



Summary of 2002 Atlantic Tropical Cyclone Season and Verification of Authors' Seasonal Forecasts

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Summary

A year with below average Atlantic basin hurricane activity but with a large number of weak sub-tropical storms. The TSR forecasts successfully anticipated the below average activity from early May (which competing forecasts did not predict until August) but underestimated the number of named storms. Our forecasts proved best for the Atlantic main development region, Caribbean Sea and Gulf of Mexico.

The Tropical Storm Risk (TSR) consortium presents a validation of their seasonal forecasts for Atlantic basin, tropical north Atlantic, USA landfalling and Caribbean Lesser Antilles landfalling tropical cyclones in 2002. These forecasts were issued monthly from 3rd December 2001 to 7th August 2002, and included separate predictions for tropical storms, hurricanes and intense hurricanes. This document reports highlights of the 2002 Atlantic season, verifies and compares our forecasts to those issued by other groups, and verifies our predictors. With the exception of landfalling US tropical storms and Atlantic basin tropical storm numbers, the TSR forecasts proved skillful from early May. The August forecast performed best for hurricanes, exactly predicting the numbers of hurricanes forming in different regions of the Atlantic basin and striking the US.

Features of the 2002 Atlantic Season and Individual Storm Summary

- The 2002 Atlantic season saw below average levels of activity. Although there were 12 named storms, only 4 hurricanes and 2 intense hurricanes formed. This compares to 1950-2000 climatologies of 5.9 and 2.3 respectively. The number of hurricane days, intense hurricane days and net tropical cyclone activity were 45%, 50% and 80% of the 1950-2000 climatological average.
- The ratio of named tropical storms to hurricanes (3:1) was the highest for at least the last 50 years.
- Seven tropical cyclones made landfall along the US coast (although only one of these struck at hurricane force). Since 1950 only 1953, 1959, 1985 and 1998 have had at least seven named storms make US landfall.



- Another late start to the season. The first hurricane did not form until September 11th, the latest start date since 1941. The season also finished early with no named storms forming in either October or November. Eight named storms formed during September setting a new record for this month.
- Hurricane Lili made landfall on the US Gulf coast, killing 8 people and causing US \$700m in damages. Prior to Lili, there had been 21 consecutive Atlantic basin hurricanes that had failed to make landfall on the US, a new record.
- Hurricane Kyle lasted for 15.25 days. This is the third longest lived Atlantic tropical cyclone on record behind hurricane Ginger (21 days; 1971) and hurricane Inga (15.5 days; 1969).
- An unusually high number of storms formed in the extra-tropics ($> 25^{\circ}\text{N}$). The ratio of extra-tropical ($>25^{\circ}\text{N}$) to tropical ($<25^{\circ}\text{N}$) forming storms was the highest (9:3) for at least the last 50 years.

Individual Storm Summary 2002						
No.	Name	Dates	Peak Wind (kts)	Minimum Pressure (mb)	Hurricane Category	Category at US Landfall
1	Arthur	14-16 Jul	50	997	-	
2	Bertha	04-09 Aug	35	1008	-	TS
3	Cristobal	05-08 Aug	40	999	-	
4	Dolly	29 Aug-04 Sep	55	994	-	
5	Edouard	01-06 Sep	55	1002	-	TS
6	Fay	05-07 Sep	50	999	-	TS
7	Gustav	08-12 Sep	80	964	1	
8	Hanna	12-14 Sep	45	1001	-	TS
9	Isidore	14-26 Oct	110	934	3	TS
10	Josephine	17-19 Sep	50	1004	-	
11	Kyle	20 Sep-11 Oct	75	980	1	TS
12	Lili	21 Sep-4 Oct	125	938	4	2

Definitions

Definitions				
Tropical Cyclone Type	Category	Peak 1-Min Sustained Wind		Minimum Pressure (mb)
		knots	mph	
Tropical Storm	TS	34-63	39-73	-
Hurricane	1	64-82	74-95	>980
Hurricane	2	83-95	96-110	965-980
Hurricane	3	96-113	111-130	945-965
Hurricane	4	114-135	131-155	920-945
Hurricane	5	>135	>155	<920

Verification of Forecasts

We compare our forecasts, where possible, with those issued by the Gray/Colorado State University, NOAA and Institute of Meteorology, Cuba, research groups. Forecasts are validated using track data obtained from the Unisys Weather Website (<http://weather.unisys.com>).

1. Atlantic Total Numbers

Atlantic Total Numbers 2002				
		Named Tropical Storms	Hurricanes	Intense Hurricanes
Average Number (\pm SD) (1992-2001)		11.5 (\pm 4.1)	6.9 (\pm 2.9)	2.9 (\pm 2.0)
Average Number (\pm SD) (1972-2001)		9.5 (\pm 3.6)	5.7 (\pm 2.4)	2.1 (\pm 1.5)
Actual Number 2002		12	4	2
TSR Forecasts(\pm SD)	07 Aug 2002	8.1 (\pm 2.2)	3.9 (\pm 1.3)	1.3 (\pm 1.4)
	08 July 2002	6.8 (\pm 2.3)	3.1 (\pm 1.5)	0.9 (\pm 1.6)
	07 June 2002	7.5 (\pm 2.1)	3.6 (\pm 1.6)	1.1 (\pm 1.4)
	07 May 2002	8.9 (\pm 2.7)	4.6 (\pm 1.9)	1.6 (\pm 1.5)
	05 Apr 2002	11.2 (\pm 3.1)	6.3 (\pm 2.3)	2.4 (\pm 1.9)
	06 Mar 2002	12.5 (\pm 3.6)	7.2 (\pm 2.5)	2.8 (\pm 1.9)
	06 Feb 2002	13.6 (\pm 3.5)	8.0 (\pm 2.5)	3.2 (\pm 1.8)
	10 Jan 2002	13.1 (\pm 3.6)	7.7 (\pm 2.6)	3.0 (\pm 1.8)
Gray/Colorado State-University Forecasts	03 Dec 2001	13.0 (\pm 3.6)	7.5 (\pm 2.5)	3.0 (\pm 1.6)
	02 Sep 2002	8	3	1
	07 Aug 2002	9	4	1
	31 May 2002	11	6	2
	05 Apr 2002	12	7	3
NOAA Forecasts	07 Dec 2001	13	8	4
	08 Aug 2002	7-10	4-6	1-3
Meteorological Institute, Cuba Forecasts	20 May 2002	9-13	6-8	2-3
	01 Aug 2002	12	9	-
	02 May 2002	12	9	-

TSR successfully predicted that Atlantic basin activity in 2002 would be below average from early May. Other forecasting groups did not anticipate a below average season until early August. All forecasts (with the exception of the Meteorological Institute, Cuba) underestimated the total number of named storms. This was due largely to the exceptionally large number of tropical storms forming in the extra-tropics for which the TSR model has no prediction skill. Of the twelve named storms, nine formed north of 25°N. Further details on the Gray/Colorado State University forecasts may be obtained from <http://typhoon.atmos.colostate.edu/forecasts>. Further details on the NOAA Atlantic hurricane outlooks may be obtained from <http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.html>.

2. MDR, Caribbean and Gulf of Mexico Total Numbers (Tropical North Atlantic)

MDR, Caribbean and Gulf of Mexico Total Numbers 2002				
		Named Tropical Storms	Hurricanes	Intense Hurricanes
Average Number (\pm SD) (1992-2001)		8.3 (\pm 4.7)	5.1 (\pm 3.0)	2.9 (\pm 2.0)
Average Number (\pm SD) (1972-2001)		6.4 (\pm 3.7)	3.8 (\pm 2.5)	1.8 (\pm 1.6)
Actual Number 2002		6	2	2
TSR Forecasts (\pm SD)	07 Aug 2002	4.9 (\pm 2.3)	2.1 (\pm 1.6)	1.3 (\pm 1.3)
	08 July 2002	3.6 (\pm 2.4)	1.3 (\pm 1.7)	0.9 (\pm 1.5)
	07 June 2002	4.3 (\pm 2.3)	1.8 (\pm 1.5)	1.1 (\pm 1.4)
	07 May 2002	5.7 (\pm 2.6)	2.8 (\pm 1.5)	1.6 (\pm 1.5)
	05 Apr 2002	8.0 (\pm 3.2)	4.5 (\pm 2.3)	2.4 (\pm 1.8)
	06 Mar 2002	9.3 (\pm 3.7)	5.4 (\pm 2.5)	2.8 (\pm 1.8)
	06 Feb 2002	10.4 (\pm 3.6)	6.2 (\pm 2.4)	3.2 (\pm 1.7)
	10 Jan 2002	9.9 (\pm 3.8)	5.9 (\pm 2.6)	3.0 (\pm 1.8)
	03 Dec 2001	9.8 (\pm 4.1)	5.8 (\pm 2.7)	3.0 (\pm 1.7)

The Atlantic Main Development Region (MDR) is the region 10°N - 20°N, 20°W - 60°W between the Cape Verde Islands and the Caribbean. A storm is defined as having formed within this region if it reached at least tropical depression status while in the area. Most of the infamous Atlantic basin hurricanes formed in the MDR, Caribbean Sea and Gulf of Mexico.

The 2002 season was relatively inactive for tropical cyclone activity in the MDR, Caribbean Sea and Gulf of Mexico. Tropical storm, hurricane and intense hurricane numbers were 72%, 39% and 69% respectively of their prior 10-year mean values. The TSR forecasts successfully predicted an inactive season from early May. Forecasts were best for hurricane numbers. While intense hurricane numbers and tropical storms were underestimated from May onwards, and forecasts overestimated before May, most were correct to within one standard error. The main reason for overpredicting before May was an underestimation of the strength of El Niño in August-September from earlier in the year.

3. US Landfalling Numbers

US Landfalling Numbers 2002			
		Named Tropical Storms	Hurricanes
Average Number (\pm SD) (1992-2001)		3.3 (\pm 1.8)	1.2 (\pm 1.2)
Average Number (\pm SD) (1972-2001)		2.6 (\pm 1.8)	1.2 (\pm 1.3)
Actual Number 2002		7	1
TSR Forecasts (\pm SD)	07 Aug 2002	2.0 (\pm 1.3)	0.9 (\pm 0.9)
	08 July 2002	1.6 (\pm 1.2)	0.7 (\pm 0.9)
	07 June 2002	1.8 (\pm 1.3)	0.8 (\pm 0.9)
	07 May 2002	2.3 (\pm 1.4)	1.1 (\pm 1.0)
	05 Apr 2002	3.0 (\pm 1.6)	1.4 (\pm 1.1)
	06 Mar 2002	3.5 (\pm 1.7)	1.7 (\pm 1.1)
	06 Feb 2002	3.8 (\pm 1.7)	1.9 (\pm 1.1)
	10 Jan 2002	3.7 (\pm 1.8)	1.8 (\pm 1.1)
	3 Dev 2001	3.7 (\pm 1.3)	1.8 (\pm 1.1)

Only one hurricane made landfall in the US which was correctly predicted by TSR but the number of landfalling tropical storms was greatly underpredicted. This is because the number of landfalling tropical storms this year was exceptionally high relative to the total number of storms which developed at sea. This may be partly because four of the storms striking US shores (Bertha, Edouard, Fay and Hanna) formed very close to land.

4. Lesser Antilles Landfalling Numbers

Lesser Antilles Landfalling Numbers 2002				
		Named Tropical Storms	Hurricanes	Intense Hurricanes
Average Number (\pm SD) (1992-2001)		1.5 (\pm 0.9)	0.7 (\pm 0.8)	0.3 (\pm 0.5)
Average Number (\pm SD) (1972-2001)		1.1 (\pm 1.0)	0.4 (\pm 0.6)	0.2 (\pm 0.4)
Actual Number 2002		1	0	0
TSR Forecasts (\pm SD)	07 Aug 2002	0.9 (\pm 0.7)	0.4 (\pm 0.6)	0.2 (\pm 0.3)
	08 July 2002	0.7 (\pm 0.8)	0.3 (\pm 0.6)	0.2 (\pm 0.4)
	07 June 2002	0.8 (\pm 0.8)	0.4 (\pm 0.6)	0.2 (\pm 0.4)
	07 May 2002	1.1 (\pm 0.8)	0.5 (\pm 0.6)	0.2 (\pm 0.4)
	05 Apr 2002	1.5 (\pm 0.9)	0.6 (\pm 0.7)	0.3 (\pm 0.4)
	06 Mar 2002	1.7 (\pm 0.9)	0.7 (\pm 0.7)	0.4 (\pm 0.4)
	06 Feb 2002	2.0 (\pm 0.9)	0.8 (\pm 0.7)	0.4 (\pm 0.4)
	10 Jan 2002	1.9 (\pm 0.9)	0.8 (\pm 0.7)	0.4 (\pm 0.4)
	03 Dec 2002	1.9 (\pm 1.0)	0.8 (\pm 0.7)	0.4 (\pm 0.4)

Landfalling numbers on the Lesser Antilles were correctly forecast to be below average from early May. Only one tropical storm (Lili) and no hurricane struck these islands. It was the second consecutive year without a hurricane strike.

Environmental Factors in 2002

1. Contemporaneous Influences

The principle of sound seasonal hurricane prediction work is to forecast the key environmental conditions at the height of the Atlantic hurricane season. We find that the most important contemporaneous factors are:

1. Aug-Sep SSTs in the Main Development Region [10°N-20°N, 20°W-60°W] (MDR SST).
2. Jul-Sep Tropical North Atlantic and Caribbean Sea 925hPa U-Winds [7.5°N-17.5°N, 40°W-110°W] (CAR U).

The first predictor encompasses SSTs where a large proportion of tropical storms develop, so we expect more storms when the SSTs therein are higher than average. The second predictor is the surface westerly component of windshear, which we find has a stronger influence on tropical storm and hurricane numbers than windshear itself. On average, the JAS 925hPa surface winds in this region are -6.4ms^{-1} (i.e. they are Easterlies). We find that when these winds are lighter than average (anomalies are positive), conditions become more favourable for tropical storm development.

A number of researchers claim that ENSO is the most important single parameter influencing Atlantic seasonal hurricane variability. ENSO is included in our model as the primary predictor for the strength of the Caribbean 925hPa U-winds, as are Caribbean SSTs.

2. Predictor Verification

Predictor Values 2002			
		MDR SST (°C)	CAR U (ms⁻¹)
Actual Value 2002 (1972-2001 Anomaly)		-0.1	-0.43
TSR Forecasts (±SD)	06 Aug 2002	-0.22 (±0.11)	-0.51 (±0.40)
	08 July 2002	-0.21 (±0.14)	-0.86 (±0.50)
	07 June 2002	-0.15 (±0.18)	-0.70 (±0.49)
	07 May 2002	-0.05 (±0.24)	-0.37 (±0.61)
	05 Apr 2002	0.16 (±0.24)	0.17 (±0.75)
	06 Mar 2002	0.22 (±0.24)	0.49 (±0.84)
	06 Feb 2002	0.31 (±0.26)	0.76 (±0.75)
	10 Jan 2002	0.25 (±0.28)	0.67 (±0.79)
	03 Dec 2001	0.27 (±0.29)	0.63 (±0.85)

TSR predictor forecasts were skillful compared to climatology from May onwards, with the forecasts correctly identifying the sign of both anomalies. Prior to May, the forecast anomalies

were of opposite sign to the actual anomalies. The improved long-range prediction of both these predictors warrants further research.

Future Forecasts and Verifications

1. The TSR extended range forecast for the 2003 Atlantic hurricane season will be issued on 16th December 2002. Monthly updated forecasts will follow through to August 2003.
2. A summary of the 2002 NW Pacific tropical cyclone season with a verification of the TSR forecasts will be issued in early January 2003.

Tropical Storm Risk.com (TSR)

Tropical Storm Risk.com (TSR) is a venture which has developed from the UK government-supported TSUNAMI initiative project on seasonal tropical cyclone prediction. The TSR consortium comprises experts on insurance, risk management and seasonal climate forecasting. The TSR industry expertise is drawn from the *Benfield Group*, the leading independent reinsurance intermediary, *Royal & SunAlliance*, the global insurance group, and from *Crawford & Company*, a global provider of risk management services. The TSR scientific grouping brings together climate physicists, meteorologists and statisticians at *UCL* (University College London) and the *Met Office*. TSR forecasts are available from <http://tropicalstormrisk.com>.

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