



Summary of 2001 Atlantic Tropical Cyclone Season and Verification of Authors' Seasonal Forecasts

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Summary

A year with significantly above average Atlantic basin activity but one without a US hurricane strike. Forecasts anticipated above average activity while underestimating its strength, and proved best for the tropical north Atlantic.

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 2001. These forecasts were issued on the 17th November 2000, 15th June 2001, 6th July 2001 and 6th August 2001. All span the official Atlantic hurricane season from 1st June to 30th November and include separate predictions for tropical storms, hurricanes and intense hurricanes. The 6th August pre-main season forecast performed the best, exactly predicting the numbers of tropical storms and hurricanes forming in the tropical North Atlantic. All TSR forecasts proved correct to within 2-standard errors of the observed totals.

Features of the 2001 Atlantic Season

- The 2001 Atlantic season was an active season, featuring 15 named storms, 9 hurricanes and 4 intense hurricanes. This compares to 1971-2000 climatologies of 9.5, 5.6 and 2.0 respectively. It was the fourth consecutive year with above average activity making 1995-2001 the most active 7-year period on record.
- This was the second consecutive year that the usually strong positive relationship between basin hurricane and landfalling hurricane numbers has broken down, with 2001 featuring the most Atlantic basin hurricane numbers without a US hurricane strike in 50 years.
- Despite no US hurricane strikes, 3 tropical storms hit the US mainland to make 2001 one of the most costly in recent years. Whilst Barry and Gabrielle caused less than US \$300m of damage between them, Allison caused catastrophic flooding in Texas taking total losses for the year to over US \$6bn (US \$3.5bn insured).
- Hurricane Michelle was the “most powerful storm to hit Cuba in a half-century” [Washington Post, 7/11/2001], causing US \$1bn of damage (US \$200m insured).
- The first hurricane formed on September 8th, continuing the recent trend of late starts. The total number forming between then and the end of the season was the greatest on record.



| Individual Storm Summary 2001 | | | | | | |
|--------------------------------------|-----------|---------------|-----------------|-----------------------|--------------------|-------------------------|
| No. | Name | Dates | Peak Wind (kts) | Minimum Pressure (mb) | Hurricane Category | Category at US Landfall |
| 1 | Allison | 05-06 June | 50 | 1002 | - | TS |
| 2 | Barry | 02-06 Aug | 60 | 990 | - | TS |
| 3 | Chantal | 15-22 Aug | 60 | 994 | - | |
| 4 | Dean | 22-28 Aug | 60 | 992 | - | |
| 5 | Erin | 01-15 Sep | 105 | 969 | 3 | |
| 6 | Felix | 07-19 Sep | 100 | 965 | 3 | |
| 7 | Gabrielle | 11-19 Sep | 70 | 975 | 1 | TS |
| 8 | Humberto | 21-27 Sep | 90 | 970 | 2 | |
| 9 | Iris | 04-09 Oct | 125 | 950 | 4 | |
| 10 | Jerry | 06-08 Oct | 45 | 1003 | - | |
| 11 | Karen | 12-15 Oct | 70 | 982 | 1 | |
| 12 | Lorenzo | 27-31 Oct | 35 | 1007 | - | |
| 13 | Michelle | 29 Oct-06 Nov | 120 | 933 | 4 | |
| 14 | Noel | 05-06 Nov | 65 | 984 | 1 | |
| 15 | Olga | 24 Nov-04 Dec | 80 | 973 | 1 | |

Verification of Forecasts

1. Atlantic Total Numbers

| Atlantic Total Numbers 2001 | | | | |
|--|--------------|-----------------------|------------------|--------------------|
| | | Named Tropical Storms | Hurricanes | Intense Hurricanes |
| Average Number (\pm SD) (1991-2000) | | 10.8 (\pm 3.6) | 6.4 (\pm 2.6) | 2.7 (\pm 1.8) |
| Average Number (\pm SD) (1971-2000) | | 9.5 (\pm 3.7) | 5.6 (\pm 2.7) | 2.0 (\pm 1.9) |
| Actual Number 2001 | | 15 | 9 | 4 |
| TSR Forecast (\pm SD) | 06 Aug 2001 | 11.8 (\pm 2.0) | 6.9 (\pm 1.4) | 2.9 (\pm 1.3) |
| | 06 July 2001 | 12.8 (\pm 2.6) | 7.7 (\pm 1.6) | 3.2 (\pm 1.4) |
| | 15 June 2001 | 10.9 (\pm 2.6) | 5.8 (\pm 1.8) | 2.4 (\pm 1.5) |
| | 17 Nov 2000 | 10.6 (\pm 3.7) | 6.9 (\pm 2.4) | 3.4 (\pm 1.6) |
| Gray Forecast | 07 Aug 2000 | 12 | 7 | 3 |
| | 07 June 2001 | 12 | 7 | 3 |
| | 06 Apr 2001 | 10 | 6 | 2 |
| | 07 Dec 2000 | 9 | 5 | 2 |

TSR successfully predicted that tropical storm activity in the Atlantic would exceed the long term average as far back as November 2000, with Gray in agreement from June 2001. TSR's

July forecast proved best with all categories of storm accurate to within one standard error of the actual. Nevertheless, all forecasts underestimated the actual activity rates, which for TSR, was largely down to a weakness in the model to predict extra-tropical activity rates. Six storms and four hurricanes occurred in this region, which is roughly twice the long-term average. For more details on Gray's forecasts, see <http://typhoon.atmos.colostate.edu/forecasts/>.

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

| MDR, Caribbean and Gulf of Mexico Total Numbers 2001 | | | | |
|---|--------------|-----------------------|------------------|--------------------|
| | | Named Tropical Storms | Hurricanes | Intense Hurricanes |
| Average Number (\pm SD) (1991-2000) | | 7.6 (\pm 4.7) | 4.6 (\pm 3.4) | 2.5 (\pm 2.1) |
| Average Number (\pm SD) (1971-2000) | | 6.3 (\pm 3.7) | 3.7 (\pm 2.5) | 1.7 (\pm 1.5) |
| Actual Number 2001 | | 9 | 5 | 4 |
| TSR Forecast (\pm SD) | 06 Aug 2001 | 8.6 (\pm 2.4) | 5.1 (\pm 1.7) | 2.7 (\pm 1.3) |
| | 06 July 2001 | 9.7 (\pm 2.8) | 5.9 (\pm 1.4) | 3.0 (\pm 1.1) |
| | 15 June 2001 | 7.7 (\pm 2.8) | 4.0 (\pm 1.9) | 2.2 (\pm 1.5) |
| | 17 Nov 2000 | 7.3 (\pm 3.7) | 4.9 (\pm 2.7) | 3.0 (\pm 1.7) |

It was recognised in 2000 that the TSR model was unable to predict storm numbers within the extra-tropical North Atlantic and so a climatology forecast was used instead. Since most US landfalling and almost all Caribbean landfalling hurricanes form in either the Main Development Region (MDR 10°N-20°N, 10°W-60°W), Caribbean Sea or Gulf of Mexico, a separate forecast was issued for these regions combined. TSR forecast accuracy was extremely good for tropical storms and hurricanes, with the August forecast being correct, the July forecast slightly over-estimating and the June and November forecasts slightly under-estimating the total numbers. All forecasts underestimated the number of intense hurricanes, though most were correct to within one standard error.

3. US Landfalling Numbers

| US Landfalling Numbers 2001 | | | |
|--|--------------|-----------------------|------------------|
| | | Named Tropical Storms | Hurricanes |
| Average Number (\pm SD) (1991-2000) | | 3.1 (\pm 2.0) | 1.3 (\pm 1.1) |
| Average Number (\pm SD) (1971-2000) | | 2.7 (\pm 1.9) | 1.3 (\pm 1.3) |
| Actual Number 2001 | | 3 | 0 |
| TSR Forecast (\pm SD) | 06 Aug 2001 | 3.7 (\pm 1.3) | 1.7 (\pm 0.9) |
| | 06 July 2001 | 3.6 (\pm 1.2) | 1.9 (\pm 0.9) |
| | 15 June 2001 | 3.1 (\pm 1.4) | 1.5 (\pm 1.0) |
| | 17 Nov 2000 | 3.3 (\pm 1.8) | 1.8 (\pm 1.5) |

TSR tropical storm forecasts were all accurate to within one standard error but the fact that no landfalling hurricane occurred was unexpected. Nevertheless, two of the landfalling storms

(Barry and Gabrielle) were within 5-knots of hurricane strength at landfall, indicating the hurricane forecasts were not as far out as they seem. Gray also forecast above average US landfalling hurricanes but they were not presented in a form suitable to be included here.

4. Lesser Antilles Landfalling Numbers

| Lesser Antilles Landfalling Numbers 2001 | | | | |
|---|--------------|-----------------------|------------------|--------------------|
| | | Named Tropical Storms | Hurricanes | Intense Hurricanes |
| Average Number (\pm SD) (1991-2000) | | 1.3 (\pm 1.0) | 0.7 (\pm 0.8) | 0.3 (\pm 0.5) |
| Average Number (\pm SD) (1971-2000) | | 1.0 (\pm 1.0) | 0.4 (\pm 0.6) | 0.2 (\pm 0.4) |
| Actual Number 2001 | | 2 | 0 | 0 |
| TSR Forecast (\pm SD) | 06 Aug 2001 | 1.7 (\pm 0.9) | 0.7 (\pm 0.6) | 0.4 (\pm 0.4) |
| | 06 July 2001 | 1.9 (\pm 0.9) | 0.8 (\pm 0.6) | 0.4 (\pm 0.4) |
| | 15 June 2001 | 1.4 (\pm 0.9) | 0.6 (\pm 0.6) | 0.3 (\pm 0.4) |

Tropical storm numbers were correctly forecast to be above average but there were no landfalling hurricanes. The closest was Hurricane Iris which was spawned in the island arc but failed to make hurricane strength until it reached the longitude of Haiti.

Environmental Factors in 2001

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, 10° W- 60° W] (MDR SST).
2. Jul-Sep Caribbean 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. 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 2001 | | | |
|---------------------------------------|--------------|-----------------|------------------------------|
| | | MDR SST (°C) | CAR U (ms ⁻¹) |
| Actual Value 2001 (1971-2000 Anomaly) | | 0.2 | 0.3 |
| TSR Forecast (±SD) | 06 Aug 2001 | 0.2 (±0.1) | 0.5 (±0.5) |
| | 06 July 2001 | 0.3 (±0.1) | 0.7 (±0.6) |
| | 15 June 2001 | 0.0 (±0.2) | 0.1 (±0.7) |
| | 17 Nov 2000 | 0.3 (±0.4) | 0.2 (±1.0) |

TSR predictor forecasts were all accurate to within 1 standard error, with every forecast correctly identifying the sign of both anomalies. This ensured that TSR correctly forecast an above average hurricane season as early as November 2000. The best forecast was August, which was accurate to within 0.02°C for the MDR SST and 0.15ms⁻¹ for the Caribbean U-winds, which in turn made it the most accurate for predicting the tropical North Atlantic storm and hurricane numbers. Of further note, to arrive at the enhanced Caribbean U-wind forecast in November 2000, TSR had correctly forecast continued weak negative ENSO (Niño 3.4) SSTs whilst most other forecasting groups felt ENSO conditions would become weak or moderately positive. This was one of the primary reasons why Gray failed to predict above average seasonal tropical cyclone numbers in December 2000 and April 2001.

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 |

Our forecast is validated using track data obtained from the Unisys Weather Website (<http://weather.unisys.com>). Position and maximum windspeeds are supplied at 6-hour time intervals. We interpolate these to 15-minute intervals.

Future Forecasts and Verifications

1. End-of-season summary for the NW Pacific 2001 tropical cyclone season will be issued later this month.
2. Next monthly update for the 2002 Atlantic hurricane season will be issued on 6th February.
3. Extended-range forecast for Australian-region tropical storms in 2002/03 will be issued in

April and an end-of-season summary for the 2001/02 Australian-region tropical storm season will be released in May.

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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