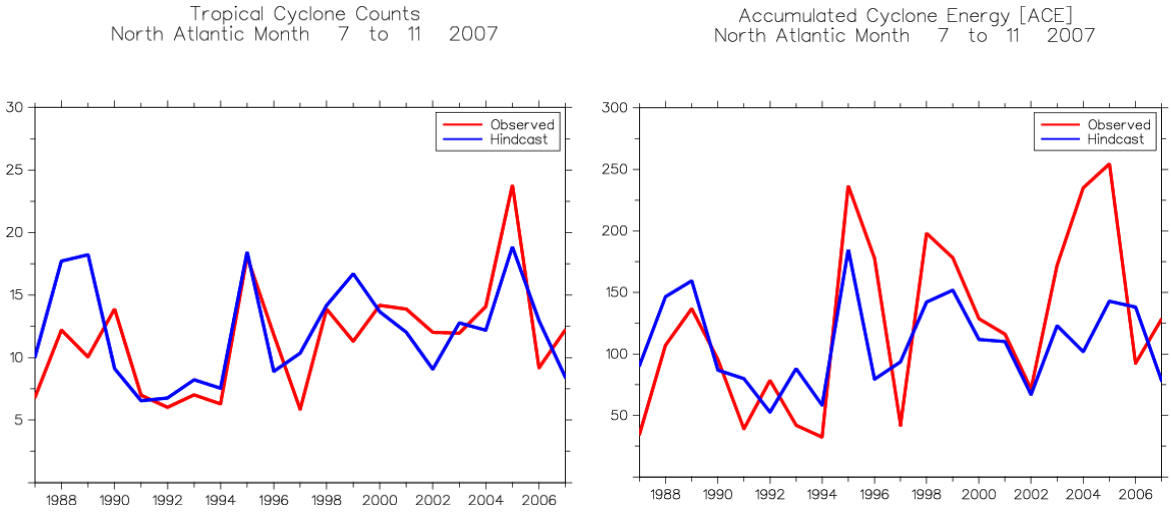

Figure 2: Timeseries of observed (red) and ensemble-mean predictions (blue) of tropical storm numbers (left) and ACE index (right) for the July–November period 1987–2007. Forecasts are initialised in June. Units of ACE are 10^4 kt^2.

The inter-annual variability of both tropical storm numbers and ACE index is generally well predicted by this method, with correlations of 0.63 for tropical storms and 0.62 for ACE index. The active seasons of 1995 and 2005 are well signalled and high ACE index values observed in 1989, 1995 and 1998 were well predicted. However both the numbers of tropical storms and ACE index were under-predicted for the active 2005 season.

Summary

The 2008 North Atlantic hurricane season was the fourth most active in terms of tropical storm numbers and second most costly season on record (NOAA's National Climatic Data Center (NCDC)), with 16 tropical storms, 8 hurricanes and 5 intense hurricanes. A total of 6 storms made landfall along the U.S. Gulf Coast — three tropical storms and three category 2 hurricanes — causing an estimated $54 billion in damage (NOAA's National Climatic Data Center (NCDC)). The public forecast by the Met Office Hadley Centre, released on 18th June 2008, predicted an above-normal season relative to the 1990–2005 long-term average, with an estimated 15 tropical storms for the July–November period. This forecast gave very accurate guidance — the observed number of tropical storms for the July–November period was 15. The probability forecast was also consistent with observations, favouring activity greater than the climate mode, both for tropical storm numbers and ACE index. However, the most likely category overestimated the observed activity, by one category for ACE index and by two categories for tropical storm numbers.

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