Atlantic, U.S. and Caribbean Landfalling Tropical Cyclones in 2000

Pre-Main Season Forecast Update Issued 2nd August, 2000

Produced in collaboration with the UK Met. Office
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Forecast Summary

Atlantic hurricane activity and US landfall probability are expected to be marginally above average in 2000

We present pre-main season forecasts for Atlantic tropical cyclone, hurricane and intense hurricane numbers in 2000, and for hurricane strike numbers on the US East Coast, the US Gulf Coast, and on the Caribbean Lesser Antilles in 2000. These forecasts span the Atlantic season from 1st June 2000 to 30th November 2000. They are based on data available through the end of June 2000. Rigorous hindcasts for 1985-1999 show that our July predictions are able to anticipate 50% of the year-to-year variance in seasonal basin numbers, and around 20% of the year-to-year variance in seasonal US strikes. Our predictors are forecast sea surface temperatures and forecast trade wind speed.

1. Atlantic Total Numbers in 2000

		Intense Hurricanes	Hurricanes	Tropical Storms
UCL July Forecast (±SD)	2000	3.0 (±1.3)	6.3 (±1.6)	10.4 (±2.5)
UCL May Forecast (±SD)	2000	2.1 (±1.4)	5.1 (±2.3)	8.7 (±3.0)
NOAA May Forecast	2000	≥3	≥7	≥11
Gray June Forecast	2000	4	8	12
Actual	1999	5	8	12
Average (±SD)	1950-1999	2.5 (±1.9)	5.9 (±2.4)	9.9 (±3.1)
Average (±SD)	1985-1999	2.3 (±1.8)	6.0 (±2.6)	10.4 (±3.6)

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 Hindcast Errors for 1985-1999		

- Tropical cyclone numbers are anticipated to be 5-10% above the 50-year average and even closer to the15-year average.
- The main factor behind the increase on our May forecast is the incorporation of forecast Caribbean July-September trade winds. These easterly winds are anticipated to be slightly weaker than normal in 2000, thereby reducing vertical wind shear and enhancing hurricane activity.

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2. US Landfalling Numbers in 2000

		Intense Hurricanes	Hurricanes	Tropical Storms
UCL July Forecast (±SD)	2000	0.8 (±0.5)	1.9 (±1.4)	3.6 (±1.6)
Actual	1999	1	3	5
Average (±SD)	1950-1999	0.8 (±0.8)	1.8 (±1.3)	3.4 (±1.7)

3. US East Coast Strikes in 2000

		Intense Hurricanes	Hurricanes	Tropical Storms
UCL July Forecast (±SD)	2000	0.5 (±0.5)	1.1 (±0.9)	2.1 (±1.1)
Actual	1999	0	2	4
Average (±SD)	1950-1999	0.5 (±0.7)	1.0 (±0.9)	2.0 (±1.3)

4. US Gulf Coast Strikes in 2000

		Intense Hurricanes	Hurricanes	Tropical Storms
UCL July Forecast (±SD)	2000	0.5 (±0.5)	1.2 (±1.0)	2.6 (±1.5)
Actual	1999	1	2	3
Average (±SD)	1950-1999	0.5 (±0.7)	1.1 (±1.1)	2.4 (±1.5)

5. Caribbean Lesser Antilles Strikes in 2000

		Intense Hurricanes	Hurricanes	Tropical Storms
UCL July Forecast (±SD)	2000	0.3 (±0.4)	0.6 (±0.7)	1.4 (±1.1)
Actual	1999	1	2	2
Average (±SD)	1950-1999	0.3 (±0.5)	0.6 (±0.8)	1.3 (±1.2)

Predictors and Key Influences in 2000

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

1. August-September forecast sea surface temperatures (SSTs) for the Atlantic Hurricane Main Development Region MDR (10°N - 20°N, 20°W - 60°W).
2. August-September forecast SSTs for the Caribbean Sea (10°N - 20°N, 60°W - 85°W).
3. August-September forecast 950mb U-winds over the Caribbean (10°N - 20°N, 60°W - 85°W). These are forecast from Nino 3.4 and Nino 4 August-September forecast SSTs.
4. August-September forecast QBO (quasi-biennial oscillation).

The forecast SSTs come from an in-house statistical model which utilises the initial conditions and trends in global SSTs. This model anticipates 70- 80% of the seasonal variance in the required August-September SSTs using data through the end of June.

The key factors behind the forecast of marginally above average activity in 2000 are the enhancing effect of cooler than normal ENSO SSTs - forecasts anomalies of -0.3°C (1950-1999 climatology) for Nino 3.4 and -0.2°C for Nino 4, combined with the suppressing efect of cooler than normal MDR SST (-0.1°C anomaly) and neutral Caribbean SST (0.0°C anomaly) .

Methodology

The interannual variability in hurricane numbers is modelled using a Gaussian distribution. All predictors are August-September forecast contemporaneous SSTs. 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 predictors used and brief details of how we forecast them 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 thus comprise the sum of (a) and (b) with climatology 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 1985-1999. 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 1985 is forecast using 1950-1984 data, 1986 using 1950-1985 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 following standard measures:

MAE (Mean Absolute Error) defined as the mean absolute difference between the predicted and actual values. The lower this value, the more skilful the model.

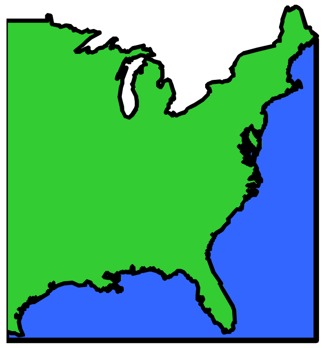
PAC (Percentage Agreement Coefficient) defined as the mean absolute difference between the predicted and actual values relative to the level expected under the model. A PAC of 100% indicates perfect skill, a PAC value of 0% indicates no forecast skill.

PVE (Percentage of Variance Explained) defined as the percent of the actual variance explained by the forecast. A PVE of 100% indicates perfect skill, a PVE of 0% indicates no skill.

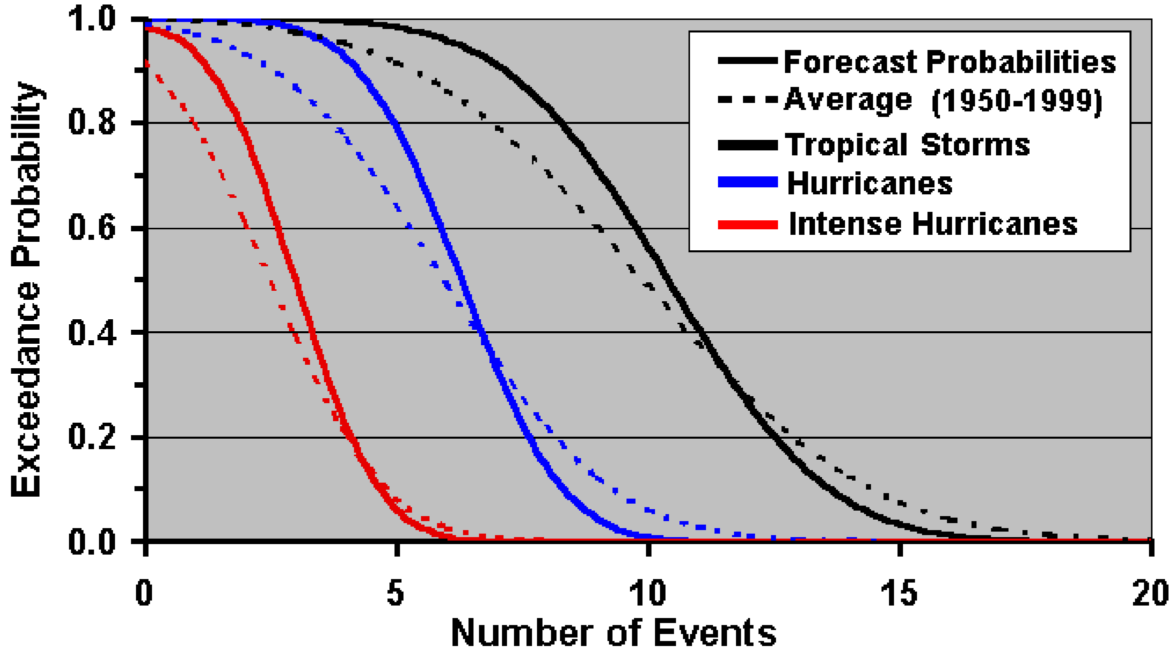
The forecast errors in the Tables on pages 1 and 2 are given as the standard deviation of the hindcast errors for 1985-1999.

A fundamental principle underlying our approach is to forecast probability distributions for hurricane occurrence. This strategy permits imperfection in the forecast to be recognised while still providing quantitative information. Probability of exceedance figures appear on pages 4 to 8.

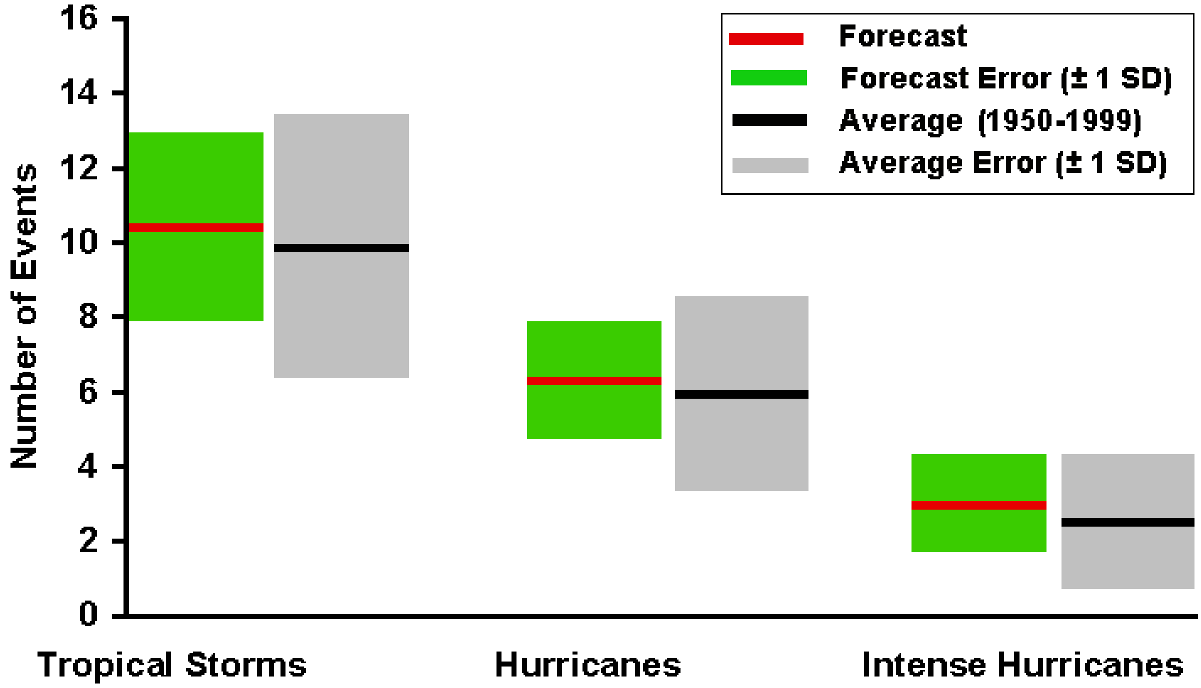
Total Number of Atlantic Tropical Cyclones



Probability of Exceedance Forecast for 2000

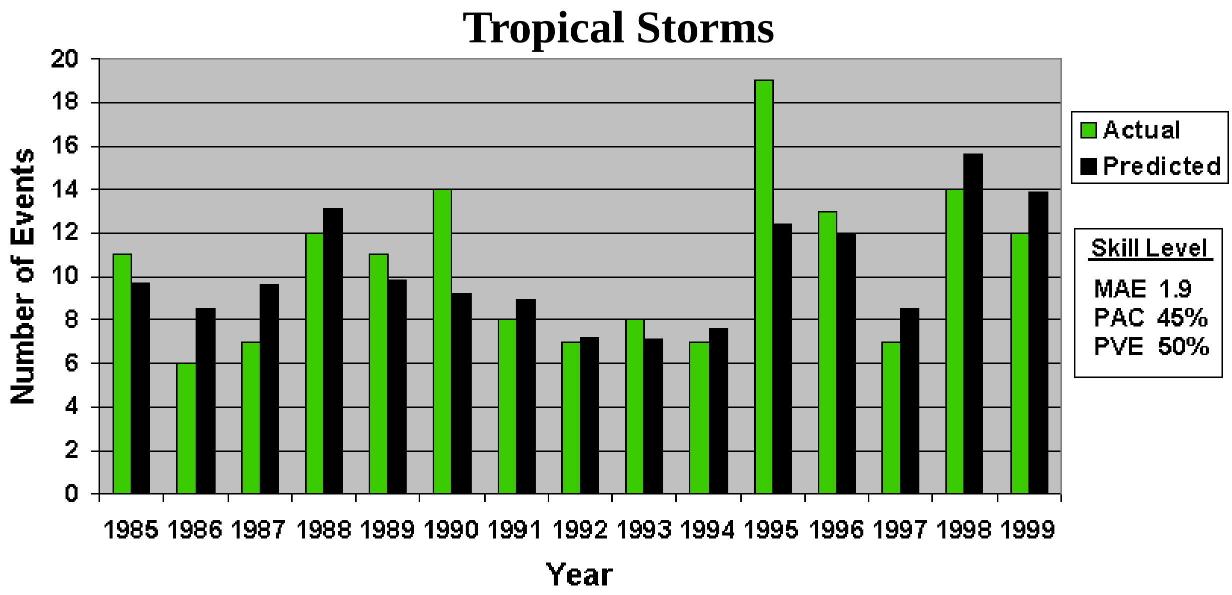


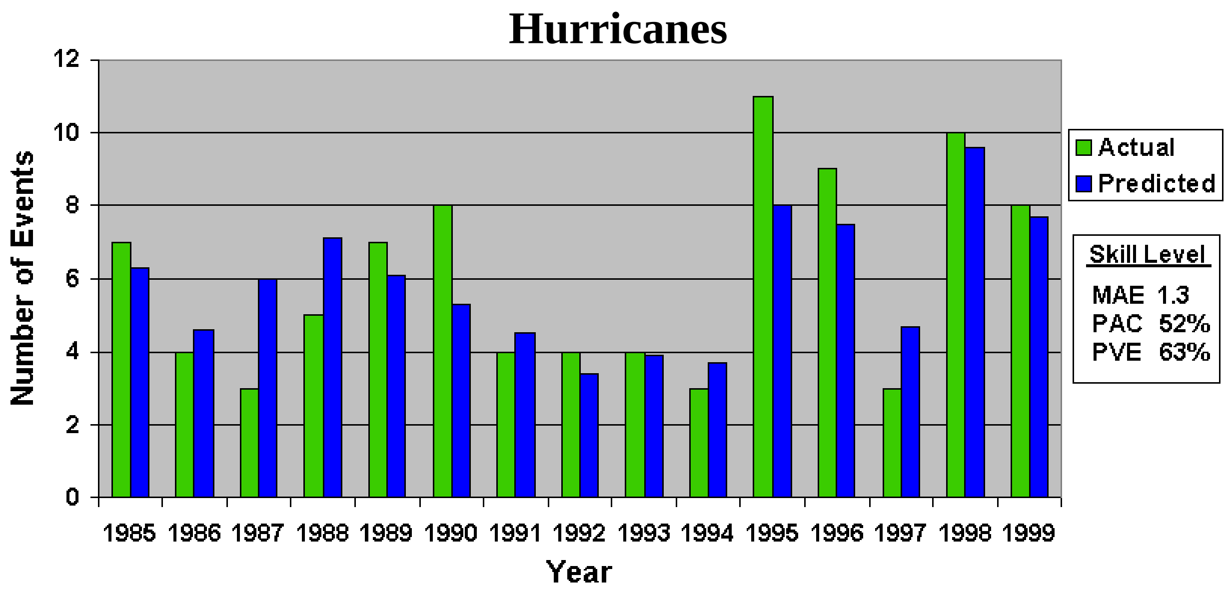
Frequency and Severity Distribution for 2000

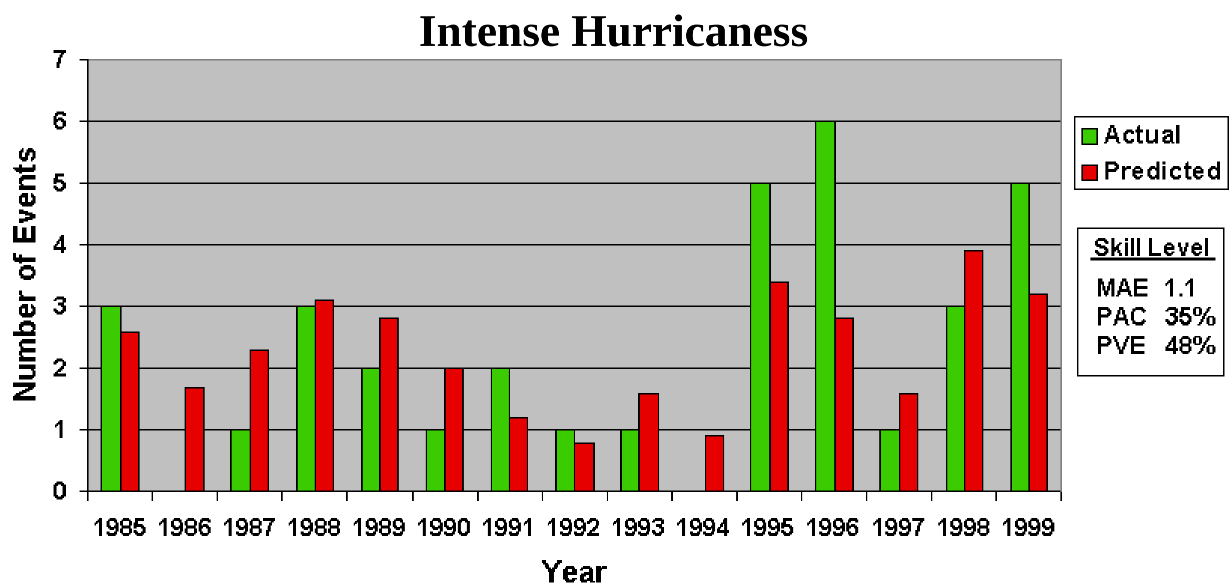


Model Hindcast Performance 1985-1999: Basin Total Numbers

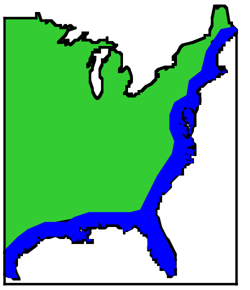
How would the pre-main season model (using data up to the end of June) perform had it been available in previous years?



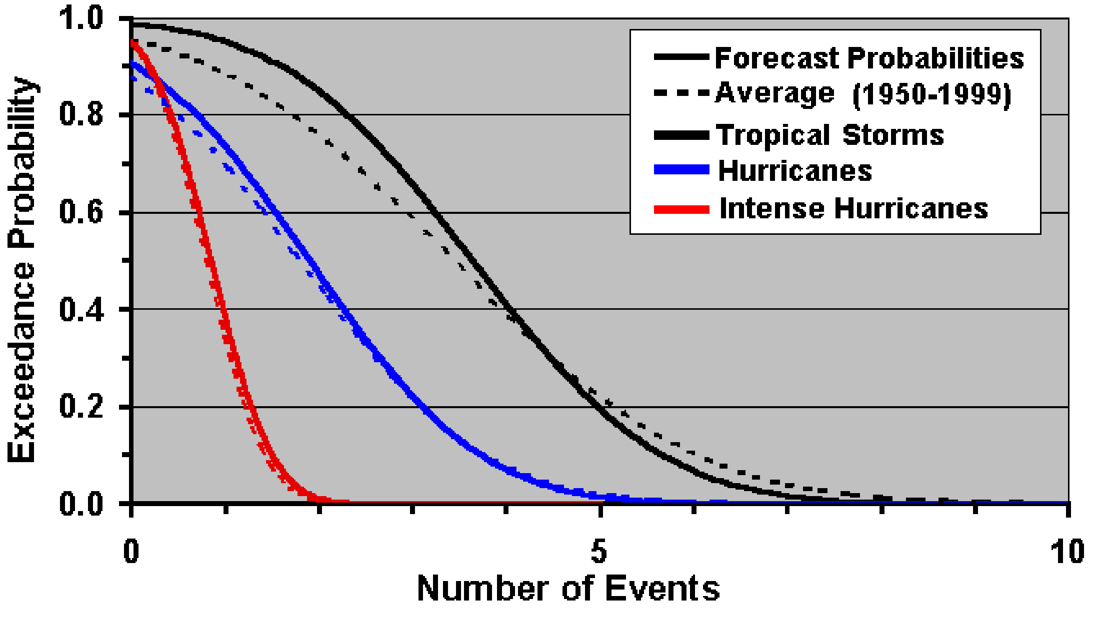




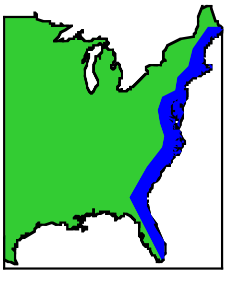
USA Landfalling Tropical Cyclones



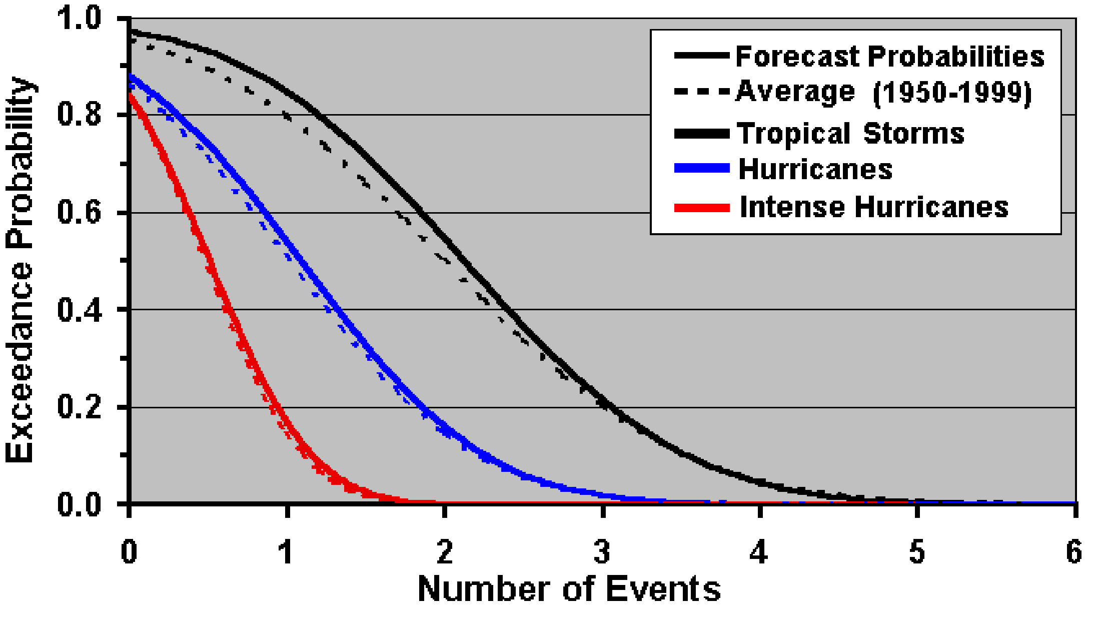
Probability of Exceedance Forecast for 2000



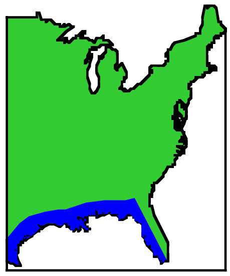
East Coast Landfalling Tropical Cyclones



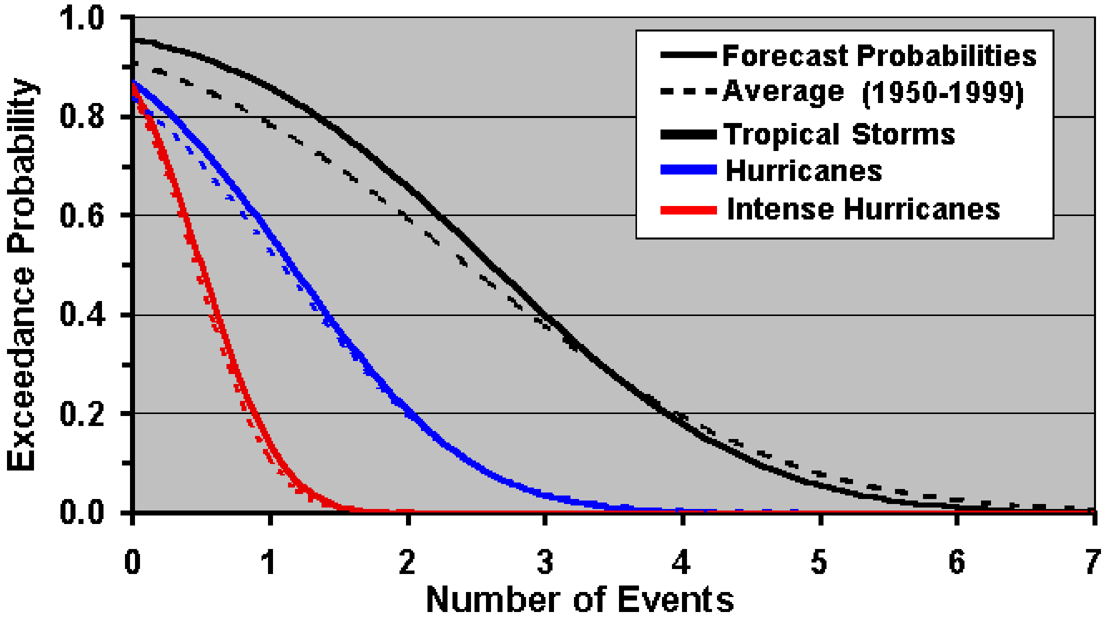
Probability of Exceedance Forecast for 2000



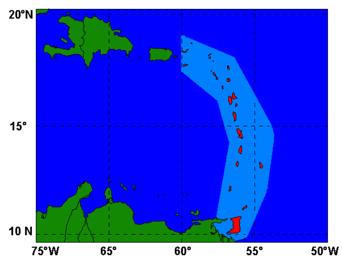
Gulf Coast Landfalling Tropical Cyclones



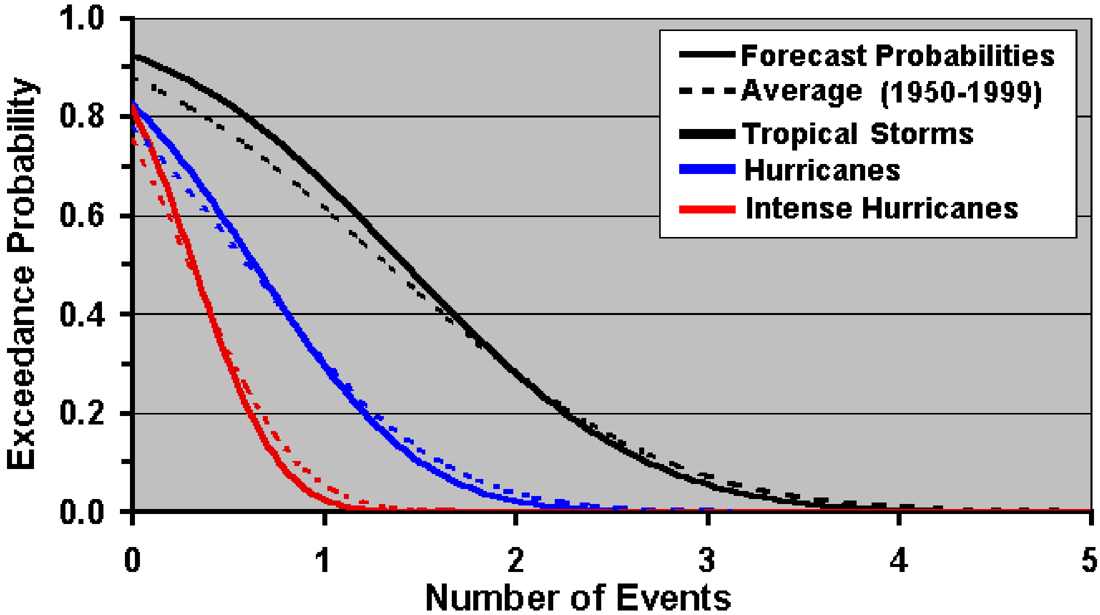
Probability of Exceedance Forecast for 2000



Lesser Antilles Landfalling Tropical Cyclones



Probability of Exceedance Forecast for 2000



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

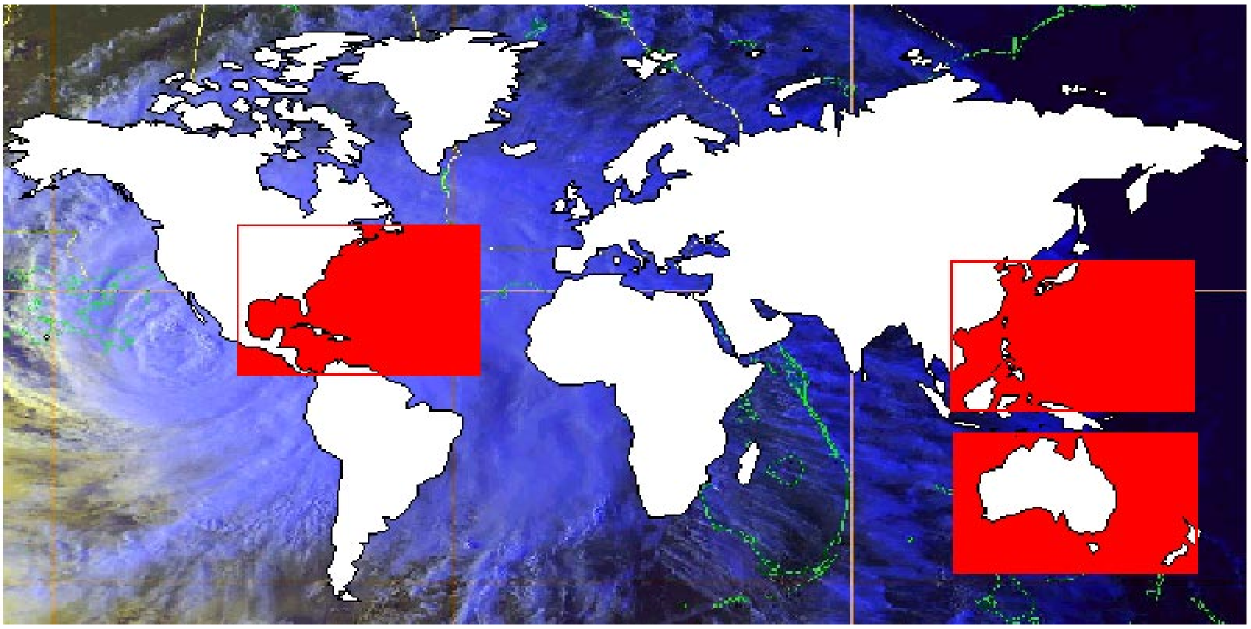
1. Extended-range forecast for Atlantic seasonal tropical cyclone activity and for US and Caribbean hurricane strike probabilities in 2001 will be issued in early October 2000.
2. Pre-season forecast for SW Pacific and Queensland landfalling tropical cyclones in 2000/01 will be issued in early November 2000.
3. End-of-year summaries and forecast verifications for the NW Pacific and Atlantic 2000 seasons will be issued in early December 2000.

New Sponsorship

We are pleased to announce the project is under new sponsorship from the 1st July 2000. 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. We gratefully acknowledge the support of these companies.

Acknowledgements

The Seasonal Prediction of Tropical Cyclones project is administered by Mrs Alyson Bedford of the UK Met. Office We wish to thank Mike Cooper (CGNU Group), David Simmons (Benfield Greig Group) and Julia Graham (Royal and Sun Alliance) for industrial liaison. We acknowledge meteorological input from Dr Mike Davey (Met. Office), statistical advice from Dr Richard Chandler (Department of Statistical Science, University College London), and computing assistance from Frank Roberts and Justin Mansley (UCL).



The three basins under research in the Seasonal Prediction of Tropical Cyclones project.