Extended Range Forecast for Atlantic and USA Landfalling Tropical Cyclones in 2001

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Forecast Summary

Atlantic hurricane activity is expected to be 20-25% above average in 2001, and US landfall numbers are anticipated to be 20% above average

We present extended range forecasts for Atlantic tropical cyclone, hurricane and intense hurricane numbers in 2001, and for tropical cyclone and hurricane strike numbers on the US mainland in 2001. Our forecasts span the Atlantic season from 1st June 2001 to 30th November 2001. They are based on data available through the end of October 2000. Rigorous independent hindcasts for 1986-2000 show that our prior November forecasts have 10-15% skill (better than chance) in predicting the following year's seasonal basin hurricane numbers, and 10% skill in predicting the following year's seasonal US tropical cyclone strikes. Our two main predictors are the July-September 2001 forecast trade wind speed in the Caribbean, and the August-September 2001 forecast sea surface temperature in the tropical north Atlantic.

1. Atlantic Total Numbers in 2001

		Intense Hurricanes	Hurricanes	Tropical Storms
UCL Forecast (±SD)	2001	3.4 (±1.6)	6.9 (±2.4)	10.6 (±3.7)
Average (±SD)	1986-2000	2.3 (±1.8)	6.1 (±2.7)	10.5 (±3.7)
Average (±SD)	1950-2000	2.5 (±1.9)	5.9 (±2.4)	9.5 (±3.2)

Key: Intense Hurricanes = Sustained Wind > 95Kts = Category 3 to 5
Hurricanes = Sustained Wind > 63Kts = Category 1 to 5
Tropical Storms = Sustained Wind > 33Kts
Forecast Error = Standard Deviation of Independent Hindcast Errors for 1985-1999

- Tropical storm, hurricane, and intense hurricane numbers are anticipated to be 20-25% above average in 2001.
- Rigorous independent hindcasts for 1986-2000 show that our prior November predictions, made 9-months prior to the August-October peak season, have 10-15% skill (better than chance) in predicting the following year's seasonal basin hurricane and intense hurricane numbers.We do not have skill for tropical storm numbers at this range.

2. Total Numbers for MDR, Caribbean Sea and Gulf of Mexico Combined in 2001

		Intense Hurricanes	Hurricanes	Tropical Storms
UCL Forecast (±SD)	2001	3.0 (±1.7)	4.9 (±2.7)	7.3 (±3.7)
Average (±SD)	1985-1999	2.1 (±1.9)	4.4 (±3.1)	7.3 (±4.2)
Average (±SD)	1950-1999	2.1 (±1.9)	3.9 (±2.6)	6.1 (±3.1)

- The number of tropical storms, hurricanes, and intense hurricanes originating in the Atlantic Hurricane Main Development Region MDR (10°N - 20°N, 10°W - 60°W), Caribbean Sea and Gulf of Mexico are anticipated to be 30% above the 50-year average and 20% above the15-year average in 2001.
- Rigorous independent hindcasts for 1986-2000 show that our prior November predictions, at a lead of 9-months, have 15% skill in predicting the following year's seasonal number of hurricanes, and 5% skill for tropical storms and intense hurricanes forming in the above region (see page 5 for a skill plot as a function of lead time out to 1-year).

3. US Landfalling Numbers in 2001

		Intense Hurricanes	Hurricanes	Tropical Storms
UCL Forecast (±SD)	2001	0.8 (±0.5)	1.8 (±1.5)	3.3 (±1.8)
Average (±SD)	1985-1999	0.4 (±0.5)	1.4 (±1.0)	3.1 (±1.7)
Average (±SD)	1950-1999	0.6 (±0.7)	1.5 (±1.2)	3.0 (±1.7)

- Tropical storm, hurricane and intense hurricane landfalling numbers in 2001 are anticipated to be about 20% above average.
- Rigorous independent hindcasts for 1986-2000 show that our prior November predictions have 10% skill (better than chance) in anticipating the following year's seasonal US tropical cyclone strikes. We do not have skill for landfalling hurricanes and intense hurricanes at this range.
- We do not present landfalling forecasts for the US East Coast, US Gulf Coast and for the Caribbean Lesser Antilles since our model does not exhibit skill at this 9-month lead.

Predictors and Key Influences in 2001

Our model exploits the predictability of tropical sea surface temperatures (SSTs). Anomalous patterns of SST are the primary source of tropical atmosphere forcing at seasonal and interannual timescales. The two main predictors in our model are:

1. July-September forecast 925mb U-winds over the Caribbean (10°N - 20°N, 60°W - 90°W). These are forecast from July-September Nino 3, Nino 3.4, Nino 4, and Caribbean forecast SSTs.
2. August-September forecast SST for the Atlantic Hurricane Main Development Region MDR (10°N - 20°N, 10°W - 60°W).

The forecast SSTs come from an in-house statistical model which utilises initial conditions and trends in global SSTs. Using data available through the prior October, the model anticipates the August-September Nino 3.4 SST, August-September MDR SST, and July-September 925mb Caribbean U-wind with skills of 30%, 20% and 12% respectively. Skill is expressed as the percentage

reduction in root-mean-square-error 1986-2000 over that obtained using forecasts based on climatology (1961-1990 base).

The key factors behind our forecast of above average activity in 2001 are: (a) the enhancing effect of weaker than normal Caribbean trade winds in July-September 2001 - we anticipate these to be 4% weaker than average (1961-1990 climatology); (b) the enhancing effect of cooler than normal ENSO SSTs - we anticipate an August-September 2001 Nino 3.4 anomaly of -0.27°C (1961-1990 climatology); (c) the enhancing effect of a warmer than normal Atlantic MDR SST - we anticipate an August-September 2001 anomaly of +0.28°C (1961-1990 climatology).

Methodology

The interannual variability in hurricane numbers is modelled using a Gaussian distribution. In selecting predictors we apply the Chow parameter stability test, as used in economics, to ensure persistence and stability. This involves running the same regression over subsections of the data to test the hypothesis that the regression parameters obtained for the subsets are not significantly different from those found for the whole regression, against the alternative that one or more are different. This hypothesis must be satisfield at the 95% level for a predictor to prove stable and acceptable. The main predictors we use appear on page 2.

Our strategy is to divide the Atlantic basin into three sub-regions: (a) the Atlantic Hurricane Main Development Region MDR (10°N - 20°N, 20°W - 60°W), (b) the Caribbean Sea and the Gulf of Mexico, and (c) the Extra-Tropical north Atlantic. We can skilfully forecasts the seasonal numbers of events forming in (a) and (b) but not in (c). Our basin forecasts comprise the sum of (a) and (b) with climatology used for (c).

We obtain forecasts for landfalling events by 'thinning' the forecasts for total numbers. The total number is multiplied by the historical fraction of the total number that has made landfall. The thinning postulate is unlikely to hold exactly on physical grounds, but is a reasonable initial approximation.

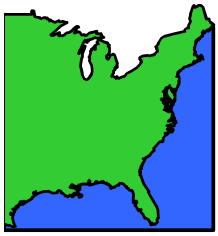
Forecast skill is assessed by rigorous hindcast testing over the period 1986-2000. We use only prior years in identifying the predictors and in calculating the regression relationship for each future year to be forecast - ie the hindcasts are performed in strict 'forecast' mode. Thus 1986 is forecast using 1950-1985 data, 1987 using 1950-1986 data, etc. We do not employ the jack-knife method of cross-validation which inflates skill, nor do we identify predictors using the whole data set which again inflates skill. The hindcast values are compared against verification, and the model skill is quantified using the $RMSE_{CL}$ Skill (%) metric defined as the percentage reduction in root-mean-square-error over what one would obtain from climatology forecasts, ie:

$$Skill\,Score \;=\; RMSE_{CL}(\%)\;Skill \;=\; \left(1 - \frac{RMSE_{FORECAST}}{RMSE_{CLIMATOLOGY}}\right) x\,100\%$$

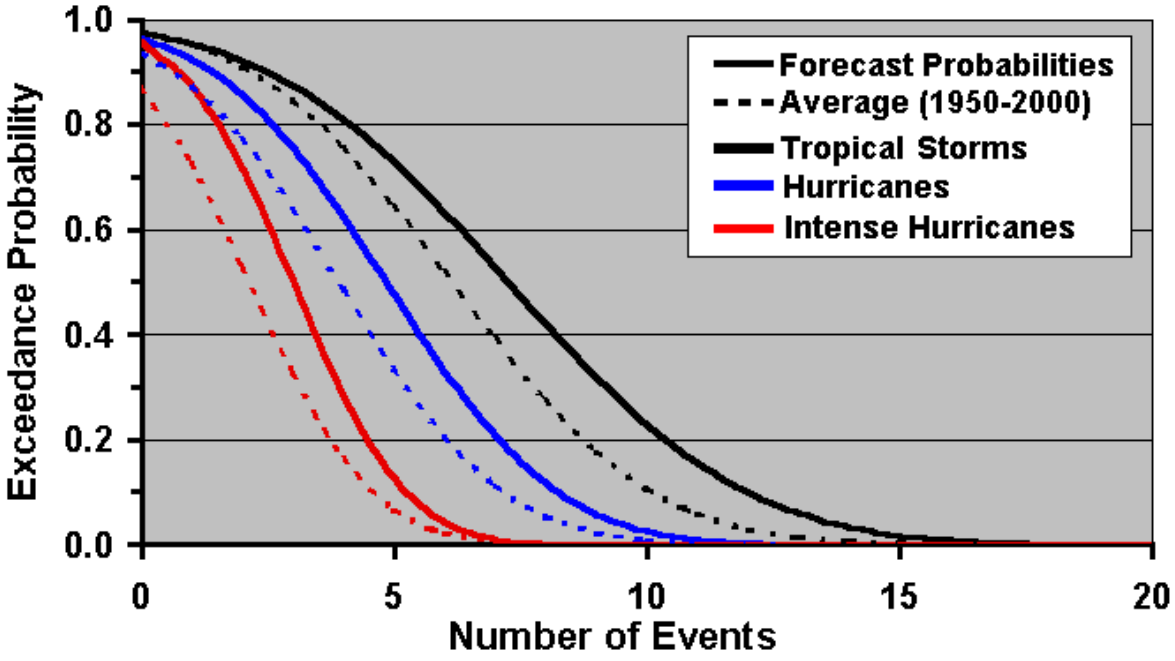
All skill measures given in this document use the $RMSE_{CL}$ skill measure. We feel this is a robust skill score which is immune to the bias problems associated with the Percentage of Variance Explained and Percentage Agreement Coefficient skill measures.

The forecast errors in the Tables on pages 1 and 2 are given as the standard deviation of the hindcast errors for 1986-2000.

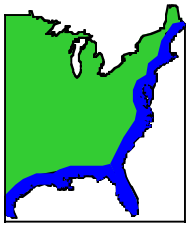
Total Number of Tropical Atlantic, Caribbean and Gulf of Mexico Tropical Cyclones



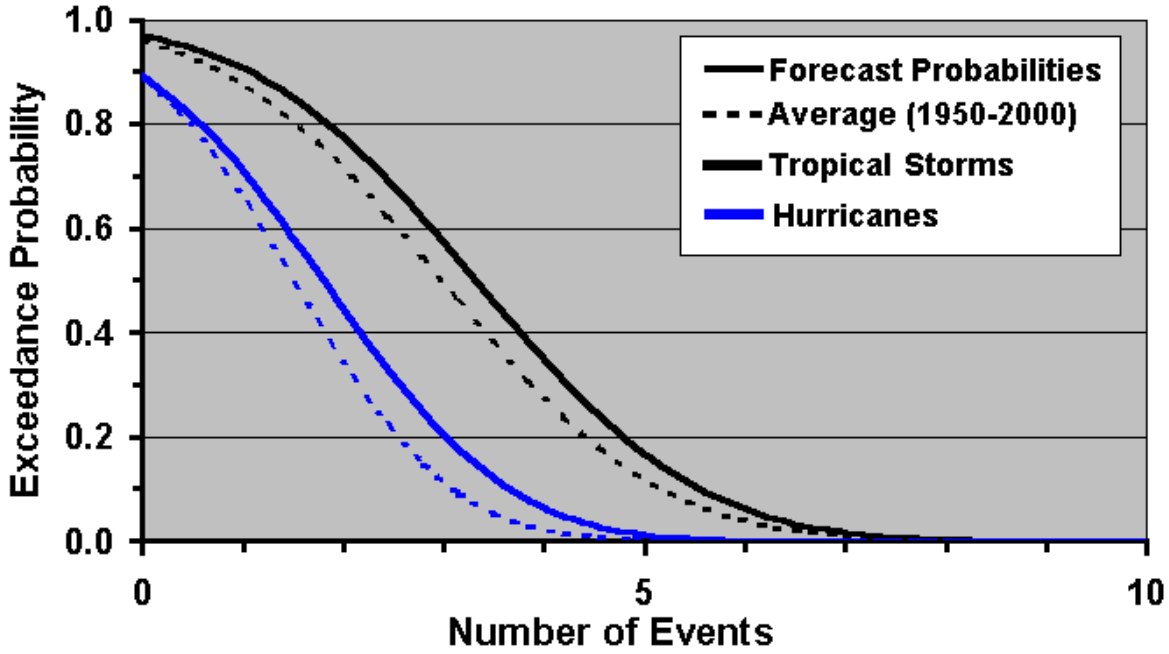
Probability of Exceedance Forecast for 2001



USA Landfalling Tropical Storms and Hurricanes

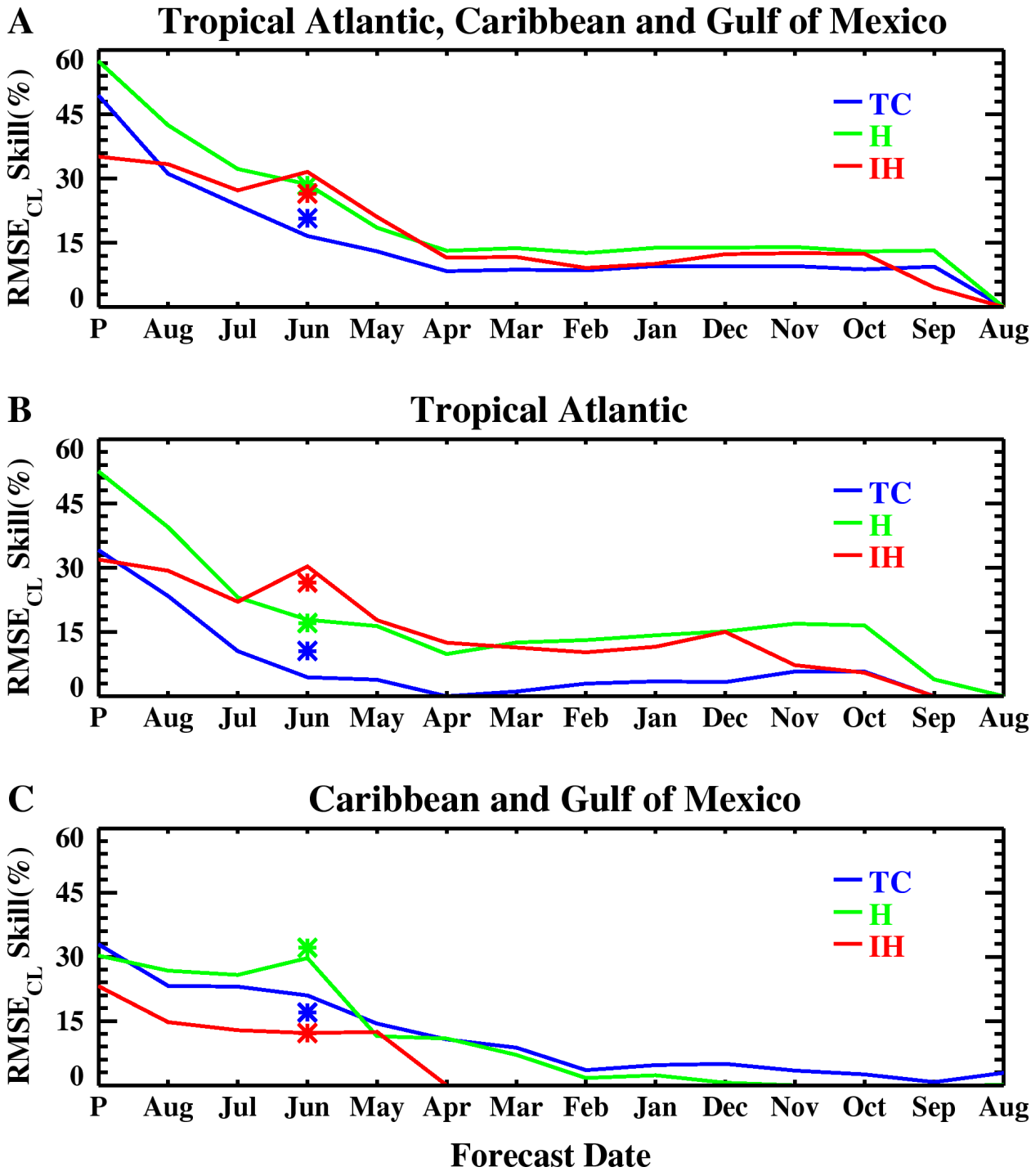


Probability of Exceedance Forecast for 2001



Seasonal Hurricane Hindcast Skill 1986-2000

What would the model forecast skill be (ie skill over random chance), as a function of lead time, had the model been available for the past 15 years?



- At 9-months lead (previous 1st November) the model forecast skill for all strengths of storm is 10-15%. This skill comes largely from the tropical Atlantic (or MDR region).
- The model forecast skill increases at leads less than 4-months (ie after 30th April).
- The *'s denote the model skill obtained by including dynamical forecasts of Caribbean trade wind speed obtained from the Met. Office Unified Model (1st June forecasts only).
- The *P* abscissa values denote the skill with perfect SST and trade wind speed predictors.

Potential Benefits

Tropical cyclones rank above earthquakes and floods as the United States' costliest natural disaster. The annual damage bill in the continental US from hurricane landfalls 1926-1999 is estimated to be US $ 5.2 billion (2000 $). Substantial interannual variability exists in these losses - witness 1999 and 1997 with bills of US $ 8.0 billion and just US $ 0.15 billion respectively. Skilful long-range forecasts of seasonal US tropical cyclone strike numbers would benefit society, business and government by reducing - through the available lead-time - the risk, uncertainty and the financial volatility inherent to varying active and inactive storm seasons.

Future Forecasts and Verifications

1. Pre-season forecast for SW Pacific and Queensland landfalling tropical cyclones in 2000/01 will be issued in early December 2000.
2. End-of-year summaries and forecast verifications for the Atlantic and NW Pacific 2000 seasons will be issued in December 2000.
3. Extended-range forecast for NW Pacific and Japan landfalling tropical cyclone activity in 2001 will be issued in January 2001.

New Name and Sponsorship

From 4th December 2000 the forecasts become known as the*"TSR (Tropical Storm Risk)"* group predictions. Forecasts will be available from http://tropicalstormrisk.com. A tripartite consortium from the UK insurance industry comprising the composite companies *CGNU Group*, and *Royal and Sun Alliance*, and the Lloyd's reinsurance broker *Benfield Greig Group* is funding the project until 30th June 2001. The project gratefully acknowledges the support of these companies.

Acknowledgements

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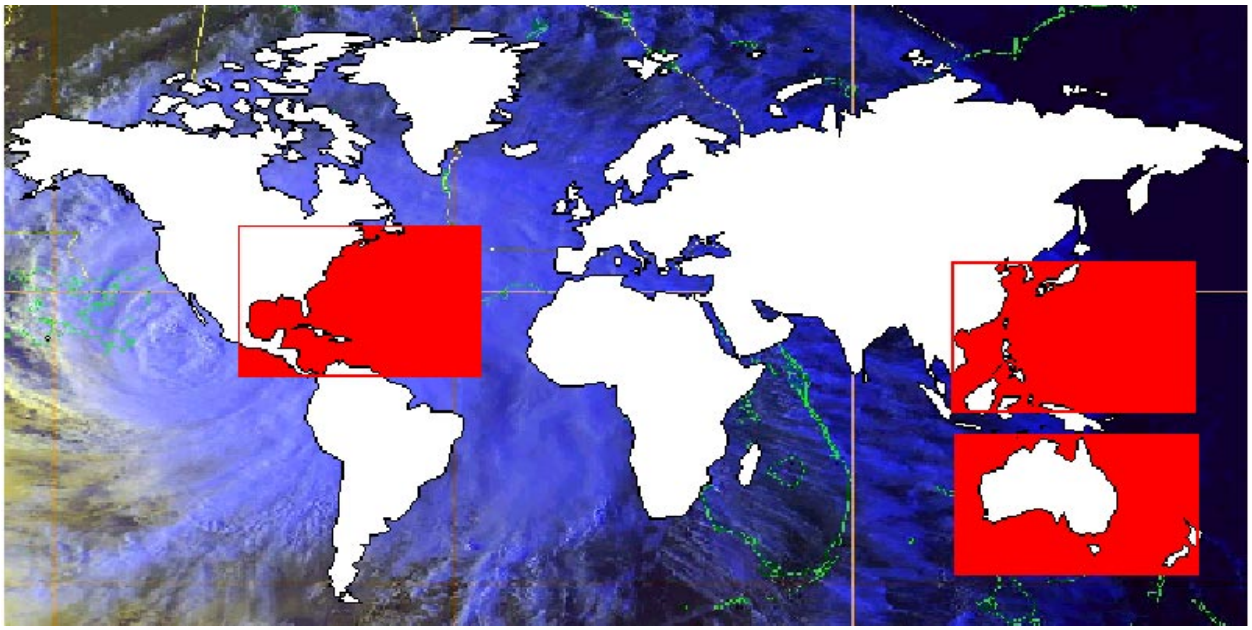

The three basins under research by the TSR Tropical Storm Risk team